

LOGGERHEAD TURTLE
NESTING IN SOUTH CAROLINA
Annual Reports for 1981



Edited by Sally R. Hopkins

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INTRODUCTION

Studies of the loggerhead turtle, Caretta caretta, in South Carolina began in 1939 on Cape Island in the Cape Romain National Wildlife Refuge. Nesting effort and predator management continued in Cape Romain, with varying degrees of intensity, but little was known concerning the status of the nesting effort for the remainder of the state. Interest in and concern for the loggerhead turtle here in South Carolina has increased during the past decade, and by the early 1980's, numerous projects were being conducted on the coastal barrier island. Several of these projects were the efforts of private citizens. All too often valuable information collected by laymen is either lost, as in the earlier turtle work conducted on Fripp Island, or is not made available to the scientific community. This report, the first of its kind in South Carolina, is an effort to ensure that this does not happen.

The editor attempted to preserve the style of the authors, while at the same time making the terminology consistent among the reports. Any questions concerning these reports should be directed to the individual authors.

Sea turtle beach projects often involve long hours under difficult conditions. All of the persons involved in this hard work should know that their efforts have aided our threatened loggerhead turtles here in South Carolina.

Loggerhead Turtle Nesting and
Stranding Count on Hilton Head Island, South Carolina

by
Nanci Polk

OBJECTIVE

This project objective was to count and mark the loggerhead nests laid in Hilton Head Island along with determining the types of predators on nests. This project also was involved with counting and taking data on the stranded loggerheads.

INTRODUCTION

This project was approached as a non-funded project, and nesting information had never been collected on Hilton Head. However, these data would be greatly needed in the next few years when decisions will be made about Hilton Head's beaches, renourishment plans, and commercial fishing law and regulations.

This project involved four volunteers: Nancy Polk, (organizer and stranding agent), Robin Bjork, (assistant), Henry Garbade, (Sea Pine security & wildlife officer), Jeff Rupert, (assistant), and many helpful, concerned citizens who called in to make reports of sightings and strandings.

METHODS

The project started in April by organizing the three other volunteers. The Audubon Society and Sierra Club were made aware of our project, and persuaded the two local newspapers to run (free) weekly ads asking people to call one of three phone numbers to report sea turtle nestings or strandings. This worked very well and we had good response from the citizens that walked the beach regularly, both residents and tourists. Each of the four volunteers would cover certain stretches of beach by foot, bicycle, or vehicle (the few times available) when reports came in by phone.

Data Taken: When recording a nest we would first determine if it was a false crawl or an actual nest from visual signs, no probing was done, then we would measure the crawl tract to determine roughly the size of the nesting

females.

After locating the body pit, we would pace off the distance from the pit to the dune line where we would hammer in a 1" x 1" stake and record the distance. The stake was painted red on the top portion and marked with a nest identification number and written on it was "PLEASE DO NOT REMOVE - S.C.W.M.R.D." Stakes were placed in the dune line to avoid disturbance or removal and so as not to pin-point the nest for predators (such as humans). Records were then kept of the date the nest was laid, it's approximate location on a large map of the island, and its identification number. The size of the crawl was also recorded.

We attempted to watch the nests through the summer to determine the types of predators and the percentage of nests preyed upon or destroyed.

We did not attempt to protect the nests with any devices since we were simply determining what types of predators on Hilton Head Island.

RESULTS AND DISCUSSION

This project determined the approximate number of nests laid on Hilton Head Island, S. C. in 1981, and recorded the density of nests in particular locations on the island. This island is 16 miles long by 5 miles wide - giving us approximately 20 miles of open beach and beach on the Port Royal Sound to survey. This project also determined the types of predators on nests and in which areas.

There were 41 nests recorded laid between May 24th and August 5th. There were several nests possibly missed due to bad weather and the lack of transportation in some areas. We believe nine nests were pouched out of the 41 nests. All were on the north end of Hilton Head Island, around the Bay Gall area, where there is vehicle access to the beach. One nest was found raided by raccoons on the north end. All of the nests had dense numbers of ghost crab holes appearing around them. Several nests were laid too low on the beach and

possibly were inundated with salt water.

The turtle strandings started on July 9th, and between July 9th and 10th there were six strandings to start out the season. These strandings directly followed a period when the shrimp trawlers increased off the front beach from 1 boat a day to 18 boats a day. Hilton Head Island strandings came to a close on September 14 with a total of 37 dead for the season. This total put Hilton Head Island second compared with the other islands on the South Carolina coast.

CONCLUSION

The objective of this project was achieved since all it originally was concerned with was determining the number of nests laid on Hilton Head in 1981, and which areas were most frequently nested. These areas showed the large percentage of turtles stayed away from populated areas with high rise hotels and villas and stayed clear of the rapidly growing areas of rip rap.

However, I feel this 1981 data or project is a start to help understand what the Sea Turtle population is doing around Hilton Head Island, and to observe the effects of man on their nesting habits.

The knowledge of predation was also informative as to the turtle's modern day enemies being ghost crabs, poachers, and shrimp trawlers.

The hatchlings information is not as complete due to stake removals and loss of nest positions, however, possibly the data on the 8 nests that hatched can assist in other studies or be able to compare with the 1982 project.

The stranding data was also interesting in the observation of the increased stranding immediately after the increase of shrimp trawlers off the front beach in July and continued to September 15 when the shrimp trawling slacked off in the Sound. The observation of a large percent of the dead turtles were mutilated by knife cuts or axes or bashed in skulls was very disturbing.

PROBLEMS

The main problem was the continual removal of nest marking stakes by persons or bad weather. We lost track of a large number of nests as far as being able to monitor for predators and for hatchings.

Only a few nests were laid apparently too low on the beach at which time we wished we were able to reposition the nest higher in the dunes.

Another major problem was not being able to check the entire beach every-day due to lack of proper transportation. With proper and fast transportation more nests would have been located and recorded in areas that were impossible to check by bike or by foot.

Another problem, previously stated in the predation section, was the poaching of eggs in certain areas of the beach.

RECOMMENDATIONS

Cooperation by shrimp trawlers to use the 90 minute tow time and the reviving of turtles on the decks is desirable. Also the perfection of the excluder device and/or mandatory use of the excluders on the nets, and assistance from the federal or state government, so shrimpers can afford the cost of the new device and the cost of tuning and rigging the nets.

A more accurate nesting and hatchling count would be possible with the bigger and faster transportation on the beach since we have over 20 miles of beach to cover a day. Conservation group-funding allotted for transportation and fuel cost to assist in a more complete project.

The state should furnish official sign decals to be used on stakes marking the location of nests. "AGAINST LAW TO REMOVE" etc.

These metal signs could be posted in areas to warn poachers or others of fines and consequences for harassing turtles or their nests and eggs. This approach may cut down on a large number of lost nesting stakes.

Loggerhead Turtle Nesting
Success on Frigg Island, South Carolina

by
Nerine Smoak

OBJECTIVE

To determine the number of nests laid on Fripp Island in 1981 to compare this information with our 1979 project.

INTRODUCTION

Fripp Island is a small 3-mile island situated between St. Helena Sound and Port Royal Sound. It has been a nesting site for Loggerhead turtles as far back as any records. Old timers in the Beaufort area recall collecting eggs on Fripp in the early 1900's for their excellent quality in pound cakes. In 1961 when the island began its first development, turtles were nesting here with evidence of feral hog and raccoon destruction.

Our first supervised project was in 1979 when nests were flagged, monitored and hatchlings counted. In 1980 our main effort was directed to the stranding count of dead sea turtles. By 1981, approximately one-third of the beach had a rock revetment to prevent further erosion (hopefully). In our project we hoped to monitor whether the number of nests changed and if there was any difference in the density of nests in the beach revetment area.

METHODS AND MATERIALS

Our count began 17 May with the first verified nest; subsequently the beach was patrolled early every morning after that. We relied upon telephone calls from the north end which was revetted and all except short and storted crawls were investigated. Each body pit was probed until the nest was located and a small hole dug with a round-pointed garden trowel until eggs were sighted. The nest site was marked with a painted stake containing the following information: nest number, date of laying and location by lot number or house. The stake was placed 3 ft. directly behind the nest the sand level marked, and the nest site covered with marsh reeds. If the nest showed any disturbance by next morning, a 4 ft. square of small chicken wire was anchored with sand and

then removed within a week. After several nests were flooded by high tides, we were permitted to move such nests to a safe location. This we did as early as nests in jeopardy were located. Eggs were carefully removed without turning to protect the embryo attached to the upper shell, the depth of nest measured and new nest dug with a post hole digger to that same size. Eggs were then replaced in the new nest without turning, covered and packed with sand. On the nest stake, it was noted as a moved (M) nest and the number of eggs recorded. Files were kept on each nest with the expected date of hatching and any remarks if nest was having a heavy sand build-up.

RESULTS AND DISCUSSION

From 17 May to 5 August, there were 125 nests laid on Fripp Island. Approximately 20 nests were flooded in the very high tides on 28 and 29 June. One or two of these nests produced a few muddy, small hatchlings. Nests contained from 79 to 169 eggs with an average of 115 eggs per nest. We had an average of 62 hatchlings per nest with a total of 6,818 hatchlings released. With constant surveillance during the hatching period, these hatchlings reached the ocean.

The number of nests and dates of laying were very similar for 1979 and 1981, but other factors were different. The extreme heat from June through July and very low rainfall, plus a heavy sand build-up over the early nests, shortened the incubation time. Nests laid in May and early June hatched in 46 days. It appeared that many of these hatchlings were too weak to dig through the sand build-up. After finding all early nests with suffocated hatchlings, we checked all expectant nests at 48 days and then at 46 days. These weak hatchlings (usually the top 20 were dead) were kept in plastic pails covered with damp news print until the egg sac was absorbed and then released to the ocean. When the heat and drought was finally broken, the incubation period

lengthened, and after the first cool spell in August reached a normal 62-63 day incubation with larger and lively hatchlings.

Raccoons did not damage any new nests in 1981, but became a problem with the final three nests due in October. The first nest was opened, infertile eggs eaten and the egg sacs removed from the top hatchlings. The second nest, several days before hatching was opened and 15 hatchlings beheaded. The final nest, covered with screen, completed its hatching on 12 October and hatchlings were released. By then the water temperature was below 65°.

There seems to be the same number of turtles laying on Fripp Island, but there was a definite relocation of nesting area. From a normal distribution of nests in 1979, there was a higher density of nests on the south end of the island in 1981. Nests were hurriedly dug sometimes with an overflow of eggs an inch or two below the surface of the sand. We suspect that turtles came in earlier to the north beach, found rock revetment and hastened back to the water, coming in again further south with less favorable tide conditions for nesting. One nest, laid in the rock revetment area, was moved and monitored, and hatched 98 turtles. This revetment area included approximately 5,700 feet of the beach. There were 15 nests laid in the next 2,000 feet, the most eroding and heavily populated area. All these nests were moved to a safer section. The south 7,500 feet of beach, with better sloped dunes, supported 109 nestings.

Since Fripp is a resort beach with a heavy influx of transient visitors during the loggerhead nesting season, we spent much of our time informing these people of the need to protect the loggerhead. This involved hours of answering questions, answering phones, and even answering doorbells at 2 a.m. But there was a tremendous interest and eager cooperation from most people. We felt the children must be reached and involved in any successful program of conservation. In the 15 years of turtle watching, we have seen a great appreciation of the

ecology of the island and more awareness of this heritage. Fripp can continue as a loggerhead rookery with careful consideration for the rights of the turtle. We constantly request that beach front homes not use flood-lights and remind all visitors that the loggerhead is protected by state and federal laws.

RECOMMENDATIONS

We would like to continue the count, marking and monitoring of nests on Fripp Island in future seasons. Perhaps in 1982 we should record all false crawls in revetment area and see if the dates correspond with the low-tide nests made on the south end.

Loggerhead Turtle Nesting
Success on Hunting Island, South Carolina

by
Laurieann Reed

OBJECTIVE

The purpose of this project was to determine the number of nests laid on Hunting Island, the success rate of the nests, and the number of hatchlings released from July 23 to September 6.

INTRODUCTION

Hunting Island, a barrier island in Beaufort County, had experienced severe erosion in past years. During the winter and spring of 1980 the beach was nourished by pumped sand and nesting of the loggerhead turtle appears to have increased over previous estimates after renourishment. The northern portion of the island is heavily used in the summer season as a state park camp ground, but the southern end has only a few private residences.

METHODS AND MATERIALS

Starting on June 12, 1981, the three mile beach was patrolled every morning until September 6, 1981 to locate turtle tracks, indicating where a loggerhead turtle had laid her nest. In order to locate the nest chamber, the nest area (the body pit of the female turtle) was probed with a stick. If the probe stick sank into a soft area of sand, this indicated the location of the eggs. If there was no body pit with the tracks, this indicated a false crawl. Once the eggs were found, the nest was uncovered, and if necessary, any eggs which were broken during probing were removed. (This was important in preventing attraction of raccoons and ghost crabs to the odor, and to prevent the nest from turning foul, i.e. - muggots). The nest was then partially covered and marked by placing a can that had the laying date, and the type of nest (N for a natural nest or R for a relocated nest) recorded on it. The nest was then completely covered, and marked by placing a stake three to five feet behind it. This stake also had the laying date, type of nest, and the number of feet from its location to the nest recorded on it. (The purpose of

the can was to help in locating the eggs when digging up the nest for re-locating, or collecting and releasing the hatchlings).

The date, type of nest, a detailed location of the nest, and the placement of the stake was then recorded in a notebook. When a nest needed to be relocated due to animal predation, poaching, or danger of inundation by high tides, the eggs were located using the techniques described above (if they had not been already uncovered by raccoons).

If the eggs had a white spot on the tops, this indicated that they were more than twenty-four hours old. In handling these eggs, they were carefully placed in a bucket lined with sand, being careful not to invert the eggs from their original position inside the nest. If an egg is inverted or handled carelessly, the embryo will detach from the egg, thus killing it.

After placing these eggs in the bucket, they were transferred to the rookery site which was chosen because of its location away from beach homes, and its protection from high tides. A two-foot deep pear-shaped chamber was dug, and the eggs carefully placed, one by one, inside the chamber, again being careful not to invert the eggs. The nest was then covered and marked using the same technique as described previously.

In order to protect nests from raccoon preation, nests that had been "Explored" by raccoons were covered by a three-by-three foot piece of chicken wire. This screening was placed on top of the nest and the edges buried with sand. The chicken wire was removed after one week when the odor of the eggs had dissipated.

At hatching, the nests were dug, the hatchlings collected, and placed in a large aluminum washtub until the evening. The hatchlings were then released after dark to help ensure a better survival rate. Releasing hatchlings at this time protected them against predation by gulls and ghost crabs.

RESULTS

The total number of emergences of loggerhead turtles was 121 with 89 nests and 32 false crawls. Of this total, 39 (32.5%) of these were destroyed by ghost crabs, raccoons, high tides, and heavy rains, 3 were poached. Twenty nests threatened by inundation by high tides, or predation were relocated to a more favorable section of beach. Of these nests, 5 were destroyed after relocation by a combination of raccoons, ghost crabs, and heavy rains. The other 15 survived, indicating that relocation of threatened nests was an effective means of preventing their further destruction. A total of 263 hatchlings that emerged before September 6 were released from eleven of these nests. Four of the seven nests screened with chicken wire for one week were destroyed. Ghost crabs were the most destructive to these nests indicating that the screen was a fairly effective deterrent against raccoons, but not against ghost crabs, which tunnel underneath the screening.

The total number of hatchlings released between 23 July and 6 September was 1,031. Hatchlings emerged naturally and were not counted after this date. There were virtually no problems with the raccoons relocating and destroying these nests, although, later in the season, some nests were destroyed by ghost crabs, and by heavy rains during tropical storm Dennis.

The average number of eggs per nest was 110, ranging from 60 to 260 eggs. The average length of incubation was 56 days, with 52 days being the shortest incubation period, and 58 days being the longest.

The greatest number of the earlier nests were laid at the north end of the beach, and nests laid later were almost equally distributed between the northern end and the middle third of the beach. The southern end of the beach had fewer nests due to offshore sandbars.

As seen from the data, raccoons did the greatest amount of damage to the

nests, along with ghost crabs, high tides, and heavy rains from tropical storm Dennis.

RECOMMENDATIONS

It is hoped that Hunting Island State Park continues its raccoon trapping program, so that the raccoons will not be such a threat to the survival of the loggerhead turtle eggs and hatchlings.

Loggerhead Turtle Nesting Survey
for Edisto Island, South Carolina

by
Ann R. Starck
and
Debole Mandell

OBJECTIVE

To determine the number of loggerhead turtle nests laid on four beaches of Edisto Island, S. C., the success rate and the causes of failure of these nests. To evaluate the effects of human beach use of nesting activity. To evaluate the need for nest protection during the 1982 season on any of the surveyed beaches.

STUDY AREA

Edisto Island, S. C., including Edisto Island State Park, Edingsville Beach, Interlude Beach, and Botany Bay Island Beach.

APPROACH

In mid-May, prior to the nesting season, each beach was marked with wooden posts set 500' apart, to assist visually in assigning each crawl a specific location. After the first crawl was seen, the beaches were surveyed on foot in daylight hours on an alternate day schedule. Observed crawls were designated as nesting or false (non-nesting) by carefully probing possible nest sites with a pointed one inch dowel, and by excavating gently down to the eggs when a nest cavity was felt.

Information obtained for each crawl included: location and description, and beach and weather conditions. The fate of each nest (hatched, failed, or unknown) and the cause of failure were recorded. When hatchlings emerged, the nest sites were located by the depression left at the surface of the nest cavity or by tracks left by hatchlings as they made their way from nest to sea.

After emergence, nests were excavated gently by hand. Live turtles in the nest were released to the sea. Nest contents were recorded and any deformities or abnormal egg shapes noted. Nest contents were returned to the cavities, which were re-filled with sand.

RESULTS AND DISCUSSION

During the 1981 nesting season, a total of 500 loggerhead crawls was observed during the survey period, May 19, (date of first crawl) to October 14, (date of last nest) on the four beaches surveyed. Of these crawls, 231 (46.2%) resulted in nesting; 269 (53.8%) were false, or non-nesting, crawls. There were, in addition to the loggerhead crawls, two leatherback crawls on Edisto Beach State Park, both non-nesting. A beach-by-beach breakdown of crawl numbers and types is presented in Table 1. Three of the four beaches surveyed had nesting densities greater than twenty nests per kilometer, a higher level of nesting activity than had been found in earlier aerial surveys. See Table 1.

Table 1. Loggerhead turtle crawls, four beaches, Edisto Island, South Carolina, 1981.

	Non-nesting Crawls	Nesting Crawls	Total Crawls
Edisto Beach State Park	70	52	122
Edingsville Beach	83	63	146
Interlude Beach	13	11	24
Botany Bay Island Beach	103	105	208
All Beaches	269	231	500

Without further analysis, it appears that peak nesting dates varied from beach to beach and that there is no distinct correlation between nesting peaks and phase of the moon.

Each beach in the study area showed a distinct pattern of nesting activity, success and predation. See Tables 1, 2 and 3.

Table 2. Loggerhead turtle nesting density, four beaches, Edisto Island, South Carolina. Nests/Km. Surveyed/Nesting Season.

	Edisto Beach	Edingsville Beach	Interlude Beach	Botany Bay Beach
1978 - Aerial Survey:				
Nests/Km. (Corrected)	4.66	15.42	18.63	18.64
Km. Beach Surveyed	8.2*	2.9	1.0	3.4
1981 - Ground Survey:				
Nests/Km. (Observed)	24.67	21.72	13.75	30.00
Km. Beach Surveyed	2.1*	2.9	0.8	3.5

*1978: Edisto Beach State Park and Edisto Beach;
 1981: Edisto Beach State Park only.

Before the survey it was speculated that the intense levels of human activity on Edisto Beach State Park might have an inhibitory effect on nesting activity and perhaps on nesting success and that this effect might also be apparent, though to lesser extent on the progressively less heavily utilized beaches Edingsville, Interlude, and Botany Bay Island. The results of the 1981 ground survey showed the most human-utilized beaches, Edisto Beach State Park and Edingsville, to have lower nesting densities, 24.6 and 21.7 nests per kilometer, respectively, than the least human-utilized beach, Botany Bay Island, 30.0 nests per kilometer. However, nesting density on the most human utilized beach, Edisto Beach State Park, was slightly higher than on Edingsville Beach

and the lowest nesting density was on Interlude Beach, which was much less heavily utilized by people than Edisto Beach State Park and Edingsville. Nesting density on Interlude may have appeared artificially low because of less frequent surveys there.

Table 3. Loggerhead turtle nest fates and causes of failure. Four Beaches, Edisto Island, South Carolina, 1981.

	Edisto Beach State Park N=52 %	Edingsville N=63 %	Interlude N=11 %	Botany Bay Island N=105 %	All Beaches N=231 %
Hatched	84.6	36.5	0.0	0.9	29.4
Failure -	9.6	61.9	90.9	96.2	67.1
Due to:					
Overwash	7.7	6.4	18.2	2.9	5.6
Overwash/ Raccoon	0.0	0.0	0.0	1.9	0.9
Raccoon	0.0	6.3	9.1	55.2	27.3
Ghost Crab	0.0	0.0	63.6	13.2	9.1
Raccoon/Crab	0.0	1.6	0.0	19.1	9.1
Human	1.9	47.6	0.0	0.0	13.4
Undetermined Cause	0.0	0.0	0.0	3.8	1.7
Unknown	<u>5.8</u>	<u>1.6</u>	<u>9.1</u>	<u>2.9</u>	<u>3.5</u>
Totals	100.0	100.0	100.0	100.0	100.0

Another indicator of possible effect of human presence on nesting activity was variation in the percentage of total crawls which resulted in nesting. If turtles attempting to nest were disturbed by beach activity, one would expect a lower percentage of total crawls to result in nesting on the most-used beaches. This was indeed the case on the four beaches surveyed. On the two

most-used beaches, Edisto Beach State Park and Edingsville, the percentage of crawls resulting in nesting was 42.6% and 43.3%, respectively. On the less-used beaches, the percentage of crawls resulting in nesting was higher, 45.8% on Interlude and 50.5% on least-used Botany Bay Island. There is the possibility, of course, that other factors such as sand texture, beach slope, and amount of shell could have also contributed to these differences.

Fates (failed, hatched, or unknown) of the 231 nests are summarized in Table 3. Overall, 68 nests hatched, 155 failed due to predation by raccoons, ghost crabs, or humans, or from erosion or overwash during high or storm tides; and 8 fates were unknown. The nest site was mislocated and signs of emergence never observed.

The hatch rate (percent of total nests from which hatchlings emerged) on one beach, Edisto Beach State Park, was very high, 84.6%. Because of losses to predators, hatch rates on the other three beaches were low: Edingsville, 36.5%; Interlude, 0%; and Botany Bay Island, 0.9%. (See Table 3). On Edisto Beach State Park there was almost no predation, and it can be speculated that the human presence there may have deterred both human and animal predators and thereby increased hatching success. Edingsville Beach, adjacent to Edisto Beach State Park, suffered heavy nest losses (47.6%) to human predation for over half the season. When one poacher extended his range to Edisto Beach State Park, he was confronted by at least three beachwalkers and chased away from a nest by one of the larger men. Only one nest was lost to poaching on this beach. One poacher was arrested twice by U. S. Fish and Wildlife Service agents; after the second arrest the poaching ceased. The majority of nest losses on Interlude and Botany Bay Island, the two other surveyed beaches, were two small animal predators. Ghost crabs and/or raccoons destroyed 72.7% of the nests on Interlude and 87.6% of the nests on Botany Bay Island. Edisto Beach State Park lost no nests to these predators.

A possible explanation for the difference in levels of predation on Edisto Beach State Park and Botany Bay Island and Interlude is that the presence of many people at the state park makes that beach, which would ostensibly be just as attractive and available to both ghost crabs and raccoons as Interlude and Botany Bay Island, somehow less desirable to them.

Losses to beach erosion/overwash were relatively low, 5.6% of nests. On Botany Bay Island and Edingsville, the two beaches most subject to overwash, these losses might be expected to increase if predation were reduced. Ten of the nests lost to overwash/erosion were lost between June 27 and July 10 during times of extreme high tides. Only one nest was destroyed during the high tides associated with tropical storm Dennis, August 19.

Table 4 presents average incubation time, nest contents and emergence success for those nests from which hatchlings emerged. Nest incubation time averaged 63 days (range 47-81) on Edingsville and 56 days (range 47-81) on Edisto Beach State Park. The higher average for Edingsville may be misleading due to the longer period between surveys on that island after the end of nesting. Comparing average minimum incubation times, 54 days for both beaches, while perhaps giving a less truthful actual incubation time gives a better idea of similarity of incubation times on the two beaches. Minimum incubation time increased to over 60 days for nests laid at the end of the season (3 after 7/26 on Edisto Beach State Park; 2 after 7/22 on Edingsville). Two nests which were severely overwashed during incubation had increased average incubation times of 73.5 days and 79.5 days, compared with less than 60 days for all other nests laid at similar dates.

The average number of eggs per nest was highest on Edisto Beach State Park, 118 (range 74-161). Botany's one nest contained 108 eggs. The average on Edingsville was 102 eggs per nest (range 20-131).

Table 4. Successful nests, incubation time, nest contents, and emergence success. Four beaches, Edisto Island, South Carolina, 1981.

	Average Incubation Time (days)	Average Number Eggs/Nest	Average Emergence Success (%)
Edisto Beach State Park	56	110	72.7
Edingeville	63	102	60.6
Interlude	-	-	-
Botany Bay Island	Unknown	108	46.3

Emergence success, not to be confused with nest success, describes the percent of hatchlings which actually leave the nest. This is calculated by subtracting the number of hatchlings - live and dead - remaining in the nest from the total number of hatched shells and dividing this number by the total number of eggs (total clutch). On the two beaches where more than one nest survived to term, Edingeville and Edisto Beach State Park, emergence success was 60.6% and 72.7%, respectively; 46.3% of the hatchlings from the one successful nest on Botany Bay Island emerged. 4,369 hatchlings emerged from 66 successful nests.

SUMMARY

The survey of sea turtle nesting on Edisto Island beaches yielded detailed information on numbers of loggerhead turtle nests, total crawls, emergence success, and causes of nest failure. Using these data a program is planned for the 1982 season which will, hopefully, ensure the addition of a maximum number of hatching turtles to the population, given the resources and personnel available.

The loggerhead nesting effort on Edisto Beach State Park appears to be successful without needing further assistance, except continued education via talks, personal contact and printed information. This beach will be surveyed as in 1981. On Edingsville Beach periodic patrols will check for signs of predation and evaluate possible need for nest protection in 1983. If human poaching is discovered, SCWMR and USF&W personnel will be called in for enforcement, as in 1981.

Edisto Beach, the heavily developed section of beach between Edisto Beach State Park and the South Edisto River, will be included in the 1982 survey of nesting activity. On Edisto Beach, volunteers will patrol the beach and report fresh crawls or strandings to a student intern who will verify, record and monitor the nests until their fates are determined.

Botany Bay Island, which lost 94 of its 105 nests to ghost crab and raccoon predation in 1981, is scheduled for nest protection in 1982. At dawn, freshly laid nests will be covered with a wire mesh screen to prevent access by raccoons. The screen will be left in place until hatchlings leave the nest. A wire mesh with openings large enough to allow hatchlings to crawl unassisted through the wire will be used. Data for each crawl and hatched nest will be recorded as in the 1981 survey.

The goal for the 1982 Botany Bay Island project is to ensure successful emergence of hatchlings from at least fifty nests. This figure is based on the assumption that 1982 nestings on Botany will approximate the number in 1981, 105. It is expected that some nests will be lost to predation. Uncertainty as to the extent of this predation necessitates moderation in predicting the total number of hatchlings that might emerge. If nests average 108 eggs per nest, with emergence success of 46% (statistics for Botany's single successful nest in 1981), almost 2,500 hatchlings could emerge on

Botany Bay compared with only 50 in 1981. Calculating production using the average of egg number and emergence success averages for the two Edisto Island beaches with a substantial number of nest successes in 1981, Edisto Beach State Park and Edingsville, increases estimated production to over 4,200 hatchlings.

Loggerhead Turtle Hatchery
Program on Kiawah Island, South Carolina

by
Michael F. Tolley

INTRODUCTION

The Kiawah Island Community Association, supported by the Kiawah Island Company, has maintained studies of the Atlantic Loggerhead sea turtle Caretta caretta caretta (Linne) during the summer nesting season since 1975. The 1981 research project has continued the collection of information of this species along with an incubation program.

Kiawah Island serves as a relatively small rookery for the loggerhead along the east coast of the United States. For the past nine years, the island has been used by researchers to study this turtle's nesting habits and the conduct of translocation (direct burial) program.

The 1981 nesting season began on May 22, with the last nest being laid on September 2. In absolute numbers, this year's project was relatively successful. A total of 142 nests were translocated with 12,179 turtles being released. The overall hatching success was 73%.

The 1981 hatchery project entailed direct burial of eggs. Procedures followed were the same as in 1979 and 1980, and are outlined in the respective Kiawah Island Hatching Success Reports. Cooperation with the Endangered Species Office of the South Carolina Wildlife & Marine Resources Center was continued in 1981. The procedures for strand data collection also were reported in 1980.

It is hoped, through the efforts of this group, that the effects of Kiawah Island's development on the loggerhead's nesting will be minimized. With this year's improvements and future improvements based on new results, the loggerhead sea turtle may endure the encroachment of man on this barrier island.

RESULTS

Data for each turtle emergence was recorded during that 1981 nesting season on data sheets showing descriptive information and weather conditions

(see Table 5). Ninety percent of the crawls resulting in nests were translocated with additional information on the fate of each egg collected also being recorded. The remaining nests were left where laid and monitored for survival. There was a 18% hatching success rate due to predation and tidal inundation. Descriptive stranding data was also recorded for each strand that washed up on Kiawah. The following is a presentation of all information collected.

Table 5. Summary of hatchery data 1981

# of Nests	142 translocated, 157 total
# of Eggs	16,768
Undeveloped	3,815
Partly Developed	121
Developed but not Hatched	111
Hatched but Dead in Nest	42
# of Eggs Hatched	12,179
Average % Success in Hatching	72.6

LEGEND: Average Success in Hatching =

$$\frac{\text{Total \# Eggs - Rotted Eggs \& Dead Turtles}}{\text{Total \# Eggs}}$$

Turtle Emergence Data

Kiawah Island's front beach was divided into nine 1-mile long sectors beginning at the southwestern end of the island to the slough at the northeastern end. There were a total of 274 crawls. Data was collected on 254 of these crawls. 61.8% of the recorded crawls resulted in nests with the remaining crawls resulting in false crawls or body pits. Of the 157 nests laid

on the beach, 142 were moved to the hatchery.

The first recorded crawl, which resulted in a nest being laid, occurred on May 24 with the last on September 2. Over the 1981 season, as with the 1980 season, nesting activity seemed to have occurred in two week cycles. The peak of the season lay between the 13th and the 17th of July. Six other peaks occurred in two week periods through the season.

Hatchery Information

Ninety percent of the nests laid on Kiawah this year were moved to the hatchery. Each nest was given a nest number with the fate of all eggs being divided into five categories. Summations and statistical results are shown on Table 5.

Table 6 shows a comparison of data over the past nine years as to project success. During the 1981 season, though the mean hatching success rate was low, this year had the greatest number of turtles released over the past nine years.

Table 6. Yearly Summary of Hatchery Data

	1973	1974	1975	1976	1977	1978	1979	1979	1980	1981
	SEED HATCHINGS									
Number of Nests Translocated	55	90	35	17	39	55	46	75	75	142
Total # of Eggs/Year	7,297	11,192	4,027	1,979	4,641	6,329	5,578	4,248	9,092	16,768
Mean # of Eggs/Nest	133 ±2.3	124 ±2.1	115 ±4.7	116 ±5.5	119 ±16	116 ±21.8	119 ±15.8	119 ±15.8	121.1 ±21.9	118.1 ±21.9
# of Hatchlings Released	5,880	0	2,789	1,013	2,771	4,595	4,072*		6,876*	12,179*
Mean Hatch Rate ± %'s	80.6 ±1.8	0	70.6 ±3.6	-	61.5 ±27.0	72.8	52.3 ±18.9	76.1 ±15.4	81.1 ±15.9	72.6

*Hand Counted

CONCLUSION

The impact of human activity on loggerhead turtles through loss of nesting habitat, nest hatchling predation, and off-shore adult mortality, is hopefully being offset by the turtle hatchery program at Kiawah Island. The release of approximately 12,000 hatchlings will help bolster the threatened loggerhead population nesting on Kiawah Island. We look forward to continuation of the hatchery program with concentration on cooperative efforts with the South Carolina Wildlife & Marine Resources Department. It is our hope that, in addition to release of hatchlings, we can collect more data on natural predation and turtle stranding.

Nesting and Management of Loggerhead
Turtles on Cape Island, South Carolina in 1981

by

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INTRODUCTION

The Atlantic loggerhead turtle (Caretta, caretta, caretta, Linne) is a threatened species and has received increasing and necessary attention in recent years. Loggerheads need undisturbed beaches for nesting, and with the rapid disappearance of such habitat, areas that continue to host nesting loggerheads have great biological importance. Raccoon Key, Bull and Cape Islands, within Cape Romain National Wildlife Refuge, are among the few remaining undisturbed loggerhead nesting sites in the United States. Of these, almost all of the nesting occurs on Cape Island (97% in 1979 and 94% in 1981).

Cape Island has one of the highest nest densities of any turtle rookery in the United States; therefore, it presents a great laboratory for studying loggerhead nesting biology. As with many loggerhead nesting areas, nests on Cape Island receive heavy predatory pressure from raccoons (Procyon lotor). During the last few years, however, nests lost due to beach erosion have equalled or exceeded those lost to raccoons on Cape Island.

As in the two preceding years, all turtle nesting activity was monitored. In an effort to increase loggerhead nesting success, nests were placed in predator-proof hatcheries, located on high dunes, to protect them from erosion and raccoon predation. Tests were conducted to discover the effectiveness of various on-beach nest protection methods that might prove beneficial in protecting nests from raccoons.

MATERIALS AND METHODS

Cape Island is a barrier island located in the northeasternmost corner of Cape Romain National Wildlife Refuge. It is approximately 8.5 km long and 2.1 km wide at its broadest point and covers 607 ha. There is sandy beach along the entire length of the island. It is this beach front that attracts hundreds of nesting female loggerheads each year.

Within these pens, 45 cm holes were dug at 60 cm centers with post-hole diggers. Each hole was rounded out at the bottom by hand. The number of eggs was recorded and written on a numbered flag which was inserted along the side of the hole. The eggs were carefully placed in the hole and covered with moist sand which was firmed with the heel of the hand. All undamaged eggs were removed from predator disturbed nests and transferred into one of the pens. If only a few eggs could be recovered from such a nest, they were combined with other clutches from damaged nests, or with small clutch whole nests.

The north and south pens were self-releasing. The main pen had 2.5 x 20 cm boards along the inner base of the walls. The boards served as barriers, and 2.5 x 20 cm shelves were placed on the boards to produce shade.

From August 2nd until September 16th the crews worked a morning shift and arrived on Cape Island at or shortly after sunrise. All baby turtles that had emerged overnight in the main pen were counted and placed in five gallon buckets and released on the beach at a part of the island where no gulls (Larus sp.) could be sighted. After the incubation period was complete, each nest within the pens was dug out and the actual number of eggs that hatched plus the number of bad eggs was recorded.

Of the nests left on the beach, 134 were used in nest protection studies. Ninety-four of these nests were left as control nests. Each one was marked by placing a numbered flag 1.24 m due north from the nest hole. Twenty nests were used in a repellent study. Ten nests were marked with bobcat (Lynx rufus) urine and 10 were marked with human (Homo sapiens) urine. Approximately 118.3 ml of urine were sprinkled on the sand around the body pit covering an area approximately 1 to 1.5 m in diameter. Each nest was marked with a numbered flag in the same manner as the controls.

The twenty remaining nests were used in a beach transplant study to determine if, by moving the nests away from the laying site, raccoon damage could be reduced. One member of a crew dug the nests and placed the eggs in a bucket. The other member chose a favorable site approximately 12 m away from the original nest site and dug and prepared a new hole with post-hole diggers. The second crew member avoided the entire area around the original crawl and carefully placed the eggs into the new hole which was flagged like the controls.

The distance from a common point to each of the 134 flagged nests was recorded to facilitate finding the nests during observations. Each of the 134 nests was checked for three consecutive days after it was flagged and every week thereafter. All successful flagged nests were dug out after the hatching period was over to determine the number of eggs that hatched. All pertinent information was recorded.

During the entire nesting season, weekly sand temperature readings at the main pen and at the beach dune line were recorded. Temperature readings at 61 cm, 46 cm, 15 cm and at the surface were recorded using a probe thermometer.

As part of a predator control program, traps were baited with sardines and placed along raccoon trails in the beach dunes in areas of heaviest raccoon activity. Due to the danger of spreading rabies, the raccoons could not be released on the mainland. Therefore, all raccoons caught had to be destroyed. Their sex and age were recorded.

Dead sea turtles that were found on the beach were measured for over-the-curve carapace length and width. An estimate of the carcass condition was noted, and the carcass was marked with fluorescent paint to prevent double-counting. All data were recorded on sea turtle stranding and salvage operations reports and submitted to the South Carolina Wildlife Department.

RESULTS AND DISCUSSION

Nesting Season

The 1981 loggerhead nesting season lasted 96 days. The first two nests were laid on May 22nd and the last false crawl was on August 25th. The last nest was laid on August 24th.

During the 1981 nesting season, there were 3,098 loggerhead turtle emergences (crawls) on Cape Island. Of these, 1,053 (34%) were nesting emergences and 2,045 were false crawls. This year's 1,053 nests represents a 23% increase over the number of nests laid in 1980, and only 3.7% fewer than those laid in 1979. The percentage of false crawls (66%) was the same as that recorded in 1980. Nest density was 131.6 per km².

There were no outstanding peak periods in nesting activity during 1981. There were two days during the season when 30 nests were laid, and one day with 29. The week with the greatest number of nests was July 5-11 when 126 nests were laid. Nesting activity was moderately uniform from the week of May 31st to the week of July 19th. Of the 1,053 nests laid, 496 were placed in the 480 spaces of predator-proof hatchery pens and 134 were used in nest protection studies. This left 423 nests that were unmonitored.

Hatchery transplants

Much interest has been generated in the area of loggerhead turtle nest protection. Several studies have been conducted to discover cost effective ways to ensure satisfactory survival of nests until they hatch (Stancyk, 1979). One of the most effective ways to ensure such protection is to transplant nests to predator-proof hatcheries. Three such hatchery pens were constructed on Cape Island, and 480 nests were transplanted to them during the nesting season.

The total number of eggs transplanted to the hatchery pens was 60,896. The average clutch size of all nests in the pen, both whole and combinations,

was 126.9. The average clutch size for whole nests was 128.2 with a range of 54 to 185 eggs per nest. Of the total, 37,135 eggs hatched yielding a hatch rate of 61%. This is lower than the 1979 hatch rate 74.4% and significantly lower than the 1980 hatch rate of 92%.

Factors contributing to the lower hatch rate of this year are not obvious. No detailed weather information was taken on Cape Island during the nesting season; however, there is strong suspicion that the lower hatch rate is weather related. The closest weather data station to Cape Island is one located in McClellanville, S. C. During the months of May through August, temperatures and rainfall amounts did not depart from normal. A total of 70.6 cm of rain fell in the city during this period. Out of the 96 day nesting season, three or more centimeters of rain fell on such of only eight days. The greatest amount of rain (9 cm) fell on August 19th when tropical storm Dennis tracked along the coast. This is much less than the 13.8 cm and 21 cm that fell on two consecutive days in September, 1955 on an island in Georgia resulting in 100% nest mortality due to drowning (Bagotzkie, 1959). It is not known whether Bagotzkie produced a scale that showed the mortality expected with any given amount of rainfall. Sand temperature comparisons between the beach and main pen were not significantly different.

One probable reason for the markedly different success rates for this year and 1980 could have been the difference in procedures for checking the fate of nests. This year, all 480 of the nests within the pens were dug out to get the precise determination of hatching success, while in 1980 only a sample of the 480-pen nests were checked to arrive at an estimate of hatching success. Therefore, direct comparisons should be made with caution.

Although hatchery pens can form the backbone of a nest protection program, we experienced some problems that should be seriously considered. The two self-releasing pens were located on dunes along the beach. The dunes not

only sloped toward the ocean, but the back and side sloped away or were parallel to the ocean. Hatchlings generally crawled with the slope, and some became lost or trapped in the vegetation when they used the back and side slopes. Those young that used the back and side slopes and were slow to escape to the front beach, were exposed to predators for a greater period of time. Gulls were quick to discover and take advantage of late emerging and trapped young turtles. Raccoons are also attracted to the pens where the emerging young turtles can provide an easy meal. Some dead hatchlings were found with their heads eaten off, presumably by raccoons.

The problem was corrected by placing 2.5 x 20 cm boards along the bottoms of three sides of the pens, leaving the side facing the ocean open. This forced the young turtles to take the shortest route to the ocean. Also traps were placed around the pens to discourage the raccoons.

If mortality is high and cannot be reduced around self-releasing pens, non-self-releasing pens may be the answer, even though, they also can present problems. Hatchlings quickly found and escaped through small gaps in, and especially under, the boards placed around the inside of the pens. The pens had to be inspected and repaired daily. In order to eliminate this problem, future non-self-releasing pens could be constructed with hardware cloth attached on the inside bottom of the hatchery pen walls extending it a few centimeters under the sand level. This band of hardware cloth would not only keep the hatchlings in, but would keep small predators, that could slip through 5 x 10 cm mesh wire, out.

Most of the releases of hatchlings occurred during daylight. Whenever present, gulls would attempt to capture the young turtles as they surfaced for air. Releasing the hatchlings when no gulls were around was a partial solution. In the future, if all releases of hatchlings are made at night or

at the latest, just before dawn, it would help to minimize losses to gulls.

Cape Island Production

The number of hatchlings loggerheads produced are summarized in Tables 7 and 8. The 480 hatchery nests produced 37,135 young. Approximately 2,195 young hatched from the 134 nests used in the predation studies. Using figures derived from control nests--28% success rate, 71% hatch; plus the 126.2 average clutch size from whole pen nests--the remaining 423 unmonitored nests produced approximately 10,761 young. Therefore, the total production for Cape Island was estimated to be 50,111 young for 1981.

Table 7. Fate of nests used in beach transplants, repellent studies, and as controls during loggerhead turtle nesting season in 1981.

Nest Type	Number Marked	Fate			Approximate Number of Young to Ocean
		Raccoon Attacks	Washed Away	Hatched out	
Number and percentage of nests marked					
Controls	94	39 41%	29 31%	26 28%	1,097 71% ^a
Bobcat Repellent	10	2 20%	1 10%	7 70%	358 60% ^a
Human Repellent	10	4 40%	1 10%	5 50%	446 82% ^a
Beach Transplants	20	14 70%	2 10%	4 20%	294 69% ^a

^aPercent of eggs that successfully hatched per successful nest.

Nest Protection Studies

Raccoon predation on the 94 control nests was compared with that on nests marked with urine repellents and on nests that were transplanted to new sites on the beach. Beach transplantation works on the principle that raccoons locate loggerhead nests by using olfaction and visual cues left by the nesting female.

Therefore, if the eggs are removed from their original nest cavity and placed in a new cavity with no surrounding visual or olfactory turtle cues, raccoons should not be able to discover the eggs and the nest will remain undisturbed until hatching time. However, a recent test suggests that raccoons are able to locate buried eggs by olfaction without guiding visual cues (Hopkins, 1981). Seventy percent of the beach transplants were attacked by raccoons by hatching time. This is a far greater incidence of predation than that recorded in 1980 for beach transplants (see Table 7), and much greater than the rate on the controls. By the third day, 25% had already been attacked. Extreme care was taken not to transfer any sand from the original crawl or body pit to the new nest cavity. Even though no scent of the turtle or of the crew member who dug the original nest was left at the new site, something made them 28.5% more attractive than the control nests. Either the raccoons cued on the human scent (Stancyk, 1979) or were able to smell the eggs themselves through the sand layer.

Table 8. Hatching success of nest transferred to hatchery pens during the loggerhead turtle nesting season in 1981.

	Number of Nests	Number of Eggs	Mean Clutch Size	Unhatched Eggs	Hatched Eggs	Percent Hatch
North Pen	50	6,687	133.70	2,373	4,314	64.5
Main Pen	200	25,423	127.10	11,496	13,927	54.8
South Pen	230	28,786	126.86	9,624	18,894	65.6
Totals	480	60,896	126.80 ^a	23,493	37,135	61.0 ^b

^an = 480

^bN = 60,896

Of the ten nests marked with bobcat urine, only one was pillaged by raccoons on the second day. Two nests were washed away and seven successfully hatched.

Human urine was not as effective a repellent. Of the ten nests, one was attacked on the first day and one on the third day. Two additional ones were attacked during the first week, bringing the raccoon damaged total to four. One of the remaining nests was washed away leaving five which hatched successfully.

Compared to the control nests, both the human and bobcat urine were able to repel raccoons sufficiently to increase nest survival to hatching (see Table 7). The fate of the control nests was as follows: 41% were attacked by raccoons, 31% were washed away, and only 28% successfully hatched. The hatching success was increased to 50% for nests marked with human urine and 70% for nests marked with bobcat urine. The lower effectiveness of the human urine as a deterrent may be due to its insignificance in an area already replete with human scent. Also, unlike signals given by animals where olfactory communication is very important, human urine, which is never used in olfactory communication, may diminish rapidly in effect--especially after rains. If all urine is applied twice, once when the nest is laid and again a couple of weeks before expected hatching time the scent would remain strong during the most vulnerable times in the cycle of a nest. In addition, re-application of all repellents should probably occur after heavy rains to ensure their effectiveness.

Predation and Parasites

By far the most important nest predator on Cape Island is the raccoon. The 94 control nests were preyed on in this pattern: 12 on day one, four on day two, six on day three, two by week one, one on week three, one on week four, four on week six, four on week seven, two on week nine and three

by week ten. A total of 39 control nests were attacked by raccoons. Thus the control nests were vulnerable throughout the nest cycle. Of all the nests laid on the beach, 110 or 10.5% were attacked by raccoons on the same night they were laid. With 95 nights of laying activity, raccoons attacked an average of 1.2 nests per night on the same night they were laid. This rate is much lower than the comparable rates for 1980 or 1979.

In past years trapping has sufficiently reduced the raccoon population so that losses from raccoon predation was reduced. This year 15 raccoons were removed from the island.

Another important factor in reducing losses from raccoon predations was the presence of people on the island during the time that loggerheads were nesting. Our presence on the beach possibly discourage some raccoons from foraging for nests. Often the approaching jeep frightened raccoons away from nests on which they had just began to prey, and we were able to salvage a majority of the eggs. By removing 45% of the nests from the beach and transferring them to hatchery pens, we became a "predator" that exerted heavy competition for the available nests. Raccoons were not able to find nests as easily and their effectiveness as a predator was reduced.

In Table 9, eight sets of control nests are compared to see if those laid early in the season have a better chance of escaping raccoon attack than those laid late in the season. In 1981 the midpoint date of the nesting season was July 8. If the marked nests are grouped into pre-July 8 and post-July 8 sets, the survival rates are 29% and 47% respectively. However, it is clear that raccoon predation was irregular with some late season sets having survival rates similar to the early season survival rates. This supports Caldwell's (1959) findings of irregular raccoon nest predation behavior.

Table 9. Control nest vulnerability to raccoon attack during the 1981 loggerhead turtle nesting season as affected by date laid and new nest availability. Sets shown are those with five or greater nests.

Nests Marked		Nests Already Laid by Date		Percent of Marked Nest Attacked by Raccoons	New Nests ^a Available
Date	Number				
6/29	19	529	50% ^b	26.3	22
7/6	12	613	58%	33.0	15
7/20	15	861	82%	53.0	16
7/27	5	946	90%	40.0	5
8/2	8	993	94%	25.0	9
8/5	5	1,022	97%	60.0	8
8/7	7	1,039	98%	57.1	9
8/8	5	1,041	99%	40.0	5

^aIncludes nests marked as controls

^bPercentage of total nests laid during 1981

Eight nests were preyed on by a canid. A red fox (*Vulpes fulva*) was seen on the island and it was probably responsible for the damage. Whenever the canid opened a nest, only two to three eggs were eaten. Whether this was usual behavior, or the result of our frightening it away before it finished, is not known.

Eleven incidents of human activity on the island, other than our own, were recorded. This represents a continued potential for poaching. Poachers took one and at most two nests from the island. Our presence on the island undoubtedly discouraged further poaching.

Of special note was the presence of egg and hatchling parasites. Nineteen of the hatchery pen nests had small red mite-like insects among the eggs. Maggots filled the nest cavity of two nests. The red mites were also seen on

some hatchlings. Caldwell (1959) reported the presence of mites also and noted that "mites collected from the sutures of a hatchling loggerhead were identified as Macrocheles sp. (Parasitidae) by Dr. Ewing of the U. S. National Museum, who stated that the group is not parasitic and doubted 'its specific association with the turtle.'" Samples of the mites were sent to the South Carolina Wildlife Department's marine lab for identification, but at this writing no information has been received. Only the south pen overlapped slightly over sand used for pen nests last year. Nest parasites were not found in the north pen. Thirteen main pen nests and six south pen nests had the red mites.

Erosion

Many nests were washed away by waves, and as rapid erosion of Cape Island continues, losses of nests from erosion will become an increasingly important damage factor. Of the 134 nests used in the nest protection studies, approximately 25% were washed away by waves. As waves cut further into the dunes, cliffs and shelves are formed which impede the travel of nesting females to safe nesting areas protected from waves. Many females proceed to lay their eggs at the base of such cliffs where the nests are drowned by extreme high tides.

Several of the nests laid on Cape Island had abnormal eggs. Some nests (n-13) contained very small yolkless eggs; one was the size of a dime. On one occasion a laying female loggerhead was observed and the majority of her eggs were abnormal. Groups of three to five eggs were connected by a ribbon of rubbery shell-like membrane. Most of the eggs were misshaped and most of the eggshells were soft and rubbery. Several clutches were made up of eggs that were smaller than normal.

Summary

Overall the 1981 loggerhead nesting season was a success. The increase of nesting females this year proves the importance that Cape Island holds as one

of the few remaining vital rookeries for this turtle. The nest protection studies indicated that there might be valuable alternative ways to protect loggerhead nests from heavy raccoon predation. Due to the small number of nests used in the experiments, no final conclusion should be reached, but enough information was obtained to warrant continuing these experiments.

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Loggerhead Turtle Study at the
Tom Yawkey Wildlife Center

by

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and

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Part I: Aerial Beach Survey

OBJECTIVE

- (1) To determine the distribution of loggerhead turtle nesting statewide.
- (2) To refine and standardize the methodology for aerial survey so as to account for the major variables affecting the reliability of track counts.

This study is not designed to quantify total nesting activity nor to provide a population estimate for the state.

INTRODUCTION

There is a two-fold problem and need for this study. One is the lack of current data on the extent and distribution of nesting in South Carolina. The other is the lack of a practical and reproducible methodology for obtaining this information.

The most efficient means of gathering these data appears to be aerial survey. But aerial survey is only useful if it provides reproducible results each time it is used. There is a need to standardize the methodology for aerial survey and to quantify the major variables affecting the reliabilities of track counts. While aerial survey has been used in the southeast for nesting estimates, (Lebuff and Hagan 1978, Carr and Carr 1977, Stancyk et al. unpub. data, and Hillestad et al. 1977) the quantification of variability in this method has not been documented.

This study would provide base line data on the extent and distribution of turtle crawl activity in South Carolina which can be used as a means of measuring the results of future, applied management and perhaps, past management practices.

A carefully documented aerial survey methodology will be developed which would optimize the use of aircraft and observers in this state and in other

areas in the future.

The data obtained will be useful to agencies such as the Corps of Engineers and the S. C. Coastal Council in making decisions that affect the beaches and dunes of the state. Permit applications for beach nourishment, seawalls and rip rap groins are continually under review by state and federal agencies. Informed decisions concerning such projects could prevent further loss of nesting beaches and will potentially aid in maintaining high quality turtle nesting beaches.

METHODS

Aerial surveys were flown over the entire South Carolina coast with known loggerhead turtle nesting (from Murrells Inlet to the Savannah River) to achieve a point-in-time reference of distribution. The timing of the flights were designed to standardize variables of light conditions, tidal stage and visibility of fresh tracks. Rotor-wing aircraft was used to assess flight variables such as speed, altitude and position relative to the beach.

Project personnel documented turtle crawl activity on selected beaches (North, Sand and South Islands and from Cape Island and Kiawah by cooperators) in order to verify what was recorded by the aerial observers as to nesting versus non-nesting tracks and fresh versus old tracks.

Variability between the aerial observers and comparisons of ground and aerial counts was quantified. This quantification will be used to develop a standardized aerial survey methodology.

Seven surveys were flown between 16 May and 13 August in 1980 and seven surveys were flown between 4 June and 2 August in 1981 at approximately fourteen-day intervals. Two sets of paired flights were flown in 1981 to assess daily variables of tidal stage and turtle activity. Ground truth data were obtained from islands in the Yawkey Wildlife Center, from Cape Island in Cape Romain FWR and from Kiawah Island.

RESULTS AND DISCUSSION

No crawl activity was observed on the ground or from the air for the first survey flight in 1980 and the 3 July flight was cancelled because of weather in 1981.

In 1980, six flights resulted in a total of 816 and 782 crawls counted by observer 1 and observer 2, respectively for a mean of 799 crawls. In 1981, seven flights resulted in a total of 1,217 and 1,204 crawls counted by observer 1 and observer 2, respectively for a mean of 1,210.5 crawls. The difference between aerial observers for total crawls counted was 34 (4.26%) in 1980 and only 13 (1.1%) in 1981. This close agreement between observers in the second year suggests that experience reduces observer bias.

When aerial observations were compared to the ground truth for 1980, there was a difference of +6.95% for observer 1 and a -2.14% difference for observer 2 for total crawls seen. When this same comparison was made for 1981, there was a difference of -10.0% for observer 1 and -9.4% for observer 2. This higher error rate occurred for the most part on the second day for each of the two paired flights and was caused by difficulty in aging the crawls. This aging difficulty occurred because the high tide after dark was one hour later the second night thereby allowing turtles enough time to come ashore on a rising tide, nest, and leave on the high tide. Therefore none of their tracks extended below the high water mark on the beach, our criterion for a fresh track. Also since the tidal stage was on a dropping cycle, the high water mark was lower on the beach the second flight day leaving some older crawls still visible. Thus fresh crawls made soon after dark, and one day old crawls appeared similar since both types of crawls did not extend below the high water mark. If this particular aging problem had not occurred on these two flights, the aerial observer bias would have been slightly over one percent for total crawls seen.

When aerial nesting crawls were compared to ground truth for each year, the bias was again greatly reduced. Observer 1 reduced this bias from 44.4% in 1980 to 15.4% in 1981. Observer 2 reduced this bias from 15.15% in 1980 to 5.5% in 1981. These data show again the improvement in technique with greater experience. The difference between aerial counts of false crawls between 1980 and 1981 with the ground truth remained about the same for both observers. Both observers consistently under counted false crawls and over counted nests, but the nesting count bias was reduced from the previous year. These percentages are based on the ground truthing of nearly half of the crawl activity on the South Carolina coast (46% in 1980, 44.6% in 1981).

An altitude of 200 feet was determined to give the best view of the crawl. The speed of the aircraft was 60 knots in 1980, but this speed was adjusted downward for higher crawl density beaches in 1981 and was a major contributing factor for the reduced biases. Timing flights with the correct tidal stage was found to be essential when two consecutive day flights were flown as shown by difficulty with aging of crawls.

RECOMMENDATIONS

Continuation of this study is necessary to obtain annual variability. Paired flights will be scheduled by flying on the day prior to the optimum tide rather than the day after the optimum tide to avoid errors in aging crawls. A major emphasis will be placed on teaching this technique of aerial survey to a new and inexperienced observer by various graphic and visual aids prior to flying. The new observer's biases will be compared to those already documented for the experienced observers to test the reliability of the methodology.

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Part II: Raccoon Predation

OBJECTIVE

To assess the effectiveness of various methods of raccoon removal on turtle nesting beaches.

INTRODUCTION

Raccoons (Procyon lotor) were the major predator on nests of loggerhead turtles on four islands in South Carolina (Hopkins et al., 1978). Lithium chloride aversion conditioning did not prove to be an effective technique for preventing nest mortality (Hopkins, unpub. data). Likewise, complete erasure of the visible signs of the crawl and body pit did not prevent raccoons from finding and destroying nests (Hopkins, unpub. data). The method of nest transplants (Stancyk, 1980) is unproven and hatcheries are labor-intensive and result in nightly beach disturbance and possible abnormal sex ratios.

There is a clear need to reduce raccoon predations where levels are excessively high. However, previous studies have shown that when one factor of nest mortality is reduced, nest loss to other factors may increase (Hopkins et al., 1978, Caldwell 1959). Since compensation may be occurring, reduction of raccoons has to be weighed against other factors, biotic and abiotic, to arrive at an acceptable level of control.

Control methods which warrant further investigation are 1) removal of raccoons prior to the nesting season by trapping, 2) removal by trapping during the season, and 3) removal during the season by shooting.

Information will be obtained on the most effective times and methods to increase nest success by removing raccoons. An indication of the effort required to significantly increase nest success by this method will also be obtained. This information will be valuable to wildlife managers throughout the range of the turtle who have similar problems with raccoons.

METHODS

Raccoons were removed on primary nesting beaches of the Tom Yawkey Wildlife Center prior to the nesting season. After monitoring nests laid in the first quarter of the nesting season, predation rates were still above acceptable levels, and night hunting of short duration with small caliber rifles were conducted. Monitoring of nests continued to assess the results of this effort. Steel leg-hold traps were the primary method for trapping and nest monitoring was the same as described in Hopkins et al. (1976). In addition, nests laid in sites subject to erosion were relocated to safer locations on the first morning after they were laid.

RESULTS AND DISCUSSION

In 1980, the predation was not reduced by the removal of 203 raccoons from the interior of the island during the first portion of the nesting season. Removal of 20 raccoons directly from the beach from 9 July to 31 July reduced the predation rate by 30%. The overall predation rate for raccoons was reduced about 10% for South Island in 1980. Due to limitations in the availability of personnel, trapping was only conducted on South Island.

In 1981, trapping was conducted on both Sand and South Islands from 5 May to 2 June. During this time two foxes (one male and one female) and two raccoons (one male and one female) were removed from Sand Island. Eight raccoons (seven males and one female) were trapped on South Island.

The fates of the nests on Sand and South Islands are shown in Table 10. The results are striking compared to previous years. The hatch rate on South Island increased from 12.7% in 1980 to 62.1% in 1981. This higher hatch rate was due to the combination of raccoon removal and transferring nests to better nest sites. The minimum number of hatchlings produced on South Island was 5,757. Natural nests had a hatchability of 73.4% whereas transferred nests had a

hatchability of 53.4%. The overall hatchability on South Island was 67.4%. (Hatchability equals the number of hatchlings which emerge from the total number of eggs contained in hatched nests expressed as a percent).

Table 10. Fates of 383 loggerhead turtle nests on two barrier islands of the Tom Yawkey Wildlife Center in 1981.

	South (N=150)	Sand (N=233)
ABIOTIC FACTORS (inundation and rain)	16.0%	16.3%
BIOTIC FACTORS		
Humans	4.7%	12.5%
Chest Crabs	2.0%	1.7%
Raccoons	10.7%	2.1%
Foxes	0.0%	2.1%
Multiple predators	3.3%	3.0%
Hatched	62.1%	60.5%
Transfer Mortality	1.3%	0.9%
Plant roots	0.0%	0.9%
TOTALS	100.0%	100.0%

The minimum number of hatchlings produced on Sand Island was 11,239. The hatchability of natural nests was 77.1% while the hatchability of transferred nests was 56.0% for an overall hatchability of 74.3%. The percent hatch rose from 8.4% in 1960 to 60.5% in 1981.

The majority of the raccoon predation on South Island occurred after 22 July thus affording a safe incubation period for most of the nesting season. The small amount of predation on Sand Island was scattered throughout the season. Much of the predator activity on both islands involved nests which were in the process of hatching and only a few hatchlings are killed at this time. Thus for the Yawkey Center, the loggerhead turtles had a very successful year with a total production of 17,000 hatchlings. A total of 424 nests were monitored, but because of the loss of marker flags, 41 nests were eliminated from the data set.

RECOMMENDATIONS

Another year of study is needed to determine if some other factors such as impoundment management or disease may have prevented additional raccoons from moving onto the beach after trapping was curtailed. The results on Sand Island had been predicted since predator density was low and the isolated nature of the island made migration of new individuals unlikely. Law enforcement efforts on Sand Island need to be stepped up since poaching has increased in 1980 and again in 1981.

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