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1993 MARINE TURTLE NEST
SCREENING PROGRAM AT
CANAVERAL NATIONAL SEASHORE
FLORIDA

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ABSTRACT

In 1993 Canaveral National Seashore completed the tenth year of its sea turtle nest screening program. A total of 3168 nests were deposited along its 23.25 miles of beach. This included 3140 loggerhead (Caretta caretta) and 28 green (Chelonia mydas) sea turtle nests.

The beach was divided into four blocks - each with a raccoon removal, nest screening and nest screening plus conditioned taste aversion area. The three treatments were compared for effectiveness in preventing depredation of sea turtle nests.

A total of 1221 (39 percent) of the nests deposited at CANA were screened. Seven percent (93) of the screened nests were observed to be depredated - five percent (64) partially and two percent (19) totally. Of the 1947 unscreened nests, 23 percent (455) were totally depredated and 18 percent (369) were partially depredated. Overall, for screened and unscreened nests, 71 percent (2261) were not depredated, 15 percent (474) were totally depredated and 14 percent (433) were partially depredated.

Nest depredation was highest in two of the four removal areas. The effectiveness of removal may require a sustained effort over several years. Conditioned taste aversion did not reduce nest depredation, possibly because individual animals did not ingest enough nausea-inducing substance.

A total of 10.6 percent (332) of the loggerhead and 28 percent (8) of the green nests were monitored to determine hatching success. It was possible to excavate 7.5 percent (236) of the loggerhead nests. Overall 67 percent (223) hatched, seventeen percent (55) were totally depredated, four percent (13) were partially depredated and twelve percent (41) were of unknown fate. Seventy percent of the green sea turtle nests hatched. None of the green nests were depredated.

The loggerhead nests yielded an average clutch size of 100.7 eggs and an average hatching rate of 79.8 percent or 80.4 eggs per nest. The average clutch size of the green nests was 129.1 eggs with a hatching rate of 70.7 percent or 91.3 eggs.

An estimated 191,305 loggerhead and 2,556 green hatchlings were produced at Canaveral National Seashore in 1993.

INTRODUCTION

Canaveral National Seashore (CANA) receives 3,000-4,000 sea turtle nests each year. These are primarily loggerhead (Caretta), with a few green (Chelonia mydas) and an occasional leatherback (Dermochelys coriacea).

Nest depredation by the raccoon (Procyon lotor) is a serious threat. In the early 1980's, over 95 percent of the nests were depredated by raccoons (McMurtray 1986). As a result, the park implemented a nest screening program in 1984.

In January of 1993, a two-year study was implemented by the University of Georgia (UGA) to obtain critical information about the raccoon population at CANA and to explore alternative methods of nest protection. These results will be used to design a long range strategy for protecting both sea turtle nests and the fragile seashore ecosystem.

CANA modified its past screening efforts to coordinate with the raccoon study (see Study Sites and Methods). The results of the first year will be analyzed to identify and implement changes which would improve the study and enhance sea turtle nest protection.

STUDY SITES AND METHODS

Canaveral National Seashore is located along the east-central coast of Florida with Bethune Beach to the north and Kennedy Space Center to the south (Figure 1). The northern 11.25 miles of beach is situated in Volusia County, the southern 12 miles in Brevard County.

The beach is essentially undeveloped with only a few artificial lights and a number of boardwalks to protect the dune vegetation. The dune is well developed along most of the beach and is stabilized by a thick growth of sea oats (Uniola paniculata), sea grape (Coccoloba uvifera), saw palmetto (Serenoa repens) and other dune species. The beach is closed to the public between sunset and sunrise except for occasional guided turtle walks. These walks are limited in size to minimize disturbance to the nesting turtles.

On May 4, the park began intermittent daytime patrols of the beach to count sea turtle nests and false crawls. The 24 mile stretch of beach was covered by using four-wheeled all-terrain vehicles (ATV's). Beginning on the night of May 14, the park switched to a nighttime operation, with two teams of one ranger and one volunteer working from 11:00 p.m. to 7:00 a.m. screening turtle nests and collecting data. Nighttime patrols were conducted seven days a week until August 31. At that time intermittent daytime patrols were reinstituted until September 18, primarily for nest excavation purposes.

Screening consisted of placing a 4 feet X 4 feet wire mesh screen over the nest and staking down the corners with three foot sections of #3 rebar. The rebar was bent over near one end to form a 70 degree angle. The 2 inches X 4 inches mesh size was large enough to allow hatchlings to emerge while discouraging raccoon attempts to reach the eggs.

All nests undepredated at the time of discovery were screened. Any depredated nests that had less than 20 percent of the eggs destroyed were cleaned up and screened as well.

Data collection for each nest included: date, observer, nest number, species, location (the beach was divided into 94 quarter mile sections) and extent of depredation or tampering, if any. The date and grid location of each false crawl were also recorded. Ten percent of the nests were marked for monitoring during the incubation period to determine hatching success. All of the nests were marked with a stake to facilitate screen retrieval and to identify unscreened nests that had been counted.

Categories included hatched, destroyed by predators, eroded away and fate unknown. Hatching and emergence was determined by the presence of hatchling tracks and nest excavation. Emergences were observed for any evidence of disorientation caused by artificial lighting.

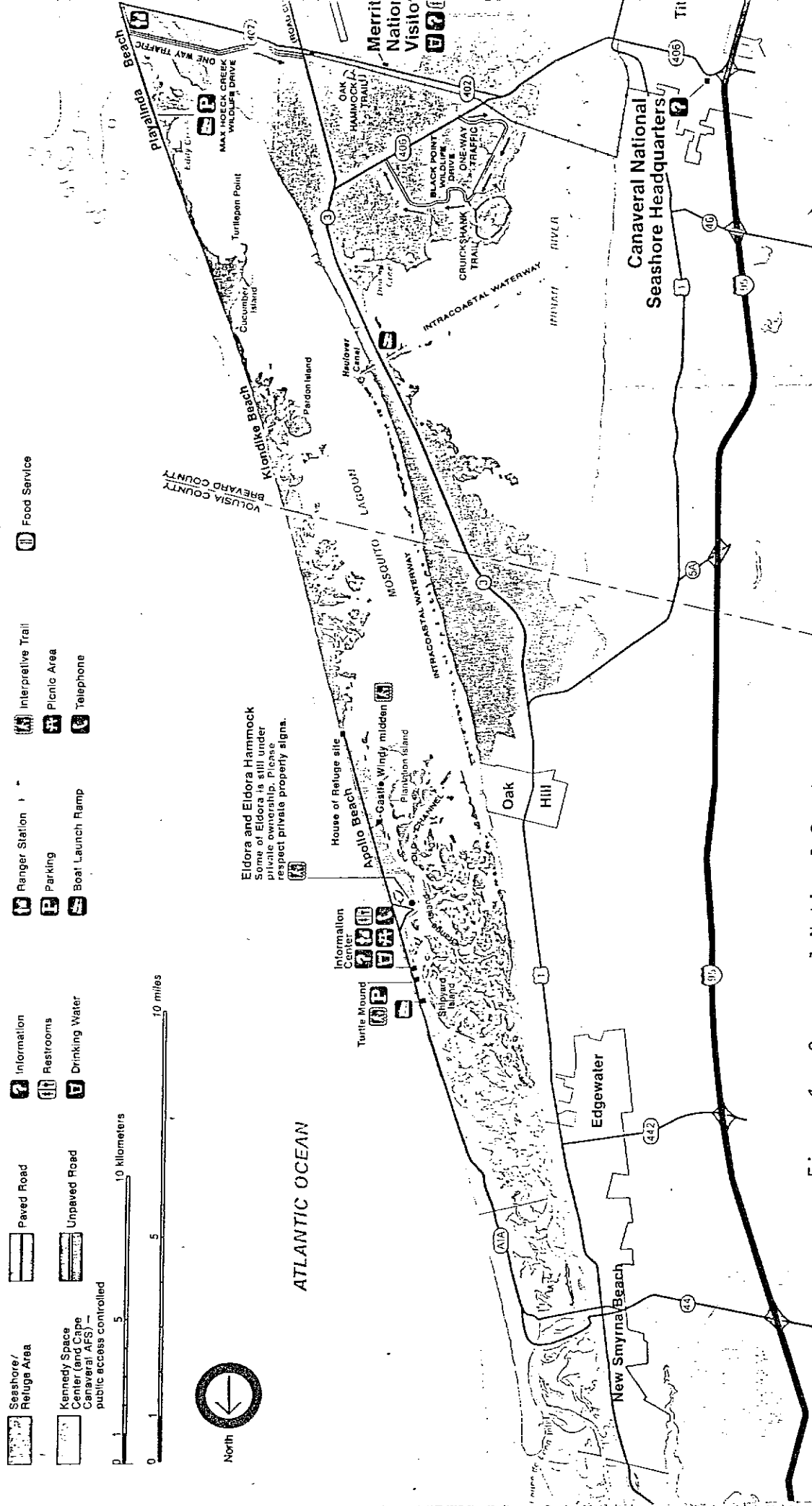


Figure 1. Canaveral National Seashore

The stake for every tenth nest was marked with spray paint for easy identification. After 65 days or evidence of hatching the screens were pulled from these nests and each unhatched egg and empty shell (hatched egg) was counted to calculate an average hatching success for the entire beach.

Nests were relocated if time permitted for one of three reasons: 1) they had been deposited near the surf line and were in danger of being inundated or washed away; 2) the nest was located at the base of a heavily travelled boardwalk; 3) the nest had been partially depredated and required major clean up of broken egg shells and yolk.

Pits approximating the natural nest cavity were dug near the base of the dune. The eggs were then carefully transferred, buried and the nest screened in the usual manner.

The beach was divided into four blocks for the raccoon study (Figure 2). In each block, three treatment areas were established. These were: 1) a removal area, where raccoons were captured and removed; 2) a screening area, where two-thirds of the sea turtle nests were screened; 3) a screening and conditioned taste aversion (CTA) area, where two-thirds of the nests were screened and eggs injected with estrogen were set out on the dune. It was hoped that raccoons ingesting estrogen-laced eggs would associate eggs with nausea and avoid eating sea turtle eggs.

An attempt was made to remove individual raccoons that had learned to tunnel under screens from the screening and screening plus CTA areas. All raccoons were captured using Tomahawk live-traps.

A portion of the raccoons were analyzed for stomach contents, presence of the rabies virus or distemper and reproductive condition. Others were tagged for mark-recapture to determine population estimates and still others fitted with radio collars to track their movements.

RESULTS

A total of 3168 sea turtle nests were deposited at CANA in 1993-3140 loggerhead and 28 green (Table 1). Overall nest density was 135.2 per mile (83.8 per kilometer) for the loggerhead and 1.2 per mile (0.75 per kilometer) for the green. No leatherback nests were recorded.

Table 1. Turtle Nest and False Crawls. 1993.
Canaveral National Seashore

<u>Species</u>	<u>False Crawls</u>	<u>Nests</u>	<u>False Crawl Nest Ratio</u>
Loggerhead	2152	3140	1:1.46
Green	<u>15</u>	<u>28</u>	<u>1:1.87</u>
Total	2167	3168	1:1.46

As in previous years, the greatest concentration of nesting occurred in the South District, although the difference in the two districts was the least that had been observed in at least five years. Fifty-eight percent (1825) of the nests or a density of 152.25 nests per mile was noted on the southern 12 miles of beach compared to 42 percent (1343) or a density of 119.5 nests per mile for the northern 11.25 miles of beach.

The total number of loggerhead false crawls was 2152 yielding a false crawl to nest ratio of 1:1.5 (Table 1). There were 15 green turtle false crawls, equalling a false crawl to nest ratio of 1:1.9. Grids 91, 85, 89 and 88 exhibited the highest false crawl totals with 58, 55, 53 and 51 respectively. Grids with false crawls numbering between 40 and 50 were 33, 78, 84, 86, 87 and 90-93.

Ninety-four percent (2985) of the nests were undepredated at the time of initial discovery (Table 2). Of the remaining six percent, two percent (62) were totally depredated and four percent (128) were partially depredated.

Table 2. Action Upon Initial Encounter. 1993
North and South Districts
Canaveral National Seashore

	<u>Action</u>	<u>Loggerhead</u>		<u>Green</u>		<u>Total</u>
		North	South	North	South	Combined
U	U/S	443 (33)	696 (38)	13 (100)	11 (73)	1163 (37)
C	U/NS	773 (58)	1045 (58)	0	4 (27)	1822 (57)
P	PD/S	38 (03)	20 (01)	0	0	58 (02)
P	PD/NS	48 (04)	15 (01)	0	0	63 (02)
C	TD/NS	28 (02)	34 (02)	0	0	62 (02)
	Total	1330	1810	13	15	3168

U/S = Undepredated/Screened
 U/NS = Undepredated/Not Screened
 PD/S = Partly Depredated/Screened
 PD/NS = Partly Depredated/Not Screened
 TD/NS = Totally Depredated/Not Screened
 () = Percent of column total

None of the 28 green sea turtle nests were depredated at initial discovery (Table 2), possibly because they are deeper and more difficult for the raccoons to uncover. Very little difference in initial depredation was noted between the North and South Districts.

A total of 1,221 or 38.5 percent of the nests were screened, 494 (37 percent) in the northern one-half of CANA and 727 (40 percent) in the southern half (Table 3).

Table 3. Depredation Rate of Sea Turtle Nests
After Initial Discovery
1993. Canaveral National Seashore

<u>Action</u>	<u>North</u>	<u>South</u>	<u>Total</u>
S/U	448 (91)	680 (94)	1128 (92)
S/PD	31 (06)	40 (05)	71 (06)
S/TD	15 (03)	7 (01)	22 (02)
Total	494	727	1221
NS/U	333 (40)	867 (81)	1200 (64)
NS/PD	178 (22)	90 (09)	268 (14)
NS/TD	310 (38)	107 (10)	417 (22)
Total	821	1064	1885

S = Screened
NS = Not Screened
U = Undepredated
PD = Partially Depredated
TD = Totally Depredated
() = Percent of Column Total

None of the 24 screened green sea turtle nests were subsequently depredated. Of the screened loggerhead nests, 22 or two percent were later totally depredated by individual raccoons which had learned to tunnel under the screens (Table 3). An additional 71 or six percent of the screened nests were partially depredated.

Tunnelling behavior was higher in the North District with three percent of the screened nests being totally depredated compared to one percent in the South District (Table 3). The partial depredation rate was also slightly higher.

Primary depredation of sea turtle nests occurred to unscreened nests after the nests had been initially recorded - either later the same night or in ensuing nights. Twenty-two percent of the unscreened nests at CANA were recorded as totally depredated with an additional 14 percent partially depredated (Table 3). Depredation rates were much higher in the North District with 38 percent of the unscreened nests being totally depredated and 22 percent partially depredated as opposed to 10 and 9 percent in the South District, respectively.

The most important total - overall depredation of the entire beach, including screened and unscreened nests and initial and subsequent observations - was 15 percent (474) total depredation and 14 percent (433) partial depredation (Table 4). To state in the inverse, CANA experienced a depredation - free rate of 71 percent.

Table 4. Overall Depredation Rate (Initial Plus After). 1993.
Canaveral National Seashore

	<u>Loggerhead</u>	<u>Green</u>	<u>Total</u>
Screened Nests	1197*	24	1221
Undepredated	1056 (88)	24	1080 (88)
Partly Dep/Screened 1	58 (05)	0	58 (05)
Partially depredated 2	64 (05)	0	64 (05)
Totally depredated 3	19 (02)	0	19 (02)
Partial + Total Dep	141 (12)*	0	141 (12)
Unscreened Nests	1943	4	1947
Undepredated	1177 (61)	4	1181 (61)
Partially depredated 4	311 (16)	0	311 (16)
Totally depredated 5	455 (23)	0	455 (23)
Partial + Total Dep	766 (39)	0	766 (39)
All Nests	3140	28	3168
Undepredated	2233	28	2261 (71)
Partially depredated	433 (14)	0	433 (14)
Totally depredated	474 (15)	0	474 (15)
Partial + Total Dep	907 (29)	0	907 (29)

- 1 = Partially depredated prior to screening = PD/S (Table 2)
 2 = Partially depredated after screening = S/PD (Table 3)
 3 = Screened/Totally depredated = S/TD (from Table 3)
 4 = Unscreened/Partially depredated = PD/NS (Table 2) + NS/PD (Table 3)
 5 = Totally depredated = TD/NS (from Table 2) + NS/TD (Table 3)
 () = Percent of column total

* 83 (7 percent) were depredated after screening; 58 (5 percent) were depredated prior to screening.

Raccoon depredation was analyzed in each treatment area of the four replicate blocks (Table 5). Only the central four grids of each treatment area were analyzed to eliminate edge effect from adjacent areas. Nest depredation was greatest in the removal areas of Block I (grids 7-10) and Block II (grids 29-32), with 30 percent and 39 percent of the unscreened nests totally depredated and 42 percent and 22 percent partially depredated, respectively. Total depredation in the screen area of Block I (grids 15-18) was also higher than in other blocks, with 20 percent being totally depredated. Block IV (grids 75-92) had the least depredation with eight percent total depredation in the removal area and four percent or less in the screen and screen plus CTA areas.

Table 5. Raccoon Predation by Block and Treatment Area. 1993.
Canaveral National Seashore

A.	Block I	<u>Removal</u>	<u>Screen</u>	<u>Screen + CTA</u>
	Grids	7 - 10	15 - 18	21 - 24
Initial sighting	U/S	0	62 (70)	49 (53)
	U/NS	93 (95)	24 (27)	22 (24)
	PD/S	0	2 (02)	12 (13)
	PD/NS	5 (05)	0	5 (05)
	TD/NS	0	1 (01)	4 (04)
Total Nests		98	89	92
Subsequent sighting	S/TD	--	3 (03)	3 (03)
	S/PD	--	6 (07)	7 (08)
	NS/PD	41 (42)	4 (04)	13 (14)
	NS/TD	29 (30)	18 (20)	9 (10)
B.	Block II	<u>Removal</u>	<u>Screen + CTA</u>	<u>Screen</u>
	Grids	29 - 32	37 - 40	43 - 46
Initial sighting	U/S	2 (01)	76 (60)	67 (60)
	U/NS	125 (92)	36 (28)	35 (32)
	PD/S	0	8 (06)	5 (05)
	PD/NS	9 (07)	1	1
	TD/NS	0	6 (05)	3 (03)
Total Nests		136	127	111
Subsequent sighting	S/TD	--	6 (05)	0
	S/PD	--	5 (04)	4 (04)
	NS/PD	30 (22)	15 (12)	6 (05)
	NS/TD	53 (39)	9 (07)	3 (03)

Table 5 (continued).

C.	Block III	<u>Removal</u>	<u>Screen</u>	<u>Screen + CTA</u>
	Grids	51 - 54	59 - 62	65 - 68
Initial sighting	U/S	6 (03)	76 (62)	87 (65)
	U/NS	167 (86)	43 (35)	37 (28)
	PD/S	3 (01)	3 (02)	4 (03)
	PD/NS	7 (04)	1 (01)	2 (01)
	TD/NS	12 (06)	0	4 (03)
Total Nests		195	123	134
Subsequent sighting	S/TD	0	0	2 (01)
	S/PD	0	15 (12)	14 (10)
	NS/PD	23 (12)	5 (04)	6 (04)
	NS/TD	13 (07)	9 (07)	9 (07)
				20
D.	Block IV	<u>Removal</u>	<u>Screen + CTA</u>	<u>Screen</u>
	Grids	75 - 78	83 - 86	89 - 92
Initial sighting	U/S	3 (02)	126 (63)	132 (67)
	U/NS	138 (97)	59 (29)	64 (32)
	PD/S	0	5 (02)	1
	PD/NS	0	3 (01)	0
	TD/NS	1 (01)	8 (04)	0
Total Nests		142	201	197
Subsequent sighting	S/TD	--	1	2 (01)
	S/PD	0	1	0
	NS/PD	4 (03)	8 (04)	2 (01)
	NS/TD	12 (08)	8 (04)	4 (02)

Initial Sighting

U/S = Undepredated/Screened
 U/NS = Undepredated/Not Screened
 PD/S = Partly Depredated/Screened
 PD/NS = Partly Depredated/Not Screened
 TD/NS = Totally Depredated/Not Screened
 () = Percent of column total

Subsequent Sighting

S/TD = Screened/Totally Predated
 S/PD = Screened/Partly Depredated
 NS/PD = Not Screened/Partly Depredated
 NS/TD = Not Screened/Totally Depredated
 () = Percent of column total

Screening combined with CTA did not demonstrate a reduction in depredation over screening (Table 5). Only in Block II, among unscreened nests that later became totally depredated, was there a notable decrease. However, in that same area, the number of initially depredated nests was higher.

Tunnelling behavior by raccoons, burrowing under the screens to reach the eggs, was highest in the screen and screen plus CTA areas of Block III (Table 5). Tunnelling was virtually absent in Block IV.

A total of 332 loggerhead nests were marked for excavation to determine hatching success. Of these 139 were screened and 193 were unscreened. Seventeen percent (55) were totally depredated, four percent (13) were partially depredated and 12 percent (41) were of unknown fate (Table 6). The remaining 67 percent hatched; 113 (81 percent) of the screened nests and 110 (55 percent) of the unscreened nests.

Table 6. Outcome of Monitored Loggerhead Sea Turtle Nests. 1993.
Canaveral National Seashore

<u>Outcome</u>	<u>Loggerhead</u>		<u>Total</u>
	<u>Screened</u>	<u>Unscreened</u>	
Hatched	113 (81)	110 (57)	223 (67)
Unhatched	7 (05)	6 (03)	13 (04)
Depredated	3 (02)	52 (27)	55 (17)
Unknown	16 (12)	25 (13)	41 (12)
Total	139	193	332

() = Percent of column total

Altogether 225 or seven percent of the loggerhead nests were excavated. Mean clutch size was 100.7 eggs and the average hatching rate was 80 percent (Table 7).

Table 7. Sea Turtle Clutch Size and Nest Production. 1993.
Canaveral National Seashore

<u>Species</u>	<u>Nests</u>	<u>Eggs Hatched</u>	<u>Eggs Unhatched</u>	<u>Average Clutch</u>	<u>Average Hatched</u>
Loggerhead	225*	18,250	4610	100.7	79.8%
Green	8	730	303	129.1	70.7%

* 11 partly predated nests not included since they did not contain full clutches

The 11 partly depredated nests that were excavated all produced at least a few hatchlings at an average of 27.4 hatchlings per nest.

The estimated number of loggerhead sea turtle hatchlings produced at CANA was determined as follows:

$[(2233 \text{ undepredated nests}) \times (100.7 \text{ eggs/nest}) \times (79.8 \text{ percent egg hatching rate})] + [(433 \text{ partially depredated nests}) \times (27.4 \text{ hatchlings per nest})] = 191,305 \text{ hatchlings.}$

For the green sea turtle, the estimate was as follows:

$(28 \text{ nests}) \times (129.1 \text{ eggs/nest}) \times (70 \text{ percent hatching rate}) = 2,556 \text{ hatchlings.}$

Eight green sea turtle nests or 28 percent of the total were excavated. Five were screened and three were unscreened. The average clutch size was 129.1 eggs and the average hatching rate was 70 percent (Table 7).

Twelve loggerhead nests were relocated in 1993. The hatching success of these nests is unknown. One case of hatchling disorientation was observed. This occurred in grid 94, which is immediately adjacent to the north boundary of Kennedy Space Center. A shuttle launch pad that is brightly lighted at night is located less than three miles away. From the tracks it appeared that approximately 25 hatchlings crawled away from the water. Three dead hatchlings were found high on the beach wedged in the opening of ghost crab holes and three others tangled in the dune vegetation.

DISCUSSION

The total of 3168 nests in 1993 demonstrated a decline for the second straight year after high nesting totals of 3922 in 1990 and 4074 in 1991 (Table 8). While the number of loggerhead nests dropped four percent from the previous year's total of 3279, the number of green nests plummeted from 298 in 1992 to 28 in 1993, a decrease of 90 percent. This sharp decline in green nests was very similar to the drop in 1991 to 25 nests from 185 nests in 1990. For the second year in a row no leatherback nests were recorded.

Table 8. Sea Turtle Nesting at Canaveral National Seashore 1984-1993

<u>Year</u>	<u>Loggerhead</u>	<u>Green</u>	<u>Leatherback</u>	<u>Unknown</u>	<u>Total</u>
1993	3140	28	0		3168
1992	3279	298	0		3577
1991	4074	25	1		4100
1990	3922	185	1		4108
1989	3091	41	1		3133
1988	2203	43	0	4	2250
1987	1670	90	1	15	1776
1986	3349	22	3		3374
1985	2389	94	0	25	2508
1984	(Individual breakdown not available)				2125

(From Bryant 1986a, 1986b, 1987 and 1988 and Stiner 1990, 1991a, 1991b and 1993)

The false crawl to nest ratio was very close to that of 1992 for both the loggerhead and green with 1:1.46 and 1:1.87 in 1993, respectively compared to 1:1.43 and 1:1.10 in 1992 (Table 9). The loggerhead exhibited more nests than false crawls in at least seven of the last 10 years, while the green nest total exceeded false crawls in at least six of the last 10 years.

Table 9. False Crawl to Nest Ratio at Canaveral National Seashore
1984-1993

<u>Year</u>	<u>Loggerhead</u>	<u>Green</u>	<u>Average</u>
1993	1:1.46	1:1.87	1:1.46
1992	1:1.43	1:1.10	1:1.39
1991	1:1.10	1:0.66	1:1.10
1990	1:1.31	1:1.17	1:1.30
1989	1:1.53	1:3.00	1:1.55
1988	1:0.94	1:1.16	1:0.94
1987	1:1.02	1:0.72	1:1.015
1986	1:0.98	1:0.76	1:0.97
1985	1:1.22	1:1.02	1:1.20
1984	--	--	1:1.24

(From Bryant 1986a, 1986b, 1987 and 1988 and Stiner 1990, 1991a, 1991b and 1993)

Grids exhibiting the greatest number of false crawls were clustered in the southern end of the beach, within four miles of the Kennedy Space Center, between grids 84 and 93. Three of these 10 grids had more than 50 false crawls and the other seven exceeded 40. A lighted shuttle pad located within three miles of the boundary may be related to this phenomena. Only two other grids had more than 40 false crawls, grids 33 and 78.

Areas exhibiting the greatest number of nests were grids 85 (66 nests), 56 (62), 33 (63), 91 (58) and 51 (56). Over the last four years, grids 85, 86 and 91 have been within the top five grids for number of nests three times (Stiner 1991a, 1991b and 1992). Grids 33, 90 and 92 have been in the top five twice. As can be seen grids 85, 86, 90, 91 and 92 lie within the area of greatest false crawls for 1993 (grids 84-93). Only grid 33 lies outside that zone and is located in the North District.

To integrate with the raccoon study, only green sea turtle nests were screened in the four removal areas and only 66 percent of the loggerhead nests were screened in the eight screen and screen plus CTA areas (see Study Sites and Methods). Overall, 39 percent of the nests deposited at CANA in 1993 were screened (Table 10). While this was considerably less than the 62 percent screened in 1992, it actually exceeded the amount screened in 1990 and 1991 and equalled that of 1988 (Table 10). The amount screened in 1989 was also less than 33 percent; however in that year sea turtle nest protection was divided between National Park Service (NPS) and Fish and Wildlife Service (FWS). The NPS screened 93 percent of the nests in the North District while FWS concentrated on removing raccoons from the South District.

Table 10. Number of Screened Sea Turtle Nests and Depredation Rate. 1984-1993. Canaveral National Seashore

<u>Year</u>	<u>Number of Nests</u>	<u>Number of Nests Screened</u>	<u>Screened Nests Depredated (%)</u>
1993	3168	1221 (39%)	7.6
1992	3579	2213 (62%)	4.3
1991	4100	1507 (37%)	3.3
1990	4108	1547 (38%)	1.9
1989	3132	1030 (33%)*	3.4
1988	2250	887 (39%)	18.7
1987	1776	766 (43%)	7.2
1986	3374	1517 (45%)	3.7
1985	2508	1023 (41%)	5.0
1984	2125	213 (19%)	---

* 93% were screened in the North District
() = Percent of column total

A total of 7.6 percent of the screened nests were depredated in 1993 - 5.8 percent partially and 1.8 percent totally (Table 3). This was an increase from the overall depredation rate of 4.3 percent in 1992. Actually the rate in the South District dropped from 7.7 in 1992 to six in 1993 while the North District rose from 2.1 to nine percent (Stiner 1992 and Table 3). As Table 10 demonstrates, the amount of depredation of screened nests (tunnelling) has varied from a high of 18.7 percent in 1988 to a low of 1.9 percent in 1990.

Tunnelling is a learned behavior. At any one time, the number of "educated" raccoons appears to vary. As young raccoons are taught the behavior by a parent or as educated raccoons are removed from the system through natural causes or management actions, the amount of tunnelling fluctuates. The fact that tunnelling has increased the past three years may indicate that the learned behavior is spreading among the raccoon population. Scarcity of unprotected nests does not appear to be a major factor. While the percent of screened nests has remained fairly uniform since 1985, tunnelling has fluctuated. Almost 600 more nests were unprotected in 1993 than in 1992 and yet the amount of tunnelling increased 1.8 times. The unusually high tunnelling rate of 18.7 percent in 1988 may have been related to screening technique. No other year reached even half of that rate.

The amount of tunnelling was fairly uniform over much of the beach. However it was virtually absent in Block IV (grids 83-92) and very low in the screen area of Block II (grids 43-46).

Prior to the 1993 nesting season, CANA consulted FWS, in accordance with the Endangered Species Act, about potential effects of the raccoon study on sea turtle nesting success. FWS determined that screening only 66 percent of the nests in the

screen and screen plus CTA areas would result in nests being lost. However, they felt that removing raccoons from the four removal areas would reduce depredation sufficiently to balance out the loss sustained in the other areas.

Beginning in March and extending through August, UGA researchers removed 148 raccoons from Canaveral National Seashore's beach area - 58 from Block I, 37 from Block II, 32 from Block III and 21 from Block IV (Ratnaswamy, et al. 1993). The vast majority of these were taken from the removal areas, with a small number of "tunnellers" being removed from the screening areas.

The expected reduction in nest depredation in the removal areas did not occur. Nest depredation was actually highest in the removal areas of Blocks I and II (grids 7-10 and 29-32) (Table 5). Nest depredation in the removal area of Block IV (grids 75-78) was slightly higher than the screen and screen plus CTA areas (grids 83-86 and 89-92) while in Block III, the removal area (grids 51-54) exhibited a slightly lower depredation rate than the other treatment areas (grids 59-62 and 65-68).

There are several possible reasons for the higher depredation rate in three of the four removal areas. Raccoons may have "bled in" from adjacent treatment areas or there simply may be so many raccoons in CANA that several years of removal are needed before a significant reduction in nest depredation is observed.

This indicates that if raccoon removal is ultimately chosen as the way to protect sea turtle nests at CANA, screening will still be necessary for a period of years until the raccoon population is sufficiently reduced.

FWS management actions at Merritt Island National Wildlife Refuge have demonstrated that raccoon removal is effective in reducing nest depredation if employed at a high enough level over a sufficient period of time. The question at CANA is, "Is that amount of removal acceptable from an ecosystem standpoint and in light of NPS policy?"

The CTA experiment did not appear to reduce nest depredation. Depredation actually was higher in the screen plus CTA areas of Blocks II and IV than the adjacent screen areas (Table 5). In Blocks I and III, depredation in screen and screen plus CTA areas was essentially the same. Ratnaswamy, et al. (1993) observed no decrease in egg consumption in experimental nests after introducing injected eggs. However, they did observe that some individuals, after treatment, did open eggs without consuming the contents or rolled them around without opening them.

CANA's raccoons are larger than those in other areas, such as Cumberland Island (Ratnaswamy, per comm). It may be that they need a larger dose of estrogen than was effective in studies conducted on predators elsewhere. Also the large number of raccoons at CANA may prevent any one animal from eating enough

injected eggs to associate eggs with nausea. Two possible modifications to the study in 1994 are to place out more injected eggs or to inject more estrogen into each egg.

CONCLUSION

Much valuable information was gained in 1993 on the health, population size, movements and foraging behavior of raccoons at CANA. Combining this with observations recorded on the effectiveness of predator removal, screening and conditioned taste aversion will assist the park in developing the best long-range plan for sea turtle nest protection. CANA will continue to strive to exceed the goal of 60 percent hatch rate established in the loggerhead sea turtle recovery plan (NMFS and USFWS 1991).

1994 will be the second year of the two year study by the University of Georgia. To maintain the study design, treatments will be kept the same with some minor modifications. The trapping period may be adjusted to avoid periods of low trapping success and estrogen may be increased to enhance conditioned taste aversion.

Cooperative efforts by CANA and UGA were essential to the success of the research project and the sea turtle nest protection program. Additional research prompted by this study, such as the impact of raccoon predation on other ground-nesting species, will greatly benefit CANA's efforts at sea turtle nest protection and the park's overall resource management program.

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