# Alabama's Artificial Reef Plan

A proposal for engineered reef deployment and marine resource management

A Joint Project by the Alabama Wildlife Federation and the Alabama Chapter of the Coastal Conservation Association in Conjunction with Alabama Marine Resources Division

AlReefs.com

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*Our mission is to manage the State's marine fishery resources through research, enforcement, and education for the maximum benefit of the resources and the citizens of Alabama.*

Christopher M. Blankenship
Director
MARINE RESOURCES DIVISION

# Alabama Marine Resources Division (AMRD) Reef Program

Alabama's artificial reef program began in 1953 when the Orange Beach Charter Boat Association was approved to deploy 250 car bodies offshore of Baldwin County, Alabama. The initial deployment of artificial substrate proved to be valuable to the fishing industry, and led to additional reefing of culverts, bridge rubble, barges, boats, and planes. In 1974 State and Federal agencies, through a cooperative permitting process, reefed 5 "ghost-fleeted" liberty ships offshore of Alabama. In 1987, a general permit was issued by the U.S. Army Corps of Engineers (USACOE) which created nearly 800 square miles available for State inspected reefing material to be deployed. The USACOE permit granted the 1994 REEF-EX program a mechanism to deploy obsolete military combat tanks as reef material within the general USACOE permit area. A total of 100 decommissioned military tanks were deployed during the REEF-EX program by 1995. A second USACOE permit in 1997 extended the general artificial reef permit areas to include deeper waters and now encompasses approximately 1,260 square miles. A component of the extension of the general USACOE permit area was the restriction of non-durable reef materials and the inclusion of Alabama Marine Police Division, U.S. Coast Guard, and Marine Resources enforcement to ensure the inspected materials were being deployed within the general permit zone boundaries. Following the success of the offshore reef program, Alabama Marine Resources Division (AMRD) began constructing inshore artificial reefs in 1996. Oyster cultch material, bridge pilings/rubble, and limestone gravel was used to increase finfish habitat complexity and to promote oyster production. To date, Alabama's artificial reef program has resulted in the deployment of approximately estimated 15,000 artificial reefs offshore of Alabama, and 33 inshore reefs in the Mississippi Sound, Mobile Bay, and Perdido/Wolf Bay.

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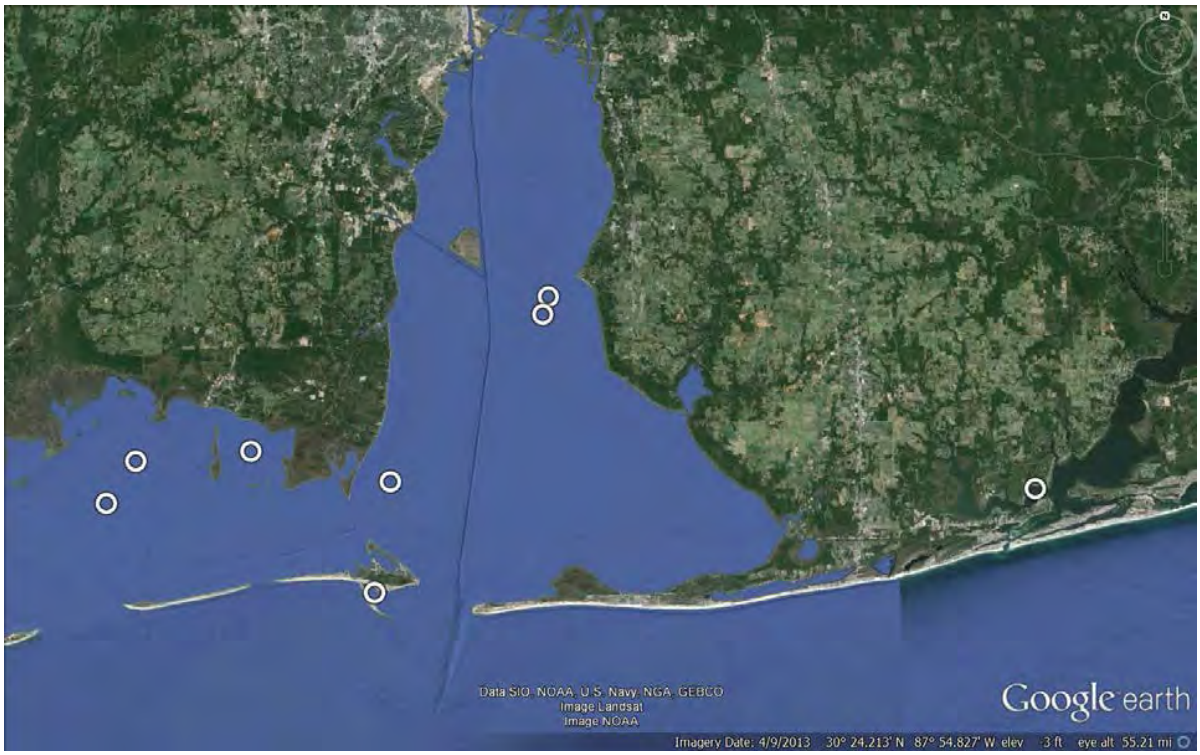
# Goals and Future Plans

- **Inshore**
  - Refurbishing all 32 existing inshore reefs to +8" of elevation with 100% coverage of 6-8" limestone gabion (approximately $20,538,478.44 assuming construction cost of $65.00/ton and 1.29 tons of 6"-8" limestone gabion per cubic yard).
  - Construct 8 additional artificial reef sites with 100% coverage of 6"-8" limestone gabion in Arnica Bay, Portersville Bay, Mobile Bay at Bouy Reef, Pelican Bay, 2 near Point Clear, and 2 reefs surrounding sunken shrimp boats in the Mississippi Sound (approximately 31,865 $yd^3$ and $2,071,192.50).
  - Develop a research program to evaluate the increased production of finfish, crustaceans, and benthic fauna associated with AMRD's inshore reef program
    - Estimated funding for research to evaluate production for 5 years is $1,250,000 ($250,000 per year).
  - Establish a monitoring program to evaluate integrity of AMRD's inshore reefs using SCUBA and side-scan sonar to determine the frequency of future maintenance deployments required to sustain maximum production during perpetual degradation of reef materials.
    - Estimated cost to monitor integrity of inshore reefs for 5 years is $125,000 ($25,000 per year).
  - Total estimated cost of inshore reef construction, refurbishment, monitoring, and research for 5 years is approximately $23,984,670

Satellite imagery and approximate location of each of the 8 proposed inshore artificial reefs constructed with 100% coverage of 6"-8" limestone gabion for an estimated cost of $2,071,192

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- **Nearshore (0-3 nautical miles offshore of Alabama in the Gulf of Mexico)**
    - Enhance the seabed at the site of 5 gas platforms in Alabama waters of the Gulf of Mexico with 6”-12” rip rap.
        - Will require additional Army Corps of Engineers permit.
        - Deploy rip rap to +24” elevation and approximately 0.25 acres of spatial coverage at the base of each rig site.
        - Approximately 5,456 tons of 6”-12” rip rap and approximately $110/ton for deployment cost
            - Project estimate = $600,187
    - Develop a snorkeling reef complex using anchored reef structures (similar to eco-reefs)
        - Will require additional Army Corps of Engineers permit.
        - Identify an area of the Gulf of Mexico near public beach access between Fort Morgan, AL and Orange Beach, AL that is within swimming distance from shore, no deeper than 20’ MLW, and is characterized as a relatively stable seabed.
        - Deploy anchored reefs in a 300’ single-file line parallel to the beach and a distance of 4’ between adjacent anchored reef modules.
        - Cost of deploying 75 anchored reefs is approximately $150,000
    - Deploy 250 “juvenile fish shelters” within the R V Minton Reef Zones.
        - Juvenile fish shelters will be constructed from modular limestone gabions and will contain interior void spaces to provide refuge for juvenile reef associated fishes from predators
        - Modular limestone juvenile fish shelters will be approximately 6’X6’X2’
        - Cost of deploying 250 modular limestone juvenile fish shelters is approximately $500,000
    - Create 3 additional nearshore reef areas approximately 2-3 nautical miles offshore in the Gulf of Mexico.
        - Deploy 150 6’ concrete/limestone pyramids within each newly formed nearshore reef zone.
            - Cost of deploying 150 concrete/limestone pyramids within each newly formed nearshore reef zone is approximately $582,750
        - Deploy 150 “juvenile fish shelters” within each newly formed nearshore reef zone.
            - Cost of deploying 150 modular limestone juvenile fish shelters within each newly formed nearshore reef zone is approximately $900,000
    - Total estimated cost of nearshore reef construction projects is approximately $2,732,928

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- **Offshore (10-65 nautical miles offshore of Alabama in the Gulf of Mexico)**
    - Utilize multi-beam side scan technology to characterize the seabed within Alabama's General Permit Reef Zones.
        - Identify juvenile red snapper habitat within Alabama's General Permit Reef Zones to prevent the deployment of high relief adult reef fish habitat in close proximity (500m) to productive juvenile habitats.
        - Identify and quantify hard bottom habitat within Alabama's General Permit Reef Zones to focus habitat enhancement efforts in spatially extensive areas consisting of barren, homogenous substrates.
        - Estimated cost to fund side-scan program within the General Permit Reef Zones for 5 years is $450,000 ($90,000 per year).
    - Utilize multi-beam side scan technology to characterize the seabed outside of Alabama's General Permit Reef Zones.
        - Identify homogenous sandy substrates that can be enhanced to increase its production potential of juvenile red snapper as well as areas of low-relief shell rubble habitats where juvenile red snapper habitat utilization is high.
            - Estimated cost to fund side-scan program to characterize juvenile habitat for 5 years is $450,000 ($90,000 per year).
    - Increase production potential of juvenile red snapper by deploying low-relief habitat in homogeneous sandy substrates that are at least 1 km from the nearest high-relief adult reef fish structures.
        - Enhance 20 acres of homogenous sandy seabed with 50% coverage of 6" limestone gabion (11,280 $yd^3$ of 6"-8" limestone gabion).
            - Will require additional Corps of Engineers permits.
            - Estimated cost to enhance the seabed to increase juvenile red snapper production is $1,600,500
            - Conduct SCUBA surveys to evaluate habitat utilization of juvenile reef fishes and quantify recruitment to estimate increased production.
                - Estimated cost to evaluate juvenile red snapper habitat enhancement project for 5 years is $112,500 ($22,500 per year).
    - Increase the relative contribution of hard bottom habitat within Alabama's General Permit Reef Zones with exceptionally high-relief reef structures
        - Exceptionally high-relief structures (+25' in height) will diversify reef habitats within the reef zones and ultimately increase production of greater amberjack and various groupers (both of which are considered overfished by Gulf of Mexico Fisheries Management Council).
        - Purchase, prepare and deploy at least 3 large ships (+300' in length) to construct artificial reefs ideal for SCUBA enthusiasts.
            - Estimated minimum cost is $300,000 in contribution to the Alabama Reef Foundation from Alabama Marine Resources Division
        - Deploy 100 reef structures that are 25' in height that contain limestone aggregate incorporated into matrix.
            - Estimated project cost is $1,341,666.67
        - Acquire decommissioned gas rig jackets and platforms to be deployed in waters between 150' and 500' depth.
            - Enhance 5 platforms/jacket reefs with mid-water Fish Attracting Devices (FADs) that extends to 55'-60' below the surface.
                - May require additional Corps of Engineers permits

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        - Estimated project cost is $32,500.
    - Utilize ex-military equipment to construct productive artificial reefs.
        - AMRD's Reef-Ex program has been exceptionally successful by utilizing decommissioned army tanks to construct artificial reefs.
            - Estimated cost to deploy 20 barge loads of demilitarized equipment is $110,000
    - Develop 10 year contracts with reef builders to prepare, transport, and deploy the multitudinous materials offered to AMRD by donation.
        - Concrete well-heads, barges, sand/mud hoppers, numerous concrete culverts, decommissioned bridges, and various concrete aggregate have been offered to AMRD to use as reef materials within the past year, but transportation/deployment cost and personnel limitations have prevented project development.
        - Estimated cost of developing 10 year contracts to transport/deploy donated reef materials is approximately $1,000,000 ($100,000 per year)
- Develop an offshore monitoring program using SCUBA and Remotely Operated Vehicles (ROVs)
    - Survey reef condition and remove anthropogenic fouling (anchors, hook/line fishing gear, trawl nets, etc)
    - Monitor rate of ecological succession associated with newly constructed reef structures to determine type and design most beneficial to reach the goals of AMRD's artificial reef program.
        - Estimated cost to monitor reef productivity and maintenance for 5 years is $112,500 ($22,500 per year)
- Develop experiments and monitoring programs with local academic research institutions to evaluate reef fish recruitment and production rates associated with AMRD's Reef Program.
    - Estimated cost to fund academic research to evaluate production rates associated with artificial reefs for 5 years is $3,750,000 ($750,000 per year).
- Develop a Fish Attracting Device (FAD) program to increase catch rates of economically important pelagic fishes (yellowfin tuna, blackfin tuna, dolphinfish (mahi mahi), wahoo, blue marlin and white marlin.
    - 10 FADs will be deployed at depths of approximately 500 to 3,000'.
    - Estimated cost to construct and deploy FADs up to 100 nm offshore is $31,000
    - Will require additional Corps of Engineers permits
- Total estimated cost of offshore reef projects, monitoring, and research for 5 years is $8,790,667

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# Marine Resources Division

# Inshore Reef Program

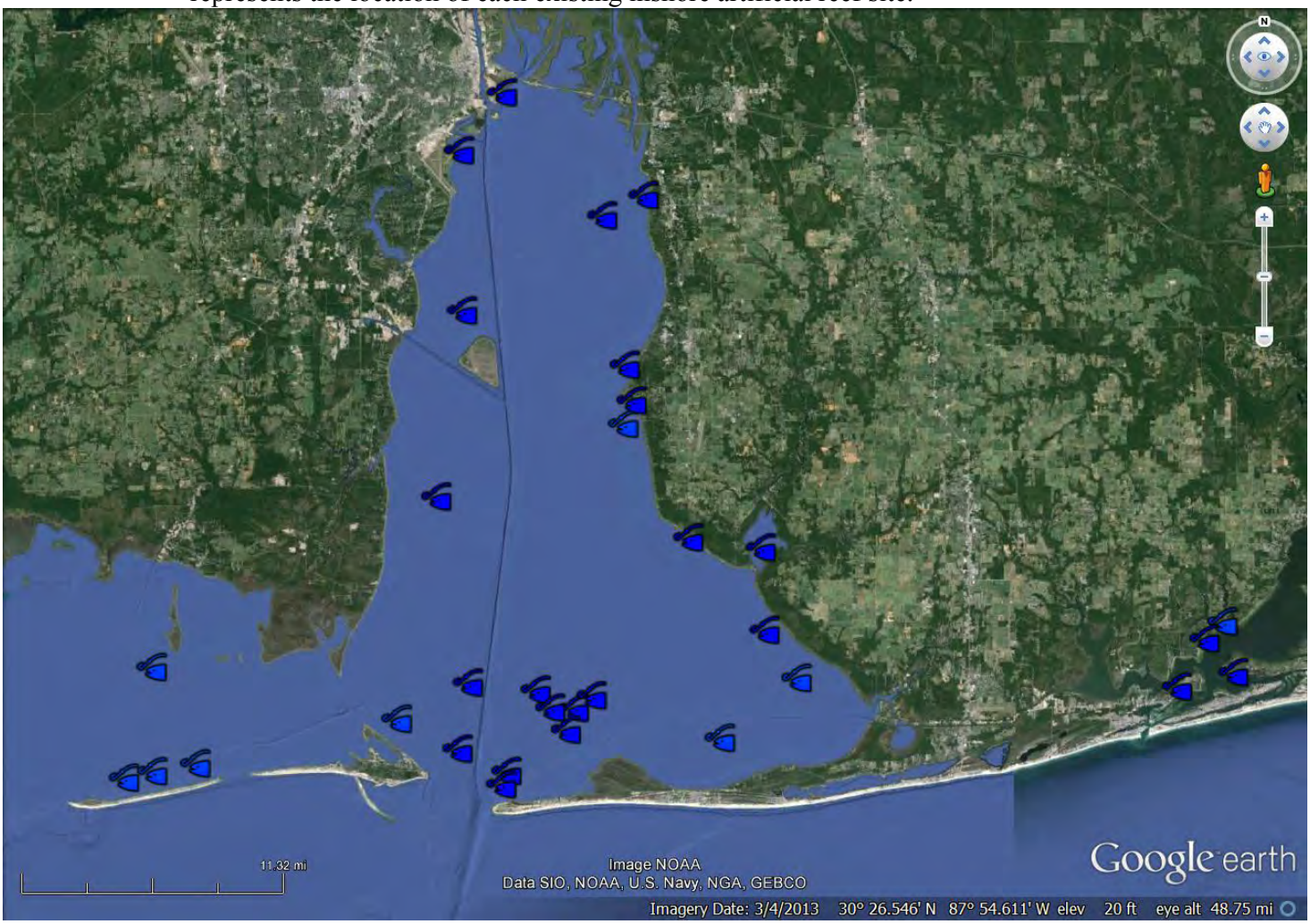
Name, acreage, volume of 6-8" limestone gabion needed for enhancement, mass of material needed for reefing, estimated cost of maintenance operations to sufficiently enhance each existing reef site, and corresponding Army Corps of Engineers permit # associated with initial construction.

| Reef | Acres | Cubic Yards of Gabion Stones for 100% Coverage | Tons of Gabion Stones | Cost of Gabion Stone | COE Permit # |
|---|---|---|---|---|---|
| Choctaw Pass | 0.5 | 580 | 749 | $48,659.66 | AL99-01112-U |
| Brookley Hole | 0.8 | 897 | 1,157 | $75,230.11 | AL99-01112-U |
| Dell Williamson | 0.3 | 338 | 437 | $28,372.50 | AL90-0136-I |
| Buddy Beiser | 3.0 | 3,348 | 4,318 | $280,676.71 | AL99-01112-U |
| Bender/Austal | 3.3 | 3,671 | 4,735 | $307,807.32 | AL99-01112-U |
| Battles Wharf | 3.8 | 4,303 | 5,551 | $360,813.61 | AL99-01112-U |
| Zundel's Landing | 1.0 | 1,083 | 1,397 | $90,814.58 | AL95-04439-U |
| P. Grey Cane, Jr | 6.4 | 7,188 | 9,272 | $602,661.60 | AL99-01112-U |
| Denton | 70.2 | 79,186 | 102,141 | $6,639,165.00 | AL97-03786-U |
| Upper Wreck | 1.5 | 1,659 | 2,140 | $139,124.69 | SAM-2006-787-JAM |
| Fish River | 4.3 | 4,809 | 6,203 | $403,198.67 | AL95-04439-U |
| Bayou Cour | 32.4 | 36,558 | 47,156 | $3,065,170.11 | AL04-02429-V |
| Shellbank | 9.9 | 11,167 | 14,405 | $936,292.50 | AL95-04439-U |
| Fort Morgan Barge | 2.1 | 2,369 | 3,056 | $198,607.50 | AL95-04439-U |
| Boykin | 5.8 | 6,528 | 8,420 | $547,301.79 | AL99-01112-U |
| Mississippi Sound #1 | 3.4 | 3,835 | 4,947 | $321,555.00 | SAM-2012-01395-DEM |
| Mississippi Sound #2 | 18.8 | 21,178 | 27,317 | $1,775,626.08 | SAM-2012-01395-DEM |
| Mississippi Sound #3 | 3.7 | 4,174 | 5,384 | $349,927.50 | SAM-2012-01395-DEM |
| Shrimpboat | 2.3 | 2,594 | 3,347 | $217,522.50 | AL99-01112-U |
| Rockpile | 14.1 | 15,905 | 20,516 | $1,333,507.50 | AL04-02429-V |
| Ross Point | 4.4 | 4,963 | 6,402 | $416,130.00 | AL04-02429-V |
| Bayou St. John | 5.3 | 5,978 | 7,712 | $501,247.50 | AL04-02429-V |
| Ono Island | 9.3 | 10,513 | 13,561 | $881,439.00 | AL04-02429-V |
| Weeks Bay | 2.6 | 2,933 | 3,783 | $245,895.00 | SAM-2013-00603-GAC |
| Exxon Mobile 76A-76A-Aux | 1.0 | 1,117 | 1,440 | $93,629.25 | SAM-2013-0438-DEM |
| Exxon Mobile 63AB | 1.0 | 1,128 | 1,455 | $94,575.00 | SAM-2013-0438-DEM |
| Exxon Mobil 62A-62AA | 1.4 | 1,579 | 2,037 | $132,405.00 | SAM-2013-0438-DEM |
| Exxon Mobil 95E | 0.4 | 395 | 509 | $33,101.25 | SAM-2013-0438-DEM |
| Legacy Resources | 0.3 | 282 | 364 | $23,643.75 | SAM-2013-0438-DEM |
| Legacy - Miocene Rig 615#3 | 0.3 | 282 | 364 | $23,643.75 | SAM-2013-0438-DEM |
| Legacy - Miocene Rig 615#1 | 0.3 | 282 | 364 | $23,643.75 | SAM-2013-0438-DEM |
| Legacy - Miocene Rig 615#4 Expanded | 3.7 | 4,140 | 5,340 | $347,090.25 | SAM-2013-0438-DEM |
| **Total** | **217.2** | **244,963** | **315,977** | **$20,538,478.44** | |

Name, acreage, volume of 6-8" limestone gabion needed for construction, mass of material needed for reefing, estimated cost of operations to sufficiently construct each existing reef site, and corresponding Army Corps of Engineers permit # associated with initial construction.

| Reef | Acres | Cubic Yards of Gabion Stones for 100% Coverage | Tons of Gabion Stones | Cost of Gabion Stone | COE Permit # |
|---|---|---|---|---|---|
| Arnica Bay | 3.0 | 3,384 | 4,365 | $283,725.00 | SAM-2012-1009-DEM |
| Portersville Bay | 3.0 | 3,384 | 4,365 | $283,725.00 | SAM-2012-1009-DEM |
| Mobile Bay @ Buoy Reef | 3.0 | 3,384 | 4,365 | $283,725.00 | SAM-2012-1009-DEM |
| Pelican Bay | 3.0 | 3,384 | 4,365 | $283,725.00 | SAM-2012-1009-DEM |
| Point Clear #1 | 0.9 | 1,015 | 1,310 | $85,117.50 | SAM-2012-1009-DEM |
| Point Clear #2 | 3.0 | 3,384 | 4,365 | $283,725.00 | SAM-2012-1009-DEM |
| Mississippi Sound Wreck #1 | 3.0 | 3,384 | 4,365 | $283,725.00 | SAM-2012-1009-DEM |
| Mississippi Sound Wreck #2 | 3.0 | 3,384 | 4,365 | $283,725.00 | SAM-2012-1009-DEM |
| **Total** | **21.9** | **24,703** | **31,865** | **$2,071,192.50** | |

Alabama Marine Resources Division (AMRD) currently has constructed 32 artificial reefs in Mobile Bay, Bon Secour Bay, Mississippi Sound, and Perdido Bay. Location of each icon represents the location of each existing inshore artificial reef site.

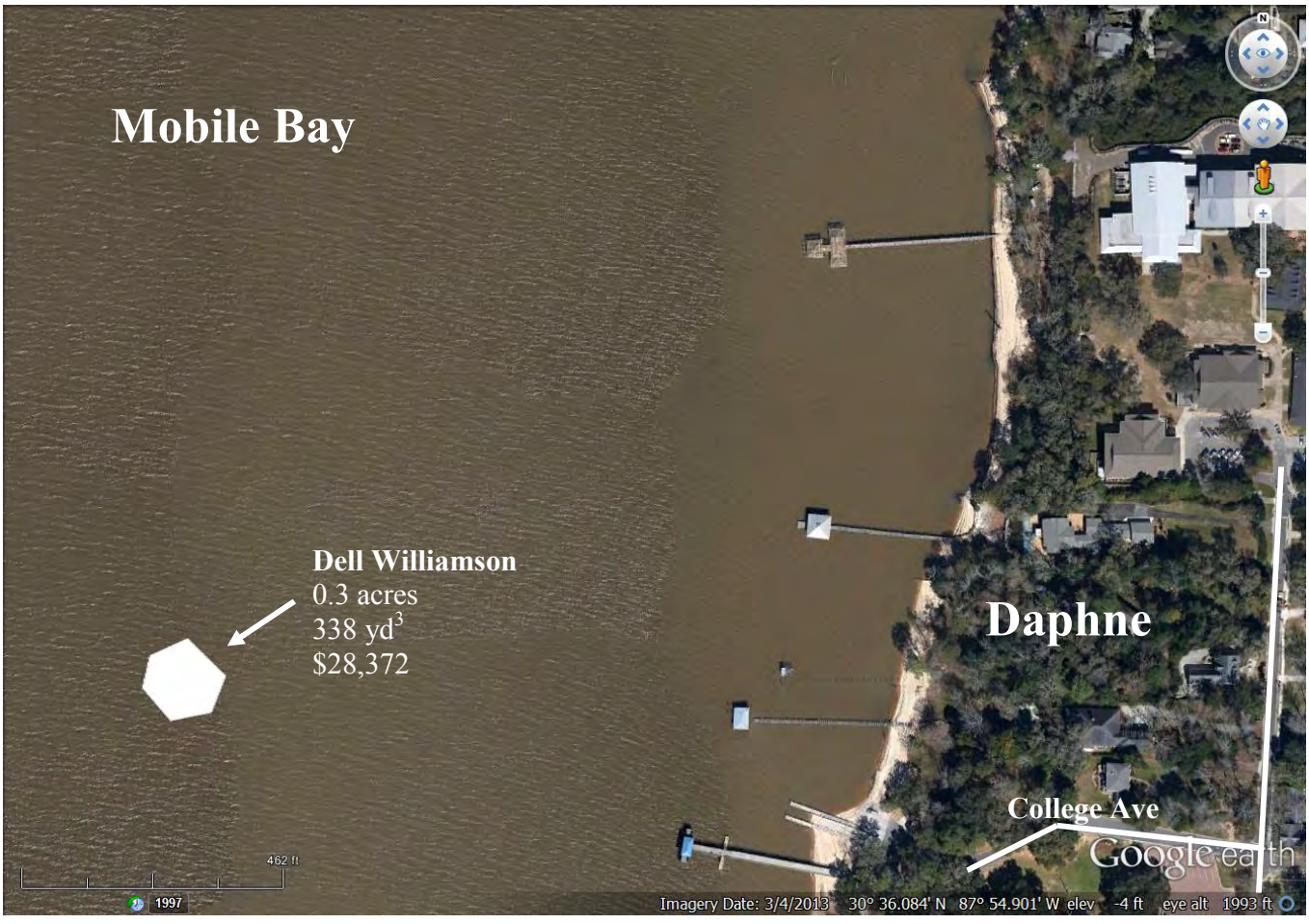


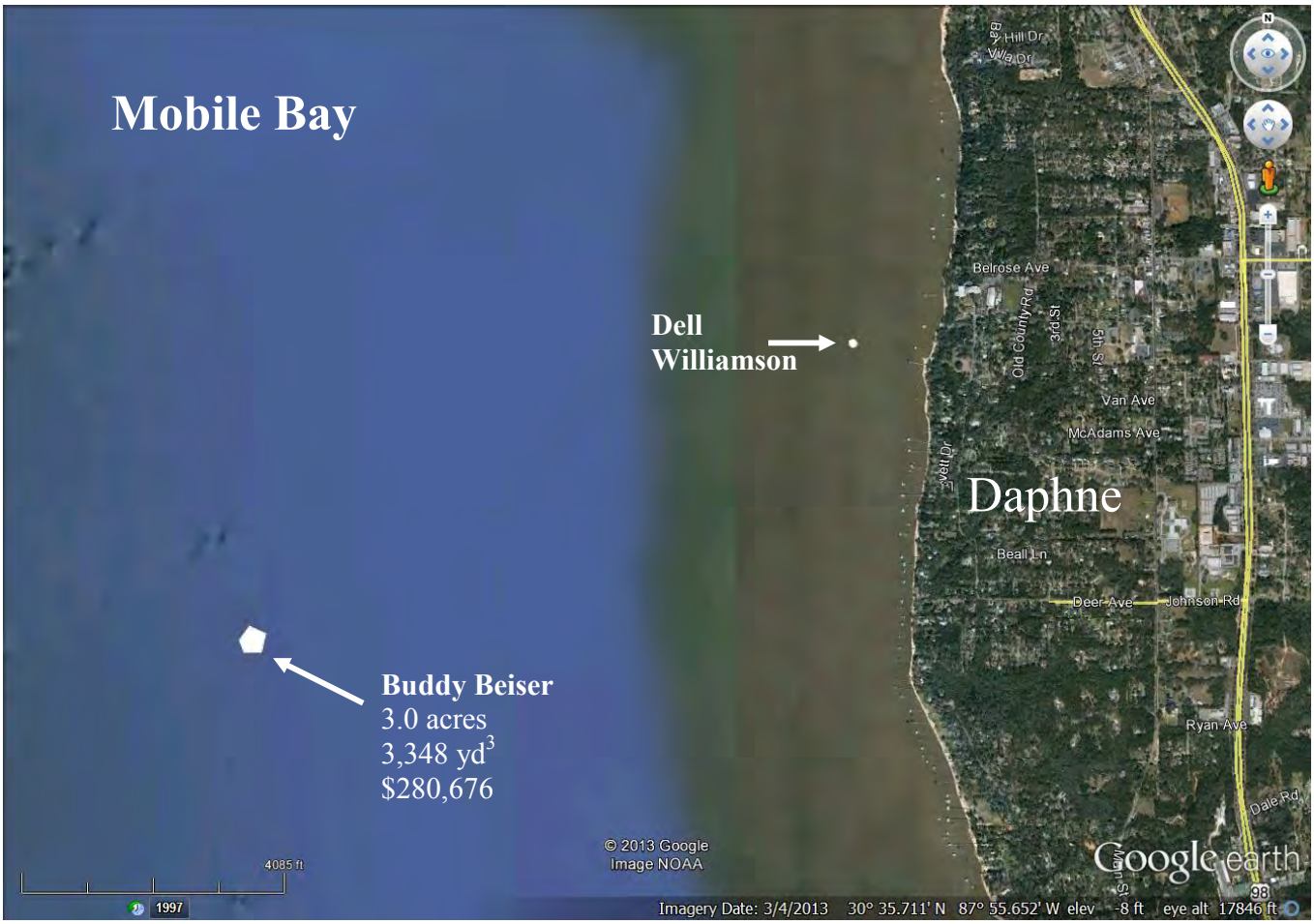
- Cost of refurbishing all inshore reefs to +8” of elevation with 100% coverage of 6”-8” limestone gabion would be approximately $20,538,478.44 (assuming construction cost of $65.00/ton of material deployed).
- The acreage of each reef site, volume of limestone gabion required to achieve 100% coverage, and the estimated cost of enhancement activities are provided in each figure.

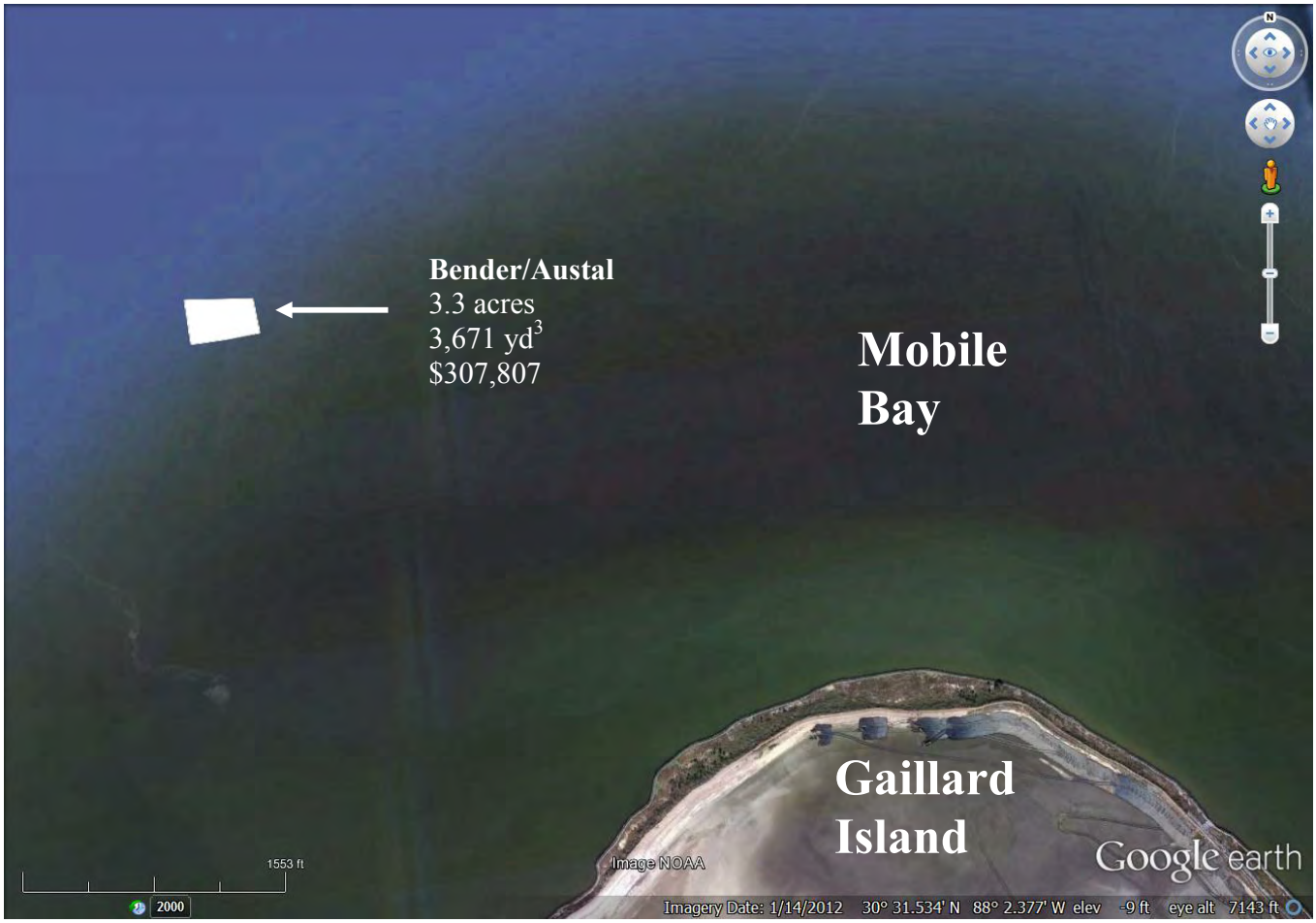
Mississippi Sound
Mississippi Sound Reef #3
3.7 acres
4,174 yd3
$349,927
Mississippi Sound Reef #2
18.8 acres
21,178 yd3
$1,775,626
Mississippi Sound Reef #1
3.4 acres
3,835 yd3
$321,555
Gulf of Mexico
Image NOAA
4159 ft
1992
Imagery Date: 1/14/2012 30° 14.528' N 88° 16.052' W elev -7 ft eye alt 18763 ft
Google earth

Choctaw Pass Reef
0.5 acres
580 yd3
$48,659
Choctaw Pass
Pinto Island
1128 ft
1997
Imagery Date: 1/14/2012 30° 39.859' N 88° 1.221' W elev -13 ft eye alt 4885 ft
Google earth

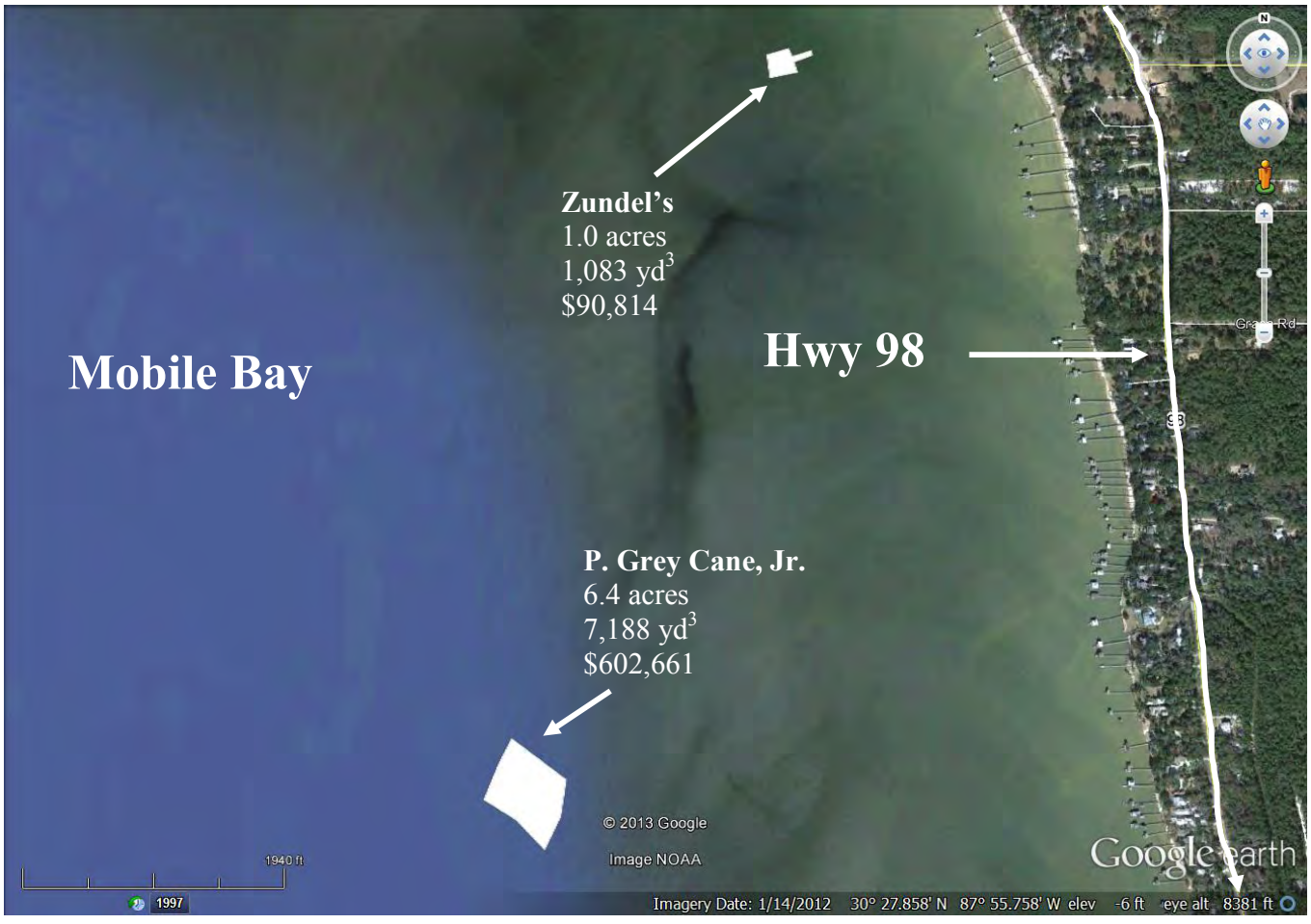
Brookley Air Field
Brookley Hole Reef
0.8 acres
897 yd3
$75,230
Mobile Bay
Google earth
2138 ft
1997
Imagery Date: 1/14/2012 30° 37.738' N 88° 3.397' W elev -2 ft eye alt 9487 ft

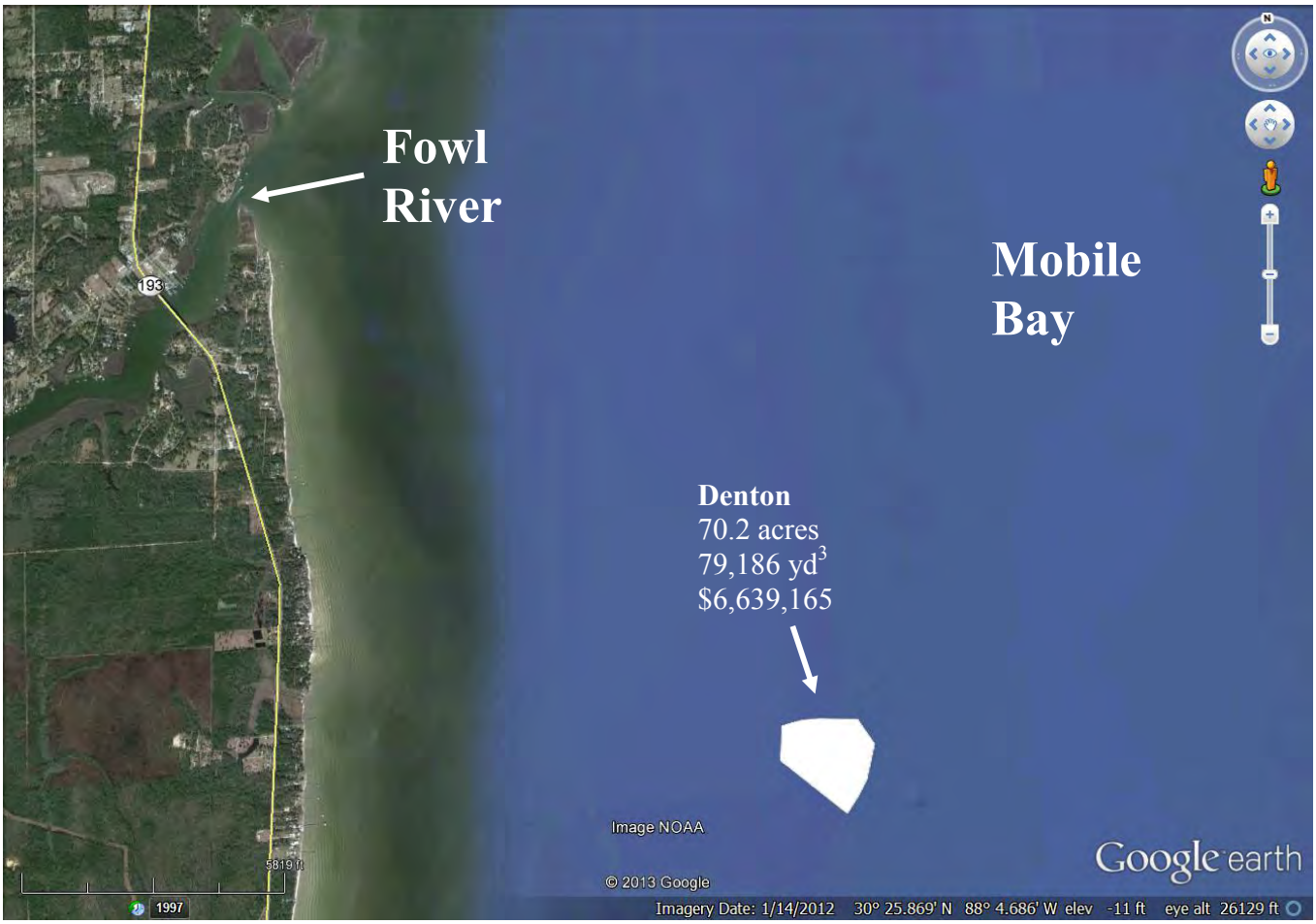

Mobile Bay
Dell Williamson
0.3 acres
338 yd3
$28,372
Daphne
College Ave
Google earth
462 ft
1997
Imagery Date: 3/4/2013 30° 36.084' N 87° 54.901' W elev -4 ft eye alt 1993 ft

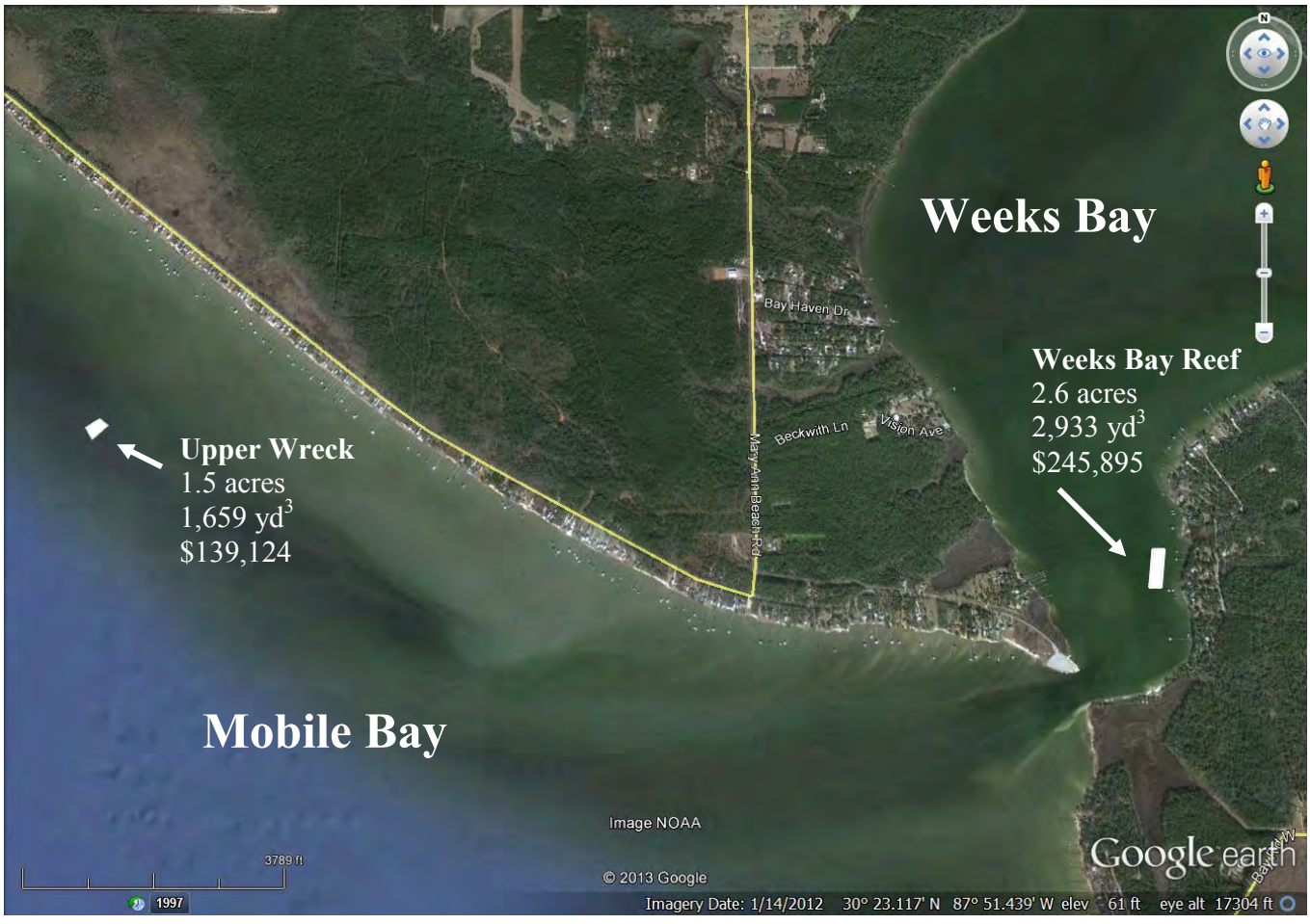

Mobile Bay
Dell
Williamson
Buddy Beiser
3.0 acres
3,348 yd3
$280,676
Daphne
Belrose Ave
Old County Rd
3rd St
5th St
Van Ave
McAdams Ave
Beall Ln
Deer Ave
Johnson Rd
Ryan Ave
Dale Rd
98
© 2013 Google
Image NOAA
4085 ft
1997
Google earth
Imagery Date: 3/4/2013 30° 35.711' N 87° 55.652' W elev -8 ft eye alt 17846 ft

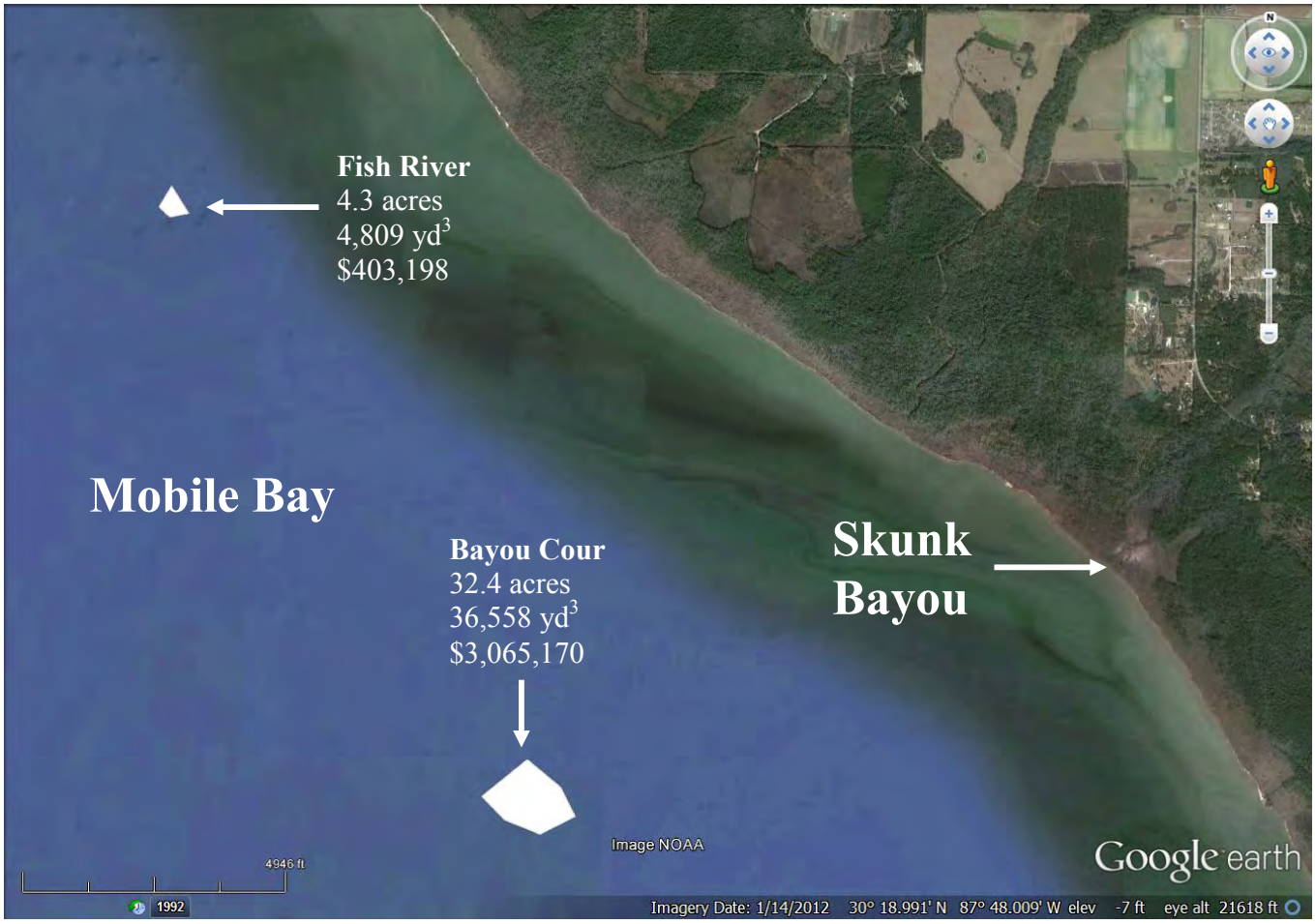

Bender/Austal
3.3 acres
3,671 yd3
$307,807
Mobile
Bay
Gaillard
Island
Image NOAA
1553 ft
2000
Google earth
Imagery Date: 1/14/2012 30° 31.534' N 88° 2.377' W elev -9 ft eye alt 7143 ft

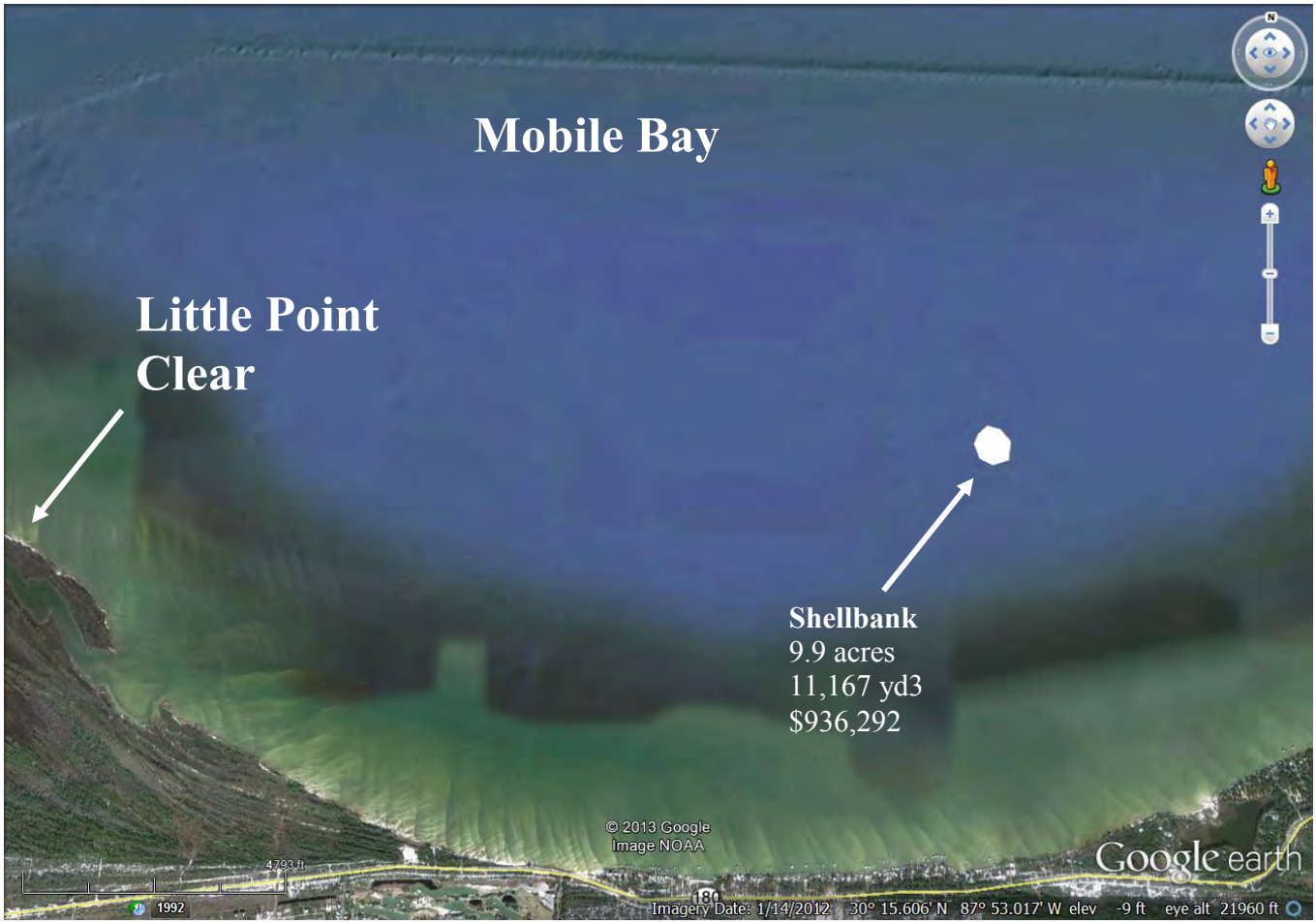
Mobile Bay
Battles Wharf
3.8 acres
4,303 yd3
$360,813
Point Clear
Bue-ge-Ln
Moog Ln
Battles Rd
Battles Wharf Dr
Guali Run Rd
Oak Ave
Grand Blvd
Woodcliff Dr
Lakewood Dr
98
© 2013 Google
Image NOAA
1826 ft
1997
Google earth
Imagery Date: 1/14/2012 30° 29.323' N 87° 56.130' W elev -4 ft eye alt 7891 ft

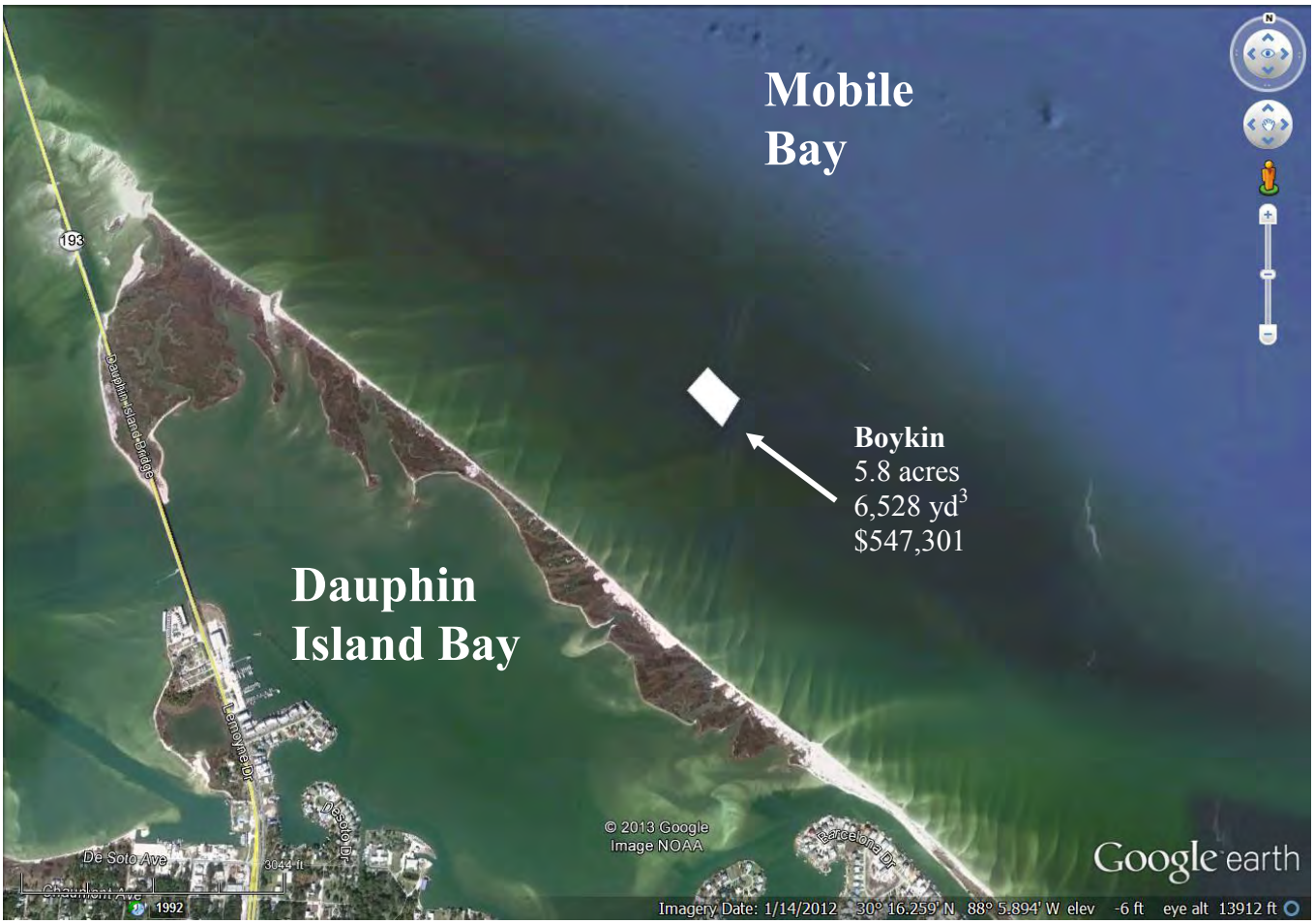

Zundel's
1.0 acres
1,083 yd3
$90,814
Hwy 98
Mobile Bay
P. Grey Cane, Jr.
6.4 acres
7,188 yd3
$602,661
98
© 2013 Google
Image NOAA
1940 ft
1997
Google earth
Imagery Date: 1/14/2012 30° 27.858' N 87° 55.758' W elev -6 ft eye alt 8381 ft


Fowl
River
Mobile
Bay
Denton
70.2 acres
79,186 yd3
$6,639,165
193
Image NOAA
© 2013 Google
Google earth
Imagery Date: 1/14/2012 30° 25.869' N 88° 4.686' W elev -11 ft eye alt 26129 ft


Weeks Bay
Weeks Bay Reef
2.6 acres
2,933 yd3
$245,895
Upper Wreck
1.5 acres
1,659 yd3
$139,124
Bay Haven Dr
Beckwith Ln
Vision Ave
Mary Ann Beach Rd
Mobile Bay
Image NOAA
© 2013 Google
Google earth
Imagery Date: 1/14/2012 30° 23.117' N 87° 51.439' W elev 61 ft eye alt 17304 ft

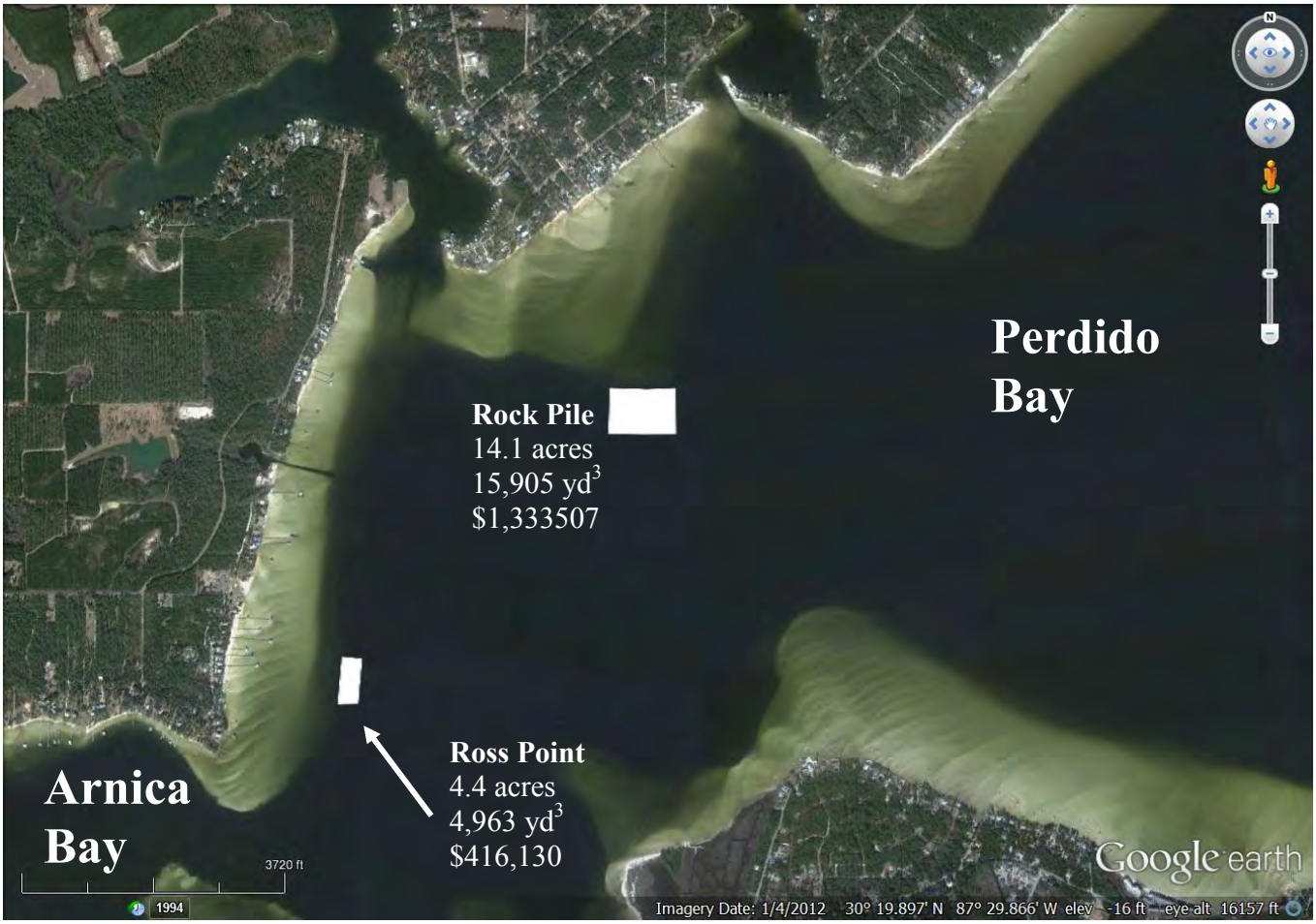

Fish River
4.3 acres
4,809 yd3
$403,198
Mobile Bay
Bayou Cour
32.4 acres
36,558 yd3
$3,065,170
Skunk
Bayou
Image NOAA
4946 ft
1992
Imagery Date: 1/14/2012 30° 18.991' N 87° 48.009' W elev -7 ft eye alt 21618 ft
Google earth


Mobile Bay
Little Point
Clear
Shellbank
9.9 acres
11,167 yd3
$936,292
© 2013 Google
Image NOAA
4793 ft
1992
Imagery Date: 1/14/2012 30° 15.606' N 87° 53.017' W elev -9 ft eye alt 21960 ft
Google earth


Mobile
Bay
193
Dauphin Island Bridge
Boykin
5.8 acres
6,528 yd3
$547,301
Dauphin
Island Bay
Lemoyne Dr
De Soto Dr
De Soto Ave
3044 ft
© 2013 Google
Image NOAA
Barcelona Dr
Google earth
1992
Imagery Date: 1/14/2012 30° 16.259' N 88° 5.894' W elev -6 ft eye alt 13912 ft

Bayou St. John Reef
5.3 acres
5,978 yd3
$501,247
Walker
Island
Bayou St. John
1169 ft
Google earth
1994
Imagery Date: 1/4/2012 30° 17.473' N 87° 32.058' W elev -2 ft eye alt 5063 ft

Russell Bayou
Ono Island
Ono Island Reef
9.3 acres
10,513 yd3
$881,439
2491 ft
1994
Imagery Date: 1/4/2012 30° 18.175' N 87° 29.337' W elev -3 ft eye alt 11388 ft
Google earth


Perdido
Bay
Rock Pile
14.1 acres
15,905 yd3
$1,333507
Ross Point
4.4 acres
4,963 yd3
$416,130
Arnica
Bay
3720 ft
1994
Imagery Date: 1/4/2012 30° 19.897' N 87° 29.866' W elev -16 ft eye alt 16157 ft
Google earth

Mobile Bay
Fort Morgan Barge
2.1 acres
25,369 yd3
$198,607
Fort Morgan
Google earth
1992
Imagery Date: 1/14/2012 30° 13.873' N 88° 1.238' W elev 1 ft eye alt 4102 ft

# Department of the Army

# Mobile District, Corps of Engineers

# Permit Number SAM-2013-0438-DEM

# Awarded to Alabama Marine Resources Division

# September 10, 2013

**Enhancement of artificial reefs by deploying limestone gabion at the seabed of gas platforms in Mobile Bay**

## DEPARTMENT OF THE ARMY PERMIT

Permittee: **THE ALABAMA DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES MARINE RESOURCES DIVISION**

Permit No: **SAM-2013-0438-DEM**

Issuing Office: **MOBILE DISTRICT**

NOTE: The term "you" and its derivatives, as used in this permit, means the permittee or any future transferee. The term "this office" refers to the appropriate district or division office of the U. S. Army Corps of Engineers (Corps) having jurisdiction over the permitted activity or the appropriate official of that office acting under the authority of the commanding officer.

You are authorized to perform work in accordance with the terms and conditions specified below.

**Project Description: The Alabama Marine Resources Division (MRD) is authorized to deploy 3-6 inch limestone gabion rocks or crushed concrete of similar size in various configurations at 8 reef complex sites in Mobile Bay and Bon Secour Bay. The eight (8) reef complexes will be sited adjacent to the nine (9) platforms and the requested six piles at the previous site of Legacy 615#4. A total of 8.17 acres of seabed will be enhanced with approximately 1,613 cubic yards of reef material per acre. Limestone rocks will be deployed within the previous permitted areas (AL03-00061-U) boundaries with the addition of a reef complex located at the site where Legacy Resource's 615#4 was located prior to its removal in April 2011. A total of 6 piles will mark the expanded Legacy 615#4 reef site and a total of 5,919 cubic yards of reef material will be deployed with the same specifications as the previous permit (i.e. =1' +/-8" elevation). The 6 piles will possess appropriate safety/navigation signage. MRD personnel proposes to closely coordinate with the operators of the Legacy and ExxonMobil platforms to ensure the reefing project will not interfere with existing pipelines. Buoys will be used during deployment to mark the location of each pipeline(s) to prevent interference. MRD proposes to enhance the existing seabed to 1' +/-8" elevation, and current water depths at selected platform ranges from 11-27 feet, thus having no impact on navigational considerations around the platforms.**

**ATTACHED: 1. Project Plans (10 pages)**
**2. Alabama Department of Environmental Management Water Quality/Coastal Zone Management Certification, dated July 8, 2013 (2 pages)**

Project Location: Mobile and Bon Secour Bays (Baldwin County and Mobile County, Alabama). *See project site location data for details.*

Permit Conditions:

General Conditions:

1. The time limit for completing the work authorized ends on **July 8, 2018**. If you find that you need more time to complete the authorized activity; submit your request for a time extension to this office for consideration at least 1 month before the above date is reached.

2. You must maintain the activity authorized by this permit in good condition and in conformance with the terms and conditions of this permit. You are not relieved of this requirement if you abandon the permitted activity, although you may make a good faith transfer to a third party in compliance with General Condition 4 below. Should you wish to cease to maintain the authorized activity or should you desire to abandon it without a good faith transfer, you must obtain a modification of this permit from this office, which may require restoration of the area.

3. If you discover any previously unknown historic or archeological remains while accomplishing the activity authorized by this permit, you must immediately notify this office of what you have found. We will initiate the Federal and State coordination required to determine if the remains warrant a recovery effort or if the site is eligible for listing in the National Register of Historic Places.

4. If you sell the property associated with this permit, you must obtain the signature of the new owner in the space provided and forward a copy of the permit to this office to validate the transfer of this authorization.

5. If a conditioned water quality certification has been issued for your project, you must comply with the conditions specified in the certification as special conditions to this permit. For your convenience, a copy of the certification is attached if it contains such conditions.

6. You must allow representatives from this office to inspect the authorized activity at any time deemed necessary to ensure that it is being or has been accomplished in accordance with the terms and conditions of your permit.

**Special Conditions:**

**1. Compliance with all terms and General and Special Conditions of this Permit is mandatory.**

**2. It is the permittee's responsibility to ensure that the contractors working on this project are aware of all General and Special permit conditions.**

**3. The permittee will maintain CWA Section 401(a) Water Quality Certification and Coastal Consistency as required by the ADEM certification letter dated July 8, 2013.**

**4. Should cultural resources be encountered during project activities, work shall cease and the U.S. Army Corps of Engineers Mobile District, Alabama State Historical Preservation Officer (SHPO) and the Choctaw Nation of Oklahoma shall be consulted immediately. This stipulation shall be placed on the construction plans, and it is the permittee's responsibility to ensure that contractors are aware of this requirement. SHPO contact information: Alabama Historical Commission, Attention: Mr. Greg Rhinehart, 468 South Perry Street, Montgomery, Alabama 36130-0900, or telephone (334) 242-3184. The ACH tracking number is 13-0931; Choctaw Nation of Oklahoma, Attention: Ms. Johnnie Jacobs, Post Office Box 1210, Durant, Oklahoma 74701.**

**5. Construction activities shall not infringe upon navigation on the waterway. These activities shall be in compliance with 33 CFR 163, which states in part: "A clear channel shall at all times be left open to permit free and unobstructed navigation by all types of vessels and tows normally using the various waterways."**

**6. The permittee understands and agrees that, if future operations by the United States require the removal, relocation, or other alteration, of the structures or work herein authorized, or if, in the opinion of the Secretary of the Army or his authorized representative, said structure or work shall cause unreasonable obstruction to the free navigation of the navigable waters, the permittee will be required, upon due notice from the Corps of Engineers, to remove, relocate, or alter the structural work or obstructions caused thereby, without expense to the United States. No claim shall be made against the United States on account of any such removal or alteration.**

**7. You must maintain the activity authorized by this permit in good condition and in conformance with the terms and conditions of this permit. You are not relieved of this requirement if you abandon the permitted activity, although you may make a good faith transfer to a third party. Should you wish to cease to maintain the authorized activity or should you desire to abandon it without a good faith transfer, you must obtain a modification of this permit from this office, which may require restoration of the area.**

**8. It is the responsibility of the permittee to coordinate this activity with the State Lands Division, Alabama Department of Conservation and Natural Resources (ADCNR), for any riparian rights issues or leases that may be required for impacting State water bottoms. ADCNR, State Lands Division, 31115 Five Rivers Boulevard, Spanish Fort, Alabama 36527, phone number (251) 621-1238.**

**9. An as-built survey the entire shoreline breakwater project shall be conducted and furnished to the Corps within 90 days after construction completion.**

**10. The permittee must install and maintain, at the permittee's expense, any safety lights, signs and signals required by the U.S. Coast Guard, through regulations or otherwise, on the permittee's fixed structures. To receive a U.S. Coast Guard Private Aids to Navigation marking determination, at no later than 30 days prior installation of any fixed structures in navigable waters and/or prior to installation of any floating private aids to navigation, you are required to contact the Eighth Coast Guard District (dpw), 500 Poydras St. Suite 1230, New Orleans, LA 70130, (504)671-2328 or via email to:**

**D8oanPATON@uscg.mil. For general information related to Private Aids to Navigation please visit the Eighth CG District web site at: http://www.uscg.mil/d8/waterways/PATON.Home.asp**

**11. This permit does not authorize impacts to wetlands, submerged grassbeds, or natural shellfish beds.**

Further Information:

1. Congressional Authorities: You have been authorized to undertake the activity described above pursuant to:

**(X)** Section 10 of the Rivers and Harbors Act of 1899 (33 U.S.C. 403).
**(X)** Section 404 of the Clean Water Act (33 U.S.C. 1344).

2. Limits of this authorization.

a. This permit does not obviate the need to obtain other Federal, State, or local authorizations required by law.

b. This permit does not grant any property rights or exclusive privileges.

c. This permit does not authorize any injury to the property or rights of others.

d. This permit does not authorize interference with any existing or proposed Federal project.

3. Limits of Federal Liability. In issuing this permit, the Federal Government does not assume any liability for the following:

A. Damages to the permitted project or uses thereof as a result of other permitted or unpermitted activities or from natural causes.

b. Damages to the permitted project or uses thereof as a result of current or future activities undertaken by or on behalf of the United States in the public interest.

C. Damages to persons, property, or to other permitted or unpermitted activities or structures caused by the activity authorized by this permit.

d. Design or construction deficiencies associated with the permitted work.

e. Damage claims associated with any future modification, suspension, or revocation of this permit.

4. Reliance on Applicant's Data: The determination of this office that issuance of this permit is not contrary to the public interest was made in reliance on the information you provided.

5. Reevaluation of Permit Decision. This office may reevaluate its decision on this permit at any time the circumstances warrant. Circumstances that could require a reevaluation include, but are not limited to, the following:

a. You fail to comply with the terms and conditions of this permit.

b. The information provided by you in support of your permit application proves to have been false, incomplete, or inaccurate (See 4 above).

c. Significant new information surfaces which this office did not consider in reaching the original public interest decision.

Such a reevaluation may result in a determination that it is appropriate to use the suspension, modification, and revocation procedures contained in 33 CFR 325.7 or enforcement procedures such as those contained in 33 CFR 326.4 and 326.5. The referenced enforcement procedures provide for the issuance of an administrative order requiring you to comply with the terms and conditions of your permit and for the initiation of legal action where appropriate. You will be required to pay for any corrective measures ordered by this office, and if you fail to comply with such directive, this office may in certain situations (such as those specified in 33 CFR 209.170) accomplish the corrective measures by contract or otherwise and bill you for the cost.

6. Extensions. General condition 1 establishes a time limit for the completion of the activity authorized by this permit. Unless there are circumstances requiring either a prompt completion of the authorized activity or a reevaluation of the public interest decision, the Corps will normally give favorable consideration to a request for an extension of this time limit.

Your signature below, as permittee, indicates that you accept and agree to comply with the terms and conditions of this permit, SAM-2013-0438-DEM.

9-5-13

(PERMITTEE) MR. CHRIS BLANKENSHIP (DATE)
ADCNR – MARINE RESOURCES DIVISION
POST OFFICE BOX 189
DAUPHIN ISLAND, ALABAMA 36528

This permit becomes effective when the Federal official, designated to act for the Secretary of the Army, has signed below.

JON J. CHYTKA
COLONEL, CORPS OF ENGINEERS
(DISTRICT COMMANDER)

BY: Sept 10, 2013
JOY B. EARP (DATE)
TEAM LEADER, SOUTH ALABAMA BRANCH
REGULATORY DIVISION

When the structures or work authorized by this permit (SAM-2013-0438-DEM) are still in existence at the time the property is transferred, the terms and conditions of this permit will continue to be binding on the new owner(s) of the property. To validate the transfer of this permit and the associated liabilities associated with compliance with its terms and conditions, have the transferee sign and date below.

(TRANSFEREE) DATE)

# Joint Application and Notification
# U.S. Department of Army, Corps of Engineers
# Alabama Department of Environmental Management

Attachment

## 5.) Project Description

Crushed limestone gabion rock was deployed at 8 reef complexes adjacent to 10 gas production platforms in 2003 (previous permit number AL03-00061-U). However, the previously deployed reefing materials have reached the end of their usable life. Subsidence, propeller wash, and storms have deteriorated the usability of the previously deployed material to such a degree that quality of finfish and invertebrate habitat at the previously reefed locations has been compromised, and additional reefing material needs to be deployed to enhance the substrate. The project described in this application will provide beneficial habitat for small cryptic finfishes, shrimp, and crabs that will serve as the base of a biological community where large predatory finfishes (spotted seatrout, flounder species, red drum, southern kingfish, sheepshead, and sand seatrout) can be supported. These predatory fishes are extremely important to the local recreational/commercial fishing community that is an essential component of the local economy.

Alabama Marine Resources Division (AMRD) requests a permit to deploy 3-6" limestone gabion rocks or crushed concrete of similar size in various configurations at 8 reef complex sites in Mobile Bay and Bon Secour Bay. Limestone rocks will be deployed within the previous permit's (AL03-00061-U) boundaries with the exception of a reef complex located at the site where Legacy 615#4 was located prior to its removal in April 2011. A total of 6 piles will mark the expanded Legacy 615#4 reef site and a total of 5,919 cubic yards of reef material will be deployed to the same specifications as the previous permit (i.e. +1' +/-8" elevation). The 6 piles will possess appropriate signage. AMRD personnel will closely coordinate with the operators of the Legacy and Exxon-Mobil platforms to ensure the proposed reefing project will not interfere with existing pipelines, and buoys will be used during deployment to mark the location of each pipeline(s) to prevent interference. AMRD proposes to enhance the existing seabed to +1' +/-8" elevation, and current water depths at selected platform ranges from 11' to 27', thus having no impact on navigational considerations around the platforms.

AMRD proposes to evenly distribute approximately 13,180 cubic yards of 3-6" limestone gabion rocks or crushed concrete of similar size throughout the 8 reef complexes. The 8 reef complexes will be sited adjacent to the 9 platforms and the requested six piles at the previous site of Legacy 615#4. A total of 8.17 acres of seabed will be enhanced with approximately 1,613 cubic yards of reef material per acre.

Figure 1. Depiction of Mobile Bay and Bon Secour Bay where the project locations will be sited.

Figure 2. Typical profile of the substrate, water column, and platform leg/piling at each reef complex indicating depth of water and change in elevation after completion of project

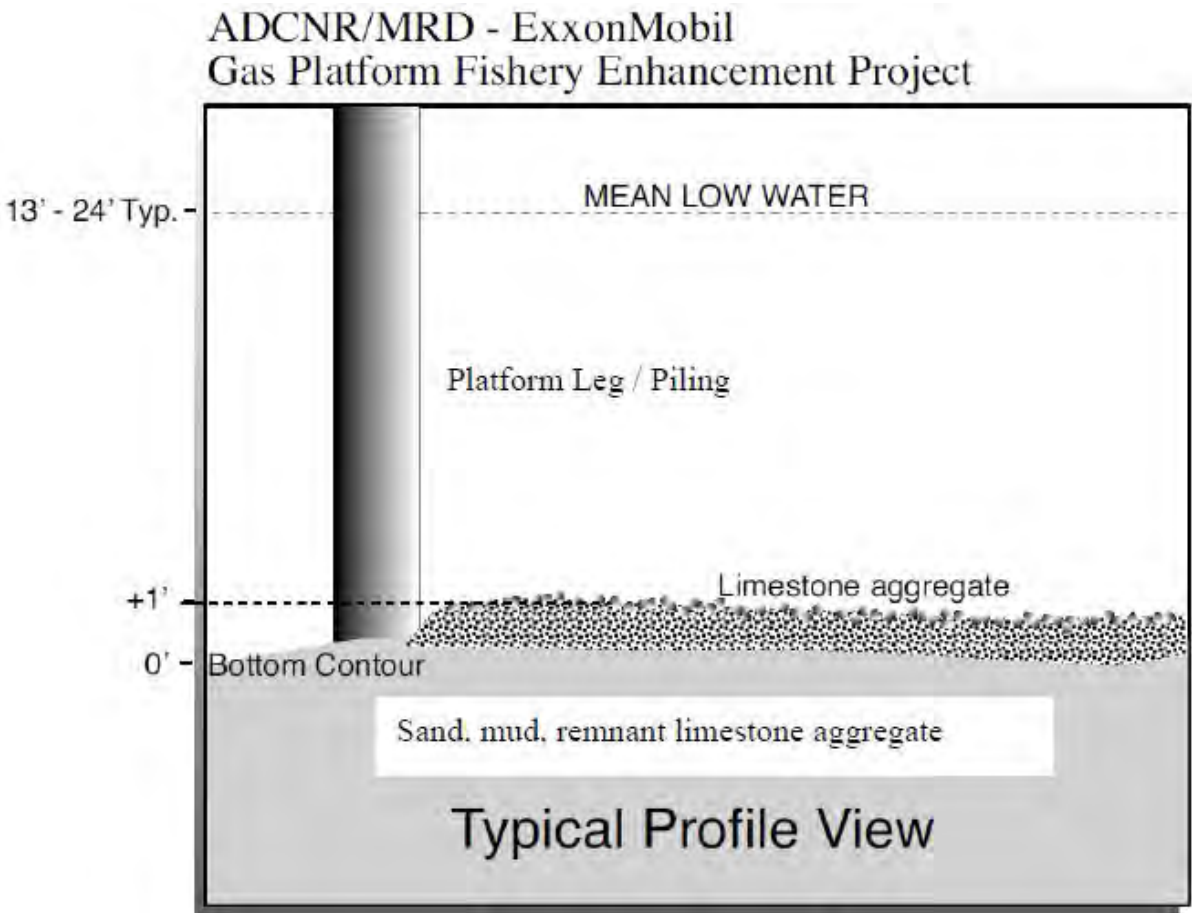


Figure 3. Project boundaries at platforms ExxonMobil76A and 76A-Aux with area of enhancement.

Figure 4. Project boundaries at platform ExxonMobil 63AB with area of enhancement.

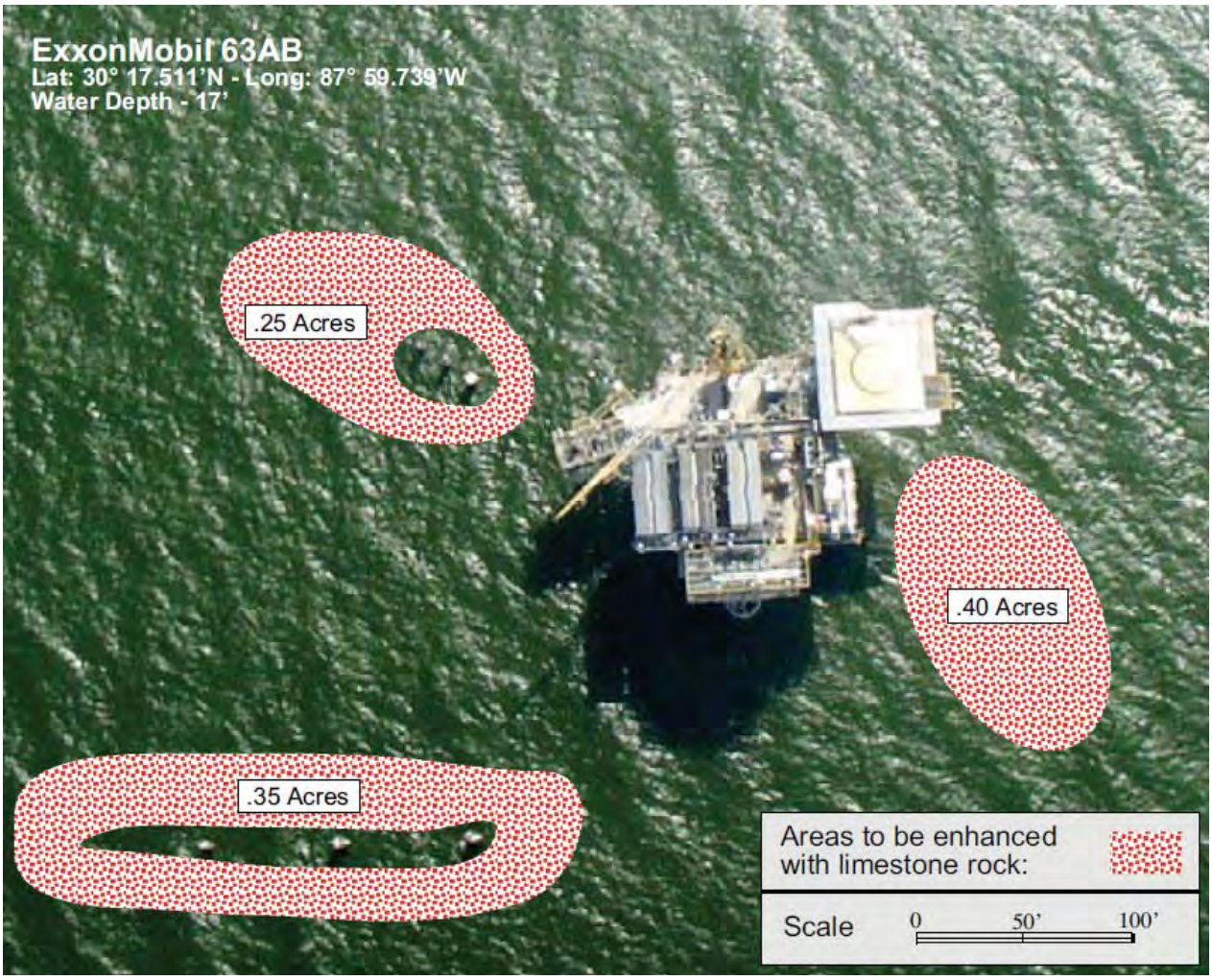


Figure 5. Project boundaries at platforms ExxonMobil 61A and 62AA with area of enhancement.

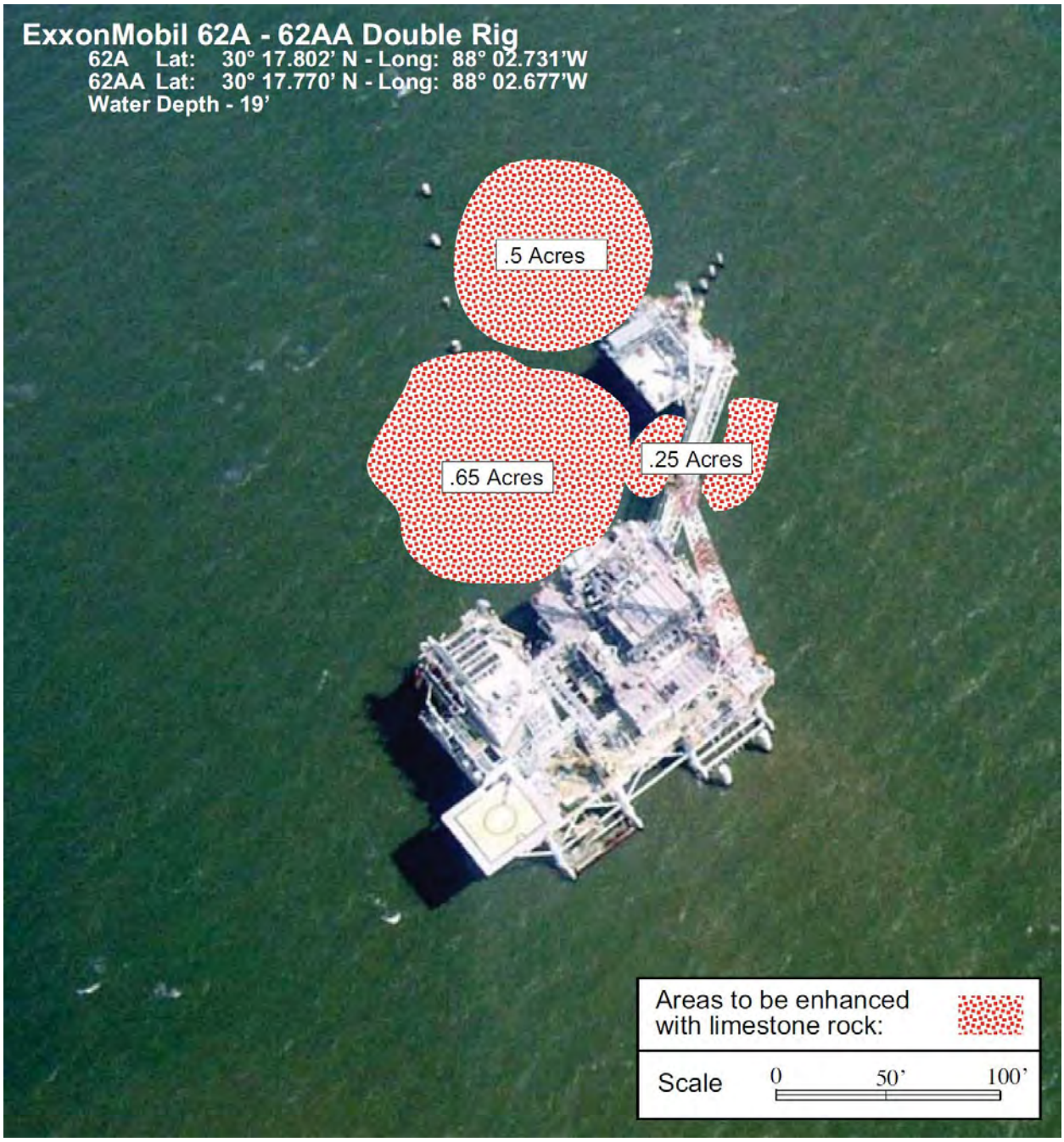


Figure 6. Project boundaries at platform ExxonMobil 95E with area of enhancement.

Figure 7. Project boundaries at platform Legacy Resources 78A with area of enhancement.

Figure 8. Project boundaries at platform Legacy Resources – Miocene 615#3 with area of enhancement.

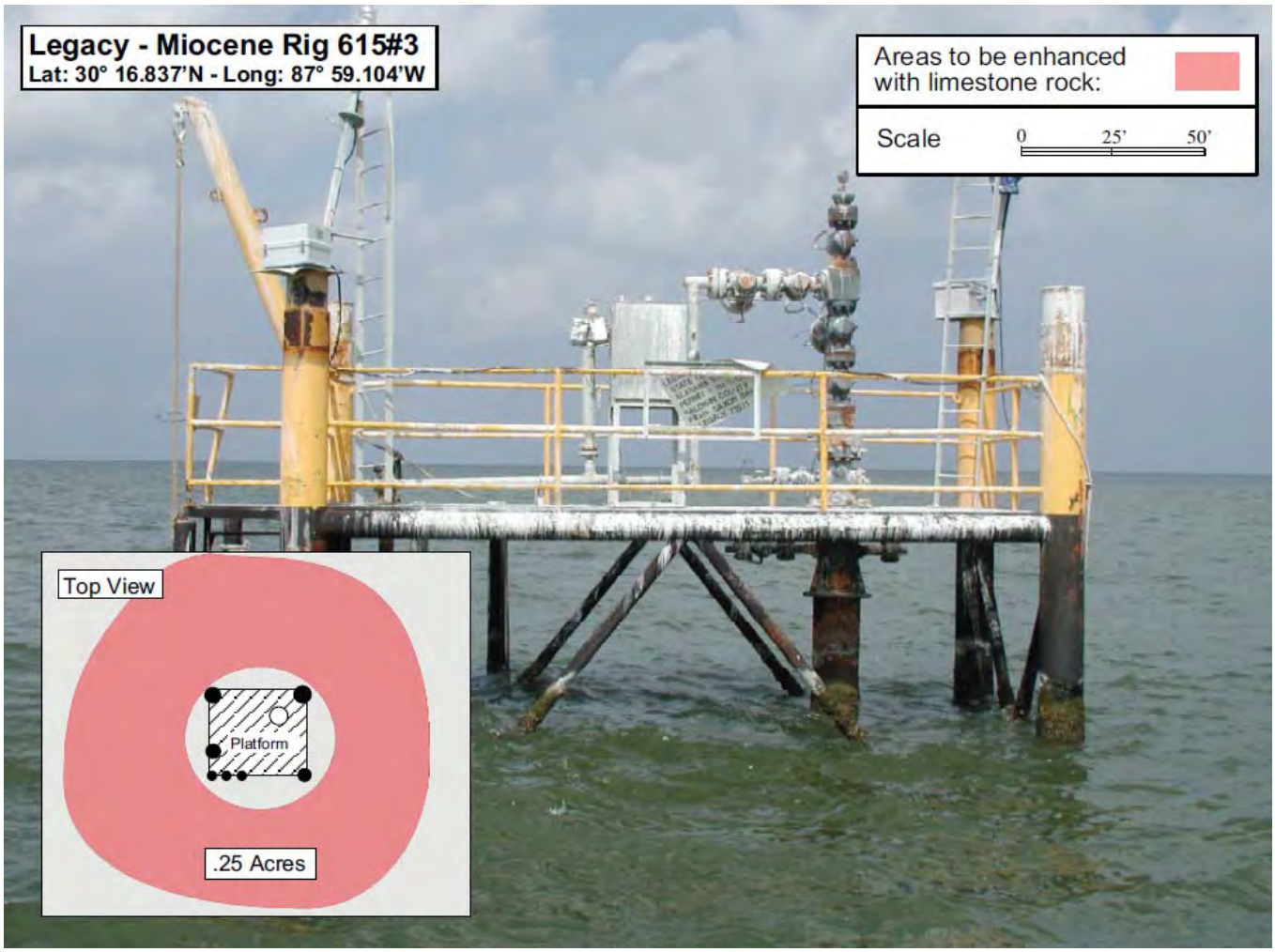


Figure 9. Project boundaries at platform Legacy Resources – Miocene 615#1 with area of enhancement.

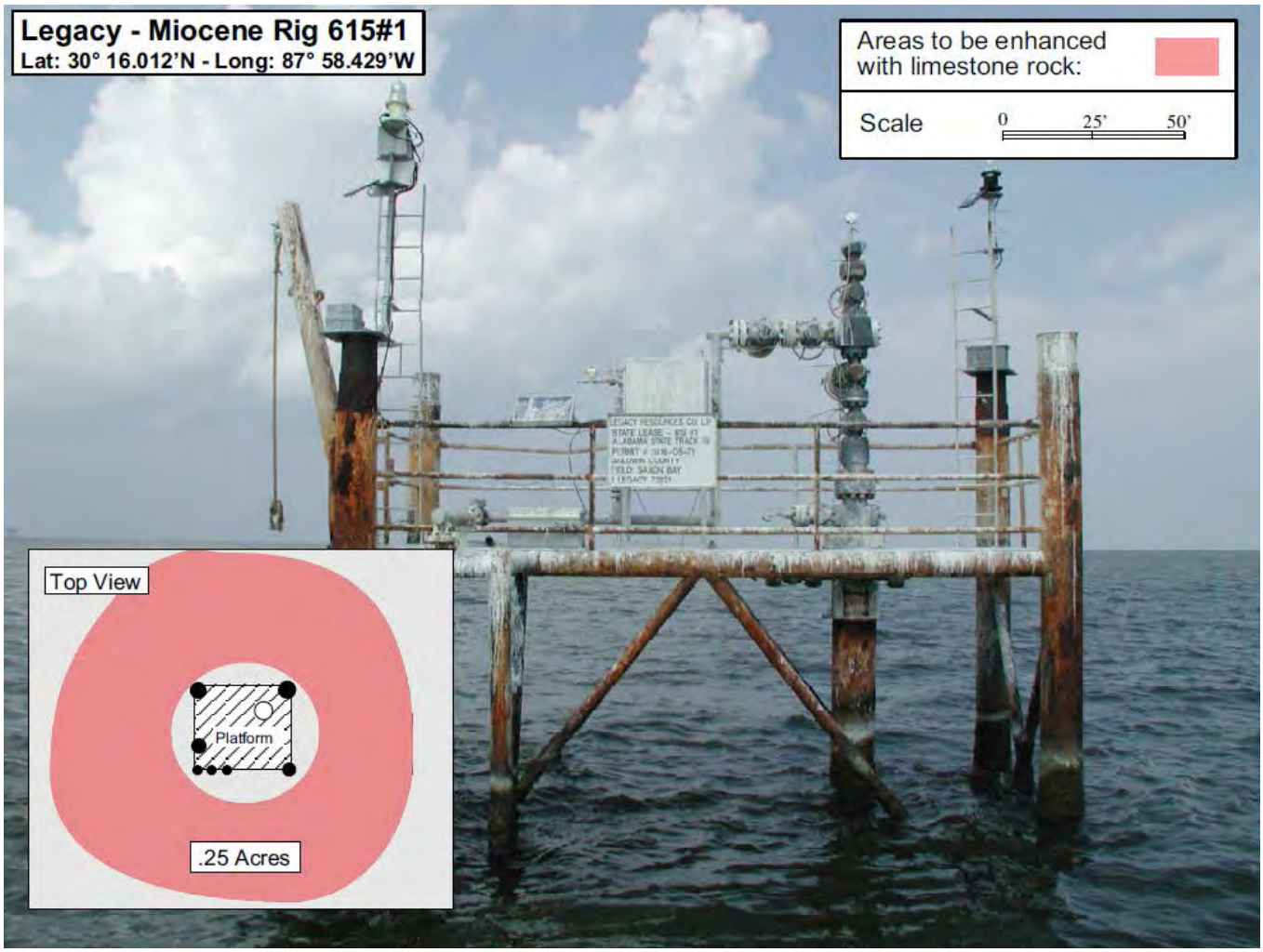
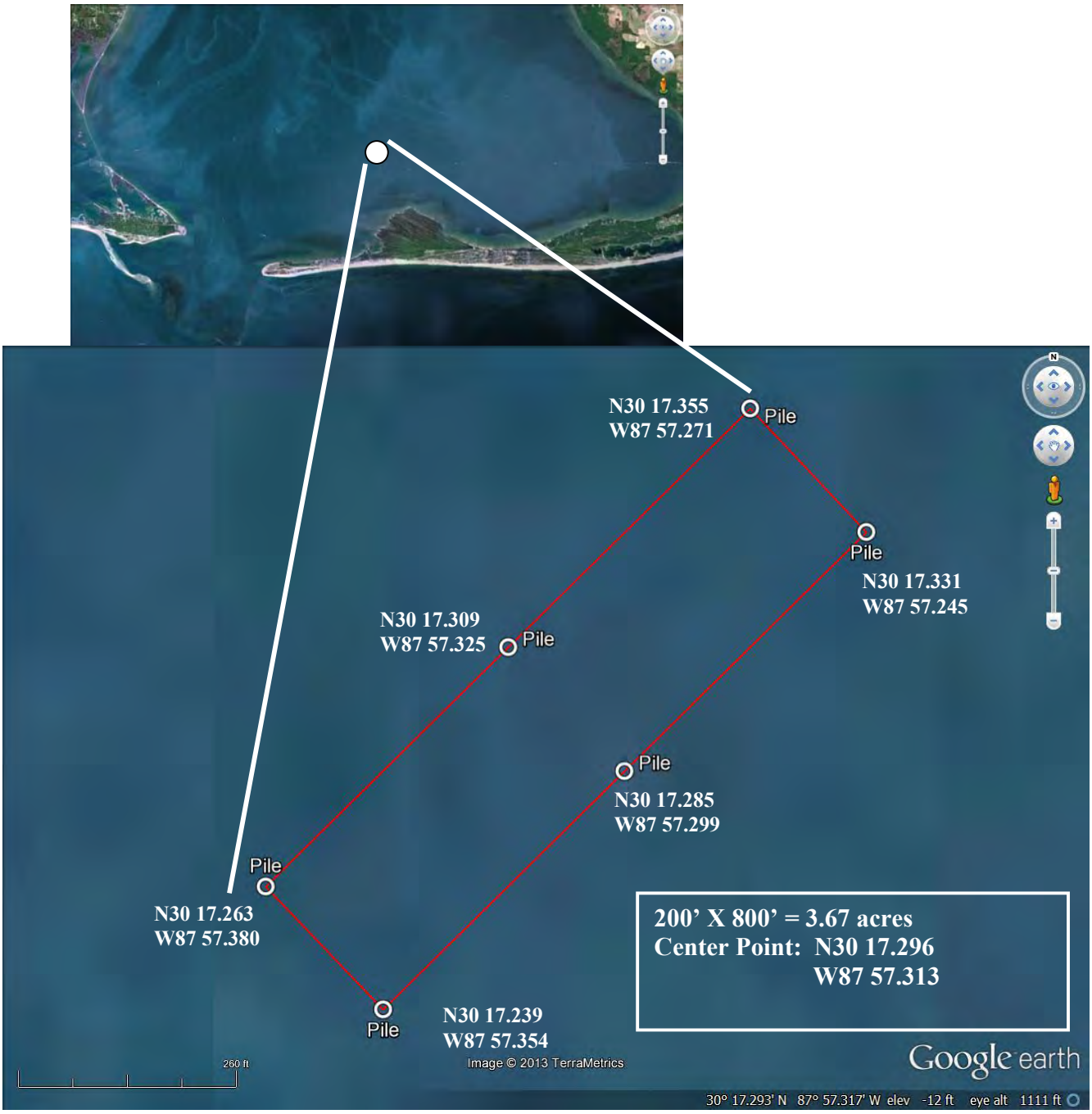


Figure 10. Expanded project boundary sited at the previous location of Legacy Resources 615#4 with area of enhancement.



91 7199 9991 7030 3344 3317

**LANCE R. LEFLEUR**
DIRECTOR

**ROBERT J. BENTLEY**
GOVERNOR

**Alabama Department of Environmental Management**
**adem.alabama.gov**
1400 Coliseum Blvd. 36110-2400 ▪ Post Office Box 301463
Montgomery, Alabama 36130-1463
(334) 271-7700 ▪ FAX (334) 271-7950

July 8, 2013

MR. CRAIG NEWTON
ALABAMA MARINE RESOURCES DIVISION
P. O. BOX 189
DAUPHIN ISLAND, ALABAMA 36528

RE: State of Alabama Clean Water Act (CWA) Section 401 (a) Water Quality Certification and Coastal Consistency Concurrence
Alabama Department of Conservation and Natural Resources - Marine Resources Division (MRD)
Mobile and Baldwin Counties, Alabama
United States Army Corps of Engineers (USACE) Permit: SAM-2013-0438-DEM
Alabama Department of Environmental Management (ADEM) Tracking Code: 2013-210-COE

Dear Mr. Newton:

On April 11, 2013, the ADEM received the MRD's consistency determination for the proposed activity described below and its request for ADEM's response. The MRD proposes to deploy 3-6 inch limestone gabion rocks or crushed concrete of similar size in various configurations at 8 reef complex sites in Mobile Bay and Bon Secour Bay. A total of 8.17 acres of waterbottoms will be enhanced with approximately 1,613 $yds^3$ of reef material per acre. Limestone rocks will be deployed within the previous permitted areas boundaries with the addition of a reef complex located at the site where Legacy Resource's 615 #4 was located prior to its removal in April 2011. The MRD proposes to enhance the existing seabed to one foot +/-8 inches in elevation and not impact navigation around the platforms. The purpose of this project is to provide beneficial habitat for small cryptic finfish, shrimp, and crabs that will serve as a base of a biological community where large predatory fin fishes (spotted sea trout, flounder species, red drum, southern kingfish, sheepshead, and sand sea trout), can be supported.

ADEM Administrative Code Rule 335-8-1-.05 (1) (b) states the conservation, repletion and research activities of the Marine Environmental Sciences Consortium, the Marine Resources Division of the Department of Conservation and Natural Resource is a **permissible use.** Pursuant to 15 CFR § 930, et seq. and Section 307 of the Coastal Zone Management Act of 1972, as amended, and based upon review of the information submitted by the MRD, the ADEM **concurs** that the proposed activity is consistent with the enforceable policies of the Alabama Coastal Area Management Program.

Action pertinent to water quality certification is required by Section 401(a) (1) of the CWA, 33 U.S.C. §1251, et seq. If conducted in accordance with the conditions prescribed herein, ADEM hereby **grants** official certification that there is reasonable assurance that the discharge resulting from the proposed activities as submitted will not violate applicable water quality standards established under Section 303 of the CWA and §22-22-9(g), Code of Alabama (1975). This certification terminates coincidentally with the expiration of SAM-2013-0438-DEM with the following caveat. In no case shall this ADEM certification exceed a maximum of five (5) years from the date the U.S. Army Corps of Engineers officially extends permit SAM-2013-0438-DEM unless specifically authorized in response to a written request for same.

ADEM certifies that there are no applicable effluent limitations under Sections 301 and 302 nor applicable standards under Sections 306 and 307 of the Clean Water Act in regard to the activities specified. However, regulations promulgated by the EPA requiring discharge permits for storm water runoff from individual and commercial facilities may be applicable. This certification does not address the requirements of those regulations.

In recognition that projects are site specific in nature and conditions can change during project implementation, the ADEM reserves the right to require the submission of additional information or require additional management measures to be implemented, as necessary on a case-by-case basis, in order to ensure the protection of water quality and coastal resources.

Liability and responsibility for compliance with this certification are not delegable by contract or otherwise. MRD shall ensure that any agent, contractor, subcontractor, or other person employed by, under contract, or paid a salary by MRD complies with this certification. Any violations resulting from the actions of such person shall be considered violations of this certification and may result in an enforcement action.

This certification does not convey any property rights in either real or personal property, or any exclusive privileges, nor does it authorize any injury to persons or property or invasion of other private rights, trespass, or any infringement of Federal, State, or local laws or regulations.

**Birmingham Branch**
110 Vulcan Road
Birmingham, AL 35209-4702
(205) 942-6168
(205) 941-1603 (FAX)

**Decatur Branch**
2715 Sandlin Road, S.W.
Decatur, AL 35603-1333
(256) 353-1713
(256) 340-9359 (FAX)

**Mobile Branch**
2204 Perimeter Road
Mobile, AL 36615-1131
(251) 450-3400
(251) 479-2593 (FAX)

**Mobile Coastal**
4171 Commanders Drive
Mobile, AL 36615-1421
(251) 432-6533
(251) 432-6598 (FAX)

**NOTICE OF COMPLETION OF WORK**
**AUTHORIZED BY PERMITS**

_____
DATE

WORK AUTHORIZED UNDER DEPARTMENT OF THE ARMY PERMIT SAM-2013-00438-DEM

DATED 9/10/2013

TO PERFORM WORK IN MOBILE AND BON SECOUR BAYS, BALDWIN COUNTY AND MOBILE COUNTY, ALABAMA

WAS COMPLETED ON _____

BY: _____
SIGNATURE

CESAM FORM 851
JUN 87

**NOTICE OF COMPLETION OF WORK**
**AUTHORIZED BY PERMITS**

DATE

WORK AUTHORIZED UNDER DEPARTMENT OF THE ARMY PERMIT SAM-2013-00438-DEM

DATED 9/10/2013

TO PERFORM WORK IN MOBILE AND BON SECOUR BAYS, BALDWIN COUNTY AND MOBILE COUNTY, ALABAMA

WAS COMPLETED ON _____

BY: _____
SIGNATURE

CESAM FORM 851
JUN 87

---

**NOTICE OF COMMENCEMENT OF WORK**
**AUTHORIZED BY PERMITS**

DATE

WORK AUTHORIZED UNDER DEPARTMENT OF THE ARMY PERMIT SAM-2013-00438-DEM

DATED 9/10/2013

TO PERFORM WORK IN MOBILE AND BON SECOUR BAYS, BALDWIN COUNTY AND MOBILE COUNTY, ALABAMA

WAS COMMENCED ON _____

BY: _____
SIGNATURE

CESAM FORM 850
JUNE 87

**This notice of authorization must be conspicuously displayed at the site of work.**

United States Army Corps of Engineers

A permit to perform work authorized by statutes and regulations of the Department of the Army

at **MOBILE AND BON SECOUR BAYS, BALDWIN COUNTY AND MOBILE COUNTY, ALABAMA**

has been issued to **MR. CHRIS BLANKENSHIP, DIRECTOR** on **SEPTEMBER 10, 2013**

Address of Permittee **POST OFFICE BOX 189, DAUPHIN ISLAND, ALABAMA 36528**

Permit Number

**SAM-2013-00438-DEM**

FOR THE *District Commander*
For the
**by B. Earp**
**Team Leader, South Alabama Branch**
**Regulatory Division**

ENG FORM 4336, Jul 81 (33 CFR 320-330) EDITION OF JUL 70 MAY BE USED (Proponent: CECW-0)

# Department of the Army

# Mobile District, Corps of Engineers

# Permit Number SAM-2013-00603-GAC

# Awarded to Alabama Marine Resources Division

# July 18, 2013

**Construction of artificial reef in Weeks Bay, AL**

DEPARTMENT OF THE ARMY
MOBILE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 2288
MOBILE, AL 36628-0001

REPLY TO
ATTENTION OF

July 18, 2013

South Alabama Branch
Regulatory Division

SUBJECT: Department of the Army Nationwide Permit Number SAM-2013-00603-GAC, Alabama Department of Conservation and Natural Resources

Alabama Department of Conservation
and Natural Resources
Marine Resources Division
Attention: Mr. Christopher Blankenship
Post Office Box 189
Dauphin Island, Alabama 36528

Dear Mr. Blankenship:

This letter is in response to your October 2, 2012 request for a Department of the Army (DA) permit for placement of approximately 2.6 acres of oyster shell fishing reef material on the waterbottoms of Weeks Bay, Baldwin County, Alabama.

Based upon the information and plans you provided, we hereby verify the work described above, which would be performed in accordance with the enclosed drawings, is authorized by **Nationwide Permit (NWP) 27, Aquatic Habitat Restoration, Establishment, and Enhancement Activities**, in accordance with 33 CFR Part 330 of our regulations. This NWP and its associated Regional and General Conditions can be viewed at our website at: www.sam.usace.army.mil/rd/reg. You must comply with all of the special and general conditions and any project specific conditions of this authorization or you may be subject to enforcement action. In the event you have not completed construction of your project within the specified time limit, a separate application or re-verification may be required. This verification will expire on March 17, 2016.

**The following project special conditions are included with this verification**:

**a. All activities associated with this permit shall be accomplished in accordance with The Best Management Practices of the Alabama Department of Environmental Management (ADEM).**

**b. It is the responsibility of the permittee to coordinate this activity with the State Lands Division, Alabama Department of Conservation and Natural Resources (ADCNR), for any lease(s) that may be required for impacting State water bottoms and information regarding riparian requirements. The contact information is: ADCNR, State Lands Division, Submerged Lands Permits, 31115 Five Rivers Boulevard, Spanish Fort, Alabama 36527, telephone number (251) 621-1238.**

**c. It is the permittee's responsibility to ensure the contractors working on this project are aware of all general and special permit conditions.**

**d. The permittee understands and agrees that if future operations of the United States require removal, relocation, or other alteration of the structures or work herein authorized or if, in the opinion of the Secretary of the Army, or his designated representative, said structures or work shall cause unreasonable obstruction to the free navigation of the navigable waters, the permittee shall be required, upon due notice from the U.S. Army Corps of Engineers(Corps), to remove, relocate, or alter the structural work or obstructions caused thereby, without expense to the United States. No claim shall be made against the United States on account of any such removal or alteration.**

**e. In order for the U.S. Coast Guard to give proper notice to the maritime community; the permitted owners, contractors, or responsible party(S) shall contact Coast Guard Sector Mobile Waterways Management Branch (spw), 1500 15th Street, Mobile, Alabama 36615 at telephone number (251) 441-5684 of (251) 441-5720, 60-days prior to performing the proposed action. The permitted owners, contractors, or responsible party(s) must install and maintain, at the permitted owner's, contractor's, or responsible party(s) expense, any safety light, signs, and signals required by the U.S. Coast Guard, through regulations or otherwise, on the owner's, contractor's or responsible party(s) fixed structures. To receive a U.S. Coast Guard Private Aids to Navigation marking determination, at no later than 30-days prior to installation of any fixed structures in navigable waters, you are required to contact the Eighth Coast Guard District (dpw), 500 Poydras St., Suite 1230, new Orleans, LA 70130, at telephone number (504) 671-2328 or via e-mail to: D8oanPATON@uscg.mil.**

Attached to this verification that your project is authorized under a NWP is an approved jurisdictional determination (JD). If you are not in agreement with that approved JD, you can make an administrative appeal under 33 CFR Part 331. Enclosed you will find a Notification of Administrative Appeal Options and Process fact sheet and Request for Appeal (RFA) form. If you choose to object to certain terms and conditions of the permit, you must follow the directions provided in Section 1, Part D and submit the completed RFA form to the letterhead address.

In order for an RFA to be accepted by the U. S. Army Corps of Engineers (Corps), the Corps must determine that it is complete, that it meets the criteria under 33 CFR Part 331.5, and that it has been received by the District office within 60 days of the date of the RFA. Should you decide to submit an RFA form, it must be received at the letterhead address by within 60 days of the date of this letter. It is not necessary to submit an RFA form to the District office, if you do not object to the determination attached to this letter.

This letter of authorization does not obviate the necessity to obtain any other Federal, State or local permits, which may be required. Please note you are also required to submit a signed certification regarding the completed work and any required mitigation. The enclosed Compliance Certification form must be completed and returned to the letterhead address within 60 days of completion of the work authorized.

A copy of this correspondence is furnished to the following: ADEM, Mobile Branch, Coastal Section, Attention: Mr. Scott Brown, 3664 Dauphin Street, Suite B, Mobile, Alabama 36608; ADCNR, State Lands Division, Attention: Mr. Jeff Jordan, 31115 Five Rivers Boulevard, Spanish Fort, Alabama 36527

Please contact me at (251) 694-4077 if you have any questions. For additional information about our Regulatory Program, visit our web site at: www.sam.usace.army.mil/rd/reg and please take a moment to complete our customer satisfaction survey while you're there or complete and return the enclosed self addressed survey form. Your responses are appreciated and will allow us to improve our services.

Sincerely,

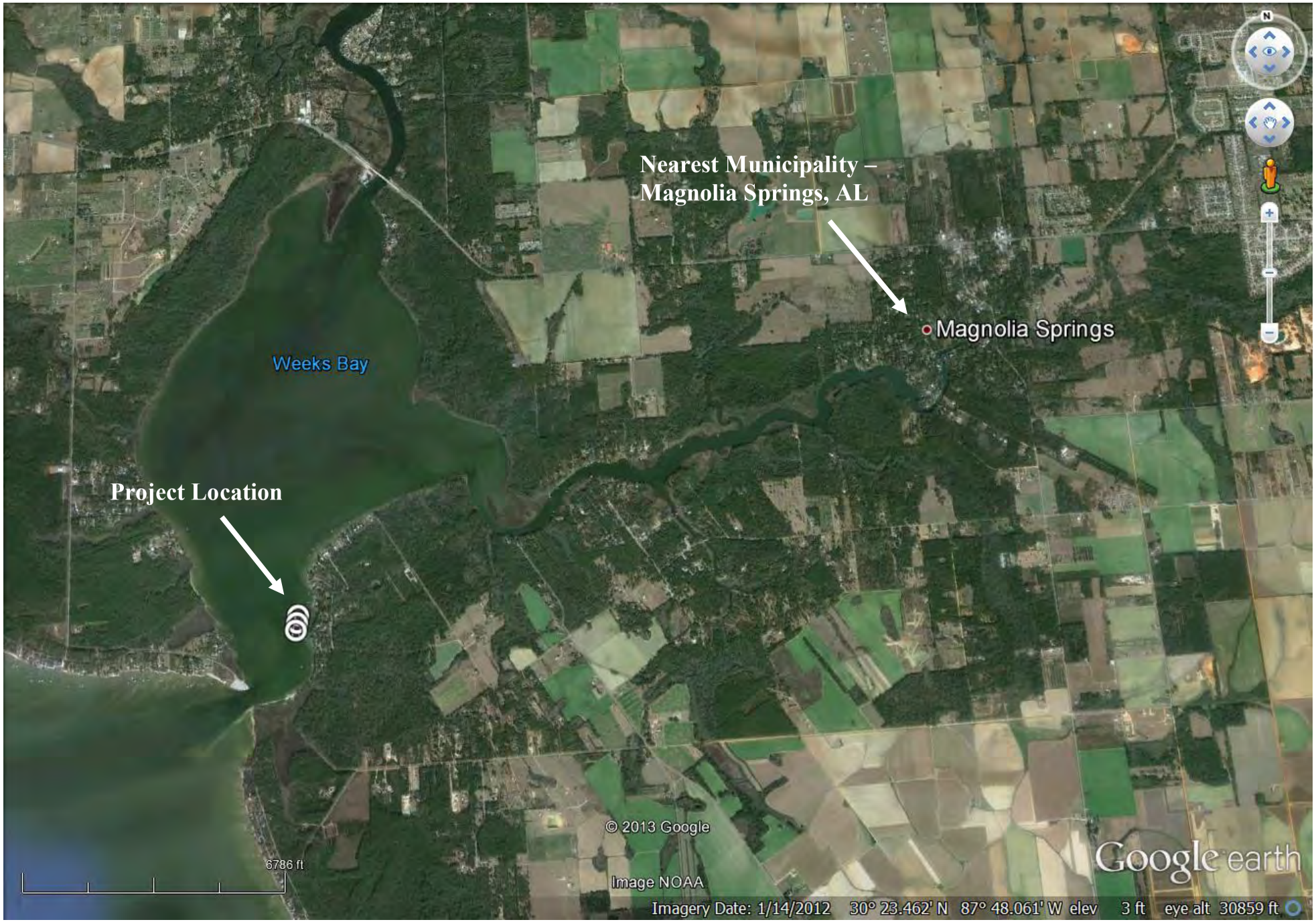
Glen A. Cunningham
Project Manager, South Alabama Branch
Regulatory Division

Enclosures

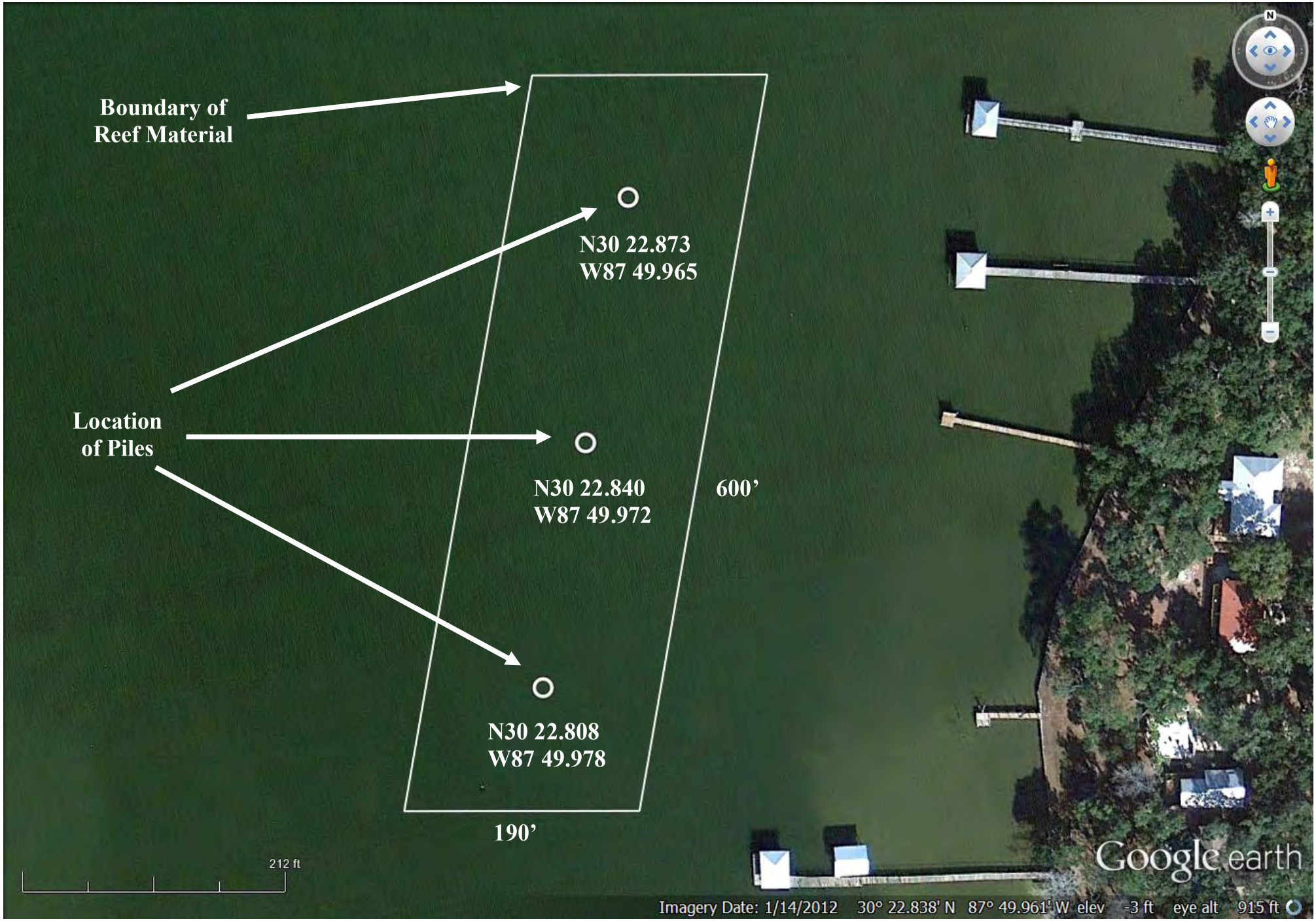
When the structures or work authorized by this NWP (SAM-2013-00603-GAC) are still in existence at the time the property is transferred, the terms and conditions of this NWP, including any special conditions, will continue to be binding on the new owner(s) of the property. To validate the transfer of this NWP and the associated liabilities associated with compliance with its terms and conditions, have the transferee sign and date below.

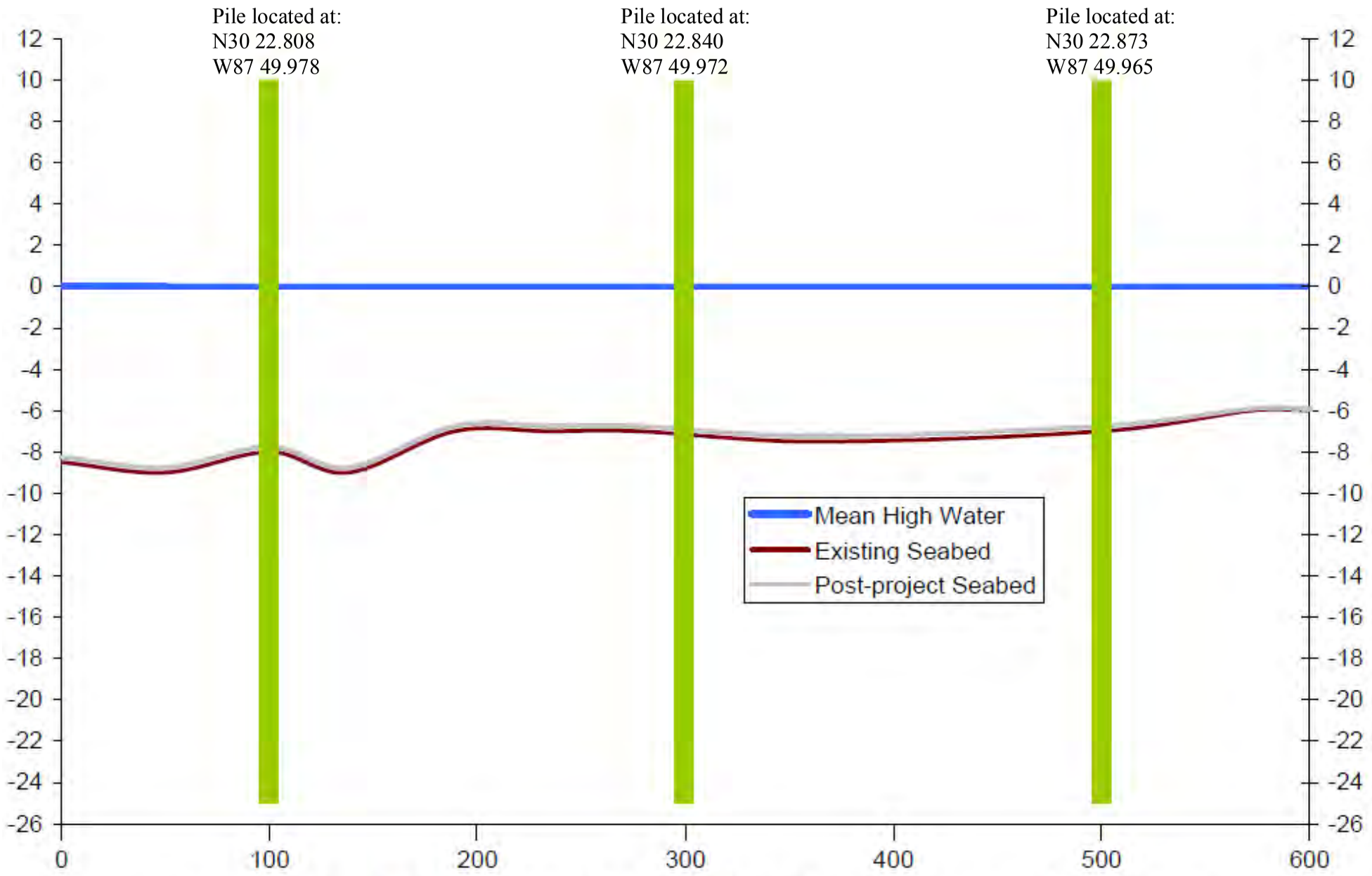
_____ _____

(TRANSFEREE) (DATE)

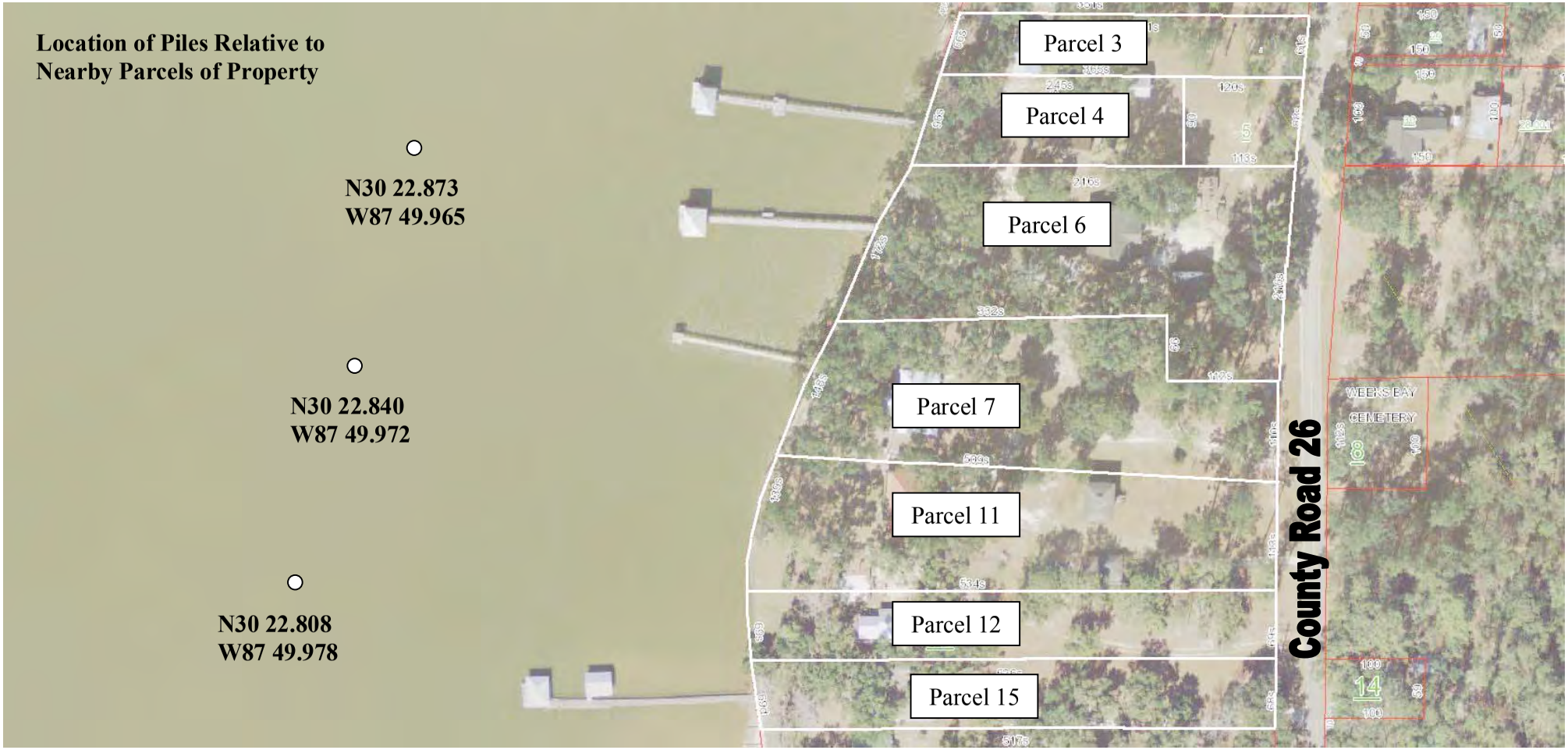

Nearest Municipality –
Magnolia Springs, AL
Magnolia Springs
Weeks Bay
Project Location
© 2013 Google
Image NOAA
6786 ft
Google earth
Imagery Date: 1/14/2012 30° 23.462' N 87° 48.061' W elev 3 ft eye alt 30859 ft

Project Location
County Road 26
Co Rd 26
Co Rd 1
County Road 1
© 2013 Google
904 ft
Google earth
Imagery Date: 1/14/2012 30° 22.705' N 87° 50.015' W elev -5 ft eye alt 3894 ft


Boundary of
Reef Material
N30 22.873
W87 49.965
Location
of Piles
N30 22.840
W87 49.972
600’
N30 22.808
W87 49.978
190’
212 ft
Google earth
Imagery Date: 1/14/2012 30° 22.838' N 87° 49.961' W elev -3 ft eye alt 915 ft




Units in feet from southern boundary of project area to northern boundary of project area




Parcel 3 and 4:
Kitchens, D Greg and Kitchens, Alan L
C/O Greg Kitchens
PO Box 123
Utica, MS 39175-0123

Parcel 6:
Rawson, Pearl L
11330 Co Rd 26
Foley, AL 36535

Parcel 7, 11, and 12:
Weeks, Everette J
11340 Weeks Bay Rd
Foley, AL 36535

Parcel 15:
Iles, James E and Iles, Edythe S
573 Sipsey Pines Rd
Arley, AL 35541

Parcel 3 (Section 2, Township 8S, Range 2E)
Parcels 4, 6, 7, 11, 12, and 15 (Section 5, Township 8S, Range 2E)

**APPROVED JURISDICTIONAL DETERMINATION FORM**
**U.S. Army Corps of Engineers**

## SECTION I: BACKGROUND INFORMATION

**A. REPORT COMPLETION DATE FOR APPROVED JURISDICTIONAL DETERMINATION (JD):** 22-Jul-2013

**B. DISTRICT OFFICE, FILE NAME, AND NUMBER:** Mobile District, SAM-2013-00603-JD1

**C. PROJECT LOCATION AND BACKGROUND INFORMATION:**

| | |
|---|---|
| **State :** | AL - Alabama |
| **County/parish/borough:** | Baldwin |
| **City:** | |
| **Lat:** | 30.38067 |
| **Long:** | -87.83287 |
| **Universal Transverse Mercator** | Folder UTM List<br>*UTM list determined by folder location*<br>• NAD83 / UTM zone 16N<br>Waters UTM List<br>*UTM list determined by waters location* |
| **Name of nearest waterbody:** | |
| **Name of nearest Traditional Navigable Water (TNW):** | |
| **Name of watershed or Hydrologic Unit Code (HUC):** | |

☐ Check if map/diagram of review area and/or potential jurisdictional areas is/are available upon request.

☐ Check if other sites (e.g., offsite mitigation sites, disposal sites, etc¿) are associated with the action and are recorded on a different JD form.

**D. REVIEW PERFORMED FOR SITE EVALUATION:**

☑ Office Determination Date:

☐ Field Determination Date(s): ☐

## SECTION II: SUMMARY OF FINDINGS

**A. RHA SECTION 10 DETERMINATION OF JURISDICTION**

**There** are"navigable waters of the U.S." within Rivers and Harbors Act (RHA) jurisdiction (as defined by 33 CFR part 329) in the review area.

☐ Waters subject to the ebb and flow of the tide.

☑ Waters are presently used, or have been used in the past, or may be susceptible for use to transport interstate or foreign commerce.

**Explain:** Traditionally navigable

**B. CWA SECTION 404 DETERMINATION OF JURISDICTION.**

There "waters of the U.S." within Clean Water Act (CWA) jurisdiction (as defined by 33 CFR part 328) in the review area.

**1. Waters of the U.S.**

**a. Indicate presence of waters of U.S. in review area:**[1]

| Water Name | Water Type(s) Present |
|---|---|
| Weeks Bay | TNWs, including territorial seas |

**b. Identify (estimate) size of waters of the U.S. in the review area:**

**Area:** (m²)
**Linear:** (m)

**c. Limits (boundaries) of jurisdiction:**

**based on:**
**OHWM Elevation:** (if known)

**2. Non-regulated waters/wetlands:**[3]

**Potentially jurisdictional waters and/or wetlands were assessed within the review area and determined to be not jurisdictional. Explain:**

## SECTION III: CWA ANALYSIS

### A. TNWs AND WETLANDS ADJACENT TO TNWs

**1.TNW**

| TNW Name | Summarize rationale supporting determination: |
|---|---|
| Weeks Bay | Traditionally navigable |

**2. Wetland Adjacent to TNW**
Not Applicable.

### B. CHARACTERISTICS OF TRIBUTARY (THAT IS NOT A TNW) AND ITS ADJACENT WETLANDS (IF ANY):

**1. Characteristics of non-TNWs that flow directly or indirectly into TNW**

**(i) General Area Conditions:**
**Watershed size:**
**Drainage area:**
**Average annual rainfall:** inches
**Average annual snowfall:** inches

**(ii) Physical Characteristics**
**(a) Relationship with TNW:**

☐ Tributary flows directly into TNW.

☐ Tributary flows through [ ] tributaries before entering TNW.

:Number of tributaries

**Project waters are** river miles from TNW.
**Project waters are** river miles from RPW.
**Project Waters are** aerial (straight) miles from TNW.
**Project waters are** aerial(straight) miles from RPW.

☐ Project waters cross or serve as state boundaries.

**Explain:**

**Identify flow route to TNW:**[5]

**Tributary Stream Order, if known:**
Not Applicable.

**(b) General Tributary Characteristics:**

**Tributary is:**
Not Applicable.

**Tributary properties with respect to top of bank (estimate):**
Not Applicable.

**Primary tributary substrate composition:**
Not Applicable.

**Tributary (conditions, stability, presence, geometry, gradient):**
Not Applicable.

**(c) Flow:**
Not Applicable.

**Surface Flow is:**
Not Applicable.

**Subsurface Flow:**
Not Applicable.

**Tributary has:**
Not Applicable.

**If factors other than the OHWM were used to determine lateral extent of CWA jurisdiction:**

**High Tide Line indicated by:**
Not Applicable.

**Mean High Water Mark indicated by:**
Not Applicable.

**(iii) Chemical Characteristics:**
**Characterize tributary (e.g., water color is clear, discolored, oily film; water quality;general watershed characteristics, etc.).**
Not Applicable.

**(iv) Biological Characteristics. Channel supports:**
Not Applicable.

**2. Characteristics of wetlands adjacent to non-TNW that flow directly or indirectly into TNW**

**(i) Physical Characteristics:**
**(a) General Wetland Characteristics:**
**Properties:**
Not Applicable.

**(b) General Flow Relationship with Non-TNW:**

**Flow is:**
Not Applicable.

**Surface flow is:**
Not Applicable.

**Subsurface flow:**
Not Applicable.

**(c) Wetland Adjacency Determination with Non-TNW:**
Not Applicable.

**(d) Proximity (Relationship) to TNW:**
Not Applicable.

**(ii) Chemical Characteristics:**
**Characterize tributary (e.g., water color is clear, discolored, oily film; water quality; general watershed characteristics, etc.).**
Not Applicable.

**(iii) Biological Characteristics. Wetland supports:**
Not Applicable.

**3. Characteristics of all wetlands adjacent to the tributary (if any):**

**All wetlands being considered in the cumulative analysis:**
Not Applicable.

**Summarize overall biological, chemical and physical functions being performed:**
Not Applicable.

## C. SIGNIFICANT NEXUS DETERMINATION

**A significant nexus analysis will assess the flow characteristics and functions of the tributary itself and the functions performed by any wetlands adjacent to the tributary to determine if they significantly affect the chemical, physical, and biological integrity of a TNW. For each of the following situations, a significant nexus exists if the tributary, in combination with all of its adjacent wetlands, has more than a speculative or insubstantial effect on the chemical, physical and/or biological integrity of a TNW. Considerations when evaluating significant nexus include, but are not limited to the volume, duration, and frequency of the flow of water in the tributary and its proximity to a TNW, and the functions performed by the tributary and all its adjacent wetlands. It is not appropriate to determine significant nexus based solely on any specific threshold of distance (e.g. between a tributary and its adjacent wetland or between a tributary and the TNW). Similarly, the fact an adjacent wetland lies within or outside of a floodplain is not solely determinative of significant nexus.**

**Significant Nexus: Not Applicable**

## D. DETERMINATIONS OF JURISDICTIONAL FINDINGS. THE SUBJECT WATERS/WETLANDS ARE:

**1. TNWs and Adjacent Wetlands:**

| Wetland Name | Type | Size (Linear) (m) | Size (Area) (m²) |
|---|---|---|---|
| Weeks Bay | TNWs, including territorial seas | - | 10521.8256 |
| **Total:** | | **0** | **10521.8256** |

**2. RPWs that flow directly or indirectly into TNWs:**
Not Applicable.

**Provide estimates for jurisdictional waters in the review area:**
Not Applicable.

**3. Non-RPWs that flow directly or indirectly into TNWs:**[8]
Not Applicable.

**Provide estimates for jurisdictional waters in the review area:**

Not Applicable.

**4. Wetlands directly abutting an RPW that flow directly or indirectly into TNWs.**
Not Applicable.

**Provide acreage estimates for jurisdictional wetlands in the review area:**
Not Applicable.

**5. Wetlands adjacent to but not directly abutting an RPW that flow directly or indirectly into TNWs:**
Not Applicable.

**Provide acreage estimates for jurisdictional wetlands in the review area:**
Not Applicable.

**6. Wetlands adjacent to non-RPWs that flow directly or indirectly into TNWs:**
Not Applicable.

**Provide estimates for jurisdictional wetlands in the review area:**
Not Applicable.

**7. Impoundments of jurisdictional waters:**[9]
Not Applicable.

**E. ISOLATED [INTERSTATE OR INTRA-STATE] WATERS INCLUDING ISOLATED WETLANDS, THE USE, DEGRADATION OR DESTRUCTION OF WHICH COULD AFFECT INTERSTATE COMMERCE, INCLUDING ANY SUCH WATERS:**[10]
Not Applicable.

**Identify water body and summarize rationale supporting determination:**
Not Applicable.

**Provide estimates for jurisdictional waters in the review area:**
Not Applicable.

**F. NON-JURISDICTIONAL WATERS, INCLUDING WETLANDS**

☐ If potential wetlands were assessed within the review area, these areas did not meet the criteria in the 1987 Corps of Engineers Wetland Delineation Manual and/or appropriate Regional Supplements:

☐ Review area included isolated waters with no substantial nexus to interstate (or foreign) commerce:

☐ Prior to the Jan 2001 Supreme Court decision in "SWANCC," the review area would have been regulated based soley on the "Migratory Bird Rule" (MBR):

☐ Waters do not meet the "Significant Nexus" standard, where such a finding is required for jurisdiction (Explain):

☐ Other (Explain):

**Provide acreage estimates for non-jurisdictional waters in the review area, where the sole potential basis of jurisdiction is the MBR factors (ie., presence of migratory birds, presence of endangered species, use of water for irrigated agriculture), using best professional judgment:**
Not Applicable.

**Provide acreage estimates for non-jurisdictional waters in the review area, that do not meet the "Significant Nexus" standard, where such a finding is required for jurisdiction.**
Not Applicable.

## SECTION IV: DATA SOURCES.

**A. SUPPORTING DATA. Data reviewed for JD**
(listed items shall be included in case file and, where checked and requested, appropriately reference below):

| Data Reviewed | Source Label | Source Description |
|---|---|---|
| --Maps, plans, plots or plat submitted by or on behalf of the applicant/consultant | - | - |

**B. ADDITIONAL COMMENTS TO SUPPORT JD:**
Not Applicable.

---

[1]-Boxes checked below shall be supported by completing the appropriate sections in Section III below.

[2]-For purposes of this form, an RPW is defined as a tributary that is not a TNW and that typically flows year-round or has continuous flow at least "seasonally" (e.g., typically 3 months).

[3]-Supporting documentation is presented in Section III.F.

[4]-Note that the Instructional Guidebook contains additional information regarding swales, ditches, washes, and erosional features generally and in the arid West.

[5]-Flow route can be described by identifying, e.g., tributary a, which flows through the review area, to flow into tributary b, which then flows into TNW.

[6]-A natural or man-made discontinuity in the OHWM does not necessarily sever jurisdiction (e.g., where the stream temporarily flows underground, or where the OHWM has been removed by development or agricultural practices). Where there is a break in the OHWM that is unrelated to the waterbody's flow regime (e.g., flow over a rock outcrop or through a culvert), the agencies will look for indicators of flow above and below the break.

[7]-Ibid.

[8]-See Footnote #3.

[9]-To complete the analysis refer to the key in Section III.D.6 of the Instructional Guidebook.

[10]-Prior to asserting or declining CWA jurisdiction based solely on this category, Corps Districts will elevate the action to Corps and EPA HQ for review consistent with the process described in the Corps/EPA Memorandum Regarding CWA Act Jurisdiction Following Rapanos.

Successfully Updated All Information. ×

**DA Number:** SAM-2013-00603-GAC (ADCNR - Marine Resources Div.)

**Applicant:** Christopher Blankenship (Alabama Department of Conservation and Natural Resources) (Agent: Craig Newton (Alabama Department of Conservation and Natural Resources))

## District-Specific Data Elements (DSDE)

No District-Specific Data Elements Have Been Added To This Action.

## Regulatory Action Folder

| | |
|---|---|
| 1. Assign to PM | GLEN CUNNINGHAM - South Alabama Branch (K5RDAGAC) ▼ Suffix GAC |
| 2. Project Name | ADCNR - Marine Resources Div. |
| 3. Proposed Project Description | Nationwide Permit 48 |
| 4. Nature Of Activity | Sections 10 & 404 |
| 5. Project Purpose | Governmental |
| 6. Comments | |
| 7. Date First Received | 20-May-2013 |
| 8. End Date | 22-Jul-2013 |

## Additional Items

## Commands

Save | Cancel

## NOTIFICATION OF ADMINISTRATIVE APPEAL OPTIONS AND PROCESS AND REQUEST FOR APPEAL

| Applicant : **AL Dept of Conservation and Natural Resources** | File No.: **SAM-2013-00603-GAC** | Date: **18 July 2013** |
|---|---|---|

| Attached is: | | See Section below |
|---|---|---|
| | INITIAL PROFFERED PERMIT (Standard Permit or Letter of permission) | A |
| | PROFFERED PERMIT (Standard Permit or Letter of permission) | B |
| | PERMIT DENIAL | C |
| **XX** | APPROVED JURISDICTIONAL DETERMINATION | D |
| | PRELIMINARY JURISDICTIONAL DETERMINATION | E |

SECTION I - The following identifies your rights and options regarding an administrative appeal of the above decision. Additional information may be found at http://www.usace.army.mil/CECW/Pages/reg_materials.aspx or Corps regulations at 33 CFR Part 331.

A: INITIAL PROFFERED PERMIT: You may accept or object to the permit.

- ACCEPT: If you received a Standard Permit, you may sign the permit document and return it to the district engineer for final authorization. If you received a Letter of Permission (LOP), you may accept the LOP and your work is authorized. Your signature on the Standard Permit or acceptance of the LOP means that you accept the permit in its entirety, and waive all rights to appeal the permit, including its terms and conditions, and approved jurisdictional determinations associated with the permit.
- OBJECT: If you object to the permit (Standard or LOP) because of certain terms and conditions therein, you may request that the permit be modified accordingly. You must complete Section II of this form and return the form to the district engineer. Your objections must be received by the district engineer within 60 days of the date of this notice, or you will forfeit your right to appeal the permit in the future. Upon receipt of your letter, the district engineer will evaluate your objections and may: (a) modify the permit to address all of your concerns, (b) modify the permit to address some of your objections, or (c) not modify the permit having determined that the permit should be issued as previously written. After evaluating your objections, the district engineer will send you a proffered permit for your reconsideration, as indicated in Section B below.

B: PROFFERED PERMIT: You may accept or appeal the permit

- ACCEPT: If you received a Standard Permit, you may sign the permit document and return it to the district engineer for final authorization. If you received a Letter of Permission (LOP), you may accept the LOP and your work is authorized. Your signature on the Standard Permit or acceptance of the LOP means that you accept the permit in its entirety, and waive all rights to appeal the permit, including its terms and conditions, and approved jurisdictional determinations associated with the permit.
- APPEAL: If you choose to decline the proffered permit (Standard or LOP) because of certain terms and conditions therein, you may appeal the declined permit under the Corps of Engineers Administrative Appeal Process by completing Section II of this form and sending the form to the division engineer. This form must be received by the division engineer within 60 days of the date of this notice.

C: PERMIT DENIAL: You may appeal the denial of a permit under the Corps of Engineers Administrative Appeal Process by completing Section II of this form and sending the form to the division engineer. This form must be received by the division engineer within 60 days of the date of this notice.

D: APPROVED JURISDICTIONAL DETERMINATION: You may accept or appeal the approved JD or provide new information.

- ACCEPT: You do not need to notify the Corps to accept an approved JD. Failure to notify the Corps within 60 days of the date of this notice, means that you accept the approved JD in its entirety, and waive all rights to appeal the approved JD.
- APPEAL: If you disagree with the approved JD, you may appeal the approved JD under the Corps of Engineers Administrative Appeal Process by completing Section II of this form and sending the form to the division engineer. This form must be received by the division engineer within 60 days of the date of this notice.

E: PRELIMINARY JURISDICTIONAL DETERMINATION: You do not need to respond to the Corps regarding the preliminary JD. The Preliminary JD is not appealable. If you wish, you may request an approved JD (which may be appealed), by contacting the Corps district for further instruction. Also you may provide new information for further consideration by the Corps to reevaluate the JD.

SECTION II - REQUEST FOR APPEAL or OBJECTIONS TO AN INITIAL PROFFERED PERMIT

REASONS FOR APPEAL OR OBJECTIONS: (Describe your reasons for appealing the decision or your objections to an initial proffered permit in clear concise statements. You may attach additional information to this form to clarify where your reasons or objections are addressed in the administrative record.)

ADDITIONAL INFORMATION: The appeal is limited to a review of the administrative record, the Corps memorandum for the record of the appeal conference or meeting, and any supplemental information that the review officer has determined is needed to clarify the administrative record. Neither the appellant nor the Corps may add new information or analyses to the record. However, you may provide additional information to clarify the location of information that is already in the administrative record.

POINT OF CONTACT FOR QUESTIONS OR INFORMATION:

If you have questions regarding this decision and/or the appeal process you may contact:
GLEN A. CUNNINGHAM
CESAM-RD-SA
U.S ARMY CORPS OF ENGINEERS
POST OFFICE BOX 2288
MOBILE, ALABAMA 36628-0001
(251)-690-2658

| RIGHT OF ENTRY: Your signature below grants the right of entry to Corps of Engineers personnel, and any government consultants, to conduct investigations of the project site during the course of the appeal process. You will be provided a 15 day notice of any site investigation, and will have the opportunity to participate in all site investigations. | | |
|---|---|---|
| _____<br>Signature of appellant or agent. | Date: | Telephone number: |

DEPARTMENT OF THE ARMY
U.S. ARMY ENGINEER DISTRICT, MOBILE
CORPS OF ENGINEERS
P.O. BOX 2288
MOBILE, ALABAMA 36628-0001

REPLY TO
ATTENTION OF:

July 18, 2013

South Alabama Branch
Regulatory Division

SUBJECT: Permit for Minor Structures and Activities within the State of Alabama - General Permit Number SAM-2013-00603-GAC, Alabama Department of Conservation and Natural Resources

Alabama Department of Conservation
and Natural Resources
Marine Resources Division
Attention: Mr. Christopher Blankenship
Post Office Box 189
Dauphin Island, Alabama 36528

Dear Mr. Blankenship:

Reference is made to your request for a Department of the Army permit to place three new, single-pile signage structures to mark a new fishing reef structure in Weeks Bay, Baldwin County, Alabama.

Upon the recommendation of the Chief of Engineers and under provisions of Section 10 of the River and Harbor Act of 1899 (33 U.S.C. 403), authorization is hereby given by the Secretary of the Army for the performance of the work in accordance with the enclosed descriptions and plans, ENG Form 4336 and Alabama General Permit Number ALG08-2011 and the General and Regional Conditions of this permit. Please note: The Alabama General Permit Program conditions include nine Special Conditions and five General Conditions. Alabama Department of Environmental Management project certification conditions include three Coastal Zone Management Certification Conditions and 39 Water Quality Conditions.

This General Permit and its associated Regional and General Conditions can be accessed at our website at www.sam.usace.army.mil/missions/regulatory, or, at your request, a paper copy will be provided to you.

**Your work is subject to the following special conditions:**

a. **All activities associated with this permit shall be accomplished in accordance with The Best Management Practices of the Alabama Department of Environmental Management.**

b. **It is the responsibility of the permittee to coordinate this activity with the State Lands Division, Alabama Department of Conservation and Natural Resources (ADCNR), for any lease(s) that may be required for impacting State**

**water bottoms and information regarding riparian requirements. The contact information is: ADCNR, State Lands Division, and Submerged Lands Permits, 31115 Five Rivers Boulevard, Spanish Fort, Alabama 36527, telephone number (251) 621-1238.**

**c. The permittee understands and agrees that if future operations of the United States require removal, relocation, or other alteration of the structures or work herein authorized or if, in the opinion of the Secretary of the Army, or his designated representative, said structures or work shall cause unreasonable obstruction to the free navigation of the navigable waters, the permittee shall be required, upon due notice from the U.S. Army Corps of Engineers (Corps), to remove, relocate, or alter the structural work or obstructions caused thereby, without expense to the United States. No claim shall be made against the United States on account of any such removal or alteration.**

**d. In order for the U.S. Coast Guard to give proper notice to the maritime community; the permitted owners, contractors, or responsible party(S) shall contact Coast Guard Sector Mobile Waterways Management Branch (spw), 1500 15th Street, Mobile, Alabama 36615 at telephone number (251) 441-5684 of (251) 441-5720, 60-days prior to performing the proposed action. The permitted owners, contractors, or responsible party(s) must install and maintain, at the permitted owner's, contractor's, or responsible party(s) expense, any safety light, signs, and signals required by the U.S. Coast Guard, through regulations or otherwise, on the owner's, contractor's or responsible party(s) fixed structures. To receive a U.S. Coast Guard Private Aids to Navigation marking determination, at no later than 30-days prior to installation of any fixed structures in navigable waters, you are required to contact the Eighth Coast Guard District (dpw), 500 Poydras St., Suite 1230, new Orleans, LA 70130, at telephone number (504) 671-2328 or via e-mail to: D8oanPATON@uscg.mil. For general information related to Private Aids to Navigation please visit the Eighth CG District web site at: http://www.uscg.mil/d8/waterways/PA**

If title to this structure is transferred or assigned to another party or in the event of removal or destruction of such structure by any cause, the District Commander shall be notified promptly in writing.

You should study and carefully adhere to all the terms and conditions of the permit. The District Commander must be notified of the commencement and completion of the permitted work. The enclosed cards may be used for that purpose. Also, the Notice of Authorization must be posted at the site during construction of the permitted activity. **Work authorized by the General Permit must be completed no later than October 1, 2016.**

A copy of this correspondence is furnished to the following: ADEM, Mobile Branch, Coastal Section, Attention: Mr. Scott Brown, 3664 Dauphin Street, Suite B, Mobile, Alabama 36608; ADCNR, State Lands Division, Attention: Mr. Jeff Jordan, 31115 Five Rivers Boulevard, Spanish Fort, Alabama 36527

Please contact me at (251) 694-4077, if you have any questions. For additional information about our Regulatory Program, please visit our web site at www.sam.usace.army.mil/missions/regulatory, and please take a moment to complete our customer satisfaction survey while you're there. Your responses are appreciated and will allow us to improve our services.

BY AUTHORITY OF THE SECRETARY OF THE ARMY:

STEVEN J. ROEMHILDT
Colonel, Corps of Engineers
District Commander

BY: _____
GLEN A. CUNNINGHAM
Project Manager
South Alabama Branch
Regulatory Division

Enclosures

When the structures or work authorized by this permit (SAM-2013-00603-GAC) are still in existence at the time the property is transferred, the terms and conditions of this permit will continue to be binding on the new owner(s) of the property. To validate the transfer of this permit and the associated liabilities associated with compliance with its terms and conditions, have the transferee sign and date below.

_____ _____
(TRANSFEREE) (DATE)

**This notice of authorization must be conspicuously displayed at the site of work.**

United States Army Corps of Engineers

A permit to perform work authorized by statutes and regulations of the Department of the Army

at Weeks Bay, Baldwin County, AL

has been issued to ADCNR-MARINE RESOURCES DIV on July 18, 2013

Address of Permittee PO Box 189, Dauphin Island AL 36528

Permit Number

SAM 2013-00603-GAC

For the District Commander
Glen A. Cunningham RD-A
Regulatory Division

ENG FORM 4336, Jul 81 (33 CFR 320-330) EDITION OF JUL 70 MAY BE USED (Proponent: CECW-0)

**NOTICE OF COMPLETION OF WORK AUTHORIZED BY PERMITS**

WORK AUTHORIZED UNDER DEPARTMENT OF THE ARMY PERMIT SAM2013-00603-GAC

DATED 18 July 2013

TO PERFORM WORK IN Weeks Bay, Baldwin Cty AL

WAS COMPLETED ON _____

BY: _____

SIGNATURE
ADCNR - Marine Resources Division

DATE _____

CESAM FORM 851
JUN 87

**NOTICE OF COMMENCEMENT OF WORK AUTHORIZED BY PERMITS**

WORK AUTHORIZED UNDER DEPARTMENT OF THE ARMY PERMIT SAM2013-00603-GAC

DATED 18 July 2013

TO PERFORM WORK IN Weeks Bay, Baldwin Cty, AL

WAS COMMENCED ON _____

BY: _____

SIGNATURE
ADCNR - Marine Resources Division

DATE _____

CESAM FORM 850
JUNE 87

# Department of the Army

# Mobile District, Corps of Engineers

# Permit Number SAM-2012-01395-DEM

# Awarded to Alabama Marine Resources Division

# March 18, 2013

**Construction of 3 artificial reefs in the Mississippi Sound**

DEPARTMENT OF THE ARMY
MOBILE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 2288
MOBILE, AL 36628-0001

REPLY TO
ATTENTION OF

March 18, 2013

Coastal Branch
Regulatory Division

SUBJECT: Department of the Army Final Permit Number SAM-2012-01395-DEM, ADCNR - Marine Resources Division, Mississippi Sound

Alabama Department of Conservation
And Natural Resources
Marine Resources Division
Mr. Chris Blankenship, Director
Post Office Box 189
Dauphin Island, Alabama 36528

Dear Mr. Blankenship:

**PLEASE READ THIS LETTER CAREFULLY AND COMPLY WITH ITS PROVISIONS**

There is enclosed a Department of the Army permit authorizing you to perform the work specified therein in accordance with the plans shown on the drawings attached thereto. This permit is issued under provision of the Federal laws for the protection and preservation of the navigable waters of the United States. These laws provide that after the proposed work has been approved by issuance of a Department of the Army permit,

**IT SHALL NOT BE LAWFUL TO DEVIATE FROM SUCH PLANS EITHER BEFORE OR AFTER COMPLETION OF THE WORK,**

unless modification of said plans has previously been submitted to and received the approval of the Department of the Army.

You should study and carefully adhere to all the terms and conditions of the permit. The District must be notified of the commencement and completion of the permitted work. The enclosed cards may be used for that purpose. Also enclosed is a "NOTICE OF AUTHORIZATION" which must be conspicuously displayed at the site during construction of the permitted work. Any inquiries relating to this permit should be directed to the Regulatory Division at phone number (251) 690-2658.

If for any reason it becomes necessary to make a material change in location or plans for this work, revised plans should be submitted promptly to the District Commander in order that the revised plans may receive the approval required by law before work is begun.

Compliance with this and other conditions of the permit is essential. Failure to submit the notices requested may result in its revocation.

Copy of this letter is being sent to Alabama Department of Environmental Management, Attention: Mr. Scott Brown, Coastal Area Division, 4171 Commanders Drive, Mobile, Alabama 36615.

For additional information about our Regulatory Program, please visit our web site at: http://www.sam.usace.army.mil/Missions/Regulatory.aspx and please take a moment to complete our customer satisfaction survey while you're there. Your responses are appreciated and will allow us to improve our services.

Sincerely,

Joy B. Earp
Team Leader, South Alabama Branch
Regulatory Division

Enclosures

## DEPARTMENT OF THE ARMY PERMIT

Permittee: **THE ALABAMA DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES MARINE RESOURCES DIVISION**

Permit No: **SAM-2012-1395-DEM**

Issuing Office: **MOBILE DISTRICT**

NOTE: The term "you" and its derivatives, as used in this permit, means the permittee or any future transferee. The term "this office" refers to the appropriate district or division office of the U. S. Army Corps of Engineers (Corps) having jurisdiction over the permitted activity or the appropriate official of that office acting under the authority of the commanding officer.

You are authorized to perform work in accordance with the terms and conditions specified below.

**Project Description: Construct and demarcate 3 artificial reefs in Alabama waters of the Mississippi Sound. Approximately 28,452 cubic yards of limestone gabion rock will be placed in 25.85 acres of waterbottoms. The reefs will be marked by the installation of 22 piles.**

**Reef 1: Six piles with appropriate markers will outline the perimeter of Reef 1 (Center at 30.236066; -88.2934833). Reef 1 will be approximately 3.27 acres in size. Water depth prior to construction of Reef 1 ranges from 6 feet to 14 feet and post construction depth will range from 6 feet to approximately 13 feet.**

**Reef 2: Ten piles with appropriate markers will outline the perimeter of Reef 2 (Center at 30.240333; -88.2729833). Reef 2 will be approximately 18.63 acres in size. Water depth prior to construction of Reef 2 ranges from 8 feet to 10 feet and post construction depth will range from approximately 7 feet to 9 feet.**

**Reef 3: Six piles with appropriate markers will outline the perimeter of Reef 3 (Center at 30.245250; -88.24180). Reef 3 will be approximately 3.95 acres in size. Water depth prior to construction of Reef 3 ranges from 6 feet to 10 feet and post construction depth will range from approximately 6 feet to 9 feet.**

**Total project size will be approximately 25.85 acres. Each reef site will consist of evenly distributed limestone gabion rock while maintaining at least 6 feet of non-obstructed water depth.**

**ATTACHED: 1. Project Plans (4 pages)**
**2. Alabama Department of Environmental Management Water Quality/Coastal Zone Management Certification, dated February 14, 2013 (6 pages)**

Project Location: Mississippi Sound (North of Dauphin Island, Mobile County, Alabama). *See project site location data for details.*

Permit Conditions:

General Conditions:

1. The time limit for completing the work authorized ends on **March 6, 2018**. If you find that you need more time to complete the authorized activity; submit your request for a time extension to this office for consideration at least 1 month before the above date is reached.

2. You must maintain the activity authorized by this permit in good condition and in conformance with the terms and conditions of this permit. You are not relieved of this requirement if you abandon the permitted activity, although you may make a good faith transfer to a third party in compliance with General Condition 4 below. Should you wish to cease to maintain the authorized activity or should you desire to abandon it without a good faith transfer, you must obtain a modification of this permit from this office, which may require restoration of the area.

3. If you discover any previously unknown historic or archeological remains while accomplishing the activity authorized by this permit, you must immediately notify this office of what you have found. We will initiate the Federal

and State coordination required to determine if the remains warrant a recovery effort or if the site is eligible for listing in the National Register of Historic Places.

4. If you sell the property associated with this permit, you must obtain the signature of the new owner in the space provided and forward a copy of the permit to this office to validate the transfer of this authorization.

5. If a conditioned water quality certification has been issued for your project, you must comply with the conditions specified in the certification as special conditions to this permit. For your convenience, a copy of the certification is attached if it contains such conditions.

6. You must allow representatives from this office to inspect the authorized activity at any time deemed necessary to ensure that it is being or has been accomplished in accordance with the terms and conditions of your permit.

**Special Conditions:**

**1. Compliance with all terms and General and Special Conditions of this Permit is mandatory.**

**2. It is the permittee's responsibility to ensure that the contractors working on this project are aware of all General and Special permit conditions.**

**3. The permittee will maintain CWA Section 401(a) Water Quality Certification and Coastal Consistency as required by the ADEM certification letter dated February 14, 2013.**

**4. Should cultural resources be encountered during project activities, work shall cease and the U.S. Army Corps of Engineers Mobile District, Alabama State Historical Preservation Officer (SHPO) and the Choctaw Nation of Oklahoma shall be consulted immediately. This stipulation shall be placed on the construction plans, and it is the permittee's responsibility to ensure that contractors are aware of this requirement. SHPO contact information: Alabama Historical Commission, Attention: Mr. Greg Rhinehart, 468 South Perry Street, Montgomery, Alabama 36130-0900, or telephone (334) 242-3184. The ACH tracking number is 13-0426; Choctaw Nation of Oklahoma, Attention: Ms. Johnnie Jacobs, Post Office Box 1210, Durant, Oklahoma 74701.**

**5. Construction activities shall not infringe upon navigation on the waterway. These activities shall be in compliance with 33 CFR 163, which states in part: "A clear channel shall at all times be left open to permit free and unobstructed navigation by all types of vessels and tows normally using the various waterways."**

**6. The permittee understands and agrees that, if future operations by the United States require the removal, relocation, or other alteration, of the structures or work herein authorized, or if, in the opinion of the Secretary of the Army or his authorized representative, said structure or work shall cause unreasonable obstruction to the free navigation of the navigable waters, the permittee will be required, upon due notice from the Corps of Engineers, to remove, relocate, or alter the structural work or obstructions caused thereby, without expense to the United States. No claim shall be made against the United States on account of any such removal or alteration.**

**7. You must maintain the activity authorized by this permit in good condition and in conformance with the terms and conditions of this permit. You are not relieved of this requirement if you abandon the permitted activity, although you may make a good faith transfer to a third party. Should you wish to cease to maintain the authorized activity or should you desire to abandon it without a good faith transfer, you must obtain a modification of this permit from this office, which may require restoration of the area.**

**8. It is the responsibility of the permittee to coordinate this activity with the State Lands Division, Alabama Department of Conservation and Natural Resources (ADCNR), for any riparian rights issues or leases that may be required for impacting State water bottoms. ADCNR, State Lands Division, 31115 Five Rivers Boulevard, Spanish Fort, Alabama 36527, phone number (251) 621-1238.**

**9. An as-built survey the entire shoreline breakwater project shall be conducted and furnished to the Corps within 90 days after construction completion.**

**10. The permittee must install and maintain, at the permittee's expense, any safety lights, signs and signals required by the U.S. Coast Guard, through regulations or otherwise, on the permittee's fixed structures. To receive a U.S. Coast Guard Private Aids to Navigation marking determination, at no later than 30 days prior installation of any fixed structures in navigable waters and/or prior to installation of any floating private aids to navigation, you are required to contact the Eighth Coast Guard District (dpw), 500 Poydras St. Suite 1230, New Orleans, LA 70130, (504)671-2328 or via email to: D8oanPATON@uscg.mil. For general information related to Private Aids to Navigation please visit the Eighth CG District web site at: http://www.uscg.mil/d8/waterways/PATON.Home.asp**

**11. This permit does not authorize impacts to wetlands, submerged grassbeds, or natural shellfish beds.**

Further Information:

1. Congressional Authorities: You have been authorized to undertake the activity described above pursuant to:

**(X)** Section 10 of the Rivers and Harbors Act of 1899 (33 U.S.C. 403).
**(X)** Section 404 of the Clean Water Act (33 U.S.C. 1344).

2. Limits of this authorization.

a. This permit does not obviate the need to obtain other Federal, State, or local authorizations required by law.

b. This permit does not grant any property rights or exclusive privileges.

c. This permit does not authorize any injury to the property or rights of others.

d. This permit does not authorize interference with any existing or proposed Federal project.

3. Limits of Federal Liability. In issuing this permit, the Federal Government does not assume any liability for the following:

a. Damages to the permitted project or uses thereof as a result of other permitted or unpermitted activities or from natural causes.

b. Damages to the permitted project or uses thereof as a result of current or future activities undertaken by or on behalf of the United States in the public interest.

c. Damages to persons, property, or to other permitted or unpermitted activities or structures caused by the activity authorized by this permit.

d. Design or construction deficiencies associated with the permitted work.

e. Damage claims associated with any future modification, suspension, or revocation of this permit.

4. Reliance on Applicant's Data: The determination of this office that issuance of this permit is not contrary to the public interest was made in reliance on the information you provided.

5. Reevaluation of Permit Decision. This office may reevaluate its decision on this permit at any time the circumstances warrant. Circumstances that could require a reevaluation include, but are not limited to, the following:

a. You fail to comply with the terms and conditions of this permit.

b. The information provided by you in support of your permit application proves to have been false, incomplete, or inaccurate (See 4 above).

c. Significant new information surfaces which this office did not consider in reaching the original public interest decision.

Such a reevaluation may result in a determination that it is appropriate to use the suspension, modification, and revocation procedures contained in 33 CFR 325.7 or enforcement procedures such as those contained in 33 CFR 326.4 and 326.5. The referenced enforcement procedures provide for the issuance of an administrative order requiring you to comply with the terms and conditions of your permit and for the initiation of legal action where appropriate. You will be required to pay for any corrective measures ordered by this office, and if you fail to comply with such directive, this office may in certain situations (such as those specified in 33 CFR 209.170) accomplish the corrective measures by contract or otherwise and bill you for the cost.

6. Extensions. General condition 1 establishes a time limit for the completion of the activity authorized by this permit. Unless there are circumstances requiring either a prompt completion of the authorized activity or a reevaluation of the public interest decision, the Corps will normally give favorable consideration to a request for an extension of this time limit.

Your signature below, as permittee, indicates that you accept and agree to comply with the terms and conditions of this permit, SAM-2012-1395-DEM.

3-14-13

(PERMITTEE) MR. CHRIS BLANKENSHIP (DATE)
ADCNR – MARINE RESOURCES DIVISION
POST OFFICE BOX 189
DAUPHIN ISLAND, ALABAMA 36528

This permit becomes effective when the Federal official, designated to act for the Secretary of the Army, has signed below.

STEVEN J. ROEMHILDT, P.E.
COLONEL, CORPS OF ENGINEERS
(DISTRICT COMMANDER)

BY: March 18, 2013
JOY B. EARP (DATE)
TEAM LEADER, SOUTH ALABAMA BRANCH
REGULATORY DIVISION

When the structures or work authorized by this permit (SAM-2012-1395-DEM) are still in existence at the time the property is transferred, the terms and conditions of this permit will continue to be binding on the new owner(s) of the property. To validate the transfer of this permit and the associated liabilities associated with compliance with its terms and conditions, have the transferee sign and date below.

(TRANSFEREE) DATE)

LANCE R. LEFLEUR
DIRECTOR

ROBERT J. BENTLEY
GOVERNOR

Alabama Department of Environmental Management
adem.alabama.gov
1400 Coliseum Blvd. 36110-2400 ■ Post Office Box 301463
Montgomery, Alabama 36130-1463
(334) 271-7700 ■ FAX (334) 271-7950

February 14, 2013

ALABAMA DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES – MARINE RESOURCES DIVISION
ATTN: MR. CHRISTOPHER M. BLANKENSHIP, DIRECTOR
POST OFFICE BOX 189
DAUPHIN ISLAND, AL 36528

RE: State of Alabama: CWA Section 401(a) Water Quality Certification and Coastal Consistency Concurrence
Alabama Department of Conservation and Natural Resources - Marine Resources Division (ADCNR-MRD)
Mobile County (097)
U.S. Army Corps of Engineers (USACOE) Joint Public Notice and Permit: SAM-2012-1395-DEM
Alabama Department of Environmental Management (ADEM) Tracking Code: 2013-032-COE

Dear Director Blankenship:

The ADEM has completed its review of the above referenced joint public notice and all submitted materials related to the ADCNR-MRD's proposal to install three (3) artificial reefs in the waters of the Mississippi Sound, north of Dauphin Island, Mobile County, Alabama. The approved project involves the installation of limestone gabion rock creating an approximately 3.27-acre artificial reef, an approximately 18.63-acre artificial reef and an approximately 3.95-acre artificial reef in the waters of the Mississippi Sound.

Action pertinent to water quality certification is required by Section 401(a)(1) of the Clean Water Act, 33 U.S.C. §1251, et. seq. If conducted in accordance with the conditions prescribed herein, ADEM hereby **grants** official certification that there is reasonable assurance that the discharge resulting from the proposed activities as submitted will not violate applicable water quality standards established under Section 303 of the Clean Water Act and §22-22-9(g), Code of Alabama (1975). This certification terminates coincidentally with the expiration of SAM-2012-1395-DEM but in no case shall this ADEM certification exceed a maximum of five (5) years from the date the USACOE issues permit SAM-2012-1395-DEM unless specifically authorized in response to a written request for same.

The ADEM **concurs** with ADCNR-MRD's determination that the project is consistent with the Alabama Coastal Area Management Program.

The ADEM certifies that there are no applicable effluent limitations under Sections 301 and 302 nor applicable standards under Sections 306 and 307 of the Clean Water Act in regard to the activities specified. However, regulations promulgated by the EPA requiring discharge permits for storm water runoff from individual and commercial facilities may be applicable. This certification does not address the requirements of those regulations.

To protect water quality and coastal resources, the ADCNR-MRD must implement and maintain appropriate, effective Best Management Practices (BMPs) for prevention and control of nonpoint sources of pollutants, during and after project implementation.

In recognition that projects are site specific in nature and conditions can change during project implementation, the ADEM reserves the right to require the submission of additional information or require additional management measures to be implemented, as necessary on a case-by-case basis, in order to ensure the protection of water quality and coastal resources.

Liability and responsibility for compliance with this certification are not delegable by contract or otherwise. The ADCNR-MRD shall ensure that any agent, contractor, subcontractor, or other person employed by, under contract, or paid a salary by

ADCNR-MRD complies with this certification. Any violations resulting from the actions of such person shall be considered violations of this certification and may result in an enforcement action.

This certification does not convey any property rights in either real or personal property, or any exclusive privileges, nor does it authorize any injury to persons or property or invasion of other private rights, trespass, or any infringement of Federal, State, or local laws or regulations.

Call or write Jennifer Robinson: (251) 432-6533 or jrobinson@adem.state.al.us anytime with questions. Always include the ADEM Tracking ID referenced above when correspondence relative to this project.

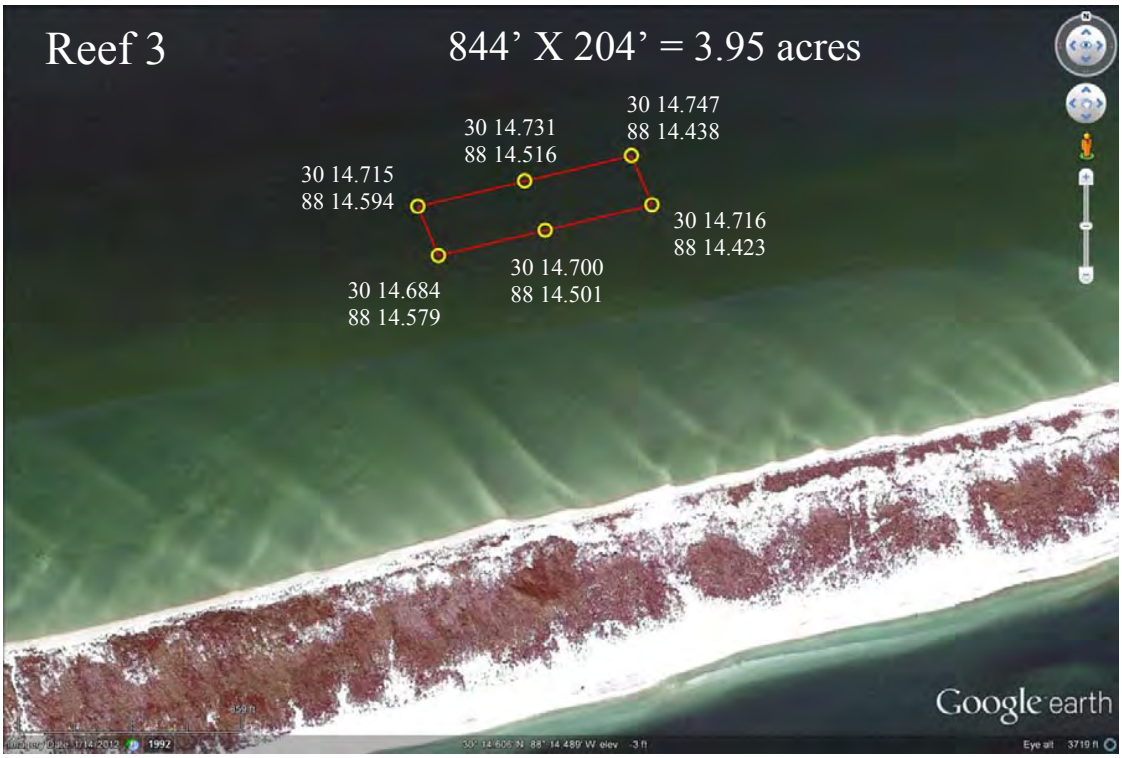
Sincerely,

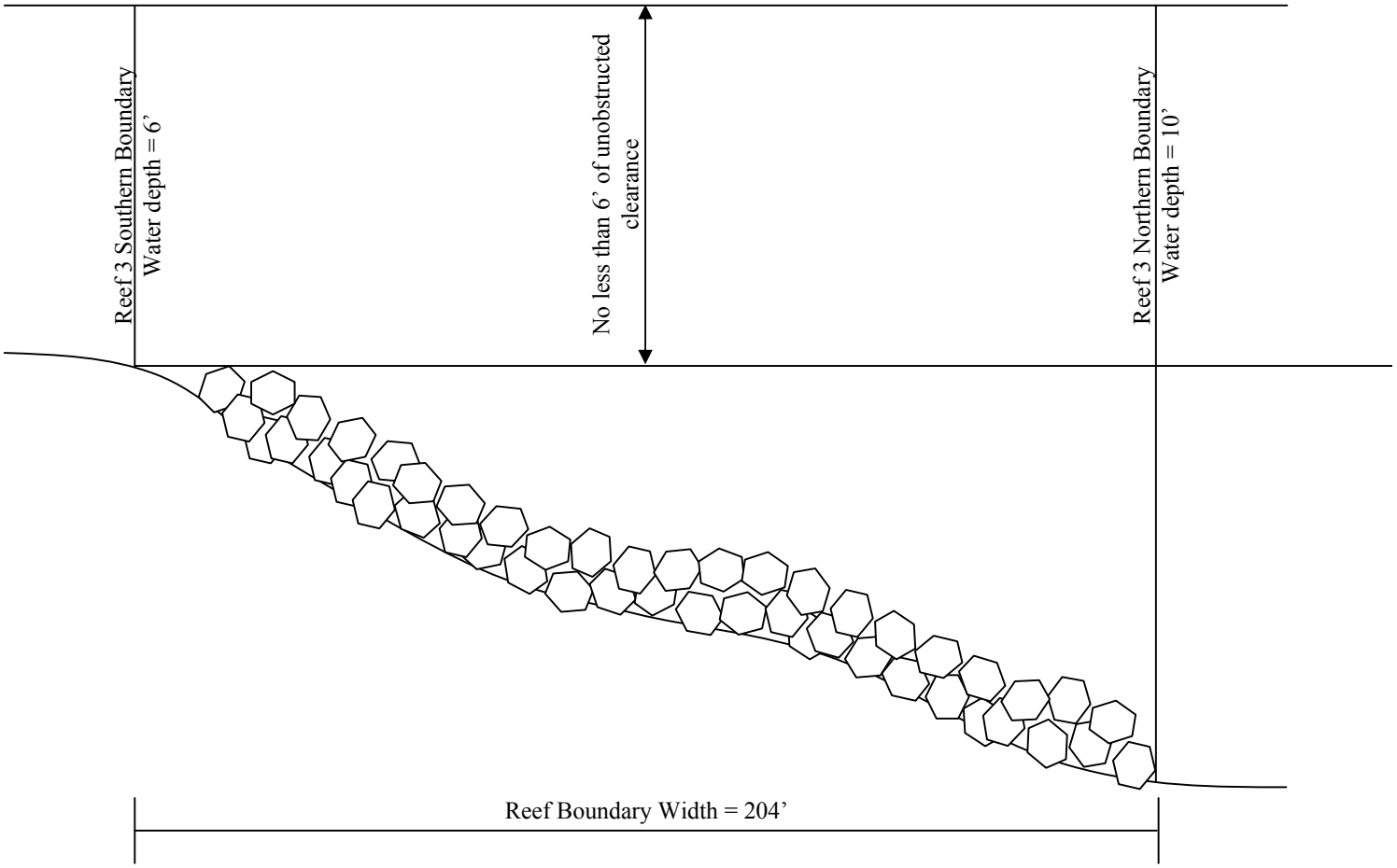
Steven O. Jenkins, Chief
Field Operations Division

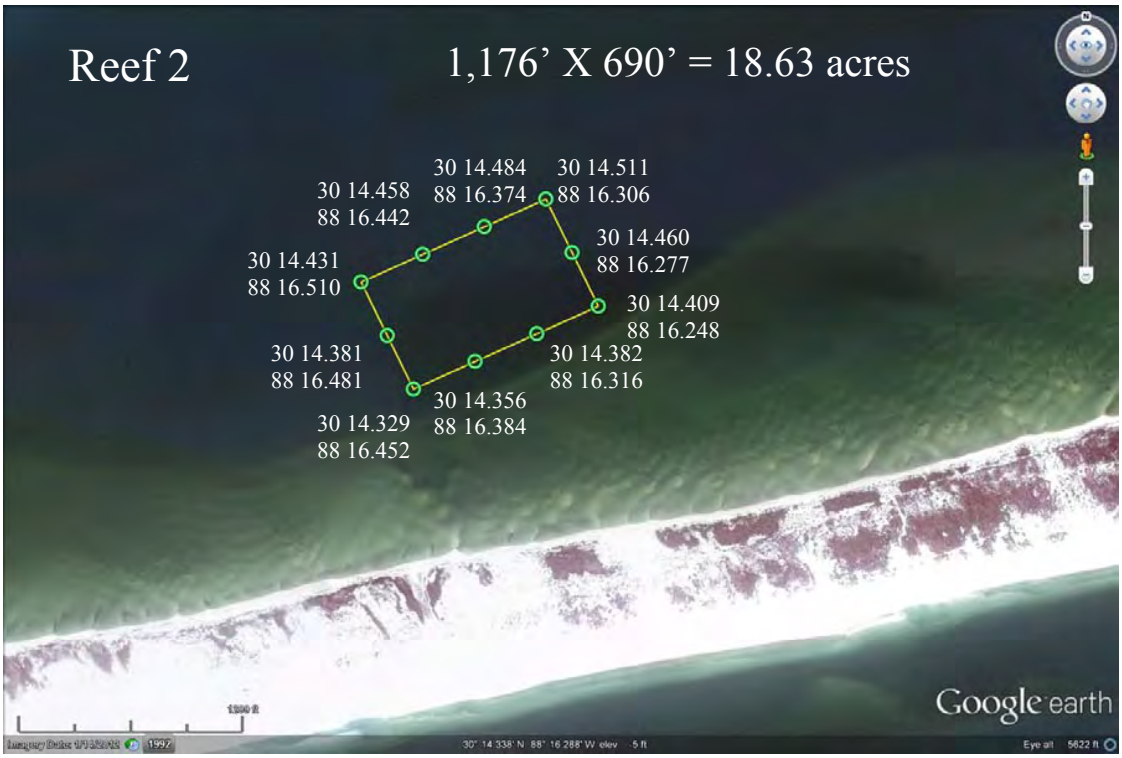
SOJ/jcr File: CZCERT/13943

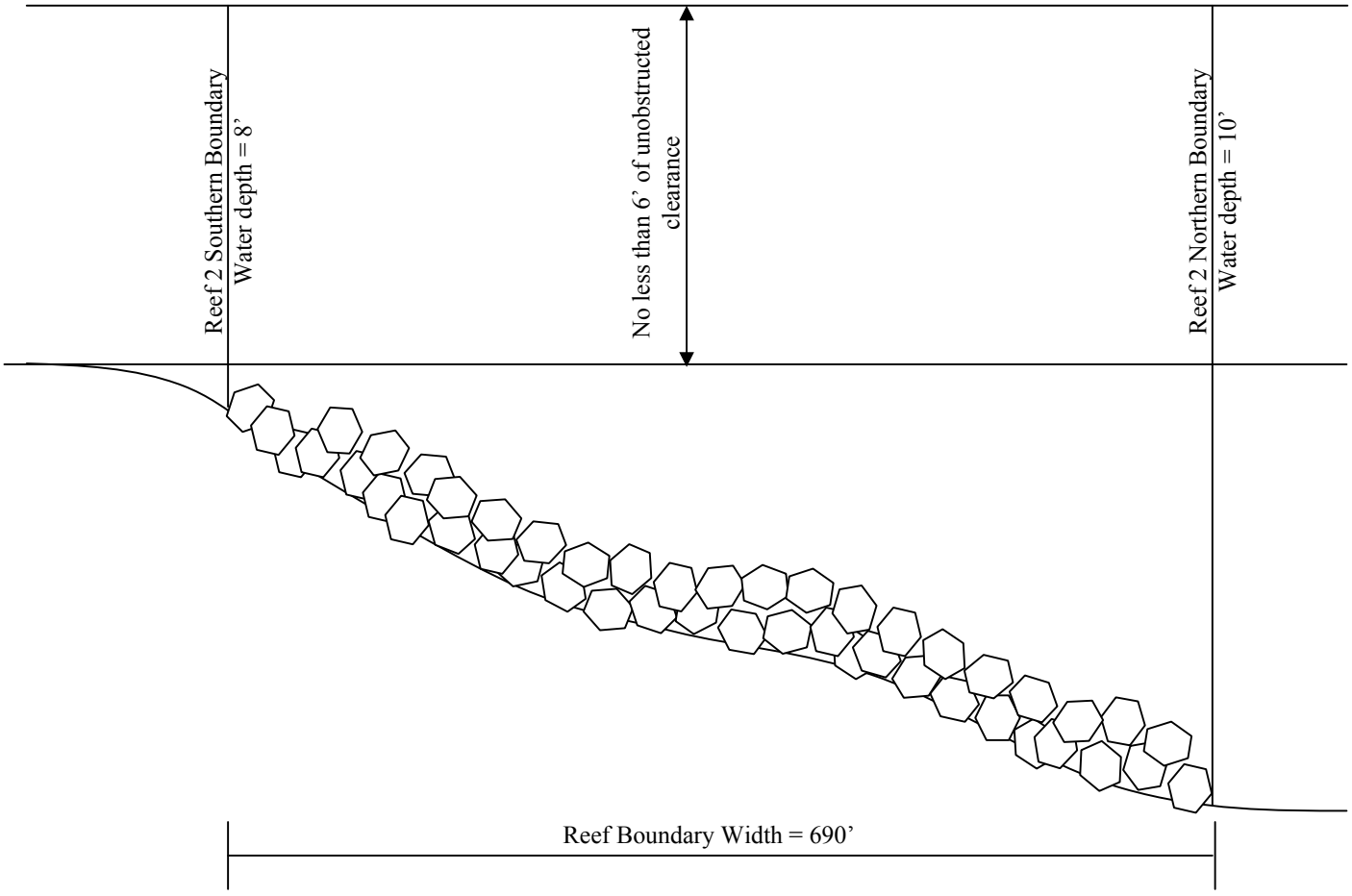
Enclosure (4 Pages)

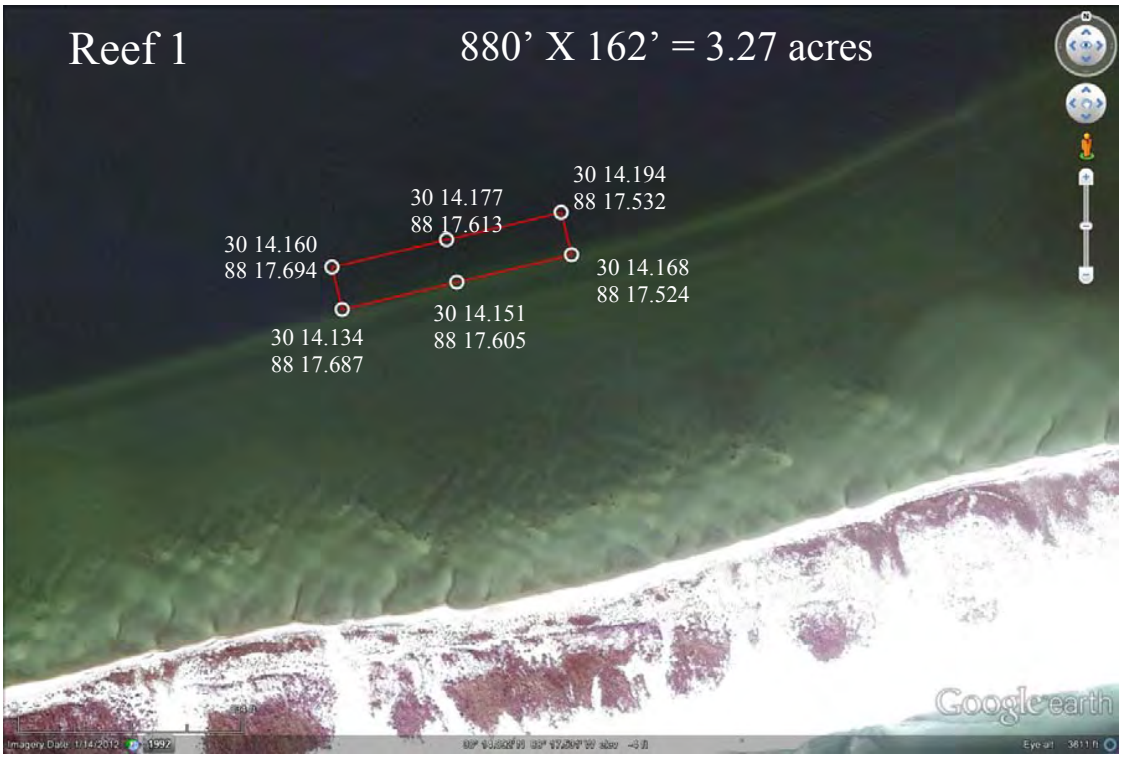
E-copy: Don Mroczko, U.S. Army Corps of Engineers
Rosemary Hall, USEPA Region IV, Atlanta
Patric Harper, USFWS, Moss Point
Mark Thompson, NMFS-HCD, St. Petersberg
Jeff Jordan, ADCNR-SLD, Spanish Fort

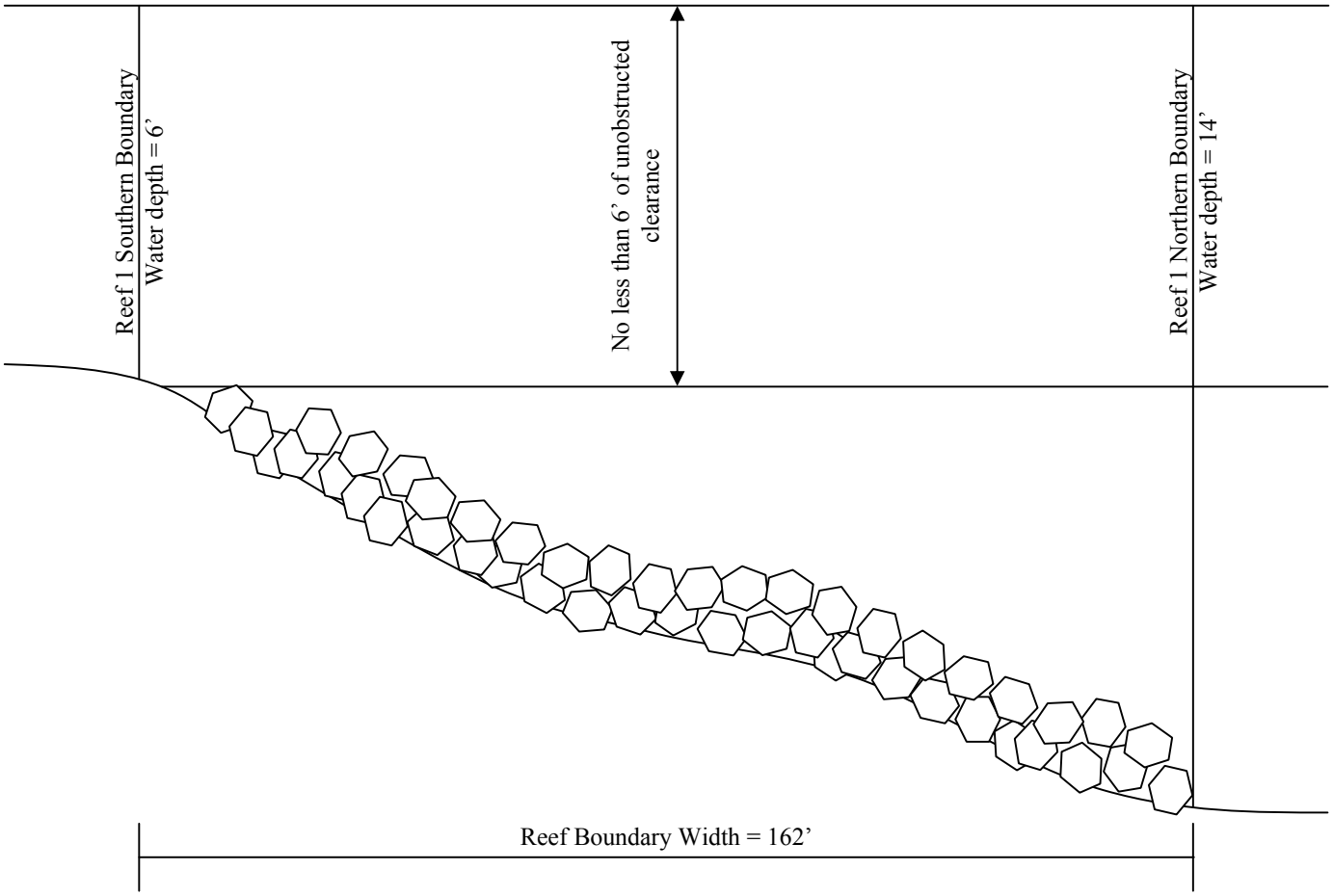

Reef 3
844’ X 204’ = 3.95 acres
30 14.747
88 14.438
30 14.731
88 14.516
30 14.715
88 14.594
30 14.716
88 14.423
30 14.700
88 14.501
30 14.684
88 14.579
Google earth


Reef 3 Southern Boundary
Water depth = 6’
No less than 6’ of unobstructed clearance
Reef 3 Northern Boundary
Water depth = 10’
Reef Boundary Width = 204’


Reef 2
1,176’ X 690’ = 18.63 acres
30 14.484
88 16.374
30 14.511
88 16.306
30 14.458
88 16.442
30 14.460
88 16.277
30 14.431
88 16.510
30 14.409
88 16.248
30 14.381
88 16.481
30 14.382
88 16.316
30 14.356
88 16.384
30 14.329
88 16.452
Google earth


Reef 2 Southern Boundary
Water depth = 8’
No less than 6’ of unobstructed clearance
Reef 2 Northern Boundary
Water depth = 10’
Reef Boundary Width = 690’


Reef 1
880’ X 162’ = 3.27 acres
30 14.194
88 17.532
30 14.177
88 17.613
30 14.160
88 17.694
30 14.168
88 17.524
30 14.151
88 17.605
30 14.134
88 17.687
Google earth


Reef 1 Southern Boundary
Water depth = 6’
No less than 6’ of unobstructed clearance
Reef 1 Northern Boundary
Water depth = 14’
Reef Boundary Width = 162’

Mississippi Sound
Gas Pipelines
Reef 3
Reef 2
Reef 1
Gulf of Mexico
6274 ft
Image © 2012 TerraMetrics
Google earth
1992
30° 14.444' N 88° 15.359' W elev -2 ft
Eye alt 27115 ft

## NOTICE OF COMMENCEMENT OF WORK AUTHORIZED BY PERMITS

DATE

WORK AUTHORIZED UNDER DEPARTMENT OF THE ARMY PERMIT SAM-2012-01395-DEM

DATED 3/18/2013

TO PERFORM WORK IN MISSISSIPPI SOUTH, NORTH OF DAUPHIN ISLAND, MOBILE COUNTY, ALABAMA

WAS COMMENCED ON _____

BY: _____

SIGNATURE

CESAM FORM 850
JUNE 87

**NOTICE OF COMPLETION OF WORK**
**AUTHORIZED BY PERMITS**

_____
DATE

WORK AUTHORIZED UNDER DEPARTMENT OF THE ARMY PERMIT SAM-2012-01395-DEM

DATED 3/18/2013

TO PERFORM WORK IN MISSISSIPPI SOUTH, NORTH OF DAUPHIN ISLAND, MOBILE COUNTY ALABAMA

WAS COMPLETED ON _____

BY: _____
SIGNATURE

CESAM FORM 851
JUN 87

**This notice of authorization must be conspicuously displayed at the site of work.**

United States Army Corps of Engineers

A permit to perform work authorized by statutes and regulations of the Department of the Army

**MISSISSIPPI SOUND NORTH OF DAUPHIN ISLAND, MOBILE COUNTY,**

at **ALABAMA**

has been issued to **ALABAMA DEPT OF CONSERVATION AND NATURAL RESOURCES MR. CHRIS BLANKENSHIP, DIR** on **MARCH 18, 2013**

Address of Permittee **POST OFFICE BOX 189, DAUPHIN ISLAND, ALABAMA 36528**

Permit Number

**SAM-2012-01395-DEM**

**FOR THE** *District Commander*
**Donald E. Mroczko**
**South Alabama Branch**
**Regulatory Division**

ENG FORM 4336, Jul 81 (33 CFR 320-330) EDITION OF JUL 70 MAY BE USED (Proponent: CECW-0)

Department of the Army

Mobile District, Corps of Engineers

Permit Number AL99-01112-U

Awarded to Alabama Marine Resources Division

June 21, 1999

DEPARTMENT OF THE ARMY
MOBILE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 2288
MOBILE, ALABAMA 36628-0001

REPLY TO
ATTENTION OF:

June 21, 1999

Regulatory Branch
Operations Division

SUBJECT: Department of the Army Final Permit Number AL99-01112-U, Alabama Department of Conservation and Natural Resources

Alabama Department of Conservation
and Natural Resources
Marine Resources Division
Attention: Mr. R. Vernon Minton
Post Office Box 189
Dauphin Island, Alabama 36528

Dear Mr. Minton:

**PLEASE READ THIS LETTER CAREFULLY AND COMPLY WITH ITS PROVISIONS**

There is enclosed a Department of the Army permit authorizing you to perform the work specified therein in accordance with the plans shown on the drawings attached thereto. This permit is issued under provision of the Federal laws for the protection and preservation of the navigable waters of the United States. These laws provide that after the proposed work has been approved by issuance of a Department of the Army permit,

**IT SHALL NOT BE LAWFUL TO DEVIATE FROM SUCH PLANS EITHER BEFORE OR AFTER COMPLETION OF THE WORK,**

unless modification of said plans has previously been submitted to and received the approval of the Department of the Army.

You should study and carefully adhere to all the terms and conditions of the permit. The District must be notified of the commencement and completion of the permitted work. The enclosed cards may be used for that purpose. Also enclosed is a "NOTICE OF AUTHORIZATION" which must be conspicuously displayed at the site during construction of the permitted work. Any telephone inquiries relating to this permit should be directed to the Regulatory Branch, telephone number (334) 694-3788.

If for any reason it becomes necessary to make a material change in location or plans for this work, revised plans should be submitted promptly to the District Engineer in

order that the revised plans may receive the approval required by law before work is begun.

Compliance with this and other conditions of the permit is essential. Failure to submit the notices requested may result in its revocation.

Sincerely,

Ronald A. Krizman
Chief, Regulatory Branch
Operations Division

Enclosures

DEPARTMENT OF THE ARMY PERMIT

Permittee: Alabama Department of Conservation and Natural Resources

Permit No.: AL99-01112-U

Issuing Office: Mobile District

NOTE: The term "you" and its derivatives, as used in this permit, means the permittee or any future transferee. The term "this office" refers to the appropriate district or division office of the Corps of Engineers having jurisdiction over the permitted activity or the appropriate official of that office acting under the authority of the commanding officer.

You are authorized to perform work in accordance with the terms and conditions specified below.

Project Description: Construct nine artificial fishing reef/oyster reef enhancement structures within Mobile Bay and one structure in Mississippi Sound. Five hundred cubic yards of concrete storm water drainage pipe (12-inch to 96-inch diameter) with associated concrete junction boxes and blemished concrete blocks will be used. Only blemished concrete blocks will be used at the Arlington and Battles Wharf sites. All large diameter pipe will be used at the Brookley Hole site (water depth +or- 32 feet). All sites will be marked with pilings and radar reflective signage which will be perpetually maintained by the Marine Resources Division. Oyster cultch material (archeological coral, crushed limestone, and/or oyster shell) will be placed within the periphery of the concrete pipe material on the dual purpose sites.

The purposes of the project is to provide fish habitat (structural relief) and eliminate illegal shrimping activities (in the case of dural purpose sites) which have been occurring for several decades.

Project Location: Mobile Bay, and Mississippi Sound, Mobile and Baldwin Counties, Alabama.

Drawings Attached: 1. Plans 2. Profiles 3. ADEM Certification

Permit Conditions:

General Conditions:

1. The time limit for completing the work authorized ends on **21 June 2002**. If you find that you need more time to complete the authorized activity, submit your request for a time extension to this office for consideration at least 1 month before the above date is reached.

2. You must maintain the activity authorized by this permit in good condition and in conformance with the terms and conditions of this permit. You are not relieved of this requirement if you abandon the permitted activity, although you may make a good faith transfer to a third party in compliance with General Condition 4 below. Should you wish to cease to maintain the authorized activity or should you desire to abandon it without a good faith transfer, you must obtain a modification of this permit from this office, which may require restoration of the area.

3. If you discover any previously unknown historic or archeological remains while accomplishing the activity authorized by this permit, you must immediately notify this office of what you have found. We will initiate the Federal and State coordination required to determine if the remains warrant a recovery effort or if the site is eligible for listing in the National Register of Historic Places.

4. If you sell the property associated with this permit, you must obtain the signature of the new owner in the space provided and forward a copy of the permit to this office to validate the transfer of this authorization.

5. If a conditioned water quality certification has been issued for your project, you must comply with the conditions specified in the certification as special conditions to this permit. For your convenience, a copy of the certification is attached if it contains such conditions.

6. You must allow representatives from this office to inspect the authorized activity at any time deemed necessary to ensure that it is being or has been accomplished in accordance with the terms and conditions of your permit.

Special Conditions:

a. The reef sites shall be marked with private aids to navigation. The aids shall be constructed and maintained in accordance with U.S. Coast Guard regulations. Permits for the private aids shall be obtained from the Eighth Coast Guard District, Private Aids to Navigation Section, phone number (504) 589-6236.

b. The Confederate Obstructions (submerged pilings) shall not be damage by construction of the Choctaw Pass Reef.

c. Construction of the sunken shrimp boat reef off the Isle aux Herbes shall be coordinated with the U.S. Coast Guard Aids to Navigation Team-Mobile, (334) 690-2244 to avoid conflicts with the maintenance of the Coast Guard aid to navigation marking the wreck.

d. The water depths shown on the drawings are the minimum depths measured from the top of the reef material to the water surface at mean lower low water.

e. An employee of the Alabama Department of Conservation or a duly authorized representative shall be present during reef construction to insure the material is placed at the locations authorized and accordance with the terms of this permit.

Further Information:

1. Congressional Authorities: You have been authorized to undertake the activity described above pursuant to Section 10 of the Rivers and Harbors Act of 1899 (33 U.S.C. 403) and Section 404 of the Clean Water Act (33 U.S.C. 1344).

2. Limits of this authorization.

a. This permit does not obviate the need to obtain other Federal, State, or local authorizations required by law.

b. This permit does not grant any property rights or exclusive privileges.

c. This permit does not authorize any injury to the property or rights of others.

d. This permit does not authorize interference with any existing or proposed Federal project.

3. Limits of Federal Liability. In issuing this permit, the Federal Government does not assume any liability for the following:

a. Damages to the permitted project or uses thereof as a result of other permitted or unpermitted activities or from natural causes.

b. Damages to the permitted project or uses thereof as a result of current or future activities undertaken by or on behalf of the United States in the public interest.

c. Damages to persons, property, or to other permitted or unpermitted activities or structures caused by the activity authorized by this permit.

d. Design or construction deficiencies associated with the permitted work.

e. Damage claims associated with any future modification, suspension, or revocation of this permit.

4. Reliance on Applicant's Data: The determination of this office that issuance of this permit is not contrary to the public interest was made in reliance on the information you provided.

5. Reevaluation of Permit Decision. This office may reevaluate its decision on this permit at any time the circumstances warrant. Circumstances that could require a reevaluation include, but are not limited to, the following:

a. You fail to comply with the terms and conditions of this permit.

b. The information provided by you in support of your permit application proves to have been false, incomplete, or inaccurate (See 4 above).

c. Significant new information surfaces which this office did not consider in reaching the original public interest decision.

Such a reevaluation may result in a determination that it is appropriate to use the suspension, modification, and revocation procedures contained in 33 CFR 325.7 or enforcement procedures such as those contained in 33 CFR 326.4 and 326.5. The referenced enforcement procedures provide for the issuance of an administrative order requiring you to comply with the terms and conditions of your permit and for the initiation of legal action where appropriate. You will be required to pay for any corrective measures ordered by this office, and if you fail to comply with such directive, this office may in certain situations (such as those specified in 33 CFR 209.170) accomplish the corrective measures by contract or otherwise and bill you for the cost.

6. Extensions. General condition 1 establishes a time limit for the completion of the activity authorized by this permit. Unless there are circumstances requiring either a prompt completion of the authorized activity or a reevaluation of the public interest decision, the Corps will normally give favorable consideration to a request for an extension of this time limit.

Your signature below, as permittee, indicates that you accept and agree to comply with the terms and conditions of this permit.

R. Vernon Minton 6-16-99

(PERMITTEE) (DATE)

ALABAMA DEPARTMENT OF CONSERVATION
AND NATURAL RESOURCES
MARINE RESOURCES DIVISION
POST OFFICE BOX 189
DAUPHIN ISLAND, ALABAMA 36528

This permit becomes effective when the Federal official, designated to act for the Secretary of the Army, has signed below.

J. DAVID NORWOOD
COLONEL, CORPS OF ENGINEERS
(DISTRICT ENGINEER)

BY: Ronald A. Krizman 23 Jun 99

RONALD A. KRIZMAN (DATE)
CHIEF, REGULATORY BRANCH
OPERATIONS DIVISION

When the structures or work authorized by this permit are still in existence at the time the property is transferred, the terms and conditions of this permit will continue to be binding on the new owner(s) of the property. To validate the transfer of this permit and the associated liabilities associated with compliance with its terms and conditions, have the transferee sign and date below.

_____ _____

(TRANSFEREE) (DATE)

**This notice of authorization must be conspicuously displayed at the site of work.**

United States Army Corps of Engineers

June 21 19 99

A permit to perform work authorized by statutes and regulations of the Department of the Army

(COSNTRUCT 9 ARTIFICIAL FISHING REEF/OYSTER REER STRUCTURES)

at Mobile Bay and Mississippi Sound, Mobile & Baldwin Counties, AL

has been issued to ADCNR on Jun 21 19 99

Address of Permittee PO Box 189, Dauphin Island, AL 36528

Permit Number

AL99-01112-U

For the *District Commander*
RONALD A. KRIZMAN, Chief, OP-S
Operations Division

ENG FORM 4336, Jul 81 (33 CFR 320-330) EDITION OF JUL 70 MAY BE USED (Proponent: CECW-0)

**NOTICE OF COMMENCEMENT OF WORK AUTHORIZED BY PERMITS**

DATE

WORK AUTHORIZED UNDER DEPARTMENT OF THE ARMY PERMIT AL99-01112-U

DATED June 21, 1999

TO PERFORM WORK IN Mobile Bay and Mississippi Sound, Mobile and Baldwin Counties, AL

WAS COMMENCED ON

BY:

SIGNATURE

ADCNR

CESAM FORM 850
JUN 87

**NOTICE OF COMPLETION OF WORK AUTHORIZED BY PERMITS**

DATE

WORK AUTHORIZED UNDER DEPARTMENT OF THE ARMY PERMIT AL99-01112-U

DATED June 21, 1999

TO PERFORM WORK IN Mobile Bay and Mississippi Sound, Mobile and Baldwin Counties, AL

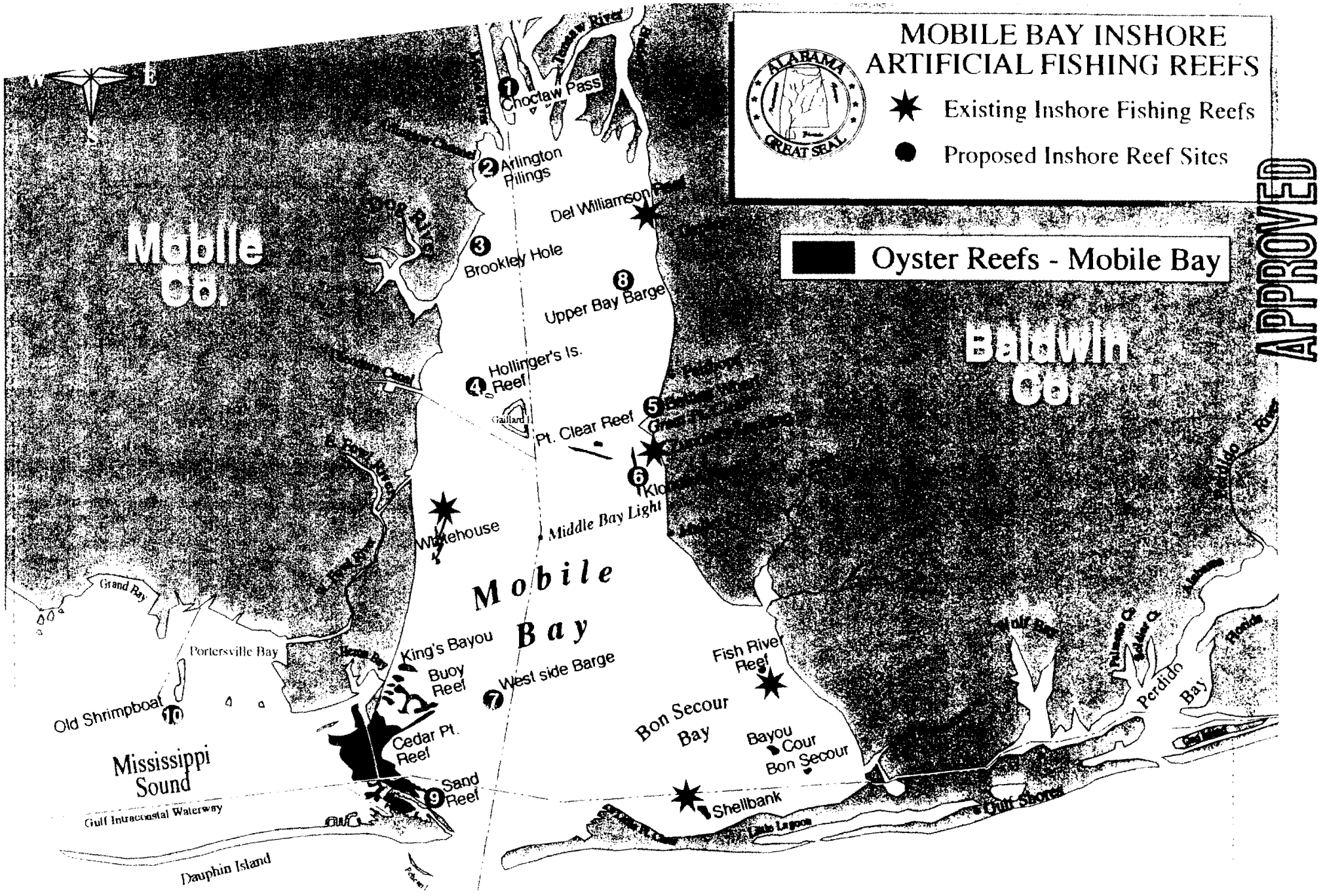
WAS COMPLETED ON

BY:

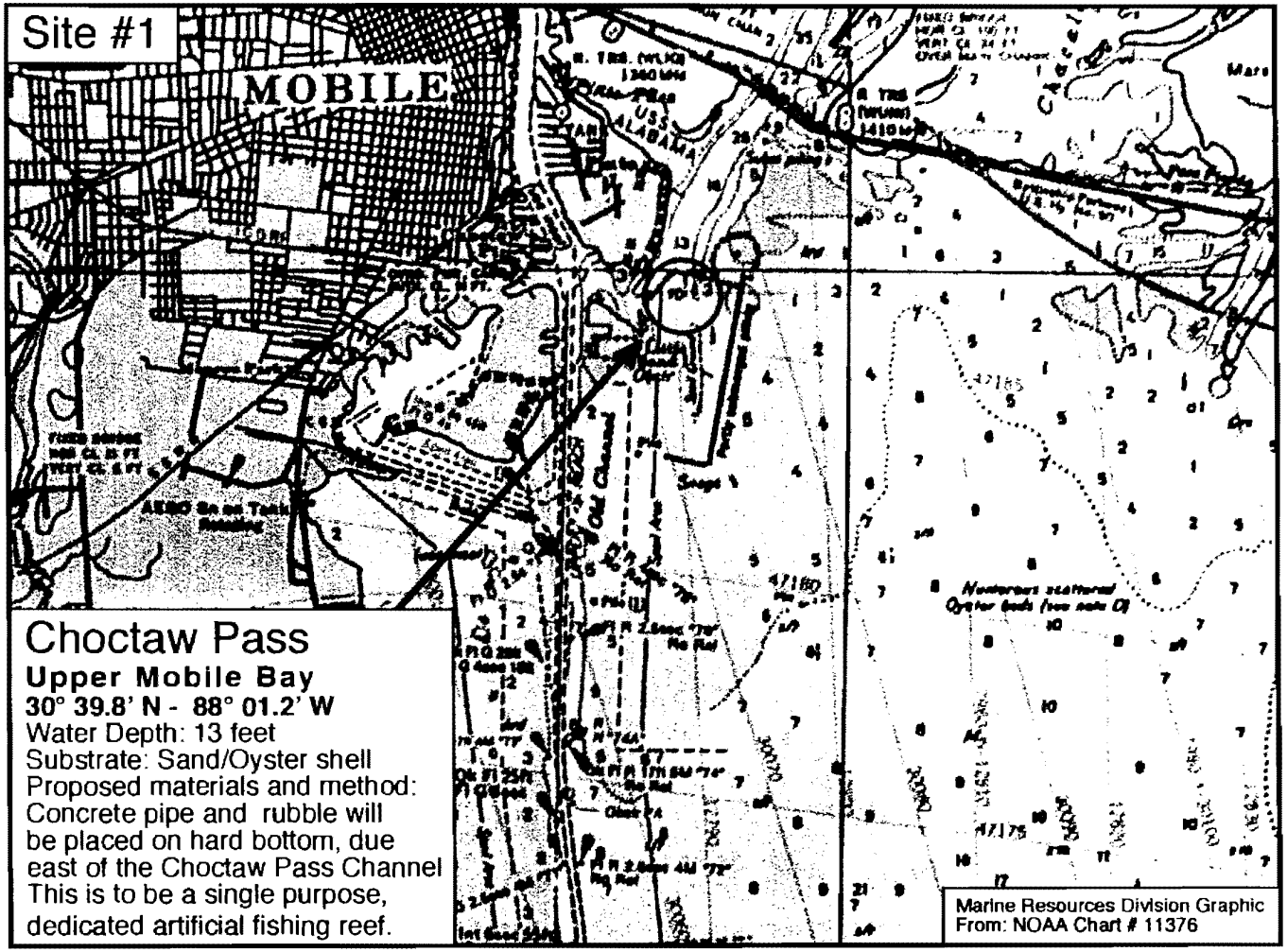
SIGNATURE

ADCNR

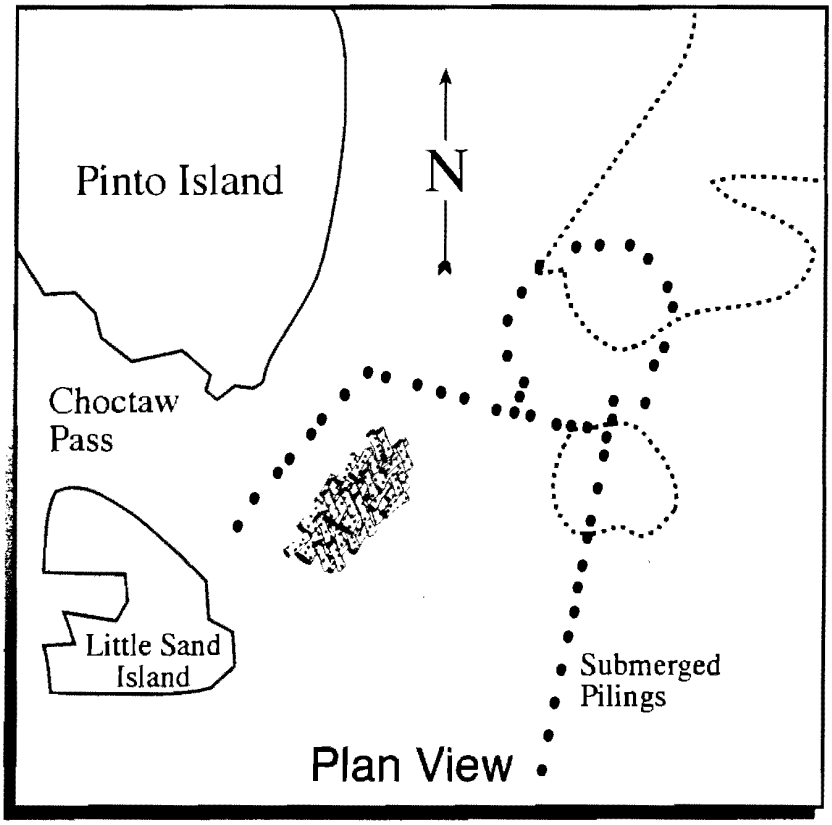
CESAM FORM 851
JUN 87

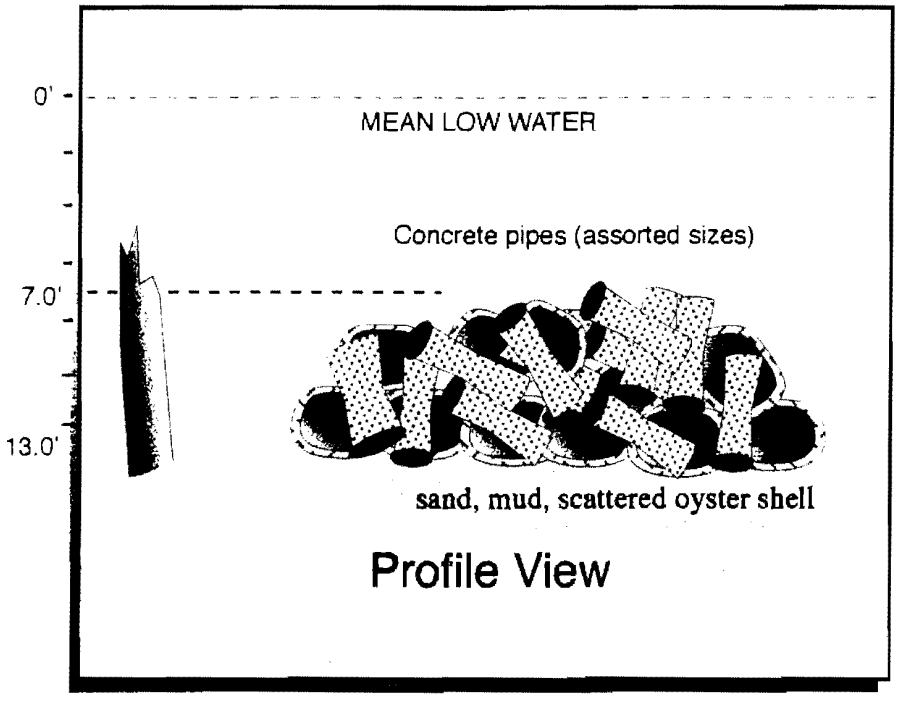

MOBILE BAY INSHORE
ARTIFICIAL FISHING REEFS
ALABAMA
GREAT SEAL
Existing Inshore Fishing Reefs
Proposed Inshore Reef Sites
Oyster Reefs - Mobile Bay
APPROVED
Mobile Co.
Baldwin Co.
1 Choctaw Pass
2 Arlington Pilings
3 Brookley Hole
4 Hollinger's Is. Reef
5 Pt. Clear Reef
6
7 West side Barge
8 Upper Bay Barge
9 Sand Reef
10 Old Shrimpboat
Del Williamson
Middle Bay Light
Wilkehouse
Mobile Bay
Grand Bay
Portersville Bay
King's Bayou
Buoy Reef
Cedar Pt. Reef
Fish River Reef
Bon Secour Bay
Bayou Cour Bon Secour
Shellbank
Perdido Bay
Florida
Mississippi Sound
Gulf Intracoastal Waterway
Dauphin Island
Gulf Shores

APPROVED


Site #1
MOBILE
Choctaw Pass
Upper Mobile Bay
30° 39.8' N - 88° 01.2' W
Water Depth: 13 feet
Substrate: Sand/Oyster shell
Proposed materials and method:
Concrete pipe and rubble will
be placed on hard bottom, due
east of the Choctaw Pass Channel
This is to be a single purpose,
dedicated artificial fishing reef.
Marine Resources Division Graphic
From: NOAA Chart # 11376

# Site #1
# Choctaw Pass

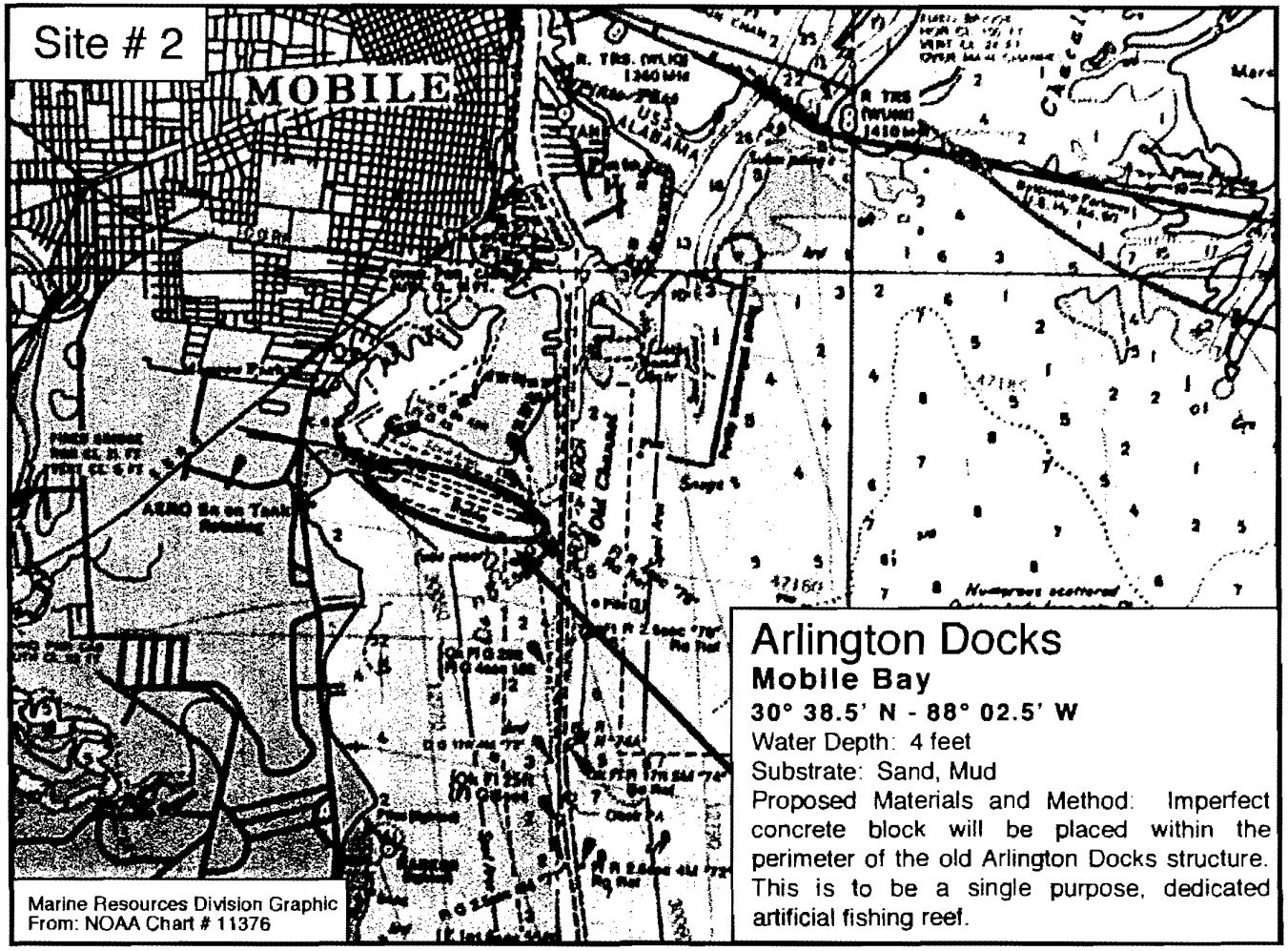



APPROVED

Alabama Marine Resources Division Graphic 2-99

APPROVED




## Arlington Docks

**Mobile Bay**

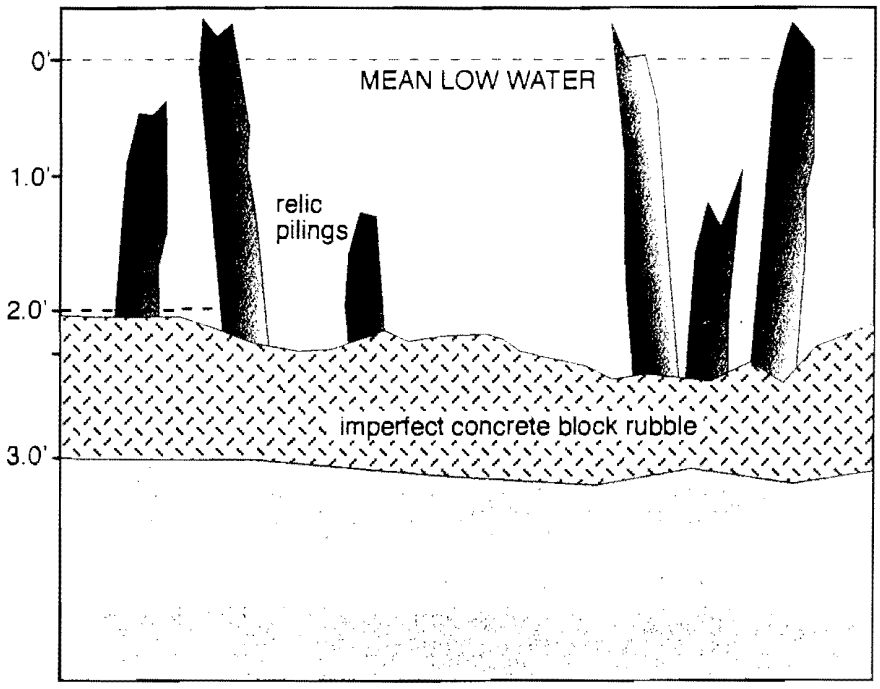
**30° 38.5' N - 88° 02.5' W**

Water Depth: 4 feet

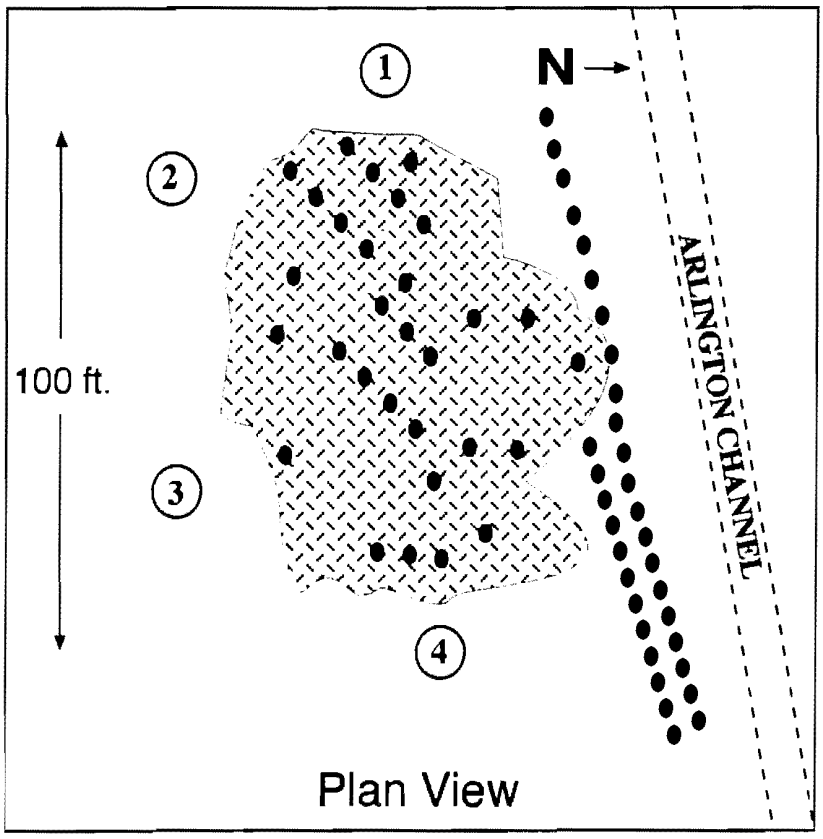
Substrate: Sand, Mud

Proposed Materials and Method: Imperfect concrete block will be placed within the perimeter of the old Arlington Docks structure. This is to be a single purpose, dedicated artificial fishing reef.

# Site #2
# Arlington Docks



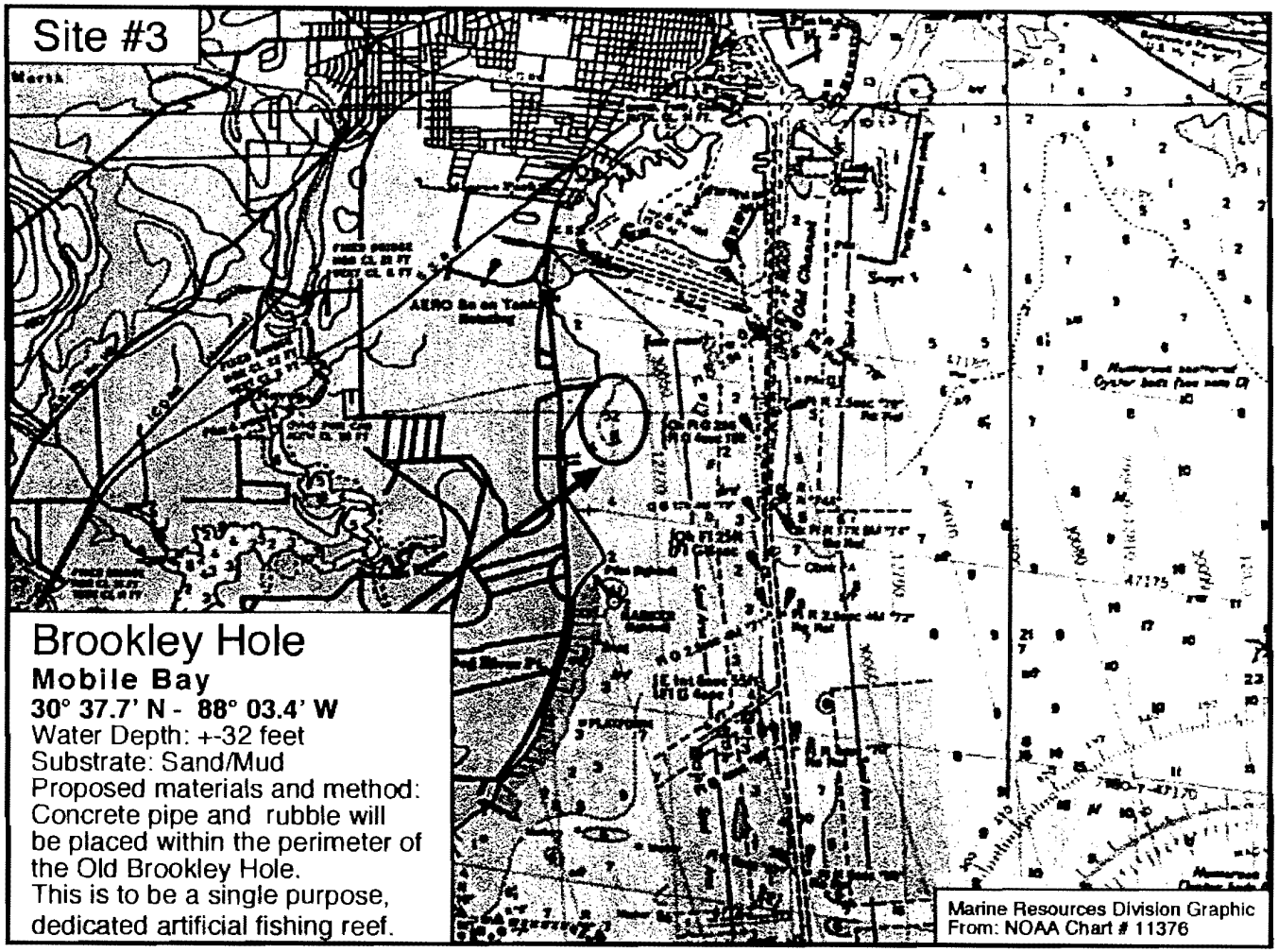

Profile View



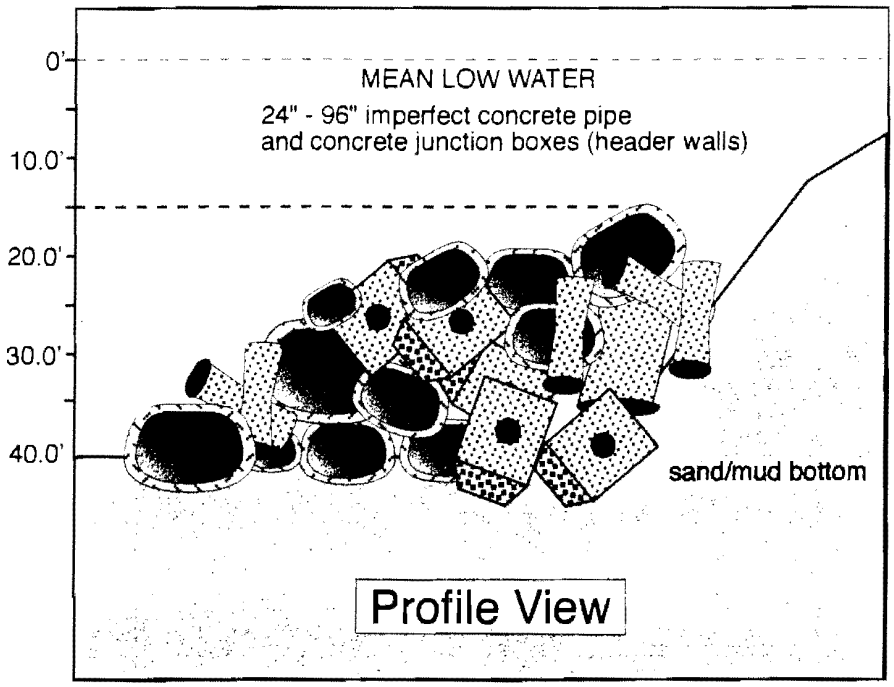

Plan View

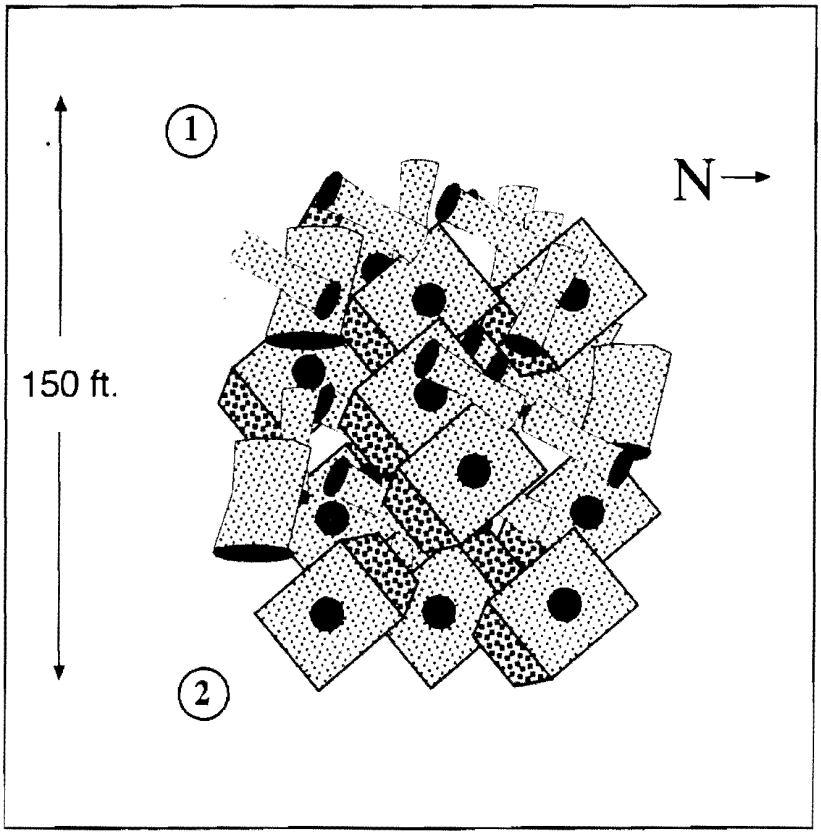
APPROVED

APPROVED


Site #3
Brookley Hole
Mobile Bay
30° 37.7' N - 88° 03.4' W
Water Depth: +-32 feet
Substrate: Sand/Mud
Proposed materials and method:
Concrete pipe and rubble will be placed within the perimeter of the Old Brookley Hole.
This is to be a single purpose, dedicated artificial fishing reef.
Marine Resources Division Graphic
From: NOAA Chart # 11376

# Site #3
# Brookley Hole

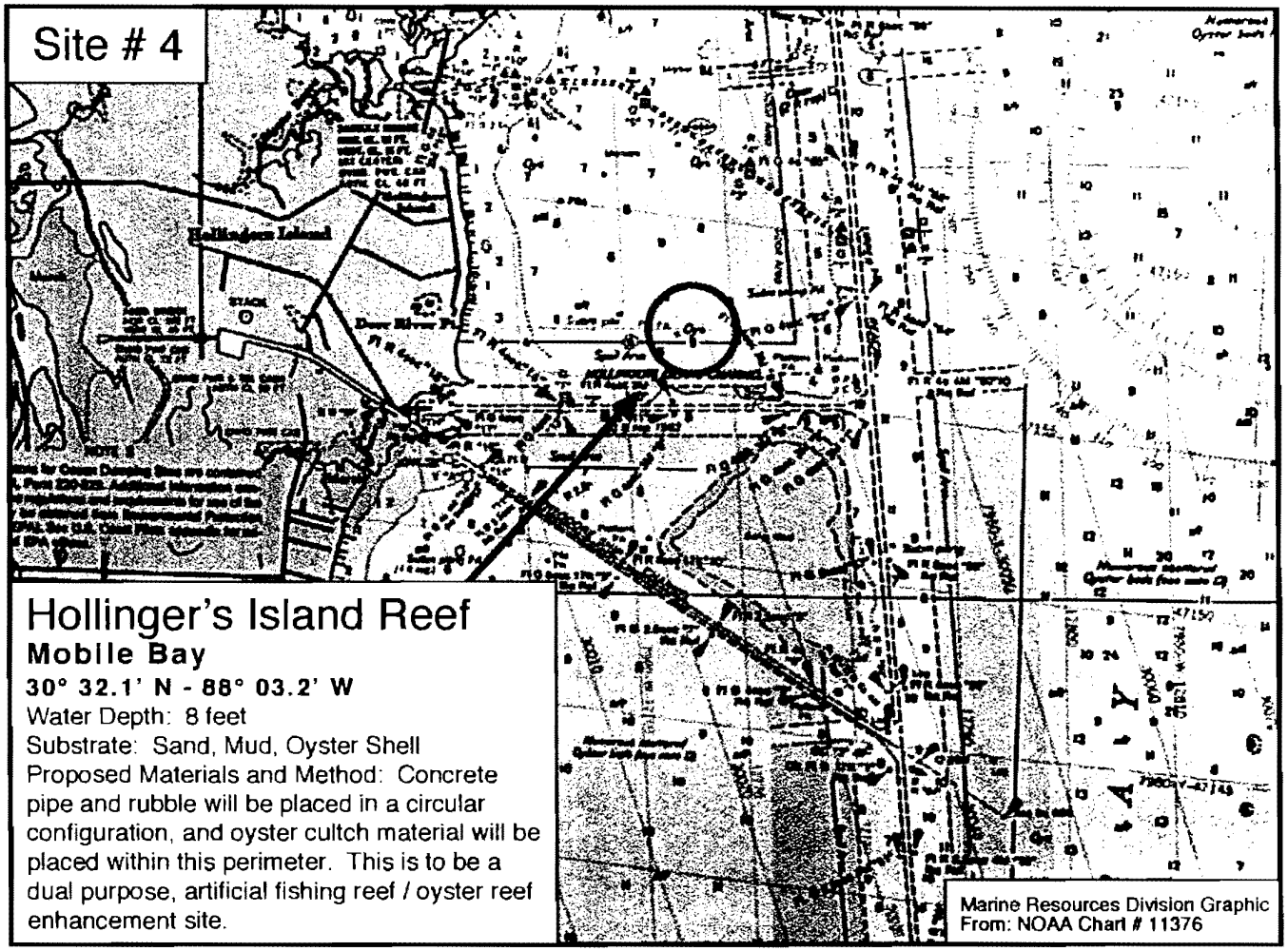


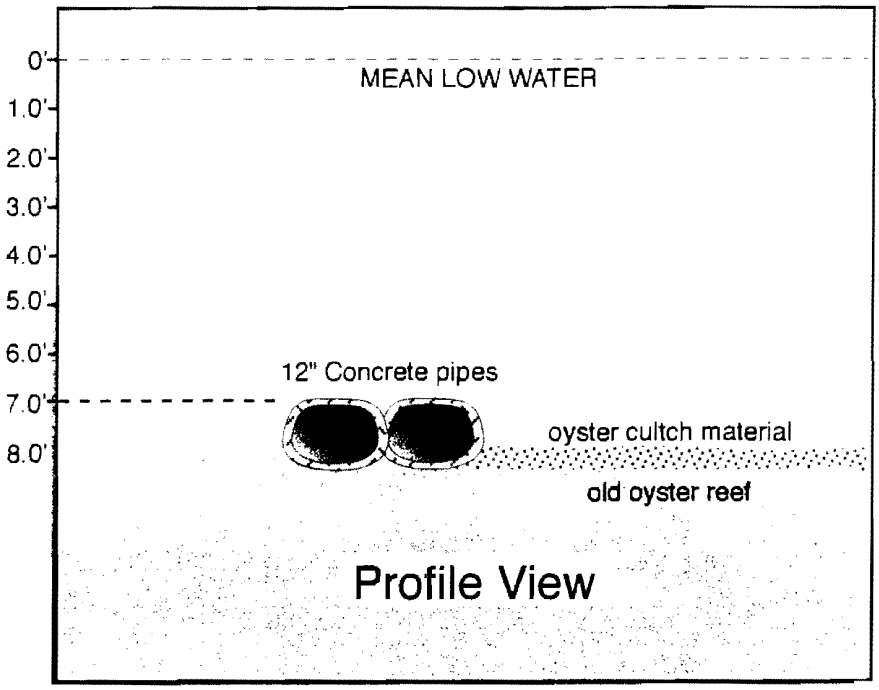

Plan View

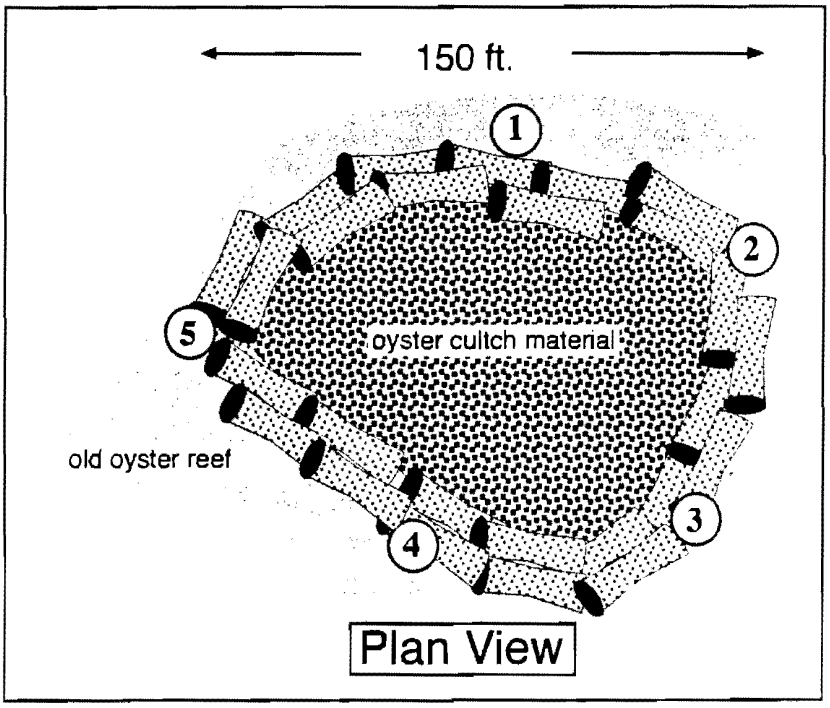
APPROVED

APPROVED


Site # 4
Hollinger's Island Reef
Mobile Bay
30° 32.1' N - 88° 03.2' W
Water Depth: 8 feet
Substrate: Sand, Mud, Oyster Shell
Proposed Materials and Method: Concrete pipe and rubble will be placed in a circular configuration, and oyster cultch material will be placed within this perimeter. This is to be a dual purpose, artificial fishing reef / oyster reef enhancement site.
Marine Resources Division Graphic
From: NOAA Chart # 11376

# Site #4
# Hollinger's Island Reef




APPROVED

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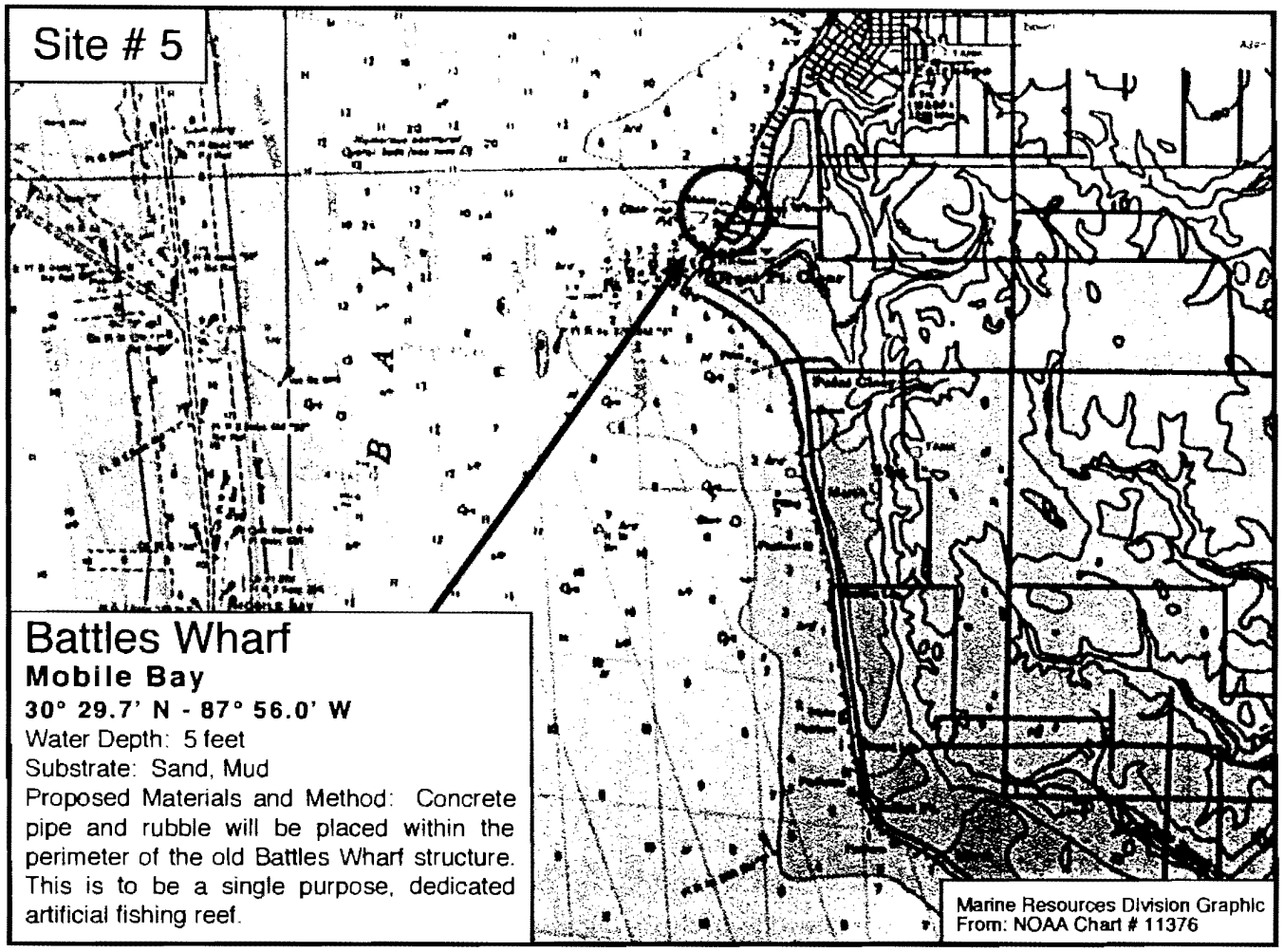
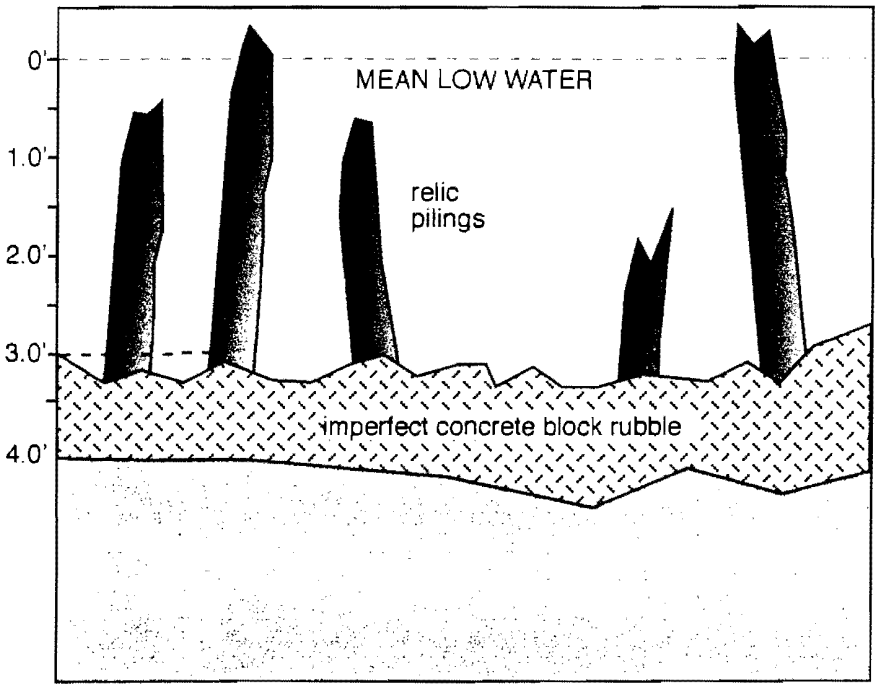
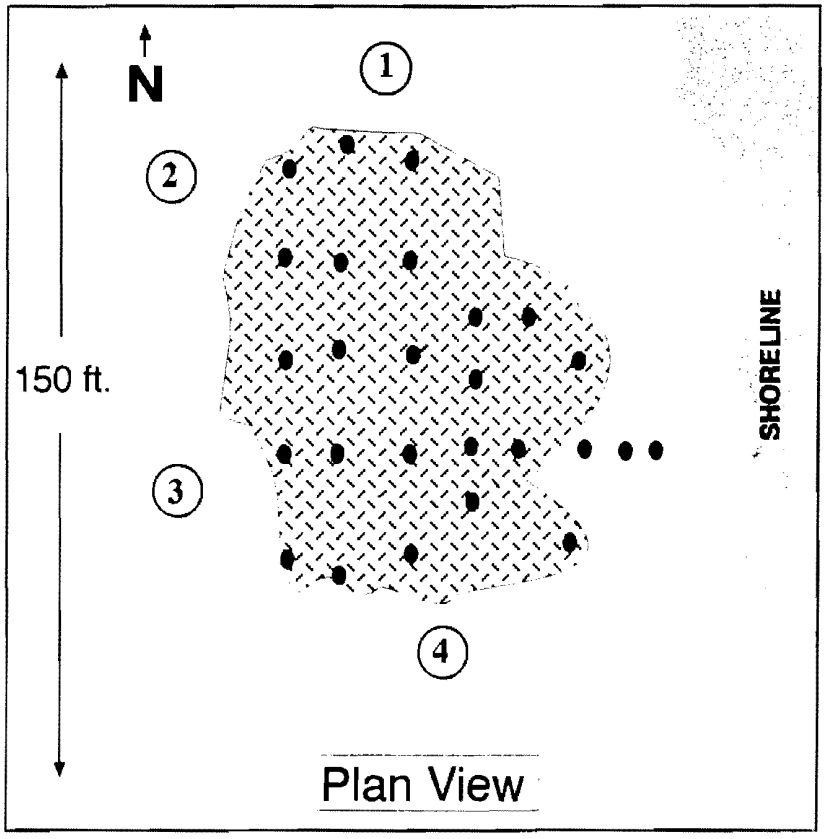

Site # 5
B A Y
Battles Wharf
Mobile Bay
30° 29.7' N - 87° 56.0' W
Water Depth: 5 feet
Substrate: Sand, Mud
Proposed Materials and Method: Concrete pipe and rubble will be placed within the perimeter of the old Battles Wharf structure. This is to be a single purpose, dedicated artificial fishing reef.
Marine Resources Division Graphic
From: NOAA Chart # 11376

# Site #5
# Battles Wharf



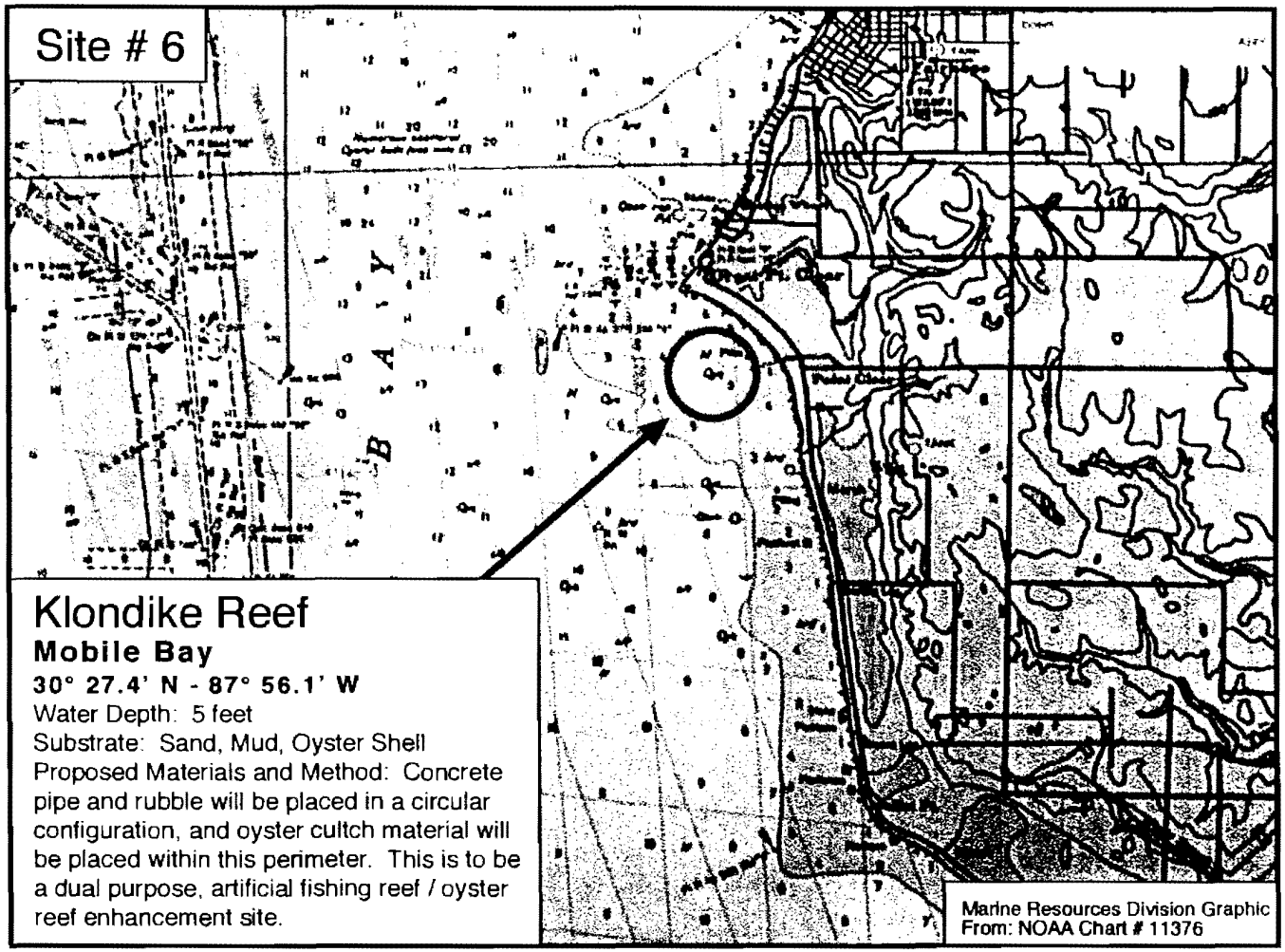

Profile View



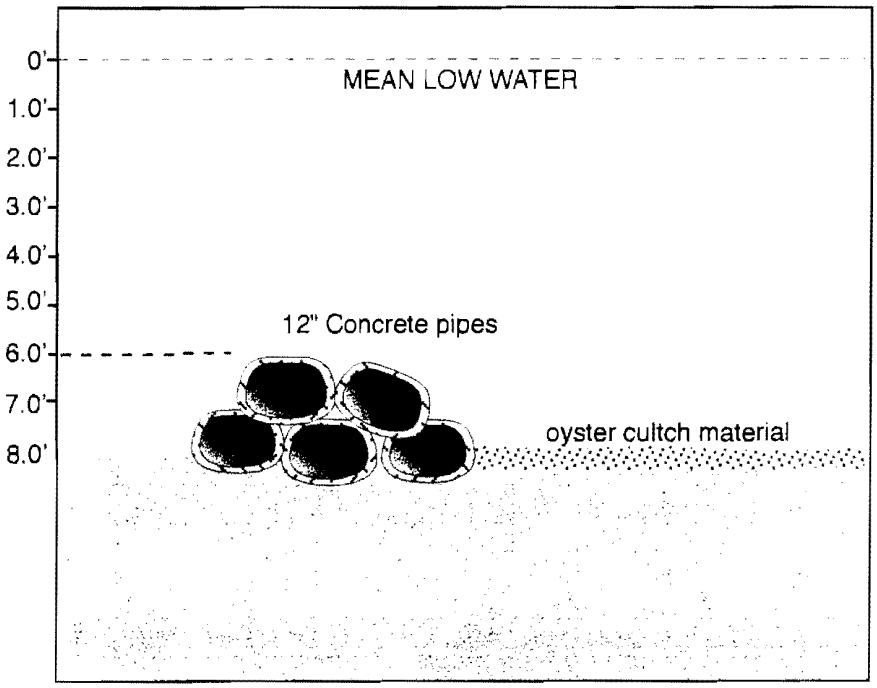

Plan View

APPROVED

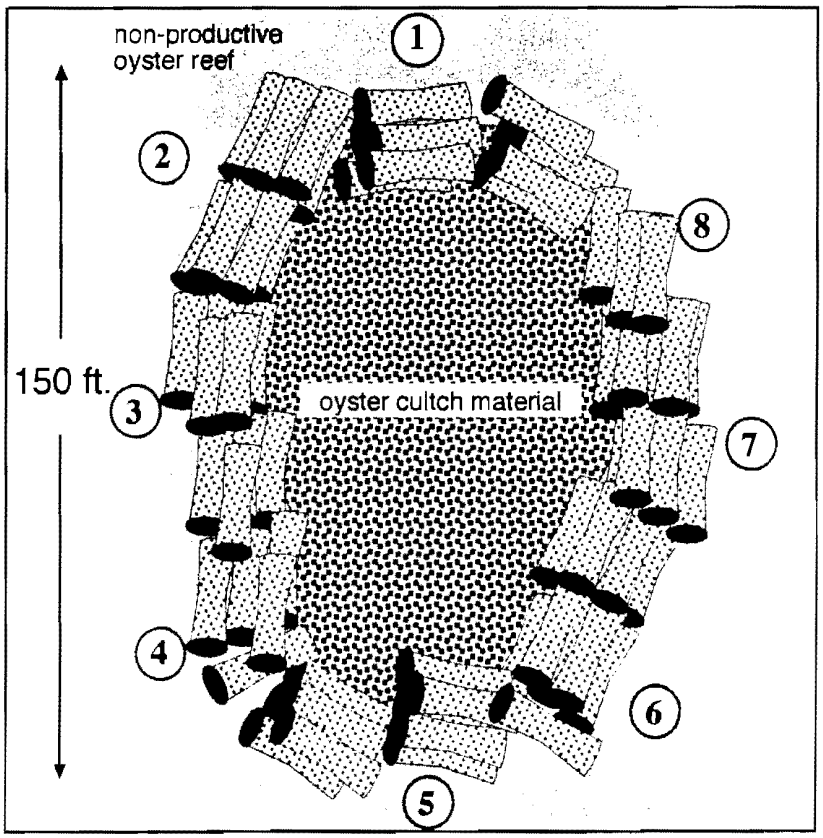
APPROVED


Site # 6
B A Y
Klondike Reef
Mobile Bay
30° 27.4' N - 87° 56.1' W
Water Depth: 5 feet
Substrate: Sand, Mud, Oyster Shell
Proposed Materials and Method: Concrete pipe and rubble will be placed in a circular configuration, and oyster cultch material will be placed within this perimeter. This is to be a dual purpose, artificial fishing reef / oyster reef enhancement site.
Marine Resources Division Graphic
From: NOAA Chart # 11376

# Site #6
# Klondike Reef




Profile View




Plan View

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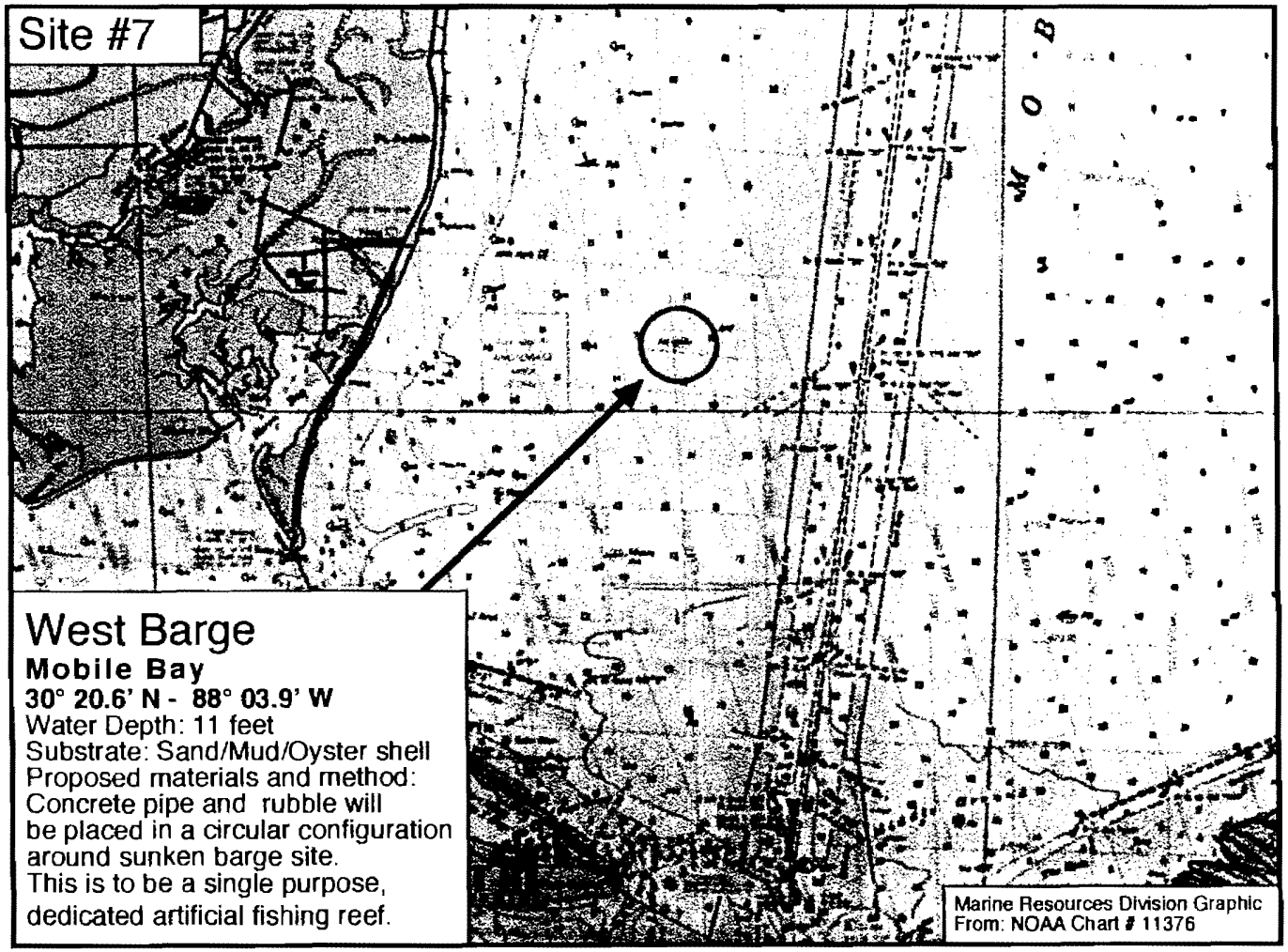
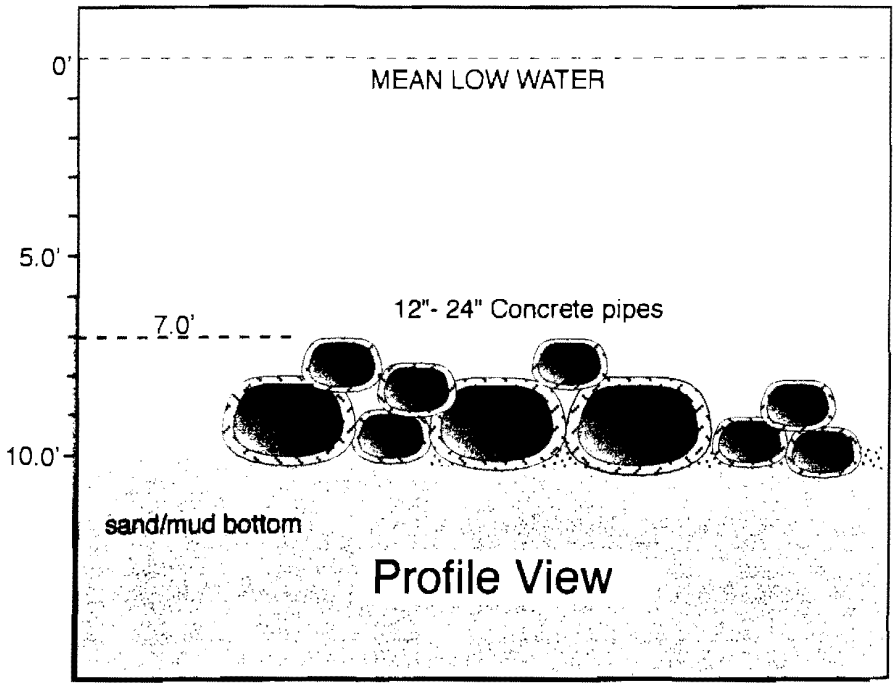
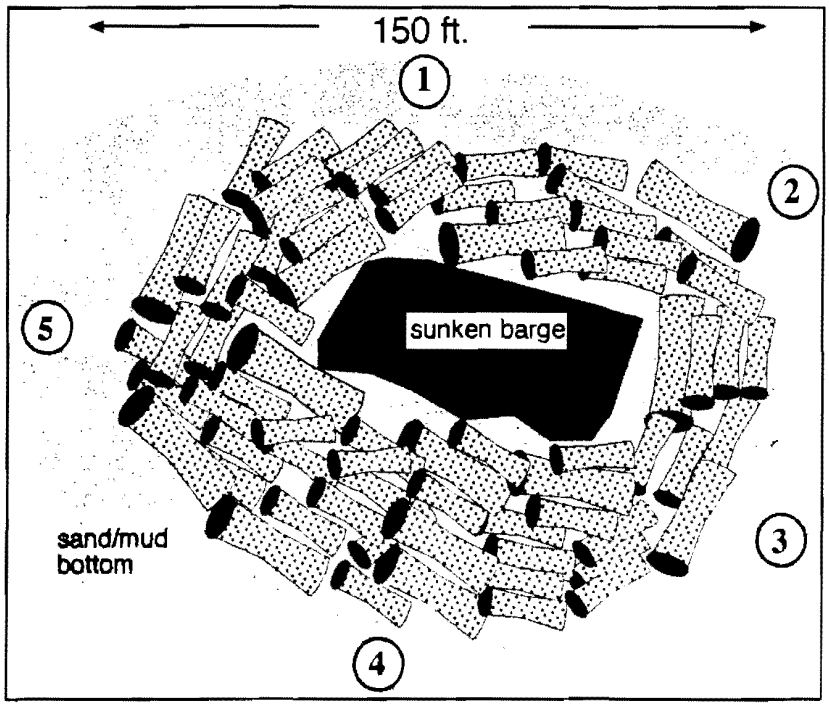

Site #7
M O B
West Barge
Mobile Bay
30° 20.6' N - 88° 03.9' W
Water Depth: 11 feet
Substrate: Sand/Mud/Oyster shell
Proposed materials and method:
Concrete pipe and rubble will
be placed in a circular configuration
around sunken barge site.
This is to be a single purpose,
dedicated artificial fishing reef.
Marine Resources Division Graphic
From: NOAA Chart # 11376

# Site #7
# West Side Barge




Plan View

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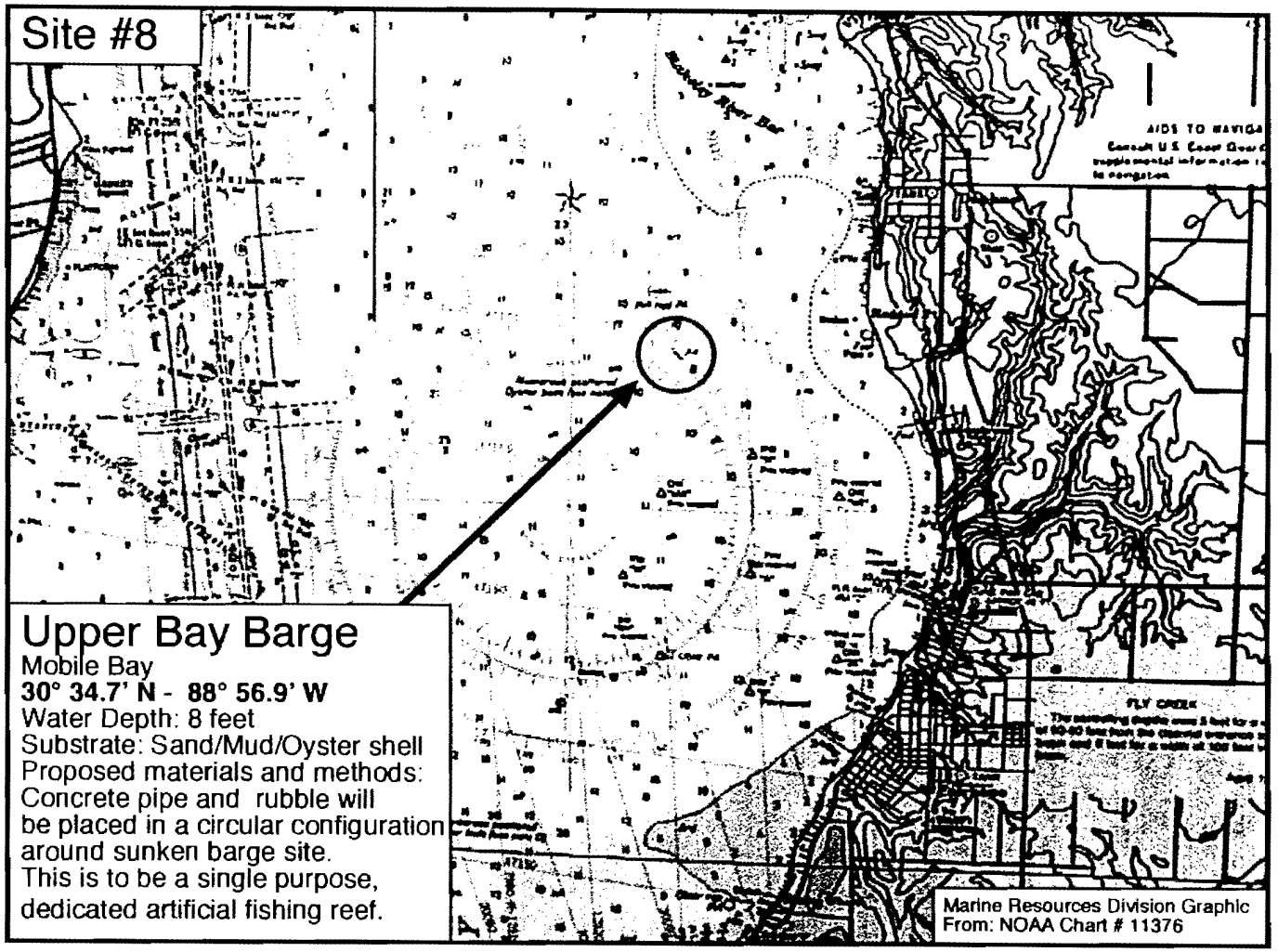
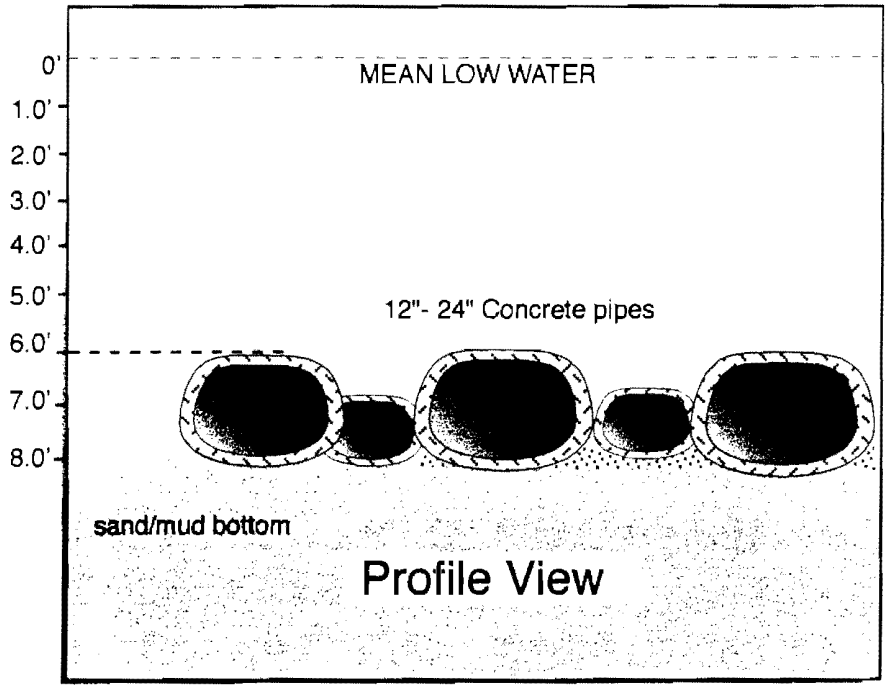
Alabama Marine Resources Division Graphic 2-99

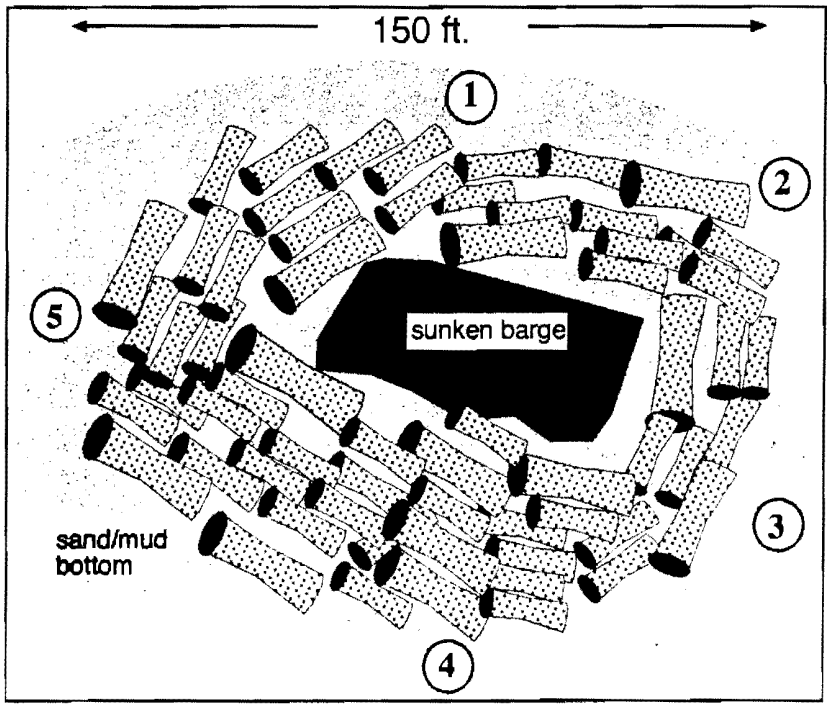
T.R. (BUDDY) GEISER

APPROVED



# Site #8
# Upper Bay Barge



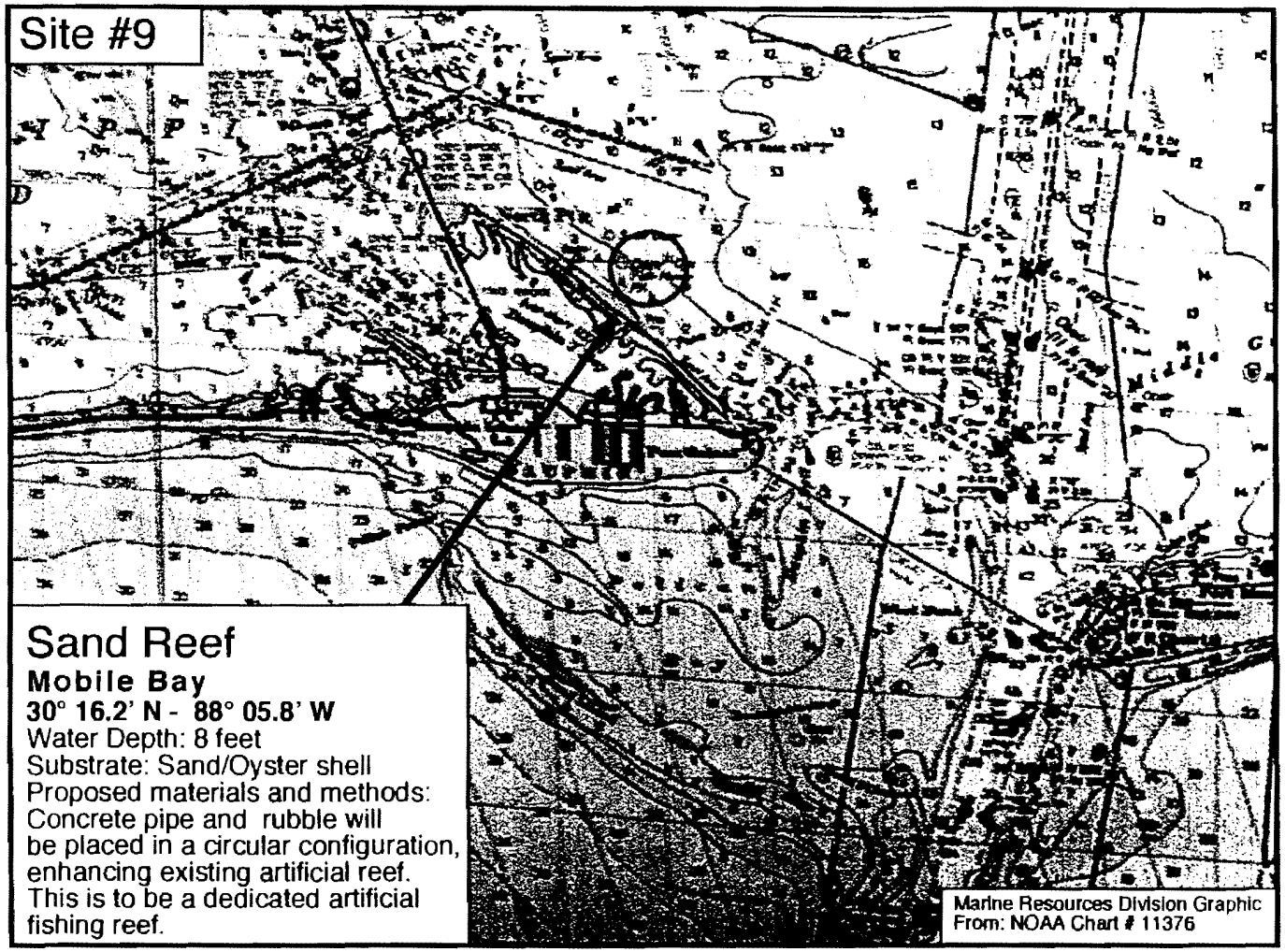




Plan View

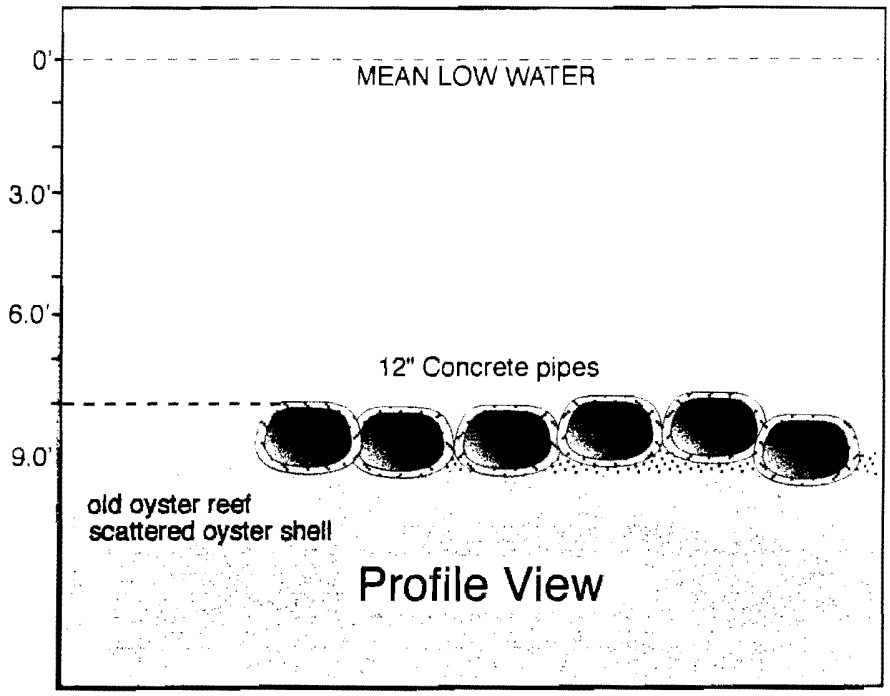
APPROVED

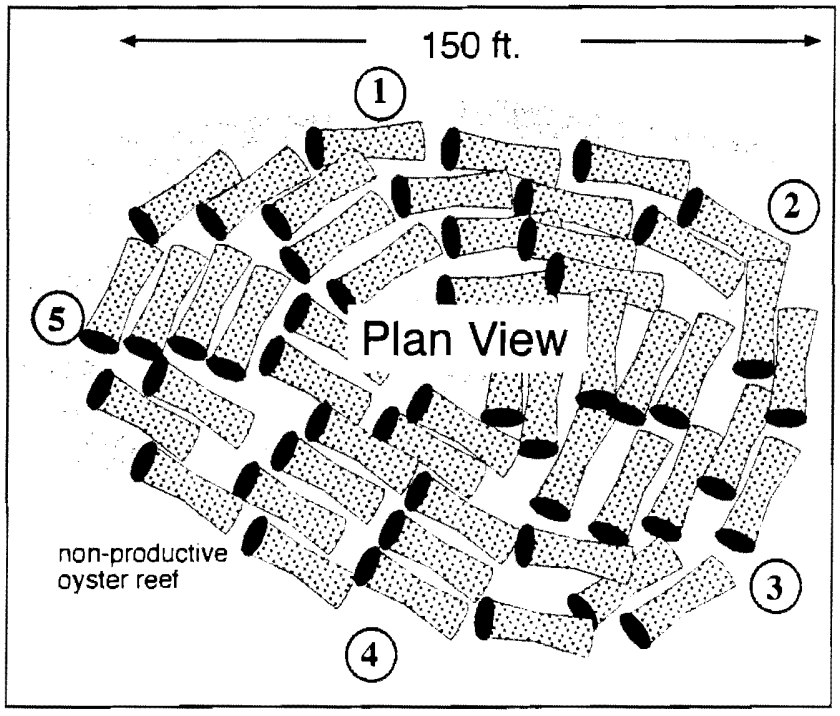
Alabama Marine Resources Division Graphic 2-99

APPROVED


Site #9
Sand Reef
Mobile Bay
30° 16.2' N - 88° 05.8' W
Water Depth: 8 feet
Substrate: Sand/Oyster shell
Proposed materials and methods:
Concrete pipe and rubble will
be placed in a circular configuration,
enhancing existing artificial reef.
This is to be a dedicated artificial
fishing reef.
Marine Resources Division Graphic
From: NOAA Chart # 11376

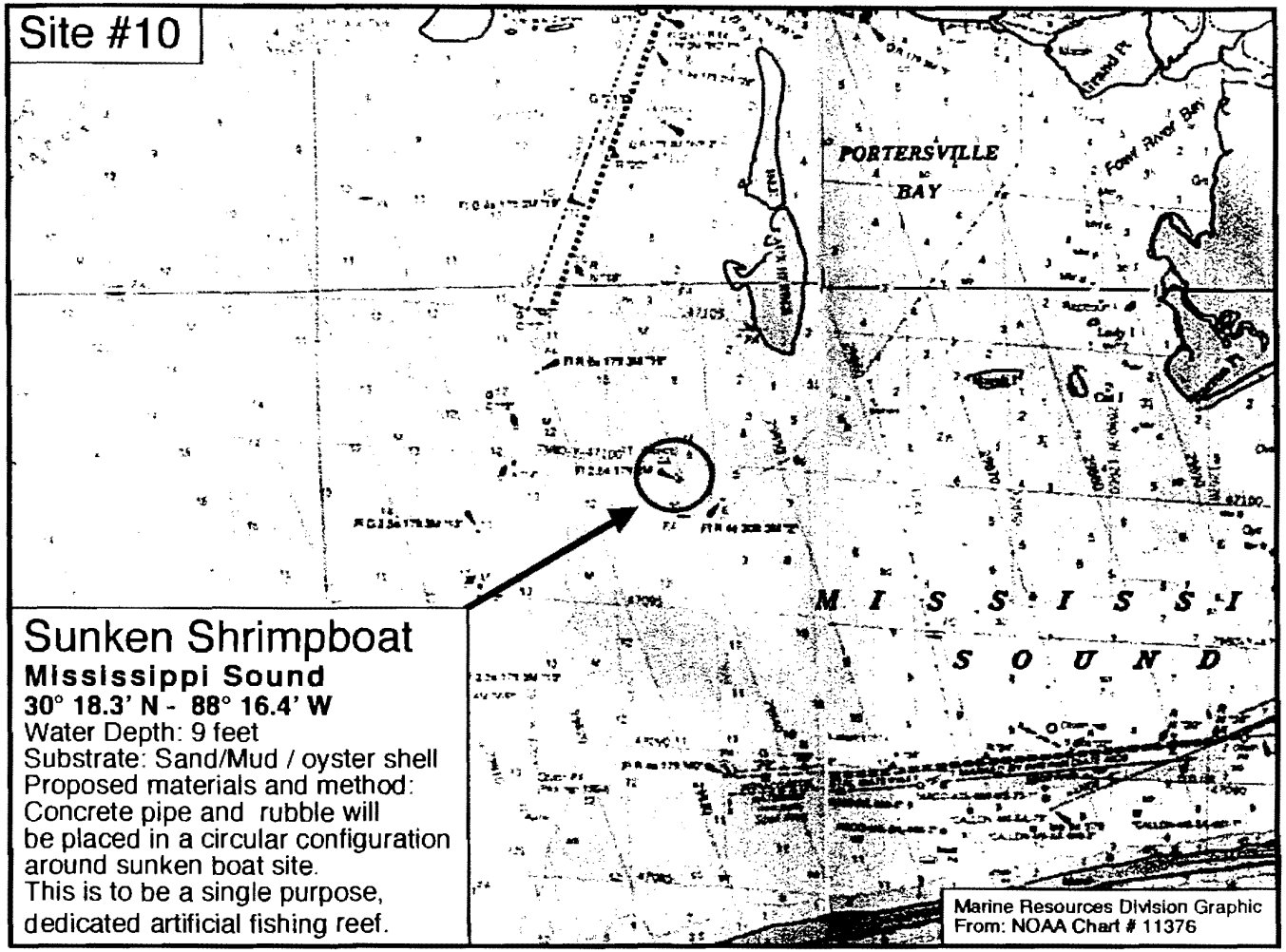
# Site #9
# Sand Reef



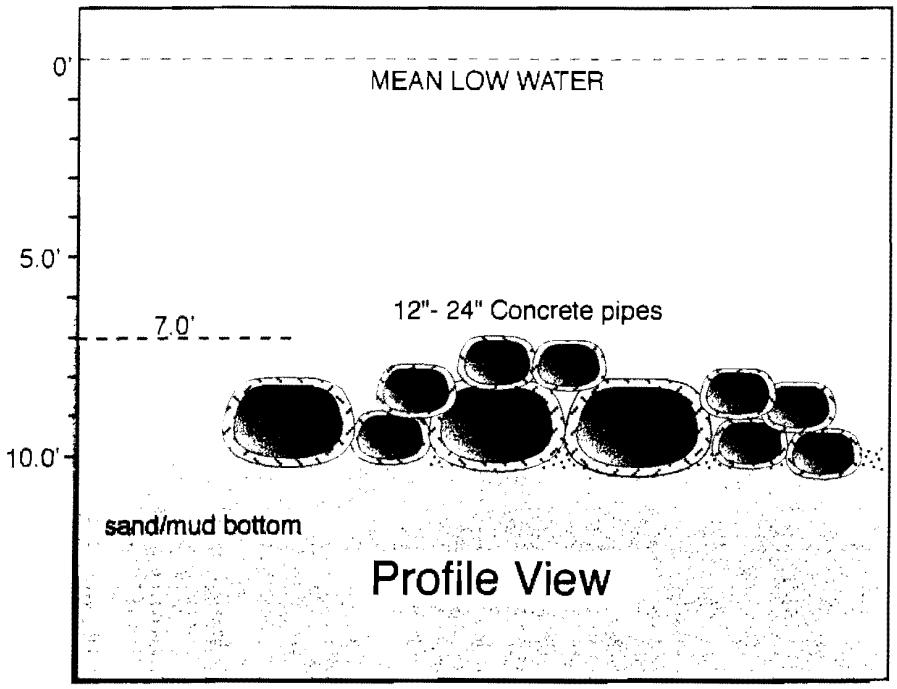




APPROVED

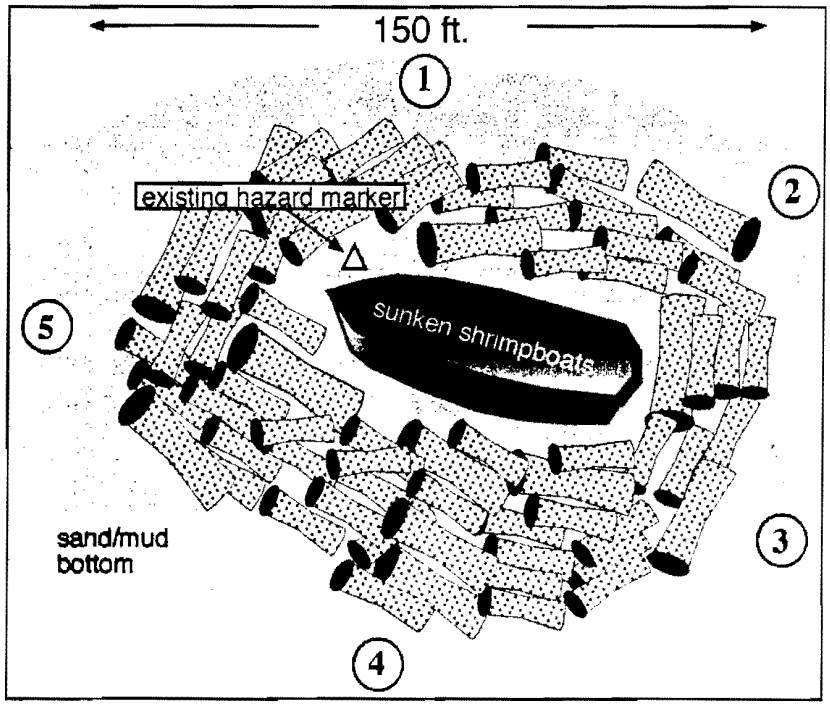
APPROVED


Site #10
PORTERSVILLE
BAY
Fowl River Bay
M I S S I S S I
S O U N D
Sunken Shrimpboat
Mississippi Sound
30° 18.3' N - 88° 16.4' W
Water Depth: 9 feet
Substrate: Sand/Mud / oyster shell
Proposed materials and method:
Concrete pipe and rubble will
be placed in a circular configuration
around sunken boat site.
This is to be a single purpose,
dedicated artificial fishing reef.
Marine Resources Division Graphic
From: NOAA Chart # 11376

# Site #10
# Sunken Shrimpboats - Mississippi Sound




Profile View




Plan View

APPROVED

Alabama Marine Resources Division Graphic 2/99

# ADEM

ALABAMA DEPARTMENT OF ENVIRONMENTAL MANAGEMENT

POST OFFICE BOX 301463 • 1400 COLISEUM BLVD. 36110-2059
MONTGOMERY, ALABAMA 36130-1463
WWW.ADEM.STATE.AL.US
(334) 271-7700

JAMES W. WARR
DIRECTOR

DON SIEGELMAN
GOVERNOR

Facsimiles: (334)
Administration: 271-7950
Air: 279-3044
Land: 279-3050
Water: 279-3051
Groundwater: 270-5631
Field Operations: 272-8131
Laboratory: 277-6718
Education/Outreach: 213-4399


May 28, 1999

U. S. Army Corps of Engineers
P. O. Box 2288
Mobile, AL 36628-0001

RE: Corps permit application
Alabama Dept. of Conservation and Natural Resources
AL99-01112-U/COE-99-023

Dear Sir:

The Alabama Department of Environmental Management has completed its review of the above referenced project involving the construction of nine artificial fishing reef/oyster reef enhancement structures within Mobile Bay and one in Mississippi Sound.

The Corps of Engineers advertisement of this project by joint public notice with ADEM has been completed. On the basis of a review of all materials submitted and associated with the proposal, it is the opinion of the technical staff that a decision relative to coastal consistency and water quality certification is appropriate.

Action pertinent to water quality and coastal management certification is required by Section 401(a)(1) of the Clean Water Act, 33 U.S.C. §1251, et. seq., and the Alabama Coastal Area Management Program. If conducted in accordance with the conditions prescribed herein, ADEM hereby issues official certification that there is reasonable assurance that the discharge resulting from the proposed activities as submitted will not violate applicable water quality standards established under Section 303 of the Clean Water Act and §22-22-9(g), Code of Alabama (1975). ADEM certifies that there are no applicable effluent limitations under Sections 301 and 302 nor applicable standards under Sections 306 and 307 of the Clean Water Act in regard to the activities specified. However, regulations promulgated by the EPA requiring discharge permits for stormwater runoff from individual and commercial facilities may be applicable. This certification does not address the requirements of those regulations. Furthermore, ADEM hereby concurs with the applicant's coastal consistency certification conditional upon continued compliance with the management program and conditions prescribed herein.


Birmingham
1400 Vulcan Road
Birmingham, Alabama 35209-4702
(205) 942-6168
(205) 941-1603 (Fax)

Decatur
2708 6th Avenue, SE, Suite B
Decatur, Alabama 35603-1508
(256) 353-1713
(256) 340-9359 (Fax)

Mobile
2204 Perimeter Road
Mobile, Alabama 36615-1131
(334) 450-3400
(334) 479-2593 (Fax)

Mobile – Coastal
4171 Commanders Drive
Mobile, Alabama 36615-1421
(334) 432-6533
(334) 432-6598 (Fax)



JUN 4 1999

Printed on Recycled Paper

Please contact Allen Phelps at 334/432-6533 if you have any questions regarding this matter.

Sincerely,

Steven O. Jenkins, Chief
Field Operations Division

cc: Mark Van Hoose, ALDCNR, Dauphin Island (certified copy)

John McFadyen, Mobile District Corps of Engineers

Jose Negron, USEPA, Atlanta

Larry Goldman, USFWS, Daphne

Allen Phelps, ADEM, Mobile

Phillip Hinesley, ADECA, Fairhope

Department of the Army

Mobile District, Corps of Engineers

Permit Number AL90-0136-I

Awarded to Alabama Marine Resources Division

June 24, 1991

# DEPARTMENT OF THE ARMY PERMIT

Permittee ALABAMA DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES

Permit No. AL90-01306-I

Issuing Office MOBILE DISTRICT

NOTE: The term "you" and its derivatives, as used in this permit, means the permittee or any future transferee. The term "this office" refers to the appropriate district or division office of the Corps of Engineers having jurisdiction over the permitted activity or the appropriate official of that office acting under the authority of the commanding officer.

You are authorized to perform work in accordance with the terms and conditions specified below.

Project Description:

To create two artificial reefs on the eastern shore of Mobile Bay by taking advantage of pilings remaining from abandoned pier structures. Approximately 600 cubic yards of concrete block will be placed at the former Daphne Steamship Pier, off Red Bluff. The attached plans furnished by the permittee detail the locations and specifications of their proposal.

DRAWINGS ATTACHED: 1. Vicinity Map
2. Plan Drawing

Project Location:

Mobile Bay East, Baldwin County, Alabama

Permit Conditions:

General Conditions:

1. The time limit for completing the work authorized ends on 20 June 1994. If you find that you need more time to complete the authorized activity, submit your request for a time extension to this office for consideration at least one month before the above date is reached.

2. You must maintain the activity authorized by this permit in good condition and in conformance with the terms and conditions of this permit. You are not relieved of this requirement if you abandon the permitted activity, although you may make a good faith transfer to a third party in compliance with General Condition 4 below. Should you wish to cease to maintain the authorized activity or should you desire to abandon it without a good faith transfer, you must obtain a modification of this permit from this office, which may require restoration of the area.

3. If you discover any previously unknown historic or archeological remains while accomplishing the activity authorized by this permit, you must immediately notify this office of what you have found. We will initiate the Federal and state coordination required to determine if the remains warrant a recovery effort or if the site is eligible for listing in the National Register of Historic Places.

4. If you sell the property associated with this permit, you must obtain the signature of the new owner in the space provided and forward a copy of the permit to this office to validate the transfer of this authorization.

5. If a conditioned water quality certification has been issued for your project, you must comply with the conditions specified in the certification as special conditions to this permit. For your convenience, a copy of the certification is attached if it contains such conditions.

6. You must allow representatives from this office to inspect the authorized activity at any time deemed necessary to ensure that it is being or has been accomplished in accordance with the terms and conditions of your permit.

Special Conditions:

Further Information:

1. Congressional Authorities: You have been authorized to undertake the activity described above pursuant to:

(X) Section 10 of the Rivers and Harbors Act of 1899 (33 U.S.C. 403).

(X) Section 404 of the Clean Water Act (33 U.S.C. 1344).

( ) Section 103 of the Marine Protection, Research and Sanctuaries Act of 1972 (33 U.S.C. 1413).

2. Limits of this authorization.

a. This permit does not obviate the need to obtain other Federal, state, or local authorizations required by law.

b. This permit does not grant any property rights or exclusive privileges.

c. This permit does not authorize any injury to the property or rights of others.

d. This permit does not authorize interference with any existing or proposed Federal project.

3. Limits of Federal Liability. In issuing this permit, the Federal Government does not assume any liability for the following:

a. Damages to the permitted project or uses thereof as a result of other permitted or unpermitted activities or from natural causes.

b. Damages to the permitted project or uses thereof as a result of current or future activities undertaken by or on behalf of the United States in the public interest.

c. Damages to persons, property, or to other permitted or unpermitted activities or structures caused by the activity authorized by this permit.

d. Design or construction deficiencies associated with the permitted work.

e. Damage claims associated with any future modification, suspension, or revocation of this permit.

4. Reliance on Applicant's Data: The determination of this office that issuance of this permit is not contrary to the public interest was made in reliance on the information you provided.

5. Reevaluation of Permit Decision. This office may reevaluate its decision on this permit at any time the circumstances warrant. Circumstances that could require a reevaluation include, but are not limited to, the following:

a. You fail to comply with the terms and conditions of this permit.

b. The information provided by you in support of your permit application proves to have been false, incomplete, or inaccurate (See 4 above).

c. Significant new information surfaces which this office did not consider in reaching the original public interest decision.

Such a reevaluation may result in a determination that it is appropriate to use the suspension, modification, and revocation procedures contained in 33 CFR 325.7 or enforcement procedures such as those contained in 33 CFR 326.4 and 326.5. The referenced enforcement procedures provide for the issuance of an administrative order requiring you to comply with the terms and conditions of your permit and for the initiation of legal action where appropriate. You will be required to pay for any corrective measures ordered by this office, and if you fail to comply with such directive, this office may in certain situations (such as those specified in 33 CFR 209.170) accomplish the corrective measures by contract or otherwise and bill you for the cost.

6. Extensions. General condition 1 establishes a time limit for the completion of the activity authorized by this permit. Unless there are circumstances requiring either a prompt completion of the authorized activity or a reevaluation of the public interest decision, the Corps will normally give favorable consideration to a request for an extension of this time limit.

Your signature below, as permittee, indicates that you accept and agree to comply with the terms and conditions of this permit.

BY: _____ 6/12/91

*(PERMITTEE)* ALABAMA DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES
Marine Resources Division
Post Office Drawer 458
Gulf Shores, Alabama 36542

*(DATE)*

This permit becomes effective when the Federal official, designated to act for the Secretary of the Army, has signed below.

MICHAEL F. THUSS, Colonel
Corps of Engineers
*(DISTRICT ENGINEER)*

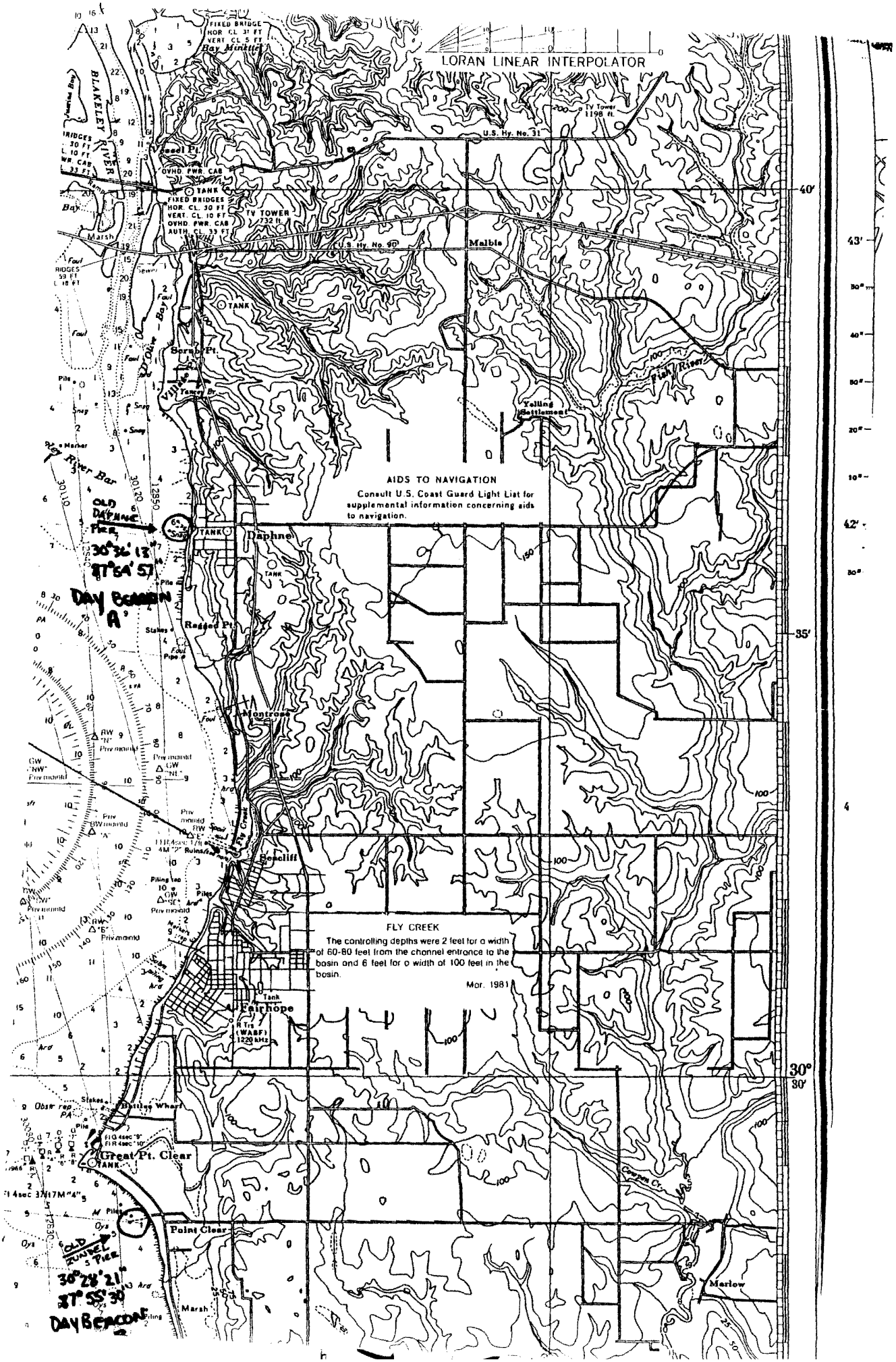
BY: _____
RONALD A. KRIZMAN *(DATE)* 6/24/91
Chief, Regulatory Branch
Operations Division

When the structures or work authorized by this permit are still in existence at the time the property is transferred, the terms and conditions of this permit will continue to be binding on the new owner(s) of the property. To validate the transfer of this permit and the associated liabilities associated with compliance with its terms and conditions, have the transferee sign and date below.

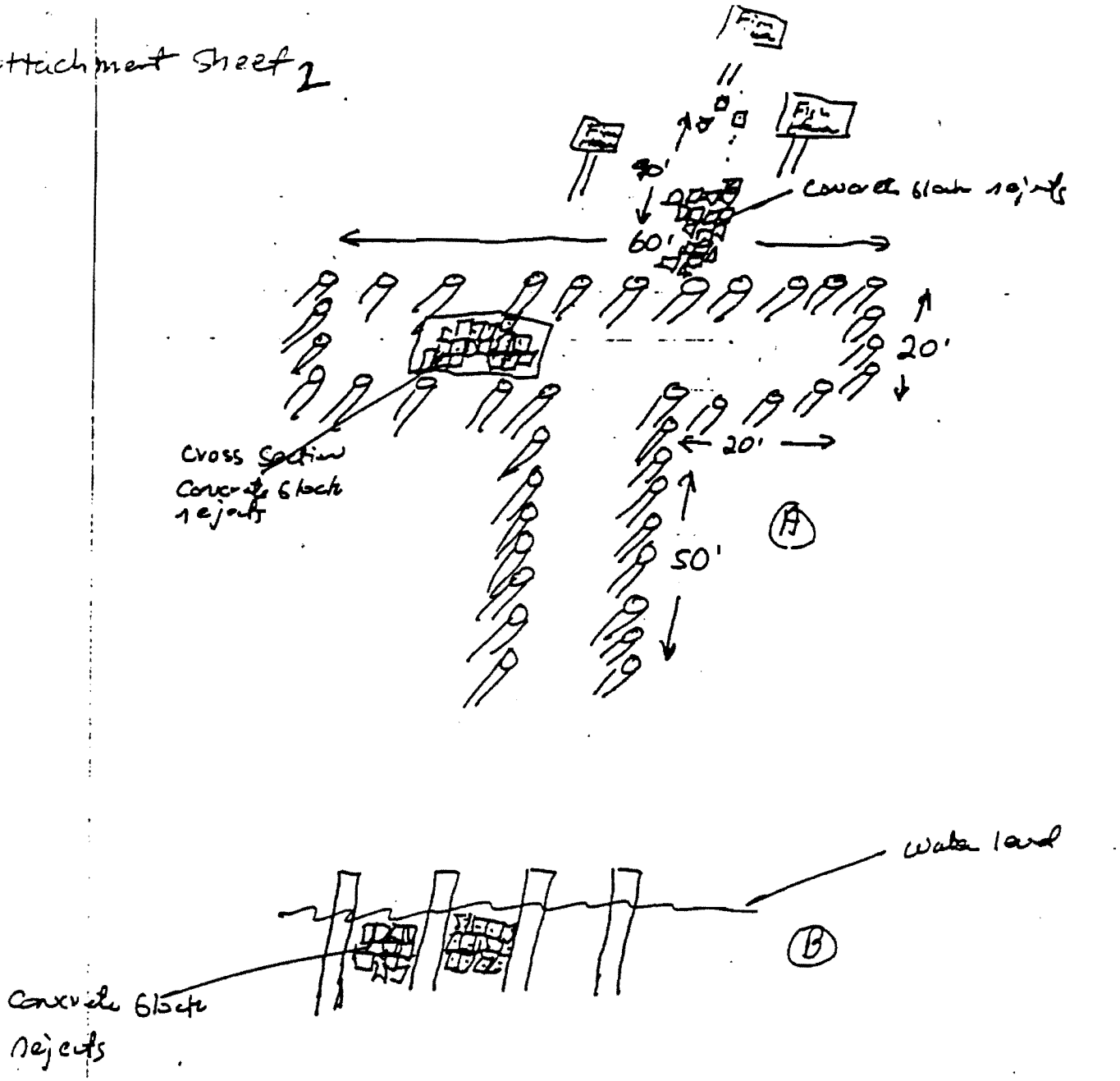
_____ _____
*(TRANSFEREE)* *(DATE)*



☆U.S. GOVERNMENT PRINTING OFFICE: 1986 — 717-425


LORAN LINEAR INTERPOLATOR
AIDS TO NAVIGATION
Consult U.S. Coast Guard Light List for supplemental information concerning aids to navigation.
FLY CREEK
The controlling depths were 2 feet for a width of 60-80 feet from the channel entrance to the basin and 6 feet for a width of 100 feet in the basin.
Mar. 1981
OLD DAPHNE PIER
30°36'13"
87°54'57"
DAY BEACON A
OLD FAIRHOPE PIER
30°28'21"
87°55'30"
DAY BEACON
Daphne
Montrose
Fairhope
Point Clear
Malbis
Bon Secour
Great Pt. Clear
Ragged Pt.
Bonsecour
Marlow
U.S. Hy. No. 31
U.S. Hy. No. 90
Fish River
Yelling Settlement
Blakeley River
Bay Minette
TV Tower 1198 ft.
TV TOWER 732 ft.
FIXED BRIDGE HOR. CL. 31 FT VERT. CL. 5 FT
FIXED BRIDGES HOR. CL. 30 FT VERT. CL. 10 FT OVHD PWR. CAB AUTH. CL. 33 FT
OVHD PWR. CAB
TANK
Marsh
Fowl
Pile
Snag
Marker
Stakes
Piling
Ruins
Privmarid
Tanner Pt.
Village Creek
Fly Creek
Bon Secour Bay
Bay
Basin
Wharf
Oyst
Arrd
Pipe
Tank
(WABF) 1220 kHz
40'
35'
30°
30'
43'
42'

Attachment Sheet 2




Spot #2, Daphne Steamship Pier: Approximately 600 $yd^3$ of concrete block rejects will be placed inside the perimeter of the old Daphne Steamship Pier. The blocks will be placed in water ranging in depths of from 6' - 8' and will come within approximately one (1) foot of the surface. Additionally, 200 $yd^3$ of concrete block rejects will be placed seawar and adjacent to the pilings covering an area of approximately 40' long and 20' wide. The material (approximately 200 $yd^3$) will come to within 3' of the water surface MHT and pilings with signs signifying "FISH HAVENS" will be placed, with reflective tape, on the west, north and south side of the material. No material will be placed within 1000' of the shoreline.

APPROVED PENDING

Department of the Army

Mobile District, Corps of Engineers

Permit Number AL95-04439-U

Awarded to Alabama Marine Resources Division

October 2, 1995

DEPARTMENT OF THE ARMY
MOBILE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 2288
MOBILE, ALABAMA 36628-0001

REPLY TO
ATTENTION OF:

October 2, 1995

Regulatory Branch
Operations Division

SUBJECT: Letter of Permission, Department of the Army Permit Number AL95-04439-U, Alabama Department of Conservation and Natural Resources

Mr. Vernon Minton
Alabama Department of Conservation
and Natural Resources
Marine Resources Division
Post Office Box 189
Dauphin Island, Alabama 36528

Dear Mr. Minton:

Reference is made to your request for a Department of the Army permit to construct four oyster/fish reefs in Mobile Bay and Bon Secour Bay, Baldwin County, Alabama.

Upon the recommendation of the Chief of Engineers and under the provisions of Section 10 of the River and Harbor Act of 1899 (33 U.S.C. 403), you are hereby authorized by the Secretary of the Army to perform this work in accordance with your submitted data and plans, the enclosed General Conditions and the following Special Conditions:

a. A member of the Alabama Department of Conservation staff or a duly authorized representative shall be present during reef construction to insure the materials are placed in accordance with this letter of permission.

b. A minimum water depth of 2 feet, measured from mean low water, shall be maintained over all reef material at sites 1 and 2.

c. All reefs will be marked by piles and signs. You shall obtain the necessary private aids to navigation permits from the U.S. Coast Guard and maintain the markers for the life of the project.

The District Engineer shall be notified in writing of the commencement and completion of the work. The enclosed cards may be used for that purpose. Also enclosed is Notice of Authorization which must be posted at the site during construction of the permitted work.

Printed on Recycled Paper

If the activity authorized herein is not completed on or before the 2nd day of October 1998, this permit, if not previously revoked or specifically extended, shall automatically expire.

BY AUTHORITY OF THE SECRETARY OF THE ARMY:

WILLIAM S. VOGEL
Colonel, Corps of Engineers
District Engineer

BY: _____
RONALD A. KRIZMAN
Chief, Regulatory Branch
Operations Division

Enclosures

General Conditions:

1. If you find that you need more time to complete the authorized activity, submit your request for a time extension to this office for consideration at least one month before the time limit for your permit expires.

2. You must maintain the activity authorized by this permit in good condition and in conformance with the terms and conditions of this permit. You are not relieved of this requirement if you abandon the permitted activity, although you may make a good faith transfer to a third party in compliance with General Condition 4 below. Should you wish to cease to maintain the authorized activity or should you desire to abandon it without a good faith transfer, you must obtain a modification of this permit from this office, which may require restoration of the area.

3. If you discover any previously unknown historic or archeological remains while accomplishing the activity authorized by this permit, you must immediately notify this office of what you have found. We will initiate the Federal and state coordination required to determine if the remains warrant a recovery effort or if the site is eligible for listing in the National Register of Historic Places.

4. If you sell the property associated with this permit, you must obtain the signature of the new owner in the space provided and forward a copy of the permit to this office to validate the transfer of this authorization.

5. If a conditioned water quality certification has been issued for your project, you must comply with the conditions specified in the certification as special conditions to this permit. For your convenience, a copy of the certification is attached if it contains such conditions.

6. You must allow representatives from this office to inspect the authorized activity at any time deemed necessary to ensure that it is being or has been accomplished in accordance with the terms and conditions of your permit.

Further Information:

1. Limits of this authorization.

a. This permit does not obviate the need to obtain other Federal, state, or local authorizations required by law.

b. This permit does not grant any property rights or exclusive privileges.

c. This permit does not authorize any injury to the property or rights of others.

d. This permit does not authorize interference with any existing or proposed Federal project.

2. Limits of Federal Liability. In issuing this permit, the Federal Government does not assume any liability for the following:

a. Damages to the permitted project or uses thereof as a result of current or future activities undertaken by or on behalf of the United States in the public interest.

b. Damages to the permitted project or uses thereof as a result of other permiited or unpermitted activities or from natural causes.

c. Damages to persons, property, or to other permitted or unpermitted activities or structures caused by the activity authorized by this permit.

d. Design or construction deficiencies associated with the permitted work.

e. Damage claims associated with any future modification, suspension, or revocation of this permit.

# JOINT APPLICATION AND NOTIFICATION
# U. S. DEPARTMENT OF ARMY, CORPS OF ENGINEERS
# ALABAMA DEPARTMENT OF ENVIRONMENTAL MANAGEMENT

This form is to be used for proposed activities in waters of the United States within the political boundaries of the State of Alabama.

PLEASE TYPE OR PRINT IN INK

1. Date: 09 (month) 25 (day) 1995 (year)

APPLICATION NUMBER (TO BE ASSIGNED BY CORPS)

2. Applicant:
Name and Address: Alabama Dept. Conservation & Natural Resources, Marine Resources Div.
P.O. Box 189
Dauphin Island, AL 36528

Telephone Number during business hours:
A/C ( ) _____ Residence
A/C (334 ) 861-2882 Office

OFFICIAL USE ONLY

COE _____
ADEM _____
STATE CLEARINGHOUSE _____
DATE RECEIVED _____

3. Designation of Agent, Statement of Authorization:
I hereby designate and authorize _____
_____
to act on my behalf in the processing of this permit application and to furnish, upon request, supplemental information in support of the application.

_____
Signature of Applicant Date

Agent:
Name and Address:

Telephone Number during business hours:
A/C ( ) _____
A/C ( ) _____

4. Project Location:
Street Address _____ City/Community _____
Name of Waterway Mobile Bay & Bon Secour Bay Latitude See Project Descript Longitude _____
Geographic Location: Section _____ Township _____ Range _____ County Baldwin
Loran C coordinates (if applicable) N/A

5. Project Description, including all aspects of the project. Describe completely and in detail. Include any str such as piers, wharfs, bulkheads, pipelines, boathouses, boatramps, groins, jetties, and appurtenances, as well dredging, excavation, or fill activities. Attach additional sheets if necessary.

Project 1: To place approximately 2300 linear feet of assorted length concrete bridge pilings around the perimeter of the remnants of Fish River oyster reef in Bon Secour Bay. This remnant is located in approximately 6 feet of water at Latitude 30°19.6' Longitude 87°49.0'. The interior of this area will be planted with oyster shell and/or seed oysters. The concrete bridge pilings will be used as a fish attractant and a low disolved oxygen water deflection system.

Project 2: To place approximately 2300 linear feet of assorted length of concrete bridge pilings around the perimeter of the remnants of Shellbank oyster reef in Bon Secour Bay. This remnant is located in approximately 7 feet of water. Pilings will be placed around a portion of this remnant located at Latitude 30°15.5' and Longitude 87° 51.7'. The interior of this area will be planted with oyster shell and/or seed oysters. The concrete bridge pilings will be used as a fish atractant and a low dissolved oxygen water deflector.

5. Cont.

Project 3: An area approximately 80 feet by 40 feet within the existing derelict pilings of the relic Quarantine Pier in Mobile Bay off the north shore of Fort Morgan, Alabama will be covered with concrete rubble or imperfect concrete blocks in order to create an artificial fish reef. This area is located in approximately 5 feet of water at Latitude 30°14.0' and Longitude 88°00.7'.

Project 4: Approximately 300 cubic yards of concrete block rejects and/or concrete bridge rubble will be placed inside the pilings of the old Zundel Steamship Pier on the eastern shore of Mobile Bay, approximately one half mile south of Great Point Clear. The arc shown in View "A" (see attached plans) is in 7.5 feet of water and the block material approximately 1300 cubic yards. This area is located at Latitude 30°23.2' and Longitude 87°54.9'.

All of the above projects will be marked with pilings equipped with reflective tape and signage indicating an artificial fishing reef.

5. Project Description (continued)

6. Dredging Project Specifications (Show locations and dimensions of proposed dredge areas on attached plans. Include existing and proposed depths.).

New Work N/A Maintenance Work _____

Cubic yards of material to be removed _____ Type of material _____

Method of excavation _____

Nature of area to be dredged (check one) Upland _____ Wetland _____ Waterbottom _____

Other (explain) _____

7. Specifications for Discharge of Dredged or Fill Material (Show locations and dimensions of all disposal or fill areas on attached plans.).

Cubic yards of fill N/A Type of fill _____

Source of fill material (check one) Commercially obtained _____ Dredged material _____ Borrowed on-site _____

Other (explain) _____

How will discharged material be contained? (Include erosion control measures, levees, etc.) _____

Nature of disposal/fill areas (check one) Upland _____ Wetland _____ Waterbottom _____

Other (explain) _____

8. Additional information relating to the proposed activity.

Are oyster reefs located within or near the project area? Yes XX No _____ If yes, explain: This is a combination oyster reef enhancement/fishing reef creation project

Will this project result in the siting, construction, and/or operation of an energy-related facility? Yes _____ No XX

Is the project area greater than 25 acres in size? Yes _____ No XX

Is any portion of the activity for which authorization is sought now complete? Yes _____ No XX If yes, explain: _____

_____ Month and year activity took place _____

If project is for maintenance work of existing structures or existing channels, describe legal authorization for the existing work. Provide permit number, dates or other form of authorization _____

9. Describe the purpose and public benefit, if any, of the project. Describe the relationship between the project and any secondary or future development the project is designed to support. This project will enhance oyster reefs which are now non-productive in Baldwin County, provideing additional oyster resource and will create fishing reefs for additional fishing opportunities for the public

Intended use: Public XX Private _____ Commercial XX Other (explain) Recreational

10. Project Schedule:

Proposed start date 1 January 1996 Proposed completion date 31 December 1997

11. Names and addresses of adjoining property owners, lessees, etc. whose property also adjoins the waterway. Also identify the owners on the plan view in Attachment.

N/A

12. List all authorizations or certifications received or applied for from federal, state or local agencies for structures, construction, discharges, deposits or other activities described in or directly related to this application. Note that the signature in item 13 certifies that application has been made to or that permits required from the following agencies. If permits are not required place NA in space for Type Approval.

| Agency | Type Approval | Identification No. | Date of Application | Date of Approval | Date of |
|---|---|---|---|---|---|
| AL Dept. of Environmental Management | | | | | |
| U. S. Army Corps of Engineers | | | | | |
| Alabama State Docks | | | | | |
| City/County_____ | | | | | |
| Other_____ | | | | | |

13. Application is hereby made for authorization to conduct the activities described herein. I agree to provide additional information/data that may be necessary to provide reasonable assurance or evidence to show that th proposed project will comply with the applicable state water quality standards or other environmental protect standards both during construction and after the project is completed. For projects within the coastal area Mobile and Baldwin Counties, I certify that the proposed project for which authorization is sought complies w the approved Alabama Coastal Area Management Program and will be conducted in a manner consistent with the pr I agree to provide entry to the project site for inspectors from the environmental protection agencies for th purpose of making preliminary analyses of the site and monitoring permitted works. I certify that I am famil with and responsible for the information contained in this application, and that to the best of my knowledge belief such information is true, complete and accurate. I further certify that I possess the authority to undertake the proposed activities or I am acting as the duly authorized agent of the applicant.
***(SIGNATURE OF APPLICANT OR AGENT REQUIRED BELOW)***

R. Union Morton, Dir. MRD — 9-25-95

Signature of Applicant or Agent — Date

*18 U.S.C. Section 1001 provides that: Whoever, in any manner within the jurisdiction of any department or agency of the United States knowingly and willingly falsifies, conceals, or covers up by any trick, scheme or device a material fact or makes any false, fictitious or fraudulent statements or representations or makes or uses any false writing or document knowing same to contain any false, fictitious or fraudulent statement or entry, shall be fined not more than $10,000 or imprisoned not more than five years or both.*

14. **In addition to the completed application, the following attachments are required:**

Provide a vicinity map showing the location of the proposed site along with a written description of how to reach the site from major highways or landmarks. Provide accurate drawings of the project site with existing structures and proposed activities shown in detail. All drawings must be to scale or with dimensions noted on drawings and must show a plan view and cross section or elevation. ***All plans and attachments must be of reproducible quality on 8 1/2 inch x 11 inch paper.*** **FEES ARE REQUIRED IN CONJUCTION WITH ADEM CERTIFICATION; ADEM WILL CONTACT APPLICANT WITH FEE REQUIREMENTS.**

15. **Send one completed application (or copy) to each agency listed below:**

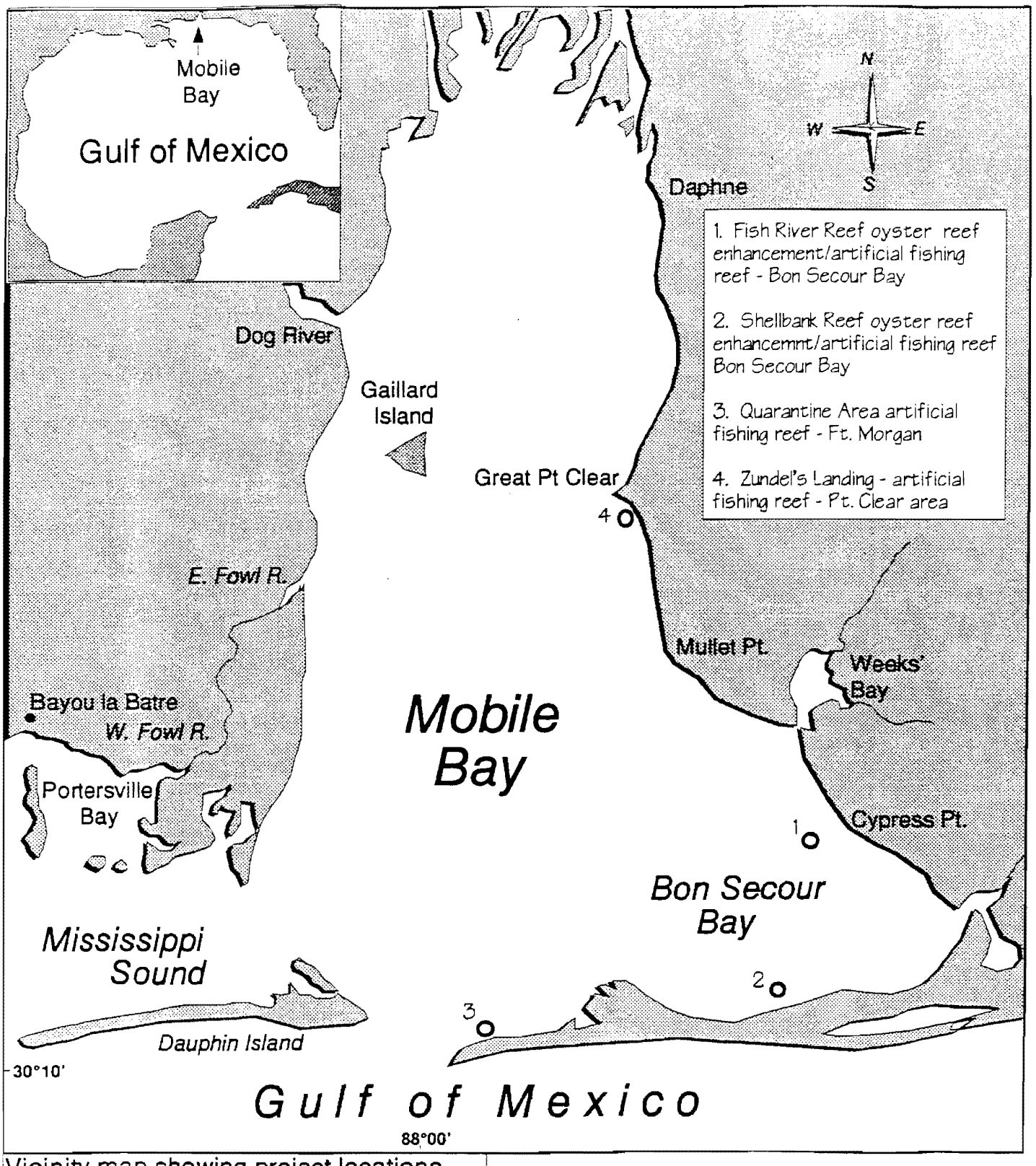
District Engineer (original application)
U. S. Army Engineer District, Mobile
Attn: Regulatory Branch
Post Office Box 2288
Mobile, Alabama 36628

Alabama State Docks
Post Office Box 1588
Mobile, Alabama 36633

Permit Coordination Center
Alabama Department of Environmental Management
1751 Cong. W.L. Dickinson Drive
Montgomery, Alabama 36130

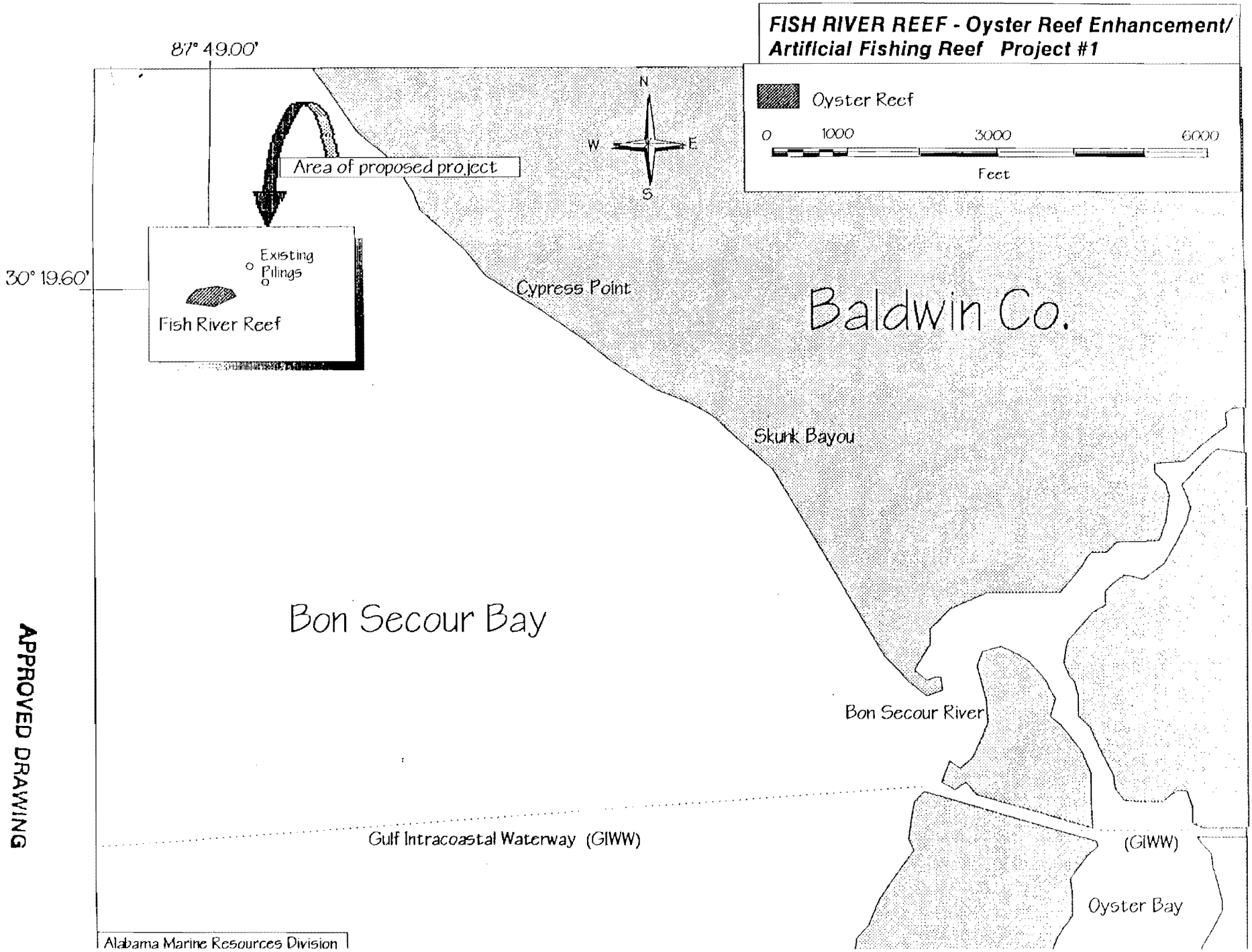
* For projects in Baldwin or Mobile Counties, includi projects requiring Coastal Program certification, s one copy to:

Alabama Department of Environmental Management
Mobile Field Office
2204 Perimeter Road
Mobile, Alabama 36615




Vicinity map showing project locations

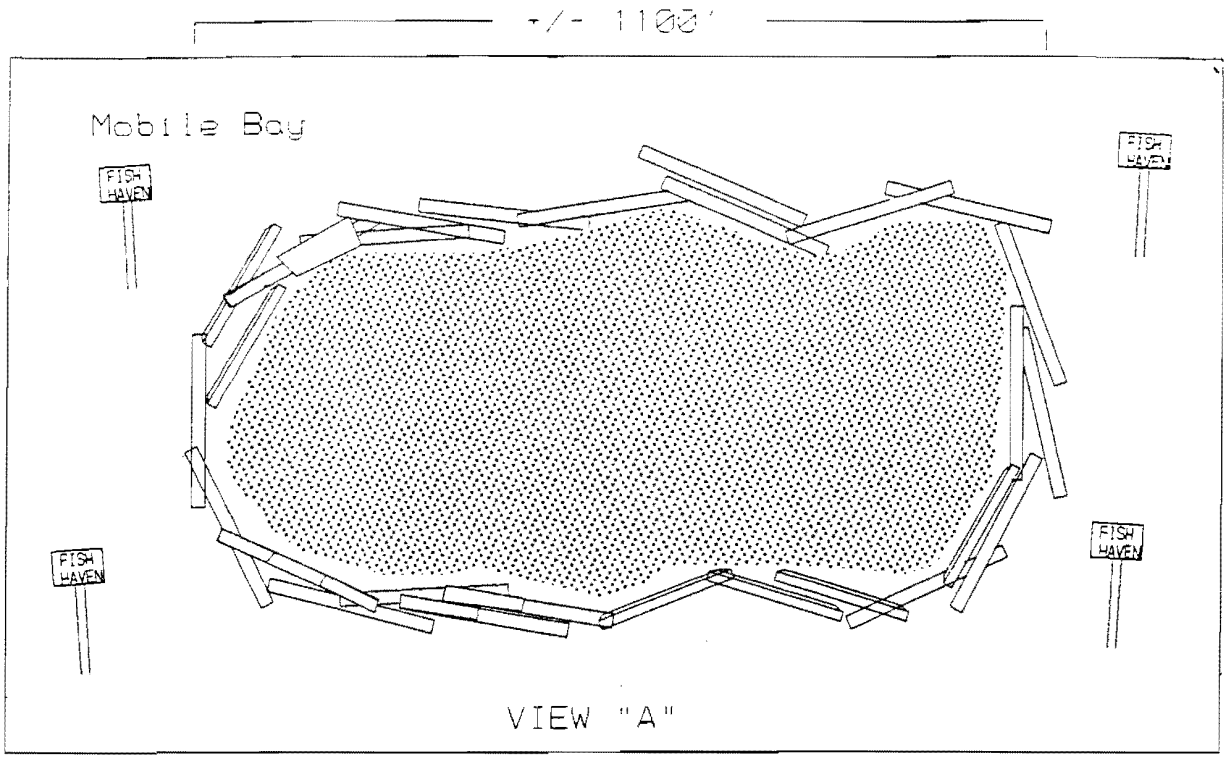
APPROVED DRAWING

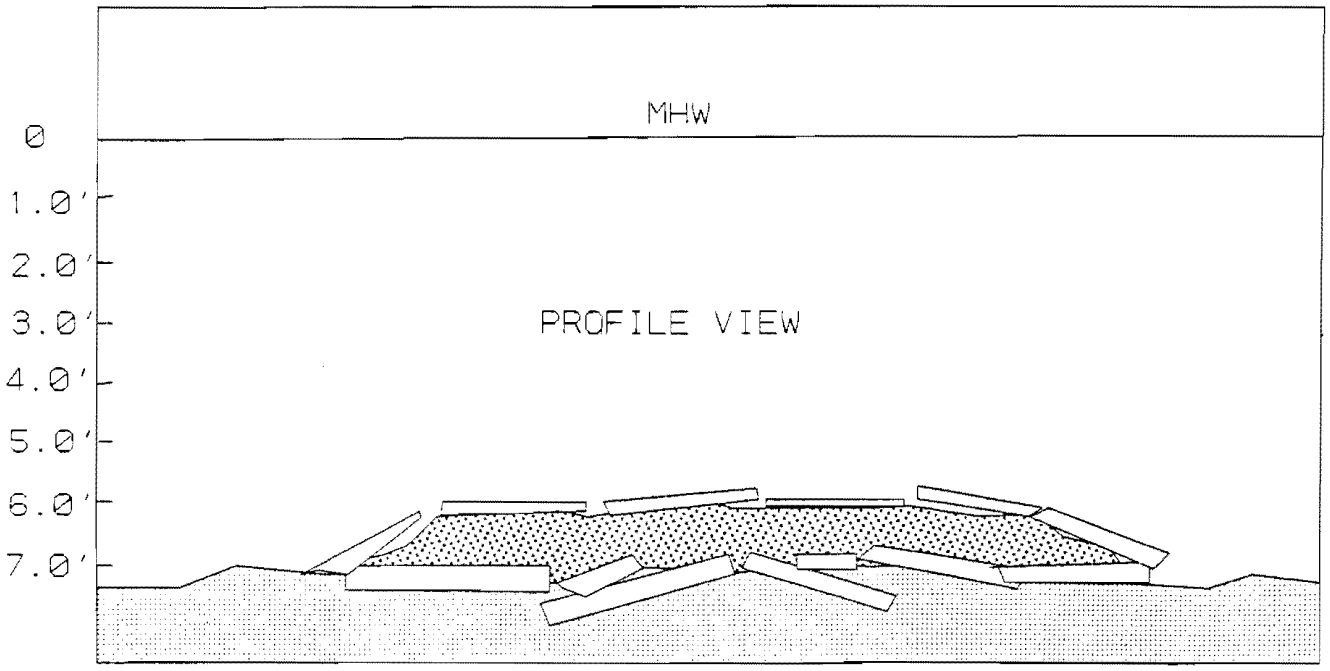



APPROVED DRAWING

Fish River Reef
Bon Secour Bay, AL

Oyster Reef Enhancement/
Artificial Fishing Reef



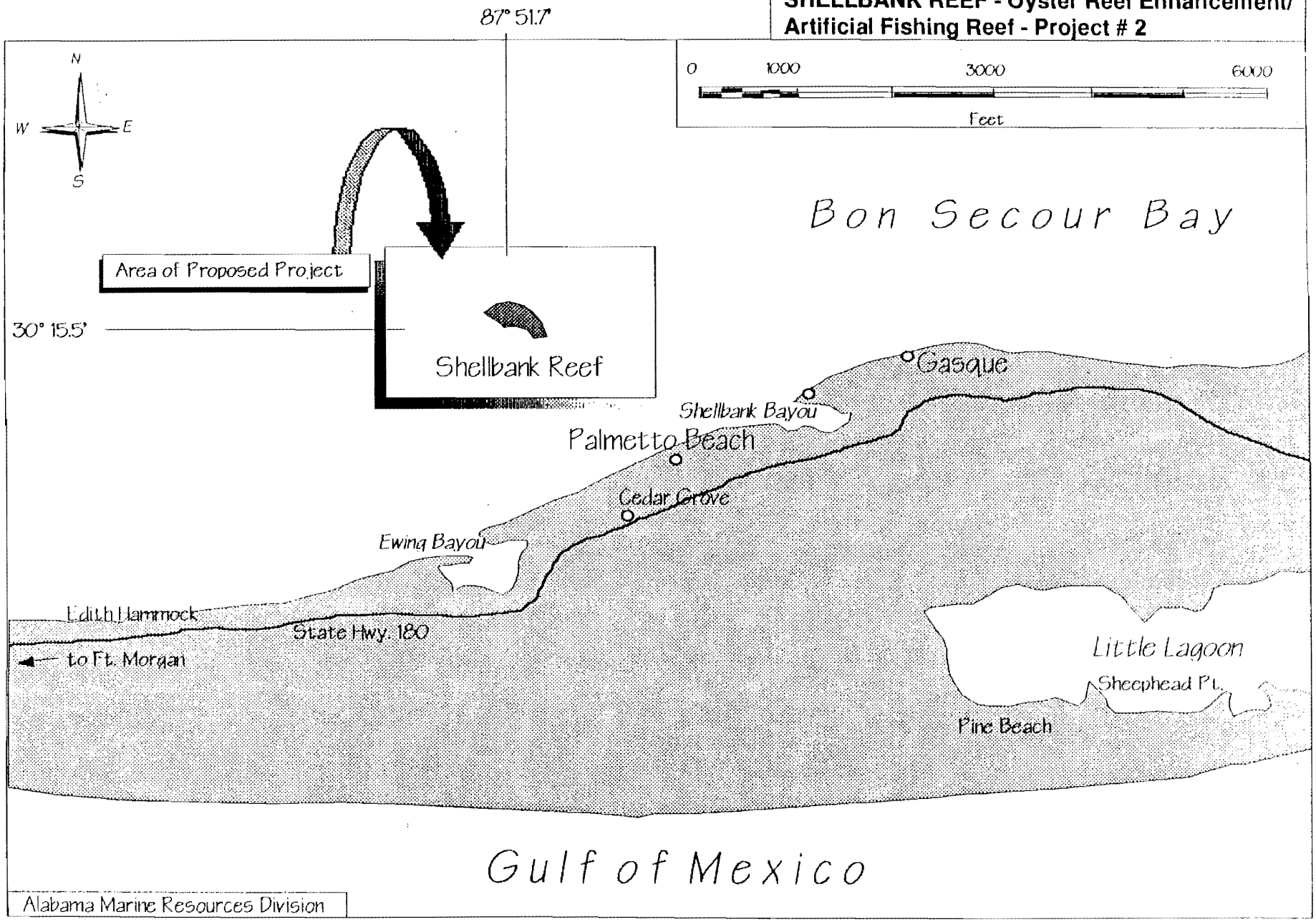




Oyster Reef

2' x 2'
Concrete Bridge Pilings

**APPROVED DRAWING**

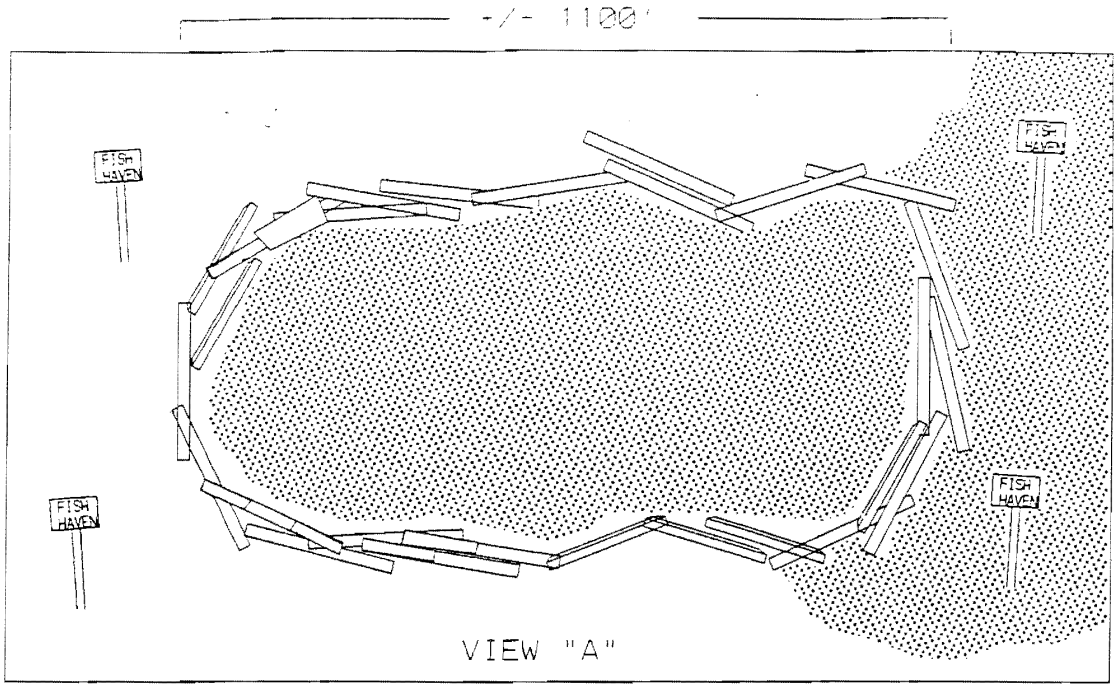
**SHELLBANK REEF - Oyster Reef Enhancement/ Artificial Fishing Reef - Project # 2**

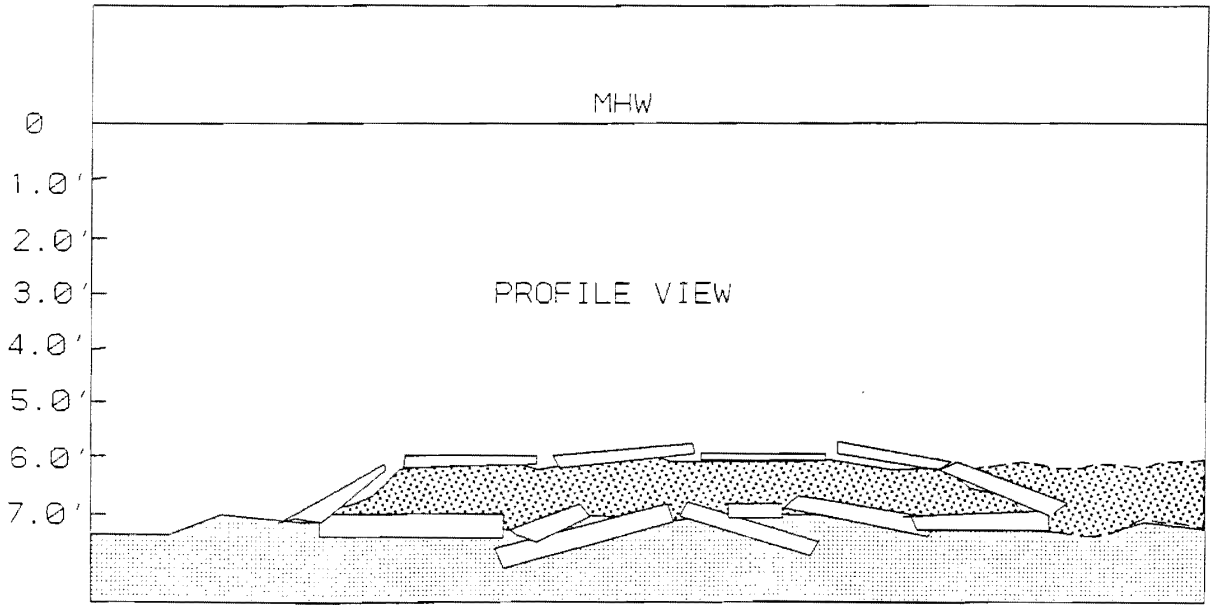



APPROVED DRAWING

Shellbank Reef
Bon Secour Bay, AL

Oyster Reef Enhancement/
Artificial Fishing Reef

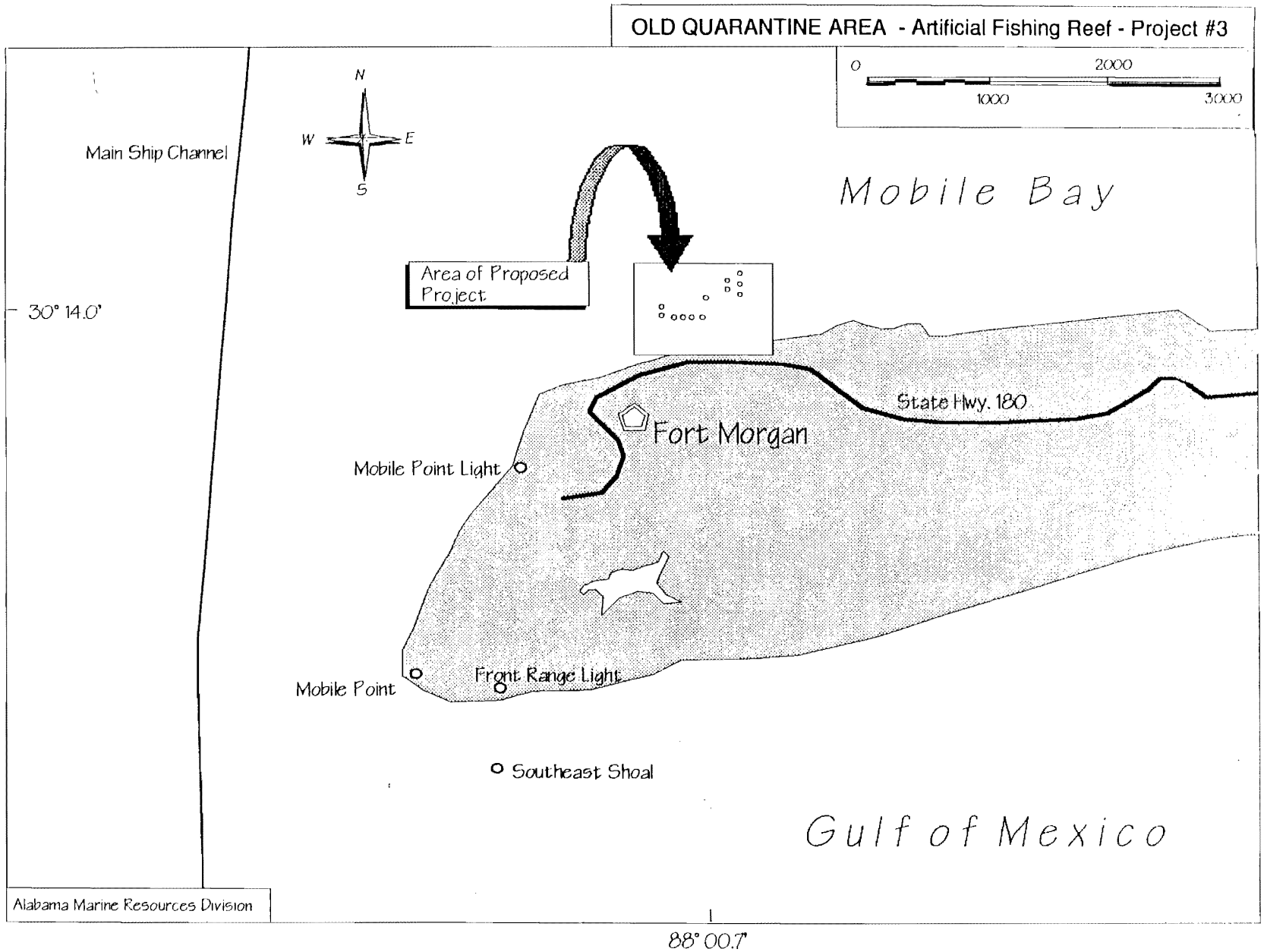



Oyster Reef

2'x 2'
Concrete Bridge Pilings

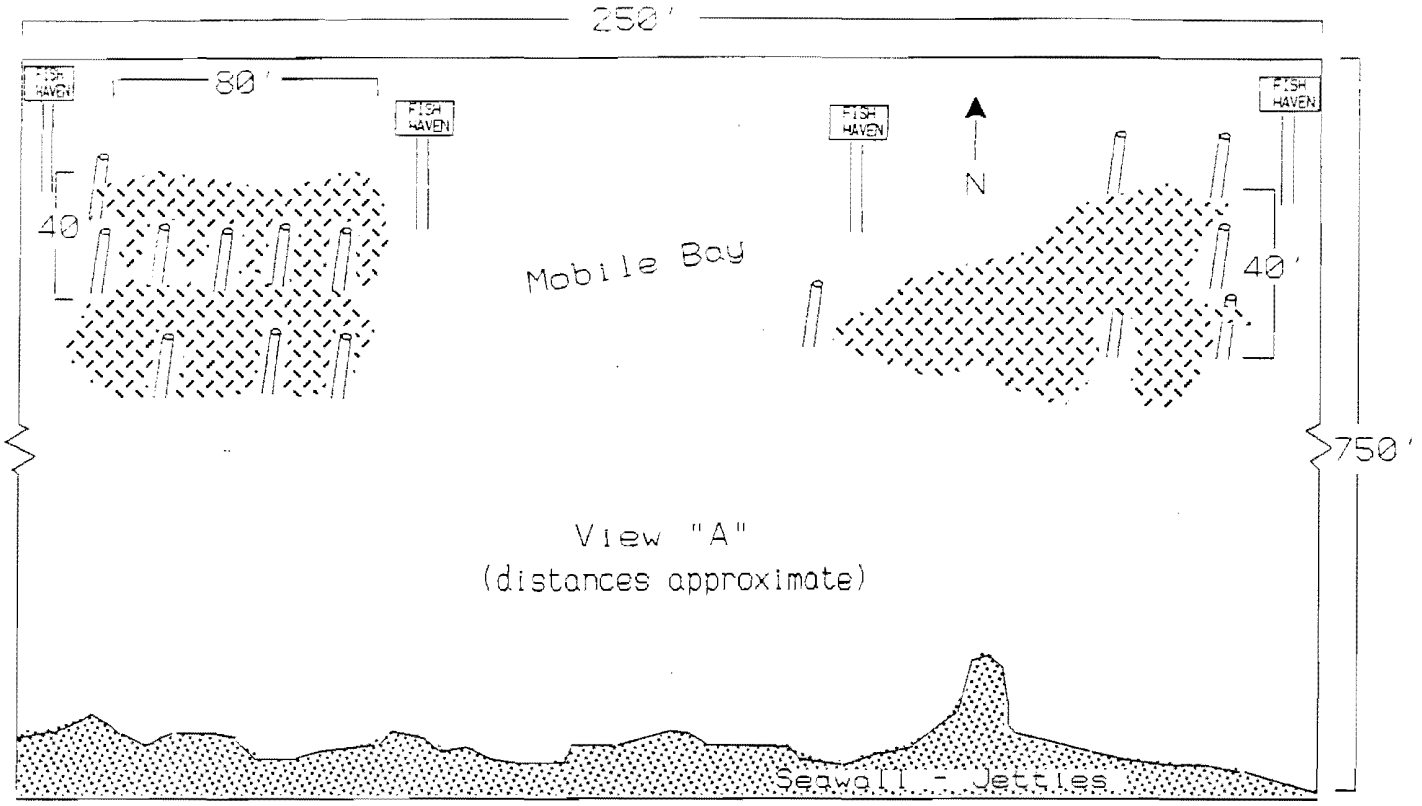
APPROVED DRAWING

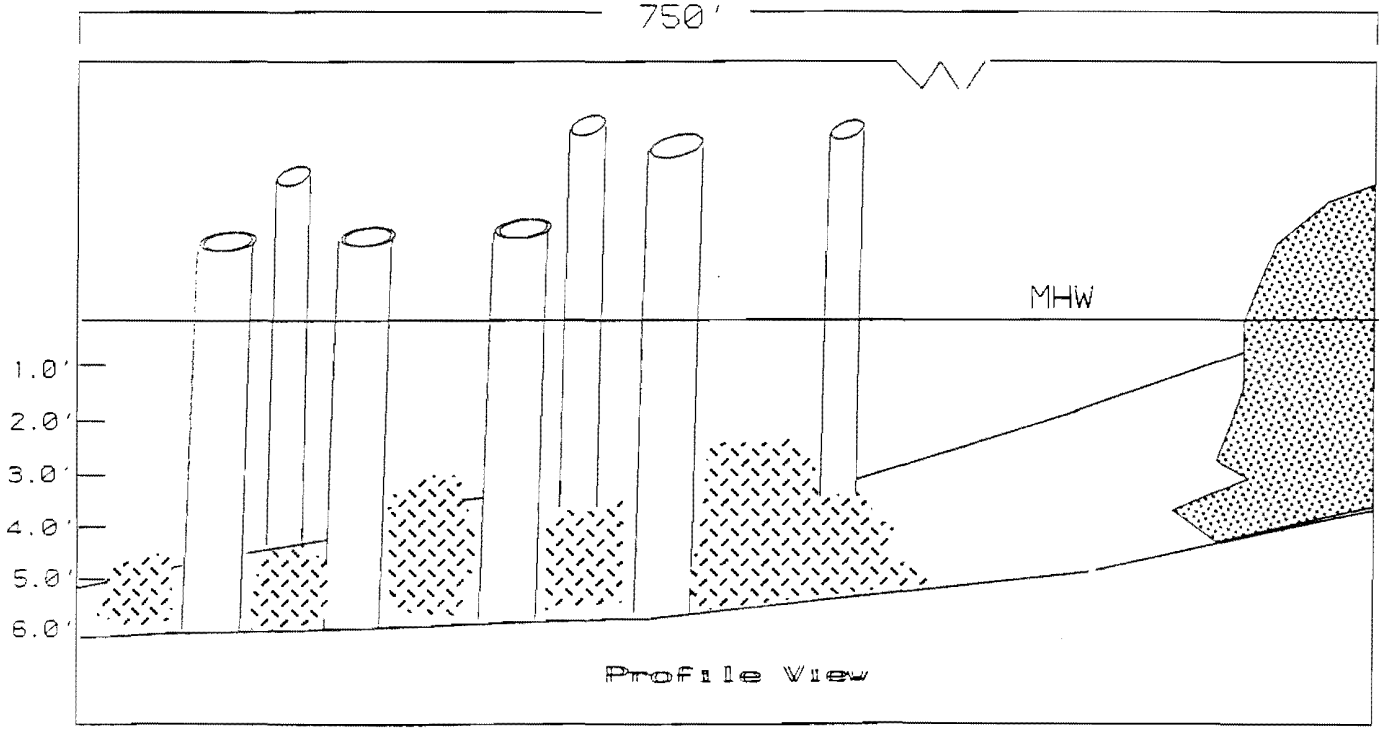

OLD QUARANTINE AREA - Artificial Fishing Reef - Project #3
0
2000
1000
3000
N
W
E
S
Main Ship Channel
Mobile Bay
Area of Proposed Project
30° 14.0'
State Hwy. 180
Fort Morgan
Mobile Point Light
Mobile Point
Front Range Light
Southeast Shoal
Gulf of Mexico
APPROVED DRAWING
Alabama Marine Resources Division
88° 00.7'

Old Quarantine Area - Ft. Morgan, AL

Proposed Artificial Fishing Reef

MARINE RESOURCES DIVISION



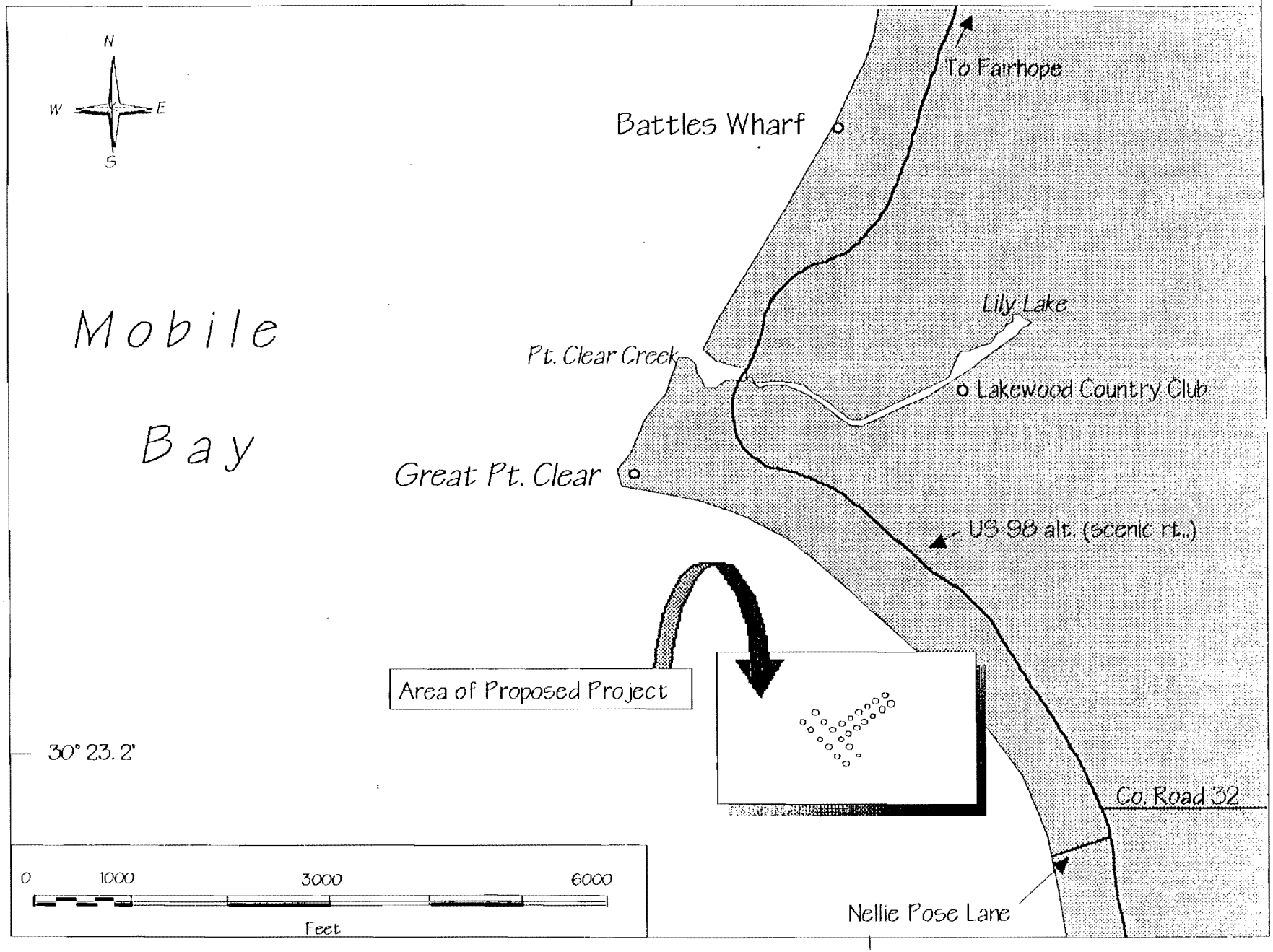




DERELICT PILINGS

IMPERFECT CONCRETE BLOCK/ CONCRETE BRIDGE RUBBLE

APPROVED DRAWING

**ZUNDEL'S LANDING -Artificial Fishing Reef - Project #4**

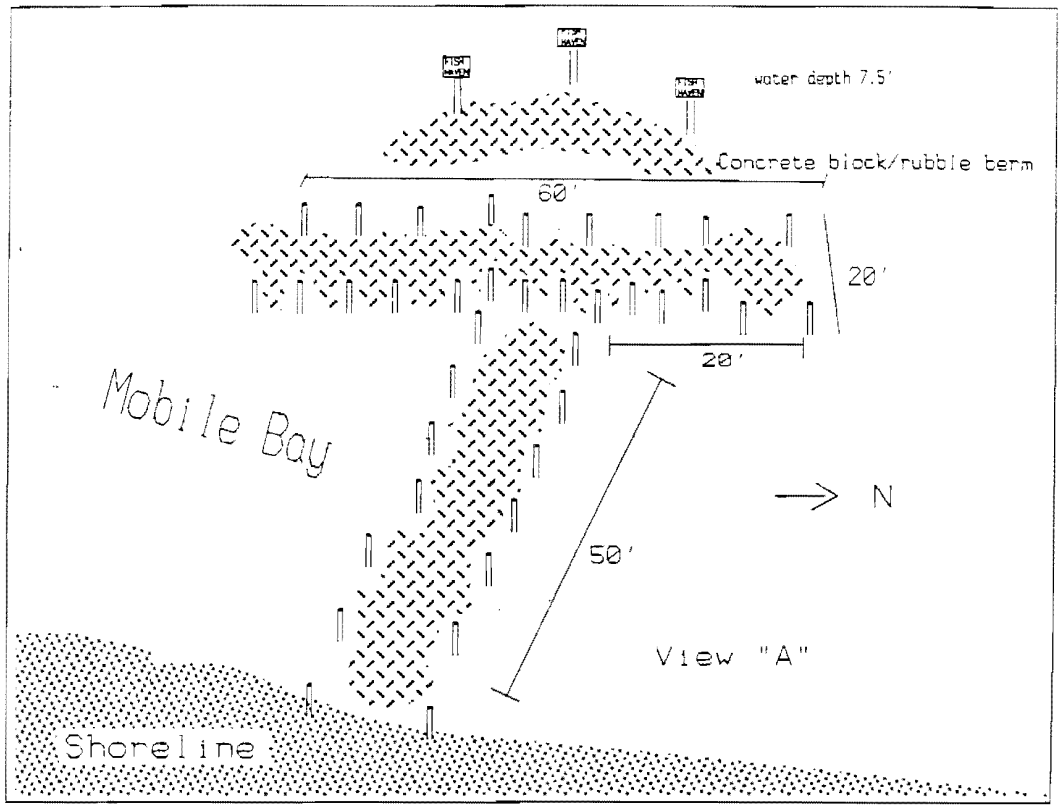


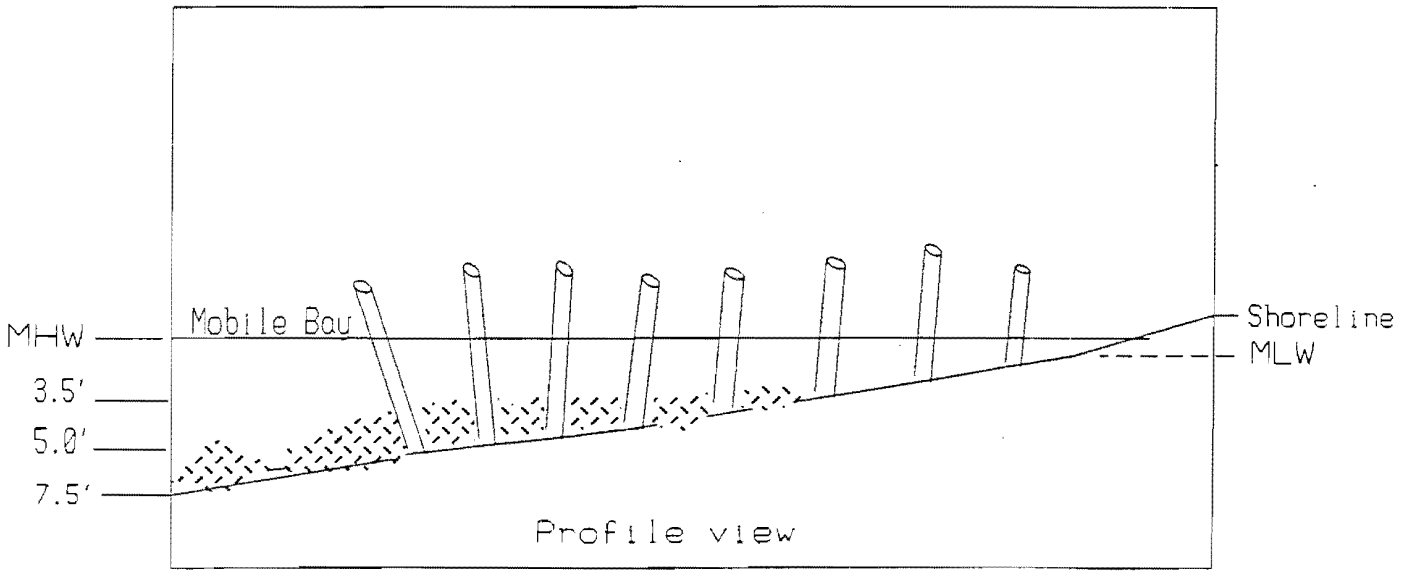

APPROVED DRAWING

# Zundel's Landing

South of Pt. Clear, AL

## Artificial Fishing Reef




Existing derelict pilings

Imperfect concrete block/concrete rubble

**APPROVED DRAWING**

Department of the Army

Mobile District, Corps of Engineers

Permit Number AL97-03786-U

Awarded to Alabama Marine Resources Division

October 23, 1997

**DEPARTMENT OF THE ARMY**
MOBILE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 2288
MOBILE, ALABAMA 36628-0001

October 23, 1997

REPLY TO
ATTENTION OF:

Regulatory Branch
Operations Division

SUBJECT: Permit for Minor Structures and Activities Within the State of Alabama - General Permit Number AL97-03786-U, Alabama Department of Conservation and Natural Resources

Alabama Department of Conservation
and Natural Resources
Marine Resources Division
Attention: Mr. Steven R. Heath
Post Office Box 189
Dauphin Island, Alabama 36528

Dear Mr. Heath:

Reference is made to your request for a Department of the Army permit to place up to 900 concrete slabs (35' x 5' x 1') to encircle a 3/8 mile diameter portion of Whitehouse Reef in Mobile Bay. The slabs will be placed in 10 feet of water and 8 feet of clearance shall be maintained over the slabs at mean low water. Oyster cultch material will be planted within the periphery of the reef. The perimeter of the project areas will be marked with pilings/radar reflectors and signage at 100 yard intervals. The purpose of the project is to provide a fishing reef/oyster reef enhancement.

Upon the recommendation of the Chief of Engineers and under provisions of Section 10 of the River and Harbor Act of 1899 (33 U.S.C. 403) and Section 404 of the Clean Water Act (33 U.S.C. 1344), authorization is hereby given by the Secretary of the Army for the performance of the work in accordance with the enclosed descriptions and plans, ENG Form 4336 and the Alabama General Permit ALG1392.

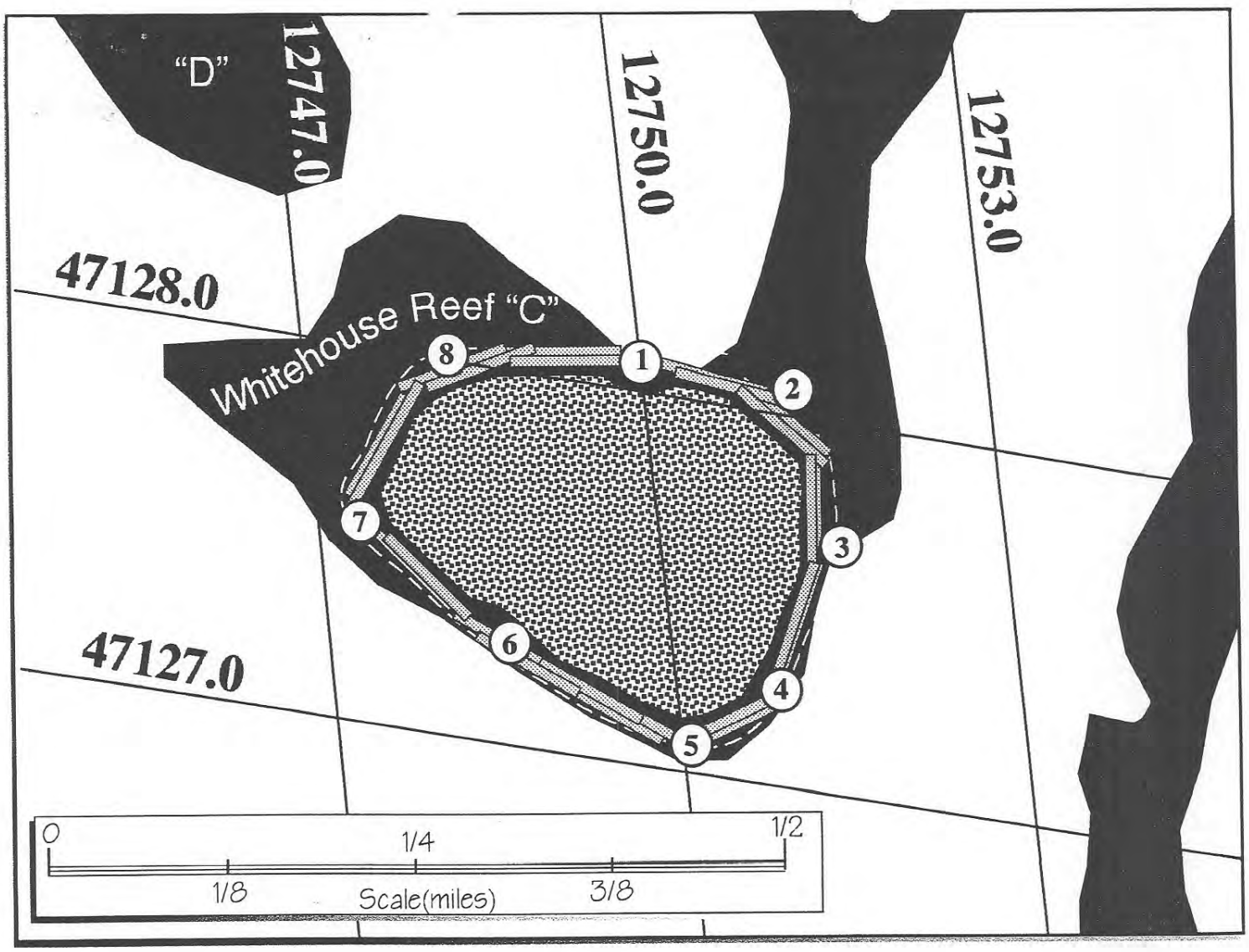
If the activity authorized herein is not completed on or before October 23, 2000, this permit, if not previously revoked or specifically extended, shall automatically expire.

BY AUTHORITY OF THE SECRETARY OF THE ARMY:

BY: _____
RONALD A. KRIZMAN
Chief, Regulatory Branch
Operations Division

WILLIAM S. VOGEL
Colonel, Corps of Engineers
District Engineer

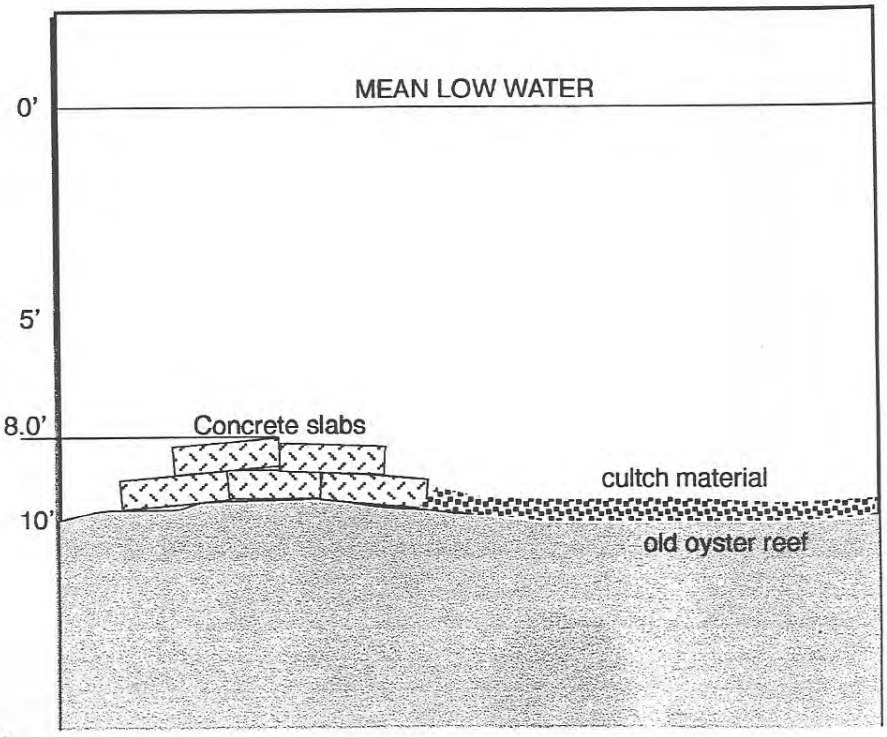
Enclosures




(5) Reef edge coordinates
– – – Approximate Reef Edges
Concrete slabs
Cultch Material

Loran C (7980) Edge Coordinates

| | |
|---|---|
| 1. | 12750.0 - 47128.2 |
| 2. | 12751.0 - 47128.3 |
| 3. | 12751.6 - 47127.6 |
| 4. | 12751.4 - 47127.6 |
| 5. | 12750.0 - 47127.0 |
| 6. | 12748.6 - 47127.3 |
| 7. | 12747.4 - 47127.6 |
| 8. | 12747.4 - 47128.1 |




APPROVED DRAWING

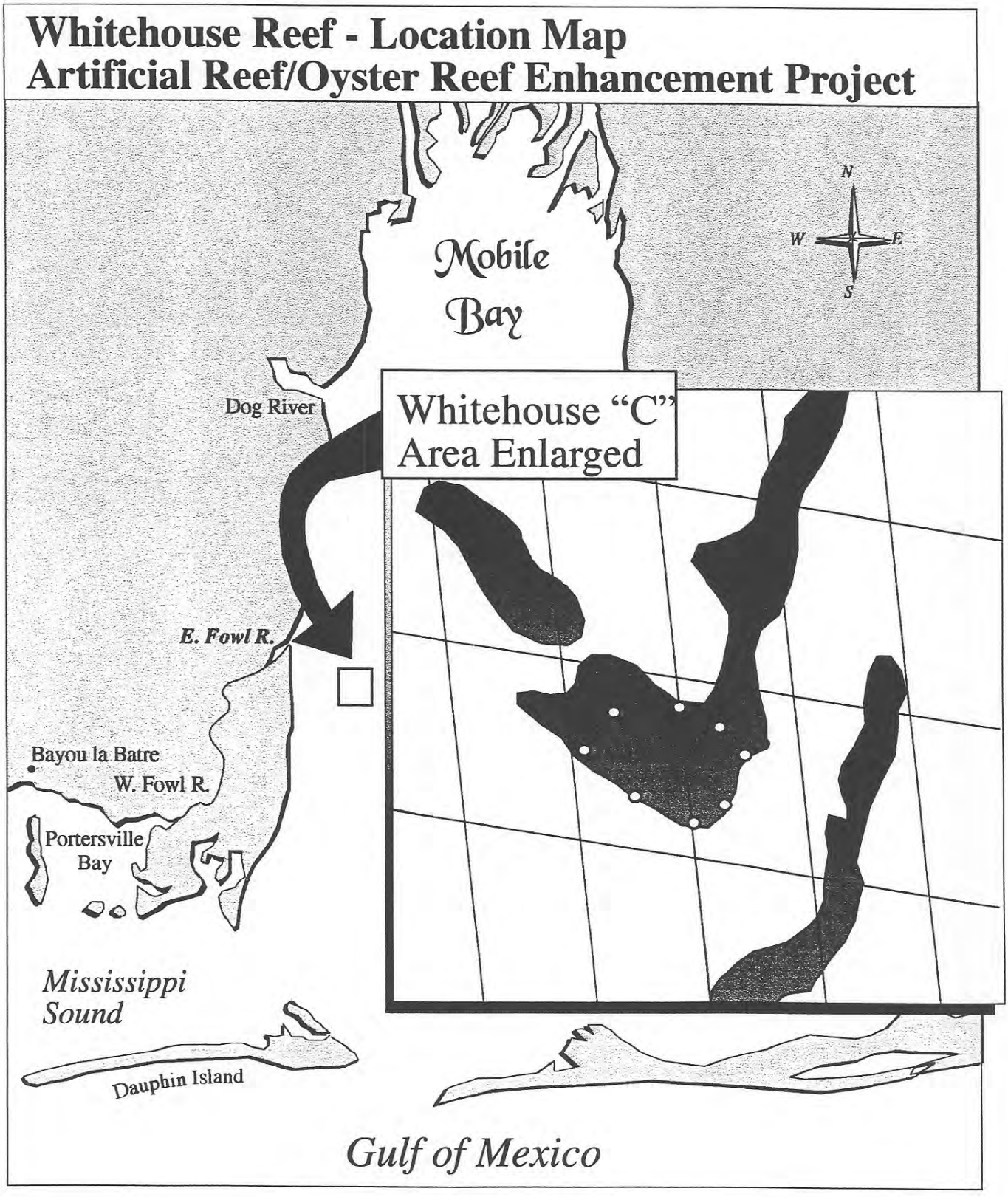



Figure 1

APPROVED DRAWING

Department of the Army

Mobile District, Corps of Engineers

Permit Number AL04-02429-V

Awarded to Alabama Marine Resources Division

March 9, 2005

BALDWIN CO. REEFS

DEPARTMENT OF THE ARMY
MOBILE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 2288
MOBILE, ALABAMA 36628-0001

March 9, 2005

REPLY TO
ATTENTION OF:

Regulatory Branch
Operations Division

SUBJECT: Department of the Army Final Permit Number AL04-02429-V, Alabama Department of Conservation and Nattural Ressources

Alabama Department of Conservation
and Natural Ressources
Marine Resources Division
Post Office Box 189
Dauphin Island, Alabama 36528

Gentlemen:

**PLEASE READ THIS LETTER CAREFULLY AND COMPLY WITH ITS PROVISIONS**

There is enclosed a Department of the Army permit authorizing you to perform the work specified therein in accordance with the plans shown on the drawings attached thereto. This permit is issued under provision of the Federal laws for the protection and preservation of the navigable waters of the United States. These laws provide that after the proposed work has been approved by issuance of a Department of the Army permit,

**IT SHALL NOT BE LAWFUL TO DEVIATE FROM SUCH PLANS EITHER BEFORE OR AFTER COMPLETION OF THE WORK,**

unless modification of said plans has previously been submitted to and received the approval of the Department of the Army.

You should study and carefully adhere to all the terms and conditions of the permit. The District must be notified of the commencement and completion of the permitted work. The enclosed cards may be used for that purpose. Also enclosed is a "NOTICE OF AUTHORIZATION" which must be conspicuously displayed at the site during construction of the permitted work. Any telephone inquiries relating to this permit should be directed to the Regulatory Branch, telephone number (251) 694-3788.

If for any reason it becomes necessary to make a material change in location or plans for this work, revised plans should be submitted promptly to the District Engineer in order that the revised plans may receive the approval required by law before work is begun.

Compliance with this and other conditions of the permit is essential. Failure to submit the notices requested may result in its revocation.

Sincerely,

Deborah J. Shoemake
Acting Chief, Regulatory Branch
Operations Division

Enclosures

DEPARTMENT OF THE ARMY PERMIT

Permittee: ALABAMA DEPARTMENT OF CONSERVATION & NATURAL RESOURCES

Permit No.: AL04-02429-V

Issuing Office: MOBILE DISTRICT

NOTE: The term "you" and its derivatives, as used in this permit, means the permittee or any future transferee. The term "this office" refers to the appropriate district or division office of the Corps of Engineers having jurisdiction over the permitted activity or the appropriate official of that office acting under the authority of the commanding officer.

You are authorized to perform work in accordance with the terms and conditions specified below.

Project Description: Construct four artificial fishing reefs in lower Perdido Bay and one reef in duel-purpose reef in eastern Bon Secour Bay in accordance with the enclosed plans and drawings.

Drawings:
1. Vicinity Map
2. Site Map
3. Bayou St. John Reef Profile/Plan View Map
4. Ono Island Reef Profile/Plan View Map
5. Rock Pile Reef Profile/Plan View Map
6. Ross Point Reef Profile/Plan View Map
7. Bon Secour Reef Profile/Plan View Map

Project Location: In lower Perdido Bay and eastern Bon Secour Bay, Baldwin County, Alabama.

Permit Conditions:

General Conditions:

1. The time limit for completing the work authorized ends on 9 March 2008. If you find that you need more time to complete the authorized activity, submit your request for a time extension to this office for consideration at least 1 month before the above date is reached.

2. You must maintain the activity authorized by this permit in good condition and in conformance with the terms and conditions of this permit. You are not relieved of this requirement if you abandon the permitted activity, although you may make a good faith transfer to a third party in compliance with General Condition 4 below. Should you wish to cease to maintain the authorized activity or should you desire to abandon it without a good faith transfer, you must obtain a modification of this permit from this office, which may require restoration of the area.

3. If you discover any previously unknown historic or archeological remains while accomplishing the activity authorized by this permit, you must immediately notify this office of what you have found. We will initiate the Federal and State coordination required to determine if the remains warrant a recovery effort or if the site is eligible for listing in the National Register of Historic Places.

4. If you sell the property associated with this permit, you must obtain the signature of the new owner in the space provided and forward a copy of the permit to this office to validate the transfer of this authorization.

5. If a conditioned water quality certification has been issued for your project, you must comply with the conditions specified in the certification as special conditions to this permit. For your convenience, a copy of the certification is attached if it contains such conditions.

6. You must allow representatives from this office to inspect the authorized activity at any time deemed necessary to ensure that it is being or has been accomplished in accordance with the terms and conditions of your permit.

Special Conditions:

-- The permittee understands and agrees that, if future operations of the United States require removal, relocation, or other alteration, of the structures or work herein authorized, or if, in the opinion of the Secretary of the Army or his authorized representative, said structures or work shall cause unreasonable obstruction to the free navigation of the navigable waters, the permittee shall be required, upon due notice from the U.S. Army Corps of Engineers, to remove, relocate, or alter the structural work or obstructions caused thereby, without expense to the United States. No claim shall be made against the United States on account of any such removal or alteration.

Further Information:

1. Congressional Authorities: You have been authorized to undertake the activity described above pursuant to Section 10 of the Rivers and Harbors Act of 1899 (33 U.S.C. 403) and Section 404 of the Clean Water Act (33 U.S.C. 1344).

2. Limits of this authorization.

a. This permit does not obviate the need to obtain other Federal, State, or local authorizations required by law.

b. This permit does not grant any property rights or exclusive privileges.

c. This permit does not authorize any injury to the property or rights of others.

d. This permit does not authorize interference with any existing or proposed Federal project.

3. Limits of Federal Liability. In issuing this permit, the Federal Government does not assume any liability for the following:

a. Damages to the permitted project or uses thereof as a result of other permitted or unpermitted activities or from natural causes.

b. Damages to the permitted project or uses thereof as a result of current or future activities undertaken by or on behalf of the United States in the public interest.

c. Damages to persons, property, or to other permitted or unpermitted activities or structures caused by the activity authorized by this permit.

d. Design or construction deficiencies associated with the permitted work.

e. Damage claims associated with any future modification, suspension, or revocation of this permit.

4. Reliance on Applicant's Data: The determination of this office that issuance of this permit is not contrary to the public interest was made in reliance on the information you provided.

5. Reevaluation of Permit Decision. This office may reevaluate its decision on this permit at any time the circumstances warrant. Circumstances that could require a reevaluation include, but are not limited to, the following:

a. You fail to comply with the terms and conditions of this permit.

b. The information provided by you in support of your permit application proves to have been false, incomplete, or inaccurate (See 4 above).

c. Significant new information surfaces which this office did not consider in reaching the original public interest decision.

Such a reevaluation may result in a determination that it is appropriate to use the suspension, modification, and revocation procedures contained in 33 CFR 325.7 or enforcement procedures such as those contained in 33 CFR 326.4 and 326.5. The referenced enforcement procedures provide for the issuance of an administrative order requiring you to comply with the terms and conditions of your permit and for the initiation of legal action where appropriate. You will be required to pay for any corrective measures ordered by this office, and if you fail to comply with such directive, this office may in certain situations (such as those specified in 33 CFR 209.170) accomplish the corrective measures by contract or otherwise and bill you for the cost.

6. Extensions. General condition 1 establishes a time limit for the completion of the activity authorized by this permit. Unless there are circumstances requiring either a prompt completion of the authorized activity or a reevaluation of the public interest decision, the Corps will normally give favorable consideration to a request for an extension of this time limit.

Your signature below, as permittee, indicates that you accept and agree to comply with the terms and conditions of this permit.

R. Vernon Minton ALAS — 3-7-05

(PERMITTEE) — (DATE)

ALABAMA DEPARTMENT OF CONSERVATION
AND NATURAL RESOURCES
MARINE RESOURCES DIVISION
POST OFFICE BOX 189
DAUPHIN ISLAND, ALABAMA 36528

This permit becomes effective when the Federal official, designated to act for the Secretary of the Army, has signed below.

PETER F. TAYLOR, JR.
COLONEL, CORPS OF ENGINEERS
(DISTRICT ENGINEER)

BY: Deborah J. Shoemake 9 March 05

DEBORAH J. SHOEMAKE (DATE)
ACTING CHIEF, REGULATORY BRANCH
OPERATIONS DIVISION

When the structures or work authorized by this permit are still in existence at the time the property is transferred, the terms and conditions of this permit will continue to be binding on the new owner(s) of the property. To validate the transfer of this permit and the associated liabilities associated with compliance with its terms and conditions, have the transferee sign and date below.

(TRANSFEREE) — (DATE)

**This notice of authorization must be conspicuously displayed at the site of work.**

United States Army Corps of Engineers

A permit to perform work authorized by statutes and regulations of the Department of the Army

at Perdido Bay/Bon Secour Bay, Baldwin Co., AL (CONSTRUCT FISHING REEFS)

has been issued to ADCNR on 9 Mar 05

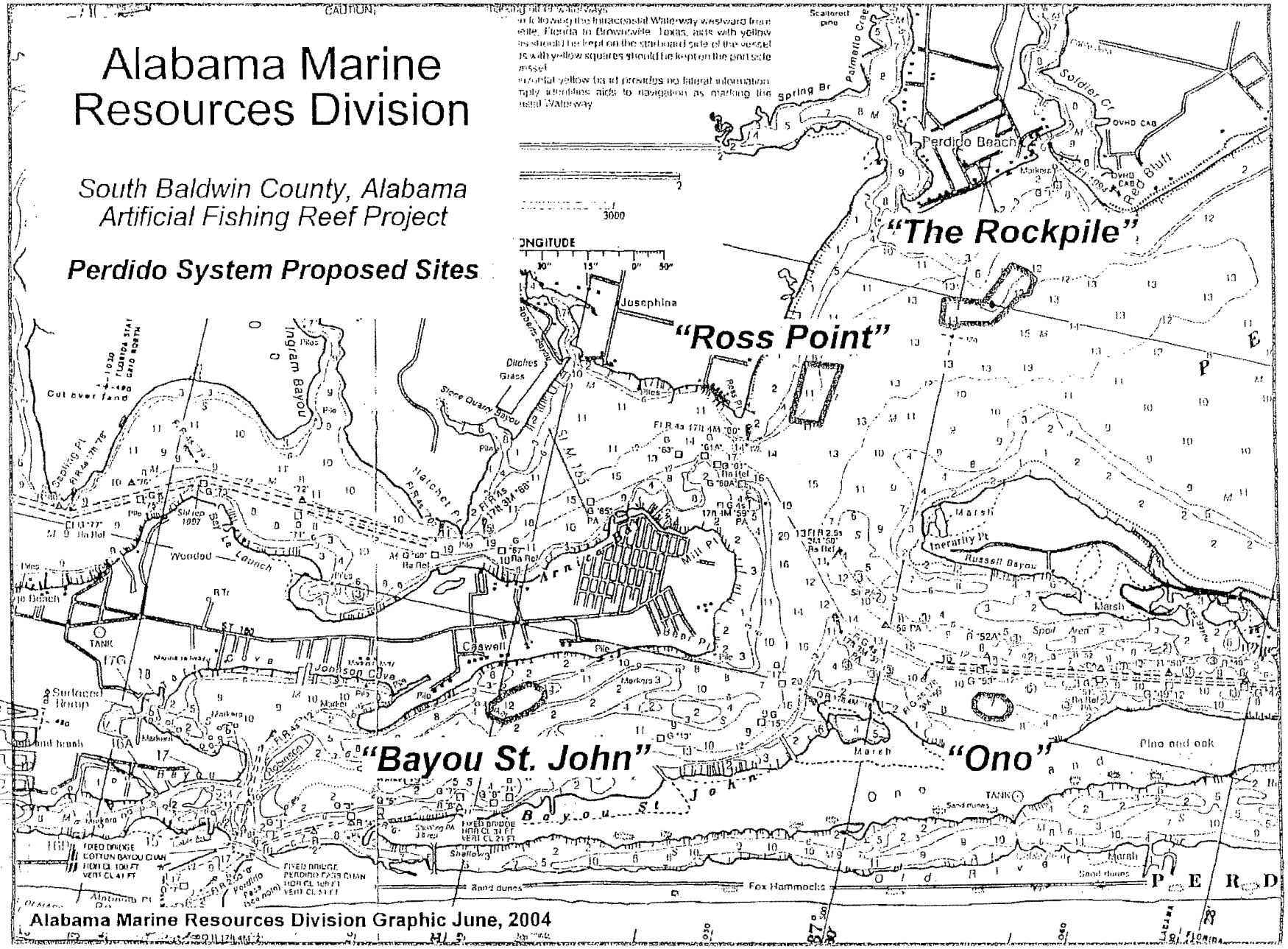
Address of Permittee PO Box 189, Dauphin Island, AL 36528

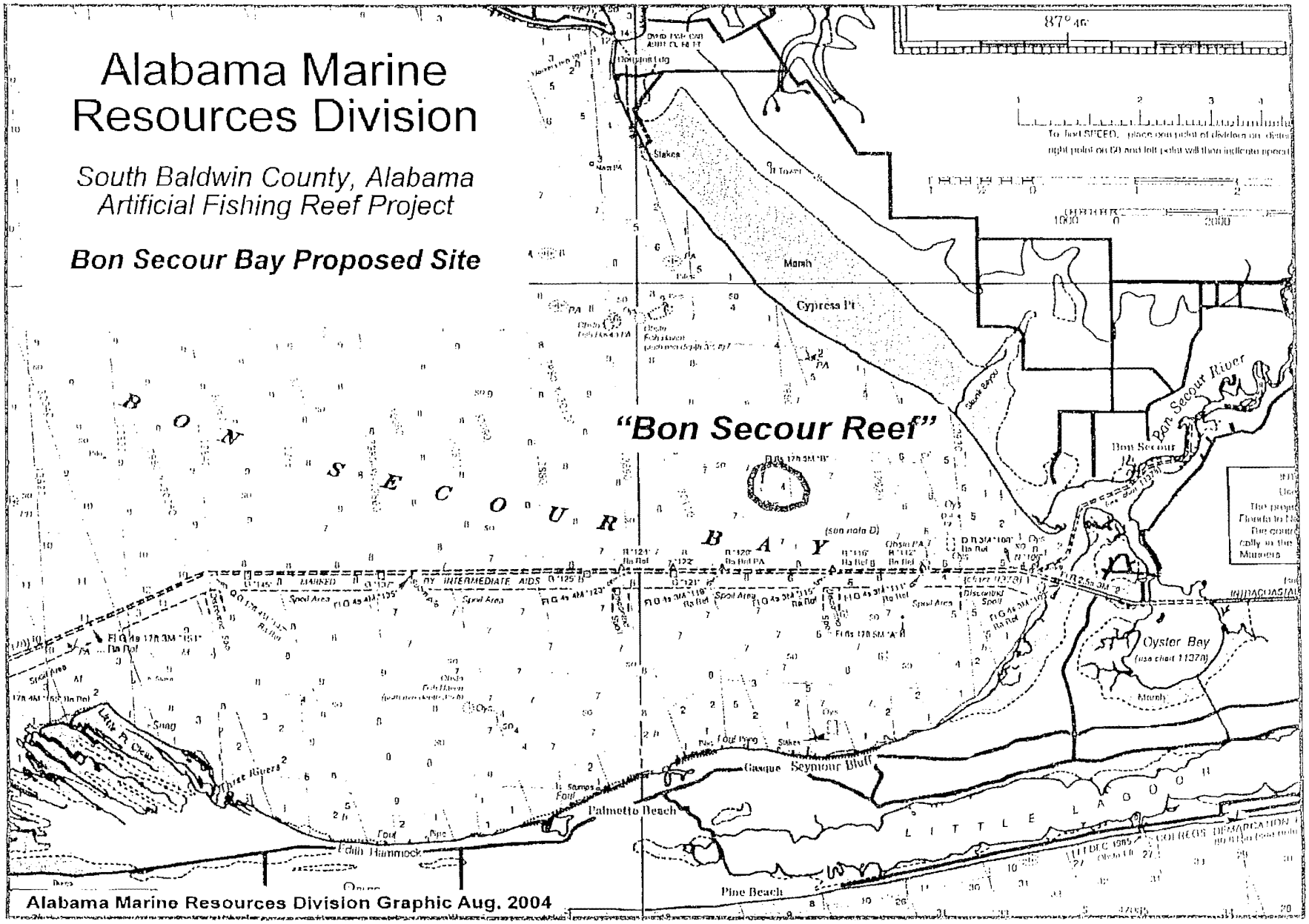
Permit Number

AL04-02429-V

For the District Commander
DEBORAH J. SHOEMAKE, ACT CH, OP-S
Operations Division

ENG FORM 4336, Jul 81 (33 CFR 320-330) EDITION OF JUL 70 MAY BE USED (Proponent: CECW-O)


Alabama Marine Resources Division
South Baldwin County, Alabama
Artificial Fishing Reef Project
Perdido System Proposed Sites
"The Rockpile"
"Ross Point"
"Bayou St. John"
"Ono"
Perdido Beach
Josephina
Alabama Marine Resources Division Graphic June, 2004


Alabama Marine Resources Division
South Baldwin County, Alabama
Artificial Fishing Reef Project
Bon Secour Bay Proposed Site
"Bon Secour Reef"
BON SECOUR BAY
Bon Secour River
Oyster Bay
Cypress Pt
Marsh
Stakes
Gasque
Seymour Bluff
Palmetto Beach
Pine Beach
LITTLE LAGOON
Alabama Marine Resources Division Graphic Aug. 2004

# Bayou St. John Reef

*Location:*

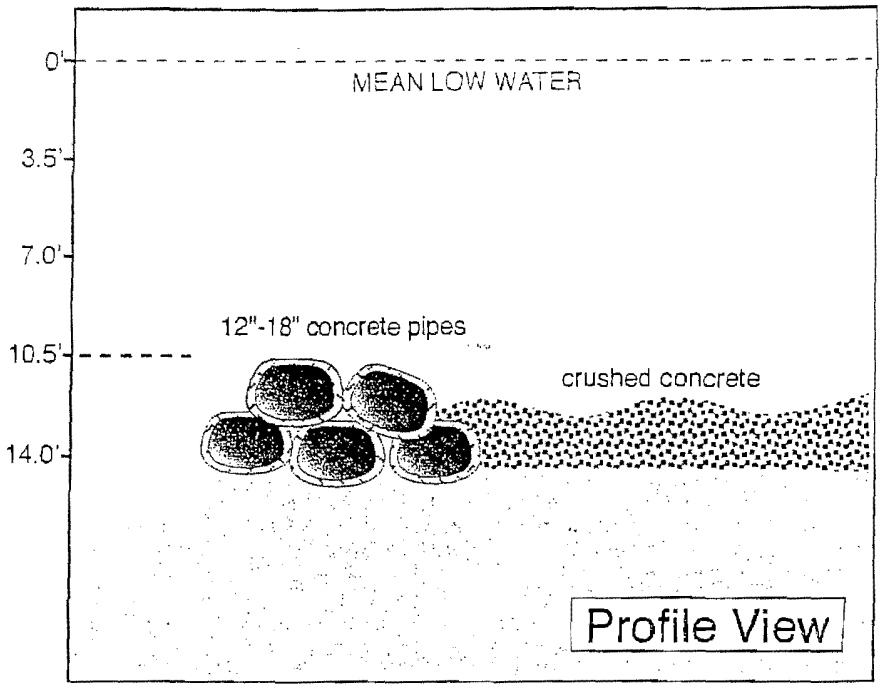
30° 17.563' N Lat.
87° 31.958 W Lon.

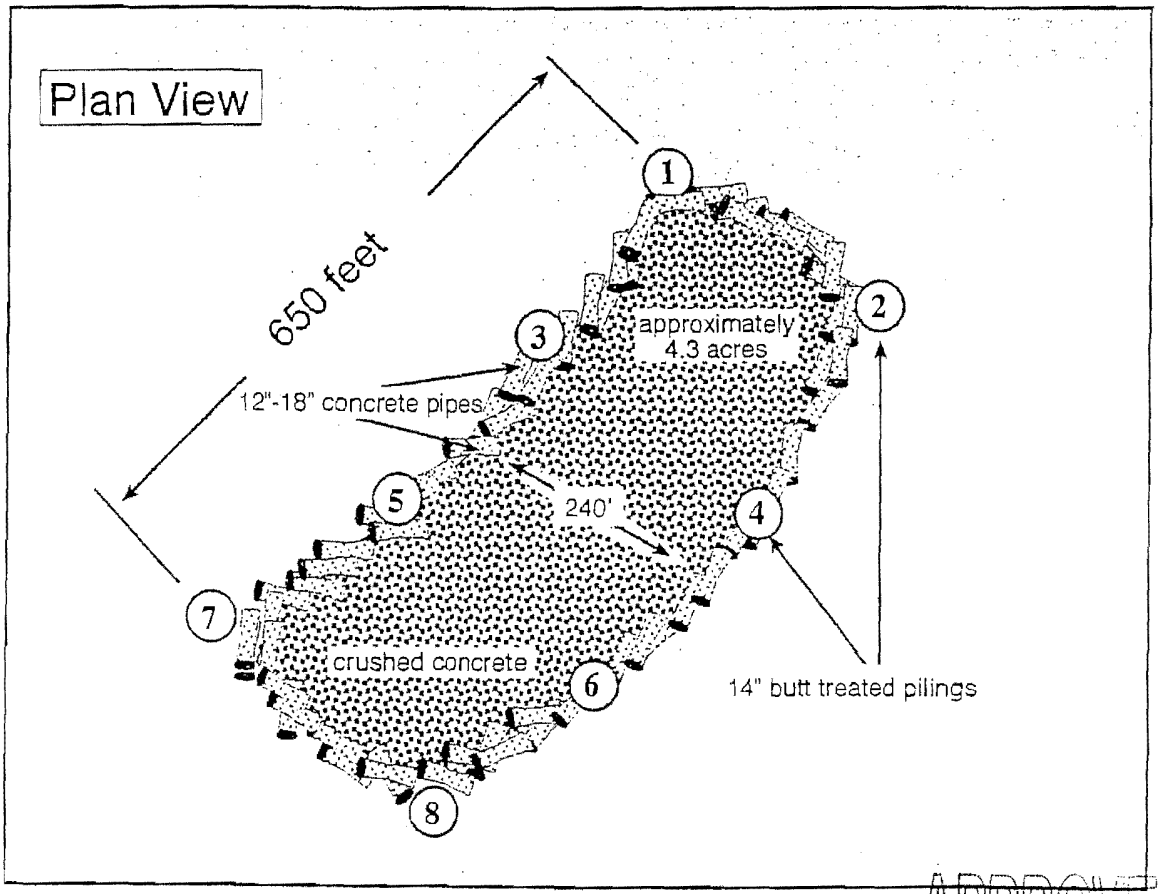
*Materials:*

*Perimeter:*
Clean, small-diameter concrete pipe, or similar concrete rubble with size suitable for long-term stability, placed in a fencing arrangement around the perimeter of the reef

*Interior:*
Clean, crushed concrete, variously sized, distributed more or less evenly throughout the interior of the reef

*Marker Pilings:*
New, 14-inch butt, 35-foot long, treated wooden pilings, installed as indicated with approximately 10 feet visible above the waterline, with Coast Guard-approved radar reflective signage




APPRO

# Ono Island Reef

*Location:*

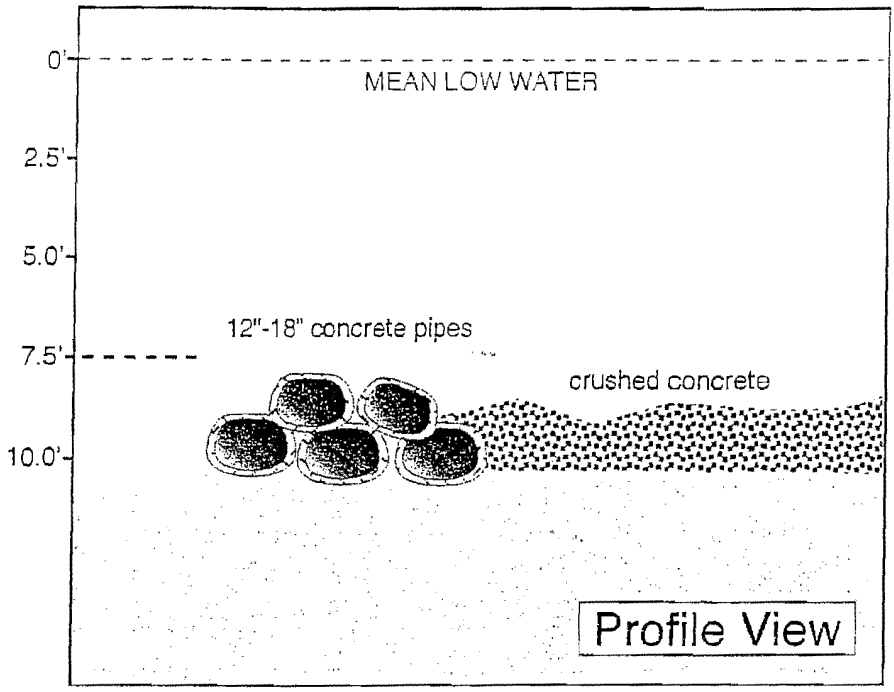
30° 18.167' N Lat.
87° 29.404' W Lon.

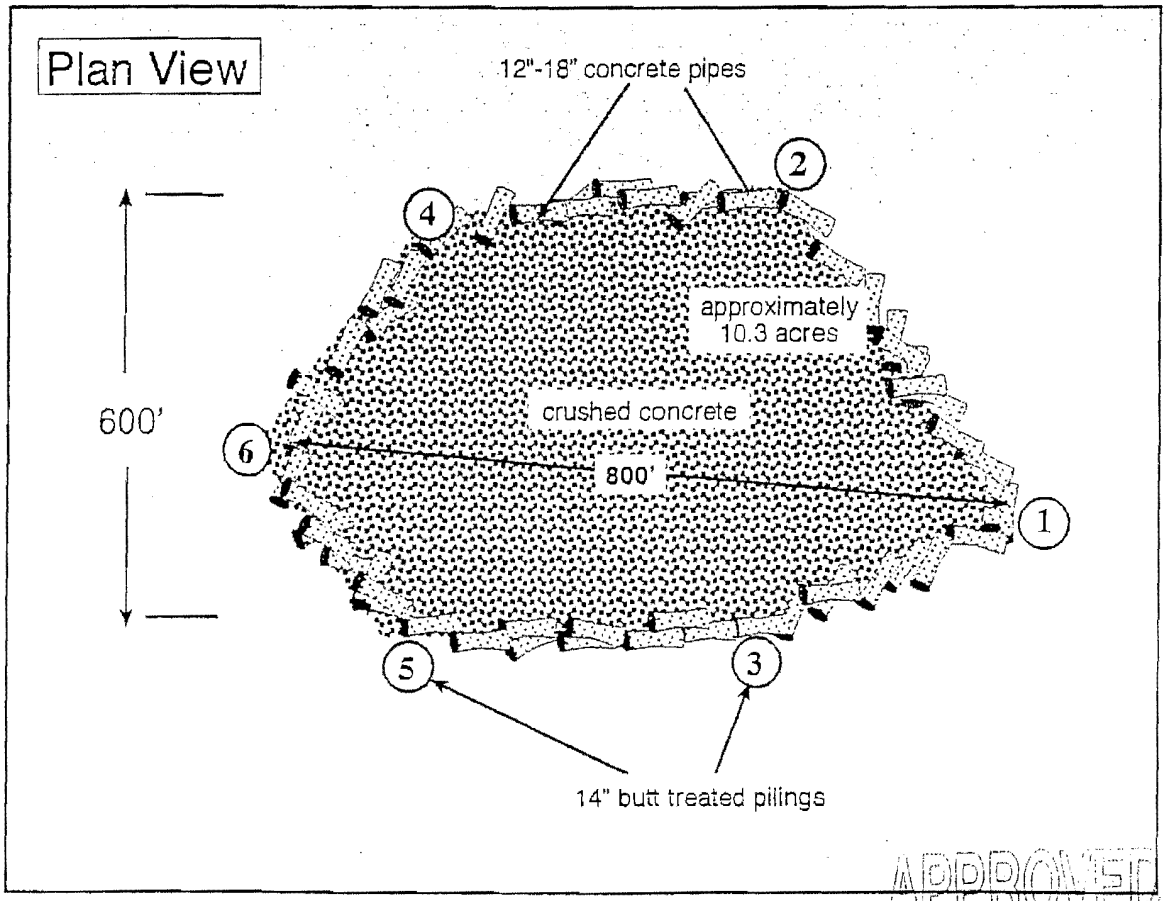
*Materials:*

*Perimeter:*
Clean, small-diameter concrete pipe, or similar concrete rubble with size suitable for long-term stability, placed in a fencing arrangement around the perimeter of the reef

*Interior:*
Clean, crushed concrete, variously sized, distributed more or less evenly throughout the interior of the reef

*Marker Pilings:*
New, 14-inch butt, 35-foot long, treated wooden pilings, installed as indicated with approximately 10 feet visible above the waterline, with Coast Guard-approved radar-reflective signage




APPROVED

# *Rock Pile Reef*

*Location:*

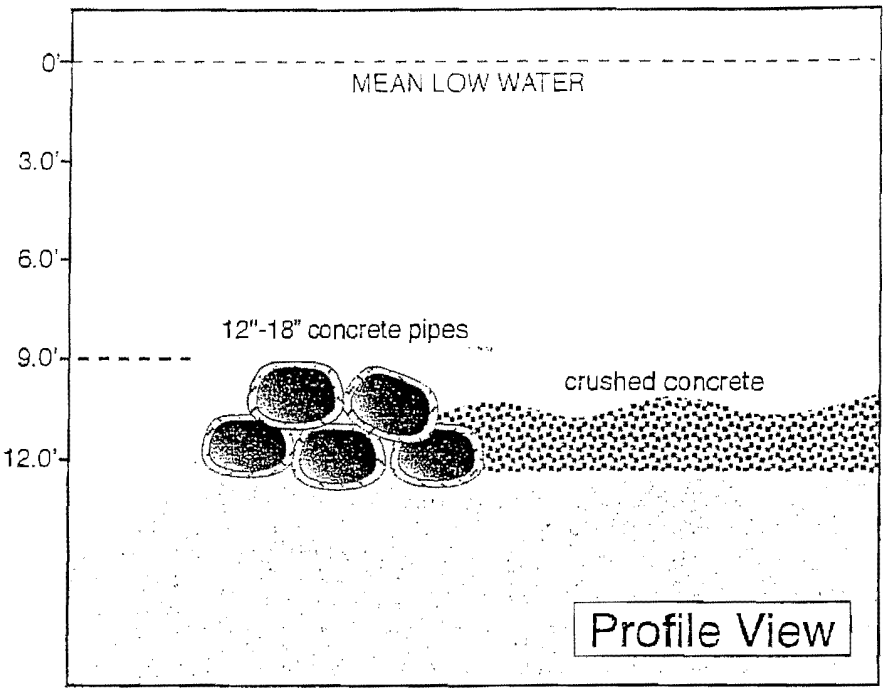
30° 20.048' N Lat.
87° 29.853' W Lon.

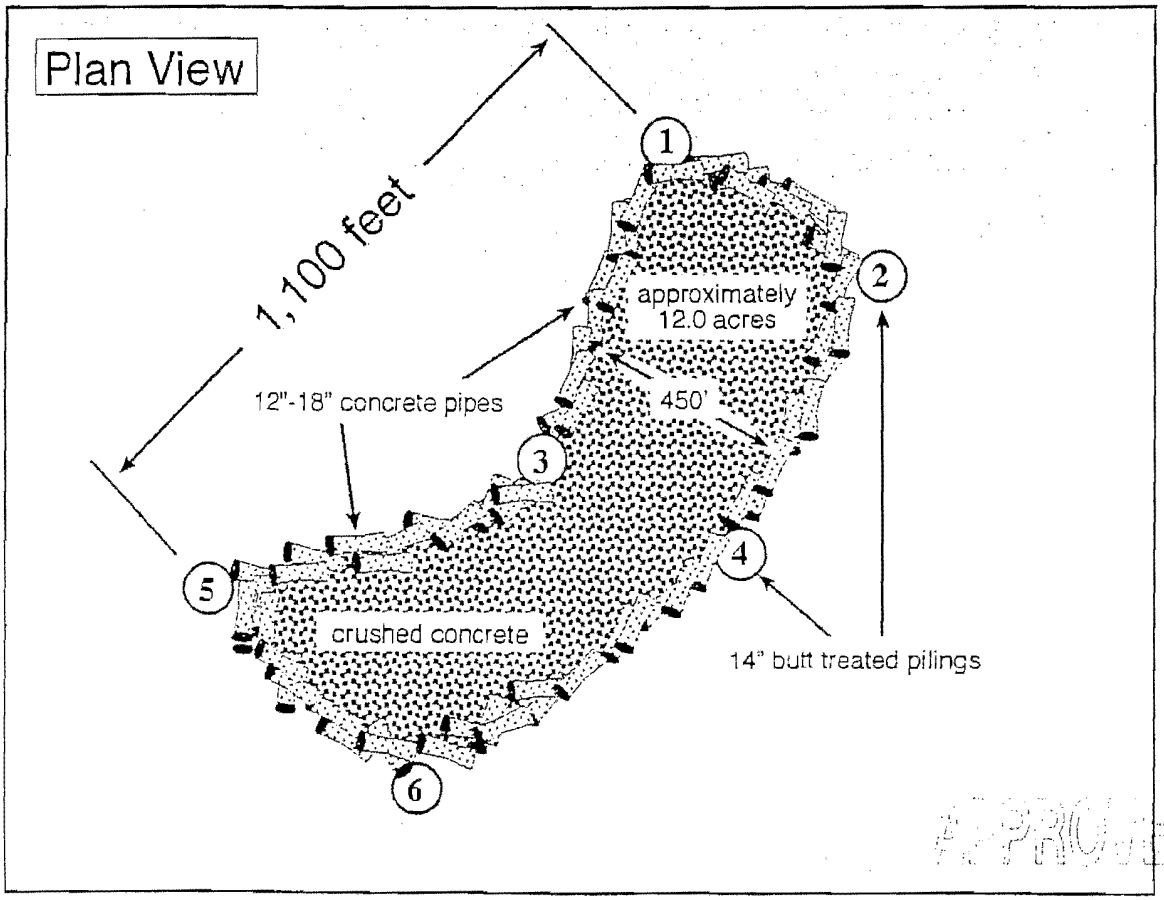
*Materials:*

*Perimeter:*
Clean, small-diameter concrete pipe, or similar concrete rubble with size suitable for long-term stability, placed in a fencing arrangement around the perimeter of the reef

*Interior:*
Clean, crushed concrete, variously sized, distributed more or less evenly throughout the interior of the reef

*Marker Pilings:*
New, 14-inch butt, 35-foot long, treated wooden pilings, installed as indicated with approximately 10 feet visible above the waterline, with Coast Guard-approved radar-reflective signage



# Ross Point Reef

*Location:*

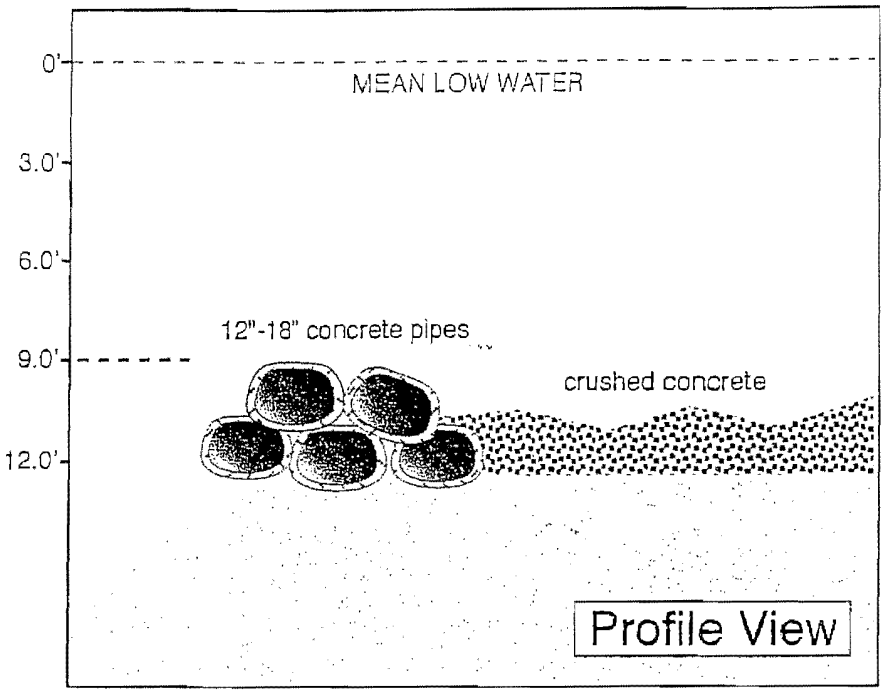
30° 19.436' N Lat.
87° 30.668' W Lon.

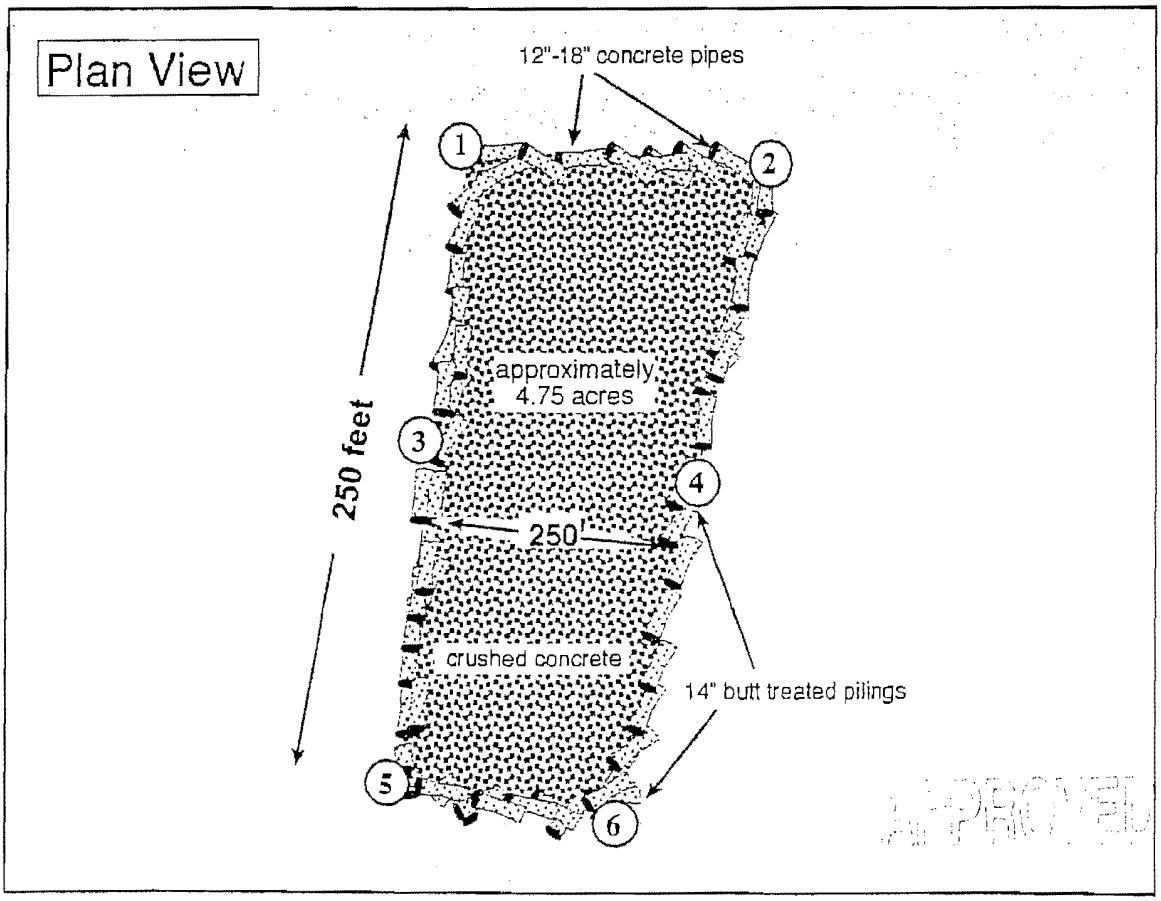
*Materials:*

*Perimeter:*
Clean, small-diameter concrete pipe, or similar concrete rubble with size suitable for long-term stability, placed in a fencing arrangement around the perimeter of the reef

*Interior:*
Clean, crushed concrete, variously sized, distributed more or less evenly throughout the interior of the reef

*Marker Pilings:*
New, 14-inch butt, 35-foot long, treated wooden pilings, installed as indicated with approximately 10 feet visible above the waterline, with Coast Guard-approved radar-reflective signage



# Bon Secour Reef

*Location:*

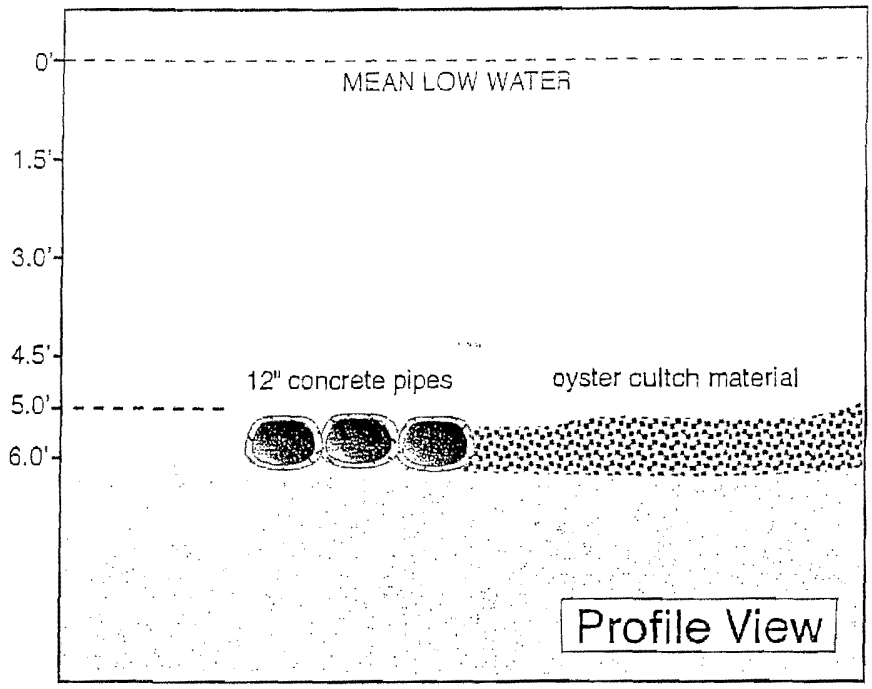
30° 17.944' N Lat.
87° 48.318' W Lon.

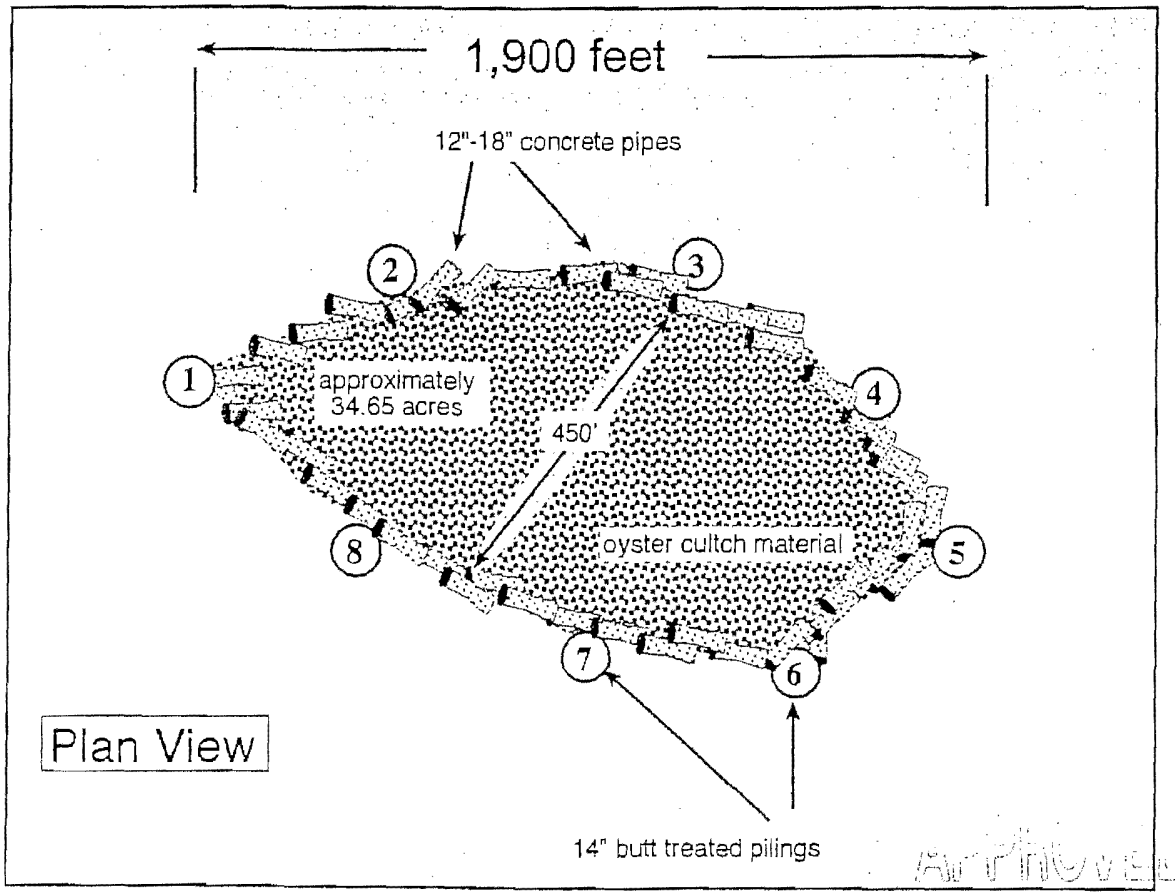
*Materials:*

*Perimeter:*
Clean, small-diameter concrete pipe, or similar concrete rubble with size suitable for long-term stability, placed in a fencing arrangement around the perimeter of the reef

*Interior:*
Oyster cultch material consisting crushed concrete, crushed limestone, oyster shell or archaeological coral distributed more or less evenly throughout the interior of the reef

*Marker Pilings:*
New, 14-inch butt, 35-foot long, treated wooden pilings, installed as indicated with approximately 10 feet visible above the waterline, with Coast Guard-approved radar-reflective signage



Department of the Army

Mobile District, Corps of Engineers

Permit Number SAM-2006-787-JAM

Awarded to Alabama Marine Resources Division

September 7, 2006

DEPARTMENT OF THE ARMY
MOBILE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 2288
MOBILE, AL 36628-0001

REPLY TO
ATTENTION OF

7 September, 2006

Coastal Branch
Regulatory Division

SUBJECT: Letter of Permission, Department of the Army Permit Number SAM-2006-787-JAM, State of Alabama, Department of Conservation and Natural Resources, Marine Resources Division.

State of Alabama,
Department of Conservation and Natural Resources
Attn: James J. Duffy Marine Resources Division
P.O. Box 189
Dauphin Island, AL 36528

Dear Mr. Duffy:

Reference is made to your request for a Department of the Army permit to include and enhance an unmarked hazard to navigation, locally, known as the "Upper Wreck," in the Mullet Point/Weeks Bay area, into the inshore artificial fishing reef program. Specifically, this site is located in Baldwin County, Alabama.

Upon the recommendation of the Chief of Engineers and under the provisions of Section 10 of the River and Harbor Act of 1899 (33 U.S.C. 403), you are hereby authorized by the Secretary of the Army to perform this work in accordance with your submitted data and plans, the enclosed General Conditions and the following Special Conditions:

a. Only clean concrete rubble will be used for reef enhancement.

b. The site will include marker pilings equipped with radar/light reflective signage and will be maintained by your agency in perpetuity.

The District Engineer shall be notified in writing of the commencement and completion of the work. The enclosed cards may be used for that purpose. Also enclosed is Notice of Authorization which must be posted at the site during construction of the permitted work.

If the activity authorized herein is not completed on or before 7 September, 2011, this permit, if not previously revoked or specifically extended, shall automatically expire.

BY AUTHORITY OF THE SECRETARY OF THE ARMY:

BY: Jason Steele

PETER F. TAYLOR, JR.
Colonel, Corps of Engineers
District Commander

JASON STEELE
Coastal Branch, Team Leader
Regulatory Division

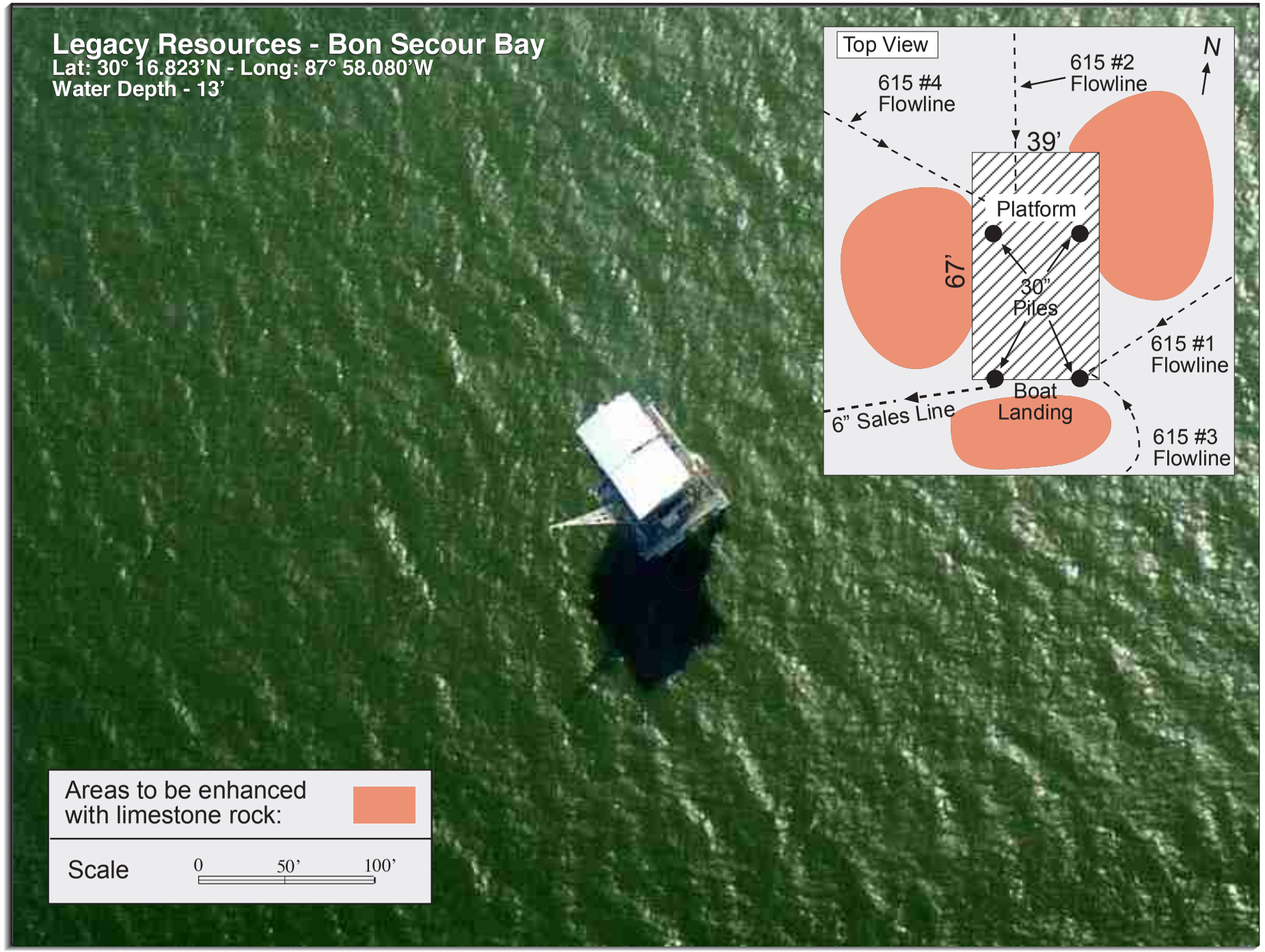
# Shelby Center for Ecosystem Based Fisheries Management

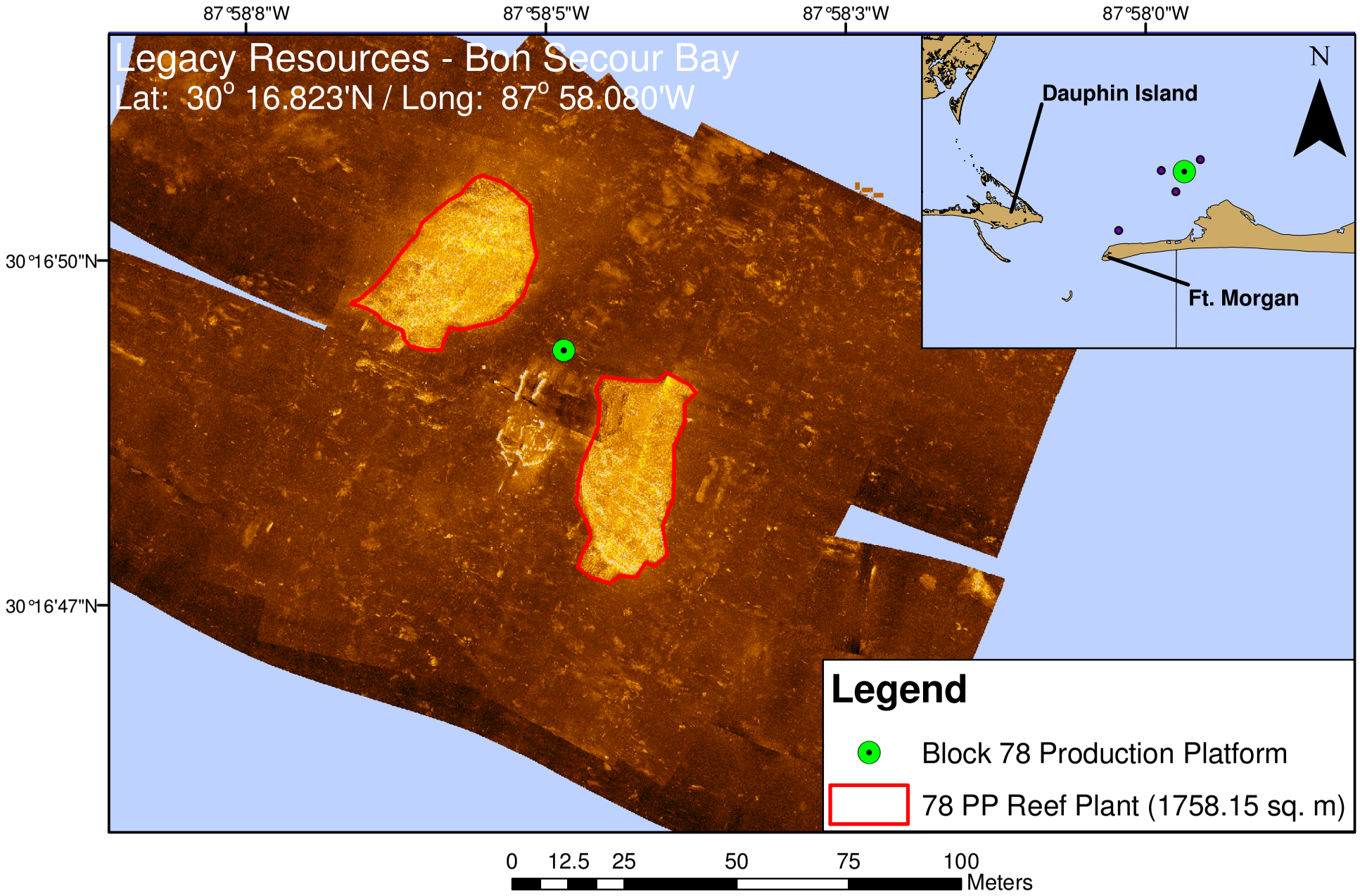
# Side-Scan Mosiacs of Legacy Platforms Reefing Project

June 2011

# Legacy Resources - Bon Secour Bay

**Lat: 30° 16.823'N - Long: 87° 58.080'W**
**Water Depth - 13'**



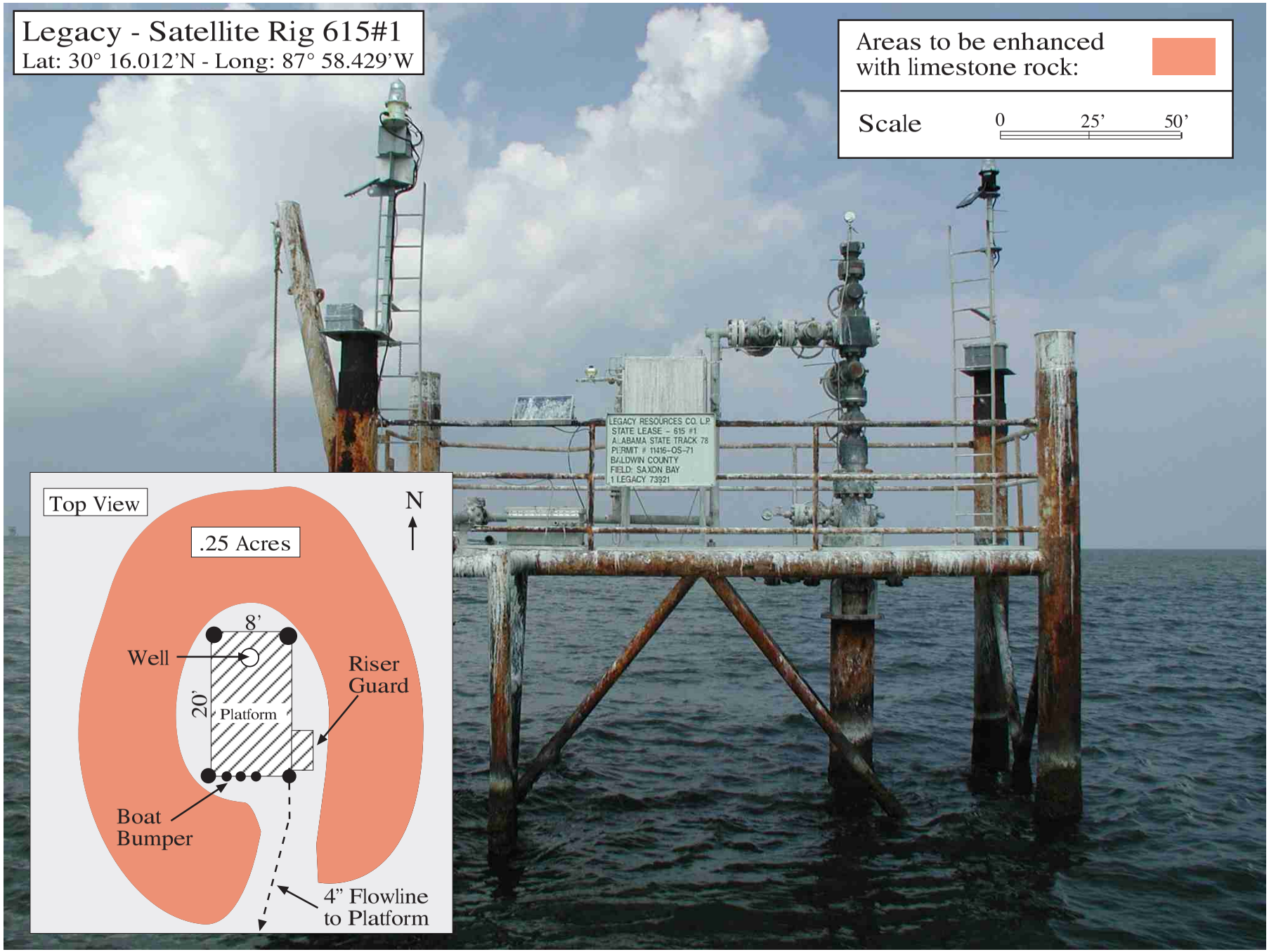


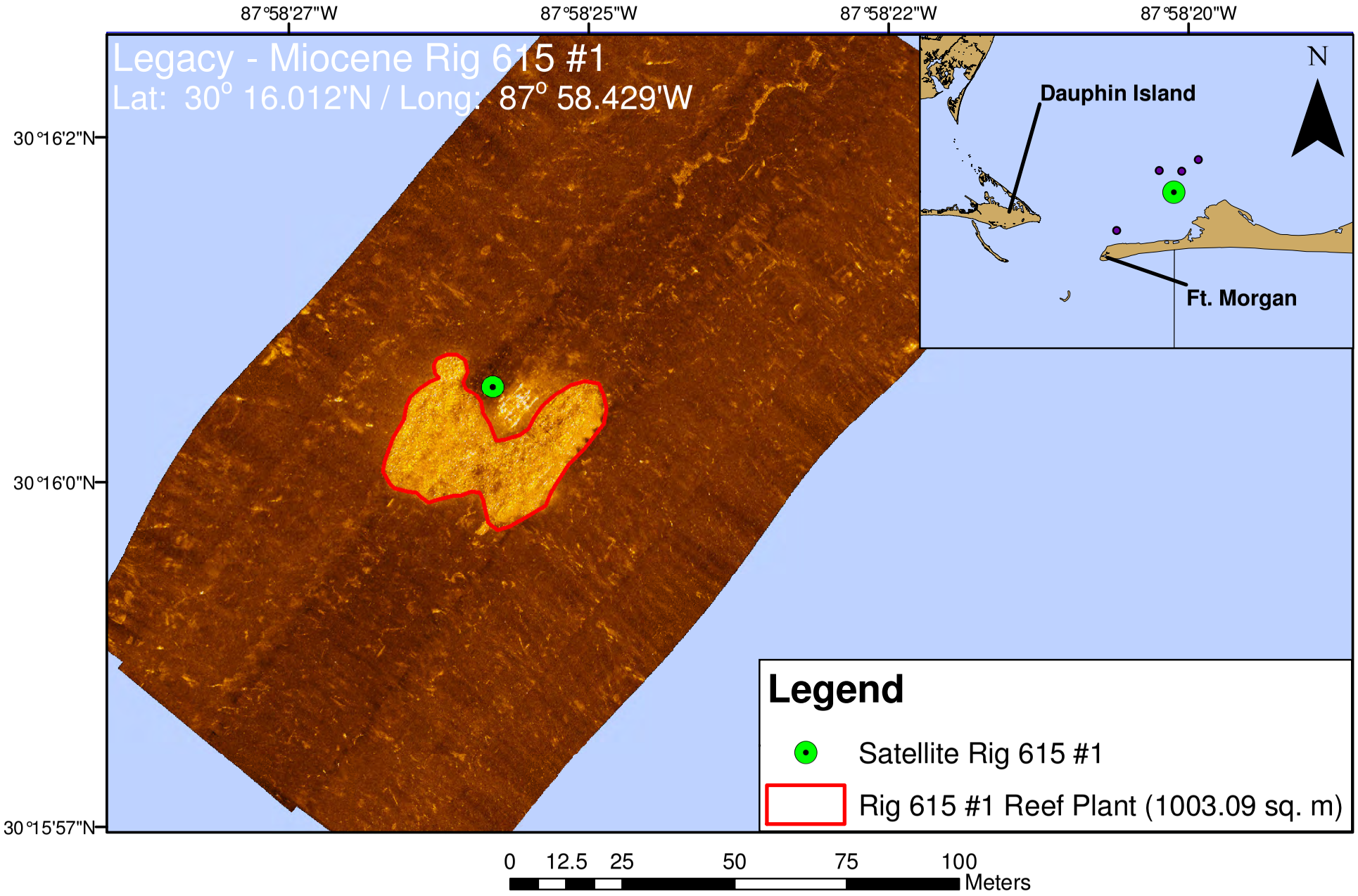

**Fisheries Ecology Lab**
**Shelby Center for Ecosystem Based Fisheries Managment**

Sean P. Powers and Stan Bosarge

Permission required for reproduction or publication

Map Projection: WGS 1984 UTM 16N


Legacy - Satellite Rig 615#1
Lat: 30° 16.012'N - Long: 87° 58.429'W
Areas to be enhanced with limestone rock:
Scale
0
25'
50'
LEGACY RESOURCES CO. L.P.
STATE LEASE – 615 #1
ALABAMA STATE TRACK 78
PERMIT # 11416-OS-71
BALDWIN COUNTY
FIELD: SAXON BAY
1 LEGACY 73921
Top View
N
.25 Acres
8'
20'
Platform
Well
Riser Guard
Boat Bumper
4" Flowline to Platform

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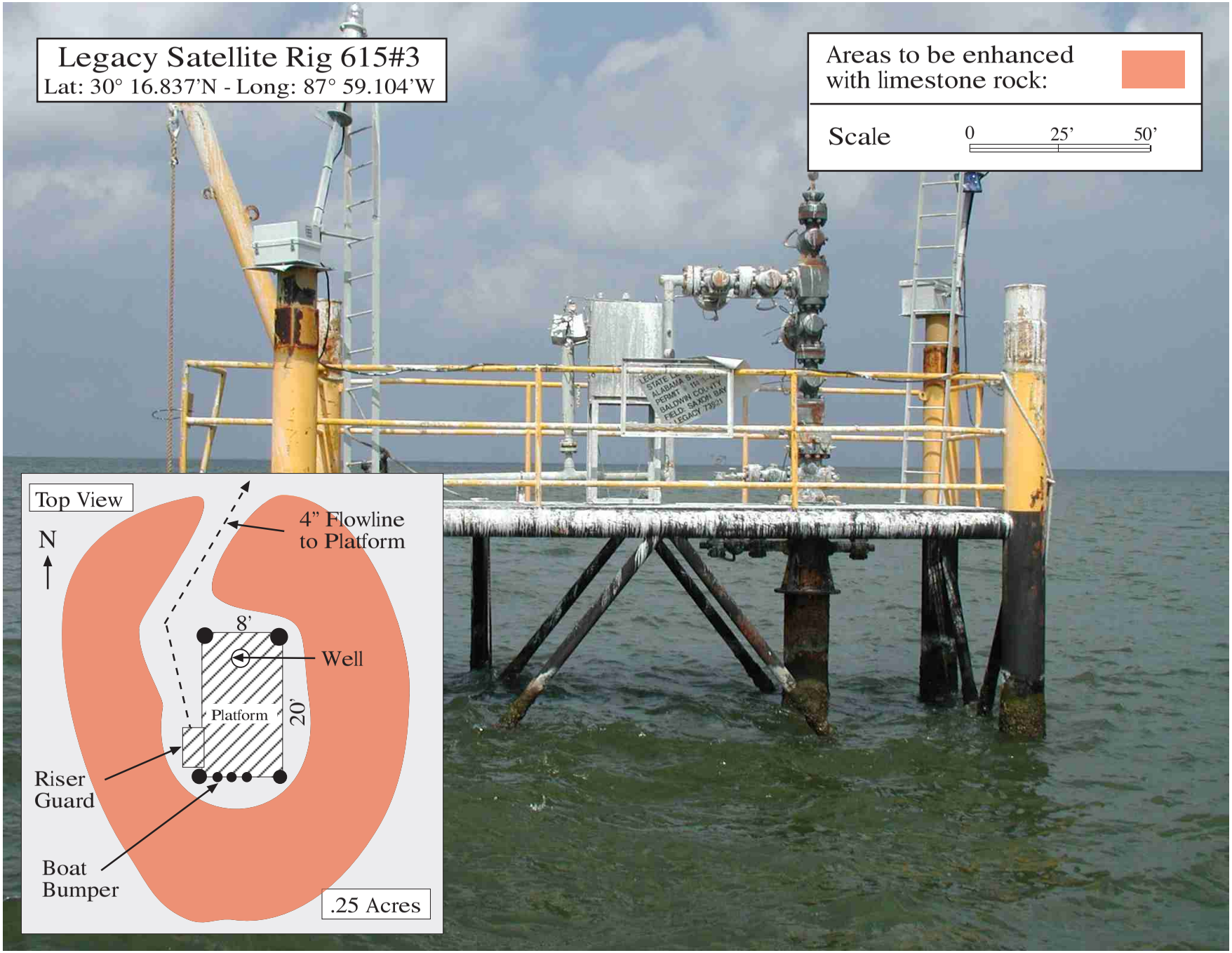
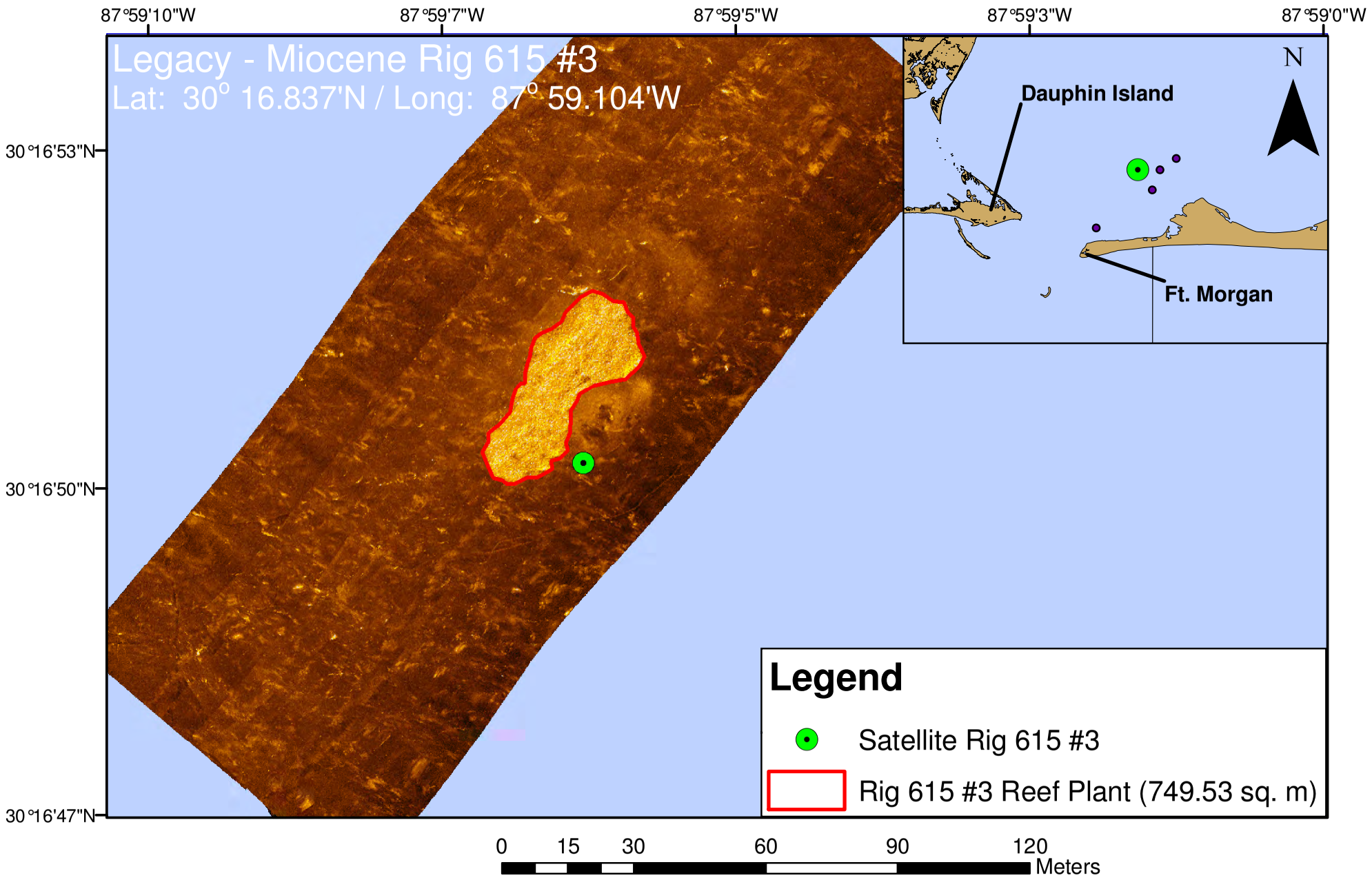

Legacy Satellite Rig 615#3
Lat: 30° 16.837'N - Long: 87° 59.104'W
Areas to be enhanced with limestone rock:
Scale
0
25'
50'
Top View
N
4" Flowline to Platform
8'
Well
Platform
20'
Riser Guard
Boat Bumper
.25 Acres

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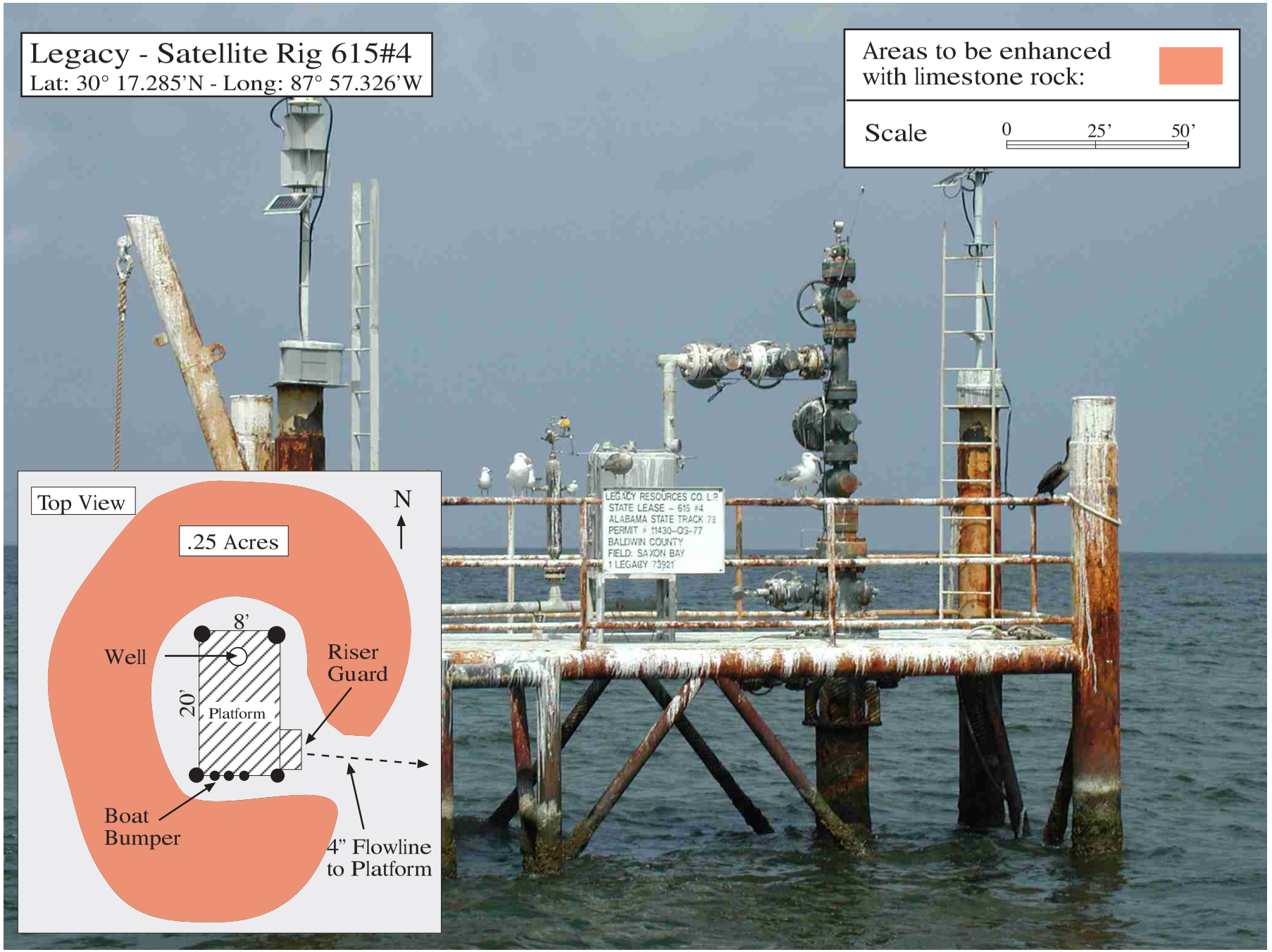
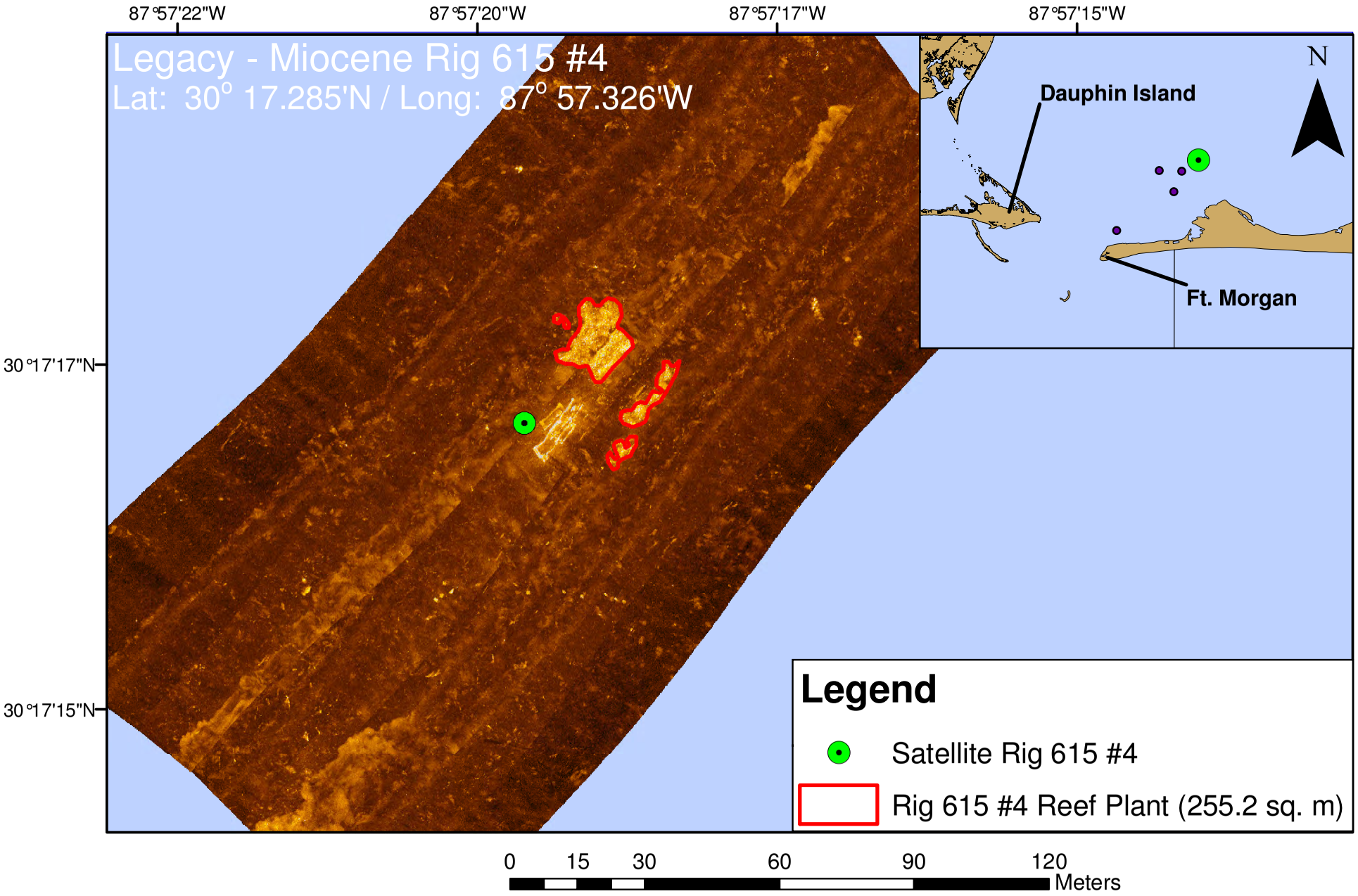
Map Projection: WGS 1984 UTM 16N


Legacy - Satellite Rig 615#4
Lat: 30° 17.285'N - Long: 87° 57.326'W
Areas to be enhanced with limestone rock:
Scale
0
25'
50'
Top View
N
.25 Acres
8'
20'
Platform
Well
Riser Guard
Boat Bumper
4" Flowline to Platform
LEGACY RESOURCES CO. L.P.
STATE LEASE – 615 #4
ALABAMA STATE TRACK 73
PERMIT # 11430-OG-77
BALDWIN COUNTY
FIELD: SAXON BAY
1 LEGACY 73921




**Fisheries Ecology Lab**
**Shelby Center for Ecosystem Based Fisheries Managment**
Sean P. Powers and Stan Bosarge
Permission required for reproduction or publication
Map Projection: WGS 1984 UTM 16N

Robert Bentley
GOVERNOR

N. Gunter Guy, Jr.
COMMISSIONER

Curtis Jones
DEPUTY COMMISSIONER

**STATE OF ALABAMA**
**DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES**
**MARINE RESOURCES DIVISION**
POST OFFICE BOX 189
DAUPHIN ISLAND, ALABAMA 36528
TEL (251861-2882
FAX (251) 861-8741
amrddi@gulftel.com

*Our mission is to manage the State's marine fishery resources through research, enforcement, and education for the maximum benefit of the resources and the citizens of Alabama.*

Christopher M. Blankenship
Director
MARINE RESOURCES DIVISION

# Department of Conservation and Natural Resources

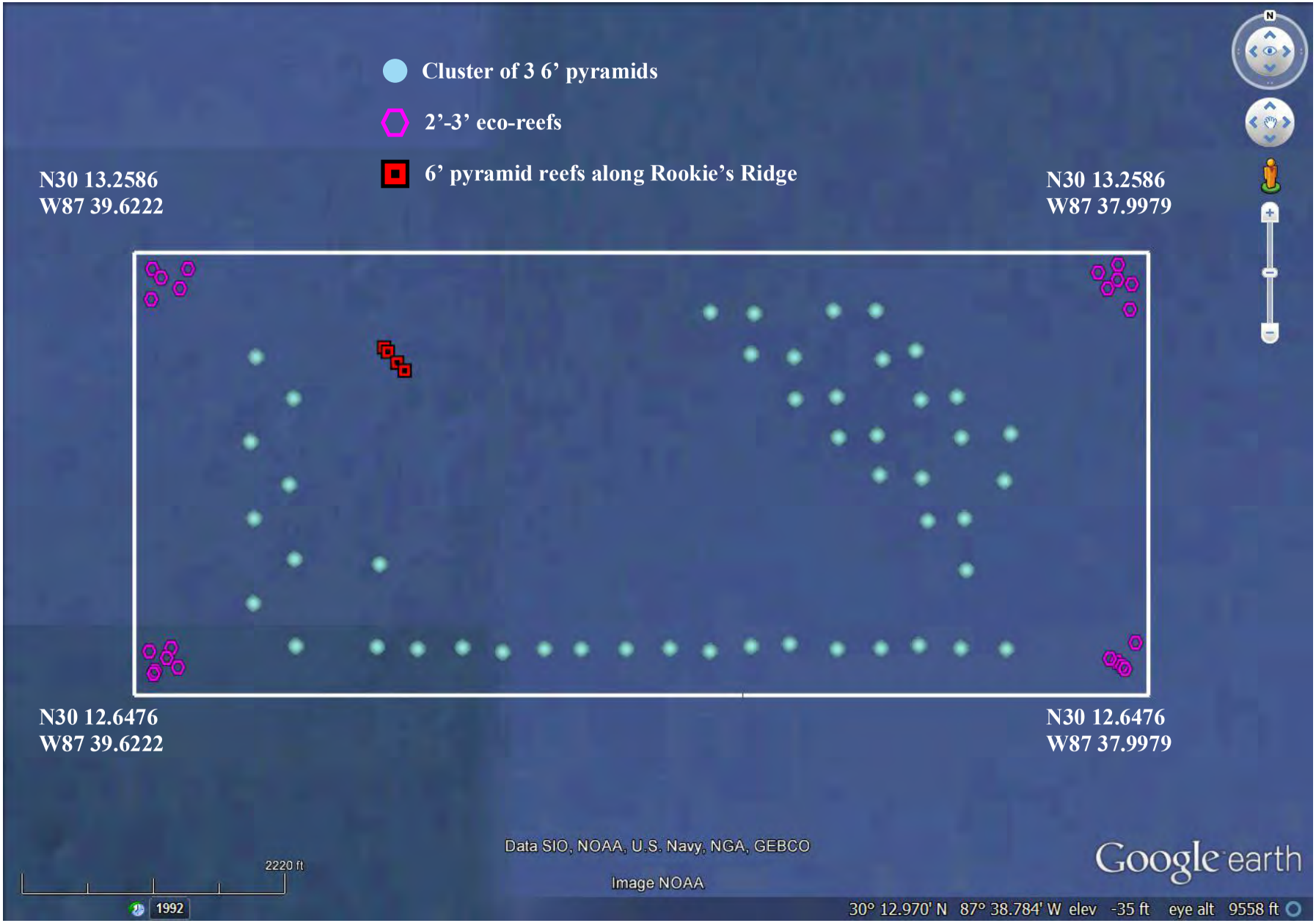
# Marine Resources Division

# Nearshore Reef Program

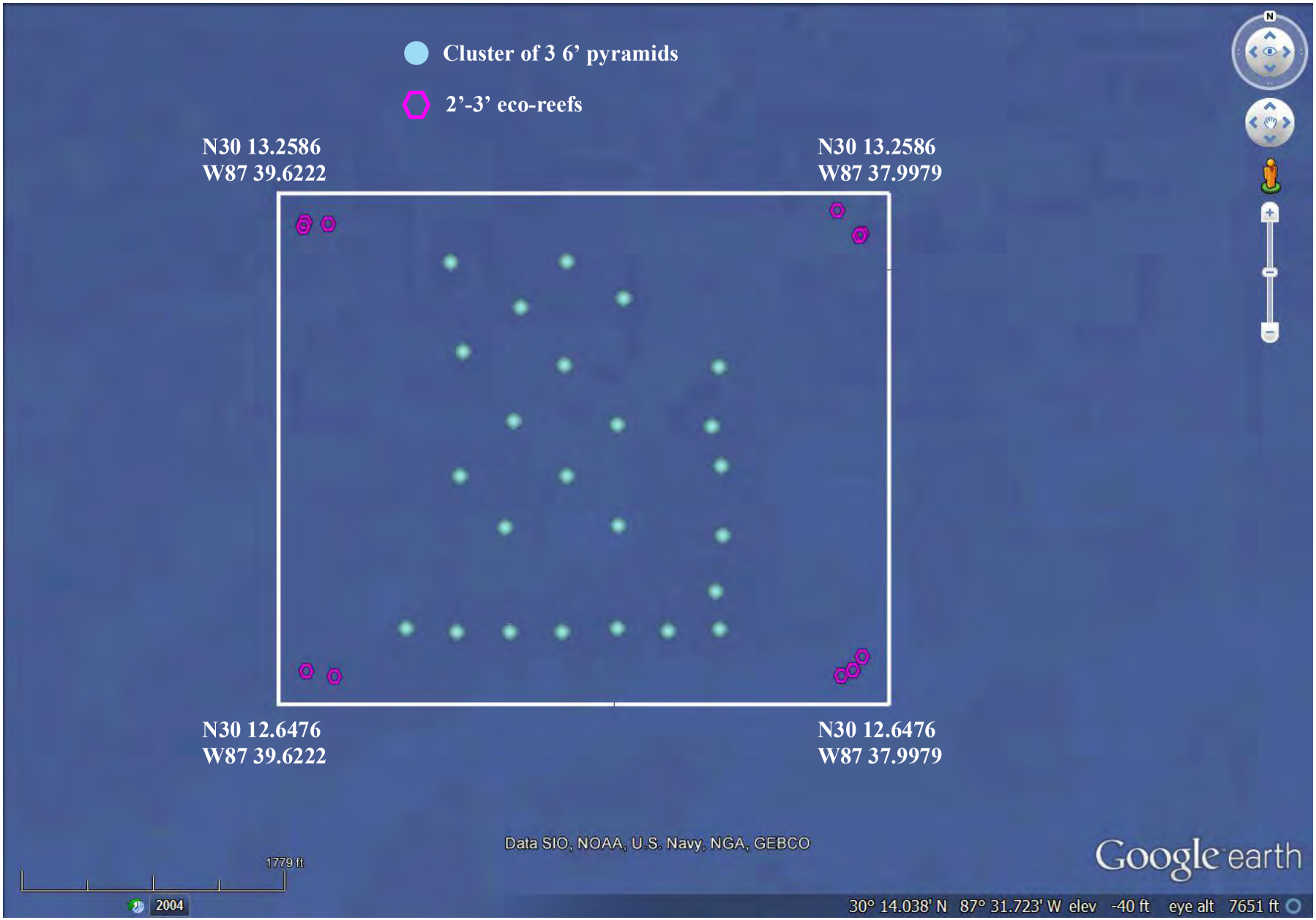
The Department of Conservation and Natural Resources does not discriminate on the basis of race, color, religion, age gender, national origin, or disability in its hiring practices nor in admission to, access to, or operations of its programs, services, or activities.
www.outdooralabama.com

Location of the two nearshore reef zones permitted by United States Army Corps of Engineers permit #SAM-2010-0505-DEM

Location of 6’ pyramid reef clusters and 2’-3’ eco-reefs deployed within the R V Minton West Artificial Reef Zone. One hundred and forty-four 6’ pyramids were deployed in clusters of 3 pyramids per cluster to create 48 reef clusters and twenty-two low relief eco-reefs were deployed within the corners of the R V Minton West Artificial Reef Zone.

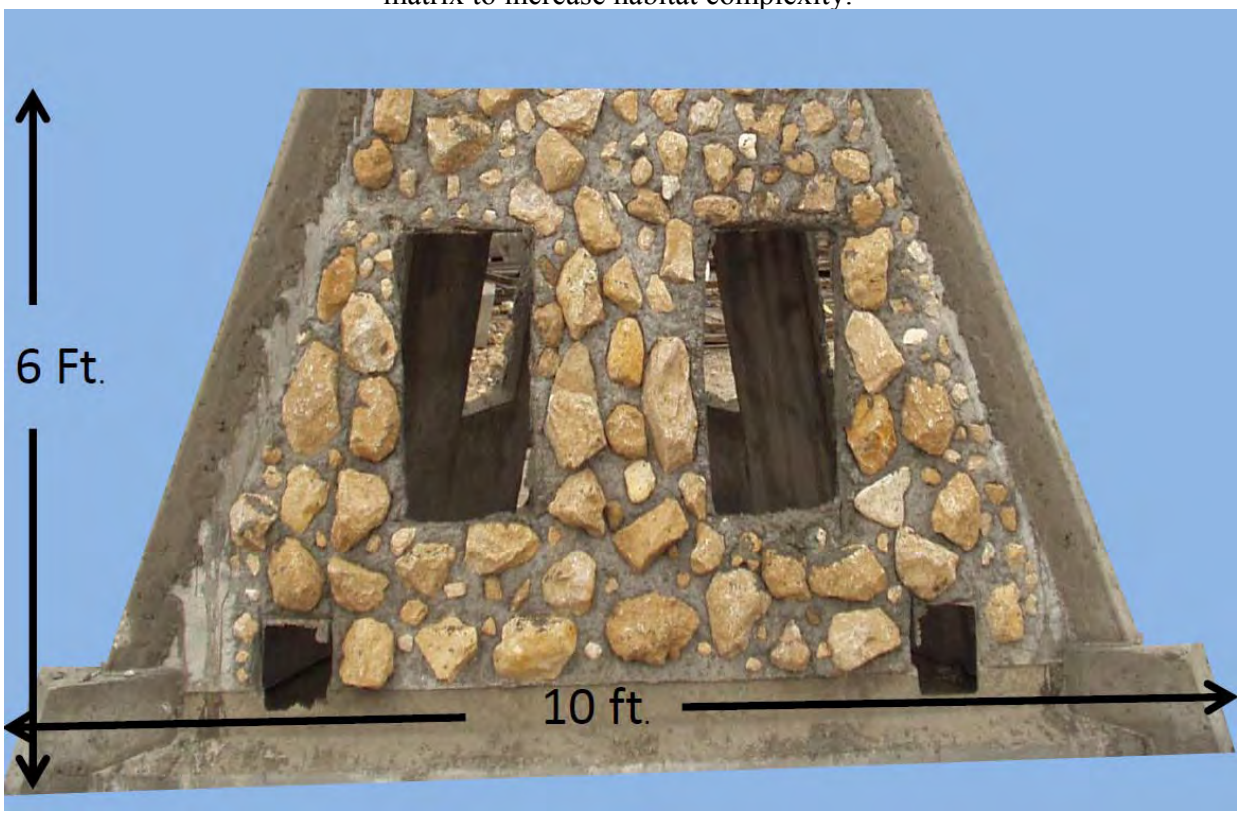


Location of 6’ pyramid reef clusters and 2’-3’ eco-reefs deployed within the R V Minton East Artificial Reef Zone. Seventy-two 6’ pyramids were deployed in clusters of 3 pyramids per cluster to create 24 reef clusters and twelve low relief eco-reefs were deployed within the corners of the R V Minton East Artificial Reef Zone.



3’ eco-reef being deployed to increase available juvenile reef fish habitat

Example of 6’ shallow water pyramid reef with Florida limestone incorporated into the concrete matrix to increase habitat complexity.



# Department of the Army

# Mobile District, Corps of Engineers

# Permit Number SAM-2010-0505-DEM

# Awarded to Alabama Marine Resources Division
# July 13, 2011

DEPARTMENT OF THE ARMY
MOBILE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 2288
MOBILE, AL 36628-0001

REPLY TO
ATTENTION OF

July 13, 2011

Coastal Branch
Regulatory Division

SUBJECT: Letter of Permission, Department of the Army Permit Number SAM-2010-0505-DEM, Alabama Department of Conservation and Natural Reources - Marine Resources Division, Gulf of Mexico

Alabama Department of Conservation and Natural Reources
Marine Resources Division Attention
Attention: Mr. R. Vernon Minton
Post Office Drawer 458
Gulf Shores, Alabama 36547

Dear Mr. Minton:

Reference is made to your request for a Department of the Army permit to designate two artificial reef zone areas in Alabama's territorial seas near Perdido Pass, Orange Beach, Baldwin County, Alabama. Proposed site locations range from 33-44 feet in depth. Reefs will not exceed 6 feet in elevation from seafloor leaving a minimum navigational clearance of 27 feet within both zones. The Alabama Department of Conservation and Natural Resources – Marine Resources Division will be the sole party designated to deploy artificial reef materials in these zones.

Upon the recommendation of the Chief of Engineers and under the provisions of Section 10 of the Rivers and Harbors Act of 1899 (33 U.S.C. 403) and Section 404 of the Clean Water Act (33 USC 1344), you are hereby authorized by the Secretary of the Army to perform this work in accordance with your submitted data and plans. The authorized work is subject to the enclosed General Conditions and the following Special Conditions:

**a. The permittee understands and agrees that, if future operations by the United States require the removal, relocation, or other alteration, of the structure or work herein authorized, or if, in the opinion of the Secretary of the Army or his authorized representative, said structure or work shall cause unreasonable obstruction to the free navigation of the navigable waters, the Permittee will be required, upon due notice from the Corps of Engineers, to remove, relocate, or alter the structural work or obstructions caused thereby, without expense to the United States. No claim shall be made against the United States on account of any such removal or alteration.**

**b. Construction activities shall not infringe upon navigation on the waterway. These activities shall be in compliance with 33 CFR 163, which states in part: "A clear channel shall at all times be left open to permit free and unobstructed navigation by all types of vessels and tows normally using the various waterways."**

**c. You are aware that your project has the potential to be built in State-owned water bottoms and may require a lease or other permission from the State of Alabama, Alabama Department of Conservation and Natural Resources (ADCNR). They can be contacted at: ADCNR, State Lands Division, 31115 Five Rivers Boulevard, Spanish Fort, Alabama 36527.**

**d. It is the permittee's responsibility to ensure that the contractors working on this project are aware of all general and special permit conditions.**

**e. Compliance with all terms and general and special conditions of this Permit is mandatory.**

Please read this letter carefully and comply with its provisions. This permit is issued under provision of the Federal laws for the protection and preservation of the navigable waters of the United States. These laws provide that after the proposed work has been approved by issuance of a Department of the Army permit, it shall not be lawful to deviate from such plans either before or after completion of the work, unless modification of said plans has previously been submitted to and received the approval of the Department of the Army.

You should study and carefully adhere to all the terms and conditions of the permit. The District must be notified of the commencement and completion of the permitted work. The enclosed cards may be used for that purpose. Also enclosed is a "NOTICE OF AUTHORIZATION" which must be conspicuously displayed at the site during construction of the permitted work. Any telephone inquiries relating to this permit should be directed to the Regulatory Division, telephone number (251) 690-2658. Compliance with this and other conditions of the permit is essential. Failure to submit the notices requested may result in its revocation.

If for any reason it becomes necessary to make a material change in location or plans for this work, revised plans should be submitted promptly to the District Commander in order that the revised plans may receive the approval required by law before work is begun.

If the activity authorized herein is not completed on or before October 21, 2015, this permit, if not previously revoked or specifically extended, shall automatically expire.

Your attention is directed to all conditions under which this permit will be issued. Failure to comply with any condition of the approved permit may result in its suspension, cancellation, or revocation. If you object to certain terms and conditions contained within the permit, you may request that the permit be modified. Enclosed you will find a Notification of Administrative Appeal Options and Process fact sheet and Request for Appeal (RFA) form. If you choose to object to certain terms and conditions of the permit, you must follow the directions provided in Section 1, Part A and submit the completed RFA form to the letterhead address.

In order for an RFA to be accepted by the U. S. Army Corps of Engineers (Corps), the Corps must determine that it is complete, that it meets the criteria under 33 CFR Part 331.5, and that it has been received by the District office within 60 days of the date of the RFA. Should you decide to submit an RFA form, it must be received at the letterhead address by within 60 days of the date of this letter. It is not necessary to submit an RFA form to the District office, if you do not object to the determination/decision in this letter.

Please contact Don Mroczko at (251) 690-3185, if you have any questions. For additional information about our Regulatory Program, please visit our web site at www.sam.usace.army.mil/RD/reg. Please take a moment to complete the enclosed our customer satisfaction survey. Your responses are appreciated and will allow us to improve our services

BY AUTHORITY OF THE SECRETARY OF THE ARMY:

STEVEN J. ROEMHILDT, P.E
Colonel, Corps of Engineers
District Commander

BY: _____
JOY B. EARP
Team Leader, Coastal Branch
Regulatory Division

Enclosures:

1. Vicinity Map
2. Project Plans (4 Pages)

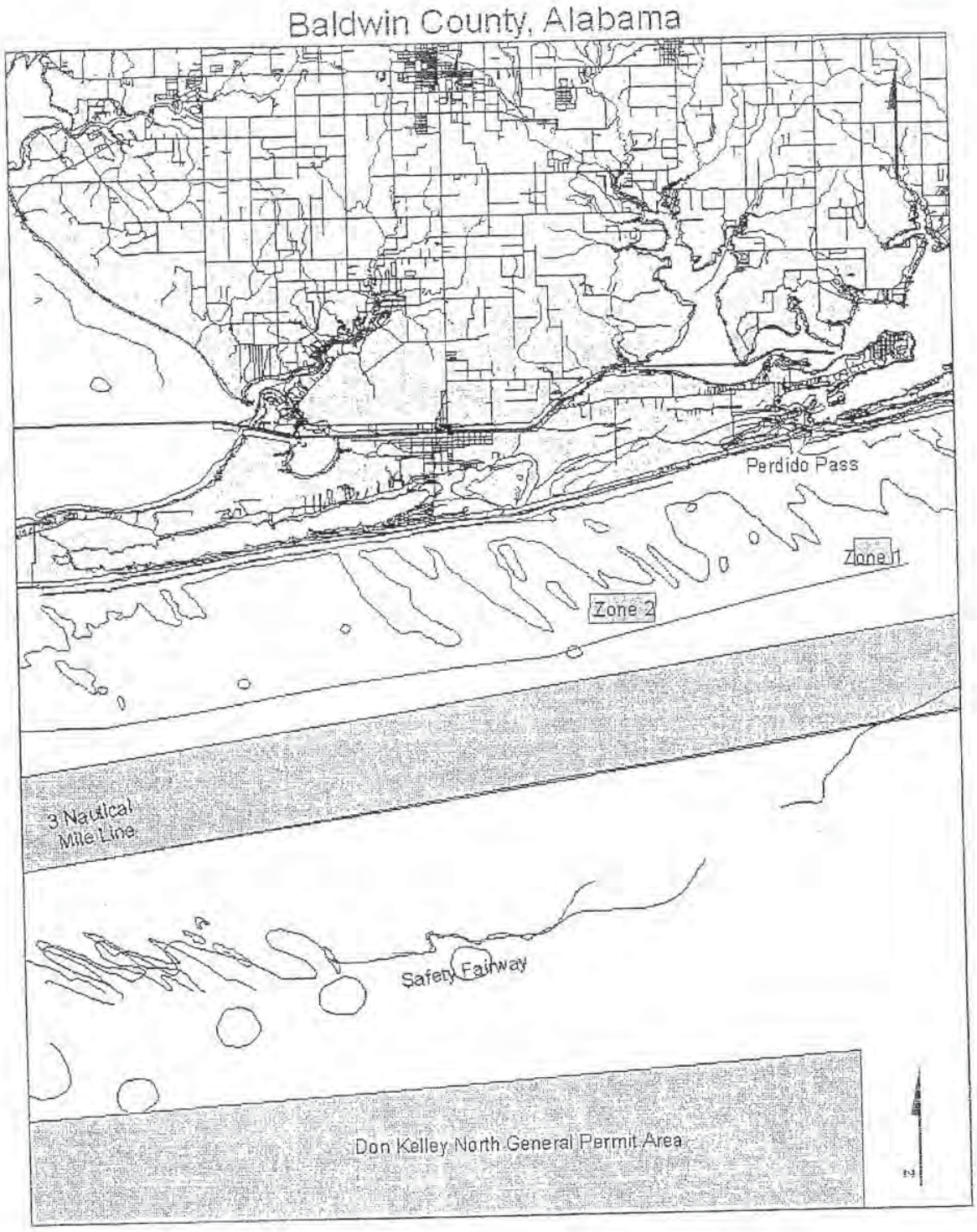
When the structures or work authorized by this permit (SAM-2010-0505-DEM) are still in existence at the time the property is transferred, the terms and conditions of this permit will continue to be binding on the new owner(s) of the property. To validate the transfer of this permit and the associated liabilities associated with compliance with its terms and conditions, have the transferee sign and date below.

_____ _____
(TRANSFEREE) (DATE)

Copy Furnished:

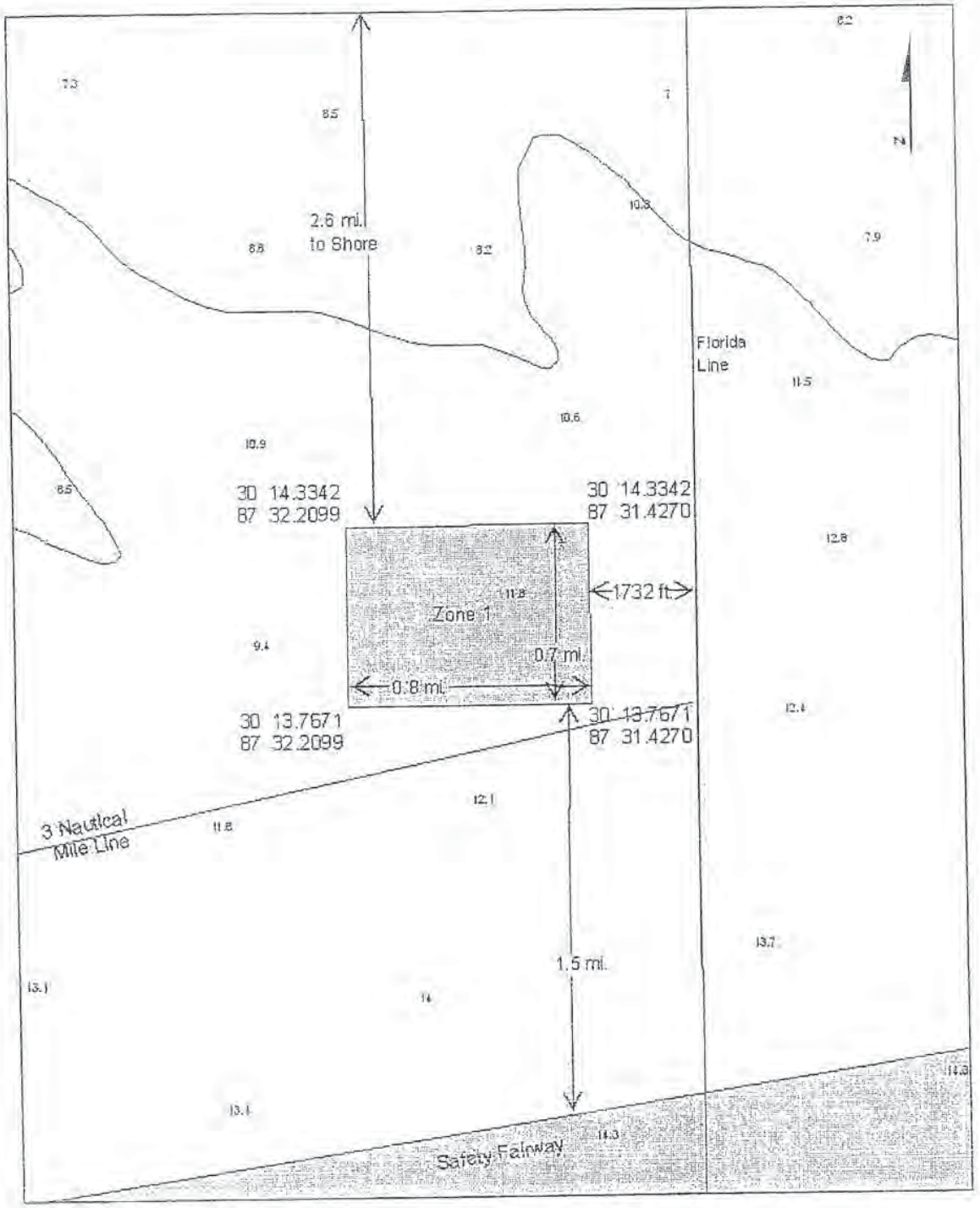
ADEM-Coastal Facilities
Attention: Mr. Scott Brown
Coastal Area Division
4171 Commanders Drive
Mobile, Alabama 36615

ADCNR, State Lands Division
Attention: Mr. Jeff Jordan
31115 Five Rivers Boulevard
Spanish Fort, Alabama 36527




Proposed Alabama Nearshore Reef Zones

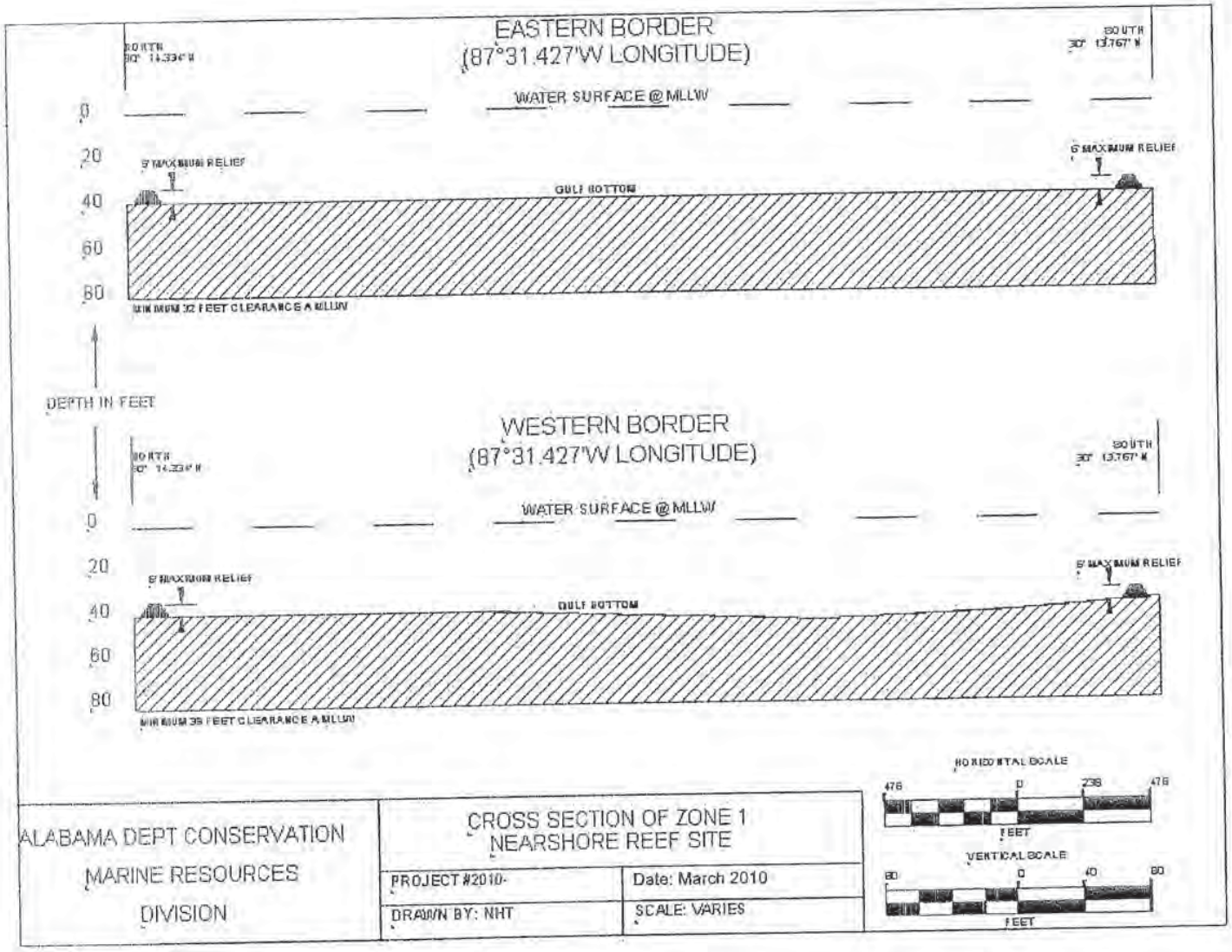
SAM-2011-00505-DEM
DEPARTMENT OF THE ARMY



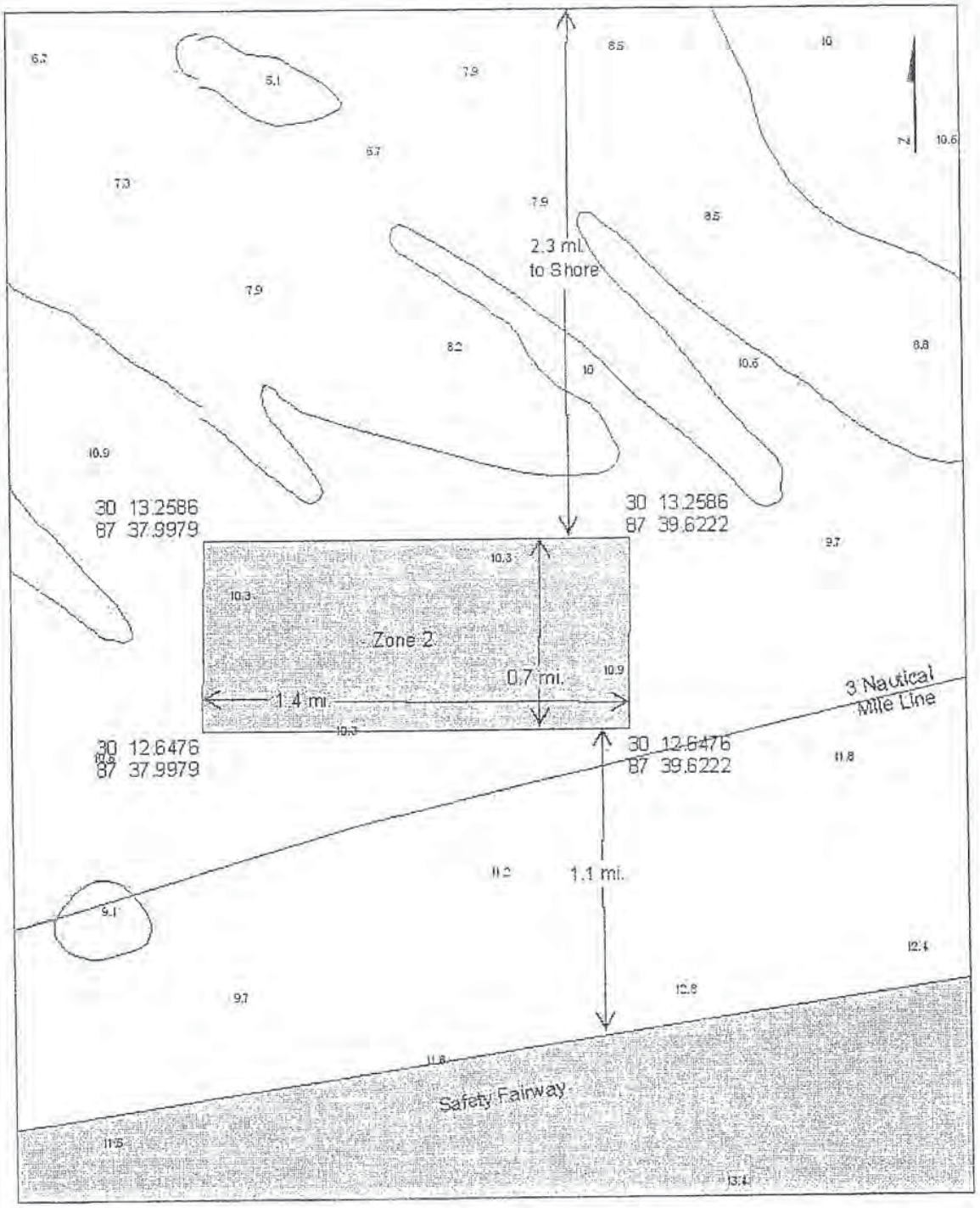

Sounding Depths in Meters

# Proposed Alabama Nearshore Reef Zone 1

SAM- 2011 00505 - DEM
DEPARTMENT OF THE ~~ARMY~~



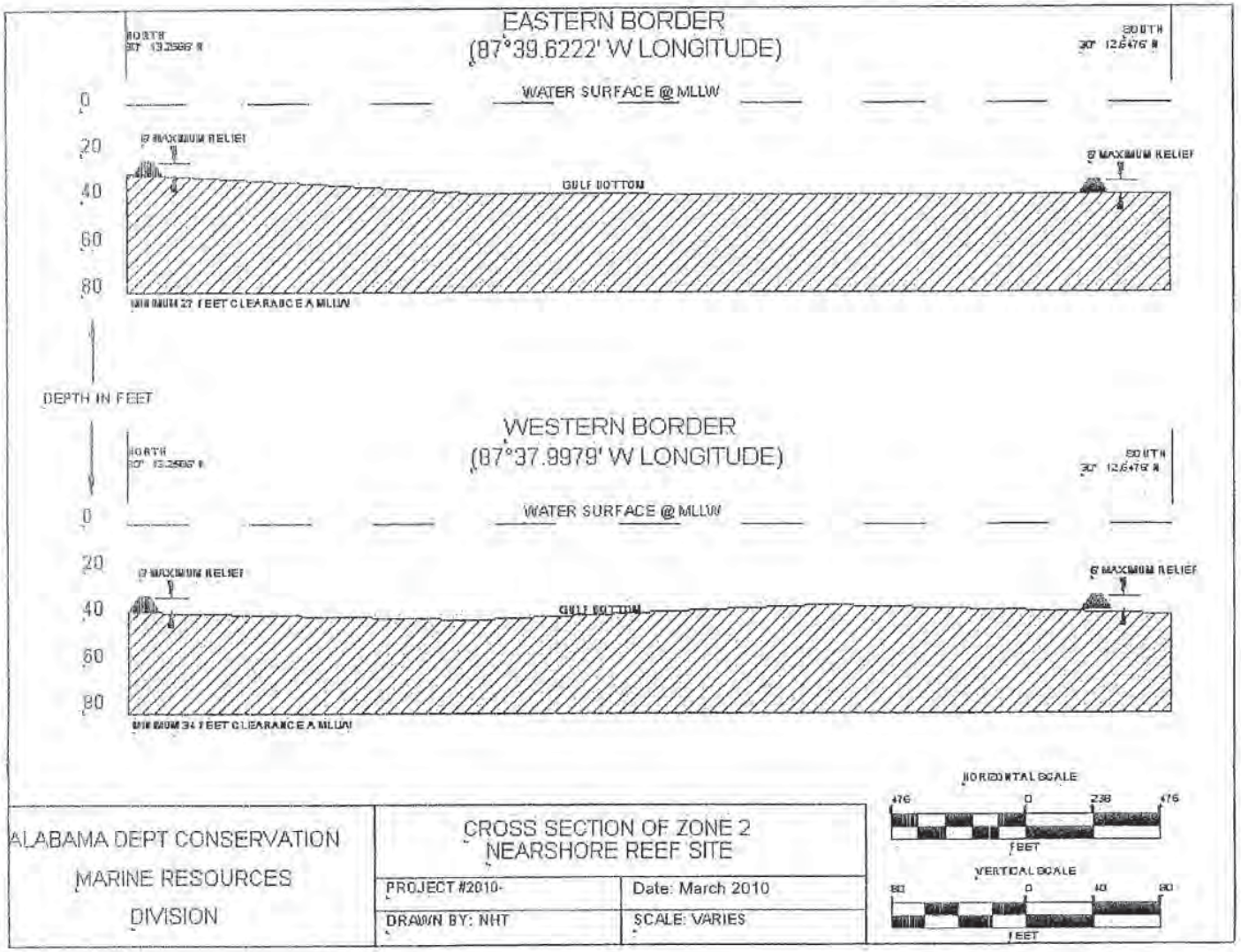

SAM-2011-00505-DEM
DEPARTMENT OF THE ARMY




Sounding Depths in Meters

# Proposed Alabama Nearshore Reef Zone 2

SAM-2011-00505-DEM
DEPARTMENT OF THE ARMY




SAM-2011-00505-DEM
DEPARTMENT OF THE ARMY

**File Number: SAM-2010-0505-DEM**
**Permittee: Alabama Department of Conservation and Natural Resources**
**Marine Resources Division**

## PERMIT GENERAL CONDITIONS / INFORMATION

### GENERAL CONDITIONS:

1. The time limit for completing the work authorized ends **5 years from the date of issuance**. If you find that you need more time to complete the authorized activity, submit your request for a time extension to this office for consideration at least 1 month before the above date is reached.

2. You must maintain the activity authorized by this permit in good condition and in conformance with the terms and conditions of this permit. You are not relieved of this requirement if you abandon the permitted activity, although you may make a good faith transfer to a third party in compliance with General Condition 4 below. Should you wish to cease to maintain the authorized activity or should you desire to abandon it without a good faith transfer, you must obtain a modification of this permit from this office, which may require restoration of the area.

3. If you discover any previously unknown historic or archeological remains while accomplishing the activity authorized by this permit, you must immediately notify this office of what you have found. We will initiate the Federal and State coordination required to determine if the remains warrant a recovery effort or if the site is eligible for listing in the National Register of Historic Places.

4. If you sell the property associated with this permit, you must obtain the signature of the new owner in the space provided and forward a copy of the permit to this office to validate the transfer of this authorization.

5. If a conditioned water quality certification has been issued for your project, you must comply with the conditions specified in the certification as special conditions to this permit. For your convenience, a copy of the certification is attached if it contains such conditions.

6. You must allow representatives from this office to inspect the authorized activity at any time deemed necessary to ensure that it is being or has been accomplished in accordance with the terms and conditions of your permit.

### FURTHER INFORMATION:

1. Congressional Authorities: You have been authorized to undertake the activity described above pursuant to Section 10 of the Rivers and Harbors Act of 1899 (33 U.S.C. 403).

2. Limits of this authorization.

   a. This permit does not obviate the need to obtain other Federal, State, or local authorizations required by law.

   b. This permit does not grant any property rights or exclusive privileges.

   c. This permit does not authorize any injury to the property or rights of others.

   d. This permit does not authorize interference with any existing or proposed Federal project.

SAM- 2010 - 00505 - DEM
DEPARTMENT OF THE ARMY 2 Pages

3. Limits of Federal Liability. In issuing this permit, the Federal Government does not assume any liability for the following:

a. Damages to the permitted project or uses thereof as a result of other permitted or unpermitted activities or from natural causes.

b. Damages to the permitted project or uses thereof as a result of current or future activities undertaken by or on behalf of the United States in the public interest.

c. Damages to persons, property, or to other permitted or unpermitted activities or structures caused by the activity authorized by this permit.

d. Design or construction deficiencies associated with the permitted work.

e. Damage claims associated with any future modification, suspension, or revocation of this permit.

4. Reliance on Applicant's Data: The determination of this office that issuance of this permit is not contrary to the public interest was made in reliance on the information you provided.

5. Reevaluation of Permit Decision. This office may reevaluate its decision on this permit at any time the circumstances warrant. Circumstances that could require a reevaluation include, but are not limited to, the following:

a. You fail to comply with the terms and conditions of this permit.

b. The information provided by you in support of your permit application proves to have been false, incomplete, or inaccurate (See 4 above).

c. Significant new information surfaces which this office did not consider in reaching the original public interest decision.

Such a reevaluation may result in a determination that it is appropriate to use the suspension, modification, and revocation procedures contained in 33 CFR 325.7 or enforcement procedures such as those contained in 33 CFR 326.4 and 326.5. The referenced enforcement procedures provide for the issuance of an administrative order requiring you to comply with the terms and conditions of your permit and for the initiation of legal action where appropriate. You will be required to pay for any corrective measures ordered by this office, and if you fail to comply with such directive, this office may in certain situations (such as those specified in 33 CFR 209.170) accomplish the corrective measures by contract or otherwise and bill you for the cost.

6. Extensions. General condition 1 establishes a time limit for the completion of the activity authorized by this permit. Unless there are circumstances requiring either a prompt completion of the authorized activity or a reevaluation of the public interest decision, the Corps will normally give favorable consideration to a request for an extension of this time limit.

**This notice of authorization must be conspicuously displayed at the site of work.**

United States Army Corps of Engineers

A permit to perform work authorized by statutes and regulations of the Department of the Army

at **GULF OF MEXICO, PERDIDO PASS, ORANGE BEACH, BALDWIN COUNTY, ALABAMA**

has been issued to **ALABAMA DEPT OF CONSERVATION & NATURAL RESOURCES** on **JULY 13, 2011**

Address of Permittee **POST OFFICE DRAWER 458, GULF SHORES ALABAMA 36547**

Permit Number

**SAM-2010-00505-DEM**

FOR

For the District Commander

**DONALD E. MROCZKO**
**REGULATORY SPECIALIST, ALABAMA COASTAL**
**REGULATORY DIVISION, RD-C/A**

ENG FORM 4336, Jul 81 (33 CFR 320-330) EDITION OF JUL 70 MAY BE USED (Proponent: CECW-0)

# Permit application and figures submitted to Department of the Army, Corps of Engineers during application process for permit:

# SAM-2010-0505-DEM

# JOINT APPLICATION AND NOTIFICATION
# U.S. DEPARTMENT OF ARMY, CORPS OF ENGINEERS
# ALABAMA DEPARTMENT OF ENVIRONMENTAL MANAGEMENT

This form is to be used for proposed activities in waters of the United States within the political boundaries of the State of Alabama.

PLEASE TYPE OR PRINT IN INK

**APPLICATION NUMBER (TO BE ASSIGNED BY CORPS)**

1. Date: March 26, 2010
   month day year

2. Applicant: R. Vernon Minton
   Name and Address: Director, AL Marine Resources
   P.O. Drawer 458
   Gulf Shores, AL 36547

   Telephone Number during business hours:

   A/C ( ) _____ Residence

   A/C (251) 968.7576 Office

**OFFICIAL USE ONLY**

COE_____

ADEM_____

STATE CLEARINGHOUSE_____

DATE Received_____

3. Designation of Agent, Statement of Authorization:

   I hereby designate and authorize Kevin Anson

   _____

   to act on my behalf in the processing of this permit application aid to furnish, upon request, supplemental information in support of the application.

   March 26, 20
   Signature of Applicant Date

Agent:

Name and Address:
Kevin Anson
Biologist III
Alabama Marine Resources Division
P.O. Drawer 458
Gulf Shores, AL 36547

Telephone Number during business hours:
A/C (251) 968.7576
A/C ( )_____

4. Project Location: Near Perdido Pass in Gulf of Mexico within three miles from shore

   Street Address N /A City/Community Offshore from Orange Beach, AL 36561

   Name of Waterway Gulf of Mexico Latitude_____ Longitude_____

   Geographic Location: Section_____ Township _____ Range _____ County_____

   Loran C coordinates (if applicable)_____

5. Project Description, including all aspects of the project. Describe completely and in detail. Include any structures such as piers, wharfs, bulkheads, pipelines, boathouses, boat ramps, groins, jetties and appurtenances, as well as any dredging, excavation, or fill activities. Attach additional sheets if necessary.

The Alabama Department of Conservation and Natural Resources/Marine Resources Division (ADCNR/MRD) wishes to apply for permission to create two (2) artificial reef zones in the vicinity of Perdido Pass, Orange Beach, AL (see enclosed maps). Proposed Zone 1 is located approx. 2.6 miles Southeast of Perdido Pass and encompasses 0.56 sq. mi. of water bottoms and proposed Zone 2 is located approx. 5.2 miles Southwest of Perdido Pass and encompasses 0.98 sq. mi. of water bottoms. Artificial reefs designs will include pre-fabricated modules of concrete and steel construction and concrete pilings and foundation material free of grease, oil or asphalt.

5. Project Description (continued) SEE ATTACHED FOR CONTINUED DESCRIPTION

Water depths range from 33' to 44'. Reefs will not exceed 6' in elevation from seafloor leaving a minimum navigational clearance of 27' within both zones.

ADCNR/MRD will be the sole party designated to deploy artificial reef materials in these zones and ADCNR/MRD staff will be on-site during all reef deployments. No submerged aquatic vegetation, oyster reefs, or wetlands will be impacted. Per conversations with representatives of Olsen Associates, Inc., the firm that consulted for the Cities of Orange Beach and Gulf Shores and the State

---

6. Dredging Project Specifications (Show locations and dimensions of proposed dredge areas on attached plans. Include existing and proposed depths.).

New Work _____Maintenance Work_____

Cubic yards of material to be removed Type of material_____

Method of excavation: _____

Nature of area to be dredged (check one) Upland_____ Wetland_____ Water bottom_____

Other (explain)_____

---

7. Specifications for Discharge of Dredged or Fill Material (Show locations and dimensions of all disposal or fill areas on attached plans.).

Cubic yards of fill_____ Type of fill_____

Source of fill material (check one) Commercially obtained _ _ Dredged material___ ___ Borrowed On-site__ ____

Other (explain)_____

How will discharged material be contained? (Include erosion control measures, levees, etc.)_____

Nature of disposal/fill areas (check one) Upland_____ Wetland_____ Water bottom_____

Other (explain)_____

---

8. Additional information relating to the proposed activity.

Are oyster reefs located within or near the project area? Yes_____ No✔ If yes, explain:

_____

Will this project result in the siting, construction, and/or operation of an energy-related facility? Yes_____

No✔

Is the project area greater than 25 acres in size? Yes✔ No_____

Is any portion of the activity for which authorization is sought now complete? Yes _____No✔_____ If yes, explain: _____

_____

Month and year activity took place_____

If project is for maintenance work of existing Structures or existing channels, describe legal authorization for the existing work. Provide permit number, dates or other form of authorization _____

---

9. Describe the purpose and public benefit, if any, of the project. Describe the relationship between the project and any secondary or future development the project is designed to support. Increase fish habitat and enhance fishing opportunities.

Intended use: Public ✔ Private Commercial (explain)_____

---

10. Project Schedule:

Proposed start date 6/01/10 Proposed completion date 05/31/15

---

11. Names and addresses of adjoining property owners, lessees, etc. whose property also adjoins the waterway. Also, identify the owners on the plan view in Attachment.

Not applicable.

12. List all authorizations or certifications received or applied for from federal, state or local agencies for any structures, construction, discharges, deposits or other activities described in or directly related to this application. Note that the signature in Item 13 certifies that application has been made to or that permits are not required from the following agencies. If permits are not required place NA in space for Type Approval.

| Agency | Type Approval | Identification No. | Date of Application | Date of Approval | Date of Denial |
|---|---|---|---|---|---|
| AL Dept. of Environmental Management | | | | | |
| U. S. Army Corps of Engineers | | | | | |
| Alabama State Docks | | | | | |
| City/County_____ | | | | | |
| Other: _____ | | | | | |

13. Application is hereby made for authorization to conduct the activities described herein. I agree to provide any additional information / data that may be necessary to provide reasonable assurance or evidence to show that the proposed project will comply with the applicable state water quality standards or other environmental protection standards both during construction and after the project is completed. For projects within the coastal area of Mobile and Baldwin Counties, I certify that the proposed project for which authorization is sought, complies with the approved Alabama Coastal Area Management Program and will be conducted in a manner consistent with with the program. the approved Alabama Coastal Area Management Program and will be conducted in a manner consistent with the program. I agree to provide entry to the project site for inspectors from the environmental protection agencies for the purpose of making preliminary analyses of the Site and monitoring permitted works. I certify that I am familiar with and responsible for the information contained in this application, and that to the best of my knowledge and belief, such information is true, complete and accurate. I further certify that I possess the authority to undertake the proposed activities or I an acting as the duly authorized agent of the applicant.

(SIGNATURE OF Applicant OR AGENT REQUIRED BELOW)

_____ March 26, 2010
Signature of Applicant or Agent Date

18 U.S C. Section 7001 provides that: Whoever, in any manner within the jurisdiction of any department or agency of the United States knowingly and willingly falsifies, conceals, or covers up by any trick, scheme or device a material fact or makes any false, fictitious or fraudulent statements or representations or makes or uses any false writing or document knowing same to contain any false, fictitious or fraudulent statement or entry, shall be fined not more than $10,000 or imprisoned not more than five years, or both.

14. In addition to the completed application, the following attachments are required:

Provide a vicinity map showing the location of the proposed site along with a written description of how to reach the site from major highways or landmarks. Provide accurate drawings of the project site with existing structures and proposed activities shown in detail. All drawings must be to scale or with dimensions noted on drawings and must show a plan view and cross section or elevation. ***All plans and attachments must be of reproducible quality on 8 1/2 inch x 11 inch paper.*** **FEES ARE REQUIRED IN CONJUNCTION WITH ADEM CERTIFICATION:**
**ADEM WILL CONTACT APPLICANT WITH FEE REQUIREMENTS.**

15. Send one completed application (or copy) to each agency listed below:

District Engineer (original application)
U. S. Army Engineer District, Mobile
ATTN: Regulatory Branch
Post Office Box 2288
Mobile, Alabama 36628

Permit Coordination Center
Alabama Department of Environmental Management
1751 Congressman W.L. Dickinson Drive
Montgomery, Alabama 36130

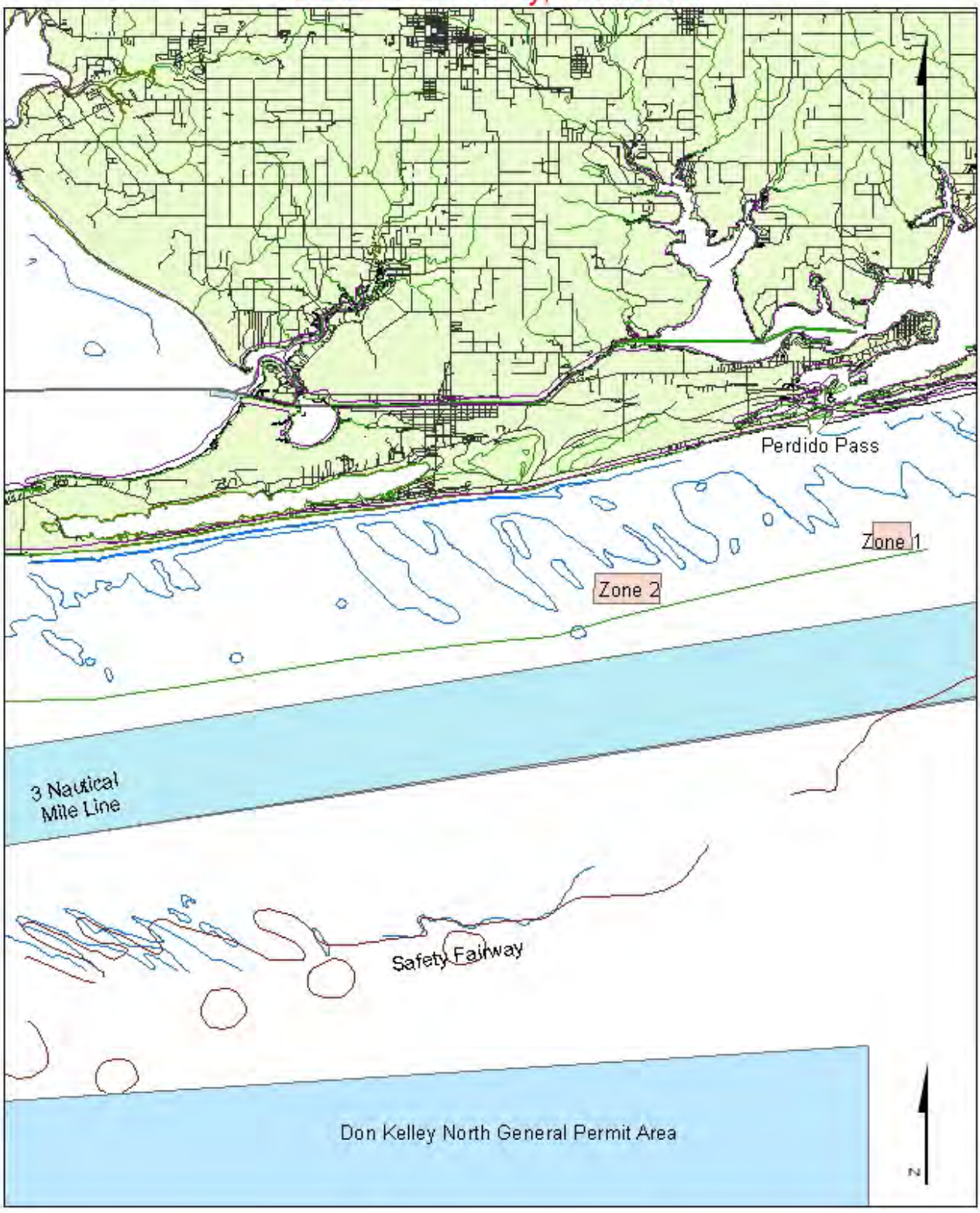
Alabama State Docks
Post Office Box 1588
Mobile, Alabama 36633

* For projects in Baldwin or Mobile Counties, including projects requiring Coastal Program certification, send one copy to:
Alabama Department of Environmental Management
Mobile Field Office
2204 Perimeter Road
Mobile, Alabama 36615

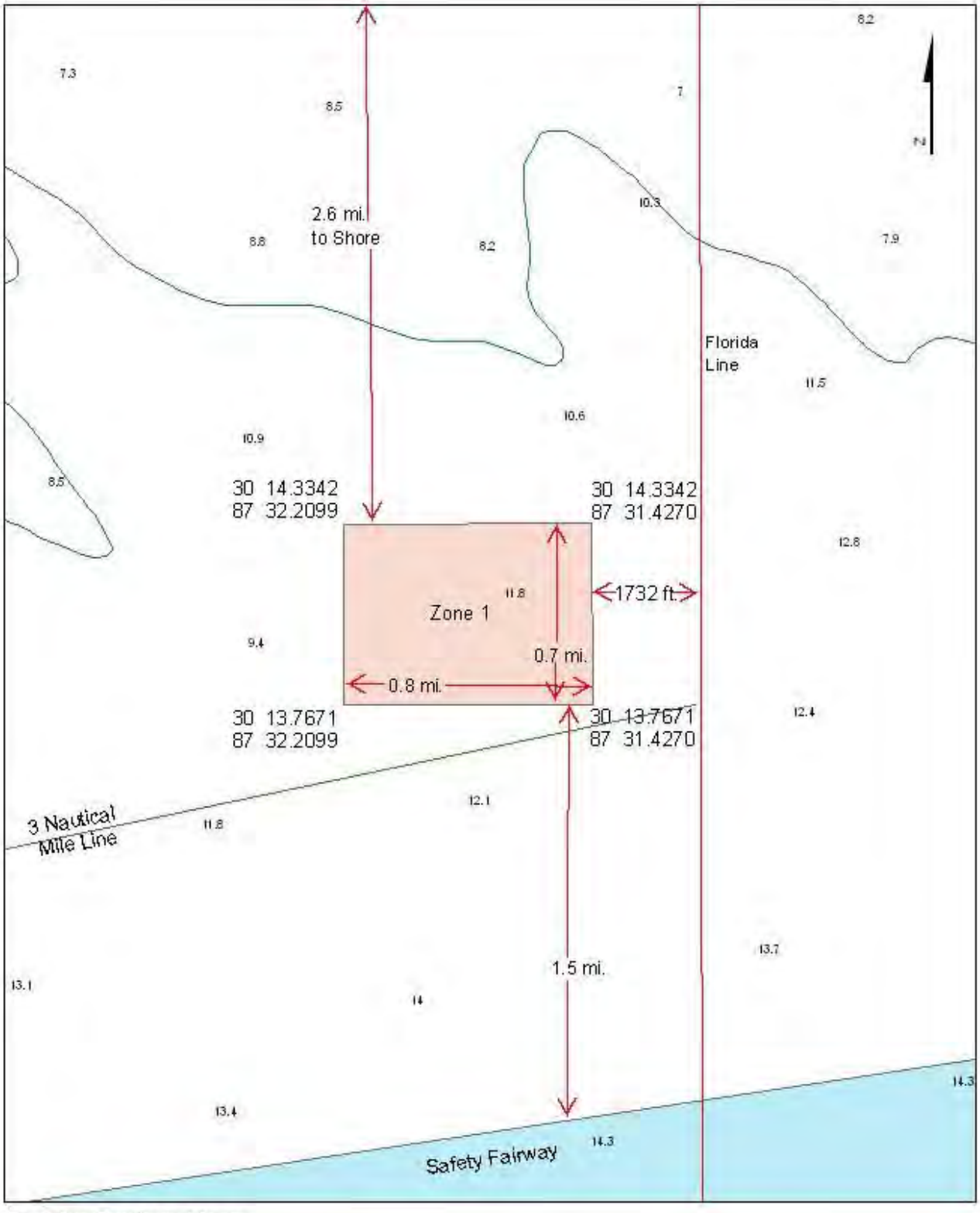
5. Project Description – Continued from Page 2

of Alabama during the 2005-2006 beach restoration project, sand deposits within the proposed artificial reef zones are of poor quality and likely will not be used for future beach restoration projects.

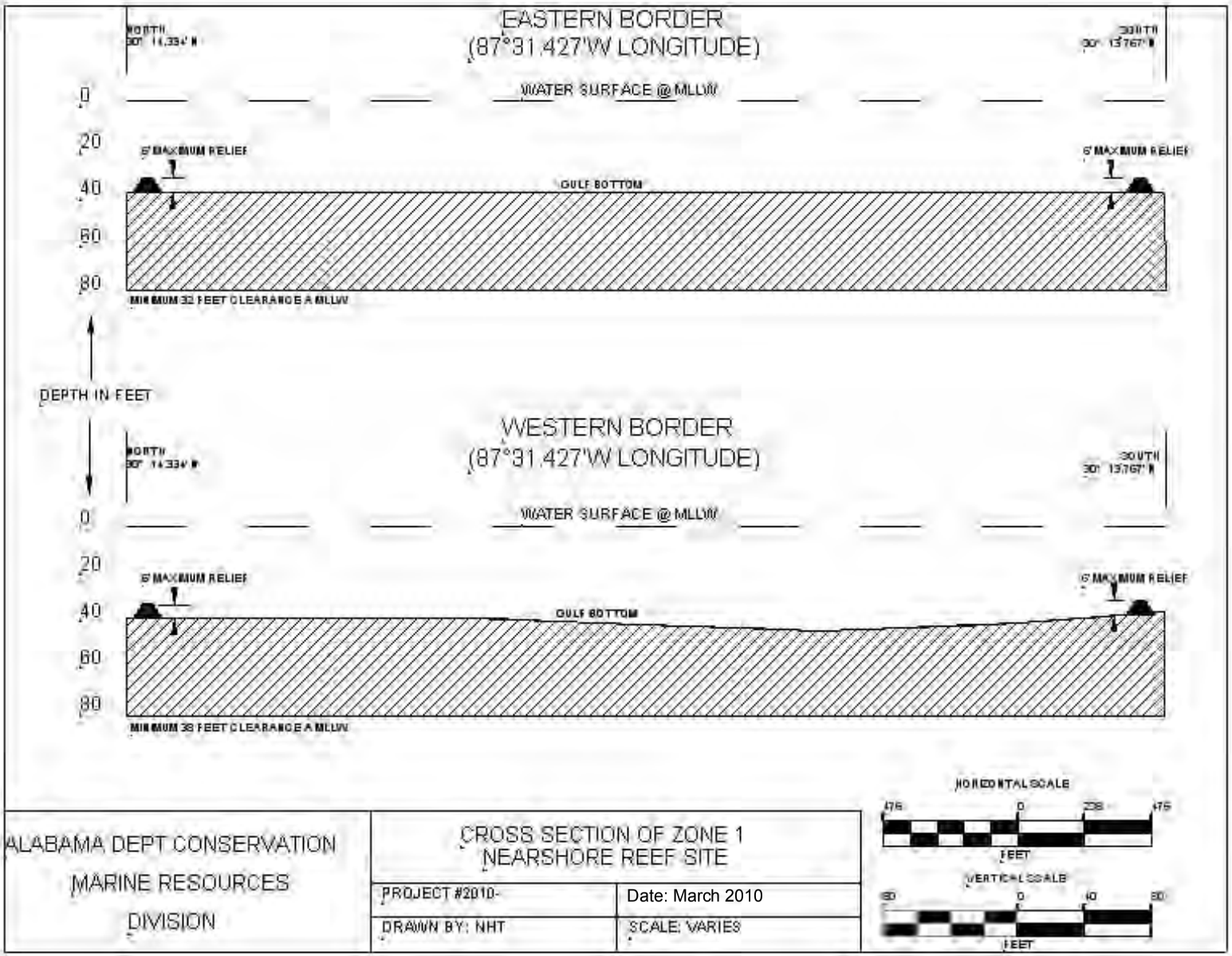
Baldwin County, Alabama



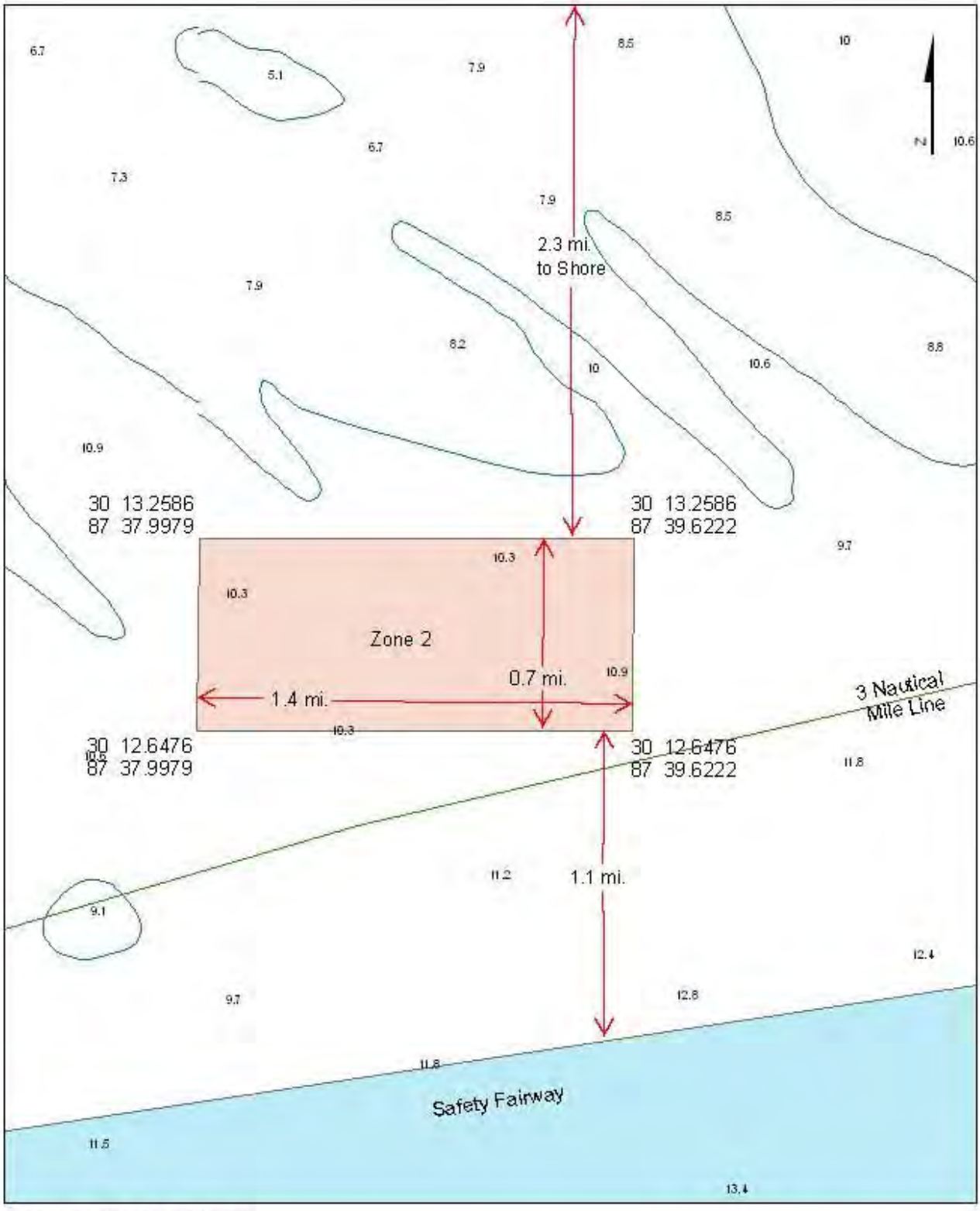

Proposed Alabama Nearshore Reef Zones




Proposed Alabama Nearshore Reef Zone 1

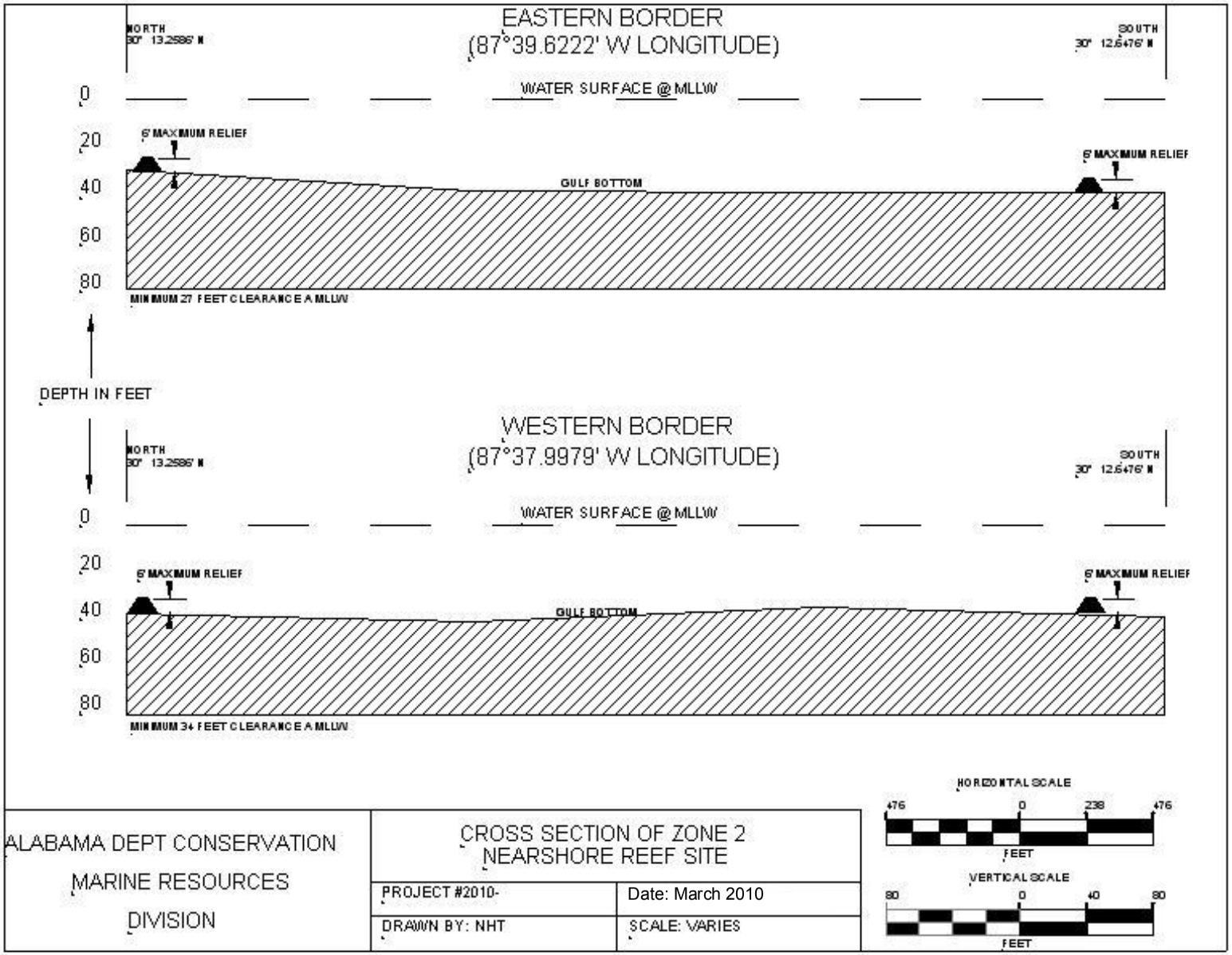



| | | |
|---|---|---|
| ALABAMA DEPT CONSERVATION<br>MARINE RESOURCES<br>DIVISION | CROSS SECTION OF ZONE 1<br>NEARSHORE REEF SITE | |
| | PROJECT #2010- | Date: March 2010 |
| | DRAWN BY: NHT | SCALE: VARIES |




Sounding Depths in Meters

Proposed Alabama Nearshore Reef Zone 2




| | | |
|---|---|---|
| ALABAMA DEPT CONSERVATION<br>MARINE RESOURCES<br>DIVISION | CROSS SECTION OF ZONE 2<br>NEARSHORE REEF SITE | |
| | PROJECT #2010- | Date: March 2010 |
| | DRAWN BY: NHT | SCALE: VARIES |

Robert Bentley
GOVERNOR

N. Gunter Guy, Jr.
COMMISSIONER

Curtis Jones
DEPUTY COMMISSIONER

**STATE OF ALABAMA**
**DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES**
**MARINE RESOURCES DIVISION**
POST OFFICE BOX 189
DAUPHIN ISLAND, ALABAMA 36528
TEL (251861-2882
FAX (251) 861-8741
amrddi@gulftel.com

*Our mission is to manage the State's marine fishery resources through research, enforcement, and education for the maximum benefit of the resources and the citizens of Alabama.*

Christopher M. Blankenship
Director
MARINE RESOURCES DIVISION

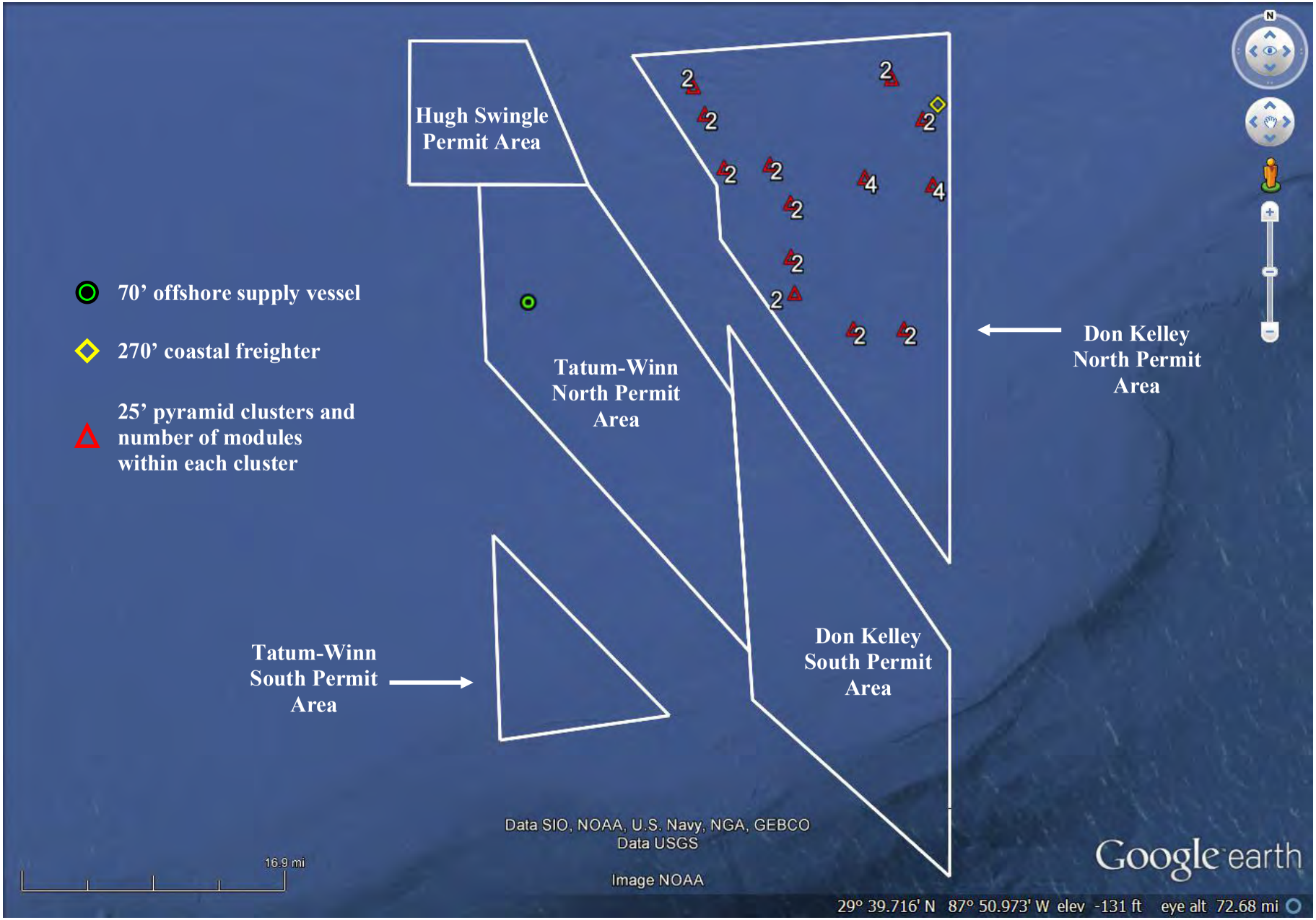
# Department of Conservation and Natural Resources

# Marine Resources Division

# Offshore Reef Program

The Department of Conservation and Natural Resources does not discriminate on the basis of race, color, religion, age gender, national origin, or disability in its hiring practices nor in admission to, access to, or operations of its programs, services, or activities.
www.outdooralabama.com

**Locations of AMRD sponsored reefs deployed during 2013 within Alabama's General Permit Reef Zones**



On March 28, 2013 Alabama Marine Resources constructed an artificial reef by deploying a 70’ offshore supply vessel in the Tatum-Winn North General Reef Permit Area (N29° 48.525; W87° 59.244).

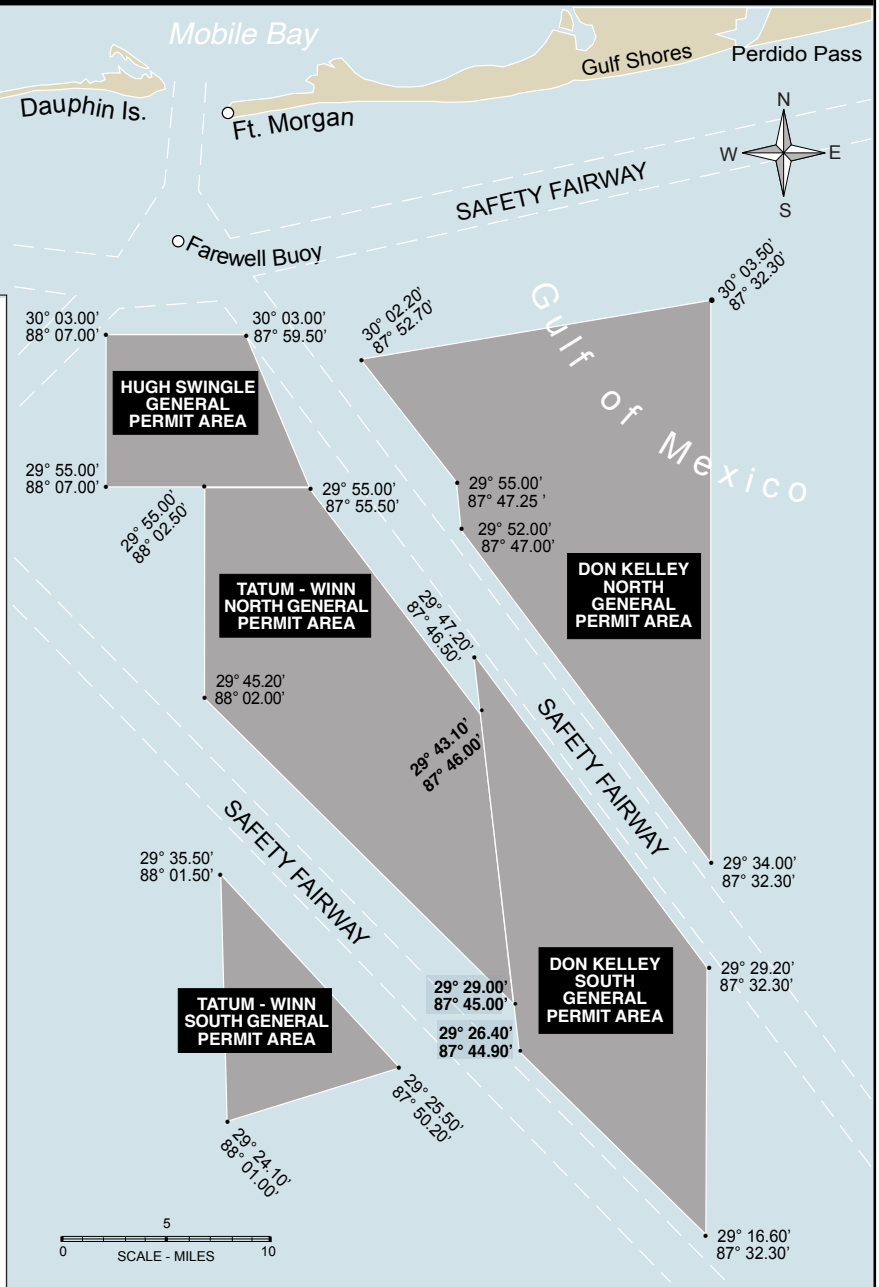
On May 26, 2013 Alabama Marine Resources constructed an artificial reef by deploying a 271’ coastal freighter in the Don Kelly North General Reef Permit Area (N29° 59.520; W87° 33.037).

During July 2013, Alabama Marine Resources constructed 13 artificial reef sites by deploying clusters of 25' concrete and limestone pyramids in the Don Kelly North General Reef Permit Area.

| Cluster 1 | Cluster 2 | Cluster 3 | Cluster 4 | Cluster 5 | Cluster 6 | Cluster 7 |
|---|---|---|---|---|---|---|
| N30° 00.496<br>W87° 48.750 | N29° 58.969<br>W87° 48.011 | N29° 55.980<br>W87° 46.763 | N29° 56.176<br>W87° 43.820 | N30° 00.984<br>W87° 36.003 | N29° 54.0277<br>W87° 42.5065 | N29° 51.0143<br>W87° 42.4871 |
| N30° 00.501<br>W87° 48.750 | N29° 58.969<br>W87° 48.015 | N29° 55.984<br>W87° 46.771 | N29° 56.178<br>W87° 43.824 | N30° 00.982<br>W87° 36.003 | N29° 54.0329<br>W87° 42.5031 | N29° 51.0305<br>W87° 42.4749 |

| Cluster 8 | Cluster 9 | Cluster 10 | Cluster 11 | Cluster 12 | Cluster 13 |
|---|---|---|---|---|---|
| N29° 49.0143<br>W87° 42.2360 | N29° 47.0083<br>W87° 38.4745 | N29° 47.0154<br>W87° 35.2312 | N29° 58.7396<br>W87° 34.0135 | N29° 55.4852<br>W87° 37.7489 | N29° 55.0675<br>W87° 33.3440 |
| N29° 49.0201<br>W87° 42.2300 | N29° 47.0203<br>W87° 38.4712 | N29° 47.0206<br>W87° 35.2225 | N29° 58.7336<br>W87° 34.0076 | N29° 55.4731<br>W87° 37.7423 | N29° 55.0678<br>W87° 33.3551 |
| | | | | N29° 55.4661<br>W87° 37.7387 | N29° 55.0624<br>W87° 33.3602 |
| | | | | N29° 55.4512<br>W87° 37.7371 | N29° 55.0624<br>W87° 33.3688 |

# ALABAMA ARTIFICIAL REEF GENERAL PERMIT AREAS




## ALABAMA'S ARTIFICIAL REEF PROGRAM

**Alabama has one of the largest artificial reef programs in the world**. The natural bottom of offshore Alabama is a predominately flat sand/mud type bottom. This bottom type attracts very few fish that are either commercially or recreationally valuable. However, it has long been known that if vertical relief is created on this bottom, many reef fish such as snappers and groupers will be produced. In fact, artificial reefs can be created that over time will appear as natural reefs with similar communities of encrusting organisms and bait fish. As various encrusting organisms such as corals and sponges cover the artificial reef material, small animals take up residence. On-going research within Alabama's artificial reef general permit areas indicates that juvenile red snapper recruit to new, uninhabited artificial reefs, aging with the reef, and recruiting to the fishery at an appropriate size. At that point the artificial reef functions as a natural reef.

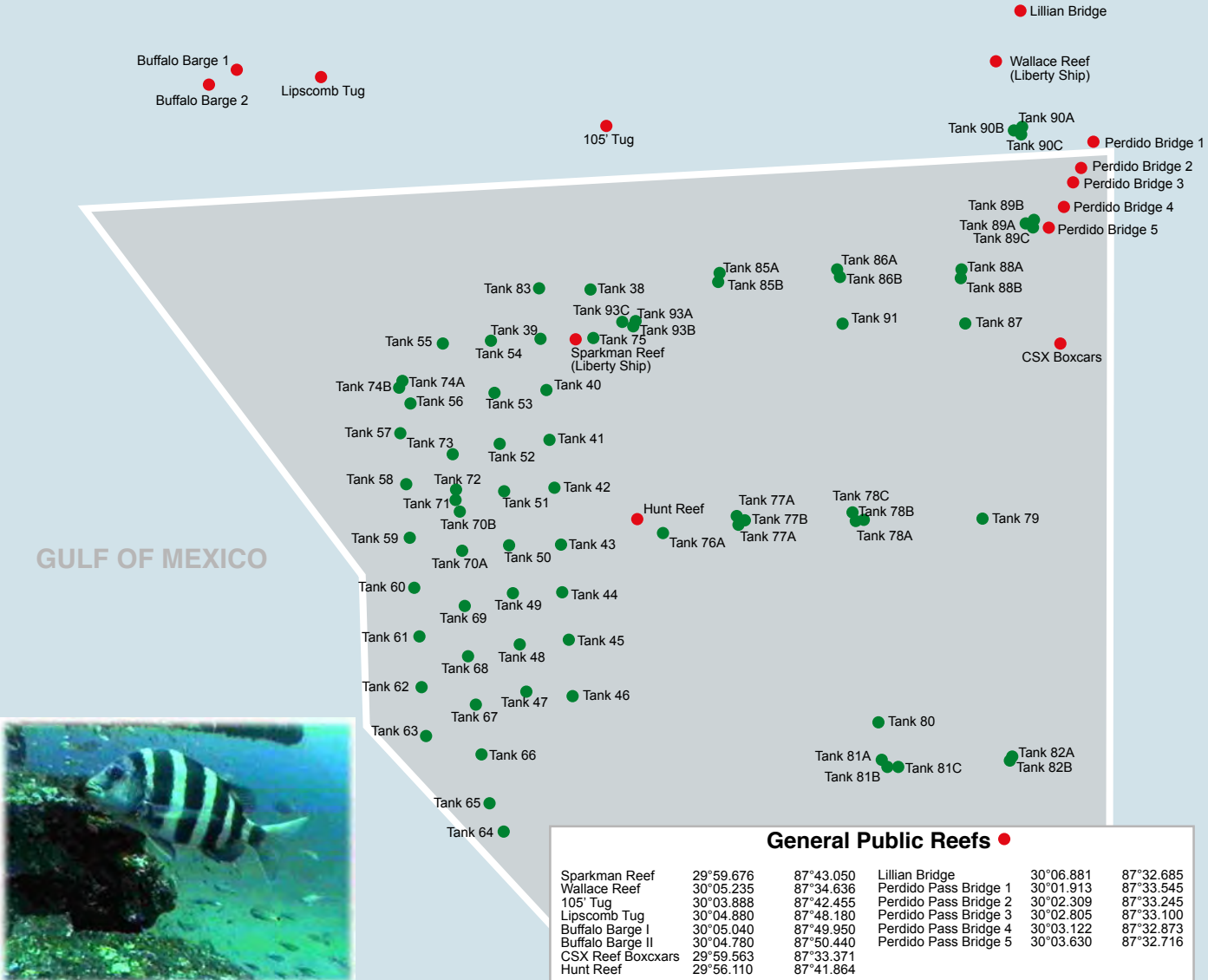
**Alabama's artificial reef building program started in 1953** when the Orange Beach Charter Boat Association asked for the authority to place 250 car bodies off Baldwin County, Alabama. This proved to be very successful and in the years since, many different types of materials have been placed offshore of Alabama. These have included additional car bodies, culverts, bridge rubble, barges, boats and planes. **In 1974,** in an excellent example of State/Federal cooperation, several "ghost-fleeted" liberty ships were sunk in five locations off Mobile and Baldwin Counties in 80-93 feet of water.

**In 1987, a general permit was issued by the U. S. Army Corps of Engineers creating specific areas offshore of Alabama for the creation of artificial reefs.** These were created in order to provide areas for these materials in order to coordinate with other users of the offshore area. In 1987 the areas encompassed almost 800 square miles.

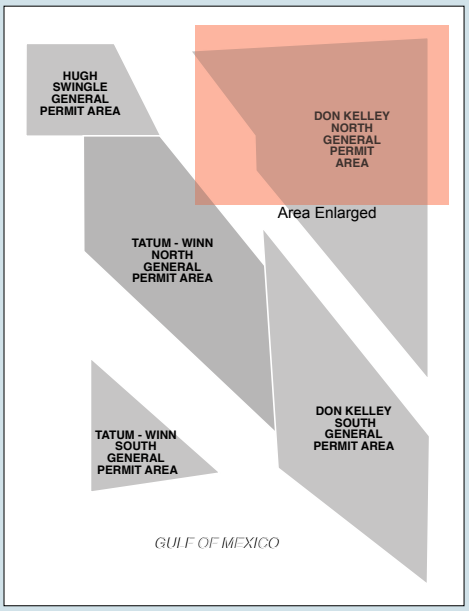
In 1993, the U. S. military in addressing the need to de-militarize obsolete battle tanks realized that immersion in sea water was an acceptable method. The idea was presented to the Marine Resources Division and development of an operation plan began. **Reef-Ex** is the program name associated this activity. In 1994, one-hundred M-60 military tanks were deployed as artificial reefs in depths of 70 to 110 feet of water within the Hugh Swingle and Don Kelley North permit areas. The conservative estimate for the life span of the tanks is 50 years as artificial reefs.

In late 1997, the U. S. Army Corps of Engineers authorized an expansion of Alabama's artificial reef construction areas to allow for greater freedom in reef placement and greater variety in depth. The combined area for all reef permit zones now encompasses approximately 1260 square miles. At the same time, the protocol for reef construction was modified. This modification limited the types of materials that can be used to construct artificial reefs. Enforcement of the protocol and placement of reefs is a joint effort of the Marine Resources Enforcement Section, the Alabama Marine Police Division, and the U. S. Coast Guard.

# PUBLIC REEFS - DON KELLEY NORTH GENERAL PERMIT AREA






## General Public Reefs

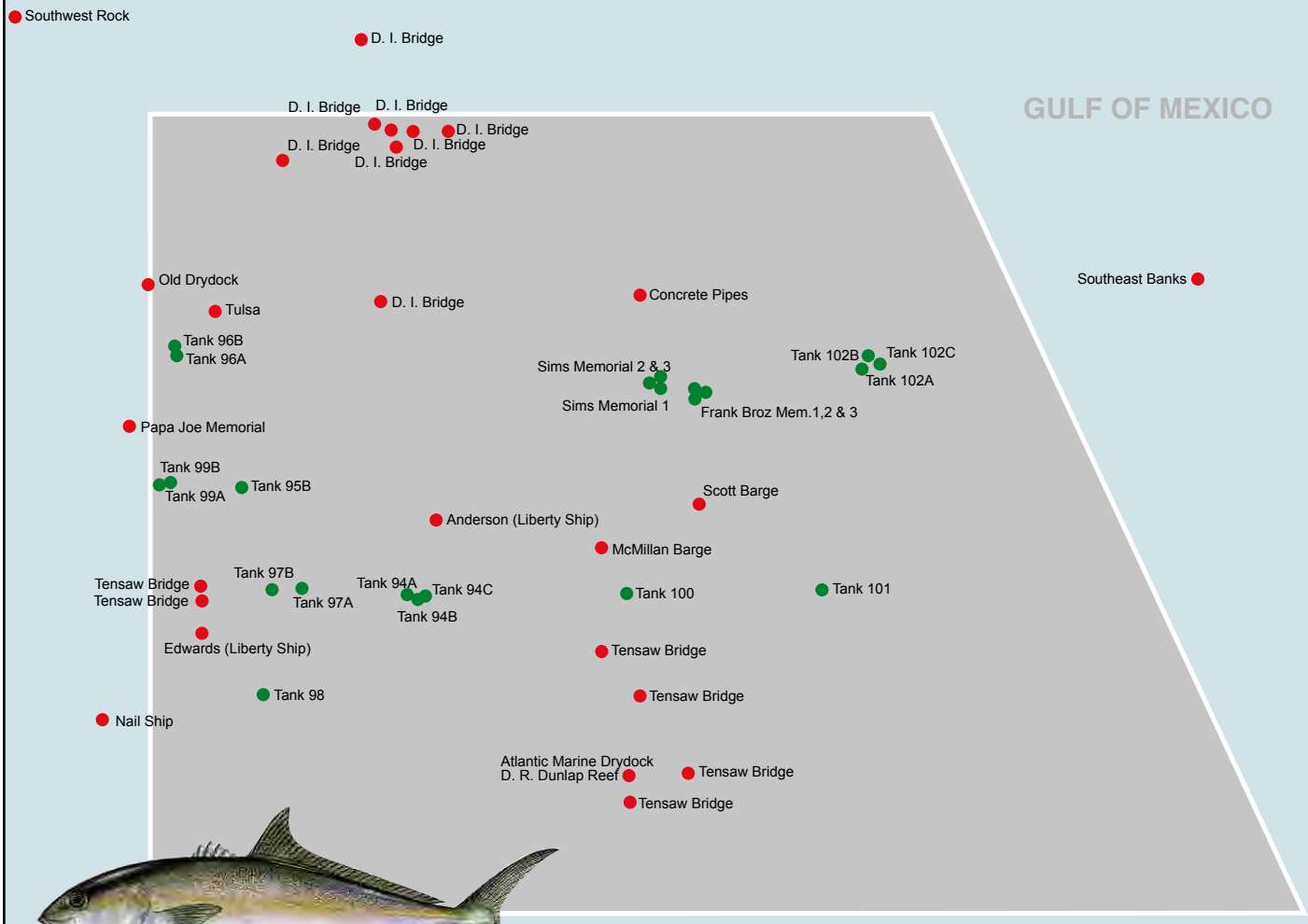
| | | | | | |
|---|---|---|---|---|---|
| Sparkman Reef | 29°59.676 | 87°43.050 | Lillian Bridge | 30°06.881 | 87°32.685 |
| Wallace Reef | 30°05.235 | 87°34.636 | Perdido Pass Bridge 1 | 30°01.913 | 87°33.545 |
| 105' Tug | 30°03.888 | 87°42.455 | Perdido Pass Bridge 2 | 30°02.309 | 87°33.245 |
| Lipscomb Tug | 30°04.880 | 87°48.180 | Perdido Pass Bridge 3 | 30°02.805 | 87°33.100 |
| Buffalo Barge I | 30°05.040 | 87°49.950 | Perdido Pass Bridge 4 | 30°03.122 | 87°32.873 |
| Buffalo Barge II | 30°04.780 | 87°50.440 | Perdido Pass Bridge 5 | 30°03.630 | 87°32.716 |
| CSX Reef Boxcxars | 29°59.563 | 87°33.371 | | | |
| Hunt Reef | 29°56.110 | 87°41.864 | | | |

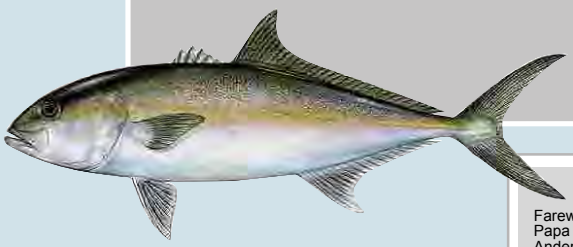
## Military Tank Reefs

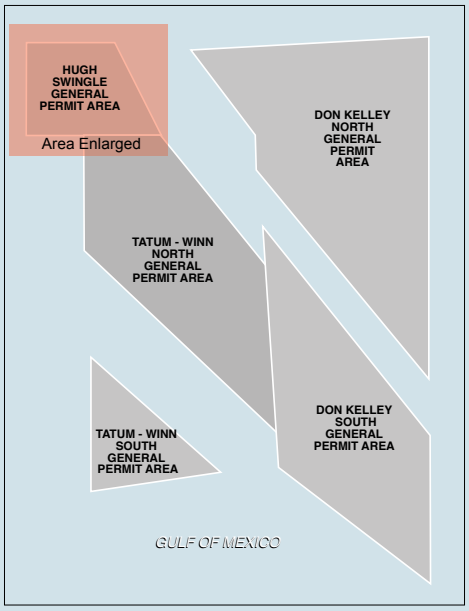
| | | | | | |
|---|---|---|---|---|---|
| Tank 38 | 30°00.691 | 87°43.911 | Tank 74 | 29°58.718 | 87°46.595 |
| Tank 39 | 29°59.715 | 87°43.791 | Tank 74 | 29°58.689 | 87°46.596 |
| Tank 40 | 29°58.652 | 87°43.714 | Tank 75 * | 29°59.736 | 87°42.790 |
| Tank 41 | 29°57.670 | 87°43.645 | Tank 76 * | 29°55.830 | 87°41.355 |
| Tank 42 | 29°56.674 | 87°43.534 | Tank 77 * | 29°55.973 | 87°39.885 |
| Tank 43 | 29°55.640 | 87°43.409 | Tank 78 | 29°56.025 | 87°37.425 |
| Tank 44 | 29°54.637 | 87°43.330 | Tank 78 | 29°56.030 | 87°37.390 |
| Tank 45 | 29°53.673 | 87°43.244 | Tank 78 | 29°56.030 | 87°37.340 |
| Tank 46 | 29°52.541 | 87°43.149 | Tank 79 | 29°56.085 | 87°34.910 |
| Tank 47 | 29°52.610 | 87°44.105 | Tank 80 | 29°51.995 | 87°37.027 |
| Tank 48 | 29°53.565 | 87°44.245 | Tank 81 | 29°51.145 | 87°36.945 |
| Tank 49 | 29°54.619 | 87°44.335 | Tank 81 | 29°51.135 | 87°36.970 |
| Tank 50 | 29°55.560 | 87°44.428 | Tank 81 | 29°51.125 | 87°36.937 |
| Tank 51 | 29°56.612 | 87°44.510 | Tank 82 | 29°51.230 | 87°34.340 |
| Tank 52 | 29°57.590 | 87°44.600 | Tank 82 | 29°51.305 | 87°34.345 |
| Tank 53 | 29°58.650 | 87°44.700 | Tank 83 ** | | |
| Tank 54 | 29°59.650 | 87°44.800 | Tank 84 ** | | |
| Tank 55 | 29°59.642 | 87°45.733 | Tank 85 | 30°00.845 | 87°40.185 |
| Tank 56 | 29°58.385 | 87°46.421 | Tank 85 | 30°00.820 | 87°40.235 |
| Tank 57 | 29°57.835 | 87°46.600 | Tank 86 | 30°00.965 | 87°37.830 |
| Tank 58 | 29°56.814 | 87°46.505 | Tank 86 | 30°00.950 | 87°37.785 |
| Tank 59 | 29°55.743 | 87°46.422 | Tank 87 | 30°00.063 | 87°35.279 |
| Tank 60 | 29°54.715 | 87°46.333 | Tank 88 | 30°00.998 | 87°35.260 |
| Tank 61 | 29°53.744 | 87°46.246 | Tank 88 | 30°00.985 | 87°35.285 |
| Tank 62 | 29°52.710 | 87°46.170 | Tank 89 | 30°01.963 | 87°33.975 |
| Tank 63 | 29°51.775 | 87°46.083 | Tank 89 | 30°01.977 | 87°33.950 |
| Tank 64 | 29°49.820 | 87°44.540 | Tank 89 | 30°01.990 | 87°33.945 |
| Tank 65 | 29°50.438 | 87°44.809 | Tank 90 | 30°03.925 | 87°34.185 |
| Tank 66 | 29°51.375 | 87°44.984 | Tank 90 | 30°03.890 | 87°34.190 |
| Tank 67 | 29°52.347 | 87°45.102 | Tank 90 | 30°03.885 | 87°34.223 |
| Tank 68 | 29°53.343 | 87°45.220 | Tank 91 | 29°59.953 | 87°37.681 |
| Tank 69 | 29°54.350 | 87°45.330 | Tank 92 ** | | |
| Tank 70 | 29°55.368 | 87°45.387 | Tank 93 | 29°59.913 | 87°41.961 |
| Tank 71 | 29°56.208 | 87°45.406 | Tank 93 | 29°59.950 | 87°41.980 |
| Tank 73 | 29°57.376 | 87°45.576 | Tank 93 | 29°59.950 | 87°41.980 |

* Multiple tanks at location  ** Coordinates not available.

# PUBLIC REEFS - HUGH SWINGLE GENERAL PERMIT AREA






## General Public Reefs

| | | |
|---|---|---|
| Farewell Buoy | 30°07.490 | 88°04.130 |
| Papa Joe Memorial | 29°59.979 | 88°07.459 |
| Anderson Reef | 29°59.041 | 88°04.305 |
| Old Dry-Dock | 30°01.347 | 88°07.163 |
| Edwards Reef | 29°57.931 | 88°06.597 |
| McMillian Barge | 29°58.766 | 88°02.700 |
| Scott Barge | 29°59.180 | 88°01.740 |
| Southeast Banks | 30°01.425 | 87°56.900 |
| Southwest Rock | 30°06.414 | 88°12.275 |
| Tulsa | 30°01.068 | 88°06.462 |
| Dauphin Isl. Bridge | 30°02.537 | 88°05.796 |
| Dauphin Isl. Bridge | 30°02.786 | 88°04.565 |
| Dauphin Isl. Bridge | 30°01.170 | 88°04.846 |
| Nail Ship | 29°57.573 | 88°09.692 |
| D.R. Dunlap Drydock | 29°56.586 | 88°01.846 |
| Tensaw Bridge | 29°56.300 | 88°02.439 |
| Tensaw Bridge | 29°56.543 | 88°02.440 |
| Tensaw Bridge | 29°57.753 | 88°02.691 |
| Tensaw Bridge | 29°57.329 | 88°02.327 |
| Tensaw Bridge | 29°58.357 | 88°06.566 |
| Tensaw Bridge | 29°58.277 | 88°06.562 |

## Military Tank Reefs

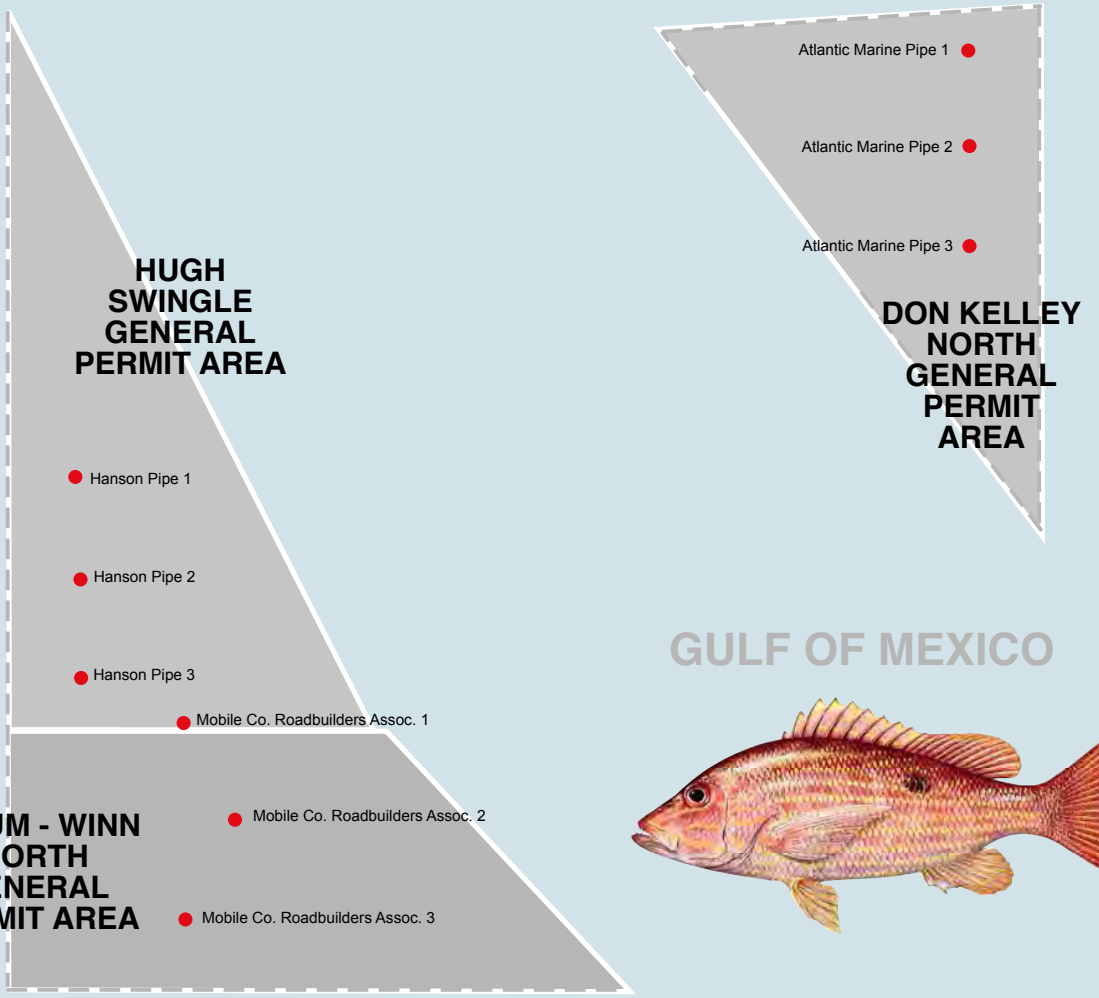
| | | |
|---|---|---|
| Lawrence Sims Reef * | 30°00.238 | 88°02.156 |
| Frank Broz Reef * | 30°00.308 | 88°01.803 |
| Tank 94 | 29°58.303 | 88°04.586 |
| Tank 94 | 29°58.290 | 88°04.480 |
| Tank 94 | 29°58.300 | 88°04.420 |
| Tank 95 * | 29°59.358 | 88°06.236 |
| Tank 96 | 30°00.642 | 88°06.818 |
| Tank 96 | 30°00.643 | 88°06.816 |
| Tank 97 | 29°58.345 | 88°05.884 |
| Tank 97 | 29°58.355 | 88°05.608 |
| Tank 98 | 29°57.339 | 88°05.985 |
| Tank 99 | 29°59.387 | 88°06.956 |
| Tank 99 | 29°59.406 | 88°06.899 |
| Tank 100 | 29°58.325 | 88°02.460 |
| Tank 101 | 29°58.474 | 88°00.568 |
| Tank 102 * | 30°00.518 | 88°00.147 |

* Multiple tanks at location

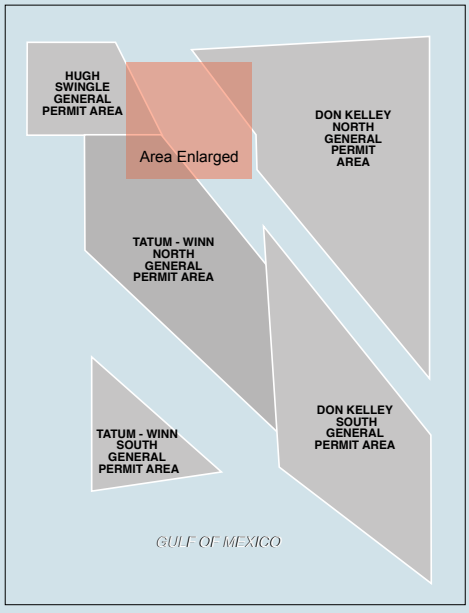
**Deployment of Atlantic Marine Drydock (D. R. Dunlap Reef)**

**M-60 Military Tank Reef**

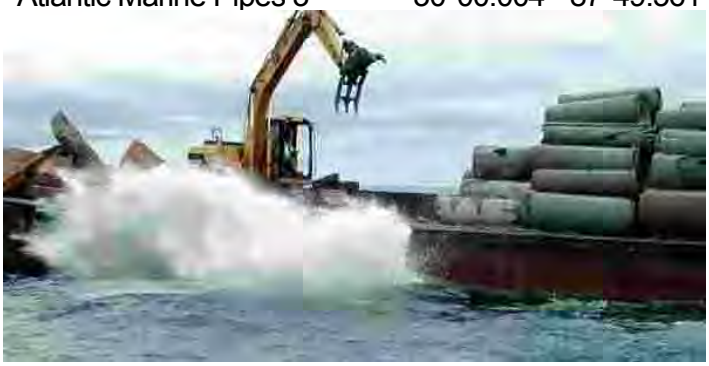
# CONCRETE CULVERT PIPE REEFS - 2004



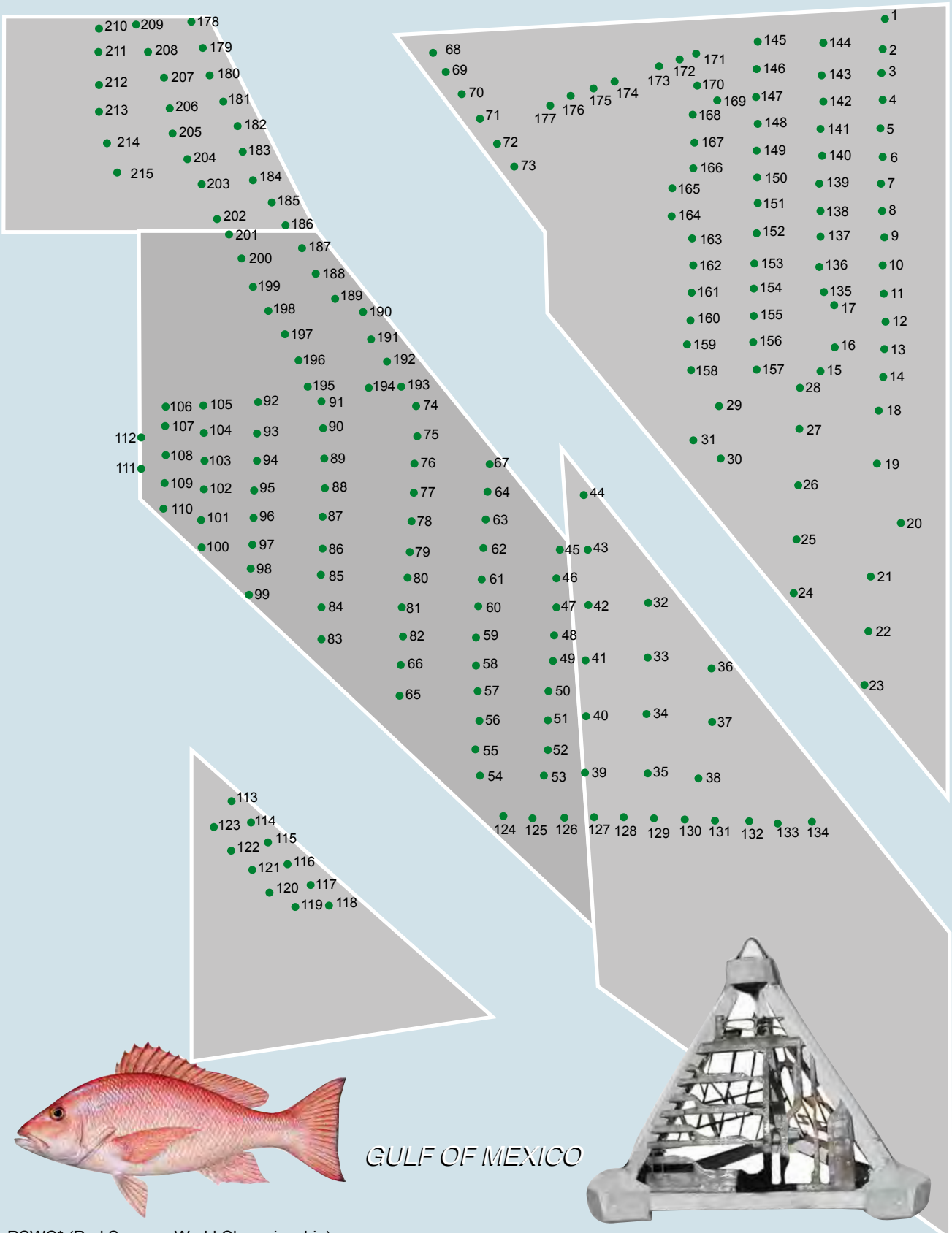



| | |
|---|---|
| Mobile Co. Roadbuilders 1 | 29°55.087 - 87°57.535 |
| Mobile Co. Roadbuilders 2 | 29°54.087 - 87°57.002 |
| Mobile Co. Roadbuilders 3 | 29°53.045 - 87°57.520 |
| Hanson Pipe 1 | 29°57.544 - 87°58.626 |
| Hanson Pipe 2 | 29°56.509 - 87°58.577 |
| Hanson Pipe 3 | 29°55.512 - 87°58.582 |
| Atlantic Marine Pipes 1 | 30°02.002 - 87°49.566 |
| Atlantic Marine Pipes 2 | 30°01.042 - 87°49.564 |
| Atlantic Marine Pipes 3 | 30°00.004 - 87°49.561 |



# RSWC* ARTIFICIAL REEF MODULES - 2004 DEPLOYMENT

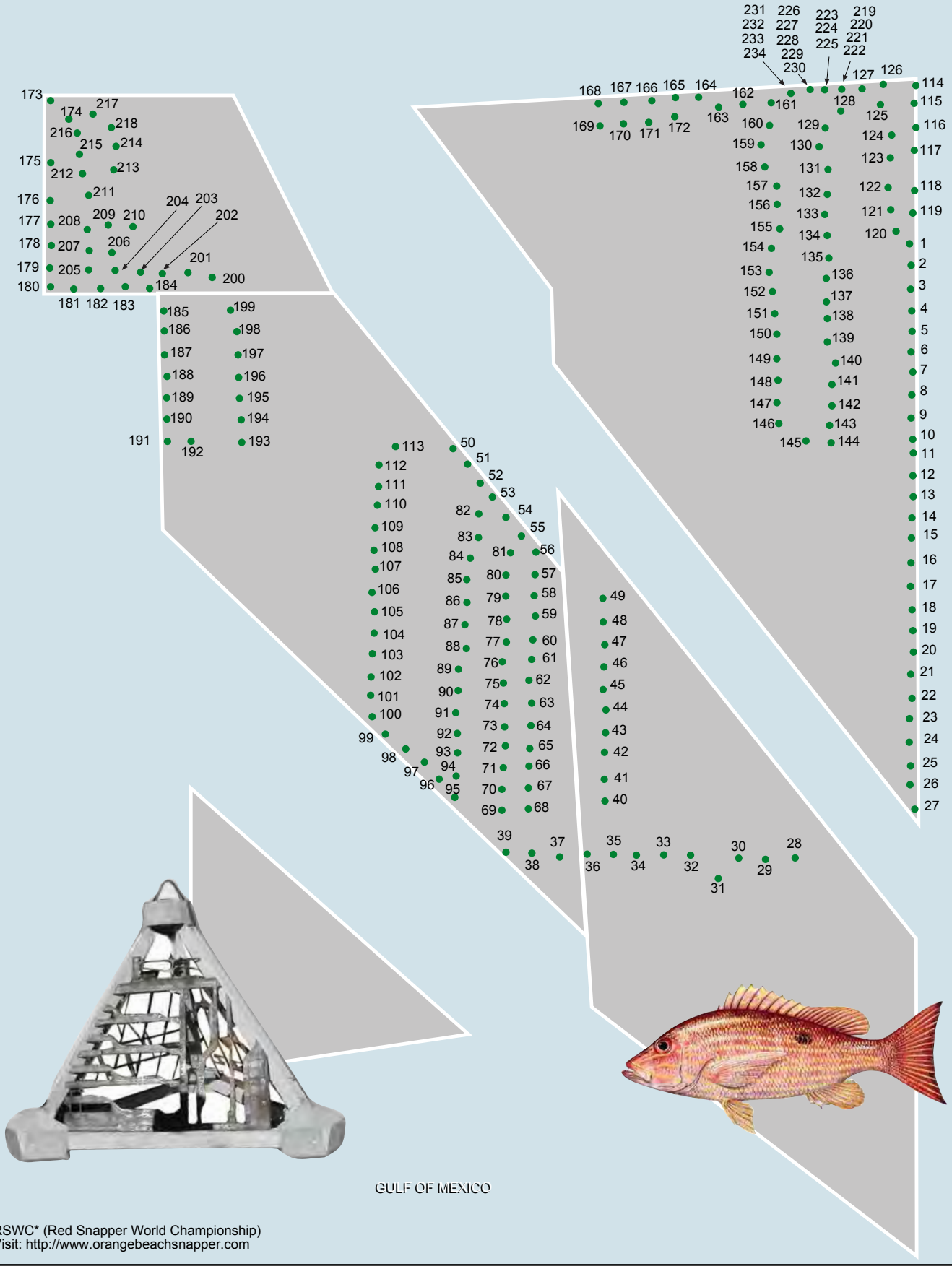



RSWC* (Red Snapper World Championship)
Visit: http://www.orangebeachsnapper.com

# RSWC 2004 REEF MODULES - GPS COORDINATES

| Reef # | Sponsor Name | Lat. | Long |
|---|---|---|---|
| 1 | Flora-Bama 1 | 30°02.894 | 87°34.648 |
| 2 | Flora-Bama 2 | 30°01.844 | 87°34.691 |
| 3 | Reynold's Ready Mix USA Pope #1 | 30°00.889 | 87°34.744 |
| 4 | Reynold's Ready Mix USA Butts #2 | 29°59.876 | 87°34.719 |
| 5 | Reynold's Ready Mix USA #3 | 29°58.854 | 87°34.800 |
| 6 | Reynold's Ready Mix USA #4 | 29°57.831 | 87°34.690 |
| 7 | Reynold's Ready Mix USA #5 | 29°56.842 | 87°34.727 |
| 8 | Joe Raley Builders - Big Momma | 29°55.832 | 87°34.696 |
| 9 | Joe Raley Builders | 29°54.855 | 87°34.636 |
| 10 | Top Gun Tackle #1 | 29°53.832 | 87°34.702 |
| 11 | Top Gun Tackle #2 | 29°52.774 | 87°34.671 |
| 12 | Home Port Marina #1 | 29°51.783 | 87°34.613 |
| 13 | Home Port Marina #2 | 29°50.728 | 87°34.653 |
| 14 | Home Port Marina #3 | 29°49.732 | 87°34.680 |
| 15 | Home Port Marina #4 | 29°49.953 | 87°36.989 |
| 16 | Home Port Marina #5 | 29°50.849 | 87°36.478 |
| 17 | Brett Robinson #1 | 29°52.410 | 87°36.467 |
| 18 | Brett Robinson #2 | 29°48.509 | 87°34.831 |
| 19 | Brett Robinson #3 | 29°46.514 | 87°34.878 |
| 20 | Brett Robinson #4 | 29°44.368 | 87°34.005 |
| 21 | Brett Robinson #5 | 29°42.390 | 87°35.126 |
| 22 | Brett Robinson #6 | 29°40.382 | 87°35.221 |
| 23 | Brett Robinson #7 | 29°38.381 | 87°35.420 |
| 24 | Brett Robinson #8 | 29°41.777 | 87°37.974 |
| 25 | Brett Robinson #9 | 29°43.751 | 87°37.875 |
| 26 | Brett Robinson #10 | 29°45.774 | 87°37.801 |
| 27 | Brett Robinson #11 | 29°47.769 | 87°37.732 |
| 28 | Brett Robinson #12 | 29°49.316 | 87°37.797 |
| 29 | Brett Robinson #13 | 29°48.685 | 87°40.695 |
| 30 | Brett Robinson #14 | 29°46.747 | 87°40.621 |
| 31 | Brett Robinson #15 | 29°47.410 | 87°41.576 |
| 32 | Brett Robinson #16 | 29°41.472 | 87°43.296 |
| 33 | Brett Robinson #17 | 29°39.426 | 87°43.323 |
| 34 | Brett Robinson #18 | 29°37.359 | 87°43.346 |
| 35 | Brett Robinson #19 | 29°35.230 | 87°43.334 |
| 36 | Brett Robinson #20 | 29°39.076 | 87°40.967 |
| 37 | J & M Tackle #1 | 29°37.023 | 87°40.997 |
| 38 | J & M Tackle #2 | 29°35.013 | 87°41.492 |
| 39 | J & M Tackle #3 | 29°35.202 | 87°45.620 |
| 40 | J & M Tackle #4 | 29°37.270 | 87°45.585 |
| 41 | J & M Tackle #5 | 29°39.318 | 87°45.617 |
| 42 | Blue Water Ship Stores #1 | 29°41.338 | 87°45.562 |
| 43 | Blue Water Ship Stores #2 | 29°43.383 | 87°45.563 |
| 44 | The Rod Room #1 | 29°45.407 | 87°45.684 |
| 45 | The Rod Room #2 | 29°43.371 | 87°46.582 |
| 46 | Zeke's Landing #1 | 29°42.358 | 87°46.691 |
| 47 | Zeke's Landing #2 | 29°41.264 | 87°46.705 |
| 48 | Zeke's Landing #3 | 29°40.218 | 87°46.761 |
| 49 | Zeke's Landing #4 | 29°39.299 | 87°46.799 |
| 50 | Zeke's Landing #5 | 29°38.174 | 87°46.982 |
| 51 | Zeke's Landing #6 | 29°37.138 | 87°46.982 |
| 52 | Zeke's Landing #7 | 29°36.022 | 87°47.020 |
| 53 | Zeke's Landing #8 | 29°35.057 | 87°47.141 |
| 54 | Zeke's Landing #9 | 29°35.053 | 87°49.472 |
| 55 | Zeke's Landing #10 | 29°36.046 | 87°49.649 |
| 56 | Foley Beach Express #1 | 29°37.105 | 87°49.491 |
| 57 | Foley Beach Express #2 | 29°38.166 | 87°49.538 |
| 58 | International Insurance - Kit Steber | 29°39.174 | 87°49.644 |
| 59 | International Insurance - Drew Steber | 29°40.206 | 87°49.610 |
| 60 | City of Orange Beach- Albacore II | 29°41.274 | 87°49.496 |
| 61 | City of Orange Beach- Annie Girl | 29°42.304 | 87°49.391 |
| 62 | City of Orange Beach- Aquastar | 29°43.408 | 87°49.309 |
| 63 | City of Orange Beach- Ashley Reene | 29°44.462 | 87°49.209 |
| 64 | City of Orange Beach- Big Adventure | 29.45.504 | 87°49.139 |
| 65 | City of Orange Beach- Boll Weevil | 29°38.044 | 87°52.451 |
| 66 | City of Orange Beach- C.A.T. | 29°39.157 | 87°52.387 |
| 67 | City of Orange Beach- C-ROSE | 29°46.512 | 87°49.148 |
| 68 | City of Orange Beach- Catch-It | 30°02.020 | 87°54.870 |
| 69 | City of Orange Beach- Chippers Clipper | 30°00.947 | 87°50.711 |
| 70 | City of Orange Beach- Class Act | 30°00.123 | 87°50.138 |
| 71 | City of Orange Beach- Cool Breeze | 29°59.261 | 87°49.511 |
| 72 | City of Orange Beach- Cool Change | 29°58.327 | 87°48.887 |
| 73 | City of Orange Beach- Crosstie | 29°57.479 | 87°48.246 |
| 74 | City of Orange Beach- Distraction | 29°48.655 | 87°51.810 |
| 75 | City of Orange Beach- Doug Out | 29°47.557 | 87°51.753 |
| 76 | City of Orange Beach- Fairwater II | 29°46.559 | 87°51.888 |
| 77 | City of Orange Beach- Fish'n Fool | 29°45.445 | 87°51.905 |
| 78 | City of Orange Beach- Fish Trap | 29°44.404 | 87°52.020 |
| 79 | City of Orange Beach- Getaway | 29°43.275 | 87°52.110 |
| 80 | City of Orange Beach- Gulf Rebel | 29°42.329 | 87°52.138 |
| 81 | City of Orange Beach- Hey Boy II | 29°41.266 | 87°52.362 |
| 82 | City of Orange Beach- Hot Spot | 29°40.176 | 87°52.304 |
| 83 | City of Orange Beach- Intimidator | 29°40.109 | 87°55.322 |
| 84 | City of Orange Beach- Intruder | 29°41.273 | 87°55.319 |
| 85 | City of Orange Beach- Island Girl | 29°42.479 | 87°55.309 |
| 86 | City of Orange Beach- Jamie G | 29°43.440 | 87°55.256 |
| 87 | City of Orange Beach- Joyce | 29°44.610 | 87°55.280 |
| 88 | City of Orange Beach- Lady D | 29°45.646 | 87°55.184 |
| 89 | City of Orange Beach- Mamas Money | 29°46.732 | 87°55.212 |
| 90 | City of Orange Beach- Miss Celeste | 29°47.850 | 87°55.267 |
| 91 | City of Orange Beach- Misty | 29°48.797 | 87°55.322 |
| 92 | City of Orange Beach- Necessity | 29°48.806 | 87°57.649 |
| 93 | City of Orange Beach- Outcast | 29°47.706 | 87°57.692 |
| 94 | City of Orange Beach- Reef Chief | 29°46.672 | 87°57.697 |
| 95 | City of Orange Beach- Reel Surprise | 29°45.600 | 87°57.781 |
| 96 | City of Orange Beach- Hip Tide | 29°44.572 | 87°57.791 |
| 97 | City of Orange Beach- Robin Lynne | 29°43.558 | 87°57.861 |
| 98 | Chris Myers Nissan | 29°42.682 | 87°57.912 |
| 99 | Chris Myers Auto Mall | 29°41.689 | 87°57.989 |
| 100 | Convention & Visitors Bureau #1 | 29°43.476 | 87°59.697 |
| 101 | Convention & Visitors Bureau #2 | 29°44.525 | 87°59.730 |
| 102 | Convention & Visitors Bureau #3 | 29°45.609 | 87°59.627 |
| 103 | Convention & Visitors Bureau #4 | 29°46.654 | 87°59.630 |
| 104 | Convention & Visitors Bureau #5 | 29°47.696 | 87°59.637 |
| 105 | Convention & Visitors Bureau #6 | 29°48.688 | 87°59.627 |
| 106 | Convention & Visitors Bureau #7 | 29°48.632 | 88°01.036 |
| 107 | Convention & Visitors Bureau #8 | 29°47.886 | 88°01.025 |
| 108 | Convention & Visitors Bureau #9 | 29°46.841 | 88°01.046 |
| 109 | Convention & Visitors Bureau #10 | 29°45.858 | 88°01.065 |
| 110 | Convention & Visitors Bureau #11 | 29°44.867 | 88°01.057 |
| 111 | Convention & Visitors Bureau #12 | 29°46.442 | 88°01.933 |
| 112 | Convention & Visitors Bureau #13 | 29°47.499 | 88°01.935 |
| 113 | Convention & Visitors Bureau #14 | 29°33.538 | 87°59.821 |
| 114 | Convention & Visitors Bureau #15 | 29°32.789 | 87°59.148 |
| 115 | The Reef Maker #1 | 29°32.030 | 87°58.452 |
| 116 | The Reef Maker #2 | 29°31.231 | 87°57.769 |
| 117 | Radcliff Economy & Marine #1 | 29°30.456 | 87°56.990 |
| 118 | ValvTect #1 | 29°29.707 | 87°56.220 |
| 119 | RE/MAX of Gulf Shores #1 | 29°29.650 | 87°57.482 |
| 120 | RE/MAX of Gulf Shores #2 | 29°30.246 | 87°58.389 |
| 121 | RE/MAX of Gulf Shores #3 | 29°31.014 | 87°59.062 |
| 122 | RE/MAX of Gulf Shores #4 | 29°31.732 | 87°59.826 |
| 123 | RE/MAX of Gulf Shores #5 | 29°32.545 | 88°00.479 |
| 124 | Kaiser Realty Inc. #1 | 29°33.568 | 87°48.617 |
| 125 | Kaiser Realty Inc. #2 | 29°33.501 | 87°47.578 |
| 126 | Kaiser Realty Inc. #3 | 29°33.523 | 87°46.449 |
| 127 | Kaiser Realty Inc. #4 | 29°33.526 | 87°45.300 |
| 128 | Kaiser Realty Inc. #5 | 29°33.541 | 87°44.210 |
| 129 | Caribe Resort #1 | 29°33.489 | 87°43.105 |
| 130 | Caribe Resort #2 | 29°33.471 | 87°41.987 |
| 131 | Tacky Jacks #1 | 29°33.440 | 87°40.875 |
| 132 | Tacky Jacks #2 | 29°33.390 | 87°39.623 |
| 133 | Orange Beach Auto & Marine #1 | 29°33.308 | 87°38.584 |
| 134 | Orange Beach Auto & Marine #2 | 29°33.364 | 87°37.324 |
| 135 | Live Bait I | 29°52.854 | 87°36.917 |
| 136 | Live Bait II | 29°53.813 | 87°37.047 |
| 137 | Live Bait III | 29°54.855 | 87°36.983 |
| 138 | Live Bait IV | 29°55.828 | 87°36.992 |
| 139 | Live Bait V | 29°56.868 | 87°37.046 |
| 140 | Baldwin Co. E.M.C. leader | 29°57.857 | 87°36.944 |
| 141 | Baldwin Co. E.M.C. member | 29°58.855 | 87°36.978 |
| 142 | Baldwin Co. E.M.C. community | 29°59.853 | 87°36.922 |
| 143 | Baldwin Co. E.M.C. cooperative | 30°00.839 | 87°37.009 |
| 144 | Baldwin Co. E.M.C. environmental | 30°02.005 | 87°36.904 |
| 145 | City of Orange Beach- Sea Spray | 30°02.043 | 87°39.276 |
| 146 | City of Orange Beach- Shady Lady | 30°01.015 | 87°39.355 |
| 147 | Bud #1 | 30°00.025 | 87°39.381 |
| 148 | Ultra #1 | 29°59.066 | 87°39.303 |
| 149 | BBD #1 | 29°58.055 | 87°39.348 |
| 150 | Busch #1 | 29°57.077 | 87°39.281 |
| 151 | Lauren #1 | 29°56.089 | 87°39.303 |
| 152 | Heavy Gravy | 29°55.033 | 87°39.329 |
| 153 | Miss Sally | 29°53.910 | 87°39.412 |
| 154 | Cummins Quantum Hole | 29°52.995 | 87°39.424 |
| 155 | Mid South Spot | 29°51.984 | 87°39.436 |
| 156 | Christian Mahlstedt | 29°51.039 | 87°39.472 |
| 157 | Lucas Mahlstedt | 29°49.980 | 87°39.347 |
| 158 | Amelie | 29°49.991 | 87°41.784 |
| 159 | Whitney | 29°50.938 | 87°41.885 |
| 160 | Mikee's | 29°51.840 | 87°41.754 |
| 161 | The Shrimp Basket | 29°52.805 | 87°41.751 |
| 162 | McCarron Insurance Group #1 | 29°53.839 | 87°41.659 |
| 163 | Sally's Fishing Hole | 29°54.810 | 87°41.682 |
| 164 | Tom Bagwell Reef | 29°55.630 | 87°42.437 |
| 165 | William Radcliff Reef | 29°56.643 | 87°42.446 |
| 166 | Capt Sunny Trimble Memorial-War Eagle | 29°57.391 | 87°41.638 |
| 167 | L.H. Washington Memorial - War Eagle | 29°58.345 | 87°41.663 |
| 168 | Outcast Marina | 29°59.394 | 87°41.694 |
| 169 | Outcast Marina | 29°59.894 | 87°40.765 |
| 170 | Jim Brown Construction | 30°00.482 | 87°41.537 |
| 171 | Sabel Steel #1 | 30°01.585 | 87°41.610 |
| 172 | Sabel Steel #2 | 30°01.396 | 87°42.217 |
| 173 | Salzman Farms #1 | 30°01.162 | 87°42.933 |
| 174 | Salzman Farms #2 | 30°00.570 | 87°44.553 |
| 175 | Sandy Wade Reef | 30°00.285 | 87°45.320 |
| 176 | SanRoc Cay Reef | 29°59.973 | 87°46.133 |
| 177 | RM #1 | 29°59.637 | 87°46.884 |
| 178 | RM #2 | 30°02.741 | 88°00.111 |
| 179 | The Sportsman Skiff | 30°01.800 | 87°59.659 |
| 180 | Sportman Marina | 30°00.821 | 87°59.372 |
| 181 | Trent Marina #1 | 29°59.869 | 87°58.926 |
| 182 | Trent Marina #2 | 29°58.974 | 87°58.396 |
| 183 | Vision Bank #1 | 29°58.001 | 87°58.204 |
| 184 | Vision Bank #2 | 29°57.008 | 87°57.825 |
| 185 | Zeke's Boat Sales #1 | 29°56.148 | 87°57.205 |
| 186 | Zeke's Boat Sales #2 | 29°55.283 | 87°56.650 |
| 187 | Dora's Reef | 29°54.431 | 87°56.037 |
| 188 | Rick's Reef | 29°53.525 | 87°55.542 |
| 189 | James' Reef | 29°52.641 | 87°54.852 |
| 190 | Nina's Reef | 29°52.123 | 87°53.800 |
| 191 | Willy's Reef | 29°51.114 | 87°53.529 |
| 192 | LCPL Philip J. Shermer, III | 29°50.311 | 87°52.927 |
| 193 | William L. Marks | 29°49.405 | 87°52.374 |
| 194 | John C. Hope III | 29°49.350 | 87°53.574 |
| 195 | Robert C. Baird | 29°49.372 | 87°55.830 |
| 196 | John M. Turner | 29°50.355 | 87°56.175 |
| 197 | Vinyl Solutions | 29°51.307 | 87°56.670 |
| 198 | Visual Effects | 29°52.209 | 87°57.261 |
| 199 | Fish Camp Restaurants #1 | 29°53.067 | 87°57.841 |
| 200 | Fish Camp Restaurants #2 | 29°54.056 | 87°58.207 |
| 201 | Performance Contractors Reef # 1 | 29°54.987 | 87°58.690 |
| 202 | Brandon Favre Reef | 29°55.539 | 87°59.121 |
| 203 | Outcast Bait & Tackle #1 | 29°56.791 | 87°59.730 |
| 204 | Outcast Bait & Tackle #2 | 29°57.737 | 88°00.213 |
| 205 | Outcast Bait & Tackle #3 | 29°58.686 | 88°00.760 |
| 206 | Outcast Bait & Tackle #4 | 29°59.600 | 88°00.900 |
| 207 | Outcast Bait & Tackle #5 | 30°00.729 | 88°01.057 |
| 208 | First National Bank #1 | 30°01.662 | 88°01.628 |
| 209 | First National Bank #2 | 30°02.623 | 88°02.175 |
| 210 | Coast Marine #1 | 30°02.572 | 88°03.491 |
| 211 | Coast Marine #2 | 30°01.617 | 88°03.463 |
| 212 | Schenck Reef | 30°00.482 | 88°03.460 |
| 213 | Schwartz Reef | 29°59.494 | 88°03.451 |
| 214 | Sam's Spot #1 | 29°58.345 | 88°03.510 |
| 215 | Sam's Spot #2 | 29°56.907 | 88°03.315 |

# RSWC ARTIFICIAL REEF MODULES - 2005 - 06 DEPLOYMENT

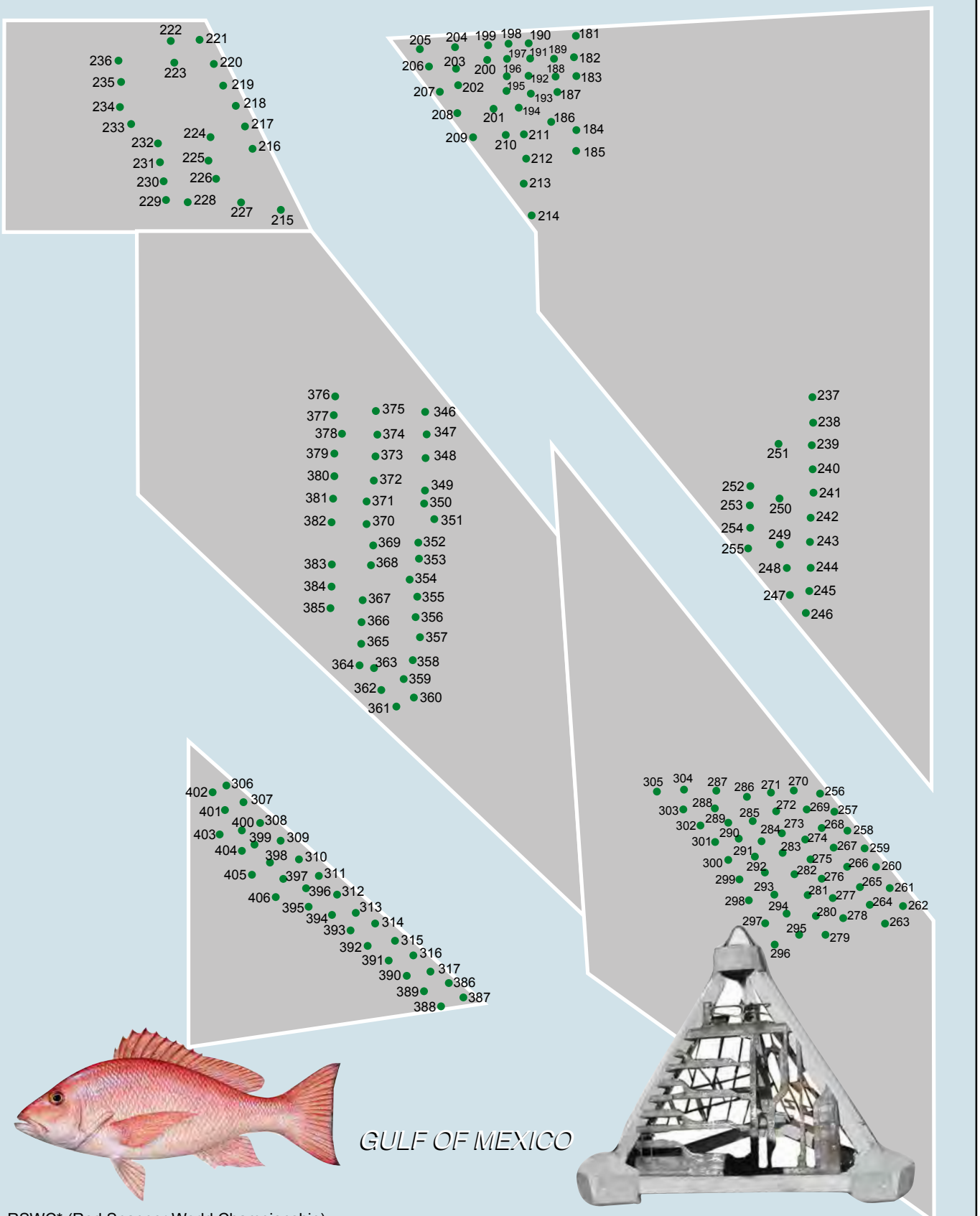



RSWC* (Red Snapper World Championship)
Visit: http://www.orangebeachsnapper.com

# RSWC 2005 - 06 REEF MODULES - GPS COORDINATES

| Reef # | Sponsor Name | Lat. | Long |
|---|---|---|---|
| 1 | Reynold's Ready Mix- Walter Pope #2 | 29°57.046 | 87°32.605 |
| 2 | Reynold's Ready Mix- Walter Pope #3 | 29°56.139 | 87°32.554 |
| 3 | Reynold's Ready Mix- Walter Pope #4 | 29°55.275 | 87°32.595 |
| 4 | Reynold's Ready Mix- Harold Butts #2 | 29°54.385 | 87°32.574 |
| 5 | Reynold's Ready Mix- Harold Butts #3 | 29°53.535 | 87°32.544 |
| 6 | Ala° Gulf Coast Chamber of Commerce | 29°52.693 | 87°32.564 |
| 7 | Ala° Gulf Coast Chamber of Commerce #2 | 29°51.866 | 87°32.547 |
| 8 | Brett/Robinson #21 | 29°50.977 | 87°32.521 |
| 9 | Brett/Robinson #22 | 29°50.108 | 87°32.564 |
| 10 | Brett/Robinson #23 | 29°49.261 | 87°32.465 |
| 11 | Brett/Robinson #24 | 29°48.793 | 87°32.558 |
| 12 | Brett/Robinson #25 | 29°47.890 | 87°32.486 |
| 13 | Brett/Robinson #26 | 29°47.021 | 87°32.548 |
| 14 | Brett/Robinson #27 | 29°46.111 | 87°32.609 |
| 15 | Brett/Robinson #28 | 29°45.242 | 87°32.564 |
| 16 | Brett/Robinson #29 | 29°44.348 | 87°32.583 |
| 17 | Brett/Robinson #30 | 29°43.412 | 87°32.643 |
| 18 | Brett/Robinson #31 | 29°42.486 | 87°32.536 |
| 19 | Brett/Robinson #32 | 29°41.639 | 87°32.531 |
| 20 | Brett/Robinson #33 | 29°40.734 | 87°32.510 |
| 21 | Brett/Robinson #34 | 29°39.891 | 87°32.574 |
| 22 | Brett/Robinson #35 | 29°38.934 | 87°32.584 |
| 23 | Brett/Robinson #36 | 29°38.109 | 87°32.573 |
| 24 | Brett/Robinson #37 | 29°37.159 | 87°32.669 |
| 25 | Brett/Robinson #38 | 29°36.306 | 87°32.633 |
| 26 | Brett/Robinson #39 | 29°35.445 | 87°32.597 |
| 27 | Brett/Robinson #40 | 29°34.551 | 87°32.551 |
| 28 | BBD Mollie | 29°32.522 | 87°37.210 |
| 29 | BBD Claire | 29°32.525 | 87°38.328 |
| 30 | BBD Maggie | 29°32.613 | 87°39.347 |
| 31 | BBD Sam | 29°31.764 | 87°40.321 |
| 32 | BBD Will | 29°32.757 | 87°41.394 |
| 33 | City of Orange Beach- Adventure Quest | 29°32.734 | 87°42.480 |
| 34 | City of Orange Beach- Job Site | 29°32.722 | 87°43.514 |
| 35 | City of Orange Beach- Barely Legal | 29°32.728 | 87°44.447 |
| 36 | City of Orange Beach- Bottom Line | 29°32.727 | 87°45.441 |
| 37 | City of Orange Beach- Lady Ann | 29°32.690 | 87°46.563 |
| 38 | City of Orange Beach- Miss Hollie | 29°32.723 | 87°47.661 |
| 39 | City of Orange Beach- Condo Money | 29°32.776 | 87°48.754 |
| 40 | City of Orange Beach- Patti Ann | 29°34.806 | 87°44.789 |
| 41 | City of Orange Beach- Red Eye | 29°35.739 | 87°44.801 |
| 42 | City of Orange Beach- Crowd Pleezer | 29°36.781 | 87°44.784 |
| 43 | City of Orange Beach- Eagle Express | 29°37.623 | 87°44.742 |
| 44 | City of Orange Beach- Sea Spray | 29°38.487 | 87°44.788 |
| 45 | City of Orange Beach- Shady Lady | 29°39.328 | 87°44.833 |
| 46 | City of Orange Beach- E-Mail | 29°40.192 | 87°44.866 |
| 47 | City of Orange Beach- Escape | 29°41.072 | 87°44.861 |
| 48 | City of Orange Beach- Shirley R. Too | 29°41.949 | 87°44.834 |
| 49 | City of Orange Beach- South Wind | 29°42.798 | 87°44.857 |
| 50 | City of Orange Beach- Summer Breeze I | 29°48.929 | 87°50.740 |
| 51 | City of Orange Beach- Summer Breeze II | 29°48.219 | 87°50.245 |
| 52 | City of Orange Beach- Summer Daze | 29°47.471 | 87°49.732 |
| 53 | City of Orange Beach- Summer Hunter | 29°46.926 | 87°49.250 |
| 54 | City of Orange Beach- Sure Shot | 29°46.099 | 87°48.682 |
| 55 | City of Orange Beach- Teacher's Pet | 29°45.427 | 87°48.091 |
| 56 | City of Orange Beach- High Cotton | 29°44.692 | 87°47.535 |
| 57 | City of Orange Beach- Traveler | 29°43.816 | 87°47.529 |
| 58 | City of Orange Beach- Undertaker | 29°42.990 | 87°47.578 |
| 59 | City of Orange Beach- Wishbone | 29°42.187 | 87°47.614 |
| 60 | City of Orange Beach- Zeke's Lady | 29°41.317 | 87°47.606 |
| 61 | City of Orange Beach- Annie Girl #2 | 29°40.474 | 87°47.690 |
| 62 | City of Orange Beach- Aquastar #2 | 29°39.642 | 87°47.718 |
| 63 | City of Orange Beach- Big Adventure #2 | 29°38.749 | 87°47.668 |
| 64 | City of Orange Beach- Boll Weevil #2 | 29°37.886 | 87°47.713 |
| 65 | City of Orange Beach- Bottom Line #2 | 29°36.935 | 87°47.787 |
| 66 | City of Orange Beach- C-ROSE #2 | 29°36.207 | 87°47.802 |
| 67 | City of Orange Beach- C.A.T. #2 | 29°35.358 | 87°47.803 |
| 68 | City of Orange Beach- Catch-It #2 | 29°34.489 | 87°47.860 |
| 69 | CVB Reef #16 | 29°34.481 | 87°48.805 |
| 70 | CVB Reef #17 | 29°35.327 | 87°48.806 |
| 71 | CVB Reef #18 | 29°36.198 | 87°48.818 |
| 72 | CVB Reef #19 | 29°37.033 | 87°48.772 |
| 73 | CVB Reef #20 | 29°37.862 | 87°48.758 |
| 74 | CVB Reef #21 | 29°38.735 | 87°48.749 |
| 75 | CVB Reef #22 | 29°39.532 | 87°48.745 |
| 76 | CVB Reef #23 | 29°40.403 | 87°48.825 |
| 77 | CVB Reef #24 | 29°41.244 | 87°48.710 |
| 78 | CVB Reef #25 | 29°42.085 | 87°48.696 |
| 79 | CVB Reef #26 | 29°42.957 | 87°48.662 |
| 80 | CVB Reef #27 | 29°43.815 | 87°48.643 |
| 81 | CVB Reef #28 | 29°44.726 | 87°48.484 |
| 82 | CVB Reef #29 | 29°46.272 | 87°49.788 |
| 83 | CVB Reef #30 | 29°45.341 | 87°49.865 |
| 84 | Foley Beach Express #3 | 29°44.496 | 87°50.156 |
| 85 | Foley Beach Express #4 | 29°43.613 | 87°50.222 |
| 86 | Homeport Marina #6 | 29°42.767 | 87°50.257 |
| 87 | Homeport Marina #7 | 29°41.823 | 87°50.329 |
| 88 | Homeport Marina #8 | 29°40.934 | 87°50.230 |
| 89 | Homeport Marina #9 | 29°40.122 | 87°50.580 |
| 90 | Homeport Marina #10 | 29°39.249 | 87°50.609 |
| 91 | Chris Steber Reef | 29°38.413 | 87°50.715 |
| 92 | Michele Steber Reef | 29°37.535 | 87°50.677 |
| 93 | Eric Mahlstedt | 29°36.722 | 87°50.684 |
| 94 | Island Wide Marine Reef | 29°35.854 | 87°50.699 |
| 95 | J&M Tackle #6 | 29°34.999 | 87°50.737 |
| 96 | J&M Tackle #7 | 29°35.710 | 87°51.375 |
| 97 | J&M Tackle #8 | 29°36.357 | 87°51.973 |
| 98 | J&M Tackle #9 | 29°36.936 | 87°52.704 |
| 99 | J&M Tackle #10 | 29°37.562 | 87°53.444 |
| 100 | Riverwalk Orange Beach | 29°38.196 | 87°54.029 |
| 101 | Gulf World Marine Park | 29°39.020 | 87°54.069 |
| 102 | Sam's Spot #3 | 29°39.819 | 87°54.059 |
| 103 | Sam's Spot #4 | 29°40.643 | 87°54.027 |
| 104 | Sam's Spot #5 | 29°41.483 | 87°53.941 |
| 105 | Sam's Spot #6 | 29°42.323 | 87°53.964 |
| 106 | Sam's Spot #7 | 29°43.165 | 87°53.980 |
| 107 | RM #3 | 29°44.031 | 87°53.909 |
| 108 | RM #4 | 29°44.877 | 87°53.961 |
| 109 | Owen's Reef | 29°45.741 | 87°53.860 |
| 110 | Toby's Reef | 29°46.574 | 87°53.805 |
| 111 | The Rod Room #3 | 29°47.408 | 87°53.769 |
| 112 | The Rod Room #4 | 29°48.294 | 87°53.771 |
| 113 | Zeke's Landing #11 | 29°48.969 | 87°53.141 |
| 114 | Zeke's Landing #12 | 30°03.380 | 87°32.471 |
| 115 | Zeke's Landing #13 | 30°02.507 | 87°32.467 |
| 116 | Zeke's Landing #14 | 30°01.657 | 87°32.475 |
| 117 | Zeke's Landing #15 | 30°00.805 | 87°32.467 |
| 118 | Zeke's Landing #16 | 29°99.961 | 87°32.496 |
| 119 | Zeke's Landing #17 | 29°59.083 | 87°32.479 |
| 120 | Zeke's Landing #18 | 29°58.226 | 87°32.490 |
| 121 | Zeke's Landing #19 | 29°57.530 | 87°33.129 |
| 122 | Zeke's Landing #20 | 29°58.375 | 87°33.440 |
| 123 | Red's Reef | 30°00.452 | 87°33.450 |
| 124 | Anthony's Reef | 30°01.307 | 87°33.435 |
| 125 | Amanda Myers Reef | 30°02.591 | 87°33.806 |
| 126 | Leslie Myers Reef | 30°03.412 | 87°33.777 |
| 127 | Tchuopitoulas | 30°03.122 | 87°35.414 |
| 128 | St. Charles | 30°02.277 | 87°35.373 |
| 129 | Poydras | 30°01.616 | 87°36.005 |
| 130 | Carondolet | 30°00.784 | 87°36.204 |
| 131 | Gravier | 29°59.947 | 87°35.931 |
| 132 | J.D.'s Hole | 29°59.052 | 87°35.930 |
| 133 | Peet's Place | 29°58.227 | 87°35.921 |
| 134 | Paradise Lost | 29°57.343 | 87°35.946 |
| 135 | Paradise Found | 29°56.483 | 87°35.929 |
| 136 | Sabel Steel #3 | 29°55.645 | 87°35.956 |
| 137 | Sabel Steel #4 | 29°54.800 | 87°35.961 |
| 138 | CITGO Supergard #1 | 29°53.965 | 87°35.943 |
| 139 | CITGO Supergard #2 | 29°53.128 | 87°35.904 |
| 140 | CITGO Supergard #3 | 29°52.319 | 87°35.590 |
| 141 | CITGO Supergard #4 | 29°51.486 | 87°35.746 |
| 142 | CITGO Supergard #5 | 29°50.619 | 87°35716 |
| 143 | CITGO Supergard #6 | 29°49.802 | 87°35.780 |
| 144 | CITGO Supergard #7 | 29°49.093 | 87°35.737 |
| 145 | CITGO Supergard #8 | 29°49.172 | 87°36.759 |
| 146 | CITGO Supergard #9 | 29°49.887 | 87°37.894 |
| 147 | CITGO Supergard #10 | 29°50.760 | 87°37.904 |
| 148 | Top Gun Tackle #3 | 29°51.649 | 87°37.875 |
| 149 | Top Gun Tackle #4 | 29°52.582 | 87°37.868 |
| 150 | Kaiser Realty, Inc. #6 | 29°53.422 | 87°37.946 |
| 151 | Kaiser Realty, Inc. #7 | 29°54.268 | 87°38.007 |
| 152 | Perdido Beach Resort Reef | 29°55.113 | 87°38.049 |
| 153 | Gulf Beach Hotels Reef | 29°55.959 | 87°38.293 |
| 154 | The Champ & Chump reef | 29°56.757 | 87°38.034 |
| 155 | The Wickware's Reef | 29°57.627 | 87°37.891 |
| 156 | Orange Beach Auto & Marine #3 | 29°47.482 | 87°37.897 |
| 157 | Orange Beach Auto & Marine #4 | 29°59.363 | 87°37.912 |
| 158 | Boss Malouf | 30°00.101 | 87°38.420 |
| 159 | Bailey Malouf | 30°00.927 | 87°38.534 |
| 160 | Lester's- Houston Pierce | 30°01.820 | 87°38.211 |
| 161 | Lester's- Leslee Faith | 30°02.621 | 87°38.107 |
| 162 | Lester's- Uncle Bud | 30°02.542 | 87°39.256 |
| 163 | Lester's- Mrs Theresa | 30°02.422 | 87°40.206 |
| 164 | Lester's- Estelle M. | 30°02.876 | 87°41.002 |
| 165 | Tacky Jacks #3 | 30°02.788 | 87°41.993 |
| 166 | Tacky Jacks #4 | 30°02.707 | 87°42.940 |
| 167 | Fish Camp Restaurants #3 | 30°02.652 | 87°44.021 |
| 168 | Fish Camp Restaurants #4 | 30°02.565 | 87°45.036 |
| 169 | Voodoo | 30°01.686 | 87°45.007 |
| 170 | Black Gold Hole | 30°01.759 | 87°44.041 |
| 171 | Robbie | 30°01.837 | 87°43.064 |
| 172 | Kevin | 30°02.089 | 87°42.101 |
| 173 | Vision Bank #3 | 30°02.920 | 88°06.853 |
| 174 | Vision Bank #4 | 30°02.043 | 88°06.049 |
| 175 | Dizzy Bean | 30°00.153 | 88°06.814 |
| 176 | Lilly French | 29°58.698 | 88°06.842 |
| 177 | Visual Effects #2 | 29°57.807 | 88°06.836 |
| 178 | Vinyl Solutions #2 | 29°56.925 | 88°06.862 |
| 179 | Flora-Bama III | 29°56.074 | 88°06.816 |
| 180 | Flora-Bama IV | 29°55.230 | 88°06.823 |
| 181 | Big Jake's | 29°55.177 | 88°05.832 |
| 182 | Francos | 29°55.171 | 88°04.851 |
| 183 | X-treme Marine Reef | 29°55.177 | 88°03.860 |
| 184 | Don't Fish Here! | 29°55.141 | 88°02.870 |
| 185 | Radcliff Economy & Marine #2 | 29°54.389 | 88°02.379 |
| 186 | ValvTect #2 | 29°53.520 | 88°02.323 |
| 187 | The Beach Club #1 | 29°52.591 | 88°02.302 |
| 188 | The Beach Club #2 | 29°51.703 | 88°02.227 |
| 189 | Hunter's Reef | 29°50.877 | 88°02.162 |
| 190 | Hyperion Construction | 29°50.015 | 88°02.190 |
| 191 | Wadeley #1 | 29°49.143 | 88°02.130 |
| 192 | Jason's Reef 21 | 29°49.164 | 88°01.196 |
| 193 | First Gulf Bank- Linda Wheatley Reef | 29°49.154 | 87°59.207 |
| 194 | First Gulf Bank- Robert Seaborn Reef | 29°50.056 | 87°59.209 |
| 195 | Kelsey Mac's Reef | 29°50.904 | 87°59.284 |
| 196 | Kaitlin B's Reef | 29°51.790 | 87°59.340 |
| 197 | In Memory of Jeff Cooper | 29°52.640 | 87°59.369 |
| 198 | We'll See | 29°53.482 | 87°59.428 |
| 199 | Jim Brown #2 | 29°54.332 | 87°59.719 |
| 200 | Jim Brown #3 | 29°55.670 | 88°00.364 |
| 201 | Outcast Marina #3 | 29°55.870 | 88°01.306 |
| 202 | Mathew's Reef | 29°55.692 | 88°02.315 |
| 203 | The Reef Maker #3 | 29°55.911 | 88°03.247 |
| 204 | Brandy Rhodes | 29°55.919 | 88°04.219 |
| 205 | Cody Rhodes | 29°55.915 | 88°05.238 |
| 206 | Bear Point Marina Reef | 29°56.641 | 88°04.368 |
| 207 | Sandy Wade Reef #2 | 29°56.787 | 88°05.260 |
| 208 | City of Gulf Shores #1 | 29°57.483 | 88°05.290 |
| 209 | City of Gulf Shores #2 | 29°57.709 | 88°04.449 |
| 210 | City of Gulf Shores #3 | 29°57.670 | 88°03.545 |
| 211 | City of Gulf Shores #4 | 29°58.955 | 88°05.258 |
| 212 | City of Gulf Shores #5 | 29°59.760 | 88°05.639 |
| 213 | City of Gulf Shores #6 | 29°59.950 | 88°04.260 |
| 214 | City of Gulf Shores #7 | 30°00.846 | 88°04.208 |
| 215 | City of Gulf Shores #8 | 30°00.606 | 88°05.732 |
| 216 | City of Gulf Shores #9 | 30°01.448 | 88°05.709 |
| 217 | City of Gulf Shores #10 | 30°02.127 | 88°05.110 |
| 218 | Caribe #3 | 30°01.605 | 88°04.359 |
| 219 | Caribe #4 | 30°03.098 | 87°36.081 |
| 220 | David Askew Jr. | 30°03.058 | 87°36.168 |
| 221 | Earlene Askew | 30°03.085 | 87°36.289 |
| 222 | Baldwin County EMC Reef #6 | 30°03.074 | 87°36.421 |
| 223 | Baldwin County EMC Reef #7 | 30°03.060 | 87°37.257 |
| 224 | Charlene Farve Reef | 30°03056 | 87°37.337 |
| 225 | Shelley Farve Reef | 30°03051 | 87°37.543 |
| 226 | Sportsman's Marine in Fairhope #1 | 30°02952 | 87°38.551 |
| 227 | Sportsman's Marine in Fairhope #2 | 30°02.981 | 87°38.617 |
| 228 | RE/MAX #1 | 30°02.971 | 87°38.697 |
| 229 | RE/MAX #2 | 30°02.972 | 87°38.783 |
| 230 | RE/MAX #3 | 30°02.938 | 87°38.932 |
| 231 | RE/MAX #4 | 30°02.953 | 87°39.470 |
| 232 | RE/MAX #5 | 30°02.938 | 87°39.527 |
| 233 | Blue Water Scott | 30°02.941 | 87°39.932 |
| 234 | Blue Water Chris | 30°02.958 | 87°40.050 |

# RSWC* ARTIFICIAL REEF MODULES - 2007 DEPLOYMENT




GULF OF MEXICO

RSWC* (Red Snapper World Championship)
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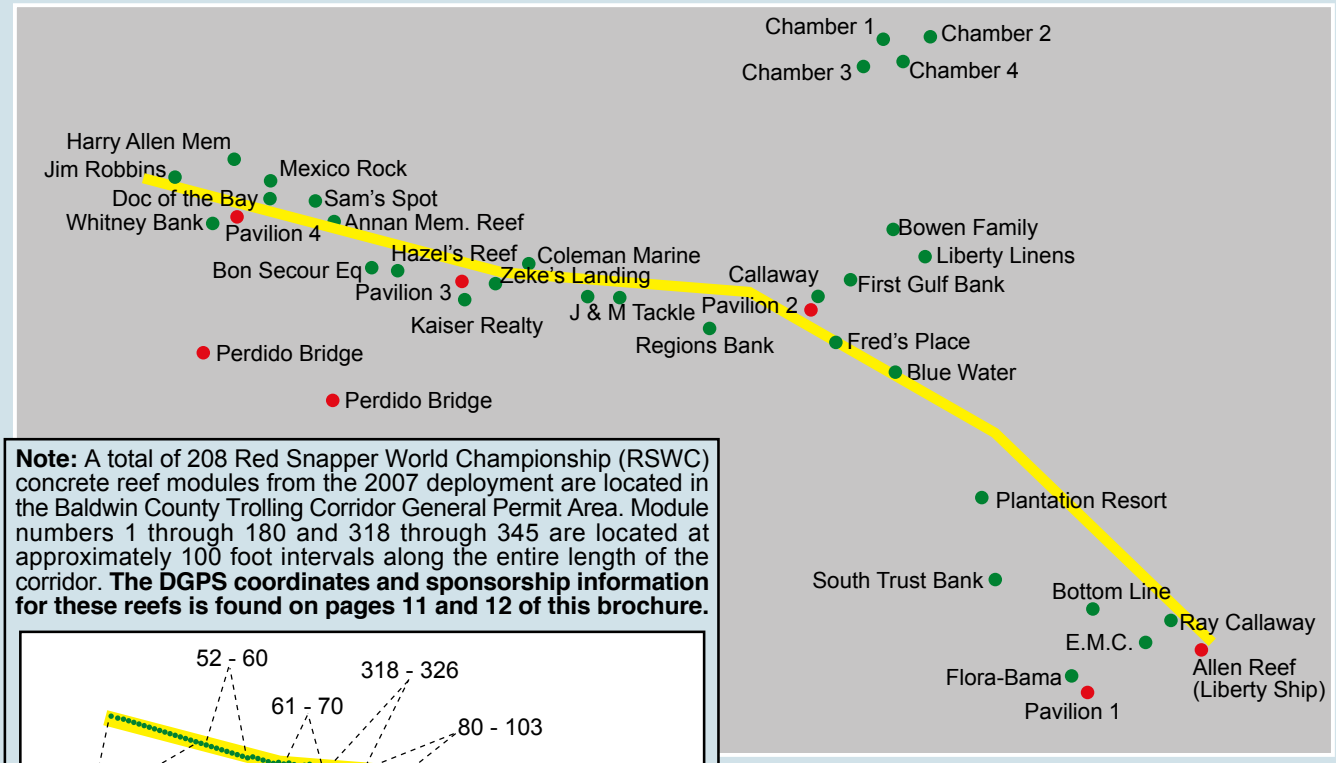
# RSWC 2007 REEF MODULES - GPS COORDINATES

| Reef # | Sponsor Name | Lat. | Long |
|---|---|---|---|
| 1 | AFTCO #1 | 30°08.866 | 87°34.175 |
| 2 | AFTCO #2 | 30°08.867 | 87°34.182 |
| 3 | AFTCO #3 | 30°08.876 | 87°34.222 |
| 4 | AFTCO #4 | 30°08.878 | 87°34.226 |
| 5 | Baldwin EMC #8 | 30°08.893 | 87°34.314 |
| 6 | Baldwin EMC #9 | 30°08.892 | 87°34.304 |
| 7 | Baldwin EMC #10 | 30°08.890 | 87°34.289 |
| 8 | Baldwin EMC #11 | 30°08.888 | 87°34.270 |
| 9 | Baldwin EMC #12 | 30°08.884 | 87°34.253 |
| 10 | Baldwin EMC #13 | 30°08.880 | 87°34.239 |
| 11 | Bender Shipyards #1 | 30°08.876 | 87°34.221 |
| 12 | Bender Shipyards #2 | 30°08.874 | 87°34.209 |
| 13 | Bender Shipyards #3 | 30°08.872 | 87°34.189 |
| 14 | Bender Shipyards #4 | 30°08.862 | 87°34.152 |
| 15 | Doc's Seafood Shack | 30°08.859 | 87°34.136 |
| 16 | Bubba's | 30°08.855 | 87°34.124 |
| 17 | Jake's Steakhouse | 30°08.850 | 87°34.107 |
| 18 | Franco's Italian | 30°08.847 | 87°34.082 |
| 19 | Blue Water John #1 | 30°08.842 | 87°34.059 |
| 20 | Blue Water John #2 | 30°08.837 | 87°34.039 |
| 21 | Brett/Robinson #41 | 30°08.832 | 87°34.021 |
| 22 | Brett/Robinson #42 | 30°08.829 | 87°33.998 |
| 23 | Brett/Robinson #43 | 30°08.817 | 87°33.953 |
| 24 | Brett/Robinson #44 | 30°08.808 | 87°33.921 |
| 25 | Brett/Robinson #45 | 30°08.805 | 87°33.909 |
| 26 | Brett/Robinson #46 | 30°08.802 | 87°33.899 |
| 27 | BBD-Dave | 30°08.796 | 87°33.866 |
| 28 | BBD-Marvin | 30°08.788 | 87°33.842 |
| 29 | BBD-Joe | 30°08.785 | 87°33.830 |
| 30 | BBD-Marlin | 30°08.769 | 87°33.776 |
| 31 | BBD-Phil | 30°08.763 | 87°33.758 |
| 32 | BBD-Tony | 30°08.761 | 87°33.749 |
| 33 | BBD-Warren | 30°08.759 | 87°33.743 |
| 34 | BBD-Herbert | 30°08.750 | 87°33.707 |
| 35 | Caribe #5 | 30°08.749 | 87°33.690 |
| 36 | Caribe #6 | 30°08.747 | 87°33.681 |
| 37 | Caribe #7 | 30°08.743 | 87°33.657 |
| 38 | Caribe #8 | 30°08.747 | 87°33.659 |
| 39 | Center Coal Co. #1 | 30°08.757 | 87°33.640 |
| 40 | Center Coal Co. #2 | 30°08.757 | 87°33.629 |
| 41 | Ala. Gulf Coast Chamber of Comm. #3 | 30°08.736 | 87°33.430 |
| 42 | Ala. Gulf Coast Chamber of Comm. #4 | 30°08.735 | 87°33.441 |
| 43 | Ala. Gulf Coast Chamber of Comm. #5 | 30°08.736 | 87°33.443 |
| 44 | Ala. Gulf Coast Chamber of Comm. #6 | 30°08.737 | 87°33.453 |
| 45 | Leslie Myers | 30°08.738 | 87°33.457 |
| 46 | Amanda Myers | 30°08.739 | 87°33.466 |
| 47 | Christian Life Church #1 | 30°08.739 | 87°33.474 |
| 48 | Christian Life Church #2 | 30°08.740 | 87°33.478 |
| 49 | Christian Life Church #3 | 30°08.741 | 87°33.485 |
| 50 | Christian Life Church #4 | 30°08.744 | 87°33.508 |
| 51 | City of Gulf Shores Johnnie Sims Reef | 30°08.747 | 87°33.533 |
| 52 | City of Gulf Shores Claude O'Connor Reef | 30°08.757 | 87°33.614 |
| 53 | City of Gulf Shores Clarence Horton Reef | 30°08.757 | 87°33.607 |
| 54 | City of Gulf Shores Eugene Ingram Reef | 30°08.753 | 87°33.607 |
| 55 | City of Gulf Shores Mixon Jones Reef | 30°08.750 | 87°33.589 |
| 56 | City of Gulf Shores Thom. Norton, M.D. Reef | 30°08.749 | 87°33.579 |
| 57 | City of Gulf Shores David Bodenhamer Reef | 30°08.749 | 87°33.570 |
| 58 | City of Gulf Shores G.W. "Billy" Duke Reef | 30°08.747 | 87°33.559 |
| 59 | City of Orange Beach | 30°08.748 | 87°33.552 |
| 60 | City of Orange Beach | 30°08.749 | 87°33.540 |
| 61 | City of Orange Beach | 30°08.738 | 87°33.430 |
| 62 | City of Orange Beach | 30°08.737 | 87°33.421 |
| 63 | City of Orange Beach | 30°08.735 | 87°33.415 |
| 64 | City of Orange Beach | 30°08.730 | 87°33.400 |
| 65 | City of Orange Beach | 30°08.733 | 87°33.389 |
| 66 | City of Orange Beach | 30°08.733 | 87°33.377 |
| 67 | City of Orange Beach | 30°08.730 | 87°33.372 |
| 68 | City of Orange Beach | 30°08.724 | 87°33.371 |
| 69 | City of Orange Beach | 30°08.719 | 87°33.355 |
| 70 | City of Orange Beach | 30°08.731 | 87°33.341 |
| 71 | City of Orange Beach | 30°08.718 | 87°33.316 |
| 72 | City of Orange Beach | 30°08.720 | 87°33.298 |
| 73 | City of Orange Beach | 30°08.716 | 87°33.287 |
| 74 | City of Orange Beach | 30°08.717 | 87°33.271 |
| 75 | City of Orange Beach | 30°08.722 | 87°33.259 |
| 76 | City of Orange Beach | 30°08.717 | 87°33.240 |
| 77 | CVB Reef #31 | 30°08.721 | 87°33.220 |
| 78 | CVB Reef #32 | 30°08.716 | 87°33.203 |
| 79 | CVB Reef #33 | 30°08.720 | 87°33.184 |
| 80 | CVB Reef #34 | 30°08.721 | 87°33.172 |
| 81 | CVB Reef #35 | 30°08.716 | 87°33.152 |
| 82 | CVB Reef #36 | 30°08.718 | 87°33.144 |
| 83 | CVB Reef #37 | 30°08.718 | 87°33.136 |
| 84 | CVB Reef #38 | 30°08.717 | 87°33.127 |
| 85 | CVB Reef #39 | 30°08.717 | 87°33.115 |
| 86 | CVB Reef #40 | 30°08.715 | 87°33.101 |
| 87 | CVB Reef #41 | 30°08.714 | 87°33.073 |
| 88 | CVB Reef #42 | 30°08.715 | 87°33.065 |
| 89 | CVB Reef #43 | 30°08.715 | 87°33.051 |
| 90 | CVB Reef #44 | 30°08.714 | 87°33.042 |
| 91 | CVB Reef #45 | 30°08.707 | 87°33.016 |
| 92 | CVB Reef #46 | 30°08.717 | 87°33.000 |
| 93 | CVB Reef #47 | 30°08.714 | 87°32.981 |
| 94 | CVB Reef #48 | 30°08.711 | 87°32.958 |
| 95 | CVB Reef #49 | 30°08.710 | 87°32.936 |
| 96 | CVB Reef #50 | 30°08.708 | 87°32.920 |
| 97 | CVB Reef #51 | 30°08.709 | 87°32.905 |
| 98 | CVB Reef #52 | 30°08.708 | 87°32.891 |
| 99 | CVB Reef #53 | 30°08.707 | 87°32.880 |
| 100 | CVB Reef #54 | 30°08.707 | 87°32.866 |
| 101 | CVB Reef #55 | 30°08.706 | 87°32.858 |
| 102 | CVB Reef #56 | 30°08.708 | 87°32.847 |
| 103 | CVB Reef #57 | 30°08.710 | 87°32.840 |
| 104 | CVB Reef #58 | 30°08.702 | 87°32.821 |
| 105 | CVB Reef #59 | 30°08.698 | 87°32.812 |
| 106 | CVB Reef #60 | 30°08.699 | 87°32.815 |
| 107 | DI Mary | 30°08.690 | 87°32.802 |
| 108 | DI Katherine | 30°08.683 | 87°32.793 |
| 109 | DI Trip | 30°08.675 | 87°32.784 |
| 110 | DI Alison | 30°08.668 | 87°32.777 |
| 111 | DI Anna | 30°08.660 | 87°32.769 |
| 112 | DI Allison | 30°08.648 | 87°32.755 |
| 113 | DI Richard | 30°08.627 | 87°32.734 |
| 114 | DI Lyndsay | 30°08.615 | 87°32.721 |
| 115 | Edgewater | 30°08.606 | 87°32.710 |
| 116 | Zarina Bella | 30°08.601 | 87°32.703 |
| 117 | Fish Camp Restaurant #5 | 30°08.597 | 87°32.696 |
| 118 | Fish Camp Restaurant #6 | 30°08.581 | 87°32.684 |
| 119 | Foley Beach Express #5 | 30°08.570 | 87°32.672 |
| 120 | Foley Beach Express #6 | 30°08.559 | 87°32.666 |
| 121 | Foley Beach Express #7 | 30°08.545 | 87°32.639 |
| 122 | Foley Beach Express #8 | 30°08.536 | 87°32.632 |
| 123 | Xtreme Marine #2 | 30°08.526 | 87°32.619 |
| 124 | Xtreme Marine #3 | 30°08.517 | 87°32.610 |
| 125 | Xtreme Marine #4 | 30°08.507 | 87°32.599 |
| 126 | Xtreme Marine #5 | 30°08.497 | 87°32.587 |
| 127 | Galati Yacht Sales #1 | 30°08.486 | 87°32.576 |
| 128 | Galati Yacht Sales #2 | 30°08.477 | 87°32.564 |
| 129 | Galati Yacht Sales #3 | 30°08.469 | 87°32.555 |
| 130 | Jason Collings Reef | 30°08.462 | 87°32.547 |
| 131 | Gary Finch Outdoors #1 | 30°08.456 | 87°32.541 |
| 132 | Gary Finch Outdoors #2 | 30°08.451 | 87°32.534 |
| 133 | Katelyn Finch | 30°08.447 | 87°32.529 |
| 134 | Christopher Finch | 30°08.439 | 87°32.521 |
| 135 | Laura Layton | 30°08.432 | 87°32.513 |
| 136 | Emily Layton | 30°08.425 | 87°32.505 |
| 137 | Geno's Reef | 30°08.417 | 87°32.496 |
| 138 | William Wyatt Reef | 30°08.407 | 87°32.485 |
| 139 | George's Water Sports #1 | 30°08.399 | 87°32.476 |
| 140 | George's Water Sports #2 | 30°08.392 | 87°32.469 |
| 141 | Glass Inc. #1 | 30°08.382 | 87°32.459 |
| 142 | Glass Inc. #2 | 30°08.370 | 87°32.442 |
| 143 | Gulf Shores Yacht Club & Marine #1 | 30°08.360 | 87°32.430 |
| 144 | Gulf Shores Yacht Club & Marine #2 | 30°08.346 | 87°32.415 |
| 145 | Gulf Shores Yacht Club & Marine #3 | 30°08.336 | 87°32.402 |
| 146 | Gulf Shores Yacht Club & Marine #4 | 30°08.323 | 87°32.390 |
| 147 | Gulf States Ready Mix #1 | 30°08.316 | 87°32.381 |
| 148 | Gulf States Ready Mix #2 | 30°08.307 | 87°32.369 |
| 149 | Guy Harvey #1 | 30°08.300 | 87°32.362 |
| 150 | Guy Harvey #2 | 30°08.294 | 87°32.355 |
| 151 | Guy Harvey #3 | 30°08.290 | 87°32.349 |
| 152 | Guy Harvey #4 | 30°08.283 | 87°32.341 |
| 153 | Hi-Liner | 30°08.278 | 87°32.336 |
| 154 | Edward R. Gaw | 30°08.272 | 87°32.332 |
| 155 | Tim Gaw | 30°08.265 | 87°32.325 |
| 156 | Brooke Lamping | 30°08.254 | 87°32.312 |
| 157 | International Assurance #1 | 30°08.241 | 87°32.296 |
| 158 | International Assurance #2 | 30°08.225 | 87°32.282 |
| 159 | International Assurance #3 | 30°08.212 | 87°32.275 |
| 160 | International Assurance #4 | 30°08.205 | 87°32.274 |
| 161 | Island House Hotel #1 | 30°08.215 | 87°32.266 |
| 162 | Island House Hotel #2 | 30°08.207 | 87°32.257 |
| 163 | Island House Hotel #3 | 30°08.201 | 87°32.250 |
| 164 | Island House Hotel #4 | 30°08.195 | 87°32.242 |
| 165 | Carol Mahlstedt | 30°08.185 | 87°32.232 |
| 166 | C.J.'s Reef | 30°08.175 | 87°32.222 |
| 167 | Island Wide Marine Reef #2 | 30°08.165 | 87°32.211 |
| 168 | Island Wide Marine Reef #3 | 30°08.152 | 87°32.197 |
| 169 | Isle of Capri #1 | 30°08.140 | 87°32.183 |
| 170 | Isle of Capri #2 | 30°08.130 | 87°32.172 |
| 171 | Isle of Capri #3 | 30°08.122 | 87°32.163 |
| 172 | Isle of Capri #4 | 30°08.112 | 87°32.153 |
| 173 | J&M Tackle #11 | 30°08.102 | 87°32.142 |
| 174 | J&M Tackle #12 | 30°08.091 | 87°32.129 |
| 175 | J&M Tackle #13 | 30°08.081 | 87°32.117 |
| 176 | J&M Tackle #14 | 30°08.072 | 87°32.107 |
| 177 | J&M Tackle #15 | 30°08.060 | 87°32.098 |
| 178 | J&M Tackle #16 | 30°08.051 | 87°32.086 |
| 179 | J&M Tackle #17 | 30°08.042 | 87°32.079 |
| 180 | J&M Tackle #18 | 30°08.031 | 87°32.076 |
| 181 | J&M Tackle #19 | 30°02.497 | 87°45.608 |
| 182 | J&M Tackle #20 | 30°01.725 | 87°45.624 |
| 183 | JetCenter South | 30°01.032 | 87°45.596 |
| 184 | Phil Martin | 29°58.890 | 87°45.596 |
| 185 | Bob | 29°58.124 | 87°45.577 |
| 186 | Copy That | 29°59.274 | 87°46.557 |
| 187 | Jim Brown #4 | 30°00.443 | 87°46.314 |
| 188 | Jim Brown #5 | 30°01.010 | 87°46.389 |
| 189 | Joe Raley Builders #1 | 30°01.732 | 87°46.461 |
| 190 | Joe Raley Builders #2 | 30°02.350 | 87°47.386 |
| 191 | Kaiser Realty #8 | 30°01.729 | 87°47.335 |
| 192 | Kaiser Realty #9 | 30°01.005 | 87°47.384 |
| 193 | Kaiser Realty #10 | 30°00.366 | 87°47.320 |
| 194 | Kaiser Realty #11 | 29°59.842 | 87°47.781 |
| 195 | Kaiser Realty #12 | 30°00.430 | 87°48.259 |
| 196 | Kaiser Realty #13 | 30°01.008 | 87°48.255 |
| 197 | Lamar #1 | 30°01.710 | 87°48.206 |
| 198 | Lamar #2 | 30°02.270 | 87°48.212 |
| 199 | Lamar #3 | 30°02.224 | 87°48.967 |
| 200 | Lamar #4 | 30°01.662 | 87°48.988 |
| 201 | Micah Cassaday #1 | 29°59.795 | 87°48.750 |
| 202 | Micah Cassaday #2 | 30°00.664 | 87°50.126 |
| 203 | Millicent Cassaday #1 | 30°01.458 | 87°50.170 |
| 204 | Millicent Cassaday #2 | 30°02.167 | 87°50.250 |
| 205 | Live Bait | 30°02.072 | 87°51.636 |
| 206 | Live Bait II | 30°01.377 | 87°51.301 |
| 207 | Live Bait at The Wharf | 30°00.439 | 87°50.854 |
| 208 | Live Bait Catering | 29°59.626 | 87°50.245 |
| 209 | Flora-Bama V | 29°58.682 | 87°49.559 |
| 210 | Homeport Marina #11 | 29°58.785 | 87°48.312 |
| 211 | Homeport Marina #12 | 29°58.781 | 87°47.602 |
| 212 | Flora-Bama VI | 29°57.890 | 87°47.566 |
| 213 | Danatana Reef | 29°56.839 | 87°47.527 |
| 214 | Sam Solomon Memorial Reef | 29°55.664 | 87°47.321 |
| 215 | McCarron Insurance Group #2 | 29°55.897 | 87°56.453 |
| 216 | Malouf #2 | 29°58.216 | 87°57.565 |
| 217 | Malouf #1 | 29°59.098 | 87°57.857 |
| 218 | Flora-Bama VII | 29°59.854 | 87°58.228 |
| 219 | Flora-Bama VIII | 30°00.650 | 87°58.693 |
| 220 | Legendary Marine #1 | 30°01.484 | 87°59.107 |
| 221 | Legendary Marine #2 | 30°02.399 | 87°59.606 |
| 222 | Legendary Marine #3 | 30°02.438 | 88°00.718 |
| 223 | Legendary Marine #4 | 30°01.567 | 88°00.581 |
| 224 | Legendary Marine #5 | 29°58.720 | 87°59.204 |
| 225 | Legendary Marine #6 | 29°57.758 | 87°59.285 |
| 226 | Century Boats #1 | 29°57.030 | 87°59.012 |
| 227 | Century Boats #2 | 29°56.167 | 87°57.962 |
| 228 | Century Boats #3 | 29°56.158 | 88°00.062 |
| 229 | Century Boats #4 | 29°56.185 | 88°00.944 |
| 230 | Century Boats #5 | 29°56.970 | 88°00.980 |
| 231 | Century Boats #6 | 29°57.659 | 88°01.149 |
| 232 | Lester's Restaurant #1 | 29°58.462 | 88°01.183 |
| 233 | Lester's Restaurant #2 | 29°59.193 | 88°02.266 |
| 234 | Lester's Restaurant #3 | 29°59.800 | 88°02.713 |

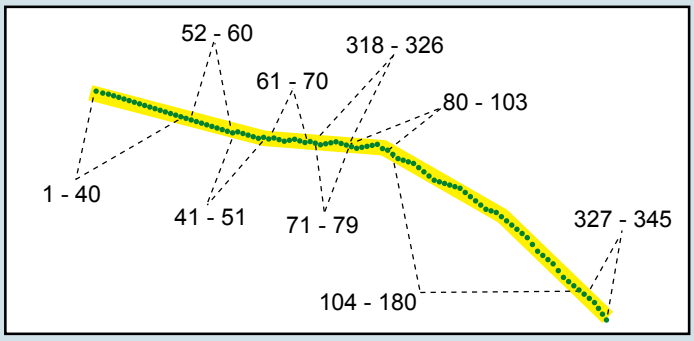
# RSWC 2007 REEF MODULES - GPS COORDINATES...cont.

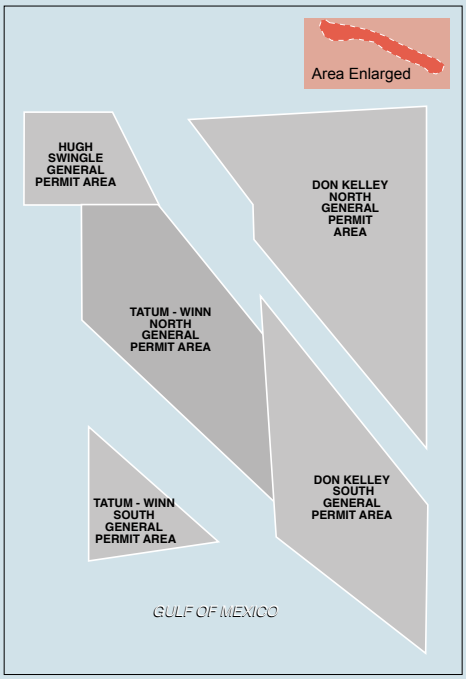
| Reef # | Sponsor Name | Lat. | Long |
|---|---|---|---|
| 235 | Lester's Restaurant #4 | 30°00.820 | 88°02.667 |
| 236 | Lester's Restaurant #5 | 30°01.688 | 88°02.755 |
| 237 | Lester's Restaurant #6 | 29°48.626 | 87°36.377 |
| 238 | Wind Deductible | 29°47.628 | 87°36.428 |
| 239 | Policy Exclusions | 29°46.736 | 87°36.426 |
| 240 | Mediation | 29°45.824 | 87°36.426 |
| 241 | Meyer Real Estate #1 | 29°44.879 | 87°36.428 |
| 242 | Meyer Real Estate #2 | 29°43.896 | 87°36.471 |
| 243 | Meyer Real Estate #3 | 29°42.937 | 87°36.531 |
| 244 | Meyer Real Estate #4 | 29°42.043 | 87°36.524 |
| 245 | Dr. Robert H. Mudd | 29°41.093 | 87°36.570 |
| 246 | Gere Austill, Sr. | 29°40.210 | 87°36.670 |
| 247 | Mo Fishin Bait & Tackle 1 | 29°40.934 | 87°37.268 |
| 248 | Slim | 29°41.932 | 87°37.414 |
| 249 | Moyer Ford #1 | 29°42.900 | 87°37.736 |
| 250 | Moyer Ford #2 | 29°44.701 | 87°37.716 |
| 251 | Rachel Moyer | 29°46.788 | 87°37.744 |
| 252 | Devin Moyer | 29°45.153 | 87°38.840 |
| 253 | Rone Negus | 29°44.338 | 87°38.872 |
| 254 | Coonie Negus | 29°43.515 | 87°38.828 |
| 255 | Ocean Waves Sunglasses #1 | 29°42.697 | 87°38.886 |
| 256 | Ocean Waves Sunglasses #2 | 29°33.864 | 87°36.284 |
| 257 | Ocean Waves Sunglasses #3 | 29°33.160 | 87°35.742 |
| 258 | Ocean Waves Sunglasses #4 | 29°32.475 | 87°35.245 |
| 259 | Orange Beach Auto & Marine #5 | 29°31.775 | 87°34.626 |
| 260 | Orange Beach Auto & Marine #6 | 29°31.051 | 87°34.140 |
| 261 | M. Radcliff, Sr. | 29°30.263 | 87°33.667 |
| 262 | N.Q. Adams | 29°29.524 | 87°33.146 |
| 263 | Capt. Jim Cox | 29°28.869 | 87°33.816 |
| 264 | Palmer Bedsole | 29°29.598 | 87°34.305 |
| 265 | Mickey Fogle | 29°30.284 | 87°34.750 |
| 266 | Lynn Siler | 29°31.059 | 87°35.263 |
| 267 | Pete Frost | 29°31.818 | 87°35.774 |
| 268 | Brenda Bryant | 29°32.548 | 87°36.197 |
| 269 | Jack Cooper | 29°33.268 | 87°36.614 |
| 270 | Prudential Cooper | 29°33.953 | 87°37.265 |
| 271 | Outcast Marina Charter Dock ('07) | 29°33.915 | 87°38.125 |
| 272 | Capt. Sonny Trimble Reef #2 | 29°33.230 | 87°37.976 |
| 273 | Cindy's Fishing Hole (We'll See) | 29°32.435 | 87°37.724 |
| 274 | Outcast Marina #4 | 29°32.152 | 87°36.893 |
| 275 | Penn Reels #1 | 29°31.359 | 87°36.665 |
| 276 | Penn Reels #2 | 29°30.588 | 87°36.196 |
| 277 | Penn Reels #3 | 29°29.874 | 87°35.769 |
| 278 | Penn Reels #4 | 29°29.072 | 87°35.423 |
| 279 | Penn Reels #5 | 29°28.419 | 87°36.046 |
| 280 | Penn Reels #6 | 29°29.211 | 87°36.445 |
| 281 | PBR/Voyagers | 29°29.953 | 87°36.786 |
| 282 | PBR/David Jackson | 29°30.774 | 87°37.293 |
| 283 | PBR/John Moloney | 29°31.607 | 87°37.702 |
| 284 | PBR/Greg Perryman | 29°32.042 | 87°38.465 |
| 285 | Tracey Thompson #1 | 29°32.857 | 87°38.833 |
| 286 | Tracey Thompson #2 | 29°33.796 | 87°39.090 |
| 287 | Capt. Carl Raffield Reef #1 | 29°34.018 | 87°40.245 |
| 288 | Capt. Carl Raffield Reef #2 | 29°33.344 | 87°40.284 |
| 289 | Capt. Gene Raffield Reef #1 | 29°32.758 | 87°39.791 |
| 290 | Capt. Gene Raffield Reef #2 | 29°32.099 | 87°39.394 |
| 291 | Randal & Colby Simmons #1 | 29°31.447 | 87°38.798 |
| 292 | Randal & Colby Simmons #2 | 29°30.829 | 87°38.397 |
| 293 | RE/MAX of Foley #1 | 29°29.970 | 87°38.017 |
| 294 | RE/MAX of Foley #2 | 29°29.216 | 87°37.575 |
| 295 | RE/MAX of Gulf Shores #6 | 29°28.431 | 87°37.058 |
| 296 | RE/MAX of Gulf Shores #7 | 29°28.010 | 87°38.012 |
| 297 | RE/MAX of Orange Beach #1 | 29°28.880 | 87°38.389 |
| 298 | RE/MAX of Orange Beach #2 | 29°29.730 | 87°38.999 |
| 299 | RE/MAX of Orange Beach #3 | 29°30.537 | 87°39.358 |
| 300 | RE/MAX of Orange Beach #4 | 29°31.304 | 87°39.816 |
| 301 | Reel Surprise Charters #1 | 29°32.016 | 87°40.309 |
| 302 | Reel Surprise Charters #2 | 29°32.681 | 87°40.874 |
| 303 | Reel Yacht Sales & Service #1 | 29°33.293 | 87°41.497 |
| 304 | Reel yacht Sales & Service #2 | 29°34.057 | 87°41.469 |
| 305 | Romar Marina #1 | 29°33.971 | 87°42.501 |
| 306 | Romar Marina #2 | 29°34.017 | 87°59.975 |
| 307 | Specchio Reef | 29°33.359 | 87°59.362 |
| 308 | Skippy Reef | 29°32.551 | 87°58.698 |
| 309 | Sam's Spot #8 | 29°31.881 | 87°57.932 |
| 310 | Sam's Spot #9 | 29°31.175 | 87°57.244 |
| 311 | Sam's Spot #10 | 29°30.476 | 87°56.461 |
| 312 | Sam's Spot #11 | 29°29.790 | 87°55.772 |
| 313 | Sam's Spot #12 | 29°29.107 | 87°55.080 |
| 314 | Sam's Spot #13 | 29°28.611 | 87°54.315 |
| 315 | Sam's Spot #14 | 29°27.978 | 87°53.549 |
| 316 | Sam's Spot #15 | 29°27.404 | 87°52.834 |
| 317 | SanRoc Cay Marina | 29°26.760 | 87°52.164 |
| 318 | Bear Point Marina Reef #2 | 30°08.732 | 87°33.340 |
| 319 | Sandy Wade Reef #3 | 30°08.731 | 87°33.324 |
| 320 | Carolyn Wade | 30°08.730 | 87°33.312 |
| 321 | Saunders Yachtworks #1 | 30°08.729 | 87°33.309 |
| 322 | Saunders Yachtworks #2 | 30°08.729 | 87°33.306 |
| 323 | Saunders Yachtworks #3 | 30°08.723 | 87°33.266 |
| 324 | Saunders Yachtworks #4 | 30°08.720 | 87°33.230 |
| 325 | The Shrimp Basket | 30°08.722 | 87°33.220 |
| 326 | Mikee's Seafood Restaurant | 30°08.717 | 87°33.202 |
| 327 | Spence Reef | 30°07.930 | 87°31.932 |
| 328 | Cahoon Reef | 30°08.016 | 87°32.048 |
| 329 | S. Baldwin Reg. Med. Center #1 | 30°08.011 | 87°32.043 |
| 330 | S. Baldwin Reg. Med. Center #2 | 30°08.003 | 87°32.027 |
| 331 | Lauren S Reef | 30°08.003 | 87°32.027 |
| 332 | Aulbree H Reef | 30°07.997 | 87°32.021 |
| 333 | Victoria A Reef | 30°07.985 | 87°32.009 |
| 334 | Samantha M Reef | 30°07.977 | 87°31.999 |
| 335 | Sportsman's Marine in Fairhope #3 | 30°07.970 | 87°31.992 |
| 336 | Sportsman's Marine in Fairhope #4 | 30°07.962 | 87°31.985 |
| 337 | Sportsman's Marine in Fairhope #5 | 30°07.953 | 87°31.972 |
| 338 | Sportsman's Marine in Fairhope #6 | 30°07.951 | 87°31.968 |
| 339 | "Sunny" 105.7-FM #1 | 30°07.947 | 87°31.958 |
| 340 | "Sunny" 105.7-FM #2 | 30°07.941 | 87°31.950 |
| 341 | "Sunny" 105.7-FM #3 | 30°07.906 | 87°31.921 |
| 342 | Kathryn & Lee Hagan | 30°07.902 | 87°31.923 |
| 343 | Tacky Jack's Bushwacker | 30°07.881 | 87°31.939 |
| 344 | Tacky Jack's Farmers Omelet | 30°07.863 | 87°31.952 |
| 345 | Tacky Jack's Mexican Garbage | 30°07.849 | 87°31.947 |
| 346 | Tacky Jack's Bloody Mary | 29°48.058 | 87°51.029 |
| 347 | Reefmaker - Miles | 29°47.250 | 87°51.009 |
| 348 | Reefmaker - Liam | 29°46.389 | 87°51.046 |
| 349 | Reefmaker - DeDe | 29°45.084 | 87°51.082 |
| 350 | Reefmaker - Turgeau | 29°44.663 | 87°51.151 |
| 351 | The Rod Room # 5 | 29°44.064 | 87°50.733 |
| 352 | The Rod Room # 6 | 29°43.168 | 87°51.332 |
| 353 | The Rod Room # 7 | 29°42.518 | 87°51.264 |
| 354 | The Rod Room # 8 | 29°41.731 | 87°51.587 |
| 355 | Top Gun Tackle #5 | 29°41.080 | 87°51.326 |
| 356 | Top Gun Tackle #6 | 29°40.247 | 87°51.361 |
| 357 | Tracey Thompson #3 | 29°39.539 | 87°51.234 |
| 358 | Tracey Thompson #4 | 29°38.683 | 87°51.478 |
| 359 | Turquoise Place #1 | 29°37.896 | 87°51.815 |
| 360 | Turquoise Place #2 | 29°37.220 | 87°51.486 |
| 361 | Turquoise Place #3 | 29°36.914 | 87°52.171 |
| 362 | Turquoise Place #4 | 29°37.457 | 87°52.744 |
| 363 | Reynolds Ready Mix - Walter Pope 4 | 29°38.286 | 87°52.986 |
| 364 | Reynolds Ready Mix - Walter Pope 5 | 29°38.388 | 87°53.539 |
| 365 | Reynolds Ready Mix - Walter Pope 6 | 29°39.245 | 87°53.484 |
| 366 | Reynolds Ready Mix - Walter Pope 7 | 29°40.077 | 87°53.439 |
| 367 | Reynolds Ready Mix - Harold Butts 4 | 29°40.908 | 87°53.438 |
| 368 | Reynolds Ready Mix - Harold Butts 5 | 29°42.310 | 87°53.123 |
| 369 | Reynolds Ready Mix - Harold Butts 6 | 29°43.063 | 87°53.052 |
| 370 | Reynolds Ready Mix - Harold Butts 7 | 29°43.850 | 87°53.302 |
| 371 | Vision Bank #5 | 29°44.685 | 87°53.298 |
| 372 | Vision Bank #6 | 29°45.527 | 87°52.984 |
| 373 | Vision Bank #7 | 29°46.396 | 87°52.933 |
| 374 | Vision Bank #8 | 29°47.290 | 87°52.889 |
| 375 | Water Ways Boat Sales | 29°48.141 | 87°52.882 |
| 376 | Down Under Dive Shop | 29°48.754 | 87°54.456 |
| 377 | West Marine #1 | 29°47.977 | 87°54.488 |
| 378 | West Marine #2 | 29°47.254 | 87°54.191 |
| 379 | Whitney Bank #1 | 29°46.530 | 87°54.509 |
| 380 | Whitney Bank #2 | 29°45.670 | 87°54.479 |
| 381 | Whitney Bank #3 | 29°44.791 | 87°54.536 |
| 382 | Whitney Bank #4 | 29°43.910 | 87°54.584 |
| 383 | Whitney Bank #5 | 29°42.275 | 87°54.611 |
| 384 | Whitney Bank #6 | 29°41.450 | 87°54.612 |
| 385 | Whitney Bank #7 | 29°40.601 | 87°54.636 |
| 386 | Whitney Bank #8 | 29°26.372 | 87°51.476 |
| 387 | Wadeley 100 | 29°25.782 | 87°50.913 |
| 388 | Wadeley 200 | 29°25.480 | 87°51.810 |
| 389 | Zac's Reef | 29°26.058 | 87°52.445 |
| 390 | Mary's Reef | 29°26.633 | 87°53.096 |
| 391 | Zeke's Charter Fleet #1 | 29°27.209 | 87°53.810 |
| 392 | Zeke's Charter Fleet #2 | 29°27.774 | 87°54.604 |
| 393 | Zeke's Charter Fleet #3 | 29°28.388 | 87°55.276 |
| 394 | Zeke's Charter Fleet #4 | 29°28.977 | 87°55.963 |
| 395 | Zeke's Charter Fleet #5 | 29°29.286 | 87°56.822 |
| 396 | Zeke's Charter Fleet #6 | 29°29.976 | 87°56.945 |
| 397 | Zeke's Charter Fleet #7 | 29°30.375 | 87°57.779 |
| 398 | Zeke's Charter Fleet #8 | 29°31.047 | 87°58.344 |
| 399 | Zeke's Charter Fleet #9 | 29°31.706 | 87°58.874 |
| 400 | Zeke's Charter Fleet #10 | 29°32.269 | 87°59.320 |
| 401 | Zeke's Charter Fleet #11 | 29°33.057 | 88°00.014 |
| 402 | Zeke's Charter Fleet #12 | 29°33.746 | 88°00.500 |
| 403 | Zeke's Charter Fleet #13 | 29°32.089 | 88°00.212 |
| 404 | Zeke's Charter Fleet #14 | 29°31.465 | 87°59.382 |
| 405 | Zeke's Charter Fleet #15 | 29°30.553 | 87°58.985 |
| 406 | Zeke's Charter Fleet #16 | 29°29.682 | 87°58.101 |

# BALDWIN COUNTY TROLLING CORRIDOR AREA



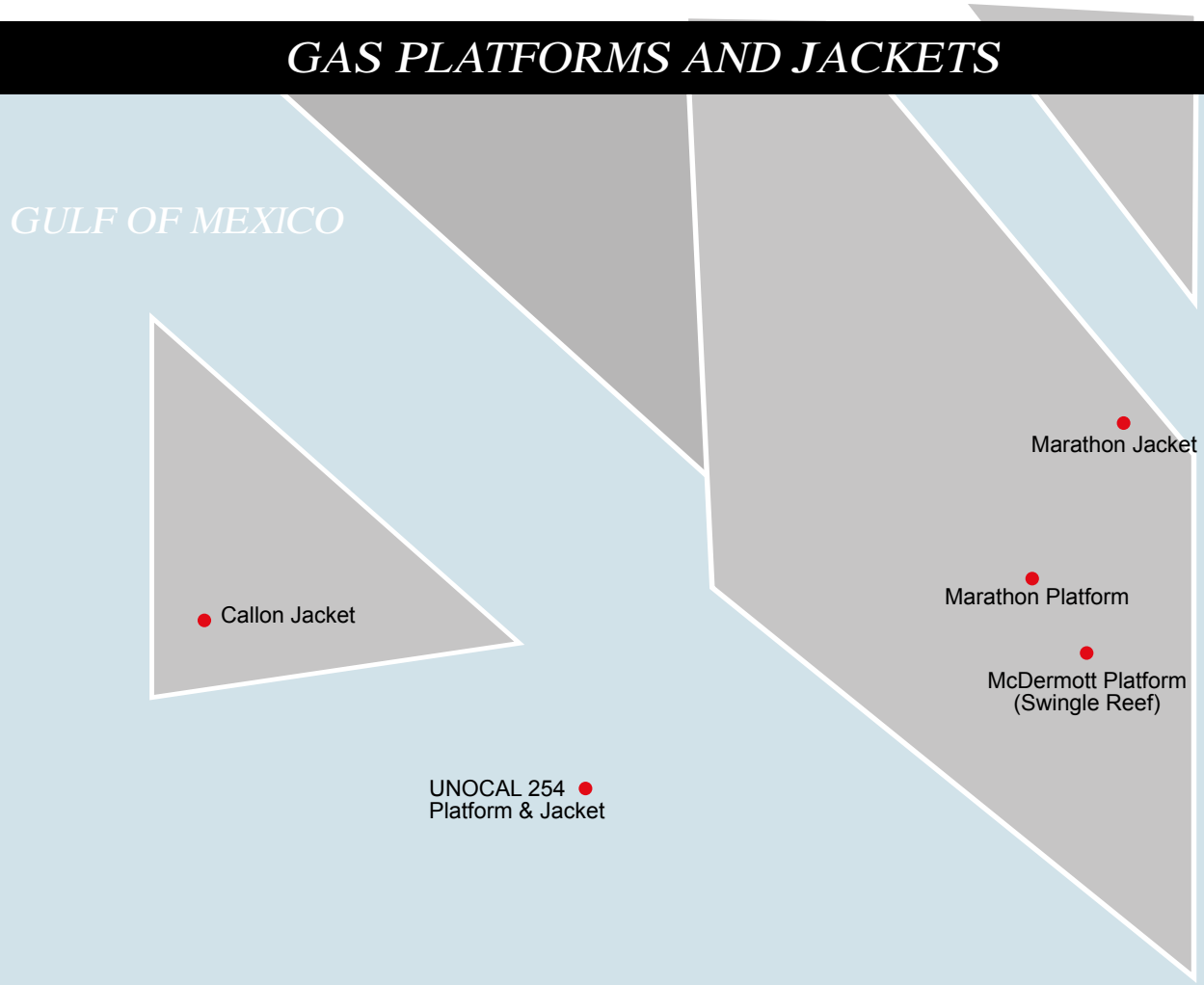

**Note:** A total of 208 Red Snapper World Championship (RSWC) concrete reef modules from the 2007 deployment are located in the Baldwin County Trolling Corridor General Permit Area. Module numbers 1 through 180 and 318 through 345 are located at approximately 100 foot intervals along the entire length of the corridor. **The DGPS coordinates and sponsorship information for these reefs is found on pages 11 and 12 of this brochure.**




| | | |
|---|---|---|
| Allen Reef | 30°07.835 | 87°31.790 |
| Perdido Pass Bridge | 30°08.446 | 87°33.956 |
| Perdido Pass Bridge | 30°08.565 | 87°34.270 |
| Gulf State Park Pavilion 1 | 30°07.737 | 87°32.059 |
| Gulf State Park Pavilion 2 | 30°08.701 | 87°32.814 |
| Gulf State Park Pavilion 3 | 30°08.749 | 87°33.633 |
| Gulf State Park Pavilion 4 | 30°08.897 | 87°34.323 |
| Chamber 1 | 30°13.729 | 87°32.928 |
| Chamber 2 | 30°13.760 | 87°32.918 |
| Chamber 3 | 30°13.733 | 87°32.941 |
| Chamber 4 | 30°13.768 | 87°32.946 |
| Jim Robbins | 30°08.981 | 87°34.341 |
| Whitney Bank | 30°08.878 | 87°34.256 |
| Harry Allen Memorial | 30°09.002 | 87°34.196 |
| Doc of the Bay | 30°08.951 | 87°34.119 |
| Mexico Rock | 30°08.976 | 87°34.113 |
| Sam's Spot | 30°08.906 | 87°34.001 |
| Armand Annan Memorial | 30°08.897 | 87°33.972 |
| Bon Secour Equipment | 30°08.768 | 87°33.852 |
| Hazel's Reef | 30°08.767 | 87°33.802 |
| Kaiser Realty | 30°08.732 | 87°33.638 |
| Coleman Marine | 30°08.781 | 87°33.478 |
| J & M Tackle | 30°08.708 | 87°33.338 |
| Outcast Charter Docks | 30°08.700 | 87°33.261 |
| Regions Bank | 30°08.640 | 87°33.036 |
| Blue Water | 30°08.519 | 87°32.853 |
| Fred's Place | 30°08.592 | 87°32.726 |
| Callaway | 30°08.706 | 87°32.774 |
| First Gulf Bank | 30°08.752 | 87°32.692 |
| Bowen Family | 30°08.867 | 87°32.592 |
| Liberty Linens | 30°08.758 | 87°32.503 |
| Plantation Resort | 30°08.207 | 87°32.376 |
| SouthTrust Bank | 30°08.006 | 87°32.341 |
| Flora-Bama | 30°07.775 | 87°32.154 |
| Bottom Line | 30°07.934 | 87°32.104 |
| E.M.C | 30°07.860 | 87°31.978 |
| Ray Callaway Memorial | 30°07.908 | 87°31.913 |
| Zeke's Landing Marina | 30°08.732 | 87°33.560 |

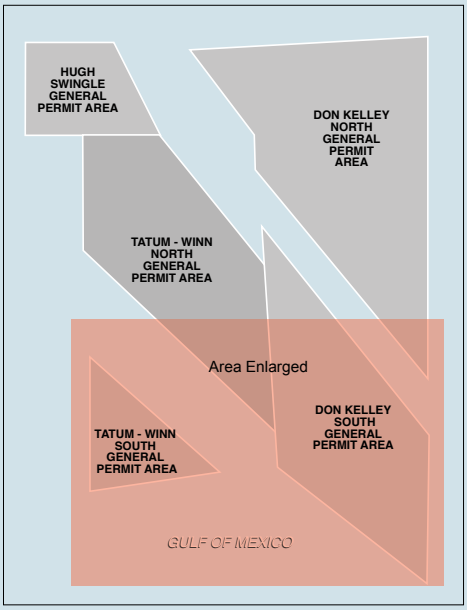
# GAS PLATFORMS AND JACKETS




| | |
|---|---|
| Swingle Reef | 29°25.160 - 87°35.600 |
| Marathon Reef | 29°26.895 - 87°36.990 |
| Marathon Jacket | 29°31.007 - 87°34.705 |
| Unocal 254 | 29°21.750 - 87°48.330 |
| Callon Jacket | 29°26.000 - 87°58.500 |

UNOCAL #254
Deployment

State Record Red Snapper
Mr. Melvin Dunn - 44 lbs. 12 oz.



# Department of the Army

# Mobile District, Corps of Engineers

# Permit Number MD61-0001-F

# Awarded to Alabama Marine Resources Division

# May 26, 1961

**Construction of artificial reefs by deploying car bodies in the Gulf of Mexico**

MD61-00001-F

# DEPARTMENT OF THE ARMY

NOTE.—It is to be understood that this instrument does not give any property rights either in real estate or material, or any exclusive privileges; and that it does not authorize any injury to private property or invasion of private rights, or any infringement of Federal, State, or local laws or regulations, nor does it obviate the necessity of obtaining *State assent* to the work authorized. IT MERELY EXPRESSES THE ASSENT OF THE FEDERAL GOVERNMENT SO FAR AS CONCERNS THE PUBLIC RIGHTS OF NAVIGATION. (See *Cummings* v. *Chicago*, 188 U. S., 410.) 16—13168-2

## PERMIT

Mobile, Alabama, Corps of Engineers.

2f May, 19 61.

State of Alabama
Department of Conservation
Montgomery 4, Alabama

Gentlemen:

Referring to written request dated 20 February 1961

I have to inform you that, upon the recommendation of the Chief of Engineers, and under the provisions of Section 10 of the Act of Congress approved March 3, 1899, entitled "An act making appropriations for the construction, repair, and preservation of certain public works on rivers and harbors, and for other purposes," you are hereby authorized by the Secretary of the Army.

to establish artificial fishing banks by placing old auto bodies fastened together in groups of five with 3/4 inch cable and dumped about 200 feet apart in not less than 60 feet of water
(Here describe the proposed structure or work.)

in Gulf of Mexico (Here to be named the river, harbor, or waterway concerned.)

at latitude 30°08'42", longitude 87°24'03", and latitude 30°06'54", longitude 88°06'45" (southerly of Perdido Pass and Dauphin Island, 9 miles offshore)
(Here locate the structure by giving its distance and direction from some definite point in the same, stating whether above or below or giving direction by points of compass.)

in accordance with the plans shown on the drawing attached hereto entitled "Proposed Artificial Snapper Bank in Gulf of Mexico", Sheets 1 and 2,
(Or drawings; give file number or other definite identification marks.)

subject to the following conditions:

(a) That the work shall be subject to the supervision and approval of the District Engineer, Corps of Engineers, in charge of the locality, who may temporarily suspend the work at any time, if in his judgment the interests of navigation so require.

(b) That any material dredged in the prosecution of the work herein authorized shall be removed evenly and no large refuse piles, ridges across the bed of the waterway, or deep holes that may have a tendency to cause injury to navigable channels or to the banks of the waterway shall be left. If any pipe, wire, or cable hereby authorized is laid in a trench, the formation of permanent ridges across the bed of the waterway shall be avoided and the back filling shall be so done as not to increase the cost of future dredging for navigation. Any material to be deposited or dumped under this authorization, either in the waterway or on shore above high-water mark, shall be deposited or dumped at the locality shown on the drawing hereto attached, and, if so prescribed thereon, within or behind a good and substantial bulkhead or bulkheads, such as will prevent escape of the material in the waterway. If the material is to be deposited in the harbor of New York, or in its adjacent or tributary waters, or in Long Island Sound, a permit therefor must be previously obtained from the Supervisor of New York Harbor, New York City.

(c) That there shall be no unreasonable interference with navigation by the work herein authorized.

(d) That if inspections or any other operations by the United States are necessary in the interest of navigation, all expenses connected therewith shall be borne by the permittee.

(e) That no attempt shall be made by the permittee or the owner to forbid the full and free use by the public of all navigable waters at or adjacent to the work or structure.

(f) That if future operations by the United States require an alteration in the position of the structure or work herein authorized, or if, in the opinion of the Secretary of the Army, it shall cause unreasonable obstruction to the free navigation of said water, the owner will be required upon due notice from the Secretary of the Army, to remove or alter the structural work or obstructions caused thereby without expense to the United States, so as to render navigation reasonably free, easy, and unobstructed; and if, upon the expiration or revocation of this permit, the structure, fill, excavation, or other modification of the watercourse hereby authorized shall not be completed, the owners shall, without expense to the United States, and to such extent and in such time and manner as the Secretary of the Army may require, remove all or any portion of the uncompleted structure or fill and restore to its former condition the navigable capacity of the watercourse. No claim shall be made against the United States on account of any such removal or alteration.

(g) That the United States shall in no case be liable for any damage or injury to the structure or work herein authorized which may be caused by or result from future operations undertaken by the Government for the conservation or improvement of navigation, or for other purposes, and no claim or right to compensation shall accrue from any such damage.

(h) That if the display of lights and signals on any work hereby authorized is not otherwise provided for by law, such lights and signals as may be prescribed by the U. S. Coast Guard, shall be installed and maintained by and at the expense of the owner.

(i) That the permittee shall notify the said district engineer at what time the work will be commenced, and as far in advance of the time of commencement as the said district engineer may specify, and shall also notify him promptly, in writing, of the commencement of work, suspension of work, if for a period of more than one week, resumption of work, and its completion.

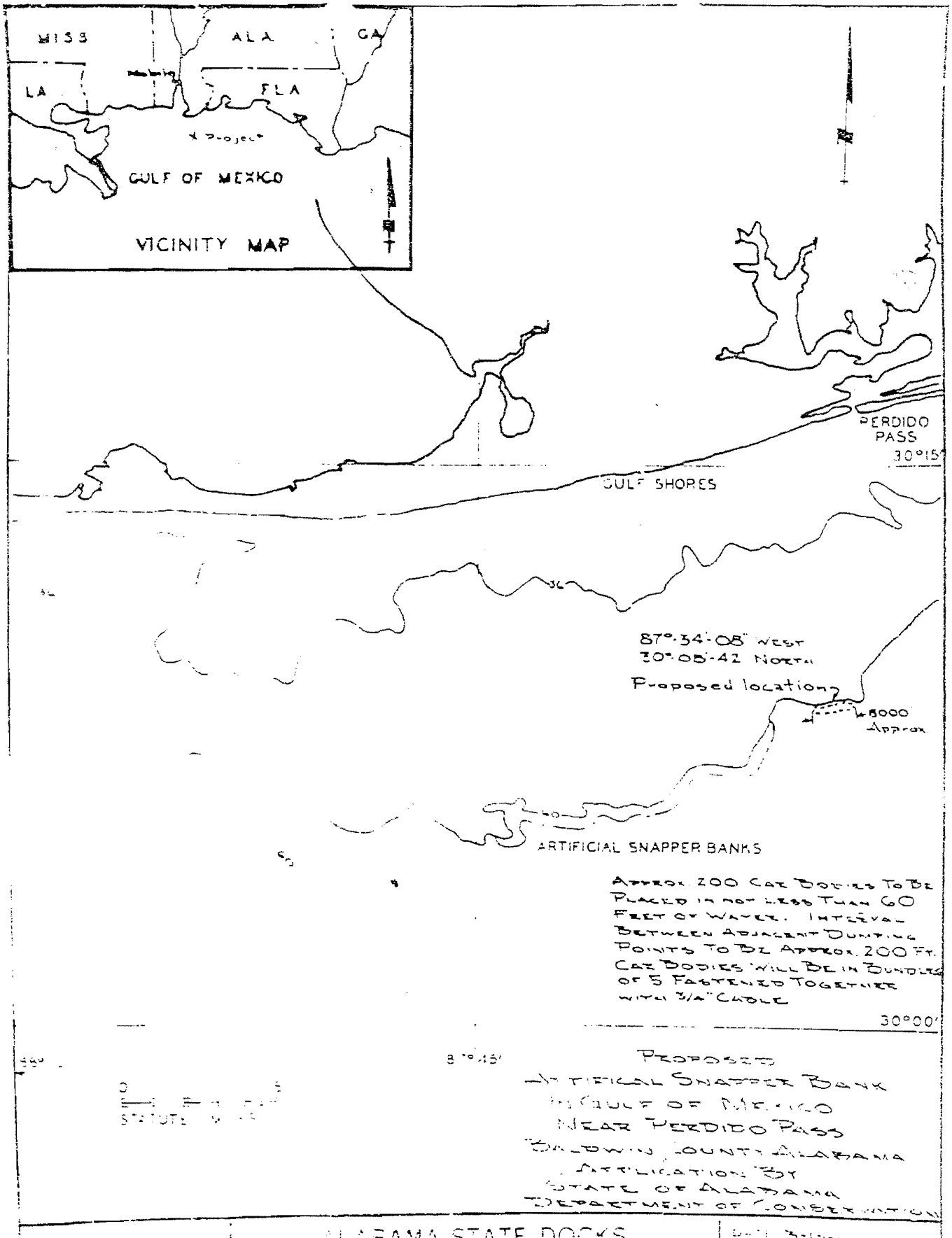
(j) That if the structure or work herein authorized is not completed on or before ..... 31st ..... day of ..... December ....., 19 54, this permit, if not previously revoked or specifically extended, shall cease and be null and void.

By authority of the Secretary of the Army:

1 Incl
Plan

R. W. LOVE
Colonel, Corps of Engineers
District Engineer

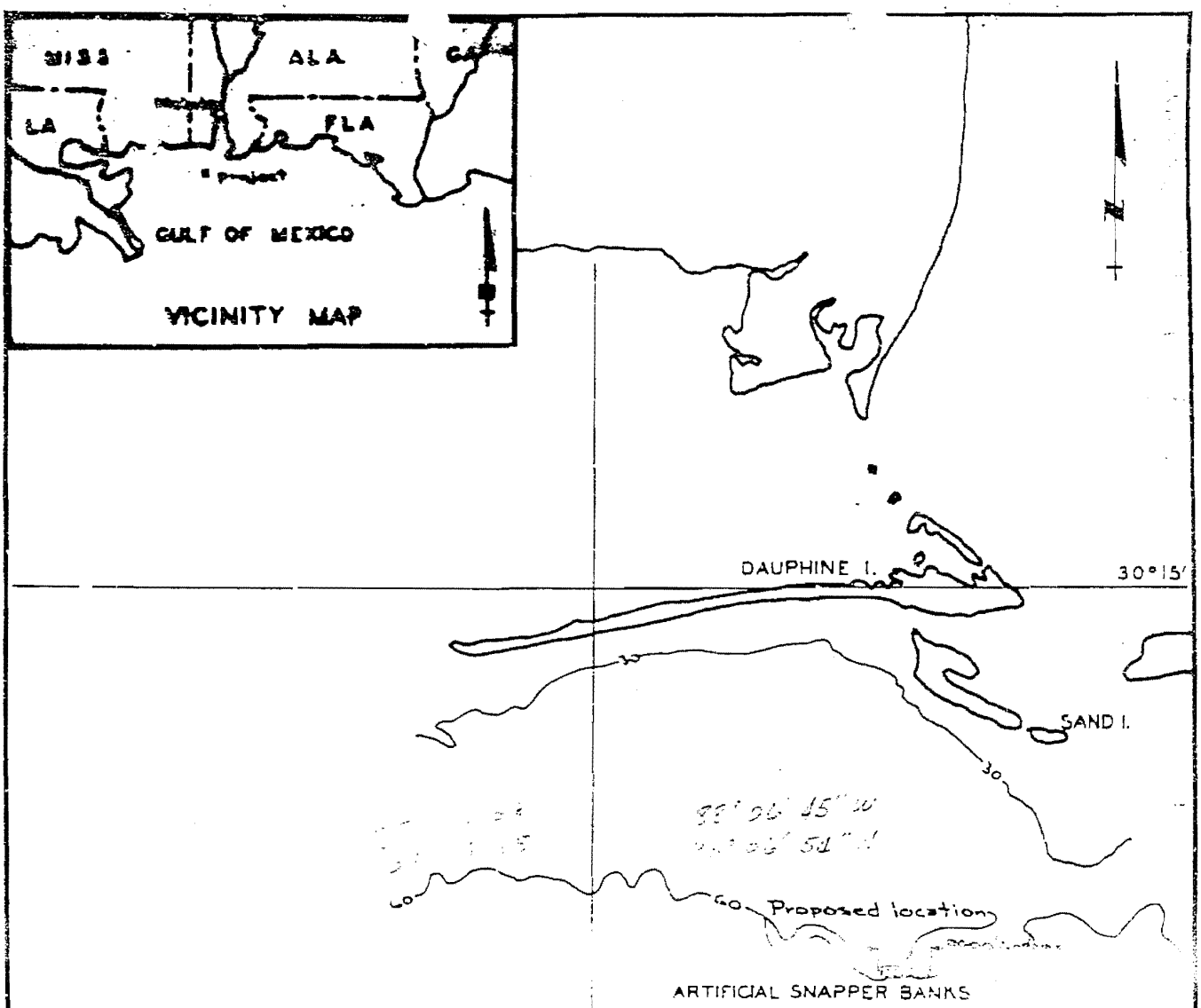
ENG FORM 1721 (Civil) 1 SEP 48 This form supersedes ED Form 96, dated 1 Apr 43, which may be used until exhausted.
EDI 1145-2-303
U. S. GOVERNMENT PRINTING OFFICE 16—71169-6




PROPOSED
ARTIFICIAL SNAPPER BANK
IN GULF OF MEXICO
NEAR PERDIDO PASS
BALDWIN COUNTY ALABAMA
APPLICATION BY
STATE OF ALABAMA
DEPARTMENT OF CONSERVATION

| | ALABAMA STATE DOCKS | DATE 3-1-60 |
|---|---|---|
| | | FILE C-1-29 |

Sheet #1




Approx. 200 Car Bodies To Be Placed in not Less Than 60 Feet of Water. Interval Between Adjacent Dumping Points To Be Approx. 200 Ft. Car Bodies Will Be In Bundles of 5 Fastened Together With 3/4" Cable.

Proposed
Artifical Snapper Bank
In Gulf of Mexico
Near Dauphine Island
Mobile County Alabama
Application By
State of Alabama
Department of Conservation

| | | |
|---|---|---|
| SCALE: 1:250,000 | ALABAMA STATE DOCKS | DATE: 3-1-61 |
| DRAWN BY: AEG | MOBILE, ALABAMA | FILE: C-1-28 |

Intaglio N. O. 1959 "Arcoproof"

Sheet 2

# Department of the Army

# Mobile District, Corps of Engineers

# Permit Number MD86-00012-I

# Awarded to Alabama Marine Resources Division

# February 13, 1987

## Creation of Don Kelly North General Permit Reef Zone

DEPARTMENT OF THE ARMY
MOBILE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 2288
MOBILE, ALABAMA 36628-0001

February 13, 1987

REPLY TO
ATTENTION OF:

Regulatory Branch

SUBJECT: Department of the Army Permit Number MD86-00012-I, Alabama Department of Conservation and Natural Resources

Alabama Department of Conservation
and Natural Resources
Marine Resources Division
Dauphin Island, Alabama 36528

Gentlemen:

PLEASE READ THIS LETTER CAREFULLY AND COMPLY WITH ITS PROVISIONS

There is enclosed a Department of the Army permit authorizing you to perform the work specified therein in accordance with the plans shown on the drawings attached thereto. This permit is issued under the provision of the Federal laws for the protection and preservation of the navigable waters of the United States. These laws provide that after proposed work has been approved by issuance of a Department of the Army permit, MD86-00012-I.

IT SHALL NOT BE LAWFUL TO DEVIATE FROM SUCH PLANS EITHER BEFORE OR AFTER COMPLETION OF THE WORK,

unless modification of said plans has previously been submitted to and received the approval of the Department of the Army.

You should study and carefully adhere to all of the terms and conditions of the permit. Your particular attention is invited to condition (n) which requires that the District Engineer be notified of the commencement (MOB Form 850) and completion (MOB Form 851) of the permitted work. The enclosed cards may be used for that purpose. Any telephone inquiries relating to this permit should be directed to the Regulatory Branch, telephone number (205) 690-2581.

Also enclosed is "NOTICE OF AUTHORIZATION" which must be conspicuously displayed at the site during construction of the permitted work.

If for any reason it becomes necessary to make a material change in location or plans for this work, revised plans should be submitted promptly to the District Engineer in order that the revised plans may receive the approval required by law before work is begun.

Compliance with this and other conditions of the permit is essential. Failure to submit the notices requested may result in its revocation.

Sincerely,

Ronald A. Krizman
Chief, Regulatory Branch
Operations Division

Enclosures

Application No. MD86-00012-I

Name of Applicant ALABAMA DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES

Effective Date 13 February 1987

Expiration Date (*If applicable*) 13 February 1990

# DEPARTMENT OF THE ARMY PERMIT

Referring to written request dated 4 August 1986 for a permit to:

(X) Perform work in or affecting navigable waters of the United States, upon the recommendation of the Chief of Engineers, pursuant to Section 10 of the Rivers and Harbors Act of March 3, 1899 (*33 U.S.C. 403*);

(X) Discharge dredged or fill material into waters of the United States upon the issuance of a permit from the Secretary of the Army acting through the Chief of Engineers pursuant to Section 404 of the Clean Water Act (*33 U.S.C. 1344*);

( ) Transport dredged material for the purpose of dumping it into ocean waters upon the issuance of a permit from the Secretary of the Army acting through the Chief of Engineers pursuant to Section 103 of the Marine Protection, Research and Sanctuaries Act of 1972 (*86 Stat. 1052; P.L. 92-532*);

Alabama Department of Conservation
and Natural Resources
Marine Resources Division
Dauphin Island, Alabama 36528

is hereby authorized by the Secretary of the Army:

to establish an area for artificial reef construction by the general public in the Gulf of Mexico, off Baldwin County, Alabama. The authorized area is bound by Loran readings 12900/47020, 13060/47040, 13040/46950, 12940/46950, and 12900/46980. The area generally begins 14 to 16 miles, and ends 32 to 34 miles south of the mainland in an area bounded on the east by an extension of the Alabama/Florida State line, and on the west by the Mobile Bay southeast safety fairway. All work shall be performed

in the Gulf of Mexico

at Baldwin County, Alabama

in accordance with the plans and drawings attached hereto which are incorporated in and made a part of this permit (*on drawings, give file number or other definite identification marks.*)

Plans attached - 1 sheet

subject to the following conditions:

**I. General Conditions:**

a. That all activities identified and authorized herein shall be consistent with the terms and conditions of this permit; and that any activities not specifically identified and authorized herein shall constitute a violation of the terms and conditions of this permit which may result in the modification, suspension or revocation of this permit, in whole or in part, as set forth more specifically in General Conditions j or k hereto, and in the institution of such legal proceedings as the United States Government may consider appropriate, whether or not this permit has been previously modified, suspended or revoked in whole or in part.



9 FEB 1987

b. That all activities authorized herein shall, if they involve, during their construction or operation, any discharge of pollutants into waters of the United States or ocean waters, be at all times consistent with applicable water quality standards, effluent limitations and standards of performance, prohibitions, pretreatment standards and management practices established pursuant to the Clean Water Act (*33 U.S.C. 1344*), the Marine Protection, Research and Sanctuaries Act of 1972 (*P.L. 92-532, 86 Stat. 1052*), or pursuant to applicable State and local law.

c. That when the activity authorized herein involves a discharge during its construction or operation, or any pollutant (*including dredged or fill material*), into waters of the United States, the authorized activity shall, if applicable water quality standards are revised or modified during the term of this permit, be modified, if necessary, to conform with such revised or modified water quality standards within 6 months of the effective date of any revision or modification of water quality standards, or as directed by an implementation plan contained in such revised or modified standards, or within such longer period of time as the District Engineer, in consultation with the Regional Administrator of the Environmental Protection Agency, may determine to be reasonable under the circumstances.

d. That the discharge will not destroy a threatened or endangered species as identified under the Endangered Species Act, or endanger the critical habitat of such species.

e. That the permittee agrees to make every reasonable effort to prosecute the construction or operation of the work authorized herein in a manner so as to minimize any adverse impact on fish, wildlife, and natural environmental values.

f. That the permittee agrees that he will prosecute the construction or work authorized herein in a manner so as to minimize any degradation of water quality.

g. That the permittee shall allow the District Engineer or his authorized representative(s) or designee(s) to make periodic inspections at any time deemed necessary in order to assure that the activity being performed under authority of this permit is in accordance with the terms and conditions prescribed herein.

h. That the permittee shall maintain the structure or work authorized herein in good condition and in reasonable accordance with the plans and drawings attached hereto.

i. That this permit does not convey any property rights, either in real estate or material, or any exclusive privileges; and that it does not authorize any injury to property or invasion of rights or any infringement of Federal, State, or local laws or regulations.

j. That this permit does not obviate the requirement to obtain state or local assent required by law for the activity authorized herein.

k. That this permit may be either modified, suspended or revoked in whole or in part pursuant to the policies and procedures of 33 CFR 325.7.

l. That in issuing this permit, the Government has relied on the information and data which the permittee has provided in connection with his permit application. If, subsequent to the issuance of this permit, such information and data prove to be materially false, materially incomplete or inaccurate, this permit may be modified, suspended or revoked, in whole or in part, and/or the Government may, in addition, institute appropriate legal proceedings.

m. That any modification, suspension, or revocation of this permit shall not be the basis for any claim for damages against the United States.

n. That the permittee shall notify the District Engineer at what time the activity authorized herein will be commenced, as far in advance of the time of commencement as the District Engineer may specify, and of any suspension of work, if for a period of more than one week, resumption of work and its completion.

o. That if the activity authorized herein is not completed on or before 13th day of Feb., 19 90, (*three years from the date of issuance of this permit unless otherwise specified*) this permit, if not previously revoked or specifically extended, shall automatically expire.

p. That this permit does not authorize or approve the construction of particular structures, the authorization or approval of which may require authorization by the Congress or other agencies of the Federal Government.

q. That if and when the permittee desires to abandon the activity authorized herein, unless such abandonment is part of a transfer procedure by which the permittee is transferring his interests herein to a third party pursuant to General Condition t hereof, he must restore the area to a condition satisfactory to the District Engineer.

r. That if the recording of this permit is possible under applicable State or local law, the permittee shall take such action as may be necessary to record this permit with the Register of Deeds or other appropriate official charged with the responsibility for maintaining records of title to and interests in real property.

The following Special Conditions will be applicable when appropriate:

**STRUCTURES IN OR AFFECTING NAVIGABLE WATERS OF THE UNITED STATES:**

a. That this permit does not authorize the interference with any existing or proposed Federal project and that the permittee shall not be entitled to compensation for damage or injury to the structures or work authorized herein which may be caused by or result from existing or future operations undertaken by the United States in the public interest.

b. That no attempt shall be made by the permittee to prevent the full and free use by the public of all navigable waters at or adjacent to the activity authorized by this permit.

c. That if the display of lights and signals on any structure or work authorized herein is not otherwise provided for by law, such lights and signals as may be prescribed by the United States Coast Guard shall be installed and maintained by and at the expense of the permittee.

d. That the permittee, upon receipt of a notice of revocation of this permit or upon its expiration before completion of the authorized structure or work, shall, without expense to the United States and in such time and manner as the Secretary of the Army or his authorized representative may direct, restore the waterway to its former conditions. If the permittee fails to comply with the direction of the Secretary of the Army or his authorized representative, the Secretary or his designee may restore the waterway to its former condition, by contract or otherwise, and recover the cost thereof from the permittee.

e. Structures for Small Boats: That permittee hereby recognizes the possibility that the structure permitted herein may be subject to damage by wave wash from passing vessels. The issuance of this permit does not relieve the permittee from taking all proper steps to insure the integrity of the structure permitted herein and the safety of boats moored thereto from damage by wave wash and the permittee shall not hold the United States liable for any such damage.

**MAINTENANCE DREDGING:**

a. That when the work authorized herein includes periodic maintenance dredging, it may be performed under this permit for _____ years from the date of issuance of this permit (*ten years unless otherwise indicated*);

b. That the permittee will advise the District Engineer in writing at least two weeks before he intends to undertake any maintenance dredging.

**DISCHARGES OF DREDGED OR FILL MATERIAL INTO WATERS OF THE UNITED STATES:**

a. That the discharge will be carried out in conformity with the goals and objectives of the EPA Guidelines established pursuant to Section 404(b) of the Clean Water Act and published in 40 CFR 230;

b. That the discharge will consist of suitable material free from toxic pollutants in toxic amounts.

c. That the fill created by the discharge will be properly maintained to prevent erosion and other non-point sources of pollution.

**DISPOSAL OF DREDGED MATERIAL INTO OCEAN WATERS:**

a. That the disposal will be carried out in conformity with the goals, objectives, and requirements of the EPA criteria established pursuant to Section 102 of the Marine Protection, Research and Sanctuaries Act of 1972, published in 40 CFR 220-228.

b. That the permittee shall place a copy of this permit in a conspicuous place in the vessel to be used for the transportation and/or disposal of the dredged material as authorized herein.

This permit shall become effective on the date of the District Engineer's signature.

Permittee bereby accepts and agrees to comply with the terms and conditions of this permit.

BY: _____ 02/05/87

PERMITTEE DATE

ALABAMA DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES

**BY AUTHORITY OF THE SECRETARY OF THE ARMY:**

C. HILTON DUNN, JR.
Colonel, CE

**DISTRICT ENGINEER,**
**U.S. ARMY, CORPS OF ENGINEERS**

BY: _____ Feb 17, '87

RONALD A. KRIZMAN DATE
Chief, Regulatory Branch
Operations Division

Transferee hereby agrees to comply with the terms and conditions of this permit.

_____ _____

TRANSFEREE DATE



U.S. GOVERNMENT PRINTING OFFICE : 1983 O - 404-308

s. That there shall be no unreasonable interference with navigation by the existence or use of the activity authorized herein.

t. That this permit may not be transferred to a third party without prior written notice to the District Engineer, either by the transferee's written agreement to comply with all terms and conditions of this permit or by the transferree subscribing to this permit in the space provided below and thereby agreeing to comply with all terms and conditions of this permit. In addition, if the permittee transfers the interests authorized herein by conveyance of realty, the deed shall reference this permit and the terms and conditions specified herein and this permit shall be recorded along with the deed with the Register of Deeds or other appropriate official.

u. That if the permittee during prosecution of the work authorized herein, encounters a previously unidentified archeological or other cultural resource within the area subject to Department of the Army jurisdiction that might be eligible for listing in the National Register of Historic Places, he shall immediately notify the district engineer.

II. **Special Conditions:** (*Here list conditions relating specifically to the proposed structure or work authorized by this permit*):

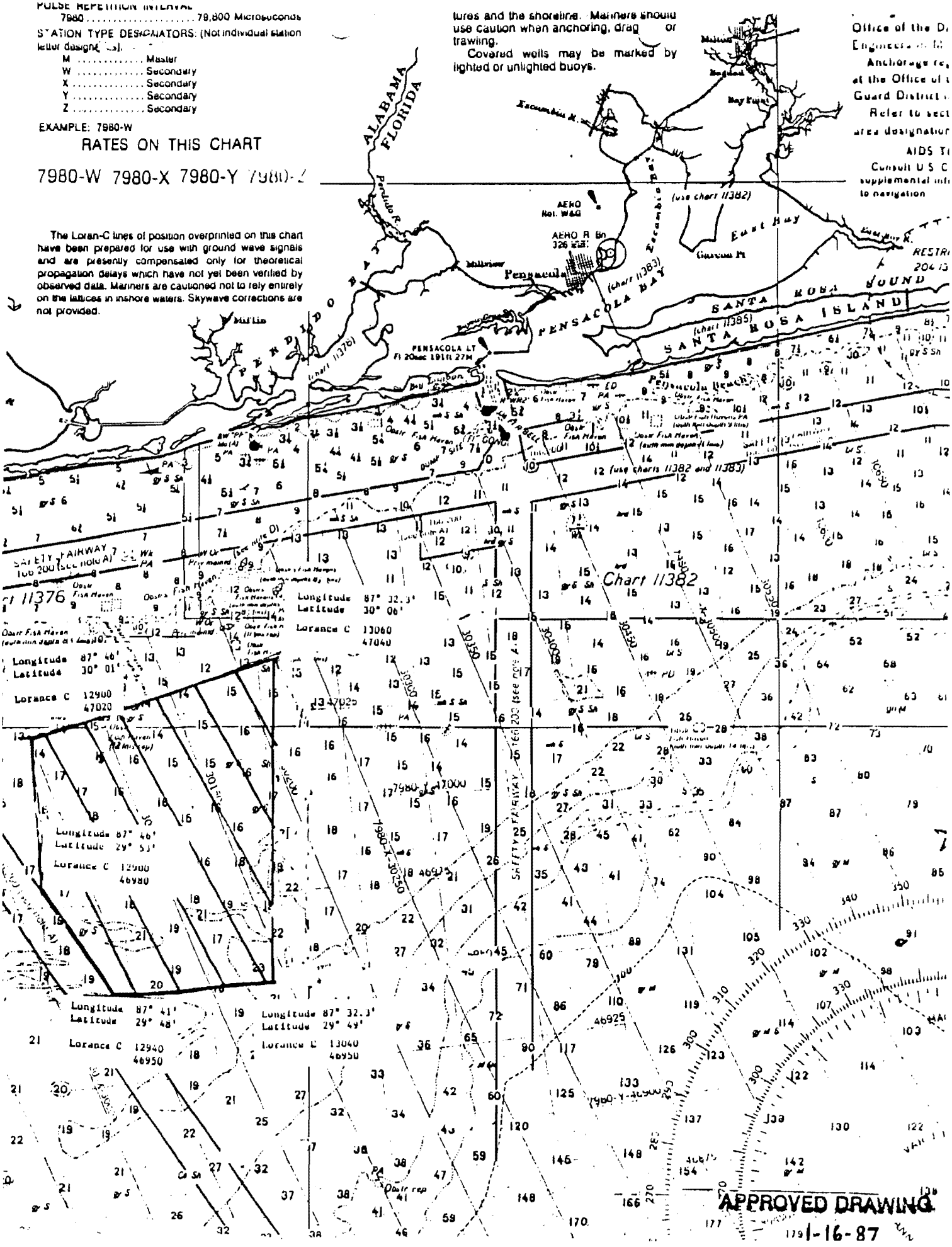
a. Reef materials shall be drained of all oil products.

b. No tires may be used except (1) tires mounted on vehicles; (2) a minimal number of tires incidental to off-loading at reef sites; (3) tires which are substantially weighted or embedded in concrete; and (4) tire bundles approved by the National Marine Fisheries Service, the Mineral Management Service, and other concerned agencies.

c. Other restrictions which are requested and appropriate from resource or other agencies.

d. The special policies for artificial reefs detailed in 33 CFR 322.5(b), with specific reference to (4)(i), (ii) and (iii), are applicable to this permit and authorizations thereunder.

e. Title to the materials used for reef construction must be clear.


PULSE REPETITION INTERVAL
7980 ..... 79,800 Microseconds
STATION TYPE DESIGNATORS. (Not individual station letter designations).
M ..... Master
W ..... Secondary
X ..... Secondary
Y ..... Secondary
Z ..... Secondary
EXAMPLE: 7980-W
RATES ON THIS CHART
7980-W 7980-X 7980-Y 7980-Z
The Loran-C lines of position overprinted on this chart have been prepared for use with ground wave signals and are presently compensated only for theoretical propagation delays which have not yet been verified by observed data. Mariners are cautioned not to rely entirely on the lattices in inshore waters. Skywave corrections are not provided.
tures and the shoreline. Mariners should use caution when anchoring, drag or trawling.
Covered wells may be marked by lighted or unlighted buoys.
Office of the D
Anchorage re
at the Office of t
Guard District
Refer to sect
area designatior
AIDS T
Consult U S C
supplemental inf
to navigation
ALABAMA
FLORIDA
Perdido R.
Escambia R.
Escambia Bay
East Bay
Bay Front
Milton
Pensacola
PENSACOLA BAY
SANTA ROSA SOUND
SANTA ROSA ISLAND
PERDIDO BAY
Millview
Gulf Breeze
AERO Rot. W&G
AERO R Bn 326 ft
(use chart 11382)
(chart 11383)
(chart 11385)
(chart 11376)
PENSACOLA LT Fl 20sec 191ft 27M
SAFETY FAIRWAY
Chart 11382
Chart 11376
Longitude 87° 46'
Latitude 30° 01'
Lorance C 12900
47020
Longitude 87° 32.3'
Latitude 30° 06'
Lorance C 13060
47040
Longitude 87° 46'
Latitude 29° 53'
Lorance C 12900
46980
Longitude 87° 41'
Latitude 29° 48'
Lorance C 12940
46950
Longitude 87° 32.3'
Latitude 29° 49'
Lorance C 13040
46950
7980-X-30250
7980-X-30300
7980-X-30350
7980-X-30400
7980-X-30450
7980-X-30500
7980-X-46925
12 (use charts 11382 and 11385)
APPROVED DRAWING
1-16-87

**This notice of authorization must be conspicuously displayed at the site of work.**

United States Army Corps of Engineers

February 13, 19 87

A permit to perform work authorized by statutes and regulations of the Department of the Army

at Gulf of Mexico, off Baldwin County, Alabama

(ARTIFICIAL REEF) ALABAMA DEPT. OF CONSERVATION
has been issued to AND NATURAL RESOURCES on Feb. 13, 19 87

Address of Permittee Marine Resources Division
Dauphin Island, Alabama 36528

Permit Number

MD86-00012-I

For the District Commander
RONALD A. KRIZMAN, Chief, OP-S
Operations Division

ENG FORM 4336, Jul 81 (ER 1145-2-303) EDITION OF JUL 70 MAY BE USED (Proponent: DAEN-CWO)

# Department of the Army

# Mobile District, Corps of Engineers

# Permit Number MD88-01140-I

# Awarded to Alabama Marine Resources Division

# September 19, 1988

## Creation of the Hugh Swingle General Permit Reef Zone

**DEPARTMENT OF THE ARMY**
MOBILE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 2288
MOBILE, ALABAMA 36628-0001

Hugh Swingle

September 19, 1988

REPLY TO
ATTENTION OF:

Regulatory Branch

SUBJECT: Department of the Army Permit Number MD88-01140-I,
Alabama Department of Conservation and Natural Resources

Alabama Department of Conservation
and Natural Resources
Marine Resources Division
Post Office Box 189
Dauphin Island, Alabama 36528

Gentlemen:

PLEASE READ THIS LETTER CAREFULLY AND COMPLY WITH ITS PROVISIONS

There is enclosed a Department of the Army permit authorizing you to perform the work specified therein in accordance with the plans shown on the drawings attached thereto. This permit is issued under provision of the Federal laws for the protection and preservation of the navigable waters of the United States. These laws provide that after proposed work has been approved by issuance of a Department of the Army permit,

IT SHALL NOT BE LAWFUL TO DEVIATE FROM SUCH PLANS EITHER BEFORE OR AFTER COMPLETION OF THE WORK,

unless modification of said plans has previously been submitted to and received the approval of the Department of the Army.

You should study and carefully adhere to all the terms and conditions of the permit. The District must be notified of the commencement and completion of the permitted work. The enclosed cards may be used for that purpose. Also enclosed is a "NOTICE OF AUTHORIZATION" which must be conspicuously displayed at the site during construction of the permitted work. Any telephone inquiries relating to this permit should be directed to the Regulatory Branch, telephone number (205) 694-3788.

If for any reason it becomes necessary to make a material change in location or plans for this work, revised plans should be submitted promptly to the District Engineer in order that the revised plans may receive the approval required by law before work is begun.

Compliance with this and other conditions of the permit is essential. Failure to submit the notices requested may result in its revocation.

Sincerely,

Ronald A. Krizman
Chief, Regulatory Branch
Operations Division

Enclosures

# DEPARTMENT OF THE ARMY PERMIT

Permittee ALABAMA DEPT OF CONSERVATION AND NATURAL RESOURCES

Permit No. MD88-01140-I

Issuing Office MOBILE DISTRICT

NOTE: The term "you" and its derivatives, as used in this permit, means the permittee or any future transferee. The term "this office" refers to the appropriate district or division office of the Corps of Engineers having jurisdiction over the permitted activity or the appropriate official of that office acting under the authority of the commanding officer.

You are authorized to perform work in accordance with the terms and conditions specified below.

Project Description: Authorization for a period of 5 years establishing an area for artificial reef construction by the general public in the Gulf of Mexico, off Dauphin Island, Alabama. The authorized area is bound by Loran readings 12700/47035, 29950/47035, 29950/47000, 12700/47000. The area generally begins 18 miles offshore and ends 32 miles south of Dauphin Island in an area bounded by marine safety fairways.

Attached: Map delineating Loran location

Project Location: Gulf of Mexico, off Mobile County, Alabama

Permit Conditions:

General Conditions:

1. The time limit for completing the work authorized ends on 19 September 1991. If you find that you need more time to complete the authorized activity, submit your request for a time extension to this office for consideration at least one month before the above date is reached.

2. You must maintain the activity authorized by this permit in good condition and in conformance with the terms and conditions of this permit. You are not relieved of this requirement if you abandon the permitted activity, although you may make a good faith transfer to a third party in compliance with General Condition 4 below. Should you wish to cease to maintain the authorized activity or should you desire to abandon it without a good faith transfer, you must obtain a modification of this permit from this office, which may require restoration of the area.

3. If you discover any previously unknown historic or archeological remains while accomplishing the activity authorized by this permit, you must immediately notify this office of what you have found. We will initiate the Federal and state coordination required to determine if the remains warrant a recovery effort or if the site is eligible for listing in the National Register of Historic Places.

ALABAMA DEPARTMENT OF CONSERVATION
AND NATURAL RESOURCES
PERMIT NO. MD88-01140-I
MOBILE DISTRICT

SPECIAL CONDITIONS:

a. Reef materials shall be drained of all oil products.

b. No tires may be used except (1) tires mounted on vehicles; (2) a minimal number of tires incidental to off-loading at reef sites; (3) tires which are substantially weighted or embedded in concrete; and (4) tire bundles approved by the National Marine Fisheries Service, the Mineral Management Service, and other concerned agencies.

c. Other restrictions which are requested and appropriate from resource or other agencies.

d. The special policies for artificial reefs detailed in 33 CFR 322.5(b), with specific reference to (4)(i), (ii), (iii), are applicable to this permit and authorizations thereunder.

e. Title to the materials used for reef construction must be clear.

f. Automobile bodies must be chained in groups of two (2) or more.

g. Appliances must be chained in groups of three (3) or more.

e. Damage claims associated with any future modification, suspension, or revocation of this permit.

4. Reliance on Applicant's Data: The determination of this office that issuance of this permit is not contrary to the public interest was made in reliance on the information you provided.

5. Reevaluation of Permit Decision. This office may reevaluate its decision on this permit at any time the circumstances warrant. Circumstances that could require a reevaluation include, but are not limited to, the following:

a. You fail to comply with the terms and conditions of this permit.

b. The information provided by you in support of your permit application proves to have been false, incomplete, or inaccurate (See 4 above).

c. Significant new information surfaces which this office did not consider in reaching the original public interest decision.

Such a reevaluation may result in a determination that it is appropriate to use the suspension, modification, and revocation procedures contained in 33 CFR 325.7 or enforcement procedures such as those contained in 33 CFR 326.4 and 326.5. The referenced enforcement procedures provide for the issuance of an administrative order requiring you to comply with the terms and conditions of your permit and for the initiation of legal action where appropriate. You will be required to pay for any corrective measures ordered by this office, and if you fail to comply with such directive, this office may in certain situations (such as those specified in 33 CFR 209.170) accomplish the corrective measures by contract or otherwise and bill you for the cost.

6. Extensions. General condition 1 establishes a time limit for the completion of the activity authorized by this permit. Unless there are circumstances requiring either a prompt completion of the authorized activity or a reevaluation of the public interest decision, the Corps will normally give favorable consideration to a request for an extension of this time limit.

Your signature below, as permittee, indicates that you accept and agree to comply with the terms and conditions of this permit.

Sept 14, 1988

*(PERMITTEE)* *(DATE)*

ALABAMA DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES
POST OFFICE BOX 189
DAUPHIN ISLAND, ALABAMA 36528

This permit becomes effective when the Federal official, designated to act for the Secretary of the Army, has signed below.

LARRY S. BONINE, Colonel
Corps of Engineers
*(DISTRICT ENGINEER)*

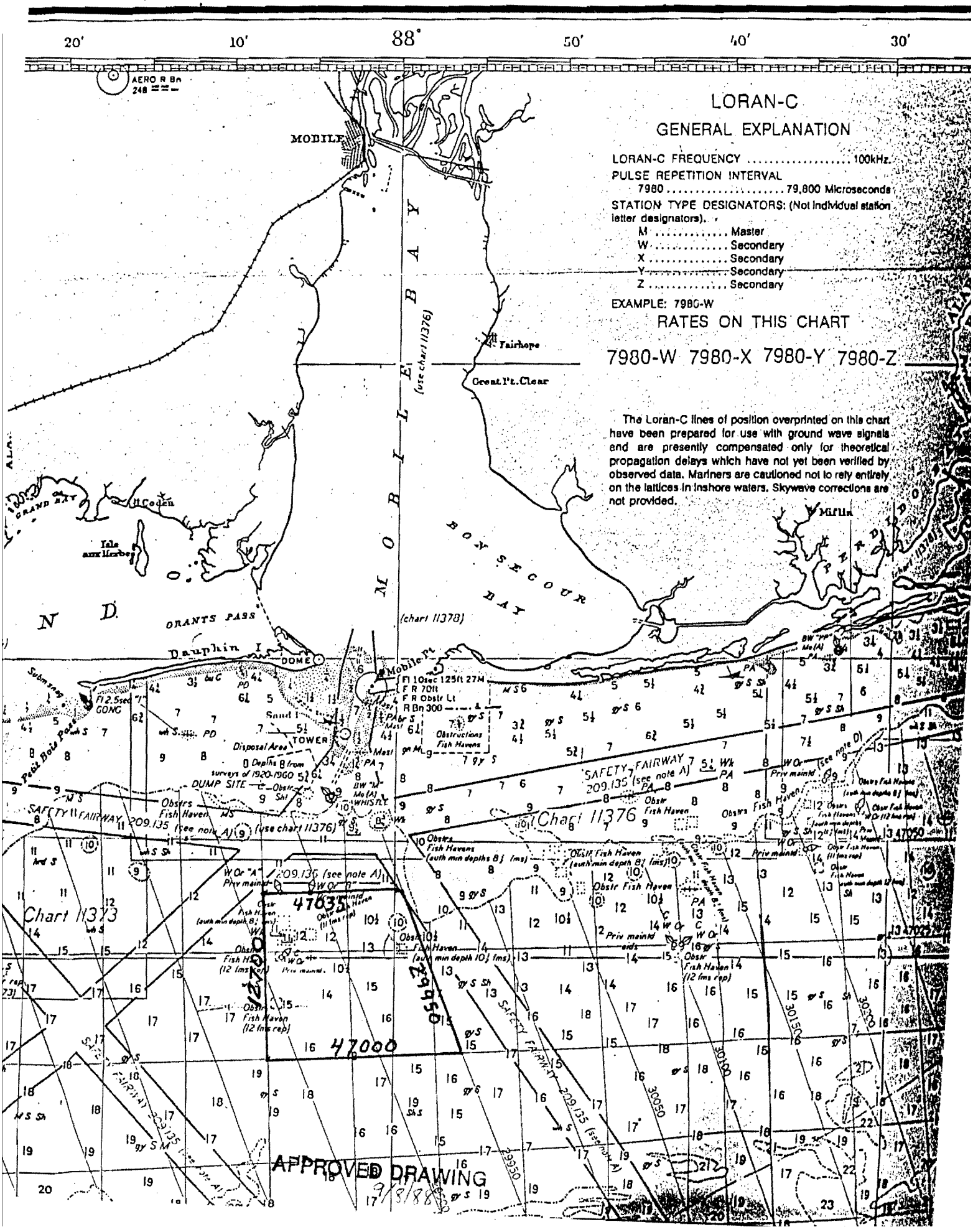
BY: Ronald A. Krizman
RONALD A. KRIZMAN *(DATE)* 20 Sep 88
Chief, Regulatory Branch
Operations Division

When the structures or work authorized by this permit are still in existence at the time the property is transferred, the terms and conditions of this permit will continue to be binding on the new owner(s) of the property. To validate the transfer of this permit and the associated liabilities associated with compliance with its terms and conditions, have the transferee sign and date below.

*(TRANSFEREE)* *(DATE)*



☆U.S. GOVERNMENT PRINTING OFFICE: 1986 — 717-425




## LORAN-C

### GENERAL EXPLANATION

LORAN-C FREQUENCY ..... 100kHz

PULSE REPETITION INTERVAL

7980 ..... 79,800 Microseconds

STATION TYPE DESIGNATORS: (Not individual station letter designators).

M ..... Master
W ..... Secondary
X ..... Secondary
Y ..... Secondary
Z ..... Secondary

EXAMPLE: 7980-W

### RATES ON THIS CHART

7980-W 7980-X 7980-Y 7980-Z

The Loran-C lines of position overprinted on this chart have been prepared for use with ground wave signals and are presently compensated only for theoretical propagation delays which have not yet been verified by observed data. Mariners are cautioned not to rely entirely on the lattices in inshore waters. Skywave corrections are not provided.

# This notice of authorization must be conspicuously displayed at the site of work.

United States Army Corps of Engineers

September 19, 19 88

A permit to perform work authorized by statutes and regulations of the Department of the Army (ARTIFICIAL REEF CONSTRUCTION)

at Gulf of Mexico, off Mobile County, Alabama

has been issued to Alabama Department of Conservation and Natural Resources Marine Resources Division on Sept. 19, 19 88

Address of Permittee Post Office Box 189
Dauphin Island, Alabama 36528

Permit Number

MD88-01140-I

For the District Commander
RONALD A. KRIZMAN, Chief, OP-S
Operations Division

**ENG FORM 4336**, Jul 81 (ER 1145-2-303) EDITION OF JUL 70 MAY BE USED *(Proponent: DAEN-CWO)*

**NOTICE OF COMPLETION OF WORK AUTHORIZED BY PERMITS**

WORK AUTHORIZED UNDER DEPARTMENT OF THE ARMY PERMIT MD88-01140-I
DATED September 19, 1988 (ARTIFICIAL REEF CONSTRUCTION)
TO PERFORM WORK IN Gulf of Mexico, off Mobile County, Alabama
WAS COMPLETED ON _____

BY: _____
SIGNATURE
ALABAMA DEPARTMENT OF CONSERVATION
AND NATURAL RESOURCES

DATE

**NOTICE OF COMMENCEMENT OF WORK AUTHORIZED BY PERMITS**

WORK AUTHORIZED UNDER DEPARTMENT OF THE ARMY PERMIT MD88-01140-I
DATED September 19, 1988 (ARTIFICIAL REEF CONSTRUCTION)
TO PERFORM WORK IN Gulf of Mexico, off Mobile County, Alabama
WAS COMMENCED ON _____

BY: _____
SIGNATURE
ALABAMA DEPARTMENT OF CONSERVATION
AND NATURAL RESOURCES

DATE

**CESAM FORM 850**
JUN 87

# Department of the Army

# Mobile District, Corps of Engineers

# Permit Number MDOFR89-00943-I

# Awarded to Alabama Marine Resources Division

# October 27, 1989

## Creation of the Don Kelly South General Permit Reef Zone

**DEPARTMENT OF THE ARMY**
MOBILE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 2288
MOBILE, ALABAMA 36628-0001

DON KELLEY SCMTH

October 27, 1989

REPLY TO
ATTENTION OF:

Regulatory Branch

SUBJECT: Department of the Army Permit Number MDOFR89-00943-I, Alabama Department of Conservation and Natural Resources

Alabama Department of Conservation
and Natural Resources
Post Office Box 189
Dauphin Island, Alabama 36528

Gentlemen:

PLEASE READ THIS LETTER CAREFULLY AND COMPLY WITH ITS PROVISIONS

There is enclosed a Department of the Army permit authorizing you to perform the work specified therein in accordance with the plans shown on the drawings attached thereto. This permit is issued under provision of the Federal laws for the protection and preservation of the navigable waters of the United States. These laws provide that after proposed work has been approved by issuance of a Department of the Army permit,

IT SHALL NOT BE LAWFUL TO DEVIATE FROM SUCH PLANS EITHER BEFORE OR AFTER COMPLETION OF THE WORK,

unless modification of said plans has previously been submitted to and received the approval of the Department of the Army.

You should study and carefully adhere to all the terms and conditions of the permit. The District must be notified of the commencement and completion of the permitted work. The enclosed cards may be used for that purpose. Also enclosed is a "NOTICE OF AUTHORIZATION" which must be conspicuously displayed at the site during construction of the permitted work. Any telephone inquiries relating to this permit should be directed to the Regulatory Branch, telephone number (205) 694-3788.

If for any reason it becomes necessary to make a material change in location or plans for this work, revised plans should be submitted promptly to the District Engineer in order that the revised plans may receive the approval required by law before work is begun.

Compliance with this and other conditions of the permit is essential. Failure to submit the notices requested may result in its revocation.

Sincerely,

Ronald A. Krizman
Chief, Regulatory Branch
Operations Division

Enclosures

# DEPARTMENT OF THE ARMY PERMIT

Permittee ALABAMA DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES

Permit No. MDOFR89-00943-I

Issuing Office MOBILE DISTRICT

NOTE: The term "you" and its derivatives, as used in this permit, means the permittee or any future transferee. The term "this office" refers to the appropriate district or division office of the Corps of Engineers having jurisdiction over the permitted activity or the appropriate official of that office acting under the authority of the commanding officer.

You are authorized to perform work in accordance with the terms and conditions specified below.

Project Description: Establish an area for artificial reef construction by the general public in the Gulf of Mexico, off Baldwin County, Alabama. The authorized area is bound by Loran Readings 12900/46960, 13022/46850, 13010/46775, and 12900/46845.

Project Location: The area begins about 32 miles south of the mainland and ends about 70 miles south of the mainland. Loran coordinates are 12900/46960, 13022/46850, 13010/46775, and 12900/46845.

Permit Conditions:

General Conditions:

1. The time limit for completing the work authorized ends on October 27, 1992. If you find that you need more time to complete the authorized activity, submit your request for a time extension to this office for consideration at least one month before the above date is reached.

2. You must maintain the activity authorized by this permit in good condition and in conformance with the terms and conditions of this permit. You are not relieved of this requirement if you abandon the permitted activity, although you may make a good faith transfer to a third party in compliance with General Condition 4 below. Should you wish to cease to maintain the authorized activity or should you desire to abandon it without a good faith transfer, you must obtain a modification of this permit from this office, which may require restoration of the area.

3. If you discover any previously unknown historic or archeological remains while accomplishing the activity authorized by this permit, you must immediately notify this office of what you have found. We will initiate the Federal and state coordination required to determine if the remains warrant a recovery effort or if the site is eligible for listing in the National Register of Historic Places.

PERMITTEE ALABAMA DEPARTMENT OF CONSERVATION
AND NATURAL RESOURCES

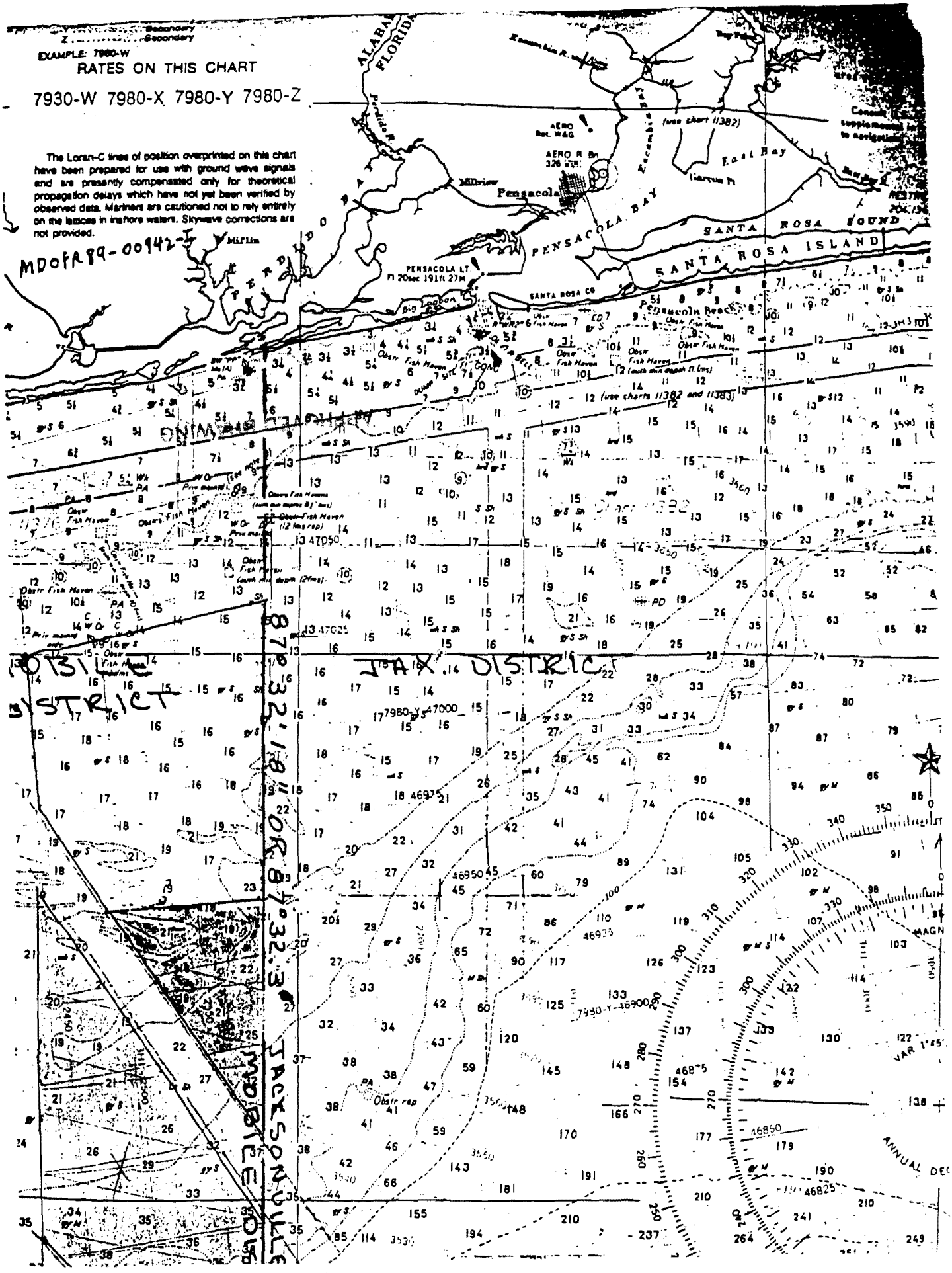
PERMIT NO. MDOFR89-00943-I

ISSUING OFFICE MOBILE DISTRICT

d. The special policies for artificial reefs detailed in 33 CFR 322.5(b), with specific reference to (4)(i), (ii) and (iii), are applicable to this permit and authorizations thereunder.

e. Title to the materials used for reef construction must be clear.

Drawings: 1. Nautical Chart (2 pages)


Secondary
Secondary
EXAMPLE: 7980-W
RATES ON THIS CHART
7930-W 7980-X 7980-Y 7980-Z
The Loran-C lines of position overprinted on this chart have been prepared for use with ground wave signals and are presently compensated only for theoretical propagation delays which have not yet been verified by observed data. Mariners are cautioned not to rely entirely on the lattices in inshore waters. Skywave corrections are not provided.
MDOT R89-00942-T
ALABAMA
FLORIDA
Pensacola
PENSACOLA BAY
SANTA ROSA SOUND
SANTA ROSA ISLAND
East Bay
Escambia R.
Perdido R.
Millview
PENSACOLA LT.
Ft 20sec 1911ft 27M
SANTA ROSA CO
Big Lagoon
Pensacola Beach
AERO Rot. WAG
AERO R Bn
326 yds
(use chart 11382)
(use charts 11382 and 11383)
Obscr Fish Haven
(12 hrs rep)
(2hrs rep)
PA
Obscr rep
MOBILE DISTRICT
JACKSONVILLE DISTRICT
JAX DISTRICT
87°32.18" OR 87°32.3"
7980-Y 46900
46950
47000
47025
46975
46850
46825
MAGN
ANNUAL DEC
VAR 1°45

e. Damage claims associated with any future modification, suspension, or revocation of this permit.

4. Reliance on Applicant's Data: The determination of this office that issuance of this permit is not contrary to the public interest was made in reliance on the information you provided.

5. Reevaluation of Permit Decision. This office may reevaluate its decision on this permit at any time the circumstances warrant. Circumstances that could require a reevaluation include, but are not limited to, the following:

a. You fail to comply with the terms and conditions of this permit.

b. The information provided by you in support of your permit application proves to have been false, incomplete, or inaccurate (See 4 above).

c. Significant new information surfaces which this office did not consider in reaching the original public interest decision.

Such a reevaluation may result in a determination that it is appropriate to use the suspension, modification, and revocation procedures contained in 33 CFR 325.7 or enforcement procedures such as those contained in 33 CFR 326.4 and 326.5. The referenced enforcement procedures provide for the issuance of an administrative order requiring you to comply with the terms and conditions of your permit and for the initiation of legal action where appropriate. You will be required to pay for any corrective measures ordered by this office, and if you fail to comply with such directive, this office may in certain situations (such as those specified in 33 CFR 209.170) accomplish the corrective measures by contract or otherwise and bill you for the cost.

6. Extensions. General condition 1 establishes a time limit for the completion of the activity authorized by this permit. Unless there are circumstances requiring either a prompt completion of the authorized activity or a reevaluation of the public interest decision, the Corps will normally give favorable consideration to a request for an extension of this time limit.

Your signature below, as permittee, indicates that you accept and agree to comply with the terms and conditions of this permit.

OCT 20

*(PERMITTEE)* ALABAMA DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES (ADCNR)
Post Office Box 189
Dauphin Island, Alabama 36528

*(DATE)*

This permit becomes effective when the Federal official, designated to act for the Secretary of the Army, has signed below.

LARRY S. BONINE, Colonel
Corps of Engineers

*(DISTRICT ENGINEER)*

BY:

*(DATE)*

RONALD A. KRIZMAN
Chief, Regulatory Branch
Operations Division

When the structures or work authorized by this permit are still in existence at the time the property is transferred, the terms and conditions of this permit will continue to be binding on the new owner(s) of the property. To validate the transfer of this permit and the associated liabilities associated with compliance with its terms and conditions, have the transferee sign and date below.

*(TRANSFEREE)*

*(DATE)*



☆U.S. GOVERNMENT PRINTING OFFICE: 1986 — 717-425

NOTICE OF COMPLETION OF WORK
AUTHORIZED BY PERMITS

WORK AUTHORIZED UNDER DEPARTMENT OF THE ARMY PERMIT MDOFR89-00943-I

DATED October 27, 1989

TO PERFORM WORK IN Gulf of Mexico, off Baldwin County, Alabama

WAS COMPLETED ON _____

BY: _____
SIGNATURE
Alabama Department of Conservation
and Natural Resources

CESAM FORM 850
JUN 87

CESAM FORM 851
JUN 87

NOTICE OF COMMENCEMENT OF WORK
AUTHORIZED BY PERMITS

_____
DATE

WORK AUTHORIZED UNDER DEPARTMENT OF THE ARMY PERMIT MDOFR89-00943-I

DATED October 27, 1989

TO PERFORM WORK IN Gulf of Mexico, off Baldwin County, Alabama

WAS COMMENCED ON _____

BY: _____
SIGNATURE
Alabama Department of Conservation
and Natural Resources

**This notice of authorization must be conspicuously displayed at the site of work.**

United States Army Corps of Engineers

October 27, 19 89

A permit to perform work authorized by statutes and regulations of the Department of the Army

at Gulf of Mexico, off Baldwin County, Alabama

has been issued to Alabama Department of Conservation and Natural Resources on Oct. 27, 19 89

Address of Permittee Post Office Box 189, Dauphin Island, Alabama 36528

Permit Number

MDOFR89-00943-I

Ronald A. Krizman

*For the District Commander*
*RONALD A. KRIZMAN, Chief, OP-S*
*Operations Division*

# Department of the Army

# Mobile District, Corps of Engineers

# Permit Number MDOFR91-00557-I

# Awarded to Alabama Marine Resources Division

# March 10, 1997

**Indefinitely extend authorization of general permit reef zones**

DEPARTMENT OF THE ARMY
MOBILE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 2288
MOBILE, ALABAMA 36628-0001

REPLY TO
ATTENTION OF:

March 10, 1997

Regulatory Branch
Operations Division

SUBJECT: Department of the Army Permit Number MDOFR91-00557-I, Alabama Department of Conservation and Natural Resources

Alabama Department of Conservation
and Natural Resources
Marine Resources Division
Post Office Box 189
Dauphin Island, Alabama 36528

Gentlemen:

In accordance with your letter dated February 27, 1997, (copy enclosed) Department of the Army authorization for the Hugh Swingle, Don Kelly South and Don Kelly North artificial fishing reef areas is hereby indefinitely extended.

All other previous conditions to which the work is made subject shall remain in full force and effect. A copy of the current "Standard Operating Protocol for Artificial Reef Construction" is enclosed.

Sincerely,

Ronald A. Krizman
Chief, Regulatory Branch
Operations Division

Enclosure

Copy Furnished:

Alabama Department of Environmental
Management - Coastal Program
2204 Perimeter Road
Mobile, Alabama 36615

Commander (oan)
8th Coast Guard District
Hale Boggs Federal Building, Room 1211
501 Magazine Street
New Orleans, Louisiana 70130-3396

U.S. Department of the Interior
Minerals Management Service
Gulf of Mexico OCS Region
Attention: Mr. Les Dauterive
1201 Elmwood Park Boulevard
New Orleans, Louisiana 70123-2394

STATE OF ALABAMA
**DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES**
POST OFFICE BOX 189
DAUPHIN ISLAND, ALABAMA 36528
TEL (334) 861-2882
FAX (334) 861-8741

FOB JAMES, JR.
GOVERNOR

JAMES D. MARTIN
COMMISSIONER

BOB MACRORY
ASSISTANT COMMISSIONER

R. VERNON MINTON, DIRECTOR
MARINE RESOURCES DIVISION

2/27/97

Mr. Davis Findley - CESAM-OP.SP
U. S. Army Corps of Engineers
P. O. Box 2288
Mobile, AL 36628-0001

Dear Mr. Findley,

The Alabama Marine Resources Division wishes to secure re-authorization of Alabama's Artificial Reef General Permit Areas for a period of ten years.

Listed below are Lat/Long. coordinates for the boundaries of Alabama's Artificial Reef General Permit Areas. The Don Kelley North General Permit Areas (86-12 & 89-942) are contiguous (please see attached map), therefore only four coordinates are listed.

| Alabama General Permit Areas | | Coordinates |
|---|---|---|
| Hugh Swingle (88-1140) | #1 | 29° 55.00' - 88° 07.00' |
| | #2 | 30° 03.00' - 87° 59.50' |
| | #3 | 29° 55.00' - 87° 55.50' |
| | #4 | 29° 55.00' - 88° 07.00' |
| Don Kelley North (86-12 & 89-942) | #1 | 29° 59.50' - 87° 47.50' |
| | #2 | 30° 04.00' - 87° 31.50' |
| | #3 | 29° 32.50' - 87° 31.00' |
| | #4 | 29° 52.00' - 87° 47.00' |
| Don Kelley South (89-943) | #1 | 29° 46.50' - 87° 47.00' |
| | #2 | 29° 29.00' - 87° 32.00' |
| | #3 | 29° 15.50' - 87° 31.50' |
| | #4 | 29° 26.50' - 87° 44.50 |

As you are aware, this program has been highly beneficial to the reef fish fishery, the fishing public as a whole, and has become a model for other coastal states.

Please let us know if we can provide further information.

Sincerely,

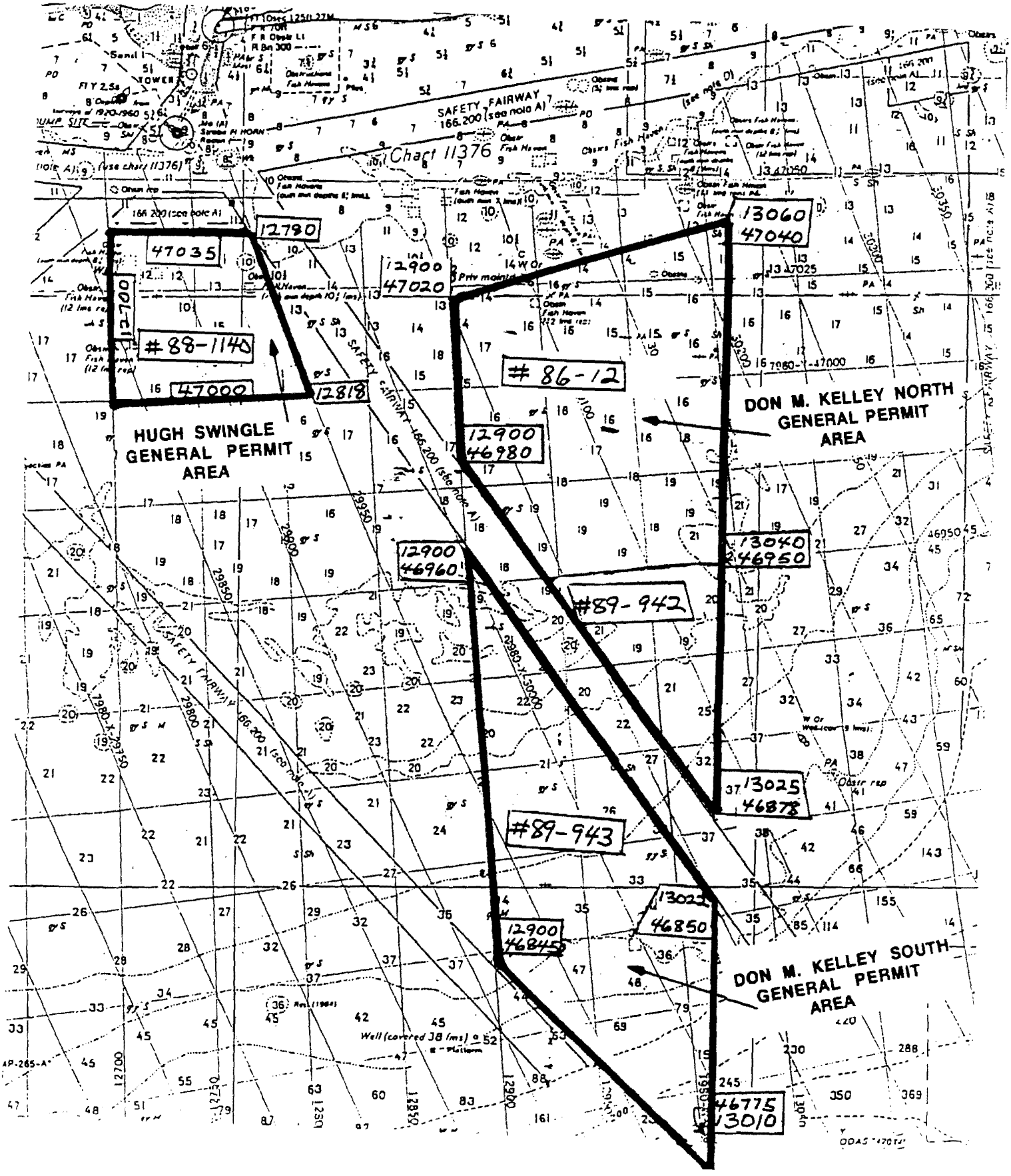
R. Vernon Minton

R. Vernon Minton, Director
Marine Resources Division

MAR 0 4 1997

The Department of Conservation and Natural Resources does not discriminate on the basis of race, color, religion, age gender, national origin, or disability in its hiring practices nor in admission to, access to, or operations of its programs, services, or activities.

# ALABAMA ARTIFICIAL REEF GENERAL PERMIT AREAS



# STANDARD OPERATING PROTOCOL FOR ARTIFICIAL REEF CONSTRUCTION
# MARINE RESOURCES DIVISION/U.S. ARMY CORPS OF ENGINEERS

## AUTOMOBILES

- As of 1 January, 1997 no automotive vehicles, engines and tranmissions will be certified for use as an artifical reef. No materials which will disassociate will be approved.

## BOATS

- No boats will be permitted until such time as additional studies have been completed. Barges and ships will be inspected on an individual basis.

## WHITE WARE (APPLIANCES) (DISCONTINUED)

## TIRES AND/OR PLASTICS

- Tires must be embedded in concrete. The minimum number of tires per unit must be four (4), with a minimum of 45 pounds of concrete per tire. Should other than car tires be used, the following formula is applicable. Concrete will equal 2X+10% of weight of tire with a minimum total weight of 260 pounds.
- Plastics (PVC) may be permitted as reef material. Inspectors will review plans and evaluate based upon durability and proper weighting.
- No floatable plastic or plastic film will be permitted. All materials which could float during deployment must be removed from the tires and/or plastics.
- The "no sheen" rule will apply to all tires and/or plastics.
- Individual plastic containers shall be heavily weighted so that they are stable on the bottom. Design and bouancy will determine appropriate weighting.

- Individual plastic containers formerly utilized to contain industrial chemicals must be certified by the permittee to be free of any harmful residue.
- All reef materials must be of such construction and material so as not disassociate and be substantially weighted to insure that material will stay in place on the bottom.
- All materials must be permitted before leaving the dock.

## OTHER MATERIALS

- All materials must comply with the "no sheen" rule.
- All materials which could float during deployment must be removed from the materials.
- All reef materials must of such construction and material so as not disassociate and be substantially weighted to insure that material will stay in place on the bottom.
- All materials loaded on barges must be loaded in such a manner as to facilitate the complete and safe inspection by Marine Resources Division and/or Corps of Engineers personnel.
- All materials must be permitted before leaving the dock.

## COMMERCIAL REEF BUILDERS (Monday - Friday 8 am to 5 pm - ONLY)

1. Marine Resources Division personnel are authorized to inspect reef material prior to deployment and to place MRD/COE approval sticker on the material.
2. Reef builders requesting pre-approval of reef building material must provide the following:

- Material to be inspected must be on the ground and in such position as to allow a complete and safe inspection.
- A sticker will not be placed on the reef material until all discrepancies identified by the inspector have been properly corrected.

- When the barge of reef material has been loaded with pre-inspected material the reef builder must obtain a permit which will be issued by the inspector, a copy of which must be returned to the inspector when the load has been dropped in the designated area.
- Reef builders will normally have thirty (30) days to deploy their reef after receiving their permit, after which a new permit must be obtained. Special provisions on deployment may be added to the permit by the inspector.
- No new permit will be issued until MRD has received from the reef builder the completed portion of the reef building permit.
- Material must be transported and placed during daylight hours. Return travel from the site is allowed during darkness.

# Department of the Army

# Mobile District, Corps of Engineers

# Permit Number AL97-01162-U

# Awarded to Alabama Marine Resources Division

# September 15, 1997

**Creation of Tatum-Winn North and Tatum-Winn South General Permit Reef Zones and extension of Don Kelly North General Permit Reef Zone**

Janet

DEPARTMENT OF THE ARMY
MOBILE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 2288
MOBILE, ALABAMA 36628-0001

SEP 1997
Received
MRD-DI

REPLY TO
ATTENTION OF:

September 15, 1997

Regulatory Branch
Operations Division

SUBJECT: Department of the Army Final Permit Number AL97-01162-U, Alabama Department of Conservation & Natural Resources

Alabama Department of Conservation
& Natural Resources
Marine Resources Division
Post Office Box 189
Dauphin Island, Alabama 36528

Gentlemen:

**PLEASE READ THIS LETTER CAREFULLY AND COMPLY WITH ITS PROVISIONS**

There is enclosed a Department of the Army permit authorizing you to perform the work specified therein in accordance with the plans shown on the drawings attached thereto. This permit is issued under provision of the Federal laws for the protection and preservation of the navigable waters of the United States. These laws provide that after the proposed work has been approved by issuance of a Department of the Army permit,

**IT SHALL NOT BE LAWFUL TO DEVIATE FROM SUCH PLANS EITHER BEFORE OR AFTER COMPLETION OF THE WORK,**

unless modification of said plans has previously been submitted to and received the approval of the Department of the Army. You should study and carefully adhere to all the terms and conditions of the permit. Any telephone inquiries relating to this permit should be directed to the Regulatory Branch, telephone number (334) 694-3788.

Sincerely,

Ronald A. Krizman
Chief, Regulatory Branch
Operations Division

Enclosures

## DEPARTMENT OF THE ARMY PERMIT

Permittee ALABAMA DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES

Permit No. AL97-01162-U

Issuing Office MOBILE DISTRICT

NOTE: The term "you" and its derivatives, as used in this permit, means the permittee or any future transferee. The term "this office" refers to the appropriate district or division office of the Corps of Engineers having jurisdiction over the permitted activity or the appropriate official of that office acting under the authority of the commanding officer.

You are authorized to perform work in accordance with the terms and conditions specified below.

Project Description: Construct artificial fishing reefs at six locations in the Gulf of Mexico. Three areas (Hugh Swingle Area, Don Kelly North Area, and Don Kelly South Area) which were previously authorized are reauthorized. Three new "extensions areas" (Extension Area 1, 2, and 3) are authorized.

You and your designated agent (s) shall deploy suitable materials in these six areas for the purposes of creating and enhancing fish habitat for recreational, sport and commercial fisheries.

Attachments:
1. Chart 11360 36th Edition
2. Latitude and longitude of Reef Areas
3. Standard Operating Protocol

Project Location:
Gulf of Mexico, Mobile and Baldwin Counties, Alabama.

Permit Conditions:

General Conditions:

1. The time limit for completing the work authorized ends on N/A. If you find that you need more time to complete the authorized activity, submit your request for a time extension to this office for consideration at least one month before the above date is reached.

2. You must maintain the activity authorized by this permit in good condition and in conformance with the terms and conditions of this permit. You are not relieved of this requirement if you abandon the permitted activity, although you may make a good faith transfer to a third party in compliance with General Condition 4 below. Should you wish to cease to maintain the authorized activity or should you desire to abandon it without a good faith transfer, you must obtain a modification of this permit from this office, which may require restoration of the area.

3. If you discover any previously unknown historic or archeological remains while accomplishing the activity authorized by this permit, you must immediately notify this office of what you have found. We will initiate the Federal and state coordination required to determine if the remains warrant a recovery effort or if the site is eligible for listing in the National Register of Historic Places.

for Artificial Reef Construction. Modifications to the protocol shall be coordinated with the Mobile District, U.S. Army Corps of Engineers prior to implementation.

c. All reefs shall be marked in accordance with U.S. Coast Guard regulations.

d. A minimum 50 feet of clearance between the top of the reef structures and the surface of the water at mean low water shall be maintained.

e. Damage claims associated with any future modification, suspension, or revocation of this permit.

4. Reliance on Applicant's Data: The determination of this office that issuance of this permit is not contrary to the public interest was made in reliance on the information you provided.

5. Reevaluation of Permit Decision. This office may reevaluate its decision on this permit at any time the circumstances warrant. Circumstances that could require a reevaluation include, but are not limited to, the following:

a. You fail to comply with the terms and conditions of this permit.

b. The information provided by you in support of your permit application proves to have been false, incomplete, or inaccurate (See 4 above).

c. Significant new information surfaces which this office did not consider in reaching the original public interest decision.

Such a reevaluation may result in a determination that it is appropriate to use the suspension, modification, and revocation procedures contained in 33 CFR 325.7 or enforcement procedures such as those contained in 33 CFR 326.4 and 326.5. The referenced enforcement procedures provide for the issuance of an administrative order requiring you to comply with the terms and conditions of your permit and for the initiation of legal action where appropriate. You will be required to pay for any corrective measures ordered by this office, and if you fail to comply with such directive, this office may in certain situations (such as those specified in 33 CFR 209.170) accomplish the corrective measures by contract or otherwise and bill you for the cost.

6. Extensions. General condition 1 establishes a time limit for the completion of the activity authorized by this permit. Unless there are circumstances requiring either a prompt completion of the authorized activity or a reevaluation of the public interest decision, the Corps will normally give favorable consideration to a request for an extension of this time limit.

Your signature below, as permittee, indicates that you accept and agree to comply with the terms and conditions of this permit.

B. Vinson Dixon — 9-9-97

*(PERMITTEE)* ALABAMA DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES
MARINE RESOURCES DIVISION
POST OFFICE BOX 189
DAUPHIN ISLAND, ALABAMA 36528

*(DATE)*

This permit becomes effective when the Federal official, designated to act for the Secretary of the Army, has signed below.

WILLIAM S. VOGEL
COLONEL, CORPS OF ENGINEERS

*(DISTRICT ENGINEER)*

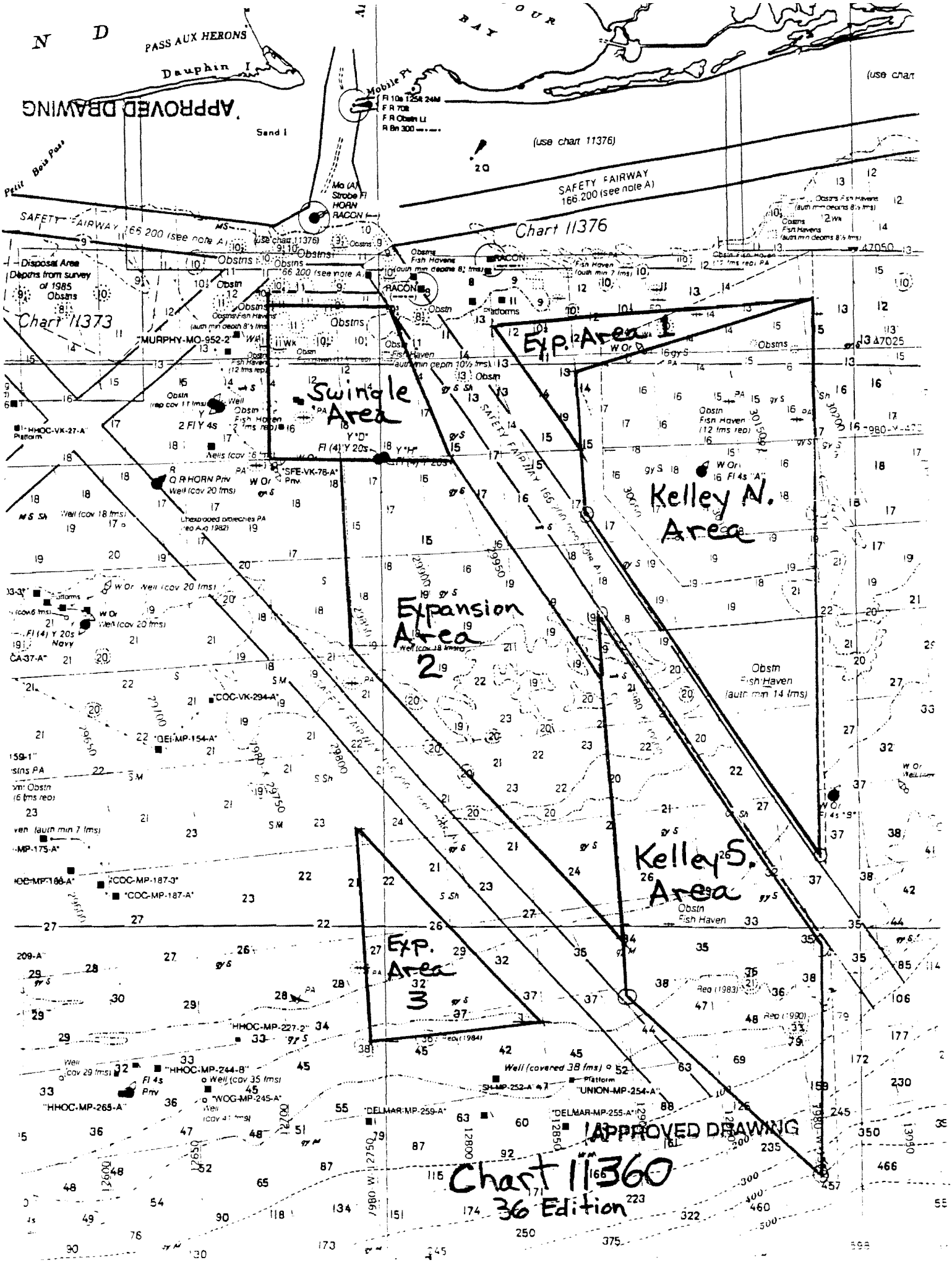
BY: Ronald A. Krizman
RONALD A. KRIZMAN *(DATE)* 9/17/97
CHIEF, REGULATORY BRANCH
OPERATIONS DIVISION

When the structures or work authorized by this permit are still in existence at the time the property is transferred, the terms and conditions of this permit will continue to be binding on the new owner(s) of the property. To validate the transfer of this permit and the associated liabilities associated with compliance with its terms and conditions, have the transferee sign and date below.

*(TRANSFEREE)* *(DATE)*



☆U.S. GOVERNMENT PRINTING OFFICE: 1986 — 717-425


APPROVED DRAWING
PASS AUX HERONS
Dauphin I
Sand I
Mobile Pt
(use chart 11376)
SAFETY FAIRWAY 166.200 (see note A)
Chart 11376
Chart 11373
Disposal Area
Depths from survey of 1985
Obstns
Swingle Area
Exp. Area 1
Kelley N. Area
Expansion Area 2
Kelley S. Area
Exp. Area 3
Obstn
Fish Haven
(auth min 14 fms)
APPROVED DRAWING
Chart 11360
36 Edition

Latitude and Longitude for Reef Areas:

Hugh Swingle Reef Area:

Corner #1 30-degrees, 03.0-minutes North
88-degrees, 07.0-minutes West

Corner #2 30-degrees, 03.0-minutes North
87-degrees, 59.5-minutes West

Corner #3 29-degrees, 55.0-minutes North
87-degrees, 55.5-minutes West

Corner #4 29-degrees, 55.0-minutes North
88-degrees, 07.0-minutes West

Don Kelly North Reef Area:

Corner #1 29-degrees, 59.5-minutes North
87-degrees, 47.5-minutes West

Corner #2 30-degrees, 03.5-minutes North
87-degrees, 32.3-minutes West

Corner #3 29-degrees, 34.0-minutes North
87-degrees, 32.3-minutes West

Corner #4 29-degrees, 52.0-minutes North
87-degrees, 47.0-minutes West

Don Kelly South Area:

Corner #1 29-degrees, 47.2-minutes North
87-degrees, 46.5-minutes West

Corner #2 29-degrees, 29.2-minutes North
87-degrees, 32.3-minutes West

Corner #3 29-degrees, 16.6-minutes North
87-degrees, 32.3-minutes West

Corner #4 29-degrees, 26.4-minutes North
87-degrees, 44.9-minutes West

Extension Area #1:

Corner #1 30-degrees, 02.2-minutes North
87-degrees, 52.7-minutes West

Corner #2 30-degrees, 03.5-minutes North
87-degrees, 32.3-minutes West

Corner #3 29-degrees, 59.5-minutes North
87-degrees, 47.5-minutes West

Corner #4 29-degrees, 52.0-minutes North
87-degrees, 47.0-minutes West

Extension Area #2:

Corner #1 29-degrees, 54.8-minutes North
88-degrees, 02.5-minutes West

Corner #2 29-degrees, 55.0-minutes North
87-degrees, 55.5-minutes West

Corner #3 29-degrees, 43.1-minutes North
87-degrees, 46.0-minutes West

Corner #4 29-degrees, 29.0-minutes North
87-degrees, 45.0 minutes West

Corner #5 29-degrees, 45.2-minutes North
88-degrees, 02.0-minutes West

Extension Area #3:

Corner #1 29-degrees, 35.5-minutes North
88-degrees, 01.5-minutes West

Corner #2 29-degrees, 25.5-minutes North
87-degrees, 50.2-minutes West

Corner #3 29-degrees, 24.1-minutes North
88-degress, 01.0-minutes West

# STANDARD OPERATING PROTOCOL FOR ARTIFICIAL REEF CONSTRUCTION MARINE RESOURCES DIVISION/U.S. ARMY CORPS OF ENGINEERS

## REEF DEPLOYMENT FLOAT PLAN

Any person, firm, or corporation wishing to deploy materials to be used as artificial reefs will file a float plan with the Alabama Department of Conservation and Natural Resources, Marine Resources Division (ADCNR/MRD) prior to material deployment. The protocol for float plan filing is as follows.

- Following material inspection and permit issuance, the prospective reef builder will notify the individual agent of the ADCNR/MRD who issued the permit, or in his absence, the administrative support staff from that ADCNR/MRD office, and provide the following specific information regarding the proposed deployment event. (The Proposed Loran Reading and Notification of Completion sections MUST be completed on the Permit form.)

1. Individual Reef Builders Name
2. Vessel Name or Registration
3. ADCNR/MRD Reef Permit Number
4. Permit Issuing Agent's Name
5. Date of Permit Issuance
6. ARGP Zone in which reef will be deployed
7. Type of Material being Deployed
8. LORAN C or Lat/Lon Coordinates of Proposed Reef Site
9. Date and Estimated Time of:
    a) Departure from Dock (No earlier than one (1) hour before sunrise)
    b) Estimated Arrival at Destination (no later than one (1) hour after sunset)
    c) Return to Dock

- Filing of float plans must be conducted one (1) day in advance of deployment and between 8:00 and 5:00 p.m. Monday through Friday. If planning a Monday deployment, contact the ADCNR/MRD agent or office of permit issuance on the Friday prior for plan filing instructions. ADCNR/MRD staff will record the above information on standardized forms, and will notify the U.S. Coast Guard of same immediately.

## AUTOMOBILES

- As of 1 January, 1997 no automotive vehicles, engines and tranmissions will be certified for use as an artifical reef. No materials which will disassociate will be approved.

## BOATS

- No boats will be permitted until such time as additional studies have been completed. Barges and ships will be inspected on an individual basis.

## WHITE WARE (APPLIANCES) *(DISCONTINUED)*

## TIRES AND/OR PLASTICS

- Tires must be embedded in concrete. The minimum number of tires per unit must be four (4), with a minimum of 45 pounds of concrete per tire. Should other than car tires be used, the following formula is applicable. Concrete will equal 2X+10% of weight of tire with a minimum total weight of 260 pounds.
- Plastics (PVC) may be permitted as reef material. Inspectors will review plans and evaluate based upon durability and proper weighting.
- No floatable plastic or plastic film will be permitted. All materials which could float during deployment must be removed from the tires and/or plastics.
- The "no sheen" rule will apply to all tires and/or plastics.
- Individual plastic containers shall be heavily weighted so that they are stable on the bottom. Design and bouancy will determine appropriate weighting.
- Individual plastic containers formerly utilized to contain industrial chemicals must be certified by the permittee to be free of any harmful residue.
- All reef materials must be of such construction and material so as not disassociate and be substantially weighted to insure that material will stay in place on the bottom.
- All materials must be permitted before leaving the dock.

## OTHER MATERIALS

- All materials must comply with the "no sheen" rule.
- All materials which could float during deployment must be removed from the materials.
- All reef materials must of such construction and material so as not disassociate and be substantially weighted to insure that material will stay in place on the bottom.
- All materials loaded on barges must be loaded in such a manner as to facilitate the complete and safe inspection by Marine Resources Division ~~and/or Corps of Engineers~~ personnel.
- All materials must be permitted before leaving the dock.

## COMMERCIAL REEF BUILDERS

1. Marine Resources Division personnel are authorized to inspect reef material prior to deployment and to place MRD/COE approval sticker on the material.
2. Reef builders requesting pre-approval of reef building material must provide the following:

- Material to be inspected must be on the ground and in such position as to allow a complete and safe inspection.
- A sticker will not be placed on the reef material until all discrepancies identified by the inspector have been properly corrected.
- When the barge of reef material has been loaded with pre-inspected material the reef builder must obtain a permit which will be issued by the inspector, a copy of which must be returned to the inspector when the load has been dropped in the designated area.
- Reef builders will normally have thirty (30) days to deploy their reef after receiving their permit, after which a new permit must be obtained. Special provisions on deployment may be added to the permit by the inspector.

- No new permit will be issued until MRD has received from the reef builder the completed portion of the reef building permit.
- Material must be transported and placed during daylight hours. Return travel from the site is allowed during darkness.
- Vessels transporting permitted artificial reef material shall depart the dock and deploy said material only during the hours of one hour before sunrise to one hour after sunset, provided, however, that the person, firm, corporation, or association which is bonded by a bonding company licensed to do business in Alabama, in the minimum amount of a penal sum of $50,000.00 for each occurrence of breach, insuring performance in accordance with the permit issued, this regulation, and all other applicable laws and regulations, may, upon written authorization of the Marine Resources Director, be authorized to transport materials during other hours of the day or night or other days of the week, as determined by the Marine Resources Director.

# ALABAMA ARTIFICIAL REEF DEPLOYMENT FLOAT PLAN

**PLEASE PRINT ALL INFORMATION**

REEF BUILDER'S NAME: _____

VESSEL NAME OR REGISTRATION: _____

ADCNR/MRD REEF PERMIT NUMBER: _____

ADCNR/MRD AGENT NAME: _____

DATE PERMIT ISSUED: _____

ARGP DEPLOYMENT ZONE: _____

MATERIAL TYPE: _____

SITE COORDINATES: _____ / _____ OR _____ / _____
LORAN C LAT / LON

DATE AND TIME OF DEPART: _____

ETA AT DEPLOYMENT SITE: _____

DATE AND TIME OF RETURN: _____

FORM COMPLETED BY: _____

# Department of the Army

# Mobile District, Corps of Engineers

# Permit Number AL97-01162-U

# Awarded to Alabama Marine Resources Division

# November 3, 1997

**Modification of previous permit to update:**

- Standard Operating Procedures
- United States Coast Guard Float Plan
- General Permit Reef Zone Coordinates
- United States Department of Army Corps of Engineers Drawings

Ralph
Dale

# DEPARTMENT OF THE ARMY

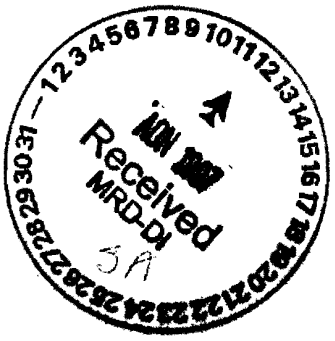
MOBILE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 2288
MOBILE, ALABAMA 36628-0001

REPLY TO
ATTENTION OF:

November 3, 1997

Regulatory Branch
Operations Division

SUBJECT: Modification Number 1 to Department of the Army Permit Number AL97-01162-U, Alabama Department of Conservation and Natural Resources




Alabama Department of Conservation
and Natural Resources
Marine Resources Division
Post Office Box 189
Dauphin Island, Alabama 36528

Gentlemen:

In accordance with your letter dated October 22, 1997, your subject permit is hereby modified as follows:

a. The enclosed Standard Operating Protocol for Artificial Reef Construction dated October 1997, including the float plan replaces the previous protocol.

b. The enclosed reef area coordinates replace the previous coordinates.

c. The enclosed chart of the reef areas and permit application form are added as permit drawings.

All other previous conditions to which the work is made subject shall remain in full force and effect.

BY AUTHORITY OF THE SECRETARY OF THE ARMY:

BY:

WILLIAM S. VOGEL
Colonel, Corps of Engineers
District Engineer

RONALD A. KRIZMAN
Chief, Regulatory Branch
Operations Division

Extension Area #1 (Don Kelly North):

Corner #1 30-degrees, 02.2-minutes North
87-degrees, 52.7-minutes West

Corner #2 30-degrees, 03.5-minutes North
87-degrees, 32.3-minutes West

Corner #3 29-degrees, 59.5-minutes North
87-degrees, 47.5-minutes West

Corner #4 29-degrees, 55.0-minutes North
87-degrees, 47.25-minutes West

Extension Area #2 (Tatum-Winn North):

Corner #1 29-degrees, 55.0-minutes North
88-degrees, 02.5-minutes West

Corner #2 29-degrees, 55.0-minutes North
87-degrees, 55.5-minutes West

Corner #3 29-degrees, 43.1-minutes North
87-degrees, 46.0-minutes West

Corner #4 29-degrees, 29.0-minutes North
87-degrees, 45.0 minutes West

Corner #5 29-degrees, 45.2-minutes North
88-degrees, 02.0-minutes West

Extension Area #3 (Tatum-Winn South):

Corner #1 29-degrees, 35.5-minutes North
88-degrees, 01.5-minutes West

Corner #2 29-degrees, 25.5-minutes North
87-degrees, 50.2-minutes West

Corner #3 29-degrees, 24.1-minutes North
88-degress, 01.0-minutes West

Latitude and Longitude for Reef Areas:

Hugh Swingle Reef Area:

Corner #1 30-degrees, 03.0-minutes North
88-degrees, 07.0-minutes West

Corner #2 30-degrees, 03.0-minutes North
87-degrees, 59.5-minutes West

Corner #3 29-degrees, 55.0-minutes North
87-degrees, 55.5-minutes West

Corner #4 29-degrees, 55.0-minutes North
88-degrees, 07.0-minutes West

Don Kelly North Reef Area:

Corner #1 29-degrees, 59.5-minutes North
87-degrees, 47.5-minutes West

Corner #2 30-degrees, 03.5-minutes North
87-degrees, 32.3-minutes West

Corner #3 29-degrees, 34.0-minutes North
87-degrees, 32.3-minutes West

Corner #4 29-degrees, 52.0-minutes North
87-degrees, 47.0-minutes West

Don Kelly South Area:

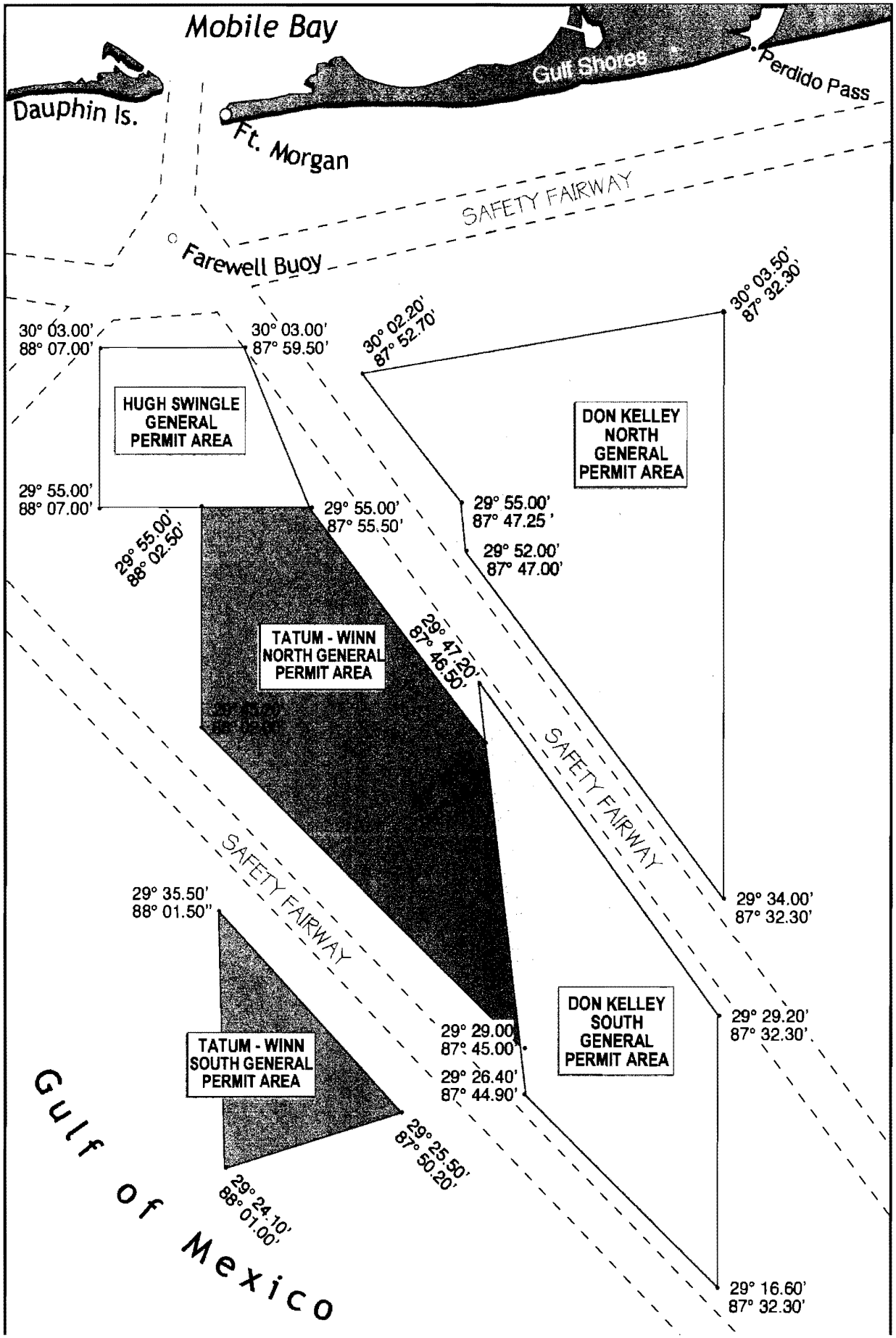
Corner #1 29-degrees, 47.2-minutes North
87-degrees, 46.5-minutes West

Corner #2 29-degrees, 29.2-minutes North
87-degrees, 32.3-minutes West

Corner #3 29-degrees, 16.6-minutes North
87-degrees, 32.3-minutes West

Corner #4 29-degrees, 26.4-minutes North
87-degrees, 44.9-minutes West

# Alabama Artificial Reef General Permit Areas



# APPLICATION FOR ARTIFICIAL REEF CONSTRUCTION 98020068
# OUTER CONTINENTAL SHELF OFF MOBILE AND BALDWIN COUNTIES, ALABAMA

**INSTRUCTIONS**

The material for reef construction must be assembled at a shore point for inspection. Contact the Alabama Department of Conservation and Natural Resources, Marine Resources Division, P.O. Box 189, Dauphin Island, Alabama 36528 (334) 861-2882); or the Alabama Department of Conservation and Natural Resources, Marine Resources Division, P.O. Drawer 458, Gulf Shores,Alabama 36542 (334) 968-7576). **No material may be placed without inspection.** At the time of inspection, the applicant will be given two signed copies; one for the applicant's records and one to be **returned to the inspector when the work is completed.** Artificial reefs may be constructed only within the areas permitted to the Alabama Department of Conservation and Natural Resources. Any construction outside of permitted areas will be considered a violation of the MARPOL Act, and shall be subject to criminal prosecution.

**Reefs Per Zone**

_____ ☐ **Don Kelley North Reef:** Off Perdido Pass bound by Lat/Long Coordinates: 30° 02.20' - 87° 52.70', 30° 03.50'- 87° 32.30', 29°34.00', 87° 32.30', 29° 52.00' - 87° 47.00', 29° 55.00' - 87° 47.25'.

_____ ☐ **Don Kelley South Reef:** Off Perdido Pass bound byLat/Long Coordinates: 29° 47.20' - 87° 46.50', 29° 29.20' - 87° 32.30', 29° 16.60' - 87° 32.30', 29° 26.40' - 87° 44.90'.

_____ ☐ **Hugh Swingle Reef:** Southeast of Dauphin Island bound by Lat/Long Coordinates: 30° 03.00' - 88° 07.00', 30° 03.00' - 87° 59.50', 29° 55.00' - 87° 55.50', 29° 55.00' - 88° 07.00'.

_____ ☐ **Tatum - Winn Reef - North:** Southeast of Dauphin Island bound by Lat/Long Coordinates: 29° 55.00' - 88° 02.50', 29° 55.00'- 87° 55.50', 29° 43.10' - 87° 46.00', 29° 29.00' - 87° 45.00', 29° 45.20' - 88° 02.00'.

_____ ☐ **Tatum - Winn Reef - South:** Southeast of Dauphin Island bound by Lat/Long Coordinates: 29° 35.50' - 88° 01.50', 29° 25.50' - 87° 50.20', 29° 24.10' - 88° 01.00'.

Privacy Act Statement: The Ala. Marine Resources Div. Permit program for artificial fishing reefs, is authorized by Section 10 of the River and Harbor Act of 1899 and Section 404 of the Clean Water Act. The information requested in this form is optional and is needed to contact applicants. However, if the information is not provided, your request cannot be evaluated, nor can an authorization be issued. Information provided in this application will be available to the public.

APPLICANT NAME: _____ ADDRESS: _____

CITY_____ STATE _____ ZIP CODE_____ PHONE NUMBER: (_____)_____

To place the following materials: _____

Vessel identification: _____ Number of Individual Reefs: _____

Proposed Lat/Long Coordinates: _____ - _____ PERMIT VALID FROM: _____ TO: _____

In applying for this authorization, I understand and acknowledge that the reef area is public and my activity does not give me any rights or private use over those of the general public, and the existence of this reef does not exclude any other authorized use of the area. I understand I shall be subject to criminal prosecution if I place materials in any area outside the permitted area. This authorization is valid for ten (10) working days from permit date.

APPLICANT'S SIGNATURE: _____ DATE: _____

**AUTHORIZATION FOR REEF CONSTRUCTION**

The reef material was inspected on _____. The applicant is authorized to place the listed materials at the stated location.

Placard # ('s) _____ BY: _____, Alabama Marine Resources Division

**NOTIFICATION OF COMPLETION**

| PLACARD # | DEPTH OVER REEF | LATITUDE | LONGITUDE |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

AFTER DEPLOYMENT OF REEF MATERIAL, PROVIDE THE NECESSARY COMPLETION INFORMATION. SIGN, DATE AND RETURN TO PERMITTING OFFICE (ADDRESS ABOVE). **NOTIFICATION OF COMPLETION MUST BE ON FILE WITH AMRD BEFORE FURTHER PERMITS CAN BE ISSUED.**

SIGNED: _____

DATE: _____

## FLOAT PLAN

**AMRD - DAUPHIN ISLAND 334-861-2882** **AMRD - GULF SHORES 334-968-7576**

DEPLOYMENT AREA: _____ PORT OF DEPARTURE/RETURN: _____

DATE/TIME OF DEPARTURE: _____ (Date) at _____ (Time)

ETA AT DEPLOYMENT SITE: _____

DATE/TIME OF RETURN: _____ (Date) at _____ (Time)

**FLOAT PLAN MUST BE CALLED IN TO A MARINE RESOURCES DIV. OFFICE AT LEAST ONE DAY BEFORE DEPLOYMENT DATE (PERMIT IS NOT VALID WITHOUT A RECORDED FLOAT PLAN).**

STATE OF ALABAMA
**DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES**
**MARINE RESOURCES DIVISION**
POST OFFICE BOX 189
DAUPHIN ISLAND, ALABAMA 36528

TEL (334) 861-2882
FAX (334) 861-8741

# ARTIFICIAL REEF DEPLOYMENT FLOAT PLAN

**PERMITTEE:** _____

**ADDRESS:** _____

**CITY:** _____

**STATE:** _____

**ZIP:** _____

**PHONE:** (  ) _____

**MATERIALS:** _____

_____

_____

_____

**VESSEL DESCRIPTION:** _____

_____

**PLACARD # (s):** _____

**INSPECTED BY:** _____ _____

Ala. Marine Resources Division (334) 861-2882 — Inspection Date

**DEPLOYMENT ZONE:** _____

**DATE & TIME OF DEPARTURE:** _____ (DATE) at _____ (TIME)

**ETA AT SITE:** _____

**DATE AND TIME OF RETURN:** _____ (DATE) at _____ (TIME)

**PORT OF DEPARTURE/ RETURN** _____

**PERMIT NUMBER: 98020068**

**REEF DEPLOYMENT ZONES**

| | |
|---|---|
| DON KELLEY - NORTH PERMIT AREA<br>30° 02.20' - 87° 52.70', 30° 03.50'- 87° 32.30',<br>29°34.00', 87° 32.30', 29° 52.00' - 87° 47.00',<br>29° 55.00' - 87° 47.25'. | ☐ |
| DON KELLEY - SOUTH PERMIT AREA<br>29° 47.20' - 87° 46.50', 29° 29.20' - 87° 32.30',<br>29° 16.60' - 87° 32.30', 29° 26.40' - 87° 44.90'. | ☐ |
| HUGH SWINGLE PERMIT AREA<br>30° 03.00' - 88° 07.00', 30° 03.00' - 87° 59.50',<br>29° 55.00' - 87° 55.50', 29° 55.00' - 88° 07.00'. | ☐ |
| TATUM - WINN NORTH PERMIT AREA<br>29° 55.00' - 88° 02.50', 29° 55.00'- 87° 55.50',<br>29° 43.10' - 87° 46.00', 29° 29.00' - 87° 45.00',<br>29° 45.20' - 88° 02.00'. | ☐ |
| TATUM - WINN SOUTH PERMIT AREA<br>29° 35.50' - 88° 01.50', 29° 25.50' - 87° 50.20',<br>29° 24.10' - 88° 01.00'. | ☐ |

**Permit Valid from:** _____ **To:** _____

# REEF PERMIT

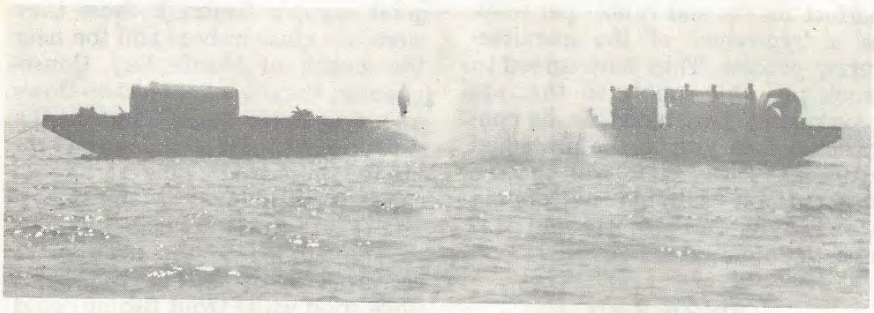
ALABAMA
DEPARTMENT OF
CONSERVATION AND
NATURAL RESOURCES

MARINE
RESOURCES
DIVISION

Permit No. 10000

# Artificial Reef Program Grows In Alabama Coastal Waters

*By WAYNE E. SWINGLE*
*Chief Marine Biologist*
*Dauphin Island*



Culvert being unloaded at reef site. The culverts are used to attract fish. Some of these in Alabama waters have produced excellent sport fishing. (Marine Resources Division photos)

The last culvert of a reef serves as an anchor for the buoy marking the reef site.

This sign marks one end of an artificial reef in Mobile Bay.

The saltwater angler in Alabama is lucky because he has a variety of species of fish and types of fishing from which to choose and generally the fishing is very good. The fishing techniques and fish vary from pole-and-line fisherman on the bank who fishes for croaker, spot and mullet, to the fighting chair enthusiast who battles marlin and other billfish off the 100-fathom curve.

Nature has provided Alabama fishermen with abundantly good estuarine fishing, offshore trolling, and with shrimp, crabs and other shellfish. The one thing that Nature has failed to provide for the Alabama angler is an abundance of submerged reefs, the haunts of bottomfish such as red snapper and grouper.

Fish are attracted to a reef because it provides a place of refuge from larger predators and also because the food supply is increased by the invertebrate organisms that live near the reef. These organisms attract smaller fish that serve as food for larger fish. However, many fish are attracted simply because the reef provides a point or place of reference in a bottom habitat that is often as barren as a desert. These fish are known as thigmotropic (attracted to an object by a touch stimulus) by those who wish to complicate things.

The Marine Resources Division (formerly the Seafoods Division) of the Alabama Department of Conservation and Natural Resources has been constructing artificial reefs to compensate for the lack of natural reefs off Alabama's coast and in its estuarine bays. The offshore reefs have been constructed in 60 to 90 feet of water. These reefs attract snapper, grouper, triggerfish and other species. The reef sites are also excellent trolling locations for king mackerel, amberjack and ling. The inshore reefs in Mobile Bay are built for the small-boat fisherman and attract white trout, ground mullet and speckled trout.

*(See Next Page)*

The Marine Resources Division began its inshore reef program in 1971. These reefs are being constructed in the estuaries (Figure 1). Two such reefs have been completed in Mobile Bay. Each reef covers an area of approximately three acres.

The reefs were constructed of imperfect concrete building blocks and broken roadway paving donated and planted by a Mobile materials firm under the supervision of the Division. Approximately 1250 tons of material were placed on each reef. This is equivalent to one block for each two square feet of reef area.

The reefs are marked at each end by 6' x 14' signs mounted on pilings 10 feet above the water. The reefs are placed on hard bottom in eight to 10 feet of water. Similar reefs were constructed in Walton County, Florida, by the materials firm and have provided very good fishing there. The firm manufactures building blocks and normally produces about 50 tons of imperfect blocks and rubble per week as a byproduct of the manufacturing process. They have agreed to stock pile this rubble so that approximately two reefs can be constructed each year in the protected estuaries. These reefs will be constructed on suitable bottom in Mobile Bay, Perdido Bay and Mississippi Sound.

### Offshore Reefs

In 1964, the Marine Resources Division placed six buoyed reefs three to five miles offshore from Ft. Morgan in 30 to 50 feet of water and buoyed the reefs. The Game and Fish Division financed these reefs which were constructed to provide fishing for the small boat fisherman.

These reefs failed to provide good snapper fishing because they were too close inshore and too near the mouth of Mobile Bay. Consequently, they were subject to flows of turbid water during much of the year. The reefs did provide good fishing for white trout. Ling were often caught by trolling near the buoys. The failure to attract large numbers of snapper led to the decision to construct reefs within the bays, since good white trout fishing could be produced in the bays where better protection was provided for the small-boat fisherman.

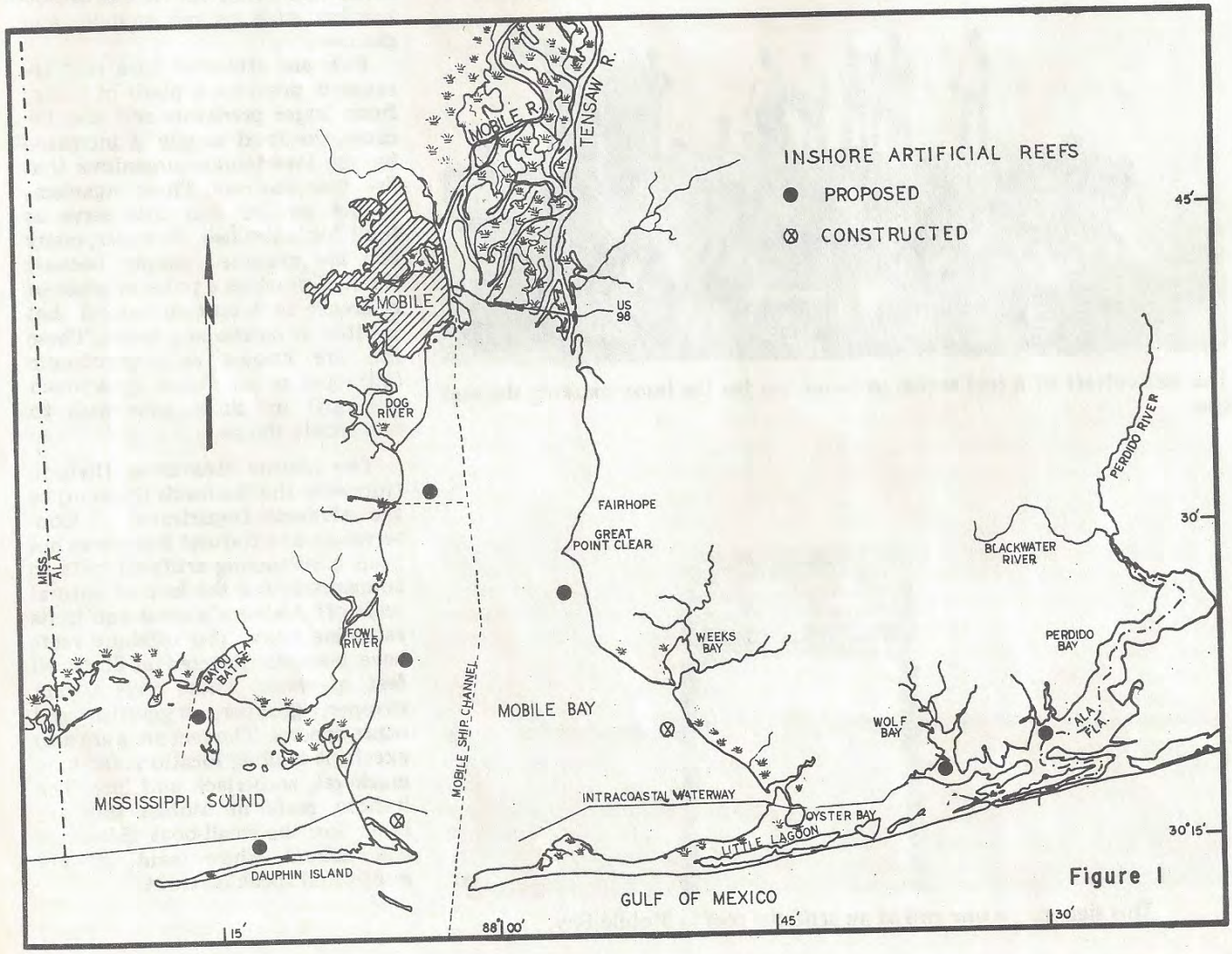
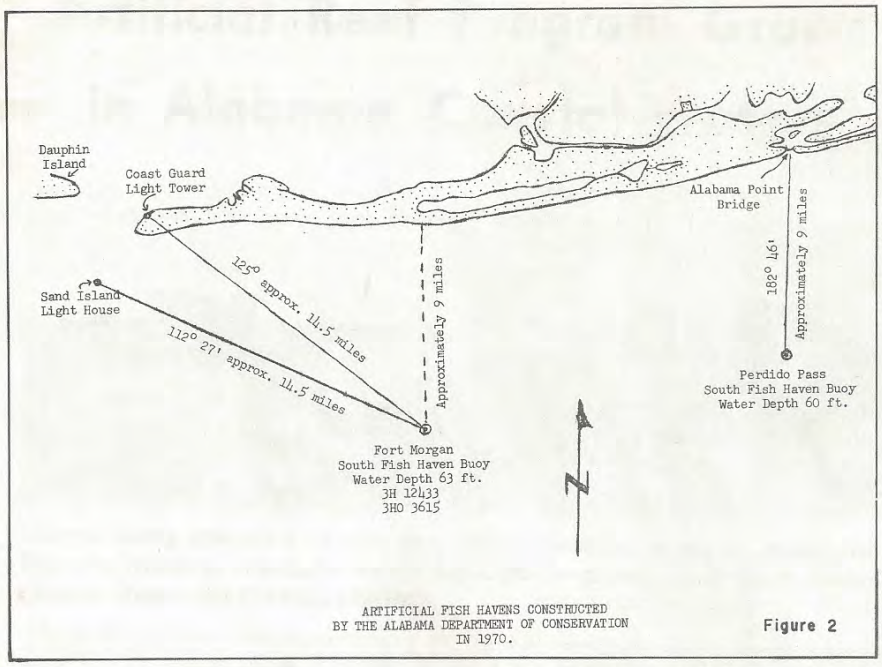



Figure 1




ARTIFICIAL FISH HAVENS CONSTRUCTED BY THE ALABAMA DEPARTMENT OF CONSERVATION IN 1970.

Figure 2

During 1970, the Game and Fish Division funded two sets of reefs off the Alabama coast and the Marine Resources Division directed their placement. The reef material consisted of imperfect roadway culverts, three to seven feet in diameter. They were donated by a Mobile concrete pipe firm. One of the reefs was placed 14.5 miles southeast of Sand Island Lighthouse on a compass bearing of 112° 27′ (See Figure 2). The other was placed nine miles south of Perdido Pass on a compass bearing of 182° 46′. Both reefs were buoyed by the Marine Resources Division and both reefs have provided very productive fishing.

### Liberty Ships

The Marine Resources Division is also very hopeful that it will be able to sink liberty ships offshore for reefs in the near future. Congress William (Bill) Dickinson introduced a bill that would allow the transfer of liberty ships from the reserve fleets to the states for use as artificial reefs. This bill was passed by both houses of Congress. President Nixon signed it into law on Aug. 25, 1972. The Marine Resources Division has allocated funds for placing these ships offshore. The division hopes to get six ships for reefs. These reefs would have to be placed in 100 feet of water, approximately 14 miles offshore. In order to avoid conflicting with offshore shrimping, the ships will have to be placed east of the Mobile Ship Channel. Each ship will be buoyed and maps will be prepared giving its location and Loran coordinates.

### History of Reef Placement

The Marine Resources Division of the Alabama Department of Conservation and Natural Resources was the first state organization in this country to attempt to establish offshore marine fishing reefs.

In 1953, the Orange Beach Fishermen's Association approached the Division with a plan for building artificial snapper banks. In the fall of that year, the first man-made reefs in the Gulf of Mexico were established when 250 automobile bodies were placed in small groups off Baldwin County in water depths of from 60 to 90 feet. Fishermen began to take snapper within six months.

In early 1957, the Department placed another 1500 used car bodies in small groups in a line extending across the greater part of the Baldwin and Mobile County coastlines. This also provided excellent fishing after the first six months. These snapper banks cost the state $71,409, or less than $41 per car body for purchase and placement. These car bodies have deteriorated, but provided good fishing for a period of from three to seven years.

In July, 1959, the Department and the Mobile County Wildlife and Conservation Association sank a 300-foot drydock off the Mobile County coast. This barge is still providing fishing. The coordinates of this reef are 30°-08'-00" N and 88°-06'-30" W on a compass course of 192° from Sand Island Light House.

In November, 1962, some 300 tons of imperfect concrete roadway culverts, ranging in diameter from two to six feet and in lengths up to 10 feet, were sunk off Perdido Pass in 75 feet of water by the Game and Fish Division. Five closely spaced, individual reefs were constructed. These reefs are still providing some fishing, but evidently many culverts were covered by Hurricane Camille. The culverts set out in 1970 were put in the same general location, except in deeper water. Both areas were buoyed by the Marine Resources Division.

### Funding Needed

The Marine Resources Division would like to increase its efforts to provide offshore and inshore fishing for Alabama's citizens. However, funds are required to provide this service and for this reason the Division and Department are advocating a marine sportsfishing license for Alabama at a modest fee. As it stands now, each person pays 10 percent federal taxes on each item of marine sportsfishing tackle he purchases. This tax is designated by law to go to the states to improve sportsfishing within the state. Since Alabama does not have a marine sportsfishing license, it does not receive its share of these federal dollars.

If such a license is approved by the people of the State, the Marine Resources Division plans to put these fees and federal matching funds into capital improvement projects such as construction of reefs, piers and launching ramps for boats. A few dollars from each of us could combine to create many benefits for all by providing a comprehensive and continuing marine sportsfisheries program. We invite your support and comments.

ALA. DEPT. OF CONSERVATION
SEAFOODS DIVISION

# PRELIMINARY REPORT OF RESEARCH ON

# FISH HAVENS IN ALABAMA WATERS

ALABAMA MARINE RESOURCES LABORATORY

BY

JACK L. GAINES
MARINE BIOLOGIST

1963

# INTRODUCTION

As part of a study on the life history of the red snapper, Lutianus aya, an evaluation of the development and potential of artificial fishing reefs is presently being carried out. This project began in June of 1962 and has presently been slowed because of the on-set of winter as well as a lack of operating funds.

Description of the Area. The floor of the Gulf of Mexico off Alabama can be described as a vast sandy plain. The contour of this plain is relatively unbroken and has a gradual slope to the south until the hundred fathom curve is reached; then drops off to the abyssal depths rather abruptly. The floor of the Gulf off Alabama is rather barren of vertebrate fauna except in the areas where the contour of the plain is broken by either natural or man-made obstructions. Around the man-made obstructions, the number of fish is unsurpassed in temperate seas. The most abundant species is still undetermined. The artificial reefs are more productive than the natural reefs in Alabama waters even though the natural reefs are much more extensive in area. This is probably because the relief of the artificial reefs is much greater.

Description of Existing Natural Reefs. There are two natural reefs or banks off the coast of Alabama called the Southeast and the Southwest banks. The Southeast bank is located approximately 12 miles southeast of Sand Island Light. (See U.S. Coast and Geodetic Chart of Mobile Bay). The banks dimensions are two miles in length and approximately one fourth mile in width, lying in a northeasterly to southwesterly direction. The depth ranges from 75 to 90 feet, though not changing abruptly.

The bottom appears to be a series of shell banks and mud gullies. This area produces several species of fish, with Lutianus being predominant. The fish taken here are considerably smaller than those taken on the artificial reefs. Lutianus larger than two pounds are seldom taken, though fairly large grouper are taken quite frequently. The Southwest bank is located 18 miles south-southwest of Sand Island Light. This bank appears to be a small ridge about one fourth mile in length and less than 100 yards in width. The bank lies in 70 feet of water with a relief of 10 feet at a maximum. This area produces the same type of fish as the Southeast bank. These two areas are well away from the effects of the turbid waters of Mobile Bay and are very clear except under extremely rough conditions.

Discription of Existing Artificial Reefs. The largest of the artificial reefs is a sunken drydock located 14 miles 190 degrees south of Sand Island Light. (See U.S. Coast and Geodetic Chart of Mobile Bay). This structure is 300 feet in length and 150 feet in width and lies in 70 feet of water. It has a relief of 10 to 20 feet. It was sunk in 1957 and left undisturbed for two years. Since the location was released this structure has been the hot spot of Alabama Gulf Coast fishing, producing more pounds of fish than any other area of comparable size. The sunken drydock is subjected to extremely heavy fishing pressure. During the summer months as many as 15 large party boats fish it each week, all having good results. It is not uncommon to see as many as eight boats fishing it at one time. Despite this heavy pressure, if left alone for several days, the drydock appears to recover completely and continues to produce good catches all through the season.

The number of fish around this structure is indescribable and the number of different species is outstanding. No attempt has been made to identify all species present, but this is forth coming in this present project.

The smallest of the artificial reefs in Alabama waters is of unknown origin, though it is believed to be scrap dumped by the Coast Guard. This is a sunken sea buoy six feet in diameter and a piece of pipe four feet in diameter and fifteen feet in length. This reef is in 56 feet of water on a moderately hard, sand bottom. Although this reef is extremely small, it produces an unbelievable amount of fish. It was discovered accidentally in June of 1962 by a trolling charter boat. On the day of discovery, 21 boats fished this hot spot. Some of the boats were outboard and had to stop fishing because of overloading the boats with fish. One of the charter boats fished the reef for one hour, with seven people catching 1500 pounds of fish. Although only the one charter boat catch mentioned above was authenticated, it was reported that all 21 boats fishing the reef made similar catches. Diving biologists made exploratory dives immediately after the discovery of this reef and reported that there were an estimated 500 to 700 fish still around the reef. The biologists reported that the fish ran from one to forty pounds in size. Aside from the great number of fish on this very small reef, another interesting fact is that all fish caught were red snapper. (Litianus aya). Only two small grouper were observed on the bottom along with the vast amount of snappers. In the mid-waters above, several other species of pelagic fish were milling around. The greatest number of these fish were amberjacks. None of these were taken because of the

type of bait used for catching the snapper.

Another artificial reef that has been constructed in Alabama waters utilized junked car bodies. The car body reef is located along the 10 fathom curve south of Dauphin Island on a mud bottom. This reef was established in 1954 by the Alabama Department of Conservation, Division of Game and Fish. It has on occasions produced large catches of snapper but is at present of questionable value because of the difficulty of locating it. Also under certain conditions the water becomes turbid and the snapper will not readily take bait under these conditions. This reef produced practically no fish in 1962, probably because the car bodies have either been buried in the mud or have disintergrated. The failure of the Car Body Reef exemplifies the fact that proper planning by experienced personnel is of upmost importance.

Another car body reef was established during the same year as the above reef off the mouth of Perdido Bay. This reef was placed in 60 feet of water and is located eight miles south of Perdido Pass. It lies on a hard sand bottom and the water is usually extremely clear. This area is extremely productive and is the mainstay of the sportsfishery of that area. Although this reef is very productive, it has not been observed by diving biologists at the present time.

In the above area, several small reefs have been established by private enterprize and are reported to be very productive. These private reefs are constructed of virtually any type of "junk" ranging from automobile tires to old stoves and refrigerators. Due to the fact that these reefs are privately built, it is practically impossible to get the local fishermen to divulge their locations. Because of this, none of the private reefs off Perdido Pass have been observed.

Recent Developments in Alabama Waters. During the month of November 1962, the Alabama Department of Conservation, Division of Game and Fish, in cooperation with the Division of Seafoods and the Alabama Marine Laboratory established a large reef eight miles off Perdido Pass in 75 feet of water. This reef was constructed with 300 tons of scrap concrete culvert pipe. The culvert pipe ranged in diameter from two to six feet and up to ten feet in length. The pipe was placed on hard sand bottom where it has least chance of being buried in the sand. Unless this reef eventually becomes buried, it should prove to be a permanent installation.

Due to bad weather, no dives have been made on this newly established reef. This reef, due to the care in selecting the location and the material used in construction should prove to be Alabama's most productive. It is the opinion of the author of this paper that this scrap culvert pipe is the answer to the problem of materials for the construction of artificial fish havens. This pipe is steel reinforced concrete and should prove to be permanent. Scrap culvert pipe is also the cheapest material that has been utilized in Alabama waters. It is relatively easy to handle and large quantities can be hauled to sites with nominal expense. The new reef was established for $1200.00, $200 being for the purchase of the material and $1000. , transportation to reef site. Considering the productivity of previously existing reefs, this reef should prove to be an invaluable asset to Alabama sportsfishing.

The Development of An Artificial Fish Haven. During the summer of 1962 the establishment and development of a small artificial fish haven was observed and studied by marine biologist utilizing S.C.U.B.A. equipment. This artificial fish reef was a 26 foot steel life boat that

sank in 56 feet of water at a location five miles southeast of Sand Island Light. (See U.S. Coast and Geodetic Chart of Mobile Bay). Weekly dives were made to observe the accumulation of fish. The first fish to take up residence around the life boat was a large school of amberjacks. These fish were observed seven days after the boat sank. Two weeks after sinking, divers noted ten small red snapper (Litianus sp.), three common triggerfish, and approximately 200 amberjacks. The third week 27 red snapper were counted along with the amberjacks and various other fish that could not be identified by the divers in the field. Due to bad weather no observation was made on the fourth week. The fifth week divers were unable to get an accurate count of the red snapper because of the turbid condition of the water but estimated there to be between 50 and 100 of these fish. Due to uncontrollable circumstances no further observations have been made of this reef.

It should be noted that this is a prelimininary paper and more work is being conducted in this area and will be published in the near future.

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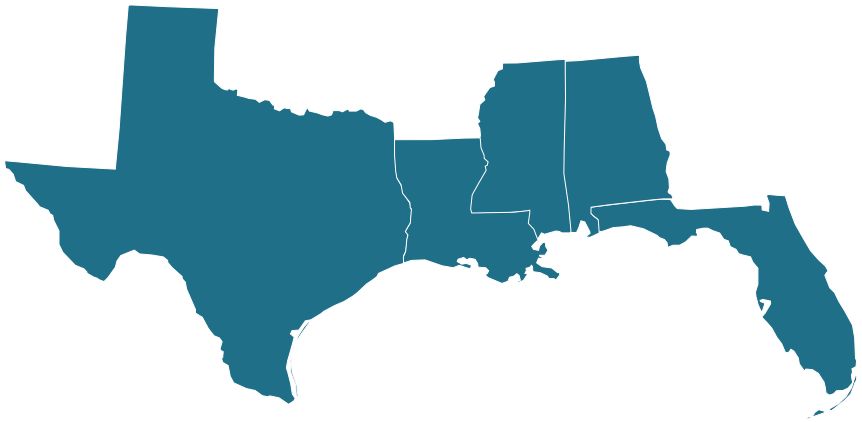
# Gulf of Mexico

- Alabama
- West Florida
- Louisiana
- Mississippi
- Texas



### Management Context

The Gulf of Mexico Region includes Alabama, Louisiana, Mississippi, Texas, and West Florida. Federal fisheries in this region are managed by the Gulf of Mexico Fishery Management Council (GMFMC) and NOAA Fisheries (NMFS) under seven fishery management plans (FMPs). The spiny lobster and coastal migratory pelagic resources fisheries are managed in conjunction with the South Atlantic Fishery Management Council (SAFMC).

**Gulf of Mexico Region FMPs**

1. Red Drum
2. Shrimp
3. Reef Fish
4. Coastal Migratory Pelagic Resources (with SAFMC)
5. Spiny Lobster (with SAFMC)
6. Corals
7. Aquaculture

Of the stocks or stock complexes covered in these fishery management plans, four are currently listed as overfished: gag, gray triggerfish, greater amberjack, and red snapper. Three stocks or stock complexes are currently subject to overfishing: gag, gray triggerfish, and greater amberjack.

There have been two recent changes to the Gulf of Mexico FMPs over the last several years. The Aquaculture FMP was approved in 2009 and is the only federal FMP to solely address aquaculture. The purpose of the plan is to develop a regional permitting process to ensure that the aquaculture industry is environmentally sound and economically sustainable. As of October 2011, the FMP had not yet been implemented. The other recent change to the Gulf of Mexico FMPs, was the repeal of the Stone Crab FMP. Stone crab was historically managed as a federal fishery, however, as of October 2011, the Gulf of Mexico states will now be responsible for management of the stone crab.

In recent years, fishing operations in the Gulf of Mexico were significantly disrupted by hurricanes, especially with major storms making landfall in Louisiana and Texas in 2005 (Hurricanes Katrina and Rita) and 2008 (Hurricanes Gustav and Ike). Locally, storm surge has severely disrupted or destroyed the infrastructure necessary to support fishing, such as vessels, fuel and ice suppliers, and fish houses. For the affected areas and individuals, recovery is a long and slow process, often involving rebuilding homes and settling insurance claims before the repair and restart of fishing operations.

In 2010, the Deep Water Horizon accident and resulting oil spill severely affected Gulf fisheries. Large parts of the Gulf of Mexico, including state and federal waters, were closed to fishing during May through October, 2010. Both Alabama and Mississippi reported less than half and Louisiana about three quarters of their annual shrimp landings compared to the average of the previous three years. While the Gulf Coast Claims Facility has paid out over $700 million to the Gulf fishing industry, the long term consequences of the oil spill on the fishing industry have yet to be assessed.

### Commercial Fisheries

In 2011, commercial fishermen in the Gulf of Mexico Region landed 1.8 billion pounds of finfish and shellfish, earning $818 million in landings revenue. Landings revenue was dominated by shrimp ($438 million) and menhaden ($104 million). These species commanded ex-vessel prices of $1.99 and $0.08 per pound, respectively, and comprised 66% of total landings revenue, and 90% of total landings in the Gulf of Mexico Region.

**Key Gulf of Mexico Region Commercial Species**

- Blue crab
- Crawfish
- Groupers
- Menhaden
- Mullets
- Oysters
- Red snapper
- Shrimp
- Stone crab
- Tunas

Louisiana and Texas had the highest landings revenue in the region in 2011, $334 million and $239 million, respectively. The next greatest landings revenue came from West Florida with $164 million in landings revenue. In terms of pounds landed, Louisiana had the highest landings (1.3 billion pounds), followed by Mississippi (278 million pounds) and Texas (98 million pounds).

#### *Economic Impacts*[1,2]

In 2011, the Gulf of Mexico Region's seafood industry generated $500 million in sales impacts in Alabama, $1.8 billion in sales impacts in Louisiana, $247 million in sales impacts in Mississippi, $2.3 billion in sales impacts in Texas, and $14 billion in sales impacts in Florida. Florida generated the largest employment, income, and value added impacts, generating 72,000 jobs, $2.7 billion, and $4.8 billion, respectively. The smallest income impacts were generated in Mississippi ($96 million) and the smallest employment impacts were also generated in Mississippi (5,500 jobs).

The sector that generated the greatest employment impacts by state was the importers sector with 37,000 jobs in Florida and 2,700 jobs in Texas. The harvest sector in Texas generated 5,800 jobs. More sales impacts were generated by importers in Florida than any other sector in any another state in the region at $10 billion and the greatest value added impacts were also generated by importers in Florida ($3.1 billion).

#### *Landings Revenue*

Landings revenue in the Gulf of Mexico Region totaled $818 million in 2011. This was a 20% increase (a 17% decrease in real terms) from 2002 levels ($682 million) and a 28% increase

[1]The NMFS Commercial Fishing Industry Input/Output Model was used to generate the impact estimates (see NMFS Commercial Fishing & Seafood Industry Input/Output Model, available at: `www.st.nmfs.noaa.gov/documents/commercial_seafood_impacts_2007-2009.pdf`)

[2]Commercial economic impacts data were not available for West Florida, data for Florida are reported here.

(a 18% increase in real terms) relative to 2010 ($639 million). Totaling $623 million in 2011, shellfish revenue experienced a 17% increase (a 19% decrease in real terms) from 2002 to 2011 and experienced a 23% increase (13% increase in real terms) from 2010 to 2011.

**Commercial Fisheries Facts**

*Landings revenue*

- On average, between 2002 and 2011, the key species or species groups accounted for 91% of total revenue, generating $615 million in the Gulf of Mexico Region.
- Shrimp had higher landings revenues than any other species or species group, averaging $371 million in landings revenue from 2002 to 2011.
- Crawfish had the largest one-year increase in landings revenue over the 10 year time period, increasing 600% from $1.3 million in 2006 to $9 million in 2007.
- Crawfish had the largest one-year decrease in landings revenue over the 10 year time period, decreasing 85% from $8.4 million in 2005 to $1.3 million in 2006.

*Landings*

- Key species or species groups contributed an average of 96% annually to total landings between 2002 and 2011.
- Menhaden contributed the most to landings in the region, averaging 1.1 billion pounds from 2002 to 2011.
- Crawfish had the largest one-year increase in landings over the 10 year time period, increasing 979% from 1.5 million in 2006 pounds to 16 million pounds in 2007.
- Crawfish had the largest one-year decrease in landings over the 10 year time period, decreasing 90% from 15 million pounds in 2005 to 1.5 million pounds in 2006.

*Prices*

- Stone crab had the highest average annual ex-vessel price per pound ($4.20) over the time period, followed by tunas ($2.92), and oysters ($2.90).
- Menhaden had the lowest average annual ex-vessel price per pound ($0.06) over the time period, followed by mullets ($0.65), and crawfish ($0.71).
- Tunas had the largest one-year increase in ex-vessel price over the 10 year time period, increasing 71% from $2.03 per pound in 2010 to $3.47 in 2011.
- Crawfish had the largest decrease in ex-vessel price over the 10 year time period, decreasing 35% from $0.88 per pound in 2006 to $0.57 in 2007.

Between 2002 and 2011, the landings revenue from shrimp increased 14% (a 21% decrease in real terms) and the landings revenue for menhaden increased 99% (a 38% increase in real terms). Although in 2011, menhaden landings (1.4 billion pounds) were six times higher than shrimp landings (220 million), the landings revenue for shrimp ($438 million) was four times higher than the landings revenue for menhaden ($104 million). In terms of finfish, Louisiana contributed the most ($112 million) followed by West Florida ($59 million), and Mississippi ($11 million). Shellfish landings revenue was dominated by Texas, which contributed the most ($231 million) followed by Louisiana ($221 million), and West Florida ($105 million).

From 2002 to 2011, species or species groups with large changes in landings revenue include menhaden (increased 99%), tunas (decreased 58%), and oysters (increased 27%). Species or species groups with large changes in landings revenue between 2010 and 2011 include tunas (increasing 105%), mullets (increasing 99%), and menhaden (increasing 57%).

*Landings*

Fishermen in the Gulf of Mexico Region landed 1.8 billion pounds of finfish and shellfish in 2011. This was a 2.1% increase from the 1.73 billion pounds landed in 2002 and a 37% increase from the 1.29 billion pounds landed in 2010. Finfish landings contributed 82% of total landings in the Gulf of Mexico Region (1.4 billion pounds) in 2011. From 2010 to 2011, finfish landings experienced a 41% increase.

Over the same time period, shellfish landings experienced a 22% increase from 261 million pounds in 2010 to 318 million in 2011 and a 10% decrease from 351 million pounds in 2002. Menhaden and shrimp had the highest annual landings in the Gulf of Mexico Region in 2011, with 1.4 billion pounds and 220 million pounds, respectively. Together they accounted for 90% of the total landings in 2011. Menhaden landings increased 6.5% and shrimp landings decreased 5.9% during this period.

From 2002 to 2011, species or species groups with large changes in landings include tunas (decreasing 67%), groupers (decreasing 42%), and crawfish (decreasing 38%). Species or species groups with large changes in landings between 2010 and 2011 include mullets (increasing 59%), groupers (increasing 43%), and menhaden (increasing 42%).

*Prices*

The ex-vessel prices for the Gulf of Mexico Region's key species and species groups in 2011 were higher than their 10 year average for ten of the key species (two of the species in real terms). Ex-vessel prices for menhaden and crawfish increased the most between 2002 and 2011, increasing 100% (39% in real terms) and 98% (37% in real terms), respectively. Relative to ex-vessel prices in 2010, the Gulf of Mexico Region's tunas experienced the greatest increase (71%, 58% in real terms) from $2.03 per pound in 2010 to $3.47 in 2011. There were no decreases in ex-vessel price experienced by any species or groups in Gulf of Mexico Region between 2010 and 2011. Relative to ex-vessel prices in 2010, eight species or species groups experienced increases, including mullets (26%).

In Alabama, the species or species group with the largest change in ex-vessel price from 2002 to 2011 was oysters (100% increase, 39% increase in real terms) from $2.11 to $4.22. The largest change in ex-vessel price experienced in Louisiana was for menhaden (100% increase, 39% increase in real terms) from $0.04 to $0.08 and in Mississippi the largest change in ex-vessel price was experienced by oysters (130% increase, 60% increase in real terms) from $1.63 per pound to $3.75.

## Recreational Fishing

In 2011, over 3 million recreational anglers took 23 million fishing trips in the Gulf of Mexico Region. Almost 90% of these anglers were residents of a regional coastal county. Of the total fishing

trips taken, 57% were taken from a private or rental boat and another 40% were shore-based. Spotted seatrout were the most frequently caught species or species group with 33 million fish caught in 2011, and represented 45% of total fish caught in the region. Of the spotted seatrout caught, 58% of them were released rather than harvested.

*Economic Impacts and Expenditures*[1]

The contribution of recreational fishing activities in the Gulf of Mexico Region are reported in terms of economic impacts at the state level (employment, sales, income, and value added impacts) and expenditures on fishing trips and durable equipment at the regional level. Employment impacts in West Florida were the highest in the region with over 47,000 full- and part-time jobs generated by recreational fishing activities in the state. Louisiana (18,000 jobs), and Texas (15,000 jobs) followed in terms of employment impacts.

Overall, these employment impacts were generated by expenditures on recreational fishing trips taken by anglers (private or rental boat, for-hire boat, or shore-based trips) and expenditures on durable equipment. Throughout the Gulf of Mexico Region, most of the employment impacts in 2011 were generated by expenditures on durable equipment: 82% in West Florida, 81% in Louisiana, and 74% in Alabama.

In addition to employment impacts, the contribution of recreational fishing activities to the Gulf of Mexico Region's economy can be measured in terms of sales impacts and the contribution of these activities to gross domestic product (value added impacts). In 2011, sales impacts were the highest in West Florida ($2.7 billion in value added impacts), followed by Texas ($952 million), Louisiana ($806 million), Alabama ($410 million), and Mississippi ($61 million). In the same year, value added impacts were the highest in West Florida ($2.7 billion in value added impacts), followed by Texas ($952 million), Louisiana ($806 million), Alabama ($410 million), and Mississippi ($61 million).

**Key Gulf of Mexico Region Recreational Species**

- Atlantic croaker
- Gulf and southern kingfish
- Sand and silver seatrout
- Spotted seatrout
- Sheepshead porgy
- Red drum
- Red snapper
- Southern flounder
- Spanish mackerel
- Striped mullet

Overall, total fishing trip and durable equipment expenditures across the Gulf of Mexico Region in 2011 were $9.8 billion. Approximately 85% of these expenditures were related to durable equipment purchases. The greatest expenditures were for boat expenses ($4.5 billion), followed by fishing tackle ($1.3 billion), vehicle expenses ($1.2 billion), second home expenses ($812 million), and other equipment ($523 million).

**Recreational Fishing Facts**

*Participation*

- An average of 3.2 million anglers fished in the Gulf of Mexico Region annually from 2002 to 2011.
- In 2011, coastal county residents made up 90% of total anglers in this region. These anglers averaged 91% of total anglers annually over the 10 year time period.
- The largest annual increase in the number of coastal anglers during the 10 year time period occurred between 2002 and 2003, increasing 22%, from 2.5 million anglers to 3 million anglers.
- The largest annual decrease during the same period for coastal anglers occurred between 2008 and 2009, decreasing 13%, from 2.9 million anglers to 2.6 million anglers.

*Fishing trips*

- In the Gulf of Mexico Region, an average of 23 million fishing trips were taken annually from 2002 to 2011.
- Private or rental boat and shore-based fishing trips accounted for 13 million and 8.9 million fishing trips, respectively, in 2011. Together these made up 97% of the fishing trips taken in that year.
- The largest annual increase in the number of total trips taken annually over the 10 year time period occurred between 2002 and 2003, increasing 17%, from 20 million trips to 23 million trips.
- The largest annual decrease during the same period in total trips taken occurred between 2004 and 2005, decreasing 12%, from 26 million trips to 23 million trips.

*Harvest and release*

- Spotted seatrout was the most commonly caught key species or species group, averaging 30 million fish over the 10 year time period. Of these, 62% were released rather than harvested.
- Of the ten commonly caught key species or species groups, six were released more often than harvested over this time period.
- The species or species group that was most commonly released was Atlantic croaker (72% released).
- Striped mullet (88% harvested), followed by southern flounder (76% harvested), and sand and silver seatrout (68% harvested) were key species or groups that experienced the greatest proportion of harvests rather than releases.

[1]Expenditure estimates were generated from the 2011 National Marine Recreational Fishing Expenditure Survey. Economic impacts from recreational fishing activities were generated using the NMFS Recreational Economic Impact Model (see The Economic Contribution of Marine Angler Expenditures in the United States, 2006, available at:`http://www.st.nmfs.noaa.gov/economics/publications/marine-angler-expenditures/marine-angler-2006`)

Fishing trip-related expenditures by the Gulf of Mexico Region's non-residents totaled over $474 million of which the greatest portion can be attributed to for-hire-based fishing trips ($207 million). Residents of the Gulf of Mexico Region spent $1 billion on saltwater fishing trips, with most of these expenses related to private boat trips ($597 million).

*Participation*

There were 3 million recreational anglers who fished in the Gulf of Mexico Region in 2011. This was a 13% increase from 2002 (2.7 million anglers). These anglers were Gulf of Mexico Region residents from either a coastal county (2.7 million anglers) or non-coastal county (311,000 anglers).

Almost 90% of total anglers in 2011 were residents of a coastal county. Coastal county angler participation in 2011 increased 10% relative to 2002 (2.5 million anglers) and increased 10% between 2010 and 2011. Non-coastal county angler participation increased 44% relative to 2002 (216,000 anglers) and increased 32% relative to 2010 (235,000 anglers).

*Fishing Trips*

Recreational fishermen took 23 million fishing trips in the Gulf of Mexico Region in 2011. This was a 15% increase from the 2002 (20 million trips) and was 1.5 million more trips than taken in 2010. Of the total trips taken in Gulf of Mexico Region in 2011, approximately 57% of the trips were private or rental boat based (13 million) trips. The other most popular mode of fishing was shore based with 8.9 million trips in 2011.

*Harvest and Release*

Of the Gulf of Mexico Region's key species and species groups, spotted seatrout (33 million fish), red drum (10 million fish), sand and silver seatrout (8.3 million fish) and Atlantic croaker (8 million fish) were the most often caught by anglers in 2011.

Red snapper (75% released), Atlantic croaker (74% released), red drum (65% released), spotted seatrout (58% released), and Spanish mackerel (56% released) were most often released rather than harvested. Species or species groups that were harvested more often than released by anglers include striped mullet (86% harvested) and southern flounder (77% harvested).

At the state level, spotted seatrout was the most commonly caught species in West Florida, Texas[1] and Louisiana with a total of 30 million fish caught across the three states. In Alabama, the most commonly caught fish was Atlantic croaker (3.5 million fish) in 2011.

Between 2002 and 2011, three of the Gulf of Mexico Region's key species or species groups showed decreases in catch totals. Key species or groups with the largest decreases were red snapper (36%), gulf and southern kingfish (12%), and Spanish mackerel (10%).

## Marine Economy[2]

The sum of the gross domestic products by state for Alabama, Louisiana, Mississippi, Texas, and Florida[3] was $2.5 trillion in 2011. Employee compensation totaled $1.3 trillion and annual payroll totaled $788 billion. These economic measures increased 39% (a 4.3% increase in real terms) and 35% (a 1.4% increase in real terms), respectively, between 2002 and 2010; and experienced a 2.2% increase (a 2% decrease in real terms), and 1.4% increase (a 2.6% decrease in real terms), respectively, between 2009 and 2010.

In 2010, the commercial fishing location quotient (CFLQ) for Louisiana was the highest in the region at 1.58. This was an 16% decrease from 2002 and a 22% decrease from 2009. Louisiana's CFLQ suggests that the level of employment in commercial fishing-related industries in this state is approximately 1.6 times higher than the level of employment in these industries nationwide. The 2010 CFLQ in West Florida was 1 (a 22% decrease from 2002).

*Seafood Sales and Processing*

In 2010, there were 414 nonemployer firms engaged in seafood product preparation and packaging across the Gulf of Mexico Region. This was a 20% increase from 2002 levels. Over the same time period, Louisiana experienced a 17% increase. In 2010, 8% of these firms were located in Alabama. Region-wide, annual receipts totaled $25 million in 2010 and increased 51% from 2002 to 2010.

Annual receipt totals experienced a 15% increase in Mississippi between 2002 and 2010 (13% decrease in real terms). In contrast to an increase in nonemployer firms region-wide, the number of employer establishments engaged in seafood product preparation and packaging decreased 25% from 166 in 2002 to 124 in 2010. Approximately 27% of these establishments were located in Louisiana. The number of employees in the seafood product preparation and packaging sector decreased 28% from 10,623 employees in 2002 to 7,639 employees in 2011.

There were 444 seafood wholesale establishments in 2010. The number of employees was not available at the region level. From 2002 to 2010, the number of seafood wholesale establishments decreased 31% across the Gulf of Mexico Region.

Nonemployer firms engaged in seafood retail in the Gulf of Mexico Region totaled 806 in 2010, a 17% increase relative to 2002. Of these firms, 7.1% were located in Alabama. At the state level, these firms decreased 1.6% in Louisiana and decreased 5.9% in Mississippi between 2002 and 2010. Annual receipts in the region totaled $79 million in 2010 a 24% increase from 2003 (a 4.5% decrease in real terms) and a 24% increase from 2010 (a 19% increase in real terms).

Employer establishments engaged in seafood retail decreased 23% from 2002 to 2010, totaling 347 in 2010. The number of

[1] The Texas Department of Wildlife only collects information about harvest and not total catch.
[2] Information for 2010 is reported in this section; 2011 data were not available for this report.
[3] Marine Economy information was not available for West Florida, information for the entire state of Florida is provided here.

employees was not available for the retail sector in the Gulf of Mexico Region in 2010.

*Transport, Support, and Marine Operations*

For the sectors in which information was available at the region level, marinas employed more people than any other industry in this sector, employing approximately 6,700 people in 2010. In contrast, the navigational services to shipping industry had the highest annual payroll in the region totaling $455 million. Marinas had the highest number of establishments (693), followed by the ship and boat building industries with 506 establishments and the navigational services to shipping industries with 394 establishments.

In Alabama, industries with large changes in establishment numbers, employees, or annual payroll from 2009 to 2010 were: marinas (119% increase in employees), marinas (44% increase in payroll) and ship and boat building (34% decrease in establishments). In Texas, large changes were seen for deep sea passenger transportation (50% decrease in establishments), port and harbor operations (35% increase in payroll) and coastal and Great Lakes freight transportation (30% decrease in employees). In Louisiana, large changes were seen in the deep sea freight transportation (93% decrease in payroll), deep sea freight transportation (92% decrease in employees) and marinas (64% increase in payroll).

### 2011 Economic Impacts of the Gulf of Mexico Region Seafood Industry (thousands of dollars)

| | With Imports | | | Without Imports | | |
|---|---|---|---|---|---|---|
| | Jobs | Sales | Valued Added | Jobs | Sales | Valued Added |
| Alabama | 11,011 | 499,805 | 250,171 | 10,348 | 421,295 | 220,521 |
| Louisiana | 32,818 | 1,801,568 | 877,911 | 30,676 | 1,467,854 | 762,430 |
| Mississippi | 5,550 | 247,106 | 125,430 | 5,439 | 231,104 | 119,876 |
| Texas | 27,717 | 2,277,959 | 1,002,928 | 22,516 | 1,357,574 | 687,876 |
| West Florida | 72,341 | 14,250,006 | 4,778,502 | 10,550 | 928,929 | 376,208 |

### Total Landings Revenue and Landings Revenue of Key Species/Species Groups (thousands of dollars)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total revenue | 681,646 | 662,902 | 669,002 | 625,038 | 691,220 | 690,211 | 662,153 | 643,880 | 639,271 | 818,017 |
| Finfish & other | 147,338 | 139,373 | 143,479 | 122,642 | 135,982 | 145,584 | 146,109 | 150,833 | 131,582 | 194,714 |
| Shellfish | 534,308 | 523,530 | 525,523 | 502,396 | 555,238 | 544,626 | 516,044 | 493,047 | 507,690 | 623,304 |
| Blue crab | 42,913 | 46,243 | 42,292 | 37,961 | 43,355 | 46,028 | 39,814 | 45,476 | 41,237 | 48,769 |
| Crawfish | 8,070 | 4,845 | 4,810 | 8,360 | 1,290 | 9,034 | 9,435 | 15,547 | 13,969 | 9,911 |
| Groupers | 24,631 | 24,257 | 25,807 | 24,692 | 22,795 | 20,242 | 22,891 | 17,291 | 13,580 | 19,667 |
| Menhaden | 52,116 | 45,863 | 44,921 | 32,938 | 44,946 | 62,110 | 64,376 | 69,456 | 66,019 | 103,521 |
| Mullets | 8,877 | 8,265 | 8,956 | 6,593 | 9,429 | 5,543 | 6,085 | 6,105 | 5,220 | 10,368 |
| Oysters | 50,756 | 61,634 | 60,845 | 56,510 | 62,316 | 69,542 | 60,272 | 73,473 | 55,060 | 64,207 |
| Red snapper | 10,714 | 10,447 | 11,676 | 11,336 | 13,167 | 9,570 | 7,966 | 7,984 | 10,202 | 11,413 |
| Shrimp | 385,679 | 365,434 | 366,426 | 360,513 | 397,706 | 367,060 | 366,576 | 327,263 | 339,706 | 438,459 |
| Stone crab | 23,091 | 23,043 | 26,704 | 21,223 | 24,115 | 26,242 | 18,898 | 17,690 | 23,384 | 24,496 |
| Tunas | 13,227 | 12,000 | 12,335 | 9,431 | 8,461 | 10,535 | 6,168 | 8,180 | 2,688 | 5,516 |

### Total Landings and Landings of Key Species/Species Groups (thousands of pounds)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total landings | 1,728,899 | 1,595,895 | 1,475,139 | 1,198,203 | 1,362,326 | 1,404,307 | 1,278,274 | 1,599,505 | 1,285,544 | 1,765,899 |
| Finfish & other | 1,377,421 | 1,228,816 | 1,110,240 | 887,920 | 974,969 | 1,071,322 | 994,159 | 1,235,041 | 1,024,166 | 1,448,055 |
| Shellfish | 351,478 | 367,080 | 364,899 | 310,283 | 387,357 | 332,985 | 284,115 | 364,464 | 261,378 | 317,844 |
| Blue crab | 66,019 | 63,961 | 60,581 | 50,041 | 67,481 | 57,964 | 49,260 | 61,272 | 41,212 | 55,571 |
| Crawfish | 15,602 | 8,337 | 8,537 | 15,177 | 1,469 | 15,848 | 15,612 | 19,312 | 14,556 | 9,597 |
| Groupers | 12,003 | 10,933 | 11,912 | 10,776 | 9,092 | 7,308 | 8,547 | 6,633 | 4,870 | 6,983 |
| Menhaden | 1,290,407 | 1,142,747 | 1,023,260 | 815,495 | 901,398 | 1,005,325 | 927,517 | 1,165,948 | 967,025 | 1,374,299 |
| Mullets | 12,661 | 12,957 | 13,750 | 9,023 | 12,727 | 8,933 | 10,580 | 11,303 | 8,960 | 14,233 |
| Oysters | 24,110 | 27,033 | 25,052 | 20,174 | 19,674 | 22,518 | 20,655 | 22,833 | 15,870 | 18,386 |
| Red snapper | 4,803 | 4,435 | 4,677 | 4,109 | 4,637 | 2,998 | 2,368 | 2,503 | 3,259 | 3,567 |
| Shrimp | 233,759 | 256,357 | 255,782 | 216,291 | 288,973 | 225,163 | 188,789 | 251,294 | 178,845 | 219,963 |
| Stone crab | 6,433 | 5,292 | 5,971 | 4,534 | 4,806 | 5,893 | 6,123 | 5,335 | 5,112 | 5,477 |
| Tunas | 4,877 | 5,063 | 3,882 | 3,050 | 2,851 | 3,426 | 1,782 | 2,836 | 1,322 | 1,588 |

### Average Annual Price of Key Species/Species Groups (dollars per pound)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Blue crab | 0.65 | 0.72 | 0.70 | 0.76 | 0.64 | 0.79 | 0.81 | 0.74 | 1.00 | 0.88 |
| Crawfish | 0.52 | 0.58 | 0.56 | 0.55 | 0.88 | 0.57 | 0.60 | 0.81 | 0.96 | 1.03 |
| Groupers | 2.05 | 2.22 | 2.17 | 2.29 | 2.51 | 2.77 | 2.68 | 2.61 | 2.79 | 2.82 |
| Menhaden | 0.04 | 0.04 | 0.04 | 0.04 | 0.05 | 0.06 | 0.07 | 0.06 | 0.07 | 0.08 |
| Mullets | 0.70 | 0.64 | 0.65 | 0.73 | 0.74 | 0.62 | 0.58 | 0.54 | 0.58 | 0.73 |
| Oysters | 2.11 | 2.28 | 2.43 | 2.80 | 3.17 | 3.09 | 2.92 | 3.22 | 3.47 | 3.49 |
| Red snapper | 2.23 | 2.36 | 2.50 | 2.76 | 2.84 | 3.19 | 3.36 | 3.19 | 3.13 | 3.20 |
| Shrimp | 1.65 | 1.43 | 1.43 | 1.67 | 1.38 | 1.63 | 1.94 | 1.30 | 1.90 | 1.99 |
| Stone crab | 3.59 | 4.35 | 4.47 | 4.68 | 5.02 | 4.45 | 3.09 | 3.32 | 4.57 | 4.47 |
| Tunas | 2.71 | 2.37 | 3.18 | 3.09 | 2.97 | 3.07 | 3.46 | 2.88 | 2.03 | 3.47 |

### 2011 Economic Impacts of Recreational Fishing Expenditures (thousands of dollars)

| | Trips | Jobs | Sales | Income | Value Added |
|---|---|---|---|---|---|
| Alabama | 2,485,000 | 8,177 | 797,280 | 262,715 | 410,222 |
| Louisiana | 4,577,000 | 17,764 | 1,602,913 | 521,949 | 806,349 |
| Mississippi | 1,616,000 | 1,181 | 145,769 | 37,783 | 60,735 |
| Texas | NA[1] | 15,150 | 1,853,361 | 586,068 | 952,284 |
| West Florida | 13,901,000 | 47,047 | 4,881,831 | 1,715,843 | 2,653,677 |

### 2011 Angler Trip & Durable Expenditures (thousands of dollars)

| Fishing Mode | Trip Expenditures | | Equipment | Durable Expenditures |
|---|---|---|---|---|
| | Non-Residents | Residents | Fishing Tackle | 1,317,095 |
| For-Hire | 207,051 | 105,140 | Other Equipment | 523,466 |
| Private Boat | 116,943 | 597,111 | Boat Expenses | 4,463,924 |
| Shore | 150,261 | 297,713 | Vehicle Expenses | 1,191,348 |
| *Total Trip Expenditures* | 474,255 | 999,964 | Second Home Expenses | 812,091 |
| | | | *Total Durable Equipment Expenditures* | 8,307,925 |
| **Total State Trip and Durable Equipment Expenditures** | | | | 9,782,144 |

### Recreational Anglers by Residential Area (thousands of anglers)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal | 2,485 | 3,039 | 3,185 | 3,133 | 3,328 | 3,235 | 2,926 | 2,550 | 2,480 | 2,737 |
| Non-Coastal | 216 | 256 | 318 | 190 | 315 | 326 | 262 | 296 | 235 | 311 |
| Out-of-State | NA[2] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| **Total Anglers** | 2,701 | 3,294 | 3,503 | 3,323 | 3,643 | 3,562 | 3,188 | 2,846 | 2,715 | 3,048 |

### Recreational Fishing Effort by Mode (thousands of angler-trips)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| For-Hire | 765 | 692 | 833 | 692 | 835 | 849 | 819 | 823 | 579 | 735 |
| Private Boat | 11,636 | 14,110 | 15,643 | 13,586 | 13,621 | 14,980 | 15,195 | 13,443 | 12,684 | 12,913 |
| Shore | 7,265 | 8,155 | 9,954 | 9,013 | 8,836 | 8,457 | 8,776 | 8,332 | 7,783 | 8,931 |
| **Total Trips** | 19,666 | 22,957 | 26,430 | 23,291 | 23,292 | 24,286 | 24,790 | 22,598 | 21,046 | 22,579 |

### Harvest (H) and Release (R) of Key Species Species Groups (thousands of fish)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Drum (Atlantic croaker) | H | 833 | 1,057 | 976 | 769 | 1,441 | 1,312 | 1,872 | 1,175 | 1,509 | 2,052 |
| | R | 2,757 | 2,432 | 3,639 | 2,844 | 2,312 | 2,614 | 3,148 | 3,858 | 3,827 | 5,899 |
| Drum (Gulf and southern kingfish) | H | 1,203 | 1,803 | 1,682 | 1,426 | 1,249 | 1,135 | 1,302 | 1,063 | 1,423 | 939 |
| | R | 477 | 538 | 810 | 781 | 924 | 844 | 726 | 576 | 625 | 538 |
| Drum (sand and silver seatrouts) | H | 3,257 | 3,114 | 2,262 | 2,035 | 2,109 | 3,088 | 3,405 | 4,203 | 4,575 | 5,733 |
| | R | 1,067 | 1,005 | 1,000 | 726 | 1,538 | 1,909 | 1,988 | 2,443 | 1,808 | 2,540 |
| Drum (spotted seatrout) | H | 7,367 | 9,566 | 11,559 | 10,028 | 13,286 | 11,187 | 14,126 | 13,335 | 10,139 | 13,581 |
| | R | 15,298 | 19,216 | 19,764 | 20,212 | 20,056 | 18,849 | 21,017 | 17,366 | 14,563 | 19,122 |
| Porgies (sheepshead) | H | 1,553 | 1,944 | 2,495 | 2,001 | 1,109 | 1,198 | 1,566 | 1,572 | 1,147 | 2,218 |
| | R | 1,701 | 2,005 | 2,171 | 2,393 | 1,506 | 1,224 | 1,487 | 1,338 | 1,740 | 1,631 |
| Red drum | H | 2,477 | 2,672 | 2,942 | 2,318 | 2,361 | 2,843 | 3,292 | 2,608 | 3,248 | 3,543 |
| | R | 4,873 | 5,914 | 5,808 | 6,235 | 6,391 | 6,222 | 7,017 | 5,522 | 6,468 | 6,447 |
| Red snapper | H | 1,106 | 992 | 1,279 | 835 | 967 | 1,223 | 677 | 795 | 333 | 520 |
| | R | 2,091 | 1,943 | 2,685 | 2,193 | 2,832 | 3,259 | 2,110 | 2,146 | 1,436 | 1,521 |
| Southern flounder | H | 504 | 660 | 742 | 541 | 475 | 650 | 473 | 644 | 771 | 764 |
| | R | 117 | 253 | 271 | 194 | 170 | 239 | 120 | 194 | 220 | 222 |
| Spanish mackerel | H | 1,963 | 1,503 | 2,124 | 1,193 | 1,757 | 1,333 | 1,897 | 1,503 | 1,563 | 1,535 |
| | R | 1,920 | 2,211 | 2,314 | 1,373 | 2,856 | 2,105 | 2,039 | 1,635 | 2,476 | 1,942 |
| Striped mullet | H | 1,264 | 1,586 | 1,163 | 1,081 | 1,102 | 1,149 | 1,257 | 743 | 1,666 | 1,901 |
| | R | 75 | 280 | 167 | 165 | 141 | 158 | 145 | 226 | 126 | 313 |

[1]The Marine Recreational Program (MRIP) does not collect effort data for Texas.
[2]NA = data are not available because out-of-state resident information is collected for individual states but whether an angler is a resident of a region is not specified

### 2011 Economic Impacts of the Alabama Seafood Industry (thousands of dollars)

| | With Imports | | | Without Imports | | |
|---|---|---|---|---|---|---|
| | Jobs | Sales | Value Added | Jobs | Sales | Value Added |
| **Total Impacts** | 11,011 | 499,805 | 250,171 | 10,348 | 421,295 | 220,521 |
| Commercial Harvesters | 1,726 | 84,014 | 37,129 | 1,726 | 84,014 | 37,129 |
| Seafood Processors & Dealers | 2,125 | 135,348 | 67,372 | 1,685 | 107,700 | 53,610 |
| Importers | 179 | 49,281 | 15,023 | 0 | 0 | 0 |
| Seafood Wholesalers & Distributors | 168 | 8,016 | 3,620 | 161 | 7,692 | 3,474 |
| Retail | 6,813 | 223,146 | 127,026 | 6,775 | 221,888 | 126,308 |

### Total Landings Revenue and Landings Revenue of Key Species/Species Groups (thousands of dollars)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total revenue | 35,925 | 36,844 | 37,036 | 39,726 | 48,558 | 48,845 | 44,356 | 38,869 | 27,660 | 50,941 |
| Finfish & other | 3,175 | 3,185 | 3,905 | 3,982 | 4,572 | 3,686 | 4,210 | 3,662 | 2,724 | 4,052 |
| Shellfish | 32,751 | 33,658 | 33,131 | 35,744 | 43,986 | 45,160 | 40,145 | 35,207 | 24,936 | 46,889 |
| Blue crab | 1,490 | 1,715 | 1,774 | 663 | 1,319 | 1,711 | 1,533 | 961 | 732 | 1,127 |
| Flounders | 291 | 210 | 230 | 247 | 223 | 261 | 214 | 197 | 97 | 222 |
| Menhaden | 102 | 104 | 89 | 63 | 48 | 71 | 59 | 42 | 15 | 58 |
| Mullets | 985 | 772 | 1,187 | 1,117 | 1,171 | 984 | 1,016 | 765 | 593 | 687 |
| Oysters | 1,602 | 1,623 | 2,120 | 3,020 | 3,639 | 2,698 | 243 | 77 | 389 | 1,322 |
| Red snapper | 368 | 359 | 382 | 638 | 536 | 213 | 239 | 263 | 329 | 314 |
| Sharks | 275 | 337 | 431 | 478 | 463 | 250 | 359 | 275 | 111 | 381 |
| Shrimp | 29,603 | 30,284 | 29,197 | 32,002 | 39,022 | 40,742 | 38,355 | 34,140 | 23,815 | 44,413 |
| Spanish mackerel | 371 | 443 | 554 | 401 | 573 | 453 | 616 | 301 | 492 | 582 |
| Vermillion snapper | 54 | 83 | 152 | 149 | 318 | 323 | 504 | 841 | 381 | 620 |

### Total Landings and Landings of Key Species/Species Groups (thousands of pounds)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total landings | 23,658 | 25,535 | 26,559 | 23,985 | 34,033 | 29,434 | 24,450 | 28,825 | 14,637 | 26,145 |
| Finfish & other | 5,451 | 5,982 | 6,248 | 5,552 | 6,498 | 4,857 | 5,414 | 4,478 | 3,414 | 4,956 |
| Shellfish | 18,207 | 19,553 | 20,311 | 18,432 | 27,535 | 24,578 | 19,036 | 24,347 | 11,222 | 21,190 |
| Blue crab | 2,575 | 2,958 | 3,329 | 1,024 | 2,384 | 2,557 | 1,799 | 1,458 | 926 | 1,614 |
| Flounders | 176 | 118 | 138 | 130 | 118 | 133 | 107 | 97 | 47 | 111 |
| Menhaden | 982 | 1,022 | 828 | 521 | 350 | 470 | 268 | 190 | 81 | 364 |
| Mullets | 1,949 | 1,700 | 2,133 | 1,976 | 1,913 | 1,798 | 1,988 | 1,814 | 1,198 | 1,262 |
| Oysters | 759 | 816 | 908 | 1,041 | 940 | 769 | 73 | 23 | 120 | 313 |
| Red snapper | 152 | 132 | 138 | 214 | 177 | 59 | 61 | 65 | 83 | 78 |
| Sharks | 329 | 803 | 716 | 800 | 1,227 | 315 | 423 | 328 | 140 | 450 |
| Shrimp | 14,857 | 15,770 | 16,064 | 16,260 | 24,201 | 21,247 | 17,154 | 22,841 | 10,175 | 19,247 |
| Spanish mackerel | 762 | 858 | 914 | 568 | 873 | 580 | 856 | 418 | 725 | 838 |
| Vermillion snapper | 28 | 36 | 66 | 66 | 122 | 129 | 197 | 346 | 147 | 223 |

### Average Annual Price of Key Species/Species Groups (dollars per pound)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Blue crab | 0.58 | 0.58 | 0.53 | 0.65 | 0.55 | 0.67 | 0.85 | 0.66 | 0.79 | 0.70 |
| Flounders | 1.65 | 1.78 | 1.67 | 1.91 | 1.89 | 1.97 | 2.01 | 2.04 | 2.05 | 2.00 |
| Menhaden | 0.10 | 0.10 | 0.11 | 0.12 | 0.14 | 0.15 | 0.22 | 0.22 | 0.18 | 0.16 |
| Mullets | 0.51 | 0.45 | 0.56 | 0.57 | 0.61 | 0.55 | 0.51 | 0.42 | 0.49 | 0.54 |
| Oysters | 2.11 | 1.99 | 2.33 | 2.90 | 3.87 | 3.51 | 3.34 | 3.33 | 3.25 | 4.22 |
| Red snapper | 2.41 | 2.72 | 2.78 | 2.98 | 3.03 | 3.62 | 3.93 | 4.04 | 3.97 | 4.04 |
| Sharks | 0.83 | 0.42 | 0.60 | 0.60 | 0.38 | 0.79 | 0.85 | 0.84 | 0.79 | 0.85 |
| Shrimp | 1.99 | 1.92 | 1.82 | 1.97 | 1.61 | 1.92 | 2.24 | 1.49 | 2.34 | 2.31 |
| Spanish mackerel | 0.49 | 0.52 | 0.61 | 0.71 | 0.66 | 0.78 | 0.72 | 0.72 | 0.68 | 0.69 |
| Vermillion snapper | 1.92 | 2.31 | 2.32 | 2.26 | 2.61 | 2.50 | 2.55 | 2.43 | 2.59 | 2.78 |

### 2011 Economic Impacts of Recreational Fishing Expenditures (thousands of dollars)

| | Jobs | Sales | Income | Value Added |
|---|---|---|---|---|
| Trip Impacts by Fishing Mode: | | | | |
| For-Hire | 539 | 40,337 | 12,500 | 22,204 |
| Private Boat | 627 | 59,726 | 18,528 | 32,698 |
| Shore | 924 | 75,250 | 23,240 | 40,480 |
| Total Durable Equipment Impacts | 6,086 | 621,967 | 208,446 | 314,840 |
| **Total State Trip and Durable Equipment Economic Impacts** | 8,177 | 797,280 | 262,715 | 410,222 |

### 2011 Angler Trip & Durable Expenditures (thousands of dollars)

| Fishing Mode | Trip Expenditures | | Equipment | Durable Expenditures |
|---|---|---|---|---|
| | Non-Residents | Residents | Fishing Tackle | 245,964 |
| For-Hire | 21,439 | 5,480 | Other Equipment | 65,634 |
| Private Boat | 17,116 | 41,439 | Boat Expenses | 176,088 |
| Shore | 32,423 | 28,291 | Vehicle Expenses | 222,460 |
| *Total Trip Expenditures* | 70,978 | 75,210 | Second Home Expenses | 0 |
| | | | *Total Durable Equipment Expenditures* | 710,146 |
| **Total State Trip and Durable Equipment Expenditures** | | | | 856,334 |

### Recreational Anglers by Residential Area (thousands of anglers)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal | 123 | 187 | 223 | 231 | 233 | 253 | 192 | 205 | 195 | 295 |
| Non-Coastal | 97 | 123 | 159 | 93 | 184 | 169 | 116 | 151 | 140 | 177 |
| Out of State | 193 | 214 | 345 | 161 | 320 | 291 | 237 | 209 | 220 | 435 |
| **Total Anglers** | 413 | 524 | 728 | 485 | 736 | 712 | 545 | 566 | 554 | 907 |

### Recreational Fishing Effort by Mode (thousands of angler-trips)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| For-Hire | 68 | 66 | 77 | 56 | 77 | 75 | 56 | 56 | 33 | 75 |
| Private | 607 | 846 | 994 | 828 | 811 | 985 | 946 | 885 | 840 | 1,207 |
| Shore | 515 | 587 | 1,181 | 720 | 1,050 | 901 | 702 | 771 | 812 | 1,203 |
| **Total Trips** | 1,190 | 1,499 | 2,252 | 1,604 | 1,938 | 1,961 | 1,704 | 1,712 | 1,685 | 2,485 |

### Harvest (H) and Release (R) of Key Species Species Groups (thousands of fish)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Bluefish | H | 51 | 44 | 132 | 15 | 13 | 26 | 17 | 15 | 30 | 74 |
| | R | 65 | 126 | 216 | 77 | 151 | 174 | 54 | 45 | 80 | 167 |
| Drum (Atlantic croaker) | H | 188 | 244 | 178 | 233 | 453 | 463 | 1,163 | 250 | 918 | 886 |
| | R | 468 | 512 | 1,070 | 1,593 | 823 | 923 | 1,370 | 1,822 | 1,861 | 2,593 |
| Drum (kingfishes)[1] | H | 411 | 487 | 619 | 263 | 443 | 476 | 667 | 592 | 633 | 626 |
| | R | 162 | 185 | 410 | 265 | 460 | 291 | 256 | 283 | 309 | 341 |
| Drum (sand seatrout) | H | 428 | 709 | 502 | 349 | 593 | 705 | 1,216 | 1,428 | 2,070 | 2,346 |
| | R | 130 | 225 | 266 | 290 | 502 | 481 | 410 | 752 | 836 | 743 |
| Drum (spotted seatrout) | H | 193 | 345 | 208 | 294 | 326 | 359 | 269 | 318 | 609 | 825 |
| | R | 166 | 430 | 168 | 322 | 598 | 488 | 844 | 758 | 453 | 1,302 |
| Porgies (sheepshead) | H | 192 | 299 | 461 | 280 | 123 | 320 | 288 | 165 | 218 | 481 |
| | R | 81 | 89 | 172 | 86 | 80 | 30 | 159 | 48 | 52 | 146 |
| Red drum | H | 84 | 114 | 118 | 155 | 101 | 84 | 87 | 62 | 122 | 143 |
| | R | 105 | 245 | 262 | 185 | 145 | 137 | 228 | 110 | 153 | 149 |
| Red snapper | H | 473 | 380 | 305 | 232 | 181 | 217 | 108 | 137 | 41 | 217 |
| | R | 984 | 666 | 589 | 493 | 640 | 852 | 340 | 394 | 287 | 488 |
| Southern flounder | H | 82 | 113 | 139 | 150 | 123 | 96 | 93 | 139 | 242 | 163 |
| | R | 15 | 68 | 73 | 83 | 64 | 38 | 37 | 22 | 65 | 60 |
| Spanish mackerel | H | 106 | 122 | 468 | 45 | 58 | 93 | 111 | 76 | 253 | 334 |
| | R | 16 | 99 | 276 | 52 | 49 | 21 | 31 | 60 | 102 | 129 |

[1] Kingfishes include southern kingfish and Gulf kingfish

### Alabama's State Economy (% of national total)

| | Establishments | Employees | Annual Payroll (million $) | Employee Compensation (million $) | Gross State Product (million $) | Commercial Location Quotient [1] |
|---|---|---|---|---|---|---|
| 2002 | 99,931 (1.4%) | 1,581,117 (1.4%) | 45,466 (1.2%) | 74,346 (1.2%) | 125,168 (1.2%) | 0.38 |
| 2010 | 99,251 (1.3%) | 1,568,111 (1.4%) | 57,448 (1.2%) | 98,478 (1.2%) | 170,219 (1.2%) | 0.87 |
| % change | -0.68% | -0.823% | 26.4% | 32.5% | 36% | 168% |

### Seafood Sales & Processing - Nonemployer Firms (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Seafood product prep. & packaging | Firms | 44 | 36 | 43 | 40 | 34 | 47 | 33 | 41 | 33 |
| | Receipts | 3,603 | 1,168 | 3,413 | 3,414 | 1,558 | 1,547 | 1,894 | 1,805 | 1,894 |
| Seafood Sales, retail | Firms | 58 | 55 | 61 | 44 | 57 | 61 | 57 | 63 | 57 |
| | Receipts | 3,456 | 3,812 | 3,645 | 3,855 | 4,802 | 4,279 | 5,632 | 4,844 | 5,632 |

### Seafood Sales & Processing - Employer Establishments (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Seafood product prep. & packaging | Establishments | 22 | 24 | 23 | 26 | 24 | 23 | 23 | 22 | 21 |
| | Employees | 1,951 | 2,057 | 2,037 | 1,925 | 1,629 | 1,510 | 1,450 | 1,086 | 1,128 |
| | Payroll | 36,198 | 36,766 | 36,130 | 38,229 | 34,703 | 32,774 | 29,277 | 24,900 | 22,824 |
| Seafood sales, wholesale | Establishments | 36 | 33 | 31 | 26 | 26 | 31 | 29 | 28 | 23 |
| | Employees | 547 | 611 | 588 | 607 | 395 | 395 | 494 | 339 | 332 |
| | Payroll | 7,062 | 6,148 | 6,752 | 6,345 | 6,195 | 6,202 | 8,751 | 5,893 | 5,119 |
| Seafood sales, retail | Establishments | 35 | 37 | 35 | 34 | 28 | 33 | 33 | 31 | 34 |
| | Employees | 110 | ND[2] | 96 | 95 | ND[2] | ND[2] | ND[2] | 130 | 132 |
| | Payroll | 1,589 | ND[2] | 1,401 | 1,399 | ND[2] | 1,809 | 1,710 | 2,044 | 2,016 |

### Transport, Support, & Marine Operations - Employer Establishments (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal & Great Lakes freight transportation | Establishments | 6 | 13 | 10 | 10 | 6 | 8 | 4 | 4 | 5 |
| | Employees | ND[2] | ND[2] | ND[2] | ND[2] | 15 | 48 | ND[2] | ND[2] | ND[2] |
| | Payroll | ND[2] | ND[2] | ND[2] | ND[2] | 754 | 3,266 | ND[2] | ND[2] | ND[2] |
| Deep sea freight transportation | Establishments | 2 | 5 | 3 | 3 | 3 | 5 | 7 | 7 | 5 |
| | Employees | ND[2] | 53 | ND[2] | ND[2] | ND[2] | 46 | ND[2] | ND[2] | ND[2] |
| | Payroll | ND[2] | 3,661 | ND[2] | ND[2] | ND[2] | 3,553 | ND[2] | ND[2] | ND[2] |
| Deep sea passenger transportation | Establishments | NA[3] | 1 | 1 | 1 | 1 | 1 | 2 | 3 | 2 |
| | Employees | NA[3] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| | Payroll | NA[3] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| Marinas | Establishments | 48 | 53 | 52 | 58 | 52 | 52 | 56 | 55 | 54 |
| | Employees | 242 | 287 | 341 | 347 | 312 | 364 | 316 | 278 | 609 |
| | Payroll | 4,966 | 6,218 | 7,631 | 8,047 | 8,388 | 9,382 | 9,170 | 8,418 | 12,149 |
| Marine cargo handling | Establishments | 19 | 17 | 18 | 17 | 14 | 19 | 20 | 19 | 19 |
| | Employees | 635 | 445 | 577 | 672 | ND[2] | 491 | 756 | 658 | 548 |
| | Payroll | 20,592 | 19,642 | 26,201 | 28,458 | ND[2] | 21,076 | 33,244 | 27,272 | 32,143 |
| Navigational services to shipping | Establishments | 15 | 12 | 16 | 17 | 18 | 16 | 17 | 16 | 16 |
| | Employees | 220 | 410 | ND[2] | ND[2] | ND[2] | 338 | 287 | 294 | 276 |
| | Payroll | 9,317 | 19,602 | ND[2] | ND[2] | ND[2] | 17,554 | 16,712 | 15,383 | 14,737 |
| Port & harbor operations | Establishments | 6 | 3 | 1 | 3 | 3 | 2 | 4 | 5 | 5 |
| | Employees | 162 | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| | Payroll | 6,321 | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| Ship & boat building | Establishments | 45 | 41 | 42 | 45 | 47 | 42 | 42 | 40 | 32 |
| | Employees | 2,901 | 2,781 | 2,195 | 2,591 | 3,027 | 3,570 | 4,435 | 3,913 | 2,598 |
| | Payroll | 92,916 | 81,092 | 83,756 | 86,453 | 121,185 | 172,380 | 188,543 | 159,065 | 151,813 |

[1] The U.S. Commercial Fishing Location Quotient (CFLQ) of 1.0 represents the national baseline from which state CFLQs can be compared.
[2] ND = these data are confidential thus not disclosable
[3] NA = these data are not available

### 2011 Economic Impacts of the Florida[1] Seafood Industry (thousands of dollars)

| | With Imports | | | Without Imports | | |
|---|---|---|---|---|---|---|
| | Jobs | Sales | Value Added | Jobs | Sales | Value Added |
| **Total Impacts** | 72,341 | 14,250,006 | 4,778,502 | 10,550 | 928,929 | 376,208 |
| Commercial Harvesters | 6,817 | 446,577 | 186,630 | 6,817 | 446,577 | 186,630 |
| Seafood Processors & Dealers | 4,219 | 679,112 | 258,376 | 548 | 95,706 | 36,412 |
| Importers | 37,278 | 10,254,318 | 3,125,965 | 0 | 0 | 0 |
| Seafood Wholesalers & Distributors | 8,983 | 1,039,625 | 507,796 | 464 | 53,716 | 26,237 |
| Retail | 15,043 | 1,830,373 | 699,735 | 2,721 | 332,930 | 126,929 |

### Total Landings Revenue and Landings Revenue of Key Species/Species Groups (thousands of dollars)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total revenue | 144,185 | 141,185 | 148,058 | 137,912 | 145,494 | 132,162 | 122,764 | 115,127 | 137,457 | 164,076 |
| Finfish & other | 51,609 | 51,451 | 52,331 | 50,600 | 50,358 | 45,890 | 50,842 | 49,537 | 40,853 | 59,398 |
| Shellfish | 92,576 | 89,734 | 95,727 | 87,312 | 95,136 | 86,272 | 71,922 | 65,589 | 96,604 | 104,678 |
| Blue crab | 5,644 | 7,061 | 7,316 | 7,035 | 7,043 | 5,769 | 3,290 | 4,183 | 6,706 | 7,718 |
| Gag | 7,380 | 6,855 | 7,615 | 7,084 | 4,151 | 4,348 | 4,898 | 2,759 | 2,079 | 1,433 |
| Lobsters | 18,932 | 17,138 | 20,724 | 15,077 | 24,885 | 24,546 | 19,175 | 12,179 | 32,752 | 35,595 |
| Mullets | 6,059 | 4,755 | 4,891 | 4,355 | 6,021 | 3,663 | 4,172 | 5,069 | 4,188 | 8,630 |
| Oyster | 3,125 | 2,932 | 2,884 | 2,854 | 5,415 | 6,631 | 5,473 | 6,968 | 6,298 | 7,600 |
| Quahog clam | 3,606 | 3,870 | 2,074 | 1,736 | 807 | 914 | 1,009 | 915 | 1,001 | 921 |
| Red grouper | 12,859 | 11,695 | 13,281 | 13,376 | 14,384 | 11,024 | 13,569 | 10,488 | 8,992 | 15,082 |
| Red snapper | 2,188 | 2,284 | 2,168 | 1,671 | 1,991 | 3,066 | 2,945 | 2,980 | 4,552 | 5,417 |
| Shrimp | 37,252 | 34,893 | 34,737 | 38,625 | 32,225 | 20,976 | 23,265 | 23,314 | 25,978 | 27,559 |
| Stone crab | 22,874 | 22,913 | 26,507 | 21,074 | 24,029 | 26,213 | 18,877 | 17,586 | 23,335 | 24,405 |

### Total Landings and Landings of Key Species/Species Groups (thousands of pounds)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total landings | 82,075 | 79,163 | 83,894 | 73,038 | 70,766 | 59,784 | 60,127 | 65,351 | 62,595 | 77,687 |
| Finfish & other | 43,586 | 41,697 | 41,134 | 36,543 | 35,887 | 30,645 | 35,250 | 38,754 | 32,018 | 42,292 |
| Shellfish | 38,489 | 37,466 | 42,760 | 36,496 | 34,879 | 29,139 | 24,877 | 26,596 | 30,577 | 35,395 |
| Blue crab | 5,567 | 7,225 | 8,083 | 7,370 | 8,610 | 6,110 | 2,663 | 3,364 | 5,759 | 6,833 |
| Gag | 3,136 | 2,691 | 3,054 | 2,688 | 1,436 | 1,339 | 1,474 | 825 | 572 | 368 |
| Lobsters | 4,080 | 3,886 | 4,565 | 3,059 | 4,372 | 3,405 | 2,981 | 3,951 | 5,287 | 5,300 |
| Mullets | 8,020 | 6,577 | 6,660 | 5,635 | 7,308 | 5,619 | 6,979 | 9,167 | 7,262 | 11,409 |
| Oyster | 1,944 | 1,753 | 1,644 | 1,417 | 2,394 | 2,959 | 2,501 | 2,877 | 2,165 | 2,746 |
| Quahog clam | 480 | 558 | 266 | 212 | 96 | 116 | 146 | 150 | 156 | 137 |
| Red grouper | 6,987 | 5,841 | 6,789 | 6,386 | 6,062 | 4,352 | 5,619 | 4,387 | 3,488 | 5,634 |
| Red snapper | 948 | 928 | 811 | 584 | 649 | 919 | 848 | 863 | 1,317 | 1,538 |
| Shrimp | 19,128 | 18,131 | 18,258 | 19,297 | 14,176 | 8,628 | 9,942 | 10,673 | 11,814 | 11,562 |
| Stone crab | 6,385 | 5,253 | 5,933 | 4,502 | 4,784 | 5,884 | 6,117 | 5,310 | 5,100 | 5,454 |

### Average Annual Price of Key Species/Species Groups (dollars per pound)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Blue crab | 1.01 | 0.98 | 0.91 | 0.95 | 0.82 | 0.94 | 1.24 | 1.24 | 1.16 | 1.13 |
| Gag | 2.35 | 2.55 | 2.49 | 2.64 | 2.89 | 3.25 | 3.32 | 3.34 | 3.63 | 3.90 |
| Lobsters | 4.64 | 4.41 | 4.54 | 4.93 | 5.69 | 7.21 | 6.43 | 3.08 | 6.19 | 6.72 |
| Mullets | 0.76 | 0.72 | 0.73 | 0.77 | 0.82 | 0.65 | 0.60 | 0.55 | 0.58 | 0.76 |
| Oyster | 1.61 | 1.67 | 1.75 | 2.02 | 2.26 | 2.24 | 2.19 | 2.42 | 2.91 | 2.77 |
| Quahog clam | 7.51 | 6.93 | 7.79 | 8.17 | 8.44 | 7.90 | 6.90 | 6.12 | 6.43 | 6.74 |
| Red grouper | 1.84 | 2.00 | 1.96 | 2.09 | 2.37 | 2.53 | 2.41 | 2.39 | 2.58 | 2.68 |
| Red snapper | 2.31 | 2.46 | 2.67 | 2.86 | 3.07 | 3.34 | 3.47 | 3.45 | 3.46 | 3.52 |
| Shrimp | 1.95 | 1.92 | 1.90 | 2.00 | 2.27 | 2.43 | 2.34 | 2.18 | 2.20 | 2.38 |
| Stone crab | 3.58 | 4.36 | 4.47 | 4.68 | 5.02 | 4.45 | 3.09 | 3.31 | 4.58 | 4.47 |

[1] Information reported in this table if for the state of Florida, not West Florida

### 2011 Economic Impacts of Recreational Fishing Expenditures (thousands of dollars)

| | Jobs | Sales | Income | Value Added |
|---|---|---|---|---|
| Trip Impacts by Fishing Mode: | | | | |
| For-Hire | 3,113 | 302,927 | 103,418 | 179,604 |
| Private Boat | 3,177 | 318,260 | 109,436 | 189,249 |
| Shore | 2,235 | 210,696 | 71,575 | 122,407 |
| Total Durable Equipment Impacts | 38,522 | 4,049,949 | 1,431,414 | 2,162,416 |
| **Total State Trip and Durable Equipment Economic Impacts** | 47,047 | 4,881,831 | 1,715,843 | 2,653,677 |

### 2011 Angler Trip & Durable Expenditures (thousands of dollars)

| Fishing Mode | Trip Expenditures | | Equipment | Durable Expenditures |
|---|---|---|---|---|
| | Non-Residents | Residents | Fishing Tackle | 647,956 |
| For-Hire | 158,309 | 29,181 | Other Equipment | 279,586 |
| Private Boat | 72,024 | 211,465 | Boat Expenses | 2,858,367 |
| Shore | 96,703 | 55,686 | Vehicle Expenses | 448,791 |
| *Total Trip Expenditures* | 327,037 | 296,332 | Second Home Expenses | 636,626 |
| | | | *Total Durable Equipment Expenditures* | 4,871,325 |
| **Total State Trip and Durable Equipment Expenditures** | | | | 5,494,694 |

### Recreational Anglers by Residential Area (thousands of anglers)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal | 1703 | 1965 | 2023 | 2088 | 2084 | 1934 | 1820 | 1551 | 1538 | 1592 |
| Non-Coastal | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| Out of State | 1990 | 2318 | 2141 | 2008 | 1988 | 2151 | 2029 | 1671 | 1470 | 1624 |
| **Total Anglers** | 3693 | 4283 | 4165 | 4096 | 4072 | 4085 | 3849 | 3222 | 3008 | 3216 |

### Recreational Fishing Effort by Mode (thousands of angler-trips)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| For-Hire | 582 | 497 | 600 | 505 | 564 | 611 | 571 | 573 | 460 | 536 |
| Private | 8,236 | 9,221 | 10,171 | 9,491 | 9,382 | 10,005 | 10,145 | 8,623 | 8,160 | 7,520 |
| Shore | 5,601 | 6,291 | 7,025 | 6,699 | 6,720 | 6,318 | 6,782 | 6,482 | 5,645 | 5,845 |
| **Total Trips** | 14,419 | 16,009 | 17,796 | 16,695 | 16,666 | 16,934 | 17,498 | 15,678 | 14,265 | 13,901 |

### Harvest (H) and Release (R) of Key Species Species Groups (thousands of fish)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Common snook | H | 50 | 44 | 70 | 62 | 24 | 36 | 26 | 13 | (1) | 1 |
| | R | 1,292 | 1,358 | 2,198 | 2,281 | 1,391 | 1,592 | 1,595 | 1,925 | 600 | 746 |
| Drum (sand and silver seatrouts) | H | 1,355 | 751 | 434 | 487 | 434 | 1,119 | 746 | 893 | 410 | 864 |
| | R | 320 | 147 | 193 | 64 | 408 | 597 | 583 | 460 | 211 | 294 |
| Drum (spotted seatrout) | H | 1,532 | 1,628 | 2,066 | 1,980 | 1,617 | 1,513 | 1,544 | 1,370 | 1,117 | 1,476 |
| | R | 10,711 | 10,469 | 9,893 | 11,749 | 9,458 | 10,059 | 9,585 | 7,673 | 8,469 | 11,382 |
| Gag | H | 491 | 471 | 690 | 491 | 357 | 284 | 434 | 202 | 232 | 98 |
| | R | 2,449 | 3,359 | 3,865 | 2,314 | 1,876 | 2,677 | 4,078 | 2,726 | 2,019 | 1,158 |
| Gray snapper | H | 655 | 981 | 1,145 | 932 | 664 | 1,046 | 1,393 | 1,176 | 560 | 419 |
| | R | 2,997 | 4,809 | 3,637 | 4,700 | 2,847 | 4,290 | 5,689 | 3,015 | 1,858 | 2,241 |
| King mackerel | H | 261 | 196 | 196 | 177 | 343 | 271 | 183 | 451 | 173 | 128 |
| | R | 138 | 97 | 107 | 131 | 392 | 84 | 155 | 139 | 81 | 47 |
| Mullets[2] | H | 1,009 | 840 | 1,077 | 987 | 1,297 | 612 | 1,236 | 656 | 967 | 855 |
| | R | 93 | 188 | 281 | 209 | 100 | 182 | 143 | 191 | 71 | 106 |
| Porgies (sheepshead) | H | 686 | 761 | 709 | 1,050 | 624 | 590 | 556 | 682 | 455 | 608 |
| | R | 1,126 | 1,369 | 1,399 | 1,857 | 942 | 895 | 855 | 808 | 1,245 | 1,274 |
| Red drum | H | 291 | 364 | 322 | 501 | 375 | 411 | 457 | 226 | 240 | 288 |
| | R | 1,374 | 1,937 | 2,100 | 3,255 | 2,828 | 2,558 | 2,561 | 1,440 | 1,992 | 2,894 |
| Spanish mackerel | H | 1,811 | 1,316 | 1,626 | 1,101 | 1,671 | 1,206 | 1,753 | 1,391 | 1,284 | 1,156 |
| | R | 1,866 | 2,085 | 2,010 | 1,278 | 2,768 | 2,065 | 1,988 | 1,545 | 2,359 | 1,780 |

[1]NA = not applicable because all West Florida residents are considered coastal county residents
[2]Mullets include species within the mullet genus including striped mullets.

### Florida's State Economy (% of national total)

| | Establishments | Employees | Annual Payroll (million $) | Employee Compensation (million $) | Gross State Product (million $) | Commercial Location Quotient [1] |
|---|---|---|---|---|---|---|
| 2002 | 450,188 (6.3%) | 6,366,964 (5.7%) | 192,932 (4.9%) | 304,181 (5.1%) | 536,061 (5%) | 1.29 |
| 2010 | 491,150 (6.6%) | 6,626,558 (5.9%) | 252,973 (5.1%) | 400,635 (5.1%) | 736,065 (5%) | 1 |
| % change | 9.1% | 4.08% | 31.1% | 31.7% | 37.3% | -10.9% |

### Seafood Sales & Processing - Nonemployer Firms (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Seafood product prep. & packaging | Firms | 116 | 142 | 177 | 164 | 174 | 173 | 202 | 216 | 202 |
| | Receipts | 5,064 | 8,047 | 8,652 | 8,756 | 10,184 | 10,497 | 11,065 | 12,399 | 11,065 |
| Seafood Sales, retail | Firms | 243 | 240 | 247 | 247 | 251 | 319 | 331 | 308 | 331 |
| | Receipts | 20,837 | 18,064 | 18,004 | 22,787 | 20,708 | 27,557 | 26,087 | 24,726 | 26,087 |

### Seafood Sales & Processing - Employer Establishments (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Seafood product prep. & packaging | Establishments | 33 | 27 | 24 | 25 | 22 | 20 | 23 | 25 | 27 |
| | Employees | 2,359 | 2,084 | 2,193 | 1,616 | 1,704 | 1,748 | 1,637 | 1,143 | 1,269 |
| | Payroll | 65,914 | 61,452 | 65,881 | 47,529 | 62,801 | 58,233 | 53,455 | 46,235 | 45,772 |
| Seafood sales, wholesale | Establishments | 314 | 293 | 261 | 258 | 259 | 267 | 229 | 215 | 229 |
| | Employees | 2,395 | 1,835 | 1,948 | 1,883 | 2,091 | 2,308 | 1,913 | 1,762 | 1,747 |
| | Payroll | 78,160 | 55,874 | 63,276 | 65,339 | 73,897 | 85,019 | 75,203 | 72,159 | 70,889 |
| Seafood sales, retail | Establishments | 190 | 174 | 190 | 176 | 173 | 169 | 168 | 158 | 145 |
| | Employees | 908 | 952 | 977 | 970 | 936 | 989 | 991 | 885 | 865 |
| | Payroll | 17,186 | 15,673 | 17,575 | 19,192 | 19,513 | 20,595 | 21,604 | 21,182 | 20,783 |

### Transport, Support, & Marine Operations - Employer Establishments (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal & Great Lakes freight transportation | Establishments | 51 | 66 | 59 | 59 | 54 | 47 | 42 | 42 | 50 |
| | Employees | 2,856 | ND[2] | 1,132 | 1,150 | 1,217 | 1,242 | 1,106 | 972 | 709 |
| | Payroll | 143,185 | ND[2] | 80,422 | 71,420 | 91,638 | 94,429 | 50,115 | 37,774 | 50,217 |
| Deep sea freight transportation | Establishments | 62 | 61 | 63 | 69 | 73 | 69 | 57 | 58 | 61 |
| | Employees | 1,858 | 2,535 | 2,567 | 2,622 | 3,729 | 3,190 | 2,486 | 2,801 | 2,279 |
| | Payroll | 107,564 | 131,904 | 150,701 | 207,300 | 226,810 | 208,144 | 169,055 | 180,139 | 159,025 |
| Deep sea passenger transportation | Establishments | 31 | 36 | 32 | 31 | 37 | 34 | 31 | 33 | 29 |
| | Employees | 7,863 | 8,879 | 8,849 | 8,492 | 9,077 | ND[2] | ND[2] | ND[2] | ND[2] |
| | Payroll | 315,551 | 428,941 | 536,753 | 504,625 | 571,590 | ND[2] | ND[2] | ND[2] | ND[2] |
| Marinas | Establishments | 481 | 528 | 532 | 551 | 513 | 493 | 442 | 428 | 430 |
| | Employees | 3,449 | 5,079 | 5,067 | 5,069 | 5,494 | 4,935 | 5,024 | 4,665 | 4,439 |
| | Payroll | 90,662 | 111,324 | 125,763 | 133,384 | 146,390 | 148,592 | 151,677 | 132,955 | 133,017 |
| Marine cargo handling | Establishments | 74 | 68 | 66 | 63 | 66 | 53 | 56 | 59 | 55 |
| | Employees | 4,405 | 5,651 | 5,671 | 6,409 | 7,266 | 6,585 | 8,052 | 7,288 | 7,547 |
| | Payroll | 109,555 | 171,481 | 175,257 | 177,983 | 189,020 | 173,788 | 192,473 | 185,309 | 191,560 |
| Navigational services to shipping | Establishments | 141 | 140 | 149 | 148 | 142 | 145 | 147 | 145 | 145 |
| | Employees | 714 | 817 | 686 | 660 | 781 | 1,484 | 894 | 829 | 980 |
| | Payroll | 34,040 | 39,524 | 39,309 | 42,200 | 48,370 | 61,470 | 56,917 | 60,641 | 76,853 |
| Port & harbor operations | Establishments | 29 | 26 | 29 | 31 | 27 | 29 | 40 | 32 | 34 |
| | Employees | 1,180 | 592 | 1,045 | 973 | 584 | 459 | 712 | 527 | 470 |
| | Payroll | 26,928 | 19,071 | 24,327 | 22,606 | 19,417 | 12,872 | 24,668 | 19,006 | 20,525 |
| Ship & boat building | Establishments | 291 | 290 | 306 | 312 | 301 | 296 | 297 | 261 | 248 |
| | Employees | 11,407 | 11,830 | 12,503 | 12,729 | 12,385 | 12,332 | 12,419 | 8,221 | 7,363 |
| | Payroll | 379,828 | 393,985 | 443,379 | 454,209 | 427,888 | 469,382 | 442,096 | 296,537 | 302,909 |

[1] The U.S. Commercial Fishing Location Quotient (CFLQ) of 1.0 represents the national baseline from which state CFLQs can be compared.
[2] ND = these data are confidential thus not disclosable

### 2011 Economic Impacts of the Louisiana Seafood Industry (thousands of dollars)

| | With Imports | | | Without Imports | | |
|---|---|---|---|---|---|---|
| | Jobs | Sales | Value Added | Jobs | Sales | Value Added |
| **Total Impacts** | 32,818 | 1,801,568 | 877,911 | 30,676 | 1,467,854 | 762,430 |
| Commercial Harvesters | 12,407 | 626,308 | 308,175 | 12,407 | 626,308 | 308,175 |
| Seafood Processors & Dealers | 1,991 | 169,492 | 83,857 | 1,833 | 156,282 | 77,322 |
| Importers | 978 | 269,047 | 82,017 | 0 | 0 | 0 |
| Seafood Wholesalers & Distributors | 1,015 | 111,792 | 49,298 | 841 | 92,654 | 40,859 |
| Retail | 16,427 | 624,929 | 354,564 | 15,595 | 592,610 | 336,076 |

### Total Landings Revenue and Landings Revenue of Key Species/Species Groups (thousands of dollars)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total revenue | 280,630 | 270,408 | 274,082 | 251,678 | 278,292 | 289,288 | 275,239 | 296,778 | 247,772 | 333,619 |
| Finfish & other | 70,327 | 63,299 | 66,074 | 49,443 | 60,735 | 65,198 | 64,116 | 71,479 | 71,155 | 112,292 |
| Shellfish | 210,303 | 207,109 | 208,008 | 202,235 | 217,557 | 224,090 | 211,124 | 225,300 | 176,617 | 221,327 |
| Blue crab | 30,685 | 33,623 | 29,881 | 27,419 | 32,605 | 35,044 | 32,202 | 37,306 | 30,299 | 36,761 |
| Crawfish | 8,070 | 4,845 | 4,810 | 8,360 | 1,290 | 9,034 | 9,435 | 15,547 | 13,969 | 9,911 |
| King mackerel | 1,046 | 990 | 1,198 | 1,273 | 1,112 | 1,298 | 1,307 | 1,184 | 1,149 | 1,593 |
| Menhaden | 40,378 | 34,464 | 35,249 | 25,776 | 36,441 | 41,368 | 45,768 | 51,405 | 57,600 | 93,547 |
| Mullets | 1,688 | 2,592 | 2,681 | 946 | 2,061 | 690 | 749 | 73 | 185 | 775 |
| Oysters | 30,296 | 33,358 | 34,814 | 33,305 | 35,999 | 40,148 | 38,852 | 50,959 | 24,963 | 41,568 |
| Red snapper | 4,696 | 3,960 | 3,861 | 3,568 | 4,472 | 2,529 | 2,038 | 2,185 | 2,311 | 2,261 |
| Shrimp | 141,213 | 135,153 | 138,466 | 133,143 | 147,652 | 139,842 | 130,623 | 121,477 | 107,372 | 133,067 |
| Tunas | 10,845 | 9,471 | 10,739 | 7,687 | 7,040 | 8,334 | 4,409 | 6,338 | 1,649 | 3,369 |
| Vermillion snapper | 1,308 | 1,896 | 1,663 | 1,137 | 762 | 991 | 819 | 806 | 399 | 517 |

### Total Landings and Landings of Key Species/Species Groups (thousands of pounds)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total landings | 1,312,139 | 1,181,607 | 1,095,571 | 849,280 | 918,675 | 999,343 | 918,827 | 1,172,327 | 1,007,016 | 1,285,875 |
| Finfish & other | 1,124,627 | 985,164 | 895,336 | 681,322 | 714,545 | 814,645 | 759,438 | 970,214 | 879,213 | 1,129,176 |
| Shellfish | 187,511 | 196,443 | 200,235 | 167,959 | 204,130 | 184,698 | 159,389 | 202,114 | 127,803 | 156,699 |
| Blue crab | 50,123 | 48,089 | 44,397 | 38,100 | 53,394 | 45,107 | 41,713 | 53,060 | 30,726 | 43,862 |
| Crawfish | 15,602 | 8,337 | 8,537 | 15,177 | 1,469 | 15,848 | 15,612 | 19,312 | 14,556 | 9,597 |
| King mackerel | 866 | 911 | 984 | 867 | 971 | 879 | 789 | 927 | 691 | 1,002 |
| Menhaden | 1,093,997 | 953,714 | 862,947 | 657,702 | 689,853 | 789,621 | 738,092 | 948,944 | 862,144 | 1,106,931 |
| Mullets | 2,555 | 4,524 | 4,754 | 1,238 | 3,361 | 1,375 | 1,503 | 189 | 362 | 1,385 |
| Oysters | 13,962 | 13,609 | 13,902 | 12,099 | 11,417 | 12,858 | 12,791 | 15,010 | 6,867 | 11,135 |
| Red snapper | 2,178 | 1,725 | 1,560 | 1,316 | 1,653 | 807 | 589 | 667 | 828 | 918 |
| Shrimp | 107,795 | 125,730 | 133,370 | 102,576 | 137,839 | 110,860 | 89,268 | 114,727 | 75,641 | 92,093 |
| Tunas | 3,587 | 3,184 | 3,230 | 2,296 | 2,143 | 2,476 | 1,248 | 2,009 | 490 | 932 |
| Vermillion snapper | 755 | 1,053 | 921 | 588 | 365 | 517 | 409 | 412 | 186 | 234 |

### Average Annual Price of Key Species/Species Groups (dollars per pound)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Blue crab | 0.61 | 0.70 | 0.67 | 0.72 | 0.61 | 0.78 | 0.77 | 0.70 | 0.99 | 0.84 |
| Crawfish | 0.52 | 0.58 | 0.56 | 0.55 | 0.88 | 0.57 | 0.60 | 0.81 | 0.96 | 1.03 |
| King mackerel | 1.21 | 1.09 | 1.22 | 1.47 | 1.15 | 1.48 | 1.66 | 1.28 | 1.66 | 1.59 |
| Menhaden | 0.04 | 0.04 | 0.04 | 0.04 | 0.05 | 0.05 | 0.06 | 0.05 | 0.07 | 0.08 |
| Mullets | 0.66 | 0.57 | 0.56 | 0.76 | 0.61 | 0.50 | 0.50 | 0.39 | 0.51 | 0.56 |
| Oysters | 2.17 | 2.45 | 2.50 | 2.75 | 3.15 | 3.12 | 3.04 | 3.39 | 3.63 | 3.73 |
| Red snapper | 2.16 | 2.30 | 2.47 | 2.71 | 2.71 | 3.13 | 3.46 | 3.28 | 2.79 | 2.46 |
| Shrimp | 1.31 | 1.07 | 1.04 | 1.30 | 1.07 | 1.26 | 1.46 | 1.06 | 1.42 | 1.44 |
| Tunas | 3.02 | 2.97 | 3.33 | 3.35 | 3.29 | 3.37 | 3.53 | 3.16 | 3.37 | 3.62 |
| Vermillion snapper | 1.73 | 1.80 | 1.81 | 1.93 | 2.09 | 1.92 | 2.00 | 1.95 | 2.15 | 2.21 |

### 2011 Economic Impacts of Recreational Fishing Expenditures (thousands of dollars)

| | Jobs | Sales | Income | Value Added |
|---|---|---|---|---|
| Trip Impacts by Fishing Mode: | | | | |
| For-Hire | 541 | 51,475 | 16,613 | 29,227 |
| Private Boat | 2,237 | 237,846 | 66,894 | 116,981 |
| Shore | 597 | 57,288 | 16,907 | 28,919 |
| Total Durable Equipment Impacts | 14,388 | 1,256,304 | 421,535 | 631,222 |
| **Total State Trip and Durable Equipment Economic Impacts** | 17,764 | 1,602,913 | 521,949 | 806,349 |

### 2011 Angler Trip & Durable Expenditures (thousands of dollars)

| Fishing Mode | Trip Expenditures | | Equipment | Durable Expenditures |
|---|---|---|---|---|
| | Non-Residents | Residents | Fishing Tackle | 245,701 |
| For-Hire | 20,975 | 12,330 | Other Equipment | 86,045 |
| Private Boat | 17,434 | 163,788 | Boat Expenses | 974,417 |
| Shore | 4,535 | 42,032 | Vehicle Expenses | 220,904 |
| *Total Trip Expenditures* | 42,944 | 218,150 | Second Home Expenses | 91,310 |
| | | | *Total Durable Equipment Expenditures* | 1,618,377 |
| **Total State Trip and Durable Equipment Expenditures** | | | | 1,879,471 |

### Recreational Anglers by Residential Area (thousands of anglers)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal | 484 | 727 | 747 | 706 | 868 | 853 | 795 | 669 | 609 | 690 |
| Non-Coastal | 68 | 79 | 133 | 68 | 108 | 124 | 120 | 108 | 67 | 86 |
| Out of State | 117 | 204 | 179 | 138 | 198 | 157 | 170 | 139 | 120 | 183 |
| **Total Anglers** | 669 | 1011 | 1059 | 911 | 1174 | 1134 | 1084 | 916 | 796 | 959 |

### Recreational Fishing Effort by Mode (thousands of angler-trips)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| For-Hire | 94 | 105 | 143 | 123 | 187 | 143 | 179 | 183 | 79 | 113 |
| Private | 2,251 | 3,295 | 3,821 | 2,784 | 2,802 | 3,156 | 3,508 | 3,176 | 3,055 | 3,342 |
| Shore | 674 | 872 | 1,238 | 1,159 | 775 | 889 | 933 | 769 | 729 | 1,122 |
| **Total Trips** | 3,019 | 4,272 | 5,202 | 4,066 | 3,764 | 4,188 | 4,620 | 4,128 | 3,863 | 4,577 |

### Harvest (H) and Release (R) of Key Species Species Groups (thousands of fish)[1]

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Black drum | H | 512 | 485 | 504 | 309 | 369 | 385 | 544 | 518 | 398 | 469 |
| | R | 886 | 835 | 1,026 | 651 | 717 | 728 | 1,117 | 974 | 1,032 | 1,085 |
| Drum (Atlantic croaker) | H | 282 | 380 | 476 | 442 | 805 | 684 | 358 | 471 | 228 | 607 |
| | R | 1,054 | 1,012 | 1,995 | 963 | 1,142 | 1,006 | 1,186 | 1,099 | 1,268 | 2,319 |
| Drum (sand seatrout) | H | 599 | 985 | 903 | 975 | 775 | 888 | 1,085 | 879 | 1,065 | 1,187 |
| | R | 506 | 302 | 453 | 254 | 454 | 541 | 822 | 853 | 514 | 1,032 |
| Drum (spotted seatrout) | H | 5,270 | 7,317 | 8,524 | 7,436 | 10,873 | 8,929 | 11,705 | 10,557 | 7,857 | 10,440 |
| | R | 3,862 | 7,485 | 8,658 | 7,303 | 9,025 | 7,393 | 9,579 | 7,975 | 5,055 | 5,804 |
| Drum(southern kingfish) | H | 104 | 159 | 201 | 239 | 89 | 67 | 74 | 103 | 42 | 16 |
| | R | 22 | 63 | 85 | 187 | 151 | 28 | 118 | 59 | 47 | 25 |
| Porgies (sheepshead) | H | 607 | 807 | 1,288 | 644 | 326 | 270 | 705 | 704 | 431 | 869 |
| | R | 433 | 520 | 567 | 428 | 462 | 288 | 448 | 473 | 440 | 187 |
| Red drum | H | 2,042 | 2,144 | 2,419 | 1,627 | 1,827 | 2,307 | 2,672 | 2,236 | 2,810 | 3,022 |
| | R | 3,278 | 3,545 | 3,293 | 2,652 | 3,320 | 3,454 | 4,075 | 3,732 | 4,111 | 3,196 |
| Red snapper | H | 47 | 70 | 88 | 111 | 172 | 159 | 84 | 98 | 7 | 31 |
| | R | 40 | 166 | 273 | 339 | 429 | 285 | 261 | 195 | 7 | 108 |
| Southern flounder | H | 271 | 407 | 471 | 280 | 290 | 348 | 235 | 286 | 328 | 398 |
| | R | 49 | 116 | 129 | 76 | 54 | 67 | 36 | 51 | 72 | 61 |
| Yellowfin tuna | H | 8 | 13 | 8 | 10 | 14 | 8 | 17 | 3 | 1 | 12 |
| | R | (1) | (1) | (1) | 1 | 1 | 1 | 6 | (1) | (1) | 4 |

[1] In this table, '(1)' = 0-999 thousand fish and '1' = 1,000-1,499 thousand fish.

### Louisiana's State Economy (% of national total)

| | Establishments | Employees | Annual Payroll (million $) | Employee Compensation (million $) | Gross State Product (million $) | Commercial Location Quotient [1] |
|---|---|---|---|---|---|---|
| 2002 | 101,885 (1.4%) | 1,583,308 (1.4%) | 45,628 (1.2%) | 74,803 (1.3%) | 139,202 (1.2%) | 1.87 |
| 2010 | 103,365 (1.4%) | 1,599,551 (1.4%) | 62,266 (1.3%) | 105,352 (1.6%) | 232,394 (1.3%) | 1.58 |
| % change | 1.45% | 1.03% | 36.5% | 40.8% | 66.9% | -17.6% |

### Seafood Sales & Processing - Nonemployer Firms (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Seafood product prep. & packaging | Firms | 66 | 73 | 75 | 76 | 99 | 85 | 77 | 68 | 77 |
| | Receipts | 3,006 | 4,678 | 10,097 | 8,513 | 8,179 | 6,523 | 7,365 | 5,306 | 7,365 |
| Seafood Sales, retail | Firms | 185 | 208 | 204 | 156 | 181 | 196 | 182 | 169 | 182 |
| | Receipts | 15,201 | 22,637 | 18,148 | 14,585 | 20,046 | 20,932 | 25,900 | 17,177 | 25,900 |

### Seafood Sales & Processing - Employer Establishments (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Seafood product prep. & packaging | Establishments | 50 | 54 | 54 | 50 | 40 | 41 | 36 | 38 | 34 |
| | Employees | 1,185 | 1,693 | 1,519 | 1,556 | 1,506 | 1,253 | 991 | 1,301 | 1,209 |
| | Payroll | 52,861 | 56,562 | 47,016 | 43,801 | 45,439 | 41,391 | 32,382 | 37,657 | 35,770 |
| Seafood sales, wholesale | Establishments | 152 | 134 | 133 | 128 | 112 | 119 | 98 | 98 | 97 |
| | Employees | 1,270 | 1,001 | 975 | 1,037 | 807 | 954 | 739 | 702 | 683 |
| | Payroll | 22,363 | 19,539 | 19,639 | 17,649 | 21,243 | 21,604 | 15,858 | 17,261 | 15,554 |
| Seafood sales, retail | Establishments | 123 | 109 | 111 | 106 | 101 | 101 | 107 | 106 | 101 |
| | Employees | 640 | 796 | 745 | 723 | 759 | 781 | 681 | 703 | 527 |
| | Payroll | 7,033 | 9,406 | 9,567 | 8,277 | 10,560 | 11,827 | 11,141 | 11,564 | 11,214 |

### Transport, Support, & Marine Operations - Employer Establishments (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal & Great Lakes freight transportation | Establishments | 109 | 160 | 148 | 136 | 137 | 138 | 123 | 117 | 125 |
| | Employees | 5,494 | 6,779 | 6,656 | 5,771 | 6,397 | 7,680 | 6,506 | 6,077 | 5,610 |
| | Payroll | 236,730 | 287,415 | 300,547 | 294,941 | 386,136 | 527,290 | 549,388 | 391,914 | 405,796 |
| Deep sea freight transportation | Establishments | 28 | 25 | 22 | 25 | 24 | 22 | 18 | 21 | 16 |
| | Employees | 647 | 831 | 705 | ND[2] | 595 | 685 | 1,095 | 1,192 | 93 |
| | Payroll | 29,432 | 43,634 | 38,949 | ND[2] | 35,269 | 39,843 | 87,479 | 91,760 | 6,147 |
| Deep sea passenger transportation | Establishments | 6 | 4 | 3 | 3 | 2 | 3 | 2 | 2 | 1 |
| | Employees | 66 | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| | Payroll | 2,748 | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| Marinas | Establishments | 57 | 53 | 52 | 53 | 41 | 50 | 43 | 43 | 43 |
| | Employees | 345 | 409 | ND[2] | 352 | ND[2] | 378 | 274 | 244 | 314 |
| | Payroll | 8,724 | 11,019 | ND[2] | 10,213 | ND[2] | 17,794 | 9,581 | 8,989 | 14,716 |
| Marine cargo handling | Establishments | 47 | 47 | 47 | 46 | 51 | 49 | 39 | 44 | 41 |
| | Employees | 3,089 | 3,784 | 3,278 | 3,263 | 3,100 | 2,978 | 2,010 | 2,193 | 2,511 |
| | Payroll | 114,659 | 131,274 | 127,896 | 110,129 | 118,748 | 128,207 | 85,484 | 92,883 | 105,063 |
| Navigational services to shipping | Establishments | 148 | 118 | 127 | 120 | 129 | 128 | 145 | 137 | 138 |
| | Employees | 3,371 | 2,738 | 2,472 | 2,136 | 2,204 | 2,508 | 2,884 | 2,893 | 3,176 |
| | Payroll | 135,223 | 112,412 | 109,008 | 96,202 | 115,222 | 141,757 | 183,381 | 175,271 | 224,533 |
| Port & harbor operations | Establishments | 15 | 13 | 18 | 18 | 18 | 14 | 22 | 17 | 21 |
| | Employees | 1,136 | 363 | ND[2] | 418 | 436 | 467 | 517 | 440 | 431 |
| | Payroll | 47,191 | 18,331 | ND[2] | 19,510 | 29,676 | 31,734 | 37,181 | 33,907 | 38,776 |
| Ship & boat building | Establishments | 113 | 113 | 113 | 111 | 108 | 112 | 117 | 109 | 109 |
| | Employees | 12,786 | 12,910 | 13,206 | 11,016 | 11,521 | 12,808 | 12,815 | 12,521 | 11,737 |
| | Payroll | 448,749 | 452,315 | 460,606 | 376,407 | 437,028 | 503,199 | 619,606 | 613,188 | 600,259 |

[1] The U.S. Commercial Fishing Location Quotient (CFLQ) of 1.0 represents the national baseline from which state CFLQs can be compared.
[2] ND = these data are confidential thus not disclosable

### 2011 Economic Impacts of the Mississippi Seafood Industry (thousands of dollars)

| | With Imports | | | Without Imports | | |
|---|---|---|---|---|---|---|
| | Jobs | Sales | Value Added | Jobs | Sales | Value Added |
| **Total Impacts** | 5,550 | 247,106 | 125,430 | 5,439 | 231,104 | 119,876 |
| Commercial Harvesters | 968 | 49,305 | 21,796 | 968 | 49,305 | 21,796 |
| Seafood Processors & Dealers | 833 | 63,085 | 31,273 | 818 | 61,936 | 30,703 |
| Importers | 46 | 12,710 | 3,875 | 0 | 0 | 0 |
| Seafood Wholesalers & Distributors | 73 | 6,821 | 3,032 | 63 | 5,936 | 2,639 |
| Retail | 3,629 | 115,185 | 65,454 | 3,590 | 113,926 | 64,738 |

### Total Landings Revenue and Landings Revenue of Key Species/Species Groups (thousands of dollars)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total revenue | 47,565 | 46,149 | 43,618 | 23,386 | 21,586 | 39,340 | 43,696 | 38,033 | 21,913 | 30,300 |
| Finfish & other | 12,627 | 12,396 | 10,485 | 7,804 | 8,959 | 21,359 | 19,233 | 18,667 | 8,963 | 10,527 |
| Shellfish | 34,938 | 33,753 | 33,133 | 15,582 | 12,628 | 17,981 | 24,464 | 19,366 | 12,950 | 19,772 |
| Blue crab | 572 | 687 | 658 | 433 | 928 | 741 | 447 | 573 | 366 | 318 |
| Flounders | 63 | 49 | 32 | 20 | 36 | 58 | 40 | 58 | 64 | 118 |
| Menhaden | 11,625 | 11,277 | 9,564 | 7,074 | 8,447 | 20,658 | 18,534 | 17,987 | 8,378 | 9,871 |
| Mullets | 22 | 34 | 54 | 38 | 23 | 35 | 32 | 30 | 31 | 56 |
| Oysters | 4,456 | 7,228 | 6,073 | 1,447 | ND[1] | 819 | 6,869 | 6,094 | 4,268 | 928 |
| Red snapper | 100 | 88 | 71 | 115 | ND[2] | ND[2] | ND[2] | 158 | ND[2] | 168 |
| Shrimp | 29,910 | 25,619 | 26,353 | 13,698 | 11,699 | 16,418 | 17,146 | 12,689 | 8,311 | 18,523 |

### Total Landings and Landings of Key Species/Species Groups (thousands of pounds)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total landings | 217,968 | 213,469 | 183,558 | 167,610 | 221,720 | 227,834 | 201,822 | 230,307 | 111,242 | 278,080 |
| Finfish & other | 197,691 | 190,733 | 161,669 | 158,721 | 212,213 | 216,375 | 190,191 | 217,461 | 105,274 | 267,407 |
| Shellfish | 20,277 | 22,736 | 21,889 | 8,889 | 9,507 | 11,459 | 11,631 | 12,846 | 5,968 | 10,673 |
| Blue crab | 717 | 877 | 811 | 429 | 1,127 | 737 | 450 | 545 | 366 | 370 |
| Flounders | 46 | 31 | 18 | 10 | 16 | 25 | 17 | 25 | 28 | 55 |
| Menhaden | 195,371 | 187,956 | 159,392 | 157,194 | 211,163 | 215,182 | 189,118 | 216,709 | 104,729 | 266,774 |
| Mullets | 64 | 94 | 128 | 99 | 66 | 70 | 57 | 62 | 59 | 93 |
| Oysters | 2,738 | 4,042 | 3,029 | 610 | ND[2] | 299 | 2,610 | 2,189 | 1,453 | 247 |
| Red snapper | 46 | 43 | 35 | 54 | ND[2] | ND[2] | ND[2] | 57 | ND[2] | 86 |
| Shrimp | 16,822 | 17,560 | 17,992 | 7,848 | 8,380 | 10,421 | 8,570 | 10,107 | 4,148 | 10,053 |

### Average Annual Price of Key Species/Species Groups (dollars per pound)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Blue crab | 0.80 | 0.78 | 0.81 | 1.01 | 0.82 | 1.01 | 0.99 | 1.05 | 1.00 | 0.86 |
| Flounders | 1.35 | 1.57 | 1.73 | 1.88 | 2.22 | 2.38 | 2.36 | 2.34 | 2.33 | 2.14 |
| Menhaden | 0.06 | 0.06 | 0.06 | 0.05 | 0.04 | 0.10 | 0.10 | 0.08 | 0.08 | 0.04 |
| Mullets | 0.34 | 0.36 | 0.42 | 0.38 | 0.35 | 0.50 | 0.57 | 0.48 | 0.52 | 0.61 |
| Oysters | 1.63 | 1.79 | 2.00 | 2.37 | ND[2] | 2.74 | 2.63 | 2.78 | 2.94 | 3.75 |
| Red snapper | 2.17 | 2.06 | 2.05 | 2.13 | ND[2] | ND[2] | ND[2] | 2.75 | ND[2] | 1.96 |
| Shrimp | 1.78 | 1.46 | 1.46 | 1.75 | 1.40 | 1.58 | 2.00 | 1.26 | 2.00 | 1.84 |

[1] ND = these data are confidential thus not disclosable

### 2011 Economic Impacts of Recreational Fishing Expenditures (thousands of dollars)

| | Jobs | Sales | Income | Value Added |
|---|---|---|---|---|
| Trip Impacts by Fishing Mode: | | | | |
| For-Hire | 49 | 4,362 | 1,375 | 2,458 |
| Private Boat | 283 | 32,645 | 8,682 | 15,646 |
| Shore | 106 | 10,118 | 2,944 | 5,044 |
| Total Durable Equipment Impacts | 742 | 98,643 | 24,782 | 37,587 |
| **Total State Trip and Durable Equipment Economic Impacts** | 1,181 | 145,769 | 37,783 | 60,735 |

### 2011 Angler Trip & Durable Expenditures (thousands of dollars)

| Fishing Mode | Trip Expenditures | | Equipment | Durable Expenditures |
|---|---|---|---|---|
| | Non-Residents | Residents | Fishing Tackle | 28,207 |
| For-Hire | 1,712 | 1,148 | Other Equipment | 9,789 |
| Private Boat | 1,386 | 27,357 | Boat Expenses | 40,733 |
| Shore | 1,519 | 8,932 | Vehicle Expenses | 28,330 |
| *Total Trip Expenditures* | 4,616 | 37,438 | Second Home Expenses | 15 |
| | | | *Total Durable Equipment Expenditures* | 107,075 |
| **Total State Trip and Durable Equipment Expenditures** | | | | 149,129 |

### Recreational Anglers by Residential Area (thousands of anglers)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal | 175 | 159 | 191 | 108 | 143 | 196 | 119 | 125 | 137 | 160 |
| Non-Coastal | 52 | 53 | 26 | 29 | 23 | 34 | 26 | 36 | 29 | 48 |
| Out of State | 49 | 48 | 46 | 39 | 27 | 55 | 48 | 50 | 50 | 60 |
| **Total Anglers** | 276 | 261 | 262 | 176 | 193 | 284 | 194 | 212 | 216 | 268 |

### Recreational Fishing Effort by Mode (thousands of angler-trips)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| For-Hire | 21 | 24 | 13 | 8 | 7 | 20 | 13 | 11 | 7 | 11 |
| Private | 542 | 748 | 657 | 483 | 626 | 834 | 596 | 759 | 629 | 844 |
| Shore | 475 | 405 | 510 | 435 | 291 | 349 | 359 | 310 | 597 | 761 |
| **Total Trips** | 1,038 | 1,177 | 1,180 | 926 | 924 | 1,203 | 968 | 1,080 | 1,233 | 1,616 |

### Harvest (H) and Release (R) of Key Species Species Groups (thousands of fish)[1]

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Drum (Atlantic croaker) | H | 206 | 198 | 135 | 40 | 59 | 71 | 182 | 340 | 209 | 453 |
| | R | 936 | 701 | 371 | 208 | 190 | 264 | 388 | 717 | 422 | 606 |
| Drum (kingfishes)[2] | H | 278 | 327 | 355 | 225 | 163 | 161 | 180 | 126 | 174 | 177 |
| | R | 119 | 60 | 111 | 63 | 29 | 48 | 57 | 61 | 48 | 36 |
| Drum (sand and silver seatrouts) | H | 866 | 667 | 423 | 222 | 304 | 295 | 351 | 1,003 | 986 | 1,336 |
| | R | 111 | 331 | 88 | 118 | 173 | 230 | 166 | 378 | 246 | 471 |
| Drum (spotted seatrout) | H | 372 | 276 | 761 | 318 | 470 | 386 | 608 | 1,090 | 556 | 840 |
| | R | 559 | 832 | 1,045 | 838 | 975 | 909 | 1,009 | 960 | 586 | 634 |
| Porgies (sheepshead) | H | 68 | 77 | 37 | 27 | 36 | 18 | 17 | 21 | 43 | 260 |
| | R | 61 | 27 | 33 | 22 | 22 | 11 | 25 | 9 | 3 | 24 |
| Red drum | H | 60 | 50 | 83 | 35 | 58 | 41 | 76 | 84 | 76 | 90 |
| | R | 116 | 187 | 153 | 143 | 98 | 73 | 153 | 240 | 212 | 208 |
| Red snapper | H | 43 | 39 | 13 | 1 | 7 | 2 | 9 | 15 | 1 | 6 |
| | R | 166 | 90 | 61 | 51 | 52 | 9 | 104 | 55 | 25 | (1) |
| Sharks[3] | H | 12 | 8 | 8 | 9 | 2 | 4 | 3 | 21 | 71 | 35 |
| | R | 118 | 59 | 38 | 37 | 39 | 41 | 12 | 36 | 87 | 37 |
| Southern flounder | H | 141 | 120 | 103 | 72 | 47 | 121 | 110 | 209 | 195 | 182 |
| | R | 48 | 67 | 55 | 30 | 35 | 31 | 45 | 120 | 79 | 99 |
| Striped mullet | H | 212 | 550 | 192 | 34 | 2 | 66 | 78 | 119 | 188 | 491 |
| | R | 12 | 65 | 2 | (1) | 3 | 14 | 4 | 4 | 13 | 83 |

[1] In this table, '(1)' = 0-999 thousand fish and '1' = 1,000-1,499 thousand fish.
[2] Kingfishes include southern kingfish and Gulf kingfish
[3] Sharks include species within the requiem shark family, blacktip sharks, Atlantic sharpnose sharks, and unidentified sharks.

### Mississippi's State Economy (% of national total)

| | Establishments | Employees | Annual Payroll (million $) | Employee Compensation (million $) | Gross State Product (million $) | Commercial Location Quotient [1] |
|---|---|---|---|---|---|---|
| 2002 | 59,902 (0.83%) | 904,252 (0.8%) | 22,773 (0.58%) | 40,415 (0.66%) | 69,527 (0.66%) | 1.64 |
| 2010 | 59,300 (0.8%) | 882,181 (0.79%) | 28,607 (0.58%) | 52,766 (0.66%) | 95,480 (0.66%) | ND[2] |
| % change | -1% | -2.44% | 25.6% | 30.6% | 37.3% | NA[3] |

### Seafood Sales & Processing - Nonemployer Firms (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Seafood product prep. & packaging | Firms | 15 | 23 | 18 | 12 | 22 | 0 | 17 | 16 | 17 |
| | Receipts | 915 | 1,561 | 1,056 | 1,045 | 1,537 | ND[2] | 1,055 | 756 | 1,055 |
| Seafood Sales, retail | Firms | 51 | 51 | 47 | 41 | 53 | 57 | 48 | 55 | 48 |
| | Receipts | 2,486 | 2,984 | 3,595 | 2,934 | 4,021 | 4,126 | 3,437 | 4,042 | 3,437 |

### Seafood Sales & Processing - Employer Establishments (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Seafood product prep. & packaging | Establishments | 34 | 37 | 33 | 28 | 24 | 22 | 20 | 20 | 20 |
| | Employees | 3,675 | 4,438 | 3,728 | 3,637 | 3,353 | 3,022 | 3,062 | 2,796 | 2,849 |
| | Payroll | 70,792 | 80,229 | 66,047 | 63,957 | 60,510 | 60,633 | 61,723 | 61,926 | 61,731 |
| Seafood sales, wholesale | Establishments | 29 | 26 | 29 | 30 | 23 | 25 | 18 | 16 | 18 |
| | Employees | 226 | 176 | 166 | 145 | 58 | 106 | 61 | 113 | ND[2] |
| | Payroll | 3,791 | 3,067 | 3,631 | 1,822 | 2,063 | 3,285 | 3,088 | 2,836 | 2,542 |
| Seafood sales, retail | Establishments | 28 | 19 | 17 | 21 | 12 | 15 | 18 | 14 | 15 |
| | Employees | ND[2] | 47 | 55 | 57 | 41 | ND[2] | 50 | 46 | 50 |
| | Payroll | ND[2] | 468 | 532 | 521 | 395 | ND[2] | 699 | 841 | 810 |

### Transport, Support, & Marine Operations - Employer Establishments (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal & Great Lakes freight transportation | Establishments | 5 | 5 | 6 | 5 | 5 | 4 | 5 | 5 | 4 |
| | Employees | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | 119 | 114 | ND[2] |
| | Payroll | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | 7,585 | 8,351 | 7,730 | 8,058 |
| Deep sea freight transportation | Establishments | 1 | 2 | 2 | 3 | 3 | 1 | NA[3] | 1 | 1 |
| | Employees | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | NA[3] | ND[2] | ND[2] |
| | Payroll | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | NA[3] | ND[2] | ND[2] |
| Deep sea passenger transportation | Establishments | NA[3] | 1 | 1 | 1 | 1 | 1 | NA[3] | NA[3] | NA[3] |
| | Employees | NA[3] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | NA[3] | NA[3] | NA[3] |
| | Payroll | NA[3] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | NA[3] | NA[3] | NA[3] |
| Marinas | Establishments | 18 | 22 | 22 | 25 | 16 | 19 | 17 | 13 | 18 |
| | Employees | 86 | 141 | 220 | 158 | ND[2] | ND[2] | 111 | 172 | 183 |
| | Payroll | 1,388 | 2,532 | 2,603 | 2,358 | ND[2] | 2,145 | 2,794 | 3,479 | 4,163 |
| Marine cargo handling | Establishments | 7 | 4 | 5 | 6 | 5 | 5 | 7 | 8 | 7 |
| | Employees | 251 | ND[2] | ND[2] | ND[2] | 238 | ND[2] | ND[2] | ND[2] | ND[2] |
| | Payroll | 9,284 | ND[2] | ND[2] | ND[2] | 8,621 | ND[2] | ND[2] | ND[2] | ND[2] |
| Navigational services to shipping | Establishments | 8 | 10 | 9 | 8 | 8 | 9 | 8 | 7 | 8 |
| | Employees | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | 141 |
| | Payroll | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | 1,754 | ND[2] | ND[2] | 6,982 |
| Port & harbor operations | Establishments | 1 | 1 | 2 | 2 | 1 | 1 | 1 | 1 | 1 |
| | Employees | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| | Payroll | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| Ship & boat building | Establishments | 26 | 21 | 19 | 17 | 20 | 23 | 24 | 20 | 20 |
| | Employees | 11,663 | ND[2] | ND[2] | 11,845 | 11,909 | 14,578 | ND[2] | ND[2] | ND[2] |
| | Payroll | 473,191 | ND[2] | ND[2] | 471,243 | 498,660 | 615,837 | ND[2] | ND[2] | ND[2] |

[1] The U.S. Commercial Fishing Location Quotient (CFLQ) of 1.0 represents the national baseline from which state CFLQs can be compared.
[2] ND = these data are confidential thus not disclosable
[3] NA = these data are not available

### 2011 Economic Impacts of the Texas Seafood Industry (thousands of dollars)

| | With Imports | | | Without Imports | | |
|---|---|---|---|---|---|---|
| | Jobs | Sales | Value Added | Jobs | Sales | Value Added |
| **Total Impacts** | 27,717 | 2,277,959 | 1,002,928 | 22,516 | 1,357,574 | 687,876 |
| Commercial Harvesters | 5,754 | 508,663 | 232,633 | 5,754 | 508,663 | 232,633 |
| Seafood Processors & Dealers | 2,019 | 167,700 | 83,088 | 1,885 | 156,733 | 77,654 |
| Importers | 2,749 | 756,118 | 230,498 | 0 | 0 | 0 |
| Seafood Wholesalers & Distributors | 1,220 | 163,689 | 75,633 | 670 | 89,848 | 41,515 |
| Retail | 15,975 | 681,788 | 381,075 | 14,207 | 602,329 | 336,074 |

### Total Landings Revenue and Landings Revenue of Key Species/Species Groups (thousands of dollars)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total revenue | 173,340 | 168,317 | 166,208 | 172,337 | 197,291 | 180,575 | 176,098 | 155,074 | 204,469 | 239,082 |
| Finfish & other | 9,600 | 9,041 | 10,684 | 10,813 | 11,359 | 9,452 | 7,709 | 7,488 | 7,888 | 8,445 |
| Shellfish | 163,741 | 159,276 | 155,524 | 161,523 | 185,932 | 171,123 | 168,389 | 147,586 | 196,581 | 230,637 |
| Atlantic croaker | 451 | 489 | 382 | 415 | 500 | 450 | 446 | 484 | 531 | 622 |
| Black drum | 1,820 | 1,365 | 1,444 | 1,917 | 2,013 | 1,660 | 1,363 | 1,377 | 1,573 | 1,448 |
| Blue crab | 4,523 | 3,157 | 2,663 | 2,410 | 1,459 | 2,763 | 2,342 | 2,454 | 3,134 | 2,845 |
| Flounders | 371 | 336 | 325 | 276 | 164 | 62 | 144 | 91 | 62 | 205 |
| Groupers | 664 | 1,028 | 785 | 795 | 628 | 417 | 553 | 641 | 356 | 549 |
| Oysters | 11,276 | 16,493 | 14,954 | 15,883 | 17,263 | 19,246 | 8,835 | 9,376 | 19,144 | 12,789 |
| Red snapper | 3,363 | 3,757 | 5,193 | 5,345 | 6,168 | 3,762 | 2,744 | 2,398 | 3,009 | 3,254 |
| Shrimp | 147,701 | 139,485 | 137,674 | 143,045 | 167,108 | 149,084 | 157,187 | 135,643 | 174,231 | 214,898 |
| Tunas | 1,190 | 720 | 0 | 340 | 0 | ND[1] | 94 | 139 | 4 | 2 |
| Vermilion snapper | 386 | 349 | 611 | 571 | 642 | 1,554 | 1,430 | 1,233 | 1,337 | 1,274 |

### Total Landings and Landings of Key Species/Species Groups (thousands of pounds)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total landings | 93,059 | 96,122 | 85,557 | 84,289 | 117,131 | 87,912 | 73,048 | 102,695 | 90,054 | 98,111 |
| Finfish & other | 6,066 | 5,240 | 5,852 | 5,782 | 5,825 | 4,800 | 3,866 | 4,134 | 4,247 | 4,224 |
| Shellfish | 86,993 | 90,883 | 79,705 | 78,507 | 111,306 | 83,111 | 69,182 | 98,561 | 85,807 | 93,887 |
| Atlantic croaker | 70 | 75 | 60 | 58 | 67 | 62 | 59 | 63 | 67 | 79 |
| Black drum | 2,331 | 1,677 | 1,717 | 2,077 | 2,212 | 1,687 | 1,468 | 1,610 | 1,729 | 1,795 |
| Blue crab | 7,037 | 4,811 | 3,961 | 3,119 | 1,966 | 3,454 | 2,635 | 2,844 | 3,436 | 2,893 |
| Flounders | 173 | 159 | 151 | 144 | 68 | 24 | 58 | 32 | 26 | 75 |
| Groupers | 274 | 416 | 329 | 303 | 220 | 141 | 170 | 208 | 144 | 190 |
| Oysters | 4,708 | 6,813 | 5,569 | 5,007 | 4,923 | 5,633 | 2,679 | 2,733 | 5,265 | 3,943 |
| Red snapper | 1,478 | 1,607 | 2,133 | 1,940 | 2,158 | 1,213 | 870 | 851 | 1,031 | 948 |
| Shrimp | 75,158 | 79,166 | 70,098 | 70,310 | 104,378 | 74,007 | 63,855 | 92,946 | 77,067 | 87,007 |
| Tunas | 430 | 275 | 0 | 112 | 0 | ND[2] | 22 | 45 | 1 | 1 |
| Vermilion snapper | 217 | 192 | 322 | 279 | 273 | 672 | 592 | 561 | 539 | 465 |

### Average Annual Price of Key Species/Species Groups (dollars per pound)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Atlantic croaker | 6.46 | 6.49 | 6.35 | 7.14 | 7.43 | 7.29 | 7.58 | 7.64 | 7.98 | 7.84 |
| Black drum | 0.78 | 0.81 | 0.84 | 0.92 | 0.91 | 0.98 | 0.93 | 0.86 | 0.91 | 0.81 |
| Blue crab | 0.64 | 0.66 | 0.67 | 0.77 | 0.74 | 0.80 | 0.89 | 0.86 | 0.91 | 0.98 |
| Flounders | 2.14 | 2.12 | 2.15 | 1.92 | 2.42 | 2.55 | 2.48 | 2.84 | 2.37 | 2.75 |
| Groupers | 2.43 | 2.47 | 2.39 | 2.62 | 2.85 | 2.96 | 3.25 | 3.07 | 2.47 | 2.88 |
| Oysters | 2.40 | 2.42 | 2.69 | 3.17 | 3.51 | 3.42 | 3.30 | 3.43 | 3.64 | 3.24 |
| Red snapper | 2.27 | 2.34 | 2.43 | 2.76 | 2.86 | 3.10 | 3.15 | 2.82 | 2.92 | 3.43 |
| Shrimp | 1.97 | 1.76 | 1.96 | 2.03 | 1.60 | 2.01 | 2.46 | 1.46 | 2.26 | 2.47 |
| Tunas | 2.76 | 2.62 | 0.80 | 3.04 | 0.69 | ND[2] | 4.26 | 3.08 | 3.19 | 1.82 |
| Vermilion snapper | 1.78 | 1.82 | 1.90 | 2.05 | 2.35 | 2.31 | 2.42 | 2.20 | 2.48 | 2.74 |

[1] ND = these data are confidential thus not disclosable

### 2011 Economic Impacts of Recreational Fishing Expenditures (thousands of dollars)

| | Jobs | Sales | Income | Value Added |
|---|---|---|---|---|
| Trip Impacts by Fishing Mode: | | | | |
| For-Hire | 1,130 | 103,768 | 32,782 | 57,841 |
| Private Boat | 2,095 | 240,615 | 72,554 | 128,583 |
| Shore | 2,350 | 257,028 | 78,973 | 138,775 |
| Total Durable Equipment Impacts | 9,576 | 1,251,949 | 401,758 | 627,085 |
| **Total State Trip and Durable Equipment Economic Impacts** | 15,150 | 1,853,361 | 586,068 | 952,284 |

### 2011 Angler Trip & Durable Expenditures (thousands of dollars)[1]

| Fishing Mode | Trip Expenditures | | Equipment | Durable Expenditures |
|---|---|---|---|---|
| | Non-Residents | Residents | | |
| For-Hire | 4,616 | 57,001 | Fishing Tackle | 149,267 |
| Private Boat | 8,983 | 153,062 | Other Equipment | 82,412 |
| Shore | 15,081 | 162,772 | Boat Expenses | 414,319 |
| *Total Trip Expenditures* | 28,680 | 372,834 | Vehicle Expenses | 270,863 |
| | | | Second Home Expenses | 84,140 |
| | | | *Total Durable Equipment Expenditures* | 1,001,002 |
| **Total State Trip and Durable Equipment Expenditures** | | | | 1,402,516 |

### Harvest (H) and Release (R) of Key Species Species Groups (thousands of fish)[2]

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Atlantic croaker | H | 111 | 96 | 109 | 95 | 101 | 95 | 64 | 117 | 125 | 157 |
| Black drum | H | 72 | 85 | 68 | 53 | 73 | 66 | 82 | 98 | 165 | 129 |
| King mackerel | H | 16 | 19 | 15 | 14 | 29 | 11 | 8 | 16 | 6 | 9 |
| Red drum | H | 233 | 270 | 273 | 231 | 318 | 289 | 266 | 285 | 264 | 347 |
| Red snapper | H | 53 | 40 | 40 | 49 | 69 | 45 | 41 | 31 | 33 | 36 |
| Sand seatrout | H | 173 | 119 | 176 | 125 | 129 | 95 | 152 | 111 | 127 | 227 |
| Sheepshead | H | 84 | 76 | 67 | 81 | 78 | 46 | 46 | 34 | 49 | 57 |
| Southern flounder | H | 91 | 111 | 100 | 81 | 64 | 49 | 64 | 47 | 30 | 92 |
| Spotted seatrout | H | 965 | 939 | 934 | 855 | 987 | 916 | 917 | 810 | 732 | 1,137 |

[1]The Marine Recreational Information Program (MRIP) does not collect participation (number of anglers) or effort (number of trips) data for Texas. To calculate trip expenditure estimates, effort by fishing mode was estimated based on 2011 data provided by the Texas Parks and Wildlife Department (TPWD). These effort estimates were reviewed by the TPWD. To calculate angler expenditure estimates (durable equipment expenditures), participation estimates were based on the sum of saltwater licenses sold in Texas plus a proportion of combination licenses sold in Texas. A change in the method of reporting landings occurred in 2007 so data from 2007 is not comparable to earlier years.

[2]Data collected by the TPWG is reported in this table. The data collected by the TPWD differs from the data collected and reported in the MRIP. Please see the TPWD for more information: www.tpwd.state.tx.us/fishboat/.

### Texas's State Economy (% of national total)

| | Establishments | Employees | Annual Payroll (million $) | Employee Compensation (million $) | Gross State Product (million $) | Commercial Location Quotient [1] |
|---|---|---|---|---|---|---|
| 2002 | 482,169 (6.7%) | 7,993,559 (7.1%) | 277,847 (7%) | 427,957 (7.4%) | 782,780 (7%) | 0.53 |
| 2010 | 522,146 (7.1%) | 8,785,238 (7.8%) | 386,654 (7.8%) | 619,854 (8.5%) | 1,222,904 (7.8%) | 0.2 |
| % change | 8.29% | 9.9% | 39.2% | 44.8% | 56.2% | -41.5% |

### Seafood Sales & Processing - Nonemployer Firms (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Seafood product prep. & packaging | Firms | 104 | 99 | 100 | 108 | 109 | 94 | 85 | 82 | 85 |
| | Receipts | 3,901 | 5,234 | 1,989 | 2,228 | 2,974 | 5,386 | 3,466 | 3,896 | 3,466 |
| Seafood Sales, retail | Firms | 152 | 170 | 159 | 159 | 141 | 182 | 188 | 195 | 188 |
| | Receipts | 13,516 | 16,636 | 19,131 | 19,534 | 18,355 | 17,442 | 18,204 | 12,947 | 18,204 |

### Seafood Sales & Processing - Employer Establishments (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Seafood product prep. & packaging | Establishments | 27 | 23 | 24 | 23 | 21 | 26 | 27 | 24 | 22 |
| | Employees | 1,453 | 1,274 | 1,177 | 1,288 | 1,155 | 1,207 | 1,169 | 1,026 | 1,184 |
| | Payroll | 25,772 | 25,426 | 24,394 | 23,842 | 24,302 | 27,813 | 27,045 | 29,006 | 24,961 |
| Seafood sales, wholesale | Establishments | 115 | 99 | 103 | 97 | 92 | 104 | 69 | 75 | 77 |
| | Employees | 999 | 1,057 | 1,009 | 1,001 | 897 | 970 | 734 | 683 | 715 |
| | Payroll | 29,430 | 27,016 | 27,730 | 26,408 | 28,586 | 51,597 | 24,498 | 23,650 | 23,879 |
| Seafood sales, retail | Establishments | 73 | 67 | 60 | 59 | 58 | 62 | 60 | 51 | 52 |
| | Employees | 287 | 227 | 219 | 176 | 207 | 189 | 206 | 189 | 199 |
| | Payroll | 3,748 | 2,985 | 2,993 | 3,162 | 3,229 | 3,703 | 3,403 | 3,393 | 3,742 |

### Transport, Support, & Marine Operations - Employer Establishments (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal & Great Lakes freight transportation | Establishments | 39 | 43 | 43 | 61 | 45 | 43 | 42 | 43 | 48 |
| | Employees | 866 | 2,705 | 2,565 | ND[2] | 2,270 | 2,513 | 2,815 | 2,729 | 1,909 |
| | Payroll | 42,377 | 88,033 | 91,995 | ND[2] | 107,328 | 131,946 | 251,997 | 200,219 | 161,080 |
| Deep sea freight transportation | Establishments | 45 | 48 | 41 | 43 | 40 | 41 | 35 | 36 | 30 |
| | Employees | 1,287 | ND[2] | 891 | ND[2] | 751 | 920 | 514 | 802 | 764 |
| | Payroll | 70,194 | ND[2] | 38,553 | ND[2] | 41,969 | 49,761 | 40,764 | 61,309 | 63,408 |
| Deep sea passenger transportation | Establishments | 5 | 5 | 3 | 4 | 3 | 4 | 3 | 2 | 1 |
| | Employees | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| | Payroll | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| Marinas | Establishments | 179 | 170 | 165 | 166 | 150 | 141 | 143 | 131 | 148 |
| | Employees | 1,255 | 1,410 | ND[2] | ND[2] | ND[2] | 1,200 | 1,486 | 1,423 | 1,198 |
| | Payroll | 28,471 | 31,197 | ND[2] | ND[2] | ND[2] | 28,359 | 34,039 | 33,803 | 33,968 |
| Marine cargo handling | Establishments | 56 | 59 | 60 | 60 | 64 | 62 | 55 | 57 | 54 |
| | Employees | 4,549 | 5,091 | 4,539 | 5,200 | 5,349 | 6,237 | 6,313 | 6,276 | 5,262 |
| | Payroll | 113,894 | 108,142 | 138,630 | 151,522 | 161,386 | 186,416 | 196,006 | 167,562 | 166,877 |
| Navigational services to shipping | Establishments | 95 | 92 | 92 | 87 | 84 | 90 | 99 | 95 | 87 |
| | Employees | 1,082 | 1,099 | 1,213 | 1,064 | 1,373 | 1,709 | 1,884 | 1,849 | 1,606 |
| | Payroll | 49,825 | 60,714 | 68,741 | 75,914 | 98,244 | 125,061 | 137,962 | 137,289 | 132,283 |
| Port & harbor operations | Establishments | 13 | 16 | 15 | 15 | 16 | 15 | 24 | 30 | 29 |
| | Employees | ND[2] | ND[2] | 215 | ND[2] | 112 | 98 | ND[2] | 421 | ND[2] |
| | Payroll | ND[2] | ND[2] | 7,128 | ND[2] | 4,992 | 5,163 | 10,538 | 13,778 | 18,627 |
| Ship & boat building | Establishments | 110 | 107 | 103 | 99 | 90 | 96 | 102 | 99 | 97 |
| | Employees | 3,360 | 4,062 | 4,204 | 3,564 | 3,515 | 4,810 | 5,368 | 3,891 | 3,386 |
| | Payroll | 137,129 | 156,565 | 163,800 | 156,259 | 170,308 | 210,275 | 235,190 | 158,261 | 147,492 |

[1] The U.S. Commercial Fishing Location Quotient (CFLQ) of 1.0 represents the national baseline from which state CFLQs can be compared.
[2] ND = these data are confidential thus not disclosable

National Marine Manufacturers Association

nmma.org

# ECONOMIC SIGNIFICANCE OF RECREATIONAL BOATING IN ALABAMA

## TOTAL ANNUAL ECONOMIC IMPACT OF RECREATIONAL BOATING:

**$2.68 BILLION**

| | |
|---|---|
| Number of Recreational Boats* | 263,652 |
| Recreational Boating Industry Businesses | 485 |
| Total Jobs | 21,140 |
| Annual Recreational Boating-Related Spending | $1.1 BILLION |

## RECREATIONAL BOATS IN ALABAMA

| TOTAL BOATS* | 263,652 |
|---|---|
| REGISTERED BOATS | 263,652 |
| Power boats | 222,158 |
| PWCs | 35,211 |
| Sailboats | 3,646 |
| Other Boats | 2,637 |
| HOUSEHOLDS PER BOAT | 7.193 |

POWER BOATS 84%

PWCs 13%

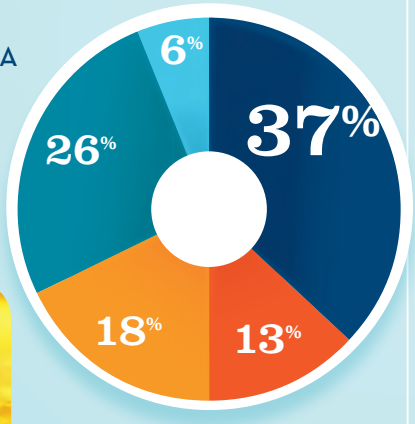
SAILBOATS 2%

OTHER BOATS 1%

* Total boats are registered boats as reported by states to the USCG.

## RECREATIONAL BOATING CREATES JOBS IN ALABAMA

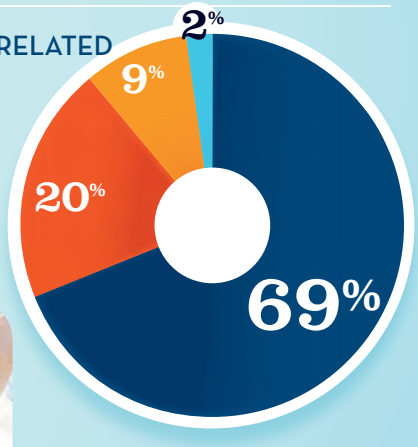
| TOTAL BOATING JOBS | 4,651 |
|---|---|
| Boat Building | 251 |
| Motor / Engine Mfgr. | 1,202 |
| Accessory / Supplies Mfgr. | 854 |
| Dealers / Wholesalers | 620 |
| Boat Services | 1,724 |




BOAT BUILDING
MOTOR/ENG. MFGR.
ACC./SUPPLIES MFGR.
DLRS/WHOLESALERS
BOAT SERVICES

## RECREATIONAL BOATING-RELATED BUSINESSES IN ALABAMA

| TOTAL BUSINESSES | 485 |
|---|---|
| Boat Building | 9 |
| Motor / Engine Mfgr. | 3 |
| Accessory / Supplies Mfgr. | 42 |
| Dealers / Wholesalers | 97 |
| Boat Services | 334 |




BOAT BUILDING
MOTOR/ENG. MFGR.†
ACC./SUPPLIES MFGR.
DLRS/WHOLESALERS
BOAT SERVICES

† 0%

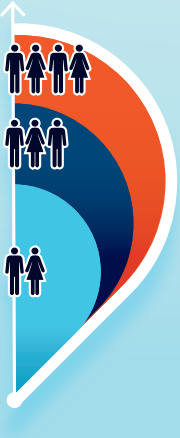
## ESTIMATED JOBS IMPACT OF RECREATIONAL BOATING-RELATED SPENDING IN ALABAMA

| EST. TOTAL JOBS | 21,141 |
|---|---|
| | MILLIONS |
| EST. TOTAL LABOR INCOME | $876.1 |
| Est. Direct Income | $355.1 |
| Est. Indirect Income | $219.3 |
| Est. Induced Income | $301.7 |

6,893 INDUCED JOBS

3,921 INDIRECT JOBS

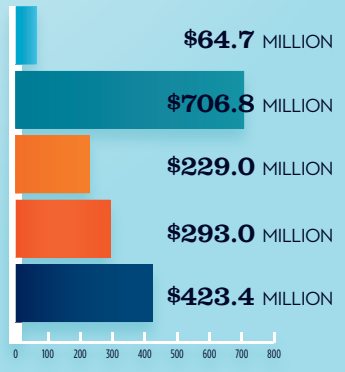
10,327 DIRECT JOBS



## RECREATIONAL BOATING INDUSTRY SALES IN ALABAMA

| | MILLIONS |
|---|---|
| Boat Building | $64.7 |
| Motor / Engine Mfgr. | $706.8 |
| Accessory / Supplies Mfgr. | $229.0 |
| TOTAL MFGR. SALES | $1,000.5 |
| Dealers / Wholesalers | $293.0 |
| Boat Services | $423.4 |
| TOTAL RETAIL & SERVICES SALES | $716.5 |

BOAT BUILDING
MOTOR/ENG. MFGR.
ACC./SUPPLIES MFGR.
DLRS/WHOLESALERS
BOAT SERVICES




Source: NMMA's Center of Knowledge; Recreational Marine Research Center at Michigan State University

# Alabama sportsmen & women

## 948,000 hunters & anglers spent $1.9 billion in 2011

**SPORTSMEN BENEFIT THE STATE ECONOMY**

948,000 people (residents and non-residents) hunted or fished in Alabama in 2011, more than the combined populations of the five largest cities in the state - Birmingham, Montgomery, Mobile, Huntsville and Tuscaloosa (948,000 vs. 884,000).

Alabama's resident sportsmen and women could fill the University of Alabama's Bryant-Denny football stadium more than seven times (744,000 sportsmen vs. 101,821 seating capacity).

Sportsmen and women spent $1.9 billion on hunting and fishing in Alabama in 2011 - that is more than the state's revenues from all crops ($1.9 billion vs. $1.17 billion).

Hunters and anglers support more jobs in Alabama than Redstone Arsenal, the largest employer in the state (37,476 vs. 25,373).

Spending by sportsmen and women in Alabama generated $165 million in state and local taxes in 2011 - that's enough to support the average salaries of 4,151 police and sheriff's patrol officers.

**Every single state makes a contribution.**
**Here are the facts on Alabama's anglers and hunters.**

| SEGMENT | PARTICIPANTS | DAYS | SPENDING | JOBS |
|---|---|---|---|---|
| Total Sportsmen * | 948,000 | 12.2 million | $1.9 billion | 37,476 |
| Total Anglers * | 682,600 | 10.9 million | $736 million | 10,489 |
| Total Hunters * | 535,100 | 1.3 million | $1.2 billion | 27,257 |

*Data includes both residents and non-residents age 16 and up, and is a snapshot of participation and spending for 2011. Total Sportsmen does not equal the sum of Anglers and Hunters as some individuals both hunt and fish.

**Alabama Sportsmen & Women Support**

Spending per Day
**$5.3 million**

Salaries and Wages
**$933 million**

Federal Taxes
**$199 million**

State and Local Taxes
**$165 million**

Ripple Effect
**$2.9 billion**

# AN OUTDOOR NATION

Sportsmen and women spent $90 billion in 2011, that's more than the combined global sales of Apple's iPhone® and iPad® the same year.

**NATIONAL STATISTICS**

| PARTICIPANTS | SPENDING | JOBS | SALARIES / WAGES | TOTAL TAXES |
|---|---|---|---|---|
| **Sportsmen:** 37.4 million * | $90.0 billion ** | 1.5 million | $61.7 billion | $26.7 billion |
| **Anglers:** 33.1 million | $47.7 billion | 828,000 | $35.3 billion | $14.9 billion |
| **Hunters:** 13.7 million | $38.3 billion | 681,000 | $26.4 billion | $11.8 billion |

**ALABAMA STATISTICS & NATIONAL RANK**

| | | | | |
|---|---|---|---|---|
| 948,000 **#17** | $1.9 billion **#14** | 37,476 **#12** | $933 million **#14** | $364 million **#17** |

* Total Sportsmen are participants age 16 and up, does not equal the sum of Anglers and Hunters as some individuals both hunt and fish.
** Total angling and hunting expenditures do not add to Total Sportsmen spending due to expenditures not categorized specifically for either pursuit.

Since 1989 the Congressional Sportsmen's Foundation (CSF) has maintained a singleness of purpose that has guided the organization to become the most respected and trusted sportsmen's organization in the political arena. CSF's mission is to work with Congress, governors, and state legislatures to protect and advance hunting, recreational fishing and shooting and trapping. The unique and collective force of the Congressional Sportsmen's Caucus (CSC), the Governors Sportsmen's Caucus (GSC) and the National Assembly of Sportsmen's Caucuses (NASC), working closely with CSF, and with the support of major hunting, recreational fishing and shooting, and trapping organizations, serves as an unprecedented network of pro-sportsmen legislators that advance the agenda of America's hunters and anglers.

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**For more information visit www.sportsmenslink.org or call Cole Henry at 202-543-6850 x19.**

Congressional Sportsmen's Foundation 110 North Carolina Avenue, SE Washington, DC 20003

**Sources:** Hunting in America: An Economic Force for Conservation, National Shooting Sports Foundation; Fishing in America: An Economic Force for Conservation, American Sportfishing Association; 2011 National Survey of Fishing, Hunting and Wildlife Associated Recreation, US Fish & Wildlife Service.
Specific sources for state comparisons available on request, 202-543-6850.

American Sportfishing Association

*Leading the Way for Sportfishing's Future*

# SPORTFISHING in America

## AN ECONOMIC FORCE FOR CONSERVATION

SPORT FISH RESTORATION

JANUARY 2013

# This is Sportfishing in America

**DRIVE PAST ANY LAKE,** river or beach and odds are you will see people, even entire families, gathered along the shore or in boats fishing. Fishing is, after all, one of America's most enduring pastimes; something in which people of all ages can participate and an activity that millions of families and friends enjoy each year as a way to have fun together and spend time in the outdoors.

But fishing is more than just the thrill of the catch or a peaceful – and sometimes adventurous – escape. It's the foundation of an industry that supports more than 800,000 jobs involved in the manufacture, sale or provision of angling products and services, such as hotels, tackle retailers, boat builders, restaurants and more.

The U.S. Fish & Wildlife Service's (USFWS) *2011 National Survey of Fishing, Hunting and Wildlife-Associated Recreation* identifies fishing as one of the most popular outdoor recreational activities in the United States.

As many as 33 million people aged 16 or older participate in the activity, and spend $48 billion annually on equipment, licenses, trips and other fishing-related items or events.

These funds help create and support more than 828,000 jobs in the United States at a time when many industries are still coping with a challenging economic climate. In some rural areas, the dollars brought in through recreational fishing help support entire communities.

## Anglers support more than 828,000 JOBS in the U.S.

### WHAT IS THE AMERICAN SPORTFISHING ASSOCIATION?

The American Sportfishing Association (ASA) is the sportfishing industry's trade association committed to representing the interests of the entire sportfishing community.

We give the industry a unified voice, speaking out on behalf of sportfishing and boating industries, state and federal natural resource agencies, conservation organizations, angler advocacy groups and outdoor journalists when emerging laws and policies could significantly affect sportfishing business or sportfishing itself.

ASA invests in long-term ventures to ensure the industry will remain strong and prosperous, as well as safeguard and promote the enduring social, economic and conservation values of sportfishing in America.

ASA also gives America's 60 million anglers a voice in policy decisions that affect their ability to sustainably fish on our nation's waterways through KeepAmericaFishing,™ our angler advocacy campaign.

ASA also represents the interests of America's nearly 60 million anglers who generated $48 billion in retail sales with a $115 billion impact on the nation's economy creating employment for more than 828,000 people in 2011.

Even more important are the vital conservation benefits fishing generates for our nation's waters and fish. Since the passage of the 1950 Federal Aid in Sport Fish Restoration Act, anglers have paid a federal excise tax on fishing tackle. In 1985 those taxes were expanded to include the federal excise tax on motorboat fuel in what is now known as the Sport Fish Restoration and Boating Trust Fund.

These tax revenues are distributed annually to state fish and wildlife agencies to help fund projects and programs that directly benefit fish, habitat and, ultimately, anglers and other recreational water enthusiasts.

In 2010 alone, the excise tax on sportfishing tackle amounted to $390 million. Along with the $657 million contributed by anglers through fishing license fees and $403 million in private donations, anglers generated $1.45 billion for fisheries conservation efforts.

# The Economic Benefits of Sportfishing

**NEAR THE SANTEE-COOPER LAKES** in South Carolina, Strawberry Reservoir in Utah, Lake Okeechobee in Florida, the White River in Arkansas and countless other lakes, rivers and seaside areas across the U.S., there are many communities that depend on the dollars from recreational anglers and related tourism for many of their citizen's livelihoods.

From direct product and service providers such as marinas, fishing guides and tackle shops to the businesses that help anglers enjoy their experience on the water such as restaurants, gas stations and hotels, the $1,441 spent annually by the average American angler in 2011 supported jobs that generated $35 billion in salaries and wages. Examine anglers' expenditures and you'll find that over half went to purchase food, lodging, transportation and other travel items. The money spent by companies and employees supporting anglers created an economic multiplier effect with a $115 billion impact on the nation's economy in 2011.

## SO HOW MANY ANGLERS ARE THERE?

Fishing is enjoyed by people of all ages. No one is ever too young or too old to enjoy a day on the water enjoying nature and catching fish. Based on the U.S. Fish and Wildlife Service's (USFWS) 2011 survey, there are 33 million anglers in the United States over the age of 16. Previous surveys by the USFWS indicated there was one youth angler (under 16 years of age) for every 2.5 adults over 16 years of age who fished.

If this ratio still holds, there are 13 million youths who fished in 2011, for a total of approximately 46 million anglers. Recent examinations of state fishing license records indicate many anglers will not buy a license every year.

Possibly one-third to one-half of people who consider themselves anglers may not be able to fish in a given year due to a variety of reasons.

Overall, ASA estimates approximately 60 million Americans may consider themselves to be anglers, regardless of buying a license in any one given year.

## Economic Contributions by Type of Fishing

| | All Fishing | Freshwater | Saltwater | Great Lakes |
|---|---|---|---|---|
| Anglers | 33,111,674 | 27,059,745 | 8,888,832 | 1,664,824 |
| Expenditures/Retail Sales | $47,697,532,293 | $30,601,946,954 | $13,416,585,025 | $2,971,195,133 |
| Total Multiplier Effect (Economic Output) | $114,531,945,219 | $73,323,352,261 | $32,279,006,619 | $7,227,424,732 |
| Salaries and Wages | $35,259,134,752 | $22,195,330,849 | $9,922,342,619 | $2,205,174,067 |
| Jobs | 828,133 | 518,270 | 243,226 | 49,298 |
| Contribution to Gross Domestic Product (GDP) | $61,721,729,003 | $39,202,948,762 | $17,446,689,683 | $3,797,932,801 |
| Federal, State and Local Taxes | $14,955,905,485 | $9,530,277,934 | $4,242,361,691 | $918,163,495 |

## Top 10 States Ranked by Angler Expenditures

| Rank | State | Total Expenditures | Number of Anglers |
|---|---|---|---|
| 1. | Florida | $4,953,493,028 | 3,091,952 |
| 2. | New York | $2,696,583,564 | 1,882,280 |
| 3. | Michigan | $2,465,535,795 | 1,744,206 |
| 4. | Minnesota | $2,440,230,389 | 1,561,881 |
| 5. | California | $2,393,961,476 | 1,673,633 |
| 6. | Texas | $2,014,497,308 | 2,246,367 |
| 7. | Ohio | $1,903,619,503 | 1,341,657 |
| 8. | North Carolina | $1,655,538,064 | 1,524,578 |
| 9. | Wisconsin | $1,459,883,024 | 1,246,775 |
| 10. | Virginia | $1,407,011,422 | 832,641 |

## Top 10 States: Non-Resident Fishing Destinations Ranked by Number of Visiting Anglers

| Rank | State | Number of Non-Resident Anglers | Total Non-Resident Expenditures |
|---|---|---|---|
| 1. | Florida | 1,197,279 | $898,283,876 |
| 2. | Michigan | 347,029 | $326,337,857 |
| 3. | Wisconsin | 336,753 | $445,006,874 |
| 4. | North Carolina | 328,810 | $260,296,738 |
| 5. | Alaska | 327,418 | $361,768,322 |
| 6. | New York | 297,070 | $282,573,249 |
| 7. | Oregon | 264,424 | $241,771,577 |
| 8. | Minnesota | 259,324 | $364,108,877 |
| 9. | New Jersey | 256,950 | $106,323,764 |
| 10. | Missouri | 244,290 | $205,686,074 |

*Angler numbers grew*
**11 PERCENT**
*since 2006*

### U.S. FISHING FACTS

- There are approximately 60 million anglers in the U.S. of which 46 million are estimated to fish in a given year.
- Anglers generate $48 billion in retail sales.
- Recreational fishing has a $115 billion impact on the nation's economy.
- Recreational fishing generates $15 billion in state and federal taxes.
- More than 828,000 jobs are supported through recreational fishing.
- One of every four anglers fishes in saltwater.
- Fishing tackle sales grew over 16 percent in the past five years.
- Since 2006, angler numbers grew 11 percent.

# Thank an Angler!

**DID YOU KNOW**

- Recreational fishing – both fresh and saltwater combined – ranks higher than bowling or playing basketball, softball or soccer, according to data from the National Sporting Goods Association.
- More Americans fish than play golf (21 million) and tennis (13 million) combined.
- If fishing were a company, the amount spent by anglers to support fishing-related retail sales would rank number 51 on the Fortune 500™ list.
- Fishing generated more revenue ($48 billion) than Lockheed Martin ($47 billion), Intel ($44 billion), Chrysler ($42 billion) or Google ($38 billion).
- The economic activity generated by sportfishing is greater than the economies, measured in Gross State Product, of 17 states.
- At more than 46 million anglers in 2011, more than twice the number of people fished in 2011 than attended every NFL game combined.

**THANK AMERICA'S ANGLERS** if you enjoy clean, healthy lakes, rivers and oceans teaming with a dynamic variety of fish and shorebird species, since it's their dollars that provide the bulk of the funding for our nation's fisheries conservation and environmental success.

In fact, you would be hard pressed to find any group of people in the country who contributes more: nearly $1.5 billion annually. And angler numbers are growing – 11 percent overall in the five years since the last national survey. In fact, accounting for regional variations, some angling demographics actually increased by a larger percentage, including Great Lakes anglers, whose numbers grew by 17 percent and saltwater anglers, whose numbers increased by 15 percent.

This growing legion of anglers is the economic engine that helps keep fisheries conservation moving successfully forward through the purchase of fishing licenses, which go directly toward the operations of state fish and wildlife agencies, and through the federal excise tax on fishing tackle as part of the long-running Sport Fish Restoration and Boating Trust Fund.

License sales in 2010 amounted to $657 million, while the excise taxes collected on the sale of fishing gear, boats and boat fuel added another $390 million in support of conservation efforts carried out in each state. It's a model that virtually powers itself.

In addition, anglers donate over $400 million more each year to various conservation and fishing organizations. Without fish and good habitat, there would be no anglers, and without anglers – men, women and children – there would be few fish and little quality habitat.

The year 2012 marked the 75th anniversary of our nation's system of conservation funding – a model that is envied throughout the world – that directs excise taxes on fishing and hunting gear toward state-based conservation. The Sport Fish Restoration and Boating Trust Fund has resulted in robust fish and wildlife populations and quality habitat that is the legacy of the sportfishing industry and sportsmen and women alike.

# Number of Anglers and Days of Fishing by State in 2011*

| | Total Anglers† | Non-Resident Anglers | Total Fishing Days†† | Total Non-Resident Fishing Days | Freshwater Anglers | Freshwater Fishing Days | Saltwater Anglers | Saltwater Fishing Days | Great Lakes Anglers | Great Lakes Fishing Days |
|---|---|---|---|---|---|---|---|---|---|---|
| Alaska | 537,927 | 327,418 | 4,360,282 | 1,287,096 | 301,976 | 2,995,374 | 333,747 | 1,446,457 | - | - |
| Alabama | 682,625 | 209,661 | 10,878,339 | 973,788 | 597,773 | 9,745,750 | 133,676 | 1,490,312 | - | - |
| Arkansas | 554,861 | 96,667 | 15,661,592 | 606,738 | 554,861 | 15,661,592 | - | - | - | - |
| Arizona | 636,966 | 104,385 | 4,825,183 | 684,382 | 636,966 | 4,825,183 | - | - | - | - |
| California | 1,673,633 | 97,967 | 23,753,676 | 486,605 | 1,352,402 | 17,382,021 | 775,329 | 7,192,655 | - | - |
| Colorado | 767,365 | 174,817 | 8,433,019 | 942,862 | 767,365 | 8,433,019 | - | - | - | - |
| Connecticut | 341,995 | 65,349 | 4,704,820 | 309,996 | 243,285 | 3,518,120 | 164,864 | 1,291,469 | - | - |
| Delaware | 165,935 | 106,807 | 2,051,866 | 723,793 | 54,724 | 654,925 | 138,392 | 1,338,609 | - | - |
| Florida | 3,091,952 | 1,197,279 | 57,593,836 | 9,543,924 | 1,214,263 | 25,729,028 | 2,397,610 | 36,347,826 | - | - |
| Georgia | 828,869 | 64,872 | 8,728,549 | 272,829 | 762,738 | 8,106,020 | 139,294 | 727,593 | - | - |
| Hawaii | 156,720 | 53,103 | 1,881,789 | 176,750 | 10,113 | 84,643 | 155,126 | 1,793,516 | - | - |
| Iowa | 473,307 | 57,522 | 5,977,722 | 187,449 | 473,307 | 5,977,722 | - | - | - | - |
| Idaho | 446,718 | 208,418 | 5,506,803 | 3,341,667 | 446,718 | 5,506,803 | - | - | - | - |
| Illinois | 1,043,780 | 88,333 | 13,343,239 | 396,939 | 936,501 | 12,312,455 | - | - | 69,300 | 147,545 |
| Indiana | 800,749 | 80,583 | 20,774,883 | 536,779 | 716,309 | 19,324,014 | - | - | 26,691 | 113,863 |
| Kansas | 400,291 | 28,059 | 4,163,391 | 74,984 | 400,291 | 4,163,391 | - | - | - | - |
| Kentucky | 554,163 | 102,860 | 10,245,109 | 859,669 | 554,163 | 10,245,109 | - | - | - | - |
| Louisiana | 824,949 | 125,028 | 18,079,467 | 493,704 | 719,933 | 16,665,476 | 195,798 | 1,532,519 | - | - |
| Massachusetts | 531,707 | 154,583 | 8,367,439 | 778,903 | 294,264 | 4,499,001 | 323,077 | 4,048,841 | - | - |
| Maryland | 426,065 | 79,509 | 4,710,872 | 550,468 | 227,210 | 3,159,998 | 223,921 | 1,533,112 | - | - |
| Maine | 341,154 | 148,635 | 3,873,441 | 976,016 | 283,268 | 3,223,132 | 133,226 | 755,746 | - | - |
| Michigan | 1,744,206 | 347,029 | 28,177,222 | 2,163,703 | 1,360,860 | 20,961,114 | - | - | 649,639 | 10,987,320 |
| Minnesota | 1,561,881 | 259,324 | 21,702,319 | 1,743,039 | 1,413,210 | 20,768,202 | - | - | 45,578 | 206,745 |
| Missouri | 1,071,487 | 244,290 | 14,865,153 | 1,602,573 | 1,071,487 | 14,865,153 | - | - | - | - |
| Mississippi | 650,905 | 50,986 | 9,175,753 | 674,787 | 609,386 | 7,751,207 | 120,161 | 2,293,475 | - | - |
| Montana | 267,213 | 82,129 | 2,449,880 | 358,495 | 267,213 | 2,449,880 | - | - | - | - |
| North Carolina | 1,524,578 | 328,810 | 23,471,581 | 1,532,266 | 1,053,713 | 15,763,631 | 632,341 | 4,503,751 | - | - |
| North Dakota** | - | - | - | - | - | - | - | - | - | - |
| Nebraska | 206,967 | 30,209 | 2,594,636 | 102,110 | 206,967 | 2,594,636 | - | - | - | - |
| New Hampshire | 228,087 | 75,412 | 4,369,752 | 499,357 | 208,913 | 3,606,384 | 49,171 | 730,144 | - | - |
| New Jersey | 766,085 | 256,950 | 9,454,230 | 1,367,089 | 258,108 | 2,679,638 | 603,966 | 7,019,976 | - | - |
| New Mexico | 278,016 | 65,264 | 3,899,329 | 277,548 | 278,016 | 3,899,329 | - | - | - | - |
| Nevada | 146,541 | 32,139 | 1,400,222 | 104,879 | 146,541 | 1,400,222 | - | - | - | - |
| New York | 1,882,280 | 297,070 | 29,874,128 | 2,070,604 | 1,212,213 | 19,199,694 | 800,811 | 7,683,521 | 331,774 | 4,484,574 |
| Ohio | 1,341,657 | 84,998 | 16,873,802 | 609,419 | 1,160,578 | 14,039,907 | - | - | 343,626 | 2,160,773 |
| Oklahoma | 729,191 | 49,102 | 8,499,045 | 555,566 | 729,191 | 8,499,045 | - | - | - | - |
| Oregon | 637,746 | 264,424 | 5,658,437 | 1,262,784 | 516,149 | 5,201,489 | 176,521 | 607,738 | - | - |
| Pennsylvania | 1,101,173 | 210,020 | 10,136,323 | 1,772,198 | 874,082 | 8,906,314 | - | - | 119,742 | 387,356 |
| Rhode Island | 174,882 | 96,061 | 2,079,990 | 500,635 | 41,983 | 738,755 | 151,138 | 1,430,260 | - | - |
| South Carolina | 743,818 | 182,404 | 11,188,820 | 702,047 | 537,136 | 9,221,130 | 305,063 | 2,318,090 | - | - |
| South Dakota | 267,862 | 111,687 | 4,068,780 | 543,548 | 267,862 | 4,068,780 | - | - | - | - |
| Tennessee | 826,293 | 116,875 | 16,956,832 | 915,811 | 826,293 | 16,956,832 | - | - | - | - |
| Texas | 2,246,367 | 113,748 | 30,667,265 | 1,095,014 | 1,757,691 | 22,616,480 | 750,759 | 8,157,241 | - | - |
| Utah | 413,568 | 70,130 | 5,979,364 | 606,114 | 413,568 | 5,979,364 | - | - | - | - |
| Virginia | 832,641 | 184,089 | 10,520,649 | 1,153,474 | 551,316 | 7,903,627 | 428,584 | 2,771,687 | - | - |
| Vermont | 207,014 | 112,395 | 2,215,244 | 463,883 | 207,014 | 2,215,244 | - | - | - | - |
| Washington | 938,053 | 102,562 | 13,448,784 | 341,327 | 743,336 | 10,939,821 | 401,377 | 2,699,664 | - | - |
| Wisconsin | 1,246,775 | 336,753 | 21,283,610 | 6,707,662 | 1,106,738 | 19,950,280 | - | - | 178,268 | 1,246,411 |
| West Virginia | 305,122 | 83,501 | 4,521,064 | 249,664 | 305,122 | 4,521,064 | - | - | - | - |
| Wyoming | 302,758 | 193,076 | 5,340,231 | 3,331,254 | 302,758 | 5,340,231 | - | - | - | - |
| **United States** | **33,111,674** | **6,963,989** | **553,841,086** | **57,528,963** | **27,059,745** | **443,222,665** | **8,888,832** | **99,473,902** | **1,664,824** | **19,660,829** |

* These numbers only report the number of anglers 16 years and older. Detailed data were not available for anglers 6–15 years of age. ** North Dakota has expressed concerns regarding their estimated number of anglers. Please refer to license data for alternate estimates. † Includes resident and non-resident anglers. †† Includes resident and non-resident fishing days. Source: *2011 National Survey of Fishing, Hunting and Wildlife-Associated Recreation*, U.S. Fish and Wildlife Service.

# Economic Impact of Sportfishing by State, All Types of Fishing in 2011

| | Retail Sales | Total Multiplier or Ripple Effect | Salaries and Wages | Jobs | Federal Tax Revenues | State and Local Tax Revenues |
|---|---|---|---|---|---|---|
| Alaska† | $718,452,401 | $1,073,716,980 | $358,679,292 | 9,992 | $73,987,017 | $86,459,590 |
| Alabama | $736,194,840 | $1,103,378,857 | $320,214,191 | 10,489 | $70,240,159 | $61,184,997 |
| Arkansas | $517,364,731 | $740,783,174 | $232,560,542 | 7,801 | $51,806,775 | $50,109,458 |
| Arizona | $893,418,656 | $1,514,085,259 | $490,946,268 | 12,505 | $108,821,355 | $89,281,673 |
| California | $2,393,961,476 | $4,580,356,969 | $1,573,094,107 | 35,748 | $365,552,269 | $334,401,009 |
| Colorado | $857,405,955 | $1,350,633,849 | $430,026,121 | 10,338 | $102,804,411 | $83,185,649 |
| Connecticut | $446,137,179 | $762,966,357 | $273,332,655 | 6,625 | $68,287,470 | $53,723,252 |
| Delaware | $109,167,791 | $149,140,677 | $42,741,504 | 1,319 | $11,259,350 | $11,951,595 |
| Florida | $4,953,493,028 | $8,663,464,085 | $2,702,670,214 | 80,211 | $685,323,663 | $516,516,023 |
| Georgia | $1,306,650,305 | $2,104,417,872 | $622,480,242 | 15,644 | $147,791,801 | $109,281,377 |
| Hawaii | $239,713,712 | $331,199,373 | $106,579,841 | 3,007 | $21,788,329 | $22,394,047 |
| Iowa | $330,071,230 | $486,330,879 | $146,685,016 | 4,574 | $33,646,934 | $29,792,679 |
| Idaho | $548,392,876 | $756,524,527 | $229,664,505 | 7,252 | $54,084,065 | $49,541,983 |
| Illinois | $1,020,000,407 | $1,731,374,441 | $548,144,825 | 13,548 | $136,903,628 | $118,506,781 |
| Indiana | $693,739,202 | $1,056,572,919 | $325,000,798 | 10,293 | $78,919,648 | $76,365,973 |
| Kansas | $224,448,862 | $321,315,860 | $103,609,537 | 3,131 | $24,807,182 | $21,997,805 |
| Kentucky | $862,888,495 | $1,254,442,696 | $361,029,199 | 12,059 | $82,294,089 | $69,516,147 |
| Louisiana | $958,784,822 | $1,452,463,864 | $453,441,513 | 13,265 | $93,009,897 | $93,390,154 |
| Massachusetts | $475,486,261 | $829,874,861 | $303,259,366 | 7,213 | $72,009,674 | $55,746,533 |
| Maryland | $549,436,134 | $844,266,915 | $258,791,438 | 6,209 | $61,010,190 | $51,680,339 |
| Maine | $395,692,015 | $614,401,445 | $201,165,974 | 6,723 | $44,501,743 | $42,878,034 |
| Michigan | $2,465,535,795 | $4,270,036,038 | $1,447,918,090 | 37,989 | $335,597,718 | $287,082,977 |
| Minnesota | $2,440,230,389 | $4,199,672,948 | $1,311,490,021 | 35,462 | $319,557,705 | $264,335,621 |
| Missouri | $692,954,973 | $1,126,041,058 | $361,357,550 | 10,842 | $84,547,273 | $73,509,816 |
| Mississippi | $902,096,726 | $1,242,395,964 | $349,050,297 | 11,073 | $73,449,699 | $74,823,920 |
| Montana | $349,913,031 | $499,332,328 | $147,910,383 | 5,375 | $38,361,371 | $36,895,735 |
| North Carolina | $1,655,538,064 | $2,710,255,374 | $899,667,215 | 25,712 | $203,218,395 | $177,290,388 |
| North Dakota†† | $74,100,683 | $105,958,178 | $34,859,486 | 1,210 | $7,626,233 | $9,436,565 |
| Nebraska | $217,640,644 | $335,635,429 | $106,275,569 | 3,230 | $23,561,091 | $21,225,298 |
| New Hampshire | $210,095,175 | $332,818,486 | $114,048,866 | 3,614 | $27,758,574 | $23,905,031 |
| New Jersey | $1,146,551,669 | $1,866,013,788 | $583,147,807 | 15,386 | $158,769,630 | $137,228,333 |
| New Mexico | $433,283,763 | $607,518,472 | $186,044,225 | 5,487 | $40,433,851 | $42,284,888 |
| Nevada | $189,689,911 | $279,450,004 | $92,700,327 | 2,268 | $21,025,417 | $16,507,952 |
| New York | $2,696,583,564 | $4,475,253,164 | $1,526,230,881 | 32,317 | $356,339,771 | $332,964,752 |
| Ohio | $1,903,619,503 | $2,925,344,790 | $789,311,723 | 26,354 | $208,530,370 | $203,191,366 |
| Oklahoma | $821,069,868 | $1,161,687,253 | $301,144,447 | 11,342 | $84,503,409 | $77,341,322 |
| Oregon | $680,636,132 | $1,172,481,577 | $382,802,979 | 11,043 | $91,781,493 | $72,381,359 |
| Pennsylvania | $502,996,175 | $853,281,964 | $303,917,251 | 9,587 | $72,812,786 | $59,880,258 |
| Rhode Island | $135,428,891 | $207,341,447 | $73,301,720 | 2,056 | $17,264,447 | $15,484,543 |
| South Carolina | $865,561,873 | $1,328,324,440 | $431,065,953 | 19,994 | $104,618,601 | $74,244,785 |
| South Dakota | $313,888,605 | $421,892,121 | $126,326,966 | 3,747 | $28,801,493 | $25,108,727 |
| Tennessee | $1,279,223,286 | $2,051,674,603 | $690,098,985 | 17,542 | $149,376,195 | $112,094,480 |
| Texas | $2,014,497,308 | $3,608,911,137 | $1,144,653,689 | 29,824 | $260,143,658 | $195,917,234 |
| Utah | $489,764,385 | $799,945,482 | $253,475,908 | 7,207 | $56,338,487 | $49,702,967 |
| Virginia | $1,407,011,422 | $2,138,776,268 | $642,302,699 | 18,672 | $164,573,465 | $139,406,127 |
| Vermont | $147,111,097 | $225,001,690 | $73,224,447 | 2,420 | $17,139,314 | $15,966,003 |
| Washington | $1,186,275,897 | $1,956,335,653 | $625,222,636 | 16,211 | $150,271,880 | $119,631,627 |
| Wisconsin | $1,459,883,024 | $2,267,459,700 | $667,112,559 | 21,542 | $166,477,700 | $148,668,219 |
| West Virginia | $448,099,697 | $626,474,347 | $199,013,407 | 7,208 | $45,426,838 | $45,289,085 |
| Wyoming | $476,766,960 | $664,347,694 | $238,166,287 | 9,008 | $54,828,250 | $28,364,285 |
| **United States†††** | **$47,697,532,293** | **$114,531,945,219** | **$35,259,134,752** | **828,133** | **$8,224,085,681** | **$6,731,819,804** |

† The Alaska Department of Fish and Game (ADFG) has expressed concern regarding the expenditure estimates from the USFWS National Survey. Readers may wish to defer to economic statistics produced by the ADFG. †† North Dakota has expressed concerns regarding their estimated number of anglers. Please refer to license data for alternate estimates. † Includes resident and non-resident anglers. ††† The sum of the states is about one percent less than the U.S. total. The difference comes from anglers unable to assign some expenditures to any specific state. For example, an online purchase that is then used in multiple states.

# Economic Impact of Freshwater Fishing by State in 2011

| | Retail Sales | Total Multiplier or Ripple Effect | Salaries and Wages | Jobs | Federal Tax Revenues | State and Local Tax Revenues |
|---|---|---|---|---|---|---|
| Alaska† | $390,455,542 | $580,993,450 | $188,878,215 | 5,261 | $38,988,480 | $48,168,228 |
| Alabama | $514,154,996 | $776,012,671 | $231,866,667 | 7,845 | $51,356,071 | $47,232,865 |
| Arkansas | $507,855,831 | $725,249,570 | $222,334,267 | 7,549 | $49,830,096 | $49,462,412 |
| Arizona | $862,298,181 | $1,456,854,992 | $464,810,603 | 12,007 | $103,458,290 | $86,916,175 |
| California | $1,417,629,003 | $2,704,701,141 | $921,946,336 | 21,515 | $213,770,199 | $198,127,762 |
| Colorado | $836,049,866 | $1,314,006,542 | $408,940,231 | 9,942 | $98,445,119 | $81,477,253 |
| Connecticut | $168,308,427 | $285,969,244 | $101,365,735 | 2,437 | $25,817,247 | $22,305,922 |
| Delaware | $12,759,486 | $18,206,232 | $6,146,028 | 173 | $1,366,397 | $1,347,706 |
| Florida | $977,018,002 | $1,689,575,866 | $520,689,055 | 14,040 | $129,932,870 | $97,608,385 |
| Georgia | $993,650,535 | $1,607,081,758 | $487,200,968 | 12,536 | $116,498,117 | $87,783,143 |
| Hawaii | $22,549,618 | $26,394,773 | $7,654,418 | 202 | $1,555,053 | $1,511,733 |
| Iowa | $323,260,844 | $475,156,512 | $140,198,334 | 4,427 | $32,357,375 | $29,249,470 |
| Idaho | $515,737,238 | $705,277,170 | $198,543,657 | 6,556 | $47,820,014 | $47,230,834 |
| Illinois | $933,451,515 | $1,572,737,782 | $489,634,660 | 12,359 | $123,703,047 | $108,596,388 |
| Indiana | $663,443,749 | $1,008,810,558 | $305,769,530 | 9,805 | $74,639,593 | $73,766,433 |
| Kansas | $217,603,874 | $310,007,835 | $96,152,266 | 2,949 | $23,345,989 | $21,514,041 |
| Kentucky | $854,326,602 | $1,240,022,840 | $351,612,169 | 11,852 | $80,542,340 | $68,902,310 |
| Louisiana | $603,081,322 | $912,819,899 | $286,114,887 | 8,363 | $58,543,402 | $58,539,594 |
| Massachusetts | $146,228,713 | $248,215,828 | $86,510,958 | 2,127 | $21,027,310 | $17,769,876 |
| Maryland | $406,854,404 | $609,146,140 | $175,756,757 | 4,020 | $41,246,734 | $34,308,875 |
| Maine | $273,456,161 | $423,408,882 | $133,834,888 | 4,530 | $29,995,120 | $30,603,293 |
| Michigan | $1,141,036,276 | $1,940,341,027 | $619,087,513 | 17,156 | $151,007,274 | $139,166,532 |
| Minnesota | $2,320,146,413 | $3,979,217,295 | $1,221,563,596 | 33,209 | $298,670,300 | $250,000,060 |
| Missouri | $669,761,464 | $1,085,076,122 | $340,945,086 | 10,344 | $80,313,790 | $71,249,964 |
| Mississippi | $458,656,309 | $628,772,461 | $176,510,964 | 5,637 | $37,179,379 | $38,483,041 |
| Montana | $304,116,923 | $429,227,798 | $121,015,027 | 4,550 | $31,965,362 | $31,747,501 |
| North Carolina | $749,934,465 | $1,217,456,822 | $401,839,252 | 11,193 | $90,604,288 | $80,734,150 |
| North Dakota†† | $72,738,103 | $103,821,939 | $33,397,440 | 1,172 | $7,332,526 | $9,298,340 |
| Nebraska | $210,607,924 | $323,918,163 | $100,219,885 | 3,076 | $22,334,717 | $20,600,233 |
| New Hampshire | $111,642,050 | $176,596,227 | $59,201,639 | 2,107 | $14,556,731 | $13,038,996 |
| New Jersey | $262,822,407 | $408,936,065 | $115,583,385 | 3,241 | $34,755,733 | $32,470,409 |
| New Mexico | $424,936,372 | $594,033,549 | $177,278,250 | 5,302 | $38,739,719 | $41,732,726 |
| Nevada | $182,050,470 | $266,826,141 | $85,889,466 | 2,152 | $19,585,371 | $15,930,980 |
| New York | $839,301,301 | $1,391,576,734 | $458,897,320 | 9,296 | $109,158,992 | $108,124,836 |
| Ohio | $1,391,620,187 | $2,119,747,271 | $557,269,663 | 18,811 | $149,620,126 | $148,527,683 |
| Oklahoma | $807,515,605 | $1,139,429,364 | $289,927,606 | 11,087 | $82,215,304 | $76,125,399 |
| Oregon | $500,852,664 | $869,271,534 | $275,042,949 | 8,324 | $66,820,783 | $53,955,770 |
| Pennsylvania | $416,652,083 | $699,865,663 | $242,733,277 | 8,037 | $58,514,838 | $49,157,022 |
| Rhode Island | $25,085,633 | $36,474,752 | $12,371,219 | 353 | $2,940,532 | $2,761,925 |
| South Carolina | $586,834,001 | $897,282,708 | $290,463,989 | 9,147 | $71,195,126 | $52,216,395 |
| South Dakota | $306,541,212 | $410,560,590 | $118,778,351 | 3,558 | $27,307,291 | $24,780,875 |
| Tennessee | $1,260,605,320 | $2,016,625,907 | $668,289,864 | 17,075 | $145,112,186 | $111,056,978 |
| Texas | $851,982,068 | $1,523,351,447 | $473,541,236 | 12,363 | $109,709,319 | $87,191,653 |
| Utah | $473,976,891 | $771,520,958 | $239,040,209 | 6,858 | $53,393,817 | $48,109,528 |
| Virginia | $864,064,448 | $1,295,588,707 | $385,885,573 | 11,496 | $101,313,898 | $86,658,382 |
| Vermont | $143,159,827 | $218,407,554 | $69,206,280 | 2,334 | $16,321,636 | $15,667,826 |
| Washington | $795,510,532 | $1,305,274,510 | $404,765,504 | 10,617 | $97,314,507 | $79,136,421 |
| Wisconsin | $1,302,884,529 | $2,005,402,272 | $565,658,587 | 18,696 | $143,422,987 | $132,312,905 |
| West Virginia | $442,571,467 | $617,811,663 | $193,105,034 | 7,063 | $44,293,906 | $44,918,702 |
| Wyoming | $458,137,962 | $637,595,532 | $219,406,253 | 8,623 | $50,788,226 | $27,681,561 |
| **United States†††** | **$30,601,946,954** | **$73,323,352,261** | **$22,195,330,849** | **518,270** | **$5,203,555,134** | **$4,326,722,800** |

† The Alaska Department of Fish and Game (ADFG) has expressed concern regarding the expenditure estimates from the USFWS National Survey. Readers may wish to defer to economic statistics produced by the ADFG. †† North Dakota has expressed concerns regarding their estimated number of anglers. Please refer to license data for alternate estimates. † Includes resident and non-resident anglers. ††† Small sample size (N = 10 to 30). Use results with caution.

## Economic Impact of Saltwater Fishing by State in 2011

| | Retail Sales | Total Multiplier or Ripple Effect | Salaries and Wages | Jobs | Federal Tax Revenues | State and Local Tax Revenues |
|---|---|---|---|---|---|---|
| Alaska† | $311,177,096 | $466,252,320 | $152,337,216 | 4,433 | $31,697,538 | $37,115,124 |
| Alabama | $214,726,406 | $315,069,227 | $80,304,577 | 2,469 | $17,369,339 | $13,487,212 |
| California | $912,235,607 | $1,747,276,278 | $577,058,036 | 13,118 | $136,555,869 | $129,364,106 |
| Connecticut | $271,891,817 | $466,370,051 | $165,692,344 | 4,098 | $41,070,915 | $30,924,256 |
| Delaware | $94,590,653 | $127,988,831 | $34,608,759 | 1,108 | $9,515,007 | $10,475,916 |
| Florida | $3,929,115,544 | $6,882,928,390 | $2,128,186,840 | 65,212 | $544,013,771 | $416,193,512 |
| Georgia | $305,666,072 | $483,602,702 | $126,750,273 | 2,916 | $29,633,102 | $20,969,298 |
| Hawaii | $216,771,862 | $304,176,449 | $98,508,995 | 2,799 | $20,158,621 | $20,855,905 |
| Louisiana | $347,327,388 | $525,289,616 | $158,364,227 | 4,715 | $32,886,617 | $34,333,181 |
| Massachusetts | $318,845,787 | $562,140,196 | $204,708,079 | 4,883 | $48,461,966 | $36,975,236 |
| Maryland | $133,088,741 | $218,824,482 | $74,609,468 | 2,017 | $17,929,654 | $16,321,873 |
| Maine | $114,313,954 | $177,376,020 | $58,820,997 | 1,998 | $12,846,727 | $11,623,291 |
| Mississippi | $432,212,327 | $595,877,028 | $162,505,447 | 5,179 | $34,355,118 | $35,410,551 |
| North Carolina | $893,331,115 | $1,470,948,574 | $484,129,047 | 14,242 | $109,926,749 | $95,589,405 |
| New Hampshire | $94,020,755 | $148,441,418 | $49,740,602 | 1,404 | $12,128,037 | $10,585,712 |
| New Jersey | $877,537,326 | $1,445,381,080 | $460,135,873 | 12,031 | $122,387,262 | $104,220,972 |
| New York | $1,194,493,042 | $1,964,723,139 | $668,641,794 | 15,371 | $156,054,231 | $144,539,079 |
| Oregon | $159,652,843 | $266,684,168 | $85,095,404 | 2,281 | $20,211,625 | $16,519,806 |
| Rhode Island | $108,549,235 | $167,786,994 | $58,942,571 | 1,670 | $13,901,720 | $12,589,140 |
| South Carolina | $268,108,559 | $413,203,002 | $131,247,177 | 10,615 | $31,432,323 | $21,173,825 |
| Texas | $1,134,814,020 | $2,032,731,533 | $639,017,620 | 16,819 | $144,213,917 | $107,129,706 |
| Virginia | $531,253,307 | $823,163,178 | $244,056,471 | 6,944 | $60,725,533 | $51,846,802 |
| Washington | $359,774,539 | $594,762,381 | $185,140,688 | 4,966 | $45,412,088 | $38,873,569 |
| **United States††** | **$13,416,585,025** | **$32,279,006,619** | **$9,922,342,619** | **243,226** | **$2,320,704,050** | **$1,921,657,641** |

† The Alaska Department of Fish and Game (ADFG) has expressed concern regarding the expenditure estimates from the USFWS National Survey. Readers may wish to defer to economic statistics produced by the ADFG.

†† Small sample size (N = 10 to 30). Use results with caution.

††† Includes impacts from purchases made in inland states for saltwater fishing.

## Economic Impact of Great Lakes Fishing by State in 2011

| | Retail Sales | Total Multiplier or Ripple Effect | Salaries and Wages | Jobs | Federal Tax Revenues | State and Local Tax Revenues |
|---|---|---|---|---|---|---|
| Illinois† | $58,496,056 | $105,389,187 | $34,388,935 | 786 | $7,937,752 | $6,632,357 |
| Indiana† | $18,918,669 | $27,872,459 | $7,114,508 | 213 | $1,848,465 | $1,677,907 |
| Michigan | $1,272,352,928 | $2,231,549,094 | $774,938,502 | 19,805 | $173,310,482 | $142,872,247 |
| Minnesota† | $85,158,787 | $154,284,123 | $51,378,186 | 1,494 | $12,731,265 | $11,031,513 |
| New York | $612,789,066 | $1,029,998,139 | $340,811,049 | 6,787 | $79,185,366 | $74,954,828 |
| Ohio | $486,482,882 | $759,942,999 | $207,718,420 | 7,048 | $54,068,658 | $52,021,856 |
| Pennsylvania† | $55,208,013 | $95,433,266 | $31,861,877 | 891 | $7,925,634 | $7,315,635 |
| Wisconsin | $114,344,635 | $185,460,010 | $56,867,409 | 1,883 | $13,810,484 | $12,540,282 |
| **United States††** | **$2,971,195,133** | **$7,227,424,732** | **$2,205,174,067** | **49,298** | **$509,320,381** | **$408,843,114** |

† Small sample size (N = 10 to 30). Use results with caution.

†† Includes impacts from purchases made in inland states for Great Lakes fishing.

# U.S. Angler Expenditures by Category in 2011

| | All Anglers | Non-Residents |
|---|---|---|
| **Travel Expenditures** | **$21,789,464,736** | **$5,046,171,594** |
| Food | $5,435,208,401 | $1,167,075,187 |
| Lodging | $2,276,110,085 | $948,887,420 |
| Airfare | $622,043,680 | $306,590,480 |
| Public transportation | $181,726,928 | $152,377,596 |
| Private transportation | $5,457,765,693 | $1,106,909,980 |
| Boat fuel | $2,209,006,533 | $232,069,910 |
| Guides | $1,102,375,347 | $628,563,276 |
| Public land use fees | $237,886,684 | $24,443,922 |
| Private land use fees | $243,705,059 | $39,845,900 |
| Boat launching | $159,626,613 | $12,984,120 |
| Boat mooring | $1,447,185,966 | $81,558,389 |
| Equipment rental | $245,547,365 | $78,882,616 |
| Bait (live, cut, prepared) | $1,497,444,900 | $155,960,368 |
| Ice | $509,494,150 | $91,775,505 |
| Heating and cooking fuel | $164,337,331 | $18,246,927 |
| **Fishing Equipment Expenditures** | **$6,141,895,285** | **$625,615,511** |
| Rods, reels and components | $2,366,773,897 | $308,271,684 |
| Lines and leaders | $593,397,572 | $63,736,755 |
| Lures, flies and artificial bait | $1,169,092,498 | $105,364,698 |
| Hooks, sinkers and other terminal tackle | $628,600,283 | $44,797,654 |
| Tackle boxes | $141,788,645 | $6,698,559 |
| Creels, stringers and landing nets | $131,514,992 | $8,067,437 |
| Bait buckets and minnow traps | $81,007,729 | $2,844,077 |
| Depth finder, fish finders and other electronics | $469,849,315 | $50,772,714 |
| Ice fishing equipment | $241,328,298 | $6,238,598 |
| Other fishing equipment | $318,542,055 | $28,823,336 |
| **Auxiliary Purchases for Fishing** | **$1,014,370,726** | **$97,843,446** |
| Camping gear | $483,399,663 | $25,446,307 |
| Binoculars | $107,278,051 | $21,511,474 |
| Special fishing clothing and foul weather gear | $423,693,011 | $50,885,665 |
| **Special Equipment Purchased for Fishing** | **$13,683,810,379** | **$1,077,927,233** |
| Bass boats | $1,037,787,838 | $2,549,720 |
| Other motorized boats | $2,453,520,343 | $348,601,670 |
| Canoes and non-motorized boats | $202,356,326 | $8,777,092 |
| Boat motors, trailers and hitches | $1,219,780,914 | $367,972,106 |
| Pick-ups, campers and motor homes | $7,070,365,952 | $342,572,041 |
| Cabins | $370,332,556 | $841,730 |
| 4x4 and off-road vehicles | $1,141,003,365 | $1,569,724 |
| Other special equipment | $188,663,084 | $5,043,150 |
| **Other Miscellaneous Fishing Expenses** | **$5,067,991,167** | **$886,524,370** |
| Taxidermy and processing | $96,356,764 | $15,510,372 |
| Books and magazines | $156,328,178 | $14,440,416 |
| Dues and contributions | $403,431,618 | $35,088,538 |
| Fishing licenses | $630,986,633 | $168,739,291 |
| Tags, permits and other special licenses | $76,818,548 | $10,567,576 |
| Land purchased for fishing | $3,143,920,672 | $302,709,448 |
| Land leased for fishing | $298,322,266 | $122,813,926 |
| Other miscellaneous fishing expenditures | $261,826,488 | $216,654,803 |
| **TOTAL** | **$47,697,532,293** | **$7,734,082,154** |

*The American Sportfishing Association (ASA) is the sportfishing industry's trade association committed to representing the interests of the entire sportfishing community. We give the industry a unified voice, speaking out on behalf of sportfishing and boating industries, state and federal natural resource agencies, conservation organizations, angler advocacy groups and outdoor journalists when emerging laws and policies could significantly affect sportfishing business or sportfishing itself. ASA invests in long-term ventures to ensure the industry will remain strong and prosperous, as well as safeguard and promote the enduring social, economic and conservation values of sportfishing in America. ASA also gives America's 60 million anglers a voice in policy decisions that affect their ability to sustainably fish on our nation's waterways through KeepAmericaFishing,™ our angler advocacy campaign. ASA also represents the interests of America's nearly 60 million anglers who generated $48 billion in retail sales with a $115 billion impact on the nation's economy creating employment for more than 828,000 people in 2011.*

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Methodology: Data were obtained from the U.S. Fish and Wildlife Service's *2011 National Survey of Fishing, Hunting and Wildlife-Associated Recreation*. Impacts were developed using the IMPLAN from MIG, Inc. of Stillwater, Minn.

Special notes include:

- For some expenditures, the state where the purchase was made was not identified. These were assigned to the angler's state of residence.
- The estimates of anglers and angler days do not exactly match numbers reported by the USFWS. The sum of the state-level numbers are reported here, whereas the USFWS calculated a single number at the national level. Either method is appropriate.
- The expenditures reported here may be higher than those reported by the USFWS. This is due to expenditures made by an individual for both fishing and hunting. In such cases, the USFWS reports these separately and not part of their fishing-only estimates. In this report, such expenditures are pro-rated into hunting and fishing portions based on the individual's total days of hunting and fishing, and then assigned to each activity as appropriate. Using either approach, the USFWS's or the method used here, the results are accurate and acceptable.
- The results can be combined with the hunting impacts reported in the hunting economics publication from the National Shooting Sports Foundation to gain a comprehensive picture of the returns from all sportsmen and women.

# WILDLIFE TOURISM
## and the Gulf Coast Economy

Shawn Stokes
Marcy Lowe

Contributing Researchers:
Russell Owen & Sarah Mine

July 9, 2013

Datu
data for the big picture

This research was prepared on behalf of Environmental Defense Fund: www.edf.org

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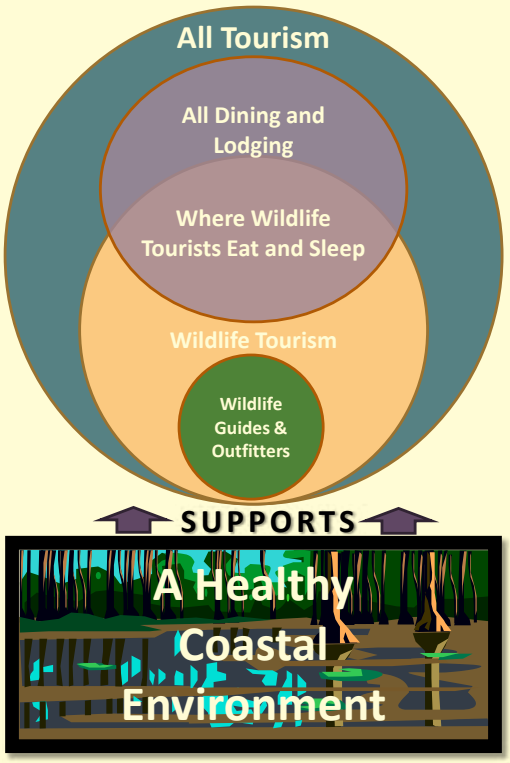
# Note

It is widely recognized that tourism plays a vital role in the Gulf Coast economy. Less commonly recognized is that tourism is largely a resource-based industry. It includes a subset we refer to in this study as "wildlife tourism," which we define as two segments: 1) guide and outfitter businesses that directly serve wildlife watchers, recreational fishers and hunters, and 2) relevant lodging and dining establishments where these customers eat and sleep.

For this study, we interviewed a number of wildlife tourism business owners across the five Gulf states. Many guide and outfitting owners expressed that their business depends entirely on the health of the coastal environment. In the lodging industry, many respondents said they benefit substantially from the visitors drawn to the region each year by wildlife guides and outfitters. Several spoke of how important these businesses are to their success, conveying the vital importance of a robust wildlife guide and outfitter industry, and in turn, a healthy coastal environment, to their long-term vitality and growth.



# Executive Summary & Key Findings

The U.S. Gulf Coast is endowed with exceptional natural beauty and ecological diversity, including wetlands, waters, beaches, forests, and all the wildlife that inhabit them. Wildlife tourism constitutes a major regional "industry." Each year, wildlife watching, recreational fishing, and hunting draw 20 million participants annually in the five states of Alabama, Florida, Louisiana, Mississippi, and Texas. The wildlife tourism industry consists not only of wildlife guide and outfitter businesses that directly serve wildlife tourists, but also the lodging and dining establishments where they eat and sleep.

Wildlife tourism depends on healthy ecosystems, which are the region's "natural capital." However, the future health and productivity of these ecosystems are in peril, in part due to natural events, such as storms, but also because human activities have altered the natural hydrology and halted natural processes, leading to severe land loss and a decrease in the health of the region's estuaries.

For example, one of the most significant and far-reaching alterations is the channelization of the Mississippi River within its delta. This deltaic system has historically played a key role in the ecologic and economic well-being of the Northern Gulf of Mexico. While the channelization of the river by an extensive levee system has benefitted commerce, ports, and communities, this way of managing the river has all but stopped the natural deltaic processes that once built and maintained the regions wetlands and barrier islands. Dredging and construction of a vast network of canals and pipelines for the oil and gas industry have also caused considerable damage to the wetlands and wildlife. These human alterations, combined with natural processes, such as wetlands subsidence, extreme weather and sea-level rise, have led to a loss of nearly 1,900 square miles of land since 1932. Large-scale land loss and decrease in water quality throughout the Gulf threatens wildlife, habitats and the tourism activities they make possible. Without bold action, the Gulf Coast economy risks losing billions of dollars in revenue.

In 2012, Congress passed the RESTORE Act, legislation mandating that 80% of Clean Water Act fines from the 2010 Deepwater Horizon oil spill go to the five Gulf Coast states to restore the ecosystem and economy. Supplementing the RESTORE Act funds, Gulf states are expected to receive significant new revenues from settlement of BP's criminal liability for the oil spill (administered by the National Fish and Wildlife Foundation), and from payments for damages from the spill under NRDA (the federal Natural Resource Damage Assessment process). Combined, these new revenue sources provide an unprecedented opportunity to reverse decades of harm to the Gulf Coast and to begin restoring the environment to a healthy and resilient condition.

Because a healthy ecosystem is at the heart of the region's economy, restoring the Gulf ecosystem is the best way to help the region economically. Owners of wildlife tourism businesses who were interviewed for this study clearly indicated what is at stake for their industry; where ecosystems can no longer support wildlife, visitors have no reason to come. This suggests the urgency of restoring ecosystems to avoid losing a key part of the economy. Funds from the RESTORE Act and other legal settlements provide an unprecedented opportunity to protect not only the coastal environment but also one of the region's most important economic drivers.

## KEY FINDINGS FOR THE GULF REGION:

1. **TOURISM GENERATES 2.6 MILLION JOBS.** This is nearly five times the number of jobs provided altogether by the region's other three largest resource-based industries (commercial fishing, oil and gas, and shipping). The Gulf's 53 coastal counties and parishes have over 25,000 tourism-related businesses and nearly 500,000 associated jobs. In coastal counties and parishes particularly dependent on wildlife activities, tourism jobs can account for 20-36% of all private sector employment.

2. **WILDLIFE TOURISM GENERATES OVER $19 BILLION IN ANNUAL SPENDING.** Wildlife tourists spend nearly $8 billion on recreational fishing, $6.5 billion on wildlife watching, and $5 billion on hunting. Of this revenue, trip-related expenditures such as lodging and dining represent $9.6 billion. Much of this lodging and dining revenue lands directly in the hands of local businesses. Other expenses such as licenses, stamps and permits represent $3.1 billion that support state and local government revenues.

3. **WILDLIFE TOURISM GENERATES $5.3 BILLION ANNUALLY IN FEDERAL, STATE AND LOCAL TAX REVENUES.** In 2011, roughly $2.8 billion, 53% of the total, was federal tax revenue. Roughly $2.5 billion, 47%, was state and local tax revenue. At $2.2 billion, fishing brings in the most taxes, followed by $2 billion from wildlife watching and $1.2 billion from hunting. Investing funds from the RESTORE Act and other legal settlements in coastal restoration will thus protect the natural capital on which the industry depends, while also protecting a current revenue generator for the public sector.

4. **OVER 1,100 GUIDE AND OUTFITTER ENTITIES AND 11,000 LODGING AND DINING ESTABLISHMENTS GENERATE BUSINESS FOR ONE ANOTHER.** The 53 coastal counties and parishes host at least 1,104 guide businesses. Most are small, with fewer than five employees, but they have a large impact. Even small guide firms can each host thousands of visitors annually. Along with 11,384 hospitality entities (6,451 dining, and 4,933 lodging), these firms constitute a coastal network of over 12,000 businesses that send customers to each other. We conducted a survey of over 500 guide and outfitter businesses. Roughly 40% of the 100 respondents said clients ask for hotel recommendations, and 55% said clients ask for restaurant recommendations. Likewise, over 60% of guide businesses receive clients upon recommendation by hotels and restaurants.

5. **WILDLIFE TOURISM BUSINESSES RELY ON HEALTHY COASTAL ENVIRONMENTS.** Because wildlife needs healthy habitat to thrive, Gulf Coast guide and outfitting entities depend on healthy coastal environments for their business. This in turn makes a healthy environment crucial to the lodging and dining entities where wildlife tourists eat and sleep. Together these businesses are an important driver of the regional economy, so coastal restoration is an economic priority. Most project types such as wetlands creation benefit wildlife watching, recreational fishing and hunting, while others such as sea turtle restoration are more targeted to one wildlife activity.

# Introduction

Wildlife tourism constitutes an important regional "industry" in the Gulf region, drawing 20 million participants annually across the five states of Alabama, Florida, Louisiana, Mississippi, and Texas. The three main activities are wildlife watching, recreational fishing, and hunting. The wildlife tourism industry consists not only of wildlife guide businesses that directly serve wildlife tourists, but also the lodging and dining establishments where they eat and sleep.

Average profiles of wildlife tourists differ by activity (see Figure 1). For example, the "average" angler or hunter tends to be a conservative republican male between the ages of 35 and 44, with an annual salary of $50,000-$74,999. Wildlife watchers do not broadly affiliate with any one particular political leaning. The average hunter lives in a rural area, while the average wildlife watcher lives in an urban setting. The average angler is only slightly more likely to live in an urban setting.

**FIGURE 1.**
Profile of a Wildlife Tourist, Gulf Coast Region

**SOURCES:**
Datu Research based on Carpenter, 2012; Southwick Associates, 2012a, 2012b; USFWS, 2008a, 2008b, 2008c, 2012, 2013

Figure 2 lists specific interests under wildlife watching, recreational fishing, and hunting. Additional details include the following:

**WILDLIFE WATCHING** in the Gulf region draws more participants than any other wildlife-related activity. It is defined by the U.S. Fish & Wildlife Service (USFWS) as "closely observing, photographing, and/or feeding wildlife" (USFWS, 2012). Some activities, such as birding or sea turtle watching, are seasonal and depend on factors such as migratory patterns. The Gulf Coast is especially attractive for birding, being the first place birds land in North America after crossing the Gulf on their migration north. Most wildlife guides have advanced degrees in ornithology or wildlife biology, and require years of training to identify the many species of wildlife (Klay, 2013; Nagel-Mason, 2013).

**RECREATIONAL FISHING** in the Gulf states raises the most revenue of the three main wildlife-related activities. It includes fishing for consumption and or sport. Charter fishing guides play a crucial role in educating guests on the marine food chain. Most Gulf fish stocks are low. To sustain them, the Gulf of Mexico Fishery Management Council imposes regulations such as catch limits and limited seasons for charter fishing businesses.

**HUNTING** is popular in all five Gulf Coast states. While most hunting in the Gulf states takes place on the more than 11 million acres of protected lands (Backcountry Chronicles, 2013), outfitters with private land also host thousands of hunters every year.

As with wildlife watching and recreational fishing, hunting often involves guides (in hunting, these are commonly called "outfitters"). Providing valuable place-based education on the vital functions of a coastal ecosystem, all three activities thus play a central role in fostering long-term stewardship of coastal resources.

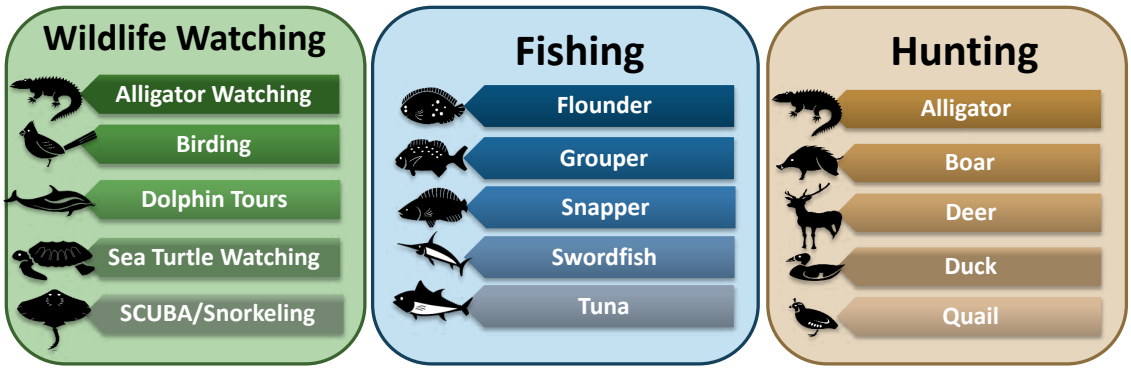



**FIGURE 2.**
Popular Wildlife-related Activities in the Gulf States

**NOTE:**
Lists are not exhaustive

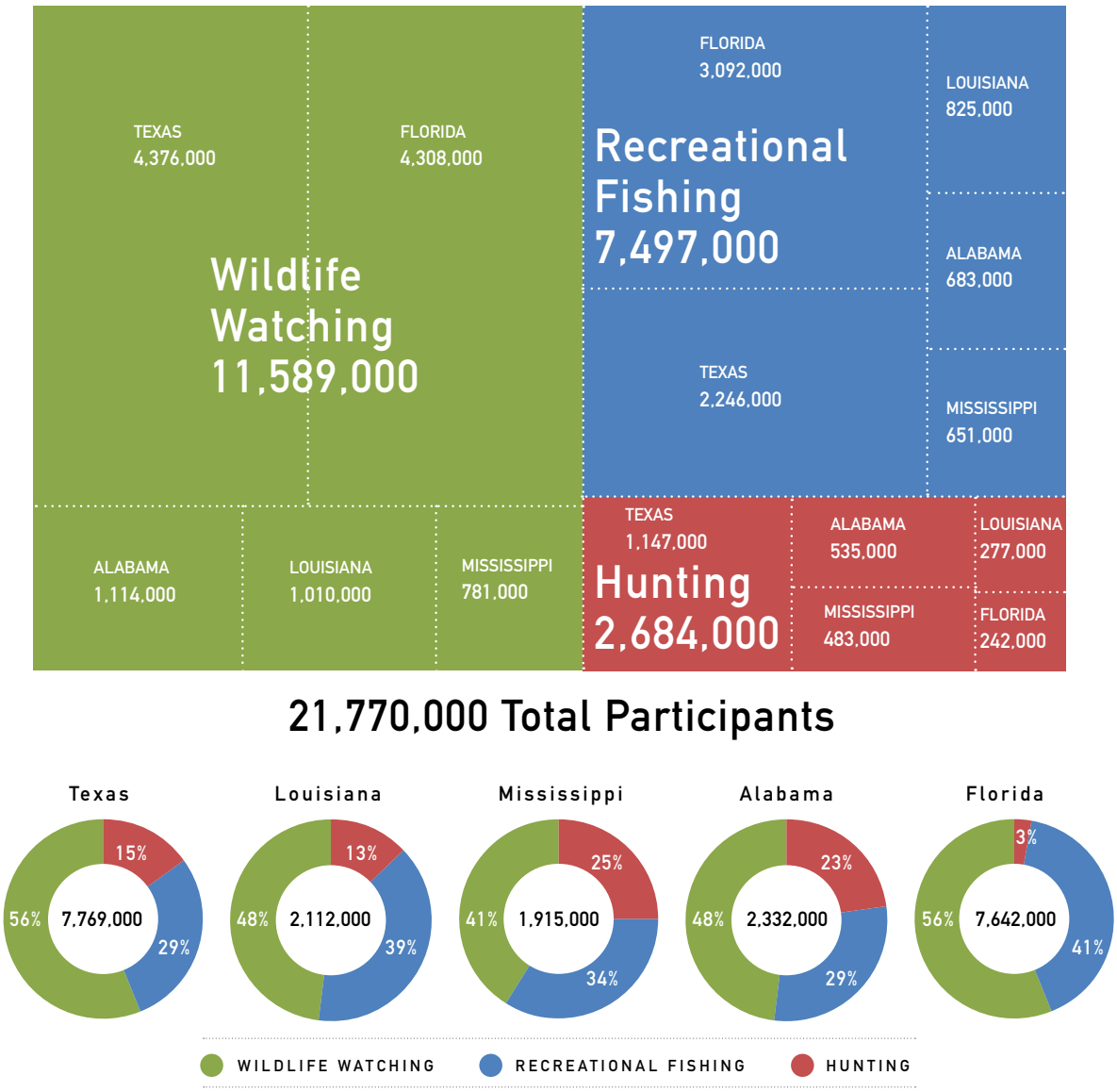
**SOURCE:**
Datu Research based on USFWS, 2008a, 2008b, 2008c, 2012, 2013 and industry interviews

Birding at Leonabelle Turnbull Birding Center in Port Aransas, TX

A breakdown of participation in wildlife activities, by state, is found in Figure 3. At 11.6 billion participants, wildlife watching in the Gulf states attracts more visitors than any other wildlife activity, followed by recreational fishing and hunting. Florida and Texas each draw over seven million wildlife tourists. Alabama, Louisiana and Mississippi each have approximately two million.

**FIGURE 3.**
Participants in Gulf States Wildlife Activities, by State, by Activity, 2011

**SOURCE:**
Datu Research based on data from USFWS, 2012




In this study we examine the economic role of wildlife tourism in the five Gulf states. We document the size of all Gulf tourism and the share of wildlife tourism within it (Sections I and II); show the federal, state and local tax revenues generated by wildlife tourism (Section III); identify over 1,100 guide businesses in the 53 coastal counties and 12,000 mutually supporting lodging and dining establishments (Section IV); and document the extent to which all these entities—together comprising the wildlife tourism industry—depend on a healthy coastal environment (Section V).

## 1 TOURISM GENERATES 2.6 MILLION JOBS IN THE REGION.

Tourism is one of the largest industries in the Gulf states, accounting for 2.6 million jobs in the region (see Figure 4). According to data from the Bureau of Labor Statistics and the National Oceanic and Atmospheric Administration, this is nearly five times the number of jobs provided by the region's other three largest resource-based industries (commercial fisheries, oil and gas, and shipping) combined (BLS, 2013).

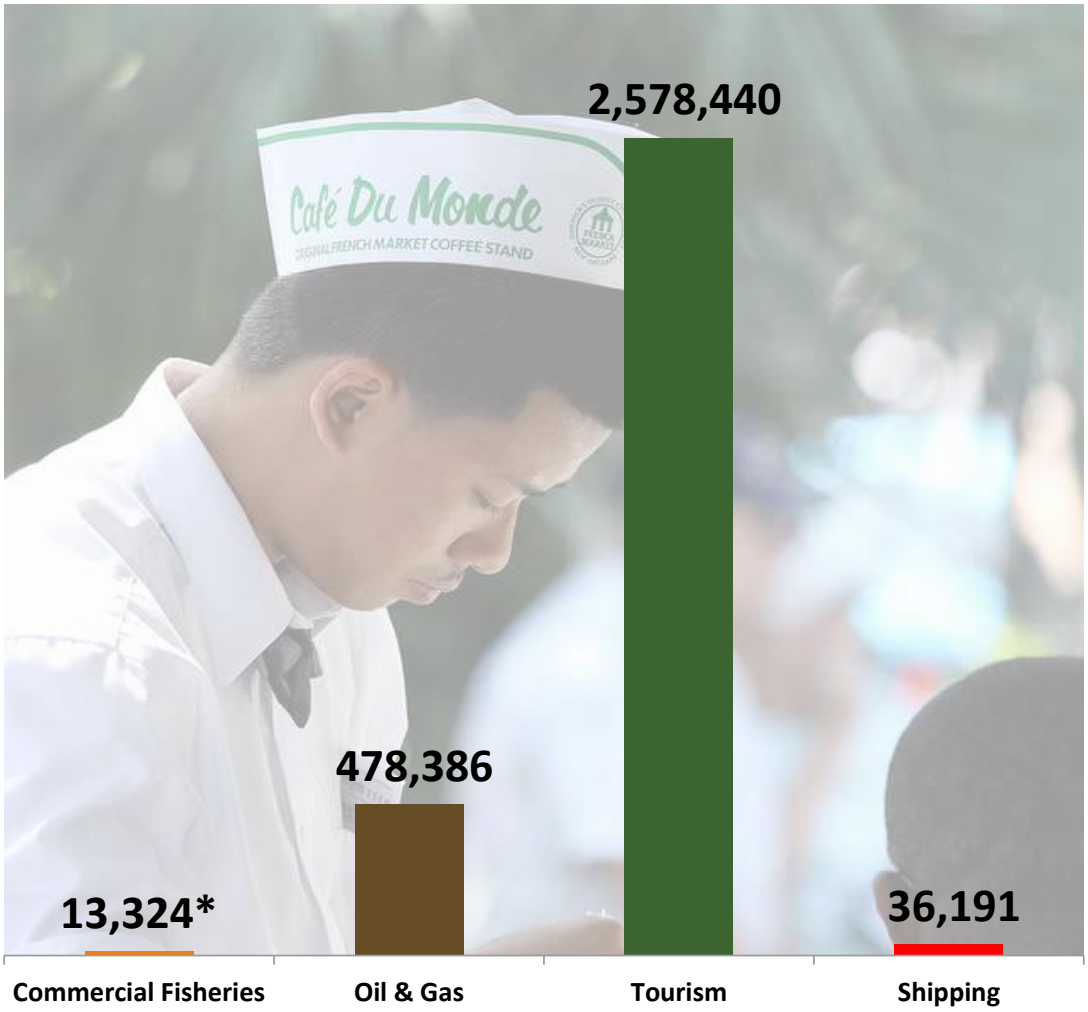


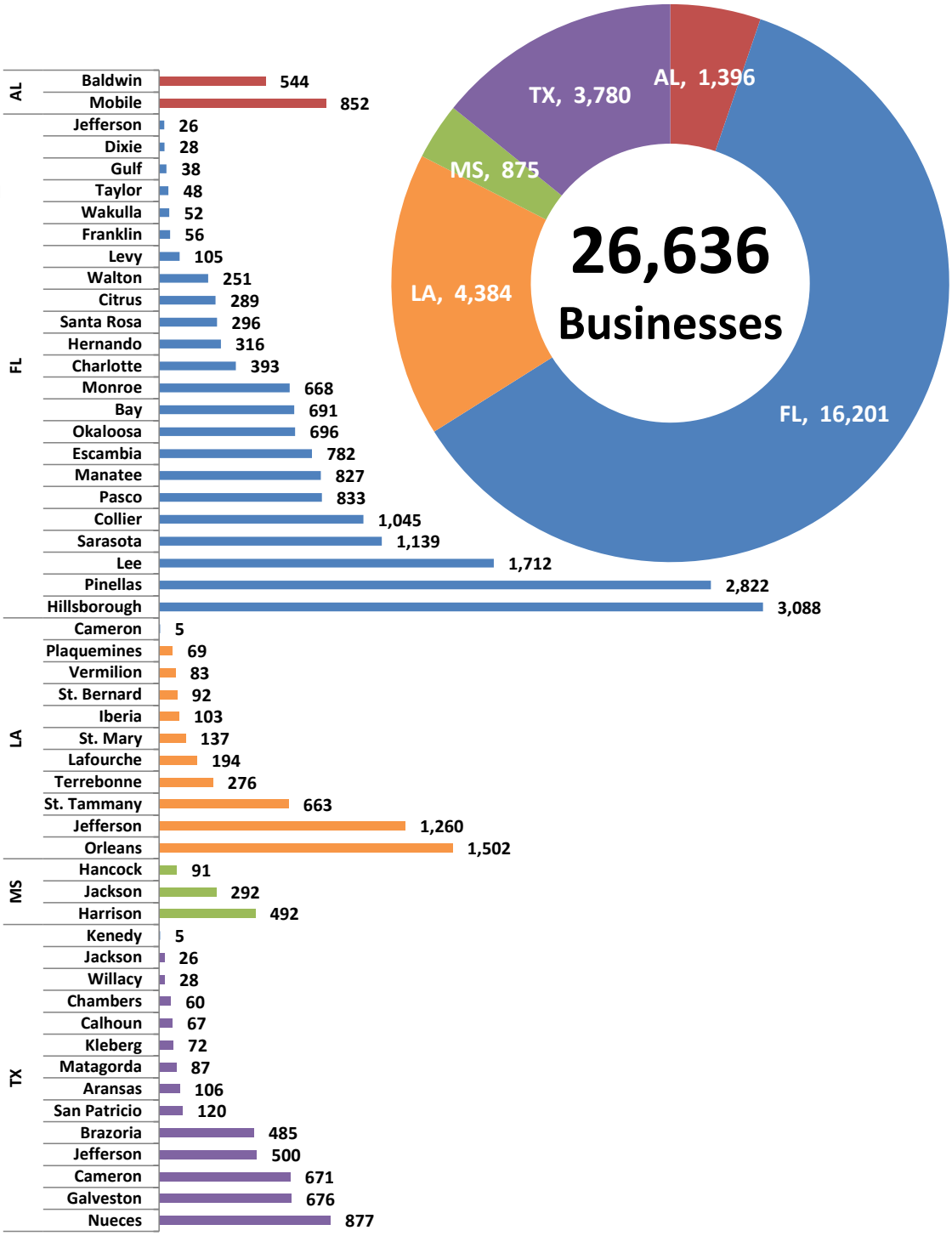

**FIGURE 4.**
Number of Jobs in Gulf States' Four Largest Resource-based Industries, 2011

**SOURCE:**
Commercial Fisheries NOAA, 2013; all others BLS, 2013.
* BLS data for commercial fishing jobs appear undercounted, reporting a total 682 jobs. For this reason, data are from NOAA

For the counties and parishes that lie along the coast, the tourism industry is even more important. Figure 5 shows the distribution of more than 25,000 tourism-related businesses operating in the 53 coastal counties and parishes. This represents roughly 10 percent of total businessesses in those counties and parishes. The highest numbers of tourism firms are in states with the most coastal counties. For example, Florida's 23 coastal counties have a total of more than 16,000 tourism businesses. Alabama's two coastal counties host nearly 1,400 tourism-related businesses (BLS, 2010, 2013).

FIGURE 5.
Number of Tourism Businesses in the 53 Coastal Counties and Parishes, Gulf States, 2011

SOURCE:
BLS, 2010, 2013



Tourism provides nearly 500,000 jobs in the Gulf Coast counties, more than all statewide jobs in the other resource-based industries combined (see Figure 6) (BLS, 2010, 2013).

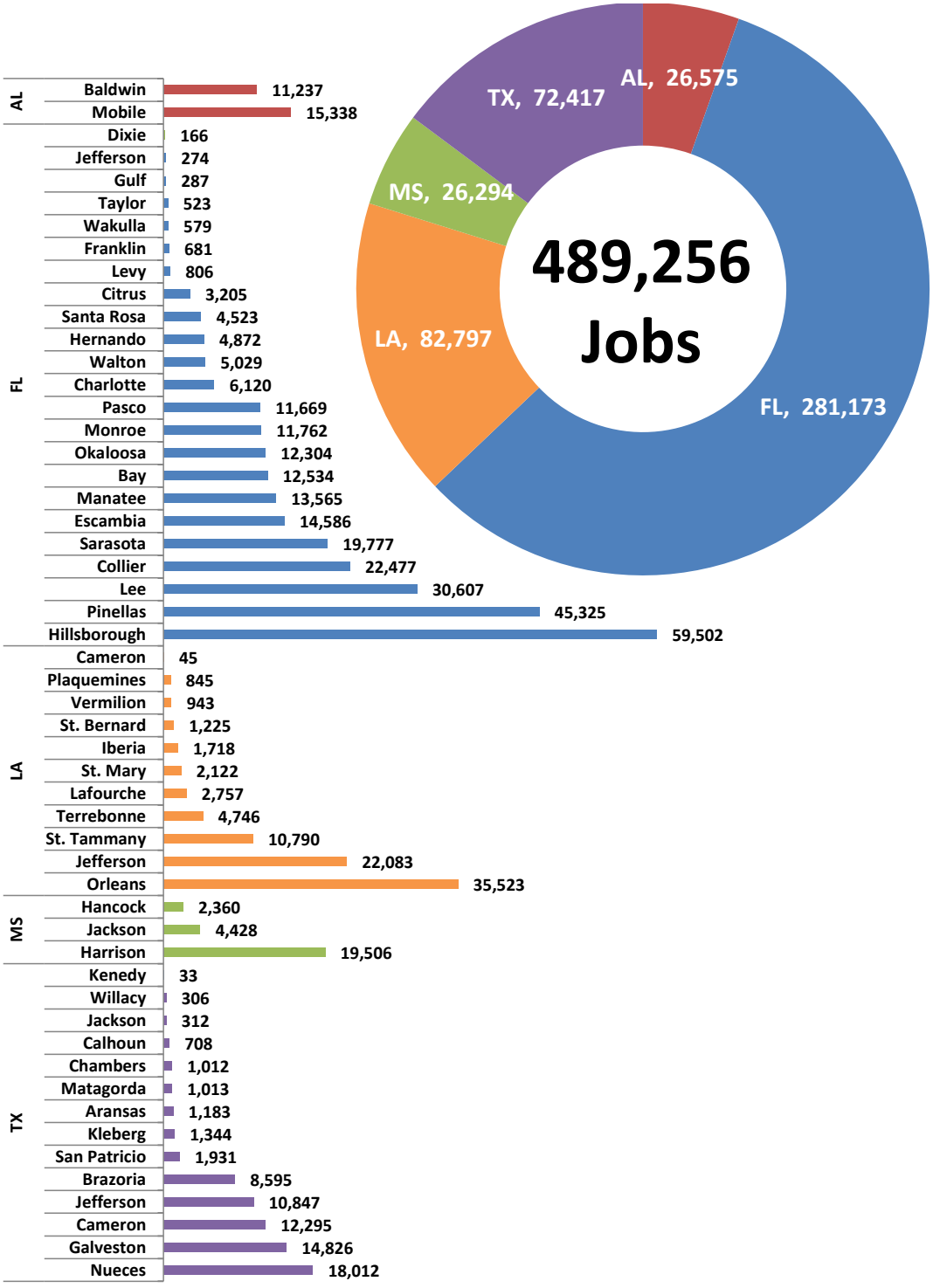



**FIGURE 6.**
Number of Tourism Jobs in the 53 Coastal Counties and Parishes, Gulf states, 2011

**SOURCE:**
BLS, 2010, 2013

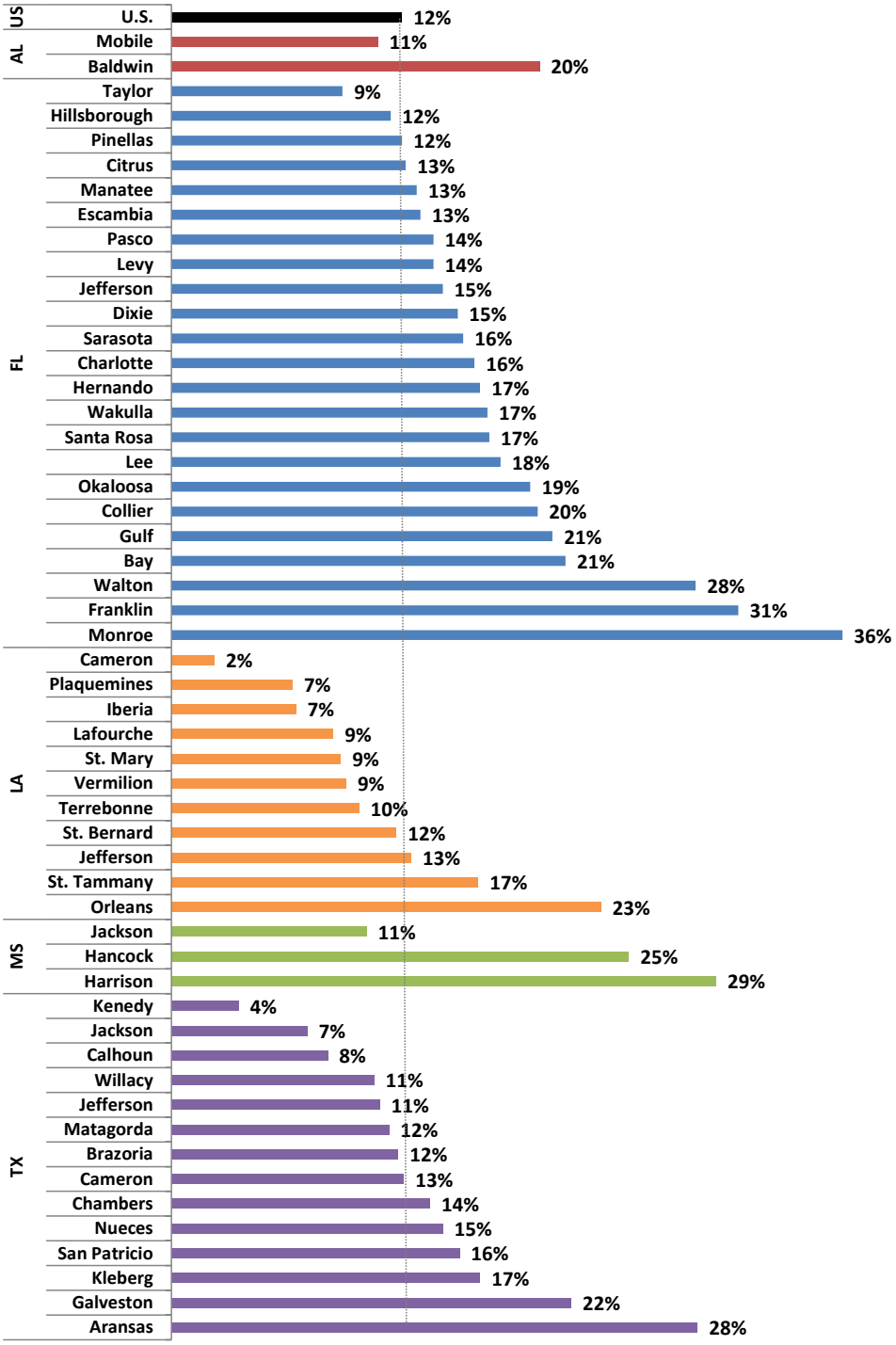



FIGURE 7.
Tourism Jobs as % of Private Sector Employment in the 53 Coastal Counties and Parishes, Gulf States

SOURCE:
BLS, 2010, 2013

Tourism jobs represent a considerable share of private sector employment in the coastal counties and parishes. Compared with the U.S. average—in which tourism jobs are 12.4% of private sector employment—the share is much higher in most coastal counties and parishes of the Gulf (see Figure 7). Thirteen counties have concentrations between 15% and 19%. In 12 counties and parishes at least 20% of private sector jobs are tourism related, and in five counties the share is 28% or higher (BLS, 2010). In Monroe County, Florida, the share is 36%.

## 2 WILDLIFE TOURISM GENERATES OVER $19 BILLION IN ANNUAL SPENDING.

Wildlife tourism is a vital segment of the Gulf region's economy. Together, the three wildlife-related activities of wildlife watching, recreational fishing, and hunting generated $19.4 billion in 2011. Recreational fishing accounts for the largest share, roughly $8 billion. Wildlife watching generates $6.5 billion, and hunting, $5 billion (see Figure 8).

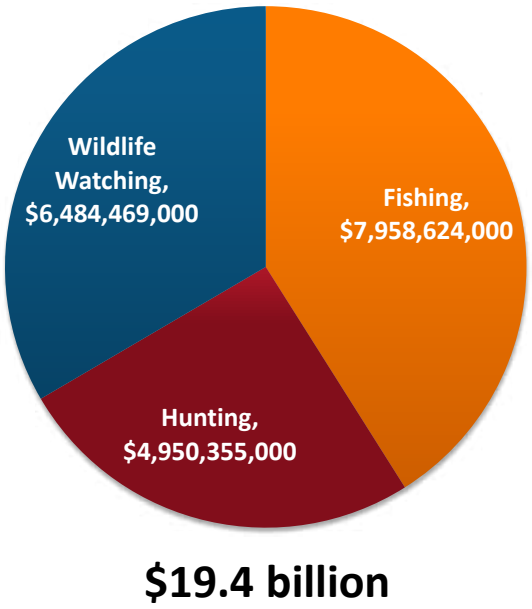



**FIGURE 8.**
Annual Revenues ($millions) from Wildlife Tourism, Gulf Region, 2011

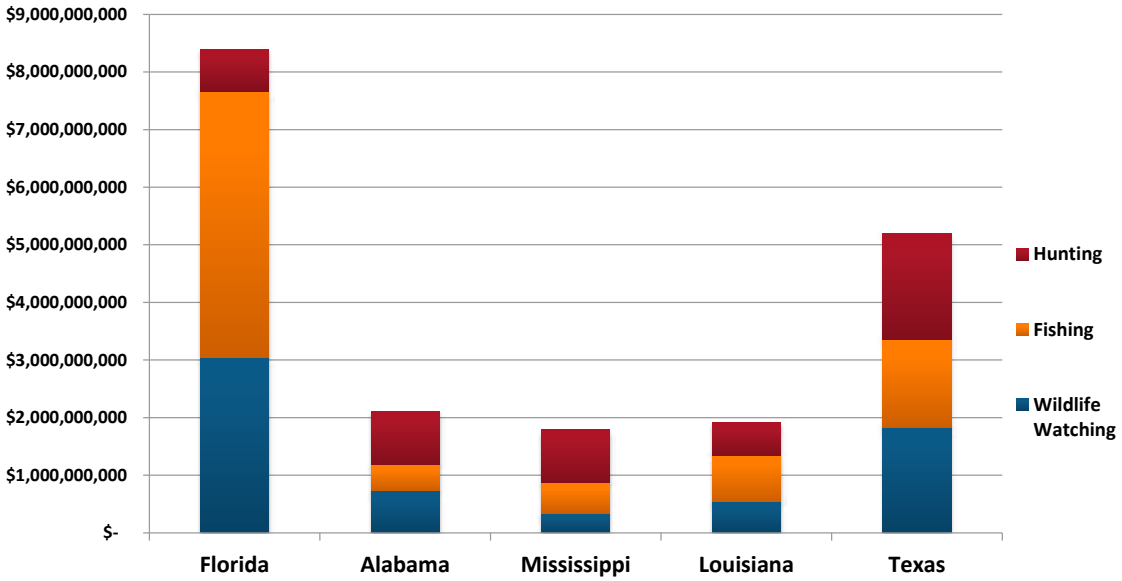
**SOURCE:**
USFWS, 2012; Yoskowitz, 2011

Swamp tour at Jean Lafitte National Park, Louisiana

Figure 9 shows how the $19.4 billion in annual revenues from wildlife activities are distributed across the three main categories. Recreational fishing accounts for roughly $8 billion. Wildlife watching generates $6.5 billion, and hunting, $5 billion. Florida hosts the largest wildlife tourism segment in the Gulf at $8 billion. At over $5 billion, Texas is second. Finally, Alabama, Louisiana, and Mississippi each bring in nearly $2 billion in wildlife tourism revenues (USFWS, 2012).

**FIGURE 9.**
Wildlife Activity Spending, Gulf Region, by State, by Activity, 2011

SOURCE:
USFWS, 2012




Alabama dolphin tour

Figure 10 further shows how the $19.4 billion in annual revenues from wildlife activities are distributed across three spending types: equipment, trip-related, and other expenditures. Trip-related spending totaled $9.6 billion in 2011, including services such as food, lodging and transportation. Equipment purchases totaled $6.7 billion and include gear such as fishing rods, guns, binoculars, dive masks, and apparel. Other expenditures totaled $3.1 billion and include items such as licenses, stamps, tags, permits, and land leasing. (USFWS, 2012).

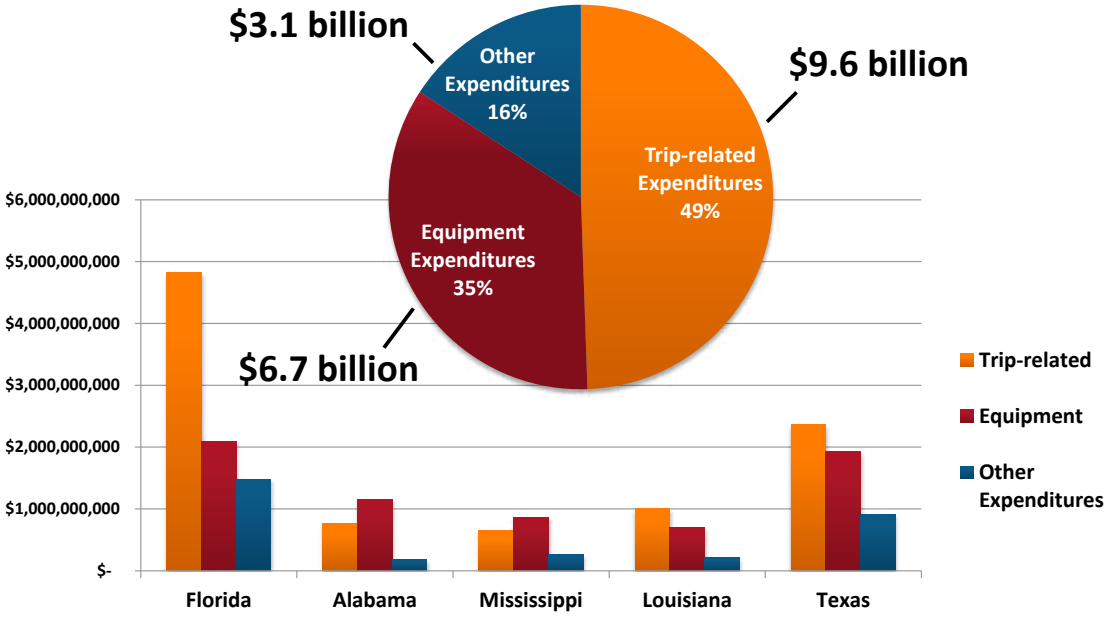



FIGURE 10.
Wildlife Activity Spending, by Type, 2011

SOURCE:
USFWS, 2012

Each type of spending has a different area of economic impact (see Table 1). Trip-related expenditures—the $9.6 billion that makes up almost half of Gulf wildlife tourism revenue—are spent in the counties and parishes where the wildlife-related activities take place, directly supporting local businesses. Equipment purchases support local retailers. Other expenditures on items such as licenses and permits become state and local government revenues to help fund public services.

| SPENDING TYPE | AMOUNT PER YEAR | EXAMPLE | LOCAL BENEFITS |
|---|---|---|---|
| Trip-related | $9.6 billion | Lodging, food, transportation | Local service businesses |
| Equipment | $6.7 billion | Fishing rods, guns, binoculars | Local retailers |
| Other | $3.1 billion | Permits, licenses, stamps | State & local government revenues |

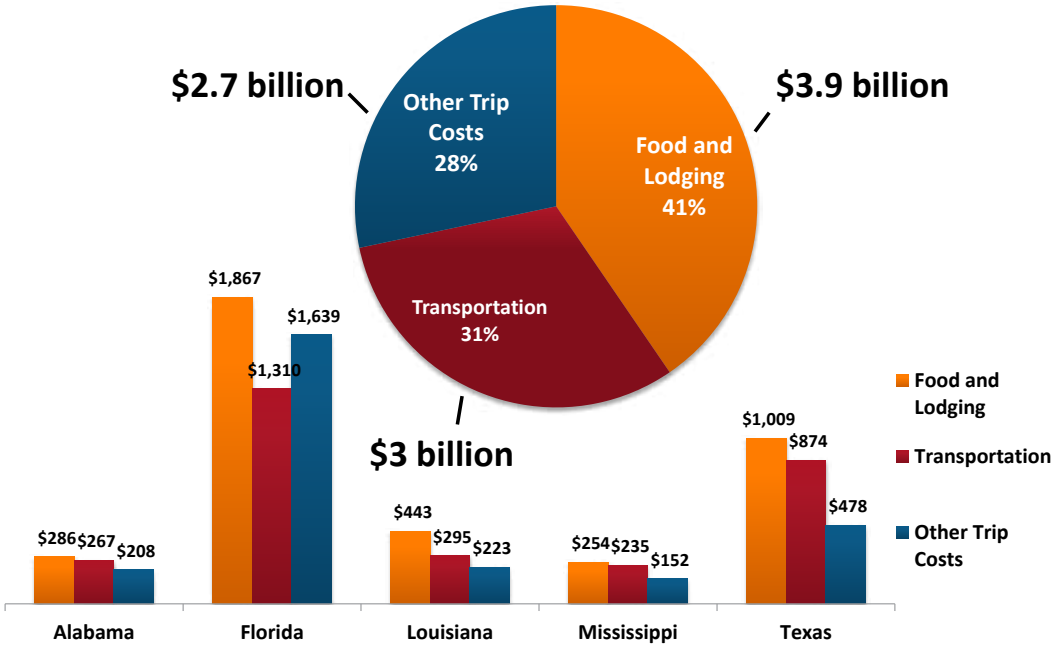
TABLE 1.
Economic Impact of Wildlife Activity Spending, Gulf Region, 2011

SOURCE:
(USFWS, 2012)

Figure 11 shows how the $9.6 billion of trip-related spending is distributed across three categories: food and lodging, transportation, and other trip costs. At 41%, food and lodging represents the largest share. Transportation expenditures represent just under a third (31%) of trip-related expenditures, including items such as car rental, boat rental, taxi services, and public transportation. Other trip costs represent 28% of all trip-related expenditures, including items such as land-use fees, guide fees, equipment rental, and bait.

FIGURE 11.
Trip-related Wildlife Activity Spending, Gulf Region, by Type, 2011

SOURCE:
USFWS, 2012




Kayak tour through a Louisiana tupelo cypress swamp

## 3 WILDLIFE TOURISM GENERATES OVER $5 BILLION ANNUALLY IN FEDERAL, STATE AND LOCAL TAX REVENUES.

Figure 12 shows taxes from wildlife activities surpassed $5.3 billion in 2011. Approximately $2.8 billion, 53%, was federal tax revenue. Approximately $2.5 billion, 47%, was state and local tax revenues. At $2.2 billion, fishing brings in the most taxes, followed by $2 billion from wildlife watching and $1.2 billion from hunting (Southwick Associates, 2012a, 2012b; USFWS, 2008). Sources of taxes include payroll taxes, sales taxes on expenditures, corporate taxes, and excise taxes (USFWS, 2008).

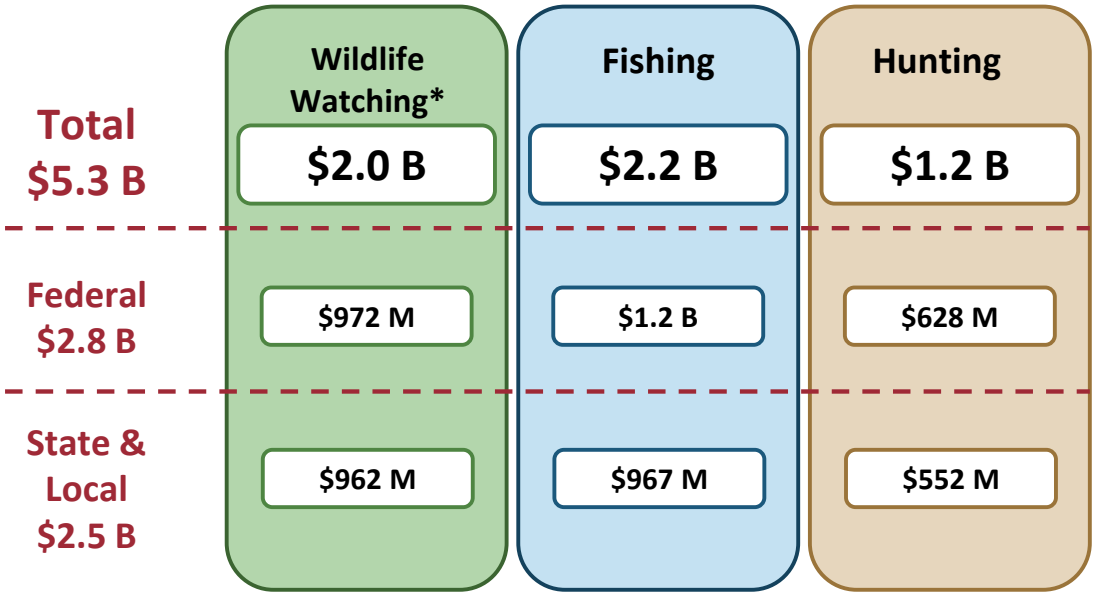



FIGURE 12.
Tax Revenues from Wildlife Tourism, 2011

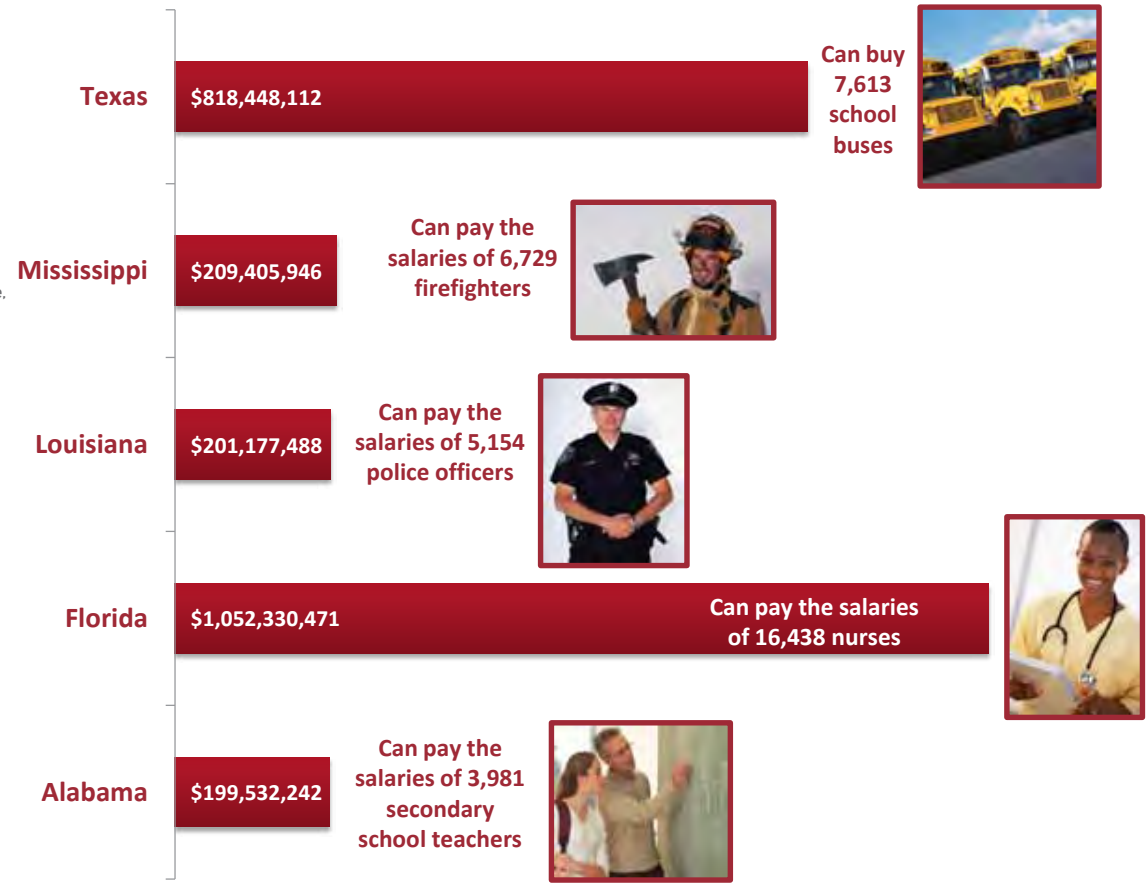
SOURCE:
Southwick Associates, 2012a, 2012b; USFWS, 2008
* Data from 2006

Investing funds from the RESTORE Act and other legal settlements in coastal restoration will rebuild the natural capital on which wildlife tourism depends. By fortifying the wildlife tourism industry, these projects also secure valuable tax revenues necessary to provide public services. Figure 13 shows the state and local tax revenues for each of the five Gulf Coast states and examples of equivalent public services they can provide.

**FIGURE 13.**
State and Local Tax Revenues from Gulf Wildlife Activities: Equivalents

**NOTE:**
Salaries are based on BLS data for each occupation, annual mean wage, by state, May 2012.

**SOURCE:**
Datu Research, based on BLS, 2013; FDOE, 2011; USFWS, 2006, 2012



## 4 OVER 1,100 GUIDE AND OUTFITTER ENTITIES AND 11,000 LODGING AND DINING ESTABLISHMENTS GENERATE BUSINESS FOR ONE ANOTHER.

For this study we define the wildlife tourism industry as two segments: 1) guide and outfitting businesses for wildlife watching, recreational fishing and hunting, and 2) relevant lodging and dining establishments that serve customers engaging in these wildlife-related activities. We first estimated the number of firms in each of the two segments, using data from county-level convention and visitor bureaus (CVBs) and tourism development councils (TDCs). Next, to determine the impact of guide and outfitting businesses on local lodging and dining businesses, we conducted a survey of over 500 firms in the 53 coastal counties.

In the guide and outfitter segment, we identified 1,104 businesses (see Table 2). Of these, 230 are wildlife watching businesses, 883 are recreational fishing, and 96 are hunting outfitter businesses. Totals in Table 2 add up to more than 1,104 because many businesses engage in two or more of the three activities. For instance, some fishing charter businesses may also offer wildlife watching tours.

**TABLE 2.**
Number of Guide Businesses in Coastal Counties & Parishes, Gulf Region, by Type

**SOURCE:**
County-level Convention and Visitors Bureaus and Tourism Development Councils

| STATE | COUNTY | POP. | WILDLIFE WATCHING | FISHING | HUNTING | TOTAL GUIDES |
|---|---|---|---|---|---|---|
| AL | Baldwin | 182,265 | 0 | 2 | 2 | 85 |
| | Mobile | 412,992 | 25 | 86 | 3 | 4 |
| FL | Bay | 168,852 | 4 | 22 | 0 | 27 |
| | Charlotte | 159,978 | 3 | 5 | 4 | 9 |
| | Citrus | 141,238 | 27 | 10 | 2 | 37 |
| | Collier | 321,520 | 1 | 6 | 1 | 8 |
| | Dixie | 16,422 | 0 | 5 | 0 | 5 |
| | Escambia | 297,619 | 4 | 9 | 0 | 11 |
| | Franklin | 11,549 | 4 | 4 | 0 | 8 |
| | Gulf | 15,863 | 4 | 18 | 0 | 20 |
| | Hernando | 172,778 | 0 | 6 | 0 | 6 |
| | Hillsborough | 1,229,226 | 2 | 23 | 5 | 26 |
| | Jefferson | 14,761 | 3 | 1 | 2 | 4 |
| | Lee | 618,754 | 4 | 11 | 0 | 12 |
| | Levy | 40,801 | 12 | 14 | 5 | 30 |
| | Manatee | 322,833 | 3 | 7 | 3 | 9 |
| | Monroe | 73,090 | 2 | 141 | 0 | 141 |
| | Okaloosa | 180,822 | 9 | 2 | 0 | 10 |
| | Pasco | 464,697 | 1 | 10 | 0 | 9 |
| | Pinellas | 916,542 | 0 | 14 | 0 | 13 |
| | Santa Rosa | 151,372 | 4 | 4 | 3 | 11 |
| | Sarasota | 379,448 | 1 | 7 | 1 | 7 |
| | Taylor | 22,570 | 0 | 3 | 0 | 3 |
| | Wakulla | 30,776 | 4 | 2 | 1 | 5 |
| | Walton | 55,043 | 3 | 6 | 1 | 10 |
| LA | Cameron Parish | 6,839 | 1 | 6 | 3 | 8 |
| | Iberia Parish | 73,240 | N/D | N/D | N/D | N/D |
| | Jefferson Parish | 432,552 | 2 | 31 | 1 | 32 |
| | Lafourche Parish | 96,318 | 3 | 19 | 1 | 22 |
| | Orleans Parish | 369,250 | 2 | 6 | 0 | 8 |
| | Plaquemines Parish | 23,042 | 0 | 33 | 6 | 34 |
| | St. Bernard Parish | 35,897 | 0 | 4 | 4 | 6 |
| | St. Mary Parish | 54,650 | 2 | 3 | 0 | 6 |
| | St. Tammany | 233,740 | 5 | 5 | 0 | 10 |
| | Terrebonne Parish | 111,860 | 10 | 26 | 3 | 36 |
| | Vermilion Parish | 57,999 | 0 | 2 | 5 | 7 |
| MS | Jackson/Hancock/ Harrison | 370,702 | 20 | 74 | 3 | 78 |
| TX | Aransas | 23,158 | 9 | 46 | 6 | 49 |
| | Brazoria | 313,166 | 0 | 2 | 1 | 3 |
| | Calhoun | 21,381 | 0 | 8 | 3 | 10 |
| | Cameron/Willacy | 428,354 | 17 | 46 | 0 | 57 |
| | Chambers | 35,096 | 0 | 0 | 5 | 5 |
| | Galveston | 291,309 | 10 | 36 | 3 | 43 |
| | Jackson | 14,075 | N/D | N/D | N/D | N/D |
| | Jefferson | 252,273 | 0 | 10 | 0 | 11 |
| | Kenedy | 416 | N/D | N/D | N/D | N/D |
| | Kleberg | 32,061 | 0 | 1 | 1 | 1 |
| | Matagorda | 36,702 | 2 | 22 | 8 | 40 |
| | Nueces | 340,223 | 19 | 82 | 10 | 92 |
| | San Patricio | 64,804 | 1 | 3 | 0 | 3 |
| TOTALS | | 10,120,918 | 230 | 883 | 96 | 1,104 |

[1] The full list of 1,104 guide and outfitter establishments is found in the appendix at the end of this report.

In the dining and lodging segment, we identified 11,384 businesses (see Table 3). Of these, 6,451 were dining establishments and 4,933 were lodging.

| STATE | COUNTY | POPULATION | DINING | MAJOR HOTELS | REGIONAL HOTELS | VACATION RENTALS | BED & BREAKFAST | CAMPING | TOTAL |
|---|---|---|---|---|---|---|---|---|---|
| AL | Baldwin | 182,265 | 155 | 7 | 11 | 258 | 2 | 14 | 292 |
| | Mobile | 412,992 | 87 | 46 | 13 | 8 | 6 | 7 | 80 |
| FL | Bay | 168,852 | 172 | 1 | 4 | 10 | N/D | 5 | 20 |
| | Charlotte | 159,978 | 190 | 10 | 36 | 50 | 1 | 9 | 106 |
| | Citrus | 141,238 | 196 | 7 | 16 | 10 | 3 | 20 | 56 |
| | Collier | 321,520 | 90 | 31 | 70 | 64 | 22 | 14 | 201 |
| | Dixie | 16,422 | 21 | N/D | 5 | 3 | 2 | 11 | 21 |
| | Escambia | 297,619 | 46 | 38 | 21 | 74 | 3 | 12 | 148 |
| | Franklin | 11,549 | 49 | 1 | 14 | 19 | 5 | 4 | 43 |
| | Gulf | 15,863 | 57 | N/D | 10 | 105 | 1 | 7 | 123 |
| | Hernando | 172,778 | 225 | 7 | 12 | 1 | 1 | 20 | 41 |
| | Hillsborough | 1,229,226 | 180 | 78 | 10 | 0 | 0 | 2 | 90 |
| | Jefferson | 14,761 | 16 | 3 | 3 | N/D | 5 | 4 | 15 |
| | Lee | 618,754 | 165 | 63 | 73 | 155 | 7 | 6 | 304 |
| | Levy | 40,801 | 63 | 2 | 29 | 3 | 2 | 20 | 56 |
| | Manatee | 322,833 | 143 | 24 | 57 | 54 | 3 | 16 | 154 |
| | Monroe | 73,090 | 143 | 13 | 102 | 97 | 69 | 12 | 293 |
| | Okaloosa | 180,822 | 195 | 22 | 21 | 266 | 3 | 4 | 316 |
| | Pasco | 464,697 | 23 | 17 | 19 | 6 | 1 | 55 | 98 |
| | Pinellas | 916,542 | 602 | 62 | 69 | 26 | 15 | 16 | 188 |
| | Santa Rosa | 151,372 | 106 | 8 | 3 | 50 | N/D | 17 | 78 |
| | Sarasota | 379,448 | 110 | 26 | 16 | 61 | 1 | 3 | 107 |
| | Taylor | 22,570 | 26 | 5 | 18 | 3 | N/D | 10 | 36 |
| | Wakulla | 30,776 | 40 | 1 | 4 | N/D | N/D | 6 | 11 |
| | Walton | 55,043 | 193 | 8 | 20 | 504 | 2 | 7 | 541 |
| LA | Cameron Parish | 6,839 | 95 | N/D | 3 | 10 | N/D | 19 | 32 |
| | Iberia Parish | 73,240 | 86 | 8 | 5 | N/D | 11 | 6 | 30 |
| | Jefferson Parish | 432,552 | 59 | 32 | 6 | N/D | N/D | 13 | 51 |
| | Lafourche Parish | 96,318 | 93 | 9 | 16 | N/D | 7 | 12 | 44 |
| | Orleans Parish | 369,250 | 775 | 50 | 67 | N/D | 71 | N/D | 188 |
| | Plaquemines Parish | 23,042 | 90 | 2 | 7 | 1 | N/D | N/D | 10 |
| | St. Bernard Parish | 35,897 | 85 | N/D | N/D | N/D | N/D | 4 | 4 |
| | St. Mary Parish | 54,650 | 76 | 13 | 7 | N/D | 6 | 15 | 41 |
| | St. Tammany | 233,740 | 246 | 22 | 11 | N/D | 17 | 7 | 57 |
| | Terrebonne Parish | 111,860 | 67 | 14 | 8 | N/D | 13 | 10 | 45 |
| | Vermilion Parish | 57,999 | 46 | 2 | 6 | N/D | 5 | 7 | 20 |
| MS | Jackson/Hancock/ Harrison | 370,702 | 406 | 60 | 38 | 28 | 8 | 36 | 170 |
| TX | Aransas | 23,158 | 41 | 5 | 17 | 42 | 6 | 30 | 100 |
| | Brazoria | 313,166 | 62 | 8 | 7 | 11 | 2 | 8 | 36 |
| | Calhoun | 21,381 | 10 | 5 | 4 | N/D | N/D | N/D | 9 |
| | Cameron/Willacy | 428,354 | 62 | 11 | 19 | 15 | N/D | 3 | 48 |
| | Chambers | 35,096 | N/D | 10 | 9 | N/D | 1 | 8 | 28 |
| | Galveston | 291,309 | 227 | 18 | 13 | 236 | 9 | 6 | 282 |
| | Jackson | 14,075 | 6 | 2 | N/D | N/D | N/D | N/D | 2 |
| | Jefferson | 252,273 | 79 | 15 | 14 | N/D | N/D | 19 | 48 |
| | Kenedy | 416 | 4 | 2 | 8 | N/D | N/D | N/D | 10 |
| | Kleberg | 32,061 | 50 | 11 | N/D | N/D | N/D | N/D | 11 |
| | Matagorda | 36,702 | 68 | 6 | 16 | 72 | 4 | 7 | 105 |
| | Nueces | 340,223 | 425 | 51 | 28 | 27 | 12 | 26 | 144 |
| | San Patricio | 64,804 | N/D | N/D | N/D | N/D | N/D | N/D | N/D |
| TOTALS | | 10,120,918 | 6,451 | 836 | 965 | 2,269 | 326 | 537 | 4,933 |

**TABLE 3.**
Number of Dining and Lodging Businesses in Coastal Counties & Parishes, Gulf Region, by Type

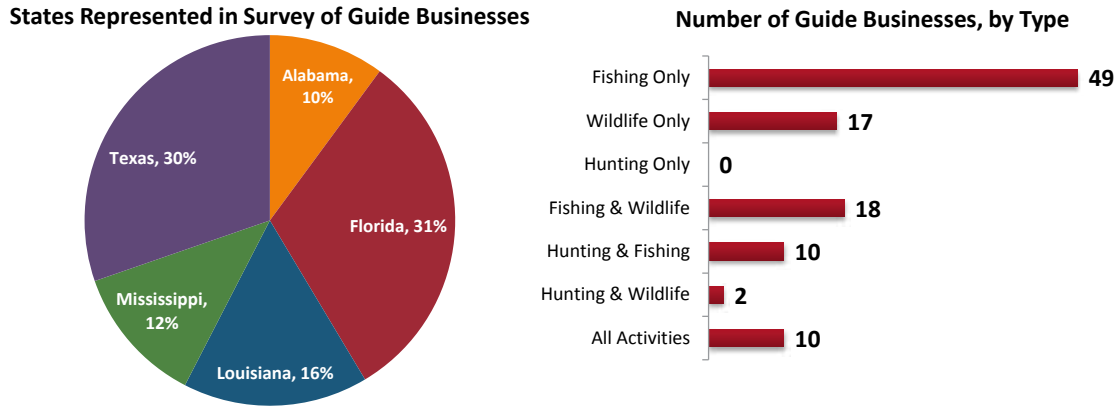
**SOURCE:**
County-level Convention and Visitors Bureaus (CVBs) and Tourism Development Councils (TDCs)

[3] To visit the CVB or TDC with the full list of firms, click on the county name. For counties without a CVB or TDC, we referenced the chamber of commerce.

Guides and outfitters cater to participants in wildlife watching, fishing and hunting providing a range of services. They captain boats, host excursions, educate visitors, and provide equipment such as kayaks. We conducted a random survey of more than 100 Gulf Coast guide businesses.[2] Survey respondents' participation, by state and by activity, is shown in Figure 14. Response rates closely reflected the number of businesses in each state, with over 60% of respondents coming from Florida and Texas. The majority of respondents own charter fishing businesses.

FIGURE 14.
Datu Survey of Over 100 Gulf Coast Guide Businesses, Respondent Data

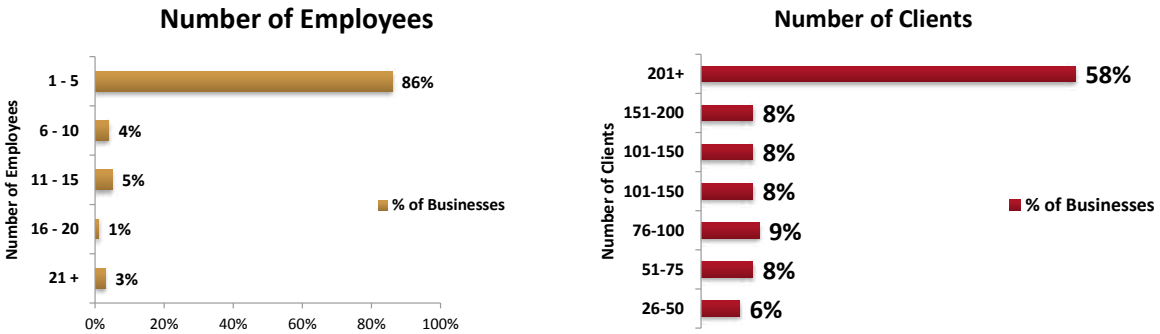
SOURCE:
Datu Research Survey




Survey results show that although guide and outfitting businesses are small, they have a large impact on local tourism (see Figure 15). Over 86% have one to five employees. However, nearly 60% host over 200 visitors per year, and many host several thousand. For example, one Texas guide business we spoke with has five employees and hosts nearly 1,400 visitors annually. Another with 13 employees hosts over 5,000 (Klay, 2013; Nagel-Mason, 2013).

FIGURE 15.
Size of Guide Businesses, Measured in Employees and Clients

SOURCE:
Datu Research Survey




[2] Internet survey distributed via email to 537 guide and outfitter firms in the 53 coastal counties and parishes of the Gulf region, April 8 – 23, 2013. Survey had a response rate of 19.74%, for a total of 106 respondents.

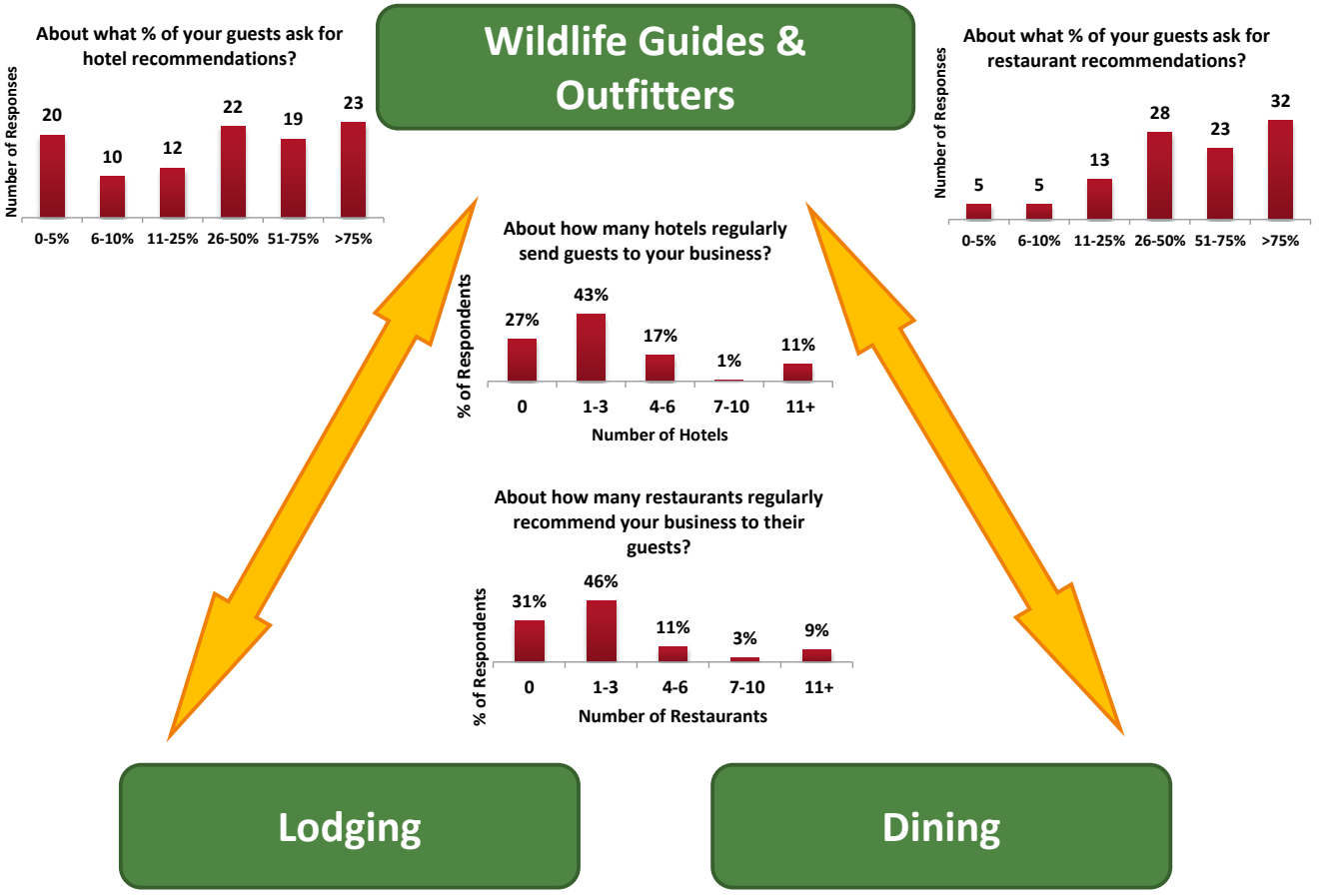
The survey revealed a network of over 12,000 guide, lodging and dining establishments working together to generate business for one another. To provide guests a wider array of services, many firms keep a list of businesses they can recommend to visitors. This arrangement provides mutual economic benefit to everyone in the network (see Figure 16).

Lodging and dining establishments benefit substantially from wildlife guide and outfitters. Approximately 40% (42 of 106 respondents) said at least half their clientele ask for hotel recommendations. Restaurants benefit even more; over 55% of guide businesses say at least half their clientele ask for restaurant recommendations.

Likewise, wildlife guides and outfitters benefit substantially from lodging and dining establishments. More than 66% of guide businesses have working relationships with area hotels, while 25% get referrals from four or more hotels. More than 66% of guide businesses have working relationships with restaurants, and more than 15% get referrals from at least four restaurants.

**FIGURE 16.**
Wildlife Tourism Business Networks

**SOURCE:**
Datu Research Survey



Manatees at Crystal River Preserve State Park in Citrus County, Florida

Industry leaders shared that these referral networks are important for business, and that these relationships are evolving (Ford, 2013; Green, 2013; Hornsby, 2013; Jackson, 2013; Reese, 2013). Guides typically make recommendations for lodging based on guest preferences, but other key factors include personal or professional relationships with the lodging owner (Gould, 2013; Wilkinson, 2013). A number of guides mentioned they prefer to recommend smaller local establishments when possible, based on where they themselves like to eat (Gould, 2013; Wilkinson, 2013) (Jackson, 2013).

Lodging institutions take special care to evaluate the guide businesses they recommend, since their guests' experience with the guides will reflect on their own establishment (Ford, 2013; Wohlford, 2013). A large vacation rental firm said its list of preferred guides resulted from decades of interaction (Maldonado, 2013). A concierge service at a large luxury hotel said when it makes reservations on behalf of guests, it prefers to call smaller outfitters, where they will know the person who answers the phone (Ford, 2013).

As guide, lodging and dining businesses realize the mutual benefits of working together, networks evolve and grow. In Mississippi, where demand for charter fishing tours is high, many hotels outsource booking to the Mississippi Hotel and Lodging Association, which now arranges trips with 25 charter fishing businesses on behalf of four large hotels (Hornsby, 2013). A charter boat captain in Alabama provides "The Captain's Choice," a source of recommendations for where to stay and eat (Boggs, 2013). Guide business owners often work with lodging and dining establishments to sell all-inclusive packages (Green, 2013; Jackson, 2013; Nagel-Mason, 2013; Reese, 2013). Some guides now use daily deal websites such as Living Social or Groupon to sell packages to a wider audience (Nagel-Mason, 2013).

## 5 WILDLIFE TOURISM BUSINESSES RELY ON HEALTHY COASTAL ENVIRONMENTS.

Because wildlife needs healthy habitat to thrive, Gulf Coast guide and outfitting entities depend on healthy coastal environments for their business. This in turn makes a healthy environment crucial to the lodging and dining entities where wildlife tourists eat and sleep. The relationship between the various tourism entities and the environment is depicted in Figure 17.

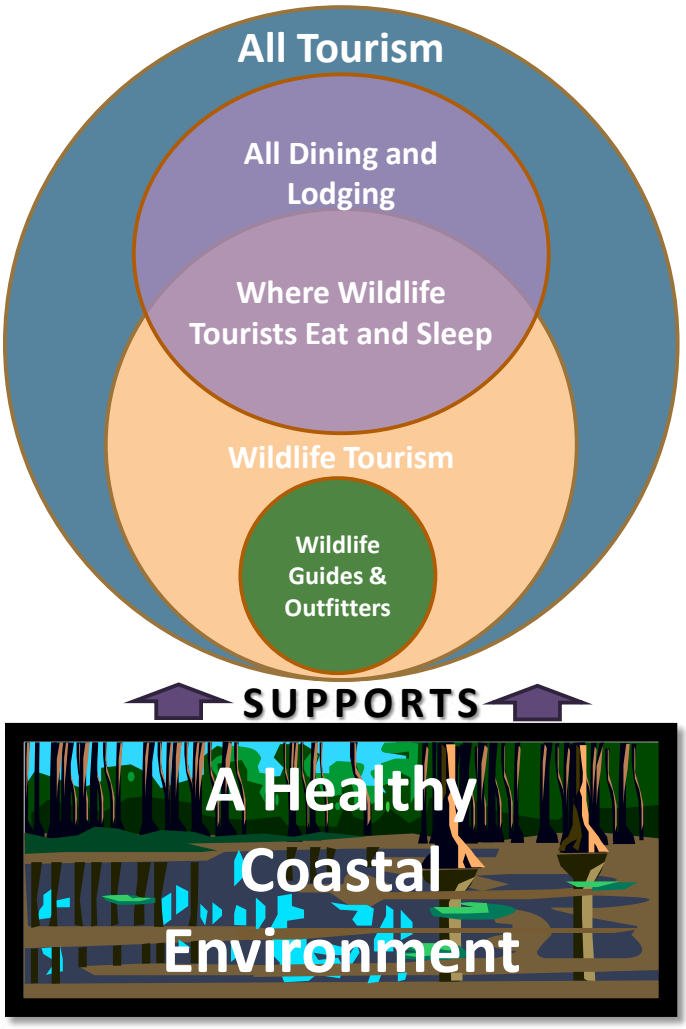


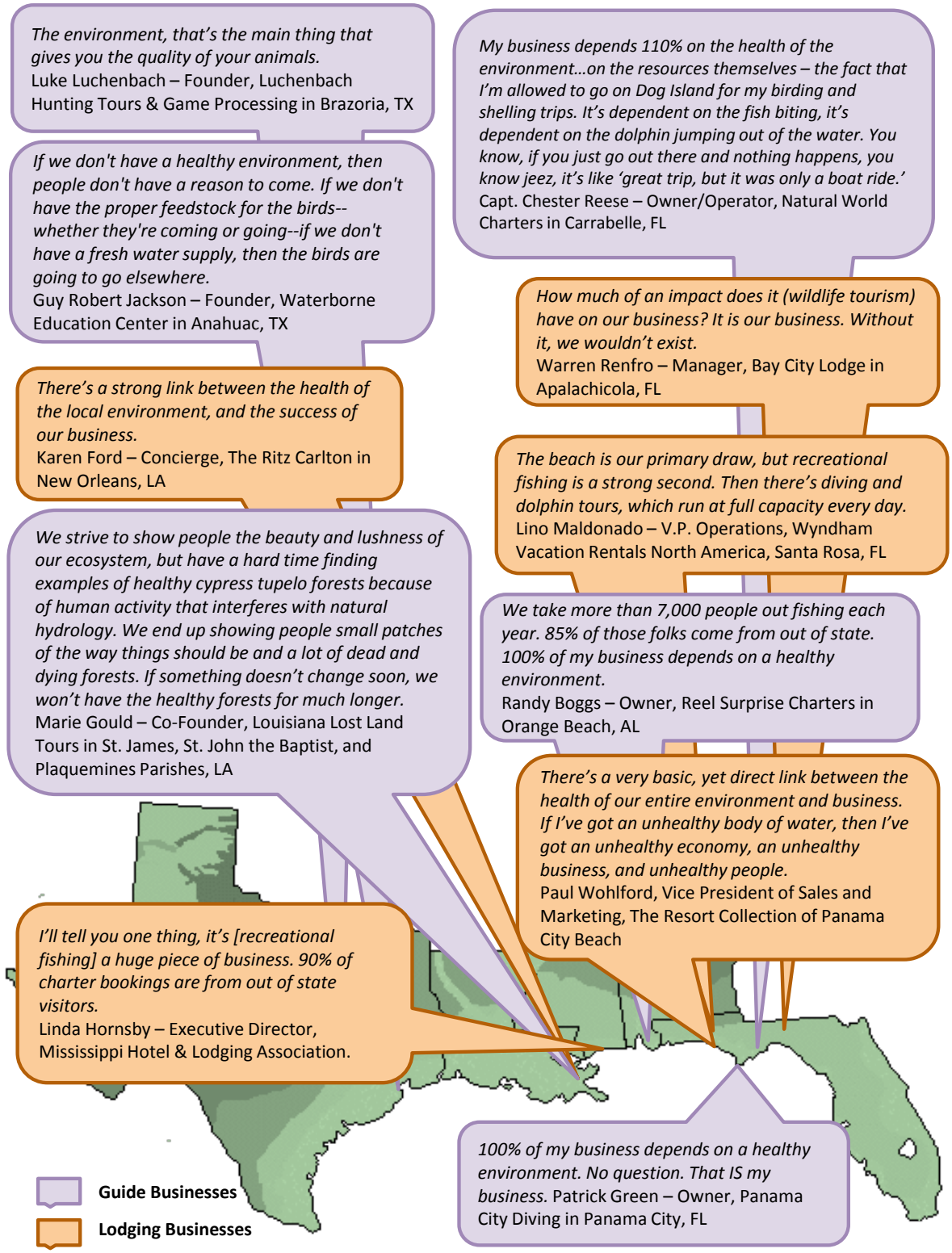

**FIGURE 17.**
Relationship between Wildlife Guides, Lodging and Dining Entities, and a Healthy Coastal Environment

**SOURCE:**
Datu Research, based on industry interviews

For this study, we interviewed a number of wildlife tourism business owners across the five Gulf states. Many guide and outfitting owners expressed that their business depends entirely on the health of the coastal environment. In the lodging industry, a number of respondents said they benefit substantially from the visitors drawn to the region each year by wildlife guides and outfitters. Several spoke of how important these businesses are to their success, conveying the vital importance of a robust wildlife guide industry, and in turn, a healthy coastal environment, to their long-term vitality and growth. Sample quotes are found in Figure 18.

**FIGURE 18.**
Wildlife Tourism Businesses and Dependence on Healthy Coastal Environments

SOURCE:
Datu Research, interviews with industry leaders



Given the critical role of a healthy environment, it follows that ongoing damage from human activities and extreme weather events puts these businesses in a precarious state. Several business owners said that even for sites far away from the 2010 Deepwater Horizon disaster, just the idea of the oil spill was enough to silence their phones for months on end (Maldonado, 2013; Reese, 2013; Wilkinson, 2013). The means to build a more secure business environment for this industry is to fortify the natural environment. Figure 19 lists some common coastal restoration project types, highlighting the relevance of each project type to hunting, recreational fishing, and wildlife watching. Most project types such as wetlands creation benefit all three wildlife activities, while others such as sea turtle conservation are more targeted.

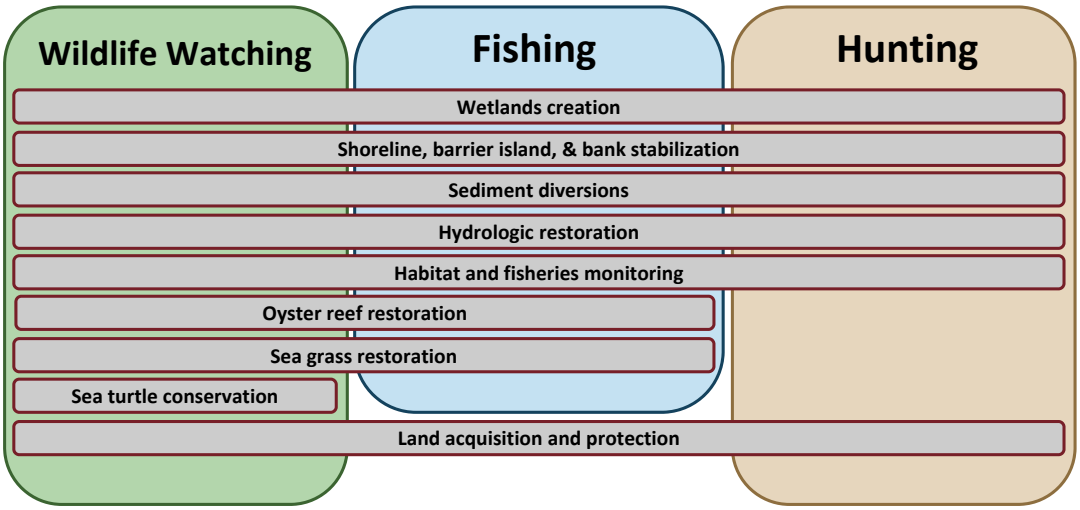



**FIGURE 19.**
Common Coastal Restoration Projects and Benefit to Wildlife Activities

**SOURCE:**
NOAA, 2013

# Conclusion

The data in this study have shown the vital role that wildlife tourism plays in the Gulf Coast economy. This industry comprises over 1,100 businesses that directly serve wildlife watchers, anglers and hunters and over 11,000 lodging and dining businesses where they eat and sleep. Wildlife tourism accounts for $19.4 billion in annual revenue and an additional $5.3 billion in tax revenue. Especially in the 53 coastal counties and parishes, wildlife tourism is a crucial mainstay of the region's economy, one that provides thousands of much-needed jobs.

Many guide and outfitter business owners interviewed for this study expressed that a healthy coastal environment is essential for their very existence. Hospitality industry leaders similarly emphasized the importance of wildlife tourism to their business. Where ecosystems can no longer support wildlife, their clients have no reason to come. Severe land loss and the decreased health of the Gulf's estuaries pose an ongoing threat to wildlife habitats and the tourism activities that depend on them. Unless bold steps are taken, the regional economy risks losing billions of dollars in annual revenue, along with the natural capital from which it comes.

Because a healthy ecosystem is at the heart of the region's economy, restoring the Gulf ecosystem is the best way to help the region economically. The RESTORE Act and additional legal settlements related to the 2010 Deepwater Horizon oil spill offer a unique chance to restore Gulf Coast ecosystems. Applying these new funding sources to restoration projects is an essential investment in restoring the coastal environment and the regional economy.

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# Appendix: Full List of Guides and Outfitters in Coastal Counties and Parishes

ALABAMA

| COMPANY NAME | CITY | COUNTY | FISHING | HUNTING | WILDLIFE |
|---|---|---|---|---|---|
| A Family Fishing Adventure | Orange Beach | Baldwin | ● | | |
| A Pair A Dice Fishing Charter | Orange Beach | Baldwin | ● | | |
| A-1 Charter/Outcast Boat | Orange Beach | Baldwin | ● | | |
| AAA Charters | Orange Beach | Baldwin | ● | | ● |
| AAA Dolphin Charters | Orange Beach | Baldwin | | | ● |
| Action Charter Service | Orange Beach | Baldwin | ● | | |
| Action Outdoors Entertainment, LLC | Orange Beach | Baldwin | ● | | ● |
| Alabama Coastal Outdoors, LLC | Orange Beach | Baldwin | | | ● |
| Alabama Deep Sea Fishing | Orange Beach | Baldwin | ● | | |
| Alabama Dolphin Cruises | Orange Beach | Baldwin | | | ● |
| Alabama Fish N Fun | Orange Beach | Baldwin | ● | | |
| Alabama Girl Inshore Fishing Charters | Orange Beach | Baldwin | ● | | |
| All Jack'd Up Charters | Orange Beach | Baldwin | ● | | |
| Amber Gene, Inc Charters | Gulf Shores | Baldwin | ● | | |
| America II Charters | Orange Beach | Baldwin | ● | | |
| America Star Dolphin Encounter and Nature Cruise | Orange Beach | Baldwin | | | ● |
| Anatare's Lost Key Cruises | Orange Beach | Baldwin | | | ● |
| Aquastar Charters | Orange Beach | Baldwin | ● | | |
| Bad Habit Charters | Orange Beach | Baldwin | ● | | |
| Captain Kurt Sportfishing Charters | Orange Beach | Baldwin | ● | | |
| Cetacean Cruises | Orange Beach | Baldwin | ● | | |
| Charter Boat Dorado | Dauphin Island | Mobile | ● | | |
| Chipper's Clipper Charters | Orange Beach | Baldwin | ● | | |
| Class Act Charters, Inc | Orange Beach | Baldwin | ● | | |
| Clyde's Inshore Fishing | Orange Beach | Baldwin | ● | | |
| Cool Change Charters | Orange Beach | Baldwin | ● | | |
| Corsair Charters | Josephine | Baldwin | ● | | |
| C-Rose Charters | Orange Beach | Baldwin | ● | | |
| Cruise OB | Orange Beach | Baldwin | | | ● |
| Dauphin Island Eco Tours | Dauphin Island | Mobile | | | ● |
| Distraction Charters | Orange Beach | Baldwin | ● | | |
| Dolphin Cruises, Inc | Orange Beach | Baldwin | | | ● |
| Dolphin Queen Cruises | Orange Beach | Baldwin | | | ● |
| Dottie Joe Charter Service | Gulf Shores | Baldwin | ● | | |

ALABAMA

| COMPANY NAME | CITY | COUNTY | FISHING | HUNTING | WILDLIFE |
|---|---|---|---|---|---|
| Down Under Dive Shop | Gulf Shores | Baldwin | | | ● |
| Downstream Charters | Orange Beach | Baldwin | ● | | |
| Emerald Spirit Charters | Orange Beach | Baldwin | ● | | |
| Escape Charters | Dauphin Island | Mobile | ● | | |
| Explorer Charters | Orange Beach | Baldwin | ● | | |
| Fairhope Boat Company | Fairhope | Baldwin | | | ● |
| Fairwater II Charters | Orange Beach | Baldwin | ● | | |
| Fins and Family Fishing Charter | Gulf Shores | Baldwin | ● | | |
| Fins and Family Fishing Charter | Gulf Shores | Baldwin | | | ● |
| Fish Trap Charters | Orange Beach | Baldwin | ● | | |
| Gary's Gulf Divers | Orange Beach | Baldwin | | | ● |
| Getaway Charters | Orange Beach | Baldwin | ● | | |
| Good Times Charter Fishing | Orange Beach | Baldwin | ● | | |
| Good Times Two Charters | Orange Beach | Baldwin | ● | | |
| Gulf Adventures - No Excuses Charters | Gulf Shores | Baldwin | ● | | ● |
| Gulf Coast Charters | Orange Beach | Baldwin | ● | | |
| Gulf of Mexico Trips | Gulf Shores | Baldwin | | | ● |
| Gulf Rebel Charters | Orange Beach | Baldwin | ● | | |
| Gulf Winds II | Orange Beach | Baldwin | ● | | |
| Gumbo Sports Inshore Fishing | Gulf Shores | Baldwin | ● | | |
| Head Hunter Fishing Charters | Orange Beach | Baldwin | ● | | |
| Hey Boy II Charters | Orange Beach | Baldwin | ● | | |
| High Cotton Charters | Orange Beach | Baldwin | ● | | |
| Highlander Charters | Orange Beach | Baldwin | ● | | |
| Hooked Up Inshore Charters | Orange Beach | Baldwin | ● | | |
| Intimidator Sport Fishing, Inc | Orange Beach | Baldwin | ● | | |
| Intruder Charters | Orange Beach | Baldwin | ● | | |
| Island Girl Charters | Orange Beach | Baldwin | ● | | |
| Island Time Charters | Orange Beach | Baldwin | ● | | |
| Jamie G Charters | Orange Beach | Baldwin | ● | | |
| Joyce Charters | Orange Beach | Baldwin | ● | | |
| Killin' Time Charters | Orange Beach | Baldwin | ● | | |
| Kittywake Charters | Orange Beach | Baldwin | ● | | |
| Kreamer Inshore | Orange Beach | Baldwin | ● | | |
| Lady D Charters | Orange Beach | Baldwin | ● | | |
| Lickety-Split Charter | Orange Beach | Baldwin | ● | | |
| Little Lagoon Guide Service | Foley | Baldwin | ● | | ● |
| Lucy L Charters | Orange Beach | Baldwin | ● | | |
| Making Waves Dolphin Cruises | Orange Beach | Baldwin | | | ● |
| Max Drag Charters, LLC | Orange Beach | Baldwin | ● | | |
| MDG Fishing Charters | Orange Beach | Baldwin | ● | | |
| Miss Hollie Charters | Orange Beach | Baldwin | ● | | |
| Mo Fishin Charters | Orange Beach | Baldwin | ● | | |
| Necessity Charters | Orange Beach | Baldwin | ● | | |
| Nicole Fishing Charters | Gulf Shores | Baldwin | ● | | |
| OB Watersports | Orange Beach | Baldwin | | | ● |

## ALABAMA

| COMPANY NAME | CITY | COUNTY | FISHING | HUNTING | WILDLIFE |
|---|---|---|---|---|---|
| On Island Time Charters | Gulf Shores | Baldwin | ● | | |
| Orange Beach Fishing Association | Orange Beach | Baldwin | ● | | |
| Orange Beach Fishing Charter Co-op | Orange Beach | Baldwin | ● | | |
| Outcast Charter Docks Marina | Orange Beach | Baldwin | ● | | |
| Pelican Pontoon Boat Delta Cruise | Spanish Fort | Baldwin | | | ● |
| Prime Tyme Charters | Gulf Shores | Baldwin | | | ● |
| Red Eye Charters | Gulf Shores | Baldwin | ● | | |
| Reel Surprise Charters | Orange Beach | Baldwin | ● | | |
| Rhodes Hunting Preserve, LLC | Bay Minette | Baldwin | | ● | |
| Rip Tide Charters | Orange Beach | Baldwin | ● | | |
| Rob's Inshore Fishing | Orange Beach | Baldwin | ● | | |
| Rookie II Charters | Orange Beach | Baldwin | ● | | |
| Sail Dolphin Cruises | Josephine | Baldwin | | | ● |
| Salty Dog Charters | Orange Beach | Baldwin | ● | | |
| Sea Hunter Charters | Orange Beach | Baldwin | ● | | |
| Sea Spray Charters | Orange Beach | Baldwin | ● | | |
| Sea Worthy Charters | Orange Beach | Baldwin | ● | | |
| Shirley R Charters | Orange Beach | Baldwin | ● | | |
| Southern Belle Alabama Cruises | Theodore | Mobile | | | ● |
| Sport's Man's Charters | Orange Beach | Baldwin | ● | | |
| Summer Breeze Charter Fishing | Orange Beach | Baldwin | ● | | |
| Summer Hunter Charters | Orange Beach | Baldwin | ● | | |
| Surf's Up Dolphin Cruises | Orange Beach | Baldwin | | | ● |
| The Hunting Company | Foley | Baldwin | | ● | |
| The Hunting Company/Bow Fishing | Orange Beach | Baldwin | ● | ● | |
| Ugly Fishing Charters | Daphne | Baldwin | ● | | |
| Undertaker Charters | Orange Beach | Baldwin | ● | | |
| Unreachable Charters | Orange Beach | Baldwin | ● | | |
| White Capps Charters | Orange Beach | Baldwin | ● | | |
| Yellowbird Fishing Charters | Orange Beach | Baldwin | ● | | |
| Zeke's Lady Charters | Orange Beach | Baldwin | ● | | ● |

## FLORIDA

| | | | | | |
|---|---|---|---|---|---|
| A Lil' Tail Charters | Islamorada | Monroe | ● | | |
| A Reel Good Time Charters | Islamorada | Monroe | ● | | |
| A Reelfishing Charter | Punta Gorda | Charlotte | ● | | |
| AAA Gulf Coast Fishing and Boating | Port Saint Joe | Gulf | ● | | |
| A1 Sea Dog Charters | Marathonq | Monroe | ● | | |
| A1A Sportfishing | Marathon | Monroe | ● | | |
| About Fun Charters | Port St. Joe | Gulf | ● | | |
| Absolute Flats Fishing | New Port Richey | Pasco | ● | | |
| Adirondack Exposure | Cedar Key | Levy | ● | | ● |
| Adventure Diving | Crystal River | Citrus | | | ● |
| Adventures Unlimited | Milton | Santa Rosa | | | ● |
| Adventure Watersport Charters | Key West | Monroe | ● | | |
| Air Tank Divers | Homosassa | Citrus | | | ● |

FLORIDA

| COMPANY NAME | CITY | COUNTY | FISHING | HUNTING | WILDLIFE |
|---|---|---|---|---|---|
| AJ Brown Charters | Cedar Key | Levy | ● | | |
| Allcatch Fishing Charters | Tampa | Hillsborough | ● | | |
| Always Fishing Guide Service | Spring Hill | Hernando | ● | | |
| American Pro Diving Center | Crystal River | Citrus | | | ● |
| Anglers Choice Outfitters | Ft. Myers | Lee | ● | | |
| Angling Adventures Charter Fishing Service | Spring Hill | Hernando | ● | | |
| Angry Bird Fishing Charters | Navarre | Santa Rosa | ● | | |
| Anna Maria Charters | Bradenton | Manatee | ● | ● | ● |
| Anna Maria Island Fishing | Tampa | Hillsborough | ● | | |
| Another Keeper Charters | Englewood | Sarasota | ● | | |
| Apalachicola Bay Serenity Charters | Apalachicola | Franklin | | | ● |
| Apalachicola Maritime Museum | Apalachicola | Franklin | | | ● |
| Aquadog Charters | Eastpoint | Franklin | | | ● |
| A-Reel Easy Charter/Dive | Pensacola Beach | Escambia | ● | | ● |
| Art N Diving | Crystal River | Citrus | | | ● |
| Back Atcha Charters | Panama City | Bay | ● | | |
| Back to Business - Capt. Brian Premaza | Islamorada | Monroe | ● | | |
| Backwater Guide Service | Apalachicola | Franklin | ● | | |
| Bad Habit Charters | Islamorada | Monroe | ● | | |
| Bad to the Bone | Big Pine Key | Monroe | ● | | |
| Bandit Charters | Panama City | Bay | ● | | |
| Bar Hop'N Charters | Port St. Joe | Gulf | ● | | |
| Barefoot Bandit Charters | Hudson | Pasco | ● | | |
| Barefoot Charters | Crawfordville | Wakulla | ● | ● | |
| Barhopper Charters | Cedar Key | Levy | ● | | |
| Bay and Reef Co | Islamorada | Monroe | ● | | |
| Bayside Guide Service | Pensacola | Escambia | ● | | |
| Bend the Rod Charters - Capt. Bill Wert | Islamorada | Monroe | ● | | |
| Bent Charters LLC | Tampa | Hillsborough | ● | | |
| Best Bet Sportfishing | Marathon | Monroe | ● | | |
| Big Bend Charters | Steinhatchee | Dixie | ● | | |
| Big Fish on a Fly | Key West | Monroe | ● | | |
| Big Game Sportfishing - Capt. Ariel Medero | Marathon | Monroe | ● | | |
| Big Kahuna Charters | Key West | Monroe | ● | | |
| Big Pine Kayak Adventures | Big Pine Key | Monroe | ● | | ● |
| Big Time Charters | Port St. Joe | Gulf | ● | | |
| Big 'Un Charters | Apalachicola | Franklin | ● | | |
| Bimini Bound Charters & Yacht Transfers | Marathon | Monroe | ● | | |
| Bird's Underwater | Crystal River | Citrus | | | ● |
| Blackwater Canoe Rentals and Sale | Milton | Santa Rosa | | | ● |
| Blue Chip Too - Captain Skip Bradeen | Islamorada | Monroe | | | |
| Blue Grotto | Williston | Levy | | | ● |
| Blue Heaven Fishing Charters | Islamorada | Monroe | ● | | |
| Monroe Bob's Canoe Rental | Milton | Santa Rosa | | | ● |
| Bonita Springs Fishing | Bonita Springs | Lee | ● | | |
| Booya Sports Fishing | Key West | Monroe | ● | | |

FLORIDA

| COMPANY NAME | CITY | COUNTY | FISHING | HUNTING | WILDLIFE |
|---|---|---|---|---|---|
| Born to Boogie Charters | Panama City | Bay | ● | | |
| Box Full Charters | Panama City | Bay | ● | | |
| Brown Eyed Girl Fishing Charter | Port St. Joe | Gulf | ● | | |
| Bud N Marys Fishing Marina | Islamorada | Monroe | ● | | |
| Bull Dog Fishin Charters | Tampa | Hillsborough | ● | | |
| Bull Red Charters | Perry | Taylor | ● | | |
| Cap. Jack Teague's Finatic Charters | Cudjoe Key | Monroe | ● | | |
| Capt. Brian Cutchins - Laid Back Charters | Islamorada | Monroe | ● | | |
| Capt. Buddy Lapointe | Marathon | Monroe | ● | | |
| Capt. Clay Fishing Charters | Land o' Lakes | Pasco | ● | | |
| Capt. Dave Schugar Sweet E'nuf Charter | Marathon | Monroe | ● | | |
| Capt. Dave Wiley's Outcast Charters | Ramrod Key | Monroe | ● | | |
| Capt. Derren Doop | Summerland Key | Monroe | ● | | |
| Capt. Don Reichert - Fishin' Mission | Islamorada | Monroe | ● | | |
| Capt. Hook's Marina & Dive Centers | Marathon | Monroe | ● | | |
| Capt. John Pfeiffer | Naples | Collier | ● | | |
| Capt. John's Greyhound V | Key West | Monroe | ● | | |
| Capt. John's Guided Flats Charters | Big Pine Key | Monroe | ● | | |
| Capt. Kevin Brown - Gold Reserve Charters | Islamorada | Monroe | ● | | |
| Capt. Larry Sydnor | Key Largo | Monroe | ● | | |
| Capt. Tad's Fishing Charters | Key Colony Beach | Monroe | ● | | |
| Capt. Tom Rowland | Key West | Monroe | ● | | |
| Captain Ben's Extreme Charters | Panama City | Bay | ● | | |
| Captain Bill Bender | Islamorada | Monroe | | | |
| Captain Bill Roberts | Cedar Key | Levy | ● | | |
| Captain Bob Smith Saltwater Sportfishing | Sarasota | Manatee | ● | | |
| Captain Clay Fishing Charters | Land O Lakes | Pasco | ● | | |
| Captain Corey Mac Charters | Chokoloskee | Collier | ● | | |
| Captain Dana's Charters | Key Largo | Monroe | | | |
| Captain Dave Atkinson - No Politics Sportfishing | Islamorada | Monroe | ● | | |
| Captain David Graham Inc. | Tarpon Springs | Pinellas | ● | | |
| Captain Dennis Fantasy Charters | Islamorada | Monroe | ● | | |
| Captain Dennis Wilson's Fishing Charters | Holiday | Pasco | ● | | |
| Captain Doug's Tidewater Tours | Cedar Key | Levy | | | ● |
| Captain Hank Charters | Panama City | Bay | ● | | |
| Captain Josh Charters | Tampa | Hillsborough | ● | | |
| Captain Law Charters | Panama City | Bay | ● | | |
| Captain Lemo's Outdoor Adventures | Floral City | Citrus | ● | ● | |
| Captain Lemo's Outdoor Adventures | Floral City | Citrus | | | ● |
| Captain Lloyd Collins | Cedar Key | Levy | ● | | |
| Captain Mark Zorn | Homosassa | Citrus | ● | | |
| Captain Mike Gore Charters | Land o' Lakes | Pasco | ● | | |
| Captain Mike Patterson and FL Keys Concierge ServiceIslamorada | Islamorada | Monroe | ● | | |
| Captain Mike's Sunshine River Tours | Crystal River | Citrus | | | ● |

FLORIDA

| COMPANY NAME | CITY | COUNTY | FISHING | HUNTING | WILDLIFE |
|---|---|---|---|---|---|
| Captain Nick Warhurst | Williston | Levy | | | ● |
| Captain Pip's Marina & Hideaway | Marathon | Monroe | ● | | |
| Captain Rapps LLC | Chokoloskee | Lee | ● | | |
| Captain Ron Bastron - Reel 'N Reef Charters | Islamorada | Monroe | ● | | |
| Captain Tony Murphy | Key West | Monroe | ● | | |
| Cara Mia Fishing Charters | Marathon | Monroe | ● | | |
| Cast-A-Way Charters | Panama City | Bay | ● | | |
| Catch 'em All Sportfishing Charters | Marathon | Monroe | ● | | |
| Catch Me if You Can Charters | Islamorda | Monroe | ● | | |
| Catchalottafish Charters | Islamorada | Monroe | ● | | |
| Cazador Charters | Panama City | Bay | ● | | |
| Cedar Key Boat Rentals and Island Tours | Cedar Key | Levy | | | ● |
| Cedar Key Outfitters | Otter Creek | Levy | | ● | |
| Cedar Key Paddling Rentals Taxis and Tours | Cedar Key | Levy | | | ● |
| Charter Sea-Clusion | Key West | Monroe | ● | | |
| Charterboats Linda D Sportfishing | Key West | Monroe | ● | | |
| Chase-N-Fins | Gulf Breeze | Escambia | | | ● |
| Coastal Fishing Adventures, LLC | Bradenton | Manatee | ● | | |
| Comin' Home Charters | Marathon | Monroe | ● | | |
| Complete Shallow Water Experience | Tavernier | Monroe | ● | | |
| Conchubine Fishing | Key West | Monroe | ● | | |
| Congo Charters | Port St. Joe | Gulf | ● | | |
| Cool Breeze Charters | Panama City | Bay | ● | | |
| Cool Change Fishing Charters | Marathon | Monroe | ● | | |
| Couple-A-Bucks Backcountry Fishing Charter | Islamorada | Monroe | ● | | |
| Crystal Lodge Dive Center | Crystal River | Citrus | | | ● |
| Custom Fishing Charters | Key West | Monroe | ● | | |
| D.R. Guarino Charters | Ruskin | Hillsborough | ● | | |
| Davy Jones Charters | Panama City | Bay | ● | | |
| DayJammer Cruises | Crystal River | Citrus | | | ● |
| Dead Fish Charter Service | Santa Rosa Beach | Walton | ● | | |
| Deep Sea Fishing Charter | Venice | Sarasota | ● | | ● |
| Deep Sea Fishing Lo-Baby | Gulf Breeze | Escambia | ● | | |
| Deep South Outfitter | Crystal River | Citrus | | ● | |
| Destin Inshore Fishing Company | Destin | Okaloosa | ● | | |
| Destin Snorkel | Destin | Okaloosa | | | ● |
| Destin's Original Sea Blaster | Destin | Okaloosa | | | ● |
| Destiny Unbound Angling | Santa Rosa Beach | Walton | ● | | |
| Devil's Den | Williston | Levy | | | ● |
| Devil's Hammock Wildlife Management Area | Bronson | Levy | | ● | |
| Dhatldoits Fishing Adventures | Englewood | Sarasota | ● | | |
| Dive Locker | Panama City | Bay | | | ● |
| Diver's Den | Panama City | Bay | | | ● |
| Dock On The Bay | East Point | Franklin | ● | | |
| Dockside Charters - Captain Jeff Pfister | Islamorada | Monroe | ● | | |
| Dog House Charters | Port St. Joe | Gulf | ● | | |

FLORIDA

| COMPANY NAME | CITY | COUNTY | FISHING | HUNTING | WILDLIFE |
|---|---|---|---|---|---|
| Doghouse Offshore Fishing Charters | Islamorada | Monroe | ● | | |
| Dove Creek Lodge | Key Largo | Monroe | | | |
| Dream Catcher Charters | Key West | Monroe | | | |
| Early Bird Fishing Charters | Islamorada | Monroe | ● | | |
| Ecofina River Resort | Lamont | Jefferson | | ● | ● |
| Emerald Coast Scuba | Destin | Okaloosa | | | ● |
| Entertainer Charters | Pensacola Beach | Escambia | ● | | |
| Eva Marie Key West Fishing Charter | Key West | Monroe | ● | | |
| Everglades Fishing Charters - Go Fish Guides | Everglades | Collier | ● | | |
| Everglades/Floridays Charters | Naples | Collier | ● | | |
| Everlastus Fishing | Hudson | Pasco | ● | | |
| Excaliber Charter | Key Largo | Monroe | ● | | |
| Extreme Flats Fishing | Tampa | Hillsborough | ● | | |
| Family Tradition Charters | Panama City | Bay | ● | | |
| Fanatic Inshore Charters | Tarpon Springs | Pinellas | ● | | |
| Fantasy Fisherman | Homosassa | Citrus | ● | | |
| Fat Cat Fishing Charters | St. Petersburg | Pinellas | ● | | |
| Fearless Fishing Charters | Islamorada | Monroe | ● | | |
| Finesse Charters | Chokoloskee | Collier | ● | | |
| Fins and Tails Guide Service | Odessa | Hillsborough | ● | | |
| Finseeker Guided Adventures | Naples | Collier | ● | | |
| Finz Dive Center | Key West | Monroe | ● | | |
| First Choice Key Largo/Islamorada Fishing | Islamorada | Monroe | ● | | |
| First Light Fishing Charters | Panama City | Bay | ● | | |
| Fish Check Deep Sea Fishing Charters | Key West | Monroe | ● | | |
| Fishdaddy Charter | Spring Hill | Hernando | ● | | |
| Fishin Tampa Bay with Captain Jazz | Tampa | Hillsborough | ● | | |
| Fishing Charters by Captain David Dunn | Homosassa | Citrus | ● | | |
| Fishmonster Charters | Key West | Monroe | ● | | |
| FishNTampa Bay | St. Petersburg | Pinellas | ● | | |
| FishSkinner Charters | Ft. Myers | Lee | ● | | |
| Flamingo Charters - Capt. Mike HLIS | Islamorada | Monroe | ● | | |
| Flat Bottom Fishing | Port St. Joe | Gulf | ● | | |
| Flat Out Inshore Charters | Navarre | Santa Rosa | ● | | |
| Flat-Out Sportfishing | Marathon | Monroe | ● | | |
| Flats & Fly Fishing Guide - Capt. Justing Rea | Key West | Monroe | ● | | |
| Flats Fishing Key West | Key West | Monroe | ● | | |
| Flats Slam Fishing Charters | | Hernando | ● | | |
| Flatsaction Charters | | Escambia | ● | | |
| Florida Bowfishing with Razorback Outfitters | Tampa | Hillsborough | ● | ● | |
| Florida Fishing Adventures | Homosassa | Citrus | ● | | |
| Florida Fishing Headquarters - Capt. Steve Murray | Islamorada | Monroe | ● | | |
| Florida Fly Fishing | Sarasota | Sarasota | ● | | |
| Florida Keys Fishin/Two Starfish | Key Largo | Monroe | ● | | |
| Florida Keys Fun Fishing | Islamorada | Monroe | ● | | |

## FLORIDA

| COMPANY NAME | CITY | COUNTY | FISHING | HUNTING | WILDLIFE |
|---|---|---|---|---|---|
| Florida Keys Reel Adventures | Marathon | Monroe | ● | | |
| Florida Manatee Adventures | Iverness | Citrus | | | ● |
| Florida Manatee Tours | Crystal River | Citrus | | | ● |
| Florida Native Fishing Charters | St. Petersburg | Pinellas | ● | | |
| Florida Straits Diving | Key West | Monroe | ● | | |
| Fly Guy Charters | St. Petersburg | Pinellas | ● | | |
| Forgotten Coast Adventures | Port St. Joe | Gulf | ● | | |
| Frayed Knot Charters | North Port | Sarasota | ● | | |
| Full Boat Charters | Bradenton | Manatee | ● | | |
| Fun 2 Dive | Sanford | Citrus | | | ● |
| Fun Flats Fishing | Tampa | Hillsborough | ● | | |
| Fun Yet Charters | Little Torch Key | Monroe | ● | | |
| Gator Guides | Tampa | Hillsborough | | ● | |
| Gator Raiderz | Punta Gorda | Charlotte | | ● | ● |
| Ghost Hunter Fishing Charters | Big Pine Key | Monroe | ● | | |
| Go Fish Charters Inc. | Punta Gorda | Charlotte | ● | | |
| Go Native Tours with Snookie | Santa Rosa Beach | Walton | | | ● |
| Gone Coastal Charters | Tampa | Hillsborough | ● | | |
| Gotta Believe Charters | Panama City | Bay | ● | | |
| Gotta Go II Charters | Islamorada | Monroe | ● | | |
| Grand Slam Backcountry Charters | Big Pine Key | Monroe | | | |
| Grand Slam Designs | Myakka City | Manatee | | ● | |
| Grouper Therapy | Cedar Key | Levy | ● | | |
| Gulf Breeze Fishing Charters | Crystal River | Citrus | | | ● |
| Gulf Breeze Guide Service | Gulf Breeze | Escambia | ● | | |
| Gulf Coast Charters of Crystal River | Hernando | Citrus | ● | | |
| Gulf Coast Flats Fishing | Cedar Key | Levy | ● | | |
| Gulf Coast Inshore Charters | Santa Rosa Beach | Walton | ● | | |
| Gulf Coast Outfitters | Navarre | Santa Rosa | | ● | |
| Gulf Grouper Charters | Spring Hill | Hernando | ● | | |
| Gump's Bait & Tackle | Port Charlotte | Charlotte | ● | | |
| Hana Pa Charters | Tavernier | Monroe | ● | | |
| Hawks Cay Resort, Spa & Marina | Marathon | Monroe | ● | | |
| Haze N Ship Charters | St. Petersburg | Pinellas | ● | | |
| Heller High Waters, LLC | Pensacola | Escambia | ● | | |
| Homosassa Offshore Charters | Homosassa | Citrus | ● | | ● |
| Hook em Harry, LLC | Tampa | Hillsborough | ● | | |
| Hooked Up Charters | Cedar Key | Levy | ● | | |
| Hook'em Up Charters | Panama City | Bay | ● | | |
| Hotfish Charters | Tampa | Hillsborough | ● | | |
| Hunt Fish with Fly - Capt. Darren Williams | Islamorada | Monroe | ● | | |
| Inshore Florida Fishing | Cedar Key | Levy | ● | | |
| Inshore Slam Fishing Charters LLC | Valrico | Hillsborough | ● | | |
| Into the Wild - Eco Diversions | Santa Rosa Beach | Walton | | | ● |
| Irish C Guide Service | Key West | Monroe | ● | | |
| Islamorada Backcountry Charters | Islamorada | Monroe | ● | | |

FLORIDA

| COMPANY NAME | CITY | COUNTY | FISHING | HUNTING | WILDLIFE |
|---|---|---|---|---|---|
| Islamorada Fishing Charters with Capt. Rick Killgore | Islamorada | Monroe | ● | | |
| J E Lee Hunting Preserve | Punta Gorda | Charlotte | | ● | |
| Jig's Bait & Tackle Charter Services | Big Pine Key | Monroe | ● | | |
| Jubilee Fishing Charters | Panama City | Bay | ● | | |
| Kayak Cedar Keys | Cedar Key | Levy | | | ● |
| Kayak SW Florida | Bonita Springs | Lee | | | ● |
| Kelley Girl Charters | Panama City | Bay | ● | | |
| Key Flat Charters | Sugarloaf Key | Monroe | ● | | |
| Key Largo Fishing Adventures | Key Largo | Monroe | ● | | |
| Key West Charter Boats | Key West | Monroe | ● | | |
| Key West Flats & Backcountry Fishing | Key West | Monroe | ● | | |
| Key West Pro Guides | Key West | Monroe | ● | | |
| Keystone Tours | Monticello | Jefferson | | | ● |
| Killfish Charters | Port St. Joe | Gulf | ● | | |
| Lady Catherine Charters | Marathon | Monroe | | | |
| Lady J Charters | Port St. Joe | Gulf | ● | | |
| Lady Pirate Charters | Cedar Key | Levy | ● | | |
| Last Local Guide Service | Panama City | Bay | ● | | |
| Les Hassel Excursions | Carrabelle | Franklin | | | ● |
| Lethal Weapon Charters | Key West | Monroe | ● | | |
| Light Tackle Adventures | Odessa | Hillsborough | ● | | |
| Light Tackle Fishing | Port St. Joe | Gulf | ● | | |
| Longwood Hammock Outfitters | Port Charlotte | Charlotte | | ● | |
| Lost Bay Guide Service | Pensacola | Escambia | ● | | |
| Lost Cause Charters | Plant City | Hillsborough | ● | ● | ● |
| Lost Coast Anglers | Tampa | Hillsborough | ● | | |
| Lost Key Charters | Perdido Key | Escambia | ● | | |
| Lower Suwanee Wildlife Excursions | Cedar Key | Levy | | | ● |
| Lucky Chucky Charters | Navarre | Santa Rosa | ● | | |
| Lyons Charters | St. Petersburg | Pinellas | ● | | |
| Main Attraction Charters | Marathon | Monroe | ● | | |
| Manatee Connection | Crystal River | Citrus | | | ● |
| Manatee Springs State Park | Chiefland | Levy | | | ● |
| Manatee Tour and Dive | Crystal River | Citrus | | | ● |
| Manatees In Paradise | Crystal River | Citrus | | | ● |
| Mangrove Creek Outfitters | Chiefland | Levy | | ● | |
| MangroveMasters, LLC | Ft. Myers | Lee | ● | | ● |
| Marathon Lady | Marathon | Monroe | | | |
| McGowan Charters | Panama City | Bay | ● | | |
| Meridian Charters | Key West | Monroe | ● | | |
| Miller Time Sportfishing | Islamorada | Monroe | ● | | |
| Miss Beck Deep Sea Fishing | Panama City | Bay | ● | | |
| Mission Fishin Charters | Hernando Beach | Hernando | ● | | |
| Naples Fishing Charters | Naples | Collier | ● | | |
| Naples Marina & Excursions | Naples | Collier | | ● | |

FLORIDA

| COMPANY NAME | CITY | COUNTY | FISHING | HUNTING | WILDLIFE |
|---|---|---|---|---|---|
| Native Guidance | Summerland Key | Monroe | ● | | |
| Native Son Sportfishing | Marathon | Monroe | ● | | |
| Native Sun Tours | Homosassa | Citrus | | | ● |
| Native Vacations | Crystal River | Citrus | | | ● |
| Nature Coast Canoe and Kayak | Cedar Key | Levy | | | ● |
| Nature Coast Manatee Tours | Homosassa | Citrus | | | ● |
| Navarre Beach Kayaks | Navarre | Santa Rosa | | | ● |
| Neptuna Charters | Key West | Monroe | ● | | |
| Neva-Miss Charters | Steinhatchee | Dixie | ● | | |
| New Beginning Fishing Charter | Panama City | Bay | ● | | |
| New Water Charters | Iverness | Citrus | ● | | |
| Off the Rock Charters | Key West | Monroe | | | |
| Old Florida Outfitters | Santa Rosa Beach | Walton | ● | | |
| On the Mark Charters | St. Petersburg | Pinellas | ● | | |
| One More Cast Guide Service | Perry | Taylor | ● | | |
| Ospree Guide Service | Yankeetown | Levy | ● | | ● |
| Osprey Charters | Panama City | Bay | ● | | |
| Outcast Charter Company | Punta Gorda | Charlotte | | ● | ● |
| Paddlefish Kayaking - Guided Excursions | Islamorada | Monroe | | | ● |
| Palmetto Expeditions | Crawfordville | Wakulla | | | ● |
| Panama City Dive Charters | Panama City | Bay | ● | | ● |
| Pelican Adventures | Destin | Okaloosa | ● | | ● |
| Pepperfish Key Charters | Steinhatchee | Dixie | ● | | |
| Plantation's Adventure Center | Crystal River | Citrus | | | ● |
| Port Hotel Dive Center | Crystal River | Citrus | | | ● |
| Premier Sportfishing Adventures | Port Saint Joe | Gulf | ● | | |
| Pristine Florida Fishing | Holiday | Pasco | ● | | |
| Quailtimber Plantation | Paxton | Walton | | ● | |
| Redfish Landing Guide Service | Ruskin | Hillsborough | ● | | |
| Redfish Sportfishing Charters | Islamorada | Monroe | ● | | |
| Reef Light Tackle | Big Pine Key | Monroe | ● | | |
| Reel Dreams Fishing Charters | Marathon | Monroe | ● | | |
| Reel Therapy Fishing Charters | Little Torch Key | Monroe | ● | | |
| Reel Addiction Sportfishing | Venice | Sarasota | ● | | |
| Reel 'em In Charters | Panama City | Bay | ● | | |
| Reel Time Charters | Steinhatchee | Dixie | ● | | |
| Relentless Fishing Charters | Key West | Monroe | ● | | |
| Rick Berry's Key Largo Rods | Islamorada | Monroe | ● | | |
| Right Choice Charters | Little Torch Key | Monroe | ● | | |
| River Safaris and Gulf Charters | Homosassa | Citrus | | | ● |
| River to Sea Excursions | Port St. Joe | Gulf | | | ● |
| River Ventures Manatee Tour | Crystal River | Citrus | | | ● |
| Riversport Kayaks | Homosassa | Citrus | | | ● |
| Roadrunner Fishing | Marathon | Monroe | ● | | |
| ROSS HAMMOCK RANCH | Inglis | Levy | | ● | |
| RU4Scuba | Fort Walton Beach | Okaloosa | | | ● |

FLORIDA

| COMPANY NAME | CITY | COUNTY | FISHING | HUNTING | WILDLIFE |
|---|---|---|---|---|---|
| Rusty IV Sportfishing | Islamorada | Monroe | ● | | |
| Sail Away | Destin | Okaloosa | | | ● |
| Sail Fish SCUBA | Key Largo | Monroe | ● | | ● |
| Saint Pete Fishing Charters | St. Petersburg | Pinellas | ● | | |
| Saltwater Assassin-Inshore Fishing Charters | Cedar Key | Levy | ● | | |
| Salty's Beach Shack | Cape San Blas | Gulf | | | ● |
| Santa Rosa Sound Cruises | Fort Walton Beach | Okaloosa | | | ● |
| Sarasota Outfitter Service LLC | Sarasota | Manatee | | ● | ● |
| Scales N Tails Charters | Perry | Taylor | ● | | |
| Scuba Tech Diving and Snorkeling | Destin | Okaloosa | | | ● |
| SEA Education Adventures | Crystal River | Citrus | | | ● |
| Sea Horse Charters | Islamorda | Monroe | ● | | |
| Sea Scrap Charters, LLC | Tarpon Springs | Pinellas | ● | | |
| Seabreeze Fishing Charters | Key West | Monroe | ● | | |
| Sea-Clusive Charters | Key West | Monroe | ● | | |
| Seahorse Water Safaris | Port St. Joe | Gulf | ● | | ● |
| Seasquared Charters | Marathon | Monroe | ● | | |
| Secret Spot Charters - Capt. Ted Wilson | Islamorada | Monroe | ● | | |
| Shallow Minded Charter Service | Tarpon Springs | Pinellas | ● | | |
| Shallow Water Charters with Captain Dale Bishop | Cudjoe Key | Monroe | ● | | |
| Shallow Water Charters | Key West | Monroe | ● | | |
| Shallow Water Expeditions Guide Service | Santa Rosa Beach | Walton | ● | | |
| Shamrock Inshore Charters | St. Petersburg | Pinellas | ● | | |
| Shepherd Guide Service | Crystal River | Citrus | ● | | ● |
| Shore Thang Charters | Port Saint Joe | Gulf | ● | | |
| Sight Fish Charters | Cudjoe Key | Monroe | ● | | |
| Sightfish | Plantation Island | Collier | ● | | |
| Sightfishing with Captain Bo Sellers | Summerland Key | Monroe S | ● | | |
| nook Doctor Charters | Tampa | Hillsborough | ● | | |
| Silver Spray Guide Service | Marathon | Monroe | ● | | |
| Skins and Fins Charters | Islamorada | Monroe | ● | | |
| Snorkel With Manatees | Homosassa | Citrus | | | ● |
| Snorkel-Fish Combo Delphine Charters | Key West | Monroe | ● | | |
| Something's Fishy Charters | Steinhatchee | Dixie | ● | | |
| Sore Back Fishing Charters | Riverview | Hillsborough | ● | | |
| South Again Charters, LLC | Navarre | Santa Rosa | ● | | |
| South Pole Charters | Key West | Monroe | ● | | |
| Southern Instinct Charters | Ft. Myers | Lee | ● | | ● |
| Southern Lady Charters | Port St. Joe | Gulf | ● | | |
| Southern Salt Charters | Cedar Key | Levy | ● | | |
| Southern Tide Charters | Port St. Joe | Gulf | ● | | |
| Southern Waterfowl, LLC | Navarre | Santa Rosa | | ● | |
| Southpaw Fishing Charters | Key West | Monroe | ● | | |
| Sportfishing Unlimited & Outdoor Communications | Tampa | Hillsborough | ● | ● | ● |

FLORIDA

| COMPANY NAME | CITY | COUNTY | FISHING | HUNTING | WILDLIFE |
|---|---|---|---|---|---|
| Spot on Charters | Ft. Myers | Lee | ● | | ● |
| St Marks Outfitters | St. Marks | Wakulla | ● | | ● |
| St. Pete Charter Fishing | St. Petersburg | Pinellas | ● | | |
| Stinger Charters | Marathon | Monroe | ● | | |
| Strike Zone Charters | Big Pine Key | Monroe | ● | | |
| Superfish Charters | Marathon | Monroe | ● | | |
| Tailchaser Charters | Key West | Monroe | ● | | |
| Tails And Scales Charters | Rotonda West | Charlotte | ● | | ● |
| Tails Up Fishing Charters with Capt. Kerry Wingo | Key Largo | Monroe | ● | | |
| Tall Tales Fishing Charters | Port St. Joe | Gulf | ● | | |
| Tampa Bay Fishing Charter - Capt. John Paiva | Apollo Beach | Hillsborough | ● | | |
| Tampa Bay Inshore Charters, LLC | Land o' Lakes | Pasco | ● | | ● |
| Tampa Fishing Charters By Capt Will Shook | Riverview | Hillsborough | ● | | |
| Tamps Fishing Charters | Safety Harbor | Pinellas | ● | | |
| Tarpon Adventures | Islamorada | Monroe | ● | | |
| Tarpon Creek Marina | Marathon | Monroe | ● | | |
| Tarpoons Fishing Charter | Ft. Myers | Lee | ● | | |
| The Deer Camp | Chiefland | Levy | | ● | |
| The Reef Chief Charters | Port Richey | Pasco | ● | | |
| The Saltwater Angler | Key West | Monroe | ● | | |
| The Scuba Shop | Fort Walton Beach | Okaloosa | | | ● |
| The Tacklebox | Marathon | Monroe | ● | | |
| The Wilderness Way | Crawfordville | Wakulla | | | ● |
| Third Generation Charters | Big Pine Key | Monroe | ● | | |
| Tight Lines Charters | Port St. Joe | Gulf | ● | | |
| Tight Loops Flyfishing and Wingshooting | Venice | Sarasota | ● | ● | |
| TNT Gators | Jay | Santa Rosa | | ● | |
| TNT Hideaway | Crawfordville | Wakulla | | | ● |
| Top Knot Charters | Palmetto | Manatee | ● | | |
| Trinity Charters | Ft. Myers | Lee | ● | | |
| TropicBird Ecotours | Naples | Collier | | | ● |
| Ultimate Fishing Adventures with Capt. George Wood | Islamorada | Monroe | ● | | |
| Under The SON Outfitters | Plant City | Hillsborough | | ● | |
| Viking Diving | Pensacola Beach | Escambia | | | ● |
| Voyles Guide Service | Cedar Key | Levy | ● | | |
| Waccasassa Bay Airboat Fishing Charters | Cedar Key | Levy | ● | | |
| Wacissa River Canoe Rentals | Monticello | Jefferson | | | ● |
| Walco Eco Tours | Santa Rosa Beach | Walton | | | ● |
| WestBound Fish Society | Bradenton | Manatee | ● | | ● |
| WetWilly Charters | Palmetto | Manatee | ● | | |
| Wheelhouse Tours | Apalachicola | Franklin | | | ● |
| Wide Open Sportfishing | Islamorada | Monroe | ● | | |
| Widow Maker Sportfishing | Marathon | Monroe | ● | | |

FLORIDA

| COMPANY NAME | CITY | COUNTY | FISHING | HUNTING | WILDLIFE |
|---|---|---|---|---|---|
| Wild Bill Sport Fishing | Key West | Monroe | ● | | |
| Wild Florida Adventures | Williston | Levy | | | ● |
| Wildlife Services Unlimited | Lamont | Jefferson | ● | ● | |
| Windward Sailing Charters | Port St. Joe | Gulf | | | ● |
| World Angling/Capt. Will Benson | Sugarloaf Key | Monroe | ● | | |
| XXL Sportfishing | Punta Gorda | Charlotte | ● | | |
| Yellowfin Ocean Sports | Santa Rosa Beach | Walton | ● | | |
| Z-horse Charters | Carrabelle | Franklin | ● | | |

LOUISIANA

| | | | | | |
|---|---|---|---|---|---|
| A Cajun Man's Swamp Cruise | Gibson | Terrebonne | | | ● |
| A Day In Paradise | Grand Isle | Jefferson | ● | | |
| Absolute Fishing Charters | Theriot | Terrebonne | ● | | |
| Action Greg's Guide Service | Houma | Terrebonne | ● | | |
| Adventure Charters | Belle Chase | Plaquemines | ● | | |
| Adventure South Guide Service | Buras | Plaquemines | ● | | |
| Airboat Charters - Fishing | Theriot | Terrebonne | ● | | |
| Airboat Charters Inc. | Houma | Terrebonne | | | ● |
| Airboat Tours by Arthur Matherne, Inc | Des Allemands | Lafourche | | | ● |
| Airboats & Alligators | Grand Chenier | Cameron | | | ● |
| Angelette's Fishing Charters | Cut Off | Lafourche | ● | | |
| Angling Adventures of LA | Slidell | Saint Tammany | ● | | |
| Annie Millers Sons Marsh and Swamp Tours | Houma | Terrebonne | | | ● |
| Arthur A. Matherne, Inc | Des Allemands | Lafourche | ● | | |
| Atchafalaya Basin Backwater Tours | Gibson | Terrebonne | | | ● |
| Avid Angler Fishing Charters | Houma | Terrebonne | ● | | |
| Backwater Charters, LLC | Houma | Terrebonne | ● | | |
| Bad Boyz Charters | Grand Isle | Jefferson | ● | | |
| Bad Lands Hunting | Abbeville | Vermilion | | ● | |
| Barousses Big Easy Fishing Charters | Marrero | Jefferson | ● | | |
| Baycoast Charters | Golden Meadow | Lafourche | ● | | |
| Bayou Adventure | Lacombe | Saint Tammany | | | ● |
| Bayou Black Airboat Service Tours | Gibson | Terrebonne | | | ● |
| Bayou Black Marina | Gibson | Terrebonne | ● | | |
| Bayou Charters | Saint Bernard | Saint Bernard | ● | | |
| Bayou Guide Service & Charters | Theriot | Terrebonne | ● | | |
| Bayou Segnette State Park | Westwago | Jefferson | ● | | |
| Beachcomber Guide Service | Theriot | Terrebonne | ● | | |
| Bell's Hackberry Lodge | Hackberry | Cameron | | ● | |
| Bent Rod Offshore | Grand Isle | Jefferson | ● | | |
| Between the Banks, LLC | Thibodaux | Lafourche | ● | | |
| Big "O" Charters LLC | Denham Springs | Livingston | ● | | |
| Big Dog Fishing Charters, LLC | Lafitte | Jefferson | ● | | |
| Blaize Charters, LLC | Buras | Plaquemines | ● | ● | |
| Blue Marine Charters | Grand Isle | Jefferson | ● | | |
| Bobby Lynn's Marina & Fishing Charters | Golden Meadow | Lafourche | ● | | |

LOUISIANA

| COMPANY NAME | CITY | COUNTY | FISHING | HUNTING | WILDLIFE |
|---|---|---|---|---|---|
| Bon Chance Fishing | Grand Isle | Jefferson | ● | | |
| Boo Too Charters | Houma | Terrebonne | ● | | |
| Born to Fish Charters | Venice | Plaquemines | ● | | |
| Boudreaux's Condeauxs & Fishing Charters | Golden Meadow | Lafourche | ● | | |
| Boudreaux's Marina | Chauvin | Terrebonne | ● | | |
| Bowfishing - Unlimited | Port Sulphur | Plaquemines | ● | | |
| Brooks-Hooks Fishing Charters | Grand Isle | Jefferson | ● | | |
| Bulls Eye Charters | Cypremort Point | Saint Mary | ● | | |
| C & B Charter Fishing | Chauvin | Terrebonne | ● | | |
| Cajun Encounters Swamp Tour | Slidell | Saint Tammany | | | ● |
| Cajun Fishing & Hunting Charters | Houma | Terrebonne | ● | | |
| Cajun Fishing Adventures | Luling | St. Charles | ● | | |
| Cajun Fishing and Hunting Charters | Houma | Terrebonne | ● | ● | |
| Cajun Houseboat and Rentals, Inc | Morgan City | Saint Mary | | | ● |
| Cajun Jacks Swamp Tour | Patterson | Saint Mary | | | ● |
| Cajun Made Charters | Golden Meadow | Lafourche | ● | | |
| Cajun Odysea | Venice | Plaquemines | ● | | |
| Cajun Resort, LLC | Galliano | Lafourche | ● | | |
| Cajun Tours: Swamp Tour | Houma | Terrebonne | | ● | |
| Cajun Unlimited Fishing Charter | Venice | Plaquemines | ● | | |
| Cajun Way Hunting Lodge | Gueydan | Vermilion | | ● | |
| Calmwater Charters | Grand Isle | Jefferson | ● | | ● |
| Capt Dude's! Dudenhefer's Fishing Charters | Saint Bernard | Saint Bernard | ● | | |
| Capt. "T-Man's" Charters | Larose | Lafourche | ● | | |
| Capt. Bennys Charter Fishing | Slidell | Saint Tammany | ● | | |
| Capt. Gene Dugas' Rather Be Fishing - Hunting Adventures | Hopedale | Saint Bernard | ● | ● | |
| Capt. Steve Tomeny Charters | Golden Meadow | Lafourche | ● | | |
| Captain Blaine Townsend | Chauvin | Terrebonne | ● | | |
| Captain Chads Fishing Adventures | Venice | Plaquemines | ● | | |
| Captain Daves Guide Service | Venice | Plaquemines | ● | | |
| Captain Gene Foret | Cocodrie | Terrebonne | ● | | |
| Captain Tilman Guide Service | Venice | Plaquemines | ● | | |
| Cast & Blast Charters | Hopedale | Saint Bernard | ● | ● | |
| Cast & Catch | Grand Isle | Jefferson | ● | | |
| Cast & Catch Charters | Golden Meadow | Lafourche | ● | | |
| Charlie Hardison & Sons | Golden Meadow | Lafourche | ● | | |
| Charter Boat Charlie | Slidell | Saint Tammany | ● | | |
| Cherece IV | Grand Isle | Jefferson | ● | | |
| Coastal Charter Services | Cocodrie | Terrebonne | ● | ● | |
| Custom Charters | Houma | Terrebonne | ● | | |
| Cypremort Point Charter Service | Cypremort Point | Saint Mary | ● | | |
| Day by Day Charters | Grand Isle | Jefferson | ● | | |
| Deep Delta Bowfishing | Belle Chase | Plaquemines | ● | | |
| Deep South Charters | Venice | Plaquemines | ● | | |
| Delacro Joes Lodge | Delacoix Island | Saint Bernard | ● | ● | |

LOUISIANA

| COMPANY NAME | CITY | COUNTY | FISHING | HUNTING | WILDLIFE |
|---|---|---|---|---|---|
| Delta Blue Sport Fishing, Inc. | Buras | Plaquemines | ● | | |
| Delta Dawn Fishing | Livingston | Livingston | ● | | |
| Doug's Hunting Lodge | Gueydan | Vermilion | | ● | |
| Dr. Wagners Honey Island Swamp Tours, Inc. | Slidell | Saint Tammany | | | ● |
| Dulac Charters | Houma | Terrebonne | ● | | |
| Escape Fishing Charters | Slidell | Saint Tammany | ● | | |
| Falgout Canal Landing | Theriot | Terrebonne | ● | | |
| Fightin' Minnow Fishing Charters | Houma | Terrebonne | ● | | |
| Fin and Feather Cabins & Adventures | Belle Chase | Plaquemines | ● | | |
| Fin and Feather Guides | Venice | Plaquemines | ● | ● | |
| Fish Commander | Grand Isle | Jefferson | ● | | |
| Good Times Charters | Grand Isle | Jefferson | ● | | |
| Goose Guides, Inc | Gueydan | Vermilion | | ● | |
| Gotcha Fishing Charter | Grand Isle | Jefferson | ● | | |
| Greenwood Gator Farm and Tours | Gibson | Terrebonne | | | ● |
| Griffin Fishing Charters | Lafitte | Jefferson | ● | | |
| H & M Charters | Grand Isle | Jefferson | ● | | |
| H20 Offshore Charters | Venice | Plaquemines | ● | | |
| Hackberry Cajun Guide | Hackberry | Cameron | ● | | |
| Hackberry Charters | Hackberry | Cameron | ● | | |
| Hackberry Rod and Gun | Hackberry | Cameron | ● | ● | |
| Hammond's Cajun Air Tours | Houma | Terrebonne | | | ● |
| Hard Times Fishing Charters | Grand Isle | Jefferson | ● | | |
| Hot Rods Guide Service | Grand Isle | Jefferson | ● | | |
| Impulse Fishing Charters | Theriot | Terrebonne | ● | | |
| Irwins Guide Service | Grand Isle | Jefferson | ● | | |
| Jean Lafitte Charters, Inc | Barataria | Jefferson | ● | | |
| Joes Landing | Lafitte | Jefferson | ● | | |
| Joe's Landing, Inc | Barataria | Jefferson | ● | | |
| K & J Hunting and Fishing Lodge | Cameron | Cameron | ● | ● | |
| Korys Charters | Lafitte | Jefferson | ● | | |
| Kris' Fishing Charters | Lafitte | Jefferson | ● | | |
| LA Marsh Guide Service | Saint Bernard | Saint Bernard | | ● | |
| Lagniappe Fishing Charters | Barataria | Jefferson | ● | ● | |
| Louisiana Bow Fishing | Venice | Plaquemines | ● | | |
| Louisiana Flyway Lodge | Kaplan | Vermilion | | ● | |
| Louisiana Lost Land Tours | New Orleans | Orleans | | | ● |
| Louisiana Offshore Fishing | Venice | Plaquemines | ● | | |
| Louisiana Tour Company, LLC | Marrero | Jefferson | | | ● |
| Lucky Egg Charters LLC | Venice | Plaquemines | ● | | |
| Marsh Madness | Houma | Terrebonne | ● | | |
| Marsh Masters | Golden Meadow | Lafourche | ● | | |
| Marsh Rat Fishing Guide | Raceland | Lafourche | ● | | |
| Marshland Guide Service | Golden Meadow | Lafourche | ● | | |
| Mississippi Delta Guide Service Inc. | Venice | Plaquemines | ● | | |
| Mr. Dennys Voyageur Swamp Tour | Slidell | Saint Tammany | | | ● |

## LOUISIANA

| COMPANY NAME | CITY | COUNTY | FISHING | HUNTING | WILDLIFE |
|---|---|---|---|---|---|
| Munsons World Famous Swamp Tour | Schriever | Terrebonne | | | ● |
| Myrtle Grove Charters | Port Sulphur | Plaquemines | ● | | |
| Paradise Outfitters of Louisiana | Venice | Plaquemines | ● | | |
| Pearl River Eco-Tours | Slidell | Saint Tammany | | | ● |
| Pecan Island Redfish Charters | Pecan Island | Vermilion | ● | | |
| Pelagic Charters | Grand Isle | Jefferson | ● | | |
| Pelican State Fishing Charters, LLC | Barataria | Jefferson | ● | | |
| Plaisance Tidewater Charters | Golden Meadow | Lafourche | ● | | |
| Pointe Aux Chenes Marina | Montegut | Terrebonne | ● | | |
| Pontchartrain Charters | Slidell | Saint Tammany | ● | | |
| Premier Charters | Grand Isle | Jefferson | ● | | |
| Pure Pleasure Fishing Charters | Buras | Plaquemines | ● | | |
| Rippin Lip Guide Service, L.L.C. | Cut Off | Lafourche | ● | | |
| River Oaks Fishing Cottages | Buras | Plaquemines | ● | | |
| Rivers End Outfitters | Venice | Plaquemines | ● | | |
| Ron's Charters | Hackberry | Cameron | ● | | |
| SALT Charters - Saltwater & Light Tackle | Cocodrie | Terrebonne | ● | | |
| Salt Water Guide Service | Larose | Lafourche | ● | | |
| Saltgrass Outdoors | Buras | Plaquemines | ● | | |
| Sea Creature Fishing Charters | Dulac | Terrebonne | ● | | |
| Southern Nights Bowfishing Charter, LLC | Chauvin | Terrebonne | ● | | |
| Speck-Tackler Charters | Golden Meadow | Lafourche | ● | | |
| Spicer-Hugh's Marina and Motel | Hackberry | Cameron | ● | | |
| Spots & Specks Charters, LLC | Galliano | Lafourche | ● | | |
| Stillwater Outfitters | Cypremort Point | Saint Mary | ● | | |
| Strike Zone Charters | Venice | Plaquemines | ● | | |
| Super Strike Charters | Venice | Plaquemines | ● | ● | |
| Todd Semar Fishing Guide Service | Pecan Island | Vermilion | ● | | |
| Torres Cajun Swamp Tours | Kraemer | Lafourche | | | ● |
| Ultimate Hunting and Fishing Charters, LLC | Houma | Terrebonne | ● | ● | |
| Venice Charter Fishing | Venice | Plaquemines | ● | ● | |
| Venice Offshore Charters | Venice | Plaquemines | ● | | |
| Venice Outdoor | Venice | Plaquemines | ● | ● | |
| Voodoo Fishing Charters | Venice | Plaquemines | ● | | |
| Wetland Tours | Theriot | Terrebonne | | | ● |
| Wildlife Gardens | Gibson | Terrebonne | | | ● |
| Xtreme Fishing Charters | Boothville | Plaquemines | ● | | |
| Zam's Swamp Tours, Inc | Thibodaux | Lafourche | | | ● |
| Zutie's Bay Coast Charters | Grand Isle | Jefferson | ● | | |

MISSISSIPPI

| COMPANY NAME | CITY | COUNTY | FISHING | HUNTING | WILDLIFE |
|---|---|---|---|---|---|
| 9-Ball Fishing Charters | Long Beach | Harrison | ● | | |
| Adventure Charters & Dive | Moss Point | Jackson | ● | | ● |
| Amberjack Charters | Biloxi | Harrison | ● | | |
| Amberjack Sport Fishing Charters | Biloxi | Harrison | ● | | |
| Bay Breeze Bike & Kayak Rentals | Bay St. Louis | Hancock | | | ● |
| Beverlee Ann Charters | Biloxi | Harrison | ● | | |
| Big Fish Charters | Biloxi | Harrison | ● | | |
| Biloxi Bay Charter | Biloxi | Harrison | ● | | |
| Biloxi Cruise Company | Biloxi | Harrison | ● | | |
| Biloxi Fishing Trip | Biloxi | Harrison | ● | | |
| Biloxi Shrimping Trip | Biloxi | Harrison | | | ● |
| Bojohla Charters | Biloxi | Harrison | ● | | |
| Bo-Jo-La Charters | Biloxi | Harrison | ● | | |
| Break Away Charter Boat | Gulfport | Harrison | ● | | |
| Cajun Boss Charters | Long Beach | Harrison | ● | | |
| Cam-Lo Charters | Long Beach | Harrison | ● | | |
| Captain Ron's Charters | Biloxi | Harrison | ● | | |
| Chandeleur Outfitters | Ocean Springs | Jackson | ● | | |
| Chasing Tail Charters, LLC | Bay St. Louis | Hancock | ● | | |
| Dominator Fishing Charters, LLC | Biloxi | Harrison | ● | | |
| Due South Charters | Biloxi | Harrison | ● | | |
| Ecogeno Bicycle Shop | Biloxi | Harrison | | | ● |
| Eco-Tours Of South Mississippi | Gautier | Jackson | | | ● |
| Fins & Grins Charter Service, LLC | D'Iberville | Harrison | ● | | |
| First Priority Charters | Biloxi | Harrison | ● | | |
| Fish Finder Charters | Biloxi | Harrison | ● | | |
| Fish South Mississippi | Gulfport | Harrison | ● | | |
| Fisha-Tractor Charters | Pascagoula | Jackson | ● | | |
| Fishfinder Charters | Biloxi | Harrison | ● | | |
| Fishing Frenzy Charters | Long Beach | Harrison | ● | | |
| Fish-On Charters | Biloxi | Harrison | ● | | |
| Fishtales Charters | Christian | Harrison | ● | | |
| Fishy Business | Gulfport | Harrison | ● | | |
| Fort Bayou Charters | Ocean Springs | Jackson | ● | | |
| Gaff-In Charters | Ocean Springs | Jackson | ● | | |
| Geaux Fish Charters, Inc | Ocean Springs | Jackson | ● | | |
| Gofish Charters of MS | Gulfport | Harrison | ● | | |
| Goin' Coastal Charters | Biloxi | Harrison | ● | | |
| Grand Bay National Estuarine Research Reserve | Moss Point | Jackson | | | ● |
| Gulf Coast Charters | Waveland | Hancock | ● | | |
| Gulf Coast Gator Ranch & Airboat Tours | Moss Point | Jackson | | | ● |
| Gulf Cruisers | Long Beach | Harrison | ● | | |
| Gulf Islands National Seashore | Pascagoula | Jackson | | | ● |
| Happy Hooker | Biloxi | Harrison | ● | | |
| High Tide Fishing Charter | Pass Christian | Harrison | ● | | |

MISSISSIPPI

| COMPANY NAME | CITY | COUNTY | FISHING | HUNTING | WILDLIFE |
|---|---|---|---|---|---|
| High Times Charters | Biloxi | Harrison | ● | | |
| Horn Island Charters | Biloxi | Harrison | ● | | |
| I'm Alone Charters | Pascagoula | Jackson | ● | | |
| Impulsive Charters | Long Beach | Harrison | ● | | |
| Island Breeze Charters | Biloxi | Harrison | ● | | |
| Jig-A-Low Charters, LLC | Biloxi | Harrison | ● | | |
| Joka's Wild Charters | Biloxi | Harrison | ● | | |
| Jourdan River Blueway | Kiln | Hancock | | | ● |
| Least Tern Nesting Areas | Gulfport | Harrison | | | ● |
| Mccoy's River & Marsh Tours | Moss Point | Jackson | | | ● |
| Mega-Bite Fishing Charter | Biloxi | Harrison | ● | | |
| Miss Hospitality Charter Boat | Biloxi | Harrison | ● | | |
| Mississippi Charter Boat Captain's Association | Biloxi | Harrison | ● | | |
| Mississippi Outdoor Specialists | Long Beach | Harrison | | ● | |
| Mississippi Sandhill Crane National Wildlife Refuge | Gautier | Jackson | | | ● |
| Mossy Island Outfitters | Morgan City | Leflore | | ● | |
| Mr. Champ Charters | Biloxi | Harrison | ● | | |
| Ms. Biggy Deer Island Fishing | Ocean Springs | Jackson | ● | | |
| Mystic Angel Charters | Biloxi | Harrison | ● | | |
| Old Fort Bayou Blueway | Ocean Springs | Jackson | | | ● |
| Pascagoula River Audubon Center | Moss Point | Jackson | | | ● |
| Prime Tyme Charters | Biloxi | Harrison | ● | | |
| Right Tackle Charters | Biloxi | Harrison | ● | | |
| Ring Dang Do Charter | Gulfport | Harrison | ● | | |
| Scranton Nature Center | Pascagoula | Jackson | | | ● |
| Shallow Draft Bayou Cruises | Coastwide | Harrison | | | ● |
| Shallow Draft Charters | Biloxi | Harrison | ● | | |
| Shearwater Charters | Biloxi | Harrison | ● | | |
| Shore Thing Fishing Charters | Bay St. Louis | Hancock | ● | | |
| Silver Dollar III | Biloxi | Harrison | ● | | |
| South Coast Paddling Company | Ocean Springs | Jackson | | | ● |
| South MS Charters, LLC | Gulfport | Harrison | ● | | |
| Southeast Adventure Company | Biloxi | Harrison | | | ● |
| Southern Belle Fishing Tours, Inc | Gulfport | Harrison | ● | | |
| Southern Comfort Fishing Charters | Christian | Harrison | ● | | |
| Southern Sports Fishing, Inc | Biloxi | Harrison | ● | | |
| Southern Way Charters | Gulfport | Harrison | ● | | |
| Still Water Fishing Charters | Long Beach | Harrison | ● | | |
| Strictly Business | Biloxi | Harrison | ● | | |
| Strictly Fishin' Charters | Ocean Springs | Jackson | ● | | |
| Syl Charters | Biloxi | Harrison | ● | | |
| T & D Charters, Skipper | Biloxi | Harrison | ● | | |
| Team Brodie Charters | Biloxi | Harrison | ● | ● | ● |
| The V Fishing Charter | Biloxi | Harrison | ● | | |
| Three Sons IV | Biloxi | Harrison | ● | | ● |

| COMPANY NAME | CITY | COUNTY | FISHING | HUNTING | WILDLIFE |
|---|---|---|---|---|---|
| Whipasnapa Charters | D'Iberville | Harrison | ● | | ● |
| Wolf River Canoe & Kayak | Long Beach | Harrison | | | ● |

TEXAS

| | | | | | |
|---|---|---|---|---|---|
| 3G Fishing Charters | Galveston | Galveston | ● | | |
| 4 "Reel" Fishing Charters | Galveston | Galveston | ● | | |
| 61st St. Fishing Pier | Galveston | Galveston | ● | | |
| A Fishing Fantasy Guide Service & Outfitters | Aransas Pass | Nueces | ● | | |
| AAA Adventures | Fulton | Aransas | ● | | |
| Aaron's Guide Service | Corpus Christi | Nueces | ● | | |
| Ace in the Hold Guide Service | Corpus Christi | Nueces | ● | | |
| Adams Sportfishing Charters | Freeport | Brazoria | ● | | |
| Airboat Adventures | Rockport | Aransas | | | ● |
| All American Fishing Charters | Galveston | Galveston | ● | | |
| All-Star Fishing Service | Corpus Christi | Nueces | ● | | |
| Al's Guide Service | Wadsworth | Matagorda | ● | | |
| Ambush Charters | Port Aransas | Nueces | ● | | |
| American Diving | South Padre Island | Willacy | | | ● |
| Andy's Guide Service | South Padre Island | Willacy | ● | | |
| Angell Fishing Guide Service | Corpus Christi | Nueces | ● | | |
| Anglers Choice Guide Service | Port Isabel | Cameron | ● | | |
| Angling Adventures | Galveston | Galveston | ● | ● | |
| Applebe Guide Service | Galveston | Galveston | ● | | |
| Aqua Safari Charters | Galveston | Galveston | ● | | |
| AQUA SAFARI CHARTERS | Galveston | Galveston | ● | | |
| Aransas Bay Birding Charters | Lamar | Aransas | | | ● |
| Aransas Bay Fishing Charters | Rockport | Aransas | ● | | |
| Arroyo River Wildlife Boat Tours | South Padre Island | Willacy | | | ● |
| Artist Boat Kayak Adventures | Galveston | Galveston | | | ● |
| Austin's Fishing Service | Port Isabel | Cameron | ● | | |
| B&B Outfitters | Aransas Pass | Nueces | | ● | |
| Back Bay Adventures | Corpus Christi | Nueces | ● | ● | |
| Back Bay Guide Service | Port O'Connor | Calhoun | ● | | |
| Backlash Fishing Charters | Corpus Christi | Nueces | ● | | |
| Backwater Safari Guide Service | Rockport | Aransas | ● | | |
| Barnard's Guide Serivce | Rockport | Aransas | ● | | |
| Barnhart Ranch and Nature Retreat | Berclair | Nueces | | ● | ● |
| Bay Adventures Sportfishing | Galveston | Galveston | ● | | |
| Bay Drifters | Arroyo City | Cameron | ● | | |
| Bay Flats Lodge | Seadrift | Calhoun | | ● | |
| Bay Flats Waterfowl & Fishing Guide Service | Port O'Connor | Calhoun | ● | ● | |
| Bay King | South Padre Island | Willacy | ● | | |
| Bay Prairie Outfitters and Lodge | Midfield | Matagorda | | ● | |
| Bay Rat Guide Service | Port O'Connor | Calhoun | ● | | |
| Baylor Outdoor Adventures | Matagorda | Matagorda | ● | ● | |
| Baywatch Dolphin Tours | Galveston | Galveston | | | ● |

TEXAS

| COMPANY NAME | CITY | COUNTY | FISHING | HUNTING | WILDLIFE |
|---|---|---|---|---|---|
| Beach & Bay Charters | Galveston | Galveston | ● | | |
| Beacon Charter Service | Port Aransas | Nueces | ● | | |
| Big Papa's Bay Fishing | Palacios | Matagorda | ● | ● | |
| Big Reef Nature Park | Galveston | Galveston | | | ● |
| Bill Busters Fishing | Port Aransas | Nueces | ● | | |
| Blue Heron Adventures | Corpus Christi | Nueces | ● | | ● |
| Bobs Bay Fishing | South Padre Island | Willacy | ● | | |
| Bode's Bay Fishing & Beyond | South Padre Island | Willacy | ● | | |
| Born to Fish, Forced to Work Charters | South Padre Island | Willacy | ● | | |
| Breakaway Cruises | South Padre Island | Willacy | | | ● |
| Brian Holden - Redfish Lodge, Inc | Rockport | Aransas | ● | | |
| Brooks Guide Service | Rockport | Aransas | ● | | |
| Brush Country Charters | Corpus Christi | Nueces | ● | | |
| Bryan Ray's South Padre Island Fishing Adventure | South Padre Island | Willacy | ● | | |
| C K & R Rockport Charters | Rockport | Aransas | ● | | ● |
| C&T Bay Charters | Port Aransas | Nueces | ● | | |
| Capt. Brad Smythe | Corpus Christi | Nueces | ● | ● | ● |
| Capt. Casey Barrera | Corpus Christi | Nueces | ● | | |
| Capt. Curtis Bartek | Corpus Christi | Nueces | ● | | |
| Capt. Gary D. Croker | Corpus Christi | Nueces | ● | | |
| Capt. Glen Anderson | Corpus Christi | Nueces | | | ● |
| Capt. Hal Newsom's Airboat Tours | Galveston | Galveston | | | ● |
| Capt. Hollis Forresters's Guide Service | Brazoria | Matagorda | ● | | |
| Capt. Ken's Guide Service | Wadsworth | Matagorda | ● | | |
| Capt. Kevin Ward | Corpus Christi | Nueces | ● | | |
| Capt. Leaf's Offshore & Bay Charters | Galveston | Galveston | ● | | |
| Capt. Terry`s Rip Tide Charters | Port O'Connor | Calhoun | ● | | |
| Captain Bill Cannan | Port O'Connor | Calhoun | ● | | |
| Captain Bills Bay Charters | South Padre Island | Willacy | ● | | |
| Captain Black's Outdoor Adventures | Riviera | Nueces | ● | | |
| Captain Charlie Cates | Matagorda | Matagorda | ● | | |
| Captain Charlie Paradoski | Matagorda | Matagorda | ● | | |
| Captain Chuck's Fishing | Corpus Christi | Nueces | ● | | ● |
| Captain Dan the Flounder Man | Aransas Pass | Nueces | ● | | |
| Captain Gordon's Angler | Ingleside | San Patricio | ● | | |
| Captain Hal Newsom's Airboat Tours | Galveston | Galveston | | | ● |
| Captain Jay Huitt's Saltwater Fishing Guide Service | Bay City | Matagorda | ● | | |
| Captain Jeff Hartung | South Padre Island | Willacy | ● | | |
| Captain Joe's Flounder Ventures | Fulton | Aransas | ● | | |
| Captain Kyle Tomek | Matagorda | Matagorda | ● | | |
| Captain Leaf's Offshore & Bay Charters | Galveston | Galveston | | | ● |
| Captain Len's Fishing | Corpus Christi | Nueces | ● | | ● |
| Captain Lens Fishing Guide Service | Corpus Christi | Nueces | ● | | |
| Captain Murphy's Deep Sea Fishing | South Padre Island | Willacy | ● | | |

TEXAS

| COMPANY NAME | CITY | COUNTY | FISHING | HUNTING | WILDLIFE |
|---|---|---|---|---|---|
| Captain Noe Garza Guide Service | Corpus Christi | Nueces | ● | | |
| Captain Randy's Charters | South Padre Island | Willacy | ● | | |
| Captain RJ Shelly LLC | Port O'Connor | Calhoun | ● | | |
| Captain Ron Thomas | Arroyo City | Cameron | ● | | |
| Captain Sally's Reel Fun Charters | Corpus Christi | Nueces | ● | | |
| Captain Steve Holtzclaw Fishing Guide Service | Corpus Christi | Nueces | ● | | |
| Captain Thiggy's Guide Service | Palacios | Matagorda | ● | | |
| Captain TJ Guide Service | Bay City | Matagorda | ● | | |
| Casa de Cuentos Outfitters | Rockport | Aransas | | ● | |
| Castin' Coach | Galveston | Galveston | ● | | |
| Casting Call Charters | Corpus Christi | Nueces | ● | | |
| Causeway Bait and Tackle | Port Arthur | Jefferson | ● | | |
| Central Flyway Outfitters, Inc. | Winnie | Chambers | | ● | |
| Chasin Tails Guide Service | Corpus Christi | Nueces | ● | | |
| Chuck's Guide Service | Port Arthur | Jefferson | ● | | |
| Circle H Outfitters | Galveston | Galveston | ● | ● | |
| CK&R Rockport Charters | Corpus Christi | Nueces | ● | | |
| Coastal Adventures Guide Service | Sargent | Matagorda | ● | | |
| Coastal Bend Guides Association | Aransas Pass | Nueces | ● | | |
| Coastal Legends Guide Service | Rockport | Aransas | ● | | |
| Coastal Rod Bender | Corpus Christi | Nueces | ● | | |
| Coastal Studies Lab | South Padre Island | Willacy | | | ● |
| Coastal Waterfowl | Seadrift | Calhoun | | ● | |
| Coastal Wild Wings | Blessing | Matagorda | | ● | |
| Coastal Wings | Bay City | Matagorda | | ● | |
| Colburn's Sabine Connection | Port Arthur | Jefferson | ● | | |
| Colley's Fins to Feathers | South Padre Island | Willacy | | | ● |
| Colonel Paddlewheel Boat | Galveston | Galveston | | | ● |
| Crystal Flats Guide Service | Port Isabel | Cameron | ● | | |
| Custom Sport Fishing | Port Isabel | Cameron | ● | | |
| Cut Bait Charters | Corpus Christi | Nueces | ● | | |
| D&S Charters | Port Arthur | Jefferson | ● | | |
| Dances With Fish | Rockport | Aransas | ● | | |
| David Pena | Corpus Christi | Nueces | ● | | |
| Doctor's Orders Charter Guide Service | Fulton | Aransas | | | ● |
| DoDaBlu Charters | Galveston | Galveston | ● | | |
| Dolphin and Nature Research Center | Port Isabel | Cameron | | | ● |
| Dolphin Docks | Port Isabel | Cameron | ● | | ● |
| Don Wood's Guide Service | Matagorda | Matagorda | ● | | |
| Don's Diving Service | Palacios | Matagorda | | | ● |
| El Canelo Charters | Rockport | Aransas | ● | ● | ● |
| El Pescador Guide Service | Corpus Christi | Nueces | ● | | |
| Family Fun Fishing Adventure | Port Isabel | Cameron | ● | | |
| Fill-A-Bite | Rockport | Aransas | ● | | |
| Fin and Fowl Guide Service | Houston | Chambers | | ● | |

TEXAS

| COMPANY NAME | CITY | COUNTY | FISHING | HUNTING | WILDLIFE |
|---|---|---|---|---|---|
| Fish N Divers | Galveston | Galveston | ● | | |
| Fish On Guide Service | Corpus Christi | Nueces | ● | | |
| Fish Tales Guide Service | Port Aransas | Nueces | ● | | ● |
| Fish'Aholics Charters | Galveston | Galveston | ● | | |
| Fishin Addiction | Galveston | Galveston | ● | | |
| Fishing Galveston TX | Galveston | Galveston | ● | | |
| FishNTexas | Rockport | Aransas | ● | | |
| Flying Feathers, Inc | Winnie | Chambers | | ● | |
| Four Alarm Guide Service | Rockport | Aransas | ● | | |
| Friebele Outdoors | Corpus Christi | Nueces | ● | | |
| Galveston Adventures Guide Service | Galveston | Galveston | ● | | |
| Galveston Bay Fishing Adventures by Tom Brown | Galveston | Galveston | ● | | |
| Galveston Fishing Adventures | Galveston | Galveston | ● | | |
| Galveston Fishing Charter | Galveston | Galveston | ● | | |
| Galveston Fishing Guides | Galveston | Galveston | ● | | |
| Galveston Fishing Pier | Galveston | Galveston | ● | | |
| Galveston Harbor Tours | Galveston | Galveston | | | ● |
| Galveston Island Duck Tours | Galveston | Galveston | | | ● |
| Galveston Party Boats | Galveston | Galveston | ● | | |
| Galveston Saltwater Charters | Galveston | Galveston | ● | | |
| Galveston Shark Fishing | Galveston | Galveston | ● | | |
| Gamewell Fishing Guide | Corpus Christi | Nueces | ● | | |
| Gardner's Guide Service | Matagorda | Matagorda | ● | | |
| George Rose | Rockport | Aransas | ● | | |
| Get Hooked Charters | Galveston | Galveston | ● | | |
| Goin Coastal Kayak Charters | Corpus Christi | Nueces | | | ● |
| Gold Spoon Charters, Inc. | Rockport | Aransas | ● | ● | ● |
| Gold Tip Guide Service | Matagorda | Matagorda | ● | | |
| Golden Hook Guide Service | Port Arthur | Jefferson | ● | | |
| Gone Fishin' Guide | Rockport | Aransas | ● | | |
| Green Hornet Guide Service | Rockport | Aransas | ● | | |
| Half Breed Guide Service | Matagorda | Matagorda | ● | | |
| Happytide Charters | Port Isabel | Cameron | ● | | |
| Hart's Fishing Guide | Corpus Christi | Nueces | ● | | |
| Have Boat Will Travel Guide Service | Port Arthur | Jefferson | ● | | |
| Herzog Guide Service | Rockport | Aransas | ● | | |
| Hook Down Charters | Port Mansfield | Willacy | ● | | |
| Hook Line and Sinker Charters | Rockport | Aransas | ● | | |
| Hooked Up Guide Service | Aransas Pass | Nueces | ● | | |
| Hook-em Guide Services | Corpus Christi | Nueces | ● | | |
| Hough's Guide Service | Corpus Christi | Nueces | ● | | |
| HuntNTexas | Rockport | Aransas | | ● | |
| Irresistable Charters | Port Aransas | Nueces | ● | | |
| Isabella Charters | South Padre Island | Willacy | ● | | ● |
| Isla Tours | South Padre Island | Willacy | ● | | ● |

TEXAS

| COMPANY NAME | CITY | COUNTY | FISHING | HUNTING | WILDLIFE |
|---|---|---|---|---|---|
| Island Native Surf House | South Padre Island | Willacy | ● | | |
| Island Outfitters | South Padre Island | Willacy | ● | | |
| J Hearne Performance Guide Service | Rockport | Aransas | ● | | ● |
| Jack Nelson's Guide Service | Corpus Christi | Nueces | ● | | |
| JB Hunting Ranch | Bay City | Matagorda | | ● | |
| JCG Outfitters | Corpus Christi | Nueces | ● | | |
| Jeff Parker Images | Corpus Christi | Nueces | | | ● |
| Joel Pruitt - Redfish Lodge, Inc | Rockport | Aransas | ● | | |
| Johans's Fishing Guide Service | Rockport | Aransas | ● | | |
| John Frankson Fishing Charter Service | Port O'Connor | Calhoun | ● | | |
| John's Guide Service | Rockport | Aransas | ● | | |
| Just 1 More Outfitter | Port Aransas | Nueces | ● | | |
| Just Add Water Guide Service | Port Aransas | Nueces | ● | | |
| Just One More Guide Service | Rockport | Aransas | ● | | |
| Kapt. Keepers Charters | Galveston | Galveston | ● | | |
| Kayak Tours and Rental | South Padre Island | Willacy | | | ● |
| Keeler Bay Fishing | Aransas Pass | Nueces | ● | | |
| Keeler Guide Service | Corpus Christi | Nueces | ● | ● | |
| King Ranch | Kingsville | Kleberg | | ● | ● |
| Kingfisher Guide Service | Matagorda | Matagorda | ● | | |
| Kiskadee Charters and Breakaway Tours | Port Isabel | Cameron | ● | | ● |
| Koohootz Dolphin and Lighthouse Tours | Port Aransas | Nueces | | | ● |
| Krejci Guide Service | Matagorda | Matagorda | ● | | |
| Laguna Atascosa Wildlife Refuge | Los Fresnos | Cameron | | | ● |
| Laguna Madre Nature Trail | South Padre Island | Willacy | | | ● |
| Laguna Madre Sight Casters | Corpus Christi | Nueces | ● | | |
| Leeward Adventures | Corpus Christi | Nueces | ● | | |
| Lil Spoon Guide Service | Port Mansfield | Willacy | ● | | |
| Lloyd Lassiter Ent., LLC | Corpus Christi | Nueces | ● | | |
| Lone Star Guide Service | Matagorda | Matagorda | ● | | |
| Lost Anchor | Palacios | Matagorda | ● | | |
| Lower Laguna Madre Guide Service | South Padre Island | Willacy | ● | | |
| Mack's Guide Service | Rockport | Aransas | ● | | |
| Mansfield Charters | Port Mansfield | Willacy | ● | | |
| Matagorda Bay Fishing and Hunting | Bay City | Matagorda | ● | ● | |
| Matagorda County Birding Nature Center | Bay City | Matagorda | | | ● |
| Mike O'Dell -A Fishing Fantasy Guide Service & Outfitters | Aransas Pass | Nueces | ● | | |
| Miller Time Guide Service | Port O'Connor | Calhoun | ● | | |
| Nauticharters Fishing | Corpus Christi | Nueces | ● | | |
| North Padre Boating Adventures | Corpus Christi | Nueces | ● | | ● |
| Oak Island Hunting Lodge | Oak Island | Chambers | | ● | |
| Offshore Adventures | Port Aransas | Nueces | ● | | |
| On the Hook Charters | South Padre Island | Willacy | ● | | |
| Osprey Deep Sea Fishing | South Padre Island | Willacy | ● | | |
| Osprey Fishing Trips | Port Mansfield | Willacy | ● | | |

TEXAS

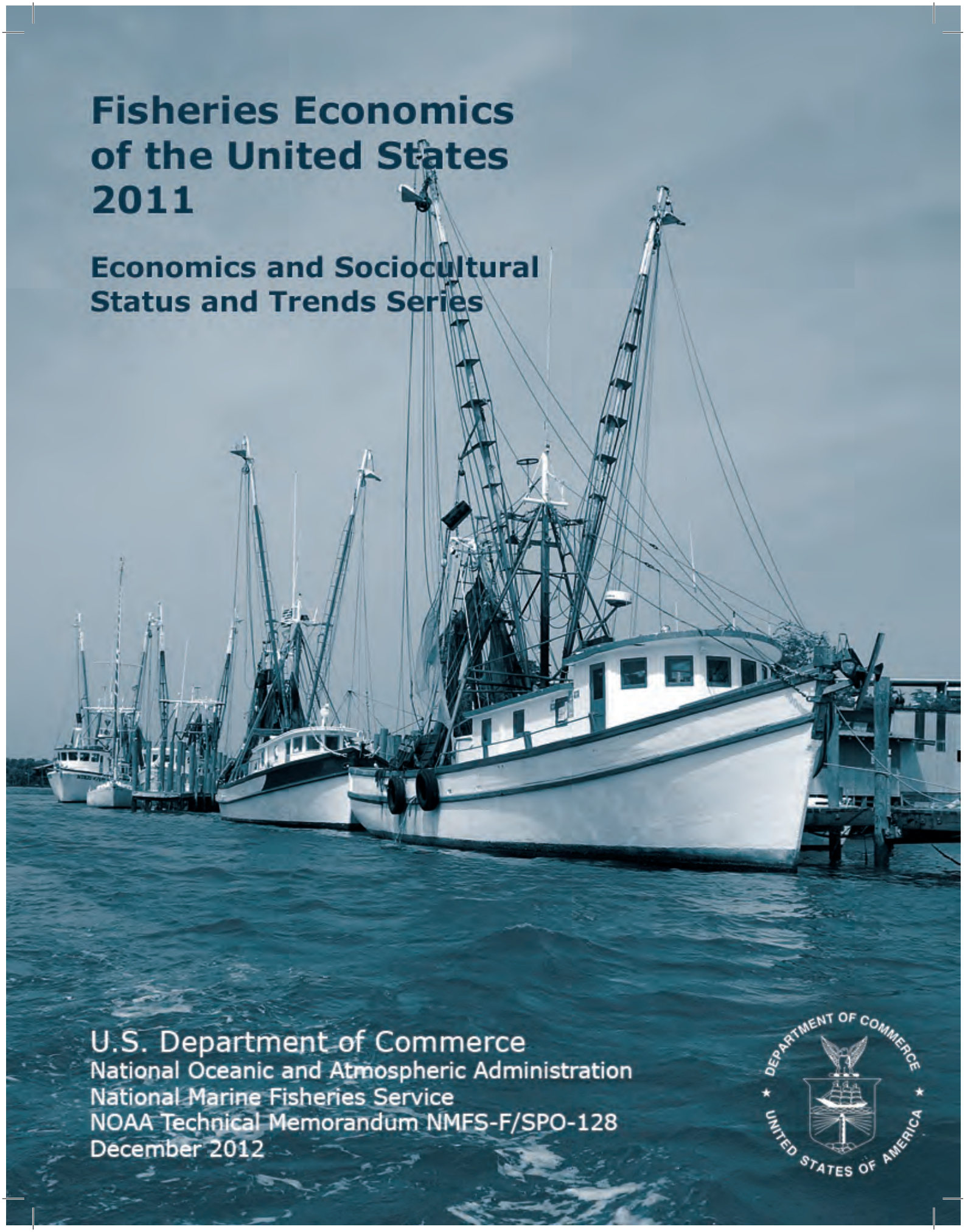
| COMPANY NAME | CITY | COUNTY | FISHING | HUNTING | WILDLIFE |
|---|---|---|---|---|---|
| Out to Sea Adventures | Corpus Christi | Nueces | ● | | ● |
| P2 Outfitters | Rockport | Aransas | ● | | |
| Palacios Guide Service | Palacios | Matagorda | ● | | |
| Pat Hunt's Fishing Guide Service | Aransas Pass | Nueces | ● | | |
| Pearl Guide Service | Corpus Christi | Nueces | ● | | |
| Pirates of the Bay | Rockport | Aransas | ● | | ● |
| Port A Bay Charters | Port Aransas | Nueces | ● | | ● |
| Redfish Bay Safaris | Aransas Pass | Nueces | ● | ● | ● |
| Redfish Charters | Rockport | Aransas | ● | | |
| Redfish Lodge | Rockport | Aransas | ● | ● | |
| Redfish Raymond | Matagorda | Matagorda | ● | | |
| Reel Fiddler Charter | Aransas Pass | Nueces | ● | | |
| Reel Life Adventures | Bay City | Matagorda | ● | | |
| Reel McCoy Guide Service | Corpus Christi | Nueces | ● | | |
| Reel 'N' With Ron Guide Service | Rockport | Aransas | ● | | |
| Reel Satisfaction Charters | Angleton | Brazoria | ● | | |
| Reel Tails Guide Service | Arroyo City | Cameron | ● | | |
| Reel Threel Fishing Charters | Galveston | Galveston | ● | | |
| Reel Time Guide Service | Port Arthur | Jefferson | ● | | |
| Riddle's Guide Service | Matagorda | Matagorda | ● | | |
| Rip-A-Lip Inc. | Corpus Christi | Nueces | ● | | |
| Rive's Fishing and Towing | Aransas Pass | Nueces | ● | ● | |
| Rockport Birding and Kayaking Adventures | Fulton | Aransas | | | ● |
| Rockport Guides and Charter | Rockport | Aransas | ● | ● | ● |
| Rockport Outdoor Adventures | Rockport | Aransas | ● | | |
| Rockport Redrunner | Rockport | Aransas | ● | | |
| Rod Bending Charters | Galveston | Galveston | ● | | |
| ROD BENDING CHARTERS | Galveston | Galveston | ● | | |
| Ron's Guide Service | Rockport | Aransas | ● | | |
| Run-N-Gun Adventures | Matagorda | Matagorda | | ● | |
| Rusted Hook Guide Service | Port O'Connor | Calhoun | ● | | |
| Ryan Waggoner's Guide Service | Rockport | Aransas | ● | ● | |
| Sabine Lake Charter | Port Arthur | Jefferson | ● | | |
| Sabine Lake Guide Service | Port Arthur | Jefferson | ● | | |
| Sabine Outdoors Fishing Charters | Port Arthur | Jefferson | ● | | |
| Sail Port A | Port Aransas | Nueces | ● | | ● |
| Salt Life Guide Service | Corpus Christi | Nueces | ● | | |
| Saltgrass Charters | Bay City | Matagorda | ● | | |
| Salty Aggie Guide Service | Corpus Christi | Nueces | ● | | |
| Sea Life Safari | South Padre Island | Willacy | | | ● |
| Sea Ranch Charter Fishing Guides | South Padre Island | Willacy | ● | | |
| Sea Ranch Marina | South Padre Island | Willacy | ● | | |
| Sea Turtle, Inc | South Padre Island | Willacy | | | ● |
| Seidel Guide Service | Aransas Pass | Nueces | ● | ● | |
| Sexton's Guide Service | Palacios | Matagorda | ● | | |
| Silver King Adventures | Galveston | Galveston | ● | | |

TEXAS

| COMPANY NAME | CITY | COUNTY | FISHING | HUNTING | WILDLIFE |
|---|---|---|---|---|---|
| Singleterry Guide Service | Corpus Christi | Nueces | ● | | |
| Skinny Water Adventures | Port Mansfield | Willacy | ● | | |
| Slick's Guide Service | Rockport | Aransas | ● | | |
| Slowride Guide Service and Kayak Rentals | Aransas Pass | San Patricio | ● | | |
| Smith Guide Service | Fulton | Aransas | ● | | |
| South Bay Bait and Charters | Aransas Pass | Nueces | ● | | |
| South Padre Fly Fishing | South Padre Island | Willacy | ● | | |
| South Padre Island Birding and Nature Center | South Padre Island | Willacy | | | ● |
| South Padre Island Fishing | Brownsville | Cameron | ● | | ● |
| South Texas Charters | South Padre Island | Willacy | ● | | |
| Specks and Spots Guide Service | Bay City | Matagorda | ● | | |
| SPI Guide Service | South Padre Island | Willacy | ● | | |
| Sport Fishing Texas | Aransas Pass | San Patricio | ● | | |
| Spots 'n Dots Fishing | Corpus Christi | Nueces | ● | | |
| Steve Brown's Galveston Fishing Charters | Galveston | Galveston | ● | | |
| Sun Time Watersports | Galveston | Galveston | | | ● |
| Take Me South Fishing Charters | Port Mansfield | Willacy | ● | | |
| Talasek's Guide Service | Bay City | Matagorda | ● | | |
| Taryn It Up | Port Aransas | Nueces | ● | | |
| Texas Coastal Outfitters | Galveston | Galveston | | ● | |
| Texas Gulf Duck Hunting | Port Aransas | Nueces | | ● | |
| Texas Saltwater Fishing | Palacios | Matagorda | ● | | |
| The Drake Plantation | Winnie | Chambers | | ● | |
| The Karma | Corpus Christi | Nueces | ● | | ● |
| The Key Hole Outdoors | Port Isabel | Cameron | ● | | |
| The Living Dream Charters | Rockport | Aransas | ● | | |
| The Original Dolphin Watch | South Padre Island | Willacy | | | ● |
| The Pelican Services | South Padre Island | Willacy | ● | | |
| The Producers Guide Services | Corpus Christi | Nueces | ● | ● | ● |
| The Saltwater Cowboy | Port Aransas | Nueces | ● | ● | ● |
| Third Coast Charters | Matagorda | Matagorda | ● | ● | |
| Tiger Net Fish Guide Service | Corpus Christi | Nueces | ● | | |
| TLC Guide and Towing | Rockport | Aransas | ● | | |
| Tommy's Guide Service | Matagorda | Matagorda | ● | | |
| Walking on Water Guide | Corpus Christi | Nueces | ● | | |
| Wave Dancer Charters | Galveston | Galveston | ● | | |
| Weldon Charter Service | Arroyo City | Cameron | ● | | |
| Wetland Adventures | Lake Jackson | Brazoria | | ● | |
| Wharf Cat | Port Aransas | Nueces | | | ● |
| White Wing Ranch | Brownsville | Cameron | ● | | |
| Yankee Skipper Charter & Guide Service | Port Aransas | Nueces | ● | | |
| Zepeda's Guide Service | Galveston | Galveston | ● | | |

# Fisheries Economics of the United States 2011

## Economics and Sociocultural Status and Trends Series



U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
NOAA Technical Memorandum NMFS-F/SPO-128
December 2012

# Fisheries Economics of the United States, 2011

Economics and Social Analysis Division
Office of Science and Technology
National Marine Fisheries Service
1315 East-West Highway, 12th floor
Silver Spring, MD 20910

**NOAA Technical Memorandum NMFS-F/SPO-128**
**December 2012**

U.S. Department of Commerce
Rebecca Blank, Acting Secretary of Commerce

National Ocean and Atmospheric Administration
Jane Lubchenco, Ph.D., Administrator of NOAA

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Eric Schwaab, Assistant Administrator for Fisheries

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Silver Spring, MD 20910

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Front cover photo: Shem Creek, South Carolina (photo credit: Amber Von Harten)
Inside cover photo: Nanticoke River, Maryland (photo credit: Sean Howard)

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# Preface

**Fisheries Economics of the U.S., 2011**

*Fisheries Economics of the U.S., 2011* is the sixth volume in this annual series, which is intended to provide the public with easily accessible economic information about the Nation's commercial and recreational fishing activities, and fishing-related industries. This year's report covers the years 2002 to 2011 and provides descriptive statistics for the following categories: economic impacts of the seafood industry, commercial fisheries landings, revenue, and price trends; angler expenditures and economic impacts of recreational fishing, recreational fishing catch, effort, and participation rates; and employer and non-employer establishment, payroll, employees, and annual receipt information for fishing-related industries.

**Sources of Data**

Information in this report came from many sources. Commercial landings, revenue, and price data, and recreational fishing effort and participation data was primarily obtained from the Fisheries Statistics Division, Office of Science and Technology, NOAA Fisheries. Other data sources included the: Alaska Fisheries Science Center, NOAA Fisheries; Alaska Department of Fish and Game; California Department of Fish and Game; Oregon Department of Fish and Wildlife; Washington Department of Fish and Wildlife; the Pacific Coast Fisheries Information Network (PacFIN); Texas Department of Parks and Wildlife Department; and Western Pacific Fisheries Information Network (WPacFIN). Economic impacts from the commercial fishing industry and recreational fisheries are from two separate national IMPLAN models of the Economics and Sociocultural Analysis Division, Office of Science and Technology, NOAA Fisheries. Fishing related industry information was obtained from the: U.S. Census Bureau, Bureau of Economic Analysis, and Bureau of Labor Statistics.

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# In Memory of Dr. Jim Kirkley

We would like to dedicate this volume of *Fisheries Economics of the U.S.* to Dr. Jim Kirkley, PhD, professor of Marine Science at the Virginia Institute of Marine Science, College of William and Mary. Dr. Kirkley provided invaluable expertise in development of the Commercial Seafood Impacts model.

The information obtained from his models have been an integral piece of the report since its inception. Over time, these data have become a fundamental component of the public's understanding of the role of the commercial seafood industry.

Today, this information is included in a wide array of documents including congressional briefing documents and nationally syndicated newspaper articles.

Dr. Kirkley was one of the first economists to develop models to demonstrate the comprehensive effects of fisheries in the national economy. The community of fisheries economists will always be in debt to Dr. Kirkley's contributions.

Dungeness crabs, Moss Landing, California (photo credit: Richael Young)

# National Overview

## Management Context

The authority to manage federal fisheries in the United States was granted to the Secretary of Commerce by the Magnuson-Stevens Fishery Conservation and Management Act, also known as the Magnuson-Stevens Act (P.L. 94-265 as amended by P.L. 109-479). NOAA Fisheries or the National Marine Fisheries Service (NMFS) is the federal agency delegated authority from the Secretary of Commerce to oversee fishing activities in federal waters. Federal fisheries are generally defined as fishing activities that are prosecuted between 3 and 200 nautical miles from the coastline. Generally, individual states retain management authority over fishing activities within 3 nautical miles of their coasts.

Nationwide, there are 45 fishery management and ecosystem plans[1] that provide a framework for managing the harvest of 230 major fish stocks or stock complexes that comprise 90% of the commercial harvest. These fishery management plans (FMPs) are developed by Regional Fishery Management Councils (FMCs) in each of eight regions nationwide: the North Pacific, Western Pacific, Pacific, New England, Mid-Atlantic, South Atlantic, Gulf of Mexico, and Caribbean Regions. Once an FMP is developed, it must be approved by the Secretary of Commerce in consultation with NOAA Fisheries before it is implemented and enforced.

**Regional Fishery Management Councils**

- North Pacific Fishery Management Council
- Western Pacific Fishery Management Council
- Gulf of Mexico Fishery Management Council
- Mid-Atlantic Fishery Management Council
- New England Fishery Management Council
- Pacific Fishery Management Council
- South Atlantic Fishery Management Council
- Caribbean Fishery Management Council

Of the 230 major fish stocks and stock complexes currently managed under a FMP, the overfished status of 177 stocks or stock complexes and the overfishing status of 194 stocks or stock complexes is known. Currently, 39 stocks or stock complexes are categorized as overfished and 32 are categorized as subject to overfishing[2].

Less is known about the 248 minor stocks or stock complexes. The overfished status of 42 of these stocks or stock complexes is known and four of these are currently considered overfished. The overfishing status of 2 of the 248 minor stocks or stock complexes is known and NA of these are currently considered to be subject to overfishing[2].

*Transboundary and International Fisheries*

NOAA Fisheries is also actively involved in negotiating conservation measures and fishery allocations for fisheries conducted in areas where the Exclusive Economic Zone (EEZ) of the U.S. overlaps with other nations (transboundary areas), and in areas beyond the U.S. EEZ (international waters or the high seas). The Gulf of Alaska and the Gulf of Maine are examples of these transboundary areas. An area in the Bering Sea outside of EEZs of Canada, Japan, and Russia, called the Donut Hole, is an example of international waters. Loss of sea ice will create new transboundary areas and international waters in the Arctic.

**Regional Fishery Management Organizations**

- International Convention for the Conservation of Atlantic Tunas (Basic Instrument for the International Commission for the Conservation of Atlantic Tunas - ICCAT),
- Convention for the Conservation of Salmon in the North Atlantic Ocean (Basic Instrument for the North Atlantic Salmon Conservation Organization - NASCO),
- Convention on Future Multilateral Cooperation in the Northwest Atlantic Fisheries (Basic Instrument for the Northwest Atlantic Fisheries Organization - NAFO),
- Convention for the Establishment of an Inter-American Tropical Tuna Commission (IATTC),
- Convention for the Conservation of Anadromous Stocks in the North Pacific Ocean (Basic Instrument for the North Pacific Anadromous Fish Commission - NPAFC),
- Western and Central Pacific Fisheries Convention (WCPFC),
- Asia-Pacific Fishery Commission (APFIC),
- Fishery Committee for the Eastern Central Atlantic (CECAF)

Regional Fishery Management Organizations (RFMOs) are multinational organizations with interests in transboundary and international fish stocks and associated fishing activities. NOAA Fisheries is party to eight RFMOs globally[3]. The goal of these RFMOs is to adopt measures for the conservation and coordinated management of target species such as bluefin tuna. RFMOs also provide measures for the conservation and scientific assessment of non-target species. Also known as bycatch, non-target species include seabirds, marine mammals, sea turtles, and fish species caught incidentally to target species. The commitment to conserving and protecting all species associated with, or affected by, fishing activities is outlined in the Food and Agricultural Organization's (FAO's) Code of Conduct for Responsible Fisheries established in 1995.

[1] Fishery management plans and fishery ecosystem plans for each region covered in this report are listed in their respective sections. The Caribbean region and its four FMPs are not currently included in this report. These FMPs are developed by the Caribbean Fishery Management Council (San Juan, Puerto Rico). In addition, the Atlantic Highly Migratory Species FMP is not listed in this report. This FMP is developed by the Office of Sustainable Fisheries at NOAA Fisheries Headquarters (Silver Spring, MD).

[2] Fish Stock Sustainability Index (FSSI) - 2012 Quarter 3 Update through September 30, 2012. The NOAA Fisheries Office of Sustainable Fisheries. http://www.nmfs.noaa.gov/sfa/statusoffisheries/SOSmain.htm

[3] http://www.nmfs.noaa.gov/ia/agreements/regional_agreements/intlagree.html

Another issue of particular concern for NOAA Fisheries is the problem of illegal, unreported, and unregulated (IUU) fishing activities in international waters. The RFMOs report estimates that in 2011, there were 42 vessels flying the national flags of 22 nations participating in IUU fishing activities.[1] NOAA Fisheries is actively working bilaterally and multilaterally with other nations on the adoption of strategies to reduce the level of IUU fishing around the world.

*Threatened and Engangered Species*

NOAA Fisheries is also the lead agency for the conservation and protection of over 87 fish and non-fish species that fall within the purview of the Endangered Species Act (ESA). Status determinations related to the viability and health of these populations have been made. The status of these populations have been determined as 'threatened' or 'endangered', and, in one case, 'recovered'.

Currently, there are 44 marine and anadromous fish species and subspecies[2] that are protected under the ESA. These species include: Atlantic salmon, coho salmon, green sturgeon, shortnose sturgeon, smalltooth sawfish, steelhead trout, and totoaba. Many of these species are further delineated into distinct population segments or evolutionarily significant units that are based on genetic similarities within geographically- or reproductively-isolated populations.

**Endangered and Threatened Species under NMFS Jurisdiction**

| Species Group | Number of Species |
|---|---|
| Marine and Anadromous Fish | 44 |
| Marine Mammals: Whales | 12 |
| Marine Mammals: Dolphins | 2 |
| Marine Mammals: Porpoise | 1 |
| Marine Mammals: Seals | 5 |
| Marine Mammals: Sea Lions | 2 |
| Sea Turtles | 16 |
| Marine Invertebrates | 4 |
| Marine Plants | 1 |
| **Total** | **87** |

In addition to threatened and endangered fish species, NOAA Fisheries is also involved in the conservation and protection of ESA-listed non-fish species. Marine mammals such as whales, dolphins, and seals, as well as species of sea turtles, marine invertebrates, and one marine plant are listed. There are currently 102 candidate species for listing (82 are coral species) and 7 species proposed for listing.

In 1970, the Eastern North Pacific gray whale was listed under the ESA, but has since made a comeback and was considered 'recovered' in 1994. The Caribbean monk seal, listed in 1967, was delisted in 2008. This species is considered to be extinct.

In addition to endangered and threatened species under the Endangered Species Act, NOAA Fisheries is also responsible for providing protection for marine mammals under the Marine Mammal Protection Act. Passed in 1972, Congress recognized that protecting populations of marine mammals contributes to the overall health of marine ecosystems.

NOAA Fisheries is responsible for preventing the harrassment, capture, or killing of whales, dolphins, porpoises, seals, and sea lions.[3] However, exceptions are made for scientific research, unintended interactions with commercial fisheries, subsistence and traditional uses by Alaska natives, and public display at some aquaria.

*Essential Fish Habitats*

Sustainable commercial and recreational fisheries depend on healthy habitats. These habitats include rivers, estuaries, and the open ocean where marine and anadromous species feed, grow, and reproduce. Consideration of these habitat areas are part of an ecosystem-based management approach for managing fisheries in a more sustainable and holistic manner. Since 1996, federal fishery management plans are required to identify and describe essential fish habitat (EFH) for all federally-managed species.[4] Habitat areas that are necessary for a fish species' growth, reproduction, and development are considered EFH. To the extent practicable, NOAA Fisheries and the Councils must minimize adverse effects to EFH caused by fishing activities.

Though not required, habitat areas of particular concern (HAPC) can be identified to help focus EFH conservation efforts. HAPCs are a subset of EFH and are particularly vulnerable or ecologically important. To date, approximately 100 HAPCs have been designated including specific coral, seamount, and spawning areas.

A recent effort undertaken by the NOAA Fisheries Office of Science and Technology was to create a Habitat Assessment Improvement Plan[5] to advance NOAA Fisheries' ability to identify EFH and HAPCs and to provide information needed to assess impacts to EFH.

*Catch Share Programs*

A variety of market-based tools are available to fishery managers. NOAA Fisheries is currently implementing several different types of catch share programs such as limited access privilege programs (LAPPs), which include individual fishing quota programs (IFQs), regional fishery associations, and fishing community

[1] An additional 33 vessels with unknown country affiliation also participate in IUU fishing activities.
[2] Subspecies includes distinct population segments and evolutionarily significant units, terms defined under the ESA.
[3] The U.S. Fish and Wildlife Service provides protection for walrus, manatees, otters, and polar bears.
[4] The 1996 reauthorization of the Magnuson-Stevens Fishery-Conservation and Management Act included this requirement.
[5] The Habitat Assessment Improvement Plan is available at: `http://www.st.nmfs.noaa.gov/st4/documents/HabitatAssesmentImprovementPlan_052110.PDF`

**Existing Catch Shares Programs**

| Region | Program | First Year | Value 2010 $ million | Pre-catch share price | Post-catch share price | Unit |
|---|---|---|---|---|---|---|
| New England | Northeast Scallop IFQ | 2010 | 20 | 6.69 | 8.78 | per lb |
| New England | Northeast Multispecies Sectors | 2010 | 87.1 | 1.31 | 1.43 | per lb |
| Mid-Atlantic | Atlantic Surf Clam ITQ | 1990 | 26 | 13.32 | 11.72 | per bushel |
| Mid-Atlantic | Atlantic Ocean Quahog ITQ | 1990 | 20.8 | 6.1 | 6.84 | per bushel |
| Mid-Atlantic | Golden Tilefish IFQ | 2010 | 5.3 | 2.57 | 2.82 | per lb |
| South Atlantic | Wreckfish IFQ | 1992 | ND | ND | ND | |
| Gulf of Mexico | Red Snapper IFQ | 2007 | 10.3 | 3.32 | 3.36 | per lb |
| Gulf of Mexico | Grouper-Tilefish IFQ | 2010 | 14.3 | 3.16 | 3.23 | per lb |
| Pacific | Pacific Coast Sablefish Permit Stacking | 2002 | 14.9 | 1.84 | 4.83 | per lb |
| Pacific | Pacific Groundfish Trawl Rationalization | 2011 | 52 | 0.22 | 0.23 | per lb |
| North Pacific | Western Alaska CDQ | 1992 | NA | NA | NA | |
| North Pacific | Alaska Halibut IFQ | 1995 | 199 | 1.94 | 4.58 | per lb |
| North Pacific | Alaska Sablefish IFQ | 1995 | 99.8 | 2.8 | 4.38 | per lb |
| North Pacific | AFA Pollock Co-ops | 1998 | 226.2 | 314 | 321 | per mt |
| North Pacific | Alaska Weatervane Scallop Co-ops | 2001 | ND | ND | ND | |
| North Pacific | BSAI Crab Rationalization | 2005 | 130.5 | 1.9 | 2.04 | per lb |
| North Pacific | Non-Pollock Trawl Catcher/Processor Co-ops | 2008 | 245.3 | 1082 | 939 | per mt |

quotas[1]; community development quota programs (CDQs); fishing cooperatives; and sector allocation programs[2]. Catch share programs are a fishery management tool that dedicates a secure share of quota that entitles individual fishermen, fishing cooperatives, fishing communities, or other entities to harvest a fixed amount of fish.

With clearly defined fishing privileges, fishermen no longer need to ''race to fish'', but instead can make harvest decisions based upon market conditions, improving economic performance, and weather conditions, which improves crew safety. These incentives can reduce the cost of taking conservation actions and can encourage individual fishing choices that are more consistent with sustainable fishing practices such as reducing bycatch of species not being targeted for harvest and reducing the wasteful practice of ''discarding'', i.e., throwing back low-value or undersized catch, which is often associated with high mortality rates. The ability to align fishermen's economic incentives with the long-term biological health of the fishery singularly distinguishes catch share programs from traditional fishery management strategies (i.e., trip limits, gear restrictions, etc.).

The NOAA catch shares policy[3], released in 2010, encourages well-designed catch share programs to help maintain or rebuild fisheries, and sustain fishermen, communities and vibrant working waterfronts, including the cultural and resource access traditions that have been part of this country since its founding. Nationwide, there are 15 catch share programs currently in operation; some programs have been in operation for more than 20 years and others have been implemented more recently.

Recently, there has been an effort to characterize the federal catch share programs and develop standard performance indicators that measure the economic performance of catch share programs, regardless of their design. The standard performance measures include metrics for catch and landings, effort, revenue, accumulation limits and cost recovery. These indicators over the duration of the catch share program and compared to the Baseline Period, which is defined as the average of the three years prior to the Program's implementation. One of the indicators measuring economic efficiency, average price of catch share species reveals that with the exception of two catch share programs (Atlantic Surf Clam Individual Transferable Quota and Non-Pollock Trawl Catcher/Processor Groundfish Cooperatives Amendment 80), the average price for the most recent year is greater than average prices during the baseline period. Nationwide, there are 15 catch share programs currently in operation in six different regions. The total landings revenue of the fisheries for which information was available was about $1.2 billion in 2010.

*Other Market-based Management Tools*

Vessel or permit buyback programs are another market-based tool used by fishery managers. Under these programs, fishing vessels or permits are purchased by the government to permanently decrease the number of participants in the fishery to ease fishing-related pressure on marine resources. To date, there have been ten buyback programs instituted nationwide. The cost of seven[4] of these buyback programs totaled of $397 million. Eighty-five percent of this total cost was funded by loans from the federal government that will be repaid by the commercial fishing industry.

License limitation programs, also known as limited entry programs, are another management tool available to fishery managers. In these programs, the number of fishing vessels allowed to harvest a specific fish stock or stock complex is limited to a fishermen or vessels with permission to fish. Unlike catch share programs, license limitation programs have been implemented for almost all federally-managed commercial fisheries and have been implemented in every region except the Caribbean.

Ecolabels are a market-based tool available to improve fisheries sustainability. An ecolabeling program entitles a fishery product to bear a distinctive logo or statement that certifies the fishery resource was harvested in compliance with specified conservation and sustainability standards. This ecolabel is intended to inform the consumer or purchaser of the fishery product of this compliance. It allows the buyer to potentially influence the sustainable harvest of fishery resources through the purchase of such ecolabeled seafood products at a price premium.

One example of an ecolabeling program is run by the Marine Stewardship Council (MSC), one of the largest and most recognizable ecolabeling programs in the world. Under this program, MSC sets standards for sustainable fishing practices and seafood traceability. Capture fisheries can voluntarily seek certification that it meets these standards from an accredited third-party certifier. If a fishery meets a set of performance standards then its products can bear the MSC logo and have access to wholesalers and retailers that have been approved through the MSCs chain-of-custody certification. There are currently 184 fisheries worldwide that meet MSC sustainability standards, [5] 19 of which are U.S. fisheries.

[1] See Section 303(A) of the Magnuson-Stevens Act for more information

[2] For more information about LAPPs and other catch share programs, please see *Excess Harvesting Capacity in U.S. Fisheries: A Report to Congress* available at:www.nmfs.noaa.gov/msa2007/docs/042808_312_b_6_report.pdf and *National Assessment of Excess Harvesting Capacity in Federally Managed Commercial Fisheries* available at: `http://spo.nmfs.noaa.gov/tm/spo93.pdf`.

[3] `http://www.nmfs.noaa.gov/sfa/domes_fish/catchshare/index.htm`

[4] This total excludes three buyback programs associated with Northwest Pacific salmon disasters in 1994, 1995, and 1998 because data were not available.

[5] For more information about the Marine Stewardship Council and its certification process is available at: `http://www.msc.org/track-a-fishery/certified`.

**U.S. Fisheries with MSC Certification**

| Region | Fishery | Certified |
|---|---|---|
| North Pacific | Alaskan salmon | Sep 2000; Nov 2007 |
| North Pacific | Bering Sea/Aleutian Islands (BSAI) pollock | Feb 2005; Dec 2010 |
| North Pacific | Gulf of Alaska (GOA) pollock | Apr 2005; Sep 2010 |
| North Pacific | US North Pacific halibut | Apr 2006 |
| North Pacific | US North Pacific sablefish | May 2006 |
| Pacific | Pacific albacore tuna - (American Albacore Fishing Association) | Aug 2007 |
| Pacific | Oregon pink shrimp | Dec 2007 |
| Mid-Atlantic | Atlantic deep sea red crab | Sep 2009 |
| Pacific | Pacific hake mid-water trawl | Oct 2009 |
| North Pacific | BSAI Pacific cod | Jan 2010 |
| North Pacific | GOA Pacific cod | Jan 2010 |
| North Pacific | North Pacific albacore tuna (American Western Fish Boat Owners Association) | Mar 2010 |
| North Pacific | Bering Sea and Aleutian Islands flatfish | Jun 2010 |
| North Pacific | Gulf of Alaska flatfish | Jun 2010 |
| Pacific | Oregon dungeness crab | Dec 2010 |
| Southeast | Southeast Atlantic swordfish | Dec 2011 |
| Southeast | Lousiana blue crab | Mar 2012 |
| Northeast & Mid-Atlantic | US Atlantic spiny dogfish | Aug 2012 |

## Commercial Fisheries

Commercial fishermen in the U.S. harvested 9.9 billion pounds of finfish and shellfish in 2011, earning $5.3 billion for their catch. Pacific salmon ($618 million) followed by sea scallop ($585 million), shrimp ($536 million), and American lobster ($423 million) contributed most to total revenue in the U.S. In terms of pounds landed, walleye pollock (2.8 billion pounds), menhaden (1.9 billion), and Pacific salmon (780 million) comprised over half of total pounds landed in 2011.

**Key U.S. Commercial Species**

- American lobster
- Blue crab
- Menhaden
- Pacific halibut
- Pacific salmon
- Sablefish
- Sea scallop
- Shrimp
- Tunas
- Walleye pollock

When looking at key species or species groups, commercial fishermen in Alaska caught the most salmon (738 million pounds) and earned $565 million for their catch in 2011. Tuna was caught in large numbers in Hawai'i (19 million pounds) and generated $67 million in landings revenue.

On the East Coast, Maine fishermen contributed most to the total landings of American lobster (105 million pounds) and earned $334 million for their catch in 2011. In Massachusetts, sea scallop was a major contributor to total revenue, earning $331 million for 33 million pounds landed. More blue crab was caught in Maryland (50 million pounds) than any other state, earning fishermen in this state over $59 million. Louisiana landed over half of the menhaden in 2011 with fisherman landing 1.1 billion pounds and generating $94 million in landings revenue.

In the Gulf of Mexico, shrimp is a highly valued species. Fishermen in Texas earned $215 million for their catch (87 million pounds). Although, more shrimp was landed in Louisiana (92 million pounds) the total landings revenue was less ($133 million). The ex-vessel price in Texas ($2.47) was greater than that in Louisiana ($1.44).

[1] In earlier years, the NMFS Commercial Fishing & Seafood Industry Input/Output Model did not separate out the import sector but rather only included the commercial harvester, seafood processors and dealers, seafood wholesalers and distributors and retail sectors. Note that 2007 and 2008 estimates have been updated using the newer version of the model. For more information, see: `www.st.nmfs.noaa.gov/documents/commercial_seafood_impacts_2007-2009.pdf`

*Economic Impacts*[1]

In this report, the U.S. seafood industry includes the commercial harvest sector, seafood processors and dealers, seafood wholesalers and distributors, importers, and seafood retailers. In 2011, this industry supported approximately 1.2 million full- and part-time jobs and generated $129 billion in sales impacts, $37 billion in income impacts, and $55 billion in value added impacts.

**Commercial Economic Impacts Trends for the United States**
(thousands of dollars)

| | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|
| Jobs | 1,144,353 | 1,029,542 | 1,196,683 | 1,233,204 |
| Income | 34,544,909 | 31,556,643 | 36,269,724 | 36,568,695 |
| Sales | 126,175,684 | 116,224,548 | 133,135,986 | 129,386,335 |
| Value Added | 52,726,594 | 48,282,319 | 55,434,189 | 55,321,482 |
| Total Revenue | 4,399,402 | 3,894,864 | 4,511,171 | 5,338,063 |

Seafood retailers, which generated the largest job and value added impacts, contributed 618,000 jobs, $32 billion in sales impacts, and $17.7 billion in value added impacts to the national economy in 2011. Imports, which generated the largest sales impacts, contributed 176,000 jobs, $48.4 billion in sales impacts, and $14.8 billion in value added impacts. The wholesalers and distributors sector was the smallest of the seafood industry sectors and contributed 54,000 jobs, $7.5 billion in sales impacts, and $3.5 billion in value added impacts to the national economy.

Employment impacts from the U.S. seafood industry were higher in 2011 than in 2010. Overall, employment impacts increased by 3.1%, with the gains concentrated in the commercial harvesting (up 17%) and retail (up 8.8%) sectors. Income impacts were 0.82% higher in 2011. Sales (down -2.8%) and value added (down -0.2%) impacts were somewhat smaller than the previous year. For all four types of impacts, the impacts increased substantially in the commercial harvesting and retail sectors.

The greatest employment impacts generated by the seafood industry were generated in California with 122,000 jobs, followed by Massachusetts (98,000 jobs), Florida (72,000 jobs), and Washington (67,000 jobs). The lowest number of jobs were supported in Delaware (339 jobs).

**Jobs supported by the U.S. Seafood Industry (2011)**

| State | Jobs | State | Jobs |
|---|---|---|---|
| United States | 1,233,204 | Oregon | 18,562 |
| California | 122,074 | Maryland | 15,274 |
| Massachusetts | 98,358 | Georgia | 11,137 |
| Florida | 72,341 | Alabama | 11,011 |
| Washington | 67,007 | Rhode Island | 9,157 |
| Alaska | 63,295 | North Carolina | 8,850 |
| New Jersey | 43,638 | Hawai'i | 8,627 |
| New York | 41,847 | New Hampshire | 5,968 |
| Louisiana | 32,818 | Mississippi | 5,550 |
| Maine | 31,127 | Connecticut | 4,514 |
| Texas | 27,717 | South Carolina | 1,547 |
| Virginia | 22,082 | Delaware | 339 |

The highest sales impacts were generated by the seafood industry in California with $20 billion in sales, followed by Florida ($14 billion), Washington ($8 billion), and Massachusetts ($7.8 billion). The importers sector generated the highest level of sales impacts in all four states. The lowest sales were generated in Delaware ($44 million).

**Total sales generated by the U.S. Seafood Industry (2011)**
*(thousands of dollars)*

| State | In-State Sales | State | In-State Sales |
|---|---|---|---|
| United States | 129,386,335 | Maine | 1,734,058 |
| California | 20,053,619 | Georgia | 1,489,958 |
| Florida | 14,250,006 | Oregon | 1,351,116 |
| Washington | 8,026,068 | Rhode Island | 1,024,748 |
| Massachusetts | 7,754,140 | North Carolina | 795,541 |
| New Jersey | 6,563,733 | New Hampshire | 766,257 |
| New York | 5,102,910 | Connecticut | 740,263 |
| Alaska | 4,684,638 | Hawai'i | 694,228 |
| Texas | 2,277,959 | Alabama | 499,805 |
| Virginia | 1,866,659 | Mississippi | 247,106 |
| Louisiana | 1,801,568 | South Carolina | 88,131 |
| Maryland | 1,743,095 | Delaware | 43,746 |

The greatest value added impacts were generated by the seafood industry in California with $7.2 billion in sales, followed by Florida ($4.8 billion), Washington ($3.3 billion), and Massachusetts ($3.1 billion). The smallest value added impacts were generated in Delaware ($15 million).

**Total value added impacts generated by the U.S. Seafood Industry (2011)**

*(thousands of dollars)*

| State | Value Added | State | Value Added |
|---|---|---|---|
| United States | 55,321,482 | Maryland | 665,883 |
| California | 7,168,389 | Oregon | 633,483 |
| Florida | 4,778,502 | Georgia | 548,826 |
| Washington | 3,297,368 | Rhode Island | 397,018 |
| Massachusetts | 3,090,449 | North Carolina | 329,451 |
| Alaska | 2,493,124 | Hawai'i | 311,097 |
| New Jersey | 2,407,754 | New Hampshire | 287,785 |
| New York | 1,801,303 | Connecticut | 257,905 |
| Texas | 1,002,928 | Alabama | 250,171 |
| Louisiana | 877,911 | Mississippi | 125,430 |
| Maine | 829,833 | South Carolina | 46,495 |
| Virginia | 800,243 | Delaware | 14,661 |

*Landings Revenue*

Landings revenue in the U.S. totaled $5.3 billion in 2011. This was a 69% increase (17% increase in real terms) from 2002 levels ($3.2 billion) and a 18% increase (9.1% increase in real terms) relative to 2010 ($4.5 billion). Both the finfish and shellfish components contributed to the increasing landing revenues trend. Totaling $2.6 billion in 2011, finfish revenue experienced a 88% increase (31% increase in real terms) from 2002 to 2011 and increased 19% (9.4% increase in real terms) from 2010 to 2011.

U.S. shellfish revenue totaled $2.7 billion in 2011, increasing 53.5% (6.6% increase in real terms) from 2002 to 2011 and increased 18% (a 8.9% increase in real terms) from 2010 to 2011.

**Total Landings Revenue by Region (2011)**
*(thousands of dollars)*

| Region | Total Revenue | Region | Total Revenue |
|---|---|---|---|
| United States | 5,338,063 | Pacific | 710,495 |
| North Pacific | 1,911,540 | Mid-Atlantic | 527,493 |
| New England | 1,109,057 | South Atlantic | 171,302 |
| Gulf of Mexico | 818,017 | Western Pacific | 91,513 |

The ten U.S. key species and species groups comprised 63% of total revenue in 2011. Of these, Pacific salmon, sea scallop, shrimp, American lobster, and walleye pollock contributed most to total revenue in the U.S. in 2011. These species or groups totaled approximately $2.5 billion in 2011 or 47% of total revenue. The largest increases in total revenue among the national key species or species groups from 2002 to 2011 were experienced by: Pacific salmon (296%, 175% in real terms), sea scallop (190%, 101% in real terms), and sablefish (142%, 68% in real terms).

All key species or species groups showed increases in nominal revenue from 2002 to 2011, though three species groups decreased in real revenue over that time period: blue crab (down less than 1%), menhaden (down 14%), and shrimp (down 29%).Relative to 2010 totals, key species or species groups with the largest increases in total revenue in 2011 were: sablefish (37%, 26% in real terms), menhaden (34%, 24% in real terms), and sea scallop (28%, 18% in real terms).

**Total Landings Revenue by State (2011)**
*(thousands of dollars)*

| State | Total Revenue | State | Total Revenue |
|---|---|---|---|
| Alaska | 1,911,540 | Maryland | 76,722 |
| Massachusetts | 565,238 | Rhode Island | 75,956 |
| Maine | 424,712 | North Carolina | 71,177 |
| Louisiana | 333,619 | East Florida | 60,570 |
| Washington | 331,404 | Alabama | 50,941 |
| Texas | 239,082 | New York | 37,625 |
| New Jersey | 214,191 | Mississippi | 30,300 |
| California | 201,269 | New Hampshire | 23,483 |
| Virginia | 191,665 | South Carolina | 23,268 |
| West Florida | 164,076 | Connecticut | 19,668 |
| Oregon | 148,337 | Georgia | 16,295 |
| Hawai'i | 91,513 | Delaware | 7,091 |

Overall, the greatest portion of the nation's landings revenue was generated in Alaska ($1.9 billion), which contributed 36% to the U.S. total. Alaska also contributed more than any other state to total U.S. finfish revenue ($2.6 billion), accounting for 64% of total finfish revenue. More than half of Alaska's finfish landings revenue came from walleye pollock and salmon. Massachusetts ($433 million) and Maine ($381 million) contributed most to total U.S. shellfish revenue, contributing 15.8% and 13.9%, respectively. Sea scallop accounted for most of the revenue generated in Massachusetts and American lobster contributed the most to revenue in Maine.

**Commercial Fisheries Facts**

*Landings revenue*

- The ten key U.S. key species or species groups accounted for 63% of total landings revenue in 2011.
- Finfish and other fishery products ($2.6 billion) contributed slightly less than shellfish ($2.7 billion) to total landings revenue in the U.S. in 2011.
- Together, Pacific salmon and walleye pollock accounted for 38% of total finfish revenue.
- Sea scallop, shrimp, and American lobster earned the most in shellfish revenue in 2011, contributing 21.3% 19.5%, and 15.4%, respectively.
- Pacific salmon had the largest one-year increase in landings revenue over the 10 year time period, increasing 52% from $199 million in 2003 to $303 million in 2004.
- Pacific halibut had the largest decrease in landings revenue over the 10 year time period, decreasing 35% from $218 million in 2008 to $141 million in 2009.

*Landings*

- The U.S. key species and species groups accounted for 64% of total landings in 2011.
- Finfish and other fishery products accounted for 86% of total U.S. landings in 2011 or 8.5 billion pounds.
- Walleye pollock and menhaden contributed 33% and 22%, respectively, to U.S. finfish landings.
- Shrimp and blue crab contributed 23% and 15%, respectively, to shellfish landings.
- Walleye pollock had the largest one-year increase in landings over the 10 year time period, increasing 44% from 1.9 billion pounds in 2010 to 2.8 billion pounds in 2011.
- Pacific salmon had the largest one-year decrease in landings over the 10 year time period, decreasing 26% from 900 million pounds in 2005 to 664 million pounds in 2006.

*Prices*

- Of the top ten key species or species groups, sea scallop ($9.9), Pacific halibut ($4.98), and sablefish ($4.56) had the highest ex-vessel price per pound in 2011.
- Walleye pollock ($0.13) and menhaden ($0.08) had the lowest ex-vessel price per pound in 2011.
- Pacific halibut had the largest one-year increase in ex-vessel price over the 10 year time period, increasing 56% from $2.35 per pound in 2009 to $3.67 in 2010.
- Shrimp had the largest decrease in ex-vessel price over the 10 year time period, decreasing 31% from $1.79 per pound in 2008 to $1.24 in 2009.

*Landings*

In 2011, U.S. commercial fishermen landed 9.9 billion pounds of finfish and shellfish. Relative to 2002 levels, this was an 4.6% increase and a 20% increase relative to 2010 (8.2 billion pounds). Finfish landings totaled 8.5 billion pounds in 2011, a 3.2% increase from 8.2 billion pounds in 2002 and a 22% increase from 2010 (6.9 billion pounds).

**Total Landings by Region (2011)**
*(thousands of pounds)*

| Region | Total Landings | Region | Total Landings |
|---|---|---|---|
| United States | 9,867,148 | Mid-Atlantic | 779,829 |
| North Pacific | 5,272,554 | New England | 622,355 |
| Gulf of Mexico | 1,765,899 | South Atlantic | 123,460 |
| Pacific | 1,175,506 | Western Pacific | 29,289 |

Almost 60% of total catch in 2011 was made up of the ten U.S. key species and species groups. Walleye pollock and menhaden had the highest landings totals in 2011 with 2.8 billion pounds and 1.9 billion pounds landed, respectively. These two species accounted for 47% of total U.S. landings in 2011.

**Total Landings by State (2011)**
*(thousands of pounds)*

| State | Total Landings | State | Total Landings |
|---|---|---|---|
| Alaska | 5,272,554 | West Florida | 77,687 |
| Louisiana | 1,285,875 | Rhode Island | 77,236 |
| Virginia | 494,028 | North Carolina | 67,483 |
| California | 408,181 | East Florida | 31,215 |
| Mississippi | 278,080 | Hawai'i | 29,289 |
| Oregon | 274,525 | New York | 27,104 |
| Maine | 269,923 | Alabama | 26,145 |
| Massachusetts | 255,798 | Georgia | 12,646 |
| Washington | 210,672 | New Hampshire | 12,321 |
| New Jersey | 175,516 | South Carolina | 12,116 |
| Texas | 98,111 | Connecticut | 7,078 |
| Maryland | 78,197 | Delaware | 4,921 |

The greatest increases in landings between 2002 and 2011 occurred in American lobster (52%), Pacific salmon (39%), and blue crab (13%). During the same time period, decreases were seen in Pacific halibut (47%), walleye pollock (16%), and shrimp (10%).The largest increase in landings of key species or groups between 2010 and 2011 was experienced by walleye pollock (44%) and the largest decrease was experienced by Pacific halibut (24%).

Alaskan fishermen harvested the majority of the nation's total landings. Alaska contributed 56% to the U.S. total in 2011, landing 5.3 billion pounds of finfish and shellfish. Alaska also contributed most to the U.S. finfish total, landing 5.2 billion pounds or 61% of the U.S. finfish total. Walleye pollock comprised much of landings in Alaska (53%). More shellfish was landed in California (300 million pounds) and Louisiana (157 million pounds) than any other single state. The landings in these two states comprised 33% of all shellfish landed in the United States in 2011.

*Prices*

Of the ten U.S. key species and species groups, sea scallop, Pacific halibut, and sablefish received the highest ex-vessel prices in 2011 at $9.9 per pound, $4.98 per pound, and $4.56 per pound respectively.

Significant increases in price were observed for Pacific halibut, which increased 195% (105% in real terms) from 2002 to 2011, and experienced an increase of 35.7% (25.2% in real terms) from 2010 to 2011. Pacific salmon ex-vessel price experienced the next largest change between 2002 and 2011, with an increase of 182% (96% in real terms). The greatest change in price between 2010 and 2011 was experienced by Pacific halibut (35.7% increase a 25.2% increase in real terms), followed by sablefish with a 33.7% increase (a 23.2% increase in real terms).

Menhaden and walleye pollock had the lowest ex-vessel prices in 2011 at $0.08 and $0.13 per pound, respectively. However, landings of menhaden and walleye pollock were the largest among the U.S. key species and groups: 1.87 billion pounds of menhaden and 2.81 billion pounds of walleye pollock.

## Recreational Fisheries

In 2011, there were approximately 11 million recreational saltwater anglers across the U.S. who took 70 million saltwater fishing trips around the country. These anglers spent $4.5 billion on fishing trips and $22 billion on durable fishing-related equipment. These expenditures contributed $70 billion in sales impacts to the U.S. economy, generated $32 billion in value added impacts, and supported over 455,000 job impacts. Of the U.S. key recreational species or species groups, seatrout (51 million fish), and Atlantic croaker and spot (31 million fish) were the most often caught by recreational saltwater anglers in 2011.

**Key United States Recreational Species**

- Atlantic croaker and spot
- Seatrout
- Little tunny and Atlantic bonito
- Pacific halibut
- Sharks
- Striped bass
- Summer flounder
- Large Atlantic tuna

*Expenditures and Economic Impacts*

Economic impacts from recreational fishing activities (impacts from fishing trips and durable equipment combined) supported over 455,000 full- and part-time jobs across the U.S. in 2011. Sales impacts from recreational angling trips and durable expenditures totaled $70 billion and value added impacts totaled $32 billion. Durable equipment impacts contributed most to these totals, accounting for 81% of employment impacts, 85% of total sales impacts, and 83% of value added impacts. Of the three fishing trip modes, private boat-based fishing trips contributed most to the number of jobs supported by recreational angling with 7.4% of employment impacts. For-hire sales ($2.5 billion) and value added impacts ($1.4 billion) were approximately half the magnitude of impacts generated by either private boat ($4.6 billion, $2.3 billion) or shore-based trips ($3.5 billion, $1.8 billion).

**Recreational Economic Impacts Trends for the United States**
(thousands of dollars and trips)

| | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|
| Jobs | 384,707 | 327,124 | 326,188 | 454,542 |
| Income | NA | 14,574,464 | 14,570,210 | 20,518,517 |
| Sales | 58,877,647 | 49,811,961 | 49,832,341 | 70,315,216 |
| Value Added | 27,350,783 | 23,196,423 | 23,170,932 | 32,471,761 |
| Total Trips[1] | 85,548 | 74,559 | 72,464 | 70,194 |

U.S. anglers spent a total of $4.5 billion on expenditures related for fishing trips in 2011. Of this total, expenditures for private boat-based fishing trips contributed the most ($2 billion), followed by shore-based fishing trips ($1.5 billion), and for-hire-based fishing trips ($1 billion). Expenditures on fishing-related equipment totaled over $22 billion in 2011. Anglers spent more on boat expenses ($11 billion) than any other durable good. Other major expenditures include vehicle expenses ($4.1 billion), fishing tackle ($3.8 billion) and second home expenses ($2.1 billion).

**Jobs supported by the U.S. Recreational Fishing Industry (2011)**

| State | Jobs | State | Jobs |
|---|---|---|---|
| West Florida | 47,047 | Washington | 4,939 |
| East Florida | 28,701 | South Carolina | 3,254 |
| Louisiana | 17,764 | Oregon | 3,147 |
| North Carolina | 17,737 | New York | 2,972 |
| Texas | 15,150 | Hawai'i | 2,948 |
| New Jersey | 9,965 | Georgia | 2,880 |
| Alabama | 8,177 | Rhode Island | 1,273 |
| California | 7,703 | Mississippi | 1,181 |
| Virginia | 7,237 | Connecticut | 909 |
| Alaska | 6,291 | Maine | 843 |
| Maryland | 5,745 | Delaware | 795 |
| Massachusetts | 5,322 | New Hampshire | 376 |

The greatest employment impacts from expenditures on recreational angling were generated in East Florida with 29,000 jobs, followed by Louisiana(18,000 jobs), North Carolina(18,000 jobs), and Texas(15,000 jobs). The lowest number of jobs were supported in New Hampshire (376 jobs). The highest sales impacts from expenditures on recreational angling were also generated in East Florida with $3.3 billion in sales, followed by Louisiana($2 billion), Texas($1.9 billion, and New Jersey($1.9 billion). The lowest sales were generated in 41 million ($41 million).

**Total Sales generated by the U.S. Recreational Fishing Industry (2011)**
*(thousands of dollars)*

| State | Sales | State | Sales |
|---|---|---|---|
| West Florida | 4,881,831 | Washington | 514,088 |
| East Florida | 3,255,774 | Oregon | 370,032 |
| North Carolina | 1,961,144 | New York | 369,382 |
| Texas | 1,853,361 | Georgia | 348,742 |
| New Jersey | 1,697,115 | Hawai'i | 309,923 |
| Louisiana | 1,602,913 | South Carolina | 282,049 |
| California | 1,031,068 | Rhode Island | 157,111 |
| Virginia | 833,508 | Mississippi | 145,769 |
| Alabama | 797,280 | Connecticut | 128,921 |
| Maryland | 783,833 | Delaware | 120,877 |
| Massachusetts | 726,164 | Maine | 77,071 |
| Alaska | 557,958 | New Hampshire | 41,005 |

### *Participation*[2]

Nationwide, there were 11 million recreational saltwater anglers who fished in their home states in 2011. Approximately 9.2 million of these anglers were residents of a U.S. coastal county and 1.4 million anglers were residents of a non-coastal county. Between 2002 and 2011, the total number of U.S. anglers fishing in their home states increased 6.3%. However, the number of anglers decreased 4.1% between 2010 and 2011. The number of coastal county anglers increased 6.7% from 2002 to 2011 and decreased 4% from 2010 to 2011. The number of non-coastal county anglers increased 4.1% between 2002 and 2011 and from 2010 to 2011, there was a 4.9% decrease.

### *Fishing Trips* [3]

The total number of fishing trips taken in the U.S. decreased 2.7% from 2002 to 2011. Relative to 2010, total fishing trips taken in the U.S. decreased 3% with largest increase occurring in the for-hire mode (22%)

### *Harvest and Release*

Among the ten key U.S. recreational species or species groups, seatrout, Atlantic croaker and spot, summer flounder, and striped bass were the most commonly caught by anglers in 2011. These species or groups were caught in large numbers relative to the other key species or groups: seatrout (51 million fish), Atlantic croaker and spot (31 million fish), summer flounder (22 million fish), and striped bass (8.4 million fish). Anglers fishing in the Mid-Atlantic and New England caught most of the Atlantic croaker, summer flounder, and striped bass in 2011, while most seatrout were caught in the Gulf of Mexico and the South Atlantic.

[1]The number of trips is in thousands and excludes Alaska and Texas.
[2]Participation estimates do not include Alaska and Texas. Hawai'i is included for 2003-2011; Numbers include the Caribbean.
[3]Effort numbers do not include Alaska and Texas. They include Hawai'i only for 2003-2010. California numbers were estimated differently from 2004-2011.

**Recreational Fishing Facts**

*Participation*

- An average of 12 million anglers fished in United States annually from 2002 to 2011.
- In 2011, coastal county residents made up 87% of total anglers. These anglers averaged 87% of total anglers annually over the 10 year time period.
- The largest annual increase in the number of coastal anglers during the 10 year time period was between 2002 and 2003, increasing 21%, from 8.6 million anglers to 10 million anglers. The largest one-year decrease during the same period for coastal anglers occurred between 2007 and 2008, decreasing 13%, from 12 million anglers to 11 million anglers.

*Fishing trips*

- In the United States, an average of 80 million fishing trips were taken annually from 2002 to 2011.
- Private or rental boat and shore-based fishing trips accounted for 35 million and 32 million fishing trips, respectively in 2011. Together, these made up 95.5% of the fishing trips taken in that year.
- The largest increase in number of total trips taken annually over the 10 year time period occurred between 2002 and 2003, increasing 17%, from 72 million trips to 84 million trips.
- The largest one-year decrease in total trips taken during this period in total trips taken occurred between 2008 and 2009, decreasing 13%, from 86 million trips to 75 million trips.

*Harvest and release*

- Seatrout was the most commonly caught key species or species group, averaging 45 million fish caught over the 10 year time period. Of these, 61% were released rather than harvested.
- Of the eight commonly caught key species or species groups, six were released more often than harvested over this time period. The species or species group that was most commonly released was sharks (96% released).
- Large Atlantic tuna (88% harvested), followed by Pacific halibut (57% harvested), and Atlantic croaker and spot (50% harvested) were key species or groups that experienced the greatest proportion of harvests rather than releases.

In the North Pacific Region, salmon (Chinook, chum, coho, pink, and sockeye) and Pacific halibut were the most commonly caught species or group in 2011 with 963,000 fish and 705,000 fish caught, respectively. Bigeye and mackerel (662,000 fish) comprised 44% of fish caught by anglers in the Western Pacific in 2011.

Recreational catch of striped bass experienced a 47% decrease between 2002 and 2011, the largest change during this 10 year time period. There were 2.7 million sharks caught in 2011. Other key species or groups with large changes in recreational catch include: seatrout (40% increase), summer flounder (29% increase), little tunny and Atlantic bonito (27% decrease), and Pacific halibut (21% increase).

From 2010 to 2011, decreases occurred in the recreational catch of sharks, summer flounder, and large Atlantic tuna. Of these, the largest decreases occurred in sharks (36%), large Atlantic tuna (24%), and summer flounder (9%). The largest increase observed for this time period was for seatrout, which experienced a 25% increase.

## Marine Economy[1]

In 2010, there were 7.4 billion establishments in the U.S, including marine and non-marine related establishments. These establishments employed almost 112 million full- and part-time employees and had a total annual payroll of $4.9 trillion. From 2002 to 2010, the number of establishments increased 2.7%, employee numbers decreased 0.38%, and total annual payroll increased 25% (a 5.7% decrease in real terms) nationwide. More modest changes were seen from 2009 to 2010: 0.5% decrease, 2.2% decrease, and 1.8% increase (a 2.3% decrease in real terms), respectively.

The nation's gross domestic product was $14.4 trillion in 2010, a 36% increase (a 2.6% increase in real terms) relative to 2002 levels ($11 trillion) and a 4.2% increase (a 0% increase in real terms) relative to 2009 levels ($13.8 trillion). Employee compensation in 2002 was $6.1 trillion, a 30% increase (a 1.9% decrease in real terms).

For this report, the marine economy, a subset of the national economy, is comprised of two industry sectors: 1) seafood sales and processing (employer establishments and nonemployer firms) and 2) transport, support, and marine operations (employer establishments). These sectors are comprised of several different marine-related industries. The following sections discuss the contribution of these industries to the national marine economy in terms of the number of establishments or firms, employees, and total annual payroll or receipts.

### *Seafood Sales and Processing*

In 2010, there were 1,617 nonemployer firms engaged in seafood product preparation and packaging, a 79% increase from 2002 levels. Annual receipts increased 88% (42% increase in real terms) from $56 million (2002) to $105 million (2010). More of these firms were located in Florida (202 firms) than any other state.

In contrast to nonemployer firms, the number of employer establishments in seafood product and packaging decreased 15% from 754 in 2002 to 638 in 2010. These firms employed approximately 32,000 full- and part-time employees in 2010 and had a total annual payroll of $1.1 billion. Relative to 2002 levels, this was an 18% decrease in workers but a 2.2% increase (a 23% decrease in real terms) in annual payroll. More of these establishments were located in Alaska (119 establishiments) and Washington (93 establishments) than any other states.

There were over 2,000 employer establishments involved in seafood wholesale activities in 2010. Most of these establishments

[1] Information for 2010 is reported in this section; 2011 data were not available for this report.

were in California (314 firms), New York (263 firms), and Florida (229 firms) Establishments in the seafood wholesaling sector employed 19,386 workers and had an annual payroll of $799 million. From 2002 to 2010, the number of establishments in the seafood wholesale sector decreased 24%, the number of employees decreased 27%, and the annual payroll decreased 11% (a 33% decrease in real terms).

Nonemployer firms and employer establishments engaged in seafood retail activities saw varying trends from 2002 to 2010. There was a 14% increase in firms (2,513 in 2010) and a 11% decrease in establishments (1,982 in 2010). Annual receipts for nonemployer firms totaled $200 million in 2010, a 0.1% decrease (25% decrease in real terms) relative to 2002 levels.

Annual payroll for employer establishments totaled over $219 million, a 31% increase (1.7% decrease in real terms) relative to 2002 levels. Approximately 9,857 full- and part-time workers were employed by the 1,982 establishments in 2010, a 0.88% increase and a 11% decrease, respectively from 2002. The employer establishments for retail seafood sales were primarily located in New York (394 firms), California (158 firms), and Florida (145 firms). Most non-employer firms in the retail sector were located in Florida (331), New York (247), and California (210).

*Transport, Support, and Marine Operations*

In the U.S. transport, support, and marine operations industry sector, industries involved in marina activities had the highest number of establishments. In 2010, there were over 3,900 marina industries that employed 27,000 full- and part-time workers. Compared to 2002 levels, this was a 2.1% decrease in establishment numbers and a 16% increase in number of employees.

Annual payroll for this industry was $927 million in 2010, a 37% increase (3.3% increase in real terms) over 2002 levels. Most of these marina industries were located in California (236235 industries), Florida (159025), and New York (98499).

### 2011 Economic Impacts of the United States Seafood Industry (thousands of dollars)

| | With Imports | | | Without Imports | | |
|---|---|---|---|---|---|---|
| | Jobs | Sales | Value Added | Jobs | Sales | Value Added |
| **Total Impacts** | 1,233,204 | 129,386,335 | 55,321,482 | 786,505 | 52,870,191 | 27,489,114 |
| Commercial Harvesters | 186,726 | 14,148,340 | 7,351,409 | 186,726 | 14,148,340 | 7,351,409 |
| Seafood Processors & Dealers | 198,001 | 27,231,326 | 11,946,661 | 59,752 | 8,309,304 | 3,645,377 |
| Importers | 176,037 | 48,424,097 | 14,761,785 | 0 | 0 | 0 |
| Seafood Wholesalers & Distributors | 54,273 | 7,478,706 | 3,516,426 | 27,711 | 3,818,492 | 1,795,423 |
| Retail | 618,166 | 32,103,866 | 17,745,201 | 512,317 | 26,594,055 | 14,696,905 |

### Total Landings Revenue and Landings Revenue of Key Species/Species Groups (thousands of dollars)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total revenue | 3,164,209 | 3,346,066 | 3,769,942 | 3,952,692 | 4,041,780 | 4,203,688 | 4,394,152 | 3,927,630 | 4,511,633 | 5,338,063 |
| Finfish & other | 1,374,489 | 1,518,330 | 1,777,802 | 1,860,060 | 1,950,757 | 2,068,233 | 2,254,846 | 1,887,456 | 2,183,578 | 2,590,197 |
| Shellfish | 1,789,720 | 1,827,736 | 1,992,140 | 2,092,632 | 2,091,023 | 2,135,455 | 2,139,306 | 2,040,174 | 2,328,055 | 2,747,866 |
| American lobster | 293,894 | 283,516 | 374,306 | 415,415 | 395,150 | 367,500 | 326,814 | 310,370 | 399,476 | 423,354 |
| Blue crab | 146,974 | 153,685 | 145,905 | 140,818 | 126,043 | 148,866 | 160,682 | 163,159 | 205,683 | 181,842 |
| Menhaden | 81,607 | 71,988 | 75,045 | 62,520 | 69,683 | 92,725 | 90,996 | 99,092 | 107,130 | 143,679 |
| Pacific halibut | 136,789 | 172,846 | 176,893 | 177,599 | 202,163 | 227,348 | 217,726 | 140,613 | 207,233 | 213,518 |
| Pacific salmon | 156,194 | 198,946 | 302,775 | 330,816 | 310,865 | 381,589 | 395,253 | 369,744 | 554,798 | 618,300 |
| Sablefish | 77,637 | 102,983 | 99,153 | 101,759 | 109,026 | 106,504 | 121,869 | 123,231 | 137,573 | 188,217 |
| Sea scallop | 202,092 | 229,097 | 320,039 | 432,514 | 384,758 | 386,044 | 370,057 | 376,331 | 455,694 | 585,090 |
| Shrimp | 523,882 | 441,622 | 446,043 | 412,718 | 454,610 | 429,993 | 444,522 | 379,152 | 416,976 | 535,509 |
| Tunas | 85,473 | 86,818 | 89,952 | 86,358 | 86,760 | 93,875 | 106,867 | 96,072 | 108,257 | 136,004 |
| Walleye pollock | 203,263 | 203,018 | 271,612 | 306,906 | 329,879 | 297,460 | 323,212 | 270,595 | 282,399 | 362,592 |

### Total Landings and Landings of Key Species/Species Groups (thousands of pounds)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total landings | 9,436,477 | 9,505,337 | 9,688,745 | 9,712,427 | 9,484,055 | 9,309,281 | 8,357,614 | 8,060,769 | 8,248,510 | 9,867,148 |
| Finfish & other | 8,232,370 | 8,367,711 | 8,516,634 | 8,630,877 | 8,303,972 | 8,227,911 | 7,290,705 | 6,792,319 | 6,948,622 | 8,499,132 |
| Shellfish | 1,204,107 | 1,137,626 | 1,172,111 | 1,081,550 | 1,180,083 | 1,081,370 | 1,066,909 | 1,268,450 | 1,299,888 | 1,368,016 |
| American lobster | 83,087 | 71,683 | 90,073 | 87,809 | 92,609 | 80,842 | 88,106 | 100,507 | 116,248 | 126,264 |
| Blue crab | 175,574 | 170,890 | 174,561 | 159,242 | 166,133 | 156,599 | 162,192 | 176,184 | 199,334 | 199,149 |
| Menhaden | 1,755,398 | 1,590,510 | 1,495,240 | 1,243,807 | 1,304,250 | 1,484,230 | 1,344,468 | 1,570,733 | 1,473,329 | 1,874,995 |
| Pacific halibut | 80,977 | 78,862 | 79,181 | 76,264 | 71,897 | 69,967 | 67,000 | 59,812 | 56,460 | 42,877 |
| Pacific salmon | 561,489 | 669,998 | 738,746 | 899,759 | 663,567 | 886,054 | 659,196 | 705,063 | 787,712 | 780,066 |
| Sablefish | 40,734 | 47,998 | 52,851 | 51,296 | 46,842 | 43,884 | 43,314 | 42,826 | 40,318 | 41,284 |
| Sea scallop | 52,672 | 55,968 | 64,108 | 56,626 | 59,013 | 58,450 | 53,385 | 58,003 | 57,529 | 59,112 |
| Shrimp | 345,249 | 324,170 | 316,566 | 264,163 | 337,012 | 273,636 | 248,609 | 305,701 | 262,295 | 310,570 |
| Tunas | 49,632 | 61,762 | 56,323 | 44,252 | 49,923 | 50,642 | 47,878 | 49,062 | 48,001 | 49,708 |
| Walleye pollock | 3,333,647 | 3,361,261 | 3,353,236 | 3,410,065 | 3,400,810 | 3,066,600 | 2,276,144 | 1,866,171 | 1,947,578 | 2,810,787 |

### Average Annual Price of Key Species/Species Groups (dollars per pound)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| American lobster | 3.54 | 3.96 | 4.16 | 4.73 | 4.27 | 4.55 | 3.71 | 3.09 | 3.44 | 3.35 |
| Blue crab | 0.84 | 0.90 | 0.84 | 0.88 | 0.76 | 0.95 | 0.99 | 0.93 | 1.03 | 0.91 |
| Menhaden | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.06 | 0.07 | 0.06 | 0.07 | 0.08 |
| Pacific halibut | 1.69 | 2.19 | 2.23 | 2.33 | 2.81 | 3.25 | 3.25 | 2.35 | 3.67 | 4.98 |
| Pacific salmon | 0.28 | 0.30 | 0.41 | 0.37 | 0.47 | 0.43 | 0.60 | 0.52 | 0.70 | 0.79 |
| Sablefish | 1.91 | 2.15 | 1.88 | 1.98 | 2.33 | 2.43 | 2.81 | 2.88 | 3.41 | 4.56 |
| Sea scallop | 3.84 | 4.09 | 4.99 | 7.64 | 6.52 | 6.60 | 6.93 | 6.49 | 7.92 | 9.90 |
| Shrimp | 1.52 | 1.36 | 1.41 | 1.56 | 1.35 | 1.57 | 1.79 | 1.24 | 1.59 | 1.72 |
| Tunas | 1.72 | 1.41 | 1.60 | 1.95 | 1.74 | 1.85 | 2.23 | 1.96 | 2.26 | 2.74 |
| Walleye pollock | 0.06 | 0.06 | 0.08 | 0.09 | 0.10 | 0.10 | 0.14 | 0.15 | 0.15 | 0.13 |

### 2011 Economic Impacts of Recreational Fishing Expenditures (thousands of dollars)

| | Jobs | Sales | Income | Value Added |
|---|---|---|---|---|
| Trip Impacts by Fishing Mode: | | | | |
| For-Hire | 22,806 | 2,537,215 | 804,012 | 1,377,196 |
| Private Boat | 33,720 | 4,589,856 | 1,356,127 | 2,334,562 |
| Shore | 28,740 | 3,512,042 | 1,074,793 | 1,826,550 |
| Total Durable Equipment Impacts | 369,277 | 59,676,104 | 17,283,585 | 26,933,452 |
| **Total State Trip and Durable Equipment Economic Impacts** | 454,542 | 70,315,216 | 20,518,517 | 32,471,761 |

### 2011 Angler Trip & Durable Expenditures (thousands of dollars)[1]

| Fishing Mode | Trip Expenditures | | Equipment | Durable Expenditures |
|---|---|---|---|---|
| | Non-Residents | Residents | Fishing Tackle | 3,829,739 |
| For-Hire | NA | 1,011,001 | Other Equipment | 1,406,941 |
| Private Boat | NA | 2,027,441 | Boat Expenses | 10,865,232 |
| Shore | NA | 1,481,376 | Vehicle Expenses | 4,050,431 |
| *Total Trip Expenditures* | NA | 4,519,818 | Second Home Expenses | 2,111,150 |
| | | | *Total Durable Equipment Expenditures* | 22,263,493 |
| **Total State Trip and Durable Equipment Expenditures** | | | | 26,783,311 |

### Recreational Anglers by Residential Area (thousands of anglers)[2]

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal | 8,608 | 10,434 | 10,199 | 11,330 | 11,644 | 12,389 | 10,725 | 9,408 | 9,557 | 9,183 |
| Non-Coastal | 1,372 | 1,562 | 1,579 | 1,492 | 1,685 | 1,616 | 1,591 | 1,747 | 1,502 | 1,428 |
| **Total Anglers** | 9,981 | 11,996 | 11,779 | 12,822 | 13,329 | 14,005 | 12,316 | 11,155 | 11,059 | 10,611 |

### Recreational Fishing Effort by Mode (thousands of angler-trips)[2]

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| For-Hire | 3,197 | 3,244 | 3,424 | 3,524 | 3,734 | 4,173 | 3,416 | 3,281 | 2,597 | 3,179 |
| Private | 38,525 | 45,013 | 44,007 | 43,249 | 42,719 | 46,465 | 44,912 | 37,647 | 37,760 | 35,321 |
| Shore | 30,437 | 36,199 | 38,015 | 37,345 | 38,694 | 37,021 | 37,220 | 33,631 | 32,107 | 31,694 |
| **Total Trips** | 72,159 | 84,456 | 85,446 | 84,118 | 85,147 | 87,659 | 85,548 | 74,559 | 72,464 | 70,194 |

### Harvest (H) and Release (R) of Key Species Species Groups (thousands of fish)[3]

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Drum (Atlantic croaker and spot) | H | 17,836 | 20,879 | 19,793 | 20,352 | 22,936 | 26,567 | 24,020 | 15,762 | 13,355 | 13,319 |
| | R | 16,436 | 18,203 | 17,821 | 23,760 | 19,371 | 21,365 | 24,974 | 20,374 | 15,981 | 18,092 |
| Drum (seatrouts) | H | 13,943 | 15,228 | 16,947 | 16,095 | 18,903 | 17,559 | 21,081 | 20,187 | 16,743 | 22,234 |
| | R | 22,458 | 25,552 | 27,214 | 30,632 | 30,351 | 28,970 | 32,349 | 25,807 | 23,936 | 28,649 |
| Little tunny & Atlantic bonito [4] | H | 321 | 254 | 405 | 179 | 313 | 293 | 204 | 231 | 190 | 281 |
| | R | 1,020 | 865 | 1,099 | 464 | 868 | 1,221 | 725 | 807 | 597 | 703 |
| Pacific halibut | H | 351 | 403 | 483 | 500 | 463 | 585 | 516 | 440 | 398 | 394 |
| | R | 233 | 290 | 369 | 380 | 353 | 438 | 359 | 321 | 304 | 311 |
| Rockfishes & scorpionfishes | H | 2,856 | 3,742 | 2,593 | 3,617 | 2,677 | 2,454 | 2,068 | 2,199 | NA | NA |
| | R | 1,065 | 1,796 | 977 | 1,347 | 895 | 691 | 636 | 836 | NA | NA |
| Salmon | H | 1,321 | 1,626 | 1,569 | 1,481 | 873 | 1,286 | 722 | 1,574 | NA | NA |
| | R | 692 | 881 | 1,010 | 844 | 513 | 710 | 375 | 659 | NA | NA |
| Sharks[5] | H | 156 | 168 | 148 | 203 | 131 | 144 | 108 | 126 | 157 | 104 |
| | R | 2,076 | 2,796 | 3,052 | 3,983 | 3,507 | 3,954 | 4,134 | 3,980 | 4,012 | 2,574 |
| Striped bass | H | 1,891 | 2,579 | 2,617 | 2,488 | 2,740 | 2,438 | 2,341 | 1,990 | 1,973 | 2,249 |
| | R | 13,971 | 14,996 | 17,480 | 18,227 | 23,415 | 16,218 | 12,695 | 8,120 | 6,355 | 6,174 |
| Summer flounder | H | 3,280 | 4,574 | 4,389 | 4,107 | 4,034 | 3,105 | 2,363 | 1,829 | 1,509 | 1,844 |
| | R | 13,417 | 15,974 | 16,055 | 21,869 | 17,511 | 17,627 | 20,547 | 22,297 | 22,230 | 19,723 |
| Tunas (large Atlantic species) [6] | H | 428 | 889 | 772 | 667 | 566 | 729 | 799 | 530 | 594 | 421 |
| | R | 28 | 112 | 132 | 109 | 135 | 95 | 87 | 53 | 51 | 69 |

[1] All anglers reported in this table are U.S. residents; NA = not applicable

[2] Information was included for all states but Alaska and Texas. Most information was provided by the Marine Recreational Information Program (MRIP). Pacific data were provided by the Pacific states and Hawaii data were not included from 2000 to 2002.

[3] This table excludes all Texas data and Hawaii data for 2002.

[4] This species may not be equivalent to species with similar names listed in the commercial tables.

[5] Sharks include species within the requiem shark family, blacktip sharks, Atlantic sharpnose sharks, and unidentified sharks.

[6] Includes all tunas in the thunnus family.

### United States's State Economy (% of national total)

| | Establishments | Employees | Annual Payroll (million $) | Employee Compensation (million $) | Gross State Product (million $) | Commercial Location Quotient [1] |
|---|---|---|---|---|---|---|
| 2002 | 7,200,770 | 112,400,654 | 3,943,180 | 6,099,602 | 10,572,388 | 1 |
| 2010 | 7,396,628 | 111,970,095 | 4,940,983 | 7,952,204 | 14,416,601 | 1 |
| % change | 2.72% | -0.383% | 25.3% | 30.4% | 36.4% | -- |

### Seafood Sales & Processing - Nonemployer Firms (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Seafood product prep. & packaging | Firms | 903 | 1,038 | 1,110 | 1,080 | 1,142 | 1,303 | 1,308 | 1,383 | 1,617 |
| | Receipts | 55,750 | 70,071 | 81,871 | 78,745 | 80,066 | 88,230 | 89,670 | 92,358 | 104,990 |
| Seafood Sales, retail | Firms | 2,210 | 2,346 | 2,260 | 2,098 | 2,089 | 2,610 | 2,522 | 2,407 | 2,513 |
| | Receipts | 199,937 | 210,231 | 210,450 | 203,951 | 211,186 | 231,776 | 233,002 | 198,495 | 199,810 |

### Seafood Sales & Processing - Employer Establishments (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Seafood product prep. & packaging | Establishments | 754 | 764 | 734 | 717 | 670 | 685 | 663 | 645 | 638 |
| | Employees | 38,663 | 39,580 | 38,102 | 37,684 | 35,894 | 33,169 | 33,323 | 30,894 | 31,789 |
| | Payroll | 1,092,500 | 1,177,582 | 1,151,780 | 1,180,396 | 1,205,890 | 1,196,086 | 1,161,637 | 1,091,727 | 1,116,305 |
| Seafood sales, wholesale | Establishments | 2,883 | 2,456 | 2,330 | 2,314 | 2,222 | 2,438 | 2,063 | 2,099 | 2,183 |
| | Employees | 26,719 | 23,091 | 22,501 | 22,666 | 22,013 | 24,232 | 20,116 | 19,290 | 19,386 |
| | Payroll | 895,718 | 743,479 | 771,749 | 781,459 | 826,720 | 924,654 | 782,178 | 758,332 | 798,794 |
| Seafood sales, retail | Establishments | 2,238 | 2,125 | 2,151 | 2,155 | 2,115 | 2,094 | 2,044 | 1,967 | 1,982 |
| | Employees | 9,771 | 10,346 | 10,714 | 10,381 | 10,545 | 10,380 | 9,732 | 9,439 | 9,857 |
| | Payroll | 167,634 | 186,087 | 192,187 | 194,602 | 200,971 | 209,404 | 205,423 | 211,264 | 219,045 |

### Transport, Support, & Marine Operations - Employer Establishments (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal & Great Lakes freight transportation | Establishments | 520 | 606 | 579 | 610 | 579 | 573 | 513 | 513 | 547 |
| | Employees | 20,149 | 22,449 | 21,928 | 21,025 | 22,172 | 22,568 | 21,019 | 20,919 | 17,528 |
| | Payroll | 1,096,771 | 1,183,071 | 1,179,549 | 1,232,342 | 1,376,033 | 1,552,467 | 1,694,613 | 1,470,159 | 1,288,001 |
| Deep sea freight transportation | Establishments | 471 | 472 | 435 | 465 | 456 | 427 | 365 | 376 | 372 |
| | Employees | 12,916 | 12,175 | 11,314 | 11,357 | 11,473 | 11,308 | 10,231 | 11,180 | 10,288 |
| | Payroll | 784,149 | 734,781 | 735,804 | 801,863 | 825,752 | 855,683 | 852,063 | 863,363 | 867,797 |
| Marinas | Establishments | 4,021 | 4,150 | 4,092 | 4,143 | 4,025 | 4,085 | 3,972 | 3,891 | 3,937 |
| | Employees | 23,047 | 27,928 | 28,100 | 27,511 | 28,339 | 28,788 | 28,686 | 26,643 | 26,657 |
| | Payroll | 675,529 | 773,538 | 814,821 | 839,848 | 894,097 | 945,355 | 954,032 | 905,488 | 927,499 |
| Marine cargo handling | Establishments | 595 | 542 | 551 | 549 | 540 | 552 | 532 | 541 | 507 |
| | Employees | 50,428 | 50,644 | 58,618 | 59,670 | 61,905 | 62,941 | 63,736 | 56,386 | 57,275 |
| | Payroll | 2,425,187 | 2,422,537 | 2,899,703 | 3,034,672 | 3,261,953 | 3,428,126 | 3,272,723 | 2,776,791 | 3,026,861 |
| Navigational services to shipping | Establishments | 828 | 782 | 804 | 803 | 802 | 830 | 868 | 846 | 847 |
| | Employees | 11,224 | 11,795 | 11,881 | 10,819 | 12,043 | 12,997 | 13,419 | 12,689 | 13,529 |
| | Payroll | 509,953 | 629,541 | 591,510 | 584,689 | 699,375 | 756,552 | 847,938 | 826,384 | 937,980 |
| Port & harbor operations | Establishments | 212 | 223 | 234 | 244 | 229 | 223 | 268 | 258 | 287 |
| | Employees | 6,304 | 6,413 | 6,888 | 7,453 | 7,002 | 6,573 | 5,608 | 5,100 | 4,844 |
| | Payroll | 245,979 | 279,970 | 300,692 | 319,338 | 323,554 | 318,608 | 282,671 | 250,358 | 290,467 |
| Ship & boat building | Establishments | 1,736 | 1,739 | 1,793 | 1,799 | 1,764 | 1,771 | 1,782 | 1,615 | 1,540 |
| | Employees | 131,292 | 133,395 | 137,633 | 141,620 | 142,057 | 148,864 | 157,512 | 137,759 | 127,691 |
| | Payroll | 5,111,708 | 5,119,596 | 5,499,783 | 5,654,818 | 5,877,830 | 6,405,570 | 7,269,306 | 6,674,187 | 6,529,523 |

[1] The U.S. Commercial Fishing Location Quotient (CFLQ) of 1.0 represents the national baseline from which state CFLQs can be compared.

# North Pacific

## - Alaska

### Management Context

The North Pacific Region includes the fisheries in the Exclusive Economic Zone off of the state of Alaska. Federal fisheries in this region are managed by the North Pacific Fishery Management Council (NPFMC) and NOAA Fisheries (NMFS) under six fishery management plans (FMPs).

**North Pacific Fishery Management Plans**

1. Bering Sea/Aleutian Islands (BSAI) Groundfish
2. Gulf of Alaska (GOA) Groundfish
3. BSAI King and Tanner Crabs
4. Alaska Scallop Fishery
5. Salmon in the EEZ
6. Arctic

Of the stocks or stock complexes covered in these fishery management plans, none are currently listed as overfished. No stocks in this region are currently subject to overfishing. The North Pacific Region has nine catch share programs, more than any other region. These are the: 1) Western Alaska community development quota program; 2) Pacific halibut and sablefish individual fishing quota program; 3) American Fisherie Act (Bering Sea) pollock cooperatives; 4) Alaska weathervane scallop cooperative; 5) Bering Sea king and tanner crab (Crab Rationalization) program that includes both an individual fishing quota program and a fishing cooperative; 6) Central Gulf of Alaska rockfish cooperatives; 7) Non-Pollock Trawl Catcher/Processor Groundfish (Amendment 80); 8) Freezer Longline Cooperatives; and 9) Bering Sea Chinook Salmon Bycatch. The landings revenues for these nine programs totaled over $907 million in 2010, which exceeds the total landings revenue of any other state.

A management measure that is unique to Alaska is the western Alaska Community Development Quota (CDQ) program. This program was originally implemented in 1992 as part of a restructuring of the Bering Sea/Aleutian Islands (BSAI) groundfish fishery. Under this program, a percentage of the total allowable catch for groundfish, prohibited species, halibut, and crab is apportioned to the coastal western Alaskan native communities. The purpose of the program is to provide western Alaskan communities the opportunity to participate and invest in BSAI fisheries, to support economic development in western Alaska, to alleviate poverty and provide economic and social benefits for residents of western Alaska, and to achieve sustainable and diversified local economies in western Alaska.

Annual CDQ allocations provide a revenue stream for CDQ groups through various channels, including the direct catch and sale of some species and the leasing of quota to various harvesting partners. These communities participate in the CDQ Program through six non-profit corporations (CDQ groups), which manage and administer the CDQ allocations, investments, and economic development projects. CDQ groups use the revenue derived from the harvest of their fisheries allocations to fund economic development activities and provide employment opportunities. In 2011, 180 million pounds of pollock were caught under the BSAI CDQ program, with a value of approximately $49 million.

### Commercial Fisheries

North Pacific fishermen earned over $1.9 billion from their commercial harvest (5.3 billion pounds) in 2011. Landings revenue was dominated by salmon ($565 million), walleye pollock ($363 million), crab ($249 million), and Pacific cod ($210 million). Walleye pollock contributed the most to landings in 2011, accounting for 53% of total landings (2.8 billion pounds) and 19% of landings revenue, with an average annual price of $0.13 per pound. In contrast, salmon accounted for 14% of total landings (738 million pounds) and generated 30% of landings revenue, with an average annual price of $0.77 per pound in 2011.

The North Pacific groundfish fishery is different from most other fisheries in the nation in that a large portion of the fishery is processed at sea and, therefore, no landings revenues are reported. The landings revenue for the species landed and processed at sea are estimated by using prices obtained from the shore-side sector. These species include Pacific cod, flatfish, atka mackerel, walleye pollock, rockfish, and sablefish. When data from the shore-side sector are inadequate, historical information about the relationship between the ex-vessel price and the wholesale price of finished products is used to estimate ex-vessel prices and revenue for portions of the fishery mostly processed at sea.

*Economic Impacts*[1]

Alaska's seafood industry generated $4.7 billion in sales impacts, $2 billion in income impacts, and over 63,000 jobs in 2011. Seafood processing and dealer operations contributed 26% to in-state sales for Alaskan businesses, with over $1.2 billion generated in 2011. The commercial harvester sector generated more impacts than any other sector with approximately 70% of total impacts. The importer sector consisted of less than one percent of the total impacts for the state in 2011.

**Key North Pacific Commercial Species**

- Atka mackerel
- Pacific cod
- Crab
- Flatfish
- Pacific halibut
- Pacific herring
- Rockfish
- Sablefish
- Salmon
- Walleye pollock

*Landings Revenue*

In 2011, landings revenue for finfish and shellfish totaled over $1.9 billion, a 126% increase from total revenue generated in 2002. When adjusting for inflation, real landings revenue increased 57%. Landings revenue in 2011 was a 21% increase relative to 2010 ($1.6 billion). Finfish and other catch contributed more than shellfish to the 2011 total, accounting for 86% or $1.6 billion. This was a 136% increase (64% increase in real terms) from 2002 finfish revenue totals. Similarly, shellfish revenues increased 79%

[1]The NMFS Commercial Fishing Industry Input/Output Model was used to generate the impact estimates (see NMFS Commercial Fishing & Seafood Industry Input/Output Model, available at: `www.st.nmfs.noaa.gov/documents/commercial_seafood_impacts_2007-2009.pdf`)

(24% increase in real terms) from $146 million in 2002 to $263 million in 2011. The largest changes in landings revenue between 2002 and 2011 were for Atka mackerel (831% increase), salmon (335% increase), and flatfish (178% increase).

**Commercial Fisheries Facts**

*Landings revenue*

- On average, the key species or species groups account for 99% of total revenue, ($1.9 billion) generated in the North Pacific Region.
- Salmon contributed more than any other species or species group, averaging $325 million in landings revenue from 2002 to 2011.
- Atka mackerel had the largest one-year increase in landings revenue over the 10 year time period, increasing 257% from $3 million in 2003 to $11 million in 2004.
- Pacific cod had the largest decrease in landings revenue over the 10 year time period, decreasing 52% from $273 million in 2008 to $131 million in 2009.

*Landings*

- Key species or species groups contributed an average of 99% annually to total landings between 2002 and 2011.
- Walleye pollock, contributed the most to landings in the region, averaging 2.9 billion pounds from 2002 to 2011.
- Walleye pollock had the largest one-year increase in landings over the 10 year time period, increasing 44% from 1.9 billion pounds in 2010 to 2.8 billion pounds in 2011.
- Salmon had the largest one-year decrease in landings over the 10 year time period, decreasing 27% from 872 million pounds in 2005 to 634 million pounds in 2006.

*Prices*

- Sablefish had the highest average annual ex-vessel price per pound ($2.96) over the time period, followed by Pacific halibut ($2.85), and crab ($2.47).
- Walleye pollock had the lowest average annual ex-vessel price per pound ($0.10) over the time period, followed by Atka mackerel ($0.12), and flatfish ($0.16).
- The largest annual increase in ex-vessel price during the 10 year period was for Atka mackerel had the largest one-year increase in ex-vessel price over the 10 year time period, increasing 228% from $0.03 per pound in 2003 to $0.10 in 2004.
- Pacific cod had the largest decrease in ex-vessel price over the 10 year time period, decreasing 52% from $0.55 per pound in 2008 to $0.27 in 2009.

*Landings*

In 2011, North Pacific commercial fishermen landed 5.3 billion pounds of finfish and shellfish, a 5% increase from 2002 totals. Finfish and catch other than shellfish accounted for 98% of this total (5.2 billion) and increased 4.7% from 2002 (5 billion pounds) and increased 24% from 2010 (4.2 billion pounds). Shellfish landings in 2011 increased 35% from 63 million pounds in 2002 to 85 million pounds in 2011. Between 2010 and 2011, shellfish landings increased 0.2%. Overall, an average of 5 billion pounds were landed annually in the North Pacific from 2002 to 2011, ranging from a low of 4 billion pounds (2009) to a high of 5.6 billion pounds (2005).

In terms of key species or species groups, walleye pollock landings contributed the most to landings during the 10 year period, accounting for 53% of total landings in 2011 (2.8 billion pounds). Landings of salmon (738 million pounds), Pacific cod (663 million pounds), and flatfish (650 million pounds) also significantly contributed to the total landings.

Relative to 2002, landings of flatfish, Pacific herring, and salmon in 2011 increased more than any other key species or group, increasing 128%, 41.1%, and 41.1% respectively. In contrast, the largest decreases between 2002 and 2011 were experienced by Pacific halibut (47%) and walleye pollock (16%).

*Prices*

In all, 2011 ex-vessel prices per pound for seven of the key species and species groups were above their average annual price for the 10 year time period. When comparing 2011 ex-vessel prices to those in 2002 the largest changes occurred in Atka mackerel (588% increase, 378% increase in real terms), salmon (208% increase, 114% increase in real terms), Pacific halibut (200% increase, 109% increase in real terms), and sablefish (159% increase, 80% increase in real terms). Relative to ex-vessel prices in 2010 the largest changes in the ex-vessel values were for Pacific herring (41% decrease, 46% decrease in real terms), Pacific halibut (36% increase, 25% increase in real terms), sablefish (31% increase, 21% increase in real terms), and crab (30% increase, 20% increase in real terms),

**Recreational Fisheries**

Recreational fishermen spent approximately 811,000 days fishing in Alaska in 2011. These anglers numbered over 286,000, with 56% of them non-residents. Pacific halibut was the most caught species or species group, with approximately 705,000 harvested or released in 2011. Coho salmon and razor clam were also caught in large numbers, with 474,000 and 436,000 caught, respectively. Together, these three species accounted for 64% of total catch by anglers in the North Pacific Region.

*Economic Impacts and Expenditures*[1]

In 2011, approximately 6,300 jobs in the North Pacific were generated by recreational fishing activities and over $446 million was spent by anglers who fished in the region. Most of these employment impacts were generated by industries that provided services to anglers who fished from a for-hire boat (2,600 jobs) or a private boat (2,400). These fishing trip modes also generated the most in trip-related expenditures: $138 million for for-hire fishing trips (44% of total trip expenditures) and $165 million for private boat trips (52% of total trip expenditures). Over 87% of total trip-related expenditures in Alaska came from non-resident anglers.

[1]Expenditure estimates were generated from the 2011 National Marine Recreational Fishing Expenditure Survey. Economic impacts from recreational fishing activities were generated using the NMFS Recreational Economic Impact Model (see The Economic Contribution of Marine Angler Expenditures in the United States, 2006, available at:`http://www.st.nmfs.noaa.gov/economics/publications/marine-angler-expenditures/marine-angler-2006`)

**Key North Pacific Recreational Species**

- Chinook salmon,
- Chum salmon,
- Coho salmon,
- Greenlings (lingcod)
- Pacific halibut,
- Pink salmon,
- Razor clam,
- Rockfish,
- Sockeye salmon

In addition to jobs generated by recreational fishing activities, other economic impacts include sales impacts and the contribution of recreational fishing activities to gross domestic product (value added impacts). For-hire fishing trips generated $209 million in sales (46% of total trip-related sales) and $116 million in value added impacts (46% of total trip-related value added impacts) in 2011. Private boat trips contributed $233 million in sales (51%) and $125 million (50%) in value added impacts. Shore-based fishing trips contributed $18 million in trip-related sales (3.9%) and $9.8 million in trip-related value added impacts (3.9%).

Anglers spent over $129 million on durable equipment in 2011, contributing 29% to total expenditures in the region (trip and durable equipment combined). Most of this was spent on boat expenses ($81 million). Expenditures related to vehicles were $1.9 million; second home expenses, $2.15 million; other equipment, $20.4 million; and fishing tackle, $23 million.

Economic impacts from durable equipment expenditures in 2011 include over 1,000 jobs, $98 million in sales impacts, and $67 million in value added impacts. These impacts represented 16% of the employment impacts, 18% of the sales impacts, 24% of the income impacts, and 21% of the value added impacts generated by recreational fishing activities.

*Participation*

In 2011, there were 286,000 recreational saltwater anglers who fished in Alaska. This was an 4% increase from 2002 (275,000 anglers) and a 1.8% increase from 2010 (281,000 anglers). Recreational fishermen in Alaska are categorized as either a resident of Alaska or a non-resident. In 2011, non-resident anglers made up 56% of total anglers (161,000 anglers). There was no change in number of anglers from 2002 and a 1.5% increase from 2010 (159,000 anglers). In terms of resident anglers, there were 124,000 resident anglers who fished in the North Pacific Region in 2011, which was a 10% increase from 2002 and a 2.2% increase from 2010.

*Days Fished*[1]

Anglers who fished in Alaska spent approximately 811,000 days fishing in 2011. This was a 5.1% decrease from the 855,000 days spent fishing in 2002. From 2010 to 2011, there was a 0.1% increase in the number of days fished (811,000 days) in 2010.

*Harvest and Release*

Of Alaska's key species and species groups, Pacific halibut, coho salmon, and razor clam were most frequently caught by recreational fishermen. In 2011, 705,000 Pacific halibut, 474,000 coho salmon, and 436,000 razor clam were caught by anglers in Alaska. Razor clam (100% harvested), coho salmon (81%), and sockeye salmon (76%) were more often harvested than released, while pink salmon were more often released (65% released).

**Recreational Fish Facts**

*Participation*

- An average of 304,000 anglers fished in North Pacific annually between 2002 to 2011.
- In 2011, residents made up 44% of total anglers in this region and averaged 41% of total anglers annually over the 10 year time period.
- The largest annual increase in anglers was a 14% increase in Alaska resident anglers from 2002 to 2003.
- The largest annual decrease in anglers was a 17% decrease in the number of non-resident anglers from 2008 to 2009.

*Fishing trips*

- On average, recreational fishermen spent an average of 925,000 days fishing annually in Alaska from 2002 to 2011.
- The largest annual increase in total days fished was 16% from 868,000 days in 2003 to 1 million in 2004.
- The largest annual decrease in total days fished was an 11% decrease from 914,000 days in 2009 to 811,000 days in 2010.

*Harvest and release*

- Pacific halibut was the most commonly caught key species or species group, averaging 789,000 fish caught over the 10 year time period. Of these, 43% were released rather than harvested.
- Of the nine commonly caught key species or species groups, four were released more often than harvested over this time period. The species or species group that was most commonly released was chum salmon (68% released on average).
- Chum salmon had the largest annual increase in catch, increasing 98% from 2010 to 2011. Pink salmon had the largest annual decrease in catch, decreasing 53% from 2005 to 2006.

Between 2002 and 2011, five of the North Pacific's key species or groups experienced increases in catch totals. Those with the largest increases include: chum salmon (32%), rockfish (30%), and Pacific halibut (21%). Over the same time period, decreases were experienced by chinook salmon (6%) and coho salmon (25%).

In the short term, the largest increases were experienced bychum salmon and chinook salmon from 2010 to 2011. Decreases over the same time period occurred in two species or species groups, the largest of which were experienced by rockfish (11%) and greenlings (lingcod) (4%). The dramatic changes in pink salmon catch between 2010 and 2011 can at least be partially attributed to the biannual biological cycle.

[1] In Alaska, information related to how often a recreational fisherman fishes is collected in terms of the number of days spent fishing rather than the number of fishing trips taken.

## Marine Economy[1]

In Alaska, approximately 255,000 full- and part-time employees were employed by 20,000 establishments in 2010. Annual payroll totaled $12 billion, employee compensation totaled $24 billion and gross state product totaled $48 billion. The Bureau of Labor Statistics did not disclose CFLQ data for Alaska for 2010.

### *Seafood Sales and Processing*

The number of nonemployer firms, businesses that have no paid employees and are subject to federal income tax, engaged in seafood product preparation and packaging increased 24% from 25 firms in 2002 to 31 firms in 2010. Despite this, annual receipts decreased 32% to $1.5 million in 2010 (a 49% decrease in real terms).

### *Transport, Support, and Marine Operations*

Data were largely unavailable for industries in this sector. When looking at available data, coastal and Great Lakes freight transportation had the highest number of establishments with 55 establishments in 2010. This was a 139% increase relative to 2002 totals.

[1] Information for 2010 is reported in this section; 2011 data were not available for this report.

### 2011 Economic Impacts of the Alaska Seafood Industry (thousands of dollars)

| | With Imports | | | Without Imports | | |
|---|---|---|---|---|---|---|
| | Jobs | Sales | Value Added | Jobs | Sales | Value Added |
| **Total Impacts** | 63,295 | 4,684,638 | 2,493,124 | 62,972 | 4,655,932 | 2,478,543 |
| Commercial Harvesters | 44,713 | 3,276,246 | 1,732,120 | 44,713 | 3,276,246 | 1,732,120 |
| Seafood Processors & Dealers | 14,689 | 1,198,307 | 648,337 | 14,387 | 1,174,056 | 635,207 |
| Importers | 14 | 3,986 | 1,215 | 0 | 0 | 0 |
| Seafood Wholesalers & Distributors | 431 | 45,647 | 20,409 | 428 | 45,370 | 20,285 |
| Retail | 3,448 | 160,453 | 91,044 | 3,444 | 160,260 | 90,931 |

### Total Landings Revenue and Landings Revenue of Key Species/Species Groups (thousands of dollars)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total Revenue | 844,763 | 1,026,015 | 1,161,519 | 1,259,540 | 1,323,872 | 1,465,810 | 1,668,448 | 1,301,661 | 1,583,681 | 1,911,540 |
| Finfish & other | 698,310 | 851,572 | 996,113 | 1,100,155 | 1,199,905 | 1,284,964 | 1,416,810 | 1,108,427 | 1,381,821 | 1,648,941 |
| Shellfish | 146,453 | 174,443 | 165,406 | 159,385 | 123,967 | 180,846 | 251,638 | 193,234 | 201,860 | 262,599 |
| Atka mackerel | 2,525 | 3,022 | 10,795 | 14,893 | 15,703 | 14,253 | 19,523 | 26,732 | 27,523 | 23,499 |
| Pacific cod | 107,188 | 162,397 | 142,905 | 150,537 | 210,282 | 223,209 | 272,669 | 130,755 | 144,775 | 209,908 |
| Crab | 139,828 | 165,834 | 153,430 | 146,131 | 110,572 | 168,195 | 240,747 | 180,264 | 189,553 | 248,693 |
| Flatfish | 40,665 | 39,945 | 41,325 | 61,923 | 71,107 | 76,014 | 95,912 | 71,235 | 80,312 | 113,150 |
| Pacific halibut | 128,922 | 165,906 | 168,658 | 170,075 | 192,905 | 217,399 | 208,983 | 134,603 | 200,454 | 205,211 |
| Pacific herring | 9,139 | 8,930 | 14,029 | 13,429 | 7,455 | 14,817 | 22,912 | 29,294 | 23,026 | 12,305 |
| Rockfish | 6,461 | 7,968 | 6,582 | 5,663 | 7,237 | 7,082 | 7,854 | 7,599 | 9,099 | 6,927 |
| Sablefish | 65,314 | 84,166 | 81,923 | 81,393 | 86,035 | 85,520 | 94,590 | 88,750 | 101,596 | 143,309 |
| Salmon | 129,902 | 168,093 | 255,000 | 293,562 | 276,513 | 347,625 | 368,218 | 344,655 | 505,693 | 564,788 |
| Walleye pollock | 203,263 | 203,018 | 271,612 | 306,906 | 329,879 | 297,460 | 323,212 | 270,595 | 282,399 | 362,592 |

### Total Landings and Landings of Key Species/Species Groups (thousands of pounds)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total Landings | 5,019,820 | 5,276,714 | 5,306,169 | 5,610,287 | 5,373,085 | 5,253,164 | 4,471,034 | 4,005,498 | 4,275,477 | 5,272,554 |
| Finfish & other | 4,957,262 | 5,214,835 | 5,247,370 | 5,545,864 | 5,299,194 | 5,177,143 | 4,366,531 | 3,910,859 | 4,190,949 | 5,187,877 |
| Shellfish | 62,558 | 61,879 | 58,799 | 64,423 | 73,891 | 76,021 | 104,503 | 94,639 | 84,528 | 84,677 |
| Atka mackerel | 83,244 | 99,542 | 108,423 | 129,482 | 130,814 | 126,961 | 127,029 | 156,887 | 145,206 | 112,596 |
| Pacific cod | 509,574 | 568,660 | 583,747 | 547,849 | 520,955 | 488,496 | 494,429 | 490,568 | 538,201 | 662,976 |
| Crab | 57,879 | 56,956 | 52,434 | 57,310 | 69,002 | 70,700 | 99,445 | 89,532 | 79,875 | 80,463 |
| Flatfish | 284,767 | 290,926 | 270,675 | 341,699 | 383,194 | 423,338 | 599,882 | 506,393 | 564,170 | 649,689 |
| Pacific halibut | 77,939 | 76,616 | 76,558 | 73,922 | 69,154 | 67,242 | 64,639 | 57,749 | 54,857 | 41,291 |
| Pacific herring | 69,858 | 68,984 | 70,893 | 85,701 | 79,845 | 67,137 | 83,787 | 86,951 | 108,116 | 98,600 |
| Rockfish | 22,907 | 26,465 | 23,197 | 22,694 | 23,308 | 24,424 | 25,725 | 24,974 | 28,626 | 25,441 |
| Sablefish | 32,057 | 35,794 | 39,946 | 37,554 | 33,124 | 32,254 | 30,336 | 27,004 | 25,263 | 27,139 |
| Salmon | 523,057 | 630,527 | 697,897 | 872,318 | 634,227 | 861,254 | 640,070 | 671,181 | 756,826 | 738,122 |
| Walleye pollock | 3,333,647 | 3,361,261 | 3,353,236 | 3,410,065 | 3,400,810 | 3,066,600 | 2,276,144 | 1,866,171 | 1,947,578 | 2,810,787 |

### Average Annual Price of Key Species/Species Groups (dollars per pound)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Atka mackerel | 0.03 | 0.03 | 0.10 | 0.12 | 0.12 | 0.11 | 0.15 | 0.17 | 0.19 | 0.21 |
| Pacific cod | 0.21 | 0.29 | 0.24 | 0.27 | 0.40 | 0.46 | 0.55 | 0.27 | 0.27 | 0.32 |
| Crab | 2.42 | 2.91 | 2.93 | 2.55 | 1.60 | 2.38 | 2.42 | 2.01 | 2.37 | 3.09 |
| Flatfish | 0.14 | 0.14 | 0.15 | 0.18 | 0.19 | 0.18 | 0.16 | 0.14 | 0.14 | 0.17 |
| Pacific halibut | 1.65 | 2.17 | 2.20 | 2.30 | 2.79 | 3.23 | 3.23 | 2.33 | 3.65 | 4.97 |
| Pacific herring | 0.13 | 0.13 | 0.20 | 0.16 | 0.09 | 0.22 | 0.27 | 0.34 | 0.21 | 0.12 |
| Rockfish | 0.28 | 0.30 | 0.28 | 0.25 | 0.31 | 0.29 | 0.31 | 0.30 | 0.32 | 0.27 |
| Sablefish | 2.04 | 2.35 | 2.05 | 2.17 | 2.60 | 2.65 | 3.12 | 3.29 | 4.02 | 5.28 |
| Salmon | 0.25 | 0.27 | 0.37 | 0.34 | 0.44 | 0.40 | 0.58 | 0.51 | 0.67 | 0.77 |
| Walleye pollock | 0.06 | 0.06 | 0.08 | 0.09 | 0.10 | 0.10 | 0.14 | 0.15 | 0.15 | 0.13 |

### 2011 Economic Impacts of Recreational Fishing Expenditures (thousands of dollars)[1]

| | Jobs | Sales | Income | Value Added |
|---|---|---|---|---|
| Trip Impacts by Fishing Mode: | | | | |
| For-Hire | 2,620 | 209,409 | 67,137 | 116,039 |
| Private Boat | 2,439 | 232,717 | 73,798 | 125,417 |
| Shore | 201 | 18,027 | 5,887 | 9,821 |
| Total Durable Equipment Impacts | 1,030 | 97,805 | 45,694 | 66,574 |
| **Total State Trip and Durable Equipment Economic Impacts** | 6,291 | 557,958 | 192,517 | 317,852 |

### 2011 Angler Trip & Durable Expenditures (thousands of dollars)

| Fishing Mode | Trip Expenditures | | Equipment | Durable Expenditures |
|---|---|---|---|---|
| | Non-Residents | Residents | Fishing Tackle | 23,279 |
| For-Hire | 118,820 | 19,267 | Other Equipment | 20,448 |
| Private Boat | 145,444 | 19,486 | Boat Expenses | 81,477 |
| Shore | 9,396 | 3,904 | Vehicle Expenses | 1,865 |
| *Total Trip Expenditures* | 273,660 | 42,658 | Second Home Expenses | 2,150 |
| | | | *Total Durable Equipment Expenditures* | 129,219 |
| **Total State Trip and Durable Equipment Expenditures** | | | | 445,537 |

### Recreational Anglers by Residential Area (thousands of anglers)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Out of State | 162 | 170 | 193 | 207 | 197 | 205 | 190 | 158 | 159 | 161 |
| In State | 113 | 129 | 130 | 127 | 120 | 127 | 119 | 127 | 122 | 124 |
| **Total Anglers** | 275 | 299 | 323 | 334 | 317 | 332 | 309 | 284 | 281 | 286 |

### Recreational Fishing Effort by Mode (thousands of days)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Total Days Fished** | 855 | 868 | 1,007 | 1,054 | 941 | 1,052 | 935 | 914 | 811 | 811 |

### Harvest (H) and Release (R) of Key Species Species Groups (thousands of fish)[2,3]

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Chinook salmon | H | 89 | 96 | 110 | 116 | 117 | 110 | 71 | 89 | 78 | 85 |
| | R | 104 | 105 | 124 | 127 | 104 | 110 | 80 | 96 | 66 | 95 |
| Chum salmon | H | 14 | 23 | 24 | 17 | 14 | 18 | 12 | 22 | 11 | 21 |
| | R | 31 | 51 | 61 | 42 | 34 | 34 | 28 | 34 | 19 | 38 |
| Coho salmon | H | 497 | 537 | 560 | 695 | 395 | 506 | 403 | 418 | 350 | 386 |
| | R | 136 | 156 | 193 | 191 | 107 | 122 | 89 | 94 | 74 | 88 |
| Greenlings (lingcod) | H | 20 | 22 | 31 | 38 | 35 | 42 | 37 | 32 | 32 | 33 |
| | R | 43 | 44 | 52 | 67 | 53 | 70 | 65 | 46 | 39 | 36 |
| Pacific halibut | H | 351 | 403 | 483 | 500 | 463 | 585 | 516 | 440 | 398 | 394 |
| | R | 233 | 290 | 369 | 380 | 353 | 438 | 359 | 321 | 304 | 311 |
| Pink salmon | H | 114 | 111 | 132 | 149 | 65 | 133 | 88 | 117 | 82 | 72 |
| | R | 194 | 291 | 297 | 343 | 167 | 280 | 151 | 224 | 121 | 135 |
| Razor clam | H | 789 | 590 | 551 | 451 | 483 | 389 | 593 | 556 | 357 | 436 |
| | R | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Rockfish | H | 120 | 118 | 180 | 184 | 173 | 198 | 226 | 209 | 224 | 211 |
| | R | 135 | 132 | 227 | 199 | 165 | 178 | 171 | 149 | 151 | 122 |
| Sockeye salmon | H | 24 | 29 | 24 | 27 | 21 | 32 | 29 | 34 | 28 | 31 |
| | R | 14 | 14 | 10 | 11 | 7 | 21 | 10 | 10 | 6 | 10 |

[1] Data reported in this table is includes saltwater fishing activities only.

[2] Information reported in this table is from the Sport Fish Division of the Alaska Department of Fish and Game (ADF&G) and includes saltwater fishing activities only

[3] In this table, '(1)' = 0-999 fish.

### Alaska's State Economy (% of national total)

| | Establishments | Employees | Annual Payroll (million $) | Employee Compensation (million $) | Gross State Product (million $) | Commercial Location Quotient [1] |
|---|---|---|---|---|---|---|
| 2002 | 18,856 (0.26%) | 213,600 (0.19%) | 8,439 (0.21%) | 15,236 (0.27%) | 28,894 (0.25%) | ND[23] |
| 2010 | 19,985 (0.27%) | 254,734 (0.23%) | 12,821 (0.26%) | 23,569 (0.33%) | 47,713 (0.3%) | [2] |
| % change | 5.99% | 19.3% | 51.9% | 54.7% | 65.1% | -- |

### Seafood Sales & Processing - Nonemployer Firms (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Seafood product prep. & packaging | Firms | 25 | 34 | 26 | 17 | 22 | 33 | 31 | 32 | 31 |
| | Receipts | 2,140 | 1,864 | 1,731 | 1,315 | 1,055 | 1,837 | 1,455 | 1,699 | 1,455 |
| Seafood Sales, retail | Firms | 0 | 16 | 0 | 11 | 12 | 12 | 13 | 0 | 13 |
| | Receipts | ND[2] | 625 | ND[2] | 752 | 649 | 1,358 | 1,431 | ND[2] | 1,431 |

### Seafood Sales & Processing - Employer Establishments (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Seafood product prep. & packaging | Establishments | 105 | 109 | 113 | 124 | 113 | 114 | 122 | 121 | 119 |
| | Employees | ND[2] | 6,493 | 6,749 | 6,621 | 6,866 | 6,506 | 7,707 | 7,572 | 8,074 |
| | Payroll | ND[2] | 205,702 | 216,599 | 235,457 | 246,067 | 262,127 | 254,894 | 255,403 | 268,208 |
| Seafood sales, wholesale | Establishments | 99 | 90 | 93 | 88 | 77 | 68 | 57 | 54 | 52 |
| | Employees | 179 | 228 | 187 | 177 | 224 | 167 | 143 | ND[2] | ND[2] |
| | Payroll | 10,232 | 7,103 | 7,561 | 7,928 | 8,509 | 8,528 | 8,389 | 8,445 | 9,141 |
| Seafood sales, retail | Establishments | 12 | 8 | 6 | 11 | 7 | 7 | 9 | 10 | 10 |
| | Employees | 37 | 21 | ND[2] | 22 | ND[2] | ND[2] | 37 | 44 | ND[2] |
| | Payroll | 1,669 | 1,340 | ND[2] | 1,175 | ND[2] | ND[2] | 1,839 | 1,824 | 1,986 |

### Transport, Support, & Marine Operations - Employer Establishments (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal & Great Lakes freight transportation | Establishments | 23 | 30 | 30 | 43 | 46 | 46 | 49 | 50 | 55 |
| | Employees | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| | Payroll | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | 27,357 | 33,888 | 33,132 | ND[2] |
| Deep sea freight transportation | Establishments | 10 | 5 | 4 | 5 | 5 | 3 | 3 | 3 | 3 |
| | Employees | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| | Payroll | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| Deep sea passenger transportation | Establishments | NA[4] | NA[3] | 1 | 1 | 1 | 6 | 1 | 1 | NA[3] |
| | Employees | NA[3] | NA[3] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | NA[3] |
| | Payroll | NA[3] | NA[3] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | NA[3] |
| Marinas | Establishments | 22 | 22 | 22 | 22 | 21 | 13 | 14 | 13 | 14 |
| | Employees | 101 | ND[2] | 62 | 71 | ND[2] | 48 | 66 | 56 | ND[2] |
| | Payroll | 3,625 | ND[2] | 2,367 | 2,612 | ND[2] | 1,763 | 2,303 | 2,181 | 1,932 |
| Marine cargo handling | Establishments | 16 | 15 | 13 | 13 | 11 | 17 | 12 | 13 | 13 |
| | Employees | ND[2] | 621 | 488 | 703 | 503 | 677 | ND[2] | ND[2] | ND[2] |
| | Payroll | ND[2] | 20,443 | 21,078 | 20,827 | 22,876 | 35,345 | ND[2] | ND[2] | ND[2] |
| Navigational services to shipping | Establishments | 25 | 28 | 29 | 32 | 31 | 31 | 25 | 23 | 25 |
| | Employees | 271 | 273 | 280 | 318 | ND[2] | ND[2] | 296 | 312 | 303 |
| | Payroll | 19,251 | 20,758 | 20,676 | 20,334 | ND[2] | 25,058 | 23,233 | 25,630 | 27,543 |
| Port & harbor operations | Establishments | 4 | 2 | 3 | 2 | 2 | 2 | 7 | 8 | 9 |
| | Employees | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| | Payroll | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| Ship & boat building | Establishments | 12 | 10 | 14 | 14 | 17 | 16 | 17 | 21 | 22 |
| | Employees | ND[2] | ND[2] | 286 | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| | Payroll | ND[2] | ND[2] | 8,815 | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |

[1] The U.S. Commercial Fishing Location Quotient (CFLQ) of 1.0 represents the national baseline from which state CFLQs can be compared.
[2] ND = these data are confidential thus not disclosable
[3] ND = these data are confidential thus not disclosable
[4] NA = these data are not available

# Pacific

- California
- Oregon
- Washington

### Management Context

The Pacific Region includes California, Oregon, and Washington. Federal fisheries in this region are managed by the Pacific Fishery Management Council (PFMC) and NOAA Fisheries (NMFS) under six fishery management plans (FMPs).

**Pacific Region Fishery Management Plans**

1. Pacific coast groundfish
2. Pacific coast salmon
3. Coastal pelagic species
4. West coast highly migratory species

Of the stocks or stock complexes covered in these fishery management plans, five are currently listed as overfished: canary rockfish, Chinook salmon, cowcod, pacific ocean perch, and yelloweye rockfish. No stocks in this region are currently subject to overfishing. Interesting management techniques are employed in the Pacific Region's fisheries. The Pacific groundfish and salmon fisheries are subject to 'weak stock management' where access to the harvestable surplus of healthier stocks is often restricted to protect weaker stocks with which they co-mingle in the ocean. These weaker stocks include eight rebuilding groundfish stocks and salmon listed under the Endangered Species Act as well as other non-listed stocks that also constrain the fishery.

Salmon management is further complicated by the need to ensure equitable allocation of harvest among diverse user groups and to coordinate with other entities that have jurisdiction over other aspects of salmon management. Decades of habitat modification, hatchery practices, harvest, and growing competition for water have affected the viability of salmon stocks and made them more vulnerable to adverse environmental conditions including the prolonged drought and adverse ocean conditions experienced in recent years. Low returns of salmon to the Klamath River in 2006 and to the Sacramento River in 2008 and 2009 resulted in unprecedented closures of ocean and in-river fisheries and federal disaster relief to affected entities.

Coastal pelagic species (CPS) are highly variable, environmentally sensitive stocks that provide forage for marine mammals, birds, and fish. These species include Pacific sardine, northern anchovy, Pacific and jack mackerel, and market squid. Of these, Pacific sardine is the most commonly targeted CPS finfish and is managed via an innovative harvest control rule whereby allowable harvest varies with sea surface temperature. Because the geographic range of sardine tends to expand with abundance, harvest allocation between California and Pacific Northwest fisheries is an ongoing and dynamic issue.

Catch limits for Pacific halibut, a transboundary fish stock, are set in January by the International Pacific Halibut Commission (IPHC). This bilateral commission between the U.S. and Canada determines total allowable catch levels (TACs) for Pacific halibut that will be caught in the U.S. and Canadian Exclusive Economic Zones (EEZs)[1]. Once catch levels are determined, the PFMC develops a catch-sharing plan for tribal and non-tribal (commercial and recreational) fisheries conducted in the federal waters of California, Oregon, and Washington.

Ecolabels are another market-based management tool that is intended to encourage fishermen to adopt harvest practices that are considered sustainable by an organization such as the Marine Stewardship Council (MSC). The Oregon pink shrimp fishery, Pacific hake midwater trawl, the American Albacore Fishing Association albacore tuna fishery and the Oregon dungeness crab fishery have received certifications from the MSC.

The annual sardine harvest guideline is allocated coast-wide on a seasonal basis. Recent decreases in harvest guideline limits has contributed to the development of an intense derby fishery.

The Fishery Management Plan for Highly Migratory Species (HMS) includes tunas, billfish and pelagic sharks as manage species. The albacore surface hook-and-line fishery is by far the most economically important commercial HMS fishery, followed by the drift gillnet fishery for swordfish and thresher shark. HMS are also a very important component of the catch for West Coast recreational commercial passenger fishing vessel fleet, and the private recreational boat fishery.

Market-based management tools are used by fishery managers to reduce overcapitalization, increase the economic viability of fisheries, and promote individual accountability for harvest and harvesting practices. Limited access privilege programs (LAPPs) and other catch share programs comprise a category of such tools. LAPPs are used in various sectors of the groundfish fishery. The whiting industry voluntarily instituted the Pacific Whiting Conservation Cooperative in 1997. In 2001, the PFMC implemented the Pacific sablefish permit stacking program, whereby vessels are allowed to stack multiple vessel permits on a single vessel in order to obtain additional trip limits for that vessel. The trawl rationalization program involving individual fishing quotas (IFQs) for non-whiting groundfish and whiting trawlers, and coops for whiting mothership and catcher processor sectors was implemented in January 2011. The shore-based commercial groundfish fishery had an ex-vessel value of $66.1 million in 2009.

### Commercial Fisheries

In 2011, commercial fishermen in the Pacific Region landed roughly 1.2 billion pounds of finfish and shellfish, earning $710 million in landings revenue. Landings revenue was dominated by crab ($182 million) and other shellfish ($162 million). These species groups commanded ex-vessel prices of $2.74 and $5.78 per pound, respectively, and comprised 48% of total landings revenue, but only 8% of total landings in the Pacific Region.

Washington had the highest landings revenue in the region with $331 million in 2011, followed by California ($201 million) and Oregon ($148 million). In terms of pounds landed, California contributed the most (408 million pounds), followed by Oregon (275 million pounds) and Washington (211 million pounds).

[1] Waters off the coasts of California, Oregon, Washington, and Alaska comprise the U.S. EEZ subject to management by the IPHC

**Key Pacific Region Commercial Species**

- Albacore tuna
- Crab
- Flatfish
- Hake
- Other shellfish
- Rockfish
- Sablefish
- Salmon
- Shrimp
- Squid

*Economic Impacts*[1]

In 2011, the Pacific Region's seafood industry generated $20 billion in sales impacts in California, $1.4 billion in sales impacts in Oregon, and $8 billion in sales impacts in Washington. California also generated the largest income, value added, and employment impacts ($4.3 billion; $7.2 billion; 122,000 jobs). The smallest income impacts were generated in Oregon ($443 million) and the smallest employment impacts were also generated in Oregon (19,000 jobs).

The sector that generated the greatest employment impacts in California was the importers sector (55,000 jobs) followed by the retail sector with 48,000 jobs.In Washington, the retail sector generated the largest employment impacts and contributed 23,500 jobs to the state economy. In Oregon, the retail sector generated the larges employment impacts, 9,400 jobs, followed by the commercial harvest sector with 5,100 jobs.The importers sector contributed more to the total value added impacts than any other single sector in California and Washington. In California, the importers sector generated $4.6 billion, followed by the retail sector with $1.5 billion in value added impacts. The commercial harvester sector generated a larger portion (26%) of total state value added impacts in Oregon, than in any other state in the Pacific Region. In Washington, other than the importers sector, the seafood processors and dealers sector contributed the most to value added impacts (25%).

**Commercial Fisheries Facts**

*Landings revenue*

- On average, between 2002 and 2011, the key species or species groups accounted for 92% of total revenue, generating $446 million in the Pacific Region.
- Crab had higher landings revenues than any other species or species group, averaging $123 million in landings revenue from 2002 to 2011.
- Squid had the largest one-year increase in landings revenue over the 10 year time period, increasing 114% from $27 million in 2008 to $57 million in 2009.
- Hake had the largest one-year decrease in landings revenue over the 10 year time period, decreasing 76% from $58 million in 2008 to $14 million in 2009.

*Landings*

- Key species or species groups contributed an average of 75% annually to total landings between 2002 and 2011.
- Hake (whiting), contributed the most to landings in the region, averaging 429 million pounds from 2002 to 2011.
- Squid had the largest one-year increase in landings over the 10 year time period, increasing 141% from 85 million in 2008 pounds to 206 million pounds in 2009.
- Shrimp had the largest one-year decrease in landings over the 10 year time period, decreasing 52% from 82 million pounds in 2002 to 39 million pounds in 2003.

*Prices*

- Other shellfish had the highest average annual ex-vessel price per pound ($4.04) over the time period, followed by crab ($1.99), and sablefish ($1.91).
- Hake (whiting) had the lowest average annual ex-vessel price per pound ($0.07) over the time period, followed by squid ($0.25), and flatfish ($0.41).
- Squid had the largest one-year increase in ex-vessel price over the 10 year time period, increasing 136% from $0.11 per pound in 2002 to $0.26 in 2003.
- Salmon had the largest decrease in ex-vessel price over the 10 year time period, decreasing 48% from $1.42 per pound in 2008 to $0.74 in 2009.

*Landings Revenue*

Landings revenue in the Pacific Region totaled $710 million in 2011. This was a 81% increase (a 25% increase in real terms) from 2002 levels ($394 million) and a 28% increase (a 18% increase in real terms) relative to 2010 ($554 million). Totaling $450 million in 2011, shellfish revenue experienced a 78% increase (a 24% increase in real terms) from 2002 to 2011 and experienced a 28% increase (18% increase in real terms) from 2010 to 2011.

Hake and squid had the highest annual landings in the Pacific Region in 2011, with 496 million pounds and 268 million pounds, respectively. Although they together accounted for 65% of the total landings in the Pacific Region, they only accounted for 17% of the total landings revenue generated in 2011.

Between 2002 and 2011, the greatest changes in landings were experienced by hake (increasing 74%), squid (increasing 67%), and sablefish (increasing 63%). In the short term, between 2010 and 2011 the largest changes were experienced by shrimp (increasing 44%), hake (increasing 40%), and salmon (increasing 36%). In terms of finfish, Washington contributed the most ($99 million) followed by Oregon ($77 million), and California ($56 million). Shellfish landings revenue was also dominated by Washington, which contributed the most ($233 million) followed by California ($146 million), and Oregon ($72 million).

Crab and other shellfish had the highest landings revenue in the Pacific Region in 2011, with $182 million and $162 million, respectively. Together they accounted for 48% of the total landings revenue generated in 2011. Between 2002 and 2011, the landings revenue for crab increased 149% and increased 84%

[1]The NMFS Commercial Fishing Industry Input/Output Model was used to generate the impact estimates (see NMFS Commercial Fishing & Seafood Industry Input/Output Model, available at: `www.st.nmfs.noaa.gov/documents/commercial_seafood_impacts_2007-2009.pdf`)

for other shellfish.

From 2002 to 2011, species or species groups with large changes in landings revenue include hake (increased 289%), squid (increased 265%), and sablefish (increased 264%). Species or species groups with large changes in landings revenue between 2010 and 2011 include hake (increasing 94%), shrimp (increasing 85%), and albacore tuna (increasing 50%).

Between 2008 and 2009, hake experienced a 76% decrease in landings revenue from $58 million to $14 million (a 76% decrease in real terms). A major driver of this decrease was the 52% reduction in landings resulting from a forecast of lower stocks and rockfish bycatch restrictions. Other drivers of this decrease in revenue include international economic conditions and the conditions in fisheries which produce product closely related to hake such as walleye pollock.

*Landings*

Fishermen in the Pacific Region landed 1.2 billion pounds of finfish and shellfish in 2011. This was a 7.6% increase from the 1.1 billion pounds landed in 2002 and a 11% increase from the 1.1 billion landed in 2010. Finfish landings contributed 64% of total landings in the Pacific Region (757 million pounds) in 2011. From 2010 to 2011, finfish landings experienced a 16% increase. Over the same time period, shellfish landings experienced a 1.5% increase from 413 million pounds in 2010 to 419 million in 2011 and a 38% increase from 303 million pounds in 2002.

*Prices*

The ex-vessel prices for the Pacific Region's key species and species groups in 2011 were higher than their 10 year average for nine of the key species (five of the species in real terms). Ex-vessel prices for albacore tuna and squid experienced the biggest increases between 2002 and 2011, increasing 170% (90% in real terms) and 130% (58% in real terms), respectively. Relative to the ex-vessel prices in 2010, the Pacific Region's albacore tuna experienced the greatest increase (57.5%, 45.3% in real terms) from $1.13 in 2010 to $1.78 in 2011; salmon experienced the greatest decrease (20%, 26% in real terms) from $1.6 to $1.28.

In California, the species or species group with the largest change in ex-vessel price from 2002 to 2011 was salmon (236% increase, 133% increase in real terms) from $1.34 to $4.50. The largest change in ex-vessel price experienced in Oregon was for Albacore tuna (185% increase, 98% increase in real terms from $0.68 to $1.94 and in Washington the largest change in ex-vessel price was experienced by tuna, albacore (167% increase, 85% increase in real terms from $0.63 to $1.68).

## Recreational Fishing

In 2011, over 1.5 million recreational anglers took 6.1 million fishing trips in the Pacific Region. Over 73% of these anglers were residents of a regional coastal county. Of the total saltwater fishing trips taken, 27% of them were taken from a private or rental boat and another 62% were shore-based.

*Economic Impacts and Expenditures*[1]

The contribution of recreational fishing activities in the Pacific Region are reported in terms of economic impacts at the state level (employment, sales, income, and value added impacts) and expenditures on fishing trips and durable equipment at the regional level. Employment impacts in California were the highest in the region with over 7,700 full- and part-time employment impacts generated by recreational fishing activities in the state. Washington (4,900 jobs), and Oregon (3,100 jobs) followed in terms of employment impacts generated by recreational fishing activities.

**Key Pacific Region Recreational Species**

- Albacore and other tunas
- Barracuda, bass and bonito
- Croakers
- Flatfishes
- Greenlings
- Mackerel
- Rockfishes and scorpionfishes
- Salmon
- Sculpins
- Surfperches

In addition to employment impacts, the contribution of recreational fishing activities to Pacific Region's economy can be measured in terms of sales impacts and the contribution of these activities to gross domestic product (value added impacts). In 2011, sales impacts were also the highest in California ($1 billion in sales impacts), followed by Washington ($514 million), and Oregon ($370 million). In California, shore-based fishing trips had the highest employment impacts relative to the other fishing models; in Oregon and Washington, private boat fishing trips contributed the most to employment impacts.

Overall, these employment impacts were generated by expenditures on recreational fishing trips taken by anglers (private or rental boat, for-hire boat, or shore-based trips) or expenditures on durable equipment. Throughout the Pacific Region, most of the employment impacts in 2011 were generated by expenditures on durable equipment: 73% in Oregon, 72% in Washington, and 35% in California. In the same year value added impacts were the highest in California ($551 million in value added impacts), followed by Washington ($275 million), and Oregon ($201 million).

[1]Expenditure estimates were generated from the 2011 National Marine Recreational Fishing Expenditure Survey. Economic impacts from recreational fishing activities were generated using the NMFS Recreational Economic Impact Model (see The Economic Contribution of Marine Angler Expenditures in the United States, 2006, available at:`http://www.st.nmfs.noaa.gov/economics/publications/marine-angler-expenditures/marine-angler-2006`)

### Recreational Fishing Facts

*Participation*

- An average of 1.6 million anglers fished in Pacific Region annually from 2002 to 2011.
- In 2011, coastal county residents made up 73% of total anglers in this region. These anglers averaged 72% of total anglers annually over the 10 year time period.
- The largest annual increase in the number of coastal anglers during the 10 year time period occurred between 2005 and 2006, increasing 22%, from 1 million anglers to 1.3 million anglers.
- The largest annual decrease during the same period for coastal anglers occurred between 2003 and 2004, decreasing 19%, from 1.4 million anglers to 1.2 million anglers.

*Fishing trips*

- In the Pacific Region, an average of 6.7 million fishing trips were taken annually from 2002 to 2011.
- Private or rental boat and shore-based fishing trips accounted for 1.7 million and 3.8 million fishing trips, respectively, in 2011. Together these made up 89% of the fishing trips taken in that year.
- The largest annual increase in the number of total trips taken annually over the 10 year time period occurred between 2008 and 2009, increasing 9.1%, from 5.8 million trips to 6.3 million trips.
- The largest annual decrease during the same period in total trips taken occurred between 2003 and 2004, decreasing 20%, from 8.3 million trips to 6.7 million trips.

*Harvest and release*

- Albacore and other tunas was the most commonly caught key species or species group, averaging 99,000 fish over the 9 year time period. Of these, NA% were released rather than harvested.
- Of the ten commonly caught key species or species groups, six were released more often than harvested over this time period. The species or species group that was most commonly released was sculpins (76% released).
- Albacore and other tunas (84% harvested), followed by rockfishes and scorpionfishes (75% harvested), and salmon (73% harvested) were key species or groups that experienced the greatest proportion of harvests rather than releases.

The total saltwater fishing trip and durable equipment expenditures were $1.7 billion across the Pacific Region in 2011. Approximately 66% of these expenditures were related to durable equipment purchases. The greatest expenditures were for boat expenses ($573 million), followed by fishing tackle ($242 million), and vehicle expenses ($174 million). Fishing trip related expenditures by Pacific Region's non-residents totaled over $32 million of which the greatest portion can be attributed to for-hire-based fishing trips ($22 million). Residents of the Pacific Region spent $536 million on trip-related expenses with the majority of these expenses related to shore trips ($242 million).

*Participation*

There were 1.5 million recreational anglers who fished in the Pacific Region in 2011. This was a 28% decrease from 2002 (2 million anglers). These anglers were Pacific Region residents from either a coastal (1.1 million anglers) or non-coastal county (390,000 anglers). Over 73% of total anglers in 2011 were residents of a coastal county. Coastal county angler participation in 2011 experienced a 27% decrease relative to 2002 (1.5 million anglers) and experienced a 2.1% increase between 2010 and 2011. Non-coastal county angler participation experienced a 30% decrease relative to 2002 (559,000 anglers) and experienced a 1.6% increase relative to 2010 (384,000 anglers).

*Fishing Trips*

Recreational fishermen took 6.1 million fishing trips in the Pacific Region in 2011. This was a 25% decrease from 2002 (8.2 million trips) and was 479,000 more trips than were taken in 2010. Of the total trips taken in the Pacific Region in 2011, approximately 62% of the trips were shore based (3.8 million trips). The other most popular mode of fishing was private or rental boat based with 1.7 million trips in 2011.

*Harvest and Release*

Harvest and release estimates were not available for the Pacific Region in 2010 and 2011.

## Marine Economy[1]

The sum of the gross domestic products by state for California, Oregon, and Washington was $2.4 trillion in 2010. Employee compensation totaled $1.3 trillion and annual payroll totaled $801 billion. These economic measures experienced increases of 38%, 30%, and 26% respectively, between 2002 and 2010, and experienced a 3% increase, a 1.9% increase, and a 2% increase, respectively between 2009 and 2010. Approximately 1.1 million establishments employed 16 million full- and part-time employees across the region in 2010. This was a 4.1% increase in establishment numbers and a 1% decrease in employee numbers from 2002 to 2010. In 2010, California had the highest establishment and employee numbers, annual payroll, employee compensation, and gross state product levels in the Pacific Region. California's approximately 850,000 establishments employed approximately 13 million employees in 2010. Gross state product in California was $1.9 trillion, followed by Washington ($340 billion) and Oregon ($185 billion).

In 2010, the commercial fishing location quotient (CFLQ) for Washington was the highest in the region at 12.2. This was an 5.4% decrease from 2002 and a 6.4% decrease from 2009. Washington's CFLQ indicates that the level of employment in commercial fishing-related industries in this state is approximately 12 times higher than the level of employment in these industries nationwide. The 2010 CFLQ in Oregon was 3.39 (a 0.9% increase from 2002 and a 6.4% decrease from 2009), while the 2010 CFLQ in California was 0.66 (a 27% decrease from 2002 and a 5.7% decrease from 2009).

*Seafood Sales and Processing*

[1] Information for 2010 is reported in this section; 2011 data were not available for this report.

In 2010, there were 202 nonemployer firms engaged in seafood product preparation and packaging across the Pacific Region. In 2010, 69% of these firms were located in California. Region-wide, annual receipts totaled $18 million in 2010. Annual receipt totals experienced a 87% increase in Washington over the same time period. In contrast to the increase in nonemployer firms region-wide, the number of employer establishments engaged in seafood product preparation and packaging decreased 14% from 188 in 2002 to 162 in 2010. Approximately 57% of these establishments were located in Washington. The numbers of employees in these industries also decreased across the region, decreasing 27% to approximately 7,900 full- and part-time workers in 2010, despite an annual payroll increase of 5.9% to $344 million.

There were 441 seafood wholesale establishments in 2010. The number of employees was not available at the region level. From 2002 to 2010, the number of seafood wholesale establishments decreased 19% across the Pacific Region.

Nonemployer firms engaged in seafood retail in the Pacific Region totaled 259 in 2010, a 25% increase relative to 2002. Of these firms, 81% were located in California. At the state level, these firms increased 10% in Washington and increased 27% in California between 2002 and 2010. Oregon experienced a 23% increase. Annual receipts from the nonemployer retail sector in the region totaled $24 million in 2010 a 10% increase from 2002 (a 17% decrease in real terms) and a 17% increase from 2009 (a 12% increase in real terms).

Employer establishments engaged in seafood retail decreased 12% from 2002 to 2010, totaling 226 in 2010. These establishments employed 1,429 workers. Over 70% of these establishments were located in California. Region-wide, the numbers of employees in the seafood retail sector increased 5.7% between 2002 and 2010. Across the states within the region, the largest change occurred in Oregon(26% increase). Annual payroll also increased across the Pacific Region, a 39% increase region-wide (4.8% increase in real terms), to $35 million in 2010.

*Transport, Support, and Marine Operations*

For sectors in which there were data available for all states in the region, the ship and boat building employed more people than any other industry in this sector, employing approximately 16,000 people in 2010. This industry also had the highest annual payroll in the region totaling $775 million. Marinas had the highest number of establishments (417), followed by the ship and boat building industries with 303 establishments and the navigational services to shipping industries with 138 establishments. Of all of the industries, port and harbor operations had the fewest number of establishments (33).

In California, industries with large changes in establishment numbers, employees, or annual payroll from 2009 to 2010 were: deep sea passenger transportation (40% decrease in establishments), port and harbor operations (40% increase in payroll), deep sea freight transportation (32% increase in establishments) and port and harbor operations (26% increase in establishments). In Oregon, large changes were seen for port and harbor operations (200% increase in establishments), ship and boat building (54% decrease in payroll), ship and boat building (48% decrease in employees) and navigational services to shipping (24% decrease in establishments). In Washington, large changes were seen in the port and harbor operations (37% decrease in employees), deep sea freight transportation (31% decrease in employees), port and harbor operations (28% decrease in payroll) and coastal and Great Lakes freight transportation (25% increase in employees).

### 2011 Economic Impacts of the Pacific Region Seafood Industry (thousands of dollars)

| | With Imports | | | Without Imports | | |
|---|---|---|---|---|---|---|
| | Jobs | Sales | Value Added | Jobs | Sales | Value Added |
| California | 122,074 | 20,053,619 | 7,168,389 | 15,330 | 1,141,093 | 590,691 |
| Oregon | 18,562 | 1,351,116 | 633,483 | 15,183 | 798,937 | 442,848 |
| Washington | 67,007 | 8,026,068 | 3,297,368 | 27,022 | 1,772,689 | 992,738 |

### Total Landings Revenue and Landings Revenue of Key Species/Species Groups (thousands of dollars)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total revenue | 393,571 | 423,244 | 440,474 | 414,584 | 471,788 | 459,772 | 500,447 | 491,183 | 553,909 | 710,495 |
| Finfish & other | 141,259 | 156,596 | 178,693 | 166,922 | 176,425 | 176,104 | 215,784 | 168,495 | 202,527 | 260,608 |
| Shellfish | 252,312 | 266,647 | 261,781 | 247,662 | 295,363 | 283,668 | 284,663 | 322,688 | 351,383 | 449,888 |
| Albacore tuna | 14,219 | 24,366 | 27,242 | 20,574 | 23,767 | 21,612 | 28,845 | 27,541 | 28,780 | 43,308 |
| Crab | 73,073 | 130,952 | 115,365 | 97,127 | 143,758 | 121,136 | 107,107 | 123,865 | 132,843 | 182,076 |
| Flatfish | 12,004 | 13,441 | 12,741 | 13,816 | 12,974 | 14,462 | 15,738 | 14,155 | 10,511 | 11,225 |
| Hake (whiting) | 13,576 | 17,150 | 21,819 | 29,139 | 34,425 | 32,603 | 58,492 | 14,104 | 27,316 | 52,869 |
| Other shellfish | 88,164 | 89,222 | 102,423 | 107,438 | 116,161 | 120,569 | 129,947 | 131,593 | 129,561 | 161,820 |
| Rockfish | 11,365 | 7,803 | 6,832 | 6,559 | 6,848 | 7,541 | 9,257 | 8,974 | 9,226 | 9,445 |
| Sablefish | 12,323 | 18,817 | 17,230 | 20,366 | 22,991 | 20,984 | 27,279 | 34,481 | 35,977 | 44,908 |
| Salmon | 26,170 | 30,773 | 47,676 | 37,188 | 34,306 | 33,865 | 26,992 | 24,986 | 48,986 | 53,424 |
| Shrimp | 82,634 | 28,175 | 30,586 | 15,706 | 12,433 | 17,298 | 25,132 | 16,594 | 21,941 | 40,662 |
| Squid | 18,260 | 25,340 | 19,748 | 31,516 | 26,998 | 29,169 | 26,585 | 56,928 | 71,173 | 66,578 |

### Total Landings and Landings of Key Species/Species Groups (thousands of pounds)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total landings | 1,092,377 | 993,985 | 1,138,763 | 1,301,649 | 1,169,906 | 1,109,222 | 1,091,673 | 897,222 | 1,063,491 | 1,175,506 |
| Finfish & other | 789,574 | 756,538 | 932,610 | 1,070,529 | 935,523 | 902,887 | 906,773 | 582,120 | 650,822 | 756,705 |
| Shellfish | 302,803 | 237,447 | 206,153 | 231,120 | 234,383 | 206,335 | 184,900 | 315,102 | 412,669 | 418,801 |
| Albacore tuna | 21,996 | 36,577 | 31,764 | 19,649 | 28,117 | 25,483 | 24,507 | 27,055 | 25,477 | 24,264 |
| Crab | 42,441 | 81,892 | 69,247 | 61,849 | 85,301 | 51,888 | 45,075 | 59,158 | 61,668 | 66,516 |
| Flatfish | 29,365 | 31,849 | 29,895 | 31,495 | 27,689 | 33,502 | 37,409 | 40,599 | 33,281 | 25,557 |
| Hake (whiting) | 285,547 | 309,300 | 474,460 | 569,273 | 558,078 | 454,533 | 531,277 | 253,053 | 355,216 | 496,363 |
| Other shellfish | 31,813 | 27,884 | 31,275 | 30,907 | 30,611 | 29,543 | 28,557 | 28,911 | 26,159 | 27,974 |
| Rockfish | 13,346 | 9,275 | 8,057 | 7,406 | 6,633 | 7,447 | 9,469 | 10,458 | 11,038 | 9,910 |
| Sablefish | 8,677 | 12,204 | 12,905 | 13,742 | 13,718 | 11,630 | 12,978 | 15,822 | 15,055 | 14,145 |
| Salmon | 38,077 | 39,234 | 40,609 | 27,249 | 29,172 | 24,600 | 19,040 | 33,742 | 30,693 | 41,792 |
| Shrimp | 81,909 | 38,997 | 29,422 | 26,069 | 20,290 | 26,497 | 35,799 | 33,456 | 46,191 | 66,687 |
| Squid | 160,669 | 99,115 | 88,215 | 123,090 | 108,561 | 109,464 | 85,200 | 205,643 | 288,678 | 268,078 |

### Average Annual Price of Key Species/Species Groups (dollars per pound)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Albacore tuna | 0.65 | 0.67 | 0.86 | 1.05 | 0.85 | 0.85 | 1.18 | 1.02 | 1.13 | 1.78 |
| Crab | 1.72 | 1.60 | 1.67 | 1.57 | 1.69 | 2.33 | 2.38 | 2.09 | 2.15 | 2.74 |
| Flatfish | 0.41 | 0.42 | 0.43 | 0.44 | 0.47 | 0.43 | 0.42 | 0.35 | 0.32 | 0.44 |
| Hake (whiting) | 0.05 | 0.06 | 0.05 | 0.05 | 0.06 | 0.07 | 0.11 | 0.06 | 0.08 | 0.11 |
| Other shellfish | 2.77 | 3.20 | 3.27 | 3.48 | 3.79 | 4.08 | 4.55 | 4.55 | 4.95 | 5.78 |
| Rockfish | 0.85 | 0.84 | 0.85 | 0.89 | 1.03 | 1.01 | 0.98 | 0.86 | 0.84 | 0.95 |
| Sablefish | 1.42 | 1.54 | 1.34 | 1.48 | 1.68 | 1.80 | 2.10 | 2.18 | 2.39 | 3.17 |
| Salmon | 0.69 | 0.78 | 1.17 | 1.36 | 1.18 | 1.38 | 1.42 | 0.74 | 1.60 | 1.28 |
| Shrimp | 1.01 | 0.72 | 1.04 | 0.60 | 0.61 | 0.65 | 0.70 | 0.50 | 0.48 | 0.61 |
| Squid | 0.11 | 0.26 | 0.22 | 0.26 | 0.25 | 0.27 | 0.31 | 0.28 | 0.25 | 0.25 |

### 2011 Economic Impacts of Recreational Fishing Expenditures (thousands of dollars)

| | Trips | Jobs | Sales | Income | Value Added |
|---|---|---|---|---|---|
| California | 4,288,000 | 7,703 | 1,031,068 | 349,937 | 551,328 |
| Oregon | 655,000 | 3,147 | 370,032 | 136,881 | 200,835 |
| Washington | 1,162,000 | 4,939 | 514,088 | 175,209 | 275,425 |

### 2011 Angler Trip & Durable Expenditures (thousands of dollars)

| Fishing Mode | Trip Expenditures | | Equipment | Durable Expenditures |
|---|---|---|---|---|
| | Non-Residents | Residents | Fishing Tackle | 241,763 |
| For-Hire | 22,458 | 116,120 | Other Equipment | 110,215 |
| Private Boat | 5,984 | 177,467 | Boat Expenses | 573,050 |
| Shore | 3,909 | 242,265 | Vehicle Expenses | 173,539 |
| *Total Trip Expenditures* | 32,351 | 535,850 | Second Home Expenses | 6,918 |
| | | | *Total Durable Equipment Expenditures* | 1,105,486 |
| **Total State Trip and Durable Equipment Expenditures** | | | | 1,673,687 |

### Recreational Anglers by Residential Area (thousands of anglers)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal | 1,463 | 1,437 | 1,168 | 1,028 | 1,257 | 1,184 | 1,065 | 1,136 | 1,047 | 1,069 |
| Non-Coastal | 559 | 538 | 429 | 409 | 481 | 379 | 385 | 638 | 384 | 390 |
| Out-of-State | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| **Total Anglers** | 2,022 | 1,975 | 1,597 | 1,437 | 1,738 | 1,563 | 1,450 | 1,774 | 1,431 | 1,459 |

### Recreational Fishing Effort by Mode (thousands of angler-trips)[2]

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| For-Hire | 695 | 619 | 649 | 624 | 635 | 605 | 514 | 492 | 455 | 654 |
| Private Boat | 3,990 | 4,247 | 1,752 | 1,849 | 1,761 | 1,828 | 1,421 | 1,471 | 1,432 | 1,659 |
| Shore | 3,507 | 3,445 | 4,255 | 3,962 | 4,548 | 3,818 | 3,846 | 4,345 | 3,739 | 3,792 |
| **Total Trips** | 8,192 | 8,311 | 6,656 | 6,435 | 6,944 | 6,251 | 5,781 | 6,308 | 5,626 | 6,105 |

### Harvest (H) and Release (R) of Key Species Species Groups (thousands of fish)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Albacore & other tunas | H | 116 | 168 | 80 | 23 | 45 | 106 | 51 | 80 | NA | NA |
| | R | 6 | 83 | 10 | 2 | 4 | 7 | 0 | 13 | NA | NA |
| Barracuda, bass & bonito | H | 1,965 | 1,888 | 2,126 | 1,015 | 668 | 537 | 434 | 412 | NA | NA |
| | R | 4,427 | 3,727 | 2,597 | 2,011 | 1,660 | 1,407 | 1,093 | 1,211 | NA | NA |
| Croakers | H | 1,513 | 758 | 619 | 572 | 456 | 427 | 321 | 427 | NA | NA |
| | R | 1,016 | 871 | 660 | 618 | 553 | 631 | 272 | 362 | NA | NA |
| Flatfishes | H | 1,209 | 680 | 499 | 560 | 325 | 260 | 344 | 329 | NA | NA |
| | R | 2,061 | 948 | 343 | 513 | 520 | 338 | 361 | 297 | NA | NA |
| Greenlings | H | 454 | 512 | 210 | 270 | 236 | 194 | 171 | 190 | NA | NA |
| | R | 958 | 858 | 342 | 281 | 207 | 151 | 139 | 192 | NA | NA |
| Mackerel | H | 800 | 918 | 945 | 1,023 | 1,158 | 823 | 940 | 753 | NA | NA |
| | R | 1,730 | 2,011 | 1,715 | 1,872 | 3,287 | 1,209 | 1,765 | 1,267 | NA | NA |
| Rockfishes & scorpionfishes | H | 2,736 | 3,624 | 2,413 | 3,433 | 2,504 | 2,256 | 1,842 | 1,990 | NA | NA |
| | R | 930 | 1,664 | 750 | 1,148 | 730 | 513 | 465 | 687 | NA | NA |
| Salmon | H | 598 | 853 | 744 | 494 | 275 | 505 | 131 | 916 | NA | NA |
| | R | 244 | 314 | 386 | 171 | 127 | 177 | 45 | 235 | NA | NA |
| Sculpins | H | 116 | 110 | 78 | 78 | 61 | 54 | 65 | 64 | NA | NA |
| | R | 403 | 291 | 240 | 232 | 216 | 202 | 222 | 194 | NA | NA |
| Surfperches | H | 829 | 1,143 | 1,301 | 949 | 1,168 | 865 | 836 | 756 | NA | NA |
| | R | 728 | 1,175 | 1,556 | 1,237 | 1,670 | 856 | 812 | 701 | NA | NA |

[1] NA = data are not available because out-of-state resident information is collected for individual states but whether an angler is a resident of a region is not specified

[2] Due to changes in data collection methods, the Pacific Region's effort (number of trips) and catch (number of fish harvested or released) estimates for 2001-2003 are not comparable to the 2004-2009 estimates.

### 2011 Economic Impacts of the California Seafood Industry (thousands of dollars)

| | With Imports | | | Without Imports | | |
|---|---|---|---|---|---|---|
| | Jobs | Sales | Value Added | Jobs | Sales | Value Added |
| **Total Impacts** | 122,074 | 20,053,619 | 7,168,389 | 15,330 | 1,141,093 | 590,691 |
| Commercial Harvesters | 4,253 | 405,059 | 204,131 | 4,253 | 405,059 | 204,131 |
| Seafood Processors & Dealers | 4,597 | 472,985 | 232,721 | 1,749 | 181,719 | 89,410 |
| Importers | 54,519 | 14,997,138 | 4,571,784 | 0 | 0 | 0 |
| Seafood Wholesalers & Distributors | 10,793 | 1,545,962 | 700,537 | 601 | 86,121 | 39,025 |
| Retail | 47,912 | 2,632,475 | 1,459,216 | 8,727 | 468,194 | 258,125 |

### Total Landings Revenue and Landings Revenue of Key Species/Species Groups (thousands of dollars)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total revenue | 111,923 | 136,152 | 140,615 | 116,084 | 129,907 | 127,580 | 120,861 | 150,752 | 176,252 | 201,269 |
| Finfish & other | 59,888 | 56,402 | 58,798 | 46,640 | 43,164 | 50,363 | 46,968 | 46,682 | 44,291 | 55,736 |
| Shellfish | 52,035 | 79,750 | 81,816 | 69,444 | 86,743 | 77,217 | 73,893 | 104,070 | 131,960 | 145,533 |
| Crab | 15,074 | 37,455 | 43,381 | 19,653 | 46,483 | 28,626 | 24,227 | 32,508 | 43,016 | 53,753 |
| Pacific sardine | 5,848 | 2,874 | 3,957 | 3,150 | 5,100 | 8,218 | 7,575 | 5,544 | 4,366 | 4,398 |
| Rockfish | 6,560 | 4,761 | 4,447 | 4,145 | 4,630 | 4,924 | 5,781 | 5,330 | 5,453 | 5,644 |
| Sablefish | 3,508 | 4,721 | 3,724 | 4,295 | 4,892 | 4,873 | 6,224 | 9,765 | 11,491 | 15,121 |
| Salmon | 7,611 | 12,153 | 17,770 | 12,804 | 5,261 | 7,835 | 6 | ND[1] | 1,215 | 5,067 |
| Sea urchins | 10,411 | 7,906 | 7,300 | 6,156 | 5,145 | 5,400 | 6,550 | 7,806 | 7,413 | 8,101 |
| Shrimp | 5,901 | 3,520 | 3,783 | 4,338 | 4,213 | 4,064 | 5,696 | 5,462 | 4,951 | 8,626 |
| Spiny lobster | 4,784 | 5,278 | 6,160 | 6,039 | 8,111 | 6,916 | 8,008 | 7,934 | 11,386 | 12,971 |
| Squid | 18,259 | 25,333 | 19,740 | 31,467 | 26,959 | 29,131 | 26,477 | 56,877 | 71,165 | 66,567 |
| Swordfish | 6,401 | 7,850 | 4,834 | 1,896 | 2,695 | 3,127 | 2,365 | 1,932 | 2,203 | 3,348 |

### Total Landings and Landings of Key Species/Species Groups (thousands of pounds)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total landings | 499,676 | 382,146 | 379,591 | 442,353 | 341,661 | 384,826 | 323,884 | 374,795 | 437,847 | 408,181 |
| Finfish & other | 321,539 | 252,764 | 257,944 | 301,993 | 203,107 | 258,625 | 223,912 | 147,934 | 120,103 | 108,106 |
| Shellfish | 178,138 | 129,381 | 121,647 | 140,360 | 138,554 | 126,200 | 99,972 | 226,861 | 317,744 | 300,075 |
| Crab | 8,609 | 23,922 | 27,016 | 12,028 | 27,391 | 12,393 | 9,845 | 16,660 | 23,352 | 22,202 |
| Pacific sardine | 128,584 | 76,528 | 97,509 | 76,324 | 102,683 | 178,480 | 126,945 | 82,842 | 73,814 | 60,993 |
| Rockfish | 5,991 | 4,399 | 3,843 | 3,181 | 3,252 | 3,136 | 3,933 | 3,984 | 3,949 | 3,450 |
| Sablefish | 2,893 | 3,636 | 3,158 | 3,645 | 3,617 | 3,240 | 3,507 | 5,089 | 5,501 | 5,646 |
| Salmon | 5,661 | 7,328 | 7,113 | 4,962 | 1,184 | 1,743 | 1 | ND[2] | 255 | 1,127 |
| Sea urchins | 14,176 | 11,107 | 12,219 | 11,304 | 10,664 | 11,131 | 10,283 | 12,205 | 11,230 | 11,464 |
| Shrimp | 5,867 | 3,498 | 3,520 | 2,944 | 1,197 | 2,015 | 3,011 | 3,596 | 4,522 | 8,217 |
| Spiny lobster | 702 | 736 | 860 | 761 | 886 | 663 | 741 | 706 | 716 | 751 |
| Squid | 160,665 | 99,088 | 88,167 | 122,887 | 108,410 | 109,150 | 84,071 | 205,278 | 288,497 | 267,985 |
| Swordfish | 3,803 | 4,706 | 2,613 | 653 | 1,187 | 1,210 | 1,168 | 898 | 815 | 1,364 |

### Average Annual Price of Key Species/Species Groups (dollars per pound)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Crab | 1.75 | 1.57 | 1.61 | 1.63 | 1.70 | 2.31 | 2.46 | 1.95 | 1.84 | 2.42 |
| Pacific sardine | 0.05 | 0.04 | 0.04 | 0.04 | 0.05 | 0.05 | 0.06 | 0.07 | 0.06 | 0.07 |
| Rockfish | 1.10 | 1.08 | 1.16 | 1.30 | 1.42 | 1.57 | 1.47 | 1.34 | 1.38 | 1.64 |
| Sablefish | 1.21 | 1.30 | 1.18 | 1.18 | 1.35 | 1.50 | 1.77 | 1.92 | 2.09 | 2.68 |
| Salmon | 1.34 | 1.66 | 2.50 | 2.58 | 4.44 | 4.50 | 4.16 | ND[2] | 4.76 | 4.50 |
| Sea urchins | 0.73 | 0.71 | 0.60 | 0.54 | 0.48 | 0.49 | 0.64 | 0.64 | 0.66 | 0.71 |
| Shrimp | 1.01 | 1.01 | 1.07 | 1.47 | 3.52 | 2.02 | 1.89 | 1.52 | 1.09 | 1.05 |
| Spiny lobster | 6.81 | 7.18 | 7.16 | 7.93 | 9.15 | 10.44 | 10.80 | 11.24 | 15.91 | 17.27 |
| Squid | 0.11 | 0.26 | 0.22 | 0.26 | 0.25 | 0.27 | 0.31 | 0.28 | 0.25 | 0.25 |
| Swordfish | 1.68 | 1.67 | 1.85 | 2.90 | 2.27 | 2.58 | 2.03 | 2.15 | 2.70 | 2.45 |

[1] ND = these data are confidential thus not disclosable

### 2011 Economic Impacts of Recreational Fishing Expenditures (thousands of dollars)

| | Jobs | Sales | Income | Value Added |
|---|---|---|---|---|
| Trip Impacts by Fishing Mode: | | | | |
| For-Hire | 1,672 | 181,394 | 60,457 | 103,522 |
| Private Boat | 783 | 104,944 | 32,639 | 55,982 |
| Shore | 2,527 | 291,961 | 96,312 | 159,266 |
| Total Durable Equipment Impacts | 2,721 | 452,768 | 160,528 | 232,558 |
| **Total State Trip and Durable Equipment Economic Impacts** | 7,703 | 1,031,068 | 349,937 | 551,328 |

### 2011 Angler Trip & Durable Expenditures (thousands of dollars)

| Fishing Mode | Trip Expenditures | | Equipment | Durable Expenditures |
|---|---|---|---|---|
| | Non-Residents | Residents | Fishing Tackle | 137,287 |
| For-Hire | 19,794 | 93,189 | Other Equipment | 62,381 |
| Private Boat | 1,668 | 73,517 | Boat Expenses | 92,305 |
| Shore | 1,963 | 211,448 | Vehicle Expenses | 82,310 |
| *Total Trip Expenditures* | 23,425 | 378,153 | Second Home Expenses | 5,046 |
| | | | *Total Durable Equipment Expenditures* | 379,330 |
| **Total State Trip and Durable Equipment Expenditures** | | | | 780,908 |

### Recreational Anglers by Residential Area (thousands of anglers)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal | 1110 | 1113 | 865 | 740 | 991 | 878 | 819 | 888 | 803 | 714 |
| Non-Coastal | 379 | 378 | 280 | 263 | 335 | 226 | 246 | 490 | 241 | 238 |
| Out of State | 111 | 115 | 98 | 79 | 109 | 65 | 83 | 71 | 69 | 93 |
| **Total Anglers** | 1600 | 1606 | 1243 | 1082 | 1435 | 1168 | 1148 | 1449 | 1113 | 1045 |

### Recreational Fishing Effort by Mode (thousands of angler-trips)[1]

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| For-Hire | 569 | 483 | 521 | 504 | 522 | 489 | 424 | 385 | 357 | 560 |
| Private | 2,905 | 3,117 | 708 | 902 | 896 | 768 | 640 | 676 | 655 | 682 |
| Shore | 2,501 | 2,699 | 3,509 | 3,216 | 3,802 | 3,072 | 3,100 | 3,599 | 2,993 | 3,046 |
| **Total Trips** | 5,975 | 6,299 | 4,738 | 4,622 | 5,220 | 4,329 | 4,164 | 4,660 | 4,005 | 4,288 |

### Harvest (H) and Release (R) of Key Species Species Groups (thousands of fish)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Albacore & other tunas | H | 107 | 146 | 49 | 6 | 9 | 22 | 5 | 13 | NA | NA |
| | R | 6 | 83 | 10 | 2 | 3 | 7 | (1) | 13 | NA | NA |
| Barracuda, bass & bonito [2] | H | 1,965 | 1,888 | 2,126 | 1,015 | 668 | 537 | 434 | 412 | NA | NA |
| | R | 4,427 | 3,727 | 2,597 | 2,011 | 1,660 | 1,407 | 1,093 | 1,211 | NA | NA |
| Croakers | H | 1,513 | 758 | 619 | 572 | 456 | 427 | 321 | 427 | NA | NA |
| | R | 1,016 | 871 | 660 | 618 | 553 | 631 | 272 | 362 | NA | NA |
| Flatfishes | H | 962 | 603 | 410 | 478 | 241 | 187 | 276 | 258 | NA | NA |
| | R | 1,844 | 850 | 295 | 465 | 471 | 292 | 313 | 241 | NA | NA |
| Greenlings | H | 215 | 357 | 72 | 125 | 104 | 69 | 48 | 64 | NA | NA |
| | R | 641 | 717 | 239 | 179 | 113 | 67 | 53 | 83 | NA | NA |
| Mackerel | H | 800 | 918 | 945 | 1,023 | 1,158 | 823 | 940 | 753 | NA | NA |
| | R | 1,730 | 2,011 | 1,715 | 1,872 | 3,287 | 1,209 | 1,765 | 1,267 | NA | NA |
| Rockfishes & scorpionfishes | H | 2,116 | 3,035 | 1,778 | 2,725 | 1,891 | 1,674 | 1,318 | 1,383 | NA | NA |
| | R | 844 | 1,621 | 701 | 1,058 | 668 | 456 | 402 | 605 | NA | NA |
| Salmon | H | 201 | 109 | 256 | 167 | 119 | 59 | (1) | 1 | NA | NA |
| | R | 40 | 39 | 103 | 71 | 74 | 36 | (1) | (1) | NA | NA |
| Sculpins | H | 60 | 70 | 41 | 39 | 25 | 19 | 29 | 27 | NA | NA |
| | R | 184 | 140 | 98 | 87 | 74 | 58 | 78 | 50 | NA | NA |
| Surfperches | H | 586 | 878 | 1,046 | 694 | 913 | 610 | 581 | 501 | NA | NA |
| | R | 563 | 1,016 | 1,402 | 1,083 | 1,516 | 702 | 658 | 546 | NA | NA |

[1] Due to changes in data collection methods, California's participation (number of anglers), effort(number of trips), and catch (number of fish harvested or released) estimates for 2001-2003 are not comparable to 2004-2009 estimates.

[2] This species may not be equivalent to species with similar names listed in the commercial tables.

### California's State Economy (% of national total)

| | Establishments | Employees | Annual Payroll (million $) | Employee Compensation (million $) | Gross State Product (million $) | Commercial Location Quotient [1] |
|---|---|---|---|---|---|---|
| 2002 | 820,997 (11%) | 12,856,426 (11%) | 510,841 (13%) | 786,803 (13%) | 1,387,213 (13%) | 0.9 |
| 2010 | 849,875 (11%) | 12,536,402 (11%) | 635,620 (13%) | 1,010,410 (13%) | 1,877,568 (13%) | 0.66 |
| % change | 3.52% | -2.49% | 24.4% | 28.4% | 35.3% | -18.9% |

### Seafood Sales & Processing - Nonemployer Firms (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Seafood product prep. & packaging | Firms | 70 | 77 | 98 | 88 | 91 | 121 | 139 | 156 | 139 |
| | Receipts | 9,123 | 9,858 | 14,312 | 10,207 | 8,298 | 10,842 | 11,460 | 10,432 | 11,460 |
| Seafood Sales, retail | Firms | 165 | 192 | 193 | 166 | 163 | 222 | 210 | 200 | 210 |
| | Receipts | 18,225 | 19,771 | 19,092 | 16,892 | 19,875 | 19,703 | 19,892 | 17,047 | 19,892 |

### Seafood Sales & Processing - Employer Establishments (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Seafood product prep. & packaging | Establishments | 63 | 60 | 55 | 48 | 47 | 49 | 45 | 47 | 48 |
| | Employees | 3,357 | 2,896 | 2,931 | 2,963 | 2,592 | 2,229 | 2,024 | 2,167 | 1,820 |
| | Payroll | 82,116 | 74,637 | 72,178 | 92,642 | 78,065 | 75,886 | 65,215 | 69,529 | 62,480 |
| Seafood sales, wholesale | Establishments | 334 | 269 | 263 | 258 | 252 | 300 | 278 | 289 | 314 |
| | Employees | 4,539 | 3,536 | 3,744 | 3,925 | 4,063 | 4,429 | 3,321 | 3,183 | 3,223 |
| | Payroll | 151,789 | 115,669 | 124,657 | 134,576 | 144,758 | 159,672 | 132,139 | 128,813 | 137,810 |
| Seafood sales, retail | Establishments | 186 | 175 | 169 | 180 | 184 | 182 | 161 | 153 | 158 |
| | Employees | 988 | 968 | 945 | 999 | 1,031 | 1,004 | 932 | 976 | 985 |
| | Payroll | 16,775 | 19,919 | 16,686 | 18,832 | 19,900 | 21,224 | 20,585 | 21,785 | 22,718 |

### Transport, Support, & Marine Operations - Employer Establishments (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal & Great Lakes freight transportation | Establishments | 31 | 22 | 20 | 26 | 22 | 29 | 28 | 30 | 25 |
| | Employees | 1,776 | 1,341 | ND[2] | 1,346 | ND[2] | ND[2] | ND[2] | ND[2] | 554 |
| | Payroll | 132,432 | 117,982 | ND[2] | 129,262 | ND[2] | ND[2] | ND[2] | ND[2] | 30,431 |
| Deep sea freight transportation | Establishments | 44 | 51 | 50 | 54 | 54 | 51 | 43 | 41 | 54 |
| | Employees | ND[2] | 902 | 901 | ND[2] | 957 | 1,643 | ND[2] | ND[2] | 2,562 |
| | Payroll | ND[2] | 62,417 | 69,815 | ND[2] | 84,199 | 116,628 | ND[2] | ND[2] | 236,235 |
| Deep sea passenger transportation | Establishments | 11 | 14 | 15 | 15 | 16 | 13 | 5 | 5 | 3 |
| | Employees | ND[2] | ND[2] | ND[2] | ND[2] | 1,552 | ND[2] | ND[2] | ND[2] | ND[2] |
| | Payroll | ND[2] | ND[2] | ND[2] | ND[2] | 72,119 | ND[2] | ND[2] | ND[2] | ND[2] |
| Marinas | Establishments | 248 | 263 | 271 | 263 | 268 | 276 | 277 | 276 | 270 |
| | Employees | 1,851 | 2,485 | 2,476 | 2,426 | 2,457 | 2,680 | 2,652 | 2,514 | 2,390 |
| | Payroll | 57,393 | 70,640 | 73,338 | 71,318 | 74,778 | 80,216 | 85,315 | 78,890 | 80,631 |
| Marine cargo handling | Establishments | 64 | 56 | 54 | 54 | 52 | 56 | 61 | 62 | 63 |
| | Employees | 15,274 | 15,557 | 20,456 | 19,303 | 20,975 | 22,395 | 22,086 | 17,428 | 18,449 |
| | Payroll | 1,000,809 | 1,040,515 | 1,179,221 | 1,273,698 | 1,448,623 | 1,484,308 | 1,453,281 | 1,211,572 | 1,273,268 |
| Navigational services to shipping | Establishments | 30 | 35 | 38 | 37 | 36 | 39 | 40 | 39 | 41 |
| | Employees | 476 | 850 | ND[2] | ND[2] | 817 | 858 | 815 | 804 | 765 |
| | Payroll | 28,197 | 53,162 | ND[2] | ND[2] | 63,893 | 63,610 | 65,225 | 61,720 | 58,899 |
| Port & harbor operations | Establishments | 23 | 19 | 20 | 20 | 20 | 18 | 17 | 19 | 21 |
| | Employees | 139 | 417 | ND[2] | ND[2] | 582 | 443 | 256 | 345 | 435 |
| | Payroll | 7,668 | 23,110 | ND[2] | ND[2] | 32,523 | 30,001 | 23,316 | 26,889 | 37,560 |
| Ship & boat building | Establishments | 145 | 141 | 143 | 141 | 132 | 136 | 136 | 123 | 117 |
| | Employees | 7,782 | 8,574 | 8,865 | 10,132 | 9,801 | 9,250 | 11,630 | 10,483 | 9,720 |
| | Payroll | 315,090 | 314,706 | 354,404 | 410,446 | 453,255 | 433,846 | 477,300 | 460,239 | 448,338 |

[1] The U.S. Commercial Fishing Location Quotient (CFLQ) of 1.0 represents the national baseline from which state CFLQs can be compared.
[2] ND = these data are confidential thus not disclosable

### 2011 Economic Impacts of the Oregon Seafood Industry (thousands of dollars)

| | With Imports | | | Without Imports | | |
|---|---|---|---|---|---|---|
| | Jobs | Sales | Value Added | Jobs | Sales | Value Added |
| **Total Impacts** | 18,562 | 1,351,116 | 633,483 | 15,183 | 798,937 | 442,848 |
| Commercial Harvesters | 5,110 | 279,483 | 162,154 | 5,110 | 279,483 | 162,154 |
| Seafood Processors & Dealers | 1,702 | 146,243 | 73,385 | 1,550 | 133,367 | 66,923 |
| Importers | 1,636 | 450,066 | 137,200 | 0 | 0 | 0 |
| Seafood Wholesalers & Distributors | 716 | 86,752 | 39,472 | 431 | 52,217 | 23,759 |
| Retail | 9,399 | 388,572 | 221,272 | 8,093 | 333,870 | 190,011 |

### Total Landings Revenue and Landings Revenue of Key Species/Species Groups (thousands of dollars)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total revenue | 68,292 | 86,779 | 101,022 | 88,196 | 106,093 | 97,298 | 103,042 | 104,706 | 104,719 | 148,337 |
| Finfish & other | 32,073 | 40,889 | 49,634 | 53,192 | 46,326 | 47,589 | 56,912 | 52,749 | 58,730 | 76,698 |
| Shellfish | 36,218 | 45,890 | 51,388 | 35,005 | 59,767 | 49,709 | 46,130 | 51,957 | 45,990 | 71,639 |
| Albacore tuna | 2,952 | 6,169 | 9,145 | 8,815 | 8,067 | 9,468 | 10,666 | 10,191 | 12,425 | 18,748 |
| Crab | 20,767 | 37,122 | 42,960 | 26,603 | 53,810 | 38,208 | 29,168 | 42,413 | 32,757 | 44,702 |
| Flatfish | 5,156 | 6,632 | 6,460 | 7,281 | 7,547 | 7,930 | 9,163 | 8,468 | 6,861 | 6,780 |
| Hake (whiting) | 3,219 | 3,642 | 4,641 | 7,107 | 7,974 | 6,501 | 6,830 | 3,783 | 5,414 | 16,518 |
| Oysters | 3,143 | 3,292 | 3,292 | 1,232 | 1,163 | 1,847 | 2,748 | 2,253 | 1,658 | 1,869 |
| Pacific sardine | 2,819 | 2,941 | 4,870 | 6,199 | 3,743 | 4,551 | 5,665 | 5,291 | 5,252 | 3,192 |
| Rockfish | 3,511 | 2,327 | 1,633 | 1,387 | 1,564 | 2,002 | 2,610 | 2,500 | 2,520 | 2,473 |
| Sablefish | 4,405 | 7,381 | 6,935 | 8,657 | 9,787 | 9,494 | 13,737 | 15,919 | 15,069 | 17,351 |
| Salmon | 6,933 | 8,869 | 12,995 | 10,437 | 4,940 | 4,647 | 4,166 | 3,546 | 7,698 | 6,736 |
| Shrimp | 11,353 | 5,051 | 4,740 | 6,901 | 4,494 | 9,365 | 13,937 | 6,813 | 11,006 | 24,607 |

### Total Landings and Landings of Key Species/Species Groups (thousands of pounds)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total landings | 210,750 | 226,317 | 294,866 | 312,636 | 282,846 | 253,543 | 195,688 | 198,895 | 201,560 | 274,525 |
| Finfish & other | 155,609 | 180,788 | 254,330 | 278,646 | 236,998 | 216,134 | 155,837 | 154,147 | 153,588 | 208,436 |
| Shellfish | 55,140 | 45,529 | 40,536 | 33,990 | 45,848 | 37,410 | 39,851 | 44,747 | 47,972 | 66,089 |
| Albacore tuna | 4,362 | 9,165 | 10,754 | 8,087 | 8,534 | 10,468 | 8,876 | 10,082 | 10,703 | 9,673 |
| Crab | 12,452 | 23,934 | 27,276 | 17,734 | 33,291 | 17,007 | 13,875 | 21,848 | 15,817 | 17,242 |
| Flatfish | 11,489 | 14,372 | 14,846 | 16,910 | 16,385 | 19,697 | 23,842 | 26,047 | 22,226 | 15,958 |
| Hake (whiting) | 71,220 | 80,648 | 130,238 | 135,503 | 122,804 | 81,481 | 55,511 | 53,466 | 57,017 | 142,092 |
| Oysters | 786 | 823 | 823 | 308 | 255 | 197 | 162 | 563 | 415 | 467 |
| Pacific sardine | 50,069 | 55,683 | 79,610 | 99,450 | 74,669 | 90,037 | 49,298 | 45,902 | 44,743 | 23,479 |
| Rockfish | 4,653 | 3,434 | 2,574 | 2,007 | 1,967 | 2,905 | 3,820 | 4,207 | 4,533 | 3,819 |
| Sablefish | 3,185 | 4,798 | 5,627 | 5,834 | 5,838 | 5,349 | 6,514 | 7,219 | 6,269 | 5,074 |
| Salmon | 6,117 | 6,720 | 5,914 | 4,666 | 1,810 | 1,370 | 1,860 | 2,311 | 2,765 | 2,386 |
| Shrimp | 41,584 | 20,546 | 12,207 | 15,784 | 12,128 | 19,990 | 25,400 | 22,019 | 31,429 | 48,198 |

### Average Annual Price of Key Species/Species Groups (dollars per pound)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Albacore tuna | 0.68 | 0.67 | 0.85 | 1.09 | 0.95 | 0.90 | 1.20 | 1.01 | 1.16 | 1.94 |
| Crab | 1.67 | 1.55 | 1.58 | 1.50 | 1.62 | 2.25 | 2.10 | 1.94 | 2.07 | 2.59 |
| Flatfish | 0.45 | 0.46 | 0.44 | 0.43 | 0.46 | 0.40 | 0.38 | 0.33 | 0.31 | 0.42 |
| Hake (whiting) | 0.05 | 0.05 | 0.04 | 0.05 | 0.06 | 0.08 | 0.12 | 0.07 | 0.09 | 0.12 |
| Oysters | 4.00 | 4.00 | 4.00 | 4.00 | 4.56 | 9.40 | 16.96 | 4.00 | 4.00 | 4.00 |
| Pacific sardine | 0.06 | 0.05 | 0.06 | 0.06 | 0.05 | 0.05 | 0.11 | 0.12 | 0.12 | 0.14 |
| Rockfish | 0.75 | 0.68 | 0.63 | 0.69 | 0.80 | 0.69 | 0.68 | 0.59 | 0.56 | 0.65 |
| Sablefish | 1.38 | 1.54 | 1.23 | 1.48 | 1.68 | 1.78 | 2.11 | 2.21 | 2.40 | 3.42 |
| Salmon | 1.13 | 1.32 | 2.20 | 2.24 | 2.73 | 3.39 | 2.24 | 1.53 | 2.78 | 2.82 |
| Shrimp | 0.27 | 0.25 | 0.39 | 0.44 | 0.37 | 0.47 | 0.55 | 0.31 | 0.35 | 0.51 |

### 2011 Economic Impacts of Recreational Fishing Expenditures (thousands of dollars)

| | Jobs | Sales | Income | Value Added |
|---|---|---|---|---|
| Trip Impacts by Fishing Mode: | | | | |
| For-Hire | 214 | 16,475 | 5,364 | 9,288 |
| Private Boat | 453 | 39,461 | 13,415 | 22,752 |
| Shore | 173 | 14,765 | 5,000 | 8,413 |
| Total Durable Equipment Impacts | 2,306 | 299,331 | 113,101 | 160,382 |
| **Total State Trip and Durable Equipment Economic Impacts** | 3,147 | 370,032 | 136,881 | 200,835 |

### 2011 Angler Trip & Durable Expenditures (thousands of dollars)

| Fishing Mode | Trip Expenditures | | Equipment | Durable Expenditures |
|---|---|---|---|---|
| | Non-Residents | Residents | | |
| For-Hire | 706 | 9,934 | Fishing Tackle | 42,357 |
| Private Boat | 2,344 | 29,948 | Other Equipment | 19,559 |
| Shore | 1,173 | 11,073 | Boat Expenses | 168,129 |
| *Total Trip Expenditures* | 4,223 | 50,955 | Vehicle Expenses | 49,639 |
| | | | Second Home Expenses | 761 |
| | | | *Total Durable Equipment Expenditures* | 280,445 |
| **Total State Trip and Durable Equipment Expenditures** | | | | 335,623 |

### Recreational Anglers by Residential Area (thousands of anglers)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal | 101 | 91 | 90 | 87 | 82 | 86 | 79 | 85 | 82 | 81 |
| Non-Coastal | 153 | 135 | 125 | 123 | 125 | 130 | 120 | 128 | 124 | 122 |
| Out of State | 21 | 15 | 16 | 14 | 15 | 15 | 14 | 15 | 14 | 14 |
| **Total Anglers** | 275 | 242 | 231 | 224 | 222 | 231 | 213 | 228 | 221 | 217 |

### Recreational Fishing Effort by Mode (thousands of angler-trips)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| For-Hire | 67 | 67 | 64 | 58 | 56 | 61 | 48 | 56 | 51 | 52 |
| Private | 448 | 426 | 426 | 382 | 373 | 399 | 353 | 396 | 378 | 370 |
| Shore | 295 | 233 | 233 | 233 | 233 | 233 | 233 | 233 | 233 | 233 |
| **Total Trips** | 810 | 726 | 723 | 673 | 662 | 693 | 634 | 685 | 662 | 655 |

### Harvest (H) and Release (R) of Key Species Species Groups (thousands of fish)[1]

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Albacore tuna | H | 3 | 11 | 17 | 5 | 12 | 59 | 24 | 43 | NA | NA |
| | R | (1) | (1) | (1) | (1) | (1) | (1) | (1) | (1) | NA | NA |
| Baitfishes | H | 772 | 320 | 322 | 320 | 320 | 320 | 320 | 320 | NA | NA |
| | R | 21 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | NA | NA |
| Flatfishes | H | 31 | 15 | 27 | 21 | 21 | 22 | 21 | 17 | NA | NA |
| | R | 8 | 6 | 7 | 7 | 7 | 6 | 8 | 9 | NA | NA |
| Greenlings | H | 154 | 96 | 99 | 106 | 99 | 97 | 94 | 92 | NA | NA |
| | R | 176 | 77 | 78 | 77 | 72 | 65 | 67 | 70 | NA | NA |
| Rockfishes | H | 383 | 405 | 379 | 401 | 331 | 322 | 308 | 362 | NA | NA |
| | R | 36 | 23 | 24 | 57 | 39 | 38 | 47 | 49 | NA | NA |
| Salmon | H | 118 | 235 | 186 | 61 | 37 | 92 | 28 | 157 | NA | NA |
| | R | 67 | 146 | 148 | 23 | 16 | 55 | 16 | 120 | NA | NA |
| Sculpins | H | 21 | 23 | 20 | 22 | 20 | 20 | 21 | 21 | NA | NA |
| | R | 77 | 50 | 51 | 54 | 51 | 53 | 53 | 53 | NA | NA |
| Sturgeon | H | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | NA | NA |
| | R | 27 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | NA | NA |
| Surfperches | H | 139 | 122 | 122 | 122 | 122 | 122 | 122 | 122 | NA | NA |
| | R | 60 | 34 | 34 | 34 | 34 | 34 | 34 | 34 | NA | NA |

[1] In this table, '(1)' = 0-999 thousand fish and '1' = 1,000-1,499 thousand fish.

### Oregon's State Economy (% of national total)

| | Establishments | Employees | Annual Payroll (million $) | Employee Compensation (million $) | Gross State Product (million $) | Commercial Location Quotient [1] |
|---|---|---|---|---|---|---|
| 2002 | 101,933 (1.4%) | 1,329,235 (1.2%) | 43,522 (1.1%) | 70,770 (1.1%) | 119,571 (1.2%) | 3.36 |
| 2010 | 107,397 (1.5%) | 1,351,164 (1.2%) | 54,368 (1.1%) | 89,334 (1.3%) | 185,211 (1.1%) | 3.39 |
| % change | 5.36% | 1.65% | 24.9% | 26.2% | 54.9% | 3.87% |

### Seafood Sales & Processing - Nonemployer Firms (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Seafood product prep. & packaging | Firms | 0 | 0 | 0 | 9 | 7 | 0 | 19 | 15 | 19 |
| | Receipts | ND[2] | ND[2] | ND[2] | 309 | 54 | ND[2] | 957 | 469 | 957 |
| Seafood Sales, retail | Firms | 13 | 10 | 11 | 7 | 11 | 11 | 16 | 12 | 16 |
| | Receipts | 644 | 428 | 507 | 985 | 914 | 1,210 | 2,101 | 1,133 | 2,101 |

### Seafood Sales & Processing - Employer Establishments (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Seafood product prep. & packaging | Establishments | 19 | 19 | 18 | 20 | 21 | 22 | 23 | 20 | 21 |
| | Employees | 707 | 720 | 738 | 762 | 896 | 819 | 850 | 812 | 806 |
| | Payroll | 20,867 | 21,980 | 20,593 | 19,022 | 25,881 | 27,394 | 27,616 | 26,202 | 27,007 |
| Seafood sales, wholesale | Establishments | 33 | 26 | 21 | 23 | 16 | 18 | 18 | 19 | 22 |
| | Employees | ND[2] | ND[2] | 126 | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| | Payroll | ND[2] | ND[2] | 4,446 | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| Seafood sales, retail | Establishments | 28 | 21 | 24 | 24 | 22 | 23 | 21 | 23 | 21 |
| | Employees | 129 | ND[2] | 171 | 204 | 306 | 171 | 178 | 151 | 162 |
| | Payroll | 2,311 | ND[2] | 3,259 | 3,464 | 3,294 | 3,185 | 3,370 | 3,515 | 3,651 |

### Transport, Support, & Marine Operations - Employer Establishments (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal & Great Lakes freight transportation | Establishments | 10 | 8 | 8 | 9 | 9 | 13 | 8 | 9 | 8 |
| | Employees | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | 476 | ND[2] | ND[2] | ND[2] |
| | Payroll | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | 25,206 | ND[2] | ND[2] | ND[2] |
| Deep sea freight transportation | Establishments | 7 | 6 | 6 | 6 | 6 | 5 | 4 | 3 | 3 |
| | Employees | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| | Payroll | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| Deep sea passenger transportation | Establishments | NA[3] | NA[3] | NA[3] | NA[3] | NA[3] | 2 | NA[3] | NA[3] | NA[3] |
| | Employees | NA[3] | NA[3] | NA[3] | NA[3] | NA[3] | ND[2] | NA[3] | NA[3] | NA[3] |
| | Payroll | NA[3] | NA[3] | NA[3] | NA[3] | NA[3] | ND[2] | NA[3] | NA[3] | NA[3] |
| Marinas | Establishments | 41 | 42 | 41 | 40 | 37 | 38 | 37 | 33 | 30 |
| | Employees | ND[2] | 122 | 133 | 113 | ND[2] | 138 | 106 | 109 | 102 |
| | Payroll | ND[2] | 2,742 | 2,988 | 3,550 | ND[2] | 3,754 | 2,178 | 2,602 | 2,290 |
| Marine cargo handling | Establishments | 7 | 8 | 8 | 8 | 9 | 9 | 13 | 13 | 12 |
| | Employees | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| | Payroll | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| Navigational services to shipping | Establishments | 18 | 21 | 21 | 21 | 20 | 17 | 20 | 17 | 18 |
| | Employees | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | 183 | 200 | 189 | 144 |
| | Payroll | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | 11,331 | 11,808 | 10,154 | 9,577 |
| Port & harbor operations | Establishments | 1 | 1 | NA[3] | NA[3] | NA[3] | 2 | 1 | 1 | 3 |
| | Employees | ND[2] | ND[2] | NA[3] | NA[3] | NA[3] | ND[2] | ND[2] | ND[2] | ND[2] |
| | Payroll | ND[2] | ND[2] | NA[3] | NA[3] | NA[3] | ND[2] | ND[2] | ND[2] | ND[2] |
| Ship & boat building | Establishments | 44 | 43 | 50 | 43 | 41 | 40 | 41 | 35 | 34 |
| | Employees | 1,323 | 1,284 | 1,285 | 1,298 | 1,230 | 1,441 | 1,692 | 1,886 | 980 |
| | Payroll | 47,303 | 42,270 | 43,357 | 45,183 | 43,416 | 47,950 | 74,583 | 90,446 | 42,004 |

[1] The U.S. Commercial Fishing Location Quotient (CFLQ) of 1.0 represents the national baseline from which state CFLQs can be compared.
[2] ND = these data are confidential thus not disclosable
[3] NA = these data are not available

### 2011 Economic Impacts of the Washington Seafood Industry (thousands of dollars)

| | With Imports | | | Without Imports | | |
|---|---|---|---|---|---|---|
| | Jobs | Sales | Value Added | Jobs | Sales | Value Added |
| **Total Impacts** | 67,007 | 8,026,068 | 3,297,368 | 27,022 | 1,772,689 | 992,738 |
| Commercial Harvesters | 7,928 | 660,330 | 396,726 | 7,928 | 660,330 | 396,726 |
| Seafood Processors & Dealers | 17,241 | 1,638,466 | 814,366 | 2,944 | 283,533 | 140,924 |
| Importers | 15,535 | 4,273,279 | 1,302,683 | 0 | 0 | 0 |
| Seafood Wholesalers & Distributors | 2,800 | 364,502 | 166,616 | 983 | 127,928 | 58,477 |
| Retail | 23,503 | 1,089,491 | 616,977 | 15,167 | 700,898 | 396,612 |

### Total Landings Revenue and Landings Revenue of Key Species/Species Groups (thousands of dollars)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total revenue | 143,720 | 172,829 | 166,247 | 193,317 | 217,030 | 216,119 | 232,841 | 227,773 | 255,332 | 331,404 |
| Finfish & other | 39,854 | 47,415 | 55,906 | 50,145 | 68,201 | 59,386 | 68,213 | 61,115 | 81,902 | 98,697 |
| Shellfish | 103,867 | 125,414 | 110,342 | 143,172 | 148,829 | 156,733 | 164,628 | 166,658 | 173,430 | 232,706 |
| Clams | 34,339 | 36,060 | 42,297 | 48,503 | 55,786 | 56,428 | 64,141 | 72,646 | 73,625 | 90,587 |
| Crab | 37,232 | 56,374 | 29,024 | 50,872 | 43,464 | 54,302 | 53,712 | 48,944 | 57,070 | 83,621 |
| Hake (Whiting) | 1,022 | 1,601 | 2,341 | 4,937 | 7,296 | 7,121 | 7,249 | 2,334 | 4,105 | 7,183 |
| Halibut | 6,777 | 5,991 | 7,264 | 6,512 | 8,303 | 8,842 | 7,525 | 4,879 | 5,764 | 6,792 |
| Mussels | 1,613 | 2,513 | 3,096 | 3,729 | 6,564 | 3,820 | 5,293 | 4,851 | 4,318 | 4,652 |
| Oysters | 25,578 | 26,142 | 31,257 | 33,697 | 38,302 | 37,437 | 34,794 | 34,993 | 30,370 | 42,816 |
| Sablefish | 4,354 | 6,675 | 6,517 | 7,395 | 8,307 | 6,608 | 7,312 | 8,796 | 9,402 | 12,414 |
| Salmon | 11,780 | 9,941 | 17,316 | 14,319 | 24,586 | 22,026 | 23,376 | 22,003 | 40,622 | 42,433 |
| Shrimp | 4,473 | 3,723 | 3,648 | 4,335 | 3,602 | 3,746 | 5,380 | 4,139 | 5,677 | 7,139 |
| Tuna, Albacore | 7,375 | 15,621 | 15,657 | 10,643 | 15,176 | 10,439 | 17,225 | 16,390 | 14,575 | 22,241 |

### Total Landings and Landings of Key Species/Species Groups (thousands of pounds)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total landings | 172,277 | 189,479 | 192,181 | 213,502 | 241,606 | 194,449 | 173,176 | 163,937 | 189,486 | 210,672 |
| Finfish & other | 125,903 | 132,940 | 155,224 | 156,902 | 191,717 | 151,762 | 128,208 | 120,452 | 142,608 | 158,120 |
| Shellfish | 46,374 | 56,539 | 36,957 | 56,600 | 49,889 | 42,687 | 44,968 | 43,485 | 46,878 | 52,552 |
| Clams | 3,087 | 3,127 | 3,319 | 3,621 | 4,617 | 3,363 | 4,070 | 4,266 | 3,876 | 4,030 |
| Crab | 21,380 | 34,037 | 14,955 | 32,086 | 24,619 | 22,487 | 21,355 | 20,651 | 22,500 | 27,071 |
| Hake (Whiting) | 22,564 | 35,124 | 69,117 | 93,654 | 120,058 | 91,272 | 67,159 | 36,378 | 58,900 | 73,494 |
| Halibut | 2,487 | 1,868 | 2,254 | 1,948 | 2,451 | 2,428 | 2,055 | 1,731 | 1,371 | 1,315 |
| Mussels | 214 | 337 | 427 | 504 | 774 | 475 | 593 | 568 | 589 | 535 |
| Oysters | 9,935 | 9,649 | 11,058 | 12,190 | 12,306 | 11,189 | 10,258 | 9,386 | 8,650 | 9,776 |
| Sablefish | 2,559 | 3,736 | 4,064 | 4,240 | 4,259 | 3,035 | 2,954 | 3,514 | 3,277 | 3,416 |
| Salmon | 26,626 | 25,493 | 27,918 | 17,926 | 26,570 | 21,938 | 17,641 | 31,821 | 28,086 | 38,705 |
| Shrimp | 11,149 | 8,867 | 6,599 | 7,279 | 6,926 | 4,455 | 7,355 | 7,775 | 10,153 | 10,195 |
| Tuna, Albacore | 11,708 | 23,672 | 18,044 | 10,505 | 19,133 | 13,129 | 14,801 | 16,112 | 13,148 | 13,203 |

### Average Annual Price of Key Species/Species Groups (dollars per pound)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Clams | 11.12 | 11.53 | 12.74 | 13.40 | 12.08 | 16.78 | 15.76 | 17.03 | 19.00 | 22.48 |
| Crab | 1.74 | 1.66 | 1.94 | 1.59 | 1.77 | 2.41 | 2.52 | 2.37 | 2.54 | 3.09 |
| Hake (Whiting) | 0.05 | 0.05 | 0.03 | 0.05 | 0.06 | 0.08 | 0.11 | 0.06 | 0.07 | 0.10 |
| Halibut | 2.73 | 3.21 | 3.22 | 3.34 | 3.39 | 3.64 | 3.66 | 2.82 | 4.20 | 5.17 |
| Mussels | 7.53 | 7.46 | 7.26 | 7.40 | 8.48 | 8.05 | 8.93 | 8.54 | 7.33 | 8.69 |
| Oysters | 2.57 | 2.71 | 2.83 | 2.76 | 3.11 | 3.35 | 3.39 | 3.73 | 3.51 | 4.38 |
| Sablefish | 1.70 | 1.79 | 1.60 | 1.74 | 1.95 | 2.18 | 2.48 | 2.50 | 2.87 | 3.63 |
| Salmon | 0.44 | 0.39 | 0.62 | 0.80 | 0.93 | 1.00 | 1.33 | 0.69 | 1.45 | 1.10 |
| Shrimp | 0.40 | 0.42 | 0.55 | 0.60 | 0.52 | 0.84 | 0.73 | 0.53 | 0.56 | 0.70 |
| Tuna, Albacore | 0.63 | 0.66 | 0.87 | 1.01 | 0.79 | 0.80 | 1.16 | 1.02 | 1.11 | 1.68 |

### 2011 Economic Impacts of Recreational Fishing Expenditures (thousands of dollars)

| | Jobs | Sales | Income | Value Added |
|---|---|---|---|---|
| Trip Impacts by Fishing Mode: | | | | |
| For-Hire | 247 | 22,956 | 7,380 | 12,818 |
| Private Boat | 902 | 103,234 | 31,909 | 53,946 |
| Shore | 249 | 25,871 | 8,439 | 13,878 |
| Total Durable Equipment Impacts | 3,542 | 362,027 | 127,481 | 194,783 |
| **Total State Trip and Durable Equipment Economic Impacts** | 4,939 | 514,088 | 175,209 | 275,425 |

### 2011 Angler Trip & Durable Expenditures (thousands of dollars)

| Fishing Mode | Trip Expenditures | | Equipment | Durable Expenditures |
|---|---|---|---|---|
| | Non-Residents | Residents | Fishing Tackle | 62,119 |
| For-Hire | 1,958 | 12,997 | Other Equipment | 28,275 |
| Private Boat | 1,972 | 74,002 | Boat Expenses | 312,616 |
| Shore | 773 | 19,744 | Vehicle Expenses | 41,590 |
| *Total Trip Expenditures* | 4,703 | 106,742 | Second Home Expenses | 1,111 |
| | | | *Total Durable Equipment Expenditures* | 445,711 |
| **Total State Trip and Durable Equipment Expenditures** | | | | 557,156 |

### Recreational Anglers by Residential Area (thousands of anglers)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal | 252 | 233 | 213 | 201 | 184 | 220 | 167 | 163 | 162 | 274 |
| Non-Coastal | 27 | 25 | 24 | 23 | 21 | 23 | 19 | 20 | 19 | 30 |
| Out of State | 24 | 20 | 19 | 18 | 17 | 19 | 15 | 16 | 15 | 17 |
| **Total Anglers** | 303 | 278 | 255 | 242 | 222 | 262 | 201 | 198 | 196 | 321 |

### Recreational Fishing Effort by Mode (thousands of angler-trips)[1]

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| For-Hire | 59 | 69 | 64 | 62 | 57 | 55 | 42 | 51 | 47 | 42 |
| Private | 637 | 704 | 618 | 565 | 492 | 661 | 428 | 399 | 399 | 607 |
| Shore | 711 | 513 | 513 | 513 | 513 | 513 | 513 | 513 | 513 | 513 |
| **Total Trips** | 1,407 | 1,286 | 1,195 | 1,140 | 1,062 | 1,229 | 983 | 963 | 959 | 1,162 |

### Harvest (H) and Release (R) of Key Species Species Groups (thousands of fish)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Albacore tuna | H | 6 | 11 | 14 | 12 | 24 | 25 | 22 | 24 | NA | NA |
| | R | (1) | (1) | (1) | (1) | 1 | (1) | (1) | (1) | NA | NA |
| Flatfishes | H | 216 | 62 | 62 | 61 | 63 | 51 | 47 | 54 | NA | NA |
| | R | 209 | 92 | 41 | 41 | 42 | 40 | 40 | 47 | NA | NA |
| Greenlings | H | 85 | 59 | 39 | 39 | 33 | 28 | 29 | 34 | NA | NA |
| | R | 141 | 64 | 25 | 25 | 22 | 19 | 19 | 39 | NA | NA |
| Rockfishes [2] | H | 237 | 184 | 256 | 307 | 282 | 260 | 216 | 245 | NA | NA |
| | R | 50 | 20 | 25 | 33 | 23 | 19 | 16 | 33 | NA | NA |
| Salmon | H | 279 | 509 | 302 | 266 | 119 | 354 | 103 | 758 | NA | NA |
| | R | 137 | 129 | 135 | 77 | 37 | 86 | 29 | 115 | NA | NA |
| Sculpins | H | 35 | 17 | 17 | 17 | 16 | 15 | 15 | 16 | NA | NA |
| | R | 142 | 101 | 91 | 91 | 91 | 91 | 91 | 91 | NA | NA |
| Sharks & Skates | H | 27 | 15 | 1 | 1 | 1 | (1) | 1 | 1 | NA | NA |
| | R | 331 | 203 | 14 | 12 | 14 | 9 | 12 | 10 | NA | NA |
| Smelt & herring | H | 3,254 | 2,487 | 2,486 | 2,486 | 2,486 | 2,486 | 2,486 | 2,486 | NA | NA |
| | R | 196 | 136 | 126 | 126 | 126 | 126 | 126 | 126 | NA | NA |
| Sturgeon | H | 11 | 8 | 8 | 8 | 7 | 8 | 8 | 9 | NA | NA |
| | R | 30 | 18 | 25 | 30 | 21 | 18 | 12 | 17 | NA | NA |
| Surfperches | H | 104 | 143 | 133 | 133 | 133 | 133 | 133 | 133 | NA | NA |
| | R | 105 | 125 | 120 | 120 | 120 | 120 | 120 | 121 | NA | NA |

[1] In this table, '(1)' = 0-999 thousand fish and '1' = 1,000-1,499 thousand fish.
[2] This species may not be equivalent to species with similar names listed in the commercial tables.

### Washington's State Economy (% of national total)

| | Establishments | Employees | Annual Payroll (million $) | Employee Compensation (million $) | Gross State Product (million $) | Commercial Location Quotient [1] |
|---|---|---|---|---|---|---|
| 2002 | 165,933 (2.3%) | 2,185,658 (1.9%) | 83,127 (2.1%) | 135,795 (2.2%) | 237,117 (2.2%) | 12.9 |
| 2010 | 175,914 (2.4%) | 2,326,731 (2.1%) | 111,399 (2.3%) | 187,718 (2.4%) | 339,829 (2.4%) | 12.2 |
| % change | 6.02% | 6.45% | 34% | 38.2% | 43.3% | -8.84% |

### Seafood Sales & Processing - Nonemployer Firms (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Seafood product prep. & packaging | Firms | 48 | 59 | 53 | 54 | 53 | 63 | 44 | 44 | 44 |
| | Receipts | 2,763 | 5,680 | 4,446 | 5,568 | 4,149 | 4,698 | 5,167 | 4,007 | 5,167 |
| Seafood Sales, retail | Firms | 30 | 32 | 30 | 31 | 29 | 32 | 33 | 40 | 33 |
| | Receipts | 2,681 | 1,623 | 2,202 | 1,836 | 1,727 | 1,458 | 1,807 | 2,132 | 1,807 |

### Seafood Sales & Processing - Employer Establishments (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Seafood product prep. & packaging | Establishments | 106 | 110 | 101 | 98 | 96 | 98 | 96 | 86 | 93 |
| | Employees | 6,728 | 5,968 | 5,851 | 5,743 | 5,705 | 5,249 | 5,893 | 4,860 | 5,296 |
| | Payroll | 221,978 | 231,153 | 247,316 | 239,962 | 255,129 | 275,662 | 306,213 | 232,543 | 254,592 |
| Seafood sales, wholesale | Establishments | 175 | 121 | 116 | 126 | 115 | 127 | 107 | 108 | 105 |
| | Employees | 1,185 | 1,112 | 883 | 1,094 | 1,015 | 1,086 | 996 | 1,103 | 970 |
| | Payroll | 51,959 | 39,206 | 37,292 | 42,852 | 42,934 | 46,085 | 48,251 | 48,044 | 45,871 |
| Seafood sales, retail | Establishments | 44 | 37 | 40 | 47 | 49 | 50 | 44 | 43 | 47 |
| | Employees | 235 | 284 | 222 | 291 | 292 | 244 | 247 | 239 | 282 |
| | Payroll | 6,379 | 6,363 | 6,578 | 9,322 | 8,998 | 8,001 | 7,947 | 8,324 | 9,098 |

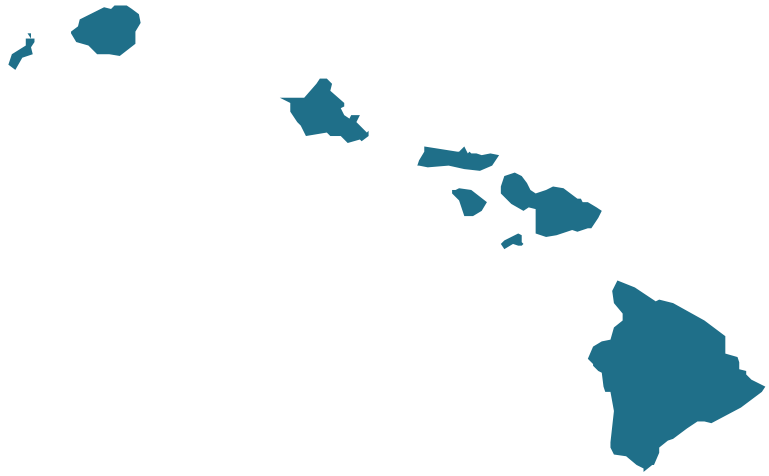
### Transport, Support, & Marine Operations - Employer Establishments (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal & Great Lakes freight transportation | Establishments | 33 | 36 | 38 | 41 | 43 | 37 | 24 | 24 | 30 |
| | Employees | 2,173 | 1,607 | 2,039 | 1,672 | 2,353 | 1,903 | 2,222 | 2,245 | 1,731 |
| | Payroll | 130,456 | 112,319 | 128,786 | 122,000 | 145,144 | 136,543 | 168,832 | 168,783 | 130,398 |
| Deep sea freight transportation | Establishments | 23 | 27 | 23 | 24 | 23 | 30 | 21 | 25 | 20 |
| | Employees | ND[2] | 276 | 311 | 378 | 197 | 227 | 263 | 305 | 209 |
| | Payroll | ND[2] | 16,147 | 20,559 | 22,655 | 14,390 | 19,692 | 24,843 | 28,897 | 24,711 |
| Deep sea passenger transportation | Establishments | 7 | 3 | 2 | 3 | 3 | 3 | 4 | 5 | 4 |
| | Employees | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| | Payroll | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| Marinas | Establishments | 111 | 102 | 96 | 96 | 103 | 114 | 116 | 110 | 117 |
| | Employees | 406 | 430 | 449 | 442 | 466 | 485 | 573 | 570 | 560 |
| | Payroll | 11,283 | 12,400 | 12,763 | 13,556 | 14,269 | 15,623 | 18,931 | 18,811 | 18,783 |
| Marine cargo handling | Establishments | 33 | 23 | 30 | 30 | 29 | 28 | 25 | 27 | 26 |
| | Employees | 2,538 | ND[2] | ND[2] | 4,459 | 3,764 | 4,913 | 4,821 | 2,953 | ND[2] |
| | Payroll | 194,398 | ND[2] | ND[2] | 318,873 | 303,375 | 334,601 | 334,193 | 239,490 | ND[2] |
| Navigational services to shipping | Establishments | 55 | 52 | 53 | 53 | 56 | 61 | 76 | 69 | 79 |
| | Employees | 218 | 834 | ND[2] | 841 | 942 | 950 | 1,213 | 1,168 | 1,225 |
| | Payroll | 20,962 | 51,092 | ND[2] | 60,034 | 72,120 | 72,912 | 100,542 | 102,934 | 102,766 |
| Port & harbor operations | Establishments | 4 | 3 | 4 | 6 | 5 | 6 | 11 | 11 | 9 |
| | Employees | 37 | ND[2] | ND[2] | ND[2] | 53 | 129 | 111 | 118 | 74 |
| | Payroll | 1,565 | ND[2] | ND[2] | ND[2] | 3,436 | 4,631 | 6,359 | 6,437 | 4,662 |
| Ship & boat building | Establishments | 135 | 138 | 141 | 154 | 164 | 167 | 169 | 162 | 152 |
| | Employees | 4,974 | 6,056 | 6,474 | 7,154 | 7,669 | 7,742 | 8,067 | 6,710 | 5,406 |
| | Payroll | 219,980 | 244,124 | 272,336 | 307,735 | 313,230 | 354,084 | 402,253 | 312,240 | 284,759 |

[1] The U.S. Commercial Fishing Location Quotient (CFLQ) of 1.0 represents the national baseline from which state CFLQs can be compared.
[2] ND = these data are confidential thus not disclosable

# Western Pacific

## - Hawai’i



## Management Context

The Western Pacific Region includes the state of Hawai'i.[1] Federal fisheries in this region are managed by the Western Pacific Fishery Management Council (WPFMC) and NOAA Fisheries (NMFS) under five fishery ecosystem plans (FEPs). Fishery ecosystem plans manage marine resources from a place-based perspective rather than managing fishing activities in terms of targeted species. These FEPs replace the Council's existing fishery management plans (FMPs) for Bottomfish and Seamount Groundfish, Coral Reef Ecosystems, Crustaceans, and Precious Corals.

**Western Pacific Fishery Ecosystem Plans**

1. American Samoa Archipelago
2. Hawai'i Archipelago
3. Mariana Archipelago
4. Pacific Remote Island Areas
5. Pacific Pelagics

Of the stocks covered in these fishery ecosystem plans, the Hancock Seamount groundfish complex is currently considered overfished. This fishery has been closed since 1986. Bigeye tuna is currently subject to overfishing and this status is considered to be primarily due to international fishing pressure. The U.S. harvested 6% (14 million pounds) of the Pacific-wide (western-central and eastern Pacific Ocean) total of Pacific bigeye tuna landings reported in 2011. Currently, there are no catch share programs in place in this region.

In addition to management oversight provided by the WPFMC and NOAA Fisheries, pelagic fish species such as bigeye and yellowfin tunas are also managed by two regional fishery management organizations (RFMOs). The Western and Central Pacific Fisheries Commission (WCPFC) is active in the western and central Pacific Ocean and the Inter-American Tropical Tuna Commission (IATTC) is active in the eastern Pacific Ocean. Species under the purview of the WCPFC and IATTC migrate across international boundaries and require coordinated management between countries with fishing interests in the Pacific Ocean.

The annual bigeye tuna catch limit recommended by WCPFC for the U.S. longline fleet in the Western and Central Pacific Ocean is 8.3 million pounds. NMFS responded to the measure by establishing a quota of 8.3 million pounds of bigeye tuna that may be caught in the Western and Central Pacific Ocean and retained by U.S. longline vessels beginning in 2009. The fishery was closely monitored during the year. The quota in the Western Pacific ocean was reached toward the end of the year and, therefore, the Hawai'i longline fishery was only closed for three days in 2009. In the meantime, the harvest limit established by the IATTC for the U.S. longline bigeye tuna is 1.1 million pounds. However, this quota is only applied to U.S. longline vessels greater than 78.7 feet in length, all other vessels are not bound by any catch limit in the Eastern tropical Pacific.[2]

## Commercial Fisheries

Fishermen in Hawai'i earned $92 million from their commercial harvest in 2011, landing over 29 million pounds of finfish and shellfish. Tunas comprised 73% of landings revenue ($67 million) as well as 63% of total landings (19 million pounds). Swordfish ($6.7 million), mahimahi ($4.3 million), moonfish ($2.9 million), and marlin ($2.4 million) also contributed to landings revenue. Lobsters commanded the highest ex-vessel price in 2011, with an average annual price of $10.39 per pound.

**Key Western Pacific Commercial Species**

- Lobsters
- Mahimahi
- Marlin
- Moonfish
- Pomfret
- Scad
- Snappers
- Swordfish
- Tunas
- Wahoo

### *Economic Impacts*[3]

In 2011, the Western Pacific's seafood industry generated $694 million in sales impacts, $213 million in income impacts, and approximately 8,600 full- and part-time jobs. Importers contributed the most to sales (38% of the total), while the retail sector contributed the most to employment impacts (41%), income impacts (37%), and valued added impacts (33%). The commercial harvest sector generated 3,200 jobs, $159 million in sales, $58 million in income, and $84 million in value added impacts.

### *Landings Revenue*

Landings revenue for finfish and shellfish totaled over $91.5 million in 2011, a 75% increase from total revenue generated in 2002; when adjusted for inflation, real landings revenues increased 21%. Landings trends for this time period (2002-2011) can only be understood in light of the extensive closure of fishing grounds to the Hawai'i-based swordfish longline fishery in 2000 due to concern about the high frequency of interactions with loggerhead and leatherback sea turtles. From 2000 to 2001, swordfish landings revenue decreased 95% from $12.8 million to $1.3 million. A few years later when the fishery was re-opened, landings revenue increased 534% from $1.2 million in 2004 to $7.8 million in 2005. Swordfish landings revenue between 2001 and 2004 averaged $1.2 million while between 2005 to 2011,

[1] The Western Pacific Region also includes the U.S. territories of American Samoa, Guam, and the Commonwealth of the Northern Mariana Islands. However, due to data availability, only information from Hawai'i is reported here.
[1] Under the Tuna Conventions Act of 1950 (64 Stat. 777) as amended (16 U.S.C., 951-961), NMFS must publish regulations that carry out IATTC recommendations and resolutions that have been approved by the Department of State.
3 The NMFS Commercial Fishing Industry Input/Output Model was used to generate the impact estimates (see NMFS Commercial Fishing & Seafood Industry Input/Output Model, available at: www.st.nmfs.noaa.gov/documents/commercial_seafood_impacts_2007-2009.pdf)

swordfish landings revenue averaged $7 million, an increase of more than 500%.

Landings revenue in 2011 increased 8.9% (0.5% increase in real terms) from the 2010 level ($84 million). Finfish and other catch contributed nearly 100% of total revenue in 2011 ($91 million), a 75% increase from 2002 (22% increase in real terms). Revenue earned from shellfish landings decreased 48% (a 64% decrease in real terms) from $306,000 in 2002 to $158,000 in 2011. Landings revenue in 2011 was dominated by tunas which contributed $67 million or 73% of total landings revenue. On average, tunas contributed 69% to total revenue over the 10 year time period. The largest increases in landings revenue from 2002 to 2011 were for swordfish (386% or 238% in real terms) and moonfish (134% or 62% in real terms).

### *Landings*

In 2011, Hawai'ian commercial fishermen landed 29 million pounds of finfish and shellfish, a 22% increase from 2002 landings totals. This was a 4.3% increase compared to landings in 2010 (28 million pounds). Finfish and other catch accounted for nearly 100% of total landings annually. Shellfish landings decreased 34% from 31,000 pounds landed in 2002 to 20,000 pounds in 2011 and also decreased 6.7% from 2010 to 2011.

Tunas contributed more to the Western Pacific's total landings than any other species or group with 18.5 million pounds landed in 2011. This was a 17% increase from 2002 total landings of tunas (15.9 million pounds). Swordfish followed with 2.6 million pounds landed in 2011. Swordfish landings experienced dramatic changes from 2002 to 2011 due to the aforementioned closure of the swordfish longline fishery in late 2000. From 2000 to 2001, landings decreased 91% from 6.4 million pounds to 559,000 pounds when the Hawai'i longline fishery was largely closed to protect sea turtles. When the fishery re-opened a few years later, landings increased 561% from 520,000 pounds in 2004 to 3.4 million pounds in 2005. Swordfish landings between 2001 and 2004 averaged approximately a half million pounds, while in between 2005 and 2011 the average was 2.9 million pounds.

### *Prices*

Overall, the 2011 ex-vessel price for nine of the key species or species groups were above their ten year average annual price. Only lobster had a lower price per pound ($10.39) in 2011 relative to its annual average ($11.54) over the time period.
The ex-vessel price for swordfish in 2011 was $2.57, $0.41 more than the ten year average. Relative to ex-vessel prices in 2010, mahimahi (40%) experienced a double digit increase in 2011 while lobster experienced a double digit decrease (16%) from 2010 to 2011.

## Commercial Fisheries Facts

*Landings revenue*

- On average, the key species or species groups account for 97% of total revenue, ($88 million) generated in the Western Pacific Region.
- Tunas contributed more than any other species or species group, averaging $49 million in landings revenue from 2002 to 2011.
- Swordfish had the largest one-year increase in landings revenue over the 10 year time period, increasing 534% from $1.2 million in 2004 to $7.8 million in 2005 due to the re-opening of the swordfish longline fishery.
- Swordfish had the largest one-year decrease in landings revenue over the 10 year time period, decreasing 50% from $1.4 million in 2002 to $691,000 in 2003.

*Landings*

- Key species or species groups contributed an average of 94% annually to total landings between 2002 and 2011.
- Tunas, contributed the most to landings in the region, averaging 16 million pounds from 2002 to 2011.
- Swordfish had the largest one-year increase in landings over the 10 year time period, increasing 561% from 520,000 in 2004 pounds to 3.4 million pounds in 2005.
- Swordfish had the largest one-year decrease in landings over the 10 year time period, decreasing 56% from 703,000 pounds in 2002 to 306,000 pounds in 2003 due to the re-opening of the swordfish longline fishery.

*Prices*

- Lobsters had the highest average annual ex-vessel price per pound ($11.54) over the time period, followed by snappers ($4.61), and tunas ($3.01).
- Marlin had the lowest average annual ex-vessel price per pound ($1.23) over the time period, followed by moonfish ($1.59), and swordfish ($2.16).
- Marlin had the largest one-year increase in ex-vessel price over the 10 year time period, increasing 58% from $0.85 per pound in 2003 to $1.34 in 2004.
- Marlin had the largest decrease in ex-vessel price over the 10 year time period, decreasing 37% from $1.34 per pound in 2002 to $0.85 in 2003.

## Recreational Fisheries

In 2011, there were 87,000 recreational anglers who fished in the state of Hawai'i. These anglers took 1.4 million fishing trips and of these, 84% were shore-based trips. Scads (bigeye and mackerel) was the most caught species group with 662,000 fish caught in 2011. Almost all of these fish were harvested by anglers rather than released. The most released species or species group was trevallys and other jacks (38%). All others were harvested at least 88% of the time in 2011.

**Key Western Pacific Recreational Species**

- Barracuda (smallmouth bonefish)
- Blue marlin
- Dolphinfish (mahimahi)
- Goatfishes
- Jacks (trevallys and other jacks)
- Bigeye and mackerel scad
- Snappers
- Skipjack tuna
- Yellowfin tuna
- Wahoo

### *Economic Impacts and Expenditures*[4]

In 2011, approximately 2,900 jobs in the Western Pacific were generated by recreational fishing activities and over $285 million was spent by anglers who fished in the region. Most of these employment impacts were generated by industries that provided services to anglers who fished from shore (603 jobs) or from a for-hire fishing vessel (570 jobs). These fishing trip modes also generated the most in trip-related expenditures: $45 million for shore-based fishing trips (43% of total trip expenditures) and $40 million for for-hire trips (38% of total trip expenditures). Thirty five percent of total trip-related expenditures in the Western Pacific came from non-resident anglers.

In addition to employment impacts generated by recreational fishing activities, other economic impacts include sales impacts and the contribution of recreational fishing activities to gross domestic product (value added impacts). For-hire fishing trips generated $55 million in sales impacts (42% of total trip-related sales) and $30 million in value added impacts (43% of total trip-related value added impacts) in 2011. Private boat trips contributed $25 million in sales (19%) and $13 million (18%) in value added impacts. Shore-based fishing trips contributed $52 million in trip-related sales (39%) and $27 million in trip-related value added impacts (39%).

Anglers spent over $179 million on durable equipment in 2011, contributing 63% to total expenditures in the region (trip and durable equipment combined). Fishermen spent more on fishing tackle ($67 million) and boat expenses (also $67 million) than other durable goods. Expenditures related to vehicle expenses ($35 million) and other equipment ($10 million) followed in size of expenditures. Economic impacts from durable equipment expenditures in 2011 include about 1,500 jobs, $179 million in sales impacts, and $87 million in value added impacts.

### *Participation*[5]

In 2011, there were 87,000 recreational anglers who fished in Hawai'i. This was an 80% decrease from 2003 (440,000 anglers) and a 82% decrease from 2010 (475,000 anglers). In 2011, non-resident anglers made up 4.2% of total anglers (3,700 anglers). There was a 98% decrease in non-resident anglers from 2003 (180,000 anglers) and a 99% decrease from 2010 (293,000 anglers). In terms of resident anglers, there were 84,000 resident anglers who fished in Hawai'i in 2011, which was a 68% decrease from 2003 and a 54% decrease from 2010. The large decline in participation is a result of the significant decrease in fishing effort (42% decrease, described below) coupled with a 23% increase in the number of trips taken by active anglers, which is commonly referred to as "angler avidity." An increase in angler avidity coupled with a decrease in trips necessarily results in a decrease in participation.

### Fishing Trips[5]

Anglers who fished in Hawai'i took approximately 1.38 million fishing trips in 2011. This was a 42% decrease from the 2.4 million fishing trips taken in 2003. From 2010 to 2011, there was a 42% decrease in the number of trips taken (2.4 million trips) in 2010.

### *Harvest and Release*[5]

Of Hawai'i's key species and species groups, bigeye and mackerel scad, goatfishes, and trevallys and other jacks were most frequently caught by recreational fishermen. In 2011, 662,000 bigeye and mackerel scad, 185,000 goatfishes, and 159,000 trevallys and other jacks were caught by anglers in Hawai'i. Blue marlin (100% harvested), dolphinfish (100%), and yellowfin tuna (100%) were more often harvested than released, while trevallys and other jacks were released more often (38%) than any of the other key species or species groups.

Between 2004 (the first year for which recreational catch data for Hawai'i are available) and 2011 one of Hawai'i's key species or groups experienced increases in catch totals: bigeye and mackerel scad (268%). Over the same time period, the largest decreases were experienced by: wahoo (84%), smallmouth bonefish (77%), and goatfishes (75%).

[4] Expenditure estimates were generated from the 2011 National Marine Recreational Fishing Expenditure Survey. Economic impacts from recreational fishing activities were generated using the NMFS Recreational Economic Impact Model (see The Economic Contribution of Marine Angler Expenditures in the United States, 2006, available at :http://www.st.nmfs.noaa.gov/economics/publications/marine-angler-expenditures/marine-angler-2006)

[5] Due to data availability, the time period 2003 to 2011 is discussed in this section.

Between 2010 and 2011, the largest (and only) increase in catch occurred in the blue marlin (100%) fishery. Decreases over the same time period occurred in nine of the species or species groups, the largest of which were experienced by smallmouth bonefish (76%) and snappers (65%).

### Recreational Fisheries Facts

*Participation*

- An average of 341,000 anglers fished in the Western Pacific annually from 2003 to 2011.
- In 2011, in-state residents made up 96% of total anglers in this region. These anglers averaged 53% of total anglers annually over the nine year time period.

*Fishing trips*

- In the Western Pacific, an average of 2.4 million fishing trips was taken annually from 2003 to 2011.
- Private or rental boat and shore-based fishing trips accounted for 224,000 and 1.2 million fishing trips, respectively in 2011.

*Harvest and release*

- The bigeye and mackerel scad species group was the most commonly caught key species or species group, averaging 728,000 fish caught over the 10 year time period. Of these, 0.22% were released rather than harvested.
- Of the ten commonly caught key species or species groups none were released more often than harvested over this time period. The species or species group that was most commonly released was trevallys and other jacks (38% released).
- Species or species groups that were harvested 100% of the time included blue marlin, dolphinfish, and bigeye and mackerel scad.
- Between 2010 and 2011, blue marlin experienced the largest annual increase in catch (100%), and smallmouth bonefish had the largest decrease (76%).

## Marine Economy[6]

In 2010, over 32,000 establishments employed approximately 479,000 full- and part-time employees in Hawai'i. Annual payroll totaled $18 billion, employee compensation totaled $38 billion, and gross product by state totaled $66 billion. Gross state product, annual payroll, and employee compensation increased 47%, 31%, and 44%, respectively between 2002 and 2010. The commercial fishing location quotient (CFLQ) for Hawai'i was 4.71. Between 2002 and 2010 the CFLQ for Hawai'i decreased 35%. Hawai'i's level of commercial fishing-related employment continues to be well above the national baseline.

### *Transport, Support, and Marine Operations*

Data were largely unavailable for the transport, support, and marine operations sector. According to the available information, the marine cargo handling had the highest numbers of establishments in 2010 (14 establishments). The marine cargo handling sector had the largest payroll ($109 million) and the largest number of employees was also in the marine cargo handling sector (1,236). The largest increase in number of establishments between 2002 and 2010 was in the marine cargo handling sector (100%) and the greatest decrease occurred in the coastal and Great Lakes freight transportation sector (82%)

[6] The CFLQ for the U.S. is 1.0. This provides a national baseline from which state CFLQs can be compared.

### 2011 Economic Impacts of the Hawaii Seafood Industry (thousands of dollars)

| | With Imports | | | Without Imports | | |
|---|---|---|---|---|---|---|
| | Jobs | Sales | Value Added | Jobs | Sales | Value Added |
| **Total Impacts** | 8,627 | 694,228 | 311,097 | 6,667 | 364,073 | 195,754 |
| Commercial Harvesters | 3,154 | 159,444 | 83,529 | 3,154 | 159,444 | 83,529 |
| Seafood Processors & Dealers | 509 | 44,786 | 22,865 | 366 | 32,350 | 16,516 |
| Importers | 964 | 265,307 | 80,877 | 0 | 0 | 0 |
| Seafood Wholesalers & Distributors | 476 | 45,551 | 21,253 | 277 | 26,518 | 12,372 |
| Retail | 3,523 | 179,139 | 102,574 | 2,869 | 145,761 | 83,337 |

### Total Landings Revenue and Landings Revenue of Key Species/Species Groups (thousands of dollars)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total revenue | 52,384 | 52,755 | 57,679 | 71,040 | 66,120 | 75,705 | 85,120 | 71,168 | 84,023 | 91,513 |
| Finfish & other | 52,078 | 52,493 | 57,274 | 70,677 | 66,013 | 75,531 | 84,753 | 70,985 | 83,851 | 91,354 |
| Shellfish | 306 | 262 | 406 | 364 | 106 | 174 | 367 | 183 | 172 | 158 |
| Lobsters | 122 | 68 | 91 | 111 | 61 | 93 | 120 | 136 | 116 | 104 |
| Mahimahi (dolphin) | 2,630 | 2,940 | 4,909 | 3,597 | 3,640 | 3,482 | 3,182 | 2,850 | 3,300 | 4,310 |
| Marlin | 2,010 | 1,986 | 2,472 | 2,512 | 2,558 | 2,028 | 2,072 | 2,141 | 1,756 | 2,373 |
| Moonfish (opah) | 1,219 | 1,509 | 1,343 | 1,897 | 1,873 | 2,170 | 2,197 | 2,408 | 2,591 | 2,852 |
| Pomfret | 675 | 777 | 1,316 | 1,440 | 1,311 | 1,460 | 1,665 | 1,379 | 1,549 | 1,449 |
| Scad | 1,067 | 1,105 | 944 | 839 | 1,020 | 1,099 | 896 | 555 | 1,251 | 964 |
| Snappers | 2,009 | 2,035 | 2,201 | 2,005 | 1,756 | 1,680 | 1,710 | 1,844 | 1,637 | 1,372 |
| Swordfish | 1,371 | 691 | 1,225 | 7,768 | 5,125 | 7,726 | 7,176 | 7,334 | 7,302 | 6,669 |
| Tunas | 37,598 | 37,381 | 38,484 | 46,071 | 44,085 | 51,148 | 60,874 | 47,674 | 59,756 | 66,580 |
| Wahoo | 1,452 | 1,919 | 2,201 | 2,253 | 2,329 | 2,087 | 2,235 | 1,672 | 1,745 | 1,806 |

### Total Landings and Landings of Key Species/Species Groups (thousands of pounds)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total landings | 23,968 | 23,740 | 24,456 | 28,140 | 25,659 | 28,938 | 30,682 | 26,906 | 28,069 | 29,289 |
| Finfish & other | 23,937 | 23,711 | 24,426 | 28,113 | 25,644 | 28,916 | 30,653 | 26,884 | 28,047 | 29,269 |
| Shellfish | 31 | 28 | 31 | 26 | 15 | 22 | 29 | 22 | 22 | 20 |
| Lobsters | 10 | 6 | 8 | 10 | 6 | 8 | 10 | 11 | 9 | 10 |
| Mahimahi (dolphin) | 1,376 | 1,326 | 2,225 | 1,440 | 1,342 | 1,388 | 1,252 | 1,287 | 1,518 | 1,423 |
| Marlin | 1,497 | 2,337 | 1,844 | 2,190 | 2,389 | 1,376 | 1,951 | 1,678 | 1,220 | 1,826 |
| Moonfish (opah) | 912 | 1,095 | 786 | 1,086 | 1,071 | 1,226 | 1,313 | 1,884 | 1,824 | 1,564 |
| Pomfret | 490 | 459 | 766 | 646 | 576 | 593 | 672 | 627 | 593 | 427 |
| Scad | 571 | 630 | 478 | 398 | 442 | 463 | 320 | 205 | 460 | 323 |
| Snappers | 499 | 501 | 508 | 436 | 377 | 376 | 376 | 386 | 314 | 249 |
| Swordfish | 703 | 306 | 520 | 3,439 | 2,514 | 3,643 | 3,835 | 3,881 | 3,153 | 2,592 |
| Tunas | 15,871 | 14,421 | 14,965 | 16,118 | 14,631 | 17,589 | 18,303 | 14,589 | 16,704 | 18,518 |
| Wahoo | 660 | 990 | 852 | 818 | 891 | 715 | 853 | 605 | 600 | 564 |

### Average Annual Price of Key Species/Species Groups (dollars per pound)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Lobsters | 12.66 | 11.88 | 11.08 | 10.99 | 9.66 | 11.84 | 12.14 | 12.37 | 12.36 | 10.39 |
| Mahimahi (dolphin) | 1.91 | 2.22 | 2.21 | 2.50 | 2.71 | 2.51 | 2.54 | 2.21 | 2.17 | 3.03 |
| Marlin | 1.34 | 0.85 | 1.34 | 1.15 | 1.07 | 1.47 | 1.06 | 1.28 | 1.44 | 1.30 |
| Moonfish (opah) | 1.34 | 1.38 | 1.71 | 1.75 | 1.75 | 1.77 | 1.67 | 1.28 | 1.42 | 1.82 |
| Pomfret | 1.38 | 1.69 | 1.72 | 2.23 | 2.28 | 2.46 | 2.48 | 2.20 | 2.61 | 3.39 |
| Scad | 1.87 | 1.75 | 1.97 | 2.11 | 2.30 | 2.37 | 2.80 | 2.71 | 2.72 | 2.98 |
| Snappers | 4.02 | 4.06 | 4.33 | 4.59 | 4.64 | 4.44 | 4.54 | 4.78 | 5.20 | 5.53 |
| Swordfish | 1.95 | 2.26 | 2.36 | 2.26 | 2.04 | 2.12 | 1.87 | 1.89 | 2.32 | 2.57 |
| Tunas | 2.37 | 2.59 | 2.57 | 2.86 | 3.01 | 2.91 | 3.33 | 3.27 | 3.58 | 3.60 |
| Wahoo | 2.20 | 1.94 | 2.58 | 2.75 | 2.61 | 2.92 | 2.62 | 2.76 | 2.91 | 3.20 |

### 2011 Economic Impacts of Recreational Fishing Expenditures (thousands of dollars)

| | Jobs | Sales | Income | Value Added |
|---|---|---|---|---|
| Trip Impacts by Fishing Mode: | | | | |
| For-Hire | 570 | 54,641 | 17,687 | 30,043 |
| Private Boat | 237 | 24,980 | 7,512 | 12,774 |
| Shore | 603 | 51,518 | 16,955 | 27,197 |
| Total Durable Equipment Impacts | 1,538 | 178,784 | 59,031 | 86,582 |
| **Total State Trip and Durable Equipment Economic Impacts** | 2,948 | 309,923 | 101,185 | 156,595 |

### 2011 Angler Trip & Durable Expenditures (thousands of dollars)

| Fishing Mode | Trip Expenditures | | Equipment | Durable Expenditures |
|---|---|---|---|---|
| | Non-Residents | Residents | Fishing Tackle | 67,017 |
| For-Hire | 36,718 | 2,960 | Other Equipment | 10,316 |
| Private Boat | 102 | 21,171 | Boat Expenses | 66,574 |
| Shore | 69 | 44,801 | Vehicle Expenses | 35,182 |
| *Total Trip Expenditures* | 36,890 | 68,933 | Second Home Expenses | 0 |
| | | | *Total Durable Equipment Expenditures* | 179,089 |
| **Total State Trip and Durable Equipment Expenditures** | | | | 284,912 |

### Recreational Anglers by Residential Area (thousands of anglers)[1]

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal | | 261 | 223 | 204 | 173 | 170 | 192 | 140 | 182 | 84 |
| Non-Coastal | | NA[2] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| Out of State | | 180 | 183 | 166 | 224 | 146 | 137 | 106 | 293 | 4 |
| **Total Anglers** | | 440 | 407 | 370 | 396 | 317 | 329 | 246 | 475 | 87 |

### Recreational Fishing Effort by Mode (thousands of angler-trips)[1,3]

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Private | | 510 | 709 | 578 | 570 | 475 | 565 | 441 | 484 | 224 |
| Shore | | 1,893 | 2,162 | 1,893 | 2,075 | 2,102 | 1,966 | 1,722 | 1,907 | 1,158 |
| **Total Trips** | | 2,403 | 2,871 | 2,471 | 2,645 | 2,577 | 2,531 | 2,163 | 2,391 | 1,382 |

### Harvest (H) and Release (R) of Key Species Species Groups (thousands of fish)[1,4]

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Blue marlin | H | | 4 | 5 | 19 | 3 | 2 | 11 | 3 | 1 | 2 |
| | R | | (1) | (1) | (1) | (1) | 1 | (1) | (1) | (1) | (1) |
| Dolphinfish (mahimahi) | H | | 109 | 225 | 178 | 219 | 137 | 184 | 103 | 164 | 63 |
| | R | | 1 | (1) | 1 | (1) | (1) | (1) | (1) | (1) | (1) |
| Goatfishes[5] | H | | 793 | 716 | 444 | 812 | 298 | 467 | 713 | 271 | 172 |
| | R | | 10 | 17 | 8 | 16 | 9 | 7 | 6 | 17 | 13 |
| Jacks (trevallys and other jacks)[6] | H | | 124 | 330 | 254 | 207 | 169 | 276 | 121 | 142 | 99 |
| | R | | 171 | 146 | 182 | 213 | 129 | 121 | 84 | 127 | 60 |
| Scads (bigeye and mackerel) | H | | 1,950 | 180 | 726 | 812 | 1,089 | 402 | 1,103 | 841 | 662 |
| | R | | 2 | (1) | 13 | (1) | (1) | (1) | (1) | (1) | (1) |
| Skipjack tuna | H | | 439 | 419 | 301 | 201 | 228 | 568 | 230 | 288 | 125 |
| | R | | 1 | 6 | 1 | 1 | 5 | 2 | (1) | (1) | (1) |
| Smallmouth bonefish | H | | 24 | 61 | 24 | 64 | 19 | 50 | 36 | 55 | 14 |
| | R | | 4 | 9 | 11 | 2 | 13 | 4 | 2 | 13 | 2 |
| Snappers[7] | H | | 232 | 234 | 221 | 178 | 105 | 140 | 145 | 340 | 114 |
| | R | | 17 | 18 | 57 | 35 | 39 | 7 | 24 | 25 | 14 |
| Wahoo | H | | 106 | 97 | 54 | 62 | 57 | 78 | 61 | 40 | 16 |
| | R | | (1) | (1) | (1) | (1) | 1 | (1) | (1) | (1) | (1) |
| Yellowfin tuna | H | | 183 | 267 | 231 | 124 | 273 | 461 | 198 | 302 | 141 |
| | R | | 5 | (1) | 10 | 1 | 2 | (1) | 1 | 1 | (1) |

[1]Participation (number of anglers), effort (number of trips), and catch (number of fish harvested or released) data were not available for 2001 and 2002.
[2]NA = not applicable because all Hawaii residents are considered coastal county residents
[3]Effort data (number of trips) for for-hire boat trips were not available and effort data were not available for 2002.
[4]In this table, '(1)' = 0-999 thousand fish and '1' = 1,000-1,499 thousand fish.
[5]Goatfishes include yellowstripe, yellowfin, pfulgers, bandtail, doublebar, diespot, whitesaddle, manybar, blue, and 'Goastfish famil/genus'
[6]Trevallys & other jacks includes bluefin trevally, giant trevally, bigeye trevally, black trevally, African pompano, greater amberjack, island jack, and other species in the jack family.
[7]Snappers include bluestip, blacktail, ruby, longtailed, pink, VonSiebolds, Binghams, green jobfish, ironjaw, and smalltooth jobfish.

### Hawaii's State Economy (% of national total)

| | With Imports | | | Without Imports | | |
|---|---|---|---|---|---|---|
| | Jobs | Sales | Value Added | Jobs.1 | Sales.1 | Value Added.1 |
| **Total Impacts** | 8,627 | 694,228 | 311,097 | 6,667 | 364,073 | 195,754 |
| Commercial Harvesters | 3,154 | 159,444 | 83,529 | 3,154 | 159,444 | 83,529 |
| Seafood Processors & Dealers | 509 | 44,786 | 22,865 | 366 | 32,350 | 16,516 |
| Importers | 964 | 265,307 | 80,877 | 0 | 0 | 0 |
| Seafood Wholesalers & Distributors | 476 | 45,551 | 21,253 | 277 | 26,518 | 12,372 |
| Retail | 3,523 | 179,139 | 102,574 | 2,869 | 145,761 | 83,337 |

### Seafood Sales & Processing - Nonemployer Firms (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Seafood product prep. & packaging | Firms | 7 | 9 | 11 | 5 | 11 | 10 | 9 | 7 | 9 |
| | Receipts | 1,566 | 1,034 | 1,309 | 409 | 1,011 | 1,023 | 1,020 | 713 | 1,020 |
| Seafood Sales, retail | Firms | 0 | 36 | 33 | 29 | 31 | 41 | 37 | 34 | 37 |
| | Receipts | ND[1] | 4,753 | 2,875 | 3,487 | 3,627 | 4,353 | 4,394 | 3,559 | 4,394 |

### Seafood Sales & Processing - Employer Establishments (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Seafood product prep. & packaging | Establishments | 4 | 4 | 4 | 3 | 3 | 1 | 1 | 1 | 1 |
| | Employees | 86 | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| | Payroll | 2,584 | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| Seafood sales, wholesale | Establishments | 44 | 33 | 36 | 32 | 33 | 36 | 37 | 38 | 37 |
| | Employees | 525 | 654 | 404 | 485 | 462 | 550 | 695 | 538 | 531 |
| | Payroll | 15,203 | 12,653 | 13,949 | 15,163 | 16,786 | 18,932 | 20,665 | 19,347 | 19,290 |
| Seafood sales, retail | Establishments | 29 | 31 | 31 | 29 | 27 | 25 | 25 | 25 | 24 |
| | Employees | 229 | 317 | 321 | 326 | 315 | 393 | 173 | 158 | 177 |
| | Payroll | 3,737 | 5,187 | 5,038 | 5,007 | 5,564 | 7,209 | 3,674 | 3,559 | 3,533 |

### Transport, Support, & Marine Operations - Employer Establishments (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal & Great Lakes freight transportation | Establishments | 11 | 10 | 11 | 13 | 13 | 11 | 5 | 5 | 2 |
| | Employees | ND[2] | ND[2] | ND[2] | ND[2] | 543 | 557 | 478 | 475 | ND[2] |
| | Payroll | ND[2] | ND[2] | ND[2] | ND[2] | 36,941 | 36,635 | 34,544 | 34,367 | ND[2] |
| Deep sea freight transportation | Establishments | 2 | 1 | NA[2] | NA[3] | NA[3] | NA[3] | 1 | NA[3] | 1 |
| | Employees | ND[2] | ND[2] | NA[3] | NA[3] | NA[3] | NA[3] | ND[2] | NA[3] | ND[2] |
| | Payroll | ND[2] | ND[2] | NA[3] | NA[3] | NA[3] | NA[3] | ND[2] | NA[3] | ND[2] |
| Deep sea passenger transportation | Establishments | 1 | 1 | 1 | 2 | 2 | 1 | 1 | 1 | 1 |
| | Employees | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| | Payroll | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| Marinas | Establishments | 8 | 11 | 11 | 10 | 9 | 11 | 9 | 10 | 13 |
| | Employees | 56 | 177 | 178 | 181 | 152 | 167 | 156 | 164 | 189 |
| | Payroll | 1,414 | 3,285 | 3,439 | 3,354 | 3,719 | 4,151 | 4,317 | 4,368 | 5,362 |
| Marine cargo handling | Establishments | 7 | 8 | 8 | 8 | 7 | 8 | 11 | 11 | 14 |
| | Employees | 756 | ND[2] | ND[2] | 694 | ND[2] | 1,048 | 1,098 | 1,075 | 1,236 |
| | Payroll | 49,975 | ND[2] | ND[2] | 53,061 | ND[2] | 87,770 | 89,104 | 87,833 | 109,059 |
| Navigational services to shipping | Establishments | 7 | 7 | 6 | 6 | 6 | 8 | 11 | 11 | 11 |
| | Employees | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | 105 | 120 | 90 |
| | Payroll | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | 3,340 | 5,846 | 5,258 | 5,113 |
| Port & harbor operations | Establishments | 2 | 2 | 2 | 2 | 2 | 2 | 4 | 3 | 2 |
| | Employees | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| | Payroll | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | 3,218 | 2,031 | ND[2] |
| Ship & boat building | Establishments | 16 | 14 | 17 | 16 | 14 | 13 | 14 | 13 | 15 |
| | Employees | ND[2] | 480 | 589 | ND[2] | 545 | ND[2] | ND[2] | ND[2] | ND[2] |
| | Payroll | ND[2] | 22,053 | 20,908 | ND[2] | 23,134 | ND[2] | ND[2] | ND[2] | ND[2] |

[1] ND = these data are confidential thus not disclosable
[2] NA = these data are not available

# New England

- Connecticut
- Maine
- Massachusetts
- New Hampshire
- Rhode Island

### Management Context

The New England Region includes Connecticut, Maine, Massachusetts, New Hampshire, and Rhode Island. Federal fisheries in this region are managed by the New England Fishery Management Council (NEFMC) and NOAA Fisheries (NMFS) under nine fishery management plans (FMPs). Two of these FMPs are developed in conjunction with the Mid-Atlantic Fisheries Management Council (MAFMC). The MAFMC is the lead Council for the Dogfish FMP and the NEFMC is the lead for the Monkfish FMP.

**New England Region FMPs**

1. Northeast multispecies
2. Sea scallops
3. Monkfish (with the MAFMC)
4. Atlantic herring
5. Small mesh multispecies
6. Spiny dogfish (with the MAFMC)
7. Red crab
8. Northeast skate complex
9. Atlantic salmon

Of the stocks or stock complexes covered in these fishery management plans, thirteen are currently listed as overfished: Atlantic cod (two stocks), Atlantic halibut, Atlantic salmon, Atlantic wolffish, ocean pout, thorny skate, white hake, windowpane, winter flounder, witch flounder, and yellowtail flounder (two stocks). Seven stocks or stock complexes are currently subject to overfishing: Atlantic cod (two stocks), haddock, white hake, windowpane, witch flounder, and yellowtail flounder.

Between 1990 and 1994, there was a 68% drop in total landings of sea scallop in the New England Region from 24 million pounds to 7.6 million pounds. Additionally, an Emergency Action was enacted in December 1994, which closed three large fishing grounds on the Northeast Continental Shelf to rebuild certain groundfish stocks, but which also affected a large percentage of the scallop biomass. Portions of these closed areas were reopened to scallop fishing in 1999, resulting in a total catch of 13.7 million pounds. Building on the success from the previous closure management system, Amendment 10 to the Atlantic Sea Scallop FMP was implemented in 2004, which uses rotational area management. Since that time, total landings have continued to increase, reaching a peak of 41 million pounds in 2006.

### Commercial Fisheries

In 2011, commercial fishermen in the New England Region landed 622 million pounds of finfish and shellfish, earning $1.1 billion in landings revenue. Landings revenue was dominated by American lobster ($419 million) and sea scallop ($353 million). These species groups commanded ex-vessel prices of $3.35 and $10.01 per pound, respectively and comprised 70% of total landings revenue, but only 26% of total landings in the New England Region.

Massachusetts had the highest landings revenue in the region with $565 million in 2011, followed by Maine ($425 million) and Rhode Island ($76 million). In terms of pounds landed, Maine contributed the most (270 million pounds), followed by Massachusetts (256 million pounds) and Rhode Island (77 million pounds).

*Economic Impacts*[1]

In 2011, the New England Region's seafood industry generated $740 million in sales impacts in Connecticut, $1.7 billion in sales impacts in Maine, $7.8 billion in sales impacts in Massachusetts, $766 million in sales impacts in New Hampshire, and $1 billion in sales impacts in Rhode Island. Massachusetts generated the largest impacts across the three other impact categories, generating 98,000 job, $2 billion in income, and $3.1 billion in value added impacts. The smallest income impacts were generated in Connecticut ($154 million) and the smallest employment impacts were also generated in Connecticut (4,500 jobs).

**Key New England Region Commercial Species**

- American lobster
- Atlantic herring
- Atlantic mackerel
- Bluefin tuna
- Cod and haddock
- Flounders
- Goosefish
- Quahog clam
- Sea scallop
- Squid

The sector that generated the greatest employment impacts by state was the retail sector with 60,000 employment impacts in Massachusetts and 13,000 employment impacts in Maine. The harvest sector in Maine generated 14,000 employment impacts. More sales impacts were generated by importers in Massachusetts than any other sector in any another state in the region at $4 billion and the greatest value added impacts were also generated by importers in Massachusetts ($1.2 billion).

*Landings Revenue*

Landings revenue in the New England Region totaled $1.1 billion in 2011. This was a 59% increase (a 11% increase in real terms) from 2002 levels ($696 million) and a 16% increase (a 6.8% increase in real terms) relative to 2010 ($958 million). Totaling $898 million in 2011, shellfish revenue experienced a 83% increase (a 27% increase in real terms) from 2002 to 2011 and experienced a 17% increase (8% increase in real terms) from 2010 to 2011.

In the New England Region, Massachusetts had the highest finfish landings revenue ($132 million), followed by Maine ($44 million), and Rhode Island ($25 million). Shellfish landings revenue was also dominated by Massachusetts, which contributed the most ($433 million) followed by Maine ($381 million), and Rhode Island ($51.4 million).

[1]The NMFS Commercial Fishing Industry Input/Output Model was used to generate the impact estimates (see NMFS Commercial Fishing & Seafood Industry Input/Output Model, available at: `www.st.nmfs.noaa.gov/documents/commercial_seafood_impacts_2007-2009.pdf`)

### Commercial Fisheries Facts

*Landings revenue*

- On average, between 2002 and 2011, the key species or species groups accounted for 85% of total revenue, generating $738 million in the New England Region.
- American lobster had higher landings revenues than any other species or species group, averaging $353 million in landings revenue from 2002 to 2011.
- Atlantic mackerel had the largest one-year increase in landings revenue over the 10 year time period, increasing 363% from $2.9 million in 2005 to $14 million in 2006.
- Atlantic mackerel had the largest one-year decrease in landings revenue over the 10 year time period, decreasing 92% from $3.5 million in 2010 to $269,000 in 2011.

*Landings*

- Key species or species groups contributed an average of 72% annually to total landings between 2002 and 2011.
- Atlantic herring contributed the most to landings in the region, averaging 179 million pounds from 2002 to 2011.
- Atlantic mackerel had the largest one-year increase in landings over the 10 year time period, increasing 1113% from 8.2 million in 2005 pounds to 100 million pounds in 2006.
- Atlantic mackerel had the largest one-year decrease in landings over the 10 year time period, decreasing 95% from 17 million pounds in 2010 to 888,000 pounds in 2011.

*Prices*

- Sea scallop had the highest average annual ex-vessel price per pound ($6.62) over the time period, followed by bluefin tuna ($6.26), and quahog clam ($4.99).
- Atlantic herring had the lowest average annual ex-vessel price per pound ($0.11) over the time period, followed by Atlantic mackerel ($0.18), and squid ($0.68).
- Atlantic mackerel had the largest one-year increase in ex-vessel price over the 10 year time period, increasing 200% from $0.12 per pound in 2004 to $0.36 in 2005.
- Atlantic mackerel had the largest decrease in ex-vessel price over the 10 year time period, decreasing 61% from $0.36 per pound in 2005 to $0.14 in 2006.

American lobster and sea scallop had the highest landings revenue in the New England Region in 2011, with $419 million and $353 million, respectively. Together they accounted for 70% of total landings revenue in 2011. Between 2002 and 2011, the landings revenue from these species experienced a 46% increase for American lobster and 222% increase for sea scallop.

From 2002 to 2011, species or species groups with large changes in landings revenue include Atlantic herring (increased 168%), Atlantic mackerel (decreased 93%), and quahog clam (decreased 52%). Species or species groups with large changes in landings revenue between 2010 and 2011 include Atlantic mackerel (92% decrease), squid (55% increase), and goosefish (41% increase).

*Landings*

Fishermen in the New England Region landed 622 million pounds of finfish and shellfish in 2011. This was a 5.7% increase from the 589 million pounds landed in 2002 and a 7.7% increase from the 578 million landed in 2010. Finfish landings contributed 57% of total landings in the New England Region (353 million pounds) in 2011. From 2010 to 2011, finfish landings experienced a 6.1% increase. Shellfish landings experienced a 10% increase from 245 million pounds in 2010 to 269 million in 2011 and a 33% increase from 202 million pounds in 2002. Atlantic herring and American lobster had the highest annual landings in the New England Region in 2011, with 171 million pounds and 125 million pounds, respectively. Together they accounted for 48% of the total landings in 2011. Atlantic herring landings increased 27% and American lobster landings increased 54% during this period.

From 2002 to 2011, species or species groups with large changes in landings include Atlantic mackerel (decreasing 97%), quahog clam (decreasing 74%), and goosefish (decreasing 65%). Species or species groups with large changes in landings between 2010 and 2011 include Atlantic mackerel (decreasing 95%), squid (increasing 28%), and cod and haddock (decreasing 23%).

*Prices*

The ex-vessel prices for the New England Region's key species and species groups in 2011 were higher than their 10 year average for nine of the key species (five of the species in real terms). Ex-vessel prices for sea scallop and atlantic mackerel experienced the biggest increases between 2002 and 2011, increasing 150% (74% in real terms) and 110% (49% in real terms), respectively. Relative to 2010 ex-vessel prices, New England's Atlantic mackerel experienced the greatest increase (50%, 38.3% in real terms) from $0.20 in 2010 to $0.30 in 2011. Flounders experienced the greatest price decrease between 2010 and 2011 decling from $1.91 to $1.72 (9.95%, 16.9% in real terms). Relative to ex-vessel prices in 2010, six species or species groups experienced increases, including Atlantic mackerel (50%), and cod & haddock (28%).

In Connecticut, the species or species group with the largest change in ex-vessel price from 2002 to 2011 was sea scallop (144% increase, 69% increase in real terms) from $4.05 to $9.87. The largest change in ex-vessel price experienced in Maine was for Atlantic herring (114% increase, 49% increase in real terms from $0.07 to $0.15 and in Massachusetts the largest change in ex-vessel price was experienced by clams, all other (192% increase, 102% increase in real terms) from $0.48 to $1.40.

### Recreational Fishing

In 2011, almost 1.3 million recreational anglers took 6.1 million fishing trips in the New England Region. Over 90% of these anglers were residents of a regional coastal county. Of the total fishing trips taken, 52% were taken from a private or rental boat and another 42% were shore-based. Atlantic mackerel was the most frequently caught species or species group with 5.9 million fish caught in 2011 and represented 30% of total fish caught in

[1] Expenditure estimates were generated from the 2011 National Marine Recreational Fishing Expenditure Survey. Economic impacts from recreational

the region. Of the Atlantic mackerel caught, 9.1% of them were released rather than harvested.

*Economic Impacts and Expenditures*[1]

The contribution of recreational fishing activities in the New England Region are reported in terms of economic impacts at the state level (employment, sales, income, and value added impacts) and expenditures on fishing trips and durable equipment at the regional level. Employment impacts in Massachusetts were the highest in the region with over 5,320 full- and part-time jobs generated by recreational fishing activities in the state. Rhode Island (1,300 jobs), and Connecticut (909 jobs), followed in terms of employment impacts.

**Key New England Region Recreational Species**

- Atlantic cod
- Atlantic mackerel
- Bluefin tuna
- Bluefish
- Little tunny
- Scup
- Striped bass
- Summer flounder
- Winter flounder
- Tautog

Overall, these employment impacts were generated by expenditures on recreational fishing trips taken by anglers (private or rental boat, for-hire boat, or shore-based trips) or expenditures on durable equipment. Throughout the New England Region, expenditures on durable equipment in 2011 generated more employment impacts than any other expenditure: 69% in Rhode Island, 64% in Connecticut, and 62% in Maine.

In addition to jobs, the contribution of recreational fishing activities to the New England Region's economy can be measured in terms of sales impacts and the contribution of these activities to gross domestic product (value added impacts). In 2011, sales impacts were the highest in Massachusetts ($726 million in sales impacts), followed by Rhode Island ($157 million), Connecticut ($129 million), Maine ($77 million), and New Hampshire ($41 million). In the same year, value added impacts were the highest in Massachusetts ($391 million in value added impacts), followed by Connecticut ($76 million), Rhode Island ($74 million), Maine ($39 million), and New Hampshire ($23 million).

Overall, there were $1.2 billion in expenditures on fishing trip and durable equipment expenditures across the New England Region in 2011. Approximately 74% of these expenditures were durable equipment purchases. The greatest expenditures were for boat expenses ($461 million), followed by fishing tackle ($236 million), vehicle expenses ($111 million), other equipment ($50 million), and second home expenses ($2 million). Fishing trip expenditures by New England's non-residents totaled almost $126 million, of which the greatest portion can be attributed to for-hire-based fishing trips ($56 million). Residents of the New England Region spent $178 million on saltwater fishing trips, with the most of these expenses related to private boat trips ($107 million).

**Recreational Fishing Facts**

*Participation*

- An average of 1.4 million anglers fished in the New England Region annually from 2002 to 2011.
- In 2011, coastal county residents made up 90% of total anglers in this region. These anglers averaged 88% of total anglers annually over the 10 year time period.
- The largest annual increase in the number of coastal anglers during the 10 year time period occurred between 2004 and 2005, increasing 17%, from 1.2 million anglers to 1.3 million anglers.
- The largest annual decrease during the same period for coastal anglers occurred between 2010 and 2011, decreasing 12%, from 1.3 million anglers to 1.2 million anglers.

*Fishing trips*

- In the New England Region, an average of 8.3 million fishing trips were taken annually from 2002 to 2011.
- Private or rental boat and shore-based fishing trips accounted for 3.2 million and 2.5 million fishing trips, respectively, in 2011. Together these made up 94% of the fishing trips taken in that year.
- The largest annual increase in the number of total trips taken annually over the 10 year time period occurred between 2004 and 2005, increasing 6.5%, from 8.6 million trips to 9.2 million trips.
- The largest annual decrease during the same period in total trips taken occurred between 2008 and 2009, decreasing 22%, from 9.1 million trips to 7.2 million trips.

*Harvest and release*

- Striped bass was the most commonly caught key species or species group, averaging 7.8 million fish over the 10 year time period. Of these, 92% were released rather than harvested.
- Of the ten commonly caught key species or species groups, seven were released more often than harvested over this time period.
- The species or species group that was most commonly released was little tunny (94% released).
- Atlantic mackerel (91% harvested), followed by winter flounder (60% harvested), and bluefin tuna (55% harvested) were key species or groups that experienced the greatest proportion of harvests rather than releases.

*Participation*

There were 1.3 million recreational anglers who fished in the New England Region in 2011. This was a 7.9% increase from 2002 (1.2 million anglers). These anglers were New England Region residents from either a coastal (1.2 million anglers) or non-coastal county (131,000 anglers). Almost 90% of total anglers in 2011 were residents of a coastal county. Coastal county angler participation in 2011 increased 8.1% relative to 2002 (1.1 million anglers) and decreased 12% between 2010 and 2011. Non-coastal county angler participation increased 5.7% relative to 2002 (124,000 anglers) and decreased 22% relative to 2010 (169,000 anglers).

fishing activities were generated using the NMFS Recreational Economic Impact Model (see The Economic Contribution of Marine Angler Expenditures in the United States, 2006, available at:http://www.st.nmfs.noaa.gov/economics/publications/marine-angler-expenditures/marine-angler-2006)

*Fishing Trips*

Recreational fishermen took 6.1 million fishing trips in New England Region in 2011. This was a 30% decrease from the 2002 (8.6 million trips) and was 1.2 million fewer trips than those taken in 2010. Approximately 52% of the saltwater trips were private or rental boat based (3.2 million trips). The other most popular mode of fishing was shore-based with 2.5 million trips in 2011.

*Harvest and Release*

The New England Region's species and species groups caught most frequently in 2011 were Atlantic mackerel (5.9 million fish), scup (4.7 million fish), bluefish (2.6 million fish), and striped bass (2.5 million fish) in 2011. Little tunny (100% released), tautog (83% released), summer flounder (82% released), striped bass (82% released), bluefish (75% released), bluefin tuna (71% released), Atlantic cod (63% released), and scup (51% released) were more often released rather than harvested.

Anglers harvested more often than released Atlantic mackerel (91% harvested) and winter flounder (63% harvested). In 2011, most of the striped bass were caught in Massachusetts (1.2 million fish) and Connecticut (676,000), making up 76% of the total catch. Atlantic mackerel were caught in large numbers in Maine and New Hampshire which represented 71% of the total catch of Atlantic mackerel in the New England Region. Between 2002 and 2011, eight of the New England Region's key species or species groups showed decreases in catch totals. Key species or groups with the largest decreases were striped bass (73%), tautog (49%), and summer flounder (24%).

## Marine Economy[1]

The sum of the gross domestic products by state for Connecticut, Maine, Massachusetts, New Hampshire, and Rhode Island was $760 billion in 2010. Employee compensation totaled $442 billion and annual payroll totaled $297 billion. These economic measures experienced increases of 31%, 27%, and 22% respectively, between 2002 and 2010, and experienced a 4% increase, a 2.3% increase, and a 2.5% increase, respectively, between 2009 and 2010. Approximately 366,000 establishments employed 5.8 million full- and part-time employees across the region in 2010. This was a 2.6% decrease in establishment numbers and a 3.7% decrease in employee numbers from 2002 to 2010.

In 2010, the commercial fishing location quotient (CFLQ) for Maine was the highest in the region at 14.24. This was an 60% increase from 2002 (the Bureau of Labor Statistics did not report a CFLQ value for Maine in 2009). Maine's CFLQ suggests that the level of employment in commercial fishing-related industries in this state is approximately 14 times higher than the level of employment in these industries nationwide. The 2010 CFLQ in Rhode Island was 2.27 (a 0.4% increase from 2002).

*Seafood Sales and Processing*

In 2010, there were 115 nonemployer firms engaged in seafood product preparation and packaging across the New England Region, a 24% increase from 2002 levels. Over the same time period, Massachusetts experienced a 4% increase. In 2010, 56% of these firms were located in Maine. Annual receipt totals experienced a 41% increase in Maine between 2002 and 2010. In contrast to the increase in nonemployer firms region-wide, the number of employer establishments engaged in seafood product preparation and packaging decreased 15% from 98 in 2002 to 86 in 2010. Approximately 51% of these establishments were located in Massachusetts in 2010.

There were 376 seafood wholesale establishments in 2010 that employed 3,244 full- and part-time workers. From 2009 to 2010, the number of seafood wholesale establishments increased 0.3% and the number of employees increased 2.3% in the New England Region.

Nonemployer firms engaged in seafood retail in the New England Region totaled 171 in 2010, a 12% decrease relative to 2002. Of these firms, 37% were located in Massachusetts. At the state level, these firms showed a 3.8% decrease in Connecticut and a 5% decrease in Rhode Island between 2002 and 2010. Annual receipts in the region totaled $20 million in 2010, a 13% decrease from 2002 (a 34% decrease in real terms) and a 18% increase from 2010 (a 13% increase in real terms). Employer establishments engaged in seafood retail decreased 2% from 2002 to 2010, totaling 240 in 2010. These establishments employed 1,179 workers. Almost 47% of these establishments were located in Massachusetts.

*Transport, Support, and Marine Operations*

For the sectors where information was available, marinas employed more people than any other industry in this sector, employing approximately 3,400 people in 2010. This industry also had the highest annual payroll in the region totaling $160 million. Marinas had the highest number of establishments (497), followed by the ship and boat building industries with 160 establishments and the navigational services to shipping industries with 38 establishments.

In Massachusetts, industries with large changes in establishment numbers, employees, or annual payroll from 2009 to 2010 were: navigational services to shipping (117% increase in payroll), navigational services to shipping (111% increase in employees), port and harbor operations (101% increase in payroll) and port and harbor operations (100% increase in establishments). In Maine, large changes were seen for marine cargo handling (33% decrease in establishments), coastal and Great Lakes freight transportation (27% increase in employees), navigational services to shipping (27% decrease in employees) and ship and boat building (9% decrease in establishments). In Connecticut, large changes were seen in the navigational services to shipping (65% decrease in payroll), port and harbor operations (63% decrease in payroll), deep sea freight transportation (35% decrease in payroll) and port and harbor operations (27% decrease in employees).

[1] Information for 2010 is reported in this section; 2011 data were not available for this report.

### 2011 Economic Impacts of the New England Region Seafood Industry (thousands of dollars)

| | With Imports | | | Without Imports | | |
|---|---|---|---|---|---|---|
| | Jobs | Sales | Valued Added | Jobs | Sales | Valued Added |
| Connecticut | 4,514 | 740,263 | 257,905 | 1,165 | 69,507 | 33,212 |
| Massachusetts | 98,358 | 7,754,140 | 3,090,449 | 63,078 | 2,376,805 | 1,196,219 |
| Maine | 31,127 | 1,734,058 | 829,833 | 29,844 | 1,543,494 | 762,644 |
| New Hampshire | 5,968 | 766,257 | 287,785 | 2,044 | 114,586 | 58,059 |
| Rhode Island | 9,157 | 1,024,748 | 397,018 | 4,642 | 269,101 | 136,313 |

### Total Landings Revenue and Landings Revenue of Key Species/Species Groups (thousands of dollars)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total revenue | 696,423 | 690,692 | 821,573 | 970,516 | 953,372 | 895,573 | 809,110 | 789,281 | 957,876 | 1,109,057 |
| Finfish & other | 207,082 | 200,351 | 194,911 | 200,751 | 184,219 | 178,831 | 190,251 | 177,947 | 190,723 | 211,139 |
| Shellfish | 489,341 | 490,341 | 626,662 | 769,765 | 769,153 | 716,742 | 618,859 | 611,334 | 767,153 | 897,918 |
| American lobster | 287,621 | 277,946 | 368,649 | 408,719 | 386,034 | 359,754 | 317,925 | 305,335 | 395,263 | 418,933 |
| Atlantic herring | 9,005 | 15,274 | 14,931 | 20,085 | 21,593 | 18,766 | 20,478 | 24,721 | 20,645 | 24,172 |
| Atlantic mackerel | 3,776 | 4,404 | 10,416 | 2,923 | 13,528 | 6,000 | 5,265 | 7,927 | 3,459 | 269 |
| Bluefin tuna | 14,349 | 8,267 | 4,297 | 3,864 | 1,715 | 2,077 | 2,993 | 4,450 | 8,470 | 9,258 |
| Cod & haddock | 49,679 | 44,386 | 40,089 | 39,824 | 31,885 | 39,317 | 47,166 | 38,733 | 49,707 | 48,779 |
| Flounders | 49,201 | 47,221 | 43,737 | 42,339 | 37,717 | 33,716 | 30,610 | 27,340 | 27,695 | 30,849 |
| Goosefish | 29,194 | 30,031 | 27,960 | 34,408 | 26,571 | 21,203 | 19,945 | 14,320 | 14,075 | 19,792 |
| Quahog clam | 17,193 | 16,857 | 16,721 | 6,707 | 26,811 | 30,027 | 8,902 | 9,004 | 9,632 | 8,315 |
| Sea scallop | 109,634 | 116,454 | 158,014 | 250,762 | 263,623 | 237,299 | 203,126 | 209,969 | 265,460 | 352,586 |
| Squid | 15,786 | 17,283 | 28,133 | 20,206 | 20,006 | 17,711 | 19,848 | 16,820 | 14,787 | 22,887 |

### Total Landings and Landings of Key Species/Species Groups (thousands of pounds)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total landings | 588,891 | 660,283 | 723,130 | 684,292 | 704,258 | 582,321 | 600,977 | 648,505 | 577,818 | 622,355 |
| Finfish & other | 387,327 | 468,511 | 487,785 | 461,038 | 466,873 | 368,813 | 388,225 | 421,926 | 333,201 | 353,371 |
| Shellfish | 201,564 | 191,772 | 235,345 | 223,254 | 237,385 | 213,508 | 212,752 | 226,579 | 244,617 | 268,984 |
| American lobster | 81,382 | 70,502 | 88,679 | 86,224 | 90,837 | 79,433 | 86,226 | 99,221 | 115,253 | 125,240 |
| Atlantic herring | 134,605 | 209,933 | 188,201 | 212,389 | 207,530 | 155,986 | 166,222 | 209,270 | 139,554 | 170,565 |
| Atlantic mackerel | 26,649 | 34,839 | 88,124 | 8,223 | 99,751 | 50,760 | 38,359 | 39,427 | 16,904 | 888 |
| Bluefin tuna | 2,386 | 1,787 | 704 | 837 | 274 | 300 | 447 | 772 | 1,201 | 1,085 |
| Cod & haddock | 45,469 | 38,482 | 34,158 | 30,500 | 19,810 | 24,848 | 33,109 | 32,463 | 39,261 | 30,108 |
| Flounders | 41,758 | 39,782 | 40,966 | 30,290 | 19,538 | 16,079 | 15,391 | 16,225 | 14,528 | 17,908 |
| Goosefish | 41,975 | 46,751 | 39,735 | 34,873 | 26,136 | 19,579 | 17,401 | 13,973 | 12,193 | 14,541 |
| Quahog clam | 6,116 | 5,173 | 6,231 | 1,088 | 4,216 | 4,630 | 1,468 | 1,628 | 1,786 | 1,602 |
| Sea scallop | 27,394 | 27,587 | 30,462 | 32,038 | 40,587 | 35,390 | 28,868 | 31,693 | 32,878 | 35,208 |
| Squid | 27,893 | 29,405 | 47,901 | 26,748 | 25,330 | 26,421 | 28,615 | 28,124 | 21,722 | 27,907 |

### Average Annual Price of Key Species/Species Groups (dollars per pound)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| American lobster | 3.53 | 3.94 | 4.16 | 4.74 | 4.25 | 4.53 | 3.69 | 3.08 | 3.43 | 3.35 |
| Atlantic herring | 0.07 | 0.07 | 0.08 | 0.09 | 0.10 | 0.12 | 0.12 | 0.12 | 0.15 | 0.14 |
| Atlantic mackerel | 0.14 | 0.13 | 0.12 | 0.36 | 0.14 | 0.12 | 0.14 | 0.20 | 0.20 | 0.30 |
| Bluefin tuna | 6.01 | 4.63 | 6.10 | 4.62 | 6.26 | 6.93 | 6.69 | 5.76 | 7.05 | 8.54 |
| Cod & haddock | 1.09 | 1.15 | 1.17 | 1.31 | 1.61 | 1.58 | 1.42 | 1.19 | 1.27 | 1.62 |
| Flounders | 1.18 | 1.19 | 1.07 | 1.40 | 1.93 | 2.10 | 1.99 | 1.69 | 1.91 | 1.72 |
| Goosefish | 0.70 | 0.64 | 0.70 | 0.99 | 1.02 | 1.08 | 1.15 | 1.02 | 1.15 | 1.36 |
| Quahog clam | 2.81 | 3.26 | 2.68 | 6.16 | 6.36 | 6.49 | 6.07 | 5.53 | 5.39 | 5.19 |
| Sea scallop | 4.00 | 4.22 | 5.19 | 7.83 | 6.50 | 6.71 | 7.04 | 6.63 | 8.07 | 10.01 |
| Squid | 0.57 | 0.59 | 0.59 | 0.76 | 0.79 | 0.67 | 0.69 | 0.60 | 0.68 | 0.82 |

### 2011 Economic Impacts of Recreational Fishing Expenditures (thousands of dollars)

| | Trips | Jobs | Sales | Income | Value Added |
|---|---|---|---|---|---|
| Connecticut | 1,307,000 | 909 | 128,921 | 48,613 | 75,685 |
| Massachusetts | 2,813,000 | 5,322 | 726,164 | 252,277 | 390,731 |
| Maine | 528,000 | 843 | 77,071 | 25,283 | 39,313 |
| New Hampshire | 294,000 | 376 | 41,005 | 14,177 | 22,614 |
| Rhode Island | 1,113,000 | 1,273 | 157,111 | 47,957 | 73,650 |

### 2011 Angler Trip & Durable Expenditures (thousands of dollars)

| Fishing Mode | Trip Expenditures | | Equipment | Durable Expenditures |
|---|---|---|---|---|
| | Non-Residents | Residents | Fishing Tackle | 236,216 |
| For-Hire | 55,917 | 23,910 | Other Equipment | 50,376 |
| Private Boat | 27,532 | 106,582 | Boat Expenses | 461,383 |
| Shore | 42,059 | 47,905 | Vehicle Expenses | 110,989 |
| *Total Trip Expenditures* | 125,509 | 178,399 | Second Home Expenses | 1,954 |
| | | | *Total Durable Equipment Expenditures* | 860,918 |
| **Total State Trip and Durable Equipment Expenditures** | | | | 1,164,826 |

### Recreational Anglers by Residential Area (thousands of anglers)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal | 1,069 | 1,198 | 1,155 | 1,349 | 1,408 | 1,408 | 1,389 | 1,222 | 1,317 | 1,156 |
| Non-Coastal | 124 | 152 | 165 | 169 | 188 | 205 | 187 | 165 | 169 | 131 |
| Out-of-State | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| **Total Anglers** | 1,194 | 1,349 | 1,319 | 1,518 | 1,596 | 1,614 | 1,576 | 1,387 | 1,486 | 1,288 |

### Recreational Fishing Effort by Mode (thousands of angler-trips)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| For-Hire | 235 | 318 | 331 | 417 | 455 | 517 | 511 | 463 | 321 | 364 |
| Private Boat | 4,511 | 4,425 | 4,371 | 5,060 | 4,650 | 4,821 | 4,892 | 3,374 | 3,968 | 3,160 |
| Shore | 3,844 | 3,835 | 3,934 | 3,719 | 4,107 | 3,950 | 3,735 | 3,322 | 2,926 | 2,531 |
| **Total Trips** | 8,590 | 8,578 | 8,636 | 9,196 | 9,212 | 9,288 | 9,138 | 7,159 | 7,215 | 6,055 |

### Harvest (H) and Release (R) of Key Species Species Groups (thousands of fish)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Atlantic cod | H | 644 | 704 | 421 | 486 | 203 | 305 | 385 | 391 | 508 | 531 |
| | R | 1,144 | 1,175 | 775 | 1,108 | 722 | 965 | 954 | 834 | 1,070 | 912 |
| Atlantic mackerel | H | 3,544 | 2,397 | 1,577 | 2,941 | 4,181 | 1,885 | 3,356 | 2,464 | 3,473 | 5,335 |
| | R | 363 | 212 | 172 | 62 | 559 | 116 | 453 | 343 | 379 | 533 |
| Bluefin tuna | H | 1 | 5 | 1 | 12 | 3 | 11 | 9 | 8 | 1 | 2 |
| | R | (1) | 4 | 4 | 8 | 7 | 10 | 1 | 5 | (1) | 5 |
| Bluefish | H | 1,167 | 1,189 | 1,228 | 1,202 | 1,647 | 1,514 | 1,458 | 672 | 1,185 | 660 |
| | R | 2,146 | 2,535 | 3,126 | 3,013 | 3,637 | 2,906 | 2,995 | 1,437 | 1,845 | 1,929 |
| Little tunny[2] | H | 6 | 4 | 9 | (1) | 1 | 5 | (1) | 1 | 2 | (1) |
| | R | 52 | 33 | 85 | 55 | 26 | 65 | 16 | 16 | 20 | 45 |
| Porgies (scup) | H | 2,461 | 4,179 | 5,204 | 1,595 | 1,429 | 3,049 | 1,944 | 1,498 | 2,411 | 2,287 |
| | R | 2,382 | 2,831 | 2,543 | 2,193 | 2,638 | 2,801 | 4,048 | 3,280 | 3,586 | 2,376 |
| Striped bass | H | 520 | 699 | 689 | 699 | 594 | 591 | 601 | 548 | 527 | 457 |
| | R | 8,575 | 6,760 | 7,251 | 9,940 | 14,092 | 8,365 | 7,715 | 4,165 | 2,771 | 2,038 |
| Summer flounder | H | 439 | 549 | 690 | 588 | 641 | 426 | 583 | 168 | 198 | 267 |
| | R | 1,558 | 1,068 | 895 | 1,418 | 2,851 | 1,044 | 2,112 | 907 | 819 | 1,252 |
| Winter flounder | H | 105 | 86 | 57 | 43 | 51 | 52 | 179 | 113 | 106 | 100 |
| | R | 73 | 39 | 35 | 41 | 46 | 43 | 70 | 101 | 86 | 59 |
| Wrasses (tautog) | H | 266 | 335 | 163 | 269 | 362 | 570 | 304 | 194 | 358 | 78 |
| | R | 637 | 668 | 367 | 597 | 639 | 1,425 | 515 | 394 | 560 | 384 |

[1]NA = data are not available because out-of-state resident information is collected for individual states but whether an angler is a resident of a region is not specified

[2]This species may not be equivalent to species with similar names listed in the commercial tables.

### 2011 Economic Impacts of the Connecticut Seafood Industry (thousands of dollars)

| | With Imports | | | Without Imports | | |
|---|---|---|---|---|---|---|
| | Jobs | Sales | Value Added | Jobs | Sales | Value Added |
| **Total Impacts** | 4,514 | 740,263 | 257,905 | 1,165 | 69,507 | 33,212 |
| Commercial Harvesters | 582 | 34,877 | 14,739 | 582 | 34,877 | 14,739 |
| Seafood Processors & Dealers | 185 | 19,152 | 9,455 | 72 | 7,549 | 3,727 |
| Importers | 2,071 | 569,579 | 173,633 | 0 | 0 | 0 |
| Seafood Wholesalers & Distributors | 296 | 47,773 | 21,010 | 23 | 3,669 | 1,613 |
| Retail | 1,381 | 68,881 | 39,069 | 489 | 23,412 | 13,133 |

### Total Landings Revenue and Landings Revenue of Key Species/Species Groups (thousands of dollars)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total revenue | 27,779 | 29,825 | 33,399 | 37,570 | 36,892 | 42,053 | 17,207 | 16,476 | 18,099 | 19,668 |
| Finfish & other | 4,283 | 4,136 | 4,575 | 5,097 | 3,731 | 3,421 | 3,988 | 3,757 | 5,898 | 4,646 |
| Shellfish | 23,496 | 25,690 | 28,825 | 32,474 | 33,161 | 38,632 | 13,219 | 12,719 | 12,201 | 15,022 |
| American lobster | 4,226 | 3,170 | 3,166 | 3,821 | 4,031 | 3,222 | 2,102 | 1,799 | 1,757 | 798 |
| Eastern oyster | 2,012 | 2,274 | 1,356 | ND[1] | 2,206 | 5,142 | ND[2] | ND[2] | ND[2] | ND[2] |
| Flounders | 909 | 896 | 1,075 | 1,170 | 1,026 | 881 | 802 | 756 | 892 | 1,036 |
| Goosefish | 790 | 683 | 580 | 658 | 346 | 512 | 551 | 591 | 572 | 976 |
| Hake | 1,307 | 1,602 | 2,028 | 2,432 | 1,628 | 1,232 | 1,619 | 1,354 | 1,417 | 1,705 |
| Quahog clam | 9,202 | 10,470 | 10,690 | ND[2] | 18,135 | 20,531 | ND[2] | ND[2] | ND[2] | ND[2] |
| Scups or Porgies | 195 | 167 | 191 | 263 | 302 | 311 | 384 | 363 | 271 | 406 |
| Sea scallop | 6,400 | 8,125 | 11,203 | 9,761 | 7,229 | 8,605 | 10,032 | 9,737 | 9,458 | 13,007 |
| Snails (conchs) | 199 | 119 | 209 | 233 | 533 | 312 | 35 | 53 | ND[2] | ND[2] |
| Squid, loligo | 1,178 | 1,400 | 1,298 | 1,224 | 954 | 744 | 546 | 384 | 473 | 694 |

### Total Landings and Landings of Key Species/Species Groups (thousands of pounds)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total landings | 16,177 | 16,420 | 18,192 | 13,628 | 11,747 | 10,050 | 7,115 | 7,951 | 6,623 | 7,078 |
| Finfish & other | 7,799 | 7,825 | 6,832 | 6,548 | 5,807 | 3,931 | 4,537 | 5,390 | 4,458 | 4,997 |
| Shellfish | 8,378 | 8,595 | 11,359 | 7,080 | 5,940 | 6,119 | 2,578 | 2,561 | 2,165 | 2,080 |
| American lobster | 1,067 | 671 | 647 | 714 | 793 | 569 | 426 | 447 | 396 | 159 |
| Eastern oyster | 247 | 279 | 186 | ND[2] | 77 | 193 | ND[2] | ND[2] | ND[2] | ND[2] |
| Flounders | 633 | 565 | 637 | 582 | 456 | 345 | 282 | 312 | 334 | 428 |
| Goosefish | 1,029 | 1,023 | 897 | 524 | 496 | 460 | 409 | 546 | 358 | 630 |
| Hake | 2,904 | 2,875 | 2,936 | 3,735 | 2,632 | 1,839 | 2,465 | 2,492 | 2,151 | 2,199 |
| Quahog clam | 3,435 | 4,038 | 5,137 | ND[2] | 2,665 | 3,067 | ND[2] | ND[2] | ND[2] | ND[2] |
| Scups or Porgies | 314 | 292 | 256 | 328 | 298 | 256 | 282 | 346 | 324 | 643 |
| Sea scallop | 1,579 | 1,908 | 2,172 | 1,272 | 1,104 | 1,313 | 1,407 | 1,475 | 1,260 | 1,318 |
| Snails (conchs) | 128 | 70 | 31 | 50 | 101 | 117 | 47 | 34 | ND[2] | ND[2] |
| Squid, loligo | 1,778 | 1,572 | 1,699 | 1,537 | 1,157 | 811 | 523 | 366 | 366 | 498 |

### Average Annual Price of Key Species/Species Groups (dollars per pound)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| American lobster | 3.96 | 4.72 | 4.89 | 5.35 | 5.08 | 5.67 | 4.93 | 4.03 | 4.43 | 5.00 |
| Eastern oyster | 8.16 | 8.14 | 7.30 | ND[2] | 28.61 | 26.64 | ND[2] | ND[2] | ND[2] | ND[2] |
| Flounders | 1.44 | 1.59 | 1.69 | 2.01 | 2.25 | 2.55 | 2.84 | 2.42 | 2.67 | 2.42 |
| Goosefish | 0.77 | 0.67 | 0.65 | 1.26 | 0.70 | 1.11 | 1.35 | 1.08 | 1.60 | 1.55 |
| Hake | 0.45 | 0.56 | 0.69 | 0.65 | 0.62 | 0.67 | 0.66 | 0.54 | 0.66 | 0.78 |
| Quahog clam | 2.68 | 2.59 | 2.08 | ND[2] | 6.80 | 6.69 | ND[2] | ND[2] | ND[2] | ND[2] |
| Scups or Porgies | 0.62 | 0.57 | 0.75 | 0.80 | 1.01 | 1.22 | 1.36 | 1.05 | 0.84 | 0.63 |
| Sea scallop | 4.05 | 4.26 | 5.16 | 7.67 | 6.55 | 6.55 | 7.13 | 6.60 | 7.51 | 9.87 |
| Snails (conchs) | 1.55 | 1.69 | 6.69 | 4.66 | 5.28 | 2.66 | 0.75 | 1.55 | ND[2] | ND[2] |
| Squid, loligo | 0.66 | 0.89 | 0.76 | 0.80 | 0.82 | 0.92 | 1.04 | 1.05 | 1.29 | 1.39 |

[1] ND = these data are confidential thus not disclosable

### 2011 Economic Impacts of Recreational Fishing Expenditures (thousands of dollars)

| | Jobs | Sales | Income | Value Added |
|---|---|---|---|---|
| Trip Impacts by Fishing Mode: | | | | |
| For-Hire | 99 | 10,288 | 3,647 | 6,358 |
| Private Boat | 183 | 23,248 | 8,475 | 14,603 |
| Shore | 44 | 4,909 | 1,819 | 3,038 |
| Total Durable Equipment Impacts | 583 | 90,477 | 34,671 | 51,686 |
| **Total State Trip and Durable Equipment Economic Impacts** | 909 | 128,921 | 48,613 | 75,685 |

### 2011 Angler Trip & Durable Expenditures (thousands of dollars)

| Fishing Mode | Trip Expenditures | | Equipment | Durable Expenditures |
|---|---|---|---|---|
| | Non-Residents | Residents | Fishing Tackle | 16,020 |
| For-Hire | 1,523 | 5,379 | Other Equipment | 3,105 |
| Private Boat | 2,556 | 21,195 | Boat Expenses | 71,546 |
| Shore | 158 | 4,874 | Vehicle Expenses | 0 |
| *Total Trip Expenditures* | 4,236 | 31,448 | Second Home Expenses | 0 |
| | | | *Total Durable Equipment Expenditures* | 90,671 |
| **Total State Trip and Durable Equipment Expenditures** | | | | 126,355 |

### Recreational Anglers by Residential Area (thousands of anglers)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal | 283 | 361 | 297 | 323 | 336 | 302 | 381 | 438 | 402 | 420 |
| Non-Coastal | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| Out of State | 87 | 112 | 63 | 77 | 44 | 61 | 123 | 93 | 112 | 98 |
| **Total Anglers** | 371 | 473 | 359 | 400 | 380 | 363 | 504 | 531 | 514 | 518 |

### Recreational Fishing Effort by Mode (thousands of angler-trips)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| For-Hire | 51 | 64 | 31 | 34 | 50 | 63 | 73 | 43 | 40 | 45 |
| Private | 954 | 875 | 956 | 1,174 | 868 | 1,097 | 1,292 | 711 | 871 | 863 |
| Shore | 645 | 625 | 573 | 485 | 571 | 559 | 608 | 665 | 614 | 399 |
| **Total Trips** | 1,650 | 1,564 | 1,560 | 1,693 | 1,489 | 1,719 | 1,973 | 1,419 | 1,525 | 1,307 |

### Harvest (H) and Release (R) of Key Species Species Groups (thousands of fish)[2]

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Atlantic cod | H | (1) | 2 | (1) | (1) | (1) | (1) | (1) | (1) | (1) | (1) |
| | R | (1) | (1) | (1) | (1) | (1) | (1) | (1) | (1) | (1) | (1) |
| Bluefish | H | 569 | 458 | 589 | 248 | 507 | 452 | 624 | 261 | 592 | 308 |
| | R | 662 | 542 | 979 | 576 | 1,167 | 888 | 1,144 | 296 | 715 | 997 |
| Hickory shad | H | 71 | 71 | 12 | 54 | 63 | 36 | (1) | (1) | 1 | 16 |
| | R | 377 | 79 | 21 | 32 | 144 | 4 | 5 | (1) | (1) | (1) |
| Little tunny[3] | H | (1) | 1 | (1) | (1) | (1) | (1) | (1) | (1) | 1 | (1) |
| | R | 28 | 8 | 3 | (1) | (1) | 1 | (1) | 9 | 8 | 15 |
| Porgies (scup) | H | 882 | 1,528 | 1,071 | 508 | 533 | 926 | 549 | 288 | 1,088 | 933 |
| | R | 569 | 804 | 539 | 753 | 740 | 1,005 | 974 | 1,204 | 1,192 | 538 |
| Striped bass | H | 51 | 96 | 103 | 141 | 115 | 118 | 108 | 61 | 92 | 64 |
| | R | 697 | 843 | 826 | 1,762 | 987 | 984 | 3,105 | 1,161 | 671 | 612 |
| Summer flounder | H | 93 | 166 | 216 | 157 | 137 | 112 | 146 | 45 | 35 | 47 |
| | R | 453 | 474 | 269 | 779 | 1,111 | 297 | 991 | 428 | 373 | 345 |
| White perch | H | 1 | 11 | (1) | (1) | (1) | (1) | 7 | 60 | (1) | (1) |
| | R | 27 | 28 | 11 | (1) | 15 | 18 | 52 | 72 | (1) | (1) |
| Winter flounder | H | 16 | 24 | 4 | 3 | (1) | (1) | (1) | 12 | 15 | 19 |
| | R | 9 | 5 | 14 | (1) | 22 | 15 | (1) | 7 | 12 | (1) |
| Wrasses (tautog) | H | 101 | 168 | 17 | 36 | 201 | 353 | 167 | 86 | 116 | 26 |
| | R | 219 | 283 | 77 | 149 | 107 | 744 | 250 | 112 | 256 | 36 |

[1]NA = not applicable because all Connecticut residents are considered coastal county residents
[2]In this table, '(1)' = 0-999 thousand fish and '1' = 1,000-1,499 thousand fish.
[3]This species may not be equivalent to species with similar names listed in the commercial tables.

### Connecticut's State Economy (% of national total)

| | Establishments | Employees | Annual Payroll (million $) | Employee Compensation (million $) | Gross State Product (million $) | Commercial Location Quotient [1] |
|---|---|---|---|---|---|---|
| 2002 | 92,375 (1.3%) | 1,555,595 (1.4%) | 68,478 (1.7%) | 97,062 (1.6%) | 168,865 (1.6%) | 0.49 |
| 2010 | 89,234 (1.2%) | 1,436,992 (1.3%) | 79,919 (1.6%) | 120,921 (1.5%) | 221,347 (1.5%) | ND[2] |
| % change | -3.4% | -7.62% | 16.7% | 24.6% | 31.1% | NA[3] |

### Seafood Sales & Processing - Nonemployer Firms (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Seafood product prep. & packaging | Firms | 0 | 7 | 7 | 7 | 11 | 0 | 18 | 16 | 18 |
| | Receipts | ND[2] | 1,022 | 1,404 | 551 | 3,206 | ND[2] | 2,375 | 2,331 | 2,375 |
| Seafood Sales, retail | Firms | 26 | 26 | 25 | 24 | 15 | 26 | 25 | 23 | 25 |
| | Receipts | 3,225 | 2,966 | 3,115 | 3,313 | 2,915 | 4,436 | 3,247 | 2,139 | 3,247 |

### Seafood Sales & Processing - Employer Establishments (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Seafood product prep. & packaging | Establishments | 2 | 2 | 3 | 3 | 4 | 3 | 3 | 2 | 2 |
| | Employees | ND[2] | ND[2] | ND[2] | 113 | 119 | ND[2] | 59 | ND[2] | ND[2] |
| | Payroll | ND[2] | ND[2] | ND[2] | 3,656 | 4,242 | ND[2] | 1,040 | ND[2] | ND[2] |
| Seafood sales, wholesale | Establishments | 28 | 19 | 19 | 17 | 19 | 20 | 24 | 25 | 23 |
| | Employees | ND[2] | 169 | 181 | ND[2] | ND[2] | 183 | 185 | 212 | 216 |
| | Payroll | ND[2] | 7,738 | 7,688 | ND[2] | ND[2] | 8,347 | 8,551 | 8,842 | 9,219 |
| Seafood sales, retail | Establishments | 36 | 34 | 38 | 39 | 35 | 36 | 35 | 36 | 39 |
| | Employees | 165 | 206 | 202 | 187 | 196 | 177 | 203 | 205 | 204 |
| | Payroll | 3,859 | 5,110 | 5,060 | 5,028 | 4,937 | 5,252 | 5,248 | 5,551 | 5,563 |

### Transport, Support, & Marine Operations - Employer Establishments (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal & Great Lakes freight transportation | Establishments | 5 | 6 | 5 | 5 | 4 | 4 | 5 | 5 | 6 |
| | Employees | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| | Payroll | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | 8,148 |
| Deep sea freight transportation | Establishments | 11 | 12 | 13 | 11 | 14 | 14 | 12 | 12 | 10 |
| | Employees | 238 | 270 | 260 | 310 | 235 | 228 | 243 | 222 | 225 |
| | Payroll | 18,271 | 29,086 | 37,013 | 36,766 | 47,845 | 48,110 | 46,595 | 45,045 | 29,407 |
| Deep sea passenger transportation | Establishments | 2 | 2 | 2 | 2 | 1 | 2 | 1 | 1 | 1 |
| | Employees | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| | Payroll | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| Marinas | Establishments | 108 | 116 | 117 | 117 | 119 | 124 | 125 | 126 | 129 |
| | Employees | 722 | 1,006 | 1,016 | 994 | 1,024 | 1,224 | 1,352 | 1,261 | 1,284 |
| | Payroll | 29,690 | 39,691 | 41,952 | 42,754 | 44,829 | 50,809 | 60,016 | 58,065 | 58,877 |
| Marine cargo handling | Establishments | 1 | NA[3] | 1 | 3 | 3 | 5 | 4 | 3 | 3 |
| | Employees | ND[2] | NA[3] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| | Payroll | ND[2] | NA[3] | ND[2] | ND[2] | ND[2] | 5,925 | ND[2] | ND[2] | ND[2] |
| Navigational services to shipping | Establishments | 8 | 6 | 6 | 8 | 9 | 6 | 6 | 6 | 6 |
| | Employees | ND[2] | ND[2] | ND[2] | 45 | 69 | ND[2] | ND[2] | 5 | ND[2] |
| | Payroll | ND[2] | ND[2] | ND[2] | 1,768 | 2,423 | 432 | 338 | 696 | 242 |
| Port & harbor operations | Establishments | 5 | 4 | 4 | 4 | 4 | 4 | 8 | 8 | 6 |
| | Employees | 185 | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | 179 | 166 | 122 |
| | Payroll | 5,527 | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | 6,136 | 5,787 | 2,162 |
| Ship & boat building | Establishments | 12 | 14 | 17 | 17 | 17 | 22 | 15 | 13 | 12 |
| | Employees | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| | Payroll | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |

[1] The U.S. Commercial Fishing Location Quotient (CFLQ) of 1.0 represents the national baseline from which state CFLQs can be compared.
[2] ND = these data are confidential thus not disclosable
[3] NA = these data are not available

### 2011 Economic Impacts of the Maine Seafood Industry (thousands of dollars)

| | With Imports | | | Without Imports | | |
|---|---|---|---|---|---|---|
| | Jobs | Sales | Value Added | Jobs | Sales | Value Added |
| **Total Impacts** | 31,127 | 1,734,058 | 829,833 | 29,844 | 1,543,494 | 762,644 |
| Commercial Harvesters | 14,020 | 815,274 | 364,618 | 14,020 | 815,274 | 364,618 |
| Seafood Processors & Dealers | 2,337 | 164,767 | 84,528 | 2,133 | 150,540 | 77,229 |
| Importers | 541 | 148,725 | 45,338 | 0 | 0 | 0 |
| Seafood Wholesalers & Distributors | 958 | 92,400 | 43,130 | 839 | 80,928 | 37,775 |
| Retail | 13,271 | 512,892 | 292,219 | 12,852 | 496,752 | 283,022 |

### Total Landings Revenue and Landings Revenue of Key Species/Species Groups (thousands of dollars)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total revenue | 290,315 | 287,049 | 367,459 | 392,122 | 361,920 | 344,018 | 308,211 | 292,465 | 377,821 | 424,712 |
| Finfish & other | 47,489 | 49,292 | 48,904 | 47,141 | 37,084 | 36,827 | 36,440 | 30,343 | 30,115 | 43,700 |
| Shellfish | 242,826 | 237,757 | 318,555 | 344,982 | 324,836 | 307,191 | 271,771 | 262,122 | 347,706 | 381,012 |
| American lobster | 210,950 | 205,715 | 289,079 | 317,948 | 297,143 | 280,634 | 245,146 | 237,673 | 315,875 | 334,183 |
| Atlantic herring | 4,618 | 7,296 | 76 | 56 | 29 | 9,170 | 8,374 | 7,868 | 8,632 | 14,261 |
| Bloodworms | 5,759 | 5,292 | 7,524 | 6,039 | 5,037 | 6,051 | 5,913 | 6,197 | 5,874 | 5,845 |
| Blue mussel | 4,117 | 4,487 | 3,319 | 2,625 | 2,618 | 1,934 | 1,627 | 2,203 | 2,071 | 1,940 |
| Cod & haddock | 5,944 | 4,673 | 5,392 | 5,177 | 3,982 | 3,728 | 5,257 | 1,751 | 1,528 | 1,671 |
| Goosefish | 6,248 | 7,852 | 6,828 | 6,232 | 3,238 | 2,402 | 1,478 | 525 | 393 | 579 |
| Ocean quahog clam | 4,748 | 4,480 | 3,842 | 3,607 | 3,919 | 3,194 | 2,195 | 1,821 | 1,721 | 7,524 |
| Pollock | 2,386 | 2,206 | 2,346 | 3,106 | 2,309 | 2,160 | 2,321 | 2,045 | 1,502 | 1,953 |
| Sea Urchins | 7,657 | 8,569 | 7,866 | 5,142 | 3,693 | 4,367 | 5,410 | 5,866 | 5,490 | 5,113 |
| Softshell clam | 14,370 | 15,859 | 16,628 | 14,081 | 13,163 | 12,574 | 12,826 | 11,686 | 12,959 | 15,692 |

### Total Landings and Landings of Key Species/Species Groups (thousands of pounds)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total landings | 202,483 | 223,533 | 228,502 | 214,514 | 217,659 | 184,233 | 185,242 | 186,858 | 199,063 | 269,923 |
| Finfish & other | 113,132 | 141,621 | 130,368 | 121,278 | 121,268 | 91,638 | 86,440 | 80,878 | 78,370 | 121,673 |
| Shellfish | 89,351 | 81,912 | 98,134 | 93,236 | 96,391 | 92,595 | 98,801 | 105,979 | 120,694 | 148,250 |
| American lobster | 63,626 | 54,971 | 71,574 | 68,730 | 72,662 | 63,959 | 69,863 | 81,176 | 95,506 | 104,693 |
| Atlantic herring | 67,169 | 96,681 | 911 | 558 | 258 | 72,726 | 66,277 | 63,084 | 56,522 | 95,806 |
| Bloodworms | 683 | 594 | 615 | 456 | 450 | 549 | 537 | 574 | 533 | 526 |
| Blue mussel | 4,793 | 4,287 | 4,102 | 3,357 | 2,897 | 2,643 | 2,289 | 2,760 | 2,582 | 2,804 |
| Cod & haddock | 5,172 | 3,860 | 4,588 | 4,045 | 2,448 | 2,345 | 2,455 | 1,401 | 876 | 845 |
| Goosefish | 11,127 | 13,291 | 10,552 | 7,130 | 3,666 | 2,376 | 1,178 | 601 | 404 | 533 |
| Ocean quahog clam | 1,287 | 1,194 | 1,013 | 1,001 | 1,214 | 1,011 | 669 | 556 | 549 | 10,636 |
| Pollock | 2,958 | 4,085 | 4,189 | 5,260 | 3,678 | 4,245 | 4,064 | 3,039 | 1,640 | 2,359 |
| Sea Urchins | 6,321 | 5,963 | 5,742 | 3,517 | 2,800 | 2,761 | 2,900 | 3,487 | 2,592 | 2,407 |
| Softshell clam | 2,423 | 2,364 | 2,380 | 1,857 | 1,868 | 1,948 | 1,998 | 1,902 | 2,076 | 2,341 |

### Average Annual Price of Key Species/Species Groups (dollars per pound)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| American lobster | 3.32 | 3.74 | 4.04 | 4.63 | 4.09 | 4.39 | 3.51 | 2.93 | 3.31 | 3.19 |
| Atlantic herring | 0.07 | 0.08 | 0.08 | 0.10 | 0.11 | 0.13 | 0.13 | 0.12 | 0.15 | 0.15 |
| Bloodworms | 8.43 | 8.91 | 12.24 | 13.24 | 11.20 | 11.02 | 11.01 | 10.79 | 11.03 | 11.12 |
| Blue mussel | 0.86 | 1.05 | 0.81 | 0.78 | 0.90 | 0.73 | 0.71 | 0.80 | 0.80 | 0.69 |
| Cod & haddock | 1.15 | 1.21 | 1.18 | 1.28 | 1.63 | 1.59 | 2.14 | 1.25 | 1.74 | 1.98 |
| Goosefish | 0.56 | 0.59 | 0.65 | 0.87 | 0.88 | 1.01 | 1.26 | 0.87 | 0.97 | 1.09 |
| Ocean quahog clam | 3.69 | 3.75 | 3.79 | 3.60 | 3.23 | 3.16 | 3.28 | 3.27 | 3.13 | 0.71 |
| Pollock | 0.81 | 0.54 | 0.56 | 0.59 | 0.63 | 0.51 | 0.57 | 0.67 | 0.92 | 0.83 |
| Sea Urchins | 1.21 | 1.44 | 1.37 | 1.46 | 1.32 | 1.58 | 1.87 | 1.68 | 2.12 | 2.12 |
| Softshell clam | 5.93 | 6.71 | 6.99 | 7.58 | 7.05 | 6.46 | 6.42 | 6.14 | 6.24 | 6.70 |

### 2011 Economic Impacts of Recreational Fishing Expenditures (thousands of dollars)

| | Jobs | Sales | Income | Value Added |
|---|---|---|---|---|
| Trip Impacts by Fishing Mode: | | | | |
| For-Hire | 106 | 7,784 | 2,543 | 4,399 |
| Private Boat | 76 | 6,460 | 2,229 | 3,814 |
| Shore | 139 | 9,959 | 3,257 | 5,489 |
| Total Durable Equipment Impacts | 521 | 52,867 | 17,254 | 25,612 |
| **Total State Trip and Durable Equipment Economic Impacts** | 843 | 77,071 | 25,283 | 39,313 |

### 2011 Angler Trip & Durable Expenditures (thousands of dollars)

| Fishing Mode | Trip Expenditures | | Equipment | Durable Expenditures |
|---|---|---|---|---|
| | Non-Residents | Residents | Fishing Tackle | 18,165 |
| For-Hire | 4,671 | 901 | Other Equipment | 4,452 |
| Private Boat | 2,177 | 4,271 | Boat Expenses | 52,608 |
| Shore | 5,697 | 1,606 | Vehicle Expenses | 0 |
| *Total Trip Expenditures* | 12,546 | 6,779 | Second Home Expenses | 40 |
| | | | *Total Durable Equipment Expenditures* | 75,264 |
| **Total State Trip and Durable Equipment Expenditures** | | | | 94,589 |

### Recreational Anglers by Residential Area (thousands of anglers)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal | 127 | 165 | 113 | 190 | 182 | 174 | 121 | 117 | 122 | 85 |
| Non-Coastal | 17 | 23 | 21 | 20 | 22 | 13 | 9 | 12 | 9 | 7 |
| Out of State | 172 | 170 | 148 | 173 | 285 | 260 | 180 | 324 | 159 | 107 |
| **Total Anglers** | 316 | 358 | 282 | 383 | 489 | 447 | 310 | 453 | 290 | 198 |

### Recreational Fishing Effort by Mode (thousands of angler-trips)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| For-Hire | 13 | 14 | 19 | 39 | 31 | 33 | 25 | 26 | 23 | 22 |
| Private | 421 | 410 | 338 | 520 | 547 | 460 | 408 | 333 | 327 | 265 |
| Shore | 471 | 496 | 420 | 523 | 497 | 530 | 421 | 544 | 367 | 241 |
| **Total Trips** | 905 | 920 | 777 | 1,082 | 1,075 | 1,023 | 854 | 903 | 717 | 528 |

### Harvest (H) and Release (R) of Key Species Species Groups (thousands of fish)[1]

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| American Shad | H | (1) | (1) | (1) | (1) | 1 | (1) | (1) | (1) | (1) | (1) |
| | R | (1) | 1 | 2 | (1) | 7 | 4 | 5 | 19 | 9 | 5 |
| Atlantic cod | H | 15 | 11 | 5 | 29 | 14 | 19 | 41 | 46 | 14 | 40 |
| | R | 16 | 26 | 19 | 37 | 49 | 72 | 50 | 36 | 44 | 99 |
| Atlantic mackerel | H | 1,207 | 615 | 1,022 | 607 | 450 | 806 | 836 | 1,111 | 1,094 | 1,544 |
| | R | 234 | 105 | 87 | 29 | 103 | 80 | 265 | 194 | 177 | 304 |
| Blue shark | H | (1) | (1) | (1) | (1) | (1) | (1) | (1) | (1) | (1) | (1) |
| | R | (1) | (1) | (1) | (1) | (1) | (1) | (1) | 1 | (1) | 10 |
| Bluefin tuna | H | (1) | (1) | (1) | (1) | (1) | (1) | (1) | (1) | (1) | (1) |
| | R | (1) | (1) | (1) | (1) | (1) | (1) | (1) | (1) | (1) | (1) |
| Bluefish | H | 24 | 14 | 16 | 38 | 8 | 50 | 30 | 3 | 14 | (1) |
| | R | 42 | 23 | 42 | 49 | 49 | 74 | 55 | 26 | 9 | 7 |
| Haddock | H | 3 | 1 | 4 | 6 | 9 | 13 | 19 | 11 | 3 | 12 |
| | R | 4 | 3 | 2 | 2 | 4 | 10 | 2 | 2 | 3 | 4 |
| Pollock | H | 76 | 10 | 59 | 28 | 66 | 51 | 68 | 62 | 59 | 57 |
| | R | 47 | 18 | 56 | 32 | 23 | 24 | 135 | 34 | 105 | 134 |
| Striped bass | H | 71 | 58 | 49 | 83 | 75 | 54 | 58 | 62 | 17 | 18 |
| | R | 1,391 | 847 | 694 | 2,985 | 4,001 | 1,115 | 465 | 264 | 193 | 143 |
| Winter flounder | H | (1) | (1) | (1) | (1) | (1) | (1) | (1) | (1) | (1) | (1) |
| | R | (1) | 1 | (1) | (1) | 1 | (1) | 1 | 5 | (1) | (1) |

[1] In this table, '(1)' = 0-999 thousand fish and '1' = 1,000-1,499 thousand fish.

### Maine's State Economy (% of national total)

| | Establishments | Employees | Annual Payroll (million $) | Employee Compensation (million $) | Gross State Product (million $) | Commercial Location Quotient [1] |
|---|---|---|---|---|---|---|
| 2002 | 40,292 (0.56%) | 486,766 (0.43%) | 14,375 (0.36%) | 23,508 (0.38%) | 39,989 (0.39%) | 8.88 |
| 2010 | 40,571 (0.55%) | 480,932 (0.43%) | 17,279 (0.35%) | 29,610 (0.35%) | 50,674 (0.37%) | 14.2 |
| % change | 0.692% | -1.2% | 20.2% | 26% | 26.7% | 49.2% |

### Seafood Sales & Processing - Nonemployer Firms (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Seafood product prep. & packaging | Firms | 50 | 62 | 57 | 52 | 54 | 65 | 64 | 63 | 64 |
| | Receipts | 3,023 | 4,699 | 5,642 | 5,082 | 6,463 | 7,177 | 4,261 | 6,642 | 4,261 |
| Seafood Sales, retail | Firms | 62 | 60 | 55 | 51 | 45 | 55 | 46 | 46 | 46 |
| | Receipts | 8,980 | 8,365 | 8,621 | 7,331 | 7,115 | 5,905 | 4,035 | 3,212 | 4,035 |

### Seafood Sales & Processing - Employer Establishments (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Seafood product prep. & packaging | Establishments | 33 | 35 | 28 | 27 | 27 | 27 | 29 | 25 | 27 |
| | Employees | 639 | 656 | 576 | 614 | 616 | 536 | 490 | 545 | 594 |
| | Payroll | 11,301 | 13,999 | 19,767 | 12,349 | 12,304 | 9,351 | 9,288 | 10,427 | 12,851 |
| Seafood sales, wholesale | Establishments | 190 | 181 | 177 | 177 | 167 | 170 | 168 | 164 | 164 |
| | Employees | 1,256 | 985 | 1,048 | 1,152 | 996 | 1,015 | 1,210 | 1,126 | 1,153 |
| | Payroll | 36,043 | 29,643 | 30,108 | 30,513 | 32,192 | 32,005 | 36,185 | 37,687 | 39,915 |
| Seafood sales, retail | Establishments | 47 | 51 | 50 | 49 | 55 | 50 | 45 | 49 | 51 |
| | Employees | 173 | 181 | 189 | 184 | 179 | 181 | 148 | 152 | 176 |
| | Payroll | 3,971 | 4,663 | 5,112 | 4,678 | 4,753 | 4,635 | 4,148 | 4,481 | 5,126 |

### Transport, Support, & Marine Operations - Employer Establishments (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal & Great Lakes freight transportation | Establishments | 4 | 5 | 4 | 3 | 3 | 3 | 5 | 4 | 4 |
| | Employees | 30 | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | 22 | 28 |
| | Payroll | 939 | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | 1,058 | 1,037 | 1,067 |
| Deep sea freight transportation | Establishments | 3 | 2 | 2 | 1 | 1 | NA[3] | 1 | 1 | 1 |
| | Employees | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | NA[3] | ND[2] | ND[2] | ND[2] |
| | Payroll | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | NA[3] | ND[2] | ND[2] | ND[2] |
| Deep sea passenger transportation | Establishments | 4 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 1 |
| | Employees | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| | Payroll | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| Marinas | Establishments | 85 | 79 | 84 | 84 | 84 | 86 | 87 | 89 | 86 |
| | Employees | 503 | 416 | 406 | 411 | 417 | 464 | 411 | 376 | 395 |
| | Payroll | 16,055 | 12,853 | 13,369 | 14,215 | 15,353 | 18,600 | 15,206 | 14,654 | 14,699 |
| Marine cargo handling | Establishments | 4 | 4 | 4 | 3 | 3 | 3 | 3 | 3 | 2 |
| | Employees | 91 | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| | Payroll | 3,183 | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| Navigational services to shipping | Establishments | 18 | 17 | 16 | 16 | 12 | 15 | 15 | 14 | 13 |
| | Employees | 88 | 106 | 91 | 88 | 93 | 105 | 138 | 93 | 68 |
| | Payroll | 4,341 | 5,521 | 4,927 | 5,890 | 6,260 | 6,737 | 6,148 | 5,369 | 4,928 |
| Port & harbor operations | Establishments | NA[3] | 1 | 1 | 1 | 1 | 2 | 2 | 1 | 1 |
| | Employees | NA[3] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| | Payroll | NA[3] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| Ship & boat building | Establishments | 87 | 91 | 86 | 92 | 89 | 94 | 90 | 82 | 75 |
| | Employees | ND[2] | 7,630 | 7,753 | ND[2] | 6,808 | 6,751 | 6,930 | ND[2] | ND[2] |
| | Payroll | ND[2] | 332,332 | 328,179 | ND[2] | 320,288 | 345,036 | 354,899 | ND[2] | ND[2] |

[1] The U.S. Commercial Fishing Location Quotient (CFLQ) of 1.0 represents the national baseline from which state CFLQs can be compared.
[2] ND = these data are confidential thus not disclosable
[3] NA = these data are not available

### 2011 Economic Impacts of the Massachusetts Seafood Industry (thousands of dollars)

| | With Imports | | | Without Imports | | |
|---|---|---|---|---|---|---|
| | Jobs | Sales | Value Added | Jobs | Sales | Value Added |
| **Total Impacts** | 98,358 | 7,754,140 | 3,090,449 | 63,078 | 2,376,805 | 1,196,219 |
| Commercial Harvesters | 13,269 | 1,032,684 | 484,877 | 13,269 | 1,032,684 | 484,877 |
| Seafood Processors & Dealers | 7,587 | 977,819 | 484,709 | 1,799 | 234,730 | 116,357 |
| Importers | 14,708 | 4,045,936 | 1,233,379 | 0 | 0 | 0 |
| Seafood Wholesalers & Distributors | 3,097 | 495,150 | 219,547 | 1,138 | 181,928 | 80,666 |
| Retail | 59,697 | 1,202,551 | 667,938 | 46,872 | 927,463 | 514,319 |

### Total Landings Revenue and Landings Revenue of Key Species/Species Groups (thousands of dollars)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total revenue | 296,922 | 292,602 | 325,937 | 427,332 | 437,157 | 420,066 | 399,921 | 400,832 | 478,627 | 565,238 |
| Finfish & other | 122,845 | 116,767 | 109,163 | 117,003 | 110,426 | 109,434 | 122,004 | 114,709 | 126,578 | 132,097 |
| Shellfish | 174,077 | 175,835 | 216,774 | 310,330 | 326,731 | 310,632 | 277,917 | 286,122 | 352,048 | 433,141 |
| American lobster | 56,569 | 52,329 | 51,581 | 49,563 | 52,553 | 51,255 | 45,423 | 42,725 | 50,367 | 54,859 |
| Atlantic herring | 2,285 | 5,461 | 4 | 69 | ND[1] | 8,265 | 11,336 | 15,322 | 10,253 | 8,719 |
| Atlantic mackerel | 713 | 1,888 | 6,542 | ND[2] | 10,203 | 4,736 | 4,265 | 4,548 | 1,487 | 138 |
| Clams, all other | 8,169 | 823 | 4,721 | 19,010 | 14,064 | 15,682 | 15,257 | 16,746 | 17,885 | 15,894 |
| Cod & haddock | 40,550 | 36,668 | 31,452 | 31,954 | 25,451 | 32,033 | 38,696 | 33,684 | 45,210 | 43,393 |
| Eastern oyster | ND[2] | ND[2] | 24 | 2,738 | 4,618 | 4,559 | 5,496 | 6,432 | 8,171 | 9,070 |
| Flounders | 33,092 | 32,995 | 29,897 | 28,815 | 24,592 | 22,091 | 20,926 | 19,646 | 19,975 | 22,021 |
| Goosefish | 15,546 | 15,585 | 15,675 | 21,485 | 17,712 | 14,381 | 14,036 | 9,902 | 9,922 | 13,434 |
| Ocean quahog clam | ND[2] | 7,325 | 6,919 | ND[2] | 8,297 | 10,100 | 9,575 | 10,710 | 8,981 | 4,042 |
| Sea scallop | 100,551 | 106,938 | 144,748 | 226,949 | 234,668 | 218,292 | 189,893 | 197,296 | 252,290 | 330,921 |

### Total Landings and Landings of Key Species/Species Groups (thousands of pounds)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total landings | 243,501 | 295,439 | 337,603 | 337,304 | 351,426 | 304,436 | 326,234 | 355,872 | 282,835 | 255,798 |
| Finfish & other | 175,490 | 231,978 | 267,342 | 267,311 | 271,352 | 227,230 | 255,604 | 279,097 | 201,007 | 179,370 |
| Shellfish | 68,011 | 63,461 | 70,261 | 69,993 | 80,074 | 77,206 | 70,630 | 76,775 | 81,828 | 76,428 |
| American lobster | 12,853 | 11,385 | 11,295 | 9,880 | 10,966 | 10,143 | 10,598 | 11,781 | 12,768 | 13,717 |
| Atlantic herring | 40,508 | 79,873 | 40 | 700 | ND[2] | 73,268 | 94,233 | 133,531 | 71,922 | 66,515 |
| Atlantic mackerel | 5,549 | 23,451 | 72,687 | ND[2] | 89,535 | 46,240 | 35,406 | 30,199 | 12,156 | 521 |
| Clams, all other | 17,057 | 1,045 | 6,315 | 19,881 | 4,593 | 4,135 | 4,376 | 6,552 | 10,196 | 11,315 |
| Cod & haddock | 37,521 | 32,013 | 26,926 | 24,539 | 15,862 | 20,290 | 28,524 | 28,514 | 36,461 | 27,160 |
| Eastern oyster | ND[2] | ND[2] | 9 | 105 | 212 | 123 | 138 | 159 | 214 | 252 |
| Flounders | 28,987 | 29,418 | 30,704 | 22,115 | 13,182 | 10,966 | 11,589 | 12,399 | 11,158 | 13,690 |
| Goosefish | 22,794 | 23,979 | 22,357 | 21,849 | 17,495 | 13,308 | 12,446 | 9,829 | 8,740 | 10,022 |
| Ocean quahog clam | ND[2] | 14,226 | 14,085 | ND[2] | 16,798 | 20,158 | 18,126 | 18,691 | 15,646 | 5,797 |
| Sea scallop | 25,290 | 25,371 | 27,944 | 29,045 | 36,088 | 32,540 | 27,012 | 29,782 | 31,157 | 33,016 |

### Average Annual Price of Key Species/Species Groups (dollars per pound)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| American lobster | 4.40 | 4.60 | 4.57 | 5.02 | 4.79 | 5.05 | 4.29 | 3.63 | 3.94 | 4.00 |
| Atlantic herring | 0.06 | 0.07 | 0.09 | 0.10 | ND[2] | 0.11 | 0.12 | 0.11 | 0.14 | 0.13 |
| Atlantic mackerel | 0.13 | 0.08 | 0.09 | ND[2] | 0.11 | 0.10 | 0.12 | 0.15 | 0.12 | 0.27 |
| Clams, all other | 0.48 | 0.79 | 0.75 | 0.96 | 3.06 | 3.79 | 3.49 | 2.56 | 1.75 | 1.40 |
| Cod & haddock | 1.08 | 1.15 | 1.17 | 1.30 | 1.60 | 1.58 | 1.36 | 1.18 | 1.24 | 1.60 |
| Eastern oyster | ND[2] | ND[2] | 2.74 | 26.09 | 21.75 | 37.00 | 39.77 | 40.36 | 38.25 | 35.94 |
| Flounders | 1.14 | 1.12 | 0.97 | 1.30 | 1.87 | 2.01 | 1.81 | 1.58 | 1.79 | 1.61 |
| Goosefish | 0.68 | 0.65 | 0.70 | 0.98 | 1.01 | 1.08 | 1.13 | 1.01 | 1.14 | 1.34 |
| Ocean quahog clam | ND[2] | 0.51 | 0.49 | ND[2] | 0.49 | 0.50 | 0.53 | 0.57 | 0.57 | 0.70 |
| Sea scallop | 3.98 | 4.21 | 5.18 | 7.81 | 6.50 | 6.71 | 7.03 | 6.62 | 8.10 | 10.02 |

[1] ND = these data are confidential thus not disclosable

### 2011 Economic Impacts of Recreational Fishing Expenditures (thousands of dollars)

| | Jobs | Sales | Income | Value Added |
|---|---|---|---|---|
| Trip Impacts by Fishing Mode: | | | | |
| For-Hire | 815 | 78,396 | 27,484 | 46,772 |
| Private Boat | 742 | 86,783 | 31,780 | 53,208 |
| Shore | 958 | 98,753 | 35,342 | 58,470 |
| Total Durable Equipment Impacts | 2,808 | 462,231 | 157,671 | 232,281 |
| **Total State Trip and Durable Equipment Economic Impacts** | 5,322 | 726,164 | 252,277 | 390,731 |

### 2011 Angler Trip & Durable Expenditures (thousands of dollars)

| Fishing Mode | Trip Expenditures | | Equipment | Durable Expenditures |
|---|---|---|---|---|
| | Non-Residents | Residents | Fishing Tackle | 133,323 |
| For-Hire | 38,515 | 13,394 | Other Equipment | 36,214 |
| Private Boat | 14,582 | 63,018 | Boat Expenses | 251,688 |
| Shore | 31,254 | 37,526 | Vehicle Expenses | 100,595 |
| *Total Trip Expenditures* | 84,351 | 113,938 | Second Home Expenses | 1,914 |
| | | | *Total Durable Equipment Expenditures* | 523,735 |
| **Total State Trip and Durable Equipment Expenditures** | | | | 722,024 |

### Recreational Anglers by Residential Area (thousands of anglers)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal | 465 | 434 | 535 | 585 | 623 | 664 | 655 | 489 | 586 | 490 |
| Non-Coastal | 96 | 112 | 131 | 135 | 151 | 179 | 170 | 144 | 152 | 115 |
| Out of State | 344 | 306 | 335 | 391 | 484 | 465 | 469 | 421 | 433 | 293 |
| **Total Anglers** | 906 | 852 | 1000 | 1112 | 1258 | 1309 | 1293 | 1054 | 1171 | 897 |

### Recreational Fishing Effort by Mode (thousands of angler-trips)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| For-Hire | 106 | 145 | 210 | 236 | 230 | 233 | 255 | 240 | 156 | 190 |
| Private | 2,399 | 2,329 | 2,273 | 2,336 | 2,411 | 2,441 | 2,338 | 1,759 | 2,149 | 1,318 |
| Shore | 1,701 | 1,611 | 1,968 | 1,739 | 1,938 | 1,948 | 1,929 | 1,451 | 1,186 | 1,305 |
| **Total Trips** | 4,206 | 4,085 | 4,451 | 4,311 | 4,579 | 4,622 | 4,522 | 3,450 | 3,491 | 2,813 |

### Harvest (H) and Release (R) of Key Species Species Groups (thousands of fish)[1]

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Atlantic bonito | H | 6 | 11 | 5 | 29 | 13 | 3 | 7 | 4 | 1 | 5 |
| | R | 17 | (1) | 2 | 9 | 38 | 12 | 9 | 1 | 3 | (1) |
| Atlantic cod | H | 585 | 582 | 348 | 388 | 120 | 232 | 261 | 213 | 412 | 360 |
| | R | 1,050 | 937 | 658 | 932 | 424 | 658 | 671 | 582 | 884 | 542 |
| Atlantic mackerel | H | 2,024 | 1,313 | 481 | 1,927 | 3,603 | 951 | 2,024 | 471 | 2,084 | 1,649 |
| | R | 61 | 45 | 75 | 17 | 422 | 27 | 152 | 68 | 185 | 42 |
| Bluefish | H | 229 | 374 | 354 | 551 | 653 | 681 | 519 | 344 | 476 | 226 |
| | R | 627 | 1,020 | 1,295 | 1,814 | 1,843 | 1,241 | 1,302 | 953 | 1,027 | 597 |
| Haddock | H | 63 | 75 | 127 | 247 | 121 | 292 | 232 | 155 | 143 | 53 |
| | R | 125 | 130 | 56 | 62 | 62 | 56 | 158 | 36 | 33 | 13 |
| Porgies (scup) | H | 975 | 1,624 | 3,315 | 657 | 425 | 1,771 | 762 | 1,070 | 925 | 785 |
| | R | 879 | 1,221 | 1,486 | 751 | 1,097 | 1,183 | 1,687 | 1,743 | 1,858 | 1,175 |
| Striped bass | H | 308 | 405 | 445 | 340 | 315 | 314 | 378 | 344 | 341 | 256 |
| | R | 5,719 | 4,362 | 4,980 | 3,987 | 7,811 | 5,331 | 3,650 | 2,283 | 1,672 | 972 |
| Summer flounder | H | 156 | 177 | 225 | 267 | 238 | 138 | 233 | 51 | 45 | 59 |
| | R | 337 | 244 | 348 | 358 | 611 | 136 | 273 | 96 | 215 | 182 |
| Winter flounder | H | 51 | 45 | 45 | 39 | 44 | 41 | 167 | 87 | 86 | 69 |
| | R | 34 | 30 | 14 | 40 | 20 | 19 | 62 | 83 | 68 | 58 |
| Wrasses (tautog) | H | 103 | 47 | 21 | 73 | 80 | 92 | 34 | 24 | 45 | 33 |
| | R | 284 | 189 | 68 | 127 | 332 | 413 | 78 | 96 | 117 | 210 |

[1] In this table, '(1)' = 0-999 thousand fish and '1' = 1,000-1,499 thousand fish.

### Massachusetts's State Economy (% of national total)

| | Establishments | Employees | Annual Payroll (million $) | Employee Compensation (million $) | Gross State Product (million $) | Commercial Location Quotient [1] |
|---|---|---|---|---|---|---|
| 2002 | 175,991 (2.4%) | 3,023,126 (2.7%) | 127,902 (3.2%) | 179,522 (2.7%) | 288,352 (2.9%) | 8.42 |
| 2010 | 169,790 (2.3%) | 2,928,545 (2.6%) | 158,404 (3.2%) | 229,031 (2.6%) | 377,846 (2.9%) | ND[2] |
| % change | -3.52% | -3.13% | 23.8% | 27.6% | 31% | NA[3] |

### Seafood Sales & Processing - Nonemployer Firms (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Seafood product prep. & packaging | Firms | 26 | 23 | 25 | 28 | 36 | 24 | 26 | 22 | 26 |
| | Receipts | 1,296 | 676 | 2,284 | 2,266 | 2,525 | 908 | 1,250 | 1,944 | 1,250 |
| Seafood Sales, retail | Firms | 78 | 59 | 64 | 59 | 62 | 57 | 64 | 62 | 64 |
| | Receipts | 7,314 | 5,409 | 5,933 | 5,528 | 4,905 | 4,421 | 7,982 | 6,889 | 7,982 |

### Seafood Sales & Processing - Employer Establishments (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Seafood product prep. & packaging | Establishments | 45 | 55 | 53 | 50 | 47 | 52 | 44 | 44 | 44 |
| | Employees | 2,231 | 2,717 | 2,743 | 2,671 | 2,607 | 2,684 | 2,355 | 2,396 | 2,159 |
| | Payroll | 92,776 | 110,917 | 112,642 | 115,704 | 120,912 | 113,580 | 109,747 | 119,282 | 107,635 |
| Seafood sales, wholesale | Establishments | 207 | 163 | 148 | 151 | 139 | 160 | 141 | 144 | 149 |
| | Employees | 2,393 | 1,880 | 1,890 | 1,836 | 1,706 | 1,803 | 1,442 | 1,542 | 1,591 |
| | Payroll | 107,871 | 74,431 | 75,689 | 76,070 | 77,106 | 81,863 | 68,898 | 70,864 | 83,467 |
| Seafood sales, retail | Establishments | 126 | 124 | 128 | 116 | 115 | 126 | 118 | 115 | 112 |
| | Employees | 490 | 720 | 686 | 677 | 692 | 737 | 549 | 542 | 584 |
| | Payroll | 10,673 | 17,760 | 17,454 | 17,725 | 18,165 | 19,267 | 15,017 | 15,261 | 16,495 |

### Transport, Support, & Marine Operations - Employer Establishments (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal & Great Lakes freight transportation | Establishments | 10 | 13 | 13 | 10 | 12 | 14 | 14 | 12 | 12 |
| | Employees | ND[2] | ND[2] | 688 | ND[2] | 623 | 283 | 169 | 166 | ND[2] |
| | Payroll | ND[2] | ND[2] | 36,533 | ND[2] | 38,421 | 18,620 | 11,701 | 10,011 | ND[2] |
| Deep sea freight transportation | Establishments | 12 | 10 | 10 | 10 | 11 | 12 | 8 | 10 | 8 |
| | Employees | ND[2] | ND[2] | ND[2] | ND[2] | 509 | ND[2] | 361 | ND[2] | 313 |
| | Payroll | ND[2] | ND[2] | ND[2] | ND[2] | 38,982 | ND[2] | 38,908 | 35,473 | 36,069 |
| Deep sea passenger transportation | Establishments | 2 | 1 | 1 | 4 | 4 | 1 | NA[3] | 1 | NA[3] |
| | Employees | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | NA[3] | ND[2] | NA[3] |
| | Payroll | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | NA[3] | ND[2] | NA[3] |
| Marinas | Establishments | 139 | 145 | 135 | 139 | 141 | 173 | 175 | 177 | 175 |
| | Employees | 988 | 969 | 989 | 973 | 1,064 | 1,154 | 1,138 | 1,188 | 1,150 |
| | Payroll | 35,169 | 40,700 | 41,474 | 43,103 | 45,894 | 51,705 | 53,694 | 56,663 | 57,002 |
| Marine cargo handling | Establishments | 7 | 6 | 6 | 5 | 4 | 5 | 3 | 2 | 2 |
| | Employees | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | 69 | ND[2] | ND[2] | ND[2] |
| | Payroll | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | 2,867 | 2,271 | ND[2] | ND[2] |
| Navigational services to shipping | Establishments | 5 | 5 | 7 | 6 | 11 | 9 | 8 | 11 | 9 |
| | Employees | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | 65 | 75 | 71 | 150 |
| | Payroll | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | 4,540 | 4,355 | 4,342 | 9,413 |
| Port & harbor operations | Establishments | NA[3] | 3 | 3 | 3 | 4 | 3 | 4 | 4 | 8 |
| | Employees | NA[3] | ND[2] | ND[2] | ND[2] | ND[2] | 69 | 63 | 66 | 86 |
| | Payroll | NA[3] | ND[2] | ND[2] | ND[2] | ND[2] | 647 | 1,289 | 1,323 | 2,662 |
| Ship & boat building | Establishments | 50 | 53 | 55 | 50 | 47 | 49 | 43 | 38 | 37 |
| | Employees | 617 | ND[2] | ND[2] | 588 | ND[2] | 588 | 603 | 579 | 535 |
| | Payroll | 21,710 | ND[2] | ND[2] | 20,050 | ND[2] | 26,445 | 28,402 | 20,685 | 20,196 |

[1] The U.S. Commercial Fishing Location Quotient (CFLQ) of 1.0 represents the national baseline from which state CFLQs can be compared.
[2] ND = these data are confidential thus not disclosable
[3] NA = these data are not available

## 2011 Economic Impacts of the New Hampshire Seafood Industry (thousands of dollars)

| | With Imports | | | Without Imports | | |
|---|---|---|---|---|---|---|
| | Jobs | Sales | Value Added | Jobs | Sales | Value Added |
| **Total Impacts** | 5,968 | 766,257 | 287,785 | 2,044 | 114,586 | 58,059 |
| Commercial Harvesters | 695 | 41,186 | 18,077 | 695 | 41,186 | 18,077 |
| Seafood Processors & Dealers | 629 | 67,994 | 34,451 | 164 | 17,920 | 9,079 |
| Importers | 1,845 | 507,565 | 154,728 | 0 | 0 | 0 |
| Seafood Wholesalers & Distributors | 360 | 46,329 | 21,492 | 61 | 7,844 | 3,639 |
| Retail | 2,439 | 103,183 | 59,038 | 1,124 | 47,637 | 27,264 |

## Total Landings Revenue and Landings Revenue of Key Species/Species Groups (thousands of dollars)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total revenue | 16,689 | 15,127 | 17,214 | 22,084 | 18,915 | 16,996 | 17,471 | 17,757 | 20,653 | 23,483 |
| Finfish & other | 7,350 | 5,748 | 6,449 | 6,840 | 4,855 | 4,151 | 4,824 | 5,571 | 5,122 | 6,153 |
| Shellfish | 9,339 | 9,380 | 10,765 | 15,244 | 14,059 | 12,845 | 12,647 | 12,186 | 15,531 | 17,330 |
| American lobster | 2 | ND[1] | 10,199 | 14,377 | 13,915 | 12,492 | 12,267 | 11,919 | 14,890 | 16,337 |
| Atlantic cod | 1,983 | 1,853 | 2,244 | 1,913 | 1,705 | 1,972 | 2,311 | 2,587 | 2,184 | 2,501 |
| Atlantic herring | 783 | 1,170 | 3 | ND[2] | ND[2] | 147 | 134 | 271 | 375 | 208 |
| Goosefish | 1,853 | 1,097 | 1,456 | 1,484 | 794 | 375 | 290 | 280 | 214 | 208 |
| Haddock | 134 | 144 | 157 | 136 | 132 | 123 | 89 | 68 | 29 | 35 |
| Hake | 321 | 303 | 200 | 279 | 219 | 244 | 167 | 215 | 237 | 445 |
| Pollock | 847 | 589 | 569 | 1,138 | 1,221 | 902 | 1,093 | 1,284 | 843 | 1,359 |
| Sea scallop | 726 | 375 | 276 | 527 | 24 | 30 | 16 | 4 | 3 | 26 |
| Shrimp | 104 | 212 | 222 | 340 | 120 | ND[2] | ND[2] | ND[2] | 567 | ND[2] |
| Spiny dogfish | 85 | 27 | 0 | ND[2] | 183 | ND[2] | 419 | 557 | 292 | 451 |

## Total Landings and Landings of Key Species/Species Groups (thousands of pounds)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total landings | 23,200 | 27,435 | 23,796 | 21,281 | 10,820 | 8,422 | 10,463 | 13,887 | 11,820 | 12,321 |
| Finfish & other | 20,354 | 24,747 | 21,074 | 18,081 | 7,857 | 5,166 | 7,178 | 10,094 | 7,026 | 7,151 |
| Shellfish | 2,846 | 2,688 | 2,722 | 3,200 | 2,963 | 3,256 | 3,284 | 3,793 | 4,794 | 5,169 |
| American lobster | 0 | ND[2] | 2,097 | 2,556 | 2,666 | 2,469 | 2,567 | 2,985 | 3,659 | 3,917 |
| Atlantic cod | 1,583 | 1,458 | 1,633 | 1,293 | 1,023 | 1,168 | 1,479 | 1,985 | 1,227 | 1,287 |
| Atlantic herring | 14,125 | 18,933 | 32 | ND[2] | ND[2] | 936 | 1,198 | 3,120 | 2,830 | 1,514 |
| Goosefish | 1,876 | 1,629 | 1,640 | 1,226 | 621 | 317 | 249 | 249 | 172 | 153 |
| Haddock | 95 | 108 | 123 | 99 | 73 | 61 | 53 | 45 | 18 | 19 |
| Hake | 557 | 729 | 405 | 372 | 241 | 313 | 222 | 423 | 322 | 587 |
| Pollock | 997 | 1,109 | 1,202 | 1,997 | 2,566 | 2,025 | 2,456 | 2,019 | 1,042 | 1,737 |
| Sea scallop | 177 | 100 | 44 | 76 | 3 | 4 | 2 | 1 | 0 | 3 |
| Shrimp | 90 | 223 | 432 | 567 | 294 | ND[2] | ND[2] | ND[2] | 963 | ND[2] |
| Spiny dogfish | 349 | 175 | 0 | ND[2] | 620 | ND[2] | 1,370 | 2,073 | 1,214 | 1,647 |

## Average Annual Price of Key Species/Species Groups (dollars per pound)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| American lobster | 3.86 | ND[2] | 4.86 | 5.62 | 5.22 | 5.06 | 4.78 | 3.99 | 4.07 | 4.17 |
| Atlantic cod | 1.25 | 1.27 | 1.37 | 1.48 | 1.67 | 1.69 | 1.56 | 1.30 | 1.78 | 1.94 |
| Atlantic herring | 0.06 | 0.06 | 0.10 | ND[2] | ND[2] | 0.16 | 0.11 | 0.09 | 0.13 | 0.14 |
| Goosefish | 0.99 | 0.67 | 0.89 | 1.21 | 1.28 | 1.18 | 1.17 | 1.13 | 1.24 | 1.36 |
| Haddock | 1.41 | 1.33 | 1.27 | 1.38 | 1.82 | 2.01 | 1.70 | 1.52 | 1.55 | 1.91 |
| Hake | 0.58 | 0.41 | 0.49 | 0.75 | 0.91 | 0.78 | 0.75 | 0.51 | 0.74 | 0.76 |
| Pollock | 0.85 | 0.53 | 0.47 | 0.57 | 0.48 | 0.45 | 0.45 | 0.64 | 0.81 | 0.78 |
| Sea scallop | 4.10 | 3.76 | 6.22 | 6.89 | 7.44 | 8.26 | 7.68 | 7.22 | 8.84 | 10.42 |
| Shrimp | 1.16 | 0.95 | 0.51 | 0.60 | 0.41 | ND[2] | ND[2] | ND[2] | 0.59 | ND[2] |
| Spiny dogfish | 0.24 | 0.16 | 0.18 | ND[2] | 0.30 | ND[2] | 0.31 | 0.27 | 0.24 | 0.27 |

[1] ND = these data are confidential thus not disclosable

### 2011 Economic Impacts of Recreational Fishing Expenditures (thousands of dollars)

| | Jobs | Sales | Income | Value Added |
|---|---|---|---|---|
| Trip Impacts by Fishing Mode: | | | | |
| For-Hire | 149 | 12,231 | 4,083 | 7,166 |
| Private Boat | 71 | 7,354 | 2,544 | 4,445 |
| Shore | 12 | 1,062 | 371 | 629 |
| Total Durable Equipment Impacts | 145 | 20,358 | 7,179 | 10,374 |
| **Total State Trip and Durable Equipment Economic Impacts** | 376 | 41,005 | 14,177 | 22,614 |

### 2011 Angler Trip & Durable Expenditures (thousands of dollars)

| Fishing Mode | Trip Expenditures | | Equipment | Durable Expenditures |
|---|---|---|---|---|
| | Non-Residents | Residents | Fishing Tackle | 8,476 |
| For-Hire | 4,912 | 3,590 | Other Equipment | 2,294 |
| Private Boat | 554 | 6,876 | Boat Expenses | 9,135 |
| Shore | 618 | 379 | Vehicle Expenses | 6,218 |
| *Total Trip Expenditures* | 6,085 | 10,846 | Second Home Expenses | 0 |
| | | | *Total Durable Equipment Expenditures* | 26,123 |
| **Total State Trip and Durable Equipment Expenditures** | | | | 43,054 |

### Recreational Anglers by Residential Area (thousands of anglers)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal | 60 | 91 | 81 | 105 | 90 | 97 | 63 | 67 | 46 | 56 |
| Non-Coastal | 11 | 16 | 13 | 14 | 15 | 13 | 8 | 9 | 7 | 10 |
| Out of State | 65 | 75 | 69 | 84 | 82 | 63 | 46 | 58 | 33 | 30 |
| **Total Anglers** | 137 | 182 | 163 | 203 | 187 | 172 | 118 | 134 | 86 | 96 |

### Recreational Fishing Effort by Mode (thousands of angler-trips)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| For-Hire | 29 | 35 | 28 | 53 | 90 | 113 | 91 | 98 | 61 | 69 |
| Private | 142 | 230 | 154 | 238 | 182 | 233 | 138 | 148 | 90 | 178 |
| Shore | 146 | 151 | 161 | 214 | 227 | 155 | 103 | 155 | 92 | 47 |
| **Total Trips** | 317 | 416 | 343 | 505 | 499 | 501 | 332 | 401 | 243 | 294 |

### Harvest (H) and Release (R) of Key Species Species Groups (thousands of fish)[1]

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | H | (1) | (1) | 1 | (1) | (1) | 3 | (1) | (1) | (1) | (1) |
| | R | 4 | (1) | 2 | 2 | 9 | 1 | 3 | (1) | 1 | (1) |
| Atlantic cod | H | 38 | 108 | 67 | 68 | 65 | 53 | 81 | 128 | 80 | 127 |
| | R | 70 | 207 | 96 | 137 | 247 | 235 | 232 | 209 | 130 | 258 |
| Atlantic mackerel | H | 214 | 409 | 71 | 407 | 116 | 128 | 496 | 882 | 294 | 2,142 |
| | R | 68 | 61 | 10 | 16 | 34 | 9 | 36 | 81 | 17 | 187 |
| Bluefin tuna | H | (1) | (1) | (1) | (1) | (1) | (1) | (1) | (1) | (1) | (1) |
| | R | (1) | (1) | (1) | (1) | (1) | (1) | (1) | (1) | (1) | 2 |
| Bluefish | H | 19 | 7 | 13 | 21 | 9 | 35 | 5 | (1) | 1 | 2 |
| | R | 14 | 18 | 9 | 47 | 23 | 18 | 3 | 2 | (1) | 1 |
| Bottomfish, unidentified | H | (1) | (1) | (1) | (1) | (1) | (1) | (1) | (1) | (1) | (1) |
| | R | (1) | (1) | (1) | (1) | (1) | (1) | (1) | (1) | (1) | (1) |
| Haddock | H | 19 | 44 | 68 | 103 | 167 | 97 | 90 | 100 | 48 | 76 |
| | R | 43 | 127 | 22 | 38 | 109 | 43 | 18 | 29 | 11 | 20 |
| Pollock | H | 89 | 62 | 57 | 60 | 76 | 70 | 52 | 40 | 51 | 100 |
| | R | 64 | 43 | 33 | 34 | 46 | 17 | 20 | 49 | 77 | 104 |
| Striped bass | H | 13 | 25 | 8 | 24 | 14 | 5 | 5 | 9 | 6 | 32 |
| | R | 237 | 260 | 226 | 572 | 459 | 258 | 78 | 59 | 52 | 98 |
| Winter flounder | H | 8 | 8 | 1 | 1 | 7 | 10 | 11 | 10 | 3 | 12 |
| | R | 10 | 2 | 2 | 1 | 3 | 7 | 6 | 5 | 5 | 1 |

[1] In this table, '(1)' = 0-999 thousand fish and '1' = 1,000-1,499 thousand fish.

### New Hampshire's State Economy (% of national total)

| | Establishments | Employees | Annual Payroll (million $) | Employee Compensation (million $) | Gross State Product (million $) | Commercial Location Quotient [1] |
|---|---|---|---|---|---|---|
| 2002 | 37,928 (0.53%) | 550,725 (0.49%) | 18,652 (0.47%) | 27,285 (0.44%) | 46,730 (0.45%) | 0.29 |
| 2010 | 37,452 (0.51%) | 562,505 (0.5%) | 24,224 (0.49%) | 35,224 (0.43%) | 61,636 (0.44%) | 0.16 |
| % change | -1.26% | 2.14% | 29.9% | 29.1% | 31.9% | -31% |

### Seafood Sales & Processing - Nonemployer Firms (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Seafood product prep. & packaging | Firms | 0 | 7 | 4 | 4 | 4 | 5 | 0 | 0 | 0 |
| | Receipts | ND[2] | 1,205 | 1,147 | 842 | 1,087 | 927 | ND[2] | ND[2] | ND[2] |
| Seafood Sales, retail | Firms | 9 | 14 | 15 | 11 | 10 | 11 | 17 | 14 | 17 |
| | Receipts | 862 | 960 | 1,438 | 1,330 | 1,496 | 1,540 | 1,894 | 1,858 | 1,894 |

### Seafood Sales & Processing - Employer Establishments (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Seafood product prep. & packaging | Establishments | 9 | 11 | 10 | 10 | 10 | 7 | 7 | 8 | 8 |
| | Employees | 368 | 322 | 448 | 418 | ND[2] | ND[2] | ND[2] | 115 | 292 |
| | Payroll | 13,452 | 13,676 | 18,886 | 16,275 | ND[2] | ND[2] | ND[2] | 3,234 | 10,971 |
| Seafood sales, wholesale | Establishments | 14 | 11 | 12 | 10 | 9 | 8 | 8 | 8 | 8 |
| | Employees | 78 | ND[2] | 82 | ND[2] | ND[2] | 92 | 101 | 88 | 80 |
| | Payroll | 2,093 | ND[2] | 2,511 | ND[2] | ND[2] | 3,360 | 4,142 | 4,268 | 4,171 |
| Seafood sales, retail | Establishments | 9 | 12 | 12 | 12 | 15 | 15 | 14 | 14 | 12 |
| | Employees | ND[2] | ND[2] | ND[2] | 79 | 78 | 93 | 83 | 95 | 102 |
| | Payroll | ND[2] | ND[2] | ND[2] | 2,053 | 2,201 | 2,077 | 2,011 | 2,299 | 2,296 |

### Transport, Support, & Marine Operations - Employer Establishments (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal & Great Lakes freight transportation | Establishments | 1 | NA[3] | NA[3] | 1 | 1 | 1 | NA[3] | NA[3] | NA[3] |
| | Employees | ND[2] | NA[3] | NA[3] | ND[2] | ND[2] | ND[2] | NA[3] | NA[3] | NA[3] |
| | Payroll | ND[2] | NA[3] | NA[3] | ND[2] | ND[2] | ND[2] | NA[3] | NA[3] | NA[3] |
| Deep sea freight transportation | Establishments | 1 | 1 | 1 | 2 | 2 | 1 | 1 | 1 | 1 |
| | Employees | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| | Payroll | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| Deep sea passenger transportation | Establishments | 1 | NA[3] | NA[3] | NA[3] | NA[3] | NA[3] | NA[3] | NA[3] | NA[3] |
| | Employees | ND[2] | NA[3] | NA[3] | NA[3] | NA[3] | NA[3] | NA[3] | NA[3] | NA[3] |
| | Payroll | ND[2] | NA[3] | NA[3] | NA[3] | NA[3] | NA[3] | NA[3] | NA[3] | NA[3] |
| Marinas | Establishments | 36 | 40 | 40 | 38 | 35 | 35 | 37 | 37 | 35 |
| | Employees | 228 | 196 | 226 | 194 | ND[2] | 171 | 173 | 146 | 135 |
| | Payroll | 10,872 | 9,043 | 9,315 | 8,871 | ND[2] | 7,774 | 8,114 | 7,022 | 6,920 |
| Marine cargo handling | Establishments | NA[3] | NA[3] | NA[3] | NA[3] | NA[3] | 1 | NA[3] | NA[3] | NA[3] |
| | Employees | NA[3] | NA[3] | NA[3] | NA[3] | NA[3] | ND[2] | NA[3] | NA[3] | NA[3] |
| | Payroll | NA[3] | NA[3] | NA[3] | NA[3] | NA[3] | ND[2] | NA[3] | NA[3] | NA[3] |
| Navigational services to shipping | Establishments | 2 | 3 | 3 | 4 | 4 | 2 | 2 | 2 | 2 |
| | Employees | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| | Payroll | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| Port & harbor operations | Establishments | 1 | NA[3] | NA[3] | NA[3] | NA[3] | NA[3] | NA[3] | NA[3] | NA[3] |
| | Employees | ND[2] | NA[3] | NA[3] | NA[3] | NA[3] | NA[3] | NA[3] | NA[3] | NA[3] |
| | Payroll | ND[2] | NA[3] | NA[3] | NA[3] | NA[3] | NA[3] | NA[3] | NA[3] | NA[3] |
| Ship & boat building | Establishments | 8 | 10 | 8 | 6 | 6 | 8 | 9 | 8 | 7 |
| | Employees | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| | Payroll | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |

[1] The U.S. Commercial Fishing Location Quotient (CFLQ) of 1.0 represents the national baseline from which state CFLQs can be compared.
[2] ND = these data are confidential thus not disclosable
[3] NA = these data are not available

## 2011 Economic Impacts of the Rhode Island Seafood Industry (thousands of dollars)

| | With Imports | | | Without Imports | | |
|---|---|---|---|---|---|---|
| | Jobs | Sales | Value Added | Jobs | Sales | Value Added |
| **Total Impacts** | 9,157 | 1,024,748 | 397,018 | 4,642 | 269,101 | 136,313 |
| Commercial Harvesters | 2,068 | 130,996 | 61,578 | 2,068 | 130,996 | 61,578 |
| Seafood Processors & Dealers | 463 | 48,609 | 24,478 | 292 | 30,835 | 15,527 |
| Importers | 2,249 | 618,743 | 188,620 | 0 | 0 | 0 |
| Seafood Wholesalers & Distributors | 483 | 58,591 | 27,316 | 119 | 14,385 | 6,707 |
| Retail | 3,894 | 167,808 | 95,026 | 2,164 | 92,884 | 52,501 |

## Total Landings Revenue and Landings Revenue of Key Species/Species Groups (thousands of dollars)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total revenue | 64,718 | 66,088 | 77,565 | 91,408 | 98,488 | 72,441 | 66,300 | 61,751 | 62,677 | 75,956 |
| Finfish & other | 25,115 | 24,408 | 25,821 | 24,672 | 28,123 | 24,998 | 22,995 | 23,566 | 23,009 | 24,545 |
| Shellfish | 39,602 | 41,679 | 51,744 | 66,736 | 70,366 | 47,442 | 43,306 | 38,185 | 39,668 | 51,412 |
| All other flounders | 3,194 | 2,728 | 2,136 | 1,734 | 3,499 | 3,585 | 2,171 | 1,455 | 593 | 805 |
| American lobster | 15,875 | 16,731 | 14,624 | 23,009 | 18,391 | 12,151 | 12,987 | 11,218 | 12,374 | 12,756 |
| Atlantic herring | 1,312 | 1,195 | 1,187 | 1,075 | 2,667 | 982 | 631 | 1,260 | 1,385 | 981 |
| Atlantic mackerel | 3,031 | 2,385 | 3,815 | 2,888 | 3,293 | 1,182 | 882 | 3,301 | 1,886 | 73 |
| Goosefish | 4,757 | 4,813 | 3,421 | 4,549 | 4,481 | 3,533 | 3,590 | 3,022 | 2,974 | 4,594 |
| Quahog clam | 7,043 | 6,370 | 5,868 | 3,438 | 3,481 | 4,010 | 3,273 | 2,849 | 3,293 | 3,920 |
| Scups or porgies | 2,229 | 2,098 | 1,990 | 2,319 | 2,778 | 2,782 | 2,335 | 2,689 | 2,833 | 3,312 |
| Sea scallop | ND[1] | 279 | 1,512 | 13,268 | 20,783 | 8,963 | 2,170 | 2,342 | 2,156 | 6,834 |
| Squid | 13,208 | 14,319 | 25,133 | 16,973 | 16,753 | 15,339 | 17,687 | 15,249 | 12,589 | 20,379 |
| Summer flounder | 3,992 | 4,060 | 5,309 | 5,866 | 5,042 | 4,416 | 4,592 | 4,541 | 5,547 | 6,415 |

## Total Landings and Landings of Key Species/Species Groups (thousands of pounds)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total landings | 103,530 | 97,456 | 115,037 | 97,565 | 112,606 | 75,179 | 71,923 | 83,937 | 77,477 | 77,236 |
| Finfish & other | 70,552 | 62,340 | 62,169 | 47,820 | 60,590 | 40,848 | 34,465 | 46,467 | 42,340 | 40,180 |
| Shellfish | 32,978 | 35,116 | 52,868 | 49,745 | 52,016 | 34,331 | 37,458 | 37,471 | 35,137 | 37,056 |
| All other flounders | 2,781 | 2,428 | 2,360 | 1,315 | 1,848 | 1,871 | 1,144 | 1,027 | 358 | 615 |
| American lobster | 3,835 | 3,475 | 3,064 | 4,344 | 3,749 | 2,293 | 2,772 | 2,832 | 2,923 | 2,753 |
| Atlantic herring | 12,774 | 13,440 | 13,491 | 11,605 | 23,150 | 7,537 | 4,504 | 9,528 | 8,279 | 6,717 |
| Atlantic mackerel | 20,930 | 10,768 | 15,269 | 8,075 | 10,143 | 4,242 | 2,385 | 9,057 | 4,356 | 132 |
| Goosefish | 5,148 | 6,830 | 4,288 | 4,143 | 3,858 | 3,117 | 3,120 | 2,748 | 2,519 | 3,202 |
| Quahog clam | 1,192 | 1,131 | 1,080 | 642 | 679 | 610 | 556 | 511 | 599 | 666 |
| Scups or porgies | 3,675 | 3,814 | 3,425 | 3,424 | 3,643 | 3,932 | 2,151 | 3,619 | 4,298 | 6,335 |
| Sea scallop | ND[2] | 76 | 249 | 1,612 | 3,290 | 1,357 | 310 | 356 | 267 | 690 |
| Squid | 23,713 | 25,862 | 43,697 | 22,135 | 21,294 | 23,718 | 26,417 | 26,452 | 19,799 | 25,995 |
| Summer flounder | 2,286 | 2,178 | 3,085 | 2,925 | 2,123 | 1,516 | 1,473 | 1,794 | 2,289 | 2,824 |

## Average Annual Price of Key Species/Species Groups (dollars per pound)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| All other flounders | 1.15 | 1.12 | 0.90 | 1.32 | 1.89 | 1.92 | 1.90 | 1.42 | 1.66 | 1.31 |
| American lobster | 4.14 | 4.82 | 4.77 | 5.30 | 4.91 | 5.30 | 4.69 | 3.96 | 4.23 | 4.63 |
| Atlantic herring | 0.10 | 0.09 | 0.09 | 0.09 | 0.12 | 0.13 | 0.14 | 0.13 | 0.17 | 0.15 |
| Atlantic mackerel | 0.14 | 0.22 | 0.25 | 0.36 | 0.32 | 0.28 | 0.37 | 0.36 | 0.43 | 0.55 |
| Goosefish | 0.92 | 0.70 | 0.80 | 1.10 | 1.16 | 1.13 | 1.15 | 1.10 | 1.18 | 1.43 |
| Quahog clam | 5.91 | 5.63 | 5.43 | 5.35 | 5.13 | 6.57 | 5.88 | 5.58 | 5.50 | 5.89 |
| Scups or porgies | 0.61 | 0.55 | 0.58 | 0.68 | 0.76 | 0.71 | 1.09 | 0.74 | 0.66 | 0.52 |
| Sea scallop | ND[2] | 3.67 | 6.07 | 8.23 | 6.32 | 6.61 | 7.00 | 6.58 | 8.07 | 9.90 |
| Squid | 0.56 | 0.55 | 0.58 | 0.77 | 0.79 | 0.65 | 0.67 | 0.58 | 0.64 | 0.78 |
| Summer flounder | 1.75 | 1.86 | 1.72 | 2.01 | 2.38 | 2.91 | 3.12 | 2.53 | 2.42 | 2.27 |

[1] ND = these data are confidential thus not disclosable

### 2011 Economic Impacts of Recreational Fishing Expenditures (thousands of dollars)

| | Jobs | Sales | Income | Value Added |
|---|---|---|---|---|
| Trip Impacts by Fishing Mode: | | | | |
| For-Hire | 100 | 9,212 | 3,124 | 5,507 |
| Private Boat | 196 | 18,451 | 6,509 | 11,053 |
| Shore | 104 | 8,739 | 3,031 | 5,025 |
| Total Durable Equipment Impacts | 873 | 120,709 | 35,293 | 52,065 |
| **Total State Trip and Durable Equipment Economic Impacts** | 1,273 | 157,111 | 47,957 | 73,650 |

### 2011 Angler Trip & Durable Expenditures (thousands of dollars)

| Fishing Mode | Trip Expenditures | | Equipment | Durable Expenditures |
|---|---|---|---|---|
| | Non-Residents | Residents | Fishing Tackle | 60,232 |
| For-Hire | 6,296 | 646 | Other Equipment | 4,311 |
| Private Boat | 7,663 | 11,222 | Boat Expenses | 76,406 |
| Shore | 4,332 | 3,520 | Vehicle Expenses | 4,176 |
| *Total Trip Expenditures* | 18,291 | 15,388 | Second Home Expenses | 0 |
| | | | *Total Durable Equipment Expenditures* | 145,125 |
| **Total State Trip and Durable Equipment Expenditures** | | | | 178,804 |

### Recreational Anglers by Residential Area (thousands of anglers)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal | 134 | 147 | 129 | 145 | 177 | 171 | 169 | 111 | 161 | 105 |
| Non-Coastal | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| Out of State | 214 | 253 | 237 | 241 | 291 | 229 | 297 | 209 | 225 | 190 |
| **Total Anglers** | 348 | 400 | 366 | 386 | 468 | 401 | 465 | 320 | 387 | 296 |

### Recreational Fishing Effort by Mode (thousands of angler-trips)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| For-Hire | 36 | 60 | 43 | 55 | 54 | 75 | 67 | 56 | 41 | 38 |
| Private | 595 | 581 | 650 | 792 | 642 | 590 | 716 | 423 | 531 | 536 |
| Shore | 881 | 952 | 812 | 758 | 874 | 758 | 674 | 507 | 667 | 539 |
| **Total Trips** | 1,512 | 1,593 | 1,505 | 1,605 | 1,570 | 1,423 | 1,457 | 986 | 1,239 | 1,113 |

### Harvest (H) and Release (R) of Key Species Species Groups (thousands of fish)[2]

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Atlantic bonito | H | 12 | 2 | 3 | 1 | (1) | 6 | (1) | (1) | (1) | (1) |
| | R | 1 | 4 | 8 | (1) | (1) | 4 | 1 | (1) | (1) | (1) |
| Atlantic cod | H | 6 | 1 | 1 | 1 | 4 | 1 | 2 | 4 | 2 | 4 |
| | R | 8 | 5 | 2 | 2 | 2 | (1) | 1 | 7 | 12 | 13 |
| Black seabass | H | 77 | 70 | 26 | 86 | 42 | 42 | 53 | 36 | 160 | 51 |
| | R | 242 | 206 | 24 | 64 | 160 | 119 | 128 | 133 | 211 | 221 |
| Bluefish | H | 326 | 336 | 256 | 344 | 470 | 296 | 280 | 64 | 102 | 124 |
| | R | 801 | 932 | 801 | 527 | 555 | 685 | 491 | 160 | 94 | 327 |
| Porgies (scup) | H | 604 | 1,027 | 818 | 430 | 471 | 352 | 633 | 140 | 398 | 569 |
| | R | 934 | 806 | 518 | 689 | 801 | 613 | 1,387 | 333 | 536 | 663 |
| Striped bass | H | 77 | 115 | 84 | 111 | 75 | 100 | 52 | 72 | 71 | 87 |
| | R | 531 | 448 | 525 | 634 | 834 | 677 | 417 | 398 | 183 | 213 |
| Summer flounder | H | 190 | 206 | 249 | 164 | 265 | 176 | 203 | 72 | 118 | 161 |
| | R | 768 | 350 | 278 | 279 | 1,129 | 611 | 848 | 382 | 231 | 725 |
| Winter flounder | H | 30 | 9 | 7 | (1) | (1) | 1 | 1 | 4 | 2 | (1) |
| | R | 20 | 1 | 5 | (1) | (1) | 2 | 1 | 1 | 1 | (1) |
| Wrasses (tautog) | H | 62 | 120 | 125 | 160 | 81 | 125 | 103 | 84 | 197 | 19 |
| | R | 134 | 196 | 222 | 321 | 200 | 268 | 187 | 186 | 187 | 138 |
| Yellowfin tuna | H | 2 | 2 | (1) | 1 | (1) | (1) | (1) | (1) | (1) | (1) |
| | R | (1) | 11 | (1) | 2 | (1) | (1) | (1) | (1) | (1) | (1) |

[1]NA = not applicable because all Rhode Island residents are considered coastal county residents
[2]In this table, '(1)' = 0-999 thousand fish and '1' = 1,000-1,499 thousand fish.

### Rhode Island's State Economy (% of national total)

| | Establishments | Employees | Annual Payroll (million $) | Employee Compensation (million $) | Gross State Product (million $) | Commercial Location Quotient [1] |
|---|---|---|---|---|---|---|
| 2002 | 28,860 (0.4%) | 415,970 (0.37%) | 13,547 (0.34%) | 21,530 (0.36%) | 38,135 (0.35%) | 2.26 |
| 2010 | 28,521 (0.39%) | 399,000 (0.36%) | 16,832 (0.34%) | 27,127 (0.34%) | 48,840 (0.34%) | 2.27 |
| % change | -1.17% | -4.08% | 24.2% | 26% | 28.1% | -40.7% |

### Seafood Sales & Processing - Nonemployer Firms (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Seafood product prep. & packaging | Firms | 0 | 0 | 0 | 6 | 8 | 8 | 7 | 9 | 7 |
| | Receipts | ND[2] | ND[2] | ND[2] | 2,024 | 1,662 | 2,291 | 1,376 | 1,045 | 1,376 |
| Seafood Sales, retail | Firms | 20 | 16 | 14 | 16 | 24 | 23 | 19 | 16 | 19 |
| | Receipts | 2,433 | 2,227 | 2,186 | 2,215 | 3,266 | 3,536 | 2,748 | 2,821 | 2,748 |

### Seafood Sales & Processing - Employer Establishments (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Seafood product prep. & packaging | Establishments | 9 | 7 | 7 | 7 | 7 | 6 | 8 | 7 | 5 |
| | Employees | 184 | 355 | 355 | 270 | 231 | 196 | 270 | 275 | 193 |
| | Payroll | 7,284 | 10,381 | 10,867 | 5,549 | 6,137 | 6,876 | 6,354 | 5,821 | 6,096 |
| Seafood sales, wholesale | Establishments | 39 | 38 | 35 | 32 | 36 | 35 | 29 | 34 | 32 |
| | Employees | 380 | 394 | 259 | 206 | 188 | 224 | 226 | 202 | 204 |
| | Payroll | 14,505 | 15,724 | 12,269 | 9,851 | 10,209 | 11,447 | 10,505 | 9,534 | 9,815 |
| Seafood sales, retail | Establishments | 27 | 29 | 34 | 31 | 28 | 27 | 23 | 24 | 26 |
| | Employees | 151 | 162 | 163 | 140 | ND[2] | 109 | 94 | 127 | 113 |
| | Payroll | 3,015 | 2,870 | 2,707 | 2,447 | ND[2] | 2,207 | 2,027 | 2,398 | 2,309 |

### Transport, Support, & Marine Operations - Employer Establishments (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal & Great Lakes freight transportation | Establishments | 2 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 |
| | Employees | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| | Payroll | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| Deep sea freight transportation | Establishments | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| | Employees | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| | Payroll | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| Deep sea passenger transportation | Establishments | 2 | 3 | NA[3] | NA[3] | NA[3] | 1 | 1 | 1 | 1 |
| | Employees | ND[2] | ND[2] | NA[3] | NA[3] | NA[3] | ND[2] | ND[2] | ND[2] | ND[2] |
| | Payroll | ND[2] | ND[2] | NA[3] | NA[3] | NA[3] | ND[2] | ND[2] | ND[2] | ND[2] |
| Marinas | Establishments | 56 | 61 | 60 | 66 | 63 | 68 | 73 | 70 | 72 |
| | Employees | 522 | 405 | 475 | 408 | 457 | 463 | 476 | 459 | 428 |
| | Payroll | 17,609 | 14,456 | 15,111 | 15,843 | 18,748 | 22,029 | 23,204 | 21,372 | 22,227 |
| Marine cargo handling | Establishments | 3 | 1 | 1 | 1 | 2 | 2 | 5 | 5 | 5 |
| | Employees | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| | Payroll | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| Navigational services to shipping | Establishments | 10 | 8 | 8 | 8 | 7 | 7 | 8 | 8 | 8 |
| | Employees | 36 | 46 | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| | Payroll | 2,162 | 2,585 | ND[2] | ND[2] | ND[2] | ND[2] | 5,904 | 3,728 | 3,955 |
| Port & harbor operations | Establishments | NA[3] | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 1 |
| | Employees | NA[3] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| | Payroll | NA[3] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| Ship & boat building | Establishments | 31 | 37 | 38 | 36 | 38 | 37 | 39 | 33 | 29 |
| | Employees | 1,329 | ND[2] | ND[2] | ND[2] | 1,325 | 1,374 | 1,342 | 1,085 | 954 |
| | Payroll | 47,328 | ND[2] | ND[2] | ND[2] | 52,682 | 55,788 | 54,225 | 41,246 | 40,004 |

[1] The U.S. Commercial Fishing Location Quotient (CFLQ) of 1.0 represents the national baseline from which state CFLQs can be compared.
[2] ND = these data are confidential thus not disclosable
[3] NA = these data are not available

# Mid-Atlantic

- Delaware
- Maryland
- New Jersey
- New York
- Virginia

### Management Context

The Mid-Atlantic Region includes Delaware, Maryland, New Jersey, New York, and Virginia. Federal fisheries in this region are managed by the Mid-Atlantic Fishery Management Council (MAFMC) and NOAA Fisheries (NMFS) under seven fishery management plans (FMPs). Two of these FMPs are developed in conjunction with the New England Fisheries Management Council (NEFMC). The MAFMC is the lead Council for the Dogfish FMP and the NEFMC is the lead for the Monkfish FMP.

**Mid-Atlantic Region FMPs**

1. Atlantic mackerel squids and butterfish
2. Bluefish
3. Spiny dogfish (with the NEFMC)
4. Summer flounder scup and black sea bass
5. Surfclam and ocean quahog
6. Golden tilefish
7. Monkfish (with the NEFMC)

Of the stocks or stock complexes covered in these fishery management plans, noneNo stocks in this region are currently subject to overfishing. Releases of winter flounder increased 331% between 2008 and 2009. This increase was partially driven by an addendum to Amendment 1 to the Interstate Fishery Management Plan for Inshore Stocks of Winter Flounder in 2009, which reduced the harvest limit from ten fish to two fish per day. The effect of the management action was compounded by a 182% increase in catch overall in between 2008 and 2009.

### Commercial Fisheries

In 2011, commercial fishermen in the Mid-Atlantic Region landed 780 million pounds of finfish and shellfish, earning $527 million in landings revenue. Landings revenue was dominated by sea scallop ($227 million) and blue crab ($99 million). These species commanded ex-vessel prices of $9.73 and $0.98 per pound, respectively, and comprised 62% of total landings revenue, but only 16% of total landings in the Mid-Atlantic Region.

**Key Mid-Atlantic Region Commercial Species**

- American lobster
- Atlantic surf clam
- Blue crab
- Eastern oyster
- Menhaden
- Quahog clam
- Sea scallop
- Squid
- Striped Bass
- Summer flounder

New Jersey and Virginia had the highest landings revenue in the region in 2011, $214 million and $192 million, respectively. The next greatest landings revenue came from Maryland with $77 million in landings revenue. In terms of pounds landed, Virginia had the highest landings (494 million pounds), followed by New Jersey (176 million pounds) and Maryland (78 million pounds).

#### *Economic Impacts*[1]

In 2011, the Mid-Atlantic Region's seafood industry generated 339 in employment impacts in Delaware, 15,000 in employment impacts in Maryland, 44,000 in employment impacts in New Jersey, 42,000 in employment impacts in New York, and 22,000 in employment impacts in Virginia. New Jersey generated the largest impacts across the three other impact categories, generating $6.6 billion sales impacts, $1.5 billion in income, and $2.4 billion in value added impacts. The smallest income impacts were generated in Delaware ($8.9 million) and the smallest employment impacts were also generated in Delaware (339 jobs).

The sector that generated the greatest employment impacts by state was the retail sector with 21,000 jobs in New York and 15,000 jobs in New Jersey. The harvest sector in Maryland generated 2,800 jobs. More sales impacts were generated by importers in New Jersey than any other sector in any another state in the region at $4.4 billion and the greatest value added impacts were also generated by importers in New Jersey ($1.3 billion).

#### *Landings Revenue*

Landings revenue in the Mid-Atlantic Region totaled $527 million in 2011. This was a 54% increase (a 6.9% increase in real terms) from 2002 levels ($342 million) and a 3.7% increase (a 4.4% decrease in real terms) relative to 2010 ($509 million). Totaling $404 million in 2011, shellfish revenue experienced a 57% increase (a 8.7% increase in real terms) from 2002 to 2011 and experienced a 2.4% increase (5.6% decrease in real terms) from 2010 to 2011.

In terms of finfish, Virginia contributed the most ($59 million), followed by New Jersey ($27 million), and New York ($22 million). Shellfish landings revenue was dominated by New Jersey ($187 million), followed by Virginia ($133 million), and Maryland ($63 million).

Sea scallop and blue crab had the highest landings revenue in the Mid-Atlantic Region in 2011. Between 2002 and 2011, the landings revenue from sea scallop increased 149% (a 73% increase in real terms) and the landings revenue for blue crab 61% increase (a 12% increase in real terms).

From 2002 to 2011, species or species groups with large changes in landings revenue include squid (increased 122%), summer flounder (increased 82%), and Atlantic surf clam (decreased 68%). Species or species groups with large changes in landings revenue between 2010 and 2011 include squid (increasing 72%), Atlantic surf clam (decreasing 38%), and eastern oyster (decreasing 33%).

#### *Landings*

Fishermen in the Mid-Atlantic Region landed 780 million pounds of finfish and shellfish in 2011. This was a 11% increase from the 702 million pounds landed in 2002 but a 3.4% decrease from the 808 million pounds landed in 2010. Finfish landings contributed 74% of total landings in the Mid-Atlantic Region (578 million

[1]The NMFS Commercial Fishing Industry Input/Output Model was used to generate the impact estimates (see NMFS Commercial Fishing & Seafood Industry Input/Output Model, available at: `www.st.nmfs.noaa.gov/documents/commercial_seafood_impacts_2007-2009.pdf`)

pounds) in 2011. From 2010 to 2011, finfish landings experienced a 0.3% decrease. Over the same time period, shellfish landings experienced a 11% decrease from 228 million pounds in 2010 to 202 million pounds in 2011 and a 1.8% decrease from 206 million pounds in 2002.

### Commercial Fisheries Facts

*Landings revenue*

- On average, between 2002 and 2011, the key species or species groups accounted for 84% of total revenue, generating $358 million in the Mid-Atlantic Region.
- Sea scallop had higher landings revenues than any other species or species group, averaging $155 million in landings revenue from 2002 to 2011.
- Squid had the largest one-year increase in landings revenue over the 10 year time period, increasing 120% from $6.5 million in 2003 to $14 million in 2004.
- American lobster had the largest one-year decrease in landings revenue over the 10 year time period, decreasing 43% from $8.9 million in 2008 to $5 million in 2009.

*Landings*

- Key species or species groups contributed an average of 84% annually to total landings between 2002 and 2011.
- Menhaden, contributed the most to landings in the region, averaging 429 million pounds from 2002 to 2011.
- Squid had the largest one-year increase in landings over the 10 year time period, increasing 297% from 10 million in 2003 pounds to 42 million pounds in 2004.
- Squid had the largest one-year decrease in landings over the 10 year time period, decreasing 71% from 42 million pounds in 2004 to 12 million pounds in 2005.

*Prices*

- Eastern oyster had the highest average annual ex-vessel price per pound ($7.23) over the time period, followed by quahog clam ($6.70), and sea scallop ($6.34).
- Menhaden had the lowest average annual ex-vessel price per pound ($0.07) over the time period, followed by Atlantic surf clam ($0.59), and squid ($0.68).
- Squid had the largest one-year increase in ex-vessel price over the 10 year time period, increasing 121% from $0.34 per pound in 2004 to $0.75 in 2005.
- Eastern oyster had the largest decrease in ex-vessel price over the 10 year time period, decreasing 49% from $8.92 per pound in 2010 to $4.55 in 2011.

Menhaden and blue crab had the highest annual landings in the Mid-Atlantic Region in 2011, with 497 million pounds and 101 million pounds, respectively. Together they accounted for 77% of the total landings in 2011. Menhaden landings increased 26% and blue crab landings increased 61% from 2002 to 2011.

From 2002 to 2011, species or species groups with large changes in landings include squid (increasing 119%), Atlantic surf clam (decreasing 73%), and blue crab (increasing 61%). Species or species groups with large changes in landings between 2010 and 2011 include Atlantic surf clam (decreasing 39%), summer flounder (increasing 36%), and eastern oyster (increasing 31%).

*Prices*

The ex-vessel prices for the Mid-Atlantic Region's key species and species groups in 2011 were higher than their 10 year average for six of the key species (two of the species in real terms). Ex-vessel prices for sea scallop and summer flounder experienced the biggest increases between 2002 and 2011, increasing 165% (84% in real terms) and 36% (-5.9% in real terms), respectively. Relative to the ex-vessel prices in 2010, the Mid-Atlantic Region's squid experienced the greatest increase (37.8%, 27.1% in real terms) from $0.45 in 2010 to $0.62 in 2011. Of the changes in ex-vessel price experienced by species or species groups between 2010 and 2011, eastern oyster experienced the greatest decrease (49%, 53% in real terms) from $8.92 to $4.55. Relative to ex-vessel prices in 2010, five species or species groups experienced increases, including squid (38%), and sea scallop (27%).

In Delaware, the species or species group with the largest change in ex-vessel price from 2002 to 2011 was American eel (131% increase, 61% increase in real terms) from $1.31 to $3.03. The largest change in ex-vessel price experienced in Maryland was for Sea scallop (179% increase, 94% increase in real terms from $3.52 to $9.83 and in New Jersey the largest change in ex-vessel price was experienced by atlantic mackerel (456% increase, 286% increase in real terms from $0.09 to $0.50).

### Recreational Fishing

In 2011, over 2.4 million recreational anglers took 16 million fishing trips in the Mid-Atlantic Region. Over 94% of these anglers were residents of a regional coastal county. Of the total fishing trips taken, 53% of them were taken from a private or rental boat and another 40% were shore-based. Summer flounder were the most frequently caught species or species group with 20 million fish caught in 2011, and represented 35% of total fish caught in the region. Of the summer flounder caught, 92% of them were released rather than harvested.

*Economic Impacts and Expenditures*[1]

The contribution of recreational fishing activities in the Mid-Atlantic Region are reported in terms of economic impacts at the state level (employment, sales, income, and value added impacts) and expenditures on fishing trips and durable equipment at the regional level. Employment impacts in New Jersey were the highest in the region with over 10,000 full- and part-time jobs generated by recreational fishing activities in the state. Virginia (7,200 jobs), and Maryland (5,700 jobs), followed in terms of employment impacts.

Overall, these employment impacts were generated by expenditures on recreational fishing trips taken by anglers (private or rental boat, for-hire boat, or shore-based trips) and expenditures on durable equipment. Throughout the Mid-Atlantic Region, most of the employment impacts in 2011 were generated

[1]Expenditure estimates were generated from the 2011 National Marine Recreational Fishing Expenditure Survey. Economic impacts from recreational fishing activities were generated using the NMFS Recreational Economic Impact Model (see The Economic Contribution of Marine Angler Expenditures in the United States, 2006, available at:`http://www.st.nmfs.noaa.gov/economics/publications/marine-angler-expenditures/marine-angler-2006`)

by expenditures on durable equipment: 75% in Virginia, 74% in New Jersey, and 67% in Maryland.

In addition to employment impacts, the contribution of recreational fishing activities to Mid-Atlantic Region's economy can be measured in terms of sales impacts and the contribution of these activities to gross domestic product (value added impacts). In 2011, sales impacts were the highest in New Jersey ($1.7 billion in sales impacts), followed by Virginia ($834 million), Maryland ($784 million), New York ($369 million), and Delaware ($121 million). In the same year, value added impacts were the highest in New Jersey ($871 million in value added impacts), followed by Virginia ($434 million), Maryland ($397 million), New York ($212 million), and Delaware ($56 million).

Overall, total fishing trip and durable equipment expenditures across the Mid-Atlantic Region in 2011 were $3.7 billion. Approximately 78% of these expenditures were generated by durable equipment purchases. The greatest expenditures were for boat expenses ($1.4 billion), followed by fishing tackle ($731 million), vehicle expenses ($428 million), other equipment ($193 million), and second home expenses ($141 million). Fishing trip-related expenditures by the Mid-Atlantic Region's non-residents totaled over $222 million of which the greatest portion can be attributed to shore-based fishing trips ($89 million). Residents of the Mid-Atlantic Region spent $580 million on saltwater fishing trips, with the most of these expenses generated by private boat trips ($353 million).

**Key Mid-Atlantic Region Recreational Species**

- Black seabass
- Bluefish
- Atlantic croaker
- Spot
- Scup
- Striped bass
- Summer flounder
- Weakfish drum
- Winter flounder
- Tautog

*Participation*

There were 2.4 million recreational anglers who fished in the Mid-Atlantic Region in 2011. This was a 34% increase from 2002 (1.8 million anglers). These anglers were Mid-Atlantic Region residents from either a coastal county (2.2 million anglers) or non-coastal county (145,000 anglers). About 94% of total anglers in 2011 were residents of a coastal county. Coastal county angler participation in 2011 increased 37% relative to 2002 (1.6 million anglers) and decreased 14% between 2010 and 2011. Non-coastal county angler participation increased 4.4% relative to 2002 (139,000 anglers) and decreased 18% relative to 2010 (178,000 anglers).

*Fishing Trips*

Recreational fishermen took 16 million fishing trips in the Mid-Atlantic Region in 2011. This was a 4% decrease from 2002 (17 million trips) and was 607,000 fewer trips than taken in 2010. Of the total trips taken in the Mid-Atlantic Region in 2011, approximately 53% of the trips were private or rental boat-based (8.5 million trips). The other most popular mode of fishing was shore based with 6.4 million trips in 2011.

**Recreational Fishing Facts**

*Participation*

- An average of 2.7 million anglers fished in the Mid-Atlantic Region annually from 2002 to 2011.
- In 2011, coastal county residents made up 94% of total anglers in this region. These anglers averaged 93% of total anglers annually over the 10 year time period.
- The largest annual increase in the number of coastal anglers during the 10 year time period occurred between 2002 and 2003, increasing 36%, from 1.6 million anglers to 2.2 million anglers.
- The largest annual decrease during the same period for coastal anglers occurred between 2008 and 2009, decreasing 14%, from 2.8 million anglers to 2.4 million anglers.

*Fishing trips*

- In the Mid-Atlantic Region, an average of 19 million fishing trips were taken annually from 2002 to 2011.
- Private or rental boat and shore-based fishing trips accounted for 8.5 million and 6.4 million fishing trips, respectively, in 2011. Together these made up 93% of the fishing trips taken in that year.
- The largest annual increase in the number of total trips taken annually over the 10 year time period occurred between 2002 and 2003, increasing 19%, from 17 million trips to 20 million trips.
- The largest annual decrease during the same period in total trips taken occurred between 2008 and 2009, decreasing 18%, from 21 million trips to 17 million trips.

*Harvest and release*

- Summer flounder was the most commonly caught key species or species group, averaging 20 million fish over the 10 year time period. Of these, 87% were released rather than harvested.
- Of the ten commonly caught key species or species groups, eight were released more often than harvested over this time period.
- The species or species group that was most commonly released was summer flounder (87% released).
- Spot (65% harvested), followed by winter flounder (59% harvested), and Atlantic croaker (48% harvested) were key species or groups that experienced the greatest proportion of harvests rather than releases.

*Harvest and Release*

Of the Mid-Atlantic Region's key species and species groups, summer flounder (20 million fish), Atlantic croaker (9.4 million fish), bluefish (6.7 million fish) and spot (6.6 million fish) were the most often caught by anglers in 2011. Weakfish drum (99% released), summer flounder (92% released), black seabass (86% released), tautog (81% released), striped bass (70% released), bluefish (63% released), winter flounder (58% released), Atlantic croaker (57% released), and scup (57% released) were more often released rather than harvested. The only species harvested more often than released was spot (61% harvested).

At the state level, summer flounder was the most often caught key species or species group in the Mid-Atlantic Region with

20 million fish caught, region-wide. Most of these fish were caught in New Jersey, New York, and Delaware with 8.8 million, 7.7 million, and 683,000 fish, respectively. The most frequently caught fish in Maryland was white perch with 3.9 million fish and Atlantic croaker was the most commonly caught fish in Virginia (8.2 million) in 2011.

Between 2002 and 2011, eight of the Mid-Atlantic Region's key species or species groups showed decreases in catch totals. Key species or groups with the largest decreases were weakfish drum (82%), black seabass (72%), and winter flounder (65%).

## Marine Economy[1]

The sum of the gross domestic products by state for Delaware, Maryland, New Jersey, New York, and Virginia was $2.4 trillion in 2011. Employee compensation totaled $1.4 trillion and annual payroll totaled $851 billion. These economic measures increased 34% (a 0.6% increase in real terms) and 26% (a 4.9% decrease in real terms), respectively between 2002 and 2010; and experienced a 2.9% increase (a 1.3% decrease in real terms), and 2.7% increase (a 1.4% decrease in real terms), respectively between 2009 and 2010. Approximately 1.1 million establishments employed 16 million full- and part-time employees across the region in 2010. This was a 2.5% increase in establishment numbers and a 0.8% decrease in employee numbers from 2002 to 2010.

In 2010, the commercial fishing location quotient (CFLQ) for New Jersey was the highest in the region at 1.19. This was an 18% increase from 2002 and a remained unchanged from 2009. New Jersey's CFLQ suggests that the level of employment in commercial fishing-related industries in this state is approximately 1.2 times higher than the level of employment in these industries nationwide. The 2010 CFLQ in Virginia was 0.59 (a 18% increase from 2002).

### *Seafood Sales and Processing*

In 2010, there were 228 nonemployer firms engaged in seafood product preparation and packaging across the Mid-Atlantic Region. In 2010, 32% of these firms were located in New York. Region-wide, annual receipts totaled $14 million in 2010 and0 from 2005 to 2009. Annual receipt totals experienced a 3.5% increase in Maryland between 2002 and 2010 from $3.2 million to $3.3 million. In contrast to an increase in nonemployer firms region-wide, the number of employer establishments engaged in seafood product preparation and packaging decreased 29% from 97 in 2002 to 68 in 2010. Approximately 26% of these establishments were located in Maryland. The number of employees was not available for the seafood product preparation and packaging sector in the Mid-Atlantic Region.

There were 499 seafood wholesale establishments in 2010. The number of employees was not available at the region level. From 2002 to 2010, the number of seafood wholesale establishments decreased 15% across the Mid-Atlantic Region.

Nonemployer firms engaged in seafood retail in the Mid-Atlantic Region totaled 512 in 2010, a 0.4% decrease relative to 2002. Of these firms, 16% were located in Maryland. At the state level, these firms showed a remained unchanged in New Jersey and decreased 15% in Virginia between 2002 and 2010. Annual receipts in the region totaled $53 million in 2010.

Employer establishments engaged in seafood retail decreased 4.1% from 2002 to 2010, totaling 663 in 2010. These establishments employed 2,647 workers in 2009. In the Mid-Atlantic Region, annual payroll for seafood retail0 from $NA in 2003 to $60 million in 2010.

### *Transport, Support, and Marine Operations*

For industries where data were available, marinas employed more people than any other industry in this sector, employing approximately 5,000 people in 2010. In contrast, the marine cargo handling industry had the highest annual payroll in the region totaling $483 million. Marinas had the highest number of establishments (950), followed by the ship and boat building industries with 158 establishments and the coastal and great lakes freight transportation industries with 99 establishments.

In Maryland, industries with large changes in establishment numbers, employees, or annual payroll from 2009 to 2010 were: marine cargo handling (104% increase in payroll), marine cargo handling (71% increase in employees), deep sea freight transportation (53% increase in employees) and deep sea passenger transportation (50% decrease in establishments). In New Jersey, large changes were seen for port and harbor operations (130% increase in employees), port and harbor operations (89% increase in payroll), port and harbor operations (83% increase in establishments) and navigational services to shipping (44% decrease in employees). In New York, large changes were seen in the navigational services to shipping (162% increase in payroll), port and harbor operations (100% increase in establishments), navigational services to shipping (92% increase in employees) and deep sea passenger transportation (50% decrease in establishments).

[1] Information for 2010 is reported in this section; 2011 data were not available for this report.

### 2011 Economic Impacts of the Mid-Atlantic Region Seafood Industry (thousands of dollars)

| | With Imports | | | Without Imports | | |
|---|---|---|---|---|---|---|
| | Jobs | Sales | Valued Added | Jobs | Sales | Valued Added |
| Delaware | 339 | 43,746 | 14,661 | 302 | 34,728 | 11,796 |
| Maryland | 15,274 | 1,743,095 | 665,883 | 6,966 | 368,398 | 184,663 |
| New Jersey | 43,638 | 6,563,733 | 2,407,754 | 10,115 | 818,397 | 390,460 |
| New York | 41,847 | 5,102,910 | 1,801,303 | 2,963 | 138,229 | 67,182 |
| Virginia | 22,082 | 1,866,659 | 800,243 | 16,634 | 906,586 | 473,802 |

### Total Landings Revenue and Landings Revenue of Key Species/Species Groups (thousands of dollars)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total revenue | 342,397 | 357,210 | 407,276 | 440,084 | 362,198 | 422,272 | 454,508 | 434,969 | 508,808 | 527,493 |
| Finfish & other | 84,091 | 87,702 | 87,648 | 101,538 | 95,508 | 104,079 | 91,633 | 101,999 | 113,732 | 123,033 |
| Shellfish | 258,306 | 269,508 | 319,628 | 338,547 | 266,689 | 318,193 | 362,876 | 332,970 | 395,076 | 404,460 |
| American lobster | 6,273 | 5,569 | 5,656 | 6,696 | 9,116 | 7,746 | 8,889 | 5,036 | 4,214 | 4,421 |
| Atlantic surf clam | 34,692 | 35,366 | 26,760 | 27,084 | 29,580 | 32,479 | 30,019 | 26,426 | 17,719 | 10,981 |
| Blue crab | 61,660 | 60,799 | 69,364 | 71,073 | 55,638 | 69,201 | 80,883 | 79,894 | 128,244 | 99,340 |
| Eastern oyster | 9,814 | 8,903 | 5,663 | 6,703 | 6,485 | 8,972 | 11,146 | 9,309 | 9,897 | 6,601 |
| Menhaden | 24,123 | 24,352 | 25,570 | 28,188 | 24,466 | 29,918 | 24,458 | 28,581 | 40,339 | 39,674 |
| Quahog clam | 16,935 | 20,160 | 19,918 | 20,773 | 20,229 | 23,437 | 35,852 | 23,022 | 21,783 | 19,994 |
| Sea scallop | 91,237 | 111,969 | 160,665 | 181,327 | 120,142 | 147,053 | 165,919 | 161,775 | 184,282 | 227,438 |
| Squid | 9,287 | 6,497 | 14,278 | 9,163 | 7,729 | 7,446 | 7,724 | 7,158 | 12,032 | 20,646 |
| Striped Bass | 8,215 | 9,751 | 7,633 | 11,335 | 9,947 | 10,994 | 10,684 | 11,451 | 11,422 | 12,632 |
| Summer flounder | 8,700 | 10,678 | 13,244 | 13,615 | 12,364 | 10,857 | 9,694 | 9,984 | 12,886 | 15,872 |

### Total Landings and Landings of Key Species/Species Groups (thousands of pounds)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total landings | 702,234 | 710,738 | 757,107 | 708,741 | 667,307 | 748,267 | 687,708 | 694,170 | 807,543 | 779,829 |
| Finfish & other | 496,430 | 514,804 | 529,453 | 517,898 | 488,011 | 556,786 | 482,090 | 490,157 | 579,127 | 577,628 |
| Shellfish | 205,804 | 195,934 | 227,654 | 190,843 | 179,296 | 191,481 | 205,619 | 204,013 | 228,416 | 202,201 |
| American lobster | 1,705 | 1,181 | 1,394 | 1,585 | 1,772 | 1,409 | 1,880 | 1,286 | 995 | 1,024 |
| Atlantic surf clam | 62,134 | 64,601 | 50,984 | 50,921 | 50,556 | 53,952 | 48,099 | 41,692 | 27,662 | 16,930 |
| Blue crab | 63,076 | 56,047 | 68,979 | 70,983 | 61,873 | 64,589 | 67,935 | 75,893 | 119,280 | 101,485 |
| Eastern oyster | 1,713 | 1,493 | 859 | 1,202 | 984 | 794 | 1,391 | 1,024 | 1,110 | 1,451 |
| Menhaden | 394,606 | 398,744 | 421,309 | 412,672 | 400,784 | 472,086 | 397,537 | 395,464 | 499,859 | 496,823 |
| Quahog clam | 2,318 | 3,311 | 3,537 | 3,735 | 3,728 | 4,115 | 5,246 | 3,255 | 2,469 | 2,345 |
| Sea scallop | 24,887 | 28,213 | 33,381 | 24,526 | 18,279 | 22,793 | 24,355 | 25,639 | 23,998 | 23,383 |
| Squid | 15,187 | 10,462 | 41,586 | 12,260 | 9,746 | 8,608 | 8,241 | 8,310 | 26,822 | 33,332 |
| Striped Bass | 4,591 | 5,273 | 3,927 | 5,706 | 4,746 | 5,477 | 5,693 | 5,852 | 5,621 | 5,406 |
| Summer flounder | 6,433 | 7,315 | 8,400 | 8,360 | 6,609 | 4,723 | 4,258 | 5,134 | 6,384 | 8,653 |

### Average Annual Price of Key Species/Species Groups (dollars per pound)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| American lobster | 3.68 | 4.71 | 4.06 | 4.22 | 5.15 | 5.50 | 4.73 | 3.92 | 4.23 | 4.32 |
| Atlantic surf clam | 0.56 | 0.55 | 0.52 | 0.53 | 0.59 | 0.60 | 0.62 | 0.63 | 0.64 | 0.65 |
| Blue crab | 0.98 | 1.08 | 1.01 | 1.00 | 0.90 | 1.07 | 1.19 | 1.05 | 1.08 | 0.98 |
| Eastern oyster | 5.73 | 5.96 | 6.59 | 5.58 | 6.59 | 11.30 | 8.02 | 9.09 | 8.92 | 4.55 |
| Menhaden | 0.06 | 0.06 | 0.06 | 0.07 | 0.06 | 0.06 | 0.06 | 0.07 | 0.08 | 0.08 |
| Quahog clam | 7.31 | 6.09 | 5.63 | 5.56 | 5.43 | 5.70 | 6.83 | 7.07 | 8.82 | 8.53 |
| Sea scallop | 3.67 | 3.97 | 4.81 | 7.39 | 6.57 | 6.45 | 6.81 | 6.31 | 7.68 | 9.73 |
| Squid | 0.61 | 0.62 | 0.34 | 0.75 | 0.79 | 0.86 | 0.94 | 0.86 | 0.45 | 0.62 |
| Striped Bass | 1.79 | 1.85 | 1.94 | 1.99 | 2.10 | 2.01 | 1.88 | 1.96 | 2.03 | 2.34 |
| Summer flounder | 1.35 | 1.46 | 1.58 | 1.63 | 1.87 | 2.30 | 2.28 | 1.94 | 2.02 | 1.83 |

### 2011 Economic Impacts of Recreational Fishing Expenditures (thousands of dollars)

| | Trips | Jobs | Sales | Income | Value Added |
|---|---|---|---|---|---|
| Delaware | 926,000 | 795 | 120,877 | 36,133 | 55,535 |
| Maryland | 2,820,000 | 5,745 | 783,833 | 260,839 | 396,620 |
| New Jersey | 5,162,000 | 9,965 | 1,697,115 | 554,318 | 870,983 |
| New York | 4,168,000 | 2,972 | 369,382 | 128,738 | 212,169 |
| Virginia | 2,898,000 | 7,237 | 833,508 | 280,954 | 433,725 |

### 2011 Angler Trip & Durable Expenditures (thousands of dollars)

| Fishing Mode | Trip Expenditures | | Equipment | Durable Expenditures |
|---|---|---|---|---|
| | Non-Residents | Residents | Fishing Tackle | 731,471 |
| For-Hire | 46,468 | 100,767 | Other Equipment | 192,747 |
| Private Boat | 86,361 | 353,011 | Boat Expenses | 1,390,841 |
| Shore | 89,457 | 126,512 | Vehicle Expenses | 428,052 |
| *Total Trip Expenditures* | 222,287 | 580,288 | Second Home Expenses | 140,956 |
| | | | *Total Durable Equipment Expenditures* | 2,884,068 |
| **Total State Trip and Durable Equipment Expenditures** | | | | 3,686,643 |

### Recreational Anglers by Residential Area (thousands of anglers)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal | 1,643 | 2,229 | 2,363 | 3,002 | 2,876 | 3,234 | 2,823 | 2,437 | 2,598 | 2,244 |
| Non-Coastal | 139 | 144 | 157 | 252 | 224 | 212 | 197 | 187 | 178 | 145 |
| Out-of-State | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| **Total Anglers** | 1,783 | 2,372 | 2,520 | 3,254 | 3,100 | 3,446 | 3,020 | 2,623 | 2,776 | 2,389 |

### Recreational Fishing Effort by Mode (thousands of angler-trips)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| For-Hire | 1,025 | 1,181 | 1,099 | 1,268 | 1,337 | 1,688 | 1,144 | 1,110 | 870 | 1,048 |
| Private Boat | 9,550 | 11,287 | 11,244 | 11,901 | 11,863 | 12,372 | 11,567 | 9,708 | 9,365 | 8,514 |
| Shore | 6,070 | 7,383 | 6,243 | 7,668 | 7,370 | 8,124 | 8,006 | 6,195 | 6,346 | 6,412 |
| **Total Trips** | 16,645 | 19,851 | 18,586 | 20,837 | 20,570 | 22,184 | 20,717 | 17,013 | 16,581 | 15,974 |

### Harvest (H) and Release (R) of Key Species Species Groups (thousands of fish)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Black seabass | H | 3,059 | 3,034 | 1,317 | 995 | 1,116 | 1,303 | 923 | 1,335 | 1,316 | 533 |
| | R | 10,332 | 8,383 | 5,528 | 5,414 | 5,739 | 6,401 | 8,473 | 6,270 | 6,458 | 3,203 |
| Bluefish | H | 2,517 | 3,192 | 4,142 | 4,667 | 3,904 | 4,945 | 3,516 | 2,932 | 2,558 | 2,465 |
| | R | 4,582 | 4,196 | 6,305 | 6,640 | 5,696 | 8,012 | 7,211 | 4,456 | 3,933 | 4,246 |
| Drum (Atlantic croaker) | H | 10,866 | 9,350 | 10,399 | 10,492 | 9,254 | 8,584 | 9,981 | 7,308 | 6,020 | 3,992 |
| | R | 10,364 | 9,426 | 8,966 | 12,244 | 7,416 | 11,023 | 12,912 | 9,405 | 6,233 | 5,390 |
| Drum (spot) | H | 2,316 | 4,771 | 2,604 | 4,769 | 6,657 | 11,998 | 6,557 | 4,346 | 3,699 | 4,033 |
| | R | 1,015 | 1,658 | 1,305 | 4,755 | 2,885 | 3,940 | 4,492 | 2,238 | 2,574 | 2,609 |
| Porgies (scup) | H | 1,186 | 5,268 | 1,948 | 992 | 2,005 | 1,699 | 1,544 | 1,638 | 2,735 | 771 |
| | R | 1,551 | 2,379 | 3,730 | 2,254 | 3,543 | 2,500 | 3,170 | 2,293 | 2,414 | 1,041 |
| Striped bass | H | 1,251 | 1,663 | 1,472 | 1,598 | 2,025 | 1,772 | 1,681 | 1,382 | 1,403 | 1,655 |
| | R | 5,052 | 7,801 | 9,579 | 8,033 | 9,227 | 7,730 | 4,787 | 3,802 | 3,465 | 3,782 |
| Summer flounder | H | 2,634 | 3,918 | 3,467 | 3,339 | 3,195 | 2,540 | 1,725 | 1,563 | 1,226 | 1,509 |
| | R | 11,851 | 14,901 | 15,122 | 20,359 | 14,547 | 16,578 | 18,431 | 21,372 | 21,402 | 18,466 |
| Weakfish drum | H | 919 | 307 | 418 | 1,102 | 554 | 331 | 372 | 37 | 14 | 7 |
| | R | 1,688 | 1,363 | 1,421 | 1,972 | 2,054 | 1,037 | 1,983 | 179 | 458 | 468 |
| Winter flounder | H | 361 | 540 | 267 | 132 | 325 | 106 | 44 | 76 | 55 | 92 |
| | R | 265 | 182 | 64 | 222 | 188 | 42 | 32 | 138 | 103 | 126 |
| Wrasses (tautog) | H | 1,231 | 382 | 598 | 275 | 679 | 728 | 668 | 692 | 759 | 352 |
| | R | 2,531 | 1,011 | 1,369 | 856 | 2,005 | 2,203 | 1,979 | 1,912 | 2,319 | 1,531 |

[1]NA = data are not available because out-of-state resident information is collected for individual states but whether an angler is a resident of a region is not specified

### 2011 Economic Impacts of the Delaware Seafood Industry (thousands of dollars)

| | With Imports | | | Without Imports | | |
|---|---|---|---|---|---|---|
| | Jobs | Sales | Value Added | Jobs | Sales | Value Added |
| **Total Impacts** | 339 | 43,746 | 14,661 | 302 | 34,728 | 11,796 |
| Commercial Harvesters | 148 | 12,993 | 4,186 | 148 | 12,993 | 4,186 |
| Seafood Processors & Dealers | 29 | 5,175 | 1,750 | 28 | 5,030 | 1,702 |
| Importers | 28 | 7,659 | 2,335 | 0 | 0 | 0 |
| Seafood Wholesalers & Distributors | 23 | 3,154 | 1,430 | 19 | 2,541 | 1,152 |
| Retail | 112 | 14,765 | 4,960 | 107 | 14,163 | 4,756 |

### Total Landings Revenue and Landings Revenue of Key Species/Species Groups (thousands of dollars)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total revenue | 6,067 | 5,204 | 5,419 | 6,113 | 5,677 | 7,931 | 6,900 | 7,542 | 7,840 | 7,091 |
| Finfish & other | 986 | 1,465 | 1,258 | 1,273 | 1,315 | 1,300 | 1,100 | 1,067 | 1,069 | 1,328 |
| Shellfish | 5,081 | 3,739 | 4,161 | 4,840 | 4,361 | 6,631 | 5,801 | 6,475 | 6,772 | 5,763 |
| American eel | 118 | 230 | 169 | 100 | 275 | 292 | 190 | 134 | 206 | 274 |
| Black sea bass | 21 | 181 | 181 | 157 | 190 | 198 | 156 | 25 | 8 | 2 |
| Blue crab | 3,511 | 1,899 | 2,839 | 3,429 | 2,961 | 5,329 | 4,605 | 5,435 | 5,957 | 4,819 |
| Eastern oyster | 478 | 305 | 361 | 485 | 459 | 490 | 410 | 334 | 404 | 347 |
| Quahog clam | 392 | 435 | 175 | 220 | 193 | ND[1] | ND[2] | ND[2] | ND[2] | ND[2] |
| Sea scallop | ND[2] | ND[2] | 12 | 102 | 121 | ND[2] | 256 | 173 | ND[2] | ND[2] |
| Spot | 8 | 46 | 38 | 98 | 53 | 57 | 40 | 49 | 50 | 67 |
| Striped bass | 336 | 479 | 497 | 494 | 501 | 300 | 403 | 327 | 396 | 410 |
| Weakfish | 176 | 83 | 61 | 82 | 55 | 31 | 18 | 5 | 4 | 2 |
| Whelks | 694 | 1,079 | 690 | 562 | 601 | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |

### Total Landings and Landings of Key Species/Species Groups (thousands of pounds)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total landings | 5,857 | 5,018 | 4,288 | 4,851 | 4,369 | 5,346 | 4,706 | 5,011 | 5,214 | 4,921 |
| Finfish & other | 1,933 | 2,264 | 1,349 | 1,470 | 1,144 | 1,102 | 817 | 1,154 | 851 | 1,157 |
| Shellfish | 3,925 | 2,754 | 2,938 | 3,381 | 3,224 | 4,244 | 3,890 | 3,857 | 4,363 | 3,764 |
| American eel | 90 | 156 | 142 | 110 | 120 | 131 | 80 | 60 | 69 | 91 |
| Black sea bass | 12 | 98 | 84 | 73 | 87 | 73 | 61 | 6 | 3 | 4 |
| Blue crab | 3,062 | 1,792 | 2,276 | 2,924 | 2,856 | 3,799 | 3,508 | 3,414 | 4,110 | 3,502 |
| Eastern oyster | 133 | 76 | 79 | 84 | 75 | 80 | 67 | 67 | 71 | 62 |
| Quahog clam | 134 | 141 | 54 | 69 | 60 | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| Sea scallop | ND[2] | ND[2] | 2 | 13 | 20 | ND[2] | 38 | 25 | ND[2] | ND[2] |
| Spot | 14 | 77 | 59 | 155 | 57 | 62 | 32 | 61 | 60 | 82 |
| Striped bass | 146 | 191 | 176 | 174 | 182 | 143 | 189 | 184 | 185 | 185 |
| Weakfish | 173 | 91 | 51 | 71 | 33 | 25 | 11 | 3 | 2 | 1 |
| Whelks | 590 | 729 | 491 | 276 | 203 | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |

### Average Annual Price of Key Species/Species Groups (dollars per pound)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| American eel | 1.31 | 1.48 | 1.19 | 0.91 | 2.28 | 2.22 | 2.38 | 2.24 | 3.00 | 3.03 |
| Black sea bass | 1.69 | 1.86 | 2.17 | 2.15 | 2.18 | 2.73 | 2.57 | 4.25 | 2.65 | 0.50 |
| Blue crab | 1.15 | 1.06 | 1.25 | 1.17 | 1.04 | 1.40 | 1.31 | 1.59 | 1.45 | 1.38 |
| Eastern oyster | 3.60 | 4.00 | 4.57 | 5.76 | 6.10 | 6.14 | 6.09 | 4.97 | 5.67 | 5.56 |
| Quahog clam | 2.92 | 3.09 | 3.26 | 3.18 | 3.22 | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| Sea scallop | ND[2] | ND[2] | 5.18 | 8.08 | 6.19 | ND[2] | 6.81 | 6.80 | ND[2] | ND[2] |
| Spot | 0.59 | 0.60 | 0.65 | 0.63 | 0.92 | 0.92 | 1.24 | 0.81 | 0.84 | 0.82 |
| Striped bass | 2.30 | 2.50 | 2.82 | 2.84 | 2.75 | 2.09 | 2.13 | 1.77 | 2.13 | 2.21 |
| Weakfish | 1.02 | 0.91 | 1.18 | 1.16 | 1.64 | 1.27 | 1.75 | 1.92 | 1.56 | 2.01 |
| Whelks | 1.18 | 1.48 | 1.41 | 2.04 | 2.96 | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |

[1] ND = these data are confidential thus not disclosable

### 2011 Economic Impacts of Recreational Fishing Expenditures (thousands of dollars)

| | Jobs | Sales | Income | Value Added |
|---|---|---|---|---|
| Trip Impacts by Fishing Mode: | | | | |
| For-Hire | 34 | 3,269 | 1,064 | 1,869 |
| Private Boat | 179 | 21,101 | 6,093 | 10,519 |
| Shore | 188 | 18,081 | 5,697 | 9,603 |
| Total Durable Equipment Impacts | 394 | 78,426 | 23,279 | 33,545 |
| **Total State Trip and Durable Equipment Economic Impacts** | 795 | 120,877 | 36,133 | 55,535 |

### 2011 Angler Trip & Durable Expenditures (thousands of dollars)

| Fishing Mode | Trip Expenditures | | Equipment | Durable Expenditures |
|---|---|---|---|---|
| | Non-Residents | Residents | Fishing Tackle | 29,440 |
| For-Hire | 1,906 | 461 | Other Equipment | 11,564 |
| Private Boat | 6,650 | 12,047 | Boat Expenses | 26,932 |
| Shore | 9,142 | 6,856 | Vehicle Expenses | 21,844 |
| *Total Trip Expenditures* | 17,698 | 19,363 | Second Home Expenses | 5,347 |
| | | | *Total Durable Equipment Expenditures* | 95,127 |
| **Total State Trip and Durable Equipment Expenditures** | | | | 132,188 |

### Recreational Anglers by Residential Area (thousands of anglers)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal | 89 | 127 | 116 | 120 | 137 | 150 | 134 | 114 | 128 | 129 |
| Non-Coastal | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| Out of State | 177 | 199 | 243 | 191 | 205 | 224 | 182 | 173 | 165 | 190 |
| **Total Anglers** | 266 | 326 | 359 | 311 | 342 | 374 | 315 | 287 | 293 | 318 |

### Recreational Fishing Effort by Mode (thousands of angler-trips)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| For-Hire | 64 | 38 | 32 | 42 | 62 | 70 | 56 | 44 | 20 | 17 |
| Private | 536 | 553 | 654 | 553 | 595 | 722 | 529 | 487 | 408 | 512 |
| Shore | 429 | 514 | 389 | 431 | 427 | 459 | 444 | 379 | 391 | 397 |
| **Total Trips** | 1,029 | 1,105 | 1,075 | 1,026 | 1,084 | 1,251 | 1,029 | 910 | 819 | 926 |

### Harvest (H) and Release (R) of Key Species Species Groups (thousands of fish)[2]

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Atlantic mackerel | H | 6 | (1) | 13 | (1) | (1) | (1) | (1) | (1) | (1) | (1) |
| | R | (1) | (1) | (1) | (1) | (1) | (1) | (1) | 2 | (1) | (1) |
| Black seabass | H | 608 | 308 | 43 | 67 | 113 | 94 | 21 | 37 | 22 | 44 |
| | R | 1,233 | 832 | 276 | 275 | 329 | 583 | 464 | 292 | 232 | 210 |
| Bluefish | H | 116 | 89 | 128 | 126 | 98 | 152 | 68 | 98 | 31 | 45 |
| | R | 435 | 120 | 408 | 190 | 288 | 539 | 166 | 166 | 57 | 128 |
| Drum (Atlantic croaker) | H | 261 | 342 | 389 | 825 | 764 | 359 | 370 | 452 | 75 | 92 |
| | R | 362 | 656 | 599 | 675 | 938 | 672 | 603 | 539 | 230 | 88 |
| Drum (weakfish)[3] | H | 121 | 20 | 5 | 19 | 10 | 3 | 4 | 6 | (1) | (1) |
| | R | 101 | 39 | 72 | 104 | 96 | 22 | 61 | 4 | 12 | 6 |
| Striped bass | H | 29 | 29 | 25 | 20 | 20 | 8 | 26 | 20 | 15 | 18 |
| | R | 114 | 169 | 155 | 250 | 248 | 247 | 260 | 146 | 65 | 110 |
| Summer flounder | H | 107 | 105 | 110 | 73 | 88 | 108 | 36 | 87 | 52 | 66 |
| | R | 497 | 415 | 737 | 795 | 446 | 1,072 | 605 | 964 | 619 | 617 |
| White perch | H | 40 | 30 | 63 | 37 | 69 | 34 | 40 | 64 | 187 | 113 |
| | R | 72 | 134 | 303 | 105 | 194 | 190 | 243 | 121 | 397 | 272 |
| Wrasses (tautog) | H | 185 | 62 | 70 | 60 | 111 | 100 | 103 | 121 | 56 | 46 |
| | R | 411 | 167 | 198 | 232 | 194 | 266 | 165 | 224 | 196 | 88 |
| Yellowfin tuna | H | 10 | 2 | 1 | 5 | 6 | (1) | 1 | (1) | (1) | (1) |
| | R | (1) | (1) | (1) | (1) | (1) | (1) | (1) | (1) | (1) | (1) |

[1]NA = not applicable because all Delaware residents are considered coastal county residents
[2]In this table, '(1)' = 0-999 thousand fish and '1' = 1,000-1,499 thousand fish.
[3]This species may not be equivalent to species with similar names listed in the commercial tables.

### Delaware's State Economy (% of national total)

| | Establishments | Employees | Annual Payroll (million $) | Employee Compensation (million $) | Gross State Product (million $) | Commercial Location Quotient [1] |
|---|---|---|---|---|---|---|
| 2002 | 24,377 (0.34%) | 389,304 (0.35%) | 14,716 (0.37%) | 20,439 (0.41%) | 43,672 (0.34%) | ND[2][3] |
| 2010 | 24,290 (0.33%) | 359,007 (0.32%) | 17,167 (0.35%) | 25,358 (0.44%) | 64,010 (0.32%) | [2] |
| % change | -0.357% | -7.78% | 16.7% | 24.1% | 46.6% | -- |

### Seafood Sales & Processing - Nonemployer Firms (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Seafood product prep. & packaging | Firms | 0 | 0 | 0 | 3 | 3 | 0 | 3 | NA[4] | 3 |
| | Receipts | ND[2] | ND[2] | ND[2] | 64 | 214 | ND[2] | 27 | NA[3] | 27 |
| Seafood Sales, retail | Firms | 5 | 7 | 9 | 12 | 9 | 12 | 9 | 9 | 9 |
| | Receipts | 435 | 959 | 803 | 1,523 | 835 | 1,025 | 418 | 664 | 418 |

### Seafood Sales & Processing - Employer Establishments (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Seafood product prep. & packaging | Establishments | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | Employees | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| | Payroll | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| Seafood sales, wholesale | Establishments | 7 | 5 | 2 | 3 | 3 | 3 | 6 | 7 | 7 |
| | Employees | 65 | ND[2] | ND[2] | ND[2] | 9 | ND[2] | ND[2] | ND[2] | ND[2] |
| | Payroll | 2,279 | ND[2] | ND[2] | ND[2] | 337 | ND[2] | ND[2] | ND[2] | ND[2] |
| Seafood sales, retail | Establishments | 15 | 18 | 16 | 14 | 17 | 19 | 18 | 16 | 15 |
| | Employees | 94 | ND[2] | 144 | 138 | 135 | 105 | ND[2] | 50 | 47 |
| | Payroll | 1,779 | ND[2] | 3,363 | 3,264 | 3,133 | 2,997 | 1,498 | 1,348 | 1,414 |

### Transport, Support, & Marine Operations - Employer Establishments (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal & Great Lakes freight transportation | Establishments | 8 | 5 | 3 | 3 | 3 | 3 | 2 | 2 | 1 |
| | Employees | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| | Payroll | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| Deep sea freight transportation | Establishments | 2 | 2 | 1 | 1 | NA[5] | NA[3] | 4 | 4 | 5 |
| | Employees | ND[2] | ND[2] | ND[2] | ND[2] | NA[3] | NA[3] | ND[2] | ND[2] | 120 |
| | Payroll | ND[2] | ND[2] | ND[2] | ND[2] | NA[3] | NA[3] | ND[2] | ND[2] | 10,768 |
| Deep sea passenger transportation | Establishments | 1 | NA[3] | NA[3] | 1 | NA[3] | NA[3] | NA[3] | NA[3] | 1 |
| | Employees | ND[2] | NA[3] | NA[3] | ND[2] | NA[3] | NA[3] | NA[3] | NA[3] | ND[2] |
| | Payroll | ND[2] | NA[3] | NA[3] | ND[2] | NA[3] | NA[3] | NA[3] | NA[3] | ND[2] |
| Marinas | Establishments | 13 | 17 | 17 | 16 | 18 | 17 | 19 | 16 | 19 |
| | Employees | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | 88 | 65 | ND[2] | 65 |
| | Payroll | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | 2,540 | 1,738 | 1,877 | 2,342 |
| Marine cargo handling | Establishments | 6 | 5 | 5 | 4 | 4 | 3 | 3 | 3 | 3 |
| | Employees | 199 | 513 | ND[2] | ND[2] | 597 | 527 | 629 | ND[2] | 434 |
| | Payroll | 14,718 | 14,879 | ND[2] | ND[2] | 18,812 | 19,027 | 19,204 | 16,952 | 16,835 |
| Navigational services to shipping | Establishments | 10 | 10 | 9 | 9 | 8 | 8 | 9 | 8 | 8 |
| | Employees | ND[2] | ND[2] | ND[2] | ND[2] | 75 | 76 | 79 | 85 | 76 |
| | Payroll | ND[2] | ND[2] | ND[2] | ND[2] | 4,783 | 4,961 | 5,360 | 5,672 | 5,176 |
| Port & harbor operations | Establishments | NA[3] | 1 | 2 | 2 | 3 | 2 | 2 | 2 | 3 |
| | Employees | NA[3] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | 29 |
| | Payroll | NA[3] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | 1,182 |
| Ship & boat building | Establishments | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 |
| | Employees | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| | Payroll | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |

[1] The U.S. Commercial Fishing Location Quotient (CFLQ) of 1.0 represents the national baseline from which state CFLQs can be compared.
[2] ND = these data are confidential thus not disclosable
[3] ND = these data are confidential thus not disclosable
[4] NA = these data are not available
[5] NA = these data are not available

## 2011 Economic Impacts of the Maryland Seafood Industry (thousands of dollars)

| | With Imports | | | Without Imports | | |
|---|---|---|---|---|---|---|
| | Jobs | Sales | Value Added | Jobs | Sales | Value Added |
| **Total Impacts** | 15,274 | 1,743,095 | 665,883 | 6,966 | 368,398 | 184,663 |
| Commercial Harvesters | 2,779 | 135,387 | 60,155 | 2,779 | 135,387 | 60,155 |
| Seafood Processors & Dealers | 1,822 | 161,514 | 80,372 | 632 | 56,620 | 28,175 |
| Importers | 3,894 | 1,071,272 | 326,571 | 0 | 0 | 0 |
| Seafood Wholesalers & Distributors | 822 | 109,633 | 49,484 | 200 | 26,618 | 12,014 |
| Retail | 5,956 | 265,289 | 149,301 | 3,355 | 149,773 | 84,319 |

## Total Landings Revenue and Landings Revenue of Key Species/Species Groups (thousands of dollars)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total revenue | 49,013 | 49,038 | 49,200 | 63,754 | 53,579 | 65,329 | 73,196 | 75,892 | 104,877 | 76,722 |
| Finfish & other | 8,135 | 8,095 | 4,670 | 10,766 | 9,896 | 12,170 | 11,090 | 11,614 | 13,157 | 13,608 |
| Shellfish | 40,878 | 40,943 | 44,530 | 52,988 | 43,684 | 53,158 | 62,106 | 64,278 | 91,720 | 63,114 |
| Atlantic croaker | 512 | 576 | 751 | 543 | 440 | 335 | 442 | 415 | 509 | 469 |
| Black sea bass | 436 | 555 | 573 | 724 | 811 | 454 | 445 | 450 | 592 | 508 |
| Blue crab | 30,338 | 34,532 | 39,104 | 39,962 | 31,141 | 41,690 | 50,115 | 52,049 | 79,805 | 59,193 |
| Clams or bivalves | 8,002 | 5,170 | 4,654 | 4,784 | 4,889 | 5,074 | 5,436 | 4,403 | 5,400 | 2,637 |
| Eastern oyster | 2,172 | 706 | 181 | 3,435 | 1,238 | 3,146 | 2,277 | 3,849 | 4,361 | ND[1] |
| Menhaden | 423 | 337 | 232 | 1,514 | 609 | 1,379 | 915 | 884 | 755 | 714 |
| Sea scallop | 96 | ND[2] | 417 | 4,549 | 6,200 | 2,809 | 3,758 | 3,160 | 1,187 | 568 |
| Striped bass | 3,759 | 3,916 | 1,549 | 4,259 | 4,591 | 5,333 | 5,232 | 5,180 | 5,531 | 5,610 |
| Summer flounder | ND[2] | 527 | 444 | 677 | 549 | 546 | 578 | 551 | 546 | 463 |
| White perch | 559 | 556 | 347 | 848 | 568 | 619 | 776 | 942 | 1,158 | 1,482 |

## Total Landings and Landings of Key Species/Species Groups (thousands of pounds)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total landings | 53,185 | 49,350 | 49,509 | 67,489 | 51,226 | 61,585 | 63,533 | 66,819 | 102,911 | 78,197 |
| Finfish & other | 15,275 | 13,468 | 8,055 | 25,000 | 12,719 | 21,618 | 18,626 | 19,968 | 27,881 | 21,292 |
| Shellfish | 37,909 | 35,882 | 41,454 | 42,489 | 38,507 | 39,967 | 44,908 | 46,850 | 75,031 | 56,905 |
| Atlantic croaker | 1,513 | 1,532 | 1,801 | 1,389 | 877 | 576 | 778 | 550 | 622 | 784 |
| Black sea bass | 280 | 313 | 284 | 337 | 350 | 171 | 159 | 126 | 203 | 183 |
| Blue crab | 26,481 | 27,816 | 33,826 | 34,914 | 29,446 | 30,778 | 34,872 | 38,801 | 66,661 | 50,027 |
| Clams or bivalves | 10,663 | 7,527 | 7,270 | 6,112 | 7,756 | 7,947 | 8,600 | 6,292 | 6,971 | 3,795 |
| Eastern oyster | 567 | 159 | 43 | 738 | 274 | 317 | 249 | 498 | 430 | ND[2] |
| Menhaden | 4,850 | 4,232 | 3,336 | 15,806 | 5,263 | 13,751 | 9,615 | 9,419 | 15,756 | 8,366 |
| Sea scallop | 27 | ND[2] | 94 | 591 | 931 | 450 | 569 | 521 | 153 | 58 |
| Striped bass | 2,085 | 2,193 | 885 | 2,349 | 2,485 | 2,640 | 2,655 | 2,812 | 2,549 | 2,344 |
| Summer flounder | ND[2] | 329 | 262 | 338 | 248 | 229 | 208 | 214 | 263 | 259 |
| White perch | 1,583 | 1,477 | 453 | 1,524 | 688 | 973 | 858 | 1,301 | 1,704 | 2,041 |

## Average Annual Price of Key Species/Species Groups (dollars per pound)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Atlantic croaker | 0.34 | 0.38 | 0.42 | 0.39 | 0.50 | 0.58 | 0.57 | 0.75 | 0.82 | 0.60 |
| Black sea bass | 1.56 | 1.77 | 2.02 | 2.15 | 2.31 | 2.66 | 2.79 | 3.58 | 2.91 | 2.78 |
| Blue crab | 1.15 | 1.24 | 1.16 | 1.14 | 1.06 | 1.35 | 1.44 | 1.34 | 1.20 | 1.18 |
| Clams or bivalves | 0.75 | 0.69 | 0.64 | 0.78 | 0.63 | 0.64 | 0.63 | 0.70 | 0.77 | 0.69 |
| Eastern oyster | 3.83 | 4.45 | 4.23 | 4.66 | 4.52 | 9.92 | 9.13 | 7.73 | 10.14 | ND[2] |
| Menhaden | 0.09 | 0.08 | 0.07 | 0.10 | 0.12 | 0.10 | 0.10 | 0.09 | 0.05 | 0.09 |
| Sea scallop | 3.52 | ND[2] | 4.44 | 7.70 | 6.66 | 6.25 | 6.60 | 6.06 | 7.77 | 9.83 |
| Striped bass | 1.80 | 1.79 | 1.75 | 1.81 | 1.85 | 2.02 | 1.97 | 1.84 | 2.17 | 2.39 |
| Summer flounder | ND[2] | 1.60 | 1.69 | 2.01 | 2.22 | 2.39 | 2.78 | 2.58 | 2.07 | 1.79 |
| White perch | 0.35 | 0.38 | 0.77 | 0.56 | 0.83 | 0.64 | 0.90 | 0.72 | 0.68 | 0.73 |

[1] ND = these data are confidential thus not disclosable

### 2011 Economic Impacts of Recreational Fishing Expenditures (thousands of dollars)

| | Jobs | Sales | Income | Value Added |
|---|---|---|---|---|
| Trip Impacts by Fishing Mode: | | | | |
| For-Hire | 582 | 50,524 | 17,155 | 29,700 |
| Private Boat | 557 | 60,042 | 20,972 | 36,610 |
| Shore | 740 | 68,529 | 23,903 | 40,421 |
| Total Durable Equipment Impacts | 3,866 | 604,738 | 198,808 | 289,890 |
| **Total State Trip and Durable Equipment Economic Impacts** | 5,745 | 783,833 | 260,839 | 396,620 |

### 2011 Angler Trip & Durable Expenditures (thousands of dollars)

| Fishing Mode | Trip Expenditures | | Equipment | Durable Expenditures |
|---|---|---|---|---|
| | Non-Residents | Residents | Fishing Tackle | 102,037 |
| For-Hire | 21,517 | 12,565 | Other Equipment | 25,715 |
| Private Boat | 11,504 | 46,261 | Boat Expenses | 424,367 |
| Shore | 26,772 | 30,318 | Vehicle Expenses | 107,135 |
| *Total Trip Expenditures* | 59,793 | 89,143 | Second Home Expenses | 916 |
| | | | *Total Durable Equipment Expenditures* | 660,170 |
| **Total State Trip and Durable Equipment Expenditures** | | | | 809,106 |

### Recreational Anglers by Residential Area (thousands of anglers)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal | 430 | 526 | 442 | 620 | 733 | 850 | 643 | 514 | 552 | 415 |
| Non-Coastal | 41 | 53 | 39 | 49 | 84 | 78 | 50 | 43 | 54 | 49 |
| Out of State | 330 | 418 | 333 | 425 | 447 | 528 | 507 | 327 | 462 | 372 |
| **Total Anglers** | 801 | 997 | 815 | 1095 | 1264 | 1456 | 1200 | 884 | 1068 | 836 |

### Recreational Fishing Effort by Mode (thousands of angler-trips)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| For-Hire | 183 | 187 | 176 | 212 | 238 | 269 | 195 | 202 | 138 | 161 |
| Private | 1,596 | 2,033 | 1,535 | 1,924 | 1,836 | 2,352 | 1,891 | 1,608 | 1,643 | 1,453 |
| Shore | 1,059 | 1,109 | 874 | 1,020 | 1,145 | 1,082 | 1,273 | 1,081 | 1,150 | 1,206 |
| **Total Trips** | 2,838 | 3,329 | 2,585 | 3,156 | 3,219 | 3,703 | 3,359 | 2,891 | 2,931 | 2,820 |

### Harvest (H) and Release (R) of Key Species Species Groups (thousands of fish)[1]

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Black seabass | H | 337 | 241 | 15 | 91 | 121 | 39 | 27 | 33 | 36 | 47 |
| | R | 925 | 773 | 259 | 563 | 645 | 577 | 674 | 453 | 670 | 352 |
| Bluefish | H | 197 | 213 | 367 | 167 | 421 | 676 | 550 | 591 | 273 | 259 |
| | R | 577 | 519 | 593 | 236 | 778 | 1,172 | 1,631 | 670 | 162 | 408 |
| Drum (Atlantic croaker) | H | 1,223 | 1,620 | 896 | 784 | 755 | 873 | 621 | 1,335 | 1,137 | 554 |
| | R | 2,524 | 1,393 | 854 | 1,138 | 1,783 | 1,258 | 2,128 | 1,138 | 1,011 | 366 |
| Drum (spot) | H | 692 | 3,300 | 868 | 1,789 | 2,895 | 3,616 | 1,892 | 2,064 | 1,164 | 913 |
| | R | 501 | 671 | 383 | 2,136 | 1,355 | 1,619 | 1,739 | 632 | 1,155 | 298 |
| Drum (weakfish)[2] | H | 101 | 42 | 15 | 32 | 1 | 7 | 2 | 4 | 5 | (1) |
| | R | 286 | 182 | 231 | 61 | 47 | 63 | 38 | 8 | 162 | 18 |
| Striped bass | H | 283 | 525 | 369 | 534 | 668 | 765 | 415 | 501 | 457 | 445 |
| | R | 2,928 | 4,653 | 3,479 | 3,855 | 3,711 | 3,066 | 1,338 | 1,423 | 1,509 | 1,127 |
| Summer flounder | H | 69 | 40 | 42 | 117 | 36 | 103 | 58 | 64 | 26 | 14 |
| | R | 383 | 373 | 805 | 361 | 252 | 1,018 | 922 | 817 | 1,227 | 472 |
| White perch | H | 1,156 | 2,020 | 1,623 | 2,411 | 2,560 | 2,889 | 1,509 | 550 | 2,613 | 1,571 |
| | R | 1,755 | 3,699 | 3,459 | 5,837 | 3,953 | 5,425 | 3,853 | 1,137 | 2,891 | 2,347 |
| Wrasses (tautog) | H | 43 | 13 | 8 | 28 | 15 | 43 | 19 | 39 | 57 | 12 |
| | R | 294 | 97 | 24 | 148 | 186 | 178 | 151 | 133 | 362 | 75 |
| Yellowfin tuna | H | 18 | 26 | 2 | 5 | 8 | 4 | (1) | 5 | 1 | (1) |
| | R | (1) | (1) | (1) | (1) | (1) | (1) | (1) | 2 | (1) | (1) |

[1] In this table, '(1)' = 0-999 thousand fish and '1' = 1,000-1,499 thousand fish.
[2] This species may not be equivalent to species with similar names listed in the commercial tables.

### Maryland's State Economy (% of national total)

| | Establishments | Employees | Annual Payroll (million $) | Employee Compensation (million $) | Gross State Product (million $) | Commercial Location Quotient [1] |
|---|---|---|---|---|---|---|
| 2002 | 131,815 (1.8%) | 2,062,515 (1.8%) | 75,032 (1.9%) | 127,286 (2%) | 206,624 (2.1%) | 0.7 |
| 2010 | 134,579 (1.8%) | 2,075,507 (1.9%) | 97,807 (2%) | 175,443 (2%) | 293,349 (2.2%) | 0.47 |
| % change | 2.1% | 0.63% | 30.4% | 37.8% | 42% | -42.9% |

### Seafood Sales & Processing - Nonemployer Firms (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Seafood product prep. & packaging | Firms | 50 | 47 | 51 | 57 | 55 | 56 | 56 | 41 | 56 |
| | Receipts | 3,199 | 2,487 | 2,301 | 2,727 | 2,751 | 3,940 | 3,310 | 2,106 | 3,310 |
| Seafood Sales, retail | Firms | 79 | 78 | 70 | 78 | 73 | 99 | 84 | 91 | 84 |
| | Receipts | 8,629 | 6,771 | 10,100 | 6,976 | 7,755 | 10,493 | 9,010 | 8,593 | 9,010 |

### Seafood Sales & Processing - Employer Establishments (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Seafood product prep. & packaging | Establishments | 24 | 23 | 23 | 23 | 19 | 22 | 22 | 19 | 18 |
| | Employees | 807 | 762 | 895 | 1,141 | 1,053 | 1,296 | 1,003 | 245 | 273 |
| | Payroll | 20,618 | 20,399 | 23,039 | 24,986 | 28,852 | 32,386 | 39,328 | 13,049 | 12,652 |
| Seafood sales, wholesale | Establishments | 77 | 63 | 58 | 59 | 59 | 62 | 60 | 61 | 63 |
| | Employees | 870 | 686 | 733 | 709 | 694 | 978 | 851 | 777 | 795 |
| | Payroll | 33,072 | 27,934 | 29,813 | 30,148 | 32,943 | 50,353 | 42,296 | 39,055 | 39,067 |
| Seafood sales, retail | Establishments | 88 | 97 | 96 | 95 | 97 | 102 | 94 | 87 | 87 |
| | Employees | 488 | 459 | 579 | 576 | 617 | 613 | 590 | 485 | 526 |
| | Payroll | 10,033 | 10,634 | 12,328 | 13,019 | 14,190 | 14,777 | 11,510 | 11,499 | 11,810 |

### Transport, Support, & Marine Operations - Employer Establishments (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal & Great Lakes freight transportation | Establishments | 8 | 9 | 11 | 10 | 10 | 8 | 6 | 7 | 8 |
| | Employees | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| | Payroll | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| Deep sea freight transportation | Establishments | 14 | 16 | 15 | 16 | 14 | 14 | 13 | 15 | 15 |
| | Employees | 123 | ND[2] | 281 | 316 | ND[2] | 244 | 250 | 255 | 390 |
| | Payroll | 9,216 | ND[2] | 18,983 | 14,131 | ND[2] | 14,905 | 19,765 | 20,722 | 24,185 |
| Deep sea passenger transportation | Establishments | 4 | 3 | 2 | 1 | 1 | 1 | 3 | 2 | 1 |
| | Employees | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| | Payroll | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| Marinas | Establishments | 188 | 180 | 183 | 185 | 179 | 183 | 179 | 176 | 175 |
| | Employees | 1,232 | 1,296 | 1,321 | 1,228 | 1,260 | 1,326 | 1,383 | 1,289 | 1,275 |
| | Payroll | 33,621 | 34,024 | 36,598 | 36,590 | 40,866 | 48,752 | 45,965 | 45,483 | 43,508 |
| Marine cargo handling | Establishments | 16 | 14 | 11 | 12 | 13 | 15 | 15 | 16 | 17 |
| | Employees | 1,487 | 1,862 | 1,725 | 1,639 | 1,659 | 1,791 | 1,572 | 1,599 | 2,742 |
| | Payroll | 66,525 | 69,084 | 75,911 | 81,219 | 73,367 | 85,328 | 48,382 | 46,727 | 95,182 |
| Navigational services to shipping | Establishments | 13 | 11 | 8 | 9 | 9 | 8 | 9 | 11 | 10 |
| | Employees | ND[2] | 195 | ND[2] | ND[2] | ND[2] | 157 | 92 | 77 | 84 |
| | Payroll | ND[2] | 38,619 | ND[2] | ND[2] | ND[2] | 4,882 | 3,968 | 3,807 | 4,015 |
| Port & harbor operations | Establishments | 7 | 8 | 10 | 11 | 11 | 8 | 3 | 4 | 5 |
| | Employees | 259 | 376 | 479 | ND[2] | ND[2] | 323 | ND[2] | ND[2] | ND[2] |
| | Payroll | 11,655 | 16,099 | 19,218 | ND[2] | ND[2] | 13,427 | ND[2] | ND[2] | ND[2] |
| Ship & boat building | Establishments | 44 | 55 | 58 | 57 | 55 | 48 | 46 | 38 | 35 |
| | Employees | 1,223 | 1,426 | 1,022 | ND[2] | 1,119 | 874 | 677 | 416 | ND[2] |
| | Payroll | 40,743 | 36,444 | 35,364 | ND[2] | 33,463 | 29,500 | 22,363 | 16,238 | ND[2] |

[1] The U.S. Commercial Fishing Location Quotient (CFLQ) of 1.0 represents the national baseline from which state CFLQs can be compared.
[2] ND = these data are confidential thus not disclosable

### 2011 Economic Impacts of the New Jersey Seafood Industry (thousands of dollars)

| | With Imports | | | Without Imports | | |
|---|---|---|---|---|---|---|
| | Jobs | Sales | Value Added | Jobs | Sales | Value Added |
| **Total Impacts** | 43,638 | 6,563,733 | 2,407,754 | 10,115 | 818,397 | 390,460 |
| Commercial Harvesters | 3,602 | 426,864 | 181,894 | 3,602 | 426,864 | 181,894 |
| Seafood Processors & Dealers | 6,049 | 560,815 | 277,214 | 924 | 86,813 | 42,912 |
| Importers | 16,022 | 4,407,196 | 1,343,506 | 0 | 0 | 0 |
| Seafood Wholesalers & Distributors | 2,535 | 409,652 | 179,034 | 266 | 42,948 | 18,770 |
| Retail | 15,430 | 759,207 | 426,105 | 5,324 | 261,773 | 146,885 |

### Total Landings Revenue and Landings Revenue of Key Species/Species Groups (thousands of dollars)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total revenue | 112,708 | 120,670 | 145,217 | 158,746 | 136,039 | 151,513 | 168,518 | 150,030 | 178,080 | 214,191 |
| Finfish & other | 20,062 | 22,017 | 21,369 | 22,585 | 24,476 | 24,238 | 19,945 | 24,032 | 22,929 | 26,783 |
| Shellfish | 92,646 | 98,653 | 123,847 | 136,161 | 111,563 | 127,275 | 148,573 | 125,998 | 155,152 | 187,407 |
| American lobster | 1,139 | 1,028 | 1,800 | 2,001 | 2,533 | 4,056 | 3,214 | 850 | 2,679 | 2,774 |
| Atlantic herring | 60 | 145 | 1 | 1 | ND[1] | 562 | 548 | 1,564 | 422 | 415 |
| Atlantic mackerel | 1,780 | 2,855 | 3,398 | 3,957 | 3,709 | 668 | 1,568 | 1,539 | 848 | 53 |
| Blue crab | 6,725 | 4,736 | 5,330 | 6,773 | 6,359 | 5,471 | 7,284 | 184 | 11,858 | 9,423 |
| Eastern oyster | 1,853 | 3,366 | 1,558 | 823 | 2,288 | ND[2] | 2,547 | ND[2] | ND[2] | ND[2] |
| Goosefish | 5,896 | 6,200 | 3,446 | 4,451 | 4,415 | 4,484 | 4,005 | 3,017 | 2,752 | 3,641 |
| Ocean quahog & surf clams | 39,804 | 38,054 | 31,379 | 25,567 | 31,038 | 26,547 | 30,838 | 27,496 | 23,889 | 19,428 |
| Quahog clam | ND[2] | 5,228 | 7,409 | 7,556 | 7,615 | 968 | 6,254 | ND[2] | ND[2] | ND[2] |
| Sea scallop | 33,336 | 43,507 | 67,309 | 88,486 | 57,465 | 77,359 | 91,320 | 90,111 | 109,116 | 142,482 |
| Summer flounder | 3,504 | 3,683 | 4,134 | 4,478 | 4,926 | 3,989 | 3,461 | 3,377 | 4,553 | 5,462 |

### Total Landings and Landings of Key Species/Species Groups (thousands of pounds)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total landings | 162,139 | 170,133 | 187,377 | 156,695 | 152,781 | 153,846 | 162,304 | 161,611 | 161,844 | 175,516 |
| Finfish & other | 65,737 | 75,471 | 71,450 | 74,193 | 66,316 | 65,164 | 62,816 | 73,617 | 74,803 | 94,657 |
| Shellfish | 96,401 | 94,662 | 115,926 | 82,502 | 86,465 | 88,683 | 99,487 | 87,994 | 87,041 | 80,859 |
| American lobster | 264 | 210 | 370 | 369 | 471 | 680 | 633 | 180 | 642 | 627 |
| Atlantic herring | 1,138 | 1,805 | 5 | 1 | ND[2] | 6,038 | 6,539 | 13,692 | 4,140 | 2,385 |
| Atlantic mackerel | 20,486 | 33,056 | 36,091 | 32,414 | 24,977 | 5,384 | 9,426 | 10,255 | 4,692 | 107 |
| Blue crab | 6,229 | 4,012 | 4,350 | 6,333 | 5,981 | 4,636 | 5,816 | 257 | 9,268 | 9,600 |
| Eastern oyster | 379 | 714 | 323 | 162 | 350 | ND[2] | 550 | ND[2] | ND[2] | ND[2] |
| Goosefish | 5,697 | 7,185 | 4,177 | 3,881 | 3,841 | 4,229 | 3,694 | 2,686 | 1,988 | 2,265 |
| Ocean quahog & surf clams | 73,949 | 71,683 | 61,155 | 49,849 | 55,286 | 44,791 | 51,597 | 45,306 | 38,538 | 29,342 |
| Quahog clam | ND[2] | 1,260 | 1,796 | 1,852 | 1,844 | 240 | 1,516 | ND[2] | ND[2] | ND[2] |
| Sea scallop | 8,644 | 10,638 | 13,705 | 11,831 | 8,439 | 11,808 | 13,282 | 14,038 | 14,170 | 14,543 |
| Summer flounder | 2,407 | 2,385 | 2,630 | 2,349 | 2,380 | 1,697 | 1,541 | 1,799 | 2,166 | 2,830 |

### Average Annual Price of Key Species/Species Groups (dollars per pound)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| American lobster | 4.31 | 4.90 | 4.86 | 5.42 | 5.38 | 5.96 | 5.08 | 4.73 | 4.18 | 4.42 |
| Atlantic herring | 0.05 | 0.08 | 0.23 | 0.78 | ND[2] | 0.09 | 0.08 | 0.11 | 0.10 | 0.17 |
| Atlantic mackerel | 0.09 | 0.09 | 0.09 | 0.12 | 0.15 | 0.12 | 0.17 | 0.15 | 0.18 | 0.50 |
| Blue crab | 1.08 | 1.18 | 1.23 | 1.07 | 1.06 | 1.18 | 1.25 | 0.72 | 1.28 | 0.98 |
| Eastern oyster | 4.88 | 4.72 | 4.82 | 5.09 | 6.53 | ND[2] | 4.63 | ND[2] | ND[2] | ND[2] |
| Goosefish | 1.03 | 0.86 | 0.83 | 1.15 | 1.15 | 1.06 | 1.08 | 1.12 | 1.38 | 1.61 |
| Ocean quahog & surf clams | 0.54 | 0.53 | 0.51 | 0.51 | 0.56 | 0.59 | 0.60 | 0.61 | 0.62 | 0.66 |
| Quahog clam | ND[2] | 4.15 | 4.13 | 4.08 | 4.13 | 4.04 | 4.12 | ND[2] | ND[2] | ND[2] |
| Sea scallop | 3.86 | 4.09 | 4.91 | 7.48 | 6.81 | 6.55 | 6.88 | 6.42 | 7.70 | 9.80 |
| Summer flounder | 1.46 | 1.54 | 1.57 | 1.91 | 2.07 | 2.35 | 2.25 | 1.88 | 2.10 | 1.93 |

[1] ND = these data are confidential thus not disclosable

### 2011 Economic Impacts of Recreational Fishing Expenditures (thousands of dollars)

| | Jobs | Sales | Income | Value Added |
|---|---|---|---|---|
| Trip Impacts by Fishing Mode: | | | | |
| For-Hire | 580 | 62,526 | 21,058 | 36,350 |
| Private Boat | 1,270 | 179,913 | 54,191 | 93,076 |
| Shore | 783 | 93,766 | 30,440 | 50,978 |
| Total Durable Equipment Impacts | 7,333 | 1,360,911 | 448,628 | 690,578 |
| **Total State Trip and Durable Equipment Economic Impacts** | 9,965 | 1,697,115 | 554,318 | 870,983 |

### 2011 Angler Trip & Durable Expenditures (thousands of dollars)

| Fishing Mode | Trip Expenditures | | Equipment | Durable Expenditures |
|---|---|---|---|---|
| | Non-Residents | Residents | Fishing Tackle | 307,411 |
| For-Hire | 17,405 | 23,220 | Other Equipment | 58,800 |
| Private Boat | 37,561 | 104,637 | Boat Expenses | 499,473 |
| Shore | 29,105 | 47,508 | Vehicle Expenses | 232,339 |
| *Total Trip Expenditures* | 84,072 | 175,365 | Second Home Expenses | 134,169 |
| | | | *Total Durable Equipment Expenditures* | 1,232,192 |
| **Total State Trip and Durable Equipment Expenditures** | | | | 1,491,629 |

### Recreational Anglers by Residential Area (thousands of anglers)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal | 400 | 592 | 708 | 818 | 693 | 890 | 765 | 656 | 776 | 687 |
| Non-Coastal | 17 | 20 | 31 | 39 | 25 | 19 | 26 | 35 | 36 | 23 |
| Out of State | 239 | 462 | 379 | 471 | 481 | 518 | 456 | 454 | 449 | 357 |
| **Total Anglers** | 656 | 1074 | 1117 | 1328 | 1199 | 1427 | 1246 | 1145 | 1261 | 1067 |

### Recreational Fishing Effort by Mode (thousands of angler-trips)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| For-Hire | 367 | 466 | 432 | 452 | 633 | 606 | 450 | 434 | 319 | 382 |
| Private | 2,992 | 3,603 | 3,895 | 3,753 | 3,721 | 3,614 | 3,595 | 2,671 | 3,264 | 2,446 |
| Shore | 2,049 | 2,712 | 2,121 | 2,357 | 2,682 | 2,978 | 2,858 | 2,235 | 2,279 | 2,334 |
| **Total Trips** | 5,408 | 6,781 | 6,448 | 6,562 | 7,036 | 7,198 | 6,903 | 5,340 | 5,862 | 5,162 |

### Harvest (H) and Release (R) of Key Species Species Groups (thousands of fish)[1]

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Black seabass | H | 1,759 | 1,903 | 1,079 | 660 | 530 | 725 | 579 | 584 | 685 | 149 |
| | R | 4,320 | 4,296 | 3,121 | 2,387 | 2,082 | 2,423 | 4,431 | 3,139 | 3,868 | 1,302 |
| Bluefin tuna | H | 7 | 9 | 7 | 10 | 4 | 7 | 4 | 14 | 6 | 2 |
| | R | (1) | (1) | 60 | 24 | 97 | 1 | 1 | 2 | 7 | 6 |
| Bluefish | H | 1,322 | 1,572 | 1,530 | 2,367 | 1,184 | 1,654 | 1,029 | 813 | 910 | 1,150 |
| | R | 2,169 | 1,913 | 2,226 | 2,291 | 1,803 | 2,735 | 1,478 | 1,476 | 1,885 | 1,911 |
| Drum (weakfish)[2] | H | 494 | 149 | 228 | 1,008 | 489 | 229 | 298 | 12 | 2 | 3 |
| | R | 351 | 630 | 534 | 1,374 | 1,335 | 613 | 1,433 | 79 | 103 | 101 |
| Red hake | H | 12 | 16 | 4 | 6 | 141 | 1 | 152 | 240 | 124 | 206 |
| | R | (1) | 14 | 3 | 2 | 12 | (1) | 19 | 23 | 24 | 13 |
| Striped bass | H | 415 | 392 | 423 | 411 | 509 | 288 | 310 | 281 | 318 | 394 |
| | R | 715 | 926 | 1,503 | 1,219 | 1,890 | 1,789 | 1,309 | 801 | 689 | 884 |
| Summer flounder | H | 988 | 1,784 | 1,617 | 1,302 | 1,556 | 1,067 | 763 | 825 | 552 | 737 |
| | R | 4,206 | 5,806 | 6,700 | 8,940 | 6,739 | 6,192 | 8,959 | 10,413 | 10,565 | 8,096 |
| Winter flounder | H | 208 | 307 | 40 | 32 | 64 | 96 | 3 | 7 | 24 | 28 |
| | R | 124 | 110 | 32 | 21 | 112 | 27 | 15 | 28 | 39 | 25 |
| Wrasses (tautog) | H | 347 | 102 | 90 | 43 | 202 | 300 | 172 | 127 | 374 | 137 |
| | R | 836 | 394 | 385 | 222 | 603 | 1,290 | 901 | 856 | 1,064 | 844 |
| Yellowfin tuna | H | 14 | 22 | 9 | 21 | 36 | 58 | 7 | 7 | 26 | 17 |
| | R | 4 | (1) | 8 | 1 | (1) | (1) | 1 | 16 | (1) | (1) |

[1] In this table, '(1)' = 0-999 thousand fish and '1' = 1,000-1,499 thousand fish.
[2] This species may not be equivalent to species with similar names listed in the commercial tables.

### New Jersey's State Economy (% of national total)

| | Establishments | Employees | Annual Payroll (million $) | Employee Compensation (million $) | Gross State Product (million $) | Commercial Location Quotient [1] |
|---|---|---|---|---|---|---|
| 2002 | 237,505 (3.3%) | 3,596,919 (3.2%) | 152,370 (3.9%) | 216,721 (3.6%) | 376,922 (3.6%) | ND[23] |
| 2010 | 228,937 (3.1%) | 3,367,169 (3%) | 178,657 (3.6%) | 267,771 (3.3%) | 480,446 (3.4%) | [2] |
| % change | -3.61% | -6.39% | 17.3% | 23.6% | 27.5% | -- |

### Seafood Sales & Processing - Nonemployer Firms (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Seafood product prep. & packaging | Firms | 21 | 23 | 23 | 26 | 27 | 25 | 22 | 33 | 22 |
| | Receipts | 2,673 | 2,279 | 2,694 | 3,086 | 3,027 | 2,399 | 1,851 | 3,667 | 1,851 |
| Seafood Sales, retail | Firms | 92 | 100 | 89 | 93 | 72 | 90 | 92 | 81 | 92 |
| | Receipts | 8,348 | 8,822 | 9,219 | 9,194 | 8,916 | 11,320 | 11,196 | 9,901 | 11,196 |

### Seafood Sales & Processing - Employer Establishments (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Seafood product prep. & packaging | Establishments | 17 | 16 | 15 | 17 | 16 | 16 | 14 | 13 | 11 |
| | Employees | 928 | 846 | 749 | 969 | 667 | 628 | 566 | 661 | 482 |
| | Payroll | 23,045 | 20,794 | 21,029 | 28,235 | 22,097 | 18,403 | 18,703 | 22,025 | 17,427 |
| Seafood sales, wholesale | Establishments | 102 | 84 | 85 | 85 | 89 | 101 | 81 | 83 | 90 |
| | Employees | 969 | 920 | 948 | 914 | 941 | 978 | 856 | 858 | 848 |
| | Payroll | 37,394 | 35,991 | 38,066 | 37,828 | 41,506 | 41,994 | 37,462 | 37,348 | 38,065 |
| Seafood sales, retail | Establishments | 149 | 133 | 134 | 128 | 127 | 124 | 118 | 106 | 108 |
| | Employees | 559 | 454 | 547 | 524 | 493 | 472 | 368 | 332 | 332 |
| | Payroll | 10,225 | 10,513 | 11,952 | 11,787 | 11,373 | 10,352 | 9,372 | 9,126 | 9,094 |

### Transport, Support, & Marine Operations - Employer Establishments (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal & Great Lakes freight transportation | Establishments | 13 | 15 | 17 | 18 | 18 | 23 | 18 | 19 | 18 |
| | Employees | ND[2] | 768 | ND[2] | 914 | 1,040 | 778 | 645 | 594 | 600 |
| | Payroll | ND[2] | 45,024 | ND[2] | 54,097 | 68,096 | 56,017 | 48,911 | 41,925 | 44,246 |
| Deep sea freight transportation | Establishments | 35 | 37 | 33 | 38 | 39 | 31 | 27 | 26 | 26 |
| | Employees | 1,397 | 1,287 | 1,028 | 948 | 648 | 566 | 1,115 | 1,045 | ND[2] |
| | Payroll | 78,258 | 70,996 | 65,691 | 68,633 | 45,940 | 44,133 | 75,848 | 66,547 | 78,898 |
| Deep sea passenger transportation | Establishments | 4 | 5 | 4 | 5 | 4 | 2 | 2 | 3 | 2 |
| | Employees | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| | Payroll | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| Marinas | Establishments | 199 | 203 | 201 | 206 | 204 | 216 | 211 | 214 | 212 |
| | Employees | 927 | 951 | 945 | 978 | 940 | 1,045 | 916 | 784 | 781 |
| | Payroll | 32,480 | 34,777 | 36,862 | 38,323 | 39,154 | 41,624 | 39,596 | 35,811 | 35,475 |
| Marine cargo handling | Establishments | 29 | 27 | 26 | 26 | 25 | 23 | 21 | 22 | 21 |
| | Employees | 3,408 | 4,108 | 4,685 | 4,972 | 4,599 | 4,781 | 4,244 | 3,479 | 3,292 |
| | Payroll | 247,217 | 318,325 | 340,085 | 363,714 | 345,784 | 350,690 | 278,189 | 230,886 | 260,894 |
| Navigational services to shipping | Establishments | 22 | 16 | 17 | 16 | 19 | 26 | 20 | 19 | 16 |
| | Employees | ND[2] | 210 | ND[2] | 169 | ND[2] | 227 | 191 | 133 | 75 |
| | Payroll | ND[2] | 8,028 | ND[2] | 9,673 | ND[2] | 11,403 | 7,776 | 6,638 | 6,125 |
| Port & harbor operations | Establishments | 5 | 5 | 6 | 7 | 6 | 8 | 6 | 6 | 11 |
| | Employees | ND[2] | 240 | ND[2] | 194 | ND[2] | 271 | 143 | 54 | 124 |
| | Payroll | ND[2] | 10,644 | ND[2] | 11,599 | ND[2] | 12,197 | 12,446 | 5,548 | 10,463 |
| Ship & boat building | Establishments | 41 | 37 | 35 | 37 | 34 | 31 | 30 | 25 | 24 |
| | Employees | 2,223 | 2,005 | 2,040 | 2,320 | 2,307 | 2,305 | 2,019 | 1,188 | 1,056 |
| | Payroll | 76,607 | 75,149 | 80,301 | 89,421 | 88,367 | 91,460 | 79,309 | 42,909 | 37,920 |

[1] The U.S. Commercial Fishing Location Quotient (CFLQ) of 1.0 represents the national baseline from which state CFLQs can be compared.
[2] ND = these data are confidential thus not disclosable
[3] ND = these data are confidential thus not disclosable

## 2011 Economic Impacts of the New York Seafood Industry (thousands of dollars)

| | With Imports | | | Without Imports | | |
|---|---|---|---|---|---|---|
| | Jobs | Sales | Value Added | Jobs | Sales | Value Added |
| **Total Impacts** | 41,847 | 5,102,910 | 1,801,303 | 2,963 | 138,229 | 67,182 |
| Commercial Harvesters | 1,386 | 67,485 | 29,835 | 1,386 | 67,485 | 29,835 |
| Seafood Processors & Dealers | 883 | 126,868 | 62,743 | 104 | 15,157 | 7,496 |
| Importers | 14,284 | 3,929,115 | 1,197,766 | 0 | 0 | 0 |
| Seafood Wholesalers & Distributors | 4,155 | 303,956 | 138,550 | 102 | 7,471 | 3,405 |
| Retail | 21,139 | 675,486 | 372,410 | 1,370 | 48,116 | 26,446 |

## Total Landings Revenue and Landings Revenue of Key Species/Species Groups (thousands of dollars)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total revenue | 51,264 | 51,601 | 46,878 | 56,367 | 57,725 | 59,379 | 59,143 | 49,347 | 33,924 | 37,625 |
| Finfish & other | 15,924 | 16,426 | 16,765 | 18,317 | 19,143 | 20,496 | 18,841 | 17,569 | 20,445 | 22,285 |
| Shellfish | 35,341 | 35,175 | 30,113 | 38,051 | 38,582 | 38,884 | 40,302 | 31,778 | 13,479 | 15,340 |
| American lobster | 5,131 | 4,426 | 3,722 | 4,396 | 6,289 | 3,624 | 5,498 | 3,943 | 1,329 | 1,398 |
| Atlantic surf clam | 5,520 | 7,934 | 4,475 | 7,055 | 4,473 | 5,932 | 5,670 | 5,858 | 1,708 | ND[1] |
| Eastern oyster | 4,995 | 4,263 | 3,367 | 1,961 | 2,390 | 2,627 | 2,870 | 1,428 | ND[2] | ND[2] |
| Flounder, Summer | 2,042 | 2,240 | 3,275 | 3,797 | 3,418 | 3,133 | 2,933 | 3,088 | 3,569 | 3,715 |
| Loligo squid | 6,247 | 4,353 | 5,426 | 6,054 | 5,846 | 5,159 | 5,290 | 4,167 | 4,516 | 7,249 |
| Quahog clam | 12,245 | 12,399 | 10,673 | 12,696 | 12,237 | 14,224 | 13,185 | 8,397 | ND[2] | ND[2] |
| Scups or porgies | 1,185 | 1,330 | 1,637 | 2,027 | 2,457 | 2,349 | 1,710 | 1,887 | 2,112 | 2,549 |
| Sea scallop | 90 | 164 | 720 | 3,617 | 3,518 | 3,872 | 5,050 | 5,018 | 3,777 | 4,961 |
| Softshell clam | 679 | 888 | 1,227 | 1,468 | 2,055 | 1,628 | 1,076 | 700 | ND[2] | ND[2] |
| Tilefishes | 3,195 | 2,736 | 2,082 | 2,765 | 3,323 | 3,843 | 3,343 | 3,262 | 4,077 | 4,525 |

## Total Landings and Landings of Key Species/Species Groups (thousands of pounds)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total landings | 38,548 | 39,388 | 34,514 | 38,150 | 32,659 | 35,594 | 34,521 | 34,398 | 27,665 | 27,104 |
| Finfish & other | 16,540 | 17,223 | 16,531 | 14,631 | 14,036 | 16,495 | 15,069 | 16,172 | 18,191 | 18,596 |
| Shellfish | 22,008 | 22,165 | 17,983 | 23,519 | 18,623 | 19,099 | 19,451 | 18,225 | 9,473 | 8,507 |
| American lobster | 1,440 | 946 | 996 | 1,154 | 1,243 | 716 | 1,210 | 1,047 | 307 | 344 |
| Atlantic surf clam | 8,544 | 13,264 | 7,462 | 11,953 | 6,913 | 9,161 | 8,753 | 8,799 | 2,573 | ND[2] |
| Eastern oyster | 537 | 466 | 370 | 219 | 269 | 124 | 135 | 64 | ND[2] | ND[2] |
| Flounder, Summer | 1,053 | 1,073 | 1,594 | 1,799 | 1,220 | 942 | 856 | 1,140 | 1,363 | 1,511 |
| Loligo squid | 9,613 | 4,603 | 6,363 | 6,693 | 6,462 | 5,438 | 5,469 | 4,098 | 3,900 | 5,629 |
| Quahog clam | 1,502 | 1,553 | 1,346 | 1,617 | 1,650 | 1,592 | 1,476 | 1,410 | ND[2] | ND[2] |
| Scups or porgies | 1,558 | 1,850 | 1,907 | 2,186 | 2,423 | 2,325 | 1,214 | 1,848 | 2,690 | 3,726 |
| Sea scallop | 26 | 39 | 170 | 647 | 577 | 619 | 782 | 918 | 507 | 522 |
| Softshell clam | 132 | 163 | 234 | 270 | 393 | 198 | 131 | 114 | ND[2] | ND[2] |
| Tilefishes | 1,593 | 1,755 | 1,335 | 1,142 | 1,297 | 1,393 | 1,199 | 1,435 | 1,586 | 1,521 |

## Average Annual Price of Key Species/Species Groups (dollars per pound)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| American lobster | 3.56 | 4.68 | 3.74 | 3.81 | 5.06 | 5.06 | 4.54 | 3.76 | 4.32 | 4.06 |
| Atlantic surf clam | 0.65 | 0.60 | 0.60 | 0.59 | 0.65 | 0.65 | 0.65 | 0.67 | 0.66 | ND[2] |
| Eastern oyster | 9.30 | 9.15 | 9.10 | 8.97 | 8.87 | 21.21 | 21.21 | 22.23 | ND[2] | ND[2] |
| Flounder, Summer | 1.94 | 2.09 | 2.05 | 2.11 | 2.80 | 3.33 | 3.43 | 2.71 | 2.62 | 2.46 |
| Loligo squid | 0.65 | 0.95 | 0.85 | 0.90 | 0.90 | 0.95 | 0.97 | 1.02 | 1.16 | 1.29 |
| Quahog clam | 8.15 | 7.98 | 7.93 | 7.85 | 7.42 | 8.94 | 8.93 | 5.96 | ND[2] | ND[2] |
| Scups or porgies | 0.76 | 0.72 | 0.86 | 0.93 | 1.01 | 1.01 | 1.41 | 1.02 | 0.79 | 0.68 |
| Sea scallop | 3.43 | 4.19 | 4.24 | 5.59 | 6.10 | 6.25 | 6.46 | 5.47 | 7.44 | 9.50 |
| Softshell clam | 5.15 | 5.45 | 5.24 | 5.43 | 5.23 | 8.23 | 8.24 | 6.13 | ND[2] | ND[2] |
| Tilefishes | 2.01 | 1.56 | 1.56 | 2.42 | 2.56 | 2.76 | 2.79 | 2.27 | 2.57 | 2.97 |

[1] ND = these data are confidential thus not disclosable

### 2011 Economic Impacts of Recreational Fishing Expenditures (thousands of dollars)

| | Jobs | Sales | Income | Value Added |
|---|---|---|---|---|
| Trip Impacts by Fishing Mode: | | | | |
| For-Hire | 1,043 | 102,927 | 36,048 | 62,326 |
| Private Boat | 936 | 113,282 | 40,674 | 70,922 |
| Shore | 222 | 23,992 | 8,692 | 14,646 |
| Total Durable Equipment Impacts | 770 | 129,181 | 43,324 | 64,274 |
| **Total State Trip and Durable Equipment Economic Impacts** | 2,972 | 369,382 | 128,738 | 212,169 |

### 2011 Angler Trip & Durable Expenditures (thousands of dollars)

| Fishing Mode | Trip Expenditures | | Equipment | Durable Expenditures |
|---|---|---|---|---|
| | Non-Residents | Residents | Fishing Tackle | 45,733 |
| For-Hire | 3,640 | 62,687 | Other Equipment | 20,598 |
| Private Boat | 2,156 | 113,537 | Boat Expenses | 47,804 |
| Shore | 775 | 23,108 | Vehicle Expenses | 10,276 |
| *Total Trip Expenditures* | 6,571 | 199,332 | Second Home Expenses | 0 |
| | | | *Total Durable Equipment Expenditures* | 124,412 |
| **Total State Trip and Durable Equipment Expenditures** | | | | 330,315 |

### Recreational Anglers by Residential Area (thousands of anglers)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal | 387 | 599 | 587 | 885 | 735 | 881 | 817 | 638 | 646 | 497 |
| Non-Coastal | 8 | 19 | 18 | 27 | 25 | 39 | 32 | 21 | 24 | 18 |
| Out of State | 41 | 82 | 76 | 110 | 114 | 147 | 118 | 58 | 69 | 46 |
| **Total Anglers** | 436 | 700 | 681 | 1022 | 874 | 1067 | 967 | 717 | 740 | 561 |

### Recreational Fishing Effort by Mode (thousands of angler-trips)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| For-Hire | 339 | 405 | 388 | 526 | 361 | 684 | 387 | 383 | 347 | 458 |
| Private | 2,171 | 3,030 | 2,670 | 3,108 | 3,121 | 3,315 | 3,200 | 2,819 | 2,351 | 2,321 |
| Shore | 1,606 | 2,089 | 1,755 | 2,495 | 1,961 | 2,522 | 2,341 | 1,624 | 1,675 | 1,389 |
| **Total Trips** | 4,116 | 5,524 | 4,813 | 6,129 | 5,443 | 6,521 | 5,928 | 4,826 | 4,373 | 4,168 |

### Harvest (H) and Release (R) of Key Species Species Groups (thousands of fish)[1]

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Atlantic herring[2] | H | 26 | 30 | 124 | 60 | 23 | 214 | 70 | 3 | 79 | 75 |
| | R | 14 | (1) | 2 | 2 | 2 | 230 | 50 | (1) | 17 | (1) |
| Black seabass | H | 221 | 318 | 133 | 143 | 269 | 410 | 259 | 567 | 543 | 274 |
| | R | 1,412 | 739 | 625 | 1,072 | 1,328 | 1,548 | 1,654 | 1,236 | 1,164 | 894 |
| Bluefish | H | 752 | 1,146 | 1,896 | 1,684 | 1,834 | 2,150 | 1,484 | 1,293 | 1,026 | 926 |
| | R | 1,018 | 1,305 | 2,530 | 3,381 | 2,378 | 2,650 | 3,225 | 1,794 | 1,471 | 1,600 |
| Drum (weakfish)[3] | H | 25 | 9 | 11 | (1) | 11 | 4 | 40 | (1) | 3 | (1) |
| | R | 62 | 8 | 39 | 77 | 18 | 109 | 25 | 3 | 3 | 55 |
| Porgies (scup) | H | 1,090 | 5,110 | 1,877 | 859 | 1,678 | 1,596 | 1,451 | 1,461 | 1,990 | 715 |
| | R | 1,246 | 1,806 | 3,515 | 1,738 | 2,623 | 1,963 | 2,838 | 2,124 | 1,865 | 998 |
| Shortfin mako shark | H | 1 | 3 | (1) | (1) | (1) | (1) | (1) | (1) | 1 | (1) |
| | R | 4 | 3 | 2 | 5 | (1) | (1) | (1) | (1) | (1) | 3 |
| Striped bass | H | 202 | 315 | 263 | 376 | 368 | 474 | 684 | 355 | 539 | 676 |
| | R | 588 | 1,083 | 2,709 | 1,413 | 1,722 | 1,679 | 1,347 | 1,073 | 1,068 | 1,507 |
| Summer flounder | H | 698 | 1,538 | 1,024 | 1,164 | 752 | 866 | 608 | 299 | 335 | 375 |
| | R | 4,099 | 5,722 | 3,182 | 7,754 | 4,946 | 5,272 | 5,521 | 5,565 | 6,571 | 7,295 |
| Winter flounder | H | 153 | 233 | 227 | 100 | 261 | 10 | 41 | 69 | 31 | 64 |
| | R | 141 | 72 | 32 | 201 | 76 | 15 | 17 | 110 | 63 | 101 |
| Wrasses (tautog) | H | 630 | 129 | 278 | 84 | 246 | 224 | 318 | 345 | 145 | 111 |
| | R | 953 | 298 | 640 | 178 | 823 | 388 | 728 | 666 | 567 | 488 |

[1] In this table, '(1)' = 0-999 thousand fish and '1' = 1,000-1,499 thousand fish.
[2] This species may not be equivalent to species with similar names listed in the commercial tables.
[3] This species may not be equivalent to species with similar names listed in the commercial tables.

### New York's State Economy (% of national total)

| | Establishments | Employees | Annual Payroll (million $) | Employee Compensation (million $) | Gross State Product (million $) | Commercial Location Quotient [1] |
|---|---|---|---|---|---|---|
| 2002 | 498,921 (6.9%) | 7,234,915 (6.4%) | 329,811 (8.4%) | 476,767 (7.8%) | 822,408 (7.8%) | 1.01 |
| 2010 | 519,504 (7%) | 7,266,189 (6.5%) | 418,438 (8.5%) | 638,150 (7.8%) | 1,128,823 (8%) | 1.19 |
| % change | 4.13% | 0.432% | 26.9% | 33.8% | 37.3% | 17.8% |

### Seafood Sales & Processing - Nonemployer Firms (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Seafood product prep. & packaging | Firms | 40 | 62 | 49 | 57 | 61 | 68 | 73 | 101 | 73 |
| | Receipts | 1,730 | 2,580 | 3,517 | 2,652 | 3,044 | 3,516 | 3,383 | 4,883 | 3,383 |
| Seafood Sales, retail | Firms | 244 | 272 | 241 | 219 | 206 | 266 | 247 | 192 | 247 |
| | Receipts | 29,832 | 29,321 | 28,640 | 24,987 | 24,790 | 23,157 | 23,983 | 19,278 | 23,983 |

### Seafood Sales & Processing - Employer Establishments (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Seafood product prep. & packaging | Establishments | 16 | 18 | 17 | 18 | 15 | 15 | 17 | 15 | 15 |
| | Employees | 352 | 271 | 323 | 324 | 298 | 294 | 379 | ND[2] | 272 |
| | Payroll | 20,430 | 15,676 | 14,782 | 14,810 | 16,491 | 18,723 | 18,570 | 15,227 | 16,976 |
| Seafood sales, wholesale | Establishments | 315 | 291 | 274 | 269 | 254 | 291 | 231 | 246 | 263 |
| | Employees | 2,269 | 2,183 | 2,091 | 2,003 | 2,066 | 2,058 | 1,627 | 1,741 | 1,798 |
| | Payroll | 84,367 | 75,063 | 75,411 | 76,177 | 78,198 | 84,361 | 72,233 | 68,345 | 72,442 |
| Seafood sales, retail | Establishments | 381 | 376 | 386 | 392 | 388 | 372 | 368 | 386 | 394 |
| | Employees | 1,421 | 1,518 | 1,602 | 1,513 | 1,495 | 1,575 | 1,470 | 1,509 | 1,586 |
| | Payroll | 22,867 | 25,422 | 26,489 | 25,665 | 26,701 | 28,497 | 30,741 | 31,640 | 32,001 |

### Transport, Support, & Marine Operations - Employer Establishments (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal & Great Lakes freight transportation | Establishments | 69 | 60 | 60 | 57 | 55 | 50 | 50 | 48 | 65 |
| | Employees | 2,284 | 1,751 | 1,452 | 1,448 | 1,464 | 1,746 | 1,759 | 2,299 | 1,654 |
| | Payroll | 141,213 | 115,452 | 94,074 | 91,347 | 109,315 | 125,570 | 160,735 | 198,352 | 136,577 |
| Deep sea freight transportation | Establishments | 38 | 35 | 36 | 39 | 38 | 34 | 29 | 32 | 30 |
| | Employees | 1,084 | 927 | 600 | 602 | ND[2] | ND[2] | 732 | 782 | 704 |
| | Payroll | 52,516 | 58,350 | 38,246 | 39,309 | ND[2] | 65,632 | 108,744 | 89,313 | 98,499 |
| Deep sea passenger transportation | Establishments | 4 | 8 | 7 | 6 | 4 | 4 | 3 | 4 | 2 |
| | Employees | ND[2] | 212 | ND[2] | ND[2] | ND[2] | 7 | ND[2] | 8 | ND[2] |
| | Payroll | ND[2] | 6,673 | ND[2] | ND[2] | ND[2] | 240 | 316 | 126 | ND[2] |
| Marinas | Establishments | 386 | 417 | 413 | 416 | 404 | 411 | 419 | 418 | 429 |
| | Employees | 1,680 | 2,167 | 2,185 | 2,093 | 2,112 | 2,070 | 2,263 | 2,099 | 2,052 |
| | Payroll | 69,242 | 77,398 | 81,737 | 84,832 | 83,807 | 88,862 | 100,910 | 96,640 | 94,654 |
| Marine cargo handling | Establishments | 11 | 14 | 14 | 12 | 12 | 12 | 10 | 9 | 13 |
| | Employees | ND[2] | 951 | 1,099 | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | 1,086 |
| | Payroll | ND[2] | 50,015 | 48,529 | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | 68,555 |
| Navigational services to shipping | Establishments | 32 | 34 | 34 | 35 | 36 | 36 | 32 | 37 | 37 |
| | Employees | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | 578 | 386 | 312 | 598 |
| | Payroll | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | 40,976 | 23,294 | 19,126 | 50,119 |
| Port & harbor operations | Establishments | 4 | 3 | 3 | 3 | 3 | 5 | 3 | 4 | 8 |
| | Employees | ND[2] | ND[2] | ND[2] | ND[2] | 6 | ND[2] | ND[2] | ND[2] | ND[2] |
| | Payroll | ND[2] | ND[2] | ND[2] | ND[2] | 119 | ND[2] | ND[2] | ND[2] | 568 |
| Ship & boat building | Establishments | 41 | 44 | 45 | 47 | 48 | 53 | 49 | 47 | 41 |
| | Employees | ND[2] | ND[2] | ND[2] | 590 | ND[2] | 643 | 688 | 585 | 575 |
| | Payroll | ND[2] | ND[2] | ND[2] | 21,514 | ND[2] | 26,653 | 30,462 | 28,880 | 26,771 |

[1] The U.S. Commercial Fishing Location Quotient (CFLQ) of 1.0 represents the national baseline from which state CFLQs can be compared.
[2] ND = these data are confidential thus not disclosable

### 2011 Economic Impacts of the Virginia Seafood Industry (thousands of dollars)

| | With Imports | | | Without Imports | | |
|---|---|---|---|---|---|---|
| | Jobs | Sales | Value Added | Jobs | Sales | Value Added |
| **Total Impacts** | 22,082 | 1,866,659 | 800,243 | 16,634 | 906,586 | 473,802 |
| Commercial Harvesters | 5,273 | 325,136 | 159,654 | 5,273 | 325,136 | 159,654 |
| Seafood Processors & Dealers | 1,713 | 152,230 | 76,441 | 1,593 | 141,717 | 71,162 |
| Importers | 2,922 | 803,712 | 245,007 | 0 | 0 | 0 |
| Seafood Wholesalers & Distributors | 1,096 | 134,744 | 62,081 | 542 | 66,646 | 30,706 |
| Retail | 11,078 | 450,837 | 257,062 | 9,226 | 373,086 | 212,280 |

### Total Landings Revenue and Landings Revenue of Key Species/Species Groups (thousands of dollars)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total revenue | 123,308 | 130,657 | 160,496 | 155,066 | 109,082 | 137,993 | 146,611 | 152,022 | 183,894 | 191,665 |
| Finfish & other | 38,947 | 39,661 | 43,522 | 48,559 | 40,593 | 45,748 | 40,518 | 47,580 | 55,940 | 58,829 |
| Shellfish | 84,361 | 90,996 | 116,973 | 106,507 | 68,489 | 92,245 | 106,093 | 104,442 | 127,954 | 132,835 |
| Atlantic croaker | 3,815 | 2,822 | 3,013 | 3,691 | 4,345 | 4,445 | 5,270 | 6,939 | 6,027 | 4,778 |
| Black sea bass | 1,589 | 1,306 | 1,167 | 1,242 | 1,070 | 663 | 763 | 581 | 939 | 1,006 |
| Blue crab | 21,083 | 19,130 | 21,822 | 20,578 | 14,067 | 15,496 | 17,984 | 21,044 | 29,062 | 25,116 |
| Catfishes & bullhea | 1,005 | 372 | 649 | 900 | 1,570 | 956 | 1,192 | 1,567 | 670 | 904 |
| Goosefish | 704 | 879 | 599 | 1,142 | 688 | 781 | 954 | 631 | 594 | 795 |
| Menhaden | 22,113 | 22,511 | 24,144 | 25,259 | 22,269 | 25,317 | 21,271 | 23,578 | 34,476 | 32,978 |
| Sea Scallop | 57,715 | 68,298 | 92,207 | 84,574 | 52,828 | 63,013 | 65,534 | 63,312 | 70,203 | 79,426 |
| Spot | 1,256 | 1,688 | 2,236 | 2,227 | 1,762 | 3,232 | 1,171 | 3,410 | 975 | 3,157 |
| Striped bass | 2,823 | 3,389 | 3,648 | 4,457 | 2,816 | 3,831 | 3,379 | 4,220 | 3,635 | 4,476 |
| Summer flounder | 3,150 | 4,220 | 5,376 | 4,652 | 3,460 | 3,184 | 2,719 | 2,961 | 4,214 | 6,229 |

### Total Landings and Landings of Key Species/Species Groups (thousands of pounds)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total landings | 442,490 | 446,828 | 481,374 | 441,538 | 426,235 | 491,849 | 422,595 | 426,282 | 509,841 | 494,028 |
| Finfish & other | 396,929 | 406,359 | 432,023 | 402,586 | 393,760 | 452,360 | 384,712 | 379,196 | 457,334 | 441,863 |
| Shellfish | 45,560 | 40,469 | 49,351 | 38,952 | 32,475 | 39,489 | 37,883 | 47,087 | 52,507 | 52,166 |
| Atlantic croaker | 12,448 | 10,936 | 9,488 | 9,272 | 7,830 | 10,588 | 11,214 | 8,572 | 7,830 | 5,533 |
| Black sea bass | 771 | 507 | 498 | 475 | 327 | 189 | 215 | 164 | 264 | 275 |
| Blue crab | 27,301 | 21,464 | 27,642 | 26,064 | 22,719 | 24,660 | 23,203 | 32,552 | 38,277 | 37,862 |
| Catfishes & bullhea | 1,886 | 1,799 | 1,922 | 1,622 | 1,360 | 1,555 | 1,772 | 1,876 | 871 | 905 |
| Goosefish | 970 | 1,270 | 1,002 | 1,157 | 676 | 841 | 964 | 742 | 584 | 603 |
| Menhaden | 364,941 | 373,868 | 399,798 | 372,578 | 370,989 | 420,481 | 353,895 | 351,388 | 433,241 | 413,835 |
| Sea Scallop | 16,189 | 17,536 | 19,410 | 11,444 | 8,310 | 9,916 | 9,685 | 10,137 | 9,167 | 8,260 |
| Spot | 3,062 | 3,471 | 4,338 | 3,103 | 1,696 | 4,328 | 1,977 | 3,902 | 1,024 | 3,522 |
| Striped bass | 1,841 | 2,104 | 2,120 | 2,472 | 1,391 | 1,962 | 2,196 | 2,109 | 2,139 | 2,077 |
| Summer flounder | 2,970 | 3,522 | 3,906 | 3,869 | 2,757 | 1,854 | 1,652 | 1,979 | 2,590 | 4,051 |

### Average Annual Price of Key Species/Species Groups (dollars per pound)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Atlantic croaker | 0.31 | 0.26 | 0.32 | 0.40 | 0.55 | 0.42 | 0.47 | 0.81 | 0.77 | 0.86 |
| Black sea bass | 2.06 | 2.58 | 2.34 | 2.61 | 3.27 | 3.50 | 3.54 | 3.53 | 3.56 | 3.66 |
| Blue crab | 0.77 | 0.89 | 0.79 | 0.79 | 0.62 | 0.63 | 0.78 | 0.65 | 0.76 | 0.66 |
| Catfishes & bullhea | 0.53 | 0.21 | 0.34 | 0.55 | 1.15 | 0.61 | 0.67 | 0.84 | 0.77 | 1.00 |
| Goosefish | 0.73 | 0.69 | 0.60 | 0.99 | 1.02 | 0.93 | 0.99 | 0.85 | 1.02 | 1.32 |
| Menhaden | 0.06 | 0.06 | 0.06 | 0.07 | 0.06 | 0.06 | 0.06 | 0.07 | 0.08 | 0.08 |
| Sea Scallop | 3.56 | 3.89 | 4.75 | 7.39 | 6.36 | 6.35 | 6.77 | 6.25 | 7.66 | 9.62 |
| Spot | 0.41 | 0.49 | 0.52 | 0.72 | 1.04 | 0.75 | 0.59 | 0.87 | 0.95 | 0.90 |
| Striped bass | 1.53 | 1.61 | 1.72 | 1.80 | 2.02 | 1.95 | 1.54 | 2.00 | 1.70 | 2.16 |
| Summer flounder | 1.06 | 1.20 | 1.38 | 1.20 | 1.26 | 1.72 | 1.65 | 1.50 | 1.63 | 1.54 |

### 2011 Economic Impacts of Recreational Fishing Expenditures (thousands of dollars)

| | Jobs | Sales | Income | Value Added |
|---|---|---|---|---|
| Trip Impacts by Fishing Mode: | | | | |
| For-Hire | 72 | 5,717 | 1,864 | 3,262 |
| Private Boat | 1,211 | 119,065 | 39,532 | 69,116 |
| Shore | 530 | 48,845 | 16,249 | 28,007 |
| Total Durable Equipment Impacts | 5,424 | 659,880 | 223,308 | 333,341 |
| **Total State Trip and Durable Equipment Economic Impacts** | 7,237 | 833,508 | 280,954 | 433,725 |

### 2011 Angler Trip & Durable Expenditures (thousands of dollars)

| Fishing Mode | Trip Expenditures | | Equipment | Durable Expenditures |
|---|---|---|---|---|
| | Non-Residents | Residents | Fishing Tackle | 246,850 |
| For-Hire | 2,000 | 1,834 | Other Equipment | 76,070 |
| Private Boat | 28,490 | 76,529 | Boat Expenses | 392,265 |
| Shore | 23,663 | 18,722 | Vehicle Expenses | 56,458 |
| *Total Trip Expenditures* | 54,153 | 97,085 | Second Home Expenses | 524 |
| | | | *Total Durable Equipment Expenditures* | 772,167 |
| **Total State Trip and Durable Equipment Expenditures** | | | | 923,405 |

### Recreational Anglers by Residential Area (thousands of anglers)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal | 337 | 384 | 510 | 559 | 578 | 463 | 464 | 515 | 496 | 516 |
| Non-Coastal | 73 | 52 | 69 | 137 | 90 | 76 | 89 | 87 | 63 | 56 |
| Out of State | 407 | 288 | 428 | 511 | 364 | 297 | 338 | 305 | 279 | 320 |
| **Total Anglers** | 817 | 724 | 1007 | 1206 | 1033 | 836 | 891 | 907 | 838 | 892 |

### Recreational Fishing Effort by Mode (thousands of angler-trips)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| For-Hire | 72 | 85 | 71 | 36 | 43 | 59 | 56 | 47 | 46 | 30 |
| Private | 2,255 | 2,068 | 2,490 | 2,563 | 2,590 | 2,369 | 2,352 | 2,123 | 1,699 | 1,782 |
| Shore | 927 | 959 | 1,104 | 1,365 | 1,155 | 1,083 | 1,090 | 876 | 851 | 1,086 |
| **Total Trips** | 3,254 | 3,112 | 3,665 | 3,964 | 3,788 | 3,511 | 3,498 | 3,046 | 2,596 | 2,898 |

### Harvest (H) and Release (R) of Key Species Species Groups (thousands of fish)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Black seabass | H | 134 | 264 | 47 | 34 | 83 | 35 | 37 | 114 | 30 | 19 |
| | R | 2,442 | 1,743 | 1,247 | 1,117 | 1,355 | 1,270 | 1,250 | 1,150 | 524 | 445 |
| Cobia | H | 3 | 2 | 1 | 17 | 22 | 10 | 5 | 17 | 7 | 4 |
| | R | 11 | 15 | 6 | 16 | 23 | 3 | 3 | 13 | 9 | 9 |
| Drum (Atlantic croaker) | H | 9,129 | 6,695 | 8,259 | 7,656 | 7,222 | 6,946 | 8,388 | 5,328 | 4,745 | 3,305 |
| | R | 7,108 | 6,544 | 6,276 | 8,738 | 4,193 | 8,503 | 7,807 | 7,620 | 4,824 | 4,874 |
| Drum (spot) | H | 1,602 | 1,441 | 1,718 | 2,782 | 3,584 | 8,203 | 4,398 | 2,146 | 1,670 | 2,968 |
| | R | 482 | 934 | 882 | 2,457 | 1,371 | 2,156 | 1,487 | 1,458 | 1,156 | 2,244 |
| Drum (spotted seatrout) | H | 17 | 102 | 68 | 22 | 43 | 158 | 104 | 22 | 17 | 248 |
| | R | 137 | 207 | 258 | 191 | 83 | 362 | 367 | 172 | 550 | 1,215 |
| Drum (weakfish)[1] | H | 178 | 87 | 159 | 43 | 43 | 88 | 28 | 15 | 4 | 4 |
| | R | 888 | 504 | 545 | 356 | 558 | 230 | 426 | 85 | 178 | 288 |
| Red drum | H | 50 | 14 | 5 | 3 | 13 | 46 | 20 | 39 | 11 | (1) |
| | R | 802 | 43 | 34 | 28 | 186 | 111 | 236 | 179 | 28 | 61 |
| Striped bass | H | 322 | 402 | 392 | 257 | 460 | 237 | 246 | 225 | 74 | 122 |
| | R | 707 | 970 | 1,733 | 1,296 | 1,656 | 949 | 533 | 359 | 134 | 154 |
| Summer flounder | H | 772 | 451 | 674 | 683 | 763 | 396 | 260 | 288 | 261 | 317 |
| | R | 2,666 | 2,585 | 3,698 | 2,509 | 2,164 | 3,024 | 2,424 | 3,613 | 2,420 | 1,986 |
| Wrasses (tautog) | H | 26 | 76 | 152 | 60 | 105 | 61 | 56 | 60 | 127 | 46 |
| | R | 37 | 55 | 122 | 76 | 199 | 81 | 34 | 33 | 130 | 36 |

[1] This species may not be equivalent to species with similar names listed in the commercial tables.

### Virginia's State Economy (% of national total)

| | Establishments | Employees | Annual Payroll (million $) | Employee Compensation (million $) | Gross State Product (million $) | Commercial Location Quotient [1] |
|---|---|---|---|---|---|---|
| 2002 | 180,501 (2.5%) | 2,914,804 (2.6%) | 101,693 (2.6%) | 173,455 (2.8%) | 290,904 (2.8%) | 0.5 |
| 2010 | 193,042 (2.6%) | 2,998,278 (2.7%) | 139,059 (2.8%) | 249,258 (2.9%) | 419,365 (3.1%) | 0.59 |
| % change | 6.95% | 2.86% | 36.7% | 43.7% | 44.2% | 18% |

### Seafood Sales & Processing - Nonemployer Firms (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Seafood product prep. & packaging | Firms | 35 | 53 | 68 | 65 | 74 | 62 | 74 | 69 | 74 |
| | Receipts | 1,406 | 2,370 | 3,456 | 3,665 | 4,916 | 4,845 | 5,020 | 4,039 | 5,020 |
| Seafood Sales, retail | Firms | 94 | 88 | 89 | 80 | 86 | 84 | 80 | 80 | 80 |
| | Receipts | 8,266 | 7,193 | 8,346 | 8,762 | 8,027 | 7,265 | 8,273 | 6,603 | 8,273 |

### Seafood Sales & Processing - Employer Establishments (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Seafood product prep. & packaging | Establishments | 39 | 38 | 42 | 39 | 33 | 30 | 26 | 25 | 23 |
| | Employees | 1,035 | 1,256 | 1,231 | 1,336 | 871 | 955 | 490 | 941 | 961 |
| | Payroll | 35,828 | 37,386 | 38,731 | 39,980 | 28,530 | 34,520 | 11,366 | 30,600 | 30,460 |
| Seafood sales, wholesale | Establishments | 89 | 84 | 86 | 86 | 80 | 83 | 69 | 72 | 76 |
| | Employees | 790 | 742 | 756 | 675 | 605 | 734 | 621 | 519 | 518 |
| | Payroll | 21,591 | 20,133 | 22,235 | 21,864 | 21,388 | 25,365 | 17,667 | 15,620 | 17,901 |
| Seafood sales, retail | Establishments | 74 | 61 | 68 | 69 | 75 | 73 | 68 | 62 | 59 |
| | Employees | 259 | 165 | 297 | 286 | 334 | 282 | 251 | 271 | 265 |
| | Payroll | 3,662 | 3,146 | 4,479 | 4,865 | 5,348 | 5,227 | 5,170 | 5,401 | 5,480 |

### Transport, Support, & Marine Operations - Employer Establishments (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal & Great Lakes freight transportation | Establishments | 13 | 16 | 13 | 15 | 13 | 15 | 10 | 9 | 7 |
| | Employees | ND[2] | 591 | ND[2] | ND[2] | ND[2] | 565 | ND[2] | ND[2] | ND[2] |
| | Payroll | ND[2] | 26,881 | ND[2] | ND[2] | ND[2] | 30,704 | ND[2] | ND[2] | ND[2] |
| Deep sea freight transportation | Establishments | 23 | 22 | 21 | 24 | 22 | 20 | 18 | 16 | 17 |
| | Employees | 1,254 | 1,087 | 1,124 | 1,090 | 1,564 | 1,611 | 409 | ND[2] | 421 |
| | Payroll | 92,591 | 87,099 | 91,978 | 95,871 | 141,085 | 148,502 | 32,473 | 19,241 | 35,917 |
| Deep sea passenger transportation | Establishments | 2 | 2 | 2 | 1 | 1 | 1 | 2 | 2 | 1 |
| | Employees | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| | Payroll | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| Marinas | Establishments | 122 | 136 | 137 | 141 | 131 | 126 | 119 | 118 | 115 |
| | Employees | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | 992 | 964 | 829 | 868 |
| | Payroll | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | 26,186 | 24,326 | 24,631 | 24,182 |
| Marine cargo handling | Establishments | 18 | 19 | 19 | 18 | 17 | 15 | 12 | 12 | 7 |
| | Employees | ND[2] | ND[2] | ND[2] | 1,516 | 1,110 | 1,085 | ND[2] | ND[2] | ND[2] |
| | Payroll | ND[2] | ND[2] | ND[2] | 52,254 | 51,654 | 56,696 | ND[2] | ND[2] | 41,280 |
| Navigational services to shipping | Establishments | 17 | 15 | 20 | 21 | 17 | 18 | 23 | 25 | 26 |
| | Employees | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | 216 | 375 | 384 | 411 |
| | Payroll | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | 11,700 | 21,014 | 22,177 | 22,910 |
| Port & harbor operations | Establishments | 8 | 8 | 9 | 9 | 10 | 10 | 8 | 6 | 7 |
| | Employees | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| | Payroll | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| Ship & boat building | Establishments | 62 | 50 | 52 | 50 | 51 | 52 | 59 | 53 | 56 |
| | Employees | 21,240 | 20,720 | 21,022 | 21,230 | 21,741 | ND[2] | ND[2] | ND[2] | ND[2] |
| | Payroll | 963,644 | 901,156 | 920,372 | 938,375 | 993,066 | ND[2] | ND[2] | ND[2] | ND[2] |

[1] The U.S. Commercial Fishing Location Quotient (CFLQ) of 1.0 represents the national baseline from which state CFLQs can be compared.
[2] ND = these data are confidential thus not disclosable

# South Atlantic

- East Florida
- Georgia
- North Carolina
- South Carolina

### Management Context

The South Atlantic Region includes East Florida, Georgia, North Carolina, and South Carolina. Federal fisheries in this region are managed by the South Atlantic Fishery Management Council (SAFMC) and NOAA Fisheries (NMFS) under four fishery management plans (FMPs). The spiny lobster and coastal migratory pelagic resources fisheries are managed with the Gulf of Mexico Fishery Management Council (GMFMC). The Dolphin Wahoo FMP is managed with the Mid-Atlantic Fishery Management Council (MAFMC) and the New England Fishery management Council (NEFMC)[1]

**South Atlantic Region FMPs**

1. Coastal migratory pelagic resources (with GMFMC)
2. Coral coral reef and live/hardbottom habitat plan
3. Dolphin wahoo (with MAFMC and NEFMC))
4. Golden crab
5. Pelagic Sargassum habitat
6. Shrimp
7. Snapper grouper
8. Spiny lobster (with GMFMC)

Of the stocks or stock complexes covered in these fishery management plans, five are currently listed as overfished: pink shrimp, red grouper, red porgy, red snapper, and snowy grouper. Eight stocks or stock complexes are currently subject to overfishing: black sea bass, gag, red grouper, red snapper, snowy grouper, speckled hind, vermilion snapper, and warsaw grouper.

### Commercial Fisheries

In 2011, commercial fishermen in the South Atlantic Region landed 123 million pounds of finfish and shellfish, earning $171 million in landings revenue. Landings revenue was dominated by shrimp ($54 million) and blue crab ($34 million). These species groups commanded ex-vessel prices of $2.36 and $0.80 per pound, respectively, and together comprised 51% of total landings revenue, and 53% of total landings in the South Atlantic Region.

**Key South Atlantic Region Commercial Species**

- Blue crab
- Clams
- Flounders
- Groupers
- King mackerels
- Oysters
- Shrimp
- Snappers
- Swordfish
- Tunas

North Carolina and East Florida had the highest landings revenue in the region in 2011 with $71.2 million and $60.6 million, respectively. The next greatest landings revenue came from South Carolina with $23 million in landings revenue. In terms of pounds landed, North Carolina also had the highest landings (67 million pounds), followed by East Florida (31 million pounds) and Georgia (13 million pounds).

Shrimp experienced a 21% increase in ex-vessel price (a 16% decrease in real terms) from $1.95 per pound in 2002 to $2.36 per pound in 2011. Over the same time period, the ex-vessel price per pound for blue crab decreased 12% (a 39% decrease in real terms), from $0.91 to $0.8 per pound. The decline in value of shrimp is mostly attributable to increases in competition from imports of farmed shrimp. Blue crab in the South Atlantic Region has not experienced an increase in competition, but rather has maintained its ex-vessel price due to declining harvest in the Mid-Atlantic, South Atlantic and Gulf of Mexico.

#### *Economic Impacts*[2,3]

In 2011, the South Atlantic Region's seafood industry generated $14 billion in sales impacts in Florida, $1.5 billion in sales impacts in Georgia, $796 million in sales impacts in North Carolina, and $88 million in sales impacts in South Carolina. Florida generated the largest employment, income, and value added impacts, generating 72,000 jobs, $2.7 billion, and $4.8 billion, respectively. The smallest income impacts were generated in South Carolina ($35 million) and the smallest employment impacts were also generated in South Carolina (1,500 jobs).

The sector that generated the greatest employment impacts by state was the importers sector with 37,000 jobs in Florida and 3,900 jobs in Georgia. The harvest sector in North Carolina generated 2,200 jobs. More sales impacts were generated by importers in Florida than any other sector in any another state in the region at $10 billion and the greatest value added impacts were also generated by importers in Florida ($3.1 billion).

#### *Landings Revenue*

Landings revenue in the South Atlantic Region totaled $171 million in 2011. This was a 0.2% increase (a 30% decrease in real terms) from 2002 levels ($171 million) and a 3.2% increase (a 4.8% decrease in real terms) relative to 2010 ($166 million).

Totaling $105 million in 2011, shellfish revenue experienced a 1.8% decrease (a 32% decrease in real terms) from 2002 to 2011 and experienced a 5.4% increase (2.8% decrease in real terms) from 2010 to 2011.

Shrimp and blue crab had the highest landings revenue in the South Atlantic Region in 2011, with $54 million and $34 million, respectively. Together they accounted for 51% of the total landings revenue earned in 2011. Between 2002 and 2011, the landings revenue from shrimp increased 4.3% (a 28% decrease in real terms) and the landings revenue for blue crab decreased

[1]The authority to manage red drum was transferred to the Atlantic States Marine Fisheries Commission (ASMFC) in 2008.

[2]The NMFS Commercial Fishing Industry Input/Output Model was used to generate the impact estimates (see NMFS Commercial Fishing & Seafood Industry Input/Output Model, available at: `www.st.nmfs.noaa.gov/documents/commercial_seafood_impacts_2007-2009.pdf`)

[3]Commercial economic impacts data were not available for East Florida, data for Florida are reported here.

20% (a 45% decrease in real terms).

In terms of finfish, North Carolina contributed the most ($31 million) followed by East Florida ($26 million), and South Carolina ($8.4 million). Shellfish landings revenue was dominated by North Carolina, which also contributed the most ($40 million) followed by East Florida ($34 million), and Georgia ($16 million).

**Commercial Fisheries Facts**

*Landings revenue*

- On average, between 2002 and 2011, the key species or species groups accounted for 78% of total revenue, generating $121 million in the South Atlantic Region.
- Shrimp had higher landings revenues than any other species or species group, averaging $44 million in landings revenue from 2002 to 2011.
- Swordfish had the largest one-year increase in landings revenue over the 10 year time period, increasing 56% from $2.8 million in 2006 to $4.3 million in 2007.
- Snappers had the largest one-year decrease in landings revenue over the 10 year time period, decreasing 36% from $3.6 million in 2002 to $2.3 million in 2003.

*Landings*

- Key species or species groups contributed an average of 57% annually to total landings between 2002 and 2011.
- Blue crab contributed the most to landings in the region, averaging 42 million pounds from 2002 to 2011.
- Oysters had the largest one-year increase in landings over the 10 year time period, increasing 53% from 938,000 in 2009 pounds to 1.4 million pounds in 2010.
- Shrimp had the largest one-year decrease in landings over the 10 year time period, decreasing 39% from 26 million pounds in 2004 to 16 million pounds in 2005.

*Prices*

- Clams had the highest average annual ex-vessel price per pound ($6.17) over the time period, followed by oysters ($4.64), and groupers ($3.03).
- Blue crab had the lowest average annual ex-vessel price per pound ($0.87) over the time period, followed by king mackerels ($1.74), and shrimp ($1.94).
- Blue crab had the largest one-year increase in ex-vessel price over the 10 year time period, increasing 34% from $0.74 per pound in 2006 to $0.99 in 2007.
- Shrimp had the largest decrease in ex-vessel price over the 10 year time period, decreasing 25% from $2.19 per pound in 2008 to $1.64 in 2009.

From 2002 to 2011, species or species groups with large changes in landings revenue include oysters (increased 219%), swordfish (increased 189%), and tunas (increased 81%). Species or species groups with large changes in landings revenue between 2010 and 2011 include tunas (increasing 28%), swordfish (increasing 25%), and flounders (decreasing 18%).

*Landings*

Fishermen in the South Atlantic Region landed 123 million pounds of finfish and shellfish in 2011. This was a 43% decrease from the 216 million pounds landed in 2002 and a 3.3% increase from the 119 million landed in 2010. Finfish landings contributed 40% of total landings in the South Atlantic Region (49 million pounds) in 2011. From 2010 to 2011, finfish landings experienced a 6.6% decrease.

Over the same time period, shellfish landings experienced a 11% increase from 67 million pounds in 2010 to 74 million in 2011 and a 4.6% decrease from 78 million pounds in 2002. Blue crab and shrimp had the highest annual landings in the South Atlantic Region in 2011, with 42 million pounds and 23 million pounds, respectively. Together they accounted for 53% of the total landings in 2011. Blue crab landings decreased 9.4% and shrimp landings decreased 14% during this period.

From 2002 to 2011, species or species groups with large changes in landings include oysters (increasing 123%), swordfish (increasing 83%), and tunas (increasing 56%). Species or species groups with large changes in landings between 2010 and 2011 include king mackerels (decreasing 28%), tunas (increasing 22%), and flounders (decreasing 18%).

*Prices*

The ex-vessel prices for the South Atlantic Region's key species and species groups in 2011 were higher than their 10 year average for eight of the key species (three of the species in real terms). Ex-vessel prices for groupers and swordfish experienced the biggest increases between 2002 and 2011, increasing 61% (12% in real terms) and 59% (10% in real terms), respectively. Relative to the ex-vessel prices in 2010, the South Atlantic Region's king mackerels experienced the greatest increase (21.3%, 11.9% in real terms) from $1.78 in 2010 to $2.16 in 2011. Blue crab experienced the greatest decrease in ex-vessel price during this period (14%, 20.7% in real terms) from $0.93 to $0.80. Relative to ex-vessel prices in 2010, seven species or species groups experienced increases, including shrimp (19%), and groupers (15%).

In East Florida, the species or species group with the largest change in ex-vessel price from 2002 to 2011 was swordfish (62% increase, 12% increase in real terms) from $2.32 to $3.75. The largest change in ex-vessel price experienced in Georgia was for snails (conchs) (67% increase, 16% increase in real terms from $0.78 to $1.30 and in North Carolina the largest change in ex-vessel price was experienced by Atlantic croaker (97% increase, 37% increase in real terms from $0.32 to $0.63).

**Recreational Fishing**

In 2011, over 2.3 million recreational anglers took 18 million fishing trips in the South Atlantic Region. Over 81% of these anglers were residents of a regional coastal county. Of the total fishing trips taken, 49% of them were taken from a private or rental boat and another 49% were shore-based. Atlantic croaker and spot were the most frequently caught species or species group with 7.3 million fish caught in 2011, and represented 24% of total fish caught in the region. Of the Atlantic croaker and spot caught, 58% of them were released rather than harvested.

*Economic Impacts and Expenditures*[1]

[1]Expenditure estimates were generated from the 2011 National Marine Recreational Fishing Expenditure Survey. Economic impacts from recreational

The contribution of recreational fishing activities in the South Atlantic Region are reported in terms of economic impacts at the state level (employment, sales, income, and value added impacts) and expenditures on fishing trips and durable equipment at the regional level. Employment impacts in East Florida were the highest in the region with over 29,000 full- and part-time jobs generated by recreational fishing activities in the state. North Carolina (18,000 jobs), and South Carolina (3,300 jobs), followed in terms of employment impacts.

Overall, these employment impacts were generated by expenditures on recreational fishing trips taken by anglers (private or rental boat, for-hire boat, or shore-based trips) and expenditures on durable equipment. Throughout the South Atlantic Region, most of the employment impacts in 2011 were generated by expenditures on durable equipment: 87% in Georgia, 84% in East Florida, and 63% in North Carolina.

**Key South Atlantic Region Recreational Species**

- Black sea bass
- Bluefish
- Dolphinfish
- Atlantic croaker and spot
- Spotted seatrout
- King mackerel
- Sheepshead porgy
- Red drum
- Sharks
- Spanish mackerel

In addition to jobs, the contribution of recreational fishing activities to South Atlantic Region's economy can be measured in terms of sales impacts and the contribution of these activities to gross domestic product (value added impacts).

In 2011, sales impacts were the highest in East Florida ($3.3 billion in sales impacts), followed by North Carolina ($2 billion), Georgia ($349 million), and South Carolina ($282 million). In the same year, value added impacts were the highest in East Florida ($1.7 billion in value added impacts), followed by North Carolina ($948 million), Georgia ($183 million), and South Carolina ($155 million).

Overall, total fishing trip and durable equipment expenditures across the South Atlantic Region in 2011 were $6.1 billion. Approximately 84% of these expenditures were related to durable equipment purchases. The greatest expenditures were for vehicle expenses ($2.3 billion), followed by boat expenses ($1.4 billion), fishing tackle ($1.1 billion), and other equipment ($278 million). Fishing trip-related expenditures by the South Atlantic Region's non-residents totaled over $385 million of which the greatest portion can be attributed to shore-based fishing trips ($219 million). Residents of the South Atlantic Region spent $563 million on saltwater fishing trips, with the largest part of these expenses related to private boat trips ($329 million).

**Recreational Fishing Facts**

*Participation*

- An average of 2.8 million anglers fished in the South Atlantic Region annually from 2002 to 2011.
- In 2011, coastal county residents made up 81% of total anglers in this region. These anglers averaged 83% of total anglers annually over the 10 year time period.
- The largest annual increase in the number of coastal anglers during the 10 year time period occurred between 2004 and 2005, increasing 24%, from 2.1 million anglers to 2.6 million anglers.
- The largest annual decrease during the same period for coastal anglers occurred between 2007 and 2008, decreasing 26%, from 3.2 million anglers to 2.3 million anglers.

*Fishing trips*

- In the South Atlantic Region, an average of 20 million fishing trips were taken annually from 2002 to 2011.
- Private or rental boat and shore-based fishing trips accounted for 8.7 million and 8.6 million fishing trips, respectively, in 2011. Together these made up 98% of the fishing trips taken in that year.
- The largest annual increase in the number of total trips taken annually over the 10 year time period occurred between 2002 and 2003, increasing 20%, from 18 million trips to 21 million trips.
- The largest annual decrease during the same period in total trips taken occurred between 2008 and 2009, decreasing 14%, from 22 million trips to 19 million trips.

*Harvest and release*

- Atlantic croaker and spot was the most commonly caught key species or species group, averaging 8.4 million fish over the 10 year time period. Of these, 50% were released rather than harvested.
- Of the ten commonly caught key species or species groups, five were released more often than harvested over this time period.
- The species or species group that was most commonly released was sharks (99% released).
- Dolphinfish (84% harvested), followed by king mackerel (73% harvested), and Spanish mackerel (63% harvested) were key species or groups that experienced the greatest proportion of harvests rather than releases.

*Participation*

There were 2.3 million recreational anglers who fished in the South Atlantic Region in 2011. This was a 2.7% increase from 2002 (2.3 million anglers). These anglers were South Atlantic Region residents from either a coastal county (1.9 million anglers) or non-coastal county (450,000 anglers). Almost 81% of total anglers in 2011 were residents of a coastal county. Coastal county angler participation in 2011 decreased 2.8% relative to 2002 (1.9 million anglers) and decreased 2% between 2010 and 2011. Non-coastal county angler participation increased 35% relative to 2002 (334,000 anglers) and decreased 16% relative to 2010 (536,000 anglers).

fishing activities were generated using the NMFS Recreational Economic Impact Model (see The Economic Contribution of Marine Angler Expenditures in the United States, 2006, available at:http://www.st.nmfs.noaa.gov/economics/publications/marine-angler-expenditures/marine-angler-2006)

*Fishing Trips*

Recreational fishermen took 18 million fishing trips in the South Atlantic Region in 2011. This was a 0.5% decrease from 2002 (18 million trips) and was 1.4 million fewer trips than taken in 2010. Of the total trips taken in the South Atlantic Region in 2011, approximately 49% of the trips were private or rental boat based (8.7 million trips). The other most popular mode of fishing was shore-based with 8.6 million trips in 2011.

*Harvest and Release*

Of the South Atlantic Region's key species and species groups, Atlantic croaker and spot (7.3 million fish), spotted seatrout (5.7 million fish), bluefish (5.4 million fish) and black sea bass (3.4 million fish) were the most often caught by anglers in 2011. Sharks (99% released), black sea bass (90% released), spotted seatrout (85% released), red drum (81% released), bluefish (64% released), and drum (atlantic croaker and spot) (58% released) were most often released rather than harvested. Anglers harvested more often than released king mackerel (76% harvested) and dolphinfish (70% harvested).

Between 2002 and 2011, three of the South Atlantic Region's key species or species groups showed decreases in catch totals. Key species or groups with the largest decreases were king mackerel (57%), Spanish mackerel (41%), and dolphinfish (14%).

## Marine Economy[1]

The sum of the gross domestic products by state for Florida, Georgia, North Carolina, and South Carolina was $1.7 trillion in 2010. Employee compensation totaled $940 billion and annual payroll totaled $568 billion. These economic measures increased 31% (a 1.3% decrease in real terms) and 26% (a 5.5% decrease in real terms), respectively, between 2002 and 2010; and experienced a 1.6% increase (a 2.5% decrease in real terms), and 0.4% increase (a 3.6% decrease in real terms), respectively between 2009 and 2010. Approximately 1 million establishments employed 15 million full- and part-time employees across the region in 2010. This was a 6.9% increase in establishment numbers and a 0.5% increase in employee numbers from 2002 to 2010.

In 2010, the commercial fishing location quotient (CFLQ) for East Florida was the highest in the region at 1. This was an 22% decrease from 2002 and a 5.3% increase from 2009. East Florida's CFLQ suggests that the level of employment in commercial fishing-related industries in this state is approximately 1 times lower than the level of employment in these industries nationwide. The 2010 CFLQ in North Carolina was 0.16 (a 45% decrease from 2002).

*Seafood Sales and Processing*

Annual receipts for nonemployer firms engaged in seafood product preparation and packaging across the South Atlantic Region totaled $15 million in 2007 and increased 79% from 2002 to 2007. Annual receipts totals experienced a 111% increase in South Carolina between 2002 and 2010. There were 347 seafood wholesale establishments across the South Atlantic Region in 2010 that employed 2,971 full- and part-time workers. From 2002 to 2010, the number of seafood wholesale establishments decreased 28% and the number of employees0.

Nonemployer firms engaged in seafood retail in the South Atlantic Region totaled 610 in 2010, a 22% increase relative to 2002. Of these firms, 17% were located in Georgia. At the state level, these firms showed a 36% increase in Florida and a 2.6% decrease in North Carolina between 2002 and 2010. Annual receipts in the region totaled $49 million in 2010, a 19% increase from 2002 (a 11% decrease in real terms) and a 2.8% increase from 2009 (a 1.3% decrease in real terms).

Employer establishments engaged in seafood retail decreased 13% from 2002 to 2010, totaling 331 in 2010. These establishments employed 1,548 workers. Region-wide, the numbers of employees in the seafood retail sector increased 0.2% between 2002 and 2010. Across the states within the region, the largest change occurred in South Carolina (24% increase).

*Transport, Support, and Marine Operations*

The marine cargo handling employed more people than any other industry in this sector, employing approximately 13,000 people in 2010. This industry also had the highest annual payroll in the region totaling $337 million. Marinas had the highest number of establishments (667), followed by the ship and boat building industries with 359 establishments and the navigational services to shipping industries with 173 establishments.

In Florida, industries with large changes in establishment numbers, employees, or annual payroll from 2009 to 2010 were: coastal and Great Lakes freight transportation (33% increase in payroll), coastal and Great Lakes freight transportation (27% decrease in employees), navigational services to shipping (27% increase in payroll) and coastal and Great Lakes freight transportation (19% increase in employees). In Georgia, large changes were seen for coastal and Great Lakes freight transportation (20% decrease in establishments), port and harbor operations (20% decrease in establishments), marine cargo handling (20% decrease in employees) and marinas (17% increase in establishments). In South Carolina, large changes were seen in the deep sea passenger transportation (67% decrease in establishments), marine cargo handling (14% decrease in establishments), deep sea freight transportation (12% decrease in establishments) and navigational services to shipping (12% decrease in establishments).

[1] Information for 2010 is reported in this section; 2011 data were not available for this report.

### 2011 Economic Impacts of the South Atlantic Region Seafood Industry (thousands of dollars)

| | With Imports | | | Without Imports | | |
|---|---|---|---|---|---|---|
| | Jobs | Sales | Valued Added | Jobs.1 | Sales.1 | Valued Added.1 |
| East Florida | 72,341 | 14,250,006 | 4,778,502 | 10,550 | 928,929 | 376,208 |
| Georgia | 11,137 | 1,489,958 | 548,826 | 2,222 | 104,308 | 55,698 |
| North Carolina | 8,850 | 795,541 | 329,451 | 5,086 | 248,229 | 136,504 |
| South Carolina | 1,547 | 88,131 | 46,495 | 1,495 | 79,999 | 43,701 |

### Total Landings Revenue and Landings Revenue of Key Species/Species Groups (thousands of dollars)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total revenue | 171,034 | 156,703 | 159,444 | 131,410 | 140,674 | 152,390 | 165,627 | 147,144 | 165,913 | 171,302 |
| Finfish & other | 63,906 | 54,820 | 66,858 | 56,907 | 60,707 | 61,339 | 60,811 | 62,937 | 66,138 | 66,146 |
| Shellfish | 107,140 | 101,882 | 92,592 | 74,507 | 79,976 | 91,061 | 104,817 | 84,219 | 99,784 | 105,164 |
| Blue crab | 42,397 | 46,643 | 34,249 | 31,784 | 27,050 | 33,634 | 39,985 | 37,783 | 36,199 | 33,733 |
| Clams | 6,132 | 6,248 | 5,561 | 4,779 | 4,223 | 4,039 | 3,861 | 3,571 | 4,091 | 3,364 |
| Flounders | 11,308 | 9,718 | 11,530 | 10,974 | 13,317 | 11,375 | 10,928 | 10,171 | 10,948 | 8,941 |
| Groupers | 2,831 | 2,851 | 2,728 | 2,814 | 3,416 | 4,565 | 4,084 | 3,214 | 3,016 | 3,018 |
| King mackerels | 4,067 | 4,102 | 5,260 | 5,551 | 6,495 | 6,872 | 7,695 | 8,088 | 7,571 | 6,575 |
| Oysters | 2,138 | 2,353 | 2,912 | 3,305 | 3,853 | 3,806 | 4,028 | 4,603 | 7,175 | 6,818 |
| Shrimp | 51,699 | 42,707 | 44,797 | 31,035 | 39,653 | 43,807 | 51,064 | 33,076 | 46,022 | 53,944 |
| Snappers | 3,618 | 2,331 | 3,208 | 3,314 | 2,748 | 3,922 | 4,554 | 4,024 | 3,489 | 3,752 |
| Swordfish | 3,248 | 4,113 | 3,555 | 3,134 | 2,753 | 4,298 | 3,661 | 4,821 | 7,519 | 9,400 |
| Tunas | 2,808 | 2,423 | 3,671 | 3,904 | 4,692 | 4,894 | 4,672 | 4,869 | 3,976 | 5,096 |

### Total Landings and Landings of Key Species/Species Groups (thousands of pounds)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total landings | 216,204 | 197,486 | 199,033 | 123,421 | 114,661 | 105,285 | 116,554 | 113,280 | 119,474 | 123,460 |
| Finfish & other | 138,277 | 116,081 | 121,214 | 64,925 | 52,056 | 46,631 | 44,023 | 51,012 | 52,585 | 49,133 |
| Shellfish | 77,926 | 81,405 | 77,820 | 58,497 | 62,604 | 58,654 | 72,531 | 62,268 | 66,888 | 74,327 |
| Blue crab | 46,479 | 50,881 | 45,001 | 38,218 | 36,779 | 34,045 | 44,997 | 39,015 | 38,840 | 42,093 |
| Clams | 1,004 | 983 | 886 | 747 | 685 | 663 | 628 | 619 | 641 | 554 |
| Flounders | 7,586 | 5,799 | 7,325 | 5,944 | 6,282 | 4,778 | 5,034 | 5,278 | 5,020 | 4,130 |
| Groupers | 1,166 | 1,134 | 1,057 | 1,007 | 1,152 | 1,416 | 1,266 | 992 | 884 | 772 |
| King mackerels | 2,474 | 2,848 | 3,269 | 3,106 | 3,792 | 3,736 | 4,352 | 4,858 | 4,247 | 3,046 |
| Oysters | 551 | 595 | 689 | 730 | 808 | 776 | 857 | 938 | 1,439 | 1,226 |
| Shrimp | 26,503 | 24,343 | 26,472 | 16,048 | 22,080 | 21,235 | 23,341 | 20,108 | 23,198 | 22,831 |
| Snappers | 1,529 | 958 | 1,285 | 1,286 | 967 | 1,354 | 1,515 | 1,373 | 1,196 | 1,244 |
| Swordfish | 1,429 | 1,575 | 1,314 | 1,152 | 1,036 | 1,417 | 1,307 | 1,800 | 2,288 | 2,611 |
| Tunas | 1,418 | 1,235 | 1,739 | 1,569 | 2,360 | 2,310 | 1,658 | 1,945 | 1,805 | 2,209 |

### Average Annual Price of Key Species/Species Groups (dollars per pound)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Blue crab | 0.91 | 0.92 | 0.76 | 0.83 | 0.74 | 0.99 | 0.89 | 0.97 | 0.93 | 0.80 |
| Clams | 6.11 | 6.35 | 6.27 | 6.40 | 6.16 | 6.09 | 6.15 | 5.77 | 6.38 | 6.07 |
| Flounders | 1.49 | 1.68 | 1.57 | 1.85 | 2.12 | 2.38 | 2.17 | 1.93 | 2.18 | 2.17 |
| Groupers | 2.43 | 2.51 | 2.58 | 2.79 | 2.97 | 3.22 | 3.23 | 3.24 | 3.41 | 3.91 |
| King mackerels | 1.64 | 1.44 | 1.61 | 1.79 | 1.71 | 1.84 | 1.77 | 1.66 | 1.78 | 2.16 |
| Oysters | 3.88 | 3.96 | 4.22 | 4.53 | 4.77 | 4.91 | 4.70 | 4.91 | 4.99 | 5.56 |
| Shrimp | 1.95 | 1.75 | 1.69 | 1.93 | 1.80 | 2.06 | 2.19 | 1.64 | 1.98 | 2.36 |
| Snappers | 2.37 | 2.43 | 2.50 | 2.58 | 2.84 | 2.90 | 3.01 | 2.93 | 2.92 | 3.02 |
| Swordfish | 2.27 | 2.61 | 2.71 | 2.72 | 2.66 | 3.03 | 2.80 | 2.68 | 3.29 | 3.60 |
| Tunas | 1.98 | 1.96 | 2.11 | 2.49 | 1.99 | 2.12 | 2.82 | 2.50 | 2.20 | 2.31 |

### 2011 Economic Impacts of Recreational Fishing Expenditures (thousands of dollars)

| | Trips | Jobs | Sales | Income | Value Added |
|---|---|---|---|---|---|
| East Florida | 10,157,000 | 28,701 | 3,255,774 | 1,093,766 | 1,708,369 |
| Georgia | 970,000 | 2,880 | 348,742 | 119,021 | 182,586 |
| North Carolina | 4,740,000 | 17,737 | 1,961,144 | 606,074 | 948,461 |
| South Carolina | 1,807,000 | 3,254 | 282,049 | 93,789 | 154,999 |

### 2011 Angler Trip & Durable Expenditures (thousands of dollars)

| Fishing Mode | Trip Expenditures | | Equipment | Durable Expenditures |
|---|---|---|---|---|
| | Non-Residents | Residents | Fishing Tackle | 1,059,539 |
| For-Hire | 125,489 | 29,914 | Other Equipment | 277,813 |
| Private Boat | 41,190 | 329,059 | Boat Expenses | 1,405,929 |
| Shore | 218,760 | 204,365 | Vehicle Expenses | 2,308,671 |
| *Total Trip Expenditures* | 385,437 | 563,338 | Second Home Expenses | 63,454 |
| | | | *Total Durable Equipment Expenditures* | 5,115,405 |
| **Total State Trip and Durable Equipment Expenditures** | | | | 6,064,180 |

### Recreational Anglers by Residential Area (thousands of anglers)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal | 1,948 | 2,271 | 2,105 | 2,615 | 2,603 | 3,157 | 2,330 | 1,922 | 1,933 | 1,893 |
| Non-Coastal | 334 | 473 | 511 | 472 | 477 | 493 | 560 | 462 | 536 | 450 |
| Out-of-State | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| **Total Anglers** | 2,282 | 2,744 | 2,616 | 3,087 | 3,080 | 3,650 | 2,890 | 2,384 | 2,470 | 2,343 |

### Recreational Fishing Effort by Mode (thousands of angler-trips)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| For-Hire | 442 | 412 | 490 | 505 | 456 | 503 | 415 | 391 | 368 | 374 |
| Private Boat | 8,265 | 9,962 | 9,899 | 9,896 | 9,824 | 11,535 | 10,910 | 8,923 | 9,514 | 8,663 |
| Shore | 9,057 | 10,871 | 10,829 | 10,621 | 11,251 | 9,955 | 10,468 | 9,370 | 9,186 | 8,637 |
| **Total Trips** | 17,764 | 21,245 | 21,218 | 21,022 | 21,531 | 21,993 | 21,793 | 18,684 | 19,068 | 17,674 |

### Harvest (H) and Release (R) of Key Species Species Groups (thousands of fish)[2,2]

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Black sea bass | H | 340 | 424 | 918 | 624 | 582 | 435 | 348 | 271 | 509 | 335 |
| | R | 1,456 | 1,407 | 2,758 | 2,386 | 2,513 | 2,861 | 2,566 | 1,909 | 2,594 | 3,031 |
| Bluefish | H | 1,617 | 1,664 | 1,879 | 2,078 | 1,487 | 1,915 | 1,690 | 1,585 | 2,348 | 1,939 |
| | R | 3,190 | 2,277 | 2,664 | 2,752 | 3,200 | 4,089 | 3,085 | 2,557 | 4,267 | 3,458 |
| Dolphinfish | H | 1,297 | 1,137 | 840 | 1,018 | 1,017 | 1,080 | 1,026 | 726 | 826 | 825 |
| | R | 81 | 146 | 119 | 202 | 186 | 394 | 188 | 99 | 128 | 354 |
| Drum (Atlantic croaker and spot) | H | 3,701 | 5,521 | 5,701 | 4,211 | 4,980 | 4,574 | 5,516 | 2,813 | 1,945 | 3,074 |
| | R | 2,272 | 4,653 | 3,876 | 3,882 | 6,754 | 3,775 | 4,179 | 4,869 | 3,336 | 4,182 |
| Drum (spotted seatrout) | H | 758 | 826 | 1,050 | 1,477 | 1,507 | 1,546 | 1,635 | 1,413 | 932 | 858 |
| | R | 3,218 | 2,891 | 3,561 | 6,409 | 5,264 | 5,555 | 5,167 | 4,169 | 5,771 | 4,890 |
| King mackerel | H | 364 | 600 | 461 | 392 | 491 | 821 | 485 | 422 | 231 | 152 |
| | R | 97 | 255 | 227 | 193 | 198 | 301 | 168 | 96 | 76 | 47 |
| Porgies (sheepshead) | H | 409 | 728 | 428 | 541 | 392 | 638 | 692 | 624 | 703 | 660 |
| | R | 453 | 558 | 316 | 421 | 420 | 546 | 691 | 511 | 496 | 516 |
| Red drum | H | 293 | 468 | 414 | 481 | 319 | 414 | 463 | 277 | 608 | 493 |
| | R | 1,615 | 1,527 | 1,766 | 2,612 | 2,033 | 1,840 | 2,414 | 1,870 | 3,321 | 2,139 |
| Sharks[3] | H | 9 | 25 | 23 | 76 | 6 | 15 | 16 | 19 | 3 | 11 |
| | R | 1,016 | 1,367 | 1,819 | 2,568 | 1,852 | 1,954 | 2,525 | 2,063 | 1,969 | 1,541 |
| Spanish mackerel | H | 1,353 | 1,169 | 760 | 932 | 651 | 1,060 | 1,315 | 1,126 | 1,070 | 865 |
| | R | 769 | 841 | 444 | 617 | 274 | 603 | 886 | 519 | 604 | 395 |

[1]NA = data are not available because out-of-state resident information is collected for individual states but whether an angler is a resident of a region is not specified

[2]In this table, '(1)' = 0-999 thousand fish and '1' = 1,000-1,499 thousand fish.

### 2011 Economic Impacts of the Florida[1] Seafood Industry (thousands of dollars)

| | With Imports | | | Without Imports | | |
|---|---|---|---|---|---|---|
| | Jobs | Sales | Value Added | Jobs | Sales | Value Added |
| **Total Impacts** | 72,341 | 14,250,006 | 4,778,502 | 10,550 | 928,929 | 376,208 |
| Commercial Harvesters | 6,817 | 446,577 | 186,630 | 6,817 | 446,577 | 186,630 |
| Seafood Processors & Dealers | 4,219 | 679,112 | 258,376 | 548 | 95,706 | 36,412 |
| Importers | 37,278 | 10,254,318 | 3,125,965 | 0 | 0 | 0 |
| Seafood Wholesalers & Distributors | 8,983 | 1,039,625 | 507,796 | 464 | 53,716 | 26,237 |
| Retail | 15,043 | 1,830,373 | 699,735 | 2,721 | 332,930 | 126,929 |

### Total Landings Revenue and Landings Revenue of Key Species/Species Groups (thousands of dollars)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total revenue | 34,420 | 33,111 | 39,978 | 35,489 | 42,002 | 42,767 | 47,855 | 40,992 | 51,138 | 60,570 |
| Finfish & other | 14,599 | 14,246 | 15,324 | 16,496 | 17,422 | 19,768 | 21,131 | 23,164 | 25,748 | 26,288 |
| Shellfish | 19,821 | 18,865 | 24,654 | 18,993 | 24,580 | 23,000 | 26,724 | 17,828 | 25,389 | 34,282 |
| Blue crab | 2,723 | 2,507 | 3,685 | 4,648 | 3,701 | 4,924 | 4,333 | 2,376 | 3,415 | 4,155 |
| Clams | 879 | 791 | 506 | 390 | 435 | 391 | 508 | 415 | 331 | 220 |
| Groupers | 719 | 658 | 584 | 587 | 521 | 923 | 724 | 583 | 561 | 547 |
| King mackerel | 2,816 | 2,853 | 3,650 | 3,456 | 4,318 | 4,833 | 6,036 | 6,563 | 6,903 | 5,495 |
| Lobsters | 1,939 | 1,779 | 2,148 | 1,624 | 2,462 | 2,488 | 3,312 | 1,089 | 2,825 | 3,205 |
| Sharks | 1,496 | 1,362 | 1,149 | 1,201 | 1,364 | 726 | 636 | 949 | 757 | 677 |
| Shrimp | 13,224 | 12,721 | 17,360 | 11,118 | 16,390 | 13,821 | 17,225 | 12,455 | 17,071 | 24,361 |
| Snappers | 1,113 | 919 | 1,098 | 1,009 | 972 | 1,279 | 1,905 | 2,383 | 1,454 | 1,668 |
| Spanish mackerel | 1,131 | 1,437 | 1,827 | 2,198 | 2,094 | 2,332 | 1,827 | 2,004 | 2,414 | 2,686 |
| Swordfish | 1,642 | 1,698 | 1,491 | 1,625 | 1,219 | 2,529 | 2,339 | 2,385 | 3,677 | 4,005 |

### Total Landings and Landings of Key Species/Species Groups (thousands of pounds)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total landings | 21,693 | 23,432 | 28,707 | 22,964 | 27,021 | 25,196 | 26,306 | 27,501 | 29,710 | 31,215 |
| Finfish & other | 12,144 | 12,874 | 12,497 | 12,815 | 13,848 | 13,893 | 14,111 | 16,105 | 17,137 | 16,029 |
| Shellfish | 9,549 | 10,558 | 16,209 | 10,149 | 13,173 | 11,303 | 12,196 | 11,396 | 12,573 | 15,186 |
| Blue crab | 2,233 | 1,988 | 3,536 | 4,045 | 3,130 | 4,063 | 3,342 | 1,640 | 2,553 | 3,226 |
| Clams | 109 | 99 | 54 | 42 | 47 | 41 | 55 | 54 | 42 | 22 |
| Groupers | 281 | 250 | 216 | 207 | 166 | 274 | 204 | 165 | 150 | 137 |
| King mackerel | 1,645 | 2,061 | 2,291 | 1,833 | 2,572 | 2,631 | 3,299 | 4,064 | 3,905 | 2,630 |
| Lobsters | 414 | 395 | 456 | 313 | 407 | 361 | 506 | 298 | 481 | 514 |
| Sharks | 1,795 | 1,509 | 1,273 | 1,292 | 1,472 | 818 | 776 | 1,109 | 781 | 716 |
| Shrimp | 6,217 | 6,451 | 11,728 | 5,203 | 8,843 | 6,174 | 7,619 | 8,662 | 8,743 | 10,528 |
| Snappers | 494 | 398 | 453 | 407 | 355 | 461 | 635 | 805 | 510 | 562 |
| Spanish mackerel | 1,995 | 2,741 | 3,066 | 3,134 | 3,143 | 3,264 | 2,263 | 2,629 | 3,553 | 3,433 |
| Swordfish | 708 | 725 | 511 | 543 | 407 | 772 | 791 | 838 | 1,028 | 1,067 |

### Average Annual Price of Key Species/Species Groups (dollars per pound)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Blue crab | 1.22 | 1.26 | 1.04 | 1.15 | 1.18 | 1.21 | 1.30 | 1.45 | 1.34 | 1.29 |
| Clams | 8.09 | 8.00 | 9.30 | 9.27 | 9.20 | 9.52 | 9.30 | 7.73 | 7.90 | 9.84 |
| Groupers | 2.56 | 2.63 | 2.70 | 2.84 | 3.14 | 3.37 | 3.55 | 3.53 | 3.73 | 3.99 |
| King mackerel | 1.71 | 1.38 | 1.59 | 1.89 | 1.68 | 1.84 | 1.83 | 1.61 | 1.77 | 2.09 |
| Lobsters | 4.68 | 4.50 | 4.71 | 5.18 | 6.06 | 6.90 | 6.55 | 3.65 | 5.87 | 6.23 |
| Sharks | 0.83 | 0.90 | 0.90 | 0.93 | 0.93 | 0.89 | 0.82 | 0.86 | 0.97 | 0.95 |
| Shrimp | 2.13 | 1.97 | 1.48 | 2.14 | 1.85 | 2.24 | 2.26 | 1.44 | 1.95 | 2.31 |
| Snappers | 2.25 | 2.31 | 2.42 | 2.48 | 2.74 | 2.78 | 3.00 | 2.96 | 2.85 | 2.97 |
| Spanish mackerel | 0.57 | 0.52 | 0.60 | 0.70 | 0.67 | 0.71 | 0.81 | 0.76 | 0.68 | 0.78 |
| Swordfish | 2.32 | 2.34 | 2.92 | 2.99 | 3.00 | 3.28 | 2.96 | 2.85 | 3.58 | 3.75 |

[1] Information reported in this table if for the state of Florida, not East Florida

### 2011 Economic Impacts of Recreational Fishing Expenditures (thousands of dollars)

| | Jobs | Sales | Income | Value Added |
|---|---|---|---|---|
| Trip Impacts by Fishing Mode: | | | | |
| For-Hire | 855 | 83,108 | 28,367 | 48,928 |
| Private Boat | 2,089 | 198,718 | 69,902 | 118,745 |
| Shore | 1,520 | 143,352 | 49,428 | 83,224 |
| Total Durable Equipment Impacts | 24,238 | 2,830,596 | 946,069 | 1,457,473 |
| **Total State Trip and Durable Equipment Economic Impacts** | 28,701 | 3,255,774 | 1,093,766 | 1,708,369 |

### 2011 Angler Trip & Durable Expenditures (thousands of dollars)

| Fishing Mode | Trip Expenditures | | Equipment | Durable Expenditures |
|---|---|---|---|---|
| | Non-Residents | Residents | Fishing Tackle | 680,782 |
| For-Hire | 45,395 | 5,328 | Other Equipment | 165,033 |
| Private Boat | 13,600 | 174,533 | Boat Expenses | 730,965 |
| Shore | 50,920 | 65,662 | Vehicle Expenses | 1,905,734 |
| *Total Trip Expenditures* | 109,915 | 245,524 | Second Home Expenses | 5,487 |
| | | | *Total Durable Equipment Expenditures* | 3,488,001 |
| **Total State Trip and Durable Equipment Expenditures** | | | | 3,843,440 |

### Recreational Anglers by Residential Area (thousands of anglers)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal | 1304 | 1413 | 1161 | 1565 | 1660 | 2168 | 1317 | 1099 | 1033 | 1109 |
| Non-Coastal | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| Out of State | 784 | 793 | 685 | 945 | 935 | 1008 | 703 | 643 | 629 | 553 |
| **Total Anglers** | 2089 | 2206 | 1847 | 2510 | 2595 | 3176 | 2021 | 1741 | 1662 | 1662 |

### Recreational Fishing Effort by Mode (thousands of angler-trips)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| For-Hire | 216 | 187 | 203 | 194 | 172 | 169 | 137 | 149 | 118 | 124 |
| Private | 5,429 | 6,211 | 5,544 | 6,064 | 5,913 | 7,157 | 6,452 | 5,394 | 5,706 | 5,298 |
| Shore | 4,657 | 5,045 | 5,144 | 5,092 | 5,543 | 5,277 | 4,651 | 4,577 | 4,393 | 4,735 |
| **Total Trips** | 10,302 | 11,443 | 10,891 | 11,350 | 11,628 | 12,603 | 11,240 | 10,120 | 10,217 | 10,157 |

### Harvest (H) and Release (R) of Key Species Species Groups (thousands of fish)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Bluefish | H | 758 | 644 | 513 | 446 | 433 | 471 | 377 | 623 | 787 | 557 |
| | R | 1,392 | 622 | 499 | 369 | 719 | 932 | 499 | 680 | 1,620 | 912 |
| Dolphinfish | H | 659 | 787 | 545 | 353 | 492 | 514 | 662 | 328 | 248 | 347 |
| | R | 72 | 130 | 114 | 200 | 162 | 373 | 185 | 78 | 118 | 346 |
| Drum (kingfish) | H | 930 | 590 | 1,094 | 997 | 839 | 853 | 949 | 408 | 720 | 935 |
| | R | 587 | 368 | 755 | 906 | 707 | 1,099 | 551 | 608 | 935 | 807 |
| Drum (spotted seatrout) | H | 206 | 170 | 235 | 379 | 332 | 277 | 181 | 172 | 252 | 286 |
| | R | 2,327 | 1,708 | 2,413 | 4,245 | 3,316 | 3,095 | 2,831 | 1,641 | 2,937 | 2,141 |
| Gray snapper | H | 402 | 447 | 322 | 397 | 445 | 689 | 352 | 225 | 161 | 187 |
| | R | 1,437 | 1,654 | 1,770 | 1,047 | 1,327 | 2,072 | 1,552 | 1,707 | 498 | 677 |
| Jack (Florida pompano) | H | 141 | 373 | 447 | 281 | 165 | 126 | 271 | 91 | 264 | 106 |
| | R | 175 | 307 | 417 | 188 | 129 | 163 | 359 | 80 | 161 | 297 |
| King mackerel | H | 282 | 463 | 287 | 242 | 340 | 515 | 349 | 292 | 182 | 133 |
| | R | 82 | 233 | 145 | 118 | 157 | 227 | 124 | 52 | 59 | 45 |
| Porgies (sheepshead) | H | 290 | 354 | 202 | 390 | 243 | 255 | 236 | 227 | 351 | 286 |
| | R | 352 | 351 | 252 | 289 | 314 | 306 | 465 | 355 | 336 | 357 |
| Red drum | H | 119 | 159 | 137 | 195 | 146 | 162 | 160 | 80 | 176 | 179 |
| | R | 663 | 749 | 1,006 | 1,406 | 847 | 759 | 890 | 522 | 1,415 | 1,051 |
| Spanish mackerel | H | 926 | 783 | 369 | 513 | 322 | 455 | 503 | 369 | 513 | 405 |
| | R | 555 | 446 | 209 | 248 | 141 | 196 | 364 | 150 | 282 | 147 |

[1]NA = not applicable because all East Florida residents are considered coastal county residents

### Florida's State Economy (% of national total)

| | Establishments | Employees | Annual Payroll (million $) | Employee Compensation (million $) | Gross State Product (million $) | Commercial Location Quotient [1] |
|---|---|---|---|---|---|---|
| 2002 | 450,188 (6.3%) | 6,366,964 (5.7%) | 192,932 (4.9%) | 304,181 (5.1%) | 536,061 (5%) | 1.29 |
| 2010 | 491,150 (6.6%) | 6,626,558 (5.9%) | 252,973 (5.1%) | 400,635 (5.1%) | 736,065 (5%) | 1 |
| % change | 9.1% | 4.08% | 31.1% | 31.7% | 37.3% | -10.9% |

### Seafood Sales & Processing - Nonemployer Firms (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Seafood product prep. & packaging | Firms | 116 | 142 | 177 | 164 | 174 | 173 | 202 | 216 | 202 |
| | Receipts | 5,064 | 8,047 | 8,652 | 8,756 | 10,184 | 10,497 | 11,065 | 12,399 | 11,065 |
| Seafood Sales, retail | Firms | 243 | 240 | 247 | 247 | 251 | 319 | 331 | 308 | 331 |
| | Receipts | 20,837 | 18,064 | 18,004 | 22,787 | 20,708 | 27,557 | 26,087 | 24,726 | 26,087 |

### Seafood Sales & Processing - Employer Establishments (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Seafood product prep. & packaging | Establishments | 33 | 27 | 24 | 25 | 22 | 20 | 23 | 25 | 27 |
| | Employees | 2,359 | 2,084 | 2,193 | 1,616 | 1,704 | 1,748 | 1,637 | 1,143 | 1,269 |
| | Payroll | 65,914 | 61,452 | 65,881 | 47,529 | 62,801 | 58,233 | 53,455 | 46,235 | 45,772 |
| Seafood sales, wholesale | Establishments | 314 | 293 | 261 | 258 | 259 | 267 | 229 | 215 | 229 |
| | Employees | 2,395 | 1,835 | 1,948 | 1,883 | 2,091 | 2,308 | 1,913 | 1,762 | 1,747 |
| | Payroll | 78,160 | 55,874 | 63,276 | 65,339 | 73,897 | 85,019 | 75,203 | 72,159 | 70,889 |
| Seafood sales, retail | Establishments | 190 | 174 | 190 | 176 | 173 | 169 | 168 | 158 | 145 |
| | Employees | 908 | 952 | 977 | 970 | 936 | 989 | 991 | 885 | 865 |
| | Payroll | 17,186 | 15,673 | 17,575 | 19,192 | 19,513 | 20,595 | 21,604 | 21,182 | 20,783 |

### Transport, Support, & Marine Operations - Employer Establishments (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal & Great Lakes freight transportation | Establishments | 51 | 66 | 59 | 59 | 54 | 47 | 42 | 42 | 50 |
| | Employees | 2,856 | ND[2] | 1,132 | 1,150 | 1,217 | 1,242 | 1,106 | 972 | 709 |
| | Payroll | 143,185 | ND[2] | 80,422 | 71,420 | 91,638 | 94,429 | 50,115 | 37,774 | 50,217 |
| Deep sea freight transportation | Establishments | 62 | 61 | 63 | 69 | 73 | 69 | 57 | 58 | 61 |
| | Employees | 1,858 | 2,535 | 2,567 | 2,622 | 3,729 | 3,190 | 2,486 | 2,801 | 2,279 |
| | Payroll | 107,564 | 131,904 | 150,701 | 207,300 | 226,810 | 208,144 | 169,055 | 180,139 | 159,025 |
| Deep sea passenger transportation | Establishments | 31 | 36 | 32 | 31 | 37 | 34 | 31 | 33 | 29 |
| | Employees | 7,863 | 8,879 | 8,849 | 8,492 | 9,077 | ND[2] | ND[2] | ND[2] | ND[2] |
| | Payroll | 315,551 | 428,941 | 536,753 | 504,625 | 571,590 | ND[2] | ND[2] | ND[2] | ND[2] |
| Marinas | Establishments | 481 | 528 | 532 | 551 | 513 | 493 | 442 | 428 | 430 |
| | Employees | 3,449 | 5,079 | 5,067 | 5,069 | 5,494 | 4,935 | 5,024 | 4,665 | 4,439 |
| | Payroll | 90,662 | 111,324 | 125,763 | 133,384 | 146,390 | 148,592 | 151,677 | 132,955 | 133,017 |
| Marine cargo handling | Establishments | 74 | 68 | 66 | 63 | 66 | 53 | 56 | 59 | 55 |
| | Employees | 4,405 | 5,651 | 5,671 | 6,409 | 7,266 | 6,585 | 8,052 | 7,288 | 7,547 |
| | Payroll | 109,555 | 171,481 | 175,257 | 177,983 | 189,020 | 173,788 | 192,473 | 185,309 | 191,560 |
| Navigational services to shipping | Establishments | 141 | 140 | 149 | 148 | 142 | 145 | 147 | 145 | 145 |
| | Employees | 714 | 817 | 686 | 660 | 781 | 1,484 | 894 | 829 | 980 |
| | Payroll | 34,040 | 39,524 | 39,309 | 42,200 | 48,370 | 61,470 | 56,917 | 60,641 | 76,853 |
| Port & harbor operations | Establishments | 29 | 26 | 29 | 31 | 27 | 29 | 40 | 32 | 34 |
| | Employees | 1,180 | 592 | 1,045 | 973 | 584 | 459 | 712 | 527 | 470 |
| | Payroll | 26,928 | 19,071 | 24,327 | 22,606 | 19,417 | 12,872 | 24,668 | 19,006 | 20,525 |
| Ship & boat building | Establishments | 291 | 290 | 306 | 312 | 301 | 296 | 297 | 261 | 248 |
| | Employees | 11,407 | 11,830 | 12,503 | 12,729 | 12,385 | 12,332 | 12,419 | 8,221 | 7,363 |
| | Payroll | 379,828 | 393,985 | 443,379 | 454,209 | 427,888 | 469,382 | 442,096 | 296,537 | 302,909 |

[1] The U.S. Commercial Fishing Location Quotient (CFLQ) of 1.0 represents the national baseline from which state CFLQs can be compared.
[2] ND = these data are confidential thus not disclosable

### 2011 Economic Impacts of the Georgia Seafood Industry (thousands of dollars)

| | With Imports | | | Without Imports | | |
|---|---|---|---|---|---|---|
| | Jobs | Sales | Value Added | Jobs | Sales | Value Added |
| **Total Impacts** | 11,137 | 1,489,958 | 548,826 | 2,222 | 104,308 | 55,698 |
| Commercial Harvesters | 726 | 28,252 | 13,717 | 726 | 28,252 | 13,717 |
| Seafood Processors & Dealers | 983 | 77,107 | 39,226 | 245 | 19,406 | 9,872 |
| Importers | 3,925 | 1,079,622 | 329,116 | 0 | 0 | 0 |
| Seafood Wholesalers & Distributors | 831 | 103,036 | 49,936 | 40 | 5,009 | 2,428 |
| Retail | 4,672 | 201,942 | 116,832 | 1,212 | 51,641 | 29,682 |

### Total Landings Revenue and Landings Revenue of Key Species/Species Groups (thousands of dollars)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total revenue | 14,703 | 13,685 | 14,374 | 13,465 | 11,534 | 11,331 | 13,079 | 11,750 | 13,715 | 16,295 |
| Finfish & other | 960 | 649 | 747 | 729 | 574 | 625 | 622 | 626 | 274 | 125 |
| Shellfish | 13,743 | 13,036 | 13,627 | 12,736 | 10,960 | 10,706 | 12,457 | 11,124 | 13,441 | 16,170 |
| Blue crab | 2,166 | 1,970 | 2,508 | 3,096 | 2,959 | 3,767 | 3,910 | 3,839 | 2,648 | 3,212 |
| Clams | 319 | 521 | 426 | 658 | 298 | 290 | 383 | 473 | 430 | 605 |
| Groupers | ND[1] | ND[2] | ND[2] | ND[2] | ND[2] | 123 | ND[2] | ND[2] | ND[2] | ND[2] |
| Shrimp | 11,048 | 10,320 | 10,589 | 8,936 | 7,640 | 6,446 | 7,877 | 6,602 | 10,092 | 11,690 |
| Snails (conchs) | 50 | 69 | 4 | 3 | 6 | 1 | 6 | 11 | 27 | 39 |
| Snappers | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | 269 | ND[2] | ND[2] | ND[2] | ND[2] |

### Total Landings and Landings of Key Species/Species Groups (thousands of pounds)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total landings | 9,177 | 9,437 | 9,659 | 9,638 | 8,294 | 7,908 | 8,957 | 7,357 | 7,203 | 12,646 |
| Finfish & other | 596 | 409 | 420 | 401 | 285 | 304 | 267 | 306 | 155 | 83 |
| Shellfish | 8,582 | 9,028 | 9,239 | 9,237 | 8,009 | 7,603 | 8,691 | 7,051 | 7,048 | 12,564 |
| Blue crab | 1,989 | 1,713 | 2,963 | 4,302 | 4,091 | 4,421 | 4,255 | 3,597 | 2,329 | 3,393 |
| Clams | 49 | 75 | 70 | 112 | 46 | 49 | 54 | 76 | 81 | 107 |
| Groupers | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | 37 | ND[2] | ND[2] | ND[2] | ND[2] |
| Shrimp | 5,079 | 5,591 | 5,090 | 4,531 | 3,851 | 2,797 | 3,132 | 3,321 | 4,548 | 4,246 |
| Snails (conchs) | 64 | 90 | 4 | 3 | 5 | 1 | 5 | 11 | 18 | 30 |
| Snappers | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | 93 | ND[2] | ND[2] | ND[2] | ND[2] |

### Average Annual Price of Key Species/Species Groups (dollars per pound)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Blue crab | 1.09 | 1.15 | 0.85 | 0.72 | 0.72 | 0.85 | 0.92 | 1.07 | 1.14 | 0.95 |
| Clams | 6.57 | 6.94 | 6.10 | 5.85 | 6.49 | 5.89 | 7.03 | 6.24 | 5.30 | 5.68 |
| Groupers | ND | ND | ND | ND | ND | 3.33 | ND | ND | ND | ND |
| Shrimp | 2.18 | 1.85 | 2.08 | 1.97 | 1.98 | 2.30 | 2.51 | 1.99 | 2.22 | 2.75 |
| Snails (conchs) | 0.78 | 0.77 | 1.10 | 1.03 | 1.22 | 1.25 | 1.31 | 1.00 | 1.50 | 1.30 |
| Snappers | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | 2.89 | ND[2] | ND[2] | ND[2] | ND[2] |

[1] ND = these data are confidential thus not disclosable

### 2011 Economic Impacts of Recreational Fishing Expenditures (thousands of dollars)

| | Jobs | Sales | Income | Value Added |
|---|---|---|---|---|
| Trip Impacts by Fishing Mode: | | | | |
| For-Hire | 62 | 5,245 | 1,714 | 3,061 |
| Private Boat | 200 | 22,809 | 7,741 | 13,835 |
| Shore | 111 | 12,161 | 4,096 | 7,292 |
| Total Durable Equipment Impacts | 2,507 | 308,527 | 105,470 | 158,398 |
| **Total State Trip and Durable Equipment Economic Impacts** | 2,880 | 348,742 | 119,021 | 182,586 |

### 2011 Angler Trip & Durable Expenditures (thousands of dollars)

| Fishing Mode | Trip Expenditures | | Equipment | Durable Expenditures |
|---|---|---|---|---|
| | Non-Residents | Residents | Fishing Tackle | 75,493 |
| For-Hire | 1,699 | 1,771 | Other Equipment | 19,692 |
| Private Boat | 2,521 | 21,010 | Boat Expenses | 173,848 |
| Shore | 2,378 | 9,277 | Vehicle Expenses | 19,465 |
| *Total Trip Expenditures* | 6,597 | 32,058 | Second Home Expenses | 0 |
| | | | *Total Durable Equipment Expenditures* | 288,497 |
| **Total State Trip and Durable Equipment Expenditures** | | | | 327,152 |

### Recreational Anglers by Residential Area (thousands of anglers)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal | 58 | 112 | 104 | 135 | 121 | 149 | 190 | 146 | 145 | 146 |
| Non-Coastal | 54 | 113 | 120 | 67 | 66 | 115 | 154 | 91 | 136 | 131 |
| Out of State | 37 | 42 | 53 | 43 | 33 | 45 | 98 | 45 | 61 | 78 |
| **Total Anglers** | 148 | 268 | 278 | 245 | 219 | 308 | 441 | 282 | 342 | 355 |

### Recreational Fishing Effort by Mode (thousands of angler-trips)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| For-Hire | 9 | 12 | 26 | 26 | 29 | 30 | 17 | 16 | 7 | 16 |
| Private | 338 | 549 | 485 | 538 | 481 | 577 | 732 | 516 | 530 | 620 |
| Shore | 273 | 410 | 457 | 370 | 289 | 421 | 455 | 311 | 336 | 334 |
| **Total Trips** | 620 | 971 | 968 | 934 | 799 | 1,028 | 1,204 | 843 | 873 | 970 |

### Harvest (H) and Release (R) of Key Species Species Groups (thousands of fish)[1]

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Black drum | H | 23 | 44 | 19 | 20 | 20 | 51 | 91 | 15 | 70 | 10 |
| | R | 19 | 27 | 42 | 11 | 29 | 35 | 66 | 22 | 40 | 5 |
| Black sea bass | H | 24 | 103 | 70 | 86 | 68 | 35 | 100 | 18 | 13 | 43 |
| | R | 82 | 239 | 143 | 218 | 184 | 291 | 580 | 114 | 163 | 227 |
| Bluefish | H | 2 | 1 | (1) | 4 | 3 | 11 | 8 | 1 | 13 | 3 |
| | R | 26 | 23 | 17 | 21 | 23 | 102 | 116 | 73 | 107 | 70 |
| Drum (Atlantic croaker) | H | 36 | 249 | 39 | 39 | 35 | 44 | 39 | 82 | 35 | 44 |
| | R | 194 | 964 | 154 | 281 | 283 | 229 | 294 | 434 | 264 | 262 |
| Drum (southern kingfish) | H | 427 | 504 | 662 | 511 | 448 | 576 | 697 | 587 | 586 | 873 |
| | R | 378 | 847 | 818 | 562 | 669 | 625 | 873 | 559 | 465 | 667 |
| Drum (spotted seatrout) | H | 271 | 426 | 340 | 241 | 380 | 578 | 642 | 507 | 384 | 289 |
| | R | 358 | 738 | 610 | 643 | 809 | 1,039 | 720 | 916 | 742 | 551 |
| Porgies (sheepshead) | H | 26 | 128 | 81 | 66 | 36 | 59 | 65 | 51 | 104 | 138 |
| | R | 39 | 123 | 26 | 58 | 52 | 85 | 97 | 33 | 38 | 44 |
| Red drum | H | 91 | 122 | 139 | 105 | 69 | 113 | 133 | 69 | 195 | 107 |
| | R | 169 | 272 | 142 | 334 | 137 | 226 | 314 | 167 | 483 | 213 |
| Sharks[2] | H | (1) | 4 | 1 | 2 | (1) | 2 | 3 | 1 | (1) | 3 |
| | R | 194 | 210 | 293 | 362 | 355 | 583 | 518 | 332 | 268 | 296 |
| Southern flounder | H | 30 | 82 | 53 | 38 | 23 | 94 | 49 | 34 | 35 | 28 |
| | R | 11 | 16 | 33 | 8 | 17 | (1) | 2 | 9 | 3 | 12 |

[1] In this table, '(1)' = 0-999 thousand fish and '1' = 1,000-1,499 thousand fish.
[2] Sharks include species within the requiem shark family, blacktip sharks, Atlantic sharpnose sharks, and unidentified sharks.

### Georgia's State Economy (% of national total)

| | Establishments | Employees | Annual Payroll (million $) | Employee Compensation (million $) | Gross State Product (million $) | Commercial Location Quotient [1] |
|---|---|---|---|---|---|---|
| 2002 | 206,323 (2.9%) | 3,381,244 (3%) | 113,752 (2.9%) | 178,394 (3%) | 313,952 (2.9%) | 0.12 |
| 2010 | 217,099 (2.9%) | 3,315,274 (3%) | 137,539 (2.8%) | 227,218 (2.8%) | 403,230 (2.9%) | 0.06 |
| % change | 5.22% | -1.95% | 20.9% | 27.4% | 28.4% | -50% |

### Seafood Sales & Processing - Nonemployer Firms (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Seafood product prep. & packaging | Firms | 20 | 24 | 29 | 24 | 21 | 34 | 45 | 50 | 45 |
| | Receipts | 1,560 | 2,249 | 2,030 | 2,642 | 1,957 | 2,187 | 3,489 | 3,741 | 3,489 |
| Seafood Sales, retail | Firms | 77 | 72 | 69 | 64 | 78 | 87 | 101 | 99 | 101 |
| | Receipts | 5,027 | 4,668 | 4,855 | 6,625 | 7,180 | 8,671 | 6,922 | 5,917 | 6,922 |

### Seafood Sales & Processing - Employer Establishments (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Seafood product prep. & packaging | Establishments | 11 | 11 | 11 | 11 | 8 | 6 | 7 | 6 | 6 |
| | Employees | 1,014 | 994 | ND[2] | 1,155 | 1,164 | ND[2] | ND[2] | ND[2] | 1,056 |
| | Payroll | 29,867 | 28,432 | ND[2] | 39,839 | 43,637 | ND[2] | ND[2] | ND[2] | 37,343 |
| Seafood sales, wholesale | Establishments | 53 | 39 | 36 | 29 | 30 | 42 | 30 | 33 | 36 |
| | Employees | 572 | 580 | 619 | 640 | 659 | 688 | 565 | 532 | 514 |
| | Payroll | 19,616 | 32,047 | 31,012 | 32,781 | 31,654 | 31,033 | 20,122 | 18,628 | 20,075 |
| Seafood sales, retail | Establishments | 52 | 46 | 50 | 59 | 55 | 44 | 48 | 42 | 48 |
| | Employees | 161 | 152 | 159 | 185 | 184 | 179 | 160 | 162 | 176 |
| | Payroll | 2,002 | 2,243 | 2,437 | 2,753 | 2,724 | 2,633 | 2,433 | 2,447 | 2,502 |

### Transport, Support, & Marine Operations - Employer Establishments (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal & Great Lakes freight transportation | Establishments | 5 | 6 | 6 | 7 | 6 | 6 | 6 | 5 | 4 |
| | Employees | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | 33 | 28 | ND[2] | ND[2] |
| | Payroll | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | 1,883 | 2,040 | 1,700 | ND[2] |
| Deep sea freight transportation | Establishments | 19 | 23 | 18 | 19 | 15 | 13 | 14 | 13 | 14 |
| | Employees | ND[2] | 256 | 185 | 193 | ND[2] | 132 | 156 | 29 | ND[2] |
| | Payroll | ND[2] | 12,201 | 10,306 | 10,658 | ND[2] | 10,090 | 11,275 | 2,192 | 2,465 |
| Deep sea passenger transportation | Establishments | NA[3] | NA[3] | NA[3] | NA[3] | NA[3] | 1 | NA[3] | NA[3] | NA[3] |
| | Employees | NA[3] | NA[3] | NA[3] | NA[3] | NA[3] | ND[2] | NA[3] | NA[3] | NA[3] |
| | Payroll | NA[3] | NA[3] | NA[3] | NA[3] | NA[3] | ND[2] | NA[3] | NA[3] | NA[3] |
| Marinas | Establishments | 63 | 69 | 57 | 60 | 66 | 68 | 60 | 58 | 62 |
| | Employees | ND[2] | 642 | ND[2] | ND[2] | ND[2] | 569 | 527 | 541 | 631 |
| | Payroll | ND[2] | 12,870 | ND[2] | ND[2] | ND[2] | 12,701 | 15,571 | 15,736 | 17,428 |
| Marine cargo handling | Establishments | 15 | 14 | 18 | 17 | 17 | 17 | 17 | 18 | 17 |
| | Employees | 3,197 | ND[2] | 2,018 | 2,350 | 3,003 | 2,501 | 2,660 | 3,707 | 2,971 |
| | Payroll | 75,368 | ND[2] | 68,696 | 80,706 | 104,596 | 110,857 | 97,869 | 87,410 | 84,675 |
| Navigational services to shipping | Establishments | 9 | 9 | 8 | 8 | 10 | 11 | 11 | 9 | 8 |
| | Employees | 107 | ND[2] | ND[2] | 136 | ND[2] | 217 | 182 | ND[2] | ND[2] |
| | Payroll | 5,109 | ND[2] | ND[2] | 7,784 | ND[2] | 11,141 | 10,193 | 12,185 | 11,237 |
| Port & harbor operations | Establishments | 4 | 4 | 7 | 6 | 5 | 4 | 5 | 5 | 4 |
| | Employees | ND[2] | ND[2] | ND[2] | ND[2] | 196 | 98 | ND[2] | ND[2] | ND[2] |
| | Payroll | ND[2] | ND[2] | ND[2] | ND[2] | 3,303 | 3,108 | ND[2] | ND[2] | ND[2] |
| Ship & boat building | Establishments | 20 | 18 | 20 | 17 | 16 | 21 | 20 | 14 | 12 |
| | Employees | ND[2] | 1,580 | ND[2] | ND[2] | 1,967 | 2,225 | 2,159 | ND[2] | ND[2] |
| | Payroll | ND[2] | 40,768 | ND[2] | ND[2] | 64,667 | 68,646 | 69,096 | ND[2] | ND[2] |

[1] The U.S. Commercial Fishing Location Quotient (CFLQ) of 1.0 represents the national baseline from which state CFLQs can be compared.
[2] ND = these data are confidential thus not disclosable
[3] NA = these data are not available

### 2011 Economic Impacts of the North Carolina Seafood Industry (thousands of dollars)

| | With Imports | | | Without Imports | | |
|---|---|---|---|---|---|---|
| | Jobs | Sales | Value Added | Jobs | Sales | Value Added |
| **Total Impacts** | 8,850 | 795,541 | 329,451 | 5,086 | 248,229 | 136,504 |
| Commercial Harvesters | 2,162 | 120,395 | 66,840 | 2,162 | 120,395 | 66,840 |
| Seafood Processors & Dealers | 1,050 | 70,274 | 35,307 | 403 | 27,210 | 13,671 |
| Importers | 1,543 | 424,459 | 129,394 | 0 | 0 | 0 |
| Seafood Wholesalers & Distributors | 431 | 46,974 | 21,745 | 121 | 13,232 | 6,125 |
| Retail | 3,663 | 133,439 | 76,165 | 2,399 | 87,392 | 49,869 |

### Total Landings Revenue and Landings Revenue of Key Species/Species Groups (thousands of dollars)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total revenue | 94,747 | 84,926 | 79,703 | 64,890 | 70,121 | 82,285 | 86,822 | 77,248 | 79,865 | 71,177 |
| Finfish & other | 37,274 | 31,560 | 38,910 | 34,901 | 37,716 | 36,203 | 34,445 | 34,002 | 33,376 | 31,303 |
| Shellfish | 57,473 | 53,366 | 40,793 | 29,989 | 32,405 | 46,082 | 52,377 | 43,246 | 46,489 | 39,874 |
| Atlantic croaker | 3,234 | 2,924 | 3,528 | 3,409 | 3,563 | 2,714 | 3,142 | 3,004 | 3,410 | 3,164 |
| Black sea bass | 878 | 1,417 | 1,486 | 1,332 | 1,715 | 1,195 | 1,156 | 1,401 | 948 | 628 |
| Blue crab | 33,149 | 37,108 | 24,465 | 20,274 | 17,087 | 21,432 | 27,555 | 27,429 | 26,544 | 21,282 |
| Clams | 3,534 | 3,399 | 3,390 | 2,798 | 2,656 | 2,660 | 2,435 | 2,141 | 2,640 | 1,933 |
| Flounders | 11,270 | 9,671 | 11,503 | 10,963 | 13,301 | 11,335 | 10,886 | 10,124 | 10,908 | 8,889 |
| Groupers | 1,302 | 1,200 | 1,124 | 1,214 | 1,559 | 1,995 | 1,939 | 1,609 | 1,506 | 1,302 |
| King mackerel | 1,177 | 1,214 | 1,573 | 2,054 | 2,120 | 1,967 | 1,632 | 1,500 | 644 | 1,062 |
| Shrimp | 18,365 | 10,931 | 9,463 | 4,409 | 9,141 | 17,905 | 19,251 | 8,528 | 10,691 | 10,886 |
| Snappers | 1,186 | 686 | 873 | 1,116 | 953 | 1,601 | 1,784 | 1,073 | 955 | 1,004 |
| Tunas | 2,158 | 1,989 | 3,317 | 3,321 | 4,060 | 4,046 | 3,393 | 2,922 | 1,489 | 2,437 |

### Total Landings and Landings of Key Species/Species Groups (thousands of pounds)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total landings | 160,142 | 139,401 | 134,078 | 79,607 | 68,744 | 62,871 | 71,209 | 68,962 | 71,994 | 67,483 |
| Finfish & other | 110,944 | 88,721 | 91,383 | 49,435 | 35,675 | 30,440 | 27,706 | 32,419 | 32,519 | 29,802 |
| Shellfish | 49,198 | 50,681 | 42,696 | 30,172 | 33,069 | 32,432 | 43,503 | 36,543 | 39,474 | 37,681 |
| Atlantic croaker | 10,189 | 14,429 | 11,993 | 11,903 | 10,397 | 7,271 | 5,792 | 6,135 | 7,312 | 5,054 |
| Black sea bass | 592 | 851 | 881 | 690 | 778 | 473 | 485 | 615 | 401 | 272 |
| Blue crab | 37,737 | 42,770 | 34,129 | 25,430 | 25,343 | 21,425 | 32,917 | 29,707 | 30,683 | 30,035 |
| Clams | 627 | 547 | 551 | 418 | 427 | 438 | 400 | 367 | 366 | 302 |
| Flounders | 7,568 | 5,772 | 7,302 | 5,937 | 6,272 | 4,754 | 5,009 | 5,256 | 5,001 | 4,101 |
| Groupers | 581 | 518 | 478 | 481 | 587 | 701 | 683 | 553 | 493 | 366 |
| King mackerel | 778 | 765 | 955 | 1,246 | 1,186 | 1,059 | 1,037 | 778 | 329 | 408 |
| Shrimp | 9,969 | 6,167 | 4,881 | 2,358 | 5,737 | 9,537 | 9,427 | 5,408 | 5,955 | 5,140 |
| Snappers | 490 | 269 | 339 | 433 | 345 | 550 | 603 | 374 | 320 | 326 |
| Tunas | 1,000 | 914 | 1,424 | 1,271 | 1,982 | 1,836 | 1,041 | 1,028 | 703 | 1,056 |

### Average Annual Price of Key Species/Species Groups (dollars per pound)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Atlantic croaker | 0.32 | 0.20 | 0.29 | 0.29 | 0.34 | 0.37 | 0.54 | 0.49 | 0.47 | 0.63 |
| Black sea bass | 1.48 | 1.67 | 1.69 | 1.93 | 2.21 | 2.53 | 2.39 | 2.28 | 2.36 | 2.31 |
| Blue crab | 0.88 | 0.87 | 0.72 | 0.80 | 0.67 | 1.00 | 0.84 | 0.92 | 0.87 | 0.71 |
| Clams | 5.64 | 6.22 | 6.15 | 6.69 | 6.21 | 6.08 | 6.09 | 5.83 | 7.21 | 6.39 |
| Flounders | 1.49 | 1.68 | 1.58 | 1.85 | 2.12 | 2.38 | 2.17 | 1.93 | 2.18 | 2.17 |
| Groupers | 2.24 | 2.32 | 2.35 | 2.52 | 2.65 | 2.84 | 2.84 | 2.91 | 3.06 | 3.56 |
| King mackerel | 1.51 | 1.59 | 1.65 | 1.65 | 1.79 | 1.86 | 1.57 | 1.93 | 1.96 | 2.60 |
| Shrimp | 1.84 | 1.77 | 1.94 | 1.87 | 1.59 | 1.88 | 2.04 | 1.58 | 1.80 | 2.12 |
| Snappers | 2.42 | 2.55 | 2.57 | 2.58 | 2.76 | 2.91 | 2.96 | 2.87 | 2.98 | 3.08 |
| Tunas | 2.16 | 2.18 | 2.33 | 2.61 | 2.05 | 2.20 | 3.26 | 2.84 | 2.12 | 2.31 |

### 2011 Economic Impacts of Recreational Fishing Expenditures (thousands of dollars)

| | Jobs | Sales | Income | Value Added |
|---|---|---|---|---|
| Trip Impacts by Fishing Mode: | | | | |
| For-Hire | 1,355 | 106,477 | 33,906 | 59,755 |
| Private Boat | 1,498 | 139,335 | 44,719 | 78,567 |
| Shore | 3,663 | 303,553 | 96,913 | 169,035 |
| Total Durable Equipment Impacts | 11,221 | 1,411,779 | 430,536 | 641,104 |
| **Total State Trip and Durable Equipment Economic Impacts** | 17,737 | 1,961,144 | 606,074 | 948,461 |

### 2011 Angler Trip & Durable Expenditures (thousands of dollars)

| Fishing Mode | Trip Expenditures | | Equipment | Durable Expenditures |
|---|---|---|---|---|
| | Non-Residents | Residents | Fishing Tackle | 250,075 |
| For-Hire | 53,606 | 17,838 | Other Equipment | 81,722 |
| Private Boat | 20,479 | 102,454 | Boat Expenses | 419,575 |
| Shore | 112,816 | 110,878 | Vehicle Expenses | 379,028 |
| *Total Trip Expenditures* | 186,901 | 231,169 | Second Home Expenses | 57,967 |
| | | | *Total Durable Equipment Expenditures* | 1,188,366 |
| **Total State Trip and Durable Equipment Expenditures** | | | | 1,606,436 |

### Recreational Anglers by Residential Area (thousands of anglers)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal | 409 | 524 | 613 | 685 | 588 | 564 | 587 | 446 | 544 | 490 |
| Non-Coastal | 226 | 281 | 290 | 285 | 265 | 265 | 303 | 259 | 296 | 254 |
| Out of State | 1130 | 1298 | 1156 | 1280 | 1374 | 1079 | 1079 | 976 | 1073 | 755 |
| **Total Anglers** | 1765 | 2103 | 2058 | 2250 | 2227 | 1908 | 1970 | 1681 | 1914 | 1499 |

### Recreational Fishing Effort by Mode (thousands of angler-trips)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| For-Hire | 184 | 174 | 183 | 260 | 234 | 218 | 192 | 146 | 166 | 152 |
| Private | 1,941 | 2,181 | 2,640 | 2,345 | 2,452 | 2,670 | 2,461 | 2,005 | 2,199 | 1,899 |
| Shore | 3,462 | 4,379 | 4,090 | 3,939 | 4,179 | 3,444 | 4,246 | 3,158 | 3,314 | 2,689 |
| **Total Trips** | 5,587 | 6,734 | 6,913 | 6,544 | 6,865 | 6,332 | 6,899 | 5,309 | 5,679 | 4,740 |

### Harvest (H) and Release (R) of Key Species Species Groups (thousands of fish)[1]

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Black sea bass | H | 85 | 167 | 398 | 231 | 126 | 110 | 58 | 107 | 139 | 94 |
| | R | 529 | 419 | 1,300 | 1,194 | 1,177 | 950 | 559 | 668 | 1,103 | 1,062 |
| Bluefish | H | 778 | 953 | 1,233 | 1,382 | 917 | 1,257 | 1,177 | 827 | 1,105 | 1,153 |
| | R | 1,610 | 1,417 | 1,761 | 2,044 | 1,836 | 2,378 | 2,138 | 1,551 | 2,221 | 1,924 |
| Dolphinfish | H | 621 | 334 | 268 | 662 | 522 | 533 | 357 | 367 | 499 | 473 |
| | R | 3 | 14 | 5 | 2 | 24 | 5 | 2 | 3 | 5 | 8 |
| Drum (Atlantic croaker and spot) | H | 2,996 | 4,286 | 4,337 | 3,341 | 3,534 | 3,538 | 2,163 | 1,424 | 1,314 | 1,453 |
| | R | 1,598 | 2,686 | 2,915 | 2,735 | 5,167 | 2,805 | 2,741 | 3,135 | 2,470 | 2,799 |
| Drum (spotted seatrout) | H | 197 | 107 | 285 | 585 | 564 | 531 | 656 | 609 | 195 | 216 |
| | R | 384 | 132 | 261 | 1,059 | 596 | 849 | 883 | 1,214 | 1,685 | 1,917 |
| Flounder (lefteye and summer) | H | 216 | 110 | 189 | 156 | 152 | 189 | 70 | 100 | 143 | 93 |
| | R | 1,286 | 830 | 1,341 | 878 | 925 | 1,090 | 1,691 | 1,212 | 1,584 | 988 |
| King mackerel | H | 67 | 114 | 149 | 139 | 143 | 270 | 106 | 92 | 35 | 13 |
| | R | 7 | 22 | 78 | 73 | 32 | 44 | 24 | 12 | 7 | (1) |
| Spanish mackerel | H | 403 | 350 | 327 | 335 | 305 | 495 | 745 | 678 | 482 | 366 |
| | R | 197 | 165 | 149 | 181 | 96 | 257 | 448 | 312 | 295 | 171 |
| Striped bass | H | 59 | 139 | 431 | 136 | 98 | 48 | 35 | 12 | 34 | 106 |
| | R | 154 | 285 | 586 | 123 | 62 | 81 | 175 | 122 | 107 | 295 |
| Yellowfin tuna | H | 135 | 328 | 169 | 180 | 166 | 102 | 26 | 29 | 23 | 26 |
| | R | 8 | 56 | 10 | 8 | 13 | 1 | (1) | (1) | 1 | (1) |

[1] In this table, '(1)' = 0-999 thousand fish and '1' = 1,000-1,499 thousand fish.

### North Carolina's State Economy (% of national total)

| | Establishments | Employees | Annual Payroll (million $) | Employee Compensation (million $) | Gross State Product (million $) | Commercial Location Quotient [1] |
|---|---|---|---|---|---|---|
| 2002 | 207,562 (2.9%) | 3,322,004 (3%) | 101,827 (2.6%) | 163,313 (2.9%) | 302,201 (2.7%) | 0.21 |
| 2010 | 218,104 (2.9%) | 3,234,595 (2.9%) | 125,174 (2.5%) | 219,158 (2.9%) | 424,562 (2.8%) | 0.09 |
| % change | 5.08% | -2.63% | 22.9% | 34.2% | 40.5% | -42.9% |

### Seafood Sales & Processing - Nonemployer Firms (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Seafood product prep. & packaging | Firms | 25 | 33 | 27 | 26 | 27 | 30 | 0 | 0 | 0 |
| | Receipts | 1,385 | 1,646 | 1,515 | 1,106 | 1,084 | 1,813 | ND[2] | ND[2] | ND[2] |
| Seafood Sales, retail | Firms | 117 | 133 | 144 | 130 | 115 | 150 | 114 | 139 | 114 |
| | Receipts | 11,560 | 11,565 | 12,294 | 10,913 | 11,342 | 14,999 | 10,918 | 12,073 | 10,918 |

### Seafood Sales & Processing - Employer Establishments (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Seafood product prep. & packaging | Establishments | 21 | 18 | 18 | 17 | 18 | 22 | 18 | 16 | 16 |
| | Employees | 280 | ND[2] | ND[2] | ND[2] | 475 | ND[2] | 232 | 170 | 171 |
| | Payroll | 8,547 | ND[2] | ND[2] | ND[2] | 11,563 | 12,659 | 5,373 | 4,461 | 4,749 |
| Seafood sales, wholesale | Establishments | 84 | 68 | 72 | 77 | 70 | 71 | 65 | 66 | 66 |
| | Employees | 961 | 628 | 627 | 703 | 582 | 597 | 559 | 584 | 590 |
| | Payroll | 21,716 | 16,170 | 17,411 | 17,577 | 16,543 | 15,655 | 16,843 | 17,383 | 18,348 |
| Seafood sales, retail | Establishments | 81 | 87 | 88 | 90 | 89 | 86 | 90 | 77 | 82 |
| | Employees | 301 | 304 | 340 | 316 | 250 | 241 | 219 | 243 | 247 |
| | Payroll | 3,890 | 3,982 | 4,234 | 4,185 | 4,129 | 4,170 | 4,143 | 4,494 | 5,017 |

### Transport, Support, & Marine Operations - Employer Establishments (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal & Great Lakes freight transportation | Establishments | 6 | 5 | 5 | 5 | 4 | 6 | 4 | 6 | 4 |
| | Employees | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | 54 | ND[2] | ND[2] | ND[2] |
| | Payroll | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | 2,061 | ND[2] | 2,366 | ND[2] |
| Deep sea freight transportation | Establishments | 15 | 7 | 7 | 7 | 8 | 6 | 5 | 6 | 10 |
| | Employees | 168 | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | 9 | ND[2] |
| | Payroll | 52,665 | ND[2] | ND[2] | ND[2] | ND[2] | 510 | 533 | 617 | ND[2] |
| Deep sea passenger transportation | Establishments | 3 | 3 | 2 | 2 | 1 | 1 | NA[3] | 1 | NA[3] |
| | Employees | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | NA[3] | ND[2] | NA[3] |
| | Payroll | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | NA[3] | ND[2] | NA[3] |
| Marinas | Establishments | 103 | 104 | 97 | 103 | 103 | 96 | 107 | 105 | 102 |
| | Employees | 557 | ND[2] | 644 | 654 | 681 | 522 | 656 | 501 | 536 |
| | Payroll | 13,186 | ND[2] | 16,529 | 16,530 | 16,616 | 14,922 | 17,164 | 15,858 | 16,238 |
| Marine cargo handling | Establishments | 6 | 7 | 10 | 12 | 9 | 13 | 13 | 12 | 11 |
| | Employees | ND[2] | 433 | 668 | 641 | 757 | 652 | 760 | 914 | 600 |
| | Payroll | ND[2] | 16,001 | 28,676 | 25,988 | 19,736 | 25,164 | 23,328 | 20,707 | 20,755 |
| Navigational services to shipping | Establishments | 4 | 6 | 6 | 8 | 7 | 14 | 10 | 11 | 13 |
| | Employees | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | 102 | 87 | 96 | 94 |
| | Payroll | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | 3,773 | 3,668 | 4,313 | 3,968 |
| Port & harbor operations | Establishments | 7 | 6 | 5 | 5 | 5 | 3 | 3 | 2 | 4 |
| | Employees | ND[2] | 271 | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| | Payroll | ND[2] | 12,650 | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| Ship & boat building | Establishments | 62 | 55 | 62 | 65 | 74 | 78 | 77 | 64 | 60 |
| | Employees | 3,566 | 3,290 | 3,622 | 3,957 | 4,232 | ND[2] | 4,281 | 1,983 | 1,501 |
| | Payroll | 103,506 | 106,656 | 127,472 | 133,665 | 153,672 | ND[2] | 138,243 | 68,004 | 64,807 |

[1] The U.S. Commercial Fishing Location Quotient (CFLQ) of 1.0 represents the national baseline from which state CFLQs can be compared.
[2] ND = these data are confidential thus not disclosable
[3] NA = these data are not available

### 2011 Economic Impacts of the South Carolina Seafood Industry (thousands of dollars)

| | With Imports | | | Without Imports | | |
|---|---|---|---|---|---|---|
| | Jobs | Sales | Value Added | Jobs | Sales | Value Added |
| **Total Impacts** | 1,547 | 88,131 | 46,495 | 1,495 | 79,999 | 43,701 |
| Commercial Harvesters | 549 | 38,536 | 20,967 | 549 | 38,536 | 20,967 |
| Seafood Processors & Dealers | 113 | 8,671 | 4,362 | 111 | 8,497 | 4,274 |
| Importers | 24 | 6,728 | 2,051 | 0 | 0 | 0 |
| Seafood Wholesalers & Distributors | 44 | 4,480 | 2,067 | 39 | 4,015 | 1,853 |
| Retail | 817 | 29,717 | 17,048 | 796 | 28,951 | 16,607 |

### Total Landings Revenue and Landings Revenue of Key Species/Species Groups (thousands of dollars)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total revenue | 21,340 | 21,242 | 18,542 | 17,570 | 17,025 | 16,017 | 17,872 | 17,032 | 21,205 | 23,268 |
| Finfish & other | 5,375 | 4,650 | 5,042 | 4,781 | 4,995 | 4,744 | 4,614 | 5,114 | 6,740 | 8,429 |
| Shellfish | 15,965 | 16,592 | 13,499 | 12,789 | 12,031 | 11,274 | 13,259 | 11,918 | 14,465 | 14,839 |
| Black sea bass | 95 | 168 | 302 | 191 | 168 | 236 | 257 | 362 | 213 | 182 |
| Blue crab | 4,239 | 5,057 | 3,591 | 3,766 | 3,304 | 3,511 | 4,187 | 4,059 | 3,593 | 5,084 |
| Clams | 1,399 | 1,537 | 1,238 | 934 | 834 | 697 | 535 | 542 | 688 | 606 |
| Groupers | 811 | 993 | 1,020 | 1,013 | 1,335 | 1,524 | 1,421 | 1,021 | 949 | 1,169 |
| Oysters | 1,025 | 1,199 | 1,229 | 1,471 | 1,369 | 1,375 | 1,739 | 1,738 | 1,858 | 1,975 |
| Sharks | 78 | 66 | 128 | 136 | 144 | 78 | 78 | 56 | 123 | 166 |
| Shrimp | 9,062 | 8,736 | 7,385 | 6,572 | 6,481 | 5,634 | 6,712 | 5,487 | 8,168 | 7,008 |
| Snappers | 1,319 | 725 | 1,237 | 1,190 | 823 | 773 | 864 | 568 | 1,079 | 1,080 |
| Swordfish | 670 | 616 | 555 | ND[1] | ND[2] | ND[2] | 187 | 1,116 | 1,944 | 2,777 |
| Tilefish | 423 | 287 | 221 | 143 | 271 | 5 | 66 | 9 | 25 | 8 |

### Total Landings and Landings of Key Species/Species Groups (thousands of pounds)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total landings | 13,559 | 13,728 | 12,439 | 11,212 | 10,602 | 9,310 | 10,081 | 9,375 | 10,567 | 12,116 |
| Finfish & other | 3,052 | 2,598 | 2,768 | 2,274 | 2,249 | 1,994 | 1,940 | 2,161 | 2,774 | 3,220 |
| Shellfish | 10,507 | 11,130 | 9,670 | 8,938 | 8,353 | 7,316 | 8,141 | 7,215 | 7,793 | 8,896 |
| Black sea bass | 60 | 104 | 212 | 115 | 86 | 114 | 132 | 168 | 98 | 100 |
| Blue crab | 4,435 | 4,411 | 4,374 | 4,440 | 4,215 | 4,137 | 4,484 | 4,014 | 3,275 | 5,439 |
| Clams | 219 | 263 | 211 | 175 | 165 | 135 | 119 | 123 | 152 | 123 |
| Groupers | 304 | 366 | 363 | 319 | 399 | 404 | 379 | 274 | 241 | 269 |
| Oysters | 262 | 283 | 275 | 308 | 291 | 285 | 324 | 309 | 332 | 337 |
| Sharks | 109 | 124 | 206 | 174 | 147 | 105 | 110 | 63 | 87 | 108 |
| Shrimp | 5,238 | 6,133 | 4,773 | 3,957 | 3,650 | 2,727 | 3,162 | 2,716 | 3,951 | 2,918 |
| Snappers | 544 | 290 | 492 | 447 | 267 | 250 | 277 | 194 | 365 | 356 |
| Swordfish | 240 | 219 | 200 | ND[2] | ND[2] | ND[2] | 71 | 459 | 630 | 741 |
| Tilefish | 195 | 145 | 124 | 80 | 139 | 4 | 28 | 5 | 15 | 4 |

### Average Annual Price of Key Species/Species Groups (dollars per pound)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Black sea bass | 1.56 | 1.61 | 1.42 | 1.66 | 1.97 | 2.07 | 1.94 | 2.15 | 2.16 | 1.82 |
| Blue crab | 0.96 | 1.15 | 0.82 | 0.85 | 0.78 | 0.85 | 0.93 | 1.01 | 1.10 | 0.93 |
| Clams | 6.38 | 5.85 | 5.86 | 5.34 | 5.06 | 5.17 | 4.51 | 4.42 | 4.54 | 4.95 |
| Groupers | 2.67 | 2.71 | 2.81 | 3.17 | 3.35 | 3.77 | 3.75 | 3.73 | 3.94 | 4.35 |
| Oysters | 3.91 | 4.24 | 4.46 | 4.78 | 4.71 | 4.82 | 5.36 | 5.63 | 5.60 | 5.85 |
| Sharks | 0.71 | 0.53 | 0.62 | 0.78 | 0.98 | 0.74 | 0.71 | 0.89 | 1.42 | 1.53 |
| Shrimp | 1.73 | 1.42 | 1.55 | 1.66 | 1.78 | 2.07 | 2.12 | 2.02 | 2.07 | 2.40 |
| Snappers | 2.42 | 2.50 | 2.51 | 2.66 | 3.08 | 3.09 | 3.12 | 2.92 | 2.95 | 3.03 |
| Swordfish | 2.79 | 2.81 | 2.78 | ND[2] | ND[2] | ND[2] | 2.64 | 2.43 | 3.09 | 3.75 |
| Tilefish | 2.17 | 1.98 | 1.78 | 1.78 | 1.95 | 1.36 | 2.30 | 2.00 | 1.71 | 1.84 |

[1] ND = these data are confidential thus not disclosable

### 2011 Economic Impacts of Recreational Fishing Expenditures (thousands of dollars)

| | Jobs | Sales | Income | Value Added |
|---|---|---|---|---|
| Trip Impacts by Fishing Mode: | | | | |
| For-Hire | 528 | 41,360 | 13,304 | 23,367 |
| Private Boat | 415 | 36,462 | 12,027 | 21,275 |
| Shore | 1,054 | 86,166 | 27,629 | 47,979 |
| Total Durable Equipment Impacts | 1,256 | 118,060 | 40,829 | 62,377 |
| **Total State Trip and Durable Equipment Economic Impacts** | 3,254 | 282,049 | 93,789 | 154,999 |

### 2011 Angler Trip & Durable Expenditures (thousands of dollars)

| Fishing Mode | Trip Expenditures | | Equipment | Durable Expenditures |
|---|---|---|---|---|
| | Non-Residents | Residents | Fishing Tackle | 53,189 |
| For-Hire | 24,789 | 4,977 | Other Equipment | 11,366 |
| Private Boat | 4,590 | 31,062 | Boat Expenses | 81,541 |
| Shore | 52,646 | 18,548 | Vehicle Expenses | 4,444 |
| *Total Trip Expenditures* | 82,024 | 54,587 | Second Home Expenses | 0 |
| | | | *Total Durable Equipment Expenditures* | 150,541 |
| **Total State Trip and Durable Equipment Expenditures** | | | | 287,152 |

### Recreational Anglers by Residential Area (thousands of anglers)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal | 177 | 222 | 227 | 230 | 234 | 277 | 236 | 231 | 210 | 148 |
| Non-Coastal | 55 | 79 | 101 | 120 | 146 | 113 | 103 | 112 | 104 | 66 |
| Out of State | 161 | 270 | 334 | 448 | 617 | 551 | 604 | 554 | 494 | 264 |
| **Total Anglers** | 392 | 571 | 662 | 798 | 997 | 941 | 942 | 898 | 809 | 478 |

### Recreational Fishing Effort by Mode (thousands of angler-trips)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| For-Hire | 33 | 39 | 78 | 25 | 21 | 86 | 69 | 80 | 77 | 82 |
| Private | 557 | 1,021 | 1,230 | 949 | 978 | 1,131 | 1,265 | 1,008 | 1,079 | 846 |
| Shore | 665 | 1,037 | 1,138 | 1,220 | 1,240 | 813 | 1,116 | 1,324 | 1,143 | 879 |
| **Total Trips** | 1,255 | 2,097 | 2,446 | 2,194 | 2,239 | 2,030 | 2,450 | 2,412 | 2,299 | 1,807 |

### Harvest (H) and Release (R) of Key Species Species Groups (thousands of fish)[1]

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Black sea bass | H | 113 | 45 | 238 | 75 | 183 | 125 | 89 | 37 | 216 | 56 |
| | R | 336 | 289 | 769 | 513 | 583 | 921 | 865 | 470 | 641 | 660 |
| Bluefish | H | 79 | 66 | 133 | 246 | 134 | 176 | 128 | 134 | 443 | 226 |
| | R | 162 | 215 | 387 | 318 | 622 | 677 | 332 | 253 | 319 | 552 |
| Drum (Atlantic croaker and spot) | H | 460 | 724 | 901 | 502 | 1,229 | 644 | 2,798 | 827 | 369 | 947 |
| | R | 197 | 672 | 531 | 505 | 1,092 | 376 | 393 | 840 | 353 | 462 |
| Drum (southern kingfish) | H | 226 | 982 | 1,150 | 998 | 926 | 698 | 823 | 1,057 | 389 | 611 |
| | R | 135 | 1,048 | 749 | 391 | 1,164 | 539 | 614 | 689 | (1) | 68 |
| Drum (spotted seatrout) | H | 84 | 123 | 190 | 272 | 231 | 160 | 156 | 125 | 101 | 67 |
| | R | 149 | 313 | 277 | 462 | 543 | 572 | 733 | 398 | 407 | 281 |
| Porgies (sheepshead) | H | 30 | 129 | 95 | 45 | 60 | 108 | 216 | 222 | 103 | 170 |
| | R | 21 | 50 | 22 | 47 | 27 | 21 | 60 | 24 | 58 | 93 |
| Red drum | H | 41 | 162 | 108 | 130 | 49 | 72 | 120 | 70 | 173 | 162 |
| | R | 143 | 430 | 438 | 493 | 540 | 438 | 551 | 752 | 787 | 666 |
| Sharks[2] | H | (1) | (1) | 16 | 38 | (1) | 3 | 5 | 13 | (1) | 3 |
| | R | 276 | 382 | 402 | 604 | 512 | 170 | 259 | 397 | 467 | 348 |
| Southern flounder | H | 112 | 111 | 215 | 84 | 111 | 76 | 102 | 88 | 108 | 102 |
| | R | 73 | 52 | 89 | 73 | 199 | 106 | 102 | 74 | (1) | 16 |
| Spanish mackerel | H | 23 | 25 | 56 | 71 | 23 | 95 | 52 | 74 | 70 | 87 |
| | R | 9 | 224 | 84 | 184 | 28 | 97 | 68 | 56 | 27 | 67 |

[1] In this table, '(1)' = 0-999 thousand fish and '1' = 1,000-1,499 thousand fish.
[2] Sharks include species within the requiem shark family, blacktip sharks, Atlantic sharpnose sharks, and unidentified sharks.

### South Carolina's State Economy (% of national total)

| | Establishments | Employees | Annual Payroll (million $) | Employee Compensation (million $) | Gross State Product (million $) | Commercial Location Quotient [1] |
|---|---|---|---|---|---|---|
| 2002 | 98,357 (1.4%) | 1,538,750 (1.4%) | 43,999 (1.1%) | 71,133 (1.2%) | 124,391 (1.2%) | 0.15 |
| 2010 | 102,045 (1.4%) | 1,502,853 (1.3%) | 52,548 (1.1%) | 93,371 (1.1%) | 160,374 (1.2%) | 0.1 |
| % change | 3.75% | -2.33% | 19.4% | 31.3% | 28.9% | -40% |

### Seafood Sales & Processing - Nonemployer Firms (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Seafood product prep. & packaging | Firms | 20 | 19 | 22 | 14 | 12 | 12 | 15 | 21 | 15 |
| | Receipts | 547 | 1,115 | 1,797 | 2,234 | 1,303 | 857 | 1,155 | 1,794 | 1,155 |
| Seafood Sales, retail | Firms | 64 | 74 | 74 | 61 | 76 | 75 | 64 | 76 | 64 |
| | Receipts | 3,484 | 4,599 | 4,612 | 3,588 | 3,427 | 3,876 | 4,650 | 4,534 | 4,650 |

### Seafood Sales & Processing - Employer Establishments (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Seafood product prep. & packaging | Establishments | 4 | 3 | 4 | 3 | 3 | 5 | 2 | 2 | 2 |
| | Employees | ND[2] | ND[2] | 28 | 7 | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| | Payroll | ND[2] | ND[2] | 805 | 145 | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| Seafood sales, wholesale | Establishments | 28 | 22 | 18 | 22 | 19 | 26 | 20 | 15 | 16 |
| | Employees | ND[2] | ND[2] | ND[2] | 211 | 191 | 220 | 108 | 111 | 120 |
| | Payroll | ND[2] | ND[2] | ND[2] | 5,818 | 5,542 | 6,186 | 3,770 | 3,676 | 3,868 |
| Seafood sales, retail | Establishments | 58 | 55 | 58 | 64 | 62 | 60 | 64 | 57 | 56 |
| | Employees | 175 | 244 | ND[2] | 206 | 190 | 210 | 292 | 261 | 260 |
| | Payroll | 2,391 | 2,911 | ND[2] | 2,773 | 2,905 | 3,155 | 4,871 | 4,901 | 4,580 |

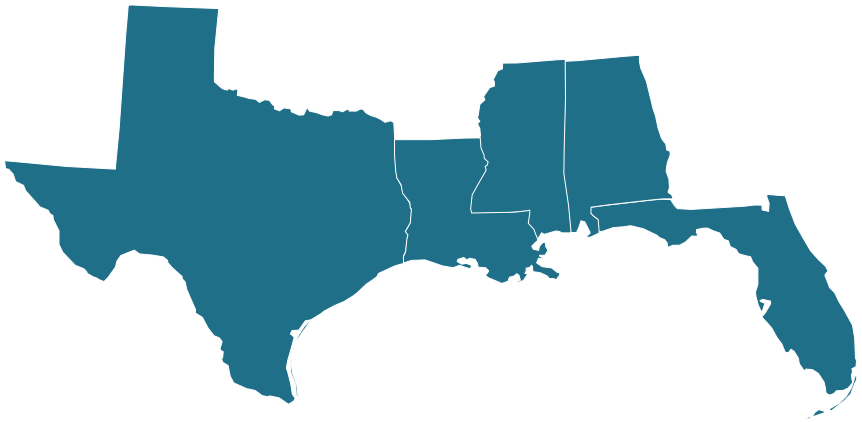
### Transport, Support, & Marine Operations - Employer Establishments (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal & Great Lakes freight transportation | Establishments | 1 | 3 | 4 | 4 | 4 | 5 | 4 | 4 | 4 |
| | Employees | ND[2] | ND[2] | ND[2] | 45 | ND[2] | 60 | ND[2] | ND[2] | ND[2] |
| | Payroll | ND[2] | ND[2] | ND[2] | 1,882 | ND[2] | 2,352 | ND[2] | ND[2] | ND[2] |
| Deep sea freight transportation | Establishments | 10 | 8 | 7 | 10 | 9 | 6 | 4 | 8 | 7 |
| | Employees | ND[2] | ND[2] | ND[2] | 113 | ND[2] | 67 | ND[2] | ND[2] | 20 |
| | Payroll | ND[2] | ND[2] | ND[2] | 4,600 | ND[2] | 3,419 | 659 | ND[2] | 758 |
| Deep sea passenger transportation | Establishments | 1 | 3 | 1 | 1 | 1 | 1 | 7 | 6 | 2 |
| | Employees | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| | Payroll | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| Marinas | Establishments | 62 | 63 | 69 | 70 | 71 | 72 | 68 | 69 | 73 |
| | Employees | 357 | 365 | 378 | 398 | 452 | 469 | 588 | 533 | 537 |
| | Payroll | 6,395 | 6,696 | 7,645 | 8,050 | 10,105 | 11,498 | 13,753 | 12,642 | 13,786 |
| Marine cargo handling | Establishments | 16 | 15 | 17 | 18 | 17 | 15 | 17 | 14 | 12 |
| | Employees | 1,793 | 2,415 | 2,253 | 1,994 | 2,707 | 1,419 | 1,282 | 1,953 | 1,731 |
| | Payroll | 54,609 | 78,941 | 81,691 | 66,767 | 83,142 | 75,967 | 56,812 | 43,170 | 39,625 |
| Navigational services to shipping | Establishments | 11 | 6 | 5 | 7 | 8 | 6 | 8 | 8 | 7 |
| | Employees | 83 | 144 | ND[2] | ND[2] | 155 | 152 | 227 | 208 | 222 |
| | Payroll | 3,422 | 5,716 | ND[2] | ND[2] | 7,588 | 7,369 | 11,916 | 12,522 | 12,591 |
| Port & harbor operations | Establishments | NA[3] | 1 | 1 | 1 | 1 | 3 | 3 | 2 | 2 |
| | Employees | NA[3] | ND[2] | ND[2] | ND[2] | ND[2] | 113 | ND[2] | ND[2] | ND[2] |
| | Payroll | NA[3] | ND[2] | ND[2] | ND[2] | ND[2] | 7,058 | ND[2] | ND[2] | ND[2] |
| Ship & boat building | Establishments | 43 | 41 | 46 | 48 | 45 | 41 | 46 | 41 | 39 |
| | Employees | 1,570 | 2,253 | 2,380 | 2,672 | 2,425 | 2,962 | 3,001 | 1,929 | 1,922 |
| | Payroll | 61,045 | 78,963 | 90,974 | 97,087 | 92,098 | 102,531 | 97,743 | 73,988 | 74,945 |

[1] The U.S. Commercial Fishing Location Quotient (CFLQ) of 1.0 represents the national baseline from which state CFLQs can be compared.
[2] ND = these data are confidential thus not disclosable
[3] NA = these data are not available

# Gulf of Mexico

- Alabama
- West Florida
- Louisiana
- Mississippi
- Texas



### Management Context

The Gulf of Mexico Region includes Alabama, Louisiana, Mississippi, Texas, and West Florida. Federal fisheries in this region are managed by the Gulf of Mexico Fishery Management Council (GMFMC) and NOAA Fisheries (NMFS) under seven fishery management plans (FMPs). The spiny lobster and coastal migratory pelagic resources fisheries are managed in conjunction with the South Atlantic Fishery Management Council (SAFMC).

**Gulf of Mexico Region FMPs**

1. Red Drum
2. Shrimp
3. Reef Fish
4. Coastal Migratory Pelagic Resources (with SAFMC)
5. Spiny Lobster (with SAFMC)
6. Corals
7. Aquaculture

Of the stocks or stock complexes covered in these fishery management plans, four are currently listed as overfished: gag, gray triggerfish, greater amberjack, and red snapper. Three stocks or stock complexes are currently subject to overfishing: gag, gray triggerfish, and greater amberjack.

There have been two recent changes to the Gulf of Mexico FMPs over the last several years. The Aquaculture FMP was approved in 2009 and is the only federal FMP to solely address aquaculture. The purpose of the plan is to develop a regional permitting process to ensure that the aquaculture industry is environmentally sound and economically sustainable. As of October 2011, the FMP had not yet been implemented. The other recent change to the Gulf of Mexico FMPs, was the repeal of the Stone Crab FMP. Stone crab was historically managed as a federal fishery, however, as of October 2011, the Gulf of Mexico states will now be responsible for management of the stone crab.

In recent years, fishing operations in the Gulf of Mexico were significantly disrupted by hurricanes, especially with major storms making landfall in Louisiana and Texas in 2005 (Hurricanes Katrina and Rita) and 2008 (Hurricanes Gustav and Ike). Locally, storm surge has severely disrupted or destroyed the infrastructure necessary to support fishing, such as vessels, fuel and ice suppliers, and fish houses. For the affected areas and individuals, recovery is a long and slow process, often involving rebuilding homes and settling insurance claims before the repair and restart of fishing operations.

In 2010, the Deep Water Horizon accident and resulting oil spill severely affected Gulf fisheries. Large parts of the Gulf of Mexico, including state and federal waters, were closed to fishing during May through October, 2010. Both Alabama and Mississippi reported less than half and Louisiana about three quarters of their annual shrimp landings compared to the average of the previous three years. While the Gulf Coast Claims Facility has paid out over $700 million to the Gulf fishing industry, the long term consequences of the oil spill on the fishing industry have yet to be assessed.

### Commercial Fisheries

In 2011, commercial fishermen in the Gulf of Mexico Region landed 1.8 billion pounds of finfish and shellfish, earning $818 million in landings revenue. Landings revenue was dominated by shrimp ($438 million) and menhaden ($104 million). These species commanded ex-vessel prices of $1.99 and $0.08 per pound, respectively, and comprised 66% of total landings revenue, and 90% of total landings in the Gulf of Mexico Region.

**Key Gulf of Mexico Region Commercial Species**

- Blue crab
- Crawfish
- Groupers
- Menhaden
- Mullets
- Oysters
- Red snapper
- Shrimp
- Stone crab
- Tunas

Louisiana and Texas had the highest landings revenue in the region in 2011, $334 million and $239 million, respectively. The next greatest landings revenue came from West Florida with $164 million in landings revenue. In terms of pounds landed, Louisiana had the highest landings (1.3 billion pounds), followed by Mississippi (278 million pounds) and Texas (98 million pounds).

#### *Economic Impacts*[1,2]

In 2011, the Gulf of Mexico Region's seafood industry generated $500 million in sales impacts in Alabama, $1.8 billion in sales impacts in Louisiana, $247 million in sales impacts in Mississippi, $2.3 billion in sales impacts in Texas, and $14 billion in sales impacts in Florida. Florida generated the largest employment, income, and value added impacts, generating 72,000 jobs, $2.7 billion, and $4.8 billion, respectively. The smallest income impacts were generated in Mississippi ($96 million) and the smallest employment impacts were also generated in Mississippi (5,500 jobs).

The sector that generated the greatest employment impacts by state was the importers sector with 37,000 jobs in Florida and 2,700 jobs in Texas. The harvest sector in Texas generated 5,800 jobs. More sales impacts were generated by importers in Florida than any other sector in any another state in the region at $10 billion and the greatest value added impacts were also generated by importers in Florida ($3.1 billion).

#### *Landings Revenue*

Landings revenue in the Gulf of Mexico Region totaled $818 million in 2011. This was a 20% increase (a 17% decrease in real terms) from 2002 levels ($682 million) and a 28% increase

[1]The NMFS Commercial Fishing Industry Input/Output Model was used to generate the impact estimates (see NMFS Commercial Fishing & Seafood Industry Input/Output Model, available at: `www.st.nmfs.noaa.gov/documents/commercial_seafood_impacts_2007-2009.pdf`)

[2]Commercial economic impacts data were not available for West Florida, data for Florida are reported here.

(a 18% increase in real terms) relative to 2010 ($639 million). Totaling $623 million in 2011, shellfish revenue experienced a 17% increase (a 19% decrease in real terms) from 2002 to 2011 and experienced a 23% increase (13% increase in real terms) from 2010 to 2011.

**Commercial Fisheries Facts**

*Landings revenue*

- On average, between 2002 and 2011, the key species or species groups accounted for 91% of total revenue, generating $615 million in the Gulf of Mexico Region.
- Shrimp had higher landings revenues than any other species or species group, averaging $371 million in landings revenue from 2002 to 2011.
- Crawfish had the largest one-year increase in landings revenue over the 10 year time period, increasing 600% from $1.3 million in 2006 to $9 million in 2007.
- Crawfish had the largest one-year decrease in landings revenue over the 10 year time period, decreasing 85% from $8.4 million in 2005 to $1.3 million in 2006.

*Landings*

- Key species or species groups contributed an average of 96% annually to total landings between 2002 and 2011.
- Menhaden contributed the most to landings in the region, averaging 1.1 billion pounds from 2002 to 2011.
- Crawfish had the largest one-year increase in landings over the 10 year time period, increasing 979% from 1.5 million in 2006 pounds to 16 million pounds in 2007.
- Crawfish had the largest one-year decrease in landings over the 10 year time period, decreasing 90% from 15 million pounds in 2005 to 1.5 million pounds in 2006.

*Prices*

- Stone crab had the highest average annual ex-vessel price per pound ($4.20) over the time period, followed by tunas ($2.92), and oysters ($2.90).
- Menhaden had the lowest average annual ex-vessel price per pound ($0.06) over the time period, followed by mullets ($0.65), and crawfish ($0.71).
- Tunas had the largest one-year increase in ex-vessel price over the 10 year time period, increasing 71% from $2.03 per pound in 2010 to $3.47 in 2011.
- Crawfish had the largest decrease in ex-vessel price over the 10 year time period, decreasing 35% from $0.88 per pound in 2006 to $0.57 in 2007.

Between 2002 and 2011, the landings revenue from shrimp increased 14% (a 21% decrease in real terms) and the landings revenue for menhaden increased 99% (a 38% increase in real terms). Although in 2011, menhaden landings (1.4 billion pounds) were six times higher than shrimp landings (220 million), the landings revenue for shrimp ($438 million) was four times higher than the landings revenue for menhaden ($104 million). In terms of finfish, Louisiana contributed the most ($112 million) followed by West Florida ($59 million), and Mississippi ($11 million). Shellfish landings revenue was dominated by Texas, which contributed the most ($231 million) followed by Louisiana ($221 million), and West Florida ($105 million).

From 2002 to 2011, species or species groups with large changes in landings revenue include menhaden (increased 99%), tunas (decreased 58%), and oysters (increased 27%). Species or species groups with large changes in landings revenue between 2010 and 2011 include tunas (increasing 105%), mullets (increasing 99%), and menhaden (increasing 57%).

*Landings*

Fishermen in the Gulf of Mexico Region landed 1.8 billion pounds of finfish and shellfish in 2011. This was a 2.1% increase from the 1.73 billion pounds landed in 2002 and a 37% increase from the 1.29 billion pounds landed in 2010. Finfish landings contributed 82% of total landings in the Gulf of Mexico Region (1.4 billion pounds) in 2011. From 2010 to 2011, finfish landings experienced a 41% increase.

Over the same time period, shellfish landings experienced a 22% increase from 261 million pounds in 2010 to 318 million in 2011 and a 10% decrease from 351 million pounds in 2002. Menhaden and shrimp had the highest annual landings in the Gulf of Mexico Region in 2011, with 1.4 billion pounds and 220 million pounds, respectively. Together they accounted for 90% of the total landings in 2011. Menhaden landings increased 6.5% and shrimp landings decreased 5.9% during this period.

From 2002 to 2011, species or species groups with large changes in landings include tunas (decreasing 67%), groupers (decreasing 42%), and crawfish (decreasing 38%). Species or species groups with large changes in landings between 2010 and 2011 include mullets (increasing 59%), groupers (increasing 43%), and menhaden (increasing 42%).

*Prices*

The ex-vessel prices for the Gulf of Mexico Region's key species and species groups in 2011 were higher than their 10 year average for ten of the key species (two of the species in real terms). Ex-vessel prices for menhaden and crawfish increased the most between 2002 and 2011, increasing 100% (39% in real terms) and 98% (37% in real terms), respectively. Relative to ex-vessel prices in 2010, the Gulf of Mexico Region's tunas experienced the greatest increase (71%, 58% in real terms) from $2.03 per pound in 2010 to $3.47 in 2011. There were no decreases in ex-vessel price experienced by any species or groups in Gulf of Mexico Region between 2010 and 2011. Relative to ex-vessel prices in 2010, eight species or species groups experienced increases, including mullets (26%).

In Alabama, the species or species group with the largest change in ex-vessel price from 2002 to 2011 was oysters (100% increase, 39% increase in real terms) from $2.11 to $4.22. The largest change in ex-vessel price experienced in Louisiana was for menhaden (100% increase, 39% increase in real terms) from $0.04 to $0.08 and in Mississippi the largest change in ex-vessel price was experienced by oysters (130% increase, 60% increase in real terms) from $1.63 per pound to $3.75.

## Recreational Fishing

In 2011, over 3 million recreational anglers took 23 million fishing trips in the Gulf of Mexico Region. Almost 90% of these anglers were residents of a regional coastal county. Of the total fishing

trips taken, 57% were taken from a private or rental boat and another 40% were shore-based. Spotted seatrout were the most frequently caught species or species group with 33 million fish caught in 2011, and represented 45% of total fish caught in the region. Of the spotted seatrout caught, 58% of them were released rather than harvested.

*Economic Impacts and Expenditures*[1]

The contribution of recreational fishing activities in the Gulf of Mexico Region are reported in terms of economic impacts at the state level (employment, sales, income, and value added impacts) and expenditures on fishing trips and durable equipment at the regional level. Employment impacts in West Florida were the highest in the region with over 47,000 full- and part-time jobs generated by recreational fishing activities in the state. Louisiana (18,000 jobs), and Texas (15,000 jobs) followed in terms of employment impacts.

Overall, these employment impacts were generated by expenditures on recreational fishing trips taken by anglers (private or rental boat, for-hire boat, or shore-based trips) and expenditures on durable equipment. Throughout the Gulf of Mexico Region, most of the employment impacts in 2011 were generated by expenditures on durable equipment: 82% in West Florida, 81% in Louisiana, and 74% in Alabama.

In addition to employment impacts, the contribution of recreational fishing activities to the Gulf of Mexico Region's economy can be measured in terms of sales impacts and the contribution of these activities to gross domestic product (value added impacts). In 2011, sales impacts were the highest in West Florida ($2.7 billion in value added impacts), followed by Texas ($952 million), Louisiana ($806 million), Alabama ($410 million), and Mississippi ($61 million). In the same year, value added impacts were the highest in West Florida ($2.7 billion in value added impacts), followed by Texas ($952 million), Louisiana ($806 million), Alabama ($410 million), and Mississippi ($61 million).

**Key Gulf of Mexico Region Recreational Species**

- Atlantic croaker
- Gulf and southern kingfish
- Sand and silver seatrout
- Spotted seatrout
- Sheepshead porgy
- Red drum
- Red snapper
- Southern flounder
- Spanish mackerel
- Striped mullet

Overall, total fishing trip and durable equipment expenditures across the Gulf of Mexico Region in 2011 were $9.8 billion. Approximately 85% of these expenditures were related to durable equipment purchases. The greatest expenditures were for boat expenses ($4.5 billion), followed by fishing tackle ($1.3 billion), vehicle expenses ($1.2 billion), second home expenses ($812 million), and other equipment ($523 million).

**Recreational Fishing Facts**

*Participation*

- An average of 3.2 million anglers fished in the Gulf of Mexico Region annually from 2002 to 2011.
- In 2011, coastal county residents made up 90% of total anglers in this region. These anglers averaged 91% of total anglers annually over the 10 year time period.
- The largest annual increase in the number of coastal anglers during the 10 year time period occurred between 2002 and 2003, increasing 22%, from 2.5 million anglers to 3 million anglers.
- The largest annual decrease during the same period for coastal anglers occurred between 2008 and 2009, decreasing 13%, from 2.9 million anglers to 2.6 million anglers.

*Fishing trips*

- In the Gulf of Mexico Region, an average of 23 million fishing trips were taken annually from 2002 to 2011.
- Private or rental boat and shore-based fishing trips accounted for 13 million and 8.9 million fishing trips, respectively, in 2011. Together these made up 97% of the fishing trips taken in that year.
- The largest annual increase in the number of total trips taken annually over the 10 year time period occurred between 2002 and 2003, increasing 17%, from 20 million trips to 23 million trips.
- The largest annual decrease during the same period in total trips taken occurred between 2004 and 2005, decreasing 12%, from 26 million trips to 23 million trips.

*Harvest and release*

- Spotted seatrout was the most commonly caught key species or species group, averaging 30 million fish over the 10 year time period. Of these, 62% were released rather than harvested.
- Of the ten commonly caught key species or species groups, six were released more often than harvested over this time period.
- The species or species group that was most commonly released was Atlantic croaker (72% released).
- Striped mullet (88% harvested), followed by southern flounder (76% harvested), and sand and silver seatrout (68% harvested) were key species or groups that experienced the greatest proportion of harvests rather than releases.

[1]Expenditure estimates were generated from the 2011 National Marine Recreational Fishing Expenditure Survey. Economic impacts from recreational fishing activities were generated using the NMFS Recreational Economic Impact Model (see The Economic Contribution of Marine Angler Expenditures in the United States, 2006, available at:`http://www.st.nmfs.noaa.gov/economics/publications/marine-angler-expenditures/marine-angler-2006`)

Fishing trip-related expenditures by the Gulf of Mexico Region's non-residents totaled over $474 million of which the greatest portion can be attributed to for-hire-based fishing trips ($207 million). Residents of the Gulf of Mexico Region spent $1 billion on saltwater fishing trips, with most of these expenses related to private boat trips ($597 million).

*Participation*

There were 3 million recreational anglers who fished in the Gulf of Mexico Region in 2011. This was a 13% increase from 2002 (2.7 million anglers). These anglers were Gulf of Mexico Region residents from either a coastal county (2.7 million anglers) or non-coastal county (311,000 anglers).

Almost 90% of total anglers in 2011 were residents of a coastal county. Coastal county angler participation in 2011 increased 10% relative to 2002 (2.5 million anglers) and increased 10% between 2010 and 2011. Non-coastal county angler participation increased 44% relative to 2002 (216,000 anglers) and increased 32% relative to 2010 (235,000 anglers).

*Fishing Trips*

Recreational fishermen took 23 million fishing trips in the Gulf of Mexico Region in 2011. This was a 15% increase from the 2002 (20 million trips) and was 1.5 million more trips than taken in 2010. Of the total trips taken in Gulf of Mexico Region in 2011, approximately 57% of the trips were private or rental boat based (13 million) trips. The other most popular mode of fishing was shore based with 8.9 million trips in 2011.

*Harvest and Release*

Of the Gulf of Mexico Region's key species and species groups, spotted seatrout (33 million fish), red drum (10 million fish), sand and silver seatrout (8.3 million fish) and Atlantic croaker (8 million fish) were the most often caught by anglers in 2011.

Red snapper (75% released), Atlantic croaker (74% released), red drum (65% released), spotted seatrout (58% released), and Spanish mackerel (56% released) were most often released rather than harvested. Species or species groups that were harvested more often than released by anglers include striped mullet (86% harvested) and southern flounder (77% harvested).

At the state level, spotted seatrout was the most commonly caught species in West Florida, Texas[1] and Louisiana with a total of 30 million fish caught across the three states. In Alabama, the most commonly caught fish was Atlantic croaker (3.5 million fish) in 2011.

Between 2002 and 2011, three of the Gulf of Mexico Region's key species or species groups showed decreases in catch totals. Key species or groups with the largest decreases were red snapper (36%), gulf and southern kingfish (12%), and Spanish mackerel (10%).

## Marine Economy[2]

The sum of the gross domestic products by state for Alabama, Louisiana, Mississippi, Texas, and Florida[3] was $2.5 trillion in 2011. Employee compensation totaled $1.3 trillion and annual payroll totaled $788 billion. These economic measures increased 39% (a 4.3% increase in real terms) and 35% (a 1.4% increase in real terms), respectively, between 2002 and 2010; and experienced a 2.2% increase (a 2% decrease in real terms), and 1.4% increase (a 2.6% decrease in real terms), respectively, between 2009 and 2010.

In 2010, the commercial fishing location quotient (CFLQ) for Louisiana was the highest in the region at 1.58. This was an 16% decrease from 2002 and a 22% decrease from 2009. Louisiana's CFLQ suggests that the level of employment in commercial fishing-related industries in this state is approximately 1.6 times higher than the level of employment in these industries nationwide. The 2010 CFLQ in West Florida was 1 (a 22% decrease from 2002).

*Seafood Sales and Processing*

In 2010, there were 414 nonemployer firms engaged in seafood product preparation and packaging across the Gulf of Mexico Region. This was a 20% increase from 2002 levels. Over the same time period, Louisiana experienced a 17% increase. In 2010, 8% of these firms were located in Alabama. Region-wide, annual receipts totaled $25 million in 2010 and increased 51% from 2002 to 2010.

Annual receipt totals experienced a 15% increase in Mississippi between 2002 and 2010 (13% decrease in real terms). In contrast to an increase in nonemployer firms region-wide, the number of employer establishments engaged in seafood product preparation and packaging decreased 25% from 166 in 2002 to 124 in 2010. Approximately 27% of these establishments were located in Louisiana. The number of employees in the seafood product preparation and packaging sector decreased 28% from 10,623 employees in 2002 to 7,639 employees in 2011.

There were 444 seafood wholesale establishments in 2010. The number of employees was not available at the region level. From 2002 to 2010, the number of seafood wholesale establishments decreased 31% across the Gulf of Mexico Region.

Nonemployer firms engaged in seafood retail in the Gulf of Mexico Region totaled 806 in 2010, a 17% increase relative to 2002. Of these firms, 7.1% were located in Alabama. At the state level, these firms decreased 1.6% in Louisiana and decreased 5.9% in Mississippi between 2002 and 2010. Annual receipts in the region totaled $79 million in 2010 a 24% increase from 2003 (a 4.5% decrease in real terms) and a 24% increase from 2010 (a 19% increase in real terms).

Employer establishments engaged in seafood retail decreased 23% from 2002 to 2010, totaling 347 in 2010. The number of

[1] The Texas Department of Wildlife only collects information about harvest and not total catch.
[2] Information for 2010 is reported in this section; 2011 data were not available for this report.
[3] Marine Economy information was not available for West Florida, information for the entire state of Florida is provided here.

employees was not available for the retail sector in the Gulf of Mexico Region in 2010.

*Transport, Support, and Marine Operations*

For the sectors in which information was available at the region level, marinas employed more people than any other industry in this sector, employing approximately 6,700 people in 2010. In contrast, the navigational services to shipping industry had the highest annual payroll in the region totaling $455 million. Marinas had the highest number of establishments (693), followed by the ship and boat building industries with 506 establishments and the navigational services to shipping industries with 394 establishments.

In Alabama, industries with large changes in establishment numbers, employees, or annual payroll from 2009 to 2010 were: marinas (119% increase in employees), marinas (44% increase in payroll) and ship and boat building (34% decrease in establishments). In Texas, large changes were seen for deep sea passenger transportation (50% decrease in establishments), port and harbor operations (35% increase in payroll) and coastal and Great Lakes freight transportation (30% decrease in employees). In Louisiana, large changes were seen in the deep sea freight transportation (93% decrease in payroll), deep sea freight transportation (92% decrease in employees) and marinas (64% increase in payroll).

### 2011 Economic Impacts of the Gulf of Mexico Region Seafood Industry (thousands of dollars)

| | With Imports | | | Without Imports | | |
|---|---|---|---|---|---|---|
| | Jobs | Sales | Valued Added | Jobs | Sales | Valued Added |
| Alabama | 11,011 | 499,805 | 250,171 | 10,348 | 421,295 | 220,521 |
| Louisiana | 32,818 | 1,801,568 | 877,911 | 30,676 | 1,467,854 | 762,430 |
| Mississippi | 5,550 | 247,106 | 125,430 | 5,439 | 231,104 | 119,876 |
| Texas | 27,717 | 2,277,959 | 1,002,928 | 22,516 | 1,357,574 | 687,876 |
| West Florida | 72,341 | 14,250,006 | 4,778,502 | 10,550 | 928,929 | 376,208 |

### Total Landings Revenue and Landings Revenue of Key Species/Species Groups (thousands of dollars)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total revenue | 681,646 | 662,902 | 669,002 | 625,038 | 691,220 | 690,211 | 662,153 | 643,880 | 639,271 | 818,017 |
| Finfish & other | 147,338 | 139,373 | 143,479 | 122,642 | 135,982 | 145,584 | 146,109 | 150,833 | 131,582 | 194,714 |
| Shellfish | 534,308 | 523,530 | 525,523 | 502,396 | 555,238 | 544,626 | 516,044 | 493,047 | 507,690 | 623,304 |
| Blue crab | 42,913 | 46,243 | 42,292 | 37,961 | 43,355 | 46,028 | 39,814 | 45,476 | 41,237 | 48,769 |
| Crawfish | 8,070 | 4,845 | 4,810 | 8,360 | 1,290 | 9,034 | 9,435 | 15,547 | 13,969 | 9,911 |
| Groupers | 24,631 | 24,257 | 25,807 | 24,692 | 22,795 | 20,242 | 22,891 | 17,291 | 13,580 | 19,667 |
| Menhaden | 52,116 | 45,863 | 44,921 | 32,938 | 44,946 | 62,110 | 64,376 | 69,456 | 66,019 | 103,521 |
| Mullets | 8,877 | 8,265 | 8,956 | 6,593 | 9,429 | 5,543 | 6,085 | 6,105 | 5,220 | 10,368 |
| Oysters | 50,756 | 61,634 | 60,845 | 56,510 | 62,316 | 69,542 | 60,272 | 73,473 | 55,060 | 64,207 |
| Red snapper | 10,714 | 10,447 | 11,676 | 11,336 | 13,167 | 9,570 | 7,966 | 7,984 | 10,202 | 11,413 |
| Shrimp | 385,679 | 365,434 | 366,426 | 360,513 | 397,706 | 367,060 | 366,576 | 327,263 | 339,706 | 438,459 |
| Stone crab | 23,091 | 23,043 | 26,704 | 21,223 | 24,115 | 26,242 | 18,898 | 17,690 | 23,384 | 24,496 |
| Tunas | 13,227 | 12,000 | 12,335 | 9,431 | 8,461 | 10,535 | 6,168 | 8,180 | 2,688 | 5,516 |

### Total Landings and Landings of Key Species/Species Groups (thousands of pounds)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total landings | 1,728,899 | 1,595,895 | 1,475,139 | 1,198,203 | 1,362,326 | 1,404,307 | 1,278,274 | 1,599,505 | 1,285,544 | 1,765,899 |
| Finfish & other | 1,377,421 | 1,228,816 | 1,110,240 | 887,920 | 974,969 | 1,071,322 | 994,159 | 1,235,041 | 1,024,166 | 1,448,055 |
| Shellfish | 351,478 | 367,080 | 364,899 | 310,283 | 387,357 | 332,985 | 284,115 | 364,464 | 261,378 | 317,844 |
| Blue crab | 66,019 | 63,961 | 60,581 | 50,041 | 67,481 | 57,964 | 49,260 | 61,272 | 41,212 | 55,571 |
| Crawfish | 15,602 | 8,337 | 8,537 | 15,177 | 1,469 | 15,848 | 15,612 | 19,312 | 14,556 | 9,597 |
| Groupers | 12,003 | 10,933 | 11,912 | 10,776 | 9,092 | 7,308 | 8,547 | 6,633 | 4,870 | 6,983 |
| Menhaden | 1,290,407 | 1,142,747 | 1,023,260 | 815,495 | 901,398 | 1,005,325 | 927,517 | 1,165,948 | 967,025 | 1,374,299 |
| Mullets | 12,661 | 12,957 | 13,750 | 9,023 | 12,727 | 8,933 | 10,580 | 11,303 | 8,960 | 14,233 |
| Oysters | 24,110 | 27,033 | 25,052 | 20,174 | 19,674 | 22,518 | 20,655 | 22,833 | 15,870 | 18,386 |
| Red snapper | 4,803 | 4,435 | 4,677 | 4,109 | 4,637 | 2,998 | 2,368 | 2,503 | 3,259 | 3,567 |
| Shrimp | 233,759 | 256,357 | 255,782 | 216,291 | 288,973 | 225,163 | 188,789 | 251,294 | 178,845 | 219,963 |
| Stone crab | 6,433 | 5,292 | 5,971 | 4,534 | 4,806 | 5,893 | 6,123 | 5,335 | 5,112 | 5,477 |
| Tunas | 4,877 | 5,063 | 3,882 | 3,050 | 2,851 | 3,426 | 1,782 | 2,836 | 1,322 | 1,588 |

### Average Annual Price of Key Species/Species Groups (dollars per pound)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Blue crab | 0.65 | 0.72 | 0.70 | 0.76 | 0.64 | 0.79 | 0.81 | 0.74 | 1.00 | 0.88 |
| Crawfish | 0.52 | 0.58 | 0.56 | 0.55 | 0.88 | 0.57 | 0.60 | 0.81 | 0.96 | 1.03 |
| Groupers | 2.05 | 2.22 | 2.17 | 2.29 | 2.51 | 2.77 | 2.68 | 2.61 | 2.79 | 2.82 |
| Menhaden | 0.04 | 0.04 | 0.04 | 0.04 | 0.05 | 0.06 | 0.07 | 0.06 | 0.07 | 0.08 |
| Mullets | 0.70 | 0.64 | 0.65 | 0.73 | 0.74 | 0.62 | 0.58 | 0.54 | 0.58 | 0.73 |
| Oysters | 2.11 | 2.28 | 2.43 | 2.80 | 3.17 | 3.09 | 2.92 | 3.22 | 3.47 | 3.49 |
| Red snapper | 2.23 | 2.36 | 2.50 | 2.76 | 2.84 | 3.19 | 3.36 | 3.19 | 3.13 | 3.20 |
| Shrimp | 1.65 | 1.43 | 1.43 | 1.67 | 1.38 | 1.63 | 1.94 | 1.30 | 1.90 | 1.99 |
| Stone crab | 3.59 | 4.35 | 4.47 | 4.68 | 5.02 | 4.45 | 3.09 | 3.32 | 4.57 | 4.47 |
| Tunas | 2.71 | 2.37 | 3.18 | 3.09 | 2.97 | 3.07 | 3.46 | 2.88 | 2.03 | 3.47 |

### 2011 Economic Impacts of Recreational Fishing Expenditures (thousands of dollars)

| | Trips | Jobs | Sales | Income | Value Added |
|---|---|---|---|---|---|
| Alabama | 2,485,000 | 8,177 | 797,280 | 262,715 | 410,222 |
| Louisiana | 4,577,000 | 17,764 | 1,602,913 | 521,949 | 806,349 |
| Mississippi | 1,616,000 | 1,181 | 145,769 | 37,783 | 60,735 |
| Texas | NA[1] | 15,150 | 1,853,361 | 586,068 | 952,284 |
| West Florida | 13,901,000 | 47,047 | 4,881,831 | 1,715,843 | 2,653,677 |

### 2011 Angler Trip & Durable Expenditures (thousands of dollars)

| Fishing Mode | Trip Expenditures | | Equipment | Durable Expenditures |
|---|---|---|---|---|
| | Non-Residents | Residents | Fishing Tackle | 1,317,095 |
| For-Hire | 207,051 | 105,140 | Other Equipment | 523,466 |
| Private Boat | 116,943 | 597,111 | Boat Expenses | 4,463,924 |
| Shore | 150,261 | 297,713 | Vehicle Expenses | 1,191,348 |
| *Total Trip Expenditures* | 474,255 | 999,964 | Second Home Expenses | 812,091 |
| | | | *Total Durable Equipment Expenditures* | 8,307,925 |
| **Total State Trip and Durable Equipment Expenditures** | | | | 9,782,144 |

### Recreational Anglers by Residential Area (thousands of anglers)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal | 2,485 | 3,039 | 3,185 | 3,133 | 3,328 | 3,235 | 2,926 | 2,550 | 2,480 | 2,737 |
| Non-Coastal | 216 | 256 | 318 | 190 | 315 | 326 | 262 | 296 | 235 | 311 |
| Out-of-State | NA[2] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| **Total Anglers** | 2,701 | 3,294 | 3,503 | 3,323 | 3,643 | 3,562 | 3,188 | 2,846 | 2,715 | 3,048 |

### Recreational Fishing Effort by Mode (thousands of angler-trips)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| For-Hire | 765 | 692 | 833 | 692 | 835 | 849 | 819 | 823 | 579 | 735 |
| Private Boat | 11,636 | 14,110 | 15,643 | 13,586 | 13,621 | 14,980 | 15,195 | 13,443 | 12,684 | 12,913 |
| Shore | 7,265 | 8,155 | 9,954 | 9,013 | 8,836 | 8,457 | 8,776 | 8,332 | 7,783 | 8,931 |
| **Total Trips** | 19,666 | 22,957 | 26,430 | 23,291 | 23,292 | 24,286 | 24,790 | 22,598 | 21,046 | 22,579 |

### Harvest (H) and Release (R) of Key Species Species Groups (thousands of fish)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Drum (Atlantic croaker) | H | 833 | 1,057 | 976 | 769 | 1,441 | 1,312 | 1,872 | 1,175 | 1,509 | 2,052 |
| | R | 2,757 | 2,432 | 3,639 | 2,844 | 2,312 | 2,614 | 3,148 | 3,858 | 3,827 | 5,899 |
| Drum (Gulf and southern kingfish) | H | 1,203 | 1,803 | 1,682 | 1,426 | 1,249 | 1,135 | 1,302 | 1,063 | 1,423 | 939 |
| | R | 477 | 538 | 810 | 781 | 924 | 844 | 726 | 576 | 625 | 538 |
| Drum (sand and silver seatrouts) | H | 3,257 | 3,114 | 2,262 | 2,035 | 2,109 | 3,088 | 3,405 | 4,203 | 4,575 | 5,733 |
| | R | 1,067 | 1,005 | 1,000 | 726 | 1,538 | 1,909 | 1,988 | 2,443 | 1,808 | 2,540 |
| Drum (spotted seatrout) | H | 7,367 | 9,566 | 11,559 | 10,028 | 13,286 | 11,187 | 14,126 | 13,335 | 10,139 | 13,581 |
| | R | 15,298 | 19,216 | 19,764 | 20,212 | 20,056 | 18,849 | 21,017 | 17,366 | 14,563 | 19,122 |
| Porgies (sheepshead) | H | 1,553 | 1,944 | 2,495 | 2,001 | 1,109 | 1,198 | 1,566 | 1,572 | 1,147 | 2,218 |
| | R | 1,701 | 2,005 | 2,171 | 2,393 | 1,506 | 1,224 | 1,487 | 1,338 | 1,740 | 1,631 |
| Red drum | H | 2,477 | 2,672 | 2,942 | 2,318 | 2,361 | 2,843 | 3,292 | 2,608 | 3,248 | 3,543 |
| | R | 4,873 | 5,914 | 5,808 | 6,235 | 6,391 | 6,222 | 7,017 | 5,522 | 6,468 | 6,447 |
| Red snapper | H | 1,106 | 992 | 1,279 | 835 | 967 | 1,223 | 677 | 795 | 333 | 520 |
| | R | 2,091 | 1,943 | 2,685 | 2,193 | 2,832 | 3,259 | 2,110 | 2,146 | 1,436 | 1,521 |
| Southern flounder | H | 504 | 660 | 742 | 541 | 475 | 650 | 473 | 644 | 771 | 764 |
| | R | 117 | 253 | 271 | 194 | 170 | 239 | 120 | 194 | 220 | 222 |
| Spanish mackerel | H | 1,963 | 1,503 | 2,124 | 1,193 | 1,757 | 1,333 | 1,897 | 1,503 | 1,563 | 1,535 |
| | R | 1,920 | 2,211 | 2,314 | 1,373 | 2,856 | 2,105 | 2,039 | 1,635 | 2,476 | 1,942 |
| Striped mullet | H | 1,264 | 1,586 | 1,163 | 1,081 | 1,102 | 1,149 | 1,257 | 743 | 1,666 | 1,901 |
| | R | 75 | 280 | 167 | 165 | 141 | 158 | 145 | 226 | 126 | 313 |

[1]The Marine Recreational Program (MRIP) does not collect effort data for Texas.
[2]NA = data are not available because out-of-state resident information is collected for individual states but whether an angler is a resident of a region is not specified

### 2011 Economic Impacts of the Alabama Seafood Industry (thousands of dollars)

| | With Imports | | | Without Imports | | |
|---|---|---|---|---|---|---|
| | Jobs | Sales | Value Added | Jobs | Sales | Value Added |
| **Total Impacts** | 11,011 | 499,805 | 250,171 | 10,348 | 421,295 | 220,521 |
| Commercial Harvesters | 1,726 | 84,014 | 37,129 | 1,726 | 84,014 | 37,129 |
| Seafood Processors & Dealers | 2,125 | 135,348 | 67,372 | 1,685 | 107,700 | 53,610 |
| Importers | 179 | 49,281 | 15,023 | 0 | 0 | 0 |
| Seafood Wholesalers & Distributors | 168 | 8,016 | 3,620 | 161 | 7,692 | 3,474 |
| Retail | 6,813 | 223,146 | 127,026 | 6,775 | 221,888 | 126,308 |

### Total Landings Revenue and Landings Revenue of Key Species/Species Groups (thousands of dollars)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total revenue | 35,925 | 36,844 | 37,036 | 39,726 | 48,558 | 48,845 | 44,356 | 38,869 | 27,660 | 50,941 |
| Finfish & other | 3,175 | 3,185 | 3,905 | 3,982 | 4,572 | 3,686 | 4,210 | 3,662 | 2,724 | 4,052 |
| Shellfish | 32,751 | 33,658 | 33,131 | 35,744 | 43,986 | 45,160 | 40,145 | 35,207 | 24,936 | 46,889 |
| Blue crab | 1,490 | 1,715 | 1,774 | 663 | 1,319 | 1,711 | 1,533 | 961 | 732 | 1,127 |
| Flounders | 291 | 210 | 230 | 247 | 223 | 261 | 214 | 197 | 97 | 222 |
| Menhaden | 102 | 104 | 89 | 63 | 48 | 71 | 59 | 42 | 15 | 58 |
| Mullets | 985 | 772 | 1,187 | 1,117 | 1,171 | 984 | 1,016 | 765 | 593 | 687 |
| Oysters | 1,602 | 1,623 | 2,120 | 3,020 | 3,639 | 2,698 | 243 | 77 | 389 | 1,322 |
| Red snapper | 368 | 359 | 382 | 638 | 536 | 213 | 239 | 263 | 329 | 314 |
| Sharks | 275 | 337 | 431 | 478 | 463 | 250 | 359 | 275 | 111 | 381 |
| Shrimp | 29,603 | 30,284 | 29,197 | 32,002 | 39,022 | 40,742 | 38,355 | 34,140 | 23,815 | 44,413 |
| Spanish mackerel | 371 | 443 | 554 | 401 | 573 | 453 | 616 | 301 | 492 | 582 |
| Vermillion snapper | 54 | 83 | 152 | 149 | 318 | 323 | 504 | 841 | 381 | 620 |

### Total Landings and Landings of Key Species/Species Groups (thousands of pounds)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total landings | 23,658 | 25,535 | 26,559 | 23,985 | 34,033 | 29,434 | 24,450 | 28,825 | 14,637 | 26,145 |
| Finfish & other | 5,451 | 5,982 | 6,248 | 5,552 | 6,498 | 4,857 | 5,414 | 4,478 | 3,414 | 4,956 |
| Shellfish | 18,207 | 19,553 | 20,311 | 18,432 | 27,535 | 24,578 | 19,036 | 24,347 | 11,222 | 21,190 |
| Blue crab | 2,575 | 2,958 | 3,329 | 1,024 | 2,384 | 2,557 | 1,799 | 1,458 | 926 | 1,614 |
| Flounders | 176 | 118 | 138 | 130 | 118 | 133 | 107 | 97 | 47 | 111 |
| Menhaden | 982 | 1,022 | 828 | 521 | 350 | 470 | 268 | 190 | 81 | 364 |
| Mullets | 1,949 | 1,700 | 2,133 | 1,976 | 1,913 | 1,798 | 1,988 | 1,814 | 1,198 | 1,262 |
| Oysters | 759 | 816 | 908 | 1,041 | 940 | 769 | 73 | 23 | 120 | 313 |
| Red snapper | 152 | 132 | 138 | 214 | 177 | 59 | 61 | 65 | 83 | 78 |
| Sharks | 329 | 803 | 716 | 800 | 1,227 | 315 | 423 | 328 | 140 | 450 |
| Shrimp | 14,857 | 15,770 | 16,064 | 16,260 | 24,201 | 21,247 | 17,154 | 22,841 | 10,175 | 19,247 |
| Spanish mackerel | 762 | 858 | 914 | 568 | 873 | 580 | 856 | 418 | 725 | 838 |
| Vermillion snapper | 28 | 36 | 66 | 66 | 122 | 129 | 197 | 346 | 147 | 223 |

### Average Annual Price of Key Species/Species Groups (dollars per pound)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Blue crab | 0.58 | 0.58 | 0.53 | 0.65 | 0.55 | 0.67 | 0.85 | 0.66 | 0.79 | 0.70 |
| Flounders | 1.65 | 1.78 | 1.67 | 1.91 | 1.89 | 1.97 | 2.01 | 2.04 | 2.05 | 2.00 |
| Menhaden | 0.10 | 0.10 | 0.11 | 0.12 | 0.14 | 0.15 | 0.22 | 0.22 | 0.18 | 0.16 |
| Mullets | 0.51 | 0.45 | 0.56 | 0.57 | 0.61 | 0.55 | 0.51 | 0.42 | 0.49 | 0.54 |
| Oysters | 2.11 | 1.99 | 2.33 | 2.90 | 3.87 | 3.51 | 3.34 | 3.33 | 3.25 | 4.22 |
| Red snapper | 2.41 | 2.72 | 2.78 | 2.98 | 3.03 | 3.62 | 3.93 | 4.04 | 3.97 | 4.04 |
| Sharks | 0.83 | 0.42 | 0.60 | 0.60 | 0.38 | 0.79 | 0.85 | 0.84 | 0.79 | 0.85 |
| Shrimp | 1.99 | 1.92 | 1.82 | 1.97 | 1.61 | 1.92 | 2.24 | 1.49 | 2.34 | 2.31 |
| Spanish mackerel | 0.49 | 0.52 | 0.61 | 0.71 | 0.66 | 0.78 | 0.72 | 0.72 | 0.68 | 0.69 |
| Vermillion snapper | 1.92 | 2.31 | 2.32 | 2.26 | 2.61 | 2.50 | 2.55 | 2.43 | 2.59 | 2.78 |

### 2011 Economic Impacts of Recreational Fishing Expenditures (thousands of dollars)

| | Jobs | Sales | Income | Value Added |
|---|---|---|---|---|
| Trip Impacts by Fishing Mode: | | | | |
| For-Hire | 539 | 40,337 | 12,500 | 22,204 |
| Private Boat | 627 | 59,726 | 18,528 | 32,698 |
| Shore | 924 | 75,250 | 23,240 | 40,480 |
| Total Durable Equipment Impacts | 6,086 | 621,967 | 208,446 | 314,840 |
| **Total State Trip and Durable Equipment Economic Impacts** | 8,177 | 797,280 | 262,715 | 410,222 |

### 2011 Angler Trip & Durable Expenditures (thousands of dollars)

| Fishing Mode | Trip Expenditures | | Equipment | Durable Expenditures |
|---|---|---|---|---|
| | Non-Residents | Residents | Fishing Tackle | 245,964 |
| For-Hire | 21,439 | 5,480 | Other Equipment | 65,634 |
| Private Boat | 17,116 | 41,439 | Boat Expenses | 176,088 |
| Shore | 32,423 | 28,291 | Vehicle Expenses | 222,460 |
| *Total Trip Expenditures* | 70,978 | 75,210 | Second Home Expenses | 0 |
| | | | *Total Durable Equipment Expenditures* | 710,146 |
| **Total State Trip and Durable Equipment Expenditures** | | | | 856,334 |

### Recreational Anglers by Residential Area (thousands of anglers)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal | 123 | 187 | 223 | 231 | 233 | 253 | 192 | 205 | 195 | 295 |
| Non-Coastal | 97 | 123 | 159 | 93 | 184 | 169 | 116 | 151 | 140 | 177 |
| Out of State | 193 | 214 | 345 | 161 | 320 | 291 | 237 | 209 | 220 | 435 |
| **Total Anglers** | 413 | 524 | 728 | 485 | 736 | 712 | 545 | 566 | 554 | 907 |

### Recreational Fishing Effort by Mode (thousands of angler-trips)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| For-Hire | 68 | 66 | 77 | 56 | 77 | 75 | 56 | 56 | 33 | 75 |
| Private | 607 | 846 | 994 | 828 | 811 | 985 | 946 | 885 | 840 | 1,207 |
| Shore | 515 | 587 | 1,181 | 720 | 1,050 | 901 | 702 | 771 | 812 | 1,203 |
| **Total Trips** | 1,190 | 1,499 | 2,252 | 1,604 | 1,938 | 1,961 | 1,704 | 1,712 | 1,685 | 2,485 |

### Harvest (H) and Release (R) of Key Species Species Groups (thousands of fish)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Bluefish | H | 51 | 44 | 132 | 15 | 13 | 26 | 17 | 15 | 30 | 74 |
| | R | 65 | 126 | 216 | 77 | 151 | 174 | 54 | 45 | 80 | 167 |
| Drum (Atlantic croaker) | H | 188 | 244 | 178 | 233 | 453 | 463 | 1,163 | 250 | 918 | 886 |
| | R | 468 | 512 | 1,070 | 1,593 | 823 | 923 | 1,370 | 1,822 | 1,861 | 2,593 |
| Drum (kingfishes)[1] | H | 411 | 487 | 619 | 263 | 443 | 476 | 667 | 592 | 633 | 626 |
| | R | 162 | 185 | 410 | 265 | 460 | 291 | 256 | 283 | 309 | 341 |
| Drum (sand seatrout) | H | 428 | 709 | 502 | 349 | 593 | 705 | 1,216 | 1,428 | 2,070 | 2,346 |
| | R | 130 | 225 | 266 | 290 | 502 | 481 | 410 | 752 | 836 | 743 |
| Drum (spotted seatrout) | H | 193 | 345 | 208 | 294 | 326 | 359 | 269 | 318 | 609 | 825 |
| | R | 166 | 430 | 168 | 322 | 598 | 488 | 844 | 758 | 453 | 1,302 |
| Porgies (sheepshead) | H | 192 | 299 | 461 | 280 | 123 | 320 | 288 | 165 | 218 | 481 |
| | R | 81 | 89 | 172 | 86 | 80 | 30 | 159 | 48 | 52 | 146 |
| Red drum | H | 84 | 114 | 118 | 155 | 101 | 84 | 87 | 62 | 122 | 143 |
| | R | 105 | 245 | 262 | 185 | 145 | 137 | 228 | 110 | 153 | 149 |
| Red snapper | H | 473 | 380 | 305 | 232 | 181 | 217 | 108 | 137 | 41 | 217 |
| | R | 984 | 666 | 589 | 493 | 640 | 852 | 340 | 394 | 287 | 488 |
| Southern flounder | H | 82 | 113 | 139 | 150 | 123 | 96 | 93 | 139 | 242 | 163 |
| | R | 15 | 68 | 73 | 83 | 64 | 38 | 37 | 22 | 65 | 60 |
| Spanish mackerel | H | 106 | 122 | 468 | 45 | 58 | 93 | 111 | 76 | 253 | 334 |
| | R | 16 | 99 | 276 | 52 | 49 | 21 | 31 | 60 | 102 | 129 |

[1] Kingfishes include southern kingfish and Gulf kingfish

### Alabama's State Economy (% of national total)

| | Establishments | Employees | Annual Payroll (million $) | Employee Compensation (million $) | Gross State Product (million $) | Commercial Location Quotient [1] |
|---|---|---|---|---|---|---|
| 2002 | 99,931 (1.4%) | 1,581,117 (1.4%) | 45,466 (1.2%) | 74,346 (1.2%) | 125,168 (1.2%) | 0.38 |
| 2010 | 99,251 (1.3%) | 1,568,111 (1.4%) | 57,448 (1.2%) | 98,478 (1.2%) | 170,219 (1.2%) | 0.87 |
| % change | -0.68% | -0.823% | 26.4% | 32.5% | 36% | 168% |

### Seafood Sales & Processing - Nonemployer Firms (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Seafood product prep. & packaging | Firms | 44 | 36 | 43 | 40 | 34 | 47 | 33 | 41 | 33 |
| | Receipts | 3,603 | 1,168 | 3,413 | 3,414 | 1,558 | 1,547 | 1,894 | 1,805 | 1,894 |
| Seafood Sales, retail | Firms | 58 | 55 | 61 | 44 | 57 | 61 | 57 | 63 | 57 |
| | Receipts | 3,456 | 3,812 | 3,645 | 3,855 | 4,802 | 4,279 | 5,632 | 4,844 | 5,632 |

### Seafood Sales & Processing - Employer Establishments (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Seafood product prep. & packaging | Establishments | 22 | 24 | 23 | 26 | 24 | 23 | 23 | 22 | 21 |
| | Employees | 1,951 | 2,057 | 2,037 | 1,925 | 1,629 | 1,510 | 1,450 | 1,086 | 1,128 |
| | Payroll | 36,198 | 36,766 | 36,130 | 38,229 | 34,703 | 32,774 | 29,277 | 24,900 | 22,824 |
| Seafood sales, wholesale | Establishments | 36 | 33 | 31 | 26 | 26 | 31 | 29 | 28 | 23 |
| | Employees | 547 | 611 | 588 | 607 | 395 | 395 | 494 | 339 | 332 |
| | Payroll | 7,062 | 6,148 | 6,752 | 6,345 | 6,195 | 6,202 | 8,751 | 5,893 | 5,119 |
| Seafood sales, retail | Establishments | 35 | 37 | 35 | 34 | 28 | 33 | 33 | 31 | 34 |
| | Employees | 110 | ND[2] | 96 | 95 | ND[2] | ND[2] | ND[2] | 130 | 132 |
| | Payroll | 1,589 | ND[2] | 1,401 | 1,399 | ND[2] | 1,809 | 1,710 | 2,044 | 2,016 |

### Transport, Support, & Marine Operations - Employer Establishments (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal & Great Lakes freight transportation | Establishments | 6 | 13 | 10 | 10 | 6 | 8 | 4 | 4 | 5 |
| | Employees | ND[2] | ND[2] | ND[2] | ND[2] | 15 | 48 | ND[2] | ND[2] | ND[2] |
| | Payroll | ND[2] | ND[2] | ND[2] | ND[2] | 754 | 3,266 | ND[2] | ND[2] | ND[2] |
| Deep sea freight transportation | Establishments | 2 | 5 | 3 | 3 | 3 | 5 | 7 | 7 | 5 |
| | Employees | ND[2] | 53 | ND[2] | ND[2] | ND[2] | 46 | ND[2] | ND[2] | ND[2] |
| | Payroll | ND[2] | 3,661 | ND[2] | ND[2] | ND[2] | 3,553 | ND[2] | ND[2] | ND[2] |
| Deep sea passenger transportation | Establishments | NA[3] | 1 | 1 | 1 | 1 | 1 | 2 | 3 | 2 |
| | Employees | NA[3] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| | Payroll | NA[3] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| Marinas | Establishments | 48 | 53 | 52 | 58 | 52 | 52 | 56 | 55 | 54 |
| | Employees | 242 | 287 | 341 | 347 | 312 | 364 | 316 | 278 | 609 |
| | Payroll | 4,966 | 6,218 | 7,631 | 8,047 | 8,388 | 9,382 | 9,170 | 8,418 | 12,149 |
| Marine cargo handling | Establishments | 19 | 17 | 18 | 17 | 14 | 19 | 20 | 19 | 19 |
| | Employees | 635 | 445 | 577 | 672 | ND[2] | 491 | 756 | 658 | 548 |
| | Payroll | 20,592 | 19,642 | 26,201 | 28,458 | ND[2] | 21,076 | 33,244 | 27,272 | 32,143 |
| Navigational services to shipping | Establishments | 15 | 12 | 16 | 17 | 18 | 16 | 17 | 16 | 16 |
| | Employees | 220 | 410 | ND[2] | ND[2] | ND[2] | 338 | 287 | 294 | 276 |
| | Payroll | 9,317 | 19,602 | ND[2] | ND[2] | ND[2] | 17,554 | 16,712 | 15,383 | 14,737 |
| Port & harbor operations | Establishments | 6 | 3 | 1 | 3 | 3 | 2 | 4 | 5 | 5 |
| | Employees | 162 | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| | Payroll | 6,321 | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| Ship & boat building | Establishments | 45 | 41 | 42 | 45 | 47 | 42 | 42 | 40 | 32 |
| | Employees | 2,901 | 2,781 | 2,195 | 2,591 | 3,027 | 3,570 | 4,435 | 3,913 | 2,598 |
| | Payroll | 92,916 | 81,092 | 83,756 | 86,453 | 121,185 | 172,380 | 188,543 | 159,065 | 151,813 |

[1] The U.S. Commercial Fishing Location Quotient (CFLQ) of 1.0 represents the national baseline from which state CFLQs can be compared.
[2] ND = these data are confidential thus not disclosable
[3] NA = these data are not available

### 2011 Economic Impacts of the Florida[1] Seafood Industry (thousands of dollars)

| | With Imports | | | Without Imports | | |
|---|---|---|---|---|---|---|
| | Jobs | Sales | Value Added | Jobs | Sales | Value Added |
| **Total Impacts** | 72,341 | 14,250,006 | 4,778,502 | 10,550 | 928,929 | 376,208 |
| Commercial Harvesters | 6,817 | 446,577 | 186,630 | 6,817 | 446,577 | 186,630 |
| Seafood Processors & Dealers | 4,219 | 679,112 | 258,376 | 548 | 95,706 | 36,412 |
| Importers | 37,278 | 10,254,318 | 3,125,965 | 0 | 0 | 0 |
| Seafood Wholesalers & Distributors | 8,983 | 1,039,625 | 507,796 | 464 | 53,716 | 26,237 |
| Retail | 15,043 | 1,830,373 | 699,735 | 2,721 | 332,930 | 126,929 |

### Total Landings Revenue and Landings Revenue of Key Species/Species Groups (thousands of dollars)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total revenue | 144,185 | 141,185 | 148,058 | 137,912 | 145,494 | 132,162 | 122,764 | 115,127 | 137,457 | 164,076 |
| Finfish & other | 51,609 | 51,451 | 52,331 | 50,600 | 50,358 | 45,890 | 50,842 | 49,537 | 40,853 | 59,398 |
| Shellfish | 92,576 | 89,734 | 95,727 | 87,312 | 95,136 | 86,272 | 71,922 | 65,589 | 96,604 | 104,678 |
| Blue crab | 5,644 | 7,061 | 7,316 | 7,035 | 7,043 | 5,769 | 3,290 | 4,183 | 6,706 | 7,718 |
| Gag | 7,380 | 6,855 | 7,615 | 7,084 | 4,151 | 4,348 | 4,898 | 2,759 | 2,079 | 1,433 |
| Lobsters | 18,932 | 17,138 | 20,724 | 15,077 | 24,885 | 24,546 | 19,175 | 12,179 | 32,752 | 35,595 |
| Mullets | 6,059 | 4,755 | 4,891 | 4,355 | 6,021 | 3,663 | 4,172 | 5,069 | 4,188 | 8,630 |
| Oyster | 3,125 | 2,932 | 2,884 | 2,854 | 5,415 | 6,631 | 5,473 | 6,968 | 6,298 | 7,600 |
| Quahog clam | 3,606 | 3,870 | 2,074 | 1,736 | 807 | 914 | 1,009 | 915 | 1,001 | 921 |
| Red grouper | 12,859 | 11,695 | 13,281 | 13,376 | 14,384 | 11,024 | 13,569 | 10,488 | 8,992 | 15,082 |
| Red snapper | 2,188 | 2,284 | 2,168 | 1,671 | 1,991 | 3,066 | 2,945 | 2,980 | 4,552 | 5,417 |
| Shrimp | 37,252 | 34,893 | 34,737 | 38,625 | 32,225 | 20,976 | 23,265 | 23,314 | 25,978 | 27,559 |
| Stone crab | 22,874 | 22,913 | 26,507 | 21,074 | 24,029 | 26,213 | 18,877 | 17,586 | 23,335 | 24,405 |

### Total Landings and Landings of Key Species/Species Groups (thousands of pounds)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total landings | 82,075 | 79,163 | 83,894 | 73,038 | 70,766 | 59,784 | 60,127 | 65,351 | 62,595 | 77,687 |
| Finfish & other | 43,586 | 41,697 | 41,134 | 36,543 | 35,887 | 30,645 | 35,250 | 38,754 | 32,018 | 42,292 |
| Shellfish | 38,489 | 37,466 | 42,760 | 36,496 | 34,879 | 29,139 | 24,877 | 26,596 | 30,577 | 35,395 |
| Blue crab | 5,567 | 7,225 | 8,083 | 7,370 | 8,610 | 6,110 | 2,663 | 3,364 | 5,759 | 6,833 |
| Gag | 3,136 | 2,691 | 3,054 | 2,688 | 1,436 | 1,339 | 1,474 | 825 | 572 | 368 |
| Lobsters | 4,080 | 3,886 | 4,565 | 3,059 | 4,372 | 3,405 | 2,981 | 3,951 | 5,287 | 5,300 |
| Mullets | 8,020 | 6,577 | 6,660 | 5,635 | 7,308 | 5,619 | 6,979 | 9,167 | 7,262 | 11,409 |
| Oyster | 1,944 | 1,753 | 1,644 | 1,417 | 2,394 | 2,959 | 2,501 | 2,877 | 2,165 | 2,746 |
| Quahog clam | 480 | 558 | 266 | 212 | 96 | 116 | 146 | 150 | 156 | 137 |
| Red grouper | 6,987 | 5,841 | 6,789 | 6,386 | 6,062 | 4,352 | 5,619 | 4,387 | 3,488 | 5,634 |
| Red snapper | 948 | 928 | 811 | 584 | 649 | 919 | 848 | 863 | 1,317 | 1,538 |
| Shrimp | 19,128 | 18,131 | 18,258 | 19,297 | 14,176 | 8,628 | 9,942 | 10,673 | 11,814 | 11,562 |
| Stone crab | 6,385 | 5,253 | 5,933 | 4,502 | 4,784 | 5,884 | 6,117 | 5,310 | 5,100 | 5,454 |

### Average Annual Price of Key Species/Species Groups (dollars per pound)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Blue crab | 1.01 | 0.98 | 0.91 | 0.95 | 0.82 | 0.94 | 1.24 | 1.24 | 1.16 | 1.13 |
| Gag | 2.35 | 2.55 | 2.49 | 2.64 | 2.89 | 3.25 | 3.32 | 3.34 | 3.63 | 3.90 |
| Lobsters | 4.64 | 4.41 | 4.54 | 4.93 | 5.69 | 7.21 | 6.43 | 3.08 | 6.19 | 6.72 |
| Mullets | 0.76 | 0.72 | 0.73 | 0.77 | 0.82 | 0.65 | 0.60 | 0.55 | 0.58 | 0.76 |
| Oyster | 1.61 | 1.67 | 1.75 | 2.02 | 2.26 | 2.24 | 2.19 | 2.42 | 2.91 | 2.77 |
| Quahog clam | 7.51 | 6.93 | 7.79 | 8.17 | 8.44 | 7.90 | 6.90 | 6.12 | 6.43 | 6.74 |
| Red grouper | 1.84 | 2.00 | 1.96 | 2.09 | 2.37 | 2.53 | 2.41 | 2.39 | 2.58 | 2.68 |
| Red snapper | 2.31 | 2.46 | 2.67 | 2.86 | 3.07 | 3.34 | 3.47 | 3.45 | 3.46 | 3.52 |
| Shrimp | 1.95 | 1.92 | 1.90 | 2.00 | 2.27 | 2.43 | 2.34 | 2.18 | 2.20 | 2.38 |
| Stone crab | 3.58 | 4.36 | 4.47 | 4.68 | 5.02 | 4.45 | 3.09 | 3.31 | 4.58 | 4.47 |

[1] Information reported in this table if for the state of Florida, not West Florida

### 2011 Economic Impacts of Recreational Fishing Expenditures (thousands of dollars)

| | Jobs | Sales | Income | Value Added |
|---|---|---|---|---|
| Trip Impacts by Fishing Mode: | | | | |
| For-Hire | 3,113 | 302,927 | 103,418 | 179,604 |
| Private Boat | 3,177 | 318,260 | 109,436 | 189,249 |
| Shore | 2,235 | 210,696 | 71,575 | 122,407 |
| Total Durable Equipment Impacts | 38,522 | 4,049,949 | 1,431,414 | 2,162,416 |
| **Total State Trip and Durable Equipment Economic Impacts** | 47,047 | 4,881,831 | 1,715,843 | 2,653,677 |

### 2011 Angler Trip & Durable Expenditures (thousands of dollars)

| Fishing Mode | Trip Expenditures | | Equipment | Durable Expenditures |
|---|---|---|---|---|
| | Non-Residents | Residents | Fishing Tackle | 647,956 |
| For-Hire | 158,309 | 29,181 | Other Equipment | 279,586 |
| Private Boat | 72,024 | 211,465 | Boat Expenses | 2,858,367 |
| Shore | 96,703 | 55,686 | Vehicle Expenses | 448,791 |
| *Total Trip Expenditures* | 327,037 | 296,332 | Second Home Expenses | 636,626 |
| | | | *Total Durable Equipment Expenditures* | 4,871,325 |
| **Total State Trip and Durable Equipment Expenditures** | | | | 5,494,694 |

### Recreational Anglers by Residential Area (thousands of anglers)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal | 1703 | 1965 | 2023 | 2088 | 2084 | 1934 | 1820 | 1551 | 1538 | 1592 |
| Non-Coastal | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| Out of State | 1990 | 2318 | 2141 | 2008 | 1988 | 2151 | 2029 | 1671 | 1470 | 1624 |
| **Total Anglers** | 3693 | 4283 | 4165 | 4096 | 4072 | 4085 | 3849 | 3222 | 3008 | 3216 |

### Recreational Fishing Effort by Mode (thousands of angler-trips)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| For-Hire | 582 | 497 | 600 | 505 | 564 | 611 | 571 | 573 | 460 | 536 |
| Private | 8,236 | 9,221 | 10,171 | 9,491 | 9,382 | 10,005 | 10,145 | 8,623 | 8,160 | 7,520 |
| Shore | 5,601 | 6,291 | 7,025 | 6,699 | 6,720 | 6,318 | 6,782 | 6,482 | 5,645 | 5,845 |
| **Total Trips** | 14,419 | 16,009 | 17,796 | 16,695 | 16,666 | 16,934 | 17,498 | 15,678 | 14,265 | 13,901 |

### Harvest (H) and Release (R) of Key Species Species Groups (thousands of fish)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Common snook | H | 50 | 44 | 70 | 62 | 24 | 36 | 26 | 13 | (1) | 1 |
| | R | 1,292 | 1,358 | 2,198 | 2,281 | 1,391 | 1,592 | 1,595 | 1,925 | 600 | 746 |
| Drum (sand and silver seatrouts) | H | 1,355 | 751 | 434 | 487 | 434 | 1,119 | 746 | 893 | 410 | 864 |
| | R | 320 | 147 | 193 | 64 | 408 | 597 | 583 | 460 | 211 | 294 |
| Drum (spotted seatrout) | H | 1,532 | 1,628 | 2,066 | 1,980 | 1,617 | 1,513 | 1,544 | 1,370 | 1,117 | 1,476 |
| | R | 10,711 | 10,469 | 9,893 | 11,749 | 9,458 | 10,059 | 9,585 | 7,673 | 8,469 | 11,382 |
| Gag | H | 491 | 471 | 690 | 491 | 357 | 284 | 434 | 202 | 232 | 98 |
| | R | 2,449 | 3,359 | 3,865 | 2,314 | 1,876 | 2,677 | 4,078 | 2,726 | 2,019 | 1,158 |
| Gray snapper | H | 655 | 981 | 1,145 | 932 | 664 | 1,046 | 1,393 | 1,176 | 560 | 419 |
| | R | 2,997 | 4,809 | 3,637 | 4,700 | 2,847 | 4,290 | 5,689 | 3,015 | 1,858 | 2,241 |
| King mackerel | H | 261 | 196 | 196 | 177 | 343 | 271 | 183 | 451 | 173 | 128 |
| | R | 138 | 97 | 107 | 131 | 392 | 84 | 155 | 139 | 81 | 47 |
| Mullets[2] | H | 1,009 | 840 | 1,077 | 987 | 1,297 | 612 | 1,236 | 656 | 967 | 855 |
| | R | 93 | 188 | 281 | 209 | 100 | 182 | 143 | 191 | 71 | 106 |
| Porgies (sheepshead) | H | 686 | 761 | 709 | 1,050 | 624 | 590 | 556 | 682 | 455 | 608 |
| | R | 1,126 | 1,369 | 1,399 | 1,857 | 942 | 895 | 855 | 808 | 1,245 | 1,274 |
| Red drum | H | 291 | 364 | 322 | 501 | 375 | 411 | 457 | 226 | 240 | 288 |
| | R | 1,374 | 1,937 | 2,100 | 3,255 | 2,828 | 2,558 | 2,561 | 1,440 | 1,992 | 2,894 |
| Spanish mackerel | H | 1,811 | 1,316 | 1,626 | 1,101 | 1,671 | 1,206 | 1,753 | 1,391 | 1,284 | 1,156 |
| | R | 1,866 | 2,085 | 2,010 | 1,278 | 2,768 | 2,065 | 1,988 | 1,545 | 2,359 | 1,780 |

[1]NA = not applicable because all West Florida residents are considered coastal county residents
[2]Mullets include species within the mullet genus including striped mullets.

### Florida's State Economy (% of national total)

| | Establishments | Employees | Annual Payroll (million $) | Employee Compensation (million $) | Gross State Product (million $) | Commercial Location Quotient [1] |
|---|---|---|---|---|---|---|
| 2002 | 450,188 (6.3%) | 6,366,964 (5.7%) | 192,932 (4.9%) | 304,181 (5.1%) | 536,061 (5%) | 1.29 |
| 2010 | 491,150 (6.6%) | 6,626,558 (5.9%) | 252,973 (5.1%) | 400,635 (5.1%) | 736,065 (5%) | 1 |
| % change | 9.1% | 4.08% | 31.1% | 31.7% | 37.3% | -10.9% |

### Seafood Sales & Processing - Nonemployer Firms (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Seafood product prep. & packaging | Firms | 116 | 142 | 177 | 164 | 174 | 173 | 202 | 216 | 202 |
| | Receipts | 5,064 | 8,047 | 8,652 | 8,756 | 10,184 | 10,497 | 11,065 | 12,399 | 11,065 |
| Seafood Sales, retail | Firms | 243 | 240 | 247 | 247 | 251 | 319 | 331 | 308 | 331 |
| | Receipts | 20,837 | 18,064 | 18,004 | 22,787 | 20,708 | 27,557 | 26,087 | 24,726 | 26,087 |

### Seafood Sales & Processing - Employer Establishments (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Seafood product prep. & packaging | Establishments | 33 | 27 | 24 | 25 | 22 | 20 | 23 | 25 | 27 |
| | Employees | 2,359 | 2,084 | 2,193 | 1,616 | 1,704 | 1,748 | 1,637 | 1,143 | 1,269 |
| | Payroll | 65,914 | 61,452 | 65,881 | 47,529 | 62,801 | 58,233 | 53,455 | 46,235 | 45,772 |
| Seafood sales, wholesale | Establishments | 314 | 293 | 261 | 258 | 259 | 267 | 229 | 215 | 229 |
| | Employees | 2,395 | 1,835 | 1,948 | 1,883 | 2,091 | 2,308 | 1,913 | 1,762 | 1,747 |
| | Payroll | 78,160 | 55,874 | 63,276 | 65,339 | 73,897 | 85,019 | 75,203 | 72,159 | 70,889 |
| Seafood sales, retail | Establishments | 190 | 174 | 190 | 176 | 173 | 169 | 168 | 158 | 145 |
| | Employees | 908 | 952 | 977 | 970 | 936 | 989 | 991 | 885 | 865 |
| | Payroll | 17,186 | 15,673 | 17,575 | 19,192 | 19,513 | 20,595 | 21,604 | 21,182 | 20,783 |

### Transport, Support, & Marine Operations - Employer Establishments (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal & Great Lakes freight transportation | Establishments | 51 | 66 | 59 | 59 | 54 | 47 | 42 | 42 | 50 |
| | Employees | 2,856 | ND[2] | 1,132 | 1,150 | 1,217 | 1,242 | 1,106 | 972 | 709 |
| | Payroll | 143,185 | ND[2] | 80,422 | 71,420 | 91,638 | 94,429 | 50,115 | 37,774 | 50,217 |
| Deep sea freight transportation | Establishments | 62 | 61 | 63 | 69 | 73 | 69 | 57 | 58 | 61 |
| | Employees | 1,858 | 2,535 | 2,567 | 2,622 | 3,729 | 3,190 | 2,486 | 2,801 | 2,279 |
| | Payroll | 107,564 | 131,904 | 150,701 | 207,300 | 226,810 | 208,144 | 169,055 | 180,139 | 159,025 |
| Deep sea passenger transportation | Establishments | 31 | 36 | 32 | 31 | 37 | 34 | 31 | 33 | 29 |
| | Employees | 7,863 | 8,879 | 8,849 | 8,492 | 9,077 | ND[2] | ND[2] | ND[2] | ND[2] |
| | Payroll | 315,551 | 428,941 | 536,753 | 504,625 | 571,590 | ND[2] | ND[2] | ND[2] | ND[2] |
| Marinas | Establishments | 481 | 528 | 532 | 551 | 513 | 493 | 442 | 428 | 430 |
| | Employees | 3,449 | 5,079 | 5,067 | 5,069 | 5,494 | 4,935 | 5,024 | 4,665 | 4,439 |
| | Payroll | 90,662 | 111,324 | 125,763 | 133,384 | 146,390 | 148,592 | 151,677 | 132,955 | 133,017 |
| Marine cargo handling | Establishments | 74 | 68 | 66 | 63 | 66 | 53 | 56 | 59 | 55 |
| | Employees | 4,405 | 5,651 | 5,671 | 6,409 | 7,266 | 6,585 | 8,052 | 7,288 | 7,547 |
| | Payroll | 109,555 | 171,481 | 175,257 | 177,983 | 189,020 | 173,788 | 192,473 | 185,309 | 191,560 |
| Navigational services to shipping | Establishments | 141 | 140 | 149 | 148 | 142 | 145 | 147 | 145 | 145 |
| | Employees | 714 | 817 | 686 | 660 | 781 | 1,484 | 894 | 829 | 980 |
| | Payroll | 34,040 | 39,524 | 39,309 | 42,200 | 48,370 | 61,470 | 56,917 | 60,641 | 76,853 |
| Port & harbor operations | Establishments | 29 | 26 | 29 | 31 | 27 | 29 | 40 | 32 | 34 |
| | Employees | 1,180 | 592 | 1,045 | 973 | 584 | 459 | 712 | 527 | 470 |
| | Payroll | 26,928 | 19,071 | 24,327 | 22,606 | 19,417 | 12,872 | 24,668 | 19,006 | 20,525 |
| Ship & boat building | Establishments | 291 | 290 | 306 | 312 | 301 | 296 | 297 | 261 | 248 |
| | Employees | 11,407 | 11,830 | 12,503 | 12,729 | 12,385 | 12,332 | 12,419 | 8,221 | 7,363 |
| | Payroll | 379,828 | 393,985 | 443,379 | 454,209 | 427,888 | 469,382 | 442,096 | 296,537 | 302,909 |

[1] The U.S. Commercial Fishing Location Quotient (CFLQ) of 1.0 represents the national baseline from which state CFLQs can be compared.
[2] ND = these data are confidential thus not disclosable

### 2011 Economic Impacts of the Louisiana Seafood Industry (thousands of dollars)

| | With Imports | | | Without Imports | | |
|---|---|---|---|---|---|---|
| | Jobs | Sales | Value Added | Jobs | Sales | Value Added |
| **Total Impacts** | 32,818 | 1,801,568 | 877,911 | 30,676 | 1,467,854 | 762,430 |
| Commercial Harvesters | 12,407 | 626,308 | 308,175 | 12,407 | 626,308 | 308,175 |
| Seafood Processors & Dealers | 1,991 | 169,492 | 83,857 | 1,833 | 156,282 | 77,322 |
| Importers | 978 | 269,047 | 82,017 | 0 | 0 | 0 |
| Seafood Wholesalers & Distributors | 1,015 | 111,792 | 49,298 | 841 | 92,654 | 40,859 |
| Retail | 16,427 | 624,929 | 354,564 | 15,595 | 592,610 | 336,076 |

### Total Landings Revenue and Landings Revenue of Key Species/Species Groups (thousands of dollars)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total revenue | 280,630 | 270,408 | 274,082 | 251,678 | 278,292 | 289,288 | 275,239 | 296,778 | 247,772 | 333,619 |
| Finfish & other | 70,327 | 63,299 | 66,074 | 49,443 | 60,735 | 65,198 | 64,116 | 71,479 | 71,155 | 112,292 |
| Shellfish | 210,303 | 207,109 | 208,008 | 202,235 | 217,557 | 224,090 | 211,124 | 225,300 | 176,617 | 221,327 |
| Blue crab | 30,685 | 33,623 | 29,881 | 27,419 | 32,605 | 35,044 | 32,202 | 37,306 | 30,299 | 36,761 |
| Crawfish | 8,070 | 4,845 | 4,810 | 8,360 | 1,290 | 9,034 | 9,435 | 15,547 | 13,969 | 9,911 |
| King mackerel | 1,046 | 990 | 1,198 | 1,273 | 1,112 | 1,298 | 1,307 | 1,184 | 1,149 | 1,593 |
| Menhaden | 40,378 | 34,464 | 35,249 | 25,776 | 36,441 | 41,368 | 45,768 | 51,405 | 57,600 | 93,547 |
| Mullets | 1,688 | 2,592 | 2,681 | 946 | 2,061 | 690 | 749 | 73 | 185 | 775 |
| Oysters | 30,296 | 33,358 | 34,814 | 33,305 | 35,999 | 40,148 | 38,852 | 50,959 | 24,963 | 41,568 |
| Red snapper | 4,696 | 3,960 | 3,861 | 3,568 | 4,472 | 2,529 | 2,038 | 2,185 | 2,311 | 2,261 |
| Shrimp | 141,213 | 135,153 | 138,466 | 133,143 | 147,652 | 139,842 | 130,623 | 121,477 | 107,372 | 133,067 |
| Tunas | 10,845 | 9,471 | 10,739 | 7,687 | 7,040 | 8,334 | 4,409 | 6,338 | 1,649 | 3,369 |
| Vermillion snapper | 1,308 | 1,896 | 1,663 | 1,137 | 762 | 991 | 819 | 806 | 399 | 517 |

### Total Landings and Landings of Key Species/Species Groups (thousands of pounds)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total landings | 1,312,139 | 1,181,607 | 1,095,571 | 849,280 | 918,675 | 999,343 | 918,827 | 1,172,327 | 1,007,016 | 1,285,875 |
| Finfish & other | 1,124,627 | 985,164 | 895,336 | 681,322 | 714,545 | 814,645 | 759,438 | 970,214 | 879,213 | 1,129,176 |
| Shellfish | 187,511 | 196,443 | 200,235 | 167,959 | 204,130 | 184,698 | 159,389 | 202,114 | 127,803 | 156,699 |
| Blue crab | 50,123 | 48,089 | 44,397 | 38,100 | 53,394 | 45,107 | 41,713 | 53,060 | 30,726 | 43,862 |
| Crawfish | 15,602 | 8,337 | 8,537 | 15,177 | 1,469 | 15,848 | 15,612 | 19,312 | 14,556 | 9,597 |
| King mackerel | 866 | 911 | 984 | 867 | 971 | 879 | 789 | 927 | 691 | 1,002 |
| Menhaden | 1,093,997 | 953,714 | 862,947 | 657,702 | 689,853 | 789,621 | 738,092 | 948,944 | 862,144 | 1,106,931 |
| Mullets | 2,555 | 4,524 | 4,754 | 1,238 | 3,361 | 1,375 | 1,503 | 189 | 362 | 1,385 |
| Oysters | 13,962 | 13,609 | 13,902 | 12,099 | 11,417 | 12,858 | 12,791 | 15,010 | 6,867 | 11,135 |
| Red snapper | 2,178 | 1,725 | 1,560 | 1,316 | 1,653 | 807 | 589 | 667 | 828 | 918 |
| Shrimp | 107,795 | 125,730 | 133,370 | 102,576 | 137,839 | 110,860 | 89,268 | 114,727 | 75,641 | 92,093 |
| Tunas | 3,587 | 3,184 | 3,230 | 2,296 | 2,143 | 2,476 | 1,248 | 2,009 | 490 | 932 |
| Vermillion snapper | 755 | 1,053 | 921 | 588 | 365 | 517 | 409 | 412 | 186 | 234 |

### Average Annual Price of Key Species/Species Groups (dollars per pound)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Blue crab | 0.61 | 0.70 | 0.67 | 0.72 | 0.61 | 0.78 | 0.77 | 0.70 | 0.99 | 0.84 |
| Crawfish | 0.52 | 0.58 | 0.56 | 0.55 | 0.88 | 0.57 | 0.60 | 0.81 | 0.96 | 1.03 |
| King mackerel | 1.21 | 1.09 | 1.22 | 1.47 | 1.15 | 1.48 | 1.66 | 1.28 | 1.66 | 1.59 |
| Menhaden | 0.04 | 0.04 | 0.04 | 0.04 | 0.05 | 0.05 | 0.06 | 0.05 | 0.07 | 0.08 |
| Mullets | 0.66 | 0.57 | 0.56 | 0.76 | 0.61 | 0.50 | 0.50 | 0.39 | 0.51 | 0.56 |
| Oysters | 2.17 | 2.45 | 2.50 | 2.75 | 3.15 | 3.12 | 3.04 | 3.39 | 3.63 | 3.73 |
| Red snapper | 2.16 | 2.30 | 2.47 | 2.71 | 2.71 | 3.13 | 3.46 | 3.28 | 2.79 | 2.46 |
| Shrimp | 1.31 | 1.07 | 1.04 | 1.30 | 1.07 | 1.26 | 1.46 | 1.06 | 1.42 | 1.44 |
| Tunas | 3.02 | 2.97 | 3.33 | 3.35 | 3.29 | 3.37 | 3.53 | 3.16 | 3.37 | 3.62 |
| Vermillion snapper | 1.73 | 1.80 | 1.81 | 1.93 | 2.09 | 1.92 | 2.00 | 1.95 | 2.15 | 2.21 |

### 2011 Economic Impacts of Recreational Fishing Expenditures (thousands of dollars)

| | Jobs | Sales | Income | Value Added |
|---|---|---|---|---|
| Trip Impacts by Fishing Mode: | | | | |
| For-Hire | 541 | 51,475 | 16,613 | 29,227 |
| Private Boat | 2,237 | 237,846 | 66,894 | 116,981 |
| Shore | 597 | 57,288 | 16,907 | 28,919 |
| Total Durable Equipment Impacts | 14,388 | 1,256,304 | 421,535 | 631,222 |
| **Total State Trip and Durable Equipment Economic Impacts** | 17,764 | 1,602,913 | 521,949 | 806,349 |

### 2011 Angler Trip & Durable Expenditures (thousands of dollars)

| Fishing Mode | Trip Expenditures | | Equipment | Durable Expenditures |
|---|---|---|---|---|
| | Non-Residents | Residents | Fishing Tackle | 245,701 |
| For-Hire | 20,975 | 12,330 | Other Equipment | 86,045 |
| Private Boat | 17,434 | 163,788 | Boat Expenses | 974,417 |
| Shore | 4,535 | 42,032 | Vehicle Expenses | 220,904 |
| *Total Trip Expenditures* | 42,944 | 218,150 | Second Home Expenses | 91,310 |
| | | | *Total Durable Equipment Expenditures* | 1,618,377 |
| **Total State Trip and Durable Equipment Expenditures** | | | | 1,879,471 |

### Recreational Anglers by Residential Area (thousands of anglers)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal | 484 | 727 | 747 | 706 | 868 | 853 | 795 | 669 | 609 | 690 |
| Non-Coastal | 68 | 79 | 133 | 68 | 108 | 124 | 120 | 108 | 67 | 86 |
| Out of State | 117 | 204 | 179 | 138 | 198 | 157 | 170 | 139 | 120 | 183 |
| **Total Anglers** | 669 | 1011 | 1059 | 911 | 1174 | 1134 | 1084 | 916 | 796 | 959 |

### Recreational Fishing Effort by Mode (thousands of angler-trips)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| For-Hire | 94 | 105 | 143 | 123 | 187 | 143 | 179 | 183 | 79 | 113 |
| Private | 2,251 | 3,295 | 3,821 | 2,784 | 2,802 | 3,156 | 3,508 | 3,176 | 3,055 | 3,342 |
| Shore | 674 | 872 | 1,238 | 1,159 | 775 | 889 | 933 | 769 | 729 | 1,122 |
| **Total Trips** | 3,019 | 4,272 | 5,202 | 4,066 | 3,764 | 4,188 | 4,620 | 4,128 | 3,863 | 4,577 |

### Harvest (H) and Release (R) of Key Species Species Groups (thousands of fish)[1]

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Black drum | H | 512 | 485 | 504 | 309 | 369 | 385 | 544 | 518 | 398 | 469 |
| | R | 886 | 835 | 1,026 | 651 | 717 | 728 | 1,117 | 974 | 1,032 | 1,085 |
| Drum (Atlantic croaker) | H | 282 | 380 | 476 | 442 | 805 | 684 | 358 | 471 | 228 | 607 |
| | R | 1,054 | 1,012 | 1,995 | 963 | 1,142 | 1,006 | 1,186 | 1,099 | 1,268 | 2,319 |
| Drum (sand seatrout) | H | 599 | 985 | 903 | 975 | 775 | 888 | 1,085 | 879 | 1,065 | 1,187 |
| | R | 506 | 302 | 453 | 254 | 454 | 541 | 822 | 853 | 514 | 1,032 |
| Drum (spotted seatrout) | H | 5,270 | 7,317 | 8,524 | 7,436 | 10,873 | 8,929 | 11,705 | 10,557 | 7,857 | 10,440 |
| | R | 3,862 | 7,485 | 8,658 | 7,303 | 9,025 | 7,393 | 9,579 | 7,975 | 5,055 | 5,804 |
| Drum(southern kingfish) | H | 104 | 159 | 201 | 239 | 89 | 67 | 74 | 103 | 42 | 16 |
| | R | 22 | 63 | 85 | 187 | 151 | 28 | 118 | 59 | 47 | 25 |
| Porgies (sheepshead) | H | 607 | 807 | 1,288 | 644 | 326 | 270 | 705 | 704 | 431 | 869 |
| | R | 433 | 520 | 567 | 428 | 462 | 288 | 448 | 473 | 440 | 187 |
| Red drum | H | 2,042 | 2,144 | 2,419 | 1,627 | 1,827 | 2,307 | 2,672 | 2,236 | 2,810 | 3,022 |
| | R | 3,278 | 3,545 | 3,293 | 2,652 | 3,320 | 3,454 | 4,075 | 3,732 | 4,111 | 3,196 |
| Red snapper | H | 47 | 70 | 88 | 111 | 172 | 159 | 84 | 98 | 7 | 31 |
| | R | 40 | 166 | 273 | 339 | 429 | 285 | 261 | 195 | 7 | 108 |
| Southern flounder | H | 271 | 407 | 471 | 280 | 290 | 348 | 235 | 286 | 328 | 398 |
| | R | 49 | 116 | 129 | 76 | 54 | 67 | 36 | 51 | 72 | 61 |
| Yellowfin tuna | H | 8 | 13 | 8 | 10 | 14 | 8 | 17 | 3 | 1 | 12 |
| | R | (1) | (1) | (1) | 1 | 1 | 1 | 6 | (1) | (1) | 4 |

[1] In this table, '(1)' = 0-999 thousand fish and '1' = 1,000-1,499 thousand fish.

### Louisiana's State Economy (% of national total)

| | Establishments | Employees | Annual Payroll (million $) | Employee Compensation (million $) | Gross State Product (million $) | Commercial Location Quotient [1] |
|---|---|---|---|---|---|---|
| 2002 | 101,885 (1.4%) | 1,583,308 (1.4%) | 45,628 (1.2%) | 74,803 (1.3%) | 139,202 (1.2%) | 1.87 |
| 2010 | 103,365 (1.4%) | 1,599,551 (1.4%) | 62,266 (1.3%) | 105,352 (1.6%) | 232,394 (1.3%) | 1.58 |
| % change | 1.45% | 1.03% | 36.5% | 40.8% | 66.9% | -17.6% |

### Seafood Sales & Processing - Nonemployer Firms (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Seafood product prep. & packaging | Firms | 66 | 73 | 75 | 76 | 99 | 85 | 77 | 68 | 77 |
| | Receipts | 3,006 | 4,678 | 10,097 | 8,513 | 8,179 | 6,523 | 7,365 | 5,306 | 7,365 |
| Seafood Sales, retail | Firms | 185 | 208 | 204 | 156 | 181 | 196 | 182 | 169 | 182 |
| | Receipts | 15,201 | 22,637 | 18,148 | 14,585 | 20,046 | 20,932 | 25,900 | 17,177 | 25,900 |

### Seafood Sales & Processing - Employer Establishments (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Seafood product prep. & packaging | Establishments | 50 | 54 | 54 | 50 | 40 | 41 | 36 | 38 | 34 |
| | Employees | 1,185 | 1,693 | 1,519 | 1,556 | 1,506 | 1,253 | 991 | 1,301 | 1,209 |
| | Payroll | 52,861 | 56,562 | 47,016 | 43,801 | 45,439 | 41,391 | 32,382 | 37,657 | 35,770 |
| Seafood sales, wholesale | Establishments | 152 | 134 | 133 | 128 | 112 | 119 | 98 | 98 | 97 |
| | Employees | 1,270 | 1,001 | 975 | 1,037 | 807 | 954 | 739 | 702 | 683 |
| | Payroll | 22,363 | 19,539 | 19,639 | 17,649 | 21,243 | 21,604 | 15,858 | 17,261 | 15,554 |
| Seafood sales, retail | Establishments | 123 | 109 | 111 | 106 | 101 | 101 | 107 | 106 | 101 |
| | Employees | 640 | 796 | 745 | 723 | 759 | 781 | 681 | 703 | 527 |
| | Payroll | 7,033 | 9,406 | 9,567 | 8,277 | 10,560 | 11,827 | 11,141 | 11,564 | 11,214 |

### Transport, Support, & Marine Operations - Employer Establishments (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal & Great Lakes freight transportation | Establishments | 109 | 160 | 148 | 136 | 137 | 138 | 123 | 117 | 125 |
| | Employees | 5,494 | 6,779 | 6,656 | 5,771 | 6,397 | 7,680 | 6,506 | 6,077 | 5,610 |
| | Payroll | 236,730 | 287,415 | 300,547 | 294,941 | 386,136 | 527,290 | 549,388 | 391,914 | 405,796 |
| Deep sea freight transportation | Establishments | 28 | 25 | 22 | 25 | 24 | 22 | 18 | 21 | 16 |
| | Employees | 647 | 831 | 705 | ND[2] | 595 | 685 | 1,095 | 1,192 | 93 |
| | Payroll | 29,432 | 43,634 | 38,949 | ND[2] | 35,269 | 39,843 | 87,479 | 91,760 | 6,147 |
| Deep sea passenger transportation | Establishments | 6 | 4 | 3 | 3 | 2 | 3 | 2 | 2 | 1 |
| | Employees | 66 | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| | Payroll | 2,748 | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| Marinas | Establishments | 57 | 53 | 52 | 53 | 41 | 50 | 43 | 43 | 43 |
| | Employees | 345 | 409 | ND[2] | 352 | ND[2] | 378 | 274 | 244 | 314 |
| | Payroll | 8,724 | 11,019 | ND[2] | 10,213 | ND[2] | 17,794 | 9,581 | 8,989 | 14,716 |
| Marine cargo handling | Establishments | 47 | 47 | 47 | 46 | 51 | 49 | 39 | 44 | 41 |
| | Employees | 3,089 | 3,784 | 3,278 | 3,263 | 3,100 | 2,978 | 2,010 | 2,193 | 2,511 |
| | Payroll | 114,659 | 131,274 | 127,896 | 110,129 | 118,748 | 128,207 | 85,484 | 92,883 | 105,063 |
| Navigational services to shipping | Establishments | 148 | 118 | 127 | 120 | 129 | 128 | 145 | 137 | 138 |
| | Employees | 3,371 | 2,738 | 2,472 | 2,136 | 2,204 | 2,508 | 2,884 | 2,893 | 3,176 |
| | Payroll | 135,223 | 112,412 | 109,008 | 96,202 | 115,222 | 141,757 | 183,381 | 175,271 | 224,533 |
| Port & harbor operations | Establishments | 15 | 13 | 18 | 18 | 18 | 14 | 22 | 17 | 21 |
| | Employees | 1,136 | 363 | ND[2] | 418 | 436 | 467 | 517 | 440 | 431 |
| | Payroll | 47,191 | 18,331 | ND[2] | 19,510 | 29,676 | 31,734 | 37,181 | 33,907 | 38,776 |
| Ship & boat building | Establishments | 113 | 113 | 113 | 111 | 108 | 112 | 117 | 109 | 109 |
| | Employees | 12,786 | 12,910 | 13,206 | 11,016 | 11,521 | 12,808 | 12,815 | 12,521 | 11,737 |
| | Payroll | 448,749 | 452,315 | 460,606 | 376,407 | 437,028 | 503,199 | 619,606 | 613,188 | 600,259 |

[1] The U.S. Commercial Fishing Location Quotient (CFLQ) of 1.0 represents the national baseline from which state CFLQs can be compared.
[2] ND = these data are confidential thus not disclosable

### 2011 Economic Impacts of the Mississippi Seafood Industry (thousands of dollars)

| | With Imports | | | Without Imports | | |
|---|---|---|---|---|---|---|
| | Jobs | Sales | Value Added | Jobs | Sales | Value Added |
| **Total Impacts** | 5,550 | 247,106 | 125,430 | 5,439 | 231,104 | 119,876 |
| Commercial Harvesters | 968 | 49,305 | 21,796 | 968 | 49,305 | 21,796 |
| Seafood Processors & Dealers | 833 | 63,085 | 31,273 | 818 | 61,936 | 30,703 |
| Importers | 46 | 12,710 | 3,875 | 0 | 0 | 0 |
| Seafood Wholesalers & Distributors | 73 | 6,821 | 3,032 | 63 | 5,936 | 2,639 |
| Retail | 3,629 | 115,185 | 65,454 | 3,590 | 113,926 | 64,738 |

### Total Landings Revenue and Landings Revenue of Key Species/Species Groups (thousands of dollars)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total revenue | 47,565 | 46,149 | 43,618 | 23,386 | 21,586 | 39,340 | 43,696 | 38,033 | 21,913 | 30,300 |
| Finfish & other | 12,627 | 12,396 | 10,485 | 7,804 | 8,959 | 21,359 | 19,233 | 18,667 | 8,963 | 10,527 |
| Shellfish | 34,938 | 33,753 | 33,133 | 15,582 | 12,628 | 17,981 | 24,464 | 19,366 | 12,950 | 19,772 |
| Blue crab | 572 | 687 | 658 | 433 | 928 | 741 | 447 | 573 | 366 | 318 |
| Flounders | 63 | 49 | 32 | 20 | 36 | 58 | 40 | 58 | 64 | 118 |
| Menhaden | 11,625 | 11,277 | 9,564 | 7,074 | 8,447 | 20,658 | 18,534 | 17,987 | 8,378 | 9,871 |
| Mullets | 22 | 34 | 54 | 38 | 23 | 35 | 32 | 30 | 31 | 56 |
| Oysters | 4,456 | 7,228 | 6,073 | 1,447 | ND[1] | 819 | 6,869 | 6,094 | 4,268 | 928 |
| Red snapper | 100 | 88 | 71 | 115 | ND[2] | ND[2] | ND[2] | 158 | ND[2] | 168 |
| Shrimp | 29,910 | 25,619 | 26,353 | 13,698 | 11,699 | 16,418 | 17,146 | 12,689 | 8,311 | 18,523 |

### Total Landings and Landings of Key Species/Species Groups (thousands of pounds)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total landings | 217,968 | 213,469 | 183,558 | 167,610 | 221,720 | 227,834 | 201,822 | 230,307 | 111,242 | 278,080 |
| Finfish & other | 197,691 | 190,733 | 161,669 | 158,721 | 212,213 | 216,375 | 190,191 | 217,461 | 105,274 | 267,407 |
| Shellfish | 20,277 | 22,736 | 21,889 | 8,889 | 9,507 | 11,459 | 11,631 | 12,846 | 5,968 | 10,673 |
| Blue crab | 717 | 877 | 811 | 429 | 1,127 | 737 | 450 | 545 | 366 | 370 |
| Flounders | 46 | 31 | 18 | 10 | 16 | 25 | 17 | 25 | 28 | 55 |
| Menhaden | 195,371 | 187,956 | 159,392 | 157,194 | 211,163 | 215,182 | 189,118 | 216,709 | 104,729 | 266,774 |
| Mullets | 64 | 94 | 128 | 99 | 66 | 70 | 57 | 62 | 59 | 93 |
| Oysters | 2,738 | 4,042 | 3,029 | 610 | ND[2] | 299 | 2,610 | 2,189 | 1,453 | 247 |
| Red snapper | 46 | 43 | 35 | 54 | ND[2] | ND[2] | ND[2] | 57 | ND[2] | 86 |
| Shrimp | 16,822 | 17,560 | 17,992 | 7,848 | 8,380 | 10,421 | 8,570 | 10,107 | 4,148 | 10,053 |

### Average Annual Price of Key Species/Species Groups (dollars per pound)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Blue crab | 0.80 | 0.78 | 0.81 | 1.01 | 0.82 | 1.01 | 0.99 | 1.05 | 1.00 | 0.86 |
| Flounders | 1.35 | 1.57 | 1.73 | 1.88 | 2.22 | 2.38 | 2.36 | 2.34 | 2.33 | 2.14 |
| Menhaden | 0.06 | 0.06 | 0.06 | 0.05 | 0.04 | 0.10 | 0.10 | 0.08 | 0.08 | 0.04 |
| Mullets | 0.34 | 0.36 | 0.42 | 0.38 | 0.35 | 0.50 | 0.57 | 0.48 | 0.52 | 0.61 |
| Oysters | 1.63 | 1.79 | 2.00 | 2.37 | ND[2] | 2.74 | 2.63 | 2.78 | 2.94 | 3.75 |
| Red snapper | 2.17 | 2.06 | 2.05 | 2.13 | ND[2] | ND[2] | ND[2] | 2.75 | ND[2] | 1.96 |
| Shrimp | 1.78 | 1.46 | 1.46 | 1.75 | 1.40 | 1.58 | 2.00 | 1.26 | 2.00 | 1.84 |

[1] ND = these data are confidential thus not disclosable

### 2011 Economic Impacts of Recreational Fishing Expenditures (thousands of dollars)

| | Jobs | Sales | Income | Value Added |
|---|---|---|---|---|
| Trip Impacts by Fishing Mode: | | | | |
| For-Hire | 49 | 4,362 | 1,375 | 2,458 |
| Private Boat | 283 | 32,645 | 8,682 | 15,646 |
| Shore | 106 | 10,118 | 2,944 | 5,044 |
| Total Durable Equipment Impacts | 742 | 98,643 | 24,782 | 37,587 |
| **Total State Trip and Durable Equipment Economic Impacts** | 1,181 | 145,769 | 37,783 | 60,735 |

### 2011 Angler Trip & Durable Expenditures (thousands of dollars)

| Fishing Mode | Trip Expenditures | | Equipment | Durable Expenditures |
|---|---|---|---|---|
| | Non-Residents | Residents | Fishing Tackle | 28,207 |
| For-Hire | 1,712 | 1,148 | Other Equipment | 9,789 |
| Private Boat | 1,386 | 27,357 | Boat Expenses | 40,733 |
| Shore | 1,519 | 8,932 | Vehicle Expenses | 28,330 |
| *Total Trip Expenditures* | 4,616 | 37,438 | Second Home Expenses | 15 |
| | | | *Total Durable Equipment Expenditures* | 107,075 |
| **Total State Trip and Durable Equipment Expenditures** | | | | 149,129 |

### Recreational Anglers by Residential Area (thousands of anglers)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal | 175 | 159 | 191 | 108 | 143 | 196 | 119 | 125 | 137 | 160 |
| Non-Coastal | 52 | 53 | 26 | 29 | 23 | 34 | 26 | 36 | 29 | 48 |
| Out of State | 49 | 48 | 46 | 39 | 27 | 55 | 48 | 50 | 50 | 60 |
| **Total Anglers** | 276 | 261 | 262 | 176 | 193 | 284 | 194 | 212 | 216 | 268 |

### Recreational Fishing Effort by Mode (thousands of angler-trips)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| For-Hire | 21 | 24 | 13 | 8 | 7 | 20 | 13 | 11 | 7 | 11 |
| Private | 542 | 748 | 657 | 483 | 626 | 834 | 596 | 759 | 629 | 844 |
| Shore | 475 | 405 | 510 | 435 | 291 | 349 | 359 | 310 | 597 | 761 |
| **Total Trips** | 1,038 | 1,177 | 1,180 | 926 | 924 | 1,203 | 968 | 1,080 | 1,233 | 1,616 |

### Harvest (H) and Release (R) of Key Species Species Groups (thousands of fish)[1]

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Drum (Atlantic croaker) | H | 206 | 198 | 135 | 40 | 59 | 71 | 182 | 340 | 209 | 453 |
| | R | 936 | 701 | 371 | 208 | 190 | 264 | 388 | 717 | 422 | 606 |
| Drum (kingfishes)[2] | H | 278 | 327 | 355 | 225 | 163 | 161 | 180 | 126 | 174 | 177 |
| | R | 119 | 60 | 111 | 63 | 29 | 48 | 57 | 61 | 48 | 36 |
| Drum (sand and silver seatrouts) | H | 866 | 667 | 423 | 222 | 304 | 295 | 351 | 1,003 | 986 | 1,336 |
| | R | 111 | 331 | 88 | 118 | 173 | 230 | 166 | 378 | 246 | 471 |
| Drum (spotted seatrout) | H | 372 | 276 | 761 | 318 | 470 | 386 | 608 | 1,090 | 556 | 840 |
| | R | 559 | 832 | 1,045 | 838 | 975 | 909 | 1,009 | 960 | 586 | 634 |
| Porgies (sheepshead) | H | 68 | 77 | 37 | 27 | 36 | 18 | 17 | 21 | 43 | 260 |
| | R | 61 | 27 | 33 | 22 | 22 | 11 | 25 | 9 | 3 | 24 |
| Red drum | H | 60 | 50 | 83 | 35 | 58 | 41 | 76 | 84 | 76 | 90 |
| | R | 116 | 187 | 153 | 143 | 98 | 73 | 153 | 240 | 212 | 208 |
| Red snapper | H | 43 | 39 | 13 | 1 | 7 | 2 | 9 | 15 | 1 | 6 |
| | R | 166 | 90 | 61 | 51 | 52 | 9 | 104 | 55 | 25 | (1) |
| Sharks[3] | H | 12 | 8 | 8 | 9 | 2 | 4 | 3 | 21 | 71 | 35 |
| | R | 118 | 59 | 38 | 37 | 39 | 41 | 12 | 36 | 87 | 37 |
| Southern flounder | H | 141 | 120 | 103 | 72 | 47 | 121 | 110 | 209 | 195 | 182 |
| | R | 48 | 67 | 55 | 30 | 35 | 31 | 45 | 120 | 79 | 99 |
| Striped mullet | H | 212 | 550 | 192 | 34 | 2 | 66 | 78 | 119 | 188 | 491 |
| | R | 12 | 65 | 2 | (1) | 3 | 14 | 4 | 4 | 13 | 83 |

[1] In this table, '(1)' = 0-999 thousand fish and '1' = 1,000-1,499 thousand fish.
[2] Kingfishes include southern kingfish and Gulf kingfish
[3] Sharks include species within the requiem shark family, blacktip sharks, Atlantic sharpnose sharks, and unidentified sharks.

### Mississippi's State Economy (% of national total)

| | Establishments | Employees | Annual Payroll (million $) | Employee Compensation (million $) | Gross State Product (million $) | Commercial Location Quotient [1] |
|---|---|---|---|---|---|---|
| 2002 | 59,902 (0.83%) | 904,252 (0.8%) | 22,773 (0.58%) | 40,415 (0.66%) | 69,527 (0.66%) | 1.64 |
| 2010 | 59,300 (0.8%) | 882,181 (0.79%) | 28,607 (0.58%) | 52,766 (0.66%) | 95,480 (0.66%) | ND[2] |
| % change | -1% | -2.44% | 25.6% | 30.6% | 37.3% | NA[3] |

### Seafood Sales & Processing - Nonemployer Firms (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Seafood product prep. & packaging | Firms | 15 | 23 | 18 | 12 | 22 | 0 | 17 | 16 | 17 |
| | Receipts | 915 | 1,561 | 1,056 | 1,045 | 1,537 | ND[2] | 1,055 | 756 | 1,055 |
| Seafood Sales, retail | Firms | 51 | 51 | 47 | 41 | 53 | 57 | 48 | 55 | 48 |
| | Receipts | 2,486 | 2,984 | 3,595 | 2,934 | 4,021 | 4,126 | 3,437 | 4,042 | 3,437 |

### Seafood Sales & Processing - Employer Establishments (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Seafood product prep. & packaging | Establishments | 34 | 37 | 33 | 28 | 24 | 22 | 20 | 20 | 20 |
| | Employees | 3,675 | 4,438 | 3,728 | 3,637 | 3,353 | 3,022 | 3,062 | 2,796 | 2,849 |
| | Payroll | 70,792 | 80,229 | 66,047 | 63,957 | 60,510 | 60,633 | 61,723 | 61,926 | 61,731 |
| Seafood sales, wholesale | Establishments | 29 | 26 | 29 | 30 | 23 | 25 | 18 | 16 | 18 |
| | Employees | 226 | 176 | 166 | 145 | 58 | 106 | 61 | 113 | ND[2] |
| | Payroll | 3,791 | 3,067 | 3,631 | 1,822 | 2,063 | 3,285 | 3,088 | 2,836 | 2,542 |
| Seafood sales, retail | Establishments | 28 | 19 | 17 | 21 | 12 | 15 | 18 | 14 | 15 |
| | Employees | ND[2] | 47 | 55 | 57 | 41 | ND[2] | 50 | 46 | 50 |
| | Payroll | ND[2] | 468 | 532 | 521 | 395 | ND[2] | 699 | 841 | 810 |

### Transport, Support, & Marine Operations - Employer Establishments (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal & Great Lakes freight transportation | Establishments | 5 | 5 | 6 | 5 | 5 | 4 | 5 | 5 | 4 |
| | Employees | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | 119 | 114 | ND[2] |
| | Payroll | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | 7,585 | 8,351 | 7,730 | 8,058 |
| Deep sea freight transportation | Establishments | 1 | 2 | 2 | 3 | 3 | 1 | NA[3] | 1 | 1 |
| | Employees | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | NA[3] | ND[2] | ND[2] |
| | Payroll | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | NA[3] | ND[2] | ND[2] |
| Deep sea passenger transportation | Establishments | NA[3] | 1 | 1 | 1 | 1 | 1 | NA[3] | NA[3] | NA[3] |
| | Employees | NA[3] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | NA[3] | NA[3] | NA[3] |
| | Payroll | NA[3] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | NA[3] | NA[3] | NA[3] |
| Marinas | Establishments | 18 | 22 | 22 | 25 | 16 | 19 | 17 | 13 | 18 |
| | Employees | 86 | 141 | 220 | 158 | ND[2] | ND[2] | 111 | 172 | 183 |
| | Payroll | 1,388 | 2,532 | 2,603 | 2,358 | ND[2] | 2,145 | 2,794 | 3,479 | 4,163 |
| Marine cargo handling | Establishments | 7 | 4 | 5 | 6 | 5 | 5 | 7 | 8 | 7 |
| | Employees | 251 | ND[2] | ND[2] | ND[2] | 238 | ND[2] | ND[2] | ND[2] | ND[2] |
| | Payroll | 9,284 | ND[2] | ND[2] | ND[2] | 8,621 | ND[2] | ND[2] | ND[2] | ND[2] |
| Navigational services to shipping | Establishments | 8 | 10 | 9 | 8 | 8 | 9 | 8 | 7 | 8 |
| | Employees | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | 141 |
| | Payroll | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | 1,754 | ND[2] | ND[2] | 6,982 |
| Port & harbor operations | Establishments | 1 | 1 | 2 | 2 | 1 | 1 | 1 | 1 | 1 |
| | Employees | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| | Payroll | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| Ship & boat building | Establishments | 26 | 21 | 19 | 17 | 20 | 23 | 24 | 20 | 20 |
| | Employees | 11,663 | ND[2] | ND[2] | 11,845 | 11,909 | 14,578 | ND[2] | ND[2] | ND[2] |
| | Payroll | 473,191 | ND[2] | ND[2] | 471,243 | 498,660 | 615,837 | ND[2] | ND[2] | ND[2] |

[1] The U.S. Commercial Fishing Location Quotient (CFLQ) of 1.0 represents the national baseline from which state CFLQs can be compared.
[2] ND = these data are confidential thus not disclosable
[3] NA = these data are not available

### 2011 Economic Impacts of the Texas Seafood Industry (thousands of dollars)

| | With Imports | | | Without Imports | | |
|---|---|---|---|---|---|---|
| | Jobs | Sales | Value Added | Jobs | Sales | Value Added |
| **Total Impacts** | 27,717 | 2,277,959 | 1,002,928 | 22,516 | 1,357,574 | 687,876 |
| Commercial Harvesters | 5,754 | 508,663 | 232,633 | 5,754 | 508,663 | 232,633 |
| Seafood Processors & Dealers | 2,019 | 167,700 | 83,088 | 1,885 | 156,733 | 77,654 |
| Importers | 2,749 | 756,118 | 230,498 | 0 | 0 | 0 |
| Seafood Wholesalers & Distributors | 1,220 | 163,689 | 75,633 | 670 | 89,848 | 41,515 |
| Retail | 15,975 | 681,788 | 381,075 | 14,207 | 602,329 | 336,074 |

### Total Landings Revenue and Landings Revenue of Key Species/Species Groups (thousands of dollars)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total revenue | 173,340 | 168,317 | 166,208 | 172,337 | 197,291 | 180,575 | 176,098 | 155,074 | 204,469 | 239,082 |
| Finfish & other | 9,600 | 9,041 | 10,684 | 10,813 | 11,359 | 9,452 | 7,709 | 7,488 | 7,888 | 8,445 |
| Shellfish | 163,741 | 159,276 | 155,524 | 161,523 | 185,932 | 171,123 | 168,389 | 147,586 | 196,581 | 230,637 |
| Atlantic croaker | 451 | 489 | 382 | 415 | 500 | 450 | 446 | 484 | 531 | 622 |
| Black drum | 1,820 | 1,365 | 1,444 | 1,917 | 2,013 | 1,660 | 1,363 | 1,377 | 1,573 | 1,448 |
| Blue crab | 4,523 | 3,157 | 2,663 | 2,410 | 1,459 | 2,763 | 2,342 | 2,454 | 3,134 | 2,845 |
| Flounders | 371 | 336 | 325 | 276 | 164 | 62 | 144 | 91 | 62 | 205 |
| Groupers | 664 | 1,028 | 785 | 795 | 628 | 417 | 553 | 641 | 356 | 549 |
| Oysters | 11,276 | 16,493 | 14,954 | 15,883 | 17,263 | 19,246 | 8,835 | 9,376 | 19,144 | 12,789 |
| Red snapper | 3,363 | 3,757 | 5,193 | 5,345 | 6,168 | 3,762 | 2,744 | 2,398 | 3,009 | 3,254 |
| Shrimp | 147,701 | 139,485 | 137,674 | 143,045 | 167,108 | 149,084 | 157,187 | 135,643 | 174,231 | 214,898 |
| Tunas | 1,190 | 720 | 0 | 340 | 0 | ND[1] | 94 | 139 | 4 | 2 |
| Vermilion snapper | 386 | 349 | 611 | 571 | 642 | 1,554 | 1,430 | 1,233 | 1,337 | 1,274 |

### Total Landings and Landings of Key Species/Species Groups (thousands of pounds)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total landings | 93,059 | 96,122 | 85,557 | 84,289 | 117,131 | 87,912 | 73,048 | 102,695 | 90,054 | 98,111 |
| Finfish & other | 6,066 | 5,240 | 5,852 | 5,782 | 5,825 | 4,800 | 3,866 | 4,134 | 4,247 | 4,224 |
| Shellfish | 86,993 | 90,883 | 79,705 | 78,507 | 111,306 | 83,111 | 69,182 | 98,561 | 85,807 | 93,887 |
| Atlantic croaker | 70 | 75 | 60 | 58 | 67 | 62 | 59 | 63 | 67 | 79 |
| Black drum | 2,331 | 1,677 | 1,717 | 2,077 | 2,212 | 1,687 | 1,468 | 1,610 | 1,729 | 1,795 |
| Blue crab | 7,037 | 4,811 | 3,961 | 3,119 | 1,966 | 3,454 | 2,635 | 2,844 | 3,436 | 2,893 |
| Flounders | 173 | 159 | 151 | 144 | 68 | 24 | 58 | 32 | 26 | 75 |
| Groupers | 274 | 416 | 329 | 303 | 220 | 141 | 170 | 208 | 144 | 190 |
| Oysters | 4,708 | 6,813 | 5,569 | 5,007 | 4,923 | 5,633 | 2,679 | 2,733 | 5,265 | 3,943 |
| Red snapper | 1,478 | 1,607 | 2,133 | 1,940 | 2,158 | 1,213 | 870 | 851 | 1,031 | 948 |
| Shrimp | 75,158 | 79,166 | 70,098 | 70,310 | 104,378 | 74,007 | 63,855 | 92,946 | 77,067 | 87,007 |
| Tunas | 430 | 275 | 0 | 112 | 0 | ND[2] | 22 | 45 | 1 | 1 |
| Vermilion snapper | 217 | 192 | 322 | 279 | 273 | 672 | 592 | 561 | 539 | 465 |

### Average Annual Price of Key Species/Species Groups (dollars per pound)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Atlantic croaker | 6.46 | 6.49 | 6.35 | 7.14 | 7.43 | 7.29 | 7.58 | 7.64 | 7.98 | 7.84 |
| Black drum | 0.78 | 0.81 | 0.84 | 0.92 | 0.91 | 0.98 | 0.93 | 0.86 | 0.91 | 0.81 |
| Blue crab | 0.64 | 0.66 | 0.67 | 0.77 | 0.74 | 0.80 | 0.89 | 0.86 | 0.91 | 0.98 |
| Flounders | 2.14 | 2.12 | 2.15 | 1.92 | 2.42 | 2.55 | 2.48 | 2.84 | 2.37 | 2.75 |
| Groupers | 2.43 | 2.47 | 2.39 | 2.62 | 2.85 | 2.96 | 3.25 | 3.07 | 2.47 | 2.88 |
| Oysters | 2.40 | 2.42 | 2.69 | 3.17 | 3.51 | 3.42 | 3.30 | 3.43 | 3.64 | 3.24 |
| Red snapper | 2.27 | 2.34 | 2.43 | 2.76 | 2.86 | 3.10 | 3.15 | 2.82 | 2.92 | 3.43 |
| Shrimp | 1.97 | 1.76 | 1.96 | 2.03 | 1.60 | 2.01 | 2.46 | 1.46 | 2.26 | 2.47 |
| Tunas | 2.76 | 2.62 | 0.80 | 3.04 | 0.69 | ND[2] | 4.26 | 3.08 | 3.19 | 1.82 |
| Vermilion snapper | 1.78 | 1.82 | 1.90 | 2.05 | 2.35 | 2.31 | 2.42 | 2.20 | 2.48 | 2.74 |

[1] ND = these data are confidential thus not disclosable

### 2011 Economic Impacts of Recreational Fishing Expenditures (thousands of dollars)

| | Jobs | Sales | Income | Value Added |
|---|---|---|---|---|
| Trip Impacts by Fishing Mode: | | | | |
| For-Hire | 1,130 | 103,768 | 32,782 | 57,841 |
| Private Boat | 2,095 | 240,615 | 72,554 | 128,583 |
| Shore | 2,350 | 257,028 | 78,973 | 138,775 |
| Total Durable Equipment Impacts | 9,576 | 1,251,949 | 401,758 | 627,085 |
| **Total State Trip and Durable Equipment Economic Impacts** | 15,150 | 1,853,361 | 586,068 | 952,284 |

### 2011 Angler Trip & Durable Expenditures (thousands of dollars)[1]

| Fishing Mode | Trip Expenditures | | Equipment | Durable Expenditures |
|---|---|---|---|---|
| | Non-Residents | Residents | | |
| For-Hire | 4,616 | 57,001 | Fishing Tackle | 149,267 |
| Private Boat | 8,983 | 153,062 | Other Equipment | 82,412 |
| Shore | 15,081 | 162,772 | Boat Expenses | 414,319 |
| *Total Trip Expenditures* | 28,680 | 372,834 | Vehicle Expenses | 270,863 |
| | | | Second Home Expenses | 84,140 |
| | | | *Total Durable Equipment Expenditures* | 1,001,002 |
| **Total State Trip and Durable Equipment Expenditures** | | | | 1,402,516 |

### Harvest (H) and Release (R) of Key Species Species Groups (thousands of fish)[2]

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Atlantic croaker | H | 111 | 96 | 109 | 95 | 101 | 95 | 64 | 117 | 125 | 157 |
| Black drum | H | 72 | 85 | 68 | 53 | 73 | 66 | 82 | 98 | 165 | 129 |
| King mackerel | H | 16 | 19 | 15 | 14 | 29 | 11 | 8 | 16 | 6 | 9 |
| Red drum | H | 233 | 270 | 273 | 231 | 318 | 289 | 266 | 285 | 264 | 347 |
| Red snapper | H | 53 | 40 | 40 | 49 | 69 | 45 | 41 | 31 | 33 | 36 |
| Sand seatrout | H | 173 | 119 | 176 | 125 | 129 | 95 | 152 | 111 | 127 | 227 |
| Sheepshead | H | 84 | 76 | 67 | 81 | 78 | 46 | 46 | 34 | 49 | 57 |
| Southern flounder | H | 91 | 111 | 100 | 81 | 64 | 49 | 64 | 47 | 30 | 92 |
| Spotted seatrout | H | 965 | 939 | 934 | 855 | 987 | 916 | 917 | 810 | 732 | 1,137 |

[1]The Marine Recreational Information Program (MRIP) does not collect participation (number of anglers) or effort (number of trips) data for Texas. To calculate trip expenditure estimates, effort by fishing mode was estimated based on 2011 data provided by the Texas Parks and Wildlife Department (TPWD). These effort estimates were reviewed by the TPWD. To calculate angler expenditure estimates (durable equipment expenditures), participation estimates were based on the sum of saltwater licenses sold in Texas plus a proportion of combination licenses sold in Texas. A change in the method of reporting landings occurred in 2007 so data from 2007 is not comparable to earlier years.

[2]Data collected by the TPWG is reported in this table. The data collected by the TPWD differs from the data collected and reported in the MRIP. Please see the TPWD for more information: www.tpwd.state.tx.us/fishboat/.

### Texas's State Economy (% of national total)

| | Establishments | Employees | Annual Payroll (million $) | Employee Compensation (million $) | Gross State Product (million $) | Commercial Location Quotient [1] |
|---|---|---|---|---|---|---|
| 2002 | 482,169 (6.7%) | 7,993,559 (7.1%) | 277,847 (7%) | 427,957 (7.4%) | 782,780 (7%) | 0.53 |
| 2010 | 522,146 (7.1%) | 8,785,238 (7.8%) | 386,654 (7.8%) | 619,854 (8.5%) | 1,222,904 (7.8%) | 0.2 |
| % change | 8.29% | 9.9% | 39.2% | 44.8% | 56.2% | -41.5% |

### Seafood Sales & Processing - Nonemployer Firms (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Seafood product prep. & packaging | Firms | 104 | 99 | 100 | 108 | 109 | 94 | 85 | 82 | 85 |
| | Receipts | 3,901 | 5,234 | 1,989 | 2,228 | 2,974 | 5,386 | 3,466 | 3,896 | 3,466 |
| Seafood Sales, retail | Firms | 152 | 170 | 159 | 159 | 141 | 182 | 188 | 195 | 188 |
| | Receipts | 13,516 | 16,636 | 19,131 | 19,534 | 18,355 | 17,442 | 18,204 | 12,947 | 18,204 |

### Seafood Sales & Processing - Employer Establishments (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Seafood product prep. & packaging | Establishments | 27 | 23 | 24 | 23 | 21 | 26 | 27 | 24 | 22 |
| | Employees | 1,453 | 1,274 | 1,177 | 1,288 | 1,155 | 1,207 | 1,169 | 1,026 | 1,184 |
| | Payroll | 25,772 | 25,426 | 24,394 | 23,842 | 24,302 | 27,813 | 27,045 | 29,006 | 24,961 |
| Seafood sales, wholesale | Establishments | 115 | 99 | 103 | 97 | 92 | 104 | 69 | 75 | 77 |
| | Employees | 999 | 1,057 | 1,009 | 1,001 | 897 | 970 | 734 | 683 | 715 |
| | Payroll | 29,430 | 27,016 | 27,730 | 26,408 | 28,586 | 51,597 | 24,498 | 23,650 | 23,879 |
| Seafood sales, retail | Establishments | 73 | 67 | 60 | 59 | 58 | 62 | 60 | 51 | 52 |
| | Employees | 287 | 227 | 219 | 176 | 207 | 189 | 206 | 189 | 199 |
| | Payroll | 3,748 | 2,985 | 2,993 | 3,162 | 3,229 | 3,703 | 3,403 | 3,393 | 3,742 |

### Transport, Support, & Marine Operations - Employer Establishments (thousands of dollars)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal & Great Lakes freight transportation | Establishments | 39 | 43 | 43 | 61 | 45 | 43 | 42 | 43 | 48 |
| | Employees | 866 | 2,705 | 2,565 | ND[2] | 2,270 | 2,513 | 2,815 | 2,729 | 1,909 |
| | Payroll | 42,377 | 88,033 | 91,995 | ND[2] | 107,328 | 131,946 | 251,997 | 200,219 | 161,080 |
| Deep sea freight transportation | Establishments | 45 | 48 | 41 | 43 | 40 | 41 | 35 | 36 | 30 |
| | Employees | 1,287 | ND[2] | 891 | ND[2] | 751 | 920 | 514 | 802 | 764 |
| | Payroll | 70,194 | ND[2] | 38,553 | ND[2] | 41,969 | 49,761 | 40,764 | 61,309 | 63,408 |
| Deep sea passenger transportation | Establishments | 5 | 5 | 3 | 4 | 3 | 4 | 3 | 2 | 1 |
| | Employees | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| | Payroll | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] | ND[2] |
| Marinas | Establishments | 179 | 170 | 165 | 166 | 150 | 141 | 143 | 131 | 148 |
| | Employees | 1,255 | 1,410 | ND[2] | ND[2] | ND[2] | 1,200 | 1,486 | 1,423 | 1,198 |
| | Payroll | 28,471 | 31,197 | ND[2] | ND[2] | ND[2] | 28,359 | 34,039 | 33,803 | 33,968 |
| Marine cargo handling | Establishments | 56 | 59 | 60 | 60 | 64 | 62 | 55 | 57 | 54 |
| | Employees | 4,549 | 5,091 | 4,539 | 5,200 | 5,349 | 6,237 | 6,313 | 6,276 | 5,262 |
| | Payroll | 113,894 | 108,142 | 138,630 | 151,522 | 161,386 | 186,416 | 196,006 | 167,562 | 166,877 |
| Navigational services to shipping | Establishments | 95 | 92 | 92 | 87 | 84 | 90 | 99 | 95 | 87 |
| | Employees | 1,082 | 1,099 | 1,213 | 1,064 | 1,373 | 1,709 | 1,884 | 1,849 | 1,606 |
| | Payroll | 49,825 | 60,714 | 68,741 | 75,914 | 98,244 | 125,061 | 137,962 | 137,289 | 132,283 |
| Port & harbor operations | Establishments | 13 | 16 | 15 | 15 | 16 | 15 | 24 | 30 | 29 |
| | Employees | ND[2] | ND[2] | 215 | ND[2] | 112 | 98 | ND[2] | 421 | ND[2] |
| | Payroll | ND[2] | ND[2] | 7,128 | ND[2] | 4,992 | 5,163 | 10,538 | 13,778 | 18,627 |
| Ship & boat building | Establishments | 110 | 107 | 103 | 99 | 90 | 96 | 102 | 99 | 97 |
| | Employees | 3,360 | 4,062 | 4,204 | 3,564 | 3,515 | 4,810 | 5,368 | 3,891 | 3,386 |
| | Payroll | 137,129 | 156,565 | 163,800 | 156,259 | 170,308 | 210,275 | 235,190 | 158,261 | 147,492 |

[1] The U.S. Commercial Fishing Location Quotient (CFLQ) of 1.0 represents the national baseline from which state CFLQs can be compared.
[2] ND = these data are confidential thus not disclosable

# Data Sources

Moss Landing, California (photo credit: Rosemary Kosaka)

## Management Context

Excess Harvesting Capacity in U.S. Fisheries, A Report to Congress. April 28, 2008. National Marine Fisheries Service, National Oceanic & Atmospheric Administration (NOAA Fisheries). www.nmfs.noaa.gov/msa2007/docs/042808_312_b_6_report.pdf

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# Publications

Fulton Fish Market, New York City (photo credit: Min-Yang Lee)

**Selected publications by NOAA Fisheries Economics and Social Sciences Program staff are grouped by geographic region of focus and then organized under the following categories:**

Climate Change Research
Coastal & Marine Recreation Research
Commercial Fisheries Economics Research
Marine Protected Areas Research
Ocean Policy & Management Research
Other Marine Environmental Research
Recreational Fisheries Economics Research
Habitat Economics Research
Seafood Marketing & Trade Research
Sociocultural Research
U.S. Territories & International Fisheries Research
Protected Resources Economics Research

## United States

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Charter boats, Cape Hatteras, North Carolina (photo credit: Amber Von Harten)

# Resources

## U.S.

*Federal Agencies*

Economics & Social Analysis Division Office of Science & Technology, NOAA Fisheries www.st.nmfs.gov/st5/index.html
Office of Science & Technology, NOAA Fisheries www.st.nmfs.gov/index.html
Marine Recreational Information Program www.st.nmfs.noaa.gov/mrip/index.html
Office of International Affairs, NOAA Fisheries www.nmfs.noaa.gov/ia/index.htm
Office of Marine Conservation U.S. Department of State www.state.gov/g/oes/ocns/

## North Pacific

*Federal Agencies* Economic & Social Sciences Research Alaska Fisheries Science Center, NOAA Fisheries www.afsc.noaa.gov/REFM/Socioeconomics/Default.php
Alaska Fisheries Science Center, NOAA Fisheries www.afsc.noaa.gov
Alaska Regional Office, NOAA Fisheries www.fakr.noaa.gov
Alaska Region, U.S. Fish & Wildlife Service alaska.fws.gov
District 17, U.S. Coast Guard www.uscg.mil/D17
*State Agencies*
Alaska Department of Fish & Game www.adfg.state.ak.us
Councils & Commissions
North Pacific Fishery Management Council www.fakr.noaa.gov/npfmc
Pacific States Marine Fisheries Commission www.psmfc.org/index.php
Fisheries Economics Data Program Pacific States Marine Fisheries Commission www.psmfc.org/efin
International Pacific Halibut Commission www.iphc.washington.edu/halcom/default.htm

## Pacific

*Federal Agencies*
Human Dimensions Program Northwest Fisheries Science Center, NOAA Fisheries www.nwfsc.noaa.gov/research/divisions/cbd/humandim.cfm
Economics, Groundfish Analysis Program Northwest Fisheries Science Center, NOAA Fisheries www.nwfsc.noaa.gov/research/divisions/fram/economics.cfm
Northwest Fisheries Science Center, NOAA Fisheries www.nwfsc.noaa.gov
Northwest Regional Office, NOAA Fisheries www.nwr.noaa.gov
Socioeconomics Research Southwest Fisheries Science Center, NOAA Fisheries swfsc.noaa.gov
Southwest Fisheries Science Center swfsc.noaa.gov
Southwest Regional Office swr.nmfs.noaa.gov
Pacific Region, U.S. Fish & Wildlife Service www.fws.gov/pacific
California & Nevada, U.S. Fish & Wildlife Service www.fws.gov/cno
District 13, U.S. Coast Guard http://www.uscg.mil/D13/
*State Agencies*
California Department of Fish & Game www.dfg.ca.gov
Oregon Department of Fish & Wildlife www.dfw.state.or.us
Washington Department of Fish & Wildlife wdfw.wa.gov
*Councils & Commissions*
Pacific Fishery Management Council www.pcouncil.org
Pacific States Marine Fisheries Commission www.psmfc.org/index.php
Fisheries Economics Data Program - Pacific States Marine Fisheries Commission www.psmfc.org/efin
International Pacific Halibut Commission www.iphc.washington.edu/halcom/default.htm

## Western Pacific

*Federal Agencies*
Fisheries Monitoring & Socioeconomics Division Pacific Islands Fisheries Science Center, NOAA Fisheries www.pifsc.noaa.gov/fmsd
Pacific Islands Fisheries Science Center, NOAA Fisheries www.pifsc.noaa.gov/index.php
Pacific Islands Regional Office, NOAA Fisheries www.fpir.noaa.gov

Pacific Region, U.S. Fish & Wildlife Service www.fws.gov/pacific
District 14, U.S. Coast Guard www.uscg.mil/d14
*State Agencies* Hawaii Department of Land & Natural Resources www.hawaii.gov/dlnr
Guam Office of the Governor www.guamgovernor.net
Department of Marine & Wildlife Resources, American Samoa Office of the Governor americansamoa.gov/departments/depts/mwr.htm
Division of Fish & Wildlife Commonwealth of the Northern Mariana Islands www.dfw.gov.mp
*Councils & Commissions*
Western Pacific Fishery Management Council www.wpcouncil.org

## New England

*Federal Agencies*
Social Sciences Branch, Northeast Fisheries Science Center, NOAA Fisheries www.nefsc.noaa.gov/read/socialsci
Northeast Fisheries Science Center, NOAA Fisheries www.nefsc.noaa.gov
Northeast Regional Office, NOAA Fisheries www.nero.noaa.gov/nero
Northeast Region, U.S. Fish & Wildlife Service www.fws.gov/northeast
District 1, U.S. Coast Guard www.uscg.mil/D1
*State Agencies*
Maine Department of Marine Resources www.maine.gov/dmr/index.htm
Rhode Island Department of Environmental Management www.dem.ri.gov
Massachusetts Division of Marine Fisheries www.mass.gov/dfwele/dmf
Connecticut Department of Environmental Protection www.ct.gov/dep/site/default.asp
New Hampshire Fish & Game Department www.wildlife.state.nh.us
*Councils & Commissions*
New England Fishery Management Council www.nefmc.org
Atlantic States Marine Fisheries Commission www.asmfc.org

## Mid-Atlantic

*Federal Agencies*
Social Sciences Branch Northeast Fisheries Science Center, NOAA Fisheries www.nefsc.noaa.gov/read/socialsci
Northeast Fisheries Science Center, NOAA Fisheries www.nefsc.noaa.gov
Northeast Regional Office, NOAA Fisheries www.nero.noaa.gov/nero
Northeast Region, U.S. Fish & Wildlife Service www.fws.gov/northeast
District 5, U.S. Coast Guard www.uscg.mil/D5
*State Agencies*
Bureau of Marine Resources, New York Department of Environmental Conservation www.dec.ny.gov/about/796.html
New Jersey Division of Fish & Wildlife www.state.nj.us/dep/fgw
Pennsylvania Fish & Boat Commission fishandboat.com/mpag1.htm
Delaware Division of Fish & Wildlife www.fw.delaware.gov
Fisheries Service, Maryland Department of Natural Resources www.dnr.state.md.us/fisheries
Virginia Marine Resources Commission www.mrc.state.va.us
Division of Marine Fisheries, North Carolina Department of Environment & Natural Resources www.ncfisheries.net
*Councils & Commissions*
Mid-Atlantic Fishery Management Council www.mafmc.org
Atlantic States Marine Fisheries Commission www.asmfc.org

## South Atlantic

*Federal Agencies*
Social Science Research Group, Southeast Fisheries Science Center, NOAA Fisheries www.sefsc.noaa.gov/socialscience.jsp
Southeast Fisheries Science Center, NOAA Fisheries www.sefsc.noaa.gov
Southeast Regional Office, NOAA Fisheries sero.nmfs.noaa.gov
Southeast Region, U.S. Fish & Wildlife Service www.fws.gov/southeast
Southwest Region, U.S. Fish & Wildlife Service www.fws.gov/southwest
District 7, U.S. Coast Guard www.uscg.mil/D7
*State Agencies*
North Carolina Division of Marine Fisheries www.ncfisheries.net

Marine Resources Division, South Carolina Department of Natural Resources www.dnr.sc.gov
Coastal Resources Division Georgia Department of Natural Resources crd.dnr.state.ga.us
Florida Fish & Wildlife Conservation Commission myfwc.com
*Councils & Commissions*
South Atlantic Fishery Management Council www.safmc.net
Atlantic States Marine Fisheries Commission www.asmfc.org

## Gulf of Mexico

*Federal Agencies*
Social Science Research Group, Southeast Fisheries Science Center, NOAA Fisheries http://www.sefsc.noaa.gov/socialscience.jsp
Southeast Fisheries Science Center, NOAA Fisheries www.sefsc.noaa.gov
Southeast Regional Office, NOAA Fisheries sero.nmfs.noaa.gov
Southeast Region, U.S. Fish & Wildlife Service www.fws.gov/southeast
Southwest Region, U.S. Fish & Wildlife Service www.fws.gov/southwest
District 8, U.S. Coast Guard www.uscg.mil/D8
*State Agencies*
Division of Marine Fisheries, Florida Fish & Wildlife Conservation Commission myfwc.com/RECREATION/Saltwater_index.htm
Marine Resources Division, Alabama Department of Conservation & Natural Resources www.outdooralabama.com
Mississippi Department of Marine Resources www.dmr.state.ms.us
Louisiana Department of Wildlife & Fisheries www.wlf.state.la.us
Texas Parks & Wildlife Department www.tpwd.state.tx.us
*Councils & Commissions*
Gulf of Mexico Fishery Management Council www.gulfcouncil.org
Gulf States Marine Fisheries Commission www.gsmfc.org

## International Organizations

Pacific Salmon Commission www.psc.org
North Atlantic Salmon Conservation Organization www.nasco.int
International Pacific Halibut Commission www.iphc.washington.edu/halcom/default.htm
InterAmerican Tropical Tuna Commission www.iattc.org/HomeENG.htm
Western & Central Pacific Fisheries Commission www.wcpfc.int
International Commission for the Conservation of Atlantic Tunas www.iccat.int/en
Commission for the Conservation of Antarctic Marine Living Resources www.ccamlr.org
International Maritime Organization www.imo.org
Red List of Threatened Species www.iucnredlist.org

## Professional Organizations

North American Association of Fisheries Economists oregonstate.edu/Dept/IIFET/NAAFE/Home.html
International Institute of Fisheries Economics & Trade oregonstate.edu/dept/iifet

## Other Organizations & Information

The Center for Independent Experts www.ciereviews.org
Organisation for Economic Co-operation & Development www.oecd.org/home
FishWatch - U.S. Seafood Facts www.nmfs.noaa.gov/fishwatch
Marine Stewardship Council www.msc.org

Oyster tonging, Chesapeake Bay, Maryland (photo credit: Harley Speir)

# Glossary

**Angler**[1]

A person catching fish or shellfish with no intent to sell, including people releasing the catch. Also known as a recreational fisherman.

**Annual Payroll**[2]

Total payroll includes all forms of compensation such as salaries, wages, reported tips, commissions, bonuses, vacation allowances, sick-leave pay, employee contributions to qualified pension plans, and the value of taxable fringe benefits. For corporations, it includes amounts paid to officers and executives; for unincorporated businesses, it does not include profit or other compensation of proprietors or partners. Payroll is reported before deductions for Social Security, income tax, insurance, union dues, etc.

**Annual Receipts**[3]

Includes gross receipts, sales, commissions, and income from trades and businesses, as reported on annual business income tax returns. Business income consists of all payments received for services rendered by nonemployer businesses such as payments received as independent agents and contractors. The composition of nonemployer receipts may differ from receipts data published for employer establishments. For example, for wholesale agents and brokers without payroll (nonemployers), the receipts item contains commissions received or earnings. In contrast, for wholesale agents and brokers with payroll (employers), the sales and receipts item published in the Economic Census represents the value of the goods involved in the transactions.

**Buyback Program**[4]

A management tool available to fishery managers intended to ease fishing-related pressure on marine resources. Fishing vessels are purchased by the government or by the fishing industry itself then removed from a specific fishery where fish stocks or stock complexes are considered overfished or subject to overfishing.

**Bycatch**[1]

Species other than the primary target species that are caught incidental to the harvest of the primary species. Bycatch may be retained or discarded; discards may occur for regulatory or economic reasons.

**Catch**[1]

1. To undertake any activity that results in taking fish out of its environment dead or alive, or to bring fish on board a vessel dead or alive; 2. The total number (or weight) of fish caught by fishing operations. Catch should include all fish killed by the act of fishing, not just those landed; 3. The component of fish encountering fishing gear, which is retained by the gear.

Catch is usually expressed in terms of wet weight. It refers sometimes to the total amount caught and sometimes only to the amount landed. The fish which are not landed, but returned to the sea, are called discards or bycatch.

For recreational fishing activities, catch refers to the total number of individual fish released (thrown back into the sea) and harvested (not thrown back into the sea) by recreational fishermen (angler).

**Catch Share Program**[5]

This is a generic term used to describe a fishery management program that allocates a specific portion of the total fishery catch to individuals, cooperatives, communities, or other entities including sectors. The term encompasses more specific programs defined in legislation such as Limited Access Privilege Programs and Individual Fishing Quotas. Note that a catch share allocated to a sector is different than a general sectoral allocation or distribution to an entire segment of a fishery (such as a recreational sector allocation or a longline gear sector allocation) because the recipient of the catch share is responsible for terminating fishing activity when their specific share is reached.

**Coastal County**[6]

A coastal county meets one of the following criteria: 1) at least 15 percent of a county's total land area is located within the Nation's coastal watershed; or 2) a portion of or an entire county accounts for at least 15 percent of a coastal cataloging unit. Any U.S. county that meets these criteria is classified as coastal.

**Coastal County Angler**

For this report, a coastal county angler refers to a recreational fishermen who lives within a given state and within a coastal county of that state.

**Commercial Fishing Location Quotient (CFLQ)**

For this report, the CFLQ is calculated as the ratio of a state's distribution of employment in commercial fishing industries compared to the distribution of commercial fishing industries in the U.S. The CFLQ is calculated using the "Location Quotient Calculator" provided by the Bureau of Labor Statistics, U.S. Department of Labor.

**Community Development Quota Program (CDQ)**[1]

A program in western Alaska under which a percentage of the total allowable catch (TAC) of Bering Sea commercial fisheries is allocated to specific communities. Communities eligible for this program must be located within 50 miles of the Bering Sea coast, or on an island within the Bering Sea; meet criteria established by the State of Alaska; be a village certified by the Secretary of the Interior pursuant to the Alaska Native Claims Settlement Act; and consist of residents who conduct more than half of their current commercial or subsistence fishing in the Bering Sea or waters surrounding the Aleutian Islands. Currently 7.5% of the TAC in the pollock, halibut, sablefish, crab, and groundfish fisheries is allocated to the CDQ program.

**Dedicated Access Privileges (DAPs)**[7]

As defined by the U.S. Commission on Ocean Policy, a DAP program assigns an individual or other entity access to a pre-determined portion of the annual catch in a particular fishery. In some cases, the privilege is transferable and may be bought and sold, creating a market. The term encompasses a range of tools, including access privileges assigned to individuals (that is, individual transferable quotas), and to groups or communities (for example, community development quotas, cooperatives, and area-based quotas).

DAP programs are sometimes known as rights-based management, and are often synonymous with Limited Access Privilege Programs (see "Limited Access Privilege Program"). However, "rights-based management" implies granting an individual the "right" to fish. With the exception of certain tribes, U.S. fishermen do not have inalienable rights to fish because the fishery resources of the U.S. belong to all people of the U.S. Under current law, fishermen are granted a "privilege" to fish, subject to certain conditions.

**Discards**[1]

To release or return a fish or other species to the sea, dead or alive, whether or not such fish or other species are brought fully on board a fishing vessel.

Estimates of discards can be made in a variety of ways, including samples from observers and logbook records. Fish (or parts of fish) can be discarded for a variety of reasons such as having physical damage, being a non-target species for the trip, and compliance with management regulations like minimum size limits or quotas.

**Durable Equipment Expenditures or Durable Goods Expenditures**[8]

For this report, this term refers to expenses related to equipment used for recreational fishing activities. These expenses include the purchase of: semi-durable goods (tackle, rods, reels, line, etc.), durable goods (motor boats and accessories, non-motorized boats, boating electronics, mooring, boat storage, boat insurance, and vehicles or homes), and angling accessories and multi-purpose items (magazines, club dues, saltwater angling specific clothing and camping gear).

**Ecolabel or Ecolabelling Scheme**[9]

In fisheries, ecolabelling schemes entitle a fishery product to bear a distinctive logo or statement which certifies that the fish has been harvested in compliance with specified conservation and sustainability standards. The logo or statement is intended to make provision for informed decisions by purchasers whose choice may promote and stimulate the sustainable use of fishery resources.

**Economic Impact Model**[10] [11]

Economic impact models capture how sales in a sector generate economic impacts directly in the sector in which the sale was made and then ripple throughout the state and national economy as each dollar spent generates additional sales by other firms and consumers. The NMFS Commercial Fishing & Seafood Industry Input / Output Model uses an IMPLAN platform to estimate the economic impacts associated with the harvesting of fish by U.S. commercial fishermen and the other major components of the U.S. seafood industry. As used here, the term fish refers to the entire range of finfish, shellfish, and other life (that is, sea urchins, seaweed, kelp, and worms) from marine and freshwaters that are included in the landings data maintained by the National Marine Fisheries Service.

The NMFS Recreational Economic Impact Model, which also uses an IMPLAN platform, estimates the economic impacts generated by expenditures made by saltwater anglers.

**Economic Impacts**

For this report, the economic impacts of the commercial fishing sector and seafood industry refer to the employment (full-time and part-time jobs), personal income, and output (sales by U.S. businesses) generated by the commercial harvest sector and other major components of the U.S. seafood industry including: processors and dealers; wholesalers and distributors; grocers; and restaurants.

Economic impacts of recreational fishing activities refer to the amount of sales generated the number of jobs supported, and the contribution to gross domestic product by state (also known as value-added impacts) from expenditures related to recreational fishing.

**Effort**

For this report, effort refers to the number of fishing trips taken by recreational fishermen (anglers). The term can also refer to the amount of time and fishing power used to harvest fish in commercial fisheries, including gear size, boat size, and horsepower.

**Employee Compensation**[12]

This is related to Gross Domestic Product (GDP) by State and is an estimate of the sum of employee wages and salaries and supplements to wages and salaries. Wages and salaries are measured on an accrual, or "when earned" basis, which may be different from the measure of wages and salaries measured on a disbursement, or "when paid" basis. Wages and salaries and supplements of Federal military and civilian government employees stationed abroad are excluded from the measure of GDP by state.

**Employer Establishments**

An establishment is a single physical location at which business is conducted or services or industrial operations are performed. It is not necessarily identical with a company or enterprise, which may consist of one or more establishments. When two or more activities are carried on at a single location under a single ownership, all activities generally are grouped together as a single establishment. The entire establishment is classified on the basis of its major activity and all data are included in that classification.

**Endangered Species**[13,1]

As defined by the Endangered Species Act, an endangered species is any species which is in danger of extinction throughout all or a significant portion of its range. A species classified as threatened is likely to become an endangered species. See also "Threatened Species."

**Endangered Species Act (ESA)**[1,13]

The ESA is a statute which was enacted in 1973 to conserve species and ecosystems. Under its auspices, species facing possible extinction are listed as threatened or endangered, or as candidate species for such listings. When such a listing is made, recovery and conservation plans are drawn up to ensure the protection of the species and its habitat.

**Expenditures**

For this report, expenditures are related to recreational fishing activities and described as being one of two types: 1) expenditures related to a specific fishing trip; or 2) durable equipment expenditures.

**Ex-vessel**[1]

Refers to activities that occur when a commercial fishing boat lands or unloads a catch. For example, the price received by a captain (at the point of landing) for the catch is an ex-vessel price.

**Exclusive Economic Zone (EEZ)**[1]

The EEZ is the area that extends from the seaward boundaries of the coastal states to 200 nautical miles. The seaward boundary for most states is 3 nautical miles with the exceptions of Texas, Puerto Rico, and the Gulf Coast of Florida which is 9 nautical miles. The U.S. claims and exercises sovereign rights and exclusive fishery management authority over all fish and continental shelf resources through this 200 nautical mile boundary.

**Fish Stock**[1]

A fish stock refers to the living resources in the community or population from which catches are taken in a fishery. Use of the term fish stock usually implies that the particular population is more or less isolated from other stocks of the same species and hence self-sustaining. In a particular fishery, the fish stock may be one or several species of fish but here it is also intended to include commercial invertebrates and plants.

**Fish Stock Complex**[14]

A group of fish stocks or species with similar geographic distribution, co-occurrence in fisheries, and life history.

**Fishery Management Council (FMC) or Regional Fishery Management Council**[4,1]

A regional fisheries management body established by the Magnuson-Stevens Act to manage fishery resources in eight designated regions of the United States.

**Fishery Management Plan (FMP)**[1,4]

1. A document prepared under supervision of the appropriate fishery management council (FMC) for management of stocks of fish judged to be in need of management. The plan must generally be formally approved. An FMP includes data, analyses, and management measures; 2. A plan containing conservation and management measures for fishery resources, and other provisions required by the Magnuson-Stevens Act, developed by fishery management councils or the Secretary of Commerce.

**Fishing Cooperatives**[4]

A market-based fisheries management tool where access to fisheries resources is limited to a specific group of fishermen. See also "Catch Share Progam."

**Fishing Day**

For this report, a fishing day refers to a partial or full day spent recreational fishing and can be different than a fishing trip. For example, one fishing trip can consist of more than one fishing day. This term is used in the Alaska recreational fishing tables.

**Fishing Effort**[9]

The amount of fishing gear of a specific type used on the fishing grounds over a given unit of time. For example, hours trawled per day, number of hooks set per day, or number of hauls of a beach seine per day. When two or more kinds of gear are used, the respective efforts must be adjusted to some standard type before being added.

For recreational fishing activities, fishing effort refers to the number of participants (that is, recreational fishermen or anglers), who engage in recreational fishing activities.

**Fishing Mode**

For this report, fishing mode refers to the type of recreational fishing a recreational fisherman (angler) engaged in such as fishing from shore, a private or rental boat, or a for-hire boat.

**Fishing Trip**

For this report, a fishing trip refers to a recreational fishing excursion and can be different than a fishing day. For example, one fishing trip can consist of more than one fishing day. Fishing trips are classified as occurring in one of three fishing modes: 1) a shore-based fishing trip; 2) by a private or rental boat; or 3) on a for-hire fishing boat.

**For-hire Mode**

For this report, this fishing mode refers to trips taken by a recreational fishermen (angler) on a party (also referred to as a headboat) or charter boat.

**Gross Domestic Product (GDP) by State or Gross State Product (GSP)**[12]

Previously known as the Gross State Product, the GDP by state is the value added in production by the labor and capital located in a state. GDP for a state is derived as the sum of the GDP originating in all industries in the state.

**Harvest**[1]

The total number of weight or fish caught and kept from an area over a period of time. Note that landings, catch, and harvest are different.

For recreational fishing activities, harvest refers to the number of individual fish not thrown back into the sea by a recreational fishermen (angler), but includes fish thrown back dead in Hawaii and the Atlantic and Gulf states. See also "Catch" and "Release."

**Individual Fishing Quota (IFQ)**[1]

A type of limited entry, an allocation to an individual (a person or a legal entity, for example, a vessel owner or company) of a right [privilege] to harvest a certain amount of fish in a certain period of time. It is also often expressed as an individual share of an aggregate quota, or total allowable catch (TAC). See also "Individual Transferable Quota" and "Catch Share Program."

**Individual Transferable Quota (ITQ)**[1]

A type of individual fishing quota (IFQ) allocated to individual fishermen or vessel owners that can be transferred (sold or leased) to others. See also "Individual Transferable Quota."

**Industry Sector**

For this report, fishing- and marine-related industries were combined into industry sectors. Two industry sectors were included in this report: 1) seafood sales & processing, and 2) transport, support, & marine operations. Fishing-and marine-related industries were chosen from the County Business Patterns Data Series based on data availability and perceived relevance to fishing or marine activities. These industries were then combined into one of these two industry sectors.

**Key Species or Species Groups**

For this report, up to ten species or species groups were chosen as "key" species or species groups due to their regional importance to commercial and recreational fisheries. The regional importance of these key species or species groups was chosen based on their economic and/or historical significance to a state or region.

**Landings**[1]

1. The number or poundage of fish unloaded by commercial fishermen or brought to shore by recreational fishermen for personal use. Landings are reported at the locations at which fish are brought to shore; 2. The part of the catch that is selected and kept during the sorting procedures on board vessels and successively discharged at dockside.

**Limited Access Privilege Program (LAPP) or Limited Access Privilege System**[4]

As defined in the Magnuson-Stevens Act, Limited Access Privilege Programs limit participation in a fishery to those satisfying certain eligibility criteria or requirements contained in a fishery management plan or associated regulation. A limited access privilege is a Federal permit, issued as part of a limited access system, to harvest a quantity of fish expressed by a unit or units representing a portion of the total allowable catch of the fishery that may be received or held for exclusive use by a person. It includes an individual fishing quota (IFQ) or an individual tradable quota (ITQ) but does not include community development quotas (CDQs).

LAPPs are sometimes known as Dedicated Access Privileges or DAPs. However, unlike LAPPs, DAPs generally encompass community development quotas as well as individual fishing quotas (see "Dedicated Access Privileges"). LAPPs are a type of catch share program. See also "Catch Share Program."

**License Limitation Program or Limited Entry Program**[1]

A management tool available to fishery managers where the number of commercial fishermen or vessels licensed to participate in a fishery is legally restricted. A management agency often uses this management tool as a means of limiting entry into a fishery.

**Limited Entry Program**

Also known as a license limitation program; see "License Limitation Program."

**Location Quotient**[15]

Location Quotients (LQs) are ratios that allow an area's distribution of employment by industry to be compared to a reference or base area's distribution. The reference area is usually the U.S., but it can also be a state or a metropolitan area. The reference or base industry is usually the all industry total. The discussion below assumes the defaults are used. LQs also allow areas to be easily compared to each other. If an LQ is equal to 1, then the industry has the same share of its area employment as it does in the reference area. An LQ greater than 1 indicates an industry with a greater share of the local area employment than is the case in the reference area.

For example (assuming the U.S. as the reference area), Las Vegas will have an LQ greater than 1 in the Leisure and Hospitality industry because this industry makes up a larger share of the Las Vegas employment total than it does for the country as a whole. LQs are calculated by first dividing local industry employment by the all industry total of local employment. Second, reference area industry employment is divided by the all industry total for the reference area. Finally, the local ratio is divided by the reference area ratio.

**Magnuson-Stevens Fishery Conservation and Management Act or Magnuson-Stevens Act (MSA)**[1]

Federal legislation responsible for establishing the Regional Fishery Management Councils (FMCs) and the mandatory and discretionary guidelines for federal fishery management plans (FMPs). This legislation was originally enacted in 1976 as the Fishery Management and Conservation Act; its name was changed to the Magnuson Fishery Conservation and Management Act in 1980, and in 1996 it was renamed the Magnuson-Stevens Fishery Conservation and Management Act.

**Market-based Management**[16,4]

Market-based management is an umbrella term that encompasses approaches that provide economic incentives to protect fisheries from overharvest. These approaches are in contrast to conventional fisheries management approaches such as buyback programs and license limitation programs (see "Buyback Program" and "License Limitation Program"). One example of a market-based management approach for fisheries is a limited access privilege program (see "Limited Access Privilege Program") that includes an individual fishing quota. A limited access privilege program provides individual fishermen an exclusive, market-based share of a harvest quota or total allowable catch of a fishery.

**Marine Coastal County**

For this report, a marine coastal county is a coastal county that is adjacent to an ocean coastline. See also "Coastal County."

**Marine Economy**

For this report, the marine economy refers to the economic activity generated by fishing- and marine-related industries located in a coastal state. Fishing- and marine-related industries were chosen from industries characterized in the County Business Patterns Data Series provided by the U.S. Census Bureau. Industries listed in this report were chosen based on that industry's direct contribution to fishing and marine activities and whether data was available for that industry. Information

such as the number of establishments and employees, and annual payroll for these fishing- and marine-related industries was used to characterize their relative levels of economic activity in a state. These industries were categories into one of two industry sectors: 1) seafood sales & processing, and 2) transport, support, & marine operations. See also "Industry Sector."

**Non-coastal County Angler**

For this report, a non-coastal county angler refers to a recreational fisherman who lives within a given state but not in a coastal county of that state.

**Nonemployer Firms**

A nonemployer business is one that has no paid employees, has annual business receipts of $1,000 or more ($1 or more in the construction industries), and is subject to federal income taxes. Most nonemployers are self-employed individuals operating very small unincorporated businesses which may or may not be the owner's principal source of income.

**Non-resident**

For this report, a non-resident in the U.S. table refers to a recreational fisherman (angler) who resides outside of the U.S; a non-resident in the regional and state tables refers to an angler who did not reside in the state where they fished.

**Out-of-state Angler**

For this report, an out-of-state angler is a recreational fisherman (angler) who does not reside within a given coastal state.

**Overcapacity**

Overcapacity refers to a situation where the harvesting capability within a given fishery exceeds the level of harvest allowed for that fishery.

**Overcapitalization**[9]

When the amount of harvesting capacity in a fishery exceeds the amount needed to harvest the desired amount of fish at least cost.

**Overfished**[1]

1. An overfished stock or stock complex "whose size is sufficiently small that a change in management practices is required to achieve an appropriate level and rate of rebuilding." A stock or stock complex is considered overfished when its population size falls below the minimum stock size threshold (MSST). A rebuilding plan is required for stocks that are deemed overfished; 2. A stock is considered "overfished" when exploited beyond an explicit limit beyond which its abundance is considered 'too low' to ensure safe reproduction. In many fisheries the term is used when biomass has been estimated to be below a limit biological reference point that is used as the signpost defining an "overfished condition."

**Overfishing**[1]

1. According to the National Standard Guidelines, "overfishing occurs whenever a stock or stock complex is subjected to a rate or level of fishing mortality that jeopardizes the capacity of a stock or stock complex to produce maximum sustainable yield (MSY) on a continuing basis." Overfishing is occurring if the maximum fishing mortality threshold (MFMT) is exceeded for 1 year or more; 2. In general, the action of exerting fishing pressure (fishing intensity) beyond the agreed optimum level. A reduction of fishing pressure would, in the medium term, lead to an increase in the total catch.

**Protected Species**[1]

Refers to any species which is protected by either the Endangered Species Act (ESA) or the Marine Mammal Protection Act (MMPA), and which is under the jurisdiction of NOAA Fisheries (NMFS). This includes all threatened, endangered, and candidate species, as well as all cetaceans and pinnipeds, excluding walruses.

**Regional Fishery Management Council or Fishery Management Council (FMC)**[4]

The Magnuson-Stevens Act established eight Regional Fishery Management Councils around the United States. Each Council consists of voting and non-voting members who represent various federal, state, and tribal government, fishing industry groups (commercial and/or recreational), and non-fishing groups (such as environmental organizations and academic institutions). Each Council is tasked with creating fishery management plans for important fisheries within their regions.

**Release**

For this report, release refers to the number of individual fish caught by a recreational fisherman (angler) that are then returned to the sea (dead or alive). In Hawaii and the Atlantic and Gulf states, release does not include fish returned to the sea that are dead. See also "Catch" and "Harvest".

**Resident**

For this report, a resident in the U.S. table refers to a recreational fisherman (angler) who resides inside of the U.S; a resident in the regional and state tables refers to an angler who resides in the state where they fished.

**Sector Allocation Program**[17]

A fisheries management tool where a group of fishermen are allocated a quota or share of a total allowable catch, in accordance with an approved plan. It is considered a type of catch share program. See also "Catch Share Program."

**Species**[1]

A group of animals or plants having common characteristics that are able to breed together to produce fertile (capable of reproducing) offspring and maintain their "separateness" from other groups.

**Species Group**[1]

Group of species considered together often because they are difficult to differentiate without detailed examination (very similar species) or because data for the separate species are not available (for example, in fishery statistics or commercial categories).

**Threatened Species**[13]

As defined by the Endangered Species Act, a threatened species is any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range. See also "Endangered Species."

**Trip Expenditures**

For this report, trip expenditures refer to expenses incurred by recreational fishermen (anglers) on a fishing trip. Trip expenditures are described for residents (individuals who reside in a coastal or non-coastal county within a given state; a U.S. resident) and non-residents (individuals who do not reside within the U.S.).

**Value-added**[1]

A firm's sales minus the cost of the goods and services it purchases from other industries to produce its outputs.

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# Notes

[1]NOAA Fisheries Glossary. October 2005. K. Blackhart, D.G. Stanton, and A.M. Shimada, eds. Revised edition, June 2006. National Marine Fisheries Service (NOAA Fisheries), National Oceanic & Atmospheric Administration, U.S. Department of Commerce. NOAA Technical Memorandum NMFS-F/SPO-69. Available at: http://www.st.nmfs.gov/st4/documents/F_Glossary.pdf[accessed 14 July 2009].

[2]CBP Definitions." County Business Patterns, U.S. Census Bureau, U.S. Department of Commerce. Available at: http://www.census.gov/epcd/cbp/view/genexpl.html/[accessed 14 July 2009/]

[3]Nonemployer Definitions." Nonemployer Statistics, U.S. Census Bureau, U.S. Department of Commerce. Available at: http://www.census.gov/epcd/nonemployer/view/define.html/[accessed 14 July 2009].

[4]Magnuson-Stevens Fishery Conservation and Management Act, as amended through January 12, 2007. (P.L. 94-265, as amended through P.L. 109-479). Available at: http://www.nmfs.noaa.gov/msa2007/docs/act_draft.pdf[accessed 14 July 2009].

[5]What is a Catch Share? Office of Sustainable Fisheries, National Marine Fisheries Service (NOAA Fisheries), National Oceanic & Atmospheric Administration, U.S. Department of Commerce. Available at: http://www.nmfs.noaa.gov/sfa/domes_fish/catchshare/index.htm/[accessed 14 July 2009].

[6]"Coastal Counties." U.S. Census Bureau, U.S. Department of Commerce. Available at: http://www.census.gov/geo/landview/lv6help/coastal_cty.html [accessed 14 July 2009].

[7]Pages 288-289 in: An Ocean Blueprint for the 21st Century, Final Report. 2004. U.S. Commission on Ocean Policy. Washington, D.C. Available at: http://www.oceancommission.gov[accessed14July2009].

[8]Page 4 in: The Economic Contribution of Marine Angler Expenditures in the United States, 2006. 2008. B. Gentner and S. Steinback. National Marine Fisheries Service (NOAA Fisheries), National Oceanic & Atmospheric Administration, U.S. Department of Commerce. NOAA Tech. Memo. NMFS-F/SPO-94. Available at: http://www.st.nmfs.noaa.gov/st5/publication/marine_angler.html[accessed 14 July 2009].

[9]"Fisheries Glossary." FAO Fisheries Department, United Nations Food & Agriculture Organization. Available at: http://www.fao.org/fi/glossary/default.asp[accessed 14 July 2009].

[10]The NMFS Commercial Fishing and Seafood Industry Input/Output Model (CFSI I/O Model). August 2009. J. Kirkley. Virginia Institute of Marine Science. Available at: http://www.st.nmfs.noaa.gov/st5/publication/marine_angler.html [accessed 14 July 2009].

[11]Pages 11-12 in: The Economic Contribution of Marine Angler Expenditures in the United States, 2006. November 2008. B. Gentner and S. Steinback. National Marine Fisheries Service (NOAA Fisheries), National Oceanic & Atmospheric Administration, U.S. Dept. of Commerce. NOAA Technical Memorandum NMFS-F/SPO-94, 301p. Available at: https://www.st.nmfs.noaa.gov/documents/Commercial\%20Fishing\%20IO\%20Model.pdf[accessed 15 September 2010].

[12]"Regional Definitions." Regional Economic Accounts, Bureau of Economic Analysis, U.S. Department of Commerce. Available at: http://www.bea.gov/regional/definitions[accessed 14 July 2009].

[13]Endangered Species Act of 1973 (P.L. 93-205, as amended through P.L. 100-707). Available at: http://www.nmfs.noaa.gov/pr/laws/esa/[accessed 14 July 2009].

[14]"Status of U.S. Fisheries." Office of Sustainable Fisheries, National Marine Fisheries Service (NOAA Fisheries), National Oceanic & Atmospheric Administration, U.S. Department of Commerce. Available at: http://www.nmfs.noaa.gov/sfa/statusoffisheries/SOSmain.htm[accessed 16 March 2009].

[15]Location Quotient Calculator. Bureau of Labor Statistics, U.S. Department of Labor. Available at: http://data.bls.gov/help/def/lq.htm\#location_quotient_application[accessed 14 July 2009].

[16]Market-based Management. In Fisheries Management: Building a Sustainable Future for America's Fisheries. National Oceanic & Atmospheric Administration, U.S. Department of Commerce. Available at: http://celebrating200years.noaa.gov/visions/fisheries/welcome.html\#impl[accessed 14 July 2009].

[17]Sector Allocation as a Management Tool. Northeast Sea Grant. Available at: http://seagrant.gso.uri.edu/fisheries/sector_allocation/index.html[accessed 14 July 2009].

### 2011 Economic Impacts of Recreational Fishing Expenditures (thousands of dollars)

| | Jobs | Sales | Income | Value Added |
|---|---|---|---|---|
| Trip Impacts by Fishing Mode: | | | | |
| For-Hire | 17,980 | 2,469,877 | 965,119 | 1,496,114 |
| Private Boat | 25,875 | 4,428,470 | 1,269,265 | 2,234,379 |
| Shore | 22,554 | 3,413,178 | 1,009,950 | 1,741,371 |
| Total Durable Equipment Impacts | 297,523 | 45,531,495 | 14,932,624 | 23,628,826 |
| **Total State Trip and Durable Equipment Economic Impacts** | 363,932 | 55,843,020 | 18,176,957 | 29,100,691 |

### 2011 Angler Trip & Durable Expenditures (thousands of dollars)[1]

| Fishing Mode | Trip Expenditures | | Equipment | Durable Expenditures |
|---|---|---|---|---|
| | Non-Residents | Residents | Fishing Tackle | 3,567,112 |
| For-Hire | NA | 1,018,353 | Other Equipment | 1,420,821 |
| Private Boat | NA | 1,973,440 | Boat Expenses | 9,637,542 |
| Shore | NA | 1,454,621 | Vehicle Expenses | 2,438,547 |
| *total* | NA | 4,446,414 | Second Home Expenses | 1,891,146 |
| | | | *Total Durable Equipment Expenditures* | 18,955,168 |
| **Total State Trip and Durable Equipment Expenditures** | | | | 23,401,582 |

### Recreational Anglers by Residential Area (thousands of anglers)[2]

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal | 8,608 | 10,434 | 10,199 | 11,330 | 11,644 | 12,389 | 10,725 | 9,408 | 9,557 | 9,183 |
| Non-Coastal | 1,372 | 1,562 | 1,579 | 1,492 | 1,685 | 1,616 | 1,591 | 1,747 | 1,502 | 1,428 |
| **Total Anglers** | 9,981 | 11,996 | 11,779 | 12,822 | 13,329 | 14,005 | 12,316 | 11,155 | 11,059 | 10,611 |

### Recreational Fishing Effort by Mode (thousands of angler-trips)[2]

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| For-Hire | 3,197 | 3,244 | 3,424 | 3,524 | 3,734 | 4,173 | 3,416 | 3,281 | 2,597 | 3,179 |
| Private | 38,525 | 45,013 | 44,007 | 43,249 | 42,719 | 46,465 | 44,912 | 37,647 | 37,760 | 35,321 |
| Shore | 30,437 | 36,199 | 38,015 | 37,345 | 38,694 | 37,021 | 37,220 | 33,631 | 32,107 | 31,694 |
| **Total Trips** | 72,159 | 84,456 | 85,446 | 84,118 | 85,147 | 87,659 | 85,548 | 74,559 | 72,464 | 70,194 |

### Harvest (H) and Release (R) of Key Species Species Groups (thousands of fish)[3]

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Drum (Atlantic croaker and spot) | H | 17,836 | 20,879 | 19,793 | 20,352 | 22,936 | 26,567 | 24,020 | 15,762 | 13,355 | 13,319 |
| | R | 16,436 | 18,203 | 17,821 | 23,760 | 19,371 | 21,365 | 24,974 | 20,374 | 15,981 | 18,092 |
| Drum (seatrouts) | H | 13,943 | 15,228 | 16,947 | 16,095 | 18,903 | 17,559 | 21,081 | 20,187 | 16,743 | 22,234 |
| | R | 22,458 | 25,552 | 27,214 | 30,632 | 30,351 | 28,970 | 32,349 | 25,807 | 23,936 | 28,649 |
| Little tunny & Atlantic bonito [4] | H | 321 | 254 | 405 | 179 | 313 | 293 | 204 | 231 | 190 | 281 |
| | R | 1,020 | 865 | 1,099 | 464 | 868 | 1,221 | 725 | 807 | 597 | 703 |
| Pacific halibut | H | 351 | 403 | 483 | 500 | 463 | 585 | 516 | 440 | 398 | 394 |
| | R | 233 | 290 | 369 | 380 | 353 | 438 | 359 | 321 | 304 | 311 |
| Rockfishes & scorpionfishes | H | 2,856 | 3,742 | 2,593 | 3,617 | 2,677 | 2,454 | 2,068 | 2,199 | NA | NA |
| | R | 1,065 | 1,796 | 977 | 1,347 | 895 | 691 | 636 | 836 | NA | NA |
| Salmon | H | 1,321 | 1,626 | 1,569 | 1,481 | 873 | 1,286 | 722 | 1,574 | NA | NA |
| | R | 692 | 881 | 1,010 | 844 | 513 | 710 | 375 | 659 | NA | NA |
| Sharks[5] | H | 156 | 168 | 148 | 203 | 131 | 144 | 108 | 126 | 157 | 104 |
| | R | 2,076 | 2,796 | 3,052 | 3,983 | 3,507 | 3,954 | 4,134 | 3,980 | 4,012 | 2,574 |
| Striped bass | H | 1,891 | 2,579 | 2,617 | 2,488 | 2,740 | 2,438 | 2,341 | 1,990 | 1,973 | 2,249 |
| | R | 13,971 | 14,996 | 17,480 | 18,227 | 23,415 | 16,218 | 12,695 | 8,120 | 6,355 | 6,174 |
| Summer flounder | H | 3,280 | 4,574 | 4,389 | 4,107 | 4,034 | 3,105 | 2,363 | 1,829 | 1,509 | 1,844 |
| | R | 13,417 | 15,974 | 16,055 | 21,869 | 17,511 | 17,627 | 20,547 | 22,297 | 22,230 | 19,723 |
| Tunas (large Atlantic species) [6] | H | 428 | 889 | 772 | 667 | 566 | 729 | 799 | 530 | 594 | 421 |
| | R | 28 | 112 | 132 | 109 | 135 | 95 | 87 | 53 | 51 | 69 |

[1] All anglers reported in this table are U.S. residents; NA = not applicable

[2] Information was included for all states but Alaska and Texas. Most information was provided by the Marine Recreational Information Program (MRIP). Pacific data were provided by the Pacific states and Hawaii data were not included from 2000 to 2002.

[3] This table excludes all Texas data and Hawaii data for 2002.

[4] This species may not be equivalent to species with similar names listed in the commercial tables.

[5] Sharks include species within the requiem shark family, blacktip sharks, Atlantic sharpnose sharks, and unidentified sharks.

[6] Includes all tunas in the thunnus family.

# North Pacific

## - Alaska

### 2011 Economic Impacts of Recreational Fishing Expenditures (thousands of dollars)[1]

| | Jobs | Sales | Income | Value Added |
|---|---|---|---|---|
| Trip Impacts by Fishing Mode: | | | | |
| For-Hire | 1,989 | 207,669 | 95,427 | 141,636 |
| Private Boat | 978 | 129,233 | 37,981 | 65,766 |
| Shore | 139 | 16,996 | 5,221 | 8,824 |
| Total Durable Equipment Impacts | 1,144 | 128,830 | 52,480 | 82,964 |
| **Total State Trip and Durable Equipment Economic Impacts** | 4,250 | 482,728 | 191,109 | 299,190 |

### 2011 Angler Trip & Durable Expenditures (thousands of dollars)

| Fishing Mode | Trip Expenditures | | Equipment | Durable Expenditures |
|---|---|---|---|---|
| | Non-Residents | Residents | Fishing Tackle | 23,279 |
| For-Hire | 118,820 | 19,267 | Other Equipment | 20,448 |
| Private Boat | 57,226 | 49,526 | Boat Expenses | 81,477 |
| Shore | 9,396 | 3,904 | Vehicle Expenses | 1,865 |
| *Total Trip Expenditures* | 185,442 | 72,697 | Second Home Expenses | 2,150 |
| | | | *Total Durable Equipment Expenditures* | 129,219 |
| **Total State Trip and Durable Equipment Expenditures** | | | | 387,359 |

### Recreational Anglers by Residential Area (thousands of anglers)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Out of State | 162 | 170 | 193 | 207 | 197 | 205 | 190 | 158 | 159 | 161 |
| In State | 113 | 129 | 130 | 127 | 120 | 127 | 119 | 127 | 122 | 124 |
| **Total Anglers** | 275 | 299 | 323 | 334 | 317 | 332 | 309 | 284 | 281 | 286 |

### Recreational Fishing Effort by Mode (thousands of days)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Total Days Fished** | 855 | 868 | 1,007 | 1,054 | 941 | 1,052 | 935 | 914 | 811 | 811 |

### Harvest (H) and Release (R) of Key Species Species Groups (thousands of fish)[2,3]

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Chinook salmon | H | 89 | 96 | 110 | 116 | 117 | 110 | 71 | 89 | 78 | 85 |
| | R | 104 | 105 | 124 | 127 | 104 | 110 | 80 | 96 | 66 | 95 |
| Chum salmon | H | 14 | 23 | 24 | 17 | 14 | 18 | 12 | 22 | 11 | 21 |
| | R | 31 | 51 | 61 | 42 | 34 | 34 | 28 | 34 | 19 | 38 |
| Coho salmon | H | 497 | 537 | 560 | 695 | 395 | 506 | 403 | 418 | 350 | 386 |
| | R | 136 | 156 | 193 | 191 | 107 | 122 | 89 | 94 | 74 | 88 |
| Greenlings (lingcod) | H | 20 | 22 | 31 | 38 | 35 | 42 | 37 | 32 | 32 | 33 |
| | R | 43 | 44 | 52 | 67 | 53 | 70 | 65 | 46 | 39 | 36 |
| Pacific halibut | H | 351 | 403 | 483 | 500 | 463 | 585 | 516 | 440 | 398 | 394 |
| | R | 233 | 290 | 369 | 380 | 353 | 438 | 359 | 321 | 304 | 311 |
| Pink salmon | H | 114 | 111 | 132 | 149 | 65 | 133 | 88 | 117 | 82 | 72 |
| | R | 194 | 291 | 297 | 343 | 167 | 280 | 151 | 224 | 121 | 135 |
| Razor clam | H | 789 | 590 | 551 | 451 | 483 | 389 | 593 | 556 | 357 | 436 |
| | R | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Rockfish | H | 120 | 118 | 180 | 184 | 173 | 198 | 226 | 209 | 224 | 211 |
| | R | 135 | 132 | 227 | 199 | 165 | 178 | 171 | 149 | 151 | 122 |
| Sockeye salmon | H | 24 | 29 | 24 | 27 | 21 | 32 | 29 | 34 | 28 | 31 |
| | R | 14 | 14 | 10 | 11 | 7 | 21 | 10 | 10 | 6 | 10 |

[1] Data reported in this table is includes saltwater fishing activities only.

[2] Information reported in this table is from the Sport Fish Division of the Alaska Department of Fish and Game (ADF&G) and includes saltwater fishing activities only

[3] In this table, '(1)' = 0-999 fish.

# Pacific

- California
- Oregon
- Washington

### 2011 Economic Impacts of Recreational Fishing Expenditures (thousands of dollars)

| | Trips | Jobs | Sales | Income | Value Added |
|---|---|---|---|---|---|
| California | 4,288,000 | 10,111 | 1,430,919 | 526,496 | 843,652 |
| Oregon | 655,000 | 2,799 | 308,602 | 119,662 | 188,069 |
| Washington | 1,162,000 | 5,093 | 653,972 | 246,678 | 389,952 |

### 2011 Angler Trip & Durable Expenditures (thousands of dollars)

| Fishing Mode | Trip Expenditures | | Equipment | Durable Expenditures |
|---|---|---|---|---|
| | Non-Residents | Residents | Fishing Tackle | 296,568 |
| For-Hire | 25,890 | 120,039 | Other Equipment | 130,300 |
| Private Boat | 6,098 | 181,531 | Boat Expenses | 509,965 |
| Shore | 4,066 | 215,352 | Vehicle Expenses | 142,344 |
| *Total Trip Expenditures* | 36,055 | 516,922 | Second Home Expenses | 5,574 |
| | | | *Total Durable Equipment Expenditures* | 1,084,750 |
| **Total State Trip and Durable Equipment Expenditures** | | | | 1,637,727 |

### Recreational Anglers by Residential Area (thousands of anglers)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal | 1,463 | 1,437 | 1,168 | 1,028 | 1,257 | 1,184 | 1,065 | 1,136 | 1,047 | 1,069 |
| Non-Coastal | 559 | 538 | 429 | 409 | 481 | 379 | 385 | 638 | 384 | 390 |
| Out-of-State | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| **Total Anglers** | 2,022 | 1,975 | 1,597 | 1,437 | 1,738 | 1,563 | 1,450 | 1,774 | 1,431 | 1,459 |

### Recreational Fishing Effort by Mode (thousands of angler-trips)[2]

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| For-Hire | 695 | 619 | 649 | 624 | 635 | 605 | 514 | 492 | 455 | 654 |
| Private Boat | 3,990 | 4,247 | 1,752 | 1,849 | 1,761 | 1,828 | 1,421 | 1,471 | 1,432 | 1,659 |
| Shore | 3,507 | 3,445 | 4,255 | 3,962 | 4,548 | 3,818 | 3,846 | 4,345 | 3,739 | 3,792 |
| **Total Trips** | 8,192 | 8,311 | 6,656 | 6,435 | 6,944 | 6,251 | 5,781 | 6,308 | 5,626 | 6,105 |

### Harvest (H) and Release (R) of Key Species Species Groups (thousands of fish)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Albacore & other tunas | H | 116 | 168 | 80 | 23 | 45 | 106 | 51 | 80 | NA | NA |
| | R | 6 | 83 | 10 | 2 | 4 | 7 | 0 | 13 | NA | NA |
| Barracuda, bass & bonito | H | 1,965 | 1,888 | 2,126 | 1,015 | 668 | 537 | 434 | 412 | NA | NA |
| | R | 4,427 | 3,727 | 2,597 | 2,011 | 1,660 | 1,407 | 1,093 | 1,211 | NA | NA |
| Croakers | H | 1,513 | 758 | 619 | 572 | 456 | 427 | 321 | 427 | NA | NA |
| | R | 1,016 | 871 | 660 | 618 | 553 | 631 | 272 | 362 | NA | NA |
| Flatfishes | H | 1,209 | 680 | 499 | 560 | 325 | 260 | 344 | 329 | NA | NA |
| | R | 2,061 | 948 | 343 | 513 | 520 | 338 | 361 | 297 | NA | NA |
| Greenlings | H | 454 | 512 | 210 | 270 | 236 | 194 | 171 | 190 | NA | NA |
| | R | 958 | 858 | 342 | 281 | 207 | 151 | 139 | 192 | NA | NA |
| Mackerel | H | 800 | 918 | 945 | 1,023 | 1,158 | 823 | 940 | 753 | NA | NA |
| | R | 1,730 | 2,011 | 1,715 | 1,872 | 3,287 | 1,209 | 1,765 | 1,267 | NA | NA |
| Rockfishes & scorpionfishes | H | 2,736 | 3,624 | 2,413 | 3,433 | 2,504 | 2,256 | 1,842 | 1,990 | NA | NA |
| | R | 930 | 1,664 | 750 | 1,148 | 730 | 513 | 465 | 687 | NA | NA |
| Salmon | H | 598 | 853 | 744 | 494 | 275 | 505 | 131 | 916 | NA | NA |
| | R | 244 | 314 | 386 | 171 | 127 | 177 | 45 | 235 | NA | NA |
| Sculpins | H | 116 | 110 | 78 | 78 | 61 | 54 | 65 | 64 | NA | NA |
| | R | 403 | 291 | 240 | 232 | 216 | 202 | 222 | 194 | NA | NA |
| Surfperches | H | 829 | 1,143 | 1,301 | 949 | 1,168 | 865 | 836 | 756 | NA | NA |
| | R | 728 | 1,175 | 1,556 | 1,237 | 1,670 | 856 | 812 | 701 | NA | NA |

[1] NA = data are not available because out-of-state resident information is collected for individual states but whether an angler is a resident of a region is not specified

[2] Due to changes in data collection methods, the Pacific Region's effort (number of trips) and catch (number of fish harvested or released) estimates for 2001-2003 are not comparable to the 2004-2009 estimates.

### 2011 Economic Impacts of Recreational Fishing Expenditures (thousands of dollars)

| | Jobs | Sales | Income | Value Added |
|---|---|---|---|---|
| Trip Impacts by Fishing Mode: | | | | |
| For-Hire | 1,541 | 220,188 | 93,987 | 142,238 |
| Private Boat | 695 | 122,078 | 37,665 | 63,970 |
| Shore | 1,871 | 290,755 | 90,993 | 153,195 |
| Total Durable Equipment Impacts | 6,003 | 797,898 | 303,851 | 484,249 |
| **Total State Trip and Durable Equipment Economic Impacts** | 10,111 | 1,430,919 | 526,496 | 843,652 |

### 2011 Angler Trip & Durable Expenditures (thousands of dollars)

| Fishing Mode | Trip Expenditures | | Equipment | Durable Expenditures |
|---|---|---|---|---|
| | Non-Residents | Residents | Fishing Tackle | 184,045 |
| For-Hire | 23,217 | 98,751 | Other Equipment | 78,229 |
| Private Boat | 1,615 | 76,737 | Boat Expenses | 180,119 |
| Shore | 2,256 | 185,592 | Vehicle Expenses | 89,508 |
| *Total Trip Expenditures* | 27,088 | 361,080 | Second Home Expenses | 3,324 |
| | | | *Total Durable Equipment Expenditures* | 535,224 |
| **Total State Trip and Durable Equipment Expenditures** | | | | 923,392 |

### Recreational Anglers by Residential Area (thousands of anglers)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal | 1110 | 1113 | 865 | 740 | 991 | 878 | 819 | 888 | 803 | 714 |
| Non-Coastal | 379 | 378 | 280 | 263 | 335 | 226 | 246 | 490 | 241 | 238 |
| Out of State | 111 | 115 | 98 | 79 | 109 | 65 | 83 | 71 | 69 | 93 |
| **Total Anglers** | 1600 | 1606 | 1243 | 1082 | 1435 | 1168 | 1148 | 1449 | 1113 | 1045 |

### Recreational Fishing Effort by Mode (thousands of angler-trips)[1]

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| For-Hire | 569 | 483 | 521 | 504 | 522 | 489 | 424 | 385 | 357 | 560 |
| Private | 2,905 | 3,117 | 708 | 902 | 896 | 768 | 640 | 676 | 655 | 682 |
| Shore | 2,501 | 2,699 | 3,509 | 3,216 | 3,802 | 3,072 | 3,100 | 3,599 | 2,993 | 3,046 |
| **Total Trips** | 5,975 | 6,299 | 4,738 | 4,622 | 5,220 | 4,329 | 4,164 | 4,660 | 4,005 | 4,288 |

### Harvest (H) and Release (R) of Key Species Species Groups (thousands of fish)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Albacore & other tunas | H | 107 | 146 | 49 | 6 | 9 | 22 | 5 | 13 | NA | NA |
| | R | 6 | 83 | 10 | 2 | 3 | 7 | (1) | 13 | NA | NA |
| Barracuda, bass & bonito [2] | H | 1,965 | 1,888 | 2,126 | 1,015 | 668 | 537 | 434 | 412 | NA | NA |
| | R | 4,427 | 3,727 | 2,597 | 2,011 | 1,660 | 1,407 | 1,093 | 1,211 | NA | NA |
| Croakers | H | 1,513 | 758 | 619 | 572 | 456 | 427 | 321 | 427 | NA | NA |
| | R | 1,016 | 871 | 660 | 618 | 553 | 631 | 272 | 362 | NA | NA |
| Flatfishes | H | 962 | 603 | 410 | 478 | 241 | 187 | 276 | 258 | NA | NA |
| | R | 1,844 | 850 | 295 | 465 | 471 | 292 | 313 | 241 | NA | NA |
| Greenlings | H | 215 | 357 | 72 | 125 | 104 | 69 | 48 | 64 | NA | NA |
| | R | 641 | 717 | 239 | 179 | 113 | 67 | 53 | 83 | NA | NA |
| Mackerel | H | 800 | 918 | 945 | 1,023 | 1,158 | 823 | 940 | 753 | NA | NA |
| | R | 1,730 | 2,011 | 1,715 | 1,872 | 3,287 | 1,209 | 1,765 | 1,267 | NA | NA |
| Rockfishes & scorpionfishes | H | 2,116 | 3,035 | 1,778 | 2,725 | 1,891 | 1,674 | 1,318 | 1,383 | NA | NA |
| | R | 844 | 1,621 | 701 | 1,058 | 668 | 456 | 402 | 605 | NA | NA |
| Salmon | H | 201 | 109 | 256 | 167 | 119 | 59 | (1) | 1 | NA | NA |
| | R | 40 | 39 | 103 | 71 | 74 | 36 | (1) | (1) | NA | NA |
| Sculpins | H | 60 | 70 | 41 | 39 | 25 | 19 | 29 | 27 | NA | NA |
| | R | 184 | 140 | 98 | 87 | 74 | 58 | 78 | 50 | NA | NA |
| Surfperches | H | 586 | 878 | 1,046 | 694 | 913 | 610 | 581 | 501 | NA | NA |
| | R | 563 | 1,016 | 1,402 | 1,083 | 1,516 | 702 | 658 | 546 | NA | NA |

[1] Due to changes in data collection methods, California's participation (number of anglers), effort(number of trips), and catch (number of fish harvested or released) estimates for 2001-2003 are not comparable to 2004-2009 estimates.

[2] This species may not be equivalent to species with similar names listed in the commercial tables.

### 2011 Economic Impacts of Recreational Fishing Expenditures (thousands of dollars)

| | Jobs | Sales | Income | Value Added |
|---|---|---|---|---|
| Trip Impacts by Fishing Mode: | | | | |
| For-Hire | 141 | 16,740 | 7,728 | 11,533 |
| Private Boat | 313 | 36,999 | 12,647 | 21,671 |
| Shore | 110 | 12,593 | 4,214 | 7,226 |
| Total Durable Equipment Impacts | 2,234 | 242,270 | 95,073 | 147,639 |
| **Total State Trip and Durable Equipment Economic Impacts** | 2,799 | 308,602 | 119,662 | 188,069 |

### 2011 Angler Trip & Durable Expenditures (thousands of dollars)

| Fishing Mode | Trip Expenditures | | Equipment | Durable Expenditures |
|---|---|---|---|---|
| | Non-Residents | Residents | Fishing Tackle | 42,544 |
| For-Hire | 615 | 10,009 | Other Equipment | 20,977 |
| Private Boat | 2,384 | 30,271 | Boat Expenses | 111,684 |
| Shore | 1,129 | 9,703 | Vehicle Expenses | 23,534 |
| *Total Trip Expenditures* | 4,128 | 49,984 | Second Home Expenses | 1,154 |
| | | | *Total Durable Equipment Expenditures* | 199,892 |
| **Total State Trip and Durable Equipment Expenditures** | | | | 254,004 |

### Recreational Anglers by Residential Area (thousands of anglers)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal | 101 | 91 | 90 | 87 | 82 | 86 | 79 | 85 | 82 | 81 |
| Non-Coastal | 153 | 135 | 125 | 123 | 125 | 130 | 120 | 128 | 124 | 122 |
| Out of State | 21 | 15 | 16 | 14 | 15 | 15 | 14 | 15 | 14 | 14 |
| **Total Anglers** | 275 | 242 | 231 | 224 | 222 | 231 | 213 | 228 | 221 | 217 |

### Recreational Fishing Effort by Mode (thousands of angler-trips)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| For-Hire | 67 | 67 | 64 | 58 | 56 | 61 | 48 | 56 | 51 | 52 |
| Private | 448 | 426 | 426 | 382 | 373 | 399 | 353 | 396 | 378 | 370 |
| Shore | 295 | 233 | 233 | 233 | 233 | 233 | 233 | 233 | 233 | 233 |
| **Total Trips** | 810 | 726 | 723 | 673 | 662 | 693 | 634 | 685 | 662 | 655 |

### Harvest (H) and Release (R) of Key Species Species Groups (thousands of fish)[1]

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Albacore tuna | H | 3 | 11 | 17 | 5 | 12 | 59 | 24 | 43 | NA | NA |
| | R | (1) | (1) | (1) | (1) | (1) | (1) | (1) | (1) | NA | NA |
| Baitfishes | H | 772 | 320 | 322 | 320 | 320 | 320 | 320 | 320 | NA | NA |
| | R | 21 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | NA | NA |
| Flatfishes | H | 31 | 15 | 27 | 21 | 21 | 22 | 21 | 17 | NA | NA |
| | R | 8 | 6 | 7 | 7 | 7 | 6 | 8 | 9 | NA | NA |
| Greenlings | H | 154 | 96 | 99 | 106 | 99 | 97 | 94 | 92 | NA | NA |
| | R | 176 | 77 | 78 | 77 | 72 | 65 | 67 | 70 | NA | NA |
| Rockfishes | H | 383 | 405 | 379 | 401 | 331 | 322 | 308 | 362 | NA | NA |
| | R | 36 | 23 | 24 | 57 | 39 | 38 | 47 | 49 | NA | NA |
| Salmon | H | 118 | 235 | 186 | 61 | 37 | 92 | 28 | 157 | NA | NA |
| | R | 67 | 146 | 148 | 23 | 16 | 55 | 16 | 120 | NA | NA |
| Sculpins | H | 21 | 23 | 20 | 22 | 20 | 20 | 21 | 21 | NA | NA |
| | R | 77 | 50 | 51 | 54 | 51 | 53 | 53 | 53 | NA | NA |
| Sturgeon | H | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | NA | NA |
| | R | 27 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | NA | NA |
| Surfperches | H | 139 | 122 | 122 | 122 | 122 | 122 | 122 | 122 | NA | NA |
| | R | 60 | 34 | 34 | 34 | 34 | 34 | 34 | 34 | NA | NA |

[1] In this table, '(1)' = 0-999 thousand fish and '1' = 1,000-1,499 thousand fish.

### 2011 Economic Impacts of Recreational Fishing Expenditures (thousands of dollars)

| | Jobs | Sales | Income | Value Added |
|---|---|---|---|---|
| Trip Impacts by Fishing Mode: | | | | |
| For-Hire | 167 | 22,366 | 9,738 | 14,655 |
| Private Boat | 676 | 105,692 | 32,323 | 55,316 |
| Shore | 202 | 28,336 | 8,796 | 14,823 |
| Total Durable Equipment Impacts | 4,048 | 497,578 | 195,821 | 305,158 |
| **Total State Trip and Durable Equipment Economic Impacts** | 5,093 | 653,972 | 246,678 | 389,952 |

### 2011 Angler Trip & Durable Expenditures (thousands of dollars)

| Fishing Mode | Trip Expenditures | | Equipment | Durable Expenditures |
|---|---|---|---|---|
| | Non-Residents | Residents | Fishing Tackle | 69,979 |
| For-Hire | 2,058 | 11,279 | Other Equipment | 31,094 |
| Private Boat | 2,099 | 74,523 | Boat Expenses | 218,162 |
| Shore | 681 | 20,057 | Vehicle Expenses | 29,302 |
| *Total Trip Expenditures* | 4,839 | 105,858 | Second Home Expenses | 1,096 |
| | | | *Total Durable Equipment Expenditures* | 349,634 |
| **Total State Trip and Durable Equipment Expenditures** | | | | 460,331 |

### Recreational Anglers by Residential Area (thousands of anglers)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal | 252 | 233 | 213 | 201 | 184 | 220 | 167 | 163 | 162 | 274 |
| Non-Coastal | 27 | 25 | 24 | 23 | 21 | 23 | 19 | 20 | 19 | 30 |
| Out of State | 24 | 20 | 19 | 18 | 17 | 19 | 15 | 16 | 15 | 17 |
| **Total Anglers** | 303 | 278 | 255 | 242 | 222 | 262 | 201 | 198 | 196 | 321 |

### Recreational Fishing Effort by Mode (thousands of angler-trips)[1]

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| For-Hire | 59 | 69 | 64 | 62 | 57 | 55 | 42 | 51 | 47 | 42 |
| Private | 637 | 704 | 618 | 565 | 492 | 661 | 428 | 399 | 399 | 607 |
| Shore | 711 | 513 | 513 | 513 | 513 | 513 | 513 | 513 | 513 | 513 |
| **Total Trips** | 1,407 | 1,286 | 1,195 | 1,140 | 1,062 | 1,229 | 983 | 963 | 959 | 1,162 |

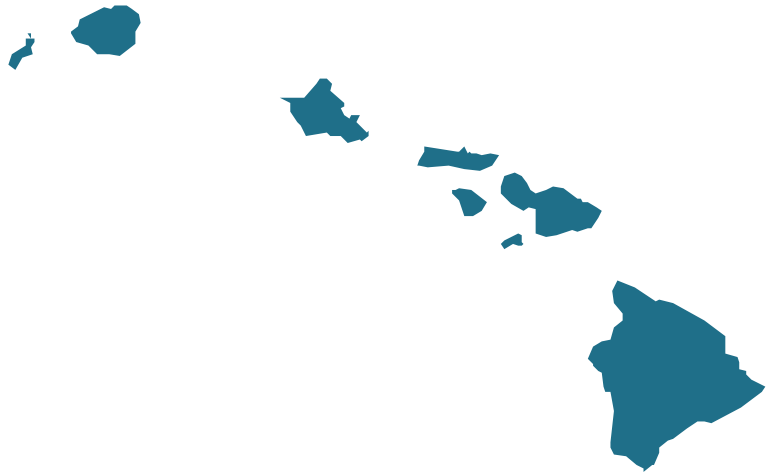
### Harvest (H) and Release (R) of Key Species Species Groups (thousands of fish)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Albacore tuna | H | 6 | 11 | 14 | 12 | 24 | 25 | 22 | 24 | NA | NA |
| | R | (1) | (1) | (1) | (1) | 1 | (1) | (1) | (1) | NA | NA |
| Flatfishes | H | 216 | 62 | 62 | 61 | 63 | 51 | 47 | 54 | NA | NA |
| | R | 209 | 92 | 41 | 41 | 42 | 40 | 40 | 47 | NA | NA |
| Greenlings | H | 85 | 59 | 39 | 39 | 33 | 28 | 29 | 34 | NA | NA |
| | R | 141 | 64 | 25 | 25 | 22 | 19 | 19 | 39 | NA | NA |
| Rockfishes [2] | H | 237 | 184 | 256 | 307 | 282 | 260 | 216 | 245 | NA | NA |
| | R | 50 | 20 | 25 | 33 | 23 | 19 | 16 | 33 | NA | NA |
| Salmon | H | 279 | 509 | 302 | 266 | 119 | 354 | 103 | 758 | NA | NA |
| | R | 137 | 129 | 135 | 77 | 37 | 86 | 29 | 115 | NA | NA |
| Sculpins | H | 35 | 17 | 17 | 17 | 16 | 15 | 15 | 16 | NA | NA |
| | R | 142 | 101 | 91 | 91 | 91 | 91 | 91 | 91 | NA | NA |
| Sharks & Skates | H | 27 | 15 | 1 | 1 | 1 | (1) | 1 | 1 | NA | NA |
| | R | 331 | 203 | 14 | 12 | 14 | 9 | 12 | 10 | NA | NA |
| Smelt & herring | H | 3,254 | 2,487 | 2,486 | 2,486 | 2,486 | 2,486 | 2,486 | 2,486 | NA | NA |
| | R | 196 | 136 | 126 | 126 | 126 | 126 | 126 | 126 | NA | NA |
| Sturgeon | H | 11 | 8 | 8 | 8 | 7 | 8 | 8 | 9 | NA | NA |
| | R | 30 | 18 | 25 | 30 | 21 | 18 | 12 | 17 | NA | NA |
| Surfperches | H | 104 | 143 | 133 | 133 | 133 | 133 | 133 | 133 | NA | NA |
| | R | 105 | 125 | 120 | 120 | 120 | 120 | 120 | 121 | NA | NA |

[1] In this table, '(1)' = 0-999 thousand fish and '1' = 1,000-1,499 thousand fish.
[2] This species may not be equivalent to species with similar names listed in the commercial tables.

# Western Pacific

## - Hawai’i



### 2011 Economic Impacts of Recreational Fishing Expenditures (thousands of dollars)

| | Jobs | Sales | Income | Value Added |
|---|---|---|---|---|
| Trip Impacts by Fishing Mode: | | | | |
| For-Hire | 586 | 64,541 | 27,072 | 41,513 |
| Private Boat | 166 | 23,162 | 6,862 | 11,755 |
| Shore | 470 | 54,551 | 16,097 | 26,730 |
| Total Durable Equipment Impacts | 1,639 | 168,528 | 68,784 | 106,198 |
| **Total State Trip and Durable Equipment Economic Impacts** | 2,861 | 310,782 | 118,815 | 186,196 |

### 2011 Angler Trip & Durable Expenditures (thousands of dollars)

| Fishing Mode | Trip Expenditures | | Equipment | Durable Expenditures |
|---|---|---|---|---|
| | Non-Residents | Residents | Fishing Tackle | 67,017 |
| For-Hire | 36,718 | 2,960 | Other Equipment | 10,316 |
| Private Boat | 102 | 21,171 | Boat Expenses | 66,574 |
| Shore | 69 | 44,801 | Vehicle Expenses | 35,182 |
| *Total Trip Expenditures* | 36,890 | 68,933 | Second Home Expenses | 0 |
| | | | *Total Durable Equipment Expenditures* | 179,089 |
| **Total State Trip and Durable Equipment Expenditures** | | | | 284,912 |

### Recreational Anglers by Residential Area (thousands of anglers)[1]

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal | | 261 | 223 | 204 | 173 | 170 | 192 | 140 | 182 | 84 |
| Non-Coastal | | NA[2] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| Out of State | | 180 | 183 | 166 | 224 | 146 | 137 | 106 | 293 | 4 |
| **Total Anglers** | | 440 | 407 | 370 | 396 | 317 | 329 | 246 | 475 | 87 |

### Recreational Fishing Effort by Mode (thousands of angler-trips)[1,3]

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Private | | 510 | 709 | 578 | 570 | 475 | 565 | 441 | 484 | 224 |
| Shore | | 1,893 | 2,162 | 1,893 | 2,075 | 2,102 | 1,966 | 1,722 | 1,907 | 1,158 |
| **Total Trips** | | 2,403 | 2,871 | 2,471 | 2,645 | 2,577 | 2,531 | 2,163 | 2,391 | 1,382 |

### Harvest (H) and Release (R) of Key Species Species Groups (thousands of fish)[1,4]

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Blue marlin | H | | 4 | 5 | 19 | 3 | 2 | 11 | 3 | 1 | 2 |
| | R | | (1) | (1) | (1) | (1) | 1 | (1) | (1) | (1) | (1) |
| Dolphinfish (mahimahi) | H | | 109 | 225 | 178 | 219 | 137 | 184 | 103 | 164 | 63 |
| | R | | 1 | (1) | 1 | (1) | (1) | (1) | (1) | (1) | (1) |
| Goatfishes[5] | H | | 793 | 716 | 444 | 812 | 298 | 467 | 713 | 271 | 172 |
| | R | | 10 | 17 | 8 | 16 | 9 | 7 | 6 | 17 | 13 |
| Jacks (trevallys and other jacks)[6] | H | | 124 | 330 | 254 | 207 | 169 | 276 | 121 | 142 | 99 |
| | R | | 171 | 146 | 182 | 213 | 129 | 121 | 84 | 127 | 60 |
| Scads (bigeye and mackerel) | H | | 1,950 | 180 | 726 | 812 | 1,089 | 402 | 1,103 | 841 | 662 |
| | R | | 2 | (1) | 13 | (1) | (1) | (1) | (1) | (1) | (1) |
| Skipjack tuna | H | | 439 | 419 | 301 | 201 | 228 | 568 | 230 | 288 | 125 |
| | R | | 1 | 6 | 1 | 1 | 5 | 2 | (1) | (1) | (1) |
| Smallmouth bonefish | H | | 24 | 61 | 24 | 64 | 19 | 50 | 36 | 55 | 14 |
| | R | | 4 | 9 | 11 | 2 | 13 | 4 | 2 | 13 | 2 |
| Snappers[7] | H | | 232 | 234 | 221 | 178 | 105 | 140 | 145 | 340 | 114 |
| | R | | 17 | 18 | 57 | 35 | 39 | 7 | 24 | 25 | 14 |
| Wahoo | H | | 106 | 97 | 54 | 62 | 57 | 78 | 61 | 40 | 16 |
| | R | | (1) | (1) | (1) | (1) | 1 | (1) | (1) | (1) | (1) |
| Yellowfin tuna | H | | 183 | 267 | 231 | 124 | 273 | 461 | 198 | 302 | 141 |
| | R | | 5 | (1) | 10 | 1 | 2 | (1) | 1 | 1 | (1) |

[1]Participation (number of anglers), effort (number of trips), and catch (number of fish harvested or released) data were not available for 2001 and 2002.
[2]NA = not applicable because all Hawaii residents are considered coastal county residents
[3]Effort data (number of trips) for for-hire boat trips were not available and effort data were not available for 2002.
[4]In this table, '(1)' = 0-999 thousand fish and '1' = 1,000-1,499 thousand fish.
[5]Goatfishes include yellowstripe, yellowfin, pfulgers, bandtail, doublebar, diespot, whitesaddle, manybar, blue, and 'Goastfish famil/genus'
[6]Trevallys & other jacks includes bluefin trevally, giant trevally, bigeye trevally, black trevally, African pompano, greater amberjack, island jack, and other species in the jack family.
[7]Snappers include bluestip, blacktail, ruby, longtailed, pink, VonSiebolds, Binghams, green jobfish, ironjaw, and smalltooth jobfish.

# New England

- Connecticut
- Maine
- Massachusetts
- New Hampshire
- Rhode Island

### 2011 Economic Impacts of Recreational Fishing Expenditures (thousands of dollars)

| | Trips | Jobs | Sales | Income | Value Added |
|---|---|---|---|---|---|
| Connecticut | 1,307,000 | 1,190 | 156,415 | 75,496 | 114,823 |
| Massachusetts | 2,813,000 | 6,550 | 799,558 | 348,511 | 540,866 |
| Maine | 528,000 | 1,197 | 118,336 | 46,977 | 71,758 |
| New Hampshire | 294,000 | 441 | 47,999 | 20,536 | 32,137 |
| Rhode Island | 1,113,000 | 1,940 | 208,021 | 81,298 | 131,016 |

### 2011 Angler Trip & Durable Expenditures (thousands of dollars)

| Fishing Mode | Trip Expenditures | | Equipment | Durable Expenditures |
|---|---|---|---|---|
| | Non-Residents | Residents | Fishing Tackle | 236,216 |
| For-Hire | 55,917 | 23,910 | Other Equipment | 50,376 |
| Private Boat | 27,532 | 106,582 | Boat Expenses | 461,383 |
| Shore | 42,059 | 47,905 | Vehicle Expenses | 110,989 |
| *Total Trip Expenditures* | 125,509 | 178,399 | Second Home Expenses | 1,954 |
| | | | *Total Durable Equipment Expenditures* | 860,918 |
| **Total State Trip and Durable Equipment Expenditures** | | | | 1,164,826 |

### Recreational Anglers by Residential Area (thousands of anglers)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal | 1,069 | 1,198 | 1,155 | 1,349 | 1,408 | 1,408 | 1,389 | 1,222 | 1,317 | 1,156 |
| Non-Coastal | 124 | 152 | 165 | 169 | 188 | 205 | 187 | 165 | 169 | 131 |
| Out-of-State | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| **Total Anglers** | 1,194 | 1,349 | 1,319 | 1,518 | 1,596 | 1,614 | 1,576 | 1,387 | 1,486 | 1,288 |

### Recreational Fishing Effort by Mode (thousands of angler-trips)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| For-Hire | 235 | 318 | 331 | 417 | 455 | 517 | 511 | 463 | 321 | 364 |
| Private Boat | 4,511 | 4,425 | 4,371 | 5,060 | 4,650 | 4,821 | 4,892 | 3,374 | 3,968 | 3,160 |
| Shore | 3,844 | 3,835 | 3,934 | 3,719 | 4,107 | 3,950 | 3,735 | 3,322 | 2,926 | 2,531 |
| **Total Trips** | 8,590 | 8,578 | 8,636 | 9,196 | 9,212 | 9,288 | 9,138 | 7,159 | 7,215 | 6,055 |

### Harvest (H) and Release (R) of Key Species Species Groups (thousands of fish)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Atlantic cod | H | 644 | 704 | 421 | 486 | 203 | 305 | 385 | 391 | 508 | 531 |
| | R | 1,144 | 1,175 | 775 | 1,108 | 722 | 965 | 954 | 834 | 1,070 | 912 |
| Atlantic mackerel | H | 3,544 | 2,397 | 1,577 | 2,941 | 4,181 | 1,885 | 3,356 | 2,464 | 3,473 | 5,335 |
| | R | 363 | 212 | 172 | 62 | 559 | 116 | 453 | 343 | 379 | 533 |
| Bluefin tuna | H | 1 | 5 | 1 | 12 | 3 | 11 | 9 | 8 | 1 | 2 |
| | R | (1) | 4 | 4 | 8 | 7 | 10 | 1 | 5 | (1) | 5 |
| Bluefish | H | 1,167 | 1,189 | 1,228 | 1,202 | 1,647 | 1,514 | 1,458 | 672 | 1,185 | 660 |
| | R | 2,146 | 2,535 | 3,126 | 3,013 | 3,637 | 2,906 | 2,995 | 1,437 | 1,845 | 1,929 |
| Little tunny[2] | H | 6 | 4 | 9 | (1) | 1 | 5 | (1) | 1 | 2 | (1) |
| | R | 52 | 33 | 85 | 55 | 26 | 65 | 16 | 16 | 20 | 45 |
| Porgies (scup) | H | 2,461 | 4,179 | 5,204 | 1,595 | 1,429 | 3,049 | 1,944 | 1,498 | 2,411 | 2,287 |
| | R | 2,382 | 2,831 | 2,543 | 2,193 | 2,638 | 2,801 | 4,048 | 3,280 | 3,586 | 2,376 |
| Striped bass | H | 520 | 699 | 689 | 699 | 594 | 591 | 601 | 548 | 527 | 457 |
| | R | 8,575 | 6,760 | 7,251 | 9,940 | 14,092 | 8,365 | 7,715 | 4,165 | 2,771 | 2,038 |
| Summer flounder | H | 439 | 549 | 690 | 588 | 641 | 426 | 583 | 168 | 198 | 267 |
| | R | 1,558 | 1,068 | 895 | 1,418 | 2,851 | 1,044 | 2,112 | 907 | 819 | 1,252 |
| Winter flounder | H | 105 | 86 | 57 | 43 | 51 | 52 | 179 | 113 | 106 | 100 |
| | R | 73 | 39 | 35 | 41 | 46 | 43 | 70 | 101 | 86 | 59 |
| Wrasses (tautog) | H | 266 | 335 | 163 | 269 | 362 | 570 | 304 | 194 | 358 | 78 |
| | R | 637 | 668 | 367 | 597 | 639 | 1,425 | 515 | 394 | 560 | 384 |

[1]NA = data are not available because out-of-state resident information is collected for individual states but whether an angler is a resident of a region is not specified

[2]This species may not be equivalent to species with similar names listed in the commercial tables.

### 2011 Economic Impacts of Recreational Fishing Expenditures (thousands of dollars)

| | Jobs | Sales | Income | Value Added |
|---|---|---|---|---|
| Trip Impacts by Fishing Mode: | | | | |
| For-Hire | 63 | 10,807 | 5,751 | 8,204 |
| Private Boat | 180 | 25,641 | 9,198 | 15,755 |
| Shore | 58 | 6,126 | 2,178 | 3,518 |
| Total Durable Equipment Impacts | 889 | 113,841 | 58,369 | 87,346 |
| **Total State Trip and Durable Equipment Economic Impacts** | 1,190 | 156,415 | 75,496 | 114,823 |

### 2011 Angler Trip & Durable Expenditures (thousands of dollars)

| Fishing Mode | Trip Expenditures | | Equipment | Durable Expenditures |
|---|---|---|---|---|
| | Non-Residents | Residents | Fishing Tackle | 16,020 |
| For-Hire | 1,523 | 5,379 | Other Equipment | 3,105 |
| Private Boat | 2,556 | 21,195 | Boat Expenses | 71,546 |
| Shore | 158 | 4,874 | Vehicle Expenses | 0 |
| *Total Trip Expenditures* | 4,236 | 31,448 | Second Home Expenses | 0 |
| | | | *Total Durable Equipment Expenditures* | 90,671 |
| **Total State Trip and Durable Equipment Expenditures** | | | | 126,355 |

### Recreational Anglers by Residential Area (thousands of anglers)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal | 283 | 361 | 297 | 323 | 336 | 302 | 381 | 438 | 402 | 420 |
| Non-Coastal | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| Out of State | 87 | 112 | 63 | 77 | 44 | 61 | 123 | 93 | 112 | 98 |
| **Total Anglers** | 371 | 473 | 359 | 400 | 380 | 363 | 504 | 531 | 514 | 518 |

### Recreational Fishing Effort by Mode (thousands of angler-trips)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| For-Hire | 51 | 64 | 31 | 34 | 50 | 63 | 73 | 43 | 40 | 45 |
| Private | 954 | 875 | 956 | 1,174 | 868 | 1,097 | 1,292 | 711 | 871 | 863 |
| Shore | 645 | 625 | 573 | 485 | 571 | 559 | 608 | 665 | 614 | 399 |
| **Total Trips** | 1,650 | 1,564 | 1,560 | 1,693 | 1,489 | 1,719 | 1,973 | 1,419 | 1,525 | 1,307 |

### Harvest (H) and Release (R) of Key Species Species Groups (thousands of fish)[2]

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Atlantic cod | H | (1) | 2 | (1) | (1) | (1) | (1) | (1) | (1) | (1) | (1) |
| | R | (1) | (1) | (1) | (1) | (1) | (1) | (1) | (1) | (1) | (1) |
| Bluefish | H | 569 | 458 | 589 | 248 | 507 | 452 | 624 | 261 | 592 | 308 |
| | R | 662 | 542 | 979 | 576 | 1,167 | 888 | 1,144 | 296 | 715 | 997 |
| Hickory shad | H | 71 | 71 | 12 | 54 | 63 | 36 | (1) | (1) | 1 | 16 |
| | R | 377 | 79 | 21 | 32 | 144 | 4 | 5 | (1) | (1) | (1) |
| Little tunny[3] | H | (1) | 1 | (1) | (1) | (1) | (1) | (1) | (1) | 1 | (1) |
| | R | 28 | 8 | 3 | (1) | (1) | 1 | (1) | 9 | 8 | 15 |
| Porgies (scup) | H | 882 | 1,528 | 1,071 | 508 | 533 | 926 | 549 | 288 | 1,088 | 933 |
| | R | 569 | 804 | 539 | 753 | 740 | 1,005 | 974 | 1,204 | 1,192 | 538 |
| Striped bass | H | 51 | 96 | 103 | 141 | 115 | 118 | 108 | 61 | 92 | 64 |
| | R | 697 | 843 | 826 | 1,762 | 987 | 984 | 3,105 | 1,161 | 671 | 612 |
| Summer flounder | H | 93 | 166 | 216 | 157 | 137 | 112 | 146 | 45 | 35 | 47 |
| | R | 453 | 474 | 269 | 779 | 1,111 | 297 | 991 | 428 | 373 | 345 |
| White perch | H | 1 | 11 | (1) | (1) | (1) | (1) | 7 | 60 | (1) | (1) |
| | R | 27 | 28 | 11 | (1) | 15 | 18 | 52 | 72 | (1) | (1) |
| Winter flounder | H | 16 | 24 | 4 | 3 | (1) | (1) | (1) | 12 | 15 | 19 |
| | R | 9 | 5 | 14 | (1) | 22 | 15 | (1) | 7 | 12 | (1) |
| Wrasses (tautog) | H | 101 | 168 | 17 | 36 | 201 | 353 | 167 | 86 | 116 | 26 |
| | R | 219 | 283 | 77 | 149 | 107 | 744 | 250 | 112 | 256 | 36 |

[1]NA = not applicable because all Connecticut residents are considered coastal county residents
[2]In this table, '(1)' = 0-999 thousand fish and '1' = 1,000-1,499 thousand fish.
[3]This species may not be equivalent to species with similar names listed in the commercial tables.

### 2011 Economic Impacts of Recreational Fishing Expenditures (thousands of dollars)

| | Jobs | Sales | Income | Value Added |
|---|---|---|---|---|
| Trip Impacts by Fishing Mode: | | | | |
| For-Hire | 97 | 8,551 | 3,818 | 5,763 |
| Private Boat | 63 | 7,145 | 2,174 | 3,796 |
| Shore | 107 | 9,904 | 3,191 | 5,498 |
| Total Durable Equipment Impacts | 930 | 92,736 | 37,794 | 56,703 |
| **Total State Trip and Durable Equipment Economic Impacts** | 1,197 | 118,336 | 46,977 | 71,758 |

### 2011 Angler Trip & Durable Expenditures (thousands of dollars)

| Fishing Mode | Trip Expenditures | | Equipment | Durable Expenditures |
|---|---|---|---|---|
| | Non-Residents | Residents | | |
| For-Hire | 4,671 | 901 | Fishing Tackle | 18,165 |
| Private Boat | 2,177 | 4,271 | Other Equipment | 4,452 |
| Shore | 5,697 | 1,606 | Boat Expenses | 52,608 |
| *Total Trip Expenditures* | 12,546 | 6,779 | Vehicle Expenses | 0 |
| | | | Second Home Expenses | 40 |
| | | | *Total Durable Equipment Expenditures* | 75,264 |
| **Total State Trip and Durable Equipment Expenditures** | | | | 94,589 |

### Recreational Anglers by Residential Area (thousands of anglers)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal | 127 | 165 | 113 | 190 | 182 | 174 | 121 | 117 | 122 | 85 |
| Non-Coastal | 17 | 23 | 21 | 20 | 22 | 13 | 9 | 12 | 9 | 7 |
| Out of State | 172 | 170 | 148 | 173 | 285 | 260 | 180 | 324 | 159 | 107 |
| **Total Anglers** | 316 | 358 | 282 | 383 | 489 | 447 | 310 | 453 | 290 | 198 |

### Recreational Fishing Effort by Mode (thousands of angler-trips)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| For-Hire | 13 | 14 | 19 | 39 | 31 | 33 | 25 | 26 | 23 | 22 |
| Private | 421 | 410 | 338 | 520 | 547 | 460 | 408 | 333 | 327 | 265 |
| Shore | 471 | 496 | 420 | 523 | 497 | 530 | 421 | 544 | 367 | 241 |
| **Total Trips** | 905 | 920 | 777 | 1,082 | 1,075 | 1,023 | 854 | 903 | 717 | 528 |

### Harvest (H) and Release (R) of Key Species Species Groups (thousands of fish)[1]

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| American Shad | H | (1) | (1) | (1) | (1) | 1 | (1) | (1) | (1) | (1) | (1) |
| | R | (1) | 1 | 2 | (1) | 7 | 4 | 5 | 19 | 9 | 5 |
| Atlantic cod | H | 15 | 11 | 5 | 29 | 14 | 19 | 41 | 46 | 14 | 40 |
| | R | 16 | 26 | 19 | 37 | 49 | 72 | 50 | 36 | 44 | 99 |
| Atlantic mackerel | H | 1,207 | 615 | 1,022 | 607 | 450 | 806 | 836 | 1,111 | 1,094 | 1,544 |
| | R | 234 | 105 | 87 | 29 | 103 | 80 | 265 | 194 | 177 | 304 |
| Blue shark | H | (1) | (1) | (1) | (1) | (1) | (1) | (1) | (1) | (1) | (1) |
| | R | (1) | (1) | (1) | (1) | (1) | (1) | (1) | 1 | (1) | 10 |
| Bluefin tuna | H | (1) | (1) | (1) | (1) | (1) | (1) | (1) | (1) | (1) | (1) |
| | R | (1) | (1) | (1) | (1) | (1) | (1) | (1) | (1) | (1) | (1) |
| Bluefish | H | 24 | 14 | 16 | 38 | 8 | 50 | 30 | 3 | 14 | (1) |
| | R | 42 | 23 | 42 | 49 | 49 | 74 | 55 | 26 | 9 | 7 |
| Haddock | H | 3 | 1 | 4 | 6 | 9 | 13 | 19 | 11 | 3 | 12 |
| | R | 4 | 3 | 2 | 2 | 4 | 10 | 2 | 2 | 3 | 4 |
| Pollock | H | 76 | 10 | 59 | 28 | 66 | 51 | 68 | 62 | 59 | 57 |
| | R | 47 | 18 | 56 | 32 | 23 | 24 | 135 | 34 | 105 | 134 |
| Striped bass | H | 71 | 58 | 49 | 83 | 75 | 54 | 58 | 62 | 17 | 18 |
| | R | 1,391 | 847 | 694 | 2,985 | 4,001 | 1,115 | 465 | 264 | 193 | 143 |
| Winter flounder | H | (1) | (1) | (1) | (1) | (1) | (1) | (1) | (1) | (1) | (1) |
| | R | (1) | 1 | (1) | (1) | 1 | (1) | 1 | 5 | (1) | (1) |

[1] In this table, '(1)' = 0-999 thousand fish and '1' = 1,000-1,499 thousand fish.

### 2011 Economic Impacts of Recreational Fishing Expenditures (thousands of dollars)

| | Jobs | Sales | Income | Value Added |
|---|---|---|---|---|
| Trip Impacts by Fishing Mode: | | | | |
| For-Hire | 731 | 85,330 | 41,011 | 60,208 |
| Private Boat | 609 | 88,088 | 32,542 | 53,908 |
| Shore | 793 | 99,957 | 36,389 | 58,963 |
| Total Durable Equipment Impacts | 4,418 | 526,183 | 238,570 | 367,788 |
| **Total State Trip and Durable Equipment Economic Impacts** | 6,550 | 799,558 | 348,511 | 540,866 |

### 2011 Angler Trip & Durable Expenditures (thousands of dollars)

| Fishing Mode | Trip Expenditures | | Equipment | Durable Expenditures |
|---|---|---|---|---|
| | Non-Residents | Residents | Fishing Tackle | 133,323 |
| For-Hire | 38,515 | 13,394 | Other Equipment | 36,214 |
| Private Boat | 14,582 | 63,018 | Boat Expenses | 251,688 |
| Shore | 31,254 | 37,526 | Vehicle Expenses | 100,595 |
| *Total Trip Expenditures* | 84,351 | 113,938 | Second Home Expenses | 1,914 |
| | | | *Total Durable Equipment Expenditures* | 523,735 |
| **Total State Trip and Durable Equipment Expenditures** | | | | 722,024 |

### Recreational Anglers by Residential Area (thousands of anglers)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal | 465 | 434 | 535 | 585 | 623 | 664 | 655 | 489 | 586 | 490 |
| Non-Coastal | 96 | 112 | 131 | 135 | 151 | 179 | 170 | 144 | 152 | 115 |
| Out of State | 344 | 306 | 335 | 391 | 484 | 465 | 469 | 421 | 433 | 293 |
| **Total Anglers** | 906 | 852 | 1000 | 1112 | 1258 | 1309 | 1293 | 1054 | 1171 | 897 |

### Recreational Fishing Effort by Mode (thousands of angler-trips)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| For-Hire | 106 | 145 | 210 | 236 | 230 | 233 | 255 | 240 | 156 | 190 |
| Private | 2,399 | 2,329 | 2,273 | 2,336 | 2,411 | 2,441 | 2,338 | 1,759 | 2,149 | 1,318 |
| Shore | 1,701 | 1,611 | 1,968 | 1,739 | 1,938 | 1,948 | 1,929 | 1,451 | 1,186 | 1,305 |
| **Total Trips** | 4,206 | 4,085 | 4,451 | 4,311 | 4,579 | 4,622 | 4,522 | 3,450 | 3,491 | 2,813 |

### Harvest (H) and Release (R) of Key Species Species Groups (thousands of fish)[1]

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Atlantic bonito | H | 6 | 11 | 5 | 29 | 13 | 3 | 7 | 4 | 1 | 5 |
| | R | 17 | (1) | 2 | 9 | 38 | 12 | 9 | 1 | 3 | (1) |
| Atlantic cod | H | 585 | 582 | 348 | 388 | 120 | 232 | 261 | 213 | 412 | 360 |
| | R | 1,050 | 937 | 658 | 932 | 424 | 658 | 671 | 582 | 884 | 542 |
| Atlantic mackerel | H | 2,024 | 1,313 | 481 | 1,927 | 3,603 | 951 | 2,024 | 471 | 2,084 | 1,649 |
| | R | 61 | 45 | 75 | 17 | 422 | 27 | 152 | 68 | 185 | 42 |
| Bluefish | H | 229 | 374 | 354 | 551 | 653 | 681 | 519 | 344 | 476 | 226 |
| | R | 627 | 1,020 | 1,295 | 1,814 | 1,843 | 1,241 | 1,302 | 953 | 1,027 | 597 |
| Haddock | H | 63 | 75 | 127 | 247 | 121 | 292 | 232 | 155 | 143 | 53 |
| | R | 125 | 130 | 56 | 62 | 62 | 56 | 158 | 36 | 33 | 13 |
| Porgies (scup) | H | 975 | 1,624 | 3,315 | 657 | 425 | 1,771 | 762 | 1,070 | 925 | 785 |
| | R | 879 | 1,221 | 1,486 | 751 | 1,097 | 1,183 | 1,687 | 1,743 | 1,858 | 1,175 |
| Striped bass | H | 308 | 405 | 445 | 340 | 315 | 314 | 378 | 344 | 341 | 256 |
| | R | 5,719 | 4,362 | 4,980 | 3,987 | 7,811 | 5,331 | 3,650 | 2,283 | 1,672 | 972 |
| Summer flounder | H | 156 | 177 | 225 | 267 | 238 | 138 | 233 | 51 | 45 | 59 |
| | R | 337 | 244 | 348 | 358 | 611 | 136 | 273 | 96 | 215 | 182 |
| Winter flounder | H | 51 | 45 | 45 | 39 | 44 | 41 | 167 | 87 | 86 | 69 |
| | R | 34 | 30 | 14 | 40 | 20 | 19 | 62 | 83 | 68 | 58 |
| Wrasses (tautog) | H | 103 | 47 | 21 | 73 | 80 | 92 | 34 | 24 | 45 | 33 |
| | R | 284 | 189 | 68 | 127 | 332 | 413 | 78 | 96 | 117 | 210 |

[1] In this table, '(1)' = 0-999 thousand fish and '1' = 1,000-1,499 thousand fish.

### 2011 Economic Impacts of Recreational Fishing Expenditures (thousands of dollars)

| | Jobs | Sales | Income | Value Added |
|---|---|---|---|---|
| Trip Impacts by Fishing Mode: | | | | |
| For-Hire | 121 | 13,081 | 6,307 | 9,330 |
| Private Boat | 61 | 7,908 | 2,872 | 4,908 |
| Shore | 13 | 1,288 | 437 | 734 |
| Total Durable Equipment Impacts | 246 | 25,723 | 10,920 | 17,165 |
| **Total State Trip and Durable Equipment Economic Impacts** | 441 | 47,999 | 20,536 | 32,137 |

### 2011 Angler Trip & Durable Expenditures (thousands of dollars)

| Fishing Mode | Trip Expenditures | | Equipment | Durable Expenditures |
|---|---|---|---|---|
| | Non-Residents | Residents | Fishing Tackle | 8,476 |
| For-Hire | 4,912 | 3,590 | Other Equipment | 2,294 |
| Private Boat | 554 | 6,876 | Boat Expenses | 9,135 |
| Shore | 618 | 379 | Vehicle Expenses | 6,218 |
| *Total Trip Expenditures* | 6,085 | 10,846 | Second Home Expenses | 0 |
| | | | *Total Durable Equipment Expenditures* | 26,123 |
| **Total State Trip and Durable Equipment Expenditures** | | | | 43,054 |

### Recreational Anglers by Residential Area (thousands of anglers)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal | 60 | 91 | 81 | 105 | 90 | 97 | 63 | 67 | 46 | 56 |
| Non-Coastal | 11 | 16 | 13 | 14 | 15 | 13 | 8 | 9 | 7 | 10 |
| Out of State | 65 | 75 | 69 | 84 | 82 | 63 | 46 | 58 | 33 | 30 |
| **Total Anglers** | 137 | 182 | 163 | 203 | 187 | 172 | 118 | 134 | 86 | 96 |

### Recreational Fishing Effort by Mode (thousands of angler-trips)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| For-Hire | 29 | 35 | 28 | 53 | 90 | 113 | 91 | 98 | 61 | 69 |
| Private | 142 | 230 | 154 | 238 | 182 | 233 | 138 | 148 | 90 | 178 |
| Shore | 146 | 151 | 161 | 214 | 227 | 155 | 103 | 155 | 92 | 47 |
| **Total Trips** | 317 | 416 | 343 | 505 | 499 | 501 | 332 | 401 | 243 | 294 |

### Harvest (H) and Release (R) of Key Species Species Groups (thousands of fish)[1]

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | H | (1) | (1) | 1 | (1) | (1) | 3 | (1) | (1) | (1) | (1) |
| | R | 4 | (1) | 2 | 2 | 9 | 1 | 3 | (1) | 1 | (1) |
| Atlantic cod | H | 38 | 108 | 67 | 68 | 65 | 53 | 81 | 128 | 80 | 127 |
| | R | 70 | 207 | 96 | 137 | 247 | 235 | 232 | 209 | 130 | 258 |
| Atlantic mackerel | H | 214 | 409 | 71 | 407 | 116 | 128 | 496 | 882 | 294 | 2,142 |
| | R | 68 | 61 | 10 | 16 | 34 | 9 | 36 | 81 | 17 | 187 |
| Bluefin tuna | H | (1) | (1) | (1) | (1) | (1) | (1) | (1) | (1) | (1) | (1) |
| | R | (1) | (1) | (1) | (1) | (1) | (1) | (1) | (1) | (1) | 2 |
| Bluefish | H | 19 | 7 | 13 | 21 | 9 | 35 | 5 | (1) | 1 | 2 |
| | R | 14 | 18 | 9 | 47 | 23 | 18 | 3 | 2 | (1) | 1 |
| Bottomfish, unidentified | H | (1) | (1) | (1) | (1) | (1) | (1) | (1) | (1) | (1) | (1) |
| | R | (1) | (1) | (1) | (1) | (1) | (1) | (1) | (1) | (1) | (1) |
| Haddock | H | 19 | 44 | 68 | 103 | 167 | 97 | 90 | 100 | 48 | 76 |
| | R | 43 | 127 | 22 | 38 | 109 | 43 | 18 | 29 | 11 | 20 |
| Pollock | H | 89 | 62 | 57 | 60 | 76 | 70 | 52 | 40 | 51 | 100 |
| | R | 64 | 43 | 33 | 34 | 46 | 17 | 20 | 49 | 77 | 104 |
| Striped bass | H | 13 | 25 | 8 | 24 | 14 | 5 | 5 | 9 | 6 | 32 |
| | R | 237 | 260 | 226 | 572 | 459 | 258 | 78 | 59 | 52 | 98 |
| Winter flounder | H | 8 | 8 | 1 | 1 | 7 | 10 | 11 | 10 | 3 | 12 |
| | R | 10 | 2 | 2 | 1 | 3 | 7 | 6 | 5 | 5 | 1 |

[1] In this table, '(1)' = 0-999 thousand fish and '1' = 1,000-1,499 thousand fish.

### 2011 Economic Impacts of Recreational Fishing Expenditures (thousands of dollars)

| | Jobs | Sales | Income | Value Added |
|---|---|---|---|---|
| Trip Impacts by Fishing Mode: | | | | |
| For-Hire | 113 | 11,080 | 5,346 | 7,808 |
| Private Boat | 178 | 20,393 | 7,171 | 12,028 |
| Shore | 73 | 8,299 | 2,960 | 4,906 |
| Total Durable Equipment Impacts | 1,576 | 168,249 | 65,821 | 106,273 |
| **Total State Trip and Durable Equipment Economic Impacts** | 1,940 | 208,021 | 81,298 | 131,016 |

### 2011 Angler Trip & Durable Expenditures (thousands of dollars)

| Fishing Mode | Trip Expenditures | | Equipment | Durable Expenditures |
|---|---|---|---|---|
| | Non-Residents | Residents | Fishing Tackle | 60,232 |
| For-Hire | 6,296 | 646 | Other Equipment | 4,311 |
| Private Boat | 7,663 | 11,222 | Boat Expenses | 76,406 |
| Shore | 4,332 | 3,520 | Vehicle Expenses | 4,176 |
| *Total Trip Expenditures* | 18,291 | 15,388 | Second Home Expenses | 0 |
| | | | *Total Durable Equipment Expenditures* | 145,125 |
| **Total State Trip and Durable Equipment Expenditures** | | | | 178,804 |

### Recreational Anglers by Residential Area (thousands of anglers)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal | 134 | 147 | 129 | 145 | 177 | 171 | 169 | 111 | 161 | 105 |
| Non-Coastal | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| Out of State | 214 | 253 | 237 | 241 | 291 | 229 | 297 | 209 | 225 | 190 |
| **Total Anglers** | 348 | 400 | 366 | 386 | 468 | 401 | 465 | 320 | 387 | 296 |

### Recreational Fishing Effort by Mode (thousands of angler-trips)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| For-Hire | 36 | 60 | 43 | 55 | 54 | 75 | 67 | 56 | 41 | 38 |
| Private | 595 | 581 | 650 | 792 | 642 | 590 | 716 | 423 | 531 | 536 |
| Shore | 881 | 952 | 812 | 758 | 874 | 758 | 674 | 507 | 667 | 539 |
| **Total Trips** | 1,512 | 1,593 | 1,505 | 1,605 | 1,570 | 1,423 | 1,457 | 986 | 1,239 | 1,113 |

### Harvest (H) and Release (R) of Key Species Species Groups (thousands of fish)[2]

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Atlantic bonito | H | 12 | 2 | 3 | 1 | (1) | 6 | (1) | (1) | (1) | (1) |
| | R | 1 | 4 | 8 | (1) | (1) | 4 | 1 | (1) | (1) | (1) |
| Atlantic cod | H | 6 | 1 | 1 | 1 | 4 | 1 | 2 | 4 | 2 | 4 |
| | R | 8 | 5 | 2 | 2 | 2 | (1) | 1 | 7 | 12 | 13 |
| Black seabass | H | 77 | 70 | 26 | 86 | 42 | 42 | 53 | 36 | 160 | 51 |
| | R | 242 | 206 | 24 | 64 | 160 | 119 | 128 | 133 | 211 | 221 |
| Bluefish | H | 326 | 336 | 256 | 344 | 470 | 296 | 280 | 64 | 102 | 124 |
| | R | 801 | 932 | 801 | 527 | 555 | 685 | 491 | 160 | 94 | 327 |
| Porgies (scup) | H | 604 | 1,027 | 818 | 430 | 471 | 352 | 633 | 140 | 398 | 569 |
| | R | 934 | 806 | 518 | 689 | 801 | 613 | 1,387 | 333 | 536 | 663 |
| Striped bass | H | 77 | 115 | 84 | 111 | 75 | 100 | 52 | 72 | 71 | 87 |
| | R | 531 | 448 | 525 | 634 | 834 | 677 | 417 | 398 | 183 | 213 |
| Summer flounder | H | 190 | 206 | 249 | 164 | 265 | 176 | 203 | 72 | 118 | 161 |
| | R | 768 | 350 | 278 | 279 | 1,129 | 611 | 848 | 382 | 231 | 725 |
| Winter flounder | H | 30 | 9 | 7 | (1) | (1) | 1 | 1 | 4 | 2 | (1) |
| | R | 20 | 1 | 5 | (1) | (1) | 2 | 1 | 1 | 1 | (1) |
| Wrasses (tautog) | H | 62 | 120 | 125 | 160 | 81 | 125 | 103 | 84 | 197 | 19 |
| | R | 134 | 196 | 222 | 321 | 200 | 268 | 187 | 186 | 187 | 138 |
| Yellowfin tuna | H | 2 | 2 | (1) | 1 | (1) | (1) | (1) | (1) | (1) | (1) |
| | R | (1) | 11 | (1) | 2 | (1) | (1) | (1) | (1) | (1) | (1) |

[1]NA = not applicable because all Rhode Island residents are considered coastal county residents
[2]In this table, '(1)' = 0-999 thousand fish and '1' = 1,000-1,499 thousand fish.

# Mid-Atlantic

- Delaware
- Maryland
- New Jersey
- New York
- Virginia

### 2011 Economic Impacts of Recreational Fishing Expenditures (thousands of dollars)

| | Trips | Jobs | Sales | Income | Value Added |
|---|---|---|---|---|---|
| Delaware | 926,000 | 1,403 | 132,223 | 60,509 | 93,806 |
| Maryland | 2,820,000 | 6,466 | 724,394 | 313,977 | 482,551 |
| New Jersey | 5,162,000 | 12,818 | 1,841,343 | 693,886 | 1,087,155 |
| New York | 4,168,000 | 3,094 | 398,881 | 160,031 | 254,728 |
| Virginia | 2,898,000 | 9,454 | 969,571 | 386,143 | 626,991 |

### 2011 Angler Trip & Durable Expenditures (thousands of dollars)

| Fishing Mode | Trip Expenditures | | Equipment | Durable Expenditures |
|---|---|---|---|---|
| | Non-Residents | Residents | Fishing Tackle | 731,471 |
| For-Hire | 46,468 | 100,767 | Other Equipment | 192,747 |
| Private Boat | 86,361 | 353,011 | Boat Expenses | 1,390,841 |
| Shore | 89,457 | 126,512 | Vehicle Expenses | 428,052 |
| *Total Trip Expenditures* | 222,287 | 580,288 | Second Home Expenses | 140,956 |
| | | | *Total Durable Equipment Expenditures* | 2,884,068 |
| **Total State Trip and Durable Equipment Expenditures** | | | | 3,686,643 |

### Recreational Anglers by Residential Area (thousands of anglers)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal | 1,643 | 2,229 | 2,363 | 3,002 | 2,876 | 3,234 | 2,823 | 2,437 | 2,598 | 2,244 |
| Non-Coastal | 139 | 144 | 157 | 252 | 224 | 212 | 197 | 187 | 178 | 145 |
| Out-of-State | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| **Total Anglers** | 1,783 | 2,372 | 2,520 | 3,254 | 3,100 | 3,446 | 3,020 | 2,623 | 2,776 | 2,389 |

### Recreational Fishing Effort by Mode (thousands of angler-trips)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| For-Hire | 1,025 | 1,181 | 1,099 | 1,268 | 1,337 | 1,688 | 1,144 | 1,110 | 870 | 1,048 |
| Private Boat | 9,550 | 11,287 | 11,244 | 11,901 | 11,863 | 12,372 | 11,567 | 9,708 | 9,365 | 8,514 |
| Shore | 6,070 | 7,383 | 6,243 | 7,668 | 7,370 | 8,124 | 8,006 | 6,195 | 6,346 | 6,412 |
| **Total Trips** | 16,645 | 19,851 | 18,586 | 20,837 | 20,570 | 22,184 | 20,717 | 17,013 | 16,581 | 15,974 |

### Harvest (H) and Release (R) of Key Species Species Groups (thousands of fish)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Black seabass | H | 3,059 | 3,034 | 1,317 | 995 | 1,116 | 1,303 | 923 | 1,335 | 1,316 | 533 |
| | R | 10,332 | 8,383 | 5,528 | 5,414 | 5,739 | 6,401 | 8,473 | 6,270 | 6,458 | 3,203 |
| Bluefish | H | 2,517 | 3,192 | 4,142 | 4,667 | 3,904 | 4,945 | 3,516 | 2,932 | 2,558 | 2,465 |
| | R | 4,582 | 4,196 | 6,305 | 6,640 | 5,696 | 8,012 | 7,211 | 4,456 | 3,933 | 4,246 |
| Drum (Atlantic croaker) | H | 10,866 | 9,350 | 10,399 | 10,492 | 9,254 | 8,584 | 9,981 | 7,308 | 6,020 | 3,992 |
| | R | 10,364 | 9,426 | 8,966 | 12,244 | 7,416 | 11,023 | 12,912 | 9,405 | 6,233 | 5,390 |
| Drum (spot) | H | 2,316 | 4,771 | 2,604 | 4,769 | 6,657 | 11,998 | 6,557 | 4,346 | 3,699 | 4,033 |
| | R | 1,015 | 1,658 | 1,305 | 4,755 | 2,885 | 3,940 | 4,492 | 2,238 | 2,574 | 2,609 |
| Porgies (scup) | H | 1,186 | 5,268 | 1,948 | 992 | 2,005 | 1,699 | 1,544 | 1,638 | 2,735 | 771 |
| | R | 1,551 | 2,379 | 3,730 | 2,254 | 3,543 | 2,500 | 3,170 | 2,293 | 2,414 | 1,041 |
| Striped bass | H | 1,251 | 1,663 | 1,472 | 1,598 | 2,025 | 1,772 | 1,681 | 1,382 | 1,403 | 1,655 |
| | R | 5,052 | 7,801 | 9,579 | 8,033 | 9,227 | 7,730 | 4,787 | 3,802 | 3,465 | 3,782 |
| Summer flounder | H | 2,634 | 3,918 | 3,467 | 3,339 | 3,195 | 2,540 | 1,725 | 1,563 | 1,226 | 1,509 |
| | R | 11,851 | 14,901 | 15,122 | 20,359 | 14,547 | 16,578 | 18,431 | 21,372 | 21,402 | 18,466 |
| Weakfish drum | H | 919 | 307 | 418 | 1,102 | 554 | 331 | 372 | 37 | 14 | 7 |
| | R | 1,688 | 1,363 | 1,421 | 1,972 | 2,054 | 1,037 | 1,983 | 179 | 458 | 468 |
| Winter flounder | H | 361 | 540 | 267 | 132 | 325 | 106 | 44 | 76 | 55 | 92 |
| | R | 265 | 182 | 64 | 222 | 188 | 42 | 32 | 138 | 103 | 126 |
| Wrasses (tautog) | H | 1,231 | 382 | 598 | 275 | 679 | 728 | 668 | 692 | 759 | 352 |
| | R | 2,531 | 1,011 | 1,369 | 856 | 2,005 | 2,203 | 1,979 | 1,912 | 2,319 | 1,531 |

[1]NA = data are not available because out-of-state resident information is collected for individual states but whether an angler is a resident of a region is not specified

### 2011 Economic Impacts of Recreational Fishing Expenditures (thousands of dollars)

| | Jobs | Sales | Income | Value Added |
|---|---|---|---|---|
| Trip Impacts by Fishing Mode: | | | | |
| For-Hire | 31 | 3,443 | 1,571 | 2,331 |
| Private Boat | 176 | 20,925 | 6,036 | 10,345 |
| Shore | 197 | 19,788 | 6,123 | 10,221 |
| Total Durable Equipment Impacts | 999 | 88,066 | 46,780 | 70,909 |
| **Total State Trip and Durable Equipment Economic Impacts** | 1,403 | 132,223 | 60,509 | 93,806 |

### 2011 Angler Trip & Durable Expenditures (thousands of dollars)

| Fishing Mode | Trip Expenditures | | Equipment | Durable Expenditures |
|---|---|---|---|---|
| | Non-Residents | Residents | Fishing Tackle | 29,440 |
| For-Hire | 1,906 | 461 | Other Equipment | 11,564 |
| Private Boat | 6,650 | 12,047 | Boat Expenses | 26,932 |
| Shore | 9,142 | 6,856 | Vehicle Expenses | 21,844 |
| *Total Trip Expenditures* | 17,698 | 19,363 | Second Home Expenses | 5,347 |
| | | | *Total Durable Equipment Expenditures* | 95,127 |
| **Total State Trip and Durable Equipment Expenditures** | | | | 132,188 |

### Recreational Anglers by Residential Area (thousands of anglers)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal | 89 | 127 | 116 | 120 | 137 | 150 | 134 | 114 | 128 | 129 |
| Non-Coastal | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| Out of State | 177 | 199 | 243 | 191 | 205 | 224 | 182 | 173 | 165 | 190 |
| **Total Anglers** | 266 | 326 | 359 | 311 | 342 | 374 | 315 | 287 | 293 | 318 |

### Recreational Fishing Effort by Mode (thousands of angler-trips)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| For-Hire | 64 | 38 | 32 | 42 | 62 | 70 | 56 | 44 | 20 | 17 |
| Private | 536 | 553 | 654 | 553 | 595 | 722 | 529 | 487 | 408 | 512 |
| Shore | 429 | 514 | 389 | 431 | 427 | 459 | 444 | 379 | 391 | 397 |
| **Total Trips** | 1,029 | 1,105 | 1,075 | 1,026 | 1,084 | 1,251 | 1,029 | 910 | 819 | 926 |

### Harvest (H) and Release (R) of Key Species Species Groups (thousands of fish)[2]

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Atlantic mackerel | H | 6 | (1) | 13 | (1) | (1) | (1) | (1) | (1) | (1) | (1) |
| | R | (1) | (1) | (1) | (1) | (1) | (1) | (1) | 2 | (1) | (1) |
| Black seabass | H | 608 | 308 | 43 | 67 | 113 | 94 | 21 | 37 | 22 | 44 |
| | R | 1,233 | 832 | 276 | 275 | 329 | 583 | 464 | 292 | 232 | 210 |
| Bluefish | H | 116 | 89 | 128 | 126 | 98 | 152 | 68 | 98 | 31 | 45 |
| | R | 435 | 120 | 408 | 190 | 288 | 539 | 166 | 166 | 57 | 128 |
| Drum (Atlantic croaker) | H | 261 | 342 | 389 | 825 | 764 | 359 | 370 | 452 | 75 | 92 |
| | R | 362 | 656 | 599 | 675 | 938 | 672 | 603 | 539 | 230 | 88 |
| Drum (weakfish)[3] | H | 121 | 20 | 5 | 19 | 10 | 3 | 4 | 6 | (1) | (1) |
| | R | 101 | 39 | 72 | 104 | 96 | 22 | 61 | 4 | 12 | 6 |
| Striped bass | H | 29 | 29 | 25 | 20 | 20 | 8 | 26 | 20 | 15 | 18 |
| | R | 114 | 169 | 155 | 250 | 248 | 247 | 260 | 146 | 65 | 110 |
| Summer flounder | H | 107 | 105 | 110 | 73 | 88 | 108 | 36 | 87 | 52 | 66 |
| | R | 497 | 415 | 737 | 795 | 446 | 1,072 | 605 | 964 | 619 | 617 |
| White perch | H | 40 | 30 | 63 | 37 | 69 | 34 | 40 | 64 | 187 | 113 |
| | R | 72 | 134 | 303 | 105 | 194 | 190 | 243 | 121 | 397 | 272 |
| Wrasses (tautog) | H | 185 | 62 | 70 | 60 | 111 | 100 | 103 | 121 | 56 | 46 |
| | R | 411 | 167 | 198 | 232 | 194 | 266 | 165 | 224 | 196 | 88 |
| Yellowfin tuna | H | 10 | 2 | 1 | 5 | 6 | (1) | 1 | (1) | (1) | (1) |
| | R | (1) | (1) | (1) | (1) | (1) | (1) | (1) | (1) | (1) | (1) |

[1]NA = not applicable because all Delaware residents are considered coastal county residents
[2]In this table, '(1)' = 0-999 thousand fish and '1' = 1,000-1,499 thousand fish.
[3]This species may not be equivalent to species with similar names listed in the commercial tables.

## 2011 Economic Impacts of Recreational Fishing Expenditures (thousands of dollars)

| | Jobs | Sales | Income | Value Added |
|---|---|---|---|---|
| Trip Impacts by Fishing Mode: | | | | |
| For-Hire | 420 | 49,954 | 20,392 | 31,419 |
| Private Boat | 486 | 58,430 | 19,794 | 33,176 |
| Shore | 651 | 70,850 | 23,735 | 39,569 |
| Total Durable Equipment Impacts | 4,909 | 545,159 | 250,056 | 378,386 |
| **Total State Trip and Durable Equipment Economic Impacts** | 6,466 | 724,394 | 313,977 | 482,551 |

## 2011 Angler Trip & Durable Expenditures (thousands of dollars)

| Fishing Mode | Trip Expenditures | | Equipment | Durable Expenditures |
|---|---|---|---|---|
| | Non-Residents | Residents | Fishing Tackle | 102,037 |
| For-Hire | 21,517 | 12,565 | Other Equipment | 25,715 |
| Private Boat | 11,504 | 46,261 | Boat Expenses | 424,367 |
| Shore | 26,772 | 30,318 | Vehicle Expenses | 107,135 |
| *Total Trip Expenditures* | 59,793 | 89,143 | Second Home Expenses | 916 |
| | | | *Total Durable Equipment Expenditures* | 660,170 |
| **Total State Trip and Durable Equipment Expenditures** | | | | 809,106 |

## Recreational Anglers by Residential Area (thousands of anglers)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal | 430 | 526 | 442 | 620 | 733 | 850 | 643 | 514 | 552 | 415 |
| Non-Coastal | 41 | 53 | 39 | 49 | 84 | 78 | 50 | 43 | 54 | 49 |
| Out of State | 330 | 418 | 333 | 425 | 447 | 528 | 507 | 327 | 462 | 372 |
| **Total Anglers** | 801 | 997 | 815 | 1095 | 1264 | 1456 | 1200 | 884 | 1068 | 836 |

## Recreational Fishing Effort by Mode (thousands of angler-trips)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| For-Hire | 183 | 187 | 176 | 212 | 238 | 269 | 195 | 202 | 138 | 161 |
| Private | 1,596 | 2,033 | 1,535 | 1,924 | 1,836 | 2,352 | 1,891 | 1,608 | 1,643 | 1,453 |
| Shore | 1,059 | 1,109 | 874 | 1,020 | 1,145 | 1,082 | 1,273 | 1,081 | 1,150 | 1,206 |
| **Total Trips** | 2,838 | 3,329 | 2,585 | 3,156 | 3,219 | 3,703 | 3,359 | 2,891 | 2,931 | 2,820 |

## Harvest (H) and Release (R) of Key Species Species Groups (thousands of fish)[1]

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Black seabass | H | 337 | 241 | 15 | 91 | 121 | 39 | 27 | 33 | 36 | 47 |
| | R | 925 | 773 | 259 | 563 | 645 | 577 | 674 | 453 | 670 | 352 |
| Bluefish | H | 197 | 213 | 367 | 167 | 421 | 676 | 550 | 591 | 273 | 259 |
| | R | 577 | 519 | 593 | 236 | 778 | 1,172 | 1,631 | 670 | 162 | 408 |
| Drum (Atlantic croaker) | H | 1,223 | 1,620 | 896 | 784 | 755 | 873 | 621 | 1,335 | 1,137 | 554 |
| | R | 2,524 | 1,393 | 854 | 1,138 | 1,783 | 1,258 | 2,128 | 1,138 | 1,011 | 366 |
| Drum (spot) | H | 692 | 3,300 | 868 | 1,789 | 2,895 | 3,616 | 1,892 | 2,064 | 1,164 | 913 |
| | R | 501 | 671 | 383 | 2,136 | 1,355 | 1,619 | 1,739 | 632 | 1,155 | 298 |
| Drum (weakfish)[2] | H | 101 | 42 | 15 | 32 | 1 | 7 | 2 | 4 | 5 | (1) |
| | R | 286 | 182 | 231 | 61 | 47 | 63 | 38 | 8 | 162 | 18 |
| Striped bass | H | 283 | 525 | 369 | 534 | 668 | 765 | 415 | 501 | 457 | 445 |
| | R | 2,928 | 4,653 | 3,479 | 3,855 | 3,711 | 3,066 | 1,338 | 1,423 | 1,509 | 1,127 |
| Summer flounder | H | 69 | 40 | 42 | 117 | 36 | 103 | 58 | 64 | 26 | 14 |
| | R | 383 | 373 | 805 | 361 | 252 | 1,018 | 922 | 817 | 1,227 | 472 |
| White perch | H | 1,156 | 2,020 | 1,623 | 2,411 | 2,560 | 2,889 | 1,509 | 550 | 2,613 | 1,571 |
| | R | 1,755 | 3,699 | 3,459 | 5,837 | 3,953 | 5,425 | 3,853 | 1,137 | 2,891 | 2,347 |
| Wrasses (tautog) | H | 43 | 13 | 8 | 28 | 15 | 43 | 19 | 39 | 57 | 12 |
| | R | 294 | 97 | 24 | 148 | 186 | 178 | 151 | 133 | 362 | 75 |
| Yellowfin tuna | H | 18 | 26 | 2 | 5 | 8 | 4 | (1) | 5 | 1 | (1) |
| | R | (1) | (1) | (1) | (1) | (1) | (1) | (1) | 2 | (1) | (1) |

[1] In this table, '(1)' = 0-999 thousand fish and '1' = 1,000-1,499 thousand fish.
[2] This species may not be equivalent to species with similar names listed in the commercial tables.

### 2011 Economic Impacts of Recreational Fishing Expenditures (thousands of dollars)

| | Jobs | Sales | Income | Value Added |
|---|---|---|---|---|
| Trip Impacts by Fishing Mode: | | | | |
| For-Hire | 416 | 62,920 | 30,295 | 44,006 |
| Private Boat | 1,336 | 185,804 | 60,144 | 98,004 |
| Shore | 848 | 105,747 | 35,362 | 56,967 |
| Total Durable Equipment Impacts | 10,218 | 1,486,872 | 568,086 | 888,178 |
| **Total State Trip and Durable Equipment Economic Impacts** | 12,818 | 1,841,343 | 693,886 | 1,087,155 |

### 2011 Angler Trip & Durable Expenditures (thousands of dollars)

| Fishing Mode | Trip Expenditures | | Equipment | Durable Expenditures |
|---|---|---|---|---|
| | Non-Residents | Residents | Fishing Tackle | 307,411 |
| For-Hire | 17,405 | 23,220 | Other Equipment | 58,800 |
| Private Boat | 37,561 | 104,637 | Boat Expenses | 499,473 |
| Shore | 29,105 | 47,508 | Vehicle Expenses | 232,339 |
| *Total Trip Expenditures* | 84,072 | 175,365 | Second Home Expenses | 134,169 |
| | | | *Total Durable Equipment Expenditures* | 1,232,192 |
| **Total State Trip and Durable Equipment Expenditures** | | | | 1,491,629 |

### Recreational Anglers by Residential Area (thousands of anglers)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal | 400 | 592 | 708 | 818 | 693 | 890 | 765 | 656 | 776 | 687 |
| Non-Coastal | 17 | 20 | 31 | 39 | 25 | 19 | 26 | 35 | 36 | 23 |
| Out of State | 239 | 462 | 379 | 471 | 481 | 518 | 456 | 454 | 449 | 357 |
| **Total Anglers** | 656 | 1074 | 1117 | 1328 | 1199 | 1427 | 1246 | 1145 | 1261 | 1067 |

### Recreational Fishing Effort by Mode (thousands of angler-trips)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| For-Hire | 367 | 466 | 432 | 452 | 633 | 606 | 450 | 434 | 319 | 382 |
| Private | 2,992 | 3,603 | 3,895 | 3,753 | 3,721 | 3,614 | 3,595 | 2,671 | 3,264 | 2,446 |
| Shore | 2,049 | 2,712 | 2,121 | 2,357 | 2,682 | 2,978 | 2,858 | 2,235 | 2,279 | 2,334 |
| **Total Trips** | 5,408 | 6,781 | 6,448 | 6,562 | 7,036 | 7,198 | 6,903 | 5,340 | 5,862 | 5,162 |

### Harvest (H) and Release (R) of Key Species Species Groups (thousands of fish)[1]

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Black seabass | H | 1,759 | 1,903 | 1,079 | 660 | 530 | 725 | 579 | 584 | 685 | 149 |
| | R | 4,320 | 4,296 | 3,121 | 2,387 | 2,082 | 2,423 | 4,431 | 3,139 | 3,868 | 1,302 |
| Bluefin tuna | H | 7 | 9 | 7 | 10 | 4 | 7 | 4 | 14 | 6 | 2 |
| | R | (1) | (1) | 60 | 24 | 97 | 1 | 1 | 2 | 7 | 6 |
| Bluefish | H | 1,322 | 1,572 | 1,530 | 2,367 | 1,184 | 1,654 | 1,029 | 813 | 910 | 1,150 |
| | R | 2,169 | 1,913 | 2,226 | 2,291 | 1,803 | 2,735 | 1,478 | 1,476 | 1,885 | 1,911 |
| Drum (weakfish)[2] | H | 494 | 149 | 228 | 1,008 | 489 | 229 | 298 | 12 | 2 | 3 |
| | R | 351 | 630 | 534 | 1,374 | 1,335 | 613 | 1,433 | 79 | 103 | 101 |
| Red hake | H | 12 | 16 | 4 | 6 | 141 | 1 | 152 | 240 | 124 | 206 |
| | R | (1) | 14 | 3 | 2 | 12 | (1) | 19 | 23 | 24 | 13 |
| Striped bass | H | 415 | 392 | 423 | 411 | 509 | 288 | 310 | 281 | 318 | 394 |
| | R | 715 | 926 | 1,503 | 1,219 | 1,890 | 1,789 | 1,309 | 801 | 689 | 884 |
| Summer flounder | H | 988 | 1,784 | 1,617 | 1,302 | 1,556 | 1,067 | 763 | 825 | 552 | 737 |
| | R | 4,206 | 5,806 | 6,700 | 8,940 | 6,739 | 6,192 | 8,959 | 10,413 | 10,565 | 8,096 |
| Winter flounder | H | 208 | 307 | 40 | 32 | 64 | 96 | 3 | 7 | 24 | 28 |
| | R | 124 | 110 | 32 | 21 | 112 | 27 | 15 | 28 | 39 | 25 |
| Wrasses (tautog) | H | 347 | 102 | 90 | 43 | 202 | 300 | 172 | 127 | 374 | 137 |
| | R | 836 | 394 | 385 | 222 | 603 | 1,290 | 901 | 856 | 1,064 | 844 |
| Yellowfin tuna | H | 14 | 22 | 9 | 21 | 36 | 58 | 7 | 7 | 26 | 17 |
| | R | 4 | (1) | 8 | 1 | (1) | (1) | 1 | 16 | (1) | (1) |

[1] In this table, '(1)' = 0-999 thousand fish and '1' = 1,000-1,499 thousand fish.
[2] This species may not be equivalent to species with similar names listed in the commercial tables.

### 2011 Economic Impacts of Recreational Fishing Expenditures (thousands of dollars)

| | Jobs | Sales | Income | Value Added |
|---|---|---|---|---|
| Trip Impacts by Fishing Mode: | | | | |
| For-Hire | 787 | 105,336 | 53,406 | 77,456 |
| Private Boat | 916 | 113,449 | 39,442 | 66,600 |
| Shore | 267 | 26,968 | 9,151 | 14,871 |
| Total Durable Equipment Impacts | 1,124 | 153,127 | 58,032 | 95,802 |
| **Total State Trip and Durable Equipment Economic Impacts** | 3,094 | 398,881 | 160,031 | 254,728 |

### 2011 Angler Trip & Durable Expenditures (thousands of dollars)

| Fishing Mode | Trip Expenditures | | Equipment | Durable Expenditures |
|---|---|---|---|---|
| | Non-Residents | Residents | Fishing Tackle | 45,733 |
| For-Hire | 3,640 | 62,687 | Other Equipment | 20,598 |
| Private Boat | 2,156 | 113,537 | Boat Expenses | 47,804 |
| Shore | 775 | 23,108 | Vehicle Expenses | 10,276 |
| *Total Trip Expenditures* | 6,571 | 199,332 | Second Home Expenses | 0 |
| | | | *Total Durable Equipment Expenditures* | 124,412 |
| **Total State Trip and Durable Equipment Expenditures** | | | | 330,315 |

### Recreational Anglers by Residential Area (thousands of anglers)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal | 387 | 599 | 587 | 885 | 735 | 881 | 817 | 638 | 646 | 497 |
| Non-Coastal | 8 | 19 | 18 | 27 | 25 | 39 | 32 | 21 | 24 | 18 |
| Out of State | 41 | 82 | 76 | 110 | 114 | 147 | 118 | 58 | 69 | 46 |
| **Total Anglers** | 436 | 700 | 681 | 1022 | 874 | 1067 | 967 | 717 | 740 | 561 |

### Recreational Fishing Effort by Mode (thousands of angler-trips)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| For-Hire | 339 | 405 | 388 | 526 | 361 | 684 | 387 | 383 | 347 | 458 |
| Private | 2,171 | 3,030 | 2,670 | 3,108 | 3,121 | 3,315 | 3,200 | 2,819 | 2,351 | 2,321 |
| Shore | 1,606 | 2,089 | 1,755 | 2,495 | 1,961 | 2,522 | 2,341 | 1,624 | 1,675 | 1,389 |
| **Total Trips** | 4,116 | 5,524 | 4,813 | 6,129 | 5,443 | 6,521 | 5,928 | 4,826 | 4,373 | 4,168 |

### Harvest (H) and Release (R) of Key Species Species Groups (thousands of fish)[1]

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Atlantic herring[2] | H | 26 | 30 | 124 | 60 | 23 | 214 | 70 | 3 | 79 | 75 |
| | R | 14 | (1) | 2 | 2 | 2 | 230 | 50 | (1) | 17 | (1) |
| Black seabass | H | 221 | 318 | 133 | 143 | 269 | 410 | 259 | 567 | 543 | 274 |
| | R | 1,412 | 739 | 625 | 1,072 | 1,328 | 1,548 | 1,654 | 1,236 | 1,164 | 894 |
| Bluefish | H | 752 | 1,146 | 1,896 | 1,684 | 1,834 | 2,150 | 1,484 | 1,293 | 1,026 | 926 |
| | R | 1,018 | 1,305 | 2,530 | 3,381 | 2,378 | 2,650 | 3,225 | 1,794 | 1,471 | 1,600 |
| Drum (weakfish)[3] | H | 25 | 9 | 11 | (1) | 11 | 4 | 40 | (1) | 3 | (1) |
| | R | 62 | 8 | 39 | 77 | 18 | 109 | 25 | 3 | 3 | 55 |
| Porgies (scup) | H | 1,090 | 5,110 | 1,877 | 859 | 1,678 | 1,596 | 1,451 | 1,461 | 1,990 | 715 |
| | R | 1,246 | 1,806 | 3,515 | 1,738 | 2,623 | 1,963 | 2,838 | 2,124 | 1,865 | 998 |
| Shortfin mako shark | H | 1 | 3 | (1) | (1) | (1) | (1) | (1) | (1) | 1 | (1) |
| | R | 4 | 3 | 2 | 5 | (1) | (1) | (1) | (1) | (1) | 3 |
| Striped bass | H | 202 | 315 | 263 | 376 | 368 | 474 | 684 | 355 | 539 | 676 |
| | R | 588 | 1,083 | 2,709 | 1,413 | 1,722 | 1,679 | 1,347 | 1,073 | 1,068 | 1,507 |
| Summer flounder | H | 698 | 1,538 | 1,024 | 1,164 | 752 | 866 | 608 | 299 | 335 | 375 |
| | R | 4,099 | 5,722 | 3,182 | 7,754 | 4,946 | 5,272 | 5,521 | 5,565 | 6,571 | 7,295 |
| Winter flounder | H | 153 | 233 | 227 | 100 | 261 | 10 | 41 | 69 | 31 | 64 |
| | R | 141 | 72 | 32 | 201 | 76 | 15 | 17 | 110 | 63 | 101 |
| Wrasses (tautog) | H | 630 | 129 | 278 | 84 | 246 | 224 | 318 | 345 | 145 | 111 |
| | R | 953 | 298 | 640 | 178 | 823 | 388 | 728 | 666 | 567 | 488 |

[1] In this table, '(1)' = 0-999 thousand fish and '1' = 1,000-1,499 thousand fish.
[2] This species may not be equivalent to species with similar names listed in the commercial tables.
[3] This species may not be equivalent to species with similar names listed in the commercial tables.

### 2011 Economic Impacts of Recreational Fishing Expenditures (thousands of dollars)

| | Jobs | Sales | Income | Value Added |
|---|---|---|---|---|
| Trip Impacts by Fishing Mode: | | | | |
| For-Hire | 52 | 5,462 | 2,414 | 3,705 |
| Private Boat | 1,004 | 113,259 | 36,311 | 64,170 |
| Shore | 576 | 53,496 | 18,073 | 30,262 |
| Total Durable Equipment Impacts | 7,823 | 797,354 | 329,345 | 528,855 |
| **Total State Trip and Durable Equipment Economic Impacts** | 9,454 | 969,571 | 386,143 | 626,991 |

### 2011 Angler Trip & Durable Expenditures (thousands of dollars)

| Fishing Mode | Trip Expenditures | | Equipment | Durable Expenditures |
|---|---|---|---|---|
| | Non-Residents | Residents | Fishing Tackle | 246,850 |
| For-Hire | 2,000 | 1,834 | Other Equipment | 76,070 |
| Private Boat | 28,490 | 76,529 | Boat Expenses | 392,265 |
| Shore | 23,663 | 18,722 | Vehicle Expenses | 56,458 |
| *Total Trip Expenditures* | 54,153 | 97,085 | Second Home Expenses | 524 |
| | | | *Total Durable Equipment Expenditures* | 772,167 |
| **Total State Trip and Durable Equipment Expenditures** | | | | 923,405 |

### Recreational Anglers by Residential Area (thousands of anglers)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal | 337 | 384 | 510 | 559 | 578 | 463 | 464 | 515 | 496 | 516 |
| Non-Coastal | 73 | 52 | 69 | 137 | 90 | 76 | 89 | 87 | 63 | 56 |
| Out of State | 407 | 288 | 428 | 511 | 364 | 297 | 338 | 305 | 279 | 320 |
| **Total Anglers** | 817 | 724 | 1007 | 1206 | 1033 | 836 | 891 | 907 | 838 | 892 |

### Recreational Fishing Effort by Mode (thousands of angler-trips)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| For-Hire | 72 | 85 | 71 | 36 | 43 | 59 | 56 | 47 | 46 | 30 |
| Private | 2,255 | 2,068 | 2,490 | 2,563 | 2,590 | 2,369 | 2,352 | 2,123 | 1,699 | 1,782 |
| Shore | 927 | 959 | 1,104 | 1,365 | 1,155 | 1,083 | 1,090 | 876 | 851 | 1,086 |
| **Total Trips** | 3,254 | 3,112 | 3,665 | 3,964 | 3,788 | 3,511 | 3,498 | 3,046 | 2,596 | 2,898 |

### Harvest (H) and Release (R) of Key Species Species Groups (thousands of fish)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Black seabass | H | 134 | 264 | 47 | 34 | 83 | 35 | 37 | 114 | 30 | 19 |
| | R | 2,442 | 1,743 | 1,247 | 1,117 | 1,355 | 1,270 | 1,250 | 1,150 | 524 | 445 |
| Cobia | H | 3 | 2 | 1 | 17 | 22 | 10 | 5 | 17 | 7 | 4 |
| | R | 11 | 15 | 6 | 16 | 23 | 3 | 3 | 13 | 9 | 9 |
| Drum (Atlantic croaker) | H | 9,129 | 6,695 | 8,259 | 7,656 | 7,222 | 6,946 | 8,388 | 5,328 | 4,745 | 3,305 |
| | R | 7,108 | 6,544 | 6,276 | 8,738 | 4,193 | 8,503 | 7,807 | 7,620 | 4,824 | 4,874 |
| Drum (spot) | H | 1,602 | 1,441 | 1,718 | 2,782 | 3,584 | 8,203 | 4,398 | 2,146 | 1,670 | 2,968 |
| | R | 482 | 934 | 882 | 2,457 | 1,371 | 2,156 | 1,487 | 1,458 | 1,156 | 2,244 |
| Drum (spotted seatrout) | H | 17 | 102 | 68 | 22 | 43 | 158 | 104 | 22 | 17 | 248 |
| | R | 137 | 207 | 258 | 191 | 83 | 362 | 367 | 172 | 550 | 1,215 |
| Drum (weakfish)[1] | H | 178 | 87 | 159 | 43 | 43 | 88 | 28 | 15 | 4 | 4 |
| | R | 888 | 504 | 545 | 356 | 558 | 230 | 426 | 85 | 178 | 288 |
| Red drum | H | 50 | 14 | 5 | 3 | 13 | 46 | 20 | 39 | 11 | (1) |
| | R | 802 | 43 | 34 | 28 | 186 | 111 | 236 | 179 | 28 | 61 |
| Striped bass | H | 322 | 402 | 392 | 257 | 460 | 237 | 246 | 225 | 74 | 122 |
| | R | 707 | 970 | 1,733 | 1,296 | 1,656 | 949 | 533 | 359 | 134 | 154 |
| Summer flounder | H | 772 | 451 | 674 | 683 | 763 | 396 | 260 | 288 | 261 | 317 |
| | R | 2,666 | 2,585 | 3,698 | 2,509 | 2,164 | 3,024 | 2,424 | 3,613 | 2,420 | 1,986 |
| Wrasses (tautog) | H | 26 | 76 | 152 | 60 | 105 | 61 | 56 | 60 | 127 | 46 |
| | R | 37 | 55 | 122 | 76 | 199 | 81 | 34 | 33 | 130 | 36 |

[1] This species may not be equivalent to species with similar names listed in the commercial tables.

# South Atlantic

- East Florida
- Georgia
- North Carolina
- South Carolina

### 2011 Economic Impacts of Recreational Fishing Expenditures (thousands of dollars)

| | Trips | Jobs | Sales | Income | Value Added |
|---|---|---|---|---|---|
| East Florida | 10,157,000 | 32,118 | 3,771,614 | 1,399,563 | 2,223,161 |
| Georgia | 970,000 | 3,217 | 344,794 | 135,146 | 216,863 |
| North Carolina | 4,740,000 | 15,831 | 1,622,060 | 604,275 | 970,422 |
| South Carolina | 1,807,000 | 3,303 | 306,678 | 114,530 | 185,318 |

### 2011 Angler Trip & Durable Expenditures (thousands of dollars)

| Fishing Mode | Trip Expenditures | | Equipment | Durable Expenditures |
|---|---|---|---|---|
| | Non-Residents | Residents | Fishing Tackle | 1,059,539 |
| For-Hire | 125,489 | 29,914 | Other Equipment | 277,813 |
| Private Boat | 41,190 | 329,059 | Boat Expenses | 1,405,929 |
| Shore | 218,760 | 204,365 | Vehicle Expenses | 2,308,671 |
| *Total Trip Expenditures* | 385,437 | 563,338 | Second Home Expenses | 63,454 |
| | | | *Total Durable Equipment Expenditures* | 5,115,405 |
| **Total State Trip and Durable Equipment Expenditures** | | | | 6,064,180 |

### Recreational Anglers by Residential Area (thousands of anglers)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal | 1,948 | 2,271 | 2,105 | 2,615 | 2,603 | 3,157 | 2,330 | 1,922 | 1,933 | 1,893 |
| Non-Coastal | 334 | 473 | 511 | 472 | 477 | 493 | 560 | 462 | 536 | 450 |
| Out-of-State | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| **Total Anglers** | 2,282 | 2,744 | 2,616 | 3,087 | 3,080 | 3,650 | 2,890 | 2,384 | 2,470 | 2,343 |

### Recreational Fishing Effort by Mode (thousands of angler-trips)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| For-Hire | 442 | 412 | 490 | 505 | 456 | 503 | 415 | 391 | 368 | 374 |
| Private Boat | 8,265 | 9,962 | 9,899 | 9,896 | 9,824 | 11,535 | 10,910 | 8,923 | 9,514 | 8,663 |
| Shore | 9,057 | 10,871 | 10,829 | 10,621 | 11,251 | 9,955 | 10,468 | 9,370 | 9,186 | 8,637 |
| **Total Trips** | 17,764 | 21,245 | 21,218 | 21,022 | 21,531 | 21,993 | 21,793 | 18,684 | 19,068 | 17,674 |

### Harvest (H) and Release (R) of Key Species Species Groups (thousands of fish)[2,2]

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Black sea bass | H | 340 | 424 | 918 | 624 | 582 | 435 | 348 | 271 | 509 | 335 |
| | R | 1,456 | 1,407 | 2,758 | 2,386 | 2,513 | 2,861 | 2,566 | 1,909 | 2,594 | 3,031 |
| Bluefish | H | 1,617 | 1,664 | 1,879 | 2,078 | 1,487 | 1,915 | 1,690 | 1,585 | 2,348 | 1,939 |
| | R | 3,190 | 2,277 | 2,664 | 2,752 | 3,200 | 4,089 | 3,085 | 2,557 | 4,267 | 3,458 |
| Dolphinfish | H | 1,297 | 1,137 | 840 | 1,018 | 1,017 | 1,080 | 1,026 | 726 | 826 | 825 |
| | R | 81 | 146 | 119 | 202 | 186 | 394 | 188 | 99 | 128 | 354 |
| Drum (Atlantic croaker and spot) | H | 3,701 | 5,521 | 5,701 | 4,211 | 4,980 | 4,574 | 5,516 | 2,813 | 1,945 | 3,074 |
| | R | 2,272 | 4,653 | 3,876 | 3,882 | 6,754 | 3,775 | 4,179 | 4,869 | 3,336 | 4,182 |
| Drum (spotted seatrout) | H | 758 | 826 | 1,050 | 1,477 | 1,507 | 1,546 | 1,635 | 1,413 | 932 | 858 |
| | R | 3,218 | 2,891 | 3,561 | 6,409 | 5,264 | 5,555 | 5,167 | 4,169 | 5,771 | 4,890 |
| King mackerel | H | 364 | 600 | 461 | 392 | 491 | 821 | 485 | 422 | 231 | 152 |
| | R | 97 | 255 | 227 | 193 | 198 | 301 | 168 | 96 | 76 | 47 |
| Porgies (sheepshead) | H | 409 | 728 | 428 | 541 | 392 | 638 | 692 | 624 | 703 | 660 |
| | R | 453 | 558 | 316 | 421 | 420 | 546 | 691 | 511 | 496 | 516 |
| Red drum | H | 293 | 468 | 414 | 481 | 319 | 414 | 463 | 277 | 608 | 493 |
| | R | 1,615 | 1,527 | 1,766 | 2,612 | 2,033 | 1,840 | 2,414 | 1,870 | 3,321 | 2,139 |
| Sharks[3] | H | 9 | 25 | 23 | 76 | 6 | 15 | 16 | 19 | 3 | 11 |
| | R | 1,016 | 1,367 | 1,819 | 2,568 | 1,852 | 1,954 | 2,525 | 2,063 | 1,969 | 1,541 |
| Spanish mackerel | H | 1,353 | 1,169 | 760 | 932 | 651 | 1,060 | 1,315 | 1,126 | 1,070 | 865 |
| | R | 769 | 841 | 444 | 617 | 274 | 603 | 886 | 519 | 604 | 395 |

[1]NA = data are not available because out-of-state resident information is collected for individual states but whether an angler is a resident of a region is not specified

[2]In this table, '(1)' = 0-999 thousand fish and '1' = 1,000-1,499 thousand fish.

### 2011 Economic Impacts of Recreational Fishing Expenditures (thousands of dollars)

| | Jobs | Sales | Income | Value Added |
|---|---|---|---|---|
| Trip Impacts by Fishing Mode: | | | | |
| For-Hire | 781 | 88,105 | 37,583 | 57,987 |
| Private Boat | 2,082 | 232,760 | 75,605 | 131,040 |
| Shore | 1,615 | 167,433 | 55,127 | 92,769 |
| Total Durable Equipment Impacts | 27,640 | 3,283,316 | 1,231,247 | 1,941,365 |
| **Total State Trip and Durable Equipment Economic Impacts** | 32,118 | 3,771,614 | 1,399,563 | 2,223,161 |

### 2011 Angler Trip & Durable Expenditures (thousands of dollars)

| Fishing Mode | Trip Expenditures | | Equipment | Durable Expenditures |
|---|---|---|---|---|
| | Non-Residents | Residents | Fishing Tackle | 680,782 |
| For-Hire | 45,395 | 5,328 | Other Equipment | 165,033 |
| Private Boat | 13,600 | 174,533 | Boat Expenses | 730,965 |
| Shore | 50,920 | 65,662 | Vehicle Expenses | 1,905,734 |
| *Total Trip Expenditures* | 109,915 | 245,524 | Second Home Expenses | 5,487 |
| | | | *Total Durable Equipment Expenditures* | 3,488,001 |
| **Total State Trip and Durable Equipment Expenditures** | | | | 3,843,440 |

### Recreational Anglers by Residential Area (thousands of anglers)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal | 1304 | 1413 | 1161 | 1565 | 1660 | 2168 | 1317 | 1099 | 1033 | 1109 |
| Non-Coastal | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| Out of State | 784 | 793 | 685 | 945 | 935 | 1008 | 703 | 643 | 629 | 553 |
| **Total Anglers** | 2089 | 2206 | 1847 | 2510 | 2595 | 3176 | 2021 | 1741 | 1662 | 1662 |

### Recreational Fishing Effort by Mode (thousands of angler-trips)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| For-Hire | 216 | 187 | 203 | 194 | 172 | 169 | 137 | 149 | 118 | 124 |
| Private | 5,429 | 6,211 | 5,544 | 6,064 | 5,913 | 7,157 | 6,452 | 5,394 | 5,706 | 5,298 |
| Shore | 4,657 | 5,045 | 5,144 | 5,092 | 5,543 | 5,277 | 4,651 | 4,577 | 4,393 | 4,735 |
| **Total Trips** | 10,302 | 11,443 | 10,891 | 11,350 | 11,628 | 12,603 | 11,240 | 10,120 | 10,217 | 10,157 |

### Harvest (H) and Release (R) of Key Species Species Groups (thousands of fish)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Bluefish | H | 758 | 644 | 513 | 446 | 433 | 471 | 377 | 623 | 787 | 557 |
| | R | 1,392 | 622 | 499 | 369 | 719 | 932 | 499 | 680 | 1,620 | 912 |
| Dolphinfish | H | 659 | 787 | 545 | 353 | 492 | 514 | 662 | 328 | 248 | 347 |
| | R | 72 | 130 | 114 | 200 | 162 | 373 | 185 | 78 | 118 | 346 |
| Drum (kingfish) | H | 930 | 590 | 1,094 | 997 | 839 | 853 | 949 | 408 | 720 | 935 |
| | R | 587 | 368 | 755 | 906 | 707 | 1,099 | 551 | 608 | 935 | 807 |
| Drum (spotted seatrout) | H | 206 | 170 | 235 | 379 | 332 | 277 | 181 | 172 | 252 | 286 |
| | R | 2,327 | 1,708 | 2,413 | 4,245 | 3,316 | 3,095 | 2,831 | 1,641 | 2,937 | 2,141 |
| Gray snapper | H | 402 | 447 | 322 | 397 | 445 | 689 | 352 | 225 | 161 | 187 |
| | R | 1,437 | 1,654 | 1,770 | 1,047 | 1,327 | 2,072 | 1,552 | 1,707 | 498 | 677 |
| Jack (Florida pompano) | H | 141 | 373 | 447 | 281 | 165 | 126 | 271 | 91 | 264 | 106 |
| | R | 175 | 307 | 417 | 188 | 129 | 163 | 359 | 80 | 161 | 297 |
| King mackerel | H | 282 | 463 | 287 | 242 | 340 | 515 | 349 | 292 | 182 | 133 |
| | R | 82 | 233 | 145 | 118 | 157 | 227 | 124 | 52 | 59 | 45 |
| Porgies (sheepshead) | H | 290 | 354 | 202 | 390 | 243 | 255 | 236 | 227 | 351 | 286 |
| | R | 352 | 351 | 252 | 289 | 314 | 306 | 465 | 355 | 336 | 357 |
| Red drum | H | 119 | 159 | 137 | 195 | 146 | 162 | 160 | 80 | 176 | 179 |
| | R | 663 | 749 | 1,006 | 1,406 | 847 | 759 | 890 | 522 | 1,415 | 1,051 |
| Spanish mackerel | H | 926 | 783 | 369 | 513 | 322 | 455 | 503 | 369 | 513 | 405 |
| | R | 555 | 446 | 209 | 248 | 141 | 196 | 364 | 150 | 282 | 147 |

[1]NA = not applicable because all East Florida residents are considered coastal county residents

### 2011 Economic Impacts of Recreational Fishing Expenditures (thousands of dollars)

| | Jobs | Sales | Income | Value Added |
|---|---|---|---|---|
| Trip Impacts by Fishing Mode: | | | | |
| For-Hire | 56 | 5,941 | 2,818 | 4,172 |
| Private Boat | 254 | 28,009 | 9,316 | 16,431 |
| Shore | 153 | 16,339 | 5,370 | 9,242 |
| Total Durable Equipment Impacts | 2,753 | 294,506 | 117,642 | 187,018 |
| **Total State Trip and Durable Equipment Economic Impacts** | 3,217 | 344,794 | 135,146 | 216,863 |

### 2011 Angler Trip & Durable Expenditures (thousands of dollars)

| Fishing Mode | Trip Expenditures | | Equipment | Durable Expenditures |
|---|---|---|---|---|
| | Non-Residents | Residents | Fishing Tackle | 75,493 |
| For-Hire | 1,699 | 1,771 | Other Equipment | 19,692 |
| Private Boat | 2,521 | 21,010 | Boat Expenses | 173,848 |
| Shore | 2,378 | 9,277 | Vehicle Expenses | 19,465 |
| *Total Trip Expenditures* | 6,597 | 32,058 | Second Home Expenses | 0 |
| | | | *Total Durable Equipment Expenditures* | 288,497 |
| **Total State Trip and Durable Equipment Expenditures** | | | | 327,152 |

### Recreational Anglers by Residential Area (thousands of anglers)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal | 58 | 112 | 104 | 135 | 121 | 149 | 190 | 146 | 145 | 146 |
| Non-Coastal | 54 | 113 | 120 | 67 | 66 | 115 | 154 | 91 | 136 | 131 |
| Out of State | 37 | 42 | 53 | 43 | 33 | 45 | 98 | 45 | 61 | 78 |
| **Total Anglers** | 148 | 268 | 278 | 245 | 219 | 308 | 441 | 282 | 342 | 355 |

### Recreational Fishing Effort by Mode (thousands of angler-trips)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| For-Hire | 9 | 12 | 26 | 26 | 29 | 30 | 17 | 16 | 7 | 16 |
| Private | 338 | 549 | 485 | 538 | 481 | 577 | 732 | 516 | 530 | 620 |
| Shore | 273 | 410 | 457 | 370 | 289 | 421 | 455 | 311 | 336 | 334 |
| **Total Trips** | 620 | 971 | 968 | 934 | 799 | 1,028 | 1,204 | 843 | 873 | 970 |

### Harvest (H) and Release (R) of Key Species Species Groups (thousands of fish)[1]

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Black drum | H | 23 | 44 | 19 | 20 | 20 | 51 | 91 | 15 | 70 | 10 |
| | R | 19 | 27 | 42 | 11 | 29 | 35 | 66 | 22 | 40 | 5 |
| Black sea bass | H | 24 | 103 | 70 | 86 | 68 | 35 | 100 | 18 | 13 | 43 |
| | R | 82 | 239 | 143 | 218 | 184 | 291 | 580 | 114 | 163 | 227 |
| Bluefish | H | 2 | 1 | (1) | 4 | 3 | 11 | 8 | 1 | 13 | 3 |
| | R | 26 | 23 | 17 | 21 | 23 | 102 | 116 | 73 | 107 | 70 |
| Drum (Atlantic croaker) | H | 36 | 249 | 39 | 39 | 35 | 44 | 39 | 82 | 35 | 44 |
| | R | 194 | 964 | 154 | 281 | 283 | 229 | 294 | 434 | 264 | 262 |
| Drum (southern kingfish) | H | 427 | 504 | 662 | 511 | 448 | 576 | 697 | 587 | 586 | 873 |
| | R | 378 | 847 | 818 | 562 | 669 | 625 | 873 | 559 | 465 | 667 |
| Drum (spotted seatrout) | H | 271 | 426 | 340 | 241 | 380 | 578 | 642 | 507 | 384 | 289 |
| | R | 358 | 738 | 610 | 643 | 809 | 1,039 | 720 | 916 | 742 | 551 |
| Porgies (sheepshead) | H | 26 | 128 | 81 | 66 | 36 | 59 | 65 | 51 | 104 | 138 |
| | R | 39 | 123 | 26 | 58 | 52 | 85 | 97 | 33 | 38 | 44 |
| Red drum | H | 91 | 122 | 139 | 105 | 69 | 113 | 133 | 69 | 195 | 107 |
| | R | 169 | 272 | 142 | 334 | 137 | 226 | 314 | 167 | 483 | 213 |
| Sharks[2] | H | (1) | 4 | 1 | 2 | (1) | 2 | 3 | 1 | (1) | 3 |
| | R | 194 | 210 | 293 | 362 | 355 | 583 | 518 | 332 | 268 | 296 |
| Southern flounder | H | 30 | 82 | 53 | 38 | 23 | 94 | 49 | 34 | 35 | 28 |
| | R | 11 | 16 | 33 | 8 | 17 | (1) | 2 | 9 | 3 | 12 |

[1] In this table, '(1)' = 0-999 thousand fish and '1' = 1,000-1,499 thousand fish.
[2] Sharks include species within the requiem shark family, blacktip sharks, Atlantic sharpnose sharks, and unidentified sharks.

### 2011 Economic Impacts of Recreational Fishing Expenditures (thousands of dollars)

| | Jobs | Sales | Income | Value Added |
|---|---|---|---|---|
| Trip Impacts by Fishing Mode: | | | | |
| For-Hire | 1,117 | 110,140 | 50,471 | 75,437 |
| Private Boat | 1,322 | 143,221 | 46,422 | 81,190 |
| Shore | 3,206 | 308,303 | 101,569 | 172,829 |
| Total Durable Equipment Impacts | 10,187 | 1,060,397 | 405,813 | 640,966 |
| **Total State Trip and Durable Equipment Economic Impacts** | 15,831 | 1,622,060 | 604,275 | 970,422 |

### 2011 Angler Trip & Durable Expenditures (thousands of dollars)

| Fishing Mode | Trip Expenditures | | Equipment | Durable Expenditures |
|---|---|---|---|---|
| | Non-Residents | Residents | Fishing Tackle | 250,075 |
| For-Hire | 53,606 | 17,838 | Other Equipment | 81,722 |
| Private Boat | 20,479 | 102,454 | Boat Expenses | 419,575 |
| Shore | 112,816 | 110,878 | Vehicle Expenses | 379,028 |
| *Total Trip Expenditures* | 186,901 | 231,169 | Second Home Expenses | 57,967 |
| | | | *Total Durable Equipment Expenditures* | 1,188,366 |
| **Total State Trip and Durable Equipment Expenditures** | | | | 1,606,436 |

### Recreational Anglers by Residential Area (thousands of anglers)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal | 409 | 524 | 613 | 685 | 588 | 564 | 587 | 446 | 544 | 490 |
| Non-Coastal | 226 | 281 | 290 | 285 | 265 | 265 | 303 | 259 | 296 | 254 |
| Out of State | 1130 | 1298 | 1156 | 1280 | 1374 | 1079 | 1079 | 976 | 1073 | 755 |
| **Total Anglers** | 1765 | 2103 | 2058 | 2250 | 2227 | 1908 | 1970 | 1681 | 1914 | 1499 |

### Recreational Fishing Effort by Mode (thousands of angler-trips)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| For-Hire | 184 | 174 | 183 | 260 | 234 | 218 | 192 | 146 | 166 | 152 |
| Private | 1,941 | 2,181 | 2,640 | 2,345 | 2,452 | 2,670 | 2,461 | 2,005 | 2,199 | 1,899 |
| Shore | 3,462 | 4,379 | 4,090 | 3,939 | 4,179 | 3,444 | 4,246 | 3,158 | 3,314 | 2,689 |
| **Total Trips** | 5,587 | 6,734 | 6,913 | 6,544 | 6,865 | 6,332 | 6,899 | 5,309 | 5,679 | 4,740 |

### Harvest (H) and Release (R) of Key Species Species Groups (thousands of fish)[1]

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Black sea bass | H | 85 | 167 | 398 | 231 | 126 | 110 | 58 | 107 | 139 | 94 |
| | R | 529 | 419 | 1,300 | 1,194 | 1,177 | 950 | 559 | 668 | 1,103 | 1,062 |
| Bluefish | H | 778 | 953 | 1,233 | 1,382 | 917 | 1,257 | 1,177 | 827 | 1,105 | 1,153 |
| | R | 1,610 | 1,417 | 1,761 | 2,044 | 1,836 | 2,378 | 2,138 | 1,551 | 2,221 | 1,924 |
| Dolphinfish | H | 621 | 334 | 268 | 662 | 522 | 533 | 357 | 367 | 499 | 473 |
| | R | 3 | 14 | 5 | 2 | 24 | 5 | 2 | 3 | 5 | 8 |
| Drum (Atlantic croaker and spot) | H | 2,996 | 4,286 | 4,337 | 3,341 | 3,534 | 3,538 | 2,163 | 1,424 | 1,314 | 1,453 |
| | R | 1,598 | 2,686 | 2,915 | 2,735 | 5,167 | 2,805 | 2,741 | 3,135 | 2,470 | 2,799 |
| Drum (spotted seatrout) | H | 197 | 107 | 285 | 585 | 564 | 531 | 656 | 609 | 195 | 216 |
| | R | 384 | 132 | 261 | 1,059 | 596 | 849 | 883 | 1,214 | 1,685 | 1,917 |
| Flounder (lefteye and summer) | H | 216 | 110 | 189 | 156 | 152 | 189 | 70 | 100 | 143 | 93 |
| | R | 1,286 | 830 | 1,341 | 878 | 925 | 1,090 | 1,691 | 1,212 | 1,584 | 988 |
| King mackerel | H | 67 | 114 | 149 | 139 | 143 | 270 | 106 | 92 | 35 | 13 |
| | R | 7 | 22 | 78 | 73 | 32 | 44 | 24 | 12 | 7 | (1) |
| Spanish mackerel | H | 403 | 350 | 327 | 335 | 305 | 495 | 745 | 678 | 482 | 366 |
| | R | 197 | 165 | 149 | 181 | 96 | 257 | 448 | 312 | 295 | 171 |
| Striped bass | H | 59 | 139 | 431 | 136 | 98 | 48 | 35 | 12 | 34 | 106 |
| | R | 154 | 285 | 586 | 123 | 62 | 81 | 175 | 122 | 107 | 295 |
| Yellowfin tuna | H | 135 | 328 | 169 | 180 | 166 | 102 | 26 | 29 | 23 | 26 |
| | R | 8 | 56 | 10 | 8 | 13 | 1 | (1) | (1) | 1 | (1) |

[1] In this table, '(1)' = 0-999 thousand fish and '1' = 1,000-1,499 thousand fish.

### 2011 Economic Impacts of Recreational Fishing Expenditures (thousands of dollars)

| | Jobs | Sales | Income | Value Added |
|---|---|---|---|---|
| Trip Impacts by Fishing Mode: | | | | |
| For-Hire | 498 | 43,606 | 19,763 | 29,985 |
| Private Boat | 393 | 36,659 | 11,674 | 20,428 |
| Shore | 935 | 86,743 | 27,968 | 49,345 |
| Total Durable Equipment Impacts | 1,477 | 139,669 | 55,125 | 85,559 |
| **Total State Trip and Durable Equipment Economic Impacts** | 3,303 | 306,678 | 114,530 | 185,318 |

### 2011 Angler Trip & Durable Expenditures (thousands of dollars)

| Fishing Mode | Trip Expenditures | | Equipment | Durable Expenditures |
|---|---|---|---|---|
| | Non-Residents | Residents | Fishing Tackle | 53,189 |
| For-Hire | 24,789 | 4,977 | Other Equipment | 11,366 |
| Private Boat | 4,590 | 31,062 | Boat Expenses | 81,541 |
| Shore | 52,646 | 18,548 | Vehicle Expenses | 4,444 |
| *Total Trip Expenditures* | 82,024 | 54,587 | Second Home Expenses | 0 |
| | | | *Total Durable Equipment Expenditures* | 150,541 |
| **Total State Trip and Durable Equipment Expenditures** | | | | 287,152 |

### Recreational Anglers by Residential Area (thousands of anglers)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal | 177 | 222 | 227 | 230 | 234 | 277 | 236 | 231 | 210 | 148 |
| Non-Coastal | 55 | 79 | 101 | 120 | 146 | 113 | 103 | 112 | 104 | 66 |
| Out of State | 161 | 270 | 334 | 448 | 617 | 551 | 604 | 554 | 494 | 264 |
| **Total Anglers** | 392 | 571 | 662 | 798 | 997 | 941 | 942 | 898 | 809 | 478 |

### Recreational Fishing Effort by Mode (thousands of angler-trips)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| For-Hire | 33 | 39 | 78 | 25 | 21 | 86 | 69 | 80 | 77 | 82 |
| Private | 557 | 1,021 | 1,230 | 949 | 978 | 1,131 | 1,265 | 1,008 | 1,079 | 846 |
| Shore | 665 | 1,037 | 1,138 | 1,220 | 1,240 | 813 | 1,116 | 1,324 | 1,143 | 879 |
| **Total Trips** | 1,255 | 2,097 | 2,446 | 2,194 | 2,239 | 2,030 | 2,450 | 2,412 | 2,299 | 1,807 |

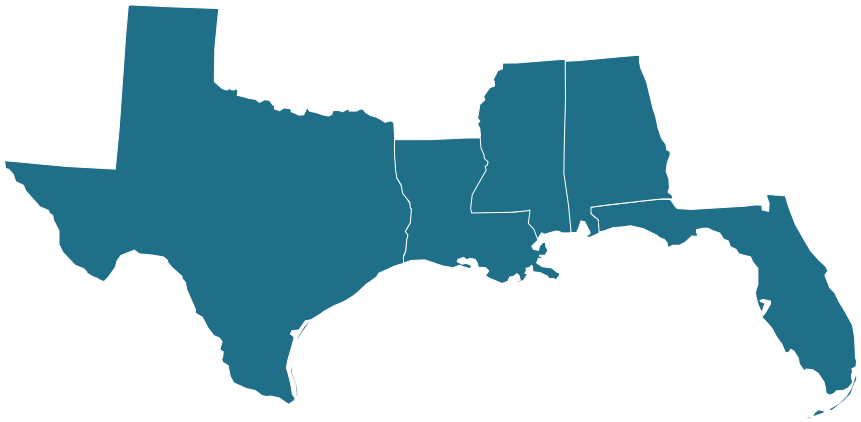
### Harvest (H) and Release (R) of Key Species Species Groups (thousands of fish)[1]

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Black sea bass | H | 113 | 45 | 238 | 75 | 183 | 125 | 89 | 37 | 216 | 56 |
| | R | 336 | 289 | 769 | 513 | 583 | 921 | 865 | 470 | 641 | 660 |
| Bluefish | H | 79 | 66 | 133 | 246 | 134 | 176 | 128 | 134 | 443 | 226 |
| | R | 162 | 215 | 387 | 318 | 622 | 677 | 332 | 253 | 319 | 552 |
| Drum (Atlantic croaker and spot) | H | 460 | 724 | 901 | 502 | 1,229 | 644 | 2,798 | 827 | 369 | 947 |
| | R | 197 | 672 | 531 | 505 | 1,092 | 376 | 393 | 840 | 353 | 462 |
| Drum (southern kingfish) | H | 226 | 982 | 1,150 | 998 | 926 | 698 | 823 | 1,057 | 389 | 611 |
| | R | 135 | 1,048 | 749 | 391 | 1,164 | 539 | 614 | 689 | (1) | 68 |
| Drum (spotted seatrout) | H | 84 | 123 | 190 | 272 | 231 | 160 | 156 | 125 | 101 | 67 |
| | R | 149 | 313 | 277 | 462 | 543 | 572 | 733 | 398 | 407 | 281 |
| Porgies (sheepshead) | H | 30 | 129 | 95 | 45 | 60 | 108 | 216 | 222 | 103 | 170 |
| | R | 21 | 50 | 22 | 47 | 27 | 21 | 60 | 24 | 58 | 93 |
| Red drum | H | 41 | 162 | 108 | 130 | 49 | 72 | 120 | 70 | 173 | 162 |
| | R | 143 | 430 | 438 | 493 | 540 | 438 | 551 | 752 | 787 | 666 |
| Sharks[2] | H | (1) | (1) | 16 | 38 | (1) | 3 | 5 | 13 | (1) | 3 |
| | R | 276 | 382 | 402 | 604 | 512 | 170 | 259 | 397 | 467 | 348 |
| Southern flounder | H | 112 | 111 | 215 | 84 | 111 | 76 | 102 | 88 | 108 | 102 |
| | R | 73 | 52 | 89 | 73 | 199 | 106 | 102 | 74 | (1) | 16 |
| Spanish mackerel | H | 23 | 25 | 56 | 71 | 23 | 95 | 52 | 74 | 70 | 87 |
| | R | 9 | 224 | 84 | 184 | 28 | 97 | 68 | 56 | 27 | 67 |

[1] In this table, '(1)' = 0-999 thousand fish and '1' = 1,000-1,499 thousand fish.
[2] Sharks include species within the requiem shark family, blacktip sharks, Atlantic sharpnose sharks, and unidentified sharks.

# Gulf of Mexico

- Alabama
- West Florida
- Louisiana
- Mississippi
- Texas



### 2011 Economic Impacts of Recreational Fishing Expenditures (thousands of dollars)

| | Trips | Jobs | Sales | Income | Value Added |
|---|---|---|---|---|---|
| Alabama | 2,485,000 | 8,867 | 819,340 | 318,759 | 504,980 |
| Louisiana | 4,577,000 | 17,808 | 2,062,048 | 758,673 | 1,152,657 |
| Mississippi | 1,616,000 | 1,383 | 120,644 | 45,502 | 71,868 |
| Texas | NA[1] | 13,332 | 1,644,672 | 585,857 | 958,064 |
| West Florida | 13,901,000 | 66,237 | 8,054,526 | 2,954,453 | 4,629,218 |

### 2011 Angler Trip & Durable Expenditures (thousands of dollars)

| Fishing Mode | Trip Expenditures | | Equipment | Durable Expenditures |
|---|---|---|---|---|
| | Non-Residents | Residents | Fishing Tackle | 1,317,095 |
| For-Hire | 207,051 | 105,140 | Other Equipment | 523,466 |
| Private Boat | 116,943 | 597,111 | Boat Expenses | 4,463,924 |
| Shore | 150,261 | 297,713 | Vehicle Expenses | 1,191,348 |
| *Total Trip Expenditures* | 474,255 | 999,964 | Second Home Expenses | 812,091 |
| | | | *Total Durable Equipment Expenditures* | 8,307,925 |
| **Total State Trip and Durable Equipment Expenditures** | | | | 9,782,144 |

### Recreational Anglers by Residential Area (thousands of anglers)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal | 2,485 | 3,039 | 3,185 | 3,133 | 3,328 | 3,235 | 2,926 | 2,550 | 2,480 | 2,737 |
| Non-Coastal | 216 | 256 | 318 | 190 | 315 | 326 | 262 | 296 | 235 | 311 |
| Out-of-State | NA[2] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| **Total Anglers** | 2,701 | 3,294 | 3,503 | 3,323 | 3,643 | 3,562 | 3,188 | 2,846 | 2,715 | 3,048 |

### Recreational Fishing Effort by Mode (thousands of angler-trips)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| For-Hire | 765 | 692 | 833 | 692 | 835 | 849 | 819 | 823 | 579 | 735 |
| Private Boat | 11,636 | 14,110 | 15,643 | 13,586 | 13,621 | 14,980 | 15,195 | 13,443 | 12,684 | 12,913 |
| Shore | 7,265 | 8,155 | 9,954 | 9,013 | 8,836 | 8,457 | 8,776 | 8,332 | 7,783 | 8,931 |
| **Total Trips** | 19,666 | 22,957 | 26,430 | 23,291 | 23,292 | 24,286 | 24,790 | 22,598 | 21,046 | 22,579 |

### Harvest (H) and Release (R) of Key Species Species Groups (thousands of fish)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Drum (Atlantic croaker) | H | 833 | 1,057 | 976 | 769 | 1,441 | 1,312 | 1,872 | 1,175 | 1,509 | 2,052 |
| | R | 2,757 | 2,432 | 3,639 | 2,844 | 2,312 | 2,614 | 3,148 | 3,858 | 3,827 | 5,899 |
| Drum (Gulf and southern kingfish) | H | 1,203 | 1,803 | 1,682 | 1,426 | 1,249 | 1,135 | 1,302 | 1,063 | 1,423 | 939 |
| | R | 477 | 538 | 810 | 781 | 924 | 844 | 726 | 576 | 625 | 538 |
| Drum (sand and silver seatrouts) | H | 3,257 | 3,114 | 2,262 | 2,035 | 2,109 | 3,088 | 3,405 | 4,203 | 4,575 | 5,733 |
| | R | 1,067 | 1,005 | 1,000 | 726 | 1,538 | 1,909 | 1,988 | 2,443 | 1,808 | 2,540 |
| Drum (spotted seatrout) | H | 7,367 | 9,566 | 11,559 | 10,028 | 13,286 | 11,187 | 14,126 | 13,335 | 10,139 | 13,581 |
| | R | 15,298 | 19,216 | 19,764 | 20,212 | 20,056 | 18,849 | 21,017 | 17,366 | 14,563 | 19,122 |
| Porgies (sheepshead) | H | 1,553 | 1,944 | 2,495 | 2,001 | 1,109 | 1,198 | 1,566 | 1,572 | 1,147 | 2,218 |
| | R | 1,701 | 2,005 | 2,171 | 2,393 | 1,506 | 1,224 | 1,487 | 1,338 | 1,740 | 1,631 |
| Red drum | H | 2,477 | 2,672 | 2,942 | 2,318 | 2,361 | 2,843 | 3,292 | 2,608 | 3,248 | 3,543 |
| | R | 4,873 | 5,914 | 5,808 | 6,235 | 6,391 | 6,222 | 7,017 | 5,522 | 6,468 | 6,447 |
| Red snapper | H | 1,106 | 992 | 1,279 | 835 | 967 | 1,223 | 677 | 795 | 333 | 520 |
| | R | 2,091 | 1,943 | 2,685 | 2,193 | 2,832 | 3,259 | 2,110 | 2,146 | 1,436 | 1,521 |
| Southern flounder | H | 504 | 660 | 742 | 541 | 475 | 650 | 473 | 644 | 771 | 764 |
| | R | 117 | 253 | 271 | 194 | 170 | 239 | 120 | 194 | 220 | 222 |
| Spanish mackerel | H | 1,963 | 1,503 | 2,124 | 1,193 | 1,757 | 1,333 | 1,897 | 1,503 | 1,563 | 1,535 |
| | R | 1,920 | 2,211 | 2,314 | 1,373 | 2,856 | 2,105 | 2,039 | 1,635 | 2,476 | 1,942 |
| Striped mullet | H | 1,264 | 1,586 | 1,163 | 1,081 | 1,102 | 1,149 | 1,257 | 743 | 1,666 | 1,901 |
| | R | 75 | 280 | 167 | 165 | 141 | 158 | 145 | 226 | 126 | 313 |

[1]The Marine Recreational Program (MRIP) does not collect effort data for Texas.
[2]NA = data are not available because out-of-state resident information is collected for individual states but whether an angler is a resident of a region is not specified

### 2011 Economic Impacts of Recreational Fishing Expenditures (thousands of dollars)

| | Jobs | Sales | Income | Value Added |
|---|---|---|---|---|
| Trip Impacts by Fishing Mode: | | | | |
| For-Hire | 379 | 37,481 | 17,056 | 25,650 |
| Private Boat | 654 | 58,845 | 18,229 | 31,845 |
| Shore | 880 | 73,217 | 24,100 | 40,686 |
| Total Durable Equipment Impacts | 6,955 | 649,797 | 259,374 | 406,799 |
| **Total State Trip and Durable Equipment Economic Impacts** | 8,867 | 819,340 | 318,759 | 504,980 |

### 2011 Angler Trip & Durable Expenditures (thousands of dollars)

| Fishing Mode | Trip Expenditures | | Equipment | Durable Expenditures |
|---|---|---|---|---|
| | Non-Residents | Residents | Fishing Tackle | 245,964 |
| For-Hire | 21,439 | 5,480 | Other Equipment | 65,634 |
| Private Boat | 17,116 | 41,439 | Boat Expenses | 176,088 |
| Shore | 32,423 | 28,291 | Vehicle Expenses | 222,460 |
| *Total Trip Expenditures* | 70,978 | 75,210 | Second Home Expenses | 0 |
| | | | *Total Durable Equipment Expenditures* | 710,146 |
| **Total State Trip and Durable Equipment Expenditures** | | | | 856,334 |

### Recreational Anglers by Residential Area (thousands of anglers)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal | 123 | 187 | 223 | 231 | 233 | 253 | 192 | 205 | 195 | 295 |
| Non-Coastal | 97 | 123 | 159 | 93 | 184 | 169 | 116 | 151 | 140 | 177 |
| Out of State | 193 | 214 | 345 | 161 | 320 | 291 | 237 | 209 | 220 | 435 |
| **Total Anglers** | 413 | 524 | 728 | 485 | 736 | 712 | 545 | 566 | 554 | 907 |

### Recreational Fishing Effort by Mode (thousands of angler-trips)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| For-Hire | 68 | 66 | 77 | 56 | 77 | 75 | 56 | 56 | 33 | 75 |
| Private | 607 | 846 | 994 | 828 | 811 | 985 | 946 | 885 | 840 | 1,207 |
| Shore | 515 | 587 | 1,181 | 720 | 1,050 | 901 | 702 | 771 | 812 | 1,203 |
| **Total Trips** | 1,190 | 1,499 | 2,252 | 1,604 | 1,938 | 1,961 | 1,704 | 1,712 | 1,685 | 2,485 |

### Harvest (H) and Release (R) of Key Species Species Groups (thousands of fish)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Bluefish | H | 51 | 44 | 132 | 15 | 13 | 26 | 17 | 15 | 30 | 74 |
| | R | 65 | 126 | 216 | 77 | 151 | 174 | 54 | 45 | 80 | 167 |
| Drum (Atlantic croaker) | H | 188 | 244 | 178 | 233 | 453 | 463 | 1,163 | 250 | 918 | 886 |
| | R | 468 | 512 | 1,070 | 1,593 | 823 | 923 | 1,370 | 1,822 | 1,861 | 2,593 |
| Drum (kingfishes)[1] | H | 411 | 487 | 619 | 263 | 443 | 476 | 667 | 592 | 633 | 626 |
| | R | 162 | 185 | 410 | 265 | 460 | 291 | 256 | 283 | 309 | 341 |
| Drum (sand seatrout) | H | 428 | 709 | 502 | 349 | 593 | 705 | 1,216 | 1,428 | 2,070 | 2,346 |
| | R | 130 | 225 | 266 | 290 | 502 | 481 | 410 | 752 | 836 | 743 |
| Drum (spotted seatrout) | H | 193 | 345 | 208 | 294 | 326 | 359 | 269 | 318 | 609 | 825 |
| | R | 166 | 430 | 168 | 322 | 598 | 488 | 844 | 758 | 453 | 1,302 |
| Porgies (sheepshead) | H | 192 | 299 | 461 | 280 | 123 | 320 | 288 | 165 | 218 | 481 |
| | R | 81 | 89 | 172 | 86 | 80 | 30 | 159 | 48 | 52 | 146 |
| Red drum | H | 84 | 114 | 118 | 155 | 101 | 84 | 87 | 62 | 122 | 143 |
| | R | 105 | 245 | 262 | 185 | 145 | 137 | 228 | 110 | 153 | 149 |
| Red snapper | H | 473 | 380 | 305 | 232 | 181 | 217 | 108 | 137 | 41 | 217 |
| | R | 984 | 666 | 589 | 493 | 640 | 852 | 340 | 394 | 287 | 488 |
| Southern flounder | H | 82 | 113 | 139 | 150 | 123 | 96 | 93 | 139 | 242 | 163 |
| | R | 15 | 68 | 73 | 83 | 64 | 38 | 37 | 22 | 65 | 60 |
| Spanish mackerel | H | 106 | 122 | 468 | 45 | 58 | 93 | 111 | 76 | 253 | 334 |
| | R | 16 | 99 | 276 | 52 | 49 | 21 | 31 | 60 | 102 | 129 |

[1] Kingfishes include southern kingfish and Gulf kingfish

### 2011 Economic Impacts of Recreational Fishing Expenditures (thousands of dollars)

| | Jobs | Sales | Income | Value Added |
|---|---|---|---|---|
| Trip Impacts by Fishing Mode: | | | | |
| For-Hire | 2,988 | 327,398 | 143,326 | 218,883 |
| Private Boat | 3,206 | 357,950 | 117,674 | 202,691 |
| Shore | 2,144 | 222,503 | 73,788 | 124,007 |
| Total Durable Equipment Impacts | 57,899 | 7,146,674 | 2,619,665 | 4,083,637 |
| **Total State Trip and Durable Equipment Economic Impacts** | 66,237 | 8,054,526 | 2,954,453 | 4,629,218 |

### 2011 Angler Trip & Durable Expenditures (thousands of dollars)

| Fishing Mode | Trip Expenditures | | Equipment | Durable Expenditures |
|---|---|---|---|---|
| | Non-Residents | Residents | Fishing Tackle | 647,956 |
| For-Hire | 158,309 | 29,181 | Other Equipment | 279,586 |
| Private Boat | 72,024 | 211,465 | Boat Expenses | 2,858,367 |
| Shore | 96,703 | 55,686 | Vehicle Expenses | 448,791 |
| *Total Trip Expenditures* | 327,037 | 296,332 | Second Home Expenses | 636,626 |
| | | | *Total Durable Equipment Expenditures* | 4,871,325 |
| **Total State Trip and Durable Equipment Expenditures** | | | | 5,494,694 |

### Recreational Anglers by Residential Area (thousands of anglers)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal | 1703 | 1965 | 2023 | 2088 | 2084 | 1934 | 1820 | 1551 | 1538 | 1592 |
| Non-Coastal | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] | NA[1] |
| Out of State | 1990 | 2318 | 2141 | 2008 | 1988 | 2151 | 2029 | 1671 | 1470 | 1624 |
| **Total Anglers** | 3693 | 4283 | 4165 | 4096 | 4072 | 4085 | 3849 | 3222 | 3008 | 3216 |

### Recreational Fishing Effort by Mode (thousands of angler-trips)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| For-Hire | 582 | 497 | 600 | 505 | 564 | 611 | 571 | 573 | 460 | 536 |
| Private | 8,236 | 9,221 | 10,171 | 9,491 | 9,382 | 10,005 | 10,145 | 8,623 | 8,160 | 7,520 |
| Shore | 5,601 | 6,291 | 7,025 | 6,699 | 6,720 | 6,318 | 6,782 | 6,482 | 5,645 | 5,845 |
| **Total Trips** | 14,419 | 16,009 | 17,796 | 16,695 | 16,666 | 16,934 | 17,498 | 15,678 | 14,265 | 13,901 |

### Harvest (H) and Release (R) of Key Species Species Groups (thousands of fish)

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Common snook | H | 50 | 44 | 70 | 62 | 24 | 36 | 26 | 13 | (1) | 1 |
| | R | 1,292 | 1,358 | 2,198 | 2,281 | 1,391 | 1,592 | 1,595 | 1,925 | 600 | 746 |
| Drum (sand and silver seatrouts) | H | 1,355 | 751 | 434 | 487 | 434 | 1,119 | 746 | 893 | 410 | 864 |
| | R | 320 | 147 | 193 | 64 | 408 | 597 | 583 | 460 | 211 | 294 |
| Drum (spotted seatrout) | H | 1,532 | 1,628 | 2,066 | 1,980 | 1,617 | 1,513 | 1,544 | 1,370 | 1,117 | 1,476 |
| | R | 10,711 | 10,469 | 9,893 | 11,749 | 9,458 | 10,059 | 9,585 | 7,673 | 8,469 | 11,382 |
| Gag | H | 491 | 471 | 690 | 491 | 357 | 284 | 434 | 202 | 232 | 98 |
| | R | 2,449 | 3,359 | 3,865 | 2,314 | 1,876 | 2,677 | 4,078 | 2,726 | 2,019 | 1,158 |
| Gray snapper | H | 655 | 981 | 1,145 | 932 | 664 | 1,046 | 1,393 | 1,176 | 560 | 419 |
| | R | 2,997 | 4,809 | 3,637 | 4,700 | 2,847 | 4,290 | 5,689 | 3,015 | 1,858 | 2,241 |
| King mackerel | H | 261 | 196 | 196 | 177 | 343 | 271 | 183 | 451 | 173 | 128 |
| | R | 138 | 97 | 107 | 131 | 392 | 84 | 155 | 139 | 81 | 47 |
| Mullets[2] | H | 1,009 | 840 | 1,077 | 987 | 1,297 | 612 | 1,236 | 656 | 967 | 855 |
| | R | 93 | 188 | 281 | 209 | 100 | 182 | 143 | 191 | 71 | 106 |
| Porgies (sheepshead) | H | 686 | 761 | 709 | 1,050 | 624 | 590 | 556 | 682 | 455 | 608 |
| | R | 1,126 | 1,369 | 1,399 | 1,857 | 942 | 895 | 855 | 808 | 1,245 | 1,274 |
| Red drum | H | 291 | 364 | 322 | 501 | 375 | 411 | 457 | 226 | 240 | 288 |
| | R | 1,374 | 1,937 | 2,100 | 3,255 | 2,828 | 2,558 | 2,561 | 1,440 | 1,992 | 2,894 |
| Spanish mackerel | H | 1,811 | 1,316 | 1,626 | 1,101 | 1,671 | 1,206 | 1,753 | 1,391 | 1,284 | 1,156 |
| | R | 1,866 | 2,085 | 2,010 | 1,278 | 2,768 | 2,065 | 1,988 | 1,545 | 2,359 | 1,780 |

[1]NA = not applicable because all West Florida residents are considered coastal county residents
[2]Mullets include species within the mullet genus including striped mullets.

### 2011 Economic Impacts of Recreational Fishing Expenditures (thousands of dollars)

| | Jobs | Sales | Income | Value Added |
|---|---|---|---|---|
| Trip Impacts by Fishing Mode: | | | | |
| For-Hire | 415 | 51,668 | 24,468 | 35,528 |
| Private Boat | 1,838 | 231,334 | 64,456 | 111,165 |
| Shore | 474 | 57,347 | 15,390 | 26,710 |
| Total Durable Equipment Impacts | 15,081 | 1,721,699 | 654,359 | 979,254 |
| **Total State Trip and Durable Equipment Economic Impacts** | 17,808 | 2,062,048 | 758,673 | 1,152,657 |

### 2011 Angler Trip & Durable Expenditures (thousands of dollars)

| Fishing Mode | Trip Expenditures | | Equipment | Durable Expenditures |
|---|---|---|---|---|
| | Non-Residents | Residents | Fishing Tackle | 245,701 |
| For-Hire | 20,975 | 12,330 | Other Equipment | 86,045 |
| Private Boat | 17,434 | 163,788 | Boat Expenses | 974,417 |
| Shore | 4,535 | 42,032 | Vehicle Expenses | 220,904 |
| *Total Trip Expenditures* | 42,944 | 218,150 | Second Home Expenses | 91,310 |
| | | | *Total Durable Equipment Expenditures* | 1,618,377 |
| **Total State Trip and Durable Equipment Expenditures** | | | | 1,879,471 |

### Recreational Anglers by Residential Area (thousands of anglers)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal | 484 | 727 | 747 | 706 | 868 | 853 | 795 | 669 | 609 | 690 |
| Non-Coastal | 68 | 79 | 133 | 68 | 108 | 124 | 120 | 108 | 67 | 86 |
| Out of State | 117 | 204 | 179 | 138 | 198 | 157 | 170 | 139 | 120 | 183 |
| **Total Anglers** | 669 | 1011 | 1059 | 911 | 1174 | 1134 | 1084 | 916 | 796 | 959 |

### Recreational Fishing Effort by Mode (thousands of angler-trips)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| For-Hire | 94 | 105 | 143 | 123 | 187 | 143 | 179 | 183 | 79 | 113 |
| Private | 2,251 | 3,295 | 3,821 | 2,784 | 2,802 | 3,156 | 3,508 | 3,176 | 3,055 | 3,342 |
| Shore | 674 | 872 | 1,238 | 1,159 | 775 | 889 | 933 | 769 | 729 | 1,122 |
| **Total Trips** | 3,019 | 4,272 | 5,202 | 4,066 | 3,764 | 4,188 | 4,620 | 4,128 | 3,863 | 4,577 |

### Harvest (H) and Release (R) of Key Species Species Groups (thousands of fish)[1]

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Black drum | H | 512 | 485 | 504 | 309 | 369 | 385 | 544 | 518 | 398 | 469 |
| | R | 886 | 835 | 1,026 | 651 | 717 | 728 | 1,117 | 974 | 1,032 | 1,085 |
| Drum (Atlantic croaker) | H | 282 | 380 | 476 | 442 | 805 | 684 | 358 | 471 | 228 | 607 |
| | R | 1,054 | 1,012 | 1,995 | 963 | 1,142 | 1,006 | 1,186 | 1,099 | 1,268 | 2,319 |
| Drum (sand seatrout) | H | 599 | 985 | 903 | 975 | 775 | 888 | 1,085 | 879 | 1,065 | 1,187 |
| | R | 506 | 302 | 453 | 254 | 454 | 541 | 822 | 853 | 514 | 1,032 |
| Drum (spotted seatrout) | H | 5,270 | 7,317 | 8,524 | 7,436 | 10,873 | 8,929 | 11,705 | 10,557 | 7,857 | 10,440 |
| | R | 3,862 | 7,485 | 8,658 | 7,303 | 9,025 | 7,393 | 9,579 | 7,975 | 5,055 | 5,804 |
| Drum(southern kingfish) | H | 104 | 159 | 201 | 239 | 89 | 67 | 74 | 103 | 42 | 16 |
| | R | 22 | 63 | 85 | 187 | 151 | 28 | 118 | 59 | 47 | 25 |
| Porgies (sheepshead) | H | 607 | 807 | 1,288 | 644 | 326 | 270 | 705 | 704 | 431 | 869 |
| | R | 433 | 520 | 567 | 428 | 462 | 288 | 448 | 473 | 440 | 187 |
| Red drum | H | 2,042 | 2,144 | 2,419 | 1,627 | 1,827 | 2,307 | 2,672 | 2,236 | 2,810 | 3,022 |
| | R | 3,278 | 3,545 | 3,293 | 2,652 | 3,320 | 3,454 | 4,075 | 3,732 | 4,111 | 3,196 |
| Red snapper | H | 47 | 70 | 88 | 111 | 172 | 159 | 84 | 98 | 7 | 31 |
| | R | 40 | 166 | 273 | 339 | 429 | 285 | 261 | 195 | 7 | 108 |
| Southern flounder | H | 271 | 407 | 471 | 280 | 290 | 348 | 235 | 286 | 328 | 398 |
| | R | 49 | 116 | 129 | 76 | 54 | 67 | 36 | 51 | 72 | 61 |
| Yellowfin tuna | H | 8 | 13 | 8 | 10 | 14 | 8 | 17 | 3 | 1 | 12 |
| | R | (1) | (1) | (1) | 1 | 1 | 1 | 6 | (1) | (1) | 4 |

[1] In this table, '(1)' = 0-999 thousand fish and '1' = 1,000-1,499 thousand fish.

### 2011 Economic Impacts of Recreational Fishing Expenditures (thousands of dollars)

| | Jobs | Sales | Income | Value Added |
|---|---|---|---|---|
| Trip Impacts by Fishing Mode: | | | | |
| For-Hire | 43 | 4,175 | 2,021 | 2,941 |
| Private Boat | 259 | 25,600 | 7,395 | 13,021 |
| Shore | 116 | 10,066 | 2,910 | 4,950 |
| Total Durable Equipment Impacts | 965 | 80,803 | 33,176 | 50,956 |
| **Total State Trip and Durable Equipment Economic Impacts** | 1,383 | 120,644 | 45,502 | 71,868 |

### 2011 Angler Trip & Durable Expenditures (thousands of dollars)

| Fishing Mode | Trip Expenditures | | Equipment | Durable Expenditures |
|---|---|---|---|---|
| | Non-Residents | Residents | Fishing Tackle | 28,207 |
| For-Hire | 1,712 | 1,148 | Other Equipment | 9,789 |
| Private Boat | 1,386 | 27,357 | Boat Expenses | 40,733 |
| Shore | 1,519 | 8,932 | Vehicle Expenses | 28,330 |
| *Total Trip Expenditures* | 4,616 | 37,438 | Second Home Expenses | 15 |
| | | | *Total Durable Equipment Expenditures* | 107,075 |
| **Total State Trip and Durable Equipment Expenditures** | | | | 149,129 |

### Recreational Anglers by Residential Area (thousands of anglers)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal | 175 | 159 | 191 | 108 | 143 | 196 | 119 | 125 | 137 | 160 |
| Non-Coastal | 52 | 53 | 26 | 29 | 23 | 34 | 26 | 36 | 29 | 48 |
| Out of State | 49 | 48 | 46 | 39 | 27 | 55 | 48 | 50 | 50 | 60 |
| **Total Anglers** | 276 | 261 | 262 | 176 | 193 | 284 | 194 | 212 | 216 | 268 |

### Recreational Fishing Effort by Mode (thousands of angler-trips)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| For-Hire | 21 | 24 | 13 | 8 | 7 | 20 | 13 | 11 | 7 | 11 |
| Private | 542 | 748 | 657 | 483 | 626 | 834 | 596 | 759 | 629 | 844 |
| Shore | 475 | 405 | 510 | 435 | 291 | 349 | 359 | 310 | 597 | 761 |
| **Total Trips** | 1,038 | 1,177 | 1,180 | 926 | 924 | 1,203 | 968 | 1,080 | 1,233 | 1,616 |

### Harvest (H) and Release (R) of Key Species Species Groups (thousands of fish)[1]

| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Drum (Atlantic croaker) | H | 206 | 198 | 135 | 40 | 59 | 71 | 182 | 340 | 209 | 453 |
| | R | 936 | 701 | 371 | 208 | 190 | 264 | 388 | 717 | 422 | 606 |
| Drum (kingfishes)[2] | H | 278 | 327 | 355 | 225 | 163 | 161 | 180 | 126 | 174 | 177 |
| | R | 119 | 60 | 111 | 63 | 29 | 48 | 57 | 61 | 48 | 36 |
| Drum (sand and silver seatrouts) | H | 866 | 667 | 423 | 222 | 304 | 295 | 351 | 1,003 | 986 | 1,336 |
| | R | 111 | 331 | 88 | 118 | 173 | 230 | 166 | 378 | 246 | 471 |
| Drum (spotted seatrout) | H | 372 | 276 | 761 | 318 | 470 | 386 | 608 | 1,090 | 556 | 840 |
| | R | 559 | 832 | 1,045 | 838 | 975 | 909 | 1,009 | 960 | 586 | 634 |
| Porgies (sheepshead) | H | 68 | 77 | 37 | 27 | 36 | 18 | 17 | 21 | 43 | 260 |
| | R | 61 | 27 | 33 | 22 | 22 | 11 | 25 | 9 | 3 | 24 |
| Red drum | H | 60 | 50 | 83 | 35 | 58 | 41 | 76 | 84 | 76 | 90 |
| | R | 116 | 187 | 153 | 143 | 98 | 73 | 153 | 240 | 212 | 208 |
| Red snapper | H | 43 | 39 | 13 | 1 | 7 | 2 | 9 | 15 | 1 | 6 |
| | R | 166 | 90 | 61 | 51 | 52 | 9 | 104 | 55 | 25 | (1) |
| Sharks[3] | H | 12 | 8 | 8 | 9 | 2 | 4 | 3 | 21 | 71 | 35 |
| | R | 118 | 59 | 38 | 37 | 39 | 41 | 12 | 36 | 87 | 37 |
| Southern flounder | H | 141 | 120 | 103 | 72 | 47 | 121 | 110 | 209 | 195 | 182 |
| | R | 48 | 67 | 55 | 30 | 35 | 31 | 45 | 120 | 79 | 99 |
| Striped mullet | H | 212 | 550 | 192 | 34 | 2 | 66 | 78 | 119 | 188 | 491 |
| | R | 12 | 65 | 2 | (1) | 3 | 14 | 4 | 4 | 13 | 83 |

[1] In this table, '(1)' = 0-999 thousand fish and '1' = 1,000-1,499 thousand fish.
[2] Kingfishes include southern kingfish and Gulf kingfish
[3] Sharks include species within the requiem shark family, blacktip sharks, Atlantic sharpnose sharks, and unidentified sharks.

### 2011 Economic Impacts of Recreational Fishing Expenditures (thousands of dollars)

| | Jobs | Sales | Income | Value Added |
|---|---|---|---|---|
| Trip Impacts by Fishing Mode: | | | | |
| For-Hire | 842 | 104,649 | 44,174 | 68,244 |
| Private Boat | 2,021 | 256,920 | 77,257 | 135,933 |
| Shore | 2,427 | 284,745 | 87,109 | 152,220 |
| Total Durable Equipment Impacts | 8,042 | 998,358 | 377,317 | 601,667 |
| **Total State Trip and Durable Equipment Economic Impacts** | 13,332 | 1,644,672 | 585,857 | 958,064 |

### 2011 Angler Trip & Durable Expenditures (thousands of dollars)[1]

| Fishing Mode | Trip Expenditures | | Equipment | Durable Expenditures |
|---|---|---|---|---|
| | Non-Residents | Residents | | |
| For-Hire | 4,616 | 57,001 | Fishing Tackle | 149,267 |
| Private Boat | 8,983 | 153,062 | Other Equipment | 82,412 |
| Shore | 15,081 | 162,772 | Boat Expenses | 414,319 |
| *Total Trip Expenditures* | 28,680 | 372,834 | Vehicle Expenses | 270,863 |
| | | | Second Home Expenses | 84,140 |
| | | | *Total Durable Equipment Expenditures* | 1,001,002 |
| **Total State Trip and Durable Equipment Expenditures** | | | | 1,402,516 |

### Harvest (H) and Release (R) of Key Species Species Groups (thousands of fish)[2]

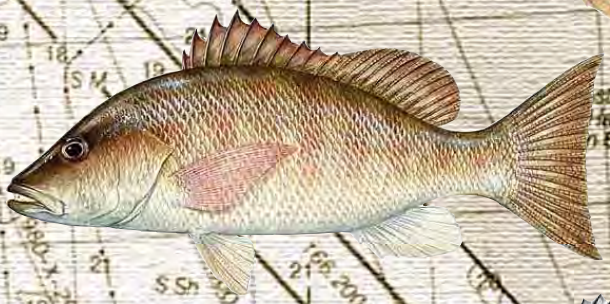
| | | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Atlantic croaker | H | 111 | 96 | 109 | 95 | 101 | 95 | 64 | 117 | 125 | 157 |
| Black drum | H | 72 | 85 | 68 | 53 | 73 | 66 | 82 | 98 | 165 | 129 |
| King mackerel | H | 16 | 19 | 15 | 14 | 29 | 11 | 8 | 16 | 6 | 9 |
| Red drum | H | 233 | 270 | 273 | 231 | 318 | 289 | 266 | 285 | 264 | 347 |
| Red snapper | H | 53 | 40 | 40 | 49 | 69 | 45 | 41 | 31 | 33 | 36 |
| Sand seatrout | H | 173 | 119 | 176 | 125 | 129 | 95 | 152 | 111 | 127 | 227 |
| Sheepshead | H | 84 | 76 | 67 | 81 | 78 | 46 | 46 | 34 | 49 | 57 |
| Southern flounder | H | 91 | 111 | 100 | 81 | 64 | 49 | 64 | 47 | 30 | 92 |
| Spotted seatrout | H | 965 | 939 | 934 | 855 | 987 | 916 | 917 | 810 | 732 | 1,137 |

[1]The Marine Recreational Information Program (MRIP) does not collect participation (number of anglers) or effort (number of trips) data for Texas. To calculate trip expenditure estimates, effort by fishing mode was estimated based on 2011 data provided by the Texas Parks and Wildlife Department (TPWD). These effort estimates were reviewed by the TPWD. To calculate angler expenditure estimates (durable equipment expenditures), participation estimates were based on the sum of saltwater licenses sold in Texas plus a proportion of combination licenses sold in Texas. A change in the method of reporting landings occurred in 2007 so data from 2007 is not comparable to earlier years.

[2]Data collected by the TPWG is reported in this table. The data collected by the TPWD differs from the data collected and reported in the MRIP. Please see the TPWD for more information: www.tpwd.state.tx.us/fishboat/.

# Alabama's Artificial Reefs
## A Fishing Information Guide

- Offshore and Inshore Reefs
- Reef Location Charts
- GPS Coordinates
- Reef Construction Protocol
- Program History

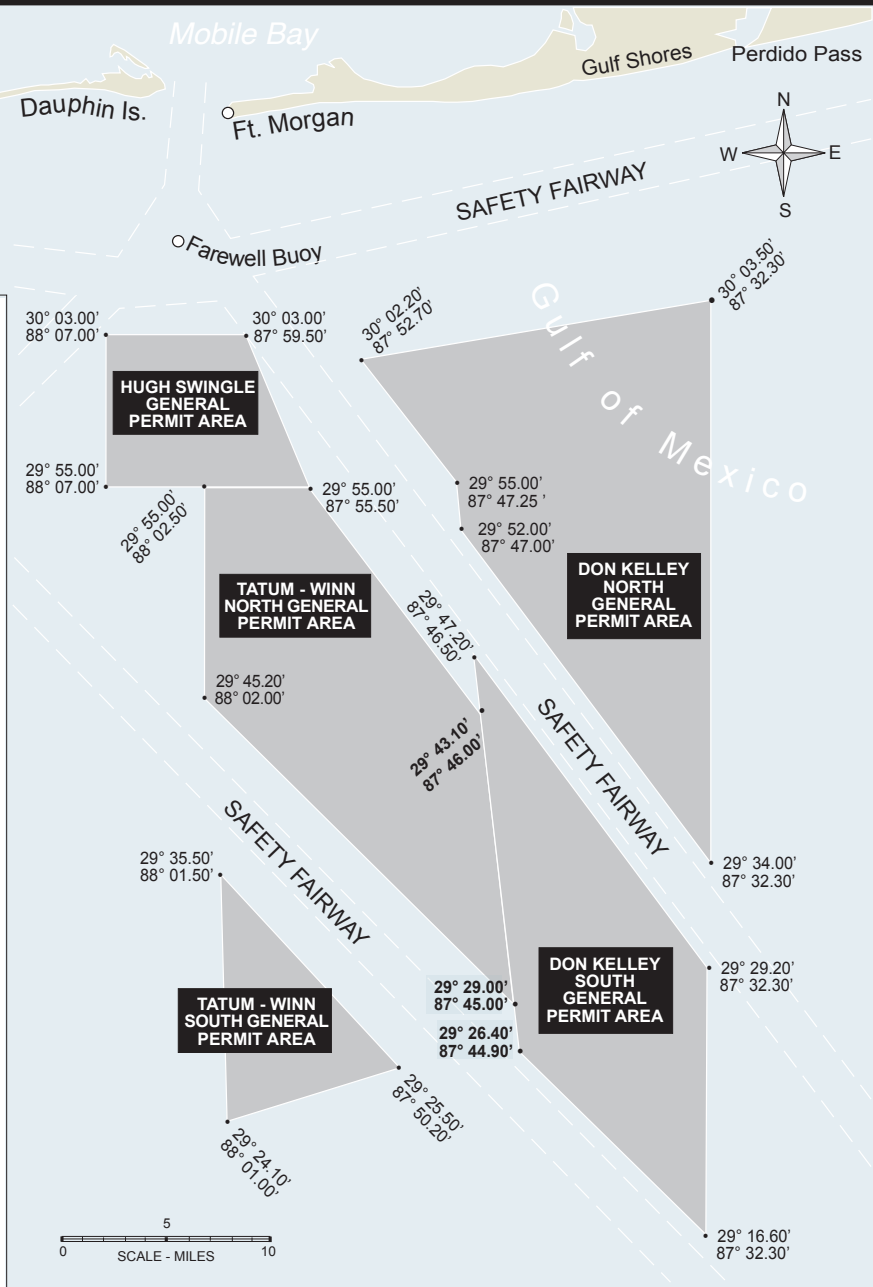


Revised 2009

# Marine Resources Division

ALABAMA DEPARTMENT OF CONSERVATION
AND NATURAL RESOURCES

# ALABAMA ARTIFICIAL REEF GENERAL PERMIT AREAS




## ALABAMA'S ARTIFICIAL REEF PROGRAM

**Alabama has one of the largest artificial reef programs in the world**. The natural bottom of offshore Alabama is a predominately flat sand/mud type bottom. This bottom type attracts very few fish that are either commercially or recreationally valuable. However, it has long been known that if vertical relief is created on this bottom, many reef fish such as snappers and groupers will be produced. In fact, artificial reefs can be created that over time will appear as natural reefs with similar communities of encrusting organisms and bait fish. As various encrusting organisms such as corals and sponges cover the artificial reef material, small animals take up residence. On-going research within Alabama's artificial reef general permit areas indicates that juvenile red snapper recruit to new, uninhabited artificial reefs, aging with the reef, and recruiting to the fishery at an appropriate size. At that point the artificial reef functions as a natural reef.

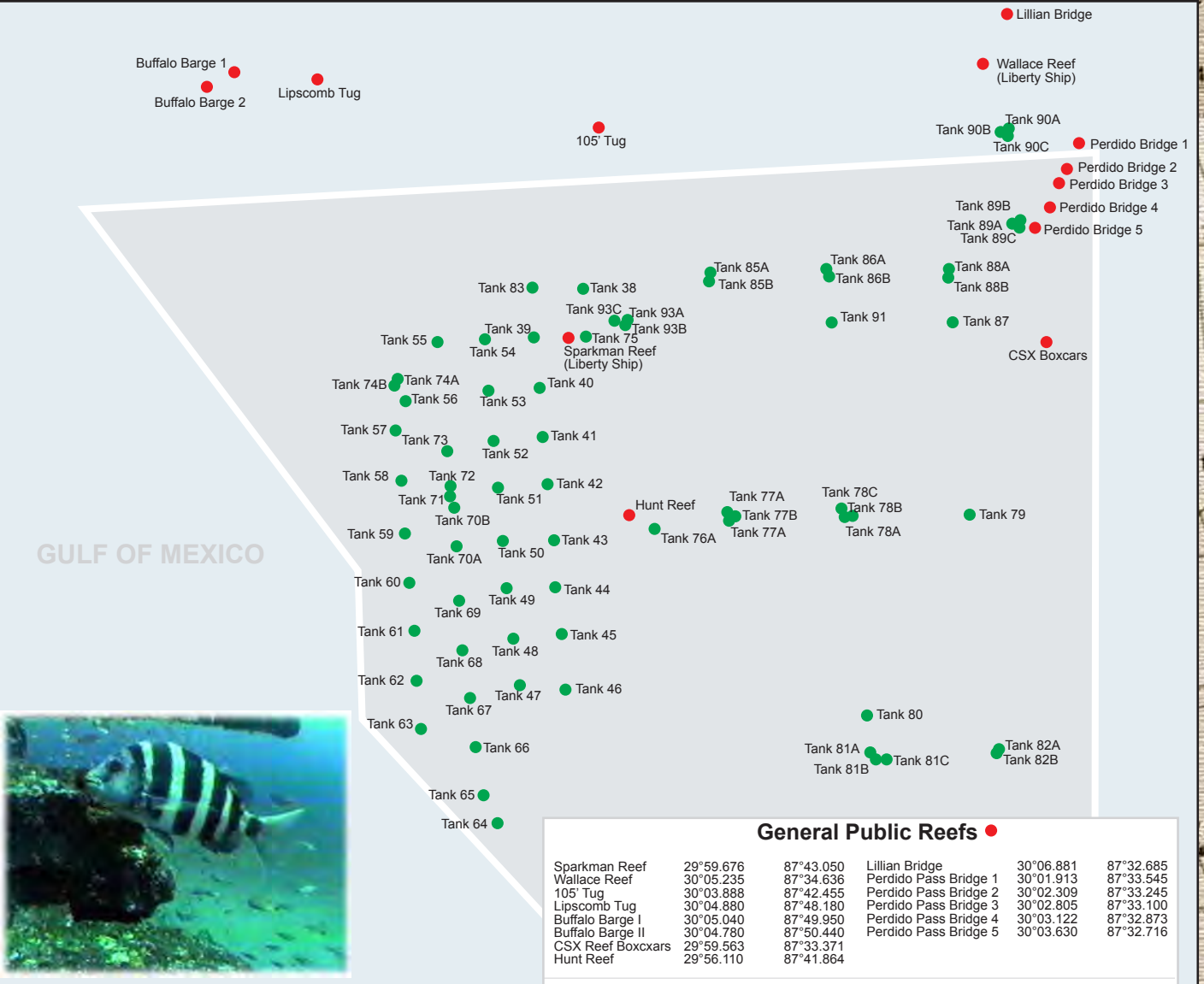
**Alabama's artificial reef building program started in 1953** when the Orange Beach Charter Boat Association asked for the authority to place 250 car bodies off Baldwin County, Alabama. This proved to be very successful and in the years since, many different types of materials have been placed offshore of Alabama. These have included additional car bodies, culverts, bridge rubble, barges, boats and planes. **In 1974,** in an excellent example of State/Federal cooperation, several "ghost-fleeted" liberty ships were sunk in five locations off Mobile and Baldwin Counties in 80-93 feet of water.

**In 1987, a general permit was issued by the U. S. Army Corps of Engineers creating specific areas offshore of Alabama for the creation of artificial reefs.** These were created in order to provide areas for these materials in order to coordinate with other users of the offshore area. In 1987 the areas encompassed almost 800 square miles.

In 1993, the U. S. military in addressing the need to de-militarize obsolete battle tanks realized that immersion in sea water was an acceptable method. The idea was presented to the Marine Resources Division and development of an operation plan began. **Reef-Ex** is the program name associated this activity. In 1994, one-hundred M-60 military tanks were deployed as artificial reefs in depths of 70 to 110 feet of water within the Hugh Swingle and Don Kelley North permit areas. The conservative estimate for the life span of the tanks is 50 years as artificial reefs.

In late 1997, the U. S. Army Corps of Engineers authorized an expansion of Alabama's artificial reef construction areas to allow for greater freedom in reef placement and greater variety in depth. The combined area for all reef permit zones now encompasses approximately 1260 square miles. At the same time, the protocol for reef construction was modified. This modification limited the types of materials that can be used to construct artificial reefs. Enforcement of the protocol and placement of reefs is a joint effort of the Marine Resources Enforcement Section, the Alabama Marine Police Division, and the U. S. Coast Guard.

# PUBLIC REEFS - DON KELLEY NORTH GENERAL PERMIT AREA



## General Public Reefs

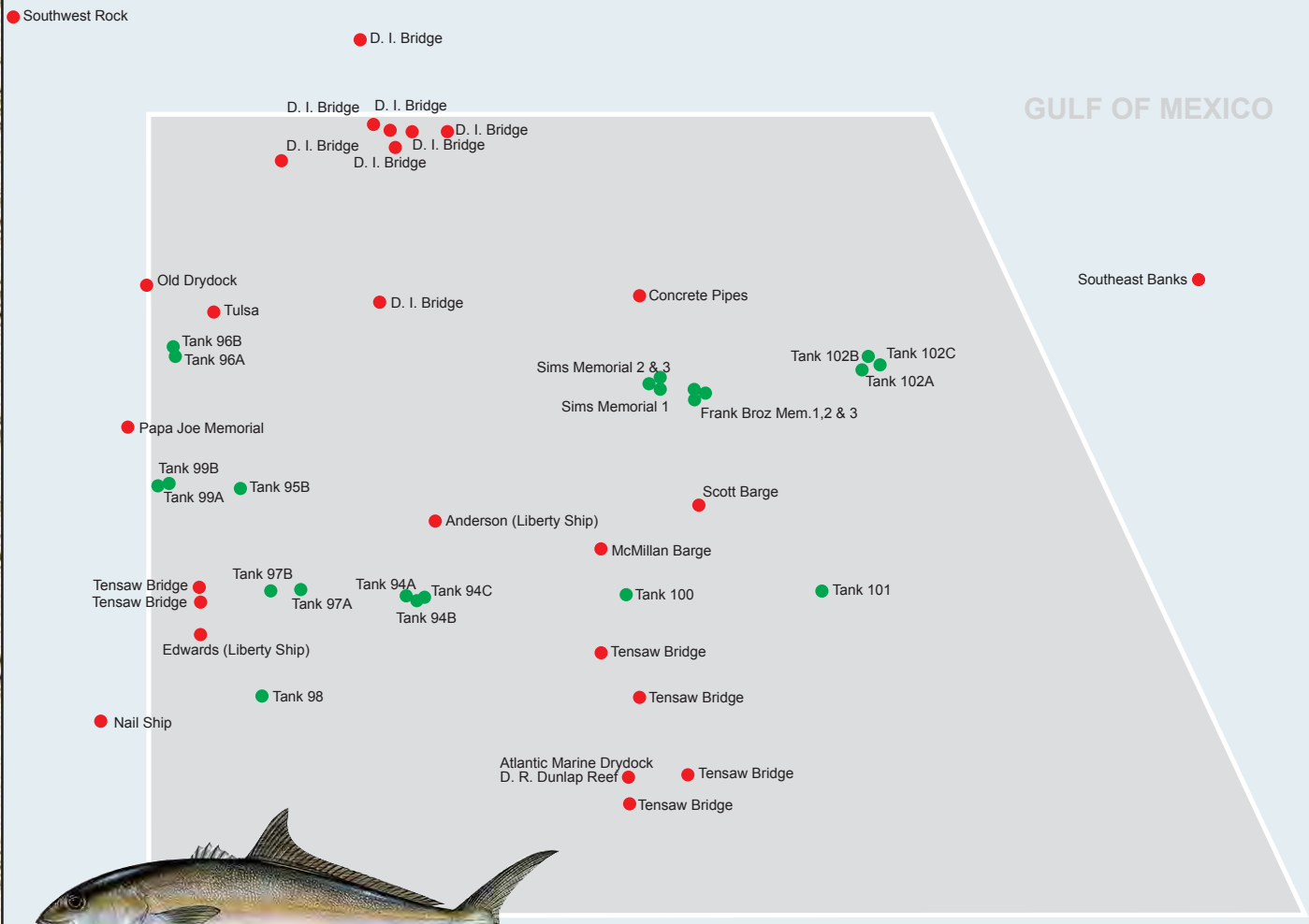
| | | | | | |
|---|---|---|---|---|---|
| Sparkman Reef | 29°59.676 | 87°43.050 | Lillian Bridge | 30°06.881 | 87°32.685 |
| Wallace Reef | 30°05.235 | 87°34.636 | Perdido Pass Bridge 1 | 30°01.913 | 87°33.545 |
| 105' Tug | 30°03.888 | 87°42.455 | Perdido Pass Bridge 2 | 30°02.309 | 87°33.245 |
| Lipscomb Tug | 30°04.880 | 87°48.180 | Perdido Pass Bridge 3 | 30°02.805 | 87°33.100 |
| Buffalo Barge I | 30°05.040 | 87°49.950 | Perdido Pass Bridge 4 | 30°03.122 | 87°32.873 |
| Buffalo Barge II | 30°04.780 | 87°50.440 | Perdido Pass Bridge 5 | 30°03.630 | 87°32.716 |
| CSX Reef Boxcxars | 29°59.563 | 87°33.371 | | | |
| Hunt Reef | 29°56.110 | 87°41.864 | | | |

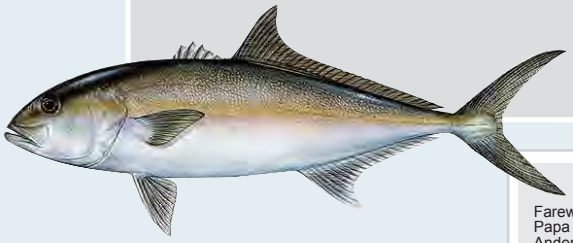
## Military Tank Reefs

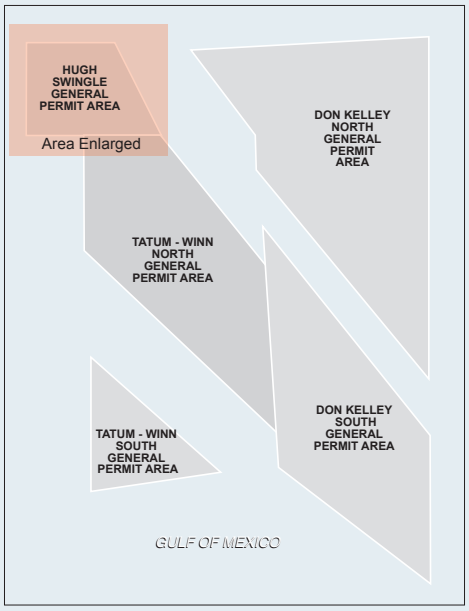
| | | | | | |
|---|---|---|---|---|---|
| Tank 38 | 30°00.691 | 87°43.911 | Tank 74 | 29°58.718 | 87°46.595 |
| Tank 39 | 29°59.715 | 87°43.791 | Tank 74 | 29°58.689 | 87°46.596 |
| Tank 40 | 29°58.652 | 87°43.714 | Tank 75 * | 29°59.736 | 87°42.790 |
| Tank 41 | 29°57.670 | 87°43.645 | Tank 76 * | 29°55.830 | 87°41.355 |
| Tank 42 | 29°56.674 | 87°43.534 | Tank 77 * | 29°55.973 | 87°39.885 |
| Tank 43 | 29°55.640 | 87°43.409 | Tank 78 | 29°56.025 | 87°37.425 |
| Tank 44 | 29°54.637 | 87°43.330 | Tank 78 | 29°56.030 | 87°37.390 |
| Tank 45 | 29°53.673 | 87°43.244 | Tank 78 | 29°56.030 | 87°37.340 |
| Tank 46 | 29°52.541 | 87°43.149 | Tank 79 | 29°56.085 | 87°34.910 |
| Tank 47 | 29°52.610 | 87°44.105 | Tank 80 | 29°51.995 | 87°37.027 |
| Tank 48 | 29°53.565 | 87°44.245 | Tank 81 | 29°51.145 | 87°36.945 |
| Tank 49 | 29°54.619 | 87°44.335 | Tank 81 | 29°51.135 | 87°36.970 |
| Tank 50 | 29°55.560 | 87°44.428 | Tank 81 | 29°51.125 | 87°36.937 |
| Tank 51 | 29°56.612 | 87°44.510 | Tank 82 | 29°51.230 | 87°34.340 |
| Tank 52 | 29°57.590 | 87°44.600 | Tank 82 | 29°51.305 | 87°34.345 |
| Tank 53 | 29°58.650 | 87°44.700 | Tank 83 ** | | |
| Tank 54 | 29°59.650 | 87°44.800 | Tank 84 ** | | |
| Tank 55 | 29°59.642 | 87°45.733 | Tank 85 | 30°00.845 | 87°40.185 |
| Tank 56 | 29°58.385 | 87°46.421 | Tank 85 | 30°00.820 | 87°40.235 |
| Tank 57 | 29°57.835 | 87°46.600 | Tank 86 | 30°00.965 | 87°37.830 |
| Tank 58 | 29°56.814 | 87°46.505 | Tank 86 | 30°00.950 | 87°37.785 |
| Tank 59 | 29°55.743 | 87°46.422 | Tank 87 | 30°00.063 | 87°35.279 |
| Tank 60 | 29°54.715 | 87°46.333 | Tank 88 | 30°00.998 | 87°35.260 |
| Tank 61 | 29°53.744 | 87°46.246 | Tank 88 | 30°00.985 | 87°35.285 |
| Tank 62 | 29°52.710 | 87°46.170 | Tank 89 | 30°01.963 | 87°33.975 |
| Tank 63 | 29°51.775 | 87°46.083 | Tank 89 | 30°01.977 | 87°33.950 |
| Tank 64 | 29°49.820 | 87°44.540 | Tank 89 | 30°01.990 | 87°33.945 |
| Tank 65 | 29°50.438 | 87°44.809 | Tank 90 | 30°03.925 | 87°34.185 |
| Tank 66 | 29°51.375 | 87°44.984 | Tank 90 | 30°03.890 | 87°34.190 |
| Tank 67 | 29°52.347 | 87°45.102 | Tank 90 | 30°03.885 | 87°34.223 |
| Tank 68 | 29°53.343 | 87°45.220 | Tank 91 | 29°59.953 | 87°37.681 |
| Tank 69 | 29°54.350 | 87°45.330 | Tank 92 ** | | |
| Tank 70 | 29°55.368 | 87°45.387 | Tank 93 | 29°59.913 | 87°41.961 |
| Tank 71 | 29°56.208 | 87°45.406 | Tank 93 | 29°59.950 | 87°41.980 |
| Tank 73 | 29°57.376 | 87°45.576 | Tank 93 | 29°59.950 | 87°41.980 |

* Multiple tanks at location ** Coordinates not available.

# PUBLIC REEFS - HUGH SWINGLE GENERAL PERMIT AREA






## General Public Reefs

| | | |
|---|---|---|
| Farewell Buoy | 30°07.490 | 88°04.130 |
| Papa Joe Memorial | 29°59.979 | 88°07.459 |
| Anderson Reef | 29°59.041 | 88°04.305 |
| Old Dry-Dock | 30°01.347 | 88°07.163 |
| Edwards Reef | 29°57.931 | 88°06.597 |
| McMillian Barge | 29°58.766 | 88°02.700 |
| Scott Barge | 29°59.180 | 88°01.740 |
| Southeast Banks | 30°01.425 | 87°56.900 |
| Southwest Rock | 30°06.414 | 88°12.275 |
| Tulsa | 30°01.068 | 88°06.462 |
| Dauphin Isl. Bridge | 30°02.537 | 88°05.796 |
| Dauphin Isl. Bridge | 30°02.786 | 88°04.565 |
| Dauphin Isl. Bridge | 30°01.170 | 88°04.846 |
| Nail Ship | 29°57.573 | 88°09.692 |
| D.R. Dunlap Drydock | 29°56.586 | 88°01.846 |
| Tensaw Bridge | 29°56.300 | 88°02.439 |
| Tensaw Bridge | 29°56.543 | 88°02.440 |
| Tensaw Bridge | 29°57.753 | 88°02.691 |
| Tensaw Bridge | 29°57.329 | 88°02.327 |
| Tensaw Bridge | 29°58.357 | 88°06.566 |
| Tensaw Bridge | 29°58.277 | 88°06.562 |

## Military Tank Reefs

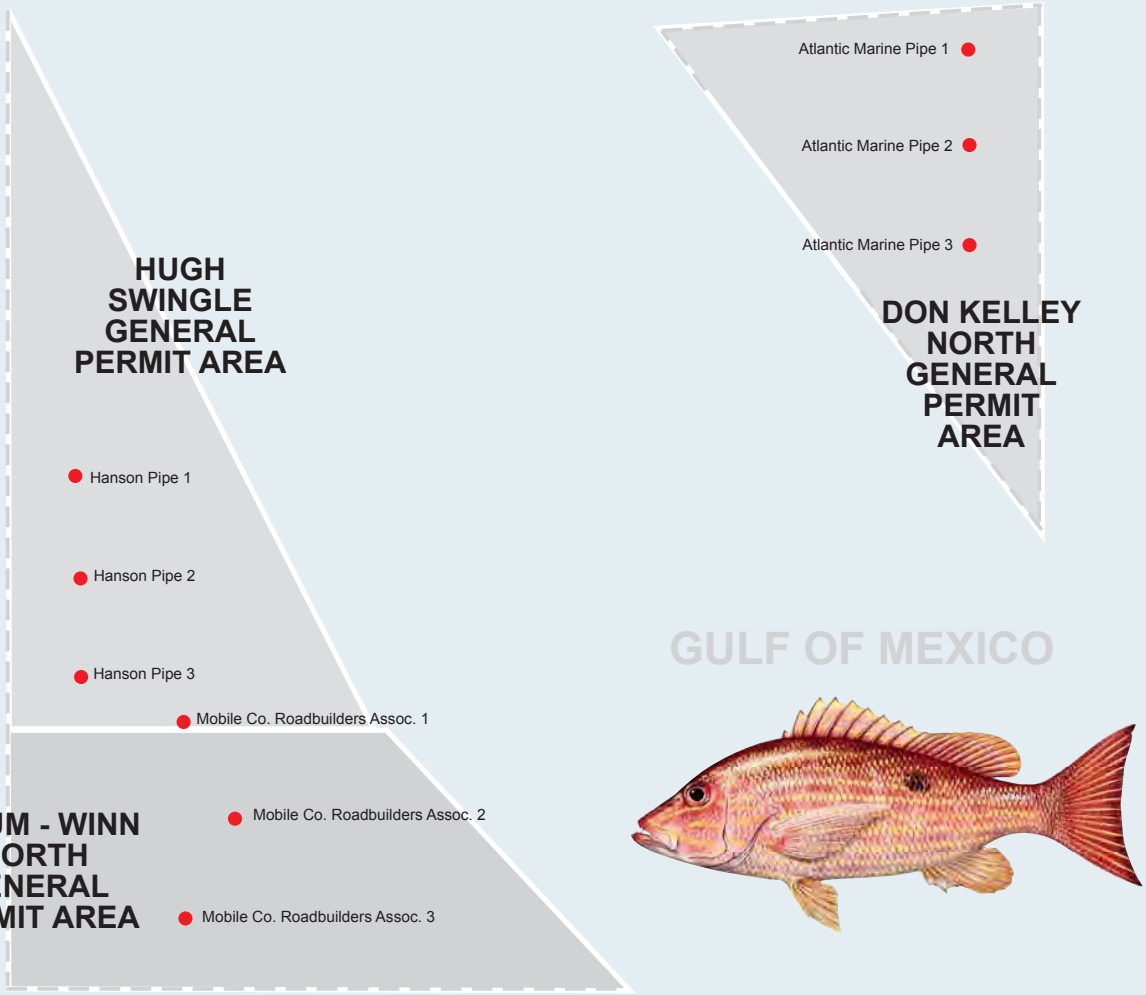
| | | |
|---|---|---|
| Lawrence Sims Reef * | 30°00.238 | 88°02.156 |
| Frank Broz Reef * | 30°00.308 | 88°01.803 |
| Tank 94 | 29°58.303 | 88°04.586 |
| Tank 94 | 29°58.290 | 88°04.480 |
| Tank 94 | 29°58.300 | 88°04.420 |
| Tank 95 * | 29°59.358 | 88°06.236 |
| Tank 96 | 30°00.642 | 88°06.818 |
| Tank 96 | 30°00.643 | 88°06.816 |
| Tank 97 | 29°58.345 | 88°05.884 |
| Tank 97 | 29°58.355 | 88°05.608 |
| Tank 98 | 29°57.339 | 88°05.985 |
| Tank 99 | 29°59.387 | 88°06.956 |
| Tank 99 | 29°59.406 | 88°06.899 |
| Tank 100 | 29°58.325 | 88°02.460 |
| Tank 101 | 29°58.474 | 88°00.568 |
| Tank 102 * | 30°00.518 | 88°00.147 |

* Multiple tanks at location

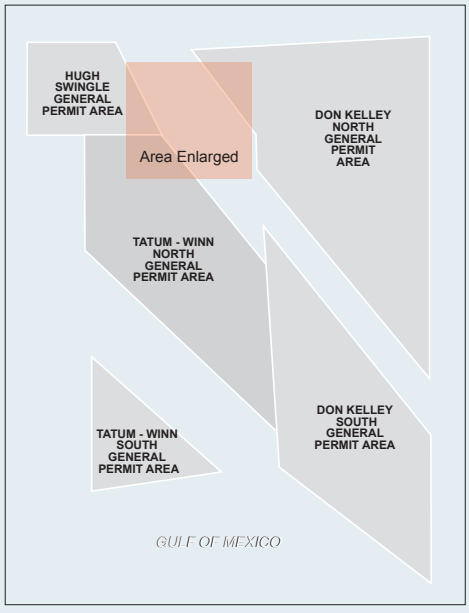
**Deployment of Atlantic Marine Drydock (D. R. Dunlap Reef)**

**M-60 Military Tank Reef**

# CONCRETE CULVERT PIPE REEFS - 2004

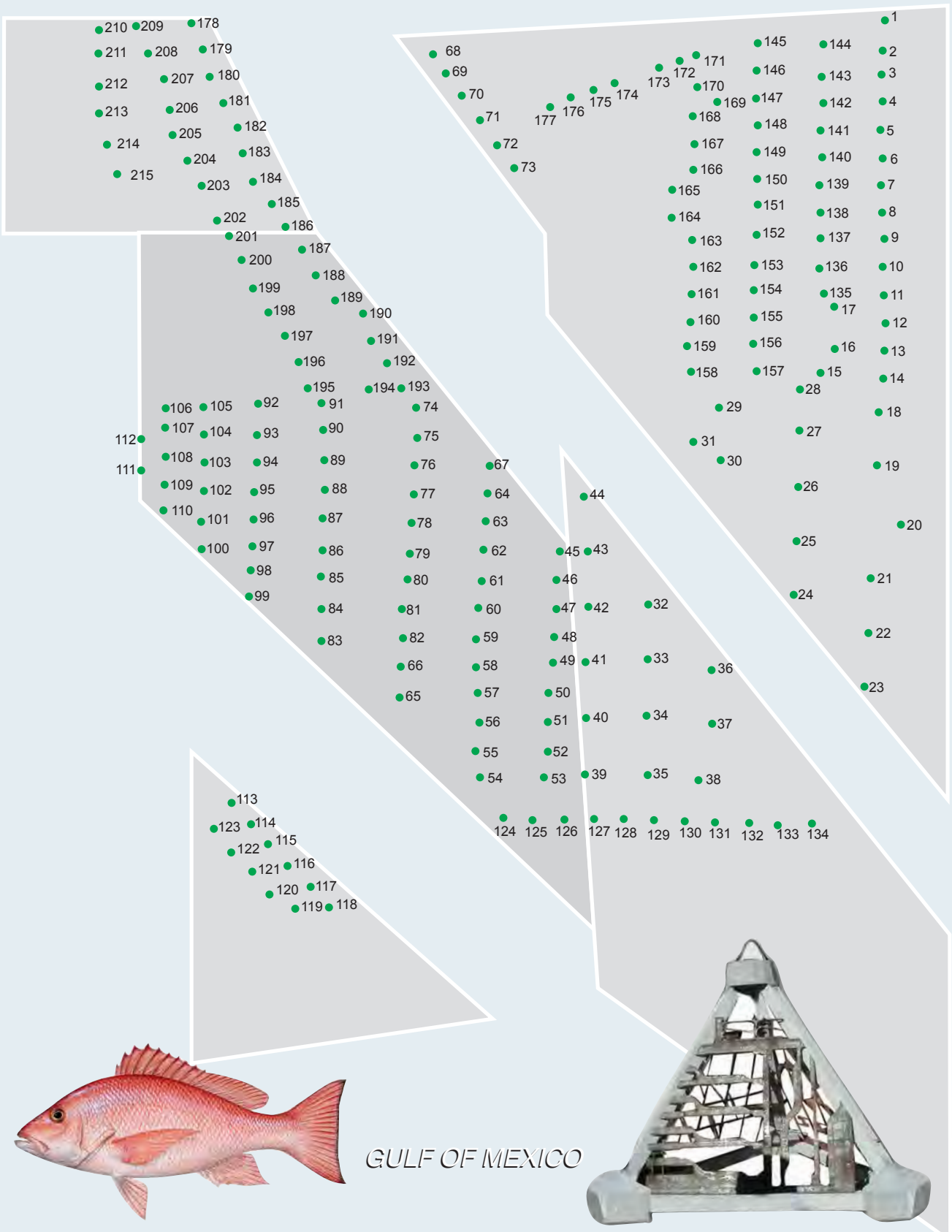





| | |
|---|---|
| Mobile Co. Roadbuilders 1 | 29°55.087 - 87°57.535 |
| Mobile Co. Roadbuilders 2 | 29°54.087 - 87°57.002 |
| Mobile Co. Roadbuilders 3 | 29°53.045 - 87°57.520 |
| Hanson Pipe 1 | 29°57.544 - 87°58.626 |
| Hanson Pipe 2 | 29°56.509 - 87°58.577 |
| Hanson Pipe 3 | 29°55.512 - 87°58.582 |
| Atlantic Marine Pipes 1 | 30°02.002 - 87°49.566 |
| Atlantic Marine Pipes 2 | 30°01.042 - 87°49.564 |
| Atlantic Marine Pipes 3 | 30°00.004 - 87°49.561 |

# RSWC* ARTIFICIAL REEF MODULES - 2004 DEPLOYMENT






GULF OF MEXICO



RSWC* (Red Snapper World Championship)
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# RSWC 2004 REEF MODULES - GPS COORDINATES

| Reef # | Sponsor Name | Lat. | Long |
|---|---|---|---|
| 1 | Flora-Bama 1 | 30°02.894 | 87°34.648 |
| 2 | Flora-Bama 2 | 30°01.844 | 87°34.691 |
| 3 | Reynold's Ready Mix USA Pope #1 | 30°00.889 | 87°34.744 |
| 4 | Reynold's Ready Mix USA Butts #2 | 29°59.876 | 87°34.719 |
| 5 | Reynold's Ready Mix USA #3 | 29°58.854 | 87°34.800 |
| 6 | Reynold's Ready Mix USA #4 | 29°57.831 | 87°34.690 |
| 7 | Reynold's Ready Mix USA #5 | 29°56.842 | 87°34.727 |
| 8 | Joe Raley Builders - Big Momma | 29°55.832 | 87°34.696 |
| 9 | Joe Raley Builders | 29°54.855 | 87°34.636 |
| 10 | Top Gun Tackle #1 | 29°53.832 | 87°34.702 |
| 11 | Top Gun Tackle #2 | 29°52.774 | 87°34.671 |
| 12 | Home Port Marina #1 | 29°51.783 | 87°34.613 |
| 13 | Home Port Marina #2 | 29°50.728 | 87°34.653 |
| 14 | Home Port Marina #3 | 29°49.732 | 87°34.680 |
| 15 | Home Port Marina #4 | 29°49.953 | 87°36.989 |
| 16 | Home Port Marina #5 | 29°50.849 | 87°36.478 |
| 17 | Brett Robinson #1 | 29°52.410 | 87°36.467 |
| 18 | Brett Robinson #2 | 29°48.509 | 87°34.831 |
| 19 | Brett Robinson #3 | 29°46.514 | 87°34.878 |
| 20 | Brett Robinson #4 | 29°44.368 | 87°34.005 |
| 21 | Brett Robinson #5 | 29°42.390 | 87°35.126 |
| 22 | Brett Robinson #6 | 29°40.382 | 87°35.221 |
| 23 | Brett Robinson #7 | 29°38.381 | 87°35.420 |
| 24 | Brett Robinson #8 | 29°41.777 | 87°37.974 |
| 25 | Brett Robinson #9 | 29°43.751 | 87°37.875 |
| 26 | Brett Robinson #10 | 29°45.774 | 87°37.801 |
| 27 | Brett Robinson #11 | 29°47.769 | 87°37.732 |
| 28 | Brett Robinson #12 | 29°49.316 | 87°37.797 |
| 29 | Brett Robinson #13 | 29°48.685 | 87°40.695 |
| 30 | Brett Robinson #14 | 29°46.747 | 87°40.621 |
| 31 | Brett Robinson #15 | 29°47.410 | 87°41.576 |
| 32 | Brett Robinson #16 | 29°41.472 | 87°43.296 |
| 33 | Brett Robinson #17 | 29°39.426 | 87°43.323 |
| 34 | Brett Robinson #18 | 29°37.359 | 87°43.346 |
| 35 | Brett Robinson #19 | 29°35.230 | 87°43.334 |
| 36 | Brett Robinson #20 | 29°39.076 | 87°40.967 |
| 37 | J & M Tackle #1 | 29°37.023 | 87°40.997 |
| 38 | J & M Tackle #2 | 29°35.013 | 87°41.492 |
| 39 | J & M Tackle #3 | 29°35.202 | 87°45.620 |
| 40 | J & M Tackle #4 | 29°37.270 | 87°45.585 |
| 41 | J & M Tackle #5 | 29°39.318 | 87°45.617 |
| 42 | Blue Water Ship Stores #1 | 29°41.338 | 87°45.562 |
| 43 | Blue Water Ship Stores #2 | 29°43.383 | 87°45.563 |
| 44 | The Rod Room #1 | 29°45.407 | 87°45.684 |
| 45 | The Rod Room #2 | 29°43.371 | 87°46.582 |
| 46 | Zeke's Landing #1 | 29°42.358 | 87°46.691 |
| 47 | Zeke's Landing #2 | 29°41.264 | 87°46.705 |
| 48 | Zeke's Landing #3 | 29°40.218 | 87°46.761 |
| 49 | Zeke's Landing #4 | 29°39.299 | 87°46.799 |
| 50 | Zeke's Landing #5 | 29°38.174 | 87°46.982 |
| 51 | Zeke's Landing #6 | 29°37.138 | 87°46.982 |
| 52 | Zeke's Landing #7 | 29°36.022 | 87°47.020 |
| 53 | Zeke's Landing #8 | 29°35.057 | 87°47.141 |
| 54 | Zeke's Landing #9 | 29°35.053 | 87°49.472 |
| 55 | Zeke's Landing #10 | 29°36.046 | 87°49.649 |
| 56 | Foley Beach Express #1 | 29°37.105 | 87°49.491 |
| 57 | Foley Beach Express #2 | 29°38.166 | 87°49.538 |
| 58 | International Insurance - Kit Steber | 29°39.174 | 87°49.644 |
| 59 | International Insurance - Drew Steber | 29°40.206 | 87°49.610 |
| 60 | City of Orange Beach- Albacore II | 29°41.274 | 87°49.496 |
| 61 | City of Orange Beach- Annie Girl | 29°42.304 | 87°49.391 |
| 62 | City of Orange Beach- Aquastar | 29°43.408 | 87°49.309 |
| 63 | City of Orange Beach- Ashley Reene | 29°44.462 | 87°49.209 |
| 64 | City of Orange Beach- Big Adventure | 29.45.504 | 87°49.139 |
| 65 | City of Orange Beach- Boll Weevil | 29°38.044 | 87°52.451 |
| 66 | City of Orange Beach- C.A.T. | 29°39.157 | 87°52.387 |
| 67 | City of Orange Beach- C-ROSE | 29°46.512 | 87°49.148 |
| 68 | City of Orange Beach- Catch-It | 30°02.020 | 87°54.870 |
| 69 | City of Orange Beach- Chippers Clipper | 30°00.947 | 87°50.711 |
| 70 | City of Orange Beach- Class Act | 30°00.123 | 87°50.138 |
| 71 | City of Orange Beach- Cool Breeze | 29°59.261 | 87°49.511 |
| 72 | City of Orange Beach- Cool Change | 29°58.327 | 87°48.887 |
| 73 | City of Orange Beach- Crosstie | 29°57.479 | 87°48.246 |
| 74 | City of Orange Beach- Distraction | 29°48.655 | 87°51.810 |
| 75 | City of Orange Beach- Doug Out | 29°47.557 | 87°51.753 |
| 76 | City of Orange Beach- Fairwater II | 29°46.559 | 87°51.888 |
| 77 | City of Orange Beach- Fish'n Fool | 29°45.445 | 87°51.905 |
| 78 | City of Orange Beach- Fish Trap | 29°44.404 | 87°52.020 |
| 79 | City of Orange Beach- Getaway | 29°43.275 | 87°52.110 |
| 80 | City of Orange Beach- Gulf Rebel | 29°42.329 | 87°52.138 |
| 81 | City of Orange Beach- Hey Boy II | 29°41.266 | 87°52.362 |
| 82 | City of Orange Beach- Hot Spot | 29°40.176 | 87°52.304 |
| 83 | City of Orange Beach- Intimidator | 29°40.109 | 87°55.322 |
| 84 | City of Orange Beach- Intruder | 29°41.273 | 87°55.319 |
| 85 | City of Orange Beach- Island Girl | 29°42.479 | 87°55.309 |
| 86 | City of Orange Beach- Jamie G | 29°43.440 | 87°55.256 |
| 87 | City of Orange Beach- Joyce | 29°44.610 | 87°55.280 |
| 88 | City of Orange Beach- Lady D | 29°45.646 | 87°55.184 |
| 89 | City of Orange Beach- Mamas Money | 29°46.732 | 87°55.212 |
| 90 | City of Orange Beach- Miss Celeste | 29°47.850 | 87°55.267 |
| 91 | City of Orange Beach- Misty | 29°48.797 | 87°55.322 |
| 92 | City of Orange Beach- Necessity | 29°48.806 | 87°57.649 |
| 93 | City of Orange Beach- Outcast | 29°47.706 | 87°57.692 |
| 94 | City of Orange Beach- Reef Chief | 29°46.672 | 87°57.697 |
| 95 | City of Orange Beach- Reel Surprise | 29°45.600 | 87°57.781 |
| 96 | City of Orange Beach- Hip Tide | 29°44.572 | 87°57.791 |
| 97 | City of Orange Beach- Robin Lynne | 29°43.558 | 87°57.861 |
| 98 | Chris Myers Nissan | 29°42.682 | 87°57.912 |
| 99 | Chris Myers Auto Mall | 29°41.689 | 87°57.989 |
| 100 | Convention & Visitors Bureau #1 | 29°43.476 | 87°59.697 |
| 101 | Convention & Visitors Bureau #2 | 29°44.525 | 87°59.730 |
| 102 | Convention & Visitors Bureau #3 | 29°45.609 | 87°59.627 |
| 103 | Convention & Visitors Bureau #4 | 29°46.654 | 87°59.630 |
| 104 | Convention & Visitors Bureau #5 | 29°47.696 | 87°59.637 |
| 105 | Convention & Visitors Bureau #6 | 29°48.688 | 87°59.627 |
| 106 | Convention & Visitors Bureau #7 | 29°48.632 | 88°01.036 |
| 107 | Convention & Visitors Bureau #8 | 29°47.886 | 88°01.025 |
| 108 | Convention & Visitors Bureau #9 | 29°46.841 | 88°01.046 |
| 109 | Convention & Visitors Bureau #10 | 29°45.858 | 88°01.065 |
| 110 | Convention & Visitors Bureau #11 | 29°44.867 | 88°01.057 |
| 111 | Convention & Visitors Bureau #12 | 29°46.442 | 88°01.933 |
| 112 | Convention & Visitors Bureau #13 | 29°47.499 | 88°01.935 |
| 113 | Convention & Visitors Bureau #14 | 29°33.538 | 87°59.821 |
| 114 | Convention & Visitors Bureau #15 | 29°32.789 | 87°59.148 |
| 115 | The Reef Maker #1 | 29°32.030 | 87°58.452 |
| 116 | The Reef Maker #2 | 29°31.231 | 87°57.769 |
| 117 | Radcliff Economy & Marine #1 | 29°30.456 | 87°56.990 |
| 118 | ValvTect #1 | 29°29.707 | 87°56.220 |
| 119 | RE/MAX of Gulf Shores #1 | 29°29.650 | 87°57.482 |
| 120 | RE/MAX of Gulf Shores #2 | 29°30.246 | 87°58.389 |
| 121 | RE/MAX of Gulf Shores #3 | 29°31.014 | 87°59.062 |
| 122 | RE/MAX of Gulf Shores #4 | 29°31.732 | 87°59.826 |
| 123 | RE/MAX of Gulf Shores #5 | 29°32.545 | 88°00.479 |
| 124 | Kaiser Realty Inc. #1 | 29°33.568 | 87°48.617 |
| 125 | Kaiser Realty Inc. #2 | 29°33.501 | 87°47.578 |
| 126 | Kaiser Realty Inc. #3 | 29°33.523 | 87°46.449 |
| 127 | Kaiser Realty Inc. #4 | 29°33.526 | 87°45.300 |
| 128 | Kaiser Realty Inc. #5 | 29°33.541 | 87°44.210 |
| 129 | Caribe Resort #1 | 29°33.489 | 87°43.105 |
| 130 | Caribe Resort #2 | 29°33.471 | 87°41.987 |
| 131 | Tacky Jacks #1 | 29°33.440 | 87°40.875 |
| 132 | Tacky Jacks #2 | 29°33.390 | 87°39.623 |
| 133 | Orange Beach Auto & Marine #1 | 29°33.308 | 87°38.584 |
| 134 | Orange Beach Auto & Marine #2 | 29°33.364 | 87°37.324 |
| 135 | Live Bait I | 29°52.854 | 87°36.917 |
| 136 | Live Bait II | 29°53.813 | 87°37.047 |
| 137 | Live Bait III | 29°54.855 | 87°36.983 |
| 138 | Live Bait IV | 29°55.828 | 87°36.992 |
| 139 | Live Bait V | 29°56.868 | 87°37.046 |
| 140 | Baldwin Co. E.M.C. leader | 29°57.857 | 87°36.944 |
| 141 | Baldwin Co. E.M.C. member | 29°58.855 | 87°36.978 |
| 142 | Baldwin Co. E.M.C. community | 29°59.853 | 87°36.922 |
| 143 | Baldwin Co. E.M.C. cooperative | 30°00.839 | 87°37.009 |
| 144 | Baldwin Co. E.M.C. environmental | 30°02.005 | 87°36.904 |
| 145 | City of Orange Beach- Sea Spray | 30°02.043 | 87°39.276 |
| 146 | City of Orange Beach- Shady Lady | 30°01.015 | 87°39.355 |
| 147 | Bud #1 | 30°00.025 | 87°39.381 |
| 148 | Ultra #1 | 29°59.066 | 87°39.303 |
| 149 | BBD #1 | 29°58.055 | 87°39.348 |
| 150 | Busch #1 | 29°57.077 | 87°39.281 |
| 151 | Lauren #1 | 29°56.089 | 87°39.303 |
| 152 | Heavy Gravy | 29°55.033 | 87°39.329 |
| 153 | Miss Sally | 29°53.910 | 87°39.412 |
| 154 | Cummins Quantum Hole | 29°52.995 | 87°39.424 |
| 155 | Mid South Spot | 29°51.984 | 87°39.436 |
| 156 | Christian Mahlstedt | 29°51.039 | 87°39.472 |
| 157 | Lucas Mahlstedt | 29°49.980 | 87°39.347 |
| 158 | Amelie | 29°49.991 | 87°41.784 |
| 159 | Whitney | 29°50.938 | 87°41.885 |
| 160 | Mikee's | 29°51.840 | 87°41.754 |
| 161 | The Shrimp Basket | 29°52.805 | 87°41.751 |
| 162 | McCarron Insurance Group #1 | 29°53.839 | 87°41.659 |
| 163 | Sally's Fishing Hole | 29°54.810 | 87°41.682 |
| 164 | Tom Bagwell Reef | 29°55.630 | 87°42.437 |
| 165 | William Radcliff Reef | 29°56.643 | 87°42.446 |
| 166 | Capt Sunny Trimble Memorial-War Eagle | 29°57.391 | 87°41.638 |
| 167 | L.H. Washington Memorial - War Eagle | 29°58.345 | 87°41.663 |
| 168 | Outcast Marina | 29°59.394 | 87°41.694 |
| 169 | Outcast Marina | 29°59.894 | 87°40.765 |
| 170 | Jim Brown Construction | 30°00.482 | 87°41.537 |
| 171 | Sabel Steel #1 | 30°01.585 | 87°41.610 |
| 172 | Sabel Steel #2 | 30°01.396 | 87°42.217 |
| 173 | Salzman Farms #1 | 30°01.162 | 87°42.933 |
| 174 | Salzman Farms #2 | 30°00.570 | 87°44.553 |
| 175 | Sandy Wade Reef | 30°00.285 | 87°45.320 |
| 176 | SanRoc Cay Reef | 29°59.973 | 87°46.133 |
| 177 | RM #1 | 29°59.637 | 87°46.884 |
| 178 | RM #2 | 30°02.741 | 88°00.111 |
| 179 | The Sportsman Skiff | 30°01.800 | 87°59.659 |
| 180 | Sportman Marina | 30°00.821 | 87°59.372 |
| 181 | Trent Marina #1 | 29°59.869 | 87°58.926 |
| 182 | Trent Marina #2 | 29°58.974 | 87°58.396 |
| 183 | Vision Bank #1 | 29°58.001 | 87°58.204 |
| 184 | Vision Bank #2 | 29°57.008 | 87°57.825 |
| 185 | Zeke's Boat Sales #1 | 29°56.148 | 87°57.205 |
| 186 | Zeke's Boat Sales #2 | 29°55.283 | 87°56.650 |
| 187 | Dora's Reef | 29°54.431 | 87°56.037 |
| 188 | Rick's Reef | 29°53.525 | 87°55.542 |
| 189 | James' Reef | 29°52.641 | 87°54.852 |
| 190 | Nina's Reef | 29°52.123 | 87°53.800 |
| 191 | Willy's Reef | 29°51.114 | 87°53.529 |
| 192 | LCPL Philip J. Shermer, III | 29°50.311 | 87°52.927 |
| 193 | William L. Marks | 29°49.405 | 87°52.374 |
| 194 | John C. Hope III | 29°49.350 | 87°53.574 |
| 195 | Robert C. Baird | 29°49.372 | 87°55.830 |
| 196 | John M. Turner | 29°50.355 | 87°56.175 |
| 197 | Vinyl Solutions | 29°51.307 | 87°56.670 |
| 198 | Visual Effects | 29°52.209 | 87°57.261 |
| 199 | Fish Camp Restaurants #1 | 29°53.067 | 87°57.841 |
| 200 | Fish Camp Restaurants #2 | 29°54.056 | 87°58.207 |
| 201 | Performance Contractors Reef # 1 | 29°54.987 | 87°58.690 |
| 202 | Brandon Favre Reef | 29°55.539 | 87°59.121 |
| 203 | Outcast Bait & Tackle #1 | 29°56.791 | 87°59.730 |
| 204 | Outcast Bait & Tackle #2 | 29°57.737 | 88°00.213 |
| 205 | Outcast Bait & Tackle #3 | 29°58.686 | 88°00.760 |
| 206 | Outcast Bait & Tackle #4 | 29°59.600 | 88°00.900 |
| 207 | Outcast Bait & Tackle #5 | 30°00.729 | 88°01.057 |
| 208 | First National Bank #1 | 30°01.662 | 88°01.628 |
| 209 | First National Bank #2 | 30°02.623 | 88°02.175 |
| 210 | Coast Marine #1 | 30°02.572 | 88°03.491 |
| 211 | Coast Marine #2 | 30°01.617 | 88°03.463 |
| 212 | Schenck Reef | 30°00.482 | 88°03.460 |
| 213 | Schwartz Reef | 29°59.494 | 88°03.451 |
| 214 | Sam's Spot #1 | 29°58.345 | 88°03.510 |
| 215 | Sam's Spot #2 | 29°56.907 | 88°03.315 |

# RSWC ARTIFICIAL REEF MODULES - 2005 - 06 DEPLOYMENT

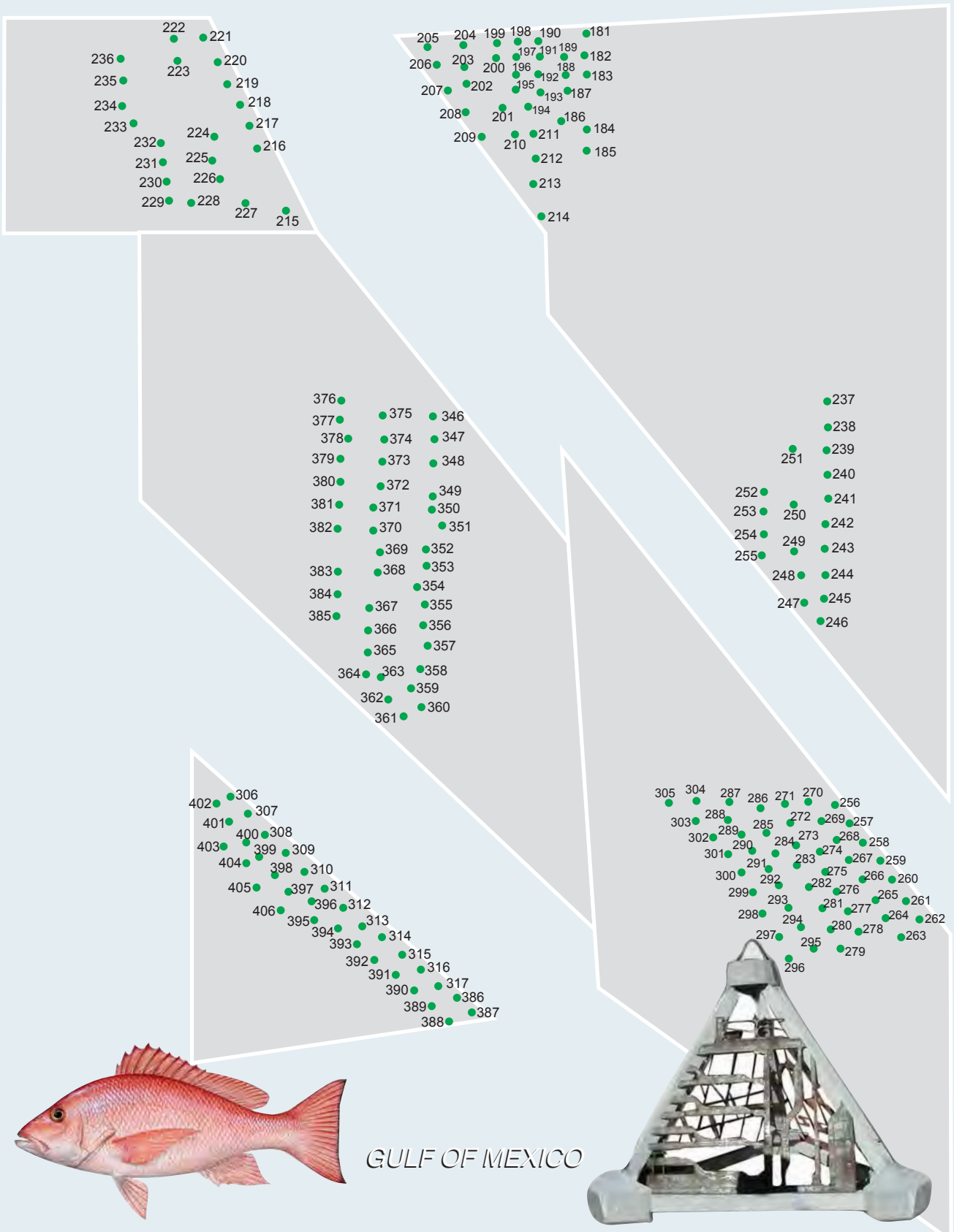
GULF OF MEXICO

RSWC* (Red Snapper World Championship)
Visit: www.redsnapperworldchampionship.com

# RSWC 2005 - 06 REEF MODULES - GPS COORDINATES

| Reef # | Sponsor Name | Lat. | Long |
|---|---|---|---|
| 1 | Reynold's Ready Mix- Walter Pope #2 | 29°57.046 | 87°32.605 |
| 2 | Reynold's Ready Mix- Walter Pope #3 | 29°56.139 | 87°32.554 |
| 3 | Reynold's Ready Mix- Walter Pope #4 | 29°55.275 | 87°32.595 |
| 4 | Reynold's Ready Mix- Harold Butts #2 | 29°54.385 | 87°32.574 |
| 5 | Reynold's Ready Mix- Harold Butts #3 | 29°53.535 | 87°32.544 |
| 6 | Ala° Gulf Coast Chamber of Commerce | 29°52.693 | 87°32.564 |
| 7 | Ala° Gulf Coast Chamber of Commerce #2 | 29°51.866 | 87°32.547 |
| 8 | Brett/Robinson #21 | 29°50.977 | 87°32.521 |
| 9 | Brett/Robinson #22 | 29°50.108 | 87°32.564 |
| 10 | Brett/Robinson #23 | 29°49.261 | 87°32.465 |
| 11 | Brett/Robinson #24 | 29°48.793 | 87°32.558 |
| 12 | Brett/Robinson #25 | 29°47.890 | 87°32.486 |
| 13 | Brett/Robinson #26 | 29°47.021 | 87°32.548 |
| 14 | Brett/Robinson #27 | 29°46.111 | 87°32.609 |
| 15 | Brett/Robinson #28 | 29°45.242 | 87°32.564 |
| 16 | Brett/Robinson #29 | 29°44.348 | 87°32.583 |
| 17 | Brett/Robinson #30 | 29°43.412 | 87°32.643 |
| 18 | Brett/Robinson #31 | 29°42.486 | 87°32.536 |
| 19 | Brett/Robinson #32 | 29°41.639 | 87°32.531 |
| 20 | Brett/Robinson #33 | 29°40.734 | 87°32.510 |
| 21 | Brett/Robinson #34 | 29°39.891 | 87°32.574 |
| 22 | Brett/Robinson #35 | 29°38.934 | 87°32.584 |
| 23 | Brett/Robinson #36 | 29°38.109 | 87°32.573 |
| 24 | Brett/Robinson #37 | 29°37.159 | 87°32.669 |
| 25 | Brett/Robinson #38 | 29°36.306 | 87°32.633 |
| 26 | Brett/Robinson #39 | 29°35.445 | 87°32.597 |
| 27 | Brett/Robinson #40 | 29°34.551 | 87°32.551 |
| 28 | BBD Mollie | 29°32.522 | 87°37.210 |
| 29 | BBD Claire | 29°32.525 | 87°38.328 |
| 30 | BBD Maggie | 29°32.613 | 87°39.347 |
| 31 | BBD Sam | 29°31.764 | 87°40.321 |
| 32 | BBD Will | 29°32.757 | 87°41.394 |
| 33 | City of Orange Beach- Adventure Quest | 29°32.734 | 87°42.480 |
| 34 | City of Orange Beach- Job Site | 29°32.722 | 87°43.514 |
| 35 | City of Orange Beach- Barely Legal | 29°32.728 | 87°44.447 |
| 36 | City of Orange Beach- Bottom Line | 29°32.727 | 87°45.441 |
| 37 | City of Orange Beach- Lady Ann | 29°32.690 | 87°46.563 |
| 38 | City of Orange Beach- Miss Hollie | 29°32.723 | 87°47.661 |
| 39 | City of Orange Beach- Condo Money | 29°32.776 | 87°48.754 |
| 40 | City of Orange Beach- Patti Ann | 29°34.806 | 87°44.789 |
| 41 | City of Orange Beach- Red Eye | 29°35.739 | 87°44.801 |
| 42 | City of Orange Beach- Crowd Pleezer | 29°36.781 | 87°44.784 |
| 43 | City of Orange Beach- Eagle Express | 29°37.623 | 87°44.742 |
| 44 | City of Orange Beach- Sea Spray | 29°38.487 | 87°44.788 |
| 45 | City of Orange Beach- Shady Lady | 29°39.328 | 87°44.833 |
| 46 | City of Orange Beach- E-Mail | 29°40.192 | 87°44.866 |
| 47 | City of Orange Beach- Escape | 29°41.072 | 87°44.861 |
| 48 | City of Orange Beach- Shirley R. Too | 29°41.949 | 87°44.834 |
| 49 | City of Orange Beach- South Wind | 29°42.798 | 87°44.857 |
| 50 | City of Orange Beach- Summer Breeze I | 29°48.929 | 87°50.740 |
| 51 | City of Orange Beach- Summer Breeze II | 29°48.219 | 87°50.245 |
| 52 | City of Orange Beach- Summer Daze | 29°47.471 | 87°49.732 |
| 53 | City of Orange Beach- Summer Hunter | 29°46.926 | 87°49.250 |
| 54 | City of Orange Beach- Sure Shot | 29°46.099 | 87°48.682 |
| 55 | City of Orange Beach- Teacher's Pet | 29°45.427 | 87°48.091 |
| 56 | City of Orange Beach- High Cotton | 29°44.692 | 87°47.535 |
| 57 | City of Orange Beach- Traveler | 29°43.816 | 87°47.529 |
| 58 | City of Orange Beach- Undertaker | 29°42.990 | 87°47.578 |
| 59 | City of Orange Beach- Wishbone | 29°42.187 | 87°47.614 |
| 60 | City of Orange Beach- Zeke's Lady | 29°41.317 | 87°47.606 |
| 61 | City of Orange Beach- Annie Girl #2 | 29°40.474 | 87°47.690 |
| 62 | City of Orange Beach- Aquastar #2 | 29°39.642 | 87°47.718 |
| 63 | City of Orange Beach- Big Adventure #2 | 29°38.749 | 87°47.668 |
| 64 | City of Orange Beach- Boll Weevil #2 | 29°37.886 | 87°47.713 |
| 65 | City of Orange Beach- Bottom Line #2 | 29°36.935 | 87°47.787 |
| 66 | City of Orange Beach- C-ROSE #2 | 29°36.207 | 87°47.802 |
| 67 | City of Orange Beach- C.A.T. #2 | 29°35.358 | 87°47.803 |
| 68 | City of Orange Beach- Catch-It #2 | 29°34.489 | 87°47.860 |
| 69 | CVB Reef #16 | 29°34.481 | 87°48.805 |
| 70 | CVB Reef #17 | 29°35.327 | 87°48.806 |
| 71 | CVB Reef #18 | 29°36.198 | 87°48.818 |
| 72 | CVB Reef #19 | 29°37.033 | 87°48.772 |
| 73 | CVB Reef #20 | 29°37.862 | 87°48.758 |
| 74 | CVB Reef #21 | 29°38.735 | 87°48.749 |
| 75 | CVB Reef #22 | 29°39.532 | 87°48.745 |
| 76 | CVB Reef #23 | 29°40.403 | 87°48.825 |
| 77 | CVB Reef #24 | 29°41.244 | 87°48.710 |
| 78 | CVB Reef #25 | 29°42.085 | 87°48.696 |
| 79 | CVB Reef #26 | 29°42.957 | 87°48.662 |
| 80 | CVB Reef #27 | 29°43.815 | 87°48.643 |
| 81 | CVB Reef #28 | 29°44.726 | 87°48.484 |
| 82 | CVB Reef #29 | 29°46.272 | 87°49.788 |
| 83 | CVB Reef #30 | 29°45.341 | 87°49.865 |
| 84 | Foley Beach Express #3 | 29°44.496 | 87°50.156 |
| 85 | Foley Beach Express #4 | 29°43.613 | 87°50.222 |
| 86 | Homeport Marina #6 | 29°42.767 | 87°50.257 |
| 87 | Homeport Marina #7 | 29°41.823 | 87°50.329 |
| 88 | Homeport Marina #8 | 29°40.934 | 87°50.230 |
| 89 | Homeport Marina #9 | 29°40.122 | 87°50.580 |
| 90 | Homeport Marina #10 | 29°39.249 | 87°50.609 |
| 91 | Chris Steber Reef | 29°38.413 | 87°50.715 |
| 92 | Michele Steber Reef | 29°37.535 | 87°50.677 |
| 93 | Eric Mahlstedt | 29°36.722 | 87°50.684 |
| 94 | Island Wide Marine Reef | 29°35.854 | 87°50.699 |
| 95 | J&M Tackle #6 | 29°34.999 | 87°50.737 |
| 96 | J&M Tackle #7 | 29°35.710 | 87°51.375 |
| 97 | J&M Tackle #8 | 29°36.357 | 87°51.973 |
| 98 | J&M Tackle #9 | 29°36.936 | 87°52.704 |
| 99 | J&M Tackle #10 | 29°37.562 | 87°53.444 |
| 100 | Riverwalk Orange Beach | 29°38.196 | 87°54.029 |
| 101 | Gulf World Marine Park | 29°39.020 | 87°54.069 |
| 102 | Sam's Spot #3 | 29°39.819 | 87°54.059 |
| 103 | Sam's Spot #4 | 29°40.643 | 87°54.027 |
| 104 | Sam's Spot #5 | 29°41.483 | 87°53.941 |
| 105 | Sam's Spot #6 | 29°42.323 | 87°53.964 |
| 106 | Sam's Spot #7 | 29°43.165 | 87°53.980 |
| 107 | RM #3 | 29°44.031 | 87°53.909 |
| 108 | RM #4 | 29°44.877 | 87°53.961 |
| 109 | Owen's Reef | 29°45.741 | 87°53.860 |
| 110 | Toby's Reef | 29°46.574 | 87°53.805 |
| 111 | The Rod Room #3 | 29°47.408 | 87°53.769 |
| 112 | The Rod Room #4 | 29°48.294 | 87°53.771 |
| 113 | Zeke's Landing #11 | 29°48.969 | 87°53.141 |
| 114 | Zeke's Landing #12 | 30°03.380 | 87°32.471 |
| 115 | Zeke's Landing #13 | 30°02.507 | 87°32.467 |
| 116 | Zeke's Landing #14 | 30°01.657 | 87°32.475 |
| 117 | Zeke's Landing #15 | 30°00.805 | 87°32.467 |
| 118 | Zeke's Landing #16 | 29°99.961 | 87°32.496 |
| 119 | Zeke's Landing #17 | 29°59.083 | 87°32.479 |
| 120 | Zeke's Landing #18 | 29°58.226 | 87°32.490 |
| 121 | Zeke's Landing #19 | 29°57.530 | 87°33.129 |
| 122 | Zeke's Landing #20 | 29°58.375 | 87°33.440 |
| 123 | Red's Reef | 30°00.452 | 87°33.450 |
| 124 | Anthony's Reef | 30°01.307 | 87°33.435 |
| 125 | Amanda Myers Reef | 30°02.591 | 87°33.806 |
| 126 | Leslie Myers Reef | 30°03.412 | 87°33.777 |
| 127 | Tchuopitoulas | 30°03.122 | 87°35.414 |
| 128 | St. Charles | 30°02.277 | 87°35.373 |
| 129 | Poydras | 30°01.616 | 87°36.005 |
| 130 | Carondolet | 30°00.784 | 87°36.204 |
| 131 | Gravier | 29°59.947 | 87°35.931 |
| 132 | J.D.'s Hole | 29°59.052 | 87°35.930 |
| 133 | Peet's Place | 29°58.227 | 87°35.921 |
| 134 | Paradise Lost | 29°57.343 | 87°35.946 |
| 135 | Paradise Found | 29°56.483 | 87°35.929 |
| 136 | Sabel Steel #3 | 29°55.645 | 87°35.956 |
| 137 | Sabel Steel #4 | 29°54.800 | 87°35.961 |
| 138 | CITGO Supergard #1 | 29°53.965 | 87°35.943 |
| 139 | CITGO Supergard #2 | 29°53.128 | 87°35.904 |
| 140 | CITGO Supergard #3 | 29°52.319 | 87°35.590 |
| 141 | CITGO Supergard #4 | 29°51.486 | 87°35.746 |
| 142 | CITGO Supergard #5 | 29°50.619 | 87°35716 |
| 143 | CITGO Supergard #6 | 29°49.802 | 87°35.780 |
| 144 | CITGO Supergard #7 | 29°49.093 | 87°35.737 |
| 145 | CITGO Supergard #8 | 29°49.172 | 87°36.759 |
| 146 | CITGO Supergard #9 | 29°49.887 | 87°37.894 |
| 147 | CITGO Supergard #10 | 29°50.760 | 87°37.904 |
| 148 | Top Gun Tackle #3 | 29°51.649 | 87°37.875 |
| 149 | Top Gun Tackle #4 | 29°52.582 | 87°37.868 |
| 150 | Kaiser Realty, Inc. #6 | 29°53.422 | 87°37.946 |
| 151 | Kaiser Realty, Inc. #7 | 29°54.268 | 87°38.007 |
| 152 | Perdido Beach Resort Reef | 29°55.113 | 87°38.049 |
| 153 | Gulf Beach Hotels Reef | 29°55.959 | 87°38.293 |
| 154 | The Champ & Chump reef | 29°56.757 | 87°38.034 |
| 155 | The Wickware's Reef | 29°57.627 | 87°37.891 |
| 156 | Orange Beach Auto & Marine #3 | 29°47.482 | 87°37.897 |
| 157 | Orange Beach Auto & Marine #4 | 29°59.363 | 87°37.912 |
| 158 | Boss Malouf | 30°00.101 | 87°38.420 |
| 159 | Bailey Malouf | 30°00.927 | 87°38.534 |
| 160 | Lester's- Houston Pierce | 30°01.820 | 87°38.211 |
| 161 | Lester's- Leslee Faith | 30°02.621 | 87°38.107 |
| 162 | Lester's- Uncle Bud | 30°02.542 | 87°39.256 |
| 163 | Lester's- Mrs Theresa | 30°02.422 | 87°40.206 |
| 164 | Lester's- Estelle M. | 30°02.876 | 87°41.002 |
| 165 | Tacky Jacks #3 | 30°02.788 | 87°41.993 |
| 166 | Tacky Jacks #4 | 30°02.707 | 87°42.940 |
| 167 | Fish Camp Restaurants #3 | 30°02.652 | 87°44.021 |
| 168 | Fish Camp Restaurants #4 | 30°02.565 | 87°45.036 |
| 169 | Voodoo | 30°01.686 | 87°45.007 |
| 170 | Black Gold Hole | 30°01.759 | 87°44.041 |
| 171 | Robbie | 30°01.837 | 87°43.064 |
| 172 | Kevin | 30°02.089 | 87°42.101 |
| 173 | Vision Bank #3 | 30°02.920 | 88°06.853 |
| 174 | Vision Bank #4 | 30°02.043 | 88°06.049 |
| 175 | Dizzy Bean | 30°00.153 | 88°06.814 |
| 176 | Lilly French | 29°58.698 | 88°06.842 |
| 177 | Visual Effects #2 | 29°57.807 | 88°06.836 |
| 178 | Vinyl Solutions #2 | 29°56.925 | 88°06.862 |
| 179 | Flora-Bama III | 29°56.074 | 88°06.816 |
| 180 | Flora-Bama IV | 29°55.230 | 88°06.823 |
| 181 | Big Jake's | 29°55.177 | 88°05.832 |
| 182 | Francos | 29°55.171 | 88°04.851 |
| 183 | X-treme Marine Reef | 29°55.177 | 88°03.860 |
| 184 | Don't Fish Here! | 29°55.141 | 88°02.870 |
| 185 | Radcliff Economy & Marine #2 | 29°54.389 | 88°02.379 |
| 186 | ValvTect #2 | 29°53.520 | 88°02.323 |
| 187 | The Beach Club #1 | 29°52.591 | 88°02.302 |
| 188 | The Beach Club #2 | 29°51.703 | 88°02.227 |
| 189 | Hunter's Reef | 29°50.877 | 88°02.162 |
| 190 | Hyperion Construction | 29°50.015 | 88°02.190 |
| 191 | Wadeley #1 | 29°49.143 | 88°02.130 |
| 192 | Jason's Reef 21 | 29°49.164 | 88°01.196 |
| 193 | First Gulf Bank- Linda Wheatley Reef | 29°49.154 | 87°59.207 |
| 194 | First Gulf Bank- Robert Seaborn Reef | 29°50.056 | 87°59.209 |
| 195 | Kelsey Mac's Reef | 29°50.904 | 87°59.284 |
| 196 | Kaitlin B's Reef | 29°51.790 | 87°59.340 |
| 197 | In Memory of Jeff Cooper | 29°52.640 | 87°59.369 |
| 198 | We'll See | 29°53.482 | 87°59.428 |
| 199 | Jim Brown #2 | 29°54.332 | 87°59.719 |
| 200 | Jim Brown #3 | 29°55.670 | 88°00.364 |
| 201 | Outcast Marina #3 | 29°55.870 | 88°01.306 |
| 202 | Mathew's Reef | 29°55.692 | 88°02.315 |
| 203 | The Reef Maker #3 | 29°55.911 | 88°03.247 |
| 204 | Brandy Rhodes | 29°55.919 | 88°04.219 |
| 205 | Cody Rhodes | 29°55.915 | 88°05.238 |
| 206 | Bear Point Marina Reef | 29°56.641 | 88°04.368 |
| 207 | Sandy Wade Reef #2 | 29°56.787 | 88°05.260 |
| 208 | City of Gulf Shores #1 | 29°57.483 | 88°05.290 |
| 209 | City of Gulf Shores #2 | 29°57.709 | 88°04.449 |
| 210 | City of Gulf Shores #3 | 29°57.670 | 88°03.545 |
| 211 | City of Gulf Shores #4 | 29°58.955 | 88°05.258 |
| 212 | City of Gulf Shores #5 | 29°59.760 | 88°05.639 |
| 213 | City of Gulf Shores #6 | 29°59.950 | 88°04.260 |
| 214 | City of Gulf Shores #7 | 30°00.846 | 88°04.208 |
| 215 | City of Gulf Shores #8 | 30°00.606 | 88°05.732 |
| 216 | City of Gulf Shores #9 | 30°01.448 | 88°05.709 |
| 217 | City of Gulf Shores #10 | 30°02.127 | 88°05.110 |
| 218 | Caribe #3 | 30°01.605 | 88°04.359 |
| 219 | Caribe #4 | 30°03.098 | 87°36.081 |
| 220 | David Askew Jr. | 30°03.058 | 87°36.168 |
| 221 | Earlene Askew | 30°03.085 | 87°36.289 |
| 222 | Baldwin County EMC Reef #6 | 30°03.074 | 87°36.421 |
| 223 | Baldwin County EMC Reef #7 | 30°03.060 | 87°37.257 |
| 224 | Charlene Farve Reef | 30°03056 | 87°37.337 |
| 225 | Shelley Farve Reef | 30°03051 | 87°37.543 |
| 226 | Sportsman's Marine in Fairhope #1 | 30°02952 | 87°38.551 |
| 227 | Sportsman's Marine in Fairhope #2 | 30°02.981 | 87°38.617 |
| 228 | RE/MAX #1 | 30°02.971 | 87°38.697 |
| 229 | RE/MAX #2 | 30°02.972 | 87°38.783 |
| 230 | RE/MAX #3 | 30°02.938 | 87°38.932 |
| 231 | RE/MAX #4 | 30°02.953 | 87°39.470 |
| 232 | RE/MAX #5 | 30°02.938 | 87°39.527 |
| 233 | Blue Water Scott | 30°02.941 | 87°39.932 |
| 234 | Blue Water Chris | 30°02.958 | 87°40.050 |

# RSWC* ARTIFICIAL REEF MODULES - 2007 - 08 DEPLOYMENT






GULF OF MEXICO



RSWC* (Red Snapper World Championship)
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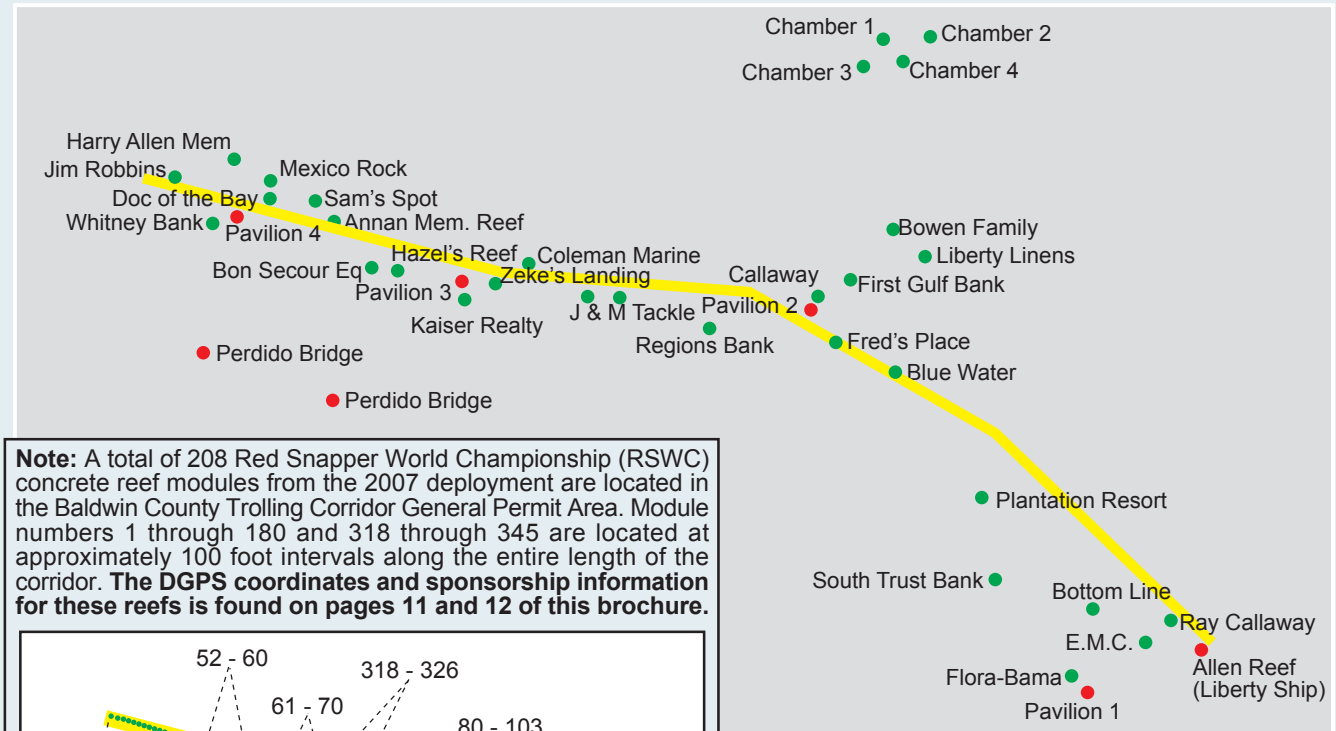
# RSWC 2007 REEF MODULES - GPS COORDINATES

| Reef # | Sponsor Name | Lat. | Long |
|---|---|---|---|
| 1 | AFTCO #1 | 30°08.866 | 87°34.175 |
| 2 | AFTCO #2 | 30°08.867 | 87°34.182 |
| 3 | AFTCO #3 | 30°08.876 | 87°34.222 |
| 4 | AFTCO #4 | 30°08.878 | 87°34.226 |
| 5 | Baldwin EMC #8 | 30°08.893 | 87°34.314 |
| 6 | Baldwin EMC #9 | 30°08.892 | 87°34.304 |
| 7 | Baldwin EMC #10 | 30°08.890 | 87°34.289 |
| 8 | Baldwin EMC #11 | 30°08.888 | 87°34.270 |
| 9 | Baldwin EMC #12 | 30°08.884 | 87°34.253 |
| 10 | Baldwin EMC #13 | 30°08.880 | 87°34.239 |
| 11 | Bender Shipyards #1 | 30°08.876 | 87°34.221 |
| 12 | Bender Shipyards #2 | 30°08.874 | 87°34.209 |
| 13 | Bender Shipyards #3 | 30°08.872 | 87°34.189 |
| 14 | Bender Shipyards #4 | 30°08.862 | 87°34.152 |
| 15 | Doc's Seafood Shack | 30°08.859 | 87°34.136 |
| 16 | Bubba's | 30°08.855 | 87°34.124 |
| 17 | Jake's Steakhouse | 30°08.850 | 87°34.107 |
| 18 | Franco's Italian | 30°08.847 | 87°34.082 |
| 19 | Blue Water John #1 | 30°08.842 | 87°34.059 |
| 20 | Blue Water John #2 | 30°08.837 | 87°34.039 |
| 21 | Brett/Robinson #41 | 30°08.832 | 87°34.021 |
| 22 | Brett/Robinson #42 | 30°08.829 | 87°33.998 |
| 23 | Brett/Robinson #43 | 30°08.817 | 87°33.953 |
| 24 | Brett/Robinson #44 | 30°08.808 | 87°33.921 |
| 25 | Brett/Robinson #45 | 30°08.805 | 87°33.909 |
| 26 | Brett/Robinson #46 | 30°08.802 | 87°33.899 |
| 27 | BBD-Dave | 30°08.796 | 87°33.866 |
| 28 | BBD-Marvin | 30°08.788 | 87°33.842 |
| 29 | BBD-Joe | 30°08.785 | 87°33.830 |
| 30 | BBD-Marlin | 30°08.769 | 87°33.776 |
| 31 | BBD-Phil | 30°08.763 | 87°33.758 |
| 32 | BBD-Tony | 30°08.761 | 87°33.749 |
| 33 | BBD-Warren | 30°08.759 | 87°33.743 |
| 34 | BBD-Herbert | 30°08.750 | 87°33.707 |
| 35 | Caribe #5 | 30°08.749 | 87°33.690 |
| 36 | Caribe #6 | 30°08.747 | 87°33.681 |
| 37 | Caribe #7 | 30°08.743 | 87°33.657 |
| 38 | Caribe #8 | 30°08.747 | 87°33.659 |
| 39 | Center Coal Co. #1 | 30°08.757 | 87°33.640 |
| 40 | Center Coal Co. #2 | 30°08.757 | 87°33.629 |
| 41 | Ala. Gulf Coast Chamber of Comm. #3 | 30°08.736 | 87°33.430 |
| 42 | Ala. Gulf Coast Chamber of Comm. #4 | 30°08.735 | 87°33.441 |
| 43 | Ala. Gulf Coast Chamber of Comm. #5 | 30°08.736 | 87°33.443 |
| 44 | Ala. Gulf Coast Chamber of Comm. #6 | 30°08.737 | 87°33.453 |
| 45 | Leslie Myers | 30°08.738 | 87°33.457 |
| 46 | Amanda Myers | 30°08.739 | 87°33.466 |
| 47 | Christian Life Church #1 | 30°08.739 | 87°33.474 |
| 48 | Christian Life Church #2 | 30°08.740 | 87°33.478 |
| 49 | Christian Life Church #3 | 30°08.741 | 87°33.485 |
| 50 | Christian Life Church #4 | 30°08.744 | 87°33.508 |
| 51 | City of Gulf Shores Johnnie Sims Reef | 30°08.747 | 87°33.533 |
| 52 | City of Gulf Shores Claude O'Connor Reef | 30°08.757 | 87°33.614 |
| 53 | City of Gulf Shores Clarence Horton Reef | 30°08.757 | 87°33.607 |
| 54 | City of Gulf Shores Eugene Ingram Reef | 30°08.753 | 87°33.607 |
| 55 | City of Gulf Shores Mixon Jones Reef | 30°08.750 | 87°33.589 |
| 56 | City of Gulf Shores Thom. Norton, M.D. Reef | 30°08.749 | 87°33.579 |
| 57 | City of Gulf Shores David Bodenhamer Reef | 30°08.749 | 87°33.570 |
| 58 | City of Gulf Shores G.W. "Billy" Duke Reef | 30°08.747 | 87°33.559 |
| 59 | City of Orange Beach | 30°08.748 | 87°33.552 |
| 60 | City of Orange Beach | 30°08.749 | 87°33.540 |
| 61 | City of Orange Beach | 30°08.738 | 87°33.430 |
| 62 | City of Orange Beach | 30°08.737 | 87°33.421 |
| 63 | City of Orange Beach | 30°08.735 | 87°33.415 |
| 64 | City of Orange Beach | 30°08.730 | 87°33.400 |
| 65 | City of Orange Beach | 30°08.733 | 87°33.389 |
| 66 | City of Orange Beach | 30°08.733 | 87°33.377 |
| 67 | City of Orange Beach | 30°08.730 | 87°33.372 |
| 68 | City of Orange Beach | 30°08.724 | 87°33.371 |
| 69 | City of Orange Beach | 30°08.719 | 87°33.355 |
| 70 | City of Orange Beach | 30°08.731 | 87°33.341 |
| 71 | City of Orange Beach | 30°08.718 | 87°33.316 |
| 72 | City of Orange Beach | 30°08.720 | 87°33.298 |
| 73 | City of Orange Beach | 30°08.716 | 87°33.287 |
| 74 | City of Orange Beach | 30°08.717 | 87°33.271 |
| 75 | City of Orange Beach | 30°08.722 | 87°33.259 |
| 76 | City of Orange Beach | 30°08.717 | 87°33.240 |
| 77 | CVB Reef #31 | 30°08.721 | 87°33.220 |
| 78 | CVB Reef #32 | 30°08.716 | 87°33.203 |
| 79 | CVB Reef #33 | 30°08.720 | 87°33.184 |
| 80 | CVB Reef #34 | 30°08.721 | 87°33.172 |
| 81 | CVB Reef #35 | 30°08.716 | 87°33.152 |
| 82 | CVB Reef #36 | 30°08.718 | 87°33.144 |
| 83 | CVB Reef #37 | 30°08.718 | 87°33.136 |
| 84 | CVB Reef #38 | 30°08.717 | 87°33.127 |
| 85 | CVB Reef #39 | 30°08.717 | 87°33.115 |
| 86 | CVB Reef #40 | 30°08.715 | 87°33.101 |
| 87 | CVB Reef #41 | 30°08.714 | 87°33.073 |
| 88 | CVB Reef #42 | 30°08.715 | 87°33.065 |
| 89 | CVB Reef #43 | 30°08.715 | 87°33.051 |
| 90 | CVB Reef #44 | 30°08.714 | 87°33.042 |
| 91 | CVB Reef #45 | 30°08.707 | 87°33.016 |
| 92 | CVB Reef #46 | 30°08.717 | 87°33.000 |
| 93 | CVB Reef #47 | 30°08.714 | 87°32.981 |
| 94 | CVB Reef #48 | 30°08.711 | 87°32.958 |
| 95 | CVB Reef #49 | 30°08.710 | 87°32.936 |
| 96 | CVB Reef #50 | 30°08.708 | 87°32.920 |
| 97 | CVB Reef #51 | 30°08.709 | 87°32.905 |
| 98 | CVB Reef #52 | 30°08.708 | 87°32.891 |
| 99 | CVB Reef #53 | 30°08.707 | 87°32.880 |
| 100 | CVB Reef #54 | 30°08.707 | 87°32.866 |
| 101 | CVB Reef #55 | 30°08.706 | 87°32.858 |
| 102 | CVB Reef #56 | 30°08.708 | 87°32.847 |
| 103 | CVB Reef #57 | 30°08.710 | 87°32.840 |
| 104 | CVB Reef #58 | 30°08.702 | 87°32.821 |
| 105 | CVB Reef #59 | 30°08.698 | 87°32.812 |
| 106 | CVB Reef #60 | 30°08.699 | 87°32.815 |
| 107 | DI Mary | 30°08.690 | 87°32.802 |
| 108 | DI Katherine | 30°08.683 | 87°32.793 |
| 109 | DI Trip | 30°08.675 | 87°32.784 |
| 110 | DI Alison | 30°08.668 | 87°32.777 |
| 111 | DI Anna | 30°08.660 | 87°32.769 |
| 112 | DI Allison | 30°08.648 | 87°32.755 |
| 113 | DI Richard | 30°08.627 | 87°32.734 |
| 114 | DI Lyndsay | 30°08.615 | 87°32.721 |
| 115 | Edgewater | 30°08.606 | 87°32.710 |
| 116 | Zarina Bella | 30°08.601 | 87°32.703 |
| 117 | Fish Camp Restaurant #5 | 30°08.597 | 87°32.696 |
| 118 | Fish Camp Restaurant #6 | 30°08.581 | 87°32.684 |
| 119 | Foley Beach Express #5 | 30°08.570 | 87°32.672 |
| 120 | Foley Beach Express #6 | 30°08.559 | 87°32.666 |
| 121 | Foley Beach Express #7 | 30°08.545 | 87°32.639 |
| 122 | Foley Beach Express #8 | 30°08.536 | 87°32.632 |
| 123 | Xtreme Marine #2 | 30°08.526 | 87°32.619 |
| 124 | Xtreme Marine #3 | 30°08.517 | 87°32.610 |
| 125 | Xtreme Marine #4 | 30°08.507 | 87°32.599 |
| 126 | Xtreme Marine #5 | 30°08.497 | 87°32.587 |
| 127 | Galati Yacht Sales #1 | 30°08.486 | 87°32.576 |
| 128 | Galati Yacht Sales #2 | 30°08.477 | 87°32.564 |
| 129 | Galati Yacht Sales #3 | 30°08.469 | 87°32.555 |
| 130 | Jason Collings Reef | 30°08.462 | 87°32.547 |
| 131 | Gary Finch Outdoors #1 | 30°08.456 | 87°32.541 |
| 132 | Gary Finch Outdoors #2 | 30°08.451 | 87°32.534 |
| 133 | Katelyn Finch | 30°08.447 | 87°32.529 |
| 134 | Christopher Finch | 30°08.439 | 87°32.521 |
| 135 | Laura Layton | 30°08.432 | 87°32.513 |
| 136 | Emily Layton | 30°08.425 | 87°32.505 |
| 137 | Geno's Reef | 30°08.417 | 87°32.496 |
| 138 | William Wyatt Reef | 30°08.407 | 87°32.485 |
| 139 | George's Water Sports #1 | 30°08.399 | 87°32.476 |
| 140 | George's Water Sports #2 | 30°08.392 | 87°32.469 |
| 141 | Glass Inc. #1 | 30°08.382 | 87°32.459 |
| 142 | Glass Inc. #2 | 30°08.370 | 87°32.442 |
| 143 | Gulf Shores Yacht Club & Marine #1 | 30°08.360 | 87°32.430 |
| 144 | Gulf Shores Yacht Club & Marine #2 | 30°08.346 | 87°32.415 |
| 145 | Gulf Shores Yacht Club & Marine #3 | 30°08.336 | 87°32.402 |
| 146 | Gulf Shores Yacht Club & Marine #4 | 30°08.323 | 87°32.390 |
| 147 | Gulf States Ready Mix #1 | 30°08.316 | 87°32.381 |
| 148 | Gulf States Ready Mix #2 | 30°08.307 | 87°32.369 |
| 149 | Guy Harvey #1 | 30°08.300 | 87°32.362 |
| 150 | Guy Harvey #2 | 30°08.294 | 87°32.355 |
| 151 | Guy Harvey #3 | 30°08.290 | 87°32.349 |
| 152 | Guy Harvey #4 | 30°08.283 | 87°32.341 |
| 153 | Hi-Liner | 30°08.278 | 87°32.336 |
| 154 | Edward R. Gaw | 30°08.272 | 87°32.332 |
| 155 | Tim Gaw | 30°08.265 | 87°32.325 |
| 156 | Brooke Lamping | 30°08.254 | 87°32.312 |
| 157 | International Assurance #1 | 30°08.241 | 87°32.296 |
| 158 | International Assurance #2 | 30°08.225 | 87°32.282 |
| 159 | International Assurance #3 | 30°08.212 | 87°32.275 |
| 160 | International Assurance #4 | 30°08.205 | 87°32.274 |
| 161 | Island House Hotel #1 | 30°08.215 | 87°32.266 |
| 162 | Island House Hotel #2 | 30°08.207 | 87°32.257 |
| 163 | Island House Hotel #3 | 30°08.201 | 87°32.250 |
| 164 | Island House Hotel #4 | 30°08.195 | 87°32.242 |
| 165 | Carol Mahlstedt | 30°08.185 | 87°32.232 |
| 166 | C.J.'s Reef | 30°08.175 | 87°32.222 |
| 167 | Island Wide Marine Reef #2 | 30°08.165 | 87°32.211 |
| 168 | Island Wide Marine Reef #3 | 30°08.152 | 87°32.197 |
| 169 | Isle of Capri #1 | 30°08.140 | 87°32.183 |
| 170 | Isle of Capri #2 | 30°08.130 | 87°32.172 |
| 171 | Isle of Capri #3 | 30°08.122 | 87°32.163 |
| 172 | Isle of Capri #4 | 30°08.112 | 87°32.153 |
| 173 | J&M Tackle #11 | 30°08.102 | 87°32.142 |
| 174 | J&M Tackle #12 | 30°08.091 | 87°32.129 |
| 175 | J&M Tackle #13 | 30°08.081 | 87°32.117 |
| 176 | J&M Tackle #14 | 30°08.072 | 87°32.107 |
| 177 | J&M Tackle #15 | 30°08.060 | 87°32.098 |
| 178 | J&M Tackle #16 | 30°08.051 | 87°32.086 |
| 179 | J&M Tackle #17 | 30°08.042 | 87°32.079 |
| 180 | J&M Tackle #18 | 30°08.031 | 87°32.076 |
| 181 | J&M Tackle #19 | 30°02.497 | 87°45.608 |
| 182 | J&M Tackle #20 | 30°01.725 | 87°45.624 |
| 183 | JetCenter South | 30°01.032 | 87°45.596 |
| 184 | Phil Martin | 29°58.890 | 87°45.596 |
| 185 | Bob | 29°58.124 | 87°45.577 |
| 186 | Copy That | 29°59.274 | 87°46.557 |
| 187 | Jim Brown #4 | 30°00.443 | 87°46.314 |
| 188 | Jim Brown #5 | 30°01.010 | 87°46.389 |
| 189 | Joe Raley Builders #1 | 30°01.732 | 87°46.461 |
| 190 | Joe Raley Builders #2 | 30°02.350 | 87°47.386 |
| 191 | Kaiser Realty #8 | 30°01.729 | 87°47.335 |
| 192 | Kaiser Realty #9 | 30°01.005 | 87°47.384 |
| 193 | Kaiser Realty #10 | 30°00.366 | 87°47.320 |
| 194 | Kaiser Realty #11 | 29°59.842 | 87°47.781 |
| 195 | Kaiser Realty #12 | 30°00.430 | 87°48.259 |
| 196 | Kaiser Realty #13 | 30°01.008 | 87°48.255 |
| 197 | Lamar #1 | 30°01.710 | 87°48.206 |
| 198 | Lamar #2 | 30°02.270 | 87°48.212 |
| 199 | Lamar #3 | 30°02.224 | 87°48.967 |
| 200 | Lamar #4 | 30°01.662 | 87°48.988 |
| 201 | Micah Cassaday #1 | 29°59.795 | 87°48.750 |
| 202 | Micah Cassaday #2 | 30°00.664 | 87°50.126 |
| 203 | Millicent Cassaday #1 | 30°01.458 | 87°50.170 |
| 204 | Millicent Cassaday #2 | 30°02.167 | 87°50.250 |
| 205 | Live Bait | 30°02.072 | 87°51.636 |
| 206 | Live Bait II | 30°01.377 | 87°51.301 |
| 207 | Live Bait at The Wharf | 30°00.439 | 87°50.854 |
| 208 | Live Bait Catering | 29°59.626 | 87°50.245 |
| 209 | Flora-Bama V | 29°58.682 | 87°49.559 |
| 210 | Homeport Marina #11 | 29°58.785 | 87°48.312 |
| 211 | Homeport Marina #12 | 29°58.781 | 87°47.602 |
| 212 | Flora-Bama VI | 29°57.890 | 87°47.566 |
| 213 | Danatana Reef | 29°56.839 | 87°47.527 |
| 214 | Sam Solomon Memorial Reef | 29°55.664 | 87°47.321 |
| 215 | McCarron Insurance Group #2 | 29°55.897 | 87°56.453 |
| 216 | Malouf #2 | 29°58.216 | 87°57.565 |
| 217 | Malouf #1 | 29°59.098 | 87°57.857 |
| 218 | Flora-Bama VII | 29°59.854 | 87°58.228 |
| 219 | Flora-Bama VIII | 30°00.650 | 87°58.693 |
| 220 | Legendary Marine #1 | 30°01.484 | 87°59.107 |
| 221 | Legendary Marine #2 | 30°02.399 | 87°59.606 |
| 222 | Legendary Marine #3 | 30°02.438 | 88°00.718 |
| 223 | Legendary Marine #4 | 30°01.567 | 88°00.581 |
| 224 | Legendary Marine #5 | 29°58.720 | 87°59.204 |
| 225 | Legendary Marine #6 | 29°57.758 | 87°59.285 |
| 226 | Century Boats #1 | 29°57.030 | 87°59.012 |
| 227 | Century Boats #2 | 29°56.167 | 87°57.962 |
| 228 | Century Boats #3 | 29°56.158 | 88°00.062 |
| 229 | Century Boats #4 | 29°56.185 | 88°00.944 |
| 230 | Century Boats #5 | 29°56.970 | 88°00.980 |
| 231 | Century Boats #6 | 29°57.659 | 88°01.149 |
| 232 | Lester's Restaurant #1 | 29°58.462 | 88°01.183 |
| 233 | Lester's Restaurant #2 | 29°59.193 | 88°02.266 |
| 234 | Lester's Restaurant #3 | 29°59.800 | 88°02.713 |

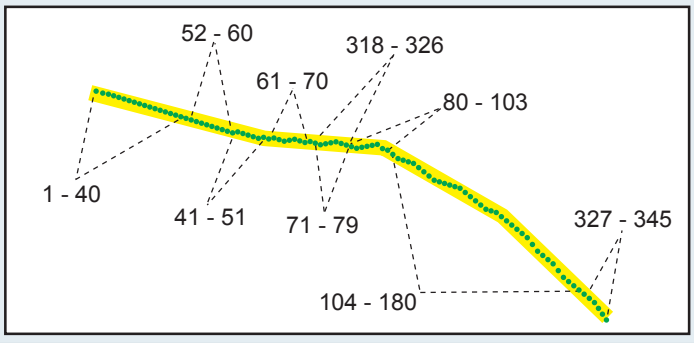
# RSWC 2007 REEF MODULES - GPS COORDINATES...cont.

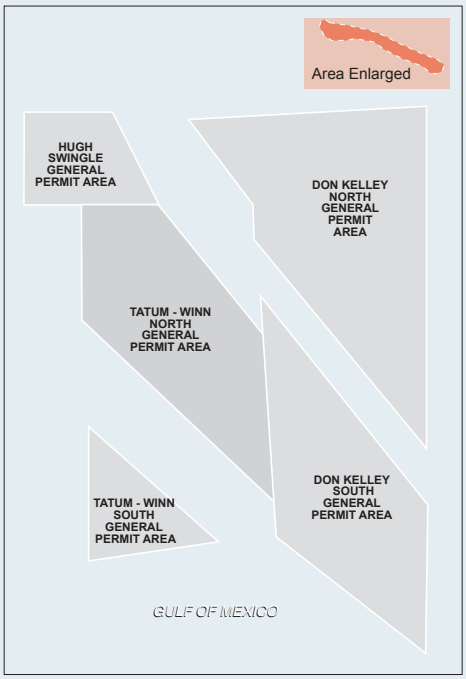
| Reef # | Sponsor Name | Lat. | Long |
|---|---|---|---|
| 235 | Lester's Restaurant #4 | 30°00.820 | 88°02.667 |
| 236 | Lester's Restaurant #5 | 30°01.688 | 88°02.755 |
| 237 | Lester's Restaurant #6 | 29°48.626 | 87°36.377 |
| 238 | Wind Deductible | 29°47.628 | 87°36.428 |
| 239 | Policy Exclusions | 29°46.736 | 87°36.426 |
| 240 | Mediation | 29°45.824 | 87°36.426 |
| 241 | Meyer Real Estate #1 | 29°44.879 | 87°36.428 |
| 242 | Meyer Real Estate #2 | 29°43.896 | 87°36.471 |
| 243 | Meyer Real Estate #3 | 29°42.937 | 87°36.531 |
| 244 | Meyer Real Estate #4 | 29°42.043 | 87°36.524 |
| 245 | Dr. Robert H. Mudd | 29°41.093 | 87°36.570 |
| 246 | Gere Austill, Sr. | 29°40.210 | 87°36.670 |
| 247 | Mo Fishin Bait & Tackle 1 | 29°40.934 | 87°37.268 |
| 248 | Slim | 29°41.932 | 87°37.414 |
| 249 | Moyer Ford #1 | 29°42.900 | 87°37.736 |
| 250 | Moyer Ford #2 | 29°44.701 | 87°37.716 |
| 251 | Rachel Moyer | 29°46.788 | 87°37.744 |
| 252 | Devin Moyer | 29°45.153 | 87°38.840 |
| 253 | Rone Negus | 29°44.338 | 87°38.872 |
| 254 | Coonie Negus | 29°43.515 | 87°38.828 |
| 255 | Ocean Waves Sunglasses #1 | 29°42.697 | 87°38.886 |
| 256 | Ocean Waves Sunglasses #2 | 29°33.864 | 87°36.284 |
| 257 | Ocean Waves Sunglasses #3 | 29°33.160 | 87°35.742 |
| 258 | Ocean Waves Sunglasses #4 | 29°32.475 | 87°35.245 |
| 259 | Orange Beach Auto & Marine #5 | 29°31.775 | 87°34.626 |
| 260 | Orange Beach Auto & Marine #6 | 29°31.051 | 87°34.140 |
| 261 | M. Radcliff, Sr. | 29°30.263 | 87°33.667 |
| 262 | N.Q. Adams | 29°29.524 | 87°33.146 |
| 263 | Capt. Jim Cox | 29°28.869 | 87°33.816 |
| 264 | Palmer Bedsole | 29°29.598 | 87°34.305 |
| 265 | Mickey Fogle | 29°30.284 | 87°34.750 |
| 266 | Lynn Siler | 29°31.059 | 87°35.263 |
| 267 | Pete Frost | 29°31.818 | 87°35.774 |
| 268 | Brenda Bryant | 29°32.548 | 87°36.197 |
| 269 | Jack Cooper | 29°33.268 | 87°36.614 |
| 270 | Prudential Cooper | 29°33.953 | 87°37.265 |
| 271 | Outcast Marina Charter Dock ('07) | 29°33.915 | 87°38.125 |
| 272 | Capt. Sonny Trimble Reef #2 | 29°33.230 | 87°37.976 |
| 273 | Cindy's Fishing Hole (We'll See) | 29°32.435 | 87°37.724 |
| 274 | Outcast Marina #4 | 29°32.152 | 87°36.893 |
| 275 | Penn Reels #1 | 29°31.359 | 87°36.665 |
| 276 | Penn Reels #2 | 29°30.588 | 87°36.196 |
| 277 | Penn Reels #3 | 29°29.874 | 87°35.769 |
| 278 | Penn Reels #4 | 29°29.072 | 87°35.423 |
| 279 | Penn Reels #5 | 29°28.419 | 87°36.046 |
| 280 | Penn Reels #6 | 29°29.211 | 87°36.445 |
| 281 | PBR/Voyagers | 29°29.953 | 87°36.786 |
| 282 | PBR/David Jackson | 29°30.774 | 87°37.293 |
| 283 | PBR/John Moloney | 29°31.607 | 87°37.702 |
| 284 | PBR/Greg Perryman | 29°32.042 | 87°38.465 |
| 285 | Tracey Thompson #1 | 29°32.857 | 87°38.833 |
| 286 | Tracey Thompson #2 | 29°33.796 | 87°39.090 |
| 287 | Capt. Carl Raffield Reef #1 | 29°34.018 | 87°40.245 |
| 288 | Capt. Carl Raffield Reef #2 | 29°33.344 | 87°40.284 |
| 289 | Capt. Gene Raffield Reef #1 | 29°32.758 | 87°39.791 |
| 290 | Capt. Gene Raffield Reef #2 | 29°32.099 | 87°39.394 |
| 291 | Randal & Colby Simmons #1 | 29°31.447 | 87°38.798 |
| 292 | Randal & Colby Simmons #2 | 29°30.829 | 87°38.397 |
| 293 | RE/MAX of Foley #1 | 29°29.970 | 87°38.017 |
| 294 | RE/MAX of Foley #2 | 29°29.216 | 87°37.575 |
| 295 | RE/MAX of Gulf Shores #6 | 29°28.431 | 87°37.058 |
| 296 | RE/MAX of Gulf Shores #7 | 29°28.010 | 87°38.012 |
| 297 | RE/MAX of Orange Beach #1 | 29°28.880 | 87°38.389 |
| 298 | RE/MAX of Orange Beach #2 | 29°29.730 | 87°38.999 |
| 299 | RE/MAX of Orange Beach #3 | 29°30.537 | 87°39.358 |
| 300 | RE/MAX of Orange Beach #4 | 29°31.304 | 87°39.816 |
| 301 | Reel Surprise Charters #1 | 29°32.016 | 87°40.309 |
| 302 | Reel Surprise Charters #2 | 29°32.681 | 87°40.874 |
| 303 | Reel Yacht Sales & Service #1 | 29°33.293 | 87°41.497 |
| 304 | Reel yacht Sales & Service #2 | 29°34.057 | 87°41.469 |
| 305 | Romar Marina #1 | 29°33.971 | 87°42.501 |
| 306 | Romar Marina #2 | 29°34.017 | 87°59.975 |
| 307 | Specchio Reef | 29°33.359 | 87°59.362 |
| 308 | Skippy Reef | 29°32.551 | 87°58.698 |
| 309 | Sam's Spot #8 | 29°31.881 | 87°57.932 |
| 310 | Sam's Spot #9 | 29°31.175 | 87°57.244 |
| 311 | Sam's Spot #10 | 29°30.476 | 87°56.461 |
| 312 | Sam's Spot #11 | 29°29.790 | 87°55.772 |
| 313 | Sam's Spot #12 | 29°29.107 | 87°55.080 |
| 314 | Sam's Spot #13 | 29°28.611 | 87°54.315 |
| 315 | Sam's Spot #14 | 29°27.978 | 87°53.549 |
| 316 | Sam's Spot #15 | 29°27.404 | 87°52.834 |
| 317 | SanRoc Cay Marina | 29°26.760 | 87°52.164 |
| 318 | Bear Point Marina Reef #2 | 30°08.732 | 87°33.340 |
| 319 | Sandy Wade Reef #3 | 30°08.731 | 87°33.324 |
| 320 | Carolyn Wade | 30°08.730 | 87°33.312 |
| 321 | Saunders Yachtworks #1 | 30°08.729 | 87°33.309 |
| 322 | Saunders Yachtworks #2 | 30°08.729 | 87°33.306 |
| 323 | Saunders Yachtworks #3 | 30°08.723 | 87°33.266 |
| 324 | Saunders Yachtworks #4 | 30°08.720 | 87°33.230 |
| 325 | The Shrimp Basket | 30°08.722 | 87°33.220 |
| 326 | Mikee's Seafood Restaurant | 30°08.717 | 87°33.202 |
| 327 | Spence Reef | 30°07.930 | 87°31.932 |
| 328 | Cahoon Reef | 30°08.016 | 87°32.048 |
| 329 | S. Baldwin Reg. Med. Center #1 | 30°08.011 | 87°32.043 |
| 330 | S. Baldwin Reg. Med. Center #2 | 30°08.003 | 87°32.027 |
| 331 | Lauren S Reef | 30°08.003 | 87°32.027 |
| 332 | Aulbree H Reef | 30°07.997 | 87°32.021 |
| 333 | Victoria A Reef | 30°07.985 | 87°32.009 |
| 334 | Samantha M Reef | 30°07.977 | 87°31.999 |
| 335 | Sportsman's Marine in Fairhope #3 | 30°07.970 | 87°31.992 |
| 336 | Sportsman's Marine in Fairhope #4 | 30°07.962 | 87°31.985 |
| 337 | Sportsman's Marine in Fairhope #5 | 30°07.953 | 87°31.972 |
| 338 | Sportsman's Marine in Fairhope #6 | 30°07.951 | 87°31.968 |
| 339 | "Sunny" 105.7-FM #1 | 30°07.947 | 87°31.958 |
| 340 | "Sunny" 105.7-FM #2 | 30°07.941 | 87°31.950 |
| 341 | "Sunny" 105.7-FM #3 | 30°07.906 | 87°31.921 |
| 342 | Kathryn & Lee Hagan | 30°07.902 | 87°31.923 |
| 343 | Tacky Jack's Bushwacker | 30°07.881 | 87°31.939 |
| 344 | Tacky Jack's Farmers Omelet | 30°07.863 | 87°31.952 |
| 345 | Tacky Jack's Mexican Garbage | 30°07.849 | 87°31.947 |
| 346 | Tacky Jack's Bloody Mary | 29°48.058 | 87°51.029 |
| 347 | Reefmaker - Miles | 29°47.250 | 87°51.009 |
| 348 | Reefmaker - Liam | 29°46.389 | 87°51.046 |
| 349 | Reefmaker - DeDe | 29°45.084 | 87°51.082 |
| 350 | Reefmaker - Turgeau | 29°44.663 | 87°51.151 |
| 351 | The Rod Room # 5 | 29°44.064 | 87°50.733 |
| 352 | The Rod Room # 6 | 29°43.168 | 87°51.332 |
| 353 | The Rod Room # 7 | 29°42.518 | 87°51.264 |
| 354 | The Rod Room # 8 | 29°41.731 | 87°51.587 |
| 355 | Top Gun Tackle #5 | 29°41.080 | 87°51.326 |
| 356 | Top Gun Tackle #6 | 29°40.247 | 87°51.361 |
| 357 | Tracey Thompson #3 | 29°39.539 | 87°51.234 |
| 358 | Tracey Thompson #4 | 29°38.683 | 87°51.478 |
| 359 | Turquoise Place #1 | 29°37.896 | 87°51.815 |
| 360 | Turquoise Place #2 | 29°37.220 | 87°51.486 |
| 361 | Turquoise Place #3 | 29°36.914 | 87°52.171 |
| 362 | Turquoise Place #4 | 29°37.457 | 87°52.744 |
| 363 | Reynolds Ready Mix - Walter Pope 4 | 29°38.286 | 87°52.986 |
| 364 | Reynolds Ready Mix - Walter Pope 5 | 29°38.388 | 87°53.539 |
| 365 | Reynolds Ready Mix - Walter Pope 6 | 29°39.245 | 87°53.484 |
| 366 | Reynolds Ready Mix - Walter Pope 7 | 29°40.077 | 87°53.439 |
| 367 | Reynolds Ready Mix - Harold Butts 4 | 29°40.908 | 87°53.438 |
| 368 | Reynolds Ready Mix - Harold Butts 5 | 29°42.310 | 87°53.123 |
| 369 | Reynolds Ready Mix - Harold Butts 6 | 29°43.063 | 87°53.052 |
| 370 | Reynolds Ready Mix - Harold Butts 7 | 29°43.850 | 87°53.302 |
| 371 | Vision Bank #5 | 29°44.685 | 87°53.298 |
| 372 | Vision Bank #6 | 29°45.527 | 87°52.984 |
| 373 | Vision Bank #7 | 29°46.396 | 87°52.933 |
| 374 | Vision Bank #8 | 29°47.290 | 87°52.889 |
| 375 | Water Ways Boat Sales | 29°48.141 | 87°52.882 |
| 376 | Down Under Dive Shop | 29°48.754 | 87°54.456 |
| 377 | West Marine #1 | 29°47.977 | 87°54.488 |
| 378 | West Marine #2 | 29°47.254 | 87°54.191 |
| 379 | Whitney Bank #1 | 29°46.530 | 87°54.509 |
| 380 | Whitney Bank #2 | 29°45.670 | 87°54.479 |
| 381 | Whitney Bank #3 | 29°44.791 | 87°54.536 |
| 382 | Whitney Bank #4 | 29°43.910 | 87°54.584 |
| 383 | Whitney Bank #5 | 29°42.275 | 87°54.611 |
| 384 | Whitney Bank #6 | 29°41.450 | 87°54.612 |
| 385 | Whitney Bank #7 | 29°40.601 | 87°54.636 |
| 386 | Whitney Bank #8 | 29°26.372 | 87°51.476 |
| 387 | Wadeley 100 | 29°25.782 | 87°50.913 |
| 388 | Wadeley 200 | 29°25.480 | 87°51.810 |
| 389 | Zac's Reef | 29°26.058 | 87°52.445 |
| 390 | Mary's Reef | 29°26.633 | 87°53.096 |
| 391 | Zeke's Charter Fleet #1 | 29°27.209 | 87°53.810 |
| 392 | Zeke's Charter Fleet #2 | 29°27.774 | 87°54.604 |
| 393 | Zeke's Charter Fleet #3 | 29°28.388 | 87°55.276 |
| 394 | Zeke's Charter Fleet #4 | 29°28.977 | 87°55.963 |
| 395 | Zeke's Charter Fleet #5 | 29°29.286 | 87°56.822 |
| 396 | Zeke's Charter Fleet #6 | 29°29.976 | 87°56.945 |
| 397 | Zeke's Charter Fleet #7 | 29°30.375 | 87°57.779 |
| 398 | Zeke's Charter Fleet #8 | 29°31.047 | 87°58.344 |
| 399 | Zeke's Charter Fleet #9 | 29°31.706 | 87°58.874 |
| 400 | Zeke's Charter Fleet #10 | 29°32.269 | 87°59.320 |
| 401 | Zeke's Charter Fleet #11 | 29°33.057 | 88°00.014 |
| 402 | Zeke's Charter Fleet #12 | 29°33.746 | 88°00.500 |
| 403 | Zeke's Charter Fleet #13 | 29°32.089 | 88°00.212 |
| 404 | Zeke's Charter Fleet #14 | 29°31.465 | 87°59.382 |
| 405 | Zeke's Charter Fleet #15 | 29°30.553 | 87°58.985 |
| 406 | Zeke's Charter Fleet #16 | 29°29.682 | 87°58.101 |

# BALDWIN COUNTY TROLLING CORRIDOR AREA




**Note:** A total of 208 Red Snapper World Championship (RSWC) concrete reef modules from the 2007 deployment are located in the Baldwin County Trolling Corridor General Permit Area. Module numbers 1 through 180 and 318 through 345 are located at approximately 100 foot intervals along the entire length of the corridor. **The DGPS coordinates and sponsorship information for these reefs is found on pages 11 and 12 of this brochure.**




| | | |
|---|---|---|
| Allen Reef | 30°07.835 | 87°31.790 |
| Perdido Pass Bridge | 30°08.446 | 87°33.956 |
| Perdido Pass Bridge | 30°08.565 | 87°34.270 |
| Gulf State Park Pavilion 1 | 30°07.737 | 87°32.059 |
| Gulf State Park Pavilion 2 | 30°08.701 | 87°32.814 |
| Gulf State Park Pavilion 3 | 30°08.749 | 87°33.633 |
| Gulf State Park Pavilion 4 | 30°08.897 | 87°34.323 |
| Chamber 1 | 30°13.729 | 87°32.928 |
| Chamber 2 | 30°13.760 | 87°32.918 |
| Chamber 3 | 30°13.733 | 87°32.941 |
| Chamber 4 | 30°13.768 | 87°32.946 |
| Jim Robbins | 30°08.981 | 87°34.341 |
| Whitney Bank | 30°08.878 | 87°34.256 |
| Harry Allen Memorial | 30°09.002 | 87°34.196 |
| Doc of the Bay | 30°08.951 | 87°34.119 |
| Mexico Rock | 30°08.976 | 87°34.113 |
| Sam's Spot | 30°08.906 | 87°34.001 |
| Armand Annan Memorial | 30°08.897 | 87°33.972 |
| Bon Secour Equipment | 30°08.768 | 87°33.852 |
| Hazel's Reef | 30°08.767 | 87°33.802 |
| Kaiser Realty | 30°08.732 | 87°33.638 |
| Coleman Marine | 30°08.781 | 87°33.478 |
| J & M Tackle | 30°08.708 | 87°33.338 |
| Outcast Charter Docks | 30°08.700 | 87°33.261 |
| Regions Bank | 30°08.640 | 87°33.036 |
| Blue Water | 30°08.519 | 87°32.853 |
| Fred's Place | 30°08.592 | 87°32.726 |
| Callaway | 30°08.706 | 87°32.774 |
| First Gulf Bank | 30°08.752 | 87°32.692 |
| Bowen Family | 30°08.867 | 87°32.592 |
| Liberty Linens | 30°08.758 | 87°32.503 |
| Plantation Resort | 30°08.207 | 87°32.376 |
| SouthTrust Bank | 30°08.006 | 87°32.341 |
| Flora-Bama | 30°07.775 | 87°32.154 |
| Bottom Line | 30°07.934 | 87°32.104 |
| E.M.C | 30°07.860 | 87°31.978 |
| Ray Callaway Memorial | 30°07.908 | 87°31.913 |
| Zeke's Landing Marina | 30°08.732 | 87°33.560 |

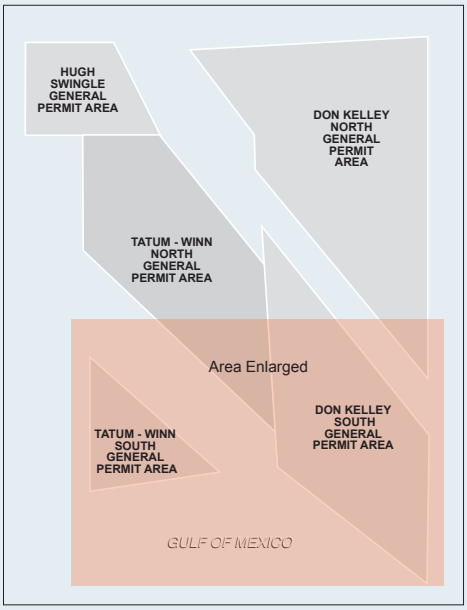
RSWC* (Red Snapper World Championship)
Visit: www.redsnapperworldchampionship.com

# GAS PLATFORMS AND JACKETS

| | |
|---|---|
| Swingle Reef | 29°25.160 - 87°35.600 |
| Marathon Reef | 29°26.895 - 87°36.990 |
| Marathon Jacket | 29°31.007 - 87°34.705 |
| Unocal 254 | 29°21.750 - 87°48.330 |
| Callon Jacket | 29°26.000 - 87°58.500 |

UNOCAL #254
Deployment

State Record Red Snapper
Mr. Melvin Dunn - 44 lbs. 12 oz.



# INSHORE FISHING REEFS

Mobile Bay's ample surface area – about 450 square miles – and its shallow waters... coupled with the influx of copious amounts of freshwater and nutrients from rivers and tributaries, produce some of the very best saltwater gamefish populations to be found anywhere. Speckled trout and white trout, redfish and black drum, sheepshead and flounder all abound in local waters. Head to one of Alabama's 21 inshore artificial fishing reefs and there you will find an inshore fishing experience that is second to none on the Gulf Coast.

Prior to the construction of formal fish attractors in Mobile Bay, knowledgeable local fishermen understood and appreciated the community relationship between the Bay's prolific oyster reefs and exploitable fish populations. First, there's something structurally different about an oyster reef from the surrounding sand and mud bottoms. Oyster reefs are usually raised ever so slightly above the surrounding aquatic terrain, providing linear habitat and home range anchors for schools of predatory fish. This reef structure would attract schools of fish even if devoid of biological activity. But an oyster reef is anything but devoid of life. In addition to the oysters, dozens of types of aquatic invertebrates call the "nooks and crannies" of the oyster reef home, filling each biological niche. Barnacles, mussels, worms and bryozoans, along with a variety of crabs and shrimp abound, taking advantage of the large variety of available food supported by the oyster reef ecosystem. And where such abundant food is available, you find gamefish...and lots of them!

In past geologic history, when the sea stretched much farther inland than today, oyster and marine fish populations thrived in areas which are now human habitat. As the seas retreated, so did the oysters and fish, slowly moving southward out of what is now the Mobile Delta. Good oyster habitat, hard bottom and medium salinity, continued to move southward as sea level fell and river discharge increased. This progression of natural events created a chain of oyster reefs all the way down both sides of the Bay, and left behind vast deposits of shell. Many of these old reefs continued to support marginal populations of oysters, but typically only enough for very localized harvest and marketing strategies. Man's agricultural activities upstate dumped heavy loads of sediment into the waters of the Bay, and rapid human encroachment into the Bay area coupled with dredging and channelization changed the flow patterns of the Bay, impacting most of the middle bay and particularly the eastern shore reefs, including the once prolific reefs in Bon Secour Bay.

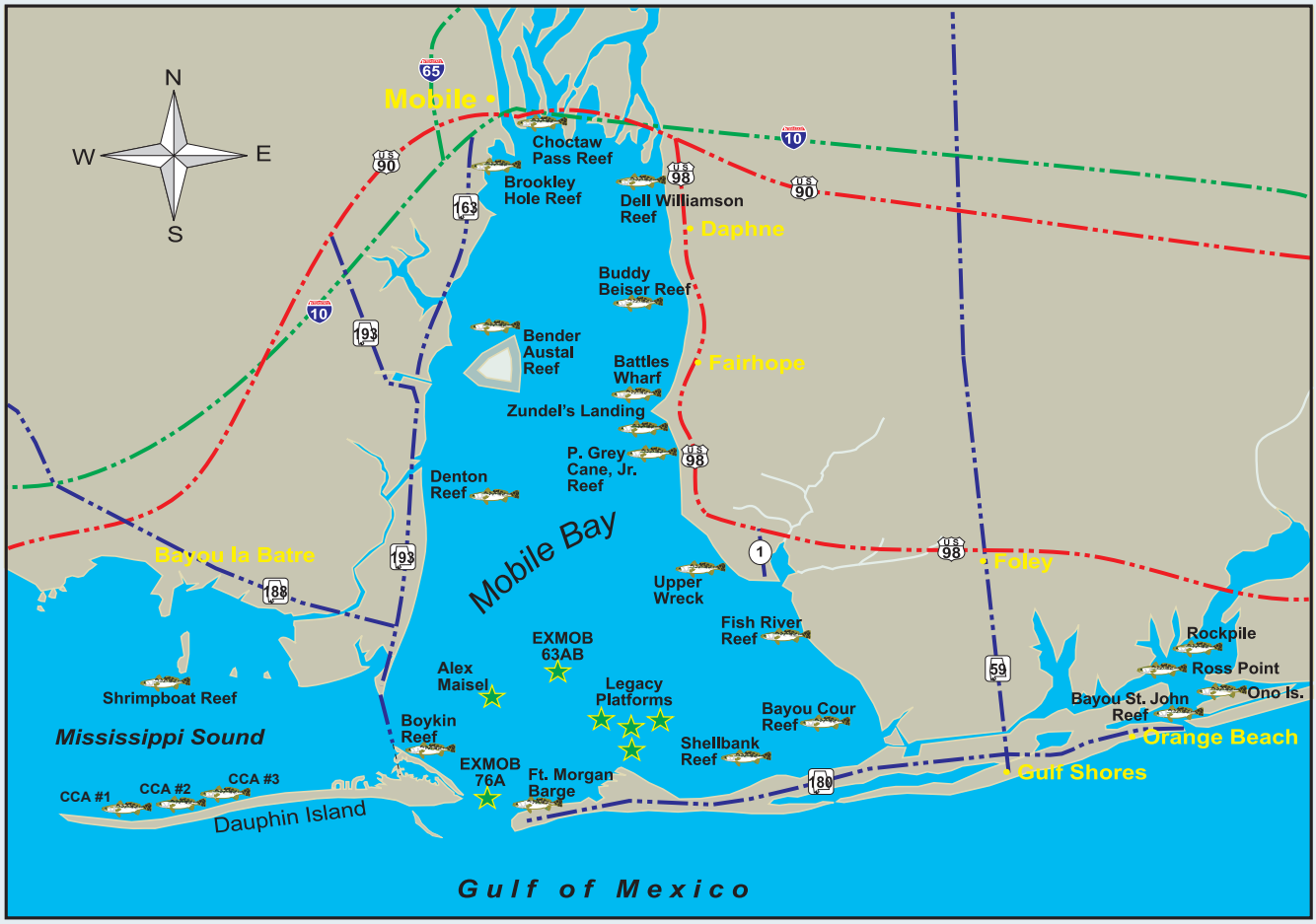
For the Alabama Marine Resources Division, enhancement of these relict oyster areas seemed logical and responsible. An idea was developed to ring marginally productive oyster reefs in the bay with some form of hard, durable material, and fill the areas with oyster cultch such as shell or crushed limestone for vertical relief. All that was needed was the appropriate material, something hard, cheap, and durable. It was believed that such an enhancement could help revitalize oyster production in these relict reef areas, possibly resuscitating an oyster industry which made the Bon Secour area famous in days past. Additionally, the agency anticipated improved sportfishing at the sites due to increased vertical relief and biological diversity. The agency did not anticipate just how good the fishing would become!

In the spring and summer of 1996 various concrete rubble became available from the demolition of the old Mobile Bay Causeway bridges (Tensaw, Blakely, and Apalachee rivers). The Marine Resources Division with the help of local contractors and conservation groups decided to build fish attractors with the material. This was precisely the material needed for the ringing of the oyster reefs that had earlier been envisioned by the agency. Now was the time to move ahead with what has since proven to be the most comprehensive fishing enhancement project in the history of the Bay and the finest example of inshore fishery enhancement in the nation. Your purchase of motorboat fuel and fishing tackle helps pay for these construction efforts through the Wallop-Breaux funding program.

Refer to the map within this document. Shellbank, Denton, Grey Cane and Fish River reefs are dual purpose sites serving as both fishing reefs and as experimental oyster reef rehabilitation areas. These three areas received oyster cultch material (crushed limestone) during the summer of 1998 and fall of 1999. All of these sites are producing spectacular catches of speckled trout and redfish. The water depth above all the construction material is approximately 3.5 feet at mean low water (MLW). Anglers should exercise caution at all times when approaching these sites, but particularly during times of extreme low (winter) tidal conditions.

The Marine Resources Division and its industry and public partners are proud to be involved in such tremendous enhancement of our oyster and sportfish resources in the Mobile Bay area. The agency is committed to continuing this trend, sprinkling great fishing areas and, where possible, enhanced oystering areas within the reach of even the most modestly outfitted angler.

# ALABAMA'S INSHORE FISHING REEFS




## Gas Platform Reefs ★

ExxonMobil 76A-AUX
30°15.250' - 88°03.120'

Alex Maisel Memorial
30°17.802' – 88°02.731'

ExxonMobil 63AB
30°17.511' – 87°59.739'

Legacy Platform
30°16.823' – 87°58.080'

Legacy Satellite 615-1
30°16.837' – 87°59.104'

Legacy Satellite 615-3
30°16.012' – 87°58.429'

Legacy Satellite 615-4
30°17.285' – 87°57.326'

A total of 30 inshore fishing reefs are located within Mobile and Bon Secour Bays, Mississippi Sound, and the Perdido System. Concrete bridge materials, culvert pipes, concrete roof panels, oyster shells and crushed limestone were utilized as reef materials. Five reefs are experimental dual-purpose sites, providing excellent inshore fishing while improving oyster production on nonproductive relict oyster reefs. In addition, seven gas production platforms in lower Mobile Bay have been enhanced with limestone rock fish attracting pads.

## Existing Reefs

**Battles Wharf Reef**
30°29.634' - 87°55.918'

**Bayou Cour Reef**
30°17.945' - 87°48.427'

**Bayou St. John Reef**
30°17.561' - 87°31.960'

**Bender - Austal Reef**
30°31.642' - 88°02.877'

**Brookley Hole Reef**
30°37.965' - 88°03.119'

**"Buddy" Beiser Reef**
30°35.269' - 87°57.002'

**CCA #1**
30°14.162' - 88°17.607'

**CCA #2**
30°14.411' - 88°16.380'

**CCA #3**
30°14.709' - 88°14.508'

**Choctaw Pass Reef**
30°39.750' - 88°01.500'

**Dell Williamson Reef**
30°36.020' - 87°55.060'

**Denton Reef**
30°24.531' - 88°03.989'

**Fish River Reef**
30°19.705' - 87°49.830'

**Ft. Morgan Barge Reef**
30°14.002' - 88°01.226'

**Lynn Dent Boykin Reef**
30°16.390' - 88°05.770'

**Ono Island Reef**
30° 18.167' - 87° 29.404'

**P. Grey Cane, Jr. Reef**
30°27.460' - 87°55.940'

**Rockpile**
30°20.011' - 87°29.912'

**Ross Point Reef**
30°19.436' - 87°30.668'

**Shellbank Reef**
30°15.716' - 87°51.682'

**Shrimpboat Reef**
30°18.332' - 88°16.394'

**Upper Wreck**
30°23.230' - 87°53.111'

**Zundel's Landing**
30°28.700' - 87°55.600'

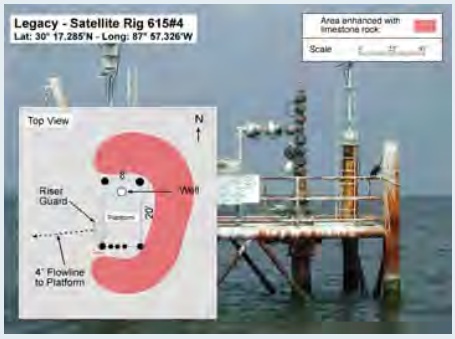
# GAS PLATFORM FISHING ENHANCEMENT - MATERIAL LOCATIONS

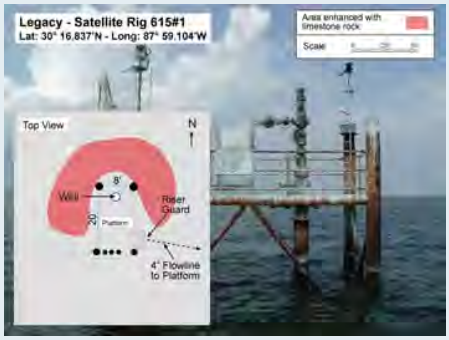
**2003 Deployment (Phase I)**

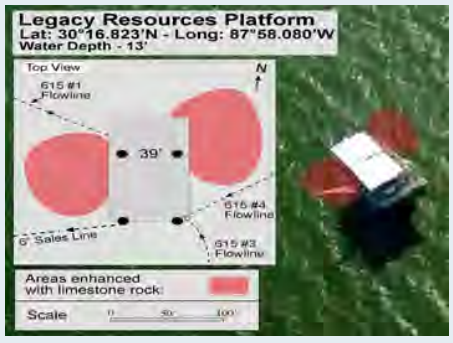
Alex Maisel Memorial Reef – 30°17.802' - 88°02.731'
ExxonMobil production platform 63 AB – 30°17.511' - 87°59.739'
ExxonMobil production platform 76 A – 30°15.250' - 88°03.120'

**2005 Deployment (Phase II)**

Legacy Resources Platform – 30°16.823' - 87°58.080'
Legacy Resources Satellite Rig 615-1 – 30°16.837' - 87°59.104'
Legacy Resources Satellite Rig 615-3 – 30°16.012' - 87°58.429'
Legacy Resources Satellite Rig 615-4 – 30°17.285' - 87°57.326'





## Gas Platform Fishery Habitat Enhancement Program

Substrate stabilization materials originally placed around gas platform locations in lower Mobile Bay once provided excellent benthic invertebrate habitat, supporting large populations of predatory fishes. Years of storms and propeller wash have covered or moved these materials, and fishing success was declining noticeably around the platforms.

Crushed limestone aggregate provides an ideal substrate for the settlement and growth of oysters and other benthic invertebrates. A complex ecological web including baitfishes and recreationally important predatory fishes will be established and maintained throughout the life of the material on the bottom. Local recreational fisheries associated with these gas platforms will benefit as a direct result of this work.

These four additions complete this phase of MRD's Gas Platform Fishery Habitat Enhancement Program and will afford excellent fishing around these easily accessible gas platforms, adding to the three platforms similarly enhanced in 2003.

# ALABAMA MARINE RESOURCES DIVISION

**Dauphin Island Office: 251-861-2882**

**Gulf Shores Office: 251-968-7576**

**www.outdooralabama.com/fishing/saltwater**

**As a recreational boater and fisherman I recognize that:**

**The waters of the Gulf of Mexico and its associated bays, sounds, lakes and tributaries are valuable public resources entrusted to the stewardship of all who enjoy them. A pollution-free aquatic environment is essential to the health and productivity of coastal fisheries and to high quality recreational fishing and boating experiences.**

**Trash deliberately discarded or carelessly lost overboard is harmful to marine life and shorebirds, creates a blight on the shorefront, and threatens the safe, efficient operation of boats and equipment.**

**Waterborne debris in the Gulf of Mexico is detrimental to all Gulf states and other countries that share the waters of the Gulf.**

**BOATER'S AND FISHERMAN'S PLEDGE FOR A CLEAN GULF**

**I PLEDGE:**

- **To transport to shore, for proper disposal, all trash generated aboard my boat, especially plastic, glass, and metal;**
- **To make every effort to prevent accidental loss of food and drink containers, fishing gear, and other debris from my boat;**
- **To retrieve for proper disposal onshore, plastic refuse, cans, and other man-made debris I find floating in navigable waters; and**
- **To encourage fellow boaters and fishermen to "Take Pride in the Gulf of Mexico."**

**DISCLAIMER**

**This product is intended for use solely as a reference guide to Alabama fishing. It is not intended for navigational use. This agency makes no warranty, expressed or implied, with respect to the accuracy or completeness of the information contained in this document. Furthermore, this agency assumes no liability with respect to the use of, or damages resulting from the use of any information contained in this document.**

**ACKNOWLEDGMENTS**

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**Photos: Marine Resources Division**

**Fish Illustrations: © Diane Rome Peebles - www.dianepeebles.com**

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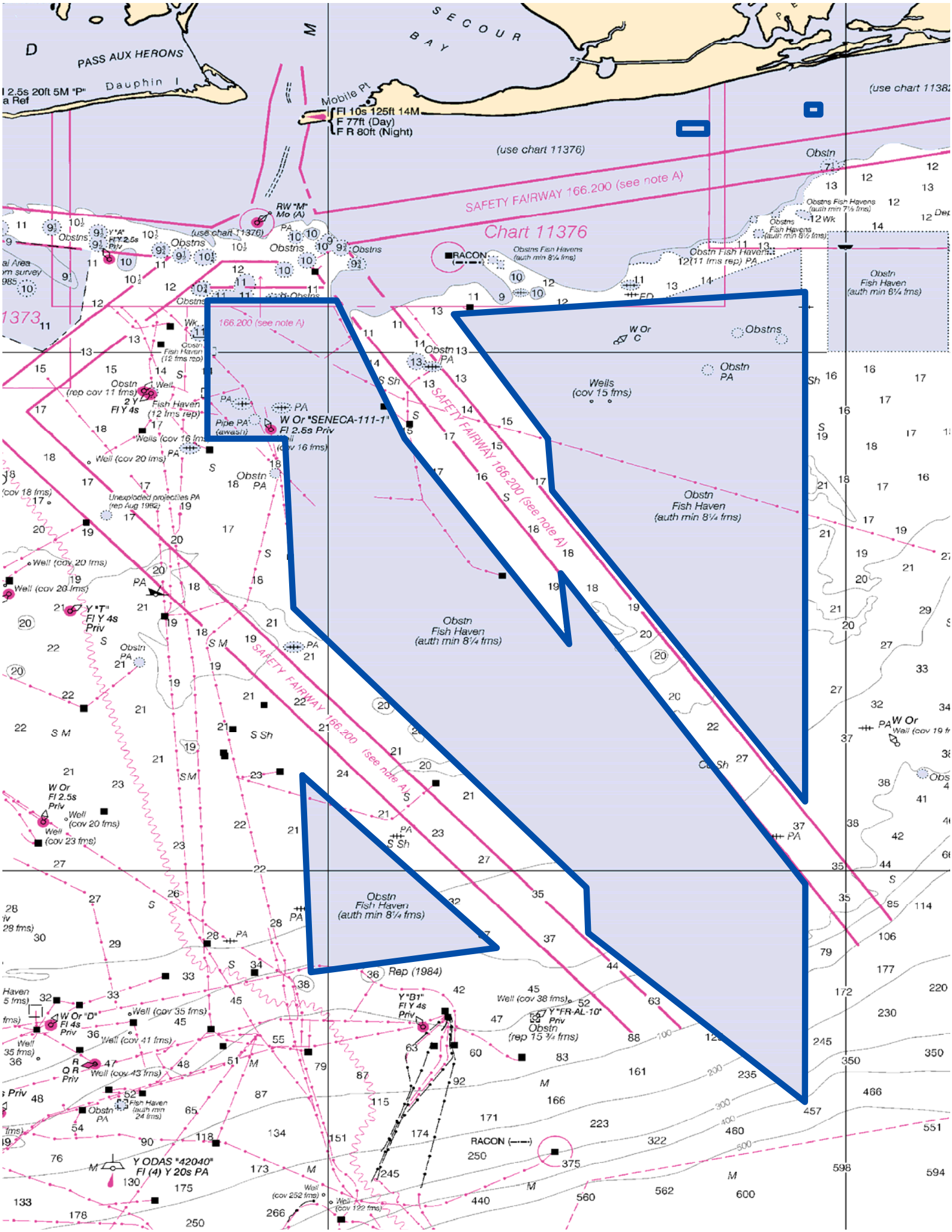
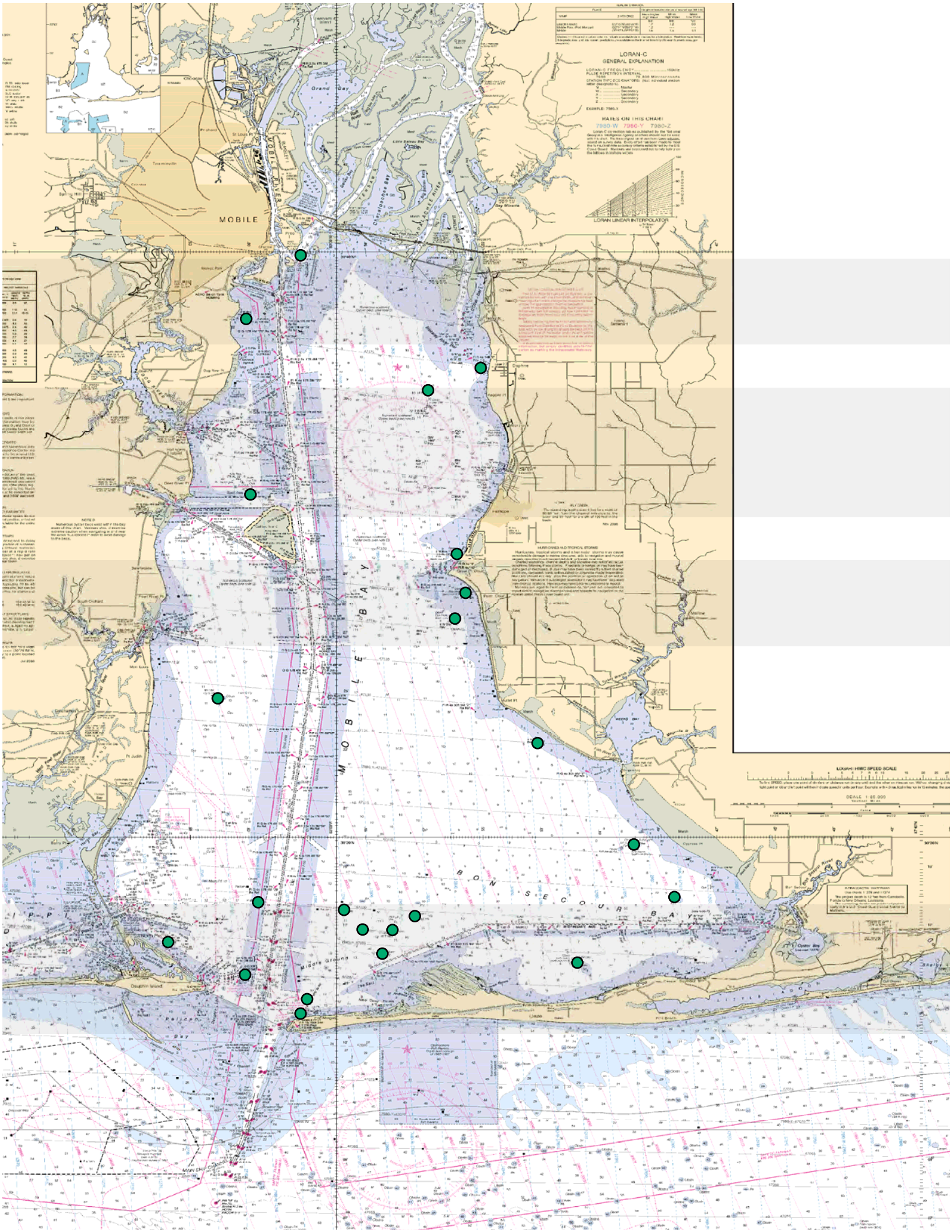
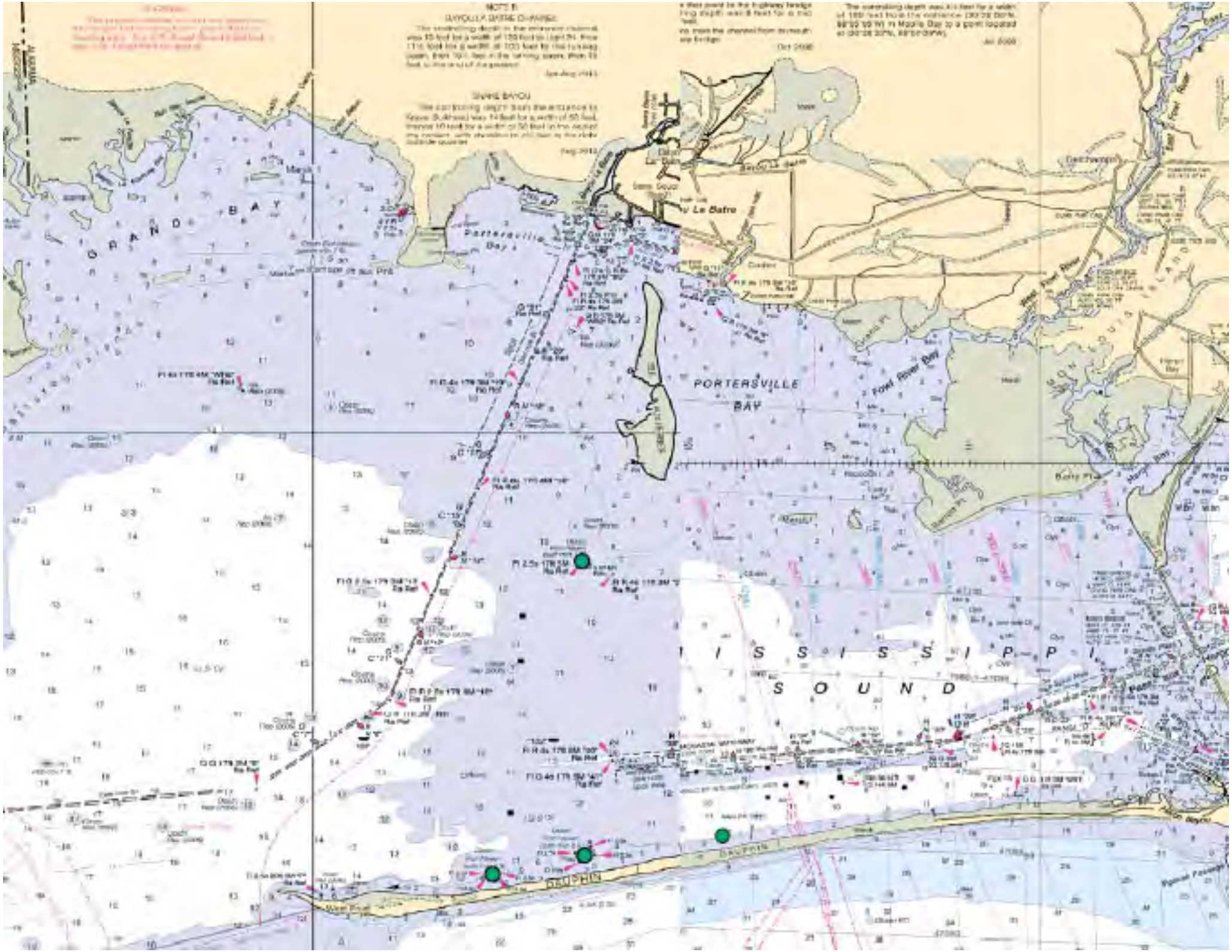

PASS AUX HERONS
Dauphin I
SECOUR BAY
Mobile Pt
Fl 10s 125ft 14M
F 77ft (Day)
F R 80ft (Night)
(use chart 11376)
(use chart 11382
Chart 11376
SAFETY FAIRWAY 166.200 (see note A)
RACON
RW "M" Mo (A)
W Or "SENECA-111-1"
Fl 2.5s Priv
Y "A" Fl Y 2.5s Priv
Y "T" Fl Y 4s Priv
W Or Fl 2.5s Priv
W Or "D" Fl 4s Priv
Y "B1" Fl Y 4s Priv
Y "FR-AL-10" Priv
R Q R Priv
Y ODAS "42040" Fl (4) Y 20s PA
Obstn
Obstns
Wells (cov 15 fms)
Obstn Fish Haven (auth min 8¼ fms)
Obstn Fish Haven (auth min 7⅞ fms)
Obstn Fish Haven (auth min 8½ fms)
Obstn Fish Haven (11 fms rep) PA
Fish Haven (12 fms rep)
Pipe PA (awash)
Unexploded projectiles PA (rep Aug 1982)
Rep (1984)
Obstn (rep 15 ¾ fms)
RACON
PA
S
S Sh
S M
Well (cov 20 fms)
Well (cov 23 fms)
Well (cov 35 fms)
Well (cov 38 fms)
Well (cov 41 fms)
Well (cov 43 fms)
Well (cov 252 fms)
Well (cov 122 fms)


LORAN-C
GENERAL EXPLANATION
LORAN-C FREQUENCY ..... 100kHz
PULSE REPETITION INTERVAL
7980 ..... 79,800 MICROSECONDS
STATION TYPE DESIGNATIONS: (Not all values shown below designated to this chain)
Master
W ..... Secondary
X ..... Secondary
Y ..... Secondary
Z ..... Secondary
EXAMPLE: 7980-X
RATES ON THIS CHART
7980-W 7980-Y 7980-Z
LORAN LINEAR INTERPOLATOR
MOBILE
Grand Bay
Bay Minette
Dog River
Fowl River
Chickasaboque Bay
Little Bateau Bay
Bayou La Batre
Dauphin Island
Pelican Bay
Main Ship Channel
Middle Ground
MOBILE BAY
BON SECOUR BAY
Oyster Bay
Weeks Bay
Point Clear
Fairhope
Daphne
Spanish Fort
Mobile Point
Fort Morgan
Gulf Shores
Orange Beach
Perdido Pass
HURRICANES AND TROPICAL STORMS
LOXAH / HMC SPEED SCALE
SCALE 1:80,000


GRAND BAY
PORTERSVILLE BAY
Pascagoula
Moss Point
Gautier
Ocean Springs
Biloxi
Point Cadet
Back Bay of Biloxi
Fort Point
Deer Island
Round Island
Petit Bois Island
Horn Island
MISSISSIPPI SOUND
DAUPHIN ISLAND
Mobile Pass
Pascagoula River
Bayou Casotte
Bayou La Croix
Bayou Le Batre
Fort Bayou
Back Bay
Point Aux Pins
Middle Ground
Pascagoula Channel
Dauphin Island Channel
Mobile Channel
Pascagoula Entrance Channel
Pascagoula Lower Range
Pascagoula Upper Range
Pascagoula Lighted Buoy 1
Pascagoula Lighted Buoy 2
Pascagoula Lighted Buoy 3
Pascagoula Lighted Buoy 4
Pascagoula Lighted Buoy 5
Pascagoula Lighted Buoy 6
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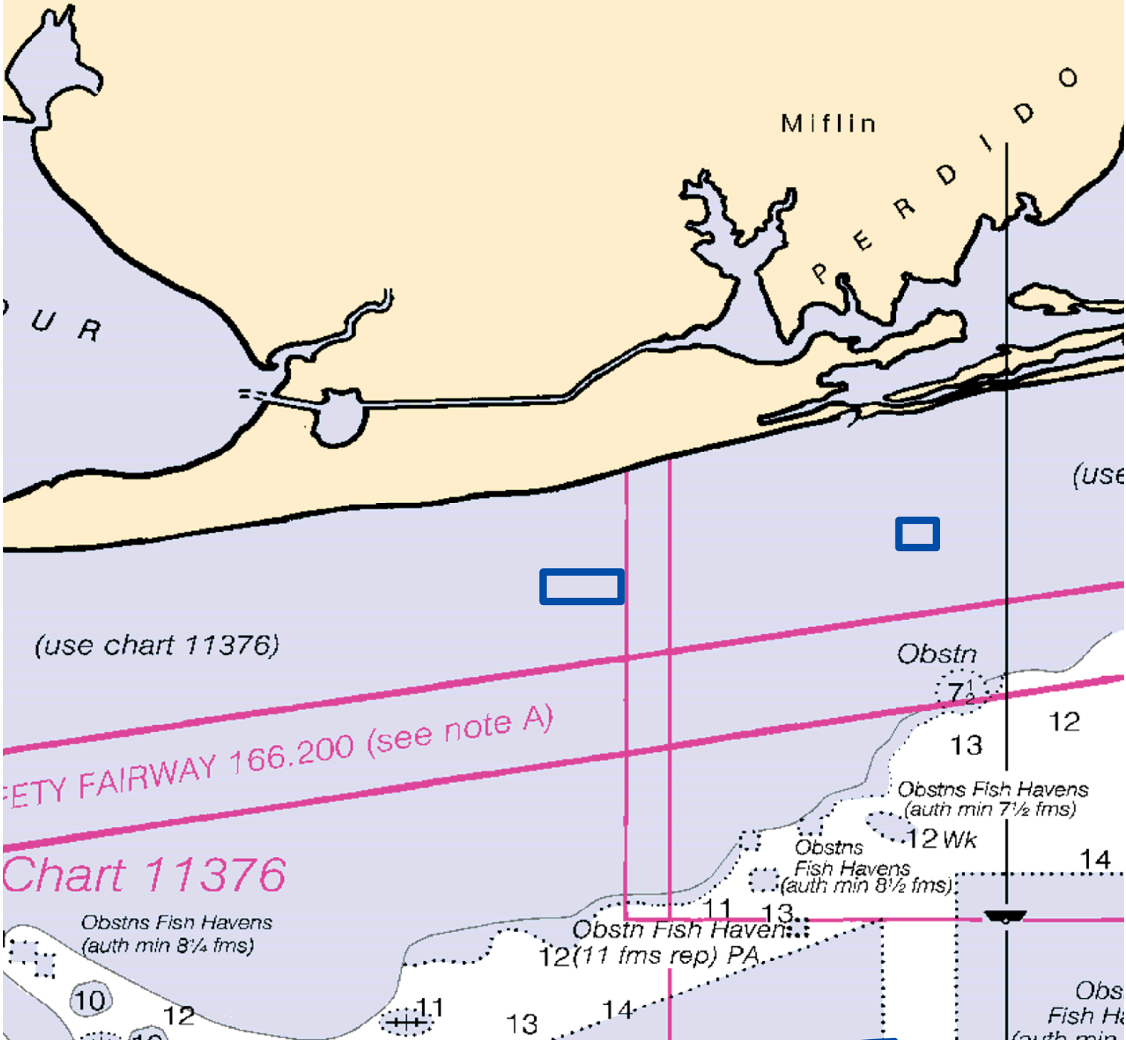
Pascagoula Lighted Buoy 100

River. Vessel operating procedures and designated radiotelephone frequencies are published in 33 CFR 161, the U.S. Coast Pilot, and/or the VTS User's Manual. Mariners should consult these sources for applicable rules and reporting requirements. Although mandatory VTS participation is limited to the navigable waters of the United States, certain vessels are encouraged or may be required, as a condition of port entry, to report beyond this area to facilitate advance vessel traffic management within the VTS area.



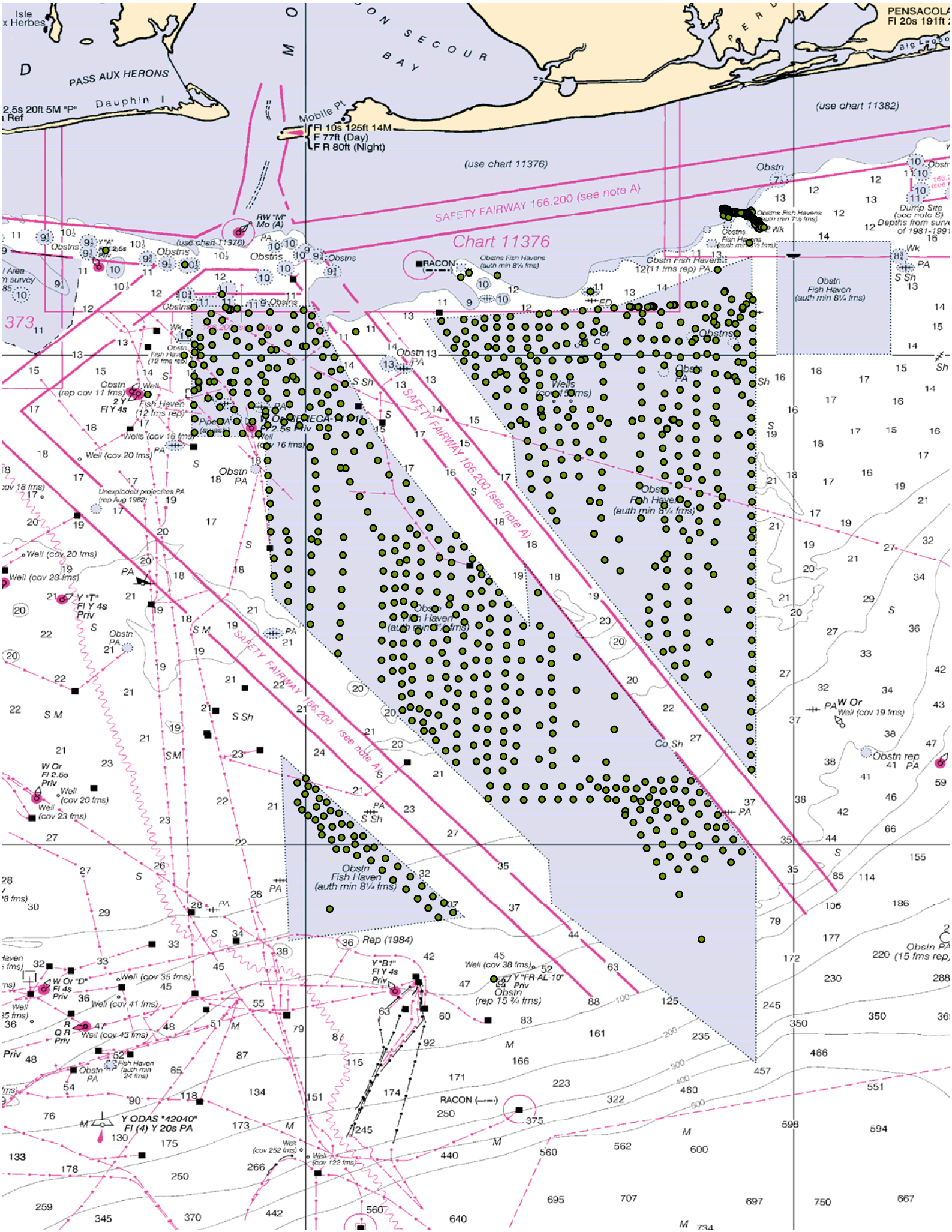
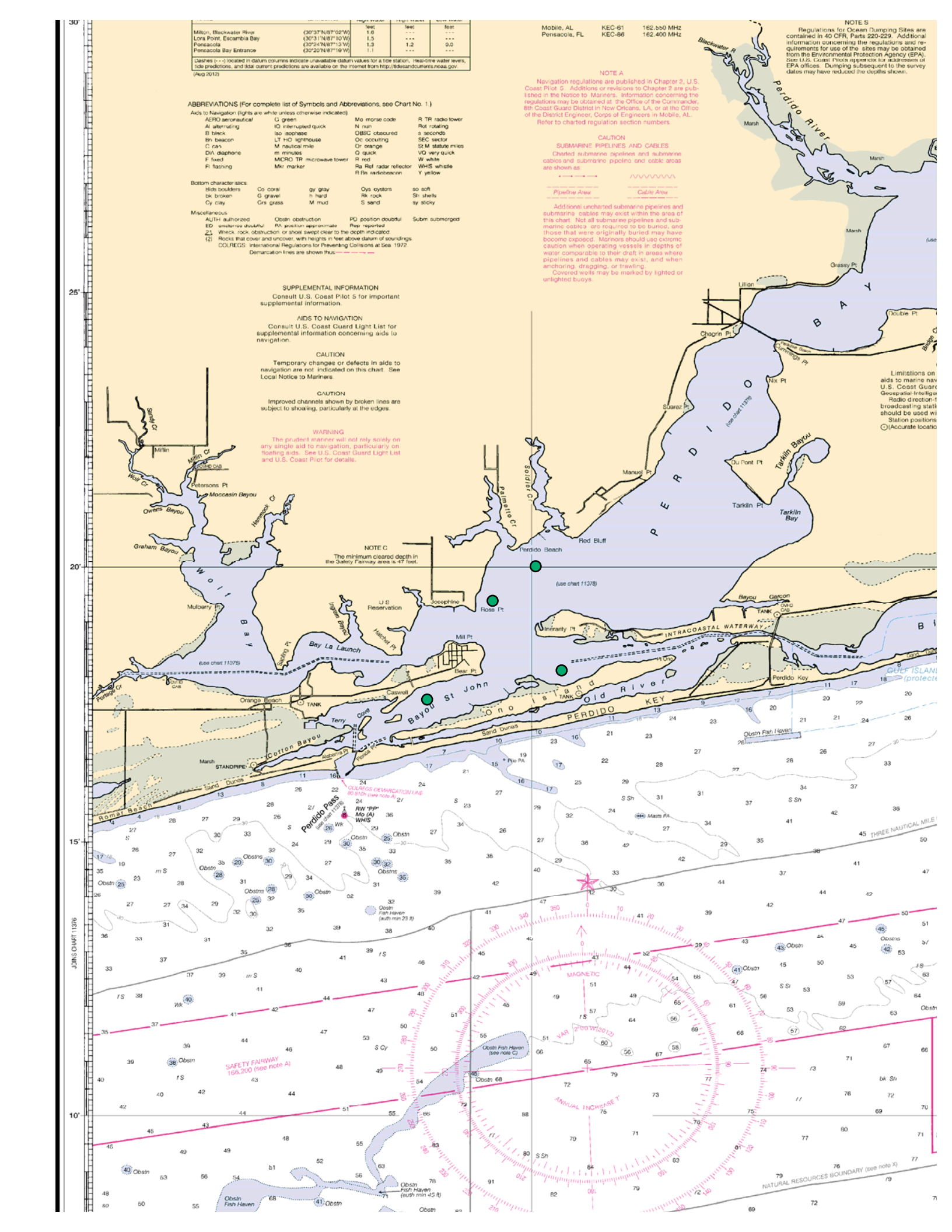
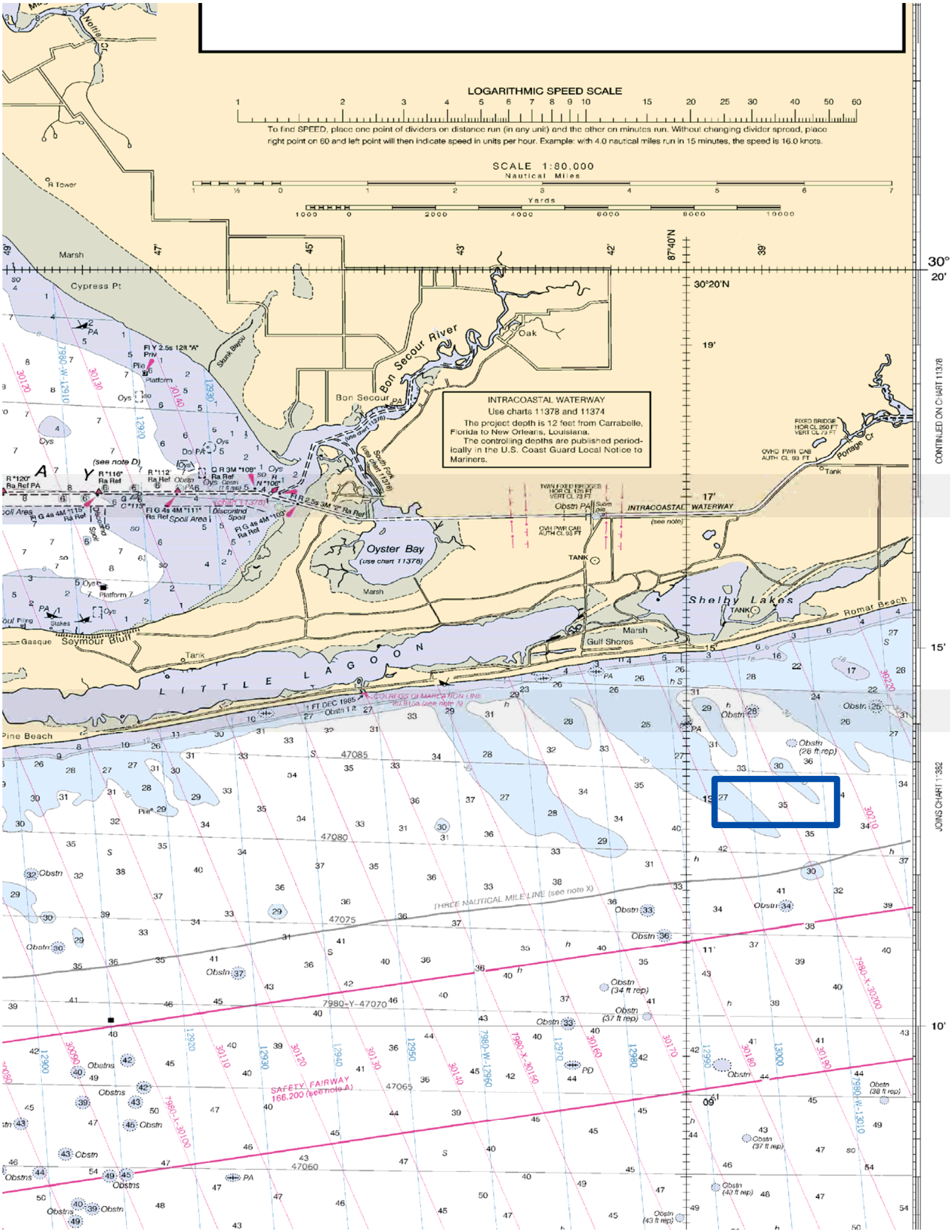
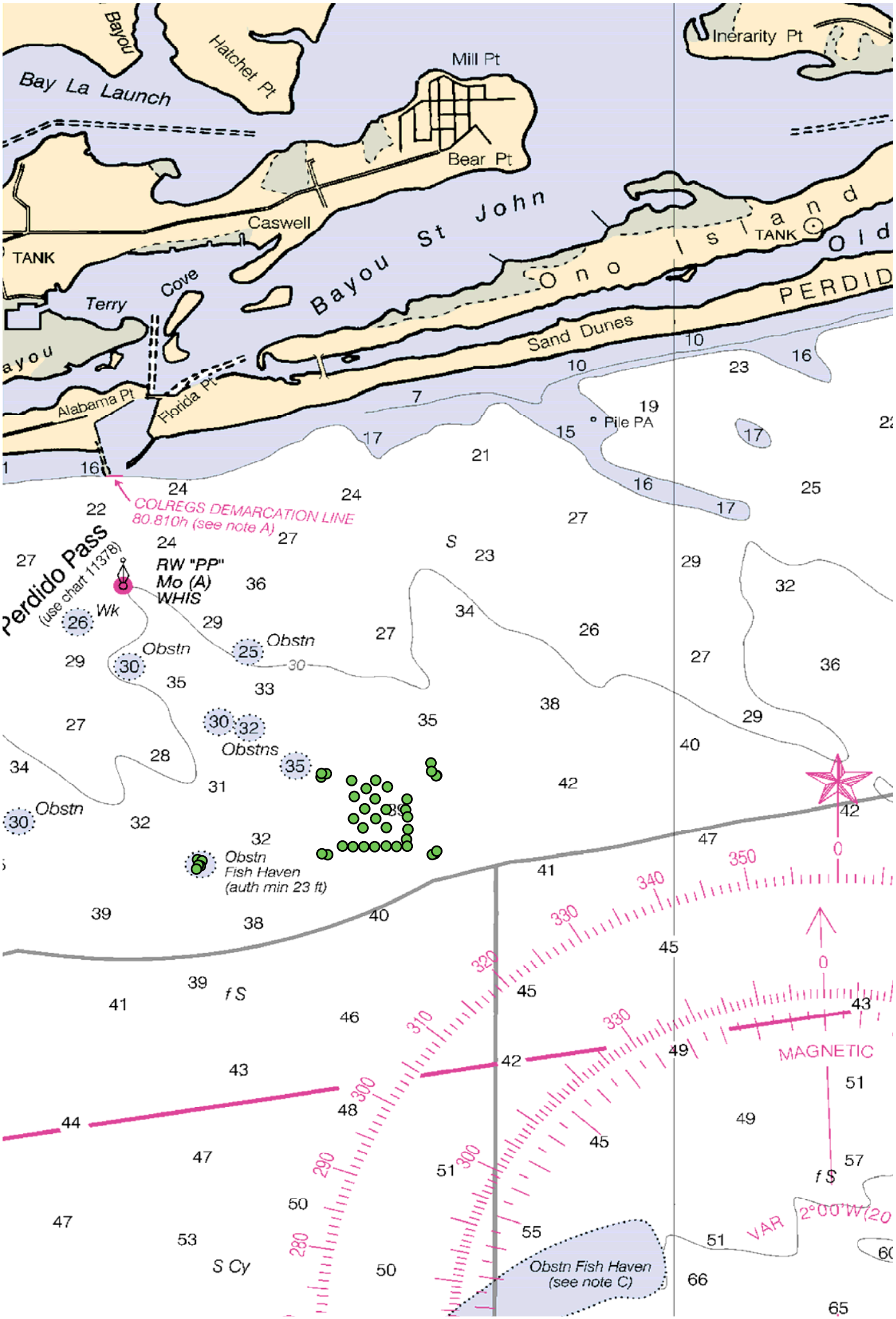
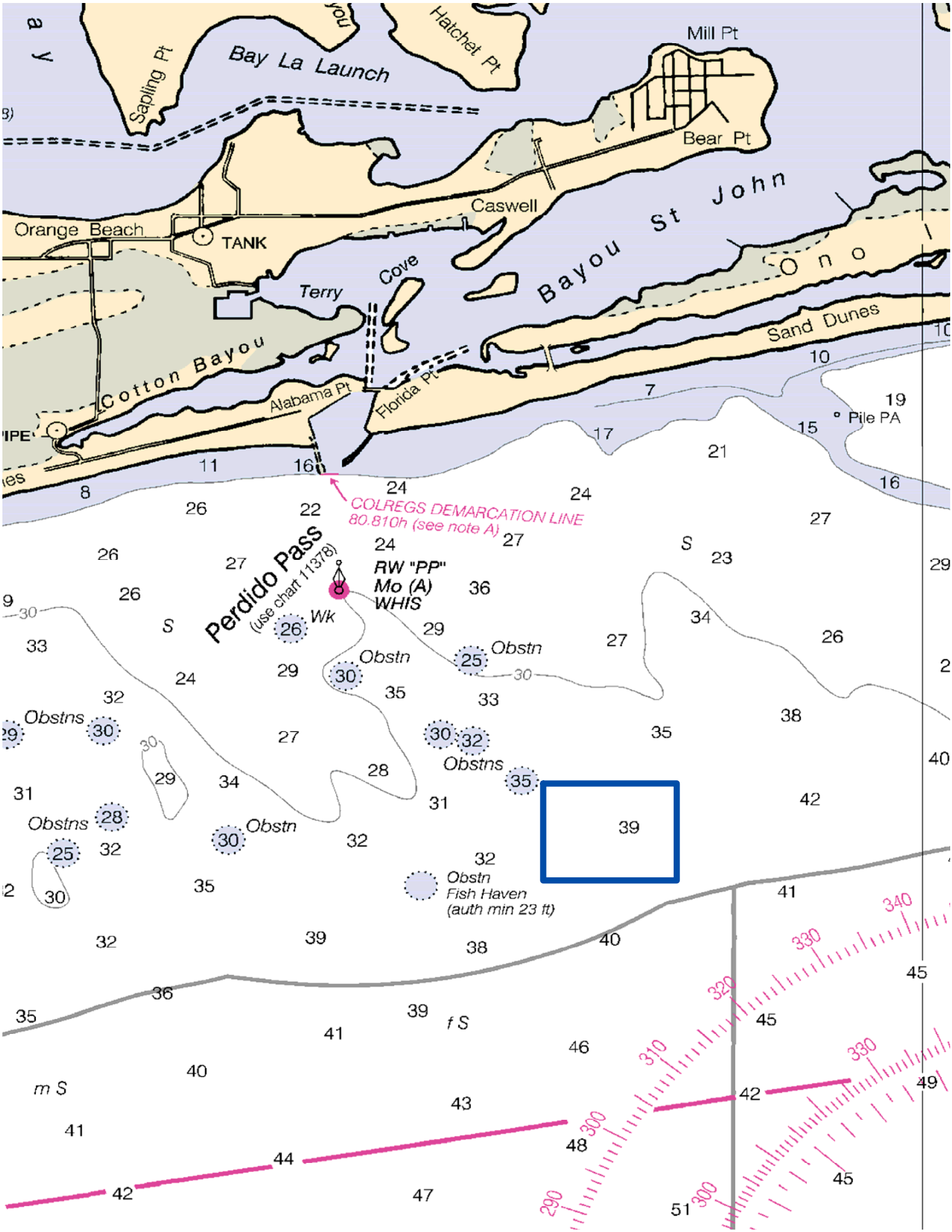


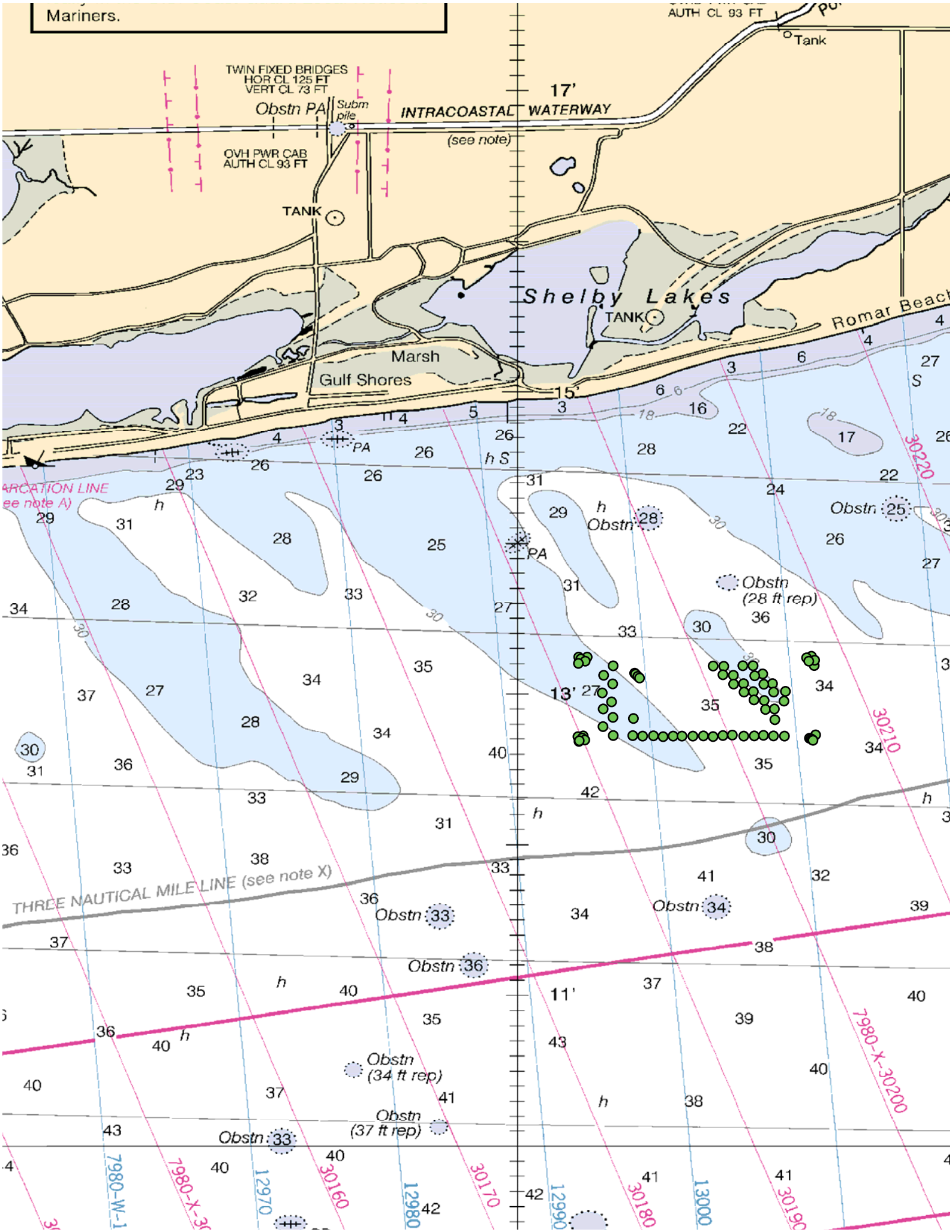
Chart 11376
PASS AUX HERONS
Dauphin I
Mobile Pt
Fl 10s 125ft 14M
F 77ft (Day)
F R 80ft (Night)
(use chart 11376)
(use chart 11382)
SAFETY FAIRWAY 166.200 (see note A)
RACON
Obstn Fish Haven (auth min 8¼ fms)
Obstn Fish Haven (auth min 7½ fms)
Obstn Fish Haven (11 fms rep) PA
Dump Site (see note S)
Depths from survey of 1981-1991
Wells (cov 15 fms)
Obstn Fish Haven (auth min 8¼ fms)
Obstn rep (1984)
Obstn rep (15 fms rep)
Obstn rep (15 fms rep)
Obstn rep 15 ¾ fms)
Y ODAS "42040" Fl (4) Y 20s PA
Y "T" Fl Y 4s Priv
Y "B1" Fl Y 4s Priv
Y "FR AL 10" Priv
W Or "D" Fl 4s Priv
W Or Fl 2.5s Priv
W Or Well (cov 19 fms)
R Q R Priv
Well (cov 20 fms)
Well (cov 23 fms)
Well (cov 35 fms)
Well (cov 38 fms)
Well (cov 41 fms)
Well (cov 43 fms)
Well (cov 252 fms)
Well (cov 122 fms)
Fish Haven (auth min 24 fms)
Unexploded projectiles PA (rep Aug 1982)
Pipeline PA
Co Sh
S Sh
S M
PENSACOLA
Fl 20s 191ft

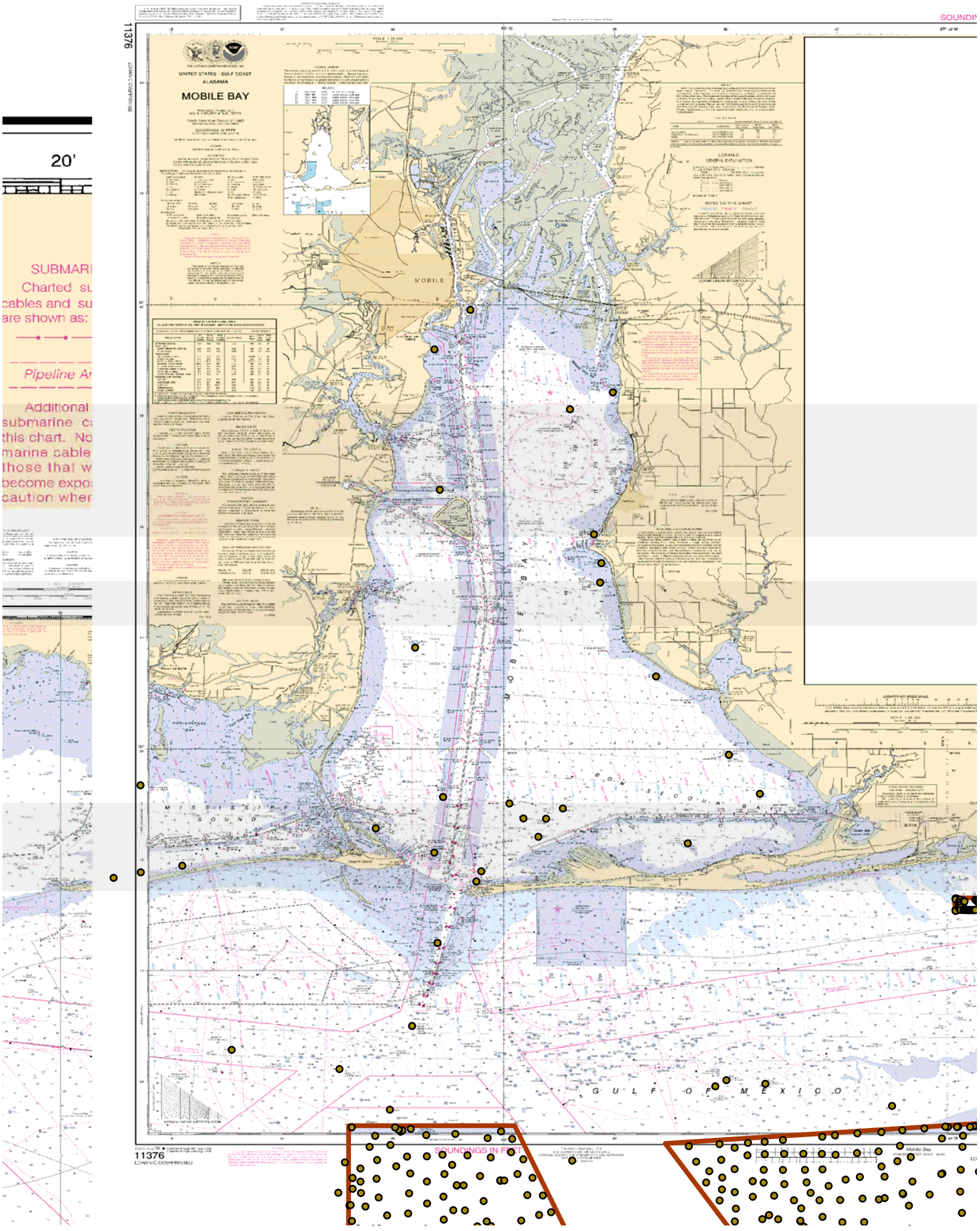

Millton, Blackwater River (30°37'N/87°02'W) feet 1.6 --- ---
Lora Point, Escambia Bay (30°31'N/87°10'W) 1.5 --- ---
Pensacola (30°24'N/87°13'W) 1.3 1.2 0.0
Pensacola Bay Entrance (30°20'N/87°19'W) 1.1 --- ---
Dashes (- - -) located in datum columns indicate unavailable datum values for a tide station. Real-time water levels, tide predictions, and tidal current predictions are available on the Internet from http://tidesandcurrents.noaa.gov.
(Aug 2012)
Mobile, AL KEC-61 162.550 MHz
Pensacola, FL KEC-86 162.400 MHz
NOTE S
Regulations for Ocean Dumping Sites are contained in 40 CFR, Parts 220-229. Additional information concerning the regulations and requirements for use of the sites may be obtained from the Environmental Protection Agency (EPA). See U.S. Coast Pilots appendix for addresses of EPA offices. Dumping subsequent to the survey dates may have reduced the depths shown.
NOTE A
Navigation regulations are published in Chapter 2, U.S. Coast Pilot 5. Additions or revisions to Chapter 2 are published in the Notice to Mariners. Information concerning the regulations may be obtained at the Office of the Commander, 8th Coast Guard District in New Orleans, LA, or at the Office of the District Engineer, Corps of Engineers in Mobile, AL.
Refer to charted regulation section numbers.
CAUTION
SUBMARINE PIPELINES AND CABLES
Charted submarine pipelines and submarine cables and submarine pipeline and cable areas are shown as:
Pipeline Area
Cable Area
Additional uncharted submarine pipelines and submarine cables may exist within the area of this chart. Not all submarine pipelines and submarine cables are required to be buried, and those that were originally buried may have become exposed. Mariners should use extreme caution when operating vessels in depths of water comparable to their draft in areas where pipelines and cables may exist, and when anchoring, dragging, or trawling.
Covered wells may be marked by lighted or unlighted buoys.
ABBREVIATIONS (For complete list of Symbols and Abbreviations, see Chart No. 1.)
Aids to Navigation (lights are white unless otherwise indicated)
AERO aeronautical
Al alternating
B black
Bn beacon
C can
DIA diaphone
F fixed
Fl flashing
G green
IQ interrupted quick
Iso isophase
LT HO lighthouse
M nautical mile
m minutes
MICRO TR microwave tower
Mkr marker
Mo morse code
N nun
OBSC obscured
Oc occulting
Or orange
Q quick
R red
Ra Ref radar reflector
R Bn radiobeacon
R TR radio tower
Rot rotating
s seconds
SEC sector
St M statute miles
VQ very quick
W white
WHIS whistle
Y yellow
Bottom characteristics:
blds boulders
bk broken
Cy clay
Co coral
G gravel
Grs grass
gy gray
h hard
M mud
Oys oysters
Rk rock
S sand
so soft
Sh shells
sy sticky
Miscellaneous
AUTH authorized
ED existence doubtful
2½ Wreck, rock, obstruction, or shoal swept clear to the depth indicated.
(2) Rocks that cover and uncover, with heights in feet above datum of soundings.
COLREGS International Regulations for Preventing Collisions at Sea, 1972
Demarcation lines are shown thus
Obstn obstruction
PA position approximate
PD position doubtful
Rep reported
Subm submerged
SUPPLEMENTAL INFORMATION
Consult U.S. Coast Pilot 5 for important supplemental information.
AIDS TO NAVIGATION
Consult U.S. Coast Guard Light List for supplemental information concerning aids to navigation.
CAUTION
Temporary changes or defects in aids to navigation are not indicated on this chart. See Local Notice to Mariners.
CAUTION
Improved channels shown by broken lines are subject to shoaling, particularly at the edges.
WARNING
The prudent mariner will not rely solely on any single aid to navigation, particularly on floating aids. See U.S. Coast Guard Light List and U.S. Coast Pilot for details.
NOTE C
The minimum cleared depth in the Safety Fairway area is 47 feet.
Limitations on aids to marine nav
U.S. Coast Guard
Geospatial-Intelligence
Radio direction-f
broadcasting stati
should be used wi
Station positions
(Accurate locatio
Blackwater R.
Perdido River
Marsh
Grassy Pt
Lillian
Double Pt
Chagrin Pt
Cummings Pt
Nix Pt
Suarez Pt
Manuel Pt
Du Pont Pt
Tarklin Bayou
Tarklin Pt
Tarklin Bay
Red Bluff
Perdido Beach
Soldiers Cr
Palmetto Cr
Sandy Cr
Mirlin
Mirlin Cr
Wolf Cr
Petersons Pt
Moccasin Bayou
Owens Bayou
Hammock Cr
Graham Bayou
Wolf Bay
Mulberry Pt
U S Reservation
Josephine
Rose Pt
Ingram Bayou
Hatchet Pt
Mill Pt
Bay La Launch
Sibley Pt
Portage Cr
Orange Beach
TANK
Caswell
Terry
Coral
Bayou St John
Ono Island
Old River
PERDIDO KEY
Sand Dunes
Cotton Bayou
Alabama Pt
Florida Pt
STANDPIPE
Romar Beach
Perdido Pass
RW "PP" Mo (A) WHIS
COLREGS DEMARCATION LINE 80.810's (see note A)
Bayou Garcon
Inerranty Pt
INTRACOASTAL WATERWAY
Perdido Key
Obstn Fish Haven
Masts PA
THREE NAUTICAL MILE
SAFETY FAIRWAY 166.200 (see note A)
Obstn Fish Haven (see note C)
Obstn Fish Haven (auth min 23 ft)
Obstn Fish Haven (auth min 45 ft)
MAGNETIC
VAR 2°00'W(2012)
ANNUAL INCREASE 7'
NATURAL RESOURCES BOUNDARY (see note X)
(use chart 11378)
JOINS CHART 11376
30'
25'
20'
15'
10'


LOGARITHMIC SPEED SCALE
1 2 3 4 5 6 7 8 9 10 15 20 25 30 40 50 60
To find SPEED, place one point of dividers on distance run (in any unit) and the other on minutes run. Without changing divider spread, place right point on 60 and left point will then indicate speed in units per hour. Example: with 4.0 nautical miles run in 15 minutes, the speed is 16.0 knots.
SCALE 1:80,000
Nautical Miles
Yards
INTRACOASTAL WATERWAY
Use charts 11378 and 11374
The project depth is 12 feet from Carrabelle, Florida to New Orleans, Louisiana.
The controlling depths are published periodically in the U.S. Coast Guard Local Notice to Mariners.
Bon Secour River
Bon Secour
Oyster Bay
(use chart 11378)
Cypress Pt
Marsh
Oak
Stunk Bayou
South Fork
Portage Cr
Tank
TANK
Shelby Lakes
Romar Beach
Gulf Shores
Seymour Bluff
Gasque
Pine Beach
LITTLE LAGOON
INTRACOASTAL WATERWAY
(see note)
COLREGS DEMARCATION LINE
THREE NAUTICAL MILE LINE (see note X)
SAFETY FAIRWAY
166.200 (see note A)
1 FT DEC 1985
Obstn 1 ft
Obstn (28 ft rep)
Obstn (34 ft rep)
Obstn (37 ft rep)
Obstn (43 ft rep)
Obstn (36 ft rep)
47085
47080
47075
47070
47065
47060
7980-Y-47070
7980-X-30200
7980-X-30100
7980-X-30150
7980-W-12960
7980-W-13010
87°40'N
30°20'N
30°
20'
19'
17'
15'
11'
10'
09'
CONTINUED ON CHART 11378
JOINS CHART 11362


Bayou
Hatchet Pt
Bay La Launch
Mill Pt
Inerarity Pt
Bear Pt
Caswell
TANK
Bayou St John
Ono Island
TANK
Old
PERDID
Terry
Cove
Sand Dunes
Alabama Pt
Florida Pt
Pile PA
COLREGS DEMARCATION LINE
80.810h (see note A)
Perdido Pass
(use chart 11378)
RW "PP"
Mo (A)
WHIS
Wk
Obstn
Obstns
Obstn
Fish Haven
(auth min 23 ft)
Obstn Fish Haven
(see note C)
S Cy
f S
MAGNETIC
VAR 2°00'W(20


Sapling Pt
Bay La Launch
Hatchet Pt
Mill Pt
Bear Pt
Caswell
Orange Beach
TANK
Terry Cove
Bayou St John
Sand Dunes
Cotton Bayou
Alabama Pt
Florida Pt
Pile PA
COLREGS DEMARCATION LINE
80.810h (see note A)
Perdido Pass
(use chart 11378)
RW "PP"
Mo (A)
WHIS
Wk
Obstn
Obstns
Fish Haven
(auth min 23 ft)


Mariners.
TWIN FIXED BRIDGES
HOR CL 125 FT
VERT CL 73 FT
Obstn PA
Subm pile
INTRACOASTAL WATERWAY
(see note)
17'
OVH PWR CAB
AUTH CL 93 FT
TANK
Shelby Lakes
TANK
Romar Beach
Marsh
Gulf Shores
15'
PA
h S
ARCATION LINE
ee note A)
Obstn 28
Obstn 25
Obstn (28 ft rep)
13' 27
Obstn 33
Obstn 34
Obstn 36
11'
THREE NAUTICAL MILE LINE (see note X)
Obstn (34 ft rep)
Obstn (37 ft rep)
Obstn 33
30220
30210
7980-X-30200
7980-W-1
7980-X-30
12970
30160
12980
30170
12990
30180
13000
30190


11376
LORAN-C OVERPRINTED
UNITED STATES - GULF COAST
ALABAMA
MOBILE BAY
MOBILE
MOBILE BAY
MISSISSIPPI SOUND
BON SECOUR BAY
GULF OF MEXICO
SOUNDINGS IN FEET
11376
LORAN-C OVERPRINTED

DEPARTMENT OF THE ARMY
MOBILE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 2288
MOBILE, AL 36628-0001

REPLY TO
ATTENTION OF

February 5, 2014

South Alabama Branch
Regulatory Division

SUBJECT: Department of the Army Nationwide Permit Number SAM-2013-1399-DEM, ADCNR, Mobile Bay

Mr. Chris Blankenship
Post Office Box 189
Dauphin Island, Alabama 36528

Dear Mr. Blankenship:

This letter is in response to your request for a Department of the Army (DA) permit for the placement of navigational aid pilings into Mobile Bay. Specifically, the project is located at 30.4660833° North and -87.96161666° West in eastern Mobile Bay, near Point Clear, Baldwin County, Alabama. The proposed work will entail the placement of six (6) pilings as aids to navigation into Mobile Bay to demarcate an existing 9.74 acre shellfish reef.

DA permit authorization is necessary because your project would involve the placement of structures into waters of the United States.

Based upon the information and plans you provided, we hereby verify the work described above, which would be performed in accordance with the enclosed drawings, is authorized by Nationwide Permit (NWP) 1, *Aids to Navigation*, in accordance with 33 CFR Part 330 of our regulations. This NWP and its associated Regional and General Conditions can be viewed at our website at http://www.sam.usace.army.mil/Missions/Regulatory.aspx.

You must comply with all the general conditions and any project specific conditions of this authorization or you may be subject to enforcement action. In the event you have not completed construction of your project within the specified time limit, a separate application or verification may be required. The following project special conditions are included with this verification:

**a. The permittee must install and maintain, at the permittee's expense, any safety lights, signs and signals required by the U.S. Coast Guard, through regulations or otherwise, on the permittee's fixed structures. To receive a U.S. Coast Guard Private Aids to Navigation marking determination, at no later than 30 days prior installation of any fixed structures in navigable waters and/or prior to installation of any floating private aids to navigation, you are required to contact the Eighth Coast Guard District (dpw), 500 Poydras St. Suite 1230, New Orleans, LA 70130, (504)671-2328 or via email to: D8oanPATON@uscg.mil. For general information related to Private Aids to Navigation please visit the Eighth CG District web site at: http://www.uscg.mil/d8/waterways/PATON.Home.asp.**

**b. If any evidence of the presence of Threatened/Endangered Species is found during the authorized work, activities in the immediate vicinity must cease and the permittee shall notify the U.S. Army Corps of Engineers (Corps), Mobile District.**

**c. Should artifacts or archaeological features be encountered during project activities, work shall cease and the Alabama Historical Commission and the Mobile District shall be consulted immediately.**

**U.S. Army Corps of Engineers . . . . . Telephone: (251) 690-2658**
**Alabama Historical Commission . . . . Telephone: (334) 242-3184**

**d. It is the permittee's responsibility to ensure the contractor(s) working on this project are aware of all general and special conditions.**

This **verification is valid until March 18, 2017**. In the event you have not completed construction of your project within the specified time limit, a separate application or re-verification may be required.

If you commence or are under contract to commence this activity before the date the relevant NWP is modified or revoked, you will have 12 months from the date of the modification or revocation of the NWP to complete the activity under the present terms and conditions of this NWP permit. The statements contained herein do not convey any property rights, or any exclusive privileges and does not authorize any injury to property or obviate the requirements to obtain other local, State or Federal assent required by law. Nothing in this letter shall be construed as excusing you from compliance with other Federal, State, or local statutes, ordinances, or regulations which may affect this work.

This letter of authorization does not obviate the necessity to obtain any other Federal, State, or local permits, which may be required. The statements contained herein do not convey any property rights, or any exclusive privileges, and does not authorize any injury to property. Nothing in this letter shall be construed as excusing you from compliance with other Federal, State, or local statutes, ordinances, or regulations which may affect this work

Please note that NWP General Condition 30 (Compliance Certification) requires that every permittee who has received NWP verification must submit signed certifications regarding the completion of authorized work as well as any required mitigation. In addition, the Mobile District also requires that every permittee submit a notification of commencement of the authorized work. The permittee shall provide notifications to the U.S. Army Corps of Engineers, Regulatory Division, Post Office Box 2288, Mobile, Alabama 36628-0001 within 5 days of initiation and completion of the authorized work. Enclosed are the forms you must complete and return to us in order to satisfy this requirement. The enclosed yellow Notice of Authorization card must be posted at the site during construction of the authorized activity.

A copy of this letter is being provided to the Alabama Department of Environmental Management, Mobile Branch, Coastal Section, 3664 Dauphin Street, Suite B, Mobile, Alabama 36608.

Please contact me at (251) 690-3185 if you have any questions. For additional information about our Regulatory Program, visit our web site at www.sam.usace.army.mil/Missions/Regulatory.aspx. Also, our customer satisfaction survey is located at

http://corpsmapu.usace.army.mil/cm_apex/f?p=regulatory_survey. Your responses are appreciated and will allow us to improve our services.

Sincerely,

Don Mroczko
South Alabama Branch
Regulatory Division

Enclosures

Permit Transfer: When the structures or work authorized by this permit (**SAM-2013-1399-DEM**) are still in existence at the time the property is transferred, the terms and conditions of this permit will continue to be binding on the new owner(s) of the property. To validate the transfer of this permit and the associated liabilities associated with compliance with its terms and conditions, have the transferee sign and date below.

_____ _____

(NAME) (DATE)

**COMMENCEMENT CERTIFICATION**

**U.S. Army Corps of Engineers**
**Mobile District**

Permit Number: **SAM-2013-1399-DEM**

Name of Permittee: **ADCNR – MARINE RESOURCES DIVISION**

Date of Issuance: **February 5, 2014**

Upon commencement of the activity authorized by this permit and any mitigation required by the permit, please sign this certification and return it to the following address:

U.S. Army Corps of Engineers
Mobile District
Regulatory Division
Coastal Branch
Post Office Box 2288
Mobile, Alabama 36628-0001

Please note that your permitted activity is subject to a compliance inspection by a U.S. Army Corps of Engineers representative. If you fail to comply with all terms and conditions of this permit the permit is subject to permit suspension, modification, or revocation and you are subject to an enforcement action by this office.

I hereby certify that the work authorized by the above-referenced permit has commenced and shall be completed in accordance with the terms and conditions of the said permit, and the required mitigation was completed in accordance with the permit conditions.

_____ _____
Signature of Permittee Date

**COMPLIANCE CERTIFICATION**

**US Army Corps of Engineers**
**Mobile District**

Permit Number: **SAM-2013-1399-DEM**

Name of Permittee: **ADCNR- MARINE RESOURCES DIVISION**

Date of Issuance: **February 5, 2014**

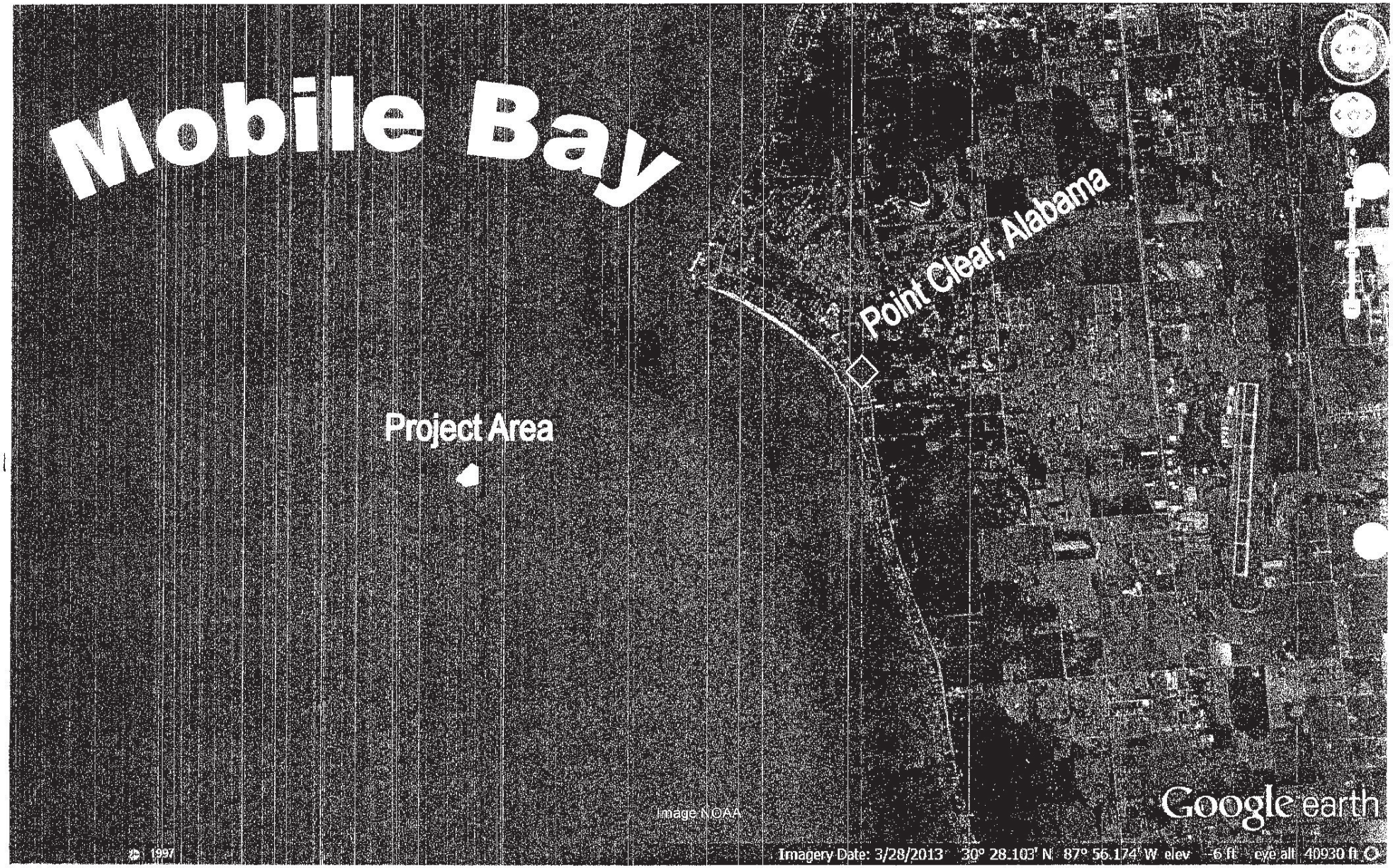
Upon completion of the activity authorized by this permit and any mitigation required by the permit, please sign this certification and return it to the following address:

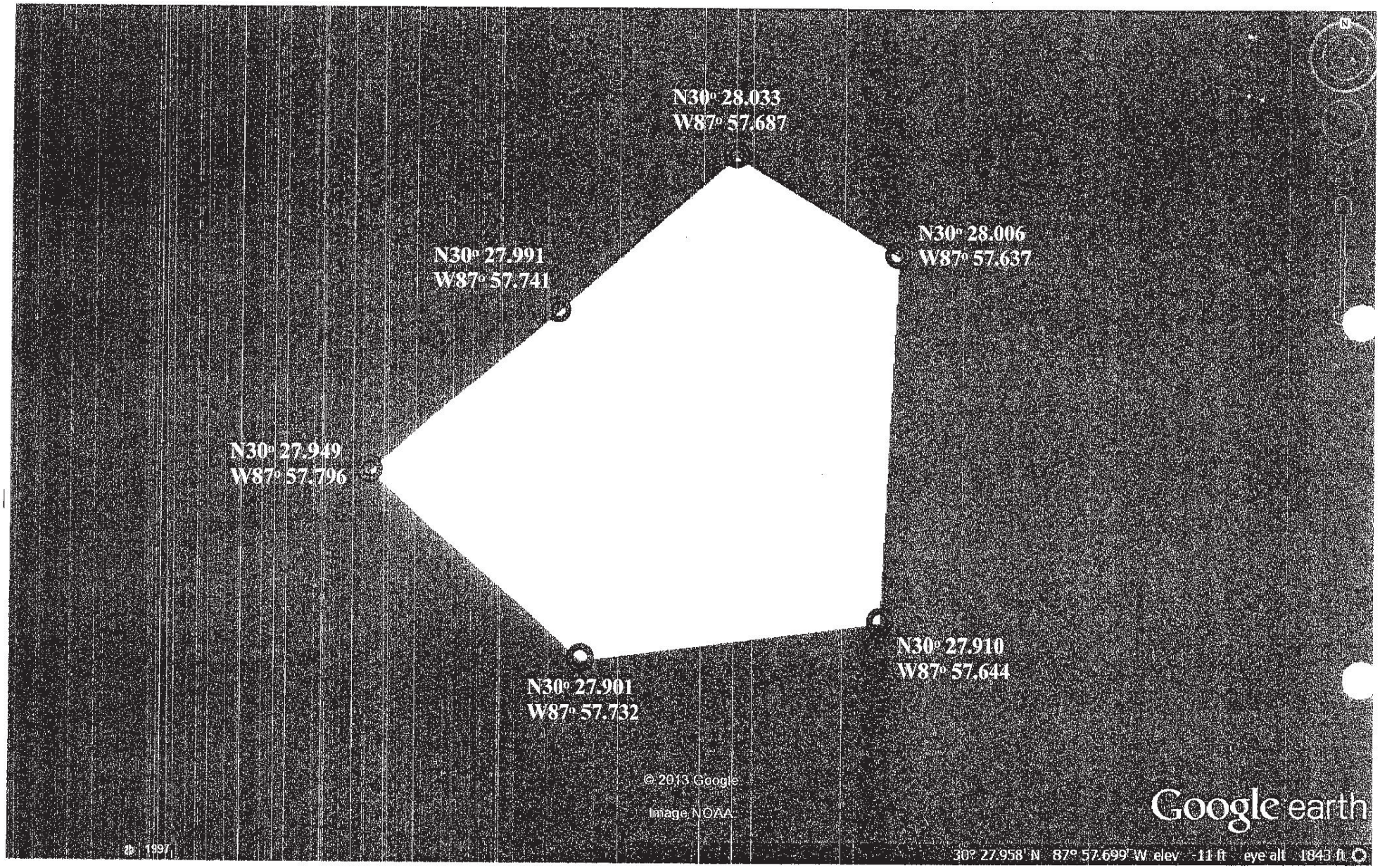
U.S. Army Corps of Engineers
Mobile District
Regulatory Division
Coastal Branch
Post Office Box 2288
Mobile, Alabama 36628-0001

Please note that your permitted activity is subject to a compliance inspection by a U.S. Army Corps of Engineers representative. If you fail to comply with all terms and conditions of this permit the permit is subject to permit suspension, modification, or revocation and you are subject to an enforcement action by this office.

I hereby certify that the work authorized by the above-referenced permit has been completed in accordance with the terms and conditions of the said permit, and the required mitigation was completed in accordance with the permit conditions.

_____ _____
Signature of Permittee Date


Mobile Bay
Point Clear, Alabama
Project Area
Image NOAA
Google earth
© 1997
Imagery Date: 3/28/2013 30° 28.103' N 87° 56.174' W elev -6 ft eye alt 40930 ft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W87° 57.687
N30° 28.006
W87° 57.637
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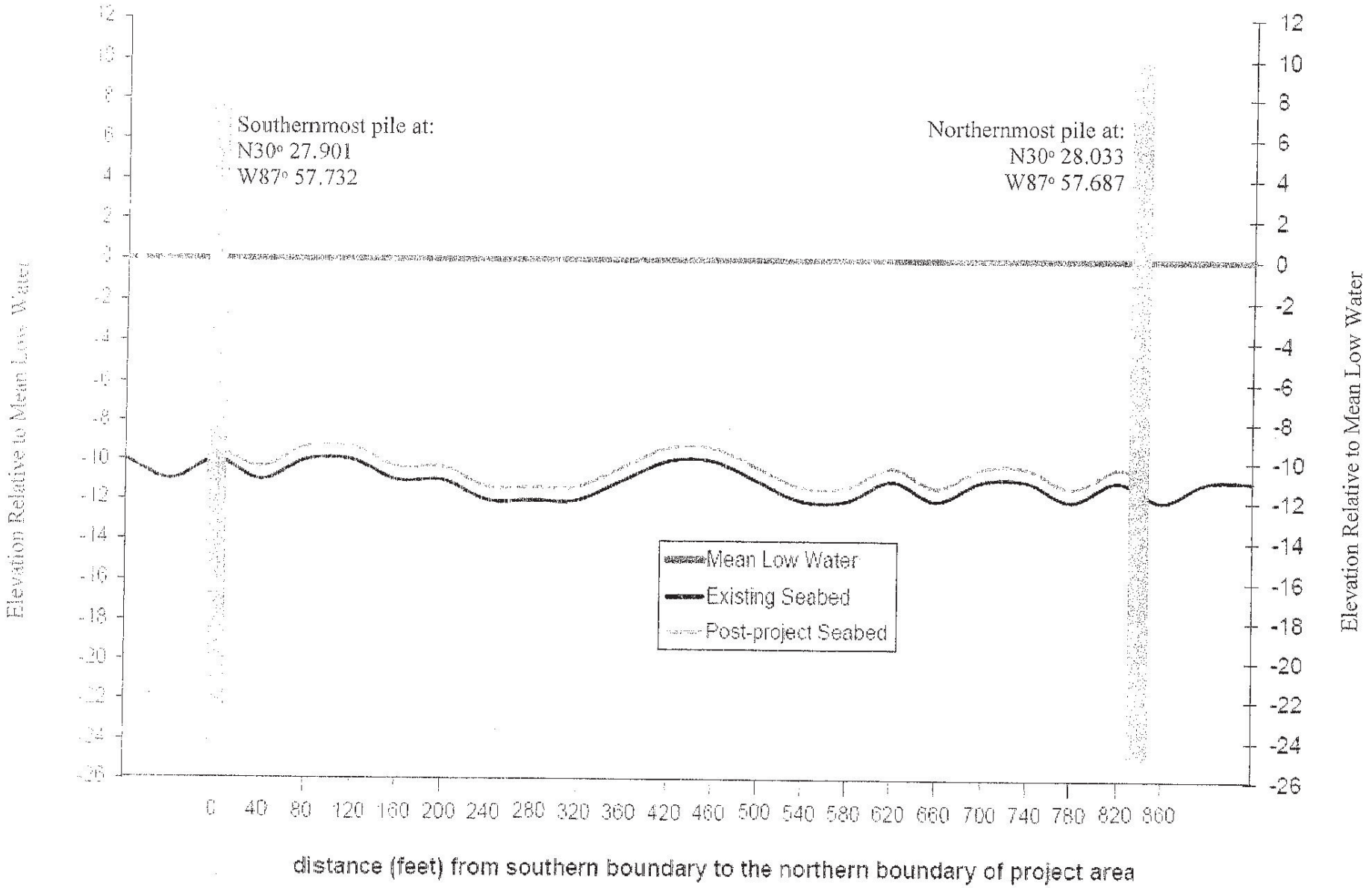
N30° 27.949
W87° 57.796
N30° 27.910
W87° 57.644
N30° 27.901
W87° 57.732
© 2013 Google
Image NOAA
Google earth
1997
30° 27.958' N 87° 57.699' W elev -11 ft eye alt 1843 ft

Profile of the existing seabed, proposed seabed, southernmost pile, and northernmost pile at the proposed reef site.



# This notice of authorization must be conspicuously displayed at the site of work.

United States Army Corps of Engineers

A permit to perform work authorized by statutes and regulations of the Department of the Army

at **MOBILE BAY, NEAR POINT CLEAR, BALDWIN COUNTY, ALABAMA**

has been issued to **ADCNR – MARINE RESOURCES DIVISION** on **FEB 5, 2014**

Address of Permittee **C/O MR. CHRIS BLANKENSHIP**
**POST OFFICE BOX 189**
**DAUPHIN ISLAND, ALABAMA 36528**

Permit Number

**SAM-2013-1399-DEM**

For the *District Commander*

**DONALD E. MROCZKO**
**REGULATORY DIVISION RD-A**

ENG FORM 4336, Jul 81 (33 CFR 320-330) EDITION OF JUL 70 MAY BE USED (Proponent: CECW-0)

Fisheries Research 147 (2013) 349–358

Contents lists available at ScienceDirect

Fisheries Research

journal homepage: www.elsevier.com/locate/fishres

# Implications of reef fish movement from unreported artificial reef sites in the northern Gulf of Mexico

Dustin T. Addis [a,*], William F. Patterson III [a,1], Michael A. Dance [a,2], G. Walter Ingram Jr. [b]

[a] University of West Florida, Biology Department, Building 58, 11000 University Parkway, Pensacola, FL 32514, USA
[b] NOAA Fisheries, Southeast Fisheries Science Center, Mississippi Laboratories, 3209 Frederic Street, Pascagoula, MS 39567, USA

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ABSTRACT

Artificial reefs were deployed in the northeastern Gulf of Mexico (GOM) by the state of Florida's marine fisheries agency but not reported to the public in an attempt to create no-harvest refuges for exploited fishes. As part of a broader examination of the efficacy of this approach, a tagging study was conducted at a subset ($n = 9$) of these unreported artificial reefs to examine the likelihood that reef fishes would remain associated with them and to test factors affecting species-specific movement. Quarterly tagging trips ($n = 12$) were made between March 2005 and December 2007 during which 3109 fish among 12 species were tagged with internal anchor tags. Red snapper (*Lutjanus campechanus*, $n = 2114$), gray triggerfish (*Balistes capriscus*, $n = 267$), and groupers (Family: Serranidae, $n = 148$), were among the most frequently tagged fishes. Eighty-six fish were recaptured on subsequent tagging trips and fishermen reported 249 recaptures caught away from study sites. Mean (SD) distance moved among recaptures with reported recapture location was 37.1 (6.6) km for red snapper ($n = 173$), 8.8 (3.1) km for gray triggerfish ($n = 47$), and 25.2 (14.9) km for groupers ($n = 26$). During the study, a hurricane passed over the study area, thus adding an unplanned factor to movement analyses. Fish size, reef depth, time free, and hurricane exposure significantly affected the likelihood of red snapper movement ($p < 0.020$), but only fish size significantly affected distance moved ($p = 0.036$). No factors significantly affected gray triggerfish movement, and low sample size precluded statistical tests of grouper movement. Overall, results indicate that large scale (>100 km) red snapper movement was not dependent on hurricane occurrence, while gray triggerfish displayed mostly limited (<10 km) movement irrespective of factors tested. The scale of movement observed suggests the efficacy of unreported artificial reefs to serve as no-harvest refuges is doubtful, especially when regional fishing mortality is high. Marine protected areas may be an effective alternative approach to facilitate the recovery of overfished stocks, but would need to be expansive to account for reef fish movement.

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## 1. Introduction

Reef fishes are highly susceptible to fishing given their strong association with structured habitat makes them easy to target in the coastal zone (Polunin and Roberts, 1996). Their affinity for structured habitat, the ability of fishers to predict their spatial distribution, and a generally high market demand for reef fish meat have resulted in reef fishes being among the more imperiled groups of marine fishes (Dulvy et al., 2003; Hawkins et al., 2000; Paddack et al., 2009; Sadovy and Domeier, 2005). Reef fishes are highly targeted in waters off the southeastern United States and several species of lutjanids, serranids, carangids, and balistids are estimated to be overfished in the region (Coleman et al., 2004b; NMFS, 2012).

The overfished status of reef fishes is an important fisheries management issue in the eastern Gulf of Mexico (GOM) where numerous species are targeted at artificial reefs (Dance et al., 2011; Patterson and Cowan, 2003). Artificial reefs have been widely deployed as fishing tools in the region and their usage also has become increasingly incorporated into management plans (Lindberg and Seaman, 2011; Seaman, 2007). In the state of Florida, fisheries management strategies have been directed to limit fishing pressure by deploying artificial reefs in areas of little or no fishing activity, creating unpublished artificial reefs, and incorporating reef designs aimed at increasing juvenile survivorship (FWC, 2003; Lindberg and Loftin, 1998; Lindberg and Seaman, 2011). Alternatively, deploying artificial reefs within marine protected areas

* Corresponding author. Present address: Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute, 100 8th Avenue S.E., St. Petersburg, FL 33701, USA. Tel.: +1 727 502 4935; fax: +1 727 893 1374.
*E-mail address:* Dustin.Addis@myfwc.com (D.T. Addis).
[1] Present address: University of South Alabama and Dauphin Island Sea Lab, 101 Bienville Boulevard, Dauphin Island, AL 36528, USA.
[2] Present address: Department of Marine Biology, Texas A&M University at Galveston, 1001 Texas Clipper Road, Galveston, TX 77554, USA.

0165-7836/$ – see front matter © 2013 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.fishres.2013.07.011

**Table 1**
Dimensions of study artificial reef types deployed in the Escambia East Large Area Artificial Reef Site. Reef dimensions are for single modules of all types. Reef volumes are total volumes for solitary type A modules, and for type B and type C paired modules.

| Reef parameter | Type A: | Type B: | Type C: |
|---|---|---|---|
| Construction material | Concrete/rebar | Concrete | Concrete |
| Modules per site | 1 | 2 | 2 |
| Module height (m) | 3.05 | 1.83 | 1.45 |
| Module base (m) | 3.05 | 3.05 | 1.83 |
| Reef volume ($m^3$) | 4.09 | 4.90 | 2.84 |

(MPAs) is a management strategy with the potential to protect reef fish populations via gear restrictions or no fishing effort allowed inside MPA boundaries (Albouy et al., 2011; Claudet et al., 2006; McClanahan et al., 2006).

An important ecological component to consider when proposing artificial reefs as a management tool is the site fidelity and movement of reef fish associated with artificial reefs (Patterson and Cowan, 2003; Shipp, 2003). Bohnsack (1989) hypothesized that production of fishes that exhibit low site fidelity and partial reef dependence would be less likely to be enhanced through artificial reef creation. Furthermore, in the context of management strategies, fishes that display greater movement may have increased exposure to fishing mortality when moving between areas of lower and higher fishing effort (Crowder et al., 2000; Hampton and Fournier, 2001; Kaunda-Arara and Rose, 2004).

In 2003, the state of Florida took a new management approach in deploying unpublished artificial reefs (i.e., reef creation and coordinates not reported to the public) in an effort to establish no-harvest refuges for reef fishes in the eastern GOM. The Florida marine resource agency, the Florida Fish and Wildlife Conservation Commission (FWC), constructed 525 of these unreported artificial reefs off northwest Florida which were distributed equally among four Large (~225 $km^2$) Area Artificial Reef Sites (LAARS). The objective of the program was to create no-harvest refuges to mitigate high regional fishing mortality for overfished reef fishes such as red snapper (*Lutjanus campechanus*), gray triggerfish (*Balistes capriscus*), and gag (*Mycteroperca microlepis*). As part of a broader examination of the efficacy of this approach (Dance et al., 2011), a tagging study was conducted to estimate movement and dispersion of tagged reef fishes. The objective of this study was to determine the likelihood that species of interest would remain associated with unreported reef sites versus displaying movement to other, known reefs targeted by fishers. Factors affecting reef movement also were tested.

## 2. Materials and methods

### 2.1. Study area

Study reefs were located in the Escambia East-LAARS (EE-LAARS) approximately 24–32 km south of Pensacola, Florida in the northeastern GOM (Fig. 1). Reefs consisted of three different prefabricated designs (Table 1) and were deployed in spring 2003 at depths between 28 and 38 m. The first, or A-type reefs consisted of a single pyramid module with a concrete frame, open base, and steel rebar in a lattice configuration along their sides. B-type reefs were a pair of concrete modules that shared the same base dimensions as A-type modules but were shorter and had flattened tops. They also had several triangular openings and secondary smaller modules inserted inside the larger modules. C-type reefs consisted of a pair of Reef Ball® modules which were constructed of concrete with several wall openings and an open top.

### 2.2. Fish tagging

Quarterly tagging trips were made between winter 2005 and fall 2007. Tagging effort was standardized among reefs. Over a given site, five anglers targeted fish to be tagged for 30 min. Four anglers used bottom rigs that consisted of two 3/0 Mustad 34007 J hooks each tied to a 0.5-m leader and baited with squid (*Loligo* sp.) or cut mackerel scad (*Decapterus macarellus*). A fifth angler fished in the water column above the reef using a rig that consisted of two 5/0 Mustad 34007 J hooks snelled 10 cm apart to the end of a 1.5-m leader and baited with a whole mackerel scad. Fish were brought to the surface at a rate of approximately 1 m $s^{-1}$. Fish were immediately removed from hooks and placed into a 475-L holding tank filled with flowing seawater. Fish were removed from the tank and measured to the nearest mm fork length (FL) or total length (TL). Fish >250 mm TL were tagged with an internal anchor tag inserted into a small (<5 mm) incision in the abdominal cavity and then released. Anchor tags were marked with the word "REWARD," an identifying tag number, and a toll free number to report tag recoveries. The tagging study was advertised to recreational and commercial fishers via several media outlets to encourage fisherman to report tag recoveries. Posters advertising the tagging study also were placed in marinas and tackle shops between Bay St. Louis, Mississippi and Panama City Beach, Florida. Those who reported a tag recovery received a $10 reward per tag and were entered into a $500 annual lottery of all tag returnees. Tag recovery information obtained from those who called the toll-free number included the tag number, location of recapture (GPS coordinates if available), date of capture, and fish length.

Recapture location was plotted in a geographic information system (GIS) for tag recoveries for which sufficient information on recapture location was reported by fishermen (ArcView 9.3.1). Fish movement was estimated as the straight-line distance between tagging reef and recapture location, and dispersion rate was estimated as this distance divided by time free. Movement could not be estimated for recaptures for which location was not reported. Tag recoveries for which recapture location was reported imprecisely but in the general direction and area of the EE-LAARS (e.g., 30 km southeast of Pensacola Beach), were conservatively assumed to be caught within the EE-LAARS. For these recoveries and others reported as being caught within the EE-LAARS but without specific GPS coordinates, movement was estimated based on the distributions of taxa-specific movement of fish recaptured within the EE-LAARS for which exact location of recapture was reported. This was performed by generating a random probability and calculating the inverse of the normal cumulative distribution for the mean and variance of taxa-specific movement estimated from fish with exact EE-LAARS recapture locations reported. This was done because omitting samples caught near (<10 km) study reefs but without precise recapture location would bias movement estimates high. Movement analyses described below were computed both with and without these additional samples.

### 2.3. Movement analysis

Analysis of the effect of fish size, time free, reef depth, and reef type on taxa-specific reef fish movement was planned a priori. During the study, the center of Hurricane Dennis (maximum winds 235 km/h) passed within 10 km of tagging sites and made landfall in northwest Florida on July 10, 2005, thus adding an unplanned factor to movement analyses. Therefore, statistical models of reef fish movement included exposure to hurricane as an independent

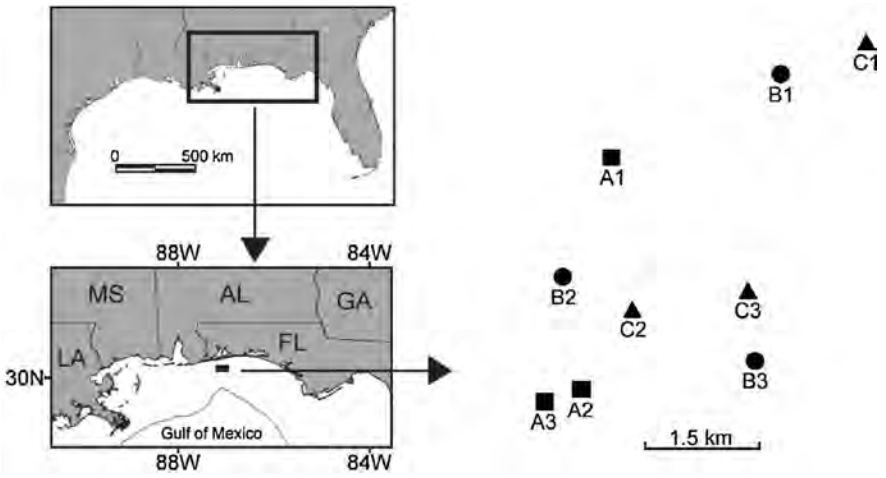


**Fig. 1.** Map of the northern Gulf of Mexico indicating the location of the Escambia East-Large Area Artificial Reef Site (black rectangle) and artificial reef study sites ($n = 9$). The letters A, B, and C correspond to artificial reef types listed in Table 1.

variable, and taxa-specific estimates of mean movement and dispersion rates were made separately for tagged fish exposed and not exposed to Hurricane Dennis. To maintain independence, only data from terminal recaptures of fish recaptured more than once were used to compute mean distance moved, mean dispersion rate, or statistical models of movement.

The delta method was employed to estimate unbiased taxa-specific estimates of mean distance moved and mean dispersion rate, as well as their standard deviation (SD) (Aitchison, 1955; Patterson and Cowan, 2003). Delta lognormal models were computed to test whether factors significantly affected the probability and magnitude of distance moved by tagged fish away from release sites (Lo et al., 1992). Models were only run for red snapper and gray triggerfish due to the low sample size for groupers and other species. The tested main effects included fish size, reef type, depth, time free, and hurricane exposure on distance moved. Movement data with zero inflation from true zeros were modeled with a combination of two distinct generalized linear submodels computed within the delta lognormal model. A binomial submodel (Proc GLIMMIX, SAS Inc., 2008) was computed to test factors affecting the proportion of positive movement values (i.e., movement versus non-movement), and a lognormal submodel (Proc MIXED, SAS Inc., 2008) was computed to test the effect of the same factors on the magnitude of movement among fish recaptured away from tagging sites (Lo et al., 1992). Significance was evaluated at $\alpha = 0.05$ based on results of type 3 tests.

## 3. Results

### 3.1. Fish tagging

Twelve tagging trips were conducted quarterly from March 2005 to December 2007. A total of 3109 fish among 12 species were tagged with internal anchor tags (Table 2). An additional 345 fish were caught but not tagged due to small size or being non-target species. The most frequently tagged species was red snapper ($n = 2114$), followed by red porgy (*Pagrus pagrus*, $n = 422$), gray triggerfish ($n = 267$), and gag ($n = 96$), respectively (Table 2). A total of 620 fish were tagged during the first two tagging events before Hurricane Dennis passed through the study area.

### 3.2. Tag recaptures, movement, and dispersion

Eighty-six tagged fish were recaptured at study reefs during subsequent tagging trips, and fisherman reported 249 fish recaptured away from study reefs through September 2009 (fisher return rate = 8.0%). The most commonly recaptured species was red snapper ($n = 44$ at study sites, $n = 188$ reported by fishermen), followed by gray triggerfish ($n = 30$ at study sites, $n = 25$ reported by fishermen) and gag ($n = 5$ at study sites, $n = 14$ reported by fishermen). Movement was generated for imprecisely reported EELAARS recapture locations for 38 red snapper (18% of recaptures), 6 gray triggerfish (11% of recaptures), and 3 grouper (10% of recaptures). The inclusion of movement estimates for these fish resulted in lower estimates of mean distance moved and dispersion rate (Table 3). Red snapper displayed the highest movement among all species (Table 3; Fig. 2A and B). Mean distance moved by individuals not exposed to Hurricane Dennis ($n = 157$) was 25.2 (4.7) km (Fig. 5A), while mean movement of individuals exposed to the hurricane ($n = 53$) was 44.0 (12.5) km (Fig. 5B). The estimated mean dispersion rate (SD) for red snapper was the highest among all species (Table 3), with a rate of 119.9 (27.1) m $d^{-1}$ for individuals not exposed to the hurricane (Fig. 6A) and 132.8 (39.6) m $d^{-1}$ for individuals exposed to the hurricane (Fig. 6B). One red snapper was recaptured during two separate tagging events, and 16 red snapper moved farther than 100 km away from release sites. The farthest movement observed among all tagged fish was 320 km for a red snapper free for 395 d, which was one of 7 red snapper recaptured south or east of Cape San Blas, Florida. The longest time free among all tagged fish was displayed by a red snapper exposed to the hurricane and recaptured 1566 days post tagging and 238 km away from its release site.

Gray triggerfish had the highest percentage of recaptures made at tagging reefs (54.5%) and showed the least movement among tagged species (Table 3; Fig. 3A and B). Individuals not exposed to Hurricane Dennis ($n = 34$) moved a mean distance of 5.9 (2.7) km (Fig. 5C) and individuals exposed to the hurricane ($n = 11$) moved 18.4 (6.8) km (Fig. 5D). Gray triggerfish displayed the lowest movement overall, with a mean dispersion rate of 55.9 (30.5) m $d^{-1}$ for individuals not exposed to the hurricane (Fig. 6C) and 69.6 (17.8) m $d^{-1}$ for individuals exposed to the hurricane (Fig. 6D). Five recaptured gray triggerfish were free for longer than a year, all of which were recaptured at tagging sites. The longest time free (616 d) was for a fish exposed to the hurricane and recaptured 61 km to the east southeast of its initial tagging site. Four gray triggerfish were recaptured multiple times during tagging events.

Collectively, grouper movement was intermediate to that of red snapper and gray triggerfish (Table 3; Fig. 4A and B). However, grouper movement was highly variable, especially among individuals exposed to the hurricane. Individuals not exposed to Hurricane

**Table 2**
List of reef fish species tagged at artificial reef study sites in the northeastern Gulf of Mexico. Lengths (mm) are total length for all species except gray triggerfish, for which fork length is reported.

| Species | Number tagged | Mean length at tagging (SD) | Reported by fishermen (% total tagged) | Recaptures at study sites (% total recaptures) | Mean days free among all recaptures (SD) |
|---|---|---|---|---|---|
| Red snapper | 2114 | 358 (55.8) | 188 (8.9%) | 44 (19.0%) | 313 (278.6) |
| Red porgy | 422 | 300 (26.3) | 12 (2.8%) | 2 (14.3%) | 81 (135.5) |
| Gray triggerfish | 267 | 344 (50.6) | 25 (9.4%) | 30 (54.5%) | 195 (137.9) |
| Gag | 96 | 518 (83.2) | 14 (14.6%) | 5 (26.3%) | 257 (348.7) |
| Vermilion snapper | 84 | 327 (34.4) | 2 (2.4%) | 1 (33.3%) | 310 (233.0) |
| Almaco jack | 32 | 357 (41.6) | 0 (0%) | 0 (0%) | – |
| Red grouper | 31 | 521 (90.4) | 2 (6.5%) | 4 (66.7%) | 93 (66.0) |
| Scamp | 21 | 409 (58.5) | 5 (23.8%) | 0 (0%) | 273 (251.0) |
| Greater amberjack | 21 | 414 (65.9) | 0 (0%) | 0 (0%) | – |
| Lane snapper | 10 | 327 (67.2) | 1 (10%) | 0 (0%) | – |
| Other species | 11 | 426 (141.0) | 0 (0%) | 0 (0%) | – |
| Total | 3109 | | 249 | 86 | |

**Table 3**
Delta mean taxa-specific estimates of mean (SD) distance moved and mean (SD) dispersion rate of recaptured tagged fish. Additional movement estimates were generated for red snapper ($n = 38$), gray triggerfish ($n = 6$), and groupers ($n = 3$) recaptured within the Escambia East Large Area Artificial Reef Site (EE-LAARS) for which imprecise recapture location was reported based on taxa-specific movement distribution of recaptures made within the EE-LAARS for which latitude and longitude of recapture location were reported.

| Taxon | No additional EE-LAARS estimates included | | | Additional EE-LAARS estimates included | | |
|---|---|---|---|---|---|---|
| | $n$ | Distance (km) (SD) | Dispersion (m d$^{-1}$) (SD) | $n$ | Distance (km) (SD) | Dispersion (m d$^{-1}$) (SD) |
| Red snapper | 173 | 37.1 (6.6) | 140.2 (27.7) | 211 | 29.5 (4.6) | 123.1 (23.3) |
| Gray triggerfish | 47 | 8.8 (3.1) | 51.7 (20.3) | 53 | 7.9 (2.6) | 47.8 (16.5) |
| Groupers | 26 | 25.2 (14.9) | 98.3 (39.9) | 29 | 19.5 (10.3) | 93.1 (37.5) |

Dennis ($n = 19$) moved 2.2 (1.0) km (Fig. 5E) and individuals exposed to the hurricane ($n = 10$) moved 63.8 (37.3) km (Fig. 5F). Dispersion rates for groupers were also variable, with a rate of 58.3 (29.3) m d$^{-1}$ for individuals not exposed to the hurricane (Fig. 6E) and 130.0 (64.9) m d$^{-1}$ for individuals exposed to the hurricane (Fig. 6F). The farthest movement observed among groupers was for a gag that moved 259 km and was recaptured just west of the mouth of the Mississippi River after being free for 806 d. Of the nine groupers recaptured at release sites, the longest residency observed was for a gag free for 353 d.

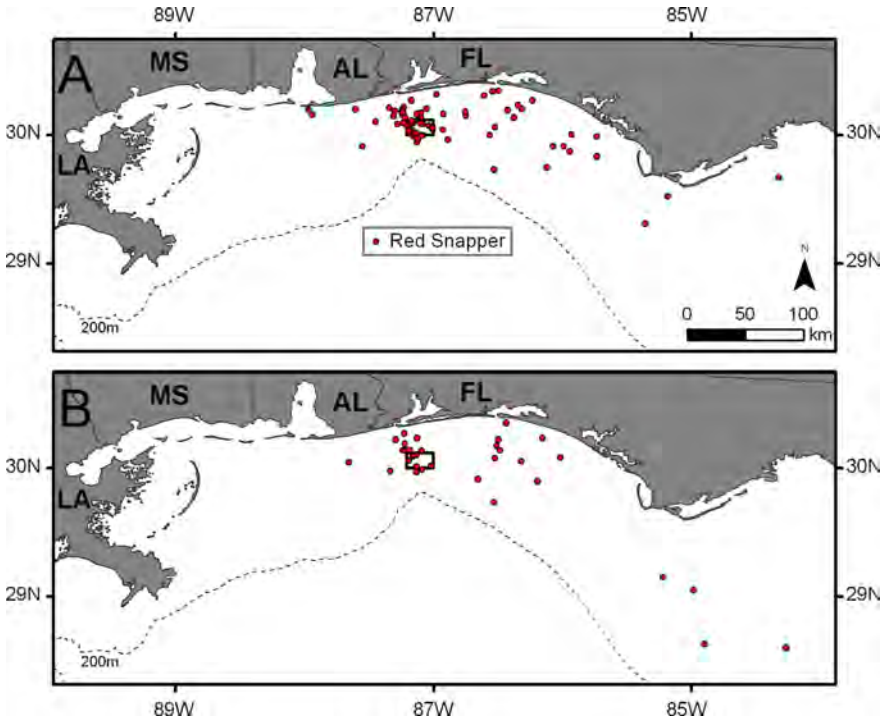


**Fig. 2.** Maps of northern Gulf of Mexico recapture locations reported by fishermen for red snapper (A) exposed and (B) not exposed to Hurricane Dennis. The black rectangle indicates the perimeter of the Escambia East-Large Area Artificial Reef Site where tagging reefs were located. The dashed line indicates the 200 m isobath.

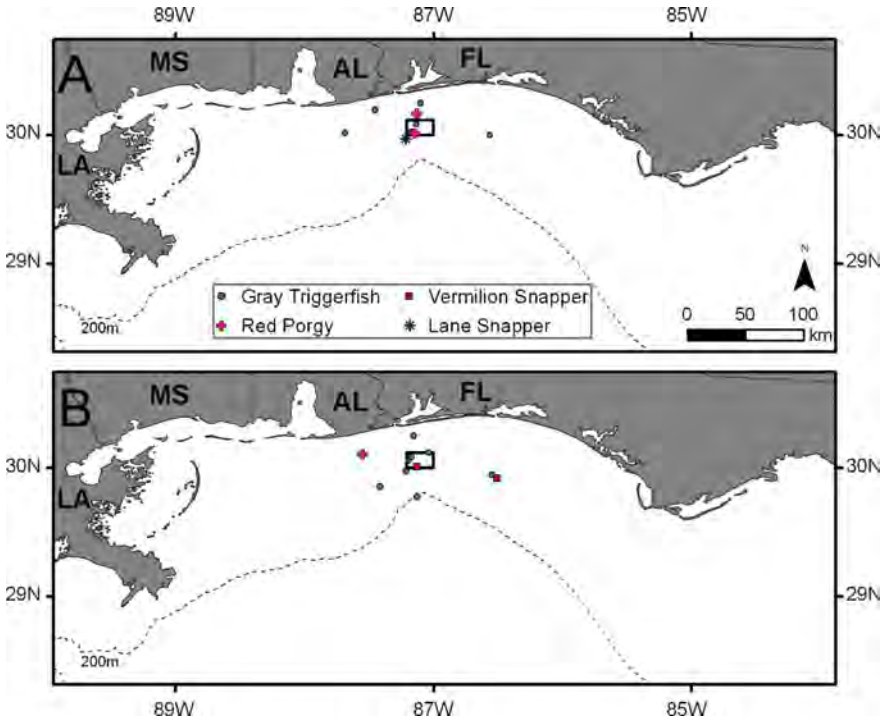


**Fig. 3.** Maps of northern Gulf of Mexico recapture locations reported by fishermen for reef fishes (A) exposed and (B) not exposed to Hurricane Dennis. The black rectangle indicates the perimeter of the Escambia East-Large Area Artificial Reef Site where tagging reefs were located. Legend on panel A indicates species-specific symbols. The dashed line indicates the 200 m isobath.

### 3.3. Movement analysis

Results from the GLIMMIX procedure indicate the probability of red snapper movement away from tagging sites was significantly affected by fish size, depth of tagging sites, time free, and hurricane exposure ($p < 0.02$; Table 4). However, only fish size significantly affected distance moved ($p = 0.036$). The same factors were significant for both the probability and distance of red snapper movement

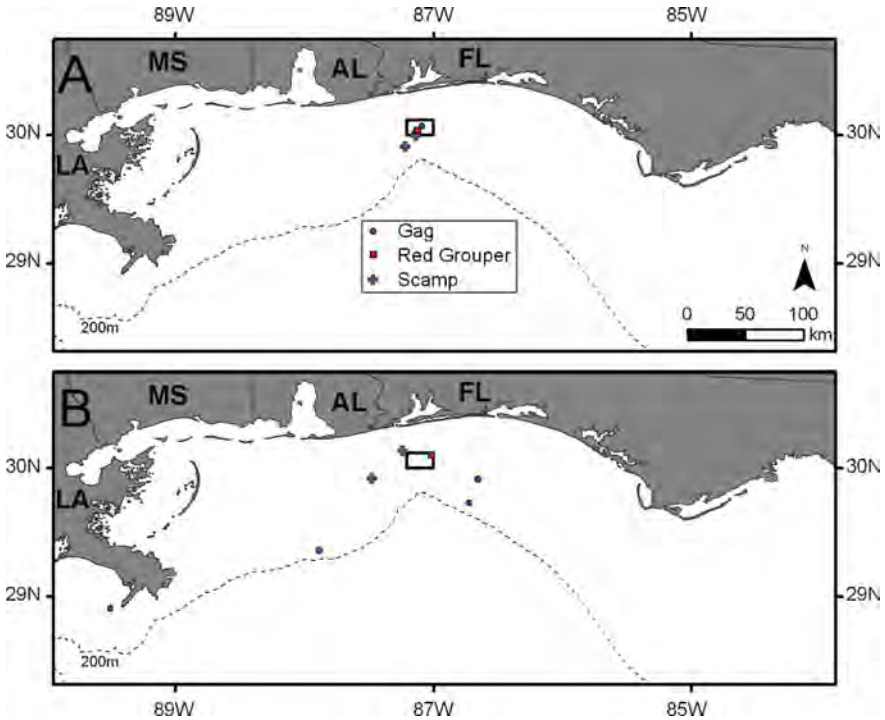


**Fig. 4.** Maps of northern Gulf of Mexico recapture locations reported by fishermen for groupers (A) exposed and (B) not exposed to Hurricane Dennis. The black rectangle indicates the perimeter of the Escambia East-Large Area Artificial Reef Site where tagging reefs were located Legend on panel A indicates species-specific symbols. The dashed line indicates the 200 m isobath.

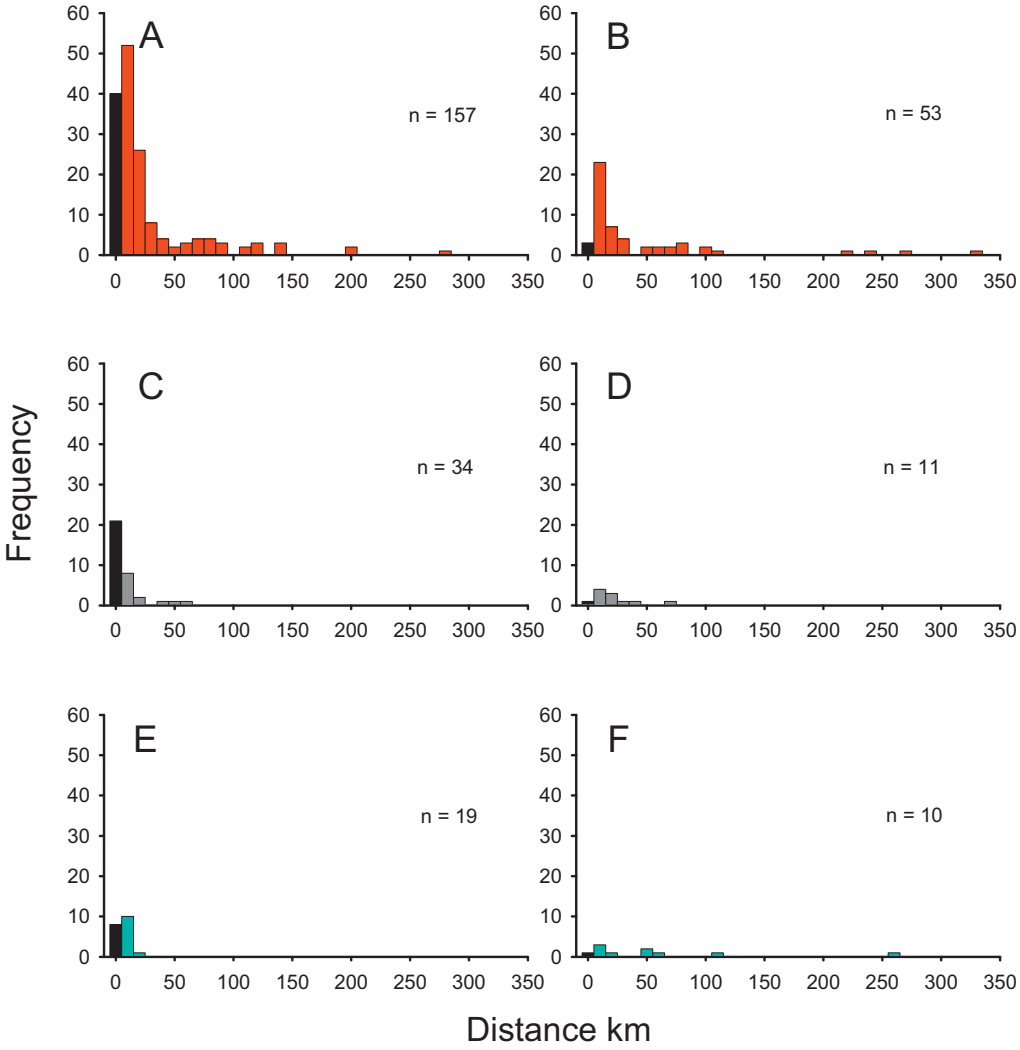


**Fig. 5.** Frequency distributions of estimated distance moved (km) observed for tagged fish exposed to a hurricane: (A) red snapper, (C) gray triggerfish, and (E) groupers; and frequency distributions of estimated distance moved (km) observed for tagged fish not exposed to a hurricane: (B) red snapper, (D) gray triggerfish, and (F) groupers. Recaptures made at study reefs on tagging trips are shown in black (zero movement).

when estimated movement was included for the 38 fish reported as being recaptured within the EE-LAARS but without precise recapture coordinates.

No factors significantly affected gray triggerfish movement in the base model run for that species (Table 4). However, a different result occurred when estimated movement was included for the 6 fish reported as being recaptured within the EE-LAARS but without precise recapture coordinates. In that model, hurricane exposure significantly affected the probability of movement away from tagging sites ($p = 0.035$), but no factors were significant for distance moved.

## 4. Discussion

### 4.1. Fish movement

Red snapper clearly displayed movement on the largest scale among reef fishes tagged in this study. Several individuals tagged in the EE-LAARS moved >100 km to the east and southeast along the west Florida shelf. That scale of movement has been reported previously for this species (reviewed in Patterson, 2007), and is indicative of connectivity between the north central and eastern GOM being facilitated by post-settlement movement of sub-adult and adult fish. Despite significant fishing pressure targeting reef fishes on artificial and natural reefs on the shelf off Alabama and Mississippi (Minton and Heath, 1998; Shipp and Bortone, 2009), relatively few red snapper recaptures were reported west of study reefs. Patterson et al. (2001) also reported movement of red snapper tagged on artificial reefs off Alabama was predominantly to the east, with many recaptures reported from waters off Florida. Therefore, post-settlement movement may provide a recruitment subsidy to the rebuilding red snapper population along the west Florida shelf which exhibited signs of severe depletion as early as the late 19th century (reviewed in Porch, 2007). Furthermore, the scale and predominant direction of movement is consistent with the current approach of assessing GOM red snapper as separate east and west subunits, with the dividing line being the terminus of the Mississippi River, given that no connectivity between the eastern and western GOM was observed despite otherwise significant movement of tagged fish.

Less than 20% of red snapper recaptures in the current study were made at tagging reefs on subsequent tagging trips, which is consistent with low (<50% $y^{-1}$) red snapper site fidelity estimates reported from analysis of conventional and acoustic tagging data

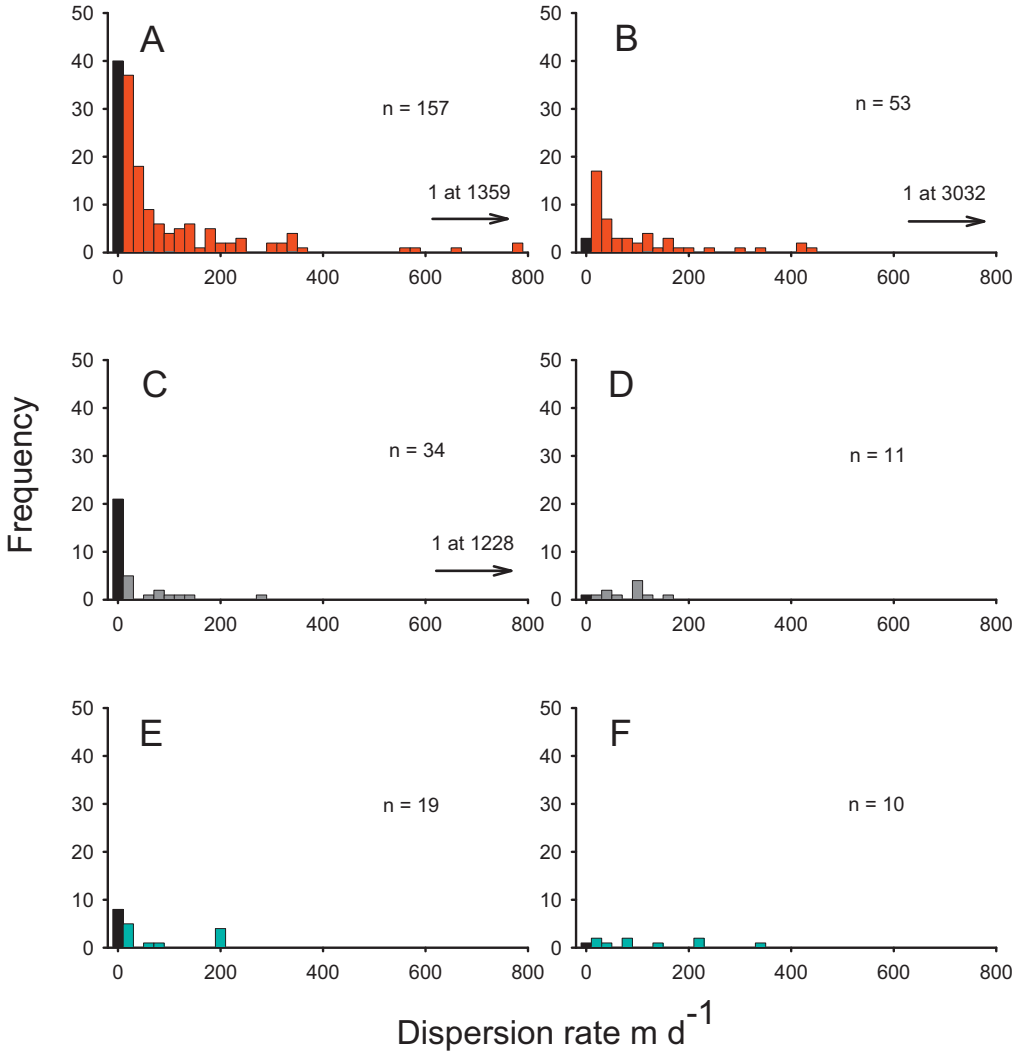


**Fig. 6.** Frequency distributions of estimated dispersion rates (m $d^{-1}$) observed for tagged fish exposed to a hurricane: (A) red snapper, (C) gray triggerfish, and (E) groupers; and frequency distributions of estimated dispersion rates (m $d^{-1}$) observed for tagged fish not exposed to a hurricane: (B) red snapper, (D) gray triggerfish, and (F) groupers. Recaptures made at study reefs on tagging trips are shown in black (zero movement).

(Patterson and Cowan, 2003; Strelcheck et al., 2007; Szedlmayer, 1997; Szedlmayer and Schroepfer, 2005). Topping and Szedlmayer (2011) acoustically tracked adult red snapper at a series of artificial reefs off Alabama in the north central GOM for up to 968 d and concluded that red snapper displayed high site fidelity to their study reefs. While their results may seem inconsistent with the large scale movement reported here and from several other conventional tagging studies (reviewed in Patterson, 2007), a sizeable (20–40%) percentage of red snapper recaptures among conventional tagging studies, including this one, have been what Diamond et al. (2007) referred to as "stayers" (versus "movers"). A key advantage of acoustic telemetry is the ability to estimate daily activity or foraging behavior in stayers, but we are aware of no acoustic arrays in the GOM capable of tracking fish movement over the area of red snapper movement (~40,000 $km^2$) observed in the current study. While the ability to track fish with acoustic tags is limited to the area of detection, conventional tagging enables estimation of larger scale movement, such as reported here for red snapper and other reef fishes (Patterson and Cowan, 2003; Patterson et al., 2001). Clearly, conventional tagging has its own set of limitations, such as tag loss, imprecise recapture location reporting, or low reporting rates, but those limitations tend to cause under – not over-estimation of movement.

Watterson et al. (1998) and Patterson et al. (2001) reported that Hurricane Opal, which made landfall just east of Pensacola, Florida on October 4, 1995, significantly affected movement of red snapper tagged at artificial reef sites in the northern GOM off Alabama. In fact, all the large scale (>100 km) movement of red snapper in their study was of fish at liberty during Hurricane Opal. In the current study, however, more tagged fish ($n = 10$) not potentially affected by Hurricane Dennis moved >100 km than fish ($n = 7$) at liberty during that storm, which is counter to the inference that large scale movement in red snapper only occurs due to hurricanes (Diamond et al., 2007; Gallaway et al., 2009; Gold and Salliant, 2007). It is unclear why the difference in non-storm movement exists between this study and earlier results. Drawing comparisons between tagging studies may also be limited by the many factors that could influence movement that were not tested, such as differences in study locations (e.g., AL versus western FL), habitat type (e.g., mud versus sand), prey availability, or hurricane factors (e.g., duration, direction, or intensity). However, it has been suggested that the expansive shell rubble habitat found 75–200 km to the west of our

**Table 4**
Results of delta-lognormal models (Type III) testing the effect of factors on red snapper ($n = 173$) and gray triggerfish ($n = 47$) movement in the northern Gulf of Mexico. Binomial submodels tested the effect of factors on the probability of movement, while lognormal submodels tested the effect of factors on distance moved for fish recaptured away from tagging sites.

| Model | Effect | D.F. | $\chi^2$ | $F$ value | Pr > $F$ |
|---|---|---|---|---|---|
| Red snapper | | | | | |
| Binomial submodel | Fish size | 1; 165 | 9.94 | 9.94 | 0.011* |
| | Reef type | 2; 165 | 0.68 | 0.34 | 0.721 |
| | Depth | 1; 165 | 9.94 | 9.94 | 0.002* |
| | Time free | 1; 165 | 45.32 | 45.32 | <0.001* |
| | Hurricane | 1; 165 | 42.46 | 42.46 | <0.001* |
| Lognormal submodel | Fish size | 1; 122 | 4.51 | 4.51 | 0.036* |
| | Reef type | 2; 122 | 1.96 | 0.98 | 0.378 |
| | Depth | 1; 122 | 1.18 | 1.18 | 0.280 |
| | Time free | 1; 122 | 0.89 | 0.89 | 0.349 |
| | Hurricane | 1; 122 | 0.13 | 0.13 | 0.719 |
| Gray triggerfish | | | | | |
| Binomial submodel | Fish size | 1; 32 | 2.58 | 2.58 | 0.118 |
| | Reef type | 1; 32 | 0.17 | 0.17 | 0.680 |
| | Depth | 1; 32 | 2.27 | 2.27 | 0.142 |
| | Time free | 1; 32 | 3.34 | 3.34 | 0.077 |
| | Hurricane | 1; 32 | 1.93 | 1.93 | 0.174 |
| Lognormal submodel | Fish size | 1; 10 | 0.11 | 0.11 | 0.752 |
| | Reef type | 2; 10 | 1.38 | 0.69 | 0.525 |
| | Depth | 1; 10 | 0.44 | 0.44 | 0.521 |
| | Time free | 1; 10 | 0.21 | 0.21 | 0.655 |
| | Hurricane | 1; 10 | 0.03 | 0.03 | 0.861 |

* Significance at $\alpha = 0.05$.

study reefs is the most significant red snapper nursery habitat in the north central GOM (Patterson et al., 2005; Wells et al., 2008). Density-dependent emigration of fish from an expanding red snapper population may have resulted in more extensive movement than was observed previously in the absence of hurricanes (SEDAR, 2013).

Small sample sizes of recaptures for several other reef fish species tagged in this study prevented quantitative analysis of movement. However, among those for which modest sample sizes existed, gray triggerfish displayed the most limited movement, while grouper movement was intermediate to that of red snapper and gray triggerfish. Results of the few previous studies of gray triggerfish movement indicate they display limited post-settlement movement and high fidelity to natural and artificial reefs (Beaumariage, 1969; Ingram and Patterson, 2001; Johnson and Saloman, 1984). Specifically, Ingram (2001) estimated gray triggerfish site fidelity to be 63–87% $y^{-1}$ for fish tagged at artificial reefs off Alabama, and recaptured fish moved distances similar to those reported here. Ingram (2001) also reported that hurricanes significantly affected gray triggerfish movement. Hurricane Dennis affected the probability of gray triggerfish movement in the current study when additional EE-LAARS movement estimates were included, but no factors significantly affected the distance gray triggerfish moved. Mean distance moved by fish exposed to Hurricane Dennis was three times greater than that of fish not exposed to the storm. However, high variance and low sample size resulted in a non-significant result for the effect of the hurricane on the distance moved by gray triggerfish.

Grouper are known to display high short term (weeks to months) site fidelity to northern GOM artificial and natural reefs (Lindberg et al., 2006); however, tagged individuals also have displayed significant movement (>100 km) (Heinisch and Fable, 1999; Lindberg et al., 2006; McGovern et al., 2005). Similar patterns of dispersion were apparent for gag in this study, with several recaptures near or at release sites but a few individuals moving significant distances. Additionally, other GOM shallow water groupers (e.g., red grouper *Epinephelus morio*, scamp *Mycteroperca phenax*) have been shown to display similar dichotomous movement behavior (Wilson and Burns, 1996). However, due to a small number of tagged red grouper and scamp, and consequently a low number of reported recaptures, the movement pattern was not apparent for those two species. Most recaptures of red grouper and scamp were at or near tagging sites with no significant movement observed apart from a tagged scamp that moved 41 km to the west of its release site. Overall, grouper recaptures at study sites paired with the significant number of fisherman recaptures within 50 km of the tagging area indicates that groupers perhaps have lower site fidelity than gray triggerfish, but do not move nearly as much as red snapper. It is also well established that GOM shallow water grouper species exhibit ontogenetic shifts in movement to offshore habitats and spawning aggregation sites (Beaumariage, 1969; Coleman et al., 2011; Lindberg et al., 2006; McGovern et al., 2005; Wilson and Burns, 1996). Given that groupers tagged in this study were relatively small, young fish, it is possible that mid-shelf artificial reefs such as those in the EE-LAARS serve as intermediate habitat along this inshore to offshore transition.

### 4.2. Implications for management

Results from this study have several implications for reef fish management in the northern GOM, as well as for the broader use of artificial reefs in reef fish fisheries. Foremost, movement results indicate that mobile reef fish, such as red snapper, would be unlikely to remain resident at unreported artificial reef sites. Among the reef fishes for which we have the most movement data, red snapper, gag, and gray triggerfish are all estimated to be severely overfished in the northern GOM (SEDAR, 2006, 2011, 2013). Not coincidentally, these fishes also are among the most heavily targeted species in the northern GOM reef fish fishery. Therefore, even small scale (<5 km) movement away from unreported reef sites likely exposed fish to high regional fishing mortality among publically known natural or artificial reefs. We did not witness any fishing occurring at tagging reefs or at other unreported reefs in the EE-LAARS during remotely operated vehicle based video sampling (Dance et al., 2011), nor were any tag recaptures reported with GPS coordinates that matched those of study reefs. However, given the amount of known natural and artificial reef habitat in the region it is unlikely that unreported reef sites could go undetected by fishers indefinitely. Therefore, the long term efficacy of unreported reef sites serving as no-harvest refuges would be doubtful even for fish such as gray triggerfish that display limited post-settlement movement.

Reef fish movement estimates reported here also have implications for consideration of MPAs as fishery management tools in the northern GOM. Coleman et al. (2011) reported that large (>700 mm TL) red snapper and gag demonstrated site fidelity to offshore grouper spawning aggregation sites in the northeastern GOM. They inferred that MPA creation or expansion would likely protect spawning stock biomass for both those species. However, it is apparent from this study and others that young red snapper and gag are capable of moving extensive distances. For gag, protection by MPAs across life stages would require corridors of protected habitats across the shelf from estuarine nursery areas to shelf edge spawning aggregation sites. For red snapper, however, the issue is even more complex given they do not aggregate to spawn, and movement within a given depth stratum can be extensive.

The state of Florida's artificial reef strategic plan (FWC, 2003) calls for the design and placement of artificial reefs within zoned management areas for the enhancement of reef fish stocks. Results from this study indicate that deploying unpublished artificial reefs near known natural or artificial reef habitat is unlikely to create no-harvest refuges toward achieving this enhancement goal.

Furthermore, modern sonar and GPS technologies would likely facilitate discovery of unreported artificial reefs over time. However, deploying unpublished artificial reefs within the boundaries of a no-take MPAs, presuming areas were planned and sited effectively, could potentially benefit the recovery or maintenance of reef fish biomass (Crowder et al., 2000; Pitcher et al., 2002; Coleman et al., 2004a; Claudet et al., 2006). A network of MPAs exists in the GOM, but individual protected areas are limited in spatial extent (<1000 $km^2$), only exclude certain fishing gears, or are only seasonally closed to fishing (Coleman et al., 2004a). Some managers have expressed general skepticism about the utility of creating MPAs as a fisheries management tool in the region (Shipp, 2003), while movement patterns of many exploited species suggest the dimensions of future MPAs would have to be much larger than current MPAs to have a significant impact on the spawning stock biomass of overfished stocks (Walters, 2000; Walters et al., 2007). Clearly, the potential benefits of MPAs go beyond fisheries management (Lester et al., 2009), but much of the discussion of developing a network of MPAs in federal waters of the GOM has centered on fisheries conservation, access to fisheries, or both.

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# FISH COMMUNITY AND TROPHIC STRUCTURE AT ARTIFICIAL REEF SITES IN THE NORTHEASTERN GULF OF MEXICO

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## ABSTRACT

Fish community and trophic structure were examined quarterly from fall 2004 through spring 2007 at 27 artificial reef sites located 15–20 mi south of Pensacola, Florida. Location of study sites was not reported to the public when reef modules were deployed in 2003, thus sites were presumed to be unfished. Community structure estimates were derived from video sampling that was performed with a micro remotely operated vehicle (ROV) equipped with a laser scale to estimate fish size. A total of 81,207 individuals from 77 different taxa was enumerated from video samples. Fish assemblages were dynamic in species richness, fish community structure, and trophic structure across time and by reef design. Total fish density, biomass, and species richness increased across time. Red snapper, *Lutjanus campechanus* (Poey, 1860), was by far the most abundant species (29% of individuals, 45% of total biomass), and its density and biomass increased over the course of the study. Differences in fish community structure were driven by sharp declines in grouper abundance and the proliferation of smaller fishes across time. Trophic structure was consistently dominated by invertivore/piscivores, while fluctuation in piscivore biomass and increased abundance of planktivores drove differences in trophic structure. Size distributions for many fishery species known to display low annual site fidelity were composed primarily of young, sub-legal individuals. Disappearance with increasing fish size was likely due to shifting ontogenetic habitat requirements or exposure to high regional fishing mortality for species that displayed low annual site fidelity to study sites.

Artificial reefs are commonly deployed in marine waters off the southeastern United States for a variety of purposes, including mitigating loss of hard-bottom habitat, enhancing fishery yields, enhancing production of reef-associated invertebrates and fishes, and creating opportunities for diving and fishing in nearshore environments (Stone et al. 1991, Spanier and Barshaw 1994, Baine 2001). Perhaps the most frequently stated objective of artificial reef construction is to recover overfished reef fish populations (Lindberg 1997). Increased catch rates and high fish densities at artificial reef sites have led some to perceive these structures as beneficial to fish stocks by providing increased hard bottom habitat to reef fishes (Minton and Heath 1998, Shipp and Bortone 2009). Recreational and commercial fishermen have been the biggest supporters of artificial reefs, and the idea that these structures provide beneficial habitat enhancement likely has been widely accepted because it is consistent with the conservation ethic of many fishermen (Lindberg 1997). This is of particular importance in the northern Gulf of Mexico (GOM) where many large reef fishes (e.g., gag *Mycteroperca microlepis*, red snapper *Lutjanus campechanus*, greater amberjack *Seriola dumerili*, and gray triggerfish *Balistes capriscus*) found at artificial reefs are estimated to either be fully exploited or overfished (Patterson and Cowan 2003).


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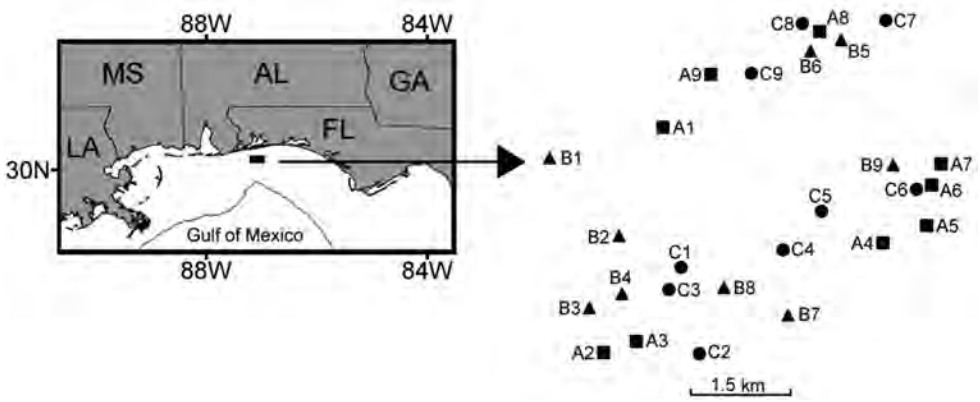


Figure 1. Map indicating the locations of study artificial reefs within the Escambia East Large Area Artificial Reef Site (black rectangle). Letters in reef names indicate A-, B-, or C-type reefs. The 200-m isobath is shown to indicate the edge of the continental shelf.

If reefs function ecologically to generate a net increase in fish production, then increased catch rates may be supported by enhanced productivity (Bohnsack 1989). Alternatively, if reefs function as a net sink of production, then high catch rates may encourage the continued mass deployment of artificial reefs, which in turn may push fishing mortality to unsustainable levels or exacerbate the already poor stock status of many species (Grossman et al. 1997). Historically, this dilemma has been called the attraction-production debate (Bohnsack and Sutherland 1985, Bohnsack 1989, Grossman et al. 1997). However, attraction and production are not mutually exclusive, but instead are two endpoints along a continuum (Bohnsack 1989, Lindberg 1997, Osenberg et al. 2002). A multitude of factors may influence where a given reef fish species will fall along this continuum, including fish behavior and site fidelity, fishing pressure, habitat availability, and recruitment limitation (Bohnsack 1989).

A unique opportunity to examine artificial reef function was created in 2003 in the northeastern GOM when the Florida Fish and Wildlife Conservation Commission (FWCC) deployed over 500 artificial reefs within four Large Area Artificial Reef Sites (LAARS) off northwest Florida. The coordinates of these sites were not reported to the public in hopes that the reefs would serve as no-harvest refugia for exploited reef fishes. In theory, enhanced production at these sites would allow them to act as net sources for local reef fish populations. While the purpose of establishing refugia sites was to mitigate against heavy fishing pressure on reef fishes, the hypothesis that they have a beneficial effect must be tested by examining community succession over time, as well as monitoring the size and population dynamics of fishes present on these reefs.

The objective of this research was to examine reef fish community and trophic structure among unpublished artificial reef sites of three different designs deployed within the Escambia East LAARS (EE-LAARS) off Pensacola, Florida (Fig. 1). Quarterly remotely operated vehicle (ROV) based video sampling was conducted over 3 yrs to examine seasonal and interannual shifts in community and trophic structure, as well as differences among reef types. The effects of sampling quarter and reef type on taxa- and trophic level-specific density, biomass, and size distribution estimates also were examined.

## Methods

Reef Design and ROV Sampling.—Sampling occurred at a randomly chosen subset of 27 artificial reef sites located within the EE-LAARS off Pensacola, Florida, at depths ranging from 27 to 41 m (Fig. 1). Sites consisted of one of three different reef designs (Fig. 2), which was pre-determined based on FWC deployment of reefs in 2003. A-type reefs were pyramids that had concrete corners, mesh rebar sides, a height of 3.05 m, and a total reef volume of ~4.1 $m^3$ (Fig. 2A). B-type reefs consisted of paired three-sided, flat-topped concrete models with five triangular holes cut in each side and a smaller concrete module deployed in the center of each of the larger modules (Fig. 2B). Height of each module was 1.83 m and total reef volume was ~4.9 $m^3$. Lastly, C-type reefs consisted of paired 1.45-m tall dome-shaped concrete reefs that had a hollow center, a hole in the top, and numerous small cavities or passages into the reef center (Fig. 2C). Total volume for C-type reefs was the smallest of the three reef types at ~2.8 $m^3$.

Sampling was conducted quarterly from December 2004 through June 2007 (December, March, June, and September) with a VideoRay Pro3 micro ROV, which was equipped with a red laser scale (10 cm between lasers) to estimate fish length. The video feed from the ROV's 570-line camera was viewed on a 38-cm monitor and recorded with a digital videocassette recorder. At each site, the ROV first was flown to the seabed and then the point count method described by Patterson et al. (2009) was employed to video sample fishes. This method entailed conducting a series of four 30-s, 360° ROV spins to video sample fishes in a 15-m cylinder spanning the water column with the reef at the center of the bottom of the cylinder. Two spins were made just above the seabed on opposing sides of the reef at a distance of ~4 m from single or paired modules, a third spin 1 m above the reef, and a fourth spin ~10 m above the seafloor. Although B-type and C-type reefs were meant to be deployed such that modules were immediately adjacent to one another (Fig. 2B,C), modules of seven out of nine B-type reefs and two out of nine C-type reefs were > 8 m apart on the seabed. Therefore, modules of those sites were sampled independently.

Video Analysis.—In the laboratory, fishes from each video sample were identified to the lowest taxonomic level possible and then enumerated during video playback on a high resolution LCD monitor. Taxa-specific fish density was computed by dividing fish counts by the area of the sampling cylinder's base, which was 176.7 $m^2$. Fish density at B- and C-type reefs for which paired modules had to be sampled separately was computed by dividing the combined total count of the two cylinders by 353.4 $m^{2.}$

Fish length was estimated by multiplying the measured fork length (FL) of an individual fish in a digital image by the known distance between lasers (100 mm), and then dividing by the measured distance between the lasers in the image. Length was not estimated for any fish whose angular deviation from perpendicular to the camera, hence lasers, was evaluated to be > 15° based on results of a pool experiment reported by Patterson et al. (2009), from which measurement error was estimated to be < 5% for fish models viewed at angles < 20° from perpendicular and at distances < 5 m. Based on conditions observed in situ and results reported by Patterson et al. (2009), we estimated the mean bias of underestimating fish length with the ROV's laser scale was 3% with a standard deviation of 0.6%. Therefore, length estimates of all fishes measured with the laser scale were adjusted based on a random probability draw and normally distributed bias with mean equal to 3% and standard deviation equal to 0.6%. After correcting for measurement bias, fish length was converted to fish mass based on taxa-specific mass-length relationships reported in the literature (Nelson and Manooch 1982, Bohnsack and Harper 1988, Zhao et al. 1997). For taxa that were too small to be scaled with lasers, biomass estimates were computed by multiplying the total number of fishes observed by 80% of the maximum individual mass reported for a given taxon. Unidentified small fishes were assigned a mass of 1 g, which corresponds to the approximate mean mass at settlement for the predominant reef fishes observed in the study (Drass et al. 2000, Wells et al. 2008). Although

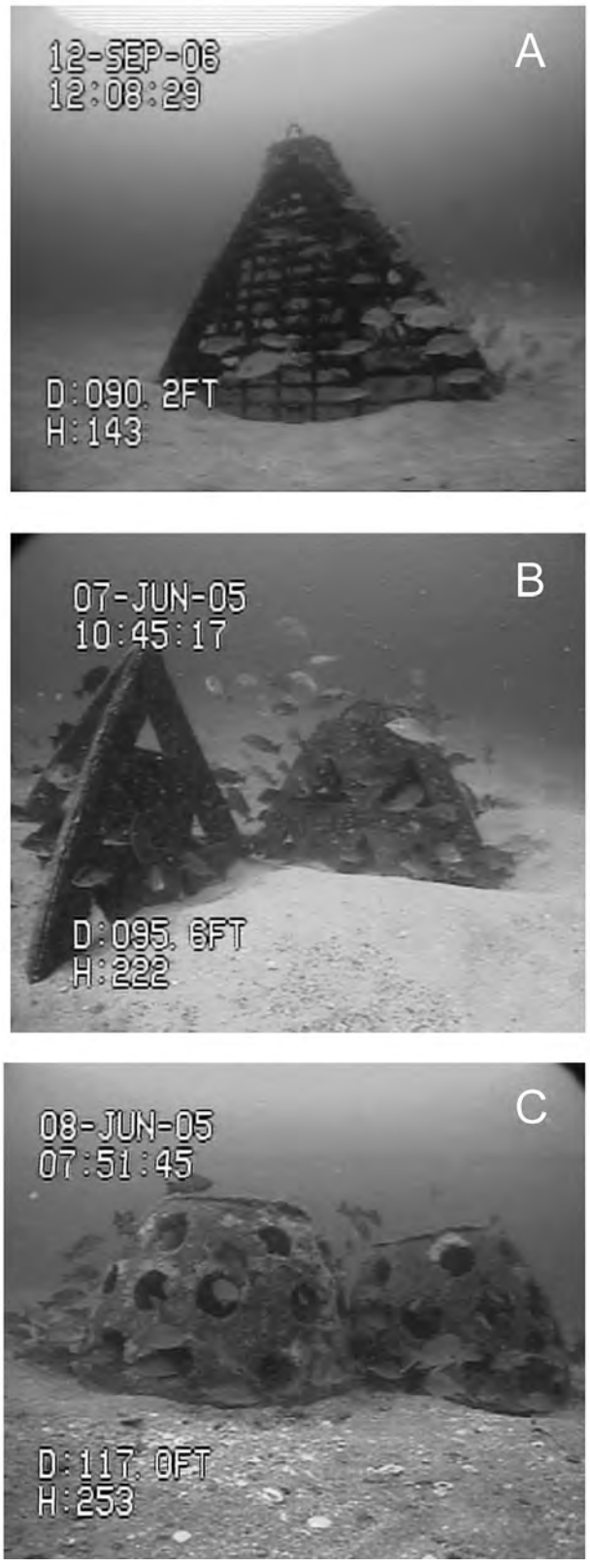


Figure 2. Digital images of (A) A-type, (B) B-type, and (C) C-type artificial reef study sites in the northeastern Gulf of Mexico.

these latter two methods may be somewhat arbitrary, taxa for which mass was assigned using either of them accounted for only 3.3% of the total fish biomass estimated at reef sites.

Data Analysis.—Two-way analysis of variance (ANOVA) models were computed to test the effects of sampling quarter and reef type, and their interaction, on species richness (number of fish taxa present), fish density (number 100 $m^{-2}$), and fish biomass (biomass 100 $m^{-2}$, SAS 2004). Normality was tested for each dependent variable with a Shapiro-Wilk's test and the assumption of homogeneity of variance was tested with a F-max test. Data were transformed when necessary to meet parametric assumptions.

The effects of sampling quarter and reef type were tested on reef fish community and trophic structure with analysis of similarity (ANOSIM) computed in Primer (Clarke 1993, Clark and Gorley 2001). First, taxa-specific fish density (number 100 $m^{-2}$) and biomass (biomass 100 $m^{-2}$) were square-root transformed to down-weight highly abundant taxa. Bray-Curtis similarity matrices were computed from the square-root transformed abundance data, and then two-factor (reef type × sampling quarter) ANOSIM models ($\alpha = 0.05$) were computed to test for differences in reef fish communities. For trophic structure analysis, fishes first were assigned to one of five trophic positions (planktivore, planktivore/invertivore, invertivore, invertivore/piscivore, and piscivore) based on literature reports of their predominant prey, as well as on unpublished stomach content and muscle stable isotope data from fishes sampled in the northern GOM. Then, ANOSIM models were computed as described above to test the effect of sampling quarter and reef type on trophic level-specific fish density and biomass.

## Results

In total, 81,207 individuals from 77 different taxa were enumerated from video samples among the 3 yrs of sampling (Table 1), with 97.5% of individuals identified to species. The four most frequently encountered families in decreasing order of prevalence were Lutjanidae, Serranidae, Balistidae, and Carangidae, together accounting for 72% of the individuals by number and 89% of the total fish biomass. Red snapper was the dominant species among all samples, regardless of reef type or sampling quarter. Red snapper was observed in 97.6% of samples, constituted 29.9% of individuals observed, and its estimated biomass represented 45.1% of total fish biomass. Other large, exploited reef fishes observed frequently were gray triggerfish (81.1% of samples), scamp *Mycteroperca phenax* (61.5%), gag *Mycteroperca microlepis* (57.4%), red grouper *Epinephelus morio* (56.0%), greater amberjack *Seriola dumerili* (52.2%), and vermilion snapper *Rhomboplites aurorubens* (51.9%). However, no single species within that group constituted > 4% of total fish observed, although all ranked among the top 10 species in percent total biomass due to the relatively large size of individuals. Among smaller fishes, mackerel scad *Decapterus macarellus* (23.2%), tomtate *Haemulon aurolineatum* (8.9%), pinfish *Lagodon rhomboides* (6.1%), and round sardinella *Sardinella aurita* (3.4%) all ranked among the top 10 species in terms of the percent individuals observed, but only mackerel scad (4.6%) was among the top 10 with respect to percent total biomass. While small planktivores, such as mackerel scad, round sardinella, and blue runner *Caranx crysos* occurred infrequently at study sites (12.7% frequency of occurrence for mackerel scad was highest among these species), they often occurred in large numbers when present.

Species richness varied significantly with sampling quarter, as did fish density and biomass (ANOVA: $F_{10;255} > 2.67$, $P < 0.001$; Fig. 3). Only species richness was significantly different among reef types (ANOVA: $F_{2;255} = 6.31$, $P = 0.002$), and the interaction between reef type and sampling quarter was not significant in any model

Table 1. Fish taxa observed in video samples collected with a micro remotely operated vehicle at artificial reef study sites in the northeastern Gulf of Mexico. Family is given for groups in which at least two taxa were observed, with the exception of Haemulidae. For reef residency, R = reef resident, RA = seasonally reef-associated neritic pelagic species, S = demersal or benthic shelf species, and T = transient. For trophic position, H = herbivore, P = planktivore, I = invertivore, F = piscivore. For life stage, J = juvenile and A = adult. Multiple letters for trophic position indicate feeding at more than one trophic level. Multiple letters for life stage indicate more than one life stage present at study sites. Percent number is the taxon-specific percentage of total individuals observed among all sampling events. Percent mass is the taxon-specific percentage of total biomass estimated among all sampling events.

| Taxon | Common name | Reef residency | Trophic position | Life stage | % frequency of occurrence | % number | % mass |
|---|---|---|---|---|---|---|---|
| Balistidae | | | | | 81.9 | 3.78 | 7.12 |
| Unknown Balistidae | triggerfish | R | I | A | 1.0 | 0.01 | 0.01 |
| *Balistes capriscus* Gmelin, 1789 | gray triggerfish | R | I | A | 81.1 | 3.77 | 7.11 |
| Blennidae | | | | | 22.2 | 0.72 | 0.02 |
| Unknown Blennidae | blenny | R | PI | J, A | 0.7 | 0.01 | < 0.01 |
| *Hypleurochilus bermudensis* Beebe and Tee-Van, 1933 | barred blenny | R | I | A | 0.3 | < 0.01 | < 0.01 |
| *Parablennius marmoreus* (Poey, 1876) | seaweed blenny | R | I | A | 21.3 | 0.71 | 0.02 |
| Carangidae | | | | | 72.2 | 27.83 | 13.26 |
| *Caranx crysos* (Mitchill, 1815) | blue runner | T | PI | A | 11.3 | 0.65 | 0.71 |
| *Caranx ruber* (Bloch, 1793) | bar jack | T | IF | A | 1.4 | 0.02 | 0.03 |
| *Decapterus macarellus* (Cuvier, 1833) | mackerel scad | T | P | A | 12.7 | 23.20 | 4.64 |
| *Elagatis bipinnulata* (Quoy and Gaimard, 1825) | rainbow runner | T | IF | A | 0.7 | < 0.01 | 0.01 |
| *Hemicaranx amblyrhynchus* (Cuvier, 1833) | bluntnose jack | T | IF | A | 2.1 | 0.02 | 0.01 |
| *Seriola dumerili* (Risso, 1810) | greater amberjack | RA | F | A | 52.2 | 3.21 | 6.59 |
| *Seriola fasciata* (Bloch, 1793) | lesser amberjack | RA | F | A | 2.7 | 0.09 | 0.22 |
| *Seriola rivoliana* Valenciennes, 1833 | almaco jack | RA | F | A | 36.4 | 0.63 | 0.99 |
| *Seriola zonata* (Mitchill, 1815) | banded rudderfish | RA | F | A | 1.0 | 0.01 | 0.06 |
| Carcharhinidae | | | | | 6.9 | 0.03 | 1.79 |
| *Carcharhinus limbatus* (Müller and Henle, 1839) | blacktip shark | T | F | A | 4.1 | 0.02 | 0.71 |
| *Carcharhinus plumbeus* (Nardo, 1827) | sandbar shark | T | F | A | 2.1 | 0.01 | 0.89 |
| *Carcharhinus* spp. | requiem shark | T | F | A | 0.7 | < 0.01 | 0.19 |
| Haemulidae | | | | | 25.4 | 8.89 | 2.45 |
| *Haemulon aurolineatum* Cuvier, 1830 | tomtate | R | I | A | 25.4 | 8.89 | 2.45 |

Table 1. Continued.

| Taxon | Common name | Reef residency | Trophic position | Life stage | % frequency of occurrence | % number | % mass |
|---|---|---|---|---|---|---|---|
| Labridae | | | | | 15.3 | 1.41 | 0.21 |
| *Halichoeres bivittatus* (Bloch, 1791) | slippery dick | R | I | A | 14.8 | 1.40 | 0.21 |
| *Xyrichtys novacula* (Linnaeus, 1758) | pearly razorfish | R | I | A | 1.0 | 0.01 | < 0.01 |
| Lutjanidae | | | | | 99.0 | 36.71 | 54.49 |
| *Lutjanus campechanus* (Poey, 1860) | red snapper | R | IF | A | 97.3 | 29.92 | 45.05 |
| *Lutjanus griseus* (Linnaeus, 1758) | gray snapper | R | IF | A | 34 | 2.20 | 4.81 |
| *Lutjanus synagris* (Linnaeus, 1758) | lane snapper | R | IF | A | 32.6 | 0.64 | 0.61 |
| *Rhomboplites aurorubens* (Cuvier, 1829) | vermilion snapper | R | PI | J, A | 51.9 | 3.95 | 4.02 |
| Monacanthidae | | | | | 17.7 | 0.10 | 0.23 |
| *Aluterus heudeloti* Hollard, 1855 | dotterel filefish | R | I | A | 0.7 | < 0.01 | 0.01 |
| *Aluterus monoceros* (Linnaeus, 1758) | unicorn filefish | R | I | A | 8.9 | 0.05 | 0.12 |
| *Aluterus schoepfi* (Walbaum, 1792) | orange filefish | R | I | A | 4.8 | 0.03 | 0.06 |
| *Aluterus scriptus* (Osbeck, 1765) | scrawled filefish | R | I | A | 0.3 | < 0.01 | < 0.01 |
| *Monacanthus hispidus* (Linnaeus, 1766) | planehead filefish | R | I | A | 2.1 | 0.01 | 0.03 |
| *Monacanthus setifer* (Bennett, 1831) | pygmy filefish | R | PI | A | 0.7 | 0.01 | 0.01 |
| Ostraciidae | | | | | 2.1 | 0.01 | 0.01 |
| *Lactophrys quadricornis* (Linnaeus, 1758) | scrawled cowfish | R | I | A | 1.7 | 0.01 | 0.01 |
| *Lactophrys trigonus* (Linnaeus, 1758) | buffalo trunkfish | R | I | A | 0.3 | < 0.01 | < 0.01 |
| Pomacentridae | | | | | 10.1 | 0.50 | 0.04 |
| *Chromis enchrysurus* Jordan and Gilbert, 1882 | yellowtail reeffish | R | P | J, A | 7.2 | 0.48 | 0.04 |
| *Chromis* spp. | damselfish | R | P | J, A | 0.3 | < 0.01 | < 0.01 |
| *Stegastes leucostictus* (Müller and Troschel, 1848) | beaugregory | R | P | J, A | 0.3 | < 0.01 | < 0.01 |
| *Stegastes variabilis* (Castelnau, 1855) | cocoa damselfish | R | P | J, A | 1.7 | 0.01 | < 0.01 |
| *Stegastes* spp. | damselfish | R | P | J, A | 0.3 | 0.01 | < 0.01 |

Table 1. Continued.

| Taxon | Common name | Reef residency | Trophic position | Life stage | % frequency of occurrence | % number | % mass |
|---|---|---|---|---|---|---|---|
| Sciaenidae | | | | | 12.8 | 0.18 | 0.13 |
| *Equetus acuminatus* (Bloch and Schneider, 1801) | high-hat | R | I | A | 2.1 | < 0.01 | < 0.01 |
| *Equetus iwamotoi* (Miller and Woods, 1988) | blackbar drum | R | I | A | 0.3 | 0.01 | 0.01 |
| *Equetus lanceolatus* (Linnaeus, 1758) | jackknife fish | R | I | A | 9.6 | 0.13 | 0.06 |
| *Equetus* spp. | reef drum | R | I | A | 0.3 | < 0.01 | < 0.01 |
| *Pareques umbrosus* (Jordan and Eigenmann, 1889) | cubbyu | R | I | A | 6.2 | 0.04 | 0.01 |
| *Sciaenops ocellatus* (Linnaeus, 1766) | red drum | T | IF | A | 0.3 | < 0.01 | 0.05 |
| Serranidae | | | | | 97.9 | 4.47 | 14.27 |
| *Centropristis ocyurus* (Jordan and Evermann, 1887) | bank seabass | S | I | A | 17.9 | 1.17 | 0.82 |
| *Diplectrum formosum* (Linnaeus, 1766) | sand perch | S | IF | A | 6.5 | 0.16 | 0.08 |
| *Epinephelus drummondhayi* Good and Bean, 1878 | speckled hind | R | IF | J | 0.7 | < 0.01 | < 0.01 |
| *Epinephelus morio* (Valenciennes, 1828) | red grouper | R | IF | A | 56.0 | 0.58 | 4.36 |
| *Epinephelus nigritus* (Holbrook, 1855) | warsaw grouper | R | IF | J | 1.4 | 0.01 | < 0.01 |
| *Epinephelus niveatus* (Valenciennes, 1828) | snowy grouper | R | IF | J | 1.4 | 0.29 | 0.05 |
| *Hypoplectrus* spp. | hamlet | R | IF | A | 0.7 | < 0.01 | < 0.01 |
| *Mycteroperca microlepis* (Good and Bean, 1879) | gag | R | F | A | 57.4 | 1.14 | 7.31 |
| *Mycteroperca phenax* Jordan and Swain, 1884 | scamp | R | F | A | 61.5 | 0.70 | 1.54 |
| *Rypticus maculates* Holbrook, 1855 | whitespotted soapfish | R | I | A | 52.9 | 0.47 | 0.11 |
| Sparidae | | | | | 36.8 | 6.92 | 2.47 |
| *Calamus leucosteus* Jordan and Gilbert, 1885 | whitebone porgy | S | I | A | 0.7 | < 0.01 | 0.01 |
| *Calamus nodosus* Randall and Caldwell, 1966 | knobbed porgy | S | I | A | 2.7 | < 0.01 | 0.01 |
| *Calamus* spp. | porgy | S | I | A | 1.4 | 0.01 | 0.02 |
| *Lagodon rhomboids* (Linnaeus, 1766) | pinfish | T | I | A | 3.4 | 6.14 | 1.86 |
| *Pagrus pagrus* (Linnaeus, 1758) | red porgy | R | I | A | 33.7 | 0.76 | 0.57 |
| *Stenotomus caprinus* Jordan and Gilbert, 1882 | longspine porgy | S | I | A | 0.7 | 0.01 | < 0.01 |

Table 1. Continued.

| Taxon | Common name | Reef residency | Trophic position | Life stage | % frequency of occurrence | % number | % mass |
|---|---|---|---|---|---|---|---|
| Other taxa | | | | | | | |
| *Apogon pseudomaculatus* Longley, 1932 | twospot cardinalfish | R | P | J, A | 5.8 | 0.65 | 0.01 |
| *Chaetodipterus faber* (Broussonet, 1782) | Atlantic spadefish | R | I | A | 9.6 | 1.73 | 0.48 |
| *Chaetodon ocellatus* Bloch, 1787 | spotfin butterflyfish | R | I | A | 1.0 | < 0.01 | < 0.01 |
| *Chilomycterus atinga* (Linnaeus, 1758) | spotted burrfish | R | I | A | 2.7 | 0.01 | 0.03 |
| *Dasyatis Americana* Hildebrand and Schroeder, 1928 | southern stingray | S | IF | A | 0.7 | < 0.01 | 0.02 |
| *Echeneis naucrates* Linnaeus, 1758 | shark sucker | T | IF | A | 2.4 | 0.02 | 0.04 |
| *Fistularia tabacaria* Linnaeus, 1758 | cornetfish | R | F | A | 1.4 | 0.01 | 0.03 |
| *Ginglymostoma cirratum* (Bonnaterre, 1788) | nurse shark | S | IF | A | 3.1 | 0.01 | 1.24 |
| *Holacanthus bermudensis* Goode, 1876 | blue angelfish | R | I | A | 20.3 | 0.08 | 0.16 |
| *Hyperoglyphe perciformis* (Mitchill, 1818) | barrelfish | T | PI | A | 0.3 | < 0.01 | < 0.01 |
| *Kyphosus spectator* (Linnaeus, 1758) | Bermuda chub | R | HI | A | 0.3 | < 0.01 | < 0.01 |
| *Paralichthys albigutta* Jordan and Gilbert, 1882 | gulf flounder | S | IF | A | 1.4 | < 0.01 | 0.01 |
| *Priacanthus arenatus* Cuvier, 1829 | Atlantic bigeye | R | PI | A | 1.0 | 0.01 | 0.01 |
| *Rachycentron canadum* (Linnaeus, 1766) | cobia | T | F | A | 0.7 | < 0.01 | 0.18 |
| *Sardinella aurita* Valenciennes, 1847 | round sardinella | T | P | A | 0.7 | 3.39 | 0.73 |
| *Scomberomorus cavalla* (Cuvier, 1829) | king mackerel | T | F | A | 3.8 | 0.02 | 0.17 |
| *Sphyraena barracuda* (Edwards, 1771) | greater barracuda | RA | F | A | 3.4 | 0.01 | 0.16 |
| Unknown small fishes | Unk. small fishes | | | | 14.4 | 2.44 | 0.27 |

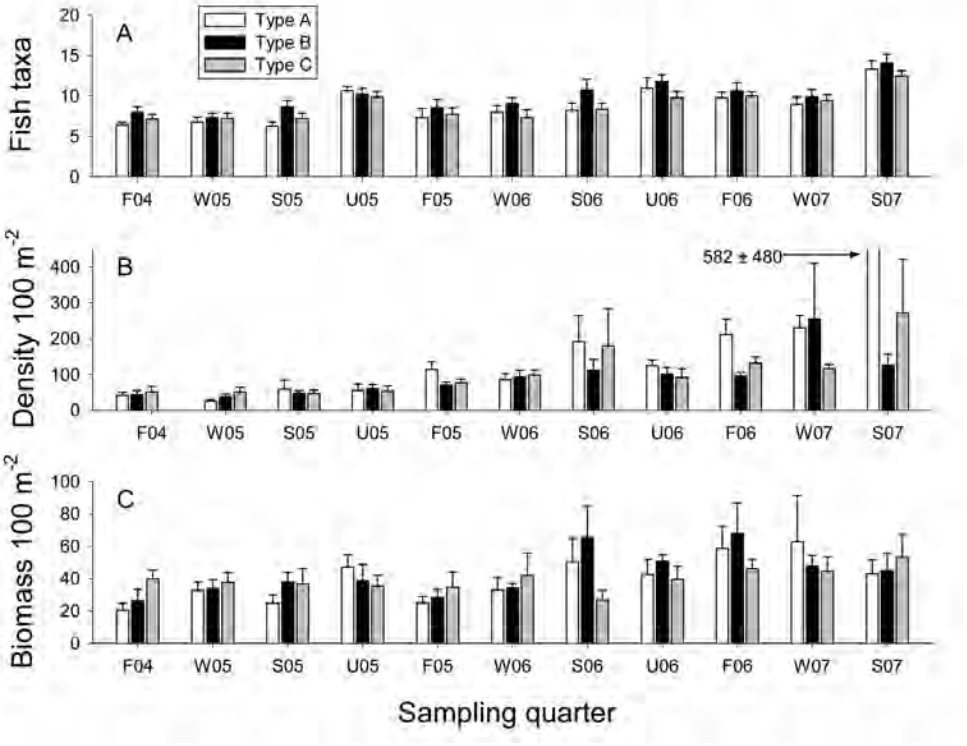


Figure 3. Mean + SE (A) number of fish taxa, (B) fish density, (C) fish biomass, estimated from video samples of fish communities associated with artificial reef sites in the northeastern Gulf of Mexico. The legend in panel A applies to all panels. Abbreviations along *x*-axis: F = fall, W = winter, S = spring, and U = summer.

(ANOVA: $F_{20;255} = 1.05$, $P > 0.405$). In general, species diversity increased over the course of the study (Fig. 3A), with annual peaks in summer. B-type reefs (10.0 species) displayed greater mean diversity than either A-type or C-type reefs (8.8 species for both).

Fish community structure for both taxa-specific density and biomass was significantly different among sampling quarters and reef types (ANOSIM: $P < 0.001$). Trophic position-specific density and biomass were also significantly different for both sampling quarter and reef type (ANOSIM: $P < 0.001$). Fish communities in the first year consisted almost entirely of groupers, snappers, and gray triggerfish (Fig. 4). Fish assemblages in the second and third year of the study were characterized by a dramatic decline in grouper density, followed by increases in densities of mackerel scad, tomtate, and greater amberjack (Fig. 4). Small cryptic and juvenile fishes such as two-spot cardinalfish *Apogon pseudomaculatus*, slippery dick *Halichoeres bivittatus*, blenniids, and pomacentrids were also observed increasingly in the latter portion of the study. Pinfish and round sardinella were rare at study sites, but were observed in vast schools when present (Fig 4). Mackerel scad and tomtate were found in greater abundance at A-type reefs (Fig. 4). Two C-type reefs, C7 and C9, had increased densities of bank sea bass *Centropristis ocyurus*, sand perch *Diplectrum formosum*, and occasionally round sardinella beginning in the fall of 2005 (Fig. 4).

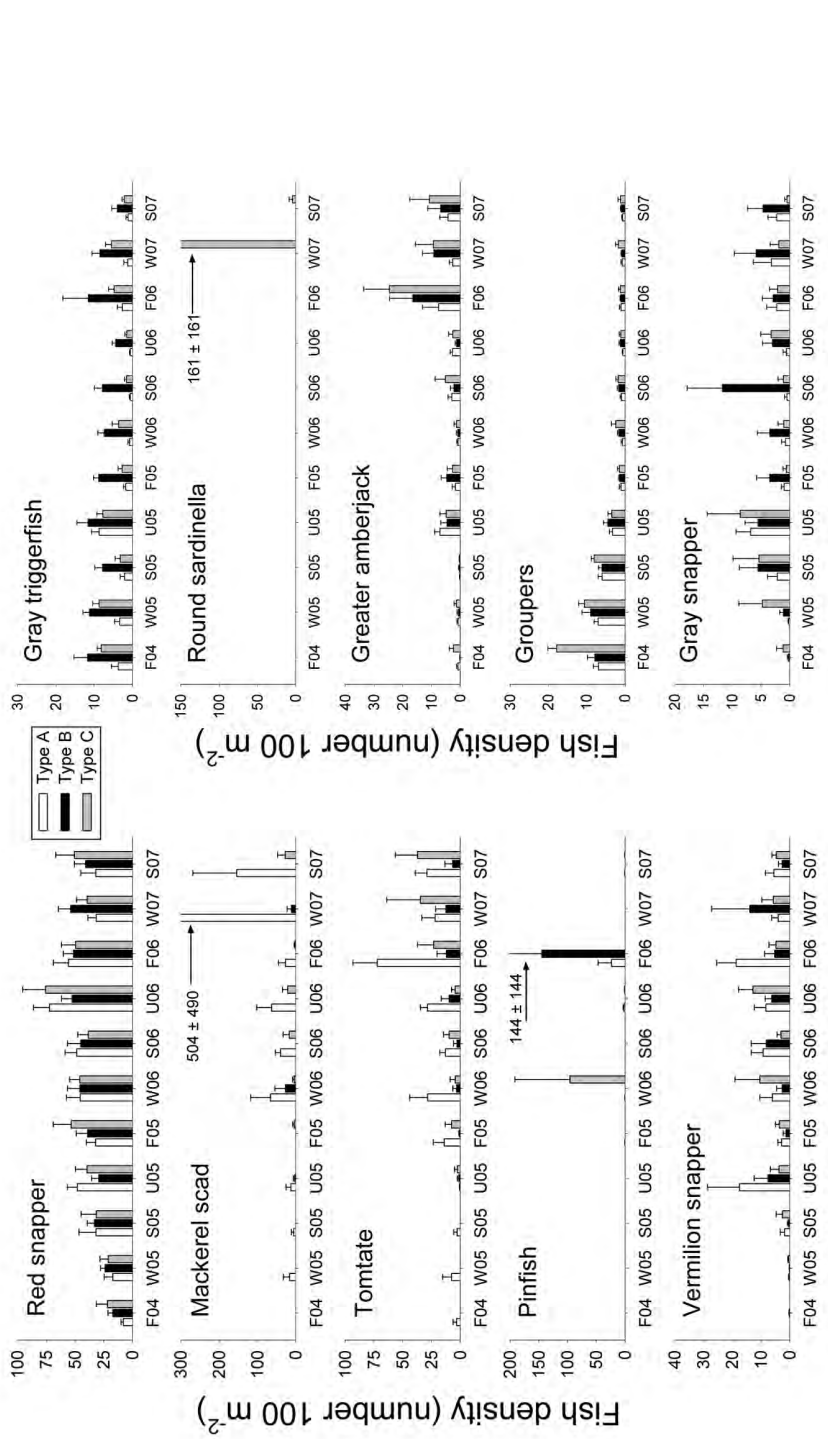


Figure 4. Mean + SE density of the 10 most abundant species estimated from video samples of fish communities associated with artificial reef sites in the northeastern Gulf of Mexico. Species presented in order of decreasing total abundance. Abbreviations along x-axis: F = fall, W = winter, S = spring, and U = summer. Legend applies to all panels.

Several trends were observed among fishes for which significant fisheries exist in the northern GOM. Red snapper density and biomass generally increased throughout the study, although there was a peak in summer 2006, and all three reef types tended to have high red snapper biomass (Fig. 4). Sharp declines in densities of gag, scamp, and red grouper likely drove an order of magnitude decline in grouper biomass in year one, which then remained at low levels (Fig. 4). Groupers tended to have the highest biomass on C-type reefs; gag, in particular, were often found in the central cavities of those modules. Density of gray triggerfish was variable among sampling quarters, but was highest on B-type reefs (Fig. 4). Greater amberjack and other *Seriola* spp. displayed the opposite pattern of groupers in that their density and biomass increased by an order of magnitude across the study (Fig. 4). Lastly, both vermilion snapper and gray snapper *Lutjanus griseus* displayed variable biomass among sampling quarters, although their biomass tended to increase from 2004 to 2007, particularly for vermilion snapper. Vermilion snapper densities were highest at A-type reefs, while gray snapper densities were greatest at B-type reefs (Fig. 4).

A-type reefs generally had the highest density of planktivorous fishes, and this trend became more pronounced over time (Fig. 5). The increasing yet variable presence of large schools of planktivores (e.g., mackerel scad, round sardinella, blue runner) at study sites was also largely responsible for the spike in fish density estimates in the latter part of the study (Fig. 3). Piscivore density and biomass decreased over the first year, and then increased in the last year of the study (Fig. 5). Planktivore/invertivores and invertivores generally increased across time in both density and biomass (Fig. 5). While planktivores displayed the highest densities of fishes overall, their small individual size translated to a biomass that was < 25% of that observed for piscivores and < 10% of that observed for invertivore/piscivores. Invertivore/piscivores density increased during the first year of the study and then remained high. (Fig. 5). Trophic assemblages were affected by the degree of reef residency among fishes present (Fig. 6). Reef residents were mostly invertivore/piscivore or invertivores (i.e., snappers, grunts, and triggerfish). Among transient or seasonally reef-associated pelagic species, planktivores were the most abundant numerically, while piscivores, such as *Seriola* spp. and sharks, were predominant by biomass.

Estimated fish length distributions provide important information about fishes present at study reefs beyond density and biomass estimates. Only 9% of red snapper were estimated to be > 406 mm TL, which was the recreational size limit for harvesting the species throughout the study (Fig. 7). Conversely, gray and vermilion snappers had the highest percentage of individuals above recreational size limits, with 72% of gray snapper above their size limit of 305 mm TL and 63% of vermilion snapper above their size limit of 255 mm TL (Fig. 7). Similarly, 38% of gray triggerfish were estimated to be above its recreational size limit of 305 mm FL (Fig. 7). *Seriola* spp. displayed a normal size distribution, with a mode at ~350 mm FL, which is well short of the recreational size limit for greater amberjack (762 mm FL), the predominant *Seriola* spp. observed (Fig. 7). Groupers had a broad size distribution, but this mostly reflects the species-specific variation in body size among gag, scamp, and red grouper.

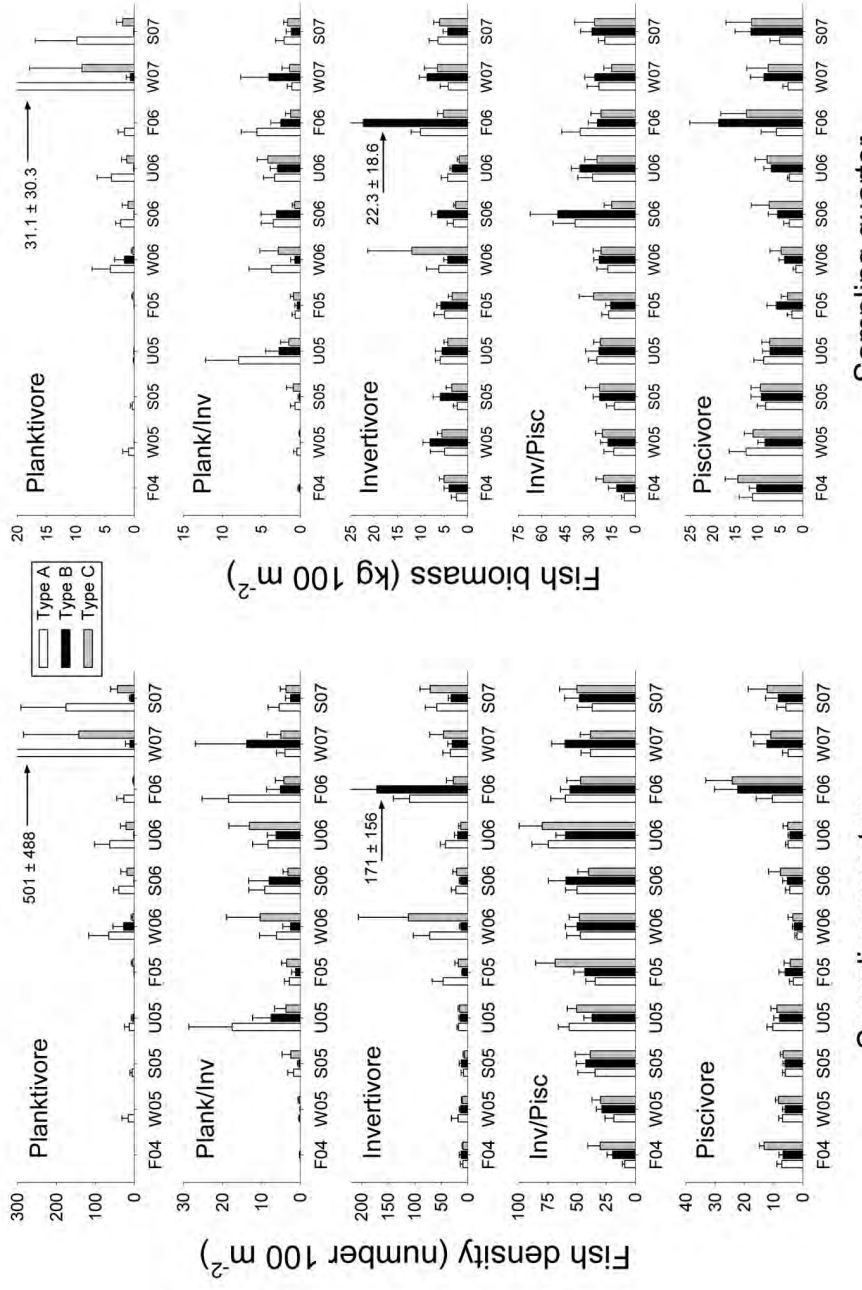


Figure 5. Mean + SE density and mean + SE biomass of different trophic groups observed within fish communities associated with artificial reef study sites in the northeastern Gulf of Mexico. Plank/Inv refers to planktivore/invertivore and Inv/Pisc refers to invertivore/piscivore. Legend applies to all panels.

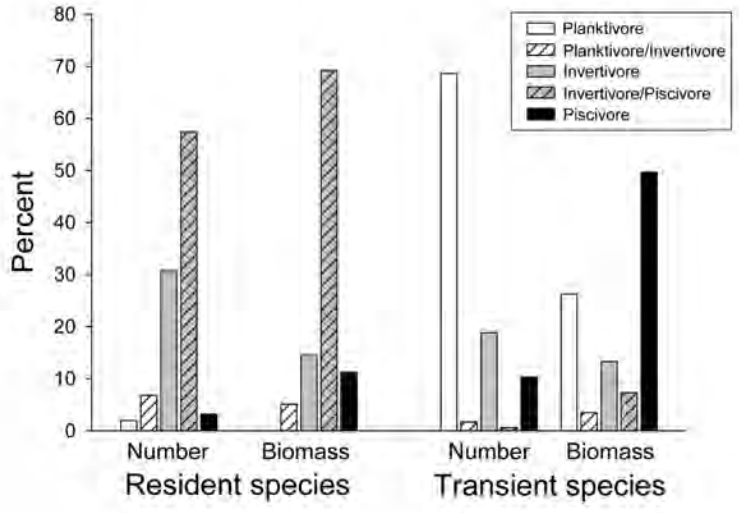


Figure 6. Percent contribution of different trophic groups in number and biomass to resident and transient (all non-resident taxa) fish communities associated with artificial reef study sites in the northeastern Gulf of Mexico.

## Discussion

Perhaps the most striking result of the present study was the overwhelming dominance of reef fish communities by red snapper, which were nearly ubiquitous on study sites throughout the course of the sampling period and were even more dominant by biomass than by number. Red snapper density and biomass increased during the study, but both were high relative to other fishes throughout the study period. Despite this constancy with respect to red snapper's predominance, fish communities were temporally dynamic in species richness, trophic structure, overall fish density, and taxa-specific biomass of fishery species. Furthermore, the total number of species observed at reef sites during our study was greater than diversity observed in previous studies at artificial reefs of similar design and size both in the northern GOM (Strelcheck et al. 2005, Lingo and Szedlemayer 2006) and in other regions with comparable climate (Leitão et al. 2008).

Artificial reef sites were a little over 1 yr old when the present study began, thus were 4 yrs old at its conclusion. Previous research suggests that artificial reefs typically reach a mature, equilibrium community within 1–5 yrs (Bohnsack and Sutherland 1985). The development of complex fouling communities (e.g., macroalgae, bryozoans, sponges, and barnacles) as reef sites aged likely provided greater structural complexity and an increased forage base known to contribute to greater species diversity (Gratwicke and Speight 2005, Redman and Szedlmayer 2009). In a given year, species diversity was highest in summer, which coincided with an annual peak in the fouling community observed on reefs, as well as with the presence of tropical species not seen during other quarters.

Several factors can influence temporal changes in trophic structure and fish communities at artificial reefs beyond increased rugosity from fouling communities (Rooker et al. 1997). Among these are top-down predator control exerted by predators (Carr and Hixon 1995) and seasonal effects on hydrographic parameters or

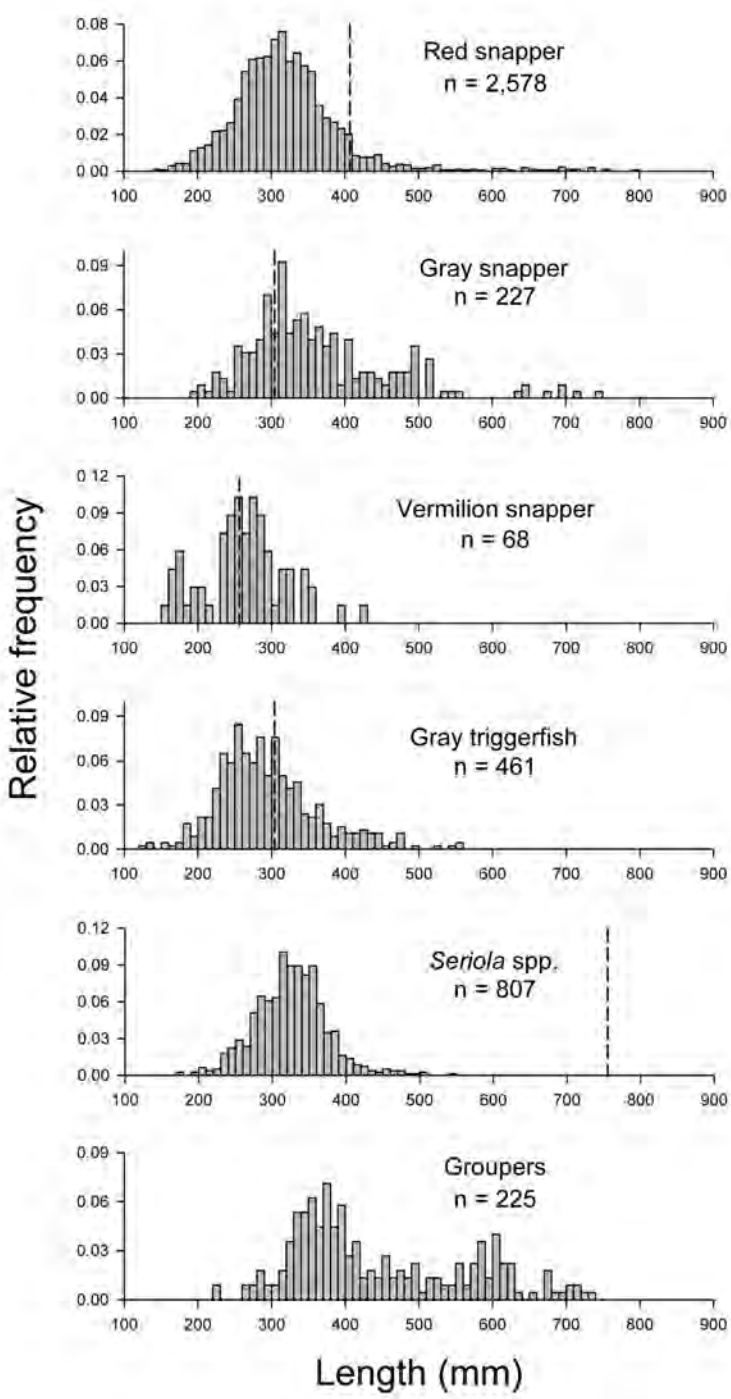


Figure 7. Length distributions of species for which significant fisheries exist observed at artificial reef sites in the northeastern Gulf of Mexico. Fork length is reported for gray triggerfish and *Seriola* spp. *Seriola* spp. includes greater amberjack (n = 661), almaco jack (n = 145), and lesser amberjack (n = 1). Groupers include scamp (n = 105), red grouper (n = 89), gag (n = 27), and snowy grouper (n = 4). Dashed vertical lines indicate minimum size limits in recreational fisheries for red snapper (406 mm TL), gray snapper (305 mm TL), vermilion snapper (254 TL), gray triggerfish (305 mm FL), and greater amberjack (762 mm FL)

recruitment (Bohnsack et al. 1994). Resident piscivores are known to affect the densities and size structure of fishes found at artificial reefs (Carr and Hixon 1995, Beets 1997, Hixon and Carr 1997). Though transient piscivores, such as greater amberjack, gradually replaced groupers as the predominant piscivores at study reefs, the decline of resident piscivores may have strongly influenced the changes in trophic structure of fishes present. Trophic assemblages, though dominated by invertivore/piscivores, such as red snapper, became more diverse over time with increased densities and biomass of lower trophic level fishes. Transient planktivores such as scads and sardines are known to be prey items for piscivores such as gag (Lindberg et al. 2006), and the proliferation of these taxa drove the increases in planktivore and fish density across time. While their presence is often infrequent, aggregations of transient planktivores can have a profound influence on fish communities at artificial reefs (Bohnsack et al. 1994). Furthermore, small invertivores, such as tomtate and red porgy, invertivore/planktivores, such as vermilion snapper and blue runner, and various small cryptic and juvenile fishes became more abundant and were observed more frequently after the decrease in resident piscivores. Success of lower trophic fishes, especially cryptic species, may be attributed to increased foraging opportunity and shelter afforded by reef attached organisms, but the results of the present study also indicate that these trophic groups may have been inhibited by high densities of resident piscivores earlier in the study.

Seasonal shifts in prey availability and processes of recruitment influenced temporal patterns in fish assemblages at study sites, as well as contributed to differences in trophic structure between resident and transient assemblages. The most consistently abundant fishes (red snapper and gray triggerfish) have diets that consist of either reef-attached organisms or benthic invertebrates and fishes associated with surrounding mud/sand substrates (Vose and Nelson 1994, Wells et al. 2008). Despite increasing in abundance, red snapper densities showed no distinguishable intra-annual seasonal patterns, which was consistent with other studies from the north-central GOM (Wells and Cowan 2007, Redman and Szedlmayer 2009). Species that exhibited variability in intra-annual and site-specific abundance were often dependent on pelagic prey, thus more subject to hydrographic processes. High variability in observed densities of planktivores among individual reef sites in our study may be attributed to local fluxes in plankton abundance. Zooplankton distributions and abundance are known to vary both across multiple time scales and vertically within a single diel period (Le Borgne et al. 2010, Heidelberg et al. 2010). Furthermore, large schools of transient planktivores, such as mackerel scad, round sardinella, and blue runner, may have also attracted transient piscivores, such as greater amberjack, all of which were observed in greater abundance in the latter part of the study. Intra-annual differences in amberjack abundance were likely due to recruitment pulses of sub-adult amberjack, which are known to transition from pelagic to demersal habitats (e.g., outcroppings and reefs) in the first year of life (Wells and Rooker 2004). Increased species richness, as well as variation in fish assemblages, are often attributed to an annual influx of juvenile recruits in the summer months (Rooker et al. 1997, Lingo and Szedlmayer 2006). Most individuals observed at reef sites in this study were sub-adults and adults; however, newly-settled and older age-0 fishes were encountered more frequently starting in the summer of 2006 and likely contributed to seasonal differences in fish community structure.

The most extreme taxa-specific shift that occurred during the study was the order of magnitude decline in grouper (gag, red grouper, and scamp) abundance during year one. It is possible that the passing of Hurricane Ivan through the study area in September 2004 redistributed groupers from offshore shelf-edge or other habitats to study reefs prior to the beginning of video sampling. Hurricanes have been shown previously to affect reef fish distributions (Turpin and Bortone 2002, Patterson et al. 2001), and increased grouper densities were observed on artificial reefs off South Carolina following Hurricane Hugo (Bell and Hall 1994). Similar to the present study, Bell and Hall (1994) also reported a subsequent steady decline in grouper densities as fishes either were removed by fishing pressure or they simply dispersed in the months following Hugo. Outside of potential storm effects, recent stock assessments indicated that gag and red grouper numbers experienced precipitous declines regionally from 2005 to 2006, which also may explain declines observed at study reefs. However, decreases in gag and red grouper spawning stock biomass estimates in the eastern GOM were attributed largely to a significant red tide event along the west Florida shelf that occurred hundreds of km to the southeast of reef sites examined in this study (SEDAR 2009a,b).

Effects of Reef Design.—Direct quantitative tests of factors, such as reef vertical relief, volume, hole size, and surface area, that possibly drove differences in fish communities among reef types, were not possible due to uncontrolled differences in reef design and dimensions. However, observed differences in fish communities among reefs are consistent with what would be predicted based on results of previous studies in which reef dimension and complexity were controlled (Hixon and Beets 1989, Beets and Hixon 1994, Lindberg et al. 2006). For example, A-type reefs in the present study were open structures with relatively high relief and few prefabricated hiding places. Although all reef designs supported high densities of invertivore/piscivores (primarily red snapper), trophic structure at A-type reefs was typified by high but variable densities of planktivores. Increased vertical relief at artificial reefs has been hypothesized to facilitate higher zooplankton concentrations (Rilov and Benyahu 2002, Arena et al. 2007), suggesting that planktivore abundance may be linked to higher vertical relief at A-type reefs vs the other two designs. Several species that feed high in the water column and are at least partially planktivorous, such as scad, round sardinella, blue runner, and vermilion snapper, were all observed at highest densities at A-type reefs. Alternatively, relatively lower densities of resident piscivores, such as groupers, at A-type reefs also may have contributed to the high mean abundance of some planktivores.

Ambush predators, such as groupers, typically prefer reefs that afford greater cover (Hixon and Beets 1989, Lindberg et al. 2006), which was lacking at A-type modules. This idea is reinforced by fish communities observed at two C-type reefs (C7 and C9) that were mostly buried and/or damaged following Hurricane Rita in September 2005, thus leaving little surface area for fouling growth and a lack of cover for larger fishes. Thereafter, those two sites had consistently higher densities of transient planktivores, small reef residents, and juvenile fishes, and an absence of groupers or other large piscivores, relative to other C-type reefs.

Greater surface area at B-type reefs promoted growth of barnacles and other sessile reef-attached invertebrates, adding more structural complexity and rugosity to the habitat, which resulted in greater reef fish diversity than the other two reef

types. Previous studies have also shown that complex three dimensional habitat can promote species richness (Rooker et al. 1997, Lingo and Szedlmayer 2006, Redman and Szedlmayer 2009). Increased invertivore biomass at B-type reefs was mostly attributed to elevated gray triggerfish abundance, a species which has been shown to feed disproportionately on barnacles and encrusting organisms at artificial reef sites (Vose and Nelson 1994). Greater structural complexity afforded by fouling communities likely also benefitted gray snapper, a species commonly associated with coral reefs and found at higher densities at B-type reefs (Burton 2001). While the increased surface area appeared to encourage settlement of sessile organisms, including algae, herbivores were practically non-existent at study sites, a finding consistent with the artificial reef literature (Bohnsack et al. 1994, Thanner et al. 2006). Lastly, reef spacing was an uncontrolled issue with paired B-type modules, and our conservative estimates of fish density and biomass due to this factor may have down-weighted some of the distinctiveness of fish communities at this reef type.

C-type modules had well-defined holes, a hollow central cavity, and a higher surface area to volume ratio to promote fouling communities. These characteristics perhaps offered greater habitat complexity and shelter for resident piscivores (Hixon and Beets 1989, Beets and Hixon 1994, Lingo and Szedlmayer 2006). As many as six gag were observed on multiple occasions in the central cavity of one C-type module, a phenomenon not observed at other reef types, despite their larger volumes compared to C-type modules. Lindberg et al. (2006) also frequently observed multiple gag retreating and hiding inside the central internal cavities of artificial reef modules in the northeastern GOM, and they reported that high gag density actually had a negative, density-dependent effect on growth. Lastly, condition of C-type reefs was more variable than other reef types which likely contributed to disparity in fish communities within reefs of this design. Reef fish communities at sites partially buried after Hurricane Rita more closely resembled those previously described at shell rubble habitats and low vertical relief structure in the northern GOM (Wells and Cowan 2007, Wells et al. 2009).

Size-Structure of Fishery Species.—The size structure of fishery species has great relevance for inferring the ecological function of artificial reefs, as well as determining the efficacy of unreported reefs to serve as no-harvest refugia or as potential sources (vs sinks) of recruits to other habitats (Bohnsack and Sutherland 1985, Bohnsack et al. 1994, Crowder et al. 2000). Species that display high site fidelity would be more likely to display enhanced production from artificial reef creation than species that do not, especially if not reporting reef coordinates successfully precludes fishing at created reefs (Bohnsack 1989, Willis and Millar 2005). Therefore, species that display high site fidelity would be expected to have broad size distributions representative of several age classes present on reefs. In fact, species such as gray triggerfish, vermilion snapper, and gray snapper that are known to display high site fidelity to reefs (Burton et al. 2001, Ingram and Patterson 2001, Allman 2007) also were characterized by having wide size distributions in the present study. Moreover, relatively high percentages of individuals of these species exceeded the legal size limit in the recreational fishery, the predominant fishing sector targeting reef fishes in the study area. Therefore, it appears gray triggerfish, vermilion snapper, and gray snapper experienced minimal if any fishing mortality at unreported study reefs, which is corroborated by the fact that no evidence of fishing was observed at study

reefs (e.g., no hooks or line observed fouling reefs, and no vessels observed at study sites during sampling trips).

Fishes known to display temporary residency or low annual site fidelity, such as amberjack (Ingram and Patterson 2001), groupers (Lindberg et al. 2006), and red snapper (Patterson and Cowan 2003), were characterized by truncated size distributions consisting of mostly small, young fishes. While it is not known why individuals of these species often disappeared from study sites before reaching large sizes, we suggest three possible scenarios. First, the lack of larger, older fishes simply may have reflected ontogenetic movement away from study reefs. If fishing occurred at study sites, then direct removal of larger fishes could have occurred. Lastly, if fishes moved among habitats, then their size distributions may have reflected regional size structure affected by fishing pressure away from study reefs.

Ontogenetic shifts in habitat utilization are well documented for many reef fish taxa (Koenig et al. 2000, Wells and Rooker 2004), and shifts in the size distributions of certain species observed during this study clearly could be attributed to ontogeny. Greater amberjack size distribution was the most limited of all fishery species (mode 250–350 mm FL), with fish sizes indicating virtually all observed individuals were age-1 or -2 (Thompson et al. 1999), and none approached the recreational size limit of 762 mm FL. The observation that study sites were occupied only by sub-adult amberjack not yet recruited to the fishery (Ingram and Patterson 2001, Wells and Rooker 2004) indicates that amberjack may utilize reefs as transitional habitat before moving to larger offshore structures. Species such as snowy grouper, speckled hind, and warsaw grouper were only observed at study sites as small juveniles; therefore, they also likely used study sites as transitional habitat, a trend previously documented in deepwater groupers (Arena et al. 2007). Groupers such as gag, scamp, and red grouper are protogynous hermaphrodites known to utilize mid-shelf artificial reefs as pre-reproductive females transitioning across the shelf as they mature (Koenig et al. 2000, Lindberg et al. 2006). Pre-reproductive females can vary in size considerably and may attain large sizes at mid-shelf reefs (Koenig et al. 2000), and many groupers were larger than legal sizes for retention. However, it is still most likely that groupers utilized study reefs only as transitional habitat prior to moving farther offshore.

There is evidence that red snapper also undergo ontogenetic shifts in habitat utilization towards deeper shelf-edge reefs or other habitats as they age (Mitchell et al. 2004, Gallaway et al. 2009). Larger, older red snapper were conspicuously absent from reefs examined in the present study, which may indicate that fish moved to other habitats as they aged. However, there was no trend in red snapper size with depth among study reefs that ranged in depth from 27 to 41 m. Moreover, red snapper size distribution dropped markedly right at the legal size limit for the recreational fishery, thus implicating a fishery effect rather than ontogenetic movement. This inference is further supported by results of fishery-independent sampling that indicate older (> 10 yrs) red snapper are an order of magnitude less abundant in the north central GOM vs the stock's center of abundance off southwestern Louisiana (Gledhill 2001, Mitchell et al. 2004), a trend that has been attributed to exceedingly high apical fishing mortality rates (0.7–0.9 $yr^{-1}$) in the recreational fishery in the north central GOM (Porch 2007, SEDAR 2009c).

The question remains whether fish were targeted at study reefs vs elsewhere if the red snapper size distribution observed at study reefs was due to fishing mortality. As stated above, we have no direct evidence of fishing at study sites. Furthermore,

other species that are targeted by the recreational fishery with the same gear as red snapper did not display size distributions truncated at fishery size limits. A key difference is that these other species, such as gray triggerfish, vermilion snapper, and gray snapper, are known to display high site fidelity to reefs while red snapper site fidelity has been estimated as only 25%–50% $yr^{-1}$ to artificial reefs in the northern GOM (Patterson and Cowan 2003, Schroepfer and Szedlmayer 2006, Strelcheck et al. 2007). Intense fishing pressure near marine reserves has been shown to negatively impact the size structure (i.e., a greater proportion of sub-legal fish) and abundance of exploited species that move between protected and unprotected areas, thus reducing the effectiveness of reserves (Larsen 2005, Willis and Millar 2005). Mean distances moved by red snapper tagged at artificial reefs in the northern GOM range from 10–25 km $yr^{-1}$ (Patterson et al. 2001, Strelcheck et al. 2007, Addis et al. 2008), and even small scale movements (< 5 km) of red snapper among artificial reefs within the EE-LAARS could have exposed fish to high regional fishing mortality. Therefore, it appears unlikely that red snapper benefitted as much as other species from a lack of fishing pressure at study reefs given the likelihood that they were moving among fished and unfished reefs.

Overall, results from the present study suggest that unreported artificial reef sites can support diverse fish communities in the northern GOM. Fish assemblages, species diversity, and trophic structure at study sites were dynamic across time and among reef designs, despite the predominance of age-2 to age-3 red snapper at all sites. Truncated size distributions of many fishery species, such as red snapper, greater amberjack, and several groupers, that indicate individuals disappeared from study sites with size or age, is worrisome considering that study reefs were deployed to serve as no-harvest refugia, thus as sources vs sinks for these species. To properly site and utilize artificial reefs as mitigating tools within protected areas (Wilson et al. 2002), managers need to consider patterns of movement and habitat use at multiple spatial scales for fishery species as success of any marine reserve depends on the geographic extent needed to encompass the range of habitats utilized by exploited species (Crowder et al. 2000, Willis and Millar 2005). Results from our study suggest that artificial reefs should not be viewed as isolated habitats, but as part of a larger regional network of habitats (Grossman et al. 1997). Given the prevalence of artificial reef deployment in the northern GOM, there is a growing need for comprehensive experimental research and long-term monitoring to better understand how these habitats function ecologically and as fishery tools. The present study provides an important baseline for future research in the EE-LAARS aimed at this question, and also may prove to be useful for examining the impact of the Deepwater Horizon oil spill on reef fishes in this region of the GOM.

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# A Review of Movement in Gulf of Mexico Red Snapper: Implications for Population Structure

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*Abstract.*—A review of studies examining stage-specific distribution and movement of various life stages of red snapper, *Lutjanus campechanus*, in U.S. waters of the Gulf of Mexico (GOM) was conducted to draw inference about population structure. Hydrodynamic modeling of neither egg nor larval transport has been conducted for GOM red snapper; thus, the potential for planktonic dispersal among regions is currently unknown. However, recent studies of other reef fishes have demonstrated that larval fishes may not act as passive particles. Postsettlement movement, or the lack thereof, may be just as important for describing population connectivity and structure as planktonic transport. Red snapper juveniles display thigmotaxis and have been shown to undergo an ontogentic shift in which the dimension and complexity of their habitat increases with fish size. Tagging data demonstrate that while a substantial percentage of tagged fish were recaptured near their release sites, movement on the scale of hundreds of km also has been reported. Direct estimates of movement and population mixing from ultrasonic tagging, conventional tagging, and otolith chemistry studies indicate movement of some individuals may be sufficient to promote genetic exchange among regions, but overall movement is likely insufficient to affect population demographic differences observed among regions. Therefore, GOM red snapper meet criteria for consideration as a metapopulation: subpopulations are distinct, dispersal mechanisms exist among subpopulations, and asynchrony in population demographics is apparent among subpopulations.

## Introduction

Red snapper, *Lutjanus campechanus*, have been intensively managed in U.S. waters of the Gulf of Mexico (GOM) since the late 1980s when they were first estimated to be overfished and undergoing overfishing (Goodyear 1988; reviewed in Hood et al. 2007, this volume). Despite increasingly stringent harvest regulations placed on the directed fishery since the early 1990s, the stock has failed to recover, or even show significant signs of moving toward recovery (Hood et al. 2007, this volume; Porch 2007, this volume). Goodyear (1995) estimated shrimp trawl bycatch was the most significant source of mortality for GOM red snapper, the implications of which were the directed fishery would have to be either severely curtailed or closed in order to recover the stock if bycatch could not

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be minimized. Although more restrictive size and daily catch limits were put in place, other management options also have been explored in hopes of lessening the impact of regulations on the directed fisheries. Bycatch reduction devices (BRDs) were required in 1998 for shrimp trawlers operarting west of Cape San Blas, Florida, and in the entire U.S. GOM in 2004 (Hood et al. 2007, this volume). Stock enhancement also has been suggested as a means to recover red snapper without restricting the directed fishery (Papanikos et al. 2003; Ogle and Lotz 2006). Last, marine protected areas (MPAs) have been recommended as another alternative to increase red snapper biomass, although MPAs may provide additional conservation benefits that extend well beyond the fishery (Holland and Brazee 1993; Trexler and Travis 2000; Baskett et al. 2005).

Nearly all of the significant conservation questions concerning GOM red snapper have at their core the issues of population structure and the stage-specific distribution and movement of individuals. Clearly, red snapper are not unique in that respect as the importance of understanding population structure and connectivity has been stressed since early in the 20th century (Hjort 1914; Secor 2002, 2006). In reef fishes, eggs and larvae traditionally have been viewed as the most likely life history stages during which population mixing may occur given the potential for long-distance dispersal of planktonic early life stages and the often sedentary nature of adults (Jones et al. 1999; Swearer et al. 2002). Following that logic, several authors invoked planktonic transport of red snapper early life stages to explain the lack of genetic divergence reported among northern GOM regions (Goodyear 1995; Gold et al. 1997, 2001; Saillant and Gold 2006). Recent studies of other reef fishes, however, have indicated larvae may not act as passive particles in the sea and that self-recruitment mechanisms are prevalent (Cowen and Castro 1994; Jones et al. 1999, 2005; Swearer et al. 2002; Cowen et al. 2006; Almany et al. 2007). As a corollary, postsettlement movement may be more important than previously realized in facilitating population mixing in reef fishes, especially in large reef fishes, such as snappers and groupers, that may at times move great distances (Patterson et al. 2001; Lindberg et al. 2006).

The objective of this paper was to review the literature on GOM red snapper movement in order to draw inference about the implications observed movement has for red snapper population structure. Little is known about oceanographic transport of red snapper eggs and larvae, but what has been described about the occurrence of these life stages and their distributions is discussed briefly. The bulk of the paper reviews studies of postsettlement habitat, site fidelity, and movement of red snapper. Much research effort has been expended in recent years describing ontogentic shifts in red snapper habitat-specific distribution, as well as the potential for postsettlement movement to affect population connectivity, or the lack of movement, to shape localized population demographics. Overall, this review is aimed at facilitating a better understanding of GOM red snapper population structure and connectivity.

## Methods

A literature search was conducted for GOM red snapper within Cambridge Scientific Abstracts' Natural Sciences Database (www.csa.com). Separate searches were conducted for "*Lutjanus campechanus*" or "red snapper" appearing anywhere within citations published between 1980 and 2006. Unique citations of peer-reviewed publications were placed into one of ten categories: age and growth, bycatch, culture, diet/bioenergetics, fisheries management, genetics, habitat, movement, MPAs, reproduction and early life history, and miscellaneous. Papers were evaluated in the context of red snapper movement, population connectivity, and population structure. Additional papers reviewed include technical documents presented at the 2004 Southeast Data Assessment and Review (SEDAR) workshops for GOM red snapper (SEDAR7), technical reports featuring red snapper movement that were cited in other studies, and peer-reviewed publications published prior to 1980 and cited in subsequent papers.

## Results and Discussion

The literature search within Cambridge Scientific Abstracts' Natural Sciences Database

yielded 149 GOM red snapper papers that appeared in the literature between 1980 and 2006. More papers were published in the genetics ($n$ = 23) category than any other. Nine of those manuscripts detailed studies examining molecular markers in red snapper fillets in order to distinguish them from mislabeled species in the marketplace (e.g., Marko et al. 2004), but the subject of the majority of the genetics papers ($n$ = 13) was estimating genetic population structure in GOM red snapper (e.g., Pruett et al. 2005; Saillant and Gold 2006). Papers examining red snapper fisheries management ($n$ = 15) ranged from examining the effect of regulatory discards in the directed fisheries to estimating the value of the recreational fishery to an assessment of implementing an individual transferable quota system in the commercial fishery. Several papers ($n$ = 19) described red snapper habitat affinity and ontogentic shifts in habitat utilization, with papers split among juvenile habitat studies ($n$ = 9), natural hardbottom habitat of adults ($n$ = 1, but 2 others in the MPA category), and artificial reefs ($n$ = 9). Diet and bioenergetics studies ($n$ = 7) also tended to emphasize ontogentic shifts and habitat-specific differences in diet. Age and growth papers were prevalent ($n$ = 16), but only in one were differences in red snapper size at age tested among GOM regions (Fischer et al. 2004). Movement studies ($n$ = 13) examined life stage specific site fidelity and movement, as well as the residency of adult red snapper at artificial reef sites. Twenty-one percent ($n$ = 32) of the studies examined alternative management strategies for rebuilding red snapper, including stock enhancement (culture; $n$ = 15), bycatch reduction ($n$ = 11), and the efficacy of MPAs for rebuilding red snapper spawning stock biomass ($n$ = 6). Relatively few studies were directed at reproductive biology ($n$ = 4) or early life stages ($n$ = 4), the latter result highlighting the paucity of information available on red snapper eggs and larvae in the wild.

## Dispersal of Early Life Stages

Authors of early studies of GOM red snapper reproductive biology concluded that fish began reaching sexual maturity at small size (<300 mm total length TL) and had protracted spawning seasons extending throughout summer months (Bradley and Bryan 1975; Futch and Bruger 1976; Moseley 1966). Collins et al. (1996) were the first to estimate batch fecundity in red snapper and to establish that the spawning season extended from April through October in both the eastern and western GOM. The protracted spawning season for red snapper, combined with a larval stage duration of approximately 20 d (Szedlmayer and Conti 1999; Drass et al. 2000; Rooker et al. 2004), provides the potential for significant planktonic dispersal, and several authors have hypothesized that oceanographic transport of eggs and larvae is at least partially responsible for the lack of significant differences reported in selectively neutral genetic markers among GOM regions (Goodyear 1995; Gold et al. 1997; Saillant and Gold 2006). Despite the lack of significant genetic differences, Jackson et al. (this volume) reported maturity schedules and size-specific fecundity were significantly different between red snapper populations east and west of the mouth of the Mississippi River. They suggested early maturity at smaller size in the eastern GOM may be a genotypic response to high fishing mortality having selectively removed later maturing genotypes, a response that would not be apparent in selectively neutral genetic markers such as mitochondrial DNA (mtDNA) or nuclear DNA microsatellites (Pruett et al. 2005; Saillant and Gold 2006). Regardless of the causative factor of differences in reproductive biology parameters between the eastern and western GOM, the fact that regional population demographic differences exist implies some degree of isolation between the eastern and western GOM. Regional differences in size at age reported by Fischer et al. (2004) further support that population structure exists in GOM red snapper, which has not been revealed by traditional fisheries genetics applications (Pruett et al. 2005; Gold and Saillant 2007, this volume).

Relatively little was known until recently about the distribution of red snapper eggs and larvae in the GOM, and the extent to which interregional mixing may occur in the plankton remains unresolved (Hanisko et al. 2007, this volume; Lyczkowski-Shultz and Hanisko 2007, this volume). Collins et al. (1980) described morphometric and meristic characteristics of

larvae and Potthoff et al. (1988) described their osteological development. Drass et al. (2000) were the first to describe characters that distinguished larval red snapper as small as 3.5 mm (mid-flexion) from potentially co-occurring congeners and confamilials. Based on those characters, Lyczkowski-Shultz and Hanisko (this volume) reported a total of 1,692 red snapper larvae were identified in >14,000 bongo and neuston net samples collected on National Marine Fisheries Service (NMFS) research surveys between 1982 and 2003. Those data were used to compute fishery-independent indices of spawning stock biomass (Hanisko et al. 2007, this volume), but as yet no modeling exercise has been conducted to estimate the effect of oceanographic processes on the distribution and potential dispersal of larvae (e.g., Hanisko and Lyczkowski-Shultz 2003; Fitzhugh et al. 2005; Cowen et al. 2006).

Several authors hypothesized that oceanographic transport of eggs and larvae may be sufficient to facilitate population mixing despite the lack of hydrodynamic modeling of egg or larval transport in the northern GOM. Gold et al. (1997) reported mtDNA haplotype frequencies were not significantly different among northern GOM regions; thus, the authors failed to reject the null hypothesis that GOM red snapper constitute a single panmictic stock. They suggested genetic mixing among regions, or populations, may occur during planktonic egg and larval stages due to the preponderance of evidence, at that time, that red snapper adults were sedentary. However, the authors also suggested, based on intrapopulational mtDNA diversity differences, that GOM red snapper might include recently derived, but as yet not genetically distinct, population subunits. Pruett et al. (2005) conducted nested clade analysis of mtDNA haplotypes and concluded the genetic history of GOM red snapper was complex, as mtDNA frequencies suggested periods of both range expansion and ones of restricted flow resulting from isolation by distance. They hypothesized that apparently restricted gene flow among contemporary red snapper populations may yield metapopulation structure, but that hypothesis likely is not testable with selectively neutral genetic markers. Nevertheless, Pruett et al. (2005) suggested asynchrony observed in red snapper population demographics among northern GOM regions (Fischer et al. 2004; Jackson et al. 2007, this volume) was evidence that metapopulation structure may exist within GOM red snapper, despite the lack of divergence in selectively neutral genetic markers. Last, the authors concluded that precise estimates of exchange (i.e., movement) among regions was required to further examine the existence of metapopulation structure.

Discussions of interregional or interpopulational connectivity in GOM red snapper, as presented above, typically have centered on hypothesized, but as yet untested, oceanographic transport of eggs and larvae. Recent studies of other reef fishes, however, have indicated that larvae may not behave as passive particles in the sea and that self-recruitment mechanisms, including ones promoting endemism, are prevalent (Cowen and Castro 1994; Jones et al. 1999, 2005; Swearer et al. 2002; Cowen et al. 2006; Almany et al. 2007). Cowen et al. (2000) reported hydrographic model simulations of larval fish transport within the Caribbean Basin tended to overestimate dispersal when simple advection was assumed, thus demonstrating the importance of local retention in maintaining population structure. Other authors have demonstrated retention mechanisms in meroplanktonic invertebrates that metamorphose into sessile adults (e.g., Ayre and Hughes 2000; Johnson and Black 2006; Gilg and Hilbish 2003), as well as in reef fishes that display limited postsettlement home ranges (e.g., Doherty et al. 1995; James et al. 2002; Almany et al. 2007). However, the potential for interpopulational mixing clearly is greater, postsettlement, for reef-associated fishes that do not demonstrate high long-term site fidelity (Ingram and Patterson 2001; Patterson et al. 2001; Meyer et al. 2007) or that display ontogentic habitat shifts that occur over significant distances (Bryant et al. 1989; Lindberg et al. 2006).

### Ontogenetic Shifts in Red Snapper Habitat

Postsettlement movement in GOM red snapper has been investigated with several different approaches to address various questions about red snapper population ecology. Several authors

have examined ontogenetic habitat shifts (e.g., Bradley and Bryan 1975; Szedlmayer and Howe 1997; Szedlmayer and Conti 1999; Rooker et al. 2004), with recent studies aimed at defining essential fish habitat (EFH) of juveniles in order to mitigate shrimp trawl bycatch (e.g., Patterson et al. 2005; Wells 2007). When results of habitat studies are considered in totality, some consistent themes begin to emerge relative to red snapper habitat requirements and how they shift ontogenetically. First, like most reef fishes, juvenile red snapper display a strong thigmotaxis, thus seek structured environments (Workman et al. 1994; Szedlmayer and Howe 1997; Bailey et al. 2001; Franks et al. 2004). Szedlmayer and Howe (1997) reported juvenile red snapper selected oyster shell versus sand habitat in tank trials, while Patterson et al. (2005) reported highest juvenile red snapper densities in trawl samples off Alabama and Mississippi came from high-relief (2–3 m) shell rubble ridge habitats. Seemingly contrary results were presented by Rooker et al. (2004) and Geary et al. (this volume) that demonstrated juvenile red snapper associated with Texas bank systems were found in high densities in relatively unstructured mud habitats, and Patterson et al. (2005) reported moderately high juvenile densities occurred in sand habitats off Alabama and Mississippi. However, sampling trawls deployed by Rooker et al. (2004) and Geary et al. (this volume) contained small-mesh bags that retained recently-settled juveniles for which biogenic structures such as worm tubes may provide sufficient structure in soft sediments (Workman et al. 2002). Furthermore, mud habitats were immediately adjacent to shell rubble habitats and may have served as foraging areas. Patterson et al. (2005) reported red snapper juvenile density in sand habitats was significantly correlated with sponge biomass. Hence, they concluded sponges provided habitat complexity at a scale sufficient for juvenile snapper. Similarly, Workman and Foster (1994) reported juvenile red snapper encountered in sand habitats typically were associated with objects, such as squid egg cases, woody debris, or discarded drink cans, that fish used for either refuge or orientation.

Much evidence suggests that as red snapper age they recruit to habitats characterized by increasing vertical dimension. Patterson et al. (2005) demonstrated age-0 red snapper were found in low-relief shell rubble and sand (interspersed with sponge) habitats, but age-1 fish were found at deeper (40 versus 20 m depth) sites that had greater vertical relief and complexity. Bailey et al. (2001) conducted tank trials in which they tested the effect of structure (concrete blocks) and the presence of adult conspecifics on the location of juvenile red snapper within tanks. When adults were not present, juveniles oriented to experimental reefs, but when present, adults displayed agonistic behavior in excluding juveniles from the preferred habitat. Wells (2007) reported that age-0 fish off Alabama were abundant in shell rubble habitats, but larger, older (age-2+) fish were concentrated in natural reef habitats. Bradley and Bryan (1975) reported ontogenetic movement of red snapper to structured habitats of increasing dimension occurred as an onshore to offshore migration throughout the juvenile stage. [It should be noted that natural hardbottoms and banks that constitute the most significant natural reef areas in both the western and eastern GOM are found predominantly on the outer shelf, while lower-relief shell rubble ridges and banks are found in relatively shallow (<20 m) nearshore waters (Parker et al. 1983; Schroeder et al. 1988; Laswell et al. 1990; Dufrene et al. 2003; Gledhill and David 2004; Rooker et al. 2004; Kraus et al. 2006)]. Mitchell et al. (2004) reported larger (median TL ranged from 545 to 815 mm among surveys), older red snapper were captured at higher rates in outer shelf habitats during experimental longline surveys in the eastern (off Alabama-Mississippi) and western (off Texas) GOM. Fishery-dependent data confirm that larger, older fish are captured much more frequently in commercial fishery sectors operating farther from shore (Allman and Fitzhugh 2007, this volume).

Analysis of natural ontogenetic shifts in red snapper habitat utilization is complicated due to the proliferation of artificial reefs deployed in the north-central GOM and the vast number of petroleum platforms, which function as artificial reefs, erected in the northwestern GOM (Wilson and Nieland 2004). However, examination of the literature on red snapper recruitment to and resi-

dency at artificial reefs and platforms reveals the same pattern of increasing dimension of utilized habitats with increasing fish size. Szedlmayer and Lee (2004) reported juvenile red snapper as small as 18 mm settled in relatively unstructured open shelf habitats in summer, but by winter age-0 fish had recruited to experimental artificial reefs that provided greater habitat complexity and relief. Nieland and Wilson (2003) randomly sampled red snapper ($n$ = 300) killed during the explosive removal of an obsolete oil platform off Louisiana. Otolith-based aging revealed the majority of fish were 2 and 3 year olds (53% and 37%, respectively), while virtually no ($n$ = 2) age-1 fish were present in their sample. Similarly, size frequency data from small-scale (<5 $m^3$) artificial reefs off Alabama and northwest Florida indicate the majority of red snapper present are 2 and 3 year old fish (Strelcheck et al. 2005; Patterson, unpublished data). The lack of older red snapper at both platforms and artificial reef sites may indicate thigmotaxis or the threat of predation subsides with age and size; thus, larger, older fish display lower site fidelity and greater movement (Patterson et al. 2001; Patterson and Cowan 2003; Stelcheck et al. 2007, this volume). Alternatively, high fishing mortality rates at platforms and artificial reefs may remove snapper very quickly from the population once fish recruit to the commercial or recreational fisheries (Nieland and Wilson 2003).

### Direct Estimates of Post Settlement Movement

More important to population connectivity than the distribution of fish at single points in space or time is the degree of site fidelity (philopatry) individuals display and the spatial scale over which movement occurs. Some inference can be drawn about red snapper movement due to seasonal occurrence of fish in certain habitats and ontogenetic habitat shifts described above, but movement on multiple temporal and spatial scales has been estimated directly in several studies. The two main approaches that have been applied to estimate red snapper site fidelity and movement are conventional and, more recently, ultrasonic tagging. Benefits of conventional tagging include tags being inexpensive and relatively unobtrusive to fish; individual tagged fish can be identified; and, nonscientists can be trained to apply tags (Patterson et al. 2001; Diamond et al. 2007, this volume). However, movement can only be estimated as straight-line distances between release and recapture locations, and reporting rates by fishers often are low in heavily regulated fisheries (Fable 1990). Tag loss also can be problematic (Patterson et al. 2001). With ultrasonic tagging, individuals can be tracked nearly continuously within the range of receivers. Depending on the types of tags deployed, individual tags (fish) can be identified based on their frequency or ping rate, but the ability to track individuals is affected by receiver range and tag battery life. If functionality of tags is compromised, then a fish present but not detected would be perceived as having left the study area (Westmeyer et al. 2007, this volume).

Szedlmayer (1997) conducted the first ultrasonic tagging experiment on red snapper at artificial reef sites off Alabama (Table 1). He concluded from study results that red snapper displayed "high" site fidelity to artificial reefs, yet the mean time fish were detected in his study area was only 150 d for a species with maximum longevity >50 years (Wilson and Nieland 2001). While one tagged individual was detected for 597 d, several others ($n$ = 6 of 23) were lost from the study area. Both "stayers" and "movers" (from Diamond et al. 2007, this volume) have important implications for population connectivity and structure (Dieckmann et al. 1999; Doebeli and Ruxton 1997; Fraser et al. 2001), but movers can no longer be tracked with ultrasonic receivers once they move beyond the range of receivers. Hence, emphasis in red snapper ultrasonic tagging analysis and interpretation has tended to be weighted toward the stayers. For example, Schroepfer and Szedlmayer (2006) concluded that ultrasonically tagged red snapper displayed high site fidelity to artificial reef sites because 87% (13 of 15) of fish were detected within 200 m of study sites 99% of the time they were detected. However, the probability that fish remained resident at reef sites after a year was only approximately 50% (i.e., 50% annual site fidelity). Westmeyer et al. (this volume) reported even lower probability of detection at petroleum platforms off Louisiana after one year, but tag battery failure and thermocline

**Table 1.** Results from ultrasonic tagging studies of sub-adult and adult red snapper in the northern Gulf of Mexico.

| Study | Location and Habitat | Area of Detection per Hydrophone | Hydrophones per Site | Number Tagged | Mean TL at Tagging mm | Mean Days Detected in Study Area | Max Days Detected in Study Area |
|---|---|---|---|---|---|---|---|
| Szedlmayer (1997) | Alabama; artificial reefs | 3.1 $km^2$ | 1; roving | 23 | 349 | 150 | 597 |
| Szedlmayer and Schroepfer (2005) | Alabama; artificial reefs | ≤ 8.0 $km^2$ | 3–4; fixed | 54 | 589 | 212 | 595 |
| Schroepfer and Szedelmayer (2006) | Alabama; artificial reefs | ≤ 8.0 $km^2$ | 3–4; fixed | 77 | 542 | 179 | 597 |
| Westmeyer et al. (this volume) | Louisiana; petroleum platforms | 0.02 $km^2$ | 7 within a 35 $km^2$ area | 125 | 360 | 64 | 202 |

[a] Area of detection was estimated based on maximum detection radii from hydrophones reported in each study.

effects on receivers likely negatively affected their estimates of site fidelity.

Ultrasonic tagging data are useful for examining short-term movements in resident individuals (stayers), but understanding population connectivity and structure is perhaps more dependent on estimating dispersion distances and rates of movers (Doebeli and Ruxton 1997). Conventional tagging studies are better suited for that purpose, despite the limitations cited above, and several large-scale conventional tagging studies have been conducted on GOM red snapper since the 1960s (Table 2). Among the various studies, fish were captured at natural reefs, artificial reefs (including petroleum platforms), or both. However, most of the existing movement data available from conventional tagging studies are from studies conducted over artificial reef sites in the north-central GOM (e.g., Szedlmayer and Shipp 1994; Patterson and Cowan 2003; Strelcheck et al. 2007, this volume). An exception to that are data from the Schlitz Tagging Program conducted off Florida in the 1960s by Florida Department of Natural Resources personnel. Fish in that program were captured and tagged over natural reef sites, most of which occurred off northwest Florida (Beaumariage 1969). Fable (1980) also reported movement data from fish captured and tagged over a variety of natural and artificial habitats off Texas, as did Diamond et al. (this volume).

Several consistent trends exist in the movement data among conventional tagging studies, although considerable variability also exists in results among them. Most tagged individuals have been small, young fish, with mean TL between 299 and 363 mm across studies (Table 2). Patterson et al. (2001) reported fish size significantly affected the likelihood and distance of movement away from release sites, and Diamond et al. (this volume) reported larger fish had a higher probability of movement than had smaller ones. Red snapper can attain sizes of nearly 1 m TL (Wilson and Nieland 2001); thus, movement estimates based on a sample of small, young individuals may be conservative when applied to larger, older fish in the population.

The scale of observed movement generally increased with sample size and the temporal scale of tagging studies. Movement data presented by Diamond et al. (this volume) from tag returns of fish tagged off Texas represents one

departure from that trend. Substantially more fish were tagged in their study ($n$ = 5,614) than in any other, yet only modest levels of movement were observed. However, some of their samples came from deep water (to 100 m); thus, acute or chronic effects of barotrauma may have affected their functional sample size (Patterson et al. 2002; Rummer 2007, this volume) and overall tag return rate (2.8% versus ~6–35% among other studies). Furthermore, the mean and maximum times that recaptured fish were free in their study (564 d) were only about a third of those reported by others (Table 2).

Perhaps the most striking characteristic of red snapper movement data that is consistent among tagging studies is that data tend to be positively skewed and are characterized by a negative binomial distribution (Patterson et al. 2001). That consistent pattern results from a high percentage of zeros in the data (stayers) and the fact that most movers moved only small (<10 km) rather than large (>50 km) distances prior to recapture [e.g., Table 8 in Beaumariage (1969); Figure 5 in Szedlmayer and Shipp (1994); Figure 5 in Patterson and Cowan (2003)]. Fraser et al. (2001) reported similar movement distributions are common across many taxa, and sought to explain the ecological and evolutionary significance of dispersing phenotypes in populations. They demonstrated movers (their "dispersers") within populations of giant rivulus, *Rivulus hartii*, in Trinidadian streams were individuals who displayed boldness versus fearfulness in traversing open spaces in test tanks prior to tagging. Once tagged and released back into the wild, bold individuals not only moved greater distances in streams, but also had higher individual growth rates. Diamond et al. (this volume) also reported tagged red snapper that moved away from tagging sites off Texas grew at faster rates than ones that stayed. Fraser et al. (2001) concluded that bold behavior traits contributed to greater fitness of surviving movers versus stayers, although the cost of boldness, hence movement, was greater exposure to predation risk.

Currently, it is unknown what the cost of movement away from reef structure is for red snapper. Observed postsettlement movement has been lower in juveniles than in sub-adults,

**Table 2.** Movement and site fidelity estimates from conventional tagging studies of sub-adult and adult red snapper conducted in the northern Gulf of Mexico.

| Study | Location and Habitat | Number Tagged | Mean TL at Tagging mm | Number Recaptured | Mean/Max Days Free | Mean/Max km Moved | Site Fidelity[a] |
|---|---|---|---|---|---|---|---|
| Beaumariage (1969) | West Florida; natural reefs | 1,126 | NA | 384 | 113/ 2,049 | NA/ 279 | 90% recaptured within 5 km of release site |
| Fable (1980) | Texas; natural reefs and oil platforms | 299 | 286 | 17 | 112/ 253 | 0.3/ 5 | 94% recaptured at release site |
| Szedlmayer and Shipp (1994) | Alabama; artificial reefs | 1,155 | 287 | 146 | 137/ 430 | 4.6/ 32 | 74% recaptured within 2 km of release site |
| Patterson and Cowan (2003)[b] | Alabama; artificial reefs | 2,932 | 335 | 599 | 404/ 1,501 | 30.9/ 558 | 25–27% per year |
| Strelcheck et al. this volume | Alabama; artificial reefs | 4,317 | 335 | 629 | 401/ 1,587 | 2.1/ 202 | 48–50% per year |
| Diamond et al. this volume (TTU Tagging) | Texas; artificial and natural reefs | 5,614 | 363 | 130 | 166/ 564 | 9.8/ 58.3 | 52.4% recaptured at release site |

[a]Site fidelity to release site was directly estimated as an annual rate by Patterson and Cowan (2003) and Strelcheck et al. (this volume) from the decline in recaptures made by researchers at unreported study sites over time.
[b]Data presented in Patterson and Cowan (2003) include data presented in Patterson et al. (2001) plus additional recaptures.

and the scale of movement generally increased with size in the adult life stage (Patterson et al. 2001; Workman et al. 2002; Diamond et al. 2007, this volume). Lorenzen (2000, 2006) demonstrated the existence of an allometric relationship between natural mortality (*M*) and fish body weight. He demonstrated *M* declines with increasing body size, which in turn most likely results from a concomitant decrease in predation risk (Sogard 1997; Murakami et al. 2005). Therefore, adult red snapper site fidelity to reefs may decrease, and their movement distances increase, with increasing size and/or age due to a relaxation of predation risk as fish attain larger sizes. But despite the potential for interpopulational genetic mixing resulting from extreme (>100 km) movement observed in some tagged fish (e.g., Beaumariage 1969; Patterson et al. 2002; Strelcheck et al. 2007, this volume), Pruett et al. (2005) reported evidence of evolutionarily recent isolation by distance was apparent in mtDNA haplotype frequencies, and Saillant and Gold (2006) reported significant differences in red snapper genetic effective population size among northern GOM regions. Therefore, although some selection pressure may exist to maintain mover phenotypes in red snapper populations (Fraser et al. 2001), competing pressures must also exist else selection likely would have driven red snapper populations to display even greater movement than what has been observed (Jonsson and Jonsson 1994; Doebeli and Ruxton 1997). Perhaps selection pressures for movement versus philopatry are stage-dependent in red snapper, as has been demonstrated in other marine and anadromous species that maintain divergent migratory tactics (reviewed in Secor 1999). For small, young fish, fitness tradeoffs existing between growth and defense (Sibly et al. 1985) likely favor high site fidelity to reef structure (thigmotaxis) as a refuge from predation (Overholtzer-McLeod 2005), even when high fish density compromises growth (Strelcheck et al. 2005; Lindberg et al. 2006). Predation pressure likely is lower for larger, older fish, for which large size alone may convey fitness, especially in females (Munch and Conover 2003; Andersen et al. 2007); therefore, reef dependency is relaxed (Patterson et al. 2001; McCawley et al. 2007, this volume). It is unknown, however, what factors may contribute to extreme (>100 km) movement observed in some red snapper. Patterson et al. (2001) reported tagged fish at liberty during hurricanes moved significantly farther than ones which were not exposed to storms. However, Beaumariage (1969) did not report storm effects and several fish recently tagged off northwest Florida have moved extreme distances in the absence of storms (Patterson, unpublished data).

### Implications for Population Structure

Postsettlement movement observed in red snapper has significant implications for population structure. Traditionally, population, or stock, structure in GOM red snapper has been evaluated with population genetics techniques. Results of studies designed to examine genetic population structure consistently have shown that interregional variability in selectively-neutral genetics markers, such as mtDNA and nuclear DNA microsatellites, is low. Thus, significant differences among regions in haplotype frequencies have not been found (Gold et al. 1997; Saillant and Gold 2006; Gold and Saillant 2007, this volume). However, Saillant and Gold (2006) reported 10-fold differences in genetic effective population size estimates among southwest, northwest, and north-central regions of the U.S. GOM, which they inferred likely reflected interregional differences in patterns and intensity of migration. Pruett et al. (2005) reported results of nested clade analysis performed on region-specific mtDNA haplotype frequencies were consistent with the hypothesis that red snapper populations were semi-isolated within regions, despite the lack of significant interregional genetic heterogeneity found in selectively neutral markers. Even in the absence of significant gene flow due to oceanographic transport of eggs and larvae, it is possible that extreme (>100 km) movement observed in some adults is sufficient to facilitate genetic mixing among regions (Nolan et al. 1991), yet also so rare as to be inconsequential to the maintenance of persistent interregional differences in population demographics (Policansky and Magnuson 1998). This may be especially true currently as relatively few large fish that are more likely to

be movers exist in the truncated age distribution of the overfished stock (Porch 2007, this volume).

Previously narrow definitions of genetic stock structure in marine fishes have been replaced in recent years with metapopulation concepts due to issues similar to those raised above for red snapper (Thorrold et al. 2001; Kritzer and Sale 2004, 2005). Kritzer and Sale (2005) stated that in order to invoke metapopulation dynamics, subpopulations must be distinct, have dispersal mechanisms among them, and display asynchrony in population dynamics; Levins' (1969) earlier emphasis on extinction risk was abandoned. Pruett et al. (2005) concluded that results of nested clade analysis, in light of asynchronous population dynamics parameters among GOM regions, were consistent with the interpretation that GOM red snapper constituted a metapopulation. I submit that red snapper movement data, presented here in their various forms, also are consistent with that interpretation. Movement sufficient to affect mixing of genetic resources among regions has been demonstrated, but not on scales that would be likely to diminish regional differences in population demographics, such as those demonstrated by Fischer et al. (2004) and Jackson et al. (this volume).

Pruett et al. (2005) indicated precise estimates of movement among regions are required in order to test whether GOM red snapper constitute a metapopulation. Other authors also have recognized that estimates of interpopulational mixing rates on ecological versus evolutionary time scales are required to assess metapopulation structure in fishes (Secor 1999; reviewed in Sale et al. 2005). Perhaps the most powerful tool yet found for that purpose is the use of otolith chemistry as a natural tag to track movement of fish among regions (Begg et al. 2005; Campana 2005). Since Thorrold et al.'s (2001) groundbreaking work employing otolith chemistry as a natural tag to examine weakfish, *Cynoscion regalis*, natal homing and population connectivity, several authors have likewise drawn inferences about population structure in marine fishes via natural tags based on otolith elemental signatures (e.g., Geffen et al. 2003; Miller and Shanks 2004; Hamer et al. 2005; Jonsdottir et al. 2006).

Application of otolith chemistry as a natural tag also has been applied to examine population structure in GOM red snapper. Patterson et al. (1998) reported otolith elemental signatures of age-0 red snapper were significantly different among north-central, northwestern, and southwestern regions of the U.S. GOM. Patterson et al. (in press) reported region-specific otolith elemental signatures (Ba, Mg, Mn, and Sr concentrations) of age-0 fish were significantly different among five successive (1996–2000) year classes, and that classification success in most ($n$ = 4 of 5) years was sufficient to employ signatures as natural tags (e.g., jackknifed classification success of liner discriminant function models approached 80%). Analysis of the core elemental chemistry of otoliths collected from members of the 1996–2000 year classes sampled among study regions in 2001 revealed red snapper displayed strong intraregional philopatry in the first year of life (Cowan et al. 2002). Almost no mixing was estimated to have occurred between the north-central and northwestern GOM as fish aged, which is consistent with data from conventional tagging studies that have not demonstrated mixing between areas east and west of the Mississippi River. Mixing between the northwestern and southwestern regions, however, was greater, with a net subsidy of recruits apparently provided to the southwestern region from the northwestern region.

Overall, postsettlement movement data presented herein are consistent with the inference that GOM red snapper constitute a metapopulation. However, as suggested by Pruett et al. (2005) and despite the resources already invested in estimating movement in red snapper, more precise estimates of movement and exchange rates are required to assess interpopulational connectivity. For example, conventional tagging studies conducted to date have been designed to estimate movement away from tagging sites in a given GOM region, but not necessarily to estimate connectivity among regions. Coordination among ongoing tagging programs would prove beneficial for that purpose. Otolith chemistry has shown great promise as a tool to examine population structure and connectivity in GOM red snapper, but misclassification error (~20%) of age-0 fish is

problematic. Furthermore, not all regions of the GOM where red snapper occur have been studied. Future otolith elemental chemistry research should examine elemental signatures from age-0 fish across the entire GOM Basin, as well as examine the potential for increased region-specific classification accuracies of age-0 fish by addition of other elements and stable isotope values of C and O to otolith signatures.

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# Age and growth of red snapper, *Lutjanus campechanus*, from an artificial reef area off Alabama in the northern Gulf of Mexico

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**Abstract**–Age and growth were examined of red snapper, *Lutjanus campechanus*, captured in an extensive (3100 km$^2$) artificial reef area off Alabama in the northern Gulf of Mexico. Sagittal otoliths were removed from individuals ($n$=1755) sampled from recreational catches and tournament landings. Marginal increment analysis of sectioned otoliths revealed that a single opaque zone formed annually in sagittae from January through May. Fish ages were estimated from the number of opaque zones in otoliths, timing of opaque zone formation, sampling date, and a presumed birthdate of 1 July. Estimated growth of recaptured red snapper ($n$=288) from a tagging experiment was similar to growth estimated from otolith-aged fish and corroborated otolith aging methods. The von Bertalanffy growth function fitted to length-at-age data was $TL = 969 \text{ mm } (1-e^{-0.192(t-0.020)})$ ($P$<0.001; $r^2$=0.99), which was similar to reported growth functions for western Gulf of Mexico and Atlantic red snapper. Results of our study are consistent with the single stock hypothesis for Gulf of Mexico red snapper.

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Fish. Bull. 99:617–627 (2001).

Red snapper, *Lutjanus campechanus*, are large, predatory reef fish belonging to the family Lutjanidae. They generally are found from Cape Hatteras, North Carolina, to the Yucatan Peninsula, including the waters of the Gulf of Mexico (GOM) but not the Caribbean Sea (Hoese and Moore, 1998). Throughout their range red snapper are distributed along the continental shelf out to the shelf's edge and demonstrate affinity for vertical structure. Adults aggregate on or near coral reefs, gravel bottoms, or rock outcrops, as well as on artificial reefs, oil rigs, and wrecks (Moseley, 1966; Szedlmayer and Shipp, 1994; Stanley and Wilson, 1997).

Red snapper support economically valuable recreational and commercial fisheries in U.S. waters of the GOM (GMFMC, 1989). Federal management of GOM red snapper is based on the assumption that fish from Florida to Texas constitute a single stock. Although genetic evidence supports this assumption (Camper et al., 1993; Gold et al., 1997; Heist and Gold, 2000), fish are not distributed uniformly across the northern GOM. Fisheries-dependent data suggest there is a center of red snapper abundance off southwest Louisiana and a second, smaller center of abundance off Alabama (Goodyear, 1995a; Schirripa and Legault, 1999). For example, from 1981 to 1998 estimated Louisiana landings of red snapper (commercial and recreational catch from state and federal waters) accounted for 32.6% (mean) ±1.5% (SE) of the total GOM harvest, whereas Alabama landings accounted for 11.4% ±0.9% of the total catch (Schirripa and Legault, 1999).

Although fewer red snapper are harvested from waters off Alabama than from the northwestern GOM, the red snapper fishery off Alabama is unique in several ways. Given that Alabama's GOM coastline represents only about 3.0% of the coastline from Tampa, Florida, to Brownsville, Texas, a disproportionately high percentage of the GOM red snapper harvest is caught and land-

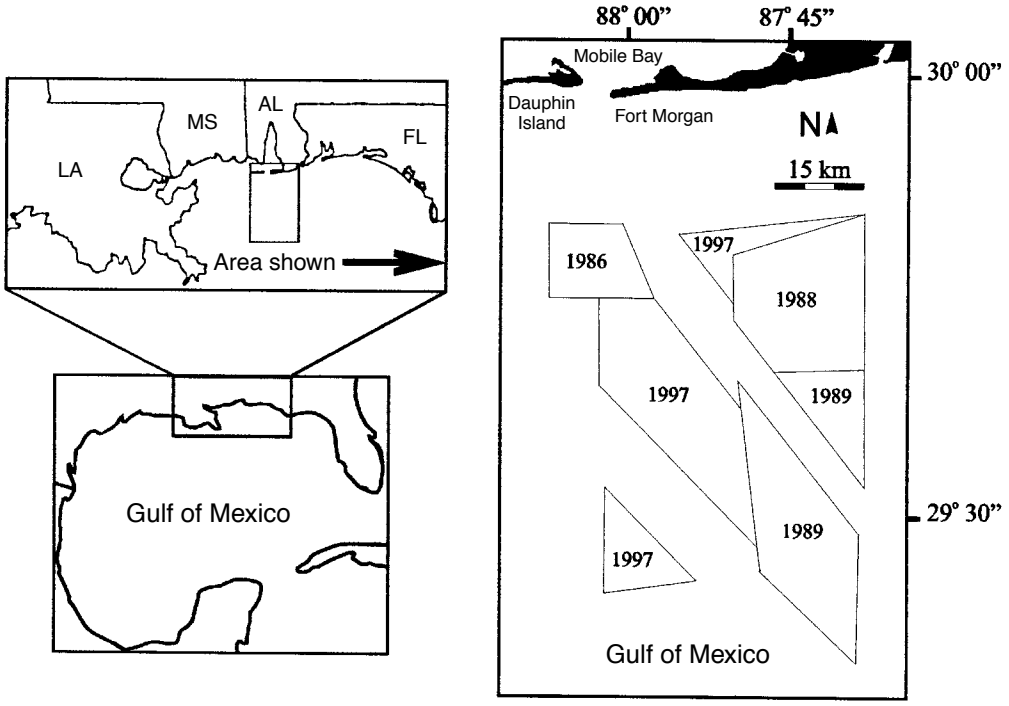


**Figure 1**
Map of artificial reef permit areas off Alabama. Date of creation is given for each area.

ed there. The productivity of the red snapper fishery off Alabama occurs despite the fact that few high-relief (>1 m) natural reefs exist on the continental shelf in the north central GOM (Parker et al., 1983; Shultz et al., 1987; Schroeder et al., 1989); however, off the coast of Alabama exists a 3100-km$^2$ area designated for artificial reef deployment (Fig. 1). The correlation between high catch rates and the creation of artificial reefs off Alabama has caused some to speculate that artificial reefs have increased the productivity of the GOM red snapper stock in this area (Szedlmayer and Shipp, 1994; Minton and Heath, 1998).

Despite the implied effect of artificial reefs on the red snapper fishery off Alabama, few studies have focused on red snapper in this area. The objective of our study was to estimate growth rates of adult red snapper captured off Alabama with otolith-aging and mark-recapture methods and to compare growth estimates with growth of adult red snapper from the western GOM and the southeastern United States. As a corollary to our primary objective, we also attempted to validate presumed annual growth rings in otoliths with marginal increment analysis and present a comparison of estimated growth of otolith-aged red snapper with estimated growth of tagged individuals.

## Methods

### Otolith aging

Red snapper were sampled from July 1995 to September 1999. All fish were caught over artificial reef sites off Alabama. Red snapper shorter than the legal size limit (380 mm total length [TL] for most of the study) were randomly sampled from undersize fish caught during research cruises to tag red snapper. Fish longer than the legal size limit were either randomly sampled from recreational catches or sampled opportunistically at spearfishing or hook-and-line fishing tournaments. Total length and fork length (FL) were measured to the nearest mm for all fish, and whole weight was measured to the nearest 0.1 g. Sex was determined for most fish by macroscopic examination of the gonads. Both sagittae were removed from each sampled individual, rinsed of any adhering tissue, and stored in paper coin envelopes until processing.

Otoliths were sectioned in a transverse plane following the methods of Cowan et al. (1995) and were read under transmitted light with either a Micro Design® model 925 microfiche projector or an Optimas® image analysis system (Media Cybernetics, 1999). Otoliths were read independently by two readers. Blind counts of opaque zones of each sectioned otolith were made along the ventral margin of the sulcus acousticus from the core to the proximal surface; marginal increments were scored following Beckman et al. (1991) (Table 1, Fig. 2). Otoliths for which counts of opaque zones differed between readers were read a second time. Precision among readers was evaluated with the coefficient of variation (CV) (Chang, 1982), index of precision (D) (Chang, 1982), and average percent error (APE) (Beamish and Fournier, 1981).

Age was estimated from the number of opaque zones in otolith sections, timing of opaque zone formation, assumed birthdate, and sampling date. It was assumed that opaque

**Table 1**

Scale used in determining condition of red snapper otolith marginal increments.

| Margin score | Margin description |
|---|---|
| 1 | Opaque zone begins to form at edge; zone is <1/3 the thickness of the previous opaque zone. |
| 2 | Opaque zone at edge is between 1/3 and 2/3 the thickness of the previous opaque zone. |
| 3 | Opaque zone at edge is >2/3 the thickness of the previous opaque zone. |
| 4 | Translucent zone begins to form at edge; zone is <1/3 the thickness of the previous translucent zone. |
| 5 | Translucent zone at edge is between 1/3 and 2/3 the thickness of the previous translucent zone. |
| 6 | Translucent zone at edge is >2/3 the thickness of the previous translucent zone. |

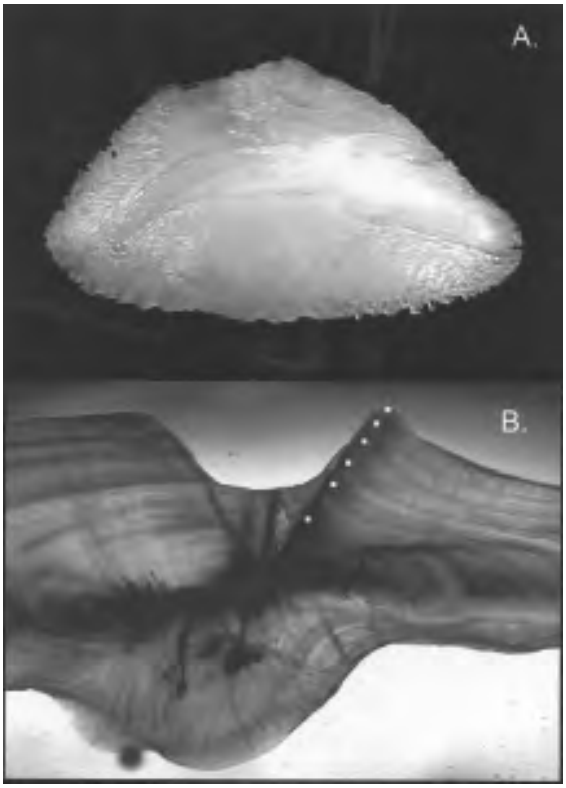


**Figure 2**

Digital images of (**A**) the proximal view of the left sagitta from a 408-mm-TL female red snapper sampled in August 1996 and (**B**) a thin section of a sagitta from a 683-mm-TL female red snapper sampled in January 1996. White squares on the thin section designate opaque zones ($n$=6); edge score is one.

zones constitute annuli and that annulus formation begins 1 January (see "Results" section). The birthdate for red snapper in the north central GOM was assumed to be 1 July, which follows the convention of Goodyear (1995a) and is based on the peak in red snapper spawning in the north central and northeastern GOM (Collins et al., 1996; Szedlmayer and Conti, 1999). According to these assumptions, young-of-the-year northern GOM red snapper form their first annulus in sagittae beginning in January when fish are approximately 0.5 yr old. Therefore, the opaque zone closest to the otolith core represents only 0.5 yr of life, which was accounted for in the aging algorithm.

Age (in d) was estimated (for most fish) by first subtracting one opaque zone from the total number of opaque zones in a given otolith and multiplying the difference by 365 d. Next, 182 d was added to the product to account for the first 0.5 yr of life. Finally, the day of year (number of days since 1 January) the fish was sampled was added to account for the number of days in the sampling year that the fish was alive. The result was divided by 365 d to estimate age in years. Age was estimated similarly for fish that were sampled in November and December and had already begun forming opaque margins, except two was subtracted from the total number of opaque zones before multiplying by 365 d in order to assign fish to the correct year class. For fish that were sampled in January that did not have an opaque margin, zero was subtracted from the total number of opaque zones.

Von Bertalanffy (1938, 1957) growth functions (VBGFs) were fitted to TL-at-age data with Proc NLIN in SAS (SAS Institute, Inc., 1996). Von Bertalanffy growth functions were fitted separately for males and females and a likelihood ratio test was used to test for difference in growth between sexes (Kimura, 1980; Cerrato, 1990). Von Bertalanffy growth functions also were fitted for the complete data set and for the complete set excluding tournament sampled fish.

Weight-TL relationships were modeled with non-linear regression for females and males following Ricker (1975). The functions were computed with Proc NLIN in SAS (SAS Institute, Inc., 1996). Sex-specific weight-TL relationships were made linear by taking the log of weight and TL, and difference between sexes was tested with an analysis of covariance (ANCOVA) on the log-transformed data (SAS Institute, Inc., 1996). Lastly, a weight-TL nonlinear regression was computed for females and males combined with Proc NLIN in SAS (SAS Institute, Inc., 1996).

## Mark-Recapture

A tagging study of adult red snapper was conducted off Alabama from March 1995 to August 1999. Fish were caught with hook and line over nine artificial reef tagging sites in the Hugh Swingle general permit area for arti-

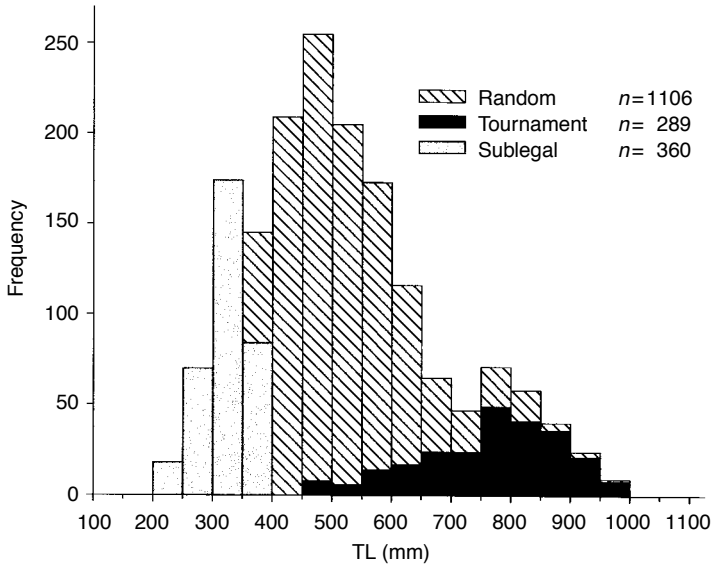


**Figure 3**

Distribution of total length (TL) of red snapper sampled for age and growth estimation.

ficial reef deployment (labeled 1986 in Fig. 1). Each fish was measured to TL and FL, tagged with a yellow Floy® (Seattle, WA) internal anchor tag, and released. Individuals were recaptured on subsequent tagging trips or were recovered by recreational and commercial fishermen. Red snapper recaptured on tagging trips were measured to TL and FL and recovered fish were measured when fishermen retained carcasses of tagged fish.

To corroborate red snapper age estimates, VBGF parameters estimated from otolith-aged fish were incorporated into Fabens' (1965) length increment model to predict TL at recapture of tagged fish (Labelle et al., 1993; Thompson et al., 1999). Solving for TL at recapture, Fabens' model is computed as

$$TLr_i = Tl_i + (L_\infty - t_i)\,(1 - e^{-k\Delta t_i}), \quad (1)$$

where $TLr_i$ = predicted $TL$ at recapture of individual $i$;
$TL_i$ = $TL$ at release of individual $i$;
$L_\infty$ = $TL$ asymptote from VBGF estimated from otolith-aged fish;
$K$ = growth coefficient from VBGF estimated from otolith-aged fish; and
$t_i$ = time at liberty of individual $i$.

Predicted TL at recapture from Fabens' method was plotted against observed TL at recapture to compare growth model predictions to observed values.

Growth of tagged red snapper was estimated by regressing their change in TL on days at liberty (SAS Institute, Inc., 1996). A linear regression also was computed on TL-at-age data over the size range of recaptured individuals from the tagging study (SAS Institute, Inc., 1996). Slopes of resultant regressions were compared to assess if estimated growth rates were different between tagged and otolith aged fish.

## Results

### Age and growth

Sagittae were collected from 1755 red snapper, including 360 fish shorter than the minimum size limit (380 mm TL) caught on tagging cruises, 289 fish from tournaments, and 1106 fish randomly sampled from recreational catches (Fig. 3). Sex was not determined for 279 fish, of which 61 individuals were immature. Mean TL (±SE) was 518.3 (±5.04) mm for males and 529.5 (±5.96) mm for females. Total length of immature individuals ranged from 208 to 309 mm.

Of the 1755 otoliths sectioned for age determination, reader 1 and reader 2 agreed on the number of opaque zones for 1610 (91.7%) fish after the first reading; opaque zones in 23 otoliths were deemed not interpretable owing to sample preparation. Count disagreement between readers was the following: one opaque zone for 123 fish, two zones for 18 fish, and three zones for four fish. Otoliths were read a second time if reader counts were not in agreement and second otoliths were sectioned and read of the 23 fish for which otoliths were rejected after the first reading. After the second reading, agreement was reached for 1676 (95.6%) otoliths, including all 23 otoliths that were second sections. Disagreement between readers after the second reading was as follows: one opaque zone for 71 fish, two zones for 7 fish, and three zones for one fish; fish for

which agreement was not reached after the second reading were not assigned ages or included in the growth estimation. Precision estimates were 1.25% for APE, 0.90% for CV, and 0.64% for D after the second reading.

A clear pattern exists in the marginal increment scores, demonstrating that one opaque zone is formed annually in winter (Fig. 4). Most otoliths had opaque margins by January and had translucent margins by June, thus, timing of opaque zone formation appears to be from January through May for most fish. Eight fish (of 118) sampled in November (1997) and six fish (of 66) sampled in December (1996) had opaque margins. Four fish (of 47) sampled in January (1997) had translucent margins.

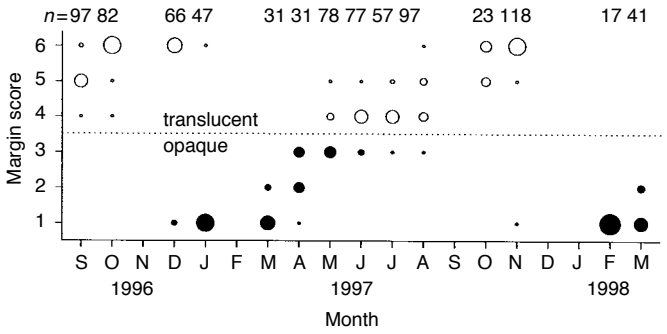


**Figure 4**

Plot of monthly margin edge scores of red snapper sagittae. Symbol size is relative to the percentage of fish with the corresponding margin edge score. Monthly sample size is given.

The oldest female sampled was 34.1 yr old and the oldest male sampled was 33.2 yr old. The female to male ratio was 1.1:1 overall but was 1.5:1 for fish between 10 and 20 yr old and 3.4:1 for fish greater than 20 yr old (Fig 5, A and B). Von Bertalanffy growth functions for females and males modeled separately were

Females: $TL = 976(1-e^{-0.191(t-0.051)})$

$(F_{3;735} = 21{,}952;\ P<0.001;\ r^2 = 0.99)$

Males: $TL = 956(1-e^{-0.194(t+0.054)})$

$(F_{3;726} = 19{,}058;\ P<0.001;\ r^2 = 0.99).$

Computed VBGFs were not significantly different between males and females (likelihood ratio test; $P>0^2_{df=1} = 0.2879$), therefore, sexes were modeled together. Von Bertalanffy growth functions computed for all fish and excluding tournament sampled fish were

All fish: $TL = 969(1-e^{-0.192(t-0.020)})$

$(F_{3;1,672}=47{,}690;\ P<0.001;\ r^2=0.99)$ (Fig. 6)

Excluding tournament fish: $TL = 1181(1-e^{-0.120(t+0.652)})$

$(F_{3;1,461}=43{,}550;\ P<0.001;\ r^2=0.99).$

The growth model including all fish was similar to other VBGFs estimated for GOM and southeast U.S. Atlantic red snapper (Fig. 7, Table 2).

Weight-TL nonlinear regression models for females and males modeled separately were

Females: $Weight = (4.46 \times 10^{-9})TL^{3.18}$

$(F_{1;73}= 42{,}577;\ P<0.001;\ r^2=0.98)$

Males: $Weight = (5.18 \times 10^{-9})TL^{3.16}$

$(F_{1;728}= 43{,}956;\ P<0.001;\ r^2=0.99).$

Log-transformed weight-TL relationships were not significantly different between males and females (ANCOVA test for equal slopes; $F_{1;1,465}=1.54$, $P=0.2145$; ANCOVA test for equal intercepts; $F_{1;1,465}=1.49$, $P=0.2226$), therefore, sexes were modeled together. The resultant nonlinear regression model was

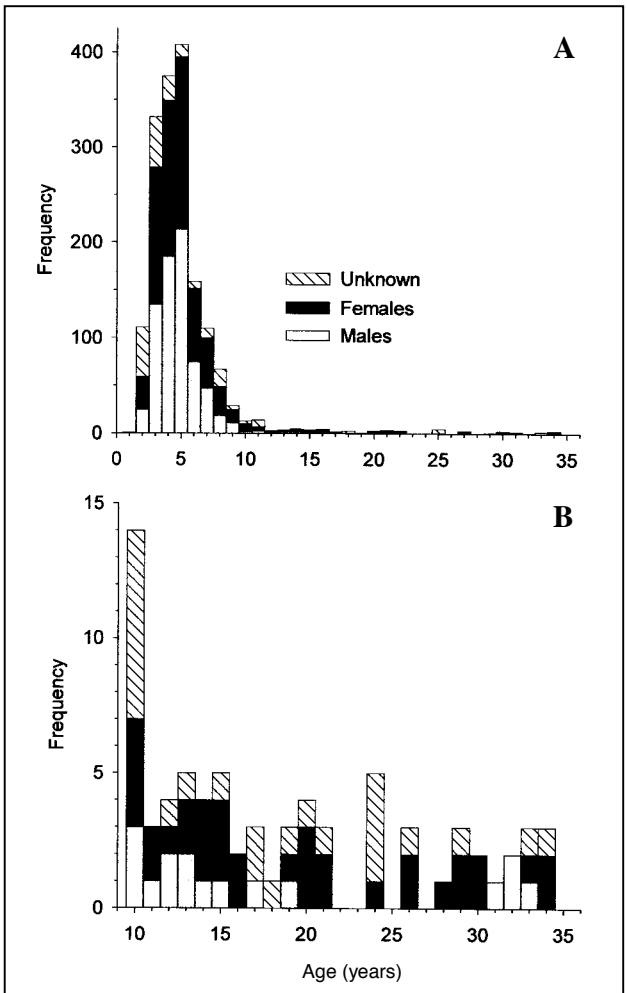


**Figure 5**

Distributions of age for (**A**) all sampled red snapper and (**B**) all fish greater than 10 yr old. Legend in section A is the same for both distributions.

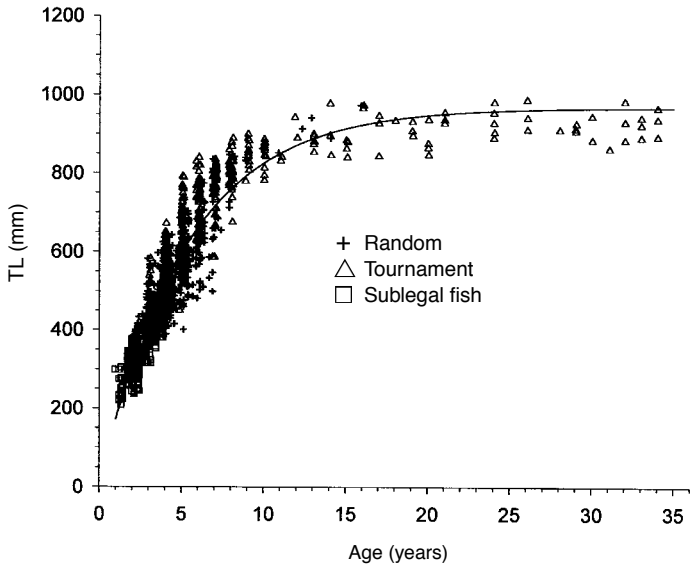


**Figure 6**

Scatterplot of red snapper TL-at-age data for all fish assigned ages. Plotted line is the von Bertalanffy growth function fitted to the data.

$$Weight = (4.68 \times 10^{-9}) TL^{3.17}$$

($F_{1;1,467}$=85,961; $P$<0.001; $r^2$=0.98).

## Mark-Recapture

A total of 2932 adult red snapper were tagged. Total length at recapture was measured for 288 of 519 recaptured individuals. Mean TL (±SE) of recaptures was 344 (±4.1) mm (range: 183–660 mm) at release and 423 (±5.6) mm (range: 253–726 mm) at recapture, and mean time at liberty (±SE) was 334 (±16.3) d (range: 12–1501 d). Predicted TL from Faben's method corresponded well to observed TL at recapture for tagged fish (Fig. 8). The linear regression of change in TL on days at liberty was statistically significant ($F_{1;286}$=631.0, $P$<0.001, $r^2$=0.76) and had a slope of 0.238 mm/d (Fig. 9A). The range in estimated ages of otolith-aged fish for the linear regression of TL on age was 356–2599 d (approximately one to seven years). The model was statistically significant ($F_{1;1,541}$=6309, $P$<0.001, $r^2$=0.80) and had a slope of 0.240 mm/d (Fig. 9B).

## Discussion

Validating the periodicity of opaque zone formation in otoliths as annual is imperative for age and growth studies where otoliths are used as aging structures (Beamish and McFarlane, 1983, 1987). Annual formation of opaque zones in otoliths has been validated for several tropical and subtropical lutjanids (Manooch, 1987; Fowler, 1995; Cappo et al., 2000), and annual formation of opaque zones in red snapper sagittae has been reported from the northwestern GOM and the southeastern U.S. Atlantic (Render, 1995; Manooch and Potts, 1997; Wilson and Nieland, 2001). Our marginal increment analysis of red snapper otoliths demonstrates that opaque zones in adult red snapper sagittae also are formed annually in the north central GOM. The pattern of monthly marginal increment scores reveals that some fish begin opaque zone formation as early as November and some do not have translucent margins until midsummer; however, the general pattern of opaque zone formation is from January through May. Render (1995) and Wilson and Nieland (2001) have reported a similar pattern for adult red snapper in the northwestern GOM, and opaque zone formation in winter–spring has been shown for sagittae of several other teleosts in the northern GOM (Maceina et al., 1987; Beckman et al., 1989, 1990, 1991; Thompson et al., 1999).

Because relatively few old red snapper were sampled in our study, and samples of old fish came mostly from tournaments in summer months, we were unable to validate ages beyond 8 years. Baker (1999) compared age estimates of otolith-aged GOM red snapper with age estimates from radiometric dating of their otolith cores and reported that age estimates from the two methods were highly correlated for fish up to 37 yr old, thus corroborating otolith-based estimates of age for older fish. Therefore, despite lack of annulus validation for older red snapper ages in our study, we are confident that otolith-based age estimates of older individuals are accurate.

## Age and growth

Red snapper are long-lived reef fish; we observed a maximum age of 34 yr for females and 33 yr for males. Other

**Table 2**

Results from previous studies of the age and growth of Gulf of Mexico and southeastern U.S. Atlantic red snapper.

| Study and location | Aging structure | Maximum age (yr) | $L_\infty$ mm (TL) | $K$ | $t_0$ |
|---|---|---|---|---|---|
| Szedlmayer and Shipp (1994); north central GOM | sectioned otoliths | 42 | 1025 | 0.150 | not reported |
| Wilson and Nieland, 2001; northwest GOM | sectioned otoliths | 53 | 938 | 0.175 | –0.530 |
| Nelson and Manooch (1982); GOM | scales and sectioned otoliths | 15 | 941 | 0.170 | –0.10 |
| Nelson and Manooch (1982); southeast U.S. Atlantic | scales and sectioned otoliths | 15 | 975 | 0.160 | 0.00 |
| Manooch and Potts (1997); southeast U.S. Atlantic | sectioned otoliths | 25 | 955 | 0.146 | 0.182 |

authors have reported fish over 40 yr old (Szedlmayer and Shipp, 1994; Render, 1995; Wilson and Nieland, 2001) and the oldest fish aged to date is 53 yr old (Render, 1995; Wilson and Nieland, 2001). Among western Atlantic lutjanids for which maximum age has been reported, GOM red snapper has the greatest longevity (Acosta and Appledoorn, 1992; Manickchand-Heileman and Phillip, 1996; Potts et al., 1998; Hood and Johnson, 1999). Maximum ages of 30+ and 40+ yr have been reported for several species of Pacific lutjanids (reviewed in Rocha-Olivares, 1998).

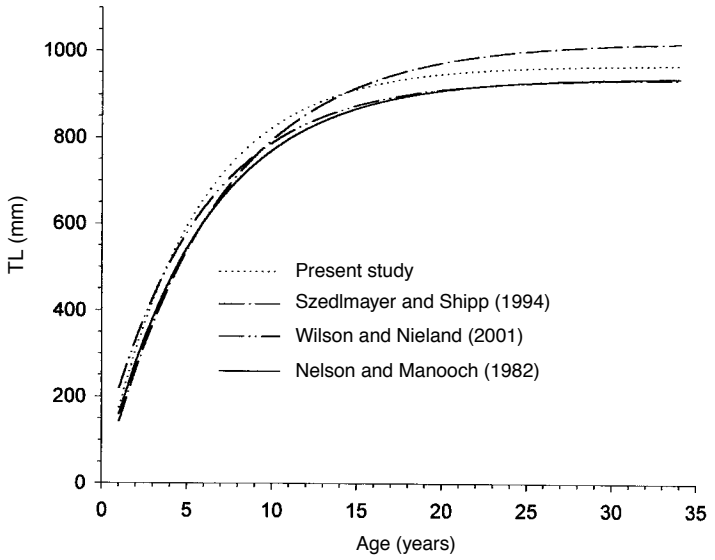


**Figure 7**

Von Bertalanffy growth functions estimated from TL-at-age data for Gulf of Mexico red snapper. Legend indicates source of each function.

Overall, the numbers of sampled males and females were nearly equal, but females were predominant in samples greater than 10 yr old. A similar pattern was observed in Pacific red snapper, *Lutjanus peru*, where the female-to-male ratio was essentially equal (1.1:1) for fish less than 10 yr old and 2.4:1 for fish older than 10 yr (Rocha-Olivares, 1998, Fig. 6). Rocha-Olivares (1998) concluded from catch curve analyses that differences in sex-specific numbers at age for *L. peru* resulted from males experiencing a higher mortality rate. Differential mortality between sexes is not unusual in lutjanids (Grimes, 1987) and the predominance of female GOM red snapper in older age classes may result from a higher mortality rate for males.

Fish sampled from tournaments were included in growth estimation because few large, old individuals were sampled randomly from the recreational catch. The inclusion of tournament sampled fish could bias growth estimates because tournament anglers target large fish; thus the potential exists for them to catch or spear the fastest growing individuals at a given age (Ottera, 1992; Vaughan and Burton, 1993; Goodyear, 1995b). Without the fish sampled from tournaments, however, the VBGF did not reach an asymptote; therefore growth parameters were poorly estimated (Hirschhorn, 1974). We feel that excluding the tournament fish from growth function estimation introduced far greater bias than including them.

## Mark-Recapture

Comparisons between estimated growth of tagged red snapper and otolith-aged fish corroborate otolith aging methods. Predicted TL of tagged individuals obtained with Fabens' (1965) method and VBGF parameters estimated from otolith-aged fish are coincident with observed TL at recapture because predicted and observed values corresponded well to the line of 1:1 agreement. Although ours

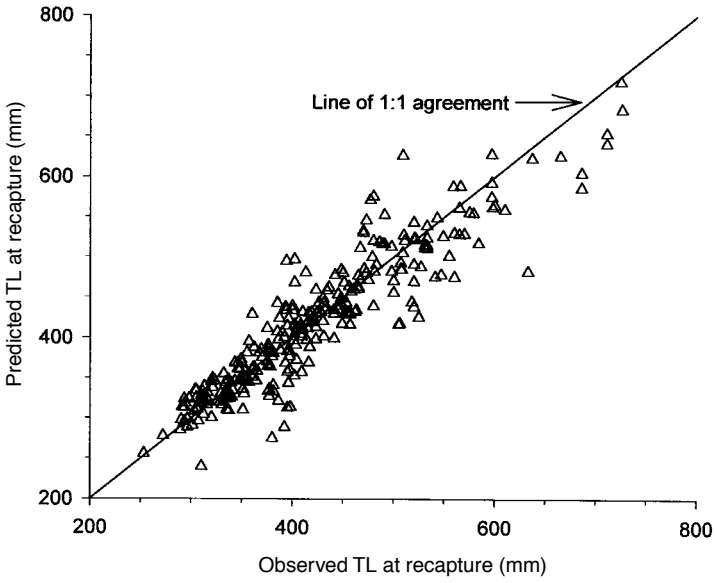


**Figure 8**

Predicted total length (TL) at recapture computed for tagged red snapper ($n$=288) plotted versus observed TL at recapture. Diagonal line is the line of one-to-one agreement between predicted and observed values.

was a graphical rather than a statistical exercise (Labelle et al., 1993; Thompson et al., 1999), results corroborate otolith-based estimates of growth.

Direct comparison of linear growth functions computed for tagged fish and otolith-aged fish provides further support for otolith-based estimates of growth (slopes from the two equations differed by only 0.002 mm/d). Francis (1988) cautioned against direct comparison of age-based growth estimates with growth estimates from tagging data because different information results from the different data types. The linear model fitted to length-at-age data predicts TL of fish for a given age (in d), whereas the linear model fitted to tagging data predicts the increment of growth expected of a fish at liberty for a given number of days. However, because the relationship between TL and age is linear over the range of TL from the tagging data (Szedlmayer and Shipp, 1994), we submit that the slopes can be compared as estimates of mean growth. The slope of the age-based linear model is an estimate of the population growth rate of young fish, whereas the slope of the length-based linear model is an estimate of the mean growth of tagged individuals. That growth estimates for otolith-aged and tagged red snapper are very similar corroborates the aging method with otoliths and indicates that on average tagging did not affect fish growth.

## Red snapper off Alabama

The red snapper fishery off Alabama is unique in several ways. Despite the reported lack of high-relief natural reef structures on the continental shelf off Alabama (Parker et al., 1983; Shultz et al., 1987; Schroeder et al., 1989), fishermen land a disproportionately high percentage of the annual GOM red snapper harvest from Alabama coastal waters (Schirripa and Legault, 1999). Although Alabama red snapper landings have accounted for approximately 11% of total GOM landings from 1981 to 1998, the recreational fishery off Alabama accounted for mean (±SE) 21.1 (±2.25)% of GOM recreational landings from 1981 to 1998 and 26.5 (±1.83)% of recreational landings from 1990 to 1998 (Schirripa and Legault, 1999). Total landings of red snapper from the U.S. GOM averaged $3.5 \times 10^3$ metric tons from 1981 to 1998, with commercial and recreational landings essentially equal; however, 94% of Alabama red snapper landings from 1990 to 1998 came from the recreational sector of the fishery (Schirripa and Legault, 1999).

The red snapper fishery off Alabama is also unique because it is prosecuted almost entirely over artificial reefs (Minton and Heath, 1998; Shipp, 1999). Artificial reef construction began in the 1950s when charter boat operators gained permission from the Marine Resources Division of the Alabama Department of Conservation to place 250 car bodies on the sea floor off Alabama (Hosking and Swingle, 1989; Minton and Heath, 1998). Since the 1950s, artificial reefs have been constructed of a variety of materials including car bodies, liberty ships, army tanks, kitchen appliances, newspaper bins, and most recently, prefabricated concrete structures. Reef building increased dramatically in the 1980s with the creation (by permit) of artificial reef areas that now encompass a total of 3100 $km^2$,

and it is estimated that over 15,000 artificial reefs currently exist off Alabama (Hosking and Swingle, 1989; Szedlmayer and Shipp, 1994; Minton and Health, 1998; Havard[1]).

The correlation of catch rates with artificial reef construction has caused some to conclude that artificial reefs off Alabama have increased the production of red snapper, as opposed to merely aggregating fish from surrounding areas (Szedlmayer and Shipp, 1994; Minton and Health, 1998). Among the evidence cited in support of this conclusion was that red snapper grew faster, attained larger sizes, and lived longer over artificial reefs off Alabama than other places throughout their range (Szedlmayer and Shipp, 1994). More recent data, including those from the current study, indicate that GOM red snapper off Alabama grow similarly to and reach similar sizes as fish from the northwestern GOM and the Atlantic (Render, 1995; Manooch and Potts, 1997; Wilson and Nieland, 2001). It is also apparent that the maximum longevity of fish off Alabama is no greater than that of fish of other locations in the GOM (Szedlmayer and Shipp, 1994; Render,1995; Wilson and Nieland, 2001).

These results have important implications for management of GOM red snapper. That growth of fish off Alabama is similar to growth of fish in the northwestern GOM is consistent with the management paradigm that northern GOM red snapper constitute a single stock (Goodyear, 1995a) and contrary to the hypothesis that fish off Alabama are unique (Szedlmayer and Shipp, 1994). Moreover, if fishing mortality rates are higher off Alabama than other places in the northern GOM but growth is the same, production of red snapper may be lower off Alabama than in other areas. Furthermore, if red snapper recruit to artificial reefs off Alabama from other areas in the northern GOM, Alabama's red snapper fishery may serve as a net sink for stock-specific production. Future research is needed to compare mortality as well as growth of fish from different areas in the northern GOM and to estimate the source of recruits to Alabama's artificial reefs.

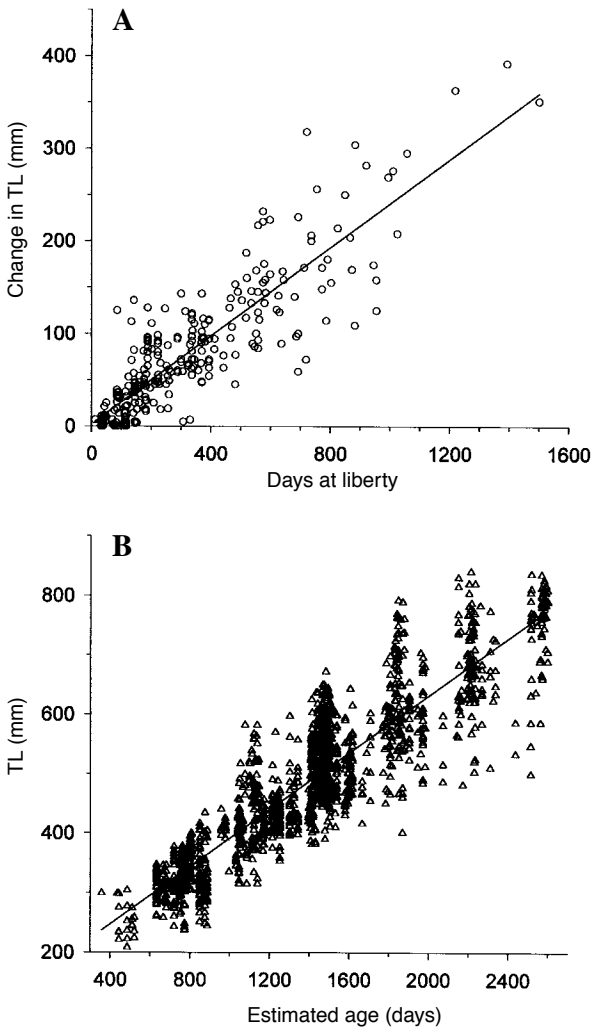


**Figure 9**

Linear regressions fitted to (**A**) change in total length (TL) versus days at liberty for recaptured red snapper ($n$=288) from the tagging study and (**B**) TL-at-age data for otolith-aged red snapper in the size range of fish from the tagging study ($n$=1543).

## Acknowledgments

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# Movement of Tagged Red Snapper in the Northern Gulf of Mexico

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*Abstract.*—A tagging study of adult red snapper *Lutjanus campechanus* was conducted in an area of artificial reefs in the northcentral Gulf of Mexico during March 1995 through August 1999. A total of 2,932 red snapper angled at nine artificial reef tagging sites were measured and tagged with internal anchor tags. Tagged fish were either released over their site of capture or transported to another tagging site for release. Of the 561 recaptures made of 519 fish (42 multiple recaptures), 235 recaptures were made at tagging sites on subsequent tagging trips and 326 recoveries were reported by recreational and commercial fishers. Mean distance moved was 29.6 km; the farthest distance moved was 352 km. Mean time at liberty was 404 d; the longest time at liberty was 1,501 d. During the study, two strong hurricanes passed near the study area. The occurrence of hurricanes significantly affected the probability of red snapper movement, as did time at liberty, total length of fish tagged, and transportation of fish to other release sites. The occurrence of hurricanes also significantly affected the distance of red snapper movement, as did time at liberty. Resultant direction of reported movement for all fish was to the east. Observed movement was greater than previously reported for adult red snapper and may be sufficient to facilitate stock mixing in the northern Gulf of Mexico.

Red snapper *Lutjanus campechanus* is a long-lived reef fish that supports economically important commercial and recreational fisheries in the northern Gulf of Mexico (hereafter Gulf). In United States' waters of the Gulf, red snapper are managed as one continuous or unit stock. This management approach is based upon population genetics studies that reported few differences among red snapper from different geographic areas in the northern Gulf. Camper et al. (1993) and Gold et al. (1997) examined mitochondrial DNA (mtDNA) haplotype frequencies of red snapper from different areas in the northern Gulf and concluded that differences were not sufficiently large to reject their null hypothesis of a single panmictic stock. Heist and Gold (2000) concluded that fish from three locations in the northern Gulf and one location off the Yucatan Peninsula in the southern Gulf were not genetically distinct, based on genetic variation in five polymorphic microsatellite loci developed from genomic DNA.

Contrary to the genetic evidence, results of red snapper tagging studies generally have not supported the conclusion that red snapper in the northern Gulf belong to a single stock. Many authors have reported that adult red snapper demonstrate high site fidelity and move little (Beaumariage 1969; Beaumariage and Bullock 1976; Fable 1980; Szedlmayer and Shipp 1994; Szedlmayer 1997). The vast majority of tag recoveries in these studies have been of fish that moved short distances (<10 km), if at all. However, some movement on the scale of tens to hundreds of kilometers has been reported (Beaumariage 1969; Beaumariage and Bullock 1976; Szedlmayer and Shipp 1994; Watterson et al. 1998). Nonetheless, it seemed unlikely that large-scale movements by adult red snapper and related stock mixing were extensive enough to produce the observed genetic homogeneity, which was therefore hypothesized to result from other factors. Goodyear (1992, 1995) hypothesized

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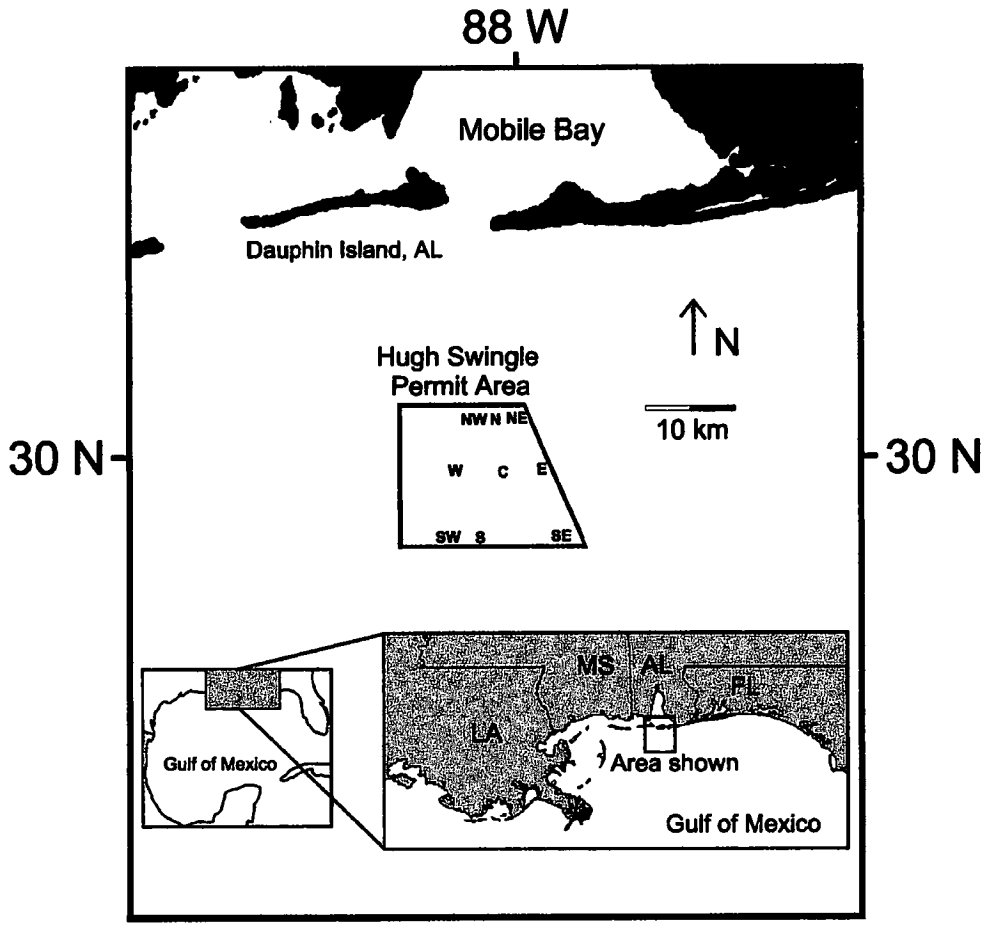


FIGURE 1.—Map of the Hugh Swingle General Permit Area for artificial reef deployment and locations of nine artificial reef tagging sites. Letters indicate geographical location of reefs.

that stock mixing could result from oceanographic transport of planktonic eggs and larvae or from gradual diffusion of adults away from centers of abundance. Gold et al. (1997) hypothesized that observed genetic patterns may indicate historical gene flow, perhaps during the Pleistocene glaciation.

The objective of our study was to examine movement of adult red snapper tagged at artificial reefs off Alabama and to evaluate whether movement of adults was sufficient to facilitate stock mixing. Our approach was to test if time at liberty, fish size, and releasing fish at sites other than the capture site affected the probability and distance of red snapper movement. Effort also was made to test several assumptions of the tagging study, including that tagging did not increase mortality of fish or affect growth of fish, that tags were recognized by fishers, and that recovered tags were reported. When assumptions were not met, we examined potential biases introduced into the statistical analyses of fish movement.

## Methods

*Tagging and recovery.*—Adult red snapper were caught and tagged over nine artificial reef sites located in the Hugh Swingle General Permit Area between 20 and 38 km south–southeast of Dauphin Island, Alabama, from March 22, 1995, to July 20, 1998. Reefs were constructed by a charter boat operator 18 months before the start of the tagging study to allow sufficient time for each reef to attract fish. The nine reefs were deployed over a grid pattern such that reefs were 4–16 km apart (Figure 1; see Watterson et al. 1998 for details). Each reef served as an individual tagging site and was designated by a compass heading which denoted its orientation within the grid. Reefs in each row within the grid occupied similar depths. Approximate depths were 21 m for the northern, 27 m for the central, and 32 m for the southern sites.

TABLE 1.—Scale used to visually assess the condition at release of tagged red snapper.

| Condition | Characteristics displayed by fish |
|---|---|
| 1 | Fish oriented toward the bottom and swam down vigorously. |
| 2 | Fish appeared disoriented upon entering the water, oriented toward the bottom and swam down slowly. |
| 3 | Fish appeared very disoriented upon entering the water and remained at the surface. |
| 4 | Fish was either dead or unresponsive upon entering the water. |

We attempted to sample at least three tagging sites on each tagging trip. Red snapper were angled at tagging sites, measured for total length (TL), and tagged with a yellow Floy FM-89 internal anchor tag, which was inserted through a small (<5 mm) incision made with a scalpel in the fish's abdominal cavity. Each tag was marked with a tag number, the word "reward," and a phone number for fishers to report tag recoveries. A $5 reward was paid for each tag return, and those fishers were entered into a drawing with a chance to win $500. Once tagged, red snapper were either released immediately overboard or transported in holding tanks to other sites for release. The purpose of releasing fish at other sites was to determine whether they homed back to their original site of capture.

Condition categories of tagged red snapper at release were determined (Table 1). Fish released in conditions other than condition 1 were assumed to suffer acute mortality due to the tagging process (see discussion). Therefore, tagging mortality was estimated as the total percentage of fish released in conditions 2, 3, and 4.

Tagged fish were recaptured at tagging sites on subsequent tagging trips and were recovered by recreational and commercial fishers. When a fish was recaptured on a tagging trip, its tag number and total length were recorded and the fish was released. When a fisher reported a tag recovery, as much information as possible was collected. Data from recoveries by fishers were collected through August 31, 1999, which included the tag number, the date of capture, and when possible, the exact location of capture (i.e., Loran C or GPS coordinates). When possible, total length following recapture was obtained from carcasses.

*Statistical analyses.*—To meet the assumption of independence, only data from terminal recaptures of fish recaptured more than once were used in statistical analyses. The effect of depth of capture, season of capture (winter, spring, summer, or fall), and noncapture-site release on red snapper condition was tested with analysis of variance (ANOVA; SAS 1996). Normality and homogeneity of variances of release condition data were tested with Shapiro–Wilke $W$ and Bartlett's tests, respectively (Sokal and Rohlf 1981; SAS 1996).

Growth rate (mm/d) of recaptured fish (where recapture length was available) was estimated as the slope of the linear regression of their change in total length versus days at liberty (SAS 1996). For fisher recoveries lacking recapture length, the distribution of total length at recapture was simulated with a bootstrap approach. A normal probability density function was constructed based on the estimated growth rate and its variance. To estimate length at recapture for an individual fish, a probability value from 0.0001 to 0.9999 was randomly drawn (with replacement) and the corresponding growth rate was assigned to the fish. The assigned growth rate was multiplied by days at liberty and the product was added to length at tagging to obtain estimated length at recapture. One simulation run was complete when total length at recapture was estimated for all unmeasured fish, and simulated distributions of lengths at recapture were calculated 500 times to account for variability in fish growth. Results from each simulation run were combined with data from measured recaptures, yielding an estimated distribution of lengths at recapture for all fisher recoveries.

The probability of external tag retention as a function of time at liberty was modeled with logistic regression (SAS 1996). Only data from fish recaptured on tagging trips were used in the model. We assumed that all tagged fish recaptured on tagging trips were recognized, even if the external portions of their tags were missing. This assumption was based on the fact that tagged fish that lost the external portions of their tags were easily recognized by their tagging scars. (New tags were inserted into fish that had lost the external portion of their original tags). In the logistic regression analysis, fish that retained their external tags were coded as a success (1) and fish that lost their external tags were coded as a failure (0).

An unplanned factor was added to the study when two strong hurricanes passed near the tagging sites. The center of Hurricane Opal, with maximum winds of 200 km/h, passed within 40 km of the tagging sites on October 4, 1995, and the center of Hurricane Georges, with maximum sustained winds of 150 km/h, passed within 50 km

TABLE 2.—Dates of tagging trips, tagging sites sampled, and number of red snapper tagged.

| Date | Tagging sites[a] | Number tagged |
|---|---|---|
| Mar 22, 1995 | C, WE | 94 |
| May 3, 1995 | N, NE, NW, C | 107 |
| Jun 20, 1995 | W, S, SW | 153 |
| Jun 21, 1995 | E, SE, C | 118 |
| Aug 19, 1995 | SE, E, NE | 129 |
| Jul 13, 1995 | NW, W, SW | 100 |
| Jul 14, 1995 | N, C, S | 112 |
| Nov 30, 1995 | S, SE, NW, C | 107 |
| Dec 12, 1995 | N, SW | 73 |
| Feb 27, 1996 | SW, W, NW | 42 |
| Mar 22, 1996 | N, C, S | 41 |
| Mar 29, 1996 | NE, SE, E | 38 |
| May 1, 1996 | S, SE, C | 37 |
| Jun 12, 1996 | SW, S, W, N, C | 50 |
| Aug 7, 1996 | SE, NE, N | 86 |
| Oct 31, 1996 | C, W, NW, SW | 163 |
| Nov 1, 1996 | NE, E, SE | 152 |
| Dec 2, 1996 | N, C, S | 150 |
| Dec 9, 1996 | NE, E SE | 122 |
| Mar 26, 1997 | NW, N, NE | 114 |
| Mar 27, 1997 | SW, S, C | 117 |
| Apr 29, 1997 | NW, N, NE | 42 |
| Sep 18, 1997 | NW, N, NE, E | 147 |
| Sep 23, 1997 | C, SE, S | 65 |
| Nov 3, 1997 | NW, N, NE | 136 |
| Nov 5, 1997 | W, SW, S, C | 186 |
| Feb 25, 1998 | NW, N, NE | 147 |
| Jul 20, 1998 | NW, N, NE | 104 |

[a] See Figure 1 for locations of these sites.

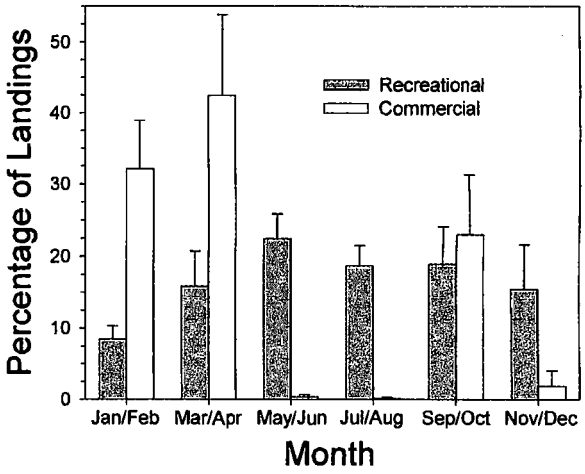


FIGURE 2.—Mean bimonthly commercial and recreational landings (+SE) of northern Gulf of Mexico red snapper from 1995 to 1998 (Schirripa and Legault 1999).

of the tagging sites on September 28, 1998. It became apparent that movement of fish that were at liberty during the hurricanes was on a larger scale than fish not exposed to the storms. In statistical analyses of movement, exposure to hurricanes was therefore included as an independent variable to test the effect of Hurricanes Opal and Georges on the probability and distance of red snapper movement.

Logistic regression was used to test whether time at liberty, length at tagging, exposure to hurricanes, and noncapture-site release significantly affected the probability that tagged fish moved away from their release sites (SAS 1996). In the model, fish recaptured at sites other than their release sites were coded as a success (1), and fish that were recaptured at their release sites were coded as a failure (0).

There were many failures in the distance of movement data; therefore, the delta method was employed to obtain unbiased estimates of mean distance moved and the variance of the mean (Aitchison 1955; Pennington 1983). To test the effects of time at liberty, length at tagging, exposure to hurricanes, and noncapture-site release on distance of red snapper movement, a negative binomial regression model was computed using PROC GENMOD in SAS (Hilbe 1994). In the model, units of distance were hectometers and were rounded to the nearest integer. The model was built using a forward stepwise approach in which regressions first were computed for each of the four independent variables. The single variable model with the lowest significant $P$-value ($\alpha = 0.05$) was chosen as the base model. Individual variables were added in order of significance, and improvement of fit was assessed by testing whether adding a variable significantly decreased the deviance of the model to which it was added (Agresti 1990). The model building process was complete when no more significant variables were available to be added or the addition of a variable did not significantly improve the fit of the model to which it was added.

## Results

### *Tag Recovery Data*

We made 28 trips to tag red snapper from March 1995 to July 1998 (Table 2). The temporal distribution of tagging trips was similar to the temporal distribution of recreational fishing effort in the northern Gulf during that period (Figure 2). Of the total of 2,932 red snapper tagged, we released 2,053 fish at their capture and tagging site and 879 at sites other than their capture sites. Mean TL (±SE) of tagged red snapper was 335.1 mm (±1.34) (Figure 3). Throughout most of the project the minimum legal size for possession of red snapper in U.S. waters of the Gulf was 381 mm TL for

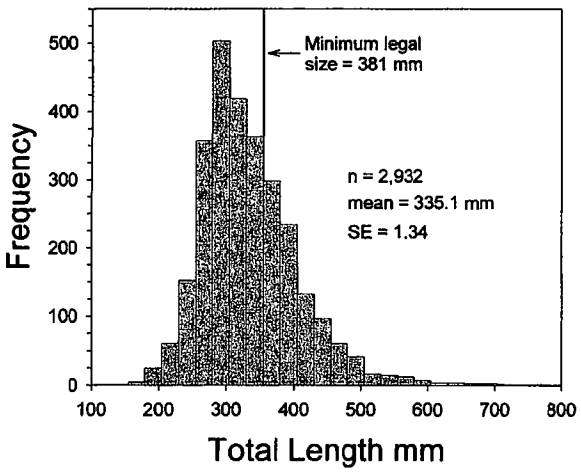


FIGURE 3.—Distribution of red snapper total lengths at tagging. The vertical line indicates the minimum legal size for possession of red snapper in the northern Gulf of Mexico at the time of tagging.

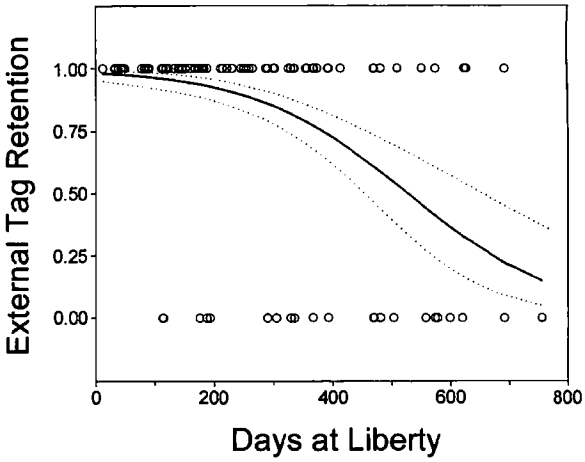


FIGURE 4.—Logistic regression of tag retention versus time at liberty for red snapper recaptured at tagging sites ($N$ = 214). Probability of tag retention = 1/[1 + exp(−4.042 + 0.00767·D)], where D = days at liberty. Plotted are the fitted line (solid) and 95% confidence intervals (dotted).

both the commercial and recreational fisheries; the size limit was increased to 457 mm TL from June through August 1999 for the recreational fishery. When tagged, 80% of the fish ($N$ = 2,366) were shorter than the legal size limit.

Overall, 86% of tagged fish ($N$ = 2,535) were condition 1 when released (Table 3). Percentage data were not significantly different from normal (Shapiro–Wilke test, $P > 0.05$), and variances were not significantly different among factor levels (Bartlett's test, $P > 0.05$). Depth of capture site (ANOVA, $F_{2,100} = 6.19$, $P = 0.003$) and release of fish at noncapture sites (ANOVA, $F_{1,101} = 17.26$, $P < 0.001$) significantly affected the percentage of fish released in condition 1; season of capture did not significantly affect fish release condition (ANOVA, $F_{3,99} = 1.27$, $P = 0.41$).

During the study, 561 recaptures were tallied, involving 519 red snapper; that is 42 were recaptured more than once, 40 being recaptured twice (21 by fishers and 19 on tagging trips) and 1 three times (all during tagging trips). Of the 519 recaptured fish, 98.5% were condition 1 when released; 255 were at liberty during the hurricanes (154 during Opal, 94 during Georges, and 7 during both hurricanes); 408 had been released where captured and 111 had been released at noncapture sites; and 214 were recaptured on tagging trips (of which 193 recaptures were terminal recaptures). Of the 326 recoveries reported by fishers (fisher return rate = 11.1%), recreational fishers reported 321 (recreational return rate = 10.9%) and commercial fishers reported 5 (commercial return rate = 0.2%).

The probability of external tag retention declined significantly with time at liberty (logistic regression, $\chi^2 = 40.08$, df = 1, $P < 0.001$; Figure 4). Lack-of-fit analysis was not significant for the model ($\chi^2 = 132.88$, df = 212, $P = 0.9999$), but the fitted line was estimated better for fewer days at liberty because there were more samples over this portion of the curve. For example, the esti-

TABLE 3.—Number and percentage of tagged red snapper released in condition 1 in the northern Gulf of Mexico, Hugh Swingle Permit Area, March 1995 to July 1998.

| Transportation and condition | Number and percent in condition by depth of release site | | | |
|---|---|---|---|---|
| | 21 m | 27 m | 32 m | All depths |
| Fish transported | 91% (113 of 124) | 80% (280 of 351) | 74% (299 of 404) | 79% (692 of 879) |
| Fish not transported | 91% (855 of 940) | 91% (459 of 505) | 87% (529 of 608) | 90% (1,843 of 2,053) |
| Mean in condition 1 | 91% (968 of 1,064) | 86% (740 of 856) | 82% (828 of 1,012) | 86% (2,535 of 2,932) |

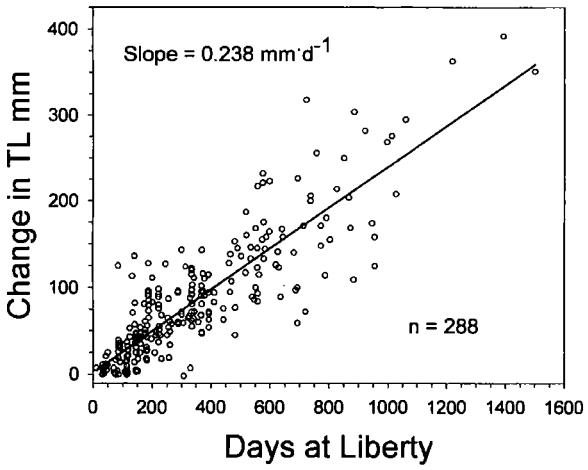


FIGURE 5.—Linear regression of change in total length (ΔTL) versus time at liberty for tagged red snapper [ΔTL = 2.34 mm + (0.238 mm/days at liberty)].

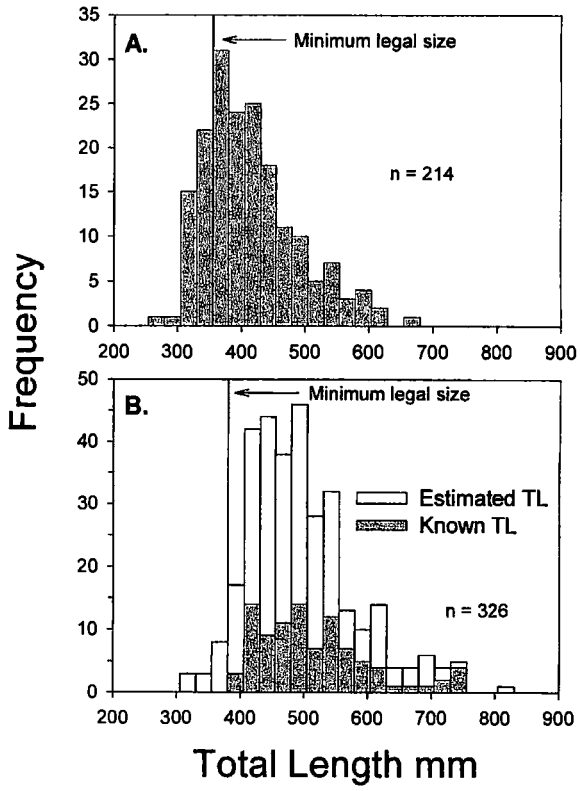


FIGURE 6.—Distribution of total length (TL) at recapture for terminal recaptures of red snapper that were (**A**) recaptured on tagging trips or (**B**) recovered by fishers. Distribution of estimated total length for fisher recoveries is the average of 500 simulations. Vertical lines in each plot represent the minimum legal size for possession of red snapper in the northern Gulf of Mexico during most of the study.

mated 95% confidence interval for probability of tag retention for fish at liberty for 200 d was 0.87–0.96 but was 0.05–0.37 for fish at liberty for 755 d, the longest time at liberty for fish recaptured at tagging sites (Figure 4).

Total length at recapture was measured for all terminal recaptures made on tagging trips and for 95 (29%) recaptures reported by fishers. The linear regression of change in length versus time at liberty was statistically significant ($F_{1;286} = 631.0$, $P < 0.001$, $R^2 = 0.76$). The slope of the regression was 0.238 mm/d with a variance of 0.0231 (Figure 5). Mean length at recapture (±SE) was 390 mm (±5.50) for recaptures made on tagging trips and 490 mm (±8.83) for measured recoveries reported by fishers (Figure 6). Mean length at recapture of combined distributions of fisher recoveries with known and estimated lengths at recapture ranged from 470 mm (±6.42) to 483 mm (±6.92) for 500 bootstrapped simulation runs (Figure 6b).

*Red Snapper Movement*

Five red snapper recaptured on tagging trips were recaptured at tagging sites other than those where they were released. Of these five fish, two moved from site SE to site C (8.5 km), one moved from site SE to site N (13.1 km), one moved from site C to site N (6.0 km), and one moved from site S to site SW (0.5 km). The fish that moved from site S to site SW had been transported from site SW to site S before release; this was the only transported fish (out of 111) that was recaptured at its original capture site.

Location of recapture was reported for 232 recoveries reported by fishers (71% of fisher recoveries). The farthest distance a red snapper moved was 352 km; it had been at liberty for 598 d (Figure 7). This individual, recaptured off Dog Island, Florida, following Hurricane Georges, moved farther than any red snapper reported from previous tagging studies (Table 4). Another red snapper at liberty during Hurricane Georges was caught by a recreational fisher west of the Mississippi River delta and southeast of Grand Isle, Louisiana, or approximately 259 km southwest of its release site; it was at liberty for 1,367 d (Figure 7b). The maximum time at liberty was 1,501 d; this fish had moved 3.5 km to the east–southeast of its release site. Mean time at liberty was 404 d, which was 2 to 3.5 times longer than the mean time at liberty for recaptures from previous studies (Table 4).

Although some westward movement was reported, the predominant direction of red snapper movement was east, which corresponded to the areas of highest recreational landings in the north-

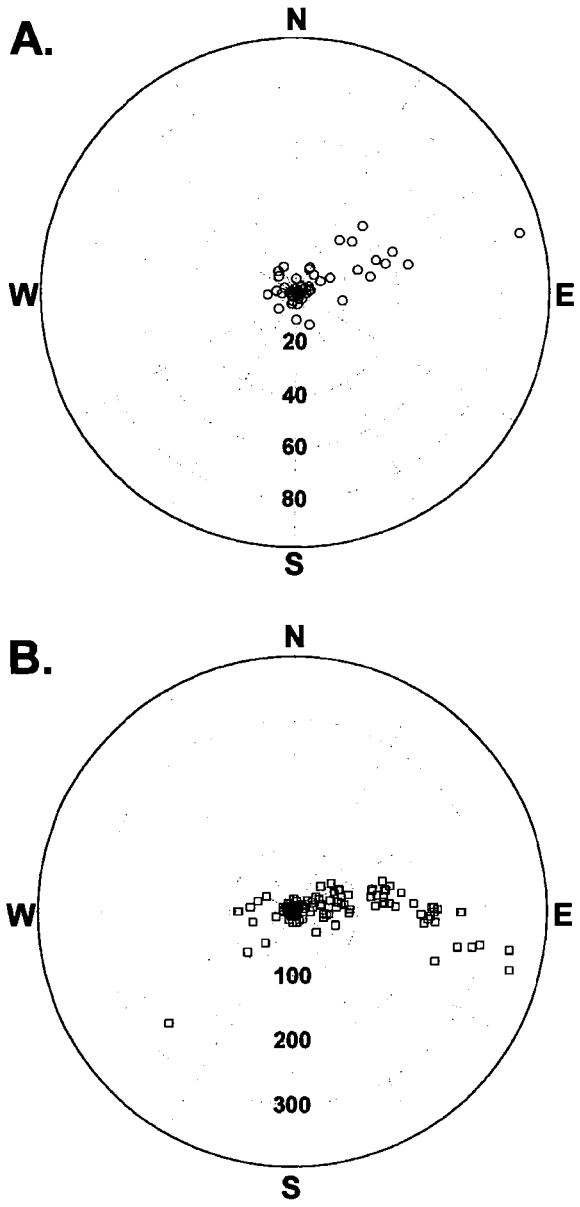


FIGURE 7.—Polar diagrams of red snapper movement for (A) fish not at liberty during Hurricanes Opal or Georges and (B) fish at liberty during those hurricanes, where the center is the tagging site and the circles or squares are the recovery locations (as defined by distance and compass direction). Units of distance for each plot are kilometers.

ern Gulf (Figures 7, 8). The mean vector of reported movement was 42.4 km to the east (compass heading = 271°) for individuals at liberty during hurricanes and 7.4 km to the east–northeast (compass heading = 293°) for individuals not at liberty during the two hurricanes.

The logistic regression that modeled the probability of fish movement was significant ($\chi^2$ = 204.76, df = 4, $P < 0.001$), and lack-of-fit analysis for the model was not significant ($\chi^2$ = 455.727, df = 5, $P$ = 0.9693). All four independent variables were significant in the model ($P < 0.01$), and each had a positive effect on the probability of red snapper movement. Therefore, as time at liberty and length at tagging increased, the probability of fish movement increased. Hurricane exposure and noncapture-site release also increased the probability of fish movement.

Mean distance moved by recaptured red snapper was 29.4 km (Figure 9). Distance of movement in single-variable, negative binomial regressions was significant for exposure to hurricanes ($\chi^2$ = 131.33, df = 1, $P < 0.001$), time at liberty ($\chi^2$ = 24.35, df = 1, $P < 0.001$) and length at tagging ($\chi^2$ = 4.63, df = 1, $P$ = 0.023) but not for noncapture-site release ($\chi^2$ = 0.05, df = 1, $P$ = 0.830). When time at liberty was added to the hurricane-exposure model, lack of fit was not significant ($\chi^2$ = 412.00, df = 421, $P$ = 0.6136) and the model's deviance was significantly decreased ($\chi^2$ = 39.31, df = 1, $P < 0.001$). Length at tagging then was added to the model, but its addition increased the model's deviance. Therefore, the final model included only exposure to hurricanes and time at liberty effects, both of which had a positive effect on distance of red snapper movement.

## Discussion

The current study differed from previous tagging studies of Gulf red snapper in several ways. The temporal and spatial scales of the study and the large number of fish tagged ensured large numbers of recaptures over time, which enabled us to test factors potentially affecting red snapper movement. Previous studies relied on relatively small samples sizes and authors only conjectured as to what factors affected red snapper movement. This study was designed to test which factors affected the probability and distance of red snapper movement; we also tested several assumptions and addressed potential biases introduced into statistical tests when assumptions were not met.

### *Condition of Tagged Fish*

Patterson (1999) proposed that the percentage of tagged red snapper released in condition 1 could be used as a proxy for survival, the assumption being that fish released in conditions 2, 3, and 4 suffered acute mortality as a result of the tagging process. This assumption is supported by results of previous studies of red snapper release mortality, as well as by the fact that nearly all recaptures

TABLE 4.—Results from red snapper tagging studies conducted in the northern Gulf of Mexico.

| Study | Maximum distance moved (km) | Maximum time at liberty (d) | Site fidelity | Mean time at liberty (d) |
|---|---|---|---|---|
| Beaumariage 1969 | 279 | 2,049 | 90% recaptured within 5 km of release site | 113 |
| Fable 1980 | 5 | 253 | 94% recaptured at release site | 112 |
| Szedlmayer and Shipp 1994 | 32 | 430 | 76% recaptured within 2 km of release site | 137 |
| Watterson et al. 1998 | 265 | 622 | 55% recaptured within 2 km of release site | 207 |
| This study | 352 | 1,501 | 36% recaptured within 2 km of release site | 404 |

had been released in condition 1. Gitschlag and Renaud (1994) reported that red snapper release mortality inferred from the condition of released fish at the surface correlated well with mortality estimates from in situ caging experiments. They also reported that most mortality suffered by red snapper held in cages or laboratory tanks occurred soon after capture, as did Render and Wilson (1994). Szedlmayer and Shipp (1994) held 30 tagged red snapper in the laboratory for 6 months with no mortality or signs of infection, implying that fish released in condition 1 in our study probably did not suffer chronic injuries leading to mortality.

If the percentage of tagged red snapper released in conditions 2, 3, and 4 is used as an estimate of tagging mortality, then the estimates of mortality presented here (14% overall) are within the range of red snapper release mortality reported from other studies. Render and Wilson (1994) reported an overall release mortality rate of 20% for red snapper caught off Louisiana. Gitschlag and Renaud (1994) presented data from several studies of red snapper release mortality, and mean mortality rate (±SE) was 14% (±4.5) for seven studies that were conducted at depths similar to our study. Therefore, it did not appear that our tagging methods significantly affected release mortality of tagged red snapper.

### *Growth of Tagged Fish*

Tagging did not appear to affect growth of red snapper. We estimated the growth of tagged fish to be 0.238 mm/d (TL), whereas Patterson et al. (in press) estimated that otolith-aged red snapper in the size range of individuals we tagged grew at a rate of 0.240 mm/d (TL). The growth rate of our tagged fish also was similar to growth rates of Gulf red snapper reported by other investigators (Render 1995; Szedlmayer and Shipp 1994).

### *Recognition of Tagged Fish*

Several factors may have influenced whether tags were recognized by fishers. The ventral placement of internal anchor tags may have made them more difficult to see than dorsally placed tags (Fable 1990; Nielsen 1992). Fouling of tag shafts by algae and barnacles also may have decreased tag visibility. Many recaptures made on tagging trips were of fish with badly fouled tags, and several

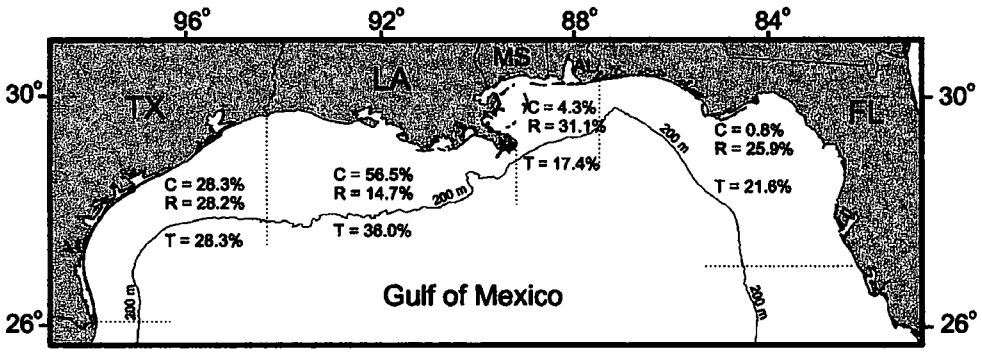


FIGURE 8.—Map depicting the mean percentage (from 1995 to 1998) of northern Gulf of Mexico commercial (C), recreational (R), and total (T) red snapper landings from demarcated areas (Schirripa and Legault 1999).

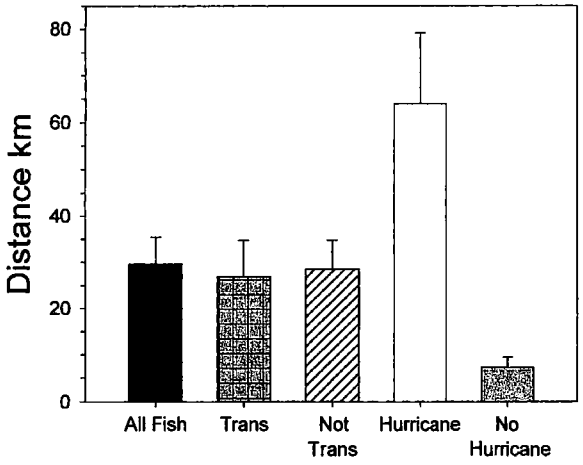


FIGURE 9.—Unbiased estimates of the mean distance (+SE) of red snapper movement computed with the delta method. Fish were either transported from the capture and tagging site to another site for release (trans) or released at the capture and tagging site (not trans).

fishers reported recovering red snapper with fouled tags. Not only can fouling render tags unrecognizable, it also can cause harm to tagged fish and increase tag abrasion leading to tag loss (Dunning et al. 1987; Mattson et al. 1990; Nielsen 1992).

Internal anchor tags were chosen for use in this study due to high retention rates reported for red snapper and other species. Szedlmayer and Shipp (1994) reported 100% tag retention for red snapper held in laboratory tanks for 6 months, and Smith et al. (1990) reported pond-reared shortnose sturgeon *Acipenser brevirostrum* had 100% tag retention after 139 d. Dunning et al. (1987), in a double tagging experiment with Hudson River striped bass *Morone saxatilis,* estimated that retention rate of internal anchor tags was 98% after 2 years but was only 42% for T-bar anchor tags after 1 year. Fable (1990) reported tag return rates for Gulf and south Atlantic king mackerel *Scomberomorus cavalla* that were eight times higher for internal anchor tags than dart tags, and 84% of individuals at liberty less than 2 years retained internal anchor tags.

Contrary to the high retention rates reported for internal anchor tags, tag retention was relatively poor in our study. Although confidence intervals for tag retention were wide for fish at liberty longer than 450 d, even the upper 95% levels were much lower than retention rates reported for other species. Of the 245 recoveries reported by fishers after January 1997, 61 (25%) were of fish missing the external portion of their tags; anchor portions of these tags were found by chance when fish were cleaned. With such a high percentage of tags found only by chance, we speculate that many recaptures went completely unnoticed by fishers.

Tag loss may have caused the fisher reporting rate of recaptured tagged fish to be much lower than the actual recovery rate, and a low reporting rate would have caused movement of tagged fish to be underestimated. That is, time at liberty significantly affected both the probability and distance of red snapper movement, so that fish that were the most likely to move, and probably moved the farthest, were least likely to be recognized as tagged and reported.

*Reporting Rate*

In addition to tag loss, other factors may have affected the fisher reporting rate. Fishers may have been reluctant to report recoveries of undersized fish, reporting few shorter than the legal size limit (381 or 457 mm, depending on when the recapture occurred). As might be expected, no carcasses of undersized fish were returned by fishers. Five recoveries were reported as undersized and discarded when caught, and the remaining undersized recoveries (9–16, depending on the simulation) may have been sublegal discards or estimated to be shorter than they actually were. If undersized recoveries were not fully reported, movement of small fish would be underestimated. We attempted to avoid this potential bias in statistical analyses by using length at tagging instead of length at recapture as the factor representing fish size.

Management regulations also may have affected the fisher reporting rate in other ways. Although token regulations were in place by the late 1980s, before 1990 both the recreational and commercial fisheries were essentially unregulated (Goodyear 1995). Because of concerns over the status of the Gulf red snapper stock, the commercial fishery has been managed under a quota system since 1991, and the National Marine Fisheries Service (NMFS) has closed the fishery when the quota was met in every year since. During the same period the recreational fishery routinely overran its total allowable catch (TAC) until congressional passage of the Sustainable Fisheries Act of 1996 (U.S. Public Law 104–297), which mandates that NMFS close the recreational fishery when its portion of TAC has been landed. As a result, NMFS closed the recreational fishery in December 1998 and from September through December 1999. These regulatory actions may have caused fishers to be less willing to cooperate in returning tagged fish. Beaumariage (1969) tagged fish off northwest Florida

in the 1960s when no fishery regulations existed for Gulf red snapper and reported a tag return rate of 28% for red snapper, which is 2.5 times higher than the fisher reporting rate in our study. Citing a sharp drop in tag return rates for Gulf and south Atlantic king mackerel following the advent of fishery regulations in the early 1980s, Fable (1990) suggested that by not reporting tag recoveries fishers were expressing their resentment of the regulations.

Differences in the spatial and temporal distribution of effort between the commercial and recreational red snapper fisheries also may have affected tag recoveries. During the study, the recreational fishery was much more evenly distributed across all months than was the commercial fishery (Schirripa and Legault 1997, 1999). Total allowable catch was essentially equal for each fishery (approximately $2.1 \times 10^3$ metric tons per year), but the commercial fishery was only open each year for brief periods during winter and fall and operated as a derby. In a derby fishery, commercial fishers may not have taken the time, or even had access to a telephone, to report tag returns. The number of tags reported by commercial fishers was disproportionately low, even though the commercial fishery averaged only about 10% of annual landings east of the Mississippi River (the area where all but one of the reported recoveries were made). If nonreporting of tag recoveries by commercial fishers existed, it may have biased reported movement to appear eastward because the bulk of commercial landings came from the northwestern Gulf. Alternatively, there is much more natural hard-bottom habit for red snapper off northwest Florida than to the immediate west of the artificial reef area where we tagged fish (Parker et al. 1983; Schroeder et al. 1995); thus, reported movement to the east may accurately reflect movement in the tagged population.

### *Red Snapper Movement and Implications for Stock Mixing*

Authors of previous studies of red snapper movement generally concluded that adult fish demonstrate high site fidelity (Beaumariage 1969; Fable 1980; Szedlmayer and Shipp 1994; Szedlmayer 1997). Even Watterson et al. (1998), working with preliminary data from our study, reported that 80% of fish not at liberty during Hurricane Opal were recaptured at their sites of release and concluded that fish not exposed to hurricanes remained loyal to their release sites. In the expanded study presented here, increases in sample size and the temporal scale allowed us to observe red snapper movement on two different scales, one for fish exposed to hurricanes and one for fish not exposed to hurricanes. This demonstrated that, over time, fish not exposed to hurricanes also had a low probability of remaining at their release sites. We found that only 55% of recaptures not at liberty during hurricanes had remained at their release sites, a scale of movement away from release sites much greater than that reported by Watterson et al. (1998). Moreover, our estimates of red snapper movement away from release sites are probably conservative because of tag loss and probable under-reporting of tag recoveries made by fishers.

Mean time at liberty of fish recaptured in this study was much longer than mean time at liberty reported from previous red snapper tagging studies (Beaumariage 1969; Fable 1980; Szedlmayer and Shipp 1994; Watterson et al. 1998). It is possible that fish from other studies were as likely to move as a function of time at liberty as were fish from this study; however, the temporal scale of previous studies may have been too short to observe fish movement. In a 4-year study of 1,126 tagged red snapper off northwest Florida, Beaumariage (1969) reported a high tag recovery rate of 28%. However, recaptured red snapper were at liberty on average for only 113 d; hence, most recaptures were made near their sites of release. We report here that time at liberty significantly affected the probability and distance of red snapper movement away from release sites; similarly, other studies have shown that the longer the mean time at liberty, the greater movement of tagged red snapper (Beaumariage 1969; Fable 1980; Szedlmayer and Shipp 1994; Szedlmayer 1997; Watterson et al. 1998).

Distances moved by individual red snapper in this study also were greater than distances previously reported; the greatest distance had been 279 km (Beaumariage 1969). Beaumariage (1969) reported that six red snapper recaptured off northwest Florida in the 1960s moved over 100 km, which until now was the largest scale of movement reported for Gulf red snapper. In our study, 34 fish moved over 100 km from their release sites, 15 of which moved over 200 km and 2 of those over 300 km. We also recorded, for the first time, a fish movement from the northeastern Gulf to the northwestern Gulf.

Before this study, the conclusion that Gulf red snapper constitute a single stock was not supported by tagging data, which had suggested adult red snapper move little. Although some

studies showed movement of red snapper on spatial scales of tens to hundreds of kilometers (Beaumariage 1969; Szedlmayer and Shipp 1994), most recaptured fish did not move at all. Because existing data indicated that movement of adult red snapper was limited, Goodyear (1992, 1995) proposed that stock mixing may result from oceanographic transport of eggs and larvae, or from gradual diffusion of adult fish away from centers of abundance. Gold et al. (1997) added that the contemporary genetic homogeneity of northern Gulf red snapper possibly resulted from historical mixing and that if modern subpopulations exist, they have had insufficient time for genetic divergence.

Although stock mixing may occur planktonically and although current genetic variability in Gulf red snapper surely reflects historical mixing, we have documented movement of adult red snapper that may be sufficient to promote stock mixing, especially considering the relatively small number of migrants necessary to maintain genetic homogeneity between geographic areas (Allendorf 1983; Shaw et al. 1999; Heist and Gold 2000). In fact, as few as 1 migrant per 1,000 breeding individuals in a generation may be sufficient to preclude genetic differentiation among areas (Nolan et al. 1991). In light of this, and because all recoveries reported by fishers were larger than estimated size at maturity for Gulf red snapper (approximately 290 mm TL; Goodyear 1995; Render 1995; Collins et al. 1996), fish at liberty during Hurricanes Opal or Georges demonstrated movement that potentially could affect genetic mixing in the northern Gulf. Clearly, movement of fish exposed to hurricanes was on a scale and in a direction that would facilitate genetic mixing in the northeastern Gulf. Our first-time documented movement of a red snapper from east to west of the Mississippi River delta is also pertinent to stock mixing. If other recoveries of tagged individuals that moved from the northeastern to the northwestern Gulf went unreported (for reasons discussed above), the potential for stock mixing was even greater than reported movement would indicate.

Although the scale of movement was much greater for fish at liberty during Hurricanes Opal or Georges, movements of fish at liberty at times other than during the storms may be sufficient to support Goodyear's (1992) hypothesis that stock mixing of Gulf red snapper could result from gradual diffusion of adults away from centers of abundance. Our observed movement to the east may also support that hypothesis. From fisheries-dependent data, it appears there is a center of red snapper abundance off southwest Louisiana and a second center off Alabama (Goodyear 1995). Waters off northwest Florida historically supported a large red snapper fishery; however, during the late 1980s and early 1990s the abundance of red snapper in this area plummeted (Camber 1955; Carpenter 1965; Goodyear 1995). Estimates from virtual population analysis indicate that young cohorts of red snapper (fish $<5$ years old) now are much more abundant Gulf-wide than they have been in the recent past (Schirripa and Leg ault 1999). Management regulations have successfully decreased fishing mortality on young Gulf red snapper, and as the abundance of young fish has increased, anecdotal information and fisheries-dependent data suggest that numbers of red snapper off northwest Florida are increasing (Schirripa and Legault 1999). It is possible that, as the stock recovers, fish from a center of abundance off Alabama are recruiting to Florida waters.

## Summary

This study supports the conclusion that northern Gulf red snapper constitute a single stock. Hurricanes had the greatest effect on red snapper movement, but movement of fish not at liberty during hurricanes may be sufficient to support stock mixing via gradual diffusion of adults. Before this study, limited evidence indicated that larger, older fish may move greater distances than small, young fish (Beaumariage and Wittich 1966; Moe 1966). We report here that size significantly affected probability of movement, and the longer fish were at liberty the farther they moved. Therefore, because mostly small, young fish were tagged in this study, the rates of movement we reported here may be less than rates for larger fish. Movement of fish that were at liberty during Hurricanes Opal or Georges demonstrated the greatest potential to promote stock mixing. The frequency of hurricanes in the Gulf implies that they potentially play an important role in stock mixing dynamics of red snapper, especially considering that Gulf red snapper can reach age 50 or more and are likely to be exposed to several hurricanes over the course of their lives (Patterson et al. in press; Render 1995; Watterson et al. 1998).

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# Examination of Red Snapper Fisheries Ecology on the Northwest Florida Shelf (FWC-08304): Final Report

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# Introduction

Reef fishes are both ecologically important members of shelf communities and economically important to the fishing economy of Florida's Panhandle region. Among the fishes targeted in this region, none is more economically significant than red snapper, *Lutjanus campechanus*, which is targeted at both natural and artificial reefs throughout the region. Red snapper are long-lived fish that occur across the shelf of the northern Gulf of Mexico (Gulf) from the mouths of bays to the shelf break. Recent work has suggested that red snapper associate with habitats that provide small scale (cm) vertical relief and complexity, such as worm tubes or shell rubble, soon after settling out of the plankton (Patterson et al. 2005; Wells et al. 2008), but relatively little is known about their ontogentic movement to more complex habitats, or whether fish are spatially segregated by size class across the shelf. These are important questions not only for understanding red snapper ecology, but they also have important fishery implications. If small fish are predominantly found closer to shore, then protecting inshore nursery habitats would be key to rebuilding this severely overfished stock. Alternatively, if large, older fish are predominantly found farther out in deeper waters, then protecting those areas may protect spawning stock biomass. If no size segregation with depth is apparent, then perhaps altering gear selectivity would be a means to protect undersized fish from being captured, regardless of depth.

Red snapper fishermen tend to focus on artificial reef sites in the Panhandle when fishing within 20 miles of the coast. Artificial reefs have been deployed on the northeastern Gulf shelf since just after World War II with the goals of enhancing reef fish populations as well as providing fishing opportunities close to shore. While resource managers often cite more than one goal for a given artificial reef program, recreational and commercial fishers generally are among the most vocal proponents of artificial reefs because increased catch rates often follow reef creation (Bohnsack 1989; Lindberg 1997; Grossman et al. 1997; Bortone 1998). This increase in catch rates is the subject of an ongoing debate among fishery biologists and managers as to whether artificial reefs function more as enhancers of reef fish production, or are more likely to simply increase catchability due to attracting fishes from surrounding areas (Bohnsack 1989; Lindberg 1997; Pickering and Whitmarsh 1997). This issue is especially important in the northern Gulf of Mexico (Gulf) where many large reef fishes (e.g., snappers and groupers) targeted at artificial reefs are estimated to be fully exploited or overfished (NOAA 2007; Patterson and Cowan 2003). Therefore, concern exists that creation of artificial reefs actually may exacerbate unsustainable levels of fishing mortality if artificial reefs function more as reef fish attractants than as production enhancers (Polovina and Sakai1989; Polovina 1991; Grossman et al. 1997; Pitcher and Seaman 2000).

Currently, insufficient data exist in many artificial reef systems to evaluate the ecological versus fishery role of reefs. However, several scientists working in the state of Florida and off Alabama have been leaders in trying to tease apart these aspects of artificial reef function. Bohnsack and Sutherland (1985) were among the first scientists to question whether artificial reefs generally increased fish production or merely aggregated fishes from surrounding natural hardbottom habitats. They suggested a greater understanding was needed of how artificial reefs effect fish populations and marine ecosystems prior to the mass deployment of reefs. Bohnsack (1989) developed a conceptual model, based on his empirical studies, as to what conditions may favor enhanced productivity versus enhanced catchability of reef fishes following artificial reef creation. While holistic, Bohnsack's (1989) model did not explicitly include reef density as a factor that might predict artificial reef function, but later Ingram (2001) and Strelcheck et al.

(2005) showed that density of artificial reefs, as well as proximity to natural hardbottom areas, could affect fish growth and mortality due to density-dependent effects. Lindberg et al. (2006) also demonstrated that artificial reefs might negatively affect gag, *Mycteroperca microlepis*, population dynamics on the west Florida shelf, as fish selected artificial reef habitat even when sub-optimal spacing lead to depressed growth due to density effects. Together, these studies indicate reef spacing and surrounding habitat types have important implications for artificial reef function.

Since 2004, we have been studying the ecological function of a subset (n = 27; Fig. 1) of the so-called refugia (i.e., unreported) reefs that were built by the state of Florida in the Escambia East Large Area Artificial Reef Site (EE-LAARS) off the Panhandle in 2003 (Patterson et al. 2009a, 2010). Patterson et al. (2009a) reported that artificial reefs had a lower biomass of fishery important species and an elevated biomass of planktivores after their coordinates were reported to the public. They linked these differences to an increase in disappearance rates of fishery species that they inferred resulted from fishing mortality at reported sites. However, high disappearance rates for red snapper (but not other species) even at unreported reefs indicates they were either leaving unfished reefs and were targeted by fishermen at other reefs in the region, or that fish recruited to unsampled, and presumably deeper, reefs as they grew larger. These issues could not be resolved, however, because the spatial distribution of red snapper size classes across the shelf is not known. Furthermore, little is known about differences in fish communities or ecological function between natural and artificial reefs, which is especially important in this case due to the fact that artificial reefs have mostly been deployed in waters <30 m deep and within 20 miles of the coast, while high relief (>1 m) natural hardbottom habitats are most common in waters >60 m deep out to the shelf edge.

The primary goal of the current study was to examine aspects of red snapper fisheries biology and ecology at artificial and natural reefs in the northeastern Gulf. Secondary objectives were to compare community and trophic structure of the entire reef fish community between natural and artificial reefs. Lastly, because sampling of northeastern Gulf reef sites began in spring 2009, a dataset of reef community and trophic structure estimates existed prior to the Deepwater Horizon (DWH) oil spill. Sampling in the current study was ongoing from May to August 2010, thus any acute effects of the DWH spill on reef communities and trophic structure could be assessed.

## Methods

**Video Sampling and Analysis:**

Video sampling of reef fish communities on the northeastern Gulf of Mexico continental shelf occurred on 24 research cruises conducted between June 11, 2009 and August 23, 2010. Eighty video samples were recorded at natural (n = 23) and artificial (n = 26) reefs that ranged in depth between 18 and 72 m (Fig. 1). Sampling was conducted with either a VideoRay Pro3 (dimensions: 30 cm long, 24 cm tall, 22 cm wide; mass = 3.8 kg) or Pro4 micro remotely operated vehicle (ROV; dimensions: 36 cm long, 28 cm tall, 22 cm wide; mass = 4.8 kg). Both ROVs have a depth rating of 170 m, a wide angle (105º or 116 º, respectively) lens on a 570-line forward-looking color camera, and can be equipped with a red laser scale (10 cm between lasers) to estimate fish size. The ROVs were tethered to the surface where they were controlled by a

pilot via an integrated control box that contains a 38-cm video monitor to observe video captured by the ROV's camera during sampling.

Video sampling was conducted at study reefs with either a point-count or transect method, depending on habitat type and dimensions (Fig. 2). The point-count method, which is described in Patterson et al. (2009b), was used to sample a 15-m cylinder around isolated reef habitat, such as single artificial reef modules (Fig. 2C,D). In that method, the ROV was positioned 1 m above the seafloor and approximately 5.5 m away from a given reef. The ROV slowly was pivoted 360º and then moved to the opposite side of the reef. Once there, it was positioned 1 m above the seafloor and approximately 5.5 m away from the reef and pivoted 360º. The ROV then was flown to 1 m directly above the reef and pivoted 360º to video fishes in the water column above the reef. Next, the ROV was flown to ~10 m above the reef and pivoted 360º. Once all sample segments were completed, the ROV was flown back down to the reef and positioned such that fishes inside the reef structure were captured on video.

A transect sampling method was utilized for reef habitat that was more broadly distributed, such as was characteristic of natural reef habitat examined in this study (Fig. 2A,B). The goal of that method is to video sample a 10-m wide transect as the ROV moved forward along a 25-m long transect. Given known viewing angles for the forward cameras of Pro3 (105º) and Pro4 (116º) ROVs, the ratio of the height of an ROV off the seafloor to the width of a video transect (i.e., distance across field of view) can be controlled by changing the camera's tilt (Fig. 3). This can be accomplished prior to deployment for a Pro3 ROV, but a Pro4 ROV's operating system has the capability of controlling the camera's tilt within the software. Either way, simple trigonometry allowed for the field of view of a transect to be estimated, thus the total area video sampled to be computed. Typically, 3 to 4 transects were sampled at a given reef site, with transects being offset from adjacent transects by headings of 120º or 90º, respectively.

Analysis of video samples was performed in the Fisheries Laboratory at UWF with a Sony DVCAM DSR-11 digital VCR and a Sony LMD-170 high resolution LCD monitor. When the point-count method was employed, fish counts were summed among all sampling segments and then divided by the sampling cylinder's area (176.7 $m^2$) to estimate fish density. Fish density for transect samples was computed by summing taxa-specific fish counts and then dividing by the total area estimated to have been sampled among transects.

Fork length (FL) was estimated for fishes struck by the laser scale during video sampling at study reefs. This was accomplished by multiplying the length of a given fish measured in a video frame by the known distance between lasers (100 mm), and then dividing that product by the distance measured between lasers in the frame. For example, if a red snapper measured 38 mm in a video frame and the distance between the laser points measured 12 mm, the fish would be estimated to be 317 mm {[(38 mm*100 mm)/12mm)] = 317 mm}. Fork length was converted to total length (TL) with regression equations developed from fish captured with hook and line.

**Community Structure Analysis:**

Differences in reef fish community structure were tested between habitat types (natural versus artificial), among three depth strata (<30 m, 30-45m, and >45 m), and between two time stanzas (before May 2010 and between May and August 2010) with single-factor analysis of similarity (ANOSIM) models in the Primer software package (Clark 1993; Clark and Warwick 2001), with taxa-specific fish density (fish $10^3$ $m^{-2}$) as the dependent variables. Fish density was square-root transformed and standardized. Then, a Bray-Curtis similarity matrix was computed, which consisted of all of the individual similarity coefficients computed among sites. Individual

ANOSIM models then were computed for habitat type, depth stratum, and time stanzas. The experiment-wise error rate was set *a priori* to 0.05 for all ANOSIM models. However, since three separate analyses were conducted, α was split three ways such that the resultant critical value was 0.0167 for each model. An analysis of similarity percentages (SIMPER) was also computed in Primer for significant ANOSIM models to determine which taxa contributed most to Bray-Curtis dissimilarity between factor levels.

**Fishing Experiments:**

Following video sampling, fish were captured with hook and line for 30 minutes by between 6 and 8 fishermen. Two-hook bottom rigs were deployed on each fishing rod and consisted of a 1.5-m leader constructed of 60-lb monofilament which had two shorter leaders extending ~0.5 m horizontally from the main leader. Terminal tackle on the ends of the horizontal leaders was either 9/0, 12/0, or 15/0 Mustad circle hooks. Hooks were fished with either cut squid or mackerel scad as bait. At a given site, half the fishermen fished with one size of circle hooks and the other half fished with another size. Fish were randomly sampled for biological samples and retained, otherwise they were returned to the water following measurement of their fork length (FL) and total length (FL). Retained fish had coded cable ties attached to them that identified individual fish, and then were placed on ice.

Fish were weighed to the nearest 0.01 kg once back on shore and several biological samples were extracted from each fish, including both sagittal otoliths, stomachs, and ~100 g of lateral muscle. Otoliths were rinsed of adhering tissue and placed in plastic cell wells. Stomach samples were wrapped in cheesecloth and placed in plastic bags, fixed in 10% neutral buffered formalin for at least 48 hours, and then transferred to plastic bottles and stored in 70% isopropyl alcohol. Muscle tissue samples were placed in plastic bags and frozen. Frozen muscle tissue samples were stored in an ultralow freezer at between -70 and -80 ºC.

**Red Snapper Age and Growth:**

Red snapper sagittae were embedded in epoxy and sectioned through their core with an Isomet low-speed saw. Otolith sections were ~500 μm thick and were glued to microscope slides with Cytoseal adhesive. Sections that were judged to be too thick after observing with transmitted light under a dissecting microscope were sanded with 3500 grit polishing cloth and then polished with 0.3 μm alumina suspension on a felt pad. Cytoseal then was applied to the surface of all sections.

Fish were aged by counting opaque zones in otolith sections. The algorithm of Patterson et al. (2001) was used to assign fractional age based on number of opaque zones observed, marginal condition (opaque or translucent), and date of sampling. Size at age was plotted separately for red snapper captured at natural versus artificial reefs. A linear regression was fit to each plots, as well as to the combined data, and a likelihood ratio test was computed in Excel to test if slopes, hence growth rates, were significantly different between habitat types. Lastly, catch curve analysis was performed by fitting linear regressions to descending limbs of plots of the natural log of numbers of fish versus integer age. Regressions were fit to data from natural and artificial reefs separately.

**Diet Analysis:**

Gut contents were identified to the lowest taxonomic level possible with the aid of a dissecting microscope. Prey were separated by taxa, dried in an oven at 60 ºC for at least 24

hours, and weighed. The percent frequency of occurrence was calculated for abundant fish taxa as (Bowen 1996):

$$\%FO = \frac{\text{Number of stomachs containing a prey category}}{\text{Number of stomachs with any prey category}}$$

An index of relative importance (IRI) also was computed as (Hacunda 1981):

$$IRI = (\%N + \%M) \times \%FO$$

where:

%N = % by total number of prey

%M = % by total weight of prey

%FO = frequency of occurrence.

Percent IRI (%IRI) was computed as:

$$\%IRI = \left( \frac{\text{IRI for each prey category}}{\text{Sum of the IRI values among categories}} \right) \text{x } 100.$$

Qualitative differences in diet were assessed by inspection of %IRI results among fish taxa and habitat types.

**Stable Isotope Analysis:**

Fish muscle samples were removed from the ultralow freezer placed in a -20 ºC freezer and then a refrigerator at 40 ºC to thaw. Once thawed, any associated bone and scales were removed and samples were rinsed with double-distilled 18 MΩ $cm^{-1}$ polished water. Tissue samples then were placed in aluminum weighing boats and placed in a drying oven at 60 °C for 24-48 hours. Dried samples were mechanically ground with an electric tissue grinder and then further pulverized with acid-leached glass mortar and pestles. Pulverized samples were stored in plastic microcentrifuge tubes and approximately 10 g of each sample was sent to Iso-Analytical, a contract analytical chemistry laboratory in Cheshire, England, for analysis of stable isotopes of C, N, and S.

Stable isotope analysis was performed with a Europa Scientific GSL/Geo 20-20 isotope ratio mass spectrometer. Analytes included $\delta^{13}C_{V\text{-}PBD}$ ($\delta^{13}C$), $\delta^{15}N_{Air}$ ($\delta^{15}N$), and $\delta^{34}S_{V\text{-}CDT}$ ($\delta^{34}S$). International Atomic Energy Agency (IAEA) standard reference materials (SRMs) were run periodically to assess machine performance, while analytical precision was estimated from duplicate analysis of randomly selected samples. Results from IR-MS analysis of C, N, and S stable isotopes are reported in the standard delta notation. Delta values are deviations in parts per mil (‰) from a standard reference material. Values were computed as:

$$\delta X = [(R_{sample}/R_{standard}) - 1] \times 1{,}000$$

where:

$X = {}^{13}C$, ${}^{15}N$, or ${}^{34}S$

$R = {}^{13}C/{}^{12}C$, ${}^{15}N/{}^{14}N$, or ${}^{34}S/{}^{32}S$.

Standards were Pee Dee Belemnite for C, air for N, and Canyon Diablo Triolite for S.

Results of stable isotope analysis were used to infer source of production and trophic position of fish and invertebrate samples. Typical northern Gulf of Mexico phytoplankton ranges of -20 to -18‰ for $\delta^{13}C$, 8 to 9‰ for $\delta^{15}N$, and 18 to 20‰ for $\delta^{34}S$ (Fry 1988). Trophic fractionation (enrichment of the heavier isotope) from prey to consumer was assumed to average 1‰ for $\delta^{13}C$ and 3‰ for $\delta^{15}N$ (Fry et al. 1984; Fry 2006); trophic fractionation is known not to occur for $\delta^{34}S$ (Connolly et al. 2004; Fry 2006). Thus, trophic level was inferred from $\delta^{13}C$ and $\delta^{15}N$ values. Values of $\delta^{34}S$ were used to estimate if the predominant prey source(s) of fish samples was pelagic or benthic. Benthic S processes impart a $\delta^{34}S$ signature of ~15‰ in benthic prey species, while pelagic phytoplankton has a $\delta^{34}S$ signature approximately 19 to 20‰ (Connolly et al. 2004). Lastly, $\delta^{13}C$ values of fishes collected between May and August 2010 were examined to assess whether there was any evidence that organic carbon from the DWH oil spill had entered the foodweb and been transferred to fishes (MacAvoy et al. 2002), which would be evidenced by extremely low fish muscle $\delta^{13}C$ values (i.e., -25 to -30‰).

## Results and Discussion

Eighty-one fish taxa were observed at study reefs during 2009-10, with 88% of taxa being identified to the level of species (Table 1). There was a significant difference in fish community structure between natural and artificial reefs (ANOSIM; $p = 0.004$), but no difference was detected among depth strata (ANOSIM; $p = 0.121$) or between the two time stanzas of sampling (ANOSIM; $p = 0.623$). Differences in fish communities between habitat types were driven by relatively large reef fishes, such as lutjanids, haemulids, and balistids having much higher densities on artificial reefs than on natural reef habitat (Tables 2&3). Artificial reefs also had much higher numbers of unidentified small fishes observed. That may have resulted from there being high densities of gobioid fishes present that were observed within the invertebrate fowling community on artificial reefs, but their small size and cryptic nature left them unidentifiable. Alternatively, many more small, cryptic fishes could have occurred on natural reefs but went undetected due to the higher rugosity and structural complexity of those habitats (Fig. 2). Of the gobioid fishes that were identified, gobies, blennies, and jawfishes had much higher densities on natural reefs (Table 2).

Another key difference in fish communities between natural and artificial reefs was that small planktivores or invertivores had higher densities at natural than artificial reefs (Table 2, Fig. 4). Pomacentrids (damselfishes) had the third highest density on natural reefs among all families, and had the second highest number of species observed ($n = 10$), yet were rarely observed on artificial reefs. Other small, obligate reef fishes, such as apogonids, chaetodontids, labrids, priacanthids, pomacanthids, and tetraodontids had much higher densities on natural than artificial reefs. These trends become even more apparent in the SIMPER results examining habitat differences (Table 3), as grunts, snappers, and damselfishes dominant the cumulative Bray-Curtis dissimilarity in fish communities between natural and artificial reefs.

One interesting result was that small transient planktivores or invertivores, such as mackerel scad, sardines, or pinfish, were not observed on any of the reef sites. Patterson et al. (2009a) reported that those fishes combined made up approximately 25% of the total numbers of fishes observed at 27 artificial reef sites off Pensacola, Florida that were sampled quarterly from 2004-2008. However, they also reported that those species were highly abundant (100s to 1000s of individuals) when present, but their frequency of occurrence was <10%. Therefore, it is likely

that schooling, transient fishes did visit study reef sites but were not observed on days when sampling occurred. This issue deserves greater scrutiny moving forward as small planktivorous fishes would be most likely to suffer food web effects if DWH oil or dispersants negatively impacted plankton communities in the ecosystem.

Another point to make when examining differences in fish communities at natural versus artificial reefs is that while large invertivorous or piscivorous reef fishes were more dense at artificial reefs, the footprint of artificial reefs also was much smaller. Many artificial reefs in the northern Gulf occur on spatial scales of a 100 $m^2$ or smaller, while much of the natural reef habitat occurs on spatial scales of $km^2$. The artificial reefs examined in this study also typically had vertical relief between 2 and 5 m, while natural reef habitats typically had vertical relief <2 m, and often <1 m. Therefore, tall artificial reefs may have attracted larger reef fishes, which in turn occurred at higher densities than the same species on natural reefs, but those high densities occurred over spatial scales that were several orders of magnitude smaller than spatial scales typical of natural reefs.

Species-specific fish size ranges, as scaled by lasers attached to the ROV, were similar between natural and artificial habitats for all species except greater amberjack, which were nearly 20% larger on artificial reefs (Fig. 5). Among all reef fishes, there was no apparent trend in fish size range with increasing depth (Fig. 6A), although most fish >800 mm TL were observed in water depths >50 m. In the case of red snapper, there was substantial overlap in the range of fish observed among depths sampled, but few fish <250 mm TL, and all fish scaled to be >650 mm TL, were observed at reef sites >50 m deep (Fig. 6B). There was also a clear trend of red snapper TL increasing with depth (Fig. 6C), but the mean size of fish scaled even in the deepest stratum (>45 m) was <380 mm for a fish that can reach lengths of 1 m. Therefore, while there was some increase is TL with depth for red snapper, small young fish were observed across the shelf and few fish >600 mm TL were observed regardless of depth.

**Fishing Experiments:**

A total of 1,605 fish from 31 species was captured during hook and line sampling, with red snapper dominating the catch (66.4% of individuals caught). Size distributions of fishes present on reef sites versus those captured with hook and line demonstrates that larger circle hooks selected for larger fish (Fig. 7). That trend was even more prominent for red snapper than it was for all fishes in general (Figs. 8&9). Interestingly, the catch rates of other reef fishes declined precipitously with increasing hook size, but red snapper catch rate remained fairly constant (Fig. 10). Therefore, the percentage of the catch that was red snapper increased from 46% for 9/0 hooks to 76% for 12/0 hooks to 86% for 15/0 hooks.

Currently, maximum sustainable yield (MSY) for Gulf red snapper is estimated as the yield a $F_{26\%SPR}$. For a fish with red snapper's life history, biomass at MSY ($B_{MSY}$) or a $B_{MSY}$ proxy would be higher than 26%SPR were it not for fish being fully selected by the predominant fishing gears at relatively small sizes and ages. For example, Porch (2007) estimated that fish were fully vulnerable to recreational fishing gear by age 1 when fish are still much smaller than the legal size limit of 408 mm (16 inches) TL. The size limit itself would be set much higher to maximize yield per recruit were it not for discarding issues that also result from small fish being fully selected by the fishing gear. Discard mortality, especially in the recreational fishery, is not only significant issue for red snapper fisheries management, but it also is critical to the assessment and management of other large reef fishes like gag or greater amberjack.

The hook selectivity work presented here is an important first step in beginning to examine what the likely effects on the recreational reef fish fishery in the northeastern Gulf would be if hook size were regulated. While the results presented herein are only semi-quantitative and no attempt was made to estimate selectivity directly, results clearly indicate that altering hook size would have important implications for the fishery. Sub-legal red snapper catch rates dropped when larger hook sizes were used, but not nearly as sharply as did catch rates for other species. Therefore, regulating hook size to facilitate red snapper stock recovery likely would have direct effects on fisherman attempting to target other reef fishes as well.

Lastly, minimum size limits in heavily prosecuted fisheries have been shown potentially to have unintended negative effects on population genetics in that the fastest growing fish reach the size limit first, thus fast growing genes are disproportionately removed from the population (Conover and Munch 2002). It is possible that altering hook size such that only larger fish are fully selected to the gear could elicit similar effects, not to mention that selecting large females might have unintended negative implications for spawning stock biomass. Simulation analysis to explore these likely population-level effects should be part of the selectivity work in the future.

**Red Snapper Age and Growth:**

Sample sizes for red snapper age and growth analysis were 182 fish for natural reefs and 286 for artificial reefs (Fig. 11A). Fish size ranged from 238 to 762 mm TL, and age ranged from 1 to 9 years. Linear regressions fit separately to natural and artificial reef red snapper size at age data did not significantly improve the fit over the regression fit to the combined data (Likelihood Ratio Test; $p = 0.624$). Therefore, no significant difference in red snapper growth rate was detected between habitat types.

One thing that is apparent in the linear regression of red snapper size versus age is the considerable variability in size at age among the samples (Fig. 11A). To evaluate that issue further, the distribution of residuals of the red snapper von Bertalanffy growth function (VBGF) reported by Patterson et al. (2001) were compared to residuals of observed size at age from the current study minus predicted size at age that resulted from applying the Patterson et al. (2001) VBGF. The residual distributions are nearly identical (Fig. 11B), thus indicating that growth has not changed in the 10 years since the Patterson et al. (2001) data were collected and that variability in red snapper size at age is similar today to what it was estimated to be historically.

Catch curve analysis resulted in slopes of -1.31 and -1.24 for natural and artificial reefs, which translate to instantaneous disappearance rates (D) of 1.31 and 1.24 $y^{-1}$, respectively (Fig. 12). To put that in perspective, Gulf red snapper is estimated to have an instantaneous rate of natural mortality (M) of 0.1 $y^{-1}$ for fish 2+ years old (Porch 2007), and that is not accounting for the likely decrease in M with age. Therefore, the ratio of D:M for samples collected in this study was 13.1 for natural reefs and 12.4 for artificial reefs. However, selectivity could affect estimates of numbers at age if selectivity declined with fish size, therefore age. A comparison of red snapper FL distributions from laser data versus the catch reveals that the catch actually had a higher percentage of larger fish than did the overall population of red snapper on study sites (Fig. 13). One caveat to that interpretation would be that if larger fish avoided the ROV and fishing gear, then they would appear in neither data set. From observing fish behavior in video samples, that scenario seems unlikely.

The components of D are M plus instantaneous fishing mortality (F) plus net instantaneous emigration (E´). If M is basically equal between natural and artificial reefs, and there is no bias in estimates of D due to selectivity issues, then the enormous difference between

D and M must be due to F and/or E′. Patterson et al. (2009a) reported that D for unreported (i.e., unfished) artificial reef sites off Pensacola was 0.93 $y^{-1}$ and 1.16 $y^{-1}$ for reported sites. They concluded that the difference in D between fished and unfished reefs was clearly due to F. However, that did not explain a D:M ratio of 9.3 for unfished sites. That high D must have been due to fish being targeted by fishermen at unreported reefs (there was no evidence of that and gray triggerfish did not show this pattern), high regional F affecting the age composition of the red snapper population in the entire region, or net movement of fish to other habitats, presumably offshore.

In the current study, F was known to occur at all study sites, so a reef being unreported or reported to the public is not an issue. In the most recent red snapper stock assessment, mean F in the eastern Gulf in 2008 was estimated to be 0.77 $y^{-1}$ among age classes observed in the current study. Therefore, either mortality has increased despite more restrictive fishing regulations, or a large percentage of fish emigrated away from study reefs with increasing size and age. Interestingly, when catch curves were recomputed with data collected prior to May 2010 versus between May and August 2010, estimated D was 1.28 and 1.32 $y^{-1}$, respectively. Therefore, no acute mortality effects on red snapper appear to have occurred during the time period when significant amounts of DWH oil were present in surface waters over the shelf.

The issue of high D for red snapper in this study, as well as in the study reported by Patterson et al. (2009a), clearly warrants further investigation. Sample reefs in the Patterson et al. (2009a) study were mostly <35 m deep, with the deepest site being 41 m. In the current study, both natural and artificial reefs were examined, with several study sites being 60 to 72 m deep, yet few fish older than 5 years were observed (15% of samples) for a species that can live to be 60 years old. The question remains, where are the older fish? Are they dead, do they avoid both the ROV and hook and line gear, or have they recruited to unsampled habitat?

Mitchell et al.'s (2004) longline study of the size and age distribution of red snapper along shelf-edge banks in the northeastern and northwestern Gulf provides some insight into this latter possibility. The terminal tackle on longlines they deployed was 15-0 circle hooks, for which Porch (2007) reported that 3 year-old red snapper had a vulnerability of less than 10% and that vulnerability increased almost linearly from age 3 until age 8, when it was nearly 100%. Adjusting the age distribution reported by Mitchell et al. (2004) in the northeastern Gulf for this change in vulnerability with age, and then computing a linear regression on the ln(catch) at age, yields a positive slope of 0.08 $y^{-1}$, which would correspond to the instantaneous rate of immigration to offshore reefs, or the converse of instantaneous net emigration (E′). If 0.08 $y^{-1}$ were subtracted from the Ds computed here, we would still be unable to account for much of the decline in numbers of red snapper at age.

**Diet and Trophic Analyses:**

The diet of 854 fish representing 27 species was analyzed via examination of stomach contents, with red snapper constituting 58% of the samples. Among all samples, 77% had identifiable prey items present in their stomachs and 99 different prey items were identified. Prey items were placed into 9 categories, which included fish, Decapoda, Stomatopoda, Cephalopoda, Gastropoda, Amphipoda, other invertebrates, zooplankton, and macroalgae to examine diet differences among species and habitats. It should be noted that most (>90%) of the amphipods identified in stomach samples were pelagic hyperiid amphipods, thus zooplankton themselves.

There were 18 reef fish species for which there were multiple stomach samples that contained prey items (Fig. 14), although not all were collected in both natural and artificial

habitats. Sampled gag, lane snapper, greater amberjack, scamp, and whitespotted soapfish were principally if not exclusively piscivores. Among the invertivores, several ate fish as well. After fish, decapods (principally crabs and shrimps) were the next most important prey type, especially with respect to %IRI (Fig. 14C). Vermilion snapper diet had the highest percentage of zooplankton, with over 50% of their diet consisting of amphipods and other zooplankton, which was true regardless of habitat type.

Small sample sizes for many reef fishes makes it difficult to infer predominant diet or trophic position from stomach content analysis. Sufficient samples sizes existed for red snapper, however, to examine habitat and ontogenetic effects on diet (Fig. 15). Overall, red snapper were fairly omnivorous regardless of size category or habitat type. All fish tended to have a high percentage (20-60%) of their diet being fish, with decapods also being important. Fish sampled in natural reef environments tended to have higher percentages of cephalopods by mass than fish captured at artificial reef sites. McCawley and Cowan (2007) indicated that zooplankton appearing in the diet of adult red snapper off Alabama likely indicated that high densities of artificial reefs resulted in too many fish grazing down the forage base, thus causing red snapper to switch to a sub-optimal food source. However, in the current study about a third of red snapper diet consisted of pelagic amphipods and other zooplankton regardless of habitat or fish size (Fig. 15).

Analysis of fish muscle stable isotope ratios allows inference to be draw about a species' trophic position without the need for large (n >50) sample sizes. Also, stable isotope signatures are integrated over weeks to months as muscle tissue turnover rates are much longer than digestions rates for stomach contents (Fry 2006). Among the samples analyzed in this study, the one gray snapper sampled from natural habitat had the highest $\delta^{15}N$ and $\delta^{13}C$ values, thus fed at the highest trophic level, while vermilion snapper, gray triggerfish, and bank seabass all fed at about a trophic level below gray snapper and other reef fishes like greater amberjack, lane snapper, and gag (Fig. 16A). The omnivorous red snapper and tomtate, along with the invertivore red grouper, all clustered together in the middle of the range of $\delta^{15}N$ values.

Most of the fishes analyzed tended to have pelagic $\delta^{34}S$ signatures, with mean values mostly ranging between 17.5 and 19‰. Tomtate and gag had the lowest $\delta^{34}S$ values, indicating they mostly ate benthic prey. Those two species also displayed a trend that was common among several fishes in that their $\delta^{34}S$ values from natural reefs had a more benthic signature than samples from artificial reefs did. High densities of reef fishes can deplete benthic prey in soft or sandy bottom foraging halos around reef structure (Frazer et al. 1991; Galvan et al. 2008). That might explain the more pelagic versus benthic $\delta^{34}S$ signatures for fish sampled in artificial versus natural habitats if high fish densities on artificial reefs grazed down benthic prey, thus fish had to switch to pelagic prey resources.

Larger red snapper sample size (n = 90) permits a more comprehensive assessment of their trophic position based on stable isotope values. The range in $\delta^{15}N$ and $\delta^{13}C$ values indicates that among fish sampled there was a full trophic level range in their feeding (Fig. 17A). However, there was no relationship between trophic position and fish size (Fig. 17C,D), and there was no difference in mean trophic level between fish sampled in natural versus artificial reefs (Fig. 17F). Plotting $\delta^{34}S$ versus $\delta^{13}C$ values indicates that fish that fed at higher trophic levels tended to consume benthic versus pelagic prey (Fig. 17B), but no relationship in $\delta^{34}S$ with fish size was apparent and there was no difference in $\delta^{34}S$ between natural and artificial reefs (Fig. 17E,F). With increased sample sizes it may be possible to examine the effect of fish density

on trophic position and $\delta^{34}S$ values, as well as to relate red snapper trophic ecology to mean size at age.

Lastly, the timing of muscle tissue sampling, before and after May 2010, permits the examination of whether differences in trophic ecology occurred among sampled reef fishes before versus after the DWH oil spill. Few differences exist between the two time periods among all the fish sampled (Fig. 18), any differences that do exist are minor, and no general trend in higher versus lower trophic position or a general switch between pelagic and benthic prey is apparent. Plots of mean stable isotope values among all fishes sampled also confirms that no general difference existed between reef fish trophic ecology before May 2010 versus between May and August 2010 (Fig. 19). A slight increase in both $\delta^{15}N$ and $\delta^{13}C$ in samples collected after May 2010 is apparent in the data (Fig. 19A), but it is important to note that mean $\delta^{15}N$ was only approximately 0.15‰ higher and $\delta^{13}C$ was only approximately 0.2‰ higher after May 2010. Regardless, trophic position did not decrease, and there is no evidence that oil-derived carbon, with is depleted $^{13}C$ signature, had reached the upper trophic levels of the ecosystem by late August 2010. These data do provide an excellent baseline to examine that issue in the future, and this study in general provides several sources of data that will allow us to test for potential chronic effects of the DWH spill on reef fish community structure, size at age, and trophic ecology in the northeastern Gulf of Mexico

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**Tables and Figures**

Table 1. Reef fish taxa observed at natural (NR) and artificial (AR) reef sites during 2009-2010. Residency: R = reef resident, RA = seasonally reef-associated neritic pelagic species, S = demersal or benthic shelf species, and T = transient. Trophic position: H = herbivore, P = planktivore, I = invertivore, F = piscivore. Life stage: J = juvenile and A = adult. Reef limited: O = obligate reef resident likely to demonstrate habitat-limited populations and G = fishes for which reefs may function to increase growth or decrease natural mortality. Multiple letters for trophic position indicate feeding on more than one trophic level. Multiple letters for life stage indicate more than one stage present. Mean density is the taxa-specific mean among all sampling events; density units are fish $10^3$ $m^{-2}$.

| Family | Scientific Name | Common | Residency | Trophic Position | Life Stage | Reef Limited | Mean Density on NR | Mean Density on AR | Overall Mean Density |
|---|---|---|---|---|---|---|---|---|---|
| Acanthuridae | *Acanthurus chirurgus* | doctorfish | R | H | A | G | 0.14 | 0.00 | 0.06 |
| Apogonidae | *Apogon pseudomaculatus* | twospot cardinalfish | R | P | J,A | O | 0.42 | 0.21 | 0.30 |
| Balistidae | *Balistes capriscus* | gray triggerfish | R | I | A | G | 1.05 | 14.72 | 8.95 |
| Batrachoididae | *Opsanus pardus* | leopard toadfish | R | I | A | G | 0.00 | 0.05 | 0.03 |
| Blenniidae | Blenniidae | blenny | R | PI | J,A | O | 6.32 | 0.00 | 2.67 |
| Blenniidae | *Parablennius marmoreus* | seaweed blenny | R | I | A | O | 1.61 | 2.39 | 2.06 |
| Bothidae | *Paralichthys albigutta* | gulf flounder | S | IF | A | G | 0.00 | 0.15 | 0.09 |
| Bothidae | *Paralichthys lethostigma* | southern flounder | S | IF | A | G | 0.00 | 0.92 | 0.53 |
| Carangidae | Carangidae | jack | T | PIF | A | G | 0.42 | 0.00 | 0.18 |
| Carangidae | *Caranx crysos* | blue runner | T | PI | A | G | 0.42 | 0.00 | 0.18 |
| Carangidae | *Seriola dumerili* | greater amberjack | RA | F | A | G | 18.04 | 16.76 | 17.30 |
| Carangidae | *Seriola rivoliana* | almaco jack | RA | F | A | G | 1.68 | 0.53 | 1.01 |
| Carcharhinidae | *Carcharhinus limbatus* | blacktip shark | T | F | A | G | 0.21 | 0.00 | 0.09 |
| Carcharhinidae | *Carcharhinus plumbeus* | sandbar shark | T | F | A | G | 0.14 | 0.00 | 0.06 |
| Carcharhinidae | *Carcharhinus sp.* | requiem shark | T | F | A | G | 0.28 | 0.00 | 0.12 |
| Chaetodontidae | *Chaetodon aya* | bank butterflyfish | R | PI | A | O | 1.96 | 0.00 | 0.83 |
| Chaetodontidae | *Chaetodon ocellatus* | spotfin butterflyfish | R | PI | A | O | 0.84 | 2.34 | 1.71 |
| Chaetodontidae | *Chaetodon sedentarius* | reef butterflyfish | R | PI | A | O | 1.12 | 0.00 | 0.47 |
| Dasyatidae | *Dasyatis americana* | southern stingray | S | IF | A | G | 0.14 | 0.10 | 0.12 |
| Ephippidae | *Chaetodipterus faber* | Atlantic spadefish | R | I | A | G | 0.00 | 51.99 | 30.04 |
| Gobiidae | Gobiidae | goby | R | PI | J,A | O | 0.42 | 0.00 | 0.18 |

Table 1. continued.

| Family | Scientific Name | Common | Residency | Trophic Position | Life Stage | Reef Limited | Mean Density on NR | Mean Density on AR | Overall Mean Density |
|---|---|---|---|---|---|---|---|---|---|
| Haemulidae | *Haemulon aurolineatum* | tomtate | R | I | A | G | 133.61 | 865.00 | 556.19 |
| Haemulidae | *Orthopristis chrysoptera* | pigfish | R | I | A | G | 0.98 | 0.00 | 0.41 |
| Holocentridae | *Holocentrus poco* | saddle squirrelfish | R | PI | A | O | 6.46 | 0.00 | 2.73 |
| Holocentridae | *Holocentrus sp.* | squirrelfish | R | PI | A | O | 0.14 | 0.00 | 0.06 |
| Holocentridae | *Myripristis jacobus* | blackbar soldierfish | R | PI | A | O | 0.21 | 0.00 | 0.09 |
| Labridae | *Bodianus pulchellus* | spotfin hogfish | R | I | A | O | 1.26 | 0.00 | 0.53 |
| Labridae | *Bodianus rufus* | Spanish hogfish | R | I | A | O | 0.00 | 0.63 | 0.36 |
| Labridae | *Halichoeres bivittatus* | slippery dick | R | I | A | O | 16.35 | 2.68 | 8.45 |
| Labridae | Labridae | wrasse | R | I | J,A | O | 0.28 | 0.00 | 0.12 |
| Lutjanidae | *Lutjanus campechanus* | red snapper | R | IF | A | G | 55.65 | 378.44 | 242.15 |
| Lutjanidae | *Lutjanus griseus* | gray snapper | R | IF | A | G | 28.49 | 36.11 | 32.89 |
| Lutjanidae | *Lutjanus synagris* | lane snapper | R | IF | A | G | 2.39 | 15.08 | 9.72 |
| Lutjanidae | *Rhomboplites aurorubens* | vermilion snapper | R | PI | J,A | G | 147.65 | 15.28 | 71.17 |
| Monocanthidae | *Aluterus monoceros* | unicorn filefish | R | I | A | G | 0.00 | 0.64 | 0.37 |
| Monocanthidae | *Aluterus schoepfii* | orange filefish | R | I | A | G | 0.14 | 0.87 | 0.56 |
| Monocanthidae | *Aluterus scriptus* | scrawled filefish | R | I | A | G | 0.28 | 0.00 | 0.12 |
| Monocanthidae | *Monacanthus setifer* | pygmy filefish | R | PI | A | G | 0.00 | 0.44 | 0.25 |
| Opistognathidae | *Opistognathus sp.* | jawfish | R | P | J,A | O | 0.84 | 0.00 | 0.36 |
| Ostraciidae | *Lactophrys quadricornis* | scrawled cowfish | R | I | A | G | 0.00 | 0.00 | 0.00 |
| Pomacanthidae | *Holacanthus bermudensis* | blue angelfish | R | I | A | G | 2.18 | 1.17 | 1.59 |
| Pomacanthidae | *Holacanthus ciliaris* | queen anglefish | R | I | A | G | 0.28 | 0.21 | 0.24 |
| Pomacanthidae | *Pomacanthus paru* | French anglefish | R | I | A | G | 0.14 | 0.00 | 0.06 |
| Pomacentridae | *Chromis cyanea* | blue chromis | R | P | J,A | O | 17.12 | 0.00 | 7.23 |
| Pomacentridae | *Chromis enchrysura* | yellowtail reeffish | R | P | J,A | O | 13.82 | 0.00 | 5.84 |
| Pomacentridae | *Chromis scotti* | purple reef fish | R | P | J,A | O | 48.56 | 0.00 | 20.50 |
| Pomacentridae | *Chromis sp.* | damselfish | R | P | J,A | O | 0.28 | 0.00 | 0.12 |

Table 1. continued.

| Family | Scientific Name | Common | Residency | Trophic Position | Life Stage | Reef Limited | Mean Density on NR | Mean Density on AR | Overall Mean Density |
|---|---|---|---|---|---|---|---|---|---|
| Pomacentridae | *Microspathodon chrysurus* | yellowtail damselfish | R | P | J,A | O | 0.14 | 0.00 | 0.06 |
| Pomacentridae | *Stegastes fuscus* | dusky damselfish | R | P | J,A | O | 2.95 | 0.00 | 1.24 |
| Pomacentridae | *Stegastes leucostictus* | beaugregory | R | P | J,A | O | 0.42 | 0.21 | 0.30 |
| Pomacentridae | *Stegastes partitus* | bicolor damselfish | R | P | J,A | O | 1.96 | 0.00 | 0.83 |
| Pomacentridae | *Stegastes sp.* | damselfish | R | P | J,A | O | 0.42 | 0.00 | 0.18 |
| Pomacentridae | *Stegastes variabilis* | cocoa damselfish | R | P | J,A | O | 2.81 | 0.96 | 1.74 |
| Priacanthidae | *Priacanthus arenatus* | Atlantic bigeye | R | PI | A | O | 2.81 | 0.00 | 1.19 |
| Priacanthidae | *Pristigenys alta* | short bigeye | R | PI | A | O | 1.54 | 0.00 | 0.65 |
| Sciaenidae | *Equetus acuminatus* | high-hat | R | I | A | O | 0.42 | 0.00 | 0.18 |
| Sciaenidae | *Equetus iwamotoi* | blackbar drum | R | I | A | G | 0.28 | 0.00 | 0.12 |
| Sciaenidae | *Equetus lanceolatus* | jacknife fish | R | I | A | O | 0.49 | 4.79 | 2.97 |
| Sciaenidae | *Equetus sp.* | reef drum | R | I | A | R | 0.56 | 0.00 | 0.24 |
| Sciaenidae | *Paraques umbrosus* | cubbyu | R | I | A | O | 5.05 | 2.82 | 3.76 |
| Scorpaenidae | *Scorpaena brasiliensis* | barbfish | S | IF | A | G | 0.00 | 0.22 | 0.13 |
| Serranidae | *Centropristis ocyurus* | bank seabass | S | I | A | G | 1.82 | 1.52 | 1.65 |
| Serranidae | *Diplectrum formosum* | sandperch | S | IF | A | G | 0.14 | 0.00 | 0.06 |
| Serranidae | *Epinephelus adscensionis* | rock hind | R | IF | A | G | 0.14 | 0.00 | 0.06 |
| Serranidae | *Epinephelus cruentatus* | graysby | R | IF | A | G | 0.84 | 0.00 | 0.36 |
| Serranidae | *Epinephelus morio* | red grouper | R | IF | A | G | 1.05 | 0.42 | 0.69 |
| Serranidae | *Holanthias martinicensis* | roughtongue bass | R | P | J,A | O | 0.56 | 0.00 | 0.24 |
| Serranidae | *Liopropoma eukrines* | wrasse bass | R | PI | A | O | 0.42 | 0.00 | 0.18 |
| Serranidae | *Mycteroperca microlepis* | gag | R | F | A | G | 0.84 | 0.91 | 0.88 |
| Serranidae | *Mycteroperca phenax* | scamp | R | F | A | G | 7.37 | 6.53 | 6.89 |
| Serranidae | *Rypticus maculatus* | whitespotted soapfish | R | I | A | G | 0.14 | 8.79 | 5.14 |
| Serranidae | Serranidae | grouper | RA | IF | A | G | 0.14 | 0.00 | 0.06 |
| Serranidae | *Serranus phoebe* | tattler | R | I | A | O | 2.53 | 0.00 | 1.07 |

Table 1. continued.

| Family | Scientific Name | Common | Residency | Trophic Position | Life Stage | Reef Limited | Mean Density on NR | Mean Density on AR | Overall Mean Density |
|---|---|---|---|---|---|---|---|---|---|
| Serranidae | *Serranus subligarius* | belted sandfish | S | I | A | G | 1.12 | 0.21 | 0.59 |
| Sparidae | *Archosargus probatocephalus* | sheepshead | R | I | A | G | 0.00 | 0.94 | 0.54 |
| Sparidae | *Calamus leucosteus* | whitebone porgy | S | I | A | G | 0.14 | 0.10 | 0.12 |
| Sparidae | *Calamus penna* | sheepshead porgy | T | I | A | G | 0.00 | 0.10 | 0.06 |
| Sparidae | *Pagrus pagrus* | red porgy | R | I | A | G | 15.30 | 1.93 | 7.58 |
| Sphyraenidae | *Sphyraena barracuda* | greater barracuda | RA | F | A | G | 0.00 | 2.36 | 1.36 |
| Tetraodontidae | *Canthigaster rostrata* | Caribbean sharpnose puffer | R | I | A | G | 1.12 | 0.22 | 0.60 |
| | Unidentified small fish | | | | | | 3.79 | 130.26 | 76.86 |

Table 2. Estimated density (fish $10^3$ $m^{-2}$) of reef fish families observed at natural and artificial reefs in the northeastern Gulf of Mexico in 2009-2010.

| Family | Species | Mean Density on Natural Reefs | Mean Density on Artificial Reefs | % Difference Between Natural and Artificial | Mean Overall Density |
|---|---|---|---|---|---|
| Lutjanidae | 4 | 234.18 | 444.91 | -90 | 355.94 |
| Haemulidae | 2 | 134.60 | 865.00 | -543 | 556.61 |
| Pomacentridae | 10 | 91.09 | 2.54 | 97 | 39.92 |
| Carangidae | 4 | 20.56 | 17.28 | 16 | 18.67 |
| Labridae | 4 | 17.89 | 3.31 | 82 | 9.47 |
| Serranidae | 13 | 17.12 | 18.38 | -7 | 17.85 |
| Sparidae | 4 | 15.44 | 3.07 | 80 | 8.30 |
| Blenniidae | 2 | 7.93 | 2.39 | 70 | 4.73 |
| Holocentridae | 3 | 6.81 | 0.00 | | 2.87 |
| Sciaenidae | 5 | 6.81 | 7.61 | -12 | 7.27 |
| Priacanthidae | 2 | 4.35 | 0.00 | | 1.84 |
| Chaetodontidae | 3 | 3.93 | 2.34 | 40 | 3.01 |
| UID smal fish | 1 | 3.79 | 130.26 | -3,337 | 76.86 |
| Pomacanthidae | 3 | 2.60 | 1.37 | 47 | 1.89 |
| Tetraodontidae | 1 | 1.12 | 0.22 | 81 | 0.60 |
| Balistidae | 1 | 1.05 | 14.72 | -1,298 | 8.95 |
| Opistognathidae | 1 | 0.84 | 0.00 | | 0.36 |
| Carcharhinidae | 3 | 0.63 | 0.00 | | 0.27 |
| Apogonidae | 1 | 0.42 | 0.21 | 51 | 0.30 |
| Gobiidae | 1 | 0.42 | 0.00 | | 0.18 |
| Monocanthidae | 4 | 0.42 | 1.95 | -362 | 1.30 |
| Acanthuridae | 1 | 0.14 | 0.00 | | 0.06 |
| Dasyatidae | 1 | 0.14 | 0.10 | 27 | 0.12 |
| Batrachoididae | 1 | 0.00 | 0.05 | | 0.03 |
| Ephippidae | 1 | 0.00 | 51.99 | | 30.04 |
| Ostraciidae | 1 | 0.00 | 0.00 | | 0.00 |
| Scorpaenidae | 1 | 0.00 | 0.22 | | 0.13 |

Table 3. Results from SIMPER analysis examining differences in fish community structure between natural and artificial reefs that were video sampled with a micro remotely operated vehicle in the northeastern Gulf of Mexico during 2009-10. Dissimilarity between habitat types is indicated for the twenty species that displayed the greatest Bray-Curtis dissimilarity between habitats. Units for fish density are fish per $10^3$ $m^2$.

| | Habitat Type | | Mean Bray-Curtis | % Total | Cumulative |
|---|---|---|---|---|---|
| Species | Natural | Artificial | Dissimilarity (SD) | Dissimilarity | % Dissimilarity |
| *Haemulon aurolineatum* | 865.0 | 133.6 | 8.92 (1.14) | 12.17 | 12.2 |
| *Lutjanus campechanus* | 378.4 | 55.7 | 8.72 (1.41) | 11.90 | 24.1 |
| *Rhomboplites aurorubens* | 15.3 | 147.7 | 7.05 (9.16) | 9.63 | 33.7 |
| *Lutjanus griseus* | 36.1 | 28.5 | 4.57 (0.92) | 6.23 | 39.9 |
| *Chromis scotti* | 0.0 | 48.6 | 2.36 (0.56) | 3.23 | 43.2 |
| *Halichoeres bivittatus* | 2.7 | 16.4 | 2.28 (0.72) | 3.11 | 46.3 |
| *Balistes capriscus* | 14.7 | 1.1 | 2.23 (1.07) | 3.04 | 49.3 |
| *Pagrus pagrus* | 1.9 | 15.3 | 2.16 (0.69) | 2.94 | 52.3 |
| *Chromis enchrysura* | 0.0 | 13.8 | 2.08 (0.69) | 2.84 | 55.1 |
| *Chaetodipterus faber* | 52.0 | 0.0 | 2.00 (0.46) | 2.73 | 57.8 |
| *Seriola dumerili* | 16.8 | 18.0 | 1.85 (0.74) | 2.53 | 60.4 |
| *Mycteroperca phenax* | 6.5 | 7.4 | 1.85 (1.15) | 2.52 | 62.9 |
| Unidentified Small Fish | 130.3 | 3.8 | 1.58 (0.36) | 2.16 | 65.0 |
| *Paraques umbrosus* | 2.8 | 5.1 | 1.52 (0.65) | 2.08 | 67.1 |
| *Rypticus maculatus* | 8.8 | 0.1 | 1.45 (0.92) | 1.98 | 69.1 |
| *Lutjanus synagris* | 15.1 | 2.4 | 1.37 (0.54) | 1.87 | 71.0 |
| *Priacanthus arenatus* | 0.0 | 2.8 | 1.31 (0.68) | 1.79 | 72.8 |
| *Holacanthus bermudensis* | 1.2 | 2.2 | 1.16 (0.96) | 1.58 | 74.3 |
| *Parablennius marmoreus* | 2.4 | 1.6 | 1.07 (0.47) | 1.46 | 75.8 |
| *Stegastes variabilis* | 1.0 | 2.8 | 1.02 (0.70) | 1.40 | 77.2 |

Figure 1. Geographic distribution of study reefs along the northeastern Gulf of Mexico Continental Shelf. Green circles indicate natural reefs that were sampled during 2009-10, while yellow circles indicated artificial reefs. Pink stars demarcate the corners of the Escambia East Large Area Artificial Reef Site. The red star indicates the location of Pensacola, Florida. Bay abbreviations: MB = Mobile Bay, PB = Pensacola Bay, CB = Choctawhatchee Bay, and SAB = St Andrews Bay.

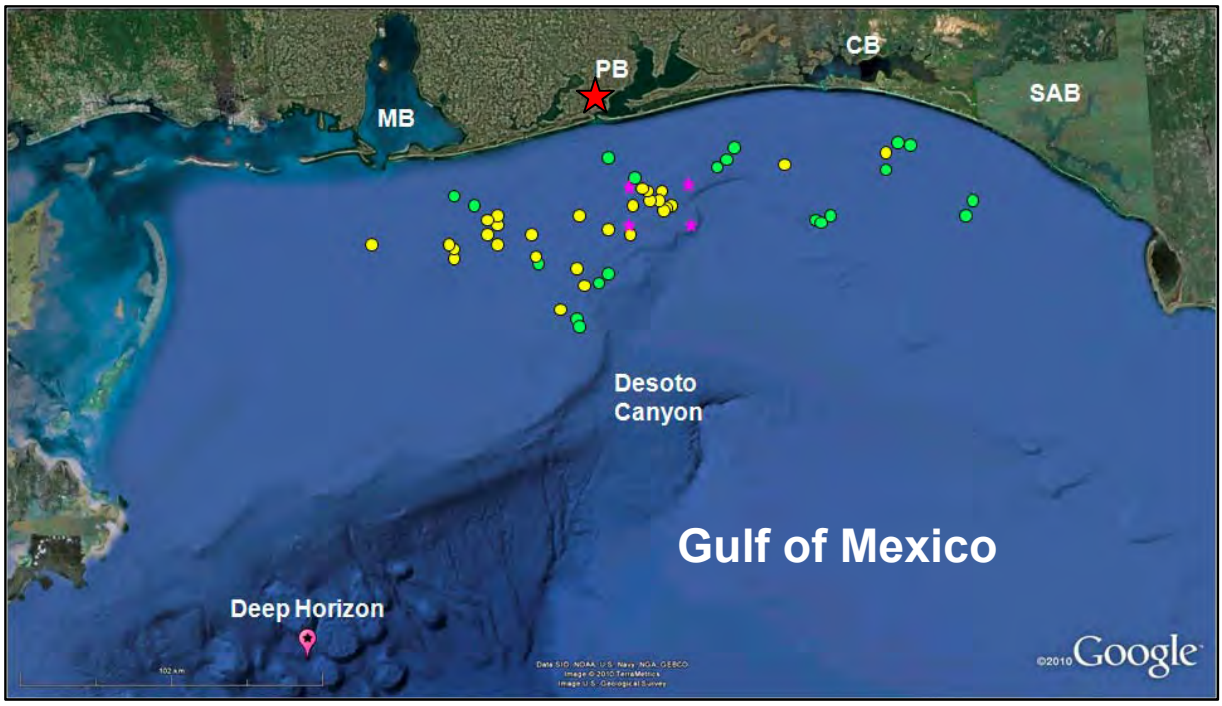


Figure 2. Digital images of A&B) natural and C&D) artificial reef habitats video sampled with a micro remotely operated vehicle during this study.

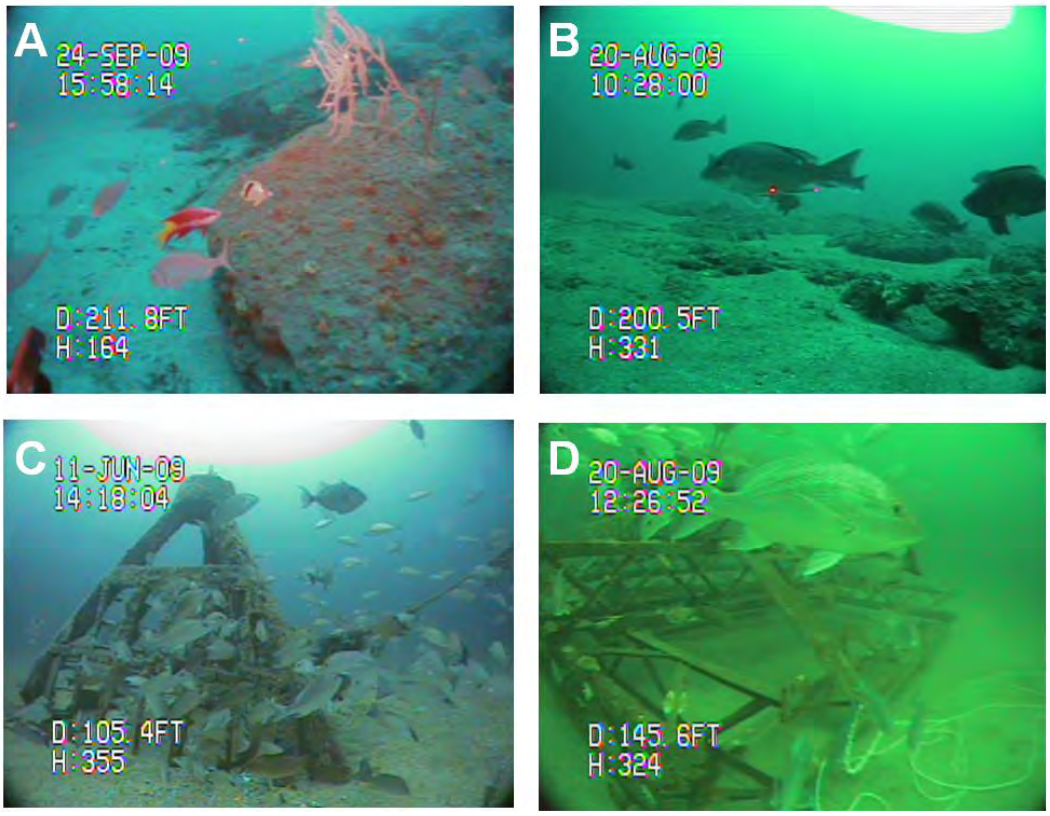



Figure 3. Trigonometry of estimating the width of a video transect given the height a remotely operated vehicle (ROV) is above the seafloor, the angle of its camera's tilt ($\theta_1$), and the angle of the camera's view. The view angle ($2 \bullet \theta_2$) is 105° for a VideoRay Pro3 ROV and 116° for a Pro4 ROV; therefore, $\theta_2$ would be 52.5° and 58°, respectively, for the ROVs. If the camera's tilt angle ($\theta_1$) was set to 45°, then the ratio of transect width (w) to ROV height (h) would be 3.69 for a Pro3 ROV and 4.53 for a Pro4. The same ratios would be 5.21 and 6.40 for Pro3 and Pro4 ROVs, respectively, if $\theta_1$ was set to 60°.

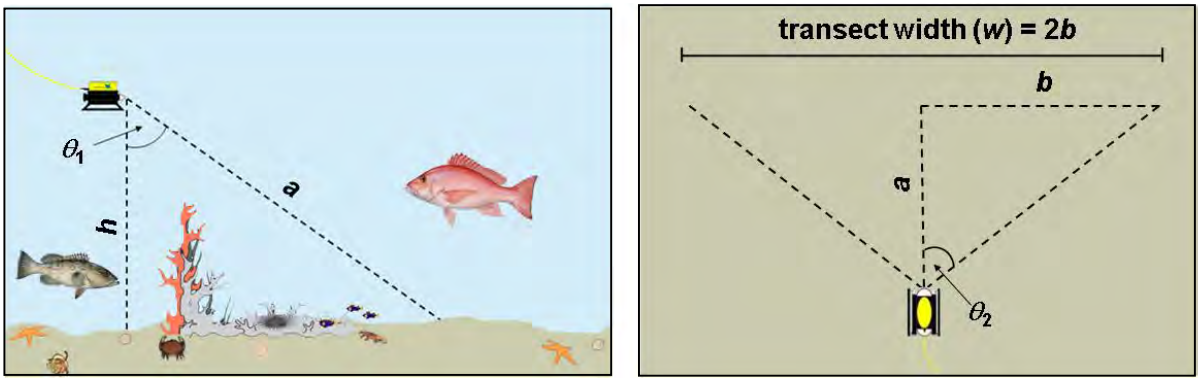


Figure 4. Mean (±SE) trophic level-specific fish density A) between natural and artificial reefs and B) among depth strata by trophic level for fishes video sampled with a micro remotely operated vehicle at reef sites in the northeastern Gulf of Mexico during 2009-2010.

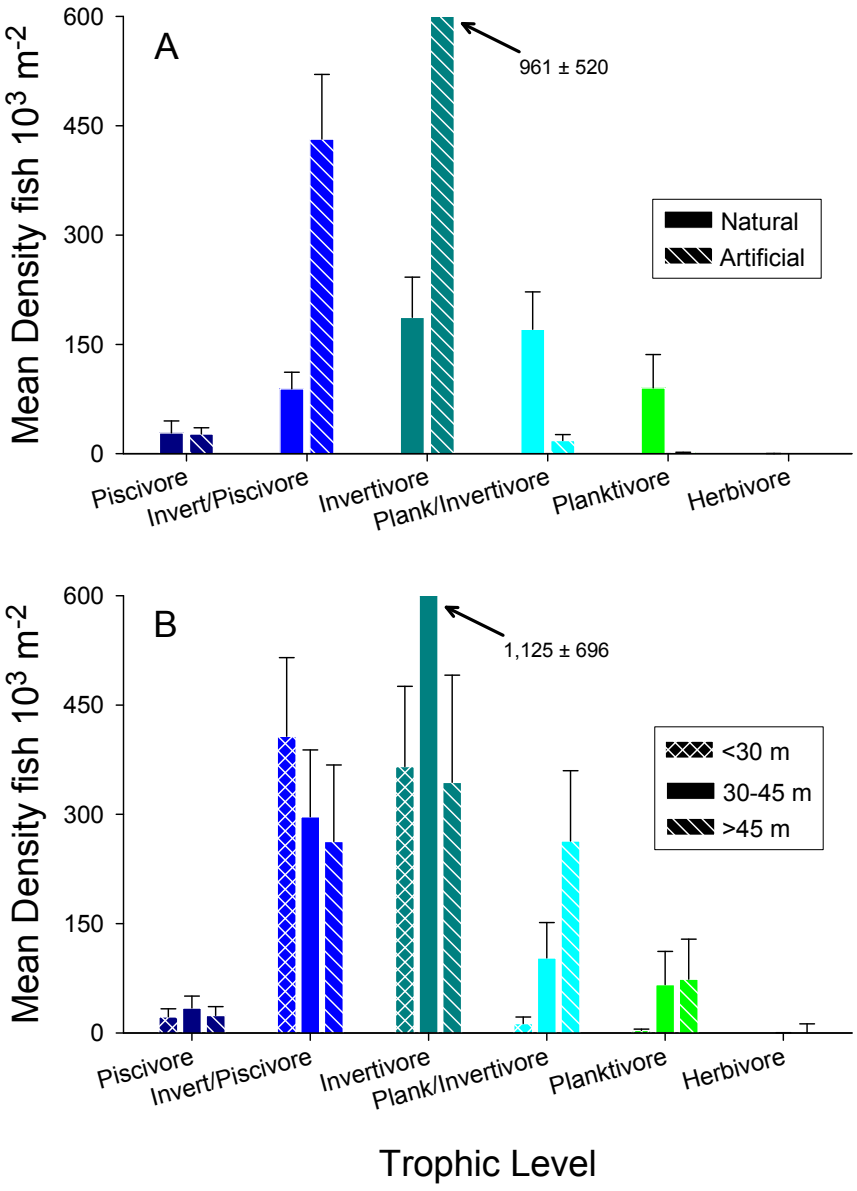


Figure 5. A) Mean (± SE) FL of predominant reef fish taxa estimated from laser scale data at study reef sites at natural and artificial reef sites in the northeastern Gulf of Mexico. B) Box plots of fork length (FL) distributions of predominant reef fish species scaled with lasers. Horizontal bars in the center of boxes indicate median FL. Upper and lower extended bars indicate 10$^{th}$ and 90$^{th}$ percentiles of FL, while symbols indicate individual fish whose FL was outside those percentiles for natural (circles) or artificial (triangles) reefs.

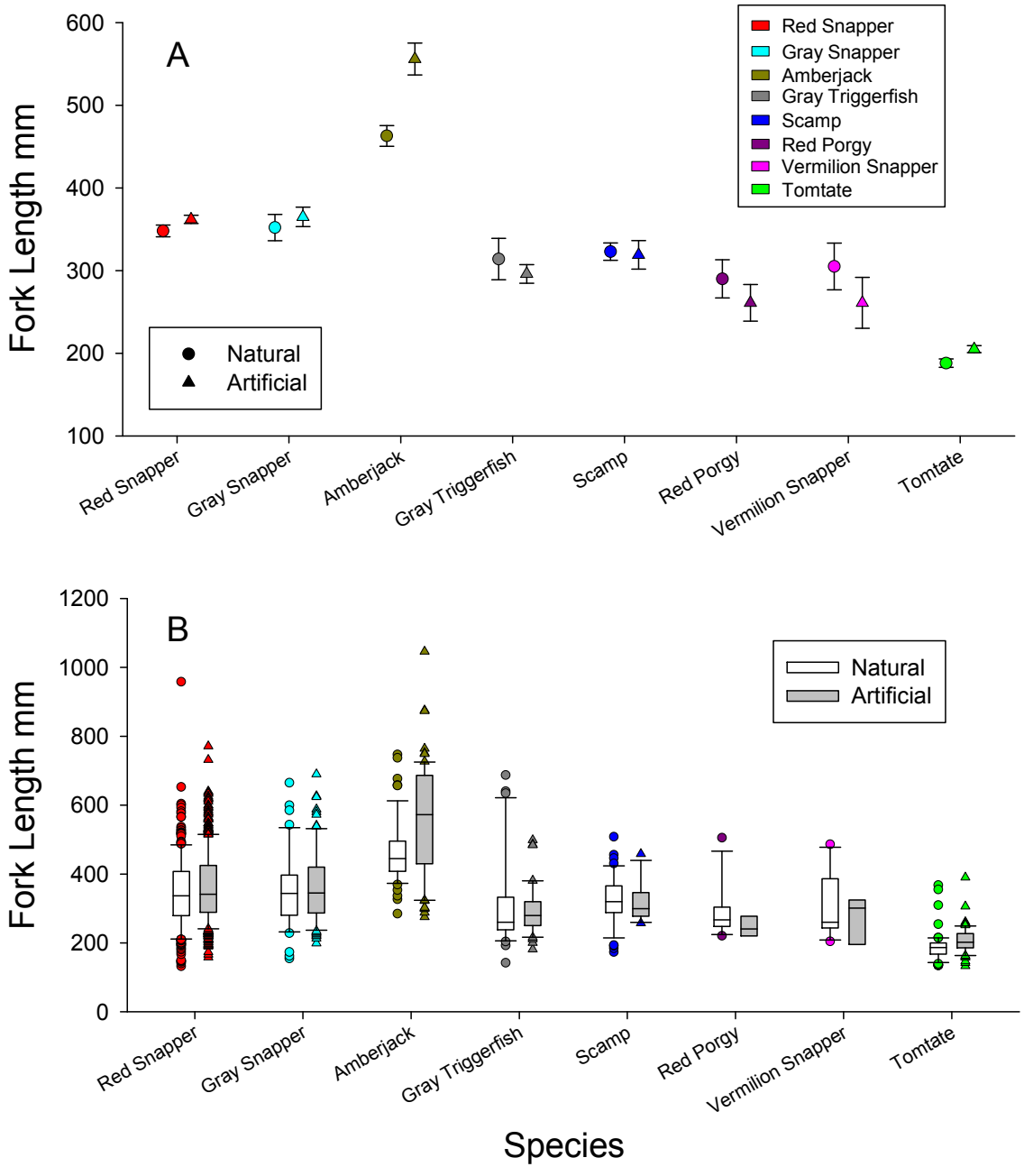


Figure 6. Distribution of fork length for A) all fishes observed and B) red snapper that were estimated with a laser scale attached to a micro remotely operated vehicle while video sampling at study reefs in the northeastern Gulf of Mexico during 2009-10. Panel C indicates mean fork length of all fishes and red snapper from the three depth strata sampled.

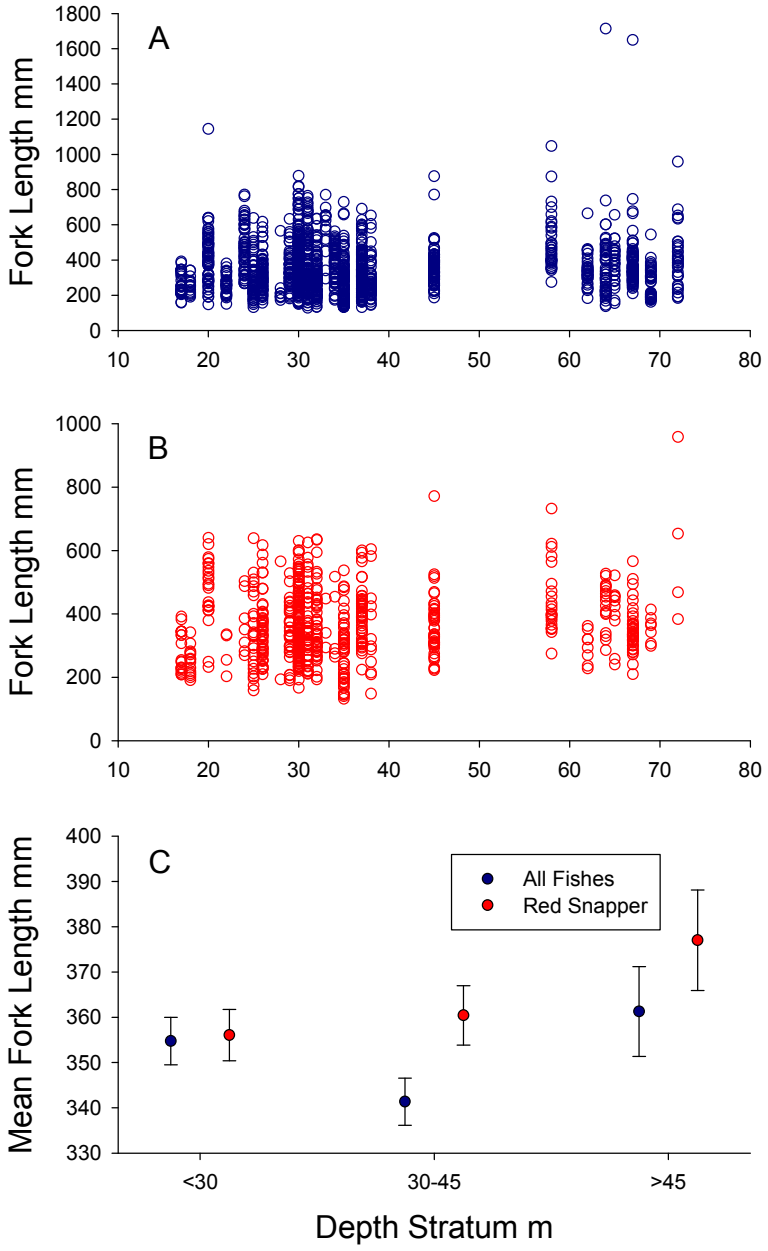


Figure 7. Total length (TL) frequency distributions of all fish scaled with lasers at natural and artificial reef study sites in the northeastern Gulf of Mexico plotted next to TL distributions of all fish captured at study sites with 9/0, 12/0, and 15/0 Mustad circle hooks.

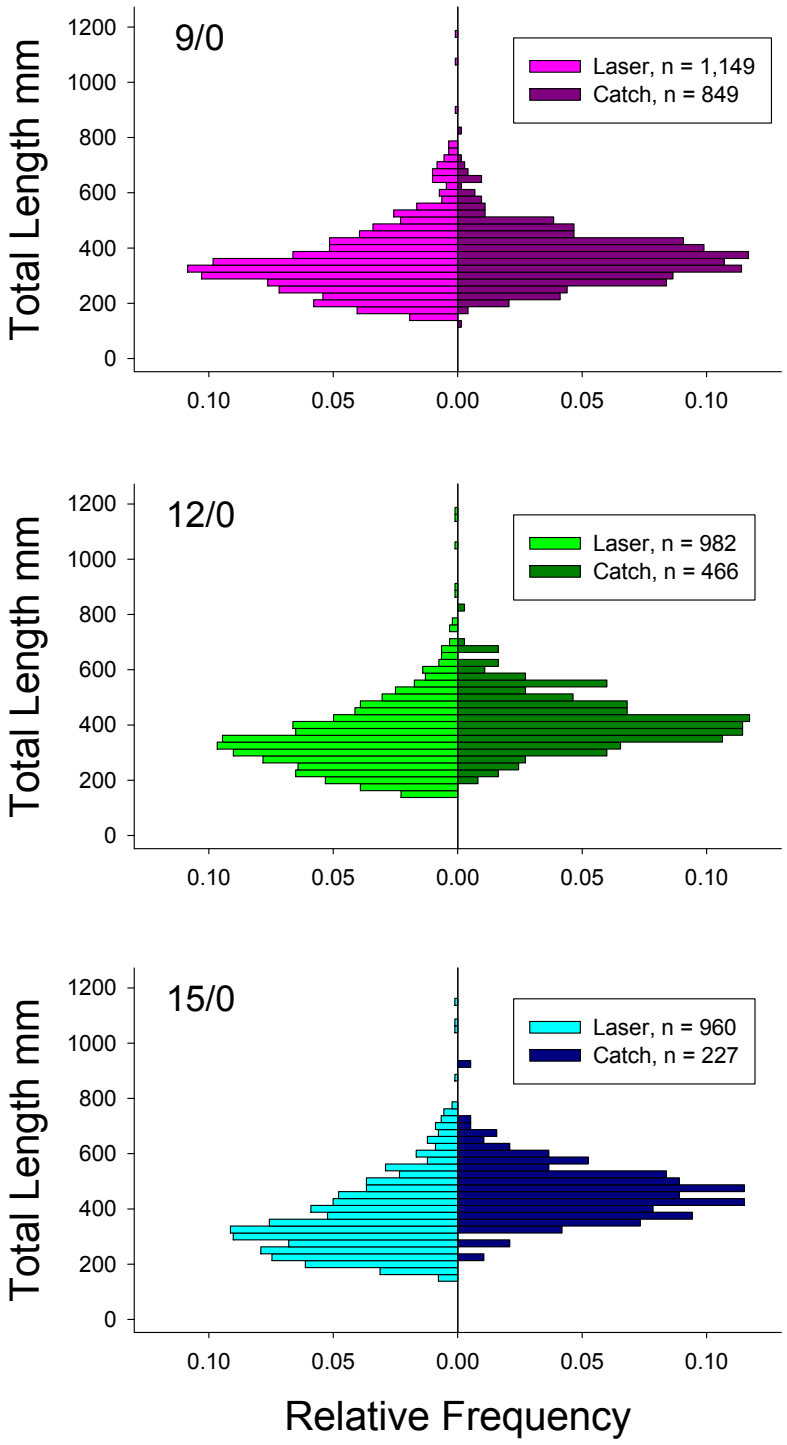


Figure 8. Frequency distributions of red snapper total length (TL) scaled with lasers at natural and artificial reef study sites in the northeastern Gulf of Mexico plotted next to TL distributions of red snapper captured at study sites with 9/0, 12/0, and 15/0 Mustad circle hooks.

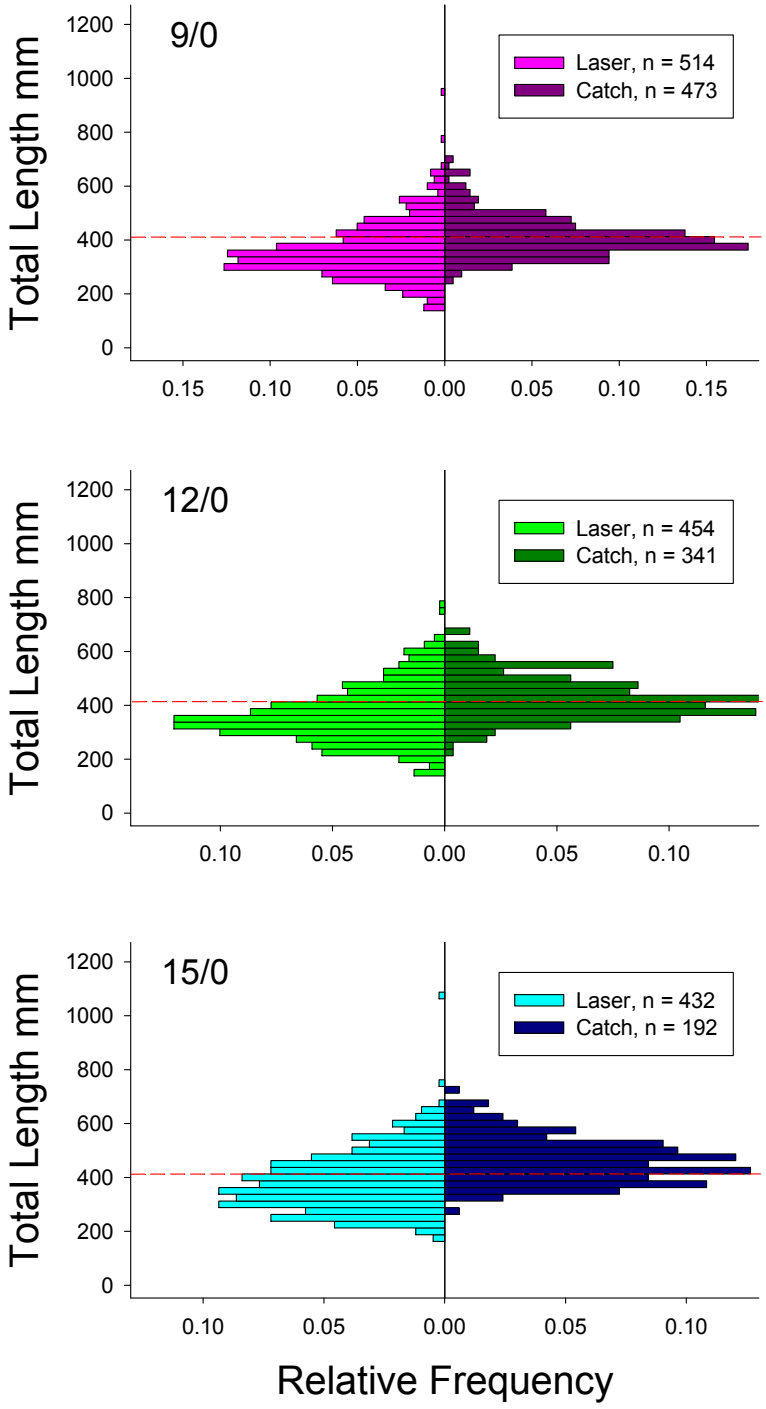


Figure 9. Mean total length (±) of A) all fish and B) red snapper scaled with a laser scale attached to a micro remotely operated vehicle or captured with Mustad circle hooks at natural and artificial reef study sites in the northeastern Gulf of Mexico during 2009-10. The horizontal dashed line on panel B indicates the minimum size (408 mm) for retention of red snapper in the recreational fishery.

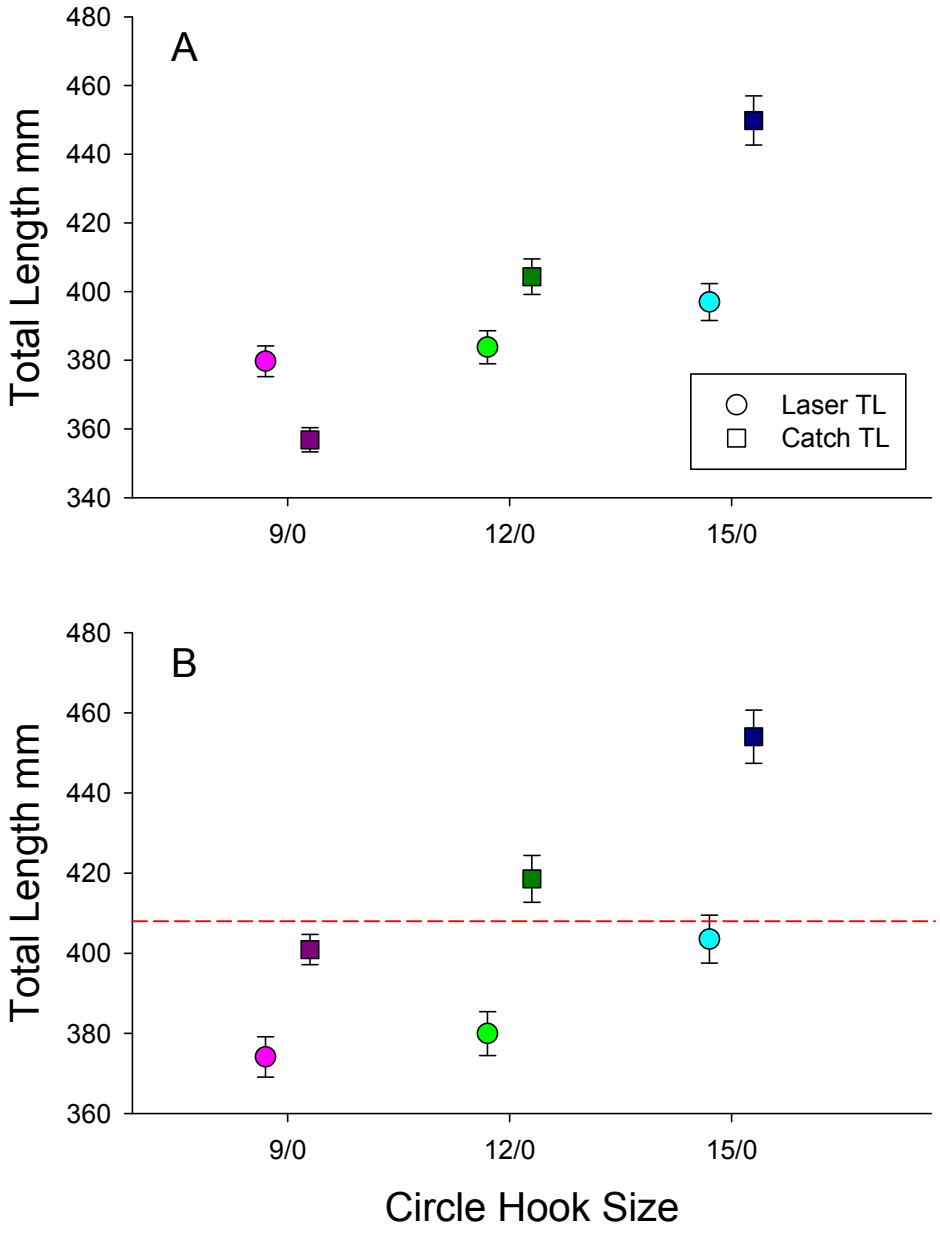


Figure 10. Overall catch per unit of effort for sampling conducted during 2009-10 with three different sized circle hooks at natural and artificial reef sites in the northern Gulf of Mexico.

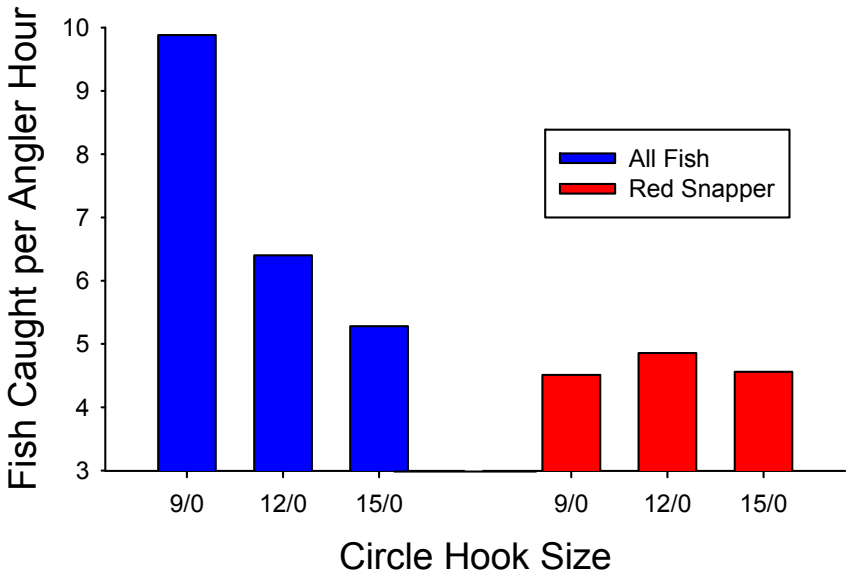


Figure 11. A) Size at age for red snapper sampled at natural (n = 182 fish) and artificial (n = 286 fish) reefs in the northeastern Gulf of Mexico, with fractional ages determined from counts of opaque zones in thin sections of sagittal otoliths, edge condition of otolith sections, and date of sampling. The plotted linear regression was fitted to the combined data. B) Residual distributions of observed minus size at age predicted from the Patterson et al. (2001) red snapper von Bertalanffy growth function (VBGF) for the original data to which the VBGF was fit, as well as for the fish aged in the current study.

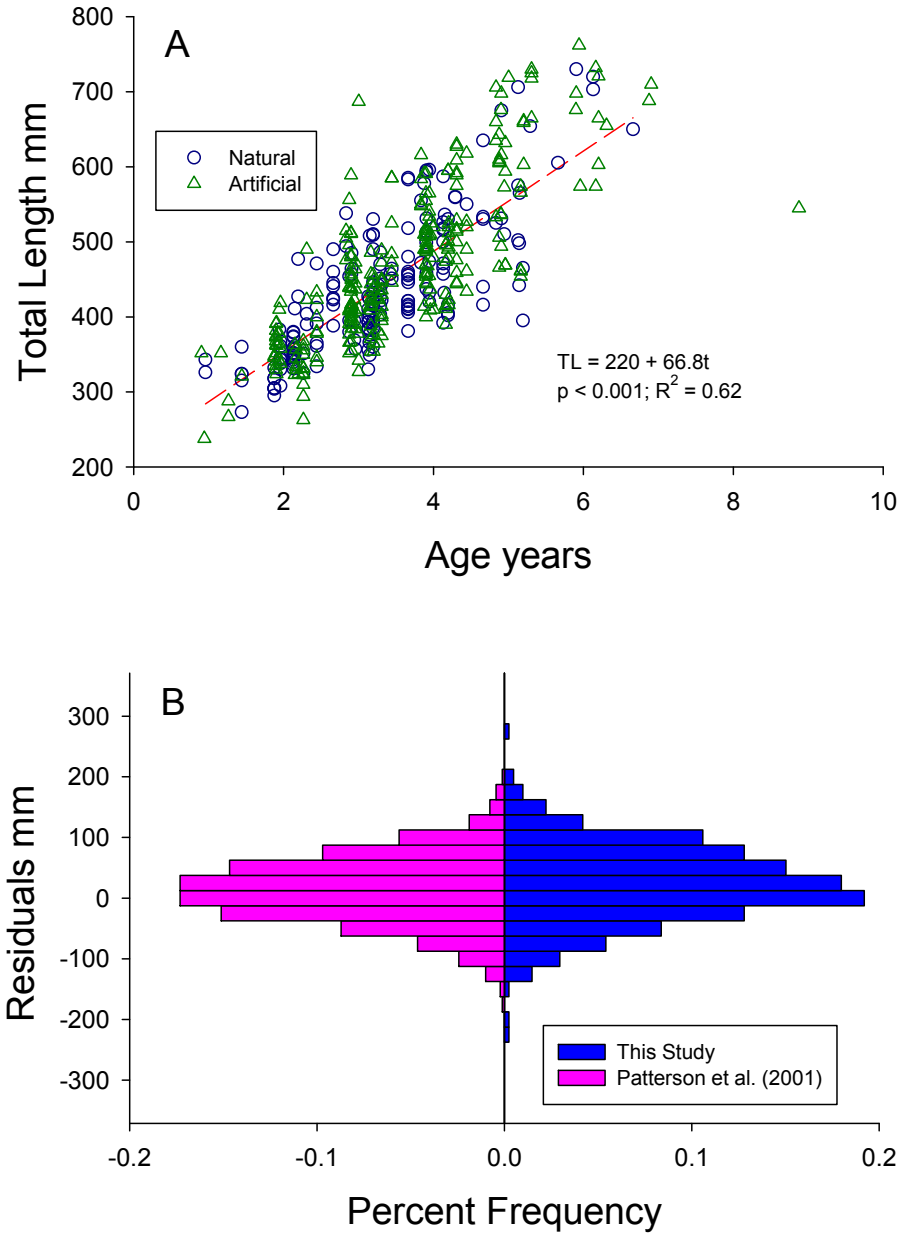


Figure 12. Catch curves fit to the ln(numbers at age) data for red snapper captured with hook and line at natural and artificial reef sites in the northeastern Gulf of Mexico. Total sample sizes were 182 for fish captured at natural reefs and 286 for artificial reefs. Curves were fit only to data shown with filled symbols. Instantaneous rates of disappearance with age ($y^{-1}$) are shown for each curve; both regressions were highly significant ($p < 0.001$) with $R^2$ values >0.98.

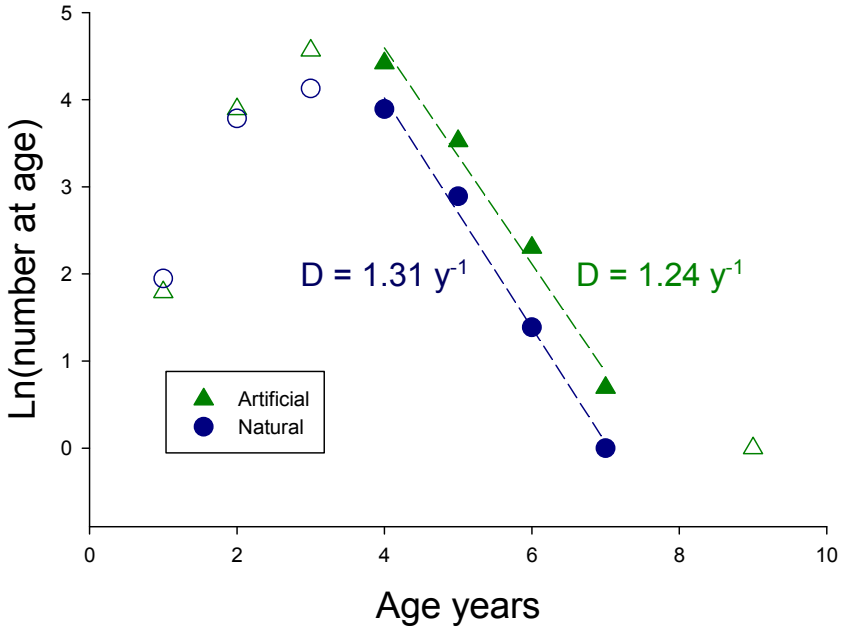


Figure 13. Distribution of red snapper total lengths either estimated with a laser scale attached to a micro remotely operated vehicle while video sampling at study reefs in the northeastern Gulf of Mexico during 2009-10, or measured directly for fish captured with hook and line gear while collecting biological samples at study reefs.

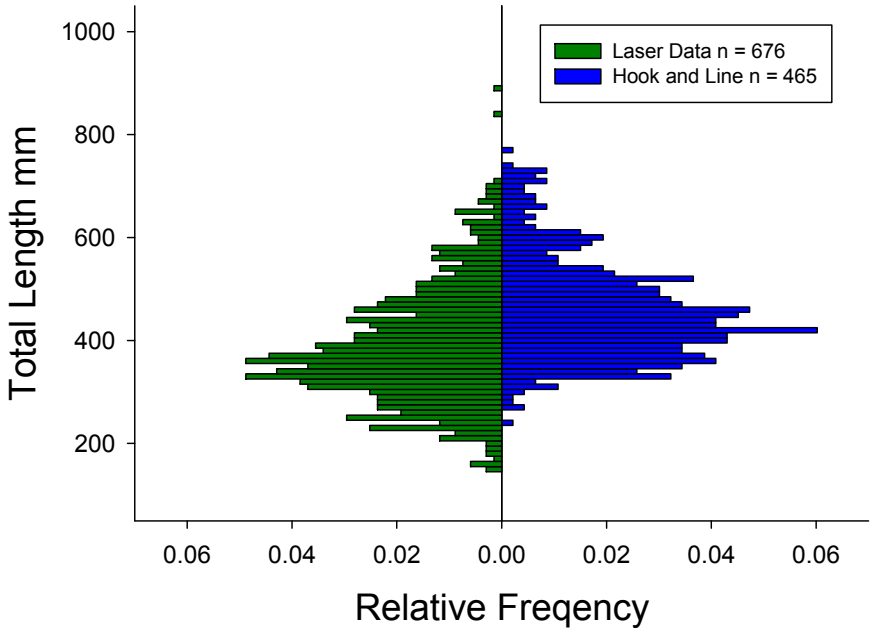


Figure 14. Species- and habitat-specific diet of predominant reef fishes sampled in the northeastern Gulf of Mexico based on gut content analysis. Plots indicate diet differences based on A) percent number of prey items observed, B) percent mass of total prey mass, and C) percent index of relative importance. Plain bars indicate samples from natural reefs and hatched bars indicate samples from artificial reefs. Species abbreviations: LS = lane snapper, AJ = greater amberjack, Soap = whitespotted soapfish, TT = tomtate, BR = blue runner, BRf = banded rudderfish, BSB = bank seabass, GT = gray triggerfish, Tat = tattler, RG = red grouper, RP = red porgy, GS = gray snapper, VS = vermilion snapper, AlJ = almaco jack, HH = highhat, and BlA = blue angelfish.

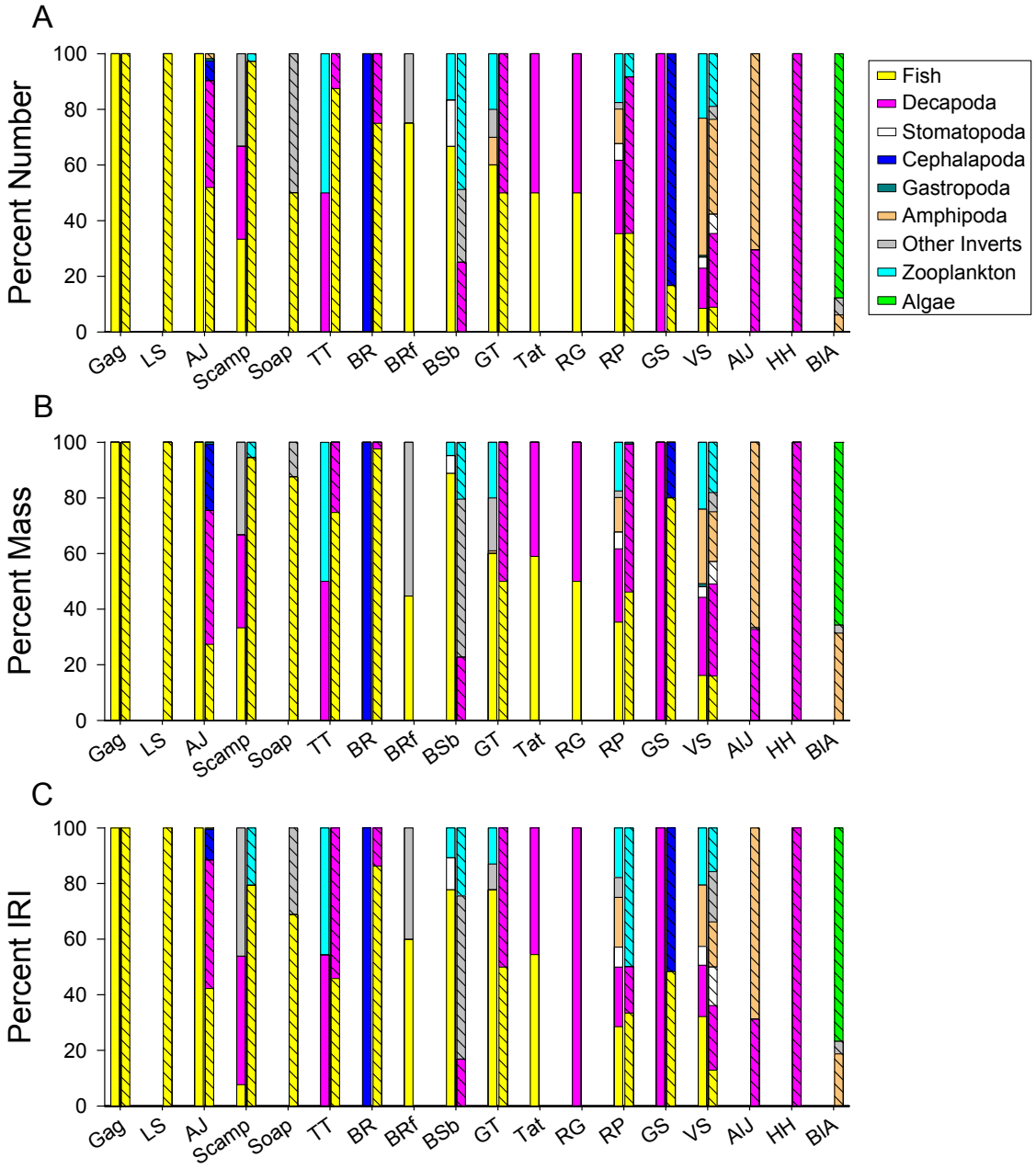


Figure 15. Percentage of red snapper diet derived from different prey categories estimated from gut content analysis of fish from three different size ranges samples on natural and artificial reefs in the northeastern Gulf of Mexico. The prey category-specific percentage of diet is presented based on A) percent number of prey items observed, B) percent mass of total prey mass, and C) percent index of relative importance. Plain bars indicate samples from natural reefs and hatched bars indicate samples from artificial reefs.

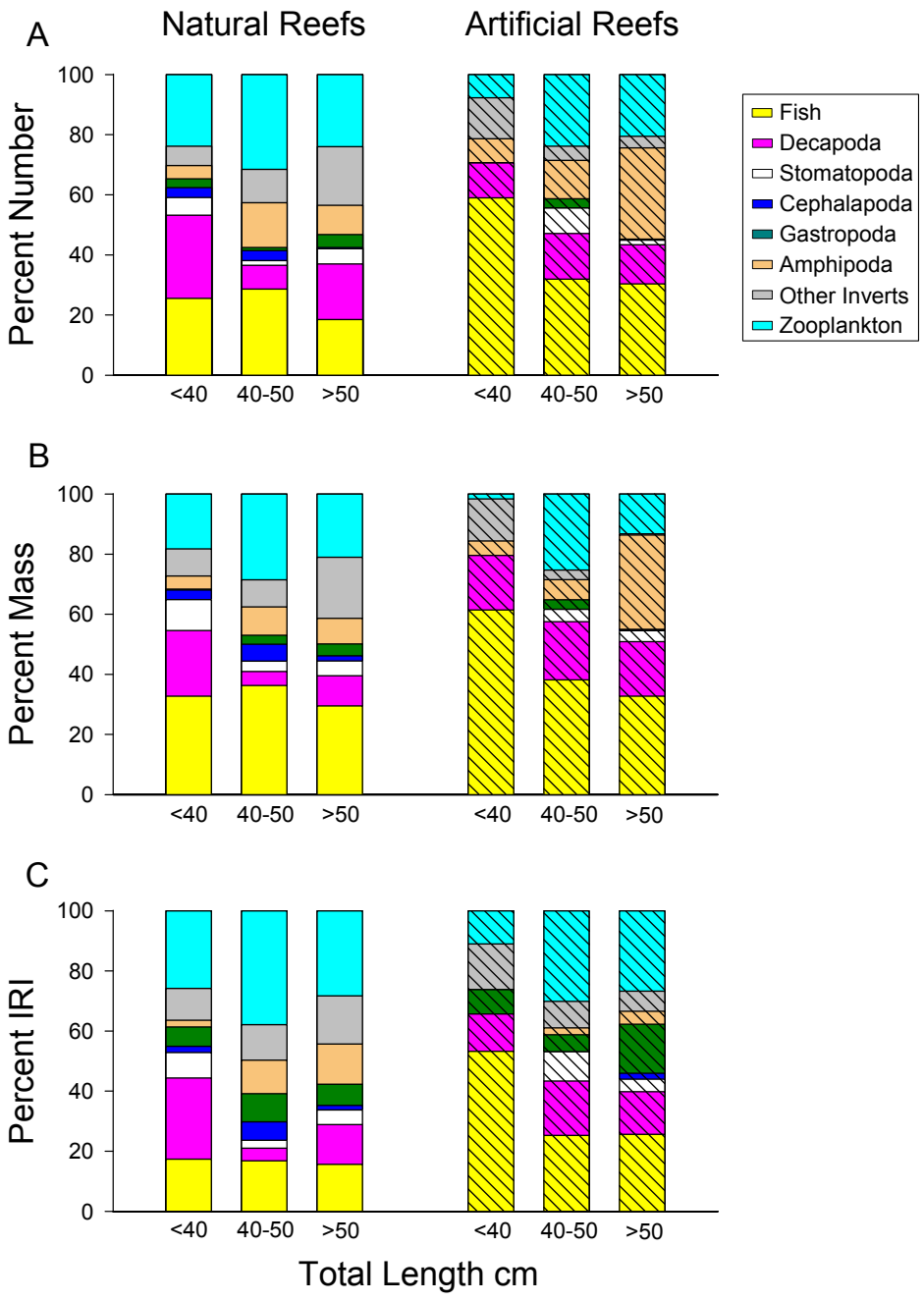


Figure 16. Plots of mean (± SE) stable isotope ratios for fish sampled at natural and artificial reef sites in the northeastern Gulf of Mexico during 2009-10.

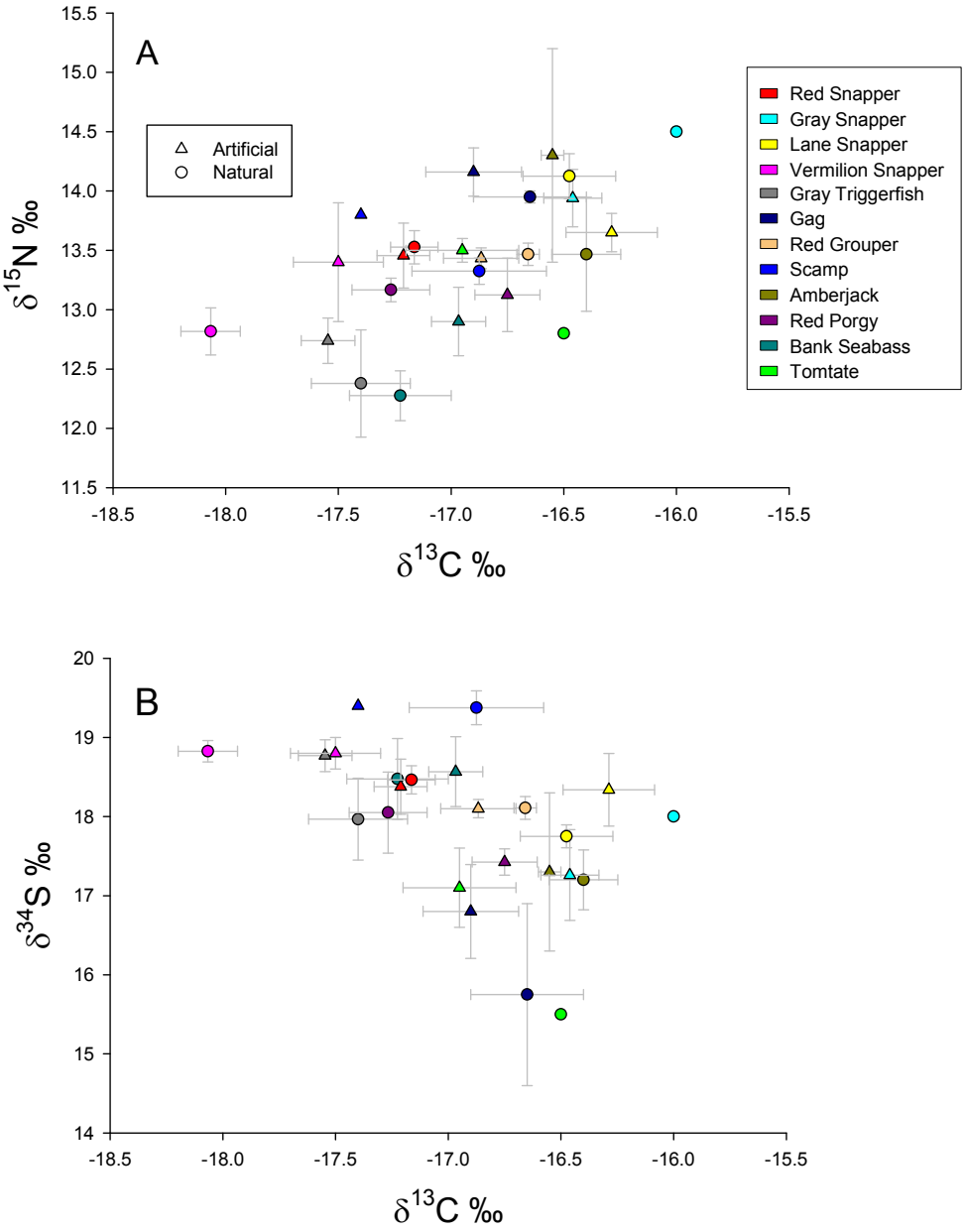


Figure 17. Plots of red snapper A) $\delta^{15}N$ versus $\delta^{13}C$, B) $\delta^{34}S$ versus $\delta^{13}C$, C) $\delta^{15}N$ versus total length, D) $\delta^{13}C$ versus total length, E) $\delta^{34}S$ versus total length, and F) mean (±SE) standardized $\delta^{15}N$, $\delta^{13}C$, and $\delta^{34}S$ values for fish sampled at natural (circles; n = 56) and artificial (triangles; n = 34) reef sites in the northeastern Gulf of Mexico during 2009-10.

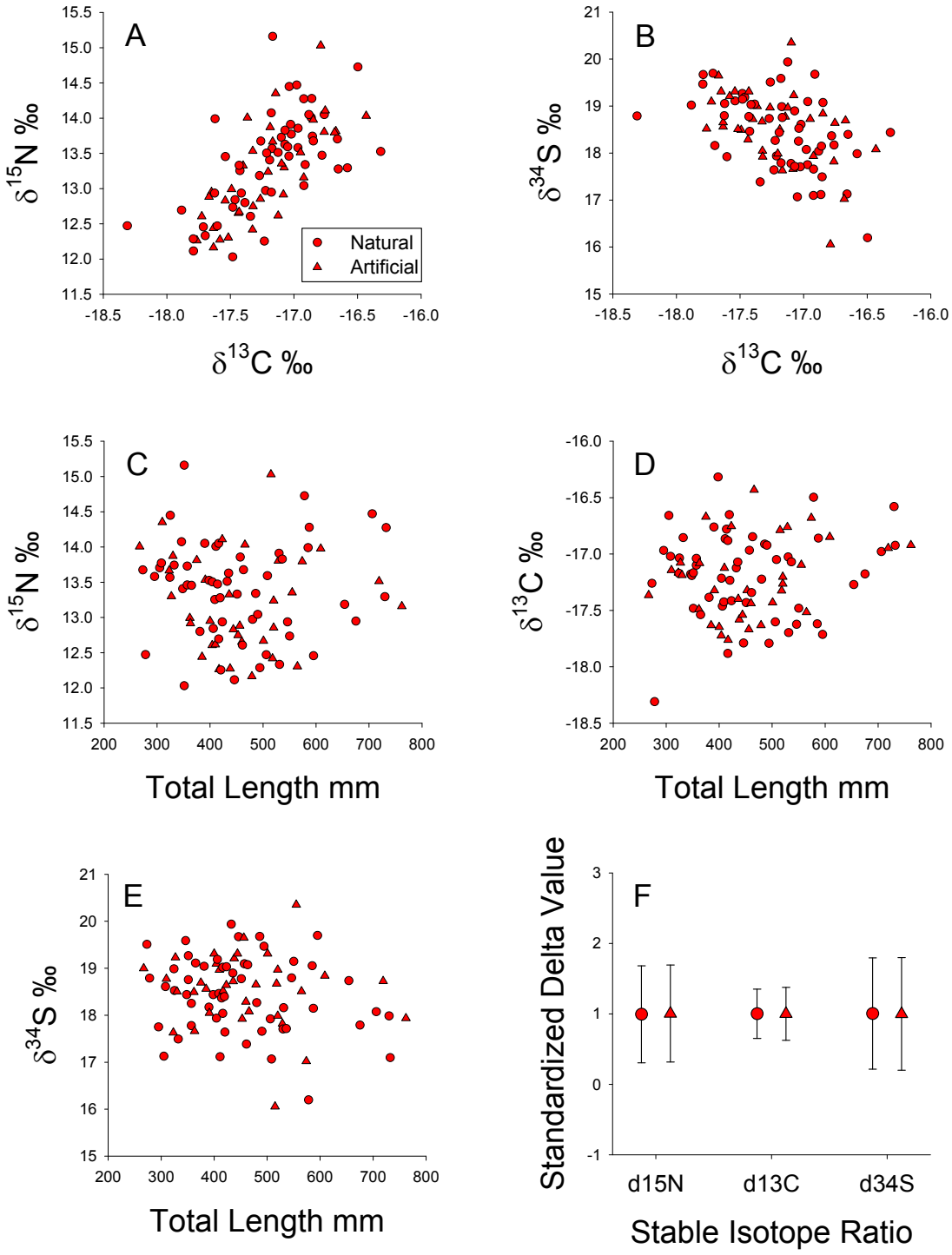


Figure 18. Species-specific stable isotope plots for fish sampled at natural and artificial reef sites in the northeastern Gulf of Mexico from September 2009 to May 2010 (n = 84 fish; pre DWH) and between May and August 2010(n = 67 fish; post DWH), when oil from Deepwater Horizon was over the shelf. Error bars in each plot are standard error of the mean.

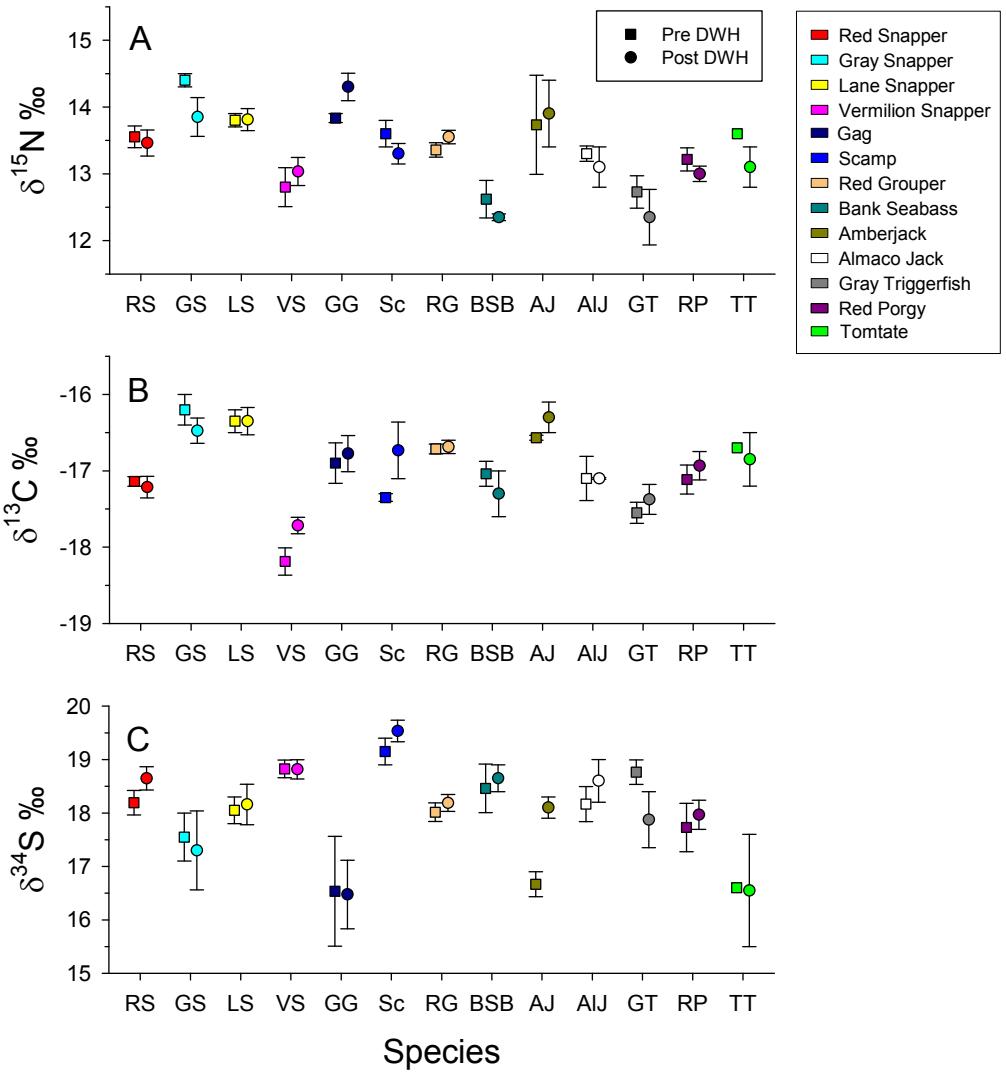
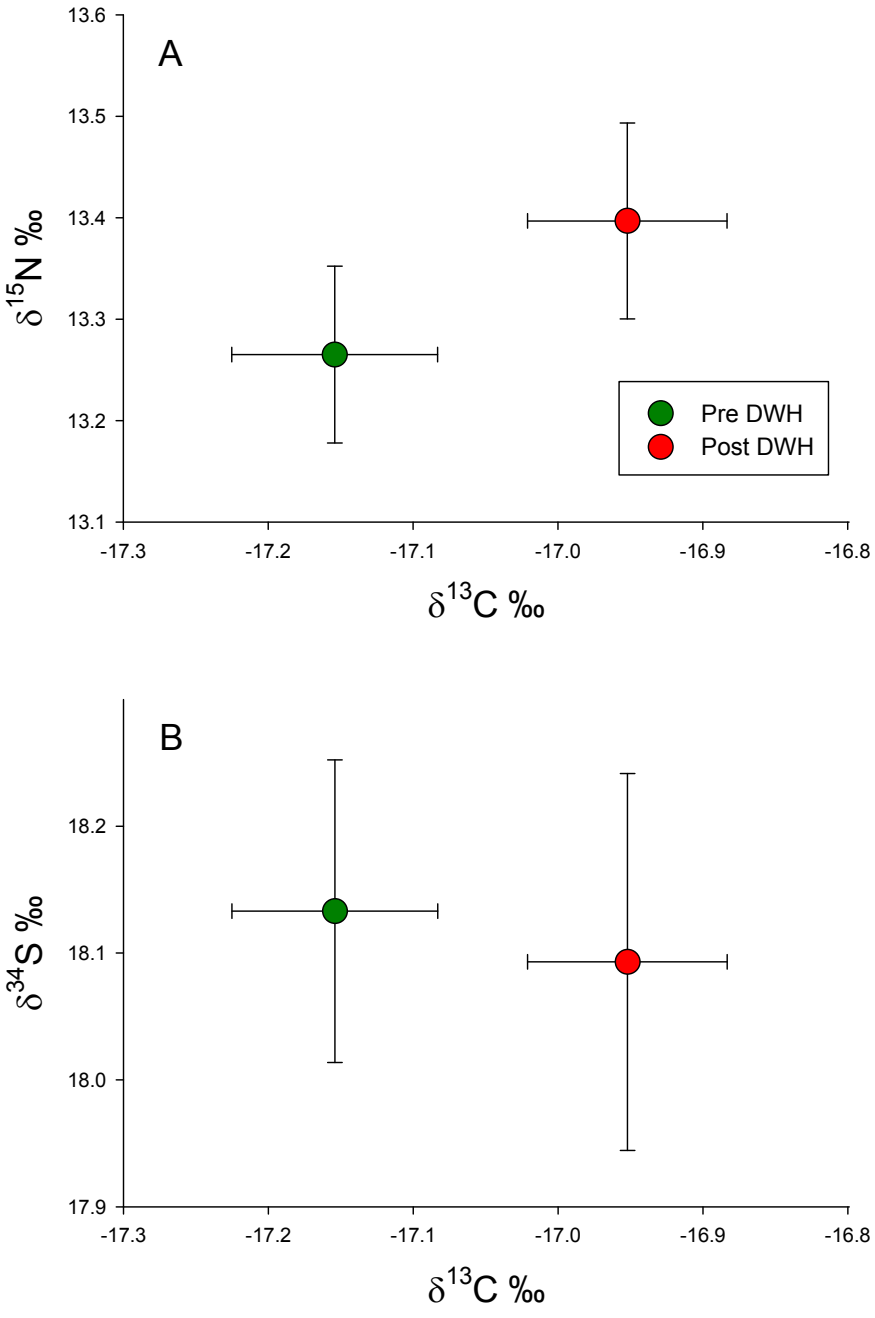


Figure 19. Plots of mean (± SE) stable isotope ratios for fish sampled at natural and artificial reef sites in the northeastern Gulf of Mexico from September 2009 to May 2010 (n = 76 fish; pre DWH) and between May and August 2010(n = 75 fish; post DWH), when significant amounts of oil from the Deepwater Horizon (DWH) spill existed over the shelf.



# THE EFFECT OF FISH SIZE, HABITAT TYPE, AND THE DEEPWATER HORIZON OIL SPILL ON RED SNAPPER, *Lutjanus campechanus*, DIET AND TROPHIC ECOLOGY IN THE NORTHERN GULF OF MEXICO

by

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B.S. University of West Florida, 2009

A thesis submitted to the Department of Biology
College of Arts and Sciences
The University of West Florida
In partial fulfillment of the requirements for the degree of
Master of Science

2014

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ABSTRACT

THE EFFECT OF FISH SIZE, HABITAT TYPE, AND THE DEEPWATER HORIZON OIL SPILL ON RED SNAPPER, *Lutjanus campechanus*, DIET AND TROPHIC ECOLOGY IN THE NORTHERN GULF OF MEXICO

Joseph Henry Tarnecki

Red snapper, *Lutjanus campechanus*, were sampled with hook and line at natural (n = 33) and artificial (n = 27) reef sites in the northern Gulf of Mexico from 2009-2011. Stomachs (n = 708) were extracted and their contents preserved for gut content analysis, and muscle tissue samples (n = 200) were dissected and frozen for stable isotope ratio-mass spectrometry ($\delta^{13}C$, $\delta^{15}N$, and $\delta^{34}S$) analysis. Forty-eight percent of sampled fish had identifiable prey which were grouped into seven categories: fish, decapods, cephalopods, stomatopods, gastropods, zooplankton, and other invertebrates. A permutational multivariate analysis of variance (PERMANOVA) was computed to test the effect of fish size, habitat type, and the Deepwater Horizon Oil Spill (DHOS) on red snapper diet. Fish size (PERMANOVA, $p = 0.021$), and the DHOS (PERMANOVA, $p = 0.001$) were both significant effects in the model, but interactions between habitat type and the DHOS (PERMANOVA, $p = 0.049$) was also significant. Significant differences in diet among red snapper size categories were due to low trophic position prey items, such as pelagic zooplankton, being more abundant in the diet of larger (>500mm) red snapper, while red snapper in smaller size classes contained greater amounts of higher trophic level prey such decapods and fish. Although no significant difference existed in red snapper diet between habitat types, they consumed slightly higher amounts of decapods at artificial reefs (21.9% of total diet) than natural (14.8%). The significant DHOS effect was driven by an increase in fish and a decrease in zooplankton in red snapper diet following the spill; however, this effect cannot be interpreted independently given the significant interaction

between habitat type and the DHOS effect. Zooplankton prey consumption declined and fish consumption increased for red snapper sampled at both artificial and natural reefs after the DHOS, but fish consumption increased to a greater extent at artificial reef sites following the spill. A significant increase in $\delta^{15}N$ after the DHOS (ANOVA, $p < 0.001$) also indicates red snapper sampled fed on higher trophic position prey following the spill, and lower $\delta^{34}S$ values indicate an increase in benthic versus pelagic prey consumption following the DHOS (ANOVA, $p < 0.001$). The ontogenetic shift in diet observed via gut content analysis was also apparent in the significant effect of fish size on $\delta^{15}N$ (ANOVA, $p = 0.015$). Overall, results clearly indicate the DHOS affected red snapper diet and trophic position and likely affected the abundance of prey resources as well. Study results also confirm the utility of stable isotope analysis to infer aspects of reef fish trophic ecology.

# INTRODUCTION

Artificial reefs (ARs) are manmade structures on the seabed that mimic characteristics of natural reefs (Baine 2001). These structures have been deployed over vast areas of the northern Gulf of Mexico (GOM) continental shelf, but they are also prevalent in other regions of the United States and globally (Bohnsack 1989; Baine 2001). Goals of AR construction, as stated in the revised National Artificial Reef Plan (NARP) of 2007, include enhancing fishery resources, facilitating access and use of fishery resources by US recreational and commercial fishermen, and minimizing user conflicts due to competition for resources. Although the primary goals focus on fishing, ARs also provide other revenue-generating opportunities such as diving and ecotourism (Bohnsack 1989; Ditton et al. 2000).

Artificial reefs typically are created in areas where natural hardbottom habitat is lacking in an attempt to mimic habitat required by reef-dependent fishes (Bohnsack 1989). Most ARs that follow the NARP (2007) guidelines are created to work in conjunction with surrounding natural reefs (NRs) (Hueckel and Buckley 1987; Beets 1989; Pickering and Whitmarsh 1997). However, Baine (2001) reported few ARs actually meet their management objectives. In several studies, researchers concluded that reef-associated fishes did not feed directly on artificial reef associated organisms, but instead foraged in surrounding natural habitats (Hueckel and Buckley 1987; Bohnsack 1989; McCawley and Cowan 2007). This implies that reef fishes move back and forth from aggregation areas to feeding grounds, or often rely more on natural foraging areas surrounding ARs than on AR-based production (Ouzts and Szedlmayer 2003; McCawley and Cowan 2007).

Authors of previous artificial reef studies often overlooked aspects of colonization of organisms including various corals, sessile invertebrates, algae, and motile invertebrates which

may provide food or cover for various motile invertebrates and fishes (Fitzhardinge and Bailey-Brock 1989; Bortone et al. 1998). This fouling and colonization of algae and invertebrates on ARs can occur within a time period of weeks to years following reef creation (Schumacher 1977; Fitzhardinge and Bailey-Brock 1989). Once established, reef fouling organisms aid in giving an AR greater rugosity and structural complexity (Bohnsack et al. 1994; Pickering and Whitmarsh 1997). These organisms serve to attract fish by providing food, altering reef topography, and providing shelter from predation, tidal forces, and desiccation (Pickering and Whitmarsh 1997). Habitat addition or restoration is dependent on the fouling community's ability to create enough resources to sustain a population of reef-dependent organisms (Hueckel and Buckley 1987). An established reef should be able to supply not only refuge but also aid in the production of essential food needed to support reef-dependent fishes. In many cases, the success of an AR is due to sustaining its reef fouling community (Baine 2001).

The ability of ARs to mimic natural hardbottom habitat depends on creating energetic links among reef-dependent organisms. Hueckel and Buckley (1987) observed several stages of reef succession at newly-created ARs to explain how climax communities become established on some reefs and what factors may hinder their establishment on others. Previously, small scaled experiments conducted over short time periods were used to examine the ecological processes of reef community development (Hueckel and Buckley 1987; Hixon and Beets 1989; Bohnsack 1989). General observations were that ARs often yielded the highest diversity of fishes within the first two years of establishment, after which fish diversity generally showed a decrease (Hueckel and Buckley 1987). Hueckel and Buckley (1987) proposed that progression in reef fish assemblages parallels biotic and abiotic factors associated with succession. Initially formed communities typically are composed of small, fast growing opportunistic species which feed on

prey items that are quick recruit to ARs (e.g., algae, invertebrates). However, artificial reefs also have been shown to attract large equilibrium species within hours of deployment. New ARs can sustain large predatory fishes because these transient fishes often forage away from the actual reef structure and not directly on it (Hueckel and Buckley 1987; McCawley and Cowan 2007).

Fish community succession often begins immediately following artificial reef creation. As previously stated, predatory fish have been reported to aggregate on reefs in as little as a few hours, feeding on the surrounding benthic community (Hueckel and Buckley 1987; Bohnsack 1989). The second stage of succession occurs when piscivorous fish begin colonizing the reef and consuming the initially colonizing fishes. The third stage of succession occurs when invertebrate fouling communities and other reef-dependent organisms begin to produce adequate amounts of prey to support other reef-dependent fishes (Hueckel and Buckley 1987). Finally, a climax community includes energetic links among reef-associated invertebrates (attached and motile), reef-dependent fishes, predatory fishes, and piscivorous fishes, as well as additional interactions among reef, planktonic, and surrounding benthic communities (Hueckel and Buckley 1987; McCawley and Cowan 2007).

Understanding the relationship between ARs and reef fish communities has important implications for whether ARs function to enhance reef fish production or merely aggregate fish thus making them more vulnerable to fishing mortality (Bohnsack 1989; Lindberg 1997; Perkol-Finkel et al. 2006), and few fisheries issues in the northern GOM are as controversial as the ecological versus fishery function of ARs. The rapid colonization of ARs by exploited fish species, as well as high fish densities and catch rates at ARs, have been cited as evidence by fisheries managers that AR creation enhances fish production (Bohnsack 1989; Szedlmayer and Shipp 1994; Shipp and Bortone 2009). Additionally, shelter provided by ARs can affect

settlement, early survival, and post-recruitment interactions of reef fishes (Hixon and Beets 1989).

If ARs do not enhance reef fish production, but catch rates are higher at ARs than NRs, then ARs would be functioning as net sinks of reef fish biomass (Crowder et al. 2000; Strelcheck et al. 2007; Cowan et al. 2011). However, the attraction versus production debate, as this dichotomy has been called, is a bit of a misnomer because attraction and enhanced production are not necessarily mutually exclusive (Bohnsack 1989; Lindberg 1997). The concept of attraction implies the movement of individuals from natural to artificial habitats (Carr and Hixon 1997). Sale (1980) documented recruitment of adult fish to ARs from NRs with little to no reciprocal movement. This phenomenon has been noted by many authors (Fast and Pagan 1974; Matthews 1985; Bohnsack et al. 1994). As Bohnsack (1989) explained, there have been many proposed models that specify ARs to be either attractors or producers of reef fishes. However, there are no definitive answers for the questions of whether fish found at a given AR would have found suitable habitat if the AR was not present, whether fish had an increased chance of survival at the AR, or whether foraging success is improved by the AR (Bohnsack et al. 1994).

Enhancement of fish production, on the other hand, implies that reef fish either grow faster or have lower mortality at ARs versus NRs. Increased size at age at ARs, which is presumed to be a response of increased foraging success, would imply an increase in overall fitness leading to greater fecundity and enhanced stock biomass (Powers et al. 2003). Foraging success on AR habitats has been demonstrated to decrease the distance of travel required for predatory fish, thereby increasing the overall net energy gain which can be utilized for growth and reproduction (Bohnsack 1989). However, this enhanced productivity hypothesis is problematic. To account for a change in population biomass over time, other factors such as

births (most often in the form of planktonically-dispersed larvae), immigration and emigration, growth, and death rates must all be taken into account and are difficult to measure (Carr and Hixon 1997).

According to Shipp (1999), the large-scale deployment of ARs in the north-central GOM in the 1970s and 1980s resulted in a fundamental habitat transformation which improved fishing, in particular for red snapper, *Lutjanus campechanus*, and allowed for fish to be harvested at larger sizes. However, a central premise to the arguments of Shipp (1999) and Shipp and Bortone (2009) that artificial reefs have enhanced red snapper production is that natural reef habitat was limiting for red snapper. While red snapper have been shown to constitute a large percentage of reef fish numbers and biomass at northern GOM ARs (Lingo and Szedlmayer 2006; Dance et al. 2011), ARs make up less than 10% of the reef habitat in the northern GOM thus habitat limitation prior to ARs seems unlikely (Cowan et al. 2011). Furthermore, the period of rapid fishing down of GOM red snapper biomass in the 1970s and 1980s coincided with the period of greatest AR construction (Patterson and Cowan 2003; Cowan et al. 2011).

A key to addressing the question of whether ARs in the northern GOM are likely enhancers of reef fish production is understanding the ecology of reef fishes at NRs versus ARs in the system. For example, Lindberg et al. (2006) reported that gag, *Mycteroperca microlepis*, occurred at much higher densities at experimental AR than NR sites in the Big Bend area of northwest Florida, but that growth rates of fish were lower at ARs due to density-dependent effects. In theory, reefs with adequate food sources and low competition should yield higher residency times and therefore may have further implications regarding increased growth rates and fitness. Foraging space along with shelter availability were deemed vital to gag residency

time, and smaller ARs yielded faster growth rates due to lower gag density (Lindberg et al. 2006).

Lindberg et al.'s (2006) work represents a fundamental advance in distinguishing the ecological function of ARs versus NRs. In the north central GOM off Florida's Panhandle and Alabama, a first step to examining the ecological function of ARs versus NRs was to examine differences in species-specific diet and trophic position between these habitat types. Diet analysis is straightforward and simply entails examination of gut contents. However, to draw inference about the predominant diet of a given species or size class, often hundreds to thousands of samples are required over the course of at least a year to capture the natural variability that exists (McCawley and Cowan 2007). An alternative approach is to examine C, N, and S stable isotope ratios in muscle tissue as they can provide information on source of primary production, fish trophic position, and whether fish have a benthic or pelagic prey base (Fry 2006). Furthermore, stable isotope signatures turn over on the scale of weeks to months, thus trophic signatures are integrated over much longer time scales than gut contents which can be digested in hours to days (Fry 2006; Post 2007; Nelson et al. 2010).

Unlike radioactive isotopes, stable isotopes are energetically stable and do not decay. Isotopes are of the same element, containing equal numbers of protons and electrons, yet differ in number of neutrons (Michener and Kaufman 2007; Sulzman 2007). While protons and electrons are used to achieve a positive-negative balance required for bonding, neutrons are responsible for stability by maintaining the proper spacing between the protons and electrons. Although there are over 300 stable isotopes among elements, ecological research primarily relies on lighter elements which dominate biological compounds. A few of the more commonly used isotopes pertaining to trophic analysis consist of carbon (C), nitrogen (N), and sulfur (S) stable

isotopes found in the biosphere. The percent relative abundances of C, N, and S stable isotopes are held in fairly constant proportions within the environment (McCutchan et al. 2003; Fry 2006; Michener and Kaufman 2007; Sulzman 2007), but biogeochemical and ecological processes can alter their relative concentrations in animal or plant tissues. In stable isotope analysis, the ratio of heavier to lighter isotopes (e.g., $^{13}C$:$^{12}C$, $^{15}N$:$^{14}N$, and $^{34}S$:$^{32}S$) is analyzed with mass spectrometry (Peterson and Fry 1987; Cravotta 2002). The isotopic ratio of a sample relative to the ratio in a standard is reported as a delta value (Peterson and Fry 1987; Cravotta 2002), which is computed as

$$\delta X = [(R_{sample}/R_{standard}) - 1] \text{ X } 1{,}000 \qquad \text{Equation 1}$$

where:

$X$ = $^{13}C$, $^{15}N$, or $^{34}S$ and

R = $^{13}C$:$^{12}C$, $^{15}N$:$^{14}N$, or $^{34}S$:$^{32}S$.

Stable isotope ratios of carbon, nitrogen, and sulfur are used as biogeochemical tracers in marine systems to identify production sources, trophic position, or benthic versus pelagic food sources (Schoeller 1999; Mill et al. 2007). Sources of primary production such as seagrass beds, marsh grass, and epiphytic communities all provide distinct carbon signatures which can be traced throughout the foodweb (Moncreiff et al 1992; Moncrieff and Sullivan 2001). Moncreiff et al. (1992) estimated microalgae was responsible for 87% of total system primary production in northern GOM seagrass beds, and the carbon isotope signature of microalgae could be linked to resident fauna. In the case of C and N, isotope ratios become enriched in heavier isotopes occurs through assimilatory or metabolic fractionation in which molecules with lighter isotopes are assimilated or catabolized more quickly than the heavier isotopes (McCutchan et al. 2003; Fry 2006; Mill et al. 2007). For example, trophic fractionation occurs in both $\delta^{13}C$ and $\delta^{15}N$, with

these ratios increasing by approximately 1.0‰ and 3.0‰, respectively, for each trophic level increase in marine systems (Vanderklift and Ponsard 2003; Fry 2006; Sulzman 2007).

Sulfur isotope ratios, on the other hand, do not undergo trophic fractionation. Pelagic phytoplankton has $\delta^{34}S$ values of approximately 17‰ to 21‰, while values of 10‰ to 13‰ are typical of benthic primary producers (Fry 2006; Van Dover 2007). These differences result from the primary S source in the water column being sulfate. Anaerobic sulfate reducing bacteria reduce sulfate to hydrogen sulfide in the sediments which is the primary benthic sulfur source. The implication of this and the fact that S isotope ratios do not fractionate trophically is that $\delta^{34}S$ values can be used to estimate the percentage of pelagic versus benthic production for a given consumer (Fry 2006; Van Dover 2007).

Stable isotope analysis is a useful tool for providing information on source(s) of production and trophic relationships (Michener and Schell 1994; Peterson 1999; Michener and Kaufman 2007), as well as for verification of diet studies aimed at drawing inference on both short- and long-term trophic changes related to ontogeny, habitat use, or environmental perturbation (Peterson 1999). However, stable isotope analysis often requires too many assumptions to be used independently. Therefore, stable isotope data often are best used in conjunction with other techniques such as mesocosm feeding experiments, gut content analysis, or behavioral studies which may provide greater insight leading to more robust conclusions with respect to diet and trophic ecology (Peterson 1999).

Analysis of gut contents and muscle stable isotopes should provide powerful tools to examine the effect of habitat on red snapper diet and trophic ecology, as well as to test for the presence of ontogenetic effects. However, an unplanned factor was added to this study during its second year when the Deepwater Horizon Oil Spill (DHOS) occurred. On April 20, 2010, an

explosion causing the collapse of the *Deepwater Horizon* drilling ship occurred 52 miles southeast of Venice, Louisiana. This resulted in an estimated 4.9 million barrels of sweet Louisiana crude oil being released from the Macondo (MC) 252 well over an 87 day period (Camilli et al. 2010; Hemmer et al. 2011). In an attempt to mitigate large surface slicks and coastal impacts, 2.1 million gallons of dispersant were released at the well head and surface waters during the spill (Kujawinski et al. 2011). Dispersants such as Corexit 9527 (surface application only) and Corexit 9500A (surface and wellhead application) had never been applied in large-scale applications prior to this event. (Kujawinski et al. 2011). Additionally, the depth of the well head (1500 m) and intense discharge pressure made this spill event unique (Kujawinski et al. 2011; Peterson et al. 2012).

Potential environmental implications of the DHOS were relatively unknown because few oil spills had occurred on comparable scales (Atlas 2011). The *Exxon Valdez* spill in Prince William Sound, Alaska, was one of the largest and most informative for constructing risk assessment models for determining acute and chronic exposure effects (Peterson et al. 2003). The grounding of the *Exxon Valdez* spill resulted in 42 million gallons of heavy oil [American Petroleum Institute (API) gravity = 29.0 °API)] being released in a shallow subarctic region exposing approximately 14,500 km of pristine shoreline to the slick (Peterson et al. 2003; Rice 2009). Within days following that spill, strong storms washed much of the oil onto the shoreline, thus diminishing the possibility of using dispersants to minimize the impact of the spill on coastal habitats (Atlas 2011). The *Exxon Valdez* spill has been termed “traditional” in the sense that it occurred within shallow waters, had minimal residence time in the water column, and primarily encountered organisms located on the coastline and sea surface (Peterson et al. 2003). Acute effects were felt largely on coastal communities including local birds, coastal mammals,

and salmon populations, while lingering chronic effects are poorly understood due to the lack of biological information prior to the spill (Piatt et al. 1990; Rice 2009).

Few species were studied as well as the pink salmon, *Oncorhynchus gorbuscha*, prior to the grounding of the *Exxon Valdez*. Pink salmon was the most commercially valuable and heavily researched fishery species within Prince William Sound. Salmon eggs and larvae reared in the intertidal springs were vulnerable to being exposed to stranded oil, and furthermore juvenile salmon (>8-9 months) which exit the protection of streams and migrate to estuaries became saturated with oil (Rice 2009). Although acute affects related to exposure were not observed among larvae and juveniles, growth rates of wild pink salmon fry captured in oiled areas were half of those captured in reference areas (Wertheimer and Celewycz 1996; Willette 1996). While salmon food resources were not reduced, oil globules and sheen were observed in the stomachs of the fry (Sturdevant et al. 1996). Hatchery experiments suggest oil contaminated prey items divert energy that would be used for growth instead was used metabolizing and excreting hydrocarbons (Carls et al. 1996). The reduction in growth rates during early life stages carries implications associated with increased predation, chronic effects such as long-term sensitivity of embryos, and reduction of the pink salmon stock (Bue et al. 1996; Heintz et al. 1999; Rice 2009).

Another large oil spill occurred on September 19, 2002, when the oil tanker *Prestige* sunk at a depth of 3,500 meters 130 miles off the Galician coast of Spain and released 60,000 tonnes of heavy oil (De la Huz et al. 2005; Sanchez et al. 2006; Diez et al. 2007). The oil from the *Prestige* was drifting on the surface for nearly a year before washing up along the northern Spanish coast (Diez et al. 2007). Drifting oil slicks were exposed to weathering processes that were responsible for changing the oil's chemical and physical properties. Due to its heavy state,

processes such as evaporation, dissolution, biodegradation, and photo-oxidation did little to alter its composition and suggests that mechanical intervention and bioremediation by dispersants may have been appropriate actions to consider beyond natural weathering (Diez et al. 2007).

Despite the evidence of oiling on the seafloor caused by mixing waters, trawl surveys performed by Sanchez et al. (2006) indicated an increase in European hake, *Merluccius merluccius*, and four-spot megrim, *Lepidorhombus boscii*, populations. The mixing and increased oil exposure was apparent; however, low temperatures resulted in lower oil toxicity during the winter months and may have minimized harmful effects on the highly targeted fishery (De la Huz et al. 2005; Sanchez et al. 2006). In addition, offshore prey resources for these groundfish, such as euphausiids, shrimps, and small fishes, were found in greater concentration and diversity within the stomachs of these fish than in prior years (Sanchez et al. 2006). Negative effects were felt more heavily along the coastline as heavy oiling affected nearshore fauna and food resources. De la Huz et al. (2005) reported the nearshore macrofaunal community suffered a decline in both composition and abundance following the spill event. Particular species such as amphipods exhibited increased sensitivity to oil exposure making them more vulnerable to mortality.

The grounding of the *Exxon Valdez*, the sinking of the *Prestige*, and the collapse of the *Deepwater Horizon* drilling ship all represent very different spill events in regards to volume, oil type, and environments impacted (Atlas 2011). As previously stated, the DHOS released 4.9 million barrels of light crude oil (35.2 °API), which contains lower molecular weight hydrocarbons that are more readily biodegraded compared to heavy crude (Atlas 2011). The Corexit 9500 dispersant added to the well head caused small particles (<10 μm) to be dispersed in deeper water and larger droplets (10-60 μm) to be neutrally buoyant but still increasing

surface area for bacterial biodegradation. Unfortunately, the increased surface area also increases exposure to organisms residing in the water column including environmentally sensitive planktonic prey (De la Huz et al. 2005; Atlas 2011). Ongoing research being conducted in numerous laboratories may clarify the role of dispersants in the bioavailability of oil compounds. Mesocosm experiments performed recently by Ortman et al. (2012) suggest dispersants may have inhibited the flow of carbon throughout higher levels of the food web possibly effecting zooplankton and fishes off the Alabama shelf. While neither the toxicity of dispersants or oil compounds themselves to red snapper were examined in the current study, pre-spill samples collected for diet and trophic position analysis did enable me to test for the effect of the DHOS on those parameters.

## OBJECTIVES AND HYPOTHESES

The primary goal of this study was to determine the effects of habitat type (i.e., natural versus artificial reefs) and fish size on red snapper trophic ecology in the northern GOM. The effect of the Deepwater Horizon Oil Spill (DHOS) on red snapper trophic ecology also was tested given the availability of samples collected before and after the spill.

Objective 1: The first objective of this study was to test if red snapper diet differs between natural and artificial reefs in the northern GOM.

$H_{0\text{-}1}$: Habitat type does not significantly affect red snapper diet or trophic position.

$H_{A\text{-}1}$: Differences in red snapper diet or trophic are apparent between reef types which has important implications for the ecology of reef fishes on natural versus artificial reefs in northern GOM.

Objective 2: The second objective in this study was to test if red snapper diet or trophic position shift ontogenetically in the northern GOM.

$H_{0\text{-}2}$: Fish size has no effect on red snapper diet or trophic position.

$H_{A\text{-}2}$: Differences in red snapper diet or trophic position are apparent among size classes. A shift to greater piscivory would indicate greater energetic demands for larger, older red snapper.

Objective 3: The third objective of this study was to test the effect of the DHOS on red snapper diet and trophic position.

$H_{0\text{-}3}$: The DHOS did not significantly affect red snapper diet or trophic position.

$H_{A\text{-}3}$: Differences in red snapper diet or trophic position are apparent post-spill which implies that the DHOS had a significant impact on food web structure, therefore availability of red snapper prey.

## METHODS

After receiving permission from the Institutional Animal Care and Use committee (Appendix A), red snapper were sampled by hook and line between summer 2009 and fall 2011, from locations south of Mobile Bay, Alabama, to southeast of Destin, Florida (Figure 1). Verification of habitat type was achieved by video samples collected at reef sites with a remotely operated vehicle (ROV) and the methodology developed by Patterson et al. (2009). A Seabird 19 plus CTD was cast at each site to measure depth, salinity, temperature, dissolved oxygen, fluorescence, and turbidity 1 m off the bottom. Hook and line fishing was performed with two hook rigs comprised of 9/0, 12/0, and 15/0 Mustad circle hooks on 60-lb fluorocarbon leader material. Sampling cruises were performed onboard several charter boats: *F/V*s *Rip Tide*, *Total Package*, *Intimidator*, and *Backdown*[2], with home ports between Orange Beach, Alabama, and Destin, Florida. Additional hook and line sampling occurred aboard the Florida Institute of Oceanography's *R/V Weatherbird II* in May 2011. Bait for hook and line sampling was kept uniform and consisted of cut squid, *Loligo* spp., and mackerel scad, *Decapterus macarellus*, which allowed for easy identification and removal during stomach content analysis.

Upon capture, fish were weighed to the nearest 0.1 kg, fork length (FL) and total length (TL) were measured to the nearest mm, and sex was determined by examination of gonads. A sample (~50 g) of white muscle tissue was removed from the shoulder of each fish and placed in a zipper seal bag on ice for transport and then frozen in the ultralow freezer at -80°C at either the University of West Florida (UWF) or the Dauphin Island Sea Lab (DISL). Fish carcasses were placed on ice until stomach and otolith dissections were performed the following day in the laboratory. An analysis of variance (ANOVA) was computed to test for significant differences in TL of red snapper samples between levels of the factors habitat type and the DHOS.

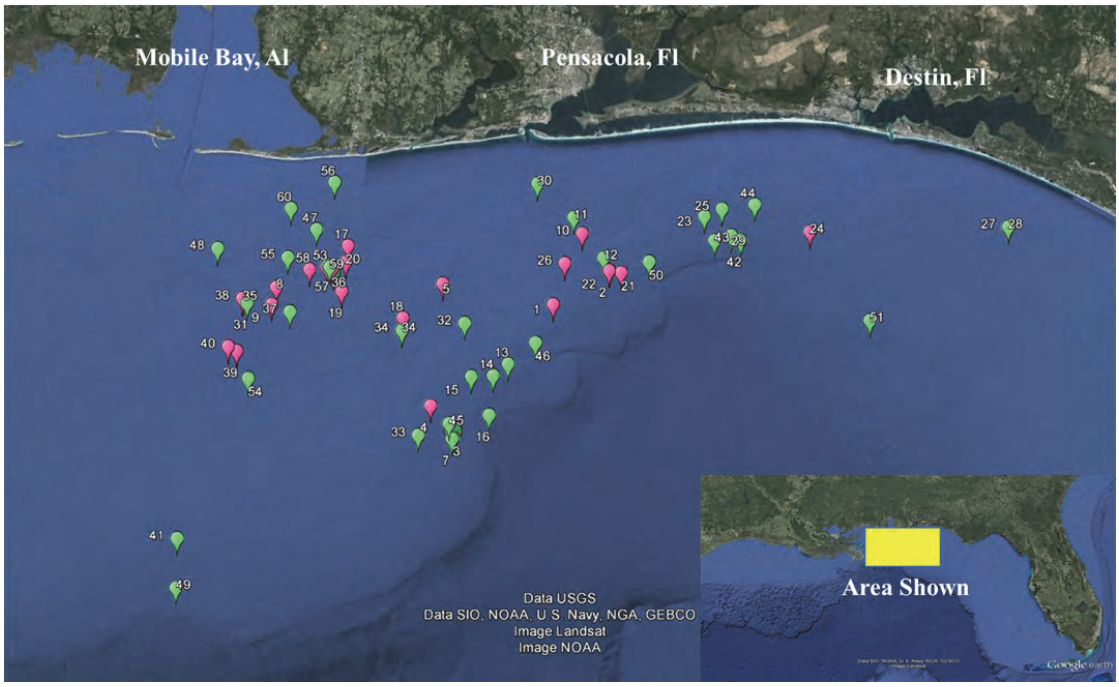


FIGURE 1.—Locations of study reef sites (n = 60) in the northern Gulf of Mexico. Natural reef sites = green (n = 33); artificial reef sites = pink (n = 27). See Appendix B for site location information.

**Diet Analysis**

Fish stomachs were weighed in the laboratory and their contents fixed in 10% formalin for at least 48 hours. Their contents then were transferred to 70% isopropyl alcohol for preservation. Diet composition analysis was performed by identifying stomach contents to the lowest taxonomic level possible and enumerating them with the aid of a dissecting microscope. Samples were sorted by prey type and then prey were identified to the lowest taxonomic level possible. A wet mass was obtained for each prey type and then samples were placed in an oven to dry for 48 hours at 60°C, after which a final dry mass was obtained.

Prey were sorted into one of seven categories for statistical analysis of diet: fish, decapods, cephalopods, stomatopods, gastropods, zooplankton, and other invertebrates. A permutational multivariate analysis of variance (PERMANOVA) was computed within the Primer statistical

package (ver. 6; Clarke and Gorley 2006) to test for differences in diet among red snapper size classes (<400mm, 400-500mm, >500mm), habitat types (natural versus artificial reefs), and pre- versus post-DHOS (before versus after 5/4/2010). First, the Bray-Curtis dissimilarity measure was computed between each pair of samples ($j$,$k$):

$$D_{jk} = \frac{\sum_{i=1}^{n} |y_{ij} - y_{ik}|}{\sum_{i=1}^{n} (y_{ij} + y_{ik})} \quad \text{Equation 2}$$

where:

$y_{ij}$ = count of $i^{th}$ species in $j^{th}$ sample

$y_{ik}$ = count of $i^{th}$ species in $k^{th}$ sample,

and n = number of species.

Then, a 3-way (fish size, habitat type, and DHOS effects) fully-crossed PERMANOVA was computed with 10,000 permutations. Type III sums of squares were utilized to determine significance at $\alpha = 0.05$.

**Stable Isotope Analysis**

Muscle stable isotope analysis was performed on a subset of red snapper samples. Muscle tissue samples were dried at 60°C for at least 24 hours and then ground into a fine powder with a glass or agate mortar and pestle. Mortar and pestles were cleaned with 2% nitric acid and rinsed with Milli-Q water between samples to prevent cross contamination. Ground samples containing between 0.2 and 0.5 g of pulverized dried tissue were placed in sterile plastic centrifuge tubes and shipped to Iso-Analytical, a contract laboratory in Cheshire, England, to perform analysis of $\delta^{13}C$, $\delta^{15}N$, and $\delta^{34}S$ with a Europa Scientific GSL/Geo 20-20 stable isotope ratio-mass spectrometer (SIR-MS). Standards included Pee Dee Belemnite ($\delta^{13}C_{V\text{-}PBD}$), Nitrogen in air ($\delta^{15}N_{Air}$), and Canyon Diablo Troilite ($\delta^{34}S_{V\text{-}CDT}$). International Atomic Energy Agency (IAEA)

standard reference materials (SRMs) were run periodically as check samples to assess machine performance for each stable isotope ratio analyze. Analytical precision was estimated from duplicate analysis of 20 randomly selected samples. Three-way fully crossed ANOVAs were computed to test the effects of fish size, habitat type, and the DHOS on red snapper muscle $\delta^{13}C$, $\delta^{15}N$, and $\delta^{34}S$.

# RESULTS

Fifty-three cruises were conducted from June 2009 through August 2011 to sample red snapper at 60 locations consisting of NRs (n=33) and ARs (n=27). CTD recordings indicated reef depth ranged from 17 - 92 meters between locations, temperature ranged from 14.2 - 30.7°C, salinity 31.5 - 37.1 PSU, oxygen 1.0 - 7.3 mg/l, fluorescence 0.1 - 14.9 mg/$m^3$, and beam transmission 74.5 - 98.2%. Dissolved oxygen was the lowest during the summer months of July and August and was nearly anoxic on shallower reefs. Turbidity measured by beam transmission was greater in the western sites which were affected by bay and river discharge closest to shore. On trips the CTD was sent for maintenance or repair, the abbreviation "na" or not applicable was used (Appendix B).

Red snapper ranged in TL from 238 mm to 890 mm, with a mean ± standard error (SE) TL of 467 ± 10 mm. There was no significant difference in TL between habitat types (ANOVA, $F_{1;706} = 0.30$; $p = 0.586$) or between pre- versus post-DHOS samples (ANOVA, $F_{1;706} = 2.45$; $p = 0.118$) (Figure 2A). Similarly, there was no difference in TL between habitat types for red snapper sampled for muscle stable isotope analysis (ANOVA, $F_{1;198} = 0.77$; $p = 0.380$), but TL was significantly different between pre versus post-DHOS samples (ANOVA, $F_{1;198} = 5.73$; $p = 0.018$) (Figure 2B). Mean red snapper TL ± SE was 440 ± 14 mm pre- versus 489 ± 11 mm post-spill post-DHOS.

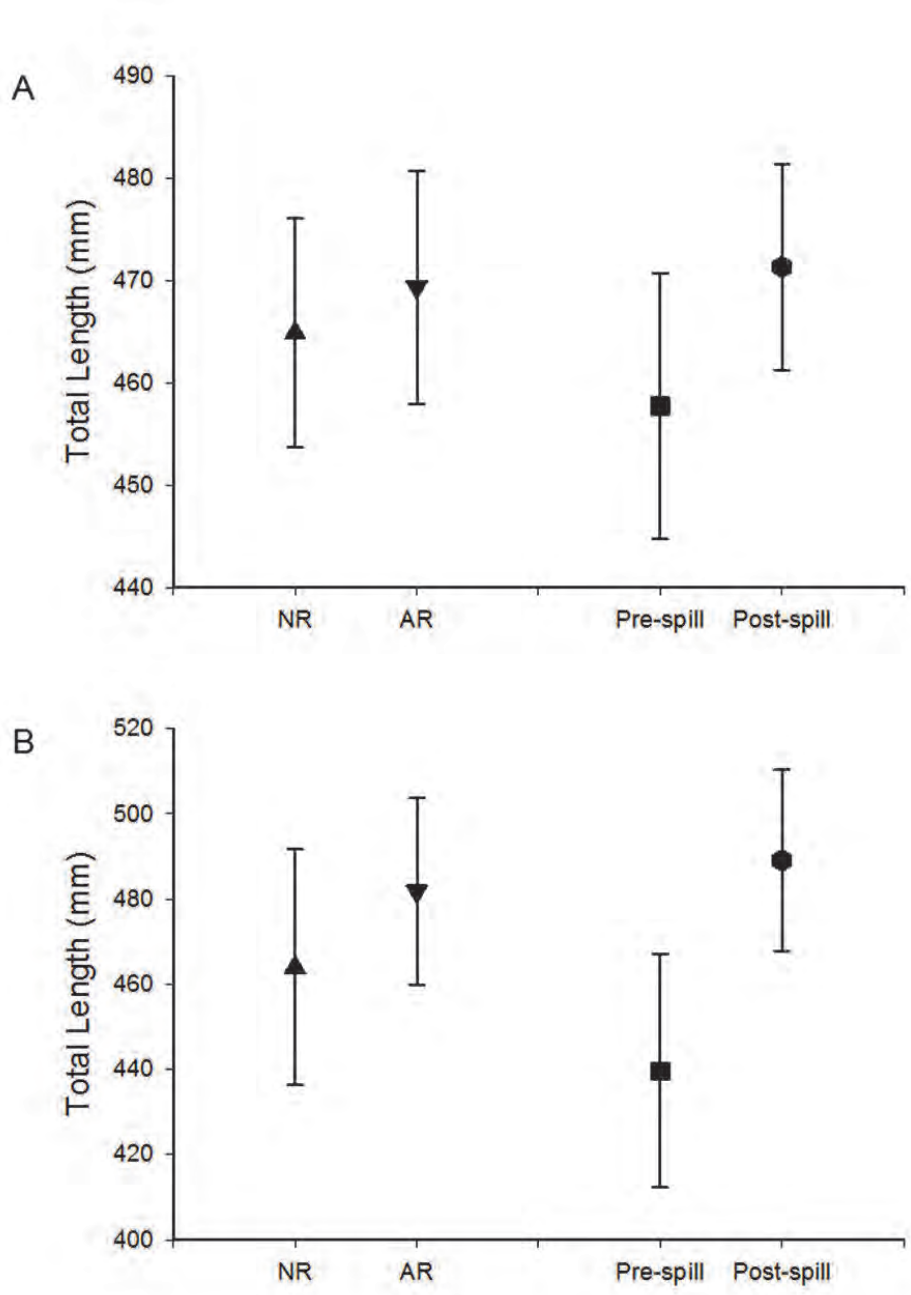


FIGURE 2.—Mean red snapper total length (± 95% confidence interval) by habitat type (natural versus artificial reefs) and pre- versus post-DHOS for: **(A)** all fish sampled (n = 708), **(B)** fish whose muscle tissue was analyzed with stable isotope ratio-mass spectrometry used in isotope analysis (n = 200).

**Gut Content Analysis**

Red snapper had a broad diet with prey items consisting of 85 unique taxa (Appendix C). 563 of 708 (79.5%) red snapper stomachs analyzed had prey items present and only 343 (48.4%) had identifiable prey items. With unidentifiable material removed, red snapper diet was significantly different among size classes (PERMANOVA, pseudo-$F_{2;331} = 2.39$, $p = 0.021$), and pre- versus post-DHOS (PERMANOVA, pseudo-$F_{1;331} = 6.52$, $p < 0.001$). Additionally, interactions between DHOS and habitat type (PERMANOVA, pseudo-$F_{1;331} = 2.73$, $p = 0.049$) were significantly different (Table 1).

Three of the seven prey categories were responsible for greater than 80% of the total diet. Overall, fish prey constituted nearly half (43.2%) of the identifiable prey of red snapper diet by dry mass, with the majority labeled as unidentifiable fish. The smallest size category of red snapper, <400 mm, contained the greatest amount of fish prey by dry mass (45.1%) but consisted primarily of unidentifiable fish (78.3%), while fish constituted 40.2% of the diet of red snapper in the 400-500 mm size class and 45.0% of the diet of fish >500 mm (Appendix D). The diet of red snapper sampled on natural reef sites was composed principally of non-reef benthic taxa (Appendix E), such as lizardfishes (Family Synodontidae), sea robins (*Bellator* sp.), longspine porgy (*Stenotomus caprinus*), and Gulf hake (*Urophysis floridana*), while stomach samples of fish from artificial reefs contained a combination of non-reef benthic and pelagic fishes, such as harvestfish (*Peprilus* sp.) and herrings (Family Clupeidae). Reef fish taxa identified in red snapper stomach samples were rare and consisted of grunts (Family Haemulidae) and triggerfish (Family Balistidae).

Overall, zooplankton accounted for 22.6% of the identifiable prey by dry mass and included 22 unique taxa. Zooplankton made up 14.1% of total identifiable prey within the

TABLE 1.—Permutational Multivariate Analysis of Variance (PERMANOVA) Results for the Model Testing the Effect of Fish Size, Habitat Type, and DHOS Spill on Red Snapper Diet.

| Source | Df | SS | MS | Pseudo-F | p-value |
|---|---|---|---|---|---|
| Fish Size | 2 | 15,567 | 7,783 | 2.39 | 0.021 |
| Habitat Type | 1 | 5,503 | 5,503 | 1.69 | 0.150 |
| DHOS | 1 | 21,225 | 21,225 | 6.52 | 0.001 |
| Fish Size x DHOS | 2 | 13,989 | 6,995 | 2.15 | 0.053 |
| Fish Size x Habitat Type | 2 | 9,454 | 4,727 | 1.45 | 0.193 |
| DHOS x Habitat Type | 1 | 8,903 | 8,903 | 2.73 | 0.049 |
| Fish Size x habitat type x DHOS | 2 | 11,177 | 5,589 | 1.72 | 0.108 |
| Residual | 331 | 1,080,000 | 3,256 | | |
| Total | 342 | 1,170,000 | | | |

<400mm size class, 25.3% for 400-500 mm, and 27.4% for >500 mm red snapper. Although there was no statistically significant difference in the amount of zooplankton consumed between habitat types (NR = 22.6% versus AR = 22.7%), there was a difference in zooplankton taxa that were consumed. On natural habitats, members of Order Thecosomata, small pelagic gastropods, constituted 52.8% of zooplankton prey but made a much smaller (5.5%) contribution to red snapper diets on artificial reefs. The greatest zooplankton consumption on artificial reefs was of the pelagic amphipod, *Phrosina semiluna,* with constituted 84% of zooplankton dry mass.

Decapods contributed 17.6% of total identifiable prey consumed, and, like zooplankton, 22 decapod taxa were identified in red snapper stomach samples. Decapod prey items were most abundant in stomachs of the largest red snapper size class (mean = 2.64 items/stomach) versus medium (mean = 1.88 items/stomach) and small fish (mean = 1.50 items/stomach), yet made a lesser contribution to overall diet in larger size fish. A 492% increase by dry mass was observed

from the smallest to the largest red snapper size categories, indicating larger decapods were consumed by bigger red snapper. The largest prey items, such as box crabs (Family Calappidae) and lady crabs (*Ovalipes floridanus*), were only found in stomachs of red snapper >500 mm TL. No difference in decapod diversity was observed between habitat types, yet red snapper did consume slightly higher amounts of decapods at artificial (21.9% of overall diet) versus natural (14.8% of overall diet) reefs.

Cephalopods, stomatopods, gastropods, and other invertebrates made up the remaining 17.1% of overall red snapper diet. The cephalopod category was composed of squid (*Loligo* sp.), and octopuses (Order Octopoda). Stomatopods (adult mantis shrimp) made up 4.7% of red snapper diet, with stomatopod consumption being approximately 33% greater on natural versus artificial reefs. Benthic gastropods totaled less than 1% of total diet and other invertebrates consisted of non-parasitic worms, echinoderms, isopods, sponges, barnacles, tunicates, and prey that could not be classified below Order Malacostraca (Figure 3). Other invertebrates were consumed in fairly constant proportions (approximately 9%) among all sizes classes and were 57% more abundant in stomach samples from natural reefs.

The significant interaction between DHOS and habitat type effects on red snapper diet preclude interpretation of the significant DHOS main effect independently. Fish contribution to diets at ARs more than doubled post-DHOS but there was no change at NR sites, and decapod consumption increased by 58.3% at NRs but declined by 19.8% at ARs (Figure 4). Fish captured at both habitat types had lower zooplankton contribution to their diets after the spill, with zooplankton percent dry mass decreasing by 55.7% on natural and 64.7% on artificial reefs following the spill. Pteropods, mysid shrimp, and the hyperiid amphipod, *Phorina semiluna*, were the most abundant pre-DHOS zooplankton prey items on NRs, but were entirely absent

from post-DHOS red snapper diet at NR sites. Mysid shrimp and *Phorina semiluna* were more abundant in pre-DHOS red snapper diet samples at artificial versus natural reefs, but were also entirely absent from AR red snapper diets after the DHOS. Among the minor prey categories, the most substantial change following the DHOS was the appearance of stomatopods in NR diets where they had been absent prior to the spill.

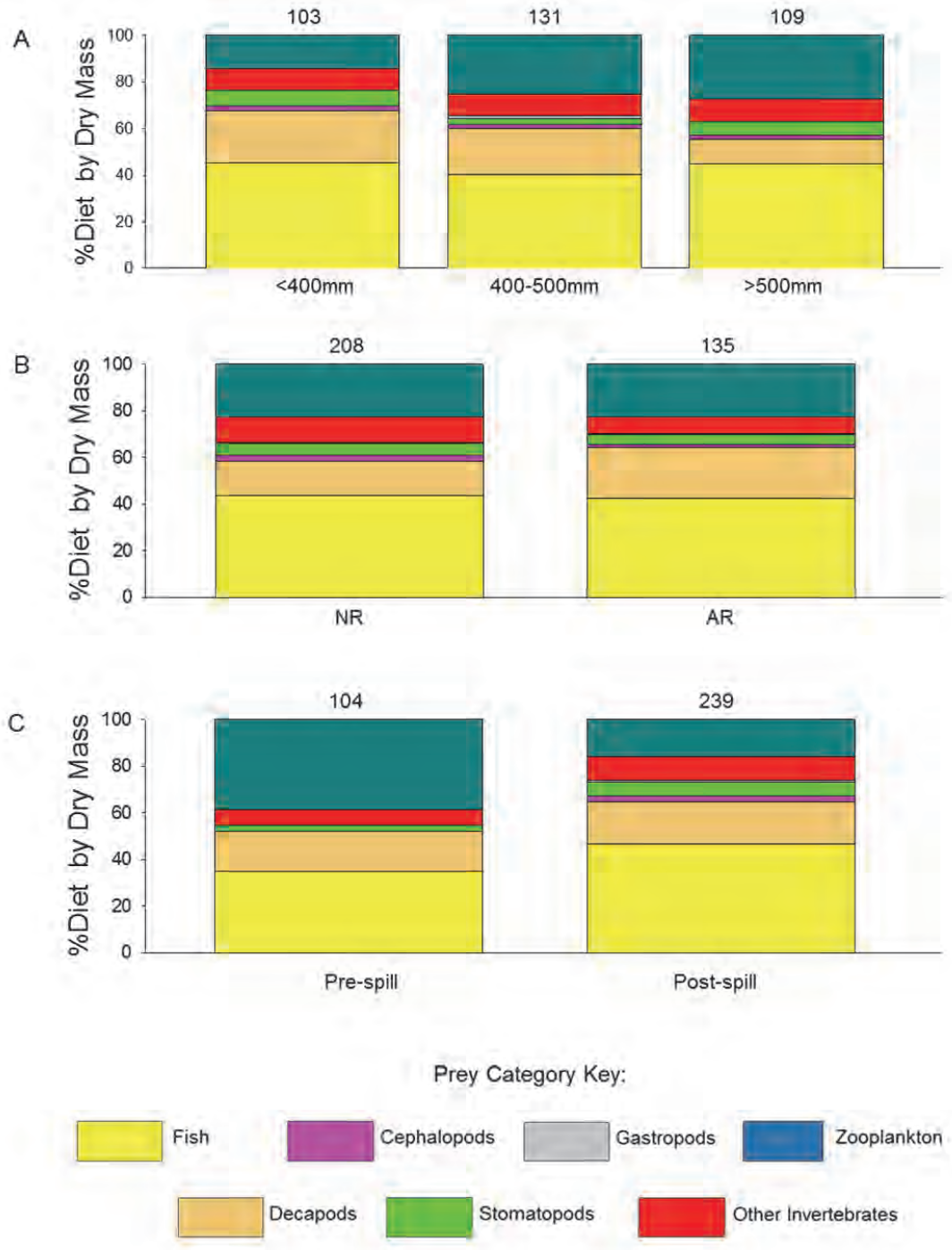


FIGURE 3.—Percent red snapper diet among seven prey categories derived from gut content analysis among **(A)** fish size categories, **(B)** habitat types, and **(C)** pre- versus post-Deepwater Horizon Oil Spill. Sample sizes are listed above the bars.

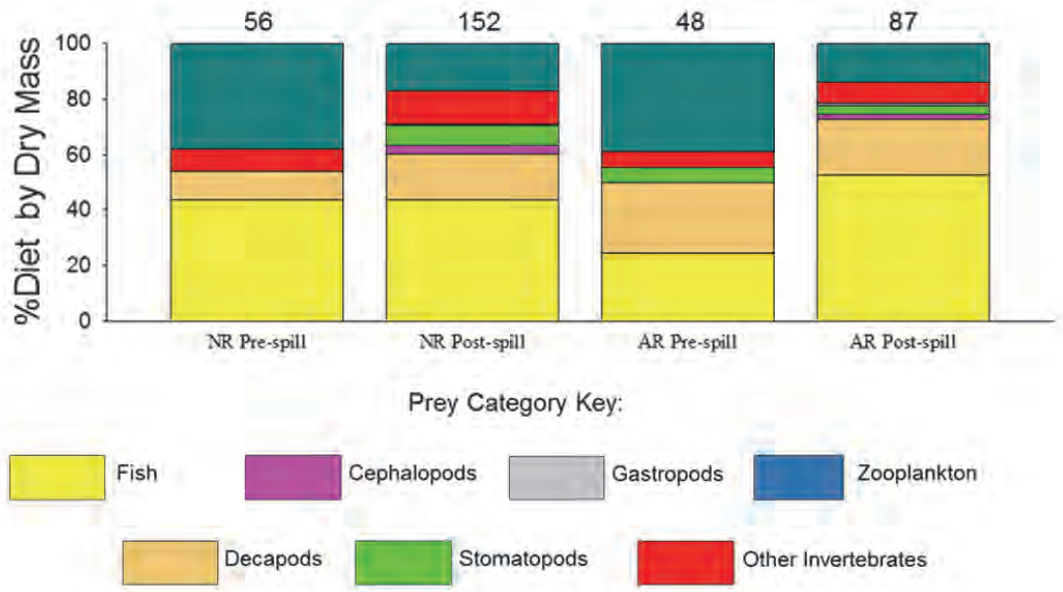


FIGURE 4.—Percent red snapper diet among seven prey categories derived from gut content analysis for the interactions between habitat type and the Deepwater Horizon Oil Spill (DHOS) effect.

**Stable Isotope Analysis**

From SIR-MS analysis, $\delta^{13}C$ values ranged from -16.0 to -18.6‰ with a mean (± SE) value of 17.2‰ ± 0.03, $\delta^{15}N$ ranged from 10.4 to 15.2‰ with a mean value of 13.6‰ ± 0.05, and $\delta^{34}S$ ranged from 15.9 to 20.4‰ with a mean value 18.2‰ ± 0.06 (Figure 6). There were no significant differences in $\delta^{13}C$ among red snapper size classes, habitat type, or pre-versus post-spill samples (ANOVA, $p > 0.086$). The values of $\delta^{15}N$ were significantly different for fish size (ANOVA, $F_{2:198} = 4.31$; $p = 0.015$) and DHOS (ANOVA, $F_{1:198} = 21.65$; $p < 0.001$) (Table 2) suggesting both ontogeny and the DHOS affected feeding ecology. Red snapper had a mean $\delta^{15}N$ value of 13.9‰ ± 0.10 SE for the smallest size class (<400mm), and lower mean values of 13.1‰ ± 0.08 and 13.4‰ ± 0.09 for the two larger size classes. Additionally, pre-spill samples had a lower mean $\delta^{15}N$ (13.4‰ ± 0.10) versus post-spill samples (13.7‰ ± 0.06). The pre-versus post- DHOS samples were also significantly different for $\delta^{34}S$ (ANOVA, $F_{1:198} = 35.46$; $p < 0.001$) (Table 2). Mean $\delta^{34}S$ was 18.7‰ ± 0.10 in samples taken before the oil spill versus 18.0‰ ± 0.06 after the spill.

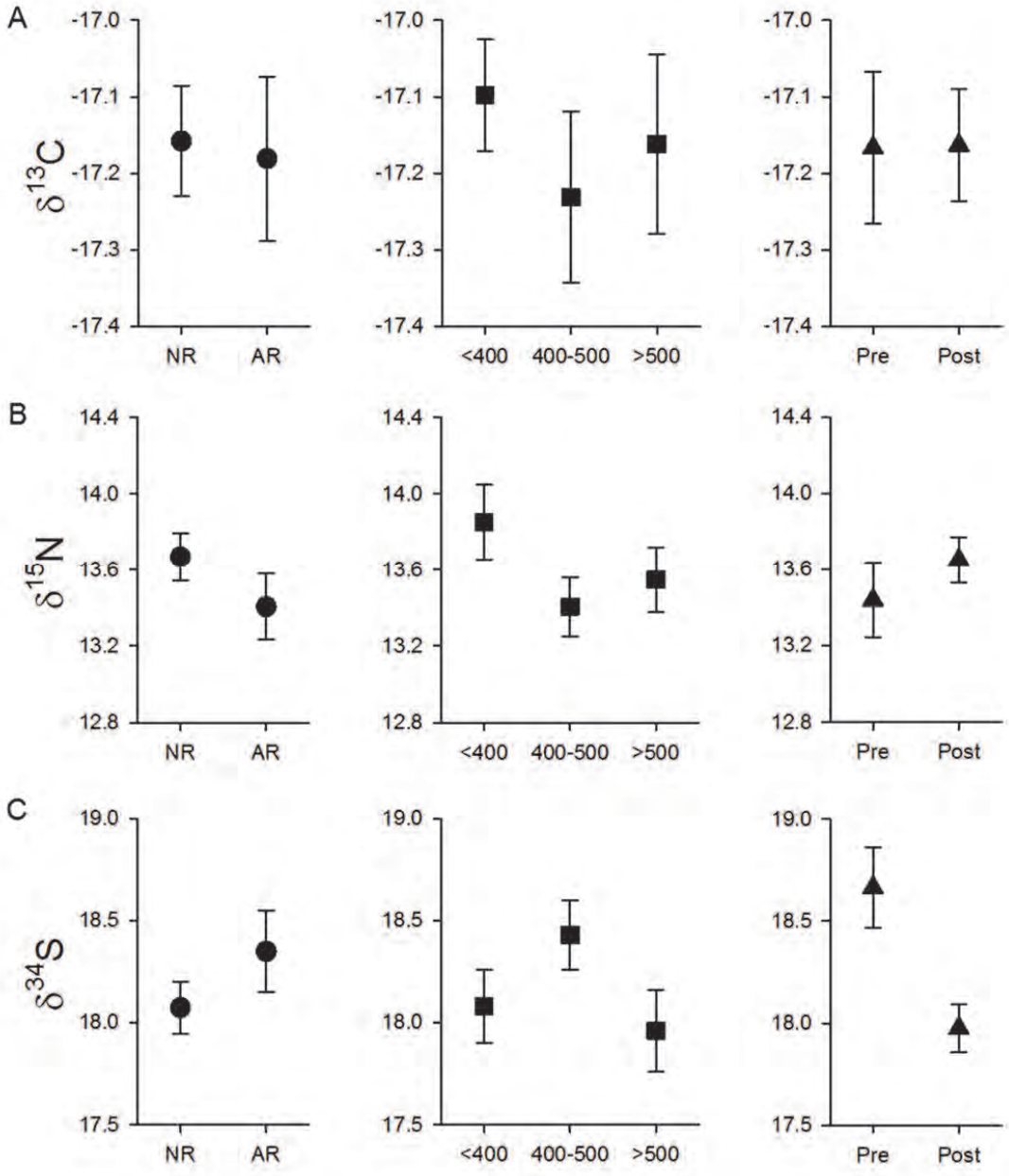


Figure 5.—Mean (±SE) red snapper muscle stable isotope values of **(A)** $\delta^{13}C$, **(B)** $\delta^{15}N$ and **(C)** $\delta^{34}S$ computed for habitat types, fish length categories, and pre- versus post-Deepwater Horizon Oil Spill.

TABLE 2.—Three-way Analysis of Variance (ANOVA) Testing the Effects of Fish Size, Habitat Type and the Deepwater Horizon Oil Spill on Red Snapper Muscle **(A)** $\delta^{13}C$, **(B)** $\delta^{15}N$, and **(C)** $\delta^{34}S$.

(A)

| Source | df | Type III SS | Mean Square | F-Value | Pr > F |
|---|---|---|---|---|---|
| Fish Size | 2 | 0.203 | 0.102 | 0.55 | 0.576 |
| Habitat Type | 1 | 0.015 | 0.015 | 0.08 | 0.778 |
| DHOS | 1 | 0.546 | 0.546 | 2.98 | 0.086 |
| Fish Size x DHOS | 2 | 0.329 | 0.164 | 0.9 | 0.410 |
| Fish Size x Habitat Type | 2 | 0.110 | 0.055 | 0.3 | 0.742 |
| DHOS x Habitat Type | 1 | 0.100 | 0.100 | 0.55 | 0.461 |
| Fish Size x Habitat type x DHOS | 2 | 1.043 | 0.521 | 2.84 | 0.061 |

(B)

| Source | df | Type III SS | Mean Square | F-Value | Pr > F |
|---|---|---|---|---|---|
| Fish Size | 2 | 3.835 | 1.917 | 4.31 | 0.015 |
| Habitat Type | 1 | 0.461 | 0.461 | 1.04 | 0.310 |
| DHOS | 1 | 9.637 | 9.637 | 21.65 | <0.001 |
| Fish Size x DHOS | 2 | 2.045 | 1.022 | 2.3 | 0.104 |
| Fish Size x Habitat Type | 2 | 0.641 | 0.321 | 0.72 | 0.488 |
| DHOS x Habitat Type | 1 | 0.010 | 0.010 | 0.02 | 0.880 |
| Fish Size x Habitat type x DHOS | 2 | 0.042 | 0.021 | 0.05 | 0.954 |

(C)

| Source | df | Type III SS | Mean Square | F-Value | Pr > F |
|---|---|---|---|---|---|
| Fish Size | 2 | 1.523 | 0.762 | 1.56 | 0.213 |
| Habitat Type | 1 | 0.375 | 0.375 | 0.77 | 0.381 |
| DHOS | 1 | 17.292 | 17.292 | 35.46 | <0.001 |
| Fish Size x DHOS | 2 | 0.174 | 0.087 | 0.18 | 0.836 |
| Fish Size x Habitat Type | 2 | 1.435 | 0.718 | 1.47 | 0.232 |
| DHOS x Habitat Type | 1 | 0.752 | 0.752 | 1.54 | 0.216 |
| Fish Size x Habitat type x DHOS | 2 | 0.292 | 0.146 | 0.3 | 0.742 |

# DISCUSSION

Overall, red snapper were found to be generalist predators with prey ranging from zooplankton to fish. A generalist feeding strategy had been noted previously for red snapper (Bradley and Bryan 1975; Siegel 1983), but only McCawley and Cowan (2007) reported a similarly high zooplankton contribution to red snapper diet. Fish prey was the largest contributor to red snapper diet in this study, which is similar to findings by Bradley and Bryan (1975) off the Texas coast, and Bailey (1995) and McCawley and Cowan (2007) off Alabama. Bradley and Bryan (1975) indicated a seasonal variability in red snapper diet as their winter samples consumed greater amounts of crabs than fish sampled during summer. However, Wells et al. (2008) reported seasonal effects were negligible for adult red snapper two years or older, and fish were the predominate prey items in red snapper diets in the current study.

Prey items found in the guts of red snapper were vulnerable to differential digestion and barotrauma effects which caused their stomachs to become everted (Camber 1955; Bradley and Bryan 1975; Siegel 1983; McCawley and Cowan 2007). Partially digested prey in this study resulted in either classifying prey broadly (e.g., order versus family or genus), or as unidentifiable material, while softer-bodied prey, such as Pteropods, may have constituted an even greater percentage of the prey items actually consumed by red snapper than was observed in their stomach samples. Unidentified material made up a relatively small portion of overall diet by dry mass (8.6%), but was consistent with other reports in which it contributed to approximately half (48.1%) of the total diet by %Mass (Seigal 1983; McCawley and Cowan 2007). Differential digestion has been shown to cause errors by underrepresenting soft bodied prey, while more slowly-digested hard parts such as bones, appendages, carapaces, and shells have longer evacuation rates (Hess and Rainwater 1939; Hyslop 1980). Horton (1961) suggested

avoiding numerical counts of individual prey items and using a mean dry weight approach to correct for some of the uncertainty. However, it is still likely that some prey taxa were underrepresented in some cases.

Everted stomachs caused by barotrauma also likely affected diet analysis of red snapper during the current study. Pressure changes associated with fish being brought to the surface rapidly by hook and line fishing expands the swim bladder and forces the esophagus and sometimes the stomach through the buccal cavity (Siegal 1983). The loss of prey due to barotrauma effects is problematic in deeper waters and often requires more samples to be taken to compensate for the loss of prey. In this study, everted stomachs were not factored in the data analysis due to the absence of prey. Approximately 51.6% (365/708) of all red snapper had empty stomachs due to either regurgitation or simply containing no recently ingested prey.

Significant differences were observed in red snapper diet among size classes. Much like Outz and Sedlmayer (2003) described, higher trophic level prey, such as decapods and fish, were dominant in the smallest size class and became less prevalent as red snapper length increased. Although decapod contribution to diet decreased as red snapper TL increased, the mass of individual prey was notably greater in the diet of larger fish. Counterintuitively, zooplankton prey was consumed in greater abundance with increasing size classes, along with slight increases in diversity among stomatopods, cephalopods, and other invertebrates, although McCawley and Cowan (2007) also reported that larger red snapper sampled on artificial reefs had a higher percentage of zooplankton in their diet than smaller fish. Results from $\delta^{15}N$ isotope analysis in the current study corroborate a decrease in red snapper trophic position with increasing size, which also indicates that the observed diet difference was not ephemeral given the turnover time of muscle tissue is typically weeks to months (Fry 2006).

Authors of prior studies reported more of a traditional ontogenetic diet shift, with higher trophic level prey (e.g., fish and crabs) increasing with red snapper size and age (Szedlemayer and Lee 2003; Wells et al. 2008). That trend was confirmed by Wells et al. (2008) with muscle $\delta^{15}N$ values that increased with fish size, thus indicating the increasing trophic position of larger, older red snapper. However; it is important to note that Szedlmayer and Lee (2003) examined diet of age-0 and age-1 red snapper and Wells et al. (2008) examined diet of age-0 to age-3 fish, while the fish examined in the current study were age-3 and older based on otolith aging conducted in a companion study (J. Neese, unpublished data).

McCawley and Cowan (2007) were the first to report adult red snapper subsidized their diet with zooplankton. In their study, zooplankton contribution ranged from 10% to 63% of overall diet for fish between 300 and 499 mm fork length (FL), with the greatest amounts consumed during spring. Alternatively, Parrish (1987) reported that red snapper fed on greater amounts of benthic invertebrates than any other category and placed their foraging range in close proximity to the bottom but with some nektonic prey also being consumed. Szedlemayer and Lee (2004) also reported benthic prey such as shrimp and fish were consumed most heavily by juvenile red snapper. Red snapper examined in the current study primarily fed on fish and decapods, but zooplankton was a major diet component across all sizes categories at both NR and AR sites. Furthermore, zooplankton consumption actually increased for larger fish.

Clearly, others have reported red snapper to be generalist predators with a broad diet, but the fact that larger fish consume relatively small zooplankters was first pointed out by McCawley and Cowan (2007). They concluded that larger red snapper consumed zooplankton as an energetic response either to limited prey resources due to artificial reefs being too closely spaced off Alabama, or that fish preparing for their protracted spawning season (mid spring through

mid-fall) subsidized their predominantly fish and decapods diet with pelagic zooplankton. In the current study, adult red snapper also subsidized their diet with pelagic zooplankton, but that trend did not differ appreciably between natural and artificial reefs. Therefore, it seems more likely that adult red snapper simply shift their food resources relative to local abundance, but also that their diet may broaden during spawning seasons. This later possibility is compounded due to the fact that red snapper spawn during the warmer months of the year when metabolic rates are highest.

Overall, habitat was not a significant factor with respect to red snapper or trophic position, and few reef-dependent taxa were present in red snapper stomach samples regardless of habitat type (Parrish 1987; McCawley 2003). Artificial reefs have typically been shown to aggregate greater densities of large (>250 mm TL) reef fish compared to NRs (Patterson et al. 2009), which may lead to greater competition for resources and decreased food web complexity (Bohnsack and Sutherland 1985). However, only subtle variations in prey consumption were observed in red snapper diet between habitat types in the current study, most notably within pelagic zooplankton (e.g., greater amounts of pteropods on NRs and hyperiid amphipods on ARs), and those differences were most likely related to differential local abundance than to prey selectivity by red snapper. Despite the habitat type examined, red snapper mostly fed on non-reef taxa, thus they foraged away from both artificial and natural reefs. McCawley and Cowan (2007) concluded that red snapper gain little nutrition from reef habitat as they often travel long distances away from reefs to forage on prey most commonly associated with mud and sand habitat, or subsidize their diet with pelagic zooplankton. Outz and Szedlmayer (2003) reported similar prey taxa in red snapper stomach as reported here and by McCawley and Cowan (2007).

Overall, the lack of reef-associated prey in red snapper stomachs indicates a reliance on non-reef foraging habitat, regardless of whether fish are associated with natural and artificial reefs. That finding, much like the consumption of zooplankton being common between red snapper sampled at both natural and artificial reefs, changes the perception of red snapper feeding ecology markedly. Red snapper have an affinity for reef structure, especially as juvenile and sub-adult fish, but they display low site fidelity to individual reefs (e.g., <50% $y^{-1}$) and clearly derive most of their nutrition for adjacent habitats. Given their biomass in the northern GOM, this feeding behavior has the potential to translocate enormous amounts of organic carbon from non-reef to reef habitats (Deegan 1993; Appeldoorn et al. 2009; Berkstrom et al. 2012). Therefore, red snapper themselves may be enhancing reef productivity through horizontal energy transfer.

The factor that had the greatest impact on red snapper diet and trophic ecology was the DHOS, although the significant DHOS main effect on diet cannot be interpreted independently due to the interaction between habitat and DHOS effects. As previously stated, zooplankton consumption decreased similarly at both natural and artificial reefs. On NRs red snapper consumption of decapods, cephalopods, and stomatopods increased, while increased fish consumption was the primary post-DHOS change observed for fish sampled at AR sites. These shifts clearly were persistent for weeks to months as higher post-DHOS muscle $\delta^{15}N$ values and lower $\delta^{34}S$ values indicated a shift to higher trophic level and more benthic prey resources (i.e., less lower trophic level pelagic zooplankton and more higher trophic level benthic decapods and fishes post-DHOS).

Results of studies published after the DHOS indicate the planktonic community was negatively impacted by the DHOS (Graham et al. 2010; Abbriano et al. 2011; Ortmann et al.

2012). Graham et al. (2010) documented oil derived carbon was being consumed by hydrocarbon-degrading microbes and the trophic transfer of oil carbon (indicated by a decrease in $\delta^{13}C$) implied the uptake and transfer of oil compounds through the planktonic foodweb. Ortmann et al. (2012) conducted a mesocosm experiment on the effects of DHOS oil and the Corexit dispersant on plankton and concluded oil compounds could be incorporated into zooplankton biomass, but that the toxicological effects of the oil were magnified with the addition of dispersant which resulted in higher zooplankton mortality. Therefore, the shift in red snapper diet and trophic position following the DHOS likely resulted from the toxicological effects of oil and dispersant negatively impacting zooplankton communities on the shelf, thus shifting the relative abundance of potential red snapper prey.

The objective of adding chemical dispersants to surface slicks was to increase surface area and prohibit gas exchange needed for bacterial biodegradation (Abbriano et al. 2011). However, by increasing the number of microscopic droplets of suspended oil and surface area, instances of exposure of oil to planktonic communities also increased. The accumulation and depuration of hydrocarbons by zooplankton causes physiological and developmental damage to the organisms (Davenport et al. 1982). Additionally, crude oil plus Corexit (specifically 9527) has been shown to be more toxic to phytoplankton and fish larvae than only crude oil alone (Hasio et al. 1978; Middaugh and Whiting 1995; Ortmann et al. 2012). In zooplankton, toxicological effects associated with oil and dispersants ranged from membrane permeability differences, decreased respiration, and lysis (Singer et al. 1991). Therefore, while adding Corexit to surface oil likely kept larger amounts of oil from reaching shorelines, a negative side effect of that policy was likely the degradation of plankton communities. Given the broad diet of red snapper, that impact

was recorded in its diet and muscle stable isotope values, which seems fairly remarkable given the large size (to 1,000 mm TL and 25 kg body mass) these fish can attain.

Overall, results of this study contribute significantly to our understanding of red snapper feeding ecology. No difference was observed in red snapper diet or trophic position between natural and artificial reefs, thus indicating no trophic advantage for fish associated with either habitat type. Furthermore, earlier suggestions that adult red snapper associated with ARs may subsidize their diet with zooplankton due to reefs being too closely spaced are not supported by the fact that fish on NRs had a similar contribution of zooplankton to their diet. The fact that zooplankton consumption increased with red snapper size supports the hypothesis that mature fish subsidize their diets with zooplankton due to energetic demands of spawning, although *post hoc* analysis of pre-DHOS data indicate no significant difference in diet between males and females. Lastly, initial samples collected in 2009-10 provided a unique opportunity to test the effect of the DHOS on red snapper diet and trophic position, which was significant. Oddly enough, these relatively large generalist predators may have been the perfect species to examine such an effect given the fact they typically consume zooplankton but can easily shift their diet to match local abundance of prey taxa. The fact that muscle stable isotope ratios exactly matched the trophic signal apparent in the stomach content data provides greater confidence that stable isotope approaches could be applied to examine the trophic impacts of the DHOS for other fishes for which pre-DHOS muscle isotope data may exist but for which little diet data are available.

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# APPENDICES

# Appendix A

## Animal Care and Use Acceptance Form

University of West Florida

Research and Sponsored Programs
11000 University Parkway, Bldg. 11
Pensacola, FL 32514-5750

# MEMORANDUM

October 20, 2010

TO: Mr. Joseph H. Tarnecki
Dr. William F. Patterson III
Biology Department

FROM: Dr. Richard S. Podemski, Associate Vice President for Research and Dean of the Graduate School

SUBJECT: Institutional Animal Care and Use Committee (IACUC) Approval

The IACUC has completed its review of your proposal entitled "Analysis of Reef Fish Diet at Natural and Artificial Reefs in the Northeastern Gulf of Mexico" and has granted approval for you to proceed with your study. Please note the following:

- Prior IACUC approval is required for significant changes to your protocol.
- The maximum approval period is three years. Should your project continue beyond the three-year period, you must request IACUC approval prior to the end of the approval period.
- Annual status reports may be required by the IACUC. These reports must include a complete description of any and all changes in your project.

Please take time to review our IACUC web page at: http://research.uwf.edu/internal/integrity/iacuc.cfm which includes the IACUC Policies and Procedures, the PHS Policy on Humane Care and Use of Laboratory Animals, the Guide for the Care and Use of Laboratory Animals, and other pertinent IACUC documents.

Good luck in your research endeavors.

CC: Dr. George Stewart, IACUC Chair

Phone 850.474.2824 Fax 850.474.2082
Web research.uwf.edu
An Equal Opportunity/Equal Access/Affirmative Action Employer

Appendix B

Sampling Cruises and Seabird 19+ CTD Information [Depth (m), Salinity (PSU), Temperature (C), Oxygen (mg/l), Fluorescence ($mg/m^3$), and Beam Transmission (%)] From 2009 to 2011 at all Red Snapper Capture Locations in the Northern Gulf of Mexico.

Appendix B:

| Cruise | Date | Reef Type | Vessel | Site No. | Site | Depth | Salinity | Temperature | Oxygen | Fluorescence | Beam Trans. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 6/11/2009 | AR | Rip Tide | 1 | Avocet | 33 | 35.8 | 22.4 | 7.0 | 10.6 | 91.5 |
| 1 | 6/11/2009 | AR | Rip Tide | 2 | A-Module | 32 | 35.7 | 22.9 | 7.0 | 10.3 | 94.0 |
| 2 | 8/20/2009 | NR | Rip Tide | 3 | Yellow Gravel 1 | 60 | na | na | na | na | na |
| 2 | 8/20/2009 | AR | Rip Tide | 4 | Scaffold Tower AR | 45 | na | na | na | na | na |
| 3 | 9/15/2009 | AR | Rip Tide | 5 | Tire Scaffold | 30 | na | na | na | na | na |
| 3 | 9/15/2009 | NR | Rip Tide | 6 | Tree Bottom | 20 | na | na | na | na | na |
| 4 | 9/24/2009 | NR | Rip Tide | 7 | Yellow Gravel 2 | 60 | na | na | na | na | na |
| 4 | 9/24/2009 | NR | Rip Tide | 3 | Yellow Gravel 1 | 61 | na | na | na | na | na |
| 5 | 10/1/2009 | NR | Rip Tide | 6 | Tree Bottom | 18 | na | na | na | na | na |
| 5 | 10/1/2009 | AR | Rip Tide | 8 | Shipwreck | 31 | na | na | na | na | na |
| 5 | 10/1/2009 | AR | Rip Tide | 9 | Sailboat | 30 | na | na | na | na | na |
| 6 | 11/19/2009 | AR | Rip Tide | 10 | Bridge Rubble | 26 | na | na | na | na | na |
| 6 | 11/19/2009 | NR | Rip Tide | 11 | Greens Hole | 35 | na | na | na | na | na |
| 6 | 11/19/2009 | AR | Rip Tide | 12 | Chicken Coops (CB3) | 29 | na | na | na | na | na |
| 7 | 2/19/2010 | NR | Rip Tide | 7 | Yellow Gravel 2 | 60 | na | na | na | na | na |
| 7 | 2/19/2010 | NR | Rip Tide | 13 | The Edge 2 | 65 | na | na | na | na | na |
| 7 | 2/19/2010 | NR | Rip Tide | 14 | The Edge Site #1 | 67 | na | na | na | na | na |
| 8 | 4/12/2010 | AR | Rip Tide | 15 | Wood Crate | 47 | na | na | na | na | na |
| 8 | 4/12/2010 | NR | Rip Tide | 16 | Edge | 64 | na | na | na | na | na |
| 8 | 4/12/2010 | AR | Rip Tide | 1 | Avocet | 28 | na | na | na | na | na |
| 9 | 4/29/2010 | NR | Rip Tide | 6 | Tree Bottom | 19 | na | na | na | na | na |
| 9 | 4/29/2010 | AR | Rip Tide | 8 | Shipwreck | 27 | na | na | na | na | na |
| 9 | 4/29/2010 | AR | Rip Tide | 9 | Sailboat | 30 | na | na | na | na | na |
| 10 | 5/4/2010 | AR | Rip Tide | 17 | Barge | 32 | na | na | na | na | na |
| 10 | 5/4/2010 | AR | Rip Tide | 18 | Chicken Coops | 37 | na | na | na | na | na |
| 11 | 5/5/2010 | AR | Rip Tide | 19 | Tugboat | 31 | 35.3 | 18.8 | 3.2 | na | na |
| 11 | 5/5/2010 | AR | Rip Tide | 20 | Tank 1 | 24 | 35.3 | 19.1 | 3.9 | na | na |
| 11 | 5/5/2010 | AR | Rip Tide | 21 | Three Barges | 26 | 35.1 | 19.0 | 2.9 | na | na |
| 12 | 5/6/2010 | AR | Rip Tide | 22 | A Frame Pyramid | 32 | 34.5 | 19.9 | 4.3 | na | na |
| 12 | 5/6/2010 | NR | Rip Tide | 11 | Green's Hole | 35 | 34.8 | 19.3 | 4.0 | na | na |

Appendix B Continued:

| Cruise | Date | Reef Type | Vessel | Site No. | Site | Depth | Salinity | Temperature | Oxygen | Fluorescence | Beam Trans. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 12 | 5/6/2010 | AR | Rip Tide | 10 | Bridge Rubble | 33 | 34.8 | 19.3 | 4.4 | na | na |
| 13 | 5/7/2010 | NR | Rip Tide | 23 | Timberhole | 37 | 35.1 | 19.6 | 4.3 | na | na |
| 13 | 5/7/2010 | AR | Rip Tide | 24 | Airplane | 37 | 34.9 | 20.0 | 4.9 | na | na |
| 13 | 5/7/2010 | NR | Rip Tide | 25 | Amberjack Rock | 34 | 35.0 | 19.9 | 4.2 | na | na |
| 14 | 5/12/2010 | AR | Rip Tide | 1 | Avocet | 34 | na | na | na | na | na |
| 15 | 5/20/2010 | AR | Rip Tide | 2 | A-Module | 36 | 35.7 | 19.0 | 4.0 | na | na |
| 15 | 5/20/2010 | AR | Rip Tide | 18 | Chicken Coops | 30 | 34.4 | 21.5 | 4.9 | na | na |
| 15 | 5/20/2010 | AR | Rip Tide | 26 | B-Module | 28 | 34.4 | 21.4 | 4.9 | na | na |
| 16 | 5/21/2010 | NR | Rip Tide | 27 | Unnamed Boat | 32 | 35.4 | 19.7 | 4.0 | na | na |
| 16 | 5/21/2010 | NR | Rip Tide | 28 | Good Rock | 32 | 35.5 | 19.7 | 3.9 | na | na |
| 16 | 5/21/2010 | NR | Rip Tide | 29 | The End | na | 35.3 | 20.3 | 4.4 | na | na |
| 17 | 5/26/2010 | NR | Rip Tide | 30 | Dutch Banks | 23 | 36.0 | 18.4 | 4.4 | na | na |
| 17 | 5/26/2010 | AR | Rip Tide | 24 | Airplane | 27 | na | na | na | na | na |
| 17 | 5/26/2010 | AR | Rip Tide | 17 | Barge | 27 | na | na | na | na | na |
| 18 | 7/28/2010 | NR | Rip Tide | 6 | Tree Bottom | 17 | 33.0 | 29.0 | 4.4 | 11.2 | 90.6 |
| 18 | 7/28/2010 | NR | Rip Tide | 31 | Natural Bottom West 1 | 30 | 35.8 | 22.3 | 3.7 | 11.4 | 91.4 |
| 18 | 7/28/2010 | NR | Rip Tide | 32 | Natural Bottom West 2 | 32 | 35.6 | 22.2 | 3.5 | 10.9 | 91.1 |
| 19 | 8/2/2010 | NR | Rip Tide | 7 | Yellow Gravel 2 | 58 | 36.3 | 18.2 | 3.8 | 9.9 | 96.2 |
| 19 | 8/2/2010 | NR | Rip Tide | 33 | Trysler Grounds 1 | 37 | 36.0 | 21.4 | 3.8 | 11.2 | 96.2 |
| 19 | 8/2/2010 | NR | Rip Tide | 34 | Trysler Grounds 2 | 39 | 36.2 | 21.4 | 3.9 | 11.2 | 95.4 |
| 20 | 8/4/2010 | NR | Rip Tide | 11 | Green's Hole | 35 | 35.9 | 24.0 | 2.8 | 0.3 | 93.7 |
| 20 | 8/4/2010 | NR | Rip Tide | 30 | Dutch Banks | 22 | 35.7 | 23.6 | 4.3 | 10.8 | 92.3 |
| 20 | 8/4/2010 | AR | Rip Tide | 10 | Bridge Rubble | 34 | 36.1 | 21.3 | 4.0 | 10.1 | 91.9 |
| 21 | 8/9/2010 | AR | Rip Tide | 35 | Tire Pyramid | 29 | 35.9 | 21.9 | 2.9 | 11.8 | 93.7 |
| 21 | 8/9/2010 | AR | Rip Tide | 17 | Barge | 26 | 35.7 | 22.9 | 3.2 | 11.1 | 94.7 |
| 21 | 8/9/2010 | AR | Rip Tide | 36 | Tank | 30 | 35.9 | 22.7 | 3.3 | 10.7 | 95.3 |
| 21 | 8/9/2010 | NR | Rip Tide | 37 | Site 3 | 30 | 36.0 | 21.8 | 3.0 | 11.0 | 94.7 |
| 22 | 8/23/2010 | AR | Rip Tide | 38 | Tire Pyramid Alabama | 29 | 36.2 | 21.5 | 2.3 | 11.6 | 88.0 |
| 22 | 8/23/2010 | AR | Rip Tide | 39 | Concrete Pipeline | 36 | 36.3 | 21.5 | 2.5 | 11.3 | 90.7 |
| 22 | 8/23/2010 | NR | Rip Tide | 40 | 1 Tire | 33 | 36.5 | 21.4 | 2.2 | 11.2 | 90.6 |

Appendix B Continued:

| Cruise | Date | Reef Type | Vessel | Site No. | Site | Depth | Salinity | Temperature | Oxygen | Fluorescence | Beam Trans. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 23 | 9/18/2010 | NR | Intimidator | 41 | Mobile Edge | 92 | 36.4 | 19.7 | 3.4 | 9.3 | 85.2 |
| 24 | 10/31/2010 | NR | Backdown | 42 | Destin Edge 4 | 51 | 36.4 | 20.6 | 3.8 | 11.4 | 94.9 |
| 24 | 10/31/2010 | NR | Backdown | 43 | Destin Edge 2 | 51 | 36.2 | 20.5 | 3.8 | 11.6 | 93.8 |
| 24 | 10/31/2010 | NR | Backdown | 44 | Nikki Grounds | 43 | 36.4 | 21.1 | 3.8 | 11.7 | 98.0 |
| 25 | 11/9/2010 | NR | Rip Tide | 45 | Yellow Gravel 3 | 58 | 36.4 | 18.0 | 3.4 | 11.3 | 96.7 |
| 25 | 11/9/2010 | NR | Rip Tide | 7 | Yellow Gravel 2 | 58 | 36.4 | 17.7 | 3.4 | 11.4 | 97.0 |
| 25 | 11/9/2010 | NR | Rip Tide | 3 | Yellow Gravel 1 | 59 | 36.2 | 17.9 | 3.4 | 11.4 | 97.0 |
| 25 | 11/9/2010 | NR | Rip Tide | 46 | The Edge 1 | 65 | 36.0 | 15.6 | 3.1 | 11.5 | 95.9 |
| 26 | 11/10/2010 | NR | Total Package | 30 | Dutch Banks | 21 | 34.4 | 23.0 | 4.7 | 12.6 | 92.4 |
| 26 | 11/10/2010 | NR | Total Package | 33 | Trysler Grounds | 40 | 36.5 | 22.0 | 3.2 | 11.6 | 95.2 |
| 26 | 11/10/2010 | NR | Total Package | 11 | Green's Hole | 33 | 35.5 | 23.9 | 4.2 | 11.3 | 95.1 |
| 27 | 12/3/2010 | NR | Total Package | 30 | Dutch Banks | 22 | 34.9 | 21.0 | 4.9 | 14.9 | 80.3 |
| 27 | 12/3/2010 | NR | Total Package | 11 | Green's Hole | 32 | 34.8 | 20.4 | 5.1 | 13.2 | 94.8 |
| 27 | 12/3/2010 | NR | Total Package | 23 | Timberhole | 35 | 36.4 | 18.9 | 3.4 | 12.5 | 94.2 |
| 27 | 12/3/2010 | NR | Total Package | 25 | Amberjack Rock | 32 | 36.4 | 18.6 | 3.3 | 11.8 | 93.8 |
| 28 | 12/4/2010 | NR | Rip Tide | 6 | Tree Bottom | 17 | 34.2 | 20.2 | 5.0 | 12.9 | 77.0 |
| 28 | 12/4/2010 | NR | Rip Tide | 47 | Tree Bottom 2 | 21 | 34.8 | 21.1 | 4.7 | 12.1 | 79.4 |
| 28 | 12/4/2010 | NR | Rip Tide | 48 | SE Banks | 25 | na | na | na | na | Na |
| 29 | 12/10/2010 | NR | Intimidator | 34 | Trysler Grounds 2 | 39 | 35.5 | 19.8 | 4.9 | 13.0 | 94.6 |
| 29 | 12/10/2010 | NR | Intimidator | 3 | Yellow Gravel 1 | 59 | na | na | na | na | Na |
| 29 | 12/10/2010 | NR | Intimidator | 46 | The Edge 1 | 63 | 36.3 | 17.1 | 3.3 | 12.2 | 95.0 |
| 29 | 12/10/2010 | NR | Intimidator | 49 | The Edge 2 | 62 | 36.3 | 17.4 | 3.1 | 11.8 | 94.3 |
| 30 | 12/20/2010 | AR | Total Package | 50 | Oriskany | 62 | 35.9 | 17.0 | 4.3 | 14.1 | 95.4 |
| 31 | 2/13/2011 | NR | Total Package | 51 | Destin Edge 1 | 57 | 36.1 | 16.4 | 4.3 | 13.1 | 97.0 |
| 32 | 2/15/2011 | NR | Total Package | 32 | Natural Bottom West 2 | 42 | 35.8 | 14.2 | 6.0 | 13.9 | 94.0 |
| 32 | 2/15/2011 | NR | Total Package | 23 | Timberhole | 35 | 35.9 | 15.0 | 4.9 | 12.8 | 94.2 |
| 33 | 2/22/2011 | NR | Backdown | 52 | Mingo Ridge | 47 | 36.1 | 16.3 | 5.0 | 12.5 | 98.0 |
| 33 | 2/22/2011 | NR | Backdown | 28 | Good Rock | 32 | 35.8 | 14.4 | 5.3 | 11.9 | 98.2 |
| 34 | 3/23/2011 | NR | Intimidator | 48 | SE Banks | 25 | 35.3 | 16.6 | 4.8 | 11.9 | 74.5 |
| 34 | 3/23/2011 | NR | Intimidator | 6 | Tree Bottom | 17 | 35.3 | 17.4 | 4.6 | 11.0 | 85.1 |

Appendix B Continued:

| Cruise | Date | Reef Type | Vessel | Site No. | Site | Depth | Salinity | Temperature | Oxygen | Fluorescence | Beam Trans. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 34 | 3/23/2011 | NR | Intimidator | 31 | Natural Bottom West 1 | 29 | 35.5 | 17.0 | 5.2 | 12.0 | 83.2 |
| 35 | 3/29/2011 | AR | Intimidator | 53 | Shrimp Boat | 29 | 35.4 | 17.0 | 4.6 | 12.4 | 92.9 |
| 35 | 3/29/2011 | NR | Intimidator | 54 | No Structure | 29 | 35.4 | 17.0 | 4.6 | 12.2 | 93.5 |
| 35 | 3/29/2011 | AR | Intimidator | 55 | Far Pyramid | 29 | 35.4 | 17.0 | 4.2 | 12.3 | 93.1 |
| 36 | 4/10/2011 | NR | Rip Tide | 33 | Trysler Grounds | 40 | na | na | na | na | Na |
| 36 | 4/10/2011 | NR | Rip Tide | 46 | The Edge 1 | 63 | na | na | na | na | Na |
| 37 | 4/13/2011 | NR | Backdown | 28 | Good Rock | 33 | na | na | na | na | Na |
| 38 | 4/14/2011 | NR | Total Package | 25 | Amberjack Rock | 35 | na | na | na | na | Na |
| 39 | 4/17/2011 | NR | Total Package | 30 | Dutch Banks | 23 | na | na | na | na | Na |
| 39 | 4/17/2011 | NR | Total Package | 11 | Green's Hole | 36 | na | na | na | na | Na |
| 40 | 5/6/2011 | NR | Rip Tide | 41 | Mobile Edge | 46 | 36.3 | 20.2 | 7.3 | 4.1 | Na |
| 40 | 5/6/2011 | NR | Rip Tide | 32 | Natural Bottom West 2 | 41 | 36.0 | 20.3 | 7.3 | 4.1 | Na |
| 40 | 5/6/2011 | NR | Rip Tide | 48 | SE Banks | 24 | 34.5 | 21.7 | 7.2 | 4.1 | Na |
| 41 | 5/11/2011 | NR | Rip Tide | 6 | Tree Bottom | 17 | 34.7 | 21.7 | 7.2 | 4.2 | Na |
| 41 | 5/11/2011 | NR | Rip Tide | 33 | Trysler Grounds | 40 | 37.1 | 21.9 | 7.1 | 3.9 | Na |
| 41 | 5/11/2011 | NR | Rip Tide | 30 | Dutch Banks | 21 | 34.8 | 22.4 | 7.1 | 4.1 | Na |
| 42 | 5/13/2011 | NR | Total Package | 46 | The Edge 1 | 34 | 36.0 | 21.8 | 7.1 | 3.9 | Na |
| 43 | 5/16/2011 | NR | Weather Bird | 43 | Destin Edge 2 | 55 | na | na | na | na | Na |
| 44 | 5/18/2011 | NR | Weather Bird | 7 | Yellow Gravel 2 | 60 | na | na | na | na | Na |
| 44 | 5/18/2011 | NR | Weather Bird | 51 | Destin Edge 1 | 67 | na | na | na | na | Na |
| 45 | 5/19/2011 | NR | Weather Bird | 11 | Green's Hole | 35 | na | na | na | na | Na |
| 46 | 5/26/2011 | NR | Backdown | 44 | Nikki Grounds | 31 | 36.0 | 20.2 | 7.3 | 4.0 | Na |
| 47 | 5/31/2011 | NR | Intimidator | 56 | Site 1 | 29 | 35.9 | 21.4 | 7.2 | 4.1 | Na |
| 47 | 5/31/2011 | AR | Intimidator | 57 | Site 2 | 29 | 35.9 | 21.3 | 7.2 | 4.1 | Na |
| 47 | 6/1/2011 | AR | Intimidator | 58 | Tank 17 | 30 | na | na | na | na | Na |
| 47 | 6/1/2011 | AR | Intimidator | 59 | Site 6 | 23 | na | na | na | na | Na |
| 48 | 7/24/2011 | NR | Rip Tide | 31 | Natural Bottom West | 34 | 36.2 | 23.5 | 1.0 | 0.2 | 83.3 |
| 48 | 7/24/2011 | NR | Rip Tide | 48 | SE Banks | 26 | 36.1 | 24.1 | 1.8 | 0.4 | 86.4 |
| 48 | 7/24/2011 | NR | Rip Tide | 60 | Tree Bottom | 19 | 36.1 | 24.6 | 2.3 | 13.8 | 78.9 |
| 49 | 7/25/2011 | NR | Rip Tide | 3 | Yellow Gravel 1 | 60 | 36.3 | 20.4 | 4.0 | 0.1 | 95.3 |

Appendix B Continued:

| Cruise | Date | Reef Type | Vessel | Site No. | Site | Depth | Salinity | Temperature | Oxygen | Fluorescence | Beam Trans. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 49 | 7/25/2011 | NR | Rip Tide | 33 | Trysler Grounds | 37 | 36.1 | 23.5 | 2.5 | 0.3 | 93.1 |
| 50 | 7/27/2011 | NR | Backdown | 28 | Good Rock | 32 | 36.1 | 22.9 | 3.0 | 0.2 | 95.8 |
| 51 | 7/29/2011 | NR | Total Package | 30 | Dutch Banks | 20 | 32.2 | 28.6 | 4.1 | 0.9 | 81.0 |
| 52 | 8/1/2011 | NR | Backdown | 44 | Nikki Grounds | 32 | 35.6 | 26.3 | 5.0 | 0.4 | 94.2 |
| 52 | 8/1/2011 | NR | Backdown | 25 | Amberjack Rock | 32 | 35.6 | 26.5 | 3.9 | 0.4 | 94.0 |
| 52 | 8/1/2011 | NR | Backdown | 43 | Destin Edge 2 | 52 | 36.0 | 22.3 | 3.5 | 11.2 | 92.4 |
| 53 | 8/4/2011 | NR | Total Package | 30 | Dutch Banks | 21 | 31.5 | 30.7 | 3.5 | 0.4 | 90.9 |

# Appendix C

List of all Prey Taxa (n = 85) Identified in Red Snapper Stomachs

Appendix C:

Prey Items

Fish
- Infraclass Teleost
- Order Anguiliformes
- Order Pleuronectiformes
- Family Balistidae
- Family Clupeidae
- Family Haemulidae larvae
- Family Synodontidae
  - *Bellator* sp.
  - *Micropogonias undulatus*
  - *Peprilus burti*
  - *Peprilus* sp.
  - *Stenotomus caprinus*
  - *Urophycis floridana*
- Unidentifiable Fish

Decapods
- Order Decapoda
  - *Parthenope granulata*
  - *Sicyonia brevirsotris*
- Infraorder Brachyura
  - *Leiolambrus nitidus*
  - *Myropsis quinguespinosa*
  - *Raninoides louisianensis*
- Infraorder Carida
  - *Ogyrides* sp.
- Superfamily Hippoidea
  - *Albunea* sp.
- Family Calappidae
  - *Calappa sulcata*
- Family Paguroidea
- Family Penaeidae
  - *Penaeus aztecus*
- Family Portunidae
  - *Ovalipes floridanus*
  - *Portunis gibbesii*
  - *P. saya*
  - *P. spinacarpus*
  - *P.spinimanus*

Cephalopods
- Class Cephalopoda

Appendix C Continued:

*Loligo* sp.
Order Octopoda

Stomatopods
Order Stomatopoda
Family Squillidae
*Squilla empusa*

Gastropods
Class Gastropoda

Other Invertebrates
Phylum Annelida
Class Polychaeta
Family Chaetophteridae
Phylum Arthropoda
Phylum Nematoda
Phylum Porifera
Division Invertebrata
Subphylum Tunicata
Class Ascidiacea
Subphylum Crustacea
Class Malacostraca
Suborder Asellota
Order Isopoda
*Aegathoa oculata*
*Sphaeroma quadridentata*
Infraclass Cirripedia
Order Sessilia
Class Turbellaria
Worm Tubes

Zooplankton
Class Astroidea larvae
Class Branchiopoda
Order Amphipoda
Family Aoridae
Family Hyperiidae
*Phrosina semiluna*
*Phronima* sp.
Order Cladocera
Order Decapoda Megalopa
Order Decapoda Zoea
Order Lophogastrida

Appendix C Continued:

Order Mysidacea
Family Mysidae
*Mysidopsis* sp.
Order Thecosomata
Infraorder Brachyura megalopa
Superfamily Carinarioidea
Family Scyllaridae larvae
Family Sergestidae
*Lucifer faxoni*
Phyllosoma
Unidentifiable Zooplankton

Appendix D

Red Snapper Diet Indices (g) of all Prey Items (n = 85) for the Factor:

Fish Size (<400, 400-500, >500 mm TL), in the Northern Gulf of Mexico.

Appendix D:

| | <400mm | | 400-500mm | | >500mm | |
|---|---|---|---|---|---|---|
| **Prey Type** | **Mass (g)** | **±(SE)** | **Mass (g)** | **±(SE)** | **Mass (g)** | **±(SE)** |
| Unidentified Material | 2.52 | (0.00) | 5.05 | (0.01) | 18.83 | (0.05) |
| **Total Unidentified Material** | **2.52** | **(0.00)** | **5.05** | **(0.01)** | **18.83** | **(0.05)** |
| | | | | | | |
| Fish | | | | | | |
| Infraclass Teleost | 3.32 | (0.08) | 6.51 | (0.34) | 10.81 | (0.88) |
| Order Anguilliformes | 0.02 | (0.00) | 0.00 | (0.00) | 0.11 | (0.00) |
| Order Pleuronectiformes | 0.01 | (0.00) | 0.00 | (0.00) | 0.00 | (0.00) |
| Family Balistidae | 0.00 | (0.00) | 0.22 | (0.00) | 0.00 | (0.00) |
| Family Clupeidae | 0.00 | (0.00) | 0.00 | (0.00) | 2.14 | (0.00) |
| Family Haemulidae larvae | 0.00 | (0.00) | 0.01 | (0.00) | 0.00 | (0.00) |
| Family Synodontidae | 0.00 | (0.00) | 2.64 | (0.27) | 0.00 | (0.00) |
| *Bellator* sp. | 0.00 | (0.00) | 0.00 | (0.00) | 1.04 | (0.00) |
| *Micropogonias undulatus* | 0.90 | (0.00) | 0.00 | (0.00) | 0.00 | (0.00) |
| *Peprilus burti* | 0.00 | (0.00) | 0.00 | (0.00) | 0.52 | (0.00) |
| *Peprilus* sp. | 0.86 | (0.07) | 0.00 | (0.00) | 0.00 | (0.00) |
| *Stenotomus caprinus* | 0.00 | (0.00) | 5.59 | (0.00) | 15.17 | (1.37) |
| *Urophycis floridana* | 0.00 | (0.00) | 4.11 | (0.00) | 0.00 | (0.00) |
| Unidentifiable Fish | 18.49 | (0.21) | 37.60 | (0.23) | 113.26 | (1.29) |
| **Total Fish** | **23.59** | **(0.15)** | **56.68** | **(0.23)** | **143.05** | **(0.97)** |
| | | | | | | |
| Decapoda | | | | | | |
| Order Decapoda | 0.43 | (0.03) | 0.70 | (0.03) | 0.67 | (0.03) |
| *Parthenope granulate* | 0.54 | (0.00) | 0.68 | (0.00) | 0.00 | (0.00) |
| *Sicyonia brevirsostris* | 0.11 | (0.00) | 1.10 | (0.00) | 1.40 | (0.02) |
| Infraorder Brachyura | 0.29 | (0.02) | 0.47 | (0.06) | 0.32 | (0.00) |
| *Leiolambrus nitidus* | 0.63 | (0.00) | 0.00 | (0.00) | 0.00 | (0.00) |
| *Myropsis quinguespinosa* | 0.03 | (0.00) | 0.00 | (0.00) | 0.00 | (0.00) |
| *Raninoides louisianensis* | 0.61 | (0.00) | 0.00 | (0.00) | 0.00 | (0.00) |
| Infraorder Caridea | 0.00 | (0.00) | 0.01 | (0.00) | 0.00 | (0.00) |
| *Ogyrides* sp. | 0.00 | (0.00) | 0.00 | (0.00) | 0.00 | (0.00) |
| Superfamily Hippoidea | 0.00 | (0.00) | 4.64 | (0.00) | 0.00 | (0.00) |
| *Albunea* sp. | 0.00 | (0.00) | 2.53 | (0.00) | 0.37 | (0.00) |
| Family Calappidae | 0.00 | (0.00) | 0.00 | (0.00) | 5.00 | (2.50) |
| *Calappa sulcata* | 0.00 | (0.00) | 0.60 | (0.00) | 0.00 | (0.00) |
| Family Paguroidea | 0.00 | (0.00) | 0.00 | (0.00) | 0.00 | (0.00) |
| Family Penaeidae | 0.21 | (0.01) | 0.08 | (0.01) | 0.04 | (0.01) |
| *Penaeus aztecus* | 0.00 | (0.00) | 0.03 | (0.00) | 0.00 | (0.00) |
| Family Portunidae | 0.19 | (0.03) | 1.55 | (0.27) | 0.00 | (0.00) |
| *Ovalipes floridanus* | 0.00 | (0.00) | 0.00 | (0.00) | 10.48 | (2.66) |
| *Portunus Gibbesii* | 0.00 | (0.00) | 2.79 | (0.00) | 2.17 | (0.00) |
| *P. saya* | 0.00 | (0.00) | 0.07 | (0.00) | 0.00 | (0.00) |

Appendix D Continued:

| Prey Type | <400mm Mass (g) | ±(SE) | 400-500mm Mass (g) | ±(SE) | >500mm Mass (g) | ±(SE) |
|---|---|---|---|---|---|---|
| *P. spinacarpus* | 0.35 | (0.09) | 0.38 | (0.06) | 0.64 | (0.00) |
| *P. spinimanus* | 0.17 | (0.00) | 0.00 | (0.00) | 0.00 | (0.00) |
| **Total Decapoda** | **3.56** | **(0.03)** | **15.61** | **(0.02)** | **21.08** | **(0.45)** |
| | | | | | | |
| Gastropoda | | | | | | |
| Class Gastropoda | 0.00 | (0.00) | 0.12 | (0.01) | 0.14 | (0.01) |
| **Total Gastropoda** | **0.00** | (0.00) | **0.12** | **(0.01)** | **0.14** | **(0.01)** |
| | | | | | | |
| Cephalopoda | | | | | | |
| Class Cephalopoda | 0.01 | (0.00) | 0.84 | (0.35) | 0.00 | (0.00) |
| Loligo sp. | 0.33 | (0.01) | 0.03 | (0.00) | 0.18 | (0.01) |
| Order Octopoda | 0.00 | (0.00) | 7.19 | (3.59) | 0.00 | (0.00) |
| **Total Cephalopoda** | **0.34** | **(0.03)** | **8.06** | **(1.40)** | **0.18** | **(0.01)** |
| | | | | | | |
| Stomatopoda | | | | | | |
| Order Stomatopoda | 0.36 | (0.06) | 0.10 | (0.01) | 0.85 | (0.03) |
| Family Squillidae | 0.08 | (0.00) | 0.00 | (0.00) | 0.03 | (0.00) |
| Squilla sp. | 2.12 | (0.25) | 0.20 | (0.00) | 0.16 | (0.07) |
| **Total Stomatopoda** | **2.56** | **(0.14)** | **0.30** | **(0.03)** | **1.05** | **(0.02)** |
| | | | | | | |
| Other Invertebrates | | | | | | |
| Phylum Annelida | 0.00 | (0.00) | 0.00 | (0.00) | 0.00 | (0.00) |
| Class Polychaeta | 0.00 | (0.00) | 0.09 | (0.00) | 0.01 | (0.07) |
| Family Chaetophteridae | 0.00 | (0.00) | 0.00 | (0.00) | 0.00 | (0.00) |
| Phylum Echinodermata | 0.00 | (0.00) | 0.00 | (0.00) | 0.01 | (0.07) |
| Phylum Nematoda | 0.00 | (0.00) | 0.00 | (0.00) | 0.00 | (0.00) |
| Phylum Porifera | 0.05 | (0.01) | 0.07 | (0.00) | 0.00 | (0.00) |
| Division Invertebrata | 0.16 | (0.06) | 0.06 | (0.01) | 0.07 | (0.18) |
| Subphylum Tunicata | 0.00 | (0.00) | 0.01 | (0.00) | 0.00 | (0.00) |
| Class Ascidiacea | 0.02 | (0.00) | 0.00 | (0.00) | 0.00 | (0.00) |
| Subphylum Crustacea | 0.00 | (0.00) | 0.11 | (0.03) | 0.06 | (0.13) |
| Class Malacostraca | 0.85 | (0.14) | 1.86 | (0.12) | 0.25 | (0.17) |
| Suborder Asellota | 0.02 | (0.00) | 0.00 | (0.00) | 0.00 | (0.00) |
| Order Isopoda | 0.00 | (0.00) | 0.10 | (4.00) | 0.00 | (0.00) |
| Aegathoa oculata | 0.01 | (0.00) | 0.00 | (0.00) | 0.00 | (0.00) |
| Sphaeroma quadridentata | 0.03 | (0.00) | 0.00 | (0.00) | 0.01 | (0.00) |
| Infraclass Cirripedia | 0.00 | (0.00) | 0.01 | (0.00) | 0.00 | (0.00) |
| Order Sessilia | 0.01 | (0.00) | 0.00 | (0.00) | 0.00 | (0.00) |
| Class Turbellaria | 0.00 | (0.00) | 0.00 | (0.00) | 0.00 | (0.00) |
| Worm Tubes | 0.00 | (0.00) | 0.22 | (0.00) | 0.00 | (0.00) |
| **Total Other Invertebrates** | **1.16** | **(0.04)** | **2.52** | **(0.05)** | **0.41** | **(0.16)** |

Appendix D Continued:

| | <400mm | | 400-500mm | | >500mm | |
|---|---|---|---|---|---|---|
| **Prey Type** | **Mass (g)** | **±(SE)** | **Mass (g)** | **±(SE)** | **Mass (g)** | **±(SE)** |
| Zooplankton | | | | | | |
| Class Astroidea larvae | 0.00 | (0.00) | 0.00 | (0.00) | 0.02 | (0.00) |
| Class Branchiopoda | 0.15 | (0.04) | 1.59 | (0.07) | 4.21 | (1.02) |
| Order Amphipoda | 0.00 | (0.00) | 0.20 | (0.02) | 2.26 | (0.56) |
| Family Aoridae | 0.02 | (0.00) | 0.00 | (0.00) | 0.00 | (0.00) |
| Family Hyperiidae | 0.01 | (0.00) | 0.63 | (0.04) | 0.10 | (0.01) |
| *Phronima* sp. | 0.00 | (0.00) | 0.00 | (0.00) | 0.13 | (0.01) |
| *Phrosina semiluna* | 0.00 | (0.00) | 1.16 | (0.36) | 51.35 | (3.24) |
| Order Cladocera | 0.10 | (0.02) | 0.01 | (0.00) | 1.67 | (0.39) |
| Order Decapoda Megalopa | <0.01 | (0.00) | 0.00 | (0.00) | 0.00 | (0.00) |
| Order Decapoda Zoea | 0.03 | (0.00) | 0.02 | (0.00) | 0.00 | (0.00) |
| Order Lophogastrida | 0.00 | (0.00) | 0.00 | (0.00) | 0.00 | (0.00) |
| Order Mysidacea | 0.00 | (0.00) | 0.00 | (0.00) | 0.70 | (0.07) |
| Family Mysidae | 0.12 | (0.03) | 0.60 | (0.00) | 0.33 | (0.10) |
| *Mysidopsis* sp. | 0.03 | (0.00) | 0.00 | (0.00) | 0.00 | (0.00) |
| Order Thecosomata | 0.06 | (0.01) | 9.12 | (0.20) | 8.77 | (0.51) |
| Infraorder Brachyura Megalopa | 0.01 | (0.00) | 0.08 | (0.01) | 0.02 | (0.00) |
| Superfamily Carinarioidea | 0.27 | (0.02) | 1.29 | (0.03) | 0.33 | (0.03) |
| Family Scyllaridae larvae | 0.00 | (0.00) | 0.00 | (0.00) | 1.07 | (0.00) |
| Family Sergestidae | 0.09 | (0.00) | 0.00 | (0.00) | 0.02 | (0.00) |
| *Lucifer faxoni* | 0.00 | (0.00) | 0.00 | (0.00) | 0.00 | (0.00) |
| Phyllosoma | 0.00 | (0.00) | 0.01 | (0.00) | 0.03 | (0.01) |
| Unknown Zooplankton | 0.00 | (0.00) | 0.00 | (0.00) | 0.08 | (0.00) |
| **Total Zooplankton** | **0.87** | **(0.01)** | **14.72** | **(0.08)** | **71.08** | **(0.66)** |

Appendix E

Red Snapper Diet Indices (g) of all Prey Items (n = 85) for the Factor:

Habitat Type (NRs versus ARs), in the Northern Gulf of Mexico.

Appendix E:

| | NR | | AR | |
|---|---|---|---|---|
| **Prey Type** | **Mass (g)** | **±(SE)** | **Mass (g)** | **±(SE)** |
| Unidentified Material | 18.15 | (0.04) | 8.26 | (0.01) |
| **Total Unidentified Material** | **18.15** | **(0.04)** | **8.26** | **(0.01)** |
| | | | | |
| Fish | | | | |
| Infraclass Teleost | 7.00 | (0.09) | 13.63 | (0.89) |
| Order Anguilliformes | 0.11 | (0.00) | 0.02 | (0.00) |
| Order Pleuronectiformes | 0.00 | (0.00) | 0.01 | (0.00) |
| Family Balistidae | 0.22 | (0.00) | 0.00 | (0.00) |
| Family Clupeidae | 0.00 | (0.00) | 2.14 | (0.00) |
| Family Haemulidae larvae | 0.01 | (0.00) | 0.00 | (0.00) |
| Family Synodontidae | 1.58 | (0.30) | 1.06 | (0.00) |
| *Bellator* sp. | 1.04 | (0.00) | 0.00 | (0.00) |
| *Micropogonias undulates* | 0.90 | (0.00) | 0.00 | (0.00) |
| *Peprilus burti* | 0.00 | (0.00) | 0.52 | (0.00) |
| *Peprilus* sp. | 0.86 | (0.07) | 0.00 | (0.00) |
| *Stenotomus caprinus* | 20.76 | (1.03) | 0.00 | (0.00) |
| *Urophycis floridana* | 4.11 | (0.00) | 0.00 | (0.00) |
| Unidentifiable Fish | 146.71 | (0.78) | 22.64 | (0.15) |
| **Total Fish** | **183.31** | **(0.59)** | **40.01** | **(0.17)** |
| | | | | |
| Decapoda | | | | |
| Order Decapoda | 0.65 | (0.02) | 1.15 | (0.03) |
| *Parthenope granulate* | 0.54 | (0.00) | 0.68 | (0.00) |
| *Sicyonia brevirsostris* | 1.21 | (0.49) | 1.40 | (0.02) |
| Infraorder Brachyura | 0.70 | (0.03) | 0.37 | (0.13) |
| *Leiolambrus nitidus* | 0.00 | (0.00) | 0.63 | (0.00) |
| *Myropsis quinguespinosa* | 0.03 | (0.00) | 0.00 | (0.00) |
| *Raninoides louisianensis* | 0.00 | (0.00) | 0.61 | (0.00) |
| Infraorder Caridea | 0.01 | (0.00) | 0.00 | (0.00) |
| *Ogyrides* sp. | 0.00 | (0.00) | 0.00 | (0.00) |
| Superfamily Hippoidea | 0.00 | (0.00) | 4.64 | (0.00) |
| *Albunea* sp. | 2.53 | (0.00) | 0.37 | (0.00) |
| Family Calappidae | 5.00 | (2.50) | 0.00 | (0.00) |
| *Calappa sulcata* | 0.00 | (0.00) | 0.60 | (0.00) |
| Family Paguroidea | 0.00 | (0.00) | 0.00 | (0.00) |
| Family Penaeidae | 0.20 | (0.01) | 0.12 | (0.01) |
| *Penaeus aztecus* | 0.03 | (0.00) | 0.00 | (0.00) |
| Family Portunidae | 1.34 | (0.28) | 0.41 | (0.07) |
| *Ovalipes floridanus* | 1.32 | (0.00) | 9.16 | (4.21) |
| *Portunus Gibbesii* | 0.00 | (0.00) | 4.96 | (0.31) |
| *P. saya* | 0.07 | (0.00) | 0.00 | (0.00) |

Appendix E Continued:

| | NR | | AR | |
|---|---|---|---|---|
| **Prey Type** | **Mass (g)** | **±(SE)** | **Mass (g)** | **±(SE)** |
| *P. spinacarpus* | 0.35 | (0.09) | 1.01 | (0.15) |
| *P. spinimanus* | 0.17 | (0.00) | 0.00 | (0.00) |
| **Total Decapoda** | **14.15** | **(0.12)** | **26.10** | **(0.27)** |
| | | | | |
| Gastropoda | | | | |
| Class Gastropoda | 0.15 | (0.01) | 0.02 | (0.00) |
| **Total Gastropoda** | **0.15** | **(0.01)** | **0.02** | (0.00) |
| | | | | |
| Cephalopoda | | | | |
| Class Cephalopoda | 0.84 | (0.35) | 0.01 | (0.00) |
| Loligo sp. | 0.32 | (0.02) | 0.22 | (0.02) |
| Order Octopoda | 7.19 | (3.59) | 0.00 | (0.00) |
| **Total Cephalopoda** | **8.35** | **(0.79)** | **0.24** | **(0.02)** |
| | | | | |
| Stomatopoda | | | | |
| Order Stomatopoda | 0.69 | (0.02) | 0.62 | (0.03) |
| Family Squillidae | 0.00 | (0.00) | 0.11 | (0.02) |
| Squilla sp. | 2.28 | (0.23) | 0.22 | (0.10) |
| **Total Stomatopoda** | **2.97** | **(0.07)** | **0.94** | **(0.03)** |
| | | | | |
| Other Invertebrates | | | | |
| Phylum Annelida | 0.00 | (0.00) | 0.00 | (0.00) |
| Class Polychaeta | 0.10 | (0.02) | 0.00 | (0.00) |
| Family Chaetophteridae | 0.00 | (0.00) | 0.00 | (0.00) |
| Phylum Echinodermata | 0.01 | (0.00) | 0.01 | (0.00) |
| Phylum Nematoda | 0.00 | (0.00) | 0.00 | (0.00) |
| Phylum Porifera | 0.00 | (0.00) | 0.12 | (0.01) |
| Division Invertebrata | 0.13 | (0.01) | 0.16 | (0.04) |
| Subphylum Tunicata | 0.01 | (0.00) | 0.00 | (0.00) |
| Class Ascidiacea | 0.02 | (0.00) | 0.00 | (0.00) |
| Subphylum Crustacea | 0.02 | (0.00) | 0.15 | (0.02) |
| Class Malacostraca | 2.89 | (0.07) | 0.07 | (0.00) |
| Suborder Asellota | 0.00 | (0.00) | 0.02 | (0.00) |
| Order Isopoda | 0.10 | (0.05) | 0.01 | (0.00) |
| Aegathoa oculata | 0.01 | (0.00) | 0.00 | (0.00) |
| Sphaeroma quadridentata | 0.03 | (0.00) | 0.01 | (0.00) |
| Infraclass Cirripedia | 0.00 | (0.00) | 0.01 | (0.00) |
| Order Sessilia | 0.01 | (0.00) | 0.00 | (0.00) |
| Class Turbellaria | 0.00 | (0.00) | 0.00 | (0.00) |
| Worm Tubes | 0.00 | (0.00) | 0.22 | (0.00) |
| **Total Other Invertebrates** | **3.32** | **(0.04)** | **0.78** | **(0.01)** |

Appendix E Continued:

| | NR | | AR | |
|---|---|---|---|---|
| **Prey Type** | **Mass (g)** | **±(SE)** | **Mass (g)** | **±(SE)** |
| Zooplankton | | | | |
| Class Astroidea larvae | 0.00 | (0.00) | 0.02 | (0.00) |
| Class Branchiopoda | 5.88 | (0.31) | 0.07 | (0.00) |
| Order Amphipoda | 0.10 | (0.01) | 2.36 | (0.74) |
| Family Aoridae | 0.00 | (0.00) | 0.02 | (0.00) |
| Family Hyperiidae | 0.12 | (0.00) | 0.63 | (0.03) |
| *Phronima* sp. | 0.00 | (0.00) | 0.13 | (0.01) |
| *Phrosina semiluna* | 3.05 | (0.29) | 49.46 | (4.62) |
| Order Cladocera | 1.74 | (0.17) | 0.03 | (0.00) |
| Order Decapoda Megalopa | 0.00 | (0.00) | 0.00 | (0.00) |
| Order Decapoda Zoea | 0.03 | (0.00) | 0.02 | (0.00) |
| Order Lophogastrida | 0.00 | (0.00) | 0.00 | (0.00) |
| Order Mysidacea | 0.00 | (0.00) | 0.70 | (0.07) |
| Family Mysidae | 0.70 | (0.12) | 0.35 | (0.15) |
| *Mysidopsis* sp. | 0.00 | (0.00) | 0.03 | (0.00) |
| Order Thecosomata | 14.70 | (0.36) | 3.25 | (0.12) |
| Infraorder Brachyura Megalopa | 0.10 | (0.01) | 0.01 | (0.00) |
| Superfamily Carinarioidea | 1.32 | (0.03) | 0.57 | (0.02) |
| Family Scyllaridae larvae | 0.00 | (0.00) | 1.07 | (0.00) |
| Family Sergestidae | 0.11 | (0.03) | 0.00 | (0.00) |
| *Lucifer faxoni* | 0.00 | (0.00) | 0.00 | (0.00) |
| Phyllosoma | 0.03 | (0.01) | 0.01 | (0.00) |
| Unknown Zooplankton | 0.00 | (0.00) | 0.08 | (0.00) |
| **Total Zooplankton** | **27.87** | **(0.11)** | **58.80** | **(0.62)** |

Appendix F

Red Snapper Diet Indices (g) of all Prey Items (n = 85) for the Factor:

Timing (Pre- versus Post-DHOS), in the Northern Gulf of Mexico.

Appendix F:

| | Before | | After | |
|---|---|---|---|---|
| **Prey Type** | **Mass (g)** | **±(SE)** | **Mass (g)** | **±(SE)** |
| Unidentified Material | 10.79 | (0.02) | 15.62 | (0.03) |
| **Total Unidentified Material** | **10.79** | **(0.02)** | **15.62** | **(0.03)** |
| | | | | |
| Fish | | | | |
| Infraclass Teleost | 6.21 | (0.09) | 14.43 | (0.96) |
| Order Anguilliformes | 0.02 | (0.00) | 0.11 | (0.00) |
| Order Pleuronectiformes | 0.00 | (0.00) | 0.01 | (0.00) |
| Family Balistidae | 0.22 | (0.00) | 0.00 | (0.00) |
| Family Clupeidae | 0.00 | (0.00) | 2.14 | (0.00) |
| Family Haemulidae larvae | 0.01 | (0.00) | 0.00 | (0.00) |
| Family Synodontidae | 0.00 | (0.00) | 2.64 | (0.27) |
| *Bellator* sp. | 0.00 | (0.00) | 1.04 | (0.00) |
| *Micropogonias undulatus* | 0.00 | (0.00) | 0.90 | (0.00) |
| *Peprilus burti* | 0.52 | (0.00) | 0.00 | (0.00) |
| *Peprilus* sp. | 0.00 | (0.00) | 0.86 | (0.07) |
| *Stenotomus caprinus* | 0.00 | (0.00) | 20.76 | (1.03) |
| *Urophycis floridana* | 0.00 | (0.00) | 4.11 | (0.00) |
| Unidentifiable Fish | 3.17 | (0.05) | 166.18 | (0.57) |
| **Total Fish** | **10.14** | **(0.05)** | **213.19** | **(0.50)** |
| | | | | |
| Decapoda | | | | |
| Order Decapoda | 0.92 | (0.03) | 0.88 | (0.02) |
| *Parthenope granulata* | 1.21 | (0.07) | 0.00 | (0.00) |
| *Sicyonia brevirsostris* | 0.73 | (0.00) | 1.89 | (0.29) |
| Infraorder Brachyura | 0.32 | (0.00) | 0.76 | (0.03) |
| *Leiolambrus nitidus* | 0.00 | (0.00) | 0.63 | (0.00) |
| *Myropsis quinguespinosa* | 0.03 | (0.00) | 0.00 | (0.00) |
| *Raninoides louisianensis* | 0.61 | (0.00) | 0.00 | (0.00) |
| Infraorder Caridea | 0.00 | (0.00) | 0.01 | (0.00) |
| *Ogyrides* sp. | 0.00 | (0.00) | 0.00 | (0.00) |
| Superfamily Hippoidea | 0.00 | (0.00) | 4.64 | (0.00) |
| *Albunea* sp. | 0.00 | (0.00) | 2.90 | (1.08) |
| Family Calappidae | 0.00 | (0.00) | 5.00 | (0.00) |
| *Calappa sulcata* | 0.60 | (0.00) | 0.00 | (0.00) |
| Family Paguroidea | 0.00 | (0.00) | 0.00 | (0.00) |
| Family Penaeidae | 0.21 | (0.01) | 0.11 | (0.01) |
| *Penaeus aztecus* | 0.00 | (0.00) | 0.03 | (0.00) |
| Family Portunidae | 0.44 | (0.06) | 1.30 | (0.29) |
| *Ovalipes floridanus* | 0.00 | (0.00) | 10.48 | (2.66) |
| *Portunus Gibbesii* | 4.96 | (0.31) | 0.00 | (0.00) |
| *P. saya* | 0.00 | (0.00) | 0.07 | (0.00) |

Appendix F Continued:

| | Before | | After | |
|---|---|---|---|---|
| **Prey Type** | **Mass (g)** | **±(SE)** | **Mass (g)** | **±(SE)** |
| *P. spinacarpus* | 0.00 | (0.00) | 1.36 | (0.10) |
| *P. spinimanus* | 0.17 | (0.00) | 0.00 | (0.00) |
| **Total Decapoda** | **10.19** | **(0.12)** | **30.06** | **(0.20)** |
| | | | | |
| Gastropoda | | | | |
| Class Gastropoda | 0.12 | (0.01) | 0.04 | (0.00) |
| **Total Gastropoda** | **0.12** | **(0.01)** | **0.04** | (0.00) |
| | | | | |
| Cephalopoda | | | | |
| Class Cephalopoda | 0.08 | (0.03) | 0.77 | (0.00) |
| Loligo sp. | 0.07 | (0.00) | 0.47 | (0.02) |
| Order Octopoda | 0.00 | (0.00) | 7.19 | (3.59) |
| **Total Cephalopoda** | **0.15** | **(0.02)** | **8.43** | **(0.71)** |
| | | | | |
| Stomatopoda | | | | |
| Order Stomatopoda | 0.59 | (0.06) | 0.72 | (0.01) |
| Family Squillidae | 0.03 | (0.00) | 0.08 | (0.00) |
| Squilla sp. | 0.01 | (0.00) | 2.48 | (0.19) |
| **Total Stomatopoda** | **0.64** | **(0.04)** | **3.27** | **(0.05)** |
| | | | | |
| Other Invertebrates | | | | |
| Phylum Annelida | 0.00 | (0.00) | 0.00 | (0.00) |
| Class Polychaeta | 0.00 | (0.00) | 0.10 | (0.02) |
| Family Chaetophteridae | 0.00 | (0.00) | 0.00 | (0.00) |
| Phylum Echinodermata | 0.00 | (0.00) | 0.01 | (0.00) |
| Phylum Nematoda | 0.00 | (0.00) | 0.00 | (0.00) |
| Phylum Porifera | 0.00 | (0.00) | 0.12 | (0.01) |
| Division Invertebrata | 0.22 | (0.02) | 0.07 | (0.01) |
| Subphylum Tunicata | 0.01 | (0.00) | 0.00 | (0.00) |
| Class Ascidiacea | 0.02 | (0.00) | 0.00 | (0.00) |
| Subphylum Crustacea | 0.17 | (0.01) | 0.00 | (0.00) |
| Class Malacostraca | 0.00 | (0.00) | 2.96 | (0.07) |
| Suborder Asellota | 0.02 | (0.00) | 0.00 | (0.00) |
| Order Isopoda | 0.00 | (0.00) | 0.10 | (0.02) |
| Aegathoa oculata | 0.00 | (0.00) | 0.01 | (0.00) |
| Sphaeroma quadridentata | 0.04 | (0.01) | 0.00 | (0.00) |
| Infraclass Cirripedia | 0.00 | (0.00) | 0.01 | (0.00) |
| Order Sessilia | 0.01 | (0.00) | 0.00 | (0.00) |
| Class Turbellaria | 0.00 | (0.00) | 0.00 | (0.00) |
| Worm Tubes | 0.00 | (0.00) | 0.22 | (0.00) |
| **Total Other Invertebrates** | **0.49** | **(0.01)** | **3.61** | **(0.03)** |

Appendix F Continued:

| Prey Type | Before Mass (g) | ±(SE) | After Mass (g) | ±(SE) |
|---|---|---|---|---|
| Zooplankton | | | | |
| Class Astroidea larvae | 0.02 | (0.00) | 0.00 | (0.00) |
| Class Branchiopoda | 5.95 | (0.29) | 0.00 | (0.00) |
| Order Amphipoda | 2.26 | (0.56) | 0.20 | (0.02) |
| Family Aoridae | 0.02 | (0.00) | 0.00 | (0.00) |
| Family Hyperiidae | 0.10 | (0.01) | 0.64 | (0.02) |
| *Phronima* sp. | 0.13 | (0.01) | 0.00 | (0.00) |
| *Phrosina semiluna* | 52.51 | (55.02) | 0.00 | (0.00) |
| Order Cladocera | 1.59 | (0.79) | 0.18 | (0.01) |
| Order Decapoda Megalopa | 0.00 | (0.00) | 0.01 | (0.00) |
| Order Decapoda Zoea | 0.00 | (0.00) | 0.05 | (0.00) |
| Order Lophogastrida | 0.00 | (0.00) | 0.00 | (0.00) |
| Order Mysidacea | 0.70 | (0.07) | 0.00 | (0.00) |
| Family Mysidae | 1.05 | (0.09) | 0.00 | (0.00) |
| *Mysidopsis* sp. | 0.03 | (0.00) | 0.00 | (0.00) |
| Order Thecosomata | 15.06 | (0.37) | 2.89 | (0.11) |
| Infraorder Brachyura Megalopa | 0.00 | (0.00) | 0.11 | (0.00) |
| Superfamily Carinarioidea | 0.00 | (0.00) | 1.90 | (0.02) |
| Family Scyllaridae larvae | 1.07 | (0.00) | 0.00 | (0.00) |
| Family Sergestidae | 0.00 | (0.00) | 0.11 | (0.03) |
| *Lucifer faxoni* | 0.00 | (0.00) | 0.00 | (0.00) |
| Phyllosoma | 0.00 | (0.00) | 0.03 | (0.01) |
| Unknown Zooplankton | 0.08 | (0.00) | 0.00 | (0.00) |
| **Total Zooplankton** | **80.56** | **(0.60)** | **6.11** | **(0.02)** |

Appendix G

Red Snapper Diet Indices (% Mass) of all Prey Items (n=85) for the Factor: Fish Length (<400, 400-500, >500mm TL), in the Northern Gulf of Mexico.

Appendix G:

| | <400mm | | 400-500mm | | >500mm | |
|---|---|---|---|---|---|---|
| **Prey Type** | **%Mass** | **±(SE)** | **%Mass** | **±(SE)** | **%Mass** | **±(SE)** |
| Unidentified Material | 47.47 | (0.01) | 44.20 | (0.01) | 53.13 | (0.02) |
| **Total Unidentified Material** | **47.47** | **(0.01)** | **44.20** | **(0.01)** | **53.13** | **(0.02)** |
| | | | | | | |
| Fish | | | | | | |
| Infraclass Teleost | 3.42 | (0.24) | 2.73 | (0.33) | 1.70 | (0.34) |
| Order Anguilliformes | 0.02 | (0.00) | 0.00 | (0.00) | 0.02 | (0.00) |
| Order Pleuronectiformes | 0.01 | (0.00) | 0.00 | (0.00) | 0.00 | (0.00) |
| Family Balistidae | 0.00 | (0.00) | 0.09 | (0.00) | 0.00 | (0.00) |
| Family Clupeidae | 0.00 | (0.00) | 0.00 | (0.00) | 0.34 | (0.00) |
| Family Haemulidae larvae | 0.00 | (0.00) | 0.00 | (0.00) | 0.00 | (0.00) |
| Family Synodontidae | 0.00 | (0.00) | 1.11 | (0.26) | 0.00 | (0.00) |
| *Bellator* sp. | 0.00 | (0.00) | 0.00 | (0.00) | 0.16 | (0.00) |
| *Micropogonias undulatus* | 0.93 | (0.00) | 0.00 | (0.00) | 0.00 | (0.00) |
| *Peprilus burti* | 0.00 | (0.00) | 0.00 | (0.00) | 0.08 | (0.00) |
| *Peprilus* sp. | 0.89 | (0.20) | 0.00 | (0.00) | 0.00 | (0.00) |
| *Stenotomus caprinus* | 0.00 | (0.00) | 2.35 | (0.00) | 2.38 | (0.53) |
| *Urophycis floridana* | 0.00 | (0.00) | 1.73 | (0.00) | 0.00 | (0.00) |
| Unidentifiable Fish | 19.05 | (0.28) | 15.79 | (0.15) | 17.80 | (0.26) |
| **Total Fish** | **24.31** | **(0.45)** | **23.80** | **(0.23)** | **22.48** | **(0.38)** |
| | | | | | | |
| Decapoda | | | | | | |
| Order Decapoda | 1.57 | (0.09) | 0.51 | (0.03) | 0.19 | (0.01) |
| *Parthenope granulata* | 1.98 | (0.00) | 0.49 | (0.00) | 0.00 | (0.00) |
| *Sicyonia brevirsostris* | 0.41 | (0.00) | 0.80 | (0.00) | 0.40 | (0.01) |
| Infraorder Brachyura | 1.07 | (0.05) | 0.34 | (0.06) | 0.09 | (0.00) |
| *Leiolambrus nitidus* | 2.30 | (0.00) | 0.00 | (0.00) | 0.00 | (0.00) |
| *Myropsis quinguespinosa* | 0.11 | (0.00) | 0.00 | (0.00) | 0.00 | (0.00) |
| *Raninoides louisianensis* | 2.25 | (0.00) | 0.00 | (0.00) | 0.00 | (0.00) |
| Infraorder Caridea | 0.00 | (0.00) | 0.01 | (0.00) | 0.00 | (0.00) |
| *Ogyrides* sp. | 0.00 | (0.00) | 0.00 | (0.00) | 0.00 | (0.00) |
| Superfamily Hippoidea | 0.00 | (0.00) | 3.37 | (0.00) | 0.00 | (0.00) |
| *Albunea* sp. | 0.00 | (0.00) | 1.84 | (0.00) | 0.11 | (0.00) |
| Family Calappidae | 0.00 | (0.00) | 0.00 | (0.00) | 1.44 | (0.98) |
| *Calappa sulcata* | 0.00 | (0.00) | 0.43 | (0.00) | 0.00 | (0.00) |
| Family Paguroidea | 0.00 | (0.00) | 0.00 | (0.00) | 0.00 | (0.00) |
| Family Penaeidae | 0.76 | (0.03) | 0.05 | (0.01) | 0.01 | (0.00) |
| *Penaeus aztecus* | 0.00 | (0.00) | 0.02 | (0.00) | 0.00 | (0.00) |
| Family Portunidae | 0.70 | (0.08) | 1.13 | (0.26) | 0.00 | (0.00) |
| *Ovalipes floridanus* | 0.00 | (0.00) | 0.00 | (0.00) | 3.01 | (1.04) |
| *Portunus Gibbesii* | 0.00 | (0.00) | 2.03 | (0.00) | 0.62 | (0.00) |
| *P. saya* | 0.00 | (0.00) | 0.05 | (0.00) | 0.00 | (0.00) |

Appendix G Continued:

| | <400mm | | 400-500mm | | >500mm | |
|---|---|---|---|---|---|---|
| **Prey Type** | **%Mass** | **±(SE)** | **%Mass** | **±(SE)** | **%Mass** | **±(SE)** |
| *P. spinacarpus* | 1.29 | (0.25) | 0.27 | (0.05) | 0.18 | (0.00) |
| *P. spinimanus* | 0.61 | (0.00) | 0.00 | (0.00) | 0.00 | (0.00) |
| **Total Decapoda** | **13.05** | **(0.09)** | **11.35** | **(0.02)** | **6.06** | **(0.17)** |
| | | | | | | |
| Gastropoda | | | | | | |
| Class Gastropoda | 0.05 | (0.00) | 0.58 | (0.01) | 0.05 | (0.01) |
| **Total Gastropoda** | **0.05** | **(0.00)** | **0.58** | **(0.01)** | **0.05** | **(0.01)** |
| | | | | | | |
| Cephalopoda | | | | | | |
| Class Cephalopoda | 0.04 | (0.00) | 0.09 | (0.34) | 0.00 | (0.00) |
| Loligo sp. | 1.23 | (0.02) | 0.00 | (0.00) | 1.07 | (0.00) |
| Order Octopoda | 0.00 | (0.00) | 0.81 | (3.48) | 0.00 | (0.00) |
| **Total Cephalopoda** | **1.27** | **(0.07)** | **0.91** | **(1.36)** | **1.07** | **(0.00)** |
| | | | | | | |
| Stomatopoda | | | | | | |
| Order Stomatopoda | 0.51 | (0.16) | 0.29 | (0.01) | 1.80 | (0.01) |
| Family Squillidae | 0.11 | (0.00) | 0.00 | (0.00) | 0.07 | (0.00) |
| Squilla sp. | 3.02 | (0.72) | 0.60 | (0.00) | 0.35 | (0.03) |
| **Total Stomatopoda** | **3.64** | **(0.41)** | **0.89** | **(0.03)** | **2.22** | **(0.01)** |
| | | | | | | |
| Other Invertebrates | | | | | | |
| Phylum Annelida | 0.00 | (0.00) | 0.00 | (0.00) | 0.00 | (0.00) |
| Class Polychaeta | 0.00 | (0.00) | 0.16 | (0.00) | 0.09 | (0.03) |
| Family Chaetophteridae | 0.00 | (0.00) | 0.00 | (0.00) | 0.00 | (0.00) |
| Phylum Echinodermata | 0.00 | (0.00) | 0.00 | (0.00) | 0.12 | (0.03) |
| Phylum Nematoda | 0.00 | (0.00) | 0.00 | (0.00) | 0.00 | (0.00) |
| Phylum Porifera | 0.20 | (0.01) | 0.13 | (0.00) | 0.00 | (0.00) |
| Division Invertebrata | 0.61 | (0.17) | 0.11 | (0.01) | 0.73 | (0.07) |
| Subphylum Tunicata | 0.00 | (0.00) | 0.02 | (0.00) | 0.00 | (0.00) |
| Class Ascidiacea | 0.09 | (0.00) | 0.00 | (0.00) | 0.00 | (0.00) |
| Subphylum Crustacea | 0.00 | (0.00) | 0.21 | (0.02) | 0.63 | (0.05) |
| Class Malacostraca | 3.19 | (0.40) | 3.55 | (0.11) | 2.55 | (0.07) |
| Suborder Asellota | 0.07 | (0.00) | 0.00 | (0.00) | 0.00 | (0.00) |
| Order Isopoda | 0.00 | (0.00) | 0.20 | (3.88) | 0.00 | (0.00) |
| Aegathoa oculata | 0.05 | (0.00) | 0.00 | (0.00) | 0.00 | (0.00) |
| Sphaeroma quadridentata | 0.12 | (0.00) | 0.00 | (0.00) | 0.06 | (0.00) |
| Infraclass Cirripedia | 0.00 | (0.00) | 0.03 | (0.00) | 0.00 | (0.00) |
| Order Sessilia | 0.02 | (0.00) | 0.00 | (0.00) | 0.00 | (0.00) |
| Class Turbellaria | 0.00 | (0.00) | 0.00 | (0.00) | 0.00 | (0.00) |
| Worm Tubes | 0.00 | (0.00) | 0.41 | (0.00) | 0.00 | (0.00) |
| **Total Other Invertebrates** | **4.35** | **(0.13)** | **4.83** | **(0.05)** | **4.19** | **(0.06)** |

Appendix G Continued:

| Prey Type | <400mm %Mass | ±(SE) | 400-500mm %Mass | ±(SE) | >500mm %Mass | ±(SE) |
|---|---|---|---|---|---|---|
| Zooplankton | | | | | | |
| Class Astroidea larvae | 0.00 | (0.00) | 0.00 | (0.00) | 0.00 | (0.00) |
| Class Branchiopoda | 0.99 | (0.02) | 1.46 | (0.10) | 0.64 | (1.68) |
| Order Amphipoda | 0.00 | (0.00) | 0.18 | (0.00) | 0.34 | (0.50) |
| Family Aoridae | 0.10 | (0.00) | 0.00 | (0.00) | 0.00 | (0.00) |
| Family Hyperiidae | 0.06 | (0.00) | 0.58 | (0.02) | 0.02 | (0.00) |
| *Phronima* sp. | 0.00 | (0.00) | 0.00 | (0.00) | 0.02 | (0.00) |
| *Phrosina semiluna* | 0.00 | (0.00) | 1.06 | (0.41) | 7.81 | (65.09) |
| Order Cladocera | 0.65 | (0.00) | 0.01 | (0.00) | 0.25 | (0.25) |
| Order Decapoda Megalopa | <0.01 | (0.00) | 0.00 | (0.00) | 0.00 | (0.00) |
| Order Decapoda Zoea | 0.17 | (0.00) | 0.02 | (0.00) | 0.00 | (0.00) |
| Order Lophogastrida | 0.00 | (0.00) | 0.00 | (0.00) | 0.00 | (0.00) |
| Order Mysidacea | 0.00 | (0.00) | 0.00 | (0.00) | 0.11 | (0.02) |
| Family Mysidae | 0.80 | (0.01) | 0.55 | (0.00) | 0.05 | (0.01) |
| *Mysidopsis* sp. | 0.22 | (0.00) | 0.00 | (0.00) | 0.00 | (0.00) |
| Order Thecosomata | 0.38 | (0.00) | 8.34 | (1.78) | 1.33 | (1.75) |
| Infraorder Brachyura Megalopa | 0.05 | (0.00) | 0.07 | (0.00) | 0.00 | (0.00) |
| Superfamily Carinarioidea | 1.85 | (0.02) | 1.18 | (0.04) | 0.05 | (0.00) |
| Family Scyllaridae larvae | 0.00 | (0.00) | 0.00 | (0.00) | 0.16 | (0.00) |
| Family Sergestidae | 0.59 | (0.00) | 0.00 | (0.00) | 0.00 | (0.00) |
| *Lucifer faxoni* | 0.00 | (0.00) | 0.00 | (0.00) | 0.00 | (0.00) |
| Phyllosoma | 0.00 | (0.00) | 0.01 | (0.00) | 0.00 | (0.00) |
| Unidentifiable Zooplankton | 0.00 | (0.00) | 0.00 | (0.00) | 0.01 | (0.00) |
| **Total Zooplankton** | **5.86** | **(0.02)** | **13.45** | **(1.13)** | **10.81** | **(18.43)** |

Appendix H

Red Snapper Diet Indices (% Mass) of all Prey Items (n=85) for the Factor:

Habitat Type (NRs versus ARs), in the Northern Gulf of Mexico.

Appendix H:

| | NR | | AR | |
|---|---|---|---|---|
| **Prey Type** | **%Mass** | **±(SE)** | **%Mass** | **±(SE)** |
| Unidentified Material | 45.10 | (0.00) | 52.26 | (0.00) |
| **Total Unidentified Material** | **45.10** | **(0.00)** | **52.26** | **(0.00)** |
| | | | | |
| Fish | | | | |
| Infraclass Teleost | 0.99 | (0.04) | 6.89 | (0.66) |
| Order Anguilliformes | 0.02 | (0.00) | 0.01 | (0.00) |
| Order Pleuronectiformes | 0.00 | (0.00) | 0.01 | (0.00) |
| Family Balistidae | 0.03 | (0.00) | 0.00 | (0.00) |
| Family Clupeidae | 0.00 | (0.00) | 1.08 | (0.00) |
| Family Haemulidae larvae | 0.00 | (0.00) | 0.00 | (0.00) |
| Family Synodontidae | 0.22 | (0.12) | 0.53 | (0.00) |
| *Bellator* sp. | 0.15 | (0.00) | 0.00 | (0.00) |
| *Micropogonias undulatus* | 0.13 | (0.00) | 0.00 | (0.00) |
| *Peprilus burti* | 0.00 | (0.00) | 0.26 | (0.00) |
| *Peprilus* sp. | 0.12 | (0.03) | 0.00 | (0.00) |
| *Stenotomus caprinus* | 2.94 | (0.40) | 0.00 | (0.00) |
| *Urophycis floridana* | 0.58 | (0.00) | 0.00 | (0.00) |
| Unidentifiable Fish | 20.78 | (0.89) | 11.44 | (0.09) |
| **Total Fish** | **25.97** | **(0.23)** | **20.21** | **(0.12)** |
| | | | | |
| Decapoda | | | | |
| Order Decapoda | 0.43 | (0.01) | 0.49 | (0.02) |
| *Parthenope granulata* | 0.35 | (0.00) | 0.29 | (0.00) |
| *Sicyonia brevirsostris* | 0.80 | (0.19) | 0.60 | (0.02) |
| Infraorder Brachyura | 0.46 | (0.01) | 0.16 | (0.10) |
| *Leiolambrus nitidus* | 0.00 | (0.00) | 0.27 | (0.00) |
| *Myropsis quinguespinosa* | 0.02 | (0.00) | 0.00 | (0.00) |
| *Raninoides louisianensis* | 0.00 | (0.00) | 0.26 | (0.00) |
| Infraorder Caridea | 0.01 | (0.00) | 0.00 | (0.00) |
| *Ogyrides* sp. | 0.00 | (0.00) | 0.00 | (0.00) |
| Superfamily Hippoidea | 0.00 | (0.00) | 2.00 | (0.00) |
| *Albunea* sp. | 1.66 | (0.00) | 0.16 | (0.00) |
| Family Calappidae | 3.28 | (0.97) | 0.00 | (0.00) |
| *Calappa sulcata* | 0.00 | (0.00) | 0.26 | (0.00) |
| Family Paguroidea | 0.00 | (0.00) | 0.00 | (0.00) |
| Family Penaeidae | 0.13 | <0.01 | 0.05 | (0.01) |
| *Penaeus aztecus* | 0.02 | (0.00) | 0.00 | (0.00) |
| Family Portunidae | 0.88 | (0.11) | 0.17 | (0.05) |
| *Ovalipes floridanus* | 0.86 | (0.00) | 3.95 | (3.12) |
| *Portunus Gibbesii* | 0.00 | (0.00) | 2.13 | (0.23) |
| *P. saya* | 0.05 | (0.00) | 0.00 | (0.00) |

Appendix H Continued:

| | NR | | AR | |
|---|---|---|---|---|
| **Prey Type** | **%Mass** | **±(SE)** | **%Mass** | **±(SE)** |
| *P. spinacarpus* | 0.23 | (0.03) | 0.44 | (0.11) |
| *P. spinimanus* | 0.11 | (0.00) | 0.00 | (0.00) |
| **Total Decapoda** | **9.28** | **(0.05)** | **11.24** | **(0.20)** |
| | | | | |
| Gastropoda | | | | |
| Class Gastropoda | 0.10 | (0.00) | 0.44 | (0.00) |
| **Total Gastropoda** | **0.10** | **(0.00)** | **0.44** | **(0.00)** |
| | | | | |
| Cephalopoda | | | | |
| Class Cephalopoda | 0.14 | (0.14) | 0.03 | (0.00) |
| Loligo sp. | 0.05 | (0.01) | 0.67 | (0.01) |
| Order Octopoda | 1.16 | (1.39) | 0.00 | (0.00) |
| **Total Cephalopoda** | **1.35** | **(0.30)** | **0.70** | **(0.02)** |
| | | | | |
| Stomatopoda | | | | |
| Order Stomatopoda | 0.60 | (0.01) | 1.05 | (0.03) |
| Family Squillidae | 0.00 | (0.00) | 0.19 | (0.02) |
| Squilla sp. | 1.98 | (0.09) | 0.37 | (0.07) |
| **Total Stomatopoda** | **2.58** | **(0.03)** | **1.60** | **(0.02)** |
| | | | | |
| Other Invertebrates | | | | |
| Phylum Annelida | 0.00 | (0.00) | 0.00 | (0.00) |
| Class Polychaeta | 0.15 | (0.01) | 0.00 | (0.00) |
| Family Chaetophteridae | 0.00 | (0.00) | 0.00 | (0.00) |
| Phylum Echinodermata | 0.02 | (0.00) | 0.04 | (0.00) |
| Phylum Nematoda | 0.00 | (0.00) | 0.00 | (0.00) |
| Phylum Porifera | 0.00 | (0.00) | 0.57 | (0.01) |
| Division Invertebrata | 0.20 | (0.00) | 0.75 | (0.03) |
| Subphylum Tunicata | 0.02 | (0.00) | 0.02 | (0.00) |
| Class Ascidiacea | 0.04 | (0.00) | 0.00 | (0.00) |
| Subphylum Crustacea | 0.03 | (0.00) | 0.70 | (0.01) |
| Class Malacostraca | 4.47 | (0.03) | 0.31 | (0.00) |
| Suborder Asellota | 0.00 | (0.00) | 0.08 | (0.00) |
| Order Isopoda | 0.15 | (0.02) | 0.03 | (0.00) |
| Aegathoa oculata | 0.02 | (0.00) | 0.00 | (0.00) |
| Sphaeroma quadridentata | 0.05 | (0.00) | 0.03 | (0.00) |
| Infraclass Cirripedia | 0.00 | (0.00) | 0.06 | (0.00) |
| Order Sessilia | 0.01 | (0.00) | 0.00 | (0.00) |
| Class Turbellaria | 0.00 | (0.00) | 0.00 | (0.00) |
| Worm Tubes | 0.00 | (0.00) | 0.99 | (0.00) |
| **Total Other Invertebrates** | **5.14** | **(0.01)** | **3.57** | **(0.01)** |

Appendix H Continued:

| | NR | | AR | |
|---|---|---|---|---|
| Prey Type | %Mass | ±(SE) | %Mass | ±(SE) |
| Zooplankton | | | | |
| Class Astroidea larvae | 0.00 | (0.00) | 0.00 | (0.00) |
| Class Branchiopoda | 2.21 | (0.70) | 0.01 | (0.00) |
| Order Amphipoda | 0.04 | (0.00) | 0.40 | (1.29) |
| Family Aoridae | 0.00 | (0.00) | 0.00 | (0.00) |
| Family Hyperiidae | 0.04 | (0.00) | 0.11 | (0.02) |
| *Phronima* sp. | 0.00 | (0.00) | 0.02 | (0.00) |
| *Phrosina semiluna* | 1.15 | (0.34) | 8.40 | (169.02) |
| Order Cladocera | 0.66 | (0.12) | 0.00 | (0.00) |
| Order Decapoda Megalopa | 0.00 | (0.00) | 0.00 | (0.00) |
| Order Decapoda Zoea | 0.01 | (0.00) | 0.00 | (0.00) |
| Order Lophogastrida | 0.00 | (0.00) | 0.00 | (0.00) |
| Order Mysidacea | 0.00 | (0.00) | 0.12 | (0.03) |
| Family Mysidae | 0.26 | (0.03) | 0.06 | (0.04) |
| *Mysidopsis* sp. | 0.00 | (0.00) | 0.01 | (0.00) |
| Order Thecosomata | 5.53 | (2.03) | 0.55 | (0.30) |
| Infraorder Brachyura Megalopa | 0.04 | (0.00) | 0.00 | (0.00) |
| Superfamily Carinarioidea | 0.50 | (0.02) | 0.10 | (0.01) |
| Family Scyllaridae larvae | 0.00 | (0.00) | 0.18 | (0.00) |
| Family Sergestidae | 0.04 | (0.00) | 0.00 | (0.00) |
| *Lucifer faxoni* | 0.00 | (0.00) | 0.00 | (0.00) |
| Phyllosoma | 0.01 | (0.00) | 0.00 | (0.00) |
| Unidentifiable Zooplankton | 0.00 | (0.00) | 0.01 | (0.00) |
| **Total Zooplankton** | **10.48** | **(1.16)** | **9.99** | **(26.82)** |

Appendix I

Red Snapper Diet Indices (%Mass) of all Prey Items (n = 85) for the Factor: Timing (Pre- versus Post-DHOS), in the Northern Gulf of Mexico.

Appendix I:

| | Before | | After | |
|---|---|---|---|---|
| **Prey Type** | **%Mass** | **±(SE)** | **%Mass** | **±(SE)** |
| Unidentified Material | (56.35) | (0.00) | 43.96 | (0.00) |
| **Total Unidentified Material** | **56.35** | (0.00) | **43.96** | (0.00) |
| | | | | |
| Fish | | | | |
| Infraclass Teleost | 9.44 | (0.08) | 1.87 | (0.34) |
| Order Anguilliformes | 0.03 | (0.00) | 0.01 | (0.00) |
| Order Pleuronectiformes | 0.00 | (0.00) | 0.00 | (0.00) |
| Family Balistidae | 0.34 | (0.00) | 0.00 | (0.00) |
| Family Clupeidae | 0.00 | (0.00) | 0.28 | (0.00) |
| Family Haemulidae larvae | 0.01 | (0.00) | 0.00 | (0.00) |
| Family Synodontidae | 0.00 | (0.00) | 0.34 | (0.09) |
| *Bellator* sp. | 0.00 | (0.00) | 0.14 | (0.00) |
| *Micropogonias undulatus* | 0.00 | (0.00) | 0.12 | (0.00) |
| *Peprilus burti* | 0.78 | (0.00) | 0.00 | (0.00) |
| *Peprilus* sp. | 0.00 | (0.00) | 0.11 | (0.02) |
| *Stenotomus caprinus* | 0.00 | (0.00) | 2.69 | (0.37) |
| *Urophycis floridana* | 0.00 | (0.00) | 0.53 | (0.00) |
| Unidentifiable Fish | 4.82 | (0.18) | 21.55 | (0.54) |
| **Total Fish** | **15.42** | **(0.04)** | **27.65** | **(0.18)** |
| | | | | |
| Decapoda | | | | |
| Order Decapoda | 0.76 | (0.02) | 0.32 | (0.01) |
| *Parthenope granulata* | 1.01 | (0.06) | 0.00 | (0.00) |
| *Sicyonia brevirsostris* | 0.60 | (0.00) | 0.69 | (0.10) |
| Infraorder Brachyura | 0.26 | (0.00) | 0.28 | (0.01) |
| *Leiolambrus nitidus* | 0.00 | (0.00) | 0.23 | (0.00) |
| *Myropsis quinguespinosa* | 0.02 | (0.00) | 0.00 | (0.00) |
| *Raninoides louisianensis* | 0.51 | (0.00) | 0.00 | (0.00) |
| Infraorder Caridea | 0.00 | (0.00) | 0.01 | (0.00) |
| *Ogyrides* sp. | 0.00 | (0.00) | 0.00 | (0.00) |
| Superfamily Hippoidea | 0.00 | (0.00) | 1.69 | (0.00) |
| *Albunea* sp. | 0.00 | (0.00) | 1.06 | (0.39) |
| Family Calappidae | 0.00 | (0.00) | 1.82 | (0.00) |
| *Calappa sulcata* | 0.49 | (0.00) | 0.00 | (0.00) |
| Family Paguroidea | 0.00 | (0.00) | 0.00 | (0.00) |
| Family Penaeidae | 0.17 | (0.01) | 0.04 | (0.00) |
| *Penaeus aztecus* | 0.00 | (0.00) | 0.01 | (0.00) |
| Family Portunidae | 0.37 | (0.06) | 0.48 | (0.10) |
| *Ovalipes floridanus* | 0.00 | (0.00) | 3.82 | (0.95) |
| *Portunus Gibbesii* | 4.11 | (0.27) | 0.00 | (0.00) |
| *P. saya* | 0.00 | (0.00) | 0.03 | (0.00) |

Appendix I Continued:

| | Before | | After | |
|---|---|---|---|---|
| **Prey Type** | **%Mass** | **±(SE)** | **%Mass** | **±(SE)** |
| *P. spinacarpus* | 0.00 | (0.00) | 0.50 | (0.03) |
| *P. spinimanus* | 0.14 | (0.00) | 0.00 | (0.00) |
| **Total Decapoda** | **8.44** | **(0.11)** | **10.97** | **(0.07)** |
| | | | | |
| Gastropoda | | | | |
| Class Gastropoda | 0.03 | (0.00) | 0.35 | (0.00) |
| **Total Gastropoda** | **0.03** | **(0.00)** | **0.35** | **(0.00)** |
| | | | | |
| Cephalopoda | | | | |
| Class Cephalopoda | 0.05 | (0.02) | 0.14 | (0.00) |
| Loligo sp. | 0.05 | (0.00) | 0.09 | (0.01) |
| Order Octopoda | 0.00 | (0.00) | 1.34 | (1.28) |
| **Total Cephalopoda Mass** | **0.10** | **(0.02)** | **1.57** | **(0.25)** |
| | | | | |
| Stomatopoda | | | | |
| Order Stomatopoda | 1.10 | (0.05) | 0.58 | (0.01) |
| Family Squillidae | 0.06 | (0.00) | 0.06 | (0.00) |
| Squilla sp. | 0.02 | (0.00) | 2.02 | (0.07) |
| **Total Stomatopoda** | **1.19** | **(0.04)** | **2.66** | **(0.02)** |
| | | | | |
| Other Invertebrates | | | | |
| Phylum Annelida | 0.00 | (0.00) | 0.00 | (0.00) |
| Class Polychaeta | 0.00 | (0.00) | 0.14 | (0.01) |
| Family Chaetophteridae | 0.00 | (0.00) | 0.00 | (0.00) |
| Phylum Echinodermata | 0.00 | (0.00) | 0.02 | (0.00) |
| Phylum Nematoda | 0.00 | (0.00) | 0.00 | (0.00) |
| Phylum Porifera | 0.00 | (0.00) | 0.19 | (0.01) |
| Division Invertebrata | 1.12 | (0.02) | 0.11 | (0.00) |
| Subphylum Tunicata | 0.06 | (0.00) | 0.01 | (0.00) |
| Class Ascidiacea | 0.12 | (0.00) | 0.00 | (0.00) |
| Subphylum Crustacea | 0.86 | (0.01) | 0.00 | (0.00) |
| Class Malacostraca | 0.00 | (0.00) | 4.51 | (0.02) |
| Suborder Asellota | 0.09 | (0.00) | 0.00 | (0.00) |
| Order Isopoda | 0.00 | (0.00) | 0.16 | (0.01) |
| Aegathoa oculata | 0.00 | (0.00) | 0.02 | (0.00) |
| Sphaeroma quadridentata | 0.19 | (0.01) | 0.00 | (0.00) |
| Infraclass Cirripedia | 0.00 | (0.00) | 0.02 | (0.00) |
| Order Sessilia | 0.03 | (0.00) | 0.00 | (0.00) |
| Class Turbellaria | 0.00 | (0.00) | 0.00 | (0.00) |
| Worm Tubes | 0.00 | (0.00) | 0.33 | (0.00) |
| **Total Other Invertebrates** | **2.46** | **(0.01)** | **5.50** | **(0.01)** |

Appendix I Continued:

| | Before | | After | |
|---|---|---|---|---|
| Prey Type | %Mass | ±(SE) | %Mass | ±(SE) |
| Zooplankton | | | | |
| Class Astroidea larvae | 0.00 | (0.00) | 0.00 | (0.00) |
| Class Branchiopoda | 1.18 | (1.51) | 0.00 | (0.00) |
| Order Amphipoda | 0.45 | (1.13) | 0.23 | (0.00) |
| Family Aoridae | 0.00 | (0.00) | 0.00 | (0.00) |
| Family Hyperiidae | 0.02 | (0.00) | 0.77 | (0.01) |
| *Phronima* sp. | 0.03 | (0.00) | 0.00 | (0.00) |
| *Phrosina semiluna* | 10.44 | (2555.10) | 0.00 | (0.00) |
| Order Cladocera | 0.32 | (1.12) | 0.22 | (0.00) |
| Order Decapoda Megalopa | 0.00 | (0.00) | 0.01 | (0.00) |
| Order Decapoda Zoea | 0.00 | (0.00) | 0.05 | (0.00) |
| Order Lophogastrida | 0.00 | (0.00) | 0.00 | (0.00) |
| Order Mysidacea | 0.14 | (0.04) | 0.00 | (0.00) |
| Family Mysidae | 0.21 | (0.08) | 0.00 | (0.00) |
| *Mysidopsis* sp. | 0.01 | (0.00) | 0.00 | (0.00) |
| Order Thecosomata | 2.99 | (4.97) | 3.48 | (0.11) |
| Infraorder Brachyura Megalopa | 0.00 | (0.00) | 0.14 | (0.00) |
| Superfamily Carinarioidea | 0.00 | (0.00) | 2.28 | (0.02) |
| Family Scyllaridae larvae | 0.21 | (0.00) | 0.00 | (0.00) |
| Family Sergestidae | 0.00 | (0.00) | 0.13 | (0.00) |
| *Lucifer faxoni* | 0.00 | (0.00) | 0.00 | (0.00) |
| Phyllosoma | 0.00 | (0.00) | 0.04 | (0.00) |
| Unidentifiable Zooplankton | 0.02 | (0.00) | 0.00 | (0.00) |
| **Total Zooplankton** | **16.01** | **(42.86)** | **7.34** | **(0.05)** |

# Effect of trawling on juvenile red snapper (*Lutjanus campechanus*) habitat selection and life history parameters

**R.J. David Wells, James H. Cowan, Jr., William F. Patterson III, and Carl J. Walters**

**Abstract:** This study documents ontogenetic habitat shifts of red snapper (*Lutjanus campechanus*) and highlights possible impacts of shrimp trawling on age-0 fish life history parameters on the northern Gulf of Mexico (GOM) continental shelf. Red snapper were collected quarterly during 2004 and 2005 over sand, low-relief shell rubble, high-relief shell rubble, and natural high-relief reef habitats within a de facto nontrawl area and in similar habitats on the open shelf where commercial shrimp trawling occurred. Age-0 red snapper were most dense over sand and low-relief shell rubble habitats and moved to higher-relief shell rubble and natural reef habitats by age-1. Habitat-specific daily growth rates of age-0 fish were highest over sand (range 0.65–1.03 mm·day$^{-1}$). Densities of age-0 red snapper were highest over trawled sand, but higher over nontrawled shell rubble by 6 months of age (age-0.5+). Red snapper collected over sand and low-relief shell rubble areas exposed to trawling had truncated size distributions, higher mortality estimates, and lower production potential (the latter evaluated with *G–Z* and *P–B* ratios) compared with fish over nontrawled areas of similar habitat. Results suggest that juvenile red snapper residing over nontrawled areas may have a higher probability of survival than fish in areas exposed to commercial shrimp trawling.

**Résumé :** Notre étude renseigne sur les modifications ontogéniques de l'habitat chez le vivaneau rouge (*Lutjanus campechanus*) et met en évidence les impacts possibles de la pêche à la crevette au chalut sur les paramètres démographiques des poissons d'âge 0 sur la plate-forme continentale du nord du golfe du Mexique (GOM). Nous avons récolté des vivaneaux rouges à tous les trimestres en 2004 et 2005 sur des substrats de sable, de débris de coquillages à relief bas, de débris de coquillages à relief accentué et dans des habitats de récifs naturels à fort relief dans une zone en fait sans chalutage, ainsi que dans des habitats similaires sur la plate-forme découverte où il se fait de la pêche commerciale à la crevette. Les vivaneaux rouges d'âge 0 se retrouvent en plus forte densité sur les substrats de sable ou de débris de coquillages à bas relief et, à l'âge 1, ils se sont déplacés vers les habitats de débris de coquillages à relief accentué et vers les récifs naturels. Les taux de croissance spécifiques à l'habitat des poissons d'âge 0 les plus élevés s'observent sur les substrats de sable (étendue : 0,65–1,03 mm·jour$^{-1}$). Les densités les plus grandes de vivaneaux rouges d'âge 0 se retrouvent sur les substrats sablonneux soumis au chalutage, mais, à l'âge de six mois (âge 0,5+), elles sont plus élevées sur les débris de coquillages non affectés par le chalutage. Les vivaneaux rouges récoltés dans les zones de sable et de débris de coquillage à bas relief soumises au chalutage affichent des distributions tronquées des tailles, des estimations plus élevées de la mortalité et un potentiel de production plus faible (ce dernier évalué d'après les rapports *G–Z* et *P–B*) que les poissons vivant dans des habitats similaires dans des zones non exposées au chalutage. Nos résultats laissent croire que les jeunes vivaneaux rouges vivant dans des zones non soumises au chalutage ont une plus grande probabilité de survie que les poissons exposés à la pêche commerciale à la crevette par chalutage.

[Traduit par la Rédaction]

## Introduction

Trawling may affect targeted and nontargeted species directly by fishing or bycatch mortality and indirectly by reducing habitat complexity and thus quality (Auster et al. 1996; National Research Council (NRC) 2002). Shrimp trawl bycatch of juveniles is the most significant source of mortality for red snapper (*Lutjanus campechanus*) in US waters of the Gulf of Mexico (GOM) (Goodyear 1995). An estimated 25–30 million individuals are caught annually in

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shrimp trawls (Ortiz et al. 2000), which may account for as much as 90% of juvenile red snapper mortality (Goodyear and Phares 1990; Goodyear 1995). The GOM trawl fishery, which currently produces the highest discard to landings ratio of any US marine fishery (Harrington et al. 2005), targets shrimp on soft-sediment habitats that are assumed to be of low structural complexity and species diversity. However, soft-sediment habitats support a high diversity of organisms that play key roles in the ecosystem and provide important prey resources for fishes such as red snapper (Bradley and Bryan 1975; Arreguin-Sanchez et al. 2004; McCawley et al. 2006). Furthermore, trawling in the northern GOM is not confined to soft sediments and often affects more complex habitats, such as sandbanks and shell rubble habitats. Auster (1998) identified habitats such as biogenic structures and shell aggregates as some of the more susceptible habitats to adverse impacts of trawling.

Reduction in juvenile bycatch by shrimp trawls appears to be necessary to increase the spawning stock biomass of adult red snapper. It has been surmised that a technological solution to bycatch reduction may not exist, and the addition of shrimp nontrawl areas or time closures may be necessary for fisheries management to provide additional protection for juvenile red snapper (Gallaway et al. 1999; Diamond 2004; Patterson et al. 2005). However, studies addressing the relative importance of different habitats (i.e., differential growth rates and production potential) for juvenile red snapper are necessary to evaluate that management option. The following four habitat-specific levels of information have been proposed to evaluate habitat quality and to assess whether a given habitat should be considered essential fish habitat (EFH) (Minello 1999): (*i*) fish presence–absence, (*ii*) fish density, (*iii*) fish growth, reproduction, or survival, and (*iv*) fish production. Furthermore, large-scale closure experiments are needed to test for possible compensatory changes in mortality rates of juveniles protected from bycatch mortality, as such effects could cancel the intended positive benefits of reduced mortality.

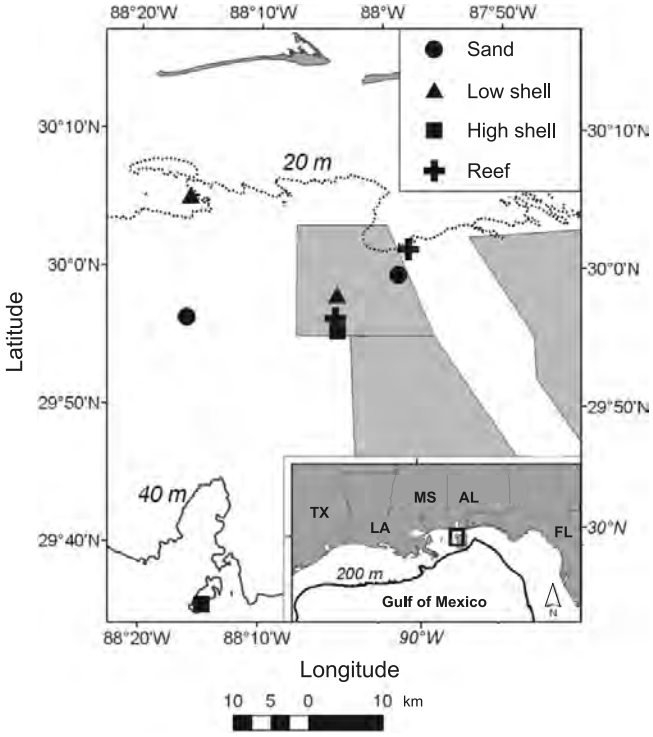
The purpose of this study was to characterize ontogenetic habitat use of red snapper among natural substrates on the GOM inner continental shelf in areas that have historically supported high concentrations of red snapper. Specifically, we investigated habitat use over sand, low-relief shell rubble, high-relief shell rubble, and natural reefs. We assessed habitat value with comparisons of red snapper density, size, age, growth, mortality, and production potential among habitat types. In addition, we assessed habitat-specific effects of shrimp trawling on red snapper demographics, vital rates, and production potential, with comparisons focused on sand and low-relief shell rubble habitats where juvenile red snapper were most abundant.

## Materials and methods

### Study sites

Our study region was located on the northern GOM continental shelf and had two main subregions (Fig. 1). The first subregion was an area of open shelf that was exposed to shrimp trawling. Based on the surface area of the seafloor and shrimp effort data, Wells et al. (2008*a*) conservatively estimated that shrimp trawling effort in this subregion was

**Fig. 1.** Map of habitat types on the north-central Gulf of Mexico (GOM). Inset map shows the location of the study region in relation to the Gulf coast of southern USA. The 20 and 40 m depth contours are shown; in the inset, the 200 m depth contour represents the shelf edge. Enclosed shaded regions indicate the de facto nontrawl areas inside the Alabama artificial reef permit areas.




sufficient to sweep the area at least once per year during 2004 and 2005. Moreover, electronic logbook data indicate that some areas of the shelf are targeted with much greater frequency (Benny Gallaway, LGL Ltd., 1410 Cavitt Street, Bryan, TX 77801, USA, personal communication). The second subregion of our study was an extensive (>3000 km$^2$) artificial reef permit area in the northern GOM that was directly adjacent to our open shelf areas (Fig. 1). This artificial reef permit area served as a de facto nontrawl area because shrimp vessels rarely enter it for fear of losing their nets (Link 1997; NRC 2002).

Seabed characterization of the region inside and outside the permit areas was recently performed with digital side-scan sonar and analysis of box core sediment samples during previous studies (Dufrene 2005; Patterson et al. 2005). Results indicate that similar habitat types inside and outside the permit areas have similar geotechnical properties (e.g., sand–mud ratio, percent $CaCO_3$, organic carbon content) (Dufrene 2005; Patterson et al. 2005). Habitat types identified include sand sites with interspersed mud (hereafter sand), low-relief shell-rubble sites (<1 m vertical relief; <40% $CaCO_3$) (hereafter low shell), high-relief shell-rubble sites (1–3 m vertical relief; >40% $CaCO_3$) (hereafter high shell), and natural high-relief (>2 m vertical relief) reef sites (hereafter reef) (Fig. 1). However, because no trawling occurs directly on reef sites and the proximity of the trawled high shell site was distant and at a greater depth

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than other sites, our trawling comparisons were limited to sand and low shell habitats.

Shell rubble ridges in the study area are relict oyster reefs formed prior to the Holocene transgression (Schroeder et al. 1988; Dufrene 2005). Ridges are oriented in a northwest to southeast direction, extend for several kilometres in length with distances between ridges varying from 100s of metres to over a kilometre, and are thought to be part of the Perdido shoals on the eastern Alabama–Florida continental shelf (Dufrene 2005). McBride et al. (1999) described the Perdido shoals over the midshelf as two long (30–120 km) and relatively narrow (<6 km) parallel shore features.

### Field sampling

Trawl sampling was conducted quarterly in 2004 and 2005 from the R/V *Caretta*, an 18 m research vessel operated by NOAA Fisheries Pascagoula Laboratory (hereafter NMFS). Three sampling stations were selected for trawl sampling over each habitat type both exposed and not exposed to trawling; stations were fixed for the duration of the study, although care was taken to avoid repeatedly sampling the same transects. A total of 171 trawl samples was obtained for the duration of the study: trawl sand ($n$ = 21), nontrawl sand ($n$ = 24), trawl low shell ($n$ = 21), nontrawl low shell ($n$ = 24), trawl high shell ($n$ = 12), nontrawl high shell ($n$ = 24), trawl reef ($n$ = 21), and nontrawl reef ($n$ = 24). All stations were trawled in a northwest to southeast direction and remained on the habitat of interest. Vessel position was overlain onto bathymetric side-scan mosaics in ArcPad 6.0 (ESRI, Redlands, California) for continuous global positioning system (GPS) tracking of trawl position and to aid in navigation. This enabled trawls to be towed along the edges of the reefs to minimize damage to immobile fauna (i.e., sponges, corals).

Standard NMFS Fall Groundfish Survey trawl gear was used, which included a single, 12.8 m wide otter trawl with 4 cm mesh size, towed at approximately 4.6 km·h$^{-1}$ for 10 min·sample$^{-1}$. A 0.7 cm cod-end lining was added to increase capture efficiencies for smaller individuals. Trawl sampling occurred only during daylight hours (30 min after sunrise and 30 min before sunset). All red snapper were immediately frozen and taken back to the laboratory following each cruise. Fish were measured to the nearest millimetre total length (TL) and weighed to the nearest gram. Water mass characteristics (salinity, temperature, depth, and dissolved oxygen) were measured at each site with a conductivity–temperature–depth (CTD) instrument (model SBE-25; Sea-Bird Electronics, Inc., Bellevue, Washington).

### Density and size

Differences in densities of red snapper from the trawl surveys (number·ha$^{-1}$) were assessed with a block-designed four-way factorial analysis of variance (ANOVA) with habitat, the presence or absence of trawling, season, and age group as the factors and year (2004 and 2005) as the block. In addition, an analysis of covariance (ANCOVA), with depth as the covariate, was performed with all factors to assess red snapper density with respect to depth differences among study sites. Prior to ANCOVA testing, the homogeneity of slopes was examined using an interaction regression, and main effects ($y$ intercepts) were then tested when the homogeneity of slopes assumption was met (Ott 1993). Red snapper densities were $\log_e(x + 1)$-transformed to normalize data and reduce heteroscedasticity. A posteriori differences among means were detected with Tukey's honestly significant difference (HSD) test with an $\alpha$ level of 0.05. Length differences among habitats and between trawled and nontrawled areas of similar habitats were analyzed with a two-factor ANCOVA (factors: habitat, presence of trawling), with season as the covariate. A linear regression was used to examine the relationship between red snapper TL and depth.

### Age and growth

Sagittal otoliths of red snapper collected at each habitat were used for age estimates. A subsample ($n$ = 25 if available) of juvenile red snapper from each habitat during each quarter was selected so that the entire juvenile size range was included in daily age estimates. Subsamples were obtained by randomly selecting five to 10 fish from three 50 mm size bins (0–50, 51–100, 101–150 mm TL) for each habitat by quarter. Because of the large size range of red snapper collected, either daily or annual increment analysis was performed depending on fish size and time of year. Left or right sagittal otoliths were selected and measured to the nearest 0.001 mm and weighed to the nearest 0.0001 g. Otoliths for daily age estimates were prepared using standard techniques (Secor et al. 1992). Because of the compression of daily rings with increasing age, it was difficult to discern daily ages of red snapper larger than 150 mm TL; thus only red snapper less than this size were used for daily increment analysis. Two readers independently counted increments of a random subsample of red snapper otoliths. Subsamples represented 27% and 20% of 2004 and 2005 daily otoliths, respectively.

Annual age estimates for fish larger than 150 mm TL were determined by counting the number of opaque rings from the core to the outer margin. Otoliths were processed and read following the methods of Cowan et al. (1995). Age was determined based on counts of opaque zones, assuming a mean birth date of 1 July and that opaque zone formation occurs between January and March in the northern GOM (Patterson et al. 2001). A large number of red snapper ages were classified as 0.5+. These fish were too old to discern daily ages but were not yet 365 days old because no opaque annual ring was present; thus, 0.5+ represents an age between 180 days and 1 year. Two readers independently counted annuli of all adult red snapper otoliths. Differences in the annulus counts were evaluated by the coefficient of variation (CV), index of precision ($D$), and average percent error (APE).

Growth rates of age-0 red snapper were estimated from slopes of linear regressions of TL versus otolith-derived daily age. Habitat-specific growth comparisons were performed only from winter and fall samples when sufficient sample sizes of age-0 red snapper were collected over most habitats. Analysis of covariance models were used to test for differences in growth rates (slope effect) of age-0 red snapper, with age as the covariate. Student's $t$ tests and ANOVA models were also used to compare average growth rates for individual fish; however, results were similar to ANCOVA models and are therefore not reported.

Daily growth was modeled for all aged red snapper with a

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von Bertalanffy growth equation using Proc NLIN (SAS Institute Inc. 2006). This equation was used to estimate ages of red snapper that were not aged with otolith-based techniques. Length-at-age data were also fit with other models (i.e., linear, logistic), but the percent variation in length explained by age was maximized with the von Bertalanffy.

### Mortality and production potential

Mortality estimates of red snapper were derived using a maximum likelihood approach for monthly birth cohorts, where catch per effort for each cohort was assumed to be distributed as a Poisson random variate with mean dependent on three parameters: initial cohort size, catchability, and monthly survival rate. This is a dynamic catch curve method in which decline in abundance of monthly cohorts from each annual spawning is estimated. In addition, mortality estimates were also derived from regressions of $\log_e$-transformed abundance on age, in a static catch curve. Instantaneous daily mortality rates of age-0 red snapper were estimated using an exponential model of decline in numbers at age (Ricker 1975). Mortality estimates were based on 10-day groupings of the 2004 cohort collected over consecutive seasons over the age range in which a descending catch curve was observed. An ascending catch curve was observed for young red snapper (<120 days), and only a small number of older red snapper (>200 days) were collected because of both gear avoidance and emigration. Thus, all red snapper collected from the 2004 cohort between 120 and 199 days of age from sand and low shell sites were used to obtain mortality estimates. Analysis of covariance models were used to test for differences in mortality rates (slope effect) of age-0 red snapper, with age as the covariate.

Mortality estimates were based on the assumptions that equal immigration and emigration took place on the habitats of interest and that the only difference between sites was the presence of trawling. The age range used for mortality estimates was most frequently observed over the sand and low shell habitat types, suggesting that these were the preferred habitats at this life stage. In addition, our comparisons were limited to similar habitat types (sand and low shell) that were and were not likely exposed to trawling and did not compare among habitat types owing to possible ontogenetic habitat shifts. Red snapper mortality rates over high shell trawled and nontrawled areas were not estimated because of the small number of red snapper collected, remote distance, and depth of the trawled site relative to other sites.

The ratio of the weight-specific growth coefficient ($G$) to the instantaneous mortality coefficient ($Z$) was used to index habitat-specific and life-stage-specific production potential. The incorporation of both $G$ ($g \cdot day^{-1}$) and $Z$ ($day^{-1}$) allows these to be used to assess stage-specific productivity. Estimates of $G$ were calculated from slopes of linear regressions relating changes in weight with respect to age. Cohorts of red snapper with $G$–$Z$ ratios less than one lose biomass, whereas those with $G$–$Z$ ratios greater than one gain biomass and have higher survivorship and production potential (Cowan and Houde 1990; Houde 1996; Rooker et al. 1999). In addition, habitat-specific $G$ and $Z$ estimates were incorporated into the Ricker (1975) production model to calculate production to biomass ratios ($P$–$B$ ratios).

Production and biomass relationships were calculated using the following equations:

$$\overline{B} = \frac{B_0\left(e^{(G-Z)} - 1\right)}{G - Z}$$

$$P = G\overline{B}$$

where $\overline{B}$ is the mean biomass over the time interval, $B_0$ is the initial biomass, and $P$ is the production estimate in grams wet weight per hectare. Initial habitat-specific biomass estimates were derived from mean weight multiplied by total number per hectare over the 120–129 day age group. The $G$–$Z$ and $P$–$B$ ratios were calculated for red snapper collected over trawled and nontrawled sand and low shell habitats to assess differences in the production potential that may be attributable to trawling.

## Results

Water mass characteristics were similar among all habitats within each quarter (Table 1). Low dissolved oxygen (1.76 $mg \cdot L^{-1}$, which is characterized as hypoxic (<2 $mg \cdot L^{-1}$)) was observed during the summer cruise in 2004. A total of 1454 red snapper was collected in trawl samples over the two-year study period. Red snapper between 23 and 435 mm TL were captured in trawls, with ages ranging from 28 days to 5 years.

### Density and size

Red snapper densities increased with age over higher relief habitats (e.g., high shell and reef) and were higher over nontrawled areas; however, differences were age-specific (Fig. 2). Red snapper densities were significantly affected by habitat type (ANOVA: $F_{[3,711]} = 6.56$, $p < 0.001$), exposure to trawling (ANOVA: $F_{[1,710]} = 6.53$, $p = 0.011$), and age group (ANOVA: $F_{[4,710]} = 30.25$, $p < 0.001$). Seasonal differences were not significant (ANOVA: $F_{[3,708]} = 2.20$, $p = 0.087$), thus age-specific, post-hoc density comparisons were analyzed with both habitat and the exposure to trawling as factors. In addition, parallelism of slopes assumptions were met and significant main effects for habitat, trawling, and age group were found when depth was included as a covariate. A significant habitat effect was observed for age-1 red snapper (ANOVA: $F_{[3,166]} = 3.71$, $p = 0.013$), with significantly higher densities associated with reef (2.65 $fish \cdot ha^{-1}$) compared with sand (0.16 $fish \cdot ha^{-1}$) habitat ($p = 0.014$). In addition, a significant trawling effect was observed for age-0.5+ red snapper (ANOVA: $F_{[1,165]} = 6.63$, $p = 0.011$), with higher densities over nontrawled areas (5.41 $fish \cdot ha^{-1}$) relative to areas exposed to trawling (2.69 $fish \cdot ha^{-1}$). However, pairwise density differences of red snapper collected from trawled versus nontrawled areas of similar habitats were not significant. Habitat × trawl interactions were not significant for both age-0.5+ and age-1 fish ($p > 0.05$).

Red snapper size-frequency distributions correlated well with age-specific density estimates, indicative of an ontogenetic habitat shift from lower-relief to higher-relief habitats with size and age. Habitat-specific size-frequency distributions varied among seasons. A significant habitat effect was detected (ANCOVA: $p < 0.001$), with the smallest

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**Table 1.** Bottom water mass characteristics at each site on quarterly surveys during 2004 and 2005.

| Water parameter | Habitat | Winter, March 2004 | Spring, May 2004 | Summer, August 2004 | Fall, October 2004 | Winter, January 2005 | Spring, April 2005 | Summer, July 2005 | Fall, October 2005 |
|---|---|---|---|---|---|---|---|---|---|
| Temperature (°C) | NT Sand | 18.62 | 21.08 | 22.34 | 25.78 | 19.25 | 20.38 | 25.81 | 24.21 |
| | T Sand | NA | 19.91 | 22.85 | 23.11 | 20.10 | 20.20 | 26.28 | 25.47 |
| | NT Low shell | 17.92 | 20.55 | 22.56 | 27.04 | 20.76 | 20.47 | 26.13 | 25.23 |
| | T Low shell | NA | 22.21 | 23.46 | 25.98 | 20.10 | 20.20 | 25.92 | 24.18 |
| | NT High shell | 18.05 | 20.74 | 22.90 | 26.74 | 20.76 | 20.20 | 25.83 | 24.74 |
| | T High shell | NA | 19.52 | 20.72 | 28.13 | NA | NA | 26.06 | NA |
| | NT Reef | 17.98 | 20.56 | 22.51 | 26.48 | 19.80 | 20.55 | 25.92 | 25.02 |
| | T Reef | 18.72 | 24.38 | 24.01 | 25.95 | 18.10 | 20.31 | 25.99 | NA |
| Salinity (ppt) | NT Sand | 35.73 | 35.01 | 36.18 | 35.80 | 35.21 | 35.91 | 35.50 | 34.65 |
| | T Sand | NA | 35.18 | 36.34 | 36.27 | 35.61 | 36.28 | 35.76 | 35.43 |
| | NT Low shell | 35.51 | 35.17 | 36.11 | 36.33 | 35.68 | 35.94 | 35.45 | 35.33 |
| | T Low shell | NA | 34.20 | 35.98 | 35.52 | 35.61 | 36.28 | 35.44 | 34.70 |
| | NT High shell | 35.49 | 35.13 | 36.06 | 36.29 | 35.68 | 36.28 | 35.47 | 35.01 |
| | T High shell | NA | 35.73 | 36.39 | 36.24 | NA | NA | 35.77 | NA |
| | NT Reef | 35.50 | 35.15 | 36.13 | 36.27 | 35.47 | 35.98 | 35.46 | 35.25 |
| | T Reef | 35.56 | 34.63 | 35.95 | 35.32 | 34.45 | 35.47 | 35.47 | NA |
| Dissolved oxygen ($mg \cdot L^{-1}$) | NT Sand | 7.78 | 7.45 | 1.76 | 4.65 | 6.37 | 3.57 | 4.53 | 6.15 |
| | T Sand | NA | 6.54 | 4.18 | 4.92 | 5.93 | 3.67 | 5.30 | 5.91 |
| | NT Low shell | 7.82 | 7.25 | 3.35 | 5.73 | 5.94 | 3.97 | 4.92 | 6.01 |
| | T Low shell | NA | 7.02 | 3.30 | 3.85 | 5.93 | 3.67 | 4.82 | 6.15 |
| | NT High shell | 7.79 | 7.13 | 3.61 | 5.20 | 5.94 | 3.67 | 4.41 | 6.09 |
| | T High shell | NA | 6.33 | 5.01 | 5.82 | NA | NA | 5.44 | NA |
| | NT Reef | 7.94 | 7.29 | 2.93 | 5.16 | 6.30 | 4.10 | 4.65 | 6.09 |
| | T Reef | 7.85 | 6.92 | 4.56 | 5.35 | 6.72 | 3.90 | 4.87 | NA |
| Depth (m) | NT Sand | 24.4 | 24.0 | 23.0 | 27.5 | 23.5 | 24.0 | 25.3 | 28.1 |
| | T Sand | NA | 30.3 | 30.6 | 30.7 | 30.8 | 31.0 | 30.3 | 31.2 |
| | NT Low shell | 29.7 | 29.0 | 28.8 | 28.8 | 29.0 | 29.5 | 29.0 | 29.0 |
| | T Low shell | NA | 17.3 | 18.0 | 17.7 | 18.0 | 18.0 | 17.8 | 17.5 |
| | NT High shell | 28.0 | 27.3 | 28.0 | 26.5 | 26.5 | 27.0 | 30.1 | 28.6 |
| | T High shell | NA | 39.6 | 37.2 | 37.4 | NA | NA | 37.2 | NA |
| | NT Reef | 30.6 | 28.0 | 30.7 | 29.0 | 31.5 | 31.0 | 30.1 | 30.7 |
| | T Reef | 20.0 | 19.0 | 19.8 | 18.3 | 19.0 | 18.6 | 17.5 | NA |

**Note:** NT, nontrawl; T, trawl; NA, not applicable because no samples were taken at the site because of inclement weather.

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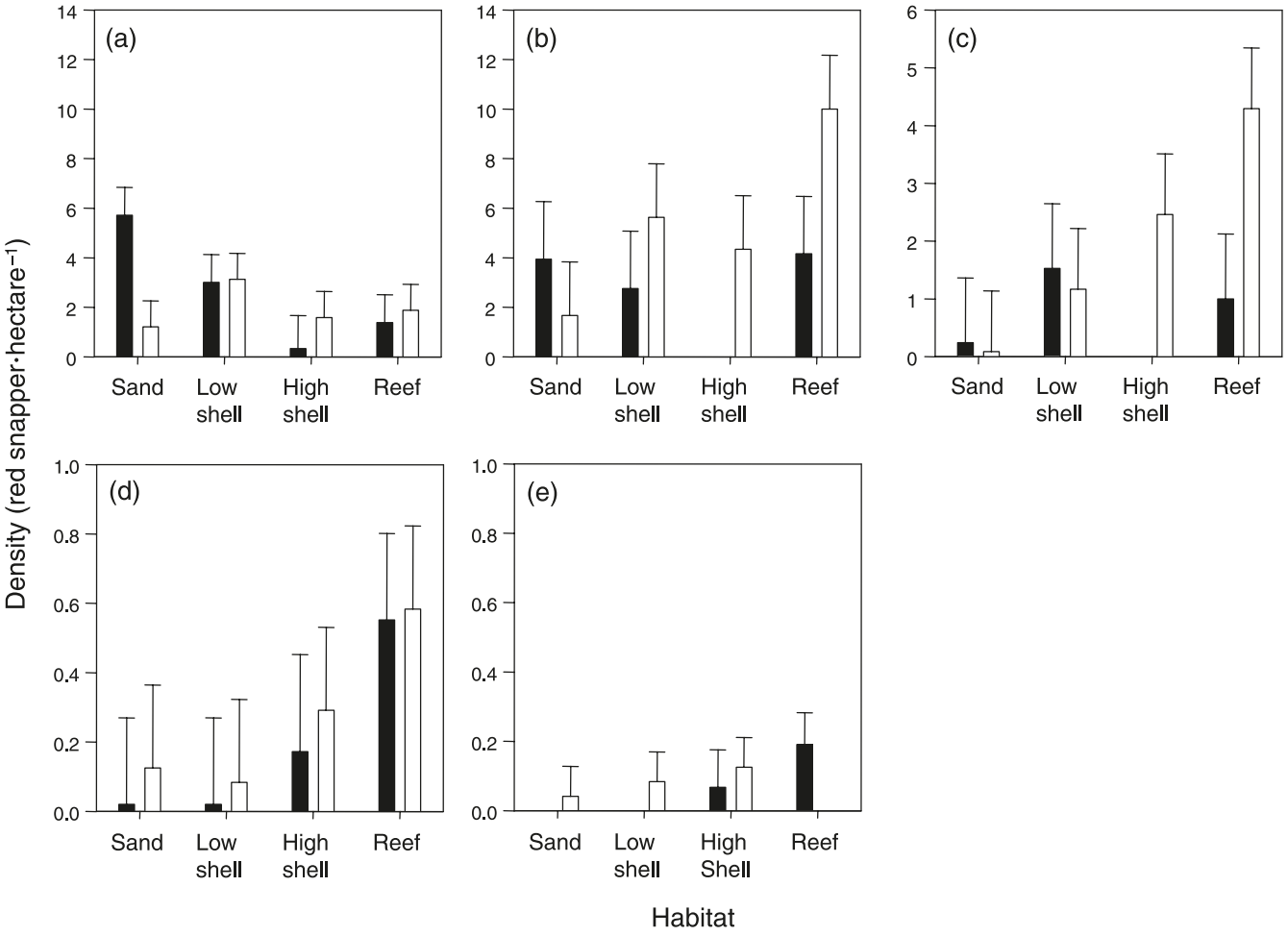
**Fig. 2.** Age-specific density estimates (±1 standard error, SE) of red snapper (*Lutjanus campechanus*) collected using trawls: (*a*) age-0; (*b*) age-0.5+; (*c*) age-1; (*d*) age-2; and (*e*) age-3+. Solid bars represent habitats exposed to trawling; open bars represent habitats not exposed to trawling. Note the magnitude of the ordinate differs with age because of the low number of older individuals collected using trawls.




red snapper observed over sand habitat (LS mean = 111.9 ± 3.5 mm TL standard error), particularly during summer and fall. Post-hoc differences among habitats indicated that red snapper were significantly smaller over trawled sand (LS mean = 96.1 ± 3.3 mm TL) than over trawled low shell ($p < 0.001$; LS mean = 127.0 ± 4.3 mm TL) and reef habitats ($p < 0.001$; LS mean = 172.3 ± 7.9 mm TL). Red snapper collected over nontrawled sand habitats (LS mean = 127.8 ± 6.1 mm TL) were significantly smaller than those collected over nontrawled high shell ($p < 0.001$; LS mean = 166.0 ± 3.2 mm TL) and reef ($p < 0.001$; LS mean = 158.1 ± 2.3 mm TL) habitats. Red snapper between 50 and 200 mm TL (LS mean = 133.5 ± 2.6 mm TL) were consistently collected over the low shell habitats in all seasons, whereas the 100–250 mm TL (LS mean = 143.4 ± 11.8 mm TL) size range was collected over high shell habitats. The largest red snapper were found over reef habitat, where red snapper larger than 300 mm TL (LS mean = 165.2 ± 4.1 mm TL) were frequently captured. Pairwise comparisons among habitats indicated that red snapper were significantly larger on reefs than over both sand and low shell habitats in the trawled and nontrawled areas ($p < 0.001$). Lastly, results of the linear regression showed no significant relationship with increasing red snapper TL and depth ($r^2 = 0.003$, $p = 0.270$).

Red snapper were significantly larger on nontrawled habitats than over similar trawled habitats (ANCOVA: $p = 0.012$) (Fig. 3). Specifically, sand and low shell habitats were the two habitats investigated for post-hoc trawl effects, which was significant for both (sand $p < 0.001$; low shell $p = 0.012$). Average TL (± standard error, SE) of red snapper collected over nontrawled and trawled sand habitats were 127.8 ± 6.1 and 96.1 ± 3.3, respectively, and those over nontrawled and trawled low shell habitats were 140.1 ± 2.9 and 127.0 ± 4.3, respectively.

## Age and growth

A total of 942 (65%) red snapper collected in this study was aged; daily ages were obtained for 377 fish (40% of aged fish) and annual age estimates were obtained for 565 (60% of aged fish). Agreement between readers of red snapper daily otolith counts was high (2004, reader 1 age =

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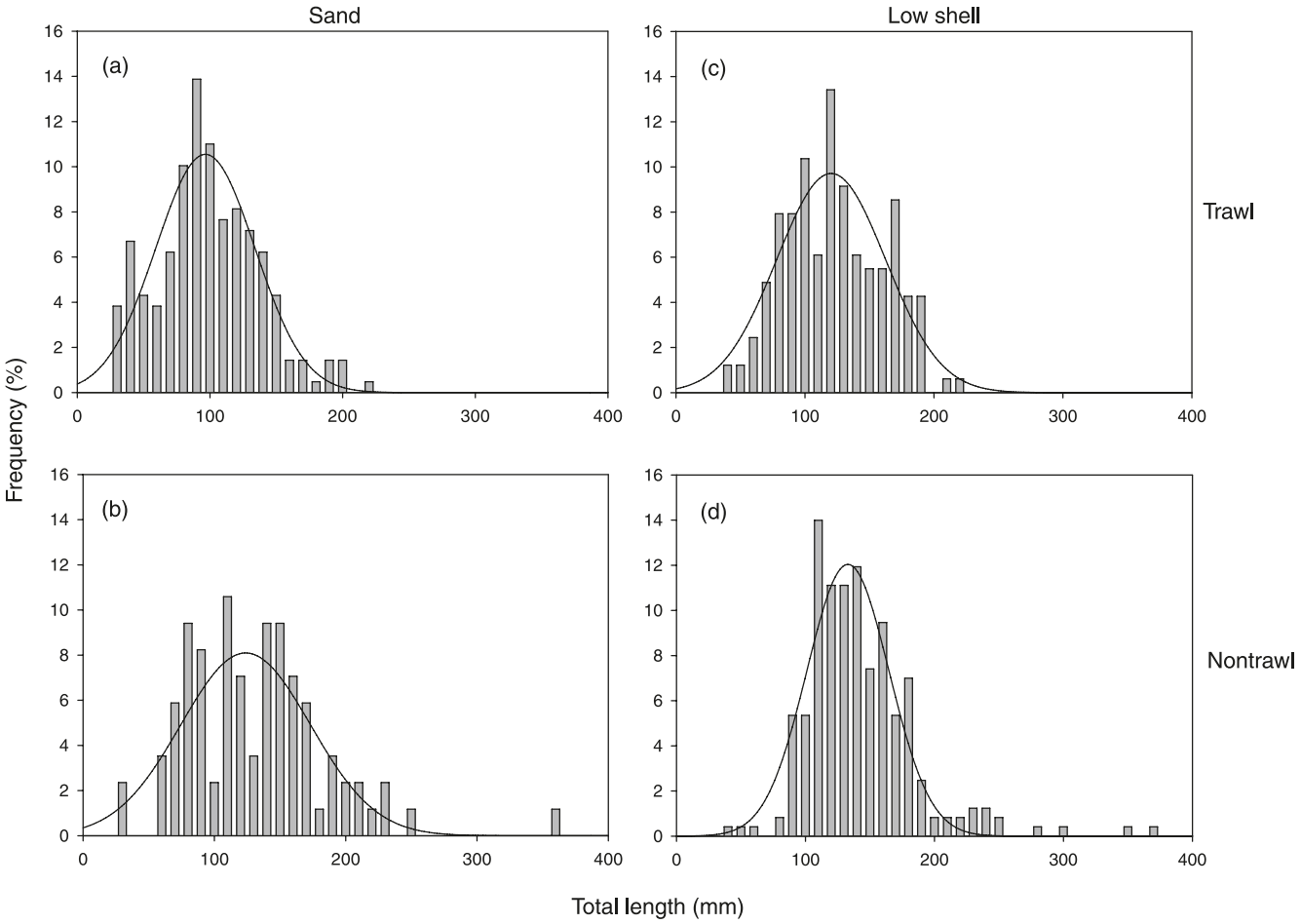
**Fig. 3.** Size-frequency distributions of red snapper (*Lutjanus campechanus*) collected relative to the exposure to trawling over sand and low shell habitats: (*a*) sand trawl; (*b*) sand nontrawl; (*c*) low shell trawl; (*d*) low shell nontrawl.




0.95 × reader 2 age + 12.72, $r^2$ = 0.91; 2005, reader 1 age = 0.93 × reader 2 age + 5.16, $r^2$ = 0.93). In addition, annual age estimates differed for only 4.4% of the readings. Because of the low variability between reader counts (CV = 0.011, $D$ = 0.008, APE = 0.500%), annulus counts by reader 1 were used.

Habitat-specific growth rates of age-0 red snapper showed differences among habitats during winter and fall, with highest growth rates over sand habitat (Fig. 4). A significant growth rate difference was detected for red snapper collected among habitats exposed to trawling during winter, with the highest growth rates of 1.03 mm·day$^{-1}$ over the sand habitat (ANCOVA test for equal slopes: $p$ = 0.047) (Fig. 4*a*). No significant winter growth differences were detected for red snapper in habitats that were not exposed to trawling (ANCOVA slopes: $p$ = 0.116) (Fig. 4*b*). However, trends in habitat-specific growth rates were similar, as red snapper collected over sand habitat had average growth rates of 1.01 mm·day$^{-1}$, followed by reef (0.74 mm·day$^{-1}$), and low shell (0.72 mm·day$^{-1}$) habitats. Growth rates were similar for red snapper collected among habitats exposed (ANCOVA slopes: $p$ = 0.575) (Fig. 4*c*) and not exposed (ANCOVA slopes: $p$ = 0.207) (Fig. 4*d*) to trawling in fall. Fall habitat-specific growth rates averaged 0.65 and 0.84 mm·day$^{-1}$ over trawled and nontrawled sand habitats, respectively.

In general, red snapper collected on habitats not exposed to trawling grew faster than their counterparts on trawled habitats. Red snapper collected over nontrawled sand habitats in fall grew significantly faster than conspecifics collected over similar sand habitats exposed to trawling (ANCOVA slopes: $p$ = 0.022) (Fig. 5*c*). Average fall daily growth rate of red snapper over nontrawled sand was 0.84 mm·day$^{-1}$, in contrast to red snapper collected on trawled sand with an average growth rate of 0.65 mm·day$^{-1}$. A similar difference in fall was observed over low shell habitat; however, differences were not significant (ANCOVA slopes: $p$ = 0.425) (Fig. 5*d*). Growth rates of red snapper in fall over nontrawled and trawled low shell habitat averaged 0.67 and 0.62 mm·day$^{-1}$, respectively. Winter growth rates were similar, regardless of the exposure to trawling (Figs. 5*a*, 5*b*).

## Mortality and production potential

Mortality rate estimates over the size ranges examined show that red snapper in trawled areas suffered higher mortality rates than those in similar nontrawled areas, regardless of the approach used. Using the maximum likelihood

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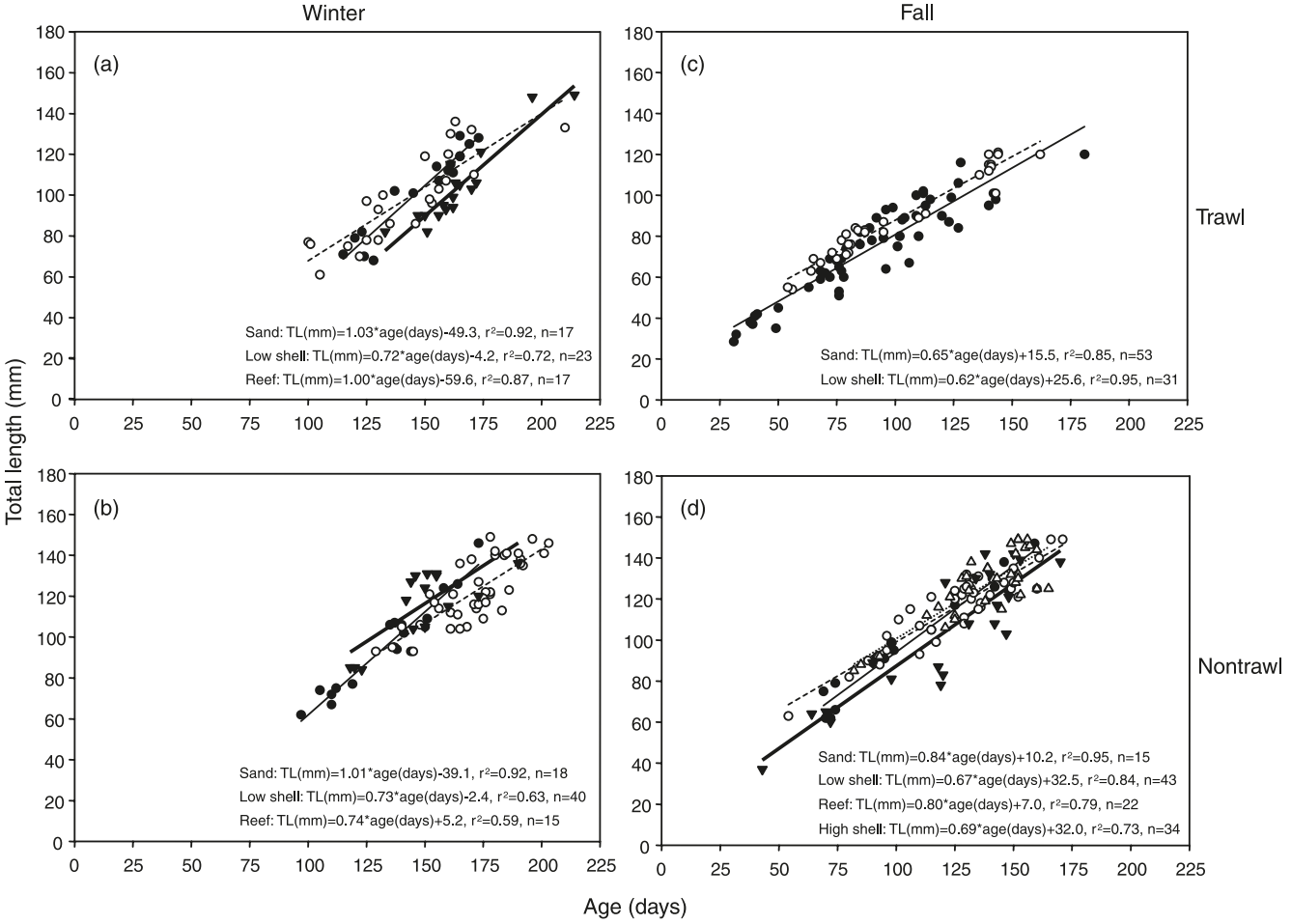
**Fig. 4.** Size-at-age relationships of age-0 red snapper (*Lutjanus campechanus*) collected during winter and fall trawl cruises determined with linear growth curves for habitat-specific comparisons: (*a*) winter trawl; (*b*) winter nontrawl; (*c*) fall trawl; (*d*) fall nontrawl. Habitats consist of sand (solid circles, solid line), low shell (open circles, broken line), high shell (open triangles, dotted line), and reefs (solid triangles, solid bold line).




method, total mortality estimates ($Z$) were 0.042 and 0.007·day$^{-1}$ over trawled and nontrawled low shell habitats, respectively. Similarly, mortality estimates were 0.043 and 0.025·day$^{-1}$ over trawled and nontrawled sand habitats, respectively. Mortality estimates were similar using the catch-curve method (Fig. 6). Red snapper collected over trawled low shell habitats had mortality rates of 3.54%·day$^{-1}$ ($Z$ = 0.036·day$^{-1}$) compared with red snapper collected over nontrawled low shell of 1.69%·day$^{-1}$ ($Z$ = 0.017·day$^{-1}$) (ANCOVA slopes: $p$ = 0.005) (Fig. 6*b*). Similar trends were observed for red snapper collected over sand habitats, with red snapper mortality rates of 3.63%·day$^{-1}$ ($Z$ = 0.037·day$^{-1}$) on trawled areas and 2.37%·day$^{-1}$ ($Z$ = 0.024·day$^{-1}$) on similar nontrawled areas (Fig. 6*a*), but results were not significant (ANCOVA slopes: $p$ = 0.176). Differences in mortality rates between similar habitat types exposed or not exposed to trawling provided a trawl-related fishing mortality ($F$) of 1.88%·day$^{-1}$ ($F$ = 0.019·day$^{-1}$) over low shell and 1.29%·day$^{-1}$ ($F$ = 0.013·day$^{-1}$) over sand.

Juvenile red snapper collected from habitats exposed to trawling had lower $G$–$Z$ ratios than those collected from similar nontrawled habitats. The highest $G$–$Z$ ratio of 0.93 was observed for red snapper over nontrawled sand, whereas similar trawled sand areas had a ratio of 0.40, indicating over a twofold difference in production potential between habitats. The $G$–$Z$ ratio of red snapper collected on nontrawled low shell habitats was 0.89, in contrast to 0.59 for red snapper residing on similar trawled habitat. Similar trends of higher $P$–$B$ ratios of red snapper collected from nontrawled relative to similar trawled habitats were observed with production estimates of 0.022 and 0.014 from red snapper collected over nontrawled and trawled sand habitats, respectively. Similarly, the $P$–$B$ ratios of red snapper collected from nontrawled and trawled low shell habitats were 0.022 and 0.021, respectively.

## Discussion

Our results suggest that postsettlement processes acting on age-0 red snapper are affected by trawling. Truncated size distributions observed in this study are consistent with previous studies that reported decreases in the biomass of demersal fish and invertebrate fauna due to trawling and

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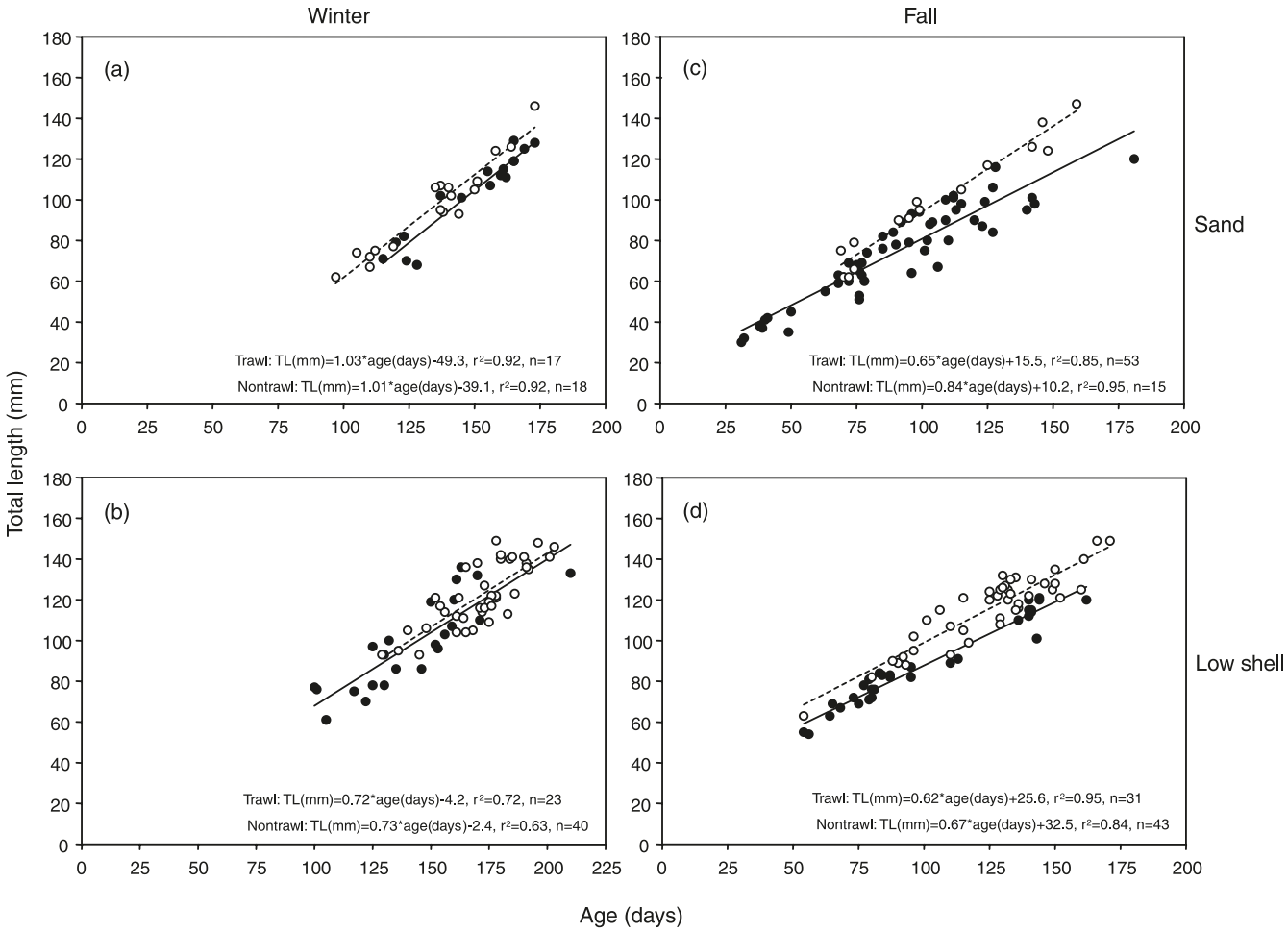
**Fig. 5.** Size-at-age relationships of age-0 red snapper (*Lutjanus campechanus*) collected during winter and fall surveys over sand and low shell habitats in trawled (solid circles, solid line) and nontrawled (open circles, broken line) areas: (*a*) winter sand; (*b*) winter low shell; (*c*) fall sand; (*d*) fall low shell.




dredging (Bianchi et al. 2000; Zwanenburg 2000; Duplisea et al. 2002). In addition, large declines of small coastal elasmobranchs in the northern GOM have been documented where shrimp effort was highest (Shepherd and Myers 2005). In contrast, we found higher densities of age-0 red snapper over trawled sand habitat, but by age-0.5+, densities were higher over nontrawled low shell habitat. A possible explanation for this pattern is the size selectivity of the shrimp trawls targeting red snapper at the age-0.5+ range, which is the age at which juvenile red snapper are more vulnerable to the trawl gear. Results herein also are consistent with those of Diamond et al. (2000), who showed that bycatch mortality has an impact on population growth rates of GOM Atlantic croaker, *Micropogonias undulatus*, a fish species commonly collected as shrimp trawl bycatch in the GOM. However, Diamond et al. (1999) also reported that life history parameters such as size distribution, number of large fish, and size at maturity of GOM Atlantic croaker have not changed since the 1930s, despite major declines in abundance.

The greater habitat complexity and absence of commercial shrimp trawling over nontrawled habitats in this study may contribute to faster growth and decreased mortality rates of age-0 red snapper. Habitat complexity has been shown to enhance the survivorship of age-0 Atlantic cod, *Gadus morhua*, at both the microhabitat (Lindholm et al. 1999) and landscape (Lindholm et al. 2001) levels by reducing the vulnerability of fish to predation. Likewise, the epibenthic community (i.e., tubeworms, bryozoans, anemones, corals, and algae) and vertical relief estimates in our study area were greater over nontrawled habitats (Wells et al. 2008*a*) and may therefore provide additional protection from predators. The concept of habitat-mediated survivorship has been well documented in tropical and temperate reef systems (Carr 1991; Connell and Jones 1991; Sale 1991) but has not been well studied for red snapper. However, more than 20 000 artificial reefs are estimated to exist within the permit areas off Alabama (Patterson et al. 2001), and these reefs may have an effect on the distribution and abundance of red snapper and co-occurrence of predators and prey. Differences in the predation pressure between sites exposed and not exposed to trawling may have existed. Large piscivorous fishes and sharks are frequently found over highly structured habitats such as artificial reefs that aggregate large quantities of potential prey (Simpfendorfer and Milward 1993; Rademacher and Render 2003), which

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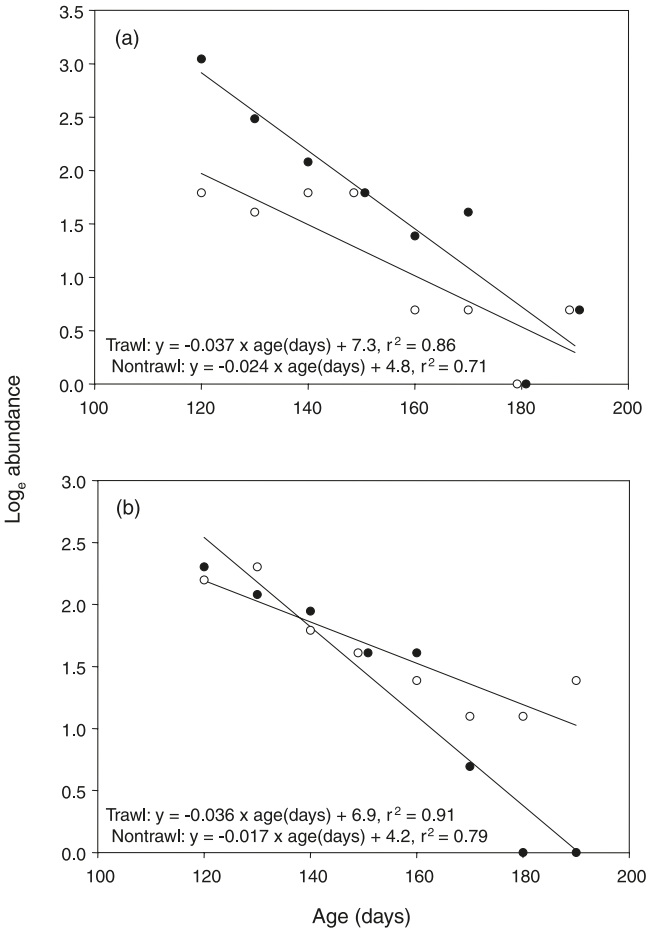
**Fig. 6.** Mortality estimates of red snapper (*Lutjanus campechanus*) collected from (*a*) sand and (*b*) low shell habitats exposed (solid circles) and not exposed (open circles) to trawling. Mortality estimates are based on age-specific catch curves using regression plots of $\log_e$ abundance on age for 10-day cohorts.




would increase the predation potential within the nontrawled area. Additionally, fishing pressure for adult red snapper may have been higher over the nontrawled habitats owing to the presence of the artificial reefs that attract recreational anglers. If true, these factors likely would have increased mortality rates of age-0 and adult red snapper over nontrawled areas, resulting in reported differences between trawled and nontrawled habitats being conservative.

Movement between trawled and nontrawled areas or to different habitats such as artificial reefs within the reef permit area may have occurred during this study. An assumption in our approach was that the presence or absence of commercial shrimp trawling was the primary factor responsible for the observed differences between similar habitat types within and outside of the de facto nontrawl permit area. Workman et al. (2002) concluded that juvenile red snapper display site fidelity and may have homing capabilities based on ultrasonic tagging data. In addition, Bailey et al. (2001) found that age-0 red snapper were excluded from reefs by older (age-1 and above) conspecifics. Our results are consistent with the finding of Patterson et al. (2005) that although red snapper habitat use was age-specific, similar ages overlapped among different habitat types and dispersion between areas is therefore possible.

Production estimates indicate that age-0 red snapper were losing biomass, therefore suffered decreasing production potential within all habitats. However, production estimates were lower in habitats exposed to trawling. One explanation may be that trawl selection for fastest-growing individuals of a given age is higher in trawled relative to nontrawled areas, which would have biased down our estimates of growth and production for red snapper collected from trawled habitats. Mortality estimates for juvenile red snapper in this study were high and should be interpreted with caution given the inherent assumptions. Movement and gear avoidance of red snapper likely affected the mortality estimates and consequently overestimated total mortality and therefore underestimated production potential in this study. Our estimates of bycatch mortality rates (1.29%–1.88%·day$^{-1}$) imply annual loss rates (4.7–6.9·year$^{-1}$) that are two to four times higher than those reported from stock assessment modeling and analysis of survey data by recent stock assessment teams (Southeast Data Assessment and Review 2005). However, our results are consistent with the mortality rates estimated by Rooker et al. (2004), where habitat-specific mortality rates of juvenile red snapper ranged from 4% to 12%·day$^{-1}$ for fish 47–57 days of age. Growth, mortality, and production results also were age-specific in that we focused on juvenile red snapper between the ages of 120 and 199 days. Wang and Houde (1995) found that annual *P–B* ratios of bay anchovy (*Anchoa mitchilli*) in Chesapeake Bay decreased from 8.07 to 0.97, after excluding the larval and youngest juvenile stages (3 months posthatch), and to 0.19 for age-1 anchovy. To date, most studies have used *G–Z* ratios to evaluate production potential of larvae (Cowan and Houde 1990; Houde 1996) and recently settled individuals (<50 days) (Rooker et al. 1999). Thus, caution should be used when interpreting production calculations for annual estimates because we used an 80-day period during the late juvenile stage. Additional studies clearly are needed to estimate life-stage-specific mortality rates and production potential of red snapper.

Several other factors may have led to the observed differences in this study. Distance and depth differences among study sites may have affected density and size, particularly over the high relief shell site located on the 40 m depth contour. However, this site was not used to test for the effects of trawling, nor did we see any increasing size with depth relationships. Gallaway et al. (1999) found that juvenile red snapper habitat preference lies between 18 and 64 m, similar to the depth range of our study area. Additionally, mortality estimates in this study may have been affected by differences in location or depth, and these differences may account for the faster rate of emigration in trawled habitats. Given that red snapper display ontogenetic habitat shifts, as observed in this study, a significant component of our mortality estimates may have been attributed to movement. Studies also found decreased numbers of juvenile red snapper when dissolved oxygen levels become hypoxic (<2 mg·L$^{-1}$) (Szedlmayer and Shipp 1994; Gallaway et al. 1999). Consequently, the low dissolved oxygen level (1.76 mg·L$^{-1}$) observed in the summer of 2004 at the nontrawled sand

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habitat may have had the effect of depressing age-0 red snapper numbers, resulting in a shallower slope and lower mortality estimate. It should also be noted that our study was limited to one artificial reef permit area, which may affect overall conclusions regarding the exposure to trawling activities. Future studies should aim at greater replication over a larger area of the shelf to test for the presence of fishing activities on vital rates of commercial and recreationally important species. Unfortunately, as was the case in this study, limited spatial closures exist on the northern GOM shelf, which limited our ability to cover a large spatial area.

Changes in juvenile red snapper vital rates may have repercussions at the subadult and adult stages. Results of this study demonstrate the effects that trawling has on life history parameters of juvenile red snapper, while others have observed demographic differences in adult populations of red snapper. Fischer et al. (2004) found that adult red snapper off Texas reached smaller maximum sizes at a faster rate and had smaller weight-at-age than red snapper collected off Louisiana and Alabama. In addition, Woods et al. (2003) reported that female red snapper off Alabama reached sexual maturity at smaller sizes and at earlier ages than conspecifics off Louisiana. It has been suggested that fishing pressure may select for phenotypic traits of fishes, such as reduced size-at-maturity and size-at-age, in addition to changes in growth rates (Law 2000). For example, the North Sea plaice (*Pleuronectes platessa*) has decreased in both length- and age-at-maturity since 1900 as the result of fishing pressure (Rijnsdorp 1993). In addition, Kamukuru et al. (2005) reported that blackspot snapper (*Lutjanus fulviflamma*) collected in intensively fished areas off Tanzania had higher total and fishing mortality rates, lower maximum and average ages, and smaller sizes than conspecifics in an adjacent marine reserve. Diamond et al. (1999) found severe declines in the abundances of both Atlantic Ocean and GOM Atlantic croaker, but only the Atlantic fish demonstrated changes in vital rates and demographics. These changes were attributed to the fishing pressure on both juveniles (as bycatch in shrimp trawls) and adults (recreational and commercial catch). Similar selective pressures appear to be occurring on GOM red snapper. Therefore, demographic differences in GOM red snapper may be driven by fishing practices during early life when fishing mortality rates are highest.

Our findings of age-specific habitat use of red snapper, specifically an ontogenetic shift from low-relief to higher-relief habitats with increasing size and age, were similar to results from other studies. Studies characterizing juvenile red snapper habitat use have found juveniles in association with a variety of habitats, including mud, sand, relict shell rubble, low-relief microhabitats (sponges, rubble patches, debris) (Szedlmayer and Conti 1999; Rooker et al. 2004; Patterson et al. 2005), and artificial structures with vertical relief (Bradley and Bryan 1975). In contrast to juveniles, both subadult (age-1) and adult (age-2+) red snapper have been shown to occupy habitats such as gravel bottoms, coral reefs, and rock outcrops, as well as artificial reefs, petroleum platforms, and submerged wreckage (Bradley and Bryan 1975; Moran 1988; Szedlmayer and Shipp 1994). Differences in age-specific habitat use may be attributed to the agonistic behavior by adults toward younger conspecifics (Bailey et al. 2001), but later occupation of offshore reef structures occurs as these younger fish reach a size refuge and recruit into the adult population, generally at or around age-2 (Nieland and Wilson 2003). Results herein suggest that juvenile red snapper begin recruiting to the reef structure as early as age-0 but are primarily found over these natural reefs at age-1 and older.

To date, studies have been equivocal with respect to the habitat-specific enhancement of early life survival of red snapper. Rooker et al. (2004) found higher growth rates and lower mortality rates of age-0 red snapper over an inshore mud habitat than at a shell bank in the northwestern GOM. They found no density differences in the first year of the study but found juvenile red snapper densities to be higher over shell substrates during a limited survey in the following year. Patterson et al. (2005) found no differences in red snapper densities between sand and shell substrates but inferred that sponges found on sand habitat provided similar structural complexity as shell rubble among sites within the trawled area of our study region. Other studies investigating density differences have found that age-0 red snapper have an affinity for shell-rubble habitat over sand habitat (Szedlmayer and Howe 1997; Szedlmayer and Conti 1999). Our results highlight the benefits of occupying both sand and low shell habitats because of faster daily growth rates over sand habitat, lower mortality over nontrawled shell habitat, and corresponding changes in production potential. The consistently higher growth rates of age-0 red snapper found over sand habitat may be due to prey availability. Age-0 red snapper have been shown to feed on prey associated with open sand and mud habitats (Bradley and Bryan 1975; Szedlmayer and Lee 2004), and diet analyses from fish in this study suggest the same (Wells et al. 2008*b*). Nagelkerken and van der Velde (2004) found that the majority of fishes utilizing both seagrass beds and mangrove habitats obtained most of their food sources from seagrass beds and attributed these habitat-specific feeding differences to the greater food availability in seagrass beds. Wells et al. (2008*b*) showed that red snapper rely on sand- and mud-associated prey, regardless of the habitat from which the red snapper were collected, suggesting that shell rubble may be more important for providing refuge than additional prey resources.

This study was unique in that all four levels of information needed to identify and evaluate EFH for red snapper were analyzed and the apparent effects of shrimp trawls on red snapper life history parameters were quantified. Based on the four habitat-specific levels by Minello (1999), it appears that all habitats (sand, shell, reefs) may be essential at some life history stage. Other studies that have attempted to delineate EFH for federally managed fish species have found similar results, identifying almost all waters and habitats encountered over the life history of a species as EFH (Packer and Hoff 1999; Roni et al. 1999). In addition, higher densities of age-0.5+ combined with larger sizes, faster growth rates in the fall, lower mortality estimates, and higher estimates of production potential suggest that juvenile red snapper residing over nontrawled areas may have a higher probability of survival than juvenile red snapper in areas exposed to commercial shrimp trawling. Thus, if man-

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agement strategies such as shrimp closures are implemented in the GOM to enhance survival of age-0 and age-1 red snapper, then all habitat types in this study will need to be protected, which is consistent with an ecosystem-based management approach.

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ARTICLE

# Proximity Effects of Larger Resident Fishes on Recruitment of Age-0 Red Snapper in the Northern Gulf of Mexico

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*Abstract*

**Small artificial reefs (1.2 × 1.02 × 1.1 m) were placed near to (15 m; $n = 20$) and distant from (500 m; $n = 20$) larger artificial reefs (1.2 × 2.4 × 2.4 m; $n = 20$) in July 2008 and 2009, and each set of reefs (two small and one large) was placed 1.7 km apart at a site 28 km south of Dauphin Island, Alabama, in the northern Gulf of Mexico. Divers used visual surveys to identify and count all fish present on the small reefs and estimated fish lengths in 25-mm categories during August 2008, August 2009, and September 2009. Significantly higher numbers of age-0 red snapper *Lutjanus campechanus* were detected on the small distant reefs (500 m) than on the small nearby (15 m) reefs in all surveys. In addition, significantly higher densities of rock sea bass *Centropristis philadelphica* and pygmy filefish *Stephanolepis setifer* were observed on the small distant reefs compared with the small nearby reefs in both August and September 2009. Mean species richness was significantly higher on the small distant reefs than on the small nearby reefs in August 2009. Differences in reef fish community structure were detected in all three surveys by using nonmetric multidimensional scaling based on Czekanowski's similarity coefficient. This study indicates that if artificial reefs are built to provide habitat for juvenile red snapper, they should not be placed in areas immediately adjacent to existing adult habitat; conversely, habitats intended for adult fish should not be placed near important red snapper nursery areas.**

Many biological and physical processes can regulate reef fish abundance, with most fishes showing type III survivorship, in which a large portion of the population dies early in life. These typical high mortalities in early life indicate that the size of many fish populations may be limited during these early stages. For example, high mortality during the larval stage may cause recruitment limitation of adult abundance (Doherty 1982; Victor 1986; Doherty and Fowler 1994), while important limits may also occur at the postsettlement stage (Shulman and Ogden 1987; Hixon and Carr 1997; Hixon and Jones 2005). For example, when recruitment of the Ambon damsel *Pomacentrus amboinensis* was doubled from 1 recruit/$m^2$ to 2 recruits/$m^2$, adult abundance did not increase, thus indicating that postrecruitment processes may regulate this population (Jones 1990).

Predation has been identified as a leading cause of reef fish postsettlement mortalities (Carr and Hixon 1995; Steele and Forrester 2002; Almany and Webster 2006). For example, when resident piscivores were removed, there were higher numbers and species richness of juvenile reef fishes (Caley 1993; Beets 1997; Webster 2002; Heinlein et al. 2010). Predator additions have shown similar effects; the introduction of a single invasive lionfish *Pterois volitans* to patch reefs caused a 79% reduction in reef fish recruitment (Albins and Hixon 2008).

Fish living on a reef can affect the environment immediately surrounding the reef. For example, feeding activity by herbivorous fishes can cause a grazing halo in surrounding seagrass beds (Randal 1965). Carnivorous reef fishes are also known to create feeding halos in surrounding habitats, resulting in lower abundances of invertebrates, although these halos are not as apparent as those caused by herbivores (Kurz 1995; Galván et al. 2008). If grazing pressure and predation pressure are higher on plants and invertebrates in the areas surrounding a reef, then predation pressure is probably higher for small fishes as well.

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Previous studies have indicated that the recruit abundance and diversity of reef fishes on patch reefs increase with increasing distance from larger reefs, and this increase has been attributed to reduced predation (Shulman 1985; West et al. 1994; Steele 1997; Belmaker et al. 2005). While these previous studies showed significant predation effects, most did not examine reef fish recruitment at sites more than 50 m from the larger reefs with larger resident predators (Shulman 1985; Connell 1997; Steele 1997; Belmaker et al. 2005). In the present northern Gulf of Mexico reef system, potential predators will forage at least 50 m from the reef (Szedlmayer and Schroepfer 2005; Topping and Szedlmayer 2011). Based on the reported foraging ranges for red snapper *Lutjanus campechanus*, studies that have examined predation effects around 50 m or less from the reef structure are not applicable to systems in the northern Gulf of Mexico, and questions remain concerning the possible isolation refuge effects for northern Gulf of Mexico fishes.

Red snapper are abundant on reef structures in the northern Gulf of Mexico and support important commercial and sport fisheries (SEDAR 7 2005). The red snapper stock in the northern Gulf of Mexico has been classified as overfished, resulting in severe restrictions on harvest (Goodyear 1994; SEDAR 7 2005; SEDAR 2009). Proper management of red snapper requires an understanding of their life history and the processes that regulate abundance. Thus, identifying population bottlenecks will substantially aid in managing the fishery.

Red snapper recruits first settle to open habitat and reach their highest abundances between July and September and then move to more structured habitats in the fall of their first year (Szedlmayer and Conti 1999; Szedlmayer and Lee 2004); however, they also may settle directly onto reef structures (Szedlmayer 2011). As red snapper grow, they seek out progressively larger structures. By age 2, red snapper have recruited to higher-relief structures, such as gas platforms (Nieland and Wilson 2003; Szedlmayer 2007; Gallaway et al. 2009).

Previous studies have indicated that predators or larger competitors can affect the abundance and distribution of age-0 red snapper. In caging experiments conducted in the field, higher abundances of age-0 red snapper occurred on reefs when predators were excluded; in captivity, age-0 red snapper spent more time associated with complex habitat when a predator (Gulf flounder *Paralichthys albigutta*) was present (Piko and Szedlmayer 2007). Age-0 red snapper were also excluded from complex habitat when older red snapper were added to a tank (Bailey et al. 2001). Based on the life history of red snapper and the potential effects of predators on reef fish recruitment, the proximity of larger artificial reefs and their associated reef fish communities may affect new recruitment of juvenile red snapper to low-relief nursery structures. Through the use of experimental artificial reefs, we examined the potential effects of predator and competitor proximity to reef habitats on the recruitment of age-0 red snapper.

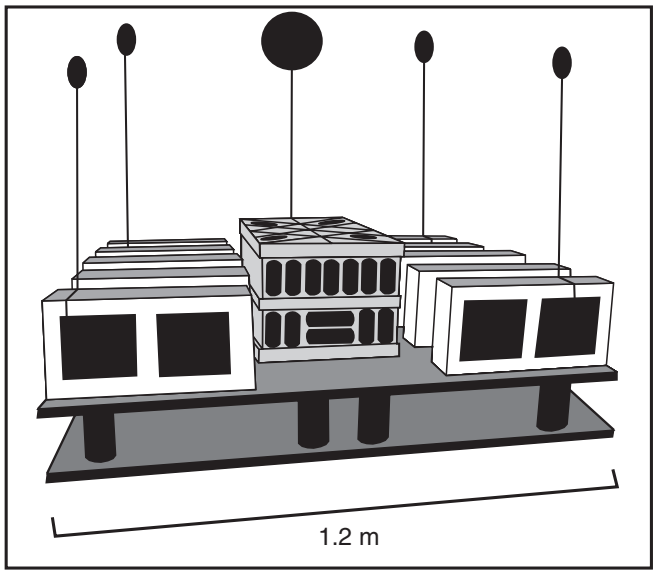


FIGURE 1. Design of the small artificial reefs that were used to study juvenile fish recruitment.

## METHODS

The study site was located 28 km south of Dauphin Island, Alabama, in the northern Gulf of Mexico; the site was characterized by sand and mud substrate, and 3% of the sea floor was composed of natural reefs (Parker et al. 1983; Dufrene 2005). Reefs were built within an artificial reef-building zone that also contains many other artificial reefs, including natural gas platforms, liberty ships, concrete pyramids, and army tanks (Minton and Heath 1998). All reefs were placed at depths ranging from 19 to 22 m.

Large steel cage reefs (1.2 × 2.4 × 2.4 m) were deployed on 2 April 2008 ($n = 10$) and 14 April 2009 ($n = 10$). These large reefs provided habitat for larger predatory fishes relative to the smaller fishes typically observed on the smaller "recruitment" reefs. Small reefs (Figure 1) were deployed on 24 and 28 July 2008 ($n = 20$) and 9–10 July 2009 ($n = 20$). Each small reef consisted of a polyethylene plastic pallet (1.22 × 1.02 × 0.14 m), 10 concrete half-blocks (41 × 20 × 10 cm), and a plastic crate (65 × 35 × 28 cm). Small reefs were assembled by using 122-cm cable ties with a tensile strength of 79 kg. A small float (5.1 × 12.7 cm) was tied to each corner of the reef and floated 1 m above the reef. One larger float (15.2-cm diameter) was tied in the center of the reef, also at a height of 1 m. The floats added vertical structure to the reef and facilitated reef relocations with sonar. The small reefs were anchored by attachment to a 1.2-m ground anchor with 1.3-cm-diameter nylon rope. The total volume of the reef was 1.42 $m^3$. The small reefs provided habitat for age-0 red snapper and other small (mostly <200 mm) reef fishes. One small reef was anchored 15 m (small nearby reef) from the large reef, and a second small reef was anchored 500 m (small distant reef) from the large reef. Each replicate set of reefs included one large reef and two small reefs, and all replicates

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were equally spaced 1.7 km apart in rows of three, four, and three large reefs. Depth differences among all reefs were less than 3 m.

In 2008, all of the reefs were surveyed on 6 and 15 August 2008 but were subsequently destroyed by Hurricane Gustav in the first week of September. In 2009, reefs were surveyed on 4 and 6 August and again on 9–10 September. A third survey was attempted on 19 November 2009 but was not completed owing to high turbidity and reef damage caused by Tropical Storm Ida.

During each survey, two SCUBA divers visually identified, counted, and estimated size-classes (in 25-mm total length [TL] intervals) of all fish present on individual small reefs. In this study, recruits were defined as newly settled age-0 juvenile fish. Divers also observed the large reefs and characterized the size and abundance of the common species that were present. In 2009, divers videotaped (Sony Hi-8) and photographed (Nikon D200) each small reef with its associated fishes. All photographs and video recordings were taken 1.2 m from the reef on a horizontal plane to the reef, facing the open holes of the concrete blocks. In the laboratory, photographs with the highest number of age-0 red snapper for a particular reef were selected for computer-aided enumeration. Each fish in the photograph was identified to species and counted by using Image-Pro image analysis software. Any photographed fish that could not be accurately identified to species was counted and labeled as unknown. Two screens were used to analyze the video recording: a single captured frame of the video was displayed on one screen while the video was played on the second screen. The second screen allowed the counter to simultaneously view the fish in the captured frame and on the moving video for more accurate identification and counting with Image-Pro software.

All fish counts were divided by the volume of the small reef to obtain density (fish/m$^3$). Red snapper age was estimated based on length. During the August surveys, all red snapper that were 102 mm TL or smaller were classified as age 0. In September, all red snapper that were 127 mm TL or smaller were classified as age 0 (Szedlmayer and Lee 2004). All tomtates *Haemulon aurolineatum* of 76 mm TL or less were considered to be age 0. A few fast-moving and large-schooling species (blue runner *Caranx crysos*, round scad *Decapterus punctatus*, greater amberjack *Seriola dumerili*, and longspine porgy *Stenotomus caprinus*) were excluded from all reef comparisons because of the difficulty in counting them and because of their transient behavior.

Visual estimates of age-0 and age-1 red snapper densities were compared between treatments with a two-way analysis of variance (ANOVA). The mean densities of other common species were compared between treatments with a *t*-test. Differences in mean species richness (species/m$^3$) were compared between treatments separately for each survey by using a *t*-test. Pearson's product-moment correlation coefficients were calculated for densities of age-0 and age-1 red snapper on the small distant (500 m) reefs. A one-way ANOVA was used to compare densities of age-0 red snapper across years for August surveys. Photograph and video estimates of age-0 red snapper densities were compared between treatments with a *t*-test. The three counting methods (visual, photograph, and video) of age-0 red snapper densities and mean species richness were compared by use of a one-way ANOVA. If significant differences were detected with ANOVA, specific differences were identified by using a Tukey's test.

Fish community patterns between reef types were also compared with nonmetric multidimensional scaling (NMDS; Szedlmayer and Able 1996; Lingo and Szedlmayer 2006; Redman and Szedlmayer 2009). Species abundance data were square-root transformed to reduce the weight of highly abundant species (Field et al. 1982). Czekanowski's similarity coefficients ($S_{jk}$) were calculated among all individual surveys of each reef and were mapped as NMDS ordination plots:

$$S_{jk} = 100 \times \left(1 - \frac{\sum |y_{ij} - y_{ik}|}{\sum y_{ij} + y_{ik}}\right),$$

where $S_{jk}$ is the similarity between the $j$th and $k$th reefs, $y_{ij}$ is abundance of the $i$th species on the $j$th reef, and $y_{ik}$ is the abundance of the $i$th species on the $k$th reef (Field et al. 1982; Yoshioka 2008). Circles describing the grouping between treatments were drawn by hand on the NMDS ordination plots. One-way analysis of similarity (ANOSIM Global $R$) was used to test for significant differences in the reef fish community between reef treatments for each survey (Clarke and Green 1988; Clarke 1993). All statistical tests were considered significant at $P$-values of 0.05 or less.

## RESULTS

In August 2008 and 2009, age-0 red snapper were significantly more abundant on the small distant (500 m) reefs than on the small nearby (15 m) reefs as shown by a significant interaction effect (2008 ANOVA: $F_{1, 36} = 19.54$, $P < 0.001$, Figure 2a; 2009 ANOVA: $F_{1, 36} = 10.02$, $P = 0.003$, Figure 2b). Similarly, in September 2009, age-0 red snapper were more abundant on the small distant reefs than on the small nearby reefs (ANOVA: $F_{1, 36} = 21.60$, $P < 0.001$; Figure 2c). No significant differences were detected for age-1 red snapper abundances between reef treatments (Figure 2). Comparisons of age-0 and age-1 red snapper abundance on the small distant reefs showed a significant negative correlation in August 2008 (Pearson's $r = -0.67$, $P = 0.03$), but significant correlations were not detected for the other two surveys (August 2009: Pearson's $r = -0.59$, $P = 0.07$; September 2009: Pearson's $r = -0.10$, $P = 0.78$). Overall, age-0 red snapper abundance did not significantly differ between August 2008 (mean $\pm$ SD $= 8.0 \pm 11.8$ fish/m$^3$) and August 2009 ($11.8 \pm 18.8$ fish/m$^3$; ANOVA: $F_{1, 38} = 0.6$, $P = 0.44$).

In August 2009, rock sea bass *Centropristis philadelphica* were marginally more abundant on the small distant reefs (mean $\pm$ SD $= 4.37 \pm 6.55$ fish/m$^3$) than on the small nearby reefs ($0.14 \pm 0.30$ fish/m$^3$; *t*-test: $t_{18} = 2.04$, $P = 0.056$); by

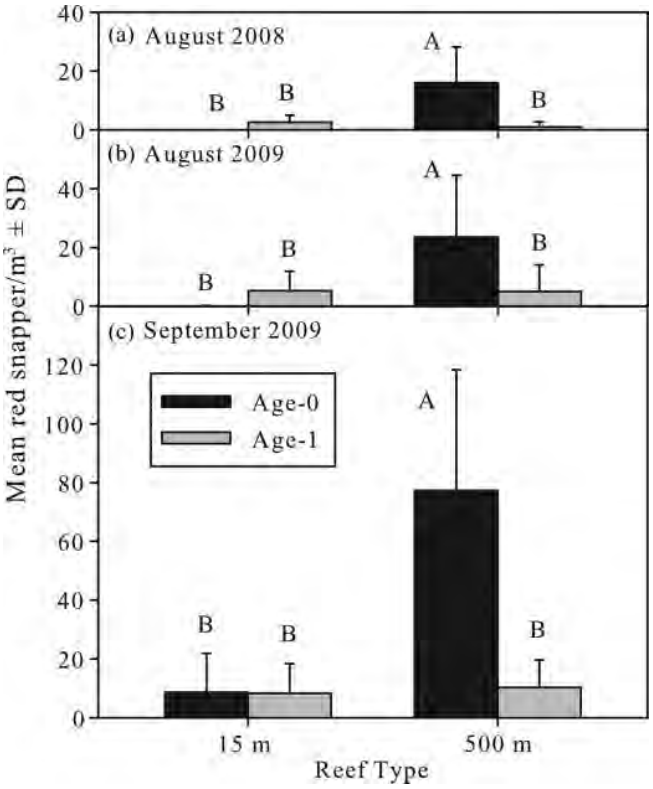


FIGURE 2. Mean (+SD) density (fish/m$^3$) of age-0 and age-1 red snapper based on visual SCUBA surveys of small artificial reefs placed 15 or 500 m from a larger artificial reef in the northern Gulf of Mexico during **(a)** August 2008, **(b)** August 2009, and **(c)** September 2009. Within a given panel, means with different uppercase letters are significantly different ($P < 0.05$).

September 2009, they were significantly more abundant on the small distant reefs (8.24 ± 9.26 fish/m$^3$) than on the small nearby reefs (0.00 fish/m$^3$; $t$-test: $t_{18} = 2.81$, $P = 0.012$). In August 2009, pygmy filefish *Stephanolepis setifer* were significantly more abundant on the small distant reefs (0.35 ± 0.50 fish/m$^3$) than on the small nearby reefs (0.00 fish/m$^3$; $t$-test: $t_{18} = 2.24$, $P < 0.05$); pygmy filefish were also more abundant in September 2009 on the small distant reefs (0.56 ± 0.80 fish/m$^3$) than on the small nearby reefs (0.00 fish/m$^3$; $t$-test: $t_{18} = 2.23$, $P < 0.05$). In contrast to most other species, age-0 tomtates were significantly more abundant on the small nearby reefs (172.1 ± 225.5 fish/m$^3$) than on the small distant reefs (2.8 ± 4.4 fish/m$^3$; $t$-test: $t_{18} = -2.37$, $P < 0.05$) in September 2009. Age-0 recruits (generally smaller than 76 mm) of several other species (including vermilion snapper *Rhomboplites aurorubens*, lane snapper *Lutjanus synagris*, cubbyu *Pareques umbrosus*, cocoa damselfish *Stegastes variabilis*, snowy grouper *Epinephelus niveatus*, sand perch *Diplectrum formosum*, and wrasses *Halichoeres* spp.) were observed on small reefs in 2009. However, no significant differences in mean abundance were detected between the small nearby reefs and small distant reefs ($P > 0.05$). In August 2009, species richness was significantly higher on the small distant reefs (4.2 ± 1.1 species/m$^3$) than on the small nearby reefs (2.7 ± 1.6 species/m$^3$; $t$-test: $t_{18} = 2.37$, $P < 0.05$).

Predators capable of consuming newly settled reef fishes (i.e., predator TL > 200 mm) were observed on all large reefs. In addition to large fishes, age-0 tomtates, vermilion snapper, and round scad were observed recruiting onto 6 of 10 large reefs in 2009. Although divers were able to detect age-0 tomtates, vermilion snapper, and round scad on the large reefs, no age-0 red snapper were observed on those reefs in August 2008 or August 2009, and fewer than 20 age-0 red snapper were observed on 2 of the 10 large reefs in September 2009.

Significant differences in reef fish communities were detected between reef treatments for all three surveys: August 2008 (ANOSIM Global $R$: $R = 0.342$, $P < 0.001$; Figure 3a), August 2009 ($R = 0.327$, $P < 0.001$; Figure 3b), and September 2009 ($R = 0.497$, $P < 0.001$; Figure 3c). In all surveys, similar species were observed between the reef treatments, but density differences for particular species probably accounted for the significant differences detected in the total reef fish communities (Table 1).

Similar to the visual surveys performed by SCUBA divers, computer-aided counts of age-0 red snapper from photographs showed significantly higher relative abundances in August 2009 on the small distant reefs (mean ± SD = 12.04 ± 15.69 fish/m$^3$) than on the small nearby reefs (0.00 fish/m$^3$; $t$-test: $t_{18} = 2.43$, $P < 0.05$); the difference was again observed in September 2009 (small distant reefs: 52.68 ± 25.24 fish/m$^3$; small nearby reefs: 6.76 ± 9.80 fish/m$^3$; $t$-test: $t_{18} = 5.36$, $P < 0.001$). Video counts also showed significantly higher age-0 red snapper relative abundances on the small distant reefs than on the small nearby reefs in August 2009 (small distant reefs: 7.51 ± 6.77 fish/m$^3$; small nearby reefs: 0.00 fish/m$^3$; $t$-test: $t_{16} = 3.33$, $P < 0.01$) and in September 2009 (small distant reefs: 21.06 ± 11.15 fish/m$^3$; small nearby reefs: 1.88 ± 3.05 fish/m$^3$; $t$-test: $t_{17} = 4.98$, $P < 0.001$). Comparisons among the three methods for September 2009 showed significantly more age-0 red snapper from diver visual surveys (42.96 ± 46.14 fish/m$^3$) than from counts derived from photographs (29.72 ± 30.04 fish/m$^3$) and video recordings (11.97 ± 12.77 fish/m$^3$; ANOVA: $F_{2,56} = 4.35$, $P < 0.05$). Similarly, in August 2009, visual surveys indicated significantly higher species richness (3.49 ± 1.56 species/m$^3$) than did photographs (1.80 ± 0.90 species/m$^3$) and video surveys (1.17 ± 0.68 species/m$^3$; ANOVA: $F_{2,55} = 21.91$, $P < 0.001$). This was also the case for species richness in September 2009 (visual surveys: 4.68 ± 1.50 species/m$^3$; photographs: 2.89 ± 0.94 species/m$^3$; videos: 2.04 ± 0.88 species/m$^3$; ANOVA: $F_{2,56} = 27.27$, $P < 0.001$).

## DISCUSSION

Age-0 red snapper were always more abundant on the small distant (500 m) reefs than on the small nearby (15 m) reefs. In fact, no age-0 red snapper were observed on the small nearby reefs during August 2008, and only one age-0 red snapper was

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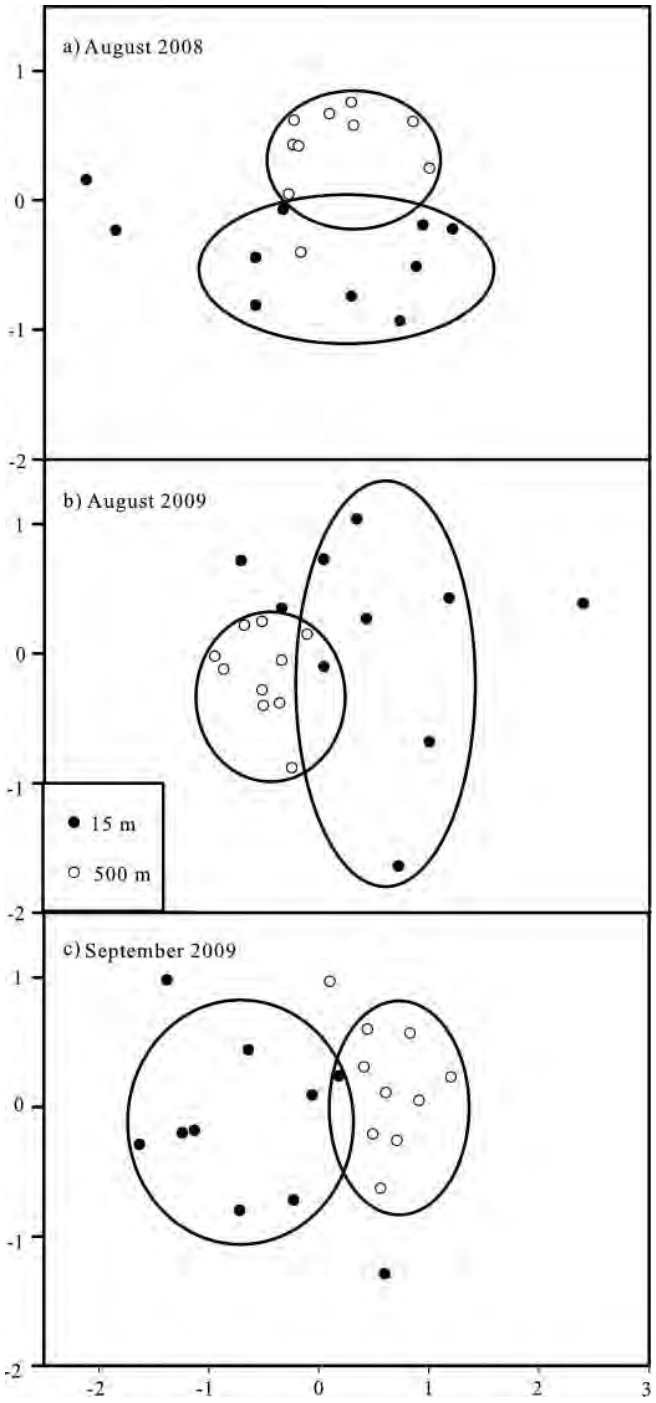


FIGURE 3. Multidimensional scaling plot of Czekanowski's similarity coefficient, showing differences in resident reef fish communities between small artificial reefs placed 15 and 500 m from a large artificial reef in the northern Gulf of Mexico during **(a)** August 2008, **(b)** August 2009, and **(c)** September 2009. Axes are unitless. Hand drawn ovals indicate similar groupings.

observed on the small nearby reefs during August 2009. This clearly shows the strong effect that the proximity of predators and competitors can have on new recruits. Similarly, several previous studies have shown that predators reduced recruitment near larger reefs (Shulman 1985; West et al. 1994; Steele 1997; Belmaker et al. 2005). It was only in September 2009 that age-0 red snapper began to appear in low numbers on the small nearby reefs, indicating that by this time the age-0 red snapper had grown beyond the gape size of smaller potential predators that occupied the large reefs (e.g., tomtate, pigfish, and age-1 red snapper). In addition, by September, the age-0 recruits were probably more competent swimmers, which made them better able to evade larger predators and aggression from other fish.

Several mechanisms may be responsible for the pattern of reduced age-0 red snapper on the small nearby reefs compared with the small distant reefs. Shortly after settlement, age-0 red snapper may suffer predation mortality from the predators inhabiting the larger reefs. In fact, recent observations showed direct predation by adult red snapper (2.5-kg fish) on age-0 red snapper (22 mm standard length; our unpublished data). Though direct observation of predation on recruits attempting to settle onto reefs nearby is difficult to obtain, Belmaker et al. (2005) moved patch reefs closer to a continuous reef with a resident fish community and observed aggregation of predators along with numerous predatory strikes; those authors suggested that the predators were consuming many of the new recruits on the patch reef. Another possibility is that older conspecifics were driving off any new recruits that attempted to settle onto the small nearby reefs, as was shown in a laboratory study of red snapper (Bailey et al. 2001). New recruits may also be able to detect predators or conspecifics on the larger reefs and simply choose to settle elsewhere. Sweatman (1988) found evidence that reef fish recruits used chemical cues to preferentially choose settlement sites based on the presence or absence of conspecifics or competitors. Ultimately, all three mechanisms are probably operating, but it is difficult to partition these factors in the present study.

Distance from large reefs clearly affected the abundance of age-0 red snapper on the small reefs. We assumed that the small nearby reefs were well within the range of the predatory fishes living on the large reefs, whereas the small distant reefs were beyond the usual range of resident predators on the large reefs. This assumption was supported by previous tracking studies in which adult red snapper were continuously located at distances between 5 and 66 m from a reef over 24-h periods (Szedlmayer and Schroepfer 2005; Topping and Szedlmayer 2011). Our assumption was also supported by diver observations indicating that larger resident fish (>300 mm TL) on the large reefs would swim over to the small nearby reefs during visual surveys. The larger fishes included the red snapper, gag *Mycteroperca microlepis*, gray triggerfish, and greater amberjack. No fish over 280 mm TL were observed on the small distant reefs, suggesting

TABLE 1. Comparison of reef fish densities (fish/m$^3$; for species that contributed >0.02% of the total) between small artificial reefs placed 15 m (nearby) and 500 m (distant) from a larger artificial reef over all surveys conducted during 2008 and 2009 in the northern Gulf of Mexico.

| | Distant reefs | | Nearby reefs | |
|---|---|---|---|---|
| Species | Density (fish/m$^3$) | Percent of total | Density (fish/m$^3$) | Percent of total |
| Red snapper | 66.58 | 47.39 | 12.39 | 2.38 |
| Vermilion snapper | 53.27 | 37.92 | 404.15 | 77.52 |
| Rock sea bass | 6.69 | 4.76 | 0.07 | 0.01 |
| Sand perch | 3.49 | 2.48 | 0.67 | 0.13 |
| Tomtate | 2.46 | 1.75 | 96.58 | 18.53 |
| Pigfish *Orthopristis chrysoptera* | 1.94 | 1.38 | 1.34 | 0.26 |
| Bank sea bass *Centropristis ocyurus* | 1.83 | 1.30 | 0.04 | 0.01 |
| Cubbyu | 1.62 | 1.15 | 2.78 | 0.53 |
| Gray triggerfish *Balistes capriscus* | 0.95 | 0.68 | 0.53 | 0.10 |
| Pygmy filefish | 0.46 | 0.33 | | |
| Lane snapper | 0.39 | 0.28 | 0.28 | 0.05 |
| Wrasses *Halichoeres* spp. | 0.32 | 0.23 | 0.35 | 0.07 |
| Snowy grouper | 0.21 | 0.15 | 0.04 | 0.01 |
| Short bigeye *Pristigenys alta* | 0.07 | 0.05 | | |
| Dwarf goatfish *Upeneus parvus* | 0.07 | 0.05 | | |
| Blennies (Blenniidae) | 0.04 | 0.03 | 0.60 | 0.11 |
| Cocoa damselfish | 0.04 | 0.03 | 0.42 | 0.08 |
| Atlantic spadefish *Chaetodipterus faber* | 0.04 | 0.03 | 0.21 | 0.04 |
| Glasseye snapper *Heteropriacanthus cruentatus* | 0.04 | 0.03 | | |
| Twospot cardinalfish *Apogon pseudomaculatus* | | | 0.74 | 0.14 |

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that observed fish typically did not cross the 500 m of open habitat between reefs. In addition (although not quantified), when age-0 red snapper were observed on the small nearby reefs, they tended to hide within the holes and refuges of the reef structure, while age-0 red snapper on the small distant reefs moved freely above and around the reef structure.

A negative correlation was observed between the abundances of age-1 and age-0 red snapper on the small distant reefs. Although this pattern was only significant in August 2008, it was also apparent in August 2009. The lack of any negative correlation in September 2009 again suggests that by this time, age-0 red snapper had grown to sizes that were large enough to afford them some protection from predation or aggression from age-1 red snapper. Similarly, enhanced recruitment of Ward's damsel *Pomacentrus wardi* was observed on reefs from which adult conspecifics had been removed (Sale 1976). If conspecifics are responsible for the exclusion of age-0 red snapper, this may be an example of density dependence. Other studies have found evidence of density dependence in reef fishes. For example, adult bridled goby *Coryphopterus glaucofraenum* caused a density-dependent reduction in the recruitment of juveniles (Forrester 1995), and there was an inverse relation between adult density and subsequent recruitment in millet butterflyfish *Chaetodon miliaris* (Stimson 1990). Tupper and Boutilier (1995) showed that older conspecifics reduced the survival of cunners *Tautogolabrus adspersus*, and no new recruits survived on reefs with the highest densities of conspecifics. Based on the present study results, it is difficult to conclude that older conspecifics were causing density-dependent recruitment in red snapper, as a large number of other predators were also present on the larger reefs. Even so, it appears that predator-free nursery structures may be a limiting resource for age-0 red snapper.

Rock sea bass and pygmy filefish were significantly more abundant on the small distant reefs than on the small nearby reefs. However, most of the individuals observed were adults rather than new recruits, and the adults of these species are generally small; in this study, the largest rock sea bass was 15 cm and the largest pygmy filefish was 12 cm. Thus, in addition to juvenile fish, the adults of smaller reef fishes may also benefit from the reduced predation or competition in habitats located outside of the influence of larger reefs.

Age-0 tomtates showed a pattern opposite to that of red snapper and had higher abundances on the small nearby reefs than on the small distant reefs. Divers observed tomtate recruits on the large reefs—sometimes in numbers exceeding 1,000—despite the presence of numerous predators. It appears that higher counts of tomtates on the small nearby reefs result from their high abundance on the larger reefs. In September 2009, when this pattern was detected, tomtates settled onto reefs at much higher densities than did red snapper. Tomtate densities may be high enough to satiate predators and to allow survival despite heavy predation. These patterns indicate a different survival strategy for tomtates

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compared with red snapper. Red snapper may actively select predator-free habitat, while tomtates seek out larger reef habitat independent of predator presence. Such differences in life history are known for other reef fishes. Some species (e.g., Ambon damsel) settle directly onto adult habitats (McCormick and Makey 1997), whereas others (e.g., Nassau grouper *Epinephelus striatus* and gag) exploit nursery habitats before moving to larger reefs later in life (Eggleston 1995; Ross and Moser 1995).

Our finding of higher abundances of tomtates on the small nearby reefs differs from several studies that showed higher recruitment with increasing distance from a reef (Shulman 1985; Steele 1997; Belmaker et al. 2005). This difference may result from a difference in scale among studies. Previous studies looked at fine-scale differences, with the farthest reefs being less than 50 m from the large reef, while in the present study small reefs were placed 500 m from the large reefs. Alternatively, tomtates in the northern Gulf of Mexico may simply be an exception to an otherwise common pattern.

In August 2009, mean species richness was higher on the small distant reefs than on the small nearby reefs. Similar patterns were reported by Shulman (1985) and Belmaker et al. (2005), who found higher diversity on small reefs that were placed farther away from a large reef than on those placed closer to a large reef. Caley (1993) observed higher species richness of nonpiscivorous reef fish recruits on reefs where resident predators had been removed. Again, this pattern could be caused by (1) prey fish avoidance of habitats that have resident predators or (2) predator reduction of species richness by occasionally preying on members of rare species.

All three survey techniques used in this study were able to detect significantly higher densities of age-0 red snapper on the small distant reefs. On average, the visual surveys gave the highest counts, photographs gave intermediate counts, and video recordings always gave the lowest abundances. Tessier et al. (2005) also obtained higher counts with visual surveys than with video techniques. Willis et al. (2000) obtained higher abundance estimates and higher precision with video surveys than with visual surveys, but those authors used an unmanned, baited video technique rather than a diver-operated video camera. However, baited video methods may have attracted fish from the surrounding area and biased their fish counts. In any photographic or video survey, there will always be fish on the reef that are out of range and undetectable. However, as fish abundance increases, diver counts become more difficult. Thus, as a trade off, photographs can provide more-precise counts for comparative purposes without the difficulty of counting swimming fish but will be less accurate than diver visual counts of total reef fish abundance. Visual surveys also showed higher mean species richness than photographs or video recordings, similar to the results of Tessier et al. (2005). The visual survey was able to detect rare and cryptic species, such as twospot cardinalfish and belted sandfish *Serranus subligarius*, which were not detected in photographs or video counts. The visual survey was also the only method that detected the single age-0 red snapper on the small nearby reefs in August 2009. In conclusion, visual surveys are needed to detect rare or cryptic species and to measure species richness, while photographs are more appropriate for comparative measures of relative abundance.

The results of this study can be used to improve the construction and placement of artificial reefs. West et al. (1994) concluded that low-relief artificial reefs would most benefit juvenile rockfishes *Sebastes* spp. if they were built in areas without adjoining adult habitat. Likewise, this study indicates that if artificial reefs are built to provide habitat for juvenile red snapper, they should not be built in areas immediately adjacent to existing adult habitat. Furthermore, artificial reefs that are meant to provide habitat for adult fish should not be built near important red snapper nursery habitats.

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# A comparison of size and age of red snapper (*Lutjanus campechanus*) with the age of artificial reefs in the northern Gulf of Mexico

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**Abstract**—Despite extensive study, it still is not clear whether artificial reefs produce new fish biomass or whether they only attract various species and make them more vulnerable to fishing mortality. To further evaluate this question, the size and age of red snapper (*Lutjanus campechanus*) were sampled from April to November 2010 at artificial reefs south of Mobile Bay off the coast of Alabama and compared with the age of the artificial reef at the site of capture. Red snapper were collected with hook and line and a fish trap and visually counted during scuba-diver surveys. In the laboratory, all captured red snapper were weighed and measured, and the otoliths were removed for aging. The mean age of red snapper differed significantly across reefs of different ages, with older reefs having older fish. The mean age of red snapper at a particular reef was not related to reef depth or distance to other reefs. The positive correlation between the mean age of red snapper and the age of the reef where they were found supports the contention that artificial reefs in the northern Gulf of Mexico enhance production of red snapper. The presence of fish older than the reef indicates that red snapper are also attracted to artificial reefs.

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Red snapper (*Lutjanus campechanus*, Poey, 1860) has been historically targeted by both sport and commercial fishermen in the Gulf of Mexico (Camber, 1955). Because of intense fishing pressure, the estimated population abundance in this region has decreased and the stock is considered overfished (Schirripa and Legault, 1999; SEDAR[1]). Regulations that decrease the total allowable catch and shorten the recreational season have been enacted over the last several decades to reduce the harvest of this species and increase stock abundance.

The red snapper is a reef-associated fish that uses reef habitat as a resource for both shelter and prey (Ouzts and Szedlmayer, 2003; Szedlmayer and Lee, 2004; Piko and Szedlmayer, 2007; Gallaway et al., 2009). Age-0 red snapper begin to use reefs shortly after they settle out of the plankton and move to available low-relief, structured habitat (Workman and Foster, 1994; Szedlmayer and Howe, 1997; Szedlmayer and Conti, 1999; Szedlmayer and Lee, 2004). These new recruits quickly outgrow their initial benthic habitats and search for larger structured habitats by fall after the spawning season (Szedlmayer and Conti, 1999; Szedlmayer and Lee, 2004; Szedlmayer, 2011). After this initial recruitment, the presence of age-1 and older snapper, through predation and competitive exclusion, may limit the immigration of new recruits to reef structure (Bailey et al., 2001; Piko and Szedlmayer, 2007; Gallaway et al., 2009; Mudrak and Szedlmayer, 2012).

The substrate in the northern Gulf of Mexico is predominately mud and sand and has comparatively few natural reef areas (Parker et al., 1983; Kennicutt et al.,1995; Dufrene, 2005). The lack of naturally occurring reefs has stimulated the deployment of artificial reefs (e.g., decommissioned military tanks and concrete pyramids) by state agencies, private fishermen, and scientists to increase the availability of reef habitat. Several permit areas have been established off the coast of Alabama, where an estimated 15,000 artificial reefs have been deployed (Minton and Heath, 1998). The deployment of new reefs each year continues to add or replace reefs lost to major tropical storms.

The effect of artificial reefs on reef fish populations has been considered for decades. Bohnsack (1989) suggested that artificial reefs may simply aggregate fishes, making resident species easier to harvest and may ultimately decrease their populations. A second possibility is production enhancement, where reefs provide some limiting factor (e.g., habitat) that allows for an increase in the

[1] SEDAR (Southeast Data, Assessment, and Review). 2009. Stock assessment of red snapper in the Gulf of Mexico: SEDAR update assessment. Report of the update assessment workshop;, 24–28 August, 2009, 143 p. Miami, FL. NMFS, SEFSC, NOAA, Miami, Florida. [Available from http://www.sefsc.noaa.gov/sedar.]

available biomass of reef species. The artificial reef system in the northern Gulf of Mexico has been studied extensively— many studies focusing on various life history aspects of red snapper as a means to help resolve the question of whether or not artificial reefs enhance production.

The first group of studies involved diet analyses of the stomach contents of red snapper. If enhanced production is occurring, then red snapper diets should contain reef prey species; but, if only attraction is occurring, red snapper should be feeding on prey species not found on reefs. Evidence supporting both scenarios has been reported. For example, some studies reported that most red snapper prey items were species associated with the water column and sand-mud habitat (McCawley et al., 2006; Wells et al., 2008b). In contrast, other studies showed significant feeding on reef species (Ouzts and Szedlmayer, 2003; Szedlmayer and Lee, 2004; Redman and Szedlmayer, 2009).

Site fidelity of red snapper to artificial reefs also has been used to examine the question of enhanced production on artificial reefs. Again, 2 differing scenarios have been reported. Low residency and lack of site fidelity support the attraction hypothesis (Patterson et al., 2001b, Peabody, 2004), and long-term (>1020 d) residency on artificial reefs and high site fidelity support the production hypothesis (Szedlmayer and Shipp, 1994; Szedlmayer, 1997; Szedlmayer and Schroepfer, 2005; Schroepfer and Szedlmayer, 2006; Topping and Szedlmayer, 2011a; 2011b).

These previous studies indicate that attraction of red snapper to artificial reefs is occurring, but the extent to which artificial reefs also enhance production is an open question. Although it is relatively easy to provide evidence for attraction, it is not as easy to find evidence for production. Therefore, we contend that it still is not clear whether artificial reefs produce new red snapper biomass or whether they only attract fish of this species and make them more vulnerable to fishing mortality.

A new approach to this long-standing question would be to compare the age of resident fish with the age of the artificial reef where they occur. If enhanced production is occurring, new reefs should attract new recruits, and these recruits likely would stay and grow as their reef ages, becoming the dominate age class and would possibly exclude new recruits from the reef habitat. In this case, the age of fish resident at a reef should be positively correlated with the age of the reef. In contrast, if artificial reefs simply attract red snapper, reef age should not be correlated with fish age but, rather, should be related to the proximity of red snapper on other reefs and red snapper movement patterns. For our study, artificial reefs were deployed in 2006, 2009, and 2010, and the size and age of red snapper were compared among these 3 reef ages to help clarify whether artificial reefs may be enhancing red snapper production. The positions of these reefs were not released to the public to reduce the potential effects of variation in fishing mortality on age distributions of red snapper.

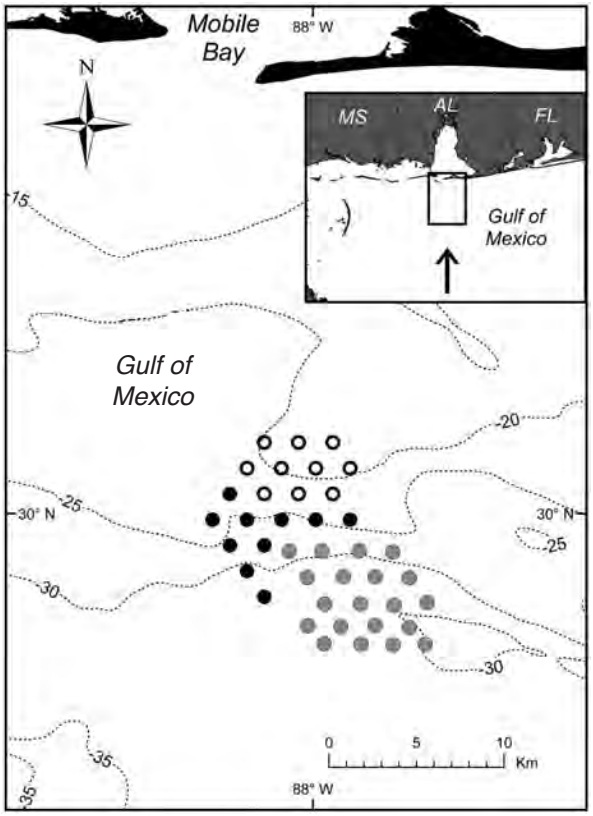


**Figure 1**

Map of sampling locations in our study of red snapper (*Lutjanus campechanus*) on artificial reefs in the northern Gulf of Mexico in 2010. Gray circles=reefs deployed in 2006; open circles=reefs deployed in 2009; and black circles=reefs deployed in 2010. Dotted lines indicate depth contours at 5-m intervals.

## Materials and methods

### Sample sites

The area of our study was located 20–30 km south of Mobile Bay, Alabama (Fig. 1). This area has more than 15,000 artificial reefs and a few natural, rocky reefs (Minton and Heath, 1998). For our study, artificial reefs (4.4×1.3×1.2 m, metal cages) were deployed in April 2006 ($n$=20, which became 4-year-old reefs in our study), April 2009 ($n$=10, which became 1-year-old reefs in our study), and January 2010 ($n$=10, which became 0.5-year-old reefs in our study). Reef locations were not published to limit potential fishing mortality. All the reefs we studied were located 1.3–1.7 km from other reefs deployed in this study. These reefs were deployed at the following depths: 27–32 m in 2006, 18–24 m in 2009, and 23–31 m in 2010.

All reefs were sampled from April to November 2010. The reefs deployed in 2010 were not sampled until at least 5 months after their deployment to allow adequate time for the immigration of red snapper (Mudrak and

Szedlmayer, 2012). Red snapper were collected with hook and line and fish trap from each reef. Hook-and-line sampling was standardized to 30 min and 2 individuals who fished. Fishing time was suspended when problems occurred (e.g., internally hooked fish) and continued once both individuals could resume fishing. For hook-and-line fishing, double 6/0 J hooks, 27.2-kg test monofilament line, 45.3-kg test monofilament leader were used, and whole Gulf menhaden (*Brevoortia patronus*) as bait. After completion of hook-and-line sampling, additional fish were collected with a baited fish trap (1.2×1.5×0.6 m; Collins, 1990). In the fish trap, both Gulf menhaden and whole squid (*Loligo* spp.) were used as bait. All fish traps were set for 15 min. After collections of red snapper reached ~50 individuals per reef, a diver released the number of fish caught above 50 fish by opening the trap door and allowing random individuals to escape at the surface—with one exception (73 red snapper were kept on 5 May 2010 because of the possibility of area closures that might have resulted from the Deepwater Horizon oil spill). When the minimum target of 30 individuals per reef was not reached after the first fish trap set, the trap was fished at least one additional time. All red snapper collected from a reef were immediately packed on ice and returned to the laboratory for further processing.

After fish collections were completed, 2 scuba divers completed visual counts and photographic (Nikon D200[2], Nikon Corp., Tokyo) and video (Sony CCD-TR101, Hi8, Sony Corp., Tokyo) recordings to use in estimation of the remaining red snapper at each sample site. A clear plastic jar containing cut Gulf menhaden was used to attract surrounding red snapper into aggregations during visual surveys for increased accuracy of total counts. Divers completed at least 3 full-circle point-and-count surveys, where the divers counted all fish within visual circular range, and the highest count was used for estimates of total abundance. Poor visibility at some sites limited these estimates. In addition, when sharks were present, diver operations were suspended, and visual estimates were completed later within 30 days of the original fish collections.

### Laboratory analyses

Red snapper size (standard length [SL], fork length [FL], and total length [TL] in millimeters) and total body weight (0.1 g) were measured in the laboratory within 24 h of capture. For red snapper ≥250 mm TL, otoliths were removed with a Bosch fine-cut electric saw. For red snapper <250 mm TL, otoliths were removed with a small knife. Both left and right otoliths were removed from each fish, cleaned, and stored in dry plastic vials for later analysis. Opaque bands were counted on all otoliths for age estimates. For fish <7 years old, bands were counted on whole otoliths that were immersed in water and viewed under a dissecting scope with transmitted light. If ages were ≥7 years, thin otolith sections were prepared and bands were counted at 40× magnification with a compound microscope (Szedlmayer and Beyer, 2011). Opaque bands of sectioned otoliths were counted along the dorsal edge of the sulcus acousticus. Bands on each otolith were counted independently 4 times. After 4 readings, 2 readers examined the remaining otoliths for which counts still differed and attempted to reach a consensus on age. If an agreement on age could not be reached for an otolith, it was rejected. A reference collection of hatchery red snapper that had been released in the wild as age-0 and recaptured as age-1fish ($n$=22) along with a group that had been reared in captivity to age-1 ($n$=13) were used to validate counting methods of wild caught age-1 fish. Some of the otoliths of these known age-1 fish showed a "false" annulus (i.e., had 2 opaque bands) but showed age-1 otolith shape patterns (Beyer and Szedlmayer, 2010). Therefore, some of the wild fish <200 mm SL caught in this study that had 2 opaque bands were defined as age-1, on the basis of their age-1 shape patterns appearing similar to the shape patterns of hatchery-reared fish as well as hatchery-born but wild-reared fish.

Video recordings and digital photographs of the studied reefs were examined in the laboratory for comparisons and validation of the divers' visual counts. In the laboratory, photographs that showed the highest number of red snapper for a particular reef were selected for computer-based counting. All red snapper in these photographs were identified and counted through image analysis with Image-Pro Plus software (vers. 4.5, Media Cybernetics, Rockville, MD). Two screens were used to count fish in video recordings. A single frame captured from the video was displayed on one screen while the video played on the second screen. Because image quality decreases when a single frame of video is captured, we used the full video on the second screen to identify all the fish in the captured frame on the first screen. The captured video image then was marked and the fish in it were counted with Image-Pro software.

## Data analyses

Catch per unit of effort (CPUE) for each reef was calculated for both hook and line (CPUE=number caught by 2 individuals/30 min) and trap (CPUE=number caught/15 min). The precision of age estimates between readers was compared with linear regression and average percent error (Beamish and Fournier, 1981). Densities of red snapper were estimated by adding the total number of red snapper caught (from both hook and line and fish trap) to the number of fish counted in the visual survey. Pearson's correlation coefficient was used to compare densities (number of fish per cubic meter of reef surveyed) among reefs of different ages, with reef age determined by the number of months that a reef had been deployed before the month of sampling. Analysis of variance (ANOVA) was used to compare the SL, weights,

[2] Mention of trade names or commercial companies is for identification purposes only and does not imply endorsement by the National Marine Fisheries Service, NOAA.

and ages of red snapper among the different ages of reefs. If significant differences were detected, a Tukey test was used to show specific differences.

Growth rates were examined with an analysis of covariance (ANCOVA) that compared the mean length at age of red snapper <10 years old between old (2006) and new (2009 and 2010) reefs. This analysis was used to determine if old reefs were providing additional resources, a difference that would be reflected in faster growth rates of red snapper on old reefs than on new reefs. For additional comparisons, Pearson's correlation coefficients were calculated for reef age with red snapper SL, weight, and age. Also examined with Pearson's correlation coefficient was the potential influence of nearby known reefs on the age and abundance of red snapper on the reefs that we surveyed in 2010. Nearby reefs were 0.17–1.7 km away (mean=0.72 km, $n$=37), or less than the distance between the reef sites sampled in our study. In an effort to remove possible depth effects, the ages of red snapper collected at the same depth (30 m) were compared between the 2006 and 2010 reefs with a $t$-test. Differences were considered significant at $P \leq 0.05$, and all data were analyzed with Statistical Analysis System software (SAS, vers. 9.1, SAS Institute, Inc., Cary, NC).

## Results

Red snapper were sampled from April to November 2010 from 37 artificial reefs (2006 reefs=18; 2009 reefs=10; 2010 reefs=9). Visual surveys were completed by divers at later dates at 2 sites because of the presence of sharks on the original sampling date and were not completed on 7 reefs (3 of the 2006 reefs and 4 of the 2010 reefs) because of poor visibility (<1 m).

A total of 1028 red snapper were collected, 439 by hook and line and 589 by trap. Mean ±standard deviation (SD) CPUE for hook and line was significantly greater on the 2006 reefs (20.4 ±8.5 30 min$^{-1}$) than on the 2009 (6.3 ±8.1 30 min$^{-1}$) and 2010 reefs (2.6 ±4.6 30 min$^{-1}$; ANOVA: $F_{2, 34}$=20.38, $P$<0.0001). No significant differences in CPUE were detected among reef years for trap collections (2006=10.6 ±10.9, 2009=16.6 ±19.9, and 2010=14.3 ±12.7; ANOVA: $F_{2, 34}$=0.6, $P$=0.55). The SL and weight of red snapper caught by hook and line (429.4 ±79.8 mm, 2531 ±1409 g) were significantly greater than those measures of fish caught by trap (232.6 ±77.6 mm, 538 ±726 g; SL $t$-test, $t_{1018}$=39.56, weight $t_{1018}$=29.41, $P$<0.0001). Red snapper ages also were significantly different between these 2 sampling methods (hook and line=4.1 ±1.3 years, trap=1.9 ±1.1 years; $t$-test, $t_{1024}$=29.68, $P$<0.0001).

The visual survey methods significantly affected counts of red snapper. Visual counts by divers (mean ±SD=78.3 ±54.8) were significantly higher than counts from image-analysis methods (photograph counts=30.7 ±20.2, video counts=16.5 ±10.3; ANOVA, $F_{2, 42}$=13.37, $P$<0.0001). Because of these differences, total densities of red snapper were estimated by adding the number of captured fish (hook-and-line and trap samples) to divers' visual counts.

**Table 1**

Average percent error for both sets of independent readings of otoliths from red snapper (*Lutjanus campechanus*) caught in 2010 during our study on artificial reefs in the northern Gulf of Mexico. Included are the percentages of agreement for each difference between readings (first and second reading, coefficient of regression [$r^2$]=0.83, $P$<0.0001; third and fourth reading, $r^2$=0.96, $P$<0.0001).

| | First and second readings | Third and fourth Readings |
|---|---|---|
| Average percent error | 7.85 | 1.41 |
| Standard deviation | 0.12 | 0.05 |
| 0 | 62.16% | 92.32% |
| ±1 | 35.89% | 7.39% |
| ±2 | 1.95% | 0.29% |
| ≥3 | 0% | 0% |

Age-1 red snapper composed the dominate age class on the 2010 reefs and recruited to these reefs in the early summer. Mean ±SD numbers of red snapper per cubic meter of reef structure increased as reef age increased (Pearson's correlation coefficient [$r$]=0.48, $P$=0.008) and were significantly greater on 2006 reefs (22 ±13) than on 2009 reefs (12 ±6) and 2010 reefs (8 ±7; ANOVA, $F_{2, 27}$=4.25, $P$<0.025).

All caught red snapper ($n$=1028: 2006 reefs=587, 2009 reefs=280, 2010 reefs=161) were used in the final age comparisons. Initial agreement between the first and second independent readings was 62.2% (639/1028). A third and fourth reading increased the accepted otoliths to 92.3% (949/1028). Average percent error was calculated for both sets of independent readings (Table 1). An age consensus was reached on all remaining otoliths ($n$=79) through simultaneous examination by the 2 readers. The reference collection of age-1 hatchery ($n$=35, laboratory and wild reared) red snapper showed 25.7% with 2 opaque bands, indicating that counting opaque bands for age-1 fish may not be reliable. Among fish that were <200 mm SL and showed 2 opaque bands ($n$=72), all were identified as age-1 based on shape, thickness, and location of the opaque bands (Beyer and Szedlmayer, 2010; Szedlmayer and Beyer, 2011).

Mean ±SD red snapper SL, weight, and age were significantly different among 2006 reefs (373.3 ±107.8 mm SL, 1883 ±1388 g, 3.5 ±1.2 years), 2009 reefs (250.2 ±114.7 mm SL, 852 ±1464 g, 2.0 ±1.7 years) and 2010 reefs (222.3 ±78.0 mm SL, 480 ±711 g, 1.7 ±1.0 years; ANOVA, $F_{2, 1025}$=194.2, $P$<0.0001; Table 2; Figs. 2 and 3). Reef age was positively correlated with red snapper age (Pearson's $r$=0.61, $P$<0.0001), standard length ($r$=0.71, $P$<0.0001), and weight ($r$=0.47, $P$=0.0035). Comparisons of linear growth rates for fish <10 years old showed no significant differences between old (2006)

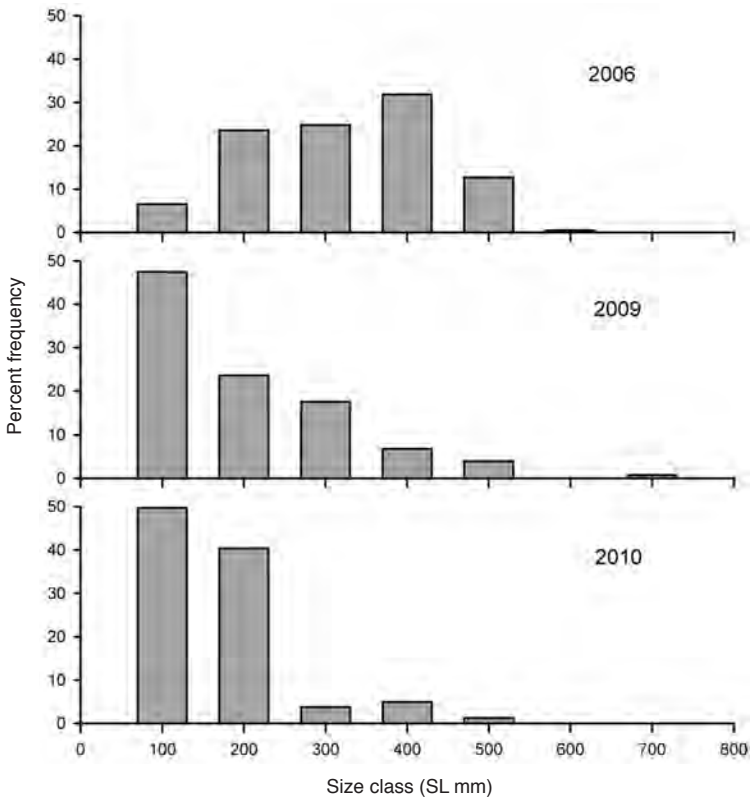


**Figure 2**

Length frequency of red snapper (*Lutjanus campechanus*) caught in our study on artificial reefs in the northern Gulf of Mexico in 2010, shown by year that reef was deployed, separated into 100-mm standard-length (SL) size classes (e.g., 100=100–199 mm).

**Table 2**

Mean (±SD) standard length (SL), weight, and age of red snapper (*Lutjanus campechanus*) caught during our study on artificial reefs deployed in 2006, 2009, and 2010 in the northern Gulf of Mexico. Superscript letters are used to indicate significant differences ($P \leq 0.05$). Included for each reef year are the total number of red snapper caught by hook-and-line and trap, mean diver count, and mean density estimate. Estimates of mean density per reef combine diver counts and catch of hook-and-line and trap.

| Reef year | SL (mm) | Weight (kg) | Age (yr) | Hook and line | Trap | Diver count | Density |
|---|---|---|---|---|---|---|---|
| 2006 | 373.3 ±107.8 [a] | 1.88 ±1.39 [a] | 3.54 ±1.24 [a] | 20.2 ±8.8 | 12.4 ±11.3 | 115.5 ±87.8 | 148.7 ±92.5 |
| 2009 | 250.2 ±114.7 [b] | 0.85 ±1.46 [b] | 1.98 ±1.70 [b] | 5.3 ±6.1 | 22.5 ±18.4 | 54.0 ±35.8 | 81.8 ±41.2 |
| 2010 | 222.3 ±78.0 [c] | 0.48 ±0.71 [c] | 1.72 ±1.00 [c] | 2.3 ±4.6 | 15.6 ±11.6 | 36.0 ±31.7 | 55.6 ±45.6 |

and new (2009 and 2010) reefs (ANCOVA, $F_{3,\ 1018}$=2.98, $P$=0.085, power>0.99).

The mean depth (30 m) of the 2006 reefs were significantly greater than the mean depth (20 m) of the 2009 reefs ($t$-test, $t_{26}$=16.32, $P$<0.0001). Because of this depth difference, red snapper also were compared among the 2006 and 2010 reefs ($n$=8) with the same depth (30 m). These comparisons also showed significantly larger and older red snapper on the 2006 reefs (mean ±SD=368.7 ±5.0 mm SL, 1821 ±1326 g, 3.60 ±1.20 years) compared to 2010 reefs (236.2 ±85.2 mm SL, 578 ±814 g, 1.91 ±1.10 years; $t$-test, $P$<0.0001).

Comparisons of our estimates of red snapper abundance and age on artificial reefs by proximity (<1.7 km) to other known reefs not sampled in our study failed to detect a significant effect. These other nearby reefs have published locations because they are part of Alabama's artificial reef program and were deployed

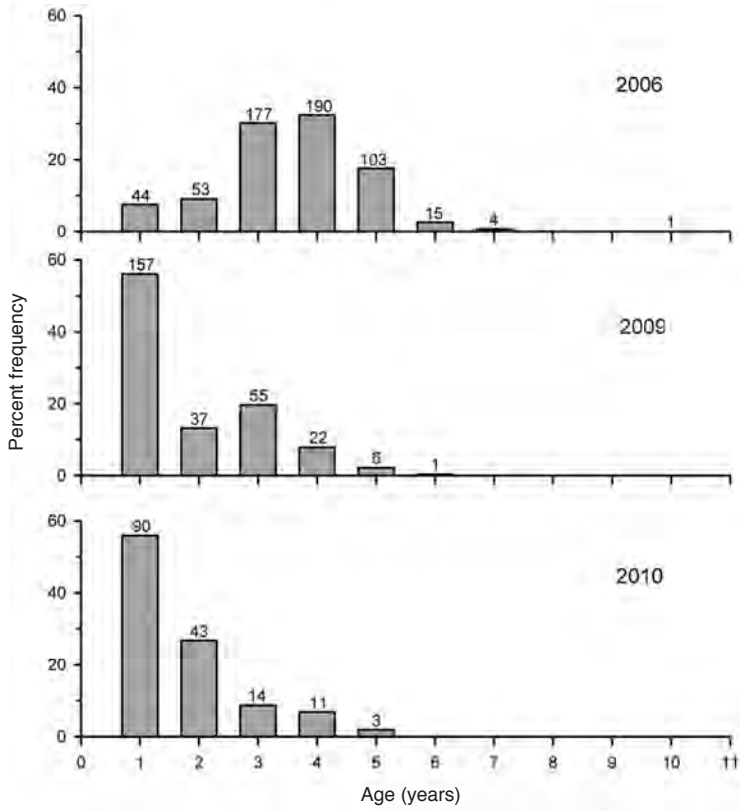


**Figure 3**

Age frequency, by year that reef was deployed, of red snapper (*Lutjanus campechanus*) caught in our study on artificial reefs in the northern Gulf of Mexico in 2010. Numbers above bars indicate total number of fish caught for each age class.

from 1992 to 2007. The oldest reef (1992) was closest to a 2010 reef that we sampled, and many of the artificial reefs deployed in 2004 and 2007 were within 1.7 km of reefs in all 3 reef ages that we sampled in our study (Fig. 4). No significant correlations were detected between distance to other reefs and abundance (Pearson's $r$=−0.045, $P$=0.781), or mean age of red snapper (Pearson's $r$=0.026, $P$=0.88; Fig. 5).

## Discussion

### Evidence for production and attraction

Our study showed that older red snapper were associated with older artificial reefs. Previous studies have compared artificial reef age with estimates of density and size of resident reef fishes but have not examined reef fish age. For example, densities of reef fishes and larger sparids (*Diplodus sargus*, *Diplodus bellottii*, and *Diplodus vulgaris*) have been reported to be significantly higher at older habitats (Lindberg et al., 2006; Santos et al., 2011). Because length varies directly with age with these species up to the age of 3 years (Gordoa and Molí, 1997), it is likely that their age also increased with reef age as was observed with red snapper in our study.

The relation between reef age and fish age shown in our own and these other studies, along with the long-term residence of red snapper on artificial reefs shown in previous studies (Schroepfer and Szedlmayer 2006; Topping and Szedlmayer, 2011a), supports the hypothesis that artificial reefs enhance the production of red snapper (Szedlmayer and Shipp, 1994; Szedlmayer, 2007; Gallaway et al., 2009). If artificial reefs enhance a population and experience no fishing pressure, Powers et al. (2003) estimated that such reefs could increase production by 6.45 kg wet weight/10 $m^2$ in the first year after their deployment. Because the locations of the reefs in our study were not published, fishing mortality was limited and therefore had the potential to increase production.

It was also clear that attraction of fish plays an important role in the function of these artificial reefs. For example, fish older than the age of the reef were

present on the reefs that we sampled, including 2 of the oldest fish (19 and 14 years old) that were caught on the 2009 reefs. It is possible that larger, older red snapper become less dependent on particular reefs because of relief from predation pressure and may show greater movement among reef sites as they search for new prey resources (including young red snapper) on newly established reefs (Mudrak and Szedlmayer, 2012). However, although attraction is clear and accounts for both the initial recruitment of young fish and the presence of older red snapper, if attraction was the only function of artificial reefs, we would not expect a positive correlation between mean fish age and reef age. Instead, the age distribution of red snapper should be random or related to the proximity of nearby reefs. Hence, this study provides evidence that both attraction and production are important ecological functions of artificial reefs for red snapper populations in the northern Gulf of Mexico.

According to our study and several other studies, young fish (age-0 and age-1) will recruit to new habitat, usually small (1–7 $m^3$) artificial reefs (Gallaway et al., 2009; Szedlmayer, 2011; Mudrak and Szedlmayer, 2012). Many of these red snapper remain at such habitats for extended periods (up to several years; Szedlmayer,1997; Szedlmayer and Schroepfer, 2005; Schroepfer and Szedlmayer, 2006; Topping and Szedlmayer, 2011a, 2011b) and then begin to show greater movement as they become older and larger and are less vulnerable to predation (Gallaway et al., 2009). For example, on the basis of a 72% residency rate per year from telemetry studies (Topping and Szedlmayer, 2011a), and a mean of 45 age-1 recruits to new (1-year-old) reefs in our study, there would be ~18 age-5 red snapper per reef after 4 years. These estimates are similar to counts recorded for the 2006 reefs in our study, with a mean of 26 age-5 fish per reef (on the basis of proportions of age-5 red snapper among all fish captured from 2006 reefs, extrapolated to mean total densities on 2006 reefs). Also, these residency estimates based on telemetry are underestimates because the time that red snapper reside on a particular reef before being tagged is not included (Topping and Szedlmayer, 2011a). Laboratory and field studies indicate that these older age-5 red snapper may then competitively exclude and even cannibalize new recruits (Bailey et al., 2001; Piko and Szedlmayer, 2007; Mudrak and Szedlmayer, 2012), and perhaps contribute to the association between fish age and reef age. However, attraction may continue to play an important role as older fish that are better able to fend off aggression and cannibalism move to favorable habitats that still harbor abundant prey resources (Ouzts and Szedlmayer, 2003; Szedlmayer and Lee, 2004).

Several studies suggest that red snapper populations have been overfished and that habitat limitation was not the most important controlling factor that contributed to declines in abundance (Schirripa and Legault, 1999; Patterson et al., 2001b; Cowan et al., 2011). Clearly, there was significant fishing mortality of red snapper in the northern Gulf of Mexico (Gillig et al., 2000). However, if fishing mortality was the only limiting factor for red snapper and habitat was not important, we would not expect reef age to have significant effects on fish age (i.e., all reefs, whether fished or not, would show similar age distributions). Red snapper enter the fishery at around age 2 (minimum size: recreational=406 mm TL, commercial=330 mm TL), and the catch consists predominately of 2- to 4-year-old fish. These ages represented 59% ($n$=602) of the total catch in our study and indicate that fishing mortality was not limiting red snapper abundance on the reefs investigated in our study.

One substantial difference between our study, which suggests habitat limitation, and previous studies, which

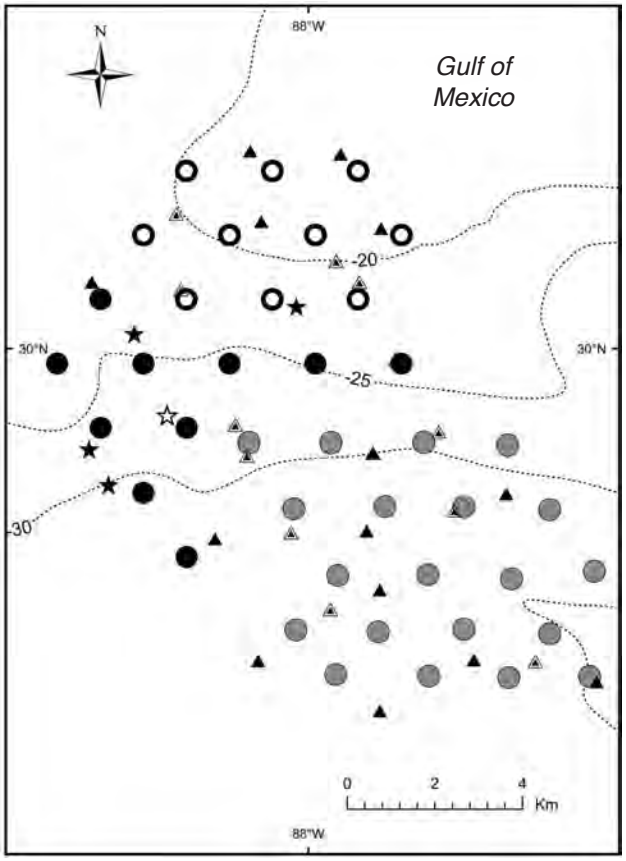


**Figure 4**

Map showing proximity of publicly known reefs to reefs sampled in 2010 in our study of red snapper (*Lutjanus campechanus*) on artificial reefs in the northern Gulf of Mexico. Note that the positions of the reefs sampled in our study were not released to the public. Study reefs: gray circles=reefs deployed in 2006; open circles=reefs deployed in 2009; and black circles=reefs deployed in 2010. Publicly known reefs: black stars=reefs of army tanks deployed in 1994–1995; black triangles=reefs made of concrete pyramids deployed in 2007; black and white triangles=pyramid reefs deployed in 2004; open star=barge deployed as a reef in 1994. Dotted lines indicate depth contours at 5-m intervals.

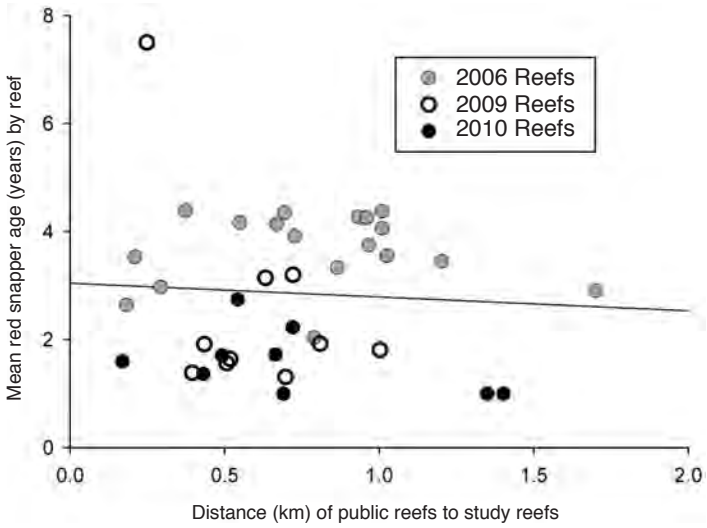


**Figure 5**

Comparison of mean age of red snapper (*Lutjanus campechanus*) caught in 2010 in our study of artificial reefs in the northern Gulf of Mexico with proximity to publicly known reefs <1.7 km from our sampled reefs, which were deployed in 2006, 2009, and 2010. Line is linear regression that showed no significant relation between red snapper age and distance to known reefs (Pearson's correlation coefficients [$r$]=0.026, $P$=0.88).

suggested fishing mortality limitation, was the use of fishery-independent data rather than fishery-dependent data. Although other studies used mainly fishery-dependent data on red snapper caught by sport and commercial fishermen (Szedlmayer and Shipp, 1994; Baker and Wilson, 2001; Patterson et al., 2001a; Wilson and Nieland, 2001), we used fishery-independent methods at unpublished artificial reef sites. These fishery-independent methods also allowed us to sample red snapper that were too small to be counted with fishery-dependent methods. In addition, fishing mortality at reef sites surveyed in our study was probably far more reduced than at known reefs because the locations of the artificial reefs that we sampled were unpublished and likely had limited access for fishing.

Several alternative factors, aside from reef age, could have affected the size and age of red snapper caught on the artificial reefs examined in our study. Additional prey may be one important factor that created differences in habitat value among reefs of different ages, and these differences may have resulted in larger, older fish at older reefs. If older reefs were providing more prey resources, we would expect that red snapper on these reefs would have higher growth rates, especially the relatively young (<10-year-old) individuals that have a nearly linear growth rate. Yet no significant differences in mean growth rates of red snapper were detected among the reefs sampled, despite their age differences. Even so, older reefs often have more well-developed epifaunal benthic communities that can influence habitat value (Redman and Szedlmayer, 2009), and this development might be expected for older artificial reefs like those in our study. If older reefs actually provide more prey resources or greater habitat complexity and shelter than younger reefs, attraction to these "better" reefs may account for some of the older ages and higher abundances of red snapper on older reefs. However, we still are left with the same conclusion: artificial reefs enhance red snapper production. One implication of our study is that habitat value may vary not only spatially (e.g., open versus structured habitats) but also temporally (e.g., new versus older, more "developed" reefs). Therefore, we need to include a temporal component to habitat value, whereby new artificial reefs may need time to develop before they start to enhance production.

Another factor that may have caused differences in the ages of fish among reefs was reef depth. The mean depth of the 2006 reefs was 30 m, but the mean depth of the 2009 reefs was 20 m, and there is some evidence that larger, older red snapper were more common in deeper offshore waters than in shallower nearshore waters (Render, 1995; Mitchell et al., 2004). However, comparisons of reefs with the same mean depth (30 m) and distance from shore (27 km) still showed significantly larger and older red snapper at the 2006 reefs than at the 2010 reefs. In addition, the distances among the reefs that were farthest apart were relatively smaller (14 km) than the distance across the continental shelf (110 km) where depth-related differences in size and age may be more apparent (Mitchell et al., 2004).

We also considered the possible emigration of larger, older red snapper from other reef sites or an effect of nearby reefs not sampled in our study. Proximity to other natural or artificial reefs has been shown in other studies to be an important factor that can affect density of reef fishes (Jessee et al., 1985; Sogard, 1989; Strelcheck et al., 2005; Shipley and Cowan, 2010). In our study, no significant relations were detected between proximity of our study reefs to other reefs and red snapper ages or abundance. In general, other artificial reefs were, for the most part, evenly distributed across our overall study area (Fig. 1) and would not be expected to bias red snapper age distribution to either younger or older reef sites in our study (Fig. 4).

### Comparison of collection methods

This study supports previous studies on the importance of using several collection methods to adequately estimate size and age distribution of red snapper on artificial reefs (Myers and Hoenig, 1997; McClanahan and Mangi, 2004; Szedlmayer, 2007; Wells et al., 2008a; Gallaway et al., 2009). Hook-and-line and fish-trap methods are known to be size selective, and red snapper caught in our study were consistently larger with hook-and-line than with fish traps. This difference occurred mostly because larger fish are able to swallow whole bait and smaller fish consume smaller portions. In addition, smaller fish are more likely to enter a trap, and larger fish may be limited by the size of a trap opening. The distinct size differences observed in our study also could have been influenced by differences in bait: the fish traps had squid in addition to Gulf menhaden, but the hook-and-line bait was strictly Gulf menhaden.

The divers' visual counts were used to estimate the red snapper remaining present on the reef after hook-and-line and trap sampling. At 2 sample sites, visual surveys were conducted a maximum of 30 days after our initial sampling because sharks were present during our initial sampling. Although it is possible that additional red snapper immigrated to the reef at these 2 sites within that 30-d time period, it is unlikely that enough fish recruited to cause a bias in our abundance estimates. This notion is supported by evidence from telemetry studies of high site fidelity for red snapper (72% residency rate per year; Topping and Szedlmayer 2011a) and by the fact that diver counts typically underestimate abundance. In comparison with results from visual surveys, counts were significantly lower from the video and photographic methods. These differences mostly were due to fish swimming throughout the part of the water column that was not within the field of view of the cameras. A bait jar was used with the intent to attract fish closer to the cameras and reduce these differences, but it had only limited success. Comparisons of counts from remote, underwater, baited cameras with those from scuba-diver surveys have shown similar results, with diver visual surveys showing the greatest abundance and diversity of fishes among the methods compared (Tessier et al., 2005; Langlois et al., 2006). Because counts from photographs and video recordings were lower, we used the divers' counts in our estimates of red snapper density for each reef. However, the photographs and video recordings were still important in verifying species identification.

### Artificial reef succession and red snapper densities

The reefs in our study supported higher densities of red snapper than reefs sampled in previous studies. In a demolition study of 9 offshore oil platforms, mean density of red snapper was 0.24 individuals/$m^3$ (Gitschlag et al.[3]). In another study of platforms where stationary hydroacoustics and visual diver counts were used, mean density was 0.16 individuals/$m^3$ (Stanley and Wilson, 1997). Substantially higher than these platform estimates, the estimates from our study of total density of red snapper were 1.6–47.9 individuals/$m^3$, with a mean of 15.7 individuals/$m^3$. One difference between our study and these previous studies was the larger size of the platforms surveyed which also encompassed the entire water column. The volume of these platforms varied: 1037–29,860 $m^3$ (Gitschlag et al.[3]) and 19,800 $m^3$ (Stanley and Wilson, 1997); in contrast, all reefs in our study had a volume of 6.9 $m^3$. However, even if the volume estimates of these platforms were reduced by two-thirds (to account for the habitat in the upper water column that red snapper typically do not use), mean densities of red snapper on platforms would be 0.73 individuals/$m^3$ (Gitschlag et al., 2000[3]) and 0.47 individuals/$m^3$ (Stanley and Wilson, 1997)—levels that would still be considerably less than the estimates from our study of artificial reefs formed from metal cages.

These differences in the density of red snapper among artificial habitats may be due to higher habitat complexity and associated enhanced protection from predation, additional prey resources, and fewer resident larger predators at cage reefs than at platforms. The densities of lemon damselfish (*Pomacentrus moluccensis*) found on highly complex coral reefs with predators were similar to densities found on reefs where predators were excluded, indicating that these complex coral habitats provided protection for this species (Beukers and Jones, 1997). Similarly, higher densities of young (age-0 and age-1) red snapper were shown to inhabit increasing complex reef structure (Lingo and Szedlmayer, 2006; Piko and Szedlmayer, 2007) with an absence of predators (Mudrak and Szedlmayer, 2012). At large structures, such as platforms, complexity probably is lower and the abundance of potential predators likely is higher than at the smaller artificial reefs used in our study. Therefore, these larger reefs may not support as

[3] Gitschlag, G. R., M. J. Schirripa, and J. E. Powers. 2001. Estimation of fisheries impacts due to underwater explosives used to sever and salvage oil and gas platforms in the U. S. Gulf of Mexico. OCS Study MMS 2000–087, 94 p. Final report prepared by the National Marine Fisheries Service for the U.S. Dept. of the Interior, Minerals Mgmt. Service, Gulf of Mexico OCS Region, New Orleans, LA. [Available from http://www.boemre.gov/itd/abstracts/2000-087a.html.]

many red snapper per unit of volume as more complex, smaller structures. For example, an inverse relation was shown between the abundance of red snapper and the density of offshore platforms—possibly a result of greater exposure of young red snapper to predators that aggregate around such platforms (Gallaway et al., 1999). The higher densities of red snapper on the reefs found in our study indicate that these artificial reefs may provide red snapper enhanced protection from predation as well as greater overall carrying capacity.

## Conclusions

The significant differences observed in ages of red snapper among artificial reefs of different ages provide support for the hypothesis that artificial reefs enhance red snapper production. Although it is obvious that red snapper are attracted to artificial reefs, especially as young new recruits, and older red snapper may show more transient behavior among reefs, it appears that many red snapper reside on particular reefs for several years and that artificial reefs may allow for higher biomass of red snapper by providing additional reef habitat. However, at some point, the number of artificial reefs placed in the northern Gulf of Mexico may surpass the region's carrying capacity and the addition of more artificial structures will no longer increase the population of red snapper. Future research that examines the carrying capacities of artificial habitats is needed and would provide information on when an overall environmental carrying capacity for red snapper has been reached. Additional fishery-independent studies throughout the northern Gulf of Mexico, with methods similar to those used in our study, would be useful for making better management decisions regarding catch limits for red snapper.

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# An Evaluation of the Benefits of Artificial Habitats for Red Snapper, *Lutjanus campechanus,* in the Northeast Gulf of Mexico

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**ABSTRACT**

Evidence for red snapper, *Lutjanus campechanus,* production from artificial habitats has been difficult to obtain. The benefits of such habitats for red snapper were evaluated by examining red snapper diets, predator exclusions, habitat complexity, and epibenthic communities in association with artificial habitats over a 10 year period. Also examined were movement patterns from ultrasonic telemetry, and population parameters estimated from fishery independent methods. These studies suggested that red snapper: 1) had a high affinity for artificial habitats, 2) showed consistent feeding on reef prey types, 3) were significantly more abundant on habitats with available prey, 4) showed a significant correlation between abundance and habitat complexity, 5) showed long term residency with some tracked over two years, and 6) abundance significantly increased when predators were excluded. In addition, population status of red snapper off coastal Alabama based on a fishery independent survey of 94 artificial habitats, using fish traps, diver surveys, and otolith aging suggested a better condition compared to previous population assessments. Collectively these results suggest that artificial habitats in the northern Gulf of Mexico contribute significantly to the production of red snapper.

KEYWORDS: red snapper, otolith aging, predator exclusion, diet, artificial reef

# Una Evaluación de los Beneficios de los Hábitat Artificiales del Huachinango del Golfo*, Lutjanus campechanus*, en el Noreste del Golfo de México

La evidencia del huachinango del Golfo, *Lutjanus campechanus*, en cuanto a su producción en hábitat artificiales ha sido dificil de obtener. Los beneficios de dichos hábitat para el huachinango del Golfo fueron evaluados examinando sus dietas, la exclusión de depredadores, la complejidad del hábitat, y las comunidades epibénticas asociadas con los hábitats artificiales por un periodo de 10 años. También fueron examinados los patrones de movimiento de la telemetría ultrasónica, y los parámetros de la población, estimados, usando métodos independientes de los de pesca. Estos estudios indicaron que el huachinango del Golfo: 1) tiene una alta afinidad con los hábitat artificiales, 2) mostró alimentación consistente con tipos de presas del arrecife, 3) fueron significantemente más abundantes en hábitat con mayor número de presas disponibles, 4) mostró números significantemente más altos en hábitat con una elevada complejidad, 5) mostró residencia a largo plazo (algunos rastreados por más de dos años), y 6) mostró significantes efectos de exclusión de depredadores. Además, el estatus de la población del huachinango del golfo fuera de la costa de Alabama, basado en un sondeo de pesca independiente de 94 hábitat artificiales, usando trampas de pescar, encuestas de buceo , y otolite de edad sugirieron una mejor condición, en comparación a cálculos o evaluaciones previas. Colectivamente, estos resultados indicaron que los hábitat artificiales en el golfo norte de México contribuyen significativamente a la producción del huachinango del golfo.

PALABRAS CLAVE: huachinango del Golfo, otolite de edad, exclusión de depredadores, dieta, arrecife artificial

## INTRODUCTION

In the aquatic environment almost any material that adds some topographical relief will attract fish and increase catch (D'Itri 1985). In coastal Alabama, U.S.A., this concept has been applied extensively with the placement of artificial habitats (Minton and Heath 1998). However, we know little about the actual effects of artificial habitats on wider scales, such as local fish stocks. If artificial habitats function mainly through attraction then we may be driving fish stocks towards faster depletion. In contrast, if artificial habitats function by increasing productivity then our habitat building efforts would be helping dwindling fish stocks. Despite the vast amount of literature on artificial habitats this critical question has not yet been adequately answered (Bohnsack 1989, Grossman *et al.* 1997, Bortone 1998). To address such questions, over a 10 year period we have examined many aspects of the life history and ecology of red snapper, *Lutjanus campechanus*, in the northeast Gulf of Mexico, and how this species relates to artificial habitats.

Red snapper have historically supported an important commercial and recreational fishery (Camber 1955) and are closely associated with structured artificial habitats (Szedlmayer 1997, Szedlmayer and Lee 2004, Szedlmayer and Schroepfer 2005, Lingo and Szedlmayer 2006,

Schroepfer and Szedlmayer 2006, Piko and Szedlmayer 2007). In the northeast Gulf of Mexico most natural habitat is relatively flat open mud/sand/shell substrata with uncommon or rare complex natural rock reef habitats with associated reef biota (Parker *et al.* 1983, Schroeder *et al.* 1988, Mitchell *et al.* 1992, 1993). Over the last 50 years part of this shelf habitat has been altered with extensive building of artificial habitats. In the northern Gulf of Mexico, more than 14,000 artificial habitats have been built including thousands of oil and gas platforms (Minton and Heath 1998). These artificial habitats show large accumulations of reef fish species, especially red snapper (Lingo and Szedlmayer 2006; Szedlmayer *et al.* 2004). Again, the important question concerning this area of the northeast Gulf, is whether or not the reef building activities are enhancing shelf habitat through increased fish production or causing detrimental effects, *i.e.*, overfishing due to ease of locating concentrated fish stocks (Grossman *et al.* 1997).

**Life History and Habitats**

Juvenile red snapper first settled from the plankton at around 17 mm TL and 26 d after hatch, and showed significant preference for shell habitats in field trawl surveys (Szedlmayer and Conti 1999, Rooker *et al.* 2004) and laboratory studies (Szedlmayer and Howe 1997). Relic-shell habitat was identified as a primary nursery location of juvenile red snapper, with mean CPUE at 4000 fish $h^{-1}$ trawl time, which far exceeded CPUE from nearby habitats that lacked relic-shell and all previous estimates (Szedlmayer and Conti 1999). Also, SCUBA observations of several low relief (approx. 20 cm) artificial substrates including oyster shells, showed significant attraction of juvenile red snapper to all sites (Workman and Foster 1994, Lingo and Szedlmayer 2006, Piko and Szedlmayer 2007). In visual observations from the above studies we observed many newly settled recruits at just under 30 mm TL, all of which were associated with some type of structure, similar to observations by Workman and Foster (1994).

After their initial settlement in July and August, age-0 red snapper will quickly outgrow their initial habitat and seek larger more structured habitats (Szedlmayer and Conti 1999, Rooker *et al.* 2004 Szedlmayer and Lee 2004). These observation of age-0 red snapper showing increased numbers on 1 $m^3$ concrete habitats in the fall suggested a recruitment to higher relief structure at earlier ages compared to previous reports that suggested recruitment to "higher" structure only after reaching age-1 or older (Render 1995, Gallaway *et al.* 1999).

One of the most obvious reasons for moving to more structured habitats would be to reduce predation pressure. For example, when age-0 first settle at around 20 mm TL, smaller structure such as oyster shells would provide adequate shelter, but as size increases in the fall, fish need increased "hole" size (Hixon and Beets 1989). In studies with predator exclusion cages, there was a clear predator exclusion effect, where shell habitats with predator exclusion cages had significantly more age-0 red snapper. Artificial habitat complexity was also associated with higher abundance of red snapper and several other species (Lingo and Szedlmayer 2006, Piko and Szedlmayer 2007).

From these life history studies it is clear that red snapper are closely associated with artificial habitats. They recruit to such structures at an early age, and probably benefit from increased complexity and potential predator protection.

**Red Snapper Diets**

One of the most important questions concerning red snapper and the function of artificial habitats must address feeding responses to changing habitats. When red snapper first settle they forage on prey types from open sand-mud habitats. When fish shifted to more structured habitats they show a corresponding shift to more feeding on reef prey types (Szedlmayer and Lee 2004). As red snapper grow they continue this shift to significant feeding on reef prey types but will also continue feeding on almost any available prey. One aspect that may confuse the question of red snapper feeding types is that red snapper show significant diel shifts with feeding on different prey types depending on day or nighttime capture (Ouzts and Szedlmayer 2003). Another aspect that makes feeding studies difficult is that red snapper stomachs frequently are empty due to barotropic stress, or large numbers fish prey are unidentifiable due to advanced digestion. However, SCUBA observation of large schools (> 500) of mixed species of tomtate *Haemulon aurolineatum*, vermilion snapper *Rhomboplites aurorubens*, and round scad *Decapterus punctatus* at small sizes (around 60 mm TL) on many artificial habitats, suggests that reef prey fish were available (Szedlmayer unpublished data). Future diet studies that are able to positively identify prey species (*e.g.*, DNA) may confirm increased feeding on these reef prey types. As red snapper continue to grow older and larger there exist little quantitative information on diets. At present we know of no studies that have quantitatively examined the diets of larger older red snapper, for example fish > 900 mm TL.

In another study concerning artificial habitats and red snapper potential prey items, the recruitment of juvenile red snapper was compared between artificial habitats with and without epibenthic prey communities (Redman and Szedlmayer In review). Copper-based antifouling paint was used to prevent the development of epibenthic organisms and red snapper abundance was compared between habitats with (n = 20) and without (n = 20) these communities over a 12 month period. Red snapper preferred habitats with epibenthic communities, and were significantly larger on these habitats. This study showed that potential food resources affected the recruitment of juvenile red snapper to artificial habitats in the northern Gulf of Mexico. Thus, the attraction of fishes to artificial habitats was not just in response to shelter, but also the associated

epibenthic communities.

Conclusions from diet studies showed that red snapper utilized "reef" prey types that would not have been available without the construction of artificial habitats, and also showed significantly higher red snapper abundances on artificial habitats that had epibenthic communities compared to identical habitats that lacked these communities.

**Red Snapper Movements**

Early studies of red snapper movement with conventional t-bar or anchor tags suggested long-term residence around hard bottom structures (Camber 1955, Moseley 1966, Bradley and Bryan 1975). Similarly, mark-recapture studies of red snapper have shown little movement and high site fidelity around artificial habitats. Beaumariage (1969) tagged 1,372 red snapper and 97% of recaptured tagged fish stayed at the original tagging site. Szedlmayer and Shipp (1994) tagged 1,155 red snapper and 76% of recaptured tagged fish stayed within 2 km. Watterson *et al*. (1998) tagged 1,604 red snapper and 61% of recaptured tagged fish stayed at the tagging site.

Some studies have also suggested greater movements of 5-275 km for tagged red snapper which would reduce the importance of artificial reefs. For example, Watterson *et al*. (1998) reported movements up to 265 km, and attributed this movement with the occurrence of hurricane Opal. Patterson *et al*. (2001) tagged 2,932 red snapper and observed that mean distance moved was 29 km and maximum distance moved was 352 km. However, mark-recapture studies with conventional tags assume the reliability of reporting date of capture, and most importantly the reliability of reporting site of capture from external sources (Schwartz 2000; Denson *et al*. 2002). Ultrasonic telemetry removed these assumptions and showed that red snapper were resident on artificial habitats in the northeastern Gulf of Mexico for 17-597 d (Szedlmayer 1997; Szedlmayer and Schroepfer 2005; Schroepfer and Szedlmayer 2006).

Red snapper may in fact show several different movement patterns depending on life stage. Clearly age-0 red snapper settle to benthic habitats early (26 d) but then move to more structured habitats in the fall of their first year (Szedlmayer and Conti 1999; Szedlmayer and Lee 2004). As fish grow during the first and second years they may still be in the process of seeking a suitable habitat. This type of behavior might result in shorter residence time estimates and longer distances between mark recaptures (Watterson *et al*. 1998; Patterson *et al*. 2001). Then as fish become larger and older (>2 years), they are better able to establish longer residence on more suitable artificial habitats (Schroepfer and Szedlmayer 2006). More suitable habitat is defined here as providing adequate protection as well as food resources, i.e., not all artificial habitats are alike. Then, as fish reach very large sizes (e.g., > 900 mm TL) they are no longer limited by predation pressure and may be able to move over wide ranging habitats with relative impunity to predation. Some evidence for such habitat shifts for older larger red snapper is supported by open habitat longline catches of high numbers of very large older red snapper (Henwood *et al*. 2004, Mitchell *et al*. 2004). Little other direct information from tagging studies has been obtained for larger older red snapper.

In conclusion, young to intermediate age red snapper (approximately 3 to 10 year old fish) show high affinity for artificial habitats with long term residence. What movement patterns will be shown for larger older fish (for example > 15 years) is still speculative.

**Growth and Population Assessment**

Accurate stock assessment is critical to the management of marine reef fish populations in the northeast Gulf of Mexico. This assessment task often proves difficult because of the inherent difficulty of sampling reef fishes with complicated life history patterns, and cryptic habitats. These sampling problems have little to do with assessment effort, i.e., since the early 90's there have been extensive stock assessments for this species. Previous stock assessments have suggested an overfished red snapper stock, and without a reduction in the annual total allowable catch, the red snapper stock will not reach the required target level (F/Fmsy and B/Bmsy) by the year 2032 (DEIS 2006).

One difficulty was that almost all previous stock assessments were based on fishery dependent landing data rather than fishery independent surveys (Goodyear 1995, Schirripa and Legault 1999, Cass-Calay and Ortiz 2004, Porch 2004). This problem has been well recognized in the fisheries literature. "Catch per unit effort can vary over time in commercial and recreational fisheries, is subject to fishers' optimizing behaviors, and is not usually the most appropriate index" (Committee on Fish Stock Assessment Methods, Natural Research Council, 1998). Also, they state "fishery independent surveys offer the best opportunity for controlling sampling conditions by maintaining

**Table 1.** Red snapper mortality estimates that were used in tSPR and yield models.

| Class | Z | M | F |
|---|---|---|---|
| age 0 | 2.3 | 1.96 | 0.35 |
| age -1 | 0.76 | 0.60 | 0.16 |
| age 2 - 54 | 0.54 | 0.35 | 0.19 |

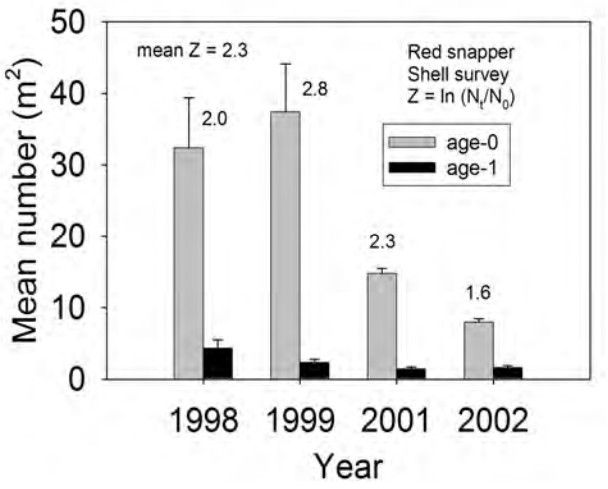


**Figure 1.** Age-0 to age-1 density estimates for red snapper from SCUBA visual surveys. Number above bars are mortality estimates.

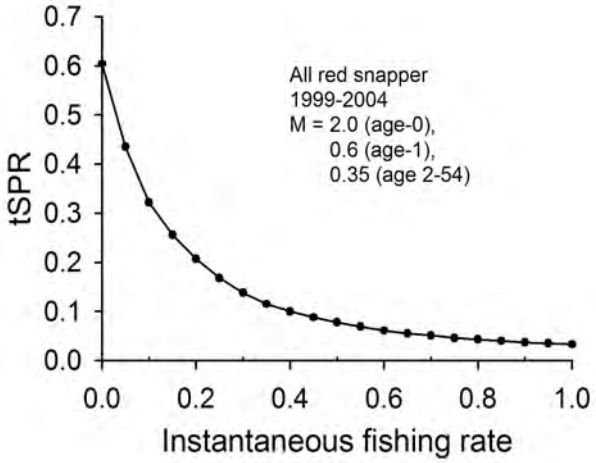


**Figure 3.** Transitional spawning potential ration (tSPR) relation to instantaneous fishing mortality (F) from fishery independent age frequency distribution of red snapper in the northeast Gulf of Mexico.

consistent gear, spatial coverage, timing and survey design". In a fishery independent long-line survey many larger older-aged red snapper were collected (Henwood *et al*. 2004, Mitchell *et al*. 2004). These collections were difficult to integrate into present stock assessments, yet they may indicate that red snapper stocks may be in better condition than suggested by past assessments. In the present study, several data sets were used to estimate red snapper abundance, age frequency, mortality and population status off coastal Alabama. SCUBA surveys of age-0 and age-1 red snapper abundance on artificial shell/block nursery habitats were used to estimate juvenile mortality rates (320 shell/block nursery habitats from 1998 through 2002; Lingo and Szedlmayer 2006; Piko and Szedlmayer 2007).

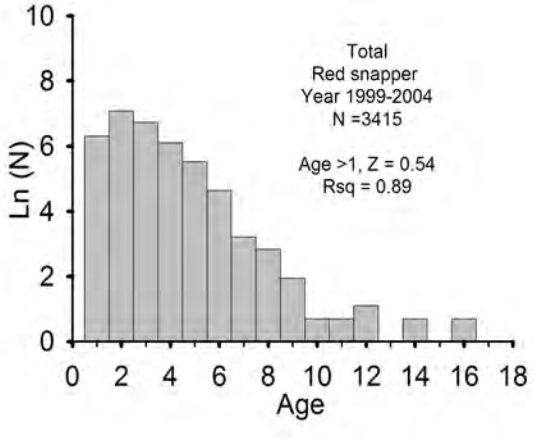


**Figure 2.** Total mortality estimate from fishery independent age frequency distribution of red snapper in the northeast Gulf of Mexico.

Mark-recapture studies were used to estimate fishing mortality (Szedlmayer and Shipp 1994), and fishery independent collections with fish traps, hook-and-line, and SCUBA visual surveys were used to estimate red snapper population parameters from artificial habitats (Szedlmayer *et al*. 2004).

Based on a total of 649 SCUBA surveys on these shell/block habitats, mean annual total mortality Z = 2.3, for age-0 to age-1 red snapper, similar to previous estimates of Z = 1.98 (Nichols *et al*. 2005) and Z = 2.12 (Nance 1998, Fig. 1). Previous estimates of trawl fishing mortality for age-0 to age-1 were relatively high, up to F = 1.38 (Nichols *et al*. 2005). With reduced trawling due to a fishing fleet reduction lower values may be applied for age-0 fish (F = 0.4 used in the present model, lower than F = 0.18 used in past stock assessments, C. Porch, NMFS, pers. comm.).

We used the same mortality rates for age-1 to age-2 used in past stock assessments (C. Porch NMFS, pers. comm). Fishing mortality rates for age 2 to 54 were based on past mark recapture studies. From May 1990 to Oct 1991, Szedlmayer and Shipp (1994) tagged and released 1,155 red snapper and recaptured 146 red snapper, and after accounting for tag shedding and fisher non-reporting annual F $\pm$ SD = 0.19 $\pm$ 0.16. From 1999 to 2004, ages were estimated from otoliths for 3,413 fish from 94 different artificial habitats, and from these ages total annual mortality was estimated at Z = 0.54 for red snapper greater than age-1 (Fig. 2). Growth was fitted to the von Bertalanffy relation where TL = 923 $(1 - e^{-0.17(age+0.79)})$ and Log wt = -0.471 + 2.96 log TL ($R^2$ = 0.98, N = 3,451, Szedlmayer *et al*. 2004). The most difficult parameter to estimate is natural mortality and values have widely ranged from 0.01 to 0.4 (Nelson and Manooch 1982; Schirripa and Legault 1999). In the present study, natural mortality was based on

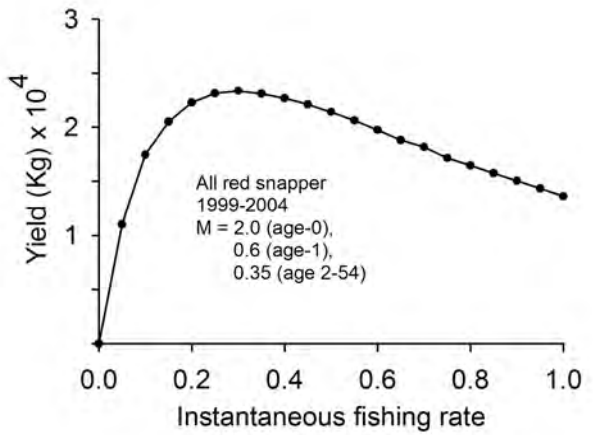


**Figure 4.** Yield (per 1 million recruits) relation to instantaneous fishing mortality (F) from fishery independent age frequency distribution of red snapper in the northeast Gulf of Mexico.

the difference between total mortality and fishing mortality, with the present estimated M = 1.9 for age-0, M = 0.60 for age 1, and M = 0.35 for > age-2 (Table 1). Combining ages, growth rates, mortalities and length-weight relations, the estimated transitional spawning potential ratio = 0.21 at F = 0.19, and maximum yield was attained when F was increased to 0.3 (Slipke and Maceina 2005; Figs. 3 and 4).

These model results suggested that red snapper populations off coastal Alabama may be in better condition compared to past assessments**.** Based on these fishery independent data red snapper stocks off coastal Alabama may be at stock levels needed for a sustainable fishery. For example, although considered overfished since the early 90's there has been little indications of decline in landings independent of catch level restrictions. One difficulty in this assessment was that data only originated from coastal Alabama and Mississippi. Clearly there may be significant differences in comparison to other areas such as Louisiana or Texas. One aspect that may account for assessment differences was that off coastal Alabama the artificial habitat program was by far the largest in the nation with some 15,000 artificial habitats in designated habitat building zones. Such correlations between artificial habitats and population estimates are difficult to prove, but combined with other more direct ecological measures, adds further to the evidence that artificial habitats have positively affected red snapper stocks off coastal Alabama.

## CONCLUSIONS

Artificial habitats off coastal Alabama have enhanced red snapper stocks, based on the collective studies over more than 10 years showing 1) early recruitment to structured habitats, 2) high residence and affinity for structured habitats, 3) diet composition showing significant reef prey in combination with other prey types, 4) growth rates showing similar plots as previous estimates, and 5) a fishery independent survey of artificial habitats that suggested a better local stock condition compared to past estimates.

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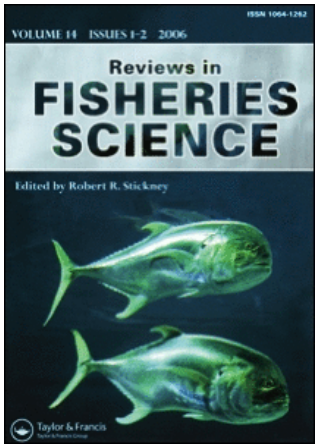


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# A Life History Review for Red Snapper in the Gulf of Mexico with an Evaluation of the Importance of Offshore Petroleum Platforms and Other Artificial Reefs

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*Red snapper mature as early as age 2, have high fecundity (a 10-year-old female produces 60 million eggs per year), and may live for over 50 years. Eggs, larvae, and post-settlement juveniles typically show high rates of natural mortality. For example, of the 60 million eggs produced annually by a 10-year-old female, only about 450 would survive to 5 cm, the size at which they enter the shrimp fishery. Changes in abundance by size and age appear to be consistent with density dependence in survival rate from ages 0 to 1 and likely ages 0 to 2. Red snapper are attracted to structure or reef habitat at all ages, but larger, older fish also occur over open habitat once they have reached a size that renders them largely invulnerable to predation. Artificial reefs comprise a small fraction of the overall high-relief reef habitat, but harbor a large fraction of the present-day age 2 red snapper populations. Prior to the proliferation of artificial reefs in the northern Gulf, age 2 red snapper may have historically occurred mainly over open-bottom, sand-mud benthic habitat where natural and shrimp trawl bycatch mortality was high. Age 2 fish dominate red snapper populations at artificial reefs, whereas the age composition of red snapper at natural reefs usually show older ages are dominant. The present day red snapper fishery is heavily dependent on catches at artificial reefs. Evidence is presented that suggests red snapper production in the northern Gulf likely has been increased by the establishment of significant numbers of artificial reefs.*

**Keywords** red snapper, *Lutjanus campechanus*, oil and gas platforms, density-dependent mortality, life history, artificial reefs

## *INTRODUCTION*

The red snapper *Lutjanus campechanus* is an unusual finfish. In the Gulf of Mexico (Gulf), red snapper mature at age 2 and can live for over 50 years (Szedlmayer and Shipp, 1994; Render, 1995; Wilson and Nieland, 2001). They are also characterized by high fecundity. A female age 0 red snapper recruit produces, on average, 55.5 million eggs over its lifespan (SEDAR7, 2005). This is more than an order of magnitude higher than any of the finfishes listed in the Ransom Myers' Stock Recruitment Database (2007).

Despite these attributes, the Gulf population of red snapper has been in an overfished condition since at least 1994 (Goodyear, 1994), and rebuilding efforts to date have been unsuccessful (SEDAR7, 2005). Generally, this failure is believed to have been attributable to the inability to reduce shrimp trawl bycatch while maintaining a high total allowable catch (TAC) in the directed fishery. However, shrimp trawl bycatch mortality of red snapper has plummeted since 2003, but there has not been any evidence that the abundance of age 1 juveniles

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has increased substantially. A possible explanation is that habitat limitation (or compensatory mortality) may be an important population control, particularly during the early life stages of red snapper.

Shipp (1999) noted that the addition of large amounts of artificial reef habitat (over 20,000 individual reefs installed) in an area offshore of Alabama was coincident with the establishment of a significant red snapper fishery. This area had formerly been devoid of all but relatively diminutive soft-bottom fish species of little or no economic importance. He noted that the ichthyofauna of a quarter century prior had been transformed from an economically depauperate biomass to one supporting an industry valued at $60 million annually. He rhetorically asked if this change had resulted in a change in total biomass? His answer was: "We don't know, but did it matter in terms of management decisions?" (Shipp, 1999:54).

Cowan et al. (1999) responded that "yes, it mattered" because a fundamental change in habitat (the placement of artificial reefs) had occurred at the expense of the small benthic fisheries in a region of the shelf that had formerly provided a nursery function to many species of fishes. They argued that nursery function had been traded for adult habitat, complete with a rich set of predators, without any consideration of the ecosystem consequences of the tradeoffs. They suggested that large-scale deployment of artificial reefs could result in large-scale modification of ecosystem function, with effects good and bad depending on specifics of critical habitat requirements and recruitment bottlenecks.

Trawl samples of today (e.g., Wells, 2007) suggest that the addition of artificial reef habitat offshore Alabama has not resulted in an area-wide displacement or loss of the soft-bottom ichthyofauna as characterized by Shipp (1999). These species still occur and dominate trawl samples. However, an increase in adult reef species has occurred that has been coincident with artificial reef placement. As will be shown below, these new populations of large predators indeed forage on prey species inhabiting the surrounding soft bottoms, as well as on reef-associated and water column organisms. The magnitude of the overall effects of artificial reefs on productivity and ecosystem function remains unanswered. Also, the question of whether the placement of artificial reefs actually increases production or merely aggregates species such as red snapper remains contentious.

In this article, we review the literature describing the life history, distribution, and ecology of the red snapper in the Gulf of Mexico. Specifically, we examine the role and relative importance of offshore oil and gas platforms and other artificial reefs as factors affecting the Gulf of Mexico red snapper population. We begin by noting that red snapper is characterized as a reef fish, and their reef association begins almost immediately after they leave the planktonic stage and settle to the bottom (e.g., Szedlmayer and Howe, 1997; Szedlmayer and Conti, 1999; Workman et al., 2002). This association has been well documented for ages 0–8, but it may weaken considerably at older ages (e.g., Render, 1995; Nieland and Wilson, 2003; Szedlmayer, 2007). We also note that, on a spatial basis, reef habitat is a relatively scarce commodity in the northern Gulf where red snapper occur (Ludwick, 1964; Parker et al., 1983). In this context, we also examine the issue of habitat limitation (or compensatory mortality) and the life stages at which habitat limitation may be important.

## *LIFE HISTORY SYNTHESIS*

For descriptive and management purposes, we first divide the life history of red snapper into pre-recruit (<50 mm total length, TL) and post-recruit (>50 mm TL) phases. The pre-recruit life stages include eggs, larvae, and post-settlement juveniles <50 mm TL. At 50 mm TL, they enter the Gulf penaeid shrimp trawl fishery as bycatch. The post-recruit life stages include early juveniles (ages 0 and 1), young adults (ages 2 to 7), and mature adults (ages 8+). Early juveniles are taken as bycatch in the shrimp fishery, whereas young and mature adults are taken in the directed fishery.

### *Pre-Recruit Life Stages*

#### *Eggs*

Spawning of red snapper in the northern Gulf of Mexico extends from April through September, with peak spawning occurring in June–August (Render, 1995; Bradley and Bryan, 1975; Futch and Burger, 1976; Collins et al., 1996). The eggs are pelagic, spherical, transparent, and about 0.8 mm in diameter (Rabalais et al., 1980). After spawning, the eggs are buoyant and float to the surface. In the laboratory, on the order of 50% of the eggs hatch within 20–27 hr after fertilization (Rabalais et al., 1980; Minton et al., 1983). Gallaway et al. (2007) estimated an egg stage duration of 1 day, with an instantaneous daily rate of natural mortality of $M = 0.4984$ (Table 1).

#### *Larvae*

At hatching, the larvae are about 2.2 mm total length (TL), and they remain pelagic until metamorphosis and settlement, which occurs when they are 16–19 mm TL and between 26 and 30 days in age (Rabalais et al., 1980; Szedlmayer and Conti, 1999; Rooker et al., 2004). Gallaway et al. (2007) used a mean larval stage duration estimate of 27 days and an estimated instantaneous daily natural mortality rate for this stage of 0.3014. That estimate is revised herein to reflect a mean larval stage duration of 28 days and an instantaneous daily rate of natural mortality of 0.2413. The estimated total mortality for this stage is $M = 6.7564$ (Table 1).

Lyczkowski-Shultz et al. (2005) showed that larval abundance determined from the SEAMAP (Southeast Area Monitoring and Assessment Program, National Marine Fisheries Service, NMFS) neuston net sampling was directly correlated

**Table 1** Life history stages and natural mortality estimates for red snapper over the first two years of life

| Age | Stage | Duration | Dates | M | Total | Reference |
|---|---|---|---|---|---|---|
| 0* | Egg | 1 | 1 July–1 July | 0.4984 | 0.4984 | Gallaway et al. (2007)*** |
| | Larvae | 28 | 2 July–29 July | 0.2413 | 6.7564 | Gallaway et al. (2007) |
| | Juvenile 1 | 38 | 30 July–5 Sept | 0.1196 | 4.5448 | Rooker et al. (2004) |
| Totals | | *67 | | | 11.7996 | |
| 0** | Juvenile 2 | 117 | 6 Sept–30 Dec | 0.0054 | 0.6318 | Szedlmayer (2007) |
| 0/1** | Juvenile 3 | 181 | 1 Jan–31 June | 0.0054 | 0.9774 | Szedlmayer (2007) |
| Totals | | 298 | | | 1.6092 | |
| 1** | Juvenile 4 | 365 | 1 July–31 June | 0.0033 | 1.2 | Gazey et al. (submitted) |

*Pre-recruit.
**Recruit.
***$M_{egg}$ values of 13.3 in Gallaway et al. (2007) revised to 11.8 and larval- and juvenile 1-stage durations changed from the Gallaway et al. (2001) estimates of 27 and 39 days to 28 and 38 days, respectively. These changes reflect new data utilized in the methodology described in Gallaway et al. (2007).

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with estimates of adult abundance ($r = 0.813$, $p = 0.004$, and $r^2 = 0.661$). Lyczkowski-Shultz and Hanisko (2007) reported occurrence and abundance patterns for red snapper larvae in the Gulf of Mexico. During summer (mid-June through July), the highest mean station abundance values were observed off central and western Louisiana at depths between 50 and 100 m. In addition, red snapper larvae were consistently taken off south Texas, Mississippi, and Alabama, but abundance was lower east of the Mississippi River as compared to areas to the west of the river.

Lyczkowski-Shultz and Hanisko (2007) also observed that abundance from 50- to beyond 100-m depths off central and south Texas in the fall was markedly higher than had been observed in this area during summer. Based upon data from the fall plankton survey, red snapper larvae are encountered much less frequently and in lower numbers in the eastern Gulf than in the western Gulf. Lyczkowski-Shultz and Hanisko (2007) noted that the consistent presence of red snapper larvae in samples taken between the 100- and 200-m depth contours in both the western and eastern Gulf supports the contention that red snapper spawn over a wide depth range, i.e., from mid-shelf to the continental slope.

### *Post-Settlement Juveniles*

We define this stage as early juveniles 19–50 mm TL, 29–66 days in age (Szedlmayer and Conti, 1999; Rooker et al., 2004). Assuming eggs were deposited on July 1 as a start date, these fish would be present for a 38-day period between July 30 and September 5 (see Table 1). Based on Gallaway et al. (2007) and Rooker et al. (2004), the instantaneous daily mortality rate for this stage is estimated to be 0.1196 ($r^2 = 0.918$). The total mortality for this stage would thus be M = 4.5448 (0.1196 × 38 days).

As for most species, natural mortality is high for pre-recruit red snapper (Table 1). The duration of the three pre-recruit stages is 67 days and total M = 11.8. Assuming that a 10-year-old female red snapper produces 69.44 million eggs per year (SEDAR7, 2005), a total of 521 juveniles would survive to 50 mm TL and be susceptible to shrimp trawl bycatch.

Newly settled red snapper quickly move to structured habitat such as low-relief, relic-shell habitat (Workman and Foster, 1994; Szedlmayer and Howe, 1997; Szedlmayer and Conti, 1999; Rooker et al., 2004; Lingo and Szedlmayer, 2006; Piko and Szedlmayer, 2007). These fish grow rapidly in summer and fall and quickly outgrow their initial habitat. As they became larger, they seek larger, more structured habitat (Szedlmayer and Lee, 2004).

### *Post-Recruit Life Stages*

These stages begin with age 0 red snapper greater than 50 mm TL, the size at which they enter the Gulf penaeid shrimp fishery as bycatch. They continue to be taken by this fishery as age 1 red snapper. Red snapper enter the directed fishery at age 2 and are harvested throughout the balance of their lifespan, which can last for over 50 years (Szedlmayer and Shipp, 1994; Render, 1995; Wilson and Nieland, 2001).

#### *Ages 0 and 1*

Age 0 red snapper enter the Gulf penaeid shrimp trawl fishery at about 67 days in age and 50 mm TL. Assuming a July 1 start date, they would enter the fishery in early September but would not be fully recruited until they reached about 100 mm TL (Goodyear, 1995). Age 0 and age 1 red snapper densities are highest in the northern Gulf at depths between 18 and 55 m, from the Alabama-Florida border to the Texas-Mexico border (Gallaway et al., 1999). Our review of the NMFS post-1998 observer data file showed that red snapper juveniles are only occasionally taken in the eastern Gulf offshore Florida.

Within the 18- to 55-m depth range in the western Gulf, red snapper settle over all substrates but show an immediate attraction to low-relief, relic shell habitat that provides protection

from predation. This oyster shell habitat provides adequate shelter for new settlers, but as their size increases the fish need larger "hole" sizes for protection. Lingo and Szedlmayer (2006) and Piko and Szedlmayer (2007) conducted *in situ* studies using predator exclusion cages. Shell habitat with predator exclusion cages had significantly more age 0 red snapper than habitat without cages. However, as the fish became larger (>60 mm TL), they moved to concrete block habitat with larger holes and adequate predator protection such that the cage effects were no longer evident.

Szedlmayer and Lee (2004) and Wells (2007) provide strong evidence of an ontogenetic shift from low-relief to higher-relief habitat with size and age. Szedlmayer and Lee (2004) documented a transition in age 0 red snapper from open or low-relief habitat to artificial reefs having relief consisting of 1-$m^3$ concrete blocks. Settlement was observed in July and the newly settled (most <40 mm TL) fish were mostly found over open habitat. At the time of settlement, the reef habitat was occupied by age 1 fish between 100 and 200 mm TL. Age 0 fish began moving onto the reefs as they reached sizes approaching 100 mm TL and by December age 0 fish were found almost entirely on the reefs from which the age 1 fish had abruptly disappeared (Figure 1). Wells (2007), also working offshore Alabama, observed an increase in mean size corresponding to a shift from sand (96.1 mm TL) to low-relief shell (127.0 mm TL) to high-relief habitat (172.3 mm TL).

Szedlmayer and Lee (2004) examined diets of juvenile red snapper between 70- and 160 mm standard length (SL) collected from both reef and non-reef habitat. They observed a diet shift as fish moved from open to reef habitat. The dietary shift reflected feeding more on reef prey than on open-water prey. The shift in habitat and diet suggested differential habitat value based not just on predation refuge but increased access to additional food resources. In contrast, Wells (2007) suggested that red snapper relied on sand- and mud-associated prey regardless of the habitat from which they were collected. However, it is difficult to evaluate this finding because the taxonomic resolution used by Wells (2007) does not appear to be at the level needed to assign the prey species to a specific habitat type.

Once the age 0 fish have occupied reef habitat having sufficient relief and complexity to afford protection from predation and provide additional food resources, they appear to show a high degree of fidelity to these habitats (Workman et al., 2002; Chapin et al., in press). Tagged fish were repeatedly sighted at the same reef over a two-month period, and fish that dispersed as far away as 0.43 km returned to the capture reef within about 25 min. Workman et al. (2002) also observed that the presence of age 1 fish appeared to limit recruitment of age 0 fish to a reef, but as age 1 fish left the reefs, new age 0 recruits were observed. These observations were supported by laboratory studies in which larger red snapper excluded smaller red snapper from reef structures (Bailey et al., 2001).

In summary, larval age 0 red snapper undergo metamorphosis and settle to the bottom in late July at sizes between 16 and 19 mm TL. They are attracted to any low-relief habitat providing cover, but the cover requirements change as the fish grow. Initially, relic shell-ridge habitats are ideal for these small fish, and the greatest known extent of these habitats occur in the mid-shelf zone offshore Alabama (Schroeder et al., 1988; Parker et al., 1992; Schroeder et al., 1995; Dufrene, 2005). In this region, shell-ridge habitat covers about 15% of the sea floor (Dufrene, 2005). Coverage by natural rock reef having greater relief and complexity than relic shell ridges is likely much smaller. Overall, Parker et al. (1983) estimated that 3% of western Gulf mid-shelf seafloor between Pensacola, Florida, and Pass Cavallo, Texas, contained reef habitat, with only 1.6% of this area consisting of reefs having relief >1 m.

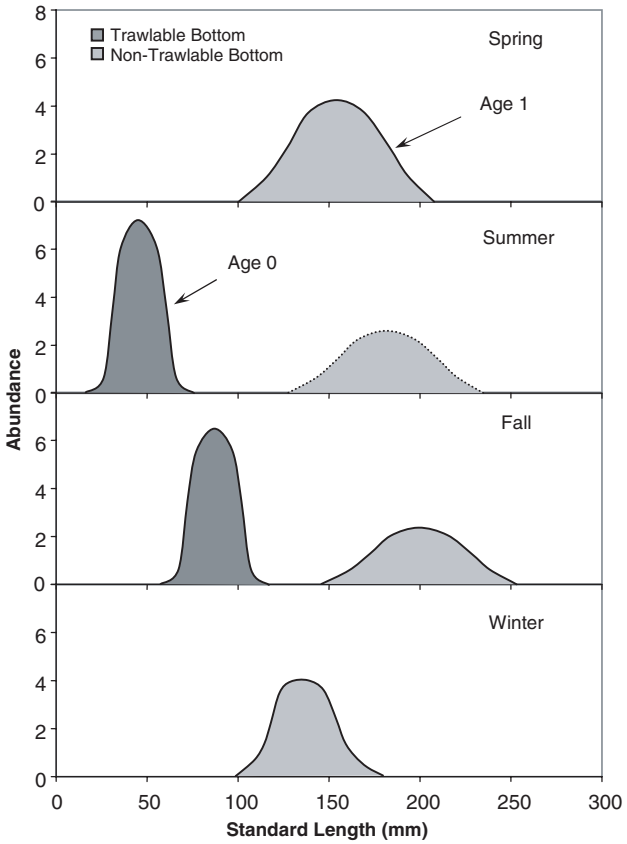


**Figure 1** A diagrammatic representation of the shift in distribution of age 0 red snapper (small size group) from trawlable bottom (dark shade) to non-trawlable reefs having intermediate relief (light shade) when age 1 fish move to large, complex reefs in winter. Based on Figure 2 in Szedlmayer and Lee (2004).

Most age 0 fish move onto reefs with intermediate relief (e.g., 1-$m^3$ structures) by December and appear to occupy these reefs until the following December. At this time, the 18-month-old fish have grown to sizes of approximately 200 mm TL and may require greater relief than is afforded by the intermediate-sized reefs. They begin recruiting to large reefs like natural rock outcroppings, offshore petroleum platforms, and large artificial reefs during their second winter at about 18 months of age (Stanley, 1994; Nieland and Wilson, 2003). In January, these



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fish are classified as age 2 fish, even though they are only 18 months old in biological age.

The natural mortality rates for age 0 and age 1 fish are not well documented. Nichols et al. (2005) used the SEAMAP size, age, and abundance data for red snapper in conjunction with shrimp effort data to estimate M = 0.6 per year (SE = 0.36) for age 1 fish. Assuming M = 0.6, SEDAR7 (2005) estimated that F for age 1 red snapper in the western Gulf was 0.62. Thus, total mortality for age 1 red snapper was estimated to be Z = 1.2.

The estimate of M = 0.6 for age 1 red snapper was used by SEDAR7 (2005) to infer M = 1.0 for age 0 based upon the Goodyear (1995) stock assessment, which assumed M for age 1 was 60% of M for age 0. Based on this value of M, SEDAR7 (2005) estimated an age 0 F of 0.52 such that $Z_{age0}$ was 1.52.

However, Wells (2007) estimated instantaneous daily rates of M = 0.017 (or more) for age 0 red snapper between age 140 and 200 days that were trawled from a low-relief shell-bed habitat in an area offshore Alabama where commercial shrimp trawling does not occur. Projected to an annual rate, M would be estimated to be on the order of 6.2. Assuming a July 1 start date, this 61-day period would be between November 18 and January 16. This period corresponds to the timeframe when age 0 fish would be moving to high-relief habitat where they are not vulnerable to trawling. We believe the estimates of M derived by Wells (2007) are unrealistically high because they reflect both emigration and mortality.

Szedlmayer (2007) provided diver counts of juvenile red snapper (ages 0 and 1) on artificial shell and shell/concrete block habitat off coastal Alabama for the years 1998 to 2002. When these data are arrayed by year class (Figure 2), estimates of Z ranged from 2.1 to 3.2, averaging 2.6. The habitat studies were in the artificial reef area off coastal Alabama where commercial shrimp trawling does not normally occur, and the habitats showed no sign that trawling occurred in this area over the life of the study. This suggests most, if not all, of the Z values would consist of M or natural mortality. This estimate of M may also be confounded by not accounting for emigration of fish to larger structures. Overall, Szedlmayer (2007) estimated M for age 0 red snapper to be on the order of 2.0 (1.96), and also suggested higher mortality for stronger year classes than for weaker year classes (Figure 2). Szedlmayer and Conti (1999) observed a similar pattern of increased mortality with more abundant year classes based upon trawl collections from the same region. Collectively, these observations are consistent with the premise that habitat is a limiting factor for juvenile red snapper at observed levels of recruitment.

Gazey et al. (2008) conducted a length-based, age-structured modeling analysis for juvenile red snapper using monthly size and abundance data collected by observers on shrimp vessels. These preliminary results suggest Z for age 0 red snapper appears to be about 2.2, reasonably consistent with the independent estimates of Z = 2.6 by Szedlmayer (2007). Both of these estimates are higher than Z = 1.5 estimated by SEDAR7 (2005). The Gazey et al. (2008) Z estimates for age 1 fish was 1.3 as opposed to the Z = 1.2 used by SEDAR7 (2005). The observer data reflect higher mortality for stronger year classes than for weaker year classes, also supporting the contention that habitat limitation is an important factor governing the dynamics of juvenile red snapper.

Overall, we suggest the best estimate of average M for age 0 fish is 2.0, based largely on estimates from artificial shell and concrete block habitats in areas without trawling (Szedlmayer, 2007), and size and abundance data collected by observers on

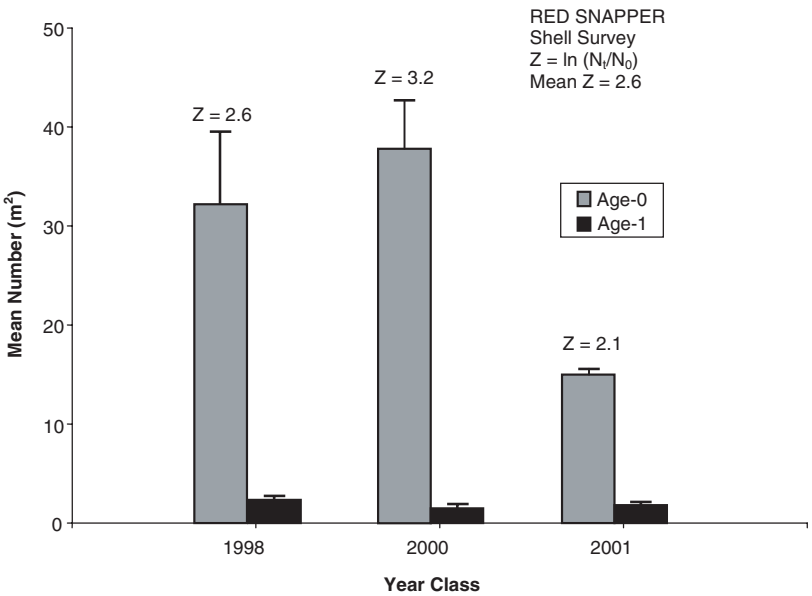


**Figure 2** Estimates of annual mortality for age 0 to age 1 red snapper based upon data from Szedlmayer (2007). Samples were taken in the artificial reef area off the coast of Alabama where shrimp trawling does not occur. Thus, Z should consist entirely of natural mortality (M).



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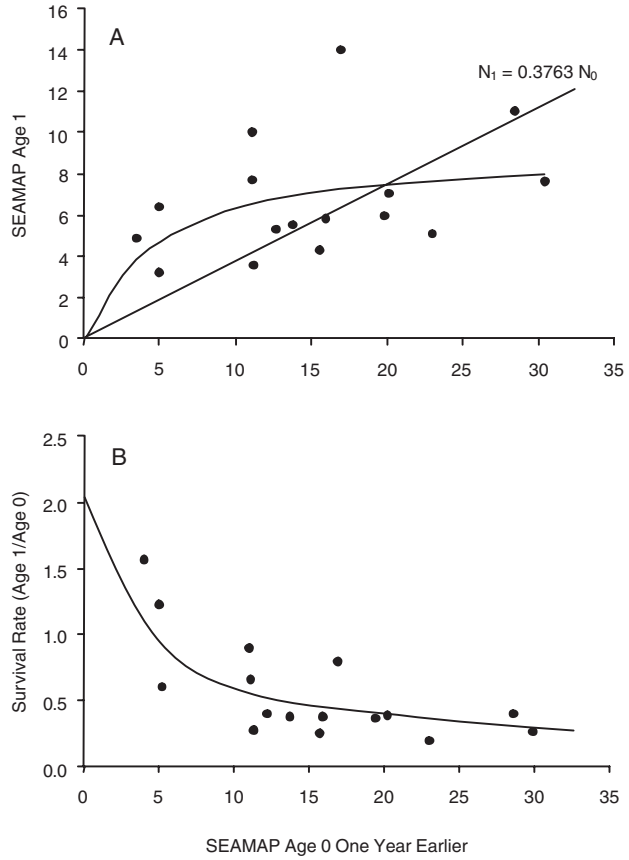


**Figure 3** Evidence of density dependence in red snapper mortality rate from age 0 to age 1 is present in the SEAMAP data, when age 0 numbers are used to predict either age 1 numbers the next year (no density dependence would result in proportional response on average, e.g., $N_1 = 0.3763\ N_0$) or survival rate to age 1. Note that the appearance of a flat response in Panel A and the decreasing response in Panel B could be due to an errors-in-variables effect; i.e., age 0 measurement errors (Source: SEDAR7 Stock Assessment Report).

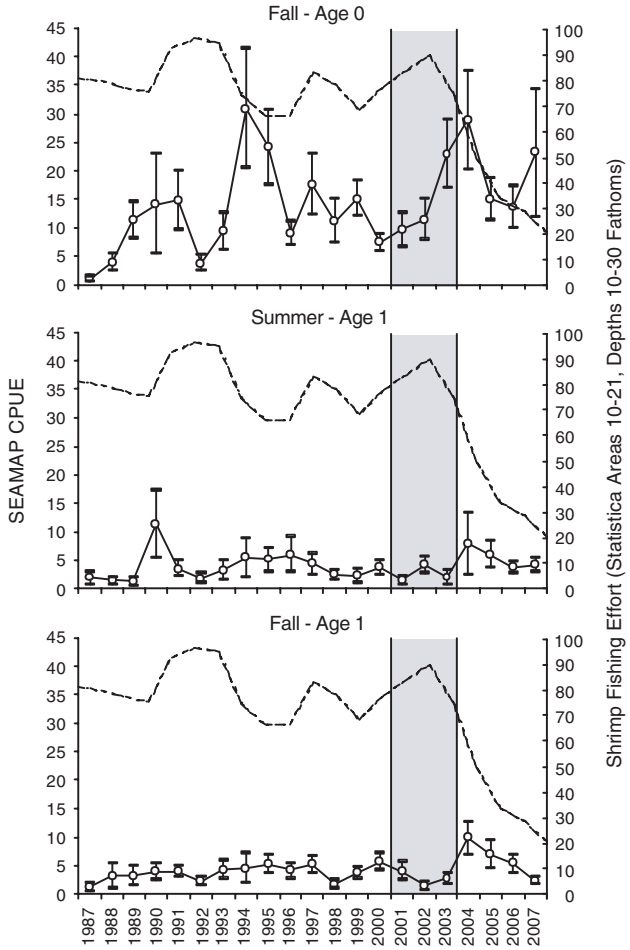


**Figure 4** Shrimp fishing effort (nominal days fished, dashed line) from LGL (2007) and juvenile red snapper abundance, 1987–2007, provided by B. Pellegrin, NMFS, Pascagoula Laboratory. Shaded area represents the reference period for evaluating shrimp fishing effort and juvenile red snapper bycatch mortality reductions.

shrimp vessels (Gazey et al., 2008). If M for age 0 is about 2.0, as suggested, then following Goodyear (1995) and SEDAR7 (2005), M for age 1 would be 1.2 (0.6 × 2.0).

The annual natural mortality rates for age 0 = 2.0 and for age 1 = 1.2 equate to daily rates of M = 0.0054 and 0.0033. As shown by Table 1, total natural mortality for age 0 red snapper recruits over the 298-day balance of their first year would be 1.6 and 1.2 for their second year. An estimated 31 of the initial 521 survivors entering the fishery following the pre-recruit stages, as described above, would live to age 2.

SEAMAP data provide evidence consistent with density dependence in red snapper mortality rate from age 0 to age 1 (Figure 3; SEDAR7, 2005). In addition, the results of a stock reduction analysis (SRA) conducted as part of SEDAR7 also suggested that density dependence for these young age groups was occurring (SEDAR7, 2005). Last, shrimp trawl bycatch mortality for juvenile red snapper has undergone a 75% reduction since the 2001–2003 baseline period, yet only moderate (if any) rather than exponential increases in age 1 abundance has been realized (Figure 4). The combination of habitat scarcity, site fidelity, exclusion of smaller conspecifics from reef habitat by larger fish, and variation in juvenile M with abundance, as described above, suggests habitat is a limiting factor for juvenile red snapper.

### *Ages 2–7*

Red snapper enter the directed fishery at about age 2 and are heavily exploited by directed and recreational fishers for most of their remaining life. They occur across the shelf to the shelf edge and demonstrate an affinity for vertical structures (Patterson et al., 2001a), especially between 2 and 7–10 years of age. They show very rapid growth during the first 8 to 10 years of life (Szedlmayer and Shipp, 1994; Patterson, 1999; Nelson and Manooch, 1982; Patterson et al., 2001b; Wilson and Nieland, 2001; Fischer et al., 2004) (Figure 5). After this period, fish continue to grow but at slower rates. Although still found



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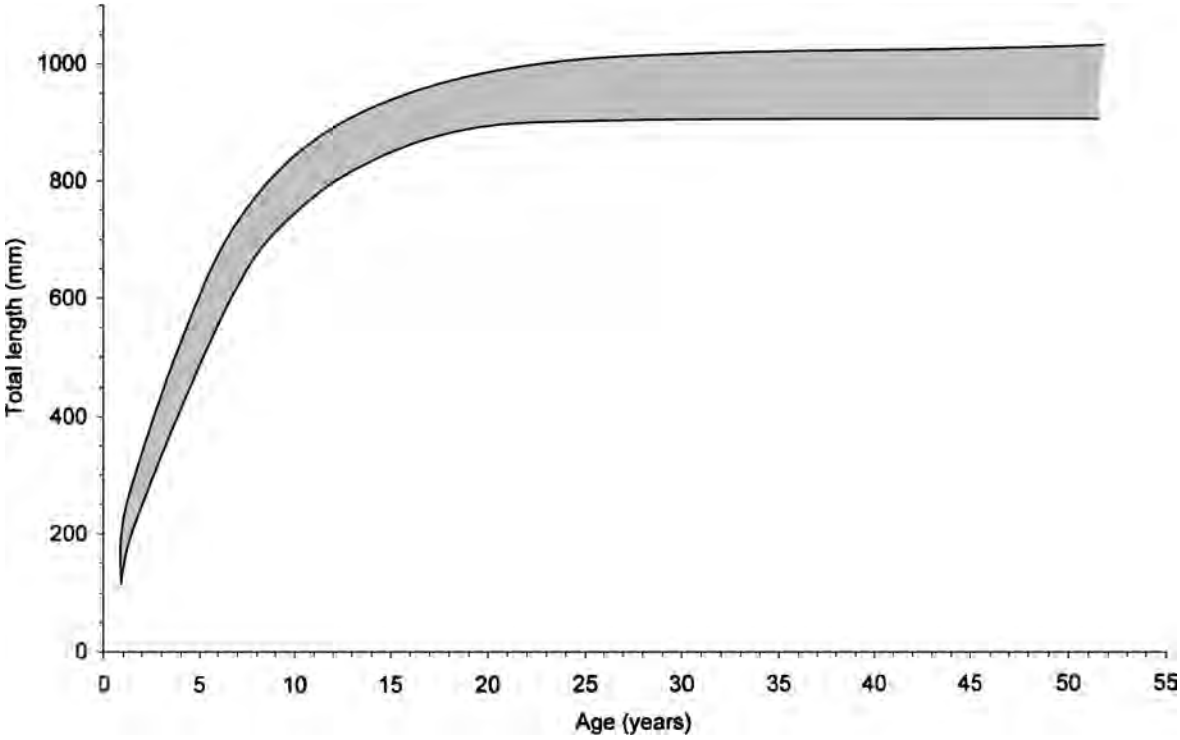


**Figure 5** Envelope of von Bertalanffy growth model results for Gulf of Mexico red snapper based upon Nelson and Manooch (1982), Szedlmayer and Shipp (1994), Manooch and Potts (1997), Patterson (1999), and Wilson and Nieland (2001).

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on reef structures, these larger fish expand their habitat and may use open areas as well (Szedlmayer, 2007). Because of these differences, we break our discussion into age groups 2 to 7 and ages 8+.

At the beginning of age 2, young red snapper are generally between 200 and 375 mm TL (Goodyear, 1995). It is at these sizes that they enter the directed fishery and recruit to large reefs. These include natural hard substrates with relief on the order of meters, e.g., reef pinnacles, exposed rock ledges, and shelf-edge banks, as well as artificial reefs like offshore oil and gas structures, shipwrecks, and constructed artificial reef areas. Wells (2007) states that "the premise that natural reefs are scarce is a misconception" (103), citing the presence of extensive shell ridges in the north-central Gulf (Schroeder et al., 1995; McBride et al., 1999; Dufrene, 2005) and inner-shelf reef banks and ledges as evidence to the contrary. We disagree with the identification of shell substrate as "reef" habitat. These habitats are actually shifting shell substrates, the distribution of which can change from year to year. They have little similarity to hard limestone reef habitat. In a geological survey, Dufrene (2005) characterized the inner-shelf area offshore eastern Louisiana to panhandle Florida and suggested that this benthic habitat was about 15% shell and 85% soft sand mud substrate. The vast majority of the inner shelf in this area, as well as elsewhere, is composed primarily of sand, mud, and silt, with little or no vertical relief (Ludwick, 1964; Kennicutt et al., 1995).

On a larger spatial scale, Parker et al. (1983) estimated that 2,571 $km^2$ of natural reef habitat (3.3% of the bottom) are present at depths between 18 and 91 m in the region between Pensacola, Florida, and Pass Cavalla, Texas. Of this, only 1.6% (1,285 $km^2$) was comprised of reefs having relief >1 m. Offshore areas known to contain large natural reefs are protected by the Minerals Management Service (MMS) by imposing "No Activity Zones" around them. In the northern Gulf, the total area of these zones is about 293 $km^2$ (Stanley and Wilson, 2003). Most of these areas are outside the depths surveyed by Parker et al. (1983). On a total area basis, natural reef habitat suitable for age 2 to 7- to 10-year-old red snapper is a scarce commodity (1,578 $km^2$, 1,285 $km^2$+ 293 $km^2$) in the northern Gulf relative to the amount of sand- and mud-bottom habitat.

The primary artificial reef habitats in the Gulf include offshore oil and gas platforms and a 3,108-$km^2$ area offshore Alabama within which about 10,000 artificial reefs are present (Minton and Heath, 1998). The footprint areas of the Alabama artificial reefs are typically small, about 9.3 $m^2$ on average. Assuming 10,000 structures are presently in place, this would equate to a total area of 23 acres or about 0.1 $km^2$ of artificial reef. The northern Gulf of Mexico also contains on the order of 4,000 oil and gas platforms. These structures provide about 12 $km^2$ of artificial reef habitat (Gallaway and Cole, 1997). On a spatial basis, the artificial reef contribution to total high-relief reef habitat in the northern Gulf has been small (an additional 12.1 $km^2$ to a natural reef area of about 1,578 $km^2$).

In summary, reef habitat with relief on the order of meters constitutes a small fraction of the total shelf area of the western Gulf of Mexico. Considering both natural and artificial reefs, the

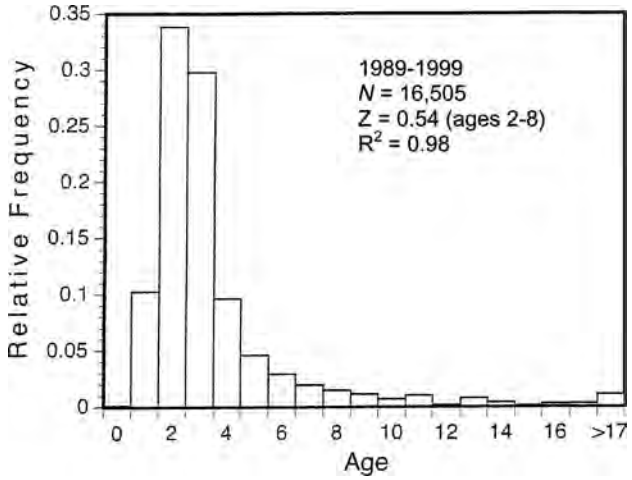


**Figure 6** Estimated age frequency of red snapper residing at offshore oil and gas platforms in the northern Gulf of Mexico estimated from fish killed by explosive structure removals (Source: Gitschlag et al., 2003).

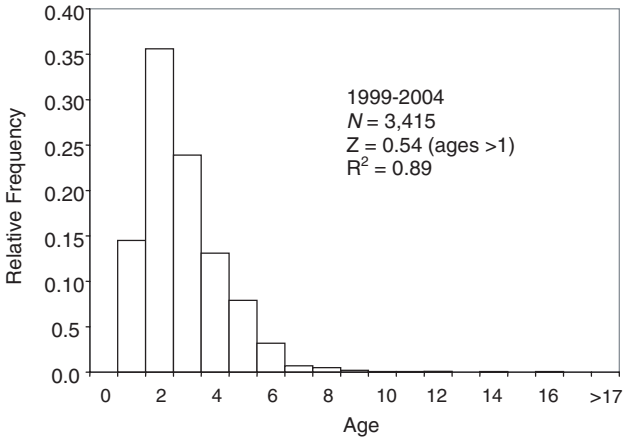


**Figure 7** Estimated age frequency of red snapper residing at artificial reefs. Total mortality estimate from fishery independent age frequency distribution in the northeast Gulf of Mexico (Source: Szedlmayer, 2007).

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total area of reef habitat on the western Gulf shelf is 1,578 km$^2$, less than 2% of the total shelf area. The area offshore Alabama where shell substrate habitat comprises an estimated 15% of the bottom area, and there are over 10,000 artificial reefs and numerous oil platforms, is an exceptional area compared to other regions of the northwestern Gulf because it contains relatively large amounts of both juvenile and adult red snapper habitat. Western Louisiana has a large number of offshore oil and gas structures but lacks the vast expanses of juvenile shell substrate habitat that occurs offshore Alabama.

Offshore oil and gas structures and other artificial reefs are, however, used by large numbers of red snapper between ages 2 and 7, and older fish may also occur at these habitats. Explosive removals of these platforms have been monitored and provide a fishery-independent measure of the age structure of resident red snapper (Gitschlag et al., 2003). Red snapper recruit to these habitats as early as age 1 (10%), but the populations appear dominated by age 2 (34%) and age 3 (29%) fish (Figure 6). Age 4 was the only other age group representing as much as 10% of the total population. The red snapper age distribution from these platforms suggested a high rate of total mortality ($Z = 0.54$; Figure 6). Red snapper are known to stratify by size at different depths around platforms in the western Gulf, with smaller fish located higher in the reef than larger fish (Render, 1995). Render (1995) also observed larger individuals to be less obligate in their association with platforms than smaller fish.

Szedlmayer (2007) estimated ages from otoliths for 3,415 red snapper collected from 94 different benthic artificial habitats off coastal Alabama (Figure 6). Age 1 fish comprised about 14%, age 2 (36%). and age 3 fish comprised 25% of the total population. No other age group comprised as much as 10% of the total population (Figure 7). These data also suggested the same high rate of total mortality at artificial reefs ($Z = 0.54$; Figure 7) as shown by Gitschlag et al. (2003).

*Population Size.* Stanley (1994) estimated that, on average, 5,307 (95% CI = 2,756, range 1,200 to 8,200) red snapper occupied each major oil platform offshore of western Louisiana in favorable red snapper habitat during the fall to winter period of 1992. Gallaway and Cole (1997) used this estimate along with distribution and platform size and count data to estimate that the total age 2 red snapper population present at oil platforms in the northern Gulf of Mexico was about 3 million (1.7–4.2 million) fish at the beginning of 1992. This compared to Goodyear's (1995) estimate of 4.2 million age 2 fish in the total red snapper population at the beginning of 1992. SEDAR7 (2005) estimated that the age 2 population size at the beginning of 1992 was about 3.7 million fish. If all these estimates were correct, the observations suggest that 70–80% of the total age 2 population occurred at oil and gas platforms in 1992. If this is true, then the platforms are used by age 2 fish much more than their proportional area would suggest. A possible explanation for such a distribution will be provided below.

Gitschlag et al. (2003) estimated red snapper population sizes at western Gulf offshore oil and gas platforms based on mortality counts associated with the explosive removals of nine of these structures. Results were provided for one platform removed in each of the years 1993, 1998, and 1999; for two platforms in 1994; and for four platforms removed in 1995. The 1995 removals were made during the May–September period and the mean number of red snapper believed to have been residing at these four platforms ranged from 487–1,193, averaging 774.5 (95% CI = 482.2 to 1,066.8). In 1995 there were on the order of 4,000 offshore oil and gas structures in the Gulf, which, multiplied times the average abundance estimated by Gitschlag et al. (2003), yields a total estimate of about 3.1 million red snapper at offshore oil and gas platforms in the western Gulf. Based on Gitschlag et al.'s (2003) age frequency estimates (see Figure 6), about 34% of these (1.1 million fish) would be age 2 fish. In 1995, the total number of age 2 red snapper in the western Gulf was estimated to have been 1.6 million red

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snapper (SEDAR7, 2005). Again, approximately 70% of the age 2 red snapper population was suggested to reside at offshore oil and gas structures. Thus, results from at least two independent studies (Stanley, 1994; Gitschlag et al., 2003) suggest that a high proportion of the age 2 red snapper population in the western Gulf of Mexico reside at offshore oil and gas platforms.

*Food Habits.* The food habits of age 2 and older red snapper in the Gulf of Mexico range from the historical observations of Stearns (1884), Collins (1885), and Adams and Kendall (1891) to present-day investigations. The first comprehensive study of red snapper food habits in the northern Gulf after the turn of the century was reported by Moseley (1966). He collected 712 red snapper stomachs of which 187 contained food. Moseley (1966:96) suggested that red snapper should be considered polyphagous, as both juveniles and adults "ate most anything that was readily available." On a volumetric basis, fish comprised 44% and 80% of the adult diet at two locations offshore Louisiana and from 40% to 59% of the diet at three locations sampled offshore Texas. Fish comprised less than 50% of the diet in only 2 of the 5 samples and, in each case, the sampled fish had gorged on tunicates, which are seasonally very abundant. Of interest, one of the tunicates (*Distalpia* sp.) was a colonial reef form, whereas the other (*Salpa confederate*) was a free-swimming, pelagic form.

Moseley (1966:98) also observed that red snapper "do not always feed on reef forms," observing that, in addition to reef species, they fed on prey occurring over soft bottoms rather than at reefs. He noted that the availability of food found in snapper stomachs was probably comparable for mud, sand, and rocky-type habitats. He also observed that, while it appeared that red snapper may have foraged over soft bottoms, it might also be true that motile, soft-bottom prey species were not necessarily confined to sand and mud habitats, but may have ventured onto or near reefs.

Moseley's (1966) study was followed by red snapper investigations conducted by Bradley and Bryan (1975) offshore Texas. They collected 1,139 snapper at natural reefs along the 40-fm curve from Port Isabel to Galveston, Texas. Of these, 190 contained prey. Fish made up the highest percentage by volume for every season except summer, when the diet was dominated by the swimming crab *Callinectes danae* (39.2%). Bradley and Bryan (1975) also showed extensive feeding on tunicates (13% by number, 21% by volume) in spring samples. They noted that red snapper feed on those items that are most readily available, and the spring blooms of tunicates in some areas provide abundant grazing material. They concluded that fish (other than eels) constituted the primary food each season, and other important foods included eels, mantis shrimp, and rock shrimp in spring; crabs and rock shrimp in summer; and eels in winter.

Red snapper diet studies were conducted in the eastern Gulf offshore Florida by Beaumariage and Bullock (1976) and Futch and Bruger (1976). In this part of the Gulf, invertebrates appeared more important than fish in the diet of red snapper. The Florida shelf habitat is markedly different than the shelf habitat of the western Gulf (Alabama to Texas) based on oceanic currents, freshwater discharge, sediments, and biota (Gallaway, 1981).

Gallaway et al. (1981) characterized the food habitats of red snapper at the Buccaneer Gas and Oil Field platforms located offshore Galveston, Texas, at depths of about 10 fathoms. They suggested that red snapper moved away from the platforms during the late night to early morning period to feed over soft bottoms. Hastings et al. (1976) obtained similar results for lutjanids at research platforms in the northeastern Gulf. Peabody and Wilson (2006) also suggested that nocturnal movements of red snapper away from Louisiana platforms was related to feeding behavior.

Ignoring squid, which was used for bait, Gallaway et al. (1981) reported that the gut contents of red snapper in winter contained mainly fish (small carangids, mainly the platform-associated rough scad). In spring, the diet was dominated by mantis shrimp (69%), and in summer the diet was dominated by fish (unidentified fish 23.5%, Atlantic cutlass fish 19.3%, and carangids, probably scad, 18.6%) and mantis shrimp (29.5%). In fall, crustaceans (shrimp 53.2% and crabs 17.2% for a total of 70.4%) and fish (26.6%) dominated the diets. Clearly, soft-bottom prey were a major component of the diet, but reef-associated fish were taken when abundant.

Siegel (1983) described red snapper food habits for habitats sampled offshore Alabama and some samples from Louisiana and Florida. For adults, fish and crabs constituted the main part of the diet. Of interest, all sizes of adults were noted to consume crabs, rock shrimp, penaeid shrimp, larval decapods, and larval mantis shrimp.

Ouzts and Szedlmayer (2003) examined the diets of red snapper collected from the artificial reef area offshore Alabama among four diel feeding periods (dawn, day, dusk, and night) and among three standard-length size classes: small (200–299 mm SL), medium (300–399 mm SL), and large (400–499 mm SL). A total of 432 stomachs were examined, of which 164 contained prey. Prey items were assigned a habitat association based upon the literature, personal observations made by the authors, and consultations with experts on the prey group in question. Small red snapper fed mostly on reef and sand prey types; medium red snapper fed on similar portions of reef, sand, and mixed habitat prey types; and large red snapper fed mainly on prey observed to use a variety of habitats. Red snapper were indicated to feed throughout the 24-hr cycle, with mean gut fullness being significantly lower at dusk than for the day period. Fish were the dominant prey throughout the 24-hr cycle. The second-most important prey group changed with period: shrimp were codominant for dawn, tunicates for day, and crabs were codominant for dusk and night periods.

The Szedlmayer and Lee (2004) food habitat studies of red snapper from open bottom and artificial reefs offshore Alabama were dominated by juveniles <200 mm SL as described above. However, 61 specimens were collected from reefs that ranged from 200 to 250 mm SL. For these fish, the principal prey categories on a volumetric basis were fish (59.7%), shrimp (27.8%), and crabs (12.5%). For the fish-prey category,

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approximately 65% were reef-associated taxa, including blennies (37.7%), *Halichoeres* sp. (13.0%), Serranidae (9.0%), *Serranus* sp. (2.9%), and *Centropristes* sp. (2.3%). The dominant "shrimp" taxa in the large red snapper stomachs included mantis shrimp (42.4%), rock shrimp (29.3%), Alpheidae (13.4%), Hippolytidae (11.5%), and unidentified shrimp (3.4% of the total shrimp component).

Szedlmayer and Lee (2004) classified rock shrimp, Alpheidae (pistol shrimp), and Hippolytidae (cleaner shrimp) as reef-associated taxa and mantis shrimp as open-bottom residents. On this basis, reef shrimp constituted 54.2% of the shrimp eaten as compared to 42.4% that were from open-bottom habitats. Rock shrimp have been treated as open-bottom species by other investigators. This species is most abundant on hard mud and/or shell substrates (NOAA, 1985). Offshore Alabama, the high density areas for rock shrimp mapped by Darnell et al. (1987) generally correspond to the area of shell-ridge or "ragged bottom" habitats described above, thus the reef designation by Szedlmayer and Lee (2004). However, this species is not typically found in high numbers on reefs having high vertical relief like that used by adult red snapper. If one treats rock shrimp as an open-habitat organism, approximately 72% of the shrimp in the diet of red snapper come from open bottoms as compared to about 25% from reefs, mainly pistol and cleaner shrimp.

The Szedlmayer and Lee (2004) data indicate that red snapper in the 200–250 mm SL length range on artificial reefs offshore Alabama fed on both reef and open habitat prey types. Even if all crabs and all the shrimp but pistol and cleaner shrimp are treated as soft-bottom species, reef prey still constituted about 46% of the total diet based upon this data set.

McCawley and Cowan (2007) evaluated red snapper food habitats for fish from the Alabama artificial reef area that were mainly caught by recreational fishermen between May 1999 and April 2000. They examined 656 red snapper stomachs, of which 268 contained prey. The empty and bait-only stomachs were excluded from further analyses. The fish with prey ranged from 240–913 mm fork length (FL) (mean = 463 mm FL). On an average percent weight basis, unidentified material contributed the largest proportion to the observed diets (35.9%) followed by crab (20.2%), fish (19.5%), adult mantis shrimp (12.6%), and pelagic zooplankton (8%). McCawley and Cowan (2007) also recalculated the mean% weight values after removing the unidentified material from the analyses. On this basis, fish dominated the diet (28.7%), followed by crabs (26.8%), pelagic zooplankton (23.5%), mantis shrimp (16.1%), and miscellaneous benthic species (2.2%).

McCawley and Cowan (2007) estimated only 1.3% of the red snapper diet (excluding unidentified material) consisted of reef-associated organisms, 1.3% of the diet consisted of *Sargassum*-associated species, and 0.7% consisted of species occupying a variety of habitats. In contrast, the dominant components of the diets were species associated with sand and mud habitats (41.2%) and the water column (31%, mainly larval mantis shrimp and larval fish). Their interpretation of these data was that adult red snapper were almost, if not entirely, trophically independent of the reefs on which they lived.

McCawley et al. (2006) collected diel food habitat data for red snapper in the Alabama artificial reef areas in July and August 2000. A total of 109 red snapper stomachs were collected from fish 295 to 560 mm FL (mean = 382 mm FL). Of these, 46 contained prey. When examined on a diel basis, red snapper appeared to feed throughout the day and night, with no obvious pattern in feeding periodicity. Unidentified material was the dominant food category in both day (35.1%) and night (31.4%) periods, followed by fish (34.7% day and 30.6% night), crabs (12.7% day and 12.2% night), and rock shrimp (10.4% day and 9.3% night). Mantis shrimp were not observed in stomachs collected during the day but comprised 9.4% by weight in the night samples. Once more, over half of the fish and crab category consisted of unidentified specimens. McCawley et al. (2006) concluded that less than 2% of the red snapper diet came from reef-associated organisms based upon the defined habitat associations of the identified prey organisms.

In summary, red snapper appear to be opportunistic feeders that feed throughout the day and night. They have been documented to feed on abundant swarms of water column organisms like pteropods and free-swimming tunicates when these occur, as well as on fish, crabs, and shrimp from surrounding soft bottoms, and on reef-associated fish, crabs, encrusting tunicates, and shrimp. However, more accurate estimates of the relative proportions of their diet derived from different habitats are needed. It is clear, however, that many studies show substantial feeding on reef prey types, which supports the contention that red snapper are obtaining significant food resources from reef habitats.

*Site Fidelity.* The degree of movement and/or site fidelity shown by red snapper in the young adult age group has been addressed by historical and recent studies. Beaumariage (1969) tagged and released 312 red snapper off the coast of Florida and reported a return rate of 26%. All but eight of these were reported to have been recaptured at the release site after being at liberty for an average of 113 days. These data indicated a high degree of site fidelity (>90%) over at least the short term (113 days or about 3.8 months). Beaumariage and Bullock (1976) also reported that red snapper in shallow water showed a high degree of site fidelity and that the only extensive movements occurred in water deeper than 15 fathoms.

Fable (1980) tagged 299 red snapper at natural reefs off the coast of Texas and 17 fish were recaptured. Of these, 16 were recaptured at the release location, and one that had been at liberty for 162 days, or about 5 months, had moved 5 km. Gallaway et al. (1981) reported very high short-term fidelity for red snapper at platforms in the Buccaneer Gas and Oil Field offshore Galveston, Texas, over the summer months. All of the tags returned by fishermen or noted during visual SCUBA census were found at the site where the fish had been released. However, fishing pressure was intense in the Buccaneer Oil and Gas Field, and most of the entire annual recruitment was estimated to have been harvested each year.

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Several other mark-recapture studies have been conducted at artificial reefs offshore Alabama. Szedlmayer and Shipp (1994) tagged and released 1,155 relatively small red snapper (mean ± SE = 287 ± 0.9 mm TL; size range 177–410 mm TL). A total of 146 tagged fish were recovered, but only 37 of these had known recapture locations. A total of 27 (74%) of these fish were recaptured within 2 km of their release site, and 21 of these were caught in the immediate vicinity of their release location. The greatest distance moved by an individual fish was 32 km, and distance moved was not related to time at large (see Figure 6 in Szedlmayer and Shipp, 1994). These data were interpreted to suggest a high degree of site fidelity.

Watterson et al. (1998) reported results of a red snapper mark-recapture study conducted off the coast of Alabama from March 1995 to January 1997. Nine artificial reef sites, with three each being placed at 21-, 27-, and 37-m depths, were constructed 18 months prior to the start of the study. A total of 1,604 fish were tagged between March 1995 and October 1996. The tagged fish had a mean TL (±SE) of 336 mm (±1.84), and 80% were less than 400 mm TL. The majority of these fish were 3-year-olds or less. A total of 167 individual fish were recaptured. Hurricane Opal passed within 40 km of the reef sites in October 1995, about eight months into the study. Eighty percent of recaptured red snapper that were not at liberty during Opal were recaptured at their site of release, suggesting strong site fidelity. Fish that were at liberty during Opal showed greater movement. They had a significantly higher likelihood of movement away from their site of release and moved far greater distances than fish not at liberty during Opal. The at-liberty fish moved an average of 32.6 km, with eight fish moving over 100 km and three fish moving over 200 km. The fish not at liberty during Opal moved much shorter distances, from 1.7 to 2.5 km. Clearly, Hurricane Opal affected the movement and site fidelity of the fish.

Patterson et al. (2001a) continued the mark-recapture study of Watterson et al. (1998) through August of 1999. Another strong hurricane occurred during the extended study. Hurricane George passed within 50 km of the reef sites in September 1998. In total 2,932 red snapper were tagged, with 2,053 released at their capture site and 879 released at locations other than their capture site. Mean TL (±SE) of these tagged fish was 335.1 ± 1.34 mm; thus, most were age 3 or less. Overall, 519 individual fish were recaptured, with 193 recaptured on tagging trips and 326 recoveries made by fishers. Of the fish recaptured at tagging sites, 188 (97%) were captured at the site where they had been released while five had changed location.

Location of recapture was reported for 232 recoveries reported by fishers (Patterson et al., 2001a). Mean time at liberty was 404 days, which was 2 to 3.5 times longer than the mean time at liberty for recaptures from previous studies. Of the fish recaptured by fishers, 36% were captured within 2 km of the release site. One fish, which had been at liberty for 598 days, moved 352 km to the east; another, which had been at liberty for 1,367 days, moved 259 km southwest of its release site. In contrast, the maximum time at liberty for a tag recovery by fishers was 1,501 days, and this fish was caught only 3.5 km from its release site. The mean vector of reported movement was 42.4 km to the east for individuals at liberty during hurricanes and 7.4 km to the east-northeast for individuals not at large during the two hurricanes. The movement observed by Patterson et al. (2001a) was greater than had been previously reported for red snapper in the northern Gulf.

Patterson and Cowan (2003) used the data described by Patterson et al. (2001a) to estimate site fidelity by modeling the decline in recaptures at the tagging sites over time to obtain an annual instantaneous rate of decline or D (daily rate × 365 days). This value would be equal to the sum of total annual instantaneous mortality (Z) and total annual instantaneous emigration defined as Q. The authors assumed that no fishing mortality occurred at the site and calculated M following Royce (1972) and Hoenig (1983). These approaches yielded M estimates of 0.0868 and 0.0855, or an average of 0.08615. Once D and M (or Z) were calculated, Q was obtained by subtraction. Site fidelity (SF) was estimated as $e^{-Q}$. Estimated SF values ranged from 24.8% for all recaptures to 25.3% for all recaptures of fish that were released at their original capture location, to 26.5% for recaptures for fish tagged and recaptured in the intervals between hurricanes.

The above estimates of SF assumed that all tagged fish were recognized. However, these authors also recognized in an earlier publication that tag shedding occurs (Patterson et al., 2001a), but did not account for this tag shedding in their latter SF estimations. For example, the estimated 95% confidence interval for probability of tag retention for a fish at liberty for 200 days was 0.87–0.96, but for a fish at liberty for 755 days, the 95% confidence interval for probability of tag retention was only 0.05–0.37. We suggest that a major component in the decline in recapture fish was related to tag shedding, and this factor needs to be accounted for in SF estimation.

The estimates of Z = 0.09 (or M, since no fishing was believed to have occurred) are highly conservative for the age of the fish in question. As described above, Szedlmayer (2007) estimated ages from otoliths for 3,415 red snapper collected from 94 different artificial habitats offshore Alabama (see Figure 7). Based upon these data, Z for ages 2 to 16 was estimated to be 0.54. If this Z value is used, Q = 0.93 and SF would be on the order of 40%, which is still low as compared to historical studies.

Two additional studies have used conventional mark-recapture methods. Strelcheck et al. (2007) tagged 4,317 red snapper at 14 experimental artificial reefs off coastal Alabama between January 1999 and October 2002. Mean length at tagging was 335 mm TL (±63.3 mm SD). Some 629 recaptures were reported, of which 412 (65%) were made by the researchers at the original release site, and 217 recaptures were reported by fishers. Mean time at liberty was 401 days, with a range of 1 and 1,587 days. Most fish (86%) showed little movement, 2 km or less, from the release site. Mean and maximum distances moved were 2.1 km and 201 km. The mean dispersion rate from release sites was 8.6 m $day^{-1}$. Annual SF estimates were made following Patterson and Cowan (2003) and ranged from 48 to

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52%. If Z for this area is 0.54 (Szedlmayer, 2007), SF would be estimated to be above 75%.

Strelcheck et al. (2007) concluded that the observations of high SF and low dispersal rates provided support for the hypothesis that artificial reefs offshore Alabama provide suitable habitat for adult red snapper. However, they suggested the ratios of instantaneous growth (G = 0.54) in weight to total mortality (Z = 0.7 to 0.9) were <1, indicating that the reefs off Alabama were not producing new biomass at current fishing mortality rates. In contrast, if Z = 0.54 (Gitschlag et al., 2003; Szedlmayer, 2007) was used, the G/Z ratio would be equal to 1.

In another conventional mark-recapture study, 5,614 red snapper were tagged between July 2002 and August 2005 (Diamond et al., 2007). Tag returns provided location information for 82 fish. Of these, 54% moved an average distance of 20.4 km. In the second program, over 9,000 fish were tagged by "Fish Trackers" (research personnel, volunteer anglers aboard charter headboats, and private boats) between 1983 and 2006. In that study, 60 returns were analyzed for movement. Most (72%) were recaptured at their release site, with 28% showing an average movement of 19.1 km. Diamond et al. (2007) concluded that the spatial scale of movements in this study was small enough to support the idea that red snapper stocks in the northern Gulf are relatively isolated and that there may be a separate demographic stock off Texas. Similarly, genetic studies have indicated that red snapper in the Gulf maintain a complex of semi-isolated populations in which relatedness is maintained over geologic time by gene flow, yet the populations are demographically independent over the short term (Gold and Salliant, 2007). Thus, all of these later studies (Strelcheck et al., 2007; Diamond et al., 2007; Gold and Salliant, 2007) support the view of limited movement and relatively high SF.

While there have been extensive mark-recapture studies of red snapper as described above, they all have the inherent difficulty of reliance on private fishers for accurate positional information for recaptures. Positional information from private fishers, especially for red snapper, is unreliable at best, and can only be counted on to add variance to SF estimations. This issue of confidence about positional information from private fisher returns has prompted a number of ultrasonic telemetry studies (Szedlmayer, 1997; Szedlmayer and Schroepfer, 2005; Schroepfer and Szedlmayer, 2006; Peabody and Wilson, 2006). Szedlmayer (1997) reported residence times on artificial reefs of 17–597 days, and Szedlmayer and Schroepfer (2005) estimated red snapper were resident on an artificial reef for a mean of 212 days, with an individual fish staying at one reef for up to 597 days. Using the previously published information along with new ultrasonic tagging studies, Schroepfer and Szedlmayer (2006) used event analysis described by Allison (1995) to provide a newer estimate of residence time on reefs. Fish were larger than previous studies (mean ± SD = 518 ± 140, range 301–840 mm TL, $n = 77$), which may account for some of the differences from previous conventional tagging studies. In this later study, however, the median residence time increased to 373 days or about one year.

Peabody and Wilson (2006) released 125 red snapper with acoustic transmitters at oil platforms arrayed in a circle around a salt dome about 50 km south of Port Fourchon, Louisiana. The mean size of these fish was 360 mm TL, and the range in length was 280–470 mm TL. Remote receivers were deployed on the platforms at 10–20 m depths and on artificial reefs within the circle of platforms. They detected 97 of 125 tagged red snapper released with transmitters. The majority (94%) of the tracked red snapper showed no movement between receiver locations on a daily, weekly, or monthly basis. There were 36 recaptures from fishers, with most (81%) captured at their release site. Seven recaptures were reported at locations other than their release site. Days at liberty for these seven fish ranged from 5 to 130 days, and distance traveled ranged from 2 to 25 km, but again, these reported recapture locations are subject to the same error as conventionally tagged red snapper. Peabody and Wilson (2006) estimated a maximum estimate of SF for six months was 90%. Assuming constant emigration rate over the next six months, they projected the annual SF would be 80%.

The higher estimates of SF obtained by Szedlmayer and Shipp (1994) and Strelcheck et al. (2007) as compared to the lower estimates of Watterson et al. (1998) and Patterson et al. (2001a), all working in the same general area off coastal Alabama, may be explained, in part, by the differences in the artificial reefs at the study sites. Reefs used in the Patterson et al. (2001a) studies were largely constructed of 55-gallon drums and newspaper dispenser machines, whereas the reefs used in the other studies were considerably more substantial (e.g., concrete tetrahedrons, concrete mats over pipelines, etc.). The small artificial reefs used by Watterson et al. (1998) and Patterson et al. (2001a) may have been more altered or dispersed by storms and hurricanes compared to the larger more stable artificial reefs used by Szedlmayer and Shipp (1994) and Strelcheck et al. (2007).

The natural mortality rate for age 2–7 red snapper may be higher than is the case for older fish. At present, it is assumed that M = 0.1 for age 2+ red snapper; i.e., this value is assumed to be constant across all ages from 2 to 53 (SEDAR7, 2005). We suggest that it is more reasonable to assume, based upon growth and habitat use patterns for young versus older fish, that natural mortality is higher at age 2–7 compared to fish greater than age 7. We also suggest that, given the scarcity of reef habitat and the relatively high estimates of SF, habitat limitation is a significant factor governing the dynamics of age 2–7 red snapper.

### *Age 8+*

As described above, red snapper grow rapidly over the first 8 to 10 years of life, after which growth slows (e.g., Fischer et al., 2004; see Figure 6). During this timeframe, snapper take up residence on structured habitat, and as the fish grow larger, there is an ontological shift to reef habitats with greater vertical relief and complexity. The reefs may provide protection from

predation and increased prey resources (Szedlmayer and Lee, 2004; Piko and Szedlmayer, 2007). Small and intermediate (up to about age 10) red snapper show greater SF to reefs compared to the largest (greater than age 10) red snapper (Render, 1995; Szedlmayer, 2007). The most plausible explanation for these changes in SF is that older fish (age 8–10) reach sizes that render them largely invulnerable to predation, and they may spend a larger portion of their time over soft bottoms, especially areas with sea bottom depressions and lumps, etc. (Boland et al., 1983; Render, 1995; Nieland and Wilson, 2003).

In 1999, the National Marine Fisheries Service (NMFS) initiated an offshore bottom-longline survey designed to address the abundance, size, and age distribution of red snapper across the shelf of the Gulf of Mexico (Mitchell et al., 2004). Pilot studies were conducted in 1999 and 2000, sampling in two areas at depths between 64 and 146 m. In 2001, the annual longline survey was expanded to cover depths between 9 and 366 m (or 5 and 200 fm) across the entire Gulf. The longline sets were randomly located, stratified only by depth and longitude rather than by habitat.

Red snapper catches varied geographically and with depth (Mitchell et al., 2004). Only 12 red snapper were caught at the 269 stations east of the Mississippi River as compared to 232 snapper caught at the 324 stations sampled west of the Mississippi River. Differences in age and size of fish were also observed, with older, larger red snapper found in the western Gulf (up to 53 years in age, median 12 years, and median TL = 784 mm) and younger, smaller fish found in the eastern Gulf (up to 19 years old, median age of 6 years, median TL of 625 mm). Red snapper were most abundant at depths ranging from 55 m to 92 m, with catches declining both inshore and offshore of these depths (Mitchell et al., 2004).

The relative age distribution observed in these studies (see Figure 5 in Mitchell et al., 2004, summarized herein by Figure 8) showed that red snapper were fully recruited to the longline gear at age 8. Abundance declined from these levels in a linear fashion through age 22 and remained relatively consistent thereafter. The populations of red snapper vulnerable to longline fishing over soft bottoms appears to consist of fish larger than those that occur around reefs (compare Figures 6, 7, and 8). One explanation is that once the fish reach 8 to 10 years of age, they are no longer totally dependent upon structured habitats and can forage over open habitat with little threat from predation.

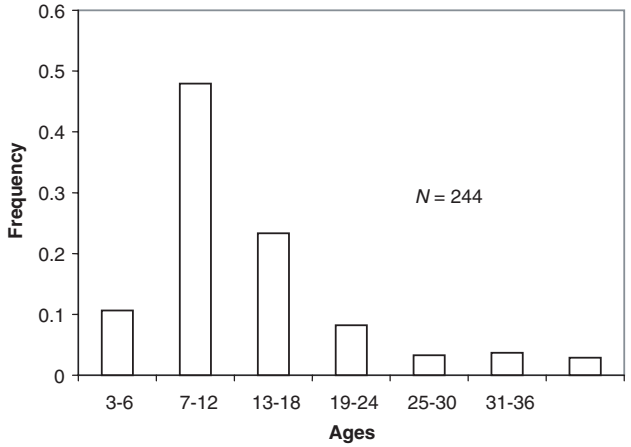


**Figure 8** Age frequency of red snapper caught during NMFS research longline surveys from 1999 to 2002 in depths of 9–366 m (Source: Mitchell et al., 2004).

The prohibition of longline fishing inside of 92 fm in the western Gulf likely has been one of the most significant management actions taken by the Gulf of Mexico Fisheries Management Council (GMFMC). In some areas, large numbers of large fish may be dispersed over open habitat where they are not highly vulnerable to vertical line fishing. However, they can be efficiently harvested using longlines (e.g., Prytherch, 1983). This soft bottom pool of fish is now protected.

## *DISCUSSION*

Site fidelity provides an annual estimate of reef fish immigration or emigration from a reef. For red snapper, 2- to 3-year-old fish at artificial reef structures in shallow water show high fidelity to a site on temporal scales of months to a year, albeit the probability of detecting ultrasonically tagged red snapper at a site one year after release was only 50% (Schroepfer and Szedlmayer, 2006). Diamond et al. (2007) provided a list of factors that have been suggested to be important in affecting the percentage of fish that move compared to the percentage of fish that remain at a site. These included size or age of fish (Moseley, 1966), depth of capture (Beaumariage, 1969; Watterson et al., 1998), seasonal patterns due to water temperature or reproductive condition (Topp, 1963; Beaumariage and Bullock, 1976), hurricanes (Watterson et al., 1998; Patterson et al., 2001a), and translocation from the tagging site (Watterson et al., 1998; Patterson et al., 2001a; Peabody, 2004). The accuracy of positional data reported for tag returns by fishers can also be an issue regarding SF.

It has also been hypothesized that SF of reef-associated organisms is dependent both upon prey availability and the availability of suitable refuge, i.e., the resource mosaic hypothesis (Lindberg et al., 1990; Frazier and Lindberg, 1994) and density-dependent habitat selection (Lindberg et al., 2006). Reef-associated fish species that rely on benthic prey as the primary component of their diet may create a gradient of prey depletion (or feeding halo) around the reefs, resulting in negative feedbacks to reef fish energetics, residence times, and local abundance, particularly when the feeding halos of adjacent reefs overlap (Lindberg et al., 2006). The degree of prey depletion and associated negative feedback can alter the potential for sustained productivity of an artificial reef or reef complex. Bioenergetic demands increase as foraging area increases, resulting in increased emigration from resource-depleted reefs to reefs containing a greater abundance of prey.

In contrast, reefs or reef complexes that can sustain prey resources over time may potentially benefit reef fishes and fishery

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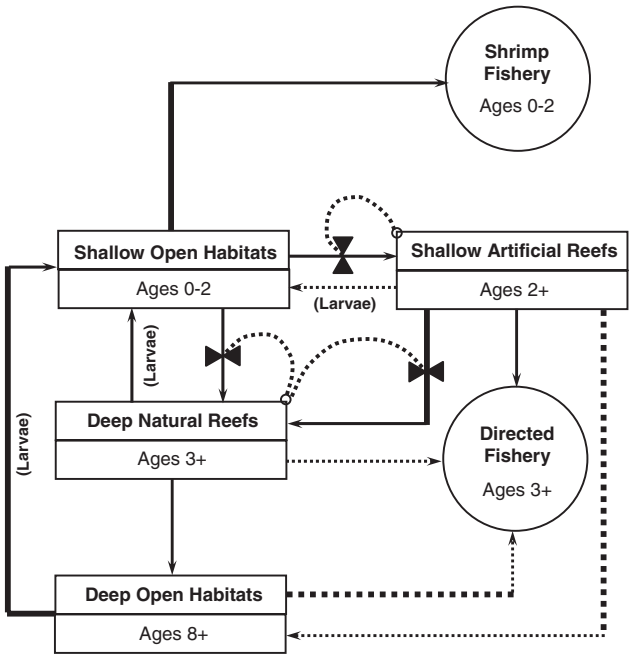


**Figure 9** Conceptual model of habitat use by age of red snapper. The fishery is heavily dependent on young fish inhabiting artificial reefs.

production by reducing the costs of foraging, increasing growth rates, and increasing SF. Under these conditions, the fish would tend to show less movement during foraging due to increased risks of predation and reduced proximity to shelter (Strelcheck et al., 2007). However, if reef densities are high in an area, the distances between them are shorter, and reef fish may move among these habitats more readily than they would otherwise, resulting in increased movement and an expanded home range. Red snapper in clustered habitats may be able to explore nearby alternative habitats with very little cost.

Mark/recapture studies support the idea that movement occurs on two scales. Large-scale climate events such as hurricanes increase the proportion of fish that move and the distances that these fish move. On the other end of the spectrum, many fish may move but only for distances of a few kilometers. These observations are well illustrated by Figure 1 in Strelcheck et al. (2007). Diamond et al. (2007) observed that almost all red snapper will relocate at some time during their lives if they survive long enough. They also noted, however, that the scale of movements they observed supported the hypothesis that, on a geographic basis, red snapper stocks in the northern Gulf are relatively isolated, with periodic long-range dispersement caused by hurricanes or some other factor that triggers long-range movements. They interpreted their data from Texas to be consistent with the idea of a separate demographic stock off Texas, as implied by Fischer et al. (2004) and Salliant and Gold (2004).

Once red snapper grow to about 8 years old, they are large enough to be invulnerable to most predation and occur over open habitat as well as at reef habitat. In the western Gulf, these fish are most abundant in longline sets at depths between 55 and 92 m (Figures 9 and 10). In this region, the zone of highest abundance of early larvae corresponds to the distribution of 8+ year adults taken by longlines (Figure 10). However, spawning is also known to occur across the shelf. The eggs and larvae are planktonic for about one month and then settle to the bottom as early age 0 fish. The natural mortality during this period is high, on the order of $M = 11.8$ (see Gallaway et al., 2007).

Although spawning occurs over most of the shelf, the age 0 new recruits are most abundant at depths between about 18

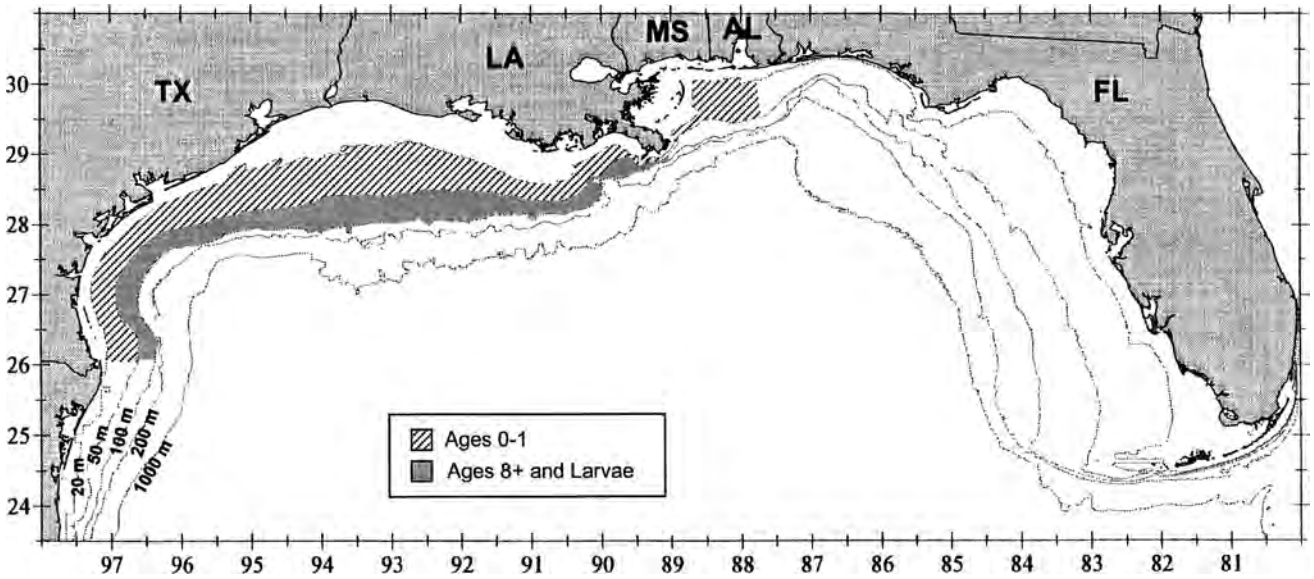


**Figure 10** Distribution of age 8+ red snapper (based on Mitchell et al., 2004), red snapper larvae (based on Lyczkowski-Shultz and Hanisko, 2008), and age 0–1 red snapper (based on Gallaway et al., 1999). These data suggest spawning mainly occurs in the western Gulf at depths between 50 and 100 m, and that the larvae are transported toward shore and settle at depths between 20 and 50 m.

and 55 m (Figure 10). Initially, they are abundant over all substrates but quickly become aggregated at low-relief habitats like relic oyster-shell beds (relief in cm), which affords protection from predation. As the fish grow, the degree of protection from predators provided by low-relief habitats diminishes, and they become large enough to be taken as bycatch in the shrimp fishery. Bycatch losses are greatest during the period from October to December.

By December, fish are able to occupy larger reefs (vertical relief about 1 m), which become vacant when their previous occupants (age 1 red snapper) move to reefs with even greater relief. The age 0 fish occupy these reefs from December of one year to December of the next year. All of the evidence is consistent with the premise that habitat is a limiting factor for age 0 to age 1 fish, as described above. The evidence includes habitat scarcity, site fidelity, exclusion of smaller conspecifics by larger fish, and variation in M with abundance.

Fish tend to move to larger artificial reefs as late age 1 or early age 2 fish. At offshore oil and gas platforms in the western Gulf, the younger, smaller fish occupy the upper water column, and larger, older fish occupy the deeper areas of the reefs. Offshore petroleum platforms may be particularly valuable because they provide shelter and feeding opportunities throughout the water column. The fish at artificial and natural reefs are known to forage on reef prey types but also forage away from the reefs, and small fish feed on water column prey as well. Small and intermediate fish at artificial reefs in shallow water (<50 m) show the highest degree of SF. Sometime after about age 8, red snapper begin to show less dependence on structured habitat and can also be found over open habitat. We suggest that this is essentially a size refugia, enabling them to spend greater amounts of time over benthic foraging grounds.

Other than the large shelf-edge banks and features like the pinnacle region off coastal Alabama, little is known about the distribution and spacing of natural reefs in the northwestern Gulf. As compared to natural reefs, artificial reefs are relatively small and occur in two main clusters: (1) oil and gas platforms off central and western Louisiana, and (2) the extensive artificial reef zones off Alabama. Off Alabama, the artificial reefs are clustered within specifically permitted artificial reef areas. The offshore platforms also occur as closely spaced clusters of platforms representing individual oil fields. Most of the artificial reefs are located in water <100-m deep, in the same zone where age 0 and age 1 fish are most abundant. Parker et al. (1983) noted that depths between 91 and 183 m in the Gulf were not surveyed for the presence of natural reefs because of gear and time constraints. They also noted that these depths were already known to contain "prime reef fish habitat and probably contribute significantly to the total amount" (Parker et al., 1983:937). However, the MMS designation of no activity zones to protect known reefs suggests the total area of shelf-edge reef habitat is small.

The creation of artificial reefs off Alabama and the deployment of petroleum platforms in the northwestern Gulf have been coincident with a shift in the fishery from a few well-known natural reef sites on the shelf to extensive artificial reef areas off Alabama and Louisiana (Camber, 1955; Carpenter, 1965; Goodyear, 1995). We suggest that there is evidence that a high (±70%) proportion of the entire age 2 red snapper population occurs at these artificial habitats. These observations and the relative scarcity of high-relief natural reefs (<1.6% of the shelf bottom area) have led us and others to speculate that natural reef habitat is a limiting factor for age 2–7 fish, and that artificial reefs have increased red snapper production in the western Gulf (Szedlmayer and Shipp, 1994; Shipp, 1999; Szedlmayer, 2007). Others (e.g., Cowan et al., 1999; Patterson and Cowan, 2003) have disagreed, arguing that based on Bohnsack's (1989) gradients of reef dependency, fishing intensity, reef availability, population control mechanisms, and behavior, red snapper are merely being attracted to artificial reefs rather than experiencing increased production because of these sites.

The observations that (1) younger (<10 year) adult fish appear to show higher SF than older fish, (2) natural mortality for age 0 appears to vary with year class strength, (3) red snapper recruitment today is higher than the estimated historical maximums, (4) fishing intensity on pre-recruit fish (ages 0 and 1) has been reduced in recent years by over 65% yet age 1 abundance has not increased, and (5) the decline in abundance of age 2 fish over open habitats (shrimp trawls and longline evidence) and their disproportionate abundance at artificial reefs all suggest increased production of young red snapper that is based on habitat enhancement by artificial structures.

As described above, a large fraction of the estimated total population of age 2 red snapper has been estimated to occur at artificial reefs, a very small component of the overall high-relief reef habitat. If true, one interpretation is that age 2 fish are being differentially attracted to these habitats, perhaps due to the predominance of artificial reefs and platforms in mid-shelf zones, where juvenile red snapper are most abundant. Once there, they show high SF for months to up to a year or more. Overall, relatively high survival and SF is shown for red snapper at artificial reefs between ages 2 and 3 (see Figures 6 and 7). Abundance between age 3 and 4, however, typically declines dramatically (e.g., Figure 6), suggesting higher fishing mortality and/or increased movement. Based upon Gitschlag et al. (2003), few fish survive or remain at offshore oil and gas platforms beyond ages 5 or 6.

There are few data describing the size/age distribution of red snapper at natural reefs in the northern Gulf. However, red snapper length and age data based on scales were collected at the Flower Garden Banks, large natural reefs in the northern Gulf, by Zastrow (1984). Samples were also obtained from south Texas fishing banks (i.e., Aransas, Baker, South Baker Dream, and Big Adam Rock) and from headboats fishing out of Galveston. The Galveston fish may have come from artificial reefs (platforms) rather than natural reefs. At the East and West Flower Garden Banks, age 2 fish were scarce, and peak abundances were observed for age 3–5 fish (middle panel of Figure 11). These data suggest that red snapper populations at deep natural reefs in the northern Gulf consist mainly of fish

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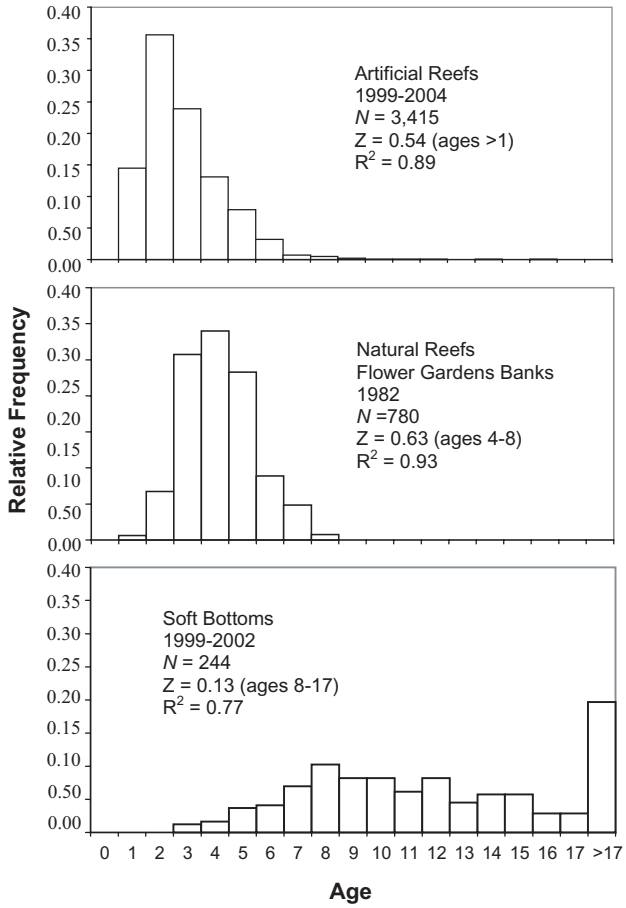


**Figure 11** Age distribution of red snapper at artificial and natural reefs and over soft bottoms. Top panel based on Szedlmayer (2007), middle panel based on Zastrow (1984), and bottom panel based on Mitchell et al. (2004).

age 3 and older, whereas fish at artificial reefs are recruited at age 2.

Collectively, we suggest that prior to the proliferation of offshore oil and gas platforms and artificial reefs (e.g., pre-1980s), young new recruits occurred over open substrates between age 0 and age 2. In this habitat, natural mortality was high due to the lack of cover affording protection from predation, and the fish were subject to shrimp trawl bycatch as well (see Figure 9). Age 2 fish were commonly taken in shrimp trawls along with age 0 and age 1 fish until about 1990, which demonstrated their abundance on open habitats (Goodyear, 1995). After this stage, natural reefs in the northern Gulf would then harbor red snapper age 3 and greater (see Figure 9). We suggest that recruitment of the age 0–2 fish to the natural reefs was inhibited by the presence of adult or larger fish occupying the reefs. After age 8, red snapper would increase their foraging range to include open soft-bottom habitat because they had reached a size that reduced predation mortality.

Not surprisingly, the construction history of oil and natural gas platforms as well as other artificial reefs has corresponded to changes in habitat distribution patterns for red snapper. In 1960, there were only about 351 offshore oil and gas platforms in the northern Gulf, but these increased to 1,520 by 1970, and reached 2,540 by 1980 (Figure 12). From 1990 to the present, the number of platforms has averaged about 4,000, considering both new installations as well as removals. Catch-per-unit effort of commercial-sized red snapper in shrimp trawls (mostly age 2) fluctuated at a level of about 3 kg/1,000 nominal days fished from 1967 to 1974, after which a decline occurred through 1989 when CPUE reached a low of 0.13 kg (Figure 12). This period of decline in abundance corresponded to the increase in platforms to present-day levels. No landings were reported after 1989 because changes in fishing regulations prohibited the sale of red

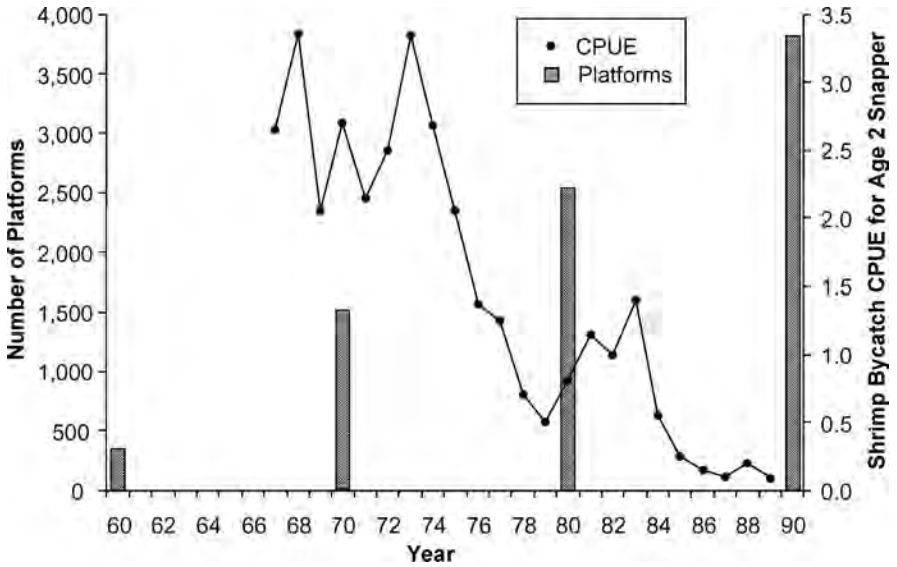


**Figure 12** Catch-per-unit effort for age 2 red snapper in shrimp trawls, 1967–1989 (Goodyear, 1995), and cumulative increase of offshore oil and gas platforms in the northern Gulf of Mexico (data provided by the Minerals Management Service, New Orleans, LA).

snapper caught by shrimp trawls (Goodyear, 1995). We suggest that this increased construction of oil and gas platforms as well as other artificial habitats has provided new protective habitat for age 2 fish that would have otherwise suffered higher mortality over open habitats. Although fishing mortality can be high at these new habitats (Nieland and Wilson, 2003), we suggest that prior to their construction mortality was even higher for age 2 fish over open habitat. This being the case, we suggest that removal of production platforms and other artificial reefs will likely result in a large reduction of red snapper available to the directed fisheries.

Cordue (2005) recommended that future red snapper stock assessments should model post-recruitment density-dependent mortality, "as this is critical for determining the impact of shrimp trawl bycatch on red snapper rebuilding." We concur and have demonstrated that the information in the existing literature is consistent with the premise of density-dependent natural mortality in red snapper for at least age 0 and age 1 fish, and likely for older fish as well. If this aspect is incorporated in the assessment models, management advice may be substantially altered.

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# A Life History Review for Red Snapper in the Gulf of Mexico with an Evaluation of the Importance of Offshore Petroleum Platforms and Other Artificial Reefs

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*Red snapper mature as early as age 2, have high fecundity (a 10-year-old female produces 60 million eggs per year), and may live for over 50 years. Eggs, larvae, and post-settlement juveniles typically show high rates of natural mortality. For example, of the 60 million eggs produced annually by a 10-year-old female, only about 450 would survive to 5 cm, the size at which they enter the shrimp fishery. Changes in abundance by size and age appear to be consistent with density dependence in survival rate from ages 0 to 1 and likely ages 0 to 2. Red snapper are attracted to structure or reef habitat at all ages, but larger, older fish also occur over open habitat once they have reached a size that renders them largely invulnerable to predation. Artificial reefs comprise a small fraction of the overall high-relief reef habitat, but harbor a large fraction of the present-day age 2 red snapper populations. Prior to the proliferation of artificial reefs in the northern Gulf, age 2 red snapper may have historically occurred mainly over open-bottom, sand-mud benthic habitat where natural and shrimp trawl bycatch mortality was high. Age 2 fish dominate red snapper populations at artificial reefs, whereas the age composition of red snapper at natural reefs usually show older ages are dominant. The present day red snapper fishery is heavily dependent on catches at artificial reefs. Evidence is presented that suggests red snapper production in the northern Gulf likely has been increased by the establishment of significant numbers of artificial reefs.*

**Keywords** red snapper, *Lutjanus campechanus*, oil and gas platforms, density-dependent mortality, life history, artificial reefs

## *INTRODUCTION*

The red snapper *Lutjanus campechanus* is an unusual finfish. In the Gulf of Mexico (Gulf), red snapper mature at age 2 and can live for over 50 years (Szedlmayer and Shipp, 1994; Render, 1995; Wilson and Nieland, 2001). They are also characterized by high fecundity. A female age 0 red snapper recruit produces, on average, 55.5 million eggs over its lifespan (SEDAR7, 2005). This is more than an order of magnitude higher than any of the finfishes listed in the Ransom Myers' Stock Recruitment Database (2007).

Despite these attributes, the Gulf population of red snapper has been in an overfished condition since at least 1994 (Goodyear, 1994), and rebuilding efforts to date have been unsuccessful (SEDAR7, 2005). Generally, this failure is believed to have been attributable to the inability to reduce shrimp trawl bycatch while maintaining a high total allowable catch (TAC) in the directed fishery. However, shrimp trawl bycatch mortality of red snapper has plummeted since 2003, but there has not been any evidence that the abundance of age 1 juveniles

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has increased substantially. A possible explanation is that habitat limitation (or compensatory mortality) may be an important population control, particularly during the early life stages of red snapper.

Shipp (1999) noted that the addition of large amounts of artificial reef habitat (over 20,000 individual reefs installed) in an area offshore of Alabama was coincident with the establishment of a significant red snapper fishery. This area had formerly been devoid of all but relatively diminutive soft-bottom fish species of little or no economic importance. He noted that the ichthyofauna of a quarter century prior had been transformed from an economically depauperate biomass to one supporting an industry valued at $60 million annually. He rhetorically asked if this change had resulted in a change in total biomass? His answer was: "We don't know, but did it matter in terms of management decisions?" (Shipp, 1999:54).

Cowan et al. (1999) responded that "yes, it mattered" because a fundamental change in habitat (the placement of artificial reefs) had occurred at the expense of the small benthic fisheries in a region of the shelf that had formerly provided a nursery function to many species of fishes. They argued that nursery function had been traded for adult habitat, complete with a rich set of predators, without any consideration of the ecosystem consequences of the tradeoffs. They suggested that large-scale deployment of artificial reefs could result in large-scale modification of ecosystem function, with effects good and bad depending on specifics of critical habitat requirements and recruitment bottlenecks.

Trawl samples of today (e.g., Wells, 2007) suggest that the addition of artificial reef habitat offshore Alabama has not resulted in an area-wide displacement or loss of the soft-bottom ichthyofauna as characterized by Shipp (1999). These species still occur and dominate trawl samples. However, an increase in adult reef species has occurred that has been coincident with artificial reef placement. As will be shown below, these new populations of large predators indeed forage on prey species inhabiting the surrounding soft bottoms, as well as on reef-associated and water column organisms. The magnitude of the overall effects of artificial reefs on productivity and ecosystem function remains unanswered. Also, the question of whether the placement of artificial reefs actually increases production or merely aggregates species such as red snapper remains contentious.

In this article, we review the literature describing the life history, distribution, and ecology of the red snapper in the Gulf of Mexico. Specifically, we examine the role and relative importance of offshore oil and gas platforms and other artificial reefs as factors affecting the Gulf of Mexico red snapper population. We begin by noting that red snapper is characterized as a reef fish, and their reef association begins almost immediately after they leave the planktonic stage and settle to the bottom (e.g., Szedlmayer and Howe, 1997; Szedlmayer and Conti, 1999; Workman et al., 2002). This association has been well documented for ages 0–8, but it may weaken considerably at older ages (e.g., Render, 1995; Nieland and Wilson, 2003; Szedlmayer, 2007). We also note that, on a spatial basis, reef habitat is a relatively scarce commodity in the northern Gulf where red snapper occur (Ludwick, 1964; Parker et al., 1983). In this context, we also examine the issue of habitat limitation (or compensatory mortality) and the life stages at which habitat limitation may be important.

## *LIFE HISTORY SYNTHESIS*

For descriptive and management purposes, we first divide the life history of red snapper into pre-recruit (<50 mm total length, TL) and post-recruit (>50 mm TL) phases. The pre-recruit life stages include eggs, larvae, and post-settlement juveniles <50 mm TL. At 50 mm TL, they enter the Gulf penaeid shrimp trawl fishery as bycatch. The post-recruit life stages include early juveniles (ages 0 and 1), young adults (ages 2 to 7), and mature adults (ages 8+). Early juveniles are taken as bycatch in the shrimp fishery, whereas young and mature adults are taken in the directed fishery.

### *Pre-Recruit Life Stages*

#### *Eggs*

Spawning of red snapper in the northern Gulf of Mexico extends from April through September, with peak spawning occurring in June–August (Render, 1995; Bradley and Bryan, 1975; Futch and Burger, 1976; Collins et al., 1996). The eggs are pelagic, spherical, transparent, and about 0.8 mm in diameter (Rabalais et al., 1980). After spawning, the eggs are buoyant and float to the surface. In the laboratory, on the order of 50% of the eggs hatch within 20–27 hr after fertilization (Rabalais et al., 1980; Minton et al., 1983). Gallaway et al. (2007) estimated an egg stage duration of 1 day, with an instantaneous daily rate of natural mortality of $M = 0.4984$ (Table 1).

#### *Larvae*

At hatching, the larvae are about 2.2 mm total length (TL), and they remain pelagic until metamorphosis and settlement, which occurs when they are 16–19 mm TL and between 26 and 30 days in age (Rabalais et al., 1980; Szedlmayer and Conti, 1999; Rooker et al., 2004). Gallaway et al. (2007) used a mean larval stage duration estimate of 27 days and an estimated instantaneous daily natural mortality rate for this stage of 0.3014. That estimate is revised herein to reflect a mean larval stage duration of 28 days and an instantaneous daily rate of natural mortality of 0.2413. The estimated total mortality for this stage is $M = 6.7564$ (Table 1).

Lyczkowski-Shultz et al. (2005) showed that larval abundance determined from the SEAMAP (Southeast Area Monitoring and Assessment Program, National Marine Fisheries Service, NMFS) neuston net sampling was directly correlated

**Table 1** Life history stages and natural mortality estimates for red snapper over the first two years of life

| Age | Stage | Duration | Dates | M | Total | Reference |
|---|---|---|---|---|---|---|
| 0* | Egg | 1 | 1 July–1 July | 0.4984 | 0.4984 | Gallaway et al. (2007)*** |
| | Larvae | 28 | 2 July–29 July | 0.2413 | 6.7564 | Gallaway et al. (2007) |
| | Juvenile 1 | 38 | 30 July–5 Sept | 0.1196 | 4.5448 | Rooker et al. (2004) |
| Totals | | *67 | | | 11.7996 | |
| 0** | Juvenile 2 | 117 | 6 Sept–30 Dec | 0.0054 | 0.6318 | Szedlmayer (2007) |
| 0/1** | Juvenile 3 | 181 | 1 Jan–31 June | 0.0054 | 0.9774 | Szedlmayer (2007) |
| Totals | | 298 | | | 1.6092 | |
| 1** | Juvenile 4 | 365 | 1 July–31 June | 0.0033 | 1.2 | Gazey et al. (submitted) |

*Pre-recruit.
**Recruit.
***$M_{egg}$ values of 13.3 in Gallaway et al. (2007) revised to 11.8 and larval- and juvenile 1-stage durations changed from the Gallaway et al. (2001) estimates of 27 and 39 days to 28 and 38 days, respectively. These changes reflect new data utilized in the methodology described in Gallaway et al. (2007).

with estimates of adult abundance ($r = 0.813$, $p = 0.004$, and $r^2 = 0.661$). Lyczkowski-Shultz and Hanisko (2007) reported occurrence and abundance patterns for red snapper larvae in the Gulf of Mexico. During summer (mid-June through July), the highest mean station abundance values were observed off central and western Louisiana at depths between 50 and 100 m. In addition, red snapper larvae were consistently taken off south Texas, Mississippi, and Alabama, but abundance was lower east of the Mississippi River as compared to areas to the west of the river.

Lyczkowski-Shultz and Hanisko (2007) also observed that abundance from 50- to beyond 100-m depths off central and south Texas in the fall was markedly higher than had been observed in this area during summer. Based upon data from the fall plankton survey, red snapper larvae are encountered much less frequently and in lower numbers in the eastern Gulf than in the western Gulf. Lyczkowski-Shultz and Hanisko (2007) noted that the consistent presence of red snapper larvae in samples taken between the 100- and 200-m depth contours in both the western and eastern Gulf supports the contention that red snapper spawn over a wide depth range, i.e., from mid-shelf to the continental slope.

### *Post-Settlement Juveniles*

We define this stage as early juveniles 19–50 mm TL, 29–66 days in age (Szedlmayer and Conti, 1999; Rooker et al., 2004). Assuming eggs were deposited on July 1 as a start date, these fish would be present for a 38-day period between July 30 and September 5 (see Table 1). Based on Gallaway et al. (2007) and Rooker et al. (2004), the instantaneous daily mortality rate for this stage is estimated to be 0.1196 ($r^2 = 0.918$). The total mortality for this stage would thus be M = 4.5448 (0.1196 × 38 days).

As for most species, natural mortality is high for pre-recruit red snapper (Table 1). The duration of the three pre-recruit stages is 67 days and total M = 11.8. Assuming that a 10-year-old female red snapper produces 69.44 million eggs per year (SEDAR7, 2005), a total of 521 juveniles would survive to 50 mm TL and be susceptible to shrimp trawl bycatch.

Newly settled red snapper quickly move to structured habitat such as low-relief, relic-shell habitat (Workman and Foster, 1994; Szedlmayer and Howe, 1997; Szedlmayer and Conti, 1999; Rooker et al., 2004; Lingo and Szedlmayer, 2006; Piko and Szedlmayer, 2007). These fish grow rapidly in summer and fall and quickly outgrow their initial habitat. As they became larger, they seek larger, more structured habitat (Szedlmayer and Lee, 2004).

### *Post-Recruit Life Stages*

These stages begin with age 0 red snapper greater than 50 mm TL, the size at which they enter the Gulf penaeid shrimp fishery as bycatch. They continue to be taken by this fishery as age 1 red snapper. Red snapper enter the directed fishery at age 2 and are harvested throughout the balance of their lifespan, which can last for over 50 years (Szedlmayer and Shipp, 1994; Render, 1995; Wilson and Nieland, 2001).

#### *Ages 0 and 1*

Age 0 red snapper enter the Gulf penaeid shrimp trawl fishery at about 67 days in age and 50 mm TL. Assuming a July 1 start date, they would enter the fishery in early September but would not be fully recruited until they reached about 100 mm TL (Goodyear, 1995). Age 0 and age 1 red snapper densities are highest in the northern Gulf at depths between 18 and 55 m, from the Alabama-Florida border to the Texas-Mexico border (Gallaway et al., 1999). Our review of the NMFS post-1998 observer data file showed that red snapper juveniles are only occasionally taken in the eastern Gulf offshore Florida.

Within the 18- to 55-m depth range in the western Gulf, red snapper settle over all substrates but show an immediate attraction to low-relief, relic shell habitat that provides protection

from predation. This oyster shell habitat provides adequate shelter for new settlers, but as their size increases the fish need larger "hole" sizes for protection. Lingo and Szedlmayer (2006) and Piko and Szedlmayer (2007) conducted *in situ* studies using predator exclusion cages. Shell habitat with predator exclusion cages had significantly more age 0 red snapper than habitat without cages. However, as the fish became larger (>60 mm TL), they moved to concrete block habitat with larger holes and adequate predator protection such that the cage effects were no longer evident.

Szedlmayer and Lee (2004) and Wells (2007) provide strong evidence of an ontogenetic shift from low-relief to higher-relief habitat with size and age. Szedlmayer and Lee (2004) documented a transition in age 0 red snapper from open or low-relief habitat to artificial reefs having relief consisting of 1-$m^3$ concrete blocks. Settlement was observed in July and the newly settled (most <40 mm TL) fish were mostly found over open habitat. At the time of settlement, the reef habitat was occupied by age 1 fish between 100 and 200 mm TL. Age 0 fish began moving onto the reefs as they reached sizes approaching 100 mm TL and by December age 0 fish were found almost entirely on the reefs from which the age 1 fish had abruptly disappeared (Figure 1). Wells (2007), also working offshore Alabama, observed an increase in mean size corresponding to a shift from sand (96.1 mm TL) to low-relief shell (127.0 mm TL) to high-relief habitat (172.3 mm TL).

Szedlmayer and Lee (2004) examined diets of juvenile red snapper between 70- and 160 mm standard length (SL) collected from both reef and non-reef habitat. They observed a diet shift as fish moved from open to reef habitat. The dietary shift reflected feeding more on reef prey than on open-water prey. The shift in habitat and diet suggested differential habitat value based not just on predation refuge but increased access to additional food resources. In contrast, Wells (2007) suggested that red snapper relied on sand- and mud-associated prey regardless of the habitat from which they were collected. However, it is difficult to evaluate this finding because the taxonomic resolution used by Wells (2007) does not appear to be at the level needed to assign the prey species to a specific habitat type.

Once the age 0 fish have occupied reef habitat having sufficient relief and complexity to afford protection from predation and provide additional food resources, they appear to show a high degree of fidelity to these habitats (Workman et al., 2002; Chapin et al., in press). Tagged fish were repeatedly sighted at the same reef over a two-month period, and fish that dispersed as far away as 0.43 km returned to the capture reef within about 25 min. Workman et al. (2002) also observed that the presence of age 1 fish appeared to limit recruitment of age 0 fish to a reef, but as age 1 fish left the reefs, new age 0 recruits were observed. These observations were supported by laboratory studies in which larger red snapper excluded smaller red snapper from reef structures (Bailey et al., 2001).

In summary, larval age 0 red snapper undergo metamorphosis and settle to the bottom in late July at sizes between 16 and 19 mm TL. They are attracted to any low-relief habitat providing cover, but the cover requirements change as the fish grow. Initially, relic shell-ridge habitats are ideal for these small fish, and the greatest known extent of these habitats occur in the mid-shelf zone offshore Alabama (Schroeder et al., 1988; Parker et al., 1992; Schroeder et al., 1995; Dufrene, 2005). In this region, shell-ridge habitat covers about 15% of the sea floor (Dufrene, 2005). Coverage by natural rock reef having greater relief and complexity than relic shell ridges is likely much smaller. Overall, Parker et al. (1983) estimated that 3% of western Gulf mid-shelf seafloor between Pensacola, Florida, and Pass Cavallo, Texas, contained reef habitat, with only 1.6% of this area consisting of reefs having relief >1 m.

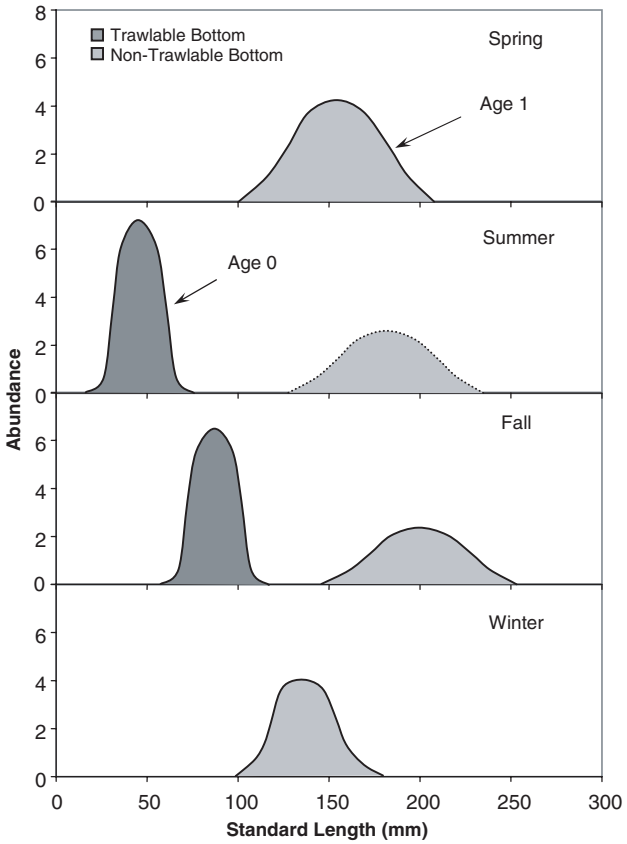


**Figure 1** A diagrammatic representation of the shift in distribution of age 0 red snapper (small size group) from trawlable bottom (dark shade) to non-trawlable reefs having intermediate relief (light shade) when age 1 fish move to large, complex reefs in winter. Based on Figure 2 in Szedlmayer and Lee (2004).

Most age 0 fish move onto reefs with intermediate relief (e.g., 1-$m^3$ structures) by December and appear to occupy these reefs until the following December. At this time, the 18-month-old fish have grown to sizes of approximately 200 mm TL and may require greater relief than is afforded by the intermediate-sized reefs. They begin recruiting to large reefs like natural rock outcroppings, offshore petroleum platforms, and large artificial reefs during their second winter at about 18 months of age (Stanley, 1994; Nieland and Wilson, 2003). In January, these

fish are classified as age 2 fish, even though they are only 18 months old in biological age.

The natural mortality rates for age 0 and age 1 fish are not well documented. Nichols et al. (2005) used the SEAMAP size, age, and abundance data for red snapper in conjunction with shrimp effort data to estimate M = 0.6 per year (SE = 0.36) for age 1 fish. Assuming M = 0.6, SEDAR7 (2005) estimated that F for age 1 red snapper in the western Gulf was 0.62. Thus, total mortality for age 1 red snapper was estimated to be Z = 1.2.

The estimate of M = 0.6 for age 1 red snapper was used by SEDAR7 (2005) to infer M = 1.0 for age 0 based upon the Goodyear (1995) stock assessment, which assumed M for age 1 was 60% of M for age 0. Based on this value of M, SEDAR7 (2005) estimated an age 0 F of 0.52 such that $Z_{age0}$ was 1.52.

However, Wells (2007) estimated instantaneous daily rates of M = 0.017 (or more) for age 0 red snapper between age 140 and 200 days that were trawled from a low-relief shell-bed habitat in an area offshore Alabama where commercial shrimp trawling does not occur. Projected to an annual rate, M would be estimated to be on the order of 6.2. Assuming a July 1 start date, this 61-day period would be between November 18 and January 16. This period corresponds to the timeframe when age 0 fish would be moving to high-relief habitat where they are not vulnerable to trawling. We believe the estimates of M derived by Wells (2007) are unrealistically high because they reflect both emigration and mortality.

Szedlmayer (2007) provided diver counts of juvenile red snapper (ages 0 and 1) on artificial shell and shell/concrete block habitat off coastal Alabama for the years 1998 to 2002. When these data are arrayed by year class (Figure 2), estimates of Z ranged from 2.1 to 3.2, averaging 2.6. The habitat studies were in the artificial reef area off coastal Alabama where commercial shrimp trawling does not normally occur, and the habitats showed no sign that trawling occurred in this area over the life of the study. This suggests most, if not all, of the Z values would consist of M or natural mortality. This estimate of M may also be confounded by not accounting for emigration of fish to larger structures. Overall, Szedlmayer (2007) estimated M for age 0 red snapper to be on the order of 2.0 (1.96), and also suggested higher mortality for stronger year classes than for weaker year classes (Figure 2). Szedlmayer and Conti (1999) observed a similar pattern of increased mortality with more abundant year classes based upon trawl collections from the same region. Collectively, these observations are consistent with the premise that habitat is a limiting factor for juvenile red snapper at observed levels of recruitment.

Gazey et al. (2008) conducted a length-based, age-structured modeling analysis for juvenile red snapper using monthly size and abundance data collected by observers on shrimp vessels. These preliminary results suggest Z for age 0 red snapper appears to be about 2.2, reasonably consistent with the independent estimates of Z = 2.6 by Szedlmayer (2007). Both of these estimates are higher than Z = 1.5 estimated by SEDAR7 (2005). The Gazey et al. (2008) Z estimates for age 1 fish was 1.3 as opposed to the Z = 1.2 used by SEDAR7 (2005). The observer data reflect higher mortality for stronger year classes than for weaker year classes, also supporting the contention that habitat limitation is an important factor governing the dynamics of juvenile red snapper.

Overall, we suggest the best estimate of average M for age 0 fish is 2.0, based largely on estimates from artificial shell and concrete block habitats in areas without trawling (Szedlmayer, 2007), and size and abundance data collected by observers on

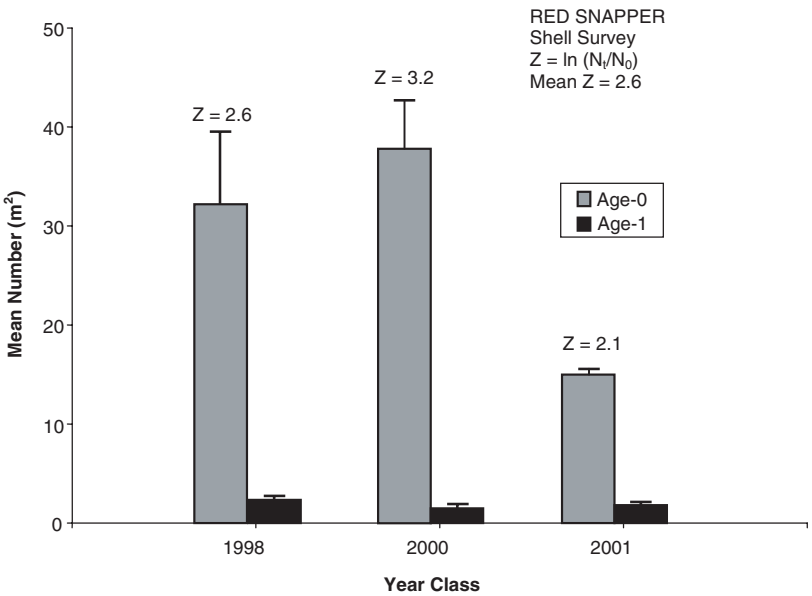


**Figure 2** Estimates of annual mortality for age 0 to age 1 red snapper based upon data from Szedlmayer (2007). Samples were taken in the artificial reef area off the coast of Alabama where shrimp trawling does not occur. Thus, Z should consist entirely of natural mortality (M).

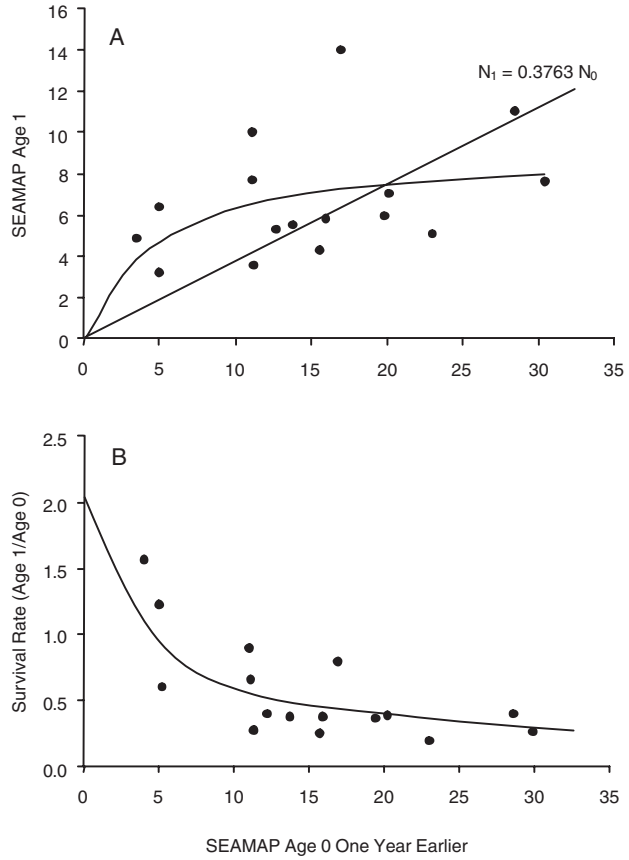


**Figure 3** Evidence of density dependence in red snapper mortality rate from age 0 to age 1 is present in the SEAMAP data, when age 0 numbers are used to predict either age 1 numbers the next year (no density dependence would result in proportional response on average, e.g., $N_1 = 0.3763\ N_0$) or survival rate to age 1. Note that the appearance of a flat response in Panel A and the decreasing response in Panel B could be due to an errors-in-variables effect; i.e., age 0 measurement errors (Source: SEDAR7 Stock Assessment Report).

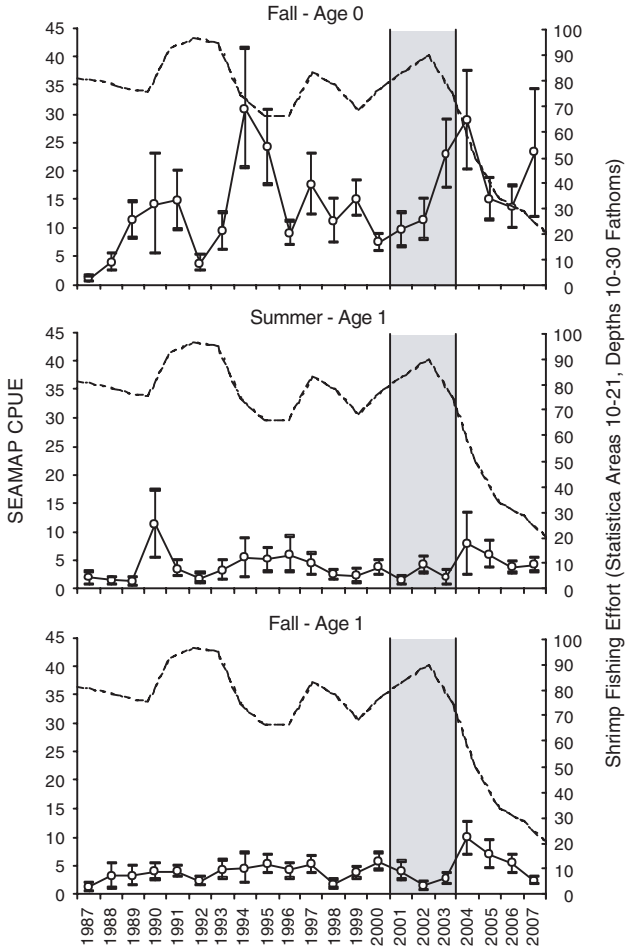


**Figure 4** Shrimp fishing effort (nominal days fished, dashed line) from LGL (2007) and juvenile red snapper abundance, 1987–2007, provided by B. Pellegrin, NMFS, Pascagoula Laboratory. Shaded area represents the reference period for evaluating shrimp fishing effort and juvenile red snapper bycatch mortality reductions.

shrimp vessels (Gazey et al., 2008). If M for age 0 is about 2.0, as suggested, then following Goodyear (1995) and SEDAR7 (2005), M for age 1 would be 1.2 (0.6 × 2.0).

The annual natural mortality rates for age 0 = 2.0 and for age 1 = 1.2 equate to daily rates of M = 0.0054 and 0.0033. As shown by Table 1, total natural mortality for age 0 red snapper recruits over the 298-day balance of their first year would be 1.6 and 1.2 for their second year. An estimated 31 of the initial 521 survivors entering the fishery following the pre-recruit stages, as described above, would live to age 2.

SEAMAP data provide evidence consistent with density dependence in red snapper mortality rate from age 0 to age 1 (Figure 3; SEDAR7, 2005). In addition, the results of a stock reduction analysis (SRA) conducted as part of SEDAR7 also suggested that density dependence for these young age groups was occurring (SEDAR7, 2005). Last, shrimp trawl bycatch mortality for juvenile red snapper has undergone a 75% reduction since the 2001–2003 baseline period, yet only moderate (if any) rather than exponential increases in age 1 abundance has been realized (Figure 4). The combination of habitat scarcity, site fidelity, exclusion of smaller conspecifics from reef habitat by larger fish, and variation in juvenile M with abundance, as described above, suggests habitat is a limiting factor for juvenile red snapper.

### *Ages 2–7*

Red snapper enter the directed fishery at about age 2 and are heavily exploited by directed and recreational fishers for most of their remaining life. They occur across the shelf to the shelf edge and demonstrate an affinity for vertical structures (Patterson et al., 2001a), especially between 2 and 7–10 years of age. They show very rapid growth during the first 8 to 10 years of life (Szedlmayer and Shipp, 1994; Patterson, 1999; Nelson and Manooch, 1982; Patterson et al., 2001b; Wilson and Nieland, 2001; Fischer et al., 2004) (Figure 5). After this period, fish continue to grow but at slower rates. Although still found

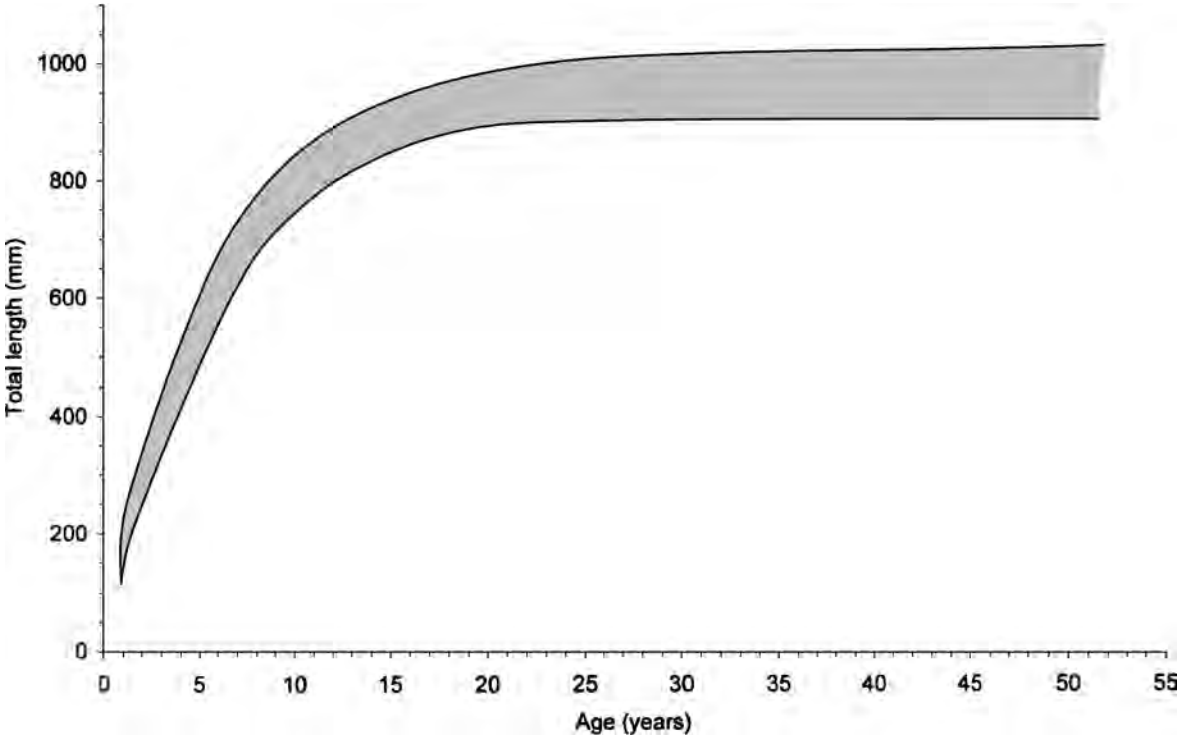


**Figure 5** Envelope of von Bertalanffy growth model results for Gulf of Mexico red snapper based upon Nelson and Manooch (1982), Szedlmayer and Shipp (1994), Manooch and Potts (1997), Patterson (1999), and Wilson and Nieland (2001).

on reef structures, these larger fish expand their habitat and may use open areas as well (Szedlmayer, 2007). Because of these differences, we break our discussion into age groups 2 to 7 and ages 8+.

At the beginning of age 2, young red snapper are generally between 200 and 375 mm TL (Goodyear, 1995). It is at these sizes that they enter the directed fishery and recruit to large reefs. These include natural hard substrates with relief on the order of meters, e.g., reef pinnacles, exposed rock ledges, and shelf-edge banks, as well as artificial reefs like offshore oil and gas structures, shipwrecks, and constructed artificial reef areas. Wells (2007) states that "the premise that natural reefs are scarce is a misconception" (103), citing the presence of extensive shell ridges in the north-central Gulf (Schroeder et al., 1995; McBride et al., 1999; Dufrene, 2005) and inner-shelf reef banks and ledges as evidence to the contrary. We disagree with the identification of shell substrate as "reef" habitat. These habitats are actually shifting shell substrates, the distribution of which can change from year to year. They have little similarity to hard limestone reef habitat. In a geological survey, Dufrene (2005) characterized the inner-shelf area offshore eastern Louisiana to panhandle Florida and suggested that this benthic habitat was about 15% shell and 85% soft sand mud substrate. The vast majority of the inner shelf in this area, as well as elsewhere, is composed primarily of sand, mud, and silt, with little or no vertical relief (Ludwick, 1964; Kennicutt et al., 1995).

On a larger spatial scale, Parker et al. (1983) estimated that 2,571 $km^2$ of natural reef habitat (3.3% of the bottom) are present at depths between 18 and 91 m in the region between Pensacola, Florida, and Pass Cavalla, Texas. Of this, only 1.6% (1,285 $km^2$) was comprised of reefs having relief >1 m. Offshore areas known to contain large natural reefs are protected by the Minerals Management Service (MMS) by imposing "No Activity Zones" around them. In the northern Gulf, the total area of these zones is about 293 $km^2$ (Stanley and Wilson, 2003). Most of these areas are outside the depths surveyed by Parker et al. (1983). On a total area basis, natural reef habitat suitable for age 2 to 7- to 10-year-old red snapper is a scarce commodity (1,578 $km^2$, 1,285 $km^2$+ 293 $km^2$) in the northern Gulf relative to the amount of sand- and mud-bottom habitat.

The primary artificial reef habitats in the Gulf include offshore oil and gas platforms and a 3,108-$km^2$ area offshore Alabama within which about 10,000 artificial reefs are present (Minton and Heath, 1998). The footprint areas of the Alabama artificial reefs are typically small, about 9.3 $m^2$ on average. Assuming 10,000 structures are presently in place, this would equate to a total area of 23 acres or about 0.1 $km^2$ of artificial reef. The northern Gulf of Mexico also contains on the order of 4,000 oil and gas platforms. These structures provide about 12 $km^2$ of artificial reef habitat (Gallaway and Cole, 1997). On a spatial basis, the artificial reef contribution to total high-relief reef habitat in the northern Gulf has been small (an additional 12.1 $km^2$ to a natural reef area of about 1,578 $km^2$).

In summary, reef habitat with relief on the order of meters constitutes a small fraction of the total shelf area of the western Gulf of Mexico. Considering both natural and artificial reefs, the

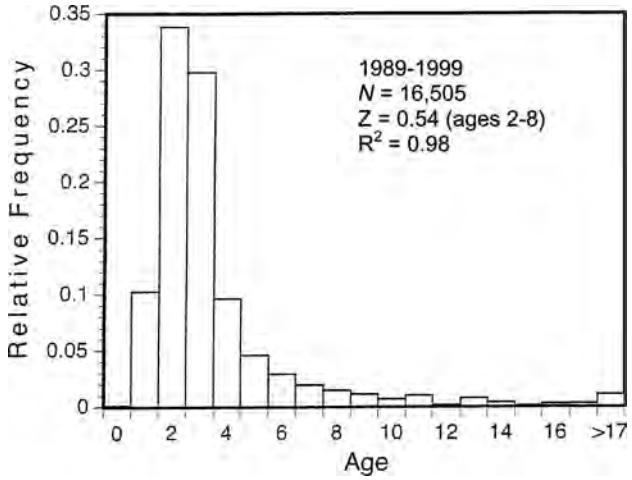


**Figure 6** Estimated age frequency of red snapper residing at offshore oil and gas platforms in the northern Gulf of Mexico estimated from fish killed by explosive structure removals (Source: Gitschlag et al., 2003).

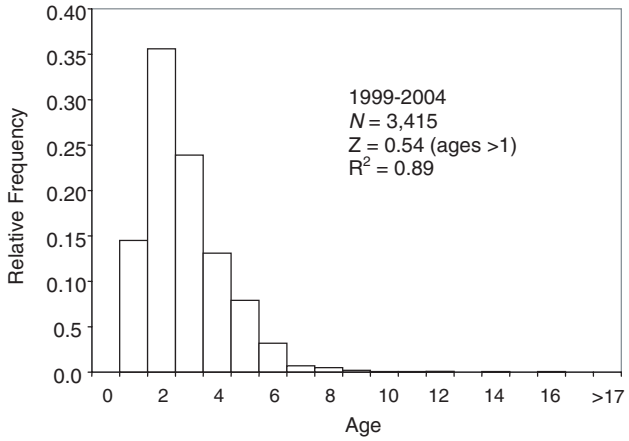


**Figure 7** Estimated age frequency of red snapper residing at artificial reefs. Total mortality estimate from fishery independent age frequency distribution in the northeast Gulf of Mexico (Source: Szedlmayer, 2007).

total area of reef habitat on the western Gulf shelf is 1,578 km$^2$, less than 2% of the total shelf area. The area offshore Alabama where shell substrate habitat comprises an estimated 15% of the bottom area, and there are over 10,000 artificial reefs and numerous oil platforms, is an exceptional area compared to other regions of the northwestern Gulf because it contains relatively large amounts of both juvenile and adult red snapper habitat. Western Louisiana has a large number of offshore oil and gas structures but lacks the vast expanses of juvenile shell substrate habitat that occurs offshore Alabama.

Offshore oil and gas structures and other artificial reefs are, however, used by large numbers of red snapper between ages 2 and 7, and older fish may also occur at these habitats. Explosive removals of these platforms have been monitored and provide a fishery-independent measure of the age structure of resident red snapper (Gitschlag et al., 2003). Red snapper recruit to these habitats as early as age 1 (10%), but the populations appear dominated by age 2 (34%) and age 3 (29%) fish (Figure 6). Age 4 was the only other age group representing as much as 10% of the total population. The red snapper age distribution from these platforms suggested a high rate of total mortality ($Z = 0.54$; Figure 6). Red snapper are known to stratify by size at different depths around platforms in the western Gulf, with smaller fish located higher in the reef than larger fish (Render, 1995). Render (1995) also observed larger individuals to be less obligate in their association with platforms than smaller fish.

Szedlmayer (2007) estimated ages from otoliths for 3,415 red snapper collected from 94 different benthic artificial habitats off coastal Alabama (Figure 6). Age 1 fish comprised about 14%, age 2 (36%). and age 3 fish comprised 25% of the total population. No other age group comprised as much as 10% of the total population (Figure 7). These data also suggested the same high rate of total mortality at artificial reefs ($Z = 0.54$; Figure 7) as shown by Gitschlag et al. (2003).

*Population Size.* Stanley (1994) estimated that, on average, 5,307 (95% CI = 2,756, range 1,200 to 8,200) red snapper occupied each major oil platform offshore of western Louisiana in favorable red snapper habitat during the fall to winter period of 1992. Gallaway and Cole (1997) used this estimate along with distribution and platform size and count data to estimate that the total age 2 red snapper population present at oil platforms in the northern Gulf of Mexico was about 3 million (1.7–4.2 million) fish at the beginning of 1992. This compared to Goodyear's (1995) estimate of 4.2 million age 2 fish in the total red snapper population at the beginning of 1992. SEDAR7 (2005) estimated that the age 2 population size at the beginning of 1992 was about 3.7 million fish. If all these estimates were correct, the observations suggest that 70–80% of the total age 2 population occurred at oil and gas platforms in 1992. If this is true, then the platforms are used by age 2 fish much more than their proportional area would suggest. A possible explanation for such a distribution will be provided below.

Gitschlag et al. (2003) estimated red snapper population sizes at western Gulf offshore oil and gas platforms based on mortality counts associated with the explosive removals of nine of these structures. Results were provided for one platform removed in each of the years 1993, 1998, and 1999; for two platforms in 1994; and for four platforms removed in 1995. The 1995 removals were made during the May–September period and the mean number of red snapper believed to have been residing at these four platforms ranged from 487–1,193, averaging 774.5 (95% CI = 482.2 to 1,066.8). In 1995 there were on the order of 4,000 offshore oil and gas structures in the Gulf, which, multiplied times the average abundance estimated by Gitschlag et al. (2003), yields a total estimate of about 3.1 million red snapper at offshore oil and gas platforms in the western Gulf. Based on Gitschlag et al.'s (2003) age frequency estimates (see Figure 6), about 34% of these (1.1 million fish) would be age 2 fish. In 1995, the total number of age 2 red snapper in the western Gulf was estimated to have been 1.6 million red

snapper (SEDAR7, 2005). Again, approximately 70% of the age 2 red snapper population was suggested to reside at offshore oil and gas structures. Thus, results from at least two independent studies (Stanley, 1994; Gitschlag et al., 2003) suggest that a high proportion of the age 2 red snapper population in the western Gulf of Mexico reside at offshore oil and gas platforms.

*Food Habits.* The food habits of age 2 and older red snapper in the Gulf of Mexico range from the historical observations of Stearns (1884), Collins (1885), and Adams and Kendall (1891) to present-day investigations. The first comprehensive study of red snapper food habits in the northern Gulf after the turn of the century was reported by Moseley (1966). He collected 712 red snapper stomachs of which 187 contained food. Moseley (1966:96) suggested that red snapper should be considered polyphagous, as both juveniles and adults "ate most anything that was readily available." On a volumetric basis, fish comprised 44% and 80% of the adult diet at two locations offshore Louisiana and from 40% to 59% of the diet at three locations sampled offshore Texas. Fish comprised less than 50% of the diet in only 2 of the 5 samples and, in each case, the sampled fish had gorged on tunicates, which are seasonally very abundant. Of interest, one of the tunicates (*Distalpia* sp.) was a colonial reef form, whereas the other (*Salpa confederate*) was a free-swimming, pelagic form.

Moseley (1966:98) also observed that red snapper "do not always feed on reef forms," observing that, in addition to reef species, they fed on prey occurring over soft bottoms rather than at reefs. He noted that the availability of food found in snapper stomachs was probably comparable for mud, sand, and rocky-type habitats. He also observed that, while it appeared that red snapper may have foraged over soft bottoms, it might also be true that motile, soft-bottom prey species were not necessarily confined to sand and mud habitats, but may have ventured onto or near reefs.

Moseley's (1966) study was followed by red snapper investigations conducted by Bradley and Bryan (1975) offshore Texas. They collected 1,139 snapper at natural reefs along the 40-fm curve from Port Isabel to Galveston, Texas. Of these, 190 contained prey. Fish made up the highest percentage by volume for every season except summer, when the diet was dominated by the swimming crab *Callinectes danae* (39.2%). Bradley and Bryan (1975) also showed extensive feeding on tunicates (13% by number, 21% by volume) in spring samples. They noted that red snapper feed on those items that are most readily available, and the spring blooms of tunicates in some areas provide abundant grazing material. They concluded that fish (other than eels) constituted the primary food each season, and other important foods included eels, mantis shrimp, and rock shrimp in spring; crabs and rock shrimp in summer; and eels in winter.

Red snapper diet studies were conducted in the eastern Gulf offshore Florida by Beaumariage and Bullock (1976) and Futch and Bruger (1976). In this part of the Gulf, invertebrates appeared more important than fish in the diet of red snapper. The Florida shelf habitat is markedly different than the shelf habitat of the western Gulf (Alabama to Texas) based on oceanic currents, freshwater discharge, sediments, and biota (Gallaway, 1981).

Gallaway et al. (1981) characterized the food habitats of red snapper at the Buccaneer Gas and Oil Field platforms located offshore Galveston, Texas, at depths of about 10 fathoms. They suggested that red snapper moved away from the platforms during the late night to early morning period to feed over soft bottoms. Hastings et al. (1976) obtained similar results for lutjanids at research platforms in the northeastern Gulf. Peabody and Wilson (2006) also suggested that nocturnal movements of red snapper away from Louisiana platforms was related to feeding behavior.

Ignoring squid, which was used for bait, Gallaway et al. (1981) reported that the gut contents of red snapper in winter contained mainly fish (small carangids, mainly the platform-associated rough scad). In spring, the diet was dominated by mantis shrimp (69%), and in summer the diet was dominated by fish (unidentified fish 23.5%, Atlantic cutlass fish 19.3%, and carangids, probably scad, 18.6%) and mantis shrimp (29.5%). In fall, crustaceans (shrimp 53.2% and crabs 17.2% for a total of 70.4%) and fish (26.6%) dominated the diets. Clearly, soft-bottom prey were a major component of the diet, but reef-associated fish were taken when abundant.

Siegel (1983) described red snapper food habits for habitats sampled offshore Alabama and some samples from Louisiana and Florida. For adults, fish and crabs constituted the main part of the diet. Of interest, all sizes of adults were noted to consume crabs, rock shrimp, penaeid shrimp, larval decapods, and larval mantis shrimp.

Ouzts and Szedlmayer (2003) examined the diets of red snapper collected from the artificial reef area offshore Alabama among four diel feeding periods (dawn, day, dusk, and night) and among three standard-length size classes: small (200–299 mm SL), medium (300–399 mm SL), and large (400–499 mm SL). A total of 432 stomachs were examined, of which 164 contained prey. Prey items were assigned a habitat association based upon the literature, personal observations made by the authors, and consultations with experts on the prey group in question. Small red snapper fed mostly on reef and sand prey types; medium red snapper fed on similar portions of reef, sand, and mixed habitat prey types; and large red snapper fed mainly on prey observed to use a variety of habitats. Red snapper were indicated to feed throughout the 24-hr cycle, with mean gut fullness being significantly lower at dusk than for the day period. Fish were the dominant prey throughout the 24-hr cycle. The second-most important prey group changed with period: shrimp were codominant for dawn, tunicates for day, and crabs were codominant for dusk and night periods.

The Szedlmayer and Lee (2004) food habitat studies of red snapper from open bottom and artificial reefs offshore Alabama were dominated by juveniles <200 mm SL as described above. However, 61 specimens were collected from reefs that ranged from 200 to 250 mm SL. For these fish, the principal prey categories on a volumetric basis were fish (59.7%), shrimp (27.8%), and crabs (12.5%). For the fish-prey category,

approximately 65% were reef-associated taxa, including blennies (37.7%), *Halichoeres* sp. (13.0%), Serranidae (9.0%), *Serranus* sp. (2.9%), and *Centropristes* sp. (2.3%). The dominant "shrimp" taxa in the large red snapper stomachs included mantis shrimp (42.4%), rock shrimp (29.3%), Alpheidae (13.4%), Hippolytidae (11.5%), and unidentified shrimp (3.4% of the total shrimp component).

Szedlmayer and Lee (2004) classified rock shrimp, Alpheidae (pistol shrimp), and Hippolytidae (cleaner shrimp) as reef-associated taxa and mantis shrimp as open-bottom residents. On this basis, reef shrimp constituted 54.2% of the shrimp eaten as compared to 42.4% that were from open-bottom habitats. Rock shrimp have been treated as open-bottom species by other investigators. This species is most abundant on hard mud and/or shell substrates (NOAA, 1985). Offshore Alabama, the high density areas for rock shrimp mapped by Darnell et al. (1987) generally correspond to the area of shell-ridge or "ragged bottom" habitats described above, thus the reef designation by Szedlmayer and Lee (2004). However, this species is not typically found in high numbers on reefs having high vertical relief like that used by adult red snapper. If one treats rock shrimp as an open-habitat organism, approximately 72% of the shrimp in the diet of red snapper come from open bottoms as compared to about 25% from reefs, mainly pistol and cleaner shrimp.

The Szedlmayer and Lee (2004) data indicate that red snapper in the 200–250 mm SL length range on artificial reefs offshore Alabama fed on both reef and open habitat prey types. Even if all crabs and all the shrimp but pistol and cleaner shrimp are treated as soft-bottom species, reef prey still constituted about 46% of the total diet based upon this data set.

McCawley and Cowan (2007) evaluated red snapper food habitats for fish from the Alabama artificial reef area that were mainly caught by recreational fishermen between May 1999 and April 2000. They examined 656 red snapper stomachs, of which 268 contained prey. The empty and bait-only stomachs were excluded from further analyses. The fish with prey ranged from 240–913 mm fork length (FL) (mean = 463 mm FL). On an average percent weight basis, unidentified material contributed the largest proportion to the observed diets (35.9%) followed by crab (20.2%), fish (19.5%), adult mantis shrimp (12.6%), and pelagic zooplankton (8%). McCawley and Cowan (2007) also recalculated the mean% weight values after removing the unidentified material from the analyses. On this basis, fish dominated the diet (28.7%), followed by crabs (26.8%), pelagic zooplankton (23.5%), mantis shrimp (16.1%), and miscellaneous benthic species (2.2%).

McCawley and Cowan (2007) estimated only 1.3% of the red snapper diet (excluding unidentified material) consisted of reef-associated organisms, 1.3% of the diet consisted of *Sargassum*-associated species, and 0.7% consisted of species occupying a variety of habitats. In contrast, the dominant components of the diets were species associated with sand and mud habitats (41.2%) and the water column (31%, mainly larval mantis shrimp and larval fish). Their interpretation of these data was that adult red snapper were almost, if not entirely, trophically independent of the reefs on which they lived.

McCawley et al. (2006) collected diel food habitat data for red snapper in the Alabama artificial reef areas in July and August 2000. A total of 109 red snapper stomachs were collected from fish 295 to 560 mm FL (mean = 382 mm FL). Of these, 46 contained prey. When examined on a diel basis, red snapper appeared to feed throughout the day and night, with no obvious pattern in feeding periodicity. Unidentified material was the dominant food category in both day (35.1%) and night (31.4%) periods, followed by fish (34.7% day and 30.6% night), crabs (12.7% day and 12.2% night), and rock shrimp (10.4% day and 9.3% night). Mantis shrimp were not observed in stomachs collected during the day but comprised 9.4% by weight in the night samples. Once more, over half of the fish and crab category consisted of unidentified specimens. McCawley et al. (2006) concluded that less than 2% of the red snapper diet came from reef-associated organisms based upon the defined habitat associations of the identified prey organisms.

In summary, red snapper appear to be opportunistic feeders that feed throughout the day and night. They have been documented to feed on abundant swarms of water column organisms like pteropods and free-swimming tunicates when these occur, as well as on fish, crabs, and shrimp from surrounding soft bottoms, and on reef-associated fish, crabs, encrusting tunicates, and shrimp. However, more accurate estimates of the relative proportions of their diet derived from different habitats are needed. It is clear, however, that many studies show substantial feeding on reef prey types, which supports the contention that red snapper are obtaining significant food resources from reef habitats.

*Site Fidelity.* The degree of movement and/or site fidelity shown by red snapper in the young adult age group has been addressed by historical and recent studies. Beaumariage (1969) tagged and released 312 red snapper off the coast of Florida and reported a return rate of 26%. All but eight of these were reported to have been recaptured at the release site after being at liberty for an average of 113 days. These data indicated a high degree of site fidelity (>90%) over at least the short term (113 days or about 3.8 months). Beaumariage and Bullock (1976) also reported that red snapper in shallow water showed a high degree of site fidelity and that the only extensive movements occurred in water deeper than 15 fathoms.

Fable (1980) tagged 299 red snapper at natural reefs off the coast of Texas and 17 fish were recaptured. Of these, 16 were recaptured at the release location, and one that had been at liberty for 162 days, or about 5 months, had moved 5 km. Gallaway et al. (1981) reported very high short-term fidelity for red snapper at platforms in the Buccaneer Gas and Oil Field offshore Galveston, Texas, over the summer months. All of the tags returned by fishermen or noted during visual SCUBA census were found at the site where the fish had been released. However, fishing pressure was intense in the Buccaneer Oil and Gas Field, and most of the entire annual recruitment was estimated to have been harvested each year.

Several other mark-recapture studies have been conducted at artificial reefs offshore Alabama. Szedlmayer and Shipp (1994) tagged and released 1,155 relatively small red snapper (mean ± SE = 287 ± 0.9 mm TL; size range 177–410 mm TL). A total of 146 tagged fish were recovered, but only 37 of these had known recapture locations. A total of 27 (74%) of these fish were recaptured within 2 km of their release site, and 21 of these were caught in the immediate vicinity of their release location. The greatest distance moved by an individual fish was 32 km, and distance moved was not related to time at large (see Figure 6 in Szedlmayer and Shipp, 1994). These data were interpreted to suggest a high degree of site fidelity.

Watterson et al. (1998) reported results of a red snapper mark-recapture study conducted off the coast of Alabama from March 1995 to January 1997. Nine artificial reef sites, with three each being placed at 21-, 27-, and 37-m depths, were constructed 18 months prior to the start of the study. A total of 1,604 fish were tagged between March 1995 and October 1996. The tagged fish had a mean TL (±SE) of 336 mm (±1.84), and 80% were less than 400 mm TL. The majority of these fish were 3-year-olds or less. A total of 167 individual fish were recaptured. Hurricane Opal passed within 40 km of the reef sites in October 1995, about eight months into the study. Eighty percent of recaptured red snapper that were not at liberty during Opal were recaptured at their site of release, suggesting strong site fidelity. Fish that were at liberty during Opal showed greater movement. They had a significantly higher likelihood of movement away from their site of release and moved far greater distances than fish not at liberty during Opal. The at-liberty fish moved an average of 32.6 km, with eight fish moving over 100 km and three fish moving over 200 km. The fish not at liberty during Opal moved much shorter distances, from 1.7 to 2.5 km. Clearly, Hurricane Opal affected the movement and site fidelity of the fish.

Patterson et al. (2001a) continued the mark-recapture study of Watterson et al. (1998) through August of 1999. Another strong hurricane occurred during the extended study. Hurricane George passed within 50 km of the reef sites in September 1998. In total 2,932 red snapper were tagged, with 2,053 released at their capture site and 879 released at locations other than their capture site. Mean TL (±SE) of these tagged fish was 335.1 ± 1.34 mm; thus, most were age 3 or less. Overall, 519 individual fish were recaptured, with 193 recaptured on tagging trips and 326 recoveries made by fishers. Of the fish recaptured at tagging sites, 188 (97%) were captured at the site where they had been released while five had changed location.

Location of recapture was reported for 232 recoveries reported by fishers (Patterson et al., 2001a). Mean time at liberty was 404 days, which was 2 to 3.5 times longer than the mean time at liberty for recaptures from previous studies. Of the fish recaptured by fishers, 36% were captured within 2 km of the release site. One fish, which had been at liberty for 598 days, moved 352 km to the east; another, which had been at liberty for 1,367 days, moved 259 km southwest of its release site. In contrast, the maximum time at liberty for a tag recovery by fishers was 1,501 days, and this fish was caught only 3.5 km from its release site. The mean vector of reported movement was 42.4 km to the east for individuals at liberty during hurricanes and 7.4 km to the east-northeast for individuals not at large during the two hurricanes. The movement observed by Patterson et al. (2001a) was greater than had been previously reported for red snapper in the northern Gulf.

Patterson and Cowan (2003) used the data described by Patterson et al. (2001a) to estimate site fidelity by modeling the decline in recaptures at the tagging sites over time to obtain an annual instantaneous rate of decline or D (daily rate × 365 days). This value would be equal to the sum of total annual instantaneous mortality (Z) and total annual instantaneous emigration defined as Q. The authors assumed that no fishing mortality occurred at the site and calculated M following Royce (1972) and Hoenig (1983). These approaches yielded M estimates of 0.0868 and 0.0855, or an average of 0.08615. Once D and M (or Z) were calculated, Q was obtained by subtraction. Site fidelity (SF) was estimated as $e^{-Q}$. Estimated SF values ranged from 24.8% for all recaptures to 25.3% for all recaptures of fish that were released at their original capture location, to 26.5% for recaptures for fish tagged and recaptured in the intervals between hurricanes.

The above estimates of SF assumed that all tagged fish were recognized. However, these authors also recognized in an earlier publication that tag shedding occurs (Patterson et al., 2001a), but did not account for this tag shedding in their latter SF estimations. For example, the estimated 95% confidence interval for probability of tag retention for a fish at liberty for 200 days was 0.87–0.96, but for a fish at liberty for 755 days, the 95% confidence interval for probability of tag retention was only 0.05–0.37. We suggest that a major component in the decline in recapture fish was related to tag shedding, and this factor needs to be accounted for in SF estimation.

The estimates of Z = 0.09 (or M, since no fishing was believed to have occurred) are highly conservative for the age of the fish in question. As described above, Szedlmayer (2007) estimated ages from otoliths for 3,415 red snapper collected from 94 different artificial habitats offshore Alabama (see Figure 7). Based upon these data, Z for ages 2 to 16 was estimated to be 0.54. If this Z value is used, Q = 0.93 and SF would be on the order of 40%, which is still low as compared to historical studies.

Two additional studies have used conventional mark-recapture methods. Strelcheck et al. (2007) tagged 4,317 red snapper at 14 experimental artificial reefs off coastal Alabama between January 1999 and October 2002. Mean length at tagging was 335 mm TL (±63.3 mm SD). Some 629 recaptures were reported, of which 412 (65%) were made by the researchers at the original release site, and 217 recaptures were reported by fishers. Mean time at liberty was 401 days, with a range of 1 and 1,587 days. Most fish (86%) showed little movement, 2 km or less, from the release site. Mean and maximum distances moved were 2.1 km and 201 km. The mean dispersion rate from release sites was 8.6 m $day^{-1}$. Annual SF estimates were made following Patterson and Cowan (2003) and ranged from 48 to

52%. If Z for this area is 0.54 (Szedlmayer, 2007), SF would be estimated to be above 75%.

Strelcheck et al. (2007) concluded that the observations of high SF and low dispersal rates provided support for the hypothesis that artificial reefs offshore Alabama provide suitable habitat for adult red snapper. However, they suggested the ratios of instantaneous growth (G = 0.54) in weight to total mortality (Z = 0.7 to 0.9) were <1, indicating that the reefs off Alabama were not producing new biomass at current fishing mortality rates. In contrast, if Z = 0.54 (Gitschlag et al., 2003; Szedlmayer, 2007) was used, the G/Z ratio would be equal to 1.

In another conventional mark-recapture study, 5,614 red snapper were tagged between July 2002 and August 2005 (Diamond et al., 2007). Tag returns provided location information for 82 fish. Of these, 54% moved an average distance of 20.4 km. In the second program, over 9,000 fish were tagged by "Fish Trackers" (research personnel, volunteer anglers aboard charter headboats, and private boats) between 1983 and 2006. In that study, 60 returns were analyzed for movement. Most (72%) were recaptured at their release site, with 28% showing an average movement of 19.1 km. Diamond et al. (2007) concluded that the spatial scale of movements in this study was small enough to support the idea that red snapper stocks in the northern Gulf are relatively isolated and that there may be a separate demographic stock off Texas. Similarly, genetic studies have indicated that red snapper in the Gulf maintain a complex of semi-isolated populations in which relatedness is maintained over geologic time by gene flow, yet the populations are demographically independent over the short term (Gold and Salliant, 2007). Thus, all of these later studies (Strelcheck et al., 2007; Diamond et al., 2007; Gold and Salliant, 2007) support the view of limited movement and relatively high SF.

While there have been extensive mark-recapture studies of red snapper as described above, they all have the inherent difficulty of reliance on private fishers for accurate positional information for recaptures. Positional information from private fishers, especially for red snapper, is unreliable at best, and can only be counted on to add variance to SF estimations. This issue of confidence about positional information from private fisher returns has prompted a number of ultrasonic telemetry studies (Szedlmayer, 1997; Szedlmayer and Schroepfer, 2005; Schroepfer and Szedlmayer, 2006; Peabody and Wilson, 2006). Szedlmayer (1997) reported residence times on artificial reefs of 17–597 days, and Szedlmayer and Schroepfer (2005) estimated red snapper were resident on an artificial reef for a mean of 212 days, with an individual fish staying at one reef for up to 597 days. Using the previously published information along with new ultrasonic tagging studies, Schroepfer and Szedlmayer (2006) used event analysis described by Allison (1995) to provide a newer estimate of residence time on reefs. Fish were larger than previous studies (mean ± SD = 518 ± 140, range 301–840 mm TL, $n = 77$), which may account for some of the differences from previous conventional tagging studies. In this later study, however, the median residence time increased to 373 days or about one year.

Peabody and Wilson (2006) released 125 red snapper with acoustic transmitters at oil platforms arrayed in a circle around a salt dome about 50 km south of Port Fourchon, Louisiana. The mean size of these fish was 360 mm TL, and the range in length was 280–470 mm TL. Remote receivers were deployed on the platforms at 10–20 m depths and on artificial reefs within the circle of platforms. They detected 97 of 125 tagged red snapper released with transmitters. The majority (94%) of the tracked red snapper showed no movement between receiver locations on a daily, weekly, or monthly basis. There were 36 recaptures from fishers, with most (81%) captured at their release site. Seven recaptures were reported at locations other than their release site. Days at liberty for these seven fish ranged from 5 to 130 days, and distance traveled ranged from 2 to 25 km, but again, these reported recapture locations are subject to the same error as conventionally tagged red snapper. Peabody and Wilson (2006) estimated a maximum estimate of SF for six months was 90%. Assuming constant emigration rate over the next six months, they projected the annual SF would be 80%.

The higher estimates of SF obtained by Szedlmayer and Shipp (1994) and Strelcheck et al. (2007) as compared to the lower estimates of Watterson et al. (1998) and Patterson et al. (2001a), all working in the same general area off coastal Alabama, may be explained, in part, by the differences in the artificial reefs at the study sites. Reefs used in the Patterson et al. (2001a) studies were largely constructed of 55-gallon drums and newspaper dispenser machines, whereas the reefs used in the other studies were considerably more substantial (e.g., concrete tetrahedrons, concrete mats over pipelines, etc.). The small artificial reefs used by Watterson et al. (1998) and Patterson et al. (2001a) may have been more altered or dispersed by storms and hurricanes compared to the larger more stable artificial reefs used by Szedlmayer and Shipp (1994) and Strelcheck et al. (2007).

The natural mortality rate for age 2–7 red snapper may be higher than is the case for older fish. At present, it is assumed that M = 0.1 for age 2+ red snapper; i.e., this value is assumed to be constant across all ages from 2 to 53 (SEDAR7, 2005). We suggest that it is more reasonable to assume, based upon growth and habitat use patterns for young versus older fish, that natural mortality is higher at age 2–7 compared to fish greater than age 7. We also suggest that, given the scarcity of reef habitat and the relatively high estimates of SF, habitat limitation is a significant factor governing the dynamics of age 2–7 red snapper.

### *Age 8+*

As described above, red snapper grow rapidly over the first 8 to 10 years of life, after which growth slows (e.g., Fischer et al., 2004; see Figure 6). During this timeframe, snapper take up residence on structured habitat, and as the fish grow larger, there is an ontological shift to reef habitats with greater vertical relief and complexity. The reefs may provide protection from

predation and increased prey resources (Szedlmayer and Lee, 2004; Piko and Szedlmayer, 2007). Small and intermediate (up to about age 10) red snapper show greater SF to reefs compared to the largest (greater than age 10) red snapper (Render, 1995; Szedlmayer, 2007). The most plausible explanation for these changes in SF is that older fish (age 8–10) reach sizes that render them largely invulnerable to predation, and they may spend a larger portion of their time over soft bottoms, especially areas with sea bottom depressions and lumps, etc. (Boland et al., 1983; Render, 1995; Nieland and Wilson, 2003).

In 1999, the National Marine Fisheries Service (NMFS) initiated an offshore bottom-longline survey designed to address the abundance, size, and age distribution of red snapper across the shelf of the Gulf of Mexico (Mitchell et al., 2004). Pilot studies were conducted in 1999 and 2000, sampling in two areas at depths between 64 and 146 m. In 2001, the annual longline survey was expanded to cover depths between 9 and 366 m (or 5 and 200 fm) across the entire Gulf. The longline sets were randomly located, stratified only by depth and longitude rather than by habitat.

Red snapper catches varied geographically and with depth (Mitchell et al., 2004). Only 12 red snapper were caught at the 269 stations east of the Mississippi River as compared to 232 snapper caught at the 324 stations sampled west of the Mississippi River. Differences in age and size of fish were also observed, with older, larger red snapper found in the western Gulf (up to 53 years in age, median 12 years, and median TL = 784 mm) and younger, smaller fish found in the eastern Gulf (up to 19 years old, median age of 6 years, median TL of 625 mm). Red snapper were most abundant at depths ranging from 55 m to 92 m, with catches declining both inshore and offshore of these depths (Mitchell et al., 2004).

The relative age distribution observed in these studies (see Figure 5 in Mitchell et al., 2004, summarized herein by Figure 8) showed that red snapper were fully recruited to the longline gear at age 8. Abundance declined from these levels in a linear fashion through age 22 and remained relatively consistent thereafter. The populations of red snapper vulnerable to longline fishing over soft bottoms appears to consist of fish larger than those that occur around reefs (compare Figures 6, 7, and 8). One explanation is that once the fish reach 8 to 10 years of age, they are no longer totally dependent upon structured habitats and can forage over open habitat with little threat from predation.

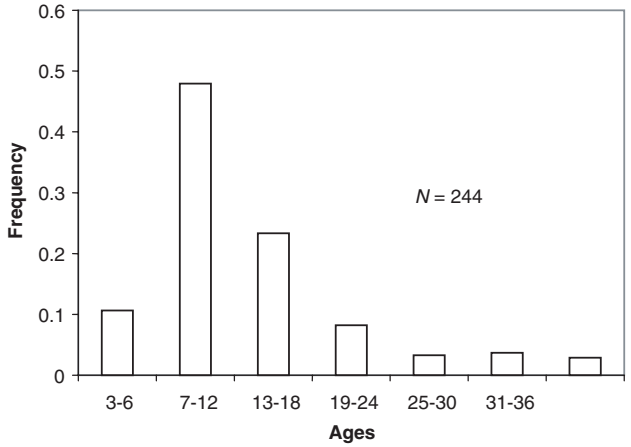


**Figure 8** Age frequency of red snapper caught during NMFS research longline surveys from 1999 to 2002 in depths of 9–366 m (Source: Mitchell et al., 2004).

The prohibition of longline fishing inside of 92 fm in the western Gulf likely has been one of the most significant management actions taken by the Gulf of Mexico Fisheries Management Council (GMFMC). In some areas, large numbers of large fish may be dispersed over open habitat where they are not highly vulnerable to vertical line fishing. However, they can be efficiently harvested using longlines (e.g., Prytherch, 1983). This soft bottom pool of fish is now protected.

## *DISCUSSION*

Site fidelity provides an annual estimate of reef fish immigration or emigration from a reef. For red snapper, 2- to 3-year-old fish at artificial reef structures in shallow water show high fidelity to a site on temporal scales of months to a year, albeit the probability of detecting ultrasonically tagged red snapper at a site one year after release was only 50% (Schroepfer and Szedlmayer, 2006). Diamond et al. (2007) provided a list of factors that have been suggested to be important in affecting the percentage of fish that move compared to the percentage of fish that remain at a site. These included size or age of fish (Moseley, 1966), depth of capture (Beaumariage, 1969; Watterson et al., 1998), seasonal patterns due to water temperature or reproductive condition (Topp, 1963; Beaumariage and Bullock, 1976), hurricanes (Watterson et al., 1998; Patterson et al., 2001a), and translocation from the tagging site (Watterson et al., 1998; Patterson et al., 2001a; Peabody, 2004). The accuracy of positional data reported for tag returns by fishers can also be an issue regarding SF.

It has also been hypothesized that SF of reef-associated organisms is dependent both upon prey availability and the availability of suitable refuge, i.e., the resource mosaic hypothesis (Lindberg et al., 1990; Frazier and Lindberg, 1994) and density-dependent habitat selection (Lindberg et al., 2006). Reef-associated fish species that rely on benthic prey as the primary component of their diet may create a gradient of prey depletion (or feeding halo) around the reefs, resulting in negative feedbacks to reef fish energetics, residence times, and local abundance, particularly when the feeding halos of adjacent reefs overlap (Lindberg et al., 2006). The degree of prey depletion and associated negative feedback can alter the potential for sustained productivity of an artificial reef or reef complex. Bioenergetic demands increase as foraging area increases, resulting in increased emigration from resource-depleted reefs to reefs containing a greater abundance of prey.

In contrast, reefs or reef complexes that can sustain prey resources over time may potentially benefit reef fishes and fishery

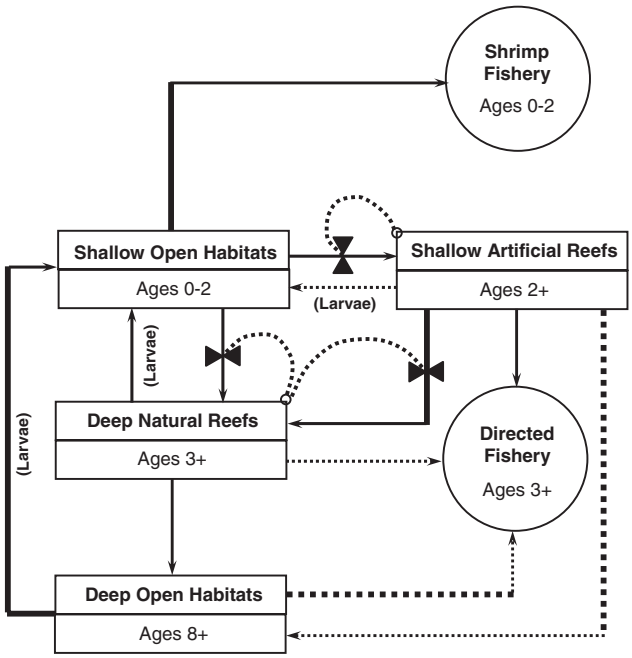


**Figure 9** Conceptual model of habitat use by age of red snapper. The fishery is heavily dependent on young fish inhabiting artificial reefs.

production by reducing the costs of foraging, increasing growth rates, and increasing SF. Under these conditions, the fish would tend to show less movement during foraging due to increased risks of predation and reduced proximity to shelter (Strelcheck et al., 2007). However, if reef densities are high in an area, the distances between them are shorter, and reef fish may move among these habitats more readily than they would otherwise, resulting in increased movement and an expanded home range. Red snapper in clustered habitats may be able to explore nearby alternative habitats with very little cost.

Mark/recapture studies support the idea that movement occurs on two scales. Large-scale climate events such as hurricanes increase the proportion of fish that move and the distances that these fish move. On the other end of the spectrum, many fish may move but only for distances of a few kilometers. These observations are well illustrated by Figure 1 in Strelcheck et al. (2007). Diamond et al. (2007) observed that almost all red snapper will relocate at some time during their lives if they survive long enough. They also noted, however, that the scale of movements they observed supported the hypothesis that, on a geographic basis, red snapper stocks in the northern Gulf are relatively isolated, with periodic long-range dispersement caused by hurricanes or some other factor that triggers long-range movements. They interpreted their data from Texas to be consistent with the idea of a separate demographic stock off Texas, as implied by Fischer et al. (2004) and Salliant and Gold (2004).

Once red snapper grow to about 8 years old, they are large enough to be invulnerable to most predation and occur over open habitat as well as at reef habitat. In the western Gulf, these fish are most abundant in longline sets at depths between 55 and 92 m (Figures 9 and 10). In this region, the zone of highest abundance of early larvae corresponds to the distribution of 8+ year adults taken by longlines (Figure 10). However, spawning is also known to occur across the shelf. The eggs and larvae are planktonic for about one month and then settle to the bottom as early age 0 fish. The natural mortality during this period is high, on the order of $M = 11.8$ (see Gallaway et al., 2007).

Although spawning occurs over most of the shelf, the age 0 new recruits are most abundant at depths between about 18

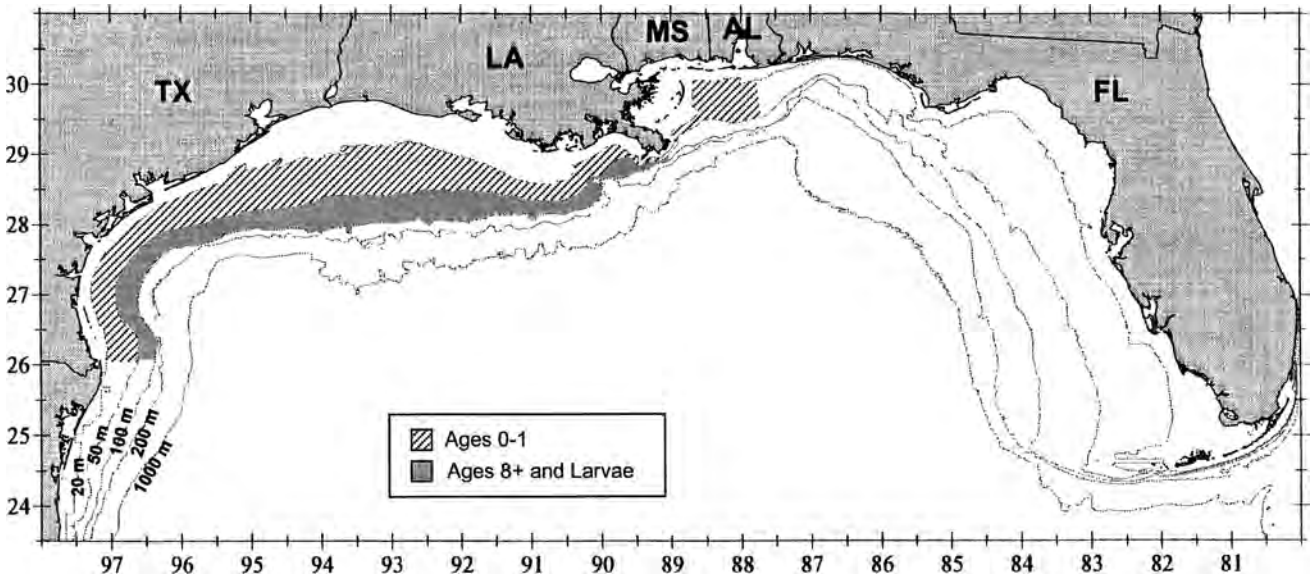


**Figure 10** Distribution of age 8+ red snapper (based on Mitchell et al., 2004), red snapper larvae (based on Lyczkowski-Shultz and Hanisko, 2008), and age 0–1 red snapper (based on Gallaway et al., 1999). These data suggest spawning mainly occurs in the western Gulf at depths between 50 and 100 m, and that the larvae are transported toward shore and settle at depths between 20 and 50 m.

and 55 m (Figure 10). Initially, they are abundant over all substrates but quickly become aggregated at low-relief habitats like relic oyster-shell beds (relief in cm), which affords protection from predation. As the fish grow, the degree of protection from predators provided by low-relief habitats diminishes, and they become large enough to be taken as bycatch in the shrimp fishery. Bycatch losses are greatest during the period from October to December.

By December, fish are able to occupy larger reefs (vertical relief about 1 m), which become vacant when their previous occupants (age 1 red snapper) move to reefs with even greater relief. The age 0 fish occupy these reefs from December of one year to December of the next year. All of the evidence is consistent with the premise that habitat is a limiting factor for age 0 to age 1 fish, as described above. The evidence includes habitat scarcity, site fidelity, exclusion of smaller conspecifics by larger fish, and variation in M with abundance.

Fish tend to move to larger artificial reefs as late age 1 or early age 2 fish. At offshore oil and gas platforms in the western Gulf, the younger, smaller fish occupy the upper water column, and larger, older fish occupy the deeper areas of the reefs. Offshore petroleum platforms may be particularly valuable because they provide shelter and feeding opportunities throughout the water column. The fish at artificial and natural reefs are known to forage on reef prey types but also forage away from the reefs, and small fish feed on water column prey as well. Small and intermediate fish at artificial reefs in shallow water (<50 m) show the highest degree of SF. Sometime after about age 8, red snapper begin to show less dependence on structured habitat and can also be found over open habitat. We suggest that this is essentially a size refugia, enabling them to spend greater amounts of time over benthic foraging grounds.

Other than the large shelf-edge banks and features like the pinnacle region off coastal Alabama, little is known about the distribution and spacing of natural reefs in the northwestern Gulf. As compared to natural reefs, artificial reefs are relatively small and occur in two main clusters: (1) oil and gas platforms off central and western Louisiana, and (2) the extensive artificial reef zones off Alabama. Off Alabama, the artificial reefs are clustered within specifically permitted artificial reef areas. The offshore platforms also occur as closely spaced clusters of platforms representing individual oil fields. Most of the artificial reefs are located in water <100-m deep, in the same zone where age 0 and age 1 fish are most abundant. Parker et al. (1983) noted that depths between 91 and 183 m in the Gulf were not surveyed for the presence of natural reefs because of gear and time constraints. They also noted that these depths were already known to contain "prime reef fish habitat and probably contribute significantly to the total amount" (Parker et al., 1983:937). However, the MMS designation of no activity zones to protect known reefs suggests the total area of shelf-edge reef habitat is small.

The creation of artificial reefs off Alabama and the deployment of petroleum platforms in the northwestern Gulf have been coincident with a shift in the fishery from a few well-known natural reef sites on the shelf to extensive artificial reef areas off Alabama and Louisiana (Camber, 1955; Carpenter, 1965; Goodyear, 1995). We suggest that there is evidence that a high (±70%) proportion of the entire age 2 red snapper population occurs at these artificial habitats. These observations and the relative scarcity of high-relief natural reefs (<1.6% of the shelf bottom area) have led us and others to speculate that natural reef habitat is a limiting factor for age 2–7 fish, and that artificial reefs have increased red snapper production in the western Gulf (Szedlmayer and Shipp, 1994; Shipp, 1999; Szedlmayer, 2007). Others (e.g., Cowan et al., 1999; Patterson and Cowan, 2003) have disagreed, arguing that based on Bohnsack's (1989) gradients of reef dependency, fishing intensity, reef availability, population control mechanisms, and behavior, red snapper are merely being attracted to artificial reefs rather than experiencing increased production because of these sites.

The observations that (1) younger (<10 year) adult fish appear to show higher SF than older fish, (2) natural mortality for age 0 appears to vary with year class strength, (3) red snapper recruitment today is higher than the estimated historical maximums, (4) fishing intensity on pre-recruit fish (ages 0 and 1) has been reduced in recent years by over 65% yet age 1 abundance has not increased, and (5) the decline in abundance of age 2 fish over open habitats (shrimp trawls and longline evidence) and their disproportionate abundance at artificial reefs all suggest increased production of young red snapper that is based on habitat enhancement by artificial structures.

As described above, a large fraction of the estimated total population of age 2 red snapper has been estimated to occur at artificial reefs, a very small component of the overall high-relief reef habitat. If true, one interpretation is that age 2 fish are being differentially attracted to these habitats, perhaps due to the predominance of artificial reefs and platforms in mid-shelf zones, where juvenile red snapper are most abundant. Once there, they show high SF for months to up to a year or more. Overall, relatively high survival and SF is shown for red snapper at artificial reefs between ages 2 and 3 (see Figures 6 and 7). Abundance between age 3 and 4, however, typically declines dramatically (e.g., Figure 6), suggesting higher fishing mortality and/or increased movement. Based upon Gitschlag et al. (2003), few fish survive or remain at offshore oil and gas platforms beyond ages 5 or 6.

There are few data describing the size/age distribution of red snapper at natural reefs in the northern Gulf. However, red snapper length and age data based on scales were collected at the Flower Garden Banks, large natural reefs in the northern Gulf, by Zastrow (1984). Samples were also obtained from south Texas fishing banks (i.e., Aransas, Baker, South Baker Dream, and Big Adam Rock) and from headboats fishing out of Galveston. The Galveston fish may have come from artificial reefs (platforms) rather than natural reefs. At the East and West Flower Garden Banks, age 2 fish were scarce, and peak abundances were observed for age 3–5 fish (middle panel of Figure 11). These data suggest that red snapper populations at deep natural reefs in the northern Gulf consist mainly of fish

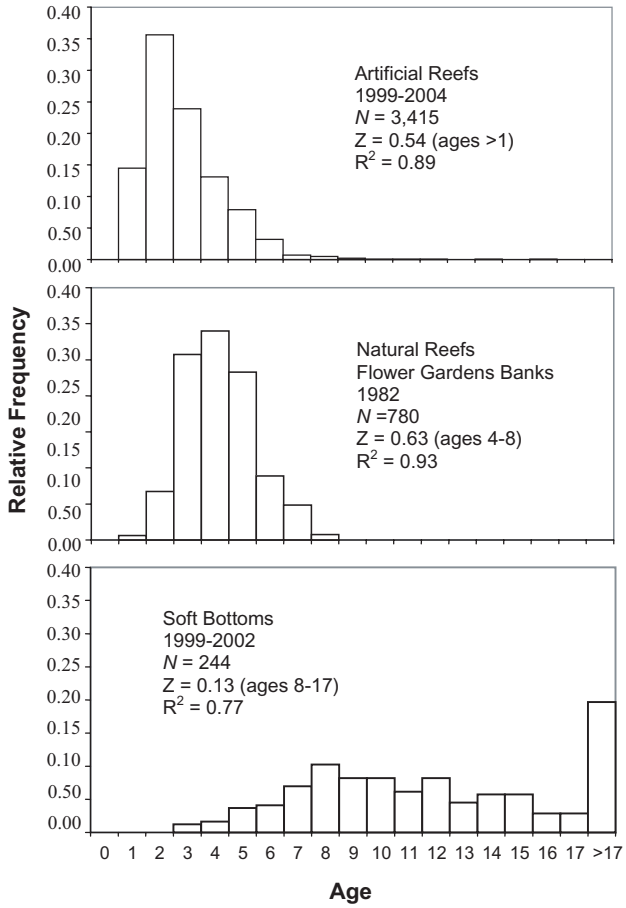


**Figure 11** Age distribution of red snapper at artificial and natural reefs and over soft bottoms. Top panel based on Szedlmayer (2007), middle panel based on Zastrow (1984), and bottom panel based on Mitchell et al. (2004).

age 3 and older, whereas fish at artificial reefs are recruited at age 2.

Collectively, we suggest that prior to the proliferation of offshore oil and gas platforms and artificial reefs (e.g., pre-1980s), young new recruits occurred over open substrates between age 0 and age 2. In this habitat, natural mortality was high due to the lack of cover affording protection from predation, and the fish were subject to shrimp trawl bycatch as well (see Figure 9). Age 2 fish were commonly taken in shrimp trawls along with age 0 and age 1 fish until about 1990, which demonstrated their abundance on open habitats (Goodyear, 1995). After this stage, natural reefs in the northern Gulf would then harbor red snapper age 3 and greater (see Figure 9). We suggest that recruitment of the age 0–2 fish to the natural reefs was inhibited by the presence of adult or larger fish occupying the reefs. After age 8, red snapper would increase their foraging range to include open soft-bottom habitat because they had reached a size that reduced predation mortality.

Not surprisingly, the construction history of oil and natural gas platforms as well as other artificial reefs has corresponded to changes in habitat distribution patterns for red snapper. In 1960, there were only about 351 offshore oil and gas platforms in the northern Gulf, but these increased to 1,520 by 1970, and reached 2,540 by 1980 (Figure 12). From 1990 to the present, the number of platforms has averaged about 4,000, considering both new installations as well as removals. Catch-per-unit effort of commercial-sized red snapper in shrimp trawls (mostly age 2) fluctuated at a level of about 3 kg/1,000 nominal days fished from 1967 to 1974, after which a decline occurred through 1989 when CPUE reached a low of 0.13 kg (Figure 12). This period of decline in abundance corresponded to the increase in platforms to present-day levels. No landings were reported after 1989 because changes in fishing regulations prohibited the sale of red

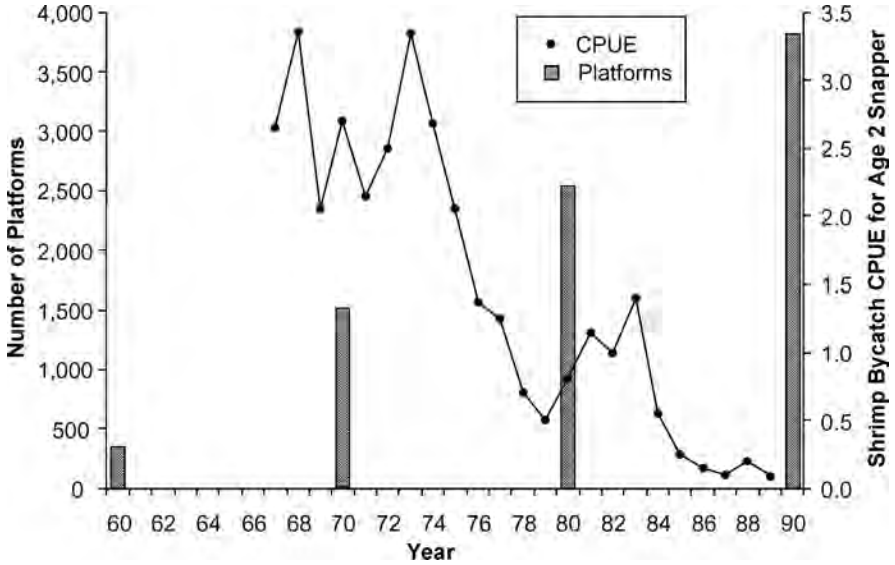


**Figure 12** Catch-per-unit effort for age 2 red snapper in shrimp trawls, 1967–1989 (Goodyear, 1995), and cumulative increase of offshore oil and gas platforms in the northern Gulf of Mexico (data provided by the Minerals Management Service, New Orleans, LA).

snapper caught by shrimp trawls (Goodyear, 1995). We suggest that this increased construction of oil and gas platforms as well as other artificial habitats has provided new protective habitat for age 2 fish that would have otherwise suffered higher mortality over open habitats. Although fishing mortality can be high at these new habitats (Nieland and Wilson, 2003), we suggest that prior to their construction mortality was even higher for age 2 fish over open habitat. This being the case, we suggest that removal of production platforms and other artificial reefs will likely result in a large reduction of red snapper available to the directed fisheries.

Cordue (2005) recommended that future red snapper stock assessments should model post-recruitment density-dependent mortality, "as this is critical for determining the impact of shrimp trawl bycatch on red snapper rebuilding." We concur and have demonstrated that the information in the existing literature is consistent with the premise of density-dependent natural mortality in red snapper for at least age 0 and age 1 fish, and likely for older fish as well. If this aspect is incorporated in the assessment models, management advice may be substantially altered.

## *ACKNOWLEDGEMENTS*

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ARTICLE

# Proximity Effects of Larger Resident Fishes on Recruitment of Age-0 Red Snapper in the Northern Gulf of Mexico

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*Abstract*

**Small artificial reefs (1.2 × 1.02 × 1.1 m) were placed near to (15 m; $n = 20$) and distant from (500 m; $n = 20$) larger artificial reefs (1.2 × 2.4 × 2.4 m; $n = 20$) in July 2008 and 2009, and each set of reefs (two small and one large) was placed 1.7 km apart at a site 28 km south of Dauphin Island, Alabama, in the northern Gulf of Mexico. Divers used visual surveys to identify and count all fish present on the small reefs and estimated fish lengths in 25-mm categories during August 2008, August 2009, and September 2009. Significantly higher numbers of age-0 red snapper *Lutjanus campechanus* were detected on the small distant reefs (500 m) than on the small nearby (15 m) reefs in all surveys. In addition, significantly higher densities of rock sea bass *Centropristis philadelphica* and pygmy filefish *Stephanolepis setifer* were observed on the small distant reefs compared with the small nearby reefs in both August and September 2009. Mean species richness was significantly higher on the small distant reefs than on the small nearby reefs in August 2009. Differences in reef fish community structure were detected in all three surveys by using nonmetric multidimensional scaling based on Czekanowski's similarity coefficient. This study indicates that if artificial reefs are built to provide habitat for juvenile red snapper, they should not be placed in areas immediately adjacent to existing adult habitat; conversely, habitats intended for adult fish should not be placed near important red snapper nursery areas.**

Many biological and physical processes can regulate reef fish abundance, with most fishes showing type III survivorship, in which a large portion of the population dies early in life. These typical high mortalities in early life indicate that the size of many fish populations may be limited during these early stages. For example, high mortality during the larval stage may cause recruitment limitation of adult abundance (Doherty 1982; Victor 1986; Doherty and Fowler 1994), while important limits may also occur at the postsettlement stage (Shulman and Ogden 1987; Hixon and Carr 1997; Hixon and Jones 2005). For example, when recruitment of the Ambon damsel *Pomacentrus amboinensis* was doubled from 1 recruit/$m^2$ to 2 recruits/$m^2$, adult abundance did not increase, thus indicating that postrecruitment processes may regulate this population (Jones 1990).

Predation has been identified as a leading cause of reef fish postsettlement mortalities (Carr and Hixon 1995; Steele and Forrester 2002; Almany and Webster 2006). For example, when resident piscivores were removed, there were higher numbers and species richness of juvenile reef fishes (Caley 1993; Beets 1997; Webster 2002; Heinlein et al. 2010). Predator additions have shown similar effects; the introduction of a single invasive lionfish *Pterois volitans* to patch reefs caused a 79% reduction in reef fish recruitment (Albins and Hixon 2008).

Fish living on a reef can affect the environment immediately surrounding the reef. For example, feeding activity by herbivorous fishes can cause a grazing halo in surrounding seagrass beds (Randal 1965). Carnivorous reef fishes are also known to create feeding halos in surrounding habitats, resulting in lower abundances of invertebrates, although these halos are not as apparent as those caused by herbivores (Kurz 1995; Galván et al. 2008). If grazing pressure and predation pressure are higher on plants and invertebrates in the areas surrounding a reef, then predation pressure is probably higher for small fishes as well.

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Previous studies have indicated that the recruit abundance and diversity of reef fishes on patch reefs increase with increasing distance from larger reefs, and this increase has been attributed to reduced predation (Shulman 1985; West et al. 1994; Steele 1997; Belmaker et al. 2005). While these previous studies showed significant predation effects, most did not examine reef fish recruitment at sites more than 50 m from the larger reefs with larger resident predators (Shulman 1985; Connell 1997; Steele 1997; Belmaker et al. 2005). In the present northern Gulf of Mexico reef system, potential predators will forage at least 50 m from the reef (Szedlmayer and Schroepfer 2005; Topping and Szedlmayer 2011). Based on the reported foraging ranges for red snapper *Lutjanus campechanus*, studies that have examined predation effects around 50 m or less from the reef structure are not applicable to systems in the northern Gulf of Mexico, and questions remain concerning the possible isolation refuge effects for northern Gulf of Mexico fishes.

Red snapper are abundant on reef structures in the northern Gulf of Mexico and support important commercial and sport fisheries (SEDAR 7 2005). The red snapper stock in the northern Gulf of Mexico has been classified as overfished, resulting in severe restrictions on harvest (Goodyear 1994; SEDAR 7 2005; SEDAR 2009). Proper management of red snapper requires an understanding of their life history and the processes that regulate abundance. Thus, identifying population bottlenecks will substantially aid in managing the fishery.

Red snapper recruits first settle to open habitat and reach their highest abundances between July and September and then move to more structured habitats in the fall of their first year (Szedlmayer and Conti 1999; Szedlmayer and Lee 2004); however, they also may settle directly onto reef structures (Szedlmayer 2011). As red snapper grow, they seek out progressively larger structures. By age 2, red snapper have recruited to higher-relief structures, such as gas platforms (Nieland and Wilson 2003; Szedlmayer 2007; Gallaway et al. 2009).

Previous studies have indicated that predators or larger competitors can affect the abundance and distribution of age-0 red snapper. In caging experiments conducted in the field, higher abundances of age-0 red snapper occurred on reefs when predators were excluded; in captivity, age-0 red snapper spent more time associated with complex habitat when a predator (Gulf flounder *Paralichthys albigutta*) was present (Piko and Szedlmayer 2007). Age-0 red snapper were also excluded from complex habitat when older red snapper were added to a tank (Bailey et al. 2001). Based on the life history of red snapper and the potential effects of predators on reef fish recruitment, the proximity of larger artificial reefs and their associated reef fish communities may affect new recruitment of juvenile red snapper to low-relief nursery structures. Through the use of experimental artificial reefs, we examined the potential effects of predator and competitor proximity to reef habitats on the recruitment of age-0 red snapper.

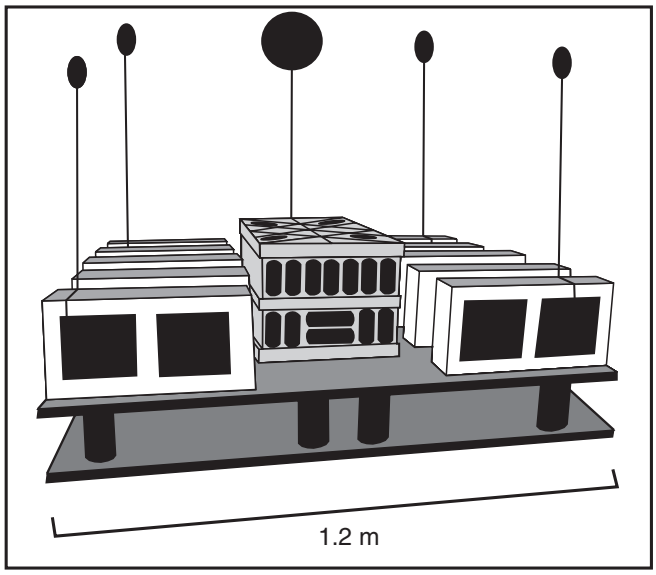


FIGURE 1. Design of the small artificial reefs that were used to study juvenile fish recruitment.

## METHODS

The study site was located 28 km south of Dauphin Island, Alabama, in the northern Gulf of Mexico; the site was characterized by sand and mud substrate, and 3% of the sea floor was composed of natural reefs (Parker et al. 1983; Dufrene 2005). Reefs were built within an artificial reef-building zone that also contains many other artificial reefs, including natural gas platforms, liberty ships, concrete pyramids, and army tanks (Minton and Heath 1998). All reefs were placed at depths ranging from 19 to 22 m.

Large steel cage reefs (1.2 × 2.4 × 2.4 m) were deployed on 2 April 2008 ($n = 10$) and 14 April 2009 ($n = 10$). These large reefs provided habitat for larger predatory fishes relative to the smaller fishes typically observed on the smaller "recruitment" reefs. Small reefs (Figure 1) were deployed on 24 and 28 July 2008 ($n = 20$) and 9–10 July 2009 ($n = 20$). Each small reef consisted of a polyethylene plastic pallet (1.22 × 1.02 × 0.14 m), 10 concrete half-blocks (41 × 20 × 10 cm), and a plastic crate (65 × 35 × 28 cm). Small reefs were assembled by using 122-cm cable ties with a tensile strength of 79 kg. A small float (5.1 × 12.7 cm) was tied to each corner of the reef and floated 1 m above the reef. One larger float (15.2-cm diameter) was tied in the center of the reef, also at a height of 1 m. The floats added vertical structure to the reef and facilitated reef relocations with sonar. The small reefs were anchored by attachment to a 1.2-m ground anchor with 1.3-cm-diameter nylon rope. The total volume of the reef was 1.42 $m^3$. The small reefs provided habitat for age-0 red snapper and other small (mostly <200 mm) reef fishes. One small reef was anchored 15 m (small nearby reef) from the large reef, and a second small reef was anchored 500 m (small distant reef) from the large reef. Each replicate set of reefs included one large reef and two small reefs, and all replicates

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were equally spaced 1.7 km apart in rows of three, four, and three large reefs. Depth differences among all reefs were less than 3 m.

In 2008, all of the reefs were surveyed on 6 and 15 August 2008 but were subsequently destroyed by Hurricane Gustav in the first week of September. In 2009, reefs were surveyed on 4 and 6 August and again on 9–10 September. A third survey was attempted on 19 November 2009 but was not completed owing to high turbidity and reef damage caused by Tropical Storm Ida.

During each survey, two SCUBA divers visually identified, counted, and estimated size-classes (in 25-mm total length [TL] intervals) of all fish present on individual small reefs. In this study, recruits were defined as newly settled age-0 juvenile fish. Divers also observed the large reefs and characterized the size and abundance of the common species that were present. In 2009, divers videotaped (Sony Hi-8) and photographed (Nikon D200) each small reef with its associated fishes. All photographs and video recordings were taken 1.2 m from the reef on a horizontal plane to the reef, facing the open holes of the concrete blocks. In the laboratory, photographs with the highest number of age-0 red snapper for a particular reef were selected for computer-aided enumeration. Each fish in the photograph was identified to species and counted by using Image-Pro image analysis software. Any photographed fish that could not be accurately identified to species was counted and labeled as unknown. Two screens were used to analyze the video recording: a single captured frame of the video was displayed on one screen while the video was played on the second screen. The second screen allowed the counter to simultaneously view the fish in the captured frame and on the moving video for more accurate identification and counting with Image-Pro software.

All fish counts were divided by the volume of the small reef to obtain density (fish/m$^3$). Red snapper age was estimated based on length. During the August surveys, all red snapper that were 102 mm TL or smaller were classified as age 0. In September, all red snapper that were 127 mm TL or smaller were classified as age 0 (Szedlmayer and Lee 2004). All tomtates *Haemulon aurolineatum* of 76 mm TL or less were considered to be age 0. A few fast-moving and large-schooling species (blue runner *Caranx crysos*, round scad *Decapterus punctatus*, greater amberjack *Seriola dumerili*, and longspine porgy *Stenotomus caprinus*) were excluded from all reef comparisons because of the difficulty in counting them and because of their transient behavior.

Visual estimates of age-0 and age-1 red snapper densities were compared between treatments with a two-way analysis of variance (ANOVA). The mean densities of other common species were compared between treatments with a *t*-test. Differences in mean species richness (species/m$^3$) were compared between treatments separately for each survey by using a *t*-test. Pearson's product-moment correlation coefficients were calculated for densities of age-0 and age-1 red snapper on the small distant (500 m) reefs. A one-way ANOVA was used to compare densities of age-0 red snapper across years for August surveys. Photograph and video estimates of age-0 red snapper densities were compared between treatments with a *t*-test. The three counting methods (visual, photograph, and video) of age-0 red snapper densities and mean species richness were compared by use of a one-way ANOVA. If significant differences were detected with ANOVA, specific differences were identified by using a Tukey's test.

Fish community patterns between reef types were also compared with nonmetric multidimensional scaling (NMDS; Szedlmayer and Able 1996; Lingo and Szedlmayer 2006; Redman and Szedlmayer 2009). Species abundance data were square-root transformed to reduce the weight of highly abundant species (Field et al. 1982). Czekanowski's similarity coefficients ($S_{jk}$) were calculated among all individual surveys of each reef and were mapped as NMDS ordination plots:

$$S_{jk} = 100 \times \left(1 - \frac{\sum |y_{ij} - y_{ik}|}{\sum y_{ij} + y_{ik}}\right),$$

where $S_{jk}$ is the similarity between the $j$th and $k$th reefs, $y_{ij}$ is abundance of the $i$th species on the $j$th reef, and $y_{ik}$ is the abundance of the $i$th species on the $k$th reef (Field et al. 1982; Yoshioka 2008). Circles describing the grouping between treatments were drawn by hand on the NMDS ordination plots. One-way analysis of similarity (ANOSIM Global $R$) was used to test for significant differences in the reef fish community between reef treatments for each survey (Clarke and Green 1988; Clarke 1993). All statistical tests were considered significant at $P$-values of 0.05 or less.

## RESULTS

In August 2008 and 2009, age-0 red snapper were significantly more abundant on the small distant (500 m) reefs than on the small nearby (15 m) reefs as shown by a significant interaction effect (2008 ANOVA: $F_{1, 36} = 19.54$, $P < 0.001$, Figure 2a; 2009 ANOVA: $F_{1, 36} = 10.02$, $P = 0.003$, Figure 2b). Similarly, in September 2009, age-0 red snapper were more abundant on the small distant reefs than on the small nearby reefs (ANOVA: $F_{1, 36} = 21.60$, $P < 0.001$; Figure 2c). No significant differences were detected for age-1 red snapper abundances between reef treatments (Figure 2). Comparisons of age-0 and age-1 red snapper abundance on the small distant reefs showed a significant negative correlation in August 2008 (Pearson's $r = -0.67$, $P = 0.03$), but significant correlations were not detected for the other two surveys (August 2009: Pearson's $r = -0.59$, $P = 0.07$; September 2009: Pearson's $r = -0.10$, $P = 0.78$). Overall, age-0 red snapper abundance did not significantly differ between August 2008 (mean $\pm$ SD $= 8.0 \pm 11.8$ fish/m$^3$) and August 2009 ($11.8 \pm 18.8$ fish/m$^3$; ANOVA: $F_{1, 38} = 0.6$, $P = 0.44$).

In August 2009, rock sea bass *Centropristis philadelphica* were marginally more abundant on the small distant reefs (mean $\pm$ SD $= 4.37 \pm 6.55$ fish/m$^3$) than on the small nearby reefs ($0.14 \pm 0.30$ fish/m$^3$; *t*-test: $t_{18} = 2.04$, $P = 0.056$); by

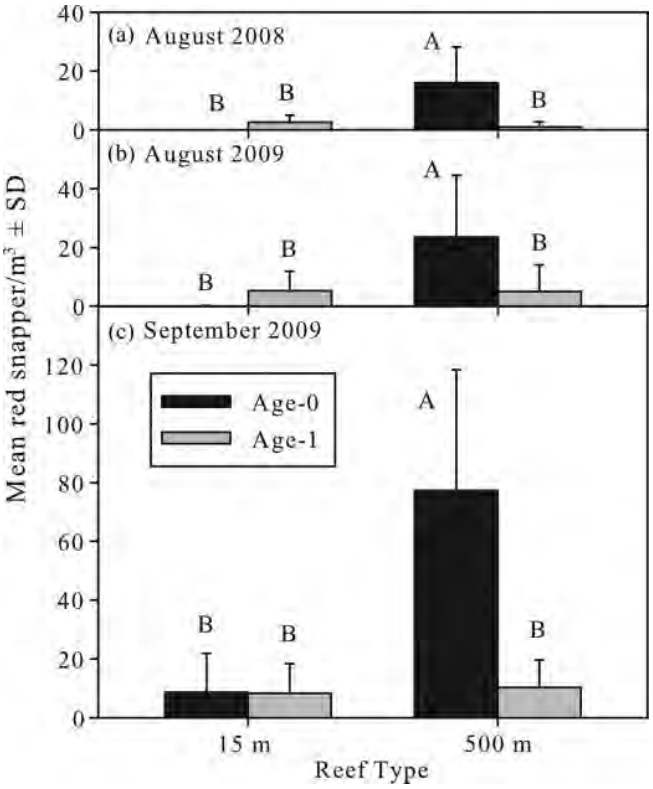


FIGURE 2. Mean (+SD) density (fish/m$^3$) of age-0 and age-1 red snapper based on visual SCUBA surveys of small artificial reefs placed 15 or 500 m from a larger artificial reef in the northern Gulf of Mexico during **(a)** August 2008, **(b)** August 2009, and **(c)** September 2009. Within a given panel, means with different uppercase letters are significantly different ($P < 0.05$).

September 2009, they were significantly more abundant on the small distant reefs (8.24 ± 9.26 fish/m$^3$) than on the small nearby reefs (0.00 fish/m$^3$; $t$-test: $t_{18} = 2.81$, $P = 0.012$). In August 2009, pygmy filefish *Stephanolepis setifer* were significantly more abundant on the small distant reefs (0.35 ± 0.50 fish/m$^3$) than on the small nearby reefs (0.00 fish/m$^3$; $t$-test: $t_{18} = 2.24$, $P < 0.05$); pygmy filefish were also more abundant in September 2009 on the small distant reefs (0.56 ± 0.80 fish/m$^3$) than on the small nearby reefs (0.00 fish/m$^3$; $t$-test: $t_{18} = 2.23$, $P < 0.05$). In contrast to most other species, age-0 tomtates were significantly more abundant on the small nearby reefs (172.1 ± 225.5 fish/m$^3$) than on the small distant reefs (2.8 ± 4.4 fish/m$^3$; $t$-test: $t_{18} = -2.37$, $P < 0.05$) in September 2009. Age-0 recruits (generally smaller than 76 mm) of several other species (including vermilion snapper *Rhomboplites aurorubens*, lane snapper *Lutjanus synagris*, cubbyu *Pareques umbrosus*, cocoa damselfish *Stegastes variabilis*, snowy grouper *Epinephelus niveatus*, sand perch *Diplectrum formosum*, and wrasses *Halichoeres* spp.) were observed on small reefs in 2009. However, no significant differences in mean abundance were detected between the small nearby reefs and small distant reefs ($P > 0.05$). In August 2009, species richness was significantly higher on the small distant reefs (4.2 ± 1.1 species/m$^3$) than on the small nearby reefs (2.7 ± 1.6 species/m$^3$; $t$-test: $t_{18} = 2.37$, $P < 0.05$).

Predators capable of consuming newly settled reef fishes (i.e., predator TL > 200 mm) were observed on all large reefs. In addition to large fishes, age-0 tomtates, vermilion snapper, and round scad were observed recruiting onto 6 of 10 large reefs in 2009. Although divers were able to detect age-0 tomtates, vermilion snapper, and round scad on the large reefs, no age-0 red snapper were observed on those reefs in August 2008 or August 2009, and fewer than 20 age-0 red snapper were observed on 2 of the 10 large reefs in September 2009.

Significant differences in reef fish communities were detected between reef treatments for all three surveys: August 2008 (ANOSIM Global $R$: $R = 0.342$, $P < 0.001$; Figure 3a), August 2009 ($R = 0.327$, $P < 0.001$; Figure 3b), and September 2009 ($R = 0.497$, $P < 0.001$; Figure 3c). In all surveys, similar species were observed between the reef treatments, but density differences for particular species probably accounted for the significant differences detected in the total reef fish communities (Table 1).

Similar to the visual surveys performed by SCUBA divers, computer-aided counts of age-0 red snapper from photographs showed significantly higher relative abundances in August 2009 on the small distant reefs (mean ± SD = 12.04 ± 15.69 fish/m$^3$) than on the small nearby reefs (0.00 fish/m$^3$; $t$-test: $t_{18} = 2.43$, $P < 0.05$); the difference was again observed in September 2009 (small distant reefs: 52.68 ± 25.24 fish/m$^3$; small nearby reefs: 6.76 ± 9.80 fish/m$^3$; $t$-test: $t_{18} = 5.36$, $P < 0.001$). Video counts also showed significantly higher age-0 red snapper relative abundances on the small distant reefs than on the small nearby reefs in August 2009 (small distant reefs: 7.51 ± 6.77 fish/m$^3$; small nearby reefs: 0.00 fish/m$^3$; $t$-test: $t_{16} = 3.33$, $P < 0.01$) and in September 2009 (small distant reefs: 21.06 ± 11.15 fish/m$^3$; small nearby reefs: 1.88 ± 3.05 fish/m$^3$; $t$-test: $t_{17} = 4.98$, $P < 0.001$). Comparisons among the three methods for September 2009 showed significantly more age-0 red snapper from diver visual surveys (42.96 ± 46.14 fish/m$^3$) than from counts derived from photographs (29.72 ± 30.04 fish/m$^3$) and video recordings (11.97 ± 12.77 fish/m$^3$; ANOVA: $F_{2,56} = 4.35$, $P < 0.05$). Similarly, in August 2009, visual surveys indicated significantly higher species richness (3.49 ± 1.56 species/m$^3$) than did photographs (1.80 ± 0.90 species/m$^3$) and video surveys (1.17 ± 0.68 species/m$^3$; ANOVA: $F_{2,55} = 21.91$, $P < 0.001$). This was also the case for species richness in September 2009 (visual surveys: 4.68 ± 1.50 species/m$^3$; photographs: 2.89 ± 0.94 species/m$^3$; videos: 2.04 ± 0.88 species/m$^3$; ANOVA: $F_{2,56} = 27.27$, $P < 0.001$).

## DISCUSSION

Age-0 red snapper were always more abundant on the small distant (500 m) reefs than on the small nearby (15 m) reefs. In fact, no age-0 red snapper were observed on the small nearby reefs during August 2008, and only one age-0 red snapper was

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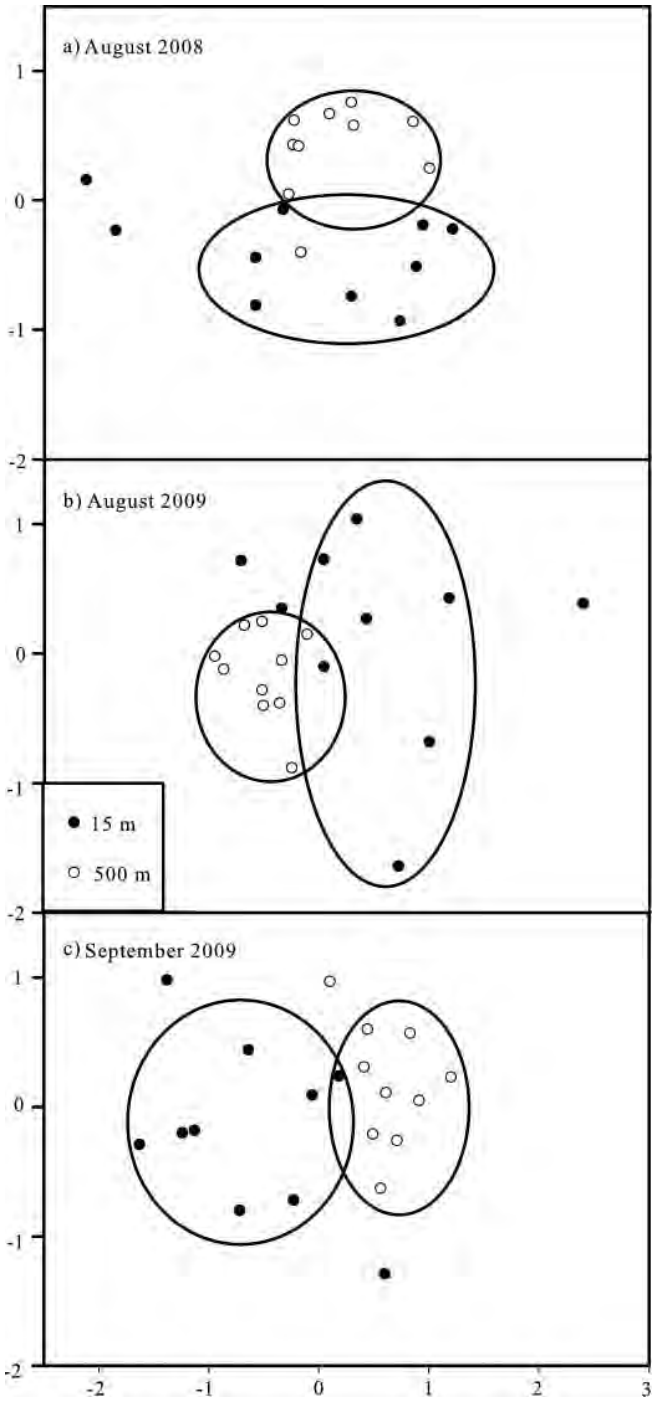


FIGURE 3. Multidimensional scaling plot of Czekanowski's similarity coefficient, showing differences in resident reef fish communities between small artificial reefs placed 15 and 500 m from a large artificial reef in the northern Gulf of Mexico during **(a)** August 2008, **(b)** August 2009, and **(c)** September 2009. Axes are unitless. Hand drawn ovals indicate similar groupings.

observed on the small nearby reefs during August 2009. This clearly shows the strong effect that the proximity of predators and competitors can have on new recruits. Similarly, several previous studies have shown that predators reduced recruitment near larger reefs (Shulman 1985; West et al. 1994; Steele 1997; Belmaker et al. 2005). It was only in September 2009 that age-0 red snapper began to appear in low numbers on the small nearby reefs, indicating that by this time the age-0 red snapper had grown beyond the gape size of smaller potential predators that occupied the large reefs (e.g., tomtate, pigfish, and age-1 red snapper). In addition, by September, the age-0 recruits were probably more competent swimmers, which made them better able to evade larger predators and aggression from other fish.

Several mechanisms may be responsible for the pattern of reduced age-0 red snapper on the small nearby reefs compared with the small distant reefs. Shortly after settlement, age-0 red snapper may suffer predation mortality from the predators inhabiting the larger reefs. In fact, recent observations showed direct predation by adult red snapper (2.5-kg fish) on age-0 red snapper (22 mm standard length; our unpublished data). Though direct observation of predation on recruits attempting to settle onto reefs nearby is difficult to obtain, Belmaker et al. (2005) moved patch reefs closer to a continuous reef with a resident fish community and observed aggregation of predators along with numerous predatory strikes; those authors suggested that the predators were consuming many of the new recruits on the patch reef. Another possibility is that older conspecifics were driving off any new recruits that attempted to settle onto the small nearby reefs, as was shown in a laboratory study of red snapper (Bailey et al. 2001). New recruits may also be able to detect predators or conspecifics on the larger reefs and simply choose to settle elsewhere. Sweatman (1988) found evidence that reef fish recruits used chemical cues to preferentially choose settlement sites based on the presence or absence of conspecifics or competitors. Ultimately, all three mechanisms are probably operating, but it is difficult to partition these factors in the present study.

Distance from large reefs clearly affected the abundance of age-0 red snapper on the small reefs. We assumed that the small nearby reefs were well within the range of the predatory fishes living on the large reefs, whereas the small distant reefs were beyond the usual range of resident predators on the large reefs. This assumption was supported by previous tracking studies in which adult red snapper were continuously located at distances between 5 and 66 m from a reef over 24-h periods (Szedlmayer and Schroepfer 2005; Topping and Szedlmayer 2011). Our assumption was also supported by diver observations indicating that larger resident fish (>300 mm TL) on the large reefs would swim over to the small nearby reefs during visual surveys. The larger fishes included the red snapper, gag *Mycteroperca microlepis*, gray triggerfish, and greater amberjack. No fish over 280 mm TL were observed on the small distant reefs, suggesting

TABLE 1. Comparison of reef fish densities (fish/m$^3$; for species that contributed >0.02% of the total) between small artificial reefs placed 15 m (nearby) and 500 m (distant) from a larger artificial reef over all surveys conducted during 2008 and 2009 in the northern Gulf of Mexico.

| | Distant reefs | | Nearby reefs | |
|---|---|---|---|---|
| Species | Density (fish/m$^3$) | Percent of total | Density (fish/m$^3$) | Percent of total |
| Red snapper | 66.58 | 47.39 | 12.39 | 2.38 |
| Vermilion snapper | 53.27 | 37.92 | 404.15 | 77.52 |
| Rock sea bass | 6.69 | 4.76 | 0.07 | 0.01 |
| Sand perch | 3.49 | 2.48 | 0.67 | 0.13 |
| Tomtate | 2.46 | 1.75 | 96.58 | 18.53 |
| Pigfish *Orthopristis chrysoptera* | 1.94 | 1.38 | 1.34 | 0.26 |
| Bank sea bass *Centropristis ocyurus* | 1.83 | 1.30 | 0.04 | 0.01 |
| Cubbyu | 1.62 | 1.15 | 2.78 | 0.53 |
| Gray triggerfish *Balistes capriscus* | 0.95 | 0.68 | 0.53 | 0.10 |
| Pygmy filefish | 0.46 | 0.33 | | |
| Lane snapper | 0.39 | 0.28 | 0.28 | 0.05 |
| Wrasses *Halichoeres* spp. | 0.32 | 0.23 | 0.35 | 0.07 |
| Snowy grouper | 0.21 | 0.15 | 0.04 | 0.01 |
| Short bigeye *Pristigenys alta* | 0.07 | 0.05 | | |
| Dwarf goatfish *Upeneus parvus* | 0.07 | 0.05 | | |
| Blennies (Blenniidae) | 0.04 | 0.03 | 0.60 | 0.11 |
| Cocoa damselfish | 0.04 | 0.03 | 0.42 | 0.08 |
| Atlantic spadefish *Chaetodipterus faber* | 0.04 | 0.03 | 0.21 | 0.04 |
| Glasseye snapper *Heteropriacanthus cruentatus* | 0.04 | 0.03 | | |
| Twospot cardinalfish *Apogon pseudomaculatus* | | | 0.74 | 0.14 |

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that observed fish typically did not cross the 500 m of open habitat between reefs. In addition (although not quantified), when age-0 red snapper were observed on the small nearby reefs, they tended to hide within the holes and refuges of the reef structure, while age-0 red snapper on the small distant reefs moved freely above and around the reef structure.

A negative correlation was observed between the abundances of age-1 and age-0 red snapper on the small distant reefs. Although this pattern was only significant in August 2008, it was also apparent in August 2009. The lack of any negative correlation in September 2009 again suggests that by this time, age-0 red snapper had grown to sizes that were large enough to afford them some protection from predation or aggression from age-1 red snapper. Similarly, enhanced recruitment of Ward's damsel *Pomacentrus wardi* was observed on reefs from which adult conspecifics had been removed (Sale 1976). If conspecifics are responsible for the exclusion of age-0 red snapper, this may be an example of density dependence. Other studies have found evidence of density dependence in reef fishes. For example, adult bridled goby *Coryphopterus glaucofraenum* caused a density-dependent reduction in the recruitment of juveniles (Forrester 1995), and there was an inverse relation between adult density and subsequent recruitment in millet butterflyfish *Chaetodon miliaris* (Stimson 1990). Tupper and Boutilier (1995) showed that older conspecifics reduced the survival of cunners *Tautogolabrus adspersus*, and no new recruits survived on reefs with the highest densities of conspecifics. Based on the present study results, it is difficult to conclude that older conspecifics were causing density-dependent recruitment in red snapper, as a large number of other predators were also present on the larger reefs. Even so, it appears that predator-free nursery structures may be a limiting resource for age-0 red snapper.

Rock sea bass and pygmy filefish were significantly more abundant on the small distant reefs than on the small nearby reefs. However, most of the individuals observed were adults rather than new recruits, and the adults of these species are generally small; in this study, the largest rock sea bass was 15 cm and the largest pygmy filefish was 12 cm. Thus, in addition to juvenile fish, the adults of smaller reef fishes may also benefit from the reduced predation or competition in habitats located outside of the influence of larger reefs.

Age-0 tomtates showed a pattern opposite to that of red snapper and had higher abundances on the small nearby reefs than on the small distant reefs. Divers observed tomtate recruits on the large reefs—sometimes in numbers exceeding 1,000—despite the presence of numerous predators. It appears that higher counts of tomtates on the small nearby reefs result from their high abundance on the larger reefs. In September 2009, when this pattern was detected, tomtates settled onto reefs at much higher densities than did red snapper. Tomtate densities may be high enough to satiate predators and to allow survival despite heavy predation. These patterns indicate a different survival strategy for tomtates

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compared with red snapper. Red snapper may actively select predator-free habitat, while tomtates seek out larger reef habitat independent of predator presence. Such differences in life history are known for other reef fishes. Some species (e.g., Ambon damsel) settle directly onto adult habitats (McCormick and Makey 1997), whereas others (e.g., Nassau grouper *Epinephelus striatus* and gag) exploit nursery habitats before moving to larger reefs later in life (Eggleston 1995; Ross and Moser 1995).

Our finding of higher abundances of tomtates on the small nearby reefs differs from several studies that showed higher recruitment with increasing distance from a reef (Shulman 1985; Steele 1997; Belmaker et al. 2005). This difference may result from a difference in scale among studies. Previous studies looked at fine-scale differences, with the farthest reefs being less than 50 m from the large reef, while in the present study small reefs were placed 500 m from the large reefs. Alternatively, tomtates in the northern Gulf of Mexico may simply be an exception to an otherwise common pattern.

In August 2009, mean species richness was higher on the small distant reefs than on the small nearby reefs. Similar patterns were reported by Shulman (1985) and Belmaker et al. (2005), who found higher diversity on small reefs that were placed farther away from a large reef than on those placed closer to a large reef. Caley (1993) observed higher species richness of nonpiscivorous reef fish recruits on reefs where resident predators had been removed. Again, this pattern could be caused by (1) prey fish avoidance of habitats that have resident predators or (2) predator reduction of species richness by occasionally preying on members of rare species.

All three survey techniques used in this study were able to detect significantly higher densities of age-0 red snapper on the small distant reefs. On average, the visual surveys gave the highest counts, photographs gave intermediate counts, and video recordings always gave the lowest abundances. Tessier et al. (2005) also obtained higher counts with visual surveys than with video techniques. Willis et al. (2000) obtained higher abundance estimates and higher precision with video surveys than with visual surveys, but those authors used an unmanned, baited video technique rather than a diver-operated video camera. However, baited video methods may have attracted fish from the surrounding area and biased their fish counts. In any photographic or video survey, there will always be fish on the reef that are out of range and undetectable. However, as fish abundance increases, diver counts become more difficult. Thus, as a trade off, photographs can provide more-precise counts for comparative purposes without the difficulty of counting swimming fish but will be less accurate than diver visual counts of total reef fish abundance. Visual surveys also showed higher mean species richness than photographs or video recordings, similar to the results of Tessier et al. (2005). The visual survey was able to detect rare and cryptic species, such as twospot cardinalfish and belted sandfish *Serranus subligarius*, which were not detected in photographs or video counts. The visual survey was also the only method that detected the single age-0 red snapper on the small nearby reefs in August 2009. In conclusion, visual surveys are needed to detect rare or cryptic species and to measure species richness, while photographs are more appropriate for comparative measures of relative abundance.

The results of this study can be used to improve the construction and placement of artificial reefs. West et al. (1994) concluded that low-relief artificial reefs would most benefit juvenile rockfishes *Sebastes* spp. if they were built in areas without adjoining adult habitat. Likewise, this study indicates that if artificial reefs are built to provide habitat for juvenile red snapper, they should not be built in areas immediately adjacent to existing adult habitat. Furthermore, artificial reefs that are meant to provide habitat for adult fish should not be built near important red snapper nursery habitats.

## ACKNOWLEDGMENTS

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# A comparison of size and age of red snapper (*Lutjanus campechanus*) with the age of artificial reefs in the northern Gulf of Mexico

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**Abstract**—Despite extensive study, it still is not clear whether artificial reefs produce new fish biomass or whether they only attract various species and make them more vulnerable to fishing mortality. To further evaluate this question, the size and age of red snapper (*Lutjanus campechanus*) were sampled from April to November 2010 at artificial reefs south of Mobile Bay off the coast of Alabama and compared with the age of the artificial reef at the site of capture. Red snapper were collected with hook and line and a fish trap and visually counted during scuba-diver surveys. In the laboratory, all captured red snapper were weighed and measured, and the otoliths were removed for aging. The mean age of red snapper differed significantly across reefs of different ages, with older reefs having older fish. The mean age of red snapper at a particular reef was not related to reef depth or distance to other reefs. The positive correlation between the mean age of red snapper and the age of the reef where they were found supports the contention that artificial reefs in the northern Gulf of Mexico enhance production of red snapper. The presence of fish older than the reef indicates that red snapper are also attracted to artificial reefs.

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Red snapper (*Lutjanus campechanus*, Poey, 1860) has been historically targeted by both sport and commercial fishermen in the Gulf of Mexico (Camber, 1955). Because of intense fishing pressure, the estimated population abundance in this region has decreased and the stock is considered overfished (Schirripa and Legault, 1999; SEDAR[1]). Regulations that decrease the total allowable catch and shorten the recreational season have been enacted over the last several decades to reduce the harvest of this species and increase stock abundance.

The red snapper is a reef-associated fish that uses reef habitat as a resource for both shelter and prey (Ouzts and Szedlmayer, 2003; Szedlmayer and Lee, 2004; Piko and Szedlmayer, 2007; Gallaway et al., 2009). Age-0 red snapper begin to use reefs shortly after they settle out of the plankton and move to available low-relief, structured habitat (Workman and Foster, 1994; Szedlmayer and Howe, 1997; Szedlmayer and Conti, 1999; Szedlmayer and Lee, 2004). These new recruits quickly outgrow their initial benthic habitats and search for larger structured habitats by fall after the spawning season (Szedlmayer and Conti, 1999; Szedlmayer and Lee, 2004; Szedlmayer, 2011). After this initial recruitment, the presence of age-1 and older snapper, through predation and competitive exclusion, may limit the immigration of new recruits to reef structure (Bailey et al., 2001; Piko and Szedlmayer, 2007; Gallaway et al., 2009; Mudrak and Szedlmayer, 2012).

The substrate in the northern Gulf of Mexico is predominately mud and sand and has comparatively few natural reef areas (Parker et al., 1983; Kennicutt et al.,1995; Dufrene, 2005). The lack of naturally occurring reefs has stimulated the deployment of artificial reefs (e.g., decommissioned military tanks and concrete pyramids) by state agencies, private fishermen, and scientists to increase the availability of reef habitat. Several permit areas have been established off the coast of Alabama, where an estimated 15,000 artificial reefs have been deployed (Minton and Heath, 1998). The deployment of new reefs each year continues to add or replace reefs lost to major tropical storms.

The effect of artificial reefs on reef fish populations has been considered for decades. Bohnsack (1989) suggested that artificial reefs may simply aggregate fishes, making resident species easier to harvest and may ultimately decrease their populations. A second possibility is production enhancement, where reefs provide some limiting factor (e.g., habitat) that allows for an increase in the

[1] SEDAR (Southeast Data, Assessment, and Review). 2009. Stock assessment of red snapper in the Gulf of Mexico: SEDAR update assessment. Report of the update assessment workshop;, 24–28 August, 2009, 143 p. Miami, FL. NMFS, SEFSC, NOAA, Miami, Florida. [Available from http://www.sefsc.noaa.gov/sedar.]

available biomass of reef species. The artificial reef system in the northern Gulf of Mexico has been studied extensively— many studies focusing on various life history aspects of red snapper as a means to help resolve the question of whether or not artificial reefs enhance production.

The first group of studies involved diet analyses of the stomach contents of red snapper. If enhanced production is occurring, then red snapper diets should contain reef prey species; but, if only attraction is occurring, red snapper should be feeding on prey species not found on reefs. Evidence supporting both scenarios has been reported. For example, some studies reported that most red snapper prey items were species associated with the water column and sand-mud habitat (McCawley et al., 2006; Wells et al., 2008b). In contrast, other studies showed significant feeding on reef species (Ouzts and Szedlmayer, 2003; Szedlmayer and Lee, 2004; Redman and Szedlmayer, 2009).

Site fidelity of red snapper to artificial reefs also has been used to examine the question of enhanced production on artificial reefs. Again, 2 differing scenarios have been reported. Low residency and lack of site fidelity support the attraction hypothesis (Patterson et al., 2001b, Peabody, 2004), and long-term (>1020 d) residency on artificial reefs and high site fidelity support the production hypothesis (Szedlmayer and Shipp, 1994; Szedlmayer, 1997; Szedlmayer and Schroepfer, 2005; Schroepfer and Szedlmayer, 2006; Topping and Szedlmayer, 2011a; 2011b).

These previous studies indicate that attraction of red snapper to artificial reefs is occurring, but the extent to which artificial reefs also enhance production is an open question. Although it is relatively easy to provide evidence for attraction, it is not as easy to find evidence for production. Therefore, we contend that it still is not clear whether artificial reefs produce new red snapper biomass or whether they only attract fish of this species and make them more vulnerable to fishing mortality.

A new approach to this long-standing question would be to compare the age of resident fish with the age of the artificial reef where they occur. If enhanced production is occurring, new reefs should attract new recruits, and these recruits likely would stay and grow as their reef ages, becoming the dominate age class and would possibly exclude new recruits from the reef habitat. In this case, the age of fish resident at a reef should be positively correlated with the age of the reef. In contrast, if artificial reefs simply attract red snapper, reef age should not be correlated with fish age but, rather, should be related to the proximity of red snapper on other reefs and red snapper movement patterns. For our study, artificial reefs were deployed in 2006, 2009, and 2010, and the size and age of red snapper were compared among these 3 reef ages to help clarify whether artificial reefs may be enhancing red snapper production. The positions of these reefs were not released to the public to reduce the potential effects of variation in fishing mortality on age distributions of red snapper.

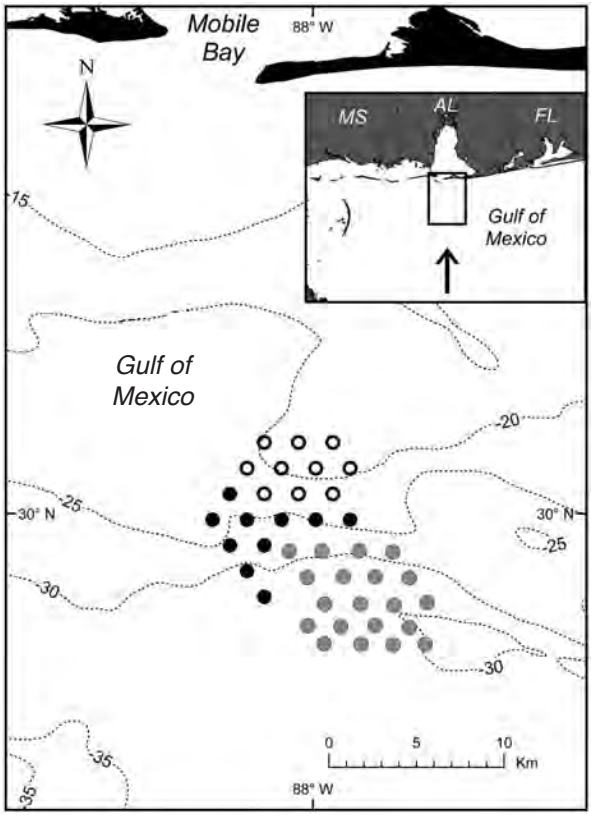


**Figure 1**

Map of sampling locations in our study of red snapper (*Lutjanus campechanus*) on artificial reefs in the northern Gulf of Mexico in 2010. Gray circles=reefs deployed in 2006; open circles=reefs deployed in 2009; and black circles=reefs deployed in 2010. Dotted lines indicate depth contours at 5-m intervals.

## Materials and methods

### Sample sites

The area of our study was located 20–30 km south of Mobile Bay, Alabama (Fig. 1). This area has more than 15,000 artificial reefs and a few natural, rocky reefs (Minton and Heath, 1998). For our study, artificial reefs (4.4×1.3×1.2 m, metal cages) were deployed in April 2006 ($n$=20, which became 4-year-old reefs in our study), April 2009 ($n$=10, which became 1-year-old reefs in our study), and January 2010 ($n$=10, which became 0.5-year-old reefs in our study). Reef locations were not published to limit potential fishing mortality. All the reefs we studied were located 1.3–1.7 km from other reefs deployed in this study. These reefs were deployed at the following depths: 27–32 m in 2006, 18–24 m in 2009, and 23–31 m in 2010.

All reefs were sampled from April to November 2010. The reefs deployed in 2010 were not sampled until at least 5 months after their deployment to allow adequate time for the immigration of red snapper (Mudrak and

Szedlmayer, 2012). Red snapper were collected with hook and line and fish trap from each reef. Hook-and-line sampling was standardized to 30 min and 2 individuals who fished. Fishing time was suspended when problems occurred (e.g., internally hooked fish) and continued once both individuals could resume fishing. For hook-and-line fishing, double 6/0 J hooks, 27.2-kg test monofilament line, 45.3-kg test monofilament leader were used, and whole Gulf menhaden (*Brevoortia patronus*) as bait. After completion of hook-and-line sampling, additional fish were collected with a baited fish trap (1.2×1.5×0.6 m; Collins, 1990). In the fish trap, both Gulf menhaden and whole squid (*Loligo* spp.) were used as bait. All fish traps were set for 15 min. After collections of red snapper reached ~50 individuals per reef, a diver released the number of fish caught above 50 fish by opening the trap door and allowing random individuals to escape at the surface—with one exception (73 red snapper were kept on 5 May 2010 because of the possibility of area closures that might have resulted from the Deepwater Horizon oil spill). When the minimum target of 30 individuals per reef was not reached after the first fish trap set, the trap was fished at least one additional time. All red snapper collected from a reef were immediately packed on ice and returned to the laboratory for further processing.

After fish collections were completed, 2 scuba divers completed visual counts and photographic (Nikon D200[2], Nikon Corp., Tokyo) and video (Sony CCD-TR101, Hi8, Sony Corp., Tokyo) recordings to use in estimation of the remaining red snapper at each sample site. A clear plastic jar containing cut Gulf menhaden was used to attract surrounding red snapper into aggregations during visual surveys for increased accuracy of total counts. Divers completed at least 3 full-circle point-and-count surveys, where the divers counted all fish within visual circular range, and the highest count was used for estimates of total abundance. Poor visibility at some sites limited these estimates. In addition, when sharks were present, diver operations were suspended, and visual estimates were completed later within 30 days of the original fish collections.

### Laboratory analyses

Red snapper size (standard length [SL], fork length [FL], and total length [TL] in millimeters) and total body weight (0.1 g) were measured in the laboratory within 24 h of capture. For red snapper ≥250 mm TL, otoliths were removed with a Bosch fine-cut electric saw. For red snapper <250 mm TL, otoliths were removed with a small knife. Both left and right otoliths were removed from each fish, cleaned, and stored in dry plastic vials for later analysis. Opaque bands were counted on all otoliths for age estimates. For fish <7 years old, bands were counted on whole otoliths that were immersed in water and viewed under a dissecting scope with transmitted light. If ages were ≥7 years, thin otolith sections were prepared and bands were counted at 40× magnification with a compound microscope (Szedlmayer and Beyer, 2011). Opaque bands of sectioned otoliths were counted along the dorsal edge of the sulcus acousticus. Bands on each otolith were counted independently 4 times. After 4 readings, 2 readers examined the remaining otoliths for which counts still differed and attempted to reach a consensus on age. If an agreement on age could not be reached for an otolith, it was rejected. A reference collection of hatchery red snapper that had been released in the wild as age-0 and recaptured as age-1fish ($n$=22) along with a group that had been reared in captivity to age-1 ($n$=13) were used to validate counting methods of wild caught age-1 fish. Some of the otoliths of these known age-1 fish showed a "false" annulus (i.e., had 2 opaque bands) but showed age-1 otolith shape patterns (Beyer and Szedlmayer, 2010). Therefore, some of the wild fish <200 mm SL caught in this study that had 2 opaque bands were defined as age-1, on the basis of their age-1 shape patterns appearing similar to the shape patterns of hatchery-reared fish as well as hatchery-born but wild-reared fish.

Video recordings and digital photographs of the studied reefs were examined in the laboratory for comparisons and validation of the divers' visual counts. In the laboratory, photographs that showed the highest number of red snapper for a particular reef were selected for computer-based counting. All red snapper in these photographs were identified and counted through image analysis with Image-Pro Plus software (vers. 4.5, Media Cybernetics, Rockville, MD). Two screens were used to count fish in video recordings. A single frame captured from the video was displayed on one screen while the video played on the second screen. Because image quality decreases when a single frame of video is captured, we used the full video on the second screen to identify all the fish in the captured frame on the first screen. The captured video image then was marked and the fish in it were counted with Image-Pro software.

## Data analyses

Catch per unit of effort (CPUE) for each reef was calculated for both hook and line (CPUE=number caught by 2 individuals/30 min) and trap (CPUE=number caught/15 min). The precision of age estimates between readers was compared with linear regression and average percent error (Beamish and Fournier, 1981). Densities of red snapper were estimated by adding the total number of red snapper caught (from both hook and line and fish trap) to the number of fish counted in the visual survey. Pearson's correlation coefficient was used to compare densities (number of fish per cubic meter of reef surveyed) among reefs of different ages, with reef age determined by the number of months that a reef had been deployed before the month of sampling. Analysis of variance (ANOVA) was used to compare the SL, weights,

[2] Mention of trade names or commercial companies is for identification purposes only and does not imply endorsement by the National Marine Fisheries Service, NOAA.

and ages of red snapper among the different ages of reefs. If significant differences were detected, a Tukey test was used to show specific differences.

Growth rates were examined with an analysis of covariance (ANCOVA) that compared the mean length at age of red snapper <10 years old between old (2006) and new (2009 and 2010) reefs. This analysis was used to determine if old reefs were providing additional resources, a difference that would be reflected in faster growth rates of red snapper on old reefs than on new reefs. For additional comparisons, Pearson's correlation coefficients were calculated for reef age with red snapper SL, weight, and age. Also examined with Pearson's correlation coefficient was the potential influence of nearby known reefs on the age and abundance of red snapper on the reefs that we surveyed in 2010. Nearby reefs were 0.17–1.7 km away (mean=0.72 km, $n$=37), or less than the distance between the reef sites sampled in our study. In an effort to remove possible depth effects, the ages of red snapper collected at the same depth (30 m) were compared between the 2006 and 2010 reefs with a $t$-test. Differences were considered significant at $P \leq 0.05$, and all data were analyzed with Statistical Analysis System software (SAS, vers. 9.1, SAS Institute, Inc., Cary, NC).

## Results

Red snapper were sampled from April to November 2010 from 37 artificial reefs (2006 reefs=18; 2009 reefs=10; 2010 reefs=9). Visual surveys were completed by divers at later dates at 2 sites because of the presence of sharks on the original sampling date and were not completed on 7 reefs (3 of the 2006 reefs and 4 of the 2010 reefs) because of poor visibility (<1 m).

A total of 1028 red snapper were collected, 439 by hook and line and 589 by trap. Mean ±standard deviation (SD) CPUE for hook and line was significantly greater on the 2006 reefs (20.4 ±8.5 30 min$^{-1}$) than on the 2009 (6.3 ±8.1 30 min$^{-1}$) and 2010 reefs (2.6 ±4.6 30 min$^{-1}$; ANOVA: $F_{2, 34}$=20.38, $P$<0.0001). No significant differences in CPUE were detected among reef years for trap collections (2006=10.6 ±10.9, 2009=16.6 ±19.9, and 2010=14.3 ±12.7; ANOVA: $F_{2, 34}$=0.6, $P$=0.55). The SL and weight of red snapper caught by hook and line (429.4 ±79.8 mm, 2531 ±1409 g) were significantly greater than those measures of fish caught by trap (232.6 ±77.6 mm, 538 ±726 g; SL $t$-test, $t_{1018}$=39.56, weight $t_{1018}$=29.41, $P$<0.0001). Red snapper ages also were significantly different between these 2 sampling methods (hook and line=4.1 ±1.3 years, trap=1.9 ±1.1 years; $t$-test, $t_{1024}$=29.68, $P$<0.0001).

The visual survey methods significantly affected counts of red snapper. Visual counts by divers (mean ±SD=78.3 ±54.8) were significantly higher than counts from image-analysis methods (photograph counts=30.7 ±20.2, video counts=16.5 ±10.3; ANOVA, $F_{2, 42}$=13.37, $P$<0.0001). Because of these differences, total densities of red snapper were estimated by adding the number of captured fish (hook-and-line and trap samples) to divers' visual counts.

**Table 1**

Average percent error for both sets of independent readings of otoliths from red snapper (*Lutjanus campechanus*) caught in 2010 during our study on artificial reefs in the northern Gulf of Mexico. Included are the percentages of agreement for each difference between readings (first and second reading, coefficient of regression [$r^2$]=0.83, $P$<0.0001; third and fourth reading, $r^2$=0.96, $P$<0.0001).

| | First and second readings | Third and fourth Readings |
|---|---|---|
| Average percent error | 7.85 | 1.41 |
| Standard deviation | 0.12 | 0.05 |
| 0 | 62.16% | 92.32% |
| ±1 | 35.89% | 7.39% |
| ±2 | 1.95% | 0.29% |
| ≥3 | 0% | 0% |

Age-1 red snapper composed the dominate age class on the 2010 reefs and recruited to these reefs in the early summer. Mean ±SD numbers of red snapper per cubic meter of reef structure increased as reef age increased (Pearson's correlation coefficient [$r$]=0.48, $P$=0.008) and were significantly greater on 2006 reefs (22 ±13) than on 2009 reefs (12 ±6) and 2010 reefs (8 ±7; ANOVA, $F_{2, 27}$=4.25, $P$<0.025).

All caught red snapper ($n$=1028: 2006 reefs=587, 2009 reefs=280, 2010 reefs=161) were used in the final age comparisons. Initial agreement between the first and second independent readings was 62.2% (639/1028). A third and fourth reading increased the accepted otoliths to 92.3% (949/1028). Average percent error was calculated for both sets of independent readings (Table 1). An age consensus was reached on all remaining otoliths ($n$=79) through simultaneous examination by the 2 readers. The reference collection of age-1 hatchery ($n$=35, laboratory and wild reared) red snapper showed 25.7% with 2 opaque bands, indicating that counting opaque bands for age-1 fish may not be reliable. Among fish that were <200 mm SL and showed 2 opaque bands ($n$=72), all were identified as age-1 based on shape, thickness, and location of the opaque bands (Beyer and Szedlmayer, 2010; Szedlmayer and Beyer, 2011).

Mean ±SD red snapper SL, weight, and age were significantly different among 2006 reefs (373.3 ±107.8 mm SL, 1883 ±1388 g, 3.5 ±1.2 years), 2009 reefs (250.2 ±114.7 mm SL, 852 ±1464 g, 2.0 ±1.7 years) and 2010 reefs (222.3 ±78.0 mm SL, 480 ±711 g, 1.7 ±1.0 years; ANOVA, $F_{2, 1025}$=194.2, $P$<0.0001; Table 2; Figs. 2 and 3). Reef age was positively correlated with red snapper age (Pearson's $r$=0.61, $P$<0.0001), standard length ($r$=0.71, $P$<0.0001), and weight ($r$=0.47, $P$=0.0035). Comparisons of linear growth rates for fish <10 years old showed no significant differences between old (2006)

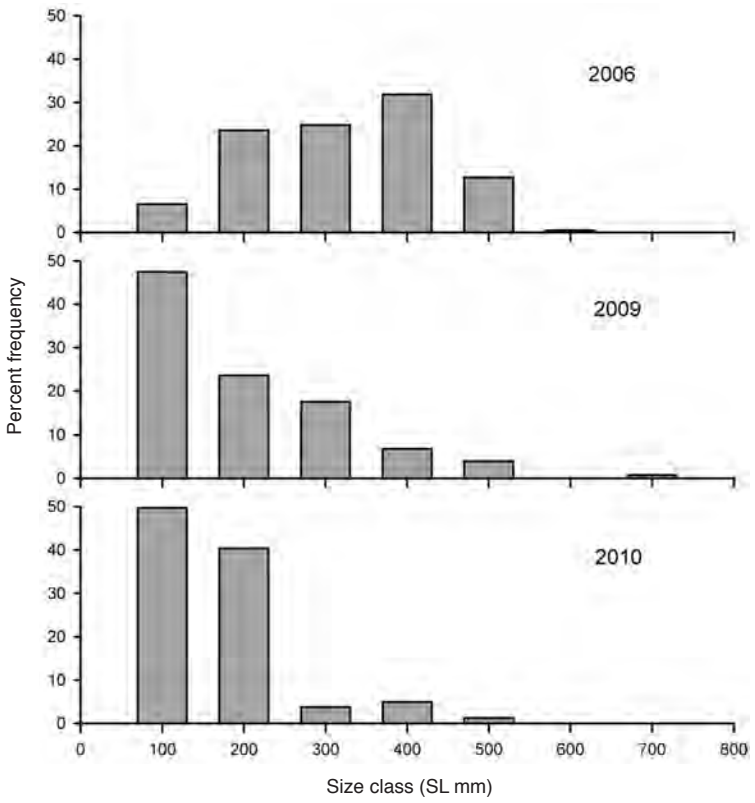


**Figure 2**

Length frequency of red snapper (*Lutjanus campechanus*) caught in our study on artificial reefs in the northern Gulf of Mexico in 2010, shown by year that reef was deployed, separated into 100-mm standard-length (SL) size classes (e.g., 100=100–199 mm).

**Table 2**

Mean (±SD) standard length (SL), weight, and age of red snapper (*Lutjanus campechanus*) caught during our study on artificial reefs deployed in 2006, 2009, and 2010 in the northern Gulf of Mexico. Superscript letters are used to indicate significant differences ($P \leq 0.05$). Included for each reef year are the total number of red snapper caught by hook-and-line and trap, mean diver count, and mean density estimate. Estimates of mean density per reef combine diver counts and catch of hook-and-line and trap.

| Reef year | SL (mm) | Weight (kg) | Age (yr) | Hook and line | Trap | Diver count | Density |
|---|---|---|---|---|---|---|---|
| 2006 | 373.3 ±107.8 [a] | 1.88 ±1.39 [a] | 3.54 ±1.24 [a] | 20.2 ±8.8 | 12.4 ±11.3 | 115.5 ±87.8 | 148.7 ±92.5 |
| 2009 | 250.2 ±114.7 [b] | 0.85 ±1.46 [b] | 1.98 ±1.70 [b] | 5.3 ±6.1 | 22.5 ±18.4 | 54.0 ±35.8 | 81.8 ±41.2 |
| 2010 | 222.3 ±78.0 [c] | 0.48 ±0.71 [c] | 1.72 ±1.00 [c] | 2.3 ±4.6 | 15.6 ±11.6 | 36.0 ±31.7 | 55.6 ±45.6 |

and new (2009 and 2010) reefs (ANCOVA, $F_{3,\ 1018}$=2.98, $P$=0.085, power>0.99).

The mean depth (30 m) of the 2006 reefs were significantly greater than the mean depth (20 m) of the 2009 reefs ($t$-test, $t_{26}$=16.32, $P$<0.0001). Because of this depth difference, red snapper also were compared among the 2006 and 2010 reefs ($n$=8) with the same depth (30 m). These comparisons also showed significantly larger and older red snapper on the 2006 reefs (mean ±SD=368.7 ±5.0 mm SL, 1821 ±1326 g, 3.60 ±1.20 years) compared to 2010 reefs (236.2 ±85.2 mm SL, 578 ±814 g, 1.91 ±1.10 years; $t$-test, $P$<0.0001).

Comparisons of our estimates of red snapper abundance and age on artificial reefs by proximity (<1.7 km) to other known reefs not sampled in our study failed to detect a significant effect. These other nearby reefs have published locations because they are part of Alabama's artificial reef program and were deployed

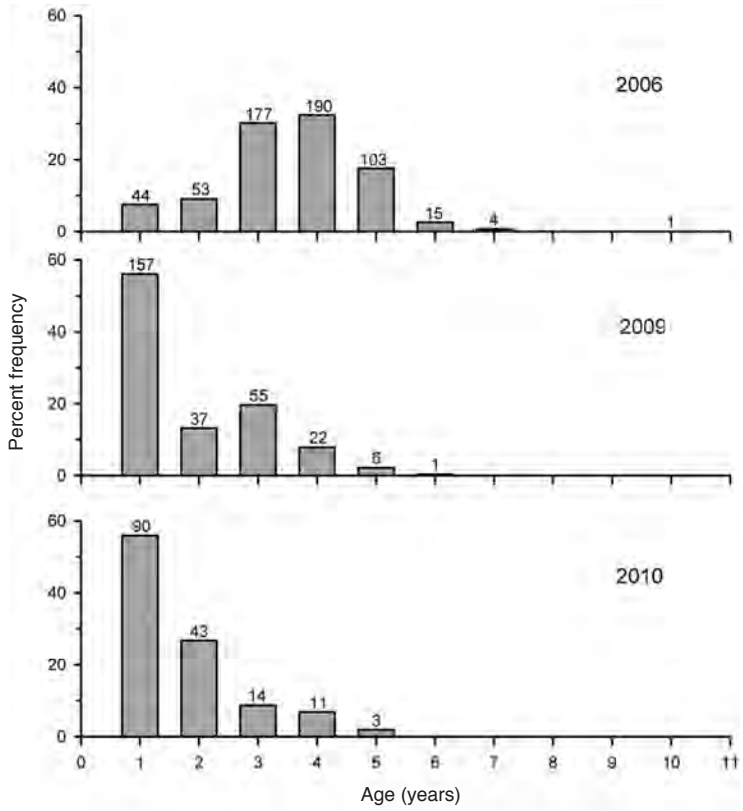


**Figure 3**

Age frequency, by year that reef was deployed, of red snapper (*Lutjanus campechanus*) caught in our study on artificial reefs in the northern Gulf of Mexico in 2010. Numbers above bars indicate total number of fish caught for each age class.

from 1992 to 2007. The oldest reef (1992) was closest to a 2010 reef that we sampled, and many of the artificial reefs deployed in 2004 and 2007 were within 1.7 km of reefs in all 3 reef ages that we sampled in our study (Fig. 4). No significant correlations were detected between distance to other reefs and abundance (Pearson's $r$=−0.045, $P$=0.781), or mean age of red snapper (Pearson's $r$=0.026, $P$=0.88; Fig. 5).

## Discussion

### Evidence for production and attraction

Our study showed that older red snapper were associated with older artificial reefs. Previous studies have compared artificial reef age with estimates of density and size of resident reef fishes but have not examined reef fish age. For example, densities of reef fishes and larger sparids (*Diplodus sargus*, *Diplodus bellottii*, and *Diplodus vulgaris*) have been reported to be significantly higher at older habitats (Lindberg et al., 2006; Santos et al., 2011). Because length varies directly with age with these species up to the age of 3 years (Gordoa and Molí, 1997), it is likely that their age also increased with reef age as was observed with red snapper in our study.

The relation between reef age and fish age shown in our own and these other studies, along with the long-term residence of red snapper on artificial reefs shown in previous studies (Schroepfer and Szedlmayer 2006; Topping and Szedlmayer, 2011a), supports the hypothesis that artificial reefs enhance the production of red snapper (Szedlmayer and Shipp, 1994; Szedlmayer, 2007; Gallaway et al., 2009). If artificial reefs enhance a population and experience no fishing pressure, Powers et al. (2003) estimated that such reefs could increase production by 6.45 kg wet weight/10 $m^2$ in the first year after their deployment. Because the locations of the reefs in our study were not published, fishing mortality was limited and therefore had the potential to increase production.

It was also clear that attraction of fish plays an important role in the function of these artificial reefs. For example, fish older than the age of the reef were

present on the reefs that we sampled, including 2 of the oldest fish (19 and 14 years old) that were caught on the 2009 reefs. It is possible that larger, older red snapper become less dependent on particular reefs because of relief from predation pressure and may show greater movement among reef sites as they search for new prey resources (including young red snapper) on newly established reefs (Mudrak and Szedlmayer, 2012). However, although attraction is clear and accounts for both the initial recruitment of young fish and the presence of older red snapper, if attraction was the only function of artificial reefs, we would not expect a positive correlation between mean fish age and reef age. Instead, the age distribution of red snapper should be random or related to the proximity of nearby reefs. Hence, this study provides evidence that both attraction and production are important ecological functions of artificial reefs for red snapper populations in the northern Gulf of Mexico.

According to our study and several other studies, young fish (age-0 and age-1) will recruit to new habitat, usually small (1–7 $m^3$) artificial reefs (Gallaway et al., 2009; Szedlmayer, 2011; Mudrak and Szedlmayer, 2012). Many of these red snapper remain at such habitats for extended periods (up to several years; Szedlmayer,1997; Szedlmayer and Schroepfer, 2005; Schroepfer and Szedlmayer, 2006; Topping and Szedlmayer, 2011a, 2011b) and then begin to show greater movement as they become older and larger and are less vulnerable to predation (Gallaway et al., 2009). For example, on the basis of a 72% residency rate per year from telemetry studies (Topping and Szedlmayer, 2011a), and a mean of 45 age-1 recruits to new (1-year-old) reefs in our study, there would be ~18 age-5 red snapper per reef after 4 years. These estimates are similar to counts recorded for the 2006 reefs in our study, with a mean of 26 age-5 fish per reef (on the basis of proportions of age-5 red snapper among all fish captured from 2006 reefs, extrapolated to mean total densities on 2006 reefs). Also, these residency estimates based on telemetry are underestimates because the time that red snapper reside on a particular reef before being tagged is not included (Topping and Szedlmayer, 2011a). Laboratory and field studies indicate that these older age-5 red snapper may then competitively exclude and even cannibalize new recruits (Bailey et al., 2001; Piko and Szedlmayer, 2007; Mudrak and Szedlmayer, 2012), and perhaps contribute to the association between fish age and reef age. However, attraction may continue to play an important role as older fish that are better able to fend off aggression and cannibalism move to favorable habitats that still harbor abundant prey resources (Ouzts and Szedlmayer, 2003; Szedlmayer and Lee, 2004).

Several studies suggest that red snapper populations have been overfished and that habitat limitation was not the most important controlling factor that contributed to declines in abundance (Schirripa and Legault, 1999; Patterson et al., 2001b; Cowan et al., 2011). Clearly, there was significant fishing mortality of red snapper in the northern Gulf of Mexico (Gillig et al., 2000). However, if fishing mortality was the only limiting factor for red snapper and habitat was not important, we would not expect reef age to have significant effects on fish age (i.e., all reefs, whether fished or not, would show similar age distributions). Red snapper enter the fishery at around age 2 (minimum size: recreational=406 mm TL, commercial=330 mm TL), and the catch consists predominately of 2- to 4-year-old fish. These ages represented 59% ($n$=602) of the total catch in our study and indicate that fishing mortality was not limiting red snapper abundance on the reefs investigated in our study.

One substantial difference between our study, which suggests habitat limitation, and previous studies, which

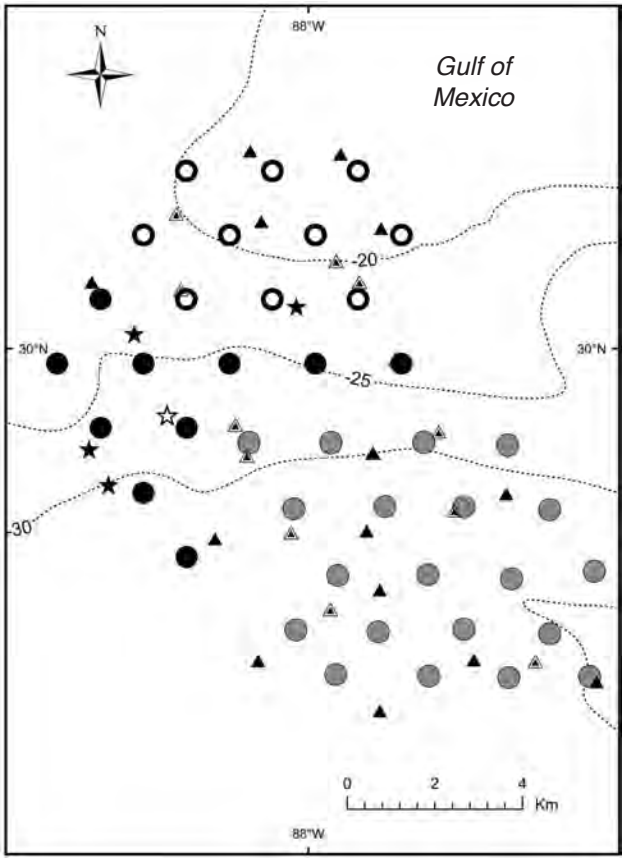


**Figure 4**

Map showing proximity of publicly known reefs to reefs sampled in 2010 in our study of red snapper (*Lutjanus campechanus*) on artificial reefs in the northern Gulf of Mexico. Note that the positions of the reefs sampled in our study were not released to the public. Study reefs: gray circles=reefs deployed in 2006; open circles=reefs deployed in 2009; and black circles=reefs deployed in 2010. Publicly known reefs: black stars=reefs of army tanks deployed in 1994–1995; black triangles=reefs made of concrete pyramids deployed in 2007; black and white triangles=pyramid reefs deployed in 2004; open star=barge deployed as a reef in 1994. Dotted lines indicate depth contours at 5-m intervals.

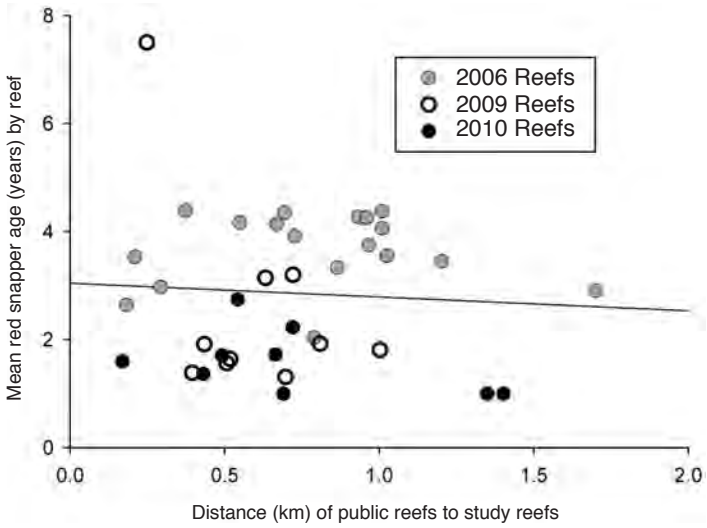


**Figure 5**

Comparison of mean age of red snapper (*Lutjanus campechanus*) caught in 2010 in our study of artificial reefs in the northern Gulf of Mexico with proximity to publicly known reefs <1.7 km from our sampled reefs, which were deployed in 2006, 2009, and 2010. Line is linear regression that showed no significant relation between red snapper age and distance to known reefs (Pearson's correlation coefficients [$r$]=0.026, $P$=0.88).

suggested fishing mortality limitation, was the use of fishery-independent data rather than fishery-dependent data. Although other studies used mainly fishery-dependent data on red snapper caught by sport and commercial fishermen (Szedlmayer and Shipp, 1994; Baker and Wilson, 2001; Patterson et al., 2001a; Wilson and Nieland, 2001), we used fishery-independent methods at unpublished artificial reef sites. These fishery-independent methods also allowed us to sample red snapper that were too small to be counted with fishery-dependent methods. In addition, fishing mortality at reef sites surveyed in our study was probably far more reduced than at known reefs because the locations of the artificial reefs that we sampled were unpublished and likely had limited access for fishing.

Several alternative factors, aside from reef age, could have affected the size and age of red snapper caught on the artificial reefs examined in our study. Additional prey may be one important factor that created differences in habitat value among reefs of different ages, and these differences may have resulted in larger, older fish at older reefs. If older reefs were providing more prey resources, we would expect that red snapper on these reefs would have higher growth rates, especially the relatively young (<10-year-old) individuals that have a nearly linear growth rate. Yet no significant differences in mean growth rates of red snapper were detected among the reefs sampled, despite their age differences. Even so, older reefs often have more well-developed epifaunal benthic communities that can influence habitat value (Redman and Szedlmayer, 2009), and this development might be expected for older artificial reefs like those in our study. If older reefs actually provide more prey resources or greater habitat complexity and shelter than younger reefs, attraction to these "better" reefs may account for some of the older ages and higher abundances of red snapper on older reefs. However, we still are left with the same conclusion: artificial reefs enhance red snapper production. One implication of our study is that habitat value may vary not only spatially (e.g., open versus structured habitats) but also temporally (e.g., new versus older, more "developed" reefs). Therefore, we need to include a temporal component to habitat value, whereby new artificial reefs may need time to develop before they start to enhance production.

Another factor that may have caused differences in the ages of fish among reefs was reef depth. The mean depth of the 2006 reefs was 30 m, but the mean depth of the 2009 reefs was 20 m, and there is some evidence that larger, older red snapper were more common in deeper offshore waters than in shallower nearshore waters (Render, 1995; Mitchell et al., 2004). However, comparisons of reefs with the same mean depth (30 m) and distance from shore (27 km) still showed significantly larger and older red snapper at the 2006 reefs than at the 2010 reefs. In addition, the distances among the reefs that were farthest apart were relatively smaller (14 km) than the distance across the continental shelf (110 km) where depth-related differences in size and age may be more apparent (Mitchell et al., 2004).

We also considered the possible emigration of larger, older red snapper from other reef sites or an effect of nearby reefs not sampled in our study. Proximity to other natural or artificial reefs has been shown in other studies to be an important factor that can affect density of reef fishes (Jessee et al., 1985; Sogard, 1989; Strelcheck et al., 2005; Shipley and Cowan, 2010). In our study, no significant relations were detected between proximity of our study reefs to other reefs and red snapper ages or abundance. In general, other artificial reefs were, for the most part, evenly distributed across our overall study area (Fig. 1) and would not be expected to bias red snapper age distribution to either younger or older reef sites in our study (Fig. 4).

### Comparison of collection methods

This study supports previous studies on the importance of using several collection methods to adequately estimate size and age distribution of red snapper on artificial reefs (Myers and Hoenig, 1997; McClanahan and Mangi, 2004; Szedlmayer, 2007; Wells et al., 2008a; Gallaway et al., 2009). Hook-and-line and fish-trap methods are known to be size selective, and red snapper caught in our study were consistently larger with hook-and-line than with fish traps. This difference occurred mostly because larger fish are able to swallow whole bait and smaller fish consume smaller portions. In addition, smaller fish are more likely to enter a trap, and larger fish may be limited by the size of a trap opening. The distinct size differences observed in our study also could have been influenced by differences in bait: the fish traps had squid in addition to Gulf menhaden, but the hook-and-line bait was strictly Gulf menhaden.

The divers' visual counts were used to estimate the red snapper remaining present on the reef after hook-and-line and trap sampling. At 2 sample sites, visual surveys were conducted a maximum of 30 days after our initial sampling because sharks were present during our initial sampling. Although it is possible that additional red snapper immigrated to the reef at these 2 sites within that 30-d time period, it is unlikely that enough fish recruited to cause a bias in our abundance estimates. This notion is supported by evidence from telemetry studies of high site fidelity for red snapper (72% residency rate per year; Topping and Szedlmayer 2011a) and by the fact that diver counts typically underestimate abundance. In comparison with results from visual surveys, counts were significantly lower from the video and photographic methods. These differences mostly were due to fish swimming throughout the part of the water column that was not within the field of view of the cameras. A bait jar was used with the intent to attract fish closer to the cameras and reduce these differences, but it had only limited success. Comparisons of counts from remote, underwater, baited cameras with those from scuba-diver surveys have shown similar results, with diver visual surveys showing the greatest abundance and diversity of fishes among the methods compared (Tessier et al., 2005; Langlois et al., 2006). Because counts from photographs and video recordings were lower, we used the divers' counts in our estimates of red snapper density for each reef. However, the photographs and video recordings were still important in verifying species identification.

### Artificial reef succession and red snapper densities

The reefs in our study supported higher densities of red snapper than reefs sampled in previous studies. In a demolition study of 9 offshore oil platforms, mean density of red snapper was 0.24 individuals/$m^3$ (Gitschlag et al.[3]). In another study of platforms where stationary hydroacoustics and visual diver counts were used, mean density was 0.16 individuals/$m^3$ (Stanley and Wilson, 1997). Substantially higher than these platform estimates, the estimates from our study of total density of red snapper were 1.6–47.9 individuals/$m^3$, with a mean of 15.7 individuals/$m^3$. One difference between our study and these previous studies was the larger size of the platforms surveyed which also encompassed the entire water column. The volume of these platforms varied: 1037–29,860 $m^3$ (Gitschlag et al.[3]) and 19,800 $m^3$ (Stanley and Wilson, 1997); in contrast, all reefs in our study had a volume of 6.9 $m^3$. However, even if the volume estimates of these platforms were reduced by two-thirds (to account for the habitat in the upper water column that red snapper typically do not use), mean densities of red snapper on platforms would be 0.73 individuals/$m^3$ (Gitschlag et al., 2000[3]) and 0.47 individuals/$m^3$ (Stanley and Wilson, 1997)—levels that would still be considerably less than the estimates from our study of artificial reefs formed from metal cages.

These differences in the density of red snapper among artificial habitats may be due to higher habitat complexity and associated enhanced protection from predation, additional prey resources, and fewer resident larger predators at cage reefs than at platforms. The densities of lemon damselfish (*Pomacentrus moluccensis*) found on highly complex coral reefs with predators were similar to densities found on reefs where predators were excluded, indicating that these complex coral habitats provided protection for this species (Beukers and Jones, 1997). Similarly, higher densities of young (age-0 and age-1) red snapper were shown to inhabit increasing complex reef structure (Lingo and Szedlmayer, 2006; Piko and Szedlmayer, 2007) with an absence of predators (Mudrak and Szedlmayer, 2012). At large structures, such as platforms, complexity probably is lower and the abundance of potential predators likely is higher than at the smaller artificial reefs used in our study. Therefore, these larger reefs may not support as

[3] Gitschlag, G. R., M. J. Schirripa, and J. E. Powers. 2001. Estimation of fisheries impacts due to underwater explosives used to sever and salvage oil and gas platforms in the U. S. Gulf of Mexico. OCS Study MMS 2000–087, 94 p. Final report prepared by the National Marine Fisheries Service for the U.S. Dept. of the Interior, Minerals Mgmt. Service, Gulf of Mexico OCS Region, New Orleans, LA. [Available from http://www.boemre.gov/itd/abstracts/2000-087a.html.]

many red snapper per unit of volume as more complex, smaller structures. For example, an inverse relation was shown between the abundance of red snapper and the density of offshore platforms—possibly a result of greater exposure of young red snapper to predators that aggregate around such platforms (Gallaway et al., 1999). The higher densities of red snapper on the reefs found in our study indicate that these artificial reefs may provide red snapper enhanced protection from predation as well as greater overall carrying capacity.

## Conclusions

The significant differences observed in ages of red snapper among artificial reefs of different ages provide support for the hypothesis that artificial reefs enhance red snapper production. Although it is obvious that red snapper are attracted to artificial reefs, especially as young new recruits, and older red snapper may show more transient behavior among reefs, it appears that many red snapper reside on particular reefs for several years and that artificial reefs may allow for higher biomass of red snapper by providing additional reef habitat. However, at some point, the number of artificial reefs placed in the northern Gulf of Mexico may surpass the region's carrying capacity and the addition of more artificial structures will no longer increase the population of red snapper. Future research that examines the carrying capacities of artificial habitats is needed and would provide information on when an overall environmental carrying capacity for red snapper has been reached. Additional fishery-independent studies throughout the northern Gulf of Mexico, with methods similar to those used in our study, would be useful for making better management decisions regarding catch limits for red snapper.

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# An evaluation of the benefits of artificial habitats for red snapper, *Lutjanus campechanus,* in the northeast Gulf of Mexico

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ABSTRACT

Evidence for red snapper, *Lutjanus campechanus,* production from artificial habitats has been difficult to obtain. The benefits of such habitats for red snapper were evaluated by examining red snapper diets, predator exclusions, habitat complexity, and epibenthic communities in association with artificial habitats over a 10 year period. Also examined were movement patterns from ultrasonic telemetry, and population parameters estimated from fishery independent methods. These studies suggested that red snapper: 1) had a high affinity for artificial habitats, 2) showed consistent feeding on reef prey types, 3) were significantly more abundant on habitats with available prey, 4) showed a significant correlation between abundance and habitat complexity, 5) showed long term residency with some tracked over two years, and 6) abundance significantly increased when predators were excluded. In addition, population status of red snapper off coastal Alabama based on a fishery independent survey of 94 artificial habitats, using fish traps, diver surveys, and otolith aging suggested a better condition compared to previous population assessments. Collectively these results suggest that artificial habitats in the northern Gulf of Mexico contribute significantly to the production of red snapper.

KEYWORDS: red snapper, otolith aging, predator exclusion, diet, artificial reef

## Una evaluación de los beneficios de los hábitat artificiales del huachinango del Golfo*, Lutjanus campechanus*, en el noreste del Golfo de México

La evidencia del huachinango del Golfo, *Lutjanus campechanus*, en cuanto a su producción en hábitat artificiales ha sido difícil de obtener. Los beneficios de dichos hábitat para el huachinango del Golfo fueron evaluados examinando sus dietas, la exclusión de depredadores, la complejidad del hábitat, y las comunidades epibénticas asociadas con los hábitats artificiales por un periodo de 10 años. También fueron examinados los patrones de movimiento de la telemetría ultrasónica, y los parámetros de la población, estimados, usando métodos independientes de los de pesca. Estos estudios indicaron que el huachinango del Golfo: 1) tiene una alta afinidad con los hábitat artificiales, 2) mostró alimentación consistente con tipos de presas del arrecife, 3) fueron significantemente más abundantes en hábitat con mayor número de presas disponibles, 4) mostró números significantemente más altos en hábitat con una elevada complejidad, 5) mostró residencia a largo plazo (algunos rastreados por más de dos años), y 6) mostró significantes efectos de exclusión de depredadores. Además, el estatus de la población del huachinango del golfo fuera de la costa de Alabama, basado en un sondeo de pesca independiente de 94 hábitat artificiales, usando trampas de pescar, encuestas de buceo , y otolite de edad sugirieron una mejor condición, en comparación a cálculos o evaluaciones previas. Colectivamente, estos resultados indicaron que los hábitat artificiales en el golfo norte de México contribuyen significativamente a la producción del huachinango del golfo.

PALABRAS CLAVE: huachinango del Golfo, otolite de edad, exclusión de depredadores, dieta, arrecife artificial

# INTRODUCTION

In the aquatic environment almost any material that adds some topographical relief will attract fish and increase catch (D'Itri 1985). In coastal Alabama, U.S.A., this concept has been applied extensively with the placement of artificial habitats (Minton and Heath 1998). However, we know little about the actual effects of artificial habitats on wider scales, such as local fish stocks. If artificial habitats function mainly through attraction then we may be driving fish stocks towards faster depletion. In contrast, if artificial habitats function by increasing productivity then our habitat building efforts would be helping dwindling fish stocks. Despite the vast amount of literature on artificial habitats this critical question has not yet been adequately answered (Bohnsack 1989, Grossman *et al.* 1997, Bortone 1998). To address such questions, over a 10 year period we have examined many aspects of the life history and ecology of red snapper, *Lutjanus campechanus*, in the northeast Gulf of Mexico, and how this species relates to artificial habitats.

Red snapper have historically supported an important commercial and recreational fishery (Camber 1955) and are closely associated with structured artificial habitats (Szedlmayer 1997, Szedlmayer and Lee 2004, Szedlmayer and Schroepfer 2005, Lingo and Szedlmayer 2006, Schroepfer and Szedlmayer 2006, Piko and Szedlmayer 2007). In the northeast Gulf of Mexico most natural habitat is relatively flat open mud/sand/shell substrata with uncommon or rare complex natural rock reef habitats with associated reef biota (Parker *et al.* 1983, Schroeder *et al.* 1988, Mitchell *et al.* 1992, 1993). Over the last 50 years part of this shelf habitat has been altered with extensive building of artificial habitats. In the northern Gulf of Mexico, more than 14,000 artificial habitats have been built including thousands of oil and gas platforms (Minton and Heath 1998). These artificial habitats show large accumulations of reef fish species, especially red snapper (Lingo and Szedlmayer 2006; Szedlmayer *et al.* 2004). Again, the important question concerning this area of the northeast Gulf, is whether or not the reef building activities are enhancing shelf habitat through increased fish production or causing detrimental effects, *i.e.*, overfishing due to ease of locating concentrated fish stocks (Grossman *et al.* 1997).

## Life History and Habitats

Juvenile red snapper first settled from the plankton at around 17 mm TL and 26 d after hatch, and showed significant preference for shell habitats in field trawl surveys (Szedlmayer and Conti 1999, Rooker *et al*. 2004) and laboratory studies (Szedlmayer and Howe 1997). Relic-shell habitat was identified as a primary nursery location of juvenile red snapper, with mean CPUE at 4000 fish $h^{-1}$ trawl time, which far exceeded CPUE from nearby habitats that lacked relic-shell and all previous estimates (Szedlmayer and Conti 1999). Also, SCUBA observations of several low relief (approx. 20 cm) artificial substrates including oyster shells, showed significant attraction of juvenile red snapper to all sites (Workman and Foster 1994, Lingo and Szedlmayer 2006, Piko and Szedlmayer 2007). In visual observations from the above studies we observed many newly settled recruits at just under 30 mm TL, all of which were associated with some type of structure, similar to observations by Workman and Foster (1994).

After their initial settlement in July and August, age-0 red snapper will quickly outgrow their initial habitat and seek larger more structured habitats (Szedlmayer and Conti 1999, Rooker *et al*. 2004 Szedlmayer and Lee 2004). These observation of age-0 red snapper showing increased numbers on 1 $m^3$ concrete habitats in the fall suggested a recruitment to higher relief structure at earlier ages compared to previous reports that suggested recruitment to “higher” structure only after reaching age-1 or older (Render 1995, Gallaway *et al*. 1999).

One of the most obvious reasons for moving to more structured habitats would be to reduce predation pressure. For example, when age-0 first settle at around 20 mm TL, smaller structure such as oyster shells would provide adequate shelter, but as size increases in the fall, fish need increased “hole”

size (Hixon and Beets 1989). In studies with predator exclusion cages, there was a clear predator exclusion effect, where shell habitats with predator exclusion cages had significantly more age-0 red snapper. Artificial habitat complexity was also associated with higher abundance of red snapper and several other species (Lingo and Szedlmayer 2006, Piko and Szedlmayer 2007).

From these life history studies it is clear that red snapper are closely associated with artificial habitats. They recruit to such structures at an early age, and probably benefit from increased complexity and potential predator protection.

**Red Snapper Diets**

One of the most important questions concerning red snapper and the function of artificial habitats must address feeding responses to changing habitats. When red snapper first settle they forage on prey types from open sand-mud habitats. When fish shifted to more structured habitats they show a corresponding shift to more feeding on reef prey types (Szedlmayer and Lee 2004). As red snapper grow they continue this shift to significant feeding on reef prey types but will also continue feeding on almost any available prey. One aspect that may confuse the question of red snapper feeding types is that red snapper show significant diel shifts with feeding on different prey types depending on day or nighttime capture (Ouzts and Szedlmayer 2003). Another aspect that makes feeding studies difficult is that red snapper stomachs frequently are empty due to barotropic stress, or large numbers fish prey are unidentifiable due to advanced digestion. However, SCUBA observation of large schools (> 500) of mixed species of tomtate *Haemulon aurolineatum*, vermilion snapper *Rhomboplites aurorubens*, and round scad *Decapterus punctatus* at small sizes (around 60 mm TL) on many artificial habitats, suggests that reef prey fish were available (Szedlmayer unpublished data). Future diet studies that are able to positively identify prey species (*e.g*., DNA) may confirm increased feeding on these reef prey types. As red snapper continue to grow older and larger there exist little quantitative information on diets. At present we know of no studies that have quantitatively examined the diets of larger older red snapper, for example fish > 900 mm TL.

In another study concerning artificial habitats and red snapper potential prey items, the recruitment of juvenile red snapper was compared between artificial habitats with and without epibenthic prey communities (Redman and Szedlmayer In review). Copper-based antifouling paint was used to prevent the development of epibenthic organisms and red snapper abundance was compared between habitats with (n = 20) and without (n = 20) these communities over a 12 month period. Red snapper preferred habitats with epibenthic communities, and were significantly larger on these habitats. This study showed that potential food resources affected the recruitment of juvenile red snapper to artificial habitats in the northern Gulf of Mexico. Thus, the attraction of fishes to artificial habitats was not just in response to shelter, but also the associated epibenthic communities.

Conclusions from diet studies showed that red snapper utilized "reef" prey types that would not have been available without the construction of artificial habitats, and also showed significantly higher red snapper abundances on artificial habitats that had epibenthic communities compared to identical habitats that lacked these communities.

**Red Snapper Movements**

Early studies of red snapper movement with conventional t-bar or anchor tags suggested long-term residence around hard bottom structures (Camber 1955, Moseley 1966, Bradley and Bryan 1975). Similarly, mark-recapture studies of red snapper have shown little movement and high site fidelity around artificial habitats. Beaumariage (1969) tagged 1,372 red snapper and 97% of recaptured tagged fish stayed at the original tagging site. Szedlmayer and Shipp (1994) tagged 1,155 red snapper and 76% of recaptured tagged fish stayed within 2 km. Watterson *et al*. (1998) tagged 1,604 red snapper and 61% of recaptured tagged fish stayed at the tagging site.

Some studies have also suggested greater movements of 5-275 km for tagged red snapper which would reduce the importance of artificial reefs. For example, Watterson *et al*. (1998) reported movements up to 265 km, and attributed this movement with the occurrence of hurricane Opal. Patterson *et al*. (2001) tagged 2,932 red snapper and observed that mean distance moved was 29 km and maximum distance moved was 352 km. However, mark-recapture studies with conventional tags assume the reliability of reporting date of capture, and most importantly the reliability of reporting site of capture from external sources (Schwartz 2000; Denson *et al*. 2002). Ultrasonic telemetry removed these assumptions and showed that red snapper were resident on artificial habitats in the northeastern Gulf of Mexico for 17-597 d (Szedlmayer 1997; Szedlmayer and Schroepfer 2005; Schroepfer and Szedlmayer 2006).

Red snapper may in fact show several different movement patterns depending on life stage. Clearly age-0 red snapper settle to benthic habitats early (26 d) but then move to more structured habitats in the fall of their first year (Szedlmayer and Conti 1999; Szedlmayer and Lee 2004). As fish grow during the first and second years they may still be in the process of seeking a suitable habitat. This type of behavior might result in shorter residence time estimates and longer distances between mark recaptures (Watterson *et al*. 1998; Patterson *et al*. 2001). Then as fish become larger and older (>2 years), they are better able to establish longer residence on more suitable artificial habitats (Schroepfer and Szedlmayer 2006). More suitable habitat is defined here as providing adequate protection as well as food resources, i.e., not all artificial habitats are alike. Then, as fish reach very large sizes (e.g., > 900 mm TL) they are no longer limited by predation pressure and may be able to move over wide ranging habitats with relative impunity to predation. Some evidence for such habitat shifts for older larger red snapper is supported by open habitat longline catches of high numbers of very large older red snapper (Henwood *et al*. 2004, Mitchell *et al*. 2004). Little other direct information from tagging studies has been obtained for larger older red snapper.

In conclusion, young to intermediate age red snapper (approximately 3 to 10 year old fish) show high affinity for artificial habitats with long term residence. What movement patterns will be shown for larger older fish (for example > 15 years) is still speculative.

**Growth and Population Assessment**

Accurate stock assessment is critical to the management of marine reef fish populations in the northeast Gulf of Mexico. This assessment task often proves difficult because of the inherent difficulty of sampling reef fishes with complicated life history patterns, and cryptic habitats. These sampling problems have little to do with assessment effort, i.e., since the early 90's there have been extensive stock assessments for this species. Previous stock assessments have suggested an overfished red snapper stock, and without a reduction in the annual total allowable catch, the red snapper stock will not reach the required target level (F/Fmsy and B/Bmsy) by the year 2032 (DEIS 2006).

One difficulty was that almost all previous stock assessments were based on fishery dependent landing data rather than fishery independent surveys (Goodyear 1995, Schirripa and Legault 1999, Cass-Calay and Ortiz 2004, Porch 2004). This problem has been well recognized in the fisheries literature. "Catch per unit effort can vary over time in commercial and recreational fisheries, is subject to fishers' optimizing behaviors, and is not usually the most appropriate index" (Committee on Fish Stock Assessment Methods, Natural Research Council, 1998). Also, they state "fishery independent surveys offer the best opportunity for controlling sampling conditions by maintaining consistent gear, spatial coverage, timing and survey design". In a fishery independent long-line survey many larger older-aged red snapper were collected (Henwood *et al*. 2004, Mitchell *et al*. 2004). These collections were difficult to integrate into present stock assessments, yet they may indicate that red snapper stocks may be in better condition than suggested by past assessments. In the present study, several data sets were used to estimate red snapper abundance, age frequency, mortality and population status off coastal Alabama. SCUBA surveys of age-0 and age-1 red snapper abundance on artificial shell/block nursery habitats

were used to estimate juvenile mortality rates (320 shell/block nursery habitats from 1998 through 2002; Lingo and Szedlmayer 2006; Piko and Szedlmayer 2007). Mark-recapture studies were used to estimate fishing mortality (Szedlmayer and Shipp 1994), and fishery independent collections with fish traps, hook-and-line, and SCUBA visual surveys were used to estimate red snapper population parameters from artificial habitats (Szedlmayer *et al*. 2004).

Based on a total of 649 SCUBA surveys on these shell/block habitats, mean annual total mortality Z = 2.3, for age-0 to age-1 red snapper, similar to previous estimates of Z = 1.98 (Nichols *et al*. 2005) and Z = 2.12 (Nance 1998, Fig. 1). Previous estimates of trawl fishing mortality for age-0 to age-1 were relatively high, up to F = 1.38 (Nichols *et al*. 2005). With reduced trawling due to a fishing fleet reduction lower values may be applied for age-0 fish (F = 0.4 used in the present model, lower than F = 0.18 used in past stock assessments, C. Porch, NMFS, pers. comm.).

We used the same mortality rates for age-1 to age-2 used in past stock assessments (C. Porch NMFS, pers. comm). Fishing mortality rates for age 2 to 54 were based on past mark recapture studies. From May 1990 to Oct 1991, Szedlmayer and Shipp (1994) tagged and released 1,155 red snapper and recaptured 146 red snapper, and after accounting for tag shedding and fisher non-reporting annual F $\pm$ SD = 0.19 $\pm$ 0.16. From 1999 to 2004, ages were estimated from otoliths for 3,413 fish from 94 different artificial habitats, and from these ages total annual mortality was estimated at Z = 0.54 for red snapper greater than age-1 (Fig. 2). Growth was fitted to the von Bertalanffy relation where TL = 923 (1 - $e^{-0.17(age+0.79)}$ ) and Log wt = -0.471 + 2.96 log TL ($R^2$ = 0.98, N = 3,451, Szedlmayer *et al*. 2004). The most difficult parameter to estimate is natural mortality and values have widely ranged from 0.01 to 0.4 (Nelson and Manooch 1982; Schirripa and Legault 1999). In the present study, natural mortality was based on the difference between total mortality and fishing mortality, with the present estimated M = 1.9 for age-0, M = 0.60 for age 1, and M = 0.35 for > age-2 (Table 1). Combining ages, growth rates, mortalities and length-weight relations, the estimated transitional spawning potential ratio = 0.21 at F = 0.19, and maximum yield was attained when F was increased to 0.3 (Slipke and Maceina 2005; Figs. 3 and 4).

These model results suggested that red snapper populations off coastal Alabama may be in better condition compared to past assessments**.** Based on these fishery independent data red snapper stocks off coastal Alabama may be at stock levels needed for a sustainable fishery. For example, although considered overfished since the early 90's there has been little indications of decline in landings independent of catch level restrictions. One difficulty in this assessment was that data only originated from coastal Alabama and Mississippi. Clearly there may be significant differences in comparison to other areas such as Louisiana or Texas. One aspect that may account for assessment differences was that off coastal Alabama the artificial habitat program was by far the largest in the nation with some 15,000 artificial habitats in designated habitat building zones. Such correlations between artificial habitats and population estimates are difficult to prove, but combined with other more direct ecological measures, adds further to the evidence that artificial habitats have positively affected red snapper stocks off coastal Alabama.

**Conclusions**

Artificial habitats off coastal Alabama have enhanced red snapper stocks, based on the collective studies over more than 10 years showing 1) early recruitment to structured habitats, 2) high residence and affinity for structured habitats, 3) diet composition showing significant reef prey in combination with other prey types, 4) growth rates showing similar plots as previous estimates, and 5) a fishery independent survey of artificial habitats that suggested a better local stock condition compared to past estimates.

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Table 1. Red snapper mortality estimates that were used in tSPR and yield models.

| Class | Z | M | F |
|---|---|---|---|
| age 0 | 2.3 | 1.96 | 0.35 |
| age -1 | 0.76 | 0.60 | 0.16 |
| age 2 - 54 | 0.54 | 0.35 | 0.19 |

LIST OF FIGURES

Figure 1. Age-0 to age-1 density estimates for red snapper from SCUBA visual surveys. Number above bars are mortality estimates.
Figure 2. Total mortality estimate from fishery independent age frequency distribution of red snapper in the northeast Gulf of Mexico.
Figure 4. Transitional spawning potential ration (tSPR) relation to instantaneous fishing mortality (F) from fishery independent age frequency distribution of red snapper in the northeast Gulf of Mexico.
Figure 5. Yield (per 1 million recruits) relation to instantaneous fishing mortality (F) from fishery independent age frequency distribution of red snapper in the northeast Gulf of Mexico.

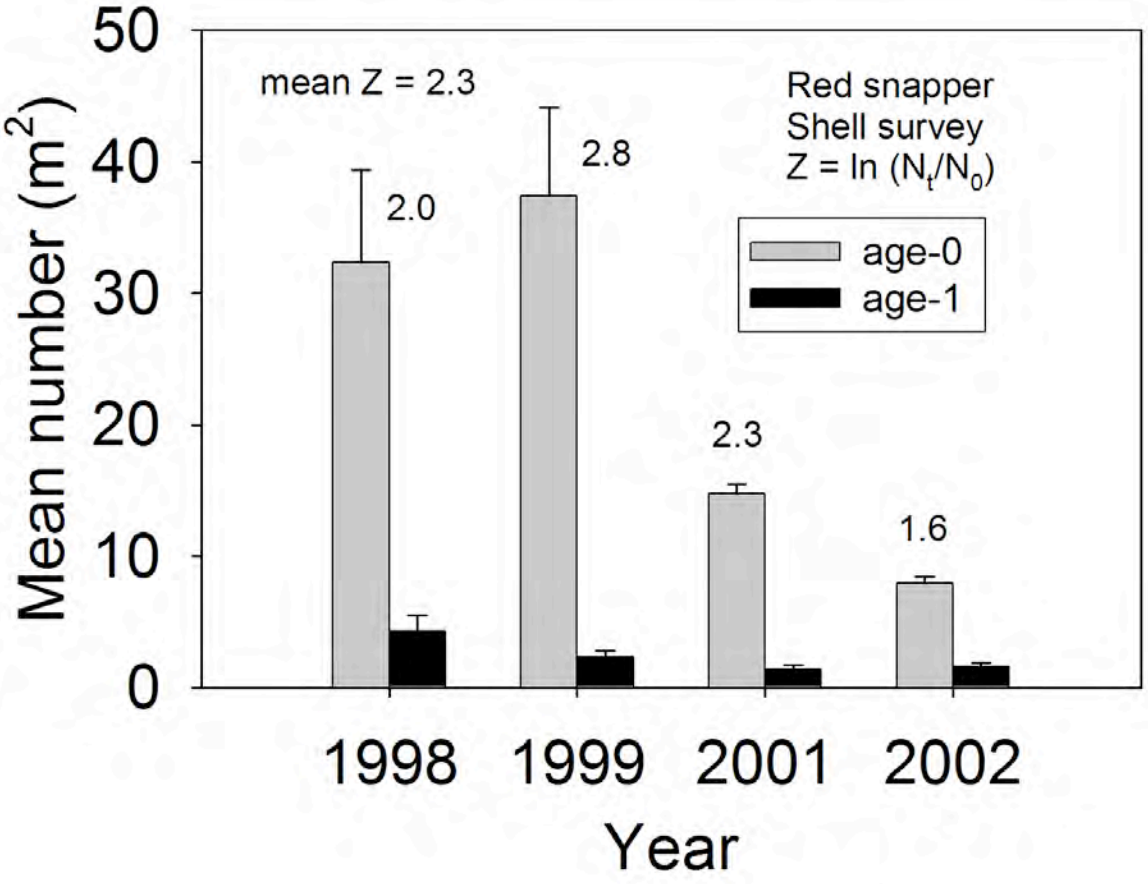
mean Z = 2.3
Red snapper
Shell survey
Z = ln (N_t/N_0)
age-0
age-1
2.0
2.8
2.3
1.6
Mean number (m^2)
50
40
30
20
10
0
1998
1999
2001
2002
Year

Figure 1.

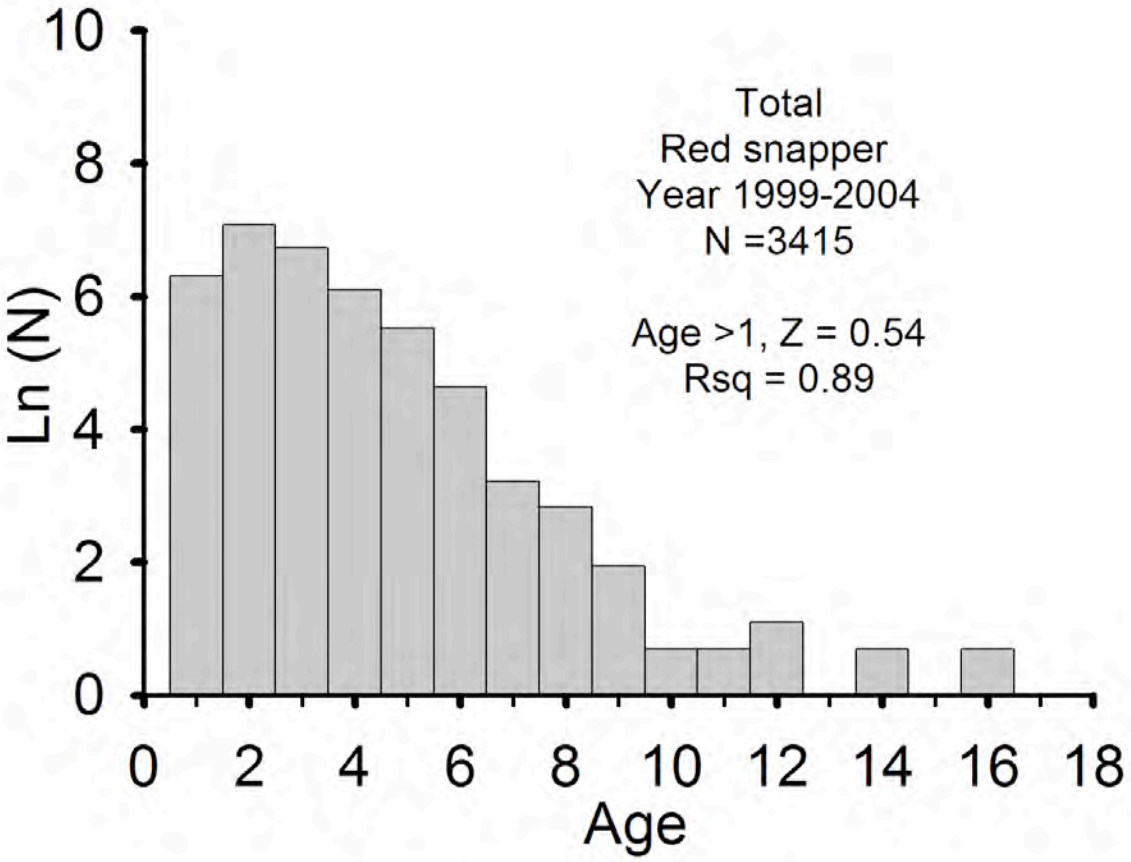
Total
Red snapper
Year 1999-2004
N =3415
Age >1, Z = 0.54
Rsq = 0.89
Ln (N)
Age
0
2
4
6
8
10
12
14
16
18

Figure 2.

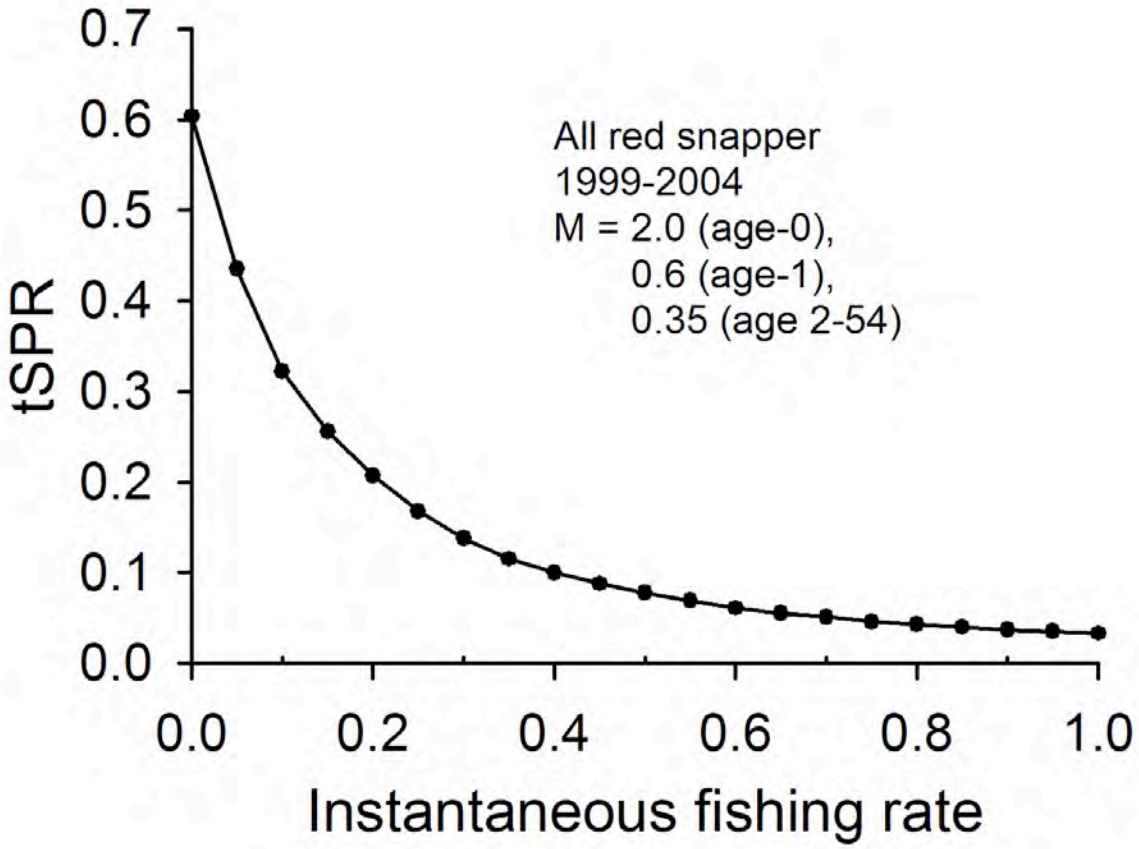
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
tSPR
All red snapper
1999-2004
M = 2.0 (age-0),
0.6 (age-1),
0.35 (age 2-54)
0.0
0.2
0.4
0.6
0.8
1.0
Instantaneous fishing rate

Figure 3.

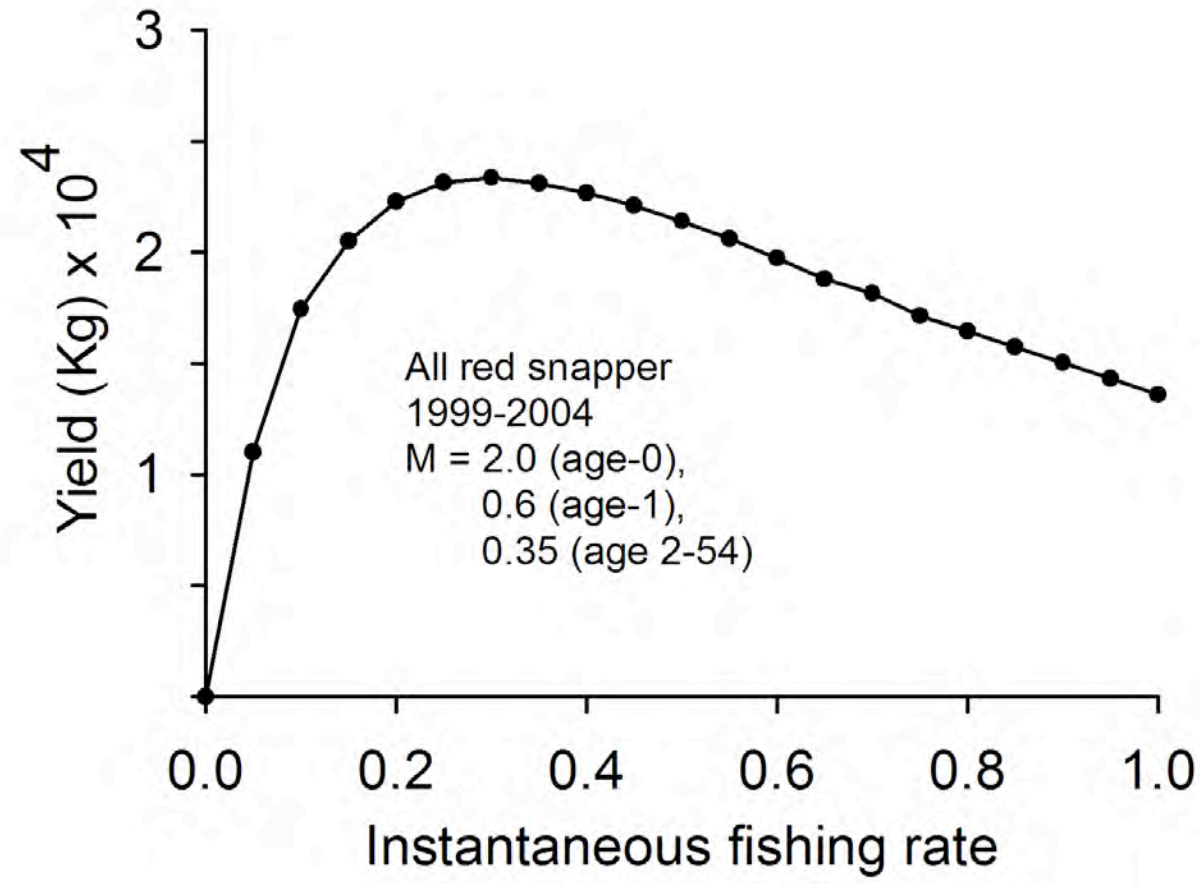
Yield (Kg) x 10^4
3
2
1
All red snapper
1999-2004
M = 2.0 (age-0),
0.6 (age-1),
0.35 (age 2-54)
0.0
0.2
0.4
0.6
0.8
1.0
Instantaneous fishing rate

Figure 4.

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# Estimated enhancement of fish production resulting from restoring oyster reef habitat: quantitative valuation

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ABSTRACT: We reviewed studies providing quantitative measurements of abundance of fishes and large mobile crustaceans on oyster reefs and on nearby sedimentary habitat in the southeast United States. For each species, we compared density by size (age) class on oyster reefs and sedimentary bottom as a means of estimating the degree to which restoration of oyster reef on sedimentary bottom could augment abundances. By applying published information on growth rates of each species and a combination of empirical data and published information on age-specific survivorship, we calculated the per-unit-area enhancement of production of fishes and large mobile crustaceans expected from the addition of oyster reef habitat. For this calculation, we gave the reef habitat full credit for the expected lifetime production of species whose recruitment was judged to be limited by the area of oyster reefs based on nearly exclusive association of recruits to reefs. For species that were only modestly enhanced in abundance by oyster reefs, we gave the reef credit for the fraction of production that is derived from consumption of reef-associated prey, using a combination of gut content data and natural history information. This combination of analyses and calculations revealed that 10 $m^2$ of restored oyster reef in the southeast United States is expected to yield an additional 2.6 kg $yr^{-1}$ of production of fish and large mobile crustaceans for the functional lifetime of the reef. Because the reef is biogenic and self-sustaining, the lifetime of a reef protected from bottom-disturbing fishing gear is limited by intense storms or sedimentation. A reef lasting 20 to 30 yr would be expected to augment fish and large mobile crustacean production by a cumulative amount of 38 to 50 kg 10 $m^{-2}$, discounted to present-day value. This set of calculations assumes that oyster reef habitat now limits production of reef-associated fish and crustaceans in the southeast United States. This assumption seems reasonable based on the tight associations of so many fishes with reef-dependent prey, and the depletion of reef habitat over the past century.

KEY WORDS: Habitat restoration · Oyster reef · Fish production · Mitigation · Restoration scaling · Essential fish habitat

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## INTRODUCTION

The application of ecology to achieve explicit goals in conservation and restoration represents a challenge to the discipline, and typically demands novel syntheses of relevant data and conceptual theory (Carpenter & Kitchell 1993, Peterson 1993, Lawton 1996). Because of societal demands to compensate for growing degradation of natural resources on land (Vitousek et al. 1997) and in the sea (Botsford et al. 1997), recent growth in the practice of restoration has been so dramatic that restoration ecology is anticipated to become a dominant focus of environmental science of the new century (Wilson 1992, Hobbs & Harris 2001). Ecological restorations have generally proceeded faster than the development of the theoretical and conceptual bases which support them (Allen et al. 1997, Palmer et al. 1997, van Diggelen et al. 2001). While the history of

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restoration of wetlands, terrestrial plant systems, salt marshes, and seagrass beds is relatively long (Jordan et al. 1987, Thayer 1992), restoration of marine biogenic habitats created by animals, such as corals, oysters, mussels, polychaetes, and vermetid gatropods, is a new development (Coen & Luckenbach 2000). For oyster reefs, even their wide recognition as an important biogenic habitat rather than merely a commodity to exploit is very recent (Lenihan & Peterson 1998).

Oyster reef habitat provides numerous important ecosystem services, which have only recently been documented and quantified. Oyster reefs serve as important biogenic habitat for benthic invertebrates (Wells 1961, Zimmerman et al. 1989) as well as fishes and mobile crustaceans (Bahr & Lanier 1981, Breitburg 1999, Coen et al. 1999, Lenihan et al. 2001). Through their filtration activities, oysters and other suspension-feeding bivalves also help counteract impacts of estuarine eutrophication (Jackson et al. 2001). Feeding oysters remove suspended inorganics, phytoplankton, and detrital particles, thereby reducing turbidity and improving water quality (Dame 1996). Biodeposits from feces and pseudofeces of oysters accumulate around reefs and induce denitrification (Newell et al. 2002). Oyster reefs sequester carbon in the form of calcium carbonate of the accumulating shell matrix (Hargis & Haven 1999), and thus contribute to global carbon budgets. Through their removal of organic particles in the water column, oysters divert energy to benthic food chains and depress pelagic energy flows that may otherwise lead to noxious sea nettles (Newell 1988). Furthermore, the physical structure of a fringing oyster reef can serve to protect salt marsh habitat by dissipating erosive wave energy (Meyer et al. 1996). Oysters and the reefs that they build have been depleted dramatically in many estuaries of the southeast USA and the world (Rothschild et al. 1994, Lenihan & Peterson 1998), motivating restoration efforts.

In part because of the short history of recognition of oyster reefs as important fish habitat, no estimates have been generated of how much additional fish production might be reasonably expected from restoring an oyster reef. Such an understanding is important in designing restoration projects to compensate for losses in fish production from chemical spills or some other environmental incident. In the USA, the National Oceanographic and Atmospheric Administration (NOAA) and other natural resource trustees use 'habitat equivalency analysis' to determine how to scale a restoration project to match, and therefore compensate for, the quantified injury to natural resources (e.g. NOAA 1997, Fonseca et al. 2000). This process seeks to replace lost ecosystem services, which are commonly based upon the lost production of higher trophic levels, such as fish and large mobile crustaceans. Losses include not only the biomass killed but also the interim losses associated with production foregone that would have been expected had those individuals been able to live their full natural life spans (French 1999).

Quantifying the expected enhancement of production by fish and large mobile crustaceans from creation of an oyster reef requires consideration of some of the most fundamental questions in fisheries ecology. First, one must address whether the recruitment of any species of fish is limited by the extent of available reef habitat. If addition of reef habitat serves to overcome a survival bottleneck in the early life history of any species, then installation of additional reefs would promote a numerical response of enhanced recruitment in those species. Because oyster reef habitat has declined dramatically by 2 orders of magnitude in many estuaries of the southeastern USA (Rothschild et al. 1994, Lenihan & Peterson 1998), we assume that any species exhibiting greatly enhanced abundance of recruits on reefs, relative to nearby unstructured sedimentary habitats, is limited in recruitment by oyster reef area. By recruitment, we adopt the marine ecologists' usage referring to individuals surviving early post-settlement mortality to a size that can be reliably censused (Doherty & Williams 1988). Second, new reefs may enhance fish production by providing spatial refuges from predation and alleviating food limitation through producing reef-associated prey resources. This response then enhances fish production, not by adding new fish to the system, but rather by enhancing survival and subsidizing growth of individuals already present in the regional population and thereby producing gains in fish production. The enhanced survival that may result from provision of structural refuges from predation (Hixon 1998) is incorporated into both of these measures of reef impact on fish production, because enhanced densities of both recruits and older fishes on reefs reflect effects of the reef on survival.

Here we utilize these concepts of habitat and food limitation on fish production on oyster reefs to estimate the augmented production of fish and large mobile crustaceans expected per unit area of created oyster reef. We focus our analysis on southwest Florida to develop information that would allow compensation for losses of fish production arising from an acidic process water spill in a Tampa Bay tributary. Losses of production by fish, shrimp, and crabs from that spill had been determined by sampling the numbers of dead organisms of each species by age class to estimate the immediate loss of biomass, and then using published survival and age-specific growth curves to calculate the future production foregone by their untimely loss (French 1999). We follow this same approach of calculating the ecosystem service of fish production provided by installation of oyster reefs so as

to allow losses to be matched to gains from restoration in an identical currency (a habitat equivalency analysis: Fonseca et al. 2000). To develop our estimates, we draw upon data from available published and gray literature from the southeast USA, thereby rendering the calculations applicable to a broad biogeographic region. This approach should be transferable to quantifying oyster reef services elsewhere.

## MATERIALS AND METHODS

**Overview.** To quantify the enhancement in fish and mobile crustacean production expected per unit area of added oyster reef habitat, we adopted the following procedure (Fig. 1) to estimate the contributions by (1) species limited in recruitment by habitat area (termed recruitment-enhanced), and (2) species limited in production by reef refuges from predation and available food (growth-enhanced). We synthesized results of available empirical, quantitative studies from the southeast USA to estimate the magnitude of density enhancement for each species of fish and mobile crustacean on oyster reefs relative to unstructured sedimentary habitat. First, species showing no numerical association with reefs made no contribution to our estimate of enhancement of fish production by reefs. Second, we identified species whose recruitment was habitat-limited based on nearly exclusive association of recruits with oyster reefs instead of mud/sand habitat, and on life-history information indicating obligate association with structural features of benthic habitat. The remaining species formed a third class that was not limited in recruitment by reef habitat but whose growth and survival was limited by reef-associated resources, as judged by significant augmentation of abundance on oyster reefs as opposed to mud/sand habitats. We then calculated the average augmentation of abundance per unit reef area by species and by age class within species. Published species-specific growth and survivorship parameters were then used to convert the augmented abundance by age class into expected enhancement of lifetime production for each species. For each species judged not to be limited in recruitment by reef area, but instead limited in production, we used dietary information to calculate an index of reef exclusivity in feeding so as to credit the oyster reef for only that fraction of growth derived from

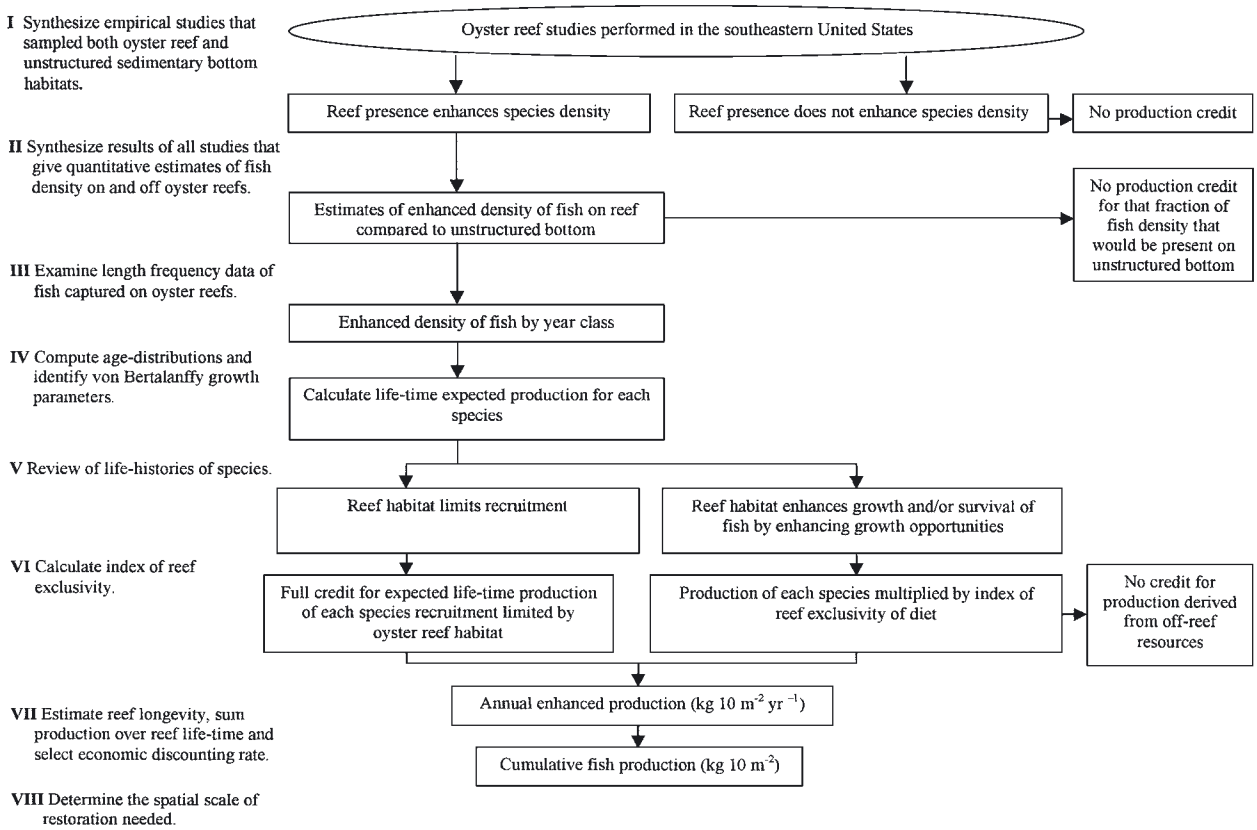


Fig. 1. Flow diagram illustrating our approach to calculating expected enhancement of fish and mobile crustacean production resulting from the restoration of oyster reefs in the southeastern USA

reef-associated prey. Partitioning growth by prey source helps address the long-standing question of whether reefs simply aggregate fish or increase their production by providing reef-associated prey resources (Bohnsack 1989). We then summed these reef-dependent enhancement estimates across all species to produce the total expected enhancement of fish and crustacean production per unit reef area. Finally, economic discounting was applied to amend these calculations to account for the time value of resources and services in matching resource loss to resource gain through creation of oyster reefs.

**Synopsis of studies.** Six studies conducted in the southeastern USA (Fig. 2) formed the basis of our synthesis (Table 1). Zimmerman et al. (1989) used 2.6 $m^2$ circular drop samplers to quantify animals that use shallow, subtidal oyster reefs and adjacent sand/mud habitats in the West Bay region of Galveston Bay, Texas. Wenner et al. (1996) quantified fish and mobile crustaceans on both restored and natural oyster reefs near Charleston Harbor, South Carolina. Their study used 3.2 mm-mesh lift nets, which were folded and buried along the perimeter of oyster reef and then raised on a falling tide to enclose the entire area (24 $m^2$). Meyer et al. (1996) used block and fyke nets to quantify fish and mobile crustaceans in 3 *Spartina* marsh-edge habitats (bordered by restored oyster reef, natural oyster reef or unstructured bottom) at each of 3 sites in North Carolina. Two block nets (19.3 m long × 1.3 m high with 3.2 mm mesh) were positioned perpendicular to the shoreline, and a 1.3 m high fyke net with 3 m wings was placed along the 5 m long, low-tide mark. Nets were set on a falling tide and animals collected at low tide. Grabowski (2002) used a variety of sampling gear (gill nets, crab traps, fish traps, minnow traps, and 1 $m^2$ colonization trays filled with oyster shell) to sample fish and mobile crustaceans on restored intertidal oyster reef and nearby unstructured bottom in Back Sound, North Carolina. Lenihan et al. (1998, 2001) used the same gear as Grabowski (2002), along with visual observations, to sample restored and natural oyster reefs and nearby sand/mud bottom in subtidal areas of the Neuse River estuary and West Bay, Pamlico Sound, North Carolina. Finally, investigators at the Virginia Institute of Marine Sciences (VIMS: Mann & Harding 1997, 1998, Harding & Mann 1999, O'Beirn et al. 1999) sampled fish and mobile crustaceans by otter trawl and gill nets at a large (210 × 30 m) restored oyster reef and 2 mud/sand flats in the Piankatank River, Virginia, and at several smaller restored reefs and unstructured bottom areas near Fisherman Island at the mouth of Chesapeake Bay.

**Relative enhancement estimates.** To evaluate the questions of whether and to what degree a species abundance was enhanced by the presence of oyster reef, we used only those 5 studies that sampled fish and mobile crustaceans both on oyster reef and on adjacent unstructured habitat (Zimmerman et al. 1989, Meyer et al. 1996, Lenihan et al. 1998, 2001, the VIMS studies [see above], and Grabowski 2002). We compiled data on comparisons of fish and mobile crustacean catches on oyster reefs to nearby unstructured bottom. The results from each of the 5 studies were then summarized into 1 database that computed the ratio of catch on-reef to catch off-reef for each sampling period by gear type (see Table 5). When a ratio could not be calculated because a species occurred in a single habitat, that fish or mobile crustacean was designated as 'all reef ' or 'all mudflat'. A species was judged to be enhanced in abundance by the presence of an oyster reef if a majority of studies either had index values above 1 or indicated 'all reef' (see Table 5). In cases where only 1 study reported data for a given species, we used the more conservative threshold of >2 to declare a species enhanced by reef presence.

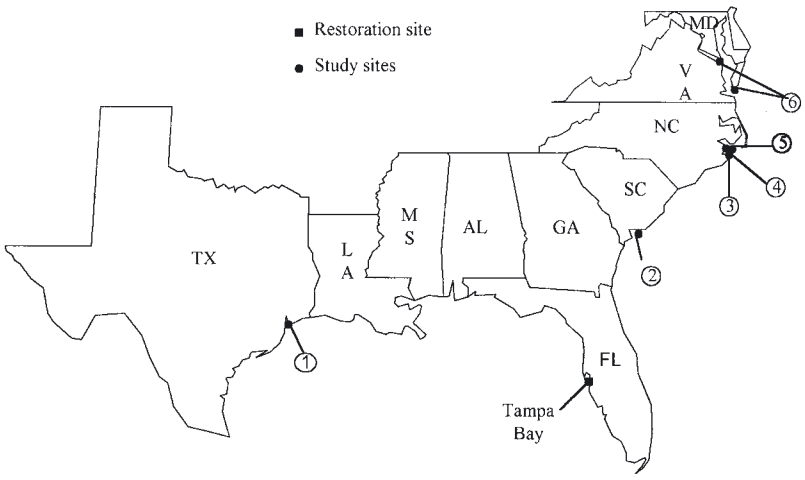


Fig. 2. Southeastern USA, with the sites of empirical studies used in our synthesis noted by filled circles and the targeted restoration site, Tampa Bay, FL, noted by the filled square. Numbers identify the location and sources of data: (1) Galveston Bay, TX, Minello & Zimmerman (1989); (2) Charleston Harbor, SC, Wenner et al. (1996); (3) Back Sound, NC, Grabowski (2002); (4) Back Sound, White Oak River and New River, NC, Meyer et al. (1996); (5) Neuse River and Pamlico Sound, Lenihan et al. (1998, 2001); and (6) Chesapeake Bay, VA, Mann & Harding (1997, 1998), Harding & Mann (1999), O'Beirn et al. (1999)

We next assigned each species of fish and crustacean judged to be enhanced by the presence of oyster reef to 1 of our 2 conceptual groupings: (1) recruitment-enhanced and (2) growth-enhanced

Table 1. Summary of some key features of the 6 studies used in our data synthesis. For number of reefs restored, date of reef construction is included in parentheses; sampling method lists only sampling methods that were used to determine whether reefs enhance fish abundance and/or to estimate fish density

| Location | Depth | Off-reef control (n) | Natural-reef reference (n) | No. of restored reefs | Sampling method | Sampling date(s) | Source |
|---|---|---|---|---|---|---|---|
| Galveston Bay, TX | 0.5 m | Yes (3) | Yes (3) | None | 2.6 $m^2$ drop-sampler | Summer and Fall 1988 | Zimmerman et al. (1989) |
| Inlet Creek, SC | Intertidal | None | Yes (3) | 3 (Oct 1994) | 24 $m^2$ lift net | Spring, Summer and Fall 1995 | Wenner et al. (1996) |
| Toler's Cove, SC | Intertidal | None | Yes (3) | 3 (Oct 1994) | | | |
| New River, NC | Intertidal | Yes (6) | Yes (6) | 6 (Aug 1992) | Block & fyke nets, $^1/_4$ $m^2$ excavations | Nets: Spring, Summer and Fall 1993, 1994 at all sites Excavations: Fall 1992, Spring and Summer 1993 and 1994 at all sites | Meyer et al. (1996) |
| White Oak River, NC | Intertidal | Yes (6) | Yes (6) | 6 (Aug 1992) | | | |
| Back Sound, NC | Intertidal | Yes (6) | Yes (6) | 6 (Aug 1992) | | | |
| Middle Marsh, NC | Intertidal | Yes (12) | None | 12 (Jul 1997) | Gill nets, colonization trays, fish, minnow and crab traps | Monthly Summer and Fall 1997 Spring to Fall 1998, 1999 | Grabowski (2002) |
| Neuse River, NC | 3, 4, 6 m | Yes (4) | None | 4 (Jun 1993) | Gill nets, fish traps and diver census | Monthly Summer and Fall 1996 Spring and Summer 1997 | Lenihan et al. (1998, 2001) |
| West Bay, NC | 3 m | Yes (8) | None | 8 (Jul 1996) | | | |
| Piankatank River, VA | Intertidal | Yes (2) | None | 1 (Jul 1993) | Gill nets, otter trawls above reef and reef perimeter | Semimonthly Spring and Summer 1996, 1997 | Mann & Harding (1997, 1998), Harding & Mann (1999) |
| Fisherman Island, VA | Intertidal | Yes (multiple) | None | 13 (2 in 1995, 11 in 1996) | Gill nets, otter trawls above reef and reef perimeter | ~ Monthly Summer 1998 to Spring 1999 | O'Beirn et al. (1999) |

species. Our distinction between these 2 classes was based on the magnitude of enhancement as well as a careful review of life-history information. Our practice was to assign demersal species that had nearly exclusive occupation of oyster reefs as recruits (demonstrated by a majority of studies characterizing that species as 'all reef') to the first group, and those demersal species that showed more moderate enhancement plus pelagic species showing all levels of enhancement to the second group.

Because comparisons of catches occurred between 2 different habitats, we must consider potential differential biases in sampling efficiency between habitats (sensu Peterson & Black 1994). Crab pots, fish-traps, minnow pots, and colonization trays constitute structural elements: fish may be attracted to such structures in greater numbers in an unstructured environment than in a highly structured one (Sheaves 1992). Any bias of this nature would result in a more conservative estimate of our enhancement ratio. Similarly, any biases in trawling would tend to produce artificially low catches of animals on reefs because of the difficulty of towing trawls over highly structured reef areas.

**Density estimates.** After we had determined that a particular species was enhanced in abundance by the presence of oyster reef habitat, we then assessed whether that species or a close ecological counterpart occured at the targeted restoration site, Tampa Bay, Florida (using faunal listings in Livingston 1984, 2001, Lewis & Estevez 1988). Next, we addressed the issue of sampling efficiency for each gear type used in the 6 studies. Of these studies, only Zimmerman et al. (1986, 1989) and Wenner et al. (1996) tested gear efficiency against a known standard number of fish and invertebrates. Zimmerman et al. (1986) found that recovery efficiency of their 2.6 $m^2$ drop samplers was 96% for small invertebrates. Efficiency of lift nets in Wenner et al. (1996) ranged from 54 to 68.5% for a small benthic fish (mummichog) and 43 to 54% for a benthic invertebrate (grass shrimp). Testing a similar lift net, Rozas (1992) had previously shown catch efficiencies of 32 to 93%. Because these methods demonstrated relatively high sampling efficiencies and wide ranges among and within species, we did

not use any correction factor for densities measured with drop samplers or lift nets.

One of 2 alternative procedures was employed to estimate the quantitative enhancement on a per-unit-area basis for each species whose abundance was judged to be enhanced by oyster reefs. For those species collected by Zimmerman et al. (1989) and/or Meyer et al. (1996) that sampled a defined area, we used their estimates (averaged across studies for any species that appeared in both studies) of absolute density on and off reefs. For reef-enhanced species that were not collected in Zimmerman et al. (1989) or Meyer et al. (1996), estimates were derived from trap catches in Lenihan et al. (2001) and Grabowski (2002) and converted to densities. The 'habitat traps' or 'M-traps' used by Lenihan et al. (2001) and Grabowski (2002) lacked standardization to the area sampled. Thus, to convert their data on differences between average catches on reefs and sand/mud flats to density enhancement per unit area, we standardized abundances of fish caught on reefs in traps by the observed densities on reefs in lift nets taken from Wenner et al. (1996) for gray snapper and pigfish (pooled), species common to all 3 studies. The resulting conversion factor was applied to transform catches in traps to densities. For example, if the average density (from Wenner et al. 1996) of gray snapper plus pigfish on reefs is $x$, and the average numbers per habitat trap on reefs is $y$, then the conversion factor would be $x/y$. The VIMS studies were not used for density calculations because, for all species judged to be enhanced by oyster reefs, quantitative data existed in the other studies at sites geographically closer and environmentally more similar to the Tampa Bay restoration area.

To determine the expected enhancement of density for each species by oyster reef presence, we subtracted our off-reef average density from our on-reef density estimate. The rationale was that the off-reef density represents fish that would be present in the absence of reef habitat, and that the reef should be credited only for the enhancement of fish. With the exception of blennies, gobies and silversides, which consist of multiple species within each group, we calculated density enhancement by species. Because of similarity in life history, mortality rate, and functional niche, and differences in biogeographic ranges of sibling species, we grouped blennies, gobies, and silversides into 3 taxa. In estimating density enhancements, we chose to use data from the date of peak density for each species, which consistently occurred in summer or early fall. We averaged these seasonal maxima across studies (except for 3 species that occurred in only a single study) to provide density estimates reflective of the time of peak recruitment and utilization of the estuarine habitats.

**Age distributions of fish on reefs.** Once the estimate of enhanced density ($N$) was calculated for a given species, we determined how various age classes (i) contributed to that density (Table 2). Using published estimates of annual growth for each species (Table 3), we partitioned available length-frequency data of fish on reefs by age class ($N_i$). This process sufficed for 3 taxa of small fishes that are readily caught and whose densities through all age classes are well estimated by lift nets (Table 2). For taxa (7 of the 11 total species that are not annuals) in which our quantitative sampling only provided reliable density estimates of 0 yr class individuals, we calculated expected abundances of older age classes based on (1) the known numbers of 0 yr-old recruits measured in the empirical studies, and (2) published estimates of their annual mortality rate (Table 3). We assumed that the distribution of age classes follows a stable age distribution, if annual mortality rate remains constant, using the formula:

$$S_i = S_o \times e^{(-M_i \times i)} \quad (1)$$

where $S_i$ is the proportion of individuals in age class $(i-1)$ surviving to age class $i$, and $M$ is the natural mortality rate for age class $i$. For species that are fished, mortality rate does not remain constant with age, but increases by the rate of fishing mortality ($F$) added at the age of first harvest ($r$). Thus, for harvested species, $S_i$ was computed using Eq. (1) until $i > r$, when:

$$S_i = S_r \times e^{[-(M_i + F_i)(i-r)]} \quad (2)$$

The density of fish in age class $i$ ($N_i$) was then determined by multiplying $N_{(i-1)}$ by the survival rate ($Sx_i$) for i, calculated by using $S_i$ and $S_{(i-1)}$ from either Eq. (1) or (2), by

$$Sx_i = S_i / S_{(i-1)} \quad (3)$$

Table 2. Age classes observed in density estimates from field sampling for those species or species groups determined to be enhanced by oyster reef. Blenny and goby species are treated as annuals; consequently, only 1 age class was present in the population. The 0 yr class includes fish from the time they recruit to their first birthday

| Species or species group | Age (yr) class(es) included in density estimate |
|---|---|
| Sheepshead | 0 |
| Stone crab | 0 |
| Gray snapper | 0 |
| Gag grouper | 0 |
| Black sea bass | 0 |
| Spottail pinfish | 0 |
| Pigfish | 0 |
| Toadfish | 0, 1, 2 |
| Sheepshead minnow | All |
| Bay anchovy | All |
| Silversides | All |

Table 3. Values of survival rate, age-length and length-weight parameters used in production calculations. See 'Materials and methods' for definitions of parameters and computation formulae

| Species or species group | Survival rates | | | Age-length and length-weight relationships | | | | | Source |
|---|---|---|---|---|---|---|---|---|---|
| | *M* | *F* | *r* | $L_\infty$ | *K* | $t_o$ | *a* | *b* | |
| Sheepshead minnow | 2.00 | 0.00 | | 19.4 | 0.130 | −0.940 | 0.0087 | 3.27 | Abraham (1985) |
| Bay anchovy | 1.50 | 1.00 | 1 | 12.0 | 0.280 | −1.100 | 0.0111 | 2.81 | French et al. (1997) |
| Silversides | 2.00 | 0.00 | | 10.0 | 0.460 | 0.000 | 0.0138 | 2.96 | Middaugh & Hemmer (1992) |
| Gobies | | | | | | | | | Annual species |
| Blennies | | | | | | | | | Annual species |
| Sheepshead | 0.20 | 0.40 | 3 | 45.1 | 0.205 | −1.540 | 0.0283 | 2.96 | French 1999 |
| Stone crab | 0.70 | 0.30 | 3 | 14.0 | 0.173 | −0.397 | 0.1170 | 3.30 | Savage & Sullivan (1978), Sullivan (1979), Lindberg & Marshall (1984), Millikin & Williams (1984) |
| Gray snapper | 0.20 | 0.53 | 2 | 50.1 | 0.130 | −1.490 | 0.0156 | 2.93 | Manooch & Mason (1984), Goodyear (1988), Brown et al. (1990), Goodyear & Schirripa (1991) |
| Toadfish | 0.60 | 0.00 | | 30.0 | 0.193 | −0.180 | 0.0170 | 4.98 | Wilson et al. (1982), Serafy et al. (1997) |
| Gag grouper | 0.20 | 0.53 | 2 | 119.0 | 0.166 | −0.740 | 0.0140 | 2.99 | Manooch & Haimovici (1978), Goodyear (1988), Brown et al. (1990), Goodyear & Schirripa (1991), Hood & Schlieder (1992) |
| Black sea bass | 0.30 | 0.30 | 3 | 35.0 | 0.222 | 0.186 | 0.0280 | 3.02 | South Atlantic Fishery Management Council (1983) |
| Spottail pinfish | 0.60 | 0.40 | 1 | 47.5 | 0.164 | −1.144 | 0.0128 | 3.06 | South Atlantic Fishery Management Council (1983) |
| Pigfish | 0.60 | 0.40 | 1 | 47.5 | 0.164 | −1.144 | 0.0128 | 3.06 | South Atlantic Fishery Management Council (1983) |

Using this calculation procedure, we compensate for the underestimation of density of larger, older fish by assuming that the expected numbers of older age classes are indeed present. This addition of ghost fish to our estimate of enhanced density makes the assumption that the older fish continue to utilize reef habitat, which was confirmed by both visual observations and gill net samples. For one species (toadfish), the quantitative sampling by traps and lift nets provided reliable estimates of densities of the first 3 age classes, but no fish in the remaining 5 age classes (Table 2). To estimate densities of these rarer, older age classes, we first applied the age-specific mortality rates to the sum of abundances of the 3 early age classes to compute the expected distribution of abundances among those 3 age classes. This computation allowed us to depreciate the numbers in the oldest (third) age class by applying the age-specific mortality schedule to estimate numbers of fish beyond age class 3. The sum of numbers of fish in the 3 early age classes remained constant, but the total numbers were augmented by ca. 14 % when older ghost fish were added.

**Production calculations.** We chose an area of 10 $m^2$ over which to calculate our estimated enhancement of annual production of fishes and large mobile crustaceans by oyster reefs. Using our estimate of enhanced density in each age class, we quantified how much annual production each age class would be expected to achieve, and summed these production estimates over all ages to estimate total annual enhanced production for each species. Our computation assumed that the 0 yr-class recruits, assessed in most studies at an age of approximately ½ yr, would all survive to their first birthday. This overestimate of annual production by fish surviving from their half birthday to their first birthday is assumed to compensate for the failure to include estimates of production of those other fish in that same age cohort that had recruited to the reefs and grew to some size but died before sampling occurred on the half birthday. For annual species (gobies and blennies), we calculated annual production by multiplying average fish weight by the estimate of density enhancement. For all other species, we first calculated the average length at age *i* ($L_i$) using the von Bertalanffy growth equation:

$$L_i = L_\infty \times \{1 - e^{[-K \times (i - t_o)]}\} \quad (4)$$

where $L_\infty$ (the asymptotic maximum length), $K$ (the Brody growth coefficient), and $t_0$ (a constant representing the age at zero length) are derived from literature values for each species (Table 3). To convert $L_i$ to an average weight at age $i$ ($W_i$), we used the length-weight relationship:

$$W_i = a \times L_i^b \quad (5)$$

where $a$ and $b$ are species-specific constants available from the literature (Table 3). The change in weight between successive age classes is equal to the annual production of an individual surviving through age class $i$ ($P_i$):

$$P_i = W_i - W_{(i-1)} \quad (6)$$

We treated the 2 groups of fishes deemed 'enhanced by reef presence' differently, in calculating the enhanced annual production credited to the construction of 10 $m^2$ of oyster reef. For recruitment-enhanced species, we credited their complete expected lifetime production to the reef, independent of whether they fed on reef-associated resources or even remained on the reef after recruitment. Our rationale is that these additional individuals that recruit to the reef would not be present in the population in the absence of the reef. Two of the augmented species, gag grouper and gray snapper, recruit to oyster reefs before migrating to offshore reefs to complete their adult lives. On the basis of the depletion of fish within the snapper-grouper complex on offshore reefs, we assume that adding to their populations by constructing oyster reefs and enhancing snapper-grouper recruitment does not lead to compensatory reductions in growth from food competition offshore. To account for the future production expected from the cohort of recruits sampled on the reef, we computed expected lifetime production using the method described above, adjusting each future year's contribution by a standardly applied 3% annual discount rate ($d$) (NOAA 1997):

$$P_i \times 1/(1+d)^i \quad (7)$$

Consequently, for gag grouper and gray snapper the annual production estimate for any year is the sum of the production of the 0 age class, plus its discounted future expected production.

For growth-enhanced species, we developed and applied an index of reef exclusivity (IRE) to weight the expected production of each of these species by the degree to which its growth is attributed to resources produced on the reef. If, for example, a species of fish merely aggregates behaviorally around the reef structure yet feeds entirely on prey from other habitats (e.g. sand bottom, water column), then it may be inappropriate to credit all its observed growth to the presence of the reef. Alternatively, if a species whose abundance is enhanced by reef presence forages exclusively on benthic or demersal resources that are produced on reefs, then its entire production should be credited to the new reef. Accordingly, we weighted the production credit for this category of fish species limited by reef resources by IREs ranging from 0.10 to 1.0 (Table 4). We used 0.10 as a minimum value to account for the likelihood that some fishes gain survival benefits from association with reef structure, despite foraging on soft-sediment or water-column resources (e.g. Lindquist et al. 1994). The index was constructed for each species from available gut content information (Mann & Harding 1997, 1998, Grabowski 2002). For species lacking quantitative information on gut contents at a level of taxonomic discrimination that allowed reef-exclusive prey to be identified, we used life-history profiles and observed feeding behaviors to set the value of the index. The index primarily reflected a distinction between fishes feeding on benthic or demersal prey versus those feeding on planktonic prey, but it is further modified by the knowledge of whether the benthic prey themselves grow on reefs or on other substrata, such as sand and mud (Table 4).

Applying the IRE, total enhanced annual production for year $y$ ($P_y$), attributable to the presence of 10 $m^2$ of oyster reef for a particular species, was calculated by:

$$P_y = \mathrm{IRE} \times \sum(P_i \times N_i) \quad (8)$$

For recruitment-enhanced species, the IRE was set to 1.0. For growth-enhanced species, the IRE ranged from 0.1 to 0.75 (Table 4). Finally, total annual enhancement of reef fish and large mobile crustacean production per 10 $m^2$ of reef was expressed as the sum of $P_y$ across all 13 species or species groups. We provide an example of the full set of calculations estimating expected enhancement of production for 1 species, sheepshead, to illustrate the sequence of operations (Appendix 1).

**Discounting and scaling factors.** The factor of time enters into valuation of ecosystem services from habitat or species restoration actions that are intended to compensate for natural resource losses. First, although replacement of lost resources by restoration of like or similar resources does not involve translation into dollar values, the time cost of lost resources enters into the process of establishing equivalency. By US federal guidance, a standard annual discount rate of 3% is applied to account for time delays between loss of resources or resource services and their restoration (NOAA 1997). Accordingly, we applied this discount rate to convert any future expected gain in fish production from reef restoration into present-day value.

Time also enters into the process of assessing the rate of establishment of ecosystem services following initiation of the restoration action. To address this issue, we examined the change in abundance of fish and large mobile crustaceans over time on restored oyster reefs (Wenner et al. 1996, Lenihan et al. 1998, Grabowski 2002). We also compared catches of mobile species on restored and naturally occurring reefs in those studies that included this contrast (Meyer et al. 1996, Wenner et al. 1996, Lenihan et al. 2001). Additionally, we evaluated changes in densities and composition of benthic prey (primarily small crustaceans)

Table 4. Estimated enhanced density and production for the 13 species or species groups (2 goby, 2 blenny, and 3 silverside species are grouped because the species within each group exhibit similar life histories) that were more densely populated on oyster reef habitat than on unstructured sedimentary habitat. For sheepshead minnow, bay anchovy, and silversides, density augmentation estimates include all age classes. The density estimate for toadfish includes age classes 1 to 3. Gobies and blennies <1 yr. All other species include estimates of young of year (YOY) only. Index of reef exclusivity (IRE) is an estimate of species utilization of food resources associated with oyster reef compared to resources from adjacent non-reef habitat; this is derived from comparison of the density of the species on and off the reef, gut content analyses where available, and life history profiles. (IRE is not calculated for species in the RE group because all production is attributed to the reef; for calculation purposes the IRE is set to 1.0) Grouping is assigned for augmented production estimates: RE = species that recruited exclusively to reefs (compared to unstructured mud/sand bottom) and were intimately associated with the reef structure — all production is attributed to the reef; G = these species showed aggregation around the reef but diet analyses and life history information did not indicate that these species were limited by reef habitat; however, these individuals probably have some augmented growth because of the presence of the reef structure/resources

| Species or species group | Average increase of density (ind. 10 $m^{-2}$) | IRE | Grouping | Annual increase in secondary production (kg 10 $m^{-2}$ $yr^{-1}$) |
|---|---|---|---|---|
| Gobies (2 spp.) | 128.85 | – | RE | 0.644 |
| Blennies (2 spp.) | 5.00 | – | RE | 0.050 |
| Sheepshead | 1.04 | – | RE | 0.586 |
| Stone crab | 25.77 | – | RE | 0.653 |
| Gray snapper | 0.96 | – | RE | 0.114 |
| Toadfish | 0.96 | – | RE | 0.022 |
| Gag grouper[a] | 0.16 | – | RE | 0.293 |
| Black sea bass | 0.39 | 0.75 | G | 0.046 |
| Spottail pinfish | 0.08 | 0.75 | G | 0.005 |
| Pigfish | 4.22 | 0.75 | G | 0.135 |
| Sheepshead minnow | 2.59 | 0.10 | G | 0.000 |
| Bay anchovy | 158.80 | 0.10 | G | 0.019 |
| Silversides (3 spp.) | 15.38 | 0.10 | G | 0.002 |
| Total annual increase in fish production: | | | | 2.570 |

[a]Although gag use oyster reefs only during their first year of life, the gag-grouper biomass-augmentation estimate is for the life span of the fish

over time in restored oyster reefs, and drew comparisons between natural and restored reefs. From this synthesis, we estimated the time to develop complete functional equivalence in fish and mobile crustacean production on a restored oyster reef as input to the valuation calculation.

Once the expected annual enhancement of fish and mobile crustacean production per unit area of restored oyster reef (kg 10 $m^{-2}$) has been calculated, including appropriate discounting to convert both losses and gains of production to present-day values, then scaling the size of the restoration project to a quantified production loss requires determination of the expected functional lifetime of the restoration. The longer the restoration successfully provides ecosystem services, such as living resource production, the smaller the spatial scale of the restoration that is required to achieve compensation. Given the uncertainty regarding the effects of storms (Livingston et al. 1999), adequacy of spawning stock biomass (Rothschild et al. 1994), water quality (Lenihan & Peterson 1998, Lenihan et al. 2001), oyster diseases (Krantz & Jordan 1996, Lenihan et al. 1999), and degradation of reef materials on oyster reef longevity, we calculated expected enhanced production values for several alternative project lifetimes. Our single best estimate of expected project lifetime was developed through consultation with other investigators in the southeastern USA, as well as our professional judgement. Once a project life span has been determined, the expected enhanced production attributable over the lifetime of a given area of restored habitat can be calculated, and the area of reef required to replace the total injury determined.

## RESULTS

### Enhancement estimates

Abundances of 19 species of fish and large mobile crustaceans were judged enhanced in abundance by the presence of oyster reef habitat. Based on the degree of observed density enhancement and life history, 10 were placed within the recruitment-enhanced group (Table 5). Included in this group were stone crabs, gag grouper, sheepshead, gray snapper, toadfish, tautog, feather blenny, striped blenny, and 2 species of gobies (skilletfish and naked goby). The remaining 9 species were classified as growth-enhanced. This second group included black seabass,

pigfish, southern flounder, spotail pinfish, sheepshead minnow, bay anchovy, and 3 species of silversides (rough, inland, and Atlantic).

The presence of oyster reef habitat probably enhanced the densities of 9 additional species; however, there were insufficient data either to provide compelling support for this conclusion or to resolve inconsistencies between studies. Five of these species (striped bass, white perch, weakfish, Atlantic spadefish, and butterfish) were collected in only a single study (striped bass and white perch in the VIMS studies; and weakfish, spadefish, and butterfish in Lenihan et al. 1998, 2001). Although catches were either higher on, or exclusive to, oyster reefs, low total numbers of these fishes failed to provide conclusive evidence of enhancement. White mullet was caught by Meyer et al. (1996) in high densities; however, the enhancement index value (1.8) did not exceed 2, our criterion for enhancement in a single study. Two species, red drum and spotted seatrout, exhibited conflicting evidence. Red drum were caught in both the VIMS and Grabowski (2002) studies: Grabowski's data indicated enhancement, whereas the VIMS studies caught red drum only away from reef sites. Spotted seatrout were collected in 2 studies: exclusively on oyster reefs in Grabowski (2002), but only on the sand/mud bottom in Zimmerman et al. (1989). This contradiction between studies may be explained by size-dependent changes in behavior. Zimmerman et al. (1989) collected small juveniles with drop samplers, whereas Grabowski (2002) caught larger adults with gill nets. Unfortunately, there were too few fish caught in either study to resolve the question. Size differences may also explain inconsistencies in blue crab data. In several studies with intense sampling effort, adult blue crabs caught in crab pots failed to show elevated densities on oyster reefs. However, in the VIMS studies, the only one reporting juvenile blue crabs separately from adults, blue crabs appeared to be enhanced by oyster reefs.

### Density estimates

Of the 19 species judged to be enhanced by oyster reefs, 2 (tautog and summer flounder) are not reported in Tampa Bay, and have no obvious ecological equivalent. Numerically, pelagic bait-fish (bay anchovy, silversides, sheepshead minnow) and small demersal residents (gobies and blennies) accounted for the largest density enhancements among fishes (Table 4). Stone crabs, the only large mobile crustacean that exhibited compelling density enhancement, were also found in high densities. Longer-lived, commercially and recreationally exploited fish (sheepshead, gray snapper, black sea bass, gag grouper) were enhanced in abundance by oyster reefs but still remained at substantially lower densities than these bait-fishes, small demersals, and stone crabs (Table 4).

### Production estimates

The 7 recruitment-enhanced species or species groups that occur in Tampa Bay account for the majority of the enhancement of production of fishes and mobile crustaceans (Table 4). Of the total enhanced production created annually by oyster reef restoration (2.57 kg 10 $m^{-2}$), 92% is attributable to recruitment-enhanced species, whose recruitment is limited by reef area and whose production did not require adjustment by an IRE. Within this group, stone crabs (0.653 kg 10 $m^{-2}$), gobies (0.644 kg 10 $m^{-2}$), sheepshead (0.586 kg 10 $m^{-2}$) and gag grouper (0.293 kg 10 $m^{-2}$) account for most of the enhanced production. Those growth-enhanced species and species groups whose recruitment did not appear limited by oyster reef area, but were credited for realizing enhanced production in the presence of reefs, account for the remaining 8% (0.21 kg 10 $m^{-2}$) after the IRE was applied to production estimates. Production of pigfish (0.135 kg 10 $m^{-2}$) and black seabass (0.046 kg 10 $m^{-2}$) represent the majority of the production from this second group. Along with spottail pinfish, these species derive the majority of their food from the reef (IRE = 0.75). For baitfish (bay anchovy, silversides, sheepshead minnow), the IRE was set at 0.10 because they have a behavior of aggregating at reefs but extract food largely from the water column. A small credit is appropriate because the reef may provide some protection against predation for this group of fishes and may interact with currents to create better feeding opportunities.

### Discounting and scaling

Our synthesis of data on how abundance of fish and large mobile crustaceans changes over time after creation of a restored oyster reef revealed that for reefs constructed in summer, development of fish and mobile crustacean abundance is virtually complete by the next spring-summer season. Densities do not increase in successive years (Grabowski 2002). The 0 age class that provides 92% of the enhancement of production by fish and mobile crustaceans exhibits densities in the summer after construction that are indistinguishable from densities in succeeding years. Furthermore, the fish community compositions and species abundances on oyster reefs restored 6 yr before sampling were largely indistinguishable from those on natural oyster reefs (Lenihan et al. 2001). Prey

Table 5. Brief synopsis, including number of studies (out of 5) in which a species was collected, number of studies showing higher density of that species on oyster reefs (enhanced), range of enhancement index values (enhancement index), and group designation (grouping) from our synthesis of common fish and mobile crustaceans found on oyster reefs in the southeastern USA. See 'Materials and methods' for definitions of terms and procedures. *Contradictory results across studies

| Species | Common name | Collected (no. of studies) | Enhanced (no. of studies ) | Enhancement Index | Grouping |
|---|---|---|---|---|---|
| **Large mobile crustaceans** | | | | | |
| *Farfantepenaeus duorarum* | Pink shrimp | 2 | 2 | All mudflat – all reef | Not enhanced |
| *Liptopenaeus setiferus* | White shrimp | 1 | 1 | 1.89 | Not enhanced |
| *Farfantepenaeus aztecus* | Brown shrimp | 1 | 0 | All mudflat | Not enhanced |
| *Callinectes sapidus* | Blue crab | 5 | 1 | 0.2 – all reef | Not enhanced |
| *Menippe mercenaria* | Stone crab | 4 | 3 | 0.8 – all reef | Recruitment enhanced |
| **Fish** | | | | | |
| *Anchoa hepsetus* | Striped anchovy | 1 | 0 | 0.1 | Not enhanced |
| *Anchoa mitchilli* | Bay anchovy | 2 | 2 | 0.3 – 18 | Growth enhanced |
| *Archosargus probatocephalus* | Sheepshead | 2 | 2 | All reef | Recruitment enhanced |
| *Bairdiella chrysoura* | Silver perch | 3 | 2 | All mudflat – all reef | Not enhanced |
| *Brevoortia patronus* | Gulf menhaden | 1 | 0 | 1.0 | Not enhanced |
| *Brevoortia tyrannus* | Atlantic menhaden | 2 | 0 | All mudflat – 0.2 | Not enhanced |
| *Carcharhinus acronotus* | Blacknose shark | 1 | 0 | All mudflat | Not enhanced |
| *Carcharhinus limbatus* | Blacktip shark | 1 | 0 | All mudflat – 0.1 | Not enhanced |
| *Centropristis striata* | Black sea bass | 2 | 2 | 0.5 – all reef | Growth enhanced |
| *Chaetodipterus faber* | Atlantic spadefish | 1 | 0 | All sand – all reef | Not enhanced* |
| *Chasmodes bosquianus* | Striped blenny | 4 | 4 | All reef | Recruitment enhanced |
| *Chilomycterus schoepfi* | Striped burrfish | 1 | 0 | All mudflat | Not enhanced |
| *Cynoscion nebulosus* | Speckled seatrout | 2 | 1 | All mudflat – all reef | Not enhanced* |
| *Cynoscion regalis* | Weakfish | 1 | 1 | 0.4 – all reef | Not enhanced* |
| *Cyprinodon variegatus* | Sheepshead minnow | 1 | 1 | 0.5 – all reef | Growth enhanced |
| *Diplodus holbrooki* | Spotail pinfish | 1 | 1 | 1.64 – all reef | Growth enhanced |
| *Eucinostomus argenteus* | Spotfin mojarra | 1 | 0 | 0.33 | Not enhanced |
| *Fundulus heteroclitus* | Mummichog | 3 | 1 | 0.32 – all reef | Not enhanced |
| *Gobiesox strumosus* | Skilletfish | 1 | 1 | All reef | Recruitment enhanced |
| *Gobionellus boleosoma* | Darter goby | 2 | 0 | All mudflat – 1.5 | Not enhanced |
| *Gobiosoma bosci* | Naked goby | 4 | 4 | 33 – all reef | Recruitment enhanced |
| *Hypsoblennius hentz* | Feather blenny | 1 | 1 | All reef | Recruitment enhanced |
| *Lagodon rhomboides* | Pinfish | 4 | 1 | All mudflat – all reef | Not enhanced |
| *Leiostomus xanthurus* | Spot | 5 | 1 | All mudflat – all reef | Not enhanced |
| *Lucania parva* | Rainwater killifish | 2 | 1 | 1 – all reef | Not enhanced* |
| *Lutjanus griseus* | Gray snapper | 2 | 2 | 4 – all reef | Recruitment enhanced |
| *Membras martinica* | Rough silversides | 1 | 1 | 23 | Growth enhanced |
| *Menidia beryllina* | Inland silversides | 1 | 1 | 4.1 | Growth enhanced |
| *Menidia menidia* | Atlantic silversides | 1 | 1 | All reef | Growth enhanced |
| *Micropogonias undulatus* | Atlantic croaker | 3 | 0 | All mudlfat – 1.2 | Not enhanced |
| *Monacanthus hispidus* | Filefish | 1 | 0 | All mudflat – all reef | Not enhanced |
| *Morone americana* | White perch | 1 | 1 | All reef | Growth enhanced |
| *Morone saxatilis* | Striped bass | 1 | 1 | All reef | Not enhanced* |
| *Mugil cephalus* | Striped mullet | 3 | 1 | All mudflat – all reef | Not enhanced |
| *Mugil curema* | White mullet | 1 | 1 | 1.8 | Not enhanced* |
| *Mycteroperca microlepis* | Gag grouper | 2 | 2 | 1 - all reef | Recruitment enhanced |
| *Opsanus* spp. | Toadfishes | 4 | 4 | 0.4 – all reef | Recruitment enhanced |
| *Orthopristis chrysoptera* | Pigfish | 4 | 3 | All mudflat – all reef | Growth enhanced |
| *Paralichthys albigutta* | Gulf flounder | 2 | 0 | All mudflat – 0.3 | Not enhanced |
| *Paralichthys dentatus* | Summer flounder | 2 | 1 | All mudflat – all reef | Not enhanced |
| *Paralichthys lethostigma* | Southern flounder | 2 | 2 | 1 – 3.3 | Growth enhanced |
| *Peprilus* spp. | Butterfish | 1 | 1 | All reef | Not enhanced* |
| *Pogonias cromis* | Black drum | 1 | 0 | 0.66 | Not enhanced |
| *Pomatomus saltatrix* | Bluefish | 2 | 0 | All mudflat – 0.5 | Not enhanced |
| *Sciaenops ocellatus* | Red drum | 2 | 1 | All sand – all reef | Not enhanced* |
| *Scomberomorus maculatus* | Spanish mackerel | 1 | 0 | All sand | Not enhanced |
| *Tautoga onitis* | Tautog | 2 | 2 | 2 – all reef | Recruitment enhanced |
| *Trinectes maculatus* | Hogchoker | 1 | 0 | All mudflat | Not enhanced |

species abundances, both sessile benthic invertebrates on reefs and also small mobile crustaceans, also reached their natural densities on restored oyster reefs by the first spring–summer after a summer restoration (Grabowski 2002). One important prey species, the grass shrimp *Paleomonetes pugio* (in Wenner et al. 1996), exhibited higher densities on oyster reefs restored within the previous year than on nearby natural reefs. Consequently, we found no evidence that restoration of this ecosystem service requires more than a single year to be realized. Furthermore, the creation of a restored oyster reef does not enhance fishing pressure to a degree that would require adjustment of mortality rates of reef-dependent fishes, a factor that could conceivably require reduction of the estimated production credit assigned to the reef. The 0-age-class recruits that comprise most of the enhanced production on oyster reefs (Tables 2 & 4) are not exploited.

The production credit attributable to the creation of a restored oyster reef is dependent on the functional lifetime of the reef. Because of the need to discount the value of future production, the cumulative production value discounted to present does not increase linearly. As reef lifetime increases, the rate of increase in cumulative value of production slows (Fig. 3). For our estimated annual production of 2.57 kg $yr^{-1}$, the discounted cumulative production credit for 20 yr of reef function is 38.2 kg 10 $m^{-2}$ of reef. For 30 yr, this credit increases to 50.4 kg 10 $m^{-2}$. By 100 yr, an asymptote of ca. 80 kg 10 $m^{-2}$ is approached (Fig. 3). Although highly variable as a consequence of unpredictable storm impacts, sedimentation, and appropriateness of site selection, a reasonable estimate for the functional lifetime of a restored oyster reef that is successfully protected from damage by bottom-disturbing fishing gear (Lenihan & Peterson 1998, Lenihan & Micheli 2000) ranges from 20 to 30 yr.

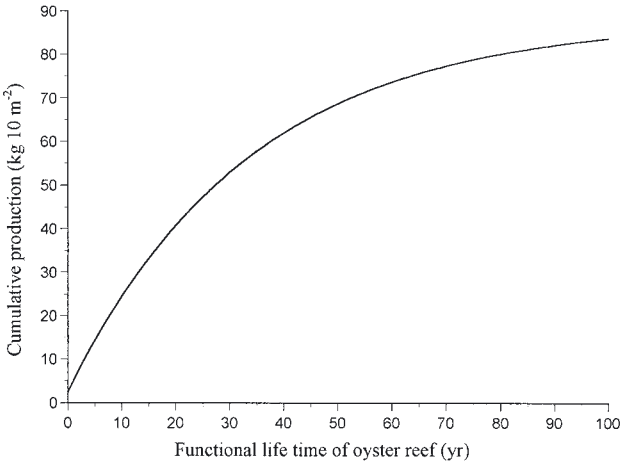


Fig. 3. Long-term projection of cumulative enhanced fish and mobile crustacean production per 10 $m^2$ of restored oyster reef habitat, discounted to adjust for annual depreciation of resources as a function of the functional lifetime of the reef. An annual discount rate of 3% was applied

## DISCUSSION

Our estimation of enhanced production of fish and large mobile crustaceans, attributable to replacing an area of unstructured mud/sand estuarine bottom in the southeast USA with a restored oyster reef, illustrates a process that combines review and synthesis of relevant empirical data bases, followed by application of appropriate basic concepts about limits on production of species at higher trophic levels in the system. The process is a generic one, analogous to what has been done to the scaling of restoration of seagrass habitat in terms of ecosystem benefits that flow from that action (Fonseca et al. 2000). We acknowledge uncertainty about the magnitude of estimates at all stages in this set of calculations that lead to the fish and mobile crustacean production credit attributable to an area of restored oyster reef. However, we defend this calculation on the grounds that it makes use of extensive empirical data on restoration effectiveness and well-conceived, current conceptual understanding in fisheries ecology. Limitations in the data on rarer species that led us to exclude some species from the list of those enhanced by reef habitat contribute very little error to our estimate of total augmented production, because the rare species contribute so little to the sum. We do not include one indirect mechanism that may contribute further production benefits from oyster reef restoration. Oyster reefs tend to interfere with trawling and other bottom-disturbing fishing practices, such that if reefs are restored in areas where historic trawling operates, then their contribution to protection of benthic habitat may need to be included in the computation of production benefits.

Results of such scaling calculations are used by government resource agencies, most notably in the USA by NOAA, in legal settings to identify and provide for restoration, as the appropriate remedy for unlawful injuries to natural resources (NOAA 1997). More broadly, however, this estimate of one important ecosystem service of oyster reefs can be used by resource and coastal managers to make decisions about estuarine management and habitat restoration for a habitat that has declined over the past century by around 2 orders of magnitude in the Chesapeake Bay and Pamlico Sound (Rothschild et al. 1994, Lenihan & Peterson 1998), and has essentially disappeared from other estuaries in the northeast USA, west coast of

North America, Adriatic, and elsewhere around the world (Jackson et al. 2001). Valuation of fish production derived from oyster reefs is also central to efforts to define and then protect essential fish habitat (Coen & Luckenbach 2000).

Our estimate of the added value of restoring oyster reefs as measured by production of fish and large mobile crustaceans should be viewed as a quantitative prediction. Testing is feasible, although it would require a spatial scale appropriate to the mobility of the species to allow isolation of treatments, and controls and establishment of a well conceived *a priori* plan to couple the project with its evaluation (e.g. Lindberg & Relini 2000, Hobbs & Harris 2001). Treatment of uncertainty in restoration and mitigation projects is an important concern to provide guarantees that resources and their services are indeed replaced. Uncertainty can be incorporated in 2 fundamentally different fashions. One approach is to establish and apply a mitigation ratio such that restored habitat is made greater than the amount expected to be necessary for full replacement of lost value (e.g. Thayer 1992). This expansion of scale incorporates uncertainty of success, with ratios increasing as uncertainty increases. An alternative approach is to monitor the restoration project carefully and modify it adaptively as needed to meet the quantitative target of restoration (e.g. Ambrose & Swarbrick 1989). The adaptive management approach has the added value of providing information that can test the prediction and enhance understanding to improve future predictions and reduce uncertainty for future applications. Nevertheless, parties held responsible for restoring the lost ecosystem services typically dislike the open-ended nature of the adaptive management commitment, and prefer a fixed level of effort, as reflected in the mitigation-ratio approach.

Realized success in enhancing fish production through oyster reef restoration will depend on many variables that influence oyster reef function. Our calculations apply to a generic oyster reef in the southeastern USA, an approach dictated by the small number of data sets preventing incorporation of modifying covariates. Such covarying factors mostly involve decisions about site selection and design criteria for the reef restoration. The landscape setting in which a reef is placed dictates the ability of many higher-level consumers to utilize it. For example, intertidal oyster reefs placed adjacent to salt marshes or adjacent to subtidal seagrass beds, rather than in isolation from other structured habitats, vary in their functioning by supporting different patterns of fish and crab utilization (Meyer et al. 1996, Irlandi & Crawford 1997, Micheli & Peterson 1999, Grabowski 2002). Intertidal and subtidal oyster reefs are likely to differ in value to fish and mobile crustaceans largely because of the need to find alternative submerged refuge at low tide. This consideration also implies that landscape setting may impact intertidal more than subtidal reef function. The choice of whether to construct a few reefs large in area or several smaller ones can affect fish utilization through modification of perimeter-to-area ratios and, thus, proportions of edges with their intrinsically higher access to mobile consumers. Networks of oyster reefs built along environmental gradients can provide refuges for fish escaping environmental degradation and thus serve to enhance fish production more than a design that isolates reefs in a single environmental regime (Lenihan et al. 2001). Because of extensive depletion of spawning stock biomass in some estuaries, siting oyster reefs where larval settlement is reliable enough to sustain oyster populations is crucial, often involving the need to understand hydrodynamic setting and locations of retention cells (Coen & Luckenbach 2000, Mann 2000). Decisions made about reef design, including height and water depth (Lenihan & Peterson 1998), shape, composition of reef material, prevailing water flow regime, and stability of underlying sediments (Luckenbach et al. 1999), all help to determine the success of achieving restoration goals.

Given that oyster reefs provide many ecosystem services beyond enhancing production of fishes and large mobile crustaceans, there are additional environmental benefits achieved by reef restoration. These include positive effects on water clarity, carbon sequestration, rate of denitrification, and oyster restocking. We do not attempt to quantify the value of these other attendant ecosystem services, largely because the currency of benefits is not comparable to the measure used in this analysis (i.e. production of fish and mobile crustaceans at high trophic levels). We chose this particular currency to match the benefit of restoration with the loss in a fundamental ecosystem service, production of fish and mobile crustaceans. The environmental incident, an acidic process water spill, which caused the loss of fish and mobile crustaceans (French 1999), clearly must have had impacts on other components of the Alafia River ecosystem. To characterize those losses fully would involve tremendous commitment of resources. For the sake of administrative simplicity and cost effectiveness, only some of the injuries to ecosystem services were estimated in this and other incidents. When compensation for those measured injuries to natural resources is achieved by habitat restoration like oyster reef creation, then one can be confident that many other ecosystem services will be simultaneously provided to help replace those that were injured, but not studied or quantified. This approach assumes that many ecosystem services scale linearly to one another. That does not seem an unreasonable assumption, yet it

also deserves rigorous testing. Independent of whether restoration of some ecosystem services is more complete than others, this approach of habitat restoration is likely to provide greater ecosystem benefits than an alternative program of species-by-species restoration at the population level. Habitat degradation is widely recognized as the greatest cause of species declines (e.g. Soule 1986), so its restoration deserves highest priority in conservation programs and in mitigation efforts.

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**Appendix 1.** Calculation of enhanced fish production for sheepshead. Equations and symbols can be found in the 'Materials and methods' section. All necessary parameters for the calculations (survival rates, age-length, length-weight) appear in Table 3

| $i$ | $S_i$ | $Sx_i$ | $N_i$ | $L_i$ | $W_i$ | $P_i$ | $P_i \times N_i$ |
|---|---|---|---|---|---|---|---|
| 0 | 1 | | | | | | |
| 1 | 0.819 | 0.819 | 1.040 | 18.306 | 152.907 | 152.907 | 159.023 |
| 2 | 0.670 | 0.819 | 0.851 | 23.272 | 311.171 | 158.264 | 134.759 |
| 3 | 0.549 | 0.819 | 0.697 | 27.318 | 500.093 | 188.921 | 131.703 |
| 4 | 0.301 | 0.549 | 0.383 | 30.614 | 700.619 | 200.526 | 76.719 |
| 5 | 0.165 | 0.549 | 0.210 | 33.299 | 898.577 | 197.958 | 41.565 |
| 6 | 0.091 | 0.549 | 0.115 | 35.486 | 1084.776 | 186.199 | 21.456 |
| 7 | 0.050 | 0.549 | 0.063 | 37.268 | 1254.072 | 169.296 | 10.706 |
| 8 | 0.027 | 0.549 | 0.035 | 38.720 | 1404.248 | 150.175 | 5.212 |
| 9 | 0.015 | 0.549 | 0.019 | 39.902 | 1535.033 | 130.785 | 2.491 |
| 10 | 0.008 | 0.549 | 0.010 | 40.866 | 1647.348 | 112.315 | 1.174 |
| 11 | 0.005 | 0.549 | 0.006 | 41.651 | 1742.765 | 95.418 | 0.547 |
| 12 | 0.002 | 0.549 | 0.003 | 42.290 | 1823.147 | 80.382 | 0.253 |
| 13 | 0.001 | 0.549 | 0.002 | 42.811 | 1890.416 | 67.268 | 0.116 |
| 14 | 0.001 | 0.549 | 0.001 | 43.235 | 1946.415 | 55.999 | 0.053 |
| Total | | | 3.435 | | | | 585.779 |

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# Success of constructed oyster reefs in no-harvest sanctuaries: implications for restoration

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ABSTRACT: Dramatic declines in populations of the eastern oyster *Crassostrea virginica* are a symptom of degradation in many US Atlantic and Gulf of Mexico estuaries. We sampled 94 oyster reefs (88 constructed, 6 natural) within 11 no-harvest sanctuaries in estuaries of central and northern North Carolina, USA, to evaluate the success of oyster sanctuaries as a conservation tool. The sanctuaries have been in existence from 3 to 30 yr; 10 sanctuaries protect constructed ('restored') oyster reefs and 1 sanctuary protects natural reefs. Measurements of vertical relief, live oyster density, recruitment, abundance of market-sized oysters, and biomass as well as disease prevalence and severity indicated that 7 of the 11 sanctuaries met criteria for minimal success by having vertical relief >20 cm in height, living oysters (>10 oysters $m^{-2}$), and evidence of recent recruitment in 1 of 2 yr of the survey. Most reefs within the 7 sanctuaries far surpassed these relatively low benchmarks. For reefs that failed, burial by sedimentation appeared to be the primary cause in 2 sanctuaries, poor water quality (low dissolved oxygen) in 1, and poor oyster recruitment in another. All intertidal reefs were successful and had significantly higher densities of all size categories of live oysters (spat, adult, marketable size) than subtidal oyster reefs. Disease prevalence and severity were low in sanctuary reefs despite high oyster densities and increased longevity of oysters on these reefs. Pronouncements that restoration of the native eastern oyster is a failure prove incorrect when a decade-long history of oyster reef sanctuaries is evaluated. The proposed introduction of a non-native oyster into the US Atlantic coast estuaries cannot be justified by claiming failure of native oyster restoration in light of promising successes within sanctuaries.

KEY WORDS: *Crassostrea virginica* · Marine protected areas · No-harvest sanctuaries · Oyster disease · Restoration · Fisheries

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## INTRODUCTION

The century-long and accelerating decline of the eastern oyster *Crassostrea virginica* in estuaries along the Atlantic and Gulf of Mexico coastlines of North America has been widely publicized (Hargis & Haven 1988, Rothschild et al. 1994, Coen & Luckenbach 2000), but until recently, this dramatic anthropogenic change (Kirby 2004) has been considered little more than a local fisheries issue. The failure to sustain oyster fisheries with the attendant economic and social costs is indeed a significant consequence of the oyster population crash. However, a century of considering eastern oysters narrowly as an exploitable fishery resource and placing responsibility for their management in the hands of fisheries management agencies (Coen & Luckenbach 2000, Luckenbach et al. 2005) has led to decisions about harvest controls, restoration, and intro-

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ductions of non-native substitutes that have not been made in a holistic context and have consequently contributed to a widespread estuarine conservation crisis (Jackson et al. 2001).

Oysters provide substantial ecosystem services that have only recently been documented and appreciated (Lenihan & Peterson 1998, Coen et al. 1999, 2007, Lenihan et al. 2001, Grabowski et al. 2005). The eastern oyster forms an emergent reef that functions like other recognized biogenic habitats to provide important ecosystem services. Unlike coral reefs, seagrass meadows, salt marshes, and mangrove forests, oyster reefs are permitted by state management agencies to be mined and degraded to extract the marketable oysters from the reef formation (DeAlteris 1988, Hargis & Haven 1988, Rothschild et al. 1994, Lenihan & Peterson 1998). Oyster reef habitat enhances estuarine biodiversity (Wells 1961, Luckenbach et al. 2005) by providing the only extensive emergent hard substratum for epibiotic invertebrates. Areal production of fish and invertebrates is increased by oyster reef habitat to a far greater degree than by salt marsh habitat (Peterson et al. 2003 as compared to Kneib 2003), whose strict regulatory protection in the US and elsewhere is largely based upon its high productivity. As a suspension-feeding bivalve, oysters may improve estuarine water quality by removing sediments and microalgae (Dame et al. 1984, Nelson et al. 2004, but see Pomeroy et al. 2006) and by stimulating denitrification (Newell et al. 2002).

Proper recognition of the value of these and other ecosystem services of oysters would imply more holistic ecosystem-based management of oysters and the reefs they build (Burreson et al. 2000, Mann 2000). A commitment to ecosystem-based management of oysters should address issues such as the optimal design of restored oyster reefs (Lenihan & Peterson 1998, Posey et al. 1999), non-destructive harvest techniques (Lenihan & Peterson 2004), establishment of networks of oyster reef sanctuaries so as to provide refuges from stresses for mobile fishes (Breitburg et al. 2000, Lenihan et al. 2001) and facilitate larval retention to sustain recruitment (Mann 2000, Lipcius et al. 2008), development and adoption of metrics to evaluate the success of restoring oyster reefs (O'Beirn et al. 1999, Coen & Luckenbach 2000, Luckenbach et al. 2005), and the consequences of non-native oysters as replacements for declining native oysters (NRC 2003). The responses to these challenges are likely to differ if based on ecosystem services as opposed to fishery production alone. After substantial efforts to restore eastern oysters in Chesapeake Bay, local fisheries managers and some scientists have been pronouncing oyster restoration a failure (Mann & Powell 2007). In response, some organizations have been advocating intentional introduction of a non-native oyster from China into Chesapeake Bay (see NRC 2003 for details) despite the known environmental risks of species introductions (Carlton 1989, Naylor et al. 2001).

Here, we examined the fate of 94 oyster reefs protected for 3 to 30 yr within 11 sanctuaries located in the North Carolina Outer Banks. Specifically, we quantified density, biomass, and recruitment of oysters over 2 successive years, and prevalence and severity of oyster disease as indications of success of restoration. Oyster disease is considered by many to be the primary inhibitor of eastern oyster recovery, motivating our disease assessment. Finally, we identified the physical site characteristics that were associated with successful oyster reef restoration.

## MATERIALS AND METHODS

**Study design.** We surveyed oyster reefs within 11 sanctuaries from May 2002 to September 2003. Beginning at the southern end of the study area (Fig. 1), 1 sanctuary was located in Bogue Sound, 3 within Back Sound (Bird Shoals, Middle Marsh I and II), 3 within the Neuse River Estuary (Neuse River shallow, mid-depth, and deep), 3 in Pamlico Sound (West Bay, Deep Bay, and Crab Hole), and 1 in Croatan Sound (Wanchese). Ten of these sanctuaries were created to prevent damage from bottom-disturbing fishing practices on reefs built by state and federal agencies or university scientists. One sanctuary, Bird Shoals, included only natural reefs protected for at least the last 30 yr by continuous closure based on water-quality concerns arising from proximity to a municipal wastewater discharge. The constructed oyster reefs varied in age, with the oldest constructed in 1992 and the most recent in 2000 (Table 1). The reefs also varied in overall dimensions, height, and configuration: 6 were composed of a network of small to medium-sized (5 to 35 $m^2$) oyster reefs (Bird Shoals, Middle Marsh I and II, Neuse River shallow, mid-depth, and deep), and 5 were continuous reefs with variable dimensions (Bogue, West Bay, Deep Bay, Crab Hole, Wanchese). Of the 11 sanctuaries, 8 were protected subtidal reefs (3 to 6 m depths) and 3 were intertidal reefs (Bird Shoals, Middle Marsh I and II). Most sanctuary areas were in relatively high-salinity waters (22 to 32 psu), the exceptions being reefs in the Neuse River, Deep Bay, and Wanchese, which were primarily mesohaline (10 to 20 psu; see hydrographic data in Lenihan & Peterson 1998). Oyster reefs in the Neuse River, particularly those in deeper waters, may experience periods (days to weeks) of hypoxia, defined as dissolved oxygen concentrations $<2.0$ mg $l^{-1}$ (Lenihan & Peterson 1998, Powers et al. 2005).

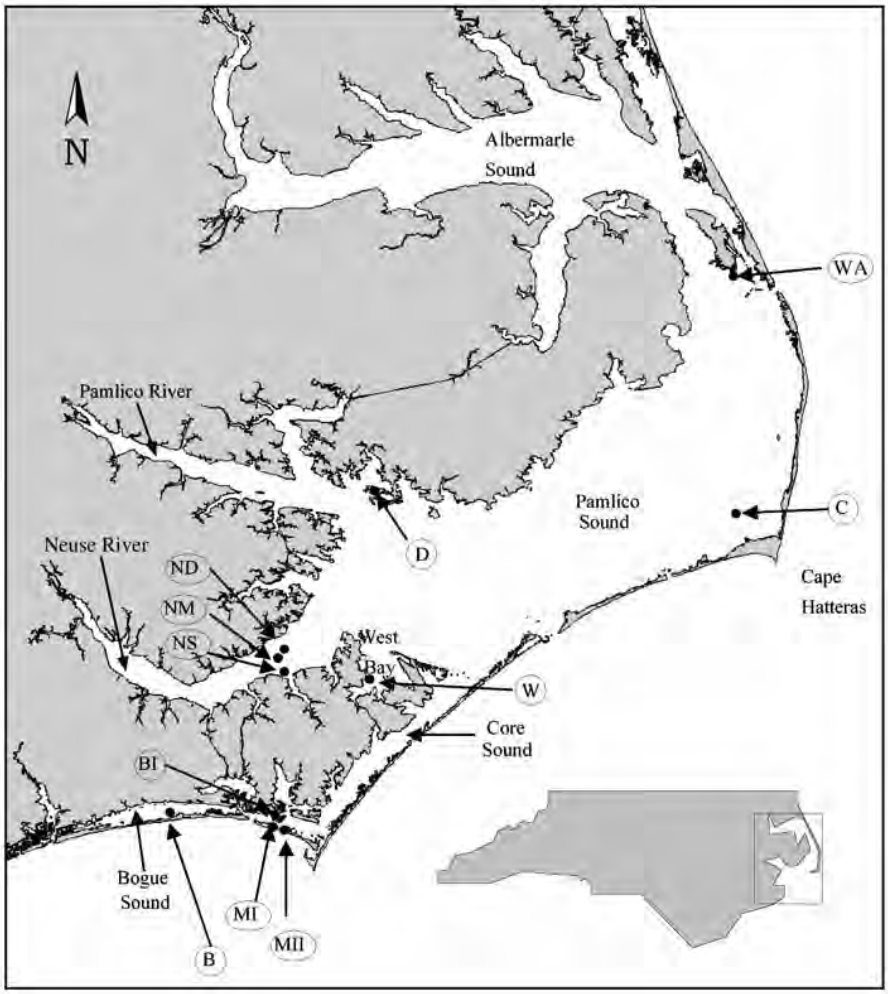


Fig. 1. Outer Banks region of North Carolina. Sanctuary areas (circles) from south to north are Bogue Sound (B), Bird Shoals (BI), Middle Marsh I and II (MI, MII), Neuse River shallow (NS), mid-depth (NM), and deep (ND), West Bay (W), Crab Hole (C), Deep River (D), and Wanchese (WA)

Because many of the sanctuaries had not been recently surveyed and had no recorded GPS coordinates, visual inspections of oyster reefs within all sanctuary areas were conducted in May or June 2002 prior to quantitative sampling. For subtidal reefs, these inspections were performed by SCUBA divers and for intertidal reefs via shoreline surveys. After the initial surveys, 3 of the sanctuary reefs were sufficiently characterized that they needed no follow-up quantitative sampling: the Bogue Sound and the Neuse River mid-depth sanctuaries were completely buried by sand, and the Crab Hole sanctuary had no live oysters. Quantitative sampling for oyster density within the remaining sanctuary areas was conducted in September 2002 and 2003; disease assessment was performed in both June and September of 2002 and 2003.

**Quantitative sampling and parameter contrasts.** To estimate densities of live oysters, quadrat samples ($0.25\ m^2$) were collected by hand, either SCUBA diving (subtidal reefs) or kneeling (intertidal reefs), from the base and crest of each oyster reef. All oyster and shell material to a depth of 15 cm within the quadrat frame was excavated, placed in mesh sacks, and returned to the University of North Carolina's Institute of Marine Sciences. Samples were temporarily stored in outdoor, flow-through-seawater tanks until analysis was completed (usually 12 to 48 h after collection). All oysters larger than 25 mm in shell height (SH = distance from umbo to anterior shell margin) and spat (newly recruited oysters ≤25 mm SH) were separately enumerated, and a subsample of 20 larger oysters was individually measured. Based on these size measurements, we placed oysters >25 mm in SH into 2 size categories: all oysters >25 mm ('oysters') and oysters ≥75 mm ('market-sized oysters'). After enumeration and measurement, the total wet weight of live oysters and

Table 1. North Carolina oyster reef sanctuaries surveyed between 2002 and 2004

| Reef location | Dimensions, configuration, and total material used to build reef(s) | Year created | Water depth (m) | Salinity (psu) | Construction material | Current protection | Source |
|---|---|---|---|---|---|---|---|
| Bogue | 1 continuous reef, >25 m in length | 1996 | 4.0 | 28–32 | Class B limestone marl | None: reef buried | NCDMF (unpubl. data) |
| Bird Shoals | Multiple natural reefs of varying sizes | 1968 | Intertidal | 24–34 | Natural oyster reef | Closed to harvest by NC Seafood Sanitary Office | |
| Middle Marsh I | 12 reefs, 3 m wide × 5 m long × 0.3 m tall | 1997 | Intertidal | 22–33 | Dead oyster shell | Research Sanctuary[a] | Grabowski et al. (2005) |
| Middle Marsh II | 11 reefs, 3 m wide × 5 m long × 0.3 m tall | 2000 | Intertidal | 22–33 | Dead oyster shell | Research Sanctuary[a] | Grabowski et al. (2005) |
| Neuse River shallow | 12 high-relief (2 m tall, 33 to 38 $m^2$ in area) and 12 low-relief reefs (1 m tall, 16 to 20 $m^2$ in area) | 1993 | 3.0 | 12–22 | Dead oyster shell | Research Sanctuary[a] | Lenihan & Peterson (1998) Lenihan et al. (1999) |
| Neuse River mid-depth | 12 low-relief reefs (1 m tall, 16 to 20 $m^2$ in area) | 1993 | 4.0 | 12–22 | Dead oyster shell | Research Sanctuary[a] | Lenihan & Peterson (1998) Lenihan et al. (1999) |
| Neuse River deep | 12 high-relief (2 m tall, 33 to 38 $m^2$ in area) and 12 low-relief reefs (1 m tall, 16 to 20 $m^2$ in area) | 1993 | 6.0 | 12–26 | Dead oyster shell | Research Sanctuary[a] | Lenihan & Peterson (1998) Lenihan et al. (1999) |
| West Bay | 1 continuous reef 50 m in length, 1.0 m tall | 1996, 1998[b] | 3.5 | 27–30 | Class B limestone marl | Shellfish Management Area[a] | NCDMF (unpubl. data) |
| Crab Hole | 1 continuous reef 75 m in length, 1.1 m tall | 1996 | 3.5 | 27–30 | Class B limestone marl | Shellfish Management Area[a] | NCDMF (unpubl. data) |
| Deep Bay | 1 continuous reef 75 m in length, 1.1 m tall | 1996 | 2.2 | 16–24 | Class B limestone marl | Shellfish Management Area[a] | NCDMF (unpubl. data) |
| Wanchese | 1 continuous reef, 600 tons Class B rip rap | 1996, 1998[b] | 2.2 | 12–24 | Class B limestone marl | Shellfish Management Area[a] | NCDMF (unpubl. data) |

[a]Area is closed by proclamation of the NCDMF to all fishing, trawling, or collection and marked with buoys
[b]Additional limestone marl was added to the ends of these reefs in 1998

spat was measured for each quadrat. We refer to this measurement as 'oyster biomass,' because both the shell and soft tissue are biogenic.

For the Bird Shoals and the Neuse River shallow and deep sanctuaries, which consisted of multiple reefs, replicate quadrat samples were collected haphazardly from the base and crest of 6 randomly selected reefs. Because the Middle Marsh I and II sanctuaries were intertidal and easily accessible, all reefs were sampled from those areas. For the West Bay, Deep Bay, and Wanchese sanctuaries, which consisted of a single large reef per sanctuary, quadrat samples were collected at the base and crest from 3 widely spaced locations: 1 sample at each end and 1 in the center of the reef. The resulting separation between samples of ~20 m was equivalent to distances between many of the replicate reefs in other sanctuaries.

We defined the success of oyster reef restoration based on 3 metrics that focus on sustainability of oysters: presence of vertical structure above the bottom, presence of live oysters, and evidence of recruitment. Settlement and growth of oysters is the key function of an oyster reef with additional benefits stemming from it. We considered an oyster reef to meet 'minimum' success criteria if (1) oyster density was >10 $m^{-2}$ (at least 2 oysters >25 mm SH per 0.25 $m^2$ quadrat), (2) the emergent reef structure was at least 20 cm above the bottom, and (3) there was evidence of spat recruitment in at least 1 of the 2 survey years. These minimum criteria would indicate some temporal sustainability. Ideally, we would use data from natural reefs to gauge the trajectory of success; however, finding such reefs throughout the large expanse of estuary was not logistically feasible. Alternative metrics for determining success that reflect ecosystem benefits (e.g. fish utilization, filtration ability, benthic infaunal and epifaunal densities) have been proposed and used by many investigators. However, assessment of many of these metrics would be far too labor intensive over 94 reefs. We acknowledge that our success criteria are low, but in practice, our successful reefs had much higher levels of oyster density and recruitment, whereas reefs that failed these minimum criteria were clearly not persistent. After assessing minimal success, we used increases in oyster densities and biomass as indicators of ecological benefit (see Luckenbach et al. 2005) and mounting densities of market-sized oysters as an indicator of oyster fishery benefit.

**Disease analysis.** The protozoan endoparasite *Perkinsus marinus,* commonly referred to as 'dermo', is transmitted by infective waterborne cells released in the pseudofeces of infected oysters or when infected oysters gape and the deteriorating flesh releases the parasite (Andrews 1988, Soniat 1996). Infection begins in the digestive tract, and parasitic cells spread throughout the body, where they cause lysis of oyster cells, particularly in connective tissue, adductor muscle, digestive epithelium, and blood vessels. Tissues become composed primarily of dermo cells, and oysters appear to die from failure of major organ systems (Andrews 1988). Dermo-related mortality is highest in oysters during the second and third yr of life, when oysters typically reach 60 to 85 mm in SH (Andrews & Ray 1989). Prior to death, sublethal effects include reduced growth and fecundity, and discolored meat (Andrews 1988, Paynter & Burreson 1991). Dermo infections are normally assessed by sampling tissue from individual oysters and, after a special culture technique, counting the infective cells.

Following the same temporal and spatial design as the quadrat sampling, 20 to 30 live oysters (65 to 95 mm SH) were collected annually from the base and crest of each sanctuary reef. Infection level of *Perkinsus marinus* for each oyster was determined by removing a 3 to 5 mm long section of the rectum of each oyster and analyzing for the presence of *P. marinus* using the thioglycolate staining method (Ray 1963, Paynter & Burreson 1991). Each rectum sample was stained with thioglycolate solution, mounted on a microscope slide after a 5 d incubation period, and the number of *P. marinus* hypnospores counted in each of 3 haphazardly selected visual fields using a Wild M20 compound microscope at 100×. The mean number of hypnospores was then determined for each oyster from counts in the 3 visual fields. Prevalence of infection was calculated as the proportion of oysters infected in each group of 20 to 30 oysters collected. A weighted intensity of infection was calculated using Mackin's scale (Quick & Mackin 1971) in which the concentration of parasite cells from each infected oyster is assigned a score of 0, 1, 3, or 5. Oysters with 10 to 100 *P. marinus* cells per field of a microscope slide are considered lightly infected (score = 1), 100 to 1000 cells mildly infected (score = 3), and >1000 cells heavily infected (score = 5). Weighted intensity of infection for each replicate group of 20 to 30 oysters was then computed.

**Statistical analysis.** Univariate analyses tested for differences in density of each of 3 size classes of oysters (≤25 mm SH [recruitment of spat], >25 mm SH, and >75 mm SH [market-sized]), oyster biomass, and disease prevalence among sanctuary reefs. Prior to all analyses, data were tested for normality (Kolmogorov-Smirnov test) and homogeneity of variances (Cochran's test) at $\alpha = 0.05$: in only 1 case, spat recruitment, was transformation ($\sqrt{x} + 0.5$) necessary. Two-way analysis of variance (ANOVA) tested for differences in densities of each size class of oyster and oyster biomass among 8 sanctuaries (Bird Shoals, Middle Marsh I, Middle Marsh II, Neuse River deep, Neuse River shallow, West Bay, Deep Bay, and Wanchese) and sampling year (September 2002 and September 2003). The oyster response variables

used in these analyses came from samples on the crest of the reef, which was normally higher than at the base and less variable. For all ANOVAs, each reef within sanctuary areas containing multiple reefs was used as a separate replicate, whereas each of the 3 locations was used as replicates for those sanctuaries composed of 1 large reef. Student-Newman-Keuls (SNK) post hoc comparisons were performed on all significant main effects from the ANOVAs.

We also performed 2-tailed, paired *t*-tests on transformed spat recruitment and untransformed oyster density, market-sized oyster density, oyster biomass, average SH of oysters, disease prevalence and disease severity to test the effects of position on the reef (base versus crest). Each base mean was paired with its corresponding crest measurement for September 2002 and 2003. Although a June data set for disease prevalence and severity was also collected, disease levels are highly correlated between early and late summer with infection levels generally increasing over the summer, allowing higher resolution of differences in September.

## RESULTS

### Reef surveys

For 9 of the 11 sanctuary areas, emergent reef structure was still evident in 2002. The exceptions were the Neuse River mid-depth and Bogue Sound sanctuaries, which appeared to have been buried by sand. The Bogue Sound sanctuary, located in a sandy-bottom, relatively energetic flow regime, had become covered by sand within 1 yr of construction (North Carolina Division of Marine Fisheries [NCDMF] unpubl. data). The Neuse River mid-depth sanctuary consisted of 12 oyster reefs (1.0 m tall) constructed in 1992. Through dive searches using poles, we located 4 of the 12 reefs buried under a 0.3 m layer of coarse sand. The remaining 8 reefs were also assumed to be buried after finding no above-bottom or subsurface structure after 2 h of searching.

Of the 9 remaining sanctuaries, 1 had no (Crab Hole) and 1 very few (Neuse River deep) adult live oysters >25 mm SH. The limestone marl and concrete materials used to create reef structure for the Crab Hole sanctuary appeared completely overgrown by tunicates, bryozoans, barnacles, and small mussels. Divers observed no live oysters or spat recruitment at this sanctuary in 2002. Of 12 high-relief (2.0 m tall) and 12 low-relief (1.0 m tall) reefs created at the Neuse River deep sanctuary, 9 high and 6 low reefs were located during a total of 4 h of diver search time and 4 h of surface-vessel search using a depth profiler. The physical structure of all 9 high and 6 low reefs in the Neuse River deep sanctuary was completely intact, with vertical relief on high reefs ranging from 1.5 to 1.9 m and on low from 0.7 to 0.9 m.

Among the 8 sanctuaries characterized by physical structure above the sediment surface and live oysters, those constructed in intertidal areas and those made of bivalve shells in subtidal areas succeeded in sustaining complex 3-dimensional habitat. Of the 12 intertidal reefs created in 1997 and 11 intertidal reefs created in 2000 for the Middle Marsh I and II sanctuaries, all were intact with 50 to 100% coverage of live oysters. Diver observations of subtidal oyster reefs within sanctuaries, as well as visual inspection of quadrat samples, suggested that reefs created with limestone marl had less structural complexity than subtidal reefs created with bivalve shell material. Reefs at the West Bay, Deep Bay, and Wanchese sanctuaries, made of 8 to 12 cm diameter pieces of limestone marl, tended to harbor only scattered single oysters attached to the marl. In contrast, oysters formed large clumps of 4 to 8 individuals on the Neuse River shallow reefs, the only subtidal sanctuary reef created with bivalve (oyster) shell material. Oyster clumps were also common in harvest areas created via deposition of bivalve shell material in locations near the West Bay and Deep Bay sanctuaries. Of the 24 reefs created at the Neuse River shallow sanctuary, 14 appeared intact with live oysters present. Vertical relief of the 14 reefs ranged from 0.5 to 1.1 m, which along with absence of initial GPS information inhibited us from establishing which reefs were originally constructed as high (2 m) or low (1 m) relief. In addition, a large quantity of shell material, some colonized by live oysters, was scattered throughout the sanctuary area, suggestive of remnants of reefs destroyed by illegal harvest or storms.

### Oyster metrics within sanctuaries

There was a significant effect of sanctuary ($F_{7,81}$ = 3.65, p = 0.002) and no effect of collection period ($F_{1,81}$ = 1.41, p = 0.232) or the interaction ($F_{7,81}$ = 0.58, p = 0.768) on oyster spat density. Spat density averaged over the 2 yr was higher in the 3 intertidal sanctuaries (Bird Shoals, Middle Marsh I and II) than in all other sanctuaries, although only the Middle Marsh sanctuaries differed significantly from the subtidal sanctuaries (SNK post hoc contrasts, $\alpha < 0.05$). Successful spat recruitment was evident on all intertidal reefs within each sanctuary area in both years. The 5 subtidal sanctuaries did not differ in spat density (Fig. 2). Lowest spat recruitment occurred on the Wanchese reef, with 4 spat $m^{-2}$ in 2002 and no recruitment in 2003. Successful spat recruitment was evident on reefs within other subtidal sanctuaries surveyed in both 2002 and 2003.

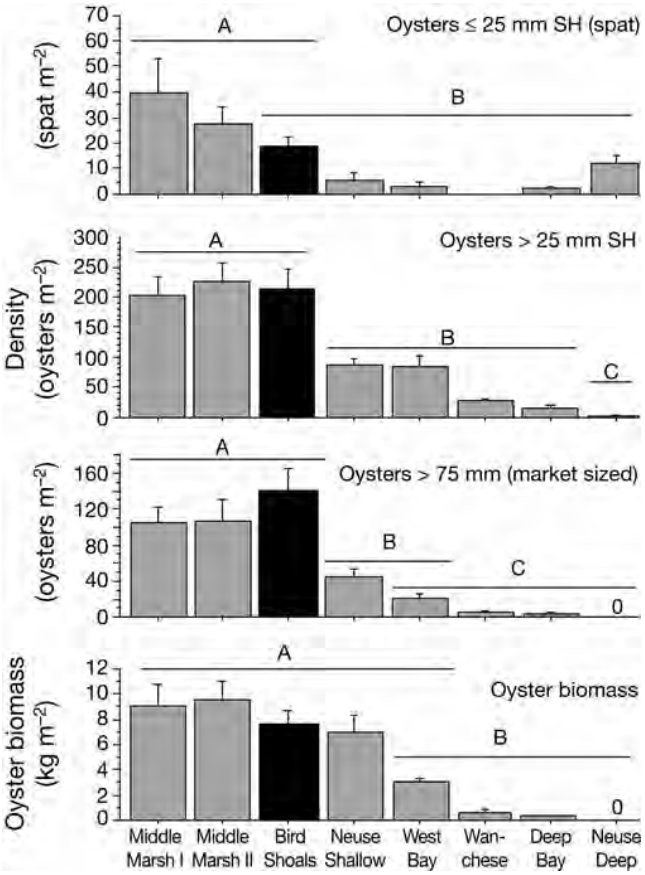


Fig. 2. Mean (+ 1 SE) density of oysters in 3 size categories, ≤25 mm shell height (SH; spat), >25 mm SH (oysters), >75 mm SH (market-sized), and biomass m$^{-2}$ (shell + soft tissue). Bars grouped under the same letters indicate no significant differences between mean values, whereas bars under different letters indicate significant differences as detected by SNK post hoc contrasts. Grey bars represent measurements of constructed oyster reefs, black bar represents a natural reef closed to harvest

Density of live oysters (>25 mm) differed among the 8 sanctuaries included in the analyses ($F_{7,81}$ = 8.85, p < 0.001), but not by sampling date ($F_{1,81}$ = 2.31, p = 0.132) nor due to the interaction between date and sanctuary ($F_{7,81}$ = 1.35, p = 0.223). Oyster density in the intertidal sanctuaries, Middle Marsh I and II and Bird Shoals, averaged 225 oysters m$^{-2}$ across the 2 yr and was higher than densities in all subtidal sanctuaries (Fig. 2; p < 0.05 for all SNK post hoc contrasts between Middle Marsh I and II and Bird Shoals versus each subtidal sanctuary). The lowest average oyster density, 0.25 m$^{-2}$, was found at the Neuse River deep sanctuary (SNK post hoc contrast, p < 0.05 for Neuse River Deep versus all other sanctuaries).

The density of market-sized oysters and oyster biomass showed a pattern similar but not identical to that of total oysters. The density of market-sized oysters also varied by sanctuary ($F_{7,81}$ = 5.05, p < 0.001), but not by collection year ($F_{1,81}$ = 0.71, p = 0.400) or the interaction ($F_{7,81}$ = 0.373, p = 0.914). Post hoc comparisons demonstrated that the average density of market-sized oysters was higher in the 3 intertidal sanctuaries than in all subtidal sanctuaries (Fig. 2). Among the subtidal sanctuaries, the density of market-sized oysters in the Neuse River shallow sanctuary was higher than the Wanchese, Deep Bay, and Neuse River deep sanctuaries, but similar to West Bay, which fell between and was indistinguishable from the Neuse River shallow and the remaining 3 subtidal sanctuaries. Oyster biomass varied by sanctuary ($F_{7,81}$ = 5.65, p < 0.001), but not by collection year ($F_{1,81}$ = 0.21, p = 0.65) or the interaction ($F_{7,81}$ = 1.48, p = 0.189). Post hoc comparisons of the sanctuary effect revealed 2 groupings of sanctuaries, with the 3 intertidal (Bird Shoals, Middle Marsh I and II) together with the subtidal Neuse River shallow sanctuaries having higher biomass than the Wanchese, Deep Bay, and Neuse River deep sanctuaries (Fig. 2). The West Bay sanctuary was intermediate and did not differ from either group.

Prevalence of *Perkinsus marinus* infection differed among sanctuaries ($F_{6,76}$ = 120.3, p < 0.001) and collection year ($F_{1,76}$ = 45.6, p < 0.001) with a significant sanctuary–collection year interaction ($F_{6,76}$ = 15.1, p < 0.001). To examine the sanctuary–collection year interaction, we performed post hoc contrasts among sanctuaries within each collection year and between years within each sanctuary (Fig. 3). For 2002, the highest prevalence (50 to 80%) occurred at oyster reefs within the Wanchese, West Bay, and Neuse River shallow sanctuaries (Fig. 3). Disease prevalence was lowest in Bird Shoals and Middle Marsh II (10 to 12%), with Deep Bay and Middle Marsh I sanctuaries intermediate (30%) and significantly different from both other groupings in 2002. In 2003, oysters within the West Bay sanctuary showed high disease prevalence levels (60%). All other sanctuaries had relatively low prevalence (0 to 22%) and did not differ among one another. For 5 sanctuaries, disease prevalence differed between years, in each case lower in 2003 (Fig. 3).

### Contrasts of reef crest versus base

Significant differences between crest and base locations on sanctuary and open reefs were evident in the paired comparisons for oyster density, density of market-sized oysters, oyster biomass, average SH of oysters, and disease prevalence (Fig. 4). Mean oyster densities at crests were nearly twice as high as densities at the base (141 versus 78 oysters m$^{-2}$, Fig. 4). The density of market-sized oysters and oyster biomass was 75%

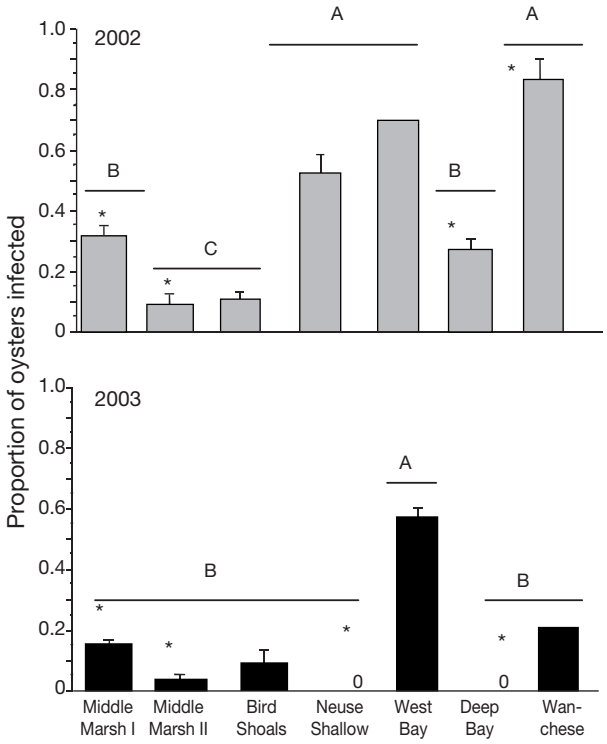


Fig. 3. Mean (+ 1 SE) prevalence of dermo infection in oysters from 7 North Carolina oyster sanctuaries in 2002 and 2003. The Neuse River deep sanctuary had no adult oysters present and was not included in the analysis. Bars grouped under the same letters indicate no significant differences between mean values, whereas bars under different letters indicate significant differences as detected by SNK post hoc contrasts. Asterisks indicate a significant difference between 2002 and 2003 for the sanctuary

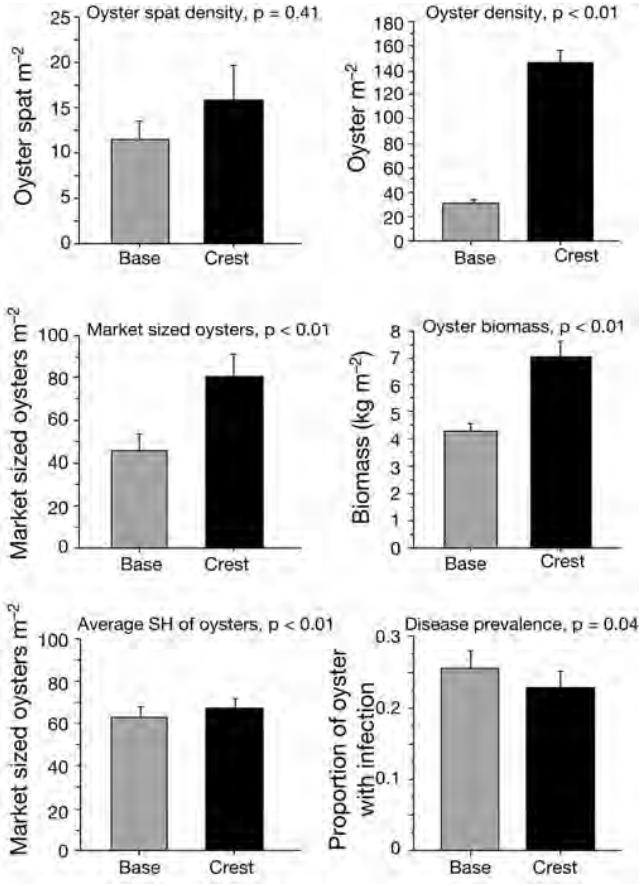


Fig. 4. Paired comparisons between selected variables measured at the base and crest of oyster reefs. All values represent the mean + 1 SD. P-values for paired *t*-tests are presented above each graph

higher at the crest than the base of the reef. Although not significant in the paired comparisons (p = 0.18), a trend existed of higher spat recruitment at crests of reefs than at their base (19 versus 14 oyster spat m$^{-2}$). Prevalence of oysters infected by *Perkinsus marinus* was higher at the bases of reefs than on crests (26% versus 22%). However, the severity of infection in those oysters infected was similar, averaging 1.5 (on a scale of 0 to 5) for both crest and base positions.

## DISCUSSION

Our surveys demonstrated that most oyster reefs within North Carolina no-harvest sanctuaries were successful (Table 2). By applying the minimal criteria of presence of vertical structure, live oysters, and evidence of successful recruitment in 1 of 2 yr, 7 sanctuaries could be judged successful, while 4 contained only failed reefs. From an oyster fishery perspective, examining the densities of market-sized oysters would be the best indication of success. Densities of market-sized oysters ranged from 0 to 142 m$^{-2}$ with only 4 sanctuaries having densities of market-sized oysters >25 m$^{-2}$ (Table 2). Although it is difficult to quantify the minimum density at which fishermen would abandon a reef for harvest, this density probably represents the low point of what they would consider harvestable. In contrast to the fishery perspective, some level of ecological success could be argued for all reefs that met the 3 minimal criteria and possibly for additional sanctuaries that did not. Ecological success does not require market-sized oysters in commercially profitable quantities. As long as oysters recruit regularly, low abundance of large oysters of market size does not preclude a restored oyster reef from sustaining valuable ecosystem services, which include enhancement of other fisheries for fish, crabs, and shrimps (Coen et al. 1999, Lenihan et al. 2001, Grabowski et al. 2005). Further, for the 2 sanctuaries that were classified as failures but which still had complex vertical structure (Crab Hole and Neuse River deep), these reefs may

Table 2. Success of North Carolina oyster reef sanctuaries as judged by the minimum criteria (vertical structure, live oysters, and 1 yr successful recruitment) and mean density of all oysters >25 mm shell height (SH), oyster biomass, and market-sized oysters (>75 mm SH)

| Sanctuary | Minimal | | | Mean oyster density (no. $m^{-2}$) | Mean oyster biomass (kg $m^{-2}$) | Mean market-size oysters (no. $m^{-2}$) |
|---|---|---|---|---|---|---|
| | Successful reefs | Failed reefs | Overall sanctuary | | | |
| **Intertidal** | | | | | | |
| Bird Shoals | 6 | 0 | Success | 210 | 7.2 | 142 |
| Middle Marsh I | 12 | 0 | Success | 205 | 9.6 | 105 |
| Middle Marsh II | 11 | 0 | Success | 227 | 9.8 | 108 |
| **Subtidal** | | | | | | |
| Bogue | 0 | 1 | Failure | 0 | 0 | 0 |
| Neuse River shallow | 14 | 10 | Success | 95 | 6.9 | 46 |
| Neuse River mid-depth | 0 | 12 | Failure | 0 | 0 | 0 |
| Neuse River deep | 9 | 15 | Failure | 0.25 | 0 | 0 |
| West Bay | 1 | 0 | Success | 92 | 3.1 | 24 |
| Deep Bay | 1 | 0 | Success | 27 | 0.8 | 9 |
| Crab Hole | 0 | 1 | Failure | 0 | 0 | 0 |
| Wanchese | 1 | 0 | Success | 23 | 1.2 | 11 |
| Total % | 60% success | 40% failure | 64% success | | | |

serve as habitat for other sessile invertebrates and fishes, fulfilling at least 1 ecological service (Coen et al. 2007, Grabowski & Peterson 2007).

Of the 3 intertidal sanctuaries containing restored reefs, all would be considered successful from an ecological or oyster fishery perspective, whereas success of restoration of subtidal reefs varied. All 3 intertidal areas had high densities of oysters including market-sized oysters. Intertidal restoration of oyster reefs may enjoy greater success in part because of relative ease of enforcement of prohibitions on use of bottom-disturbing fishing gear. Mobile fishing gear that penetrates into the bottom, like an oyster dredge or even a rake, carries the most serious risk of impact on benthic communities (Collie et al. 2000), degrades oyster reef habitat, and reduces oyster densities dramatically (Rothschild et al. 1994, Lenihan & Peterson 1998, Lenihan & Micheli 2000). The high structural relief and the abundant large oysters in the natural oyster reefs at Bird Shoals, an intertidal sanctuary where shellfishing has been prohibited for at least 30 yr, contrasts dramatically with fished intertidal reefs, which are seriously degraded (Lenihan & Micheli 2000). We observed no rake tracks indicative of illegal shellfishing at Bird Shoals or any of the other 3 intertidal reef sanctuaries.

In contrast to the high success of the 3 intertidal oyster reefs, the 8 subtidal sanctuaries (Table 2) were variable in oyster density and biomass. Peterson & Lipcius (2003) and Luckenbach et al. (2005) have suggested that oyster production or oyster density can be used as a measure of ecosystem services. As oyster density increases, bio-filtration, habitat complexity, provision of refuge, and forage species should increase. Under this metric, many of our subtidal oyster reefs still provide valuable ecosystem services, although density of market-sized oysters is low. At our subtidal reef sanctuaries, scattered tracks from dredge passage and gouges from tongs were evident. The loss of several restored subtidal oyster reefs, especially those missing in shallow and deep depths in the Neuse River estuary, can be attributed to illegal oyster fishing in those instances where we found only scattered shell debris over the site where a reef once stood.

Some environments may be intrinsically unsuitable for sustaining oyster reefs because of physical, chemical, or biological inhibitions to success. Improved capability to predict conditions leading to failure is likely to improve restoration success. We observed complete loss of all replicate reefs in 2 sanctuaries where the environment was apparently too energetic, as reflected in evidence of sand transport and total burial of the reef matrix. These failures at mid-depth in the Neuse River and in Bogue Sound could realistically be avoided by better *a priori* appreciation of prevailing physical processes, as indicated by coarse sand substrate. In our study, all such failures by burial occurred in subtidal habitats. High wave activity and sand transport are likely to render many intertidal sandflats physically unsuitable for oyster reef restoration, but such environments were not included in our study. One could also imagine extensive reef damage, even in typically quiescent intertidal areas, from hurricanes or other intense storms. Unlike persistent sedimentation, rapid recovery can follow intense storm damage to intertidal oyster reefs produced by exceptionally high oyster recruitment (Livingston et al. 1999).

The dominant chemical limitation to oyster recovery and restoration is a complex of factors induced or intensified by eutrophication of the estuaries. With added nutrient loading, resultant phytoplankton blooms lead to extensive bottom-water hypoxia and generation of hydrogen sulfide, which if sustained for several days causes mass mortality of oysters and other sessile invertebrates (Lenihan & Peterson 1998). This process primarily affects deeper areas (oysters at depths >4.5 m) in the Neuse River estuary, because sustained hypoxia is associated with density stratification of the water column, which inhibits mixing of oxygen from the surface waters. The failure of at least some Neuse River deep reefs, all of which were built in about 6 m of water (crest of reefs originally at 4 m, high relief, or 5 m, low relief), to persist was likely related to the joint impacts of hypoxia and hydrogen sulfide, which now frequently develop at that depth (Lenihan & Peterson 1998, Lenihan et al. 2001). Only by constructing tall reefs and protecting them from damage by fishing gear so as to ensure their projection upwards into surface mixed layers can restored oyster reefs succeed in waters deeper than about 4.5 m in most estuaries.

One reef sanctuary in our study, Crab Hole, failed to harbor any live oysters, probably because of biological inhibitions. The large sanctuary reef at this site in eastern Pamlico Sound near the Outer Banks was structurally intact but completely covered by tunicates and other 'fouling' organisms in both survey years. Such fouling doubtless pre-empts space and inhibits oyster settlement, but may not be the cause of the absence of oysters. This northern portion of Pamlico Sound possesses low spawning stocks of oysters, such that low settlement and recruitment of oysters may limit successful restoration (Ortega & Sutherland 1992). With oysters now so depleted in most estuaries of the Atlantic coast of the US (Kirby 2004), restoration strategies must be based on knowledge of hydrodynamics so as to concentrate reef restoration in areas of larval retention and seeded by sufficient spawning stock biomass to ensure sustained recruitment (Lipcius et al. 2008). For North Carolina's Pamlico Sound and the Maryland portion of Chesapeake Bay, spatial strategies of rebuilding of oyster stocks are necessary, first establishing core retention areas of high spawning stock biomass and then subsequently extending oyster reef restoration farther from the margins of successfully restored areas.

The biological limitation that is widely believed to represent the most serious impediment to recovery of native oysters in the Atlantic estuaries of the U.S. is the protozoan oyster disease *Perkinsus marinus* or dermo (Burreson & Calvo 1996, Powell et al. 2008). Because oyster reef sanctuaries, like marine reserves more broadly (Agardy 1994, Allison et al. 1998), are intended to allow build-up of locally high densities and enhance longevity in targeted populations, disease prevalence and severity may be expected to increase in sanctuaries. On the other hand, the protection from fishing disturbance and the resulting cultivation of high-relief structural habitat may enhance the resistance of oysters to infection given that the effects of disease on marine populations are typically greatest when combined with other physiological and environmental stressors (Anderson & May 1979, Sousa & Gleason 1989, Lenihan et al. 1999, Bruno et al. 2003). Over many generations, protecting populations from harvest may allow for natural selection of genotypes that are more resistant to dermo and other diseases (Burreson et al. 2000). Our survey revealed relatively low incidence and severity of dermo on reefs in sanctuaries. Although the size and density of oysters were greater on reef crests, oyster disease was less widespread in that more favorable (Lenihan 1999) environment. Our confirmation of previous results in Lenihan et al. (1999) and our failure to show high levels of disease prevalence or severity among large dense oysters on successful sanctuary reefs contradicts the prevailing dogma that the only means of combating dermo is to harvest oysters as quickly as possible after they reach marketable size before disease claims them (Andrews & Ray 1989). Our data imply that by sustaining the high relief on sanctuary reefs by prohibiting fishing (Krantz & Jordan 1996, Lenihan & Peterson 1998) or by preventing gear damage to the reef habitat by gear restrictions (Lenihan & Peterson 2004), oyster disease may not represent as serious an impediment to restoration and even to oyster fisheries as is currently believed (Krantz & Jordan 1996).

Our survey of oyster reef sanctuaries that have remained protected from fishing for 3 to 30 yr provides compelling evidence that restoration of the native eastern oyster is feasible. Perhaps the most encouraging sanctuary in our study was the set of Neuse River shallow reefs. Sampling of this sanctuary demonstrated that 10 yr after restoration of its reefs, oyster densities and recruitment levels met not only criteria for ecological success but also those for fishery success. This success was achieved in a subtidal environment where restoration generally proved more difficult, reinforcing similar demonstrations of restoration success in intertidal reefs of Chesapeake Bay (O'Beirn et al. 1999). Pronouncing restoration of the native oyster unachievable is at least premature if not incorrect. The basis for this judgment has been a definition of success that includes only parameters relevant to recovery of the oyster fishery. Application of a broader definition of success that acknowledges the ecosystem services of oysters and the reefs they support would lead to many more conclusions of success. The widely publicized

pronouncement that native oyster restoration is a failure has led to advocacy and state government support of a proposal to introduce an Asian oyster, *Crassostrea ariakensis*, into Chesapeake Bay to replace the native eastern oyster (NRC 2003, Zhou & Allen 2003, Grabowski et al. 2004). Our results of the first comprehensive survey of decade-scale oyster success in protected sanctuaries provides hope and incentive for patience and a more interdisciplinary ecosystem-based approach to oyster reef restoration.

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[Article]

# Restored Oyster Reef Location and Design Affect Responses of Resident and Transient Fish, Crab, and Shellfish Species in Mobile Bay, Alabama

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*Abstract.*—Recent efforts to restore oyster reefs have resulted in the creation of many reefs with the explicit objective of benefiting local shellfish and finfish fisheries. We evaluated the community responses of the fish (transient and resident), crab, and shellfish species that colonized or utilized a series of restored high- and low-relief oyster reefs at three different locations within Mobile Bay, Alabama. Sites were chosen to represent different combinations of sediment type, proximity to established oyster reefs, water quality, and water movement patterns. The results showed substantial differences in reef community among the three sites and, compared with unstructured bottoms, increased abundance of several species of small demersal fishes and sessile invertebrates. Common mud crabs *Panopeus herbstii* and flatback mud crabs *Eurypanopeus depressus* were the only species to exhibit any consistent patterns in habitat use that could be directly attributed to reef height. The species composition of transient fishes did vary among treatments, but the total abundance on low-relief reefs and unstructured control areas was similar and often greater than that on high-relief reefs. There were significant two-way interactions between season, reef location, and reef design for most species abundances. These results suggest that the responses by resident and transient species to reef restoration were highly variable and that our ability to predict the community responses of resident and transient fishes to oyster reef restoration may be limited because of the interactions among location-specific biophysical characteristics.

Reefs built by the eastern oyster *Crassostrea virginica* have long been considered an important resource of estuaries along the U.S Atlantic and Gulf coasts (Coen et al. 1999b). In addition to being an important fishery, oysters are thought to provide a significant number of ecosystem services (Lenihan and Micheli 2000; Coen et al. 2007). Oyster reefs create a three dimensional, complex habitat that provide biofiltration, influence water quality, facilitate the energetic transfer between trophic levels, sequester nutrients, and increase sediment stabilization (Dame and Libes 1993; Coen et al. 1999b; Breitburg et al. 2000; Coen and Luckenbach 2000; Ewert et al. 2005; Hodges et al. 2005). These reefs also serve as essential habitat in the life cycle of many species of estuarine-dependent fishes and shellfish (Coen et al. 1999b; Lehnert and Allen 2002). However, in many of the oyster-producing bays, oyster populations have been reduced to a fraction of historical levels (Jackson et al. 2001; Kirby 2004) because of destructive harvesting practices (Lenihan and Micheli 2000), disease (Ford and Tripp 1996), cultch removal (Luckenbach et al. 1999), hypoxia (Lenihan and Peterson 1998), and changes in sedimentation patterns (Smith et al. 1997).

Oyster reef restoration options are limited and include repairing damaged reefs by the addition of shell or new cultch, closure of existing reefs to fishing, and active transplantation of oysters (Coen et al. 1999b). For reefs that are constantly harvested, regular cultch planting often results in a put-and-take fishery (Hargis and Haven 1999; Coen and Luckenbach 2000) that, although maintainable, may offer few ecological benefits because these reefs are continually disturbed,

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are in a constant state of recovery, and have little community succession (Kaiser et al. 2002; Kaiser et al. 2003). For nonharvested reefs, successful restoration may depend on altering the environmental conditions that triggered the loss or creating a new reef that is resilient to these conditions. Because it is more affordable and results are more quickly observed, new reef construction is often preferred. Creation of taller reefs in these areas may allow reef communities to survive low oxygen events associated with stratification (Lenihan and Peterson 1998; Kaiser et al. 2003).

Ecologically, new and restored oyster reefs may result in the return of important ecosystem services (Coen et al. 2007). Potential benefits include the increase of essential biogenic habitats available to other organisms (Breitburg 1999), decreases in ambient phytoplankton levels (Ulanowicz and Tuttle 1992), redistribution of sediment (Hargis and Haven 1999), and increase in benthic primary production (Ulanowicz and Tuttle 1992). As a measure of functional equivalency, structural attributes can be used to make a determination about the function of that habitat (Bradshaw 1984; Zedler 2000). Fish and invertebrate assemblages are one of the more commonly used metrics for examining structure (e.g., Abele et al. 2000; Nestlerode 2004; Crona and Ronnback 2007). Often, community structure comparisons among restored or reference habitats are limited to demersal and resident species that can be easily sampled (e.g., Peterson et al. 1987; Plunket 2003; Tolley and Volety 2005). As a result, most transient fishes are not included in community descriptions and are rarely evaluated as a measure of structural complexity, aside from the obvious influence they can have on community structure (Laurel et al. 2003). Despite this, it is known that transient fishes can take advantage of restored reef habitats by using these habitats as refuge to escaping the effects of hypoxia, potentially having a top-down effect the reef community (Breitburg 1999; Harding and Mann 2001; Lenihan et al. 2001). Regardless, transient finfishes are thought to benefit from habitat restoration, and the explicit purpose of enhancing finfish fisheries remains an important goal of many restoration projects.

Reef restoration is an integral part of the Alabama Department of Conservation and Natural Resources' management of Mobile Bay (Tatum et al. 1995). The conversion of bay bottom from unstructured mud–sand habitat to low-relief, structured oyster habitat has the explicit purpose of increasing the oyster fishery (Hargis and Haven 1999; Lenihan et al. 2001; Soniat et al. 2004), but these activities should also enhance other fisheries (Breitburg 1999; Peterson et al. 2003). Because this type of reef creation was common in many locations beyond Mobile Bay (Hargis and Haven 1999), the goal of the study was to determine if the current restoration techniques used in Mobile Bay are the most beneficial for the reef community. Specifically, our initial objective was to test whether reef height and location altered the abundance and community structure of colonizing resident invertebrate and fish species on restored reefs. The second objective was to examine the effects of reef height, location, and season on transient and facultative species that utilize the restored reefs by comparing abundance and community structure between the restored reefs and an unrestored location. Although restoration in Mobile Bay has focused on building low-relief reefs, it is unknown which type of restored reef design may most benefit the entire community. If one reef design is shown to have more benefits that the other, a shift in the reef-building efforts may pay dividends beyond simply enhancing the oyster harvest.

## Methods

*Sites and reef construction*.—Twenty-four oyster reefs were created at three sites within Mobile Bay (30.5°N, 88°W) in the north-central Gulf of Mexico (Figure 1). These sites were located across a biophysical gradient in southern Mobile Bay that varied by sediment type, tidal exchange, and proximity to living reefs. Although we identified the general location for the reefs, the Alabama Department of Conservation and Natural Resources, Marine Resources Division selected the specific location for the reefs to minimize the impact on navigation. The site first was located along the western edge of Mobile Bay at Cedar Point (site CP). This area is surrounded by abundant natural oyster reefs (Tatum et al. 1995), and the sea floor is characterized by fine sediments (silts and fine sand). The second site, Sand Reef (site SR), is located along the north side of Little Dauphin Island at the southern end of Mobile Bay. Sand Reef is located in an area that has a sea floor that is mostly fine sand; living oyster reef habitat in close proximity was minimal. Neither Cedar Point nor Sand Reef has experienced hypoxic or anoxic events because of the relatively high amount of tidal exchange between lower Mobile Bay and the Mississippi Sound or the Gulf of Mexico (Wallace 1994; Bianchi et al. 1999). The final site was located in Bon Secour Bay (eastern Mobile Bay) at an area known as Shellbank Reef (site SB). This area has a sandy sea floor that historically supported oyster reefs (Eckmayer 1979); but extant living oyster reefs are rare (Smith 1999). Unlike the western part of Mobile Bay, the Bon Secour area is known to experience hypoxic–anoxic conditions that last for periods of hours to days (May 1973; Saoud et al. 2000a; Saoud et al. 2000b).

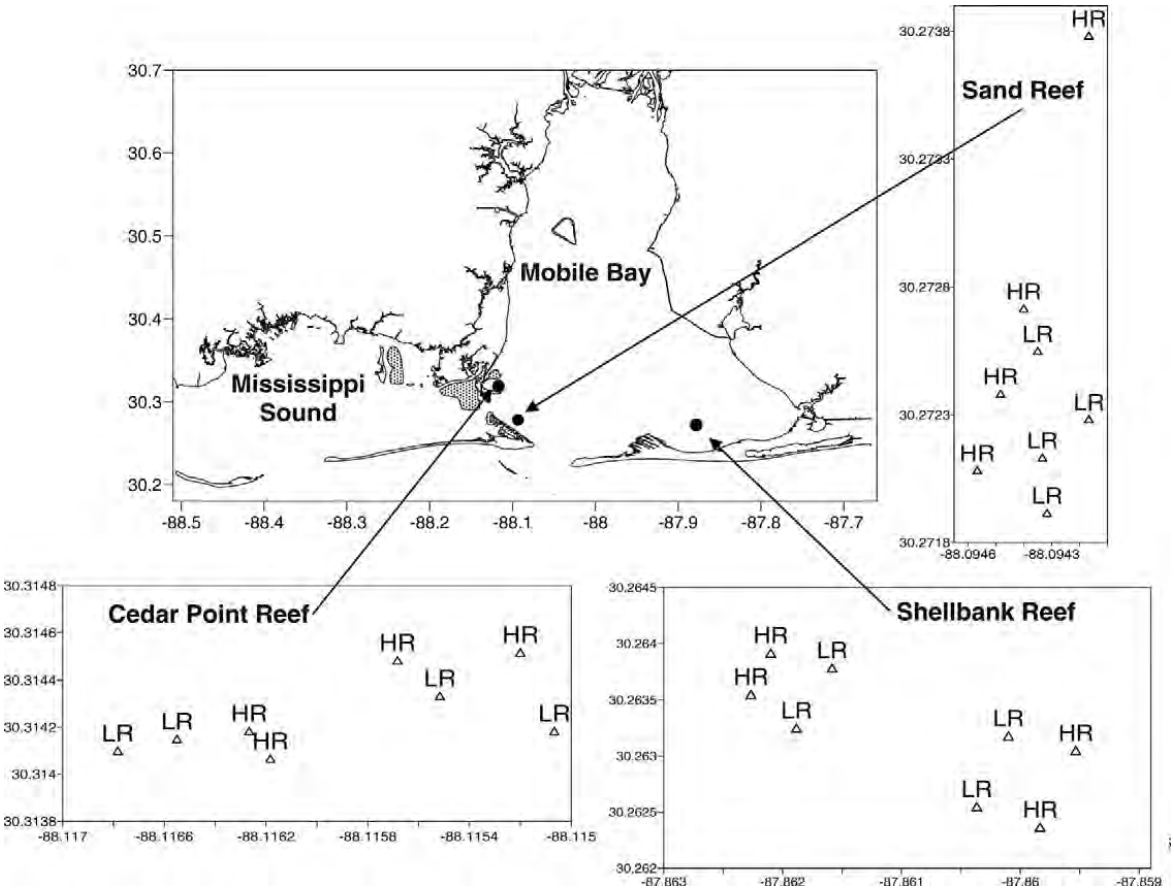


FIGURE 1.—Map of Mobile Bay, Alabama, indicating the locations of the three reef sites and the layout of newly constructed (2003–2004) high-relief (HR) and low-relief (LR) reefs at these sites (eight reefs per site). Shaded areas indicate the locations of living-oyster reefs in the bay area.

Current theories suggest that high water residence times, as effected by a cyclonic current that forms an eddy in the eastern part of the bay, may trigger or exacerbate these low oxygen events (K. Park, personal communication).

During the winter of 2003–2004, we constructed four high-relief reefs and four low-relief reefs at each of the three sites. Reefs were built in water approximately 2.5 m deep at site SB to 3.0 m deep at sites CP and SR, and each reef was 625 $m^2$ ($25 \times 25$ m). Low-relief reefs (10-cm height) had a limestone marl base covered by an oyster shell veneer, and the high-relief reefs (100-cm height) had a limestone or concrete marl base covered by an oyster-shell veneer. Each piece of limestone marl or crushed concrete had a diameter of approximately 7.6 cm (class 3 riprap), and the oyster shell veneer on both types of reefs was approximately 3–5 cm thick. All deposited shell material was obtained from local oyster harvesters. Individual reefs were spaced 25–125 m apart, and reef layout varied among the three sites. To measure facultative and transient species, four control areas at each site were haphazardly selected on the unstructured bottom habitat about 100 m from any reef. Bathymetric surveys using a Ceeducer DGPS/depth finder system were completed to verify the initial reef construction (February 2004) and their retention after Hurricanes Ivan (September 2004), Dennis (July 2005), and Katrina (August 2005) passed through the area. Water quality at the three sites was measured (YSI 650 MDS handheld meter) at the surface and near the bottom in March and April 2004 and monthly from June 2004 to August 2005. Mean values for dissolved oxygen, salinity, and temperature were calculated by averaging values taken before and after any field activities at each site. To determine if environmental conditions were similar among locations, we calculated the absolute difference for each environmental metric for all pairwise comparisons at each date.

*Resident species.*—To assess colonization and habitat utilization by epibenthic invertebrates and small resident fishes, we deployed a tray filled with oyster shell on each of the reefs. For this study, resident fishes

were defined as fishes that rely on reefs as their primary habitat (Breitburg 1999). Our trays (0.2-$m^2$ rectangles, that had a depth of 7.5 cm) had three 60-mm-diameter holes in the bottom covered by 1.5-mm mesh (similar to those used by Eggleston et al. 1998), which allowed the tray to drain without losing organisms during the removal process. The trays were filled with oyster shell identical to the shell used to create the oyster veneer on each reef and were placed near the center of each reef. Because unstructured mud–sand habitats typically contain fewer macrofaunal organisms and different infaunal species assemblages than structured habitats (Heck et al. 1995; Moksnes and Heck 2006), we did not deploy control trays at each of our sites. The introduction of shell would result in a biased sample. Settlement trays were moored to a rectangular slab of concrete used as an anchor to identify each reef.

Colonization trays were deployed during March 2004 and sampled bimonthly until October 2004, when all trays were removed. The trays were redeployed in May 2005 and sampled bimonthly until August 2005. The trays were set and recovered by scuba divers. During the removal process, divers covered each tray with a solid plastic lid to prevent organisms from escaping. New trays were then placed on the reef and allowed to colonize until the next scheduled removal. Contents of each tray were rinsed through a 1-mm-mesh sieve, and organisms were enumerated to the species or genus level. All abundances were transformed to density (individuals/$m^2$).

To analyze community structure (via multivariate statistical package Primer version 6), we constructed a Bray–Curtis similarity matrix and used this to conduct a two-way analysis of similarity (ANOSIM) to test for differences in community composition by site and reef height. To test for differences in community succession and reef height, we conducted an additional two-way ANOSIM between year and reef height. We also examined the effect of reef height (high versus low) within each site and with all sites combined using a one-way ANOSIM. All data were square root transformed to decrease the contributions of predominant species to any multivariate pattern (Clarke and Warwick 2001). Differences in community structure were significant at $\alpha = 0.01$. To test for differences in abundance and diversity among the habitats, we conducted a two-way analysis of variance (ANOVA) with interaction terms comparing the $\log_e(x + 1)$ transformed density and Shannon–Wiener diversity index. We restricted ANOVA to the species identified as contributing more than 10% of total organism abundance, but our diversity index included all species. Site location (each site) and reef height (low and high) were considered independent variables. Bimonthly abundance values were treated as temporal replicates for this analysis. When no interaction terms were observed, Student–Newman–Keuls (SNK) tests were used to make further pairwise comparisons. All results were considered significant at the 0.05 level.

*Transient and facultative residents*.—For all three sites, fish utilization was characterized by sampling monthly between July 2004 and June 2005 with 3-m × 30-m gill nets with two 15-m panels, 1 with 5-cm mesh and one with 10-cm mesh, on each reef and control site ($N = 12$ net sets/site, or 1 set for each reef or control area). Facultative residents were defined as those that are typically associated with structure that provides vertical relief. Transient fish were defined as those species that have large home ranges, but may feed on or near oyster reefs (Breitburg 1999). On the high- and low-relief reefs and control areas, nets were set diagonally in a pattern from the northwest to the southeast corner. Nets were set in random sequence in 30-min intervals starting at sunrise and allowed to soak for approximately 4 h. Early morning sets were done to maximize the catch of species that may avoid the water column during daylight hours. Although all soaks were scheduled to last 4 h, meteorological events and high catch rates occasionally resulted in longer soak times. As nets were retrieved, fish were removed and placed on ice for transportation to the laboratory, where they were later identified to species and enumerated (Table 1). Abundance was determined by calculating catch per unit effort (CPUE [number of individuals/minutes of soak time, which was then standardized to catch per hour of soak time]).

The composition of transient and facultative resident fish communities was analyzed in a manner similar to that for our settlement trays. We constructed a Bray–Curtis similarity matrix and used this to conduct a two-way crossed ANOSIM to test for differences in community composition by site and reef height. A one-way ANOSIM was used to examine differences among the reef treatments at each site. All data were square root transformed to decrease the contributions of predominant species to the multivariate pattern (Clarke and Warwick 2001). Differences in community structure were significant at $\alpha = 0.01$. For each of the species that made up at least 10% of the total abundance, we conducted a three-way ANOVA comparing $\log_e(x + 1)$ transformed CPUE. Season (summer 2004, fall 2004, winter 2005, spring 2005, and summer 2005), site location (sites CP, SR, and SB) and reef treatment (high, low, control) were considered independent variables. Red drum and spotted seatrout trout were added to these analyses owing to the recreational importance of these fishes. Although the

TABLE 1.—Species collected in Mobile Bay as part of a study of oyster reef restoration.

| Species | Collection method[a] | Number collected |
|---|---|---|
| **Bivalvia** | | |
| Dark falsemussel *Mytilopsis leucophaeata* | T | 70 |
| Recurved mussel *Ischadium recurvum* | T | 33,140 |
| Eastern oyster *Crassostrea virginica* | T | 46,530 |
| **Malacostraca** | | |
| Banded snapping shrimp *Alpheus armillatus* | T | 850 |
| Bigclaw snapping shrimp *Alpheus heterochaelis* | T | 10 |
| Striped hermit *Clibanarius vittatus* | T | 530 |
| Grass shrimp *Palaemonetes* spp. | T | 1,805 |
| Blue crab *Callinectes sapidus* | T | 50 |
| Common mud crab *Panopeus herbstii* | T | 1,355 |
| Flatback mud crab *Eurypanopeus depressus* | T | 10,970 |
| Florida stone crab *Menippe mercenaria* | T | 205 |
| **Gastropoda** | | |
| Oyster drill *Stramonita haemostoma* | T | 275 |
| **Osteichthyes** | | |
| Speckled worm eel *Myrophis punctatus* | T | 430 |
| Gulf toadfish *Opsanus beta* | T | 70 |
| Oyster toadfish *Opsanus tau* | T | 10 |
| Crested blenny *Hypleurochilus geminatus* | T | 290 |
| Feather blenny *Hypsoblennius hentz* | T | 600 |
| Freckled blenny *Hypsoblennius ionthas* | T | 430 |
| Skilletfish *Gobiesox strumosus* | T | 1,835 |
| Darter goby *Ctenogobius boleosoma* | T | 5 |
| Naked goby *Gobiosoma bosc* | T | 1,315 |
| Gulf menhaden *Brevoortia patronus* | 5; 10 | 2,376; 231 |
| Scaled sardine *Harengula jaguana* | 5 | 170 |
| Skipjack herring *Alosa chrysochloris* | 5; 10 | 232; 1 |
| Threadfin shad *Dorosoma petenense* | 5 | 40 |
| Ladyfish *Elops saurus* | 5; 10 | 53; 9 |
| Longnose gar *Lepisosteus osseus* | 5 | 5 |
| Atlantic bumper *Chloroscombrus chrysurus* | 5; 10 | 170; 1 |
| Florida pompano *Trachinotus carolinus* | 10 | 1 |
| Jack crevalle *Caranx hippos* | 5; 10 | 8; 2 |
| Leatherjack *Oligoplites saurus* | 5 | 12 |
| Sharksucker *Echeneis naucrates* | 5 | 1 |
| Atlantic spadefish *Chaetodipterus faber* | 5; 10 | 2; 1 |
| Pigfish *Orthopristis chrysoptera* | 5 | 12 |
| Bluefish *Pomatomus saltatrix* | 5; 10 | 48; 2 |
| Cobia *Rachycentron canadum* | 5; 10 | 1; 1 |
| Atlantic croaker *Micropogonias undulatus* | 5; 10 | 996; 9 |
| Banded drum *Larimus fasciatus* | 5 | 3 |
| Black drum *Pogonias cromis* | 10 | 2 |
| Red drum *Sciaenops ocellatus* | 5; 10 | 9; 2 |
| Sand seatrout *Cynoscion arenarius* | 5; 10 | 756; 72 |
| Silver perch *Bairdiella chrysoura* | 5 | 38 |
| Southern kingfish *Menticirrhus americanus* | 5; 10 | 618; 37 |
| Spotted seatrout *Cynoscion nebulosus* | 5; 10 | 32; 7 |
| Spot *Leiostomus xanthurus* | 5; 10 | 1,391; 1 |
| Star drum *Stellifer lanceolatus* | 5; 10 | 6; 2 |
| Pinfish *Lagodon rhomboides* | 5 | 86 |
| Spanish mackerel *Scomberomorus maculatus* | 5; 10 | 73; 35 |
| Sheepshead *Archosargus probatocephalus* | 10 | 2 |
| Gulf butterfish *Peprilus burti* | 5 | 4 |
| Harvestfish *Peprilus paru* | 5; 10 | 1; 84 |
| Hogchoker *Trinectes maculatus* | 5 | 1 |
| Southern flounder *Paralichthys lethostigma* | 5; 10 | 2; 12 |
| Bighead searobin *Prionotus tribulus* | 5 | 4 |
| Gafftopsail catfish *Bagre marinus* | 5; 10 | 45; 56 |
| Hardhead catfish *Ariopsis felis* | 5; 10 | 282; 107 |
| **Chondrichthyes** | | |
| Atlantic sharpnose *Rhizoprionodon terraenovae* | 5; 10 | 3; 4 |
| Blacktip shark *Carcharhinus limbatus* | 5; 10 | 8; 24 |
| Bull shark *Carcharhinus leucas* | 5; 10 | 1; 28 |
| Atlantic stingray *Dasyatis sabina* | 10 | 3 |
| Cownose ray *Rhinoptera bonasus* | 5; 10 | 1; 29 |

[a] T = settlement tray, 5 = 5-cm-mesh gill net, and 10 = 10-cm-mesh gill net.

data were transformed, there were a few instances where the data continued to violate the homogeneity of variance assumption for ANOVAs. Because these instances were infrequent, we believe that the robustness of the ANOVA test allowed for careful interpretation of any further ANOVA results (Sokal and Rohlf 1981). When there was no interaction term observed, SNK tests were used to make pairwise comparisons. All results were considered significant at $\alpha = 0.05$. Additionally, to assess the magnitude of the response to reef treatment by each species that constituted more than 5% of the fish catch, we determined the percent relative difference in mean abundance among the three treatments ($[A - B]/B) \cdot 100$, where $A$ is either the reference habitat (control or low relief) and $B$ is the low-relief or high-relief reef habitat). For these analyses, all sites and dates were combined, and mean values based on reef type were used to examine these data for generalized patterns.

## Results

### *Water Quality*

For our sample locations, at any given date, the mean differences in water quality metrics were minimal. The mean ± SE differences in temperature, salinity, and dissolved oxygen level between any two locations at any given date were 1.26 ± 0.17°C, 3.0 ± 0.53 practical salinity units (psu), and 0.69 ± 0.10 mg/L, respectively. Temperature averages ranged from 9.6°C to 32.8°C at the surface and from 9.5°C to 32.7°C at the bottom. A temperature high of approximately 30°C was evident at all sites in July of 2004. The lowest temperatures were present during January of 2005 (10°C). Average dissolved oxygen ranged from 3.5 to 15.7 mg/L at the surface and from 3.3 to 11.0 mg/L at the bottom. Dissolved oxygen levels ranged between 5.0 and 7.0 mg/L during the summer and fall and between 8.0 and 10.0 mg/L during the winter and spring. Oxygen levels between 2 and 4 mg/L were recorded in bottom waters on three occasions in 2004 (all at site CP) and on four occasions in 2005 (one at site CP and three at SB). Oxygen levels between 0 and 2 mg/L were recorded once in 2004 (site CP), but none were that low in 2005. During our study there were no recorded incidences of anoxia. Salinity averages ranged from 1.1 to 22.9 psu at the surface and from 1.1 to 24.1 psu near the bottom. Salinity values were highest during the summer and fall (17–23 psu) and then decreased in the spring (5–10 psu).

### *Resident Species*

Our colonization trays identified reef communities that consisted of 13 families and 21 species of invertebrates (bivalves, decapods, and gastropods) and fishes (Table 1). All species were collected at each of the three reef locations during this study. Our ANOSIM results indicated that for reef height, without respect to location, there were no significant differences (global $R$) between the community found on the high- and low-relief reefs (global $R = 0.049$, $P = 0.16$). For reef location without respect to reef height, there was a significant difference among the three sites (global $R = 0.48$, $P = 0.01$). Pairwise comparisons revealed that each of the three sites was unique; the separation was greater between site SB and sites CP (global $R = 0.597$, $P = 0.001$) and SR (global $R = 0.686$, $P = 0.001$) than between sites CP and SR (global $R = 0.185$, $P = 0.005$). Our measure of community succession on the different reefs did not indicate any significant differences between 2004 and 2005, indicating that the state of succession was the same in each year. Comparisons between the high- and low-relief reefs at each location did not result in any additional significant differences.

Because the eastern oyster, flatback mud crab *Eurypanopeus depressus*, recurved mussel *Ischadium recurvum*, and naked goby *Gobiosoma bosc* each constituted more than 10% of the total abundance, ANOVAs were conducted for these species. For the eastern oyster there was a significant density difference among the sites ($F_{2, 59} = 74.3$, $P < 0.001$), but no significant differences for reef height. For the three sites, oyster density decreased from site SR to sites CP and SB, and post hoc comparisons indicated that all three sites were significantly different from each other (SNK tests: $P < 0.01$; Figure 2). The flat mud crab differed significantly among the three reef sites ($F_{2, 59} = 28.7$, $P < 0.001$); sites CP and SR were both significantly different from site SB (both SNK tests: $P < 0.01$) but not from each other, and significantly more crabs were collected on high-relief than low-relief reefs ($F_{1, 59} = 4.2$, $P = 0.04$). The abundance of naked gobies was significantly different among sites ($F_{2, 59} = 9.02$, $P < 0.001$), site SB being greater than either site CP or SR (SNK test: $P < 0.05$); recurved mussel differences were also significant among sites ($F_{2, 59} = 7.90$, $P < 0.001$) and were similarly greater at site SB than at sites CP or SR (SNK test: $P < 0.01$). Density of all organisms combined did not differ significantly among the three locations, but density was significantly less on high-relief than low-relief reefs ($F_{2, 114} = 9.08$, $P = 0.003$; Figure 3). Diversity differed significantly among sites ($F_{2, 59} = 4.33$, $P = 0.018$) but not between reef heights (Figure 3).

### *Transient and Facultative Species*

Gill netting from July 2004 to July 2005 captured 40 species, of which 35 were bony fishes (Osteichthyes), 3

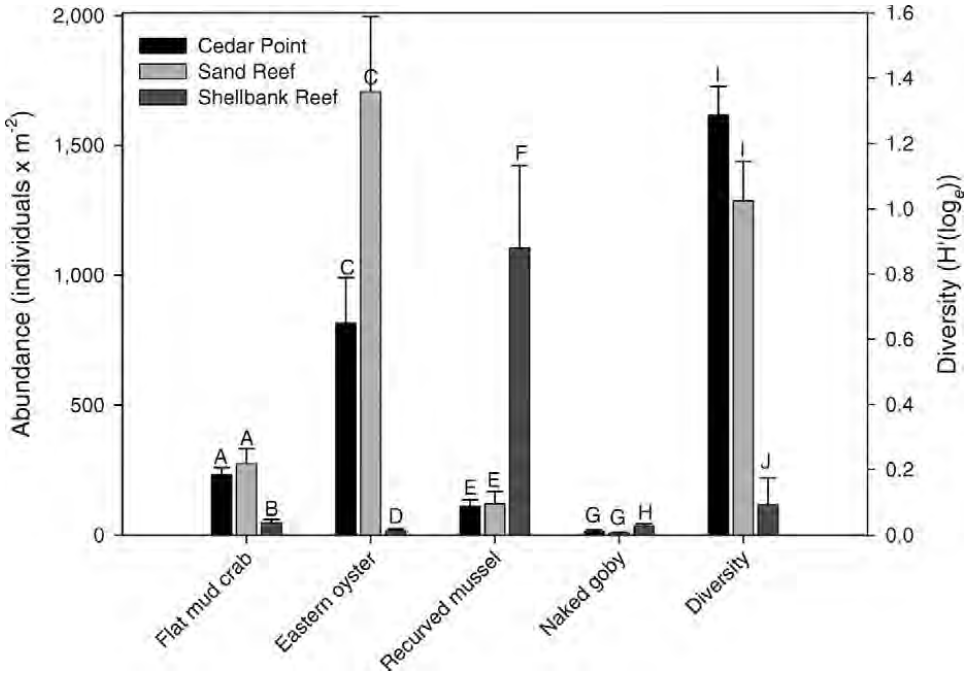


FIGURE 2.—Density of four major species (each >10% of the total; left scale) and mean + SE diversity ($\log_e[x + 1]$ transformed Shannon–Wiener diversity index; right scale) of all species occurring in settlement trays at each of three reef sites in Mobile Bay. Different letters indicate significant differences among sites for the given species and diversity.

were sharks, and 2 were rays (Table 1). For our 5-cm-mesh gill nets, all three sites had the highest CPUE in the summer, a decrease in the fall and spring, and the lowest abundance in the winter (Figure 4). In general, the control sites had the highest CPUE at all three sites followed by the low-relief and then high-relief reefs (Figure 5). Fish assemblages differed significantly (ANOSIM) by site (global $R = 0.13$, $P = 0.001$) and reef treatment (global R = 0.075, $P = 0.001$). When grouped by site, fish community was unique to each of the three site comparisons (CP versus SR: global $R = 0.086$, $P = 0.001$; CP versus SB: global $R = 0.104$, $P = 0.001$; and SR versus SB: global $R = 0.199$, $P = 0.001$). For groupings that were based on reef design, the high-relief reefs were not significantly different from the low-relief reefs (global $R = 0.013$, $P = 0.107$); however, both the high-relief (global $R = 0.124$, $P = 0.001$) and low-relief reefs (global $R = 0.09$, $P = 0.001$) were different from controls. When each site was examined individually, this pattern was constant for all three locations.

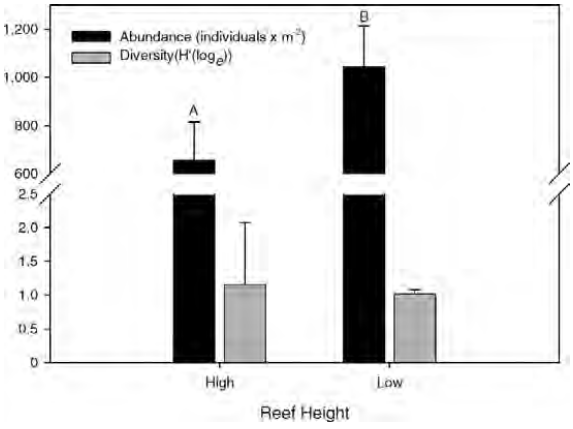


FIGURE 3.—Mean + SE combined resident species density (black bars; left scale) and community diversity (gray bars; right scale) on high- and low-relief reefs at three sites in Mobile Bay combined. Different letters indicate significant differences in abundance between reef heights. See Figure 2 for additional details.

Three-way ANOVA of CPUE of fish species with greater than 10% abundance (Table 2) by season, site, and reef height did not suggest any clear patterns, as indicted by the presence of a large number of significant two-way interactions terms (Table 3). For most fish species examined and total fish abundance, there were significant season × reef height and season × site interactions. Although the seasonal variation in fish abundance was not unexpected, the large number of significant site × reef height interactions was surprising. These results indicate that organism abundance was not consistent on the three reef types among the three sites. For three-way interaction terms, only red drum resulted in any significant differences,

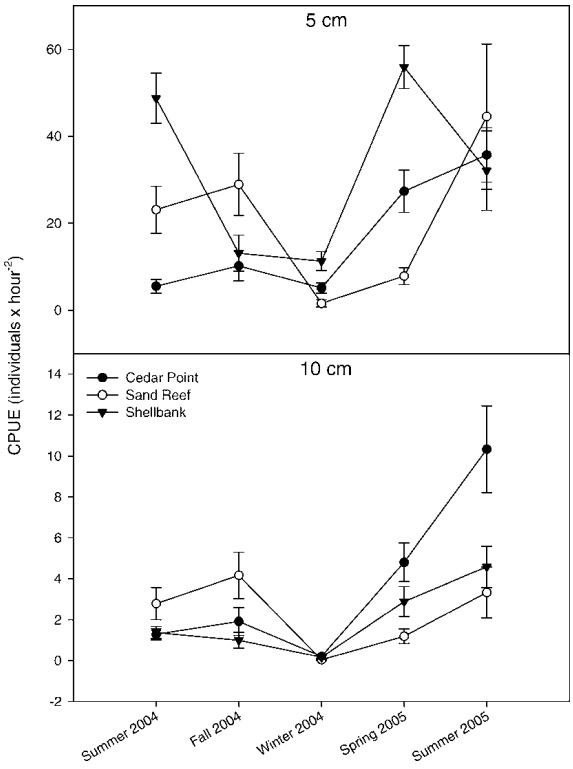


FIGURE 4.—Seasonal changes in mean + SE catch per unit effort (CPUE) of all fish taken in 5-cm-mesh and 10-cm-mesh gill nets at oyster reefs at three sites in Mobile Bay combined, 2004–2005.

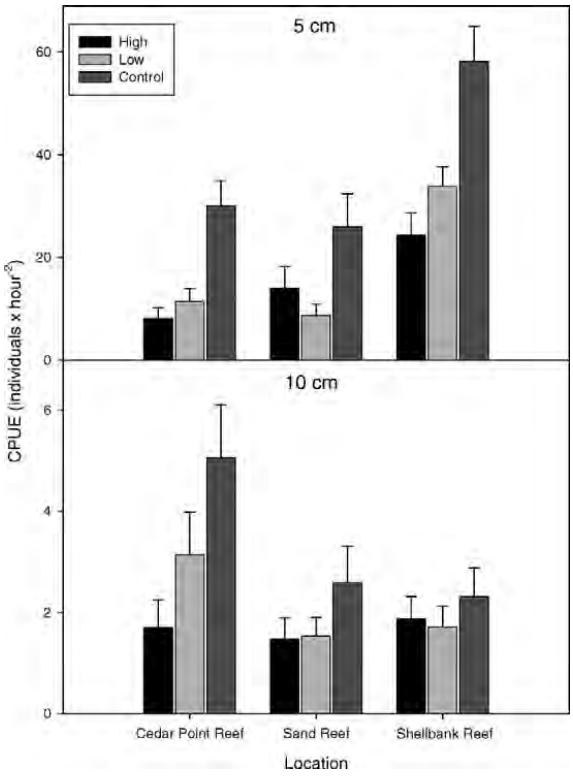


FIGURE 5.—Mean + SE catch per unit effort (CPUE) of all fish taken in 5-cm-mesh and 10-cm-mesh gill nets at three oyster reef treatments (high relief, low relief, and control) located at three separate sites in Mobile Bay, 2004–2005.

indicating that organism abundance on each reef varied depending on the site and season.

The results from fish collected in the 10-cm gill nets followed a pattern similar to those of fish collected in the 5-cm gill nets. Winter had the lowest fish CPUE among all the seasons. Spring and fall CPUEs were higher, and summer 2005 was the highest. The summer 2004 CPUE was similar to the fall 2004 CPUE (Figure 4). At each of the three locations, the CPUE of all fish combined was greater on the control sites than at the two reef types (Figure 5). Community analysis of the 10-cm gill nets resulted in significant differences among the three sites (global $R = 0.03$, $P = 0.001$) but not for the three different reef treatments. Multiple comparisons indicated that the only significant difference among the reef sites was between sites CP and SR (global $R = 0.05$, $P = 0.001$). When each site was examined individually, the only significant difference between reef treatments was between the control and high-relief reefs at site CP (global $R = 0.035$, $P = 0.003$).

Our ANOVA results for total fish CPUE and the CPUEs of Gulf menhaden, hardhead catfish, and harvestfish resulted in fewer interactions among the

TABLE 2.—Prevalence (%) of species representing at least 10% of the total abundance of species captured, by location (CP = Cedar Point, SR = Sand Reef, and SB = Shellbank Reef) and reef type (see text).

| Species | Location | | | Reef | | |
|---|---|---|---|---|---|---|
| | CP | SR | SB | High | Low | Control |
| **5-cm gill nets** | | | | | | |
| Atlantic croaker | 23.3 | 15.7 | 14 | 21.5 | 22.3 | 11.9 |
| Spot | 17.4 | 17.3 | 27.2 | 18.2 | 20.6 | 25.4 |
| Gulf menhaden | 17 | | 31.3 | 14.3 | 14.7 | 29.3 |
| Southern kingfish | 10.9 | 16.3 | | 12.1 | | 11.5 |
| Hardhead catfish | 10.8 | | | | | |
| Sand seatrout | | 12.1 | 11.2 | | 10 | 12.3 |
| Atlantic bumper | | 19.3 | | | | |
| **10-cm gill nets** | | | | | | |
| Gulf menhaden | 47 | | 30 | 40.2 | 26.8 | 36.2 |
| Hardhead catfish | 29.8 | 16.2 | 22.8 | 16.9 | 30.6 | 25.3 |
| Blacktip shark | | 10.3 | | | | |
| Harvestfish | | 31.4 | 15.8 | 26.1 | 15.7 | |
| Sand seatrout | | | 15.8 | | 12.3 | |
| Spanish mackerel | | | 12.8 | | | |

TABLE 3.—Summary of the *F*-values for three-way analysis of variance tests for catch per unit effort of selected fishes from 5-cm and 10-cm gill-net collections in Mobile Bay. Season = 5 sampling dates (see Figure 4), site = 3 separate sites, and reef = 3 reef treatments (low relief, high relief, and control). Significant values are indicated by asterisks.

| | Main effects[a] | | | Interactions[a] | | | |
|---|---|---|---|---|---|---|---|
| Species and variable | Season (A) (4) | Site (B) (2) | Reef (C) (2) | A × B (8) | A × C (8) | B × C (8) | A × B × C (16) |
| **5-cm gill nets** | | | | | | | |
| Atlantic croaker | 23.56* | 11.00* | 5.67* | 6.13* | 5.79* | 4.10* | 1.21 |
| Gulf menhaden | 28.17* | 40.48* | 24.31* | 16.95* | 1.32 | 9.97* | 1.68 |
| Red drum | 21.16* | 10.03* | 4.14 | 7.43* | 3.07* | 3.46* | 2.56* |
| Sand seatrout | 16.87* | 13.76* | 33.88* | 3.76* | 3.45* | 4.92* | 1.88 |
| Speckled seatrout | 2.38 | 1.50 | 1.30 | 1.67 | 1.30 | 0.10 | 1.02 |
| Southern kingfish | 16.96* | 0.66 | 21.58* | 7.14* | 1.90 | 2.58* | 1.40 |
| Spot | 13.8* | 22.47* | 21.86* | 8.83* | 2.78* | 1.65* | 1.64 |
| Total abundance | 25.07* | 25.79* | 29.37* | 13.25* | 0.25 | 3.50* | 1.20 |
| Error df = 279 | | | | | | | |
| **10-cm gill nets** | | | | | | | |
| Gulf menhaden | 15.17* | 11.37* | 3.74* | 8.57* | 1.36 | 0.97 | 1.06 |
| Hardhead catfish | 19.98* | 28.82* | 1.20 | 10.96* | 2.31* | 0.85 | 0.62 |
| Harvestfish | 21.83* | 13.71* | 3.77* | 15.79* | 1.64 | 2.48* | 1.62 |
| Total abundance | 29.06* | 3.31* | 6.58* | 4.97* | 0.59 | 2.36 | 1.18 |
| Error df = 279 | | | | | | | |

[a] Degrees of freedom in parentheses.

independent variables than among the fish caught with 5-cm-mesh gill nets. Seasonal differences among reefs and sites were highly variable. For Gulf menhaden, the reef treatment was significantly different (Table 3), the control sites (mean ± SE = 1.3 ± 0.3) having a greater CPUEs than either reef relief (0.45 ± 0.02; SNK test: $P < 0.05$). For hardhead catfish there was not a significant site × reef interaction or a three-way interaction term, indicating that this species' use of the reef treatments did not vary among seasons and sites (Table 3); however, hardhead catfish CPUE did vary significantly among sites (Table 3), post hoc analyses indicating that the CPUE at site CP (0.69 ± 0.13) was significantly greater than that at sites SB (0.20 ± 0.05) and SR (0.09 ± 0.03; SNK: $P < 0.05$). The response of harvestfish to reef relief varied significantly among the three sites, as evidenced by a site × reef interaction term (Table 3). Analysis of total fish CPUE did result in a significant interaction between site and season and a significant difference between reef treatments. For all fish combined, CPUE did vary significantly among the reef treatments (Table 3), post hoc analyses indicating that CPUE on the controls (3.50 ± 0.50) was significantly greater than on high-relief (1.90 ± 0.32) and low-relief (1.61 ± 0.28; SNK: $P < 0.05$) reefs.

The change in the relative number of individuals on one type of habitat as opposed to another type of habitat (percent relative abundance) indicated that for both mesh sizes, most increases in abundance were in the control areas rather than on the reefs (Table 4). Comparisons between high-relief and low-relief reefs resulted in mixed findings. Several species had a positive percent relative difference between the high-relief and low-relief reefs, two species showed no difference in percent relative difference, and the remaining species and the total fish abundance had percent increases on the low-relief over high-relief reefs. Therefore, most species showed no positive percent relative difference from the control to the two reef types. Red drum and spotted sea trout were two species that did have a positive increase between control and reef treatments because neither of these species were collected at sites away from the reefs. Additionally, for most species there was no positive percent relative difference between the high-relief and low-relief reefs (Table 4).

## Discussion

Our results indicated that after reef construction, community diversity was unique to each location for resident species and that newly settled bivalves made up largest number of resident organisms present on any reef type. Eastern oysters predominated the western bay, whereas in the eastern Bay recurved mussels predominated. The predominance of community structure by bivalves is not uncommon for restored oyster reefs (Rodney and Paynter 2006), and the differences in settlement patterns may be a direct result of the proximity of living oyster reefs. In a similar experiment conducted in Barataria Bay, Louisiana, recurved mussels were the predominant bivalve species from cultched oyster leases (Plunket 2003). Similar to results in Florida (Tolley and Volety 2005) and North

TABLE 4.—Percent differences among three reef treatments (i.e., high relief [H], low relief [L], and control [C]) for catch per unit effort of fishes collected in 5-cm and 10-cm gill nets at three sites combined in Mobile Bay. Positive values indicate increased catch per unit effort on the reference habitat.

| Species and total abundance | H versus L | H versus C | L versus C |
|---|---|---|---|
| **5-cm gill nets** | | | |
| Atlantic bumper | −3 | −181 | −173 |
| Atlantic croaker | 30 | 14 | −23 |
| Gulf menhaden | 14 | 77 | 73 |
| Hardhead catfish | 40 | 73 | 56 |
| Red drum | −200 | 40 | 80 |
| Sand seatrout | 37 | 75 | 61 |
| Skipjack herring | 16 | −157 | −206 |
| Southern kingfish | −62 | 60 | 76 |
| Spotted seatrout | −75 | −40 | 20 |
| Spot | 2 | 54 | 54 |
| Total abundance | 9 | 58 | 54 |
| **10-cm gill nets** | | | |
| Blacktip shark | −100 | 60 | 80 |
| Bull shark | 88 | 95 | 58 |
| Cownose ray | −129 | −167 | −17 |
| Gafftopsail catfish | 20 | 59 | 48 |
| Gulf menhaden | 33 | 74 | 62 |
| Hardhead catfish | 20 | 36 | 20 |
| Harvestfish | −29 | −208 | −138 |
| Ladyfish | 100 | 100 | 88 |
| Red drum | 0 | [a] | [a] |
| Spanish mackerel | 0 | 47 | 47 |
| Spotted seatrout | 25 | [a] | [a] |
| Total abundance | 17 | 54 | 45 |

[a] No fish on reference habitat.

Carolina (Peterson et al. 2003), the fish species utilizing our reefs have no fisheries potential but may indirectly benefit the system by providing an ample prey supply for other predatory fish.

Examination of our gill-net data suggested that there were site-specific differences in community structure among the three locations and that reef height had little influence on community composition or abundance. The complexity of responses exhibited by individual species and the potential for production among treatments and sites suggests that relationships fishes have with reef structure may be more complex than once believed (Peterson et al. 2003). These responses may reflect the individual biophysical characteristics of the reef locations, demonstrating the difficulty of predicting community-level responses to reef construction. From a fisheries perspective, our results indicate that the control treatments located around the reefs contained the highest concentrations of fish and that the abundance of most species increased as a result of having oyster shells present rather than as a result of the particular reef design. The community shifted from one that was predominated by Gulf menhaden, spot, and hardhead catfish to a community where these species were still present but Atlantic croaker, southern kingfish, and sand trout increased in abundance.

The effects of reef height on community composition were minimal, but abundance was significantly greater at low-relief reefs and mud crabs were the only species that benefited from increased reef height. Because the reefs are elevated off the bay floor, the ability to move up in the water column to escape hypoxia should allow for greater abundances of mud crabs on the high relief reefs. It is unknown why this pattern was not more prevalent for other demersal species besides mud crabs. This leads us to believe that there is either increased predation on high reefs, increased settlement on the low reefs, or the same environmental conditions that affect low reefs also affect tall reefs. If predation is causing this pattern, vertical movement may be occurring among other species; however, these species may not be able to take advantage of the interstitial space provided by this particular reef design for protection from predators. Of the most commonly collected fishes, small red drum, spotted seatrout, and southern kingfish each showed increases in relative abundance on the high-relief reefs, and each of these species are known to be predators on many of the smaller resident fishes and decapods (Llan et al. 1998; Parthree et al. 2006). This possibility reinforces the need to include higher trophic (i.e., transient fishes) when examining community structure in marine habitats and the need to examine the state of succession for that reef.

The community structure on our reefs was in the same state of succession after 2 years, indicating that either these reefs are only attracting organisms (Peterson et al. 2003; Powers et al. 2003) or that the environmental conditions that have led to the demise of the self-sustaining reefs in Mobile Bay are preventing reef communities from advancing to the next successional stage where the impact of predation may be mitigated. Because restored oyster reefs are known to support some level of secondary production (Peterson et al. 2003), environmental conditions may be responsible for these patterns. If these oyster reefs are consistently in an initial state of succession, the influence of flow on a habitat may be increasingly important because of the availability of suitable habitat for settlers not seen on mature habitats. Increased settlement may result from the differential flow and turbulence patterns between the two reef types (Mullineaux and Garland 1993; Crimaldi et al. 2002). Settlement of organisms to flow over low-relief consolidated structures compared with a single high relief has been shown to influence species abundance, composition, and orientation (Breitburg et al. 1995; Carballo and Nava 2007). In addition, turbulent flow

can increase the amount of oxygen in the water column and prevent stratification, limiting the possible effects and duration of low oxygen events (NSTC 2003; Verity et al. 2006).

One problem with understanding the utilization of oyster reefs by transient fishes is that most of the species collected are habitat generalists and have a broad distribution. Although they utilize oyster reefs, the organism's "extent" (i.e., the largest scale at which an organism responds to heterogeneity in an environment; Kotliar and Weins 1990), is great enough that they are not limited to these reefs (Breitburg 1999). Because of the difficulties associated with sampling transient fish (e.g., Coen et al. 1999a), the measurement of the success of a restored reef may best be done by examining the reef through food web interactions (O'Connor and Bruno 2007; Travers et al. 2007) in conjunction with measurements of community structure and diversity. Future experiments that address food web structure will have to rely on experimental methods that capture an instantaneous picture of the reef community and assess biochemical measurement (i.e., stable isotopes) among trophic levels. Although gill-net sampling does sample the species on the reef, the result is that 4 h of fish movements are compressed into a single gill-net measurement and fine-scale changes in composition are masked.

The ultimate benefit of reef creation or restoration may be more evident at a larger scale than that examined in this experiment. If we consider this collection of relatively closely arranged reefs (on a landscape scale) as a single reef unit, the benefits may simply be the habitat diversity that the structure provides in the middle of an otherwise monotypic landscape. Most of the species we collected have the ability to range widely and can utilize oyster reefs when it is beneficial (Koch and Gust 1999; Lenihan 1999; Soniat et al. 2004; Fonseca and Koehl 2006). We collected five times as many fish at our postreef control sites as another gill-net sampling study conducted in the same locations prior to the reef construction (Gregalis 2006),. This increase indicates that the effects of reef construction may cascade to the surrounding environment well beyond the immediate reef structure (Reidenbach et al. 2006).

Based on the costs and benefits, creation of low-relief reefs is preferable because higher reefs require extra cultch volume (e.g., 1 $m^3$ of cultch provides 10 times the exposed surface area at a depth of 10 cm as it does at a depth of 100 cm). This may allow for more efficient utilization of available public resources while being more effective for fish utilization. Although not conclusively established, it is possible that some of the increased recreational fisheries production experienced in Mobile Bay since 1995 is at least partly the result of the oyster shell cultch deposited annually (about 2,300 $m^3$ to enhance the oyster fishery) in low-relief reefs by the Alabama Department of Conservation and Natural Resources (Tatum et al. 1995; www.st.nmfs.gov/st1/recreational/queries/index/html). However, our study, in conjunction with others (Enriquez and Rodriguez-Roman 2006; Reidenbach et al. 2006), suggests that the belief held by many ecosystem managers—"if you build it, the important fishes will come"—may be flawed to some extent. In this area, "if you put anything on the bottom, somebody will come" may be more appropriate.

In conclusion, reef restoration resulted in positive benefits for the reef community, but the magnitude of the response was not as strong as anticipated. This study indicates that interactions between the biophysical characteristics of reef locations can influence reef communities in a manner that is often highly variable. This raises the possibility that oyster reefs are simply a component of the environment for many reef-oriented species rather than being an essential habitat. This uncertainty highlights the need to ensure that evaluation of the success or failure of reef restoration projects is based on location-specific characteristics rather than on unconfirmed—and often immeasurable—generalized benefits to fisheries.

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# Oyster *Crassostrea virginica* Spat Settlement as it Relates to the Restoration of Fish River Reef in Mobile Bay, Alabama

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*Abstract.*—Oyster spat settlement at four oyster reefs in Mobile Bay, Alabama, USA, was studied from August through October 1998 and May through mid November 1999. Spat collectors at the reefs were replaced every 2 wk and spat-set estimated as number of oysters per meter square per day. Water quality data at Fish River Reef was monitored using remote sensors. Spat-set data revealed significant variation between the four sites and between the 2 yr. Spat settlement was 5 to 10 times greater at the other three reefs than at Fish River Reef. Dates and intensity of oyster settlement at Fish River Reef were different from dates and intensity of oyster settlement at Shell Bank Reef, both on the eastern side of the bay. However, settlement was similar between Cedar Point Reef and White House Reef, both on the western side of the bay. Spat set appears to occur 3 wk after a rapid decline in water temperature, provided adequate oxygen concentrations are present at the time of settlement. Data collected suggest that intensity of settlement at Fish River Reef is considerably less than at other reefs in this study but could be adequate to reestablish the reef, if cultch and environmental conditions are suitable. The data also suggest that the source of larval oysters at Fish River Reef is different from the source of larval oysters at the other sites tested in the present study.

Several hard-bottom, mud-free areas exist in Bon Secour Bay on the eastern side of Mobile Bay, Alabama, yet few oysters grow in these areas (Smith 1999). Historical data suggest that these areas were once viable oyster reefs (Ritter 1895; Eckmayer 1979). A variety of factors have been suggested as explanations for the lack of harvestable oysters on the relic reefs of Bon Secour Bay (Ritter 1895; Mackin 1951; May 1972, 1973; Eckmayer 1979; Cake and Eckmayer 1982; Eckmayer 1983). Most studies have reported die-offs during particular events but research-based data that explains why viable oyster populations are not present today is lacking. Reasons for lack of viable oyster populations discussed include a lack of cultch on the reefs, and possibly a lack of adequate oyster-spat recruitment.

An integral part in the management of oyster reefs is the need for adequate substrate for larval settlement. A survey of the reefs of Bon Secour Bay in 1998 indicated a near-total absence of cultch material on Fish River Reef (Smith 1999). The Marine Resources Division (MRD) of the Alabama Department of Conservation and Natural Resources has indicated an interest in deploying oyster shell as cultch at Fish River Reef to help restore the reef. If cultch is deployed too early, siltation and fouling may decrease or eliminate potential settlement and recruitment of spat (Ingle 1951; Shaw 1967; Hoese et al. 1972; MacKenzie 1977; Osman et al. 1989). Timely cultch dispersal requires a proper understanding of oyster population dynamics, reproductive cycles and larval dispersal patterns. Kennedy (1996) provides a review of factors related to the timeliness of cultch dispersal, oyster reproduction, larval dispersal and spat settlement.

Oyster spatfall in Mobile Bay normally has two peaks, the higher of which is the fall set (Hoese et al. 1972; Lee 1979; Hayes and Menzel 1981). The present study was performed to evaluate the incidence of oyster settlement at Fish River Reef in order to determine if settlement is adequate to restore the reef should new cultch be deployed. Settlement at Fish River Reef was compared to settlement at three other reefs in Mobile Bay during one spring and two fall spawning periods.

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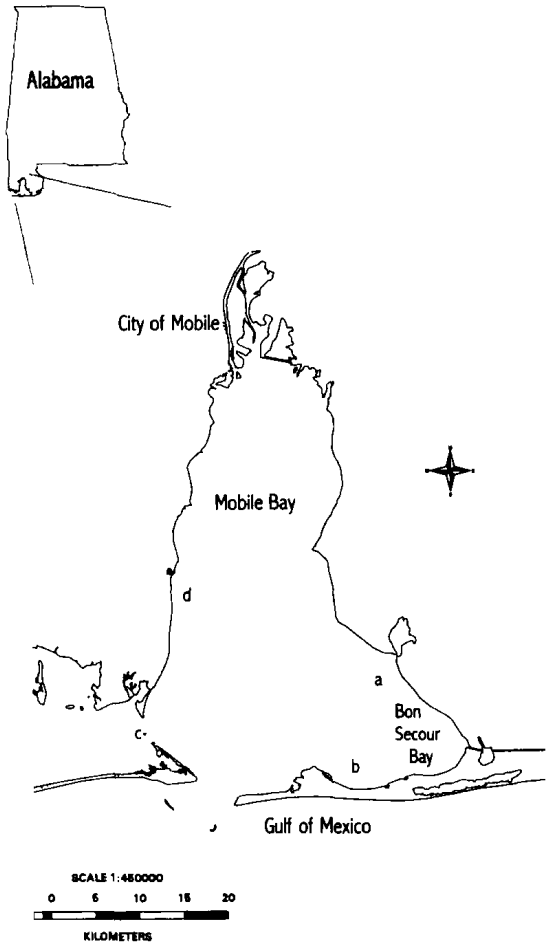


FIGURE 1. *Mobile Bay, Alabama. Point a = Fish River Reef, b = Shell Bank Reef, c = Cedar Point Reef, d = White House Reef.*

## Materials and Methods

### *Study Sites*

Spat collectors were deployed at the Fish River Reef and at three other reef locations in Mobile Bay for purposes of comparison. Study sites included four reefs; two near the eastern shore and two along the western shore of Mobile Bay. All sites were in the southern half of the bay.

Fish River Reef (FRR), the focus of this study, is a 12-ha reef located on the east side of Mobile Bay, approximately 3 km south of the mouth of Fish River and 0.5 km from the eastern shoreline of Mobile Bay (Fig. 1; point a). Spat collectors were attached to three pilings (one set per piling) set at the reef by MRD, and oyster shell was dispersed around the foot of the pilings. Temperature and oxygen concentrations 10 cm above bottom were measured hourly using remote measuring devices (Minisonde by Hydrolab) attached to one of the pilings. On 27 October 1998, 15 shells were gathered from the bottom at FRR and inspected for newly set spat.

Shellbank Reef (SBR) is located about 10 km south of FRR, and about 0.5 km north of Fort Morgan Peninsula (Fig. 1; point b). This site has also been set apart with pilings installed by the MRD. Spat collectors were attached to three pilings and replaced following the same protocol as at FRR.

Cedar Point Reef (CPR) is the primary reef of commercial oyster harvest in Mobile Bay, and is located on the western side of the bay between the mainland and Dauphin Island (Fig. 1; point c). Three sets of spat collectors were attached to pilings within the reef and monitored following the regimen described for FRR.

White House Reef (WHR) is also located on the western side of Mobile Bay, south of the mouth of Fowl River. The reef is narrow, extending for more than 2 km in a north-south direction. MRD installed pilings similar to those of FRR and SBR about 5 km south of the mouth of Foul River and 1 km from the western shore of Mobile Bay (Fig. 1; point d). Spat collectors were attached to three of the pilings and monitored similarly to the three other sites. On 27 September hurricane Georges destroyed two of the pilings at SBR, and only one set of spat collectors was attached to the remaining piling for the rest of 1998. No spat collectors were deployed at WHR in 1999.

### *Spat Collectors*

Collectors used in the study (Fig. 2) were similar to the collectors described by Supan (1983). Square plates of cement-fiber board (10 cm × 10 cm × 0.5 cm) were cut and holes drilled in the middle and on one corner of each plate. Plates were held together

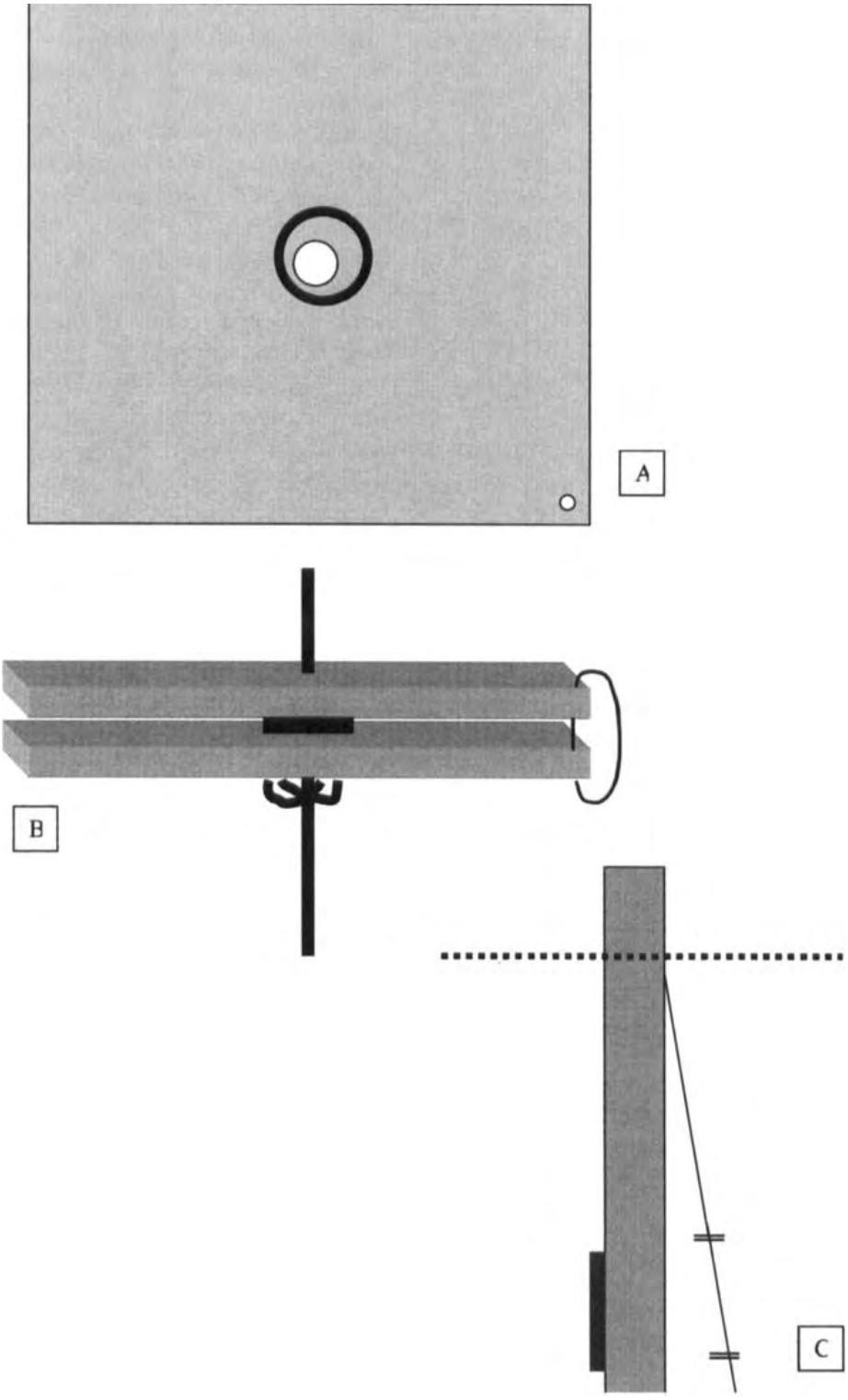


FIGURE 2. *A—Top view of spat collecting plate with PVC ring around the hole in the middle. B—Side view of two plates separated by PVC spacer, and held together by cable-tie at corner. The polypropylene rope passes through the middle hole and is knotted to hold the plates. C—A piling with the spat collecting setup and the Minisonde attached to it.*

TABLE 1. *Total number of oyster spat on collectors (spat/m² per d) at four locations in Mobile Bay between 10 August and 27 October 1998.*

| Date | FRR | SBR | CPR | WHR |
|---|---|---|---|---|
| 10 August 1998 | 0 | 5 | 60 | 123 |
| 24 August 1998 | 0 | 1,444 | 112 | 41 |
| 8 September 1998 | 12 | 69 | 837 | 1,728 |
| 6 October 1998 | 173 | 51 | 150 | 14 |
| 27 October 1998 | 0 | 5 | 62 | 36 |

TABLE 2. *Total number of oyster spat on collectors (spat/m² per d) at three locations in Mobile Bay between 18 May and 19 November 1999.*

| Date | FRR | SBR | CPR |
|---|---|---|---|
| 18 May 1999 | 1 | 0 | 268 |
| 8 June 1999 | 0 | 0 | 517 |
| 6 July 1999 | 0 | 0 | 184 |
| 9 August 1999 | 0 | 3 | 200 |
| 23 August 1999 | 280 | 123 | 14 |
| 8 September 1999 | 0 | 11 | 75 |
| 27 September 1999 | 0 | 661 | 2,293 |
| 17 October 1999 | 8 | 13 | 41 |
| 1 November 1999 | 0 | 0 | 0 |
| 19 November 1999 | 0 | 0 | 0 |

in pairs with cable-ties inserted through the corner holes (Fig. 2A). The plates were separated by a 0.6-cm piece of PVC pipe, 1.25 cm in diameter (Fig. 2B). Collectors were attached to polypropylene rope stretched between a brass ring on the piling 15 cm below mean low tide and a trailer anchor on the bay bottom. Spat collectors were attached 10 cm, 60 cm and 150 cm above the bottom of the bay (Fig. 2C). The top collector was approximately 90 cm below the surface of the water. Clean oyster shell was deployed on the bottom near the base of the pilings at FRR in 1998. Spat collectors were exchanged approximately every 2 wk. Visual observations of the shell deployed at the base of the pilings at FRR were made for comparison with the spat collectors deployed at FRR.

### *Spat Counting and Calculations*

After collection, spat collecting plates were rinsed and allowed to dry overnight. Spat numbers on the inside surface of each plate (surfaces facing paired plate) were recorded separately. Data from plates at each depth were pooled. Spat set (count/m² per d) was calculated according to the formula:

$$\text{Spat set} = (N \times 100)/(A \times D)$$

Where:
- N = the sum of all spat counted on inside surface of each plate at one site.
- A = number of plate sides counted (100 cm² per side).
- D = number of days the plates were deployed.

Colonization of fouling organisms such as barnacles, bryozoans, and mussels on the collectors was also estimated. Estimations throughout the study were performed by the same person in order to avoid bias in reporting the degree of plate coverage. Abundance was reported as degree of plate coverage on a scale of 0 to 5, with 0 indicating no occurrence and 5 denoting almost total plate coverage.

Analysis of Variance (ANOVA) was performed to test the null hypothesis that spat set was equivalent at the four study sites ($\alpha = 0.05$). Settling rates at the three experimental depths were compared using one-way ANOVA ($\alpha = 0.05$). Student's paired two-sample *t*-test ($\alpha = 0.05$) (Steel and Torrie 1980) was used to examine differences between settling rates on the various sides of the collector plates. Temperature was plotted against time in an attempt to examine the relationship between temperature changes and peak spawning events. Oxygen concentrations in the vicinity of the spat collectors were plotted to examine the relationship between time of set and dissolved oxygen concentrations.

## Results

Spat data from the four reefs showed considerable variation between sites and between years (Tables 1, 2). As reported in earlier studies, the strongest peaks occurred in the fall at all sites. Cedar Point Reef had

the most consistent spat set with at least some settlement from 10 August through 27 October 1998 and 18 May through 17 October 1999. Peak settlement at CPR occurred between 24 August and 8 September in 1998 (840 spat/m$^2$ per d) and between 8 September and 27 September in 1999 (2,300 spat/m$^2$ per d). White House Reef also had an extended settlement period throughout the fall of 1998 with a peak set occurring between 24 August and 8 September (1,730 spat/m$^2$ per d).

Spat settlement at the two sites on the east side of Mobile Bay was confined to fewer months and usually at reduced levels. Spat were collected at SBR from 24 August to 6 October 1998 with a peak occurring on 24 August (1,450 spat/m$^2$ per d) and from 23 August through 17 October 1999, with a peak occurring on 27 September (660 spat/m$^2$ per d). Fish River Reef had the shortest spat settlement period and the smallest peak set. Spat were collected on 6 October (170 spat/m$^2$ per d) in 1998, and on 23 August (280 spat/m$^2$ per d) in 1999.

Over 95% of the spat settled on the interior surfaces of spat collectors. Significantly more oysters settled on the upper side of lower plates than on lower side of upper plates (66% *vs.* 34%; $P < 0.05$; $N =$ 2,586). The rate of oyster settlement on plates at 10 cm, 60 cm and 150 cm above bottom was not significantly different when settling rates at each depth throughout the fall season are pooled together. However, the numbers of oysters that settled at the various depths during each sampling period were different from each other, with settlement occurring mostly in the upper water column during one period and near bottom during another.

Barnacles *Balanus* sp. settled on the plates in high numbers throughout the study. Most barnacles settled on the outer surfaces of the plates; few barnacles were observed on the inner surfaces. Bryozoans *Membranipora* sp. seem to colonize inner and outer surfaces of the plates in equal abundance. Mussel *Ischadium recurvum* attachment to the collectors was rare to nonexistent throughout the duration of the study. Visual observations revealed a heavy infestation of adult mussels on the bottom at FRR. Mussels were less abundant on bottom at SBR and WHR and rare at CPR. Figs. 3 and 4 show peak sets of barnacles and bryozoans at the various reefs in 1998 and 1999, respectively.

Out of the 15 shells gathered on 27 October 1998 from the bottom at FRR, only one shell had a single spat attached to it. The spat was 52 mm in height, suggesting that it had set early, probably during the first couple of weeks after the shells were deployed. Visual observations, when possible, revealed a fine layer of silt covering the shells. Disturbances to the shells and surrounding water raised a thick cloud of silt and exposed cleaner shell. Very small numbers of fouling organisms were found on the shells.

During the fall of 1998 water temperature at FRR dropped by 6.3 C (32.6–26.3 C) over the 3-d period from 31 August to 3 September (Fig. 5A). Oxygen concentrations near the bottom were above 1.0 mg/L from 13 to 18 September, and periodically dipped below 1.0 mg/L on 18 and 19 September (Fig. 6A). Water temperature dropped 3.3 C (32.1 C–28.9 C) between 7 August and 10 August 1999 (Fig. 5B). Oxygen concentrations between 16 August and 23 August 1999 never dipped below 1.0 mg/L (Fig. 6B).

## Discussion

Oyster settlement occurred at all four study sites. At FRR, the total settlement observed during the fall was 4,844 spat/m$^2$ in 1998 and 3,924 spat/m$^2$ in 1999. In contrast, settlement observed at CPR, the only actively harvested reef of the four study sites, was 18,850 spat/m$^2$ and 67,350 spat/m$^2$ during the fall of 1998 and 1999, respectively. Spat settlement at SBR (22,799 spat/m$^2$) and at WHR (27,614 spat/m$^2$) in 1998 was also considerably higher than at FRR.

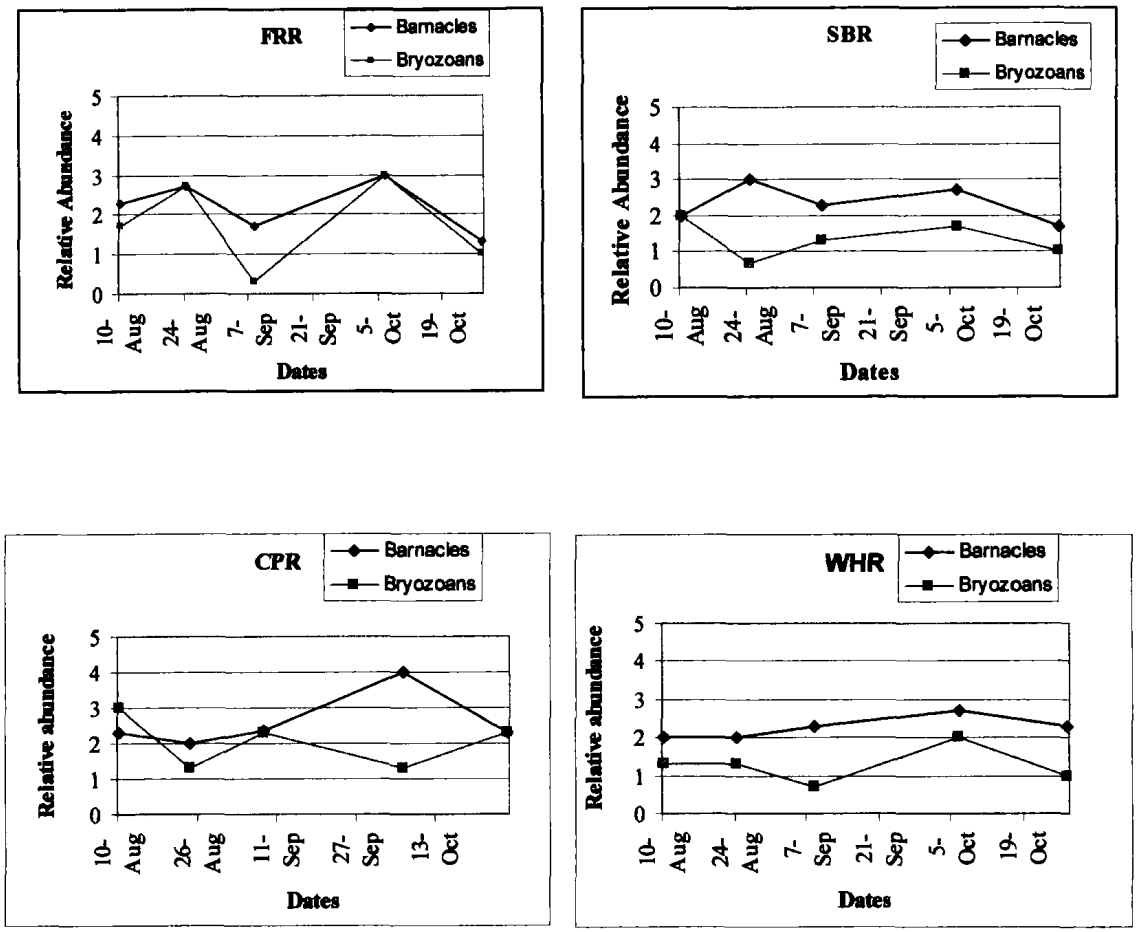


FIGURE 3. *Relative abundance of barnacles and bryozoans attached to collectors placed at four oyster reefs in Mobile Bay in 1998. FRR = Fish River Reef, SBR = Shell Bank Reef, CPR = Cedar Point Reef, WHR = White House Reef.*

Assuming a square meter of reef contains 200 oyster shells, a spat set of 20 to 24 oysters per shell was possible at FRR during the two study periods. Although total yearly spat set at the other reefs was much higher than at FRR, Lindsay et al. (1959) and MacKenzie (1981, 1996) suggest that between 2 and 35 spat per oyster shell constitute a commercial spat set. Therefore, it appears that the spat set on the collectors at FRR during the fall of 1998 and 1999 was within levels sufficient to constitute a commercial set.

Hoese et al. (1972) drew a line from just northeast of Cedar Point to near Fort Morgan, dividing Alabama waters into an area of "significant spat-fall" to the southwest, and an area of "negligible spat-fall" to the northeast. Our study conducted 26 yr later indicates that these differences between the west and east side of the Bay are still very evident. Results of our study also point out other differences in spat settlement between various areas of the Bay. In 1998, settlement peaks in CPR and WHR on the west side of the bay were coincident, and settlement at SBR on the southeastern side occurred 2 wk prior to peak settlement at the two western sites. At FRR, peak settlement was 4–6 wk behind the other three sites in 1998, and 4 wk ahead of the other sites in 1999. This suggests a different source of larvae and/or stimuli to initiate spawning at FRR than the other three locations. Austin

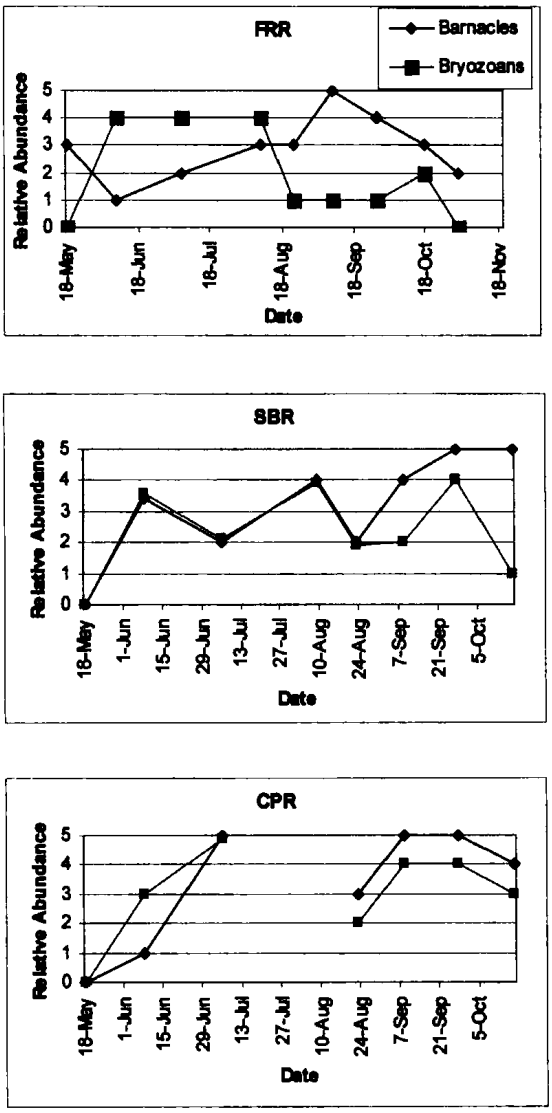


FIGURE 4. *Relative abundance of barnacles and bryozoans attached to collectors placed at three oyster reefs in Mobile Bay in 1999. 0 indicates no occurrence and 5 indicates full coverage. FRR = Fish River Reef, SBR = Shell Bank Reef, CPR = Cedar Point Reef.*

(1954) described flood tides entering and flowing up the east side of Mobile Bay. However, during ebb tide, water from Fish River flows towards FRR and water from Bon Secour River and the intercoastal canal flows towards SBR. Water temperatures of the Bon Secour River and intercoastal canal may be different from water temperature at Fish River, leading to non-coincident oyster spawns in the two systems.

Results of the present study corroborate the findings of Hoese et al. (1972) and Lee (1979) concerning peak spat sets in the fall in Mobile Bay. Based on Hayes and Menzel's (1981) suggestion that oyster spawning in the fall is cued by a rapid decline in water temperature, it is possible that spat that set on FRR in 1998, were spawned between 31 August and 3 September (Fig. 5A) and in 1999, between 7 August and 10 August (Fig. 5B). In 1998, the rapid temperature decline coincided with a rapid decline in salinity from 17.1 ppt to 12.9 ppt (Fig. 5A) suggesting a high input of cool freshwater into Bon Secour Bay. Similarly, salinity between 7 and 10 August 1999 fell from 24.1 ppt to 16.3 ppt. Prytherch (1928) reports a planktonic larval period for oysters of 13 to 16 d, when temperatures are between 21.3 C and 23.2 C. Baker and Mann (1992) found that oyster pediveligers avoid settling in hypoxic conditions. Therefore, in 1998, it is possible that pediveligers at FRR settled between 13 and 17 September, when oxygen concentrations were above 2 mg/L (Fig. 6A) and in 1999 they set on August 19 when oxygen concentrations were greater than 4 mg/L (Fig. 6B) for several hours. These findings suggest that by monitoring water temperature at FRR, one could predict appropriate times for cultch deployment.

The fact that no oyster settlement took place on the oyster shell at the base of the pilings at FRR underscores the need for timely cultch deployment. Excessive fouling (Osman et al. 1989) and, as in the present case, silting can deter oyster settling (Ingle 1951; MacKenzie 1983). Shaw (1967, 1969) proposed dates of cultch planting in the Chesapeake Bay, but Kennedy (1980) and Hargis and Haven (1988) cautioned that dates were not identical every year and suggested the need for monitoring oyster spawning before spreading cultch material. If cultch deployment and spawning are well coordinated, silting can be minimized as a deterrent to setting (Ingle 1951). If a rapid temperature decline is the

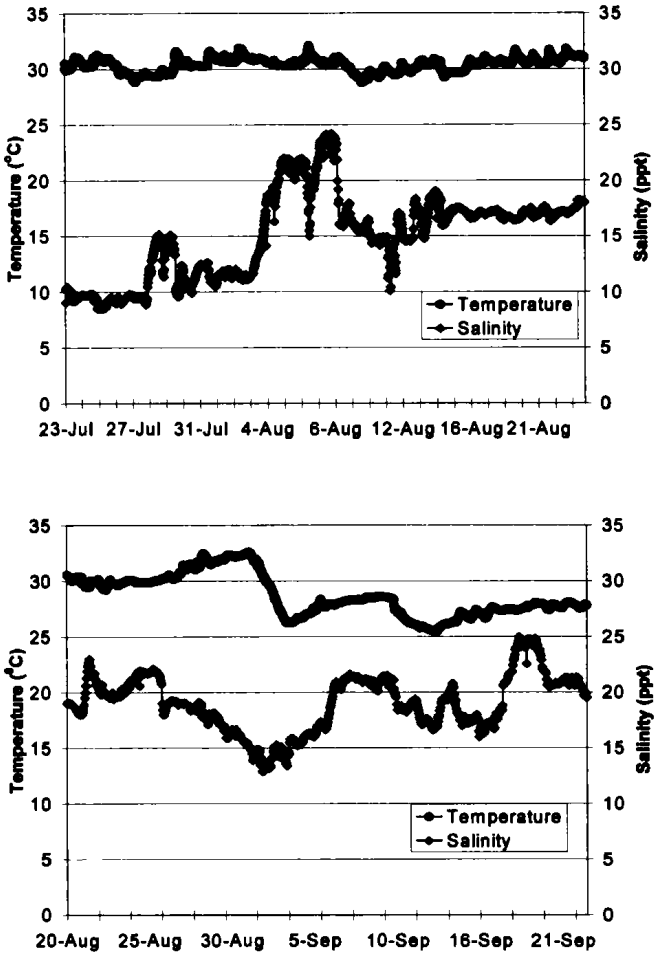


FIGURE 5. *A—Temperature and salinity at Fish River Reef from 20 August through 21 September 1998. B—Temperature and salinity at Fish River Reef from 23 July through 23 August 1999.*

main cue for spawning in the fall, monitoring water temperature over the seed producing beds would notify managers of an impending spat set, *ergo* optimum cultch dispersal times.

Shaw (1967) and Kennedy (1980) discuss contradictory results observed by various workers in regard to the orientation of the surface on which pediveligers prefer to set, without coming to any definite conclusion. Baker (1997) reports that pediveligers prefer lower surfaces of oyster shell to upper surfaces as a way to avoid siltation. Ritchie and Menzel (1969) and Baker and Mann (1998) report negative phototaxis by settling pediveligers. Settling-site selection and subsequent survival of larvae was also shown to be affected by the presence of other resident species (Osman et al. 1989). In the present study, the majority of the spat settled on the two interior surfaces of the collector plates, with most (66%) setting on the top of the lower plate. The fact that most larvae chose the surfaces of the plates facing the interior of the pair could be due to the proximity of the two plates. The narrow space probably provides refuge from predation, and also appealed to the rugotropic characteristic of oyster spat. Another reason could be the shadowing effect of the plates, thus appealing to the negatively phototaxic larvae. Moreover, the narrow space between the plates may have reduced current speed, allowing the oysters more leisure in finding a suitable spot to attach.

The period of peak barnacle settlement in

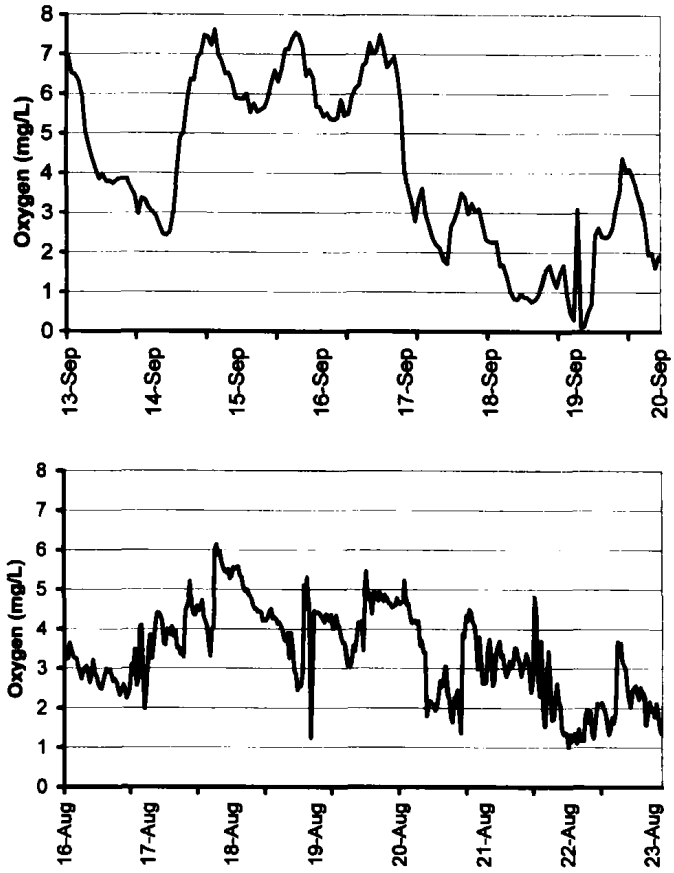


FIGURE 6. *A—Oxygen concentration (mg/L) near bottom at Fish River Reef from 13 September through 19 September 1998. B—Oxygen concentration (mg/L) near bottom at Fish River Reef from 9 August through 23 August 1999.*

Mobile Bay has been reported to occur in the spring with limited settlement in the summer and fall (Hoese et al. 1972; Lee 1979; Athanas 1996). We observed heavy barnacle sets throughout our study, especially on the western side of Mobile Bay. Our results do not agree with the findings of Hoese et al. (1972) that barnacle set in the bay is lowest on the eastern side of Mobile Bay. Bryozoans were found at all stations throughout the sampling period in 1998. In 1999, no bryozoans set on the collectors at any of the reefs in May, but were present in all subsequent samples. Lee (1979) reported bryozoan fouling on his collector plates throughout the year at Cedar Point Reef.

In this study, collectors were suspended from 10 cm to 150 cm above the bottom. Spat set on these collectors was higher than spat set on the oyster shells deployed on bottom. Spat that settle on cultch dispersed on the bay bottom are susceptible to predation, siltation, and anoxia as well as abrasion from wave action. Therefore, it is possible that spat collectors might over estimate spat set on cultch dispersed on bottom (Pineda and Caswell 1997).

The present work confirms the presence of oyster-spat settlement at FRR. However, numbers were lower than spat collected on other reefs in Mobile Bay known to be viable and productive. It is possible that deployment of cultch on Fish River Reef could help restore the reef if a lack of suitable settlement surfaces is the limiting factor. However, due to inter-annual variability in setting dates, cultch should not be spread

at similar times every year. Oyster spawning and larval presence should be monitored and cultch deployed when optimum set can be expected. Our work suggests that by monitoring water temperature, managers could predict oyster spawning events and consequently estimate the proper time to disperse new cultch.

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# Economic Valuation of Ecosystem Services Provided by Oyster Reefs

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*Valuation of ecosystem services can provide evidence of the importance of sustaining and enhancing those resources and the ecosystems that provide them. Long appreciated only as a commercial source of oysters, oyster reefs are now acknowledged for the other services they provide, such as enhancing water quality and stabilizing shorelines. We develop a framework to assess the value of these services. We conservatively estimate that the economic value of oyster reef services, excluding oyster harvesting, is between $5500 and $99,000 per hectare per year and that reefs recover their median restoration costs in 2–14 years. In contrast, when oyster reefs are subjected to destructive oyster harvesting, they do not recover the costs of restoration. Shoreline stabilization is the most valuable potential service, although this value varies greatly by reef location. Quantifying the economic values of ecosystem services provides guidance about when oyster reef restoration is a good use of funds.*

*Keywords: ecosystem services, ecosystem management, oyster reef habitat, valuation*

**The concept of valuing ecosystem services in economic** terms is not new (e.g., Freeman 1993), and efforts to apply this approach to a wide range of habitats and ecosystems have proliferated dramatically following the release of the Millennium Ecosystem Assessment (MA 2005). However, the incomplete state of scientific understanding of ecosystem function in many systems limits our ability to quantify all of their associated ecosystem services, which consequently impedes decisions about how best to manage for the long-term return and sustainability of these services (Nelson et al. 2009). Because the value of most ecosystem services is not captured in the marketplace framework (Ruffo and Kareiva 2009), nonmarket methods and modeling are usually necessary to estimate the economic value of these services. In practical terms, values of ecosystem services are likely to be highly context specific, which raises questions about the transferability of and the ability to compare service valuation efforts across different environmental conditions. Quantifying the value associated with ecosystem services will enhance our ability to allocate limited resources in order to manage ecosystems effectively. Economic valuation of services specific to habitats that have been degraded by anthropogenic activities will be particularly useful for planning, implementing, justifying, and managing mitigation and restoration efforts.

Oysters, which create reefs and are therefore an ecosystem engineer, or *foundation species* (Jones et al. 1994), form one of the most degraded estuarine habitats in the world; roughly 85% of oyster reef habitat has been lost globally over the past 130 years (Lotze et al. 2006, Beck et al. 2011). Furthermore, oyster reef restoration efforts historically lagged far behind progress in other estuarine habitats, such as salt marshes, seagrass beds, and mangroves, even though the cost of restoring and value of ecosystem services derived from oyster reefs is roughly comparable to that of these other estuarine habitats (table 1). Conversely, vegetated estuarine habitats have long been recognized for their important ecosystem services (Thayer et al. 1978). In a recent review of estuarine ecosystem services, the need for a comprehensive framework to evaluate habitat-specific services was illustrated by the lack of information on the value of associated services for many habitats (Barbier et al. 2011). Despite oyster reef habitat's acknowledged importance to estuarine ecosystem function, the value of ecosystem services provided by oyster reefs has yet to be quantified exhaustively. The paucity of information for this critical habitat underscores the acute need for a comprehensive and quantitative framework for the valuation of oyster reef ecosystem services.

Contrary to the traditional view, in which oysters are valued solely as a fishery commodity, the scientific literature clearly shows that oysters provide a host of nonmarket ecosystem services. Oysters grow vertically and in dense assemblages that create biogenic habitat rich in mollusks besides oysters and that harbors polychaetes, crustaceans,

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*Table 1. Comparison of restoration effort for five coastal habitats in the United States.*

| Habitat type | Area restored[a] | Restoration cost[b] | Percentage global loss[c] |
|---|---|---|---|
| Salt marsh | 36,625 | 3–242 | 50–80 |
| Seagrass | 3946 | 14–1035 | 29–65 |
| Mangrove | 1399 | 5–771 | 50 |
| Coral reef | 150 | 15–9267 | 20 |
| Oyster reef | 69 | 52–260 | 80–85 |

[a]Estimates (in hectares) of area restored in the United States as of 19 March 2009 using the National Estuaries Restoration database at *https://neri.noaa.gov/neri*.
[b]Restoration costs (in $1000 per hectare) were obtained from the following sources: Spurgeon (1998) for salt marshes, seagrass beds, mangroves, and coral reefs; Fonseca and colleagues (1982) for seagrass beds; Lewis and Streever (2000) for mangroves; Spurgeon and Lindhal (2000) for coral reefs; and Henderson and O'Neil (2003) for oyster reefs. All cost estimates were then transformed to 2011 dollars.
[c]The global loss estimates were obtained from the following sources: Lotze and colleagues (2006) and Airoldi and Beck (2007) for salt marshes and mangroves; Lotze and colleagues (2006) and Waycott and colleagues (2009) for seagrass beds; Wilkinson (2008) for coral reefs; and Lotze and colleagues (2006) and Beck and colleagues (2011) for oyster reefs.

and other resident invertebrates (Wells 1961, Bahr and Lanier 1981, Rothschild et al. 1994). These resident invertebrates are consumed by juvenile fish and mobile crustaceans that use oyster reefs for foraging and refuge from predators, which leads directly and indirectly through the provision of forage species to an enhanced production of economically important fishery stocks (Coen et al. 1999, Breitburg et al. 2000, Harding and Mann 2001, Peterson et al. 2003, Tolley and Volety 2005).

The authors of several studies have concluded that dramatic reductions in the abundance of filter-feeding oysters from estuaries throughout the southeastern United States have probably contributed in shallow waters to ecosystem regime shifts from communities dominated by benthic flora and fauna to those primarily consisting of planktonic and microbial organisms (Dame et al. 1984, Newell 1988, Ulanowicz and Tuttle 1992, Paerl et al. 1998, Jackson et al. 2001, Baird et al. 2004, Lotze et al. 2006). By intercepting suspended particles and nutrients before they enter microbial loops, oysters promote an increased transfer of energy among trophic levels that results in primary production moving up the food chain to bottom-feeding fishes; crabs; and higher-order predators such as red drum, tarpon, and bottle-nosed dolphins (Coen et al. 1999, Baird et al. 2004). Oyster reefs help counteract increases in anthropogenic nitrogen loading in estuaries by promoting bacterially mediated denitrification induced by concentrated bottom deposits of feces and pseudofeces (Newell et al. 2002, Piehler and Smyth 2011). Filtration by oysters also benefits submerged aquatic vegetation (SAV), a habitat long recognized as critical for many fish species (Thayer et al. 1978), by filtering sediments and phytoplankton from the water column—thereby increasing light penetration—and by continuous fertilization of the benthic plants through deposition of biodeposits (Newell 1988, Everett et al. 1995, Newell and Koch 2004, Carroll et al. 2008, Wall et al. 2008). Seston removal by dense aggregations of bivalves, including oysters, has been inferred from fluorometric field measurements (Grizzle et al. 2006), although this effect is probably strong only in shallow estuarine tributaries with abundant oysters (Pomeroy et al. 2006). Oyster reefs reduce erosion of other estuarine habitats such as salt marshes and SAV by serving as a living breakwater that attenuates wave energy and stabilizes sediments (Meyer et al. 1997). In many of its functions, the landscape setting of an oyster reef can greatly influence the provision of its ecosystem services. For instance, Grabowski and colleagues (2005) found that oyster reefs located on mud flats augmented juvenile fish abundances, whereas oyster reefs at the edges of salt marsh and seagrass habitat had no effect on juvenile fish. The large number of ecologically focused oyster reef restoration efforts since the mid-1990s offers the opportunity to review reef restoration effects on service provision and value (Rothschild et al. 1994, Lenihan and Peterson 1998, Peterson et al. 2003, Grabowski and Peterson 2007).

Destructive harvesting of oysters began over a century ago, shortly after the advent of the mechanical dredge, which allowed fishers to decimate oyster reefs and, as a result, remove the structural foundation onto which successive generations of oysters must settle and grow (Hargis and Haven 1988, Rothschild et al. 1994, Lenihan and Peterson 1998, 2004). Early attempts to rebuild reefs over the past several decades to bolster sagging oyster-fishing harvests have been further compromised by oyster disease; sedimentation impacts on relic reef footprints; the accelerating degradation of water quality; and in some locations, depressed spawning stock biomass (Rothschild et al. 1994, Lenihan and Peterson 1998, Peterson et al. 2003). All of these factors have contributed further to the decline in the quantity and quality of oyster reef habitat in the southeastern United States. Efforts to rebuild eastern oyster (*Crassostrea virginica*; Gmelin 1791) populations in this region, where harvests are less than 1% of the historic maxima circa 1900 (Wilberg et al. 2011), were typically focused on rebuilding the oyster fishery rather than on recovering the reef habitat to support its ecosystem goods and services (Newell 1988, Rothschild et al. 1994).

A century after the onset of steep declines in oyster landings around the United States (Kirby 2004), scientists and managers have finally begun focusing on managing oyster reefs as a habitat for other species and for a broader array of services instead of just for oyster harvest. This is part of a larger trend toward a more holistic and ecosystem-based approach to fisheries and ocean management (Christensen et al. 1996, Jackson et al. 2001). Although the transition from single-species to ecosystem-based management has been hindered by insufficient modeling capacity and a paucity of necessary data on ecosystem function, both of these

impediments are being increasingly addressed within the science and management communities. Efforts to quantify ecosystem functions and to value ecosystem services can provide the necessary information to convince fisheries managers, policymakers, and the public that ecosystem-based management initiatives in estuaries are worthy of continued support. For oyster reefs, significant strides have been made in measuring some ecosystem services directly or through modeling efforts. These advances provide an opportunity to estimate economic values for services that are relevant to coastal managers and thus to improve their ability to assess and implement various habitat restoration options and to manage reefs more effectively. Here, we describe approaches for quantifying some of the most valuable and important ecosystem services from oyster reefs by estimating their economic values in the southeastern United States. We then compare these service flows to the economic value derived from destructively harvesting reefs for oysters.

We begin by presenting estimates of the commercial oyster harvest value derived from a unit of oyster reef habitat and then turn to the value of services per unit area provided by unharvested reefs (table 2).

## Oyster harvest value

Dramatic declines in the density of legally harvestable oysters in historically productive regions such as the Delaware Bay, the Chesapeake Bay, Pamlico Sound, and the south Atlantic Coast of United States (Kirby 2004), coupled with regulations intended to allow natural rebuilding of oyster populations, have greatly reduced commercial oyster landings from wild-stock fisheries. Grabowski and Peterson (2007) estimated that overharvesting in Virginia reduced the value of oyster yields from a net present value (in 2011 dollars) of $65,876 per hectare of pristine oyster bottom in 1890 to $2640 per hectare of degraded bottom in 1991 (oyster yields were derived from Rothschild and colleagues [1994]). They also used sampling data on oyster densities of legally fishable size from unharvested sanctuaries in the Neuse River Estuary (Lenihan and Peterson 1998, 2004) to determine that these sanctuary reefs contain oysters worth $20,890–$52,224 per hectare in 2011 dollars. Reef sanctuaries in North Carolina contain densities of legally harvestable oysters similar to what the oyster yields were per unit area in Maryland a century ago and about one order of magnitude greater than the present landings in Maryland, as was described by Rothschild and colleagues (1994). Collectively, these studies suggest that the average oyster harvest value of a pristine reef in North Carolina and Virginia is $51,217 per hectare (in 2011 dollars). These results also suggest that traditional harvesting methods that degrade reef habitats (i.e., mechanical dredging, tonging) would probably decrease the density of legally harvestable oysters and, consequently, the value of oyster landings on restored oyster reefs in the sanctuaries of North Carolina shortly after the inception of harvesting (Lenihan and Peterson 2004).

To estimate the economic value derived from oyster harvests, the costs of harvesting must be subtracted from the value of the catch. We used estimates from the Chesapeake Bay oyster fishery from the 2006 season for the ratio of harvest value to costs associated with harvesting reported

*Table 2. Ecosystem services provided by oyster reef habitat.*

| Ecosystem service | Ecosystem process | References | Bioeconomic model valuation method |
|---|---|---|---|
| Water quality improvement | Chlorophyll *a* removal | Newell et al. 2002, Grizzle et al. 2006 | Replacement cost of using sewage treatment plant to remove nitrogen, nitrogen credit market |
| | Reduce turbidity | Newell and Koch 2004 | |
| | Denitrification | Piehler and Smyth 2011 | |
| | Increase benthic algal or pseudofecal production | Newell et al. 2002 | Not applicable |
| | Bacterial biomass removal | Cressman et al. 2003 | Not applicable |
| Seashore stabilization | Shoreline stabilization | Meyer et al. 1997 | Cost of a sill to stabilize salt marsh and seagrass habitat, value of protected habitats |
| Carbon burial | Bury carbon dioxide | Not applicable | Traded carbon pollution credits |
| Habitat provisioning for mobile fish and invertebrates | Increased fish production | Peterson et al. 2003 | Commercial dockside landings value, recreational fisher willingness to pay for improved fishing |
| Habitat for epibenthic fauna | Increased epibenthic faunal production and biodiversity | Wells 1961, Bahr and Lanier 1981, Lenihan et al. 2001 | Already captured in fish values |
| Diversification of the landscape | Synergies among habitats | Micheli and Peterson 1999, Grabowski et al. 2005 | Not applicable |
| Oyster production | Increased oyster production | Heral et al. 1990, Rothschild et al. 1994, Lenihan and Peterson 1998, 2004, Grabowski and Peterson 2007 | Commercial oyster dockside value, recreational value-license program |

by Wieland (2008). If we apply the maximum ratio of revenue to cost from the 18-year period for dredging (i.e., 1.5 in 2006) observed in Wieland's study, our average gross estimate of oyster value of $51,217 derived from pristine reefs results in a net value of $17,072. We estimate that the net annual value of oysters taken from degraded reefs worth $2639 would be $880. This estimate is probably optimistic, given that it is unlikely that harvesters would be able to sustain this profit rate at low oyster densities. We reasonably assume that if they are opened to destructive harvesting, oyster sanctuaries and pristine reefs would quickly switch from producing harvests at the upper end of this range in year 1 to levels near the annual value for degraded reefs in subsequent years.

### Water quality services

Ideally, it would be possible to estimate the direct value of each water quality service (e.g., nitrogen removal through denitrification, phytoplankton removal, seagrass enhancement) by estimating people's willingness to pay for associated improvements, such as increased recreational opportunities, enhanced aesthetics, and greater biodiversity protection. Unfortunately, we cannot estimate the marginal effects of oyster reefs on these broad services. Here, we rely on proxy measures: the cost of providing the same ecosystem service through alternative means. This *avoided-cost* approach is appropriate when the cost estimates derived reflect the actual willingness of individuals to pay for a particular service (e.g., Tietenberg 2005).

This avoided-cost proxy is most plausible for nitrogen removal by oyster reefs, because there is evidence about the cost that the nation is willing to shoulder to reduce nutrient concentrations in American waterways as a consequence of regulatory policies stemming from the Clean Water Act of 1972. Nutrient-trading programs in particular provide an estimate of the marginal cost of nutrient removal and also provide at least rudimentary adjustments for the differences in spatial characteristics and uncertainty of those nutrient removals. Even though nitrogen permit prices are not direct measures of a willingness to pay for ecosystem services, they provide a reasonable estimate of that value.

We used data on the difference between nitrogen flux in oyster reefs and that in the alternative soft-sediment bottom to determine the amount of incremental nitrogen removed from the system by oyster reefs. Piehler and Smyth (2011) quantified nitrogen fluxes in both habitats (see Piehler and Smyth [2011] for detailed methodology). They found that the primary mechanism by which oyster reefs remove nitrogen from the system is by increasing local denitrification rates. We determined the net hourly rate of nitrogen removal by each habitat to be 246 and 12 micromoles of nitrogen per square meter ($m^2$) per hour during the day in oyster reefs and in mud habitat, respectively (see supplemental table 1, available online at *http://dx.doi.org/10.1525/bio.2012.62.10.10*). We then subtracted the amount of nitrogen removed in soft-sediment habitats from that removed by oyster reefs to obtain the augmented amount of nitrogen removed by creating 1 $m^2$ of oyster reef habitat and converted this estimate to annual kilograms of nitrogen removed per hectare of oyster reef habitat.

The annual value of a hectare of oyster reef was then determined by multiplying the annual rate of nitrogen removal by $28.23, which is the current average trading price per kilogram of nitrogen removed for estuarine sites in the North Carolina Nutrient Offset Credit Program (North Coast Atlantic Conference Rule no. 15A NCAC 02B .0240). This value is reviewed annually and is likely to rise as more expensive urban best-management plans for nitrogen offsets are needed and as the lowest-cost options are used up. The value of nitrogen removal from 1 hectare of oyster reef habitat was estimated at $1385–$6716 per year in 2011 dollars.

Next, nitrogen removal through the consumption of phytoplankton was calculated. We estimated the amount of phytoplankton removed from the system using the filtration rate per oyster from Grizzle and colleagues (2006). The estimate from Grizzle and colleagues (2006) stems largely from measurements collected in early summer and, therefore, may overestimate the phytoplankton removal potential of oyster reefs. Calculations of phytoplankton removal were based on low (4 and 10 micrograms per liter [μg/L] of chlorophyll *a*) and high (40 μg/L of chlorophyll *a*) phytoplankton biomass (see supplemental table 2). Chlorophyll *a* removal was converted to carbon removal using a carbon:chlorophyll-*a* ratio of 30 (Wienke and Cloern 1987). Carbon removal was converted to nitrogen removal using the Redfield ratio (Redfield 1958). The dollar value of nitrogen removal was estimated using the same shadow price for nitrogen as was used above. This value was not included in the overall reef value presented below to avoid double crediting reefs for nitrogen removal from filtration and denitrification services.

We have not included nitrogen incorporated into oyster shells and tissue because of the uncertainty of its fate. There is the potential for long-term storage in shells or tissue, but there is also a significant likelihood of relatively short-term release of nitrogen by senescence of oysters, processing of shell for fertilizer, consumption of oysters, and the release of nutrients back into estuaries through sewage treatment facilities. We have also not included the fate of remineralized nitrogen provided to the rest of the food web through oyster excretion and biodeposition, because these processes have not been quantified adequately, and it is not completely clear that they would be characterized as an ecosystem service.

On the basis of the evidence that oysters promote recovery, productivity, and maintenance of SAV in estuaries—a habitat valued for its role as nursery grounds for many coastal fish species (Thayer et al. 1978)—it seems appropriate to credit reefs for the ecosystem services provided by this additional SAV habitat. One of the present authors, JO, used willingness-to-pay valuation surveys to determine the value of eelgrass habitat in the Peconic River Estuary to local residents. The collective value of ecosystem services in 1995 provided per hectare of seagrass habitat totaled $22,894 per

year ($33,730 in 2011 dollars after inflating in line with the annual average consumer price index). Assuming a 20-year life span of seagrass beds and a 3% discount rate for future benefit streams, the total value of a hectare of seagrass bed is $516,876 (in 2011 dollars).

Empirical data quantifying the relationship between oyster restoration and SAV recovery are lacking; however, suspension-feeding bivalves potentially promote SAV by reducing turbidity and by depositing nutrients in biodeposits (Everett et al. 1995, Carroll et al. 2008, Wall et al. 2008). Newell and Koch (2004) modeled the effects of oyster filtration on light penetration through the water column and subsequent effects on SAV. Their results suggested that relatively modest densities of oysters would promote SAV growth in shallow estuarine waters, where oyster reefs are prevalent in the southeast Atlantic and Gulf of Mexico. Therefore, we estimate that one hectare of oyster reef would promote the creation of 0.005 hectares of additional SAV, worth $2584. We recognize that the effects of oyster reef habitat on SAV will probably be influenced by several factors (e.g., the existing amount of oyster reef habitat; water turbidity, velocity, and depth; and the availability of SAV seedlings); therefore, we recommend that further research be conducted to scale these effects under meaningful variation in order to understand better how they affect the degree to which oyster reefs promote SAV habitat. Large-scale restoration efforts will probably be necessary to quantify measurable effects on water quality improvements in many key estuaries because nutrient and suspended solid loading rates currently surpass the filtration capacity of many local oyster populations.

Developing direct measures of the value of each service has been challenging because of the lack of the relevant data needed to conduct these analyses. Although the cost of providing equivalent services may seem high, many services that we have left unquantified and do not add to our sum could amount to far greater values. For instance, the valuation of regional services, such as water quality improvements in the Chesapeake Bay, has been estimated to be worth over $200 million (Bockstael et al. 1989), and the loss of 20% of the SAV habitat in the Chesapeake Bay has resulted in an estimated loss in fisheries value of $1 million to $4 million annually. It is also likely that valuable public health benefits through pathogen removal would accrue from increased oyster reef habitat. However, some fraction of these values is included in our estimates of denitrification, and we lack the data to account for this properly or to estimate the marginal value of discrete additions of restored oyster habitat. To the extent that the estimates we presented above do not fully account for all the water quality benefits of value, the indirect measures of the values associated with oyster reef ecosystem services calculated in this study are probably conservative.

### Oyster reefs as habitat for fish

Oyster reefs provide important habitat for recreationally and commercially valuable fish species (Coen et al. 1999, Lenihan et al. 2001, Peterson et al. 2003, Grabowski et al. 2005). Peterson and colleagues (2003) quantified the value of augmented fish production from a unit of oyster reef after reviewing existing data from the southeast Atlantic and Gulf of Mexico coasts on the densities of all species of fish and fished crustaceans on oyster reefs and mud bottom. They found that 10 $m^2$ of restored oyster reef habitat creates an additional 2.6 kilograms of fish and large mobile crustacean production annually, because oyster reef habitat either enhances the recruitment rate of early life stages or enhances growth and survival by the provision of habitat with food resources and shelter from predators during some life stages. Although the augmented fish production estimates from Peterson and colleagues (2003) were developed for the Tampa Bay estuary, the data were derived from a quantitative synthesis of multiple studies from Texas to Virginia and are therefore widely applicable.

Grabowski and Peterson (2007) used these data to convert augmented fish production estimates into the enhanced values of landings for each of the 13 species groups that were augmented by oyster reef habitat. Their annual estimate of fish value ($3.70 per 10 $m^2$) was adjusted to a net present value of $4.12 per 10 $m^2$ to determine the present value of commercial fish per unit oyster reef. Future landings values were then discounted at a rate of 3%. Using these estimates, we calculated the commercial fish value of a hectare of oyster reef to be $4123 per year in 2011 dollars. We did not adjust this value to account for any costs associated with fishing, because we assume that any augmented fish from oyster reef habitat would be caught with existing effort. This assumption deserves testing. Peterson and colleagues' (2003) estimate of the augmentation of fish production by a unit of oyster reef habitat that would be available to the fishery is low for older age classes, because their estimate is based on fish and crustacean populations continuously exposed to fishing pressure, which acts to cull production benefits that then go uncounted. Consequently, our estimates of the value of this service of augmenting commercial fishery production are conservative.

The value of fish produced by a unit of oyster reef will vary as a function of many ecological and economic factors as well as how these species are managed. Capturing how these dynamics interact across natural and social-science disciplines is emerging as a central challenge to the effective implementation of ecosystem-based management. For instance, the value of oysters and the price of boat fuel will undoubtedly influence harvesting pressure, which will affect the quality of oyster reef habitat and the ecosystem services that the oysters provide. Meanwhile, the implementation of fisheries regulations that modify how recreational and commercial fishermen use oyster reefs will potentially affect not only the species that use oyster reefs but also their value.

The functional role of oyster reefs as habitat for fish is probably influenced by the amount of existing oyster reef habitat available for finfish and exploited crustaceans in a given estuary. Therefore, the marginal value of each unit

of restored oyster reef may decrease as reefs are restored in the system, especially if large restoration projects or efforts in areas with large amounts of existing reef habitat result in fishery production for reef fish and crustaceans becoming limited by factors other than habitat availability. However, the abundances of many fish and crustaceans that use oyster reef habitat have been reduced by a long history of overfishing. Therefore, in studies conducted over the past two decades on fish use of restored reef habitat, the historical abundance of these species and, consequently, the functional significance of reefs as habitats for fishes within estuaries have probably been underestimated. Understanding how these processes scale across various gradients (e.g., salinity, latitude) will be especially important for taking restoration efforts to ecologically meaningful scales and especially to scales approaching historical levels of intact oyster bottom habitat.

## Erosion protection

Oyster reefs can function as natural, living (as opposed to human-designed) breakwaters, bulkheads, or jetties, because they are structures that interact with tidal and wave energy just like engineered shoreline stabilization devices by baffling waves and increasing sedimentation rates (Meyer et al. 1997). The rate of vertical oyster reef growth on unharvested reefs is far greater than any predicted sea-level rise rate, and therefore, reefs could serve as natural protection against shoreline erosion, intertidal habitat loss, and property damage and loss along many estuarine shorelines. The current standard practice for inshore erosion protection is the use of engineered shoreline stabilization devices (Titus 1998). In locations where property owners would otherwise use these engineered devices, their cost can be used as a reasonable proxy for the economic value of oyster reef restoration. This assumes that reefs are perfect substitutes for human-made devices. Because oyster reefs can grow vertically faster than sea levels are expected to rise, an argument can be made that they are more resilient to sea-level rise than a fixed engineered device would be and, therefore, have a higher value as a shoreline stabilizer. But in addition, the relative risk of storm damage to engineered and oyster reef structures needs to be considered. Given that oyster reefs and unnatural engineered devices constitute similar physical structures, we assume an equivalence of value.

Estimates of the cost of these bulkheads and rock revetments ranged from $630 to $752 (in 2011 dollars) per linear meter (Allison 2001). Assuming that oyster reef has an average width of 5 meters, the value per hectare of oyster reef habitat would range from $1,074,475 to $1,504,265 (table 3a, 3b). These estimates represent the present value of stabilization services over the life of human-made structures and not an annual flow of benefits. We estimate the annual flow by assuming that these structures have a 20-year life span, and we assumed a constant annual value at a discount rate of 3%. We then used the average cost of our estimates of shore stabilization devices—$640 per linear meter—to estimate the value of oyster reef habitat shoreline stabilization relative to the percentage of reef habitat that provides this service.

***Table 3a. The value of oyster reef habitat as a shoreline stabilizer.***

| Type | Cost (in dollars per linear meter [m]) | Cost (adjusted) | Capital cost per hectare |
|---|---|---|---|
| Bulkhead | $630 | $126 | $1,260,359 |
| Stone groin | $537 | $107 | $1,074,475 |
| Stone sill | $752 | $150 | $1,504,265 |

*Note:* The adjusted cost assumes that 5 $m^2$ of oyster is required to protect 1 m of shoreline.

***Table 3b. Approximated total value of shoreline stabilization for oyster reefs.***

| | Value (in dollars) | |
|---|---|---|
| Percentage of reefs that stabilize shorelines | Per 10 square meters | Per hectare |
| 0.1 | 0.09 | 86 |
| 1.0 | 0.86 | 860 |
| 10.0 | 8.60 | 8600 |

Shoreline stabilization provides a stark illustration of the importance of location in determining the value of ecosystem services provided by oyster reef habitat. In locations where property owners demand such services and oyster reefs function as perfect substitutes for human-made structures, one hectare of oyster reef habitat is estimated to provide $85,998 of annual value. In locations where property owners would not otherwise build protective devices, any values created by shoreline stabilization and habitat protection will likely be far lower and could be zero. The significance of this result is that the economics of oyster restoration are likely to be strongly and positively affected by proximity to property that people wish to protect from erosion.

## Conclusions

A fundamental goal of ecosystem-based management is to sustain the delivery of ecosystem goods and services that people rely on. With only 15% of the world's oyster reef habitat left (Lotze et al. 2006, Beck et al. 2011), substantial efforts are now under way to protect the remaining reef habitat, as well as to restore oyster reefs. The focus on oyster reefs has dramatically shifted from efforts to rebuild the oyster fishery to recovering and sustaining the ecosystem services associated with oyster reefs. Our estimates are aimed at helping refine future restoration efforts to quantify multiple disparate benefits of restoring oyster reef ecosystem services using a common unit of dollar valuation, a meaningful currency to people. Oyster reef restoration currently constitutes a small fraction of the overall estuarine habitat restoration efforts, even though this habitat is among the most degraded of all critical estuarine habitats. The cost of restoring oyster reef habitat is similar to those for

*Table 4. Total annual value of ecosystem services provided by oyster reefs in 2011 dollars per hectare per year.*

| Ecosystem service values | Minimum | Maximum | Average |
|---|---|---|---|
| Oyster habitat state | | | |
| Pristine | 12,186 | 21,959 | 17,072 |
| Degraded | 880 | 880 | 880 |
| Finfish and mobile crustacean value | | | |
| Recreational | n/a | n/a | n/a |
| Commercial | 4123 | 4123 | 4123 |
| Water quality services | | | |
| Chlorophyll *a* removal[a] | 0 | 0 | 0 |
| Nitrogen removal[b] | 1385 | 6716 | 4050 |
| Recreational use | n/a | n/a | n/a |
| SAV enhancement[c] | 0 | 2584 | 1292 |
| Bacterial removal | n/a | n/a | n/a |
| Carbon burial | n/a | n/a | n/a |
| Shoreline protection[c] | 0 | 85,998 | 860 |
| Habitat for epibenthic infauna | 0 | 0 | 0 |
| Landscape processes | 0 | 0 | 0 |
| Nonoyster harvest service total | 5508 | 99,421 | 10,325 |

*Note:* n/a represents insufficient data to assess the economic value of the service.
[a]The value of chlorophyll *a* removal was not included in the summary table because this service is considered potentially redundant if nitrogen removal through denitrification is also considered.
[b]The value of nitrogen removal was estimated by quantifying the value of enhanced denitrification rates on oyster reefs.
[c]The average submerged aquatic vegetation (SAV) enhancement and shoreline stabilization was valued assuming that 1% of the linear length of reefs perform this function.

seagrass, salt marsh, and mangrove restoration efforts and far less than the costs of restoring coral reefs (table 1). Therefore, one hopes that valuation efforts such as the present study, coupled with restoration cost and habitat loss information, will assist resource managers in deciding how best to use limited restoration funds and in prioritizing among the range of possible restoration projects.

In this article, we estimated an average annual value of services provided by restored and protected oyster reefs that ranges from $10,325 to $99,421 per hectare, depending on where the restored reef is located and the suite of ecosystem services that the restored reef provides. Both of these measures are at least an order of magnitude greater than the commercial value derived from harvesting the oysters produced by degraded reefs (table 4). This estimate of reef service value is probably conservative, because oyster reefs may provide additional services that are not valued here, such as recreational fishing, carbon burial, and augmented biodiversity. This value also does not include either the cost of restoring the reefs or the opportunity cost of choosing not to harvest the oysters. Using the median cost of restoration (table 1), our estimates suggest that a restored oyster reef would produce benefits equivalent to this cost (i.e., the break-even point) in 2–14 years, depending on where restoration is conducted and, consequently, on which services are achieved at what levels.

An alternative management scenario for oyster reefs is to open the restored reef to oyster harvesting as soon as it yields oysters of marketable size. Although the degree to which the ecosystem services discussed above are provided by highly degraded habitats is currently unknown, we assume that the provision of these services will be very low or nonexistent, because they scale with reef structure and oyster net metabolism, both of which are greatly degraded by harvesting (Lenihan and Micheli 2000). For the purposes of this study, we have assumed that highly degraded reefs provide little to no value other than remnant oyster harvests. Our estimates show that the value of oysters produced by such degraded reefs is insufficient to cover the cost associated with oyster reef construction (figure 1). Therefore, enhancing habitat purely to support a traditional oyster fishery with harvesting practices that result in degradation of the habitat is a poor use of public funds. A key question is whether there are socially acceptable, less destructive techniques, such as diver harvesting (Lenihan and Peterson 2004), in which oysters can be harvested without appreciable structural damage to the reefs so that a substantial fraction of the value of the other ecosystem services can still be sustained by these strategically fished oyster reefs. It is worth exploring whether such a hybrid approach is a viable management alternative.

Our estimates suggest that oyster reefs provide value not only as a commercial fishery resource for exploitation but also as a biogenic habitat providing diverse ecosystem services of substantial economic value. The total loss of goods and services from a century of overharvesting and the destruction of upward of 99% of reef habitat in some estuaries in the United States (Lotze et al. 2006, Beck et al. 2011, Wilberg et al. 2011) is staggering when one considers that our estimates imply an estimated present value ranging from $200,000 to $2,000,000 per hectare over 50 years. Because oyster reefs have been largely destroyed in areas such as the Chesapeake Bay and the southeastern United States (Kirby 2004), restoration efforts will be necessary in these regions in order to recover the goods and services potentially provided by reef habitat. Our analyses demonstrate that the total potential return on oyster reef restoration investments clearly justifies more restoration and protection of the existing oyster reefs and supports the assertion that these are economically efficient strategies. Oyster diseases have hampered many recent restoration efforts, so a 50-year life span for an oyster reef may seem unrealistic. However, historical reefs commonly existed for centuries prior to harvesting, and Lenihan and colleagues (1999) demonstrated that tall oyster reefs protected from damage by oyster-harvesting gear sustained oysters with low incidence and low intensity of the otherwise most serious oyster disease. In addition, the evaluation of reef sanctuaries in North Carolina determined that many reefs constructed two to three decades ago at natural reef elevations, undegraded by decades of dredge and tong damage, contain high densities of living oysters (Powers et al. 2009),

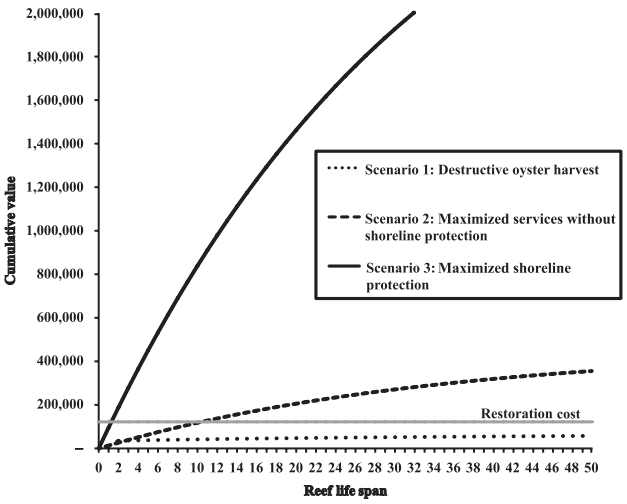


***Figure 1. The cumulative value (in 2011 dollars per hectare) of reefs of varying life spans (in years) with destructive oyster harvesting (scenario 1), with no oyster harvesting or shoreline stabilization but positioned to maximize all other services (scenario 2), and with no oyster harvesting but positioned to maximize shoreline stabilization with the average value derived from other services (scenario 3). The values for future years were adjusted using a 3% annual discount rate. The gray line is the median cost per hectare of constructing oyster reef habitat.***

which suggests that restored oyster reefs may be able to persist for several decades if they are left untouched.

In addition to making the case that resource managers should look closely at reef restoration as an efficient use of funds because of the high value of ecosystem services provided, our estimates also show the importance of location and other sources of heterogeneity in evaluating restoration projects. The clearest illustration of this is the value of shoreline stabilization services: Reefs that provide effective erosion protection potentially provide a value that dwarfs both restoration costs and the value of all other ecosystem services. A second illustration is the value of proximity to SAV habitat or potential SAV habitat: An oyster reef that is located near SAV or near an area where the presence of a high number of oysters could promote SAV development would have a higher potential to benefit this important habitat both by improving water quality and by baffling wave energy. Conversely, Grabowski and colleagues (2005) found that oyster reefs located next to a seagrass habitat did not augment juvenile fish abundance and, therefore, that this ecosystem service is not likely to be enhanced by oyster reef restoration in such landscape settings. Empirical and modeling studies that provide more detailed information will greatly enhance these assessments of how spatial location may be expected to influence of the values of diverse ecosystem services provided by oyster reefs.

Another important unknown factor is how reef characteristics, such as reef size and height, water depth, and salinity, affect ecosystem processes and the values derived from them. Establishing the relationship between oyster density and ecosystem services is particularly important, because allowing selective harvesting using nondestructive methods (*sensu* Lenihan and Peterson 2004) may ultimately maximize the total value of the goods and services provided by an oyster reef. Lenihan and Peterson (1998) also demonstrated that reef height and water depth are particularly important in areas where bottom water hypoxia and sedimentation issues are common. Developing decision-support tools that allow location-specific value estimates would be of great value in prioritizing restoration projects to enhance the value of the services that they provide.

Quantifying the value of ecosystem services should facilitate efforts to transition to ecosystem-based management by providing both an economic justification and a decision-making framework for prioritizing management actions. In this article, we developed estimates of the values of several important ecosystem services provided by oyster reef habitat. The estimates do not include the full range of services and involve some assumptions that deserve further consideration. In addition, our primary estimates are for a generic unit area of oyster reef habitat rather than for habitat with specific characteristics. We also used two restoration scenarios without oyster harvesting to demonstrate how much reef location can influence ecosystem service delivery and economic value. Nevertheless, many landscape-scale considerations will be necessary as managers attempt to maximize the utility of restoration efforts, because where an oyster reef is located will influence the degree to which it performs key functions. It is also unclear how the scale of restoration will affect processes such as water quality and SAV promotion. Our estimates of the total value of oyster reef services support the view that oyster reef restoration provides economic value through a range of diverse ecosystem services and that such restoration efforts should therefore receive serious consideration as a component of efficient estuary management.

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