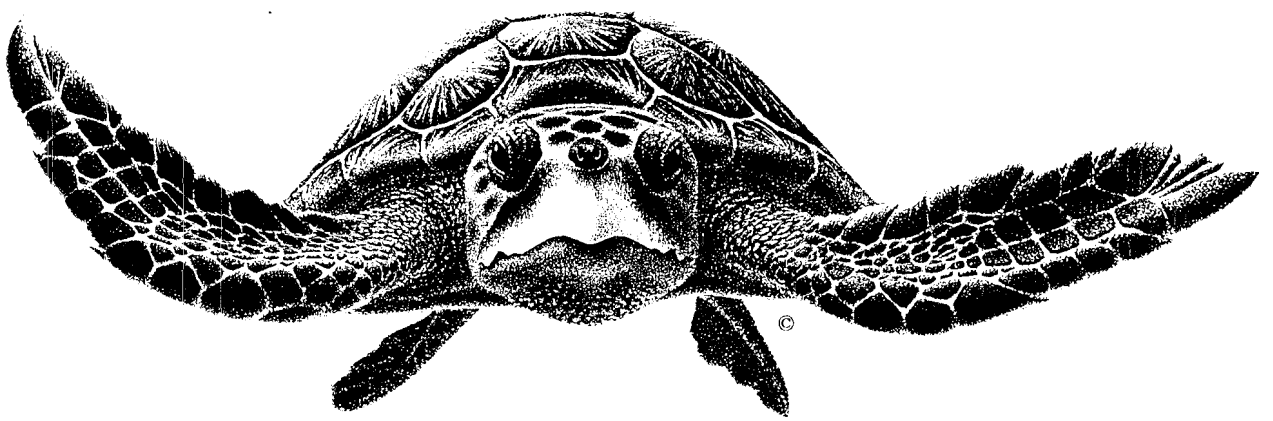
NOAA Technical Memorandum NMFS-SEFC-214

PROCEEDINGS OF THE EIGHTH ANNUAL WORKSHOP ON SEA TURTLE CONSERVATION AND BIOLOGY

24 - 26 February 1988
Fort Fisher, North Carolina

Barbara A. Schroeder, Compiler

December 1988



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PREFACE

The Eighth Annual Workshop on Sea Turtle Conservation and Biology was held 24 - 26 February 1987 at Fort Fisher, North Carolina. The Workshop was hosted and organized by the North Carolina Wildlife Resources Commission in cooperation with the North Carolina Aquarium at Fort Fisher and the University of North Carolina at Wilmington. The Workshop brought together 245 registered participants from all areas of sea turtle research, conservation, and management. Forty-four papers were presented at the Workshop, 36 are compiled here as extended abstracts. The extended abstract format was chosen because it provided a means of disseminating more complete information than simple abstracts while leaving the option open for authors to submit full length papers to peer reviewed journals. This format did not allow strict editorial control. The content of these extended abstracts does not necessarily reflect the views of the compiler, the National Marine Fisheries Service, or the Florida Department of Natural Resources. My hope is that these Proceedings will serve as a useful source of information and contribute to sea turtle recovery and conservation.

The publication of these Proceedings was funded by the National Oceanic and Atmospheric Administration, Southeast Fisheries Center, Miami Laboratory. The Florida Department of Natural Resources, Marine Research Institute contributed salary and travel funds after my departure from NMFS. Nancy Thompson gave up many days on her computer to enable me to continue with the Proceedings. Jamie Serino provided the cover artwork. For their assistance with the compilation of these Proceedings I extend my sincere appreciation to the following persons at the NMFS Miami Laboratory: Gale Morina typed all 36 extended abstracts into a common word processing format; Larry Hansen gave me a crash course in desktop publishing and helped out with problems along the way; Douglas Burn provided valuable advice and computer expertise throughout the project. Thanks also to David Cottingham for encouragement.

Barbara A. Schroeder
December 1988

This publication should be cited as : Schroeder, B. A. (Compiler) 1988. Proceedings of the eighth annual conference on sea turtle biology and conservation. NOAA Technical Memorandum NMFS-SEFC-214, 146 p.

NOAA Technical Memorandum NMFS-SEFC-214

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The Technical Memorandum Series is used for documentation and timely communication of preliminary results, interim reports, or special-purpose information, and have not received complete formal review or editorial control.

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NATIONAL MARINE FISHERIES SERVICE

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HOW TIDES AFFECT LOGGERHEAD EMERGENCE ACTIVITIES ON BALD HEAD ISLAND, NORTH CAROLINA

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There have been many implications that nesting activities of the loggerhead sea turtle (*Caretta caretta*) are associated with lunar periodicity, tidal amplitude, slope of the beach, and time of night. Frazer (1983) showed that the turtles' first emergences of a nesting season coincide with the rise and fall of the tides on beaches that are gently sloping and have relatively high tidal amplitudes (Little Cumberland Island, Georgia, 2.0 m tidal range), though not on beaches with similar slope and lower tidal amplitudes (Cape Lookout, North Carolina, and Cape Canaveral, Florida, both with a 1.1 m tidal range). There is a dearth of information, however, on how tidal cycles affect a female's decision to nest or return to the water without nesting (false crawl). This study was conducted to determine how tides influence the emergence activities of loggerhead sea turtles on Bald Head Island, North Carolina.

Bald Head Island (BHI), North Carolina, is part of the Smith Island Complex which makes up what is known locally as Cape Fear. This is an area where the coastline changes orientation from north-south to east-west. Nineteen kilometers of continuous beach strand interconnect three small islands, Bluff, Middle, and Bald Head. The Cape's physiography divides the shoreline into three distinctive beaches. East Beach is approximately 9.6 km long and is characterized by a gently sloping beach and relatively little development. South Beach is approximately 5.6 km long and is characterized by a short, steep eroding beach. Most of the beachfront development is concentrated here. The River Beach faces west towards the Cape Fear River and is approximately 2.4 km long. This area receives little turtle activity (only 2 nests in 1987) and is included herein as part of South Beach. Southeastern North Carolina is characterized by a low mesotidal wave dominated environment; tides are semi-diurnal with a mean tidal range of 1.3 m on BHI.

The 19 km of beaches at BHI were patrolled at 45-75 minute intervals each night from late May through August since 1980 as part of a nest protection project. In 1987, upon encountering a turtle on the beach, project personnel recorded time of the activity, type of activity, tidal stage, lunar stage, and other variables not pertinent to this report. There were a total of 175 emergences between May 26 and August 17 on BHI in 1987. Ninety-five (54%) of these activities resulted in nests, of which 41 were laid on East Beach and 54 on South Beach.

Since this project is not dealing with a tagged population of turtles, every emergence was included in the analysis of the 1987 data. A principle component analysis (PCA) was performed on several variables in relation to the emergence of loggerhead sea turtles at BHI: activity type (false crawl or nest), on which beach the emergence occurred (East or South), time of night, tidal stage, and phase of the moon. The PCA indicated that the turtles were behaving differently on East and South beaches in relation to the other variables, therefore the data for each beach are given separately. The type of activity was only correlated with the variable tidal stage, so only the effects of tide on activity are given in this report. Because all emergences were used in the

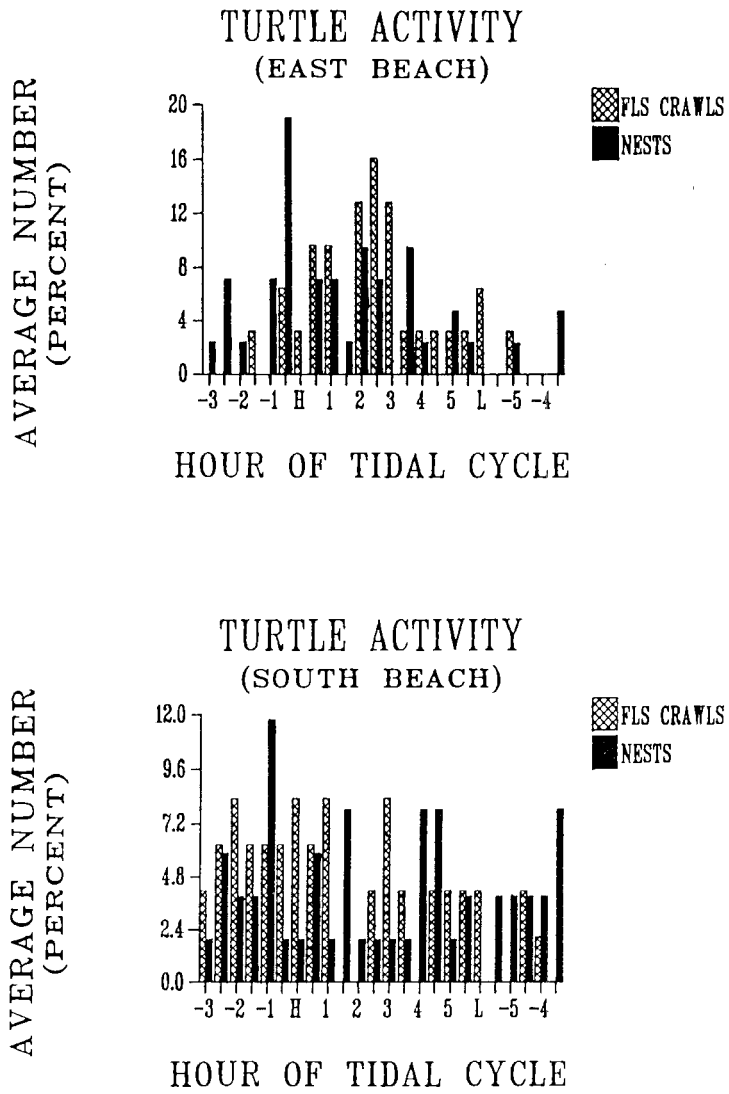

Figure 1. Emergence activity on Bald Head Island as related to the tidal cycle.

analyses and they violate the assumption of mutual independence, only nonparametric statistics (Sign Test, $P < 0.10$) were used to test the hypothesis that tidal stage had no effect on emergence activity.

Figure 1 shows the percentages of the activity type for each beach (South Beach: False Crawls = 45, Nests = 54; East Beach: False Crawls = 35, Nests = 41). There was no significant difference in nesting or false crawls in relation to the tidal cycle on South Beach, but there was a distinct pattern in the distribution of nests and a significant pattern in the distribution of false crawls in relation to the tidal cycle on East Beach, with the peak of activities occurring around high tide (Figure 2).

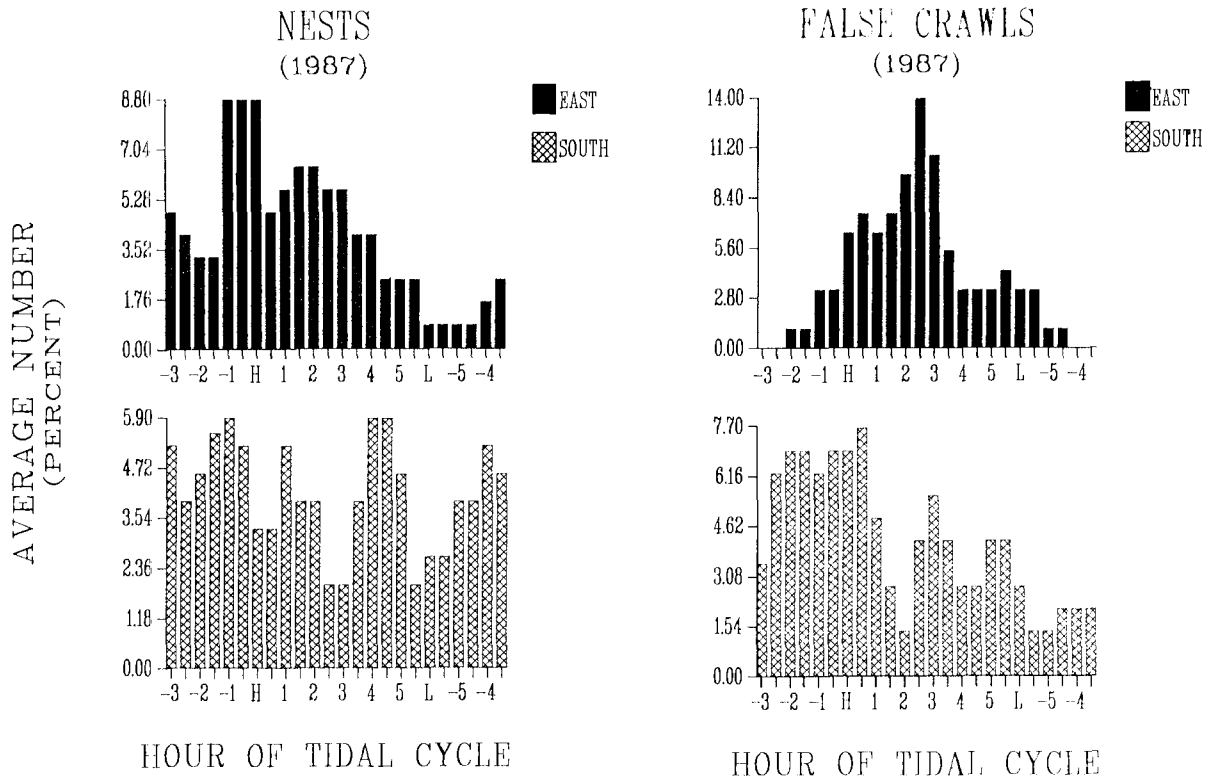

Figure 2. Running averages for emergence activity on Bald Head Island as related to the tidal cycle.

These data support Frazer's (1983) contention that loggerhead sea turtles come ashore more frequently at high tides on gently sloping beaches, but that emergences are not related to tidal activity on steep sloping beaches. The beach slope is apparently more important than tidal amplitude in determining how a gravid female behaves on her nesting beach, for Bald Head Island has a tidal amplitude more similar to those of Cape Canaveral, Florida, and Cape Lookout, North Carolina. Further, these data indicate that loggerheads nest most frequently around high tide and false crawl most frequently on a falling tide on gently sloping beaches. This latter revelation is not surprising inasmuch as gravid females have further to crawl on wet sand before they encounter the rapid changes in temperature (dry sand) necessary for nest site selection (Stoneburner and Richardson 1981).

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SOFT TURTLE EXCLUDER DEVICE (TED) TESTING AT CAPE CANAVERAL, FLORIDA

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INTRODUCTION

Regulations mandating the use of Turtle Excluder (Trawling Efficiency) Devices (TEDs) in the southeastern shrimp fishery are now a reality (Federal Register, June 29, 1987). As a consequence, several old and new designs have appeared. Although these excluders were originally designed to eliminate cannonball jellyfish (*Stomolophus meleagris*), they also eliminate a variety of other organisms. Studies conducted on four rigid TED designs in August 1986 showed 100% turtle exclusion for each TED (Christian and Harrington 1987). However, soft webbing TED designs had not been tested.

In this paper, we present findings from tests done on two different soft TED designs, commonly referred to as the Morrison soft TED and Parrish soft TED. Presently, the Morrison device is certified for usage (Federal Register, October 5, 1987). The Parrish device has also been officially certified (Federal Register, September 1, 1988). The objectives of our studies were to assist the shrimping industry by conducting experimental tows in the Port Canaveral Buoy Channel, Cape Canaveral, Florida, to determine turtle excluding efficiency for certification of the aforementioned soft TED designs.

METHODS

Research was conducted aboard the R/V GEORGIA BULLDOG, a 22m long commercial shrimp boat. The Morrison soft TED was tested at the Cape from 15-25 June 1987, and the Parrish soft TED research was conducted from 10-16 October 1987. The Cape was chosen for our study area because of the documented concentration of loggerhead turtles in the channel area (Carr et al. 1980).

Double-rig trawling was conducted throughout with two identical nets. The TED was installed in the port net and towed each time against the unaltered net, referred to as the control. All comparisons were made relative to the control net. The nets used to test the Morrison soft TED were two identical 18.2m flat nets constructed from 4.8cm stretched mesh number 15 twine, spread with 2.0 x 2.4m standard wooden trawl doors. The two nets used to test the Parrish soft TED were 19.5m balloon nets, rigged and constructed similar to the flat nets. SCANMAR mensuration measurements were taken during each tow to determine the effect of the TED on spread and height of the net, as compared to the control.

TED evaluations were conducted according to the guidelines given in the Federal Register, June 29, 1987. Statistical analyses were conducted at the 90% confidence level. The following formula was used to accept or reject a device as being 97% effective:

$$B = (0.04) \times \text{std} - \bar{x}\,\text{TED}$$

where:

$x\ std$ = observed CPUE of the standard net, and

$x\ TED$ = observed CPUE of the excluder-equipped net

Essentially, the test statistic B computed for a given number of paired tows would be compared to the acceptance values (A) as shown in Table 1, to determine if the values were exceeded. If B exceeds these values (A), then the device being tested would be accepted as excluding 97% of the turtles.

Descriptions of each TED can be found in the following publications: Morrison TED - Federal Register, Vol. 52, No. 192, October 5, 1987; Parrish TED - Cruise Report 100, R/V GEORGIA BULLDOG,University of Georgia, MAREX, P. O. Box Z, Brunswick, GA 31523, or Federal Register, Vol. 53, No. 170, September 1, 1988.

Table 1. Acceptance level (A) which must be exceeded by the test statistic B for certification that an excluder device is 97% effective.

NO. OF TOWS	ACCEPTANCE LEVEL (90% CONFIDENCE)
10	0.140
20	0.099
30	0.081
40	0.070
50	0.063
60	0.057

RESULTS

After 15 paired tows (average tow time = 0.75 hrs) with the Morrison TED, 42 loggerhead turtles (*Caretta caretta*) (Table 2) were captured in the control net with no captures in the Morrison TED-equipped net. In addition, biomass reduction was recorded as 31.1%, with 8,283 pounds captured in the TED net and 12,019 captured by the control net.

The Parrish TED was towed for 10 stations (average tow time = 0.50 hrs), with 42 loggerhead turtles captured in the control net and none in the Parrish-equipped net (Table 3). The biomass percent reduction was 73.3%, with 338 pounds captured in the TED net and 1,144 pounds captured by the control net.

SCANMAR mensuration measurements on the front-end geometry of the net showed a decrease in the Morrison TED net's spread by 30%; however, the net's headline height increased up to 20% and was accompanied by a loss of bottom contact of the leadline. With the Parrish TED, a reduction of 11.1% was seen in the height of the headline, while net spread increased 4.5%. It is quite obvious that each TED had an opposite effect on the net's front-end geometry.

Table 2. Loggerhead (Caretta caretta) catches during Morrison soft TED testing, Cape Canaveral, FL, 15-16 June 1987.

TOW NO.	CONTROL NET TURTLE CATCH	TED NET TURTLE CATCH
1	2	0
2	4	0
3	3	0
4	1	0
5	5	0
6	3	0
7	5	0
8	1	0
9	3	0
10	0	0
11	2	0
12	1	0
13	1	0
14	7	0
15	4	0
	42	0

Table 3. Loggerhead (Caretta caretta) catches during Parrish soft TED testing, Cape Canaveral, FL, 14 October 1987.

TOW NO.	CONTROL NET TURTLE CATCH	TED NET TURTLE CATCH
1	3	0
2	7	0
3	4	0
4	6	0
5	4	0
6	7	0
7	2	0
8	4	0
9	4	0
10	1	0
	42	0

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Federal Register. October 5, 1987. Vol. 52, No. 192:37152-37154.

Federal Register. September 1, 1988. Vol. 53, No. 170:33020-33022.

NESTING HAWKSBILLS IN ANTIGUA

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Pasture Bay Beach on Long Island, Antigua has a relatively high concentration of nesting hawksbill sea turtles (*Eretmochelys imbricata*). During the 1987 season (June-November) this population exhibited strong nesting beach site fidelity. The average internesting interval was 14 days. The average number of nests per turtle was five.

The Pasture Bay hawksbills preferred nesting in vegetation closest to the water. High concentrations of nests were found in the sea grape (*Coccoloba uvifera*) and the sea bush (*Suriana maritima*) on these portions of the beach. Nesting females seem to open up areas under the bushes, possibly making it easier for subsequent nesting. Areas of dense nesting also were found to have high concentrations of ants which reduced the success rate.

The Pasture Bay Project integrated an educational program along with the research. Guests of the Jumby Bay resort on Long Island were encouraged to participate. The resort has supported the project and is using caution in the development of Pasture Bay. The potential for educational projects in Antigua is very good.

SEA TURTLE STRANDINGS: NEW PERSPECTIVES ON NORTH CAROLINA BIOLOGY

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Historic records indicate a commercial fishery for at least three different species of marine turtles existed in North Carolina's sounds at the turn of the century (True 1887, Coker 1906). Nearshore aerial surveys in 1979-81, in conjunction with nesting surveys of the state's beaches, counted turtles on the surface in the Oregon Inlet - Cape Hatteras area two orders of magnitude higher than near the state's more southerly nesting beaches (Crouse 1985). In June, 1981, North Carolina began collecting data from turtles that washed up "stranded" on its shores.

METHODS

A cooperative volunteer network, supplemented by twice weekly aerial nesting surveys for the summer months of 1981, was established to report and document stranded turtles on the beaches of North Carolina. Standardized data forms solicited information regarding date, location, species, size, condition, etc. Data were collated and cross-referenced and contradictory information checked immediately upon receipt. Size-class data were expressed in centimeters and converted to straight-line-carapace length according to Frazer and Ehrhart (1983). Turtles with serious carapace damage were deleted from the size-class analysis.

RESULTS

Species Composition: Between June 1, 1981, and December 31, 1983, a total of 480 stranded turtles were reported. Data forms were completed on 420 of these. 400 loggerheads, 13 Kemp's ridley, 5 green, and 2 leatherback turtles were reported. Most turtles showed no obvious external injuries. Only 6 turtles were alive.

Phenology: Stranded turtles washed up on North Carolina beaches throughout the year (Figure 1), though the numbers were consistently higher in the summer and again in the late fall. This year-round presence is contrary to reports from neighboring states (VA - Lutcavage and Musick 1985; SC - Hopkins-Murphy pers. commun.; GA - Ruckdeschel and Zug 1982), and may result from the close juxtaposition to Cape Hatteras of the warm, nutrient rich waters of the Gulf Stream, particularly in winter.

Distribution: Strandings appeared to be randomly distributed along the beaches of the state (except Nov-Dec 1982, a special case), with no increase in stranding reports in the vicinity of the more important nesting beaches. However, more than 10% of the reports each year came from inshore waters (the sounds and estuaries), where there is no potential nesting habitat and there was no survey effort. In terms of catch per unit effort, this strongly suggests that the number of turtles that utilize, and strand in, the sounds and estuaries of North Carolina may be severely underreported.

Size-Class Distribution: The size-frequency distribution (straight-line-carapace length in 10 cm classes) of 371 loggerheads (Figure 2) indicates the majority of North Carolina's stranded loggerheads fall in the juvenile and subadult classes (Frazer 1983, Crouse et al. 1987), with the largest number being large juveniles.

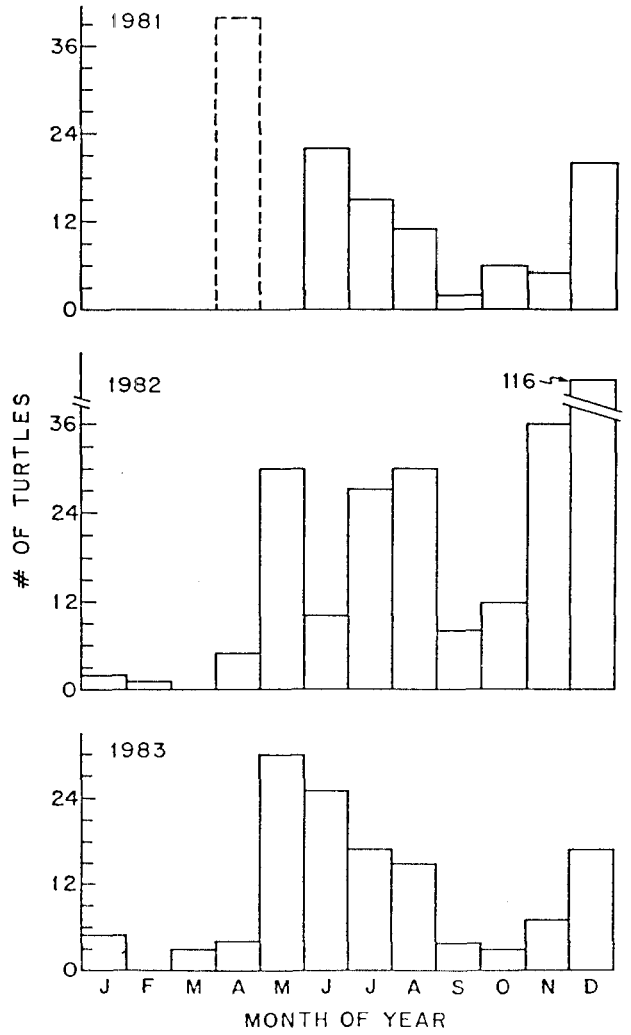

Figure 1. Monthly frequency of stranded turtles reported in North Carolina for the period of June 1981 through December 1983. The open bar for April 1981 represents the estimated strandings for a localized mass stranding that occurred prior to establishment of the stranding network.

DISCUSSION

Crouse et al. (1987) have shown that the juvenile and subadult stages may be the key to improving the outlook for our threatened populations of southeastern U.S. loggerhead turtles. Yet, almost half of all the stranded turtles reported in North Carolina during this 31-month period fit into the large juvenile stage. Ruckdeschel and Zug (1982) reported a very similar size-class distribution for 6 years of stranding data on Cumberland Island, GA, and noted an alarming increase in stranding numbers after 1977 (coinciding with an intensification in shrimp trawling activity in the area). Comparable data are not available for marine turtle strandings in North Carolina, but shrimp trawling and other fishing activities in North Carolina, as indicated by landings data (Street 1984), increased rapidly through the 1970's.

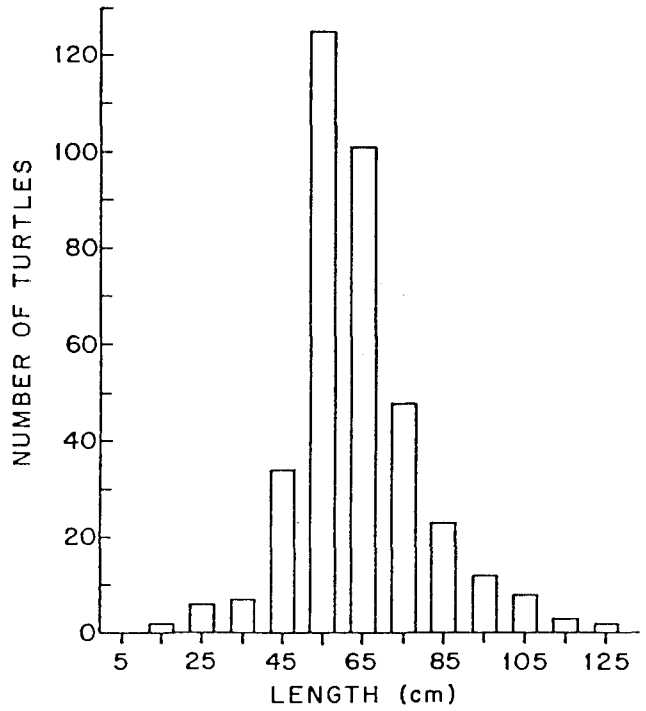

Figure 2. Size frequency distribution (straight-line length) of North Carolina strandings in 10 cm size classes.

More studies are necessary to clarify the role these North Carolina juvenile turtles and their habitats serve to the future populations of marine turtles in the southeast U.S. The most important thing we need to learn immediately is to identify what proportion of their mortality is fishery related, in particular trawling. If 70 or 80% of juvenile mortality is trawling related, we probably have the technology currently available (via TEDs and/or seasonally restricted areas) to halt and perhaps reverse the decline in our turtle populations (Crouse et al. 1987). We must also look at sea turtle use of North Carolina's sounds more closely. Even if current turtle numbers are not large, the historic information indicates these sounds are developmental habitats. Low numbers now may be a result of overfishing in recent years. The losses of juvenile turtles here may more than overcome any increase in numbers due to beach protection and headstarting efforts.

SUMMARY

North Carolina's waters may be more important to marine turtles than previously believed: they support several species of turtles; at least some individuals use these waters throughout the year and for purposes other than nesting; and a large proportion of these turtles appear to be juveniles, many of which may utilize the rich and diverse sound and estuary habitats available in North Carolina as developmental habitats. Recent demographic studies suggest that the value of these juvenile turtles and their developmental habitats to southeastern U.S. marine turtle populations may have been underestimated. Further study of the habitat use and mortality rates of juvenile and adult turtles in the sounds and offshore waters of North Carolina is imperative, with a concurrent increase in their protection recommended.

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KEMP'S RIDLEY IN CAPE COD BAY, MASSACHUSETTS - 1987 FIELD RESEARCH

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The Kemp's ridley sea turtle, the most endangered of all the marine turtles, is in critical need of relevant management and recovery efforts; yet, little is known about the ecology of juvenile ridleys. The presence of juvenile ridleys (mean curved-line carapace length of 27.1 cm) in Cape Cod Bay is indicated by the consistent annual strandings of cold-stunned individuals during the months of November through January. From 1977 to 1987, a total of 115 ridleys have stranded on Cape Cod beaches, giving an annual mean stranding number of 11.5 individuals. Of those individuals which could be sexed, 20 were males and 28 were females. Sex was determined by the examination of histologically prepared gonadal tissue and visual examination.

In an attempt to determine the status of the population and to identify habitats and periods of use, a preliminary study was undertaken in the late summer and fall of 1987. The basis of the study was the sonic and radio tracking of a Kemp's ridley turtle which stranded in Dennis, MA, in the fall of 1986, and recuperated at the National Marine Fisheries Service Woods Hole Aquarium.

This study was conducted in Cape Cod Bay which encompasses 430 square miles of open water located south of Massachusetts Bay which is a small corner of the larger Gulf of Maine. Cape Cod Bay is surrounded on three sides by land - the Plymouth uplands to the west, the Sandwich moraine to the south, and the interlobate moraine of the lower Cape to the east. The average depth of the bay is 100 feet. The deepest part, located near the mouth of the Bay, is 180 feet. There are many shallow tidal flat areas particularly along the southeastern and eastern rim in the vicinity of Orleans, Eastham, and Wellfleet.

Bottom type varies extensively; sand bottom is predominant though mud, rock, and eelgrass are common. The sand flats extend from Dennis on the west to Orleans on the east, north along Eastham and Wellfleet, and as far as 1.5 miles offshore. There are two prominent inshore rocky areas within the Bay, one between Sesuit Harbor and Corporation Beach in Dennis, extending seaward about two miles; the other off Manomet Point extending south to Ellisville. On the eastern side of Cape Cod Bay, the Wellfleet Harbor and Billingsgate Shoal areas comprise about 19 square miles of shallow, subtidal bottom composed of extensive eelgrass flats, sand and gravel, and mud.

The study was conducted from September 3, 1987 to December 8, 1987. Prior to the study, the juvenile ridley was measured, weighed, and fitted with a metal identification tag. Also, it was instrumented with a 32.77 kHz sonic transmitter (pulse-width - 15 msec) and a 163.941 MHz radio transmitter, both of which were obtained from the National Marine Fisheries Service, Northeast Regional Office.

The sonic transmitter was first epoxyed to the posterior portion of the carapace, between the central and marginal scutes. No further means of attachment were used in hopes that the unit would eventually lift off the shell within a few months time. The signal was monitored using a directional hydrophone and a sonic receiver (VR-60 Ultrasonic Receiver) within an average range of 3 to 5 miles.

In order to have the radio transmitter in a vertical position when the turtle surfaced, it was encapsulated in foam and then tethered to a posterior edge of the carapace. This involved attaching one end of a 20 cm long plastic coated wire to the tow eyelet of the transmitter and the free end to a posterior marginal scute using a corrodible break-away link. The radio signal was detected using a Telonics receiver (TR-2) and a three-element Yagi antenna.

The turtle was released at 0900 on September 3, 1987, from Indian Neck Beach, located inside Wellfleet Harbor. Visual, acoustic and radio contact with the turtle was maintained by personnel working aboard the R/V GOLDENEYE, a 20' Aquasport with a 90 Hp Yamaha engine, which was equipped with the acoustic and radio receiving systems. Tracking protocol involved following the turtle from a distance of approximately 10 to 25 meters guided by the signals produced by the transmitters. These signals could only be detected when the engine was off. The turtle's position was determined at 15 minute intervals by recording the boat's position using the Loran C Navigational System. Environmental information, such as wind direction and velocity, sea state, percent and type of cloud cover, and surface water temperature, were recorded every 6 to 8 hours.

After its release, the turtle moved out of Wellfleet Harbor and onto the extensive shallow-water area of Billingsgate Shoal. After traveling north and then south along Billingsgate Shoal, the turtle then moved off the shoal area and headed in a northwest direction into deep water. At 1845 on September 4, after 32 hours and 15 minutes of continuous observation, tracking was terminated due to weather conditions and logistical problems.

The acoustic signal was detected the next day on the southeast corner of Billingsgate Shoal. Tracking resumed for the remainder of the study but only on a day-to-day basis due to difficulties experienced in maintaining contact with the turtle. These difficulties included adverse sea conditions, equipment failure, and acoustic-detection problems experienced while working on Billingsgate Shoal where depth contours are extremely variable. Close-range tracking was infrequently obtained; however, we were able to locate the general location of the turtle on 22 out of the remaining 27 trips taken. This information indicated that the turtle not only remained in the Wellfleet Bay area, but also tended to reside in specific areas during that time.

The recovery of stranded sea turtles was carried out by a volunteer network composed of interested people willing to patrol the beaches under any weather conditions. The general public was informed of the importance of reporting stranded turtles by means of newspaper articles, lectures, and posters. Beaches were patrolled after the passing of every cold front.

Live turtles recovered were taken indoors and warmed slowly at room temperature. They were then sent to the New England Aquarium. Dead turtles were necropsied as they were recovered. Information such as external condition, stomach content, fat deposits, and sex, was noted. Tissue samples were preserved and banked at the New England Aquarium.

The information obtained in our pilot study indicated that a biotelemetry study is not only feasible but also invaluable in terms of collecting pertinent information on ridley population status and habitat preference in Cape Cod Bay. However, more extensive and elaborate techniques are required to fully ascertain the importance of the Bay to this species and to its continued survival.

We believe that a biotelemetry study in conjunction with continued effort to collect stranded ridleys is essential for obtaining pertinent information concerning ridley ecology. Although the key attraction of the area is not known, Cape Cod Bay could afford these young turtles the protection and food resources that they require after hatching. The drastically reduced state of their population requires that we look more closely at these juveniles, not as irrelevant misfits, as many have assumed in the past, but as important figures to the species' continued survival.

USE OF LONG WAVELENGTH LIGHTS TO PREVENT DISORIENTATION OF HATCHLING SEA TURTLES

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This study investigated the effects of long wavelengths of light on the sea-finding orientation behavior of newly hatched loggerhead turtles (*Caretta caretta*) through a three part experiment with varying wavelength filters, intensities, and commercial lights. Hatchlings were taken from both hatchery and *in situ* nests located in Delray Beach, Palm Beach County, Florida, and the City of Jupiter Island, Martin County, Florida during the 1986 and 1987 nesting season. A total of 295 tests (15 hatchlings each test) with a total of 4425 loggerhead hatchlings and 15 tests with a total of 225 green turtle (*Chelonia mydas*) were conducted during the two seasons. Tests were designed to give hatchlings a choice between orienting to the ocean or the light source (Figure 1). For every test, each of the 15 hatchlings were allowed to crawl 1.5 meters before being tallied as orienting normally (to the water) or disoriented (to the light or sideways). The following wavelength filters were used with a constant low light intensity of approximately five footcandles and then with a high intensity of approximately 480 footcandles: white (no filter), blue, yellow, and red. For reference, experiments were also conducted in the dark (no light - zero footcandles). The same procedure was used for the commercial light tests.

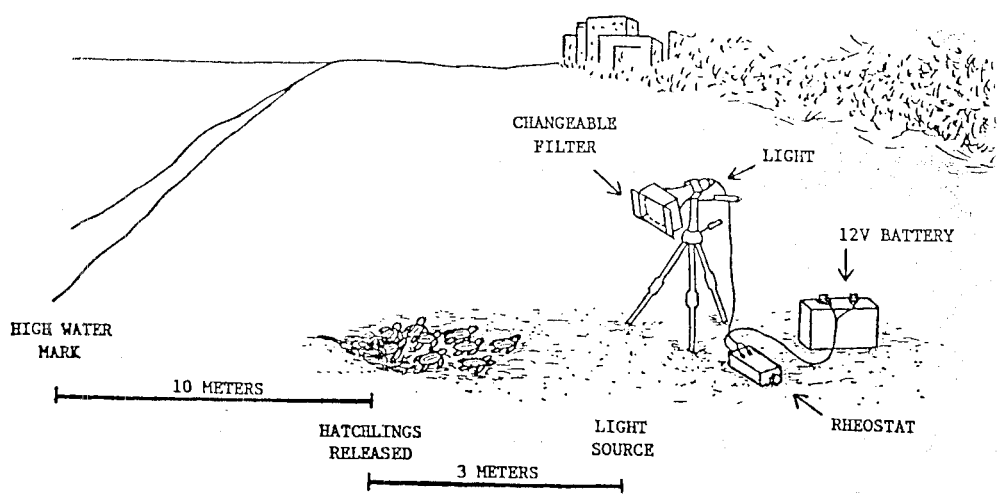

Figure 1. Diagrammatic drawing of the test set-up.

Hatchlings oriented toward the shorter wavelengths (blue) of light at both low and high intensity (Table 1). Blue filtered and non-filtered lights elicited the same disorientation responses from hatchlings at both high and low intensities. Lights which excluded the shorter wavelengths did not attract loggerhead hatchlings even at intensities of 480 footcandles. Our study demonstrates that shorter wavelength light is the primary stimuli for hatchling disorientation. When the intensity of shorter wavelengths in the beach lights exceeds the intensity emitted from the direction of the ocean, the hatchlings are disoriented. Preliminary tests on green turtle hatchlings suggest similar results.

Table 1. Mean number (SD) of loggerhead hatchlings orienting normally to the ocean per test when exposed to artificial lights. Values with a common underscore are not significantly different ($P \leq 0.05$). N = number of tests. (Student-Newman-Keuls multiple comparison test and oneway ANOVA, $\alpha = 0.05$)

WAVELENGTH FILTERS AT LOW INTENSITY LIGHT[1]

	Blue	White	Yellow	Dark	Red
Mean	0.33	2.42	12.48	14.34	14.54
SD	0.99	2.50	2.11	1.92	1.04
N	30	19	29	38	28

WAVELENGTH FILTERS AT LOW[1] AND HIGH[2] INTENSITY LIGHT

	High Blue	Low Blue	High Yellow	Low Yellow	High Red	Dark	Low Red
Mean	0.06	0.33	11.67	12.48	13.13	14.34	14.54
SD	0.24	0.99	1.91	2.11	2.47	1.92	1.04
N	18	30	15	29	15	38	28

COMMERCIAL LIGHTS

	High White	Low White	Yellow Flood	Yellow Bug	Dark	LPS[3] 18	LPS 55
Mean	0.20	2.42	5.00	13.38	14.34	14.38	14.65
SD	0.41	2.50	3.16	1.79	1.92	1.39	0.71
N	15	19	7	24	38	34	23

[1]5 foot candles
[2]480 foot candles
[3]low pressure sodium

Low pressure sodium vapor lights did not attract hatchlings at either low or high intensities. These lights are the only lights commercially available which completely exclude the blue spectral bands. They are monochromatic, emitting only the yellow wavelengths (589-590 nm). The 100 watt yellow bug lights emit very small amounts of the shorter (blue) wavelengths and predominately emit the longer wavelengths, therefore, these also did not attract hatchlings. Yellow and red flood lights are not a filtering light, therefore, these should not be used as a source of long wavelength lights.

This study showed that long wavelength light did not attract hatchlings at either low or high intensities. More recent information, from studies conducted during the 1988 nesting season, showed that hatchlings are "repelled" by lights which exclude wavelengths shorter than 530 nm. Information is needed on the effects of long wavelength lights on nesting adult turtles before widespread use of these lights can be recommended.

TRANSLOCATING LEATHERBACK SEA TURTLE EGGS: COSTS AND BENEFITS

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Methods designed to promote the recovery of sea turtle populations are many, including the preservation of critical habitat, the protection of gravid females during nesting, the safe-guarding of eggs, "head-starting" hatchlings, eliminating (or enforcing regulations concerning) the harvest of juveniles, and mitigating incidental catch. Often there are a wide range of procedural options available to the manager choosing to pursue a given recovery program; the final choice will depend on both the scientific credentials of the method, and the financial and human resources available to the manager. The purpose of this study is to evaluate the costs and benefits of an ongoing conservation program to translocate leatherback sea turtle (*Dermochelys coriacea*) eggs doomed by erosional processes on Sandy Point National Wildlife Refuge, St. Croix, U.S. Virgin Islands. The technique involves moving eggs laid in erosion-risk zones to reburial sites elsewhere on the open beach. In this manner, otherwise doomed eggs incubate among naturally placed ("turtle placed") clutches in lee areas and the expense and oversight of a hatchery facility is avoided.

METHODS AND RESULTS

In this study, eggs laid in erosion-risk zones were collected as they were laid and reburied in zones of net beach accretion. The new nest chamber was fashioned by hand and duplicated original dimensions. All clutches were reburied with the original number of yolked and yolkless eggs; yolked eggs on the bottom and yolkless eggs on top. Nest location was triangulated between the two nearest wooden stakes permanently placed along the supralittoral vegetation at 20 m intervals. Approximately 50% of all clutches laid per annum (1982-1985) were collected at deposition and moved in this manner.

In 1985, 46 leatherbacks laid 242 clutches (ca. 19,850 eggs) within the 2.4 km study area. One hundred twenty (49.6%) clutches were translocated. Mean hatching success differed significantly ($P < 0.05$) between control (*in situ*) and treatment (translocated) groups, but no significant differences existed in mean clutch size (yolked + yolkless eggs) or in the number (or proportion) of each clutch represented by yolked eggs (Table 1).

The incubation period (= the number of days between egg laying and hatchling emergence) was slightly, but significantly ($P < 0.05$), reduced by translocation (*in situ*: 63.9 days, sd = 3.2, n = 79, range = 56-71; translocated: 63.0 days, sd = 2.6, n = 103, range = 57-72).

When nest contents were exhumed post-hatching, a significantly lower proportion of eggs per clutch failed to develop among clutches that were translocated (14.5% < 18.0%; $P < 0.05$). No significant differences ($P > 0.05$) were found in the proportion of eggs per clutch revealing pre-term embryo mortality -- either cumulatively ("total midterm") or within consecutive developmental stages -- but a considerably larger proportion of pipped, dead hatchlings were recorded in translocated clutches (Figure 1). In the latter category ("pipped") are hatchlings that develop to term,

pip the egg, and expire. In no case did these hatchlings appear diseased or deformed in any way. The phenomenon was rare in *in situ* nests (5.8% < 19.8%; $P < 0.05$).

Hatch success was consistently highest in clutches of 61-75 (yolked) eggs and, in translocated nests, significantly so (Table 2). There were, however, no significant differences in hatch success among groups of *in situ* (or combined *in situ* and translocated) nests (Table 2). Regression analysis confirmed the absence of correlation between clutch size and hatch success ($Y = -0.279x + 80.399$; $r^2 = .05$). In translocated clutches, the trend of declining success with increasing clutch size was an artifact of slightly increasing proportions of pipped, dead hatchlings with clutch size.

Table 1. Clutch size and hatch success between treatment (translocated) and control (in situ) groups of leatherback sea turtle nests on Sandy Point, St. Croix, 1985.

	TRANSLOCATED			IN SITU			
	MEAN	SD	N	MEAN	SD	N	P<0.05
Hatch success	52.4	18.37	113	63.2	21.03	90	*
Total clutch size	119.5	19.51	124	118.2	19.30	102	NS
Yolked eggs/clutch	81.1	16.57	125	83.3	18.47	103	NS
% Yolked eggs/clutch	68.3	10.90	124	70.4	10.34	102	NS

DISCUSSION

In 1985, translocated clutches exhibited lower hatching success than clutches left to incubate *in situ*. The data suggest that the difference stems not from a larger proportion of undeveloped eggs or eggs containing dead embryos in various mid-development stages, but rather from a significantly larger proportion of eggs per translocated clutch ($\bar{x} = 19.8\%$, sd = 15.5, n = 113 nests) that contain pipped, dead hatchlings (Figure 1). For this reason, it is not likely that the act of moving the eggs effected a decline in hatch success. Movement of eggs, particularly during the "critical period" of extra-embryonic membrane organization (48 hrs-2.5 wks), has been shown to provoke early (pre-carapace) embryo death (Blanck and Sawyer 1981). Since eggs slated for translocation on Sandy Point are collected at deposition and reburial is complete 30-90 min later, movement-induced mortality is not a problem. Translocated clutches contain, on average, one embryo dead at 1 cm or smaller for every 200 eggs laid. In other words, about 0.4% of the eggs/clutch fall into this category, a level which is not significantly different from that found in *in situ* nests (Figure 1). It is possible that dead, term hatchlings result when eggs are packed too tightly by field personnel and compaction precludes hatchlings from completing the hatching process. This phenomenon is under study.

The shortening of the incubation interval for translocated nests undoubtedly arises from the fact that a larger proportion of these nests incubate "high and dry" than do *in situ* nests, a distribution which is intuitive if erosion is the threatening agent. Whether or not the decrease (63.9 days

Table 2. Clutch size and hatch success in leatherback sea turtle nests in Malaysia and St. Croix.

	MALAYSIA*		ST. CROIX					
Clutch Size	Translocated N	Translocated Mean	Translocated N	Translocated Mean	In Situ N	In Situ Mean	Total N	Total Mean
< 46	8	49.3 --	1	31.1	2	90.9 (2.90)	3	71.0 (34.62)
46-60	32	63.5 --	8	50.8 (13.32)	7	59.7 (25.34)	15	54.9 (19.62)
61-75	78	54.1 --	31	65.5** (16.29)	23	65.6 (18.70)	54	65.6 (17.19)
76-90	137	52.0 --	36	52.8 (15.54)	18	65.0 (20.58)	54	56.8 (18.14)
91-105	138	47.3 --	31	43.3 (18.03)	28	61.3 (25.63)	59	51.9 (23.60)
106-120	68	44.7 --	5	37.1 (11.95)	12	57.6 (9.73)	17	51.58 (13.54)
121-135	10	40.9 --	1	28.0 --	--	-- --	1	28.0 --
> 135	3	37.2 --	--	-- --	--	-- --	--	-- --
TOTAL		50.0%		52.4%		63.2%		57.2%

*Balasingham 1967
**P<0.05 (Tukey-Kramer)

vs. 63.0 days) is significant in terms of temperature or sex ratio is yet to be determined and is under study by Susan Basford and Bob Brandner, the current Field Directors on Sandy Point.

Balasingam (1967) reported that hatch success is maximized in translocated leatherback sea turtle eggs buried in groups of 46-60. Our data suggest that hatching in translocated clutches is maximized when clutch size falls within the range of 61-75 eggs (Table 2). Hatching declines in larger clutches because the proportion of pipped, dead hatchlings increases with clutch size. However, the trend is not a dramatic one, and the trend of declining hatch success with clutch size disappears when *in situ* and translocated clutches are analyzed together. Because we find no natural correlation between clutch size and hatch success, we conclude that eggs purchased in a market situation for reburial in hatcheries should be grouped according to the mean clutch size for the population concerned. If eggs are collected *in situ*, we discourage artificial grouping. Eggs should be buried with yolkless eggs and in their original number until data emerge suggesting an optimal clutch size exists.

In summary, we believe that translocation is a scientifically viable conservation technique in areas of damaging erosion such as Sandy Point, where 45-60% of the annual egg production is lost to erosion when doomed eggs are not translocated to high ground. Translocated eggs incubate in natural surroundings; the considerable costs of maintaining and safeguarding a hatchery facility

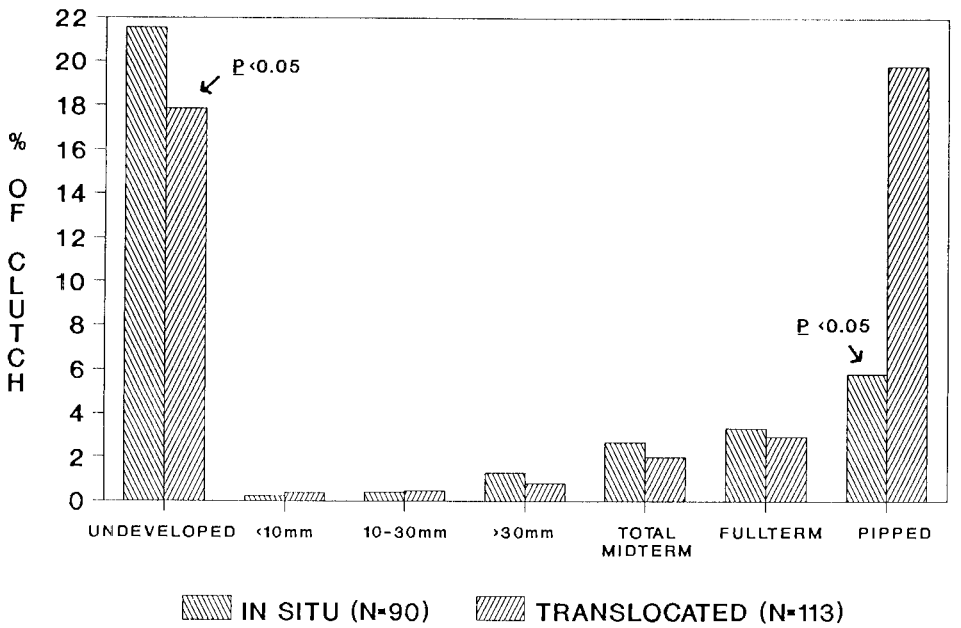

Figure 1. The composition of term nests of leatherback sea turtles nesting on Sandy Point, St. Croix, 1985 (N = 203 nests, approximately 16,700 eggs).

are avoided. When compared to eggs left *in situ*, translocated eggs compare favorably both in terms of undeveloped eggs and pre-term embryo death. Indeed, the average proportion of eggs per clutch that fail to develop is significantly reduced in translocated nests. If the slight reduction in mean incubation time is found to feminize sex ratio, the balance can easily be tipped back toward the center by choosing a wider variety of reburial locations. The technique has succeeded in doubling the number of hatchlings released from Sandy Point since 1982 and promises an additional 15-20% boost in production if the number of pipped, dead hatchlings in the nest can be reduced.

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NEST TEMPERATURE AND SEX DETERMINATION IN THE LOGGERHEAD SEA TURTLE

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Sex is determined by the temperature at which the eggs incubate during the middle trimester of development in loggerhead sea turtles (Yntema and Mrosovsky 1982). Previous studies on this topic have been conducted in a laboratory environment, but there are few field investigations that examine how fluctuating ambient temperatures within a natural nest affect the gender of loggerhead sea turtles (*Caretta caretta*), which was the purpose of this investigation.

This research was conducted on Masonboro Island, an undeveloped east-facing barrier island in southeastern North Carolina. Beginning in late May the beach was checked each day at sunrise for new nests and to record temperatures from existing nests. Temperature probes were placed at the top, middle, bottom, front, and back of the nest chamber of most nests; all others had one probe at the back of the nest. Temperatures were recorded with a Bailey BAT-12 microprobe thermometer calibrated to the nearest 0.1°C. Eleven nests from throughout the season were utilized Seven hatchlings were randomly chosen from each nest, fixed in 10% buffered formalin, and sent to the University of Toronto for histological examination of the gonads using PAS and hematoxylin stains. The data from the front and back probes have been omitted herein because they were within the ranges of the other three.

The percentage of males in the 11 nests varied from 0 to 100 percent, but it was difficult to interpret how daily fluctuations in nest temperature influenced sexual differentiation. Two nests, however, provided data that indicated that sexual differentiation occurred during the latter half of the middle trimester (Figure 1). The nest temperatures of nest 2, which produced all females, were well above Schwartz' (29.7°C; pers. commun.) and Mrosovsky's (29.1°C; 1988) pivotal estimates for approximately nine days during the second half of the middle trimester. Nest 16 had warmer temperatures in the first half of the middle trimester and cooler ones during the second part, and even though there were several warm days, this clutch contained no females. These data restricted to the second half of the middle trimester the period in which nest temperatures determine the sex of loggerhead sea turtles.

We thank the North Carolina Wildlife Resources Commission, the United States Fish and Wildlife Service, the UNCW Research and Development Fund, and the Masonboro Society for support and funding. Peggy Salmon conducted the histological examination of the turtle gonads, Nicholas Mrosovsky contributed significantly to our understanding of the problem at hand, and many UNCW students assisted with the field work.

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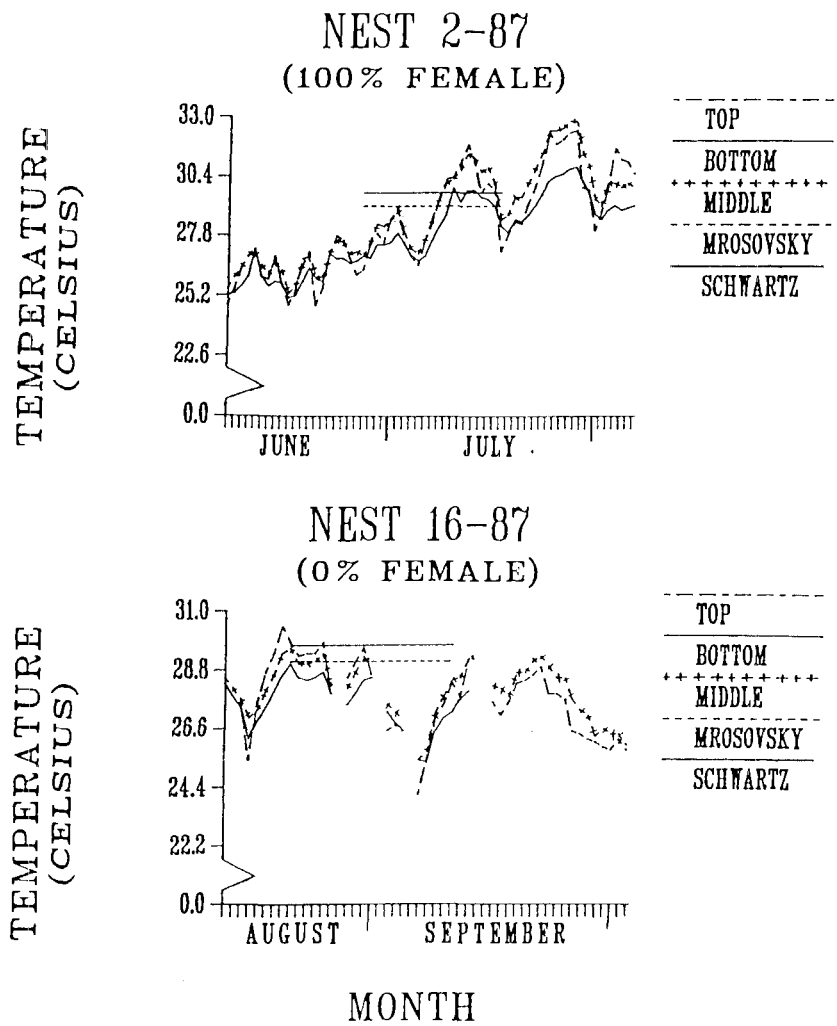

Figure 1. Nest temperatures for two Caretta caretta nests laid on Masonboro Island, NC, 1987.

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THE RELATIONSHIP BETWEEN BODY SIZE AND REPRODUCTIVE CHARACTERISTICS IN THE LEATHERBACK SEA TURTLE (DERMOCHELYS CORIACEA)

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INTRODUCTION

Little is known about intra- and inter-individual variation of sea turtle reproductive characteristics because of the difficulty of witnessing each nesting event during the season for an adequate sample of turtles. Of even greater difficulty is monitoring individuals for age-related reproductive changes throughout their lifetime, although inferences can be drawn from intensive short-term studies of different size classes, assuming that leatherbacks continue to grow after sexual maturity. However, it is possible that adult size is more a function of early juvenile growth with little growth occurring after maturation, and therefore adult size would be somewhat independent of age. In either case, size-specific fecundity and mortality are important parameters used for determining rates of population change or stability. Variability of individual reproductive characteristics is examined in this study and the null hypothesis that there is no difference in each characteristic due to body size is tested.

METHODS

The study area was located at Culebra Island, Puerto Rico, and consisted of two adjacent beaches with a combined length of 2.25 km, where over 90% of all leatherback nesting occurred. Soon after the nesting seasons started in 1984 and 1985, the beaches were patrolled hourly, seven nights a week, in an effort to tag and observe each nesting turtle. Forty-two turtles were known to nest during the two year study, and 90% of the 266 nestings were witnessed. With so few turtles each year, unwitnessed nestings (tracks found later on the study area or another beach) could often be accurately fitted into particular turtles' nesting sequences which had internesting intervals approximately twice the normal length of time (Hall and Tucker 1986). An average of one unwitnessed nest was added to each turtle's observed clutch frequency, giving an estimated clutch frequency (ECF).

Each turtle was measured approximately six different times, in order to determine over-the-curve carapace length (notch-to-tip) as accurately as possible. A random sample of approximately ten eggs was measured from 139 clutches as they were being laid. The nests were marked *in situ*; and egg number, percent hatch, and hatchling morphometrics were determined after nest excavation and correlated with maternal size. Unlike other species of sea turtles, leatherbacks characteristically lay many small yolkless eggs. These eggs were left *in situ*, yet herein the term clutch size will not include them. Percent hatch is the number of hatched eggs divided by total yolked eggs. Straight line carapace lengths of hatchlings were usually taken from stragglers found in the nest the morning after a primary emergence. Although these hatchlings may be smaller than normal, the bias was consistent for most of the nests. Not all nests contained stragglers, but from the 104 nests that did, an average of six non-deformed hatchlings were measured. The relationship between length and reproductive variables was determined by correlation/regression analysis and analysis of variance.

RESULTS

The estimated clutch frequency (clutches/female/season) was approximately six clutches per turtle (range 1-11). No 1984 turtles were seen renesting in 1985. The large number of clutches produced by many individuals allowed ample opportunity to test for variation in clutch size. Mean clutch sizes were significantly different among turtles (ANOVA, $F = 5.70$, $df = 29$, $P < 0.0001$), but a component of variance model indicated that 57.78% of the observed variance in clutch size was due to differences within individuals. Bigger turtles produced significantly larger clutches than smaller turtles (Table 1), which is common among reptiles and many other organisms (Pianka and Parker 1975). Only 16.2% (r^2) of the variation in clutch size could be explained by body size, which implies that other factors (e.g., diet) may be more important in determining clutch size (Swingland and Coe 1979).

The average clutch size during the two year study was 69.5 eggs (excavation count). From Figure 1 we see that % hatch increases to approximately 55 eggs, after which there is a decrease as clutch size increases. This could counteract the advantage of higher fecundity in larger turtles. Indeed, a direct correlation analysis of turtle size against % hatch showed that larger turtle's clutches did have lower hatch rates, and did not produce significantly more hatchlings than did smaller turtle's clutches (Table 1). There was no significant relationship between mean egg size and % hatch ($r = 0.100$, $df = 113$, $P > 0.25$).

Yolkless eggs were usually deposited towards the end of the clutch, and averaged 35% of the total clutch size. Percent hatch increased in nests with a higher proportion of yolkless eggs relative to total number of eggs ($r = 0.367$, $df = 195$, $P < 0.0001$). There was not a significant correlation between body size and number of yolkless eggs (Table 1).

There was no statistical difference in when the first clutch was laid, the number of clutches laid, or the length of the internesting interval for different size turtles (Table 1). There was a trend towards more clutches per season for bigger turtles, however clutch frequency of smaller turtles may have been underestimated because of a possible tendency to also lay on beaches outside the study area. Body size of three known migrants (to and from St. Croix, USVI) was significantly smaller than body size of all other Culebran turtles (ANOVA, $F = 5.57$, $df = 41$, $P < 0.025$).

From Table 1 we see that egg size was positively correlated with body size, although only 18.4% (r^2) of the variability in egg size was explained by body size. However, unlike the case with clutch size, only 2.84% of the observed variance was due to differences within individuals. Because bigger turtles lay larger eggs, they also produce larger hatchlings (Table 1).

DISCUSSION

As turtles grow larger, it is assumed that more space will become available within their body cavities for the production of more and/or larger eggs, providing the availability of adequate resources for their production. A positive correlation between body size and clutch size is common in sea turtles, but a positive correlation between body size and egg size has not been demonstrated previously (Frazer and Richardson 1985).

Even though bigger turtles laid more yolked eggs (higher fecundity) it was shown that this could be counterproductive, since hatching success was lower in nests with more yolked eggs, and indeed was lower for bigger turtle's clutches. Embryonic survival was highest in nests with approximately 55 eggs (Figure 1), which corroborates the findings of Balasingam (1967), who recommended that approximately 50 leatherback eggs be placed in translocated nests for best % hatch in Malaya. The embryonic mortality in larger clutches was not due to larger turtle's clutches having more rotten and infertile eggs than smaller turtle's clutches (Table 1). Perhaps it was partially caused by a restriction of gas exchange to the eggs in the center of larger clutches.

Table 1. Linear regressions of reproductive variables to over-the-curve carapace length (cm, notch-to-tip) for leatherbacks at Culebra Island, Puerto Rico in 1984 and 1985.

Variables	Intercept	Slope	r^2	P	df
Mean Number Yolked Eggs	-53.779	0.791	0.162	≤0.025	37
Mean Number Yolkless Eggs	3.152	0.205	0.015	NS	38
Deposit of 1st Clutch (Julian date)	265.852	-0.994	0.054	NS	40
Clutch Frequency (clutches per season)	-9.879	0.106	0.061	NS	41
Mean Internesting Interval (days)	6.668	0.018	0.018	NS	33
Mean Egg Size (mm)	36.493	0.111	0.184	≤0.010	37
Mean Hatchling Length (mm)	30.315	0.190	0.248	≤0.005	32
Mean % Hatch	181.137	-0.671	0.138	≤0.025	37
Number Hatchlings Produced	28.390	0.156	0.013	NS	37
Mean Number Rotten and Infertile Eggs	22.681	-0.086	0.006	NS	32

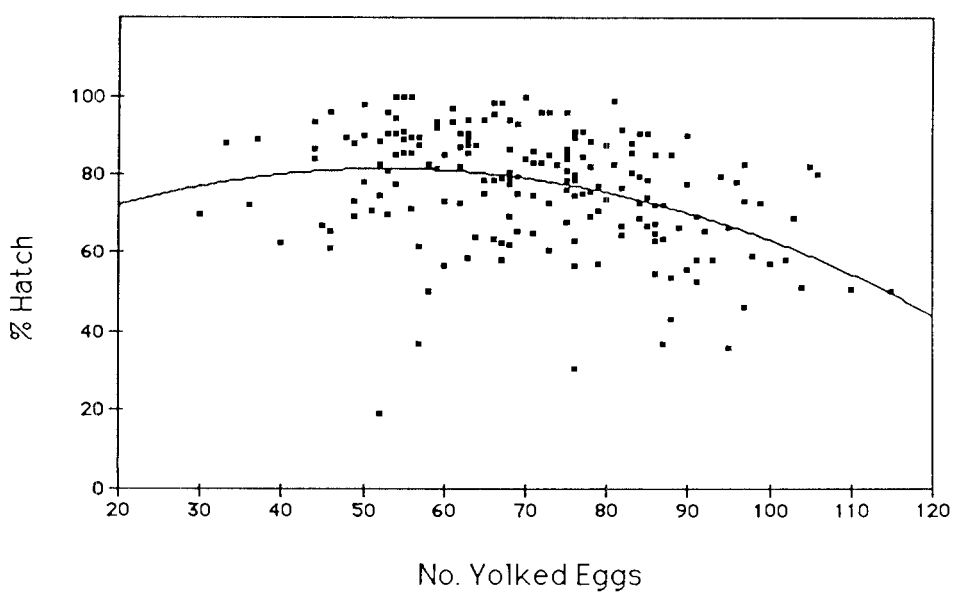

Figure 1. Relationship between number of yolked eggs and percent hatch for leatherback clutches at Culebra Island, Puerto Rico in 1984 and 1985. Polynomial regression equation is $y = 57.964 + 892x - 0.008x^2$ ($r = 0.396$, $P < 0.0001$, $df = 198$).

If gas exchange was a problem, it may have been related to grain size or moisture of the sand (Prange and Ackerman 1974).

It might be to the turtle's advantage to lay more eggs (not at the expense of egg size) when adequate resources are available, to take advantage of optimal variations in sand grain size and moisture, which occur both spatially and temporally on many beaches. On the other hand, there is no reason to assume that all characteristics of a species are adaptively valuable, or that they evolved in an environment similar to today's. It is also possible that leatherbacks do not typically nest on the same beaches their mothers nested on. If so, their inherited reproductive characteristics may not be adapted to any one set of beach conditions.

Since bigger turtles produced larger eggs, their hatchlings were also larger. Unlike large clutch size, bigger eggs may confer a decided advantage if larger hatchlings are better able to survive to maturity, as has been observed in giant tortoise populations (Swingland and Coe 1979). Conceivably, larger hatchlings may have an increased ability to exit the nest, and a greater immunity to predation. They may also be able to pass the breaker zone more easily, and have a higher swimming efficiency. In conclusion, the reproductive advantage of being a larger turtle in Culebra could lie in the ability to produce bigger hatchlings. Survival, which is fundamental to natural selection, may be enhanced by larger eggs rather than more eggs at Culebra.

ACKNOWLEDGMENTS

Funding was provided by the National Marine Fisheries Service and the United States Fish and Wildlife Service. The intensive beach coverage and research would not have been possible without the help of many people, especially Tony Tucker, and Earthwatch volunteers (Watertown, Massachusetts). Additional thanks to Dr. Paul Yoshioka for statistical advice.

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MUTILATION OF STRANDED SEA TURTLES ALONG THE TEXAS COAST

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Systematic surveys documenting sea turtle strandings along Texas beaches were initiated in 1986 by the National Marine Fisheries Service (NMFS), Southeast Fisheries Center's (SEFC) Galveston Laboratory as part of the Sea Turtle Stranding and Salvage Network (STSSN). These surveys initially covered 138 km of beach comprising Jefferson, Chambers, Galveston, and Brazoria Counties. The survey area was expanded to 296 km of beach with the addition of Matagorda and Calhoun Counties in April 1987.

Beaches were surveyed twice monthly with 4-wheel drive and all-terrain vehicles. Stranded carcasses were returned to the TAMU Marine Laboratory in Galveston and necropsied in an attempt to determine cause of death and note external and internal anomalies resulting from apparent human-inflicted and natural mutilation. Necropsies were not performed on stranded specimens reduced to dried carcasses or disarticulated skeletal remains. Natural history information including morphometric, food habit, sex, and reproductive development data was recorded during necropsy examination.

The 89 sea turtles necropsied in 1986 and 1987 included 42 Kemp's ridley (*Lepidochelys kempi*), 44 loggerheads (*Caretta caretta*), and 3 greens (*Chelonia mydas*). Each necropsied turtle was assigned to one of three mutilation categories: 1) non-mutilated; 2) human-inflicted mutilations - anatomical injuries apparently purposefully inflicted by humans to the turtle while at sea or on the beach; and 3) other mutilations - those injuries resulting from natural trauma such as shark predation and by incidental contact with man-operated machinery (i.e., boat propellers). Human inflicted mutilation was distinguished by: 1) presence of straight-edge incisions characteristic of knife or axe induced wounds; 2) lack of ragged tissue or teeth remains characteristics of predation induced wounds; 3) presence of lines or ropes purposefully tied to an appendage to restrain, bind or choke the turtle; and 4) evidence of a gunshot wound or blows from a sharp or blunt object. Turtles with human-inflicted mutilation were categorized as to the anatomical site of injury (i.e., head, front flippers, and rear flippers). The 34 turtles exhibiting human-inflicted mutilations included 10 ridleys, 21 loggerheads, and 3 greens.

The mutilation "season" tended to follow the same pattern recorded for sea turtle strandings along Texas beaches, with peak numbers in April or May and a steady decrease thereafter. However, the large percentage increase in number of mutilations per stranding from 1986 to 1987 coin-

cided with a sizeable decline in number of total strandings across the two years (1986 - 173; 1987 - 105).

Eleven (26%) of the 42 turtles necropsied in 1986 exhibited human-inflicted mutilation as compared to 23 (49%) of 47 in 1987. Five (11%) of the 1987 assemblage also exhibited other non-human inflicted mutilation. A large percentage of the 34 turtles exhibiting human inflicted mutilation exhibited trauma to more than one appendage (i.e., head and front flippers or head and all flippers mutilated). Twenty-three (68%) of these turtles exhibited head mutilation while 30 (88%) had front flipper mutilation and 19 (56%) experienced rear flipper mutilation.

All turtles found mutilated in 1986 were located in Galveston County while their 1987 counterparts showed a wider spatial distribution across all but one of the six counties surveyed (Jefferson, 5; Chambers, 0; Galveston, 10; Brazoria, 3; Matagorda, 6; and Calhoun, 4).

Rates of mutilation differed for the three sea turtle species necropsied, but all except greens exhibited an increasing percentage of mutilation from 1986 to 1987. Kemp's ridleys' increased mutilation rate (1986 - 15%; 1987 - 50%) occurred despite a reduction in yearly stranding totals. Increases in loggerhead mutilation rate (1986 - 40%; 1987 - 62%) coincided with similar stranding trends.

Carapace length statistics for mutilated loggerheads mirrored those for stranded, non-mutilated members of this species. However, carapace lengths of most mutilated ridleys appeared to indicate some selectivity for older, larger individuals. The majority of mutilated ridleys fall in the 60 to 69 cm carapace length range while most of their non-mutilated counterparts were between 30 to 39 cm. This may suggest there is selective mutilation directed towards mature ridleys but a much larger data base is needed to substantiate this hypothesis.

Mutilation of endangered sea turtles may be attributed to several causes, some of which are difficult to verify. Two causes of natural mutilation are definitely known, these being shark attack and incidental contact with boat propellers. Other possible causes of mutilation are largely conjecture. Underwater detonations used in petroleum platform salvage operations may cause mutilations. Other causes may be related to the fishing industry. Longline fishermen reportedly catch turtles on baited hooks. Fishermen on piers have caught turtles. Other fishermen who catch turtles offshore may mutilate them in an effort to prevent the carcass from floating and eventually reaching shore. Another possible cause may be beach-going tourists seeking novelty items such as a turtle skull or intact carapace. Some of our survey beaches have more public access than others and this may account for increased numbers of mutilations in these areas. Although difficult, causes of mutilations must be determined and decreased, thus possibly lowering strandings and preventing continued decline of sea turtle stocks.

STATUS OF THE LOGGERHEAD TURTLE IN SOUTH CAROLINA

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In 1980, the Nongame and Heritage Trust Section of the South Carolina Wildlife and Marine Resources Department began aerial beach surveys designed to provide long term information on the status of the loggerhead turtle in South Carolina. This paper contains the results of the first six years of surveys conducted over an eight year period. Although the study is not complete, we are reporting these early results because of the serious implications.

METHODS

A detailed description of the methodology is found in Hopkins-Murphy and Murphy (1983). Surveys are made each summer from Murrells Inlet south to the Savannah River during June and July. (So little nesting occurs from Murrells Inlet north to the North Carolina line that surveys here are not cost effective). Initially we used a Hughes 500 D helicopter for surveys, but in the last three years, we have used a Cessna 180 high wing airplane. Three consecutive days of surveys are conducted every two weeks on a particular tidal cycle. This eliminates the problem of aging tracks and ensures that only fresh tracks representing one night's nesting are counted. This is essential to our method. A total of 12 flights can be scheduled each summer under these tidal conditions. Flights begin at dawn and are completed by 0830. The aircraft is flown at approximately 150 feet and between 70-100 kt ground speed, depending upon nesting densities. Tracks are recorded using a digital counter or a tape recorder. The tape recorder is used for islands where ground surveys are used to verify aerial counts. The information recorded consists of a description of the tracks, their sequence of occurrence, and their locations relative to landmarks. Tracks are recorded as nests, false crawls, or unknown.

Ground truth, provided on several different islands, is conducted at the same time the flights are made. All body pits are probed to verify the presence of eggs and to obtain 100% accurate ground truth. In excess of 40% of all tracks are verified on the ground. The way in which these flights are conducted is strictly standardized allowing year to year comparisons.

RESULTS

Two sets of surveys, each consisting of three consecutive survey years, have been completed. Each set is conducted on a five year cycle, thus sets are separated by two non-survey years. The first set was conducted in 1980, 81, and 82 and the second set in 1985, 86, and 87. Richardson (1982) reported that 43% of Georgia loggerheads nest on a two year cycle (remigration interval), 36% on a three year cycle, and 4% nest annually. Thus, surveys flown for three consecutive years monitor approximately 83% of the nesting population.

The differences in annual nesting effort are a consequence of a species which exhibits different remigration intervals. Thus there are high and low nesting years as the two or three year cycles overlap. Therefore the three survey years must either be averaged or summed to smooth out the inherent between-year variability in nesting. This is why only two data points are reported here. The third set of flights will be conducted from 1990 through 92.

The data are based on total nesting effort rather than on estimates of nesting females. We have done this because there is still disagreement on the average number of nests a female lays each season. That number can drastically change the population estimate for nesting females.

During the five-year interval between the first and second set of flights, the nesting effort declined by 26.4%. This represents a decline of more than 4,000 nests. An ANOVA was run to compare the two sets. The difference was highly significant at $P > 0.005$ with an F value of 78.81. We believe that this decline is a true change in the status of the population and is not due to variability in the remigration intervals.

This trend was statewide and not localized on particular beaches. We compared beaches north of Charleston with those south of Charleston. The decline in nesting effort is slightly higher in the northern portion of the coast, at 28.1% compared to 23.8% in the southern portion.

A decline in nesting is often linked to development due to disturbance or alteration of habitat. We examined the nesting effort on nine developed beaches distributed along the entire coast. These include: Litchfield, Pawleys Island, Isle of Palms, Sullivans Island, Folly Beach, Kiawah, Seabrook, Fripp, and Hilton Head. The decline here was about 5% more than the statewide decline at 30.9% and may be due to the loss of nesting habitat from construction of rock revetments.

We also looked at the nesting effort for undeveloped beaches. The decline observed is almost the same as that for developed beaches. Cape Island is analyzed separately because it represents between 21% and 31% of the annual nesting effort in South Carolina and can overwhelm data for other islands. Cape Island showed a 29.2% decline. All other islands in this group are either under state or federal ownership. They include: Bull Island, Raccoon Key, Lighthouse, Murphy, Cedar, South, Sand, and North Islands. These declined by 27.9%.

Although these beaches have been eroding during the past 40 years, some portions of them have accreted. They are isolated and are probably as undisturbed as any beaches within the range of the species. The declines noted here cannot, as far as we can determine, be attributed to anything related to the quality or quantity of the nesting habitat.

CONCLUSIONS

In summary, the declines we have documented are coastwide and involve both developed and undeveloped beaches. If this decline continues at the same rate, in 25 or 30 years South Carolina's loggerheads may be in the same, critical state as the Kemp's ridley.

The difficulty with species which have deferred maturity, such as sea turtles, is that we are already 20 years behind if we begin solving the problem with beach management. The Little Cumberland Island turtle project has been protecting nests for 25 years. Their population also continues to decline at the rate of 3% per year (Frazer 1983). Crouse et al. (1987) have shown by modeling that beach management alone will not recover sea turtle populations. Data from Georgia seem to support their conclusion. The need for turtle excluder devices (TEDs) in shrimp trawls, to protect large juvenile, sub-adult and adult turtles is obvious from our data, from the Georgia data and from the Crouse et al. model.

We believe that we can no longer be complacent about loggerhead turtle populations, especially those in South Carolina, Georgia, and North Carolina. If our stocks are not being augmented by the large number of turtles nesting in Florida then they are in real trouble. The required use of TEDs should reverse the downward trend sooner than nest protection alone. Aerial beach surveys will be used to continue monitoring the long term status and trends of the South Carolina loggerhead turtle population.

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A JOINT EFFORT TO ACQUIRE CRITICAL SEA TURTLE NESTING HABITAT IN EAST-CENTRAL FLORIDA

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The Florida Natural Areas Inventory (a joint program of The Nature Conservancy and the Florida Department of Natural Resources) and the U.S. Fish and Wildlife Service have undertaken a joint effort to protect some of the world's most important yet most endangered nesting beaches of the loggerhead turtle, *Caretta caretta*. The surest way to secure protection for sea turtle nesting beaches is to purchase them and manage them as protected refuges. In this workshop we present a brief overview of these important beaches and a summary of ongoing conservation efforts.

More than any other species of sea turtle, the loggerhead depends upon the beaches of the southeastern United States, and especially Florida, for its continued existence. In the last few years, it has been discovered that by far the most important of Florida's hundreds of kilometers of nesting beaches is a 20 km stretch of coastline in southern Brevard County, below Cape Canaveral. With an estimated 400 to 600 nests per km, the breeding aggregation of loggerhead turtles on this stretch is the densest in the Western Hemisphere. The approximately 10,000 to 12,000 nests that are constructed annually between Melbourne Beach and Wabasso Beach in adjacent Indian River County account for 20 to 30 percent of all nesting within the United States. The federally endangered green turtle (*Chelonia mydas*) and leatherback turtle (*Dermochelys coriacea*) also nest on these beaches, but in much lower numbers. Approximately 30 to 40 percent of the 300 to 800 green turtle nests deposited annually in the southeast, as well as several leatherback nests, are laid along this stretch of coastline.

Unfortunately, extensive urbanization and residential development in recent years have endangered these nesting beaches and left only isolated remnant tracts. However, the people of Brevard County and the state of Florida are now recognizing the urgent need to save their remaining beaches and have made a laudable beginning at preserving them through their Beach and Riverfront Acquisition and Save Our Coasts (SOC) programs, respectively. Even after successful completion of these important efforts, though, only 2 miles of Brevard County beachfront property - of which about 1 1/2 miles are south of Melbourne Beach - will have been acquired.

Given the global significance of southern Brevard and northern Indian River County beaches to the worldwide population of loggerheads, as well as their regional significance to green turtles, we are attempting to secure additional State and/or Federal funds to continue and expand the

above efforts. However, time is extremely limited because of incipient development pressure, and costs are exceedingly high. Plans for development (as a polo club) of at least one large parcel have already been submitted for review. Indian River County has also expressed interest in developing a public park in the area.

Our proposals focus on three of the largest, available tracts of relatively undeveloped beachfront habitat remaining in southern Brevard County (note: a portion of one has just been purchased with the last SOC money). Total oceanfront footage approximates 9.8 km. Thus, up to 5850 loggerhead turtle nests, which potentially may produce as many as 650,000 hatchling turtles, may be constructed on these tracts each year. In addition, we have proposed acquisition of a 5.9 km, nearly undeveloped stretch of beach a few miles to the south in northern Indian River County. Designated as Wabasso Beach, it is one of the longest undeveloped stretches of privately owned land remaining on Florida's Atlantic coast. Wabasso Beach supports 100 to 200 loggerhead turtle nests per kilometer per year. In any given year, as much as 7-8% of all loggerhead nesting in Florida may occur on this beach. Principally through the SOC program, the State and County governments already own or are pursuing the acquisition of a substantial amount of land (approximately 1.25 km) within the overall boundaries of this proposal.

Preservation of these tracts would also benefit other rare, threatened, or endangered species, including the West Indian manatee, gopher tortoise, eastern indigo snake, Florida scrub jay, southeastern beach mouse, and least tern. Several rare plants inhabit the coastal scrub community that occurs between the dune and highway A1A. Along both sides of highway A1A, the Wabasso Beach tract contains several remnants of a tropical-temperate transitional type of maritime hammock unique to this area. The waters of the Indian River lagoon system (just to the west) are extensively utilized by juvenile and subadult turtles (loggerhead and green) as well as by manatees. By helping to limit the number of future human residents and potential boaters in the area, preservation of these beaches would provide at least some limitation on future boat traffic, a major cause of manatee mortality.

Florida's State land acquisition program is considered by many to be the best in the country. The backbone of the program is the Conservation and Recreation Lands (CARL) purchase program, which is funded by a severance tax on minerals (the phosphate industry, which is declining) and, as of 1987, a portion of the State Documentary Stamp Tax (on home sales, which are increasing). In the past, available revenue amounted to approximately $40 million per year; shifting the major source of revenue to the Documentary Stamp Tax is expected to increase this to $80 million per year by 1995. Additional funds have been available through special programs such as Save Our Coasts ($200 million bond issue, funds now exhausted) and Save Our Rivers (administered by regional Water Management Districts, principally to protect floodplains). Substantial as these programs sound, they are still inadequate. With a net human population influx of nearly 900 persons per day, the combined pressures of development and agriculture destroy our natural resources at an astounding rate, and the prices of land (particularly along the coast) rise accordingly. Currently, 68 projects, ranked in priority order, are on the CARL list, with the top 15 alone valued at approximately $100 million. Projects can be added to this list through a lengthy process that includes several votes by the CARL Committee (directors of 6 state natural resource agencies). Therefore it is imperative that any proposals receiving enough votes to be added as new projects to the existing list also be ranked very highly, or efforts to purchase them may be delayed for years. In the case of these turtle beaches, time before development may be short.

Endangered species habitat acquisition at the Federal level is accomplished through appropriated funds from the Land and Water Conservation Fund (LWCF). These funds are derived from a motor boat fuels tax and money from outer continental shelf petroleum leases and sales. However, it has been the position of the current administration to defer fund requests for en-

dangered species habitat acquisition, although Congress has appropriated $40-60 million annually for this purpose. At best, the Federal land acquisition process is lengthy.

The Brevard Turtle Beaches and Wabasso Beach proposals represent prime development land along the Atlantic Coast. Accordingly, they are extremely expensive; prices of similar nearby tracts average $1500 to $1700 per foot of oceanfront. Thus, the total cost of the proposed acquisitions may exceed $70 million. Coupled with the fact that the State has already spent millions of dollars in this region through its Save Our Coasts program, some officials might be reluctant to rank these proposals highly. A joint Federal-State cost-sharing effort is, therefore, essential to accomplish the stated goals. Strong support from conservation groups and the public will be necessary if these proposals are to receive a high enough Federal-State priority to ensure protection of these beaches in perpetuity.

CONTROL OF SKIN LESIONS IN LOGGERHEAD SEA TURTLES (CARETTA CARETTA) WITH AN IODOPHOR COMPOUND

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Hatchling turtles reared under captive conditions are highly susceptible to infection from bacteria, virus, fungi, and parasites (Wallach 1969, Frye 1973, Murphy 1973). Turtles which acquire these infections, compounded by the added stresses of captivity, often succumb to disease (Rebell et al. 1975, Haines and Kleese 1977, Haines 1978). One major infectious disease problem in the culturing of sea turtles, particularly in hatchlings, is the development of skin lesions. Necrotic skin lesions often occur within the initial months of raising hatchlings and may result in death, if not treated (Witham 1973a and 1973b, Rebell et al. 1975; Haines and Kleese 1977, Haines 1978). The purpose of this paper is to report the results of a study in which an iodophor compound was used to effectively treat skin lesions in hatchling loggerhead sea turtles.

Newly hatched loggerhead sea turtles were separated into three groups of 35 turtles each. One group was untreated. The other two groups were treated daily with either an iodophor (Vanodine™) at a final concentration of 1:10,000 (100 ppm) administered to the holding tank for 8-10 hour intervals during daylight active periods, or Potassium permanganate ($KMnO_4$) added to the holding tank at a dilution of 1,000 ppm for 8-10 hour intervals during the night time inactive periods (protocol recommended by Florida Department of Natural Resources). At the seventh week of the study, a series of experiments were initiated to test the effect on skin lesion development by discontinuing treatment in the Vanodine experimental group, and treating the initially untreated and $KMnO_4$ turtles with Vanodine. Concentrations and treatment duration were the same as the initial phase of the study. Lesion number and area were determined on a weekly basis.

Data analysis consisted of group comparison by means of the Mann-Whitney U-test because of the non-normal distribution of the data. Trends in lesion development were analyzed by Spearman rank correlation analysis.

Bacterial identification was performed weekly. Samples were collected randomly from representative lesions on turtles in all groups. Microorganisms found in skin lesions were predominantly gram negative bacilli (enteric pathogens and normal flora) associated with human waste. The only pathogen found in scute lesions was *Salmonella* sp.

The susceptibility for natural skin lesion development in hatchling loggerhead sea turtles had been reported to occur during the third to fourth month after hatching (Witham 1973a, Haines

1978). In this study, skin lesions developed during the fifth week of life, however, skin lesions occurred during the second week on the turtles exposed to $KMnO_4$.

Median skin lesion numbers and areas were smaller in the Vanodine treated group compared to the untreated group, but a highly significant ($P < 0.0005$) degree of statistical separation occurred only during week five. Skin lesions significantly increased in both number and area in the untreated group after cross-over, and the significance of statistical separation between the two groups generally increased with time.

Vanodine required approximately two weeks for an effective response in controlling established skin lesions. Following that period, the trend in lesion reduction continued but at a slower rate, suggesting that some organisms require a longer exposure time before responding to the iodophor or that some lesion types require more time to heal. It is important to note that Vanodine did not inhibit all lesions but was significant in reducing lesions when compared to the untreated and $KMnO_4$ treated groups.

Skin lesion numbers and areas were less in the untreated group compared to the $KMnO_4$ treated group. $KMnO_4$ had been used as a standard treatment for skin lesion disease in sea turtles (Witham 1973b) and is effective on some skin lesion types, if administered topically. In this study, the addition of $KMnO_4$ to the water of the holding tank was not successful in the prevention of skin and scute lesions in newly hatched loggerhead sea turtles when compared to the untreated group of turtles.

Switching the $KMnO_4$ group to Vanodine resulted in a highly significant ($P < 0.0005$) decreasing trend in skin lesion number and area. After the $KMnO_4$ turtles were exposed to Vanodine, median lesion number increased, but median skin lesion area decreased during the initial two weeks of treatment, and declined at a substantial rate thereafter. Visible $KMnO_4$ staining and matting of necrotic tissue around established lesions persisted for about two weeks after treatment was switched. The flushing of residual $KMnO_4$ was required before Vanodine could effectively treat existing skin lesions.

Scute lesions (number and area) became significantly ($P < 0.0005$) lower in the Vanodine treated group compared to the untreated group after six weeks of treatment. Scute lesions were significantly ($P < 0.0005$) greater in number and area in the untreated group after cross-over. Scute lesion number and area was reduced in the untreated group when compared to the $KMnO_4$ treated group, with the difference becoming highly significant ($P < 0.0005$) by week six. $KMnO_4$ was not effective in controlling scute lesions when compared to the untreated and Vanodine treated groups.

Vanodine seems to have two important roles in controlling skin lesion disease in sea turtle culture. First, the biocidal properties of the iodophor reduce the microbial load infiltrating the lesions. Second, Vanodine treatment of the water in the holding facility permits sufficient time for lesion healing by inhibiting the invasion of "opportunistic" pathogens. It appears that "opportunistic" pathogens which invade the already open lesion cause the high morbidity and mortality associated with skin lesion diseases in hatchling sea turtles.

The procedure developed in this study for treating an entire group of sea turtles by administering the iodophor directly into the water of the holding facility is very efficient when compared to the labor intensive practice, utilized by many previous methods in which turtles were treated individually (Witham 1973a and 1973b, Rebell et al. 1975, Haines 1978, J.G. Leong pers. commun.). Vanodine's application to raising sea turtles affords a one-step procedure for administering the iodophor to the entire stock, and enhancing the hatchling survival rate.

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DISTRIBUTION AND RELATIVE ABUNDANCE OF SURFACED SEA TURTLES IN THE NORTH-CENTRAL GULF OF MEXICO: SPRING AND FALL 1987

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INTRODUCTION

From April to December 1987 we used aerial survey methods to study the distribution of red drum (*Sciaenops ocellatus*) schools in shallow Gulf of Mexico waters. We recorded data for all sea turtles sighted. We present relative density estimates of sea turtles based on these data.

METHODS

Study Areas: For logistical reasons we divided the Gulf of Mexico into 6 study areas (Figure 1). Air space restrictions precluded our studying an area from Perdido Bay, AL to Cape San Blas, FL.

Study Periods: We divided the study into spring and fall study periods (Table 1). Each study area, except the Central Florida area which was only studied in the fall, was studied once each season. We allocated 21 study days to each study. Time of study for each study area was randomly assigned.

Study Platform: We used single-engine, overhead-wing aircraft with retractable landing gear for all surveys. These aircraft do not provide trackline visibility.

Survey Methods: Gulf of Mexico and inland waters were studied. Only offshore sightings are reported here. Transect headings were cardinal directions approximately perpendicular to the mainland. A random transect starting point for each survey day was chosen. Subsequent transects were four minutes latitude or longitude apart. The direction of work was randomly selected per study day. Transects extended from the mainland a distance 15 to 20 minutes latitude or longitude offshore.

Data from 6 to 11 survey days per study area (Table 1) were acquired. Our survey period per day was approximately 1000 to 1500 h. Weather conditions were the major limiting factor and surveys were only conducted when the sea state was estimated to be Beaufort three or less and sunlight quality was judged to be at least fair.

Two trained and interested observers collected data by observing from open windows; one observer on each side of the aircraft. Using reference marks on the window frames and wing struts, we defined a strip 34 degrees wide. The survey altitude ranged from 305 to 457m (1000-1500ft) and strip widths ranged from 637 to 955m. At the survey altitude only large turtles could be sighted, therefore immatures and perhaps even adult Kemp's ridleys may have escaped detection.

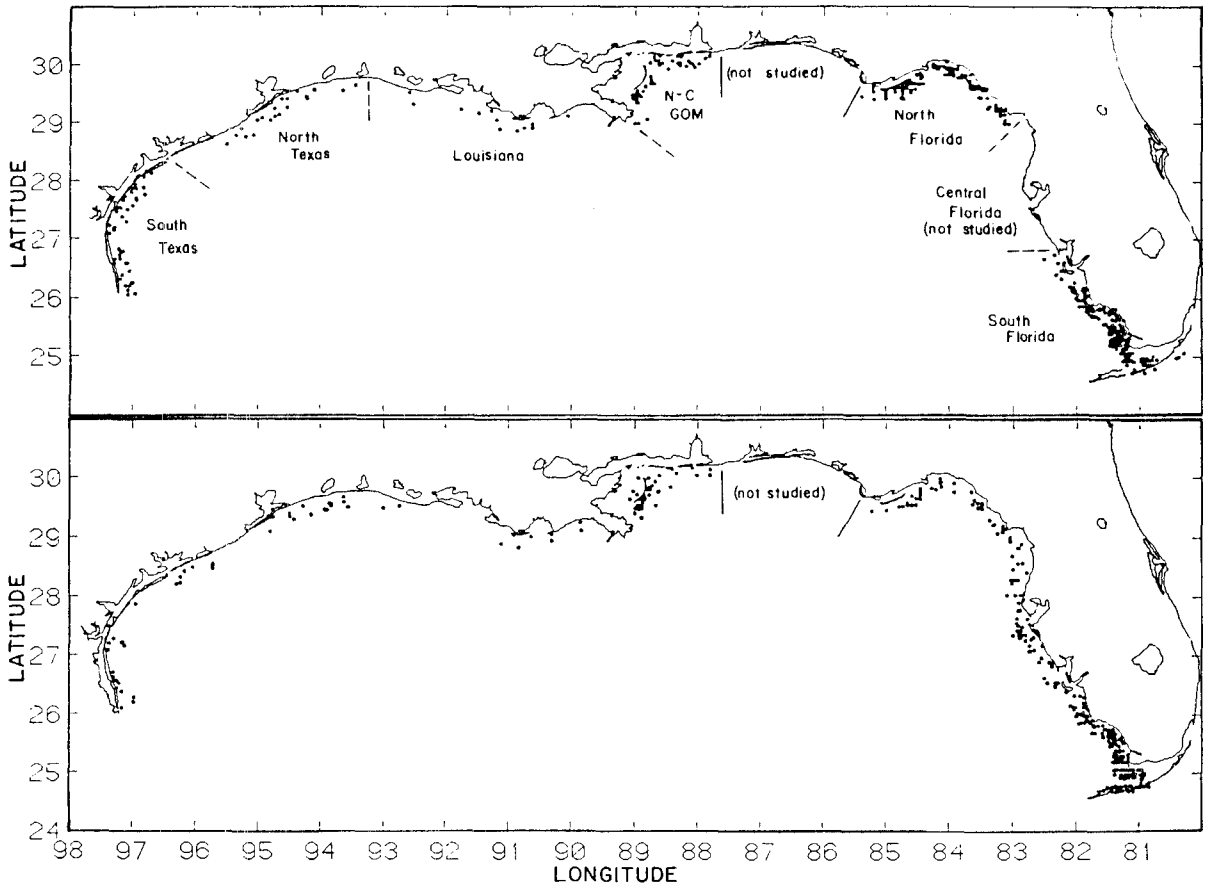

Figure 1. Spring (upper) and fall (lower) 1987 locations of hard-shelled sea turtles in the Gulf of Mexico study areas. Study areas are delineated by dashed lines in the spring plot. The same study areas were used in the fall study.

Data Acquisition: A LORAN-C navigation device was interfaced with a small portable computer. Latitude, longitude, ground speed, compass heading, and signal strength were automatically recorded every 30 seconds. Transect, environment, and marine animal description data were recorded. We identified sea turtles to: (1) hard-shelled sea turtle believed to be a loggerhead (*Caretta caretta*), (2) leatherback (*Dermochelys coriacea*), (3) hard-shelled sea turtle believed to be another species, and (4) unidentified hard-shelled sea turtle. We combined the sightings for hard-shelled sea turtles.

Data Analysis: Strip transect methods were used to estimate the density of surfaced or near-surfaced sea turtles. The overall density estimate per study area was the weighted average over all survey days. The weighting factor was total strip area searched per study day as a percentage of total strip area searched during the study. Because the number of sea turtles sighted per survey day was not necessarily a function of study effort, we estimated the weighted mean's variance as an empirical estimate over all survey days per study.

RESULTS

Seasonal Surfaced Sea Turtle Densities: Relative densities of surfaced hard-shelled sea turtles during the spring study period ranged from 0.04 turtles/100 km^2 in the Louisiana study area to

1.13 turtles/100 km^2 in the South Florida study area. Otherwise, spring hard-shelled sea turtle densities were similar (Table 1).

Hard-shelled sea turtles were generally less abundant in the fall. The relative density of Louisiana hard-shelled sea turtles (0.05 turtles/100 km^2) was similar to the spring density estimate. Southern Florida hard-shelled sea turtles were again most abundant (0.64 turtles/100 km^2) but only about half the spring density estimate. Northern Florida and Central Florida densities were similar and similar to the Northern Florida spring estimate (Table 1). Fall surfaced hard-shelled sea turtle densities in the Texas and North-central Gulf study areas were about half the spring estimates.

Leatherback sea turtles were uncommon in all study areas (Table 1). Leatherbacks were most commonly sighted in the Louisiana study area during the fall survey (0.027 leatherbacks/100 km2) and were not sighted in the Mississippi or Southern Florida study areas in either season.

Table 1. Study areas, study effort, and seasonal densities of hard-shelled and leatherback sea turtles. Total strip area is square kilometers. Density estimates (D) are surfaced sea turtles per 100 km^2 and ^{se}D is the standard error of the density estimate.

				SURFACED SEA TURTLES			
				HARD-SHELLED		LEATHERBACKS	
STUDY AREA	1987 STUDY MONTH	SURVEY DAYS	TOTAL STRIP AREA	$\hat{D}$	$\hat{se}_{\hat{D}}$	$\hat{D}$	$\hat{se}_{\hat{D}}$
South Texas	APR	8	1862	0.34	0.07	0.014	0.009
	SEP	8	1531	0.16	0.05	0	
North Texas	MAY	6	1657	0.23	0.08	0	
	SEP	8	2210	0.14	0.12	0.006	0.006
Louis-iana	APR	9	2709	0.04	0.01	0.004	0.004
	OCT	6	1223	0.05	0.03	0.027	0.027
N-C Gulf	MAY	11	1462	0.30	0.05	0	
	SEP	11	1670	0.19	0.06	0	
North Florida	JUN	11	3649	0.33	0.08	0.005	0.003
	NOV	8	1688	0.35	0.10	0.007	0.007
Central Florida	NOV	7	1856	0.32	0.07	0.007	0.007
South Florida	JUL	10	2147	1.13	0.23	0	
	DEC	9	2226	0.64	0.08	0	

DISCUSSION

We believe the majority of hard-shelled sea turtles we observed were loggerheads. Some sea turtles are known to have feeding migrations (Meylan 1981) and loggerheads offshore of Cape Canaveral, FL appear to have sex and age specific migratory patterns (Henwood 1987). The seasonal changes in abundance may be a result of loggerhead sea turtles migrating in response to prey availability and changing water temperatures.

Why large hard-shelled sea turtles (most likely loggerheads) were so rare offshore of Louisiana is not known. It may be that hard-shelled sea turtles are more localized in abundance in these waters. Seasonal changes in fresh water from the Mississippi and Atchafalaya rivers may change water salinity and distribution of loggerhead prey. Areas of surface oil pollution were common and might have influenced sea turtle distributions. Research vessels working in the area in July and August 1987 reported areas of hypoxic conditions. Most loggerhead sea turtle prey is believed to be benthic and hypoxic conditions could alter the distribution and abundance of loggerhead prey.

ACKNOWLEDGMENTS

Larry Ogren and Henry Hildebrand freely shared their knowledge of sea turtle ecology.

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OBSERVATIONS ON THE CARE OF CAPTIVE KEMP'S RIDLEYS (LEPIDOCHELYS KEMPI)

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With the inception of the Kemp's ridley (*Lepidochelys kempi*) headstart project in 1977 by governmental and private organizations of the United States and Mexico, many logistical and biological questions arose. Over the years, many problems have been overcome regarding the raising of Kemp's ridley hatchlings in captivity at the NMFS Laboratory in Galveston, Texas. However, many questions still exist regarding the general care and husbandry of adult turtles. These are, for example: What is an adequate diet for adult Kemp's ridleys in captivity? How do you recognize a healthy turtle (i.e., what criteria should be used)? What is a normal growth rate for Kemp's ridleys?

Sixteen different kinds of disease conditions have been reported to occur in captive reared Kemp's ridleys including eye infection, emaciation syndrome, fungal infection of the lung, peritonitis, and intestinal obstruction (Klima and McVey 1981). High mortalities have also been observed in captive stocks of older animals at various U.S. aquaria. Many of these can probably be attributed to poor diets comprised primarily of inexpensive fish (i.e., herring, capelin, and mackerel) which appears to correlate with either steatitis (a vitamin E deficiency related disease; Wallach and Boever 1983) or a liver syndrome histologically similar to mammalian and avian hepatic lipidosis, commonly referred to as a fatty liver. Steatitis has been documented in captive American alligators fed a diet comprised largely of mackerel and smelt which resulted in death of the animals (Wallach and Hoessle 1968). The fatty liver syndrome has been observed in other captive reptile species and has also been attributed to overfeeding (Frye 1981). The effect of the liver syndrome in captive turtles is not known, however, it is a serious problem in both mammals and birds plus it has been associated with reproductive dysfunction in caged birds (Whiteman and Bickford 1983).

The growth of captive Kemp's ridleys is also highly variable at different aquaria. This is most likely attributable to different diets and feeding regimes. Turtles maintained at Sea Arama from both the 1978 and 1984 year class have grown at a rate of 5.36 kg/year (n = 8) and 6.39 kg/year (n = 3), respectively, while turtles from the 1982 year class maintained at another aquaria have grown at a rate of 14.19 kg/year (n = 4; Figure 1). There is also an apparent difference in the size at which sexual maturity occurs at which time the rate of growth significantly declines. The 1978 year class turtles (5 females and 3 males) reached sexual maturity at approximately 8 years of age when continuous growth ceased (mean weight = 30.6 kg, mean CCL = 58.8 cm, n = 8). The reproductive maturity and sex of these turtles was verified using both external characteristics plus laparoscopic examination (Dec. 1986). Three of the turtles from the 1982 year class were examined using laparoscopy during Nov. 1987 (5 years of age), one was not examined due to health reasons. Of these three turtles, two were determined to be fully mature males in varying states of spermatogenesis and one was a pubertal male. The remaining turtle was determined to be a

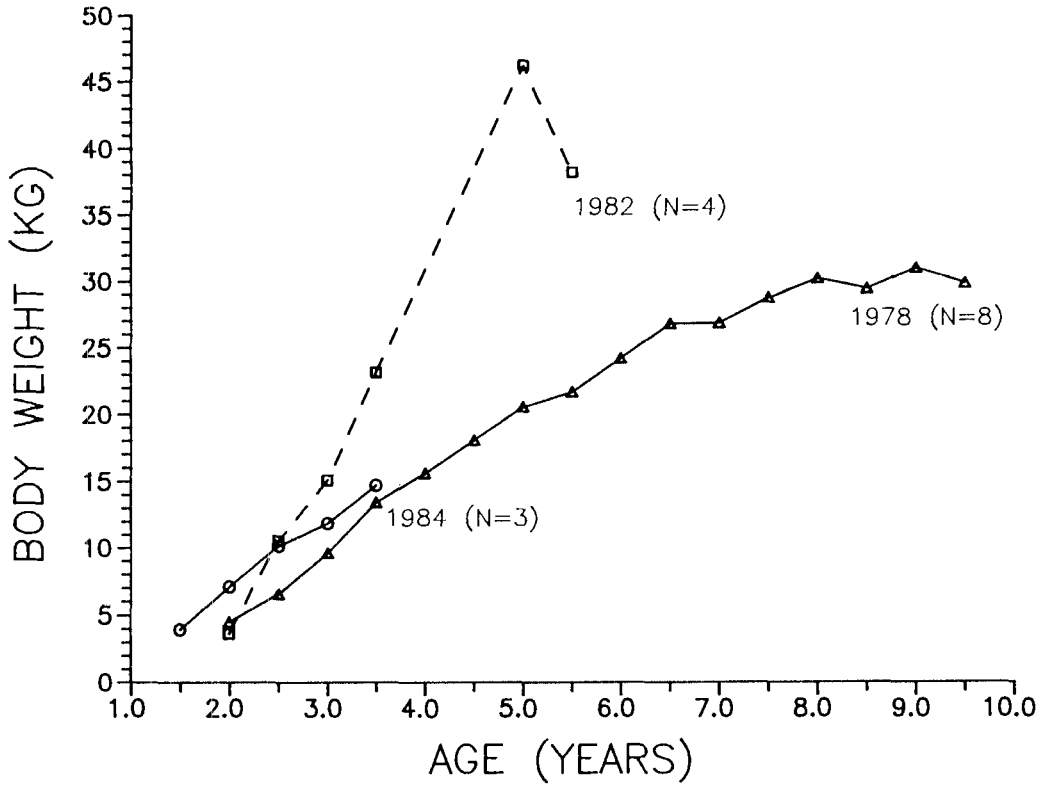

Figure 1. Growth rates of captive Kemp's ridleys maintained at U.S. aquaria.

mature male based on external characteristics (mean weight = 46.2 kg, mean CCL = 63.9 cm, n = 4). At the Cayman Turtle Farm, captive female Kemp's ridleys were observed to reach sexual maturity and begin nesting between the age of 5 and 7 years at a much smaller size (mean weight = 24.7 kg, mean CCL = 54.6 cm, n = 7; Wood and Wood 1988).

The above observations have brought to our attention important questions regarding both the care of captive adult turtles plus the influence of varying diets and conditions on sexual maturation and reproductive fitness. There are several potential reasons for raising Kemp's ridleys in captivity. These include using them as research animals, captive breeders, and as release animals to supplement wild stocks. For each of these potential uses we are obligated to produce and maintain the healthiest animals possible. For this reason we feel further research on nutritional requirements and optimal rearing enclosures is of the highest priority.

ACKNOWLEDGMENTS

We would like to thank John Kerivan for his support and supervision of the turtles at Sea Arama from 1978 to 1987. We would also like to thank Drs. Richard Henderson and Rae Stone for veterinary advice plus Dickie Rivera of the NMFS Laboratory in Galveston for her assistance over the years. This research was supported by Sea Arama Marineworld and Sea Grant College Program NA85AA-D-SG128.

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COMPARISON BETWEEN THE DIVING ADAPTATIONS OF MARINE MAMMALS AND SEA TURTLES

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The turtles belong to the most ancient line of living reptiles, first appearing at least over 200 million years ago in the late Triassic (Gaffney et al. 1987). When the turtles first entered the sea is not known, probably in the early Mesozoic, and for the next 100 million years, during the rise and reign of the dinosaurs, the sea turtles shared the ocean with a rich diversity of other air breathing reptiles, including the ichthyosaurs and plesiosaurs. But while the end of the Cretaceous witnessed the extinction of the dominant large reptiles, the sea turtles continued to flourish up until very recent times when their numbers have, by human interference, drastically declined.

In order to appreciate the causes of this collapse it must help to understand the selective advantages that have allowed sea turtles to so tenaciously survive, and, more particularly, how they have managed to hold their own against the comparatively recent invasions of the sea by mammals.

For air breathing marine animals, effective gas exchange between dives, and efficient oxygen delivery during the dive, must be primary considerations for survival. Here sea turtles and marine mammals share the same problem, but how do their solutions compare?

Lung - The habit of infrequent respiration (the loggerhead spends less than 2% of its time breathing, Lutz and Bentley 1985), requires rapid and effective lung ventilation when breathing, and efficient gas to blood transfer during the breathhold dive. In the sea turtle these functions are accommodated by having large diameter, strongly reinforced airways, which allow much faster air flows than are found in other reptiles, and most of the lung volume is exchanged in a single breath (large tidal volume) by virtue of the sea turtle (again unique for living reptiles) having a highly compliant elastic lung (Lutcavage et al. 1987). Efficient gas exchange is facilitated by the sea turtle having a lung that is subdivided to a degree much greater than any other reptile and the enhanced surface area results in a lung oxygen diffusivity that approaches that of the mammal (Lutcavage et al., in press). These solutions are similar to those of the marine mammal and demonstrate a nice degree of convergent evolution in morphological adaptations between the two groups (Table 1).

Blood - The respiratory properties of blood appear to depend upon whether oxygen is primarily stored in the tissues or in the lung during the dive (Lutz 1982). Unlike the better diving marine mammals, the sea turtle inhales before diving, using the lung as its oxygen store. Marine mammals, like the Weddel seal, exhale and rely on blood and tissue oxygen (Kooyman 1982). The result is that these marine mammals and sea turtles have quite different blood respiratory properties (Table 2, Lapennas and Lutz 1982). In the marine mammal the total amount of stored oxygen is enhanced, compared to other mammals, by having an increased blood volume, increased hematocrit, increased blood oxygen capacity and an increased tissue myoglobin content (Kooyman 1982). Oxygen delivery to the tissues is made more effective by an elevated Bohr value, causing a greater degree of blood oxygen unloading for the same fall in blood pH. In the turtle, on the other hand, not only does the blood continue to transport oxygen from the lung to the perfused tissues, but as the dive progresses it must do so in face of declining lung PO_2 and blood pH. The sea turtles requirement for continued circulation probably prohibits any substan-

tial rise in hematocrit since the work of circulation greatly increases as the red blood cell volume rises (Lutz 1982). A moderate Bohr value facilitates oxygen uptake from the lung and a Bohr effect that declines with oxygen saturation allows oxygen to be stripped from the lung down to low values (Lapennas and Lutz 1982).

Table 1. Comparison of lung adaptations for breathhold diving in marine mammals and sea turtles.

PROPERTY	SEA TURTLE	MARINE MAMMAL
Trachea diameter	↗	↗
Reinforced airways	↗	↗
Elastic tissue	↗	↗
Ventilatory flow rate	↗	↗
Tidal volume	↗	↗
Lung compliance	↗	↗
Gas exchange surface area	↗	
Lung diffusing capacity	↗	

↗ signifies a substantial increase in amount compared to terrestrial reptiles or mammals. Details are given in Lutcavage et al. (1987) and Lutcavage et al. (In press).

Tissue - Both the marine mammal and the sea turtle have an enhanced toleration of hypoxia, due to both groups possessing tissues with high anaerobic capacities. Like most vertebrates, however, this hypoxic tolerance does not extend to the marine mammals brain, and an adequate supply of oxygen to the brain is the ultimate determinant of dive endurance. By contrast, in the sea turtle the brain is able to function in the complete absence of oxygen allowing the turtle to endure long periods of total anoxia (Lutz et al. 1980, Lutz et al. 1985).

Diving strategies - Consideration of the functional aspects of breathhold diving suggests that diving strategies divide on adaptational grounds rather than phylogenetic, and that the division resolves around the different demands of shallow versus deep diving life.

We propose that the shallow divers (coastal, estuarine and fresh water inhabitants), typically breath frequently and depend upon the lung as an oxygen store, and that they have the adaptations for transferring oxygen from the lung to the tissues mentioned above (Table 2, lung store). This set of animals will include most marine turtles (Lutz and Bentley 1985), the duck bill platypus (Lutz et al. in prep.), beavers, manatees and dolphins (see Lutz and Bentley 1985). By contrast, the more oceanic species (e.g., Weddel seal, Harbour seal, various whales), who dive deeply and rely on blood and tissue stores for oxygen, will possess the "classical" morphological and physiological adaptations of the diving mammal (Table 2, blood stores).

The pelagic nature of the leatherback, and the deep diving records from Eckert et al. (1986), allow us to hypothesize that the leatherback sea turtle will be distinguished from other sea turtles in its diving adaptations and will be more similar to the deep diving mammalian group in the respiratory properties of their lung, blood and tissues.

Table 2. Differences in the respiratory properties of blood and tissue of breathhold divers that use either the lung or the blood as a primary oxygen store.

PROPERTY	LUNG STORE	BLOOD STORE
Blood volume	→	↗
Hematocrit	→	↗
Blood oxygen capacity	→	↗
p50 Bohr value	→	↗
Saturation dependent Bohr	↗	→
Tissue myoglobin	→	↗

→ signifies similar values compared with terrestrial relatives. ↗ signifies elevated values compared to terrestrial relatives. Details given in Lutz and Bentley (1985).

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PHOTOGRAPHY AS A PASSIVE TAGGING METHOD OF NESTING LOGGERHEAD SEA TURTLES

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Long-term permanent tagging programs with loggerhead sea turtles (*Caretta caretta*) have generated a wealth of information on nesting patterns of reproductively active female turtles (Richardson et al. 1978, Richardson and Dix 1978, Richardson and Hillestad 1978). These results have provided a standard for estimating population size and content which have been applied to smaller-scale tagging projects (Stoneburner 1981, Talbert et al. 1980). Having accepted these results as a solid foundation for loggerhead nesting biology, current conservation trends have been directed away from additional permanent tagging projects.

In 1982, observations from the Bald Head Island, North Carolina rookery revealed the absence of permanent tags on the local nesting population of loggerhead sea turtles. Upon denial of a permit to begin a permanent tagging program to enumerate this population, efforts were made to search out an alternative method for identifying individual turtles. Since man-emplaced markings were totally absent, the natural demarcations borne on the carapace of these turtles were targeted as a means of personal identification. Beginning with the 1983 nesting season, the Bald Head Island project adopted a passive, non-permanent method of identifying turtles by recording the physical appearance of each individual nester through photography. The method of using photography for the identification of nesting sea turtles will be termed phototagging throughout the remainder of this paper.

METHODS

Phototagging was incorporated into the Bald Head Island project format during the 1983, 1985, and 1986 nesting seasons. Two patrol teams were outfitted with 35 mm cameras loaded with color print film. In addition to standard nest protection duties, interns were to photograph every nesting turtle observed on their nightly patrols. Patrol rates were intensified to enhance the interception rate of nesting loggerheads.

Individual nesters were photographed at some point after oviposition had begun. Turtles observed during non-nesting emergences were not photographed. A standard photopoint was set to record the dorsal surface of the turtle's carapace, with the photographer stationed at the posterior end of the turtle to minimize the effect of the flash. To log the photographs, the exposure number(s) and camera identification letter (A or B) were recorded on each nest data sheet.

After 1983 photographs revealed sand on the carapace was significantly masking barnacle patterns, the methodology was augmented with a step to cleanse the carapace of sand. This was accomplished by either sweeping the sand off with a small brush while the turtle was stationary over the nest or dousing the turtle with water during her return crawl.

Completed rolls of film were sent off for developing in the order they were shot to provide a system of dating each roll. Matching the color prints by the order of the negatives, each print was placed in chronological order. Using the photo log recorded on the data sheets, prints were matched and marked with the turtle activity number. As each print was placed in an ordered file,

it was compared to all earlier photographs to check for the possibility of a matching pattern, indicating a renesting individual.

A roster listing each phototagged entry was kept, complete with corresponding data such as carapace length and width measurements, date of nest, and other variables which would serve to develop a character profile for each individual. A comparative listing of each matching pattern was formulated including internesting intervals and carapace size comparisons which served to strengthen the validity of each match.

RESULTS

The interception rate of nesting females during the three years ranged from 43.8% in 1983 to 57.9% in 1985, with a rate of 46.4% in 1986 (Table 1). These values closely parallel the interception rate of the permanent tagging project on Kiawah Island, South Carolina, which was 45.6% to 78.6% (Talbert et al. 1980). A total of 232 phototags were made, resulting in the identification of 157 individuals.

Table 1. Phototagging results, Bald Head Island, North Carolina.

NESTING SEASON	TOTAL NESTS	TURTLES PHOTOTAGGED	INTERCEPTION RATE	INDIVIDUALS REPRESENTED
1983	146	64	43.8%	57
1984	133	77	57.9%	53
1985	196	91	46.4%	47

The photographic image produced by the phototagging method provided an exacting representation of the dorsal surface of each turtle carapace. The pattern of encrusted organisms across the carapace surface and irregular nicks along its edge were depicted with sufficient resolution to serve as a diagnostic tool in the identification of individuals within the nesting population. Not only did the high degree of detail allow for matching the pattern of renesting individuals, it also chronicled barnacle growth and over-growth by algal mats during the course of one nesting season. Secondarily, the phototagging provided a record of other features such as wounds, deformities, scars, etc., incurred by the local nesting population.

CONCLUSIONS

Phototagging records the appearance of each loggerhead sea turtle observed during nesting by accurately reproducing the patterns of barnacle growth, encrustations, indentations, etc., displayed dorsally on its carapace. The microcosm of organisms attached to each carapace serves as a fingerprint for that individual, although the members comprising the fingerprint are subject to change through growth and mortality. The loggerhead barnacle, *Chelonibia caretta*, actually embeds in the turtle carapace, making it difficult to dislodge (Zullo 1979). Thus, barnacle patterns can be expected to remain constant during the course of one nesting season, but may undergo considerable change over a three year period (Zullo pers. commun.).

Relying on the previously substantiated fact that mature female loggerhead turtles nest in cycles of two or three years, it becomes obvious that phototagging may prove less diagnostic in long-term, year-to-year comparisons. However, this alternative tagging method does have merit in determining the annual number of individual female turtles using a rookery and the frequency of within-season renesters on that beach, given that a high interception rate can be maintained.

The importance of the passive, non-intrusive nature of photo-tagging with regard to maintaining the integrity of the sea turtles' private rite of nesting should not be minimized or overlooked. Many of the incongruous results from permanent tagging work, such as the disappearance of 70% of the tagged nesters after only one nest - which Carr (1980) termed "a bizarrely non-adaptive trait" - may be a biased product of the weaknesses of flipper tagging (e.g., tag loss). A passive alternative such as phototagging, may have useful application in the corroboration or refutal of these previous findings without exacting a further toll on the threatened sea turtle populations we are working so diligently to conserve.

ACKNOWLEDGEMENTS

The author would like to acknowledge the support of the following seasonal interns who shared her faith in this method nightly in the field: C. Mayes, J. Bender, G. Kosko, K. Vanness, N. Hewitt, and L. Manuel. Thanks are also extended to R. Rogers and D. Sandlin of Coastal Foto of Wilmington for quality film development. Lastly, the author is indebted to The Bald Head Conservancy, Inc. for funding this project.

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A PRELIMINARY INVESTIGATION OF THE POTENTIAL IMPACT OF AUSTRALIAN PINES ON THE NESTING ACTIVITIES OF THE LOGGERHEAD TURTLE

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The Australian pine, *Casuarina equisetifolia*, is a shallow rooted, exotic tree, which has invaded many of the coastal beach areas in Florida south of Lake Okeechobee. This tree has taken over the dune area originally occupied by such native species as sea oats, *Uniola paniculata*, beach morning glory, *Ipomoea stolonifera* and sea grape, *Coccoloba uverifera*. This dune area is also one of the major nesting sites for the loggerhead sea turtle, *Caretta caretta*.

Over the past seven years The Conservancy, Inc. has conducted a loggerhead egg relocation program on Key Island (lat. 26°01'N and long. 81°46'W) in an effort to eliminate raccoon predation on sea turtle eggs. The island has 12.2 km of beach front property, 82.5% of which is occupied by Australian pines. During the initial phase of the 1986 egg relocation program the investigators became concerned about the negative impact Australian pines were having upon the nesting activities of the loggerhead turtle. These concerns centered around three areas: first, fallen Australian pines presented barriers to nesting turtles and reduced the amount of nesting beach available to the turtles; second, the shallow rooted Australian pine would cause turtles to abort nesting activities in the dune area and seek less desirable nesting sites in the middle beach; and third, successful nesting, carried out in the shaded area of the pines, was suspected of producing lower nest temperatures and longer incubation time that would result in a disproportionate number of male hatchlings.

During the 1986 and 1987 nesting seasons, stakes were placed in the upper dune area as reference markers. Each of the reference markers was separated by a distance of 150 meters and all turtle nesting activity was recorded in relation to the markers. Two measurements were recorded for each loggerhead emergence. The first reported the distance from the water's edge to the termination point of the crawl and the second reported the distance from the dune vegetation to the termination point of the crawl.

To study the effects of shading by Australian pines, sand temperatures were closely monitored in both 1986 and 1987. In 1986 the Key Island hatchery was shaded by several Australian pines. During this period, four sand and one nest temperature stations were monitored within the hatchery. Sand temperatures were recorded randomly during 24 hour periods from June 4 to August 12 with Weksler soil thermometers placed at a depth of 22 cm. Two additional temperature stations were also monitored outside the hatchery. One was located 4.5 meters seaward of an Australian pine and the second was located 10.5 meters seaward of the pines.

In 1987 three of the Australian pines shading the hatchery were removed. Five sand and one nest temperature stations were again monitored within the hatchery. In 1987, temperatures were recorded four times daily, at 0200, 0800, 1300 and 2000 hours using Weksler soil thermometers. For both 1986 and 1987 incubation times and hatching percentages were recorded for all nests.

Of the 94 nests occurring within the Key Island study area, 60 were found within 3 meters of the dune vegetation and 26 were found 6 meters or more from the vegetation line. When comparing

nests in Australian pine dominated areas versus those in native species areas, the results show that 83.9% of the nests in native species dominated regions were within 3 meters of the vegetation line as compared to only 54.0% of the nests in the Australian pine areas. Conversely, 34.9% of the nesting activities which took place in the Australian pine dominated areas were 6 meters or more seaward of the dune vegetation line while only 12.9% of the nests in the native vegetation areas were 6 meters or more seaward of the dune vegetation line (Table 1).

Table 1. Distance of nests from Australian pine dominated dune areas vs those dominated by native vegetation (1987).

AUSTRALIAN PINE					
DISTANCE FROM VEGETATON LINE (M)	0-1.5	1.5-3	3-6	6-9	over 9
NUMBER OF NESTS	26	8	7	10	12
% OF NESTS	41.3	12.7	11.1	15.9	19.0
NATIVE VEGETATION					
DISTANCE FROM VEGETATION LINE (M)	0-1.5	1.5-3	3-6	6-9	over 9
NUMBER OF NESTS	20	6	1	0	4
% OF NESTS	64.5	19.4	3.2	0	12.9

False emergence data also revealed interesting results. One nest for every 1.48 false emergences was found in native species dominated areas while one nest per 1.73 false emergences was found in Australian pine dominated regions and one nest per 4.22 false emergences was found in areas where Australian pine barriers were prevalent.

The results of incubation times and hatching percentages for 1986 versus 1987 are found in Table 2. Mean incubation times in 1986 were 9.2 days longer than those observed in 1987. The range for monthly incubation times varied from 10.8 days in May to 3.7 days in August. Table 3 shows the results of the t-test analysis for mean incubation times for 1986 versus 1987. The overall mean incubation time for 1986 and 1987 were significantly different from one another. August is the

Table 2. Comparison of mean monthly incubation periods and hatching percentages , 1986 vs 1987. Hatching percentage is defined as the number of turtles succcessfully emerging from the egg X 100%.

MONTH	1986 INCUBATION PERIOD (DAYS)	1986 HATCHING %	1987 INCUBATION PERIOD (DAYS)	1987 HATCHING %
MAY	74.3	85.1	63.5	88.3
JUNE	71.1	83.3	60.3	87.5
JULY	66.4	73.5	60.0	79.2
AUGUST	65.3	74.1	61.6	72.7
MEAN	69.7	80.4	60.5	82.6

only month not showing a significant difference in incubation times at the .01 level. The sample size for August, however, included only three nests for 1986 and five for 1987.

Sand temperatures during 1986 were monitored within the Key Island hatchery as well as in two locations outside the hatchery. The mean sand temperature in the shaded hatchery was 26.4°C

Table 3. Analysis of incubation periods (t test), 1986 vs 1987.

MONTH	1986 INCUBATION PERIOD (DAYS)	1987 INCUBATION PERIOD (DAYS)	t VALUE	LEVEL OF SIGNIFICANCE
MAY	74.3	63.5	7.22	.001
JUNE	71.1	60.3	27.14	.001
JULY	66.4	60.0	14.23	.001
AUGUST	65.3	61.6	2.28	.10
MEAN	69.7	60.5	22.26	.001

while in a partially shaded Australian pine area outside the hatchery it was 27.0°C and on the open beach it was 27.9°C.

These results confirm the investigator's belief that Australian pines represent a serious threat to the dwindling nesting areas of loggerhead turtles along South Florida beaches. At the study site fallen Australian pines have already made 12.5% of the Key Island beach inaccessible to nesting turtles. Should Key Island be struck by a hurricane it is conceivable that over three-fourths of the island's beach would become littered with fallen pines and considerably curtail nesting for many years.

At this time it appears that Australian pines are also affecting nest site selection. As reported, a greater percentage of turtles were found nesting 6 meters or more from dune vegetation when it is dominated by Australian pines. This often results in nesting sites in the middle beach area. These nests lose the protection of the higher dune area and become jeopardized by the intrusion of saltwater during summer storms.

Finally, this study suggests that nests laid in the shaded areas of the pines are subjected to cooler incubation temperatures and, subsequently, longer incubation periods. These conditions may produce a higher percentage of male hatchlings. Over a period of time this selection process could artificially alter the natural sex ratio of the turtles.

REPRODUCTIVE HOMING AND INTERNESTING BEHAVIOR OF THE GREEN TURTLE (CHELONIA MYDAS) AT ASCENSION ISLAND, SOUTH ATLANTIC OCEAN

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Each year, between December and May, about one to three thousand female green turtles nest on the beaches of Ascension Island, an isolated volcanic peak on the mid-Atlantic ridge in the South Atlantic Ocean. The nesting grounds consist of 32 covehead beaches, which vary in size and shape, in the characteristics of their offshore approach, and in the color and texture of the sand composing them (Mortimer 1981a, 1981b) (Figure 1).

During the 1976-77 and 1977-78 nesting seasons, 1,100 nesting turtles were tagged. Of these, 371 animals were observed nesting later during the same season, and were involved in a total of 973 observed multiple emergences, ranging from 2 to 10 per turtle. The exact location of each emergence was recorded. Ascension turtles regularly make multiple trial emergences before laying eggs (Mortimer and Carr 1987) -- probably because they have difficulty constructing suitable egg chambers in the coarse, dry Ascension sand. Thus, it was possible to identify two types of within-season nesting emergence: a) emergences occurring within less than 7 days of the last recorded nesting emergence, assumed to be attempts to lay the same clutch of eggs; and b) emergences separated by longer time intervals, involving separate egg clutches.

Re-emergences were examined in terms of the precision with which turtles homed: a) to a cluster of adjacent beaches; b) to a given beach; and c) to a point within the boundaries of a given beach. Four beach clusters were identified on the island (Figure 1). The normal approximation of the binomial distribution (Mendenhall 1975) was used to quantify reproductive homing. The 95% confidence interval for the percentage of observed successive emergences made by turtles to the same beach cluster within a single nesting season was 91.8 - 98.2% for emergences separated by less than 7 days. It was only 84.2 - 90.6% for emergences separated by longer periods of time. Turtles homed less precisely to individual beaches than they did to clusters of beaches. For successive emergences separated by less than 7 days, turtles were more likely to re-emerge at the same beach than they were in successive emergences separated by 7 or more days. A z-test demonstrated that at South West Bay beach, where the greatest number of turtles were tagged ($N = 231$), site fidelity in emergences separated by less than 7 days was significantly greater than in emergences separated by seven or more days ($z = -2.31$; $P < 0.05$).

No significant correlation was found between the amount of time and the amount of geographic displacement separating emergences that occurred within a season (Pearson correlation; $N = 601$; $r = -0.01$; $P = 0.80$). In fact, there was little apparent decrease in the site fidelity of observed emergences separated by intervals of 2 to 7 years.

The travel and movements of turtles in the internesting habitat were recorded by visually tracking a brightly colored, lighted, polyurethane foam tow-float attached to the posterior margin of the carapace. The position of the float at sea was determined by triangulation from two points on the shore. Simultaneous compass bearings were taken at frequent time intervals from promontories around the perimeter of the island.

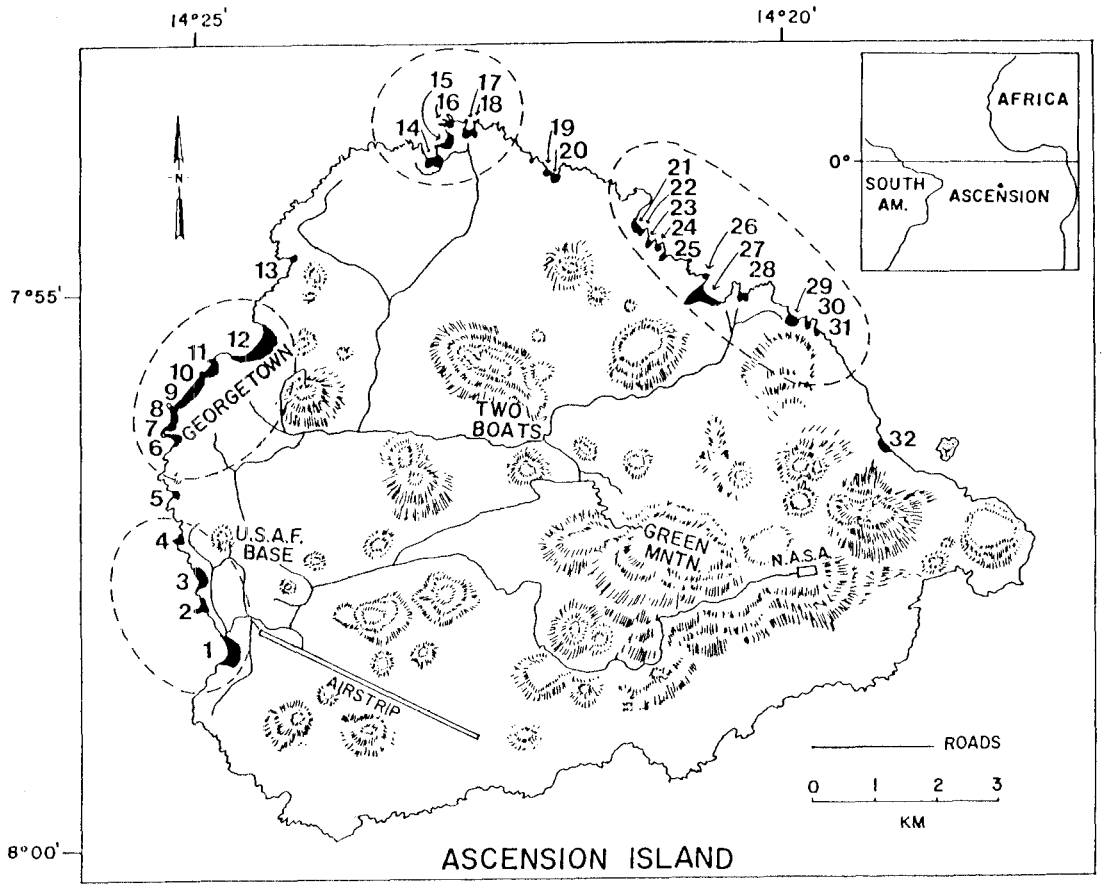

Figure 1. Nesting beaches at Ascension Island. The beach clusters referred to in the text are indicated by dashed ellipses. Individual beaches mentioned in the text include: 1. South West Bay; 3. Clarke's; 12. Long Beach; and 27. North East Bay.

Two types of tracking experiments were performed: a) after turtles laid eggs and returned to the sea, their movements were tracked; and b) turtles were tracked after abandoning a nesting attempt. Turtles were tracked in both circumstances after nesting at South West Bay beach and also at North East Bay beach.

The behavior of the tracked turtles was quite predictable. On the night that they had laid eggs, turtles tracked from South West Bay beach almost always moved straight out into water about 18-20 meters deep, and then travelled north along the coastline to a shallow area off the Long Beach cluster of beaches (Figure 2). A very different behavior pattern was apparent in the animals that had abandoned their nesting attempt prior to laying eggs. In each case, the frustrated nesters tracked from South West Bay beach spent the remainder of the night within 500 meters of that beach. During that time, they stayed in relatively shallow water and travelled back and forth just offshore--sometimes even briefly emerging onto the nesting beach (Figure 3). One turtle was tracked both after abandoning a nesting attempt and also after successfully laying eggs. She distinctly showed both types of behavior. Animals tracked from the North East Bay beach showed patterns of behavior similar to those tracked from South West Bay beach. Although the frustrated turtles tracked from North East Bay beach travelled further than did their counterparts tracked

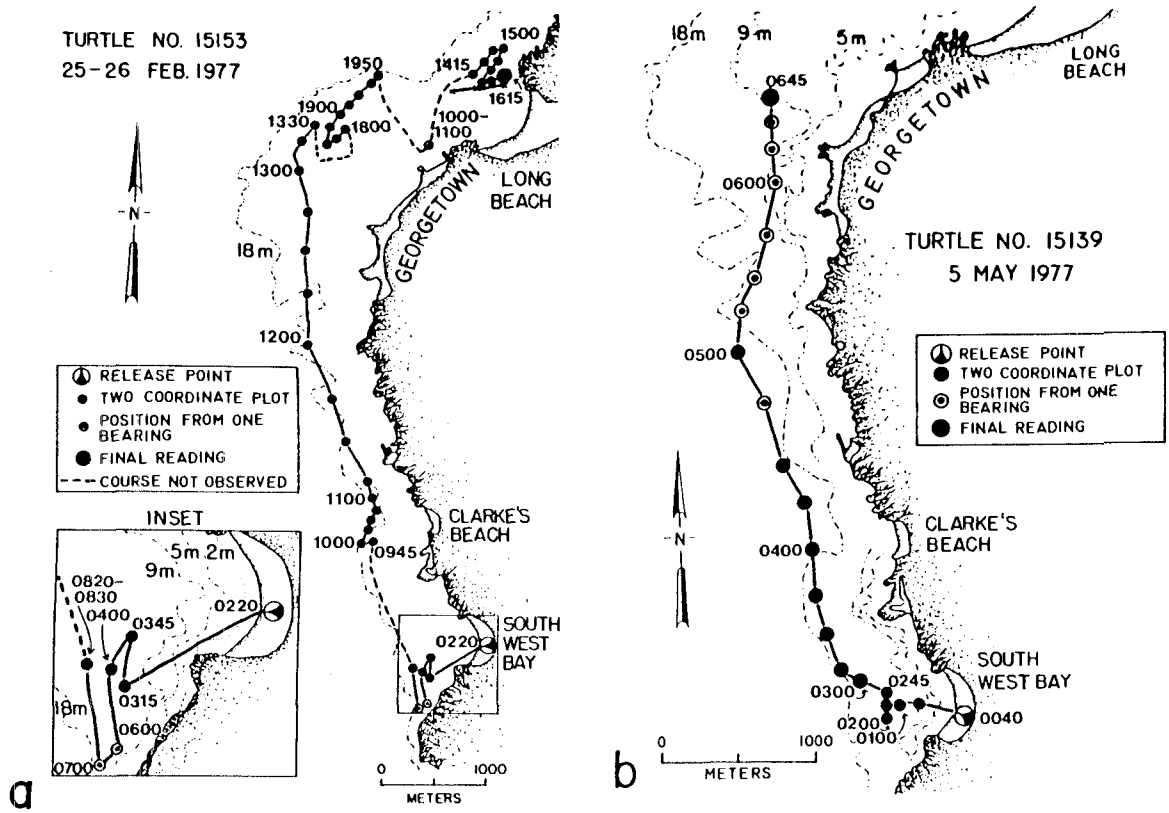

Figure 2. Movements of two turtles after laying eggs at South West Bay beach.

from South West Bay beach, they nevertheless remained within the boundaries of the North East Bay cluster of beaches.

This tendency of the frustrated nesters to remain close to the nesting beach that they had just abandoned may explain why returns after abandoned nesting attempts show greater site fidelity than do re-emergences that are separated by longer periods of time and greater distances of travel.

It is curious that none of the frustrated nesters tracked in the present study re-emerged during the same night that they had abandoned their nesting attempt. Likewise, there were only 7 occasions on which any of the 1,100 turtles tagged in the present study were recorded emerging twice during the same night--even though Ascension turtles regularly make multiple trial emergences prior to laying eggs. Although a common assumption has been that turtles disturbed on the nesting beach early in the evening will usually re-emerge to nest later that night, perhaps human disturbance at the breeding beach is more disruptive to nesting turtles than has previously been thought.

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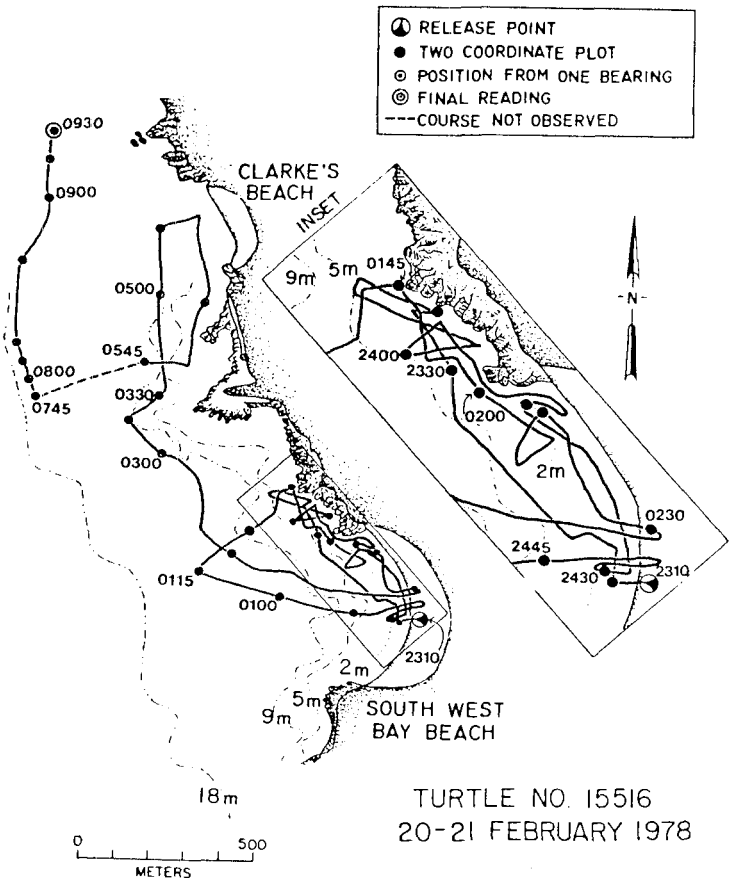

Figure 3. Movements of a turtle after abandoning a nesting attempt at South West Bay beach.

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THE EFFECTS OF NEST TEMPERATURE ON HATCHLING EMERGENCE IN THE LOGGERHEAD SEA TURTLE (CARETTA CARETTA)

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Hatchling sea turtles usually emerge under the cover of darkness but the time interval between pipping and emergence remains a mystery to students of sea turtle research. Kraemer and Richardson (1979) devised an ingenious method to determine when the nest collapsed but they unfortunately could not relate this to pipping. Mrosovsky (1968) determined that the daily drop in surface soil temperature cued the hatchlings to emerge from the neck of the nest provided ambient temperature was below 28.5°C. Otherwise no technique has been devised to predict when emergence will commence short of digging into the nest chamber and finding the hatchlings in the neck of the cavity. The purpose of this investigation, therefore, was to examine the relationship between nest temperature and hatchling emergence, and to devise a technique useful in predicting when emergence will occur in the loggerhead sea turtle (*Caretta caretta*).

We divided this experiment into two parts--predicting emergence as it relates to the entire incubation period and within the 24-hour period in which emergence will occur. To examine the first relationship, we expected a temperature increase at the top of a nest with a corresponding decrease in temperature in the middle of that nest as hatchlings moved upward in the nest cavity after pipping. For the second part of this experiment, we expected hatchling emergence to correspond to that time when soil temperatures began to drop. To test these hypotheses, we placed thermocouples at the top, middle, bottom, front, and back of loggerhead nests laid on Masonboro Island, North Carolina, during the 1985-1987 nesting seasons. Thermocouples were also placed at depths of 25 and 50 cm a similar distance from the high tide line, but away from the nests to act as a control. Nest and control temperatures were taken daily between 0600 and 0800 hours with a Bailey BAT-12 microprobe thermometer calibrated to the nearest 0.1°C.

To examine emergence as it relates to the total incubation period, temperatures at the top and middle of two nests with complete data sets were standardized by subtracting control temperatures (Figure 1). Once metabolic heat becomes evident, the middle of these nests is consistently warmer than the top until five days before emergence, at which time the top temperature exceeds that of the middle in each (Figure 1). This five-day prediction corresponds with that given by Webster and Gouveia (1988, this volume), and indicate that a reversal in top and middle nest temperatures can be used to predict when emergence will commence.

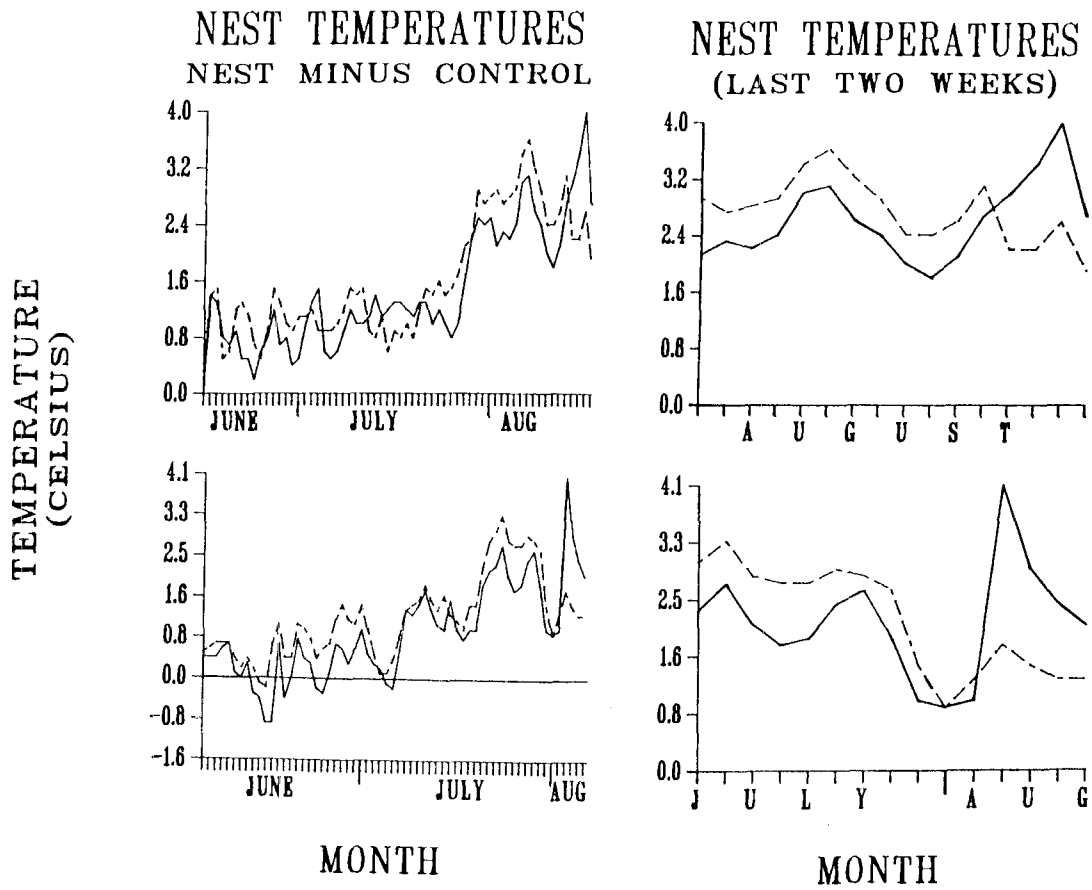

Figure 1. Standardized nest temperatures at two loggerhead nests throughout their incubation period (left) and during the last two weeks of incubation (right). Solid line indicates nest temperature at 25 cm depth, dashed line indicates nest temperature at 25 cm depth. Emergence in both nests occurred the day after the last temperature was taken.

To examine how daily fluctuations in soil temperature affect hatchling emergence, we plotted the timing of emergence and soil temperatures at 25 and 50 cm against the hours of the day (Figure 2). Soil temperatures peak between 2000 and 2200 hours at 25 cm and 0200 and 0400 hours at 50 cm, depths that approximate the top and middle of loggerhead nests laid on Masonboro Island. Emergence is most common immediately after the soil begins to cool, but the 28.5°C inhibitory limit does not appear to apply to loggerheads as it does to green turtles and hawksbills (Mrosovsky 1968). Seasonal trends were not evident in our sample (based on small samples per month) for either of our predictions, but the senior author will be gathering additional data on this topic.

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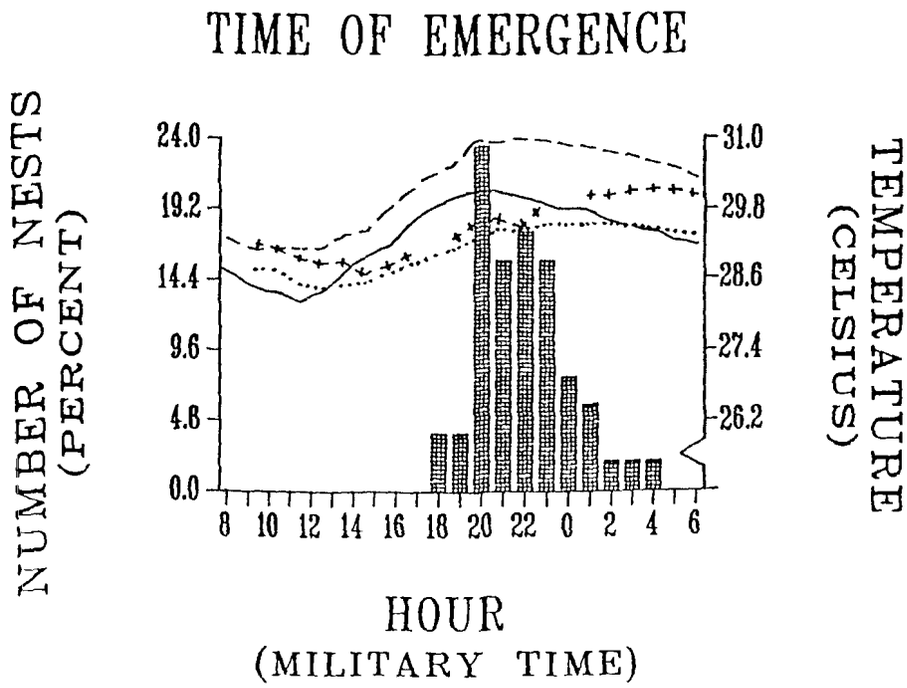

Figure 2. Average daily temperatures at 25cm depth (dash = July, n = 3; solid = August, n = 3) and 50 cm depth (cross = July, n = 3; dot = August, n = 2) and time of emergence (n = 51) for loggerhead turtles in southeast North Carolina.

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STATUS OF FEDERAL REGULATIONS TO REDUCE THE INCIDENTAL CAPTURE AND MORTALITY OF SEA TURTLES FROM SHRIMP TRAWLING

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The National Marine Fisheries Service (NMFS) published final regulations in the Federal Register on June 29, 1987, requiring certain measures to be used by shrimp trawlers in the southeastern United States to conserve endangered and threatened sea turtles. Concurrently, a final supplemental environmental impact statement was published which described the background and alternatives to address the problem of sea turtle catch and mortality in shrimp trawls.

In summary, the regulations require three things: 1) require shrimp trawlers 25 feet long and longer to use turtle excluder devices (TEDs) when shrimping in offshore waters at certain times; 2) require shrimp trawlers less than 25 feet long to limit trawl tow times to 90 minutes or less, doors in to doors out, (or use TEDs) when shrimping in offshore areas at certain times; and 3) require all shrimp trawlers to limit trawl tow times to 90 minutes (or use TEDs) in inshore waters at certain times (Table 1).

The regulations allow the use of five different models of TEDs. One is the NMFS TED first developed in 1980 and subsequently modified. The NMFS TED consists of two oval rings. Bars are attached to the bottom of the front hoop to the top of the rear hoop at a 37° angle. A trap door is at the top between the hoops. A turtle slides up the bars and is released through the door. A second authorized device is called the Cameron TED. (It was developed by a shrimper from the port of Cameron, Louisiana.) It is similar in form and function to the NMFS TED. A third type of TED is the Matagorda TED or the Texas TED, so named because it was first used in Matagorda Bay, Texas. It is different than the previous two models in that it is a rectangular single grate rather than double hooped with slanting bars between. It works on the same general principle of deflecting turtles out an opening in the top or bottom of the net. A fourth type of TED is called the Georgia TED. It is a single grate like the Matagorda TED, except it is oval rather than rectangular. The fifth and newest model TED is called the Morrison TED. It is a soft TED made out of polypropylene webbing material of 8 inch stretch mesh. It is inserted in the back of the trawl at an angle and works on the same principle as the TEDs previously discussed.

In addition to the TED requirement, there is a 90 minute tow time provision in the regulations for inshore waters and for small vessels. The primary reason for this requirement is because the NMFS lacks sufficient data on turtle mortality and workability of TEDs in inshore waters. There was extensive public testimony received during the public hearing process indicating that TEDs would cause handling problems on small vessels. The 90 minute tow time restriction was selected based on research that indicated sea turtle mortality within this tow time was less than four percent. When trawl tow times exceed 90 minutes, mortality increases significantly.

The regulations become effective in different parts of the southeast United States at different times. The purpose of this phase-in approach is to focus first on the most critical times when sea turtles are encountered during shrimp trawling and to allow shrimpers time to acquire and learn how to use TEDs. The first area for regulation implementation is the Cape Canaveral area of

Table 1. Summary of TED/tow time regulations. The line dividing inshore from offshore is the 72 COLREGS DEMARCATION line found on NOAA coastal charts 1:80,000 scale (broken purple line).

AREA	START DATE	SEASON	VESSEL REQUIREMENTS
OFFSHORE			
Canaveral	18 Sept 88	Year-round	25 ft or longer = TEDs <25 feet = 90 min tows
Southwest Florida	1 May 89	Year-round	25 ft or longer = TEDs <25 feet = 90 min tows
Gulf	1 May 89	March-November	25 ft or longer = TEDs <25 feet = 90 min tows
Atlantic	1 May 89	May-August	25 ft or longer = TEDs <25 feet = 90 min tows
INSHORE			
Canaveral	18 Sept 88	Year-round	All shrimp trawlers = 90 minute tow time or TEDs
Southwest Florida	1 May 90	Year-round	All shrimp trawlers = 90 minute tow time or TEDs
Gulf	1 May 90	March-November	All shrimp trawlers = 90 minute tow time or TEDs
Atlantic	1 May 90	May-August	All shrimp trawlers = 90 minute tow time or TEDs

Florida. The regulations go into effect in all inshore and offshore areas October 1, 1987, and are effective year-round.

The second area affected by the regulations is referred to as the southwest Florida area. It is approximately the area from Key West to Venice on the west coast of Florida. The regulations begin January 1, 1988, on a year-round basis but in 1988, extend only offshore to 15 nautical miles. In 1989, the 15 mile limit expires and TEDs are required in all waters.

The third area affected by the regulations is the Gulf. This is essentially the other waters of the Gulf of Mexico in addition to the southwest Florida area. These regulations became effective March 1, 1988, to 15 nautical miles offshore. TEDs/tow times are required between March 1 and November 30 of each year. In 1989, the 15 nautical mile limit expires and the regulations are effective in all waters.

The final area scheduled to come under the regulatory regime is called the Atlantic area. This is the area (except Canaveral) from the Keys to North Carolina/Virginia. The regulations go into effect on May 1, 1988, and are effective between May 1 and August 31 each year.

As with any set of regulations there are certain exceptions or special situations and while I won't discuss all of them, I will touch on the major three: 1) these regulations do not apply to vessels that are fishing for royal red shrimp in the Gulf of Mexico; 2) they do not apply to vessels fishing for royal red or rock shrimp in the South Atlantic area; and 3) the regulations provide for the testing and certification of new TED designs.

Needless to say, these regulations have been and still are extremely controversial, probably the most controversial regulatory action that the NMFS has ever undertaken. The 15 public hearings had record attendance. Some of the hearings had as many as 3,000 people. Governors, U.S. senators and congressmen as well as state and local officials attended and testified at these hearings. Written comments received filled a closet.

The regulations have received a number of challenges since their implementation. In September, 1987, the North Carolina Attorney General petitioned the Secretary of Commerce to rescind the rules for North Carolina waters. The Secretary denied the petition.[1] In October, 1987, the State of Louisiana filed suit in Federal district court in New Orleans seeking an injunction of and overturning of the TED rules. The case was heard on February 10, and the judge, in an order issued on February 29, upheld the rules. A more recent development has been an appeal filed by the State of Louisiana and the Concerned Shrimpers of Louisiana. This action also requested an injunction of the rules while the appeal is heard. On April 12th, 1988, the federal judge that originally heard the case granted the motion for injunction.2 In December, 1987, the United States House of Representatives passed an amendment to the Endangered Species Act. This amendment, sponsored by Walter Jones of North Carolina, would delay the implementation of the 90 minute tow time requirement in inshore waters for two years. The amendment also calls for extensive TED and turtle studies in inshore waters and would appropriate $1.5 million for this purpose. The Senate has not taken action on this Bill at this point. Congressman Solomon Ortiz of Texas introduced an amendment to the Jones Bill that would have delayed the regulations in offshore waters for two years. The amendment was defeated by the U.S. House of Representatives.

[1]On April 11, 1988, North Carolina and two fishery associations filed suit in Federal District Court in Raleigh, North Carolina, challenging the rules. Hearing of the case was subsequently delayed pending congressional action on the nationwide TED regulations. On November 16, 1988, the Department of Justice (on behalf of NOAA/NMFS) filed a motion in Federal District Court in Raleigh, NC to dismiss the case. The court has not ruled at the time of this publication.

[2]A motion by the Department of Justice to overturn the injunction pending appeal granted by the Louisiana District court was denied by the Appellate Court on April 25, 1988. On July 11, 1988, the Appellate Court affirmed the Federal District Court ruling upholding the TED regulations and set an implementation date of September 1, 1988.

Update: At publication time the TED rule is delayed (except at Canaveral) and scheduled to go into effect on May 1, 1989 for offshore waters and May 1, 1990 for inshore waters. This delay is a result of a congressional amendment to the Endangered Species Act.

ENTANGLEMENT IN AND INGESTION OF MARINE DEBRIS BY SEA TURTLES STRANDED ALONG THE SOUTH TEXAS COAST

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METHODS

Entanglement

Entanglement data were collected from sea turtle stranding reports submitted to the Sea Turtle Stranding and Salvage Network from Mustang and North Padre Islands, Texas during 1986 and 1987. Data collected included: month and location of stranding, species stranded, curved carapace length of the turtle and type of entanglement.

Ingestion

A general necropsy similar to that described by Wolke and George (1981) was performed on dead sea turtles stranded during 1986 and 1987 on Mustang, North Padre and South Padre Islands, Texas. During necropsy, the curved carapace length and width was measured, sex was determined by external examination of the gonads, the entire digestive tract was removed and all organs were examined for irregularities in an attempt to determine the cause of death of the turtle. The esophagus, stomach and intestinal tract were later opened in the lab. If debris was present, it was removed and its location in the digestive tract was noted. The remaining gut contents were preserved in 10% buffered formalin for later analysis.

RESULTS

Entanglement

A total of 25 (8.7%) sea turtles were found entangled. Entanglement was believed to have been the cause of death in 7 (28%) of these turtles. The remaining 18 (72%) turtles were stranded alive, rehabilitated at the University of Texas Marine Science Institute and with the exception of one permanently injured turtle, were released into the Gulf of Mexico.

Species found entangled included: Kemp's ridley (*Lepidochelys kempi*) (36%), loggerhead (*Caretta caretta*)(24%), hawksbill (*Eretmochelys imbricata*) (24%), green (*Chelonia mydas*) (12%) and leatherback (*Dermochelys coriacea*) (4%). Types of entanglement encountered were by fish-

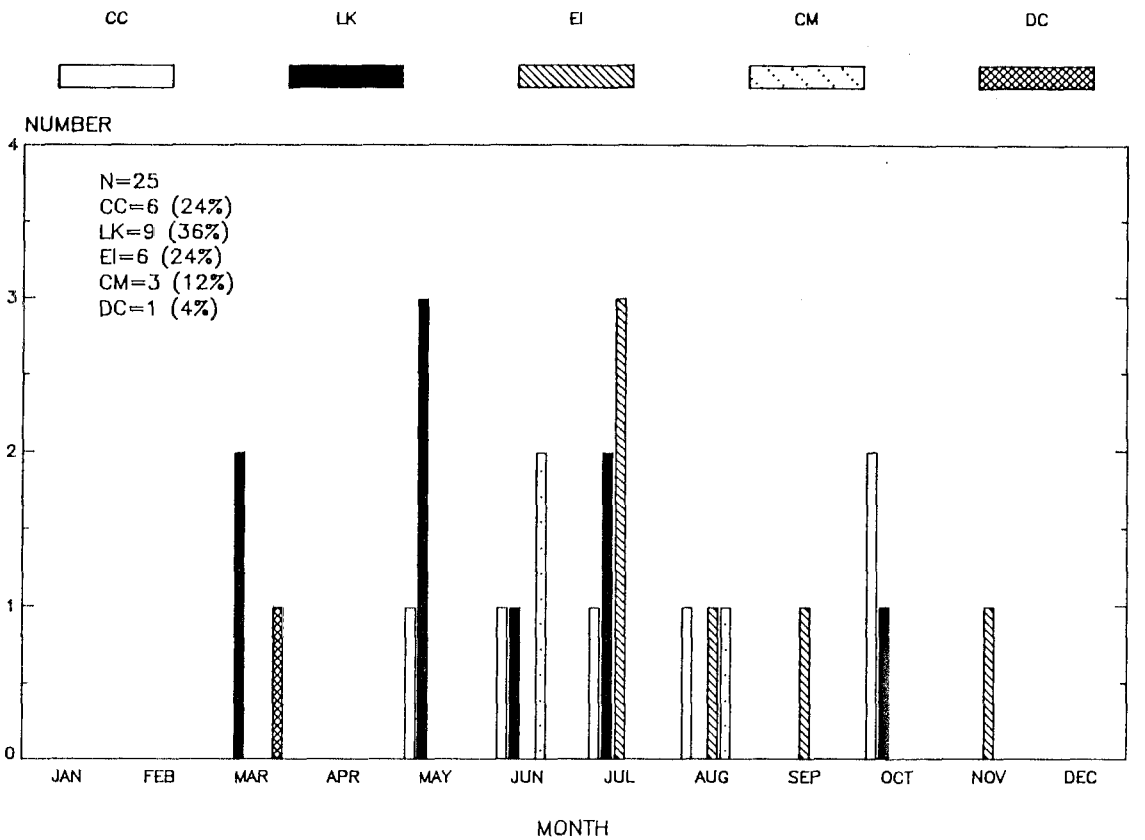

Figure 1. Entangled sea turtles along the south Texas coast, month of entanglement.

ing line/hook (32%), shrimp trawl (28%), onion sack (16%), net/rope (12%), tar (4%), crab trap (4%) and trotline (4%). Entangled turtles were reported from every month with the exception of January, February, April and December (Figure 1). With the exception of the one leatherback, all of the entangled turtles were juveniles or subadults. The mean curved carapace length of entangled turtles for each species were: Kemp's ridley 30.8 cm, loggerhead 59.1 cm, green 24.6 cm and hawksbill 24.3 cm.

Ingestion

Marine debris was present in the gut contents of 35 of the 76 (46.1%) turtles necropsied. Ingestion of debris was unquestionably the cause of death of two of these turtles. Of the remaining 33 turtles, it could not be determined with certainty that the debris they had ingested was directly responsible for their deaths. Debris was found in all portions of the digestive tract. It was found in the mouth, esophagus, stomach and intestines and was also seen protruding from the cloaca of a turtle. The actual weight of debris ingested constituted only a small portion of the overall weight of the gut contents in most of these turtles.

All of the species necropsied had ingested marine debris.It was present in 31 of the 66 (47.0%) loggerheads, 3 of the 9 (33%) greens and in the one hawksbill necropsied. Types of debris ingested (and their frequency of occurrence) included pieces of plastic bags (74.3%), pieces of hard plastic (20.0%), styrofoam (11.4%), monofilament fishing line (11.4%), polyethylene beads (8.6%), plastic strapping (5.7%), pieces of balloons (5.7%), pieces of aluminum foil (5.7%), tar (2.8%), glass (2.8%), cardboard (2.8%) and a heat-sealed tab from a beverage can (2.8%). Debris

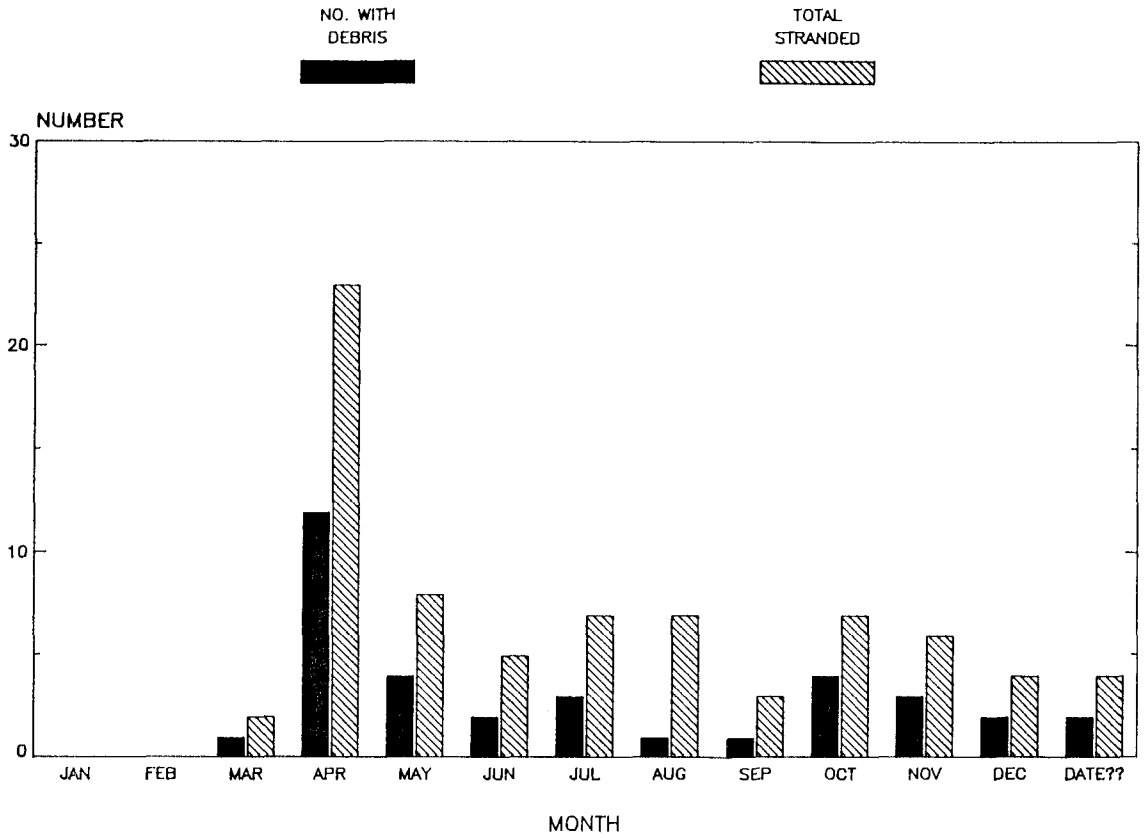

Figure 2. Sea turtles stranded along the south Texas coast, ingestion of marine debris by month.

was ingested by turtles that stranded from March through December (no turtles stranded in January or February) (Figure 2), by juveniles, subadults and adults (Figure 3) and by 46.7% of the female and 46.4% of the male turtles necropsied.

DISCUSSION

Sea turtles that were found stranded along the South Texas coast were significantly affected by ingestion of, and to a lesser extent, by entanglement in marine debris. All species found in the area, both male and female, juvenile, subadult and adult were found to have become entangled in or ingested marine debris during almost every month of the year.

Commercial and recreational fishermen and their discarded gear were responsible for the majority of the entanglement incidents. The number of entanglement cases is probably underestimated because quite often commercial and recreational fishermen are reluctant to report these incidents. One interesting note is that all of the turtles caught in shrimp trawls during this study were recovered alive and eventually were released. All had been turned in by the shrimpers who had caught them.

The offshore oil industry, cargo ships, research vessels, commercial and recreational fishing boats and other sea-going vessels are responsible for most of the trash discarded at sea which eventually is consumed by some turtles. Also responsible are the Gulf currents and winds which carry virtually all of the trash dumped into the Gulf of Mexico and to a lesser extent the Caribbean

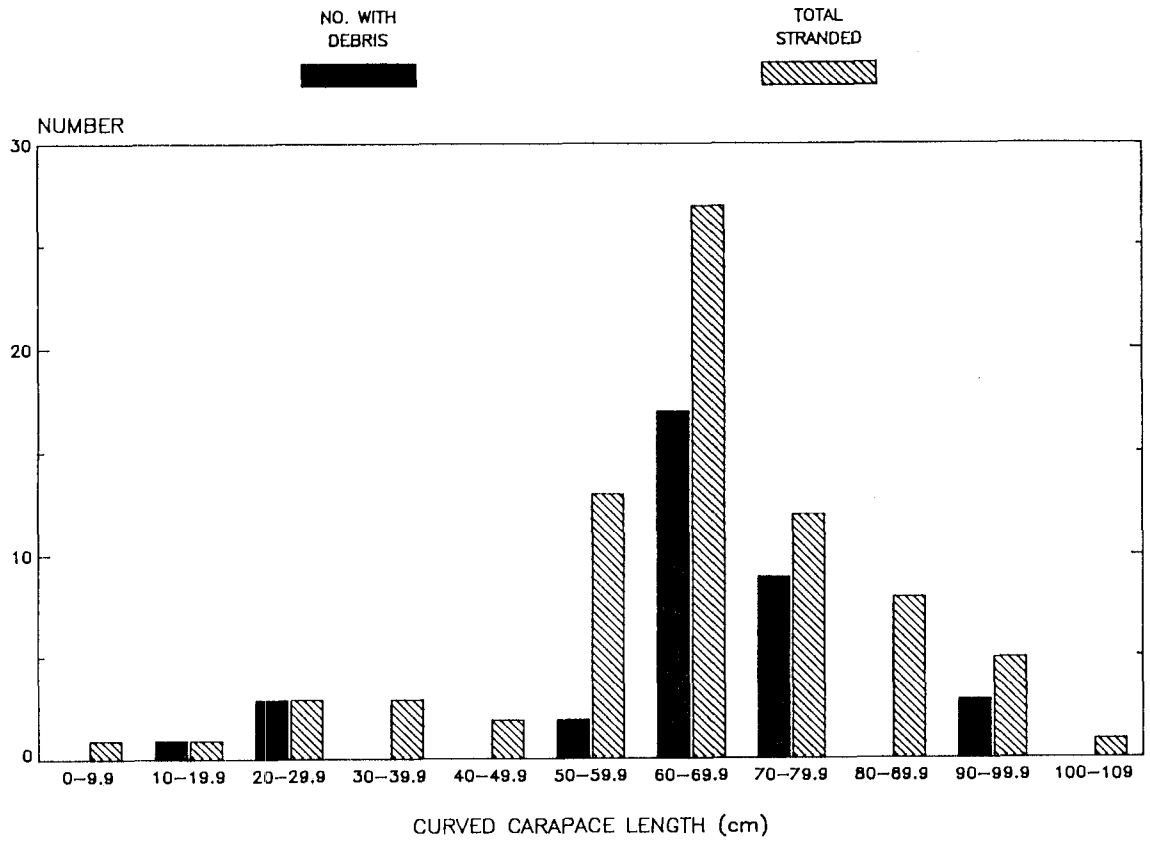

Figure 3. Sea turtles stranded along the south Texas coast, carapace lengths of turtles with marine debris in gut.

to the Texas coast. The probability that a sea turtle, inhabiting Texas coastal waters, will at some time come in contact with debris is quite high.

ACKNOWLEDGEMENTS

This study was funded in part by a Grant-in-Aid of Research from Sigma Xi, the Scientific Research Society to the senior author and in part by a grant from Texas A&M Sea Grant College Program through interagency contract #IAC(86-87)1607 to the co-author. We would like to thank Robert Whistler for providing us access to his stranding reports. We would also like to thank Pan American University, Texas Parks and Wildlife Department, Padre Island National Seashore, Donna Shaver and Rosemary Breedlove for helping us collect stranded sea turtles.

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LEATHERBACKS IN CAPE COD BAY, MASSACHUSETTS, 1977-1987

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The presence of the leatherback in the waters surrounding Cape Cod, Nantucket, and Martha's Vineyard is well documented. Bleakney (1965), Lazell (1980), and a number of additional reports clearly indicate that the leatherback is a regular migrant through our study area.

Utilizing reports of live leatherbacks and recoveries of stranded leatherbacks, we are able to ascertain the causes of mortality, identify high use areas, and possibly determine how many leatherbacks frequent the waters surrounding Cape Cod and the Islands. In addition, through the study of stranded or entangled leatherbacks, we have been able to determine the general condition, size, and sex of those individuals present in the study area.

The study area includes the waters of the Atlantic Ocean, Vineyard and Nantucket Sounds, and Cape Cod and Buzzards Bays. Information was solicited from the public through the use of posters in 1980 and 1987, and annually through the news media, Massachusetts Audubon Society newsletters, lectures, and interviews with boaters and commercial fishermen. Individuals responding to requests for information included boaters, commercial and recreational fishermen, beach walkers, natural resource officers, and volunteers.

All live sightings were logged into our data base. In most cases these were single sightings of an individual. However, over the last three years we have had sightings of groups of leatherbacks. As yet we haven't been able to determine the number of individuals in the study area.

It was not always possible to investigate every stranding so data is incomplete for some stranded leatherbacks. At other times, stranded animals were so badly decomposed that it was not possible to sex the individual or even measure carapace length. Necropsies were performed on all stranded leatherbacks seen by the author. Sex was determined by examining reproductive tissue. All leatherbacks examined appeared to be fully developed adults. Tissue samples from the major organs of fresh specimens were collected and banked.

Since 1976, 256 stranded sea turtles have been entered into our data base. Of this total, fifty-seven, or 22%, are leatherbacks (Figure 1). Of these fifty-seven, eleven were alive at the time of stranding and forty-six were dead. Nine of the stranded animals were males and fifteen were females. Sex was undetermined on the remaining thirty-three, either because they were too badly decomposed, not necropsied, or not seen by the author. In addition to stranded leatherbacks, we have eighty-four reports of live leatherback sightings during the period 1977-1987.

The curved carapace length of twenty-six of these leatherbacks ranged from 124.5 cm to 170 cm, with the average being 144.8 cm. Length was determined by measuring from the nuchal notch to the posterior tip of the carapace. The tape was stretched along the paramedian troughs, not over the median ridge.

In those cases where a stranding could be attributed to a specific cause, the cause of stranding was either entanglement in lobster pot line, capture by dragger, cold stunning, or collision with

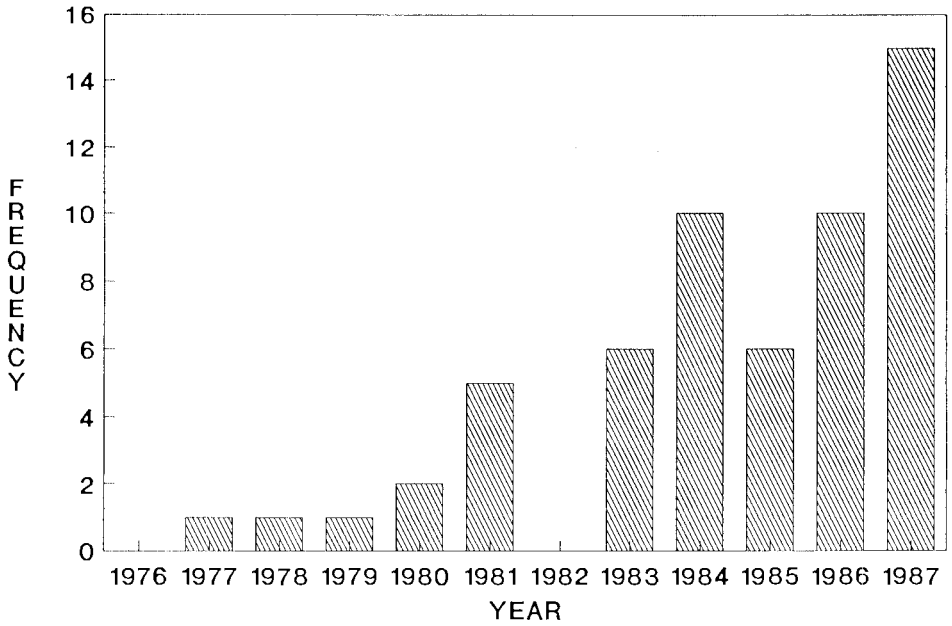

Figure 1. Annual strandings of leatherbacks, 1976 - 1987.

a boat. None of the leatherbacks examined by the author was determined to have died from ingestion of plastic.

During the period 1977-1987, leatherbacks, both dead and alive, were most frequently reported from Cape Cod Bay (66%), followed by Nantucket Sound (16%), Buzzards Bay and Vineyard Sound (7% each), and the Atlantic Ocean (4%). While reports of live animals are probably related to the number of boaters using a particular body of water, it is our impression that over the course of the summer, all water bodies in our study are equally used.

Considering that entanglement is the leading determinable cause of strandings (89%), it should be noted that lobster pots are set all along the Atlantic coast of Cape Cod, in Cape Cod Bay, and in the southern end of Vineyard Sound and Buzzards Bay. At this time, however, we do not have the data base to definitely prove that strandings are higher in those areas where lobster pots are set, but it certainly seems to be the case.

Sighting reports from the period 1977-1986, indicate that August is the month of greatest leatherback activity in the study area, followed closely by September. We have had no live sightings before June or after October.

Strandings, on the other hand, have occurred from July to January, with 82% occurring between September and November (September - 31%; October - 29%; November - 22%). This could indicate that leatherbacks move north offshore, possibly in the Gulf Stream, in early spring, and that the return migration in the late summer and into the fall brings the leatherbacks inshore.

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SEA TURTLES IN GUYANA

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Most important sea turtle nesting beaches in the world are utilized by only a single species, although a common variant is for a given beach to be utilized largely by one species, but for another species to nest in small numbers also; or for two species to utilize a beach in different seasons. Such a pattern reflects preferences for different types of beach by different species - for example, leatherbacks require a deep, reefless approach, and a relatively steep beach with deep sand free from rocks and obstructions. Hawksbills, on the other hand, are undeterred by a reef fronting the beach, but often show preference for a beach on which they can nest partially or completely beneath vegetation. Loggerheads prefer temperate latitudes, while olive ridleys are highly tropical; and so on. Moreover, interspecific competition can be expected on a beach utilized by several species, most obviously in that large, deep-nesting species such as leatherbacks or greens would be expected to destroy the nests of much smaller species such as ridleys or hawksbills in the course of their own nesting efforts.

In this context, the beaches of North-Western Guyana are unique in that they are not utilized by any one dominant species, but instead are utilized by no fewer than four species, in roughly comparable numbers.

Several features of these beaches and the turtle colonies that utilize them may be relevant to interpreting the significance and the uniqueness of the biological situation. The area is an extraordinarily undisturbed one as far as habitat destruction is concerned. The coast of Guyana between the mouths of the Waini and Pomeroon Rivers, about 140 km, is completely undeveloped. The shoreline, washed by brown, silt-laden waters of a type that quickly forestalls any attempt at tourist development, is fringed largely by red and black mangroves. Vast deposits of slimy, gray mud are present, and the beaches curiously incorporate no sand whatsoever; they are composed entirely of broken seashells. Moreover, the coast is an extremely dynamic one, and the beaches shift dramatically from year to year. For tens of kilometers the mangrove forests are undergoing intense erosion, and in some areas the presence of massive fallen trees reaching into the sea even by lowest tide makes coastal foot patrols very difficult.

The different turtle species nest at somewhat different times. The beach is so remote, and protracted stays there so difficult, that we have not yet been able to mount a season-long monitoring effort. On the other hand, human exploitation of the nesting turtles at the hands of the Arawak Indians from the Moruka River, 2-3 days away by dugout, is intense; consequently, the fresh carcasses found even on a short visit give a good index to the nesting activity during the preceding weeks. In mid-April 1988, we found remains of green turtles, almost entirely, with just two leatherback carcasses and one olive ridley. A return visit in early June, however, indicated that few further green turtles had been killed, but many leatherbacks, as well as one more ridley and a few hawksbills. On the other hand, on my first and second visits to this beach, in August of 1964 and again in 1965, the accumulated carcasses were of all four species, and the nesting that took place during August itself was primarily by hawksbills, with a few ridleys.

I believe that the multi-species utilization of the beach can be attributed in part to the fact that there are no other nesting beaches between Trinidad and eastern Surinam. Most of this coast is mud and mangrove, and although there are quite extensive beaches in eastern Guyana, these

are of poor quality and are also densely inhabited. Moreover, the beaches in the northwest of Guyana are of variable topography and geomorphology, and thus parts of them fall within the acceptable physical parameters for each of the four species. It is probably also significant that the sum total of nesting by all of the species is not very great, and thus physical interaction between nesting turtles of the same or of different species is unlikely.

In 1988, for the first time, I found evidence of immature turtles on Almond Beach -- the principal nesting beach in recent years. I found the plastron of a half-grown hawksbill; a carapace of an unusually small green turtle, about 20 cm in length; and remains or fragments of two immature loggerheads. The latter were the first records of the species from Guyana, and increased the overall species count for the beach to five, although still only four are known to nest. The immature turtles were not strandings -- they were found too far back from the sea, and they also showed evidence of having been butchered. I believe that all were caught in the nets set by Amerindian turtle hunters in the waters adjacent to the beach, principally for catching fish.

As mentioned, the rate of slaughter of the nesting turtles is intense. From my various visits to the beach, I estimate that well over 50%, possibly even 75%, of nesting attempts result in the killing of the female, and usually the taking of her eggs also. The percentage may be lower for the ridleys and hawksbills, since they are on the beach for less than half the time taken by a nesting green turtle or leatherback, and this improves their chances of escape.

In the face of such exploitation, it seems to be a miracle that turtles still nest in Guyana. Yet, despite the slaughter, at least one species, the leatherback, seems to be on the increase. By my own observations and also by reports of the oldest turtle hunters, the leatherback was a rare species in Guyana in the mid-1960's, and I saw no nestings and few carcasses in those years. Yet today it is quite common, and several may be found nesting in one night. One would have assumed that the two species that nest many times in the course of a season, and that are ashore for two hours or so when nesting, would have been rapidly decimated, with few or no individuals surviving to a second nesting season. This may indeed have happened in the case of the leatherback which, more than the cheloniid species, may continue to grow somewhat after first maturity. The average carapace length of nesting leatherbacks in Guyana in 1987 was 152.4 cm. This is significantly shorter than the average I found for the unexploited population in French Guiana (158.5 cm), and somewhat less than that of the sporadically-exploited population in Trinidad (156.8 cm). We thus may be finding leatherbacks in their first season of maturity only in Guyana, but with the Surinam population showing a full spectrum of young, middle-aged, and old adults.

It seems to me almost inconceivable that these leatherbacks were hatched on the beaches in Guyana where they nest today; a generation ago the turtles there were too few and too persecuted. The relative abundance of nesting leatherbacks in Guyana today is paralleled by a striking and hard-to-explain increase in nesting effort in Trinidad, where beaches on which one might formerly have seen three turtles in a night now have twenty or more. Moreover, many of the nesting turtles are of unusually small size, although the mean carapace length for Trinidad animals quoted above was calculated several years ago. I believe that leatherbacks in Northern South America are not separable into genetically isolated colonies, but rather that good reproductive success on the most important beaches (notably in Surinam and French Guiana, where protection is good) may serve to maintain a supply of nesting animals even on beaches hundreds of kilometers away, even if they are subject to intense exploitation on those distant beaches. This does not imply lack of philopatry once nesting has started by a given individual, but it does suggest that a hatchling, upon reaching maturity, may nest quite a long way from where it hatched. Nevertheless, there are limits to this dispersal, and it is noteworthy that leatherback nesting on the Santa Marta Peninsula of Caribbean Colombia has virtually stopped in the face of intense exploitation, despite the existence of thriving colonies to the north (in Costa Rica and Panama) and to the east (in Trinidad and the Guianas).

For both the leatherback and the green turtle, one clear effect of the beach slaughter in Guyana is early truncation of the nesting season. Few greens, for example, nest later than mid-May, although in neighboring Surinam nesting continues through June, at least. Nevertheless, green turtles in Guyana are of strikingly large size, with a mean straight-line carapace length of 105.74 cm (over curve: 112.23 cm), and with occasional individuals with over-curve length exceeding 120 cm. There may have been some slight drop in average size over the years; the mean straight-line length of 43 green turtle carapaces I measured on Shell Beach, Guyana, in 1964 was 106.85 cm. These mean lengths are very similar to those on the nearest nesting colony to the northwest (Isla Aves; 106 cm), but a little less than that of the greens in the major colonies to the east, in Surinam and Ascension (109 and 108 cm respectively).

In the face of intense beach slaughter, it is interesting to contemplate the possible reproductive history of a 120 cm, possibly 250 kg, green turtle nesting in Guyana. Did such an animal reach this immense size before reaching first maturity, or did it nest repeatedly in Guyana (miraculously escaping hunters) while growing to this size, or did it nest elsewhere during that period, shifting to Guyana for its final nesting season?

For green turtles, post-maturity growth may be so slow that carapace length, or even weight, may be a poor index for establishing relative age. However, a number of reptiles do show certain skeletal trends other than overall size increase as they age; for example, the skull may continue to increase in size, or in relative breadth, or change in texture or thickness. With this in mind, I have collected relatively large series of skulls of green turtles, and also of hawksbills and olive ridleys, from the Guyana beaches, both from Shell Beach in the mid-1960's and from Almond Beach, geomorphologically the direct descendant of Shell Beach, in the late 1980's. These will be submitted to careful morphological comparison in due course, but the results are not yet available.

SEX RATIO OF LOGGERHEAD SEA TURTLES HATCHING ON A FLORIDA BEACH IN 1986

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Sexual differentiation in several species of turtles, including *Caretta caretta*, is dependent upon ambient temperatures prevailing during incubation (Yntema and Mrosovsky 1980). Current human activities along nesting beaches, including conservation practices, could be affecting the sex ratios of loggerhead sea turtle hatchlings.

Field studies determining natural sex ratios have not been conducted in Florida where 90% of the U.S. *Caretta caretta* nests are laid (Murphy and Hopkins 1984). This study provides data from our first season of a three year project to determine the natural sex ratio of hatchlings produced on a Florida beach.

METHODS

The study area was located on Cape Canaveral Air Force Station, Brevard County, Florida. Nest selection was primarily confined to a 5 km section of high energy beach, just north of the tip of Cape Canaveral where nesting densities are generally high (>100 nests/km). Nests for subsequent sampling were designated on their day of deposition during six 2-week periods that occurred between May 15 and August 15. Nests were marked and descriptions including location, shading, nest position relative to beach profile, and potential for tidal inundation were recorded. Many nests had to be protected from predators with 1.5m^2, 14 gauge wire screens with 10 x 5 cm mesh. Screens were generally removed prior to the estimated critical period in incubation for temperature effects on sexual differentiation. Incubation duration was defined as the number of days between nest deposition and the night of the emergence of the majority of hatchlings. A chicken wire net or hatchling trap was positioned around each clutch a few days prior to emergence and then checked each morning for hatchling collection. Captured hatchlings were stirred by hand and ten animals were randomly collected from different parts of the mass. In some cases, predation and hatchling escape prohibited the selection from a full complement of hatchlings. To avoid these problems, hatchlings were sometimes dug up prior to emergence.

The gonads of each hatchling were examined histologically (Yntema and Mrosovsky 1980) to determine sex. The temporal nesting distribution was based on 33 kilometers of beach along Cape Canaveral that were patrolled almost daily during the nesting season.

Sand temperatures at a typical nesting site were recorded continuously by Hydrolab series 2020 datasondes (Hydrolab; TX) buried at 60 and 30 cm depths during 4 to 8 day periods in May, June and July. Daily fluctuations in temperatures at the 30 cm depths for May were used to determine the time +/- 30 minutes when temperatures were mid-way between maximum and minimum values. Thermistor probes (YSI) were placed along a transect with four stations. The probes were buried at 30 and 60 cm at each station. The station locations included: primary dune/sparse vegetation; primary dune/open sand, the seaward slope of the dune; and on the berm near the

high tide line. Temperatures were read twice each week at 1615 hrs +/- 30 minutes. Data for the sites were pooled due to overlap of the standard errors of biweekly means.

RESULTS

The majority of the hatchlings sampled were determined to be female and no intersexes were found. The few males that were found occurred in May and early June. Taking changes in nesting frequency into account, it is estimated that about 95% of the hatchlings produced on this beach in 1988 were females.

The continuous temperature data collected in June and July by the datasondes confirmed that our manual transect measurements were occurring close to the mean daily temperature. Both forms of temperature collection revealed that the 30 cm sand temperatures were well above 29.0°C (the pivotal temperature for *C. caretta*) nesting in the USA for most of the season. Ideally, continuous temperature monitoring throughout the season should be performed.

ACKNOWLEDGEMENTS

Support for the project was provided by World Wildlife Fund (USA) and the United States Fish and Wildlife Service. Equipment was supplied by NASA Kennedy Space Center, Biomedical Operations and Research Office and the Natural Sciences and Engineering Research Council of Canada. We greatly appreciate the assistance of J. Campbell, J. De Vore, N. Hannagan, R. Hinkle, B. Leenhouts, K. McLean, M. Mercadante, W. Penley, E. Possardt, P. Salmon, D. Turner, and J. Woody.

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THE REPRODUCTIVE BIOLOGY OF CAPTIVE KEMP'S RIDLEYS (LEPIDOCHELYS KEMPI): PILOT STUDIES

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Since relatively little is known about the reproductive biology of *Lepidochelys kempi* and since they are the most endangered of the marine turtles, we have been interested in studying their reproduction under captive conditions.

History and Status of Programs: Although many aquaria have successfully maintained Kemp's ridleys in captivity, Ila Loetscher of Sea Turtles, Inc. (STI) was the first to raise ridleys to maturity from eggs. Soon thereafter head-started ridleys from the International Mexico-U.S. Cooperative Program were raised to maturity at Sea-Arama in Galveston (SAG), the Miami Seaquarium (MSQ) and at the Cayman Turtle Farm (CTF). Some of the CTF group matured in 1984 at five years of age. Two of the turtles nested but the three hatchlings survived only 3-4 days (Wood and Wood 1984). In 1986 and 1987 the CTF females produced several clutches with many viable hatchlings (Wood and Wood 1988). Also, in 1986 an unidentified female deposited a clutch at the "Lost Islands" tank at the MSQ. A single turtle survives from this first U.S. nest. At SAG in 1986 a female dropped several eggs in her tank.

The above results and the relative ease with which CTF is now able to produce many clutches per year is a major accomplishment for marine turtle conservation. While it is important not to view captive breeding as the solution to the Kemp's ridley problem, it does provide a "last ditch" capability as well as a way to supplement conservation projects with hatchlings. In addition, we believe that these programs provide an excellent means (possibly the only means) to learn how ridleys coordinate and regulate their reproductive behavior and physiology.

Endocrine-Behavior Studies: Rabalais et al. (in press) found peaks of estrogen and testosterone coincident with mounting attempts in a pair of ridleys held at the Port Aransas Marine Lab. Subsequently we have initiated a more thorough study of the captive group of Kemp's ridleys at SAG. We also have conducted a short term pilot study at the CTF during the spring 1987.

The study at SAG entails three major components: 1) monthly measurement of circulating testosterone levels, 2) laparoscopic exams to determine potential reproductive status, and 3) observation of reproductive behavior for comparison with circulating testosterone levels in both males and females. Two male and four female Kemp's ridleys from the 1978 year class (8 years old) were chosen for this study. All animals were determined to be sexually mature based on both external and internal morphology. Animals were maintained in individual troughs and water

temperature was recorded daily. Animals were also placed under a simulated photoperiod using full-spectrum Vita-lites in February 1987 with minimum daylength of 10 hrs in January and a maximum daylength of 16 hrs in July. Blood samples (15 ml) were collected monthly from October 1986 to February 1988 from the bilateral cervical sinus. Blood samples were centrifuged for 10-15 min at 2-3000 rpm, serum was removed and stored frozen until assayed. Testosterone levels were measured using radioimmunoassay techniques at Texas A&M University (Wibbels et al. 1987). Mean blank value was 3.9 ± 1.5 pg/tube (n = 4), average recovery was 67.6 ± 2.4% (n = 4), and intraassay variation was 11.6%. Laparoscopic exams were conducted at six month intervals on both males and females to determine reproductive status (i.e., follicular sizes, oviducal status, testicular status, and epididymal development) plus testis biopsies were taken from males in May 1987 and Nov. 1987 to determine state of spermatogenesis. Behavior tests were conducted at three month intervals (April 1987, July 1987, Oct. 1987, and Jan. 1988) to record reproductive behavior levels at various times of the year. One male and two females were placed in a 4.3 m diameter circular tank and tested for 2.5 hours for a total of five hrs per male. A total of 40 hrs observation was collected. Females were varied so that each male was exposed to all females. Reproductive behaviors were defined as:

1) Investigations - one individual swims over the back of another individual from the rear or side, orients head down towards the turtle being investigated, usually in the neck region, and may pause there for several seconds.

2) Attempted mounts - one individual attempts to mount another individual but is unable to successfully grip the recipient or is positioned inappropriately (i.e., sideways or backwards).

3) Mounts - one individual grips another individual on the carapace with both foreflippers and hindflippers, and wraps its tail under the inguinal regional of the recipient turtle. Mount duration (minutes) was also recorded.

Frequency of male investigations, attempted mounts and mounts were recorded and compared with testosterone levels.

Males displayed seasonal patterns in serum testosterone with significantly elevated levels ranging from 2.04 to 11.14 ng/ml during the fall and winter (Nov. to Mar.) and reduced levels ranging from 0.20 to 1.20 ng/ml during the late spring and summer (May to Sept.) (Figure 1). Two females (#2511 and #2518) also displayed seasonal patterns in serum testosterone with elevated levels ranging from 173.4 to 315.3 pg/ml during the spring (March and April), while the other two females (#2509 and #2512) studied did not appear to display this testosterone peak during the spring (Figure 2). Laparoscopic records from Dec. 1986 revealed that both females (#2509 and #2512) contained atretic follicles which suggests that their ovaries were in a state of regression rather than maturation and may have inhibited the expected spring peak in testosterone.

Results of the behavior tests suggest that while elevated levels of testosterone are necessary for the display of reproductive behavior by males, females regulate when mating activity will occur. Male #2510 investigated, attempted to mount, and mounted significantly more during April 1987 than male #2507. At this time, male #2510's testosterone level was still elevated (6.95 ng/ml) while male #2507's testosterone level was markedly reduced (0.46 ng/ml). During April 1987 female #2518 received 55.8% of the mounts which ranged from < 1 min to 28 min in duration. Later during the year, both males displayed increased frequency of investigations which coincided with increased testosterone levels in Oct. 1987 and Jan. 1988; however, fewer attempted mounts and only four mounts (all < 1 min in duration) were observed during Jan. 1988 (Table 1).

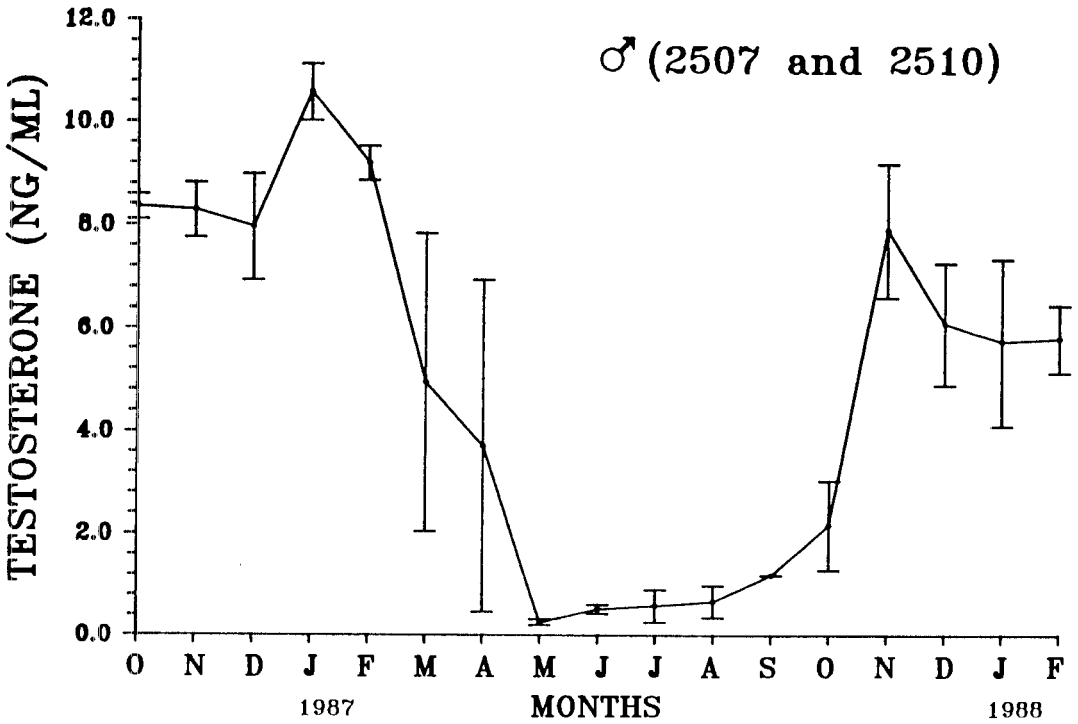

Figure 1. Mean serum testosterone levels for captive male Kemp's ridleys maintained at Sea Arama Marineworld, Galveston. Values are means ± SE, n = 2.

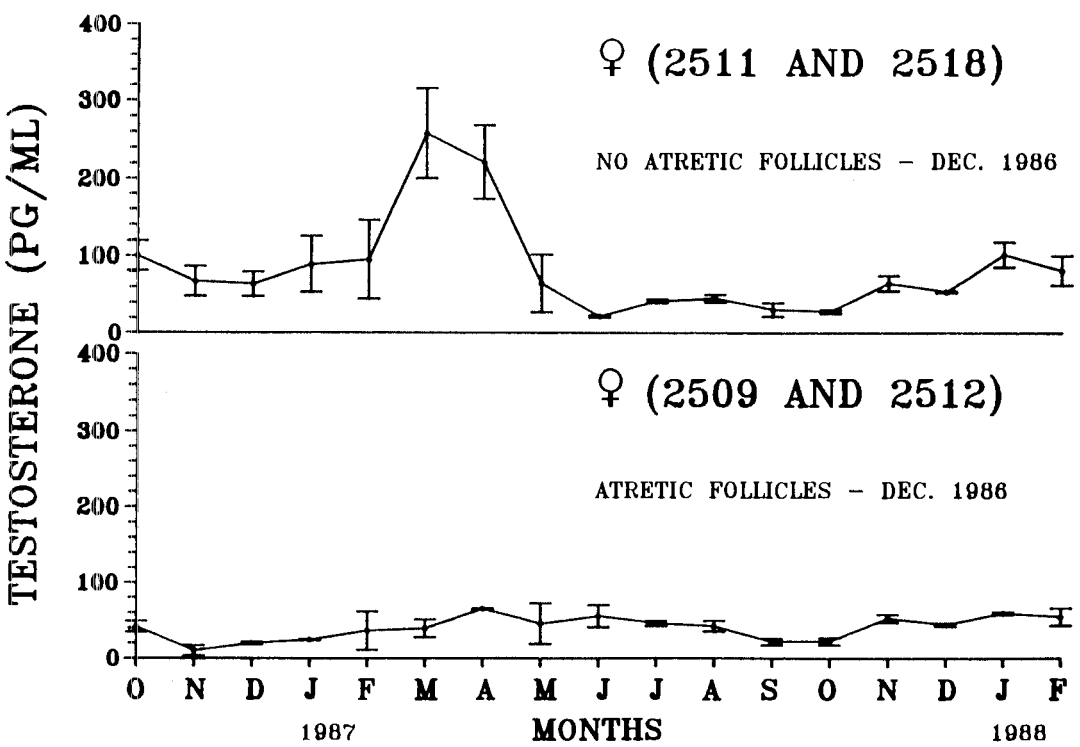

Figure 2. Mean serum testosterone levels for captive female Kemp's ridleys maintained at Sea Arama Marineworld, Galveston. Values are means ± SE, n = 2.

Table 1. Serum testosterone and reproductive behavior of male Kemp's ridleys maintained at Sea Arama Marineworld, Galveston.

APRIL 1987	TESTOSTERONE	INVESTIGATIONS	ATTEMPTED MOUNTS	MOUNTS
1) 2507 M	0.46 ng/ml	5.0 per hr	0.0 per hr	0.0 per hr
2) 2510 M	6.95 ng/ml	37.6 per hr	10.6 per hr	8.6 per hr
JULY 1987				
1) 2507 M	0.91 ng/ml	0.0 per hr	0.0 per hr	0.0 per hr
2) 2510 M	0.26 ng/ml	0.0 per hr	0.0 per hr	0.0 per hr
OCT. 1987				
1) 2507 M	3.04 ng/ml	6.4 per hr	1.6 per hr	0.0 per hr
2) 2510 M	1.30 ng/ml	4.2 per hr	0.0 per hr	0.0 per hr
JAN. 1988				
1) 2507 M	7.37 ng/ml	28.0 per hr	1.0 per hr	0.0 per hr
2) 2510 M	4.12 ng/ml	27.4 per hr	5.6 per hr	0.8 per hr

Information gleaned from laparoscopic exams has also proven important in understanding the relationship of endocrine patterns to reproductive behavior, particularly in an organism as highly synchronized as the Kemp's ridley. The early rise in testosterone levels of males during Oct. and Nov. appears to be more directly related to gonadal maturation rather than stimulation of reproductive behavior. Results of testis biopsies taken during May 1987 and Nov. 1987 for both males (#2507 and #2510) suggest that gonadal regression occurs during late spring (May 1987) and gonadal recrudescence occurs during the fall (Nov. 1987) in preparation for the subsequent mating season the following spring (Table 2). As noted above, laparoscopic exams of females also revealed important trends in follicular development. Females which contained atretic follicles did not display the expected testosterone surge during the spring (March and April). Also, changes in follicle types were observed at six month intervals with vitellogenic medium-size follicles in Dec. 1986, no medium size follicles in June 1987, and an apparent increase in number of both pre-vitellogenic and vitellogenic medium size follicles in Nov. 1987 (Table 2). These changes in follicle sizes and types present suggests a cycling and maturation process occurring throughout the year.

The reproductive behavior and serum testosterone patterns are similar to those observed during a pilot study on the captive group of Kemp's ridleys at the CTF during spring 1987. Male testosterone levels decreased from premating (6.76 $\pm$ 0.66 ng/ml, n = 6) and mating (6.53 $\pm$ 0.40 ng/ml, n = 6) to post-mating (0.48 $\pm$ 0.08 ng/ml, n = 6) while female testosterone levels peaked from premating (105.0 $\pm$ 30.4 pg/ml, n = 6) to mating (296.2 $\pm$ 55.5 pg/ml, n = 6) and then decreased during post-mating (18.3 $\pm$ 1.5 pg/ml, n = 6) (Rostal et al. 1987). Mating activity during the study appeared to coincide with the surge (March 1987) in female testosterone levels while male testosterone levels were elevated prior (Feb. 1987) to the onset of mating activity.

Further research on the reproductive behavior, endocrinology and morphology is needed on this highly endangered species of marine turtle. Improvements in management and conservation efforts may be possible through increased understanding of the reproductive biology of captive Kemp's ridleys.

Table 2. Laparoscopic data from captive male and female Kemp's ridleys maintained at Sea Arama Marineworld, Galveston.

LAPAROSCOPIC EXAMS - MALE KEMPS RIDLEYS

MAY 1986	TESTIS	EPIDIDYMIS	SPERMATOGENESIS
1) ID 2507	LARGE/VASCULARIZED	MED./TUBULES VISIBLE	POST-SPERMATOGENIC
2) ID 2510	LARGE	MED./TUBULES VISIBLE	LATE SPERMIATION
NOV. 1987			
1) ID 2507	LARGE/VASCULARIZED	SMALL/TUBULES VISIBLE	EARLY SPERMIATION
2) ID 2510	LARGE/VASCULARIZED	SMALL	EARLY SPERMIATION

LAPAROSCOPIC EXAMS - FEMALE KEMP'S RIDLEYS

DEC. 1986	OVARY	LARGE FOLL. (1.5-2.5 CM)	MEDIUM FOLL. (0.5-1.5 CM)	SMALL FOLL. (0.1-0.5 CM)	ATRETIC FOLL.
1) ID 2509	LARGE	VITELLOGENIC	VITELLOGENIC	-------	YES (2cm)
2) ID 2511	LARGE	VITELLOGENIC	VITELLOGENIC	PRE-VIT.	------
3) ID 2512	SMALL	------	------	-------	YES (1cm)
4) ID 2518	LARGE	VITELLOGENIC	VITELLOGENIC	PRE-VIT.	------
JUNE 1987					
1) ID 2509	LARGE	VITELLOGENIC	-----	PRE-VIT.	------
2) ID 2511	LARGE	VITELLOGENIC	-----	PRE-VIT.	------
3) ID 2512	SMALL	----	-----	PRE-VIT.	YES
4) ID 2518	LARGE	VITELLOGENIC	-----	PRE-VIT.	------
NOV. 1987					
1) ID 2509	LARGE	VITELLOGENIC	PRE-VIT.	PRE-VIT.	------
2) ID 2511	LARGE	VITELLOGENIC	VITELLOGENIC	PRE-VIT.	------
3) ID 2512	SMALL	----	PRE-VIT.	PRE-VIT.	------
4) ID 2518	LARGE	VITELLOGENIC	PRE-VIT.	PRE-VIT.	------

We would like to acknowledge support from Sea Grant College Program NA85AA-D-SG128 and Sea Turtles Inc. We would also like to thank Drs. Jim and Fern Wood of the Cayman Turtle Farm for their assistance and support.

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GUT CONTENTS OF LOGGERHEADS: FINDINGS, PROBLEMS, AND NEW QUESTIONS

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During the past few months we initiated a study of sea turtle gut contents collected from turtles stranded on Cumberland Island, Georgia, and the shore of Rhode Island during the period 1979 to 1988. To date, we have examined in detail contents from only 137 loggerheads from Georgia, but the preliminary findings have generated many questions concerning the feeding biology of loggerheads, including the relationship of gut contents to actual intake of food items, whether feeding occurs on the bottom or in the water column, and the relationship of gut contents to shrimping by-catch. In addition, the findings will contribute to our knowledge of feeding locations, behavior of sea turtles, and their possible vulnerability to ingestion of toxic materials and debris.

Most of the gut contents we have collected were washed over fine screens and dried. Soft parts were preserved in formalin or alcohol. The dried samples each contain up to many thousands of fragments. Although we are only in the preliminary stages of this study, we can state that gut items noted during necropsies on the beach did not adequately describe the actual contents as revealed by close scrutiny in the laboratory. Many small items are missed at necropsy, as are unfamiliar materials or non-food items that may be coated with food or modified by digestive action. Even identification of some plastics is impossible without sophisticated equipment. In short, the challenge of working up hundreds of samples is great, but we feel the results will lead to many important questions of sea turtle biology.

GENERAL FINDINGS

Several generalizations can be made about the gut contents examined to date. First, and of greatest interest to the National Marine Fisheries Service, who support this portion of the work, is that plastics are ingested by some animals, and the amounts vary from microscopic fragments to entire plastic bags and bottles. Some of the plastics are difficult to differentiate from clear, chitinous material without resorting to infra-red spectroscopy, and some are so small that they may have been ingested incidentally with other items. In no case have we noted obstruction of the gut by even the largest plastic items.

Second, crabs are ingested with the most regularity by loggerheads of all sizes, but the number of species represented is relatively small. Calico, purse, spider, and hermit crabs have been most frequently encountered. Pieces of whelk shell are frequent, and whelk opercula are common. Fish bones, scales, and otoliths are relatively common. There are many more mantid shrimp (*Squilla*) than expected, along with other various shrimp species. Barnacles are extremely common, but it is unknown if they are incidentally ingested on other food items or deliberately scraped off of a substrate. Identification of species may help answer that question. There are some pieces of plant material and an occasional gorgonian. A surprisingly large number of micro-mollusca and micro-crustaceans are present in many samples. Many of the mollusks may delineate feeding habitats because some species are microhabitat-specific or limited in geographic range or depth.

The questions developed from our first examinations of the gut material center on feeding behavior, digestive tract processing, and interpretation of findings. A number of studies are needed to answer these questions.

We assumed that loggerheads fed on the bottom, but now have evidence that they may sometimes feed in the water column or at the surface. What is the relative use of the water column? We also see signs of selective feeding (hundreds of hermit crabs in one digestive tract, or many dozens of whelk opercula, sometimes of a single species, other times a spectrum of species). Occasionally, large amounts of dead molluscan material (obviously from the sediments) is found, suggesting accidental (?) engulfing of bottom material. How much incidental material is regularly taken in? Is scraping tunicates and barnacles off substrates a common feeding practice? Are loggerheads attracted to floating debris for the attached fauna?

Some turtles have empty guts, other's intestines are only partially full, while many have the entire gut packed with the remaining hard parts of a large number of prey. Occasionally stomachs and entire guts are packed with an indigestible bryozoan. How often do loggerheads feed? What percentage normally have empty guts during the warmer seasons? How long do hard parts of prey items remain in the gut? Is the material found in the guts of nesting females left from prenesting meals? What are the daily and seasonal feeding patterns of loggerheads? Are diets related to age or sex of the animals?

How do loggerheads actually feed? The frequent occurrence of whelk bodies with attached opercula, but without the accompanying shell, or with very little shell, suggests that many indigestible parts of prey items, and perhaps substrate, are separated in the mouth. Are there a set of specific feeding behaviors related to prey type?

How much gut material can be assigned to by-catch ingestion? What is the seasonal by-catch availability, species composition, and variability? Is there anywhere in the United States that loggerheads strand where by-catch is not an available food subsidy, or are all studies of gut contents of stranded animals biased by additions of by-catch? Can we identify individuals with no by-catch components? Are diet data from one area or season applicable to other areas?

If loggerheads do sometimes ingest large amounts of bottom sediments, how vulnerable are they to heavy metal poisoning? Are areas of silt or dredge spoil particularly dangerous to sea turtles because of their feeding habits? What other pollutants might be included in sediments that sea turtles might ingest?

Finally, we have been unable to differentiate the gut components of five Kemp's ridleys from the loggerhead data. Do ridleys eat the same thing, or are they simply feeding on the same by-catch components, or is our sample too small? Do ridleys and other sea turtles feed differently in different areas? Do they choose particular food items, or take anything that is available?

It is obvious that before the results of our investigations on gut contents can be evaluated, considerable basic biological information on sea turtle behavior and digestive physiology is needed. We urge that such studies be supported by the appropriate governmental agencies charged with protecting these endangered species, and that students of sea turtle biology be encouraged to look at feeding behavior.

SEA TURTLE STRANDING AND SALVAGE NETWORK (STSSN): 1987 RESULTS

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The Sea Turtle Stranding and Salvage Network (STSSN) was formally established in 1980 to collect information on and document strandings of marine turtles along the U.S. Gulf of Mexico and Atlantic coasts. Strandings are defined as turtles which wash ashore dead or alive or are found floating dead or alive (generally in a weakened condition). The network encompasses the coastal areas of the eighteen state region from Maine through Texas, and includes portions of the U.S. Caribbean. Data are compiled through the efforts of network participants who document marine turtle strandings in their respective areas and contribute those data to the centralized STSSN data base. The figures presented are considered minimum stranding figures, as they are reported strandings only, not all stranding events. This paper presents a general summary of 1987 stranding data, complete information can be found in Schroeder and Warner (1988).

A total of 2393 stranded marine turtles were reported during 1987. Of these, 2373 were wild turtles and 20 were known headstarted turtles. Strandings of headstarted turtles are not included in this summary because they may represent a bias if their stranding was an artifact of captive rearing and release. Of the 2373 stranded turtles, 91.4% were dead, 6.4% were alive, and the conditions of the remaining 2.2% were not recorded. Of the 151 live turtles, 31% were released, 27% subsequently died, and the fates of the remaining 64 turtles (42%) are unknown.

State and Regional Distribution

Florida reported the highest number of strandings during 1987, accounting for 35% of the total (9% Florida-Gulf, 26% Florida-Atlantic). Georgia accounted for 14% of the total reported strandings and South Carolina reported the third highest frequency of strandings at 11% (Figure 1). Regionally, 25.0% of all strandings were reported from the Gulf of Mexico (TX, LA, MS, AL, FL-Gulf), 59.6% from the southeast U.S. Atlantic (FL-Atlantic, GA, SC, NC), 14.6% from the northeast U.S. Atlantic (VA, MD, DE, NJ, NY, CT, RI, MA, NH, ME), and 0.8% from the U.S. Caribbean (PR, USVI).

Network-wide, 83.7% of all strandings were classified as offshore strandings and 16.3% were classified as inshore strandings. Offshore strandings are defined as strandings occurring on the ocean beaches, while inshore strandings are those occurring landward of the ocean coastline, primarily in bays and sounds. Effort expended in data collection during 1987 was significantly lower in inshore areas (bays, sounds, etc.) of the Gulf of Mexico and southeast U.S. Atlantic as compared to offshore effort (ocean beaches). The distribution of reported strandings may not reflect the true inshore/offshore distribution of total mortality in the Gulf and southeast U.S. regions.

Species Composition

Throughout the network region, loggerheads (*Caretta caretta*) were the most frequently stranded species making up 73.3% of the total. Kemp's ridleys (*Lepidochelys kempi*) were the second most frequently stranded species at 9.1%; green turtle (*Chelonia mydas*) strandings comprised 6.6% of the total; leatherbacks (*Dermochelys coriacea*) accounted for 5.7% of all reports; and

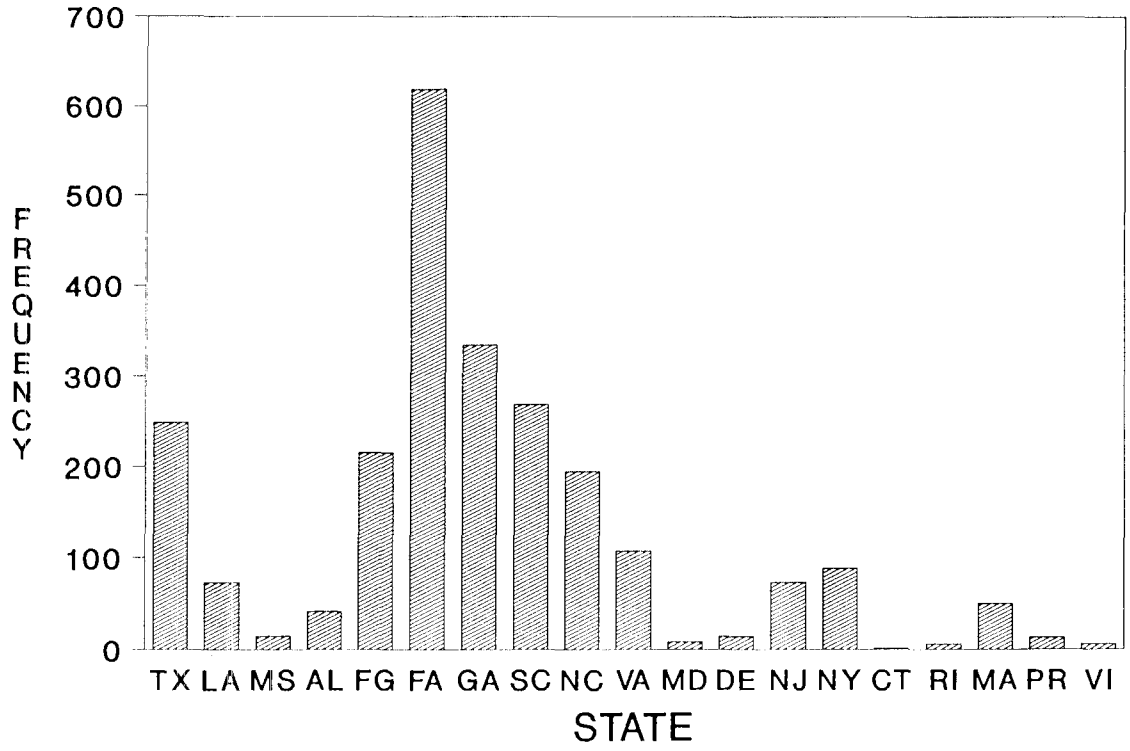

Figure 1. Marine turtle strandings reported from the U.S. Atlantic, Gulf of Mexico, and Caribbean by state or territory during 1987. FG = Florida - Gulf, FA = Florida - Atlantic.

hawksbills (*Eretmochelys imbricata*) were reported least frequently making up 1.2% of the total. Turtles not identified to species accounted for 4.1% of all reports.

Network-wide, leatherback, loggerhead, and green turtle strandings increased 123%, 43%, and 18% over 1986, respectively. Leatherback strandings increased in the southeast and northeast U.S. and decreased in the Gulf of Mexico. Strandings of leatherbacks in Florida-Atlantic and Georgia increased from 7 in 1986 to 47 in 1987. These were primarily centered around the Georgia/Florida border. In New Jersey and New York, leatherback strandings rose from 14 in 1986 to 57 in 1987. Loggerhead strandings increased over 1986 in all regions. The 1987 increase in green turtle strandings occurred principally in the Gulf of Mexico where they rose from 31 in 1986 to 62 in 1987. Strandings of hawksbills and Kemp's ridleys decreased 37% and 36%, respectively, over 1986 for all regions combined. The decrease in Kemp's ridley strandings occurred only in the western Gulf of Mexico, where ridley strandings dropped from 239 in 1986 to 79 in 1987. In the eastern Gulf of Mexico and the remaining regions, Kemp's ridley strandings increased over 1986 levels.

Monthly Distribution

In the Gulf of Mexico region, strandings occurred during all months, with peaks during the period April - June. Stranding levels were lowest during the months of January and February. In the southeast U.S. Atlantic, strandings began increasing in April, peaked in June, and gradually decreased through December. In the northeast U.S. Atlantic, 97% of all strandings were reported during the last six months of the year with peaks in June and August.

ACKNOWLEDGEMENTS

The STSSN is possible only through the efforts and dedication of the hundreds of network participants who document and compile records of stranded marine turtles. Sincere thanks to all contributors during 1987. Amy Warner served as the data entry coordinator during 1987, her efforts are greatly appreciated.

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STYROFOAM BOX AND BEACH TEMPERATURES IN RELATION TO INCUBATION AND SEX RATIOS OF KEMP'S RIDLEY SEA TURTLES

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The international program to restore and enhance the Kemp's ridley sea turtle (*Lepidochelys kempi*) population and establish a secondary breeding population of this species at Padre Island National Seashore (PAIS), Texas began in 1978. Each summer approximately 2,000 eggs (20 clutches) were collected at Rancho Nuevo (RN), Mexico, packed in Padre Island sand in styrofoam boxes and shipped to PAIS. The boxes were placed on shelves in a concrete building at Rancho Nuevo prior to shipment and then in a screen-enclosed shed at PAIS. Beginning in 1982, ambient shed and incubation box temperatures were commonly measured twice daily (usually maximum and minimum) and bihourly for a 24-hour period once a week at Rancho Nuevo and hourly each day at PAIS.

Incubating eggs of other sea turtle species in styrofoam boxes has, in some instances, subjected the eggs to slightly different thermal regimes than those occurring under natural conditions and had a masculinizing effect on the embryos. Wibbels et al (in prep.) found that 1978-1984 year-class *L. kempi* eggs incubated in styrofoam boxes produced males and females annually, but that males predominated much of the time (Table 1). They concluded that the average incubation temperature available during the critical sex determining period must have been slightly below the natural pivotal temperature (that which produces a 50:50 male to female sex ratio) of the population.

Table 1. Results of incubation and analysis of sex ratios of 1978 - 1987 year class Kemp's ridley sea turtle eggs sent to Padre Island National Seashore.

Year	Number eggs received	Percent hatched	Mean incubation period (days)	Number identified to gender[a]	Percent female
1978	2,191	88.1	51.5	32	34.4
1979	2,053	85.7	52.0	22	40.9
1980	2,976	84.1	50.5	0	-
1981	2,279	83.3	48.3	4	100.0
1982	2,017	77.6	51.0	94	31.9
1983	2,006	12.1	52.0[b]	12	50.0
1984	1,976	90.7	51.1	159	28.3
1985	1,978	84.1	48.8	156	53.8
1986	2,011	88.3	46.7	53	83.0
1987	2,001	64.3	47.6	516	99.6

[a]Using gonadal histology, necropsy, laparoscopy, tail length evaluation or serum testosterone assays
[b]Calculated based upon the 9 clutches that hatched

Temperatures for incubating eggs of the 1985-1987 year-classes were intentionally raised in an attempt to increase the proportion of females produced. At both RN and PAIS, eggs were placed on upper level shelves (as space permitted) where ambient temperatures were warmer than those recorded at lower shelf heights. The Rancho Nuevo egg house door was left closed and the windows were often covered. The walls of the PAIS incubation shed were covered with plastic sheeting and bamboo shades to trap heat and a heater was run nightly to moderate excessive fluctuations in temperatures. Mean ambient temperature at top shelf height in the PAIS shed was significantly lower during the 1984 incubation season (mean = 28.0°C, SD = 1.8°C, n = 116) than during the 1985 (mean = 31.1°C, SD = 2.8°C, n = 569) ($t = -15.1965$, $df = 683$, $P < 0.01$), 1986 (mean = 30.0°C, SD = 2.5°C, n = 945) ($t = -10.5013$, $df = 1059$, $P < 0.01$) and 1987 (mean = 30.0°C, SD = 2.3°C, n = 504) ($t = -9.9543$, $df = 618$, $P < 0.01$) seasons. Because incubation temperatures cycle with ambient temperatures, the recorded incubation temperatures of 1985-1987 were higher than those of previous years. The mean incubation period for clutches of the 1984 year-class was significantly longer than that for clutches of the 1985 ($t = 4.8049$, $df = 37$, $P < 0.01$), 1986 ($t = 12.2299$, $df = 39$, $P < 0.01$) and 1987 ($t = 6.7541$, $df = 37$, $P < 0.01$) year-classes (Table 1). Apparently the warmer incubation temperatures of the 1985-1987 year-class clutches shortened incubation periods and increased percentages of females produced. A

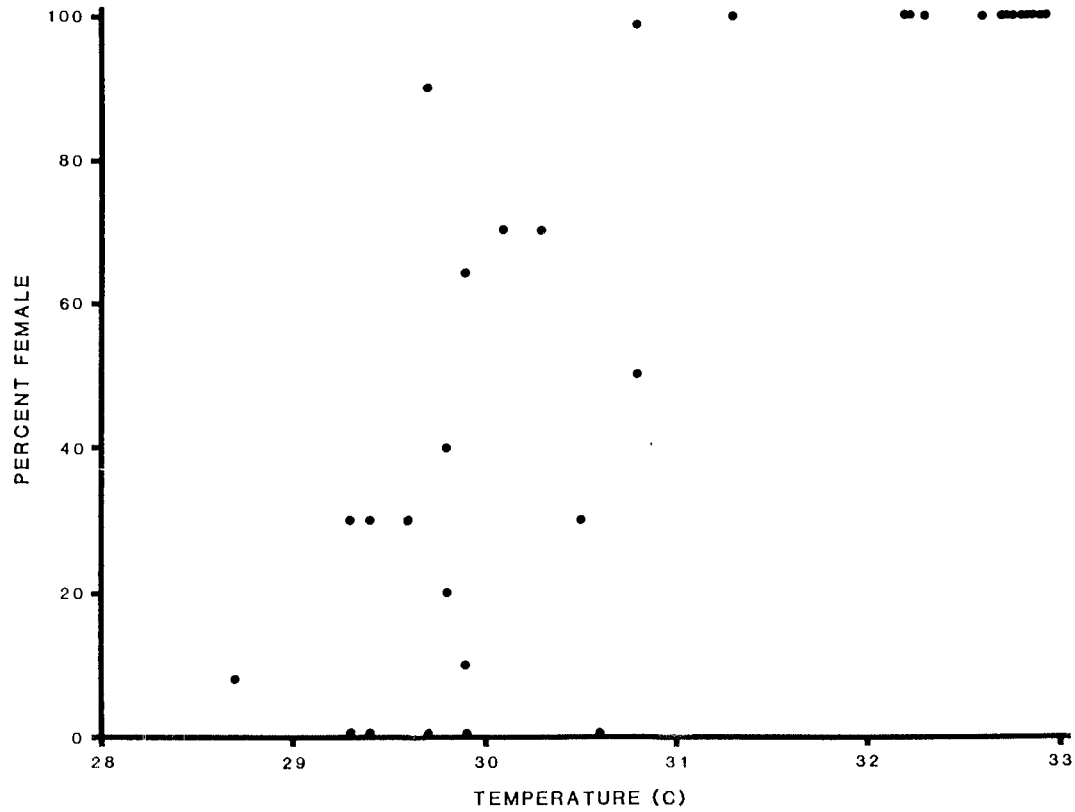

Figure 1. Kemp's ridley sea turtle mean middle third of incubation period temperatures in relation to percent of females from 1982 - 1987 clutches in which 10 or more individuals were positively identified to gender.

preponderance of the dead hatchlings, late-staged embryos and stranded yearlings examined from the 1985-1987 year-classes were identified as females. Of all specimens identified to gender, 53.8% of the 1985 year-class (n = 156), 83.0% of the 1986 year-class (n = 53), and 99.6% of the 1987 year-class (n = 516) were female.

Mean temperatures during the middle third of the incubation period and percent females for all 1982-1987 year-class clutches in which 10 or more individuals were positively identified to gender (n = 32) were correlated in an attempt to derive the first estimate of a pivotal temperature for Kemp's ridley (Figure 1). All clutches with mean temperatures exceeding 30.8°C produced100% females. However, a wide range of sex ratios were found in the clutches with lower mean temperatures. Some of the variation probably stems from lack of uniformity in the times that temperatures were recorded at Rancho Nuevo as well as differences in times that temperatures were taken at Rancho Nuevo and Padre Island. Bull (1985) found that the variance of incubation temperatures, as well as mean temperatures, influenced sex determination in *Graptemys* sp. Standora and Spotila (1985) stated that factors other than temperature, such as osmotic stress and O_2 and CO_2 levels, may influence sex within the critical range where a mixture of males and females are typically produced. Limpus et al. (1985) found that in *Caretta caretta* the pivotal temperature may vary from clutch to clutch. The scatter of our data points as well as general paucity of knowledge about the mechanism by which temperature influences sex in sea turtles affects the reliability of inferences drawn about pivotal temperatures for Kemp's ridley. However,

a preliminary analysis of the data on percent female vs. mean incubation temperature during the middle third of the incubation period was performed using only those data points associated with mean middle third temperatures below 31.5°C (n = 20). The best straight-line regression of percent female (Y) vs. mean temperature (X) was $Y = -1297.8747 + 44.7152X$, $r^2 = 0.68$, $P < 0.001$ for $H_0:B' = 0$. When variables were reversed, the equation was recalculated ($X = 29.4457 + 0.0151Y$, $r^2 = 0.68$, $P < 0.001$, $H_0:B' = 0$), from which the pivotal temperature (at which 50% females would be produced) was estimated to be 30.2°C with 95% confidence intervals from 29.9 to 30.5°C. Fitting a variety of sigmoid curves to the data did not improve the fit.

A study of beach temperature profiles was undertaken during the summer of 1986 to examine temperatures at which Kemp's ridley sea turtle eggs would incubate if laid at three locations along PAIS. These temperatures were to be compared with simultaneously measured temperatures at Rancho Nuevo. The three Padre Island sites were located approximately 30 km apart, numbered in ascending order from north to south. Thermocouple probes, placed in the same topographical areas at all study sites, were arranged in six rows ranging from the mid-beach to the middle upslope of the second foredune. Ambient, sand surface and 15, 30 and 45 cm substrate depth temperatures were recorded at PAIS but only ambient, sand surface and 30 cm depth (mid-nest depth) temperatures were monitored at Rancho Nuevo. Temperatures were monitored once a week for a 24-hour period, from noon to noon, with readings made once every 2 h. Simultaneous study dates were scheduled from mid-April to mid-August to collect data for the entire nesting and incubation season. Data were collected on all 18 study dates at PAIS and 11 of those dates at Rancho Nuevo.

During the period when most eggs would be undergoing their middle third of development, June and early July, in the preferred nesting areas (mid-beach to the top of the first foredune) at mid-nest depth, the temperatures at PAIS sites 2 and 3 and the Rancho Nuevo site were not appreciably different. Temperatures at site 1 on PAIS were only slightly cooler than temperatures at the other areas. The estimated pivotal temperature and 95% confidence intervals were plotted with the range of mean temperatures found along the entire beach width on each study date to predict seasonal trends in sex ratios (Figure 2). Clutches undergoing their middle third of incubation early in the nesting season at Rancho Nuevo should produce primarily males, later portions of the season primarily females and the middle of the season a mixture. This is similar to the pattern hypothesized by Standora and Spotila (1985) for this species. Based upon sand temperatures, a similar pattern is expected for the three sites on PAIS.

Evidently the degree of difference in temperatures between natural nests and styrofoam boxes varies with the species (natural nest depth) and individual recovery programs (hatchery conditions). Maximum 30 cm depth and styrofoam incubation box temperatures occurred between 2000-2400 h and minimum temperatures between 0800-1200 h at RN and PAIS. The duration of maximum and minimum temperatures (2-4 h) and daily range of temperatures (1-3°C) were very similar in styrofoam boxes and sand at mid-nest depth. At times, mean temperatures of eggs incubated in styrofoam boxes were higher or lower than those of sand at mid-nest depth. Direct correlations of styrofoam box and beach temperatures cannot be made with accuracy because of the wide range of temperatures available along the entire beach width, the effect of vegetative cover and local weather conditions and the production of metabolic heat by the embryos during the middle and last thirds of development.

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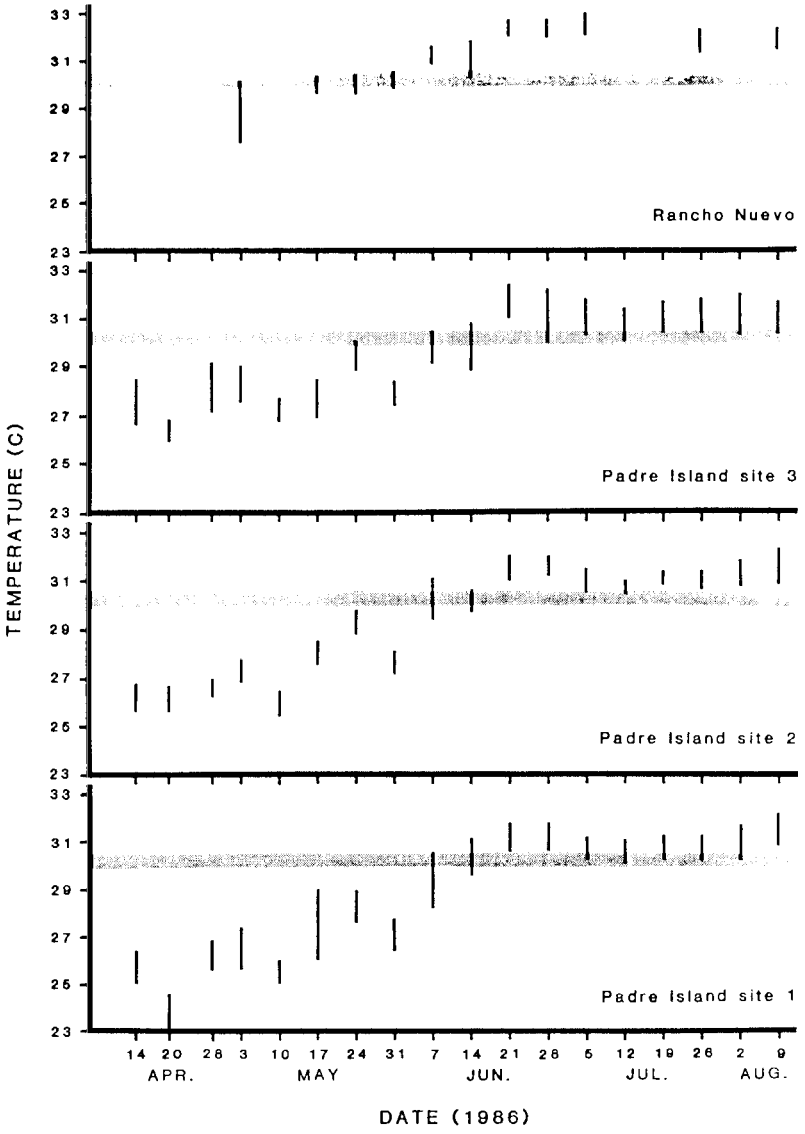

Figure 2. Range of mean 30 cm depth sand temperatures recorded from mid-beach to the middle upslope of the second foredune at three Padre Island National Seashore sites and one Rancho Nuevo site. Shaded area represents the estimated pivotal temperature and 95% confidence intervals.

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KING'S BAY, GEORGIA: DREDGING AND TURTLES

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The building of a billion dollar submarine base adjacent to one of the shallowest pieces of coastline on the eastern seaboard has necessitated a stupendous amount of dredging. King's Bay Naval Base will house our largest class of nuclear sub, the Trident II, which draws 40' of water when at the surface and is capable of speeds in excess of 40 knots submerged. The base is situated on the Georgia mainland and filled in marsh west of Cumberland Island (a National Seashore) and is the endpoint for a 50' deep, 500' wide channel which cuts through 13+ miles of sloping seafloor, from seabuoy to beach, reaches through the St. Mary's River entrance and runs 6+ miles through the estuarine waters of Cumberland Sound. The 130 million dollar excavation (and subsequent maintenance) will eventually remove over 150 million cubic yards of material from the area, approximating half the amount of material removed during construction of the Panama Canal.

This undertaking has pitted the industry's largest dredges against some of the most endangered marine animals: the North Atlantic right whale, the Kemp's ridley, loggerhead, and Atlantic green turtles, the manatee, and the shortnose sturgeon. In fact, the channel slices through the heart of the right whale's calving ground while the adjacent beaches of Cumberland and Amelia Islands provide for as many as 250 loggerhead nests each summer. Concerning Section 7 of the Endangered Species Act of 1973, commercial dredging companies answer to the Army Corps of Engineers (COE), who in turn consult with the National Marine Fisheries Service. The COE contract with the dredging companies require that all split-hull, trailing suction dredges (i.e., hopper dredges) carry two observers at all times to monitor impact on endangered species. Observers are hired through the University of Georgia, Institute of Ecology. Dr. James Richardson administers the program. This monitoring has been particularly geared toward sampling the take of sea turtles to avoid duplicating incidents such as the documented take of 71 loggerheads by a hopper dredge at the Canaveral Ship Channel in 1981.

While other dredges operate from a basically stationary position, hopper dredges dig at speeds of 1-4 knots, moving along like a gigantic vacuum, trailing a dragarm (30" diameter steel pipe) from either side of their 200 - 300' hulls. At the end of these dragarms are attachments called dragheads which measure 8 - 10' across and weigh several tons. Through the draghead is sucked the ocean floor and river bottom. The material is pulled up the dragarms, through the massive impellers of the ships pump engines and deposited in the hopper basin which displaces most of the vessel's area. Some dredges may pump over 4000 cubic yard of sediment (400 dumptruck loads) into the hopper in less than two hours. As the hopper is being filled, heavy material sinks to the bottom while light silt and water continually drain overboard. The screening of this overflow has been the primary method for sampling the take of sea turtles.

We have encountered two basic designs for draining the hopper: 1) At the forward end of the hopper are two funnel-like skimmers, approximately 7' across at the mouth. These can be raised or lowered to maintain a desired water level in the hopper. This method is often used in tandem

with lateral overflow which means the water simply washes over the sides of the hopper basin, falls onto a lower spill deck, then back into the sea. 2) This configuration employs two square ports, approximately 8' by 10', in the hopper's forward bulkhead, through which water and silt drain. Huge steel louvres regulate rate of flow. Across each of these square ports a steel-mesh cage has been welded. From the bottom half of this cage a steel mesh basket is extended which serves to trap objects suspended in the water/silt as it drains from the hopper. This proves effective for sampling objects neutrally buoyant or lighter as well as objects kept suspended by the water turbulence in the hopper. Similarly, the funnel-like skimmers are screened by steel mesh welded in place just below their opening, thereby trapping crabs, fish, any number of benthic dwelling creatures and occasionally pieces of sea turtle. Observers repeatedly check the basket or the skimmer screens and after the hopper is loaded, retrieve and document what has been collected. Thus far at King's Bay, lateral overflow has gone unscreened and skimmers are often only partially screened. Given this, and the fact that many turtle parts may sink to the bottom of the hopper with the heavy sediment, it is questionable that a representative proportion of turtle remains are being sampled.

Other checkpoints scrutinized by observers include the ventral side (the opening) of the dragheads and the surface of the hopper sediment after loading. The openings of the dragheads are sometimes grated with steel bars spaced from a few inches to several feet apart and though on two occasions turtle parts have been found lodged in the mouth of the draghead, it is more probable that, depending on the spacing of the bars, turtles are pulled through the system or wash clear of the draghead when the suction pumps are shutdown prior to bringing the dragarms to the surface.

The aforementioned tasks are performed by an observer after the dredge is loaded and headed to one of the dumpsites 7 - 10 miles south of the channel or to the pumping station used for beach renourishment. The other observer maintains a bridge or bow watch using binoculars. This is a crucial duty during the right whale calving season because hopper dredges in transit to the dump travel at 10 -12 knots, almost twice the top speed of the nearly extinct whale. Data gathered by the New England Aquarium's right whale research team over the past nine years suggests that ship collision is a major cause of mortality among this species. Two sightings of right whales have been documented by observers aboard the dredges. On one of these occasions the dredge had to change course to avoid possible collision with the whale. A realistic night watch has proved problematic, even light gathering scopes provided by the Navy.

The documented take of sea turtles at King's Bay thus far (February 1988): 10 juvenile loggerheads, 1 adult loggerhead, and 1 juvenile green. Considering the amount of dredging being done at King's Bay, this number is surprisingly low and does not indicate a significant impact on turtle populations. However, due to the inability to accurately project actual take from sampled take, such an assumption cannot be made without serious reservation.

Update: November 1988 - Since its completion in July, an estimated 750,000+ cubic yards of material has filled in parts of the channel. Emergency dredging is currently being done in anticipation of the arrival of the first Trident II submarine, as early as December 25, 1988. The situation suggests that maintenance dredging at King's Bay will be a never ending process. Therefore it is extremely important that the observer program be well coordinated (observers are now hired individually by the dredging company) and that techniques for monitoring the impact on endangered species be effective. Any problems need to be addressed now. Between October 28 and November 30 there has been one confirmed sighting of a right whale in the channel and one unconfirmed sighting of two right whales near the dumpsite. In the same time period there have been two confirmed takes of Kemp's ridleys aboard the dredges working in the St. Mary's entrance channel. Given the precarious existence of both species, corners should not be cut in efforts to ensure their survival. It should also be noted that there was no loggerhead nesting activity this

summer on a 7000' section of Amelia Island's beach which had been recently renourished. Although it could not be determined why turtles did not crawl in this section, severe beach compaction rendered the habitat unsuitable for sea turtle nesting.

SWIMMING PERFORMANCE OF HEAD STARTED KEMP'S RIDLEY SEA TURTLES

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Kemp's ridley hatchlings are reared in captivity (head started) at the National Marine Fisheries Service Southeast Fisheries Center's Galveston Laboratory for 10 months to increase survival, optimize growth and thereby reduce post-hatching mortality (Fontaine et al. 1985). However, recent (1985 and 1986) head start year classes exhibited accelerated growth and became extremely cramped in their rearing containers prior to release. Rapid growth and confinement of captive reared ridleys might render them less physically fit than their wild counter-parts because mobility is subsequently reduced as anatomical dimensions increase (Caillouet et al. 1986). The objective of the research reported herein was to conduct stamina tests to measure swimming performance of exercised and non-exercised head started Kemp's ridleys.

Thirty experimental turtles selected from one clutch were randomly assigned a plastic carton (30.5 cm wide X 32.7 cm long X 24.1 cm deep) or plastic bucket (24 cm deep X 26.2 cm inside diameter) rearing container, housed in a single raceway. Each type of container housed 15 experimental turtles. Experimental turtles were randomly assigned to one of three exercise categories. Categories included: (1) 10 turtles exercised twice weekly (Monday and Wednesday) and subjected to weekly stamina testing (Friday); (2) 10 turtles exposed only to weekly stamina testing (Friday); and (3) 10 non-exercised controls exposed to a single stamina test at the end of the study (17 April 1987). Swimming performance of Kemp's ridley hatchlings was measured in exercise and stamina tests conducted in a recirculating 46.4 cm wide X 210 cm long X 59.2 cm deep laminar flow tank. Current speeds produced in the tank ranged from 0 to 120 cm/sec. Turtles were acclimated in the test section of the flow tank 2 min prior to exposure to current flow.

Each turtle to be exercised (category 1) was placed in the flow tank test section twice weekly (Monday and Wednesday). Exercise was provided by setting water velocity at a rate which turtles would orient to and swim against. Exercise duration for each turtle was gradually increased from 5 to 30 min over 15 wk (Table 1). Exercise duration for the last 6 wk of the 21 wk study was 30 min. Initial exercise current speed of 12 cm/sec was gradually increased to 42 cm/sec over a 21 wk period (Table 1).

Stamina tests were conducted each Friday to examine differences in turtle fitness created by exercise regimen and/or rearing container. Stamina was defined as the time a turtle maintained its swimming position in current of known velocity. Stamina tests began by gradually increasing water velocity above exercise velocity. All stamina tests lasted for 10 min, unless the turtle was swept back against the downstream wire screen of the flow tank and exhibited no controlled

swimming motion. Tests were terminated after 5 min of inactivity. Weekly stamina tests were performed on all turtles (categories 1 and 2) except controls (category 3). All turtles, including controls, were exposed to a final stamina test on 17 April 1987. Current speeds during stamina tests began at 16 cm/sec and were increased 2-6 cm/sec biweekly (Table 1).

Table 1. Weekly duration and current speed regimen deployed in exercise sessions and stamina tests.

EXERCISE SESSION			STAMINA TEST		
Date	Duration (min)	Velocity (cm/sec)	Date	Duration (min)	Velocity (cm/sec)
11/24-26	05	12	11/28	10	16
12/01-03	05	16	12/05	10	20
12/08-10	05	20	12/12	10	26
12/15-17	05	22	12/19	10	26
12/22-24	10	24	12/26	10	30
12/29-31	10	26	01/02	10	30
01/05-07	10	28	01/09	10	32
01/12-14	10	30	01/16	10	32
01/19-21	15	30	01/23	10	34
01/26-28	15	30	01/30	10	34
02/02-04	20	30	02/06	10	36
02/09-11	20	30	02/13	10	36
02/16-18	25	30	02/20	10	38
02/23-25	25	30	02/27	*	*
03/02-04	30	30	03/06	10	40
03/09-11	30	34	03/13	10	44
03/16-18	30	34	03/20	10	44
03/23-25	30	38	03/27	10	48
03-30/04-01	30	38	04/03	10	48
04/06-08	30	42	04/10	10	52
04/13-15	30	42	04/17	10	52

* equipment malfunction

Swimming performances were quantified in terms of the amount of time spent swimming inefficiently and efficiently during each testing period beginning 5 January 1987. Inefficient swimming was defined as: (1) non-swimming periods longer than 2 sec, (2) periods of non-orientation into current, and (3) lack of front flipper movement. Swimming into the current with asynchronous and/or synchronous movements of the front flippers constituted efficient swimming (ES) periods. ES was analyzed by: (1) total time of efficient swimming (TES) in a test period, and (2) longest interval of efficient swimming (LES) during a test period.

Swimming data were analyzed by designating 25, 50, 75 and 96% of test duration (10 min) as performance levels. The upper limit was calculated from the mean swimming performance level of the best swimming hatchling from a randomly selected month. The number of category 1 and

2 turtles achieving each performance level by TES and LES standards was calculated for the 14 stamina test periods. Category 3 turtles (non-exercised controls) were excluded from statistical analyses because all turtles failed to achieve performance levels. Data, segregated by performance levels, were subjected to log linear model analyses to test the interaction and independence of test date, rearing container and exercise category (Sokal and Rohlf 1981). Non-significance ($P > 0.05$) of the interaction revealed each variable could be treated and analyzed independently by chi-square tests.

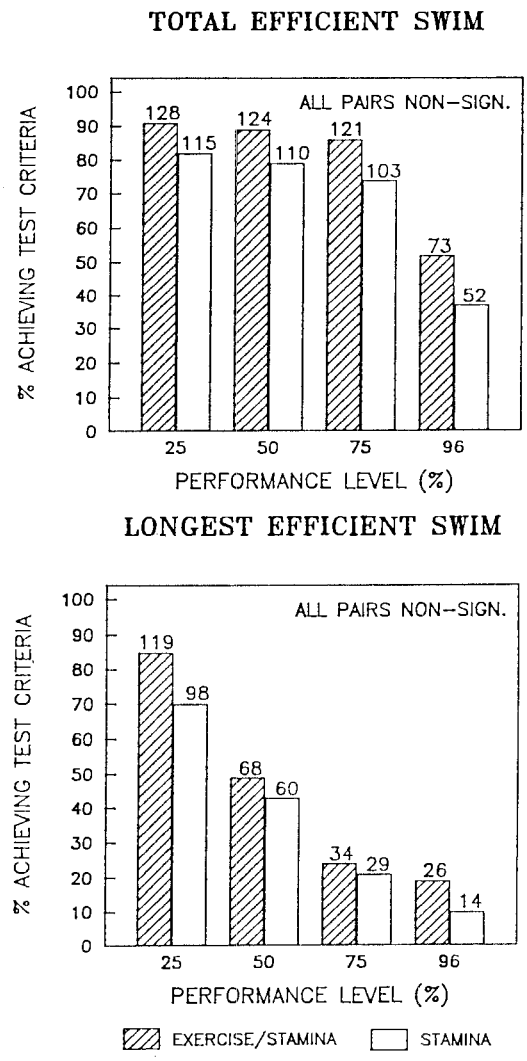

Figure 1. Percentage of category 1 (exercise/stamina) and category 2 (stamina) turtles achieving performance levels by total efficient swimming (top) and longest efficient swimming (bottom) criteria (non-significant $P > 0.05$; each bar is labeled with the number of turtles achieving test criteria out of a possible 140).

Test date did not have a significant ($P > 0.05$) effect on swimming performance at any level. Similarly, no statistical difference ($P > 0.05$) was found between category 1 and 2 turtles at any performance level by TES and LES standards. The number of exercised turtles (category 1) achieving each performance level was higher than that for hatchlings exposed only to weekly stamina tests (Figure 1).

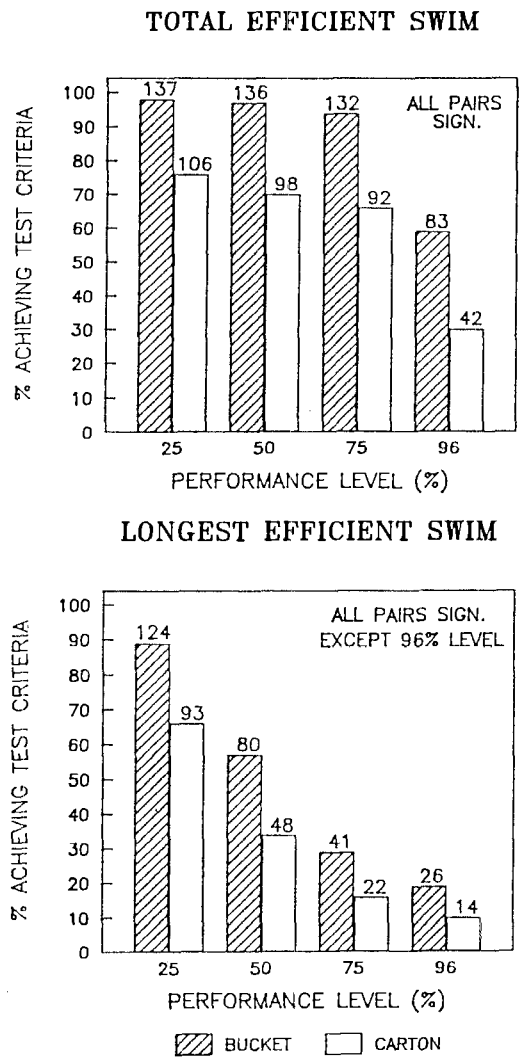

Figure 2. Percentage of bucket and carton reared turtles achieving performance levels by total efficient swimming (top) and longest efficient swimming (bottom) criteria (significant $P \leq 0.05$; each bar is labeled with the number of turtles achieving test criteria out of a possible 140).

A significant difference ($P > 0.05$) was found between bucket and carton reared hatchlings at all performance levels measured by TES and LES criteria, except the 96% LES level. Consistently, more bucket reared hatchlings achieved performance levels than did carton reared conspecifics (Figure 2).

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DEBRIS INGESTION BY SEA TURTLES ALONG THE TEXAS COAST

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Sea turtle strandings along the Texas coast are documented by the National Marine Fisheries Service (NMFS) Southeast Fisheries Center's (SEFC) Sea Turtle Stranding and Salvage Network (STSSN). Texas A&M University graduate students are employed by NMFS to survey 295 km of Texas beach from Sabine Pass at the Texas/ Louisiana border south on to Matagorda Island. These STSSN surveys are currently conducted biweekly. Turtles which strand alive are taken to the NMFS Galveston Laboratory for care and rehabilitation. Dead turtles are returned to Texas A&M University at Galveston (TAMUG) for necropsy and food habit analyses.

Necropsies are performed on all turtle carcasses, condition permitting, in an attempt to determine cause of death and gather life history information. The gastrointestinal (GI) tract is removed during necropsy for later food habit analysis. Contents of each GI tract are fixed in formalin, sorted by type and, in the case of natural food items, identified to the lowest possible taxon. Occurrence and total wet weight are recorded for each food item.

Beach debris surveys are conducted in conjunction with stranding surveys to characterize and quantify debris on Texas beaches. Debris was defined as any man-made or processed material (such as lumber). Permanent survey plots were established at randomly selected sites to monitor debris accumulation over time, while replicate survey plots were randomly selected during each survey on respective beaches. All debris was removed from each plot and subsequently identified, counted and weighed. Thirty debris plots were examined in this study.

Two hundred and sixty-nine turtle strandings were documented along the Texas coast during 1 January 1986 - 31 October 1987. One hundred and seventy-three turtles were found in 1986 and ninety-six in 1987. Of the turtles documented, Kemp's ridley sea turtles (*Lepidochelys kempi*) made up 46.5% (125), loggerheads (*Caretta caretta*) accounted for 32.3% (87) and three lesser abundant species (*Dermochelys coriacea*, *Chelonia mydas*, *Eretmochelys imbricata*) along with unidentifiable carcasses comprised the remaining 21.2% (57).

Seventy-three turtles analyzed for food habits included 37 ridleys (50.7%), 34 loggerheads (46.6%) and 2 greens (2.7%). Contents of 49 GI tracts have been completely sorted, with both natural food and debris items identified. The remaining 24 tracts have undergone preliminary analysis to determine only presence and type of man-made debris.

Debris was ingested by 32.9% (24) of all turtles examined. Yearly analysis indicated that 26.8% (11 turtles) and 40.6% (13 turtles) of the 1986 and 1987 stranding stocks, respectively, exhibited

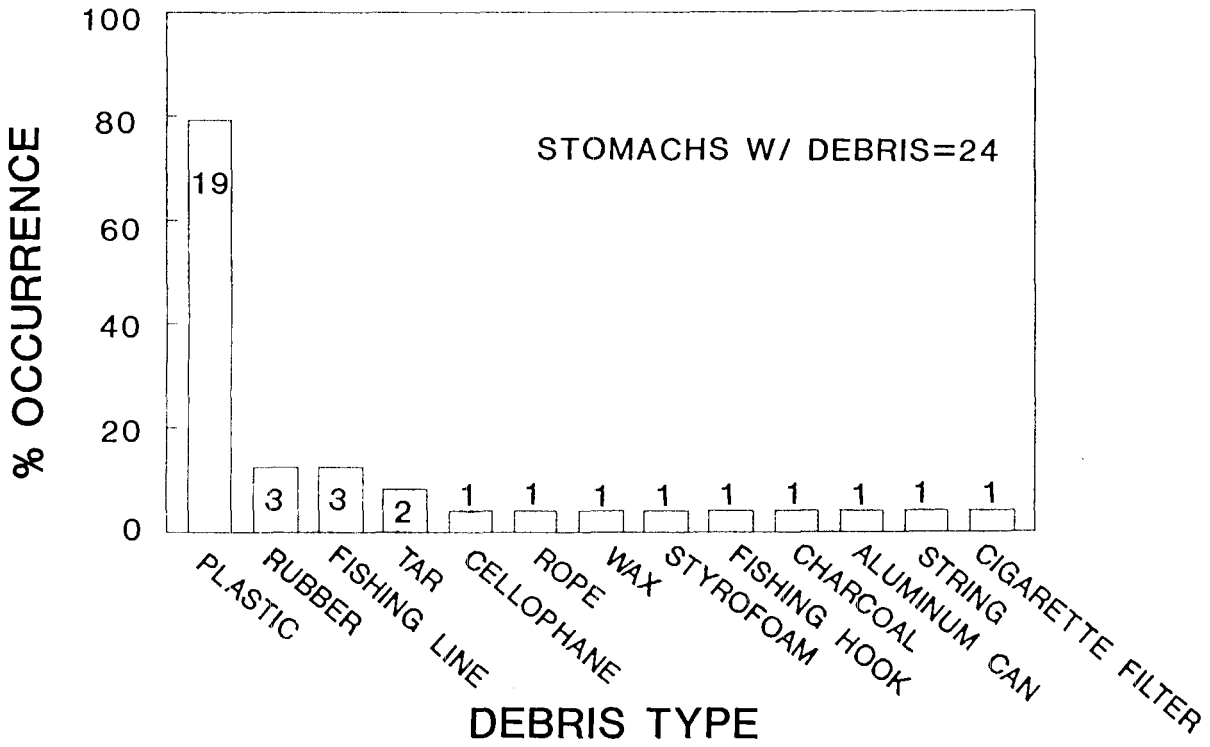

Figure 1. Percent occurrence of debris in all turtles.

debris in their gastrointestinal tracts. Debris ingestion varied by species, with both greens, 41.2% (14) of the loggerheads and 21.1% (8) of the ridleys containing foreign material. Debris was present in 24.0% (6) and 16.7% (2) of the ridleys examined from 1986 and 1987, respectively. Loggerheads ingesting debris increased from 26.7% (4) in 1986 to 52.6% (10) in 1987. Loggerheads' apparent greater susceptibility to debris ingestion could be due to indiscriminate feeding or their inability to distinguish between particular debris items (plastic) and natural foods such as jellyfish (Carr 1987).

Debris ingested by stranded turtles included plastic, rubber, fishing line, tar, cellophane, monofilament rope, wax, styrofoam, a fish hook, charcoal, an aluminum can, string, and a cigarette filter. Items occurring in at least 10% of these turtles (Figure 1) included plastic (79.2%), rubber (12.5%) and fishing line (12.5%). Plastic was the most frequently occurring debris item during both years (72.7% in 1986 and 84.6% in 1987) and among species (ridleys - 75.0%; loggerheads - 78.6%; and greens - 100%).

Beach debris was used as a measure of marine debris since it could be monitored and a major portion of the beach debris represents material that will be incorporated into the marine environment. Major debris categories identified during beach surveys included plastic, tar, glass, styrofoam, rubber, metal, paper, processed wood (lumber), natural debris, and miscellaneous debris. Natural debris includes accumulations of crab, fish or shrimp remains as occurs in shrimp bycatch. Miscellaneous debris was any unidentifiable material or items which could not be placed in an individual category. Plastic and tar were the most frequently encountered debris categories in survey plots, occurring in 29 (96.7%) and 28 (93.3%) of 30 plots, respectively (Figure 2). Other debris categories were observed in 35 to 80% of all survey plots.

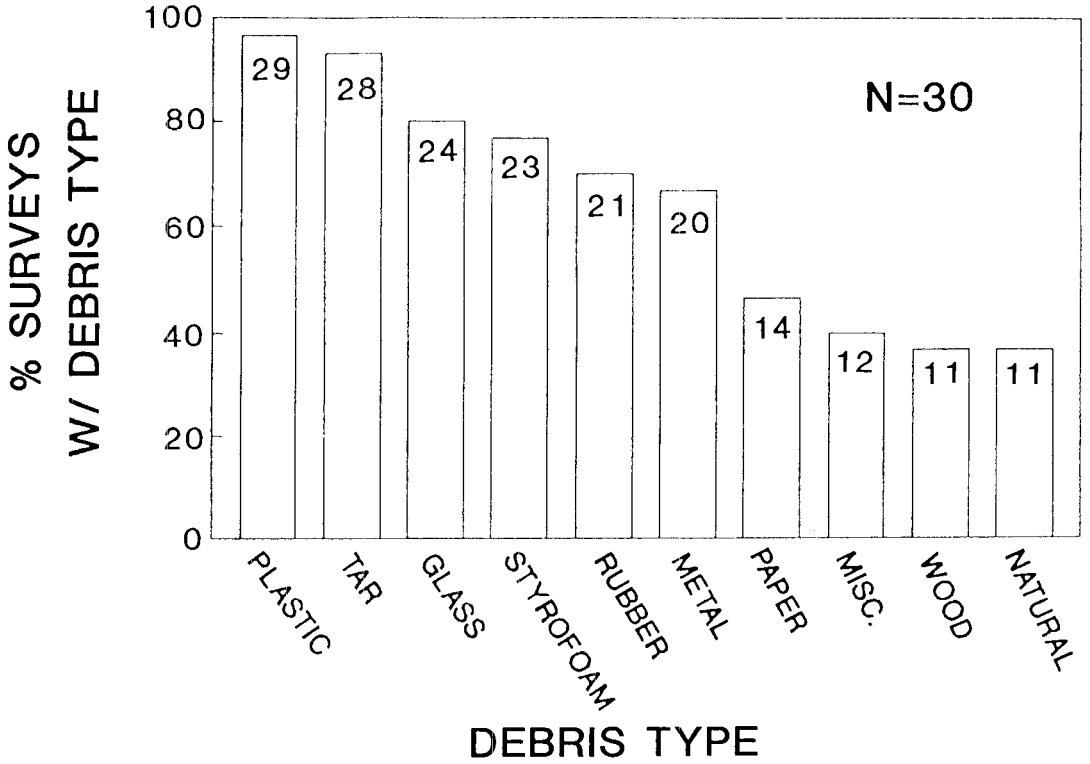

Figure 2. Occurrence of debris in beach plots.

Approximately 85% of the debris categories found in turtles were recorded during beach debris surveys. These categories include plastic, rubber, fishing line, tar, cellophane, mono-filament rope, wax, styrofoam, aluminum cans, string, and cigarette filters. There appears to be a correlation between the percent occurrence of debris in turtles and that on beaches. Plastic exhibited the highest occurrence in stomachs (79.2%) as well as on beaches (96.7%). Tar also occurred frequently on beaches but, due to its negative buoyancy, was less available as a food item and thus seen less frequently in turtles. This indicates an impact by man on sea turtles through the deposition of debris on beaches and in the marine environment.

Seventy-two different natural food items were found in the 49 turtles examined. Natural food items with the highest percent occurrence included saprophytic gastropods (*Nassarius* sp. - 69.4%), bony fish remains (Class Osteichthyes - 61.2%), tube worms (*Diopatra* sp. - 53.1%), blue crabs (*Callinectes* sp. - 44.9%), calico crabs (*Hepatus* sp. - 34.7%), and purse crabs (*Persephona* sp. - 34.7%). Slight variation was seen in frequency of occurrence between years, with the greatest differences exhibited by blue crab, calico crab and tube worm.

Natural food items found in stomachs indicate similar feeding trends for ridleys and loggerheads. Small differences may be due to contrasting abilities of each species to identify and/or capture prey. Differences in feeding trends observed between years are likely due to availability of particular food items (crabs and tube worms) based on conditions occurring each year.

Further research needs to be conducted concerning the ingestion of debris by sea turtles and man's impact on these endangered species.

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SEA TURTLE NEST PROTECTION ON UNITED STATES AIR FORCE BEACHES

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The United States Air Force uses large tracts of land for bases that support runways or target ranges to practice and hone the skills necessary to carry out its national defense mission. As stewards of land held in trust for the American people, the Air Force must safeguard natural resources, including protecting endangered and threatened species.

Four bases are involved in sea turtle protection: Cape Canaveral Air Force Base (AFB), Eglin AFB, Patrick AFB, and Tyndall AFB. Three of these employ biologists specifically to protect sea turtles and their nesting habitat, and one, Patrick AFB, has contracted for nesting surveys and management recommendations. The goal is to protect nests and to increase hatchling production on Air Force beaches.

Cape Canaveral Air Force Base

Cape Canaveral AFB is located in Brevard County and includes approximately 21 km of beach. The beach is a rapidly rising stretch of sand, less that 10m wide, ending in coastal dunes. Before 1983, hatchling productivity was low due to hundreds of nest depredations each year.

In 1983, nest destruction by raccoons was estimated as high as 66% per kilometer of beach (Provancha and Hinkle 1984). A program was initiated to monitor the turtle activity and develop a management strategy. Now the program includes daily monitoring and marking of nests, screening as many nests as possible, and trapping and shooting raccoons and feral pigs. As a result, depredations by raccoons have been drastically reduced and hatching success has markedly increased. Nesting activity is summarized in Table 1.

Of 668 *Caretta caretta* nests marked in 1984, 577 (84%) were destroyed by raccoons. In 1985, with an active protection program, 792 (66%) of 1199 nests were destroyed by raccoons. However, 129 other nests were lost to feral pigs. In 1986, only 12% of 1442 nests were destroyed by raccoons, but 641 nests were lost to feral pigs. The total depredation rate in 1986 was 56%. In 1987, 176 feral pigs and 135 raccoons were trapped and removed prior to the nesting season. The depredation rate on *Caretta* nests fell to 6% for raccoons (81 nests) and 8% for feral pigs (106 nests) for an overall depredation rate of 14% (190 of 1248 marked nests).

Eglin Air Force Base

Eglin AFB occupies the southern halves of Okaloosa, Santa Rosa, and Walton counties in the panhandle of Florida. The beach, totalling 35 km on Santa Rosa Island is wide with a gradual slope ending in moderately high dunes. Aerial surveys in 1976-1977 indicated only seven sea urtle crawls in Okaloosa and Santa Rosa counties. A 1982 survey on Eglin AFB discovered eight nests and two false crawls. In 1986, 11 nests were marked in one month on the base. Consequently, a program to protect the nests was formalized in 1987 with the hire of a fulltime turtle biologist at Eglin AFB.

Although depredations are rare, all nests are screened. Despite this, one nest was destroyed by domestic dogs in 1987. However, the amount of turtle activity appears to be increasing. Nesting activity is summarized in Table 1.

Table 1. Summary of sea turtle nesting activity (number of nests recorded) on U.S. Air Force beaches (by base) 1982 - 1987. ND = No data, IS = Incomplete survey.

	TYNDALL AFB	EGLIN AFB	CAPE CANAVERAL AFB	PATRICK AFB
1982:				
C. caretta	4	ND	ND	ND
C. mydas	0	ND	ND	ND
1983:				
C. caretta	7	ND	IS	ND
C. mydas	0	ND	IS	ND
1984:				
C. caretta	8	4	IS	ND
C. mydas	0	0	IS	ND
1985:				
C. caretta	15	5	1200	ND
C. mydas	0	0	24	ND
1986:				
C. caretta	13	11	1442	654
C. mydas	0	0	10	0
D. coriacea	0	0	1	0
1987:				
C. caretta	9	20	1284	569
C. mydas	0	1	13	10

Patrick Air Force Base

Patrick AFB is located in Brevard County, 19 km south of Cape Canaveral. The beach is narrow, 2-5m wide, with intermixed dunes and seawalls. In 1986, a survey of nesting activity noted over 600 nests. Most nests were destroyed by tidal flooding since the turtles were unable to nest above the eroded dune line. Dune restoration, initiated in 1987, is designed to allow access to the upper dune area by turtles while guarding against sand erosion. A summary of nesting activity is included in Table 1.

Tyndall Air Force Base

Tyndall AFB is located in southeastern Bay County and includes 11km of still largely wild beach. Broad, flat expanses of sand occur along Crooked Island but rise rapidly 4-20m to high dunes.

Table 1 summarizes results of annual nesting surveys initiated in 1982. Although nests were screened to deter fox and raccoon depredation, the primary threats were identified as off-road vehicle (ORV) use by private citizens and testing of U.S. Navy hovercraft on the nesting beach.

Compaction of sand by vehicular traffic over nests may preclude successful emergence of hatchlings (Fletemeyer 1970, Mann 1978). Additionally, ruts left by ORVs trapped hatchlings, preventing them from reaching the water. Mortimer (1981) noted that lights frighten nesting females and disorient hatchlings. ORV traffic and hovercraft testing were intense on Tyndall AFB beaches during the night.

In response to the identified ORV impacts, an enforcement officer was hired to control ORV activity on Tyndall AFB. The enforcement program reduced ORV use of the nesting beach nearly 95%. However, hovercraft testing activities were still extensive and adversely affecting turtles and the dunes. As a result, an environmental impact analysis was conducted and hovercraft activities were moved away from the beaches in 1987.

A major problem at all bases was inundation or erosion of sand around nests by normal and storm tides. Ten of 15 nests on Tyndall AFB were lost in 1985 during Hurricane Elena and 6% of the nests were lost on Cape Canaveral AFB in 1987 due to inundation. We now regularly move nests to avoid such losses.

SUMMARY

About 2000 sea turtle nests are deposited on Air Force beaches each year. The Air Force has gone from no management to concentrated efforts to protect sea turtle nesting activity including daily beach patrols. On Eglin and Tyndall AFB nesting activity has increased nearly every year since protection was initiated. Rapid development along the Florida coasts encroaches on nesting habitat. Much of the natural beach remaining in the Florida panhandle suitable for sea turtle nesting is on Air Force land. With the dwindling sea turtle nesting habitat, nesting on protected, undeveloped areas on Air Force bases may be significant. The Air Force is committed to protecting sea turtles and their nests.

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PREDICTING HATCHLING SEX RATIOS IN LOGGERHEAD SEA TURTLES (CARETTA CARETTA) BY INCUBATION DURATION

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Although the relationship between temperature and sexual selection has been examined under laboratory conditions, there are few studies that examine this relationship in a natural environment. Since temperature influences sexual selection and incubation duration, then it should be possible to predict the sex ratio of a nest given its incubation duration. Relatively warm nests have short incubation periods and are mostly female, whereas relatively cool nests have longer incubation periods and are mostly male. Despite this simple conclusion, there is a scant amount of empirical data that address this hypothesis. Therefore, the objective of this investigation was to determine if hatchling sex ratios can be predicted in nests of known incubation periods. For the purposes of this investigation, the term incubation duration refers to the period of time from when the nest was laid until the time hatchlings emerge from the nest cavity, thereby including the time spent in the nest cavity between pipping and emergence.

All nests laid on Masonboro Island, North Carolina, during the 1985-1987 nesting seasons ($n = 81$) were monitored daily (usually between 0600 and 0800 hours) throughout the incubation period of each nest using thermocouples and a Bailey BAT-12 temperature gauge calibrated to the nearest 0.1°C. Complete data sets were available for 23 nests, for which incubation duration was plotted against average nest temperature. The resulting equation ($Y = -5.66X + 223.26$, $r = -0.89$) indicates that an average decrease of 1.0°C during incubation results in 5-6 day increase in the incubation period. The difference between points on this equation and that provided by Mrosovsky and Yntema (1980) for lab-reared eggs indicate that the hatchlings in southeastern North Carolina spend approximately five days in the nest cavity after pipping. This equation also predicts that hatchlings in warmer nests, such as in Florida, spend 3-4 days in the nest after pipping, which is easily explained by their accelerated neonatal development due to relatively higher soil temperatures.

For the next part of this experiment, seven individuals were selected at random from each of 11 nests laid in 1987 and sexed histologically at Mrosovsky's lab in Toronto. The number of females (percent) in each nest was plotted against that nest's average incubation temperature, resulting in the equation $Y = 25.27X-674.66$, $r=0.63$). In other words, an average increase of 1.0°C throughout the incubation period results in 25 percent more females. There is obviously more variation in this equation because our sample size was smaller ($n = 10$); in fact, one nest, which was 100 percent male, was laid late in the nesting season (18 August) and never hatched. Another source of variation in this model is attributable to the process of sex determination, which probably occurs during the latter part of the middle trimester rather than throughout the entire incubation period. A nest that is relatively cool during the first and last trimesters but relatively warm during the middle trimester will be predominantly female and have a long incubation period, whereas a nest with relatively warm first and third trimesters but a relatively cool middle trimester will be mostly male with a short incubation period. Examples of both scenarios are evident in our data from Masonboro Island.

From the previous two equations, we calculated the number of females (percent) from nests with known incubation durations. The resulting equation ($Y = -4.47X + 322.76$) predicts a 4.5 percent drop in females for each day the incubation period is extended. An incubation duration of 61 days, therefore, produces a 50:50 sex ratio in loggerhead sea turtles from southeastern North Carolina. There may be geographic variation in this relationship, however, for green sea turtles (*Chelonia mydas*) from the Sarawak Islands in the South China Sea have an equal sex ratio in 61-day nests whereas those from Tortugero, Costa Rica, have an equal sex ratio in 55- or 56-day nests (Standora and Spotila 1985).

We calculated the sex ratio for all nests laid on Masonboro Island during the 1985-1987 nesting seasons, and 3705 (55 percent) of 6729 hatchlings were male. There is significant (Chi-square, P.001) seasonal variation in the sex ratio, however, with average ratios (female:male) of 38:62, 57:43,55:45, 42:58, and 0:100 for nests laid before 16 June (n = 17), 16-30 June (n = 13), 1-15 July (n = 20), 16-31 July (n = 16), and after 31 July (n = 4), respectively. Mrosovsky et al (1984) found this same pattern in nests laid on beaches in South Carolina and Georgia, but with proportionately more females in each time interval.

The results of this investigation indicate that it is possible to predict the sex ratios of hatchling loggerhead sea turtles from their incubation durations without sacrificing individuals. It is interesting to note that the overall sex ratio in southeastern North Carolina (45 females:55 males) is not greatly skewed in favor of males as might be predicted given that North Carolina represents the northernmost limit in the nesting range in the western Atlantic for this species. Perhaps the northern limit of the nesting range is determined by the environmental conditions that produces the number of females required to sustain a stable nesting population.

We thank the North Carolina Wildlife Resources Commission and the U.S. Fish and Wildlife Service for their continued support, Peggy Salmon for sexing the 77 individuals mentioned above, and the numerous individuals who assisted with various aspects of this research. Nicholas Mrosovsky stimulated our interest in this topic and provided logistical support. Funding for this research was provided by the North Carolina Wildlife Resources Commission, the UNCW Faculty Research and Development Fund, and The Masonboro Society.

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DRIFTING SARGUSSUM WEED: SAFE HAVEN OR INCREASED RISK FOR HATCHLING SEA TURTLES?

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Recently, increasing interest has been shown in a possibility of the use of drifting *Sargassum* sp. as a safe haven for the hatchling and early post-hatchling stages of some species of sea turtles. Before assuming this to be the case, we should consider the possibility that increased risks may result from such an association.

My personal involvement with sea turtles began in 1955 when I, while walking along the beach on Hutchinson Island, found a hatchling loggerhead entangled in a rather small amount of *Sargassum*. The seas were not rough and the limited wave action confined the approximately one cubic foot of *Sargassum* with its hatchling loggerhead, *Caretta caretta*, to an area of the wave ebb and flow where it was continuously tumbled about without moving either landward or seaward. When I recovered the hatchling from the seaweed, it was weakened to the extent that it did not voluntarily move. My efforts to save the turtle were unsuccessful (Schmidt and Witham, 1961).

Caldwell (1968) was the first to report the presence of small loggerhead turtles that had been washed ashore on Florida's east coast. He suggested that these turtles had been, because the sessile growths on their carapaces was the same as that found on sargassum, in association with the seaweed prior to their having been washed ashore.

Witham (1974) reported on nine hatchling sea turtles, eight loggerhead and one green, *Chelonia mydas*, from the stomach of a pelagic fish that had been caught near drifting *Sargassum*. It is common knowledge among sport fishermen that trolling near the "weed line" more frequently rewards them with good catches than does trolling in the open ocean.

Carr and Meylan (1980), while on a research cruise east of Costa Rica, reported seeing three hatchling green sea turtles in a patch of drifting *Sargassum*. While they were being observed, two of the three were eaten by frigate birds, *Fregata* sp.

Brongersma (1970) stated: "The little information we have shows that the main food items taken by the Leathery Turtle are jellyfish and salpae"; and Witham (1977) established that young leatherbacks, *Dermochelys coriacea*, could survive on a diet of jellyfish, *Cassiopea xamachana*. Witham and Futch (1977) reported that both young loggerheads and greens survived and grew on a diet limited to the same species of jellyfish.

While Mayer (1910) reported on the widespread oceanic dispersal of medusae, these or other food resources suitable for small sea turtles are seemingly more concentrated either in drifting *Sargassum* or in current confluences such as those reported by Beebe (1926). Beebe also reported seeing many turtles floating like logs in Pacific current confluences,but he did not sug-

gest that small turtles were present. However, Mayer's observations indicate that small turtles would likely find suitable cniderian food resources during their solitary movements in the oceans while away from either *Sargassum* weed or current confluences.

The risks, which may result in increased mortalities of small turtles due to predation and entanglement during stormy weather, may negate the assumed benefits of such an association. An alternative hypothesis to the *Sargassum* weed association is: Hatchling and post-hatchling sea turtles would find suitable food resources and be less subjected to predation pressure when living as individuals away from drifting seaweed and other current caused accumulations of marine biota.

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INTERNATIONAL SEA TURTLE PROGRAM OF THE U.S. FISH & WILDLIFE SERVICE

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The U.S. Fish and Wildlife Service conducts or supports a number of sea turtle management and investigative projects in the southeast United States and Caribbean area. These are done through our National Wildlife Refuges, Section 6 Agreements with the respective states, contracts, and cooperative agreements. We are also involved in a number of international projects which encompass seven species of sea turtles.

Our total Fish and Wildlife Service budget for sea turtles is modest, approximately four to five hundred thousand dollars in FY 1988, of which about two-thirds is expended in the U.S., including the U.S. Caribbean. The remaining one-third is expended in other nations of the western hemisphere-Mexico and Latin America.

International projects are carried out through a U.S. non-governmental entity, either on a cost-share basis or for administrative purposes. Primary U.S. cooperators in this work are the Center for Environmental Education, World Wildlife Fund, and Gladys Porter Zoo of Brownsville, Texas. We do not provide direct material or financial support to foreign government agencies, however we work directly with non-governmental organizations and university groups in the project nations and are continually attempting to identify additional foreign groups and individuals that are competent and able to commit themselves to sea turtle activities in other western hemisphere nations with emphasis on the east Pacific.

I emphasize the east Pacific, for we believe the sea turtle stocks of this region are of major international scope and in need of support and attention by the respective nations of the western hemisphere. Many things are being done to and for sea turtles in this region, some within the law and much of it outside the law of the respective nations. There are many horror stories but also many examples of dedicated people committing themselves and their limited resources in attempts to understand and conserve these sea turtle stocks.

In 1988, FWS will support 17 turtle projects involving seven species of sea turtles in six foreign nations. Ten of the projects are in Mexico. Our primary objectives are nesting adult turtle protection and maximization of hatchling release. These are the objectives in eleven of the projects. The remaining projects are tag supply and registry and the location and inventory of undisclosed nesting beaches. The questions we wish to answer are what do we have, where is it, and what's happening to it? The remaining projects are focused towards research aspects with future management benefits.

It is our policy in the sea turtle program that, with few exceptions, field projects will be planned and carried out by the people of the project nation and not U.S. personnel. The rationale is that if anything of meaningful long-term benefit is to be accomplished, including conservation oriented actions of the respective governments, then it will be done by the people of these nations and not visiting U.S. citizens.

A case where we have had over 10 years of direct field involvement is the Kemp's ridley project at Rancho Nuevo where we work with personnel of Mexico's Department of Fisheries. Even on

this project we have, for the last five years, had a Mexican biologist as the U.S. field crew leader for the five-month season. As a second stratagem to encourage conservation, we move individuals between projects and nations. Our objectives are to expose selected individuals to different situations, both biological and political, and attempt to broaden experience and encourage the problem solving abilities of these individuals so that they will be prepared to tackle and solve challenges within their nations.

In Mexico we are supporting ten field projects, four on the Pacific coast involving olive ridley, leatherback,and the black turtle, and on the east coast, six projects with Kemp's ridley, hawksbill, loggerhead, and green. Most of these projects are long term and must continue after many of us are no longer present if there is to be any assurance that the species of concern are to regain their former viability or maintain existing population levels.

Unfortunately, institutions (including governments) find it difficult to maintain on-going support for such a long period. Administrators want quick results and the accompanying ability to put out reports and news releases about successes. This helps the people involved feel a sense of accomplishment, but most importantly, keeps the recognition and money coming, from government and/or private donors. This is one of our greatest challenges--all of us--to keep the funding adequate to support these efforts. Will we still be able to convince the Fish and Wildlife Service to keep putting bucks into Rancho Nuevo ten years from now? We'll have to if we want to maintain the species. Even with gulf-wide use of TEDs, there will have to be nest protection and population monitoring at Rancho Nuevo and the same situation applies to a hundred or more other beaches in the western hemisphere alone. There is no great problem in finding people to work 16 hours a day for five or six months every year, but there is a problem in keeping the funds flowing to pay the wages and supply basic necessities.

I'd like to inform you about one project which, I believe, has considerable international potential for sea turtle management. A few of you may be aware of the program, but I'm sure most of you are not. At this time there is a document known as the "East Pacific Sea Turtle Accords" which we are hopeful that all nations of the east Pacific--Canada to Chile--will endorse through formal signature. These Accords were drafted by a small group of us and formalized by the foreign affairs office of the Costa Rican government approximately two years ago. To date, Costa Rica, Ecuador, and possibly Honduras have formally signed the Accords. It will take the signatures of at least six nations before the Accords are ratified. The Accords recognize the international and migratory nature of the sea turtle stocks of the east Pacific, and the requirement for cooperative international management, which unfortunately is currently extremely limited. It is of dubious benefit to have strong sea turtle protection programs in one nation if the same population is being harvested in other nations without regard for the turtles' status or needs.

The Accords recognizes the biological, socio-economic, educational, and scientific value of the sea turtle as a resource and pledge member nations to cooperative efforts to maintain these resources in perpetuity. These Accords alone will not solve the problems, but it is a beginning in encouraging the respective nations to cooperate and coordinate activities and utilize the Accords objectives in bringing about a more uniform approach to the conservation of a multi-nation resource.

Final wording of the Accords was accepted two years ago by the delegates of more than ten nations, including the United States, and an ad hoc Commission of five representatives was elected to encourage formal acceptance and signing of the Accords and to attempt to coordinate sea turtle activities in the east Pacific nations. The Commission also evaluates project proposals and, through FWS, funds those projects deemed highest priority. As a part of this work, we have established a tagging registry run by the University of Costa Rica and field projects in Costa Rica, Honduras, and Columbia. I am hopeful that the need for TEDs in the east Pacific shrimp fleets

can be addressed through the Accords and the implementing Commission. The incidental take of sea turtles by shrimp trawlers in the east Pacific is not known, but information from a number of limited short time observers and ancillary data indicate the numbers are very high. This is perhaps a reflection of the hundreds of thousands of olive ridleys which still occur in these waters, as well as more localized but significant numbers of leatherbacks and black turtles.

In the past six years, the Michoacan, Mexico, project has released approximately 600,000 black turtle hatchlings, 78,000 leatherbacks, and 40,000 olive ridleys, as well as tagging thousands of adult black turtles, including males. The Fish and Wildlife Service cost per black turtle hatchling released was approximately 15 cents each. The Oaxaca, Mexico, project is centered on the last significant olive ridley arribada beach in Mexico, La Escobilla. Approximately 2,500,000 hatchlings enter the sea each year from this relatively small beach. Thousands of adults are also tagged each season. The cost per hatchling released is two tenths of a cent.

A project was initiated on the Mexican Caribbean coast of Quintana Roo in 1987, primarily to find out what turtles were there and where they were. This first year project resulted in the release of 43,000 loggerheads and over 13,000 greens from ten different beaches at a cost of 66 cents each. Another first year project in the Mexican state of Yucatan resulted in the release of 4,545 hawksbills and approximately 500 green turtles. The cost of this was 60 cents per hatchling.

The Kemp's ridley project at Rancho Nuevo has been underway since 1966 under the auspices of the Mexican federal fisheries department. FWS began directly cooperating in 1978 and for the past 10 years there have been about 50,000 hatchlings released each year. Because of the nature of this project and direct U.S. field involvement, the cost per hatchling released is higher. In the 1987 season, which was extended from the normal five months to six months due to unusually late nesting, the cost per hatchling released was approximately 80 cents each.

These cost figures are only FWS costs and are based only on hatchlings released annually. All projects include tagging, measuring, hatchling sex ratio studies, training, technique development, education of local people and, in most cases, specific research related to the species biology and ecology or other factors bearing on the conservation and management of sea turtle resources.

Examples of work we will be supporting in 1988 (other than nesting beach and egg protection) are satellite telemetry, tag retention comparison studies, hatchling escapement quantification, embryological mortality, and oviposition bacterial studies. We will also be working with a number of entities in efforts to have additional nations become members of the East Pacific Sea Turtle Accords.

This coming field season, we hope to initiate at least three more field projects on Mexico's Gulf coast--one for Kemp's nesting at Tecolutla in the State of Veracruz, one in Campeche for hawksbills, and one in northern Quintana Roo for hawksbills. These will all be oriented to protection of adults, nests, and hatchlings.

In cooperation with the East Pacific Commission, we will institute work in Colombia and, hopefully, Peru. These will be basic inventory projects--what is it, where is it, and what's happening to it.

It would not be possible to carry out a number of these projects without support of nongovernmental organizations and individuals, especially, the Center for Environmental Education and World Wildlife Fund-U.S. The National Fish and Wildlife Foundation has provided FWS with specific research funding grants, Shell Oil and private individuals have donated vehicles to specific turtle projects in Mexico identified by FWS. Many others continue to help us in direct and indirect ways, all of which contribute immensely to the program.

It is my personal hope that international efforts of cooperation and assistance by the Fish and Wildlife Service will continue. Unfortunately, we are not active in the central Pacific region and many of the islands and Trust Territories are gaining independence. Many nations, especially Japan, are very active in this part of the world. Sea turtles are a part of this interest and little or nothing is being done by the United States to help these existing or new governments to understand and manage the sea turtle resources of their islands.

This has been but a thumb nail sketch of the program, but I hope I have provided you with some insight and information into the international aspects of our sea turtle efforts.

APPENDIX A

The following papers were presented at the Workshop, but are not included in this volume at the author's request. They are documented here for completeness, some will be published elsewhere. Only first authors addresses are given.

GEOGRAPHIC POPULATION STRUCTURE OF CHELONIA MYDAS. PART I: MITOCHONDRIAL DNA RESTRICTION ANALYSIS

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GEOGRAPHIC POPULATION STRUCTURE OF CHELONIA MYDAS. PART II: LIFE HISTORY AND CONSERVATION IMPLICATIONS

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DEMOGRAPHICS OF SEA TURTLES IN LONG ISLAND, NEW YORK

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OBSERVATIONS AND BIOTELEMETRIC TRACKING OF KEMP'S RIDLEYS NEAR LONG ISLAND, NEW YORK

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A PROTECTION PLAN FOR SEA TURTLES ON A BESIEGED ISLAND

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