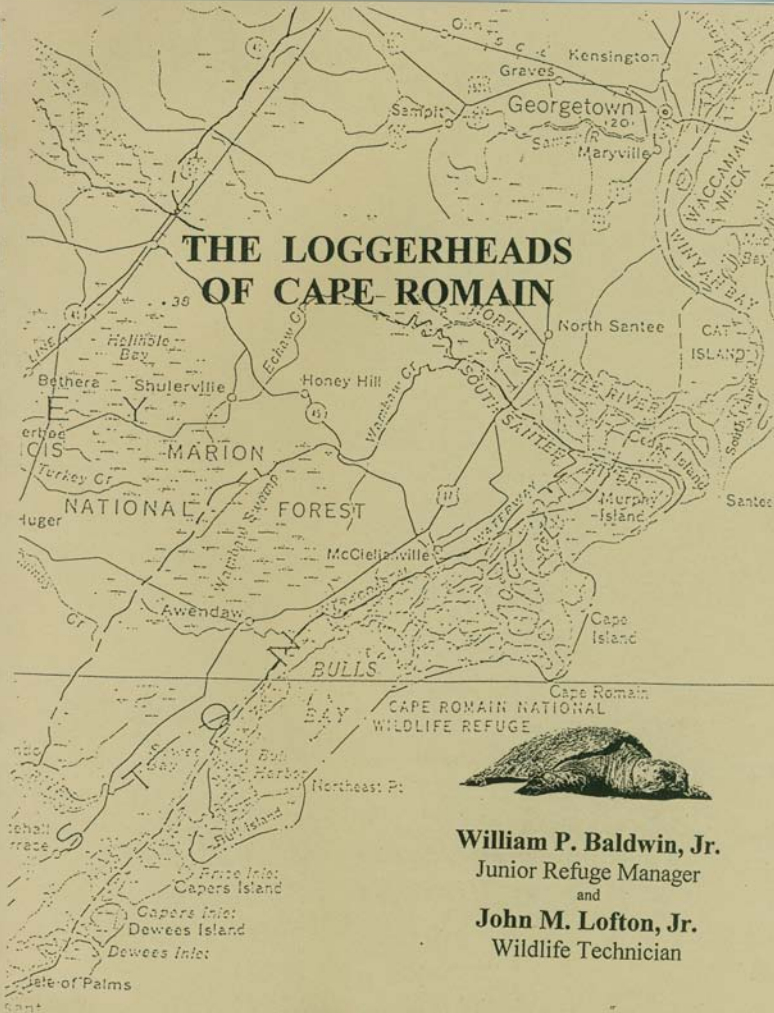


# THE LOGGERHEADS OF CAPE ROMAIN



**William P. Baldwin, Jr.**  
Junior Refuge Manager  
and  
**John M. Lofton, Jr.**  
Wildlife Technician



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by

***William P. Baldwin, Jr.***  
Junior Refuge Manager  
and  
***John M. Lofton, Jr.***  
Wildlife Technician

Edited by  
**William P. Baldwin, III**  
and  
**Patty Fulcher**

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William P. Baldwin III

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The Village Museum  
PO Box 595  
401 Pinckney Street  
McClellanville, SC 29458

## A FORWARD NOTE

My father Bill Baldwin and his assistant Johnny Lofton spent the summer of 1939 on Cape Romain doing one of the first systematic studies of loggerhead turtles. My father spoke often of this adventure. The two young men camped out in a shack set well back from the Cape's beach in a scorching, breezeless sump. By land their transportation consisted of their feet and by water an oyster bateau and a cantankerous five h.p. outboard motor. They wrestled their galvanized milk-can water supply over a half mile of narrow, sandy, cactus lined path. They smeared burnt engine oil on the screens to keep out the gnats. Needless to say, they had the time of their lives.

The resulting report, "The Loggerheads of Cape Romain," was being prepared for publication when World War II began but as a result of that war was put aside. Dog-eared typed copies existed, however, and in the years since it's been borrowed from occasionally. Still, we at McClellanville's Village Museum wanted the original to finally see the full light of day.

A special thanks must go to Patty Fulcher who did the hero's share of editing and word processing. She kept this project going. And now we all take pleasure in presenting to you "the Loggerheads of Cape Romain."

William P. Baldwin III  
Village Museum  
McClellanville, SC  
August 1999

UNITED STATES  
DEPARTMENT OF THE INTERIOR  
BUREAU OF BIOLOGICAL SURVEY

McClellanville, South Carolina  
29 June 1940

Mr. Andrew H. DuPre, Refuge Manager  
Cape Romain Migratory Bird Refuge  
McClellanville, South Carolina

Dear Mr. DuPre:

Attached is a report on the loggerhead turtle as it occurs on the refuge. During this study we examined most of the literature on this species, and we have incorporated the views of other investigators in this report. Although the most desirable facts to establish for Cape Romain Refuge were those of nest abundance and depredation, we secured considerable data on other phases of the loggerhead's life history. We have presented these, realizing that although they have little relationship to refuge administration, they are a contribution to the study of animal behavior.

This study is by no means complete. If time and facilities permitted, valuable work might be continued on this species in order to further investigate many points briefly touched upon last year.

Very truly yours,

WILLIAM F. BALWIS, JR.

JOHN E. LOFTON, JR.

# THE LOGGERHEADS OF CAPE ROMAIN



**William P. Baldwin, Jr.**

Junior Refuge Manager  
and

**John M. Lofton, Jr.**

Wildlife Technician

Cape Romain Migratory Bird Refuge  
U.S. Biological Survey  
McClellanville, SC

June 1940

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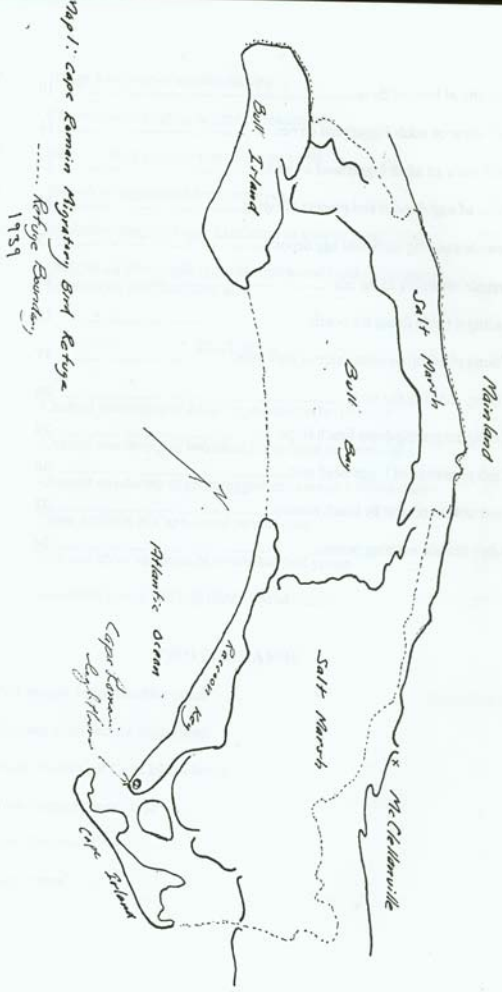
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Map 1: Cape Romain Migratory Bird Refuge

----- Refuge Boundary,  
1939

## I. Introduction

The large female turtle emerges from the night time surf and with great effort crawls to the dune line. She pauses. Then if satisfied with her circumstances, she uses her hind flippers to construct a deep hole in the beach and into this she lays her eggs. It is indeed awe inspiring to come upon one of the animals at its task, its breath sighing, eyes watering, body heaving. And on its back are bits of phosphorescent marine life blinking off and on. With luck a process has begun which will in the course of the summer lead to the next generation of loggerheads.

Compared to other sea turtles, the Atlantic Loggerheads are moderate sized - about 30 inches across the carapace and weighing around 250 pounds. Relatively common, they are found in most of the warmer parts of the North and South Atlantic and even into the Mediterranean Sea. On our coast they nest from Texas to Virginia, but the U. S. Wildlife Refuge of Cape Romain, South Carolina, which is our study site is actually on the northern boundary of its normal nesting range. Over 600 nests a season are made on the beaches of the Cape's Bull Island, Raccoon Key, and Cape Island.

These three islands are typical sea islands. These barrier strips separate the ocean from the mainland, and in the process, form a protected area of marshes, creeks and bays. Bull Island has grown thick with a maritime forest of palmetto, cedar, and windblown oak but Cape Island and Raccoon Key are relatively bare. The dune vegetation of all three, however, is very similar with the commonest plants being sea oats, cord grass, and beach tea.

As far as we can ascertain, the loggerhead nests on the Cape Romain beaches in greater numbers than anywhere else on the Carolina coast. Cape Island with five miles of front beach has 400 nests a season; Raccoon Key, with eight miles, has an estimated 200 nests; and Bull Island, about six and one-half miles long, has approximately 30 nests. Why Cape Island and Raccoon Key should be centers of such nesting activity is an interesting question. Cape Romain does project farther out than other beaches along the coast and may intercept the northern spring migration of breeding adults. The solitude of the refuge beaches may be another attractive feature partly responsible for the concentration. It is certainly evident that the increase in public activity at other beaches in this section has resulted in decreased turtle nesting there. Perhaps feeding conditions in Romain's bays and creeks are attractive to a high breeding population. The proximity of the vast discharge of fresh water from the Santee River may affect this food supply. Romain's loggerhead population today, however, is smaller than it was several decades ago. This, of course, is in accord with the recent numerical decline of this species throughout its range.\*

---

\*Though the idea wasn't original to him, years later my father suggested that the coarseness of Cape Island's sand made for easier digging. When sediment empties from the Santee River, the larger particles drop out first. The smaller particles follow the current and are released to the south. Thus the Bull Island beach would be more firmly packed and would be harder for a turtle to excavate a nest. He also mentioned that a systematic trapping of predatory raccoons in the Cape area may have allowed an above average number of turtles to hatch and thus mature into an adult-laying population.

While some work has been done on this species, not much is known about its habits. In 1700, explorer John Lawson passed through the Cape Romain area and commented on the edibility of the green turtle and Hawksbill turtle and on the loggerheads' lack of tastiness.

The loggerhead, which kind scare anyone covets, except it be for the eggs, which of this and all other turtles are very good food. None of these sorts of creatures' eggs will ever admit white to be harder than a jelly; yet the yolk, with boiling, becomes as hard as any other egg.<sup>20</sup>

Recent work includes Hay who described the loggerhead's skeletal structure.<sup>14</sup> Hooker worked chiefly on the early instincts of newly hatched loggerheads,<sup>16,17,18,19</sup> and Parker reported on the growth and reactions of the young to environment.<sup>24, 25, 26</sup> Nesting data from the North Carolina coast was presented by Coker.<sup>5</sup> The part this species has in the turtle fishing industry of Bermuda was described by Babcock.<sup>2</sup> Most of these and the many small reports in various journals have been summarized recently in Pope's popular work.<sup>27</sup>

### Work at Cape Romain

For several years notes on the loggerhead have been kept by personnel of the Cape Romain Refuge. In the summers of 1937 and 1938, under the direction of Andrew H. DuPre, Refuge Manager, Lofton worked on the north end of the refuge, and in 1938 Baldwin, on the south end. During the summer of 1939, a more intensive study of loggerhead nesting was conducted, the writers staying full time at Cape Island. A few additional notes were secured during the summer of 1940. Although most of this report is based on our 1939 work, we have drawn from the notes of our previous work, notes of Mr. DuPre, and from unpublished information contributed by the Charleston Museum staff and other local observers. Photographs were taken by the writers. Grateful acknowledgment is made to these persons for their helpful suggestions and material.

The plan of study for the 1939 nesting season was briefly as follows: notes on the first appearance and mating of the adults were recorded during the spring. Cape Island was selected as a base for the summer's work since it offered the most nests. Work was commenced here during the last of May and continued until the end of September. A daily patrol of the five miles of beach on foot or bicycle resulted in the finding and marking of the previous night's nests. At night, additional patrolling often yielded information on the nesting habits of adult females. Close check was kept on the depredation of nests. Many were enclosed with small mesh wire when the hatching time approached, and the subsequent corralling of the newly hatched turtles yielded data on length of incubation, size of young, and many other points. Some egg deposits were excavated and replanted in various experiments.

## II. ADULT TURTLES AND MATING

### Length of Stay at Cape Romain

In March the adult turtles appear in the bays and salt creeks which wind through Romain's marshes in all directions. Although previously they had been seen early in March, the first



appearance recorded in 1939 was on March 28. The first mating pair was observed in Cape Romain Harbor on March 31. It is during April and May that the turtles appear most frequently in the bays and creeks behind the islands. During this time, mating couples are seen commonly, and often several males may be observed following or even clasping the same female. The latest recorded mating in 1939 was on May 11, although it certainly was not the latest occurrence. In that summer, egg-laying commenced in the middle of May. During June, July, and August, when the adult females are laying on the front beaches, turtles are not commonly seen in the creeks, and we have no records of mating in those months. By October the majority of the adult turtles have disappeared.

### Mating

We have records of mating for every hour from dawn to dark. Night mating doubtlessly occurs but we have no information on the length of copulation. As is the case with other species of marine turtles, paired loggerheads may copulate for extended periods and perhaps the females remate after each nest is made. Fowler states that "a pair is said to remain copulating for as many as 17 days at a time,"<sup>12</sup> but such a long period seems highly improbable.

Mating turtles float in the water with the male in the superior position. While the female is submerged completely, the highest part of the male's carapace is usually out of the water. The head of the male emerges for breathing every few minutes, and the female struggles to the surface for air about every five minutes. With his plastron on the female's carapace, the male holds immovably to her with all four limbs, thus leaving the female free to swim. The very large tail of the male, which is eight inches or longer, bends down pressing the cloacal opening against the similar organ of the female, and the two are tightly joined.

Although external differences between males and females of the Atlantic Loggerhead have never been reported in print, it is interesting to note that the male has a tail at least eight inches long, with the cloacal opening near its tip. The tail of the female is about 5 inches long and the distance between the cloacal opening and the tip of the tail is two inches. In the closely related Pacific Loggerhead, this tail length difference between the sexes has been recorded but heretofore only suspected in the Atlantic species.

### Size of Adult Loggerheads

Aside from very small newly hatched specimens, the only loggerheads that frequent Cape Romain are large adults. As far as we can tell, all of the intermediate sized turtles in this section are green turtles. To illustrate the size of our nesting females, measurements and weights of some turtles are presented in Table 1.



Table 1: Measurements and weights of adult female loggerheads.

Tag No.	Length Carapace	Width Carapace	Length Plastron	Width Plastron	Width Head	Width Crawl	Weight
	36.25	26.50					
	35.00	26.50				35	
1	36.50	30.50				35	
2	34.75	24.50				35	
3	33.50	27.00				34	
4	35.00	27.75	25.50			36	
5	34.50	22.75		25.25	8.00	32	
6	36.75	27.50	28.00		8.25		
7	40.50	26.75	29.75	23.50	8.12	39	
8	38.00	29.50		24.00		36	
9	38.00	31.00	28.50		8.25	36	
10	38.50	28.50	29.50	27.75	8.00	33	
11	35.50	28.50		26.25	7.90		
12	38.60	31.75					
13	36.50	29.50			7.50		
14			27.25	26.25	7.75	36	262
15		27.75	28.00	24.60			
16	35.75	27.00	27.40	24.75	8.10		257
17	33.25	26.60	25.50	24.00	7.75		218
18	<u>39.00</u>	<u>28.75</u>	<u>29.30</u>	<u>24.00</u>	7.00	33	193
Average	36.40	27.80	27.90	<u>26.50</u> 25.30	<u>7.90</u> 7.80	<u>38</u> 35.2	<u>298</u> 245.6

Measurements in inches and weight in pounds; measurements are straight-line, taken with calipers at widest part. Some head measurements may be in error.



The average carapace measurements of 19 were 36.4 inches (length) by 27.8 inches (width). The weights of five individuals ranged from 193 to 298 pounds with an average of 245.6 pounds.

These weights, typical of all specimens observed nesting, agree well with those given for mature loggerheads by other authorities. Pope states that a very large individual weighs 300 pounds.<sup>27</sup> Four loggerheads weighed at Blackbeard Island, Georgia, by Creaser ranged from 215 to 275 pounds.<sup>7</sup> In the Charleston Museum is a skull (No.2373) of a loggerhead turtle which weighed 607 pounds and was taken on the "S. C. Coast." McGowen Holmes of Edisto Island reported to the Charleston Museum in 1935 that the largest loggerhead of the many he had observed in this section had a carapace which measured 48 by 38 inches. Babcock, in writing of the maximum weight, states that large West Indian Loggerheads may reach 450 pounds,<sup>2</sup> and makes reference to True's old account of specimens weighing 1500 to 1600 pounds.<sup>30</sup> Whether the latter weight was correct may be doubted, but Pope also mentions True's description of an 850 pounder taken in 1871 which may have been closer to the growth limit.<sup>27</sup>

Not infrequently turtles nesting at Cape Romain became lost on the return to the sea. This occurred on two types of beaches: flat barren areas and those backed by isolated dunes. Figure 1 shows the route of one turtle, after making four primary excavations, moved inland, became lost, and wandered extensively. These barren areas, from 200 to 400 feet across, gradually slope back from the crest of the ocean beach making the ocean invisible to a turtle 50 or 60 feet in. This well accounts for the instance in which the above-mentioned turtle laboriously dragged its massive body for 2,140 feet over the sandy flat. Figure 2 shows the crawls made by two turtles in laying on a barren area. In number 31, the turtle apparently made several small circles to determine its position with respect to the sea. As shown in the diagram of nest 44, the turtle crawled diagonally and reached the beach but for some undetermined reason reversed her direction and crawled for several hundred more feet around the barren area; such action was very unusual. Figure 3 indicates how a turtle becomes confused among isolated dunes. Nest 142 was made on the top of a ten-foot dune 100 feet from the ocean. Upon descending the dune, the turtle could not see the ocean and wandered extensively among the 2-5 feet high dunes, never climbing any of them, until she eventually reached the safety of the ocean beach. An occasional Loggerhead skeleton, far back among the dunes, is mute evidence that turtles do remain lost until the merciless heat of the rising sun kills them.

### III. THE NESTING

#### Duration of Nesting

On the Cape Romain's beaches, nests are made from the middle of May to the middle of August. Coker states that the laying season in North Carolina extends from the latter part of May into August.<sup>5</sup> In Florida nesting begins earlier than this time. On May 19, 1939, when work was begun at Cape Island, a few nests had already been made. The last nest made there was on the night of August 18. Thus, the laying season extended over a period of three full months with its peak in June and July.

#### Nesting and Non-Nesting Crawls

The crawling of the turtle on the beach does not necessarily signify that the animal has made a nest. If the site does not appear favorable, the turtle often returns to the water without laying, and usually tries again farther down the beach. In our counts, we differentiated between nesting and

Continue  
 to show about  
 distance between  
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 in one  
 type  
 (line  
 structure  
 etc. to  
 indicate  
 where  
 the  
 bird  
 was  
 seen)

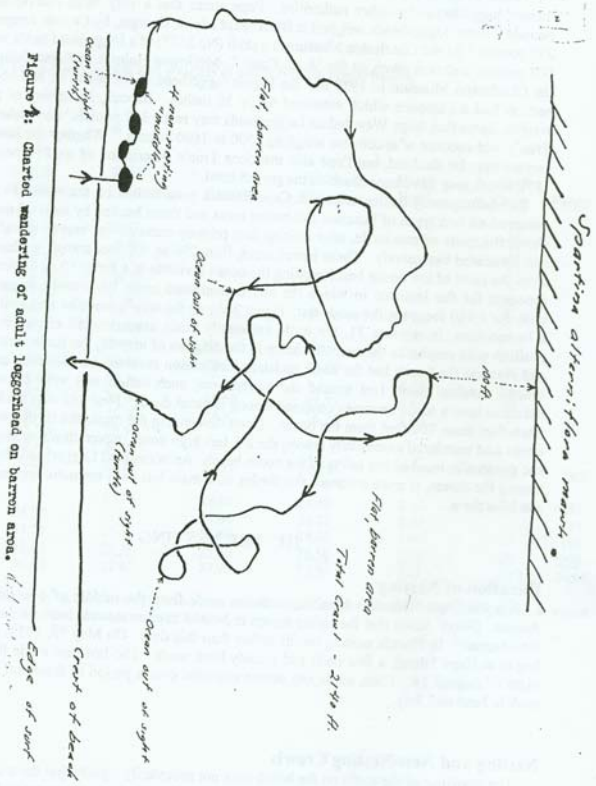


Figure 1: Mated wandering of adult logskinned on barren area.

*Spartina alterniflora* marsh

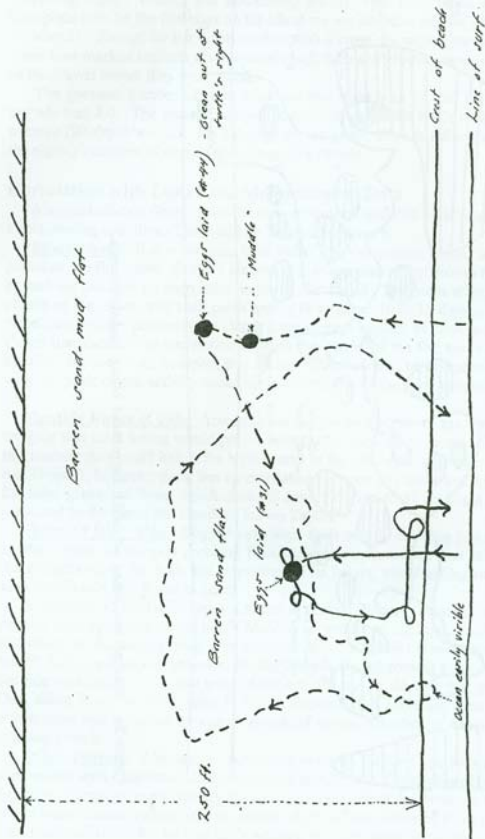


Figure 2: Charted wandering of two adult loggerheads on barren area.

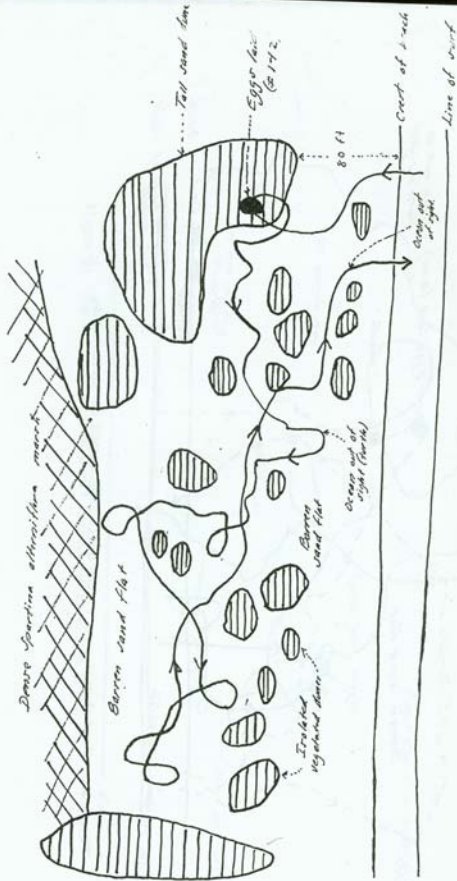


Figure 3: Charted wandering of adult loggerhead among isolated dunes.

non-nesting crawls. Each morning we patrolled the entire five miles of beach and recorded the preceding night's nesting and non-nesting crawls. This information is presented in Graph 1. Complete data for the first days on the island are not available and the information presented starts on May 21. Except for the nights marked with a cross, the nightly number of crawls is complete; those thus marked indicate that extremely high tides and blowing sand may have obliterated some of the crawls before they were noted.

The greatest number of nests made on any night was 13 and the nightly average (90-day period) was 3.0. The greatest number of non-nesting crawls made on any night was 31 and the average (90 days) was 5.3. As indicated on the graph, there is a fairly close correlation between the nightly numbers of nesting and non-nesting crawls.

### **Correlation with Lunar and Meteorological Data**

Also included on Graph 1 are the daily records of tidal and lunar phases which would possibly affect nesting activities. These will be discussed separately.

**Moon phase:** It is a common local belief that the greatest nesting activity occurs during the period of the full moon. Graph 1 diagrams the moon phase in relation to the number of crawls (a 7 b), and we can find no correlation to justify this belief. The peaks of egg-laying occur during all phases of the moon, and such peaks appear to be about 10 to 13 days apart. To further interpret these data, we are presenting in Graph 2 the average number of nests per moon phase. This also shows that there is no correlation between the period of the full moon and the greatest nesting activity. It does show, however, that the nesting season may be interpreted graphically as a curve, with the peak of the activity occurring in the middle of the laying season, near the full moon of July.

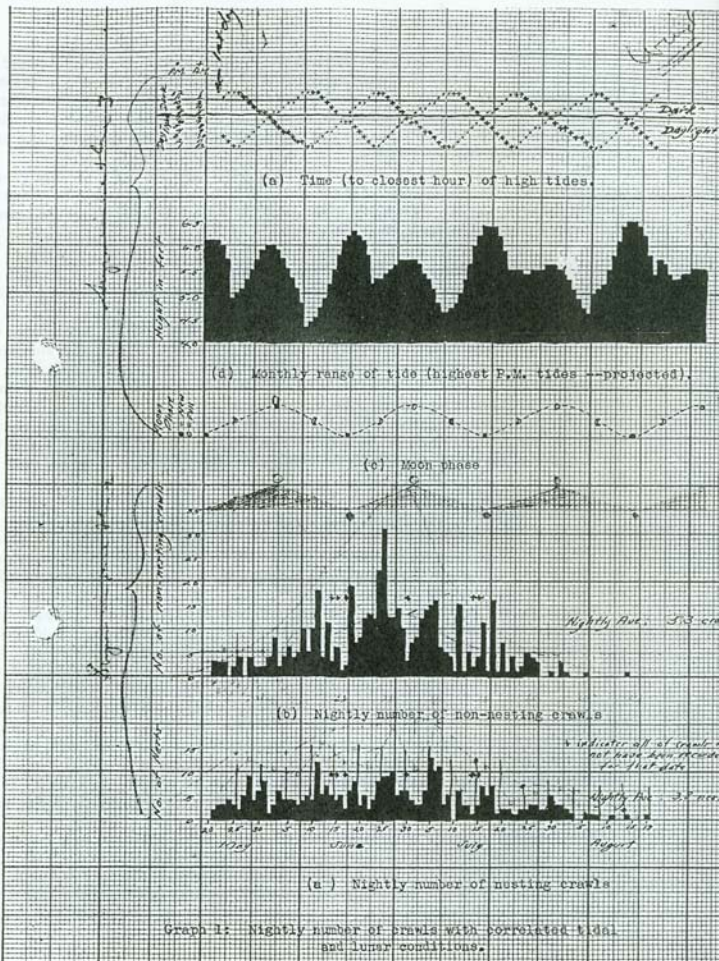
**Monthly Range of Tide:** Assuming that turtles can hold their eggs for short periods, one might imagine that most turtles would put off laying until that time of month when tides are highest. In this manner they could utilize the higher water to float in nearer to the dunes. As shown in section d of Graph 1, however, there was no correlation between this factor and egg-laying. In that section the tides given are those which occurred from 12 noon to 12 midnight and are projected tides presented in the Coast and Geodetic Survey Tables.<sup>4</sup>

**Time of High Tide:** Loggerheads begin their nightly crawling just at dark. In considering another aspect of the tide problem, therefore, one might assume that most turtles would lay on those nights when the high tide, regardless of its height, was reaching its peak just at dark. No such correlation was found to exist.

In speaking of the Bermudan sea turtles in general, Babcock mentions that they come ashore to deposit their eggs on a rising tide.<sup>2</sup> McAtee, in writing of the loggerhead (apparently in Georgia and other southeastern states), also mentions that the females come ashore chiefly on the rising tide.<sup>22</sup> At Cape Romain, however, the loggerheads started coming ashore just after dark, whether the tide was high or low, and most of the activity was in the first four or five hours after dusk. Data taken from our field notes to further illustrate this point are presented in Table 2. This information was gathered by nightly patrols of certain stretches of beach and rechecked on the morning patrol.

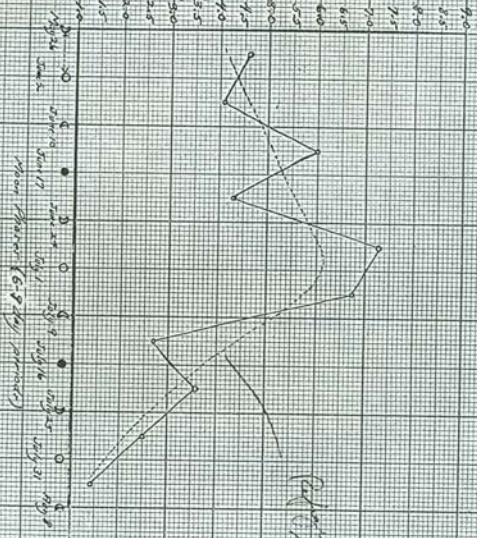
**Other Factors:** Although no barometric readings for the Cape Romain area were available, comparison with Charleston data indicated no correlation. The nesting of turtles was little affected by minor storms or even easterly squalls. In one instance, however, on the night of July 10, a severe thunderstorm (which started just after dark and was followed by an all night rain) may have been responsible for the lack of turtle activity; no nests were made that night and only one non-





Approximate number of moths per night  
 for 5 days in each phase of the moon

Average Nightly Number of Moths for Each Period



Reference: compare with results of other groups

- Moon Phases:
- New Moon
  - ◐ Waxing Crescent
  - ◑ First Quarter
  - ◒ Waxing Gibbous
  - Full Moon
  - ◓ Waning Gibbous
  - ◒ Last Quarter
  - ◐ Waning Crescent

Graph 2: Range and peak of nocturnal activity (moths only) as based on averages for successive moon phases throughout years.

nesting crawl was observed, although there was much activity on the preceding and following nights.

The highest daily air temperature throughout the laying season ranged between 81° F. and 97° F. The lowest daily temperatures ranged between 66° and 79° F. There was no correlation between air temperature and nesting activity. Likewise, there was no apparent relationship between wind direction or velocity and turtle crawling.

### Re-Nesting

We have pointed out that nest making on Cape Island appeared to be cyclical with the greatest activity occurring every 10-13 days. Many authors have pointed out that several nests a year might be made by each female. If it could be proved that Romain loggerhead turtles possessed a limited summer range and re-nested on the same stretch of beach, it would be fairly safe to say that these 10-13 day intervals represented the time between clutches.

It is fairly common knowledge that slaughtered females in this section contained eggs in various states of development. Several fishermen of McClellanville have pointed this out to us. Additional information was supplied by E. B. Chamberlain of the Charleston Museum who opened a 53-inch loggerhead (in June 1912) and found it contained 163 eggs of all sizes, ranging from those ready for laying down to very small undeveloped ones.

In further substantiation is the following item originally printed in "The State" (Columbia, SC) and reprinted in the June 6, 1929, issue of the "News and Courier" (Charleston, SC). A local loggerhead, with a carapace three feet long and one-half feet wide contained, when killed and opened, "119 mature eggs, and also over 700 eggs in various states of growth, ranging in size from a grape to full size, but without the shell developed."

Although all of the above information satisfactorily indicates re-nesting of the loggerhead, additional work was done on this point. Eighteen female loggerheads caught on the Cape Island beach were marked on the trailing edge of the carapace with aluminum tags. Each tag (Fig 6) bore a serial number and the inscription, "Notify U. S. Biological Survey, McClellanville, SC, USA." Of the 18 turtles tagged, three were later recaptured on the same beach and the pertinent information is given below:

Turtle #4	Non-nesting crawl	June 12 - tagged
	Laid eggs	June 27 - 1000 ft north of point of tagging. 15 day interval
Turtle #10	Non-nesting crawl	July 3 - tagged
	Non-nesting crawl	July 4 - 300 ft. south of point tagging 1 day interval
Turtle # 13	Non-nesting crawl	July 6 - tagged
	Non-nesting crawl	July 28 - 950 ft. south of point of tagging; 22-day interval

In this section it is conceded that this species crawls out on the beach only to lay, so the three above-mentioned turtles, even though they did not nest every time in our presence, were certainly not dragging their ponderous bulks through the darkened dunes "just for the walk." While turtles ready for laying can hold their eggs for a short time, it seems unlikely that they can hold them for



15 or 22 days. On the basis of the above examples, it is probable that all of these turtles laid a few nights after they were tagged and our recaptures were made on nights when they were investigating for a second or third nesting. This also would indicate an interval between nesting of 10-12 days. Hence, if egg-laying is so periodic, it is unlikely that tidal and lunar phenomena affect the laying process.

Our records on Turtle # 10 were very interesting. On the night this turtle was tagged, she submitted, not unwillingly, to all of the indignities of being turned on her back, having a hole bored through her shell for a tag, being surrounded by a half dozen noisy people, and having night movies taken in the presence of brilliant artificial light. She was then liberated. She was found on the beach again at the same time and under the same conditions of tide, moonlight, and wind, only 200 feet from the previous night's encounter. The necessity for egg-laying apparently made this turtle disregard the previous evening's experience (if she did "remember" it at all).

Additional information on the powers of females to retain their eggs was supplied by still another turtle. During the night, as she was returning to the sea without laying, we overturned her and left her until morning. At daybreak, we found that she had laid over 90 eggs while on her back. Other non-nesting turtles we turned never reacted like this one but retained their eggs.

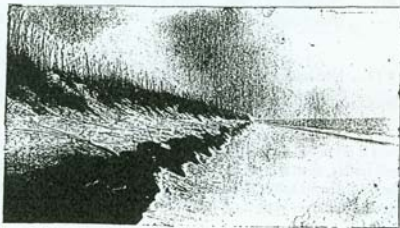
In summing up all of the aforementioned information, it is evident that the Atlantic Loggerhead, just as has already been proved for other species of marine turtles, lays several egg clutches per season at intervals of about 10-12 days, and during this time remains in a restricted area.

### **Selection of Nesting Sites**

**Beach types:** The Cape Island beach during the summer of 1939 offered six kinds of potential nesting sites to female turtles. Figure 4 shows these beach types in cross section and we have assigned descriptive titles.

**The Truncate Dunes** are sharply eroded dunes backing a beach five to 10 feet wide on an average high tide. Extremely high tides pound the base of these dunes. Turtles are not able to ascend the face of these dunes, although they often tried. The truncate dunes grade into the next type.

**The Ledge Section** is a stretch of beach that has a half-foot to three-foot ledge breaking the middle of its natural slope. This type is variable and is formed by the action of wind and tide. At times the ledge is high enough to prevent the turtles' reaching the dunes to nest. This gradually merges into the next type.

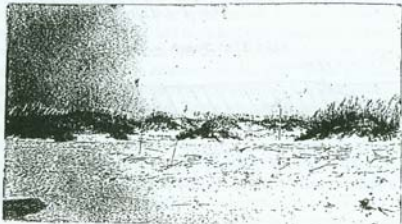


The Wide Sloping Beach is 25 to 40 feet wide (from average high tide line to base of dune). The outer dune is a continuous ridge which parallels the ocean front and is broken in only a few places. Turtles can easily crawl from the surf to the base of the dunes.



The Narrow flat Beach is 10 to 20 feet wide and is backed by small separated dunes. Turtles often climb these dunes or go through the gaps between them.

The Wide flat Beach, similar to the preceding type, is from 30 to 50 feet wide and is also backed by small isolated dunes.



Approximate Scale 1" = 20'

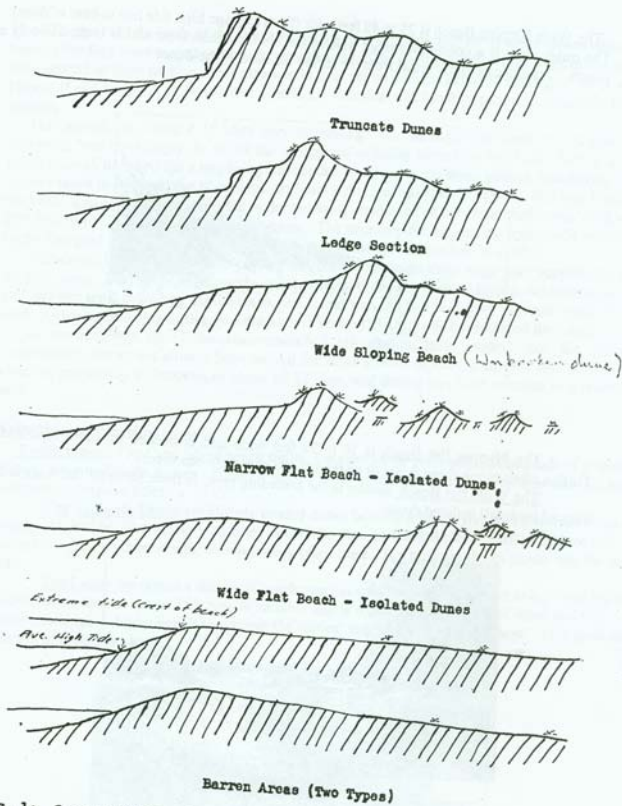
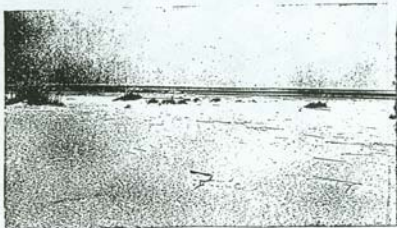


Fig. 1: Cross sections of Cape Island beach types existing summer of 1939.

Barren Areas are those stretching 100 to 400 feet back from the crest of the beach, and only traces of vegetation or low dunes break their flatness.



The Cape Island beach, in general, is much narrower and steeper than those of Raccoon Key and Bull's Island, and the sand is coarser.

The beach at Cape Island is by no means stable, but is constantly cutting away and building up. Remains of nests made in 1938 were noticed in 1939 to be on top of truncate dunes 15 feet high; this indicated considerable cutting away during the winter between those two nesting seasons. Observations in the first part of the summer of 1940 showed that the beaches changed again. In fact, the truncate dunes of 1939 had changed into a wide sloping beach in 1940 by the deposition of sand at their base so this stretch of beach, which was so unsuited for turtle nesting one summer, was an ideal type the next summer and contained an abundance of crawls. On June 15, 1940, a count of recent turtle crawls (nesting and non-nesting) revealed 152 for the entire Cape Island beach.

**Crawls per Beach Type:** Just as certain types of beach appeared to our eyes more favorable than other types for nesting, so did they to the turtles. Data to substantiate this are offered in Table 3 which is based on the location of 343 nests and 463 non-nesting crawls.

Some of the most interesting facts that can be deduced from the information presented in Table 3 are related to turtle behavior in selection of nest sites. What process of thinking made a turtle leave the truncate dunes without nesting and swim farther along the shore to nest on the wide sloping beach? Such things happened. In the truncate dunes one nest was made every 197 feet of ocean front and one non-nesting crawl every 32 feet; for every turtle that laid on this low beach, six turtles returned to the surf without laying. On the high wide sloping beach, however, turtles made one nest every 28 feet, and one non-nesting crawl every 55 feet. For every turtle that nested, a theoretical half of a turtle returned without nesting. Thus, this high type of beach, backed by rounded dunes (see cross section diagram), was chosen by turtles more often than any other type. With its one nest every 28 feet, compare it with the barren area with its one nest every 204 feet. This is further evidence that low dunes backing a high beach increase its desirability as a nesting site. Of course, other factors, such as the amount of moonlight, probably influenced the turtles in selecting various types of beach, but to what extent we do not know. In passing, it might be mentioned that statistical data, which will not be presented here, indicated that throughout the season there was no important shifting of turtle nesting from one type of beach to another.

Table 3: Number of nesting and non-nesting crawls made on each type of Cape Island Beach, Summer of 1939.

Beach Type	% of Total Beach	Total Feet of Beach	# of Nests	1 Nest/num. of Feet of Beach	# Non-Nesting Crawls	1 Non-Nesting Crawl/# of feet of Beach	Both Types of Crawls. 1/# of Feet of Beach	Ratio of Nesting Crawls to non Nesting Crawls
Truncate Dunes	7.0%	1970	10	197 ft.	61	32 ft.	28 ft.	1:6.1
Ledge Section	7.9%	2223	40	56 ft.	61	36 ft.	22 ft.	1:1.5
Wide Sloping Beach	11.0%	3096	110	28 ft.	56	55 ft.	19 ft.	1:0.5
Narrow Flat Beach	7.8%	2195	55	40 ft.	62	35 ft.	19 ft.	1:1.1
Wide Flat Beach	16.3%	4587	59	78 ft.	36	121 ft.	47 ft.	1:0.6
Barren Area	<u>50.0%</u>	<u>14071</u>	<u>69</u>	<u>204 ft.</u>	<u>185</u>	<u>76 ft.</u>	<u>55 ft.</u>	<u>1:2.7</u>
Total	100.0%	28142	343	-	463*	-	-	-
Average				82 ft.		61 ft.	35 ft.	1:1.4

\*480 actually made.





### The Making of the Nest

**Crawling Out and Inspection:** During the night (rarely during the daytime at Cape Romain), the female turtles crawl out to lay their eggs. In the dark the vision of these huge creatures does not appear to be very keen, and if one remains motionless on the beach, they will crawl past undisturbed. Movement on the part of the observer, however, will send them back to the ocean as fast as they can travel. On the other hand, loggerheads laying simultaneously a few feet apart do not appear to disturb each other.

Leaving the surf, they proceed up the smooth beach directly to the dunes, although sometimes frequent pauses are made for rest. One undisturbed turtle we watched traveled 45 feet in 8.5 minutes. The distances covered are naturally dependent on the types of beach encountered. In Table 4 data are presented showing how far from the beach crest nests were located. Similar information for the greatest distances traveled inland by non-nesting turtles is also given. This table is arranged in percentages of total number of crawls for each of the six types of beach. As shown on the table, all beaches were primarily of two types so far as the turtles were concerned—passable and impassable. On the first line the information shows that all beach types had a small percentage of nests and non-nesting crawls made at the base of the impassable ledges which occurred occasionally; it was only in the ledge section and the truncate dunes that a sizable portion of the crawls was consistently stopped by ledges.

On line two and succeeding lines of the Table, the distances crawled refer to passable beaches. In considering the barren areas, for example, we see that although 7% of the total nests of this type were below the beach crest and easily subject to washing, the majority were located one to 30 feet beyond the crest, and practically all were within 100 feet of the crest. It must be remembered that in most of these barren areas, nothing stopped the turtles from crawling inland 200 to 400 feet.

Contrast the above data with information for the wide sloping beach. On this passable beach about 50% stopped short of the base of the dunes from 11 to 30 feet in and nested on ground above the reach of the tide; 43% continued to the dunes to nest.

The interpretation of the data in Table 4 would indicate, therefore, that turtles prefer to nest on high beaches near or in the dunes, beyond the reach of the tide. In addition, on large barren sand flats where turtles may crawl hundreds of feet back from the ocean, they prefer to lay only one to 30 feet from the crest. Adult turtles crawling far back on these barrens often became confused and wandered hundreds of feet in all directions before locating and re-entering the ocean. Nesting

Table 4. Distances crawled by nesting and non-nesting turtles.

Distances Crawled	Barren		Truncate		Ledge		Wide Sloping		Narrow		Wide Flat	
	Nests-False	Nests-False	Nests-False	Nests-False	Nests-False	Nests-False	Nests-False	Nests-False	Nests-False	Nests-False	Nests-False	Nests-False
Base of non-passable ledge or truncate dune	-	2.2	100.0	100.0	20.0	54.0	1.8	5.4	1.8	6.5	-	2.6
Less than to beach crest (passable)	7.2**	25.2			2.5	5.0	1.0	1.8	1.8	9.8	3.4	7.9
From Crest (Passable)												
- * 11-20 ft	21.7	20.5			27.5	5.0	2.7	1.8	3.6	4.9	8.5	15.9
- * 21-30 ft	26.2	22.1					19.1	8.9	21.9	-	10.2	10.5
- * 31-40 ft	16.0	14.1					30.9	5.4			15.3	2.6
- * 41-50 ft	4.3	4.3									8.5	-
- * 51-75 ft	2.9	5.4										
- * 76-100 ft	14.5	3.8										
- * 101-200 ft	5.8	2.2										
- * 201-300 ft	1.4	.0										
- * 301-400 ft	-	1.1										
- * 301-400 ft	-	1.1										
All way to dunes or up and on them					32.5	36.0	43.5	76.7	54.9	1.3	47.6	47.4
In flats between or past dunes					17.50		1.00		16.00	17.50	6.50	13.10
Total Percentage	100	100	100	100	100	100	100	100	100	100	100	100
Total Crawls	69	185	10	61	40	61	110	56	55	62	59	38
Primary excavation without flying	19.4		13.1		22.9		46.4		22.5		29.0	

\*False - non nesting crawls \*\*Figures indicate % of total nests and non-nesting crawls per beach type

close to the ocean not only guarantees a safer journey for the young when they hatch, but also insures the adults' safe return to the surf.

**Primary Excavation:** When the female turtle finally has selected a desirable nesting place, the primary excavation is made. This is a shallow depression, larger than or approximating the size of the turtle, made by the turtle's movements. The turtle moves the posterior end of her body from side to side and pushes the sand out with the hind flippers, often making the middle of the excavation a foot deep. This primary excavating is largely exploratory and many times the turtle will move on farther and dig again if the site does not suit her. The last line of Table 4 presents some interesting information on this point.

Turtles made this primary excavation in 23% of their non-nesting crawls; in the best type of nesting site, the wide sloping beach, it was made in 46% of the non-nesting crawls, and in the truncate dunes, one of the least desirable sites, it was made in 13%. In short, those beach types which had the most nests per unit of ocean front, likewise had the most investigation (as represented by primary excavation) by non-nesting turtles.



Several factors are responsible for abandoning the primary depressions. One obvious condition affects digging, namely: sand packed too hard, sand too dry and soft, layers of oyster shells, and an abundance of tough vegetation roots. Another factor is position in relation to tide, for, as has already been shown in Table 4, sites well above average tide level are preferred.

**Secondary Excavation:** The loggerhead, having excavated the body hole, proceeds to dig the egg hole. This operation has been described so well by Mast (1911) and deserves quoting.

After the trench was finished, the turtle took a position so that the right hind leg was very nearly over the middle of the bottom of it. This flipper was then thrust vertically down into the sand (the flat surface being nearly parallel with the long axis of the body) and the end turned in under the sand so as to form a cup much like one formed by a



human hand partly closed. The posterior end of the animal was then raised by the action of the left leg and pushed to the right. During this process the right flipper, containing a fair-sized handful of sand, was of course raised and as the posterior end of the body moved to the right, the flipper gradually rotated so as to face backward; it was then thrust out to the side and inverted so as to empty the sand in a heap, just in front of which the foot was placed on the ground in the customary position. The left flipper was now directly over the hole made by the right one and used in removing sand just as described, except that it took the sand from the right side of the hole while the right flipper took it from the left side. Before the body was pushed back to the left by the right leg it made a sudden movement forward and threw out a considerable bit of sand, making a hole just in front of the place where the sand taken from the nest had been deposited. This sand was pushed into the hole in front of it when the turtle moved back to the right again and thrown out just before it moved to the left the following time. Thus the two hind flippers alternated in scooping the sand from the nest until a cylindrical hole was dug nearly as deep as their length. The alternation from the right to left was perfectly regular. Neither flipper ever took sand from the hole twice in succession.<sup>21</sup>

Just as the hardness or caving in of the sand or the presence of vegetation roots affected the primary excavation, so do they often cause the turtles to cease digging the egg hole. In one site examined, the female had dug eight egg holes and still had not laid her eggs. The two steps of the excavation described require 15 to 25 minutes for completion.

**The Laying:** Having dug the egg hole, the turtle was now in such a position that her tail was over it. Egg-laying begins with the exertion of the cloaca about two inches and the round white eggs are laid singly or in twos and threes every 5 to 10 seconds. As each egg or group of eggs is deposited, the trailing edges of the hind flippers are raised tremulously, and this movement is coordinated with the muscular effort required to lay the eggs. During this procedure, the animal is otherwise motionless, with her head extended and resting on the ground.



Occasionally it emits a sighing breath of effort. It is indeed awe-inspiring to come upon one of these loggerheads at its task of egg-laying. In the dark one can dimly see the huge animal lying

prostrate, its eyes watering and it breath sighing. On its back bits of phosphorescent marine life blink off and on, and small crustacea, temporarily on leave from their watery home, crawl around through the barnacles, bryozoans, and algae which encrust the turtle's arching carapace.

The actual egg-laying requires about 15 minutes. If a Loggerhead Turtle is disturbed before the eggs begin to emerge, she will head for the ocean without laying. As soon as the egg-laying commences, however, the turtle will not stop regardless of the noise or movement made in her presence.



**Covering of the Eggs:** Upon completion of egg-laying, the female begins to cover them with sand. This procedure has also been well described by Mast in the following account.

In doing this she moved the posterior end back and forth much as she did in digging the hole. As this end proceeded to the right, the left flipper was thrust backward into the sand and then suddenly moved inward so as to throw and scrape the sand onto the eggs immediately back of it. As it proceeded to the left, the right flipper acted in the same way but, of course, it threw the sand in the opposite direction. Thus the turtle filled the trench as well as the hole, stopping frequently to pack the sand especially that over the eggs. This she did by placing the posterior pointed end of the body on the sand and elevating the anterior end so as to bring her full weight to bear upon it. After the trench was nearly filled, she turned about over the region several times and threw and scattered the sand in every direction with all four flippers so as to conceal the place, especially that where the eggs were laid.<sup>21</sup>



Although it was mentioned that the turtle scattered sand in every direction to conceal the nest, we found that this usually applied when thick dune vegetation hampered her movements. On open beaches it was customary for the adult, upon completion of the covering, to crawl straight inland or to the side, often as far as 25 feet, churning up the sand with her flippers and throwing it backwards in the direction of the nest. Such extensive muddling easily confuses predators, including the two-legged form. According to our field notes, the covering of the eggs requires from 15 to 30 minutes.

**Return to the Sea:** The turtle is now ready to return to the sea. Of the 350 nest sites examined in this study, in only one instance did we find that a turtle had paused on the return crawl to make excavations similar to those normally made before digging the egg hole. In returning to the sea the female is somewhat exhausted and usually makes frequent stops to rest.



One turtle (which had not been disturbed and did not know of our presence) crawled the 180 feet to the sea in 25 minutes. Another undisturbed turtle traveled the 50 feet to the surf in three minutes. The strength of these turtles is illustrated by the fact that one which had just finished laying carried two of us back to the ocean on her back- a weight of about 275 pounds. "Turtle-riding" is still a favorite sport of vacationists at Carolina's public beaches.

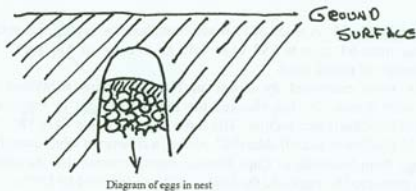
Table 5: Depth of top eggs in 317 nests of loggerhead turtles arranged according to types of laying sites.

Depth of Top Eggs (inches)	Barren and Open Areas		Base Dune and/or Edge of Vegetation		On Top or Side of Dune in Vegetation		Total	
	# Nests	%	# Nests	%	# Nests	%	# Nests	%
5-6	2	1.3	2	1.6	1	3.0	5	1.6
7-8	6	3.7	9	7.2	3	9.1	18	5.7
9-10	19	11.9	18	14.5	8	24.2	45	14.2
11-12	36	22.5	27	21.8	8	24.2	71	22.4
13-14	44	27.5	25	20.2	5	15.2	74	23.3
15-16	32	20.0	29	23.4	7	21.3	68	21.4
17-18	17	10.6	11	8.9	1	3.1	29	9.2
19-20	4	2.5	2	1.6	-	-	6	1.9
21-22	—	—	1	0.8	—	—	1	0.3
TOTAL:	160	100.0	124	100.0	33	100.0	317	100.0

cover, however, revealed only a slight tendency for nests in the dune vegetation to be a bit shallower than those on the edge of vegetation or on open beaches. The extreme depths of 19 to 22 inches were reached only by turtles making unusually deep primary excavations, and egg holes as deep as possible, with the eggs covered by sand to an extraordinary height. In conclusion, it might be mentioned that the egg deposits laid at the last of the season were buried just as deeply as those eggs first laid. Furthermore, there was no apparent correlation between the depth of the eggs and the chances of sand crab depredation.

**Sand Conditions:** The sand piled over the fresh egg deposits is usually reduced one to two inches during the incubation period by wind and tide action. Obviously this erosion and subsequent obliteration of the site decreases the chances of nest depredation.

The sand over the nest, as left by the turtle, is firmly packed immediately above the eggs and loosely piled above that. As incubation proceeds and the eggs settle, an air space often forms between this packed sand and the eggs. In many instances, by the time the young turtles have hatched, this space has grown to be a small domed chamber, as diagrammed below.



If the arch of this chamber collapses and the sand falls upon the eggs or young, a small but noticeable surface crater results. These chambers are probably easily found by foraging sand crabs to the detriment of the nest.

### The Eggs

**Method of Counting:** In this study it was the writers' belief, founded on the recorded experience of others, that handling egg deposits would affect the percentage of hatch. Since information on fertility was desired just as much as that of egg numbers, it was decided to count the eggs after hatching. This counting, which was done only in nests unmolested by predators, was accomplished by tallying the hatched egg shells, the unhatched eggs, and the dead young in the nest. The resulting composite count gave the original number of eggs laid. (It must be remembered that in an undisturbed nest, after hatching has occurred, the remaining egg shells and infertile eggs are still hidden below the surface of the sand.) Hatched eggs for the most part, were entire and fairly easily counted. While an error in count of one or two eggs might be expected, this method was



✓ *Carabidion (sp.) / 1950*



✓ *Carabidion (sp.) / 1950*

Graph 51: Clutch size in relation to time of season laid, as based on 71 masses.

Dark Eggs laid  
1 egg

round. Many of the above measurements were secured by measuring only the five top eggs in each nest. This sampling avoided handling of whole clutches and the subsequent effect on percentage of hatch. Some nests, of course, were completely excavated and the entire clutch measured and weighed. The total weight of 119 eggs in one nest was 4,155 gms, or an average weight of 35 gms per egg. To illustrate the range of egg diameters which occurs within the nest, Table 7 presents data from six clutches. In these instances the variation of egg diameter ranged from 3-11 mm.

**Size of Eggs in Relation to Order Laid:** Further investigation of egg size variation revealed that, within the clutch, the eggs laid last were smaller than those laid first. This was determined by the measurement of six freshly laid clutches, and the data are presented in Table 8. The eggs were measured as they were removed from the nest and each group of 20 is composed of eggs deposited in the same layers and within the space of a few minutes, or in short, in the order that they left the female's body. The groups of 20 are arranged in the table with the eggs found in the top of the nest (laid last) at the top of the column, and in descending order through the nest to those in the bottom (laid first).

That the eggs laid last would be smaller than those laid first seems natural if one considers their relative position to the many undeveloped eggs which remained in the turtle's egg tubes. All these measurements were made during the morning after each nest was made and the possibility of nest pressure affecting these diameters may be largely disregarded; the eggs were in no way misshapen. Moreover, the range of variation within each layer was additional proof that the size difference was natural.

Eggs of unusual sizes are occasionally found in nests. Small yolkless eggs (Fig. 6), 28-30 mm in diameter, are one type and may represent the last eggs laid by a turtle. On the other extreme, abnormally large eggs are occasionally found. One egg, almost hen-egg shaped, measured 51 x 43 mm when laid, another, with two yolks, measured 66 x 47 mm.

**Egg Size in Relation to Adult Size:** A definite correlation between the size of the eggs laid and the size of the turtle was noticed. From seven instances, as shown in Graph 4 in which the carapace lengths of the adult turtles and the average diameters of their eggs were known, it may be seen that the larger the turtle, the smaller the eggs.

## V. INCUBATION

### Development of the Embryo

From embryo measurements, secured through periodic examination of two nests, a composite growth curve has been constructed. This embryo development is presented in Graph 5. For the first two weeks, macroscopic examination of opened eggs revealed no embryos, but on the fourteenth day embryos about a millimeter long were observed in several eggs. From then on growth was rapid. When examined on the 26<sup>th</sup> day, the embryos were pale, grayish-blue and showed movement, and by the 32<sup>nd</sup> day they were very active and their eyes were open. Fifty-four days elapsed between the night of egg-laying and the appearance of the turtles on the beach. Hatched, developed turtles, however, were down in the egg deposit on the 51<sup>st</sup> day, perhaps before.

During incubation one of the most obvious external changes that occurs is the "whitening" of the egg shells. When deposited, the creamy white eggs are bathed in a clear cloacal secretion which causes them to glisten. This soon evaporates and the egg

Table 7: Variation in egg size (greatest diameters) within the egg deposit, as based on six nests.

Nest Number	Total Eggs	Average Diameter*	Range Diameter	Amount Range*
346	87	44.0	42-45	5
337	81	45.5	43-47	4
331	114	42.4	40-45	5
322	119	40.7	38-43	5
295	121	39.0	35-45	10
294	115	41.7	38-49	11

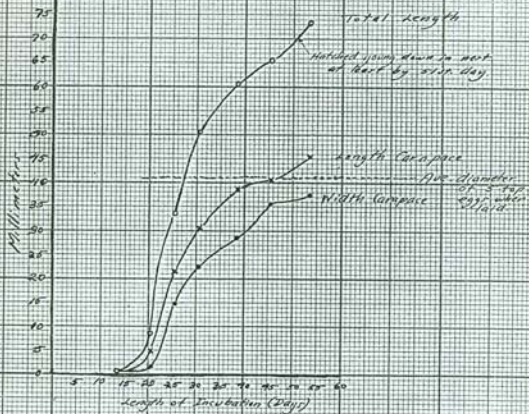
\* All measurements in millimeters



Table 8: Relation of egg size to order in which laid.

Relative Position of Egg Layers	Nest Numbers						
	294	295	322	331	357	346	
20 last laid	39.8	37.7	40.4	41.4	45.1	45.8	top of nest
20	40.6	38.4	40.6	42.6	45.7	44.3	
20	41.2	38.8	40.7	42.7	45.9	43.9	
20	42.3	39.2	40.7	42.7	45.4	43.9	
20	43.6	39.4	40.7	43.1	—	44.0	
20 laid first	—	40.2	40.9	—	—	—	Bottom of nest
Average Diameter	41.5	38.9	40.7	—	—	—	

Measurements are the average (greatest diameters in millimeters).



Graph B: Growth of loggerhead turtle embryos

it was found that on the second day of incubation the majority of the eggs throughout the deposit had small round white marks on their "tops" with a few eggs having them on the sides and none on the under surface. By the end of the first week of incubation, the whitening of each shell was three-fourths to nine-tenths complete and was proceeding at the same rate for all depths of the egg deposits. At this stage the small remaining unwhitened areas were all on the under surfaces of the eggs. By the end of the second week the shells were completely white, and this probably had occurred about the 10<sup>th</sup> or 12<sup>th</sup> day. This drying and hardening of the egg shell, which proceeds uniformly regardless of the location in the egg deposit, points to a uniform heat distribution and incubation rate throughout the nest. The shells of infertile eggs do not whiten in this manner, but by the end of several weeks acquire a deep creamy color.

Another obvious change is the gradual swelling of fertile eggs as incubation proceeds. The absorption of soil moisture is responsible for this change. The total length of the fully developed embryo (just before hatching) is greater than the largest diameter of the freshly laid egg.

### **Incubation Length**

The length of incubation was considered to be that period beginning with the egg laying and ending with the appearance on the surface of the main group of young turtles. It was impossible to dig down into each nest to record the actual state of hatching so the period of incubation was considered terminated with the appearance of the young on the beach. For 55 Cape Island nests, the incubation ranged from 49-62 days, and the average period was 55 days. Most of these incubation lengths were determined at nests surrounded by wire which caught the hatching young.

### **Factors Affecting Incubation**

Some half dozen factors might be considered a possible effect on the incubation length; these factors might be listed as sunlight and shade, nest temperature, depth of egg deposit, soil type, moisture content of the soil, and tidal and underground water level conditions.

**Sunlight and Shade:** Graph 6 charts the incubation period of 57 nests in relation to the time of season they were made. These data show that the incubation lengths of nests made at the first of the laying season (last of May) and the last of that season (last of July) are longer than those for nests made in the middle of the season.

This, of course, was due to the total amount of heat received by these nests. Disregarding the moisture factors, this heat factor naturally depended upon possible hours of sunlight, the actual hours of sunlight, and the range of air temperature. Data for the Charleston area, supplied by the U. S. Weather Bureau Station (Graph 7), indicate that the possible hours of sunlight at the start of the laying season (middle of May) were 14 hours per day, rising to 14.3 through June, and gradually dropping to 12 hours per day by the end of September (practically the incubation season)<sup>21</sup> The actual hours of sunlight, however, were much lower than the possible hours and are presented below for the various summer months.

<u>MONTH</u>	<u>ACTUAL HOURS</u>	<u>POSSIBLE HOURS</u>	<u>PERCENTAGE</u>
May*	275.4	430.1	64
June	255.8	428.4	60
July	327.9	436.9	75
August	252.6	413.7	61
September	210.3	371.1	57

\* entire month

The average daily air temperature was closely correlated with the actual hours of sunlight, those periods experiencing the most sunlight also having the highest temperatures. The temperatures through the last of June, July, and first of August averaged higher than those temperatures at the first and last of the incubation season. In short, incubation periods shortened as the temperature and amount of sunlight increased, as a comparison of Graph 6 and Graph 7 will show.

Additional information on the relation of incubation length to the amount of sunlight is supplied by the following observations by Mr. Chamberlain of the Charleston Museum. He collected 12 eggs from a nest made on Cape Island on July 6, 1927. Placed in a box of sand, these eggs were kept in a warm garage and occasionally sprinkled with water for two weeks. They were then removed to a location where they received two hours of sunlight daily. On September 16 (102 days later), the eggs were uncovered and it was found that, of the two hatched turtles, one was still alive and of normal dimensions. This extreme length of incubation caused by unnatural conditions was no doubt largely due to the absence of sufficient heat.

Under natural conditions shading is caused by dunes and thick vegetation. Table 9 presents the incubation lengths of specific nests as correlated with conditions of sun exposure, tide, and depth of egg deposit. For the most part, these data serve only to further illustrate the point already brought out in Graph 6; namely, that the incubation period varies with the amount of sun heat.

**Nest Temperature:** As determined by a fairly extensive series of thermometer readings taken under all conditions of weather, the temperature within the nest is obviously subject to less fluctuation than the surface temperature. Thus, while our extremes of daytime surface temperatures ranged from 74° to 128° F, the temperature within the egg deposit fluctuated only from 77° to 93°. In fact, the egg deposit temperature usually remained between 82° and 88° and the 77° reading was recorded only after a three day rain. This constancy of temperature within the nest was maintained not only during the day but also at night, even though the surface temperature might fall considerably. The maintenance of a stable temperature appears to be a requirement for a normal incubation length. Of course, the temperature decreases with an increase in the depth at which readings are taken but in the normal depth range of loggerhead nests, this is a matter only of one or two degrees.

**Depth of Eggs:** It will be recalled that in Table 5, the depths of eggs for Cape Island nests were given and considerable range in depth was recorded. To determine whether the depth of eggs affected the incubation length, one fresh nest was excavated and groups of eggs from all parts of the original deposit were reburied at varying depths under similar environmental conditions. Table 10 summarizes the results of the experiment.



Performance:

Length of  
Incubation  
(days)

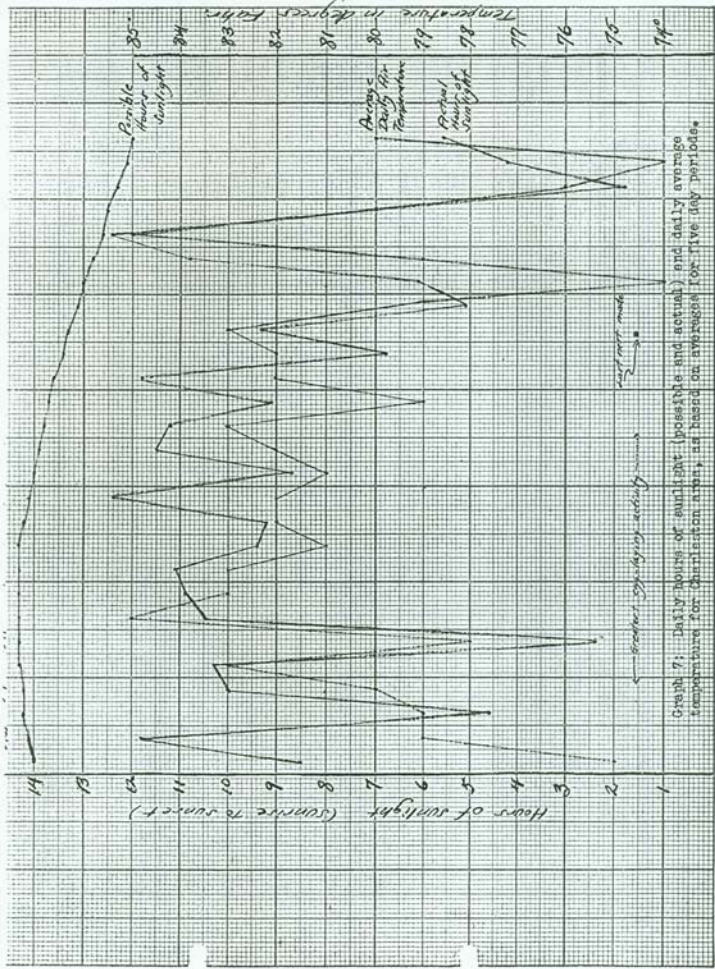


Average length of incubation  
54 days

Over 100% of eggs  
performed as  
well as  
single

Graph 6: Incubation length of eggs in relation  
to time of season laid, as shown on 57 nests.

Sum 1.3.14  
Incubation



Graph 7: Daily hours of sunlight (possible and actual) and daily average temperature for Christston area, as based on averages for five day periods.

← actual sunlight activity →  
 → not used →

Table 10: Length of incubation in relation to depth of eggs.

Time of Incubation	Depth (inches) of eggs below surface						Small Eggs* 15"
	12"	15"	18"	21"	24"	30"	
Night of 54 <sup>th</sup> day	-	-	-	-	-	-	Young on surface
55 <sup>th</sup> day	Young 6" below	Young 10" below	Young 14" below	Young 18" below	Young 22" below	Young 30" below**	-
Night of 56 <sup>th</sup> day	Young on surface	Young on surface	Young on surface	Young on surface	-	-	-
Night of 60 <sup>th</sup> day	-	-	-	Young on surface	Young on surface	-	-
Night of 63 <sup>rd</sup> day	-	-	-	-	-	Young on surface	-
Night of 64 <sup>th</sup> day	-	-	-	-	-	Young on surface	-

\*All eggs were from same nest and chosen at random; one layer of 15 eggs buried in each of 6 levels under similar environmental conditions; the 12 smallest eggs, however, were selected and placed at the 15" level and hatched before the average sized eggs.

\*\*All young down in nests on 55<sup>th</sup> day were developed and had no external egg yolk, except for these at the 30" level\*\* which had traces of navel attachment.



and their carapaces did not appear to be fully grown. On the 55<sup>th</sup> day the fully developed young, without a trace of the egg sac, appeared on the surface of the beach. The shortest period of actual incubation observed was one in which the young were pipping the eggs on the 45<sup>th</sup> day. In general, the external egg sac has been completely absorbed shortly after the young have escaped from the eggs, although it may occur before this act has been completed.

**Escape from the Nest:** Internal egg yolk must nourish the small turtles during their upward struggle through the sand, while this climb of one to two feet may take only one day, the average time is 2-3 days and not uncommonly as high as 5-6 days.

Usually at night young loggerheads appear on the surface, a phenomenon that prevents exposure to the heat of the daytime sun. The intensity of the heat is probably the factor controlling the time of this egress, for turtles found one to four inches under, in the middle of the day, were inactive but hatched in the cool of the following night. Even in the few instances where turtles reached the surface during the day they appeared stupefied by the surface heat which soon kills them. Turtles experimentally removed from the depths of a nest, however, and released on the hot sands easily reached the water before being affected.

Just as the turtles escape from the eggs more or less together throughout the nest, likewise the majority of them arrive at the surface during the same night. Those climbing up first loosen the sand and make the way easier for the last of the hatch. Sometimes the duration of the escape from the nest will cover a week, with the main hatch preceded or followed by successively smaller numbers.

**Percentage of Hatch:** The percentage of hatch is presented in Table 11, which is based on 62 nests. The nests are divided into groups according to relation to tide exposure and presence of vegetation roots.

The average and range of hatchability for each type are also presented. The latter indicates that some nests will be highly unsuccessful no matter how favorable the location. The average hatch was 73.4%. Eggs that did not hatch were opened and examined macroscopically. Some unhatched eggs had no development and may have contained extremely small dead embryos. As given in the table, however, 20.7% of all eggs were infertile and 3.8% contained embryos which died in various stages of development. One interesting fact uncovered was that 5.3% of the eggs laid in *Uniola paniculata* were destroyed by its roots. The hair roots formed thick mats around the individual eggs (Fig. 6), eroded the shells, and desiccated them; often the sharp-pointed stolons pierced the eggs. A very small number of the turtles who pipped their eggs, were unable to completely escape the shell and died. Still another small percentage escaped from the shell successfully but were caught in the nest and died. These deaths were caused by the inability to climb through the tightly packed deposit of hatched eggs or matted vegetation roots, or their infrequent tendency to burrow horizontally into hard sand instead of perpendicularly to the surface. In summing up the data in this table, it may be said that those nests located at the base of dunes (and rarely if ever covered by water) are better situated than those on exposed beaches (especially those occasionally covered by tides) or those nests on the vegetated dunes. The female loggerheads shown in Tables 3 and 4 selected sites at the base of dunes more often than other types.

Table 11: Percentage of hatch, based on 62 nests; undisturbed by predators or erosion.

	OPEN, EXPOSED SITES		BASE OF DUNES		ON DUNES IN <u>UNIOLA</u> ROOTS		AVERAGE
	Occasionally Covered by Tide	covered by tide	Occasionally covered by tide	Never covered by tide	Never covered by tide	Never covered by tide	
Successfully hatched	Ave: 66.9* Range: 29.0 - 97.0*	73.3 30 - 95	86.7 82 - 92	82.4 16 - 98	65.3 31 - 96	73.4	
Embryos died in eggs	Ave: 5.7 Range: 0 - 43	4.3 4 - 17	3.4 4 - 6	2.1 0 - 11	3.0 0 - 9	3.8	
No apparent development (sterile)	Ave: 26.3 Range: 2 - 70	20.8 4 - 69	9.7 2 - 16	14.5 1 - 78	25.5 3 - 57	20.7	
Eggs destroyed by <u>Uniola</u> Roots	Ave: None Range: None	None	None	None	5.3 0 - 42	1.0	
Young died in pipped egg	Ave: 0.5 Range: 0 - 2	0.9 0 - 4	None	0.6 0 - 2	0.2 0 - 2	0.5	
Young died in nest	Ave: 0.6 Range: 0 - 2	0.7 0 - 3	0.2 0 - 1	0.4 0 - 3	0.7 0 - 3	0.6	
Total Percent:	100.0	100.0	100.0	100.0	100.0	100.0	
Total Nests:	13	19	4	14	12	62	

\*Figures refer to percentage of total eggs in clutches laid in each of the five sites

## VI. THE YOUNG

### Size of Young

A total of 398 young Loggerheads from 31 nests were measured just after hatching and the carapace length ranged from 38-50 mm and averaged 45 mm; the carapace width ranged from 31 mm-40 mm and averaged 35.5 mm (see Fig. 5).

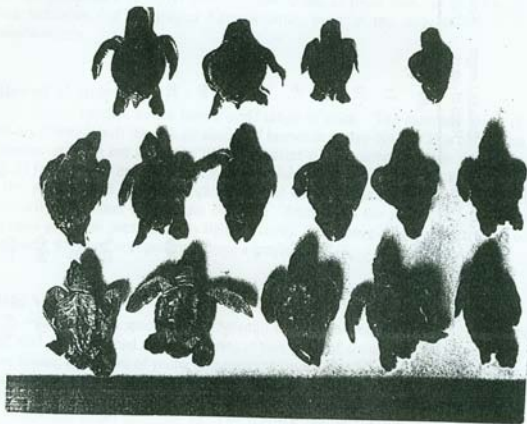


Figure 5. Size and color variation of newly-hatched young.

- Top row (left to right): first three - normal variation in carapace size and shape; fourth - abnormally small but fully developed young.
- Middle row (L to R): variation in carapace color from buff through dark brown to gray-black.
- Bottom row (L. to R.): variation in plastron color from creamy white to gray-black mottled with white.

The average weight of a newly hatched turtle as determined from 104 specimens of one nest was 21.2 gms.

The size of the young (and eggs) in relation to the size of the parent loggerhead is presented in Table 12. As shown in Graph 4, the larger turtles laid the smaller eggs, but whether or not a relationship exists between the size of the adult and young is not known.

Table 12: Size of young and eggs in relation to size of the parent loggerheads; and breadth to length ratios for adults and young.

Tag #	Adult		Eggs		Ave L.Car.	Young Ave L. Car.	No of Young	Breadth:Length Ratio of Adult	Breadth:Length Ratio of Young
	Length Carapace	Width Carapace	Range Diam	No of eggs					
1	36.5*	30.5	-	-	46.3**	36.0	18	.84	.78
2	34.75	24.5	-	-	45.7	36.9	8	.71	.81
4	35.00	27.75	42-34.5	5	42.6**	-	-	.79	-
5	34.5	22.75	-	-	47.9	37.6	22	.66	.78
6	36.75	27.50	42.43	5	42.5	36.4	5	.75	.80
7	40.5	26.75	40-41.5	5	40.7	-	-	.66	-
8	38.00	29.50	41-42	5	42.0	-	-	.78	-
11	35.5	28.50	42.5-43.5	5	43.0	34.5	27	.80	.78
16	35.75	27.00	42.5-43.5	5	43.1	34.9	5	.76	.77
18	39.00	28.75	38-43	119	40.7	-	-	.74	-
-	-	-	43-44	5	43.3	44.7	6	-	.80
-	-	-	42-44	5	43.0	44.6	5	-	.80
-	-	-	41-42	5	42.0	44.6	5	-	.78
-	-	-	41.5-43	5	42.4	45.9	5	-	.78

\*Inches

\*\* millimeters

Ave. (10)

.75 Ave. (106)

Ratios of carapace breadth to length for adults and young are also given in the table. This is 0.75 for the adults (10) and 0.79 for the young (106 taken from 10 nests). The measurements for the total of 398 young from 31 nests also give this ratio of 0.79. In short, the shape of the loggerhead's carapace does not change with growth.

It may be of interest to mention that the measurements of two Kemp's turtles, as determined by Schmidt and Dunn revealed a carapace breadth to length ratio of 0.91 (205:225 mm) and 0.85 (41:47 mm).<sup>26</sup> Comparison of these with the above loggerhead ratios indicates that the related Kemp's turtle, even in the early stages, is broader proportionately.

### Color of Young

Newly hatched turtles have a wide range of color. The carapace varies (Fig. 5) from a yellowish-buff through all shades of brown to a gray-black. This coloration is by no means uniform but lighter on the outer plates of the carapace. The plastron ranges (Fig. 5) from a pure creamy-white to a gray-black mottled with white. Prominent points on the plastron are lighter than the grooved or flat areas. A light plastron is not necessarily correlated with a light carapace. Sometimes the individuals from a single nest have plastrons predominantly light (or dark). The above colors refer to those on wet specimens, for most dry specimens have a grayish cast.

### Shield Variations

In examining 88 specimens of Atlantic Loggerhead embryos and young, Babcock found that 81 (92%) had a normal series of five pairs of costal shields. He mentions that Coker found, in a series of young and embryos from North Carolina, the small first costal wanting in seven instances, and that symmetry in this abnormality was never noted.<sup>1</sup>

For such variations 154 specimens from ten Cape Romain nests were examined, and the results are given in Table 13. The normal number of five pairs of costals was possessed by 93.4%. As for the inframarginals, which connect the carapace with the plastron, only 37% had the normal pair of three, while enlargement of some of the surrounding scales made the remaining 63% possess more than the usual number. As mentioned, Pope quoting Daraniyagala, states that the adult loggerhead has three inframarginals.<sup>27</sup> If this is usual, many specimens must experience a reduction of plates during their lifetime. De Sola states such reductions do occur.<sup>8</sup> Sometimes the anal and gular plates of the plastron have sutures which form extra plates; as shown in the table, 39% had a small extra median plate between the gulars. Apparently there is a tendency for the young of some nests to have greater shield variation than others.

Table 13: Shield variation in young loggerheads based on 154 newly hatched specimens.

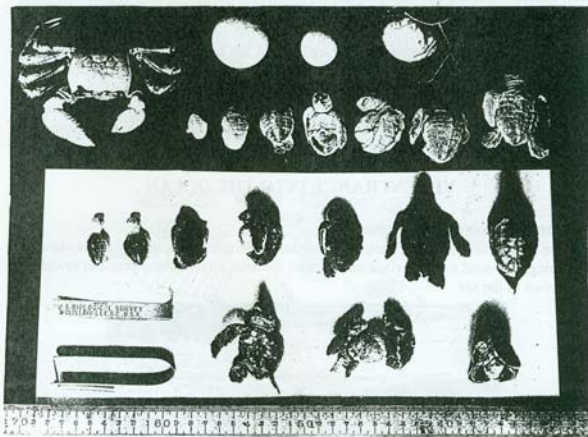
Costal Shields (Carapace)			
Right	Left	Number of Turtles	% of Total Turtles
5	5	144	93.4
5	6	7	4.5
5	4	1	0.7
6	5	1	0.7
4	4	1	0.7
		<u>154</u>	<u>100.0%</u>
Inframarginals (Plastron)			
Right	Left	Number of Turtles	% of Total Turtles
3	3	57	37.0
3	4	14	9.1
4	3	21	13.6
4	4	56	36.3
4	5	2	1.3
4	6	1	0.7
5	4	1	0.7
5	5	2	1.3
		<u>154</u>	<u>100.0%</u>
Extra Anals (Plastron)			
		Number of Turtles	% of Total Turtles
None		134	87.0
Median		13	8.4
Right & Left		5	3.3
Right, Left, & Median		2	1.3
		<u>154</u>	<u>100.0%</u>
Extra Gulars (Plastron)			
		Number of Turtles	Percent of Turtles
None		93	60.3
Median		60	39.0
Right & Left		1	0.7
		<u>154</u>	<u>100.0%</u>

For all Measurements except costals, turtles were on back when examined; thus plates mentioned in table as on right side are really on turtles' left side.



## Abnormal Young

Figure 6: Shows abnormal young. Ruler indicates scale in cm and mm.



Top Row (L to R): sand crab, average sized egg, small yolky egg, and egg with encircling mass of *Uniola paniculata* roots.

Second row: various stages in development of "white" embryos. Notice absence of eyes in second specimen and joined eyes and malformed jaws in fourth one.

Third row: Various stages in development of normal loggerhead embryos. Specimen on extreme right has had some carapace scales removed to show underlying white shell which superficially resembles the outer layer of the "white" turtles' shells.

Fourth row: bands used in tagging adult loggerheads. Young born without left front flippers. Two young attached to the same egg sac. Abnormal embryo with one head joining two bodies.

During this investigation a few specimens were uncovered that might be termed freaks. One turtle that hatched and was otherwise normal, had no external openings for the eyes, and another had no left front flipper (Fig. 6). One pair of embryos was found attached to the same egg yolk (Fig. 6), and although completely developed, was dead. In another instance an embryo that had one head joined to two bodies (Fig. 6) also died before hatching. An unusually small turtle (Fig 5), which hatched and was otherwise normal, had a carapace measuring only 34 mm x 25 mm. (Normal measurements are 45 mm x 35 mm).

The most interesting abnormality we found, however, was the presence of white embryos in about 15% of 65 nests examined. Never more than three or four were found



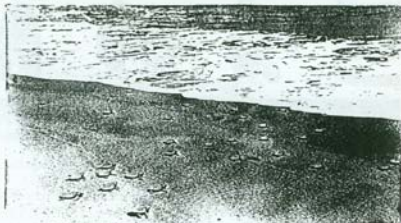
in one nest. These embryos, in all stages of development, ranged from bluish white in the younger forms to creamy white in the more fully developed ones. The carapace, plastron, and skin of the animals were uniformly colored. A series of white embryos, as well as a series of normal embryos, are shown in Figure 6.

Also shown is a normal young from which some of the carapace scales have been removed to show an underlying white layer which resembles that exhibited by the white embryos. None of these abnormal embryos hatched, but some were found fully developed and alive in the egg a week or more after the normal turtles of the nest had hatched. One was found that had pipped the egg and then died. This abnormality probably indicates that development of the white embryos requires a longer period than normal ones. In addition, this absence of color appeared to be lethally linked with the presence of malformations of the jaws and eyes (Fig. 6).

## VII. ENTRANCE INTO THE OCEAN

### Factors affecting Migration

One of the most amazing traits of newly hatched loggerheads is their ability to climb up through the sand to the surface and then set the most direct course possible toward the protection of the sea.

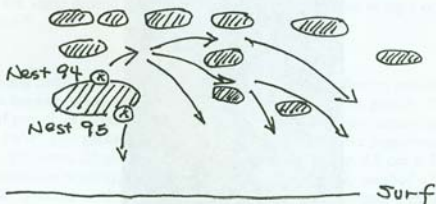


Often beset by sand crabs or other predators, the newly hatched turtles crawl down the darkened beach with all the speed of which they are capable. The factors which control this unerring movement have been worked out by Hooker<sup>16, 17, 18, 19</sup> and Parker.<sup>24, 25</sup> Their total findings, although differing slightly, are presented below with observations of our own.

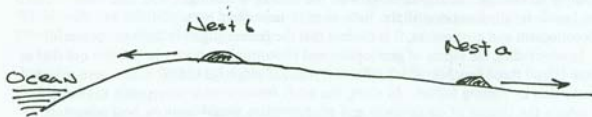
**Geotropism:** While Parker favored the idea that newly hatched loggerheads exhibited only positive geotropism,<sup>24</sup> Hooker maintained in an account, unfortunately written with transposed terms, that they are negatively geotropic while escaping from the nest and positively geotropic in following the beach slope to the water.<sup>19</sup> Excavating from the side of Cape Romain nests, the writers have found turtles in a perpendicular position "swimming" up through the packed sand. The foot or more of sand through which they have to struggle upward would certainly not make these nests the "shallow nests" of Parker, and negative geotropism certainly guided the escape of these young. Naturally the interiors of these nests were dark. Noble and Breslan, in experimenting with fresh

water turtles, reported the "marked negative geotropism which occurs in the absence of light."<sup>23</sup>

**Phototropism:** After emergence from the nest, the most important factor controlling movement to the sea is light. Hooker states that the young loggerhead turtles are positively phototropic during the first 12 hours after hatching and crawl toward areas of greatest illumination.<sup>19</sup> This idea was further developed by Parker in experiments in which turtles avoided "blocked horizons," naturally turning to the more open areas of greatest illumination.<sup>24</sup> At Cape Romain we made several observations on natural hatchings that support these contentions based on the actions of captive animals. In several instances in which nests were made on the land side of isolated dunes, the young, upon hatching, naturally found their path to the sea blocked and set a course through the flats definitely avoiding the dunes at all points. As shown in the diagram below, they eventually reached the sea.



Turtles that came from nests located well back on the so-called barren areas went toward the mud flats and open water to the west rather than to the ocean on the east. Their movement was definitely toward the area of greatest illumination, for the land slope here was away from the ocean rather than to it. As shown in the diagram below, the ocean horizon was out of sight of the turtles hatching from such nests (a). Turtles from nests near the crest (b) went east to the ocean.



Most hatching is at night, of course, but even under daytime conditions, authorities agree that the position of the sun does not influence the migration of the young.



This is in agreement with Hooker's statement that the turtles selected a large area of low intensity of illumination in preference to a point of high intensity.<sup>19</sup> Whether this holds true under all conditions of intensity is subject to speculation. The results of recent experiments with fresh water turtles have led Noble and Breslan to the conclusion that a bright sun low on the horizon would influence the direction of migration.<sup>23</sup> We have local reports of hatched turtles converging on beach campfires at night. It is even possible to confuse nesting females with the rays of a flashlight, and lead them around the beach in all directions if the light is held near their eyes. Of the two factors of phototropism and geotropism, it is evident that the former (light) is the more powerful.

In concluding the topics of geotropism and phototropism, it may be pointed out that at Cape Island those beaches which offered a decided slope backed by dunes were selected most often by nesting turtles. In short, the adult females made more nests in those sites in which the factors of geotropism and phototropism would work to best advantage in guiding the young to the sea.

**Color:** Experiments with color conducted by Hooker, found that young loggerheads move away from transparent and opaque red, orange, and green (and thus vegetation), and moved toward transparent and opaque blue (and thus the ocean). Once in the water the young turtles, who swim with their heads submerged, are attracted by the darker blue of deeper water and are guided out to sea. The greater area of illumination of the sea's horizon as opposed to the lesser area formed by the land's outline must also guide the turtles, especially at night, to deeper and safer water.<sup>19</sup> This is contrary to the statement of Ditmare who claimed they seek shallow inlets to avoid many of their enemies.<sup>10</sup> At

Cape Romain, however, we found no justification for the latter's statement. Young turtles, after leaving the beach, are seldom seen inshore in bays or creeks.

**Other Factors:** As also determined by Hooker and Parker, the sound of the surf, odor, and humidity had no influence on the migration of the young loggerheads. Noble and Breslan have shown that humidity affects the migration of fresh water turtles under certain conditions.<sup>23</sup>

### Locomotion

When crawling over the beach, the young loggerheads move their diagonal legs together in the manner of most terrestrial vertebrates. When the ocean is reached, this movement continues for surface swimming but changes when the animals submerge. Locomotion is then accomplished by the simultaneous movement of the front flippers. Parker has shown that the types of locomotion and the maintenance of proper body position in the water depend upon the ear, rather than the senses of sight or touch, for their impulses.<sup>25</sup>

### Growth

The young turtle in the open sea probably does not begin feeding until the internal egg yolk has been absorbed, and when feeding commences, so does growth. With regard to the rate of growth of loggerhead turtles, several investigators have concluded, contrary to common belief, that growth is fairly rapid. Parker says that the loggerhead turtle on hatching weighs about 20 gms and its carapace measures about 4.8 cm x 3.5 cm. An individual reared in captivity, when four and one-half years old, weighed 37 kg (81.5 lbs), or a little over one-fourth the average adult weight, and its carapace measured 63 cm (24.8 in) x 59 cm (23.2 in).<sup>26</sup> This is an indication of comparatively rapid growth, and Pope, disagreeing with Parker, thinks that among the six that Parker studied, the growth of the turtle already mentioned represents the normal rate.<sup>27</sup>

Hilderbrand and Hatsel recorded the growth of two loggerheads held in captivity in North Carolina from the hatching time until they were six years old. At four and one-half years of age, one that weighed 45 pounds had a carapace measuring 53.8 cm (21.2 in) and the other weighed 47 pounds. When released at the approximate age of six years, they weighed 55 and 61 pounds, respectively.<sup>17</sup> It may be seen that their rate of growth was slower than that reported by Parker. After sexual maturity is reached, however, the growth rate must decrease considerably.

## VIII. ENEMIES AND MORTALITY

### Enemies of Adults

Enemies of the loggerhead are numerous. Formerly, in this section, many of the adults were slaughtered for food although this practice is now outlawed in South Carolina. We have a local record of dogs killing loggerheads. According to a note in the Charleston Museum files, in the summer of 1929, T. B. Fitzsimmons on Botany Bay Beach (Edisto Island), found two dead turtles with torn necks within a few days of each other. A few nights later he saw his two hound dogs rush down to the beach and attack an adult turtle. He stopped the dogs and found the same wounds as on the other two turtles.



### Enemies of Young

The young, of course, are subject to tremendous predation by fish, sharks, sand crabs, raccoons, gulls, and, to a lesser extent, even by crows. Sand crabs, which cover the beaches at night, form a gauntlet that newly hatched turtles must run, and many of the defenseless loggerheads never reach the sea. While the larger crabs can easily carry the young turtles to the burrows and consume them, medium-sized crabs often experience difficulty in holding the struggling prey.

On September 14, 1931, according to a note in the Charleston Museum files, a young loggerhead was taken from the stomach of a "black-fish" and identified by E. B. Chamberlain. This fish was taken in 14 fathoms on "south ground" off the Charleston bar. Interesting not only in its connection with predation, this also points to a possible migration of the newly hatched turtles to deep water.

### Enemies of Eggs

Depredation of nests is very high in all parts of the loggerhead's range. McAtee says that nests of the loggerhead are pilfered by various enemies, but that the work of natural enemies is insignificant compared to the depredations of hogs, where they are present, and man.<sup>22</sup> At Cape Romain neither of these two predators is present but depredations by sand crabs and raccoons are extensive. In Table 14 the fate of 343 Cape Island nests is presented. The data are tabulated for beach types and for the entire island. Only 44% of the nests hatched without being disturbed; 40.8% were entered by sand crabs (Fig. 6), although this does not mean that some of these nests did not later hatch some young.

**Sand Crab:** Crabs enter nests regardless of the stage of incubation and condition of the nest site. It is remarkable how these predators can locate an egg deposit after all surface signs of the nest have been obliterated. It may be largely accidental or connected in some manner with the presence of the "soft" sand immediately over the eggs.

Newly made nests, still marked by the turtle's crawl, are easily found by the crabs who experimentally dig shallow holes (3-12 in) all over the site. This sometimes results in finding the egg deposit. A nest that has been entered usually has a hole surrounded by scattered egg shells. It appears that in soft sand this entrance hole may be gradually excavated to reach a foot in diameter instead of the customary three or four inches.



Table 14: Fate of 343 Cape Island Nests

	Truncate Dunes	Ledge	Wide Sloping Beach	Narrow Beach	Wide Beach	Barren	total Nests	Average Percent
Hatched Successfully	None	27.5	27.2	67.2	49.1	63.8	151	44.0
Entered by Crabs	10.0	35.0	60.9	29.0	35.6	30.4	140	40.8
Destroyed by Raccoons	None	5.0	10.9	None	5.1	2.9	19	5.6
Washed Away	90.0	32.5	1.0	3.8	10.2	2.9	33	9.6
Total Nests	10	40	110	55	59	69	343	100.0
One Nest Per	197 ft.	56 ft.	28 ft	40 ft	78 ft	204 ft	82 ft	-

Note: Figures refer to percentage of total nests per beach type.



The crabs (sometimes a dozen in the same nest) may either eat the eggs in the nest or remove them to nearby dunes or "permanent" burrows. Although only one crab may discover an egg deposit, sometimes within the space of a week, a dozen more may move into the area and dig their burrows around the original one. The number of sand crabs on the Cape Island beach is large and appears to be greatest on those types of beach having the most nests. Whether this is due to the abundance of nests or to more favorable environment for the crabs is not known. At any rate, the wide sloping beach that had the most nests (1 every 28 feet), also had the greatest amount of crab predation (60.8% of the 110 nests made on that type). The sand crab is a well known scavenger but its destruction of Romain's loggerhead nests, as well as those of the diamond-back terrapin, Wilson's Plover, and Least Tern is enough to warrant control measures.

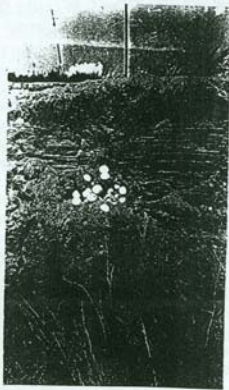
**Raccoon:** Raccoons destroyed 5.6% of the total number of nests. Predation by this animal was decidedly higher in previous years, and the decline is attributed to control measures during the winter months. The numbers of raccoon trapped during the last three winters are given below:

	1937-38	1938-39	1939-40
Cape Island & surrounding marshes	62	89	68
Bull's Island	161	153	85
Totals	223	242	153

A wide variety of foods on wooded Bull's Island makes raccoon depredation of turtle nests low. On Cape Island, with its limited flora and fauna, raccoons depend on fiddler crabs, blue crabs, fish, oysters, insects, mice, bird eggs, and turtle eggs for their food. Twenty-four raccoon droppings collected throughout June, July, and August from Cape island contained remains of fiddler crabs (100%) with a trace of insect matter (*Coleoptera*). In fact, fiddler crabs are the major year-round food on Cape Island. With such a limited diet, it is little wonder that they relish loggerhead eggs.

On Cape Island raccoons patrol the beach and dunes singly or in family groups of two or three. It appeared most nest depredation was carried on by relatively few individuals who covered the same area throughout the summer. The behavior of these animals around nests was anomalous. Many times they walked directly over egg deposits the night they were laid, not even pausing to investigate. Freshly made nests with crab burrows down to the eggs, and shells scattered on the surface, would also fail to arouse the curiosity of passing raccoons. On the other hand, nests were raided the night they were made or even many days after incubation had started and the site had been obliterated. The entire clutch of fresh eggs was usually eaten after it had been reached through a large excavation and the shells were scattered on the surface. Sometimes a few dozen eggs were left intact in the bottom of the nest. Eggs that contained developing young were usually broken and scattered rather than eaten and this was especially true in those instances where the embryos were almost ready to emerge. Young loggerheads are doubtlessly caught and eaten by raccoons. Around one nest that had hatched the preceding night, were found six young turtles with their heads missing, and tracks indicated that this was the work of raccoon.

**Erosion:** Another agency of nest destruction on Cape Island was erosion caused by the action of the surf. The periods of greatest loss occurred when the highest monthly tides were accompanied by strong winds. Nests uncovered by the pounding surf were immediately entered by sand crabs. As shown in Table 14, most washing (90%) occurred on the low beach below the truncate dunes, a type that was chosen least by nesting turtles. On the other hand, the least damage was done (1%) on the wide sloping beach, the type most used by the female loggerheads. This stretch of beach is much higher than the former.



### Invertebrate life in the Nest

In concluding the discussion of nesting, it should be mentioned that nests opened by predators soon develop a population of flies and beetles attracted for feeding and egg-laying. Such concentrations attract birds; ruddy turnstones and sanderlings have been observed feeding around the opened nests. On broken eggs, small nematodes commonly develop. Mites collected from the plastron sutures of a hatching loggerhead were identified as *Macrocheles* species (*Parasitidae* family) by Dr. Ewing of the U. S. National Museum who stated that the group was not parasitic and doubted "its specific association with turtle."

## IX. ECONOMIC RELATIONSHIPS

### Food of the Loggerhead

No adult loggerheads were killed in this study for examination of the intestinal tracts; hence we have no definite proof of what they eat in this area. It appears, however, that a common food at Cape Romain is the edible blue crab. From persons who once butchered the adults for food, we learned that the turtles contained remains of blue crabs, "large snails," and "mussels." Moreover, crabbers who daily work Romain's

creeks claim that they sometimes find the adults in the "small drains" feeding on crabs. It is customary for these crabbers to set their lines in these small salt marsh creeks and they resent the intrusion of the turtles. Our informants further stated that they often "jock" (beat) the animals with oars to drive them out. Loggerheads, according to the crabbers' statements, provide considerable competition in the crabbing business.

Fowler recorded foods of a New Jersey loggerhead were hermit crabs and borers.<sup>13</sup> Babcock says food in Bermuda's waters include the Portuguese man-of-war, a large Bermudan conch, and the "loggerhead sponge."<sup>12</sup> Coker reported captive specimens thrived on clams, blue crabs, and sand dollars.<sup>5</sup> In nearby Georgia waters, a principle food of the related Kemp's turtle, as determined by stomach examinations by De Sola and Abrams, is the spotted lady crab.<sup>9</sup>

### **The Turtle Industry of the Past**

Collecting and selling turtle eggs was once a widespread industry in this section before laws were passed prohibiting the practice. Local fishermen who have spent most of their lives around the barrier beaches, supplied us with most interesting local information. It was customary for these men to gather eggs along the beaches about once a week, thus collecting nests made in the last several days. One such haul on a short stretch of Raccoon Key netted 400 dozen eggs. In another instance on Cape Island, 700 dozen were collected in one night. Such hauls were sold to commercial fishermen from Georgetown and the price received was 7-10 cents per dozen; they retailed at fish markets for 15 cents a dozen. Howard H. Cleaves tells of how native eggers peddled the eggs in streets of Georgetown and Charleston for 12-15 cents a dozen.<sup>3</sup> North Carolina fishermen, according to Coker, sold the eggs for 5 cents a dozen.<sup>5</sup> The local fishermen further stated that impatient collectors occasionally caught a crawling turtle, cut through its side, removed the developed eggs, and left the dying animal in its tracks.

Not only eggs were taken but many turtles were slaughtered for food. According to our impressionable informants, the meat of a loggerhead turtle consisted of five types - beef meat, turtle meat, hog meat, goat meat, and sheep meat. These names arose from the respective flavors of various parts of the turtle. Beef meat which was the best, came from a four-inch layer on the breast bone. It was sliced thin, washed, salted, peppered, and hung to dry in the sun; it was then ready for cooking. Turtle meat, which was found on the neck, was a blue, tough "blubber" not particularly relished by our narrator. Hog meat, which must have resembled pork in taste, was found somewhere on the left side of the turtle. The position of the goat and sheep meat was only vaguely indicated. Several authors mention that loggerhead meat, although of a course texture, resembles beef in taste, while others maintain that its flesh is not palatable.

### **Present Status and Protection**

On the basis of local data, as well as recorded information (chiefly Babcock<sup>2</sup>), it is apparent that the loggerhead turtle, not only has decreased in numbers, but is still declining. Many of the states and countries on which shores these animals nest are doing nothing to conserve their numbers. South Carolina, however, has taken steps to aid this migratory species in its flight for existence. Under Section 818 of the South Carolina Criminal Code of 1922, turtle eggs for personal use could be collected lawfully. Egg gathering for commercial purposes, however, required a yearly license costing \$5. Adult

turtles were protected. Violators of this law were subject to smaller fines than is now the case. This law has been superseded by the later one given below.

The Coastal Fisheries Act of the 1932 Code of Laws of South Carolina, as added and amended by the acts of 1935 (No 184), decrees as follows:

Section 1. It shall be unlawful for any person, firm, or corporation to kill or offer for sale any sea turtle.

Section 2. It shall be unlawful for any person, firm or corporation to offer for sale, sell or destroy any sea turtle eggs.

Section 3. Any person, persons, firm or corporation found guilty of violating any of the provisions of this act shall be punished by a fine of not less than One Hundred (\$100.00) Dollars or imprisoned not less than thirty (30) days, or both.<sup>29</sup>

Statutes similar to this one, with their resulting protection for the loggerhead, are needed throughout its range. The protection of eggs and adults cannot offset the present destruction and slaughter in the Gulf of Mexico, the Caribbean Sea, and even Bermuda.



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