

TECHNICAL REPORT 99-

SEA TURTLE CONSERVATION  
PROGRAM  
BROWARD COUNTY, FLORIDA  
1999 REPORT

Submitted by:

**Curtis Burney**  
**Principal Investigator**  
**and**  
**William Margolis**  
**Project Manager**

**Nova Southeastern University**  
**Oceanographic Center**  
**8000 North Ocean Drive**  
**Dania, Florida 33004**

For the:

BROWARD COUNTY BOARD OF COUNTY COMMISSIONERS  
DEPARTMENT OF PLANNING AND ENVIRONMENTAL  
PROTECTION  
BIOLOGICAL RESOURCES DIVISION

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Lauderdale-By-The-Sea, Pompano Beach, Deerfield Beach,  
and the Town of Hillsboro Beach.

## INTRODUCTION

Since 1978, the Broward County Department of Planning and Environmental Protection (DPEP) has provided for the conservation of endangered and threatened sea turtle species within its area of responsibility. Broward County is within the normal nesting areas of three species of sea turtles: the loggerhead sea turtle (*Caretta caretta*), the green sea turtle (*Chelonia mydas*) and the leatherback sea turtle (*Dermochelys coriacea*). The loggerhead is listed as a threatened species, while the green and leatherback are listed as endangered under the U.S. Endangered Species Act, 1973, and Chapter 370, F.S.

Since these statutes strictly forbid any disturbance of sea turtles and their nests, conservation activities involving the relocation of nests from hazardous locations (especially necessary along heavily developed coasts) require permitting by the U.S. Fish and Wildlife Service (USFWS). In Florida, this permit is issued to the Florida Department of Environmental Protection (FDEP), which subsequently issues permits to individuals, universities and local government agencies. This project was administered by the DPEP and conducted by the Nova Southeastern University Oceanographic Center under Marine Turtle Permit #108, issued to the DPEP by the FDEP Institute of Marine Research, St. Petersburg, Florida. The DPEP is especially concerned with any environmental effects of intermittent beach nourishment projects on shorelines and the offshore reefs. As part of this concern, the DPEP has maintained the sea turtle conservation program in non-nourishment years to provide a continuous database.



Operation of the program is issued based on a review of submitted bids. Nova Southeastern University was awarded the contract to conduct the 1999 program.

In addition to fulfilling statutory requirements, the purposes of the project were:

- 1) to relocate eggs from nests deposited in sites threatened by natural processes or human activities and thus maximize hatchling recruitment,
- 2) to accurately survey sea turtle nesting patterns to document historical trends and assess natural and anthropogenic factors affecting nesting patterns and densities,
- 3) to assess the success of sea turtle recruitment and of hatchery operations in terms of nesting success, hatching success and total hatchlings released,
- 4) to dispose of turtle carcasses, respond to strandings and other emergencies and maintain a hot-line for reporting of turtle incidents, and
- 5) to inform and educate the public about sea turtles and their conservation.

## MATERIALS AND METHODS

### Beach Survey

Daily beach surveys commenced at sunrise or 6:00 AM (whichever came first), except at Fort Lauderdale where early beach cleaning required a slightly earlier start. For survey purposes the County was divided as follows:

BEACH	BEACH LENGTH (km)	BOUNDARIES	DEP SURVEY MARKER #
Hillsboro-Deerfield Beach	7.0	Palm Beach Co. line to Hillsboro Inlet	R1-24
Pompano Beach	7.7	Hillsboro Inlet to Commercial Blvd.	R25-50
Fort Lauderdale	10.6	Commercial Blvd. to Port Everglades Inlet	R51-84
John U. Lloyd Park	3.9	Port Everglades Inlet to Dania Beach fence	R86-97
Hollywood-Hallandale	9.4	Dania Beach fence to Miami Dade Co. line	R98-128

Daily surveys of Hillsboro-Deerfield, Pompano, Fort Lauderdale and Hollywood-Hallandale beaches commenced on March 1, 1998. Surveys continued through September 15th. There were no patrols on September 14 due to Hurricane Floyd. Only Pompano Beach and Fort Lauderdale beaches were patrolled on September 15. The beach at John U. Lloyd State Park was patrolled by park personnel who provided the data for that area. Except in Lloyd Park, nest locations were referenced to FDEP beach survey monuments numbered consecutively from 1 to 128 (N to S). Marker numbers corresponding to each beach area are listed above. Each nest location was initially recorded relative to the nearest building, street, or

other landmark. These locations were later cross-referenced to the nearest survey marker.

In John Lloyd Park, four 1-km zones (zone 1 farthest north) were used for recording nest locations, due to the relative lack of beach landmarks. This was also done to provide continuity with the data collected in Lloyd Park during previous years.

Surveyors used four-wheeled all-terrain vehicles that can carry up to five turtle nests per trip in plastic buckets. The usual method was to mark and record nests and false crawls on the first pass along the beach and then dig and transport nests in danger of negative impacts on the return pass. Due to early beach cleaning in Fort Lauderdale, two workers picked up the nests on the first pass. Nests were transferred, at prearranged meeting sites, to a third person who transported them to their destination by car. Nests were often transported to fenced beach hatcheries directly on the all-terrain vehicles. When there were many nests requiring relocation, additional trips were occasionally necessary. After recording all pertinent information the crawl marks were obliterated to avoid duplication.

Nests in danger of negative impacts were defined as follows:

- 1) a nest located within 20 feet of the previous evening wrack line,
- 2) a nest located near a highway or artificially lighted area defined as a beach area where a worker can see his shadow on a clear night,
- 3) a nest located in an area subject to beach nourishment.

Especially due to definition 2, all of the discovered nests at Pompano Beach, Deerfield Beach, Hollywood-Hallandale Beach, and Fort

Lauderdale beaches were considered to be in danger of negative impact and therefore were relocated to fenced beach hatcheries or to unfenced beach locations at Hillsboro Beach. As in previous years, the main relocation site was designated BH1, located at the Hillsboro Club near FDEP survey marker R23. In order to avoid concentrating all nests at one location, nests were also relocated to another site designated BH925 between survey markers R21 and R22. This site was adjacent to house number 925 on highway A1A. Nests in danger of negative impacts that were deposited on Hillsboro Beach were relocated to less hazardous nearby locations on that beach (BH), not necessarily to the hatchery areas listed above.

Nests to be relocated were carefully dug by hand, and transported in buckets containing sand from the natural nest chamber. The depths of the natural egg chambers were measured. The eggs were then transferred to hand-dug artificial egg chambers of similar dimensions, which were lined with sand from the natural nest. Care was taken to maintain the natural orientation of each egg.

Those nests not in danger on Hillsboro Beach were marked with stakes bearing yellow 5.5" X 8.8" sea turtle nest warning signs (see Appendix 3) and left *in situ*. After hatching, 152 of these nests at Hillsboro Beach were excavated for post emergence examination. An additional 97 nests from Pompano Beach, Fort Lauderdale and Hollywood-Hallandale Beach beaches were missed during the initial surveys but were discovered on the morning after hatching by observing hatchling tracks. The egg chambers of 34 of these nests were located and investigated for hatching success. Hatching success was defined as the total number of shells minus the number of hatchlings found dead in the nest (DIN), dead piped

eggs (DPIP), and eggs with visible (VD) or no visible development (NVD). The numbers of hatchlings found alive in the nest (LIN) and live piped eggs (LPIP) were also counted so that the percent of hatchlings naturally emerging from nests could be calculated. LIN and LPIP hatchlings were released and are included as hatchlings released.

### Restraining Hatcheries

As in previous years, early nests were transferred to one of three chain-link fenced hatcheries located in Pompano Beach near Atlantic Boulevard, at the South Beach municipal parking lot in Fort Lauderdale, or at North Beach Park in Hollywood. After hatching, all hatchery nests were dug, and counts of spent shells, live hatchlings, dead hatchlings, piped eggs and eggs with arrested or no visible development were made.

Hatchery nests displaying a depression over the egg chamber, indicating eminent hatchling emergence, were covered with a bottomless plastic bucket to retain hatchlings, although the turtles sometimes escaped these enclosures by digging around them. Hatching success was defined as the percentage of relocated eggs resulting in live released turtles, the same as for *in situ* nests. After hatching commenced, the hatcheries were checked at least twice each night, once between 9:00 PM and midnight and again just prior to 5:00 AM. Hatchlings were released that same night in dark sections of Fort Lauderdale, Hillsboro Beach, Hollywood or Lloyd Park beaches by allowing them to crawl through the intertidal zone into the surf. Hatchlings discovered in the morning in the hatcheries were collected and held indoors in dry plastic buckets in a cool, dark place until that night, when they were released as above.

The Pompano and Fort Lauderdale hatcheries were filled by mid May. After filling the hatcheries, Fort Lauderdale and Pompano nests were

relocated to Hillsboro Beach. The Fort Lauderdale hatchery was also used late in the season to receive 11 nests from Hollywood after that hatchery filled. All other nests relocated from Fort Lauderdale and Pompano were taken to Hillsboro Beach. Hatched nests in the hatcheries were completely dug out along with the surrounding sand and replaced with fresh sand. The sand from the old nests was spread outside the hatchery. Fresh sand was obtained from elsewhere on the beach. The Hollywood hatchery was operated throughout the season.

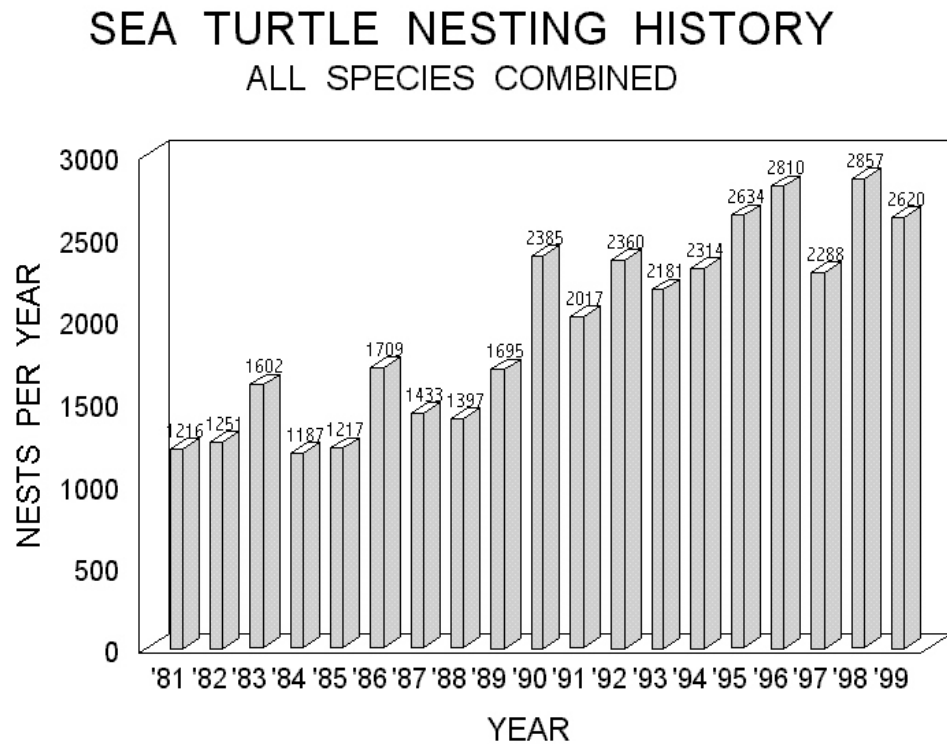
#### Data analysis

The data were compiled, analyzed and plotted primarily with Quattro Pro, version 8 (Corel Corp. Ltd.) and Statistica, release 5.1 (StatSoft, Inc.). The countywide yearly nesting densities from 1981 to 1999 for all three species were plotted and trends were assessed by linear regression and correlation analyses. Seasonal nesting patterns and nesting densities were calculated for each beach (nests per km) and the data (except for leatherbacks) were compared using 1-way analysis of variance (ANOVA) and Newman-Keuls (NK) tests at the .05 significance level. The total number of nests deposited by each species in the beach segments corresponding to each FDEP survey marker was tabulated and plotted. Total nesting success (nests/total crawls) for each species at each beach was computed and the mean daily nesting success of loggerheads and greens at each beach was compared by ANOVA and NK analyses. The total nesting success was also plotted versus its FDEP survey number. The numbers of eggs and live hatchlings of each species in relocated and evaluated *in situ* nests were recorded and the hatching successes were determined. The overall hatching success of all eggs from relocated and *in situ* nests were plotted from 1981 through 1999. The frequency

distribution of the hatching success of *in situ* and relocated loggerhead nests were plotted and compared with the Mann-Whitney U-test. The mean hatching percentages and proportions of the post-hatching egg categories (LIN, LPIP, DIN, DPIP, VD and NVD) were tabulated by species from nests deposited or relocated at each of the individual beaches or relocation sites. The Deerfield Beach/Hillsboro Beach nourishment project of 1998 was evaluated to determine the effect of the nourished sand on nesting and hatching success. Loggerhead nesting success was compared in the nourishment area R6-R12, and in the unnourished sections to the north (R1-R5) and south (R13-R24) of the nourishment project by ANOVA and NK tests. The hatching success of 46 *in situ* loggerhead nests on the nourished beach were compared to 103 *in situ* nests on the unnourished beach to the south of the nourishment project by ANOVA and the Mann-Whitney U-test.

## RESULTS

Figure 1 shows the historical trend in the total number of sea turtle nests deposited in Broward County since 1981. A total of 2620 nests were counted in 1999 which was 8.3 percent less than the previous record year, but still represented the fourth highest yearly total since project inception.



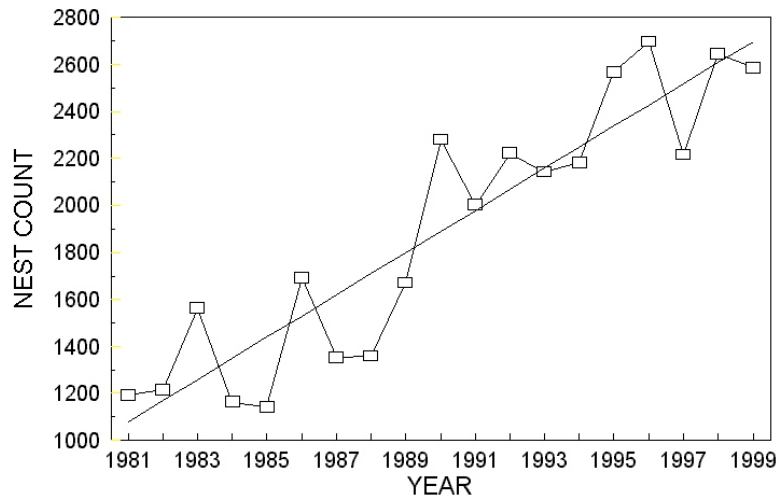
**Figure 1:** The pattern of total sea turtle nesting in Broward County since full surveys commenced in 1981.

Figure 2 shows the yearly nesting trends of loggerhead, green and leatherback sea turtles. The loggerhead nest count declined only 2.2 percent from last year and was the third highest since project inception. The correlation coefficient of the trend line increased from 0.909 in 1998 to 0.916 this year. The slope of the trend line remains at about 90 nests per year.

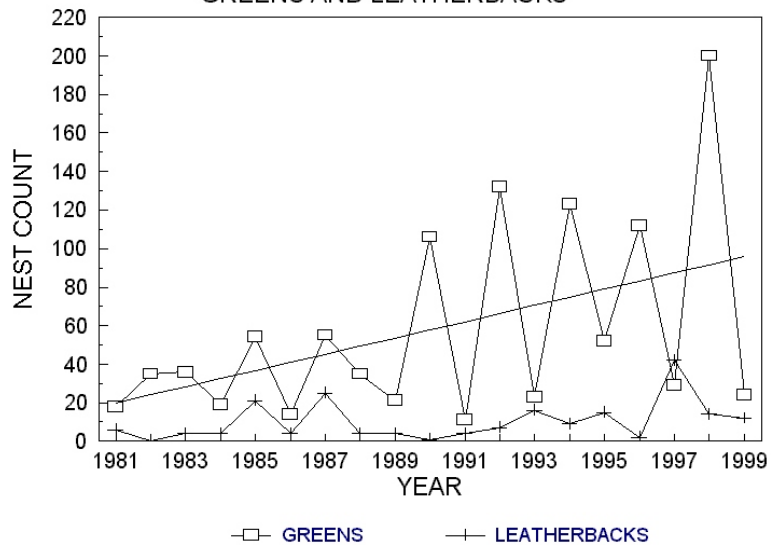


### BROWARD LOGGERHEAD NESTS

$r = .916$   $P < .0001$



### BROWARD NESTS GREENS AND LEATHERBACKS



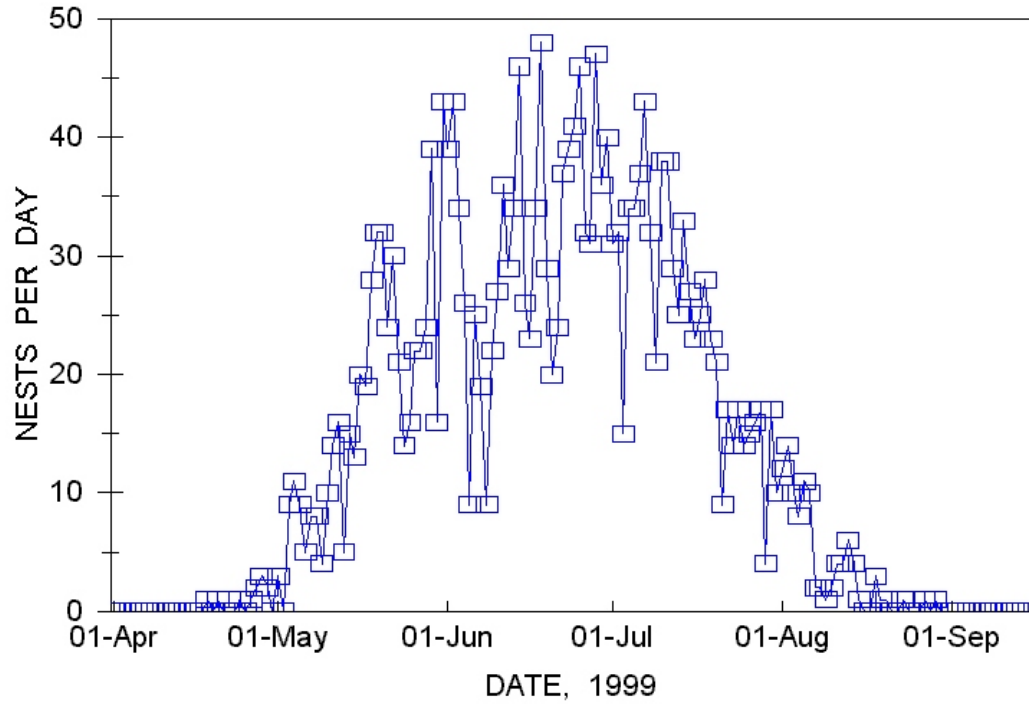
**Figure 2:** Historical nesting patterns of loggerhead, green and leatherback sea turtles in Broward County since 1981.

Nesting by the green sea turtle declined dramatically from the record level in 1998, continuing the alternating high-low pattern of the last 10 years (Fig. 2). The slope of the 19-year trend line for green turtle nesting remains significantly greater than zero ( $r = 0.456$ ;  $P = .025$ ). Leatherbacks continued to nest in Broward County. This year's count (12) was slightly above the previous 18-year average of 10.1. No significant long-term nesting trend for leatherbacks was evident.

Figure 3 shows the seasonal loggerhead nesting pattern. The first nest was deposited on 18 April and the last was found on 29 August. Table 1 and Figure 4 give the total loggerhead nesting densities and seasonal patterns for the five beaches. Nesting densities (mean daily nests/km) at Hillsboro Beach and Pompano Beach were not statistically distinguishable, but they were significantly greater than the nesting density at Fort Lauderdale, which declined 19 percent from last year (Burney and Margolis, 1998). Hollywood beach again showed the lowest nesting densities in the county, but there was a 48 percent increase from 1998. The data received from Lloyd Park was not in a form suitable for statistical comparison.

The countywide seasonal nesting patterns of greens and leatherbacks are shown in Figure 5 and for the individual beaches in Figure 6. The first and last leatherback nests were deposited on 11 March and 26 May, respectively. Green turtles nested between 24 May and 3 September. Nesting counts and densities for greens and leatherbacks are shown in Table 2 and Table 3, respectively. Nesting by greens and leatherbacks was highest on Hillsboro Beach, but nest counts for both species were too low for reliable between-beach statistical comparisons.

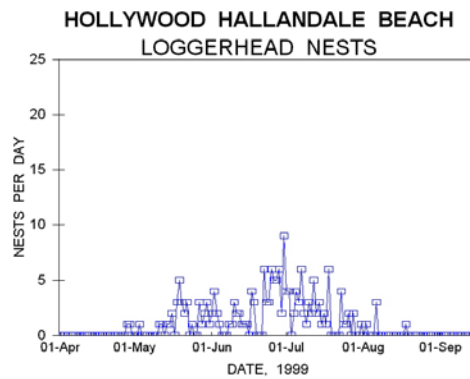
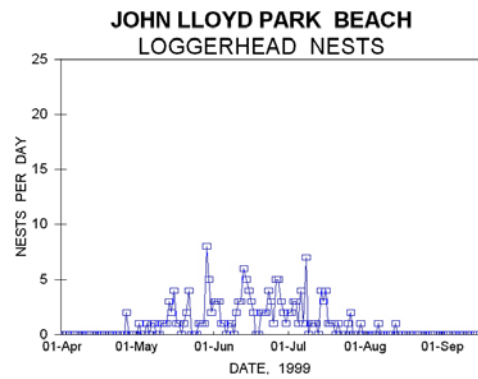
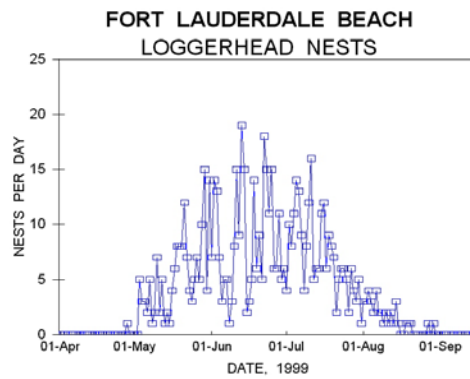
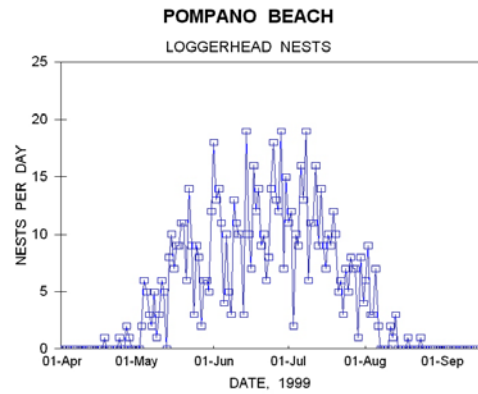
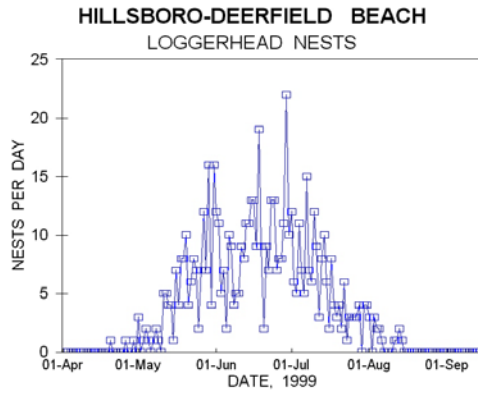
### LOGGERHEAD NESTS



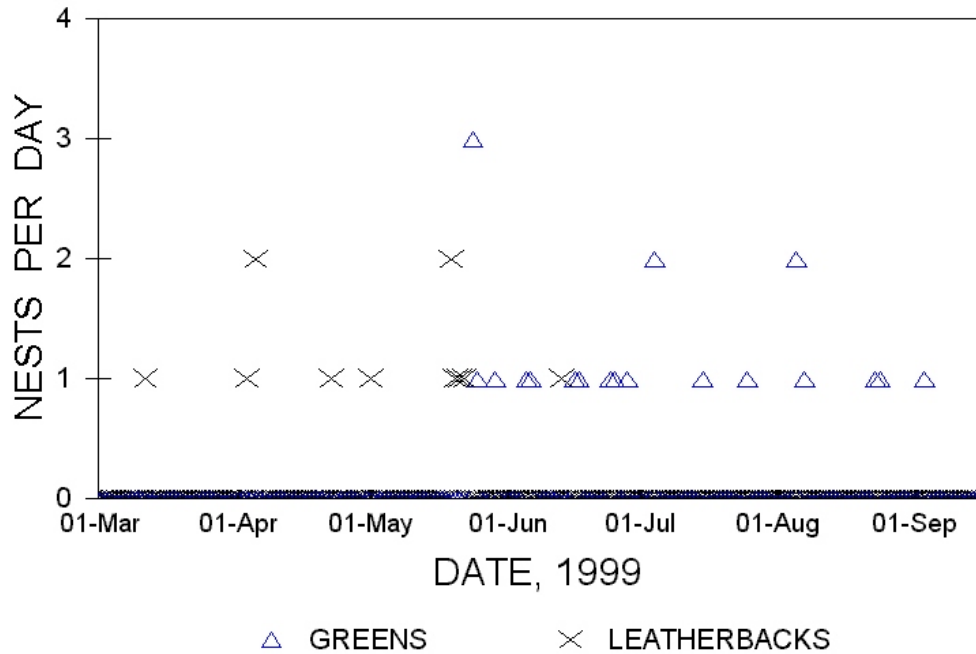
**Figure 3:** The seasonal pattern of daily loggerhead nesting in Broward County, 1999.

**Table 1:** Total loggerhead nests and nesting densities expressed as nests-per-kilometer for the 1999 season. Vertical lines at the right overlap groups where means were not distinguishable in a Newman-Keuls test (alpha = .05) of mean daily nesting per km.

BEACH	TOTAL NESTS	BEACH LENGTH (km)	Nests per km	MEAN DAILY NESTS/km
Lloyd Park	210	3.9	53.8	-
Hollywood	178	9.4	18.9	.075
Ft. Lauderdale	696	10.6	65.7	.384
Hillsboro Beach	639	7.0	91.3	.538
Pompano Beach	861	7.7	111.8	.647
OVERALL	2584	38.6	66.9	



**Figure 4:** Comparison of the daily loggerhead nesting patterns on the five Broward County beaches in 1999.



**Figure 5:** The seasonal pattern of daily green and leatherback nesting in Broward County, 1999.

Figure 7 shows the distribution of all three species nesting in each 1000-foot zone of Broward County beach (1-km zones in Lloyd Park) during 1999. The low nesting zones, including the areas near the Deerfield Beach and Commercial Boulevard piers, the Hillsboro Inlet, the Fort Lauderdale strip and all of Hollywood and Hallandale, have remained recognizable as low nesting sites since project inception.

Figure 8 and Table 4 present the countywide distribution of nesting success for the three species. Loggerhead nesting success showed no recognizable countywide trends. It was highest in Lloyd Park and lowest in Hollywood, but there was considerable statistical overlap, with statistically equivalent nesting success at Fort Lauderdale, Pompano

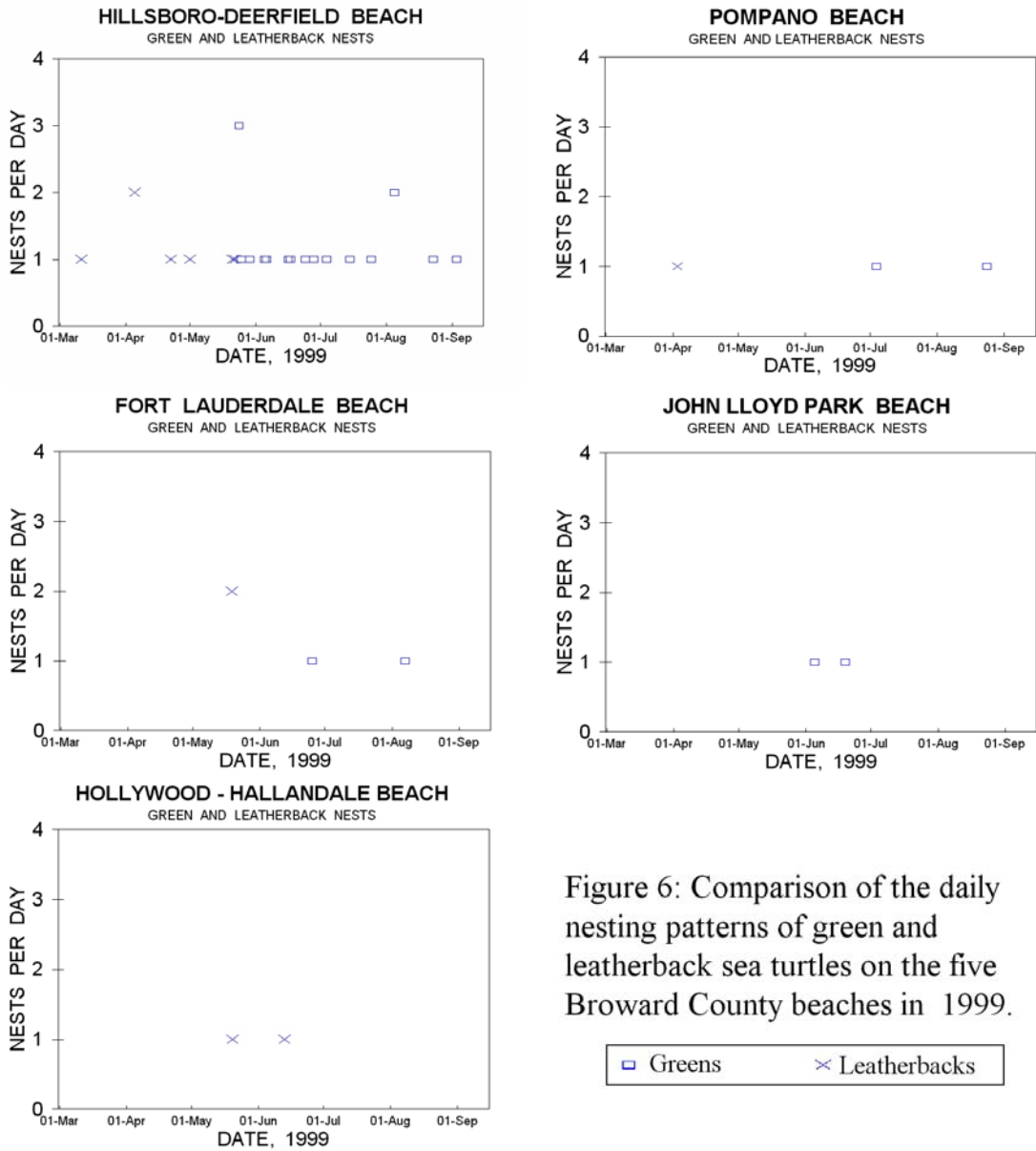


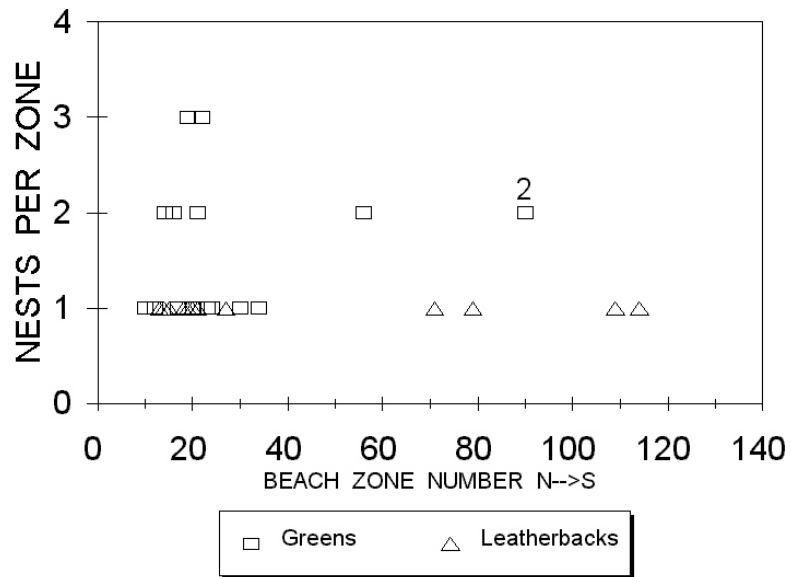
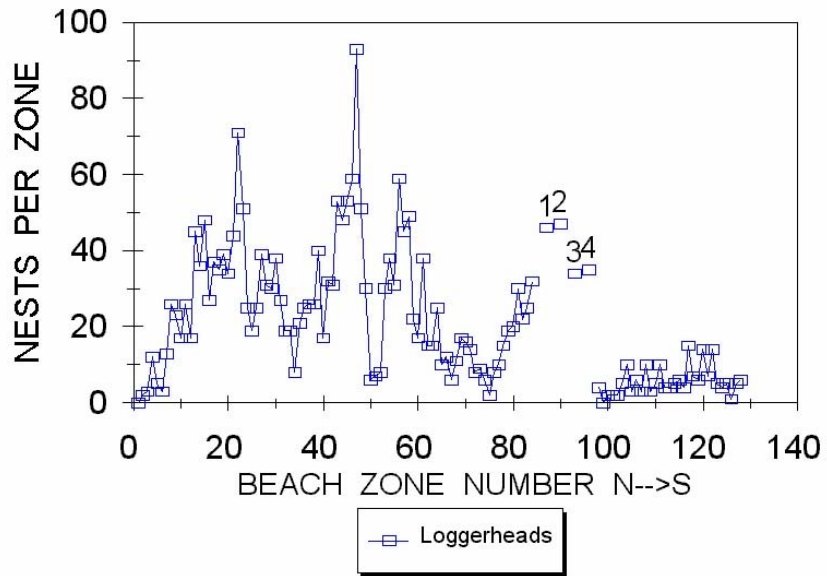
Figure 6: Comparison of the daily nesting patterns of green and leatherback sea turtles on the five Broward County beaches in 1999.

**Table 2:** Total green turtle nests and nesting densities expressed as nests-per-kilometer for the 1999 season.

BEACH	TOTAL NESTS	BEACH LENGTH (km)	Nests per km
Hollywood	0	9.4	0
Ft. Lauderdale	2	10.6	0.18
Pompano Beach	2	7.7	0.26
Lloyd Park	2	3.9	0.51
Hillsboro Beach	18	7.0	2.57
OVERALL	24	38.6	0.62

**Table 3:** Total leatherback nests and nesting densities expressed as nests-per-kilometer for the 1999 season.

BEACH	TOTAL NESTS	BEACH LENGTH (km)	Nests per km
Hollywood	2	9.4	0.21
Lloyd Park	0	3.9	0
Ft. Lauderdale	2	10.6	0.19
Pompano Beach	1	7.7	0.13
Hillsboro Beach	7	7.0	1.00
OVERALL	12	38.6	0.31



**Figure 7:** Locations of loggerhead, green and leatherback nests in Broward County, 1999. Numbers 1-4 indicate the four beach zones of John Lloyd Park.



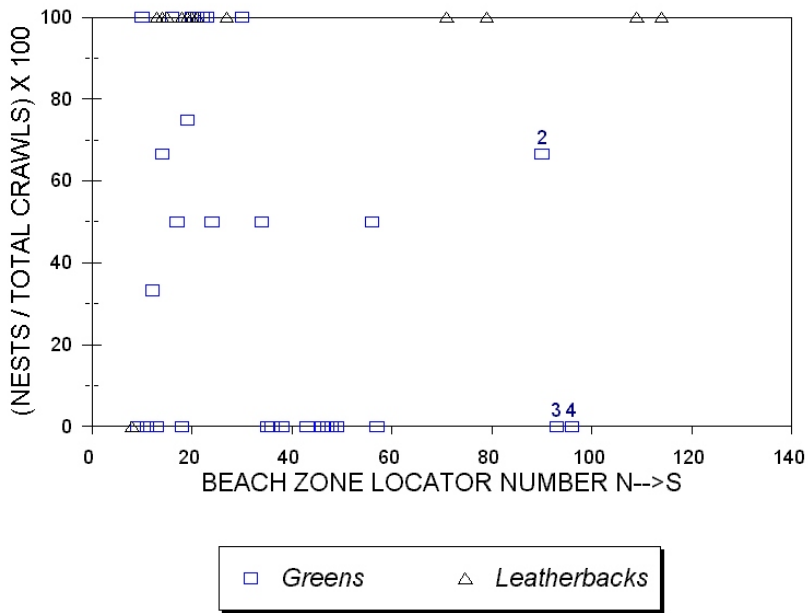
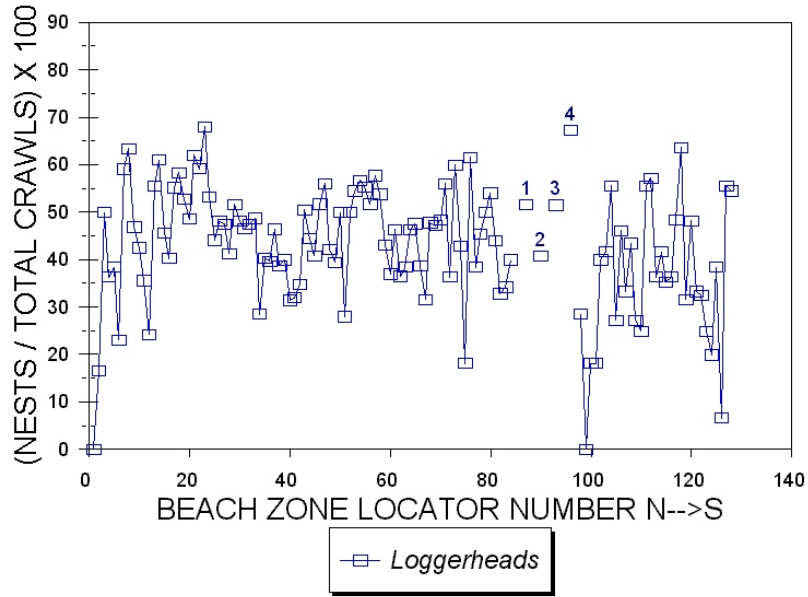
Beach and Hillsboro Beach. The nesting success of greens and leatherbacks were highest at Hillsboro Beach but the number of crawls of these species were too low to detect statistical differences between beaches.

Table 5 gives the number of nests for each species that were relocated to Hillsboro Beach or to fenced hatcheries, as well as the numbers of nests left *in situ*. Table 6 lists the number of eggs and emerged hatchlings from evaluated *in situ* and relocated nests. The numbers of predated nests and nests that were unevaluated due to stake removal or washout are also listed.

The hatching success rates of relocated and *in situ* loggerhead nests (Table 6) increased dramatically from the unusually hot, dry summer of 1998, by 10.4 and 19.9 percentage points, respectively. Too few green and leatherback nests were evaluated this year to discuss hatching success trends. The hatching success of relocated loggerhead nests was 8.6 percent lower than for *in situ* nests.

Figure 9 illustrates the seasonal patterns of the hatching success of *in situ* and relocated loggerhead nests. Hatching success in both groups showed very significant seasonal declines but the regression slopes were not significantly different. This comparison was not made this year for green or leatherback hatching success because of the small number of evaluated nests.

Figure 10 shows the frequency distributions of hatching success in relocated and *in situ* nests. *In situ* nests had lower frequencies of intermediate-hatching nests (25-60 percent) and higher frequencies of higher-hatching nests (>80percent). A Mann Whitney U test showed a small, but significant difference in the medians of these distributions.



**Figure 8:** The distribution of the nesting success of loggerhead, green and leatherback turtles across Broward County, 1999. Numbers 1-4 indicate the four beach zones of John Lloyd Park.

**Table 4:** Total nests, false crawls (FC) and percent nesting success (NS) for three sea turtle species on each of five Broward County beaches during 1999. Vertical lines overlap means that were not distinguishable in a Newman-Keuls (NK) test.

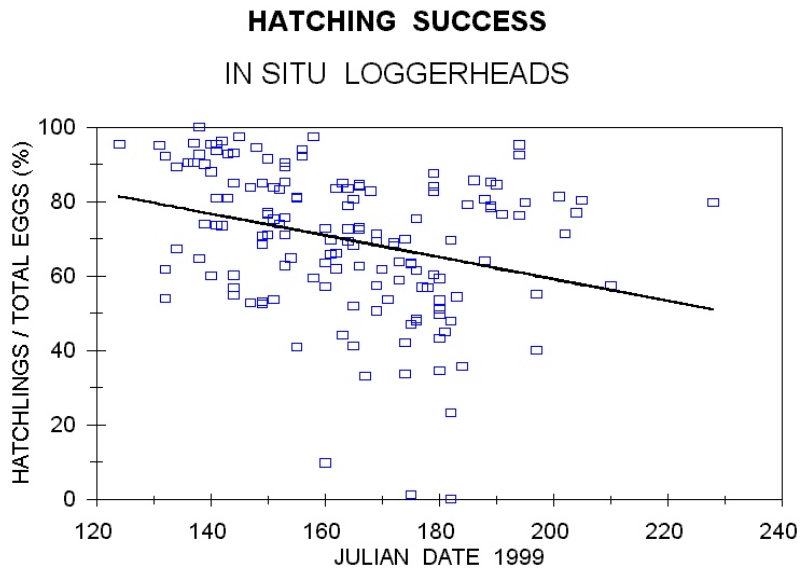
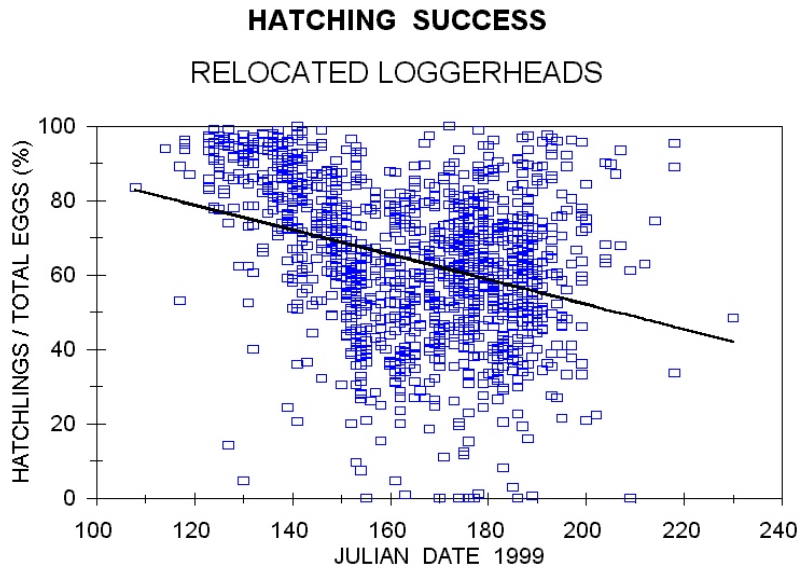
BEACH	Loggerheads				Greens				Leatherbacks		
	Nests	FC	NS	NK	Nests	FC	NS	NK	Nests	FC	NS
Hollywood	178	306	36.8		0	0	40.0		2	0	100
Pompano Beach	861	1097	44.0		2	14	12.5		1	0	100
Ft. Lauderdale	696	815	46.1		2	5	28.6		2	0	100
Hillsboro Beach	639	636	50.1		18	10	64.3		7	1	87.5
Lloyd Park	210	160	56.8		2	3	40.0		0	0	-
OVERALL	2584	3014	46.2		24	32	42.9		12	1	92.3

**Table 5:** Total Number of loggerheads, greens leatherback nests relocated to Hillsboro beach or fenced hatcheries, or left *in situ*. Not including Lloyd Park.

	Loggerheads	Greens	Leatherbacks	Totals
<b>RELOCATED</b>				
<u>Open Beach</u>				
Hillsboro Beach				
BH	77	1	0	78
BH1	674	1	2	677
BH925	708	1	0	709
Poached	7	0	0	7
<u>Hatcheries</u>				
Pompano	56	0	1	57
Ft. Lauderdale	38	0	0	38
Hollywood	153	0	1	154
Discovery Center	1	0	0	1
TOTALS	1714	3	4	1721
<b>IN SITU</b>				
Hillsboro Beach	563	17	7	587
Pompano Beach	48	0	0	48
Ft. Lauderdale	37	2	0	39
Hollywood	12	0	1	13
TOTALS	660	19	8	687
GRAND TOTALS	2374	22	12	2408

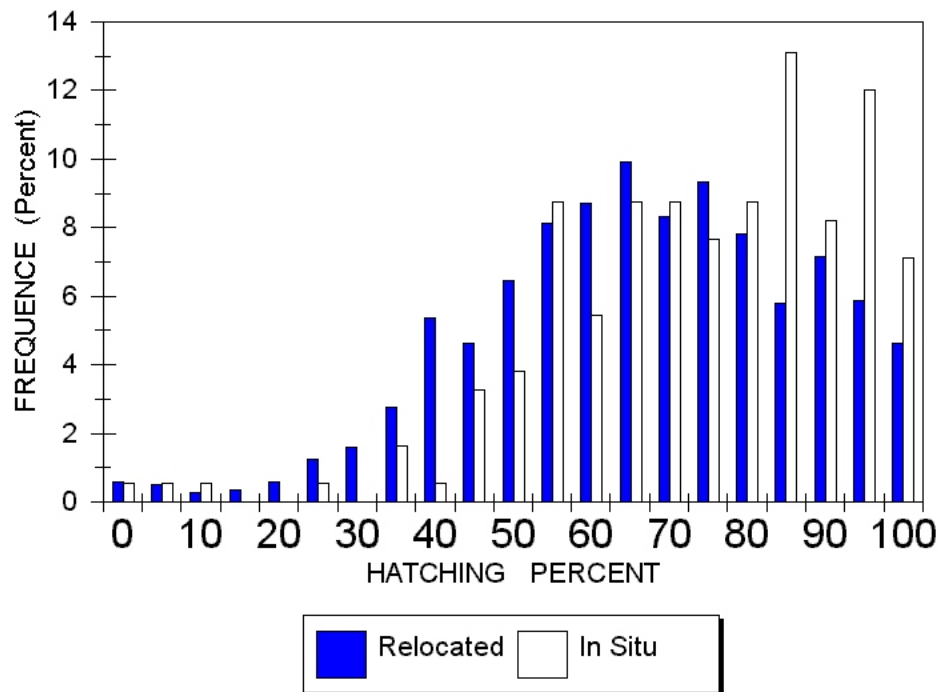
**Table 6:** Total egg counts, released hatchlings and overall hatching successes for *in situ* and relocated nests of loggerheads, greens and leatherbacks in 1999.

SPECIES	NUMBER OF EGGS	EVAL. NESTS	HATCHLINGS RELEASED	HATCHING SUCCESS (%)
<b><i>In situ</i> Nests</b>				
<i>C. caretta</i>	20089	183	14423	71.8
<i>C. mydas</i>	117	1	92	78.6
<i>D. coriacea</i>	186	2	144	77.4
Total	20392	186	14659	71.9
<b>Relocated Nests</b>				
<i>C. caretta</i>	131268	1191	83007	63.2
<i>C. mydas</i>	155	1	70	45.2
<i>D. coriacea</i>	255	3	117	45.9
Total	131678	1195	83194	63.2
<b>Overall</b>				
<i>C. caretta</i>	151357	1374	97430	64.4
<i>C. mydas</i>	272	2	162	59.6
<i>D. coriacea</i>	441	5	261	59.2
TOTAL	152070	1381	97853	64.3
<b>Predated and Unevaluated Nests and Eggs</b>				
	Predated Nests	Pred. Eggs	Unevaluated Nests	Unevaluated Eggs
<b><i>In Situ</i> Nests</b>				
<i>C. caretta</i>	27	-	58	-
<i>C. mydas</i>	0	-	2	-
<i>D. coriacea</i>	0	-	1	-
<b>Relocated</b>				
<i>C. caretta</i>	74	8838	443	46100
<i>C. mydas</i>	0	0	2	226
<i>D. coriacea</i>	0	0	0	0



**Figure 9:** Comparison of seasonal hatching success trends for relocated and *in situ* loggerhead nests during 1999.

## HATCHING SUCCESS DISTRIBUTIONS



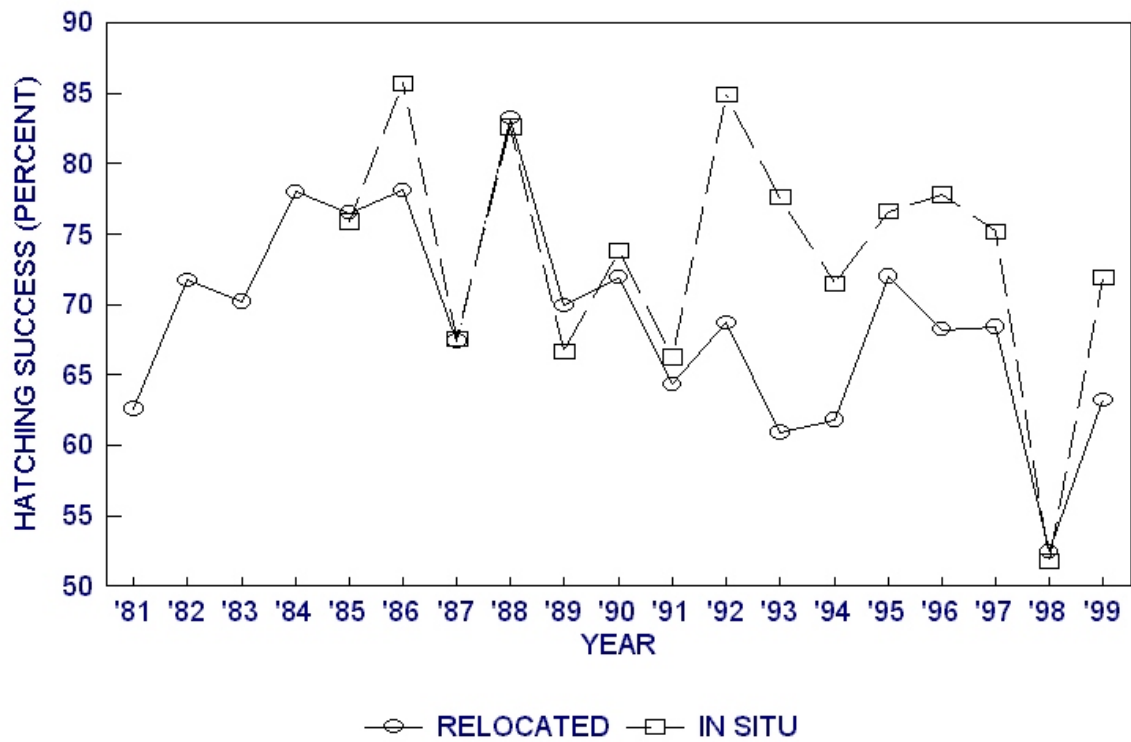
**Figure 10:** Hatching success frequencies for *in situ* and relocated loggerhead nests in 1999.

Figure 11 shows the historical patterns of the yearly hatching success of all species combined, since 1981. Overall hatching success in both relocated and *in situ* nests rebounded sharply from 1998 to levels very near the previous 10-year means of 65.9 percent for relocated and 72.2 percent for *in situ* nests, respectively.

Table 7 compares emergence success and the percentages of hatchlings and eggs in the post-hatching evaluation categories for relocated and *in situ* loggerhead nests. Tables 8 and 9 give the same results for greens and leatherbacks, respectively.

# HATCHING SUCCESS

## HISTORICAL PATTERN



**Figure 11:** The historical patterns of yearly hatching success for all evaluated *in situ* and relocated sea turtle nests, since 1981.

**Table 7:** Accounting of the status of all hatched and unhatched eggs in investigated *in situ* and relocated loggerhead nests during 1999.

Location	Total Eggs	Emerged Hatchlings (%)	LIN (%)	DIN (%)	PIP Live (%)	PIP Dead (%)	VD (%)	NVD (%)
<b><i>In situ</i> Nests</b>								
Hillsboro Beach	16142	66.9	2.4	3.1	0.3	10.0	10.7	6.7
Pompano Beach	2514	76.5	4.4	2.1	0.3	3.2	2.7	10.7
Ft. Lauderdale	1433	72.9	7.5	5.6	0.3	7.1	4.4	2.2
<b>Relocated Nests</b>								
Hillsboro Beach								
BH	371	59.6	4.3	0.5	0.0	16.4	1.1	18.1
BH1	49523	44.7	15.4	3.2	2.7	19.7	6.0	8.3
BH925	54221	37.1	15.6	1.9	2.8	18.8	11.6	12.1
Pompano Beach								
Ft. Lauderdale	6554	70.0	13.3	0.9	1.7	3.1	3.3	7.8
Discovery Center	4331	72.3	10.3	0.2	2.2	1.2	3.0	10.8
Hollywood	114	97.4	0.0	0.0	0.0	0.0	0.0	2.6
	16154	62.2	12.2	1.7	1.3	8.5	4.3	9.8

**Hatched Eggs** - The percentage of empty shells minus DIN and LIN

**DIN** - Hatchlings found dead in the nest when it was excavated

**LIN** - Hatchlings found alive in the nest when it was excavated

**PIP-Live** - Live hatchlings that partially emerged from their eggs.

**PIP-Dead** - Dead hatchlings that partially emerged from their eggs.

**VD** - Unhatched eggs with signs of visible embryo development when opened

**NVD** - Unhatched eggs with no signs of embryo development



**Table 8:** Accounting of the status of all hatched and unhatched eggs in investigated *in situ* and relocated green sea turtle nests during 1999. Abbreviations as in Table 7.

Location	Total Eggs	Emerged Hatchlings (%)	LIN (%)	DIN (%)	PIP Live (%)	PIP Dead (%)	VD (%)	NVD (%)
<b><i>In situ</i> Nests</b>								
Hillsboro Beach	117	75.2	3.4	0.0	0.0	11.1	0.9	9.4
<b>Relocated Nests</b>								
Hillsboro Beach BH925	155	32.3	10.3	2.6	2.6	15.5	15.5	21.3

**Table 9:** Accounting of the status of all hatched and unhatched eggs in investigated *in situ* and relocated leatherback nests during 1999. Abbreviations as in Table 7.

Location	Total Eggs	Emerged Hatchlings (%)	LIN (%)	DIN (%)	PIP Live (%)	PIP Dead (%)	VD (%)	NVD (%)
<b><i>In Situ</i> Nests</b>								
Hillsboro Beach	186	74.2	3.2	0.5	0.0	5.9	7.5	8.6
<b>Relocated Nests</b>								
Hillsboro Beach BH1	100	25.0	0.0	10.0	0.0	25.0	33.0	7.0
Pompano	81	53.1	7.4	1.2	0.0	11.1	12.3	14.8
Hollywood	74	48.6	9.5	1.4	0.0	0.0	1.4	39.2

Table 10 gives mean the loggerhead nesting success rates on the nourished beach, and on the beaches north and south of the nourishment area. Mean nesting success in the nourishment area in 1999 showed a statistically significant (NK test;  $P < .05$ ) 78 percent increase from 1998 but was still significantly less than the pre-erosion year 1991. Table 11 shows the same data as in Table 10, but with the comparison between zones instead of between years. In 1998, the NK test showed no significant difference in mean nesting success between the nourishment area (R-6 to R-12) and the traditionally lesser-nested region to the north (R-1 to R-5). In 1999, nesting success in the nourishment area, R-6 to R-12, was significantly greater than in R-1 to R-5 area, but not significantly different from R-13 to R-24, which has historically shown higher nesting success

**Table 10:** Mean loggerhead nesting success on the nourished beach compared to the unnourished beaches north and south of the nourishment area between years. Vertical lines overlap means which were not statistically different in an NK test.

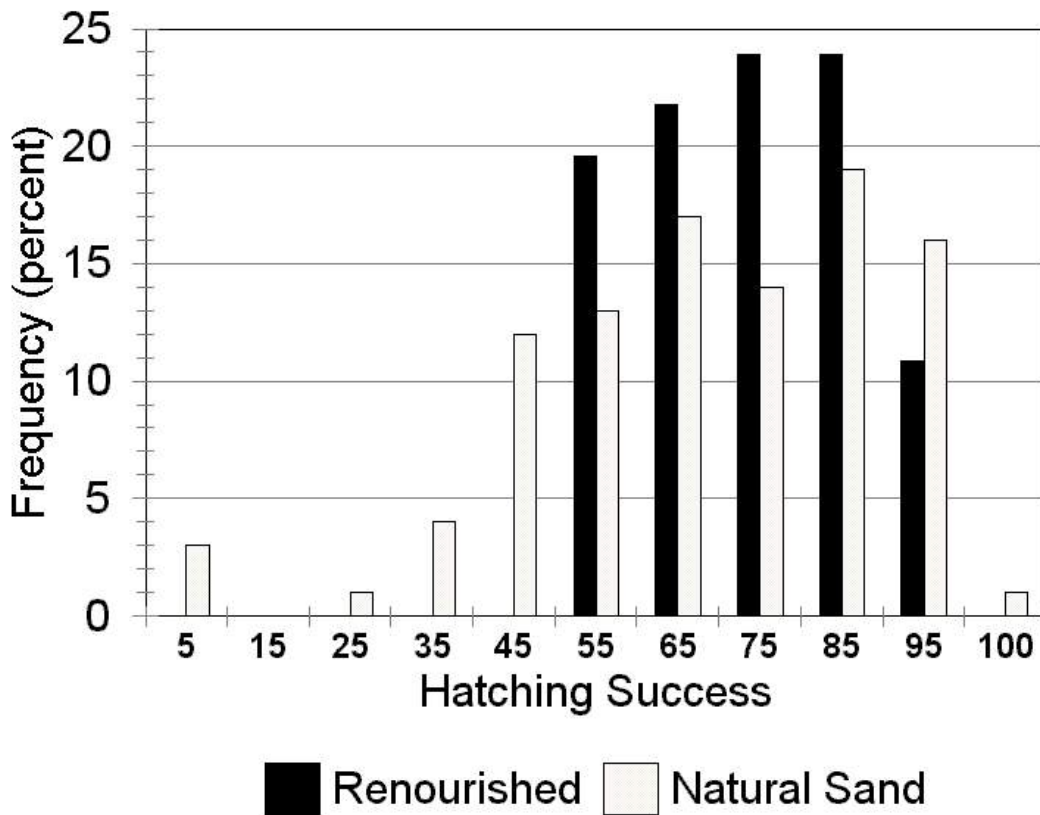
Year	R-1 to R-5	R-6 to R-12	R-13 to R-24
1999	28.3	42.1	55.0
1998	26.5	23.6	45.4
1991	62.7	61.0	64.3

**Table 11:** Mean loggerhead nesting success compared between zones to the unnourished beaches to the north and south of the nourishment area. Vertical lines overlap means which were not statistically different in an NK test.

Zones	1991	1998	1999
R-1 to R-5	62.7	26.5	28.3
R-6 to R-12	61.0	23.6	42.1
R-13 to R-24	64.3	45.4	55.0

than R1-R5.

Figure 12 shows the frequency distribution of the hatching success of nests hatched in the nourished and unnourished areas of Hillsboro Beach. Mean hatching success on the nourished and unnourished beaches were 72.9 and 67.7 percent, respectively. A one-way ANOVA indicated no significant difference between means ( $P = 0.13$ ), and a Mann-Whitney U-test indicated no statistically significant differences between the medians of these distributions ( $P = 0.35$ ).



**Figure 12:** Frequency distributions of hatching success rates for *in situ* loggerhead nests incubated on the nourished and unnourished (natural) portions of Hillsboro Beach, 1999.

## DISCUSSION

This year's total nest count was the fourth highest since project inception (Fig. 1). While overall nesting remained higher than the average of the previous ten years (2354), there has been no significant increasing trend for the last three or four years. Such a trend was observed (with some fluctuations) from 1988 through 1996, but since then nesting seems to have leveled off. Loggerhead nesting shows a similar pattern (Fig. 2), although the nest count was the third highest on record and the correlation coefficient of the trend line increased from .909 in 1998 to .916 in 1999. Fluctuations in the total nest count are partially due to the large variations in the nesting of the green sea turtle (Figure 2), which has nested more frequently in the last five even numbered years. If loggerhead nesting remains strong and greens return in large numbers, total nesting could increase dramatically in 2000.

An increased number of nests can result from an increase in the number of females nesting in a given year, or to an increased number of clutches per female, and does not necessarily indicate an increase in population size (Frazer and Richardson 1985). However, the lack of large fluctuations in loggerhead nesting in the last five years continues to suggest that at least some of the increased nesting in the last decade has been due to an increase in the size of the nesting population. Leatherback nesting (Fig. 2) remained above the previous 18-year average of 10.1, but well below the 42 nest maximum in 1997. No trend is evident.

The seasonal pattern of loggerhead nesting in Broward County (Figs. 3) again conformed to historical expectations, showing a relatively symmetrical bell-shaped trend with the first nest in mid April and the

midpoint of the season in late June. Seasonal nesting at the individual beaches (Fig. 4) also showed no obvious deviations from historical norms.

Loggerhead nesting densities were again highest at Pompano Beach and Hillsboro Beach where mean daily nests/km were statistically equivalent (Table 1). Compared to 1998, nesting densities increased by 26.2 percent in Pompano Beach and 48.3 percent in Hollywood but declined by 17.2, 19.4 and 11.7 percent in Lloyd Park, Fort Lauderdale and Hillsboro Beach, respectively (Burney and Margolis, 1998). These appear to be normal interseasonal fluctuations, with the possible exception of Hollywood nesting which was unusually high.

Seasonal nesting pattern of green turtle nesting (Fig. 5) were typical of previous low nesting years with nesting beginning in late May and ending in early September. The maximum number of green nests per day was three. Leatherbacks again nested earlier in the season beginning in early March and ending in late May.

As in previous years, green turtles nested most heavily at Hillsboro Beach but their usual preference for Lloyd Park was not observed this year (Table 2). Leatherbacks nested on all beaches except Lloyd Park. Like greens, leatherbacks nested most densely at Hillsboro Beach (Table 3), possibly because of the lower levels of beachfront lighting and other nocturnal disturbance (Table 3, Figs. 6-7).

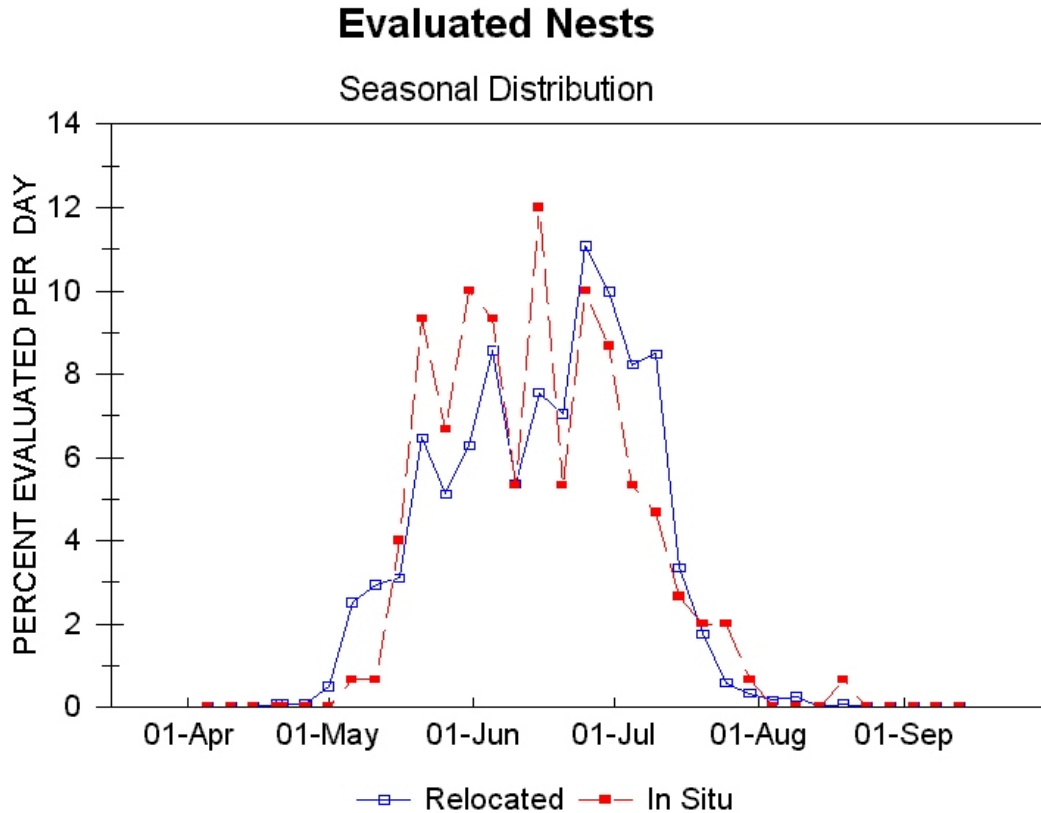
The distribution of loggerhead nests in the 128 survey zones (Figure 7) continues to highlight shoreline features identifiable since 1981. As in past surveys, beaches near piers, inlets, the Fort Lauderdale strip and throughout Dania, Hollywood and Hallandale remained lightly nested. This pattern has been discussed previously (Burney and Mattison, 1992; Mattison et al., 1993).

Loggerhead nesting success (Figure 8, Table 4) increased from 39.4 percent in 1998 to 42.6 percent in 1999. Nesting success was highest at Lloyd Park and lowest in Hollywood, but there was considerable statistical overlap between all the beaches, with statistically equivalent nesting successes at Pompano Beach, Fort Lauderdale and Hillsboro Beach. Last year's decreased nesting success could have been related to the unusually hot and dry summer of 1998 (Burney and Margolis, 1998) with the return to more seasonal conditions in 1999 contributing to this year's increase. The continuing lack of a relationship between loggerhead nesting success (Fig. 8) and nesting density (Fig. 7) indicates that nest site selection is not determined primarily by factors influencing nesting success, but is determined before the female begins her crawl.

Nesting success increased significantly from its 1998 level on the beach between R6 and R12 which underwent nourishment just prior to the 1998 nesting season (Table 10), but it was still significantly below its 1991 level before significant erosion occurred. In 1998, nesting success on the recently nourished section was low and statistically similar to the unnourished section of Deerfield Beach (R1 to R5) which has seen low nesting densities and nesting success in recent years. In 1999, nesting success on the nourished section was significantly greater than in the unnourished Deerfield Beach section and was statistically indistinguishable from the unnourished section of Hillsboro Beach (R13 to R24), which is much better nesting habitat (Table 11). It appears that the suitability of the nourished beach as loggerhead nesting habitat has improved in the year since the nourishment project.

Green turtle nesting success was statistically similar throughout the County due to the low number of crawls (Table 4). The overall nesting success of greens was virtually identical in 1998 and 1999.

Hatching success also rebounded in 1999 to levels just above the previous 10-year averages (Fig. 11), possibly due to the more seasonable weather conditions. The 8.7 percent difference in overall hatching success in relocated and *in situ* nests may be caused by the relocation process, but seasonal factors may play a role as well (see below). Hatching success showed its usual seasonal declines in both relocated and *in situ* nests (Fig. 9). Later in the season, clutches apparently experience less suitable incubation conditions, possibly caused by increased temperature or from the increasing frequency of overwash later in the season due to higher tides and storms. These factors affected *in situ* and relocated nests similarly, because the slopes of the regression lines in Figure 9 were statistically equivalent ( $P = 0.307$ ). The hatching success distributions (Fig. 10) seem to show differences in *in situ* and relocated nests. There was no difference in the frequencies of low-hatching rates (<20 percent) in relocated or *in situ* nests, however a greater proportion of relocated nests hatched in the middle range (approximately 30 to 60 percent) and higher frequencies of *in situ* nest hatched with rates of 80 percent or above. This apparent reduction in the hatching success of relocated nests may be caused in part by seasonal effects. Figure 13 gives the seasonal distribution of evaluated *in situ* and relocated loggerhead nests summed over five day intervals for clarity. It shows that a higher proportion of *in situ* nests were evaluated early in the season and that more relocated nests were evaluated later. Since earlier nests generally hatch with greater



**Figure 13:** The seasonal distribution of evaluated relocated and *in situ* loggerhead nests in 1999, expressed as percentages of the total numbers evaluated.

success than later nests (Fig. 9), this seasonal disproportion (Fig. 13) could cause the effect described in Figure 10, and contribute to the disparity in the hatching success of *in situ* and relocated nests (Fig. 11; Table 6).

The post-hatching nest evaluation data (Tables 7-9) give the percentages of hatchlings which emerged from the nest without assistance. The percentages of live-in-nest (LIN) and live-PIP (LPIP) must be added to get the percentage of hatchlings released (hatching success) reported in Table 6. Values from the different areas must be compared with caution because some percentages are derived from very few nests and some locations such as the Fort Lauderdale and Pompano Beach



hatcheries were only used early in the season. The most obvious differences in the nest evaluation data are the higher proportions of LIN and dead-PIP (DPIP) in relocated than in *in situ* nests. Many *in situ* nests were evaluated a week or more after hatching when no LIN or LPIP would be expected. Hatchery-relocated nests were generally evaluated three days after hatching. The reason for the higher proportions of DPIP in relocated nests is unclear, especially in the absence of increased proportions of LPIP. Both of these differences may be related to the seasonal effects discussed above. Tables 8 and 9 were included to present the data and maintain continuity with earlier reports, but no meaningful comparisons can be made due to the small numbers of evaluated nests.

Hatching success of *in situ* loggerhead nests on the nourished section of Deerfield Beach and Hillsboro Beach did not differ significantly from the success of *in situ* nests in the unnourished section of Hillsboro Beach to the south of the nourishment project (Fig. 12). In fact, there were increased proportions of low-hatching nests on the unnourished beach, which were not present on the nourished sand. This may have been due to the lower profile of the unnourished beach that subjected nests to more frequent over wash and poorer egg chamber drainage than on the higher profile nourished beach.

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- Mattison, C., C.M. Burney and L. Fisher. 1993. Trends in the spatial distribution of sea turtle activity on an urban beach (1981-1992). Proceedings of the 13th Annual Symposium on Sea Turtle Biology and Conservation. Jekyll Island Georgia, 23-27 February, 1993. p 102-104.

**APPENDIX 1:** Summary of sea turtle hot-line calls.

SUBJECT	HOT-LINE
EMERGENCIES	
Strandings	18
Disorientations	32
NEST LOCATIONS	>50
POACHING	0
OTHER	>200
OVERALL	> 300

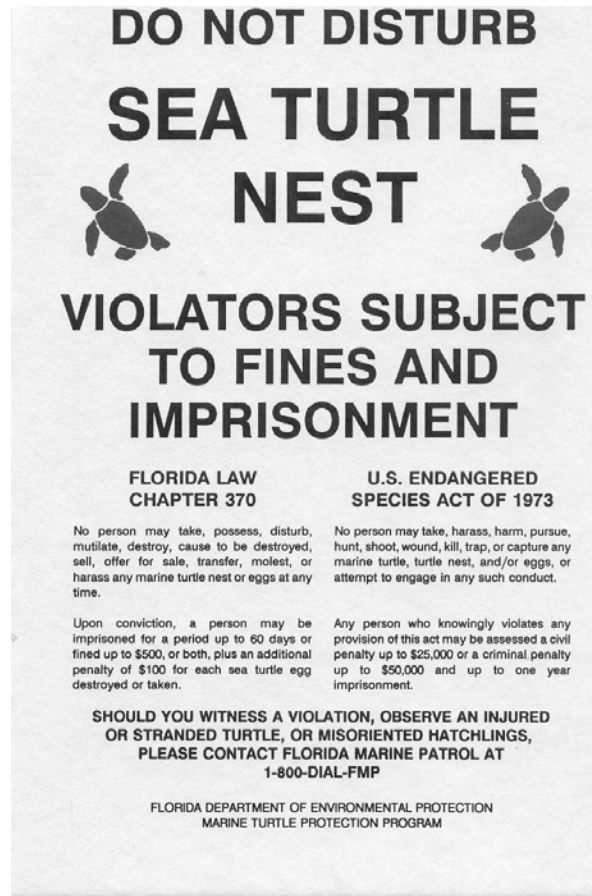
**APPENDIX 2:** Summary of Educational/Public Information Activities

Flyers were distributed along the beach, mostly to people who approached workers with questions and at the night turtle releases at Pompano and Fort Lauderdale, which usually attracted crowds. Flyers were also distributed to people touring the Oceanographic Center or requesting information by phone or mail.

Public education talks were conducted on Sunday and Wednesday evenings from July 18 to Sept. 13 at the Anne Kolb Nature Center. These slide show presentations were followed by hatchling releases at Greene St. in Hollywood. A similar slide show was presented for Piper High School students at the Oceanographic Center, followed by a hatchling release in Lloyd Park.

Public talks and slide shows were given at Cooper City High School (two talks), Nova High School (two talks), the Lauderdale-by-the-Sea Ladies Club and the Coral Ridge Kiwanis Club.

**Appendix 3:** Sea turtle nest warning sign. Black lettering on yellow background. Actual size is 5.5" X 8.5".



**Appendix 4:** Sea Turtle Summary Report Forms