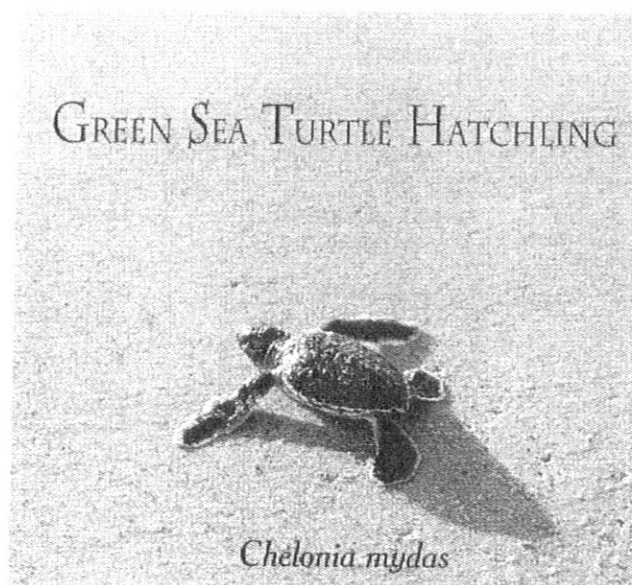


2000 MARINE TURTLE NESTING SUMMARY
CANAVERAL NATIONAL SEASHORE
FLORIDA



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2000 MARINE TURTLE NESTING SUMMARY CANAVERAL NATIONAL SEASHORE

INTRODUCTION

Canaveral National Seashore is an important nesting area for several species of threatened and endangered sea turtles. These are primarily the loggerhead (*Carretta caretta*), with a lesser number of green (*Chelonia mydas*) and an occasional leatherback (*Dermochelys coriacea*). Nest depredation, primarily by raccoons, is a serious threat, with depredation rates exceeding 90 percent in the early 1980's (McMurtray 1986). In 1984, the park implemented a nest screening program to protect nests while allowing the raccoon to remain as an integral part of the seashore ecosystem. In 1993 and 1994, the University of Georgia compared three methods of nest protection, screening, predator removal and conditioned-taste-aversion (Ratnaswamy 1995; Warren 1996). They found screening to be most effective and compatible with National Park Service guidelines and objectives.

2000 was the seventeenth year for Canaveral National Seashore's sea turtle nest protection program. Since 1995, park staff has managed to screen over 90 percent of the several thousand nests deposited each year, reducing nest depredation to less than 30 percent. The park's goal is to achieve the 60 percent hatching rate targeted in the loggerhead and green sea turtle recovery plans (NMFS and USFWS 1991) without removing predators from their important role in the barrier island ecosystem.

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 18.1 kilometers (11.25 miles) of beach is situated in Volusia County and the southern 20.2 kilometers (12.5 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 was divided into 94 quarter-mile long grids by placing numbered four by four posts along the dune line. These grids provide a reference point for documenting nest locations.

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.

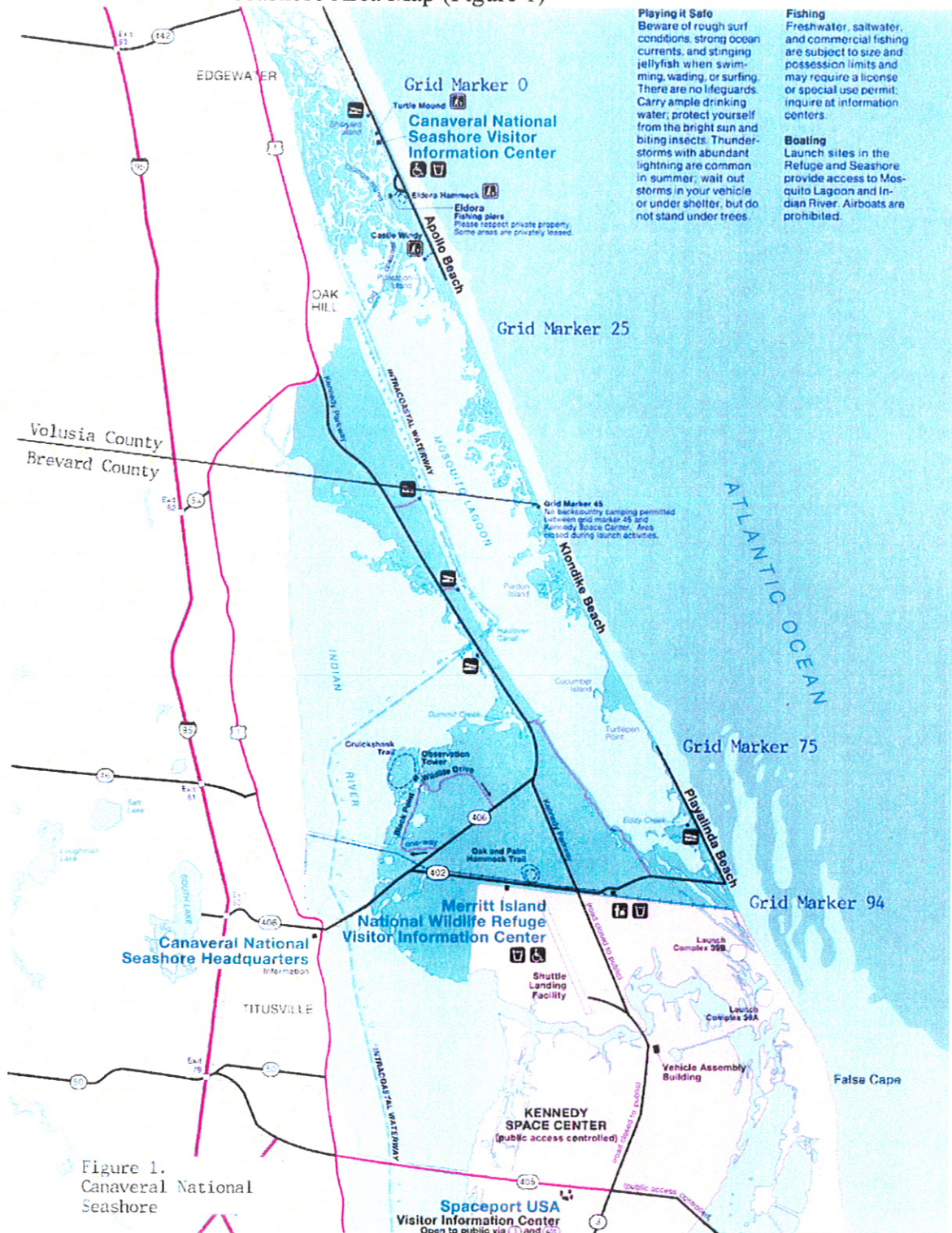
On May 05, 2000, the park initiated patrols on four-wheeled all-terrain vehicles (ATV's) to record sea turtle emergencies (nests and false crawls) and to screen nests. The 24 miles of beach was divided into two 12 mile segments, each covered by a team consisting of a ranger and a volunteer. The teams worked from 11:00 p.m. to 7:00 a.m., seven nights a week. In addition, daytime patrols were conducted at least three times a week to document any subsequent depredations to recorded nests. On July 20, 2000, patrols were switched to 4:00 a.m. to noon, due to a decrease in nesting and to enhance nest excavation activities.

Initial data collected for each nest included: date, nest number, species, grid, number of eggs depredated and sighting/treatment. Sighting/treatment referred to the condition of the nest upon discovery (undepredated, partially depredated or totally depredated) and the subsequent treatment (nest screened or left unscreened). Each nest was marked with a numbered stake for later identification. Date and grid location of each false crawl was also recorded.

The screening procedure 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 attempts by predators to reach the eggs. Partially depredated nests that retained a significant number of intact eggs had the broken eggs removed and were covered with clean sand.

During daytime patrols, all new nest depredations were recorded, the number of depredated eggs counted and all broken eggs removed from the beach. The latter was done to deter predators from easily relocating any remaining eggs and to prevent counting depredations more than once. If a significant number of viable eggs remained, broken eggs were removed and the nest was re-covered with clean sand.

Canaveral National Seashore Area Map (Figure 1)



The stake for every tenth nest was marked with white spray paint for each identification. After a minimum of 70 days, or 3 days after evidence of hatching, the nests were excavated and the following information recorded: number of hatchlings emerged (empty eggshells), number of unhatched eggs, number of live hatchlings in nest, number of dead hatchlings in nest and number of pipped eggs (hatchling still partially in eggshell). Depredated eggs recorded during daytime runs were added to the total of unhatched eggs prior to analysis. This data was then used to calculate average hatching success for the entire beach.

Sixty-six (66) nests were relocated for one of three reasons: 1) the nest was located at the base of a heavily traveled boardwalk; 2) the nest cavity and eggs had been fouled by the contents of broken eggs; 3) the nest was in imminent danger of erosion. Pits approximating the natural nest cavity were dug near the base of the dune. The eggs were then carefully transferred, buried and screened in the usual manner.

An attempt was made to remove individual raccoons that had learned how to repeatedly tunnel under the screens. These raccoons were captured using Tomahawk live-traps.

RESULTS

Nesting and False Crawl Totals

A total of 4563 sea turtle nests were deposited at CANA in 2000 - 3892 loggerhead, nine leatherback and 662 green (Table 1). Overall nest density was 101.6 per kilometer for the loggerhead, 0.2 per kilometer for the leatherback, and 17.3 per kilometer for the green.

The total number of loggerhead false crawls was 3816 or 99.6 per kilometer, a false crawl to nest ratio of 1:1.02 (Table 1). There were 929 green false crawls or 24.3 per kilometer, a false crawl to nest ratio of 1:0.71. Three leatherback false crawls were recorded, for a false crawl to nest ratio of 1:3.0.

As in former years, the greatest concentration of nesting was noted in the southern half of CANA with 60% (2716) of the nests occurring in the South District (Brevard County) and 40% (1847) in the North District (Volusia County) (Table 1). Nesting densities were 134.5 and 102.0 per kilometer respectively. Figures 2a and 2b show the number of nests and false crawls by individual grids for the entire beach.

Initial Sighting and Nests Screened

In 2000, 94 percent (4304) of the 4563 nests deposited at CANA were screened, comprising 3784 undepredated and 520 partially depredated nests (Table 2, Initial Encounter). This included nine leatherback, 653 green and 3642 loggerhead nests.

A total of 250 (06%) of the loggerhead nests were totally depredated and 485 (12%) were partially depredated prior to discovery (Table 2, Initial Encounter).

A total of 9 (01%) of the green nests were totally depredated and 34 (05%) were partially depredated prior to discovery (Table 2, Initial Encounter). One of the nine leatherback nests was partially depredated.

Table 1: 2000 Marine Turtle Crawl Survey, Canaveral National Seashore.

Overall

	Loggerhead	Green	Leatherback	Total
Nests	3892	662	9	4563
False Crawls	3816	929	3	4748
Nest Density (nest/km)	101.6	17.3	0.2	119.1
FC Density (FC/km)	99.6	24.3	0.1	124.0
FC to Nest Ratio	1:1.02	1:0.71	1:3.0	1:0.96

Distribution by District

North District (Volusia county)

	Loggerhead	Green	Leatherback	Total
Nests	1579	264	4	1847
False Crawls	1246	304	1	1551
Nest Density (nest/km)	87.2	14.6	0.2	102.0
FC Density (FC/km)	68.8	16.8	<0.1	85.7
FC to Nest Ratio	1:1.3	1:0.9	1:4.0	1:1.2

South District (Brevard County)

	Loggerhead	Green	Leatherback	Total
Nests	2313	398	5	2716
False Crawls	2570	625	2	3197
Nest Density (nest/km)	114.5	19.7	0.2	134.5
FC Density (FC/km)	127.2	31.0	0.1	158.3
FC to Nest Ratio	1:0.9	1:0.6	1:2.5	1:0.8

Figure 2a. Nests, False Crawls, Depredations, and Tunneling Activity.
Grids 0-44 (North District) - 2000

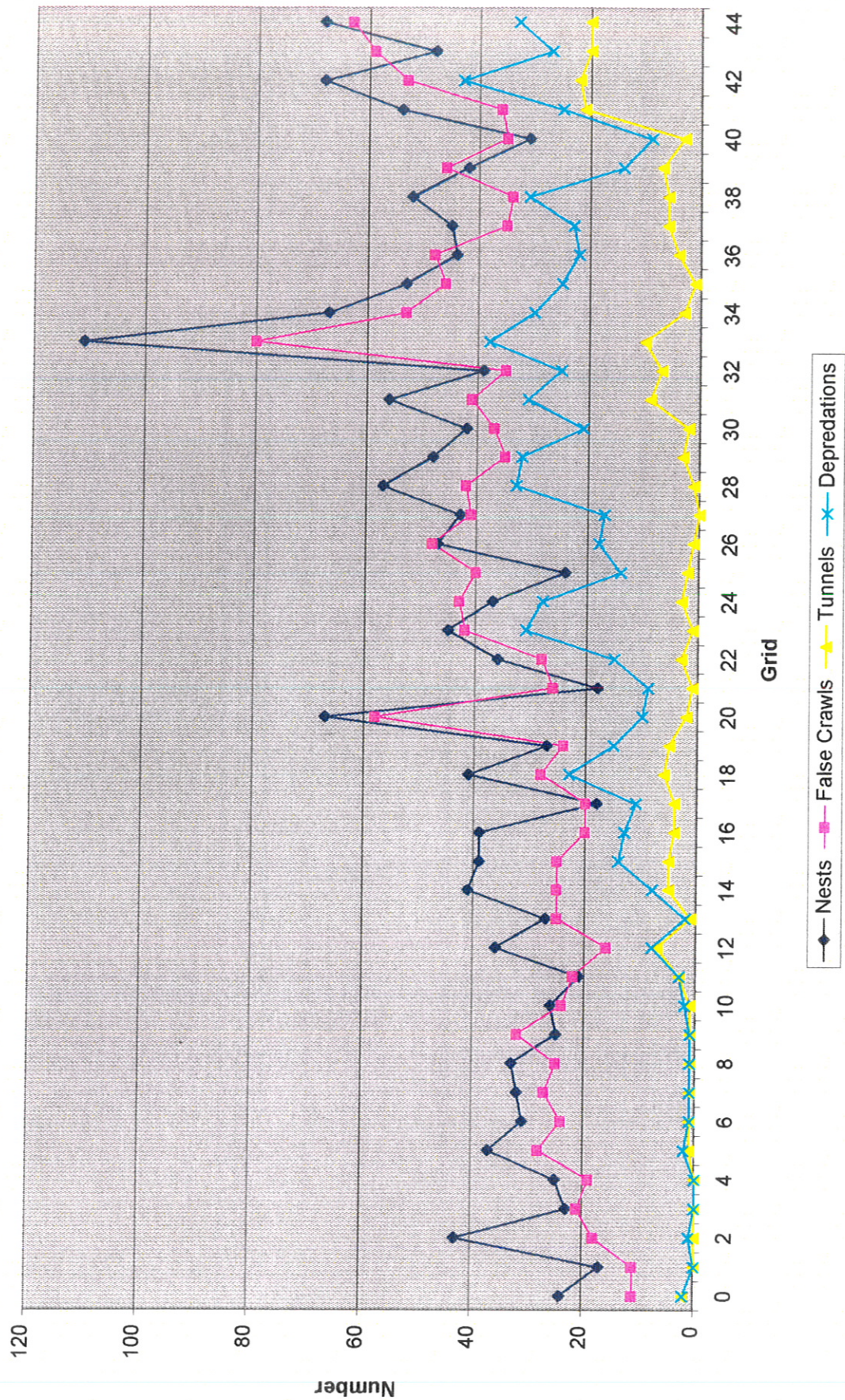


Figure 2b. Nests, False Crawls, Depredations, and Tunneling Activity.
Grids 45-94 (South District) - 2000

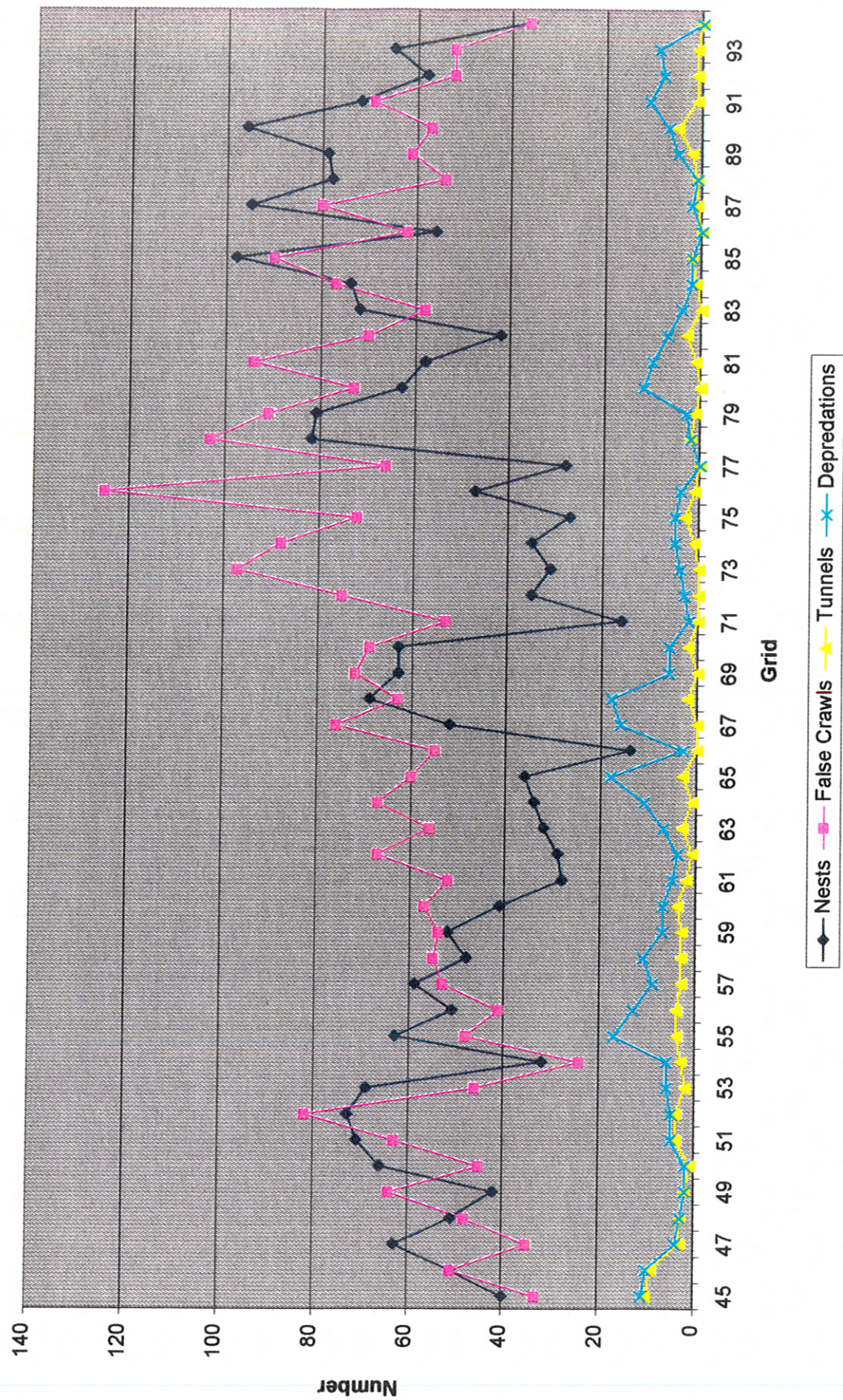


Table 2. Nest Treatment and Depredation, 2000. Canaveral National Seashore.

Initial Encounter

	Loggerhead	Green	Leatherback	Total
Not Dep/Screened	3157 (81%)	619(94%)	8 (89%)	3784 (83%)
Part Dep/Screened	485 (12%)	34 (05%)	1 (11%)	520 (11%)
Total Depredation	250 (06%)	9 (01%)	0	259 (06%)
TOTAL	3892	662	9	4563

Part=Partial Dep=Depredation

Subsequent Depredation

Screened Nests

	Loggerhead	Green	Leatherback	Total
North District	194	13	0	207 (11%)
South District	103	2	0	105 (04%)
Total	297	15	0	312 (07%)

Overall Depredation (Initial Encounter and Subsequent Depredation)

All Nests

	Loggerhead	Green	Leatherback	Total
Partial Depredation	665 (17%)*	41 (06%)	1 (11%)	707 (15%)^
Total Depredation	331 (09%)	15 (02%)	0	346 (08%)
Total	976 (25%)	56 (08%)	1 (11%)	1033 (23%)

* Percentages in species columns are derived from total number of nests for that species

^ Percentages in Total column are derived from total number of nests for all species (4563)

By District

	Loggerhead	Green	Leatherback	Total
North District	665	46	1	712 (39%)*
South District	311	10	0	321 (08%)*
Total	976	56	1	1033 (23%)

* Percentages are derived from total number of nests in each district

Subsequent Depredations

Seven percent (312) of the screened nests were depredated by predators that had learned to tunnel underneath the screens (Table 2, Subsequent Depredation). Tunneling was higher in the North District, with 11 percent (207) of the screened nests being depredated versus four percent (105) in the South District. Seventy-eight (78) nests were recorded as being depredated more than once (CANA files).

Overall, including both initial and subsequent depredations, 25 percent (976) of the loggerhead, eight percent (56) of the green and 11 percent (1) of the leatherback nests were either partially or totally depredated during the 2000 season (Table 2, Overall Depredation, All Nests). Specifically, nine percent (331) of the loggerhead nests were totally depredated and 17 percent (665) were partially depredated. Two percent (15) of the green nests were totally depredated and six percent (41) were partially depredated. The leatherback depredation was a partial.

As in past years, the highest percentage of depredations (partial and total) occurred in the North District, where 39 percent (712) of the nests were depredated, compared to 8 percent (321) in the South District (Table 2, Overall Depredation, By District). Twenty-three percent (1033) of the nests deposited at CANA were either partially or totally depredated.

A total of six problem raccoons ("tunnelers") were removed from the beach during the nesting season.

Monitored Nests

Every tenth nest was marked for excavation after the incubation period to determine hatching success. Of the 391 marked loggerhead nests, 317 (82%) were excavated (Table 3). Two-hundred-and-sixty-two (262) of these were undepredated and 55 partially or totally depredated. Hatching success for undepredated nests was 65% and 37% for depredated nests. Combining the two yields a hatching rate of 61%.

Average clutch size was 101.2 eggs for undepredated nests and 94.4 for depredated nests. If an estimated 2483 eggs are added to the unhatched total to represent 25 totally depredated nests where an egg count could not be made (25 nests times average clutch size of 100.0 eggs = 2500 eggs), the adjusted hatching success is 56%.

An estimated number of loggerhead hatchlings was calculated, based on the hatching success of marked nests. This was done as follows:

$(56\% \text{ hatchling success}) \times (100.0 \text{ eggs/clutch}) \times (3892 \text{ nests}) = 217,952 \text{ hatchlings.}$

Forty-nine nests were of unknown fate (Table 3).

Table 3. Hatching Success of marked Nests, 2000. Canaveral National Seashore.

Loggerhead

	Non-depredated	Depredated	Overall
Nests marked	287	104	391
Nests Excavated	262	55	317
Total Eggs	26,513	5,192	31,705
Ave. Clutch Size	101.2	94.4	100.0
Hatchlings Emerged	17,289	1,928	19,217
Hatching Success	65%	37%	61%
Nests Destroyed by Depredation	N/A	25	25
Adjusted Hatching Success*	N/A	26%	56%
Eroded/Unknown Fate	25 (09%)	24 (23%)	49 (12%)

* Adding average clutch size for 25 totally depredated nests where egg count not possible

Green

	Non-depredated	Depredated	Overall
Nests marked	113	6	119
Nests Excavated	106	4	110
Total Eggs	12,881	467	13,348
Ave. Clutch Size	121.5	116.7	121.3
Hatchlings Emerged	7,357	95	7,452
Hatching Success	57%	20%	56%
Nests Destroyed by Depredation	N/A	0	N/A
Eroded/Unknown Fate	7 (06%)	2 (33%)	9 (07%)

Leatherback

	Non-depredated	Depredated	Overall
Nests marked	8	1	9
Nests Excavated	7	1	8
Total Eggs	552	84	636
Ave. Clutch Size	78.9	84	79.5
Hatchlings Emerged	224	0	239
Hatching Success*	41%	0	38%
Nests Destroyed by Depredation	N/A	0	N/A
Eroded/Unknown Fate	1 (12%)	0	1 (11%)

Of the 119 marked green nests, 110 (92%) were excavated. One-hundred-and-six (106) of these were undepredated and four partially or totally depredated. Hatching success for undepredated nests was 57% and 20% for depredated nests. Combining the two yields a hatching rate of 56%. Average clutch size was 121.5 for undepredated nests and 116.7 for depredated nests.

The estimated number of green hatchlings was calculated as follows:

$(56\% \text{ hatching success}) \times (121.3 \text{ eggs/clutch}) \times (662 \text{ nests}) = 44,968 \text{ hatchlings.}$

Eight of the nine leatherback nests were excavated. Seven of these were undepredated and one was partially depredated. Average clutch size was 79.5 eggs with a hatching success of 38 percent and a total of 239 hatchlings (Table 3).

DISCUSSION

Nesting and False Crawl Totals

The 4563 nests recorded at CANA in 2000 was the highest total since surveys began in 1984 (Table 4). This surpassed the previous high noted in 1999 by 48 nests. The high number was due to a record number of greens (662) and occurred despite a slight decline in loggerhead sea turtle nesting activity from 4501 in 1999 to 3892 in 2000. True to form, the green continued the up and down pattern exhibited every year except one (1989) since 1985 (Figure 3).

The loggerhead nesting pattern also fluctuates, although it is less predictable (Figure 4). The nine leatherback nests recorded equaled the previous high reported in 1999 (Table 4). While still low, leatherback totals increased in each of the last four years and at least one leatherback nest was reported in 11 of the last 15 years.

With a false crawl to nest ratio of 1:1.02, the number of loggerhead nests exceeded false crawls for the thirteenth time in the last 16 years (Table 5). The three years that it did not, the ratio was almost one-to-one (1998-1:0.99; 1988-1:0.94; and 1986-1:0.98). While green false crawls exceeded nests in 2000 (1:0.71), nests exceeded false crawls in nine of the past 15 years (Table 5). Leatherback nest totals exceeded false crawls in eight of 11 years (Table 5). In two years they were equal; only once did leatherback false crawls exceed nests.

Screening Activity and Nest Depredation

Ninety-four percent (4304) of the sea turtle nests deposited at CANA in 2000 were screened. Overall nest depredation was almost the same as in 1999, rising slightly from 22.2 percent to 23.0 percent (Table 6). The depredation rate has fluctuated between 29.9 and 14.8 percent since 1993, when daytime runs were implemented to detect subsequent depredations to nests.

Tunneling activity, digging under the screens to reach the eggs, dropped slightly from 8.2 percent in 1999 to 7.2 percent in 2000 (Table 6). Since 1985, tunneling has ranged from 18.7 percent in 1988 to 1.9 percent in 1990. The unusually high value in 1988 was almost twice that of any prior year.

The yearly oscillations in depredation and tunneling are likely tied to periodic fluctuations in the raccoon population and number of experienced animals foraging on the beach (i.e. individuals that have learned to tunnel). There is always potential for an explosion in the raccoon population at the park. Kramer (1996) noted breeding in most months of the year at CANA. There are ample food resources and natural predators are absent. Although park staff works hard to remove trash, refuse from one million visitors a year adds to the food source. When periods of little disease coincide with the above, periodic surges in the raccoon population at CANA are inevitable. Natural factors, such as distemper, serve to return the raccoon population to lower levels.

Table 4. Sea Turtle Nest Totals, 1984-2000. Canaveral National Seashore.

YEAR	LOGGERHEAD	GREEN	LEATHERBACK	UNKNOWN	TOTAL
2000	3892	662	9		4563
1999	4501	5	9		4515
1998	3976	427	5		4408
1997	2702	21	4		2727
1996	3260	222	3		3485
1995	4121	47	1		4169
1994	3886	364	2		4252
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	*				2125

* = Individual breakdown not available.

Taken from yearly Sea Turtle Nesting Summaries, 1984-2000, Canaveral National Seashore, Titusville, Florida.

FIGURE 3. GREEN SEA TURTLE NESTING TOTALS
CANAVERAL NATIONAL SEASHORE 1985-2000

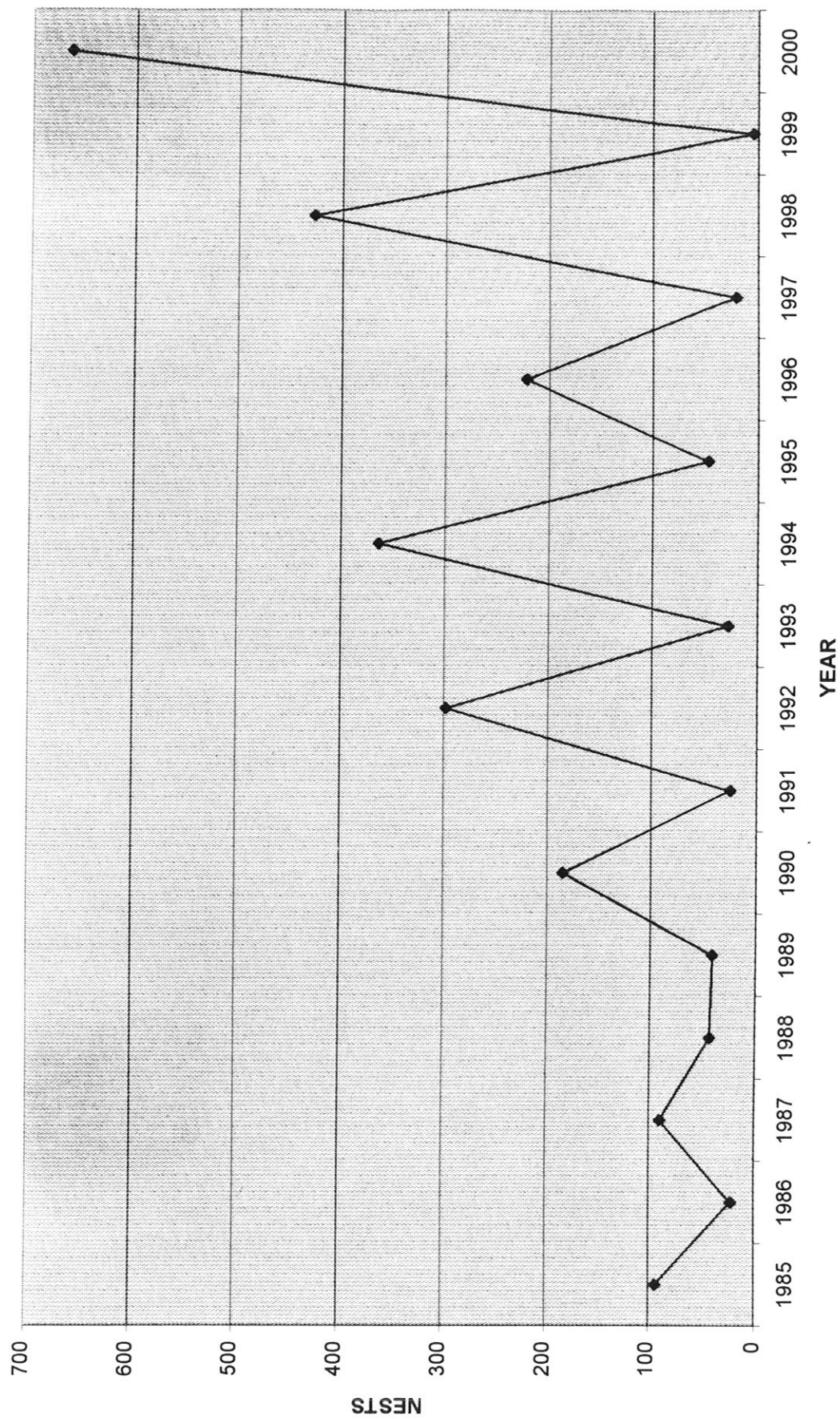


FIGURE 4. LOGGERHEAD SEA TURTLE NESTING TOTALS
CANAVERAL NATIONAL SEASHORE 1985-2000.

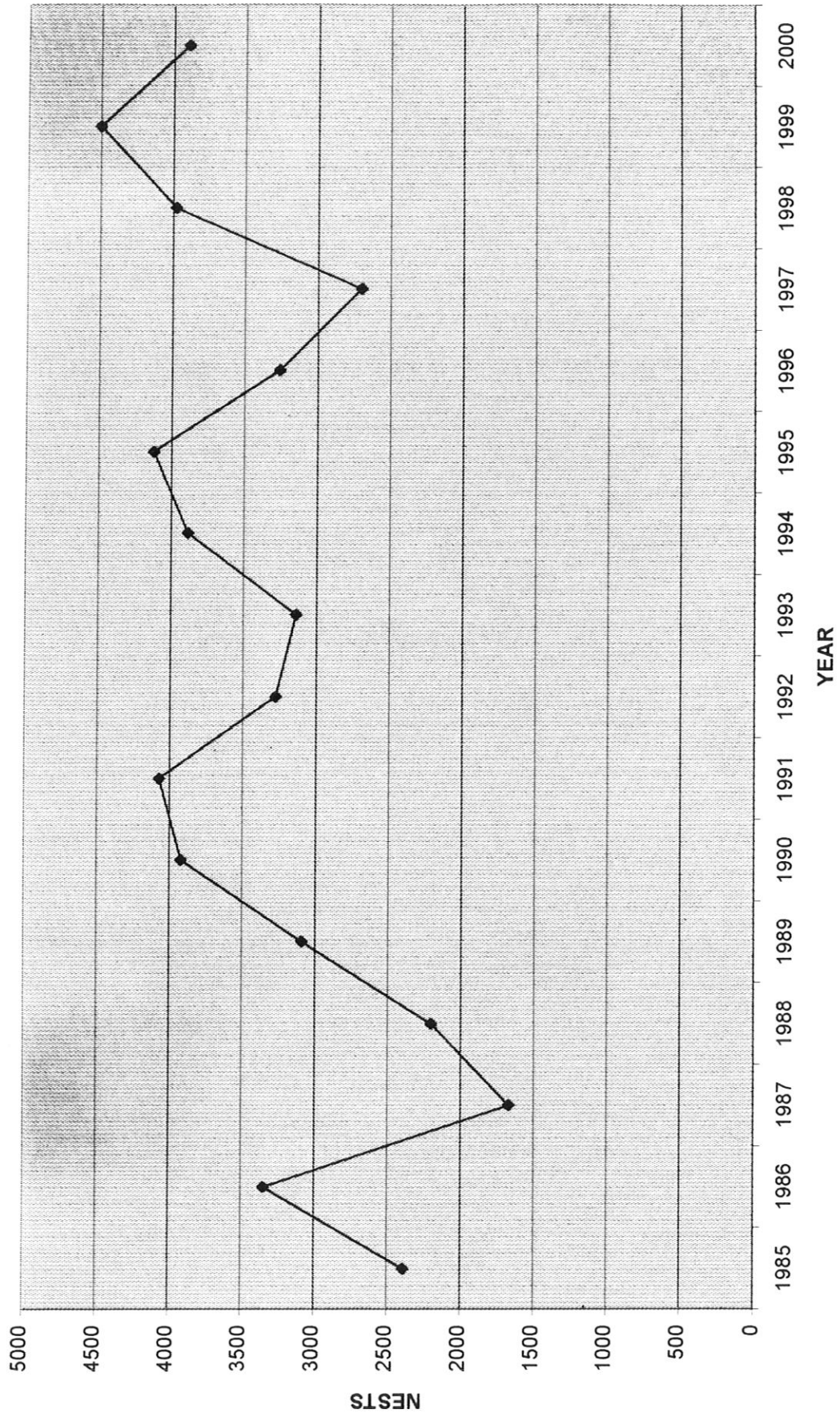


Table 5. False Crawl to Nest Ratio, 1984-2000. Canaveral National Seashore.

Year	Loggerhead	Green	Leatherback
2000	1:1.02	1:0.71	1:3.00
1999	1:1.20	1:0.63	1:3.00
1998	1:0.99	1:0.52	1:0.63
1997	1:1.19	1:0.72	0:4.00
1996	1:1.32	1:0.77	1:1.00
1995	1:1.36	1:1.21	0:1.00
1994	1:1.60	1:1.38	0:2.00
1993	1:1.46	1:1.87	--
1992	1:1.43	1:1.10	--
1991	1:1.10	1:1.66	0:1.00
1990	1:1.31	1:1.17	1:1.00
1989	1:1.53	1:3.00	--
1988	1:0.94	1:1.16	--
1987	1:1.02	1:0.72	0:1.00
1986	1:0.98	1:0.76	0:3.00
1985	1:1.22	1:1.02	--
1984	--	--	--

Taken from yearly Sea Turtle Nesting Summaries, 1984-2000, Canaveral National Seashore, Titusville, Florida.

Table 6. Amount of Screening and Depredation of Screened Nests, 1984-2000.
Canaveral National Seashore.

YEAR	NESTS	NESTS SCREENED	SCREENED NESTS DEPREDATED (%)	ESTIMATED OVERALL DEPREDATION (%)
2000	4563	4304 (94%)	7.2	23.0
1999	4515	4311 (95%)	8.2	22.2
1998	4408	4233 (96%)	7.2	19.3
1997	2727	2510 (92%)	9.6	29.9
1996	3485	3198 (92%)	5.7	19.7
1995	4169	3975 (95%)	4.8	14.8
1994	4252	1724 (41%)	4.3	18.7
1993	3168	1221 (39%)	7.6	28.6
1992	3579	2213 (62%)	4.3 *	11.6 *
1991	4100	1507 (37%)	3.3 *	13.9 *
1990	4108	1547 (38%)	1.9 *	9.2 *
1989	3132	1030 (33%)	3.4	17.5
1988	2250	887 (39%)	18.7	64.1
1987	1776	766 (43%)	7.2	58.7
1986	3374	1517 (45%)	3.7	47.3
1985	2508	1023 (41%)	5.0	41.7
1984	2125	213 (19%)	----	65.0

* Daytime runs to check secondary nest depredation were not conducted on a regular basis.

Hatching Success

The target level for hatching success was 60 percent, established in the U.S. Fish and Wildlife Service sea turtle recovery plans (NMFS and USFWS 1991). This was achieved for undepredated loggerhead nests, which yielded hatching rates of 65 percent (Table 3). The hatching rate for undepredated green nests was slightly under the 60 percent target at 57 percent. The success rate for partially depredated loggerhead nests was much lower, 37 percent for the 55 nests that were evaluated. However, most of the unhatched eggs were those destroyed by predators prior to discovery. Of the undamaged eggs remaining in the nests (after broken eggs were removed and the nest screened), 57 percent hatched. This indicates that the effort to clean up and screen partially depredated eggs can save a significant portion of the remaining eggs. Combining totals from partially depredated, totally depredated and undepredated nests lowered overall hatching success to 56 percent for both loggerhead and green turtles.

To ensure that all eggs in the marked nests were accounted for, daytime patrols were implemented at least three times a week to record any eggs lost to nest depredation. The average clutch size for partially depredated loggerhead nests was about seven eggs less (101.2 and 94.4) (Table 3). In 1999, the averages were within a single egg. This indicates that keeping a tally of depredated eggs throughout the season and adding them to the total clutch size when excavations are done is a fairly accurate indicator of actual clutch size.

Leatherback success was 38 percent, considerably below the other two species, based on excavation of eight nests (Table 3). Comparison with 1996 to 1999 observations, reveals equally low values in three of the last four years (Table 7). Loggerhead hatching success remained between 55 and 65 percent during that that period. Green hatching success observations were more variable, fluctuating between 51 and 71 percent.

Table 7. Comparison of Hatching Success With Previous Years, 1996-2000.
Canaveral National Seashore

	Loggerhead	Green	Leatherback
2000	61% (56%)	56% (N/A)	38% (N/A)
1999	62% (53%)	64% (55%)	29% (N/A)
1998	64% (62%)	71% (N/A)	56% (42%)
1997	55% (49%)	51% (N/A)	23% (N/A)
1996	59% (53%)	65% (N/A)	27% (N/A)

() Percentages in parentheses are adjusted hatching rates, adding in average clutch size for totally depredated nests.

Impact of High Tides

A strong northeaster caused large swells which impacted sea turtle nests remaining on the beach in mid-October. High tides from this weather system washed away nests and nest markers. At the time of the storm, about 700 of the 4563 nests were still unhatched. A thorough search of the beach after the tides subsided revealed approximately 100 nests that could be located. The northern half of the beach suffered more damage than the southern portion. Additional nests may have survived the high tides but could not be located since the markers were washed away.

ACKNOWLEDGEMENTS

Many people were instrumental in accomplishing the immense task of recording, screening and evaluating over 4,000 sea turtle nests along Canaveral National Seashore's 24 miles of beach. Don Mock provided training, maintained supplies and kept the aging fleet of ATV's running, no small task. The three seasonal employees, Bill Hackett, Kris Partington and Sean McKenna plugged along, night after night, often dealing with unexpected obstacles but always, through resourcefulness and grit, accomplishing the task. The four Student Conservation Association (SCA) resource assistants, Lee Anne Tome, Susannah Riedl, Beth Moeller and Megan Atkins, were a godsend, providing regular depredation patrols and handling the huge database. Their enthusiasm and energy buoyed us up through the long season. Jennifer Dennis, served as an unpaid intern, and produced this report, saving considerable time for the resource management staff. The park's maintenance, ranger and administrative divisions were most helpful with a myriad of operational details. And then there were the 60 volunteers who sacrificed sleep and comfort to brave the insects, humidity and storms, all at no pay, to help the cause of sea turtle preservation. They were a daily source of inspiration and reminded us nightly what the program was all about. Thanks to you all.

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