# Sea Turtle Bycatch Monitoring of the 2006 Fall Gillnet Fisheries in Southeastern Pamlico Sound, North Carolina

**Completion Report for Activities Under**
**ESA Section 10 Incidental Take Permit # 1528**

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## Introduction

The Pamlico Sound Gillnet Restricted Area (PSGNRA) originated in 2000. This area was established based upon increased numbers of sea turtle strandings, and subsequent observed gillnet interactions in 1999 along the Outer Banks (Gearhart 2001). Management measures in the PSGNRA restrict areas, seasons, gear, mandate observer coverage, and weekly reporting requirements. These actions are designed to protect sea turtles, allow a limited shallow water gillnet fishery, and characterize catch, effort, and bycatch along the Outer Banks and mainland side of Pamlico Sound from September through December of each year.

Habitat Conservation Plans (HCPs) within Section 10 Incidental Take Permits (ITPs) allowed establishment of an extensive monitoring program in this region since 2000 (Gearhart 2001, 2002, 2003; Price 2004, 2005, 2006). The primary goal each year in the management of the PSGNRA was to monitor and reduce sea turtle interactions in commercial gillnets with the assumption that these will result in decreased sea turtle strandings in Pamlico Sound from September through December of each year.

### *Incidental Take Permit History*

In consultation with the National Marine Fisheries Service (NMFS), the North Carolina Division of Marine Fisheries (NCDMF) has managed the PSGNRA under authority of Section 10 ITPs. All ITPs established an extensive monitoring, characterization, and reporting program to identify commercial gillnet and sea turtle interaction trends. These data were used to appropriate resources, establish restricted fishing areas, promote better fishing practices, and implement management measures to reduce the potential for sea turtle takes.

In December 2004, NCDMF consulted with NMFS to begin preparation of Section 10 ITP #1528 (ESA 1973). Management measures imposed during the 2002 –2004 fall fishing seasons allowed for a more comprehensive assessment of directed resource use for the purpose of protecting sea turtles and maintaining a limited shallow water, fall gillnet fishery. In August 2005, ITP # 1528 was issued to NCDMF to manage the PSGNRA. The ITP #1528 was authorized for six years and will expire December 31, 2010.

## Methods

The management of the PSGNRA during the 2006 fishing season contained a comprehensive conservation plan similar to previous years (Gearhart 2001, 2002, 2003; Price 2004, 2005, 2006). Stipulations of the conservation plan included: weekly logbook reporting, mandatory observer coverage, an enforced violation system, NCDMF Marine Patrol monitoring, and immediate closure of the fishery should authorized sea turtle take levels be exceeded. There were no changes to the protocols established in 2005. In 2005 changes to the HCP from previous management years included redirecting observer coverage, eliminating permit requirements in the Mainland Gillnet Restricted Area (MGNRA), and establishing increased surveillance.

*Habitat Conservation Plan*

In August 2006, NCDMF issued proclamation M-9-2006, which established the PSGNRA. This proclamation closed all internal waters of Pamlico Sound south and west of the 35 46.3000 N latitude line, east of the 760 30.0000 W longitude line, and north of the 350 00.0000 N latitude line except for the restricted areas SGNRA1 – SGNRA4, and a 200-yard corridor along the mainland side of the sound (Figure 1). Proclamation M-9-2006 also established gear restrictions including a 2,000-yard limit for all gillnet fishing operations and required small mesh gillnet attendance until November 1. Sea turtle interaction reporting was required. All fishermen along the Outer Banks utilizing large mesh (≥ 5 inch stretch) gillnets were required to obtain a PSGNRA permit from NCDMF. Provisions of the permit established mandatory logbooks, weekly reports from active fishermen, and observer coverage.

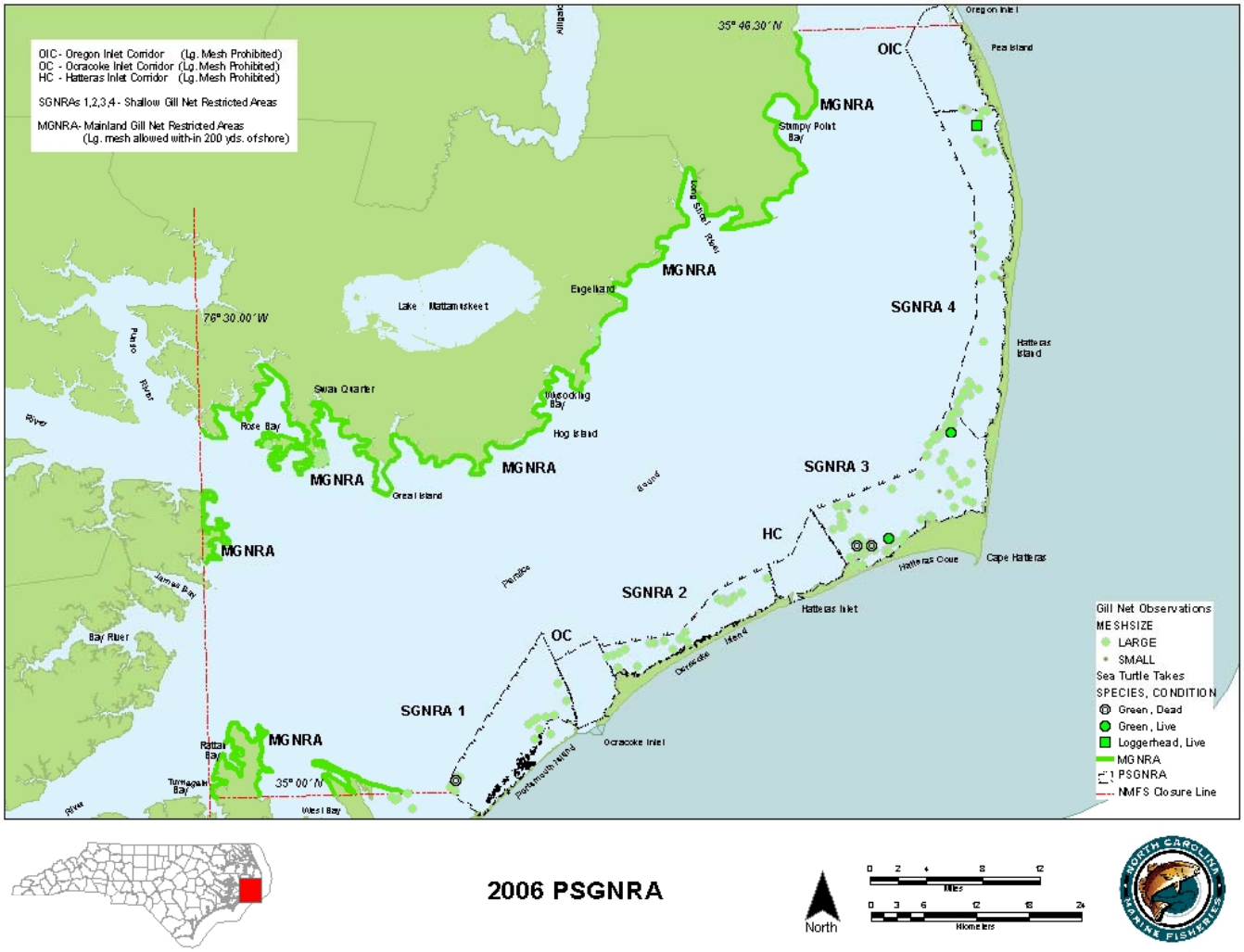


**Figure 1.** NCDMF 2006 Pamlico Sound Gillnet Restricted Area (PSGNRA). SGNRA 1 – SGNRA4 = Shallow Water Gillnet Restricted Areas; MGNRA = Mainland Gillnet Restricted Area; OC = Ocracoke Corridor; HC = Hatteras Corridor; OIC = Oregon Inlet Corridor.

*Weekly Reporting*

PSGNRA active permit holders operating along the Outer Banks (SGNRA1 – SGNRA4, Figure 1) were required to submit weekly fishing reports to NCDMF. Each fishing week began on Saturday and ended on Friday. Fishermen were required to submit reports by 6:00 p.m. on Sunday for the previous weeks catch and effort information. Active permit holders reported the following information each week: port of landing, restricted area fished, yards of gillnet fished, soak time (days), number and disposition of sea turtles caught, and whether the fishermen had taken an observer during the week.

Failure to report accurate and timely information each week resulted in permit suspensions. Fishermen were required to report all sea turtle interactions to NCDMF within 24 hours. Penalties for late and non-reporting increased with subsequent offenses ranging from a 10-day suspension to a 6-month revocation. A system of back checks was implemented with NCDMF Marine Patrol during the 2005 and continued in the 2006 PSGNRA fishing season to ensure industry compliance with reporting requirements.

*Compliance Checks*

NCDMF observer and NCDMF Marine Patrol conducted weekly fish house visits, boat patrols, fisherman spot checks, gear checks, and continued outreach to the industry for the purpose of ensuring industry compliance and communicating efforts throughout the PSGNRA (e.g., timely/accurate reporting, proper gear use). Aerial surveys were scheduled for the 2006 season as conducted in 2005, but no flights were made due to the NCDMF Marine Patrol plane experiencing mechanical difficulties and remaining in the shop for the majority of the fishing season.

NCDMF observers and Marine Patrol officers obtained trip ticket information from all fish houses throughout the PSGNRA to cross-reference with a weekly reporting database and determine late reporters, accuracy of reports, and non-reporters. Observers scheduled these visits at the end of each fishing week. Boat patrols, fishermen and gear checks were conducted regularly from September 1 – November 30, 2006. NCDMF Marine Patrol and staff were responsible for submitting weekly logs of these activities along with updated lists of violations.

Collectively, NCDMF Marine Patrol, NCDMF observers, fish house dealers and PSGNRA industry participants have worked closely to ensure compliance and protection of endangered species in the limited shallow water fishery. Establishing a state closure on top of the federal closure in Pamlico Sound during 2005 and 2006 provided jurisdictional authority for Marine Patrol surveys to be conducted and facilitated direct communication between the PSGNRA administrator and Marine Patrol officers. Outreach efforts to the commercial fishing industry and local communities along the Outer Banks and mainland side of Pamlico Sound continued to provide the public with information pertaining to federal and state management measures to protect sea turtles. Outreach materials and information were provided through memos to fish dealers, letters to PSGNRA permit holders, informal public meetings, and daily personal communication with fishermen.

*Sea sampling*

Each observer was trained to identify, measure, resuscitate, and tag sea turtles by NMFS – Beaufort Lab and NCDMF. Date, time, tag numbers, location (latitude and longitude, when possible), condition (e.g., no apparent harm, injury including a description of the nature of the injury, or mortality), species, sex (if determinable), and curved carapace length (mm) were recorded for each turtle observed. Dead sea turtles were brought to shore when feasible. All live, debilitated sea turtles were brought to shore for examination and treatment. Carcasses not brought in for post-mortem examinations were marked with external flipper tags or spray-painted before disposal overboard. Observers collected data on location, gear parameters, catch, and bycatch for each haul. The landed catch was sampled throughout each trip and total flounder weights (kgs) were obtained. Data were coded on NCDMF data sheets, double keyed, visually proofed, and uploaded to NCDMF Biological Database for analysis. All observers were debriefed within 24 hours of each trip to obtain data on flounder catch, set locations, gear parameters, and sea turtle interactions to provide estimates of sea turtle bycatch.

A minimum goal of 2% coverage of the total large mesh gillnet fishing effort was set between September 1 – September 15, and from November 1 – November 30. A goal of 10% coverage of the total large mesh gillnet fishing effort was established from September 16 – October 31 2006. Observers were also required to obtain small mesh gillnet trips throughout the PSGNRA when feasible.

The PSGNRA permit established mandatory observer coverage for the large mesh gillnet fishery. Permit holders were required to allow NCDMF fishery observers aboard their vessels to monitor catches. Failure to comply with this permit provision resulted in permit suspension. A list of permit holders was utilized to randomly assign observers to vessels by area and port. Outer Banks ports included Rodanthe, Avon, Buxton, Hatteras, Ocracoke, and Cedar Island. Mainland ports included Stumpy Point, Engelhard, Gull Rock, Swan Quarter, Rose Bay, Germantown, and Hobuken. Outer Banks observer coverage was proportionally allocated based on the 2005 PSGNRA trip distribution among ports. Mainland observer coverage was proportionally allocated based on the 2005 trip distribution of flounder gillnet trips among ports derived from trip tickets. Proportional observer coverage along the Outer Banks was updated weekly based on the relative effort from the previous week. Observer coverage along the mainland was obtained through contacts during regular fish house visits, and use of the 2005 PSGNRA database.

The total bycatch of sea turtles in the PSGNRA was estimated using the stratified ratio method. The bycatch rate (sea turtles caught per unit of fishing effort), estimated from observer data, was multiplied by the total fishing effort reported by the fishermen for each fishery. Strata consisted of the restricted areas SGNRA1, SGNRA2, SGNRA3, SGNRA4, OIC, OC, and HC. Fishing effort was the product of net length (yds) and soak time (days). Total bycatch estimates were calculated weekly by adding estimates for each fishery within each restricted area. Estimates were cumulated each week to ensure authorized take levels were not being approached.

*Authorized Takes*

Take levels for the 2006 PSGNRA fishing season were the same as the 2005 season and based upon 2002 through 2004 observations using the upper 95% confident limits around the estimated mean number of takes to account for a worst case scenario. The authorized take levels established in ITP # 1528 are scheduled to remain consistent each year from 2005 through 2010 (Table 1).

**Table 1.** Authorized sea turtle take levels in the PSGNRA by species and disposition from 1 September – 30 November 2006.

| Species | Maximum Authorized Estimated Lethal Takes | Maximum Authorized Estimated Live Takes | Total Authorized Take |
|---|---|---|---|
| Kemp's Ridley[1] | 14 | 27 | 41 |
| Green | 48 | 120 | 168 |
| Loggerhead[1] | 3 | 38 | 41 |
| **Species Aggregate** | **65** | **185** | **250** |

| Species | | Total Observed Take |
|---|---|---|
| Hawksbill | 2 lethal or live, observed, all areas | 2 |
| Leatherback | 2 lethal or live, observed, all areas | 2 |
| Kemp's ridley, green, loggerhead | 6 lethal or live, any combination of species, observed, on the western shore of Pamlico Sound only | 6 |
| **Total Observed Take** | **10** | **10** |
| **Total Estimated and Observed Take** | | **260** |

[1] Kemp's ridley and Loggerhead estimated take based on a 3-year period (i.e, Kemp's ridley = 81 live, 42 lethal for 2005 - 2007 and 81 live, 42 lethal for 2008 - 2010; Loggerhead = 114 live, 9 lethal for 2005-2007 and 114 live, 9 lethal for 2008-2010) for purposes of exceeding the threshold. Estimated take of Kemp's ridleys and loggerheads varies greatly by year, thus combining years will account for some of the variability across years.

*Conference Calls*

Conference calls were conducted between NCDMF and NMFS-Office of Protected Resources (Silver Spring, Md., and St. Petersburg, Fla.) at the beginning, middle and end of the 2006 PSGNRA season. This protocol has always been maintained in the management of the PSGNRA, was formalized in 2005, and will continue in the future. These communications provided an opportunity to discuss catch, effort, bycatch trends, evaluate observer coverage, industry compliance, and enforcement for the purpose of assessing any potential complications, and ensure that NMFS and NCDMF were prepared to implement timely management alternatives if needed.

## Results

*Permit Activity*

There were 135 permits issued throughout the 2006 PSGNRA season with less than one-half this number fishing each week (Figure 2). An average of 37 fishermen reported activity each week with permit activity remaining relatively high from the second week of September through the fourth week in October. The highest number (n = 64) of participants occurred during week 8 (ending 20-Oct) of the PSGNRA. A total of 24 participants fished the last three weeks of the November ending with three reports during the last week of the season (Figure 2).

There were no notices of violations issued to PSGNRA fishermen during the 2006 PSGNRA season. However, three permit suspensions from the 2005 PSGNRA were carried out in the month of September, and NCDMF Marine Patrol conducted regular boat patrols throughout the season.

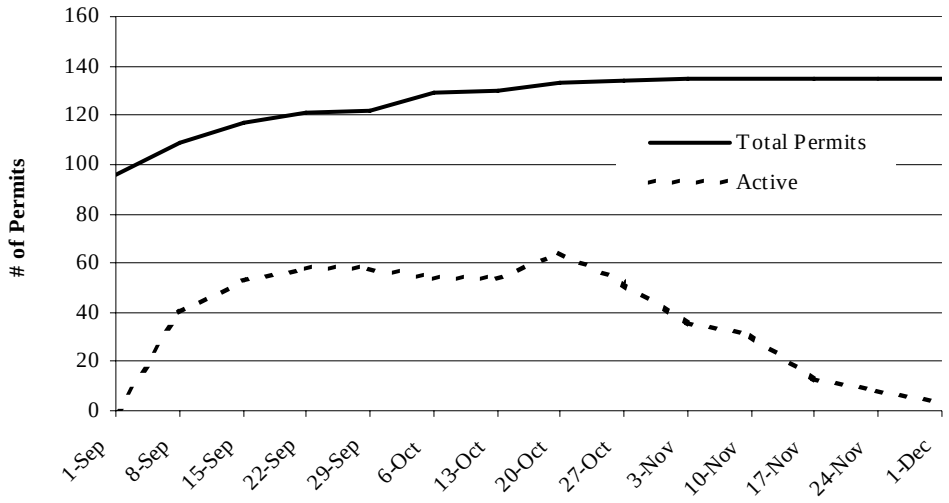


**Figure 2.** Number of total and active PSGNRA permits by week from 1 September – 30 November 2006.

*Catch and Effort*

There were 2,014 trips reported in the 2006 PSGNRA (Figure 3). An average of 144 trips were reported each week from 1 September through 30 November. Reported trips remained relatively consistent and high from the second week in September through October with an average of 187 trips per week being reported during this time frame. Throughout the remainder of the season, the total reported trips decreased with an average of 36 trips per week for the last four weeks of the season.

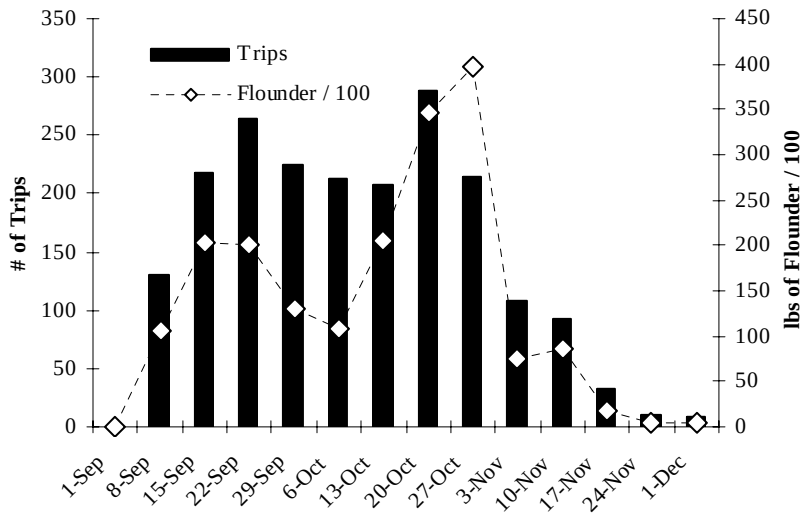


**Figure 3.** Total trips and pounds of flounder landed in the PSGNRA by week from 1 September – 30 November 2006**.**

Fishermen reported more than 2.5 million yards of large mesh gillnet effort, landing nearly 190,000 pounds of flounder during the 2006 PSGNRA (Table 2). More than one-half of the total effort was concentrated in SGNRA3, where 46% of the total landings were reported. Total effort and landings were spread relatively evenly among the other three restricted areas with SGNRA4 reporting more (20%) than SNGRA2 (14%) or SGNRA1 (10%) of the total effort (Table 2).

**Table 2.** Relative percent of total effort (yds * soak day) and total flounder landings (lbs) by area in the PSGNRA from 1 September through 30 November 2006.

| Area | Effort | Landings | % Total Effort | % Total Landings |
|---|---|---|---|---|
| **S1** | 261,100 | 19,658 | 10 | 10 |
| **S2** | 367,090 | 37,946 | 14 | 20 |
| **S3** | 1,451,643 | 86,646 | 56 | 46 |
| **S4** | 508,090 | 44,104 | 20 | 23 |
| **Totals** | **2,587,923** | **188,354** | | |

Peaks in effort and landings show similar trends throughout the four restricted areas in the 2006 PSGNRA, but in SGNRA3 these were significantly higher by week throughout the season (Figure 4). Greater than 50% of the total effort by week was reported in SGNRA3 in all weeks except week 1, week 8 and week 14 of the 2006 PSGNRA. Among the other three SGNRA's, total effort and landings by week display similar trends. Spikes in effort and landings can be seen in all areas during the last couple of weeks of September and October (Figure 4).

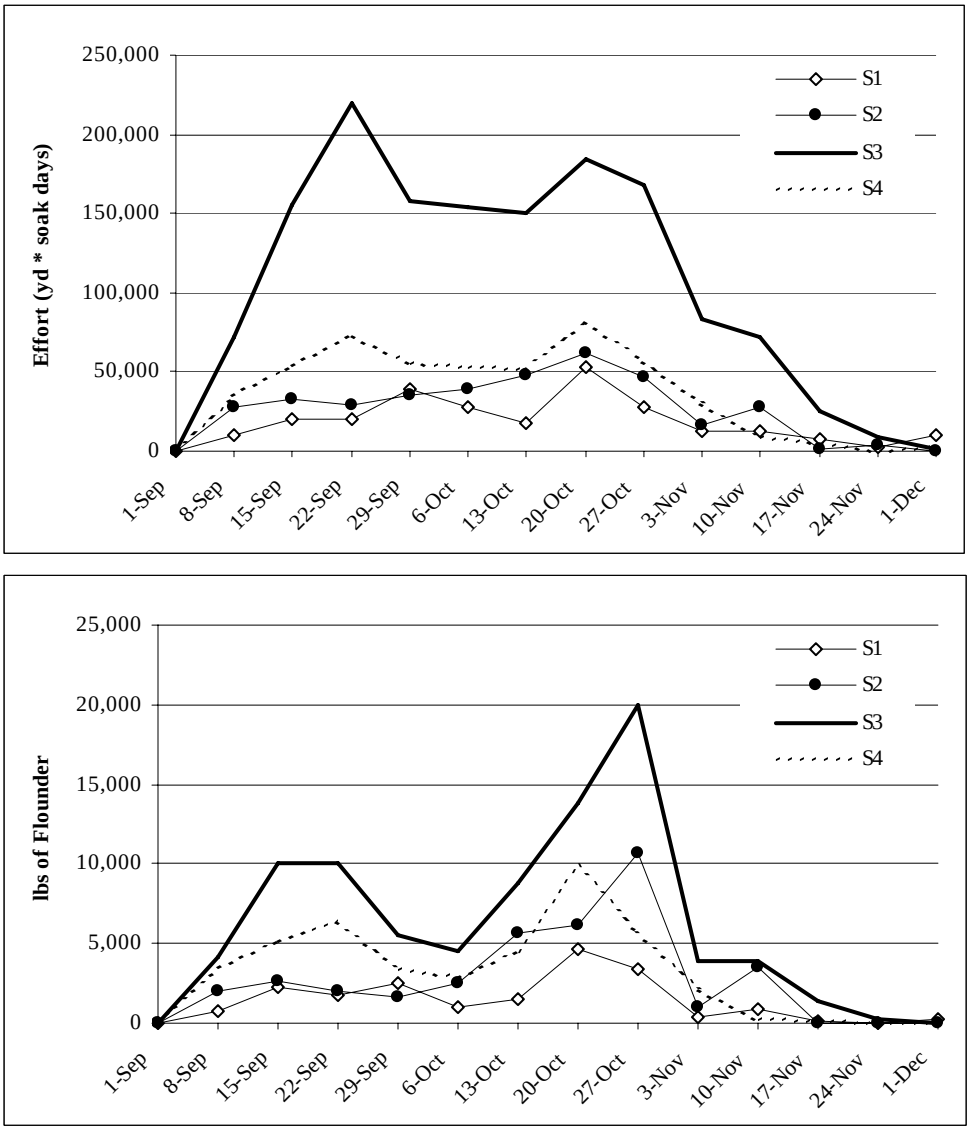


**Figure 4.** Large mesh gillnet effort and pounds of flounder reported by week from 1 September – 30 November 2006 in the PSGNRA.

*Observer Coverage*

There were a total of 187 observer trips conducted throughout the PSGNRA during 2006. These were comprised of 167 large mesh trips and eight small mesh trips along the Outer Banks (SGNRA1 – SNGRA4), nine mainland trips, and three Core Sound trips. Observers covered more than 247,000 yards of large mesh gillnet effort along the Outer Banks representing an overall 9.6% coverage of the total reported effort from 1 September – 30 November 2006 (Table 3). Observers were present on more than 8% of the total reported trips (Table 3), and observed 7.4% of the total flounder reported.

**Table 3.** Observed and reported large mesh gillnet trips and effort (yd * soak day) with relative percent coverage by week in the PSGNRA from 1 September – 30 November 2006.

| | Observed | | Reported | | % Coverage | |
|---|---|---|---|---|---|---|
| **Week** | **Trips** | **Effort** | **Trips** | **Effort** | **Trips** | **Effort** |
| 1-Sep | 0 | 0 | 0 | 0 | 0.00 | 0.00 |
| 8-Sep | 5 | 6,632 | 131 | 146,398 | 3.82 | 4.53 |
| 15-Sep | 6 | 7,850 | 218 | 262,160 | 2.75 | 2.99 |
| 22-Sep | 23 | 32,075 | 264 | 342,250 | 8.71 | 9.37 |
| 29-Sep | 19 | 26,440 | 225 | 287,660 | 8.44 | 9.19 |
| 6-Oct | 19 | 26,135 | 213 | 273,230 | 8.92 | 9.57 |
| 13-Oct | 18 | 25,675 | 207 | 267,250 | 8.70 | 9.61 |
| 20-Oct | 19 | 26,037 | 289 | 380,380 | 6.57 | 6.84 |
| 27-Oct | 19 | 30,105 | 215 | 298,980 | 8.84 | 10.07 |
| 3-Nov | 19 | 32,895 | 108 | 142,300 | 17.59 | 23.12 |
| 10-Nov | 10 | 16,520 | 92 | 121,490 | 10.87 | 13.60 |
| 17-Nov | 3 | 6,750 | 33 | 38,650 | 9.09 | 17.46 |
| 24-Nov | 5 | 7,550 | 10 | 14,275 | 50.00 | 52.89 |
| 1-Dec | 2 | 2,900 | 9 | 12,900 | 22.22 | 22.48 |
| **Totals** | **167** | **247,564** | **2,014** | **2,587,923** | **8.29** | **9.57** |

Observations and fishermen reports for catches and effort tracked directly throughout the 2006 PSGNRA (Figure 5). Towards the end of November, a divergent trend was noticed when the total effort, catches, and observations were relatively low. This trend has been typically observed in the PSGNRA (Price 2005, 2006).

Spatial coverage, similar to previous years was concentrated along the Outer Banks near Avon, Hatteras and Ocracoke, NC (Figure 1). There were reduced observed trips (n = 9) along the mainland side of Pamlico Sound, but observer fish house visits, and phone calls verified few active large mesh gillnet fishermen in this 200 yd corridor during the 2006 PSGNRA.

Collectively, fishermen logbooks appear accurate, and observer coverage of the large mesh gillnet effort in the PSGNRA was 9.6% of the total reported large mesh gillnet effort.

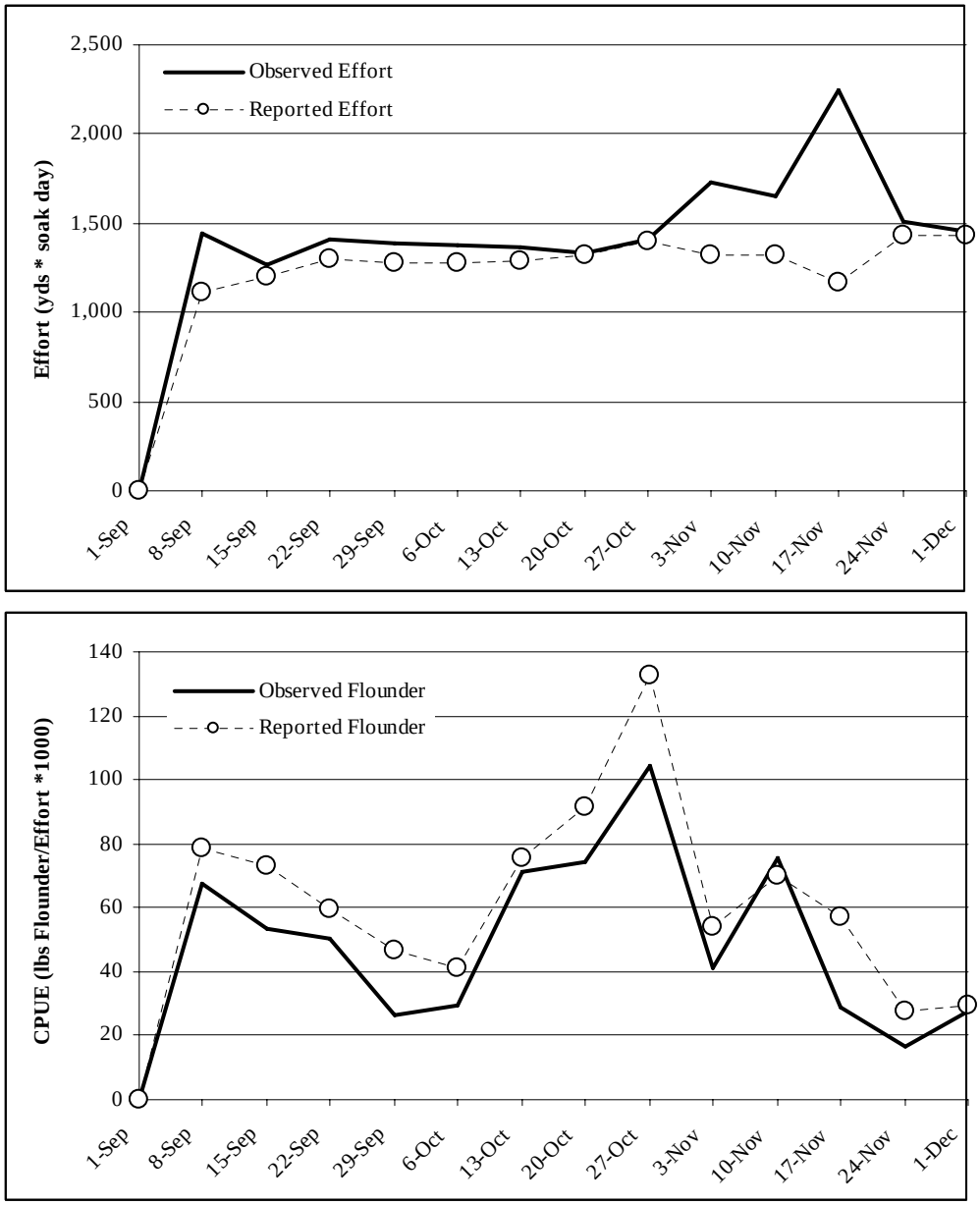


**Figure 5.** Effort (yds * soak day) and catch per unit effort (lbs flounder\1000\day) for observed large mesh gillnet trips and fishermen logbooks in the PSGNRA from 1 September – 30 November 2006.

*Gear Parameters*

Mesh sizes ranged from 7/8 to 7½ inch stretched mesh for the large and small mesh gillnet fisheries in the 2006 PSGNRA (Table 4). Commercial fishermen deployed approximately six inch stretch mesh and 3.6 inch stretch mesh on average in the large and small mesh gillnet fisheries, respectively. Observed nets were set in water depths ranging from 0.1m to 2.1m in the large mesh fishery, and in 1.1m to 2.1m of water in the small mesh fishery. Soak times averaged approximately 25 hours in the large mesh gillnet fishery and 22 hours in the small mesh fishery. A maximum soak time of 96 hours was observed in the large mesh gillnet fishery. This long soak time occurred on one occasion and consisted of a 50 yd shot of net that had been blown away from the rest of the set and was temporarily lost. An average of 1,309 yd of gillnet per trip were set in the large mesh gillnet fishery, while an average of 843 yd of small mesh gillnet was set in the small mesh fishery (Table 4).

**Table 4.** Summary statistics for large (≥ 5 in stretch) and small (< 5 in stretch) mesh gillnet observations from 1 September – 30 November 2006 in the PSGNRA.

| Mesh Size | Net Type | Gear Parameter | N | Min | Mean | Max |
|---|---|---|---|---|---|---|
| Large | Set Net | Mesh Size (in) | 2,146 | 5.50 | 6.01 | 7.50 |
| | | Twine Size (mm) | 2,146 | 0.40 | 0.50 | 0.57 |
| | | Net Set Depth (m) | 2,146 | 0.10 | 0.87 | 2.10 |
| | | Soak Time (hr) | 2,146 | 11.70 | 25.30 | 96.00 |
| | | Yards/Trip | 173 | 75 | 1,309 | 2,000 |
| Small | Set Net | Mesh Size (in) | 32 | 2.88 | 3.60 | 4.50 |
| | | Twine Size (mm) | 32 | 0.40 | 0.50 | 0.57 |
| | | Net Set Depth (m) | 32 | 1.10 | 1.37 | 2.10 |
| | | Soak Time (hr) | 32 | 2.00 | 22.17 | 48.00 |
| | | Yards/Trip | 7 | 100 | 843 | 2,000 |

*Species Composition*

The majority of the observed large mesh gillnet catches by number were paralichthid flounders (51%) (Table 5). Bluefish, Atlantic menhaden *Brevoortia tyrannus*, cownose rays *Rhinoptera bonasus*, and red drum *Sciaenops ocellatus* accounted for another 34% of the total catch by number. There were four Atlantic sturgeon *Acipenser oxyrhynchus* (found alive and released), and three striped bass *Morone saxatilis* observed in large mesh nets. Sea bird bycatch included 127 double-crested cormorants *Phalacrocorax auritus*, 32 common loons *Gavia immer*, one brown pelican *Pelecanus occidentalis*, and one great clack-backed gull *Larus marinus* (Table 5).

**Table 5.** Species, biomass (kg), and number of individuals sampled in the large mesh gillnet fishery in the PSGNRA from 1 September – 30 November 2006.

| Scientific Name | Common Name | % Biomass | % Number | Total Number | Total Wt. (kg) |
|---|---|---|---|---|---|
| *Paralichthys* spp. | Paralicthid flounders | 52.18 | 51.06 | 6,542 | 6,622.64 |
| *Pomatomus saltatrix* | bluefish | 9.82 | 13.78 | 1,765 | 1,246.03 |
| *Brevoortia tyrannus* | Atlantic menhaden | 1.86 | 10.29 | 1,319 | 236.04 |
| *Rhinoptera bonasus* | cownose ray | 19.33 | 4.95 | 634 | 2,454.08 |
| *Sciaenops ocellatus* | red drum | 8.12 | 4.91 | 629 | 1,031.03 |
| *Dasyatis sabina* | Atlantic stingray | . | 1.67 | 214 | . |
| *Pogonias cromis* | black drum | 1.77 | 1.66 | 213 | 224.42 |
| *Cynoscion regalis* | weakfish | 0.64 | 1.54 | 197 | 80.87 |
| *Lagodon rhomboides* | pinfish | 0.34 | 1.48 | 190 | 42.72 |
| *Leiostomus xanthurus* | spot | 0.26 | 1.18 | 151 | 32.47 |
| *Limulus polyphemus* | horseshoe crab | 1.51 | 1.01 | 130 | 192.11 |
| *Phalacrocorax Auritus* | double-crested cormorant | . | 0.99 | 127 | . |
| *Cynoscion nebulosus* | spotted seatrout | 1.03 | 0.90 | 115 | 131.00 |
| *Archosargus probatocephalus* | sheepshead | 0.87 | 0.57 | 73 | 110.14 |
| *Micropogonias undulatus* | Atlantic croaker | 0.14 | 0.43 | 55 | 17.22 |
| Dasyatidae | stingrays | . | 0.39 | 50 | . |
| Menticirrhus spp. | kingfishes | 0.11 | 0.31 | 40 | 13.33 |
| *Synodus foetens* | inshore lizardfish | 0.07 | 0.27 | 34 | 9.39 |
| *Dasyatis americana* | southern stingray | . | 0.25 | 32 | . |
| Gavia Immer | common loon | . | 0.25 | 32 | . |
| Dasyatis spp. | Dasyatis stingrays | 0.32 | 0.23 | 30 | 41.00 |
| *Trachinotus carolinus* | Florida pompano | 0.18 | 0.15 | 19 | 23.10 |
| Triglidae | searobins | 0.03 | 0.15 | 19 | 3.80 |
| Gymnura micrura | smooth butterfly ray | . | 0.15 | 19 | . |
| *Orthopristis chrysoptera* | pigfish | 0.03 | 0.13 | 17 | 3.72 |
| *Scophthalmus aquosus* | windowpane | 0.02 | 0.11 | 14 | 2.80 |
| *Chaetodipterus faber* | Atlantic spadefish | 0.09 | 0.10 | 13 | 11.20 |
| *Mugil cephalus* | striped mullet | 0.21 | 0.09 | 12 | 26.51 |
| *Malaclemys terrapin* | diamondback terrapin | 0.09 | 0.08 | 10 | 11.50 |
| *Callinectes sapidus* | blue crab | . | 0.08 | 10 | . |
| *Prionotus* spp. | Prionotus searobins | 0.02 | 0.06 | 8 | 2.40 |
| Rajiformes | rays | . | 0.06 | 8 | . |
| *Squalus acanthias* | spiny dogfish | 0.17 | 0.05 | 7 | 21.40 |
| Gymnura spp. | butterfly rays | . | 0.05 | 6 | . |
| *Chelonia Mydas* | green turtle | 0.16 | 0.04 | 5 | 20.17 |
| *Raja eglanteria* | clearnose skate | 0.04 | 0.04 | 5 | 5.00 |
| *Caranx latus* | horse-eye jack | 0.00 | 0.04 | 5 | 0.50 |
| *Acipenser oxyrhynchus* | Atlantic sturgeon | 0.17 | 0.03 | 4 | 21.07 |
| *Carcharhinus plumbeus(milberti)* | sandbar shark | 0.11 | 0.03 | 4 | 13.47 |
| *Astroscopus* spp. | Astroscopus stargazers | 0.02 | 0.03 | 4 | 2.53 |
| *Raja radiata* | thorny skate | . | 0.03 | 4 | . |
| *Morone saxatilis* | striped bass | 0.11 | 0.02 | 3 | 13.70 |
| *Scomberomorus maculatus* | Spanish mackerel | 0.04 | 0.02 | 3 | 4.80 |
| *Opsanus tau* | oyster toadfish | 0.01 | 0.02 | 3 | 1.10 |
| *Gymnura altavela* | spiny butterfly ray | 0.01 | 0.02 | 3 | 1.00 |
| *Trinectes maculatus* | hogchoker | 0.00 | 0.02 | 3 | 0.30 |
| *Larus Argentatus* | herring gull | . | 0.02 | 3 | . |
| Sela. Lamni. Scyliorhinoidei | cat sharks | 0.03 | 0.02 | 2 | 3.80 |
| *Rachycentron canadum* | cobia | 0.02 | 0.02 | 2 | 2.80 |
| *Morone americana* | white perch | 0.01 | 0.02 | 2 | 1.40 |
| *Mycteroperca microlepis* | gag | 0.00 | 0.02 | 2 | 0.60 |
| *Caranx hippos* | crevalle jack | 0.00 | 0.02 | 2 | 0.30 |
| *Peprilus alepidotus* | harvestfish | 0.00 | 0.02 | 2 | 0.30 |
| *Caretta caretta* | loggerhead | . | 0.01 | 1 | . |
| *Pelecanus Occidentalis* | brown pelican | . | 0.01 | 1 | . |
| *Larus marinus* | great black-backed gull | . | 0.01 | 1 | . |
| **Totals** | | **100** | **100** | **12,798** | **12,684** |

A total of 840 individuals were sampled from small mesh gillnets (Table 6). Atlantic menhaden represented the majority by number (~43% of total) and weight in observed small mesh gillnets (Table 6). The remaining catch was largely composed of weakfish *Cynoscion regalis*, bluefish, kingfishes *Menticirrhus* spp., and spot *Leiostomus xanthurus*. Collectively, these four species accounted for another 45% of the total catch by number. There was one common loon observed in small mesh gillnets (Table 6).

**Table 6.** Species, biomass (kg), and number of individuals sampled in the small mesh gillnet fishery in the PSGNRA from 1 September – 30 November 2006.

| Scientific Name | Common Name | % Biomass | % Number | Total Number | Total Wt. (kg) |
|---|---|---|---|---|---|
| *Brevoortia tyrannus* | Atlantic menhaden | 34.97 | 43.21 | 363 | 108.90 |
| *Cynoscion regalis* | weakfish | 26.56 | 22.50 | 189 | 82.70 |
| *Pomatomus saltatrix* | bluefish | 14.26 | 10.83 | 91 | 44.40 |
| *Menticirrhus* spp. | kingfishes | 5.81 | 5.95 | 50 | 18.10 |
| *Leiostomus xanthurus* | spot | 3.92 | 5.60 | 47 | 12.20 |
| *Peprilus triacanthus* | butterfish | 1.03 | 3.81 | 32 | 3.20 |
| *Cynoscion nebulosus* | spotted seatrout | 4.69 | 1.67 | 14 | 14.60 |
| *Micropogonias undulatus* | Atlantic croaker | 0.96 | 1.43 | 12 | 3.00 |
| *Paralichthys* spp. | Paralicthid flounders | 2.02 | 0.83 | 7 | 6.30 |
| *Pogonias cromis* | black drum | 0.90 | 0.83 | 7 | 2.80 |
| *Rhinoptera bonasus* | cownose ray | . | 0.83 | 7 | . |
| *Sciaenops ocellatus* | red drum | 1.54 | 0.71 | 6 | 4.80 |
| *Mugil cephalus* | striped mullet | 1.93 | 0.60 | 5 | 6.00 |
| *Dorosoma cepedianum* | gizzard shad | 0.35 | 0.24 | 2 | 1.10 |
| *Archosargus probatocephalus* | sheepshead | 0.19 | 0.24 | 2 | 0.60 |
| Triglidae | searobins | . | 0.24 | 2 | . |
| *Mustelus* spp. | Mustelus sharks | 0.87 | 0.12 | 1 | 2.70 |
| *Limulus polyphemus* | horseshoe crab | . | 0.12 | 1 | . |
| Dasyatidae | stingrays | . | 0.12 | 1 | . |
| *Gavia Immer* | common loon | . | 0.12 | 1 | . |
| **Totals** | | **100** | **100** | **840** | **311** |

### *Protected Species Bycatch*

There were no marine mammal interactions observed in the large and small mesh gillnet fisheries in the 2006 PSGNRA. In addition, there were no observed sea turtle interactions in the small mesh gillnet fisheries during the 2006 PSGNRA. There have never been observed sea turtle interactions in small mesh gillnets, and there have never been observed marine mammal interactions in the PSGNRA, where observer coverage has been completed since 2000.

### *Sea Turtles*

Six sea turtles were observed in large mesh gillnets from 1 September – 30 November 2006 in the PSGNRA (Table 7, Figure 1). All interactions were observed along the Outer Banks in SGNRA3 (n = 4), SGNRA4 (n = 1), and SGNRA1 (n = 1). There were five green and one loggerhead sea turtle observed. Three of the green sea turtle interactions resulted in mortalities, while the other two green sea turtles were tagged and released in good condition. The

loggerhead was not sampled, but was observed swimming away in good condition towards the completion of operations on 23 September 2006 (Table 7).

**Table 7.** Observed large mesh gillnet sea turtle interactions by date, species, condition, carapace length (mm), area and location from 1 September – 30 November 2006 in the PSGNRA.

| Date | Species | Condition | Carapace Length | Area | Location | Inconel Tag 1 | Inconel Tag 2 | Pit Tag |
|---|---|---|---|---|---|---|---|---|
| 18-Sep-06 | Green | Live | 257 | S3 | N 35 14.880 W 75 38.407 | 00S813 | . | 425 1711 F61 |
| 18-Sep-06 | Green | Dead | 295 | S3 | N 35 14.458 W 75 39.739 | . | . | . |
| 19-Sep-06 | Green | Live | 335 | S3 | N 35 21.287 W 75 33.459 | PPX367 | . | 433 A1D6 COC |
| 23-Sep-06 | Loggerhead* | Live | na | S4 | N 35 40.119 W 75 30.730 | na | na | na |
| 30-Oct-06 | Green | Dead | 355 | S3 | N 35 14.465 W 75 40.780 | . | . | . |
| 30-Oct-06 | Green | Dead | 330 | S1 | N 35 00.751 W 76 11.388 | . | . | . |

* Loggerhead was observed entangled near end of net, and broke free and swam away rapidly as net was lifted. Loggerhead appeared in great condition, under no obvious distress. Fishermen estimated wt. of 80 lbs; observer estimated wt. of 50 lbs.

*Sea Turtle Bycatch Estimates*

Sea turtle bycatch estimates were calculated using the stratified ratio method where the rate was determined from the number of sea turtle takes observed by area and week (Table 8). Fishing effort was measured by the multiplication of total yards and soak days. The bycatch rate was then multiplied by the total reported effort for each area and each week. Total bycatch estimates were calculated by adding weekly take estimates by species, and disposition. Cumulative estimates were monitored weekly to ensure numbers remained below authorized thresholds (Table 8).

**Table 8.** Observed large mesh gillnet sea turtle interactions by area and week with corresponding calculated bycatch rate, reported effort, and total bycatch estimates throughout the PSGNRA from 1 September – 30 November 2006.

| Week | Area | Observed Turtles | Species * | Observed Effort | Effort Bycatch Rate ** | Reported Effort | Bycatch Estimate |
|---|---|---|---|---|---|---|---|
| 4 | S3 | 1 | Green | 21,435 | 0.0467 | 219,500 | 10.2 |
| 4 | S3 | 1 | Green * | 21,435 | 0.0467 | 219,500 | 10.2 |
| 4 | S3 | 1 | Green | 21,435 | 0.0467 | 219,500 | 10.2 |
| 5 | S4 | 1 | Loggerhead | 8,440 | 0.1185 | 55,500 | 6.6 |
| 10 | S3 | 1 | Green * | 21,150 | 0.0473 | 83,700 | 4.0 |
| 10 | S1 | 1 | Green * | 4,000 | 0.2500 | 12,000 | 3.0 |

* Denotes mortality
** Effort bycatch rate is presented per 1,000 yards here.

Total take estimates for the 2006 PSGNRA were 20 live and 17 dead green sea turtles; and 7 live loggerhead sea turtles. Authorized Kemp's ridley and loggerhead sea turtles were based on three-year cycles (beginning in 2005), and cumulative estimates from the 2005 and 2006 PSGNRA for these two species were: 15 live and four dead loggerhead sea turtles; and four live Kemp's ridley's (Table 9).

**Table 9.** Allowable sea turtle take thresholds and bycatch estimates by species and disposition in the PSGNRA from 1 September – 30 November, 2006. Note: Kemp's ridley and loggerhead sea turtle estimates are cumulative from 2005 – 2007 as defined by protocols established in Section 10 ITP # 1528 (ESA 1973).

| Species | Authorized Threshold Live Takes | Effort Estimated Live Takes | Authorized Threshold Lethal Takes | Effort Estimated Lethal Takes |
|---|---|---|---|---|
| Green | 120 | 20 | 48 | 17 |
| Kemp's ridley [1] | 27 | 4 | 14 | 0 |
| Loggerhead [1] | 38 | 15 | 3 | 4 |

[1] Kemp's ridley and Loggerhead estimated take will be based on a 3-year period (i.e., Kemp's ridley = 81 live, 42 lethal for 2005 - 2007 and 81 live, 42 lethal for 2008 - 2010; Loggerhead = 114 live, 9 lethal for 2005 - 2007 and 114 live and 9 lethal for 2008 - 2010) for purposes of not exceeding the threshold. Estimated take of Kemp's ridley's and loggerheads varies greatly by year, thus combing years will account for some of the variability across years. Note: There were no Kemp's ridley and no dead loggerhead sea turtles observed in 2006.

*NCDMF Marine Patrol Monitoring*

NCDMF Marine Patrol officers conducted boat patrols, checked gillnets in the water, boarded vessels, and visited local fish houses weekly throughout the 2006 PSGNRA (Table 10). No flight surveys were conducted in 2006 due to mechanical difficulties with one of the NCDMF planes for the majority of the season. There were 29 boat patrols, and NCDMF officers observed 375 vessels and spoke with 46 fishermen. There were numerous patrols along the mainland side of Pamlico Sound, and patrol officers observed few gillnets in this area throughout the season. There were only seven violations cited by patrol officers throughout the PSGNRA, however, none of these were administered to PSGNRA gillnet participants (Table 10).

**Table 10.** NCDMF Marine Patrol surveillance summary throughout the PSGNRA from 1 September – 30 November 2006.

| | NCDMF Marine Patrol Enforcement Activities | | | | | |
|---|---|---|---|---|---|---|
| **Week** | **Boat Patrols (#)** | **Vessels Observed (#)** | **Boats Checked (#)** | **Areas Surveyed (M, S1 -S4, OIC, HC, OC, PS)** | **Violations (#)** | **Comments/Flight Survey Information** |
| **1** | 0 | 1 | 2 | n/a | 0 | week 1 was the day of September 1 only, and no patrols were made that day |
| **2** | 5 | 47 | 7 | M, S1, S2, OC, OIC, HC, PS | 0 | majority of vessels observed were shrimp trawlers and recreational fishermen |
| **3** | 2 | 29 | 0 | M, PS, OIC, S4, S3, HC | 0 | only shrimp trawlers, charter boats, and recreational vessels observed. High winds. |
| **4** | 4 | 83 | 14 | M, PS, OIC, S4, S3, S2, OC | 7 | Boarded multiple gillnet vessels - no violations; recreational vessels - 3 violations; trawlers - 4 violations |
| **5** | 1 | 45 | 2 | PS, OIC, M | 0 | 2 gillnetters in deep-water boarded - working on FRG under directed research permit # 1563 |
| **6** | 2 | 47 | 4 | S1, S3, S4, PS, OIC, M | 0 | 2 gillnets in S1 boarded - no violations; 2 trawler boardings |
| **7** | 2 | 25 | 2 | M | 0 | small mesh gillnets observed. No large mesh on mainland observed |
| **8** | 0 | 0 | 0 | n/a | 0 | no patrols - other NCDMF Marine Patrol obligations |
| **9** | 1 | 18 | 3 | OIC, M, PS | 0 | no gillnet vessels observed, all trawlers |
| **10** | 4 | 9 | 7 | M, PS, S3, S4, HC | 0 | 2 small mesh gillnets observed and 3 PSGNRA fishermen boarded - no violations |
| **11** | 3 | 7 | 2 | S1 - S4, M, OIC, HC, OC | 0 | 2 trawlers boarded; several gillnets checked, and no violations |
| **12** | 0 | 0 | 0 | n/a | 0 | no patrols - other NCDMF Marine Patrol obligations |
| **13** | 4 | 64 | 3 | M, PS | 0 | 60 out of 64 vessels were mechanical oyster harvesters |
| **14** | 1 | 0 | 0 | S2, OC, PS, M | 0 | No activity |
| **Totals** | **29** | **375** | **46** | | **7** | |

*Sea Turtle Strandings Summary*

Sea turtle strandings in North Carolina increased from 1995 – 2000. Prior to 1995, annual stranding totals averaged less than 200. Strandings reached their highest level in 2000 with 831 reported statewide. Strandings throughout North Carolina have remained relatively consistent since that time with an average of 409 strandings per year statewide from 2001 – 2006. Total reported strandings in 2006 were reduced from 378 in 2005 to 320 in 2006. The most common species of sea turtle stranded was the loggerhead representing 65% of the total strandings from 2001-2006 (North Carolina Wildlife Resources Commission Sea Turtle Stranding Network Database 2006).

**Low-Profile Gillnet Testing**

Since the closure of Pamlico Sound to all large mesh gillnets beginning in 1999, NCDMF has conducted gear testing projects in the deep water region of this area for the purpose of identifying a commercial large mesh gillnet that significantly reduces the potential for sea turtle captures, and maintains target catches. A pilot study was conducted in 2001 to determine the effect of tie down length on sea turtle entanglement rates. Results of the study indicated that the entanglement rate was inversely proportional to tie down length with entanglements increasing as tie down length decreased. This result was attributed to the increasing depth of the webbing pocket produced by decreasing tie down lengths. The entangled turtle escapement rate decreased as the length of tie down decreased (Gearhart and Price 2003).

Following the pilot study in 2001, two modified experimental flounder gillnet designs were evaluated (Gearhart and Price 2003). The first experimental gillnet was a low profile net, without tie downs, and a panel height of six feet (half the height of a standard flounder gillnet). The second experimental net was a double leadline configuration with the float line of the net replaced by a second leadline. A standard deep water flounder gillnet with a panel height of approximately 12 feet with 3-foot tie downs placed at regular intervals throughout the net served as the control for this experimental gear testing. Thirty fishing trips were conducted between October and December 2001 aboard a commercial sink gillnet vessel on traditional deep water flounder gillnet fishing grounds in southeastern Pamlico Sound. Results indicated that the low profile gillnet design had the potential to be a viable deep water fishing gear. There were no interactions with sea turtles in this gear, and while flounder catches were reduced compared to the traditional gillnet configuration, they were maintained at levels meriting further examination (Gearhart and Price 2003).

In 2004, a second study of low-profile gillnet gear was conducted comparing matched sets of the low-profile (test), and standard gillnet (control) gear (Brown and Price 2005). The objectives of this study included comparing target catch and bycatch catch per unit effort (CPUE) between the two net types. This study again provided promising results for the low-profile gillnet as no sea turtle interactions occurred in the low-profile gillnet, and flounder catches were maintained at a catch rate acceptable to the industry.

Considering these results, NCDMF initiated a final comprehensive study in the fall 2006 involving multiple commercial fishermen setting paired nets of low-profile (test) and standard (control) gillnet. This study was designed to finalize and statistically validate the potential applicability of the low-profile gillnet in the deepwater region of Pamlico Sound, and further to ascertain the potential use of this gear type in other fisheries where similar bycatch problems may exist.

There were 292,500 yards of gillnet deployed in the 2006 study (Price and Van Salisbury 2007). This resulted in 291 matched pairs of gillnet sets, in which 283 resulted in no takes of sea turtles in either net type. Of the remaining eight pairs, turtle interactions occurred in the control net six times, and the experimental net three times (Table 11). Note that while there were nine takes, the event of an interaction occurred in eight out of 291 pairs.

**Table 11.** Sea turtle interactions matrix by net type depicting total number of matched pairs in the deep water region of southeastern Pamlico Sound, 2006

| | | Experimental Net takes | |
|---|---|---|---|
| | | **Yes** | **No** |
| **Control Net Takes** | **Yes** | 1 | 5 |
| | **No** | 2 | 283 |
| **Total Matched Pairs** | | | **291** |

McNemar's test was used to test the null hypothesis that either net type has an equal probability of capturing sea turtles (SAS 1989). The results of this test indicate that the differences in catch rates of sea turtles between the two net types were not significant during the 2006 study (p = 0.257).

*Combined Low-Profile Gillnet Testing Analyses*

A total of 18 sea turtle interactions occurred in 445,500 yards of observed deep-water gillnet sets in 2001, 2004, and 2006 combined. Fifteen of these interactions occurred in the control net, while three occurred in the test net. There were no sea turtle interactions in the test net during the 2001 or 2004 study (Gearhart and Price 2003; Brown and Price 2005). Sea turtle species encountered included Kemp's ridley (n = 12, 67% of total), loggerhead (n = 4, 22% of total), and green (n = 2, 11% of total) sea turtles (Table 12).

**Table 12.** Sea turtle interactions by year, net type, species and disposition for the 2001, 2004 and 2006 low-profile gillnet testing conducted in the deep-water region of Pamlico Sound.

| | Total yds | Interactions | | Species | | | Disposition | |
|---|---|---|---|---|---|---|---|---|
| **Year** | **Fished** | **Control** | **Low-Profile** | **Kemp's** | **Loggerhead** | **Green** | **Alive** | **Dead** |
| 2001 | 81,000 | 3 | 0 | 3 | 0 | 0 | 0 | 3 |
| 2004 | 72,000 | 6 | 0 | 5 | 1 | 0 | 2 | 4 |
| 2006 | 292,500 | 6 | 3 | 4 | 3 | 2 | 5 | 4 |
| **Totals** | **445,500** | **15** | **3** | **12** | **4** | **2** | **7** | **11** |

There were a total of 501 matched pairs in the 2001, 2004 and 2006 studies, in which 484 resulted in no sea turtle interaction. Of the remaining 17 pairs, 14 interactions occurred exclusively in the control net, two interactions exclusively in the test net, and one pair resulted in an interaction in both net types. There was an 80% reduction in sea turtle takes in the test net relative to the control net. A McNemar's test, appropriate for paired designs with binary outcomes indicated that the reduction in sea turtle takes in the low-profile gillnet configuration, for all three years combined, was statistically significant (p = 0.0027) (Price and Van Salisbury 2007).

## Discussion

Management of the PSGNRA in 2006 remained successful in providing continued protection for endangered and threatened sea turtles (ESA 1973), and allowing a shallow water gillnet fishery to operate along the Outer Banks and mainland side of Pamlico Sound. Fishery management efforts in this region have been effective since 2000, and the fall southern flounder fishery remains a source of income for commercial fishermen and local communities along the Outer Banks. Along the mainland side of Pamlico Sound, there are few fishermen that conduct commercial large mesh gillnet operations, and the effort and flounder landed in this area are negligible. The reason for this is primarily twofold. First, most vessels in this region are not small skiffs, and are not designed to operate in shallow water. Secondly, most fishermen are harvesting blue crabs and oysters during this time of year, which provides their primary source of income in the fall. In addition, flounder catches along the mainland have typically been reduced per trip relative to catches along the Outer Banks making it difficult for the mainland fishermen to justify the time, effort and money into large mesh gillnet operations in this area. However, NCDMF will continue to obtain gillnet observations in this area, and NCDMF Marine Patrol officers will conduct weekly patrols.

There were six sea turtle interactions observed in large mesh gillnets along the Outer Banks during the 2006 PSGNRA comprised of five green sea turtles, and one loggerhead sea turtle. Estimated interactions calculated to 20 live and 17 dead green sea turtles, and seven live loggerhead sea turtles. These estimates remained well below allowable thresholds for 2006. Interactions were observed on 18 September (n = 2), 19 September (n = 1), 23 September (n = 1), and 30 October (n = 2). The temporal trend in observed interactions remains consistent with previous years observations. Observed mortality of three green sea turtles in 2006 was increased from previous years of observations. One of these mortalities was found in a net set that had been deployed for three days. Longer soak times are not encouraged by NCDMF, and the industry typically soaks nets overnight to 24-hr. At times, unpredictable adverse weather and subsequent unsafe conditions prevent the fishermen from reaching their gear and cause increased soak times.

There were no interactions along the mainland side of Pamlico Sound or observed in small mesh gillnets during 2006. Attendance requirements in the small mesh fishery prior to November 1 of each year decrease the number of set gillnet fishermen. Sea turtles have never been observed in small mesh gillnets in the PSGNRA (Price 2004, 2005 and 2006; Gearhart 2001, 2002 and 2003).

Management protocols established for the PSGNRA in 2005 (Price 2006) under ITP # 1528 (ESA 1973) were maintained. Compliance from the industry was excellent, and there were no citations issued to commercial fishermen. In addition to the sea turtle interactions observed (n = 6) by NCDMF observers, fishermen reported live interactions of unknown species on three separate occasions. Cross-referenced trip tickets confirmed that all large mesh gillnet activity was reported by active commercial fishermen in the PSGNRA. Weekly boat patrols, fish house visits, and spot checks conducted by NCDMF Marine Patrol greatly assisted in ensuring regulations were adhered to.

In 2005, assistance from the NMFS observer program (Northeast Fishery Science Center) assisted with the management of the PSGNRA. In 2006, NMFS observers again obtained a few trips in the PSGNRA, which was appreciated, and contributed to the monitoring efforts and continued protection of sea turtles in this area.

The low-profile gillnet testing that was conducted in 2001, 2004, and 2006 proved useful in identifying a modified gillnet that could potentially be used in the deep-water region of Pamlico Sound. This gear maintained acceptable flounder catches, and the combined results indicated that this gillnet significantly reduces ($p = 0.0027$) the potential for sea turtle interactions. In addition to the applicability of the low-profile gillnet in the deep water region of Pamlico Sound, this gear could be used in other gillnet fisheries throughout the estuarine and ocean waters of North Carolina. Reportedly, some fishermen have been using low-profile gillnets during the PSGNRA, and NCDMF will continue to encourage the use of these modified nets. There have not been any studies with this gear in the shallow water regions in the PSGNRA or elsewhere to discern species compositions and catch and bycatch rates.

The NCDMF has initially consulted with NMFS about the possibility, ramifications, and practicality of authorizing the use of the low-profile gillnet in the deep-water region of Pamlico Sound. There are many issues to consider and discuss in regards to this, and consultations among NCDMF fishery managers and NMFS will continue. NCDMF is not currently seeking to apply for an ITP in this region, and there are a few considerations that need to be addressed prior to initiating any process: first, the potential impact to the southern flounder stock by increasing effort and catches needs to be assessed, and the southern flounder stock status will not be reassessed until the spring 2008; in addition, if this area were authorized for the use of low-profile gillnets, NCDMF would want the total effort component to be known and finite, which presents difficulty in terms of limiting entry in a state fishery. Finally, substantial resources would need to be directed towards this area at a time of year when multiple resources and monetary expenditures are required for the PSGNRA. The NCDMF does not currently have additional resources that could be used in the deep-water region.

The NCDMF will continue with outreach efforts throughout the PSGNRA and all gillnet fisheries throughout the estuarine waters of North Carolina to inform the industry of potential management changes, the Endangered Species Act (1973), and to increase awareness about protected species issues. The management of the PSGNRA will continue to evolve and maintain flexibility to incorporate management alternatives that will appropriately direct resources, maintain protection and reduced interactions of sea turtles, and provide a limited fall southern flounder fishery in Pamlico Sound.

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