# Examination of Local Movement and Migratory Behavior of Sea Turtles During Spring and Summer Along the Atlantic Coast Off the Southeastern United States

**Annual Report**

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**ANNUAL REPORT TO NATIONAL MARINE FISHERIES SERVICE**

For

# Examination of Local Movement and Migratory Behavior of Sea Turtles During Spring and Summer Along the Atlantic Coast Off the Southeastern United States

by

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**Executive Summary**

Following a four-year (2000-2003) survey to collect sea turtles in coastal waters during the summer months in order to establish baseline procedures for developing a long-term index of relative abundance, the in-water sea turtle trawl project shifted it's focus in summer 2004 to collection efforts in the shipping entrance channel of Charleston, SC. This shift in focus was designed to increase trawling repetition at a small area, increasing the probability of tagging saturation, and subsequently examination of the effects of increased trawling on recapture rates. Consolidation of trawling to a single location, with historical turtle abundance, also facilitated a unique opportunity to study the seasonal distributional patterns of juvenile loggerheads occupying this location, as well as to compare abundance data in 2004 with data collected in 1990-1993.

Overall catch per unit effort (turtles per station) was 0.75, representing an increase of 150% with respect to catch rates in adjacent coastal waters near Charleston, SC, during the 2000-2003 survey (and in which trawl tows were twice as long). A strong seasonal component in catch rates was observed, with greatest abundance observed in May and declining steadily in June and August. Abundance of two known prey items, blue crabs and horseshoe crabs, also exhibited the same seasonal decline in abundance.

Recapture rates were slightly higher during the 2004 trawling survey of the entrance channel than with respect to overall recapture rates during the 2000-2003 regional survey. Loggerheads tagged as much as four years earlier in the general vicinity were recaptured, suggesting that this area has annual significance to seasonal loggerhead distributional patterns. The recapture of three additional loggerheads within the same two-week trawling block and in subsequent two-week trawling blocks suggests that the entrance channel has significance to the life cycle of loggerheads throughout the summer season.

Although the entrance channel is a focal point for turtle abundance, loggerheads do not spend all of their time in the channel. Satellite-tagged loggerheads immediately departed the entrance channel after tag and release, and resided primarily on the shoals and patchy live bottom reef areas within 10-50 km of the coast. During summer and fall, several of these turtles briefly re-visited the entrance channel on one to several occasions before departing for their respective over-wintering locations.

Over-wintering data were collected for 5 of 6 satellite-tagged loggerheads, with four of these loggerheads over-wintering on the middle to outer continental shelf off of SC, GA, and northern FL. All three loggerheads that over-wintered in southern SC and northern GA waters departed and returned to the coastal waters near Charleston, SC, within a week of each other. A fifth satellite-tagged loggerhead over-wintered in the Gulf Stream.

Continued data collection efforts in the Charleston harbor shipping entrance channel in 2005 and 2006 will allow project personnel to determine if (1) high and seasonal abundances and (2) seasonal distributional patterns observed in 2004 represent typical conditions or anomalous conditions due to environmental or other large-scale processes.

## Introduction

Loggerhead sea turtles (*Caretta caretta*) inhabiting coastal waters along the southeastern United States represent the progeny of multiple rookeries (Bowen et al. 1993; Sears et al. 1995; TEWG 2000, Maier et al. 2004). Tagging studies of nesting female loggerheads suggest that most return to the same beaches in successive breeding seasons (Bjorndal et al. 1983) and it is widely accepted that most females return to their natal regions to nest. Although considerable effort has been expended to study adult females on nesting beaches, much less is known about the distributional patterns of juveniles and adult males in coastal water bodies.

Prior to May 2000, in-water studies targeting sea turtles were primarily conducted at shipping entrance channels (Kemmerer et al. 1983; Standora et al. 1993a,b; Dickerson et al. 1995; Keinath et al. 1995) or at opportunistic inshore collection locations such as pound nets (Byles 1988; Epperly et al. 1995; Morreale and Standora 1993). The need to conduct, "…long-term, in-water indices of loggerhead abundance in coastal waters" (TEWG 1998) led to the development of a regional in-water survey of loggerheads during summers 2000-2003 (Maier et al. 2004). Coastal waters 1-15 km offshore between Winyah Bay, SC, to St. Augustine, FL, were thoroughly sampled in a nearly simultaneous manner using three research vessels. High catch rates were reported (Maier et al. 2004); however, very low recapture rates (<2%) were also reported, the cause of which was not readily evident.

Beginning in May 2004, in an effort to better understand the seasonal distributional patterns of juvenile loggerheads collected in coastal waters sampled during the 2000-2003 regional survey, the focus of the in-water survey was modified to intensively target one small trawling area to: (1) examine the effect of intensive trawling on recapture rates and (2) quickly obtain an adequate sample size of turtles to outfit with satellite transmitters. At the time that this research was initiated, satellite telemetry had only been attempted with four juvenile loggerheads in coastal waters south of Cape Hatteras (NMFS; USACOE; Whalenet); thus, detailed information on seasonal habitat utilization patterns of juveniles was virtually non-existent for this region.

In order to facilitate historical comparisons of catch-per-unit effort (VanDolah and Maier 1993; Dickerson et al. 1995), the shipping entrance channel of Charleston harbor was selected for this trawl survey. Logistical considerations, including close proximity to a turtle rehabilitation facility at the SC Aquarium in Charleston, also contributed to the decision to restrict trawling to the single location.

This annual report highlights the major findings for research activities primarily carried out during CY2004. More detailed analyses will be included in the 2004-2006 Final Report and manuscripts which will be submitted for peer-review in early 2007.

## Methods

*Study Area*

Trawling was conducted from the jetty ends out to 9km offshore in the Charleston, SC, shipping entrance channel (32°42'N, -79°48'W; Figure 1) for two weeks in May, June and August 2004. Trawling was initially conducted at all 12 index stations first utilized in 1990-1991 (VanDolah and Maier 1993); however, due to gear loss, five stations (E1-E3; B2, D2) were subsequently dropped and two others (D1 and D3) were shortened. Trawl stations were approximately 1.5 km in length and took 10-15 minutes to tow.

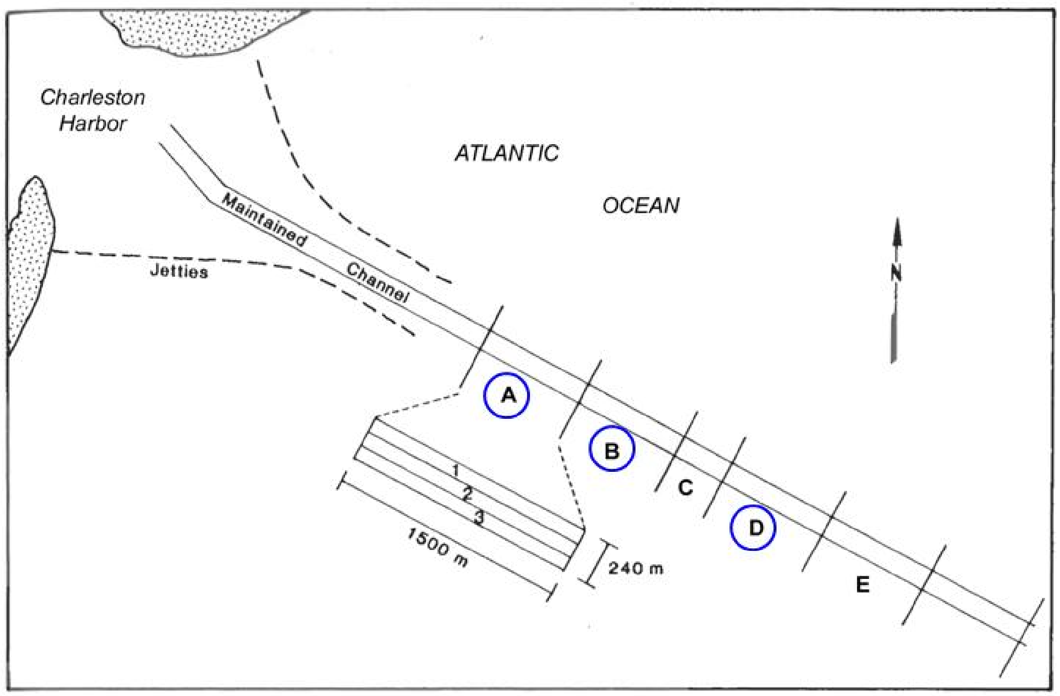



**Figure 1**. Index trawling blocks (from VanDolah and Maier, 1993) in the Charleston Harbor shipping entrance channel in 1990-1991 (all) and 2004 (blue circles).

*Capture and General Processing*

Sampling was conducted aboard double-rigged shrimp trawlers (R/V *Georgia Bulldog* in May 2004; R/V *Lady Lisa* in June and August 2004) measuring about 70 feet in length, towing at speeds of 2.5-3.0 kts. Both vessels used standardized NMFS nets routinely used in turtle surveys associated with channel dredging operations: paired 60-foot (head-rope), 4-seam, 4-legged, 2-bridal; net body is of 4" bar and 8" stretch mesh; Top's sides of #36 twisted with the bottom of #84 braided nylon line; 60' corkline to cod end; cod end consists of 2" bar and 4" stretch mesh.

Nets were towed for 10-15 minutes (doors set on bottom to start of haul back), roughly one third of the 45 minutes allowed by NMFS Permit 1245. Nets were brought on-board using winches and turtles immediately removed from nets and visually/electronically scanned for existing tags. If not previously tagged in this study, a sequential project

identification number was assigned to each turtle, after which each turtle received a qualitative physical exam to document general body condition as well as acute or chronic wounds or other possible life-threatening situations.
Blood samples were collected for all sea turtles >5kg body weight with a 21ga, 1.5 in. needle from the dorsal cervical sinus of loggerhead turtles only as described by Owens and Ruiz (1980). Blood samples consisted of a maximum of 45 ml total volume and did not exceed the total recommended volume (10% of total blood volume) based upon total weight as described by Jacobson (1998), who estimated that total blood volume in reptiles was 5 to 8% of total body weight. Blood samples were used as follows:

- genetic stock identification - 5 ml (University of South Carolina)
- sex determination - 5 ml (University of Charleston)
- CBC/Blood chemistry -- 5 ml (Antech Diagnostics)
- Toxicological screening and immunological bioassay - 30ml (National Institute of Standards and Technology; Medical University of SC)

A suite of morphometric measurements were collected for all sea turtle species. Six straight-line measurements (cm) were made using tree calipers: minimum (CLmin) and notch-tip (CLnt) carapace length; carapace width (CW); head width (HW); and body depth (BD). Curved measurements of CLmin, CLnt and CW were recorded using a nylon tape measure. Additional curved measurements included plastron width (PW), and two tail length measurements (tip of plastron to tip of tail (PT) and tip of cloaca to tip of tail (CT)). All measurements represented standard measurements accepted by sea turtle researchers globally (Bolten, 1999). Body weight (kg) was measured using spring scales; turtles were placed in a nylon mesh harness and carefully raised off of the deck.

All sea turtles >5kg received two Inconel flipper tags and one Passive Integrated Transponder (PIT) tag (Biomark, Inc.). Triple tagging minimized the probability of complete tag loss. Inconel flipper tags will be provided by the Cooperate Marine Turtle Tagging Program (CMTTP). Per instructions provided by the CMTTP, tags were cleaned to remove oil and residue prior to application. Inconel tag insertion sites, located between the first and second scales on the trailing edge of the front flippers, were swabbed with betadine prior to tag application. PIT tag insertion points, located in the right front shoulder near the base of the flipper, were swabbed with betadine prior to intramuscular injection of the sterile-packed PIT tag.

Prior to releasing turtles, a digital photograph of each turtle in a standard 'pose' (dorsal surface exposed, taken looking from anterior to posterior) was recorded. Additional photographs of unusual markings or injuries were also recorded.

*Bycatch*
Bycatch species were identified to the lowest possible taxon and a count or estimate of abundance noted. Sex and appropriate length (cm) measurements for included for all elasmobranches, as well as finfish and invertebrate species of interest. Particular emphasis was placed on bycatch species that represented potential sea turtle prey items, such as blue crabs (*Callinectes sapidus*) and horseshoe crabs (*Limulus polyphemus*).

*Acoustic telemetry*

High frequency (66.0-72.0 kHz) coded acoustic transmitters (V16-5H-F256; Vemco, Ltd.), with 6-12 s repetition intervals (battery life = 99-156 d), were attached to the right M11 and M12 scutes of juvenile loggerhead sea turtles, a standard location for acoustic telemetry studies on hard shelled sea turtles (Addison et al. 2002; Gitschlag 1996; Yano and Tanaka 1991; Mendonca 1983; Murphy and Hopkins 1981). Transmitters were placed on the carapace following the natural curve of the shell and with the transducer end of the transmitter facing slightly aft to faciliate optimal signal reception capability if the animal was swimming away from a tracking vessel.

Prior to attachment, the desired attachment area was thoroughly scrubbed with a plastic wire scrub brush and washed with betadine (Addison et al. 2002). A topical anesthetic (lidocaine) was then used (Standora et al. 1984) to numb the scute surface five minutes prior to drilling two small (0.5 cm) holes through the scute using a betadine scrubbed drill bit (Avens et al. 2002). Small (3 cm) pieces of surgical tubing wiped with Neosporin were placed into these holes to prevent infection and accelerate an adjuvant response (Addison et al. 2002). Two plastic cable ties (Addison et al. 2002; Mendonca 1983) were passed through the surgical tubing (which also helped reduce cable tie chaffing of the carapace). Epoxy resin was applied to the side of the cylindrical transmitter that was in contact with the carapace, and the transmitter glued to the carapace. After the transmitter momentarily set, the cable ties were "cinched down" on the transmitter so that it was completely immobile. Extra cable tie length was trimmed and coated with epoxy to remove any sharp edges. A small amount of epoxy was also be used to build a tear drop shaped, hydrodynamically-efficient fairing in front of transmitter to reduce drag and limit the effects of the transmitter on the turtle's energetics (Watson and Granger 1998).

Acoustically-tagged loggerheads were released < 3km from where captured approximately an hour earlier (and were kept shaded and watered down during the holding process). Turtles were immediately tracked upon release by a small boat shadowing the trawling vessel and equipped with a surface receiver (VR60; Vemco, Ltd.) and a directional hydrophone (V10; Vemco, Ltd.). The position of the tracking vessel was manually recorded every 15 min, which was assumed to represent the position of the turtle, as no directionality in acoustic signal was recorded at a Gain setting of 36 dB. Bottom and sea surface temperature and salinity were recorded hourly (or more or less frequently depending on movement of tracked turtle) using a handheld YSI-6000.

Attempts to re-locate acoustically-tagged turtles in the shipping channel were conducted by stopping every 0.4 km and slowly rotating the directional hydrophone (2 min) 360° on each of three frequencies. Channel searches routinely began at the end of the jetties (start of "A" sampling block) and ended at navigational buoys 11 & 12 (end of "E" sampling block); however, additional searches outside of this area were haphazardly conducted. Permission was obtained (i.e., U.S. Coast Guard) to deploy automated acoustic receivers (VR2; Vemco, Ltd.) on navigational buoys to continuously monitor the channel for the presence of acoustically-tagged turtles. Unfortunately, buoys were too far apart to provide sufficient monitoring coverage of the entrance channel, and intensive trawling precluded alternative placement of VR2 receivers; thus, this approach was not attempted.

*Satellite telemetry*
ST-20 (Telonics, Inc) satellite transmitters were attached to directly to the second vertebral scute on the turtle carapace using epoxy (Papi et al., 1997; Polovina et al., 2000; Griffin, 2002). Prior to attachment, barnacles and other organisms were removed with a paint scraper, the carapace sanded, washed with betadine and dried with acetone. A roll of 1.0 cm diameter Sonic Weld was placed around the bottom edge of the transmitter to form a well, followed by application of "Fast Foil" epoxy to the entire bottom surface of the transmitter within the well using a glue gun. Turtles were released approximately two hours after initial collection in close proximity (<3 km) to where originally collected.

Satellite telemetry data consisted of (1) geographic position at each surfacing; (2) water temperature at each surfacing; and (3) four descriptive dive cycle metrics for each of four, six-hour collection periods per day: time (s) of last dive; number of dives per collection period; mean dive duration (s) per collection period; and percent of time submerged per collection period. Satellite telemetry data were automatically processed, distributed and received by the Argos system. Daily data e-mails were sent to project personnel; however, data were primarily managed using "STAT" (Satellite Tracking and Analysis Tool, Coyne 2004). Data were downloaded from "STAT" monthly to a relational database (MS Access) on a local area network for analyses.

## Results

*Capture and Recapture*
One hundred twenty-two loggerhead sea turtles were collected in 162 trawling events (CPUE = 0.74 loggerheads per trawling event). Catch rates declined steadily (Figure 2) between May (50 loggerheads in 48 events; CPUE = 1.04), June (56 loggerheads in 71 events; CPUE = 0.79), and August (15 loggerheads in 43 events; CPUE = 0.35). Mean water temperature in May (24.4°C) was substantially lower than in June (26.9°C) or August (26.6°C), when water temperatures were similar (Figure 2).

Loggerhead turtle catches were highly variable among sampling stations (Table 1). Fifty-five percent of loggerheads were collected at a single station (D3) and 64% of all loggerheads were collected in the "D" block. Catch rates (turtles per trawling event) were noticeably greater on the southern (green navigational buoys) side of the harbor entrance channel (#3 stations) for the "B" and "D" sampling blocks.

Overall loggerhead turtle catch rates were also highly variable within sampling stations (Figure 3). Eighty-eight percent of trawling efforts in "A" block stations resulted in no loggerhead captures, whereas only 46% of trawling efforts in "D" block stations resulted in no loggerhead captures. Twenty-one percent of trawling efforts in "D" block stations resulted in three or more loggerheads captured, compared to only 6% of "B" block stations in which a maximum of three loggerheads were captured.

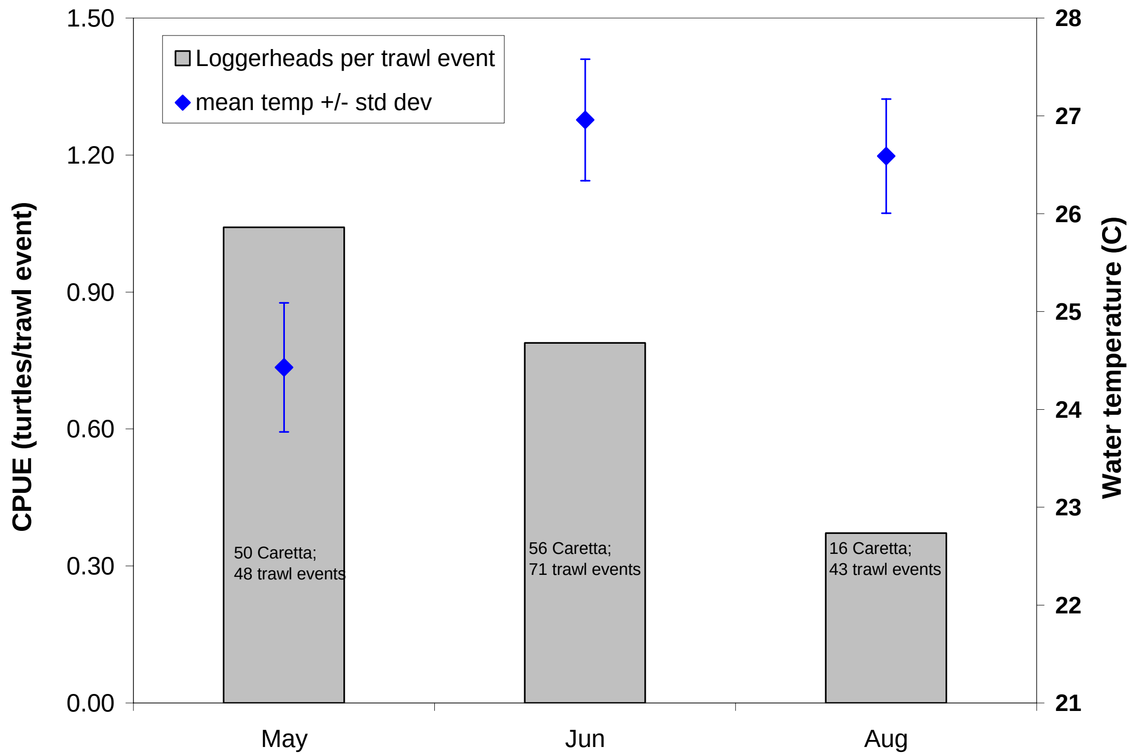



**Figure 2**. Seasonal variability in loggerhead catch-per-unit-effort (CPUE), 2004.

**Table 1**. Descriptive statistics for loggerhead catches with respect to trawl station.

| Station | N loggerheads | % Loggerhead catch | | N Trawling Events | Loggerheads/Event |
|---|---|---|---|---|---|
| A1 | 3 | 2 | | 21 | 0.14 |
| A2 | 1 | 1 | | 20 | 0.05 |
| A3 | 4 | 3 | | 19 | 0.21 |
| B1 | 11 | 9 | | 23 | 0.48 |
| B2 | 0 | 0 | | 2 | 0.00 |
| B3 | 23 | 19 | | 23 | 1.00 |
| D1 | 12 | 10 | | 22 | 0.55 |
| D2 | 0 | 0 | | 4 | 0.00 |
| D3 | 66 | 54 | | 22 | 3.00 |
| E1 | 0 | 0 | | 2 | 0.00 |
| E2 | 1 | 1 | | 2 | 0.50 |
| E3 | 1 | 1 | | 2 | 0.50 |

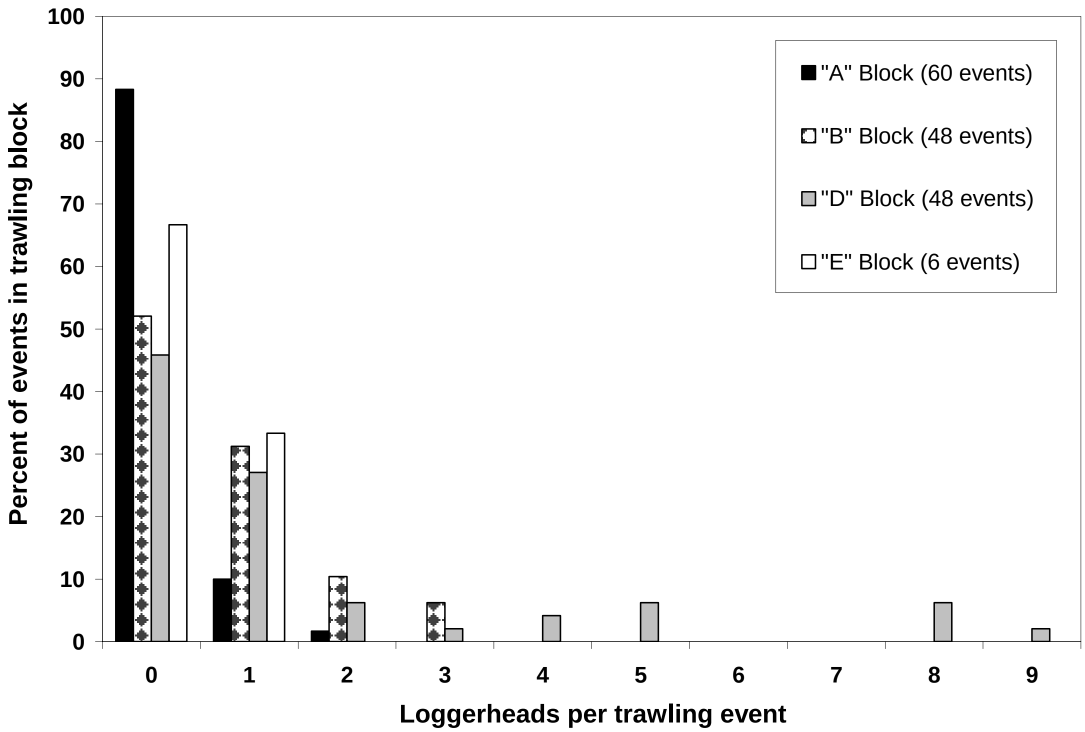



**Figure 3**. Spatial variability in loggerhead catches with respect to sampling block.

Four of 122 loggerheads (3.3%) collected in 2004 represented recapture events. Two loggerheads were recaptured in May. One of these turtles (CC0070) was recaptured within 5 km of where released (as part of the regional in-water sea turtle survey) in June 2001 (1,066 days at large). The second turtle (CC0267) was recaptured later in the same day during May sampling, in the same sampling block ("D"), but on the other side of the channel (from D1 to D3). Two turtles tagged during June sampling were recaptured again during June (CC0292, 2 days) and during August (CC0273, 78 days) at the same stations where they were originally collected, D3 and B3, respectively.

Three of 125 sea turtles (2.4%) collected during 2004 sampling were not loggerheads. One immature green sea turtle (*Chelonias mydas*) measuring 28.6 cm (SCLmin) was captured during June at station "B1". One immature Kemp's ridley sea turtle (*Lepidocheyls kempi*) measuring 29.6 cm (SCLmin) was also captured at station "B1" in August, while a larger Kemp's Ridley measuring 54.2 cm (SCLmin) was captured at station "A3" in June.

*Size Distribution*

Minimum straight-line carapace length (SCLmin, cm) was recorded for 119 of 122 loggerheads. Minimum carapace length but could not be determined for one loggerhead (CC0318) in June due to a pre-existing injury which removed ~5% of the posterior carapace (Figure 4). Two additional loggerheads (CC0243, CC0321) had no noticeable "notch"; thus, notch to carapace tip measurements were used as surrogates for SCLmin.


**Figure 4**. Pre-existing injury for turtle CC0318 which precluded length measurements.

Mean loggerhead size in August was smaller than in May or June due to the absence of loggerheads >80 cm SCLmin (Figure 5); however, sample size was only 16 turtles. Fifteen to nineteen percent of all loggerheads were < 60 cm (Figure 5).

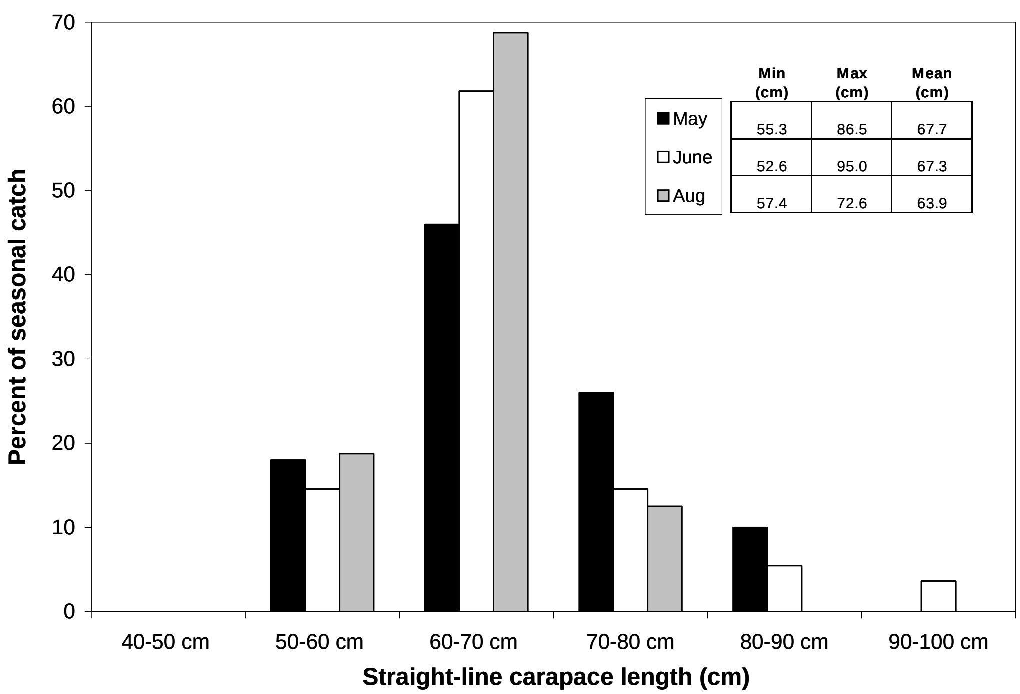



**Figure 5**. Size distribution and descriptive statistics for juvenile loggerheads collected in the Charleston Harbor shipping entrance channel, 2004.

*Blood Analyses*

Blood samples were collected for all Green (*n*=1) and Kemp's Ridley (*n*=2) sea turtles. Blood samples were collected for 120 of 122 loggerheads, including one same year recapture (CC0273; 78 days) and one long-term recapture (CC0070; 1,060 days). Blood samples were not collected for two short-term recapture events (CC0267; CC0292) because a nominal amount of time (0-2 days) had elapsed between release and recapture.

Blood parameters measured at sea (total protein, blood glucose and hematocrit) for loggerhead turtles were comparable to loggerhead values for the 2000-2003 regional survey (Figures 6-8). Hematocrit values were lower for loggerheads collected in 2004 than in 2000-2003 due to slightly greater incidence of values < 30% and zero occurrence of values > 50% (Figure 6). Conversely, total protein values were slightly greater for loggerheads collected in 2004 than in 2000-2003, with only 6% of total protein values in 2004 <5 (units) vs. 26% of total protein values <5 (units) in 2000-2003 (Figure 7). Blood glucose levels were similar for 2004 vs. 2000-2003 loggerheads (Figure 8).

Blood samples for 19 'healthy' (acoustic and satellite telemetry turtles) and two sick (CC0259, CC0306) loggerheads were sent to Antech Diagnostic Laboratories for Complete Blood Count and Chemistry analyses. Blood values for 2004 'healthy' turtles were comparable to 2000-2003 normals overall and in the general vicinity of Charleston; however, several notable departures from 2000-2003 means, primarily for complete blood count parameters, were observed in 2004 (highlighted, Table 2). Given that no reported 'healthy' turtle values in any year were >2 standard deviations from mean values, differences in 2004 mean values may have resulted from small sample sizes.

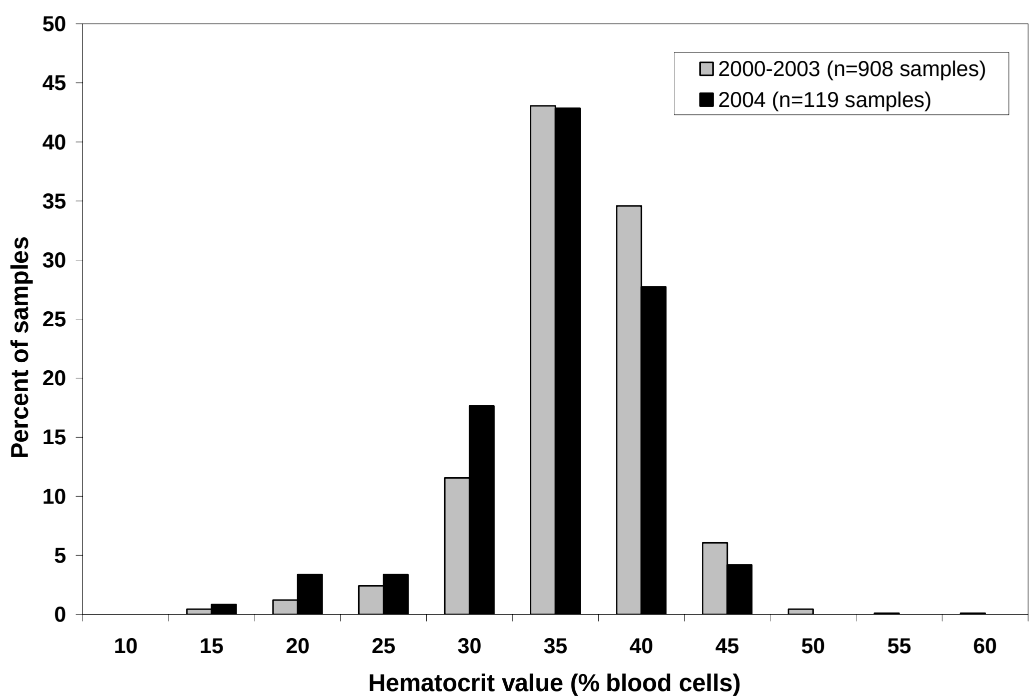



**Figure 6**. Frequency distribution for hematocrit values, 2000-2003 vs. 2004.

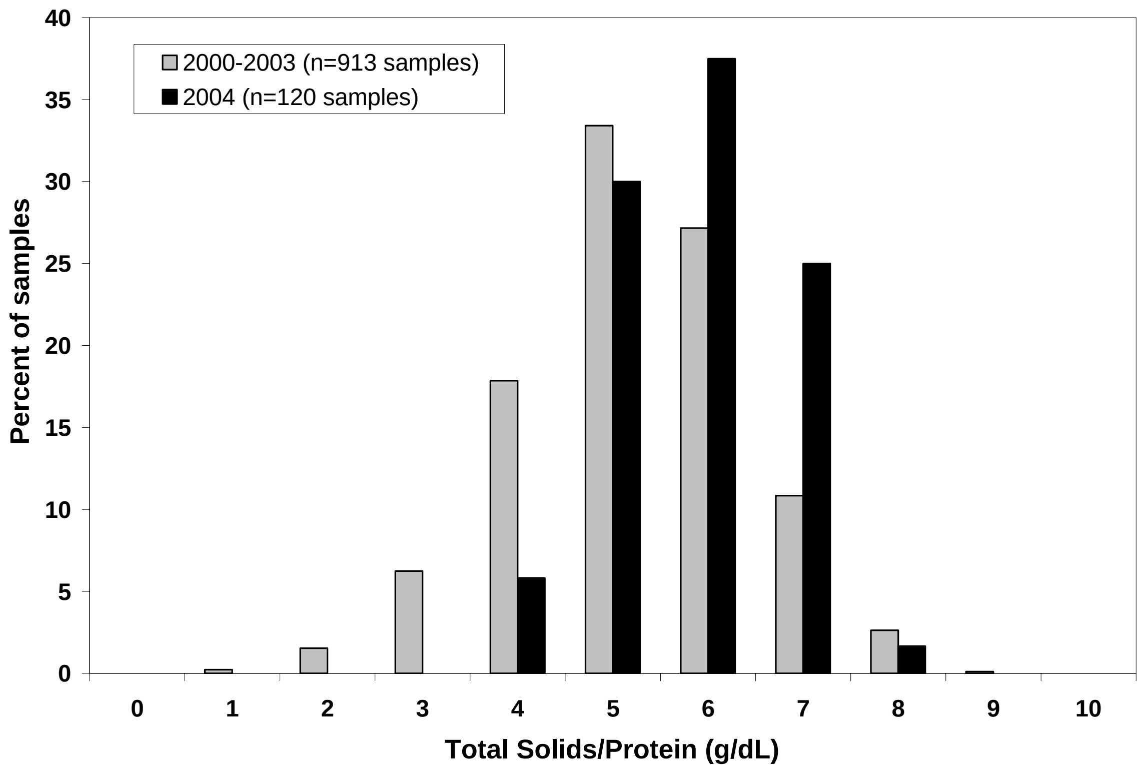



**Figure 7**. Frequency distribution for total protein values, 2000-2003 vs. 2004.

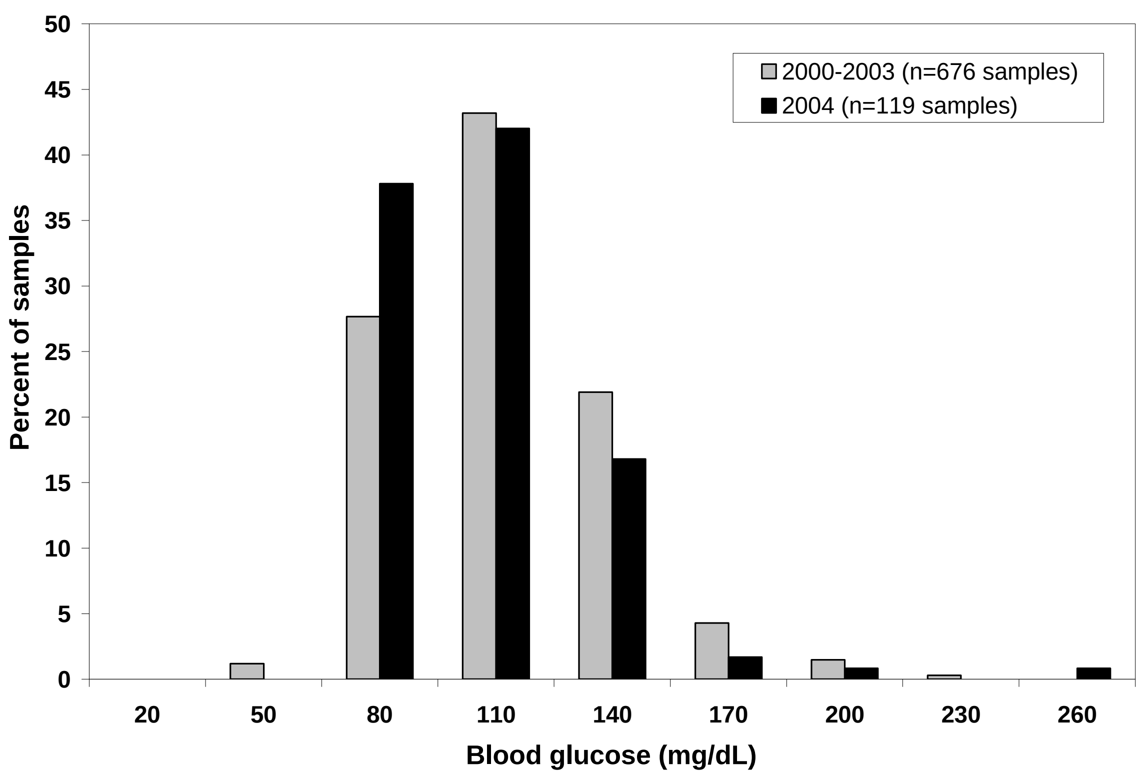



**Figure 8**. Frequency distribution for blood glucose values, 2000-2003 vs. 2004.

**Table 2**. Clinical blood values for 'normal' 2000-2003 vs. 2004 loggerheads.

| | 2000-2003 All Boats | | | | | | 2000-2003 Charleston Vicinity | | | | | | 2004 Charleston Channel | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Blood Chemistry** | N | mean | min | max | std | > 2 std | N | mean | min | max | std | > 2 std | N | mean | min | max | std | > 2 std |
| *Albu-AN* | 147 | 1.1 | 0.4 | 2.8 | 0.3 | * | 34 | 1.2 | 0.8 | 1.6 | 0.2 | * | 19 | 1.0 | 0.7 | 1.3 | 0.1 | * |
| *AST-AN* | 147 | 209.9 | 72 | 564 | 81.2 | * | 34 | 216.4 | 96 | 481 | 70.9 | * | 19 | 180.4 | 73 | 289 | 58.6 | * |
| *UrNi-AN* | 146 | 78.9 | 16 | 150 | 26.9 | * | 34 | 86.7 | 36 | 150 | 24.7 | * | 19 | 63.3 | 38 | 95 | 16.6 | * |
| *Calc-AN* | 147 | 7.8 | 1.6 | 11.7 | 1.5 | * | 34 | 8.6 | 5.5 | 11.7 | 1.2 | * | 19 | 7.5 | 6.1 | 8.4 | 0.6 | * |
| *Chlo-AN* | 147 | 117.5 | 92 | 141 | 7.4 | * | 34 | 116.7 | 106 | 131 | 5.9 | * | 19 | 118.8 | 110 | 133 | 5.4 | * |
| *CPK-AN* | 147 | 1235.3 | 126 | 13830 | 1313.8 | * | 34 | 1118.7 | 390 | 3547 | 640.0 | * | 19 | 1319.6 | 286 | 4220 | 1123.6 | * |
| *Glob-AN* | 147 | 3.2 | 1.4 | 5.1 | 0.9 | * | 34 | 3.5 | 1.7 | 5.1 | 0.8 | * | 19 | 2.4 | 0.9 | 4 | 0.9 | * |
| *Gluc-AN* | 147 | 106.8 | 7 | 202 | 33.2 | * | 34 | 111.0 | 7 | 163 | 34.6 | * | 19 | 97.3 | 75 | 147 | 19.4 | * |
| *Phos-AN* | 147 | 7.5 | 4.9 | 11.4 | 1.2 | * | 34 | 7.7 | 5.9 | 9.8 | 1.0 | * | 19 | 7.6 | 5.2 | 10.9 | 1.3 | * |
| *Pota-AN* | 147 | 4.9 | 3.2 | 19.9 | 1.5 | * | 34 | 4.9 | 3.4 | 7.8 | 0.9 | * | 19 | 4.6 | 4 | 5.7 | 0.5 | * |
| *Sodi-AN* | 147 | 156.9 | 137 | 186 | 6.0 | * | 34 | 158.3 | 152 | 166 | 2.7 | * | 19 | 158.2 | 150 | 171 | 5.1 | * |
| *ToPr-AN* | 147 | 4.3 | 1.8 | 6.6 | 1.0 | * | 34 | 4.7 | 2.5 | 6.6 | 0.9 | * | 19 | 3.4 | 1.9 | 5 | 0.9 | * |
| *Uric-AN* | 147 | 1.6 | 0.1 | 4 | 0.7 | * | 34 | 1.8 | 0.1 | 4 | 0.8 | * | 19 | 1.0 | 0.5 | 1.6 | 0.3 | * |

| | 2000-2003 All Boats | | | | | | 2000-2003 Charleston Vicinity | | | | | | 2004 Charleston Channel | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Complete Blood Count** | N | mean | min | max | std | > 2 std | N | mean | min | max | std | > 2 std | N | mean | min | max | std | > 2 std |
| *Hema-AN* | 120 | 35.1 | 21 | 80 | 5.9 | * | 32 | 37.1 | 30 | 80 | 8.4 | * | 18 | 32.9 | 25 | 41 | 4.0 | * |
| *WBC-AN* | 153 | 11.1 | 4 | 25 | 4.0 | * | 34 | 11.5 | 5 | 25 | 4.5 | * | 19 | 8.6 | 5 | 13 | 1.9 | * |
| *Baso-AN* | 153 | 0.2 | 0 | 3 | 0.6 | * | 34 | 0.2 | 0 | 3 | 0.6 | * | 19 | 0.3 | 0 | 2 | 0.6 | * |
| *Eosi-AN* | 153 | 0.9 | 0 | 16 | 2.4 | * | 34 | 0.9 | 0 | 7 | 1.9 | * | 19 | 3.7 | 0 | 10 | 3.2 | * |
| *HePo-AN* | 153 | 35.5 | 7 | 86 | 18.1 | * | 34 | 32.9 | 11 | 67 | 13.5 | * | 19 | 23.4 | 7 | 54 | 11.0 | * |
| *Lymp-AN* | 153 | 61.7 | 13 | 93 | 19.4 | * | 34 | 63.4 | 29 | 89 | 14.8 | * | 19 | 70.0 | 31 | 90 | 15.6 | * |
| *Mono-AN* | 153 | 1.1 | 0 | 7 | 1.5 | * | 34 | 1.9 | 0 | 4 | 1.6 | * | 19 | 2.1 | 0 | 13 | 4.0 | * |
| *AzMo-AN* | 27 | 2.7 | 0 | 10 | 2.2 | * | 6 | 2.2 | 1 | 4 | 1.5 | * | 17 | 0.5 | 0 | 5 | 1.4 | * |
| *AbBa-AN* | 153 | 14.7 | 0 | 270 | 47.0 | * | 34 | 13.5 | 0 | 180 | 38.0 | * | 19 | 24.2 | 0 | 200 | 53.5 | * |
| *AbEo-AN* | 153 | 80.6 | 0 | 1260 | 212.0 | * | 34 | 80.9 | 0 | 770 | 168.8 | * | 19 | 273.7 | 0 | 990 | 258.2 | * |
| *AbPo-AN* | 153 | 3784.6 | 700 | 22880 | 2472.3 | * | 34 | 3715.9 | 1540 | 12060 | 2249.1 | * | 19 | 2000.0 | 660 | 4860 | 1018.5 | * |
| *AbLy-AN* | 153 | 7146.5 | 1280 | 21000 | 4067.7 | * | 34 | 7375.6 | 2600 | 18480 | 3736.5 | * | 19 | 6044.7 | 2790 | 10920 | 1993.9 | * |
| *AbMo-AN* | 153 | 123.2 | 0 | 840 | 174.8 | * | 34 | 216.8 | 0 | 750 | 217.9 | * | 19 | 185.3 | 0 | 1100 | 363.4 | * |
| *AAMo-AN* | 27 | 221.5 | 0 | 700 | 170.4 | * | 6 | 218.3 | 100 | 400 | 145.7 | * | 17 | 51.2 | 0 | 550 | 141.9 | * |

*Collaborative Blood and Tissue Samples*

Blood samples for sex determination (all species; Dr. David Owens, CofC) and genetic analyses (loggerheads; Dr. Joseph Quattro, USC) were collected; however, analyses are pending. Dr. Jennifer Keller (NIST) received a 10ml blood sample for every loggerhead sea turtle, and toxicological analyses are pending. Mr. Rusty Day (NIST) received a 5ml blood and 1g keratin scraping for 31 loggerheads, and mercury analyses are pending. Dr. Margie Peden-Adams (MUSC) received a 10ml blood sample for 101 loggerheads and a 5ml blood sample for two Kemp's Ridleys. Seven of these samples (from May '04) were assessed to verify B-cell proliferation assay protocols and to verify optimum conditions for respiratory burst assays. In June and August sampling periods of 2004, samples from 49 and 16 animals, respectively were assessed. Detailed analyses of these data will be performed once companion contaminant data and gender information are available.

*Physical Condition of Turtles*

Twenty-three percent of (28 of 122 loggerheads) and 50% (1 of 2) of Kemp's Ridleys collected had pre-existing injuries for which human or shark interactions were suspected. Eighty-nine percent (25 of 28) of these loggerheads had damage to the carapace, most notably the posterior-most marginal scutes. Wounds were recent and severe enough to transfer one of these turtles (CC0306) to the SC Aquarium for rehabilitation (and released 345 d later). Thirty-nine percent (11 of 28) of these loggerheads had minor to extensive flipper damage, most often (8 of 11; 73%) in conjunction with damage to the carapace. Fishing tackle was implicated (i.e., leader wrapped around flipper) in one event and suspected in another (i.e., chronic ulcer on the right side of the neck). Pre-existing injuries were noted for a loggerheads of similar size distribution (56.3 to 95.0 cm; mean = 71.0 cm SCLmin) as the overall size distribution for loggerheads collected in 2004.

*ByCatch*

Bycatch taxon consisted of 103 (generally identified to genus and species) listings totaling 9,084 individual items during 2004 trawling efforts. Bycatch items were grouped into sixteen generic groupings for descriptive analyses (Figure 9). Sessile invertebrates and finfish dominated the bycatch by several orders of magnitude with respect to other groupings. Most finfish species were not species known to be primary prey species for sea turtles; however, the importance of finfish in the diet of loggerheads, particularly in the relative paucity of more typical prey, has recently come to light (Seney, 2003). Sessile invertebrates primarily consisted of species associated with habitat (i.e., sponges, sea porks, bryozoans) and were generally not considered to be important prey items; however, loggerheads may inadvertently consume these items while foraging for other targeted species. Jellyfishes, a known prey item for loggerheads when occupying non-continental shelf waters, were the third most abundant bycatch category.

Blue crabs (*Callinectes sapidus*) and horseshoe crabs (*Limulus polyphemus*), two important prey items of commercial interest, were observed with relatively high numbers in 2004, compared to the 2000-2003 regional survey (Table 3). Precipitous shifts frequency of collection and relative abundance per collection were noted for both blue crabs and horseshoe crabs during 2004 sampling (Figure 10). Blue crabs were collected in 85% of collections with 2.4 crabs per sampling event in May, compared to 16-18% of collections in June and August (Figure 10). Frequency of occurrence and relative abundance of horseshoe crabs were similar in May and June, but declined precipitously in August (Figure 10). Seasonal declines in both blue crab and horseshoe crab frequency and abundance closely paralleled turtle catch-per-unit effort (Figure 10).

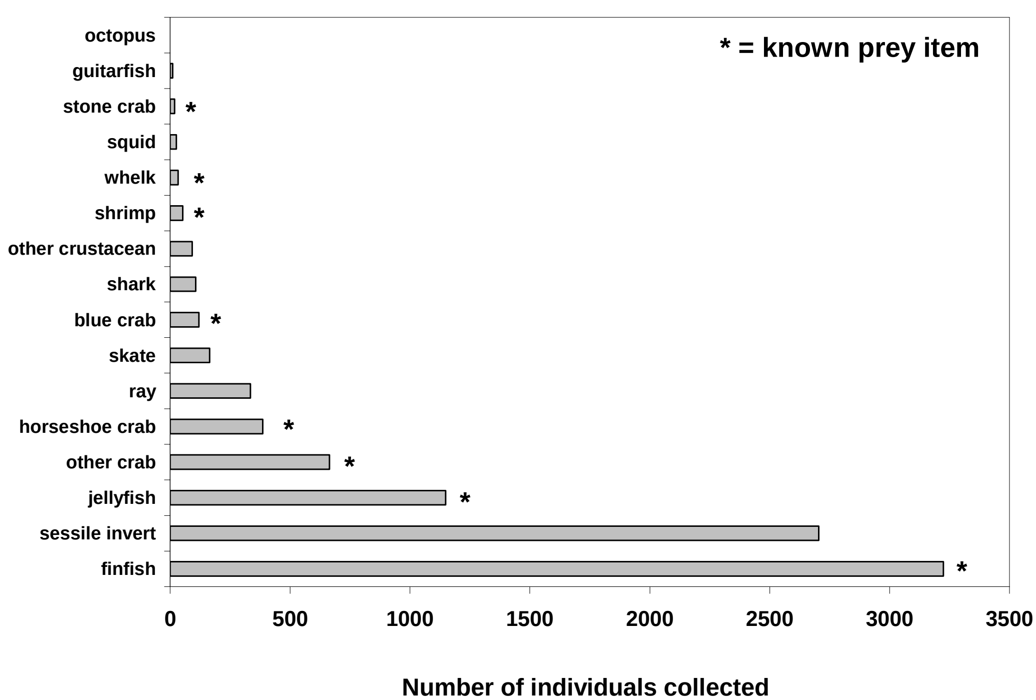



**Figure 9**. Relative abundance of bycatch (by groupings) collected in 2004.

**Table 3**. Frequency and abundance of blue and horseshoe crabs for the 2000-2003 regional survey vs. the 2004 Charleston harbor entrance channel survey.

| **Blue Crab** | **2000** | **2001** | **2002** | **2003** | **2004** |
|---|---|---|---|---|---|
| *Total Abundance* | 222 | 107 | 19 | 24 | 120 |
| *N sampling events with species* | 125 | 87 | 19 | 16 | 61 |
| *Total Sampling Events* | 630 | 604 | 684 | 717 | 162 |
| *% Catch* | 20 | 14 | 3 | 2 | **38** |
| *Abundance per Event* | 1.8 | 1.2 | 1.0 | 1.5 | 2.0 |

| **Horseshoe Crab** | **2000** | **2001** | **2002** | **2003** | **2004** |
|---|---|---|---|---|---|
| *Total Abundance* | 53 | 40 | 51 | 27 | 386 |
| *N sampling events with species* | 39 | 34 | 40 | 22 | 95 |
| *Total Sampling Events* | 630 | 604 | 684 | 717 | 162 |
| *% Catch* | 6 | 6 | 6 | 3 | **59** |
| *Abundance per Event* | 1.4 | 1.2 | 1.3 | 1.2 | **4.1** |

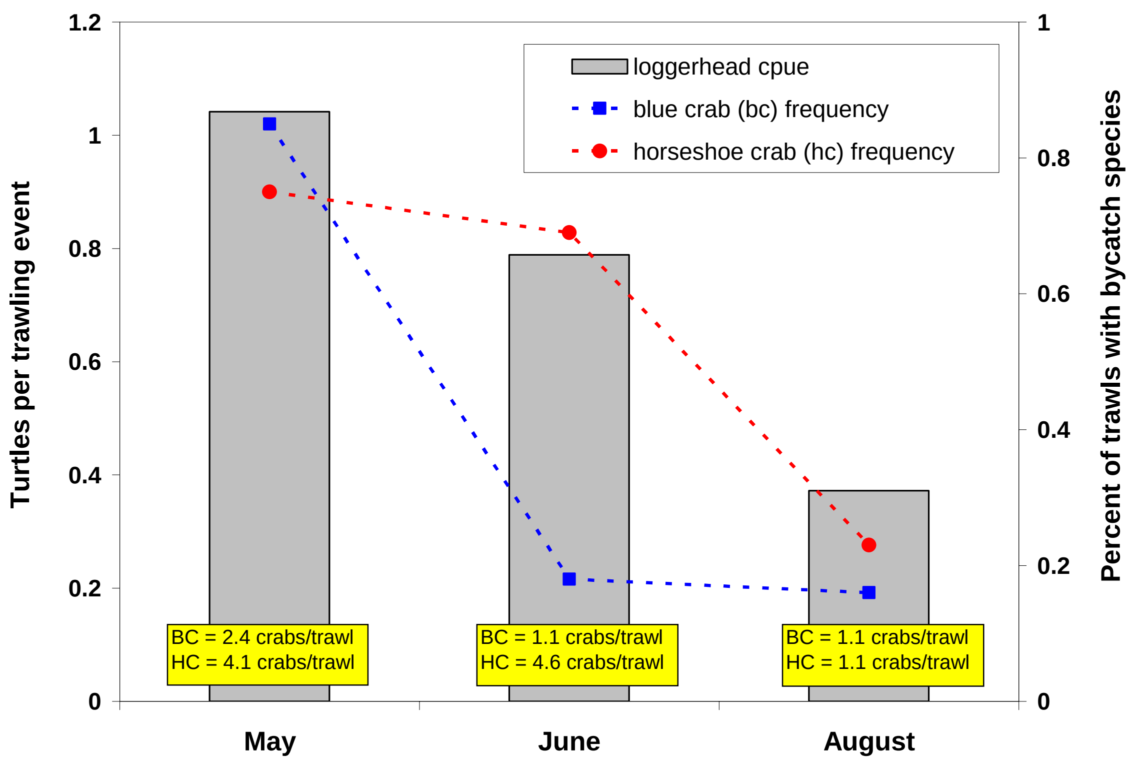



**Figure 10**. Seasonal declines in blue crabs, horseshoe crabs, and turtles, 2004.

*Acoustic Telemetry*
Twelve juvenile loggerhead turtles (56.5 to 72.6 cm SCLmin; mean = 65.0 cm) were tagged with acoustic transmitters, including one turtle (CC0273) tagged twice (ID82, ID2001) after being recaptured 78 d after release with a damaged transmitter. All post-release tracking and attempts to relocate acoustically-tagged loggerheads were conducted on 20 sampling days between 13 May and 31 August. Loggerheads were actively tracked for an average of 3.7 h immediately following tag and release (range = < 1 h to 5.9 h) and were detected in the shipping channel for periods of < 1 d to 40 d (Table 4).

Two of four loggerheads (ID81, ID83) tagged and released in May were never detected again after being tracked out of the channel and to the northeast on the day of release (Figure 11), in the direction of the prevailing wind. One loggerhead released in May (ID80) appeared to be resident within the channel for five days following tag and release, including the morning that commercial shrimp trawling began in the entrance channel, but was never detected again beginning that same afternoon. The fourth loggerhead tagged and released in May (ID84) was relocated in the channel and in between the jetties for up to 40 d after release. This turtle was subsequently re-located in August; however, the lack of movement of this turtle during August tracking efforts with respect to May and June tracking periods suggested that the transmitter had become dislodged from the turtle between late June and early August.

Two of four loggerheads (ID85, ID86) tagged and released in June were never detected again after being tracked out of the channel and to the northeast on the day of release (Figure 11), in the direction of the prevailing wind. One loggerhead released in June (ID82) appeared to be resident within channel for 11 d following tag and release, although this turtle was not detected in the channel on the fourth and seventh days following release, when sampling was conducted; however, this turtle was re-located in the channel (and subsequently tracked for 3-6 h) on the eighth and eleventh day following tag and release. The fourth loggerhead (ID87) tracked during June was tracked for 5.9 h following release and briefly re-located the next morning, but was not re-located again in early August when the next attempts to relocate tagged turtles were made.

None of the five loggerheads (ID2000-2001; ID2003-2004; ID2006) tracked in August were relocated after the day of release; however, inclement weather prevented intensive search attempts. One turtle (ID2003) was tracked for < 1 hr after the track had to be temporarily suspended following approach of a commercial shipping vessel, and the turtle was unable to be relocated after an hour of searching. Two turtles (ID2000, ID2006) were never detected again after being tracked out of the channel and to the southwest on the day of release (Figure 11), in the direction of the prevailing wind. Two turtles (ID2001, ID2004) were tracked simultaneously for 3.4 h on 31 August 2004. One of these turtles (ID2001) was previously tagged and tracked as ID82 in June 2004.

**Table 4**. Descriptive summary of acoustic tracking efforts (hours of data collected per day) for loggerheads in Charleston Harbor shipping entrance channel, during 21 d of sampling in spring/summer 2004. Zero hours (0.00) indicates a single location ("fix") collected. Single-asterisk (*) indicates turtles not relocated during search of channel. Double-asterisk (**) indicates incomplete channel search performed. Gray-shaded boxes denote days prior to turtle being acoustically-tagged and released.

| **Date** | **ID80** | **ID81** | **ID82** | **ID83** | **ID84** | **ID85** | **ID86** | **ID87** | **2000** | **2001** | **2003** | **2004** | **2006** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5/13/2004 | 5.40 | | | | | | | | | | | | |
| 5/14/2004 | 3.87 | | | | | | | | | | | | |
| 5/15/2004 | 7.22 | | | 3.33 | | | | | | | | | |
| 5/16/2004 | 7.75 | | | * | 2.73 | | | | | | | | |
| 5/17/2004 | 4.03 | 5.12 | | * | 1.50 | | | | | | | | |
| 5/20/2004 | 1.12 | * | | * | 0.00 | | | | | | | | |
| 6/14/2004 | * | * | 5.67 | * | 0.00 | | | | | | | | |
| 6/15/2004 | * | * | 0.00 | * | 0.00 | | | | | | | | |
| 6/16/2004 | * | * | 4.12 | * | 4.78 | | | | | | | | |
| 6/17/2004 | * | * | 6.28 | * | 0.82 | | 1.07 | | | | | | |
| 6/18/2004 | * | * | * | * | 0.00 | | * | | | | | | |
| 6/21/2004 | * | * | * | * | * | | * | | | | | | |
| 6/22/2004 | * | * | 6.23 | * | 7.83 | | * | | | | | | |
| 6/23/2004 | * | * | 0.00 | * | 0.00 | 5.10 | * | | | | | | |
| 6/24/2004 | * | * | 0.00 | * | * | * | * | 5.93 | | | | | |
| 6/25/2004 | * | * | 3.05 | * | 4.50 | * | * | 2.22 | | | | | |
| 8/23/2004 | * | * | * | * | *1.10* | * | * | * | | | | | |
| 8/26/2005 | * | * | * | * | *0.00* | * | * | * | | | | | |
| 8/27/2004 | ** | ** | ** | ** | ** | ** | ** | ** | 5.37 | | 0.00 | | |
| 8/30/2004 | * | * | * | * | *0.00* | * | * | * | * | | * | | 1.00 |
| 8/31/2004 | * | * | * | * | *0.00* | * | * | * | * | 3.48 | * | 3.42 | * |

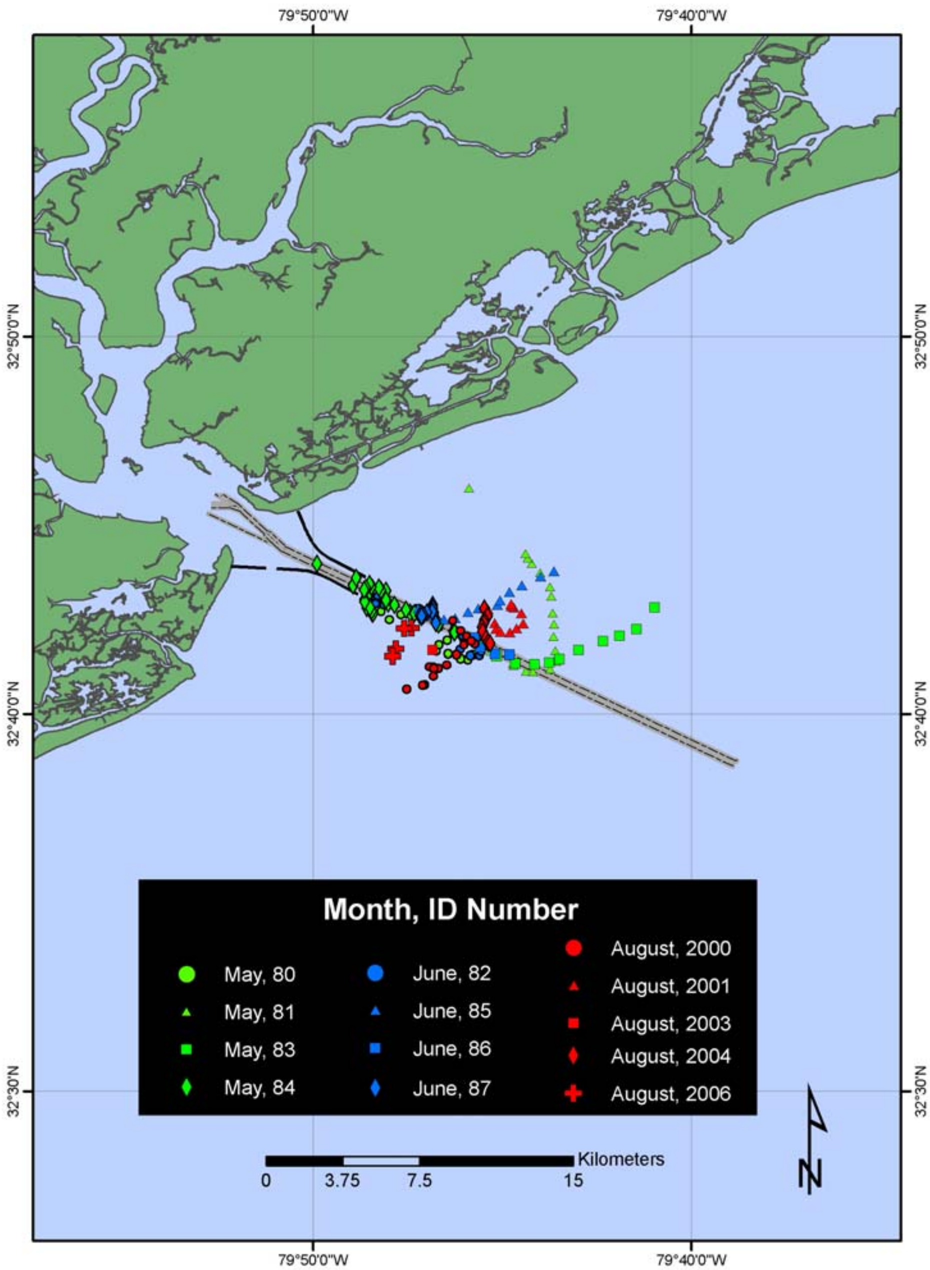



**Figure 11**. Geographic position data obtained for acoustically-tagged loggerheads during tracking efforts in May, June and August 2004.

*Satellite Telemetry*

Six juvenile loggerheads (57.4 to 65.8 cm SCLmin; mean = 60.3 cm) were released with Telonics ST-20 satellite transmitters in 2004. Two loggerheads (ID49120, 49123) were released in June and four loggerheads (ID49121, 49122, 49124, 52600) were released in August. Mean transmitter tag life was 272 days (range = 94 to 375 days, Table 5). Total detections post-release varied from 338 to 2,171 detections (Table 5). The mean number of detections per day for tagged turtles varied from 1 to 21 (Table 5).

"Good" detections (location classes 1, 2 and 3) represented only 11% of detection events (range = 3-18%; Table 6). Sensor data only detections represented approximately half of remaining detection events for most turtles (Table 6). Strong seasonal differences were noted with respect to "good" detection events, such that location classes 1, 2 and 3 were observed three times more frequently from Dec 2004 through April 2005 than during June through November 2004 and May through July 2005 (Figure 12).

**Table 5**. Size and days at large for satellite tagged loggerheads released in 2004.

| Sat ID | TurtleID | SCLmin | First Detect | Last Detect | Days at Large | N Detections | Detect/Day |
|---|---|---|---|---|---|---|---|
| 49123 | CC0296 | 65.8 | 16-Jun-04 | 25-Jun-05 | 375 | 2084 | 6 |
| 52600 | CC0330 | 60.1 | 16-Jun-04 | 23-Apr-05 | 312 | 2171 | 7 |
| 49122 | CC0329 | 57.4 | 26-Aug-04 | 26-Jun-05 | 305 | 1818 | 6 |
| 49121 | CC0337 | 60.5 | 26-Aug-04 | 27-Nov-04 | 94 | 2016 | 21 |
| 49124 | CC0334 | 57.9 | 30-Aug-04 | 05-Apr-05 | 219 | 1087 | 5 |
| 49120 | CC0297 | 60.6 | 31-Aug-04 | 23-Jul-05 | 327 | 338 | 1 |
| | *Mean* | 60.4 | | | 272 | | |
| | *Min* | 57.4 | | | 94 | | |
| | *Max* | 65.8 | | | 375 | | |

**Table 6**. Summary of location class distribution for loggerhead detection events.

| Sat ID | LC=3 | LC=2 | LC=1 | LC=0 | LC=A | LC=B | LC=Z | Sensor Only |
|---|---|---|---|---|---|---|---|---|
| 49120 | 83 | 92 | 102 | 74 | 138 | 529 | 22 | 1044 |
| 49121 | 20 | 42 | 84 | 97 | 190 | 629 | 37 | 1072 |
| 49122 | 72 | 93 | 98 | 112 | 165 | 450 | 39 | 789 |
| 49123 | 47 | 141 | 165 | 214 | 287 | 471 | 56 | 635 |
| 49124 | 32 | 46 | 57 | 68 | 166 | 309 | 40 | 369 |
| 52600 | 1 | 2 | 6 | 14 | 44 | 105 | 13 | 153 |

| | *% LC=3 to LC=1* | *% LC=0 to LC=Z* | *% Sensor Only* |
|---|---|---|---|
| 49120 | 13 | 37 | 50 |
| 49121 | 7 | 44 | 49 |
| 49122 | 14 | 42 | 43 |
| 49123 | 18 | 51 | 31 |
| 49124 | 12 | 54 | 34 |
| 52600 | 3 | 52 | 45 |
| *Mean* | *11* | *47* | *42* |

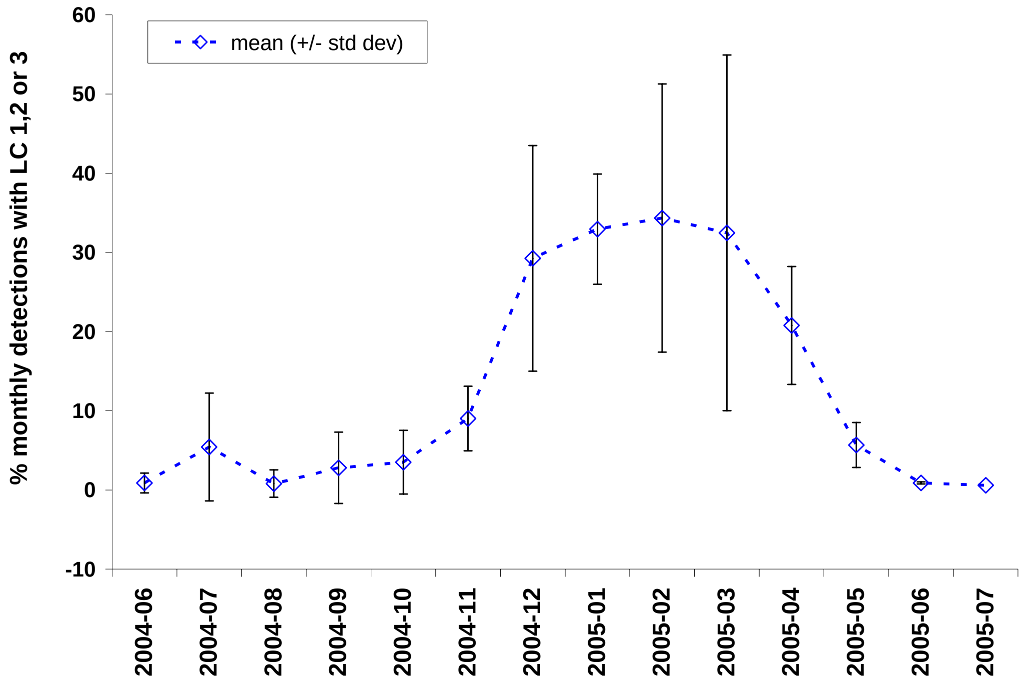
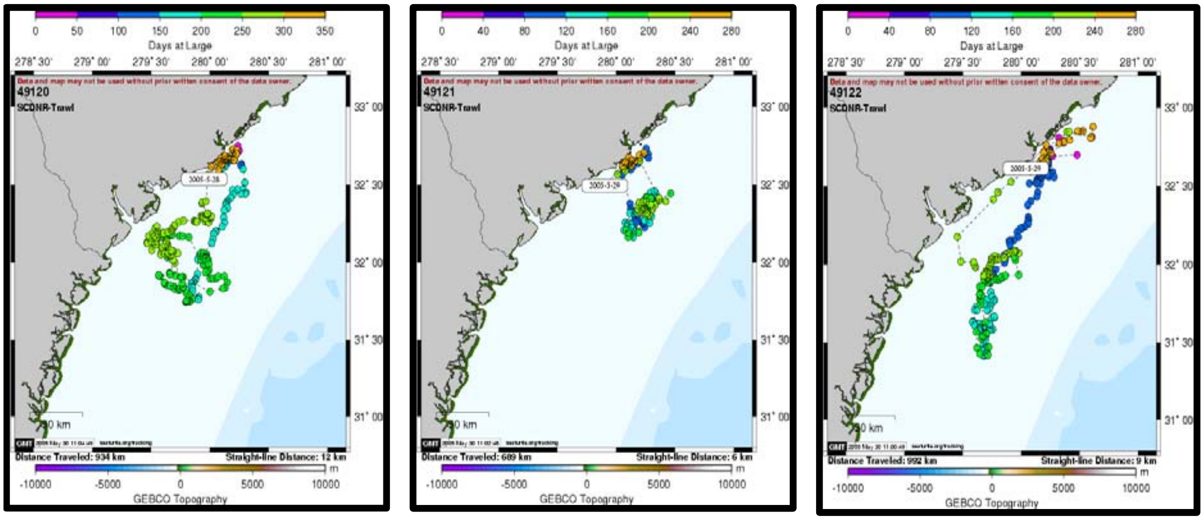



**Figure 12**. Monthly distribution of “good” location classes, June 2004 – July 2005.

Four loggerheads remained resident in coastal waters within 10 km of where collected through 27 November 2004, when the first transmitter (ID52600) ceased functioning. During the first week of December, the remaining three loggerheads (ID49120-49122) began their migration to over-wintering locations generally within 100 km of land on the middle continental shelf in southern SC and coastal GA waters; these loggerheads returned to the near-shore coastal waters of Charleston, SC, within a week of each other in the first half of April 2005 (Figure 13a-c).

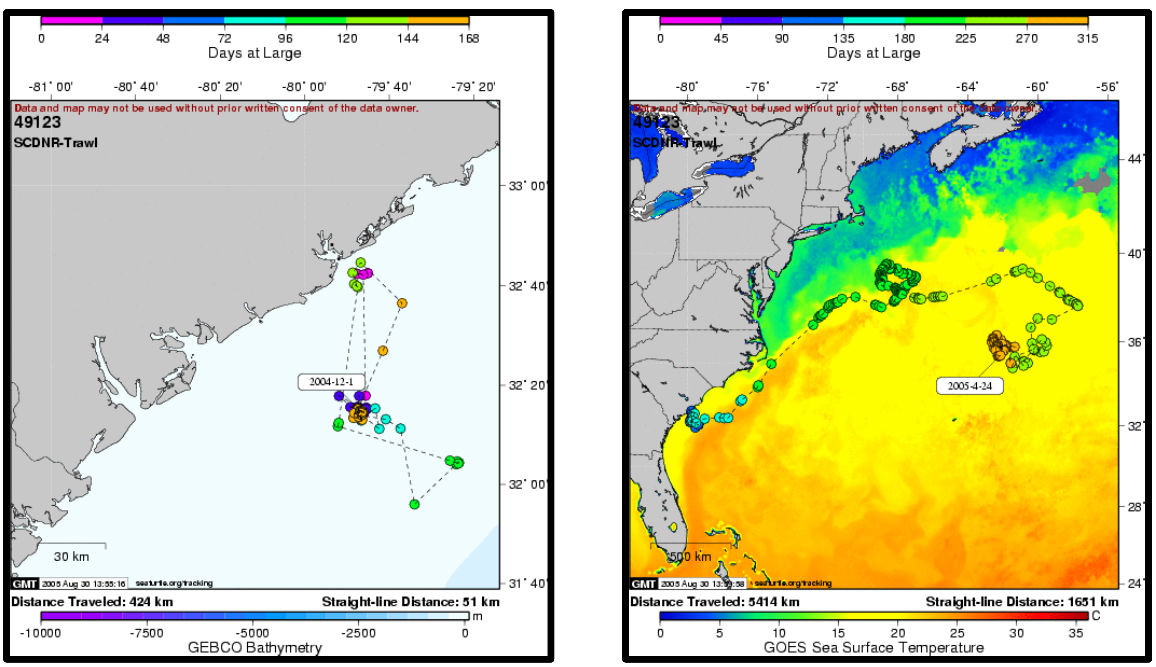
A fifth loggerhead (ID49123) remained highly resident at a location approximately 50 km offshore of Edisto Island, SC, from June through October 2004 (Figure 14a). During November, this loggerhead became more mobile, even returning to the shipping entrance channel (Figure 14a). During the first week in December, this loggerhead traveled rapidly to the northeast and became entrained in the Gulf Stream, where this loggerhead over-wintered more than 1600 km offshore of the U.S. Eastern seaboard (Figure 14b).

The sixth loggerhead (ID49124), released in late August 2004, was highly mobile with respect to the other satellite tagged loggerheads (Figure 15a-c). This loggerhead immediately entered and spent a week within Charleston harbor before traveling southwest from Charleston to northern GA waters, remaining within 30 km of shore during September through mid-October (Figure 15a). Between mid-October and mid-November, this turtle began traveled as far northeast as Edisto Island, SC, before returning to northern GA waters approximately 50 km offshore (Figure 15b). This turtle made several ‘loops’ on the middle continental shelf off of GA and northern FL for three months, before ultimately traveling to St. Augustine, FL, in March 2005 (Figure 15c).



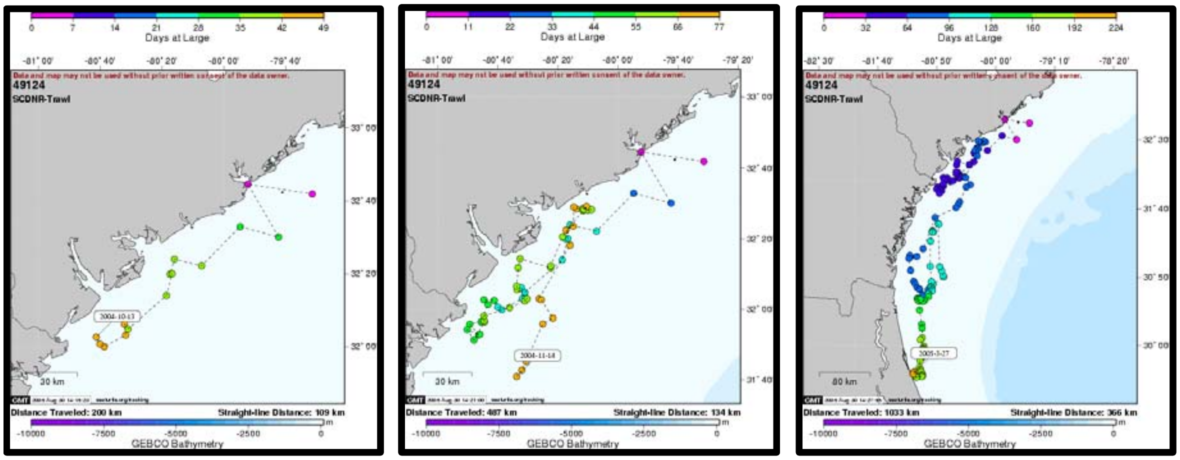

**A** **B** **C**

**Figure 13**. Seasonal distributional patterns satellite tagged loggerheads ID49120 (A), ID49121 (B) and ID49122 (C), June 2004 to July 2005. All three of these loggerheads left and returned to coastal waters of Charleston, SC, within a week of each other. One of these three turtles (ID49122) was recaptured in the entrance channel in May 2005.




**A** **B**

**Figure 14**. Seasonal distributional patterns for satellite tagged loggerhead, ID49123. From June through October 2004 (A), this turtle remained highly resident 50 km offshore of Edisto Island, SC, before ultimately over-wintering in the Gulf Stream (B).




**A** **B** **C**

**Figure 15**. Seasonal distributional patterns for satellite tagged loggerhead, ID49124. From August through mid-October (A), this turtle traveled in a southwesterly direction towards northern GA. From mid-October to mid-November (B), this turtle briefly resumed a northeasterly course towards Charleston before returning to offshore northern GA waters. This turtle over-wintered on the middle continental shelf off of GA and northern FL waters (C), eventually traveling to St. Augustine, FL.

Satellite tagged loggerheads tolerated a wide range in seasonal water temperatures (28-30°C in summer to 15-17°C in winter, Figure 16). Four loggerheads that remained in coastal waters through early December and three of these loggerheads that over-wintered on the continental shelf before returning to Charleston the following spring experienced similar mean daily water temperatures during the data collection period. Water temperatures below 15°C were frequently experienced by two loggerheads (ID49120, ID49124), particularly when these turtles traveled closer to shore in February and March 2005 (Figures 13, 15 and 16). A single loggerhead (ID49123) that remained 50km offshore of Charleston in June and July 2004 experienced considerably colder water temperatures during those months (Figure 16).

Mean daily submergence for satellite-tagged loggerheads was determined for 1,552 replicate observations for all turtles combined. On average, satellite tagged loggerheads remained submerged for 85% of each day (range = 0% to 100%). Loggerheads generally spent 4x more time on the surface on the day of release than on the day following release. A strong seasonal component to time spent on the surface was detected (Figure 17). On average, loggerheads were submerged ~95% of the day from June to November 2004 and May to July 2005, compared to ~75% of the day from December 2004 through April 2005 (Figure 17).

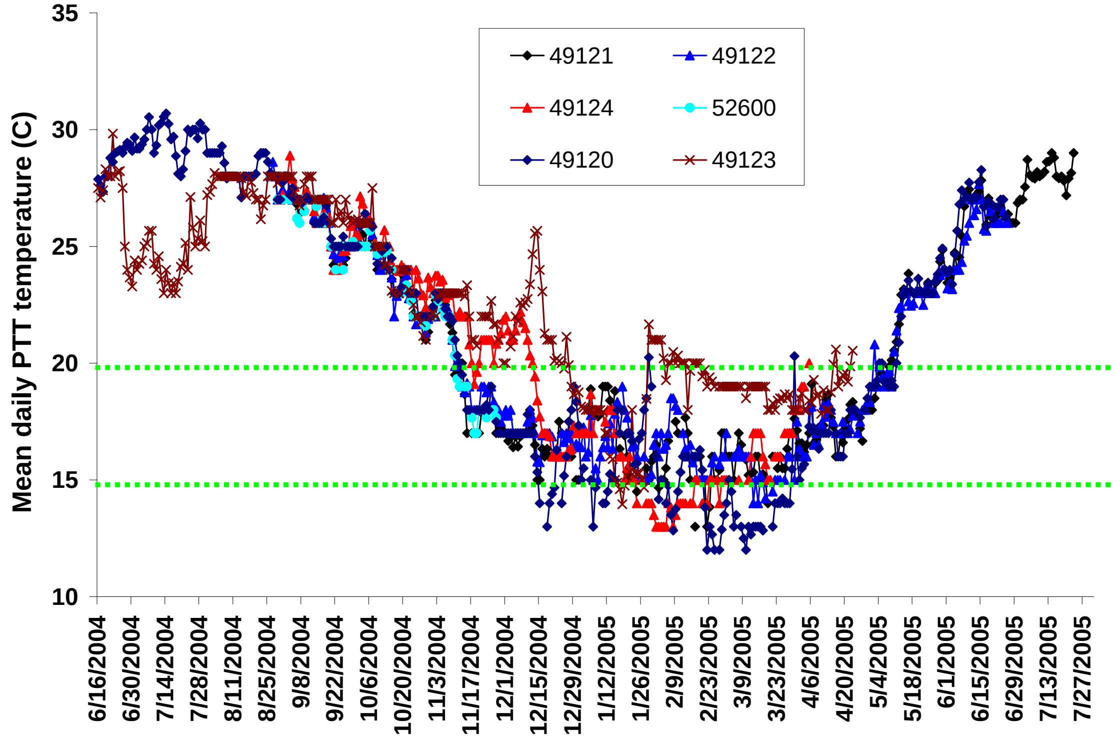



**Figure 16**. Seasonal water temperatures experienced by satellite-tagged loggerheads.

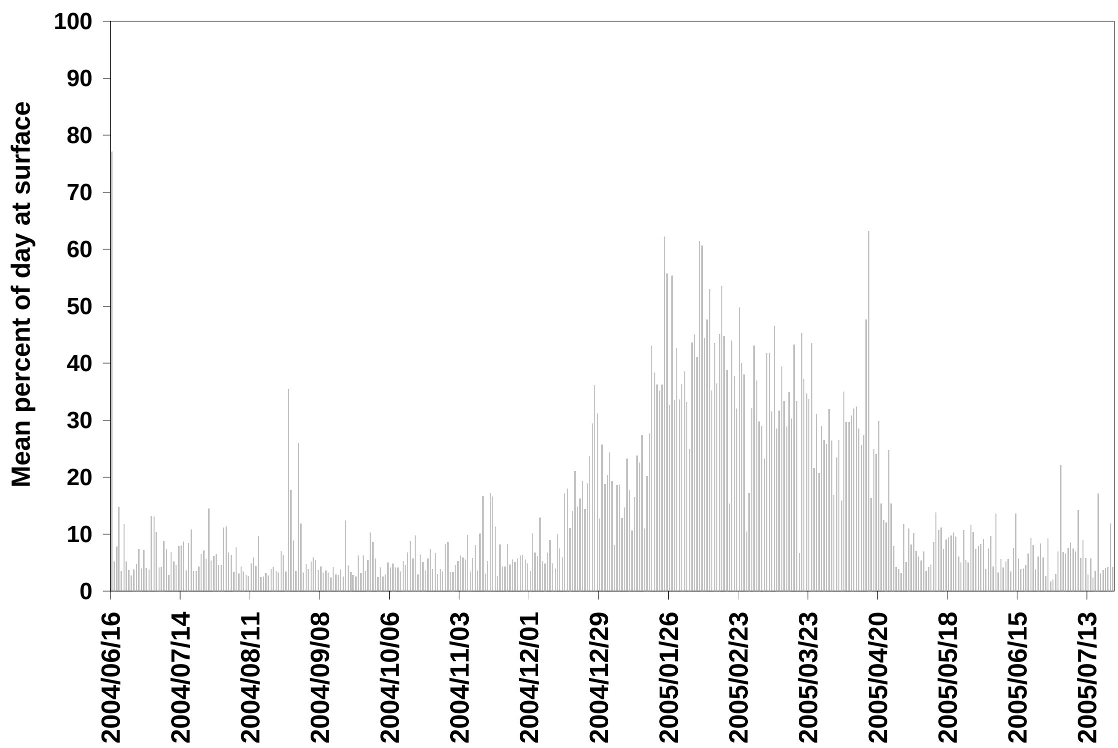



**Figure 17**. Seasonal shifts in daily submergence patterns by satellite-tagged loggerheads.

**Discussion**

Seasonal decline in loggerhead abundance in the Charleston harbor shipping entrance channel from May through August was possibly a reflection of prey availability as opposed seasonal changes in water temperature, given the stability in water temperatures throughout the 2004 sampling cruises. Catch efforts in May (*n*=48 trawl events) were comparable to efforts in August (*n*=43 trawl events). Although similar efforts were expended during these two sampling periods, reduced effort in May resulted from large turtle catches and subsequent processing time, whereas reduced effort in August resulted from inclement weather, most notably, Tropical Storm Gaston. Thus, hydrographical factors other than water temperature may have also affected August turtle catch rates.

Seasonal decline in loggerhead abundance in the Charleston harbor shipping entrance channel observed in this study was also reported in two previous trawling studies in this channel during the early 1990's (VanDolah and Maier, 1993; Dickerson et al., 1995). VanDolah and Maier (1993) reported peak catch rates (turtles/trawl event) in July 1991, with these catch rates being more than double catch rates observed in May-September 1991. Increased catch rates in July were attributed to a sharp increase in mean monthly water temperature, with catch rates in all months related to seasonal water temperatures (VanDolah and Maier, 1993). During May-July 1992, Dickerson et al. (1995) reported similar catch rates (turtles/station, 0.17 to 0.22); no sampling was conducted in August 1992, and no loggerheads were caught in 28 trawl attempts in September 1992.

Loggerhead catch rates in 2004 were highly variable among and within sampling stations, including highly productive stations such as "D3" and "B3"; thus, illustrating the importance of determining catch-per-unit-effort rates based on rigorous sampling. Although the data collected by VanDolah and Maier (1993) and Dickerson et al. (1995) enable historical comparisons of catch-unit-effort for the current investigation, study design issues warrant caution when comparing 2004 results with these earlier studies. First, although the same stations used in 2004 were the same as those sampled by VanDolah and Maier (1993), VanDolah and Maier (1993) only sampled each of 12 stations twice per month, once during the day and once during the night. In 2004, the 7 primary sampling stations were sampled 5-11 times per month, all during daylight. Second, although Dickerson et al. (1995) conducted comparable sampling effort (7-10 times per month, presumably during daylight only) as was used in 2004, Dickerson et al. (1995) sampled fewer (*n*=3) and considerably longer (3km vs. 1.5 km) stations. Furthermore, to avoid "edge effects", only the middle of the channel was surveyed by Dickerson et al. (1995); middle channel stations (i.e., "B2", "D2" and "E2") could not be surveyed in 2004 due to physical impediments to trawling, and edge effects (i.e., greater catch rates on the southern side of the channel) were certainly observed.

Despite study design issues, catch rates from the 2000-2003 regional survey (Maier et al., 2004) and 2004 Charleston harbor entrance channel suggest that overall in-water abundance of loggerhead sea turtles is indeed greater than abundances reported for 1990-1993 (VanDolah and Maier, 1993; Dickerson et al., 1995). Continued low recapture rates, likely due to a combination of tagged turtles emigrating from the channel after release and high turtle abundance, also support this notion. Of 53 loggerheads collected by VanDolah and Maier (1993), seven (13%) represented recapture events during that project and an eighth turtle (2%) was subsequently recaptured during the Dickerson et al. (1995) work. Of 45 loggerheads collected during Dickerson et al. (1995), four (9%) represented recapture events during that project and four others were previously tagged, three of which were tagged during the work of VanDolah and Maier (1993). Collectively, these two projects collected and released 79 individual loggerheads in 31 monthly surveys (860 trawling events) between September 1990 and March 1993. In comparison, 104 individual loggerheads, 30% more loggerheads than in 1990-1993, were encountered in just two monthly surveys (119 trawling events) during May and June 2004.

Loggerhead length-frequency distributions during 2004 sampling differed from length-frequency distributions reported for the Charleston harbor shipping entrance channel by VanDolah and Maier (1993) and Dickerson et al. (1995). VanDolah and Maier (1993) and the current investigation observed similar relative abundances of loggerheads >80 cm SCLmin (17% and 16%, respectively), but loggerheads <60 cm SCLmin accounted for 30% of the catch were reported by VanDolah and Maier (1993) compared with just 16% of the catch observed in the current investigation. Dickerson et al. (1995) reported even greater numbers of loggerheads <60 cm SCLmin (44%) as well as much lower collection of loggerheads >80 cm SCLmin (8%). In light of the fact that Dickerson et al. (1995) only sampled the middle of the channel, 'edge effects' may also affect size distributions, such that larger turtles may be more likely to be collected on the edges and smaller turtles are more likely to be collected in the middle of the channel. Only two of 79 individual loggerheads (3%) collected by VanDolah and Maier (1993) and Dickerson et al. (1995) were <50 cm SCLmin and no loggerheads collected during the current investigation were <50 cm SCLmin. Loggerheads <50 cm SCLmin were also rarely observed during the 2000-2003 regional survey (Maier et al., 2004), perhaps because most turtles <50 cm SCLmin have not entered the benthic foraging stage of their life cycle, and are generally located elsewhere (i.e., eastern north Atlantic Ocean; Bjorndal et al., 1994).

Satellite telemetry data and limited recapture and acoustic telemetry data collected in 2004 suggest that juvenile loggerheads collected in coastal waters off of Charleston, SC, remain fairly localized in these waters through most of the year (April – November), as opposed to undertaking long-distance migrations during these months, as reported for adult female loggerheads collected on nearby SC (SCDNR) and GA nesting beaches (NMFS, GADNR). During these months, loggerheads may remain highly localized for extended periods, particularly at offshore locations where patchy live-bottom reefs are common, but movement among multiple locations within 10-20 km of the coastline is common. In light of these observations, low recapture rates during the 2000-2003 regional survey are to be expected. Although loggerheads have distinctly different over-wintering areas from December – March, satellite telemetry data collected for a small number of loggerheads so far suggests that there is a strong affinity to return to the same waters each spring after over-wintering. These data support the assertion of Day (2003) that loggerheads may exhibit strong site-fidelity to foraging areas, based on mercury contamination values for loggerheads located near the inlets of major industrial harbors vs. further offshore.

In addition to bioaccumulation of ingested contaminants, strong site fidelity and affinity to areas with heavy commercial and recreational vessel traffic may also pose more acute health problems, due to boat strikes and entanglement in fishing tackle. Twenty-three percent of loggerheads collected in 2004 exhibited injuries associated with boat strikes, entanglement in fishing gears, and shark bite wounds. During the 2000-2003 regional survey, only 5-13% of loggerheads collected exhibited such wounds (Maier et al., 2004), with higher propensity for such injuries among loggerheads collected near shipping channels also noted. Frequency of observation of physical trauma to free-swimming loggerheads illustrates the dangers that sea turtles experience in the wild, but also underscores their hardiness with respect to conservation efforts to restore sea turtle populations to historical levels of abundance. Frequent observation of physical trauma to free-swimming sea turtles also suggests that such injuries, with respect to stranded turtles found on beaches, may not necessarily have occurred post-mortem.

Continued sampling in the Charleston harbor shipping entrance channel in years II and III of this study (2005 and 2006, respectively) will allow interpretation of 2004 results in the proper context. Climatology and inter-annual variability present unique challenges when attempting to study the ecology and distributional patterns of marine species; thus, high abundances recorded in 2004 should be interpreted with caution. Similarly, the diversity of seasonal distributional patterns exhibited by a small number of loggerheads outfitted with satellite transmitters this year, particularly with respect to over-wintering strategies, illustrates the need to continue this type of research so that conclusions will be based on greater sample sizes and replicate observations. Although additional work is needed, the results from data collection efforts that began in 2004 have already shed considerable light on several poorly understood aspects of the life history of loggerhead sea turtles in coastal waters of the South Atlantic Bight. Some previously accepted notions of this life history, such as strong site affinity patterns, are corroborated by this work, while others, such as the conventionally accepted belief that exothermic sea turtles must over-winter in waters warmer than 20°C in order to survive, are clearly not universally true.

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We are indebted to almost as many people for making our transition into the world of satellite telemetry as painless and enjoyable as possible. We wish to thank personnel from SCDNR (S. Murphy, T. Murphy, D. Griffin, C. Hope, J. Coker), Argos (J. Sparks, W. Harrison), Seaturtle.org (M. Coyne), and the equipment manufacturers (B. Burger, K. Lay, A. Ripley), and NMFS (B. Schroeder) for making this work possible.

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