Relative abundance, distribution, and health of sea turtles in near-shore coastal waters of the Southeastern United States

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For

Relative abundance, distribution, and health of sea turtles in near-shore coastal waters of the Southeastern United States

by

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EXECUTIVE SUMMARY

A stratified random trawl survey to assess the relative abundance and health of sea turtles in coastal waters between Winyah Bay, SC and St. Augustine, FL was conducted during June and July 2009, marking the sixth year during the past decade that this survey has been completed. Standardized catch-per-unit-effort (CPUE) for loggerheads has generally increased annually since 2000; however, across the entire trawl survey area increases are not statistically significant. Statistically significant increases are documented for several 10-cm size groups, notably the 65.1 to 75.0cm SCLmin and the 75.1 to 85.0cm SCLmin size groups, the latter of which includes the size (≥82.0cm SCL) at which loggerheads mature sexually. Statistically significant declines in two smaller size groups (45.1 to 55.0cm SCLmin and 55.1 to 65.0cm SCLmin) are also noted. Declines in catch rates for these smaller size classes may represent growth of individuals in strong year classes and subsequent shifting to larger size groups, reduced occurrence of smaller size classes within the regional trawl survey area and/or possible recruitment lag effects from nesting declines that occurred during the last decade. However, given spatial size discrepancies of loggerheads within the regional trawl survey area and along the U.S. Eastern Seaboard and potentially strong recruitment for these smaller size groups in the appropriate developmental habitats, it may be premature to implicate lag effects in recruitment at this time.

Loggerheads collected in 2009 appeared to be generally healthy; however, results were mixed. Fewer emaciated and/or lethargic individuals were collected, and one loggerhead that warranted transport to shore responded rapidly to treatment and was released within 3.5 months. Blood work and physical appearance was also typical, and almost 10% of all loggerheads appeared to be visibly rotund despite a precipitous decline in trawl by-catch organisms relative to 2008. The frequency and severity of physical injuries remains consistent since 2000, with most loggerhead injuries affecting the carapace and flippers presumably due to boat-strike and shark interactions. However, as evidenced by a healthy loggerhead collected in June that was reported as a boat-strike stranding just two months later, lethal injuries are at least occasionally inflicted and their frequency of occurrence relative to survivable injuries remains unknown. Also unknown is the potential of chronic debilitation from impaired health attributed to parasitic factors, such as leeches which may be more present in loggerheads today than a decade ago.

Collection of Kemp's ridley sea turtles remains infrequent, but several noteworthy observations can still be made. First, although considerable variance exists in the data, mean standardized CPUE for Kemp's ridley sea turtles in 2009 was greater than any other year during the regional survey. Second, Kemp's ridley sea turtles collected in this survey spanned a large size range (23.1 to 62.2cm SCLmin), indicating that a variety of life history stages (to include adults) utilize coastal waters off SC, GA and northern FL. Injuries documented on Kemp's ridley sea turtles are as severe as reported for loggerheads; however, smaller Kemp's may be more vulnerable to entanglement (as evidenced by scarring in the head/neck region) than boat strike interactions. Documentation of very small (<30cm SCLmin) Kemp's ridley sea turtles is encouraging for recruitment, particularly if this trend remains sustained during this regional trawl survey.

Introduction

The loggerhead sea turtles (*Caretta caretta*) is the most commonly occurring sea turtle species in coastal waters along the Southeastern United States (SE USA) and represents 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 seasonal distributional patterns of juveniles and adult males in coastal waters; hence, the importance of conducting in-water studies of sea turtles to complement nesting and stranding data.

Prior to May 2000, in-water studies targeting sea turtles were primarily conducted at shipping entrance channels (Butler et al., 1987; Standora et al., 1993; Dickerson et al., 1995) or at opportunistic inshore collection areas such as where pound nets were located (Byles, 1988; Epperly et al., 1995; Morreale and Standora, 1994). 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 1-12km offshore between Winyah Bay, SC, and St. Augustine, FL, were sampled in late spring and summer in a nearly simultaneous manner using three research vessels. High catch rates but low (<2%) recapture rates relative to historical data from shipping channels were reported (Maier et al., 2004). Nearly 85% of loggerheads collected during the 2000-2003 regional trawl survey were presumed to be sexually immature based on size distributions.

Telemetry investigations with juvenile loggerheads during 2004-2007 (Arendt et al., 2009) revealed strong seasonal affinities to areas where they were collected and released. Loggerheads collected from the Charleston, SC shipping entrance channel generally remained within 30km of the coast of SC between spring and fall, when water temperatures were above 17°C. During winter, approximately two-thirds of juvenile loggerheads remained on the middle to outer continental shelf in areas first reported by Thompson (1984), which resulted in extended exposure to waters 14-17°C. However, approximately one-third of juvenile loggerheads monitored by satellite telemetry occupied (briefly or for extended periods) waters east of the continental shelf (Arendt et al., 2009), consistent with observations for juvenile loggerheads over-wintering after departing estuaries in North Carolina (McClellan-Green and Read, 2007).

Following successful data collection efforts to document seasonal occurrence relative to the regional trawl survey design, the focus of this survey reverted to its original randomized sampling design in summer 2008. The purpose of resuming the regional survey was primarily to document potential changes in catch rates and size frequency distributions and to better understand potential population responses of loggerheads to a plethora of management regulations implemented since 1978. In addition to standard sea turtle catch demographic data, blood and tissue samples were collected from loggerhead sea turtles to assess a variety of health parameters. Non-turtle by-catch assessments were also conducted to determine if spatial distribution of turtle catch is influenced by prey species distributions, as well as to document the extent to which the randomized sampling design may result in trawling over live bottom habitats. This report presents turtle trawl data collected in summer 2009.

Methods

Study Areas, Research Vessels, and Trawl Specifications
Trawling was conducted aboard double-rigged shrimp trawlers (R/V *Georgia Bulldog,* 72', and the R/V *Lady Lisa,* 75') towing at speeds of 2.5-3.0 knots. Standardized National Marine Fisheries Service (NMFS) turtle nets were utilized for this study. Turtle nets were paired 65-foot (head-rope), 4-seam, 4-legged, 2-bridal nets. Net body consisted of 4" bar and 8" stretch mesh, with top's and sides made of #36 twisted nylon and bottom consisting of #84 braided nylon twine. Cod end consisted of 2" bar and 4" stretch mesh. Beginning in 2008, fiscal constraints necessitated scaling down the trawling operation from three (2000-2003) to two research vessels; however, a priori boot-strap analyses using 2000-2003 data demonstrated that the ability to make inter-annual comparisons would not be adversely affected by the proposed reduction in annual sampling effort.

Trawling was conducted at randomly selected stations in coastal waters (4.6 to 12.2m) between Winyah Bay, SC, and St. Augustine, FL (Figure 1). The R/V *Georgia Bulldog* sampled south of Savannah, GA, and the R/V *Lady Lisa* sampled north of Savannah, GA. A coin toss determined which direction the first cruise for each vessel would start relative to their homeport, and weekly direction was systematically alternated thereafter. Near shore (<1 to 5km) and further offshore (5 to 12km) stations were alternately sampled before and after noon to prevent fine scale spatial-temporal biases. Per permit modifications, trawl duration was 20 minutes (bottom time) which represented a 33% reduction in trawl duration used in 2000-2003.

Figure 1. Regional trawl survey zone (St. Augustine, FL to Winyah Bay, SC).

Capture and General Processing
Turtles were immediately removed from nets and examined for life-threatening injuries, then visually/electronically scanned for existing tags. Sequential project identification numbers were assigned to each turtle the first time it was collected and tagged by this study.

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 as described by Owens and Ruiz (1980). Blood samples consisted of a maximum of 45ml total volume and did not exceed the total recommended volume (10% of total blood volume) based upon total weight as described by Jacobson (1998). Blood samples were collected for the following collaborators and purposes:

1) Genetics - 3ml (University of South Carolina & University of Georgia)
2) Testosterone, corticosterone - 10ml (College of Charleston); sub-sampled for vitellogenin (Southeastern Louisiana University) and estradiol (Georgia Southern University).
3) Nutrition studies – 10ml (coordinated by the Georgia Sea Turtle Center); sub-sampled for thyroid (TX Veterinary Diagnostic Medical Lab) and lysozyme (Medical Univ. of SC).
4) Toxicological screening – 17ml (National Institute of Standards and Technology)
5) CBC/Blood chemistry - 3ml (Antech Diagnostics)

A suite of standard (Bolten, 1999) morphometric measurements were collected for all sea turtles. Six straight-line measurements (cm) were made using tree calipers for minimum (SCLmin) and notch-tip (SCLnt) carapace length, carapace width (SCW), head width (HW) and body depth (BD). Curved measurements of CCLmin, CCLnt and CCW were recorded using a nylon tape measure. Additional curved measurements included plastron width (CPW), tip of plastron to tip of tail (TLpt) and tip of cloaca to tip of tail (TLct). Turtles were placed in a nylon mesh harness and slowly raised off the deck; body weights (kg) were recorded using spring scales.

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 were provided by the Cooperate Marine Turtle Tagging Program (CMTTP). Per the 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 to create a more aseptic environment. PIT tag insertion points, located in the right front shoulder near the base of the flipper, were also swabbed with betadine prior to the 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, orientation from anterior to posterior) was recorded. Additional photographs of unusual markings or injuries were also recorded.

Data management and analysis
Hard copy data were recorded on various forms prior to being entered electronically at sea using laptop computers, enabling early error detection and correction. Proofing of at-sea-entered data on land occurred within one week of the completion of sampling for a given research vessel. Statistical testing was performed using Minitab 15 (Minitab, Inc.). Kruskal-Wallis rank testing and Dunn's multiple comparison tests were utilized for non-normal data.

Results

Sampling effort and catch demographics

Trawling was completed between 26 May (R/V *Lady Lisa*) and 24 July (R/V *Georgia Bulldog*) with a two-week lag between the start dates for the two research vessels. Sampling effort was comparable between the two vessels, with the *Lady Lisa* and *Georgia Bulldog* completing 280 and 300 sampling events, respectively. Six additional stations were terminated 8 to 19 minutes early due to encountering impediments to trawling on the seafloor and/or other logistical constraints, during which one loggerhead was collected. Although data for this loggerhead were included for demographic assessments (i.e., size, sex and genetic distributions), this loggerhead was excluded from analysis of catch-per-unit effort.

Fifty-six loggerheads and four Kemp's ridley sea turtles were collected between St. Augustine, FL and Brunswick, GA. Forty-nine loggerhead and two Kemp's ridley sea turtles were collected between Brunswick and Savannah, GA. In contrast, only 47 loggerhead and seven Kemp's ridley sea turtles were collected between Savannah, GA and Winyah Bay, SC. Two loggerheads (CC0082 and CC0512) collected off SC and one loggerhead (CC4056) collected off GA were recaptured <6km from where they were originally tagged and released one to eight years earlier. A third loggerhead (CC0553) caught off SC was tagged and nested (twice) on Blackbeard Island, GA in 2002, but for which no subsequent sightings or recaptures had since been reported.

Minimum straight-line carapace length (SCLmin) for 78% (n=119 of 152) of loggerheads was ≤ 75.0cm and these turtles were presumably sexually immature. Testosterone radioimmunoassay suggested a female to male sex ratio of 1.78 to 1 for these loggerheads with sex able to be determined for all but five individuals. Eighteen percent (n=27 of 152) of loggerheads were between 75.1 and 85.0 cm SCLmin and were classified as transitional with respect to maturity, of which 14 were female, 10 were assumed to be male (sexing by RIA in this size range has a higher error rate due to possible higher testosterone levels in maturing females) and sex was not determined for three individuals. Only six loggerheads ≥85.1cm SCLmin were collected in 2009, of which three were male, two were female and sex was not determined for one individual.

Loggerhead size distribution in 2009 was similar to 2008 (Figure 2). Statistical differences in size distributions among years ($p<0.001$, df=5, H=43.58) are attributed to mean size in all years of this survey being greater than 2000, and mean size in 2003, 2008 and 2009 being greater than 2002. However, no other differences in size distributions were statistical significant.

Median size for Kemp's ridleys was 40.2cm SCLmin (range = 23.2 to 63.7cm) of which seven were female, three were male and no blood was collected from the smallest Kemp's ridley (the smallest Kemp's collected in our surveys since 2000). Although infrequently collected in all years resulting in large variance, greatest mean catch-per-unit-effort (CPUE) for Kemp's ridleys since 2000 occurred in 2009 (0.044 Kemp's per 30.5m net-hr).

Sequencing problems delayed analysis of all 2009 genetics data by this report deadline. Among 68 completed samples, CC-A01 and CC-A02 accounted for 87% of haplotype frequency. Seven other haplotypes, including a "new" haplotype (fourth occurrence in this study) were also seen.

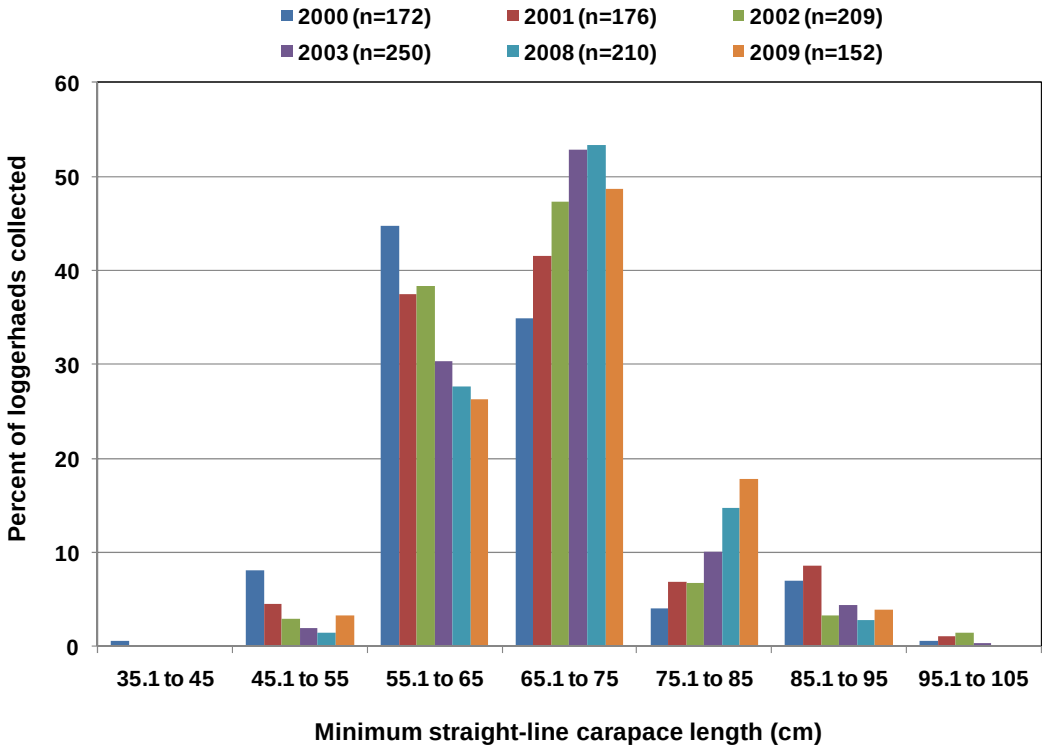

Figure 2. Loggerhead size distributions in the regional trawl survey between 2000 and 2009.

Catch-per-unit-effort (CPUE)

Standardized (n turtles per 30.5m net-hr) loggerhead catch rates across the regional sampling area were slightly lower in 2009 than 2008 (Figure 3), further contributing to non-significant increases in standardized catch rates reported for 2000 to 2008 (Arendt et al., 2009). Two region-wide changes in standardized catch rates were, however, noted for 2009. First, mean standardized catch rate for the 45.1 and 55.0cm SCLmin size bin (n=5 loggerheads) was comparable to mean standardized catch rates noted in 2000 and 2001. Second, standardized catch rates for loggerheads 55.1 to 65.0cm SCLmin in 2009 were the lowest since 2000 and resulted in a significant decrease in CPUE for this size bin between 2000 and 2009. Conversely, standardized catch rates for loggerheads 75.1 to 85.0cm SCLmin remained elevated for the second consecutive year, substantiating the encouraging trend for this size bin noted in 2008.

Greatest loggerhead catch rates (mean +/- 95% C.I. = 1.02 +/- 0.34) occurred between St. Augustine, FL and Brunswick, GA and were significantly different ($H=21.18$, $df=3$, $p<0.001$) from other sub-regions. Loggerhead catch rates between Brunswick and Savannah, GA (0.64 +/- 0.21) and Savannah, GA and Charleston, SC (0.51 +/- 0.18) were not significantly different from each other, but were significantly greater than loggerhead catch rates between Charleston and Winyah Bay, SC (0.24 +/- 0.15). Standardized catch rates in 2009 were consistent with trends reported by Arendt et al. (2009). Data collected in 2009 also distinguished greater catch rates for the 55.1 to 65.0cm SCLmin size bin between Brunswick and Savannah, GA relative to two sub-regions in SC and removed distinction between catch rates for loggerheads 65.1 to 75.0cm SCLmin for sub-regions between St. Augustine, FL and Savannah, GA (Figure 4).

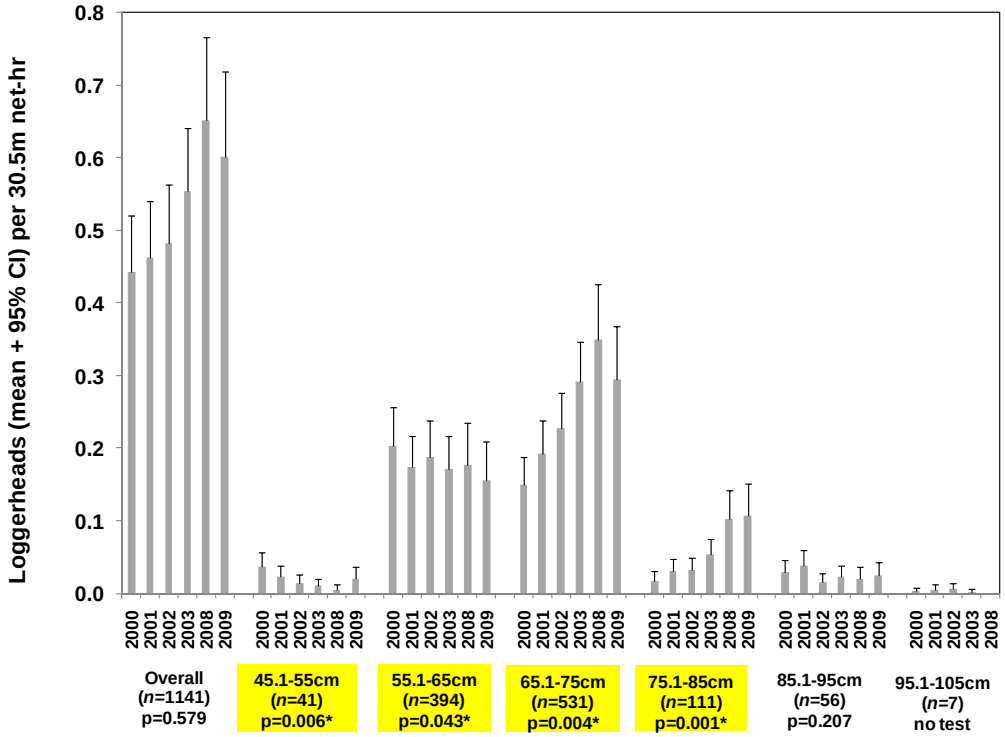

Figure 3. Standardized loggerhead catch rates throughout the trawl survey region, 2000 to 2009.

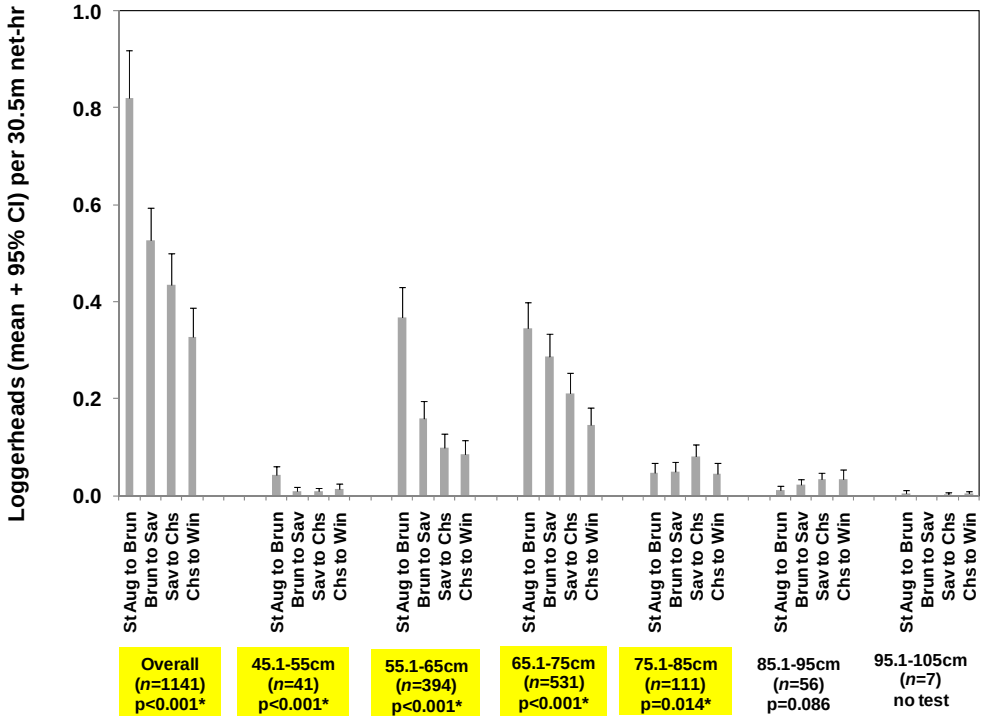

Figure 4. Standardized loggerhead catch rates among trawl survey sub-regions, 2000 to 2009.

Health assessment
Every sea turtle collected received a macroscopic physical examination to systematically assess body appearance and condition and inspect for subtle symptoms of stress such as barnacle load, tumors or growths and leeches for distinct regions of the body (Table 1).

Table 1. Physical examination checklist for sea turtles collected by trawling.

Condition	Head	Eyes	Nares	Mouth	Neck	Carapace	Flippers	Plastron	Tail/Cloaca
Nothing unusual									
Growth/tumors									
Sloughing >25%									
Leeches/eggs									
Barnacles >50%									
Emaciated/sunken									
Discharge									
Mucous membrane ok?									

Forty-three percent (*n*=66 of 152) of loggerhead and 45% (*n*=5 of 11) of Kemp's ridley sea turtles collected in 2009 were flagged for at least one observation during the physical exam. Leeches and/or leech eggs were detected on 12 loggerheads and were most commonly located in the inguinal region of the body (to include the tail), but also occurred on the neck and hard body parts. Leech eggs in fecal samples (Table 2) were also identified by the Parasitology Laboratory at the University of Florida for one loggerhead (CC0541) which outwardly exhibited evidence of leeches during the physical examination as well as a second loggerhead (CC0557) that did not. Three loggerheads were characterized as emaciated and/or lethargic, of which one (CC2686) was rehabilitated at the GA Sea Turtle Center on Jekyll Island and released three months later. This loggerhead also tested positive for *loggerhead orocutaneous herpesvirus*. Unusual growths on the head/neck and in the mouth were also noted for three loggerheads, but biopsies were not collected. In contrast to emaciation and debilitation, 14 loggerheads appeared to be exceptionally rotund and healthy and all Kemp's ridleys appeared healthy and active.

Table 2. Description of leech eggs identified from fecal samples.

Turtle ID	Test Method	Species detected
CC0541	Flotation	*Cuculanus* sp. eggs
CC0541	Sedimentation	*Kathlania*/*Tonaudia* sp. eggs; *Hapalotrema* sp. eggs; *Orchidasma* sp. eggs
CC0557	Sedimentation	1 *Pachypsolus* sp. egg

Loggerhead injuries impacted the flippers (18 individuals) and carapace (14 individuals) more often than the head/neck region or plastron (i.e., 7 individuals each). Flipper and carapace wounds generally involved amputations/cuts and cracks, respectively; however, due to the healed nature of wounds injury sources were often not apparent. A loggerhead (CC2673) missing just a small portion of the carapace in June stranded in August on Atlantic Beach, FL (6km from where tagged and released) after having been decapitated by a boat propeller. Physical injuries to Kemp's ridley sea turtles were more concentrated in the head/neck region (3 individuals) than the flippers (1 individual). Six loggerheads were injured by stingray-interactions during trawl collection; stingray barbs were removed intact and Dexmethasone (0.5 mg per kg of body weight) was intramuscularly injected into the pectoral muscle near the base of the plastron to reduce inflammation/necrotic fasciitis (per advice of Dr. Shane Boylan, SC Aquarium).

Three blood parameters (pack cell volume, total protein and glucose) were measured at sea for every turtle from which blood was collected. In 2009, blood samples were collected for all but one loggerhead (an adult male with a large/thick neck that prevented collection) and one Kemp's ridley that was deemed too small for blood collection. Pack cell volume ranged from 16 to 44 (mean = 34.2) for loggerhead and 20 to 41 (mean = 33.1) for Kemp's ridley sea turtles. Total protein ranged from 1.8 to 7.2 g/dL (mean = 4.2) for loggerhead and 2.5 to 5.2 g/dL (mean = 3.8) for Kemp's ridley sea turtles. Blood glucose levels ranged from 53 to 147 mg/dL (mean = 92.6) for loggerhead and 72 to 128 mg/dL (mean = 95.3) for Kemp's ridley sea turtles. Blood values for all three parameters were similar among these two sea turtle species in 2009 as well as similar within and among species to values measured between 2000 and 2008 (Figure 5).

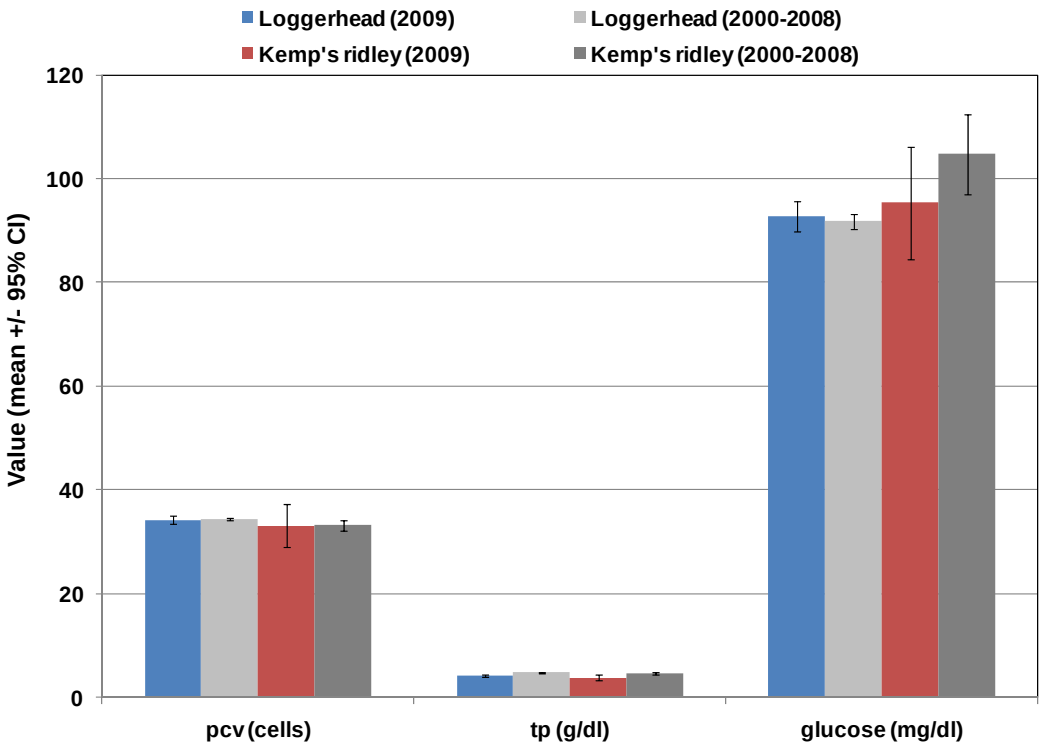

Figure 5. Comparison of blood parameters measured at sea among sea turtle species and years.

Blood samples for 23 presumably healthy and two emaciated loggerheads (CC0547, CC2686) were sent to Antech Diagnostic Laboratories (Memphis, TN) for blood chemistry and blood count screenings. Blood chemistry values for CC0547 were only within 95% confidence intervals surrounding mean values for healthy loggerheads for total protein, albumin, globulin, calcium and glucose (Figure 6). Blood chemistry values for CC2686 were only within 95% confidence intervals surrounding mean values for healthy loggerheads for potassium, AST, blood urea nitrogen, sodium and chloride (Figure 6). More absolute cell counts for CC0547 and CC2686 fell outside rather than inside of 95% confidence intervals for presumably healthy turtles (Figure 7); however, cell morphologies for only 10 of 23 healthy turtles were listed as normal. Blood parasites were not detected in any of the 25 blood samples diagnosed by Antech in 2009, consistent with 349 other samples analyzed by Antech for this trawl survey since 2000.

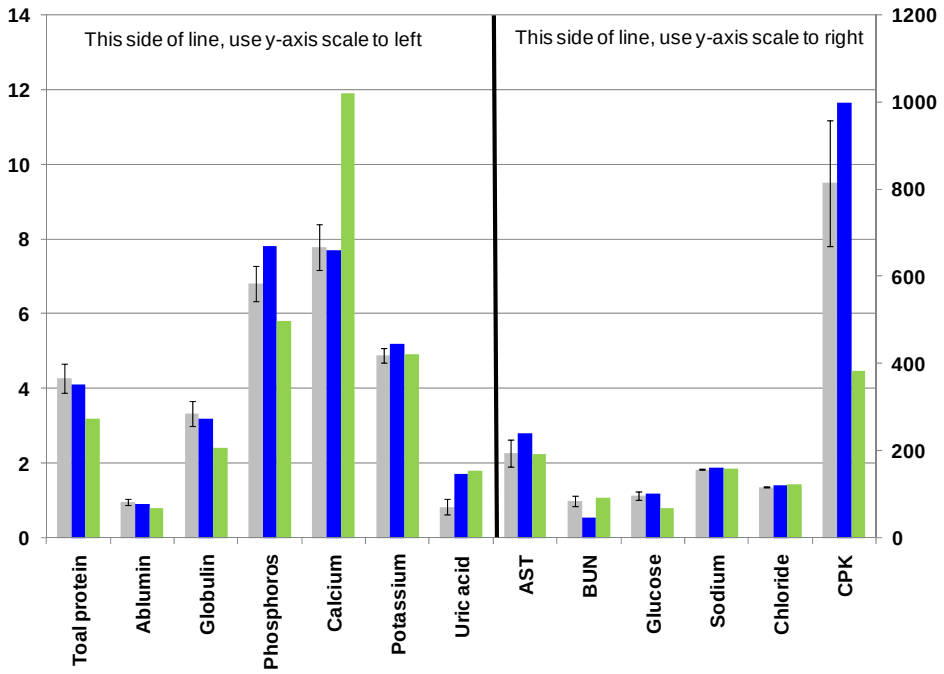

Figure 6. Comparison of blood chemistry values for presumably healthy (gray, *n*=23) vs. two emaciated loggerheads (CC0547, blue; CC2686, green) in 2009. Mean +/- 95% confidence intervals are depicted for healthy loggerheads. The second y-axis scale is associated with AST, Blood Urea Nitrogen (BUN), glucose, sodium, chloride and CPK.

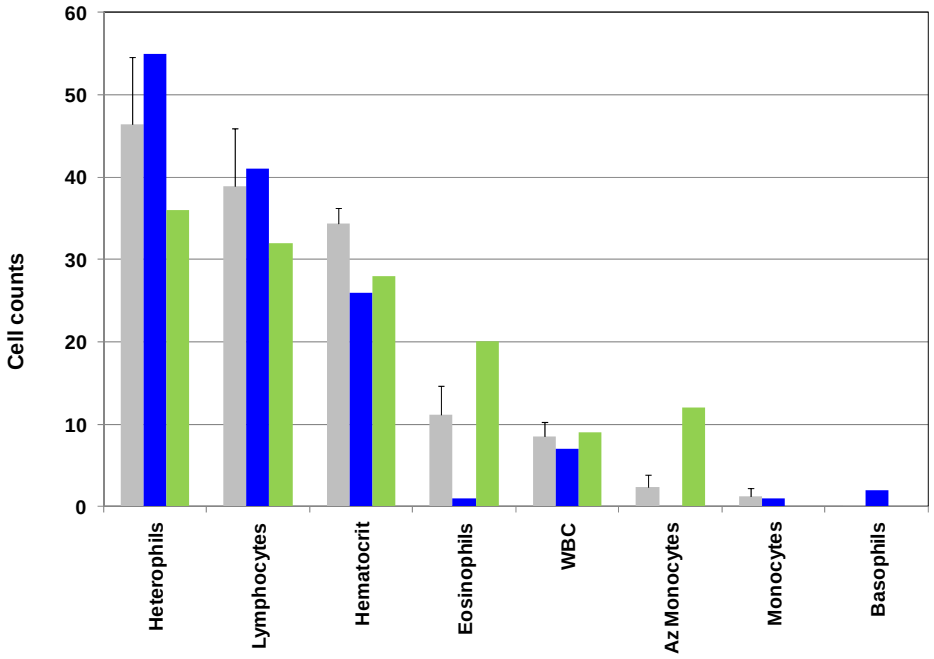

Figure 7. Comparison of cell counts between presumably healthy (gray, *n*=23; mean + 95% confidence interval) vs. two emaciated loggerheads (CC0547, blue; CC2686, green) in 2009.

Blood samples were also collected for several collaborators for which analyses are pending. For every loggerhead collected, plasma was provided (cryovial, -80°C) to Dr. Roldan Valverde at Southeastern Louisiana University and Dr. David Rostal at Georgia Southern University for vitellogenin and estradiol studies, respectively. Four cryovials for each of 40 loggerheads were also provided to Dr. Terry Norton at the Georgia Sea Turtle Center in support of a nutritional study. Cryovials for the same loggerheads were also provided to Dr. Duncan McKenzie (Texas Veterinary Diagnostic Medical Laboratory) and Dr. Margie Peden-Adams (Medical University of South Carolina) for thyroid and lysozyme studies, respectively. Frozen blood samples from these 40 loggerheads were also provided to Dr. Jennifer Keller (10ml) and Mr. Russell Day (7ml) at the National Institute of Standards and Technology (NIST) for organic contaminant and mercury analyses, respectively. Analyses for all of these samples are pending.

Barnacles

A total of 207 barnacles was sampled from 12 (six per research vessel) of 40 loggerhead sea turtles sub-sampled for additional blood samples in 2009 (Table 3). Three species of obligate commensal (on sea turtles) barnacles were identified: *Chelonibia testudinaria, Platylepas hexastylos* and *Stomatolepas elegans*. One species (*C. testudinaria*) that attaches to carapace and plastron and a second species (*P. hexastylos*) that attaches to the skin of limbs, head and body were present on all loggerheads; however, the third species (*S. elegans*) that attaches to the soft skin of the body was only found on one turtle (CC2657). Identification of *S. elegans* in 2009 marks just the third occurrence of this species in seven years of data collection during the turtle trawl survey. Although skin barnacles were collected in other years, prior to 2009 all barnacles were stored in a single vial per sea turtle rather than separate vials denoting collection location (on the body) per sea turtle. Specimens of *C. testudinaria* (from this study and other collections) will be analyzed genetically to assess divergence and connectivity among turtle populations.

Table 3. Species identification and abundance of barnacles collected from 12 loggerhead sea turtles off the SE USA.

2009 Turtle ID	Obligate Species			No. barnacles collected
	Chelonibia testudinaria	*Platylepas hexastylos*	*Stomatolepas elegans*	
CC0527	7	11		18
CC0528	6	15		21
CC0532	6	8		14
CC0537	5	12		17
CC0538	5	7		12
CC0539	5	3		8
CC2655	5	13		18
CC2656	5	16		21
CC2657	7	12	4	23
CC2658	8	12		20
CC2659	5	11		16
CC2660	5	14		19
Totals	69	134	4	207

By-catch organisms
One hundred eighty-nine different organism identifications comprising 93,008 individuals (counts plus estimated counts) were recorded during trawling efforts in 2009 (Appendix 1). Mid-water and pelagic fishes comprised 66% of organisms reported from trawling (Figure 8). Inshore fishes (Family Sciaenidae) and Echinoderms each represented 8% of trawl collections. All other groups of organisms each represented <5% of trawl by-catch. By-catch composition in 2009 was comparable to 2008; however, total reported abundance for mid-water and pelagic, inshore fishes and jellyfishes were substantially reduced relative to 2008 (Arendt et al., 2009).

Spatial differences in by-catch distribution were noted. The least number of sharks were reported between St. Augustine, FL and Brunswick, GA, but the most rays were reported in this sub-region. Similarly, the fewest number of inshore fishes were seen between St. Augustine, FL and Brunswick, GA; however, relatively high numbers of jellyfishes and mid-water and pelagic fishes were documented in this sub-region. Greatest observations of sharks, inshore fishes and sessile invertebrates were reported between Charleston and Winyah Bay, SC.

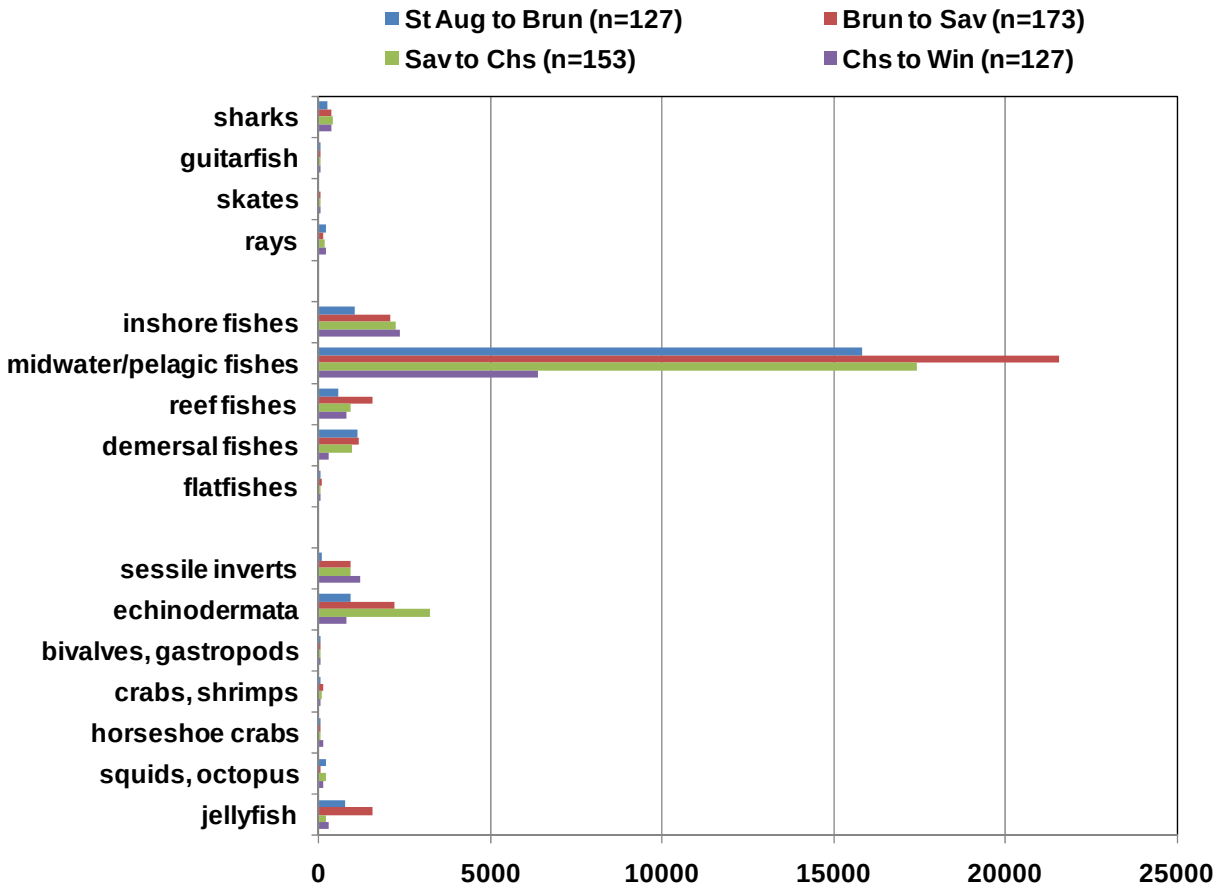

Figure 8. By-catch composition observed during the 2009 turtle trawl survey.

Discussion

Catch rates for loggerhead sea turtles across the sampling region in 2009 were slightly less than 2008, but still represented the second highest overall catch rates in this survey since 2000. The catch rate for loggerheads 75.1 to 85.0cm SCLmin in 2009 was comparable to 2008, providing further support for the legitimacy of increased catch rates for this size group which includes the size at which loggerheads become sexually mature; TWEG, 2009). The mean catch rate in 2009 for the smallest loggerhead size group (45.1 to 55.0cm SCLmin) were the third highest observed for this trawl survey, reversing a sustained decline since 2001; however, only 41 loggerheads in this size group have ever been collected during this survey. Increased catch rates for these loggerhead size groups were offset by decreases in catch rates for the 55.1 to 65.0cm (lowest of six survey years) and 65.1 to 75cm (second highest of six survey years) SCLmin size groups.

With respect to standardized CPUE calculated by Maier et al. (2004) for historical data sets, loggerhead CPUE for the entire region in 2009 was more than 40 times greater than observed during coastal surveys in the South Atlantic Bight (SAB) between 1950 and 1976 (Bullis and Drummond, 1978), more than 20 times greater than fishery-independent surveys in coastal waters in the SAB in the late 1980s and early 1990s (Beatty et al., 1992) and more than 10 times greater than observed in the shrimp fishery in FL and SC waters in the late 1970s (Ulrich, 1978; Henwood and Stuntz, 1987). Although increases in CPUE cannot automatically be assumed to represent increased abundance without first establishing the probability of loggerheads being present at the time of sampling (Anderson, 2001), it is highly improbable that CPUE increases of the magnitude documented for the SAB over the past 30 years could occur without an inherent and substantial increase in actual abundance.

Changes in loggerhead size distributions mirror changes in loggerhead catch rates; however, it is unlikely that catch rate changes are exclusively attributed to growth among a fixed number of individuals. Independent of turtle size, catch rates increased between 2000 and 2009; thus, unless increased catch rates are exclusively attributed to greater concentration of turtles in a progressively smaller area each year, increased catch rates must reflect some recruitment of new turtles into the population. Increases in mean size (and catch rates) have also been reported for slightly smaller loggerheads from NC during the past decade (Epperly et al., 2007) and near Charleston, SC during the past two decades (Van Dolah and Maier, 1993; Arendt et al., 2009). These findings, along with data from the regional trawl survey, cast a favorable light on the possibility of a coast-wide increase in the relative abundance of loggerheads in a variety of developmental habitats attributed to management efforts on nesting beaches implemented since 1978 and mandated use of Turtle Excluder Devices (TEDs) that have benefited newly recruited loggerheads in benthic foraging habitats along the SE USA since the mid-1990s. Loggerhead recapture rates since 2000 remain considerably lower (Arendt et al., 2009) than recapture rates noted in the 1990s (Van Dolah and Maier, 1993; Dickerson et al., 1995) as well as constant among years, which is also consistent with a sustained increase in population size. In other words, if the abundance of sea turtles being sampled in our coastal survey was actually declining with time (i.e., no new recruitment coupled with annual mortality of resident individuals), intensive annual sampling within the survey area since 2000 should have been reflected in greater (and annually increasing) recaptures rates than have been observed to date.

In addition to increasing catch rates and proportional increase of loggerheads approaching maturity, other demographic information collected in this trawl survey points to the potential for improved future nesting success for the northern loggerhead sub-population. First, haplotype ratios in 2009 were similar to ratios reported since 2000, and remain distinctly biased for the northern sub-population, suggesting (in accordance with the natal homing hypothesis supported by genetic evidence, Bowen et al., 2004) that many loggerheads collected during the regional trawl survey will remain in this general vicinity. Second, sex ratios for these same loggerheads continue to be female-biased. With respect to loggerheads ≤75.0cm SCLmin and presumably sexually immature, sex ratios since 2003 have been less biased (mean=1.8 females to 1 male) than during 2000-2002 (mean=2.7 females to 1 male). Thus, the sex ratio of loggerheads ≤75.0cm SCLmin should continue to be closely monitored during the next decade as even subtle changes may indicate lag effects from influences such as a decreased hatchling output from strongly female-biased nesting beaches in sFL (Mrosovsky and Provancha, 1992) and/or increased hatchling output from weakly female-biased beaches for the northern sub-population (Braun-McNeill et al., 2007) where nesting declines are not as severe (NMFS/USFWS, 2008).

Overall, loggerhead sea turtles collected in 2009 appeared to be healthy; however, examination results were mixed. Physical trauma predominantly consisted of healed injuries that most often affected the carapace and flippers and were observed with similar frequencies as noted during 2000-2003 (5-13%, Maier et al., 2004). Emaciated and/or lethargic sea turtles were observed half as frequently as during 2000-2003 (Maier et al., 2004), and even the single emaciated turtle requiring shore-based treatment was rehabilitated and released after just 3.5 months. Similarly, 8% of loggerheads ≤75.0cm SCLmin were visibly rotund, the occurrence of which seemed to be more common than in past years (Arendt, personal observation). Conversely, leeches and/or leech eggs were observed on 8% of all loggerheads in 2009, compared to <2% of all loggerheads collected between 2000 and 2003 (Maier et al., 2004). Multiple leech species were also noted, and one loggerhead was severely infected. However, consistent with all years of this study, no blood parasites were detected during Complete Reptilian Profile screenings at Antech Diagnostic Laboratories and blood parameters measured at sea were comparable to other years.

Although multiple factors govern the recovery of the loggerhead sea turtle, data collected by this survey to date suggest at least a glimmer of hope. Recapture of two loggerheads in 2009 tagged by this survey in 2001 illustrate the need for long-term monitoring and patience. Specifically, the SCLmin for these turtles increased by only 0.8 (CC0082) to 1.4 (CC4056) cm/yr, comparable to loggerhead growth rates reported elsewhere (Klinger and Musick, 1995; Parham and Zug, 1997; Bjorndal et al., 1998). Similarly, despite intensive annual sampling within the regional trawl survey and recapture of these two loggerheads in close proximity (<6km) from where released, eight years passed before these loggerheads were collected for a second time. Low recapture rates for regionally resident loggerheads with high site-fidelity may stem from the small portion of the seafloor sampled with each trawling event, high relative abundance of un-tagged turtles in the population, and fine-scale movements of loggerheads within prescribed areas in response to changes in food availability as noted by variable by-catch assemblages between 2008 and 2009. In 2010, trawling will be restricted to four core focus areas within the regional sampling area in an effort to elucidate loggerhead 'detectability' with the intended purpose of being able to refine relative abundance estimates reported to date in this study.

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References

Anderson, D.R. 2001. The need to get the basics right in wildlife field studies. Wildlife Society Bulletin, 29(4): 1294-1297.

Arendt, M., J. Byrd, A. Segars, P. Maier, J. Schwenter, D. Burgess, J. Boynton, J.D. Whitaker, L. Liguori, L. Parker, D. Owens and G. Blanvillain. 2009. Examination of local movement and migratory behavior of sea turtles during spring and summer along the Atlantic coast off the southeastern United States. South Carolina Department of Natural Resources, University of Georgia, and College of Charleston, Final Report to NOAA Fisheries, Contract Number NA03NMF4720281, 177p.

Beatty, H.R., J.M. Boylan, R.P. Webster and E.L. Wenner. 1992. Results of trawling efforts in the coastal habitat of the South Atlantic Bight, FY-1991. SEAMAP-SA Final Report, 50p.

Bjorndal, K.A., A.B. Meylan and B.J. Turner. 1983. Sea turtle nesting at Melbourne Beach, Florida, I. Size, growth and reproductive biology. Biological Conservation, 26: 65-77.

Bjorndal, K.A., A.B. Bolten, R. Avery Bennett, E.R. Jacobson, T.J. Wronski, J.J. Valeski and P.J. Eliazar. 1998. Age and growth in sea turtles: Limitations of skeletochronology for demographic studies. Copeia, 1998(1): 23-30.

Bolten, A.B. 1999. Techniques for measuring sea turtles. Pages 110-114 in Eckert, K.L., K.A. Bjorndal, F.A. Abreu-Grobois and M. Donnelly (eds). Research and Management Techniques for the Conservation of Sea Turtles. IUCN/SSC Marine Turtle Specialist Group Publication No. 4.

Bowen, B.W., J.C. Avise, J.I. Richardson, A.B. Meylan, D. Margaritoulis and S.R. Hopkins-Murphy. 1993. Population structure of loggerhead turtles (*Caretta caretta*) in the northwestern Atlantic Ocean and Mediterranean Sea. Conservation Biology, 7: 834-844.

Bowen B.W., A.L. Bass, S.M. Chow, M. Bostrom and 15 others. 2004. Natal homing in juvenile loggerhead turtles (*Caretta caretta*). Molecular Ecology, 13:3797–3808.

Braun-McNeill, J., S.P. Epperly, D.W. Owens, L. Avens, E. Williams and C.A. Harms. 2007. Seasonal reliability of testosterone radioimmunoassay (RIA) for predicting sex ratios of juvenile loggerhead (*Caretta caretta*) turtles. Herpetologica, 63(3): 275-284.

Bullis, H.R., Jr. and S.B. Drummond. 1978. Sea turtle captures off the southeastern United States by exploratory fishing vessels 1950-1976. Florida Marine Research Publications, 33: 45-50.

Butler, R.W., W.A. Nelson, and T.A. Henwood. 1987. A trawl survey method for estimating loggerhead turtle, *Caretta caretta*, abundance in five eastern Florida channels and inlets. Fishery Bulletin, 85(3): 447-453.

Byles, R.A. 1988. Behavior and ecology of sea turtles from Chesapeake Bay, Virginia. Unpublished Ph.D. dissertation, School of Marine Science, College of William and Mary/Virginia Institute of Marine Science, Gloucester Point, VA, 111p.

Dickerson, D.D., K.J. Reine, D.A. Nelson and C.E. Dickerson, Jr. 1995. Assessment of sea turtle abundance in six South Atlantic U.S. Channels. Miscellaneous Paper EL-95-5, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Epperly, S.P., J. Braun and A. Veishlow. 1995. Sea turtles in North Carolina waters. Conservation Biology, 9(2): 384-394.

Epperly, S.P., J. Braun-McNeill and P.M. Richards. 2007. Trends in catch rates of sea turtles in North Carolina, USA. Endangered Species Research, 3(3): 283-293.

Henwood, T.A. and W.E. Stuntz. 1987. Analysis of sea turtle captures and mortalities during commercial shrimp trawling. Fishery Bulletin, 85(4): 813-817.

Klinger, R.C. and J.A. Musick. 1995. Age and growth of loggerhead turtles (*Caretta caretta*) from Chesapeake Bay. Copeia, 1995(1): 204-209.

Jacobson E.R. 1998. Collecting and processing blood from sea turtles for hematologic and plasma biochemical determinations. In: Fair P., Hansen, L. (eds). Report of the Sea Turtle Health Assessment Workshop, 2-3 Feb 1998, part I: Background and Information Needs. NOAA Technical Memo NOS-NCCOS-CCEHBR-003, pp.24-28.

Maier, P.P., A.L. Segars, M.D. Arendt, J.D. Whitaker, B.W. Stender, L. Parker, R. Vendetti, D.W. Owens, J. Quattro and S.R. Murphy. 2004. Development of an Index of Sea Turtle Abundance Based Upon In-water Sampling with Trawl Gear. Final Project Report to the National Marine Fisheries Service, National Oceanographic and Atmospheric Administration Grant No. NA07FL0499, 86 p.

McClellan-Green, C.M. and A.J. Read. 2007. Complexity and variation in loggerhead sea turtle life history. Biology Letters, 3(6): 592-594.

Morreale, S.J. and E.A. Standora. 1994. Occurrence, movement and behavior of the Kemp's Ridley and other sea turtles in New York waters. Okeanos Ocean Research Foundation Annual Report April 1988 – March 1993. New York State Department of Environmental Conservation Return a Gift to Wildlife Program Contract No. C001984, 35p.

Mrosovsky, N. and J. Provancha. 1992. Sex ratio of hatchling loggerhead sea turtles: data and estimates from a 5-year study. Canadian Journal of Zoology, 70: 530–535.

National Marine Fisheries Service and U.S. Fish and Wildlife Service. 2008. Recovery Plan for the Northwest Atlantic Population of the Loggerhead Sea Turtle (*Caretta caretta*), Second Revision. National Marine Fisheries Service, Silver Spring, MD. Available online and accessed 22 January 2009. http://www.nmfs.noaa.gov/pr/pdfs/recovery/turtle_loggerhead_atlantic.pdf

Owens, D.W. and G.J. Ruiz. 1980. New methods of obtaining blood and cerebrospinal fluid from marine turtles. Herpetologica. 36: 17-20.

Parham, J.F. and G.R. Zug. 1997. Age and growth of loggerhead sea turtles (*Caretta caretta*) of coastal Georgia: An assessment of skeletochronological age-estimates. Bulletin of Marine Science, 61(2): 287-304.

Sears, C.J., B.W. Bowen, R.W. Chapman, S.B. Galloway, S.R. Hopkins-Murphy, S.R. and C.M. Woodley. 1995. Demographic composition of the feeding population of juvenile loggerhead sea turtles (*C. caretta*) off Charleston, South Carolina: evidence from mitochondrial DNA markers. Marine Biology, 123: 869-874.

Standora, E.A., M.D., Eberle, J.M. Edbauer, S.J. Morreale and A.B. Bolten. 1993. Assessment of baseline behavior and trawling efficiency in Canaveral channel, Florida. Final contract report to U.S. Army Engineer Waterways Experiment Station, Buffalo State College, Buffalo, NY; Okeanos Ocean Research Foundation, Inc. Hampton Bays, NY, and University of Florida, Gainesville, FL, 105p.

Thompson, N.B. 1984. Progress report on estimating density and abundance of marine turtles: results of first year pelagic surveys in the southeast U.S. Unpublished report. U.S. Department of Commerce, National Marine Fisheries Service, Miami Laboratory, Miami, FL, 60p. (referenced in Epperly et al., 1995)

Turtle Expert Working Group (TEWG). 1998. An assessment of the Kemp's Ridley (*Lepidochelys kempii*) and loggerhead (*Caretta caretta*) sea turtle populations in the Western North Atlantic. NOAA Technical Memorandum NMFS-SEFSC 409. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southeast Fisheries Science Center, Miami, FL, 96p.

Turtle Expert Working Group (TEWG). 2000. Assessment update for the Kemp's Ridley (*Lepidocheyls kempiii*) and Loggerhead (*Caretta caretta*) sea turtle populations in the Western North Atlantic. U.S. Department of Commerce. NOAA Technical Memorandum NMFS-SEFSC-444, 115p.

Turtle Expert Working Group (TEWG). 2009. An assessment of the loggerhead turtle population in the Western North Atlantic. U.S. Department of Commerce. NOAA Technical Memorandum NMFS-SEFSC-575, 131p.

Ulrich, G.F. 1978. Incidental catch of loggerhead turtles by South Carolina commercial fisheries. Report to National Marine Fisheries Service, Contract No's 03-7-042-35151 and 03-7-042-35121, 36p. plus appendices. Prepared by South Carolina Wildlife and Marine Resources Department, Charleston, SC.

Van Dolah, R.F. and P.P. Maier. 1993. The distribution of loggerhead turtles (*Caretta caretta*) in the entrance channel of Charleston harbor, South Carolina, U.S.A. Journal of Coastal Research, 9(4): 1004-1012.

Appendix 1: Listing of all by-catch organisms reported from four sub-regions (with number of trawling events noted) during the 2009 turtle trawl survey. Table sorted by ecological category and species code within categories.

Species Code	ScientificName	St Aug to Brun (*n* =127)	Brun to Sav (*n* =173)	Sav to Chs (*n* =153)	Chs to Win (*n* =127)	Category
N060	POLINICES DUPLICATUS				1	bivalves, gastropods
N064	SINUM PERSPECTIVUM			2		bivalves, gastropods
N069	CASSIS MADAGASCARIENSIS				1	bivalves, gastropods
N081	TONNA GALEA				3	bivalves, gastropods
N103	BUSYCON CONTRARIUM		1			bivalves, gastropods
N104	BUSYCON CARICA			8	8	bivalves, gastropods
N106	BUSYCON CANALICULATA	1			1	bivalves, gastropods
N112	PLEUROPLOCA GIGANTEA			4	1	bivalves, gastropods
N187	ANADARA OVALIS				1	bivalves, gastropods
N208	ATRINA SERRATA	2		1		bivalves, gastropods
N218	ARGOPECTEN GIBBUS	2				bivalves, gastropods
N261	DINOCARDIUM ROBUSTUM	2		4	5	bivalves, gastropods
N375	PELECYPODA			1		bivalves, gastropods
N382	BUSYCON SP.				1	bivalves, gastropods
D003	PENAEUS AZTECUS	30	6	3		crabs, shrimps
D005	PENAEUS SETIFERUS	13	5	5	6	crabs, shrimps
D019	DROMIIDAE	1	8			crabs, shrimps
D050	LYSMATA WURDEMANNI		3	1		crabs, shrimps
D059	PILUMNUS SP.	2	31	9	3	crabs, shrimps
D081	PETROCHIRUS DIOGENES			3	1	crabs, shrimps
D112	CALAPPA FLAMMEA		4	10	7	crabs, shrimps
D116	HEPATUS EPHELITICUS		1	3	1	crabs, shrimps
D120	OVALIPES STEPHENSONI	1	38	13	6	crabs, shrimps
D121	OVALIPES OCELLATUS	3	8	2	3	crabs, shrimps
D124	PORTUNUS GIBBESII		2	1	1	crabs, shrimps
D127	PORTUNUS SPINICARPUS			1		crabs, shrimps
D128	PORTUNUS SPINIMANUS	1	4	3	2	crabs, shrimps
D130	CALLINECTES SAPIDUS	5	8	3		crabs, shrimps
D131	ARENAEUS CRIBRARIUS				1	crabs, shrimps
D142	MENIPPE MERCENARIA		7	10	3	crabs, shrimps
D246	LIBINIA SP.	2	10	26	8	crabs, shrimps
D247	CALLINECTES SIMILIS		3		1	crabs, shrimps
D249	CALLINECTES SIMILIS OR				1	crabs, shrimps
D290	ALPHEIDAE		1			crabs, shrimps
D300	BRACHYURA		1	2		crabs, shrimps
D363	OVALIPES SP.	1	1			crabs, shrimps
D390	SYNALPHEUS SP.		1			crabs, shrimps
D403	PAGURIDEA	1		2	1	crabs, shrimps
D409	PORCELLANIDAE			2		crabs, shrimps
E001	SQUILLA EMPUSA		1			crabs, shrimps
E108	SQUILLA NEGLECTA			1		crabs, shrimps
E309	STOMATOPODA	1	1	3	4	crabs, shrimps
A097	SYNODUS FOETENS	74	207	238	161	demersal fishes
A108	ARIOPSIS FELIS	1				demersal fishes
A110	OPSANUS TAU			1		demersal fishes
A178	DIPLECTRUM FORMOSUM	2	9	1	4	demersal fishes
A328	ASTROSCOPUS Y-GRAECUM		21			demersal fishes
A333	HYPLEUROCHILUS GEMINATUS		1	4		demersal fishes
A392	PRIONOTUS CAROLINUS	998	826	693	98	demersal fishes
A393	PRIONOTUS EVOLANS	44	83	30	16	demersal fishes
A394	PRIONOTUS OPHRYAS			1	1	demersal fishes
A397	PRIONOTUS SCITULUS	4	2	2	13	demersal fishes
A398	PRIONOTUS TRIBULUS			4	1	demersal fishes
A460	GOBIIDAE	2	3			demersal fishes
A474	BLENNIIDAE			1		demersal fishes
A498	HIPPOCAMPUS SP.		1			demersal fishes
B084	ASTROSCOPUS SP.				1	demersal fishes

Appendix 1, continued.

Species Code	ScientificName	St Aug to Brun (*n* =127)	Brun to Sav (*n* =173)	Sav to Chs (*n* =153)	Chs to Win (*n* =127)	Category
J001	ASTERIAS FORBESII	21	76	25	69	echinodermata
J003	ASTROPECTEN ARTICULATUS	13	1	1		echinodermata
J008	LUIDIA ALTERNATA	2	4			echinodermata
J068	MELLITA QUINQUESPERFORATA		6			echinodermata
J072	LYTECHINUS VARIEGATUS	72	182	1449	306	echinodermata
J073	MOIRA ATROPOS		1			echinodermata
J085	ARBACIA PUNCTULATA	54	241	213	170	echinodermata
J086	OPHIUROIDEA	3	17	18	2	echinodermata
J100	CLYPEASTER SUBDEPRESSUS	29	185	74	27	echinodermata
J117	CLYPEASTER SP.		1	10		echinodermata
J120	ASTROPECTEN SP.				1	echinodermata
J181	MELLITA SEXIESPERFORATA			1		echinodermata
J197	MELLITA SP.				1	echinodermata
J214	HOLOTHUROIDEA	149	74	4	6	echinodermata
J215	LUIDIA SP.	582	1405	1444	205	echinodermata
J217	ENCOPE SP.	1	8			echinodermata
A401	ANCYLOPSETTA	28	81	38	4	flatfishes
A405	CITHARICHTHYS MACROPS		2	2	3	flatfishes
A406	CITHARICHTHYS SPILOPTERUS	1	2			flatfishes
A408	ETROPUS CROSSOTUS	6	4	6		flatfishes
A412	PARALICHTHYS ALBIGUTTA			1		flatfishes
A413	PARALICHTHYS DENTATUS		2	4	11	flatfishes
A414	PARALICHTHYS LETHOSTIGMA	3	2	1	1	flatfishes
A417	SCOPHTHALMUS AQUOSUS				1	flatfishes
A423	SYMPHURUS UROSPILUS			1	3	flatfishes
A475	BOTHIDAE			1		flatfishes
A039	RHINOBATOS LENTIGINOSUS	5	2	31	17	guitarfish
F001	LIMULUS POLYPHEMUS	58	48	21	115	horseshoe crabs
A275	BAIRDIELLA CHRYSOURA				1	inshore fishes
A277	CYNOSCION NOTHUS	66	44	30	61	inshore fishes
A278	CYNOSCION REGALIS	9	6	22	10	inshore fishes
A283	LARIMUS FASCIATUS	417	1569	1649	1536	inshore fishes
A284	LEIOSTOMUS XANTHURUS	295	326	458	543	inshore fishes
A285	MENTICIRRHUS AMERICANUS	29	31	58	15	inshore fishes
A286	MENTICIRRHUS LITTORALIS			4		inshore fishes
A287	MENTICIRRHUS SAXATILIS		1			inshore fishes
A288	MICROPOGONIAS UNDULATUS	176	59	19	127	inshore fishes
A291	STELLIFER LANCEOLATUS	35	31	7	55	inshore fishes
H003	CYANEA CAPILLATA	4	62	1	2	jellyfish
H005	STOMOLOPHUS MELEAGRIS	2	77	111	68	jellyfish
H244	CHRYSAORA QUINQUECIRRHA	12	1195	14	64	jellyfish
H246	AURELIA AURITA	99	8	10	3	jellyfish
H383	CUBOZOA	662	227	88	154	jellyfish
H508	CTENOPHORA			1	4	jellyfish
A084	BREVOORTIA TYRANNUS		5		2	midwater/pelagic fishes
A088	OPISTHONEMA OGLINUM	80	134	96	68	midwater/pelagic fishes
A206	POMATOMUS SALTATRIX	1	7	7	1	midwater/pelagic fishes
A207	RACHYCENTRON CANADUM	3	1	1	1	midwater/pelagic fishes
A208	ECHENEIS NAUCRATES			5		midwater/pelagic fishes
A216	CARANX CRYSOS	2	1	2		midwater/pelagic fishes
A217	CARANX HIPPOS			1		midwater/pelagic fishes
A220	CHLOROSCOMBRUS CHRYSURUS	13207	16626	12492	3268	midwater/pelagic fishes
A223	DECAPTERUS PUNCTATUS			1	7	midwater/pelagic fishes
A226	NAUCRATES DUCTOR			1		midwater/pelagic fishes
A229	SELENE VOMER	37	28	5	1	midwater/pelagic fishes
A234	TRACHINOTUS CAROLINUS	8	10	2	11	midwater/pelagic fishes
A238	SELENE SETAPINNIS	1824	4200	3899	2165	midwater/pelagic fishes
A324	SPHYRAENA GUACHANCHO		3	1		midwater/pelagic fishes
A353	TRICHIURUS LEPTURUS	192	7		79	midwater/pelagic fishes
A362	SCOMBEROMORUS MACULATUS	6	10	21	9	midwater/pelagic fishes
A376	PEPRILUS TRIACANTHUS	86	70	131	229	midwater/pelagic fishes
A464	ALECTIS CILIARIUS		5	2	1	midwater/pelagic fishes
A466	ANCHOA SP.	35	10	31	123	midwater/pelagic fishes
A487	DECAPTERUS SP.			2		midwater/pelagic fishes
A524	SERIOLA SP.				4	midwater/pelagic fishes
A941	ECHENEIS SP.	11	3	2		midwater/pelagic fishes
B423	PEPRILUS PARU	349	426	734	418	midwater/pelagic fishes
P360	AMPHINOMIDAE				1	other

Appendix 1, continued.

Species Code	ScientificName	St Aug to Brun (*n* =127)	Brun to Sav (*n* =173)	Sav to Chs (*n* =153)	Chs to Win (*n* =127)	Category
A048	DASYATIS AMERICANA	89	70	135	113	rays
A049	DASYATIS CENTROURA	8	7	13	4	rays
A050	DASYATIS SABINA			1		rays
A051	DASYATIS SAYI		8	2	2	rays
A054	GYMNURA MICRURA	67	4	15	24	rays
A056	AETOBATUS NARINARI	4	3	1		rays
A057	MYLIOBATIS FREMINVILLEI	20	4	2	27	rays
A059	RHINOPTERA BONASUS	34	15	11	16	rays
A644	MOBULA HYPOSTOMA		1			rays
A175	CENTROPRISTIS OCYURUS			1		reef fishes
A176	CENTROPRISTIS PHILADELPHICA		2	1		reef fishes
A177	CENTROPRISTIS STRIATA	1	2	7	20	reef fishes
A198	PRIACANTHUS ARENATUS	1				reef fishes
A258	HAEMULON AUROLINEATUM			1		reef fishes
A262	ORTHOPRISTIS CHRYSOPTERA	1	3	6	9	reef fishes
A263	ARCHOSARGUS			8	15	reef fishes
A271	LAGODON RHOMBOIDES	3	3	34	74	reef fishes
A273	STENOTOMUS ACULEATUS	66	400	334	470	reef fishes
A297	CHAETODIPTERUS FABER	394	856	317	59	reef fishes
A304	HOLACANTHUS CILIARIS				1	reef fishes
A313	HEMIPTERONOTUS NOVACULA				1	reef fishes
A428	BALISTES CAPRISCUS	12	8	24	2	reef fishes
A434	STEPHANOLEPIS HISPIDUS	1	1		2	reef fishes
A439	ACANTHOSTRACION	13	45	33	37	reef fishes
A442	LAGOCEPHALUS LAEVIGATUS	1				reef fishes
A444	SPHOEROIDES MACULATUS			4	10	reef fishes
A448	CHILOMYCTERUS SCHOEPFI	89	247	159	82	reef fishes
A982	SPARIDAE				2	reef fishes
B002	UPENEUS PARVUS	2		2	1	reef fishes
B601	TUNICATA	16	89	116	264	sessile inverts
B634	STYELA SP.	1	240	168	87	sessile inverts
B639	APLIDIUM STELLATUM	36	368	350	104	sessile inverts
B670	EUDISTOMA HEPATICUM	13	38	35	15	sessile inverts
C324	MICROCIONA PROLIFERA	1	7	18	55	sessile inverts
C357	CLIONA CELATA		1	19	9	sessile inverts
C374	PORIFERA	5	121	41	86	sessile inverts
C375	CLIONA SP.		10	2	2	sessile inverts
C414	HALICLONA SP.	1	1	31	415	sessile inverts
C428	IRCINIA SP.	1	35	18	3	sessile inverts
H002	LEPTOGORGIA VIRGULATA			11	60	sessile inverts
H010	MURICEA PENDULA				8	sessile inverts
H023	PARANTHUS RAPIFORMIS	17	1	8		sessile inverts
H275	LEPTOGORGIA SP.			25		sessile inverts
H283	OCULINA VALENCIENNESI	1				sessile inverts
H286	OCULINA DIFFUSA	1				sessile inverts
H288	ACTINIARIA	1		2		sessile inverts
H306	OCULINA SP.				1	sessile inverts
H309	TELESTO SP.			8		sessile inverts
H310	OCTOCORALLIA				41	sessile inverts
H351	TITANIDEUM SP.		1	44	45	sessile inverts
H381	PENNATULACEA	1				sessile inverts
M501	ALCYONIDIUM HAUFFI			7	1	sessile inverts
M563	BRYOZOA			5	1	sessile inverts
A005	CARCHARIAS TAURUS				2	sharks
A014	CARCHARHINUS ACRONOTUS	6	13	35	24	sharks
A018	CARCHARHINUS LIMBATUS	2	1	2		sharks
A023	GALEOCERDO CUVIERI	1	3	1		sharks
A028	RHIZOPRIONODON	96	243	189	251	sharks
A029	SPHYRNA LEWINI	22	2	1	4	sharks
A031	SPHYRNA TIBURO	108	114	169	76	sharks
A043	RAJA EGLANTERIA		1	2	13	skates
N328	OCTOPUS VULGARIS		2	4	1	squids, octopus
N333	LOLLIGUNCULA BREVIS	7	7	14	12	squids, octopus
N386	LOLIGO SP.	196	42	180	102	squids, octopus

Appendix 2: Press coverage of the regional turtle trawl survey that appeared in The Florida-Times Union on 28 June 2009; http://jacksonville.com/news/georgia/2009-06-28/story/research_vessels_high_numbers_of_juvenile_turtles_good_sign_for_specie

Research vessel's high numbers of juvenile turtles good sign for species

Abundance surveys find more juvenile turtles, which means efforts to increase the survival rate of the protected reptiles make a difference.

- By Terry Dickson
- Story updated at 1:00 AM on Sunday, Jun. 28, 2009

BRUNSWICK - Since 2000, the crew of the Research Vessel Georgia Bulldog has purposely done what most try to avoid.

They have caught sea turtles.

Funded by the National Marine Fisheries Service, the scientists aboard the Bulldog conduct abundance surveys of the protected turtles, said Mike Arendt, the principal investigator for the Marine Resource Division of the South Carolina Department of Natural Resources.

A Charleston resident, Arendt runs the project because the South Carolina DNR administers the $270,000 grant that funds the survey of turtles from Savannah to Georgetown, S.C. The Bulldog, which is owned by the University of Georgia Marine Extension Service, works from Savannah to St. Augustine while a South Carolina boat works the northern half.

Abundance is not a word often used in talking about sea turtles. Although Georgia DNR officials have reported record numbers of nests on the state's beaches in recent years, Florida nestings have been in a 10-year decline since 1998.

"I'm not denying it's a bad thing," he said of Florida's decline in nestings. "What we're seeing is a discouraging trend."

But he said a sea turtle does not reach sexual maturity until it is about 30.

Subtract 30 years from 1998 and you get 1968, 10 years before the passage of the Endangered Species Act. At the time, adult turtles had no protection in the ocean and the hatchlings had none on the beach, he said. With the act came restrictions on beach lighting, devices to save turtles from fishing nets and other protection regulations.

"A turtle hatched after 1978 has a much better chance of survival than one hatched in 1968," he said.

If you add 20 to 30 years to the lives of the turtles the Bulldog has caught, tagged and released, then in a few years the Florida declines should be reversed and the number of Georgia nests should increase, too, he said.

The Bulldog is netting a "bumper crop" of juvenile turtles; last year's numbers were the highest ever, Arendt said.

"What we're seeing so far, the numbers are comparable to last year. What we're doing is working. Let's not lose faith," he said.

What works

Many turtles are likely being saved by federally mandated Turtle Excluder Devices, or TEDs, Arendt said.

Lindsay Parker, the captain of the Bulldog, guided the Bulldog east toward a sampling point in clear, offshore waters. There are about 1,500, all in waters 15 to 40 feet deep. The Bulldog has randomly selected about 600 for this summer. They'll spend five days and four nights at sea for six weeks.

Parker has been on both sides of the TEDs issue. Shrimpers fought the advent of TEDs because they believed the devices released a lot of shrimp out of the same escape hole as the turtles.

The way TEDs work is simple: Built like an oversized barbecue grill, the TED's grid is spaced wide enough to let shrimp pass through into the bottom of the net, but is too narrow for a turtle. Set at an angle, the TEDs simply guide turtles to freedom through an unsecured flap in the net.

A former commercial shrimpboat captain, Parker recalled the efficient but over-designed TEDs the federal government initially wanted.

"The prototype if adopted would have killed the shrimp-fishing industry as we know it," Parker said. Besides that, the devices were so big and cumbersome they would barely fit on the deck of a boat and could have injured a shrimper if one fell on him, he said.

Enter Sinky Boone, a Darien shrimper who was working on his own device called the Georgia Jumper. Boone not only wanted to get sea turtles out of his net, he wanted to eject horseshoe crabs, waterlogged stumps, stingrays, pieces of sunken boats that tangled and damaged his nets and crabs that ate shrimp, Parker said.

Parker sailed the Bulldog to Port Canaveral, where there are always sea turtles in the channel. For a week, he took 10 to 12 passengers a day, some from the Georgia and South Carolina DNR,

and let them see his crew pull nets equipped with Boone's TED. The Georgia Jumper and some similar versions worked, and shrimping was saved, Parker said.

The Marine Extension Service gets involved in such projects because it serves both sides of marine issues, said Lisa Liguori, head of fisheries for the agency.

"We're the one in the middle. We have to come up with a practical solution. Our goal is to protect local livelihoods as well as the coastal resource," she said.

It would have been easy to find a device that would save all the turtles, she said.

"If we're testing a device, it also has to catch shrimp," Liguori said.

Into action

Sailing into the sampling point, Parker told the crew to let down the nets for a timed trawl. The upper part of the nets has mesh large enough to keep a turtle but wide enough to let out most fish. It connects to smaller mesh at the bottom.

Veteran fishermen Marty Higgins and Jim Dickey, both marine resource specialists, lowered the nets as the Bulldogs sailed smoothly forward.

In the pilothouse, Parker kept the Bulldog on course. Beside him, Brunswick native and University of Georgia veterinary student Shanna Knight, who is volunteering on the boat, sat in the best seat, looking forward with a nice breeze.

Two other vet students, Rebecca Csomos from the University of Pennsylvania and Heather Beveridge from North Carolina State, and Heather Cason of Douglas, who has a master's in biology from Georgia Southern University, waited for the end of the trawl.

Announcing that time was up, Parker idled the Bulldog as Higgins and Dickey hauled in the nets.

"Turtle," someone said.

With the netted turtle thrashing on the deck, Parker pulled out a pocketknife and cut an opening in the net. It's faster to repair a hole than to work the uncooperative turtle all the way out, he said.

With NASCAR pit-crew efficiency, the researchers placed the loggerhead upside down in a rack, where Cason quickly drew vials of blood.

Csomos and Beveridge measured it and weighed it, and Cason implanted a microchip as others clamped two metal tags on its front flippers.

The turtle's convex underside indicated it was well-nourished and healthy, Arendt said as he examined it all over.

He examined it for marks and injuries and found none except a small wound on it that was not too worrisome.

Besides, Arendt said, sea turtles are amazingly tough.

He said later it was a 75-pound "teenager."

Within 15 minutes, the work was done and the turtle lowered over the side in a makeshift sling and released. It swam away quickly.

Most of the team could relax, but Cason busily processed the turtle's blood that will be shared with other researchers doing a variety of studies. That sharing spreads out the efficiency of the grant. Indeed, from 2003-2007, the researchers took a break from the abundance and health studies to work on other research in Florida.

The team returned to the abundance studies in 2008 and are funded again for next year, Liguori said.

As Parker turned the Bulldog west, "bucking the tide" toward the mainland, Arendt announced happily it was the 687th loggerhead the boat had netted.

Later, he repeated what he said earlier.

"Take heart in the fact it's working," he said of efforts to save turtles. "The signs look good. Really good, actually."

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Pictures and captions included with article appear on the next page

Heather Cason, a Georgia Southern University graduate from Douglas, processes blood taken from a loggerhead turtle netted moments earlier by the Research Vessel Georgia Bulldog off St. Simons Island. Cason has a master's degree in biology.

A loggerhead lies on its back as researchers cut it free. The turtle was part of a turtle abundance survey.

Rebecca Csomos, a veterinary student at the University of Pennsylvania, measures a sea turtle as part of the abundance survey, with the help of Heather Beveridge, a veterinary student from North Carolina State University.

Rebecca Csomos (left) and Mike Arendt check out a loggerhead turtle Monday netted minutes earlier by the Research Vessel Georgia Bulldog, from which Arendt and others are conducting a sea turtle abundance survey.