INCIDENTAL CAPTURE OF SEA TURTLES BY SHRIMP TRAWLERMEN IN GEORGIA

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Abstract: In 1976, a survey was conducted to ascertain the incidental capture of sea turtles by shrimp trawlers in Georgia waters. Interviewed were captains and strikers representing 101 commercial trawlers (average length 17.4 m) which principally offload their catch at commercial docks on the Georgia coast. During that period, 1,388 vessels were registered to shrimp in Georgia, including a 321 vessel commercial fleet with Georgia registration and vessel length greater than 9.14 m. Commercial shrimpers trawled an average of 22 days per month during a 6.7 month shrimp season; they averaged 4.5 drags per day and 2.1 hours per drag. Commercial shrimpers estimated that 30.7 turtles are incidentally captured per vessel per year (1 turtle per 16 drags during a 5-month season when turtles are numerous in Georgia estuarine waters). The minimal mortality rate was 7.9% of captured turtles. It is estimated that a minimum of 778 turtles were drowned in 1976. Carapace length measurements of turtles found dead on beaches revealed a bimodal size distribution of turtles captured by trawlers, with juveniles (88% of total turtles) measuring 50-88 cm and adults (12%) measuring 88-107 cm, with some overlap. Most turtles were captured where shrimpers preferentially drag, particularly the sounds, channels leading into the sounds, and flats on either side of the channels. Damage by captured turtles to gear or to shrimp and other commercially important species captured with the turtles does not seem to be a significant factor for Georgia shrimp fishermen.

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Sea turtle biology and ecology are poorly known in Georgia and elsewhere along the Southeastern seaboard. Deficiencies in our knowledge of these marine resources became obvious following the recent proposal that the loggerhead (*Caretta caretta*) and green sea turtles (*Chelonia mydas*) be added to the list of threatened species, as provided in the Endangered Species Act of 1973. Species distribution, population trends, critical habitat needs, and limiting factors of the group are required data for accurate evaluation of the survival status of the species. In Georgia, the shrimp trawling industry has been historically implicated as a limiting factor on sea turtles, principally loggerheads.

The primary objective of this study was to quantify and evaluate mortality of sea turtles incidentally captured by shrimp trawlers in Georgia. We sought to interpret from capture data the total impact of the shrimping industry upon the population dynamics of loggerheads, and, as approprite, on other sea turtles in the state.

This study was conducted for the National Marine Fisheries Service under contract number 03-7-042-35129. We are grateful for liaison services provided by J. Tyler, D. Ekberg, and L. Ogren of National Marine Fisheries Service during the study.

Numerous agencies and individuals contributed in various ways to the study, greatly facilitating data collection. We thank D. Gould and the Georgia Department of Natural Resources, Division of Game and Fish for allowing access to shrimp boat registration records. D. Harrington, J. Whitted and J. Higgins, Marine Extension Service, University of Georgia, were especially helpful in establishing contact with shrimpers and assisting in the collection of data of turtle captures in the sounds.

The U.S. Fish and Wildlife Service is gratefully acknowledged for providing access to Wassaw and Blackbeard Islands and their sea turtle records. The National Park Service was very helpful in obtaining sea turtle data pertaining to Cumberland Island National Seashore.

Many of Georgia's barrier islands have resident tagging teams during the loggerhead nesting season. We acknowledge the efforts of these conservationists and thank them, collectively, for making their records available to us. We acknowledge the valuable

contributions of C. Ruckdeschel of Cumberland Island. The Little Cumberland Island Association cooperated fully with our survey of nesting activity and turtle strandings on their beaches. A. Bradford and I. Williams transmitted records of turtle nesting and strandings on Ossabaw Island.

R. Moulis is commended and acknowledged for his enthusiasm in conducting portions of this study.

The success of this study was dependent upon the cooperation of the shrimp trawler owners, captains, and strikers along the Georgia Coast. Almost without exception, we received complete cooperation from them during the interview and other phases of the study. As a group, the shrimp trawlermen of Georgia enthusiastically cooperated in the compilation of data which often were of a sensitive and implicating nature to their industry. It is our wish that our treatment of the data is equitable both to the shrimp industry of Georgia and to sea turtles.

STUDY AREAS

Five species of sea turtles are associated with the Georgia Coast. The loggerhead is Georgia's most prevalent species, occurring regularly as juveniles and adults throughout estuarine and offshore waters. Only the loggerhead nests in Georgia; it nests at least sparingly on almost every stretch of sandy beach on the Coast. The green turtle, leatherback (*Dermochelys coriacea*), and Kemp's ridley (*Lepidochelys kempi*) are incidentally caught in small but regular numbers by shrimp trawlers in Georgia waters. The hawksbill (*Eretmochelys imbricata*) is a tropical species very rarely encountered in Georgia waters.

The Georgia Coast consists of a chain of barrier islands and estuaries (Fig. 1). Individual islands are separated from each other by a network of river deltas, sounds, and tidal creeks and from the mainland by extensive saltmarshes. The Georgia beaches are part of a dynamic and fluctuating shoreline, closely linked to a complex sandsharing system (Oertel 1974, Johnson *et al.* 1974). Responding to the inexorable forces of wind, waves, and current, most nesting beaches are either growing or receding, rarely remaining stationary.

METHODS AND MATERIALS

Several methods were used to study the interaction between sea turtles and the Georgia shrimping industry. Information was accumulated through interviews, on-board observations, aerial surveys, ground surveys, results from Georgia sea turtle tagging programs, license records, and a survey of recent literature from Georgia research efforts.

We obtained from the Georgia Department of Natural Resources, Division of Game and Fish, a list of 1,388 vessels and the lengths and State of registration of these vessels for which shrimping licenses were granted for 1976. The greater portion, 728 craft less than 6.10 m in length, were noncommercial and not considered in this study. A group of 127 vessels of intermediate length (6.10 - 9.14 m) included an unknown proportion of commercial craft, but they were largely unavailable to our survey since they did not dock regularly at commercial seafood docks. Vessels of this length class represented 6% of our interview sample.

The remaining 533 vessels, 9.14 m or more in length and including 321 vessels with Georgia registry, constituted a major portion of the 1976 Georgia commercial shrimp fleet. Realizing that shrimp vessels move from state to state, depending on season and the location of catchable shrimp, we have accepted 321 vessels as our best estimate of the 1976 Georgia commercial shrimp fleet. Vessels in this category represented 94% of our interview sample.

Between 14 July and 12 October 1976, we interviewed captains and strikers representing 101 commercial shrimp vessels which consistently unload their catch at commercial docks in Georgia. These men responded to questions relating to the entire previous 1975 shrimping season as well as to that portion of the current 1976 season which

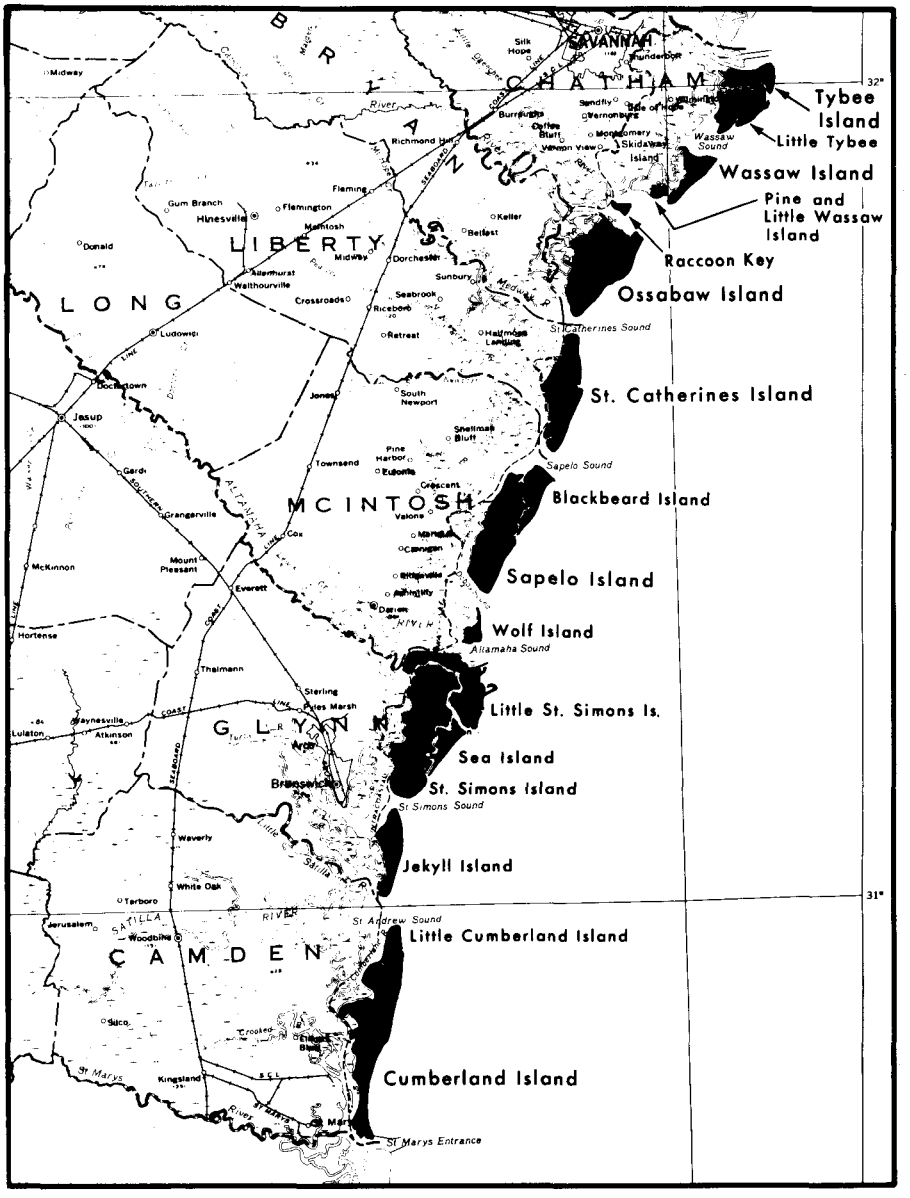

Fig. 1. Map of coastal Georgia showing locations of island complexes discussed in text.

preceded the interview date. The average length of vessels included in our interview sample was 17.4 m.

We conducted a series of aerial surveys, using a Cessna 150 aircraft, during 1977 prior to and following the opening of inshore waters to shrimping. Surveys were to count sea turtle crawls, nests, and dead turtles stranded on the beaches and to ascertain the number and location of shrimp boats in offshore and inshore waters.

Fourteen flights, covering all potential nesting beaches on the Georgia Coast, were flown on 3-day intervals, from 26 June to 31 July 1977. Flights over uninhabited beaches were conducted at an altitude of 7.6-30.5 m and at a distance of 20-30 m from the tide line, with a slightly higher altitude and greater lateral distance over inhabited beaches. Personnel consisted of a pilot and an observer/recorder, each with 5 years of experience conducting sea turtle related work on the Georgia Coast.

RESULTS AND DISCUSSION

Shrimping Patterns

Commercial shrimpers contacted by our survey fish an average of 22 days per month during a 6.7 month Georgia shrimping season (Table 1). They average 4.5 drags per day, with the nets deployed 2.1 hours per drag. Nearly all Georgia commercial shrimpers pull twin nets, with a mean net mouth width of 17.2 m per net.

Table 1. Summary of basic parameters of shrimp trawling and the incidence of loggerhead sea turtle capture and mortality in Georgia, based on 101 interviews with captains and strikers of commercial shrimp vessels with Georgia registry, 1976.

Parameters	*Values*	*Range of Responses*	*Number of Responses*
Total commercial vessels 9.1 m registered in Georgia, 1976.	321		
Average vessel length (m).	17.4	4.9-24.7	101
Average length (months) of shrimping season.	6.7	2.5- 9.0	91
Estimated shrimping season (months) when sea turtles are actively caught.	5		
Average number shrimping days per month.	22.2	13-30	81
Average number of drags per day.	4.5	3.0- 7.5	86
Average number hours per drag.	2.1	0.3- 3.5	94
Average trip length in days.	2.1	1.0- 6.5	90
Average net width (m).	17.2	9.1-24.4	98
Average minimum number of sea turtles captured per vessel per year (1975 season).	30.7	1-100	52
Average trawls per sea turtle captured during five month season when turtles active.	16		
Estimated turtles captured by the 1976 commercial fleet of 321 vessels.	9855		
Average minimum percent mortality of sea turtles caught.	7.9	0-50	58
Estimated minimum total sea turtle mortality induced by the 1976 commercial fleet of 321 vessels.	778		

Assuming an average vessel speed of 4.8 km per hour under load (D. Harrington personal communication), the total area trawled in Georgia yearly by a 321 vessel commercial fleet would be equivalent to an area of 75,061 km^2, given that no area was dragged more than once in the same year. Since Georgia's nearshore waters are no more than 800 km^2 in total area and since certain preferred fishing locations within this area receive repeated drags, a figure of 75,061 km^2 serves primarily to emphasize the considerable physical coverage of a shrimping fleet on the benthic fauna of a restricted estuarine system. The average commercial vessel has a drag path of 23,383 ha per day.

When Georgia sounds are opened to shrimping, there is a surge of activity which rapidly dwindles as the shrimp population is depleted within the area. On 4 October, the opening morning of the 1976 sound season, 175 vessels were active in St. Andrew Sound. Seventy-five vessels were active on the following morning, but by 1500 hours of the same day, only 5 vessels were still in the area. On the initial day of an open sound season, we estimate that the number of out-of-state trawlers may swell the Georgia fleet by 50%.

Incidental Capture

The total number of turtles captured in trawl nets is the best possible estimate of potential conflict between sea turtles and the shrimping industry. Loggerheads represent most, but not all, of the sea turtles captured by shrimpers in Georgia waters. A Kemp's ridley resembles a loggerhead and undoubtedly is identified as such by many shrimpers. We estimate that loggerheads make up at least 95% of turtles captured by trawlers and that Kemp's ridleys represent the majority of the remaining animals.

A total of 1595 turtles (Table 2) was reported captured by 52 vessels during the 1975 season (30.7 turtles captured per vessel). Using the 1976 figure of 321 vessels, a minimum estimate would be 9,855 turtles captured by Georgia commercial shrimpers in 1976, if the capture rates for 1975 and 1976 were similar.

The majority of McIntosh County and Liberty County interviews were conducted between 5 August and 21 August 1976. As of the completion of these interviews, the 1976 estimate of turtles caught per vessel was approximately a third of the 1975 season total for these central coastal counties. Shrimpers from the northern coastal counties of Chatham and Bryan were interviewed from 3 September to 12 October and reported that 1976 captures per vessel were approximately half their 1975 estimate.

Shrimpers from Glynn and Camden, southern coastal counties adjacent to shrimping grounds in St. Andrew Sound and the Brunswick Channel, were interviewed by the fourth week of August, well before the end of the shrimping season. These shrimpers reported 1976 mid-season capture rates that were twice their 1975 capture rates and more than twice the 1976 capture rates reported by the other Georgia counties. The unusually high 1976 capture rates from Glynn and Camden counties were caused by a number of vessels reporting 50 - 100 turtles taken per vessel by the end of August. Such high rates may perhaps be a reflection of the hatchery program on Little Cumberland Island (southern boundary of St. Andrew Sound) where 6,000 to 10,000 hatchling loggerheads have been released annually since 1965.

The number of turtles captured by shrimp boats varies within a season. On 4 October 1976, 140 vessels in St. Andrew Sound captured 7 loggerheads. One of the 7 turtles was recaptured the same day and a second turtle recaptured the following day. The delayed opening of the sounds in 1976 to commercial shrimping occurred after water temperature began to drop and apparently after most of the turtles had moved out of the area. Many more turtles would probably have been captured if the sounds had been opened on 1 September instead of 4 October. Sounds were not opened for shrimping in 1977.

The frequency with which turtles are captured is directly related to the width of the net mouth. Nets with widths less than 6.1 m catch almost no turtles. Noncommercial vessels less than 6.1 m in length nearly always pull nets in this size class. Commercial vessels generally pull larger nets (width $\geq$ 15.2 m) which capture turtles at the highest rates.

Sizes of Turtles Captured.—An analysis of the sizes of turtles captured by trawlers is important to assess the portion of the turtle's life cycle being impacted by trawlers. Using cardboard silhouettes as visual guides, boat captains and strikers were asked to estimate sizes of captured turtles corresponding to a juvenile class (carapace length $\leq$50.8 cm), a subadult class (carapace length 50.8-76.2 cm), and an adult (potential breeder) class (carapace length$\geq$76.2 cm). Enrhart (1962, P-R Job Prog. Rep., Proj. NGR-10-019-004, NASA, Kennedy Space Center, Titusville, FL) reported that the average carapace length (straight line) of a nesting female loggerhead in Florida was 91.4 cm, with a range of 78.7-109.2 cm.

Estimates by shrimp boat personnel vary in the proportions of captured individuals among size classes (Table 2). Total turtles captured in the 50.8-76.2 cm range are approximately equal in number to those in the greater than 76.2 cm range. Shrimpers in McIntosh and Liberty counties apparently capture a greater proportion of turtles in the$\geq$ 76.2 cm carapace length class than do shrimpers in other counties. There were no reports of loggerlead turtles less than 50 cm in length. Hatchlings, once they leave the nesting beach, are not captured or seen until they appear as 50 cm juvenile turtles in coastal rivers and creeks. Growth rates for wild populations of neonate and juvenile loggerheads are not known.

Nineteen loggerheads were measured during on-board observations. One animal was an adult, and the remaining 18 individuals represented a class of young turtles which frequently appear in shrimp nets. The smallest individual had a carapace length of 50.0 cm; the largest had a carapace length of 73.7 cm. It is quite possible that many of the individuals thought by shrimpers to belong to the$\geq$ 76.2 cm category are close to this largest individual in size and, therefore, part of a predominant subadult size class with a 50-80 cm carapace length.

The best estimate of the impact of shrimpers on loggerheads of reproductive size was derived from an analysis of tag returns. Approximately 2,000 nesting female loggerheads have been tagged on Georgia beaches in the last 15 years. Slightly less than 4% of shrimpers reported having seen a tagged turtle at some time in their career. Seven (30%) of 23 shrimpers from Glynn and Camden counties recalled seeing a total of 8 tagged turtles at some time in the past. This number (high, relative to other areas of the State) may be reflective of the 1,000 turtles tagged in the vicinity of St. Andrew Sound since 1964.

As of 1976, only 6 tags have been returned for reward by shrimpers in the St. Andrew Sound area and only 8 tags have been returned from all of Georgia. Thus, few breeding adults are being captured by shrimpers in the vicinity of the nesting beaches.

Mortality.—The mean estimated mortality of captured sea turtles is 7.9% of all turtles captured. Twenty-two (39%) of 58 shrimpers which responded to the mortality question stated that they had never seen a dead sea turtle in their nets. Since the probability of never experiencing a dead sea turtle must be very low, the actual mortality sustained by captured sea turtles in Georgia may approximate a normal distribution for all commercial vessels, with a mean of approximately 10% mortality per boat per year (Fig. 2).

A second independent analysis of mortality was derived from the responses of 29 shrimpers who gave estimates of total turtles killed in 1976 up to the time of the interview. Although the sample size is small, the shrimper's mean estimate of 2.5 dead turtles per vessel for approximately two-thirds of the 1976 season supports our primary mortality estimate of 7.9 percent of 30.7 turtles captured per vessel per year.

Using our preceding estimates of annual capture (30.7 turtles per boat) and mortality (7.9% of turtles captured), the 1976 Georgia commercial shrimp fleet of 321 vessels could drown a minimum of 778 sea turtles per season (Table 1).

Capture Distribution.—Captains and strikers were unanimous in reporting the existence of zones of high turtle density. However, they differed greatly on specific locations. Their responses reflected considerable bias as to home port as well as to

Table 2. Estimate of loggerhead sea turtles captured by Georgia commercial shrimp vessels in 1975 and 1976, from 101 interviews with captains and strikers, 1976.

	Counties			*State*
	Chatham, Bryan	*McIntosh, Liberty*	*Glynn, Camden*	
Distribution of sizes as percent of catch.				
carapace length 51-76 cm	56.9	41.7	59.4	54.5
range of estimates	0-100	0-100	5-100	0-100
carapace length 76 cm	43.1	58.3	40.6	45.5
range of estimates	0-100	0-100	0- 95	0-100
vessels responding	40	16	21	77
Minimal estimates of turtles captured during entire 1975 season.				
total turtles reported	840	234	521	1595
turtles per vessel	29.0	29.3	34.7	30.7
range of estimate	1-100	9- 45	1-100	1-100
vessels responding	29	8	15	52
Minimal estimates of turtles captured during partial 1976 season[a].				
total turtles reported	519	293	417	1229
turtles per vessel	14.8	10.9	34.8	16.6
range of estimates	1- 50	3- 30	1-100	1-100
vessels responding	35	27	12	74
Percentage of vessels which acknowledged previous contact with tagged adult turtles.				
percent positive contact	7	6	30	12
vessels responding	43	34	23	100

[a]Approximately one-half to one-third the regular season, depending on the date of the interviews.

preferred areas for dragging. We were unable to delineate clearly zones of high turtle concentrations or areas where shrimpers spend most of their time and/or catch most of their turtles. Certain locations, such as the Savannah River Channel and Brunswick River Channel, were frequently mentioned as areas of high turtle concentrations, but these areas are also preferred shrimping areas. Large concentrations of turtles and shrimp may occur together, particularly in the deeper channels or holes.

Because sounds were closed throughout 1977 to all shrimpers, we could not compare the vulnerability of sea turtles occurring within sounds as opposed to those outside sounds near the beach. We know that only 11 loggerheads were captured in St. Andrew Sound and 4 in Wassaw Sound during an intensive 2-day shrimping effort after sounds were opened on 4 October 1976. Most sea turtles had evidently departed Georgia waters

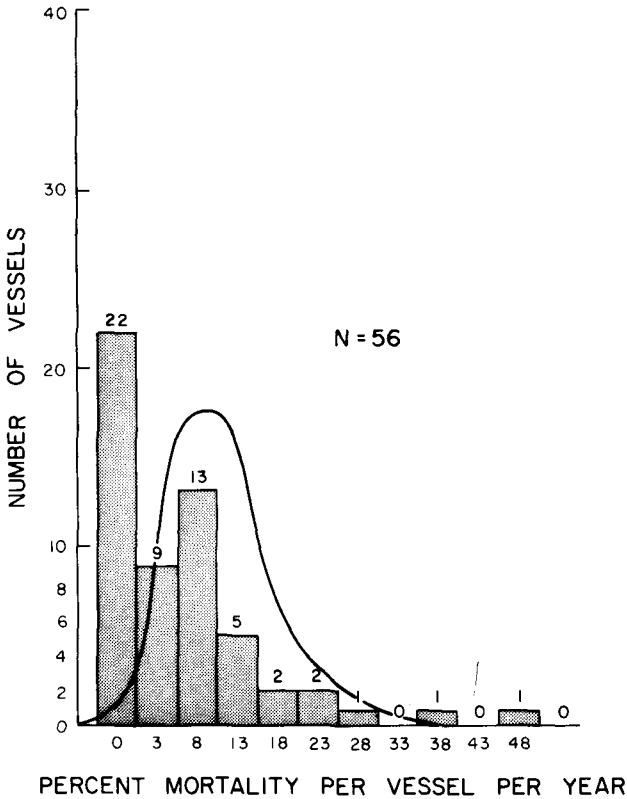

Fig. 2. Percentage of captured turtles which drown per vessel per year and a predicted mortality frequency distribution, Georgia, 1976 (based on interview data).

by that late in the shrimping season. Carcass strandings on beaches during 1976 obviously did not result from shrimping in the sounds.

Beach Strandings

Decomposing carcasses of sea turtles are frequently found stranded on Georgia beaches, and the shrimper is usually implicated in the death of these animals. The following discussion of carcass strandings reinforces that implication.

Fig. 3 depicts the number of sea turtle carcasses of all sizes reported on Georgia beaches from 1973 to 1977. The correlation of shrimping seasons with the appearance of carcasses is evident. During the years with a normal shrimping season (1973-1976), inshore waters (east of the Georgia islands and seaward to the 3 mile limit) are open to shrimping until approximately June 1; sound waters (estuarine waters west of the coastal islands) are usually opened in early fall, frequently on September 1. This schedule caused the seasonal, biomodal distribution of dead turtles recorded from 1973 to 1976 (Fig. 3 top).

In 1977, the effect on sea turtles of opening the near-shore waters to shrimping on 6 July was dramatically evident (Fig. 3 bottom, Fig. 4). Eight carcasses were found stranded prior to the inshore season, and 178 carcasses were found stranded after 6 July. Results from our aerial surveys (170 carcasses located on all Georgia beaches) corroborate the on-the-ground surveys (7 islands) and reflect the striking suddenness with

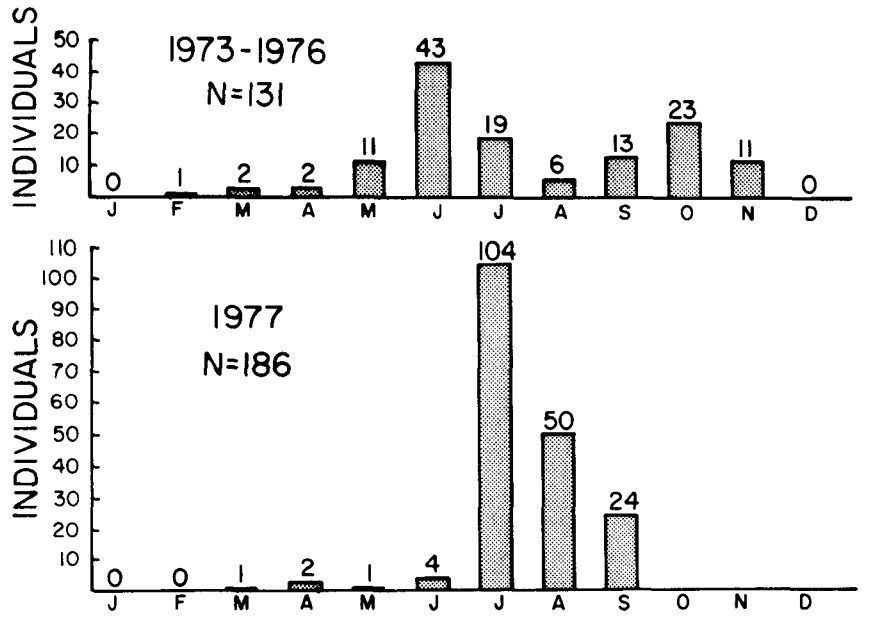

Fig. 3. Total numbers of sea turtles found dead on Georgia beaches, 1973-1976 (top) and 1977 (bottom) distributed by month. Data for October through December 1977 were unavailable.

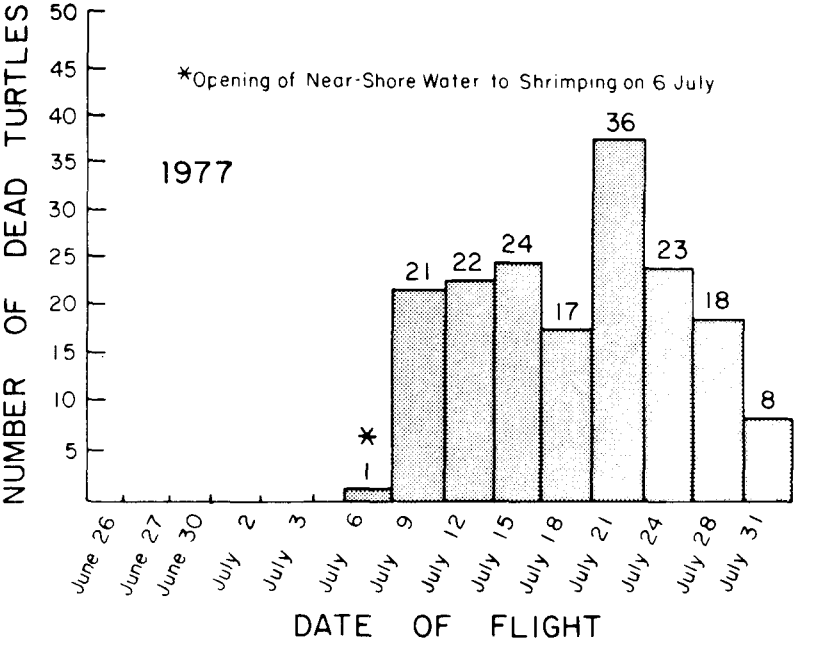

Fig. 4. Total sea turtles observed dead on Georgia beaches, 26 June - 31 July, 1977, from aerial surveys.

which carcasses appeared after the opening of nearshore waters. Our data indicate that turtles experience little mortality from shrimp vessels outside the 3 mile limit, probably reflecting reduced capture rates in these waters.

Most strandings were centered on the Blackbeard-Sapelo Island complex and on Cumberland Island. Approximately 68% of all strandings found were observed on those islands. However, the effects of littoral as well as other near shore currents on distributing loggerhead carcasses are unknown; we cannot correlate areas of high mortality with beaches where the turtles strand.

Our aerial surveys, flown on 3-day intervals, recorded 28% of the carcasses reported by ground observers on public beaches (Tybee, Sea, St. Simons, and Jekyll Islands and 77% reported by ground observers on private beaches (Ossabaw, Blackbeard, Cumberland, and Little Cumberland Islands). Beach cleanup crews daily remove the turtle carcasses found on public beaches. Aerial surveys were only a third as efficient on public beaches as on private beaches, reflecting the effect of the cleanup crews on 2 out of every 3 days.

Fig. 5 illustrates the distribution by size class (carapace length) of 144 loggerhead loggerhead carcasses measured over a 7-year period on several Georgia beaches. Functions which suggest 2 normally distributed, slightly overlapping size classes of turtles (carapace lengths) have been fitted to the data by eye. Approximately 88% of all turtle mortality on Georgia beaches may be classified as juvenile or sub-adult, with carapace lengths (straight measure or over-the-curve) ranging from 50 cm to 88 cm. The remaining 12% are probably adults with an over-the-curve carapace length of 88 cm to 107 cm. Our estimate of 778 turtles drowned per season by a fleet of 321 commercial vessels (Table 1) can be divided into 685 (88%) juveniles and 93 (12%) adults.

The scarcity of individuals in the larger juvenile category supports an observation by Georgia tagging programs on nesting beaches that relatively few adult breeding females are being captured by Georgia shrimpers (Bell and Richardson 1977). A size distribution of loggerhead turtles captured during on-board observations (Fig. 5 bottom) suggests a 1:1 relationship between a juvenile class being captured by shrimp boats and a similar size class appearing as carcass strandings on the beaches.

Damage to Gear

Damage to gear or to commercially important species (shrimp, crabs, fish) captured with the turtles does not seem to be a significant factor for the Georgia shrimp fisherman. Only 2 individuals out of 101 interviews commented on damage to gear. None of the shrimpers mentioned damage to the catch from the crushing weight or uncontrolled thrashing of captured sea turtles.

Incidental Capture of Kemp's Ridley, Leatherback, and Green Sea Turtles

The Kemp's ridley, leatherback, and green sea turtles are 3 species known to occur, though not known to breed, on the Georgia Coast. Due to small sample sizes, frequent uncertainty of proper identification, and the brief nature of this survey, the impact of the Georgia shrimping fleet on these species cannot be quantified.

Four (25%) of 16 turtles captured in St. Andrew Sound during on-board observations were Kemp's ridleys. Three of the 4 animals were males. There is some evidence that the ridley may be particularly vulnerable to shrimping pressures, appearing among the first to be caught and the first to disappear from St. Andrew Sound after the sound was opened for shrimping in early October 1976. From 7 October 1973 to 22 November 1973, 6 (12%) of 49 carcasses on Cumberland Island beach were identified as ridley turtles. From 10 May 1976 to 24 September 1977, 88 carcasses were counted from the same location, none of which were identified as ridleys. Ridleys accounted for 1 out of 9 carcasses in 1976 and 0 of 8 in 1977 on Little Cumberland Island.

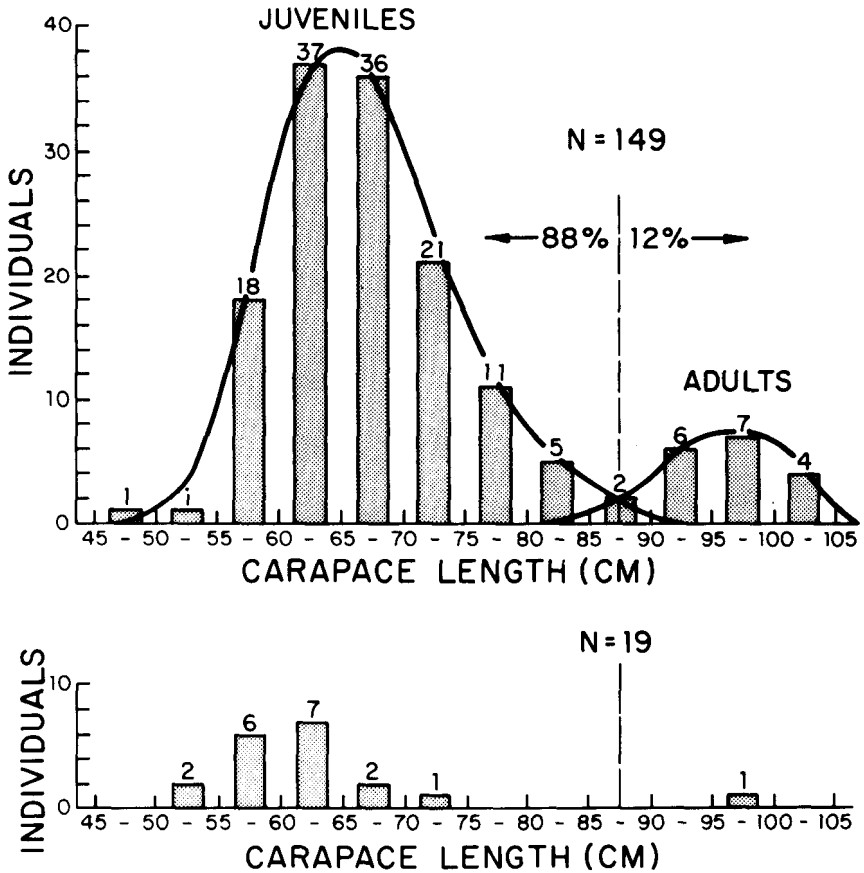

Fig. 5. Distribution of carapace lengths of loggerheads found dead on Georgia beaches (top), 1973 to 1977, compared to a similar distribution of loggerheads captured by shrimp trawlers in Georgia (bottom), 1977.

The leatherback turtle seems to be a common non-nesting visitor on the Georgia Coast. It is a cosmopolitan species, having a temperate range but nesting is tropical regions. The leatherback is well known to Georgia shrimpers. Of 59 interview respondents, 25 (42%) said they had caught a leatherback during the 1976 season. One vessel caught 4 leatherbacks and another vessel caught 10 leatherbacks in 1976. Interview data indicated 24 leatherbacks were caught 3-5 km offshore during the spring of 1976. The leatherback should be considered a rare but regular casualty of shrimp nets.

Four shrimpers stated that they had caught at least 1 green turtle during the 1976 season. Shrimpers agreed that green turtles captured in Georgia are small individuals, 35 to 46 cm in carapace length. Those turtles were caught close to shore, either near the ocean beach or within the sounds and estuaries.

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