BULLETIN

OF THE

FLORIDA STATE MUSEUM

BIOLOGICAL SCIENCES

Volume 4 Number 10

THE ATLANTIC LOGGERHEAD SEA TURTLE, CARETTA CARETTA CARETTA (L.), IN AMERICA

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Abridged and annotated by David K. Caldwell

UNIVERSITY OF FLORIDA

Gainesville

1959

The numbers of THE BULLETIN OF THE FLORIDA STATE MUSEUM, BIOLOGICAL SCIENCES, will be published at irregular intervals. Volumes will contain about 300 pages and will not necessarily be completed in any one calendar year.

OLIVER L. AUSTIN, JR., *Editor*

The publication of this number of THE BULLETIN has been made possible by a grant from the Graduate School, University of Florida.

All communications concerning purchase or exchange of the publication should be addressed to the Curator of Biological Sciences, Florida State Museum, Seagle Building, Gainesville, Florida. Manuscripts should be sent to the Editor of the BULLETIN, Flint Hall, University of Florida, Gainesville, Florida.

Published 3 June 1959 Price for this issue $.70

III. THE LOGGERHEAD TURTLES OF CAPE ROMAIN, SOUTH CAROLINA[11]

Abridged and annotated by DAVID K. CALDWELL

FOREWORD: After the first manuscript in the present series was finished and submitted for publication, and after the field work for the second study was completed and the data partially processed, general inquiry revealed a manuscript dealing with loggerheads, dated 1940, in the files of the Regional Office of the United States Fish and Wildlife Service, Bureau of Sport Fisheries and Wildlife, Atlanta, Georgia. This manuscript, resulting from Service-sponsored research (then the Bureau of Biological Survey) by Service personnel, has been made available for publication now through the efforts of Seton H. Thompson, Richard T. Whiteleather, and William W. Anderson of the Bureau of Commercial Fisheries, and W. L. Towns and E. S. Jaycocks, of the Bureau of Sport Fisheries and Wildlife.

Although many of the findings presented in the 1940 report have been published independently by subsequent workers (almost surely without knowledge of the report), and although some of the topics are covered in the first two papers in the present series, it was felt that so much of the material represents completely new data that judicious trimming would produce a valuable contribution—one somewhat overlapping, but complementary, to work completed later. Because I was actively involved in field research on the loggerhead turtle and had knowledge of its natural history, it was felt that among those Service personnel interested I might be best qualified to develop the report into a publishable paper that would not overly duplicate findings already or soon to be published.

It should be emphasized that all of the field work was done by William P. Baldwin, Jr. and John P. Lofton, Jr., or by those they acknowledge, and that the report which came to my hands is entirely theirs. I have deleted parts that are repetitious with other studies, have added later literature citations and limited data from my own findings where appropriate (so indicated), and have redrawn those of their figures retained to conform with Bulletin style. In some instances I have rewritten sentences for smoother continuity where parts were deleted. For the most part the wording has been left as it was in their original report. I hope that in no place have I changed Baldwin and Lofton's meaning. "We" or "our" refer to Baldwin and Lofton. The 1940 manuscript has been returned intact to the Bureau of Sport Fisheries and Wildlife Regional Office in Atlanta, Georgia, where it is now on permanent file.

David K. Caldwell.
March, 1959

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[11] Contribution number 44 from the United States Fish and Wildlife Service Bureau of Commercial Fisheries Biological Laboratory, Brunswick, Georgia, and a contribution from the United States Fish and Wildlife Service Bureau of Sport Fisheries and Wildlife.

SYNOPSIS: Detailed field studies show that Atlantic loggerhead sea turtles, *Caretta caretta caretta* (L.), make exploratory crawls to the beach during nesting season, and the fact that a turtle is on the beach does not necessarily mean she will nest at that spot, although she apparently will nest in the immediate vicinity on the night she explores, or very shortly thereafter.

Evidence, contrary to popular beliefs, shows no correlation between nesting activity and the stage of the moon, tide, and weather conditions. The physical features of the beach are apparently the most important factors in determining degree of nesting activity.

The nesting procedure in South Carolina is consistent with that noted in other populations throughout the species' range.

Details of the nest and of the eggs, their incubation, and hatching are presented for future comparison with other species. An average period of incubation of 55 days is demonstrated in South Carolina, and a growth rate is given for the embryos. Many hazards, such as numerous kinds of predators, roots of vegetation, and unfavorable conditions of temperature and moisture are shown to exist for the eggs and hatchlings, resulting in a high rate of mortality.

Considerable variation in size, color, and body form is demonstrated for hatchling loggerheads.

Although South Carolina lies near the northern boundary of the nesting range of the Atlantic loggerhead sea turtle, *Caretta caretta caretta* (Linnaeus), the turtle nests abundantly there. This is especially true for the beaches of the Cape Romain Migratory Bird Refuge (McClellanville, South Carolina) where over 600 nests are made each season. This refuge, also a haven for bird colonies of many species, consists of three low barrier islands and the acres of salt marsh (*Spartina alterniflora*) which lie between them and the mainland. [Similar conditions exist in Georgia at the Jekyll Island rookery discussed by Caldwell, Carr, and Ogren, 1959, herein—D.K.C.]. The South Carolina islands, known as Cape Island, Raccoon Key, and Bull's Island, possess about 19 miles of ocean beach, most of which is potential nesting ground for the loggerhead. Bull's Island is wooded but Cape Island and Raccoon Key are not. The dune vegetation on all three is very similar. The commonest plants that grow there are beach oats (*Uniola paniculata*), cord grass (*Spartina patens*), and beach tea (*Croton punctatus*).

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 5 miles of front beach has 400 nests a season; Raccoon Key with 8 miles has an estimated 200 nests; and Bull's Island, about 6½ miles long, has approximately 30 nests.

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 worked on the south end. During the summer of 1939 a more intensive study of loggerhead nesting was conducted, the writers [Baldwin and Lofton—D.K.C.] staying full time at Cape Island. 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. Grateful acknowledgment is made to these persons for their helpful suggestions and material.

Size of Mature Females at Cape Romain

[Baldwin and Lofton made measurements and recorded weights of a few loggerheads at Cape Romain. The mean carapace length for 18 turtles was 36½ inches, with a range of 33¼ to 40½. These results compare favorably with those made at Jekyll Island in 1958 and reported by Caldwell, Carr, and Ogren, (1959, herein). Baldwin and Lofton found the following relationship between weight and carapace length: 33¼ inches in carapace length, weight 193 pounds; 35¾, 218; 36½, 262; and 39, 298. Another individual with a carapace of approximately 35 inches weighed 257 pounds. Baldwin and Lofton report a skull in the Charleston Museum (catalog number 2373) reportedly taken from a South Carolina loggerhead turtle that weighed 607 pounds. They also state that a McGowan Holmes of Edisto Island, South Carolina, reported to the Charleston Museum in 1935 that the largest loggerhead of the many he had observed in that section had a carapace measuring 48 by 38 inches.—D.K.C.]

Length of Stay by Turtles 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 28 March. The first mating pair was observed in Cape Romain harbor on 31 March. 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 11 May, 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 most 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 duration 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.

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 5 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 8 inches or longer, bends down pressing the cloacal opening against the similar organ of the female, and the two are tightly joined.

Nesting

Duration of Nesting

On Cape Romain's beaches nests are made from mid-May to mid-August. When work was begun at Cape Island on 19 May 1939 a few nests had already been made. The last nest was made there on the night of 18 August. Thus the laying season extended over a period of 3 full months with its peak in June and July. [A similar season was found at Jekyll Island, Georgia—D.K.C.].

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 non-nesting crawls. Each morning we patrolled the entire 5 miles of beach and recorded the preceding

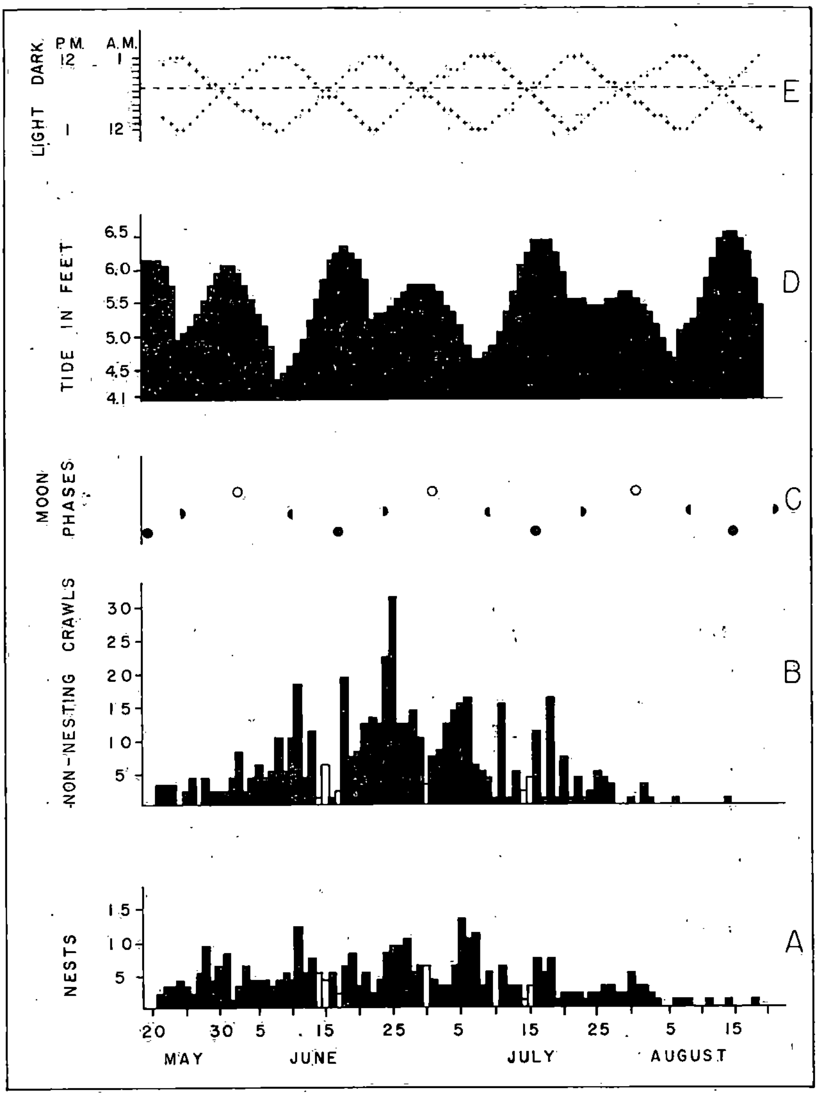

Figure 21.—Nightly number of loggerhead turtle crawls with correlated tidal and lunar conditions at Cape Romain, South Carolina, in 1939. The dates apply to all sections of the figure. Section A represents the total number of nests made each night (solid bars indicate total counts, open bars indicate that all crawls may not have been recorded for that date); Section B represents the total number of non-nesting exploratory crawls (bars as in A); Section C represents the phases of the moon, with solid symbols indicating new moon and open circles full moon; Section D represents the highest P. M. tides for the date; Section E represents the time, to the closest hour, of high tide (+ represents A.M., ° represents P.M.; symbols above the dashed line represent dark hours, those below indicate daylight hours).

night's nesting and non-nesting crawls. This information is presented in Figure 21. Complete data for the first few days on the island are not available and the information presented starts on 21 May. Except for the nights indicated, 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 we reached them.

The greatest number of nests made on any night was 13, and the nightly average for the 90-day period was 3.8. The greatest number of non-nesting crawls made on any night was 31 and the average (90-day) was 5.3. As is indicated in the figure, there is a fairly close correlation between the nightly numbers of nesting and non-nesting crawls.

Correlation of Crawls with Lunar and Meterological Data

Also included in Figure 21 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. In Figure 21 the moon phases are diagrammed in relation to the number of crawls, 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 10-13 days apart.

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 Figure 21 shows, however, there was no correlation between height of tide 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 (1939).

Time of high tide. As loggerheads begin their nightly crawling just at dark, 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.

In speaking of the Bermudian sea turtles in general, Babcock (1937) mentions that they come ashore to deposit their eggs on a rising tide. McAtee (1934), in writing of the loggerhead (apparently in Georgia and other southeastern states), also mentions that the females come ashore chiefly on the rising tide. 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 4 or 5 hours after dusk. 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 10 July, a severe thunder storm 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-nesting crawl was observed, although there was much activity on the preceding and following nights.

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

Selection of Nesting Sites

The Cape Island beach during the summer of 1939 offered six kinds of potential nesting sites to female turtles. Figure 22 shows these beach types in cross section and we have given them descriptive titles:

A. *Truncate dunes*: Sharply eroded dunes backing a beach 5 to 10 feet wide on an average high tide. Extremely high tides pounded the base of these dunes. Turtles never were able to ascend the face of these, although they often tried. The truncate dunes graded into the next type.

B. *Ledge section*: A stretch of beach that had a ½- to 3-foot ledge breaking the middle of its natural slope. This type was variable and was formed by the action of wind and tide. At times the ledge was high enough to prevent the turtles reaching the dunes to nest [see Caldwell, Carr, and Hellier, 1956.—D.K.C.].

C. *Wide sloping beach*: 25 to 40 feet wide from average high tide line to base of dune. The outer dune was a continuous ridge which paralleled the ocean front and was broken in only a few places. Turtles could easily crawl from the surf to the base of the dunes.

D. *Narrow flat beach*: 10 to 20 feet wide and backed by small separated dunes. Turtles could often climb these dunes or go through the gaps between them.

E. *Wide flat beach:* Similar to the narrow flat beach, 30 to 50 feet wide and backed by small isolated dunes.

F. *Barren areas:* Stretching 100 to 400 feet back from the crest of the beach, with only traces of vegetation or low dunes to break their flatness.

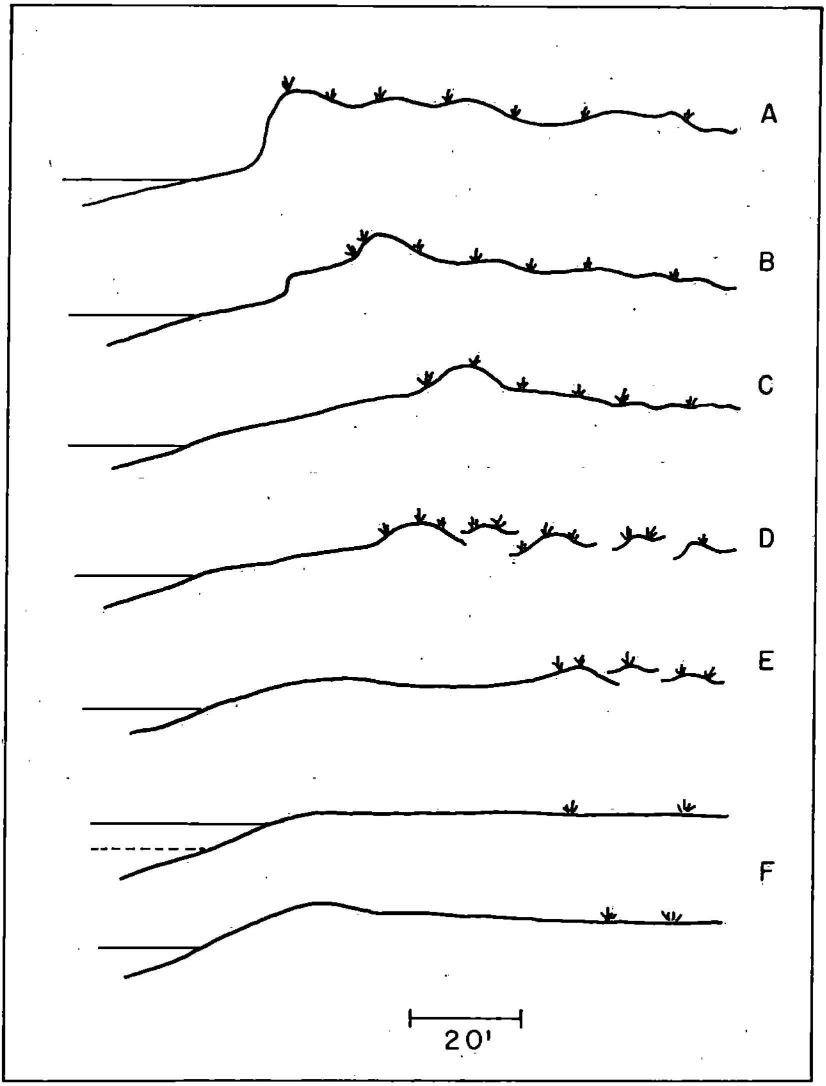

Figure 22.—Diagramatic cross sections of beach types at Cape Island, South Carolina, in 1939. See text for details.

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, which indicated considerable cutting away during the winter between these two nesting seasons. Observations in the first part of the summer of 1940 show that the beaches have changed again. In fact, the truncate dunes of 1939 have been changed into a wide sloping beach of 1940 by the deposition of sand at their base so this stretch of beach which was so unsuited for turtle nesting in 1939 is an ideal type in 1940, and contains an abundance of crawls.

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

Some of the most interesting facts that can be deduced from the information presented in Table 3 are those relating to turtle behavior in selection of nest sites. What process of thinking makes 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 Figure 22) was chosen by turtles more often than any other type. With its 1 nest every 28 feet, compare it to 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.

Other factors, such as the amount of moonlight, probably influence the turtles in selecting various types of beach, but to what extent we do not know. 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. [Aerial reconnaissances of all of the beaches of Georgia and most of those of North Carolina, South Carolina, and the Atlantic coast of Florida have indicated that nesting turtles show a preference for a beach backed by high dunes or vegetation, which thus presents a dark and broken

TABLE 3

NUMBER OF NESTING AND NON-NESTING CRAWLS MADE BY ATLANTIC LOGGERHEAD SEA TURTLES ON EACH TYPE OF BEACH AT CAPE ISLAND, SOUTH CAROLINA, IN 1939.

Beach Type	Percent of total beach	Total feet of beach	Number of nests	Number of feet of beach per nest	Number of non-nesting crawls	Number of feet of beach per non-nesting crawl	Number of feet of beach per both types of crawls	Ratio of nesting crawls to non-nesting crawls
Truncate Dunes	7.0	1970	10	197	61	32	28	1 to 6.1
Ledge Section	7.9	2223	40	56	61	36	22	1 to 1.5
Wide Sloping	11.0	3096	110	28	56	55	19	1 to 0.5
Narrow Flat	7.8	2195	55	40	62	35	19	1 to 1.1
Wide Flat	16.3	4587	59	78	38	121	47	1 to 0.6
Barrens	50.0	14071	69	204	185	76	55	1 to 2.7
TOTAL	100.0	28142	343		463			
AVERAGE				82		61	35	1 to 1.4

horizon to a turtle in the water instead of the lighter and relatively unbroken outline offered by sand flats or the open ocean. This may be one factor in drawing the turtles to such beaches. To turn seaward or along the shore to the light, unbroken, horizon would of course be disadvantageous to a turtle trying to land to nest. The apparent hesistancy for a turtle to strand on a barren flat may be a secondary result of this same phenomenon of relation to horizon, rather than some physical factor of the barren beach itself.

In an analysis of distance crawled by nesting and non-nesting females in relation to the type of beach, Baldwin and Lofton found that the 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 1 to 30 feet from the crest. They found that adult turtles crawling far back on these barrens often became confused and wandered hundreds of feet in all directions before locating and reentering the ocean. Therefore, nesting 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.—D.K.C.]

Primary Excavation

When the turtle finally has selected a desirable nesting place, she makes a primary excavation. 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 its body from side to side and pushes the sand out with its hind flippers, often making the middle of the excavation a foot deep. This primary excavation is largely exploratory, and often the turtle will move on farther and dig again if the site does not suit her. Turtles made this primary excavation in 23 percent of their non-nesting crawls; in the best type of nesting site, the wide sloping beach, it was made in 46 percent of the non-nesting crawls. In the truncate dunes, one of the least desirable sites, it was made in 13 percent. In short, those beach types that had the most nests per unit of ocean front likewise had the most investigation, as indicated by primary excavations by non-nesting turtles. Several factors are responsible for the abandoning of these primary depressions. An obvious one had to do with the conditions affecting digging, namely: sand packed too hard, sand too dry and soft, layers of oyster shells, and an abundance of tough vegetation roots. Another factor was position in relation to tide, for sites well above the average tide level are preferred. [It is presumed, though not stated, that all nesting females made the primary excavation as was the case during 1957-58 studies on the Jekyll Island rookery.—D.K.C.]

Secondary Excavation

[Here Baldwin and Lofton cite the work of others as being representative of their own findings. An illustrated description of the process is presented by Caldwell, Carr, and Ogren, (1959, herein). One comment by Baldwin and Lofton, also noted on several occasions at Jekyll Island in 1958, concerns repeated secondary digging by a turtle. They state that just as the hardness or the caving in of the sand or the presence of vegetation roots affect 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 holes and still had not laid her eggs.—D.K.C.]

Laying and Covering the Eggs

[This process, while described by Baldwin and Lofton, has been discussed in detail and illustrated by Caldwell, Carr, and Ogren (1959, herein).—D.K.C.]

Return to the Sea

After covering the nest, the turtle is ready to return to the sea. Of the 350 nest sites examined, 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 that had not been disturbed crawled the 180 feet to the sea in 25 minutes. Another undisturbed turtle traveled the 50 feet to the surf in 3 minutes. The strength of these turtles is illustrated by the fact that one which had just finished laying carried two of us to the ocean on her back—a weight of about 275 pounds.

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. 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 inland. One turtle, after making four primary excavations, moved inland, became lost, and wandered extensively for 2,140 feet over the sandy flat. Another turtle, also on a barren area, apparently made several small circles after nesting to determine her position with respect to the sea before she returned to the water. A third individual nested well back from the crest of the beach in the barren area, and on completing her nest crawled diagonally back to the crest of the beach to a point where she could see the beach. For some undetermined reason she then reversed her direction and crawled for several hundred more feet around the barren area before returning to the water. Such action was most unusual. A fourth turtle became confused among a group of isolated dunes. She nested on the top of a 10-foot dune 100 feet from the ocean. Upon descending the dune, she could not see the ocean and wandered extensively among the 2- to 5-foot dunes, never climbing any of them, until eventually she 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.

Description of the Nest

Position of the Egg Deposit

When the laying turtle has returned to the sea, its tracks lead to a nest site that is easily recognized by the churned up sand and crushed vegetation. This area, if located in dune vegetation which hampers the movements of the turtle, is usually circular and 4 or 5 feet in diameter. In sites lacking plant growth, the muddled areas are oval to oblong, and may reach a size of 6 by 25 feet. The exact position of the nest in all this muddling may appear difficult to locate, but with a little practice one can soon pick out the exact spot. To us it appeared that the egg deposit was usually near the fore, or entrance, edge of the muddling and equidistant from either side.

Depth of Eggs

The cavity the eggs fill is 6 to 10 inches deep, 8 to 10 inches wide, and slightly wider at the bottom than at the top. This egg deposit is found at varying depths. The depth of the top eggs in 317 nests ranged from 5 to 22 inches, with two-thirds of them between the 11- and 16-inch levels. This agrees with the depths of six North Carolina nests measured by Coker (1906). As already mentioned, fresh nest sites in open sand present a different appearance from those in dune vegetation, and it was thought that the depth of the egg deposits might correspondingly be affected. Distribution of the data according to the various degrees of 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 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 first laid. Furthermore, there was no apparent correlation between the depth of the eggs and the chances of sand crab depredation (see below).

Sand Conditions

The sand piled over the fresh egg deposits is usually reduced 1 to 2 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 top eggs. Many times, by the time the young turtles have hatched, this space has grown to be a small domed chamber. If the arch of this chamber collapses and the sand falls upon the eggs or young, a small but noticeable surface crater results. This probably is easily found by foraging sand crabs [or raccoons—D.K.C.] to the detriment of the nest.

Eggs

Number Laid

A study of 71 nests throughout the laying season revealed clutch sizes ranging from 64 to 198 eggs, with an average of 126.

Six nests examined by Coker (1906) in North Carolina contained 118 to 152 eggs. Alexander Sprunt, Jr. has checked the number of eggs in loggerhead nests for many years in the Charleston section. His three highest counts were 180, 219 (Raccoon Key), and 341 (Sullivan's Island). Marshall Alston, a negro fisherman who formerly collected and sold the eggs from hundreds of Cape Romain nests, reported that the smallest clutch he ever found contained 65 eggs and the largest 280.

Relation Between Number and Time of Season

Several authors have pointed out that it was "believed" that the loggerhead laid several clutches a season, the number of eggs per clutch decreasing each successive time. [It has now been shown (Caldwell, Berry, Carr, and Ragotzkie, 1959, herein) that individual loggerheads do nest several times a summer.—D.K.C.] We have analyzed the clutch size for 71 Cape Romain nests according to the time of season laid. It appears that the number of eggs does decrease as the season progresses. [A similar analysis of 26 clutches at the Jekyll Island rookery in 1958 produced the same results.—D.K.C.].

Size of Eggs

The measurement of 827 eggs taken from 44 nests the day after they were laid revealed that the greatest diameter of normal eggs ranged from 35 to 49 mm., with an average of 41.5 mm. Loggerhead eggs, when laid, appear perfectly round. Many of the measurements were secured by measuring only the 5 top eggs in each nest. This sampling avoided handling of whole clutches and the subsequent effect on percentage of hatch. Some nests were completely excavated and the entire clutch measured and weighed. The total weight of 119 eggs in one nest was 4,155 grams, or an average weight of 35 grams per egg. The variation of egg diameter within a clutch ranged from 3 to 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. The resulting data are presented in Table 4. 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 that remain in the turtle's egg tubes. All these measurements were made the morning after each nest was made and the possibility of nest pressure affecting these diameters may be largely disregarded for the eggs were in no way misshapen. Moreover the range of variation within each layer was additional evidence that the size differential was natural.

Eggs of unusual sizes are occasionally found in nests. Small yolkless eggs 28 to 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 by 43 mm. when laid. Another, with two yolks, measured 66 by 47 mm.

TABLE 4

RELATION OF EGG SIZE TO ORDER OF LAYING IN THE ATLANTIC LOGGERHEAD SEA TURTLE AT CAPE ROMAIN, SOUTH CAROLINA, IN 1939. MEASUREMENTS ARE THE AVERAGE DIAMETERS IN MILLIMETERS.

Relative position of eggs in nest	Nest Numbers					
	294	295	322	331	337	346
20 laid last (top of nest)	39.8	37.7	40.4	41.4	45.1	43.8
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 (bottom of nest)	—	40.2	40.9	—	—	—
Average diameter	41.5	38.9	40.7	42.5	45.5	43.9

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. In seven instances in which the carapace lengths of the adult turtles and the average diameters of their eggs were known, it was found that the larger the turtle, the smaller the average size of her eggs.

INCUBATION

Development of the Embryo

From embryo measurements secured through periodic examination of two nests, a composite growth curve has been constructed (Figure 23). Macroscopic examination of opened eggs revealed no embryos for the first 2 weeks, but on the 14th day embryos about one millimeter long were observed in several eggs. From then on growth was rapid. When examined on the 26th day the embryos were pale grayish blue and showed movement, and by the 32nd 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

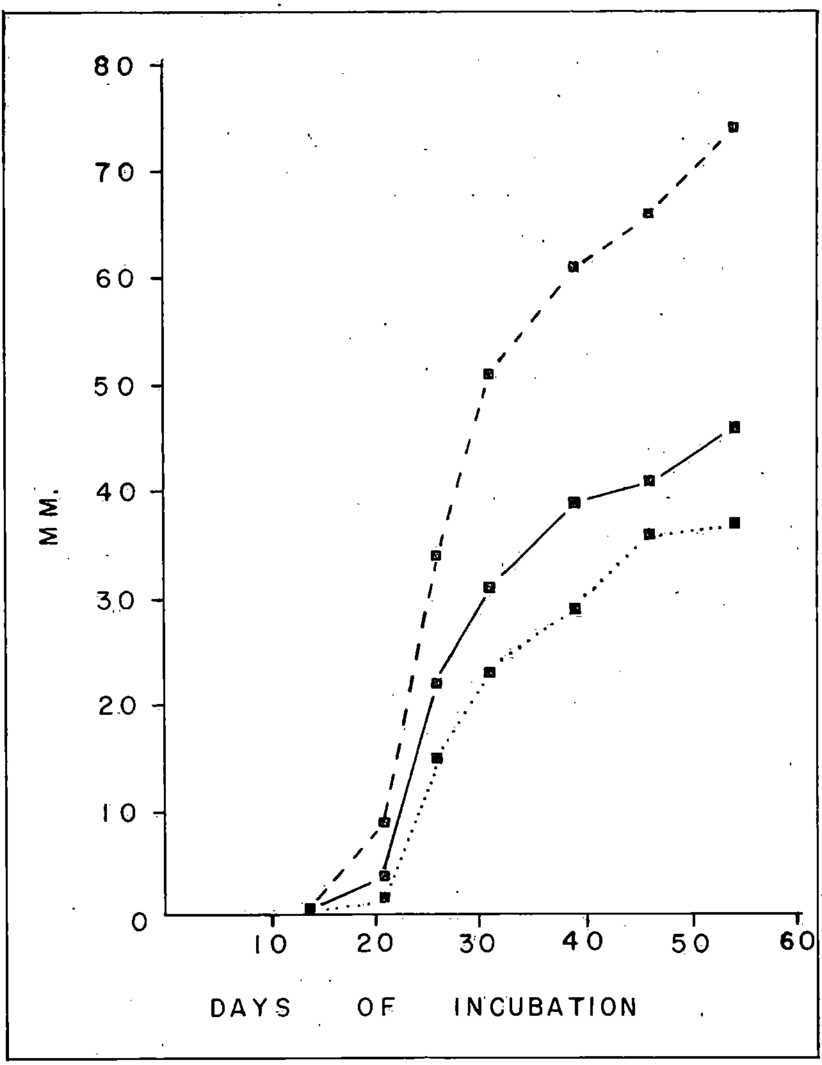

Figure 23.—Composite growth of loggerhead turtle embryos from two nests at Cape Island, South Carolina, in 1939. Dashed line represents total length, solid line represents carapace length, dotted line represents carapace width. The average diameter of the five top eggs when laid in each nest was 41 mm.

the beach. Hatched and developed turtles, however, were down in the egg deposit on the 51st day and perhaps earlier.

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 secretion which causes them to glisten. This soon evaporates and the shells gradually whiten. Several nests made in August were examined periodically and 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 deposit. 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 10th or 12th 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 have acquired 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. The total length of the fully developed embryo just before hatching is greater than the largest diameter of the freshly laid egg.

Incubation Time

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. For 55 Cape Island nests this ranged from 49 to 62 days, and the average period was 55 days. [Caldwell, Carr, and Hellier (1956) found incubation periods in Florida as long as 68 days under somewhat unnatural conditions of handling and habitat—D.K.C.]

Factors Affecting Incubation

Some half dozen factors might be considered as possibly affecting the incubation length: 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. Incubation periods of nests made at the first of the laying season (last of May) and those made at the last of that season (last of July) were found to be longer than those for nests made in the middle of the season. This, it was felt, was due to the total amount of heat received by these nests. This heat factor 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 indicate that the possible hours of sunlight at the start of the laying season (middle of May) was 14 hours per day, rising to 14.3 through June, and gradually dropping to 12 hours by the end of September (practically the incubation season). The actual hours of sunlight, however, were much lower than the possible hours: 64 percent in May, 60 percent in June, 75 percent in July, 61 percent in August, and 57 percent in September. 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 at the first and last of the incubation. In short, incubation periods shortened as the temperature and amount of sunlight increased.

Additional information on the relation of incubation length to the amount of sunlight is supplied by the following observation by Mr. Chamberlain of the Charleston Museum. He collected 12 eggs from a nest made on Cape Island on 6 June 1927. Placed in a box of sand, these eggs were kept in a warm garage and occasionally sprinkled with water for 2 weeks. They were then removed to a location where they received 2 hours of sunlight daily. On 16 September, 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 sun heat.

Under natural conditions shading is caused by dunes and thick vegetation. In analyzing the incubation lengths of specific nests in relation to natural conditions of sun exposure, tide, and depth of egg deposit, it was found that for the most part the data further illustrated 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 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° F. In fact, the egg deposit temperature usually remained between 82° and 88°, and the 77° reading was recorded only after a 3-day rain. The constancy of temperature within the nest was maintained not only during the day but also at night, even though the surface temperature might then 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 of only 1 or 2 degrees.

Depth of eggs. It will be recalled that at Cape Island there was considerable range of depth for eggs in different nests. 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. On the 55th day of incubation the young were out of the eggs in all the levels from 12 to 30 inches. From the relative position of the young it may be assumed that those in the shallower depths hatched slightly before those in the greatest depths. Twenty-four hours later they had reached the surface from the shallowest deposits, but from the extreme depth they did not reach the surface until 8 days later. Therefore the depth does not greatly affect the actual length of incubation, but only the time required for emergence. It is of additional interest to point out that the young from the 12 smallest eggs in this clutch, which were buried together at the 15-inch level, were on the surface on the 54th day, or 2 days before the young from average-sized eggs at the 15-inch level had reached the surface. This may indicate that small eggs hatch before large eggs of the same clutch.

Soil type and moisture content. Two closely related factors that doubtless affect incubation are the soil type and moisture content. On the Cape Island beach the soil types varied from crushed oyster shell to fine sand. The latter is usually very dry. Three types of sand were assayed for moisture content. These samples, taken from below the surface, were typical of the majority of nest sites. The moisture contents were determined by Dr. Horatio Hughes of the Department of Chemistry of the College of Charleston, and are presented below:

1. Fine sand at the base of dunes in *Uniola paniculata* roots 1.3%
2. Beach sand at the base of truncate dunes 3.1%

3. Coarse sand from barren flats among isolated dunes 4.2%

The above figures are the percentages of moisture by weight. Sand taken from the site of one North Carolina nest by Coker (1906) contained 3.8% water.

Underground water level and tide. Although the layer of sand on the surface is dry as a result of evaporation, the sand a few inches below is damp, and this condition extends down to the underground water level. To the touch this sand is moist and cool when compared with that at the surface. On top of the dunes the upper layer of dry sand appears to be thicker than at the base of the dunes or on flats. In all of the above sites loggerhead nests experience normal incubation, and it appears that the optimum moisture content would be 2 or 3 percent. In nests in low areas where the tide not only can cover the nests frequently but also raise the underground water level around the eggs, the incubation period is lengthened. In one Bull's Island nest so situated in 1938, the sand was so wet that earthworms (*Lumbricus*) were found in the deposit, and the incubation period, as based on the only turtle that hatched, was 80 days. The effect of water on the percentage of hatch will be discussed later.

Hatching

Escape from the Egg

As the end of the incubation period nears, the eggs have increased considerably in size through the absorption of water. The curved embryo, which completely fills the egg, develops a sharp point on the snout just before hatching. The combination of the increased internal pressure and the use of the egg tooth facilitates the escape from the egg shell. The pipping and escape from the eggs occur in all levels of the egg deposit almost simultaneously. In one nest we examined the turtles were just pipping the eggs on the 48th day of incubation; they had egg sacs measuring ¾-inch by 1 inch, and their carapaces did not appear to be fully grown. On the 55th day the fully developed young, without trace of the egg sac, appeared on the surface of the beach. The shortest period of actual incubation we recorded was one in which the young were pipping the eggs on the 45th 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 1 to 2 feet may take only 1 day, the average time is 2 to 3 days, and not uncommonly as long as 5 or 6 days.

Young loggerheads usually appear on the surface at night, which prevents their being killed by the heat of the daytime sun. The intensity of heat is probably the factor controlling the time of this egress, for turtles found 1 to 4 inches under the surface in the middle of the day were inactive, but emerged in the cool of the following night. In the few instances where turtles reached the surface during the day they appeared stupified by the surface heat which soon kills them. Turtles removed from the depths of a nest during the day, however, and released on the beach easily reach the water before being affected.

Just as the turtles escape from the eggs more or less together throughout the nest, most 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 escape from the nest will last a week, with the main emergence preceded or followed by successively smaller numbers.

Percentage of Hatch

The percentage of hatch, based on 62 nests, is presented in Table 5. The nests are divided into groups according to relation to tide exposure and presence of vegetation roots. Not only are the averages presented, but also the range of hatchability for each type. The range indicates that some nests will be highly unsuccessful no matter how favorable their location. The average hatch was 73.4 percent. Eggs that did not hatch were opened and examined macroscopically; some of those considered as having no development may well have contained extremely small dead embryos. As Table 3 shows, however, 20.7 percent of all eggs were infertile, and 3.8 percent contained embryos that died in various stages of development. One interesting discovery was that 5.3 percent of the eggs laid among *Uniola paniculata* were destroyed by its roots. The hair roots formed thick mats around the individual eggs, eroded the shells, and desiccated them; often the sharp-pointed stolons pierced the eggs. A small number of the turtles that pipped their eggs were unable to completely escape the shell and died. Still another small percentage escaped from the

TABLE 5

PERCENTAGE OF HATCH, BASED ON 62 ATLANTIC LOGGERHEAD SEA TURTLE NESTS UNDISTURBED BY PREDATORS OR EROSION, AT CAPE ISLAND, SOUTH CAROLINA, IN 1939. FIGURES REFER TO PERCENTAGE OF TOTAL EGGS IN CLUTCHES LAID IN EACH OF THE FIVE SITES (SEE TEXT FOR EXPLANATION OF TYPES OF BEACH).

		Open, Exposed Sites		Base of Dunes		On Dunes in *Uniola* roots	Average
		Occasionally covered by tide	Never covered by tide	Occasionally covered by tide	Never covered by tide	Never covered by tide	
Successfully hatched	Mean:	66.9	73.3	86.7	82.4	65.3	73.4
	Range:	29.0–97.0	30.0–95.0	82.0–92.0	16.0–98.0	31.0–96.0	
Embryos died in eggs	Mean:	5.7	4.3	3.4	2.1	3.0	3.8
	Range:	0.0–43.0	0.0–17.0	4.0–6.0	0.0–11.0	0.0–9.0	
No apparent development (sterile)	Mean:	26.3	20.8	9.7	14.5	25.5	20.7
	Range:	2.0–70.0	4.0–69.0	2.0–16.0	1.0–78.0	3.0–57.0	
Eggs destroyed by *Uniola* roots	Mean:					5.3	1.0
	Range:	None	None	None	None	0.0–42.0	
Young died in pipped eggs	Mean:	0.5	0.9		0.6	0.2	0.5
	Range:	0.0–2.0	0.0–4.0	None	0.0–2.0	0.0–2.0	
Young died in nest	Mean:	0.6	0.7	0.2	0.4	0.7	0.6
	Range:	0.0–2.0	0.0–3.0	0.0–1.0	0.0–3.0	0.0–3.0	
Total nests		13	19	4	14	12	62

shell successfully but were caught in the nest and died. This was caused by their inability to climb through the tightly packed deposit of hatched eggs or matted vegetation roots, or their tendency to burrow horizontally into hard sand instead of perpendicularly to the surface. In summing up the data this table presents, 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 on the vegetated dunes. As noted earlier in this paper, the female loggerheads selected sites at the base of dunes much more than in the other types.

The Hatchling

Size of the Young

A total of 398 young loggerheads from 31 nests were measured just after hatching. The carapace length ranged from 38 to 50 mm., with a mean of 45 mm.; the carapace width ranged from 31 mm. to 40 mm., with a mean of 35.5 mm.

The average weight of a newly hatched turtle, as determined from 104 specimens of one nest, is 21.2 grams. [These turtles are heavier than those reported by Caldwell, Carr, and Hellier (1956) from two localities in Florida—D.K.C.]

It was mentioned earlier in this paper that the larger turtles laid the smaller eggs, but whether a relationship exists between the size of the adult and young is not known.

Color of the Young

Newly hatched loggerheads have a wide range of color. The carapace varies 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 from a pure creamy white to a gray black mottled with this 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. These colors refer to those of wet specimens, for most dry specimens have a grayish cast.

Shield Variations

We examined 154 specimens from Cape Romain nests for variation in the number of costal shields [lateral laminae—D.K.C.], inframarginals, extra anals, and extra gulars—one pair of each of the latter two is the expected number. The results of this analysis are included as Table 6. Although not evident from the table, the young of some nests tended to have greater shield variation than those of others.

TABLE 6

Shield variation in young Atlantic loggerhead sea turtles. Data are based on 154 newly hatched specimens from Cape Romain, South Carolina in 1939. All counts are made viewing the turtle from the dorsal aspect.

Right	Left	Number of Turtles	Percent of Total
		Lateral laminae	
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
		Inframarginals	
3	3	57	37.0
4	3	14	9.1
3	4	21	13.6
4	4	56	36.3
5	4	2	1.3
6	4	1	0.7
4	5	1	0.7
5	5	2	1.3
		Extra (more than one pair) anals	
None		134	87.0
Median		13	8.4
Right & Left		5	3.3
Right, Left & Median		2	1.3
		Extra (more than one pair) gulars	
None		93	60.3
Median		60	39.0
Right & Left		1	0.7

Abnormal Young

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

The most interesting abnormality, however, was the presence of white embryos in about 15 percent of 65 nests examined. Never more than 3 or 4 were found in one nest. These embryos, in all stages of development, ranged from blueish white in the younger forms to creamy white in the fully developed ones. The carapace, plastron, and skin of the animals were uniformly colored. 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 probably indicates that development of the white embryos requires a longer period than normal ones. In addition, this absence of color appeared to be linked with the presence of malformations of the jaws and eyes.

Enemies and Mortality

Enemies of Adults

Enemies of the loggerhead are numerous. Formerly many of the adults were slaughtered for food in this region, although the practice is now outlawed by South Carolina. Some references indicate that sharks also destroy the adults. We have a local record of dogs killing loggerheads. According to a note in the Charleston Museum files, T. B. Fitzsimmons found two dead turtles with torn necks on the Botany Bay Beach, Edisto Island, within a few days of each other in the summer of 1929. 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 the Young

The young are subject to tremendous predation by fishes, sharks, sand crabs (*Ocypode albicans*), raccoons, gulls, and to a lesser extent by crows. Sand crabs, which cover the beaches at night, form a gauntlet that the hatchling turtles must run, and many of the defenseless loggerheads never reach the sea. While the larger crabs

TABLE 7

FATE OF 343 NESTS OF THE ATLANTIC LOGGERHEAD SEA TURTLE CAPE ISLAND, SOUTH CAROLINA IN 1939. FIGURES REFER TO PERCENTAGE OF TOTAL NESTS PER BEACH TYPE.

	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 number of nests	10	40	110	55	59	69	343	100.0
One nest per	197 feet	56 feet	28 feet	40 feet	78 feet	204 feet	82 feet	—

can easily carry the young turtles to their burrows and consume them, medium-sized crabs often have difficulty holding the struggling prey.

On 14 September 1931 according to a note in the Charleston Museum files, a young loggerhead was taken from the stomach of a "black-fish" (*Centropristes striatus*) 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. [See Caldwell, Carr, and Ogren (1959, herein)—D.K.C.]

Enemies of Eggs

Depredation of nests is very high in all parts of the loggerhead's range. McAtee (1934) 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 of man. At Cape Romain neither of these two predators is present, but depredations by sand crabs and raccoons are extensive. Table 7 presents the fate of 343 Cape Island nests. The data are tabulated for beach types and for the entire island. Only 44 percent of the nests hatched without being disturbed. Sand crabs entered 40.8 percent, although this does not mean that some of these nests did not later hatch some young.

Sand Crab. Crabs entered 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, which dig shallow 3- to 12-inch holes experimentally all over the site. This sometimes results in their finding the egg deposit. A nest that has been entered usually shows a hole surrounded by scattered egg shells. In soft sand this entrance hole may be gradually excavated to reach 1 foot in diameter instead of the customary 3 or 4 inches. The crabs, sometimes a dozen in the same nest, may either eat the eggs in the nest or remove them to nearby dunes or to their permanent burrows. Although only one crab may discover an egg deposit, sometimes a dozen more may move into the area within the space of a week and dig their burrows around the original one. The number of sand crabs on the Cape Island beach was large, and appeared to be greatest on those types of beach having the most nests. Whether this was due to the abundance of nests or to more favorable environment for the crabs is not known. The wide sloping beach that had the most nests (1 every 28 feet) also had the greatest amount of crab predation, 60.9 percent of the 110 nests made on that type.

Raccoon. Raccoons destroyed 5.6 percent 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. A wide variety of foods on wooded Bull's Island makes raccoon depredation of turtle nests there low. On Cape Island with its limited flora and fauna, raccoons must depend for their food on fiddler crabs, oysters, insects, mice, bird eggs, and turtle eggs. Twenty-four raccoon droppings collected throughout June, July, and August from Cape Island contained remains of fiddler crabs (100 percent) with a trace of insect matter (*Coleoptera*). In fact, fiddler crabs are the major year-round raccoon food on Cape Island. With such a limited diet, it is little wonder that raccoons relish loggerhead eggs.

On Cape Island raccoons patrolled the beach and dunes singly or in family groups of two or three. It is our belief that 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 irregular. 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. Other 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 they had been reached through a large excavation, and the shells scattered on the surface. Sometimes a few dozen eggs were left intact in the bottom of the nest. Eggs that contained developing young were broken and scattered rather than eaten, and especially when 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 we found six young turtles with their heads missing; tracks indicated this was raccoon work.

Erosion. Another agency of nest destruction on Cape Island was erosion by the action of the surf. The periods of greatest loss occurred whenever the highest monthly tides were accompanied by a strong wind. Nests uncovered by the pounding of the surf were immediately entered by sand crabs. As shown in Table 7, most washing (90 percent) 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 (1 percent) was 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

Nests opened by predators soon develop a population of flies and beetles, attracted for feeding and egg-laying. Such concentrations attract birds; turnstones and sanderlings have been observed feeding around the opened nests. Small nematodes commonly develop on broken eggs. Mites collected from the plastron sutures of a hatchling loggerhead were identified as *Macrocheles* sp. (Parasitidae) by Dr. Ewing of the U. S. National Museum, who stated that the group is not parasitic and doubted "its specific association with the turtle."

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