TECHNICAL REPORT 00-

SEA TURTLE CONSERVATION PROGRAM BROWARD COUNTY, FLORIDA 2000 REPORT

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For the:

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

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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 Fish and Wildlife Conservation Commission (FWCC), Bureau of Protected Species Management, Tallahassee, Florida. 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 FWCC.

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 and for monitoring of completed nourishment projects. This report analyzes sea turtle nesting and hatching data from the third year of

monitoring of the Hillsboro Beach/Deerfield Beach Nourishment Project that was completed on March 20, 1998.

A contract to operate the program is issued based on a review of submitted bids. Nova Southeastern University was awarded the contract to conduct the 2000 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 was later), 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, 2000. Surveys continued through September 15th. 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 R1 to R128 (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, and

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 sites designated BH927, BH935 and BH949. These sites were numbered to match the street addresses of the nearest houses 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 (designated 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, 143 of these nests at Hillsboro Beach were excavated for post emergence examination. An additional 124 nests were left *in situ* on Pompano, Fort Lauderdale and Hollywood beaches. One hundred of these were left because the workers could not locate the egg chambers in the nesting mounds in the time allowed. The remaining 24 nests were completely missed during the initial surveys (mostly due to heavy rains) but were discovered on the morning after hatching by observing hatchling tracks. The egg chambers of 28 of these *in situ* nests were located and investigated for hatching success. The number of hatchlings released from each nest was determined as the total

number of eggs minus the number of hatchlings found dead in the nest (DIN), dead pipped eggs (DPIP), and eggs with visible (VD) or no visible development (NVD). The number of hatchlings alive in the nest (LIN) and live pipped eggs (LPIP) were included in the number of hatchlings released but were subtracted from this number to determine the number which naturally emerged from each nest. Hatching success was defined as the number of released hatchlings divided by the total number of eggs.

Restraining Hatcheries

As in previous years, early nests were transferred to 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, live and dead pipped eggs and eggs with arrested or no visible development were made.

Hatchery nests displaying a depression over the egg chamber were covered with a bottomless plastic bucket to retain hatchlings, although the turtles sometimes escaped these enclosures by digging around them. After hatching commenced, the hatcheries were checked at least twice each day, once between 9:00 PM and midnight and again just prior to 5:00 AM. Hatchlings found in the evening 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 with nests by mid May. Thereafter, Fort Lauderdale and Pompano nests were relocated

to Hillsboro Beach. Prior to June 8, the Hollywood hatchery was under repair and Hollywood nests were relocated to other restraining hatcheries or 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.

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 2000 for the 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 2000. 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 successes of 15 loggerhead nests that incubated on the nourished beach were compared to 107 in situ nests on the unnourished sections of Deerfield Beach and Hillsboro Beach by ANOVA and NK analyses.

RESULTS

Figure 1 shows the historical trend in the total number of sea turtle nests deposited in Broward County since 1981. A total of 2942 nests were counted in 2000, which exceeded the previous record year (1998), by 3.0 percent.

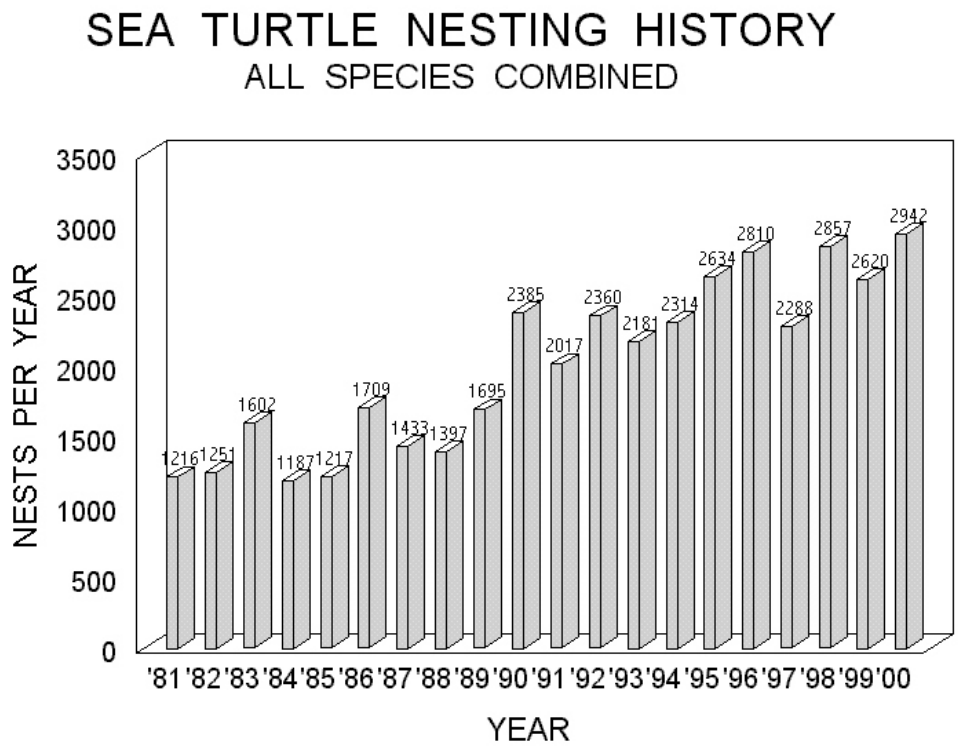

Figure 1: The pattern of total sea turtle nesting in Broward County since full surveys commenced in 1981.

Figure 2 shows the yearly nesting trends of loggerhead, green and leatherback sea turtles. The loggerhead nest count was similar to the last two seasons and still slightly below the record total in 1996. The highly significant correlation coefficient of the trend line ($P << .001$) increased from 0.916 in 1999 to 0.924 and the slope of the trend line suggests an average increase of about 88 nests per year, since 1981.

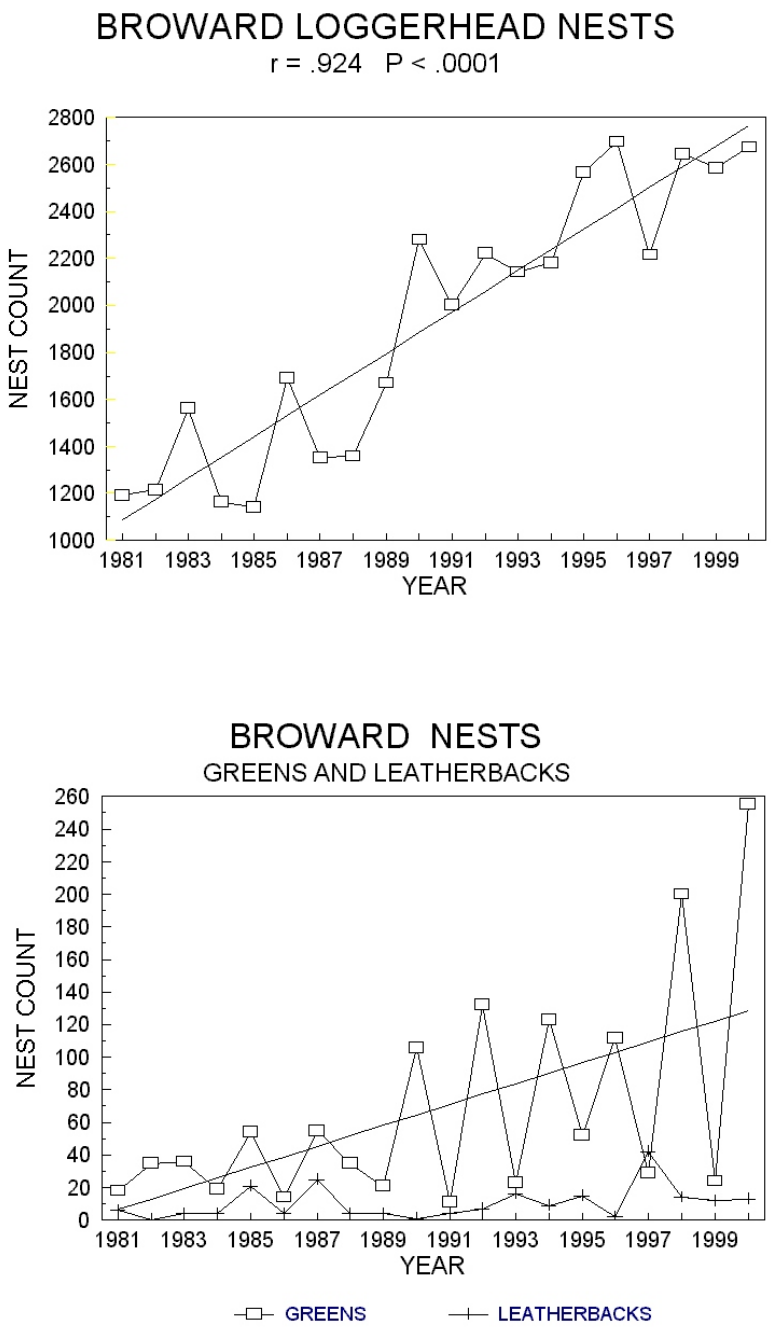

Figure 2: Historical nesting patterns of loggerhead, green and leatherback sea turtles in Broward County since 1981.

Nesting by the green sea turtle continued the alternating high-low pattern of the last 11 years (Fig. 2). This year, the total number of green turtle nests (255) exceeded the previous record year (1998) by 28 percent. Despite the large fluctuations, the slope of the 20-year trend line for green turtle nesting remains significantly greater than zero ($r = 0.566$; $P = .005$), suggesting an average increase of 6.4 nests per year since 1981. Leatherbacks continued to nest in Broward County. This year's total (13) was slightly above the previous 19-year average of 10.2. No significant long-term nesting trend for leatherbacks was evident.

Figure 3 shows the seasonal loggerhead nesting pattern. The first nest in our survey area (excluding Lloyd Park) was deposited on 18 April and the last was on 23 August. The last loggerhead nest in Broward County was deposited on September 9 in Lloyd Park (Fig. 3). 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, Pompano Beach and Fort Lauderdale were not statistically distinguishable from each other and were higher than the more southerly beaches. Nesting in Lloyd Park was less dense, but not significantly different from Fort Lauderdale. Hollywood nesting was significantly lower than all other beaches.

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 March 5 and June 3, respectively. Green turtles nested between May 17 and September 3. Nesting counts and densities for greens and leatherbacks are shown in Table 2 and Table 3, respectively. Nesting by greens and leatherbacks was significantly greater on Hillsboro Beach. Lloyd Park was the next most

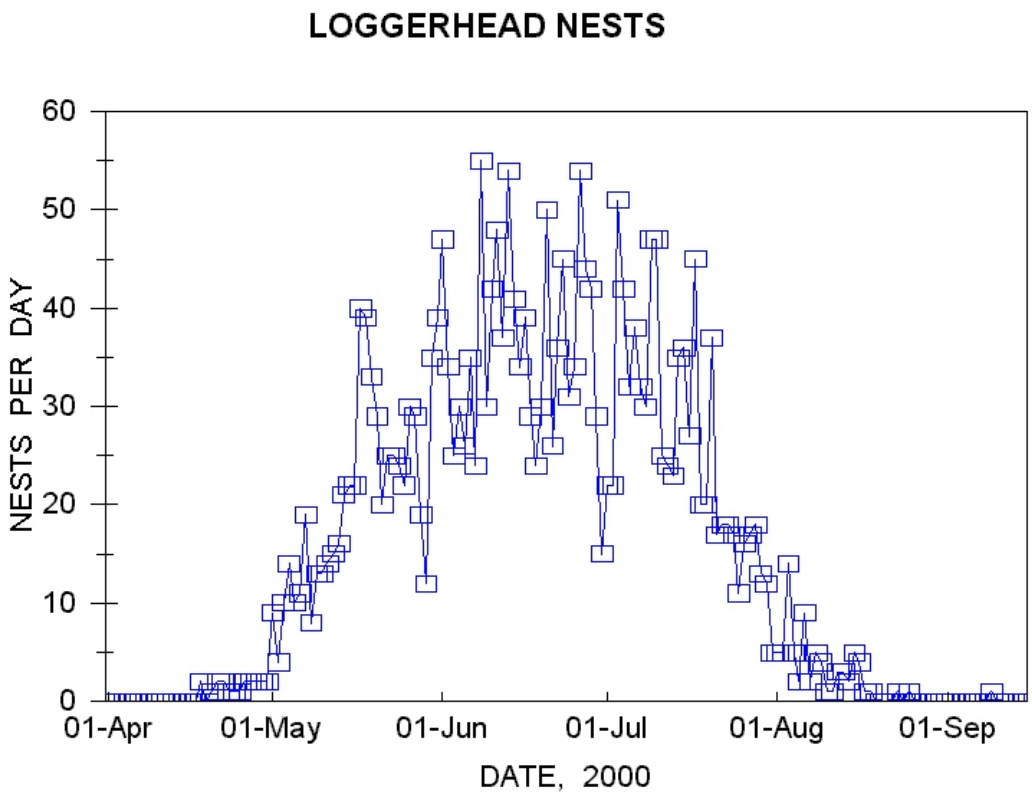

Figure 3: The seasonal pattern of daily loggerhead nesting in Broward County, 2000.

Table 1: Total loggerhead nests and nesting densities expressed as nests-per-kilometer for the 2000 season. Beaches with the same NK designation letters were not significantly different in a Newman-Keuls test (α = .05) of mean daily nesting per km. Beaches with different NK letters had significantly different nesting densities.

BEACH	TOTAL NESTS	BEACH LENGTH (km)	Nests per km	MEAN DAILY NESTS per km with NK Designation Letter	
Pompano Beach	762	7.7	99.0	.581	A
Hillsboro Beach	671	7.0	95.9	.570	A
Ft. Lauderdale	858	10.6	80.9	.475	AB
Lloyd Park	262	3.9	67.2	.395	B
Hollywood	121	9.4	12.9	.075	C
OVERALL	2674	38.6	69.3		

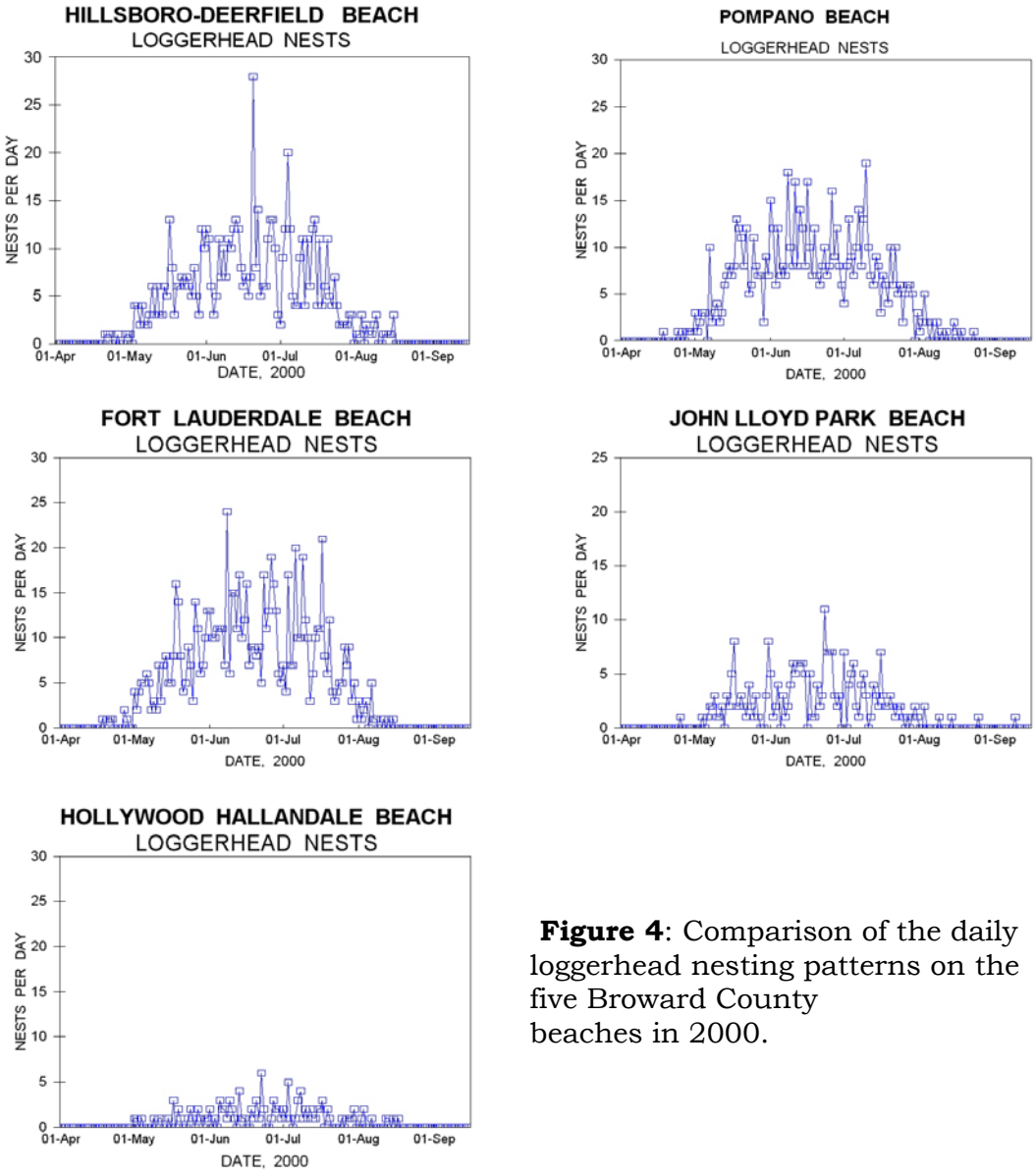

Figure 4: Comparison of the daily loggerhead nesting patterns on the five Broward County beaches in 2000.

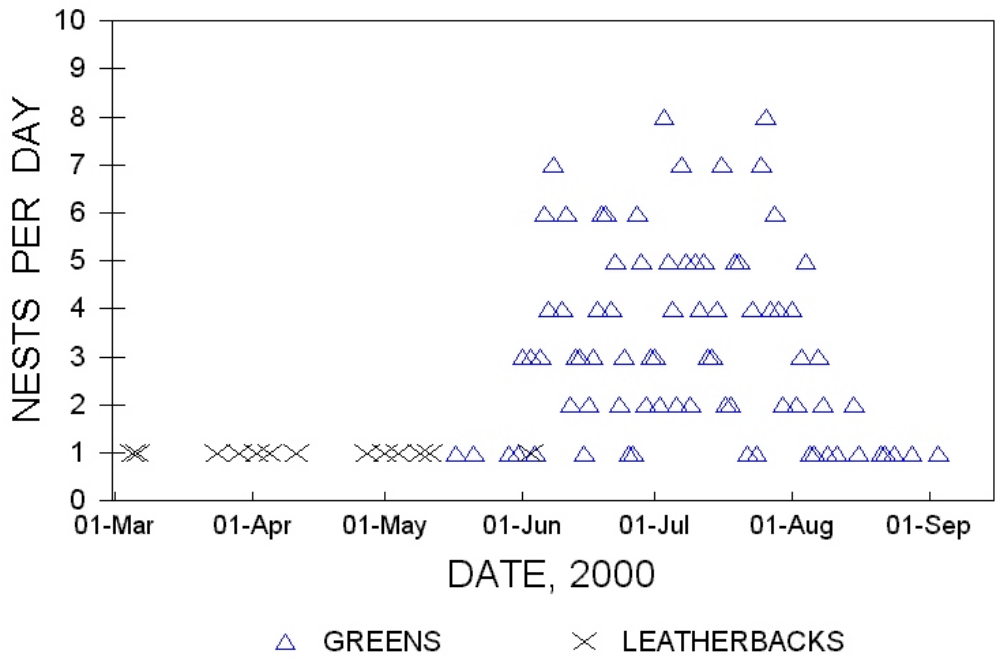

Figure 5: The seasonal pattern of daily green and leatherback nesting in Broward County, 1999.

densely nested beach and Pompano, Fort Lauderdale and Hollywood were all lower and statistically equal. The nest counts for leatherbacks were too low for statistical comparisons.

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 2000. The low nesting zones R-2, R-24, R-34 and R-50 are near the Deerfield Beach Pier, the Hillsboro Inlet, the Pompano Beach Pier and the Commercial Boulevard pier, respectively. The beach along the Fort Lauderdale strip (R-61 to R-78) and the entire beach south of R-98 were also lightly nested. These areas have been low nesting sites since project inception. Green turtles nested throughout the County, preferring Hillsboro Beach and Lloyd Park beaches.

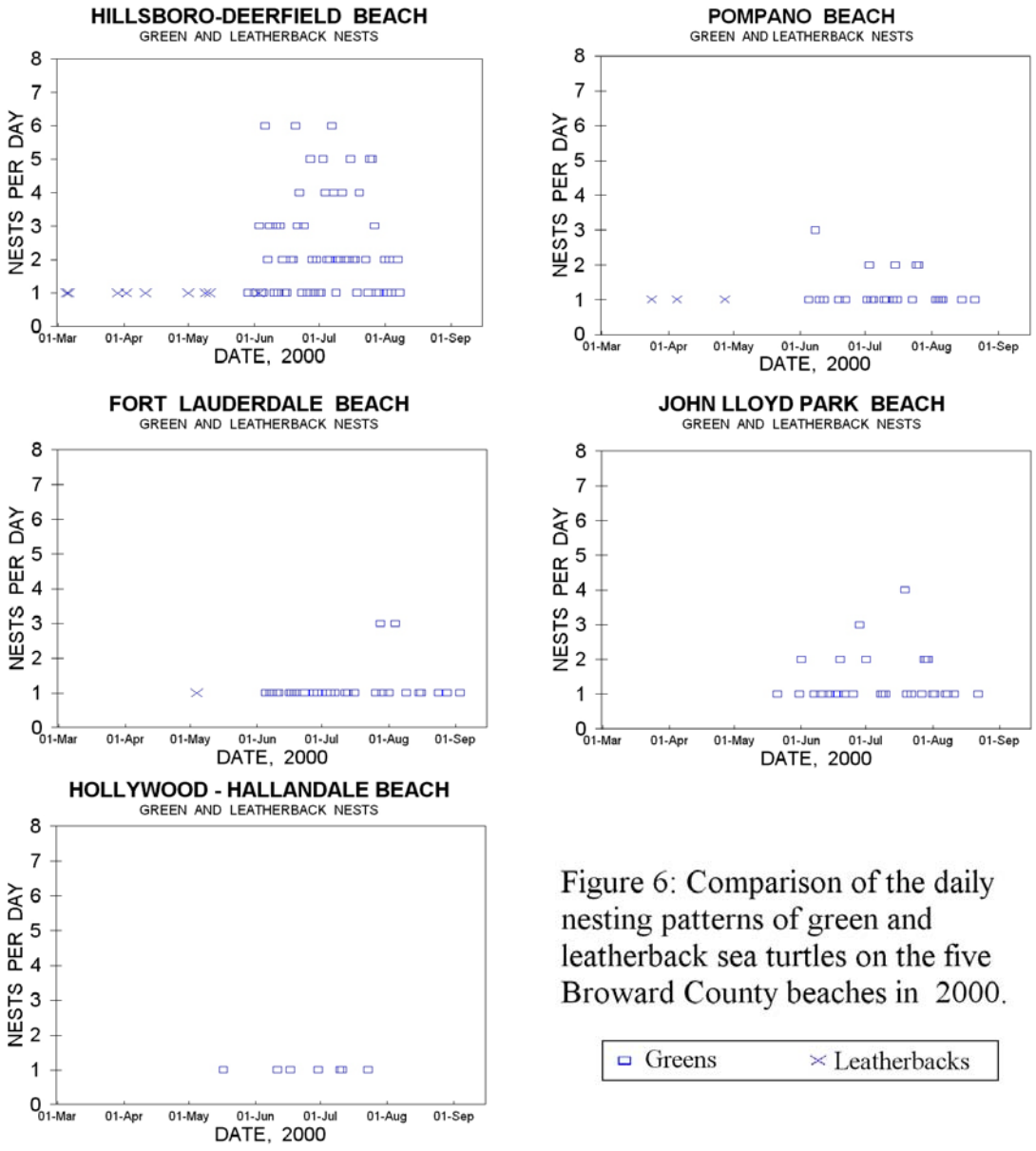

Figure 6: Comparison of the daily nesting patterns of green and leatherback sea turtles on the five Broward County beaches in 2000.

Table 2: Total green turtle nests and nesting densities expressed as nests-per-kilometer for the 2000 season. Beaches with the same NK designation letters were not significantly different in a Newman-Keuls test (alpha = .05) of mean daily nesting per km. Beaches with different NK letters had significantly different nesting densities.

BEACH	TOTAL NESTS	BEACH LENGTH (km)	Nests per km	MEAN DAILY NESTS per km with NK Designation Letter	
Hillsboro Beach	143	7.0	20.4	.122	A
Lloyd Park	41	3.9	10.5	.063	B
Pompano Beach	31	7.7	4.0	.023	C
Ft. Lauderdale	33	10.6	3.1	.019	C
Hollywood	7	9.4	0.7	.004	C
OVERALL	255	38.6	6.6		

Table 3: Total leatherback nests and nesting densities expressed as nests-per-kilometer for the 2000 season. Numbers were too low for statistical comparisons.

BEACH	TOTAL NESTS	BEACH LENGTH (km)	Nests per km
Hillsboro Beach	9	7.0	1.3
Pompano Beach	3	7.7	0.4
Ft. Lauderdale	1	10.6	0.1
Lloyd Park	0	3.9	0
Hollywood	0	9.4	0
OVERALL	13	38.6	0.3

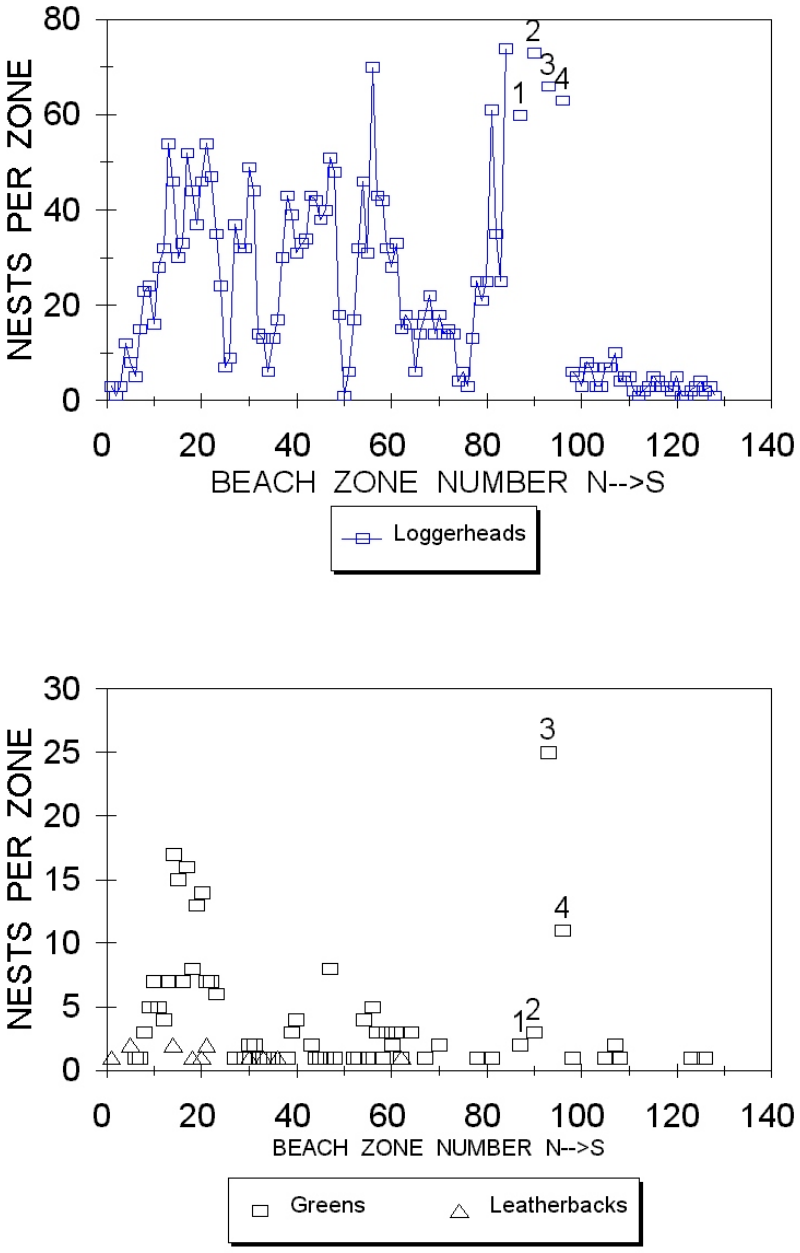

Figure 7: Locations of loggerhead, green and leatherback nests in Broward County, 2000. Numbers 1-4 indicate the four beach zones of John Lloyd Park.

Figure 8 and Table 4 present the countywide distribution of nesting success for the three species. Loggerhead nesting success showed no recognizable trends and was quite uniform throughout the County. One-way ANOVA showed no significant differences between beaches in the nesting success for the three species.

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 released 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 loggerhead nests (Table 6) increased by 3.2 percentage points from last season, but the success of *in situ* loggerheads declined by 3.8 points. There was no significant difference in the mean hatching success of 1198 relocated (66.5%) and 145 *in situ* (68.8%) loggerhead nests (t-test; p=.087). The same comparison for the hatching success of greens showed that the success of the relocated nests to be significantly lower than for *in situ* nests (p=.002).

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 (p =.135). Figure 10 shows the same data for greens. Both showed seasonal declines in hatching success. The trend was significant for relocated nests ($p < .025$) but not for *in situ* nests. The slopes of the trend lines were not significantly different (p = .081).

Figure 11 shows the frequency distributions of hatching success in relocated and *in situ* nests. A Mann Whitney U test indicated no significant

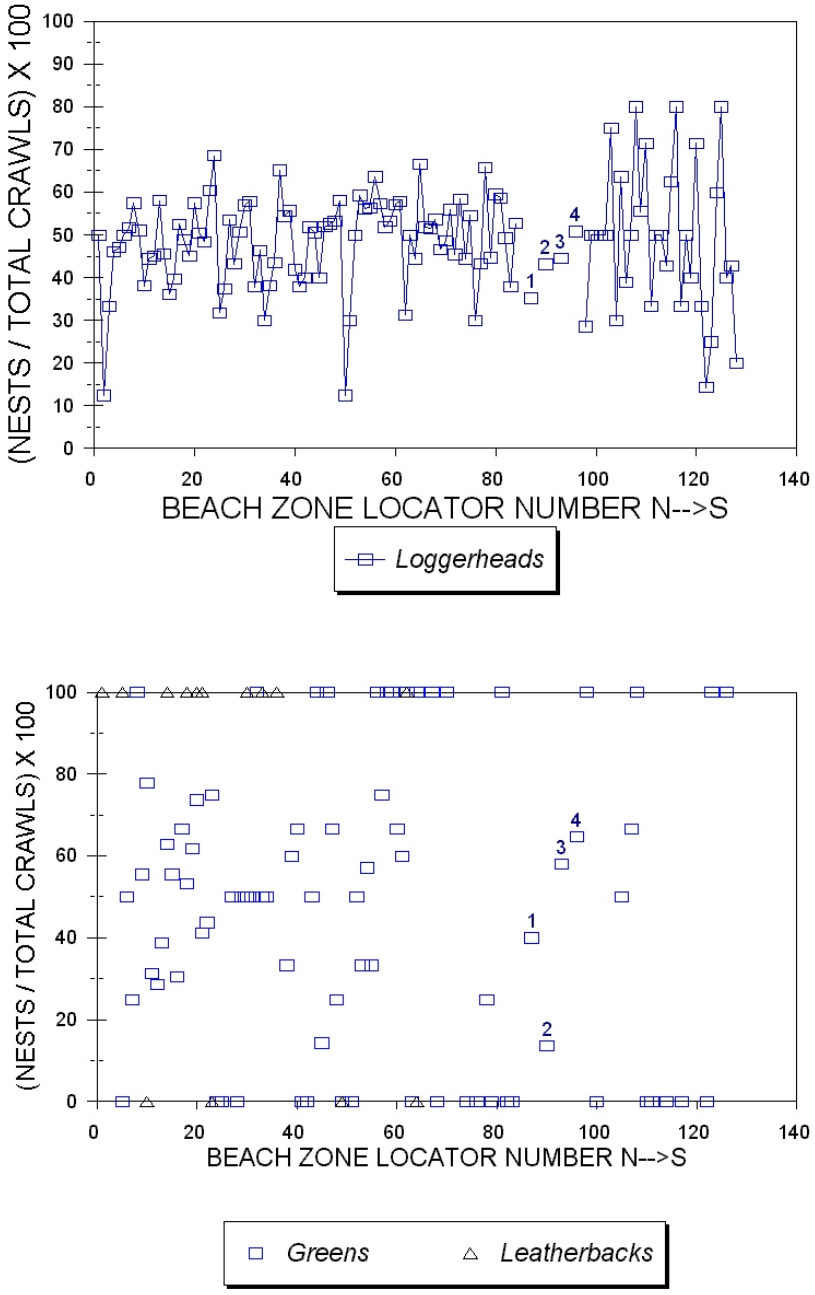

Figure 8: The distribution of the nesting success of loggerhead, green and leatherback turtles across Broward County, 2000. Numbers 1-4 indicate the four beach zones of John Lloyd Park.

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 2000. One-way ANOVA detected no significant differences in nesting success between beaches for any of the species.

BEACH	Loggerheads			Greens			Leatherbacks		
	Nests	FC	NS	Nests	FC	NS	Nests	FC	NS
Hillsboro Beach	671	704	48.8	143	132	52.0	9	2	81.8
Pompano Beach	762	809	48.5	31	35	47.0	3	1	75.0
Ft. Lauderdale	858	774	52.6	33	25	56.9	1	1	100
Lloyd Park	262	349	42.9	41	47	46.6	0	0	-
Hollywood	121	135	47.3	7	9	43.8	0	0	-
OVERALL	2674	2771	49.1	255	248	50.7	13	4	76.5

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
RELOCATED				
Open Beach				
Hillsboro Beach				
BH	73	1	0	74
BH1	912	26	0	938
BH927	129	0	0	129
BH935	381	13	0	394
BH949	50	0	0	50
Hatcheries				
Pompano	54	0	2	56
Ft. Lauderdale	33	2	1	36
Hollywood	85	4	0	89
TOTALS	1717	46	3	1766
IN SITU				
Hillsboro Beach	600	142	9	751
Pompano Beach	43	13	1	57
Ft. Lauderdale	47	11	0	58
Hollywood	5	2	0	7
TOTALS	695	168	10	873

GRAND TOTALS	2412	214	13	2639

Table 6: Total egg counts, released hatchlings and overall release successes for *in situ* and relocated nests of loggerheads, greens and leatherbacks in 2000.

SPECIES	NUMBER OF EGGS	EVAL. NESTS	HATCHLINGS RELEASED	RELEASE SUCCESS (%)
***In situ* Nests**				
C. caretta	15432	144	10492	68.0
C. mydas	2602	25	1796	69.0
D. coriacea	77	1	27	35.1
Total	18111	170	12315	68.0
Relocated Nests				
C. caretta	126560	1199	84067	66.4
C. mydas	3064	27	1639	40.9
D. coriacea	242	3	127	52.5
Total	129866	1229	85833	66.1
Overall				
C. caretta	141992	1343	94559	66.6
C. mydas	5666	52	3435	60.6
D. coriacea	319	4	154	48.3
TOTAL	147977	1399	98148	66.3

Predated and Unevaluated Nests and Eggs

	Predated Nests	Pred. Eggs	Unevaluated Nests	Unevaluated Eggs
***In Situ* Nests**				
C. caretta	12	-	536	-
C. mydas	2	-	141	-
D. coriacea	0	-	9	-
Relocated				
C. caretta	318	35003	203	21316
C. mydas	15	1734	4	509
D. coriacea	0	0	0	0

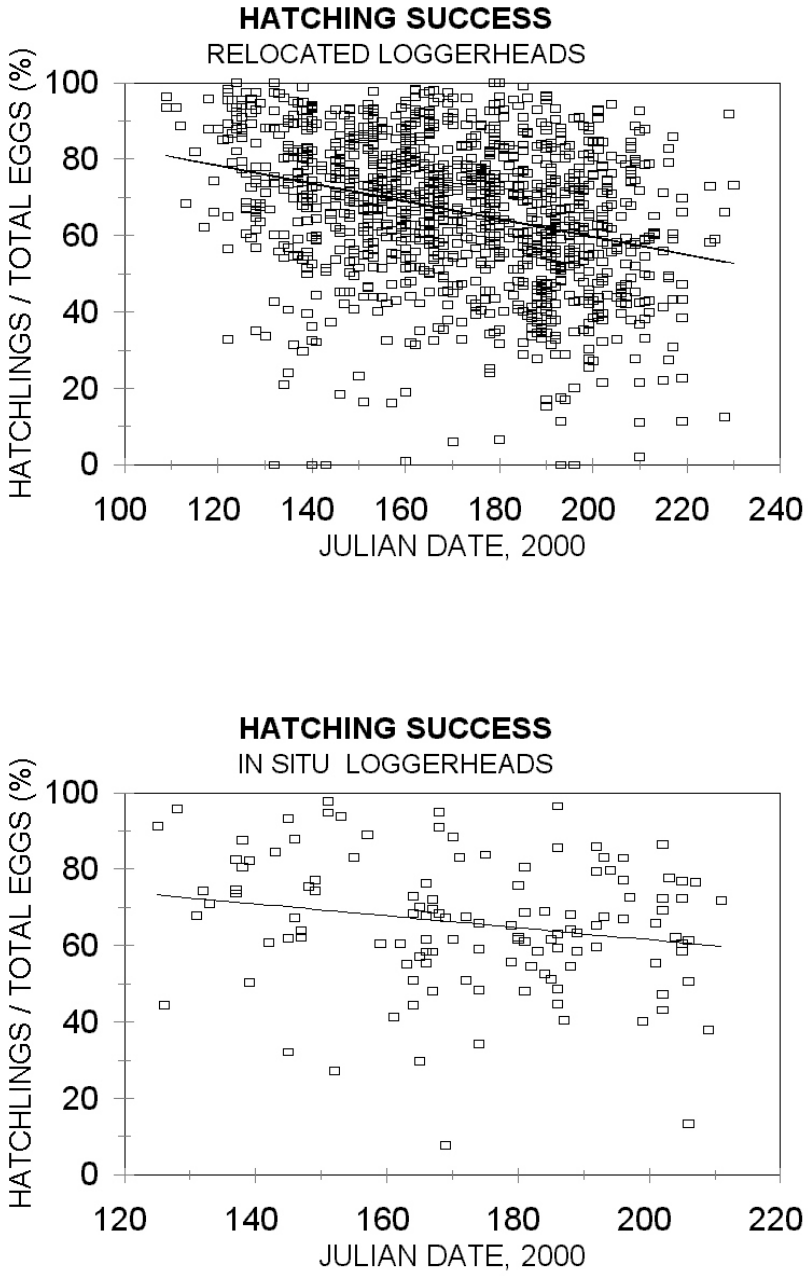

Figure 9: Comparison of seasonal hatching success for relocated and *in situ* loggerhead nests during 2000.

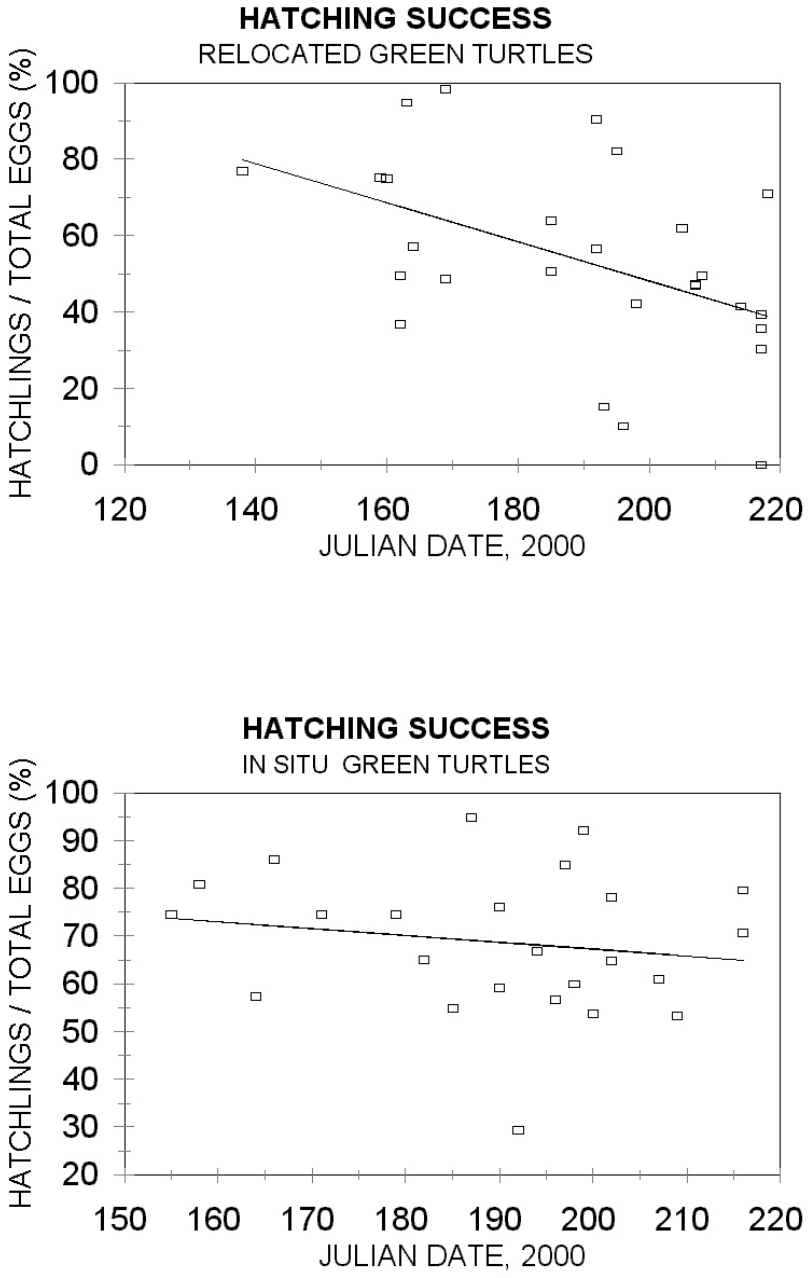

Figure 10: Comparison of seasonal hatching success for relocated and *in situ* green turtles nests during 2000.

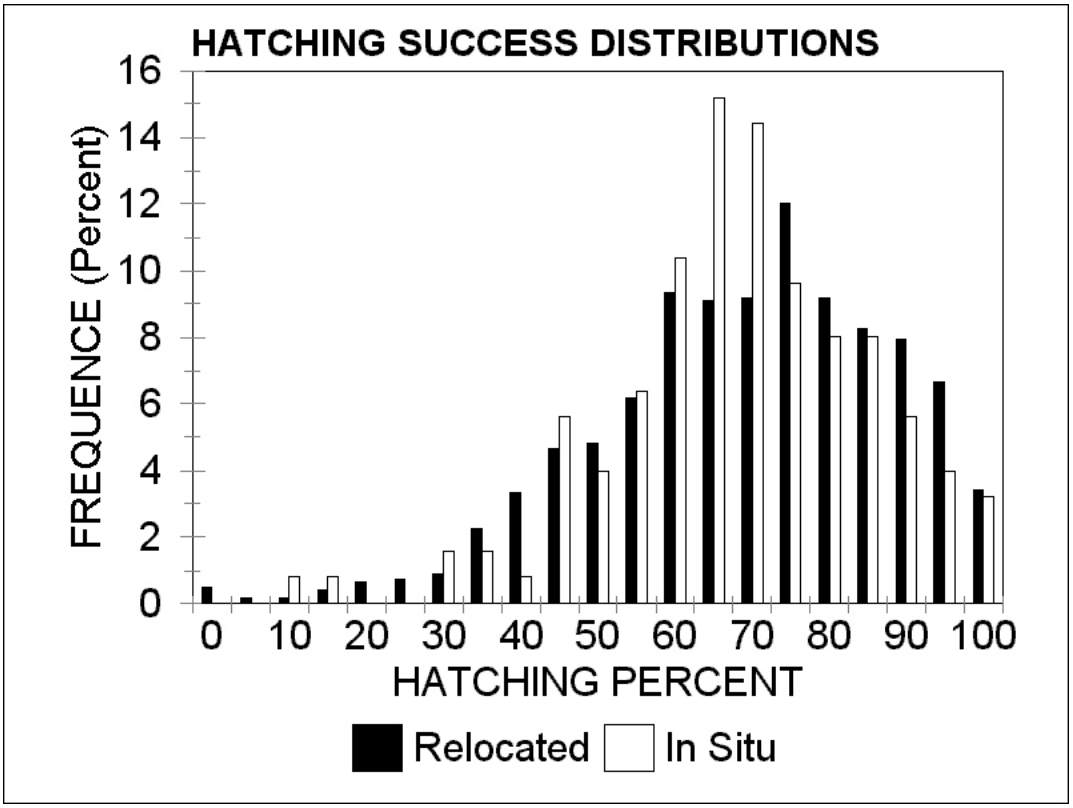

Figure 11: Hatching success frequencies for *in situ* and relocated loggerhead nests in 2000.

difference between them. The medians of the distributions were nearly identical.

Figure 12 shows the historical patterns of the yearly hatching success of all species combined, since 1981. Overall hatching success of all species combined (Table 6) increased slightly to 66.1% in relocated nests and declined slightly to 68.0% in *in situ* nests. The difference was not statistically significant.

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.

Table 10 compares the mean loggerhead nesting success rates on the

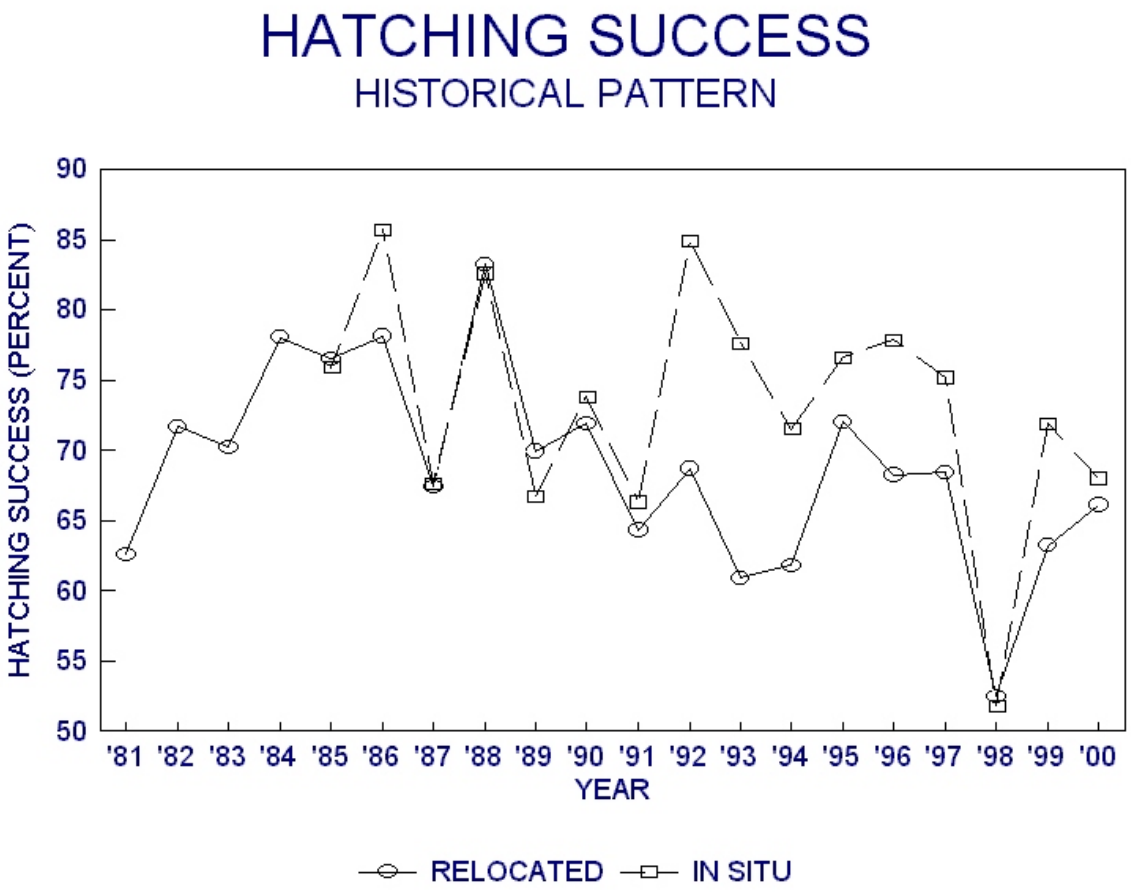

Figure 12: The historical patterns of yearly hatching success for all evaluated *in situ* and relocated sea turtle nests, since 1981.

Table 7: Accounting of the status of all hatched and unhatched eggs in investigated *in situ* and relocated loggerhead nests during 2000.

Location	Total Eggs	Emerged Hatchlings (%)	LIN (%)	DIN (%)	PIP Live (%)	PIP Dead (%)	VD (%)	NVD (%)
***In situ* Nests**								
Hillsboro Beach	12741	62.5	1.2	2.1	0.2	14.3	13.3	6.5
Pompano Beach	1215	89.8	1.6	1.8	0.2	1.2	2.0	3.5
Ft. Lauderdale	1240	74.0	9.5	5.5	0.3	4.0	3.5	3.4
Hollywood Beach	113	81.4	0.0	13.3	0.0	0.0	4.4	0.9
Relocated Nests								
Hillsboro Beach								
BH	1431	55.7	13.3	1.9	3.1	16.1	5.6	4.3
BH1	70765	54.2	9.9	2.0	1.3	14.7	6.8	11.1
BH927	9921	59.9	9.1	1.4	1.5	17.0	3.8	7.3
BH935	24128	43.4	11.9	2.3	2.3	19.9	8.0	12.3
BH949	1041	57.4	1.5	1.9	0.2	18.3	4.8	15.8
Hatcheries								
Pompano	6453	67.3	8.1	3.2	1.6	9.0	4.6	6.4
Ft. Lauderdale	3875	76.8	5.5	0.5	0.5	2.9	2.7	11.0
Hollywood	9069	68.9	9.2	0.9	1.2	5.3	6.1	8.4

Emerged Hatchlings - Percentage of hatchlings released 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 2000. Abbreviations as in Table 7.

Location	Total Eggs	Emerged Hatchlings (%)	LIN (%)	DIN (%)	PIP Live (%)	PIP Dead (%)	VD (%)	NVD (%)
***In situ* Nests**								
Hillsboro Beach	2399	66.7	0.3	0.8	0.0	10.8	11.4	10.0
Pompano Beach	84	82.1	8.3	0.0	0.0	0.0	0.0	9.5
Ft. Lauderdale	119	90.8	4.2	0.8	0.0	0.0	0.8	3.4
Relocated Nests								
Hillsboro Beach								
BH1	1842	35.2	11.3	2.0	1.1	14.8	12.4	23.2
BH935	558	27.6	12.9	1.1	1.3	22.0	21.3	13.8
Hatcheries								
Ft. Lauderdale	194	47.9	11.9	1.0	3.1	9.8	5.2	21.1
Hollywood	470	76.4	7.9	0.2	2.3	1.5	1.7	10.0

Table 9: Accounting of the status of all hatched and unhatched eggs in investigated *in situ* and relocated leatherback nests during 2000. Abbreviations as in Table 7.

Location	Total Eggs	Emerged Hatchlings (%)	LIN (%)	DIN (%)	PIP Live (%)	PIP Dead (%)	VD (%)	NVD (%)
***In Situ* Nests**								
Hillsboro Beach	77	35.1	0.0	0.0	0.0	0.0	23.4	41.6
Relocated Nests								
Hatcheries								
Pompano	183	40.4	10.4	3.8	0.5	8.2	14.2	22.4
Hollywood	59	54.2	1.7	1.7	0.0	6.8	30.5	5.1

nourished beach in the Deerfield Beach/Hillsboro Beach nourishment project conducted before the nesting season in 1998, between monuments R-6 and R-12, with the beaches north and south of the nourishment area in 1998, 1999, 2000 and 1991, before significant erosion was evident. Mean nesting success in the nourishment area increased slightly from 42.1% to 48.3% from 1999 to 2000. This was not a significant increase, but this year's value was also not significantly different from 1991 (Table 10). Table 11 shows a marked decrease in nesting success in all areas from 1991 to 1998, when nesting success on the nourished beach was significantly lower than on the less eroded beach south of the project (R-13 to R-24). In 1999, nesting success on the nourished beach increased, and was not significantly different from the southern zone. This year, there was a further increase on the nourished beach and there was no significant difference throughout Deerfield Beach and Hillsboro Beach, as in 1991.

Table 10: Mean loggerhead nesting success on the nourished beach compared to the unnourished beaches north and south of the nourishment area between years. Values with the same letter designation were not significantly different in a NK test.

Year	R-1 to R-5	R-6 to R-12	R-13 to R-24
1991	62.7 A	61.0 A	64.3 A
1998	26.5 B	23.6 B	45.4 B
1999	28.3 B	42.1 C	55.5 AB
2000	37.8 B	48.3 AC	50.9 AB

Table 11: Mean loggerhead nesting success compared between zones to the unnourished beaches to the north and south of the nourishment area. . Values with the same letter designation were not significantly different in a NK test.

Zones	1991	1998	1999	2000
R-1 to R-5	62.7 A	26.5 A	28.3 A	37.8 A
R-6 to R-12	61.0 A	23.6 A	42.1 B	48.3 A
R-13 to R-24	64.3 A	45.4 B	55.0 B	50.9 A

Figure 13 shows the distributions of the hatching successes of loggerhead nests that incubated on the nourished sand and on the unnourished sections of Deerfield Beach and Hillsboro Beach. The distributions were very similar, with almost identical medians. There was no indication of higher frequencies of lower hatching nests on the nourished beach. A Mann Whitney U test detected no significant difference between the distributions (P = .406).

DISCUSSION

Yearly Nesting Trends

This year's total nest count was the highest since project inception (Fig. 1). While the loggerhead count was slightly below the 1996 record (Fig. 2) the very large number of green turtle nests accounted for the overall nesting record. Loggerhead nesting has remained relatively stable since 1995, with the exception of the lower count in 1997. However, the correlation coefficient of the of the loggerhead trend line continues to increase, indicating an increasing level of confidence in the positive overall tendency.

An increase in nesting can result from an increase in the proportion of the female population nesting in a given year, or to an increased

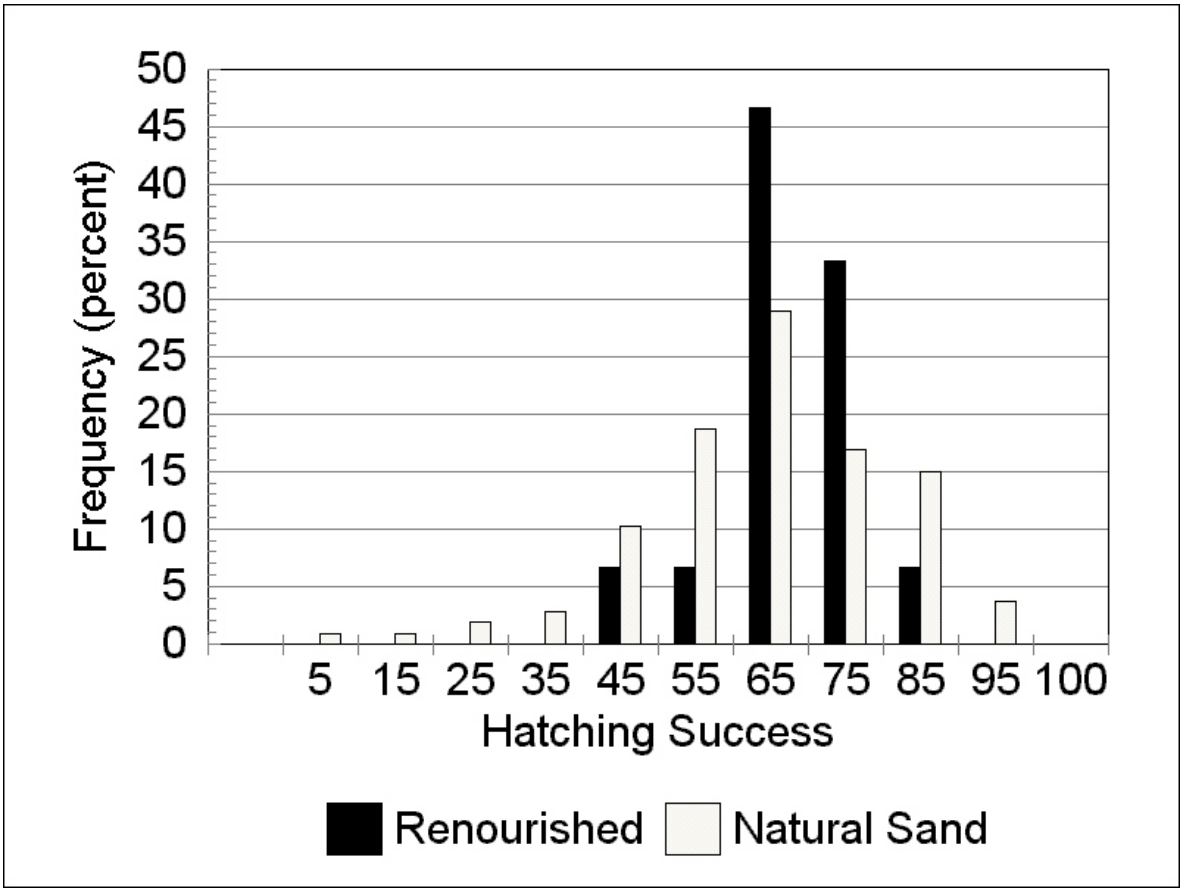

Figure 13: Frequency distributions of hatching success rates for *in situ* loggerhead nests incubated on the nourished and unnourished (natural) portions of Hillsboro Beach, 2000.

number of clutches per female, and does not necessarily indicate an increase in population size (Frazer and Richardson 1985). However, the relatively constant number of loggerhead nests in five of the last six 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.

Unlike loggerheads, the fluctuating pattern of green turtle nesting may suggest that a large proportion of the female population nests in even numbered years and remains on their feeding grounds in alternate years. Other explanations such as migrations or fluctuations in the number of clutches per female seem less likely, given the long-term duration of this

pattern. Leatherback nesting (Fig. 2) remained above the previous 19-year average of 10.2, but well below the 42-nest maximum in 1997.

Seasonal Nesting Patterns

The seasonal pattern of loggerhead nesting in Broward County (Figs. 3) again conformed to the historical norm, showing a relatively symmetrical bell-shaped trend with the first nest in mid April, the last nest in early September and the midpoint of the season in mid to late June. Seasonal nesting at the individual beaches (Fig. 4) also showed no obvious deviations from historical expectations.

As in 1999 (Burney and Margolis, 1999), loggerhead nesting per kilometer was highest at Pompano Beach and Hillsboro Beach where mean daily nests/km were statistically equivalent (Table1). Nesting was significantly less dense in Lloyd Park and Fort Lauderdale was intermediate between Lloyd Park and the two northern beaches. As usual, Hollywood nesting was significantly lower than all other areas.

The seasonal pattern of green turtle nesting (Fig. 5) was typical of previous high nesting years (Burney and Margolis, 1998) with nesting beginning in mid May and ending in early September. The maximum number of green nests per day was eight. Leatherbacks again nested earlier in the season beginning in early March and ending in early June.

As in previous years, green turtles nested most heavily at Hillsboro Beach and Lloyd Park, possibly due to the decreased beachfront lighting and human activity on these beaches, but their nesting was significantly more dense in Hillsboro Beach (Table 2, Fig. 6). Nesting on the other beaches was lower and statistically equivalent. Leatherbacks again nested most heavily at Hillsboro Beach, with lower numbers in Pompano Beach

and Fort Lauderdale. There were no leatherback nests in Lloyd Park or Hollywood.

County-wide Nest Distribution

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). The number of green turtle nests has never been large enough (even this year) to establish such a detailed horizontal nesting pattern, except for their preference for darker beaches with less nocturnal disturbance. The same is true for leatherbacks.

Nesting Success

Overall loggerhead nesting success (Fig. 8, Table 4) increased slightly from 46.2 percent in 1999 to 49.1 percent in 2000. A 1-way ANOVA indicated no statistical differences in nesting success between the five beach areas (Table 4), however some of the lower success rates were found near the piers mentioned earlier, especially at Deerfield Beach and Commercial Boulevard (Fig. 8). Unlike the nesting pattern, nesting success was not generally lower along the Fort Lauderdale strip. Nesting success on Hollywood beach was erratic, due to the very low numbers of nests and false crawls in some of the zones. The continuing lack of a correlation between loggerhead nesting success (Fig. 8) and nesting density (Fig. 7), except near piers, indicates that nest site selection is not determined primarily by factors influencing nesting success, but is determined before the female begins her crawl. The lower nesting densities near the piers may be partially due to increased human activity, which causes turtles to

return to the sea without nesting. Although there are many other areas of Broward County with high nocturnal beach activity, beaches near piers seem especially unfavorable to sea turtle nesting and nesting success.

Overall green turtle nesting success increased by 4.5 percentage points from 1999 with no statistical differences between the five beach areas. There was no discernable pattern in the countywide distribution, which showed large fluctuations due to the low number of nests and false crawls in some of the zones (Fig 8). The same was true for leatherbacks.

Hatching Success

There was no statistical difference in the hatching success of *in situ* and relocated loggerhead nests this year (Table 6, Fig. 12). Both showed the usual seasonal declines (Fig. 9), but the slopes of the trend lines for *in situ* and relocated nests were not statistically different. Likewise, there was no statistical difference in the hatching success distributions (Fig. 11) which had nearly equal medians and did not show higher proportions of low hatching or failed relocated nests. Table 7 shows that the largest percentage of unemerged hatchlings or unhatched eggs in nests relocated to Hillsboro Beach were pipped-dead. This includes nests originally deposited at Hillsboro Beach which were individually relocated to locations outside of the designated hatchery sites (BH). Since these nests were widely separated, the higher proportion of pipped-dead eggs would not be due to hatchery crowding. In addition, the percentage of pipped-dead eggs was much lower for nests relocated to the restraining hatcheries. It should also be noted that the pipped-dead percentage of nests at the Hillsboro Beach hatchery sites were not very different than for in situ nests at Hillsboro Beach. The lower proportions for *in situ* nests at Pompano Beach and Fort Lauderdale were based on few nests.

Unlike loggerheads, hatching success of green turtle nests was significantly lower in relocated nests. This has been observed previously (Burney and Margolis, 1999). Nests that were relocated to Hillsboro Beach had higher proportions of pipped-dead and unhatched eggs with visible and no visible development than did *in situ* nest at Hillsboro Beach. Perhaps green turtle eggs are more sensitive to movement or require different incubation conditions than loggerhead eggs, because the same procedures were used to relocate nests of both species. Fortunately, 168 of the 214 green turtle nests (not including Lloyd Park) were deposited at Hillsboro Beach and were left *in situ*.

Effects of Beach Nourishment

The impact of the Deerfield Beach/Hillsboro Beach Nourishment Project on nesting and hatching success seems to be minimal three nesting seasons after the project was concluded. Table 10 shows that loggerhead mean nesting success was low on the nourished beach (R-6 to R-12) immediately after the project in 1998, but it has steadily increased and this year's rate was not statistically different from the 1991 level, when severe beach erosion was not evident. The between-zone comparison for the four years (Table 11) shows that in 1998 mean loggerhead nesting success was significantly lower in the project area than on the less eroded beach to the south (R-13 to R24) but was not statistically different from the more adversely impacted region of Deerfield Beach to the north. This situation reversed in 1999 and this year there were no significant differences between the three zones, which also was the case in 1991.

There was also no significant difference in the hatching successes for loggerhead nests that incubated on the nourished and unnourished

sections of Hillsboro Beach and Deerfield Beach. A Mann-Whitney U test detected no significant differences in the distributions (Fig. 13).

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

SUBJECT	HOT-LINE
EMERGENCIES	
Strandings	28
Disorientations	17
NEST LOCATIONS	60
POACHING	0
OTHER	>200
OVERALL	> 300

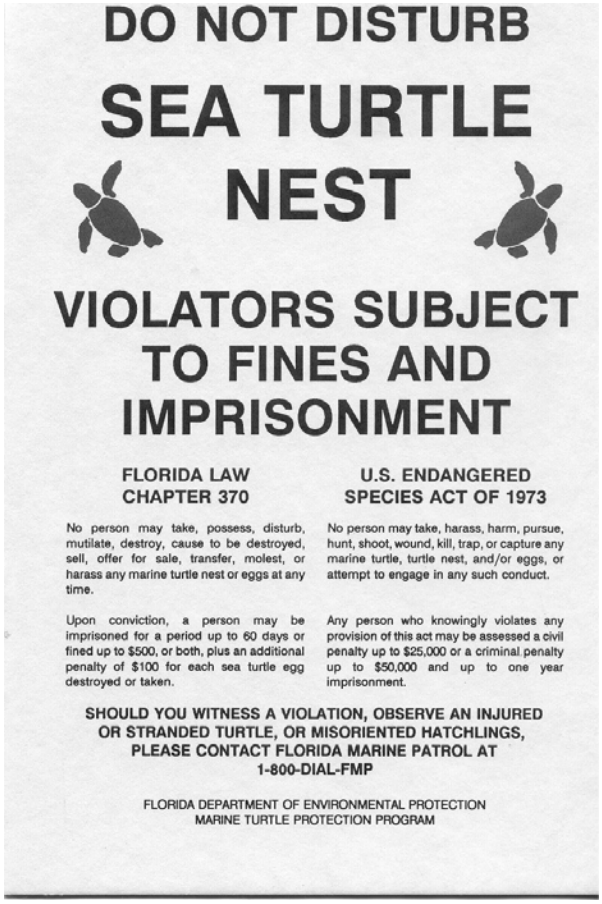
APPENDIX 2: Summary of Educational/Public Information Activities

Flyers were distributed along the beach, primarily to people who approached workers with questions and at the turtle talks, 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 Wednesday and Friday evenings from July 19 to Sept. 13 at the Anne Kolb Nature Center. These slide show presentations were followed by hatchling releases near Greene St. in Hollywood. An evening turtle talk was also given at the NSU Oceanographic Center on Sept. 22 for Cooper City High School students, followed by a hatchling release in Lloyd Park.

Talks and slide shows were also given on March 25 at Marina Bay for the Trade Winds Group and on May 14 and June 8 at Fern Forest.

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