UNITED STATES DEPARTMENT OF AGRICULTURE
BUREAU OF BIOLOGICAL SURVEY

IN REPLY REFER TO

Bull's Island

Awendaw, South Carolina

October 21, 1938

Mr. E. B. Chamberlain
Curator, Science Department
The Charleston Museum
Charleston, S. C.

Dear Mr. Chamberlain:

Thinking that perhaps you would like to see the report on turtle nesting that I mentioned to you last week, I am herewith inclosing it. Of course, it covers only a few nests and the findings only hint at things that may be. I believe you will be interested in the table of measurements that we spoke about.

I expect to get in during the first of the week to see Mr. Lunz about testing the salinity of some water samples, and I can pick the paper up at that time if you have finished with it.

Very truly yours,
W. P. Baldwin
W. P. Baldwin

Cape Romain Migratory Bird Refuge
Bull's Island Unit
Awendaw, South Carolina
October 15, 1938

Memorandum to Mr. Andrew H. DuPre relative to Loggerhead turtle nesting on Bull's Island during the summer of 1938. Rather than present only the statistics of the nests watched it was decided to incorporate all field observations in this report.

Plan of Study: Each summer the Loggerhead turtle (Caretta caretta) comes ashore in small numbers at Bull's Island to deposit eggs in the beach sands. During this nesting season some of these nests were watched and the resulting observations recorded. Not only the Loggerhead turtle (Caretta caretta L.) is found along these southern shores but other species of marine turtles, including Kemp's turtle (Caretta kempii Garman). According to Jordan's Manual of the Vertebrate Animals (1929) the latter species is very similar to the Loggerhead and the chief difference is given below.

a. Horny ridges in roof of mouth broader anteriorly, and joining or almost joining on mid-line.....
Caretta caretta

aa. Horny ridges in roof of mouth becoming lower anteriorly and widely separated in front.....
Caretta kempii

All of the many newly-hatched turtles that were examined in this study seemed to be referable to Caretta caretta.

The method employed to check on each nest was briefly as follows. The beach was patrolled every morning at which time the turtle crawls of the previous night were found. The nest sites were marked with numbered stakes and watched thereafter for signs of predation, etc. A few were enclosed with boards and chicken wire soon after the eggs were laid to protect them from sand crabs and raccoons, but most of them were left unprotected throughout the incubation period. When the approximate hatching date approached, the nest site was encircled with hardware cloth(about 2 feet high) to catch the hatching turtles. Thus, the young could be examined closely, the numbers counted, and, by digging into the nests, observations made on the hatching procedure. Some of the nests reported on have incomplete data because the nest site was not enclosed in time or the enclosure was improperly placed.

Except in one case (Nest #2), the exact egg deposit was never sought for by digging or probing, and thus the egg deposits were undisturbed during the incubation period.

Bull's Island Conditions: The ocean beach of Bull's Island, on a NE-SW axis, is about six or seven miles long. The slope is gradual and the sand is fine, unlike the nearby Cape Island where the slope is steep and the sand is coarse. Not all of the Bull's Island beach is favorable for nesting, for on the western end the land is low, easily covered by the highest tides (consequently the water level beneath that section is nearer the surface), and a thick stand of myrtles extends to the water edge. The one nest (# 6) laid in this section had an unsuccessful hatch. Three different types of nesting sites were used by turtles that came ashore.

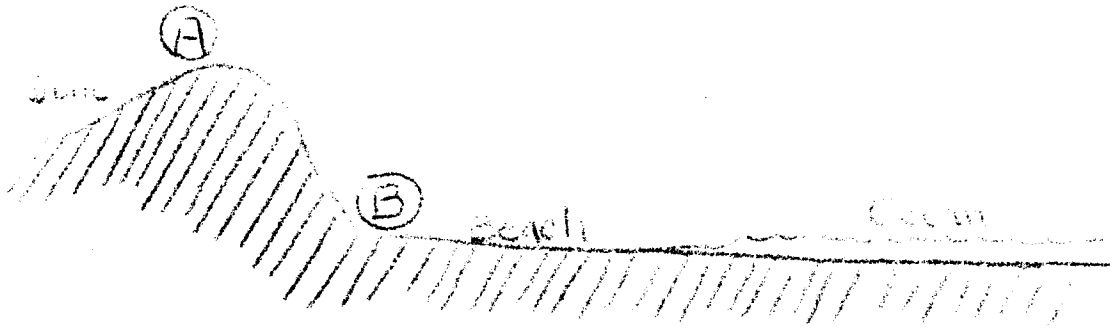
Type A: On top of or behind the outer dune. This was high ground that was never covered by water (tides). Sea oats (Uniola paniculata) and beach-tea (Croton punctatus) were dominant plants here.

Type B: On the beach at the base of the truncate outer dune. The extreme high tides easily covered these sites.

Type C: On a wide stretch of the beach (usually away from the dunes) that was slightly built up and above high water; some sites covered by the highest tides

The accompanying diagram shows in cross-section the three types of nesting sites. Since high ground can be reached by the adults only through crawling up gradual slopes or through "breaks" in the dunes it is little wonder that only one-third of the nests observed were laid in high ground, for gradual slopes are much less common on our beach than the steep, eroded approaches. Thus, turtles, unable to climb the steep dunes, made nests on the beach (type B), or returned to the sea without laying. It was noticed that turtles landing at the wide, built-up beach would usually crawl only a short distance over it and lay the eggs rather than travel the entire 40 to 75 feet to the base of the dunes.

Selection of Nesting Site: Female Loggerheads that came to nest land on the beach at night. The earliest any were reported laying was around 9 P.M., and tracks in relation to tide marks, indicated that others laid throughout the night to about 4 A.M.; the turtles usually came in on the flood tide, when possible. The majority of the crawling and egg laying took place around the time of the full moon.



Types of Loggerhead nesting sites

Type A	Type B	Type C
1	5	2
7	6	3
8	9	4
11	13	10
14	15	12
17		16
18		
7 nests	5 nests	6 nests

.....

The first turtle crawls on Bull's Island were recorded by Mr. W. L. Hills before I reported for work on the Refuge; on May 21 he saw seven fresh crawls and on May 26 he found five more. Probably not all of these turtles laid, because later observations showed that many "false" crawls were made throughout June and July, that is, the turtle would crawl out to the base of the dunes and return to the water without laying. Usually it was possible to distinguish between nesting crawls and "false" crawls, but this was not always the case. Thus, since probing into the sites was undesirable, eight so-called nests were watched throughout the season but later excavations (extensive) revealed that no eggs had been deposited. It is interesting to note that all of these eight sites were in type B situations (on the beach at the base of the truncate dune) which supports the contention that many (majority ?) turtles, upon finding their way onto the dunes blocked, will return to the water without laying. One turtle that landed in the western "myrtle section" crawled around for 260 feet, crossing and recrossing her trail, searching for a suitable nest site, but finally returned to the water without laying.

It is said that eggs covered by the high tides will not hatch. This would not seem to be true when one considers that most of the type B and type C nests were covered by tides from time to time yet hatched. Nest # 12's poor hatch might have been due to tides covering the site around the time of hatching. The preference of the turtles for the high nesting sites, rather than being wholly an attempt to get above the tides, seems primarily to be an attempt to put the eggs out of the reach of underground water. Thus, the eggs in nest # 6, which was laid on the low, flat beach because myrtles prevented the adult turtle from going farther inland, were killed by excessive moisture in the nest. Likewise, an excavation made at the base of the outer dune under a "false" crawl struck water at the 3-foot level and the sand from 2 to 3 feet was very damp. Since most turtle eggs are deposited from 1 1/2 to 2 feet below the surface such a site would not be too conducive to a successful hatch. Incidentally, this same "false" crawl, made during the night of August 9-10, was the last appearance of an adult turtle on our beach for the summer.

Egg Laying: Probably not more than thirty nests were made on Bull's Island this summer and observations were made on eighteen of these. The female turtle digs a deep, but narrow, hole in the dry sand and deposits the eggs in a group, usually from 1 1/2 to 2 feet below the surface; sand is pushed in on top of the deposit. The largest number of eggs laid was 128, the smallest number was 80, and the average number for 14 nests was 104.

An examination of Table # 1 will show (although not enough information is yet available to conclusively prove this) that apparently the earlier in the season the nest is made the greater the number of eggs. This may be correlated with the size and age of the adult females for perhaps the maturer turtles lay earlier.

Incubation Period: In this study, the average time of incubation for 17 nests was about 61 days, the shortest time was less than 55 days, and the longest normal time was 67 days. One nest (# 6), which was made in an adverse situation, had an incubation period of 80 days at the conclusion of which only one turtle hatched. Just as the data presented in Table 1 indicate that the largest number of eggs are laid during the first of the season, likewise, they seem to indicate that the incubation period shortens as the season advances (i.e., the later the nest is laid, the shorter the incubation period), although here again enough evidence is not on hand to conclusively prove this. More heat from the sun during the last of July and August than during the preceding six weeks may be responsible for this. Development within many eggs is arrested at various stages during the incubation period. Even fully-developed turtles died in the shell before hatching. Some eggs, which at the end of the incubation period showed no apparent development, were evidently not fertile when laid.

Hatching: Although the hatching date of a nest should be considered as the time when the majority of the turtles appear on the surface of the sand it is by no means confined to one night. As shown by nests # 2, # 5, and # 11, the hatching period can cover 4 or 5 consecutive nights, possibly longer, during which time the main hatch may be preceded or followed by smaller groups of turtles. On the other hand, all can hatch on the same night.

The termination of the incubation period is considered the time when the bulk of the turtles appear at the surface. However, the incubation of the eggs really terminates before this time. This was easily determined by digging down into the nests from time to time, and it was found (nests # 2, # 5, and # 14) that there often was a difference of 24 or more hours between the actual hatching time and the appearance on the surface of the turtles.

At the time of hatching the egg yolk is still large and supplies nourishment while the turtle breaks the egg shell and forces its way out. One turtle that was found still in the freshly-pipped egg (nest # 5) had, 24 hours later, almost completely absorbed the large egg yolk and was free of the shell. The average percentage of eggs successfully hatching (14 nests) was 83.3 %. The smallest percentage of hatch was 0.8 % and the largest, 98.1 %.

Number of nest	Location type	Date eggs laid	Number eggs laid	Date of main hatch	Length of incubation	Total number hatched	No.of unhatched eggs	Percentage of hatch
1	A	June 4-5	?	August 7-8	64 days	?	?	?
2	C	June 7-8	113 (?)	August 8-9	62 days	103	10	91.1 %
3	C	June 7-8	?	August 11 or 12-13	65 or 66	?	18	?
4	C	June 8-9	102	August 12-13	65 days	95	7	93.1 %
5	B	June 17-18	105	August 23-24	67 days	103	2	98.1 %
6	B	June 17-18	123	Sept. 5-6	80 days	1	122	0.8 %
7	A	June 20-21	114	Before Aug. 22	Less than 63	105	9	92.1 %
8	A	July 5-6	115	?	?	110	5	95.6 %
9	B	July 5-6	95	Sept. 2-3	59 days	93	2	97.9 %
10	C	July 8-9	128	Sept. 2-3	56 days	122	6	95.3 %
11	A	July 11-12	?	Before Sept. 6	Less than 57	?	2	?
12	C	July 11-12	104	Sept. 9-10	60 days	32	72	30.8 %
13	B	July 12-13	107	Sept. 16-17	66 days	104	3	97.2 %
14	A	July 13-14	83 (?)	Sept. 6-7	55 days	75	8	90.4 %
15	B	July 13-14	91	Sept. 13-14	62 days	83	8	92.3 %
16	C	July 13-14	?	Before Sept. 6	Less than 55	?	6(or 7)	?
17	A	July 15-16	98	Sept. 8-9	55 days	93	5	94.9 %
18	A	July 27-28	80	Sept. 22-23	58 days	77	3	96.2 %
Average:			(14 nests) 104 eggs		(17 nests) about 61	(14) 85	(17)17	(14) 83.3 %

Table 1

The young turtles, in working to the surface, literally swim up through the sand. Some that were uncovered from the side were found in a perpendicular position and were not approaching the surface at the slightest angle. By the time the first individuals have made their way out the sand is considerably loosened for the last turtles which have an easier time of it. In one instance (nest # 3), three turtles worked outward instead of upward and were trapped by the packed sand. The upward climb is not attempted until the turtle shell (carapace and plastron) has hardened considerably and most of the egg yolk been absorbed. Turtles were found near the surface with small egg yolks but none with such appendages were ever found on the surface. The appearance on the surface takes place during the cool of the night.

It was noticed as the season advanced that, generally speaking, the size of the hatching turtles decreased. This was not absolute, since the last nest hatched turtles near the size of the first nest's young. It may be that the older and larger turtles lay earliest in the season and their offspring are larger than those of the later layers. Measurements of newly-hatched turtles were taken and are given in Table 2 in millimeters. The total length (from tip of beak to hind end of carapace) does not include tail length; it is not too accurate since the necks of the turtles were undoubtedly stretched in varying degrees. The width of the plastron includes the "bridge" connecting it on either side with the carapace. The average measurements for five nests (25 specimens) of Bull's Island turtles are shown in Table 2 as well as the measurements of three Cape Island (Romain) turtles. The latter were even smaller than any recorded for Bull's Island, and were said to be typical of the group of 400 (4 nests) that hatched in a common enclosure on Sept.5.

Behaviour of Newly-hatched Turtles: Instinct, sound of the surf, or other factors, must guide the young turtles to the ocean. Attempts were made to confuse some by rotating and tumbling around in the hands, but, upon being placed in the sand, they immediately headed for the sea. Turtles in wire enclosures in the dunes, out of sight of the sea, would be found on the morning after the hatch piled up on the eastern side of the enclosure facing the morning sun and the ocean. Turtles released on the beach on dark nights invariably started for the ocean and may have been guided by the beach slope or the sound of the surf. Those placed in shallow tidal pools on the beach in the daytime would explore them for a few minutes (never more than five minutes) and then crawl out and head for the ocean.

Timings were taken on the crawling speed of nine young turtles across 50 feet of fine packed sand to the ocean's edge. The results are given on the following page.

Nest Number	Nest # 1			Nest # 12									Nest # 15				Nest # 17					
Individuals	a	b	ave.	a	b	c	d	e	f	g	h	i	ave.	a	b	c	ave.	a	b	c	d	e	ave.
Length Carapace *	49	50	49.5	43	42	42	40	40	43	42	44	42	42.0	43	41	42	42.0	48	48	46	47	45	46.6
Width Carapace	37	38	37.5	32	33	33	32	32	36	36	33	34	33.2	36	33	32	33.3	36	36	36	36	36	36.4
Length Plastron	38	38	38.0	33	33	32	31	32	33	33	34	32	32.6	33	32	33	32.6	36	37	36	36	34	36.4
Width Plastron **	33	34	33.5	28	29	30	28	28	31	31	30	30	29.4	30	29	28	29.0	31	32	30	31	31	31.0
Total Length ***	80	80	80.0	69	70	68	66	68	69	69	71	69	68.6	69	66	69	67.6	77	76	73	74	73	74.4
Width Head	17	18	17.5	15	14	15	14	14	15	15	16	15	14.7	16	15	16	15.6	16	16	15	16	15	15.6

Nest Number	Nest # 18								Bull's Is. Average (5 nests)	Cape Island			
Individuals	a	b	c	d	e	f	g	ave.		a	b	c	ave.
Length Carapace *	47	48	48	47	47	48	48	47.5	46.5	44	40	39	41.0
Width Carapace	38	38	37	38	37	38	38	37.7	35.4	33	32	31	32.0
Length Plastron	38	39	37	37	36	39	38	37.7	35.2	33	31	31	31.6
Width Plastron **	33	34	33	33	33	34	33	33.2	31.2	30	29	28	29.0
Total Length ***	74	77	76	76	78	77	74	75.6	73.3	70	65	64	66.3
Width Head	16	17	17	16	17	16	17	16.5	16.0	14	14	14	14.0

* All measurements in millimeters. ** Includes side "bridges". *** Tip of "beak" to end of carapace .

Table 2 : Measurements of turtles

8	minutes	- 2	turtles
9	1/2 "	- 2	"
10	"	- 3	"
16	"	- 1	"
18	1/2 "	- 1	"

These young were probably tired from exertions in the enclosure, and their speed at night, after hatching, is probably faster and more sustained in order to escape predators.

As the turtles enter the edge of the surf the alternate use of the limbs in walking gives way to the simultaneous use of the fore flippers in swimming as soon as the water depth permits it. Although the fore limbs are the chief source of power in swimming, one turtle (in tidal pool) was observed to fold these flippers backward on the carapace in a position of rest and to propel itself with the hind feet. This recalls to mind the behaviour of one individual from nest # 10 which refused to crawl or swim, but kept the fore flippers pointed backward on top of the carapace. Even when placed in water a foot deep it refused to swim and was last seen being buffeted around and swirled out to sea by the undertow.

Turtles placed in quiet, clear tidal pools about eight inches deep (first water they had ever entered) explored the pools by diving and swimming along the bottom and edges. Some kept their eyes closed but others had partially opened them by this time. On each dive they remained under water on the average of 15 seconds; the longest time under water was 40 seconds.

Predation and Parasitism: With the commencement of life in the open sea the small turtles must begin a life full of risk and high mortality rate. Once, while releasing a large group of turtles from a scoop net in fairly deep water, a large fish broke among the compact group as it moved out and doubtlessly took its toll. Sharks are abundant in the surf and channel bass (Sciaenops ocellatus), which frequent our shores in increasing numbers toward the end of the summer, would be in a position to catch some of the young loggerheads.

Predators on the land must also be reckoned with, however. One of the objectives of this study was to determine the extent of predation upon turtle nests by Bull's Island raccoons and sand crabs. With this in mind, a few of the nests were enclosed with wood and wire for protection during the incubation period, but later observations indicated that this was unnecessary work considering the amount of predation. In two instances (Nest # 4 and Nest # 9) raccoons walked across the nests soon after they were laid but did not disturb them. Probably because of an abundance of other foods no instance of raccoon work in turtle nests was found, a condition that is quite unlike that on nearby treeless Cape Island where a large number of eggs are eaten.

Predation by the sand crab (Ocypode albicans) was also slight and nowhere near so severe here as at other locations along the coast. In only one instance (nest # 14) did a sand crab dig into a nest and destroy eggs and it appeared that only four of the eggs were taken. Old, unhatched eggs, when placed out on the sand were removed by sand crabs at night, and were also taken during the day by crows and vultures.

A sand crab entered the enclosure of nest # 14 in early morning and killed one newly hatched turtle awaiting liberation. One turtle, hatching at night from unenclosed nest # 1, was also caught by a sand crab and carried to a nearby burrow; here it was found wedged in the entrance. It is the habit of these crabs to come out of their burrows at night and scatter over the beach searching for whatever food the preceding tides have brought them. Thus, in the role of scavengers, they consume dead fish and crabs, rotten fruits, plant roots, etc. However, they more than likely catch numbers of the newly-hatched turtles as they "run the gantlet" to the water. Observations at night on the distribution and abundance of sand crabs showed them to be scattered from the dunes to the water's edge and as high as 215 per mile were recorded (in the width of an automobile's headlights — about 20 feet). Ever on the alert, crabs would capture live turtles tossed near them (in the circle of light from a flashlight) if the turtles showed movement. Seizing the turtles behind the head and at the hind end of the carapace ("corn-on-the-cob" fashion) they would easily lift them from the ground and speed away, or start to eat the meal on the spot. The few turtles used in such experiments were all rescued and liberated unharmed.

Crows, in one case (nest # 13), stole turtles from an enclosure in the morning, but since this would not normally occur, like other occurrences of daytime predation it can not be considered natural. Other unnatural conditions which the turtles encountered in the enclosures were entanglement in fibrous plant roots, death through heat, and choking from drifting sand.

"Parasites" were found in two instances. The last turtle to hatch from nest # 5 had about 25 to 30 extremely small mites crawling around in the sutures of the plastron (especially around the navel) and in the wrinkles in the skin of the neck. These mites were living underground on the turtle. They were presented to my friend Mr. Lawrence W. Saylor, of the Section of Food Habits. In a recent letter, Mr. Saylor stated that Dr. Ewing, of the U. S. National Museum, kindly identified them for him. These mites were Macrocheles sp. (family Parasitidae), and Dr. Ewing stated that the group was not parasitic and doubted "its specific association with turtle."

In a freshly-crushed egg (nest # 18) which contained a fully-developed turtle, thousands of minute, living worms (?) were found attached in clumps to the mucous-covered turtle and egg yolk. To date, these are still unidentified, and, since their entrance was apparently gained after the egg shell was broken, this would not be a normal case of parasitism.

Following is the "case history" of each nest watched in this study, and a summary and conclusions are presented at the end of the paper.

Nest # 1

Eggs laid during the night of June 4-5 and, judging from the tracks in relation to the tide marks, on the flood tide about 1:30 A.M. A type A nest, it was located on the outer dune four feet higher than high water. Boxed in on June 7 with 12" planks (width) on the sides and chicken wire (2" mesh) on the top; this was to prevent raccoon and sand crab predation. That same night, however, crabs went over the fence and through the wire to inspect the inside of the enclosure, but they did not bother the eggs. In a few days sand had drifted up to the top of the boards and had to be removed thereafter at short intervals.

During the night of August 7-8 this nest hatched (incubation period of 64 days), but the turtles escaped from the enclosure by climbing up the drifted sand and through the wire. At 6 A.M. on the 8th I found abundant tracks leading to the sea and found five turtles back in the dunes. One of these was dead and the other four were wandering around; they had crawled as far as 100 feet paralleling the outer dune and as far back in the dunes as 50 feet. In some places they had attempted to crawl up the steep sides of the outer dune to get to the ocean but the loose sand had prevented this. One of the living ones was found on his back in a large sand crab hole and his tracks indicated that he has fallen in and had not been dragged in by a crab. This is the only instance in this study where turtles crawled the wrong way and became lost in the dunes, and the presence of the nest enclosure, which plugged the gap in the dunes, was undoubtedly responsible for this.

During the night of August 8-9, two more turtles hatched out. Since the enclosure had been purposely removed, these headed for the ocean upon hatching. One apparently made it, but the other was found dead and pulled head downward in the entrance of a sand crab burrow. At the base of its head was the characteristic gash made by the crab's great claw. The crab was in the tunnel about one foot below the entrance and only the width of the turtle had prevented its being dragged completely into the hole.

Since the nest was not excavated no data on the number of eggs laid or percentage of hatch are available. Measurements of two turtles from this nest are given in Table 2; they are typical of the "large" turtles that hatched from most of the earlier nests.

Nest # 2:

Eggs laid during the night of June 7-8 about 2 A.M. (site found at 4:30 A.M.). This nest was located in a wide flat place on the beach, typical of type C nests. It was about 15 feet from the normal high tide mark and 50 feet from the base of the outer dune. The site was low enough to be covered several times by the highest tides. 115 eggs were probably laid, but since two (more or less) were broken in locating the nest by probing, 113 eggs were considered as a basis for figuring the percentage of hatch. This nest, as in the case of most of them, was left unprotected from sand crabs and raccoons, to test predation.

On August 8 the nest was enclosed with hardware cloth (small mesh wire). Dug down into the egg deposit carefully and about 6" from the surface I pulled out one turtle which was the same size as those collected at nest # 1. Although it was very active, I replaced it and recovered with sand.

During the night of August 8-9, 85 turtles hatched out. At 7 A.M., when liberated, most of them still had their eyes closed and they remained closed even after the young had entered the water and the sand had been washed from the head. One turtle had become entangled in the fine fibrous roots of a dead plant and had to be released. Three crows nearby had not disturbed the newly-hatched turtles. Dug down into the nest (top) and found both unhatched eggs and hatched young; some of the latter still had the small egg yolk attached, but two without this were released; unhatched eggs and turtles with unabsorbed yolks were put back and recovered with sand.

On the night of August 9-10 one turtle hatched. Thus, it dug out of about one foot of sand in one day and night. On August 11 dug into nest and found 15 live turtles at 1 1/2 to 2 feet; their egg yolks were all absorbed. These were released. Ten eggs which had not hatched were also present. Two of these were opened; one showed no development and the other contained a fully developed but dead turtle. The eight remaining eggs were reburied at the one foot level. On August 18 dug into nest again; the eight eggs were still unhatched and seven showed no development while one contained a 3/4 developed but dead turtle in it.

The duration of the hatching period, if uninterrupted, would have been about 4-6 days. Figuring on a 113 egg basis, this nest had a 91.1 % successful hatch.

Nest # 3

Eggs were laid during the night of June 7-8 at the edge of the flat, built-up beach near the base of the outer dune and 75 feet from the high tide line (Type C). Covered by the tide possibly only once.

On August 8 the site was enclosed with hardware cloth. On August 11, when the nest was visited in the morning, no turtles had hatched, but at 9 P.M. of the same day one turtle had hatched. This is the only record in the entire study for early evening hatching. During the night of August 12-13 one turtle hatched. Five days later, on August 18, dug into the nest and found egg deposit under the edge of the wire, indicating that all but two of the turtles had come up on the outside of the enclosure and had escaped. Since it is not known on which of the above dates (Aug. 11-12 or 12-13) that the main hatch came off the duration of incubation is considered 65 or 66 days. Lots of the hatched eggs and 13 unhatched eggs were found. About one foot from the main body of egg shells, but on the same level (1 1/2 feet below the surface), were found three dead turtles which had dug outward (directly toward the ocean, incidentally) and had been trapped by the packed sand. The unhatched eggs were placed out on the beach, and crows robbed the area of the eggs the next day.

Nest # 4

Eggs were laid during the night of June 8-9. A type C nest, it was located on the raised beach about 15 feet away from the dunes and 25 feet from the normal high tide mark; never covered by tides. 102 eggs were deposited.

Between the time of laying and sunrise a raccoon walked across the nest but did not disturb it. On June 9 a 16" (width) plank fence was erected around the site and the top left open. The wind, however, would frequently uncover the bottom of the enclosure and sand crabs would enter. At the time of hatch, however, this enclosure had the bottom well covered and no turtles escaped.

During the night of August 12-13, 96 turtles hatched out (incubation period of 65 days). On September 15 dug into the nest and found seven unhatched eggs; of these, four showed no apparent development, two, partial development, and one contained an almost fully-developed but dead turtle. 93.1 % of the eggs hatched.

Nest # 5

Eggs were laid during the night of June 17-18 on the beach at the base of the outer dune. This location (type B) was only one foot higher than the high water level and about ten feet from the high water mark. The extremely high monthly tides covered this nest. 105 eggs were laid.

On August 22 dug down into the nest and found the top of the egg deposit 14 inches below the normal surface of the beach. The top eggs had already hatched and nine very active turtles (egg yolk absorbed) were released. The others, however, were recovered without disturbing.

During the night of August 23-24 sixty-five turtles hatched and were released. Between the time of laying and hatching (67 days) about eight inches of sand had drifted over the nest site, thus burying the eggs deeper. On August 26 the nest was dug into and eleven turtles were released; they were at the 1 1/2 foot level. Others were also hatched at this time but they were left undisturbed and the opening recovered.

During the night of August 26-27 one turtle hatched out. During the night of August 27-28 twelve more hatched out, but since high tides prevented my reaching the nest until mid-day they were killed by the sun's heat. On August 29 dug into the nest and at the one foot level one turtle was found and at 1 1/2 feet three more were found; these were released. Also found were two unhatched eggs and one pipped egg which still contained a live turtle with a large egg yolk. These last three were recovered with sand.

On August 30 dug down down and found one turtle and two unhatched eggs at same level as preceding day. The turtle which, 24 hours before, had possessed a large egg yolk and had just started from the shell now had completely absorbed this nourishment and would probably have worked its way to the surface during the night of August 30-31. On this turtle were about 25 to 30 mites of the genus Macrocheles; they were in the sutures of the plastron and the wrinkled skin of the neck (see main text). The turtle was liberated and the two unhatched eggs upon examination proved to be undeveloped.

Of the 105 eggs laid, 98.1 % successfully hatched.

Nest # 6

Eggs were laid during the night of June 17-18; 123 eggs were laid. This nest (type B) was located on the lowest part of the beach in the section where the myrtles (Myrica) extend to the tide line. Here, the myrtles, rather than the steep dunes, prevented the turtle's going farther inland to lay. This nest was about 10 feet from normal high water line and easily covered by the highest tides.

During the night of September 5-6, after 80 days of incubation, one turtle hatched. On September 15 dug into nest and found 122 unhatched eggs from 2 to 2 1/2 feet below the surface in very wet sand (but no actual water). Indicative of how wet this site was compared with other nests is the fact that two earthworms (Lumbricus sp.) were found in the sand among the eggs. The lowest eggs reposed in a layer of wet black sand and the white egg shells had been dyed a resulting ebony. The 122 eggs were in all stages of development, many having fully-developed but dead turtles in them. Undoubtedly, the reason for the long incubation period (80 days) and the unsuccessful hatch (only 0.8 %) was due to the excessive, ever-present moisture around the eggs. Some of the eggs placed out on the beach were consumed by vultures the following day.

Nest # 7

Eggs were laid during the night of June 20-21 on a leveled-off dune from which sand had been taken by workmen. A type A location, 114 eggs were laid about four feet higher than the high water level; the eggs were never covered by the tides.

On August 22 this area was enclosed with planks, but later observations indicated that this nest hatched before I enclosed it, making the incubation period less than 63 days. On October 10 the site was excavated and 105 hatched egg shells and nine unhatched eggs were found at about the 14" level. The percentage of hatch was 92.1 %. Of the nine unhatched eggs, seven were undeveloped and two contained turtles one-fourth hatching size.

Nest # 8

Eggs were laid during the night of July 5-6 in the outer dune. A type A location, 115 eggs were laid four feet higher than the highest tides and about 20 feet from the normal high tide line; the site was never covered by sea water.

On September 1 the site was enclosed but the enclosure did not cover the actual egg deposit and the turtles escaped whenever they hatched (either before or after the wire was put up). On October 8 the nest site was uncovered through extensive excavations and 110 hatched eggs and five unhatched ones were uncovered about 1 3/4 feet below the surface; this indicated a 95.6 % hatch. Of the five unhatched eggs, two were apparently undeveloped, two were slightly developed, and one contained a one-fourth grown turtle embryo.

Nest # 9

The eggs were laid during the night of July 5-6 on the beach at the base of the outer dune. A type B nest, it was covered by the extremely high tides. 95 eggs were laid.

During the night of July 8-9 a raccoon walked back and forth over the nest site but did not dig in. On September 1 this nest was enclosed with wire and, during the night of September 2-3 ninety-three turtles hatched (incubation period of 59 days).

On September 15 the nest site was dug into and two unhatched eggs were found; one was partially developed and the other contained a fully-developed but dead turtle. The hatch was 97.9 % successful.

Nest # 10

The eggs were laid during the night of July 8-9 on a wide, flat beach, 60 feet from the outer dune and ten feet from the normal high tide line. A type C nest, it was covered by the highest tides. 128 eggs were laid.

On September 1 the site was enclosed and, during the night of September 2-3, ninety-six turtles hatched (incubation period of 56 days). On September 6 dug into nest and found 23 live turtles with egg yolks completely absorbed; they were 14 inches below the surface. In addition, there were three dead turtles and six unhatched eggs. Of the dead turtles, two were still soft shelled and apparently crushed, and the other possessed a head wound. The death of these must have been due to the earlier fencing-in activities. Of the six unhatched eggs, four were apparently undeveloped and two were partially developed. 95.3 % of the eggs hatched.

Nest # 11

Eggs were laid during the night of July 11-12. This site (typeA) was in the outer dune, four feet higher than normal high water, and was never covered by tides. To reach this position, the adult female had climbed through soft sand up a 25 degree grade for about eight feet.

On September 6, when I went to enclose this nest, I found that the turtles had already hatched and dug out (incubation period less than 57 days). The eggs were from 1 1/2 to 2 feet below the surface, and the width of the deposit was about six inches. Of three unhatched eggs at this level, one was undeveloped and the other two contained turtles (could feel them through the egg shell — were not broken); these two were reburied. Another unhatched egg, the shell gastrula-like and the contents completely dehydrated, was found alone at the ten inch level, as if it had been laid as an afterthought. The greater heat in the sand at this level may have been responsible for its drying out.

On September 9 the two eggs that had been reburied were still unhatched but were not disturbed. On September 16 it was found that one turtle had hatched and departed (fence removed) and that the other was fully developed but dead within the shell.

Nest # 12

Eggs were laid during the night of July 11-12. A type C nest, it was located 20 feet from the outer dune on a flat, built-up section of beach, and was covered by the highest tides. 104 eggs were laid.

Enclosed on September 6 and during the night of September 8-9 two turtles hatched. During the night of September 9-10, thirty turtles hatched (incubation period of 60 days). Drifting sand covered some of these before release, killing one which was found with its opened mouth packed with sand.

Measurements of one of those hatched on the eighth and of seven of those hatched on the ninth are given in table 2. These were noticeably smaller than those hatching from earlier nests.

On October 7 dug into nest and found 72 eggs from 1 1/2 to 2 feet below the surface. They were all dead, and this is unexplainable since the sand surrounding the eggs was dry (unlike nest # 6) and since this nest was not covered any more often by tides than those in similar sites which had more successful hatches. However, very

high water was experienced during September 8, 9, and 10, and it may be that the eggs approaching the hatching time were killed by tide water. This would seem plausible when one considers that of the 72 unhatched eggs, 60 contained almost fully-developed turtles and only ten were undeveloped. In fact, a few of the eggs had pipped and the turtle had died in the opened shell. Only 30.6 % of the eggs hatched.

Nest # 13

Eggs were laid during the night of July 12-13. A type B nest, it was located on the beach at the base of the outer dune, and was covered by the extremely high tides. 107 eggs were laid.

The area was enclosed on September 6, and during the night of September 16-17 this nest hatched (incubation period of 66 days). At 9 A.M. on the 17th, when the enclosure was approached, a crow was seen on the nearby dune with one of the turtles. It was recovered and, still alive, placed in the enclosure with 27 others. These were left in the enclosure for a visiting party to see, and at 10 A. M., upon my return, six crows flew from the site, one carrying a turtle in its beak. Only 16 of the 28 turtles remained and these were released.

The nest was excavated on October 8, and it was found that 104 eggs had hatched but most had come up on the outside of the enclosure. Three unhatched eggs showed no development, making a 97.2 % successful hatch.

Nest # 14

Eggs were laid during the night of July 13-14 on the outer dune. A type A site, it was 20 feet from the high tide line and three feet higher than the highest tides; it was never covered by sea water. 83 (?) eggs were laid.

On September 6 signs of predation were discovered when bits of egg shell of about four eggs were found scattered in a ten foot radius around the site. The opening of a sand crab burrow was found one foot from the site of the egg deposit. Dug into the nest and at the one foot level active turtles were uncovered; after disturbing only the top 2 or 3 the site was recovered and fenced in. Revisited at 10 P.M. that night to see if they had appeared on the surface but they had not. During the night (September 6-7), however, 75 turtles hatched (incubation period of 85 days); they were found at 8:30 A. M., thus hatching in the seven hours between the two visits. Since the wire enclosing this nest was only one foot high it was not unexpected to find a

large sand crab in the middle of the enclosure, holding a turtle in its claws. The turtle, with a gash in its neck, was released but soon died. On September 15 dug into nest. Roots of Uniola paniculata had grown down through the egg deposit. Four unhatched eggs which remained were undeveloped. Assuming that only the four eggs, the remains of which were found scattered on the outside of the nest, were taken by sand crabs would make a total of 83 eggs laid and 75 hatched, or a 90.4 % hatch.

Nest # 15

Eggs were laid during the night of July 13-14 on the beach at the base of the outer dune. A type B nest, it was covered by the highest tides. 91 eggs were laid.

The site was enclosed on September 6 and during the night of September 13-14 eighty turtles hatched (incubation period of 62 days). Site was not visited until 2 P.M. the following day and three of these were killed by the sun's heat. All of the young were smaller than those of nest # 1, and the measurements of the three of them given in Table 2 are typical of this nest.

On September 15 dug into the nest and found three turtles at the two foot level. The bottom of the egg deposit was almost three feet deep because of an extra eight inches or so of sand and Spartina drift that had piled up on the nest during the incubation period. Eight unhatched eggs were also present and two that were opened showed no development. The other six were lined up on the sand above the high water mark and during the night were carried away by sand crabs, presumably down into the burrows a few feet away. This hatch was 92.3 % successful.

Nest # 15

Eggs were laid during the night of July 13-14. This was a type C site and this built-up part of the beach may have been covered a few times during the incubation period by the highest tides.

On September 6, when the nest was to be enclosed, it was found that the turtles had already hatched (less than 55 days incubation period). The empty egg shells were found 1 1/2 feet below the surface, but unfortunately were not counted. Also found were seven unhatched eggs. One of these had been pipped but the developed turtle (egg yolk absorbed) had died within the egg shell. Another of these eggs which

had been opened contained a live turtle which needed a short time to go before hatching. It moved its flippers, opened its mouth repeatedly, and even bit a piece of egg shell thrust into its mouth; its eyes, although mucous-covered, were partially open; the large egg yolk was still unabsorbed. Replaced the turtle in the egg shell and reburied it, but, since later I could not find the exact nest site, the fate of this turtle is unknown. The other six unhatched eggs showed no development. It is believed that this nest hatched about the night of September 3-4, making a probable incubation period of 53 days, the shortest time recorded in this study.

Nest # 17

Eggs were laid during the night of July 15-16 on top of the outer dune and about five feet higher than the normal high tide. A type A nest site, it was never covered by the ocean. 98 eggs were laid.

On September 6 the nest was enclosed, and during the night of September 8-9 ninety-three turtles hatched (incubation period of 55 days). Three of them, in wandering around the enclosure, became entangled in exposed roots of Uniola paniculata and had to be released. The crawling time of some of these turtles was recorded and has been mentioned previously. Measurements of five of these turtles are given in table # 2.

On September 18 dug into the nest and found five eggs in all stages of development but all were dead. One contained a turtle which had died after pipping the egg shell and pushing its head out. 94.9 % of the eggs successfully hatched.

Nest # 18

Eggs were laid during the night of July 27-28 on top of the outer dune about four feet higher than the high tides. A type A nest, it was never covered by tides. 80 eggs were laid.

The site was enclosed on September 20 and during the night of September 22-23 seventy-three turtles hatched (incubation period of 58 days). These were all large size turtles similar to those of the earliest nests. The measurements of seven of these are given in Table 2.

During the night of September 24-25 one turtle hatched out. On September 27 dug into nest and found three turtles about one foot below the surface, on their way up. Did not dig farther. On September 28 dug into nest and found three eggs from 1 1/2 to 2 feet below the surface. One was undeveloped, one had fully developed but dead turtle (small egg yolk) in it, and the other, which was crushed (probably through previous activities around the nest site) had a fully developed but dead turtle in it. The crushed one had thousands of minute living worms (?) attached in clumps on the egg yolk and elsewhere. 96.2 % of the eggs hatched.

Summary and Conclusions

1. Eighteen nests of the Loggerhead turtle (Caretta caretta) were kept under observation on Bull's Island during 1933.

2. Three types of nesting sites exist on the island — the high dunes, the narrow beach at the base of the dunes, and the wide and slightly elevated beach.

3. More nests are made and more "false" crawls are made around the time of the full moon than at other times.

4. The largest number of eggs deposited was 123, the smallest number was 30, and the average number for 14 nests was 104.

5. Apparently, the number of eggs deposited per nest decreases as the season advances.

6. The average time of incubation for 17 nests was about 61 days, the shortest time less than 55 days, and the longest normal time was 67 days.

7. Apparently, the later in the season the nest is laid, the shorter the incubation period.

8. Generally speaking, larger turtles hatch from the earlier nests than from the later nests.

9. The lowest percentage of hatch for a nest was 0.3 %, the highest was 98.1 %, and the average for 14 nests was 83.3 %.

10. Raccoon destruction to turtle nests on Bull's Island was never observed, although these animals are exceedingly abundant.

11. Sand crab destruction to nests was very slight. Sand crabs, under normal conditions of turtle hatching, may catch numbers of the freshly-hatched turtles as they crawl to the ocean.

12. Mites (Macrocheles sp.) were found on one turtle and unidentified worms (?) on one crushed egg.

It is hoped that any study on Loggerhead nesting on Bull's Island in the future will profit from the mistakes in technique made this year, and that many of the facts only hinted at by the results of this year's work will be clarified and confirmed by additional data.

W. P. Baldwin

Junior Refuge Manager