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

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ANNUAL REPORT TO NATIONAL MARINE FISHERIES SERVICE

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 May, June, and July 2011, marking the seventh year since 2000 that this survey was completed in its entirety. Four hundred ten sampling events were attempted (with four ended early due to bottom snags) which resulted in capture of 135 loggerhead sea turtles (including one individual captured twice), 33 Kemp's ridley sea turtles, and one green sea turtle.

Given the preponderance of non-sea turtle catch events, sea turtle counts were fit to a negative binomial distribution and catch analyzed using a generalized linear model, with the log of linear trawl transect length treated as an offset term. Kemp's ridley sea turtles exhibited greater zero dispersion (94% in 2011, 98% overall) than loggerhead sea turtles (75% in 2011, 77% overall), but were associated with a better final model fit as evidenced a greater percent (26% vs. 8%) of model deviation explained by model terms. Conversely, adjusted catch rates for loggerhead sea turtles yielded lower (0.24 to 0.71) coefficients of variation (CV) than were associated with adjusted catch rates for Kemp's ridley sea turtles (CV = 1.39 to 1.50).

Adjusted catch in 2011 was significantly different (non-overlap of 95% confidence intervals) for Kemp's ridley sea turtles relative to all years of the regional trawl survey and for loggerhead sea turtles relative to 2000, 2008, and 2009. However, due to relatively stable Kemp's ridley sea turtle catch prior to 2011, the trend for this species was non-significant ($P = 0.202$, $r^2 = 0.30$). Increased catch of Kemp's ridley sea turtles in 2011 was driven by turtles that measured 30.1 to 35.0 cm SCLmin, which represented 30% ($n = 10$) of total catch compared to ≤15% ($n = 0$ to 2) of Kemp's ridley sea turtle catch in previous years of this survey. Adjusted catch for loggerheads oscillated among years, with lowest catch in 2008-2009 when permitted tow time was reduced by 33%; thus, no trend was detected ($P = 0.980$, $r^2 = -0.20$). Significant and directional increase in adjusted catch was reported for loggerhead sea turtles with respect to southward sampling along a latitudinal gradient ($P = 0.030$, $r^2 = 0.91$). Significant annual increase ($P = 0.004$, $r^2 = 0.80$) in adjusted catch was noted for loggerhead sea turtles 75.1 to 80.0 cm SCLmin which were 19% ($n = 25$) of total loggerhead sea turtle catch in 2011 compared to 2% ($n = 4$) in 2000. Sustained catch increases for loggerhead sea turtles in this size class bode well for continued improvement to regional annual nest counts, particularly given the prevalence of regionally-dominant genetic haplotypes, female-biased sex ratios, and ultrasound documentation of reproductive development for a 76.6 cm SCLmin loggerhead in 2011.

Physical condition and health of sea turtles collected in 2011 continued to resemble long-term trends in this survey since 2000. Despite initial concerns of a region-wide outbreak of a degenerative condition at the onset of the sampling season in May, only two loggerhead sea turtles were deemed sufficiently debilitated to require transport to shore for treatment. Four other sea turtles were also transported to shore for wound rehabilitation, two of which involved stingray barb punctures during trawl capture. Only one sea turtle (a loggerhead) was brought on board in a mildly non-responsive manner, which was resolved without intubation. As such, we conclude that the substantial analytical gains associated with reinstatement of the original 30-min permitted trawl tow time far outweighed any potential risks associated with doing so.

Introduction

Five sea turtle species occur in the Northwest (NW) Atlantic Ocean, for which a single regional management unit is recognized for each species (Wallace et al., 2010). Loggerhead sea turtles (*Caretta caretta*) continue to be managed (NOAA, 2011) as a threatened species as originally listed under the Endangered Species Act in 1978. The second largest loggerhead sea turtle rookery in the world occurs in Florida (NMFS and USFWS, 2008) where nesting declined by 41% between 1998 and 2007 (Witherington et al., 2009); however, since 2007, nesting trends at Florida index survey beaches suggest a stabilizing to recovering trend (FWC, 2011a). Kemp's ridley sea turtles (*Lepidochelys kempii*) have been managed as an endangered species since 1970; however, the second revision to the international recovery plan for this species anticipates that a down-listing (to threatened) nesting benchmark will be achieved by 2015 (NMFS et al., 2011). Since 1978, green sea turtles (*Chelonia mydas*) have been managed as a threatened species throughout the Atlantic except for breeding populations in Florida which have been managed as endangered (NMFS and USFWS, 1991). The second largest green sea turtle rookery in the western hemisphere is located in Florida (FWC, 2011b) and between 1989 and 2011, green sea turtle nesting at Florida index survey beaches increased by a factor of 10 (FWC, 2011a). Leatherback sea turtles (*Dermochelys coriacea*) are considered endangered throughout their distribution range (NMFS and USFWS, 1992); however, a ten-fold increase in nesting for this species at Florida index survey beaches (FWC, 2011a) is encouraging for future recovery of this species in the NW Atlantic. Hawksbill sea turtles (*Eretmochelys imbricata*) are also considered globally endangered, with rare nesting of this species in the southeast USA (SE USA) restricted to south of 29°N latitude (NMFS and USFWS, 1993).

Despite encouraging trends for all species for which nesting data in the SE USA are available during the last decade, their basic life histories and management across expansive tracts of coastline and continental shelf seas dictates the need for continued monitoring. All sea turtles mature in aquatic habitats; thus, in water studies are necessary to complement terrestrial nesting surveys and stranding statistics. In near-shore coastal waters, loggerhead (Mansfield, 2006; Arendt et al., in press a) and Kemp's ridley (Renaud, 1995; Gitschlag, 1996) sea turtles generally remain submerged at least 90% of the time; thus, 'in the water' studies offer distinct advantages relative to 'over the water' surveys, the former also enabling size distribution as well as health and demographic assessments (Braun-McNeill et al., 2007). In SE USA coastal waters, in-water surveys have historically been conducted in shipping channels (Butler et al., 1987; Dickerson et al., 1995) or in conjunction with coastal fisheries (Schmid, 1995). However, the need to conduct "…long-term, in-water indices of loggerhead abundance in coastal waters" (TEWG, 1998) led to the development of this regional sea turtle trawl survey beginning in summer 2000.

A modified sampling design evaluated in summer 2010 did not significantly alter catch and recapture rates; thus, the original no-repeat, randomly selected station sampling design was resumed in 2011. This report details data collected in summer 2011, the seventh year that this survey has been conducted in its full regional entirety since 2000. Herein we report on changes in loggerhead and Kemp's ridley sea turtle catch between 2000 and 2011 using a multivariate analysis. Catch rate trends are examined for the overall data set, by geographic sub-region, and for prevalent size classes as appropriate. Demographic distributions, sea turtle health, and the co-occurrence of fish and invertebrate by-catch organisms are also discussed.

Methods

Sampling

Trawling was conducted aboard double-rigged research trawlers (the RV *Georgia Bulldog*, 21.9 m, and the RV *Lady Lisa*, 22.9 m) towing standardized National Marine Fisheries Service (NMFS) turtle nets at a target speed of 2.8 kts (5.2 km/h). Turtle nets were paired 60' (18.3 m) head-rope, 4-seam, 4-legged, 2-bridle nets. Net body consisted of 4" (10.2 cm) bar and 8" (20.3 cm) stretch mesh, with top and sides made of #36 twisted nylon and bottom consisting of #84 braided nylon twine. Cod end consisted of 2" (5.1 cm) bar and 4" (10.2 cm) stretch mesh.

An annual station list of at least 600 stations was randomly selected from a universe of 1500 coordinate pairs representing the center of 3.4 km^2 grids of trawlable bottom in coastal waters 4.6 to 12.2 m deep from Winyah Bay, SC to St. Augustine, FL (Figure 1). Within this region, four sub-regions were recognized based on sampling strata established by the Southeastern Area Monitoring and Assessment Program (SEAMAP). Stations in the northern portion of strata 27-28 through strata 33-34 corresponded to St. Augustine, FL to Brunswick, GA. Strata 35-36 to 39-40 reflected Brunswick to Savannah, GA. Strata 41-42 to 45-46 encompassed Savannah, GA to Charleston, SC. Strata 47-48 and 49-50 were designated as Charleston to Winyah Bay, SC.

The RV *Georgia Bulldog* sampled south of Savannah, GA and the RV *Lady Lisa* sampled north of Savannah, GA. A coin toss determined the direction of the first cruise for each vessel relative to its homeport, and weekly cruise direction systematically alternated thereafter. Near shore (<1 to 5 km) and offshore (5 to 12 km) stations were alternately sampled before and after 12:00 pm to prevent fine scale spatial-temporal biases. Per Section 10(A)(1)(a) permit #15566, a trawl duration of 30 minutes (bottom time) was restored (from 20 minutes in 2008-2010) in 2011.

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 captured during this survey.

Blood samples were collected for all sea turtles >5 kg body weight with a 21-ga, 1.5" (3.8 cm) needle from the dorsal cervical sinus of sea turtles 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). Blood samples were collected for the following collaborators and purposes:

1) Genetics – 3 ml (University of South Carolina)
2) Steroid hormones – 10 ml for College of Charleston (testosterone, corticosterone); sub-sampled for estradiol (Georgia Southern University).
3) Nutrition studies – 10 ml (coordinated by the Georgia Sea Turtle Center)
4) Toxicological screening – 10 ml (National Institute of Standards and Technology)
5) CBC/Blood chemistry – 3 ml (Antech Diagnostics)

A suite of standard (Bolten, 1999) morphometric measurements were recorded 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 mass (kg) was recorded using spring scales.

All sea turtles >5 kg 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, modified in 2011 per recommendations of Wyneken et al. (2010), 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.

Finfish and invertebrate species captured during each trawling event were identified to lowest possible taxon and a count or estimate of abundance made. Total length, fork length, carapace width, or wing span (cm) measurements were recorded for managed species as time permitted. By-catch and sea turtle data were processed concurrently when possible to do so, to ensure that by-catch were returned alive and as quickly as possible, with highest priority for processing and release given to elasmobranchs, followed by finfish, and invertebrates.

Data management and analysis
Raw data were recorded in hard copy format on various forms, electronically entered at-sea using laptop computers, and rigorously proofed before importing into the primary data base.

Species-specific sea turtle catch rates were analyzed among years, sub-regions, and prevalent 5-cm SCLmin size classes as appropriate. SCLmin for loggerhead sea turtles with posterior carapace injuries were estimated (SCLmin = (1.44 x SCW) - 11.7; $r^2 = 0.87$; $n = 1{,}734$) from data collected since 2000. Sea turtle counts per trawling event (i.e., the response variable) were fit to a negative binomial distribution and analyzed using a generalized linear model (GLM) with log link function in R Version 2.13.0 (R Core Team, Vienna, Austria). Log of the linear transect distance (km) between trawl start and end locations was included in the GLM as an offset term. Seventeen variables or factors and three interaction terms (where Pearson's $r > 0.40$) were also included in the null model (see descriptions in Appendix 1).

Final model selection was accomplished through stepwise regression based on the lowest Akaike's Information Criterion (AIC) score. A Chi-square analysis of deviance was performed to assess the statistical significance of variables retained in the final model. Quantile residuals (Dunn and Smyth, 1996) were then plotted against each variable to assess trends and model-assigned statistical significance of variables. Cumulative deviance attributed to all final model variables was expressed as a percentage of the null deviance to characterize the extent to which the final model accounted for catch variation. Trends among annual mean adjusted fits were evaluated statistically using linear regression. Confidence intervals ([CI], 95%) around means were calculated using t-stats from Table B3 in Zar (1996).

Size-based and temporal changes in sex and genetic ratios were evaluated using Chi-square analysis performed in Minitab 15® (Minitab, Inc., State College, PA). Sex was assessed based on testosterone concentrations (pg/ml) measured using radioimmunoassay (see Braun-McNeill et al. (2007) for methodology) as follows: female (<200 for Kemp's ridleys, <400 for loggerheads); unknown (200-300 for Kemp's ridleys, 400 to 500 for loggerheads); and male (>300 for Kemp's ridleys, >500 for loggerheads). DNA was amplified from a 378 basepair fragment of the mitochondrial control region and sequenced as described by Roberts et al. (2005) and assigned haplotype codes used for Atlantic and Mediterranean loggerheads and maintained by the Archie Carr Center for Sea Turtle Research (ACCSTR) Genetics Bank.

Observation frequencies during the physical exam were evaluated with Chi-square or a two-tailed Fisher's exact test (Vassar Stats; http://faculty.vassar.edu/lowry/fisher.html). Hematocrit, blood glucose, and total protein levels measured at sea were analyzed using Kruskal-Wallis, two-sample t-tests, or Analysis of Variance (Minitab 15). Cluster analysis (Minitab 15) compared blood chemistry (Antech; Memphis, TN) distributions among perceived sick and healthy turtles.

By-catch data were used to assess bottom type (1 = not hard, 2 = probable hard, 3 = hard bottom) based on the co-occurrence of ≤1, two, or three indicator (Reed, 1994; Van Dolah et al., 1994) species, respectively. Total actual (i.e., no estimated) counts for by-catch identifications were plotted against the weight of the net in which they were captured to assess potential relationships ($r^2 > 0.90$; MS Excel) between net weight and organism (to include sea turtles) collection.

Results

Sampling effort and catch overview

Trawling was completed between 24 May and 29 July with a three-week lag in start dates for the two research vessels. Sampling effort was comparable between vessels (190 to 216 stations). Four additional stations were terminated 19 to 22 minutes early due to trawling impediments; however, no sea turtles were captured during those sampling events.

One hundred thirty-four individual loggerhead sea turtles, 33 Kemp's ridley sea turtles, and one green sea turtle (*Chelonia mydas*) were captured during 406 completed sampling events in 2011. Only one sea turtle (a loggerhead) escaped from the trawl gear before it could be brought on board in 2011. Neither loggerhead ($r^2 = 0.17$, $n = 135$) nor Kemp's ridley ($r^2 = 0.12$, $n = 33$) sea turtle captures were correlated with the weight of the trawl net in which they were captured.

Three loggerhead sea turtles captured in 2011 were previously tagged by another program. The Southeast Area Monitoring and Assessment Program (SEAMAP) originally tagged CC0103 in August 2001; it was recaptured by the regional sea turtle trawl survey in June 2002, and again in May 2011 at a location 3.4 km (trawl mid-point) from where it was last captured in 2002. CC0608 was originally tagged and released after eight months of rehabilitation for emaciation at the SC Aquarium 391 days earlier (Appendix 3). CC2871 was originally tagged by SEAMAP in October 2005 9.4 km southwest of where it was recaptured (trawl mid-point) during the regional trawl survey in June 2011. Two additional loggerhead sea turtles (CC0632, CC2873) exhibited tag scars with no PIT tag detected; thus, their tagging origin could not be determined.

Three loggerhead sea turtles captured in 2011 were previously tagged during the regional sea turtle trawl survey. CC2276 was recaptured on 25 July, 8.4 km from where originally captured (31.1°N) in July 2002. CC2692 was recaptured 2.3 km from where originally captured (31.7°N) two years earlier, nearly to the day (22 vs. 23 June) in 2009. CC2904 was recaptured (31.3°N) in two consecutive trawls that commenced <1.5 h and 3.7 km apart in July 2011, representing the fourth within-season recapture in the history of the regional sea turtle trawl survey.

Two loggerhead sea turtles tagged by this survey in a prior year were recaptured by other programs in 2011. CC2732 (89.4 cm SCLmin) nested (8 June) on Wassaw Island, GA, 58 km southwest from where it was originally captured on 9 July 2009. CC2769 (70.0 cm SCLmin) was recaptured (26 Oct) during a trawl survey 8.3 km from where captured on 14 June 2010.

Size distribution

Loggerhead sea turtles ($n = 134$) measured (mean ± SD) 70.4 ± 8.8 cm SCLmin (Figure 2). Loggerhead sea turtles that measured 75.1 to 80.0 cm ($n = 25$) and 80.1 to 85.0 cm ($n = 26$) SCLmin accounted for 24% of all captured loggerhead sea turtles in 2011. When this survey began in 2000, these size classes represented just 4% ($n = 3$ to 4) of annual loggerhead captures.

Kemp's ridley sea turtles ($n = 33$) measured (mean ± SD) 42.1 ± 10.5 cm SCLmin (Figure 3). Kemp's ridley sea turtles that measured 30.1 to 35.0 cm SCLmin in 2011 accounted for 30% of total catch for this species, compared to 9-15% of annual catch in previous years.

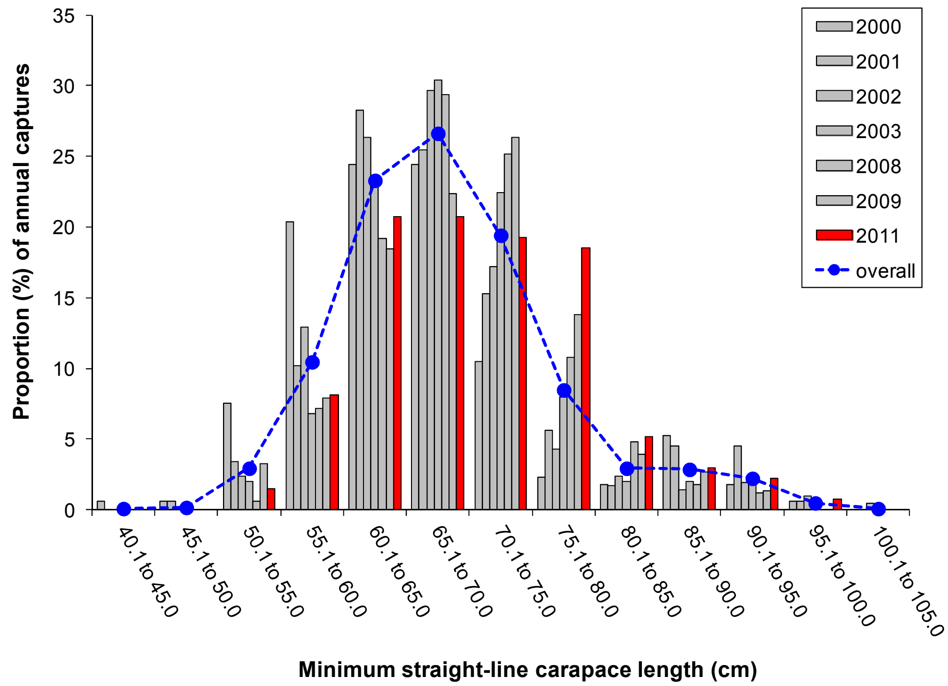

Figure 2. Loggerhead sea turtle size distribution in the regional trawl survey between 2000 and 2011. Annual measurements ranged from *n* = 134 (2011) to *n* = 250 (2003).

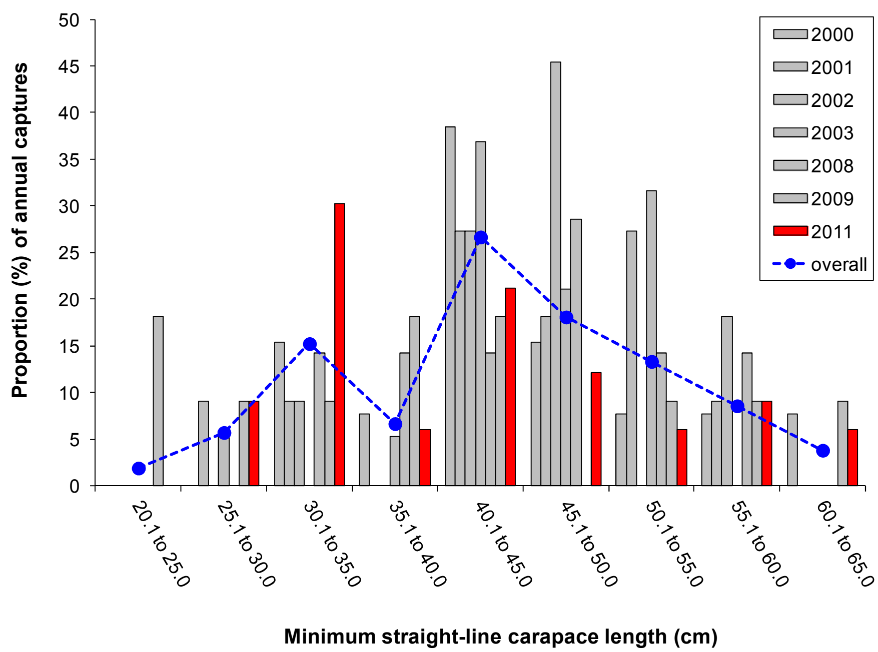

Figure 3. Kemp's ridley sea turtle size distribution in the regional trawl survey between 2000 and 2011. Annual measurements ranged from *n* = 7 (2008) to *n* = 33 (2011).

Catch rate trends

Adjusted catch (AIC = 5575; CV = 0.52) for loggerhead sea turtles in 2011 was 0.327 ± 0.016 (mean ± 95% CI) turtles per linear km, the second highest catch rate for this species since this survey began in 2000 (Figure 4). Seven model terms were determined to be significant in the final model, but only accounted for 8% of historical catch deviance (Table 1). Sub-region accounted for 52% of the explained deviance. Sub-region adjusted catch ranged from 0.174 ± 0.003 (CV = 0.24) north of Charleston, SC to 0.468 ± 0.013 (CV = 0.44) south of Brunswick, GA, with significant catch increases ($F_{1,2}$ = 31.4, adj. r^2 = 0.91, P = 0.030) with southward sampling. Distance from shore accounted for 20% of explained variance, twice as much deviance as was attributed to sampling year. Loggerhead catch (one to seven turtles) occurred in 101 sampling events. All (*n* = 9) events with ≥5 turtles occurred <10 km from shore, predominantly (i.e., 6 of 9 events) off northern Florida. Highest and lowest adjusted catch occurred in 2003 (0.352 ± 0.014; CV = 0.53) and 2009 (0.258 ± 0.010; CV = 0.47), respectively. Despite non-overlap of 95% CI in 2011 relative to 2000, 2008, and 2009, an inter-annual trend in mean adjusted catch from 2000 to 2011 was not detected ($F_{1,5}$ = 0.0, adj. r^2 = -0.20, P = 0.980).

Analysis of adjusted catch among five prevalent (88%) 5-cm size groupings revealed important temporal trends for the long-term recovery of this species (Figure 5, Table 1). Between 2000 and 2002, adjusted catch for loggerheads 55.1 to 60.0 cm SCLmin (AIC = 1050; Annual CV = 0.90 to 0.96) was significantly (i.e., no overlap in 95% CI) greater than adjusted catch for loggerheads 75.1 to 80.0 cm SCLmin (AIC = 954; Annual CV = 0.65 to 0.71). In each survey since 2003, however, adjusted catch has been significantly greater for loggerheads 75.1 to 80.0 cm SCLmin than for loggerheads 55.1 to 60.0 cm SCLmin. Decline in mean adjusted catch for loggerheads 55.1 to 60.0 cm SCLmin after 2000 was not significant ($F_{1,5}$ = 3.9, adj. r^2 = 0.32, P = 0.107). In contrast, adjusted catch for loggerhead sea turtles 75.1 to 80.0 cm SCLmin has systematically and significantly increased annually ($F_{1,5}$ = 24.3, adj. r^2 = 0.80, P = 0.004). Catch for the interim three size groupings remains stable ($F_{1,5}$ = 0.5 to 4.1, adj. r^2 = -0.09 to 0.34, P = 0.097 to 0.512).

Adjusted catch (AIC = 840; CV = 1.44) for Kemp's ridley sea turtles in 2011 was 0.083 ± 0.120 (mean ± 95% CI) turtles per linear km, the highest catch rate for this species since this survey began in 2000 (Figure 4). Adjusted catch rates for Kemp's ridley sea turtles in 2011 were seven times greater than the lowest adjusted catch in 2008 (0.012 ± 0.017; CV = 1.44) and three times greater than the previous maximum adjusted catch in 2003 (0.027 ± 0.038; CV = 1.39). Low and stable adjusted catch for this species prior to 2011 precluded the detection of a directional trend ($F_{1,5}$ = 2.2, adj. r^2 = 0.30, P = 0.202). Six significant terms in the final model accounted for 26% of model deviance (Table 1). Mean trawl depth accounted for 40% of explained deviance, twice as much deviance as accounted for by survey year. Kemp's ridley catch in 2011 (1 to 3 turtles) occurred in 24 sampling events, with all (*n* = 9) captures of two or more turtles per event in water depths <11 m, which predominantly occurred <10 and exclusively <20 km of shore. Distance from shore accounted for 15% of explained deviance. Sub-region accounted for 11% of explained deviance, but Kemp's ridley catch was not significantly different among sub-regions ($F_{1,5}$ = 90.5, adj. r^2 = 0.97, P = 0.011). Tide range accounted for 4% of explained deviance, with all multiple Kemp's ridley sea turtle captures at moderate (1.4 to 2.4 m) tide ranges versus smaller (0.7 to 1.4 m) or larger (2.4 to 3.0 m) tide ranges. Low total captures of Kemp's ridley sea turtles (*n* = 105) in this survey precluded examining catch trends among size classes.

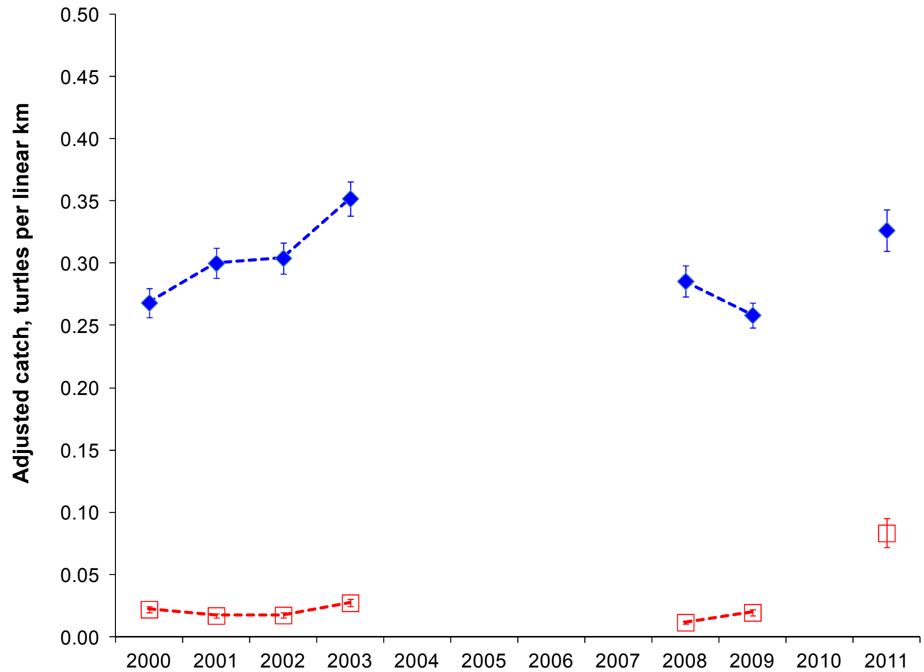

Figure 4. Overall mean (± 95% CI) adjusted catch (sea turtles per linear km) for loggerhead (diamond) and Kemp's ridley (square) sea turtles in the regional trawl survey, 2000 to 2011.

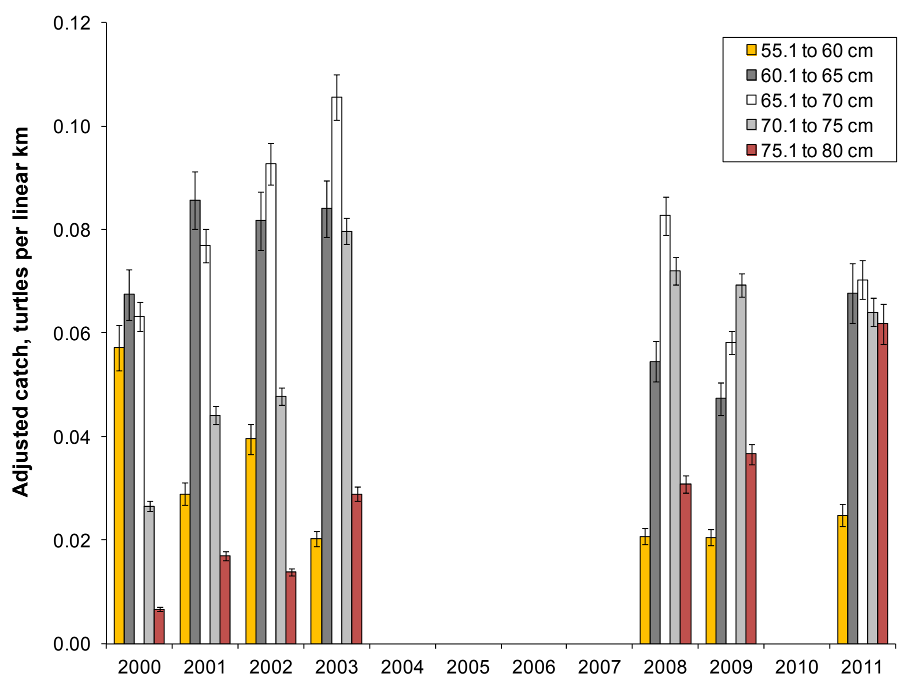

Figure 5. Mean (± 95% CI) adjusted catch (sea turtles per linear km) among 5-cm size groupings for loggerhead sea turtles collected in the regional trawl survey between 2000 and 2011.

Table 1. Significance of GLM model terms on sea turtle catch (dependent variable) per sampling event (log of linear trawl transect distance, in km, as an offset) for (1) overall loggerhead catch, (2) overall Kemp's ridley catch, and (3) prevalent 5-cm loggerhead sea turtle size classes (55.1 to 60.0 cm SCLmin to 75.1 to 80.0 cm SCLmin). Values indicated in the percent (%) column represent the percent of explained deviance accounted for by each model term. Significant terms denoted by an asterisk (*) and terms dropped from the final model denoted by dashes (---). Akaike's Information Criterion (AIC) and model deviance are also provided.

Model Term	***C. Caretta***	**%**	***L. kempi***	**%**	**55.1 to 60.0**	**%**	**60.1 to 65.0**	**%**	**65.1 to 70.0**	**%**	**70.1 to 75.0**	**%**	**75.1 to 80.0**	**%**
Year	<0.001*	10.1	<0.001*	20.1	<0.001*	14.2	0.799	2.1	0.023*	16.8	<0.001*	54.3	<0.001*	52.4
Time of day	---	---	0.066	4.4	---	---	---	---	---	---	---	---	0.025*	10.7
Sub-region	<0.001*	51.8	<0.001*	11.0	<0.001*	63.5	<0.001*	59.2	<0.001*	54.7	0.020*	11.9	0.002*	16.7
Mean trawl depth	0.966	0.0	<0.001*	40.2	---	---	0.195	1.1	0.397	0.8	0.361	1.1	0.007*	8.3
Trawl depth range	---	---	---	---	---	---	0.129	1.6	---	---	---	---	---	---
Distance from shore	<0.001*	20.1	<0.001*	14.5	<0.001*	19.7	<0.001*	21.3	0.001*	12.3	0.026*	6.0	0.420	0.8
Distance from inlet	0.275	0.5	0.603	0.2	0.117	2.6	0.049*	2.6	0.409	0.8	0.093	3.5	---	---
Mean depth x distance from shore	---	---	---	---	---	---	---	---	---	---	---	---	0.060	4.0
Mean depth x distance from inlet	<0.001*	4.9	0.033*	2.7	---	---	0.007*	4.9	0.005*	8.9	0.004*	10.0	---	---
Distance: from shore x inlet	0.026*	2.2	---	---	---	---	---		0.196	1.9	---	---	---	---
Bearing from inlet	0.001*	4.4	---	---	---	---	0.055	2.5	---	---	0.004*	10.3	---	---
Transect bearing	0.022*	2.2	---	---	---	---	0.033*	3.1	0.069	3.8	---	---	---	---
Bottom type	0.108	2.6	0.158	3.1	---	---	---	---	---	---	---	---	---	---
Wind speed	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Wind direction	---	---	---	---	---	---	0.116	1.6	---	---	---	---	---	---
Cloud cover	0.097	1.2	---	---	---	---	---	---	---	---	0.119	2.9	---	---
Mean daily barometric pressure	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Daily change in barometric pressure	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Tide stage	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Tide range	---	---	0.013*	3.8	---	---	---	---	---	---	---	---	0.012*	7.1
AIC score, null model	5590.5		852.7		1075.9		2024.9		2299.0		1820.9		970.1	
AIC score, final model	5575.0		839.7		1049.8		2009.1		2280.4		1806.3		954.1	
Null model deviance	3060.1		638.2		789.4		1402.3		1496.7		1319.7		741.0	
Final model deviance	2827.7		473.2		694.9		1253.2		1409.5		1237.4		653.5	
Percent of deviance explained	7.6		25.8		12.0		10.6		5.8		6.2		11.8	

Sex ratio and genetics
Testosterone concentrations (pg/ml) were measured for 130 of 134 loggerhead sea turtles captured in 2011. Sex ratio was not significantly different (P = 0.706) among three size classes (≤75.0 cm SCLmin, 75.1 to 85.0 cm SCLmin, and ≥85.1 cm SCLmin); however, we cautiously present sex determination data for loggerheads 75.1 to 85.0 cm SCLmin given the possibility of misinterpretation of sex associated with turtles transitioning to maturity. Overall female to male sex ratio in 2011 was 2.3 to 1. Sex was not able to be determined for CC0634 which measured 73.0 cm SCLmin with a serum testosterone concentration of 462.1 pg/ml. Sex ratio for loggerhead sea turtles ≤75.0 cm SCLmin in 2011 was not statistically different (P = 0.295) from annual sex ratio for similar sized loggerhead sea turtles during 2000-2003 and 2008-2009.

Testosterone concentrations (pg/ml) were measured for 30 of 33 Kemp's ridley sea turtles captured in 2011. Overall female to male sex ratio in 2011 was 7 to 1, with sex not able to be determined for six Kemp's ridley sea turtles (208.4 to 261.8 pg/ml) that spanned nearly the entire size spectrum (27.0 to 59.1 cm SCLmin) of Kemp's ridleys captured in this survey to date. Pooled (due to small sample size) female to male sex ratio for Kemp's ridley sea turtles was not statistically different (P = 0.995) during 2000-2003 (*n* = 48) relative to 2008-2011 (*n* = 41).

Genetic haplotypes were identified for 114 of 134 loggerhead sea turtles captured in 2011. Two regionally dominant (Bowen et al., 2004) haplotypes (CC-A01 and CC-A02) accounted for 82% (*n* = 94) of all observed haplotypes in 2011. Nine other established haplotypes (CC-A03, CC-A04, CC-A05, CC-A07, CC-A09, CC-A14, CC-A20, CC-A21, and CC-A36) and one not-yet-described haplotype comprised the remaining 20 haplotype samples in 2011. Frequency distribution of haplotypes (CC-A01 vs. CC-A02 vs. 'other') was not statistically different among loggerhead sea turtles ≤75.0 and ≥75.1 cm SCLmin (P = 0.972). In contrast, the overall ratio of CC-A01 vs. CC-A02 vs. pooled 'other' (*n* = 19 established, *n* = 3 novel) haplotypes was significantly different (χ^2_{12} = 21.4, P = 0.044) in 2011 vs. previous years when CC-A01 and CC-A02 constituted 90 ± 3% (mean ± SD) of annual haplotype frequencies.

Genetic haplotypes were identified for 20 of 33 Kemp's ridley sea turtles captured in 2011. Haplotype LK-01 accounted for 75% (*n* = 15) of all observed Kemp's ridley sea turtle haplotypes in 2011, with one (LK-02) to two (LK-03, LK-04) replicates for three other haplotypes accounting for the remainder of samples. Prior to 2011, only 28 haplotype samples had been collected and processed for Kemp's ridley sea turtles captured in this survey, with no prior record of haplotype LK-04; however, pooled haplotype distributions in 2000, 2008, and 2009 (LK-01 = 20, 'other' = 8) were not statistically different (P = 0.784) from 2011.

The sole green sea turtle (30.8 cm SCLmin) captured in 2011 was female (T = 68.8 pg/ml) and genetic analyses were not performed. During seven years of sampling in this regional sea turtle trawl survey, only eight other green sea turtles (mean ± SD = 28.9 ± 1.9 cm SCLmin) have been captured, four of which were female (T = 73.0 ± 38.3 pg/ml) and samples for sex determination not collected for the other four turtles. Genetic haplotype has only been determined for one green sea turtle captured in this regional trawl survey, which carried the CM-01 haplotype.

Physical examination
A significant difference (χ^2_1 = 13.0, P<0.001) was noted in the frequency of occurrence of at least one notable observation during the physical examination for loggerhead (*n* = 98, 73%) versus Kemp's ridley (*n* = 13, 39%) sea turtles. Observations for loggerhead sea turtles most often (27%) consisted of keratin sloughing (*n* = 37) and barnacle coverage (*n* = 37), categories that were only noted (keratin sloughing only) for two Kemp's ridley sea turtles. Twenty-nine loggerhead sea turtles had convex plastrons thought to be indicative of healthy diet, of which half (*n* = 15) also exhibited heavy keratin sloughing and/or barnacle load. In contrast, only one Kemp's ridley sea turtle was noted to have a convex plastron. Thirteen loggerhead sea turtles exhibited thin muscle mass ranging from slight to extensive (CC0610, CC0619, and CC2849) cases that required transfer to shore for rehabilitation at the South Carolina Aquarium (*n* = 2) or Georgia Sea Turtle Center (*n* = 1), where they were treated and released 42 to 116 days later. Marine leeches and/or leech eggs occurred statistically more frequently (P = 0.039) among loggerhead sea turtles exhibiting signs of emaciation (*n* = 4 of 13) than among loggerhead sea turtles that did not exhibit signs of emaciation (*n* = 11 of 122). Marine leeches were only noted for one Kemp's ridley sea turtle (LK2056) and are suspected reflect collection in the same net during the sampling event subsequent to capture of CC2849 which was inundated with leeches.

Frequency of collection of turtles with pre-existing injuries was statistically similar among Kemp's ridley (*n* = 11 of 33) and loggerhead (*n* = 32 of 135) sea turtles (χ^2_1 = 1.3, P = 0.256). Forty-seven unique wounds were observed for loggerhead sea turtles and 12 unique wounds were observed for 11 Kemp's ridley sea turtles. Carapace injuries were the most commonly observed injury for both species (*n* = 19 loggerhead and 6 Kemp's ridley wounds). Flipper damage or flipper loss was the second most commonly observed wound for loggerhead sea turtles (*n* = 14 wounds), followed by wounds to the head/neck region (*n* = 7), plastron (*n* = 5), and tail (*n* = 2). Depressions or lacerations to the head/neck region were the second most frequently observed injury noted for Kemp's ridley sea turtles (*n* = 3 wounds), followed damage to flippers (*n* = 2) or the plastron (*n* = 1). Two loggerhead sea turtles captured with fresh wounds (*n* = 4 total) were transferred to the Georgia Sea Turtle Center for treatment; CC2863 was released 124 days after care began and CC2898 will remain in care through the winter.

Stingray barb punctures during trawl gear retrieval afflicted 5% (*n* = 8) of sea turtles captured during 2011 and were not statistically different (P = 0.357) between Kemp's ridley (*n* = 3 of 30) and loggerhead (*n* = 5 of 135) sea turtles. Stingray barbs were removed intact and intra-muscular injection of Dexmethasone (0.5 mg per kg of body mass) was administered to all eight turtles. All loggerheads and one Kemp's ridley that received puncture wounds were released after standard data collection. One Kemp's ridley (LK2056) was transferred to the Georgia Sea Center for concerns of blood loss, but was released two days later. A second Kemp's ridley (LK0020) was transferred to the South Carolina Aquarium for concerns of coelemic cavity damage, which did not occur, and the turtle was released 33 days later.

Only one sea turtle (CC2907) captured during 2011 was non-responsive when brought on board. The rear of this turtle was immediately elevated and activity and regular breathing were observed within five minutes; thus, intubation was not required. This turtle was kept isolated, shaded and moist while being monitored for normal activity, and released 3.5 h later.

Health assessment
Blood parameters measured at sea were not statistically different between loggerhead (*n* = 131) and Kemp's ridley (*n* = 31) sea turtles with respect to packed cell volume (H_1 = 1.67, P = 0.196) and total protein (T_1 = -0.79, P = 0.432). Blood glucose measured at sea was statistically different (H_1 = 12.9, P<0.001) between Kemp's ridley (median = 159 mg/ml, inter-quartile range (IQR) = 128 to 180) and loggerhead sea turtles (median = 118 mg/ml, IQR = 90 to 156).

Median packed cell volume for all sea turtles captured in 2011 was 34% (IQR = 31 to 36%) and was not statistically different (P = 0.096) from packed cell volume distribution in other years of the regional survey (*n* = 161 to 258 samples annually).

Mean (± SD) total protein concentrations for all sea turtles captured in 2011 was 4.3 ± 1.0 mg/dl. Total protein concentrations in 2011 were statistically different (F_6 = 88.9, P<0.001) from levels measured in 2003 (5.9 ± 0.9 mg/dl, *n* = 264) and 2008 (4.5 ± 1.0 mg/dl, *n* = 172).

Loggerhead blood glucose levels in 2011 were statistically different (H_5 = 67.3, P<0.001) from all other years (*n* = 151 to 234) of this survey (median = 92 mg/ml; IQR = 79 to 109). Kemp's ridley blood glucose levels in 2011 were also statistically different (H_5 = 36.1, P<0.001) from all other years (*n* = 51 samples) of the regional survey (median = 103 mg/ml; IQR = 84 to 118).

Blood samples collected for 32 presumably healthy and three emaciated loggerhead sea turtles (CC0619, CC2849, and CC2904) were sent to Antech Diagnostic Laboratories (Memphis, TN) for blood chemistry and blood count screenings. Cluster analysis revealed no uni-variate relationships between blood chemistry variables (*n* = 13) and perceivably sick or healthy (group) loggerheads, and collectively all variables were weakly (56% similarity) associated with outward appearance (Figure 6). White blood cell counts (median = 8 x 10^3 per *u*l; IQR = 8 to 11) were not statistically different between healthy and sick loggerhead sea turtles (H_1 = 0.02, P = 0.881). White blood cell counts were comprised of 57% neutrophils, 39% lymphocytes, 3% eosinophils, and <1% each of basophils and monocytes.

Ultrasound
Ultrasound imaging was used in an attempt to collect data on reproductive condition for loggerhead sea turtles field identified as male (*n* = 3), female (*n* = 9), and unknown sex (*n* = 6). Field identifications of sex were confirmed via testosterone radioimmunoassay and all six loggerhead sea turtles for which sex was not field-assessed were assay-determined to be female.

Follicles were observed in two loggerhead sea turtles (76.6 and 91.3 cm SCLmin) and eggs were observed in a 96.7 cm SCLmin loggerhead sea turtle (Figure 7). Inconclusive data were collected for six other females (76.3 to 88.7 cm SCLmin), all males (79.9 to 90.5 cm SCLmin), and all six loggerhead sea turtles with undetermined field sex (73.3 to 86.7 cm SCLmin). Inconclusive images were also collected for LK2080, a 56.3 cm SCLmin Kemp's ridley sea turtle field identified as female but assay-identified (testosterone = 231.5 pg/ml) as unknown.

Low follicle density in immature turtle ovaries renders their detection with ultrasound difficult; however, follicle sighting in a 76.6 cm SCLmin loggerhead demonstrates the potential to do so.

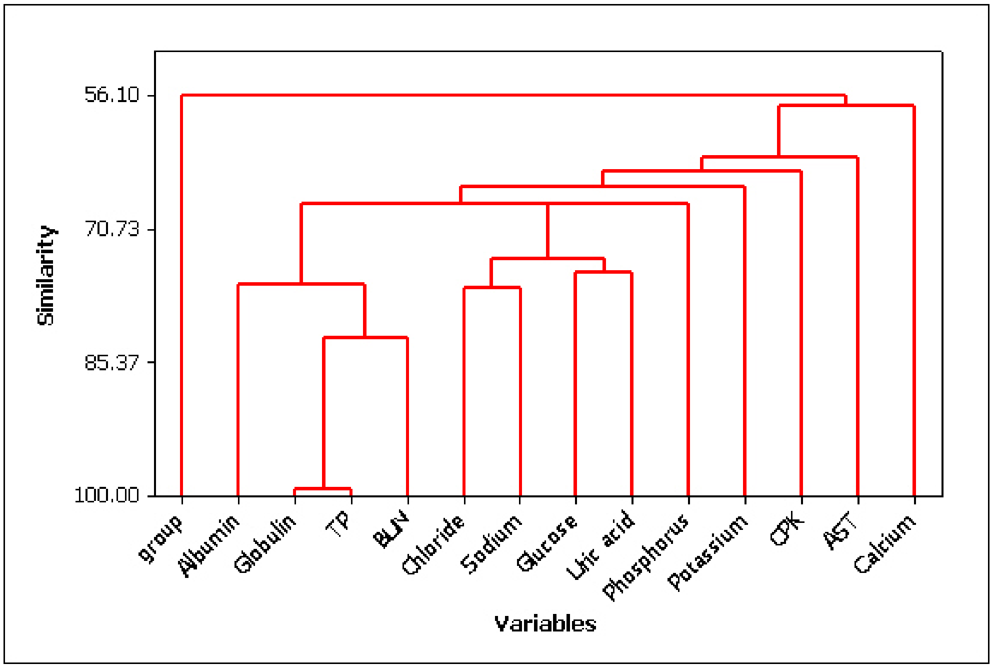

Figure 6. Relationships (single linkage, Euclidian distance) between blood chemistry values among perceivably healthy (n = 32) and sick (n = 3) loggerhead sea turtle groups in 2011.

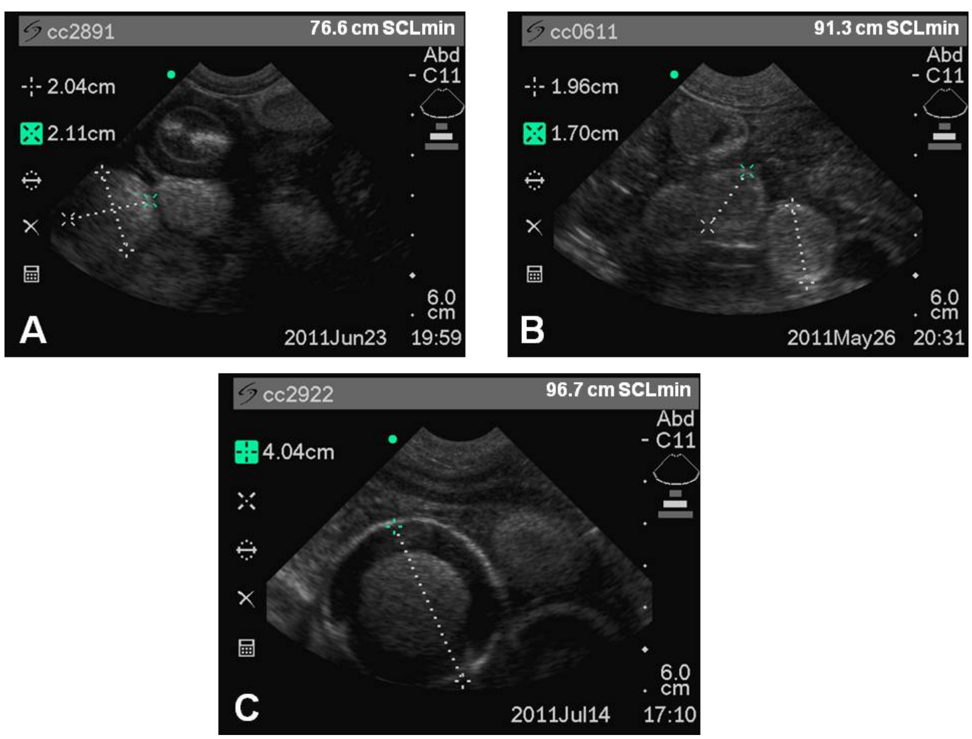

Figure 7. Follicles (A,B) and eggs (C) imaged by ultrasonography of sea turtles during 2011.

Additional collaborator samples
Blood and biological sea turtle samples were collected for five collaborators in 2011, for which data are not available at this time. Plasma from 107 loggerhead and 16 Kemp's ridley sea turtles was provided to D. Rostal at Georgia Southern University for estradiol analyses. Keratin biopsies and blood (red blood cells and plasma) for 34 loggerhead sea turtles were provided to M. Pajuelo at the University of Florida for stable isotope analyses; frozen blood samples for these same turtles were also provided to J. Keller at the National Institute of Standards and Technology for contaminant studies. Blood samples for six adult males and one adult female loggerhead sea turtle were collected for a panel of nutritional analyses overseen by the Georgia Sea Turtle Center (T. Norton). Plasma samples for 21 loggerhead and one Kemp's ridley sea turtle were also collected for Vitamin D and iron analyses overseen by the SC Aquarium (S. Boylan).

Barnacle and epibiont samples were collected for a sub-set of loggerheads sampled for stable isotopes for both the isotope research (M. Pajuelo) and for research conducted as part of the trawl survey since 2002 by J. Zardus (The Citadel; Appendix 4). Sea nettles and spider crabs were also collected for nutritional analyses for S. Ceriani (University of Central Florida) as part of a collaboration that began in 2010. Twenty-four water samples were also collected and filtered at the start ($n = 2$ replicates) and end ($n = 2$ replicates) of the first three cruises aboard each research vessel for baseline stable isotope analyses conducted by M. Pajuelo.

By-catch assessment
One hundred sixty organism identifications comprising (actual and estimated counts) 111,033 individuals were recorded during trawling efforts in 2011 (Appendix 5). Nineteen mid-water and pelagic fishes comprised 49% ($n = 32{,}131$) of counted and 11% ($n = 4{,}735$) of estimated counts of organisms captured by trawling; however, 97-98% of estimated and actual counts for these fishes were associated with just four species (Atlantic bumper, *Chloroscombrus crysurus*; moon fish, *Selene setapinnis*; butterfish, *Peprilus triancanthus*; and harvestfish, *Peprilus paru*). Six distinct gelatinous invertebrates were the second most abundant by-catch group (17% of actual and 55% of estimated counts), and were dominated by cannonball jellyfish (*Stomolophus meleagris*) which accounted for 75% ($n = 8{,}552$) of actual and 78% ($n = 19{,}109$) of estimated counts. All other bony fishes ($n = 46$ identifications) collectively comprised 21% ($n = 13{,}950$) of actual and 5% ($n = 2{,}433$) of estimated counts, comparable to all other invertebrates ($n = 69$ identifications) which comprised 10% ($n = 6{,}633$) of actual and 27% ($n = 12{,}278$) of estimated counts. Non-gelatinous invertebrates were dominated (67% of actual, 92% of estimated counts) by shrimps, crabs, and echinoderms. Twenty elasmobranch species comprised 3% ($n = 2{,}067$) of actual and 2% ($n = 690$) of estimated counts and were dominated (83-87% of category) by bonnethead (*Sphyrna tiburo*) and Atlantic sharpnose (*Rhizoprionodon terranovae*) sharks as well as southern (*Dasyatis americana*) and smooth butterfly (*Gymnura micrura*) rays.

Actual counts for 8% ($n = 13$) of by-catch identifications were correlated ($r^2 > 0.90$) with net weight, of which total catch per trawl net ranged from one to 16 individuals for 10 by-catch identifications. Among the other three by-catch identifications, the strongest ($r^2 = 0.98$) correlation was with anchovies (*Anchoa* sp., $n = 61$), followed by cannonball jellyfish ($r^2 = 0.96$; $n = 8{,}552$), and scrawled cowfish (*Acanthostracion quadricornis*; $r^2 = 0.92$; $n = 56$).

Discussion
Model-adjusted catch rates (sea turtles per linear km) for two species captured in 2011 revealed starkly different trends since the inception of this regional trawl survey in summer 2000. Significant inter-annual differences are noted for loggerhead sea turtles, but oscillation in annual catch rates (notably in 2008-2009 when trawl duration was 33% shorter) yielded a stable trend. Other factors contributing to the inability to detect a significant change in loggerhead sea turtle catch rates include slow-growth (Klinger and Musick, 1995; Bjorndal et al., 1998) and late age at maturity (Casale et al, 2011; Scott et al., 2011). Maier et al. (2004) predicted that sixteen years of sampling would be required to detect a significant trend and 2011 marked just the seventh year of data collection; thus, to some extent the stable trend is to be expected. In contrast, Kemp's ridley catch in 2011 increased three to seven fold. Increased Kemp's ridley catch corresponds with 12-16% annual population growth predicted by Heppell et al. (2005). One year does not constitute a trend (hence $r^2 = 0.30$), but given the small size of Kemp's ridleys captured in 2011, indicative of new recruits from nest counts with recent exponential growth (NMFS et al., 2011), we anticipate continued elevated Kemp's ridley catch rates in subsequent years of this survey.

The generalized linear model used to analyze catch revealed stark differences between species with respect to the ability to account for catch variability and the importance of model terms. Despite being a highly (98%) zero-dispersed data set, Kemp's ridley sea turtle catch data had a better model fit than the model fit for loggerhead sea turtles which contained 20% more positive catch events. One quarter of the variance in Kemp's ridley catch was able to be accounted for, but the adjusted catch was also associated with a higher CV. Surprisingly though, twice as much variance in Kemp's ridley sea turtle catch was attributed to water depth than year. Sub-region accounted for the fourth greatest amount of variation in Kemp's ridley catch (11%). In contrast, one-third as much total variance in loggerhead sea turtle catch was able to be accounted for, but over half of which was attributed to sub-region and none of which was attributed to water depth. Only four other model terms were deemed significant for both species, with the greatest difference between species noted for year, which accounted for half as much variance for loggerhead sea turtles (10%) as it did for Kemp's ridley sea turtles (20%). These findings collectively suggest that Kemp's ridley sea turtles are less randomly dispersed than loggerhead sea turtles within the boundaries of the regional trawl survey; however, the high preponderance of zero catch events for both species suggests that neither is randomly distributed.

Reinstatement of the original 30-minute bottom trawl time was vital to ensuring accurate catch rate comparisons among years within this survey. Although catch rate effort is most often expressed in units of time (Maier et al., 2004), we elected to substitute linear trawl transect distance given that this variable was most different in 2008-2009 when 20-min (vs. 30-min) bottom trawls were conducted under relatively constant trawl speeds among years. Lowest mean loggerhead sea turtle catch occurred in two years with the shortest trawl transect lengths, and the second highest mean catch occurred in 2011. Thus, had the original tow time not been restored we may have incorrectly concluded a decline in overall catch for loggerhead sea turtles when in fact loggerhead catch is at least stable. Reinstatement of the original tow time did not increase capture of unresponsive turtles, which we attribute to reasonable tow times given loggerhead dive durations while located within the regional trawl survey area (Arendt et al., in press a) and prior statistical analyses of the effects of tow time and drowning risk (Sasso and Epperly, 2006).

Inter-annual changes in loggerhead sea turtle catch among 5-cm size classes reflect the cyclical nature of population growth and decline. Progressive increases in catch of loggerhead sea turtles measuring 75.1 to 80.0 cm SCLmin during the past decade bode well for future nesting in the SE USA given sex and genetic ratios for loggerhead sea turtles captured in this survey to date. Furthermore, given ultrasound observation of follicles and possibly eggs in a female loggerhead 76.6 cm SCLmin (Owens and Segars, personal observation), it is possible that this size class doesn't just represent pubescent individuals approaching maturation, but rather, it also includes mature individuals. In the past two years, male loggerheads of similar size with tails extending beyond the carapace have also been collected. Pending estradiol (D. Rostal, GSU) analyses to examine size at maturity for female loggerhead sea turtles captured in this survey may provide crucial information regarding the representativeness of novel findings of maturity at smaller sizes than historically considered adult (NMFS and USFWS, 2008).

In addition to stable to increasing catch frequency, sea turtles collected during 2011 appeared to be reasonably healthy. Despite initial concerns at the beginning of the sampling season that "SCUD" (Septicemic Cutaneous Ulcerative Disease) or possibly keratin-consuming copepods (Badillo et al., 2007) were running rampant in the region, only three sea turtles (all loggerheads) were perceived to be sick, of which two were transferred to shore for treatment. Blood chemistry and cell counts were not different among sick and healthy sea turtles, suggesting, along with relatively quick rehabilitation and release turn-around times, that even these sick turtles were captured in the early (and therefore most treatable) stages of degradation. Evidence of physical trauma was noted in approximately one in three sea turtles collected, the majority of which were old injuries that had healed. These findings were consistent with long-term observations in this survey (Alderson, 2009) and suggest that sea turtles are hardy and resilient creatures. Similarity in head depressions among two live Kemp's ridleys (LK2074, LK2078) and a third dead Kemp's ridley sea turtle found floating in July was perplexing (Figure 8); however, given that these observations were made ~200 km and 10 days apart we do not suspect that they were related.

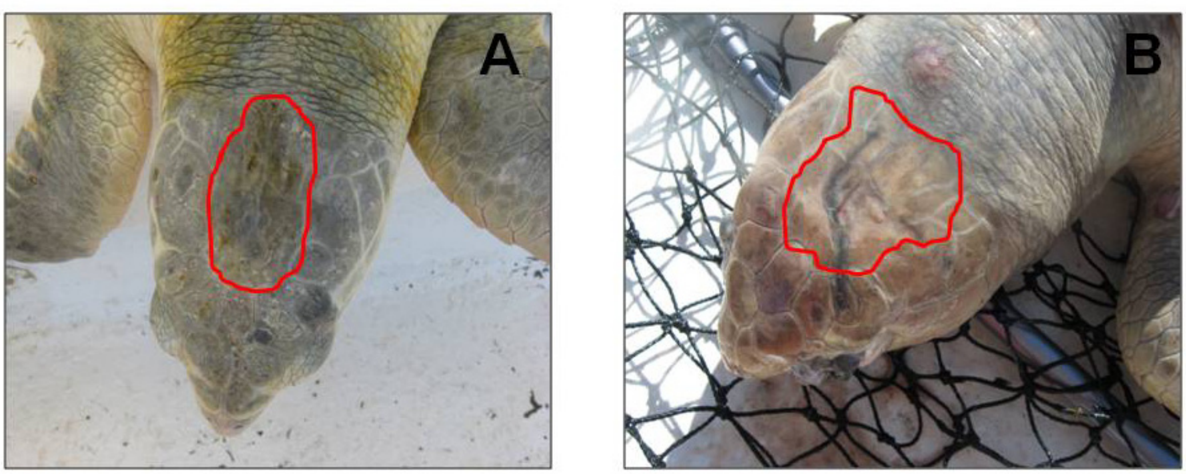

Figure 8. Cranial depressions (red circles) noted among live (A) and dead (B) Kemp's ridleys collected between north Florida (29°56'N) and south Georgia (31°16'N) in July 2011.

Data collected in this survey for loggerhead and Kemp's ridley sea turtles since 2000 are quite valuable for the respective management of each species, but also provide insight into the extent of inter-annual variation required to detect significant changes in their relative abundance. The most significant increases in loggerhead catch rates in the SE USA to date are reported from index station sampling in areas with strong seasonal aggregations (Epperly et al., 2007; Arendt et al., in press b). Conversely, long-term (1982-2005) monitoring in the Indian River Lagoon only revealed significant catch increases post-2002 (Ehrhart et al., 2007), the same timeframe during which significant catch increases were also reported by Epperly et al. (2007) and Arendt et al. (in press, b). Given similar trends across the SE USA, we surmise that significant changes in catch rates reflect large-scale fluctuations in population levels as opposed to local aggregation effects. Because detection of significant changes in catch only occurs during transition periods (i.e., the ascent and decline) following low and high populations levels, respectively, *when* sampling is conducted is equally important as how many years it encompasses. Sharp increases in Kemp's ridley sea turtle catch in 2011 illustrate this example.

<u>Given the decline in loggerhead nesting during the past decade (Witherington et al., 2009), the cyclical nature of nesting trends during the past three decades (Van Houtan and Halley, 2001), and size distributions observed in this survey, we predict that when significant increases in catch are detected in this survey, they will be driven by mature or maturing individuals</u>. This assertion contrasts with published catch increases of the past decade (Ehrhart et al., 2007; Epperly et al., 2007; Arendt et al., in press b) which were predominantly driven by loggerheads <70 cm SCL. However, given stable catch rates for loggerheads 55.1 to 75.0 cm SCLmin and increasing catch rates for loggerheads >75 cm SCLmin, the suggestion of increased catch rates driven by mature to maturing individuals seems plausible. Increased catch rates driven by mature to maturing individuals would also affirm successful transition of abundant cohorts from the juvenile to adult life history stages, validating the management and conservation efforts of the past decade and should increase regional nest counts, which have steadily increased since 2008 (FWC, 2011a). Conversely, the relative abundance of mature to maturing individuals (which in theory were more historically negatively anthropogenically impacted) should be substantially less than their younger counterparts given natural decline in cohort abundance with age; thus, it remains to be seen whether or not mature to maturing individuals could reach sufficiently high levels to actually drive a significant increase in catch rates for loggerhead sea turtles or any other species.

The preponderance of zero catches in the data sets for all sea turtle species collected in this trawl survey are not unique and 'plague' all surveys in the region, except possibly in-water monitoring at the St. Lucie Power Plant intake canal where entrainment rates have doubled in the last decade (see Discussion in Ehrhart et al., 2007). Analysis of catch using the generalized linear model greatly improved statistical confidence in reported catch trends, as evidenced by lower CV's for loggerhead sea turtles compared to previous analyses using non-parametric statistics; however, low overall catch still contributes to high CV levels for Kemp's ridley sea turtles. Despite an extensive multivariate design, substantial amounts of variance remain unexplained. Therefore, as we wait patiently for dramatic, and therefore detectable, population changes to manifest, we will continue to investigate additional variables in future years in order to continue to refine the data collection and analysis techniques presented herein, so that this trawl survey 'template' may be expanded to comprehensively monitor multiple key foraging grounds where sea turtles occur.

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Appendix 1. A summary of the 20 variables, factors, and interactions by which species specific catch counts were analyzed using a generalized linear model.

1) Temporal terms (*n* = 2)
   - Year
   - Time of day at the start of each trawling event (1 = 0700 to 0959 h LST; 2 = 1000 to 1259 h LST; 3 = 1300 to 1559 h LST; 4 = 1600 to 1959 h LST)

2) Spatial terms (*n* = 8)
   - Sub-region (1 = Charleston to Winyah Bay, SC; 2 = Savannah, GA to Charleston, SC; 3 = Brunswick to Savannah, GA; 4 = St. Augustine, FL to Brunswick, GA)
   - Mean water depth (m)
   - Absolute percent change in water depth between trawl start and end locations
   - Distance from shore (km) computed using Geographic Information System (GIS)
   - Distance (km) and bearing (°) from the closest of 31 inlets (see Appendix 2)
   - Transect bearing (°) between trawl start and end locations
   - Bottom type (1 = not hard, 2 = probable hard, 3 = hard bottom)

3) Hydrographic[1] and meteorological terms (*n* = 7)
   - Wind speed (kts) measured using a shipboard anemometer
   - Wind direction (N = 0°; NNE = 22.5°; NE = 45°; etc.) estimated from a shipboard wind vane
   - Visual estimation of percent cloud cover at the start of the trawling event
   - Daily mean (and change from the previous day) barometric pressure recorded at the centrally located Gray's Reef National Marine Sanctuary (GRNMS)[2]
   - Tide stage (0 = ebb, 1 = flood) and range (m) at the onset of trawling[3]

4) Interactions (*n* = 3)
   - Distance from shore and distance from inlet
   - Mean depth and distance from shore
   - Mean depth and distance from inlet

[1]Sea surface temperature recorded at the start of each sampling event was excluded from the model due to >500 missing observations, predominantly during 2002-2003 in the central portion of the trawl survey area. Given the significance of sub-region and sampling conducted one month plus or minus annual photoperiod maximum, we elected to exclude water temperature in order to retain the largest sample size with greatest spatial diversity possible.

[2] Barometric pressure at GRNMS (http://www.ndbc.noaa.gov/station_page.php?station=41008) was selected in lieu of shipboard observations given historically missing values for the regional data set; cluster analysis (Minitab 15®, Minitab, Inc., State College, PA) revealed a minimum of 99.2% similarity in daily mean values for seven National Ocean Service buoys located in the regional trawl survey area between 1 June and 31 July 2011.

[3] Tide stage (at the onset of trawling) and range data determined from hourly observations at four National Ocean Service stations (8720218 – Mayport, FL; 8670870 – Fort Pulaski, GA; 8665530 – Charleston, SC; 8662245 – North Inlet, SC). Ninety-five percent (*n* = 388) of trawling events in 2011 were matched to the closest water level station; however, missing water level data necessitated substitution of data from the next closest station for 22 events.

Appendix 2. Spatial distribution of inlets located in the regional sea turtle trawl survey area.

Sub-region	Inlet description	Latitude	Longitude
1	Winyah Bay	33.1967	-79.1667
1	North Santee	33.1200	-79.2417
1	South Santee	33.1067	-79.2833
1	Key Inlet	33.0167	-79.4050
1	Five Fathom Creek (Sandy Pt)	33.0000	-79.5000
1	Price Inlet	32.8667	-79.6500
1	Dewees Inlet	32.8167	-79.7167
2	Charleston Harbor	32.7333	-79.8333
2	Lighthouse Creek	32.6883	-79.8833
2	Stono Inlet	32.6167	-79.9833
2	North Edisto River	32.5500	-80.1667
2	South Edisto River	32.4750	-80.3333
2	Saint Helena Sound	32.4417	-80.3833
2	Fripp Inlet	32.3250	-80.4500
2	Trenchards Inlet	32.2667	-80.5833
2	Port Royal Sound	32.2500	-80.6500
2	Calibogue Sound	32.1000	-80.8333
3	Tybee Roads	32.0333	-80.8333
3	Wassaw Sound	31.9250	-80.9167
3	Ossabaw Sound	31.8333	-81.0000
3	Saint Catherine Sound	31.7083	-81.1333
3	Sapelo Sound	31.5333	-81.1667
3	Doboy Sound	31.3750	-81.2833
3	Altamaha Sound	31.3083	-81.2833
3	Hampton River	31.2133	-81.3083
4	Saint Simon Sound	31.1250	-81.4417
4	Saint Andrew Sound	31.0000	-81.4167
4	Saint Marys River	30.7083	-81.4167
4	Nassau Sound	30.5133	-81.4417
4	Saint John's River	30.4000	-81.4083
4	Saint Augustine Inlet	29.9133	-81.2883

Appendix 3. SCDNR News (**http://www.dnr.sc.gov/news/yr2011/june9/june9_scute.html**) Release from 7 June 2011 regarding the capture of CC0608, aka, "SCUTE".

Scute Didn't Scoot!
Rehabilitated Loggerhead recaptured near Charleston a year after release

One year and one month after being released back into the Atlantic Ocean following a successful rehabilitation at the South Carolina Aquarium's Sea Turtle Hospital, Scute, a loggerhead sea turtle, was recently recaptured during a regional turtle trawl survey managed by the S.C. Department of Natural Resources (DNR).

The Lady Lisa and her crew caught Scute off the coast of Kiawah Island, S.C. Between release and recapture, Scute's weight increased from 102 to127 pounds and the length increased almost 3 cm (1.25 inches), which is a normal rate of growth for a juvenile loggerhead of this size.

Scute is an acronym for the South Carolina United Turtle Enthusiasts, the sea turtle nest protection organization in Georgetown and Horry counties. The turtle was named after the group because the DNR sea turtle stranding network members responded to the stranded loggerhead on August 24, 2009 in Myrtle Beach, S.C. Scute was initially found with a rope entangled around its neck and a shell covered completely with tube worms and barnacles. The turtle was also anemic, severely emaciated and moderately hypoproteinemic (low levels of protein in its blood). Treatment included fluids, iron, vitamin B and antibiotics. Soon, Scute became an aggressive eater, perfected catching and consuming live blue crabs, a preferred prey item for loggerheads in the wild. After approximately eight months of care, Scute was released on May 1, 2010.

Scute is only the third sea turtle to be recaptured following successful rehabilitation and release by the Aquarium. All three were recaptured in the regional in-water trawl survey. DNR will continue to do its part to ensure accurate data is collected and available for making informed management decisions that affect the fate of loggerheads and the South Carolina Aquarium is making sure that every individual is given a fighting chance at survival.

Lighting and habitat disturbance are detrimental to sea turtle nesting and hatchling emergence. Because of this, we recommend the following steps to minimize any negative impact on sea turtles on the beach:

- Obey local and county ordinances regarding lighting, flashlights, fireworks and bonfires.
- Do not disturb (touch, flash photography or light shining) a nesting sea turtle and please observe her from a distance.
- Turn off lights and close blinds and drapes on windows visible from the beach, dusk to dawn, May through October.
- Encourage your local and county administrations to enforce their lighting ordinances.

- Fill in your holes on the beach at the end of the day (adults and hatchlings can become trapped in holes dug in the sand).

- Remove tents, chairs, etc. from the beach and dunes each day that could obstruct a sea turtle nesting at night.

- Remove trash (especially plastic bags and balloons) from the beach that could be mistaken for food by sea turtles if it blows into the ocean.
  Help increase the survival of sea turtles in our coastal waters by following these guidelines:

- While boating, look out for sea turtles that may be in your path. Mortality from boat interactions is on the rise.

- While boating, do not let litter blow out of your boat, and help remove trash from the water that could be mistaken for food by sea turtles.

If you spot an injured sea turtle on the water (or on the beach or in the marsh), call 1-800-922-5431 to report it. For all media inquiries, please contact Kate Dittloff at (843) 579-8660 or kdittloff@scaquarium.org or Brett Witt at (803) 667-0696, WittB@dnr.sc.gov

About the South Carolina Aquarium Sea Turtle Rescue Program:

In partnership with DNR, the South Carolina Aquarium Sea Turtle Rescue Program works to rescue, rehabilitate and release sea turtles that strand along the South eastern coast. Located at the Aquarium, the Sea Turtle Hospital admits 10 to 20 sea turtles each year. Many of these animals are in critical condition and some are too sick to save. To date the South Carolina Aquarium has successfully rehabilitated and released 62 sea turtles and is currently treating 18 patients. The average cost for a patient's treatment is $43 a day with the average length of stay reaching nine months.

About the DNR Marine Turtle Conservation Program:

The DNR Marine Turtle Conservation Program is responsible for managing and protecting sea turtles in the state of South Carolina. This program has several all-encompassing components: management, monitoring, research, and education. More specifically, this program implements management techniques to mitigate activities that may impact sea turtles and provides training and support to more than 1,100 volunteers across the coast who protect nests and document sea turtles that wash ashore (strandings). DNR staff members also perform necropsies on fresh dead strandings and respond to live strandings in need of care.

Over the last 10 years, the average number of sea turtle standings on South Carolina Beaches each year is 133. Of these, roughly 10 percent are alive and successfully transported to the Sea Turtle Hospital.

About the South Carolina Aquarium:

The South Carolina Aquarium, Charleston's most visited attraction, features thousands of amazing aquatic animals from river otters and sharks to loggerhead turtles in more than 60 exhibits representing the rich biodiversity of South Carolina from the mountains to the sea. Dedicated to promoting education and conservation, the Aquarium also presents fabulous views of Charleston harbor and interactive exhibits and programs for visitors of all ages.

The South Carolina Aquarium, a 501(c)(3) not-for-profit organization and is open Daily from 9 a.m. to 6 p.m. The Aquarium is closed Thanksgiving Day, half day Dec. 24 (open 9 a.m. to 1 p.m.) and Dec. 25. Admission prices are: Toddler's (1 and under) free; Youth (2-11) $12.95; Adults (12-61) $19.95; Seniors (62+) $18.95. The Aquarium plus the 4-D Theater experience is free for Toddler's, $17.95 for Children, $24.95 for Adults, and $23.95 for Seniors. The 4-D Theater experience only is $6.95 for Children, Adults and Seniors and $2.95 for Members and Member Guests. Military, senior, college and group discounts are available. For more information call 843-720-1990. Memberships are available by calling 843-577-FISH.

About the DNR Regional Sea Turtle Health and Abundance Survey:

For the past decade, DNR has managed a federally-funded survey designed to evaluate trends in catch rates and health of wild sea turtles in coastal waters between Florida and South Carolina. The regional survey is conducted by DNR and the UGA Marine Extension Service and involves dragging modified shrimp nets at about 500+ randomly determined stations each summer. Since 2000, in-water sea turtle research managed by the SCDNR has collected, tagged and released more than 1,700 loggerheads between central Florida and South Carolina of which only 17 were previously tagged by another program and only another 47 (38 live, 9 stranded) have been re-sighted again in subsequent surveys. Low recapture rates in the various in-water surveys managed by the DNR are consistent with stable to increasing catch rates for loggerheads relative to several decades ago.

Appendix 4: Summary report of barnacle analysis for sea turtles sampled since 2002.

In 2011, 274 turtle barnacles were sampled from nine loggerhead sea turtles (Table 1). Excluding opportunistic barnacle species that mostly attach to other barnacles, the assessed samples included three species that are obligate commensals of sea turtles: *Chelonibia testudinaria, Platylepas hexastylos* and *Stomatolepas elegans*. Similar to 2010, *C. testudinaria* (carapace and plastron) and *P. hexastylos* (flipper and head scales) were present on all turtles whereas *S. elegans* (soft skin of the body) was present on just one turtle. A fourth commensal turtle barnacle that attaches to the carapace, *C. caretta*, was not observed in 2011.

Excluding 2004, barnacles have been sampled annually from sea turtles (*n* = 179) collected during the various phases of this trawl survey (regional, Charleston channel, Canaveral channel) since 2002 (Table 2). Among 174 loggerhead, four Kemp's ridley, and one green sea turtle sampled to date, *C. testudinaria* (*n* = 169, 91%) and *P. hexastylos* (*n* = 66, 37%) have been the most commonly observed barnacles. A third carapace-attaching barnacle, *C. caretta*, was found in 18% (*n* = 32) of turtles sampled for barnacles, and the skin barnacle *S. elegans* was obtained from just 3% (*n* = 5) of sampled turtles. However, these patterns of occurrence and measures of abundance across years can only be considered broadly qualitative assessments as sampling procedures were not quantitative and barnacle sampling effort was not even from year-to-year.

Though equitable comparisons cannot be made within and across years several generalizations do seem possible. The first is that *S. elegans* is uncommon on loggerheads in the southeast; however, this barnacle is not as easily sampled as others since it resides in the harder to reach, soft skin areas of the turtle so it may be under-sampled to some degree. *P. hexastylos* is probably the most common barnacle and very likely is found on virtually 100% of turtles, but has been under-represented in the samples. In some years this species was not recorded although it was undoubtedly present. *Chelonibia testudinaria* is also likely present on all turtles; thus, as the most easily observed (and thus, collected) barnacle it is likely over-represented in the samples. The barnacle *C. caretta* is similar to *C. testudinaria* in appearance and life mode, but has been collected at much lower frequencies in the samples collected to date.

If the patterns observed for *S. elegans* and *C. caretta* are accurate then the question arises as to why some turtles have these barnacles while others do not? The answer may have to do with where individual turtles have traveled; however, a residential pattern among loggerheads recaptured or satellite tagged (Arendt et al., in press a) in the trawl survey area is acknowledged.

Prior to 2010, collections were focused primarily on samples from the carapace; thus, specimens of *P. hexastylos* (flippers) and *S. elegans* (soft skin) were under-represented. Since 2010, barnacles collected from the carapace, flippers, and the skin have been placed in separate vials. This practice results in some overlap of species among the vials (i.e. some barnacle species can attach in multiple places, especially as small individuals), but has had the intended result of distributing sampling effort more evenly across the turtle. As such, for 2010-2011, it can be stated confidently that all 27 loggerhead sea turtles sampled for barnacles carried *C. testudinaria* and *P. hexastylos*, two hosted *S. elegans*, and no turtles hosted *C. caretta*.

Additional improvements to the collecting protocol could perhaps be made in future years. Assessments using the 3-vial approach probably provide a reasonable qualitative approach to assaying barnacle diversity on turtles. A fifth turtle barnacle, *S. praegustator*, is known to occur with loggerheads in the southeast, but lives in the mouth of turtles which makes sampling it difficult; thus, its prevalence has not been evaluated to date but perhaps could be in future years. Every turtle caught is examined for barnacle load; however, detailed barnacle data are not recorded for every turtle nor is every turtle sampled for barnacles. Incorporation of a systematic review of barnacle coverage could enhance the quality of data collected during the turtle physical exam and would be feasible, provided that data collection was not laborious and counter to the need and desire to quickly process turtles and return them to the sea. Historically, turtles selected for barnacle sampling were generally the first turtles captured aboard each research vessel during the sampling season and/or turtles where other collaborator samples were also being collected. Therefore, a more refined and statistically rigorous protocol for selecting the subset of turtles for barnacle sampling is in order and will be implemented in 2012.

Table 1. Species identification and abundance of barnacles collected from 9 loggerhead sea turtles off the southeastern U.S. in 2011.

Turtle ID	*C. testudinaria*	*P. hexastylos*	*S. elegans*	N barnacles
CC0608	11	19	0	30
CC0609	5	24	0	29
CC0623	5	28	0	33
CC0625	7	17	0	24
CC0626	5	27	0	32
CC2866	8	30	0	38
CC2876	15	26	0	41
CC2902	10	15	0	25
CC2903	7	7	8	22
Totals	*73*	*193*	*8*	*274*

Table 2. Commensal barnacles collected from sea turtles off the SE USA, 2002 to 2011.

Year	N turtles	*C. testudinaria*	*C. caretta*	*P. hexastylos*	*S. elegans*	N barnacles
2011	9	73	0	193	8	274
2010	18	85	0	236	3	324
2009	12	69	0	134	4	207
2008	12	55	26			81
2007	24	78	19	24	0	121
2006	14	94	3	6	0	103
2005	6	48	0	93	0	141
2003*	37	89	26	36	15	166
2002**	47	159	24	37	20	240
Totals	*179*	*750*	*98*	*759*	*50*	*1657*

*includes 3 Kemp's ridleys **includes 1 Kemp's ridley and 1 green turtle

Appendix 5: Listing of all by-catch organisms reported from sampling efforts in 2011.

SpeciesCode	ScientificName	Category	Count	Estimate
A003	GINGLYMOSTOMA CIRRATUM	Shark	6	0
A005	EUGOMPHODUS TAURUS	Shark	1	0
A014	CARCHARHINUS ACRONOTUS	Shark	33	2
A018	CARCHARHINUS LIMBATUS	Shark	13	0
A023	GALEOCERDO CUVIERI	Shark	1	0
A028	RHIZOPRIONODON TERRAENOVAE	Shark	495	132
A029	SPHYRNA LEWINI	Shark	60	17
A031	SPHYRNA TIBURO	Shark	509	118
A615	CARCHARHINUS BREVIPINNA	Shark	2	0
A041	NARCINE BRASILIENSIS	Ray	1	0
A048	DASYATIS AMERICANA	Ray	465	162
A049	DASYATIS CENTROURA	Ray	21	9
A051	DASYATIS SAYI	Ray	26	0
A054	GYMNURA MICRURA	Ray	251	186
A056	AETOBATUS NARINARI	Ray	8	0
A057	MYLIOBATIS FREMINVILLEI	Ray	63	15
A059	RHINOPTERA BONASUS	Ray	92	40
A644	MOBULA HYPOSTOMA	Ray	3	3
A043	RAJA EGLANTERIA	Skate	4	6
A039	RHINOBATOS LENTIGINOSUS	Guitarfish	13	0
A084	BREVOORTIA TYRANNUS	Midwater/Pelagic	2	0
A088	OPISTHONEMA OGLINUM	Midwater/Pelagic	17	0
A206	POMATOMUS SALTATRIX	Midwater/Pelagic	14	1
A207	RACHYCENTRON CANADUM	Midwater/Pelagic	3	0
A208	ECHENEIS NAUCRATES	Midwater/Pelagic	3	0
A216	CARANX CRYSOS	Midwater/Pelagic	2	0
A220	CHLOROSCOMBRUS CHRYSURUS	Midwater/Pelagic	23479	3150
A223	DECAPTERUS PUNCTATUS	Midwater/Pelagic	11	0
A229	SELENE VOMER	Midwater/Pelagic	241	2
A234	TRACHINOTUS CAROLINUS	Midwater/Pelagic	51	20
A238	SELENE SETAPINNIS	Midwater/Pelagic	4212	723
A353	TRICHIURUS LEPTURUS	Midwater/Pelagic	32	33
A362	SCOMBEROMORUS MACULATUS	Midwater/Pelagic	11	2
A376	PEPRILUS TRIACANTHUS	Midwater/Pelagic	2053	236
A466	ANCHOA SP.	Midwater/Pelagic	61	81
A488	ECHENEIDAE	Midwater/Pelagic	0	1
A537	CARANGIDAE	Midwater/Pelagic	2	0
A941	ECHENEIS SP.	Midwater/Pelagic	11	0
B423	PEPRILUS PARU	Midwater/Pelagic	1926	486
A277	CYNOSCION NOTHUS	Sciaenid	198	41
A278	CYNOSCION REGALIS	Sciaenid	29	6
A283	LARIMUS FASCIATUS	Sciaenid	3397	777
A284	LEIOSTOMUS XANTHURUS	Sciaenid	1623	418
A285	MENTICIRRHUS AMERICANUS	Sciaenid	109	38
A288	MICROPOGONIAS UNDULATUS	Sciaenid	585	184
A291	STELLIFER LANCEOLATUS	Sciaenid	46	4

Appendix 4, continued.

SpeciesCode	ScientificName	Category	Count	Estimate
A175	CENTROPRISTIS OCYURUS	Reef	10	0
A176	CENTROPRISTIS PHILADELPHICA	Reef	2	0
A177	CENTROPRISTIS STRIATA	Reef	15	0
A258	HAEMULON AUROLINEATUM	Reef	2	0
A262	ORTHOPRISTIS CHRYSOPTERA	Reef	15	0
A263	ARCHOSARGUS PROBATOCEPHALUS	Reef	7	0
A271	LAGODON RHOMBOIDES	Reef	36	5
A273	STENOTOMUS ACULEATUS	Reef	664	26
A274	STENOTOMUS CHRYSOPS	Reef	1	0
A297	CHAETODIPTERUS FABER	Reef	2924	456
A333	HYPLEUROCHILUS GEMINATUS	Reef	7	0
A426	ALUTERUS SCHOEPFI	Reef	3	0
A427	ALUTERUS SCRIPTA	Reef	3	0
A428	BALISTES CAPRISCUS	Reef	11	0
A434	STEPHANOLEPIS HISPIDUS	Reef	20	0
A439	ACANTHOSTRACION QUADRICORNIS	Reef	56	5
A442	LAGOCEPHALUS LAEVIGATUS	Reef	2	0
A444	SPHOEROIDES MACULATUS	Reef	6	1
A448	CHILOMYCTERUS SCHOEPFI	Reef	659	61
A464	ALECTIS CILIARIUS	Reef	6	0
A474	BLENNIIDAE	Reef	14	0
A522	SCORPAENIDAE	Reef	1	0
A097	SYNODUS FOETENS	Demersal	548	27
A178	DIPLECTRUM FORMOSUM	Demersal	12	0
A392	PRIONOTUS CAROLINUS	Demersal	2240	310
A393	PRIONOTUS EVOLANS	Demersal	365	48
A397	PRIONOTUS SCITULUS	Demersal	14	0
A398	PRIONOTUS TRIBULUS	Demersal	21	0
A498	HIPPOCAMPUS SP.	Demersal	3	0
A530	SYNGNATHIDAE	Demersal	1	0
A564	PRIONOTUS SP.	Demersal	1	0
A401	ANCYLOPSETTA QUADROCELLATA	Flatfish	250	23
A405	CITHARICHTHYS MACROPS	Flatfish	3	0
A406	CITHARICHTHYS SPILOPTERUS	Flatfish	3	0
A408	ETROPUS CROSSOTUS	Flatfish	21	2
A413	PARALICHTHYS DENTATUS	Flatfish	5	1
A414	PARALICHTHYS LETHOSTIGMA	Flatfish	8	0
A417	SCOPHTHALMUS AQUOSUS	Flatfish	3	0
A420	TRINECTES MACULATUS	Flatfish	1	0
B601	TUNICATA	Tunicate	598	108
B634	STYELA SP.	Tunicate	189	139
B639	APLIDIUM STELLATUM	Tunicate	571	416
B670	EUDISTOMA HEPATICUM	Tunicate	307	101
C324	MICROCIONA PROLIFERA	Sponge	6	10
C374	PORIFERA	Sponge	126	28
C375	CLIONA SP.	Sponge	1	0

Appendix 4, continued.

SpeciesCode	ScientificName	Category	Count	Estimate
C414	HALICLONA SP.	Sponge	28	38
C428	IRCINIA SP.	Sponge	46	11
D003	PENAEUS AZTECUS	Shrimp	210	37
D005	PENAEUS SETIFERUS	Shrimp	4	20
D050	LYSMATA WURDEMANNI	Shrimp	3	0
D290	ALPHEIDAE	Shrimp	7	0
E001	SQUILLA EMPUSA	Shrimp	1	1
E002	SQUILLA SP.	Shrimp	5	0
E108	SQUILLA NEGLECTA	Shrimp	3	0
E309	STOMATOPODA	Shrimp	2	0
D019	DROMIIDAE	Crab	45	1
D023	DECAPODA	Crab	2	0
D059	PILUMNUS SP.	Crab	67	5
D070	PORCELLANA SAYANA	Crab	1	0
D081	PETROCHIRUS DIOGENES	Crab	1	0
D112	CALAPPA FLAMMEA	Crab	57	1
D116	HEPATUS EPHELITICUS	Crab	4	0
D120	OVALIPES STEPHENSONI	Crab	79	3
D121	OVALIPES OCELLATUS	Crab	12	0
D124	PORTUNUS GIBBESII	Crab	14	2
D128	PORTUNUS SPINIMANUS	Crab	10	0
D130	CALLINECTES SAPIDUS	Crab	202	37
D142	MENIPPE MERCENARIA	Crab	30	1
D244	XANTHIDAE	Crab	2	0
D246	LIBINIA SP.	Crab	449	2595
D247	CALLINECTES SIMILIS	Crab	8	0
D403	PAGURIDEA	Crab	16	53
F001	LIMULUS POLYPHEMUS	Horseshoe	415	411
H001	RENILLA RENIFORMIS	Soft coral	1	0
H002	LEPTOGORGIA VIRGULATA	Soft coral	9	41
H275	LEPTOGORGIA SP.	Soft coral	2	0
H309	TELESTO SP.	Soft coral	12	0
H005	STOMOLOPHUS MELEAGRIS	Jellyfish	8552	19109
H244	CHRYSAORA QUINQUECIRRHA	Jellyfish	318	2678
H246	AURELIA AURITA	Jellyfish	3	5
H249	SCYPHOZOA	Jellyfish	1	0
H383	CUBOZOA	Jellyfish	2581	2857
H508	CTENOPHORA	Jellyfish	12	0
H023	PARANTHUS RAPIFORMIS	Anemone	1	0
H288	ACTINIARIA	Anemone	1	0
J001	ASTERIAS FORBESII	Sea star	58	1653
J003	ASTROPECTEN ARTICULATUS	Sea star	9	22
J008	LUIDIA ALTERNATA	Sea star	1	0
J086	OPHIUROIDEA	Sea star	48	82
J166	OPHIODERMA SP.	Sea star	2	0
J215	LUIDIA SP.	Sea star	197	5376

Appendix 4, continued.

SpeciesCode	ScientificName	Category	Count	Estimate
J068	MELLITA QUINQUESPERFORATA	Dollar/biscuit	4	0
J071	SPATANGOIDEA	Dollar/biscuit	1	0
J100	CLYPEASTER SUBDEPRESSUS	Dollar/biscuit	117	193
J117	CLYPEASTER SP.	Dollar/biscuit	17	6
J072	LYTECHINUS VARIEGATUS	Urchin	1609	516
J085	ARBACIA PUNCTULATA	Urchin	696	256
J214	HOLOTHUROIDEA	Sea cucumber	29	21
M501	ALCYONIDIUM HAUFFI	Bryozoan	28	48
M563	BRYOZOA	Bryozoan	1	40
N069	CASSIS MADAGASCARIENSIS	Whelk/conch	16	2
N103	BUSYCON CONTRARIUM	Whelk/conch	7	0
N104	BUSYCON CARICA	Whelk/conch	21	0
N112	PLEUROPLOCA GIGANTEA	Whelk/conch	17	0
N328	OCTOPUS VULGARIS	Octopus/Squid	12	0
N333	LOLLIGUNCULA BREVIS	Octopus/Squid	22	0
N382	BUSYCON SP.	Octopus/Squid	1	1
N386	LOLIGO SP.	Octopus/Squid	161	3
N064	SINUM PERSPECTIVUM	Misc gastropod	1	0
N514	FASCIOLARIA SP.	Misc gastropod	1	0
N208	ATRINA SERRATA	Mollusc	2	0
N261	DINOCARDIUM ROBUSTUM	Mollusc	7	0
Q004	ALGAE	Algae	1	0