TECHNICAL REPORT 00-

SEA TURTLE CONSERVATION PROGRAM BROWARD COUNTY, FLORIDA 2001 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.

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 2001 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

The location of Broward County and the positions of the boundary lines above are shown in Figure 1 A-F.

Daily surveys of Hillsboro-Deerfield, Pompano, Fort Lauderdale and Hollywood-Hallandale beaches commenced on March 1, 2001. 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,

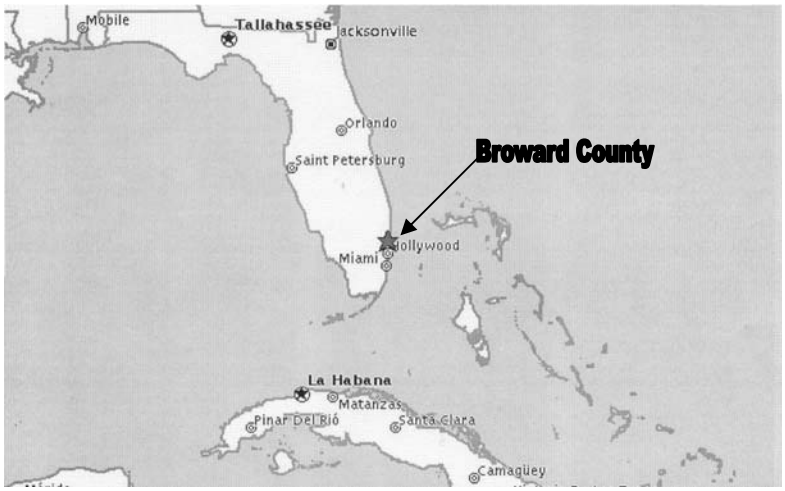

Figure 1A: The location of Broward County, FL

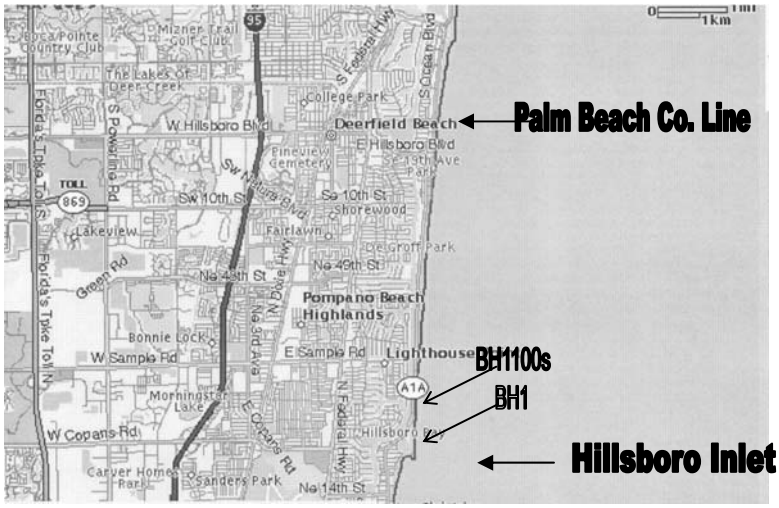

Figure 1B: Northern Broward County, showing locations of southern (BH1) and northern (BH1100s) open beach relocation sites

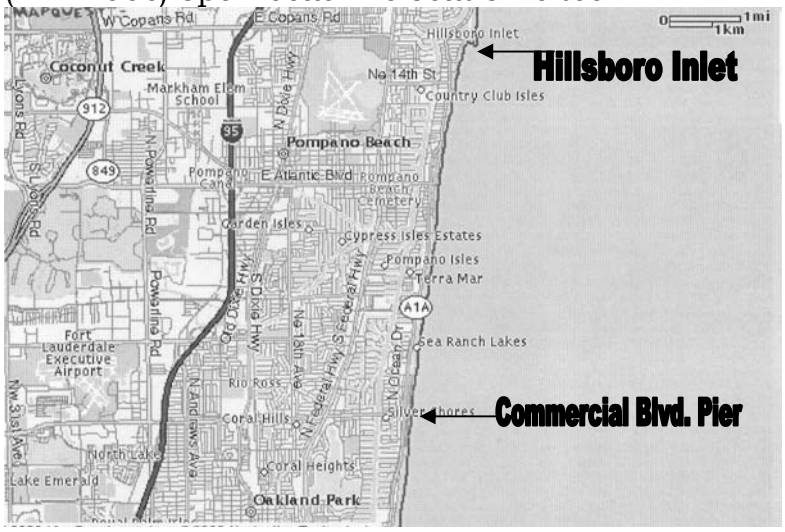

Figure 1C: North Central Broward County.

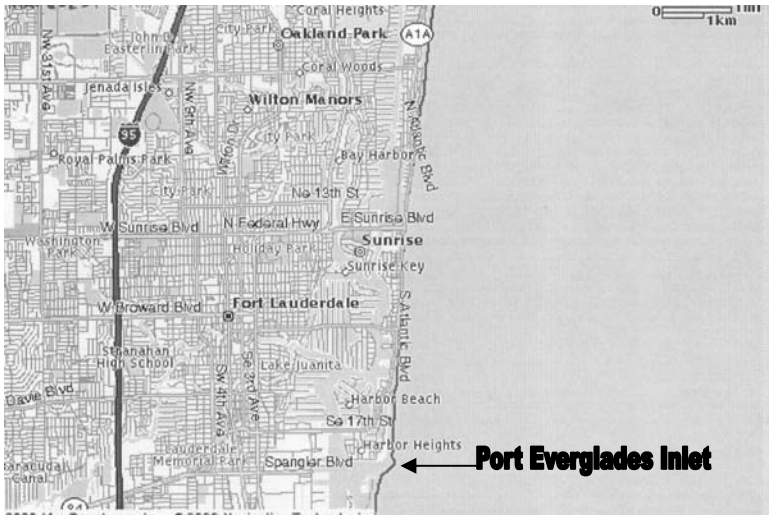

Figure 1D: Central Broward County

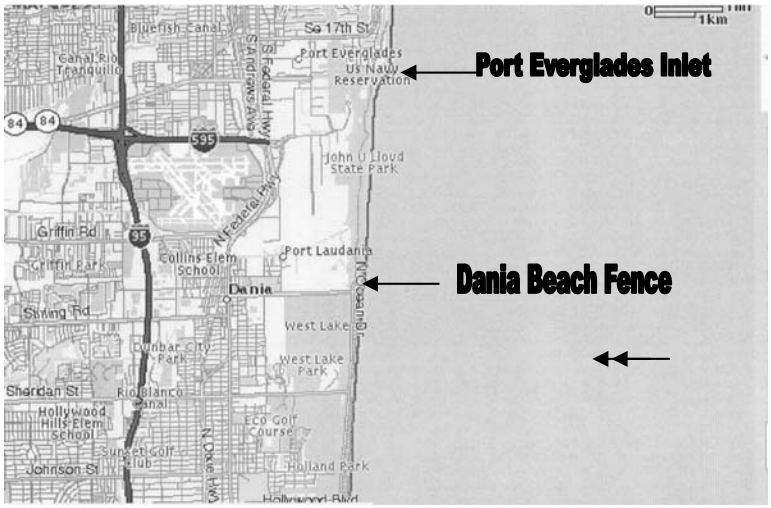

Figure 1E: South Central Broward County

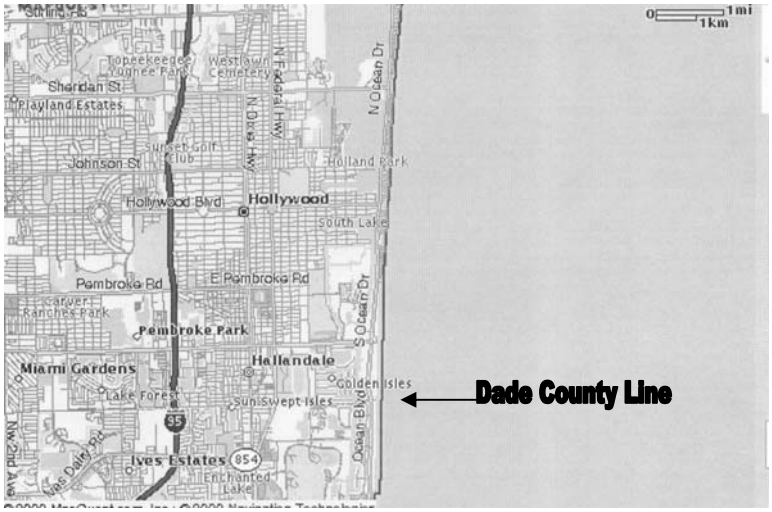

Figure 1F: Southern Broward County

or other landmark. These locations were later cross-referenced to the nearest survey marker. Nest and false crawl locations were also recorded using Global Positioning System (GPS) receivers.

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 (ATVs) 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 directly on the ATVs to fenced beach hatcheries. 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 surveyor 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, most 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, immediately north of the Hillsboro Inlet (Figure 1B). In order to avoid concentrating all nests at one location, nests from other beaches were also relocated just north of the Hillsboro Club, in the area adjacent to houses with Highway A1A addresses in the 900s. Nests in danger of negative impacts that were deposited on Hillsboro Beach were relocated to less hazardous nearby locations on that beach (designated BH). In cases where there was no nearby safe location site, Hillsboro nests were transported by ATV to beach locations adjacent to house numbers in the 1000s (HB1000s) and 1100s (HB1100s). The locations of the most southerly and northerly relocation sites (BH1 and BH1100s, respectively) are shown in Figure 1B.

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 and recorded. 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, to prevent possible injury to the embryos.

Those nests not in danger were left *in situ* and marked with stakes bearing yellow 5.5" X 8.8" sea turtle nest warning signs (Appendix 3). After hatching 34 percent of these nests (n =232) were excavated for post

emergence examination. 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 with partially emerged hatchlings (DPIP), and unhatched eggs showing 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 and the Hollywood hatchery filled by mid to late June. Thereafter, nests from these beaches were relocated to Hillsboro Beach. Some late season nests were relocated to the Hollywood hatchery after space became available. Hatched hatchery nests 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 2001 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 beaches were compared using 1-way analysis of variance (ANOVA) and Newman-Keuls (NK) tests at the 0.05 significance level. The sequential number of each leatherback nest was plotted versus the Julian date of its deposition to estimate the minimum number of nesting females. The total number of nests deposited by each species in the beach segments corresponding to each FDEP survey marker was tabulated and plotted. GPS positions for most nests and false crawls were also plotted on the 1996 Broward County Coastline Aerial Shore Line Map using the ArcView Geographic Information System (GIS) but due to the size of the printouts, these data will be presented as a separate DPEP report.

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 average nesting success in each zone 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 2001. 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.

RESULTS

Figure 2 shows the historical trend in the total number of sea turtle nests deposited in Broward County since 1981. A total of 2385 nests were counted in 2001, which represented a decline of 23 percent from the previous year.

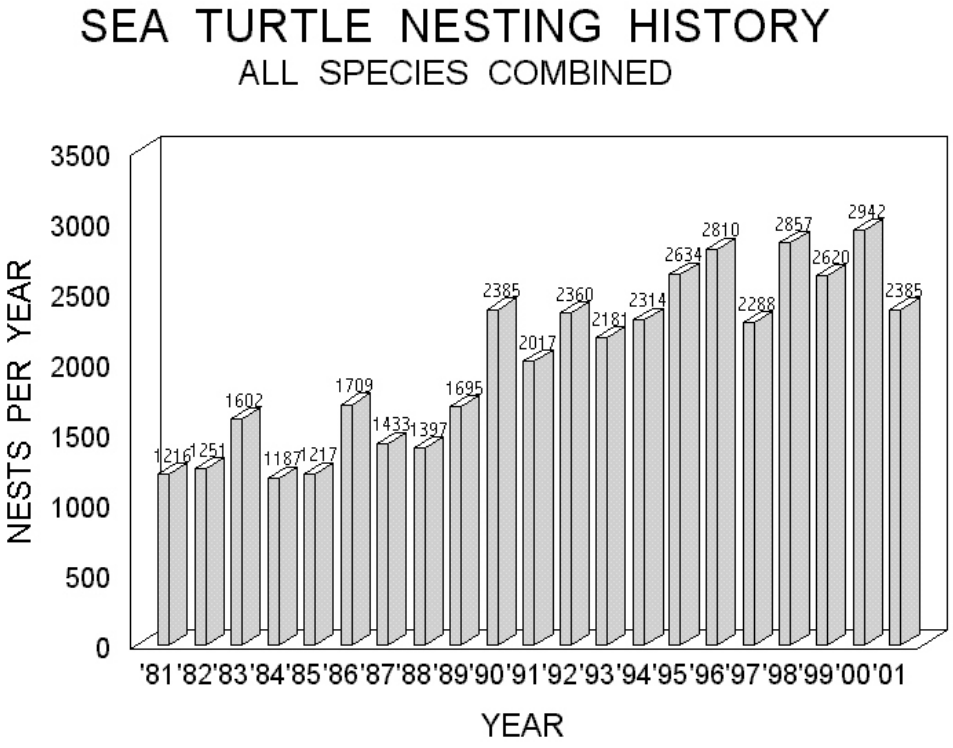

Figure 2: The pattern of total sea turtle nesting in Broward County since full surveys commenced in 1981.

Figure 3 shows the yearly nesting trends of loggerhead, green and leatherback sea turtles. The loggerhead nest count declined only 15 percent from the previous year. The positive slope of the trend line remains highly significant ($r = .905$; $P < .0001$) and suggests an average increase of about 81 nests per year, since 1981.

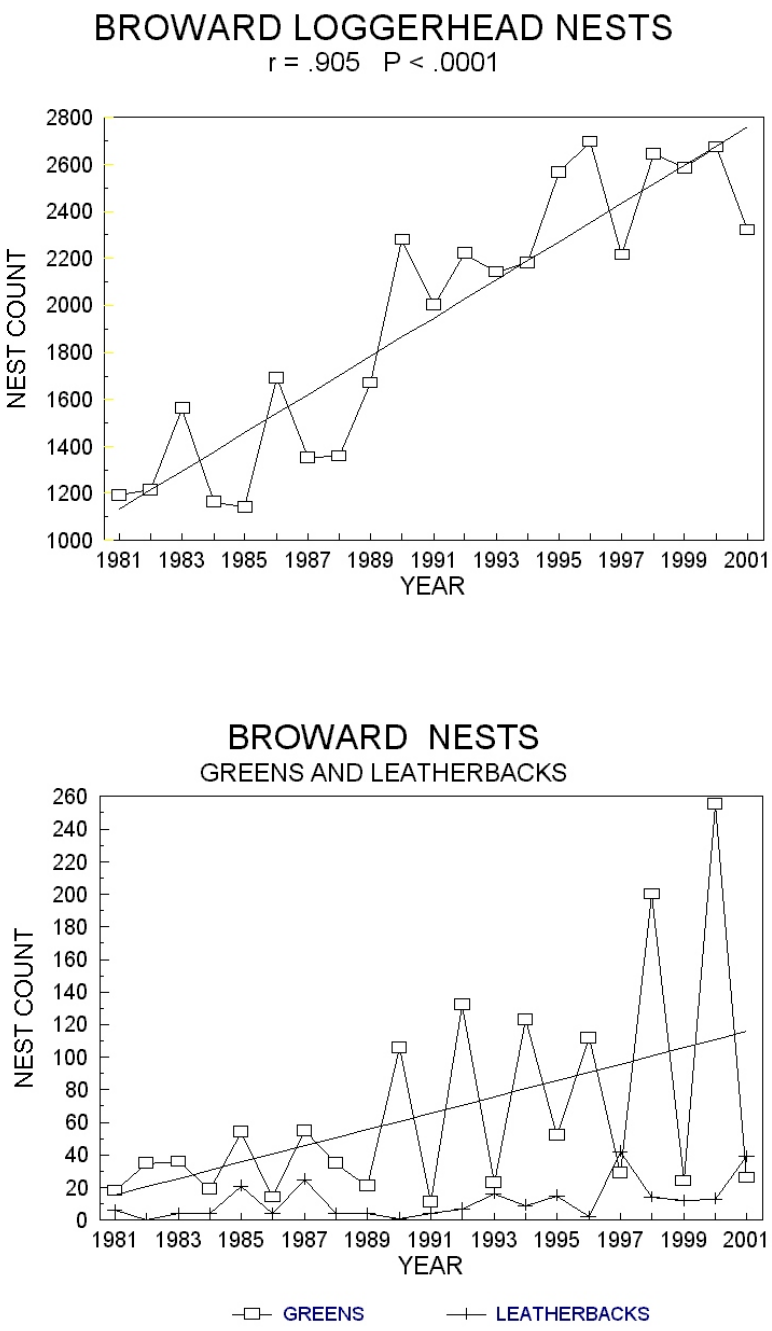

Figure 3: Historical nesting patterns of loggerhead, green and leatherback sea turtles in Broward County since 1981.

Nesting by the green sea turtle continued the alternating high-low pattern of the last 12 years, completing its sixth consecutive cycle (Fig. 3). Based on the pattern, lower numbers of green sea turtle nests were expected in 2001, and this was the case. Even with the large fluctuations, the slope of the 21-year trend line for green turtle nesting remains significantly greater than zero ($r = 0.470$; $P < .015$), suggesting an average increase of 5 nests per year since 1981. The 39 leatherback nests deposited in 2001 was the highest number since 1997 but there is still no identifiable pattern or trend in their nesting

Figure 4 shows the seasonal loggerhead nesting pattern. The first and last nest were deposited on 20 April and 28 August, both in Pompano Beach. Table 1 and Figure 5 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 highest and not statistically different. Nesting in Fort Lauderdale and Lloyd Park was intermediate and Hollywood was significantly lower than all other beaches.

The countywide seasonal nesting patterns of greens and leatherbacks are shown in Figure 6 and for the individual beaches in Figure 7. The first and last leatherback nests were deposited on 16 March and 19 June. Green turtles nested between 12 June and 21 August. Nesting counts and densities for greens and leatherbacks are shown in Table 2 and Table 3, respectively. Nesting by greens was significantly highest in Lloyd Park. Hillsboro Beach and Fort Lauderdale were intermediate and Hollywood and Pompano Beach experienced significantly lower nesting. Leatherback nesting was significantly highest in Hillsboro Beach and lowest in Lloyd Park, with the other beaches forming an intermediate, statistically overlapping group.

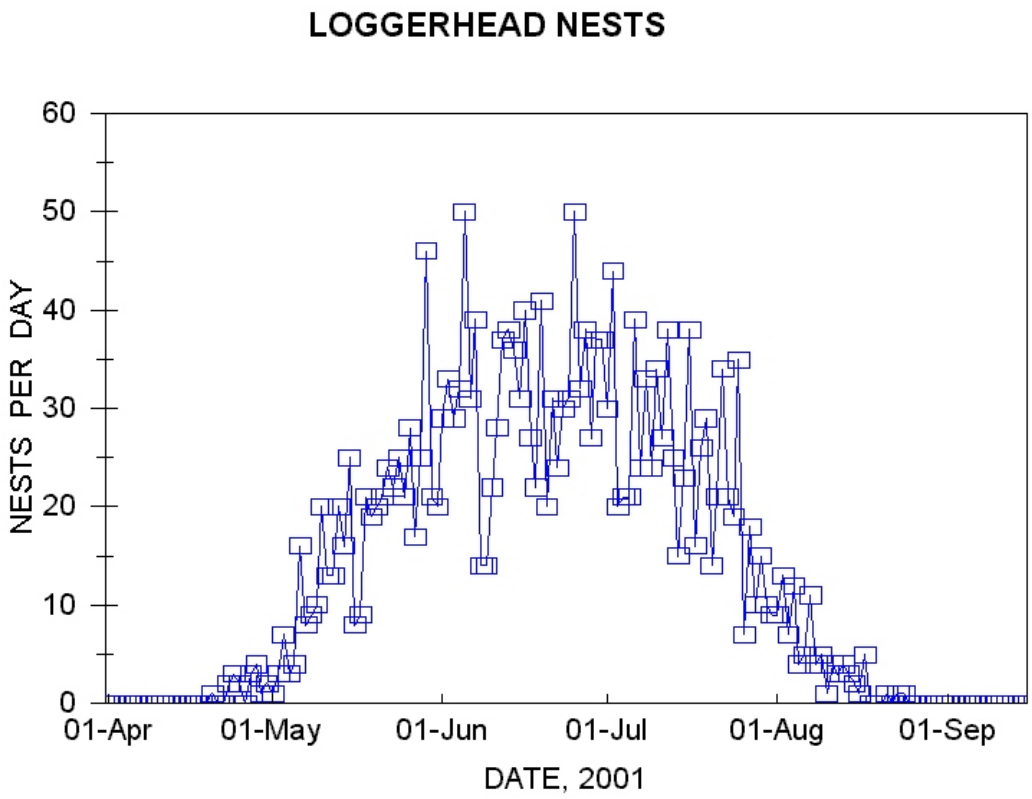

Figure 4: The seasonal pattern of daily loggerhead nesting in Broward County, 2001.

Table 1: Total loggerhead nests and nesting densities expressed as nests-per-kilometer for the 2001 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	
Hillsboro Beach	628	7.0	89.7	.534	A
Pompano Beach	648	7.7	84.2	.500	A
Ft. Lauderdale	688	10.6	64.9	.386	B
Lloyd Park	206	3.9	52.8	.314	B
Hollywood	150	9.4	16.0	.095	C
OVERALL	2320	38.6	60.1		

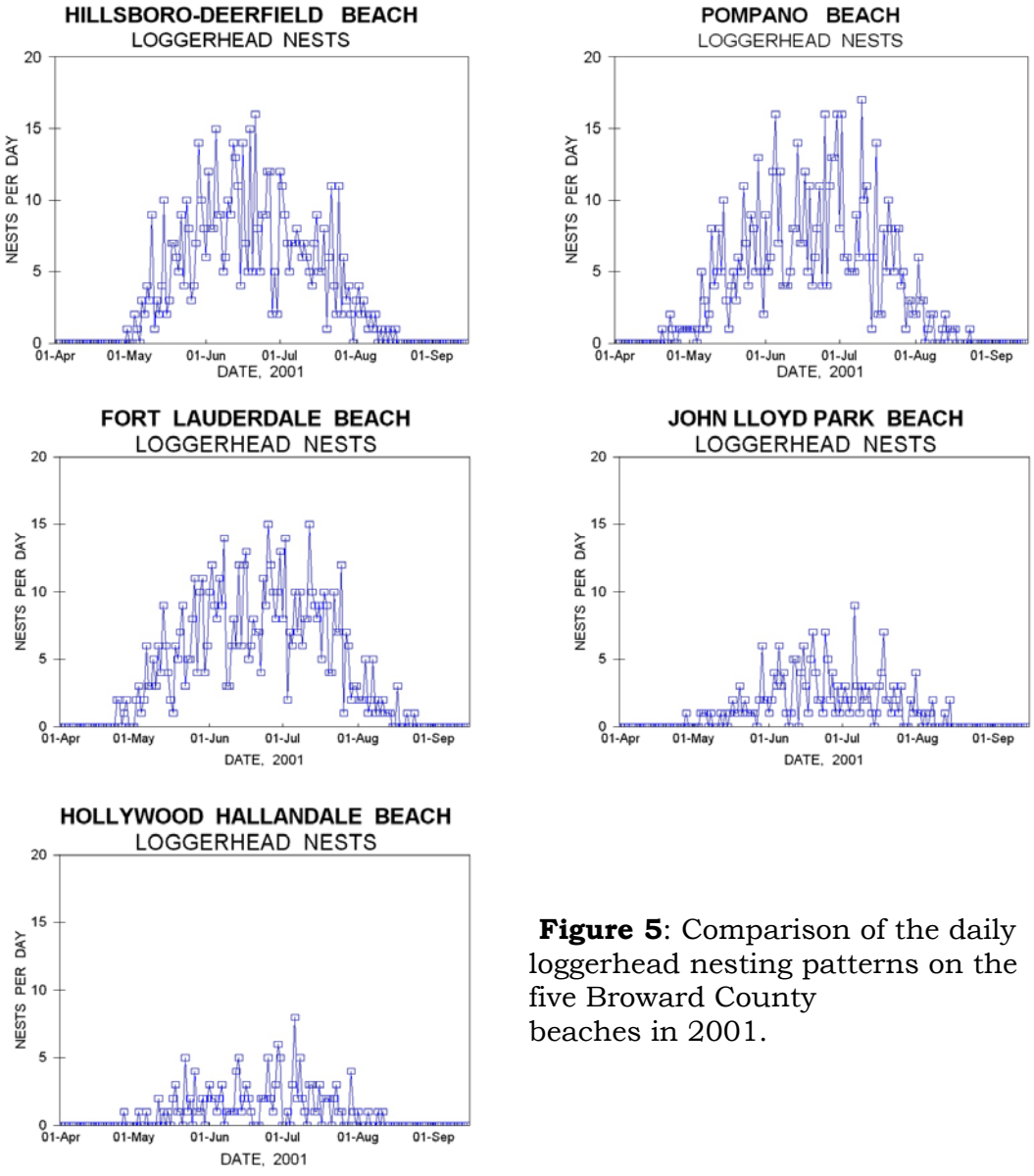

Figure 5: Comparison of the daily loggerhead nesting patterns on the five Broward County beaches in 2001.

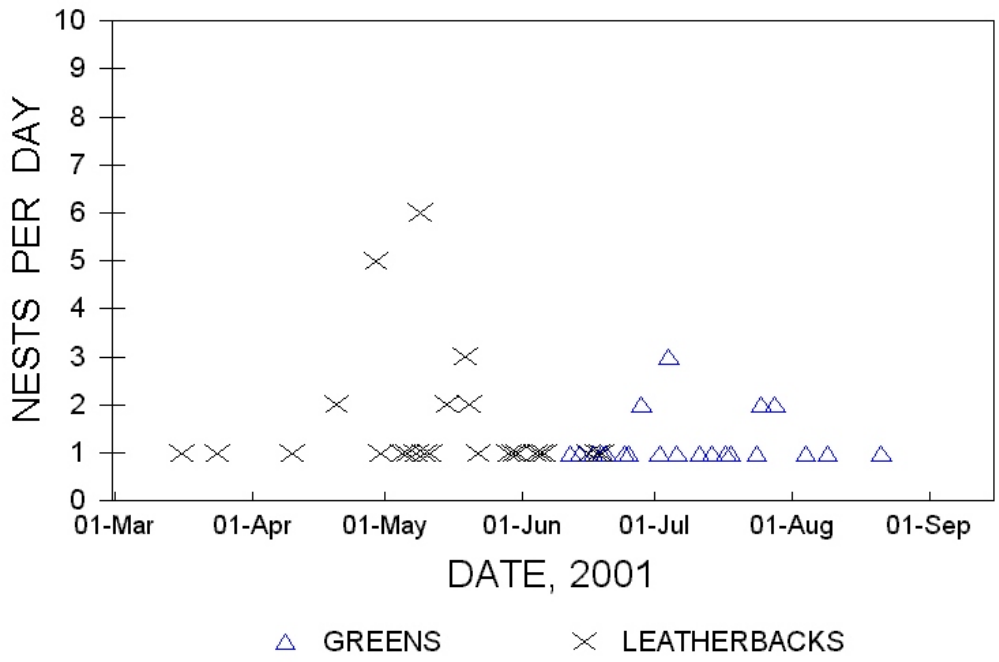

Figure 6: The seasonal pattern of daily green and leatherback nesting in Broward County, 2001.

Figure 8 plots the sequence of leatherback nests versus Julian date. Vertical sections of the curve show the most heavily nested time periods. There was a maximum of 11 nests deposited in the 9-day interval represented by the horizontal bar. Since 9 days is the minimum internesting interval for an individual (Eckert et. al, 1989: Miller, 1997), there were at least 11 leatherbacks nesting this year.

Figure 9 shows nest counts for each species in each 1000-foot zone of Broward County beach (1-km zones in Lloyd Park) during 2001. As in previous years, 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. Green turtles nested throughout

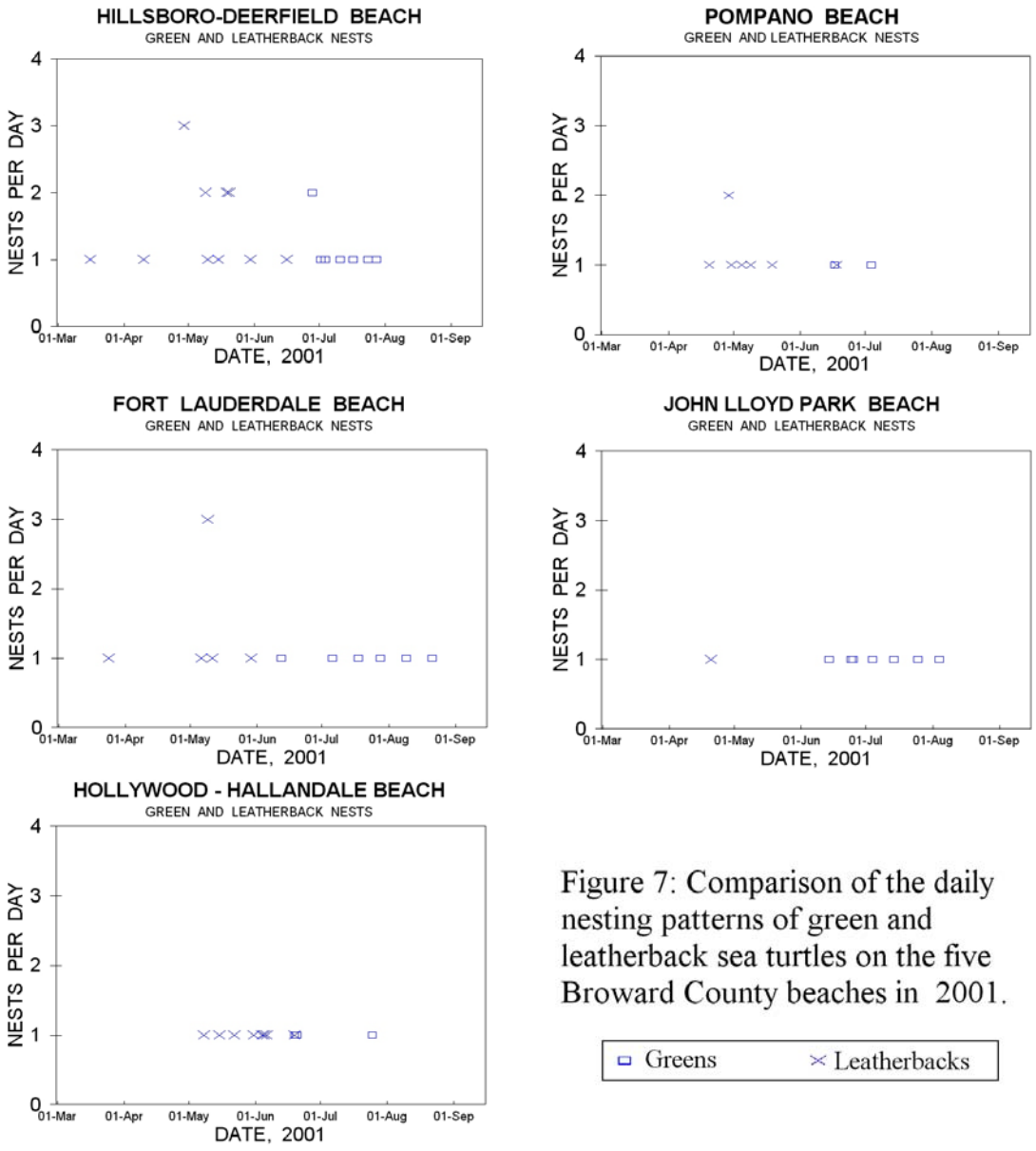

Figure 7: Comparison of the daily nesting patterns of green and leatherback sea turtles on the five Broward County beaches in 2001.

Table 2: Total green turtle nests and nesting densities expressed as nests-per-kilometer for the 2001 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
Lloyd Park	7	3.9	1.8	.0106 A
Hillsboro Beach	8	7.0	1.1	.0068 AB
Ft. Lauderdale	6	10.6	0.6	.0034 AB
Hollywood	3	9.4	0.3	.0019 B
Pompano Beach	2	7.7	0.3	.0015 B
OVERALL	26	38.6	6.6	

Table 3: Total leatherback nests and nesting densities expressed as nests-per-kilometer for the 2001 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	15	7.0	2.1	.0108 A
Pompano Beach	8	7.7	1.0	.0052 AB
Hollywood	8	9.4	0.9	.0043 AB
Ft. Lauderdale	7	10.6	0.7	.0033 AB
Lloyd Park	1	3.9	0.3	.0013 B
OVERALL	39	38.6	6.6	

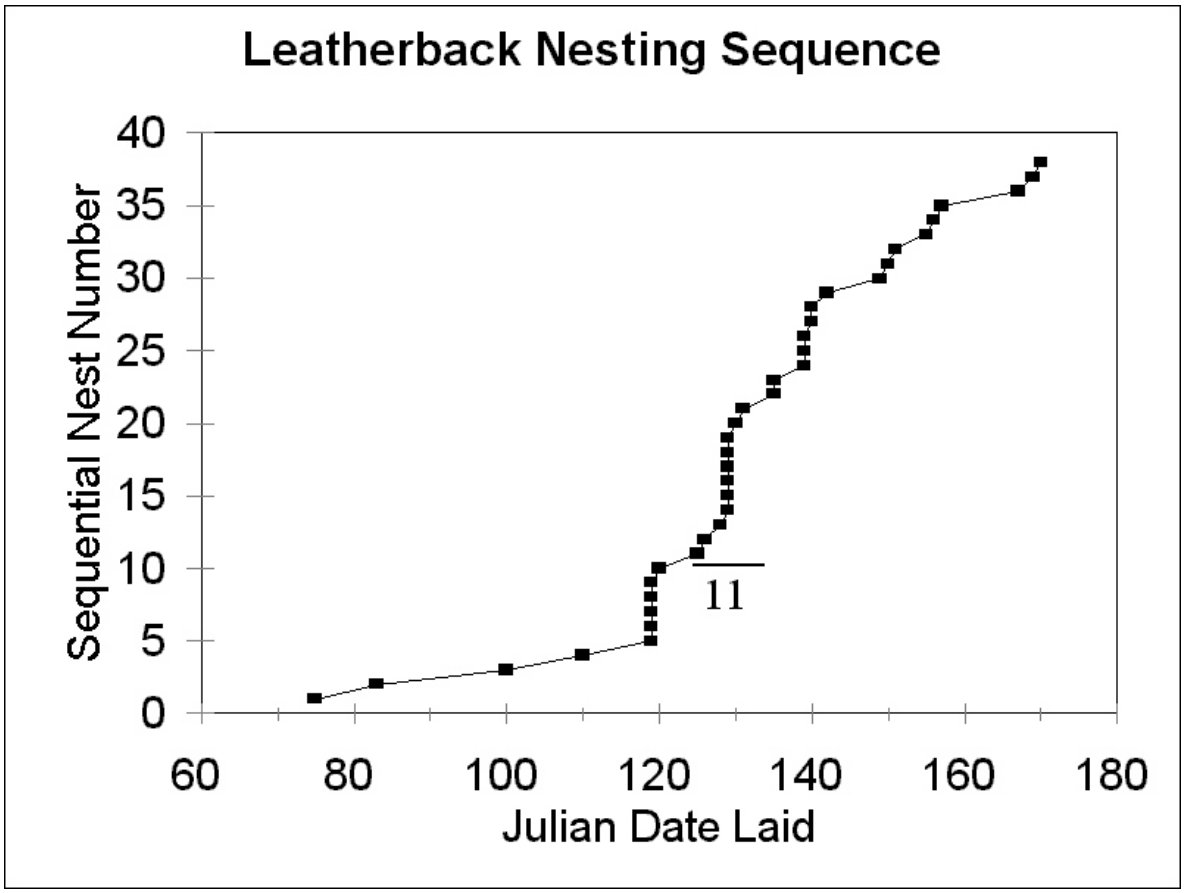

Figure 8: The sequence of leatherback nests plotted against the Julian Date of deposition. The horizontal solid line indicates the minimum nine-day internesting interval. The number below the line indicates the number of nests deposited within that interval.

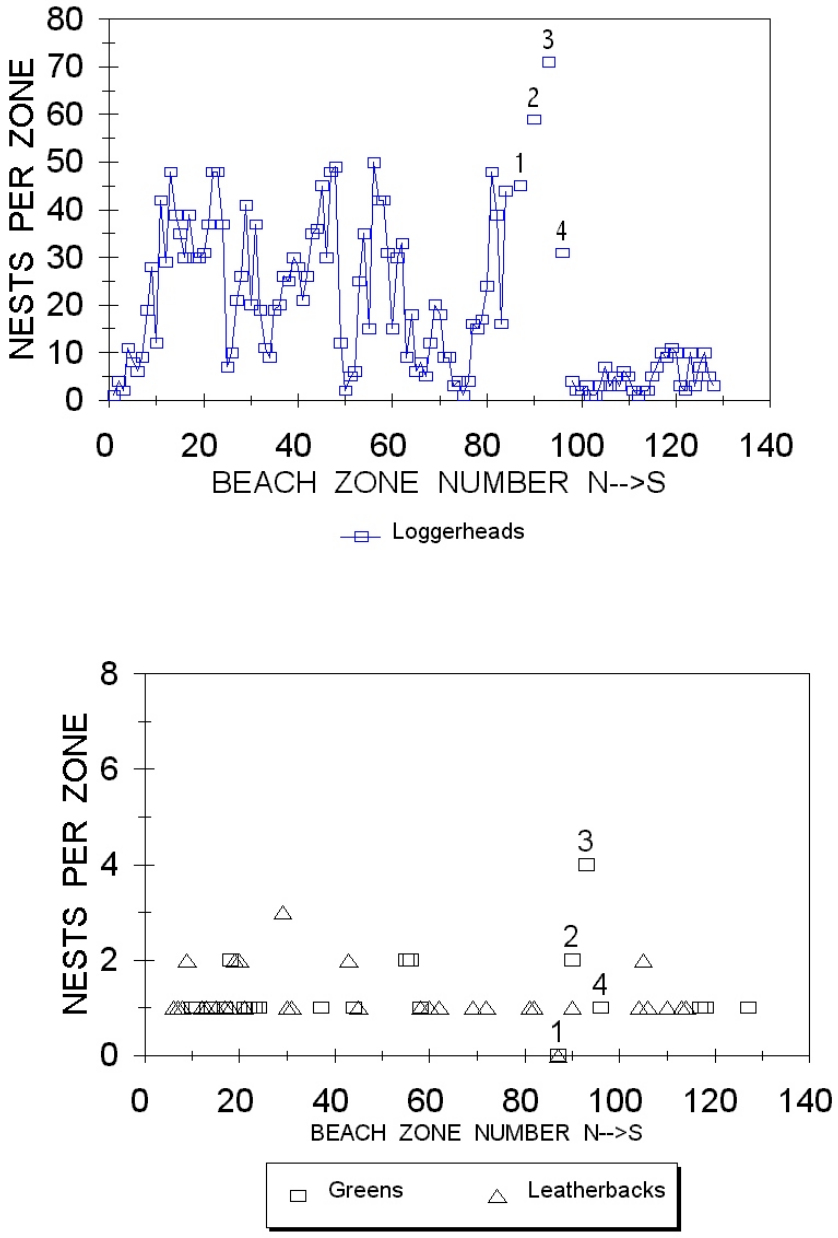

Figure 9: Locations of loggerhead, green and leatherback nests in Broward County, 2001. Numbers 1-4 indicate the four beach zones of John Lloyd Park.

the County, but more heavily in Lloyd Park. Leatherbacks also nested Countywide, but preferred Hillsboro Beach.

Figure 10 and Table 4 present the countywide distribution of nesting success for the three species. Loggerhead nesting success showed no recognizable trends but was significantly higher in Hillsboro Beach and Fort Lauderdale and lowest in Lloyd Park, with the other beaches in an intermediate statistical group. One-way ANOVA showed no significant differences in the nesting success of greens or leatherbacks throughout the County.

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 66.5 percent hatching success rates of relocated loggerhead nests (Table 6) increased by 0.1 percentage point from last season, but the 79.9 percent success of *in situ* loggerheads increased by 11.9 points. This difference was highly significant. The hatching success of *in situ* nests of greens was higher and leatherbacks were lower than the successes of their respective relocated nests, but these differences have little meaning because of the low numbers of evaluated nests of both species.

Figure 11 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 ($p = 0.185$). Figure 12 shows the frequency distributions for hatching success in relocated and *in situ* nests. A Mann

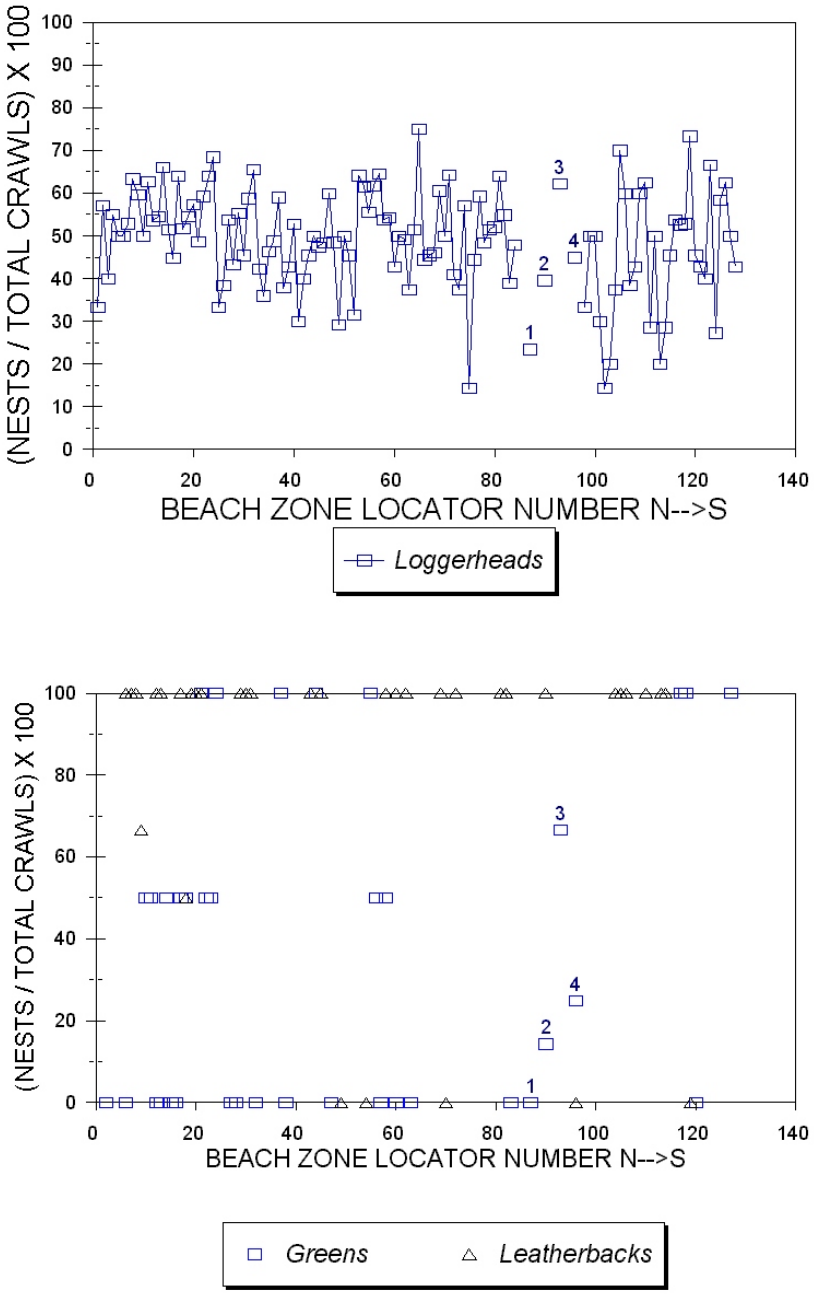

Figure 10: The distribution of the nesting success of loggerhead, green and leatherback turtles across Broward County, 2001. Numbers 1-4 indicate the four beach zones of John Lloyd Park.

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 2001. Newman-Keuls (NK) designations for loggerheads as in Table 2. One-way ANOVA detected no significant differences in nesting success for greens or leatherbacks.

BEACH	**Loggerheads**				**Greens**			**Leatherbacks**		
	Nests	FC	NS	NK	Nests	FC	NS	Nests	FC	NS
Hillsboro Beach	628	480	56.7	A	8	15	34.8	15	2	88.2
Ft. Lauderdale	688	613	52.9	A	6	8	42.9	7	2	77.8
Pompano Beach	648	729	47.0	AB	2	6	25.0	8	1	88.9
Hollywood	150	168	47.2	AB	3	1	75.0	8	1	88.9
Lloyd Park	206	318	39.3	B	7	19	26.9	1	1	50.0
OVERALL	2320	2308	50.1		26	49	34.7	39	7	84.8

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

	Loggerheads	Greens	Leatherbacks	Totals
RELOCATED				
Open Beach				
Hillsboro Beach				
BH	58	0	0	58
BH1	446	1	0	447
BH900s	830	5	0	835
BH1000s	8	0	0	8
BH1100s	13	0	0	13
Hollywood Beach	2	0	0	2
Hatcheries				
Pompano	29	0	1	30
Ft. Lauderdale	30	0	1	31
Hollywood	72	0	0	72
TOTALS	1488	6	2	1496
IN SITU				
Hillsboro Beach	487	7	15	509
Pompano Beach	64	1	7	72
Ft. Lauderdale	60	5	6	71
Hollywood	15	0	8	23
TOTALS	626	13	36	675
GRAND TOTALS	2114	19	38	2171

Table 6: Total egg counts, released hatchlings and overall release successes for *in situ* and relocated nests of loggerheads, greens and leatherbacks in 2001.

SPECIES	NUMBER OF EGGS	EVAL. NESTS	HATCHLINGS RELEASED	RELEASE SUCCESS (%)
***In situ* Nests**				
C. caretta	23838	223	19045	79.9
C. mydas	420	4	344	81.9
D. coriacea	516	5	365	70.7
Total	24774	232	19754	79.7
Relocated Nests				
C. caretta	138351	1255	92021	66.5
C. mydas	270	2	138	51.1
D. coriacea	174	2	62	35.6
Total	129866	1229	85833	66.1
Overall				
C. caretta	162189	1478	111066	68.5
C. mydas	690	6	482	69.9
D. coriacea	690	7	427	61.9
TOTAL	163569	1491	111975	68.5
Predated and Unevaluated Nests and Eggs				
	Predated Nests	Pred. Eggs	Unevaluated Nests	Unevaluated Eggs
***In Situ* Nests**				
C. caretta	31	-	373	-
C. mydas	0	-	10	-
D. coriacea	0	-	31	-
Relocated				
C. caretta	54	6910	178	18185
C. mydas	0	0	3	260
D. coriacea	0	0	0	0

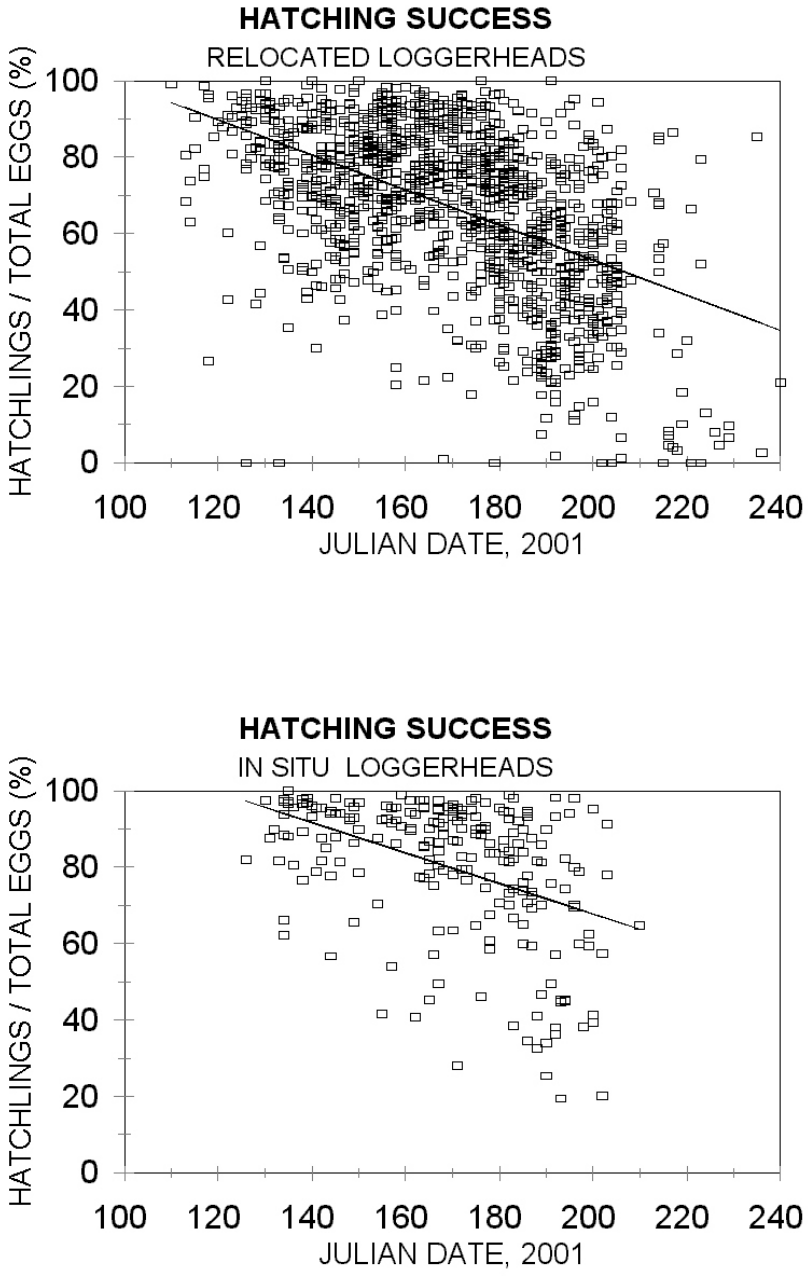

Figure 11: Comparison of seasonal hatching success for relocated and *in situ* loggerhead nests during 2001.

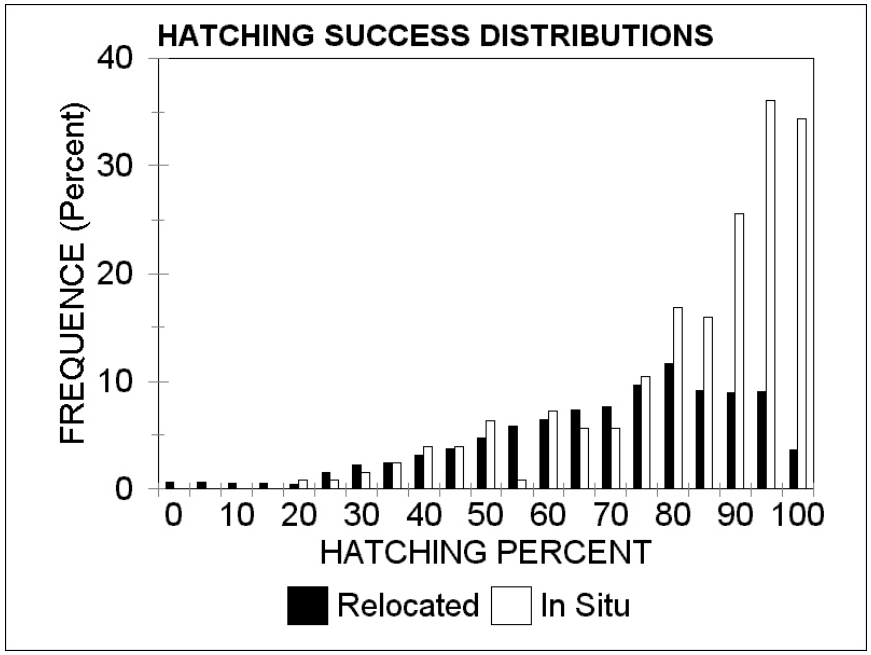

Figure 12: Hatching success frequencies for *in situ* and relocated loggerhead nests in 2001.

Whitney U test indicated a very significant difference in the medians of these distributions ($Z = 9.72$; $p << .001$).

Figure 13 shows the historical patterns of the yearly hatching success of all species combined, since 1981. Overall hatching success of all species combined (66.1 %) was identical to last year in relocated nests but increased 11.7 percentage points to 79.7% for *in situ* nests (Table 6).

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.

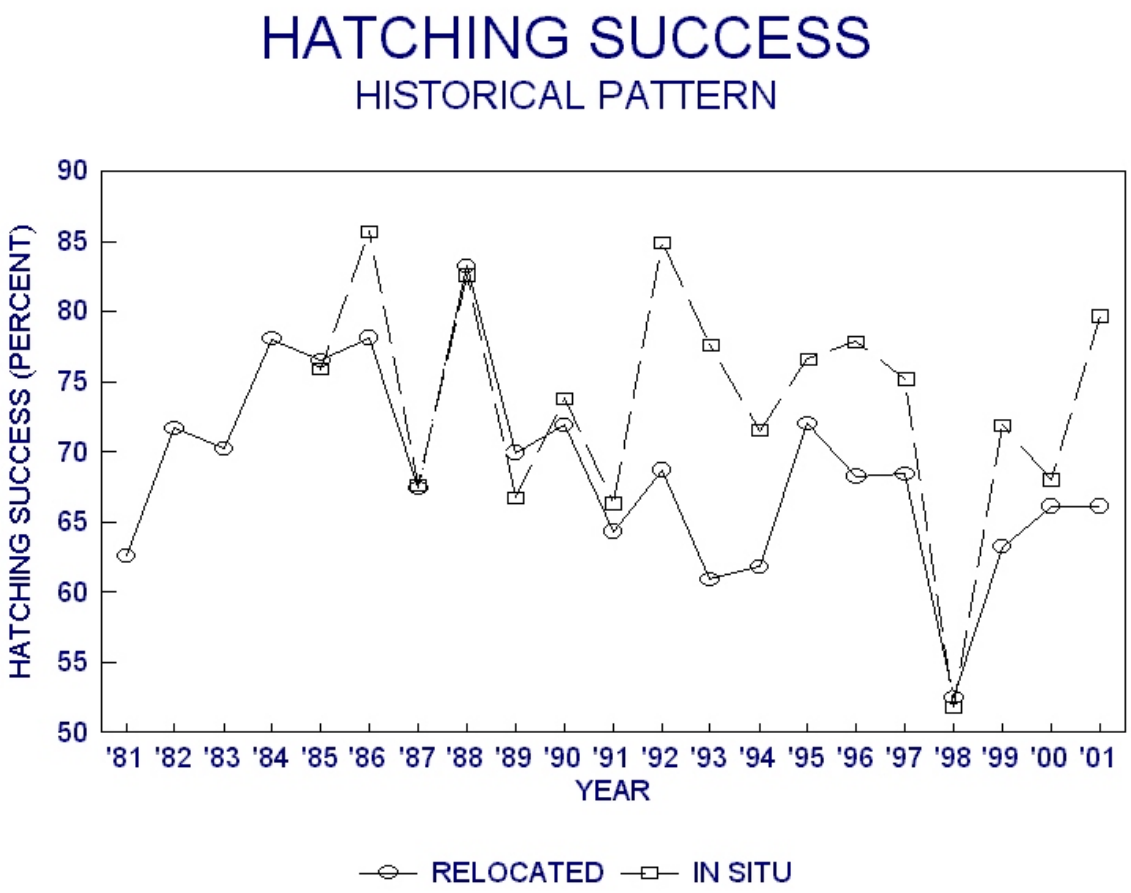

Figure 13: The historical patterns of yearly hatching success for all evaluated *in situ* and relocated sea turtle nests, since 1981.

Table 7: Accounting of the status of all hatched and unhatched eggs in investigated *in situ* and relocated loggerhead nests during 2001.

Location	Total Eggs	Emerged Hatchlings (%)	LIN (%)	DIN (%)	PIP Live (%)	PIP Dead (%)	VD (%)	NVD (%)
***In situ* Nests**								
Hillsboro Beach	18854	72.7	5.2	3.2	0.6	4.9	6.6	6.7
Pompano Beach	2459	81.3	5.3	1.7	0.2	2.2	2.2	7.0
Ft. Lauderdale	1993	71.0	9.8	4.0	0.8	5.0	4.4	5.0
Hollywood Beach	532	72.6	15.6	0.8	1.3	7.1	0.8	1.9
Relocated Nests								
Hillsboro Beach								
BH	4558	47.4	11.9	1.6	2.3	15.5	7.1	14.1
BH1	44746	55.4	15.2	2.9	2.9	14.2	1.9	7.5
BH900s	73594	45.4	11.4	3.6	2.0	19.1	8.6	9.9
BH1000s	354	63.6	10.2	0.3	4.0	12.7	1.4	7.9
BH1100s	671	54.5	24.3	1.2	2.5	8.3	2.1	7.9
Hollywood Beach	91	92.3	2.2	1.1	0.0	0.0	2.2	2.2
Hatcheries								
Pompano	3106	67.9	9.0	1.4	1.3	8.2	4.2	7.9
Ft. Lauderdale	3445	82.9	5.1	0.8	1.2	2.2	0.8	7.0
Hollywood	7786	77.5	7.2	1.3	0.9	2.9	1.8	8.3

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 2001. Abbreviations as in Table 7.

Location	Total Eggs	Emerged Hatchlings (%)	LIN (%)	DIN (%)	PIP Live (%)	PIP Dead (%)	VD (%)	NVD (%)
***In situ* Nests**								
Hillsboro Beach	312	72.1	4.2	2.2	0.0	17.0	1.6	2.9
Ft. Lauderdale	108	98.1	0.0	0.0	0.0	0.0	0.0	1.9
Relocated Nests								
Hillsboro Beach								
BH1	125	43.2	31.2	4.8	0.0	16.0	0.8	4.0
BH900s	145	11.0	13.1	8.3	6.9	44.8	10.3	5.5
Hatcheries	0	0	0	0	0	0	0	0

Table 9: Accounting of the status of all hatched and unhatched eggs in investigated *in situ* and relocated leatherback nests during 2001. Abbreviations as in Table 7.

Location	Total Eggs	Emerged Hatchlings (%)	LIN (%)	DIN (%)	PIP Live (%)	PIP Dead (%)	VD (%)	NVD (%)
***In Situ* Nests**								
Hillsboro Beach	117	53.0	31.6	1.7	0.0	6.8	0.9	6.0
Pompano Beach	183	38.8	4.9	0.0	0.0	2.7	7.7	45.9
Ft.Lauderdale	216	84.3	1.9	0.9	0.0	1.4	5.1	6.5
Relocated Nests								
Hatcheries								
Pompano	102	49.0	5.9	2.0	0.0	3.9	17.6	21.6
Ft.Lauderdale	72	4.2	4.2	0.0	0.0	1.4	31.9	58.4

DISCUSSION

Yearly Nesting Trends

This year's total nest count was the lowest since 1997 (Fig. 2). This was also the case for loggerheads (Fig. 3). Despite the drop, the slope of the loggerhead trend line remains highly significant. Such declines in nest counts may be due to an overall reduction in the size of the sea turtle populations or they may result from a smaller proportion of the female population entering the nesting phase in a given year. Female sea turtles do not usually reproduce every year and the remigration interval can range from 1 to 9 years with reproduction occurring when sufficient fat reserves have accumulated to allow for the completion of vitellogenesis. This accumulation of energy reserves may require several years (Miller, 1997). A third factor that can cause decreases in nesting densities is year-to-year variations in the average number of clutches deposited per nesting female. Frazer and Richardson (1985) reported that mean yearly loggerhead clutch frequencies varied from 4.18 to 2.81 nests/female/year on Little Cumberland Island, GA from 1979 to 1982. Such variations would easily account for the decreased loggerhead nesting in Broward County this year (Fig. 3).

The very large decline in green turtle nesting from last year's record was expected because of the two year nesting cycle established over the last decade. The leatherback nest count was the highest since 1997 and the second highest on record. Analysis of the nesting sequence (Figure 8) showed that a maximum of 11 nests were deposited within the 9-day minimum internesting interval (Eckert et al., 1989; Miller, 1997) so a minimum of 11 leatherbacks nested this year. A similar analysis in 1997

suggested a minimum of 8 nesting leatherbacks. This year's nesting sequence also showed evidence of a synchronized 9-day minimum internesting interval beginning on Julian day 119 (April 29) as indicated by the time between the vertical segments of the curve. This interval became less distinct later in the season. Such synchronization was not as evident in 1997.

Seasonal Nesting Patterns

The seasonal pattern of loggerhead nesting in Broward County (Fig. 4) again conformed to the historical norm, showing a relatively symmetrical bell-shaped trend with the first nest in mid April, the last nest in late August and the midpoint of the season in mid to late June. Seasonal nesting at the individual beaches (Fig. 5) also showed no obvious deviations from historical expectations. As in 2000 (Burney and Margolis, 2000), loggerhead nesting per kilometer was highest at Pompano Beach and Hillsboro Beach, significantly lower in Fort Lauderdale and Lloyd Park, and lowest of all in Hollywood.

The seasonal pattern of green turtle nesting (Fig. 6) was typical of previous low nesting years (Burney and Margolis, 1999) with nesting beginning in mid June and ending in late August. 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 reduced beachfront lighting and human activity on these beaches. Their nesting was highest in Lloyd Park, intermediate in Hillsboro and Fort Lauderdale and lowest in Hollywood and Pompano (Table 2, Fig. 7). Leatherback nesting densities were highest

in Hillsboro and lowest in Lloyd Park, with the other beaches forming an intermediate, statistically overlapping group (Table 3).

County-wide Nest Distribution

The distribution of loggerhead nests in the 128 survey zones (Figure 9) 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 was not large enough to establish such a detailed horizontal nesting pattern, except for their apparent preference for darker beaches with less nocturnal disturbance. The same is true for leatherbacks.

Nesting Success

Overall loggerhead nesting success (Fig. 10, Table 4) increased slightly from 49.1 percent in 2000 to 50.1 percent in 2001, but unlike last year, a 1-way ANOVA and Newman-Keuls test detected differences among the beaches. Nesting success was significantly highest in Hillsboro Beach and Fort Lauderdale, lowest in Lloyd Park and intermediate in Pompano and Hollywood. The lowest nesting success (14.3%) occurred in zones R-75 on the Fort Lauderdale strip and R-102 in north Hollywood where homes are built directly on the beach. 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. 10) and nesting density (Fig. 9) 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. Multiple regression analysis of 1999 loggerhead nesting data suggests that over 36 percent of the variance in loggerhead nesting north of the Port Everglades inlet can be explained by a combination of beach-front light intensity and the level of public access (C. Mattison, in prep).

The overall green turtle nesting success of 34.7% (Table 4) declined 16 percentage points from 2000, but there was a much smaller nesting population this year. Leatherback nesting success increased 8.3 points to 84.8 percent. There were no statistical differences in the nesting success of these species on five beaches.

Hatching Success

Unlike last year, there was a highly significant difference in the success of *in situ* and relocated nests (Table 6, Fig. 13), however the difference was caused by an increase in the success of *in situ* nests rather than a decrease in the relocated nests. The overall hatching success of relocated nests in 2001 was identical to 2000 (Fig. 13). Hatching successes of both *in situ* and relocated loggerhead nests showed the usual seasonal declines (Fig. 11) and the slopes of the trend lines were not statistically different. However, there was a large statistical difference in the medians of the two distributions (Fig. 12). *In situ* nests had much higher frequencies of nests with 80 percent or higher hatching success rates. The mode of the distribution for relocated nests was at 80 percent, with higher frequencies in the intermediate percentages. The difference in the two distributions was not due to high frequencies of low hatching nests (20 percent or less) in relocated nests, but to a decrease in the frequencies of nests hatching at rates of 85 percent or more. The absence of high frequencies of low hatching relocated nests suggests that the lower overall

hatching success of these nest was not due to careless handling of the eggs or improper technique which would cause catastrophic nest failure. Part of the difference in the hatching success distributions (Fig. 12) may have been related to the seasonal decline in hatching success which may be caused by increasing beach temperatures and increasing instances of nest overwash later in the season. Whatever the cause, the rates of decline were not statistically different in relocated and *in situ* nests. Figure 11 shows that more late season relocated nests were evaluated, compared to *in situ* nests. This is because we stopped evaluating *in situ* nests after we were sure that more than 200 nests had been examined, which was the number specified in our contract. As in previous years, Table 7 shows that the largest percentages of unemerged hatchlings or unhatched eggs in nests relocated to Hillsboro Beach were pipped-dead and live-in-nest. 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 and live-in-nest hatchlings would not be due to hatchery crowding. In addition, the percentages of pipped-dead eggs and unemerged live hatchlings were much lower for the early nests which were relocated to the restraining hatcheries, suggesting that the higher percentages in these categories in nests relocated to Hillsboro Beach were not entirely caused by the relocation process. The numbers of evaluated green and leatherback nests were too low to make meaningful comparisons of the post hatching nest evaluation data (Tables 8 and 9).

Severe beach erosion in Hillsboro Beach (especially at the Hillsboro Club) has greatly reduced the space available for nest relocation and hindered beach patrols. This forced us to transport nests to beach areas

farther to the north of our traditional sites. This increased the workload and some of the northern areas may have been less suitable incubation sites that were more susceptible to inundation late in the season. The availability of suitable hatchery sites for the upcoming season is in doubt. Beach lighting restrictions in Pompano Beach may allow more nests to be left *in situ*. This was done to a limited extent this year, but most of the suitable areas came into lighting compliance late in the season. If there is continued (and expanded) compliance next season, a greater number of nests could be left *in situ*, but this alone will not immediately solve the hatchery site problem.

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

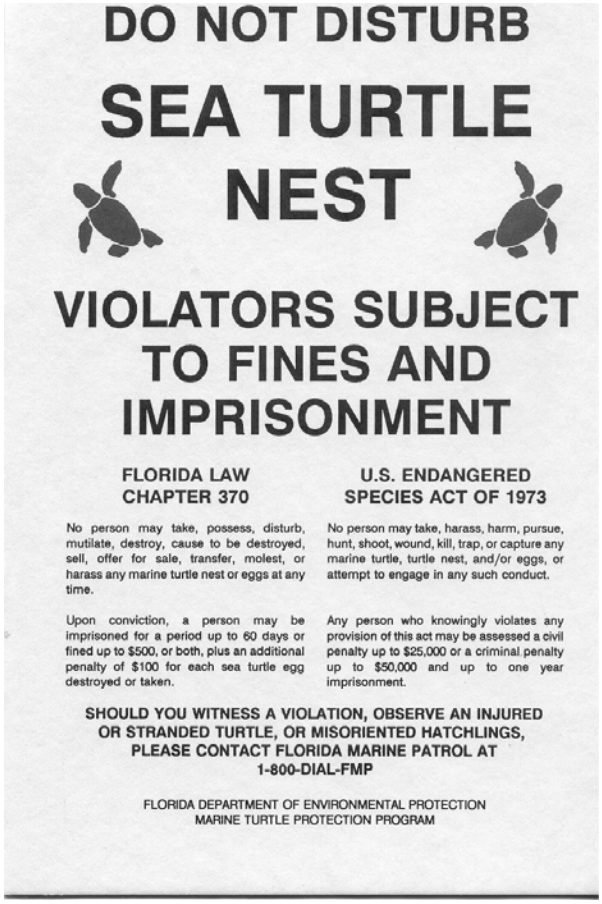
SUBJECT	HOT-LINE
ATV ACCIDENTS	1
LIVE STRANDINGS	3
DISORIENTATIONS	15
NEST LOCATIONS	80
POACHING	2
OTHER	>300
OVERALL	> 400

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 18 to Sept. 14 at the Anne Kolb Nature Center. These slide show presentations were followed by hatchling releases near Greene St. in Hollywood. Turtle talks were also given at the Hillsboro Club, an environmental camp and a summer school program.

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