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

One hundred thirty-four individual loggerhead (as well as 14 Kemp's ridley and one green) sea turtles were collected in 480 sampling events in four strata pairs sampled within the regional trawl survey during summer 2010. Among loggerheads, two were recaptured within the same season, two were recaptured after one year at large, and two others were recaptured after eight years at large. Two additional loggerheads collected in 2010 were originally tagged and released by other programs; one was a male that was originally collected in the Beaufort River in SC in summer 2000, while the other loggerhead was female and presumably tagged while nesting in Georgia but has yet to be confirmed. Body mass for more than 80% of loggerheads suggested good health which was substantiated from blood work, despite most (*n*=33 of 39) occurrences of physical injuries being associated with these otherwise healthy turtles. Only two (1.5%) loggerheads were sufficiently debilitated to warrant transport to shore for care, one of which was treated and released within five months. Body mass and blood work for Kemp's ridleys and the lone green sea turtle suggested good health, despite 43% of Kemp's ridley sea turtles exhibiting physical injuries, one of which was severe enough to warrant transporting this sea turtle to shore for care where it still remains. In addition to good health, sustained increases in median size, a strong female bias, genetic distributions consistent with regional nesting haplotypes, and emerging data on the time required for (and size at which) median-sized loggerheads transition to maturity suggest cautious optimism regarding future loggerhead nesting in the Southeast U.S.

The modified sampling design evaluated in 2010 was not associated with significantly different catch rates; however, by blocking for spatial variation the modified design did foster improved efforts to evaluate factors that influence loggerhead catch. Loggerheads were never collected at 54% of stations (*n*=96 of 178) sampled at least twice, and this theme was consistent among strata pairs throughout the sampling region. Among stations where at least one loggerhead was collected, only four stations were always associated with loggerhead catch. With the exception of passage of a low pressure system during week one of the sampling season, environmental variables were not implicated as influences on loggerhead catch rates. Water depth, distance from shore, time of day, and tide stage did not routinely influence loggerhead catch rates. Recapture rates, notably within-season recapture rates, appeared to increase with the modified sampling design; however, given low frequency of occurrence of within-season recapture rates and that both within-season recapture rates occurred in close proximity to the Altamaha Reef where four of six project and both non-project loggerhead recaptures occurred in 2010, the location of repeat sampling was likely equally (if not more) important as repeat sampling itself.

Data collected in 2010 reinforce the notion that while loggerheads have the potential to be highly mobile, during the May to July sampling season they tend to exhibit fidelity to particular areas if not specific locations. Why loggerheads cluster where they do is uncertain; however, it is clear that clustering does occur and additional efforts have been proposed to further study this important issue. In the meantime, although random sampling to collect a species with a clustered distribution likely contributes to the preponderance of zero loggerhead catches, it also provides the necessary precautions to mitigate for spatial influences on catch probability. Because single and double loggerhead catches represent 95% of positive catch events, random increases in inter-annual sampling effort at 'hot spots' should not disavow the regional trawl survey data set from use in trends analysis for management of the NW Atlantic loggerhead.

Introduction

The loggerhead sea turtle (*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 abundance and 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.

A regional in-water trawl survey was initiated in May 2000 following a call by the Turtle Expert Working Group (TEWG) to conduct "…long-term, in-water indices of loggerhead abundance in coastal waters (TEWG, 1998)." This regional survey generally operated between mid-May through July in coastal waters within 12km of shore from Winyah Bay, SC, to St. Augustine, FL during 2000 to 2003 and again during 2008 and 2009. Sampling was conducted in a nearly simultaneous manner using multiple research trawlers to complete more than 500 randomly selected stations each season. Catch rates were stable to increasing between 2000 and 2009, as well as high relative to historical data sets (Maier et al., 2004; Arendt et al., 2009). Variability in catch was reported among as well as within geographic sub-regions, the latter of which especially suggested a need to assess the "detectability" (Anderson, 2001) or probability of sea turtles being present during sampling in order to scale catch by appropriate correction factors.

A collection of data amassed in the regional survey to date suggests that loggerheads collected in this survey are seasonally resident individuals. Between 2000 and 2009, 15 loggerheads tagged in the regional study were subsequently recaptured in the same or adjacent sampling strata where they were originally collected four months to eight years earlier. Satellite telemetry studies with 34 juvenile loggerheads during 2004-2007 revealed generally localized distributions within the same season as well as affinity for the same areas the following spring/summer when over-wintering data were able to be collected (Arendt et al., 2009). Seasonal foraging areas were at least five times smaller when loggerheads were distributed on the inner continental shelf between April and December at water temperatures ≥17°C (Arendt et al., 2009).

Explanation of variation in catch rates in the context of hydrographic, meteorological or foraging factors was less precise. Spatial analyses revealed distinct clustering of loggerhead distributions; however, these clusters were not able to be attributed to specific habitats or prey distributions given limitations of companion data sets. Principal components analysis suggested only weak (PC1~18%) associations between loggerhead catch and 15 corresponding factors, of which consistent trends among geographic sub-regions were not observed. Therefore, in an effort to attempt to improve the ability to assess the probability of loggerheads being present in the survey area at the time of sampling, a modified sampling protocol was evaluated in summer 2010. Rather than randomly sample the entire regional survey area, two adjacent (inshore, offshore) strata pairs were randomly selected for each of four geographic sub-regions, from which 45 stations were randomly selected for repeat sampling. This report details the results of that design with respect to catch, recaptures and enhanced efforts to explain variation in catch rates.

Methods

Study Areas, Research Vessels, and Trawl Specifications
Trawling was conducted aboard two double-rigged research trawlers (R/V *Georgia Bulldog* and the R/V *Lady Lisa*) towing at speeds of 2.5-3.0 knots. Standardized National Marine Fisheries Service (NMFS) turtle nets (19.8m (65') head-rope, 4-seam, 4-legged, 2-bridal nets) were used. Net body consisted of 10.2cm (4") bar and 20.3cm (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 5.1cm (2") bar and 10.2cm stretch mesh. Beginning in 2008, fiscal constraints scaled the 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 within four randomly selected strata pairs corresponding to four geographic sub-regions 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 10km) and further offshore (10 to 20km) stations were alternately sampled before and after noon to prevent fine scale spatial-temporal biases. Permit requirements limited trawl duration to 20 minutes (bottom time) which represented a 33% reduction in trawl duration relative to sampling effort used in 2000-2003.

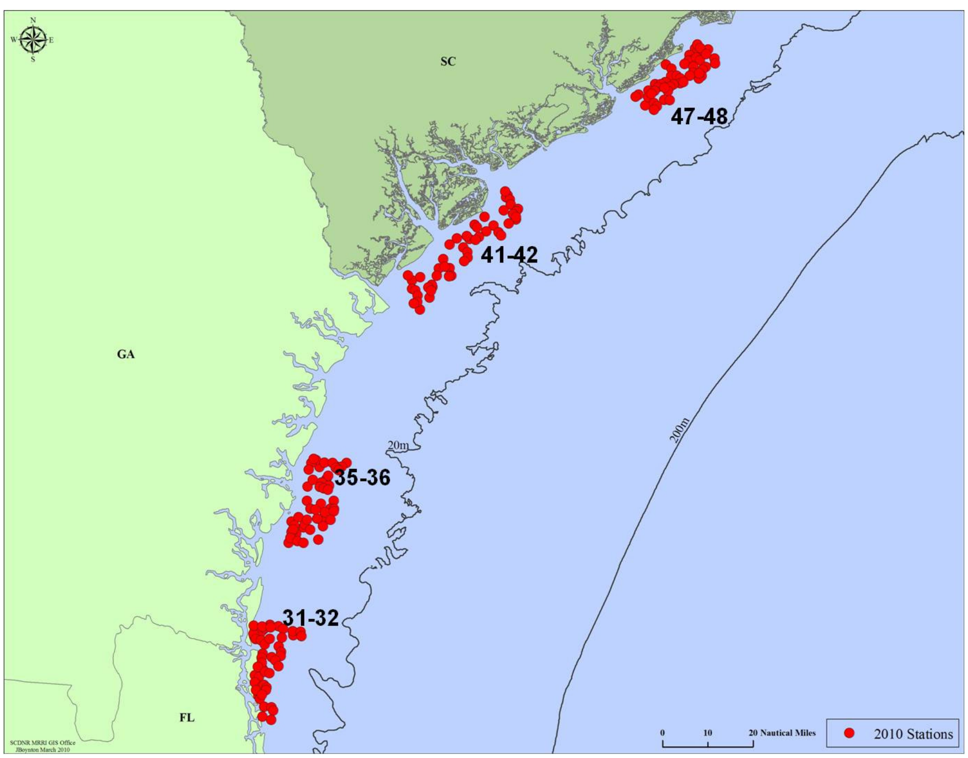


Figure 1. Spatial distribution of strata pairs and stations sampled during summer 2010.

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 from the dorsal cervical sinus of loggerhead turtles as described by Owens and Ruiz (1980). Blood samples were collected in vacutainer tubes using a 21-gauge, 3.8cm (1.5 in) vacutainer needle and hub apparatus. Blood was collected while turtles were oriented head-down in a reclined position to facilitate blood flow to the cervical sinus. Prior to inserting the sterile vacutainer needle, the blood draw site was prepped with a betadine-soaked cotton ball. A maximum of four blood sticks (two per side of the neck) were attempted per sea turtle.

Blood samples were restricted to a maximum of 45ml total volume and did not exceed the total recommended volume (10% of total blood volume) described by Jacobson (1998) who estimated that total blood volume in reptiles is 5 to 8% of total body weight. With respect to sea turtles recaptured within a 45-day window, we adhered to the additional NMFS stipulation that cumulative repeat blood collection be restricted to < 1.5ml per kg of body weight.

Blood samples were collected for the following collaborators and purposes, with vacutainer tubes sub-sampled (sterile procedures) for at sea determination of hematocrit (whole blood centrifuged and read against a chart), total protein (plasma concentration measured using a refractometer), and glucose (drop of whole blood read using a glucose meter):

1) Genetics - 3ml (University of South Carolina & University of Georgia)
2) Steriod hormones - 10ml (College of Charleston, Georgia Southern University).
3) Nutrition studies – 10ml (coordinated by the Georgia Sea Turtle Center).
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 Cooperative Marine Turtle Tagging Program (CMTTP). Per the CMTTP instructions, 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
Raw data were recorded in hard copy format on various forms before at-sea electronic entry using laptop computers. Data were generally entered electronically in between trawling events, but always on the same day as data collection. Photographs were also downloaded and renamed nightly. At-sea data entry allowed for early detection (and correction) of most errors; however, a rigorous comparison of hard copy and electronic data sets was completed at the end of sampling for each vessel before importing data into a central data base (MS Access).

Multiple Regression (R version 2.5.0; R Core Team, Vienna, Austria) was used to test for statistical differences in catch rates (running total of loggerhead catch versus number of stations sampled to achieve the running total) among triplicate cruises within each strata pair.

Given non-normal distribution of most data, non-parametric Kruskal-Wallis (KW) rank tests and Bonn-Ferroni multiple comparisons (Minitab 15; MiniTab Inc., State College, Pennsylvania) were used extensively for within and among strata pair comparisons. KW tests were used to compare loggerhead counts per sampling event among years. KW tests were used evaluate sampling condition at the start of each trawling event with respect to sea surface temperature (1.5m below water surface measured using a hull-mounted transducer), barometric pressure, wind speed and direction (text converted to numeric per Arendt et al., 2009), vessel tow speed, water depth and distance from shore (calculated in GIS). KW tests were also used to evaluate sampling effort and loggerhead catch among cruises relative to water level (i.e., tide stage) for two strata pairs (31-32, 41-42) using verified six-minute National Ocean Service (NOS) water level data. Data for Fernandina, FL (Station 8720030) and Fort Pulaski, GA (Station 8670870) were obtained from the NOS website (http://tidesandcurrents.noaa.gov/) and matched with trawl start time using a relational data base (MS Access). KW test were also used to evaluate loggerhead size distributions and clinical blood values collected at sea and in the lab.

Chi-square contingency tables (Minitab 15) were used to statistically test for differences in loggerhead catch with respect to time of day (three hour time blocks between 0700 to 0959 hrs through 1600 to 1859 hours), as well as among sex and genetic distributions.

Gear selectivity (or rather catchability given the size of sea turtles relative to mesh size) was evaluated using tag-recapture data accumulated for loggerheads collected and recaptured within the regional trawl survey area using standardized NMFS turtle nets since 2000. Myers and Hoenig (1997) proposed a method for evaluating gear selectivity by dividing the fraction of loggerheads recaptured for a given size class divided by the largest recapture rate fraction. A histogram of loggerheads collected in 10-cm size classes (SCLmin) was generated, to include measurements of recaptured turtles at the time of recapture. A second histogram was created for the number of loggerheads recaptured based on their size at initial collection. Gear selectivity was also evaluated as a function of loggerhead catch relative to the dry weight of turtle nets.

Due to low recapture rates during the 2010 sampling season, as well as overall since 2000, catchability was not analyzed using MARK Version 5.0 as was originally proposed in spring 2009 as a means for analysis of data collected in summer 2010. Similarly, due to low daily loggerhead catch and high incidence of not catching any loggerheads on the first sampling event of the day (Appendix 1), the approach (Butler et al., 1987) proposed in spring 2009 to calculate catchability (as well as to estimate the number of loggerheads present in the sampling area) was not appropriate and therefore is not included in this report.

Results

Sampling effort and overview of sea turtle catch

Fifty-three sea days of trawling were completed between 24 May (R/V *Lady Lisa*; 24 sea days) and 23 July (R/V *Georgia Bulldog*; 29 sea days) with a two-week lag between the start dates for the two research vessels. Fewer sea days were completed aboard the R/V *Lady Lisa* due to inclement weather and vessel availability; however, total sampling effort was comparable between the two vessels (232 events for the *Lady Lisa*, 248 events for the *Georgia Bulldog*).

All but three of 181 unique stations designated for sampling in 2010 were sampled at least twice, with 67% sampled on three (*n*=119) and four (*n*=1) occasions (Table 1). Daily sampling effort ranged from two to 14 stations with a median distribution of 10 stations per day for all strata pairs except strata pair 31-32 (Appendix 1). Sampling effort in all four strata pairs was more concentrated in 2010 than in 2009 (when all strata pairs in all four sub-regions were sampled), but spanned the same geographic scope within each strata pair in both years (Figures 2-5).

Loggerheads were never collected at 54% (*n*=96) of stations sampled at least twice (Table 1, Appendix 2). Loggerheads were always collected at four stations in a 60km^2 area off the southern end of Amelia Island, FL. The maximum number of loggerheads collected per day among strata pairs ranged from three (41-42) to 12 (31-32). Days with no loggerheads collected ranged from one (7%; strata 35-36) to four (29%; strata 31-32). Days with no loggerheads on the first tow, however, ranged from 73% (*n*=9; strata 47-48) to 91% (*n*=11; strata 31-32) of all days.

A total of 134 individual loggerhead sea turtles were collected, including six loggerheads originally tagged and released by this trawl survey, bringing the total number of loggerheads originally tagged and recaptured in the regional trawl survey area to 21 since 2000 (Table 2). Two loggerheads recaptured in 2010 were tagged and released during cruise one in strata pair 35-36 and recaptured in the same strata pair during cruise three (35 to 37 days at large). Two additional loggerheads (CC0532, CC2729) were tagged and released in 2009, with the remaining two loggerheads (CC4089, CC2231) originally tagged and released in 2002.

In addition to within-project loggerhead recaptures, two loggerheads originally tagged and released by other programs were also collected. The first loggerhead (CC2809) was recaptured as a mature/maturing male nearly 10 years after being collected as a live stranded juvenile in the Beaufort River in SC (Appendix 3). Tag origin for the second loggerhead (CC2829) has not been able to be determined yet after several attempts to do so. Both recaptures of non-project loggerheads also occurred in strata pair 35-36.

Species other than loggerheads comprised 10% (n=15 sea turtles) of total sea turtle catch. Fourteen Kemp's ridley (*Lepidocheyls kempi*) sea turtles were collected in strata pairs 35-36 (n=6) and 31-32 (n=8). In both strata pairs, at least one Kemp's ridley sea turtle was collected during all three cruises. A single green sea turtle (*Chelonia mydas*) was collected in strata pair 35-36 during cruise three.

Table 1. Characterization of repeat sampling efforts and loggerhead catch (presence/absence) at 181 unique stations randomly selected and sampled during summer 2010.

Strata Pair	Frequency	N stations	Zero catch	100% catch	Mixed catch
47-48	thrice	29	16	0	13
47-48	twice	13	7	0	6
47-48	once	3	2	0	1
41-42	thrice	30	15	0	15
41-42	twice	13	9	0	4
41-42	once	0			
35-36	four*	1	0	0	1
35-36	thrice	42	23	0	19
35-36	twice	3	1	0	2
35-36	once	0			
31-32	thrice	18	5	1	12
31-32	twice	29	20	3	6
31-32	once	0			

*inadvertently sampled this station twice during cruise one

Table 2. Summary of loggerheads collected, tagged (rows), and recaptured (columns) using turtle nets in coastal waters associated with the regional trawl survey. Within-season recapture data for 2008 comprises two loggerheads collected during targeted sampling.

	Recaptured										
Tagged	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
2000	0	0	1	4					0	0	0
2001		0	0	2					1	2	0
2002			1	1					0	0	2
2003				0					0	0	0
2004											
2005											
2006											
2007											
2008									2	1	0
2009										0	2
2010											2

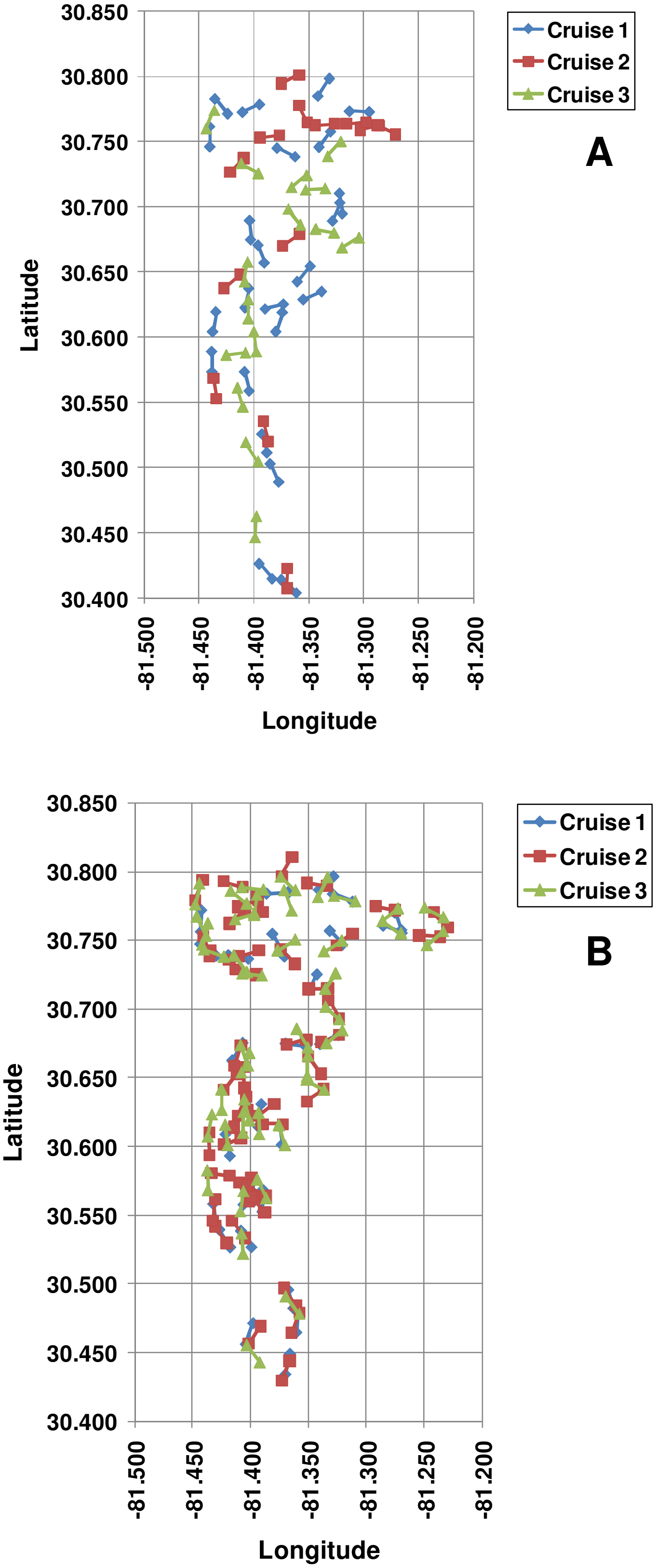


Figure 2. Spatial distribution of sampling effort in 2009 (A) vs. 2010 (B) for strata pair 31-32.

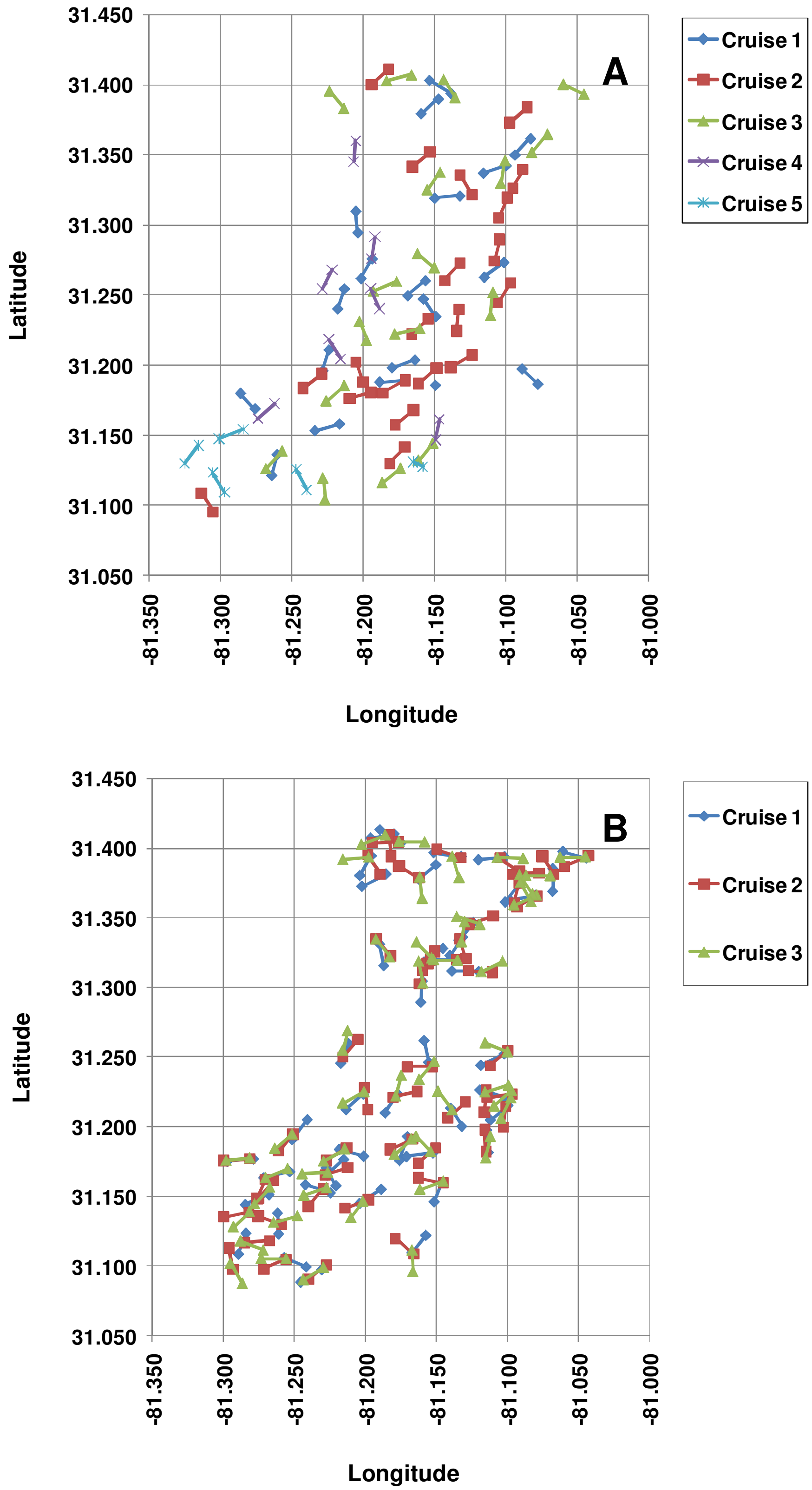
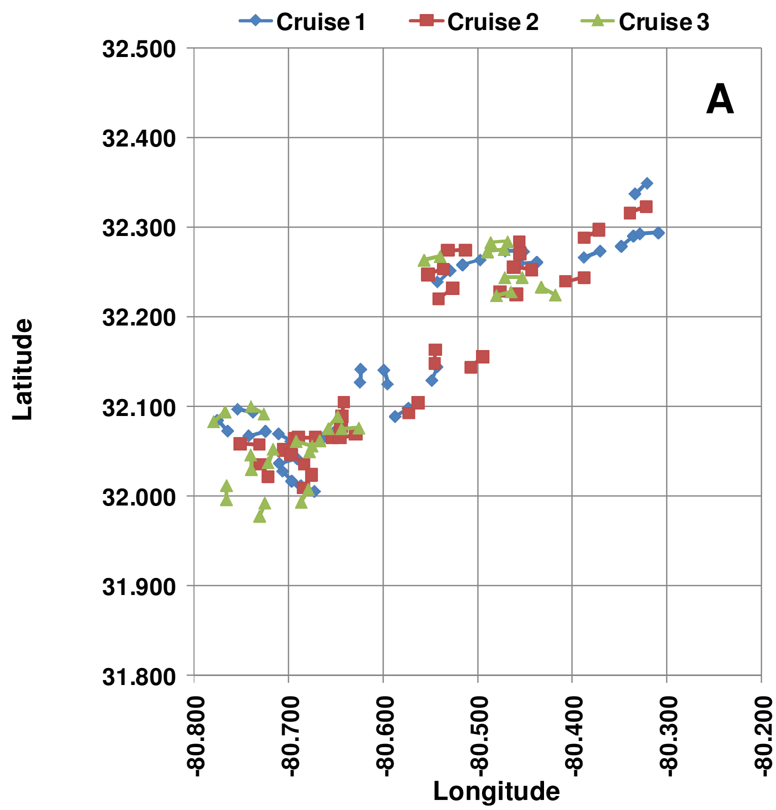


Figure 3. Spatial distribution of sampling effort in 2009 (A) vs. 2010 (B) for strata pair 35-36.



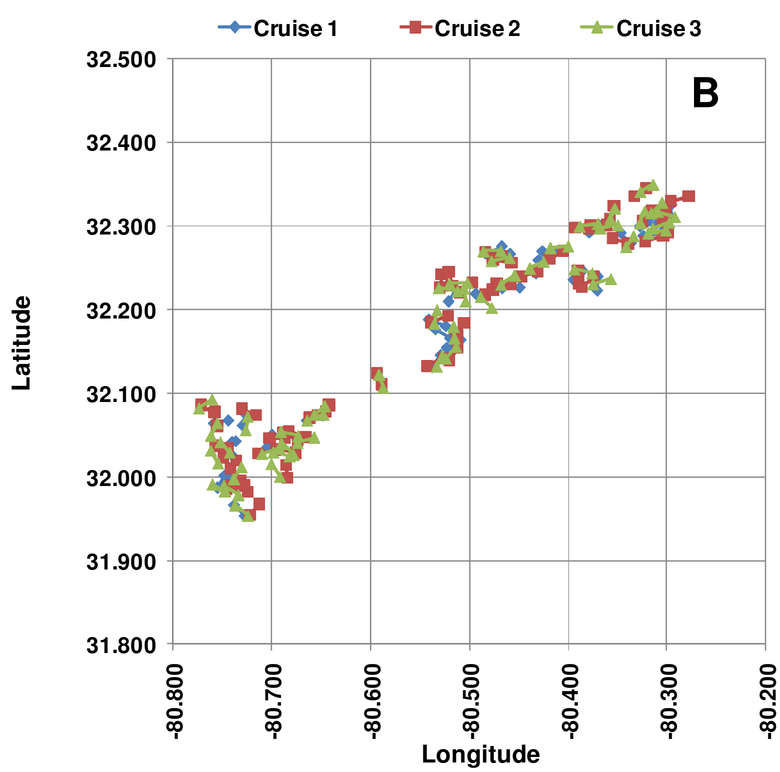


Figure 4. Spatial distribution of sampling effort in 2009 (A) vs. 2010 (B) for strata pair 41-42.

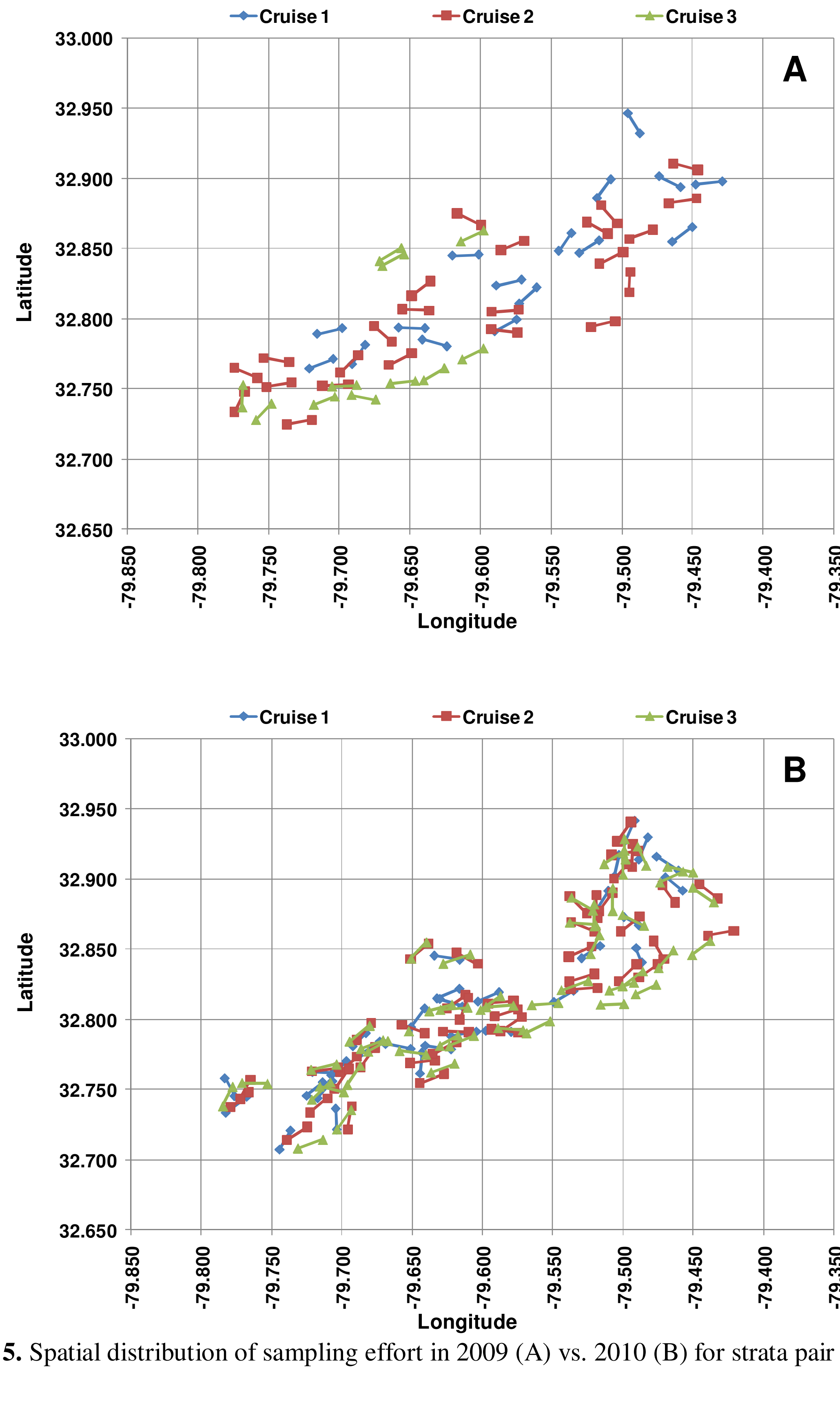


Figure 5. Spatial distribution of sampling effort in 2009 (A) vs. 2010 (B) for strata pair 47-48.

Catch rates

Catch rates during at least one research cruise in each strata pair were significantly different from the other two research cruises in the same strata pair (Figure 6, Appendix 4, Table 3).

Catch rates were significantly different among all cruises in both strata pairs (41-42 and 47-48) off SC (Table 3). In strata pair 47-48, lowest catch rates were observed during the first cruise (24-28 May); however, in strata pair 41-42, greatest catch rates were observed during the first cruise (1-4 June).

Catch rates in both strata pairs off GA and northern FL were similar in cruises one and three but significantly different from cruise two (Table 3). In strata pair 35-36, lowest catch rates were observed during cruise two (5-9 July); however, in strata pair 31-32, greatest catch rates were observed during cruise two (21-25 June).

Catch rates (count of turtles per sampling event) for each cruise in all four strata pairs sampled during 2010 were not significantly different (Table 4) relative to catch rates for these strata sampled since 2000 (20 and 30 min tow times) as well as since 2008 (20 min tow time only).

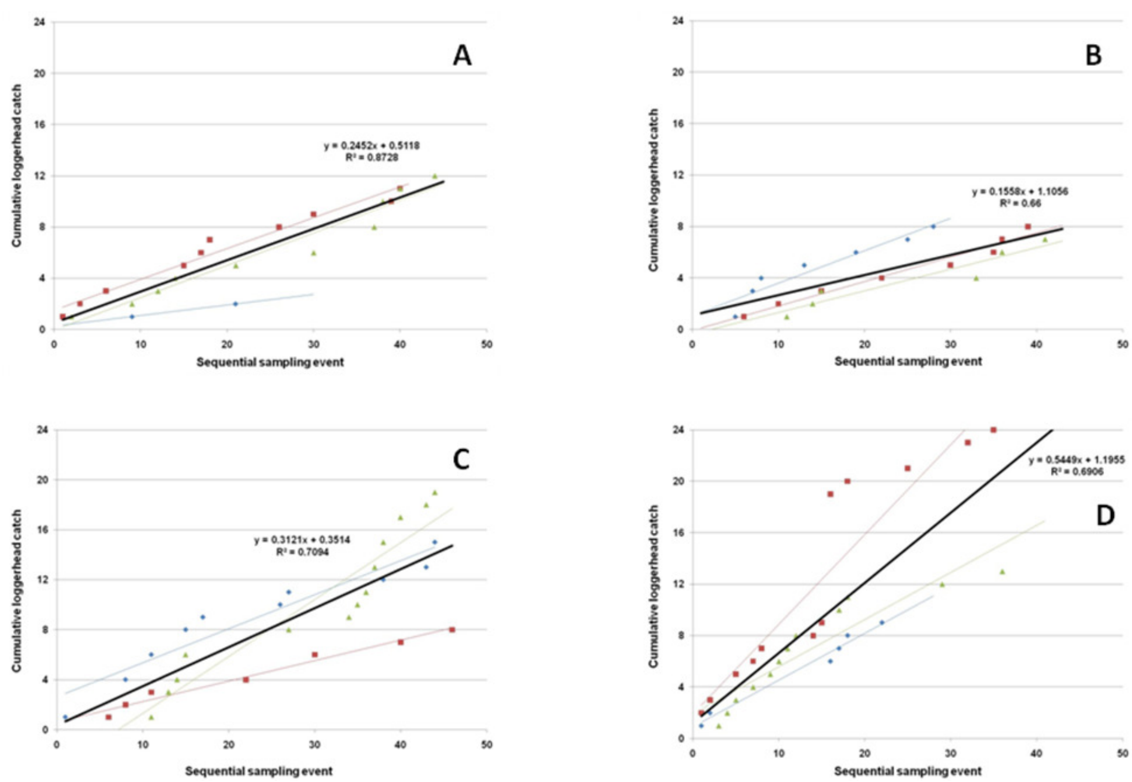


Figure 6. Relationships between cumulative loggerhead catch and expended sampling effort among strata pairs 47-48 (A), 41-42 (B), 35-36 (C) and 31-32 (D) during summer 2010. Blue diamonds and lines indicate cruise one, red squares and lines indicate cruise two and green triangles and lines indicate cruise three. Black line (and associated equation with R^2 value) indicates best fit among all three cruises; all p-values were <0.001 with R^2=0.857 to 0.980.

Table 3. A statistical comparison of catch rates (cumulative catch versus sequential sampling event) between triplicate cruises within strata pairs.

Strata Pair	Cruise Comparison	T-statistic	p-value
47-48	1 vs. 2	5.721	<0.0001
47-48	1 vs. 3	3.649	0.0002
47-48	2 vs. 3	-3.440	0.0028
Strata Pair	**Cruise Comparison**	**T-statistic**	**p-value**
41-42	1 vs. 2	-5.210	<0.0001
41-42	1 vs. 3	-6.734	<0.0001
41-42	2 vs. 3	-2.077	0.0533
Strata Pair	**Cruise Comparison**	**T-statistic**	**p-value**
35-36	1 vs. 2	-4.123	0.0003
35-36	1 vs. 3	-0.662	0.5130
35-36	2 vs. 3	3.661	0.0011
Strata Pair	**Cruise Comparison**	**T-statistic**	**p-value**
31-32	1 vs. 2	3.954	0.0005
31-32	1 vs. 3	0.664	0.5120
31-32	2 vs. 3	-4.036	0.0004

Table 4. Summary statistics from non-parametric Kruskal-Wallis testing for significant differences in loggerhead catch (per sampling event) within strata pairs among years.

	2000 to 2010				**2008 to 2010**		
Strata	H-stat	df	p-value		H-stat	df	p-value
47-48	7.79	8	0.454		4.82	4	0.306
41-42	6.16	8	0.629		1.87	4	0.759
35-36	15.24	8	0.055		4.44	4	0.350
31-32	5.75	8	0.675		3.33	4	0.504

Explanation of differences in catch rates
A gradient in confidence for explanations of differences in catch rates was noted during 2010.

Greatest catch rates during cruise two in strata pair 31-32 were directly attributable to a single sampling event that resulted in the collection of 10 loggerheads at station 31T016 located approximately two kilometers northeast of the northern boundary of Nassau Sound, FL. Historically, station 31T016 and other stations adjacent to the entrance to Nassau Sound, FL have frequently been associated with multiple loggerhead collections.

The low catch rate during cruise one in strata pair 47-48 was attributed to sampling in late May at the onset and following passage of a frontal system that was severe enough to preclude sampling during two scheduled days that week. Meteorological conditions during this cruise were associated with lowest barometric pressure for this strata pair and light, northerly winds (Table 5). Sea surface temperature during cruise one was also the lowest for this strata pair.

Explanations for greatest catch rates during cruise one in strata pair 41-42 are less precise. Because the total number of loggerheads collected weekly was similar (*n*=7 to 8) among cruises, it is worth noting that the catch rate in cruise one may have been greater because 13 stations (nine of which never yielded loggerheads during cruises two and three) were randomly not sampled during cruise one due to time constraints. The first cruise in this strata pair also occurred the week after passage of a coastal low pressure system. As such, despite residually cooler (26.2°C vs. >28°C) water temperatures and lower (1013 vs. 1016 mb) barometric pressures, foraging activity of loggerheads in the survey area may have also been greater as a means of compensation for reduced activity (or absence) during storm passage.

Lowest catch rates in strata pair 35-36 cannot be attributed to reduced sampling effort given that nearly all stations were sampled each cruise. Barometric pressure, cloud cover and wind speed during cruise two were similar to conditions during cruise one or cruise three, and only minor differences were noted between cruise two and cruises one and three with respect to sea surface temperature (cooler by 1°C), vessel speed (slower by 0.1 kt) and wind direction (more easterly influence); thus, hydrographic and/or meteorological factors should not have contributed greatly to the 47-58% reduction in total loggerhead catch in cruise two relative to cruises one and three.

In addition to standard meteorological and hydrographic data collection, project personnel made a concerted effort to record observations on other variables that may have influenced catch rates. Changes in sea surface composition associated with tidal and/or wind generated forces were noted for 34 sampling events (7.1%), with greatest frequency in strata pair 35-36 (Table 6). Among these 34 sampling events, 10 loggerheads were collected in eight events. Sea turtle sightings on the water surface were only recorded for 17 (3.5%) sampling events. Rolling ocean swells and restricted headway were both noted in 6% (*n*=29) of sampling events, but were also associated with both the lowest (strata pair 47-48) and the greatest (strata pair 31-32) catch rates among triplicate cruises for some strata pairs. Trawling on shoals adjacent to shipping channels, the presence of other trawlers or large vessels in the general vicinity, high water clarity and trawling with the current were each noted in less than 2% of trawling events during 2010.

Table 5. Summary statistics and median cruise values for standard hydrographic, meteorological and operational parameters measured during each sampling event. Underlined values indicate a significant median value relative to other cruises in the strata pair.

Strata Pair: 47-48

Variable	*H-stat*	*df*	*p-value*	*Cruise 1*	*Cruise 2*	*Cruise 3*
Barometric (mb)	30.94	2	<0.001	1013	1019	1019
SST (°C)	85.04	2	<0.001	24.0	26.2	27.8
Cloud cover (%)	0.91	2	0.635			
Wind speed (kts)	8.78	2	0.012	4	6	10
Wind direction (code)	36.51	2	<0.001	NW to NE	SSE-SSW	SW-WNW
Vessel speed (kts)	7.25	2	0.023	2.7	2.8	2.8

Strata Pair: 41-42

Variable	*H-stat*	*df*	*p-value*	*Cruise 1*	*Cruise 2*	*Cruise 3*
Barometric (mb)	26.5	2	<0.001	1013	1016	1016
SST (°C)	62.93	2	<0.001	26.2	28.5	28.1
Cloud cover (%)	29.27	2	<0.001	30	25	80
Wind speed (kts)	8.86	2	0.012	8	4	4
Wind direction (code)	9.89	2	0.007	SSE-SSW	SE-ENE	SSE-SSW
Vessel speed (kts)	0.69	2	0.708	2.8	2.8	2.8

Strata Pair: 35-36

Variable	*H-stat*	*df*	*p-value*	*Cruise 1*	*Cruise 2*	*Cruise 3*
Barometric (mb)	39.89	2	<0.001	1019	1019	1023
SST (°C)	68.96	2	<0.001	28.9	27.7	29.0
Cloud cover (%)	15.44	2	<0.001	32.5	20	15
Wind speed (kts)	26.39	2	<0.001	7	10	13
Wind direction (code)	12.73	2	0.002	SSE-SSW	SE-ENE	SSE-SSW
Vessel speed (kts)	7.94	2	0.019	2.8	2.7	2.8

Strata Pair: 31-32

Variable	*H-stat*	*df*	*p-value*	*Cruise 1*	*Cruise 2*	*Cruise 3*
Barometric (mb)	44.65	2	<0.001	1023	1023	1019
SST (°C)	18.05	2	<0.001	26.7	27.7	27.2
Cloud cover (%)	48.03	2	<0.001	5	15	50
Wind speed (kts)	7.19	2	0.029	7.5	7	10
Wind direction (code)	12.41	2	0.002	ENE-SE	ENE-SE	SSE-SSW
Vessel speed (kts)	0.18	2	0.941	2.8	2.8	2.8

Table 6. Frequency of occurrence for additional parameters emphasized for recording in 2010.

Strata Pair	Cruise	N event	N Cc	Turtle on Surf	Vessels	Channel	Plume	Clear water	Swell	Maxed RPMs	Going w/current
31-32	1	28	9				1				
31-32	2	43	24	3			2		8	5	
31-32	3	41	13	2	2	1	2	2	5	1	
35-36	1	44	15	4	2		11	1			
35-36	2	46	8		1		2			1	
35-36	3	46	19	4			1		4	5	
41-42	1	30	8	1			1			1	2
41-42	2	43	8	2			5			3	4
41-42	3	43	7		2		1			8	
47-48	1	30	2				5		11	3	
47-48	2	41	11	1			2		1	1	
47-48	3	45	12				1			1	
	Total	480	136	17	7	1	34	3	29	29	6
	%Total			3.5	1.5	0.2	7.1	0.6	6.0	6.0	1.3

Time of day and tidal influence

Temporal distribution of sampling events (Table 7) among three hour time blocks ranged from *n*=110 events (1600 to 1859 hrs) to *n*=128 events (0700 to 0959 and 1300 to 1559 hrs). Significant differences in temporal distribution of sampling effort were not detected among triplicate cruises within the four strata pairs (Chi-square=0.40 to 7.88, df=6, p=0.247 to 0.999).

Loggerhead collections among three hour time blocks ranged from *n*=29 (1600 to 1859 hrs) to *n*=39 (1300 to 1559 hrs). Significant differences in loggerhead collection among time blocks within strata pairs were not detected (Chi-square=1.34 to 3.61, df=3, p=0.306 to 0.719; Table 7).

Relationships between water level and loggerhead collection (*n*=46 in 30 of 112 trawling events) were not evident for strata 31-32. Water level at the start of sampling ranged from -0.3m to 2m (mean=0.7m). Water level at the start of sampling was not significantly different among cruises (H=2.21, df=2, p=0.331) nor were significant differences detected between water level and collection of zero, one or two or more loggerheads (H=1.69, df=2, p=0.429). Significant differences were also not detected between water level at the time of sampling among stations (H=57.58, df=47, p=0.139), nor for loggerhead catch among stations (H=58.22, df=47, p=0.126); however, statistical outputs also cautioned that one or more samples had small sample sizes.

Relationships between water level and loggerhead collection (*n*=23 in 21 of 116 trawling events) were not evident for strata 41-42. Water level at the start of sampling ranged from -0.2m to 2.3m (mean=1.0m). Water level at the start of sampling was not significantly different among cruises (H=0.60, df=2, p=0.743) nor were significant differences detected between water level and collection of zero, one or two or more loggerheads (H=0.78, df=2, p=0.678). Significant differences were also not detected between water level at the time of sampling among stations (H=45.55, df=42, p=0.327), nor for loggerhead catch among stations (H=34.75, df=42, p=0.729); however, statistical outputs also cautioned that one or more samples had small sample sizes.

Water level data were not available for strata pairs 35-36 and 47-48.

Table 7. Summary of sampling effort (start of trawl) and loggerhead catch (in parentheses) among cruises and strata pairs sampled during summer 2010.

Strata	Cruise	0700 - 0959	1000 - 1259	1300 - 1559	1600 - 1859
31-32	1	9 (4)	6 (2)	7 (2)	6 (1)
31-32	2	12 (3)	9 (4)	11 (15)	11 (2)
31-32	3	13 (5)	10 (3)	8 (3)	10 (2)
35-36	1	14 (4)	12 (3)	12 (3)	6 (5)
35-36	2	15 (1)	11 (3)	10 (2)	10 (2)
35-36	3	12 (6)	10 (8)	12 (2)	12 (3)
41-42	1	7 (2)	7 (0)	8 (2)	8 (4)
41-42	2	10 (2)	9 (2)	12 (2)	12 (2)
41-42	3	10 (3)	11 (1)	10 (2)	12 (1)
47-48	1	9 (0)	11 (0)	8 (1)	2 (1)
47-48	2	7 (3)	10 (2)	14 (2)	10 (4)
47-48	3	10 (4)	8 (3)	16 (3)	11 (2)

Water depth and distance from shore
Mean water depth (between start and end trawling positions) sampled during summer 2010 ranged from 5.5 to 16.6m (median = 11.1m). Sampling water depth distributions were significantly different among strata pairs sampled during 2010 (H=13.09, df=3, p=0.004), with differences primarily attributed to slightly shallower water depth distribution for strata pair 47-48 (median= 10.6m) relative to strata pairs 31-32 and 35-36 (median=11.6m). Sampling water depth was not significantly different among cruises within any of the strata pairs sampled (H=0.01 to 4.3, df=2, p=0.116 to 0.993).

A significant difference (H=11.32, df=2, p=0.003) between sampling water depth and loggerhead catch was noted for strata pair 35-36, with differences associated with lower catch in water depths ≤ 10.0m (*n*=43 events) but similar catch rates in water depths 10.1 to 12.0m (*n*=39 events) and ≥12.1m (*n*=54 events). Significant differences between sampling water depth and loggerhead catch were not noted for other strata pairs (H=0.75 to 2.43, df=2, p=0.297 to 0.689).

Loggerheads were collected throughout the latitudinal and longitudinal extent where sampling was conducted (Figure 7). Nearest distance to shore (mean of start and end positions for each transect) ranged from 0.2km to 19.6km and was significantly different among strata pairs (H=128.37, df=3, p<0.001). Median distance from shore was identical (10.6km) for strata pairs 35-36 and 41-42, but was more condensed for strata pair 41-42 (4.3 to 15.4km) than for 35-36 (3.4 to 17.5km). Sampling in strata pair 47-48 (median=7.6; range=2.7 to 13.8km) occurred significantly closer to shore than strata pairs 35-36 and 41-42. Sampling in strata pair 31-32 (median=4.5, range=0.2 to 19.6km) was significantly closer to shore than all other strata pairs.

Within all four strata pairs, loggerhead catch (zero, one, two or more loggerheads) was not significantly different with respect to transect distance (mean of start and end locations) from shore (H=0.26 to 3.82, df=2, p=0.148 to 0.879).

Gear selectivity and fishing efficiency of turtle nets
Twenty-one loggerheads collected and recaptured with NMFS turtle nets in the regional survey area since 2000 ranged from 57.3cm to 76.9cm SCLmin (initial collection) and correspond to three size classes that comprise 91% of 1,326 loggerheads collected in this area to date (Table 8). No significant difference (Chi-sq=0.269, df=1, p=0.604) was detected between the relative recapture rate for loggerheads measuring 55.1 to 65.0cm versus the 65.1 to 75.0cm. An insufficient number (i.e., expected cell counts less than five) of recaptures in the 75.1 to 85.0cm size class and no recaptures in other size classes precluded their inclusion in statistical testing.

A single port net was used throughout the 2010 sampling season on both the R/V *Lady Lisa* (*n*=232 events) and the R/V *Georgia Bulldog* (*n*=248 events). Two nets were utilized on the starboard side for both the R/V *Lady Lisa* (*n*=44 and 188 events) and the R/V *Georgia Bulldog* (*n*=84 and 164 events). On both vessels, the port net was lighter than the starboard net (Table 9).

More loggerheads were caught in the port net aboard both the R/V *Lady Lisa* (*n*=26; 54%) and the R/V *Georgia Bulldog* (*n*=50; 57%); however, significant differences in catch distribution (zero, one, two, three or more loggerheads) by net were not detected for either vessel (Table 10).

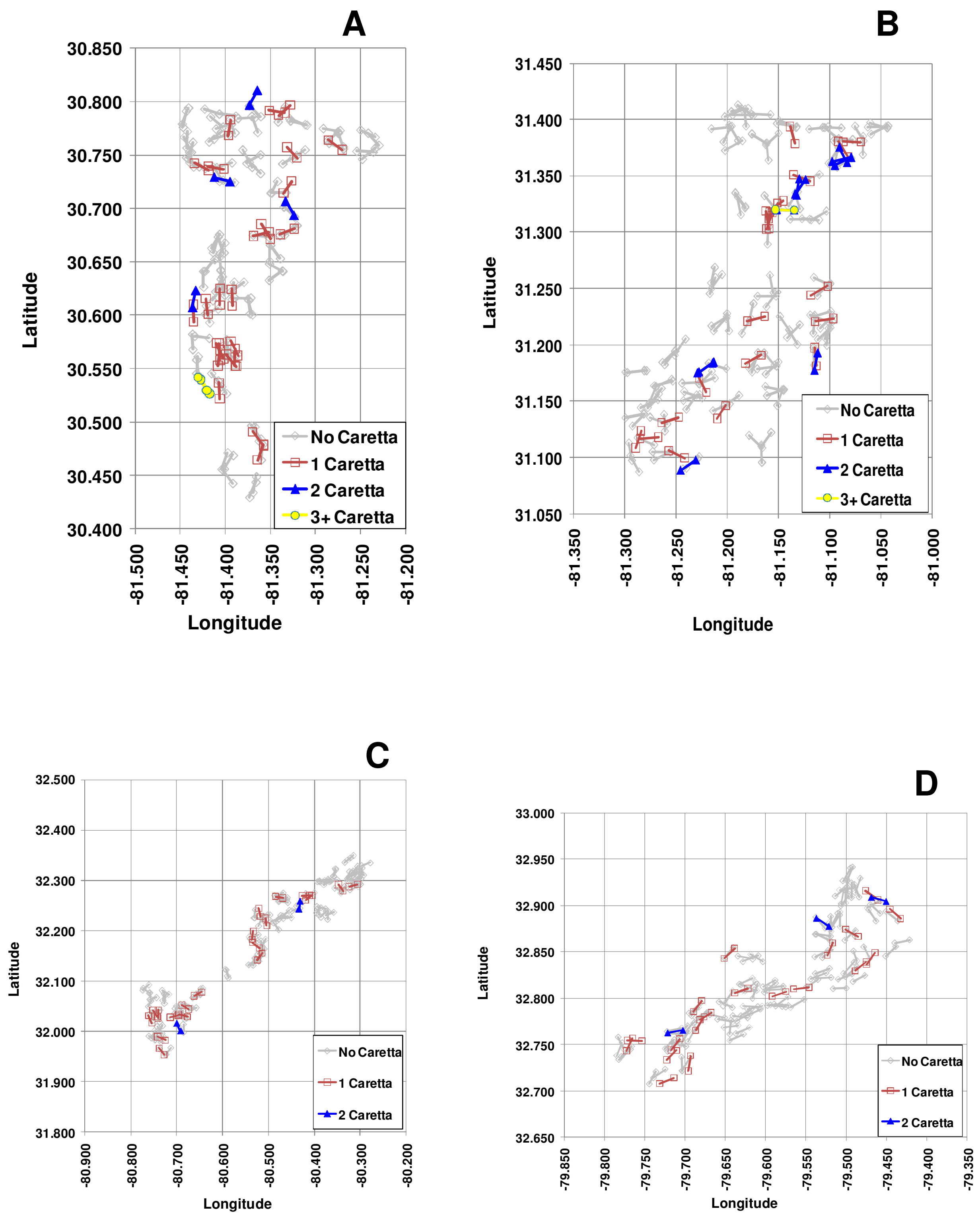


Figure 7. Spatial distribution of loggerhead catch relative to sampling effort expended for strata pairs 31-32 (A), 35-36 (B), 41-42 (C) and 47-48 (D) in summer 2010.

Table 8. Relative distribution of loggerheads collected and recaptured with NMFS turtle nets in the regional trawl survey area since 2000.

Size Class (cm)	Collected	Recaptured	% Recaptured
35.1 to 45.0	1	0	
45.1 to 55.0	45	0	
55.1 to 65.0	446	10	2.2
65.1 to 75.0	620	10	1.6
75.1 to 85.0	144	1	0.7
85.1 to 95.0	65	0	
95.1 to 105.0	5	0	

Table 9. Frequency of sampling with different weight (kg) nets, summer 2010.

Vessel	N events	Port	Starboard
R/V *Lady Lisa*	44	74.5	92.6
R/V *Lady Lisa*	188	74.5	85.4
R/V *Georgia Bulldog*	84	83.5	93.5
R/V *Georgia Bulldog*	164	83.5	96.7

Table 10. Results from statistical testing for loggerhead catch between port and starboard nets.

				Catch Level (cell value = *n* events)					
Vessel	Set	Net	N Events	0	1	2	3+	*Total*	*% of Set*
Bulldog	1	port	84	67	15	2	0	*19*	*61.3*
Bulldog	1	starboard	84	75	6	3	0	*12*	*38.7*
		Chi-sq=4.508, df=2, p=0.105							
Bulldog	2	port	164	137	24	2	1	*31*	*54.4*
Bulldog	2	starboard	164	145	17	1	1	*26*	*45.6*
		Chi-sq=1.775, df=2, p=0.625							
Lady Lisa	1	port	44	40	4	0	0	*4*	*57.1*
Lady Lisa	1	starboard	44	41	3	0	0	*3*	*42.9*
		Chi-sq=0.155, df=2, p=0.694							
Lady Lisa	2	port	188	167	20	1	0	*22*	*53.7*
Lady Lisa	2	starboard	188	169	19	0	0	*19*	*46.3*
		Chi-sq=1.308, df=2, p=0.520							

Fish and invertebrate catch

Differences in net weights were not implicated in catch distributions for other fauna larger than the trawl mesh size including sharks (*n*=1,048), rays (*n*=539), horseshoe crabs (*Limulus polyphemus*; *n*=154) and cannonball jellyfish (*Stomolophus meleagris*; *n*=611; Figure 8).

In contrast, net weight was implicated in differences in collection of fauna selected against by the large mesh webbing of the turtle trawl net. Among 62,320 finfish collected across research vessels (Appendix 5), only 33% were collected in the lighter weight port nets. This phenomenon was observed across multiple finfish groupings (Figure 9), but was most pronounced for demersal fishes for which only 21% of 1,897 total specimens were collected in port nets.

Differences in invertebrate catch (*n*=14,881 specimens) associated with net weight were less pronounced (Figures 10 and 11). Forty-two percent (*n*=3,089 specimens) of invertebrates recorded aboard the R/V *Georgia Bulldog* originated in the lighter weight port net. In contrast, 54% (*n*=4,081) of invertebrates recorded aboard the R/V *Lady Lisa* originated in the port net.

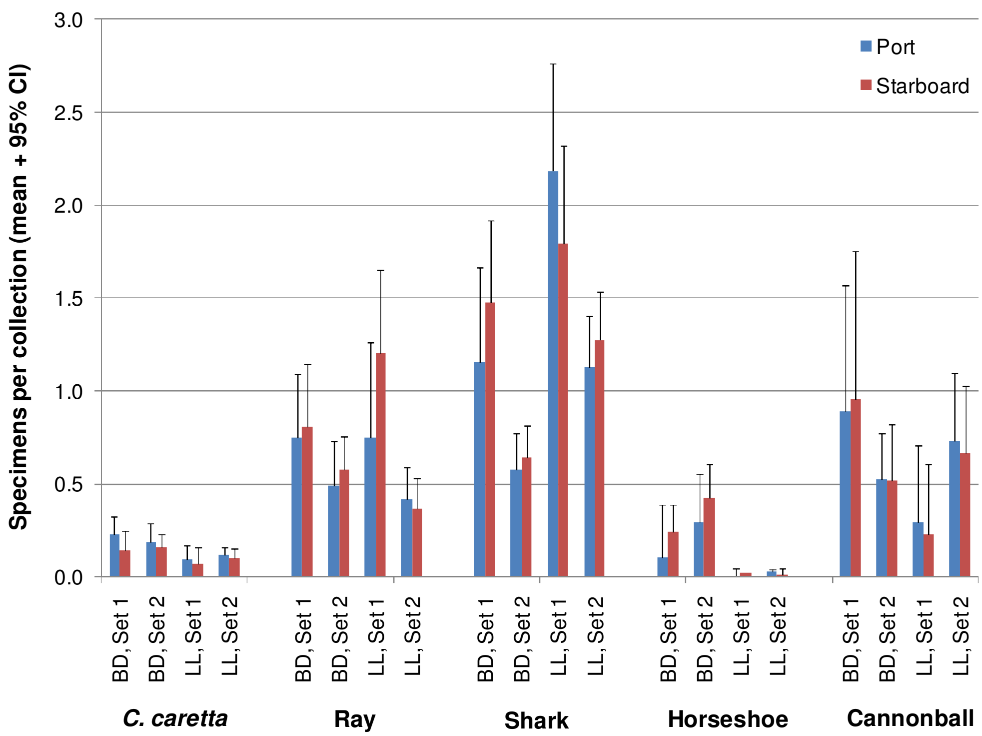


Figure 8. Frequency of occurrence (mean +95% CI) by net for loggerhead sea turtles and other fauna generally larger than trawl mesh size during summer 2010.

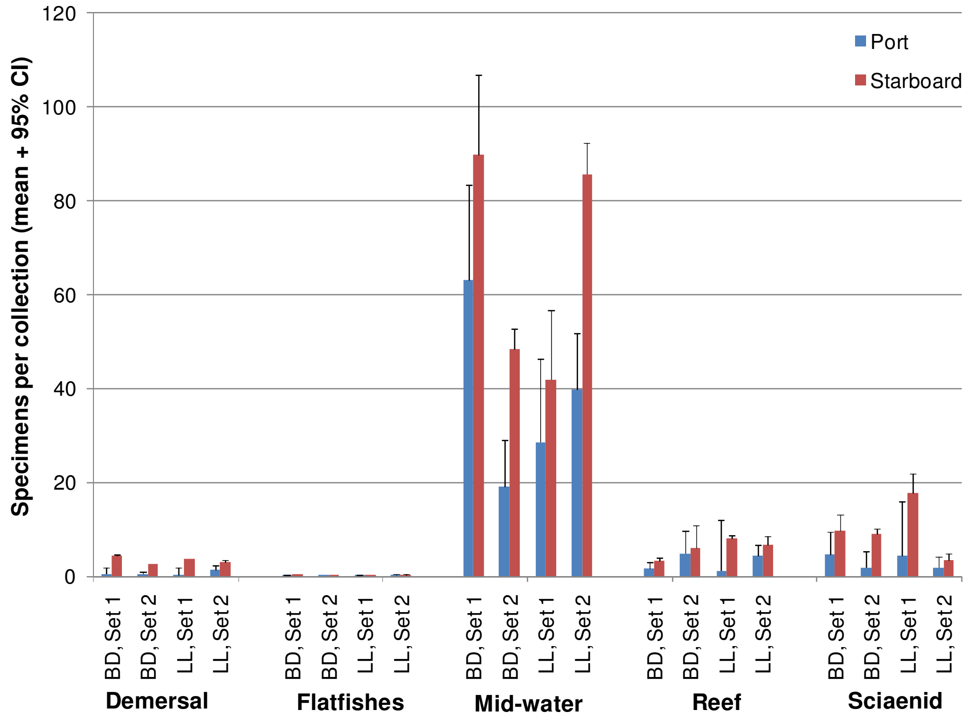


Figure 9. Frequency of occurrence (mean +95% CI) by net for finfish collected in 2010.

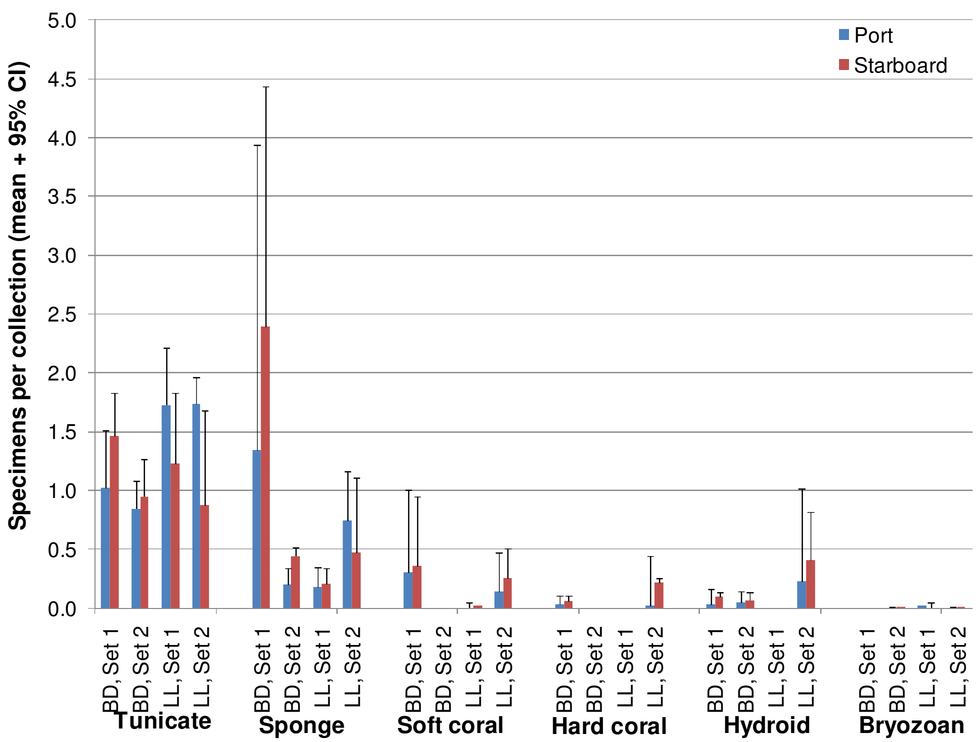


Figure 10. Frequency of occurrence (mean +95% CI) for sessile invertebrates collected in 2010.

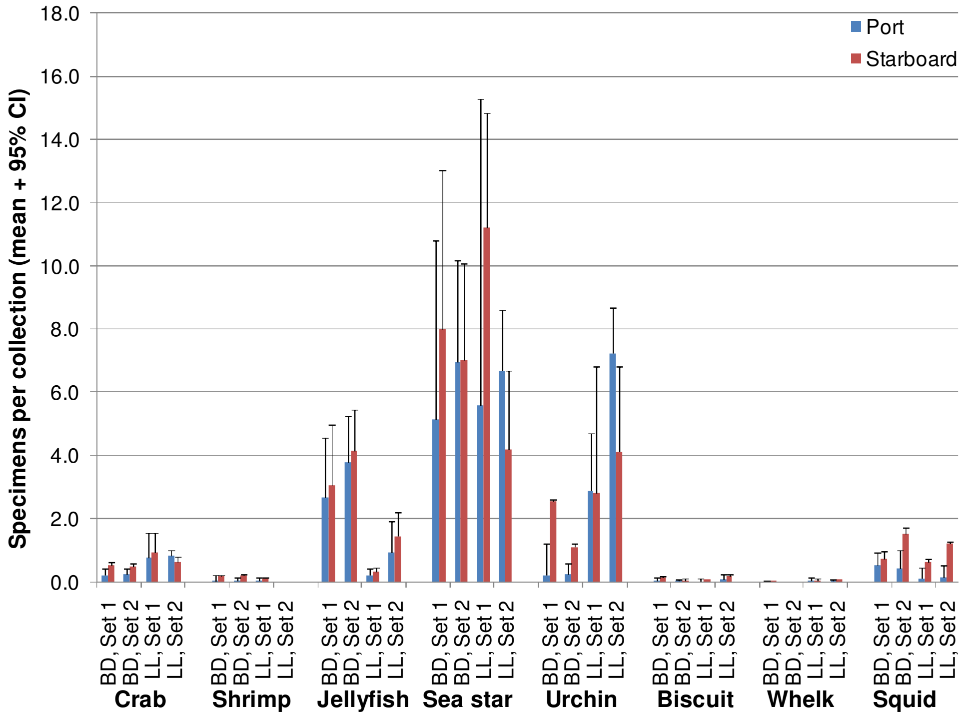


Figure 11. Frequency of occurrence (mean +95% CI) for mobile invertebrates collected in 2010.

Size, sex and genetic distributions

Median size of loggerheads was significantly different among years within all strata pairs except for strata pair 31-32 (H=6.30, df=6, p=0.391; Figure 12a). Significant differences in median size for strata pair 35-36 (H=15.92, df=6, p=0.014; Figure 12b) were attributed to a larger median size in 2010 than was observed in 2000. Significant differences in median size for strata pair 41-42 (H=14.66, df=6, p=0.023; Figure 12c) were attributed to a larger median size in 2010 than was observed in 2001. Significant differences in median size (H=15.55, df=6, p=0.016; Figure 12d) for strata pair 47-48 were attributed to larger median sizes in 2008 and 2010 than in 2000.

Blood samples for steroid hormone analyses were available for 134 loggerhead collections and all individuals collected for two other sea turtle species. Sex ratio for loggerheads (*n*=100, 75%) measuring 52.8 to 75.0cm SCLmin was skewed towards females at a 2.3 to 1 ratio. Differences in sex ratios for this size group were noted between loggerheads collected aboard the R/V *Lady Lisa* (23F, 5M, 2Unkown) and the R/V *Georgia Bulldog* (43F, 23M, 3Uknown); however, these differences were not statistically significant (Chi-sq=3.005, df=2, p=0.083). Among loggerheads measuring ≥75.1cm SCLmin, 17 were female, 11 were male and sex could not be determined for six individuals. Sex ratio for Kemp's ridley sea turtles consisted of nine females (30.7 to 56.7cm SCLmin) and four males (26.2 to 57.3cm SCLmin). The single green turtle was female.

Two unique observations in summer 2010 were made with respect to maturing male loggerheads. On 5 July, an 80.2cm SCLmin male (CC2809) was collected in strata pair 35-36 that was originally collected by the SCDNR as a live stranding in August 2000, rehabilitated at the SC Aquarium, and released from Sebastian Inlet, FL in January 2001 (Cover photo, Appendix 3).

During 9.5 years at large, this loggerhead transitioned from a 'typical' (67.4cm SCLnt) sized juvenile loggerhead encountered in this survey to a size approaching maturity (87cm CCL, NMFS and USFWS, 2008). At a tail length of 33.9cm (curved), the ratio of tail length to straight-line carapace length is above the 40% threshold associated with adult males in our data (Figure 13). This loggerhead was also noted to have a "soft plastron" on 5 July 2010 consistent with adults; however, testosterone concentration (19,030 pg/ml) was well below testosterone levels noted for reproductively-active adult males as well as elevated above reproductively-inactive adult male levels (Blanvillain et al., 2008), suggesting puberty rather than maturity. The second puberty observation occurred on 12 July when CC2818, a 71.4cm SCLmin male with CC-A01 haplotype and a tail length of 27.0cm (37.8% of SCLmin) was collected in strata pair 41-42. Although this loggerhead has the distinction of being the smallest male with a relative tail length >35% of SCLmin (Figure 13), the testosterone concentration (8,089 pg/ml) for this loggerhead was well below values associated with mature male loggerheads (Figure 14).

Genetics data were available for 126 loggerheads, with sequencing still on-going for seven additional samples at the time of this writing. Similar to trends since 2000, two haplotypes dominated the distribution with CC-A01 and CC-A02 accounting for 53% and 37% of observed haplotypes, respectively. Four other haplotypes (CC-A03, CC-A10, CC-A14 and CC-A20) and one new haplotype collectively accounted for 12 samples, only two (both CC-A14) of which were loggerheads >79cm SCLmin (CC0600, CC2827). Sex ratios (female, male, unknown) were not significantly different among CC-A01 and CC-A02 (Chi-sq=1.281, df=2, p=0.527). Four haplotypes were seen among 12 Kemp's ridley sea turtles. Haplotype LK-01 was noted for eight Kemp's ranging from 26.2 to 56.7cm SCLmin. Haplotype LK-03 was seen twice (50.6 and 57.3cm SCLmin) and haplotypes LK-02 and LK-03 were each seen once (48.4cm and 49.6cm SCLmin, respectively). The single green sea turtle (27.9cm SCLmin) was CM-01.

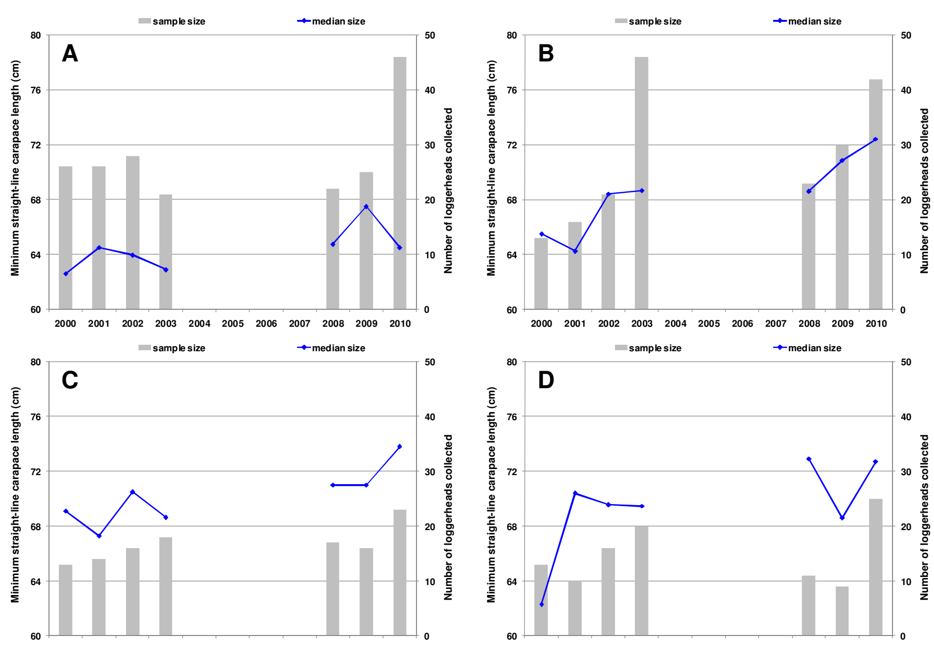


Figure 12. Median size (blue line) and number of loggerheads (gray bar) collected in strata pairs 31-32 (a), 35-36 (b), 41-42 (c) and 47-48 (d) between 2000-2003 and 2008-2010.

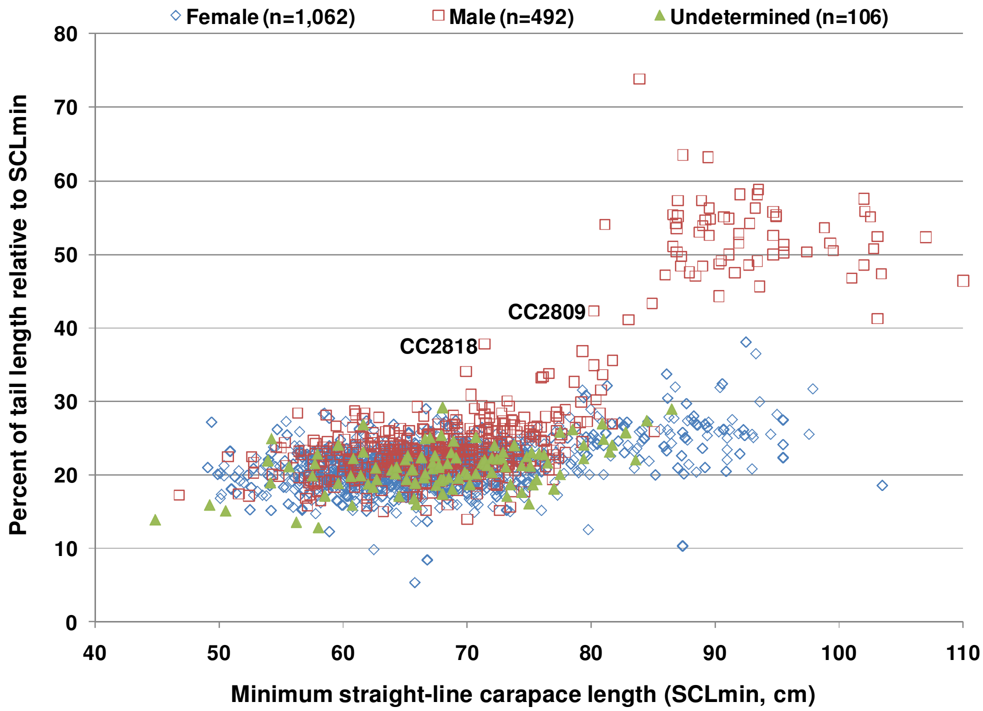


Figure 13. Curved tail length as a percent of straight-line minimum carapace length among male (*n*=492), female (*n*=1,062) and undetermined sex (*n*=106) loggerheads collected by this survey since 2000.

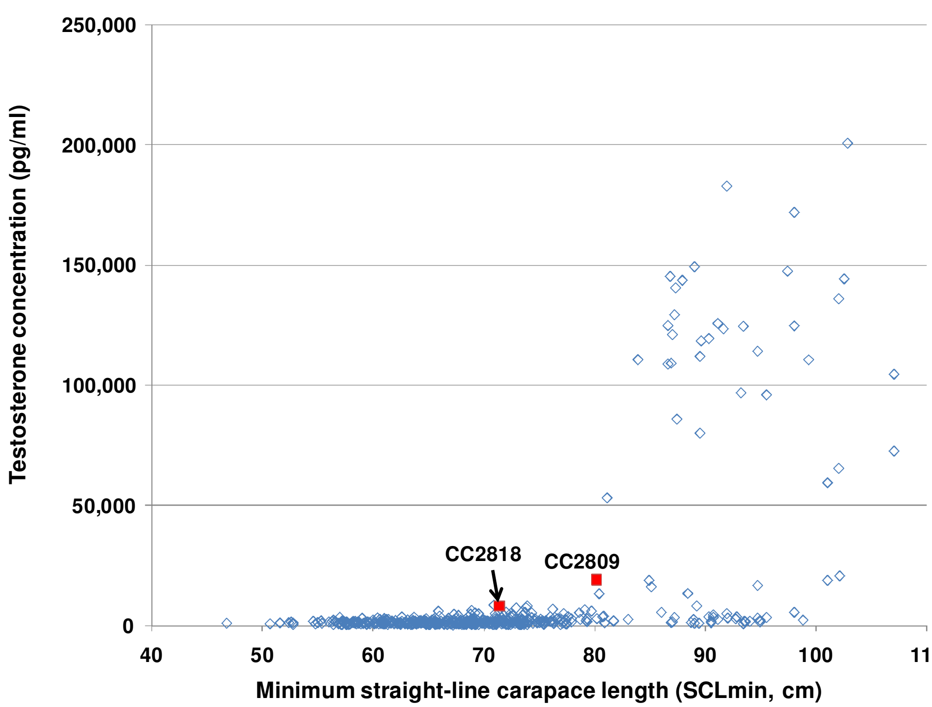


Figure 14. Relationship between testosterone concentration (pg/ml) and straight-line minimum carapace length (cm) among male loggerheads (*n*=492) collected by this survey since 2000.

Sea turtle health: Physical examination

Twenty-one of 136 loggerhead collections (15%) were noted to have at least a slightly emaciated appearance, of which two (CC2791, CC2819) were considered severe enough to be transferred to the GA Sea Turtle Center for rehabilitation. Loggerhead CC2791 (aka, "Gabi") was released on 9 October 2010; however, CC2819 (aka "Freedom") remains in treatment. In contrast, 18 loggerheads (13% of collections) had convex plastrons and appeared exceptionally healthy.

Dense (>25% coverage of a particular body part) growth of epibionts was noted for 32 loggerheads (24% of collection). Dense epibiont coverage affected multiple body parts for the same turtle and was most frequently reported from the carapace (*n*=28 records), the neck, head and mouth (*n*=13 records) and least frequently from the plastron (*n*=2 records). Epibiont growth primarily consisted of barnacles, though hard coral was noted as attached to one rehabilitated loggerhead (CC2819) and algae was noted as being present on five loggerheads. In addition to epibionts, parasites (i.e., leeches and eggs) were noted for 19 loggerheads (14% of collections).

During summer 2010, barnacles were sampled from a sub-set of 18 loggerheads. A total of 324 barnacles which consisted of three obligate commensal (of sea turtles) species were collected. Similar to previous years, *Chelonibia testudinaria* (*n*=85) which attaches to the carapace and plastron and *Platylepas hexastylos* (*n*=236) which attaches to the skin were nominally present (i.e, no skin barnacle samples were available for CC2839) on 100% of the turtles sampled. In contrast, *Stomatolepas elegans* (*n*=3) which attaches only to the skin was present on only one turtle (CC2767). In past years the paucity of *S. elegans* could have been a product of sampling effort (i.e. the soft skin was not examined); however, in 2009 and 2010 the skin was specifically examined. Barnacle sampling during 2009 (*n*=12 loggerheads) and 2010 (*n*=18 loggerheads) was not comprehensive (i.e., five barnacles targeted from the carapace, flippers and skin) so it is possible that *S. elegans* is more prevalent than has been reported in this study since 2009; however, the results do indicate that this barnacle is at least less common (i.e., *n*=2 of 30 loggerheads sampled since 2009) in this region than other barnacle species.

Twenty loggerheads (15% of collections) were noted to have dense (>25% of body part) sloughing of keratin during the on-board physical exam. Similar to epibionts, sloughing was most common on the carapace (*n*=10 records), followed by dekeratinazation of scales on the head (*n*=6 records), flippers (*n*=4 records) and plastron (*n*=3 records).

Thirty-nine loggerheads (29% of collections) were collected with a pre-existing wound and/or deformity. Flipper wounds (*n*=22 records) were most frequently noted and ranged from minor nicks to complete amputation. Wounds affecting the carapace (*n*=10 records) were observed with similar frequency as wounds affecting the head/neck/shoulder area (*n*=8 records). Wounds and deformities were least commonly associated with the plastron and/or tail region (*n*=4 records). In addition to pre-existing injuries, nine loggerheads (7%) received abrasions or puncture wounds from stingray spines (and one urchin spine) during collection; all wounds were successfully treated at sea and loggerheads released without incident.

Kemp's ridleys and the green sea turtle had a generally 'cleaner' appearance than loggerheads. None were considered emaciated or observed with dense epibiont growth or parasites, and one

Kemp's (LK2051) was noted to have a convex plastron. Keratin sloughing >25% of the carapace was only noted for one Kemp's (LK2042), although a second Kemp's (LK2041) was noted to have a soft/spongy area (prone to sloughing) on the carapace as well. Carapace and flipper wounds were noted for six Kemp's, one of which (LK2048; aka, "Arribada") was severe enough to necessitate transport to the GA Sea Turtle Center for treatment; as of this writing this sea turtle remains in treatment. Incidental injuries associated with trawling were limited to two minor cloaca prolapses (LK2041, LK2044) that were resorbed prior to release.

Sea turtle health: Clinical assessment

Hematocrit measured at sea (Table 11) was not significantly different (H=6.44, df=3, p=0.092) between loggerheads perceived to be normal (*n*=97), with convex plastrons (*n*=18), slightly emaciated (*n*=18) or requiring rehabilitation (*n*=2) as described in the previous section.

Total protein measured at sea (Table 11) was significantly different (H=18.65, df=3, p<0.001) between loggerheads perceived to be normal, extra healthy, slightly emaciated or requiring shore-based treatment. Differences were attributed to all (regardless of severity) emaciated loggerheads having lower total protein values than normal or extra healthy loggerheads.

Blood glucose measured at sea (Table 11) was significantly different (H=11.88, df=3, p=0.008) between loggerheads perceived to be normal, extra healthy, slightly emaciated or requiring shore-based treatment. Differences were attributed to normal loggerheads having higher blood glucose values than all emaciated loggerheads (regardless of severity).

Hematocrit was also significantly different (H=9.63, df=1, p=0.002) between non-emaciated loggerheads and Kemp's ridley sea turtles (Table 11); however, significant differences in total protein (H=2.32, df=1, p=0.127) and blood glucose (H=0.00, df=1, p=0.951) were not noted between these species. Hematocrit and total protein were depressed but blood glucose elevated (relative to 12 'normal' values in 2010) for LK2048 (aka "Arribada") that was rehabilitated for a severe front flipper wound and that remains in treatment as of this writing.

Table 11. Descriptive statistics (mean, standard deviation) for blood parameters measured at sea for loggerhead, Kemp's ridley and green sea turtles with respect to physical condition.

		Caretta caretta				*Lepidocheyls kempi*		*Chelonia mydas*
		Normal	Convex	Emaciated	Rehab	Normal	Rehab	Normal
Parameter	Metric	(*n* =97)	(*n* =18)	(*n* =18*)	(*n* =2)	(*n* =12*)	(*n* =1)	(*n* =1)
Hematocrit	mean	35	35	34	9, 27	31	6	28
Hematocrit	stdev	4	4	3		4		
Total protein	mean	4.3	4.3	3.5	1.0, 2.2	4.0	1.4	2.6
Total protein	stdev	0.9	0.7	0.8		0.7		
Glucose	mean	90	85	78	56, 58	89	148	92
Glucose	stdev	17	13	17		19		

**Blood was not able to be collected for CC0579 or LK2046*

Blood samples for complete blood counts and chemistries were collected from 49 loggerheads comprising nine of 21 emaciated loggerheads (including both rehabilitated loggerheads), seven of 18 convex plastron loggerheads and 33 presumably normal loggerheads (Table 12). Blood chemistries were significantly different among groups for albumin (H=9.35, df=3, p=0.009), globulin (H=10.42, df=3, p=0.015) and total protein (H=11.60, df=3, p=0.025). For all three parameters, blood chemistry values were lower among rehabilitated and emaciated loggerheads than for normal and convex plastron loggerheads. Cell counts were significantly different among groups for relative (H=8.73, df=3, p=0.033) and absolute (H=8.66, df=3, p=0.034) lymphocytes as well as relative neutrophils (H=8.54, df=3, p=0.036). Lymphocyte value distributions descended between convex plastron and rehabilitated loggerheads; however, for neutrophils an ascending trend was noted between convex plastron and rehabilitated loggerheads.

Blood and tissue samples for contaminant and nutritional analyses were collected for several collaborators during 2010; however, results were not available for inclusion in this report. Blood samples for contaminant analyses were collected for a subset of 63 loggerheads for Dr. Jennifer Keller (NIST). Blood samples for 13 loggerheads (eight female, three males, two unknown sex) measuring 79.8 to 90.4cm SCLmin were collected for nutrition studies (vitamins, lipids, minerals, peptides) under the direction of Dr. Terry Norton (GA Sea Turtle Center). Skin biopsy samples were collected for 29 of 30 loggerheads satellite-tagged in support of the Atlantic Marine Assessment Program for Protected Species (AMAPPS) managed by the NMFS Southeast Fisheries Science Center (NMFS, unpublished). In addition to loggerhead tissue samples, we also provided 289 by-catch organisms from 12 species of Crustaceans, Echinoderms, Cnidarians, Gastropods and Teleosts to Ms. Simona Cerriani, a Ph.D. student at the University of Central Florida, to characterize isotopic signatures in potential loggerhead prey items.

Table 12. Descriptive statistics and results of statistical testing for blood chemistry and cell count data collected for 49 loggerheads during 2010.

				Convex plastron			Normal			Emaciated			Rehabilitated		
Chemistries	H-stat	df	p-value	N obs	Mean	Stdev	N obs	Mean	Stdev	N obs	Mean	Stdev	N obs	Mean	Stdev
Albumin	9.35	3	0.025*	7	1.0	0.2	33	1.0	0.2	7	0.9	0.2	2	0.5	0.3
AST	0.91	3	0.823	7	184.0	45.9	33	188.7	65.0	7	176.1	66.2	2	162.5	50.2
Calcium	5.91	3	0.116	7	7.8	0.8	33	7.4	1.4	7	7.0	1.2	2	6.6	0.4
Chloride	2.47	3	0.480	7	117.4	3.8	33	117.6	4.0	7	119.1	6.5	2	121.0	1.4
CPK	1.52	3	0.677	7	769.1	351.3	33	806.8	448.1	7	604.7	298.7	2	845.5	771.5
Globulin	10.42	3	0.015*	7	3.6	0.5	33	3.7	0.8	7	2.7	0.8	2	1.9	0.3
Glucose	4.77	3	0.019	7	106.1	30.7	33	98.9	21.8	7	87.1	31.4	2	79.5	7.8
Hematocrit	1.34	2	0.512	2	36	4	14	33	3	4	34	1			
Phosphorus	1.49	3	0.686	7	6.9	0.8	33	6.9	0.8	7	7.8	1.8	2	6.5	1.3
Potassium	3.95	3	0.267	7	4.9	0.6	33	4.8	0.5	7	5.1	0.4	2	4.3	0.6
Sodium	0.63	3	0.889	7	156.4	4.0	33	156.9	3.5	7	158.0	5.7	2	155.5	2.1
Total protein	11.60	3	0.009*	7	4.6	0.6	33	4.7	0.9	7	3.6	0.9	2	2.4	0.6
Uric acid	0.57	3	0.903	7	1.0	0.5	33	1.1	0.5	7	1.0	0.6	2	1.2	0.3
Urea Nitrogen	2.98	3	0.395	7	83.7	18.1	33	82.6	24.0	7	63.1	31.8	2	71.5	7.8

				Convex plastron			Normal			Emaciated			Rehabilitated		
Cell counts	H-stat	df	p-value	N obs	Mean	Stdev	N obs	Mean	Stdev	N obs	Mean	Stdev	N obs	Mean	Stdev
Basophils	1.50	3	0.682	7	0	0	33	0	0	7	0	1	2	0	0
Ab Basophils	1.50	3	0.682	7	0	0	33	19	48	7	17	45	2	0	0
Eosinophils	3.54	3	0.316	7	10	11	33	5	6	7	3	4	2	1	1
Ab Eosinophils	3.14	3	0.370	7	1069	1140	33	669	763	7	447	529	2	120	170
Lymphocytes	8.66	3	0.034*	7	43	12	33	29	13	7	32	9	2	19	7
Ab Lymphocytes	8.73	3	0.033*	7	4849	1238	33	3132	1905	7	3559	954	2	1860	1442
Monocytes	1.53	3	0.675	7	1	1	33	1	2	7	2	1	2	1	1
Ab Monocytes	1.39	3	0.708	7	170	127	33	178	200	7	224	244	2	60	85
Neutrophils	8.54	3	0.036*	7	46	13	33	64	18	7	63	9	2	80	9
Ab Neutrophils	3.06	3	0.382	7	5199	1804	33	6062	2189	7	7610	3418	2	6960	2546
White blood cells	2.43	3	0.489	7	11	2	33	10	4	7	12	4	2	9	4

Discussion

The modified sampling design evaluated in 2010 re-affirmed as well as strengthened the assertion by Arendt et al. (2009) that the propensity of zero loggerhead events is predominantly influenced by random sampling in the marine environment to collect a species that is not randomly distributed and that by virtue of its federal protection status should be relatively uncommon. Among all four strata pairs, loggerheads were never collected at more than half of stations sampled at least twice. Similarly, for all strata pairs nearly three-quarters of total sampling events were associated with zero loggerhead catch during even the most successful cruises. Conversely, loggerheads were only always caught at four stations sampled at least twice, all of which were located in strata pair 31-32 in the Brunswick, GA to St. Augustine, FL sub-region where catch rates have consistently been the greatest since 2000 (Arendt et al., 2009). Furthermore, all four of these stations were clustered along shore and directly offshore of the southern terminus of Amelia Island, FL within a $60km^2$ area. Nearly half of stations sampled at least twice in 2010 resulted in a mixture of zero and positive loggerhead catches ranging from one to three loggerheads per sampling event. Among all four strata pairs, mixed loggerhead catch was inconsistently observed for stations sampled during multiple cruises. For example, during the least productive cruises loggerheads were collected at stations that never otherwise yielded loggerheads and in one instance, a station inadvertently sampled twice during the same cruise resulted in a loggerhead catch once but failed to produce a loggerhead on the second try.

Despite effectively tripling sampling effort within each strata pair relative to 2009, the total number of loggerheads collected generally did not increase proportionally. In strata pair 47-48 the number of loggerheads collected nearly tripled relative to 2009 (*n*=25 vs. *n*=9). In strata pair 31-32, the number of loggerheads collected in 2010 was slightly less than double the number of loggerheads collected in the same strata pair in 2009; however, in strata pairs 35-36 and 41-42, the modified sampling design in 2010 only increased total loggerhead catch by 40%. It is intriguing that the greatest increase in catch rates among sampling designs occurred in the northernmost sub-region, where catch rates are historically the lowest (Arendt et al., 2009). Loggerhead catch was not associated with mean transect distance from shore within any of the four strata pairs sampled in 2010; however, it is worth noting that strata pairs 35-36 and 41-42 also had nearly identical station distributions relative to shore, whereas stations for strata pairs 31-32 and 47-48 were distributed closer to shore. Thus, although limited in scope, these findings collectively suggest that the modified sampling design evaluated in 2010 may be most effective for increasing the total number of loggerheads collected at stations located closer to shore. However, relative to sampling effort, changes in catch rates were not significantly different among years (and therefore among sampling designs) for any of the strata pairs sampled in 2010.

Intensive repeat sampling within four strata pairs during 2010 was associated with a greater frequency of occurrence of within-season loggerhead recaptures (*n*=2 of 128 new loggerheads) than the traditional random sampling design (*n*=1 of 1,121 new loggerheads); however, the two within-season loggerhead recaptures during 2010 represented just the fourth and fifth such occurrences in the regional survey area since 2000. The single within-season loggerhead recapture utilizing the traditional random sampling design occurred in 2002 when CC2227 was recaptured after 27 days at large having moved 8.7km (center points of transects) between adjacent strata (from station 34T046 to station 35T017). The next two within-season loggerhead recaptures occurred during targeted sampling at 'hot spots' during August 2008. One loggerhead (CC2550) recaptured in August 2008 was originally collected and tagged 56 days earlier at a station 1.4km (center points of transects) away in the same strata (36). The second loggerhead recaptured in August 2008 was originally collected one day earlier at a station 1.2km away in the same strata (31); both collections of this loggerhead occurred near shore along the southern terminus of Amelia Island, FL. In 2010, both loggerheads (CC2772, CC2773) were collected in strata 36 and recaptured at either the same or an adjacent station 35 to 37 days later with mean movements of 0.3 to 0.5km.

Intensive repeat sampling within four strata pairs during 2010 was also associated with an increased collection frequency of loggerheads tagged in previous years by this study. Between 2000 and 2009, random sampling (*n*=3,858 events) in the regional trawl survey area resulted in 12 prior year loggerhead recaptures relative to 1,121 'new' loggerheads; no prior year loggerheads were collected during targeted sampling at 'hot spots' in August 2008 when 40 'new' loggerheads were collected during 69 sampling events. During 480 sampling events with repeat sampling at 181 stations in 2010, four prior year project loggerheads were collected which increased the rate of occurrence of loggerheads collected in prior years to 16 relative to 1,289 'new' loggerheads and 4,407 total sampling events. Similarly, the collection of two loggerheads in 2010 that were tagged by other programs also increased the interaction rate for that category. Increased interaction rates for loggerheads tagged in previous years by this study or by other programs may be exaggerated due to increased sampling effort in strata pair 35-36 in 2010 given a disproportionate amount of recapture activity in this strata pair relative to ten other strata pairs between St. Augustine, FL and Winyah Bay, SC. Specifically, eight of 21 (38%) of total project recaptures (including four of five within-season recaptures) and three of 14 (21%) total recaptures of loggerheads tagged by other programs have occurred in strata pair 35-36. Furthermore, five of eight project recaptures and two of three other program recaptures within this strata pair have occurred within a 60km^2 area immediately north or to the northeast of the Altamaha artificial reef complex (Figure 16), *all but one of which occurred in 2010*. Although a total of 27 state-managed artificial reef complexes exist within or along the perimeter of the regional trawl survey, clustered loggerhead catches are only associated with the Altamaha reef and the 4KI reef off the northern end of Edisto Island, SC and a research proposal has been submitted for the Protected Species Cooperative Conservation funding opportunity to use satellite and acoustic telemetry to evaluate relationships between loggerhead distributions and these two artificial reef complexes (Arendt et al., 2010a). A companion proposal to use multi-beam sonar to map the seafloor concurrent with trawling was also submitted to evaluate relationships between loggerhead distributions and bottom type (Arendt et al., 2010b).

Analysis of trawl catch in 2010 generated an important caveat for the use of historical collection of by-catch organisms in this survey for comparisons with loggerhead catch rates. In addition to size-selectivity issues due to large mesh webbing associated with turtle nets, net weight also influences observed catch. Collection of large fauna such as sea turtles, elasmobranchs, horseshoe crabs and even cannonball jellyfish were not significantly affected by net weight; however, the relative abundance of smaller organisms (most notably finfish) was significantly greater in nets that were heavier by just 15%. Although nets are purchased from the same manufacturer, over time the nets accumulate weight through repeated use that allows water and

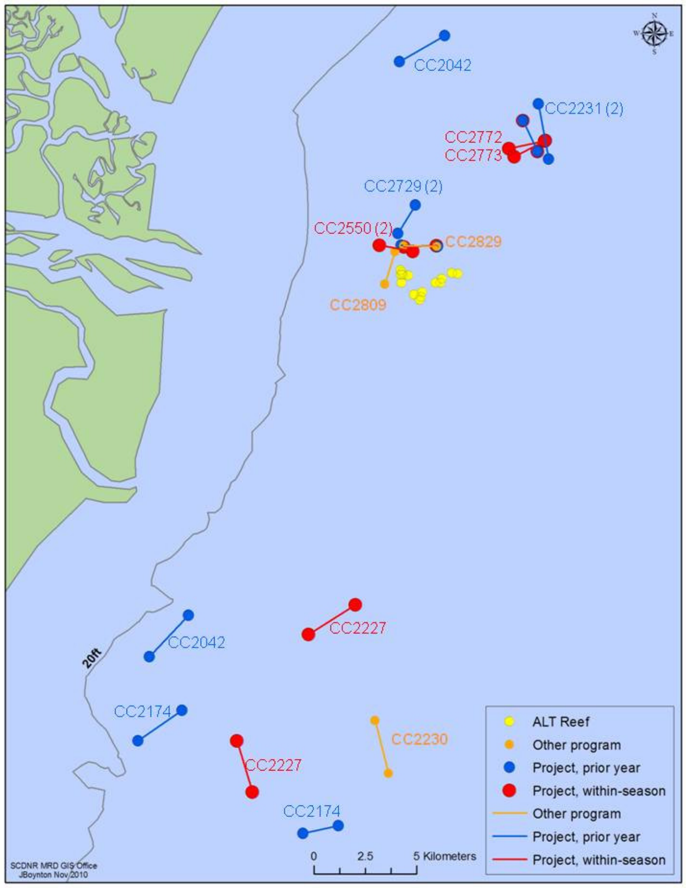


Figure 15. Spatial distribution of loggerhead recaptures in strata pair 35-36 since 2000.

sand grains to infiltrate and be retained within net twine fibers; when these nets are dipped at the end of each season to increase their life expectancy, the sand grains are effectively sealed into the webbing and net weight increases (Parker, personal observation). Prior to 2010, net dry weight at the beginning of each sampling season was not recorded nor were nets assigned numbers that were monitored (to document net use) during the sampling season. As such, for trawling events in earlier years of the study it is impossible to distinguish between limited by-catch that resulted from actual reduced abundance of organisms or due to sampling with a lighter weight net. The converse situation is also true for heavy by-catch events in earlier years of the study with respect to heavier nets. As such, in addition to the suggestion that individual loggerheads are specialist foragers within a generalist realm (Vander Zander et al., 2010), differences in net fishing efficiency may have also contributed to the inability to elucidate definitive relationships between potential prey and loggerhead catch (Byrd et al., 2008).

Environmental factors, notably sea surface temperature, are known to greatly influence the seasonal distribution of loggerheads (Arendt et al., 2009); however, the influence of environmental factors on within-season distributions for this species is less well documented. Maier et al. (2004) and Arendt et al. (2009) have suggested that reduced loggerhead catch rates in this study may result when sampling is conducted during localized wind events, but that catch rates may increase in response to large-scale phenomenon such as Gulf Stream intrusion and coast-wide upwelling events that effectively compress loggerhead distributions. While these assertions help explain inter-annual variability in this trawl survey, there remains a need to better document the influence of environmental conditions on loggerhead catch rates on temporal scales as short as tidal cycles. By minimizing large-scale spatial variability, the modified sampling design evaluated in 2010 enabled these fine-scale temporal influences to be evaluated at four replicate study areas situated along a latitudinal (as well as catch rate) gradient.

Passage of a large low pressure system off the coast of SC during week one of the 2010 sampling season was implicated in the lowest loggerhead catch rates in strata pair 47-48 (cruise one) and to a lesser extent the greatest loggerhead catch rates in strata pair 41-42 the following week. As the low pressure system approached on 24 May, nine sampling events yielded one loggerhead; however, sampling following passage of the system (on 27-28 May) resulted in just one loggerhead in 21 sampling events (Appendix 2) despite the sea state being more benign. Sampling in strata 41-42 three to five days later (five to eight days after passage of the system) was associated with the greatest loggerhead catch rates for this strata pair during 2010. Although this example of sampling a week following system passage is complicated by sampling in a different geographic location, similar barometric pressure and sea surface temperatures during cruise one in both strata pairs suggests similar pre- and post-system effects in both strata pairs. Aside from frontal system passage, environmental factors were not otherwise implicated as influences on loggerhead catch rates due to inconsistent relationships with loggerhead catch among cruises and strata. With respect to sea surface temperature, median cruise temperatures below 25°C were only noted during week one of the sampling season (and auto-correlated with the low pressure system) and with the exception of potential lag affects due to the low pressure system, varied by less than 2°C among cruises within each strata pair. Median barometric pressure among cruises in each strata pair varied by three to four milibars per strata pair; however, identical barometric pressures were recorded for two of three cruises in all strata pairs. In strata pairs 41-42 and 47-48, the same median barometric pressure reading (1013 mb) was associated with the greatest and lowest loggerhead catch rates, respectively. In strata pairs 31-32 and 35-36, loggerhead catch rates were similar among cruises where median barometric pressures differed by four milibars. Wind speed and cloud cover varied over wide ranges (calm to 15+ kts and 0 to 100%, respectively) that fluctuated both throughout the course of the day as well as among days and cruises.

Inability to detect significant relationships between loggerhead catch and water depth, distance from shore, time of day and tide stage suggests that loggerheads are widely distributed throughout the sampling area and that they remain generally localized where they occur and are therefore collected under a variety of conditions. This assertion is supported by a growing number of localized tag-recapture events (as much as eight years later) as well as more definitively by satellite telemetry. Arendt et al. (2009) reported that satellite-tagged juvenile loggerheads (n=34) were detected within boundaries of the trawl survey area nearly two-thirds of the time between May and October, and that the spatial area utilized during the same period was at least five times smaller than documented at other times of the year. Satellite telemetry data collected for 30 juvenile loggerheads tagged and released in all four strata pairs in 2010 (NMFS, unpublished) reaffirm the previous observations given that only one loggerhead (CC0582, a

73.8cm SCLmin female) emigrated out of the sampling area during the summer. Arendt et al. (2009) also noted that data points located outside of the trawl survey area were predominantly attributed to individual loggerheads that remained localized outside of the trawl survey area as opposed to numerous loggerheads routinely moving in and out of the trawl survey area, further reinforcing the notion of wide spatial distribution coupled with a generally localized nature. Thus, although satellite telemetry could be considered a viable method for establishing 'detectability' within the trawl survey area, the need to outfit a suitable number of loggerheads each year to distribute the weighting associated with any individual is cost-prohibitive without substantially (>30%) increased funding and/or substantial funding from additional data sources.

Given data collected during 2010, we do not recommend the modified sampling design as a means for evaluating 'detectability' as the modified design precludes the wide geographic sampling that this survey was established for. More than 50% of stations sampled in 2010 never resulted in collection of a loggerhead, consistent with historical observations of clustered catch (Arendt et al., 2009). Clustered and localized loggerhead distribution is also suspected to have contributed greatly to variability in daily catch within and among sampling cruises (Appendix 2), particularly given inconsistent trends between loggerhead catch and environmental conditions. As such, we believe that stratified random sampling with triplicate sampling (i.e., every other cruise) among sub-regions is sufficient for compensating for station-specific catch probabilities. Why loggerheads are never caught at some stations as well as why loggerheads are inconsistently caught at most other stations may be explained by factors other than those evaluated to date. Given the importance of identifying factors that consistently influence 'detectability', two research proposals were submitted to the Protected Species Cooperative Conservation funding source in fall 2010. The first proposal seeks to evaluate linkages between artificial reefs and loggerhead distributions. Specifically, the proposal is designed to utilize satellite telemetry to compare foraging areas between loggerheads collected randomly in the regional trawl survey (controls) and loggerheads targeted for collection near two artificial reef complexes associated with clustered loggerhead catch in SC and GA as well as with loggerheads collected by scientific divers at the Gray's Reef National Marine Sanctuary (treatments). In addition, acoustic transmitters attached to loggerheads would transmit data recorded by submerged receivers at the treatment sites to document fine-scale temporal (tide stage, time of day) and spatial (structure type) utilization of these monitored habitats. In addition to seafloor mapping using multi-beam and side-scan concurrent with trawling, the second research proposal aims to characterize vertical water column stratification during sampling and evaluate the fishing efficiency of the trawl gear using a Dual-frequency Identification Sonar (DIDSON), with a particular emphasis on how, if at all, gear fishing efficiency varies with ambient light and sound.

Demographic data continue to suggest an encouraging trend for loggerheads in the NW Atlantic. Median size in three of four strata pairs was significantly different from the first two years of the regional trawl survey, which may reflect growth among seasonally resident individuals. The most encouraging news was attributed to the collection of CC2809 which transitioned from a median-sized loggerhead to a nearly (if not already) reproductively-mature individual within a decade. Whether that rate of individual growth is representative as well as what proportion of loggerheads survive to transition from median-sized individuals to reproductively-mature individuals is speculative; however, given that Loggerhead Biological Review Team considers annual survival rates between 0.70 and 0.95 "plausible" for juveniles (Conant et al., 2009), cautious optimism about the potential implications of this exciting recapture event appears to be warranted. Sex ratios remain skewed towards females by at least a two to one ratio among juveniles and adults, and genetic distributions continue to be dominated by two haplotypes prevalent on nesting beaches throughout the Southeast U.S. (Bowen et al., 1993). The vast majority of loggerheads collected displayed no outward signs of injury or debilitation, and nearly as many overtly healthy looking loggerheads were collected as loggerheads appearing emaciated. A suite of diagnostic blood values suggested a correlative gradient with turtle appearance with respect to protein and glucose concentrations as well as lymphocyte and neutrophil counts.

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Appendix 1. Daily sampling effort, number of loggerheads collected on the first trawling event of the day, and total loggerhead catch per day.

Strata	Date	N Cc, Tow 1	Total Cc	N Events
47-48	05/24/2010	0	1	9
47-48	05/27/2010	0	1	12
47-48	05/28/2010	0	0	9
47-48	06/07/2010	1	2	5
47-48	06/08/2010	1	3	10
47-48	06/09/2010	0	3	12
47-48	06/10/2010	0	1	8
47-48	06/11/2010	0	2	6
47-48	06/21/2010	0	1	8
47-48	06/22/2010	1	4	13
47-48	06/23/2010	0	1	13
47-48	06/24/2010	0	6	11
Total	12	3 (events)	25	116

Strata	Date	N Cc, Tow 1	Total Cc	N Events
41-42	06/01/2010	0	3	7
41-42	06/02/2010	1	2	9
41-42	06/03/2010	0	3	12
41-42	06/04/2010	0	0	2
41-42	06/14/2010	0	1	8
41-42	06/15/2010	0	3	14
41-42	06/16/2010	0	1	10
41-42	06/17/2010	0	3	11
41-42	06/28/2010	0	0	8
41-42	06/29/2010	0	3	13
41-42	06/30/2010	0	1	12
41-42	07/01/2010	0	3	10
Total	12	1 (event)	23	116

Strata	Date	N Cc, Tow 1	Total Cc	N Events
35-36	06/14/2010	1	4	8
35-36	06/15/2010	0	5	9
35-36	06/16/2010	0	1	9
35-36	06/17/2010	1	2	12
35-36	06/18/2010	0	3	6
35-36	07/05/2010	0	3	11
35-36	07/06/2010	0	1	13
35-36	07/07/2010	0	2	10
35-36	07/08/2010	0	1	10
35-36	07/09/2010	0	1	2
35-36	07/19/2010	0	1	12
35-36	07/20/2010	2	5	10
35-36	07/21/2010	0	2	11
35-36	07/22/2010	1	11	11
35-36	07/23/2010	0	0	2
Total	15	4 (events)	42	136

Strata	Date	N Cc, Tow 1	Total Cc	N Events
31-32	06/07/2010	1	2	2
31-32	06/09/2010	0	0	13
31-32	06/10/2010	4	7	8
31-32	06/11/2010	0	0	5
31-32	06/21/2010	2	7	8
31-32	06/22/2010	0	12	8
31-32	06/23/2010	0	2	13
31-32	06/24/2010	0	3	10
31-32	06/25/2010	0	0	4
31-32	07/12/2010	0	4	7
31-32	07/13/2010	0	4	8
31-32	07/14/2010	0	3	10
31-32	07/15/2010	0	2	12
31-32	07/16/2010	0	0	4
Total	14	3 (events)	46	112

Appendix 2. Temporal distribution of loggerhead catch for each of 181 unique stations sampled among four strata pairs in summer 2010.

Station	Cruise 1	Cruise 2	Cruise 3
47M001	1		2
47T002		0	0
47T003	0	0	0
47T004		0	2
47T005		0	0
47T006		0	0
47T010		1	0
47T014	0	0	0
47T023	0	0	0
47T025	0	1	0
47T028	0	2	0
47T032	0	1	1
47T035	0	0	1
47T037	0	0	0
47T038	0	0	0
47T041	0	0	0
47T047	0	0	1
47T048	0	0	0
47T056	0	0	0
47T057	0	1	0
48T003		1	0
48T004	0	0	1
48T009		0	0
48T010	0	0	1
48T012	0	0	1
48T014		1	0
48T018			0
48T019		1	0
48T021			0
48T024	0	0	0
48T025	0	0	0
48T026			1
48T027	0	0	0
48T028	0	0	0
48T029	0	1	0
48T030	0	0	0
48T039	0	0	0
48T045		0	0
48T046		0	0
48T047	0	0	1
48T050		0	0
48T053	0	0	0
48T055	0	0	0
48T057	1	0	0
48T064	0	1	0
N Cc	***2***	***11***	***12***

Station	Cruise 1	Cruise 2	Cruise 3
41M001	0	0	0
41M004	0	0	1
41M005	0	0	0
41T006		0	0
41T019	0	1	0
41T026		0	0
41T028	0	0	1
41T035	1	0	0
41T043		0	0
41T051		0	0
41T066		0	0
41T067	0	0	0
41T070	0	0	0
41T075		1	0
41T083		0	0
41T087	0	1	0
41T088	0	0	0
41T091	0	0	1
42T001	0	0	0
42T003	1	0	0
42T006	1	0	0
42T029		1	0
42T034		0	2
42T036	1	0	0
42T037	0	0	0
42T038	0	0	0
42T041	0	0	0
42T046	1	1	0
42T050	2	0	0
42T052	0	0	0
42T055	0	0	0
42T056	0	0	0
42T057	0	0	0
42T063	0	0	1
42T064	0	0	0
42T069		0	0
42T072		0	0
42T074	0	1	0
42T075		1	0
42T076	1	0	1
42T077		0	0
42T080	0	1	0
42T082	0	0	0
N Cc	***8***	***8***	***7***

Station	Cruise 1	Cruise 2	Cruise 3
35M001	0	0	0
35M004	0	0	1
35M005	0	0	0
35T001	0	0	0
35T002	0	0	1
35T004	0	0	0
35T006	0	0	0
35T010	0	0	0
35T016	0	0	0
35T025		0	0
35T026	0	0	0
35T033	0	0	0
35T036	0	0	0
35T041	0	0	0
35T046	1, 0	0	0
35T047	0	0	0
35T050	0	0	0
35T054	1	1	0
36M001	0	0	0
36T003		0	1
36T005	0	0	0
36T007	0	0	0
36T008	0	0	1
36T009	0	0	2
36T010	2	0	2
36T013	0	0	2
36T014	3	0	2
36T023	1	0	0
36T025	0	0	0
36T027	0	0	0
36T028		1	0
36T031	0	0	0
36T032	0	0	0
36T035	0	1	0
36T036	0	0	1
36T038	1	0	0
36T039	2	0	0
36T047	2	0	1
36T052	1	1	0
36T054	0	0	0
36T055	0	1	1
36T069	0	1	0
36T079	0	2	2
36T080	1	0	2
36T085	0	0	0
36T094	0	0	0
N Cc	***15***	***8***	***19***

Station	Cruise 1	Cruise 2	Cruise 3
31M001		0	0
31M002		0	0
31M003		0	0
31T002	0	0	0
31T003		0	1
31T006		1	2
31T007	0	0	1
31T012		0	0
31T014	1	1	1
31T016	4	10	
31T027		2	0
31T028	1	1	0
31T029		0	1
31T030	0		0
31T031	0		0
31T036		0	0
31T038		0	0
31T039	0		0
31T047	0	1	0
31T048	1	0	0
31T051		2	0
31T055	0	0	0
31T057		0	0
31T058		0	0
31T060	0	0	
31T061	0	0	0
32T001	0	1	1
32T007	0	0	
32T008		0	1
32T012	0	0	
32T013	0	1	1
32T016	0	0	
32T021	0		1
32T022	0	0	0
32T023	0	0	1
32T027	0	0	0
32T028		0	0
32T034		0	0
32T037	1	0	0
32T044		2	0
32T045	0	1	0
32T047		0	0
32T050		0	0
32T053	0	0	1
32T054	0	0	0
32T056	1	1	
32T057	0	0	1
N Cc	***9***	***24***	***13***

Appendix 3. Press release about the capture of CC2809, the first loggerhead rehabilitated at the SC Aquarium in summer 2000. http://www.dnr.sc.gov/news/yr2010/aug30/aug30_turtle.html

DNR Media Contacts:
Columbia - Brett Witt (803) 667-0696
Clemson - Greg Lucas (864) 654-1671, ext.22
Charleston - (803) 667-0696
Spokesman - Mike Willis (803) 734-4133
After Hours Radio Room - (803) 955-4000

DNR News
SC Dept. of Natural Resources
P 0 Box 167
Columbia, SC 29202
August 24, 2010

Regional sea turtle survey recaptures first sea turtle ever rehabilitated by South Carolina Aquarium

The long-term value of rehabilitating sea turtles was substantiated on July 5, 2010 when the first loggerhead rehabilitated at the South Carolina Aquarium was recaptured nearly 10 years after it was released from what has developed into a full-fledged Sea Turtle Hospital. This loggerhead, dubbed "Stinky" by the Aquarium's animal care staff, was recently recaptured a few miles off central Georgia by the R/V Georgia Bulldog during a regional turtle trawl survey managed by the S.C. Department of Natural Resources (DNR). Between release and recapture, Stinky's weight increased from 103 to 176 pounds and his length grew by five inches, which is a normal rate of growth for a juvenile loggerhead of this size.

The story of how this loggerhead came to the Aquarium on Aug. 22, 2000 was detailed in the August-November 2000 issue of Loggerheadlines. Briefly, "he" was found floating in Port Royal Sound, Beaufort County and picked up by DNR Law Enforcement. The turtle had a heavy barnacle load but no external wounds. After being examined by Sea Islands Vet Clinic on James Island, S.C., DNR transported the turtle to the South Carolina Aquarium for rehabilitation. Upon arrival at the Aquarium, Stinky was determined to be positively buoyant and classified as a "floater." Initial supportive care (administered with guidance from the Karen Beasley Sea Turtle Rescue and Rehabilitation Center and the N.C. State University College of Veterinary Medicine) included antibiotic and vitamin injections, fluid therapy, and radiographs which confirmed internal gas pockets in the animal's body cavity. After a short period, Stinky began to eat squid, a few crabs and a lot of mackerel. Following two months of treatment his overall health had improved, but his floating disorder persisted; thus, it became apparent that additional procedures would be needed to ultimately treat the floating condition.

On Oct. 11, 2000, a team was assembled from the Aquarium and DNR, led by Dr. David Owens, a renowned endocrinologist with the College of Charleston, to perform a laparoscopy on the ill loggerhead. In this procedure, a small incision is made and an optic endoscope is inserted into the turtle's body cavity. Using this scope to visualize the interior of the body cavity, Dr. Owens was able to guide antibiotic-laced sterile fluids into the body cavity to treat the animal's internal infection and displace the air that was causing the turtle to float. The scope also enabled Dr. Owens to visualize gonads indicating the turtle was male, information not attainable from an external examination until a sea turtle reaches adulthood. A second laparoscopy was performed on Nov. 15, 2000 and revealed great improvement of the internal condition and soon after, the loggerhead was cleared for release.

On Jan. 11, 2001, Stinky was transported to the warm waters off Florida by DNR and released at the Archie Carr National Wildlife Refuge in Melbourne, Florida. For the next nine and a half years, his whereabouts and status remained unknown.

This story is a remarkable example of the success of rehabilitation, for which little data is available. While satellite-telemetry (which has been used by the South Carolina Aquarium) provides a means to gauge the initial success of rehabilitation and release, documenting long-term survivorship requires recapturing turtles which is not common. Stinky is only the second of 51 sea turtles to be recaptured following successful rehabilitation and release by the Aquarium, both of which were recaptured in the regional in-water trawl survey. Furthermore, because this turtle is a male that would not come ashore unless he stranded again, the odds were even more stacked against ever receiving a report on his whereabouts after he was released. Therefore, when Julia Byrd, DNR Biologist and Chief Scientist for the July 5-9 cruise, reported that he "looked fat and healthy and was very energetic when he was brought onboard," Sea Turtle Hospital staff were elated.

When Stinky stranded in 2000, his tail was very short (five and a half inches) and it did not extend beyond his shell, indicating that he was not a mature male. During the 10 years at large, it is very exciting to note that his tail grew eight inches to reach a length of over 13 inches. It appears that this turtle is close to or has reached maturity which would allow him to contribute reproductively. But, the significance of capturing a matured sea turtle is even more profound than adding one more adult to the population. As Dr. Owens explains, "Recapturing this turtle is an amazing and unprecedented opportunity to study a sea turtle in this part of the world that is transitioning through puberty, a critical life stage for the recovery of sea turtles that has never been properly studied." Thus, DNR is hopeful that the steroid hormone samples collected for Dr. Owens and other collaborators from this and other similar-sized turtles may help refine the estimates of the amount of time that must elapse before loggerheads fully mature.

In addition to highlighting the strong partnership between the Aquarium and SCDNR that now benefits many species statewide, this sea turtle's story also beautifully illustrates why patience is so crucial among those working to conserve and recover our state reptile, the loggerhead sea turtle. In the three decades that have passed since loggerheads were added to the Endangered Species List in 1978, nesting in the southeast, including South Carolina, has declined while in-water catch rates have increased. Because 90 percent of in-water collected loggerheads are healthy juveniles that are predominantly females (determined from testosterone levels) originating from our region, these individuals, if they survive to maturity, may lead to an increase in the number of adult nesting females in the future.

So while we all wait with bated breath to see what the future holds for loggerheads along our coast, rest assured that DNR is doing its part to ensure accurate data is collected and available for making informed management decisions that affect the fate of loggerheads, and that the South Carolina Aquarium is making sure that every individual is given a fighting chance at survival. Together, DNR and the South Carolina Aquarium are working to educate the public on how each and every person can take part in protecting and conserving sea turtles for future generations.

Help us help sea turtles in South Carolina: Lighting and habitat disturbance are detrimental to sea turtle nesting and hatchling emergence; thus, 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 (i.e., 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.
  Consistent with their name, sea turtles spend most of their life in the water; thus, here are a few recommendations to increase the survival of sea turtles in our coastal waters:
- 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 or 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.

More information on the DNR Marine Turtle Conservation Program.

More information on the South Carolina Aquarium Sea Turtle Rescue Program.

More information on the DNR Sea Turtle Trawl Survey.

Appendix 4. Summary statistics from multiple regression tests for differences in catch rates (cumulative catch versus sequential sampling event). Asterisks for cruise one in strata pair 47-48 denote regression line based two data points due to inclement weather during cruise.

Strata Pair	Cruise	Equation	p-value	R-squared
47-48	1	y = -2.158 + 0.243x	**	**
47-48	2	y = -2.158 + (0.243x + 3.602)	<0.0001	0.970
47-48	3	y = -2.158 + (0.243x + 2.334)	<0.0001	0.950

Strata Pair	Cruise	Equation	p-value	R-squared
41-42	1	y = 1.939 + 0.194x	0.0009	0.907
41-42	2	y = 1.939 + (0.194x - 2.132)	<0.0001	0.968
41-42	3	y = 1.939 + (0.194x - 2.968)	0.0004	0.900

Strata Pair	Cruise	Equation	p-value	R-squared
35-36	1	y = 1.944 + 0.0302x	<0.0001	0.920
35-36	2	y = 1.944 + (0.0302x - 4.557)	<0.0001	0.975
35-36	3	y = 1.944 + (0.0302x - 0.639)	<0.0001	0.894

Strata Pair	Cruise	Equation	p-value	R-squared
31-32	1	y = -1.131+ 0.523x	0.0001	0.980
31-32	2	y = -1.131+ (0.523x + 5.615)	<0.0001	0.868
31-32	3	y = -1.131+ (0.523x + 0.940)	<0.0001	0.857

Appendix 5. Summary of by-catch species collected aboard both research vessels in 2010.

			R/V *Georgia Bulldog*		R/V *Lady Lisa*	
Code	**Group**	***ScientificName***	**Port**	**Starboard**	**Port**	**Starboard**
A003	Shark	*Ginglymostoma cirratum*		1		
A013	Shark	*Carcharhinus isodon*		1		
A014	Shark	*Carcharhinus acronotus*	13	4	15	4
A018	Shark	*Carcharhinus limbatus*		3		
A023	Shark	*Galeocerdo cuvieri*			1	
A028	Shark	*Rhizoprionodon terraenovae*	70	89	210	230
A029	Shark	*Sphyrna lewini*	5	10		
A031	Shark	*Sphyrna tiburo*	104	121	82	85
A039	Ray	*Rhinobatos lentiginosus*	2	5	6	4
A043	Ray	*Raja eglanteria*		2		2
A048	Ray	*Dasyatis americana*	55	56	78	98
A049	Ray	*Dasyatis centroura*	9	10	3	5
A050	Ray	*Dasyatis sabina*		2		
A054	Ray	*Gymnura micrura*	30	39	17	8
A056	Ray	*Aetobatus narinari*	1	1	1	1
A057	Ray	*Myliobatis freminvillei*	19	7	3	3
A059	Ray	*Rhinoptera bonasus*	27	41	3	1
A084	Fish, Mid-water	*Brevoortia tyrannus*	1	1		
A088	Fish, Mid-water	*Opisthonema oglinum*	2	6	2	19
A097	Fish, Demersal	*Synodus foetens*	12	152	54	296
A110	Fish, Demersal	*Opsanus tau*		1		
A119	Fish, Demersal	*Ogcocephalus radiatus*	1			
A175	Fish, Reef	*Centropristis ocyurus*		1	2	1
A177	Fish, Reef	*Centropristis striata*	1	1	7	14
A178	Fish, Reef	*Diplectrum formosum*	4	18	3	8
A206	Fish, Mid-water	*Pomatomus saltatrix*	2	17		9
A207	Fish, Mid-water	*Rachycentron canadum*	1	1	1	2
A216	Fish, Mid-water	*Caranx crysos*		4	2	
A220	Fish, Mid-water	*Chloroscombrus chrysurus*	6792	13213	6261	14778
A223	Fish, Mid-water	*Decapterus punctatus*			1	5
A229	Fish, Mid-water	*Selene vomer*	14	28		
A234	Fish, Mid-water	*Trachinotus carolinus*	2	10	2	2
A237	Fish, Mid-water	*Trachurus lathami*				3
A238	Fish, Mid-water	*Selene setapinnis*	1202	1511	2244	2562
A262	Fish, Reef	*Orthopristis chrysoptera*		5	1	5
A263	Fish, Reef	*Archosargus probatocephalus*		1	2	
A271	Fish, Reef	*Lagodon rhomboides*	6	7	2	5
A273	Fish, Reef	*Stenotomus aculeatus*	19	93	340	830
A275	Fish, Sciaenid	*Bairdiella chrysoura*		1		
A277	Fish, Sciaenid	*Cynoscion nothus*	39	108	4	15
A278	Fish, Sciaenid	*Cynoscion regalis*	2	19	3	9
A283	Fish, Sciaenid	*Larimus fasciatus*	478	1232	539	1276
A284	Fish, Sciaenid	*Leiostomus xanthurus*	122	584	4	50
A285	Fish, Sciaenid	*Menticirrhus americanus*	7	47	1	17
A287	Fish, Sciaenid	*Menticirrhus saxatilis*	1	1	1	16
A288	Fish, Sciaenid	*Micropogonias undulatus*	30	249		14
A291	Fish, Sciaenid	*Stellifer lanceolatus*	1	61	1	19
A297	Fish, Reef	*Chaetodipterus faber*	720	891	295	576
A333	Fish, Cryptic	*Hypleurochilus geminatus*		3		1
A353	Fish, Mid-water	*Trichiurus lepturus*	14	24		2
A361	Fish, Mid-water	*Scomberomorus cavalla*	3			
A362	Fish, Mid-water	*Scomberomorus maculatus*		9		8
A376	Fish, Mid-water	*Peprilus triacanthus*	18	52	55	163
A392	Fish, Demersal	*Prionotus carolinus*	74	501	178	391
A393	Fish, Demersal	*Prionotus evolans*	20	77	53	32
A397	Fish, Demersal	*Prionotus scitulus*	6	37		3
A398	Fish, Demersal	*Prionotus tribulus*		2	2	5
A401	Fish, Flat	*Ancylopsetta quadrocellata*	24	60	51	51

Appendix 5. continued

			R/V *Georgia Bulldog*		R/V *Lady Lisa*	
Code	**Group**	***ScientificName***	**Port**	**Starboard**	**Port**	**Starboard**
A405	Fish, Flat	*Citharichthys macrops*		1	3	1
A408	Fish, Flat	*Etropus crossotus*	1	2	1	3
A413	Fish, Flat	*Paralichthys dentatus*	1	2		
A414	Fish, Flat	*Paralichthys lethostigma*	2	1		1
A417	Fish, Flat	*Scophthalmus aquosus*			1	2
A423	Fish, Flat	*Symphurus urospilus*				2
A428	Fish, Reef	*Balistes capriscus*		1		2
A434	Fish, Reef	*Stephanolepis hispidus*		1	1	2
A439	Fish, Reef	*Acanthostracion quadricornis*	36	42	24	19
A442	Fish, Reef	*Lagocephalus laevigatus*		1		
A444	Fish, Reef	*Sphoeroides maculatus*	2	1	7	7
A448	Fish, Reef	*Chilomycterus schoepfi*	132	204	187	123
A450	Fish, Reef	*Diodon hystrix*		1		
A460	Fish, Cryptic	Gobiidae	2		3	
A464	Fish, Mid-water	*Alectis ciliarius*		1	4	
A466	Fish, Mid-water	*Anchoa* sp.	145	219	13	31
A472	Fish, Reef	Balistidae	1			
A474	Fish, Cryptic	Blenniidae	6	5	11	11
A498	Fish, Cryptic	*Hippocampus* sp.		1		1
A941	Fish, Commensal	*Echeneis* sp.	3	5	2	4
B423	Fish, Mid-water	*Peprilus paru*	228	358	145	360
B601	Invert, Tunicate	*Tunicata*	52	111	79	40
B634	Invert, Tunicate	*Styela* sp.	40	17	68	13
B639	Invert, Tunicate	*Aplidium Stellatum*	116	118	228	145
B670	Invert, Tunicate	*Eudistoma hepaticum*	17	32	27	20
C324	Invert, Sponge	*Microciona prolifera*	2	7		
C357	Invert, Sponge	*Cliona celata*	12	12		
C374	Invert, Sponge	Porifera	41	140	20	16
C414	Invert, Sponge	*Haliclona* sp.	54	52	94	63
C422	Invert, Sponge	*Cinachyra* sp.	12	12		
C428	Invert, Sponge	*Ircinia* sp.	24	51	20	9
D003	Invert, Shrimp	*Penaeus aztecus*	2	34		
D005	Invert, Shrimp	*Penaeus setiferus*	2	10		3
D019	Invert, Crab	Dromiidae	2	8	3	6
D050	Invert, Shrimp	*Lysmata wurdemanni*		2		
D059	Invert, Crab	*Pilumnus* sp.	17	23	15	10
D081	Invert, Crab	*Petrochirus diogenes*			1	3
D101	Invert, Crab	*Dromidia antillensis*			3	1
D112	Invert, Crab	*Calappa flammea*		3	44	21
D116	Invert, Crab	*Hepatus epheliticus*			1	
D120	Invert, Crab	*Ovalipes stephensoni*	3	25	50	36
D121	Invert, Crab	*Ovalipes ocellatus*				5
D124	Invert, Crab	*Portunus gibbesii*		1	2	5
D127	Invert, Crab	*Portunus spinicarpus*		2		
D128	Invert, Crab	*Portunus spinimanus*		2	10	7
D130	Invert, Crab	*Callinectes sapidus*	5	4	12	5
D142	Invert, Crab	*Menippe mercenaria*	6	8	11	13
D246	Invert, Crab	*Libinia* sp.	23	39	31	39
D247	Invert, Crab	*Callinectes similis*	1	4		1
D290	Invert, Crab	Alpheidae	1	1	2	
D300	Invert, Crab	Brachyura	1			
D403	Invert, Crab	Paguridea		1	1	1
D409	Invert, Crab	Porcellanidae		1		2
E001	Invert, Shrimp	*Squilla empusa*		2		
E002	Invert, Shrimp	*Squilla* sp.	1	1		1
E108	Invert, Shrimp	*Squilla neglecta*			1	
E309	Invert, Shrimp	Stomatopoda		1		
F001	Invert, Horseshoe crab	*Limulus polyphemus*	57	89	5	3

Appendix 5. continued

			R/V *Georgia Bulldog*		R/V *Lady Lisa*	
Code	**Group**	***ScientificName***	**Port**	**Starboard**	**Port**	**Starboard**
H001	Invert, Soft coral	*Renilla reniformis*				1
H002	Invert, Soft coral	*Leptogorgia virgulata*	15	20	12	22
H003	Invert, Jellyfish	*Cyanea capillata*				2
H005	Invert, Cannonball jelly	*Stomolophus meleagris*	160	165	150	135
H023	Invert, Cannonball jelly	*Paranthus rapiformis*	1			
H244	Invert, Jellyfish	*Chrysaora quinquecirrha*	661	684	162	237
H246	Invert, Jellyfish	*Aurelia aurita*	30	32	1	
H288	Invert, Jellyfish	Actiniaria		2		
H300	Invert, Hydroid	Hydroidea		1	1	1
H305	Invert, Hard coral	Scleractinia		4		40
H306	Invert, Hard coral	*Oculina* sp.	2			
H309	Invert, Soft coral	*Telesto* sp.			2	4
H310	Invert, Hard coral	*Octocorallia*		1	4	
H351	Invert, Soft coral	*Titanideum* sp.	10	10	12	22
H383	Invert, Jellyfish	Cubozoa	152	221	18	42
H508	Invert, Jellyfish	Ctenophora	3		5	
J001	Invert, Sea star	*Asterias forbesii*	190	246	417	299
J003	Invert, Sea star	*Astropecten articulatus*	4	5		
J008	Invert, Sea star	*Luidia alternata*		2		2
J068	Invert, Biscuit/Dollar	*Mellita quinquesperforata*		3	2	1
J072	Invert, Urchin	*Lytechinus variegatus*	21	208	1213	713
J085	Invert, Urchin	*Arbacia punctulata*	37	182	274	183
J086	Invert, Brittle Star	Ophiuroidea	19	22	23	9
J090	Invert, Biscuit/Dollar	*Echinaster* sp.			2	1
J100	Invert, Biscuit/Dollar	*Clypeaster subdepressus*	8	16	12	31
J117	Invert, Biscuit/Dollar	*Clypeaster* sp.				1
J214	Invert, Sea cucumber	Holothuroidea	5	17	8	1
J215	Invert, Sea star	*Luidia sp.*	1377	1572	1084	978
J217	Invert, Sea star	*Encope sp.*			1	1
M501	Invert, Bryozoan	*Alcyonidium hauffi*	9	14	40	75
M563	Invert, Bryozoan	Bryozoa	1	5	2	
N083	Invert, Bivalve	*Murex oomum*				1
N084	Invert, Bivalve	*Murex fulvescens*		1		
N103	Invert, Gastropod	*Busycon contrarium*			5	2
N104	Invert, Gastropod	*Busycon carica*		1	1	5
N112	Invert, Gastropod	*Pleuroploca gigantea*			4	5
N261	Invert, Bivalve	*Dinocardium robustum*				4
N328	Invert, Octopus	*Octopus vulgaris*		1	5	1
N333	Invert, Squid	*Lolliguncula brevis*	12	33	2	10
N386	Invert, Squid	*Loligo* sp.	98	273	31	242
N540	Invert, Bivalve	Veneridae			2	