

INCIDENTAL CATCH OF LOGGERHEAD TURTLES BY
SOUTH CAROLINA COMMERCIAL FISHERIES

Report to

National Marine Fisheries Service

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INTRODUCTION

In 1971, the IUCN's Marine Turtle Group designated six species of marine turtles as endangered on a world-wide basis. This action by the IUCN pointed out the need for a thorough evaluation of present marine turtle population levels and trends in all areas of the world.

The Atlantic loggerhead turtle (Caretta caretta caretta) is the most abundant of the marine turtles in the Southeastern United States and is the only species having an established nesting population in South Carolina. The leatherback turtle (Dermochelys coriacea), juvenile, Atlantic green (Chelonia mydas mydas) and possibly the Kemp's ridley (Lepidochelys kempi) occur in South Carolina waters but are considered to be transient species.

The loggerhead turtle nests on barrier island beaches throughout South Carolina, with the highest concentration of nesting occurring within the Cape Romain National Wildlife Refuge, particularly on Cape Island, where an estimated 2359 nests were laid in 1976 (George Garris, personal communication). Islands to the north of the refuge; Cedar, South, Sand and North islands are also important nesting habitats. The northern portion of the state (from Pawley's Island to North Carolina state line) is known as the Grand Strand; a heavily developed resort area which supports only infrequent nesting activity, presumably because of the disturbance of the nesting turtles by beach lighting and numerous people. The Charleston area

(Capers Island to Folly Island) also has very limited nesting. The southern half of the state has a moderate amount of nesting on suitable beaches, but considerably less than the Cape Romain region. Sea Grant investigators in South Carolina conducted aerial surveys of nesting beaches in 1976 and 1977 which would provide the most detailed analysis of relative nesting on each beach; however, this data has not been publicly released as of this writing.

Previous studies of loggerhead turtle distribution have understandably concentrated on the nesting female because of their accessibility for tagging and collection of biological data. The populations of sub-adult animals and mature males have not been studied, although in the case of the juvenile turtles, they comprise the largest segment of South Carolina loggerhead populations.

Sightings of large, loggerhead turtles by commercial snapper fishermen in the warmer, offshore water, influenced by the Gulf stream in January, may be indicative of overwintering in the Carolinas by some segment of the population. According to Baldwin and Lofton (Caldwell, 1959) adult turtles were first observed in the inshore waters of Cape Romain in late March with the first mating pair observed at this time. They also reported that adult turtles disappeared from inshore waters by October. Juvenile loggerheads are observed in inshore waters from April through October.

Although quantitative data on historical population trends

is unavailable, the concensus of opinion among turtle biologists is that numbers are declining and there is cause for serious concern. In 1975, (Federal Register, Volume 40, Number 98), the Atlantic loggerhead was proposed for listing under the threatened category of the United States Endangered Species Act.

The accidental capture and drowning of marine turtles in the nets of commercial fishermen (primarily shrimpers) has been identified as one of the factors responsible for declining populations of marine turtles (Carr, 1972). Quantitative data on the frequency of incidental catch of turtles and mortality rates associated with such captures has been largely unavailable. Previous studies of the incidental catch on shrimp trawlers have been directed to determining the ratio of fish to shrimp and the quantity and species composition of fish discarded by these vessels (Anderson, 1968; Knowlton, 1972 and Keiser, 1976). With the exception of Keiser (1976), no reference to incidental turtle capture is made by these studies. William D. Anderson (in Caldwell et.al., 1959) noted that captures of loggerheads off the Georgia coast were frequent enough during their incidental catch study (1931-35) to constitute a nuisance to trawlermen but no catch rates were recorded. The present study was instituted to collect the best possible data on incidental catch of loggerhead turtles by South Carolina commercial fishermen, to allow management agencies to accurately assess the magnitude and impact of this mortality source on our turtle populations.

Study Objectives

The objectives of this study are:

- 1) To collect data necessary for estimation of the number of loggerhead and other marine turtles incidentally captured by shrimp trawlers during the 1976 and 1977 shrimp seasons.
- 2) To determine the relationship between trawl capture and turtle mortality.
- 3) To determine the relationship between trawl capture and turtle mortality.
- 4) To determine the age and sex composition of incidentally caught loggerhead turtles.
- 5) To determine the percentage revived and minimum recovery periods for turtles which appear to be dead when brought on deck.
- 6) To collect data on the relationship between release location and beach stranding of trawler-killed turtles and the probability of encountering these turtles on beach surveys.
- 7) To tag incidentally captured live turtles to add to our knowledge of marine turtle migration behavior.

METHODS AND MATERIALS

On-Board Sampling

Three field aides were utilized to conduct the sampling operations of this project. Their activities were divided among the following job categories in order of the time com-

committed to each:

1. On-board sampling,
2. Monitoring beach strandings of dead turtles and
3. Interviews with captains of shrimp trawlers (primarily conducted in conjunction with on-board sampling).

The majority of the project personnel's time was spent as observers aboard shrimp trawlers to record amount of effort (trawling hours), number of turtles caught, their condition, etc. Because of budgetary restrictions limiting personnel to three, and the working hours to 40 per week, interviewing was understandably a minor part of our activities during the 1976 and 1977 shrimp seasons. A cooperative tagging program with shrimpers, as originally proposed, was not initiated because of the lack of manpower for the follow-up contact which would be necessary for the success of such a project.

The coastline was divided into three sampling units as follows: Georgetown-McClellanville (Georgetown and Charleston Counties), Shem Creek-Rockville (Charleston County) and Beaufort-Hilton Head (Beaufort County) which were designated as Areas I, II and III respectively (Figure 1).

We sampled on double-rigged trawlers, which represented 44 percent of the total registered trawlers in South Carolina and accounted for the majority of commercial landings and fishing effort. Sampling was further restricted to vessels over 40 feet long which comprised 89.7 percent (446) of the double-rigged trawlers registered (Theiling, 1977). Net size on sampled vessels ranged from 55-90 feet.

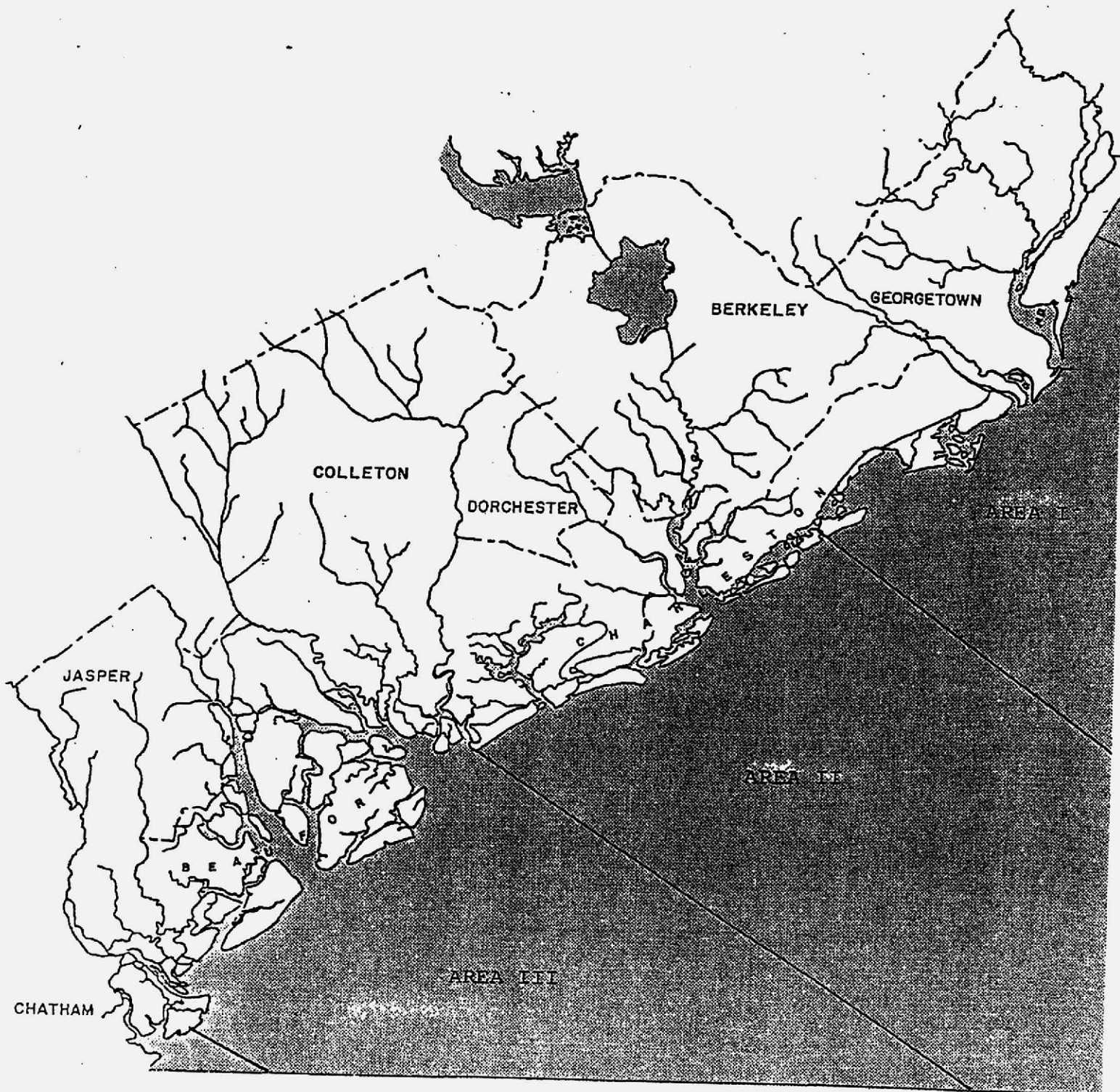


Figure 1. Areas in which on-board sampling and beach surveys were conducted.

It was the original intent to conduct on-board sampling three days per week, concurrently in all three areas, allocating effort equally between areas. Due to the variable fishing success in the different areas, it was not possible to adhere to this schedule in practice. The brown shrimp run was weak in the Georgetown-McClellanville area during August 1976 with the result that many vessels remained tied up or went to other states to shrimp. The fall 1976 crop of white shrimp was also below average, particularly in the northern and southern sampling areas, resulting in reduced effort and cessation of fishing relatively early in the season. The above reductions in the fishing activity, accordingly reduced the amount of on-board sampling we were able to do in these areas. The 1976 inshore shrimp season, (waters within three miles of the beaches) opened on May 14. The contract period for the 1976 incidental catch study was July 1, 1976 - June 30, 1977 and field sampling did not start until July 13, 1976. Sampling in 1976 was terminated on October, 31.

We had planned to resume sampling in 1977 in mid-May but due to an unusually cold winter and resulting mortality of overwintering white shrimp, the opening of inshore waters was delayed until June 15. The funding period for the 1977 project was changed to coincide with the new, federal fiscal year and sampling was terminated on September 30, 1977. Sampling of trawlers in Area I was terminated August 31, because of reduced trawling activity in this area.

The first step in on-board sampling was making contact with the trawler captains and obtaining permission to make a trip with them. While on-board, our personnel assisted with culling the catch whenever turtles were not brought aboard. We felt that providing as much help to the crew as possible was important in maintaining good relations and insuring that the captain would agree to a future request to sample his boat. The only difficulty encountered in gaining access to boats was in the Georgetown area where trawlers often stay out overnight and lack sufficient bunk space to carry an extra man. We also felt that this was an inefficient use of our manpower because the trawlers do not fish after dark.

The following data was collected by the field personnel (see data form in Appendix). Drag-time was recorded for all tows to allow calculation of CPUE values and examine any correlation between length of drag and turtle mortality.

Straight line carapace length and width was recorded for each captured turtle using a metric tree caliper (Forestry Supplier's Inc.). Whenever possible, the sex of captured animals was determined using the following criteria: animals showing obvious elongation of the tail were considered males, turtles ≥ 55 cm carapace length and showing no sign of tail elongation were classified as females and those turtles, < 55 cm were not classified.

Live turtles were tagged using Number 49 Monel tags imprinted with University of Florida return addresses. A hole

for the tag was made in the thin tissue of the flipper using a leather punch. Tags were applied to the trailing edge of the right front flipper, near the body, using the POW-R-CEPS applicator (National Band and Tag Company). Positive crimping of the tag was much more likely when inserted in the punched hole than if the tag were simply squeezed through the tissue before locking.

Dead turtles were tagged with indelibly printed, plastic laminated cards; attached to a hole drilled in the right rear marginals with stainless steel cable and crimping sleeves. After tagging, these turtles were returned to the water to provide information on the percentage of dead turtles captured which would be encountered by our beach monitoring effort and the relationship between release location and beach stranding location.

Monitoring of Beach Strandings of Dead Loggerhead Turtles

A program to monitor the incidence of dead loggerhead turtles stranding on South Carolina beaches was initiated by the author in May, 1975. In May 1976, this operation was expanded to provide more comprehensive coverage of the coastal area and attempt to examine as many of the dead turtles as possible to determine age composition (approximate by carapace length) and sex ratio. This monitoring program was incorporated into the present incidental catch study because it was felt that these turtles represented a relative indicator of the magnitude of incidental catch mortality.

Personal contact was made with private citizens and employees of agencies likely to be aware of dead turtles on the beaches, to enlist their cooperation in reporting these occurrences to us. Agencies contacted included: public service departments of beach communities, state park supervisors, federal refuge managers and coastal law enforcement district offices of the South Carolina Wildlife and Marine Resources Department. Coastal biologists of the Department also assisted in reporting strandings. Personnel conducting a Sea Grant project to determine relative nesting intensity on South Carolina beaches provided additional data from their aerial surveys.

We feel that coverage and reporting was reasonably comprehensive on populated beaches and on those island within the Cape Romain National Refuge, which are regularly patrolled during the nesting season. Aerial surveys may not always spot washed up carcasses particularly if they are covered by a fine layer of blown sand. Even with an extensive network of reporters, turtles which wash-up in marshy areas within the sounds, will probably not be observed. It is also possible that some of incidental catch mortalities drift offshore or wash ashore in other states.

Interviews

Captains or crew members of commercial, double-rigged shrimp trawlers were interviewed by our personnel at dockside, prior to on-board sampling or at the termination of a day's sampling. Shrimpers were asked the number of turtle captures

in the previous week, number of deaths and to give an estimate of numbers of turtles caught for the season to date and the percent mortality experienced.

RESULTS

On-Board Sampling Effort

A total of 73 trawling trips were sampled during July through October 1976, representing 591.6 hours of trawling effort. During 1977 (June 16-September 30) 107 trips were observed for a total of 751.5 hours of trawling. Table 1 summarizes the sampling effort allocated during each month for each area in 1976 and 1977. Variations in monthly or area sampling effort are primarily the results of fluctuations in shrimp activity; i.e. lack of sampling in Area I in September 1977 was caused by reduced shrimp catches which resulted in many vessels remaining at the dock or moving to other areas.

In 1976, a total of 22 loggerhead turtles were taken during sampling operations. The highest catch of 14 turtles occurred in Area II, with three and five captured in areas I and III, respectively. With one exception, all of the live turtles (18) were tagged with No. 49 Monel tags bearing the University of Florida return address. An observer, who forgot his tagging equipment, was responsible for the one animal not tagged. Dead turtles were also tagged according to the procedure outlined in the Methods Section.

During 1977 sampling (June 16-September 30) 30 loggerhead turtles were taken. As in 1976, Area II accounted for the most turtle captures (15) with an approximately equal distribution

Table 1. Sampling effort from on-board observations, by month and area for 1976 and 1977 incidental catch survey.

1976

MONTH	AREA I		AREA II		AREA III		TOTAL	
	No. Trips	Trawl Hrs.	No. Trips	Trawl Hrs.	No. Trips	Trawl Hrs.	No. Trips	Trawl Hrs.
July (from 7/13)	5	37.3	6	50.5	6	31.3	17	119.1
August	2	23.25	11	116.0	7	31.7	20	170.9
September	7	40.25	12	132.5	6	25.8	25	198.6
October	3	33.5	8	69.5	0	0	11	103.0
TOTAL	17	134.3	37	368.5	19	88.8	73	591.6

1977

MONTH	AREA I		AREA II		AREA III		TOTAL	
	No. Trips	Trawl Hrs.	No. Trips	Trawl Hrs.	No. Trips	Trawl Hrs.	No. Trips	Trawl Hrs.
June (from 6/16)	6	68.0	7	48.3	0	0	13	116.3
July	10	93.6	12	94.1	15	105.5	37	292.9
August	6	48.4	11	76.6	13	73.6	30	198.6
September	0	0	12	65.5	15	78.2	27	143.7
TOTAL	22	210.0	42	284.5	43	257.0	107	751.5

between Areas I (7) and II (8). Seventeen live and ten of 13 dead turtles were tagged. A complete list of all turtle captures, including carapace length, sex, condition, maturity stage, tag number and capture location is provided in the Appendix.

Mortality Rates

Mortality caused by trawl capture is the most critical portion of the shrimp/turtle interaction and as the results of our sampling indicate, the answer to the question is anything but clearcut. I feel that the most reliable mortality estimates are derived from the average of all turtle captures within a given year; however, there is considerable variation between the 1976 and 1977 cumulative mortality rates. The 1976 mortality rate was 18.2 percent and for 1977 it was 43.3 percent. Trawl duration was not increased in 1977 and the difference between years is apparently due to sampling variability. Mortality estimates derived from interviews were considerably lower than our observed data, ranging from 4-10 percent.

It should be pointed out that a dead turtle coming aboard in a trawl did not necessarily die in that particular trawl encounter. Several events in the course of our sampling indicate that already dead animals may be recaptured by shrimp trawlers. For example, a turtle was taken in the morning by a trawler, tagged by our observer and returned to the water and re-caught the same afternoon. If this animal had not been tagged, it would have been recorded as an additional kill. On another occasion,

one observer noted that the odor of a dead turtle caught in the trawl was such that he questioned whether it was a fresh kill. Another turtle was caught that was missing its head and it is unlikely that this occurred while the turtle was in the net. The extent to which already dead animals may be re-caught is unknown but is probable that in areas of heavy trawling it is not uncommon; suggesting the need to use caution in extrapolating mortality figures.

It has been suggested that trawl mortality may be related to the age or size of the turtle but our on-board data does not support this theory. Mean straight-line carapace length of live turtles in 1977 was 62.4 cm (Range 28-85) and for dead animals mean length was 66.9 cm (Range 49-106). Table 2 compares the size distribution of live and dead turtles for the combined 1976-77 data and it is apparent that there is no significant difference in the the distributions.

The relationship of turtle mortality to duration of a trawl is difficult to establish from field observations because of the uncertainty as to when the turtle actually entered the trawl. Ogren et.al. (1977) pointed out that when a trawl approaches a turtle resting on the bottom, the turtle attempts to out-swim the trawl. The trawl doors and warps exert a herding effect, preventing the turtle from escaping laterally. The turtle encountered, showed no tendency to surface to avoid the trawl. Considerable energy and oxygen reserves would be expended prior to actual entanglement in the net by the attempt to swim away from the trawl. The minimum trawl duration resulting in a turtle

Table 2. Frequency distribution of live and dead turtles taken during on-board sampling in 1976 and 1977.

Straight-line Carapace Length cm	Alive	Numbers Dead	Total
25-29	1		1
30-34			
35-39	1		1
40-44			
45-49	1	1	2
50-54	2		2
55-59	6	3	9
60-64	6	3	9
65-69	5	3	8
70-74	5	4	9
75-79	4	1	5
80-84	3		3
85-89	1		1
90-94		1	1
95-99			
100-104			
105-109		1	1
110-114			
TOTAL	35	17	52

4

28

19

death during the 1976 and 1977 field observations was one hour and twenty-five minutes.

The practice of allowing a recovery period on deck and using revival procedures for turtles which are brought aboard in an unconscious state, definitely has merit on the basis of our observations. Four turtles during 1977 were brought aboard unconscious and not breathing and were subsequently revived. After placing these animals on their backs, the observer pumped the turtle's nostrils to force water out of the lungs and trachea. This activity was repeated until the turtle was breathing normally and the turtle was retained on deck until it appeared to regain its strength. Normal breathing was resumed after 10-20 minutes and full recovery was achieved within 40 minutes.

It is doubtful that these animals would have recovered if revival methods or an on-deck recovery period had not been provided.

Size and Sex Composition of Incidental Catch Turtles

Gallagher et.al., (1972) determined the average carapace length of 164 nesting loggerhead turtles on Hutchinson Island, Florida to be 92.5 cm with a range of 77.5 - 106.7 cm. Recognizing the possibility that some females may be reproductively active at a slightly smaller size than Gallagher's minimum figure, incidental captures were categorized as either juvenile or potential, breeding adults using the following criteria:

1. Turtles < 75 cm straight lines carapace length were classified as juveniles.
2. Turtles ≥ 75 cm carapace length were classified as mature.

According to these criteria, 68.2 percent (15) of the turtles captured during the 1976 survey were juveniles and 31.8 percent (7) were classified as adults. The mean carapace length for 1976 captures was 68.7 cm with a range of 49.3 - 91.6.

During 1977 sampling 86.7 percent (26) turtles were classified as juveniles and 13.3 percent (4) were considered to be adults. Mean length of these turtles was 64.4 cm with range of 28.0 - 106.0 cm. Sampling in 1977 produced two loggerhead turtles of 28.0 and 37.0 cm carapace length, considerably smaller than any previously reported in coastal waters of South Carolina and Georgia.

Turtles less than 55 cm carapace length were not sexed because it was considered unlikely that tail elongation would be sufficiently pronounced to allow reliable identification of males. The smallest turtle exhibiting well developed male secondary sex characteristics had a carapace length of 60 cm. During 1976 on-board sampling, only three turtles were too small to be reliably sexed. Nineteen turtles were sexed with 26 percent (5) identified as males and 74 percent (14) as females. An even more skewed sex ratio was evident in our 1977 sample, in which 14.8 percent (4) were males, 85.2 percent (23) females and three turtles too small to be classified.

Male turtles were present in samples during July, August and September of 1976 but there is a suggestion that they became less abundant as the season progressed. Males comprised 50 percent of captured turtles in July, 33 percent in August, 25 percent in September and were absent from the sample in October. In the 1977 samples, male turtles were only taken in July. It seems likely that mature males would be most abundant prior to, and during the early part of the nesting season. Baldwin and Lofton (Caldwell, 1959) reported that mating pairs, usually accompanied by "escort" males were frequently sighted in the creeks and bays behind the barrier islands of Cape Romain during the months of April and May. They did not observe mating pairs in this area after early June.

Incidental capture of loggerhead turtles is often thought to pose the most serious threat to breeding females but our 1976 and 1977 data indicates that shrimp contact with this segment of the population is proportionately small. Adult females made up only 18.2 and 10.0 percent of turtles taken during on-board sampling in 1976 and 1977 respectively. All of the four adult females taken during 1976 sampling survived their encounter with the trawl, with two out of three surviving in the 1977 sample.

Catch Per Unit Effort Data

Observed monthly incidental catch of loggerhead turtles per trawling hour, by area, for 1976 and 1977 sampling are presented in Table 3. During 1976 sampling, turtle CPUE ranged from 0.025 in July to 0.050 in September. This is in contrast

Table 3. Monthly catch of loggerhead turtles per trawl hour (areas combined) from 1976 and 1977 on-board sampling.

MONTH	Trawl Hours		No. Turtles Caught		Turtles/Trawl Hour	
	1976	1977	1976	1977	1976	1977
June	*	116.3	*	7	*	.060
July	119.2	292.9	3	18	.025	.061
August	170.9	198.6	6	3	.035	.015
September	198.6	143.7	10	2	.050	.014
October	103.0	*	3	*	.029	*
TOTAL	591.7	751.5	22	30		

Turtle catch/trawling hour (month's combined) = $\frac{1976}{0.037}$ $\frac{1977}{0.040}$

* - Indicates no sampling conducted.

Table 4. Cumulative catch per trawling hour by area (months combined).

	1976	1977
AREA I	.022	.033
AREA II	.038	.053
AREA III	.056	.031

to the situation in 1977 when turtle capture per trawling hour was highest in July (0.061) and lowest in September (.014). The cumulative catch per effort, for months and areas combined was 0.037 for 1976 and 0.040 for 1977.

Differences in the number of turtles captured in each area are reflected in our CPUE values by area, presented in Table 4. Area III had the highest CPUE in 1976 and the lowest in 1977. Area I, which includes the Cape Romain National Refuge and barrier island beaches supporting the highest nesting intensity in South Carolina, had CPUE values lower than other areas of the state. Based on the distribution of dead turtles stranding on the beaches and the increased sampling effort in 1977, the 1977 figures are considered to be most representative of the actual abundance of turtles in each area.

CPUE values derived from on-board observations by other investigators and interview data collected during the course of this study, are in relatively close agreement with the values obtained from our field sampling. While conducting an incidental catch study of South Carolina trawlers to determine finfish catches, Keiser (1976) noted that turtles were captured in 7 of 29 trawler catches sampled during June-September, for a capture rate of 0.24 turtles/trawling day. Using his average, observed trawling hours per day (5.6) would result in a turtle/hour rate of 0.043. Hillestad (1977) conducting on-board sampling of incidental turtle capture during July and August 1976, noted that four turtles were captured in 19 tows averaging 2.6 hours each. The calculated turtle per trawl hour rate, for Hillestad's

on-board observations is 0.081.

In 100 interviews conducted during this study the general concensus among shrimpers was that 1-3 turtles per vessel week, were caught by shrimp trawlers during the portion of the shrimp season which we sampled. Calculating turtles per trawl hour on the basis of seven hours trawling per day and a five day week gives a catch rate ranging from 0.028 - 0.086.

Estimates of Incidental Captures and Mortality in 1976 and 1977

Estimates of the number of turtles captured were calculated by area because of the apparent differences in turtle abundance between areas. Effort data was provided by the Fisheries Statistics Section of the South Carolina Wildlife and Marine Resources Department. Tables 5 and 6 present the estimated trawling effort of the shrimp fleet in days and hours, estimated captures based on area CPUE's and two estimates of mortality. As stated in the section on mortality rates, no explanation other than sample variability can be advanced to explain the marked difference in 1976 and 1977 observed mortality rates. For this reason, we have included in the above tables a mortality estimate based on the highest figure (10 percent) obtained from interviewing.

Commercial shrimp vessels trawled an estimated 17,300 days during July-October, 1976 and 11,425 days during June-September 1977. Not included in these effort figures are trawlers registered to fish in South Carolina which land their catches in neighboring states; therefore, I feel they represent a con-

Table 5. Estimated incidental catch of loggerhead turtles by area for 1976, based on cumulative catch/trawl hour (months combined).

AREA	Estimated Days Effort	Trawl Hours	CPUE	Estimated Turtle Captures	Estimated Mortality	
					18%	10%
I	5100	35,700	.022	785	141	78
II	6200	43,400	.038	1649	296	165
III	6000	42,000	.056	2352	423	235
TOTAL	17300	121,100		4786	860	478

Table 6. Estimated incidental catch of loggerhead turtles by area for 1977, based on cumulative catch/trawl hour (months combined).

AREA	Estimated Days Effort	Trawl Hours	CPUE	Estimated Turtle Captures	Estimated Mortality	
					43%	10%
I	2375	16,625	.033	548	235	55
II	4800	33,600	.053	1780	765	178
III	4250	29,750	.031	922	396	92
TOTAL	11,425	79,975		3,250	1,396	325

servative estimate of trawling effort during the survey periods of 1976 and 1977.

Based on our observations, the average fishing day represents seven hours of actual trawling. Estimated hours of trawling for the 1976 and 1977 survey periods were 121,100 and 79,975 hours, respectively. Table 7 presents estimated turtle captures and mortalities based on cumulative CPUE values (months and areas combined) and total effort.

Estimates of total turtle captures derived from interview data are in relatively close agreement with those based on observed, CPUE extrapolations. Assuming 200 of the 446 double-rigged trawlers licensed in 1976, were fishing in any given week and the lowest interview derived catch rate (one turtle/week), would result in the capture of 3200 turtles during the four month survey period. Mortality was estimated to be 320 turtles.

The estimates presented in this section do not necessarily represent the capture of 3,199-4,786 different individuals. It seems probable that individual turtles may be caught numerous times during a shrimp season. It is unlikely that a turtle would leave an area due to a survived encounter with a shrimper's trawl.

Monitoring of Beach Strandings of Dead Loggerhead Turtles

A summary of occurrence of dead loggerhead turtles on South Carolina beaches by area, during May-October, 1976 is presented in Table 8. The highest concentration of strandings occurred

Table 7. Estimated turtle captures and mortality based on cumulative CPUE values (areas and months combined) for 1976 and 1977.

YEAR	Total Effort (Days)	Total Effort (Hours)	Cumulative CPUE	Est. Captures/ Trawl Hour	Estimated Mortality Observed Rate Inter- view Rate
1976	17,300	121,100	0.037	4,480	806 (18%) 448 (10%)
1977	11,425	79,995	0.040	3,199	1,375 (43%) 320 (10%)

TABLE 8.

Summary of Beach "Wash-ups" of Loggerhead Turtles by Area in South
Carolina May - October, 1976

Area	Juvenile	Mature Female	Mature Male	Mature Sex Unknown	No Data	Total
North Carolina state line to Bull's Is. (AREA I)	5	1	1	0	15	22
Caper's Island to Edisto Is. (AREA II)	49	8	4	8	15	84
Harbor Island to Georgia state line (AREA III)	8	1	1	1	7	18
Totals	62	10	6	9	37	124

in the Caper's Island to Edisto Island area (AREA II). Eighty-four (67.7 percent) of the 124 reported strandings were in the above area. Strandings in the North Carolina state line to Bull's Island area (AREA I) numbered 22 or 17.7 percent of the total. The area from Harbor Island to the Georgia state line (AREA III) accounted for 14.5 percent (18) of the "wash-ups." Area III had the highest overall CPUE and it would be expected that strandings of dead turtles in this area would be correspondingly high. The lower public accessibility of the beaches in this area and the possibility that incidental mortalities would wash ashore in the marshy areas surrounding the large sounds (Calibogue and Port Royal), may have been responsible for the small number of "wash-ups" reported in Area III. Reported strandings in Areas I and II corresponded to the CPUE values obtained from on-board sampling.

Occurrence of beach strandings in each area for 1977 are presented in Table 9. During 1977 the highest numbers of strandings (72) were recorded in Area I. Thirty-eight of these strandings occurred in April and May, prior to the opening of the shrimp season. If these occurrences are deducted from the "wash-up" records in Area I, the distribution of turtles by area is in general agreement with the CPUE values. As in 1976, occurrences in Area III were quite low, presumably for the reasons previously cited.

A monthly summary of beach strandings for 1976 is given in Table 10.

Table 9. Summary of beach "wash-ups" of loggerhead turtles by area, April-September, 1977.

AREA	Juvenile	Mature Female	Mature Male	Mature Sex Unknown	No Data	Total
North Carolina State lines to Bull's Island (Area I)	35	16	6	3	12	72
Capers Island to Edisto Island (Area II)	19	4		6	16	45
Harbor Island to Georgia state line (Area III)	2				4	6
TOTAL	56	20	6	9	32	123

TABLE 10.

Monthly Summary of Beach "Wash-ups" of Loggerhead Turtles in
South Carolina, May - October, 1976.

Month	Juvenile	Mature Female	Mature Male	Mature Sex Unknown	No Data	Total
May	3	1	1	1	7	13
June	33	5	2	4	5	49
July	10	1	1	1	10	23
August	16	2	2	2	15	37
September	0	0	0	1	0	1
October	0	1	0	0	0	1
Totals	62	10	6	9	37	124

Percent juveniles (from animals examined) = 71.3
 Percent adult (" " ") = 28.7
 Percent females (of mature animals examined) = 62.5
 Percent males (" " " ") = 37.5

Numbers of strandings were highest during June (49), with September and October tied for low month with an occurrence of one each. The low number of beachings of dead turtles in September is puzzling in light of having the highest CPUE values from on-board sampling during this month. Perhaps the reduction in beach use after August reduced the probability of dead turtles being reported. Monthly data from the 1977 beach survey is reported in Table 11. The highest number of strandings occurred in July 1977 (54) which was the month in which turtle captures from on-board sampling were greatest. August and September accounted for the fewest beach strandings which also concurs with the low CPUE's obtained for those months.

Age and Sex Distribution for "Wash-ups" (1976)

Of the 87 "wash-ups" for which information was available, 71.3 percent (62) were considered to be juvenile specimens using the same criteria established for turtles caught during on-board sampling.

The percentage of juveniles from beach surveys was in close agreement with on-board observations in which 68.2 percent of the animals were considered to be juveniles. Female turtles comprised 62.5 percent of the turtles for which sex could reliably be determined, compared with 74 percent females recorded during on-board sampling.

Table 11. Monthly summary of beach "wash-ups" of loggerhead turtles, April-September, 1977.

MONTH	Juvenile	Mature Female	Mature Male	Mature Sex Unknown	Data	Total
April	20	2	1			23
May	7	6	2			15
June	6	4			6	16
July	17	8	3	7	19	54
August	5			2	7	14
September	1					1
TOTALS	56	20	6	9	32	123

Percent juveniles (from animals examined) = 61.5
 Percent adult (from animals examined) = 38.5
 Percent females (of mature animals examined) = 76.9
 Percent males (of mature animals examined) = 23.1

Age and Sex Distribution for "Wash-ups" (1977)

In 1977, 61.5 percent of beach strandings were classified as juvenile specimens, with 86.7 percent of those animals taken during on-board sampling identified as juveniles. Sex ratios from on-board sampling and beach surveys were in reasonably close agreement with 85.2 and 76.9 percent females, respectively.

To provide data on the percentage of turtle kills which wash-up on the beaches and to determine the relationship between area of trawl mortality and location of beach stranding; dead turtles were tagged and released near the capture location. In 1976, four dead turtles were tagged and none were returned, indicating that these animals did not wash ashore or they went unreported. During 1977, nine dead turtles were tagged and we received a 44 percent (4) return rate. All of the returns were in close proximity to the release location. This provides some evidence that beaches having large numbers of "wash-ups" are near the area where the mortality occurred.

Beach Strandings Associated with Other South Carolina Fisheries

Thirty beach strandings of dead loggerhead turtles were reported from North, South and Sand Islands during late April and early May, 1977. No shrimp fishing was being done at this time and trawl drowning must be ruled out as a cause of death. A fishery for Atlantic sturgeon operates in this area, primarily near the entrance jetties to Winyah Bay, during the months of March-April. Large mesh (12-14 inch stretched mesh) nylon gill nets are used for catching the sturgeon and it is believed that

turtles traveling through the area become entangled in the nets and drown. Although we have no direct evidence that this is the case, the localized nature of the "wash-ups"; in close proximity to the fishing areas and the lack of any other inshore fishery operating at this time, suggests that the sturgeon nets are responsible for a limited, localized mortality source.

The majority of the strandings (20) were observed on North Island with four and six respectively, on South and Sand Island. North Island is immediately north of the Winyah Bay entrance, and Sand and South Islands lie immediately to the south.

Of the 19 turtles for which sex could be determined, 16 were females and three were males. Eighty-three percent (25) of these turtles were considered to be juvenile specimens on the basis of carapace length and 17 percent (5) were mature.

Reports of strandings of dead loggerheads on South Carolina beaches in previous years, sometimes mentioned that these turtles appeared to have been shot or bludgeoned. We did not observe any cases where it could be definitely stated that turtle damage was a result of deliberate maiming.

Although a "wash-up" monitoring program does not provide absolute numbers of incidental catch mortalities, it does provide at relatively low levels of effort, a measure of the relative magnitude of this source of mortality from year to year. With additional information on the percentage of turtle drownings reported, and the relationship between mortality and stranding location, monitoring of designated index areas could be a cost-effective method of assessing incidental catch mortality and the effects of future preventive measures.

DISCUSSION AND CONCLUSIONS

As pointed out in the introduction, little attention has been paid to obtaining objective information on the magnitude of incidental catch of marine turtles by commercial fishermen. A survey by Mauerman and Cox (1976) on incidental catch of turtles by the Brownsville-Port Isabel, Texas, shrimp fleet was conducted by distributing a questionnaire to fleet owners who asked their captains to provide the requested information. It is my opinion that because of the sensitive nature of the shrimper-turtle interaction, a survey of this type is prone to underestimate the magnitude of incidental catch. It was for this reason that we decided to rely on observers aboard shrimp trawlers to provide data for this study. It is indeed a labor intensive method of study but has the advantage of avoiding possible bias involved when asking fishermen to implicate themselves in the killing of turtles; an activity which may have future ramifications on their fishing activities.

It is apparent from the results of this study to date, that substantial numbers of turtles are caught incidental to shrimp trawling and other commercial fishing activities and that a significant percentage of these turtles die as a result. The wide variability in catch rates from the on-board sampling necessitates caution in making the wide extrapolation from data based on 1343 trawling hours to the estimated total effort of 201,075 trawling hours. Interview data and observations by Keiser (1976) and Hillestad (1977) are; however, supportive of these estimates.

What this source of mortality means to the continued survival of the southeastern United States' populations of loggerhead turtles is not known because of our lack of total population estimates, natural survival rates and annual recruitment data. In addition, the relative impact of incidental catch mortality compared to other factors cited as responsible for adverse impacts, i.e. nest predation and beach front development, is unknown. In light of the informational gaps, the most prudent course of action in terms of the loggerhead turtle seems to be to assume that incidental captures may be having a detrimental effect on turtle populations. Increased research efforts to develop methods of reducing or preventing this mortality factor are called for. A serious attempt to assess the present status of these populations, should be made prior to instituting restrictive fishery regulations or embarking on large scale turtle restoration projects.

It is often suggested that important nesting beaches must be protected from incidental catch mortality. The assumption that most incidental catch mortality involved nesting females is prevalent even among turtle biologists, but is not supported by our data. Creation of a closed trawling zone adjacent to major rookeries would not afford significant protection to turtles and would prove to be an unjustified penalty on shrimp fishermen. In our study, more captures and beach strandings occurred in the Caper's Island-Edisto Beach area (Area II) where nesting activity is minimal, than occurred from the North Carolina state

line to Bull's Island, an area encompassing the Cape Romain National Wildlife Refuge; the site of the largest loggerhead rookery in South Carolina.

It is apparent that the most productive shrimping grounds and the areas of highest turtle abundance coincide. If measures to reduce incidental mortality must be instituted; the development of selective gear seems likely to create less disruption in the southeastern United States' shrimp fishery than restrictive fishing zones or seasons.

The possibility of compensating for a known level of incidental catch mortality by releasing hatchling turtles or "head-started" yearlings should be given serious consideration. On most South Carolina beaches, many eggs serve only to feed what seems to be an increasing raccoon population. Predation levels of 87 percent have been documented on some South Carolina nesting beaches (Sally Hopkins, personal communication). A program to collect these eggs soon after laying and providing protection in a hatchery, could result in a considerable increase in hatchling production at a modest expense. Hatchlings would be released on their natal beaches shortly after emergence, to enter normal hatchling, migrational pattern.

The rearing of turtles in tanks for one - two years before release, has the advantage of increasing their survival odds at stocking but would be considerably more expensive and there is the problem of releasing turtles into an ecological niche that they would not normally inhabit at their age. Whether these turtles would become part of the reproductive population in the area of release or somewhere else is unknown.

This study will hopefully provide some insight into the problems and complexities of the interaction between logger-head turtles and commercial fishermen, and lay the ground work toward establishing rational management programs which address both the protection of turtles and the commercial fisheries.

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APPENDICES

INCIDENTAL CATCH DATA

AREA I

1976

DATE	Trawling Hours	Number Turtles Captured	Carapace Length (cm)	Sex	Juvenile Adult	Condition on Release	Tag Number	Capture Location	Release Location
'13/76	8.0	0							
'14/76	4.3	0							
'20/76	12.0	0							
'22/76	4.75	0							
'27/76	8.3	1	64.0	F	J	D	#011	32°58.3'N, 79° 28.1'W	Same as capture
'6/76	11.5	0							
'11/76	11.75	0							
'3/76	4.5	0							
'8/76	2.0	0							
'9/76	8.75	0							
'10/76	3.2	0							
'16/76	1.8	2	49.3	F	J	A	14251	32°56.5'N, 79°35.6'W	32°56.6'N, 79°34.0'W
			59.2	F	J	A	14252	32°56.6'N, 79°34.0'W	Same as above
'17/76	14.0	0							
'29/76	6.0	0							
0/6/76	12.0	0							
0/8/76	11.5	0							
0/23/76	10.0	0							
TOTAL	134.3	3							

INCIDENTAL CATCH DATA

AREA II

1976

E	Trawling Hours	Number Turtles Captured	Carapace Length (cm)	Sex	Juvenile Adult	Condition on Release	Tag Number	Capture Location	Release Location
	3/76	7.5	0						
	3/76	8.5	0						
	2/76	15.0	0						
	5/76	2.5	0						
	3/76	8.0	2						
			49.9	F	J	A	14201	32°51.4'N, 79°40.0'W	32°54.1'N, 79°40.2'W
			60.1	M	J	A	14202	32°54.1'N, 79°40.2'W	32°54.9'N, 79°46.4'W
	3/76	9.0	0						
	/76	12.0	0						
	/76	6.0	0						
	/76	12.0	0						
	0/76	12.0	2						
			81.1	M	A	A	14203	32°40.5'N, 79°51.0'W	32°41.4'N, 79°51.6'W
			69.5	F	J	A	14204	32°40.5'N, 79°51.0'W	32°41.4'N, 79°51.6'W
	1/76	9/0	0						
	3/76	10.0	0						
	7/76	9.0	0						
	8/76	4.0	0						
	4/76	15.0	0						
	5/76	15.0	1						
	6/76	12.0	0	F	J	D	14205	32°36.3'N, 79°58.9'W	32°36.2'N, 79°59.4'W
	/76	9.0	0						
	/76	13.5	0						
	/76	15.0	0						
	/76	10.5	0						
	/76	9.0	1						
	5/76	10.0	1	F	J	D	#001	32°31.2'N, 80°13.3'W	32°31.1'N, 80° 7.8'W
	7/76	12.0	0	F	J	A	14206	32°46.1'N, 79°46.4'W	32°30.8'N, 80° 8.1'W
	1/76	10.0	1	F	J	A			
	2/76	11.0	0				14207	32°43.2'N, 79°51.3'W	Same as capture
	13/76	10.0	1	F	J	A			
	14/76	11.0	0				14208	32°31.8'N, 80°14.2'W	32°16.1'N, 80°39.8'W
	19/76	11.5	2						
			91.6	M	A	D	#002	32°31.7'N, 80°14.6'W	32°34.4'N, 80°11.7'W
			60.2	F	J	A	14209	32°32.2'N, 80°13.3'W	32°32.1'N, 80°13.4'W
	1/76	8.5	2	F	A	A	14211	32°40.5'N, 79°51.8'W	32°43.8'N, 79°51.0'W
			83.0	F	A	A	14210	32°42.6'N, 79°47.1'W	32°42.8'N, 79°47.0'W
	15/76	9.0	0						
	17/76	10.5	0						
	12/76	3.0	0						
	13/76	11.5	0						

INCIDENTAL CATCH DATE

AREA II

1976

DATE	Trawling Hours	Number Turtles Captured	Carapace Length (cm)	Sex	Juvenile Adult	Condition on Release	Tag Number	Capture Location	Release Location
0/14/76	9.0	0							
0/19	6.0	0							
0/21	12.0	1	61.9	F	J	A	14212	32°31.3'N, 80°12.6'W	32°30.2'N, 80°13.7'W
TOTAL	368.5	14							

INCIDENTAL CATCH DATA

AREA III

1976

DATE	Trawling Hours	Number Turtles Captured	Carapace Length (cm)	Sex	Juvenile Adult	Condition on Release	Tag Number	Capture Location	Release Location
1/14/76	5.8	0							
1/16/76	7.0	0							
1/18/76	3.25	0							
1/21/76	5.5	0							
1/26/76	4.8	0							
1/28/76	5.0	0							
1/13/76	6.0	1	79.4	F	A	A	not tagged	32°13.1'N, 80° 40.2'W	Same as capture
1/15/76	5.5	1	78.7	M	A	A	14301	32°12.0'N, 80° 40.1'W	Same as capture
1/20/76	4.0	0							
1/23/76	3.5	0							
1/24/76	6.5	0							
1/27/76	3.0	0							
1/30/76	3.2	1	71.1	F	J	A	14302	32°22.2'N, 80° 24.2'W	Same as capture
1/6/76	5.3	0							
1/12/76	5.0	1	69.8	M	J	A	14303	32°15.3'N, 80° 41.1'W	Same as capture
1/20/76	3.0	0							
1/22/76	5.0	0							
1/25/76	4.0	0							
1/26/76	3.5	1	81.3	F	A	A	14304	32°16.1'N, 80° 39.8'W	Same as capture
TOTAL	88.8	5							

E	Trawling Hours	Number Turtles Captured	Carapace Length (cm)	Sex	Juvenile Adult	Condition on Release	Tag Number	Capture Location	Release Location
6/76	12.1	0							
0/76	11.7	0							
2/76	10.7	0							
3/76	10.8								
9/76	11.5	3	69.5	F	J	A	14254	32°57.1'N, 79°30.5'W	Same as capture
			65.0	F	J	D	#007	32°57.1'N, 79°30.5'W	Same as capture
			75.0	F	A	A	14256	32°58.3'N, 79°31.3'W	33°00.6'N, 79°28.6'
0/76	11.2	0							
7/76	9.1	0							
7/76	9.75	1	67.0 J	F	J	A			
1/76	8.2	1	37.0 J	?	J	A	14257	32°56.5'N, 79°32.2'W	Same as capture
2/76	10.0	0				A	14258	32°59.3'N, 79°26.3'W	33°00.2' N, 79°29.
3/76	11.8	0							
9/76	9.6	1	28.0J						
0/76	10.3	0							
1/76	9.4	0							
6/76	6.75	0							
8/76	8.75	0							
9/76	9.9	0							
9/76	8.8	0							
9/76	9.3	0							
0/76	9.2	1	59.0	F	J	D	#008	32°58.9'N, 79°25.7'W	32°59.5'N, 79°29.
1/76	3.3	0							
6/76	7.9	0							

INCIDENTAL CATCH DATA

AREA II

1977

Year	Trawling Hours	Number Turtles Captured	Carapace Length (cm)	Sex	Juvenile Adult	Condition on Release	Tag Number	Capture Location	Release Location
6/77	9.3	1	106	F	A	D	#003	32°32.1'N, 80°12.9'W	32°33.5'N, 80°08.5'
10/77	5.75	0							
13/77	8.5	0							
14/77	5.8	1	70	F	J	D	#004	32°34.4'N, 80°07.6'W	Same as capture
17/77	8.8	2	61	M	J	D	#005	32°42.8'N, 79°51.4'W	Same as capture
			66	F	J	D	#006	32°42.8'N, 79°51.4'W	Same as capture
8/77	4.3	0							
10/77	5.9	0							
11/77	6.8	1	59.0	F	J	A	14214	32°51.1'N, 79°39.7'W	Same as capture
11/77	9.4	1	73.0	F	J	A	14215	32°49.4'N, 79°42.2'W	32°48.1'N, 79°41.0'
11/77	6.5	1	69.0	F	J	A	14216	32°49.0'N, 79°42.1'W	32°44.4'N, 79°47.7'
11/77	4.0	0							
12/77	9.0	0							
13/77	5.0	0							
18/77	12.0	2	49.0	?	J	D	#021	32°40.6'N, 79°52.6'W	Same as capture
			70.0	F	J	D	#022	32°41.6'N, 79°51.8'W	Same as capture
19/77	7.0	2	63.0	F	J	A	14217	32°50.9'N, 79°40.4'W	Same as capture
			68	F	J	D	#023	32°51.1'N, 79°39.7'W	32°48.9'N, 79°42.1'
20/77	9.9	1	64	F	J	A	14218	32°42.4'N, 79°43.9'W	Same as capture
25/77	9.1	0							
26/77	9.25	0							
29/77	6.2	0							
3/77	9.8	0							
4/77	8.75	0							
5/77	9.0	0							
8/77	6.8	0							
9/77	3.0	0							
10/77	5.9	0							
16/77	11.3	1	64.0	F	J	A	14219	32°32.6'N, 79°50.0'W	Same as capture
17/77	1.75	0							
18/77	6.75	0							
22/77	4.9	0							
23/77	8.7	0							
6/77	6.0	0							
9/77	5.8	0							
12/77	3.75	0							
13/77	8.25	0							
14/77	5.3	0							

INCIDENTAL CATCH DATA

AREA II

1977

DATE	Trawling Hours	Number Turtles Captured	Carapace Length (cm)	Sex	Juvenile Adult	Condition on Release	Tag Number	Capture Location	Release Location
15/77	2.3	1	57.0	F	J	A	14263	32°46.8'N, 79°45.1'W	Same as capture
20/77	4.8	0							
21/77	4.25	0							
22/77	8.0	0							
27/77	5.9	0							
28/77	5.6	1	65.5	F	J	A	14262	32°42.8'N, 79°51.3'W	Same as capture
29/77	5.6	0							

INCIDENTAL CATCH DATA

AREA III

July, 1977

E	Trawling Hours	Number Turtles Captured	Carapace Length (cm)	Sex	Juvenile Adult	Condition on Release	Tag Number	Capture Location	Release Location
'6/77	9.5	1	85.0	F	A	Alive	14276	32°14.8'N, 80°34.3'W	32°17.8'N, 80°29.8'W
'7/77	9.5	1	59.0	F	J	Dead	Dead (No tag)	32°11.4'N, 80°40.6'W	Same as capture
'8/77	9.9	2							
	--	-	58.0	F	J	Alive	14280	32°23.9'N, 80°22.7'W	Same as capture
	--	-	70.0	F	J	Alive	14278	32°23.9'N, 80°22.7'W	Same as capture
'12/77	4.0	0							
'13/77	6.9	1	75.0	F	A	Dead	Dead (No tag)	32°21.7'N, 80°25.4'W	32°24.4'N, 80°27.0'W
'14/77	4.9	1	62.5	F	J	Dead	Dead (No tag)	32°26.1'N, 80°25.1'W	Same as capture
'15/77	10.0	1	57.0	F	J	Alive	14281	32°20.1'N, 80°26.0'W	Same as capture
'18/77	8.6	0							
'19/77	9.3	0							
'20/77	3.8	0							
'22/77	8.7	0							
'25/77	3.6	0							
'26/77	9.0	0							
'27/77	3.9	0							
'29/77	3.6	0							
'1/77	7.4	0							
'2/77	6.25	0							
'3/77	3.75	0							
'4/77	9.0	0							
'7/77	5.0	0							
'9/77	6.5	0							
'10/77	4.6	0							
'15/77	6.4	0							
'16/77	5.9	1	59.3	F	J	Dead	#100	32°16.5'N, 80°32.1'W	Same as capture
'19/77	5.8	0							
'22/77	4.25	0							
'23/77	6.25	0							
'30/77	2.5	0							
'1/77	2.0	0							
'5/77	6.6	0							
'6/77	4.0	0							
'9/77	4.75	0							
'12/77	5.3	0							
'13/77	3.0	0							
'14/77	7.25	0							
'15/77	6.75	0							
'16/77	9.7	0							
'19/77	6.6	0							

INCIDENTAL CATCH DATA

AREA

E	Trawling Hours	Number Turtles Captured	Carapace Length (cm)	Sex	Juvenile Adult	Condition on Release	Tag Number	Capture Location	Release Location
'20/77	5.0	0							
'21/77	4.0	0							
'22/77	1.75	0							
'26/77	7.0	0							
'27/77	4.5	0							

MARINE TURTLE INCIDENTAL CATCH DATA SHEET

DATE:	NAME OF BOAT:	BOAT'S CAPTAIN:
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BOAT DESCRIPTION:	BOAT LENGTH:
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DATE OF CAPTURE:	LOCATION, (GENERAL AND/OR LORAN):
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WEATHER CONDITIONS, WIND DIRECTION AND VELOCITY	SEAS, FT.	TIDE STAGE
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SPECIES OF TURTLE:	SEX:	DRAG No.	NET IN	NET OUT	TIME SPAN
STRAIGHT LINE MEASUREMENTS (cm):		1			
LENGTH: WIDTH:		2			
EXISTING TAG, NO. AND DATA:		3			
CONDITION BROUGHT ABOARD:		4			
CONDITION UPON RELEASE:		5			
ARRIVAL TIME, COMMENTS:		6			
		7			
		8			
		9			
DATE OF RELEASE:	NO. OF TAG APPLIED:	10			
RELEASE LOCATION:					
ADDITIONAL COMMENT:					