

TECHNICAL REPORT 98-

SEA TURTLE CONSERVATION  
PROGRAM  
BROWARD COUNTY, FLORIDA  
1998 REPORT

Submitted by:

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For the:

BROWARD COUNTY BOARD OF COUNTY COMMISSIONERS  
DEPARTMENT OF NATURAL RESOURCE PROTECTION  
BIOLOGICAL RESOURCES DIVISION

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## INTRODUCTION

Since 1978, the Broward County Department of Natural Resource Protection (DNRP) 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 DNRP and conducted by the Nova Southeastern University Oceanographic Center under Marine Turtle Permit #108, issued to the DNRP by the FDEP Institute of Marine Research, St. Petersburg, Florida. The DNRP is especially concerned with any environmental effects of intermittent beach nourishment projects on shorelines and the offshore reefs. As part of this concern, the DNRP 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 1998 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. All 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 benchmarks 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 measuring the flipper-to-flipper track width (as an index of turtle size), 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, 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, two other sites designated BH951 and BH931 were established near survey markers R19 and R21, respectively. These sites were adjacent to house numbers 951 and 931 along highway A1A. In addition, 30 nests were relocated to a recently nourished beach section located between R6 and R12 in southern Deerfield Beach and Northern Hillsboro Beach, designated BH3. Nests were moved to this site from May 23 through May 25. 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, 104 of these nests at Hillsboro Beach were excavated for post emergence examination. An additional 106 nests from Pompano Beach, Fort Lauderdale and Hollywood-Hallandale beaches were either missed during the initial surveys or were found, but the egg chambers could not be located within the mounds. These were

discovered on the morning after hatching by observing hatchling tracks and 42 of these nests were also 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 (PIP), and eggs with visible (VD) or no visible development (NVD). The numbers of hatchlings found alive in the nest (LIN) were also counted so that the percent of hatchlings naturally emerging from nests could be calculated. Live hatchlings found in nests 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 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 Styrofoam boxes 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 Pompano fenced hatchery was refilled with nests in mid July, after the first nests hatched. 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 1998 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 1998. Hatching successes of loggerhead and green nests were plotted versus deposition date, and the patterns were analyzed with linear regression and correlation analyses. The frequency distribution of the hatching success of *in situ* and relocated loggerhead nests were plotted and compared with the same distributions from 1997 with the Mann-Whitney U-test. The number of days between nest deposition and hatchling emergence was plotted versus deposition date for loggerhead nests, and compared with similar data from 1997. The mean hatching percentages and proportions of the post-hatching egg categories (LIN, DIN, PIP, VD and NVD) were tabulated by species from nests deposited or relocated at each of the individual beaches or relocation sites.

## RESULTS

Figure 1 shows the historical trend in the total number of sea turtle nests deposited in Broward County since 1981. A total of 2857 nests were counted in 1998 which represents a 24.9 percent increase from the previous year and slightly exceeds the previous 1996 record by 1.7 percent. This was the largest single-year increase since 1990.

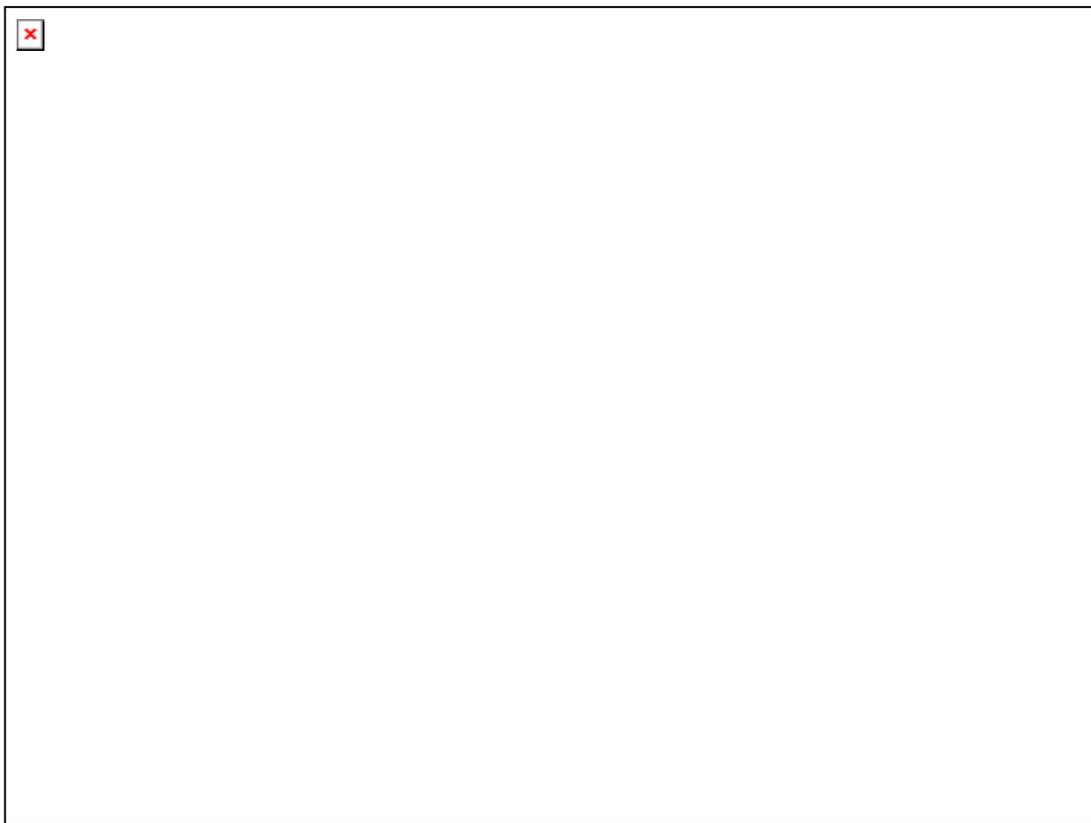


Figure 1: The pattern of total sea turtle nesting in Broward County since full surveys commenced in 1981.

Figure 2 shows the yearly nesting trends of loggerhead, green and leatherback sea turtles. The loggerhead nest count was up 19.2 percent from 1997, representing the largest single-year increase since 1990, but it fell 53 nests short of the 1996 record. The correlation coefficient of the trend line increased from 0.894 in 1997 to 0.909 this year. The slope of

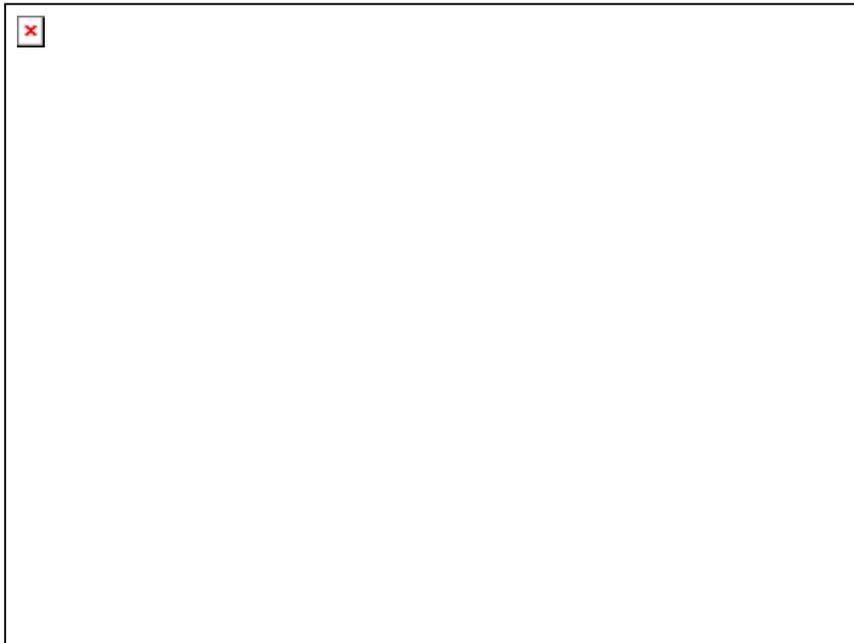


Figure 2: Historical nesting patterns of loggerhead, green and leatherback sea turtles in Broward County since 1981.

the trend line in 1998 (92 nests / year) was virtually identical to the 1997 value.

Nesting by the green sea turtle in 1998 increased dramatically from 1997 and exceeded the previous 1992 record by over 50 percent. The 1998 count was more than three standard deviations above the average of the previous 17 years. The alternating high-low pattern that commenced in 1989 continued, with 1998 representing the fifth "high nesting" year in this sequence. The slope of the 18-year trend line for green turtle nesting (Fig. 2) is now significantly greater than zero ( $r = 0.568$ ;  $P = .007$ ). Leatherback nesting declined from its record level in 1997, but this year's count remained above the previous 17-year average. No significant long-term nesting trend for leatherbacks was evident.

Figure 3 shows the seasonal loggerhead nesting pattern. The first nest was deposited on 23 April and the last was found on 13 September. Table 1 and Figure 4 give the total loggerhead nesting densities and seasonal patterns for the five beaches. Nesting densities were not statistically distinguishable throughout the County, except for Hollywood, which was significantly lower.

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 26 April and 7 June, respectively. Green turtles nested between 30 May and 6 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.

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 1998. 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 surveys began. Figure 8 and Table 4 present the countywide distribution of nesting success for the three species. Loggerhead nesting success was highest in Fort Lauderdale, but no single beach was statistically different from the others. The nesting success of greens was significantly higher on Hillsboro Beach but not statistically different on any of the other 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.

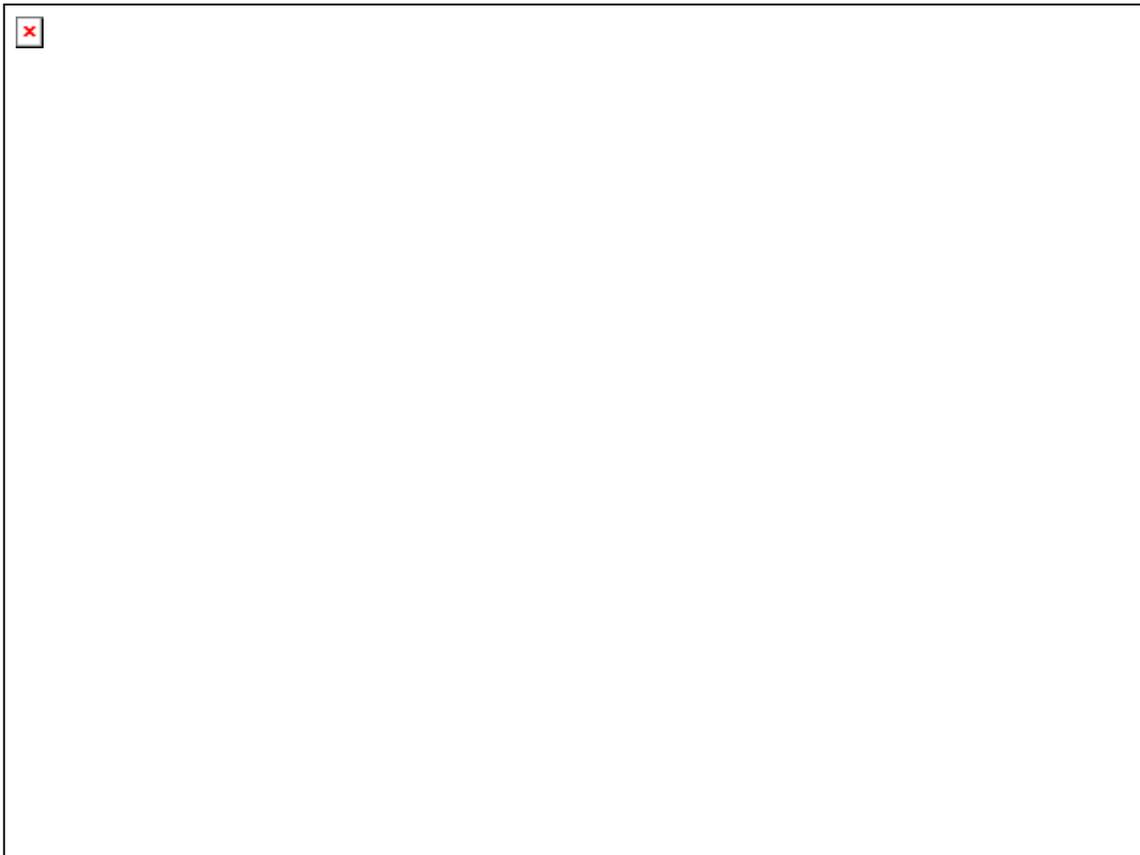


Figure 3: The seasonal pattern of daily loggerhead nesting in Broward County, 1998.

The hatching success of relocated and *in situ* loggerhead nests declined by 15.6 and 24.2 percentage points from 1997, respectively. Few greens nested in 1997, but compared to 1996 (last high-nested year) their hatching success was down by 28.3 and 32.6 percentage points in relocated and *in situ* nests, respectively. Leatherback hatching success was also lower than last year, but only 3 relocated and 3 *in situ* nests were evaluated. The hatching success of relocated loggerhead nests was slightly higher (0.9 percentage point) than for *in situ* nests, while it was 10.3 points lower in relocated green turtle 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. Figure 10 shows the same information for relocated and *in situ* green nests. Both show slight declines over time, but neither trend is significant. This was also the case for leatherbacks, however these data were not plotted because of the small number of evaluated nests.

**Table 1:** Total loggerhead nests and nesting densities expressed as nests-per-kilometer for the 1998 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
Hollywood	120	9.4	12.8	.075
Lloyd Park	253	3.9	64.9	.403
Ft. Lauderdale	864	10.6	81.5	.477
Pompano Beach	682	7.0	97.4	.530
Hillsboro Beach	724	7.7	94.0	.580
OVERALL	2643	38.6	68.5	



**FORT LAUDERDALE BEACH  
LOGGERHEAD NESTS**

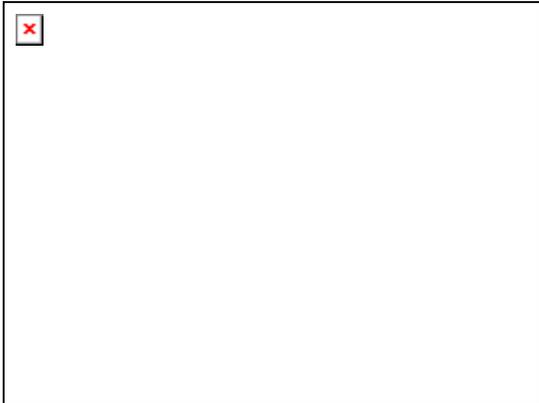
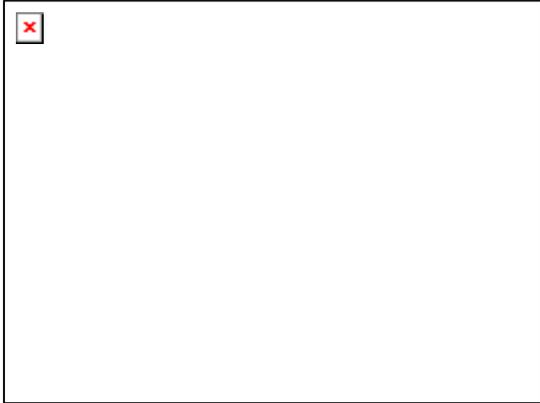
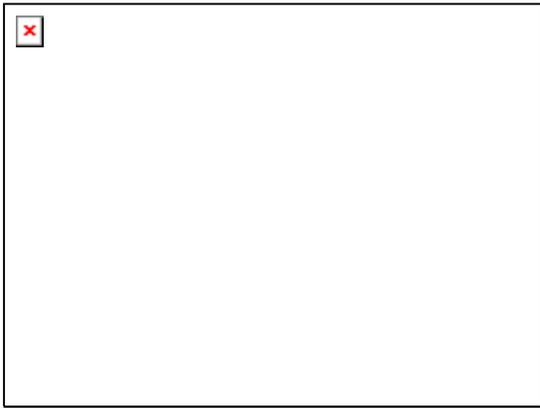
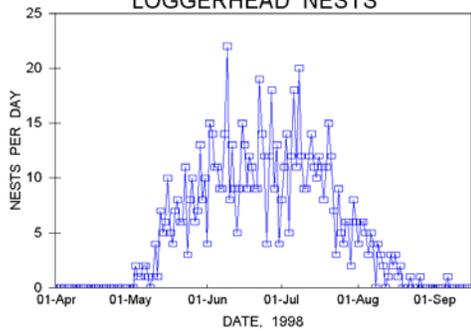


Figure 4: Comparison of the daily loggerhead nesting patterns on the five Broward County beaches in 1998

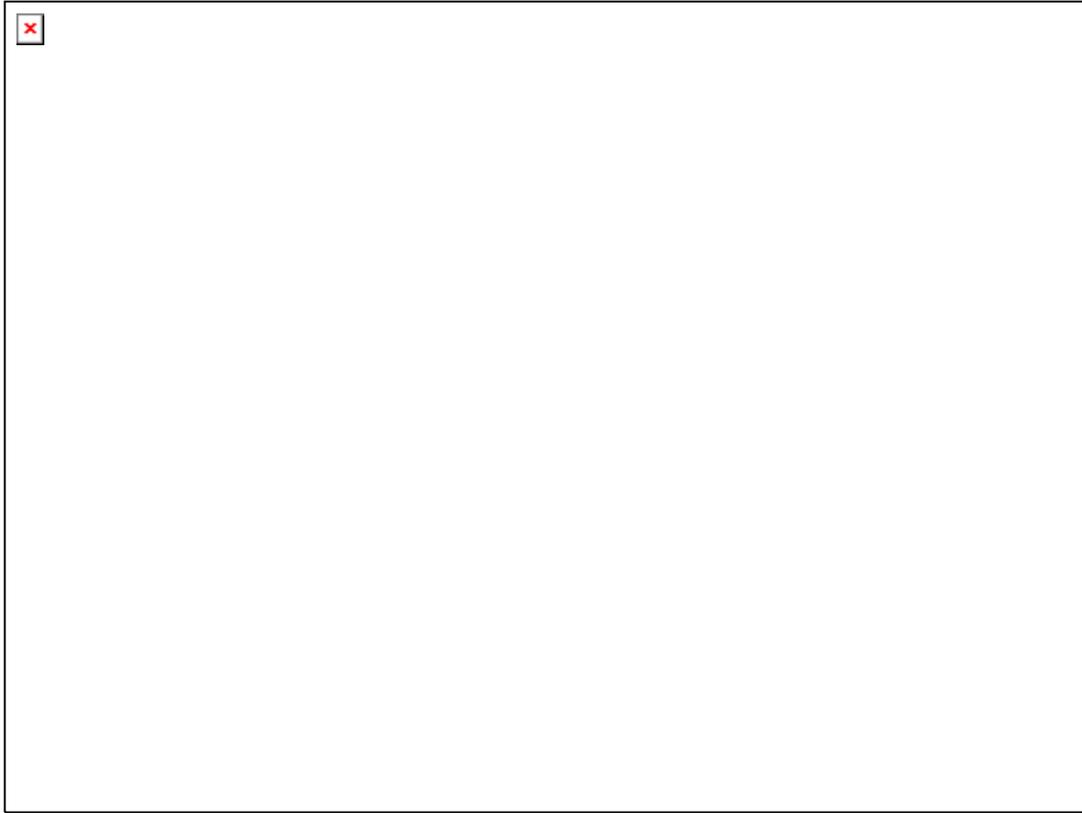


Figure 5: The seasonal pattern of daily green and leatherback nesting in Broward County, 1998

Figure 11 compares the distributions of hatching success frequencies for *in situ* and relocated loggerhead nests in 1998, compared with the 1997 distributions. In 1998, the median for both *in situ* and relocated nests were shifted significantly lower than in 1997 (Mann-Whitney U-test;  $P < .001$ ). However, the median for relocated nests was slightly, but significantly higher (U-test;  $P < .001$ ) than for *in situ* nests in 1998. This was due to the relatively high frequency of *in situ* nests hatching in the 15 to 20 percent range in 1998.

Figure 12 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 declined steeply to the lowest levels in the

history of the project.

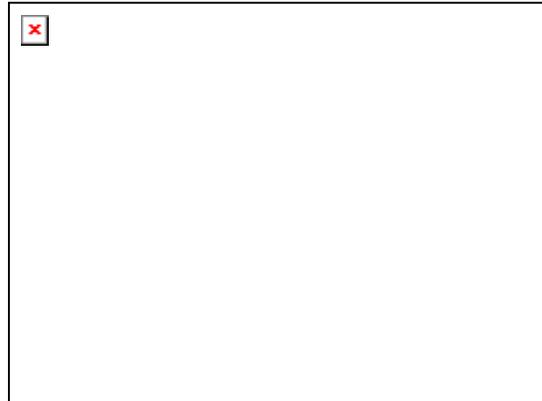
Table 7 compares emergence success and the percentages of hatchlings and eggs in the post-hatching evaluation categories for relocated and *in situ* loggerhead nests. Tables 8 and 9 give the same results for greens and leatherbacks, respectively.

**Table 2:** Total green turtle nests and nesting densities expressed as nests-per-kilometer for the 1998 season. Vertical lines at the right overlap groups whose 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
Hollywood	4	9.4	0.42	.0019
Ft. Lauderdale	21	10.6	1.98	.0118
Pompano Beach	20	7.7	2.60	.0147
Lloyd Park	21	3.9	5.38	.0321
Hillsboro Beach	134	7.0	19.1	.1140
OVERALL	200	38.6	5.18	

**Table 3:** Total leatherback nests and nesting densities expressed as nests-per-kilometer for the 1998 season.

BEACH	TOTAL NESTS	BEACH LENGTH (km)	Nests per km
Hollywood	2	9.4	0.21
Lloyd Park	3	3.9	0.77
Ft. Lauderdale	1	10.6	0.09
Pompano Beach	2	7.7	0.26
Hillsboro Beach	6	7.0	0.86
OVERALL	14	38.6	0.36



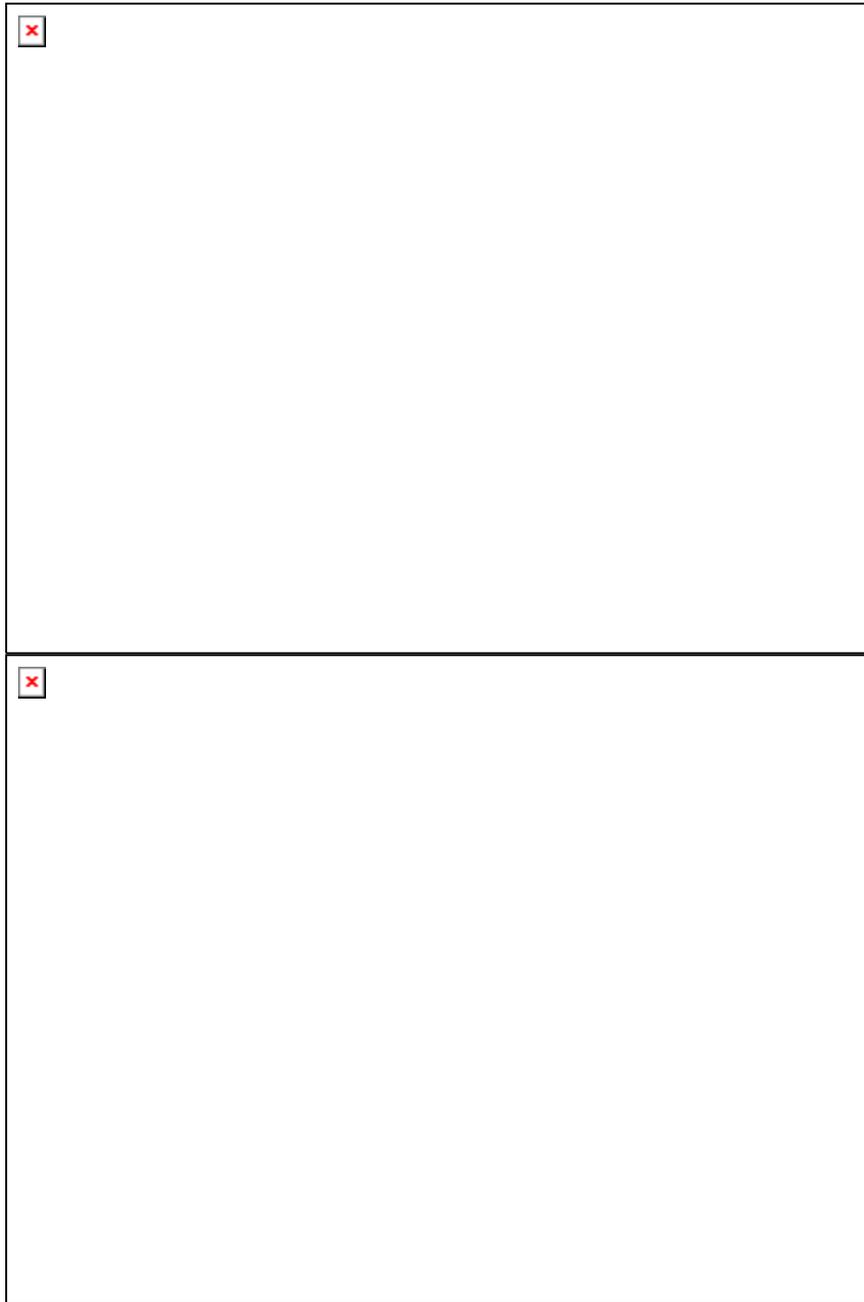


Figure 7: Locations of loggerhead, green and leatherback nests in Broward County, 1998. Numbers 1-4 indicate the four beach zones of John Lloyd Park.

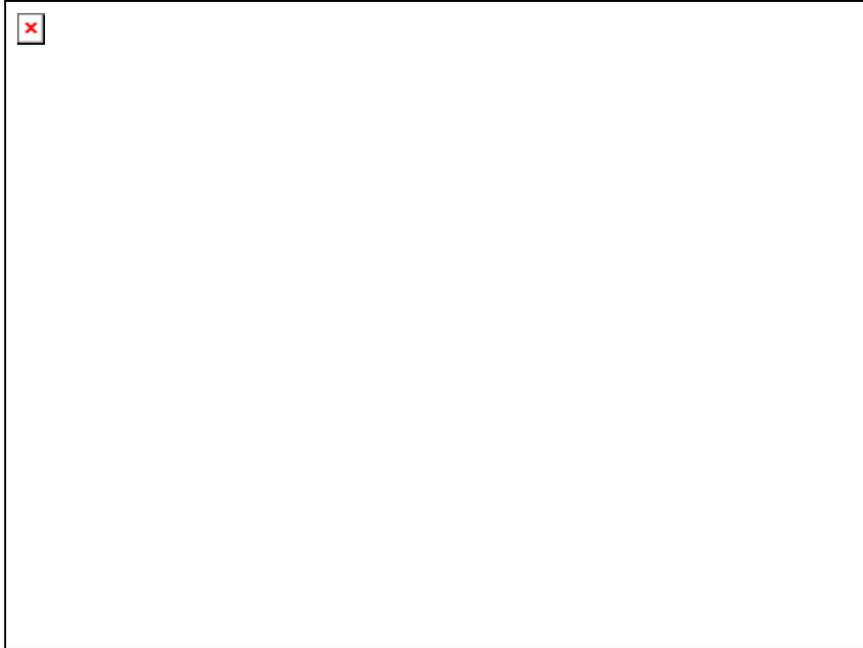


Figure 8: The distribution of the nesting success of loggerhead, green and leatherback turtles across Broward County, 1998. Numbers 1-4 indicate the four beach zones of John Lloyd Park.

**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 1998. 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
Lloyd Park	253	459	35.5		21	30	41.2		3	0	100
Hollywood	120	258	31.7		4	12	25.0		2	3	40.0
Pompano Beach	724	1221	37.2		20	35	36.4		2	1	66.7
Hillsboro Beach	682	1086	38.6		134	170	44.1		6	4	60.0
Ft. Lauderdale	864	1041	45.4		21	18	45.4		1	0	100
OVERALL	2643	4065	39.4		200	265	43.0		14	8	63.6

**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	130	10	0	140
BH1	693	21	0	714
BH951	55	0	0	55
BH931	572	9	0	581
BH3	30	0	0	30
Poached	7	0	0	7
<u>Hatcheries</u>				
Pompano	99	0	1	100
Ft. Lauderdale	29	0	0	29
Hollywood	115	2	2	119
Discovery Center	1	0	0	1
TOTALS	1731	42	3	1776
<b><i>IN SITU</i></b>				
Hillsboro Beach	553	124	6	683
Pompano Beach	66	6	1	73
Ft. Lauderdale	31	5	1	37
Hollywood	9	2	0	11
TOTALS	659	137	8	804
GRAND TOTALS	2390	179	11	2580

**Table 6:** Total egg counts, released hatchlings and overall hatching successes for *in situ* and relocated nests of loggerheads, greens and leatherbacks in 1998.

SPECIES	NUMBER OF EGGS	EVAL. NESTS	HATCHLINGS RELEASED	HATCHING SUCCESS (%)
<b><i>In situ</i> Nests</b>				
<i>C. caretta</i>	15599	146	8098	51.9
<i>C. mydas</i>	2422	21	1231	50.8
<i>D. coriacea</i>	223	3	119	53.4
Total	18244	170	9448	51.8
<b>Relocated Nests</b>				
<i>C. caretta</i>	155157	1401	81979	52.8
<i>C. mydas</i>	3359	28	1361	40.5
<i>D. coriacea</i>	239	3	47	19.7
Total	158755	1432	83387	52.5
<b>Overall</b>				
<i>C. caretta</i>	170756	1547	90077	52.8
<i>C. mydas</i>	5781	49	2592	44.8
<i>D. coriacea</i>	462	6	166	35.9
TOTAL	176999	1602	92835	52.4
<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>	39	-	476	-
<i>C. mydas</i>	8	-	108	-
<i>D. coriacea</i>	0	-	5	-
<b>Relocated</b>				
<i>C. caretta</i>	83	8941	245	26336
<i>C. mydas</i>	2	382	12	1523
<i>D. coriacea</i>	0	0	0	0

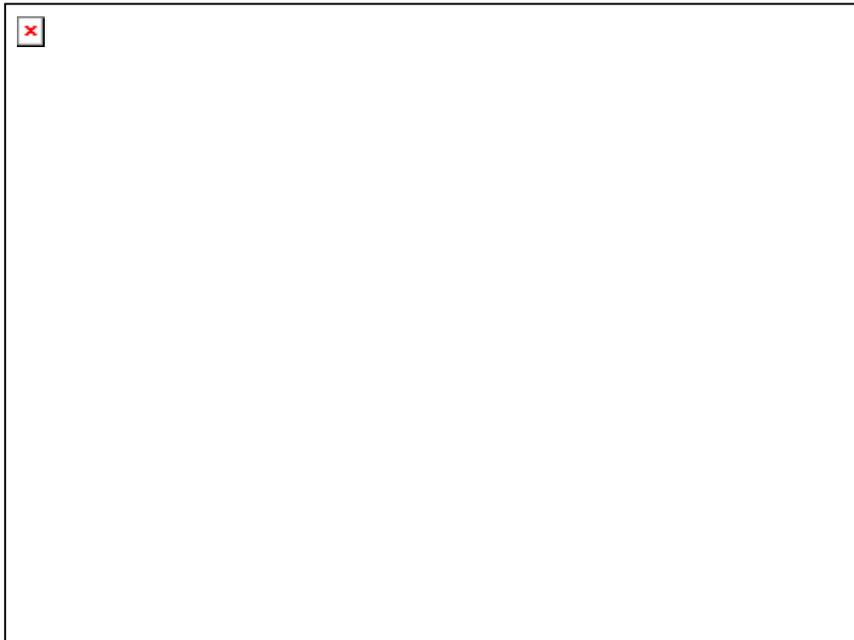


Figure 9: Comparison of seasonal hatching success trends for relocated and *in situ* loggerhead nests during 1998

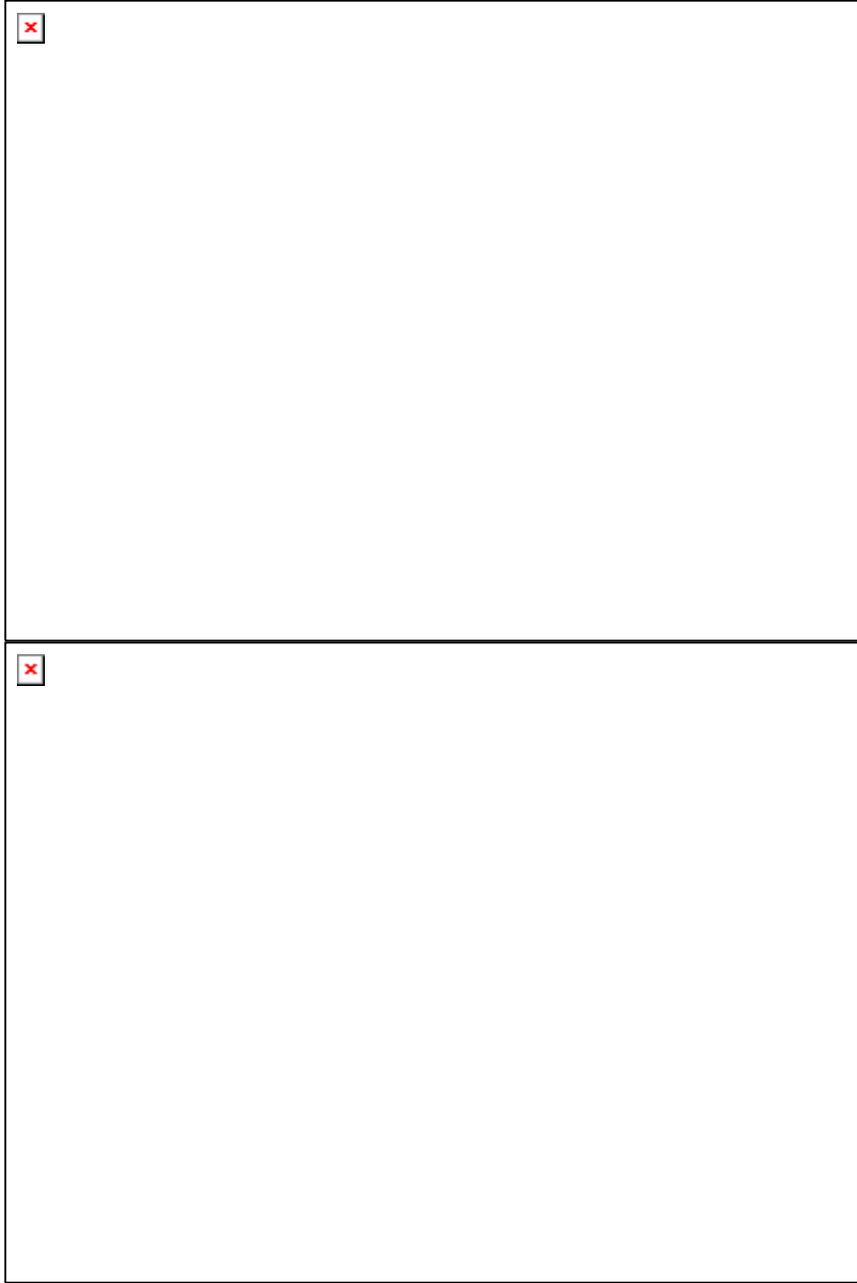


Figure 10: Comparison of seasonal hatching success trends for relocated and *in situ* green sea turtle nests during 1998.

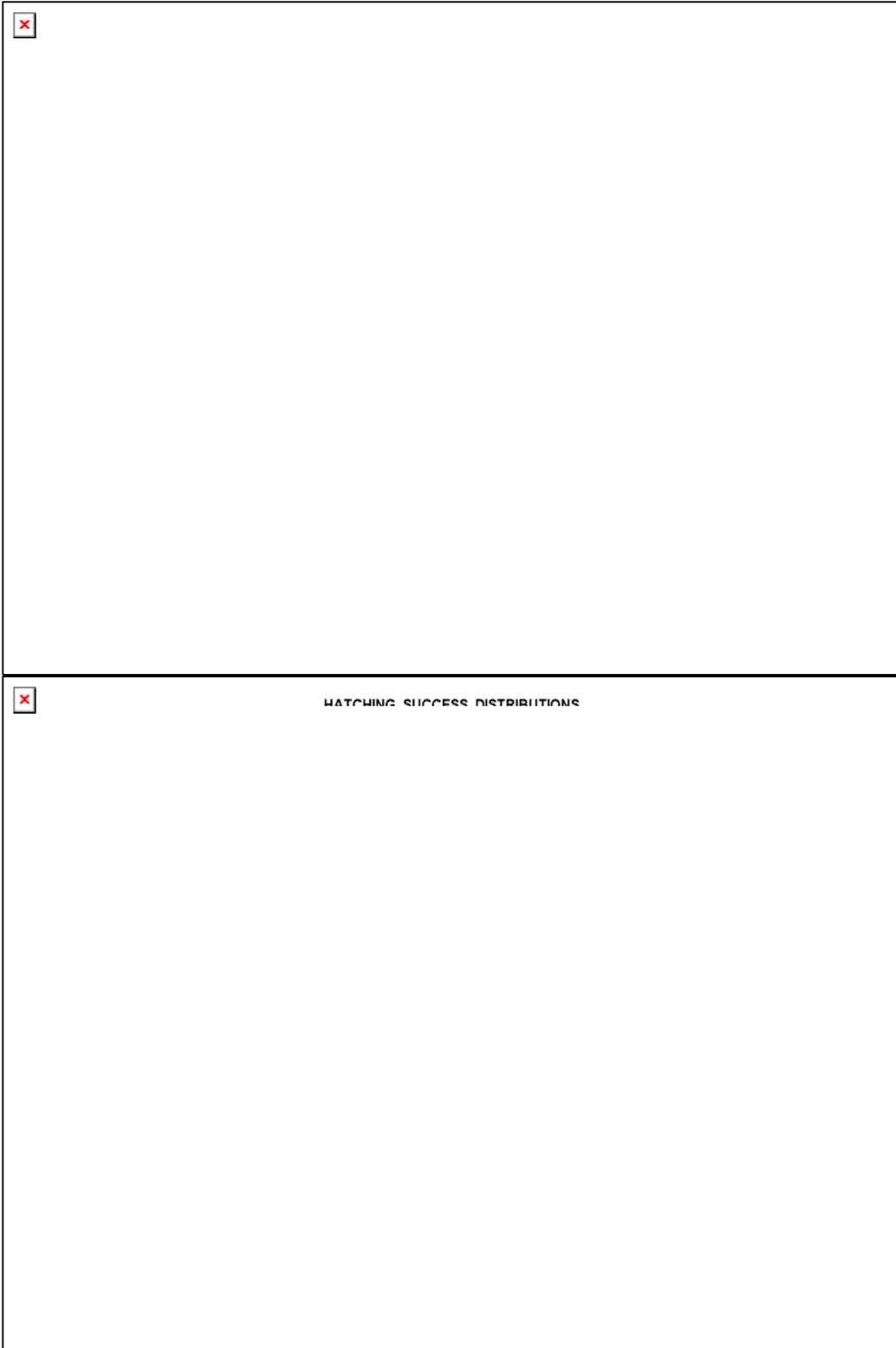


Figure 11: Hatching success frequencies for *in situ* and relocated loggerhead nests in 1997 and 1998.



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 1998.

Location	Total Eggs	Emerged Hatchlings (%)	LIN (%)	DIN (%)	PIP (%)	VD (%)	NVD (%)
<b><i>In situ</i> Nests</b>							
Hillsboro Beach	10711	37.1	5.6	3.4	13.1	23.3	17.7
Pompano Beach	3182	61.9	8.5	1.9	8.0	11.9	7.7
Ft. Lauderdale	1594	67.6	7.3	0.8	6.3	12.8	5.3
Hollywood	112	84.8	0.0	0.0	0.9	8.9	5.4
OVERALL	15599	45.6	6.3	2.8	11.3	19.8	14.3
<b>Relocated Nests</b>							
Hillsboro Beach							
BH	7592	38.3	8.5	1.9	21.9	13.3	15.9
BH1	62071	43.4	9.0	1.8	19.0	18.0	8.7
BH951	5660	44.8	14.4	3.4	21.7	9.5	6.0
BH931	49139	37.8	9.9	2.3	24.4	17.0	8.4
BH3	2999	50.9	7.5	2.2	13.4	19.3	6.5
Pompano Beach	11040	35.3	12.9	2.3	14.8	20.6	14.0
Ft. Lauderdale	3540	64.9	9.6	0.6	9.0	8.6	7.1
Discovery Center	85	65.9	0.0	1.2	2.4	17.6	12.9
Hollywood	13031	61.5	10.3	1.3	7.5	6.2	12.9
OVERALL	155157	43.0	9.8	2.0	19.4	16.2	9.5

**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** - Dead hatchlings that only 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 1998. Abbreviations as in Table 7.

Location	Total Eggs	Emerged Hatchlings (%)	LIN (%)	DIN (%)	PIP (%)	VD (%)	NVD (%)
<b><i>In situ</i> Nests</b>							
Hillsboro Beach	2187	45.4	3.6	1.2	9.0	24.7	16.2
Pompano Beach	114	58.8	0.0	1.8	7.0	26.3	6.1
Hollywood	121	75.2	1.7	7.4	6.6	3.3	5.8
OVERALL	2422	47.5	3.3	1.5	8.8	23.7	15.2
<b>Relocated Nests</b>							
Hillsboro Beach							
BH	1011	37.7	7.3	1.0	15.3	19.6	19.0
BH1	1392	29.4	5.0	0.5	9.3	33.8	22.0
BH931	674	16.6	21.2	2.5	30.1	24.0	5.5
Hollywood	282	48.9	12.1	1.8	10.6	18.8	7.8
OVERALL	3359	31.0	9.6	1.2	15.4	26.3	16.6

**Table 9:** Accounting of the status of all hatched and unhatched eggs in investigated *in situ* and relocated leatherback nests during 1998. Abbreviations as in Table 7.

Location	Total Eggs	Emerged Hatchlings (%)	LIN (%)	DIN (%)	PIP (%)	VD (%)	NVD (%)
<b><i>In Situ</i> Nests</b>							
Hillsboro Beach	140	53.6	0.0	0.0	12.1	19.3	15.0
Fort Lauderdale	83	24.1	28.9	8.4	1.2	15.7	21.7
OVERALL	223	42.6	10.8	3.1	8.1	17.9	17.5
<b>Relocated Nests</b>							
Pompano	83	25.3	3.6	4.8	19.3	22.9	24.1
Hollywood	156	12.2	2.6	2.6	3.2	14.1	64.7
OVERALL	239	16.7	2.9	3.3	8.8	17.2	50.6

## DISCUSSION

This year, Broward County experienced the largest single year increase in sea turtle nesting since 1990, and exceeded the previous record nest count in 1996 by 47 nests (Figure 1). Loggerheads did not quite break their 1996 record, but nesting by the green sea turtle increased greatly and eclipsed the previous record by more than 50 percent (Figure 2). The positive slope of the loggerhead trend line became slightly more significant than in 1997 and nesting densities of the green turtle now show a significantly positive 18 year trend ( $P = .007$ ), although there is considerable fluctuation, due to the alternate-year nesting pattern. There is also a significant positive trend ( $P = .030$ ) in loggerhead nesting since 1990. While the slope of this trend is lower than the overall 18-year slope, it suggests that nesting is still increasing after the large jump from levels in the 1980s. 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, loggerhead nesting continues to increase at a significant rate. The continuing high-low pattern of green turtle nesting is almost certainly due to an increased proportion of the population nesting in the even numbered years, but the increased magnitude of nesting this year begins to suggest an increase in the size of the nesting population as well.

Leatherback nesting (Fig. 2) declined from the record in 1997, but the 1998 count was still greater than 12 of the previous 17 years. There is

a significant positive trend ( $P=.027$ ) in leatherback nesting since 1988, but nesting remains too low to speculate on future trends.

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 late April and the mid season peak in late June. The unusually hot and dry summer in 1998 did not seem to alter the seasonal nesting pattern. Seasonal nesting at the individual beaches (Fig. 4) showed no obvious deviations from historical norms.

Unlike previous years, there was considerable statistical overlap in the loggerhead nesting density on the five beaches (Table1). Only Hollywood was statistically different (lower) than the rest of the County. Compared to last year (Burney and Margolis, 1997), nesting densities increased by 60 percent in Hollywood, 40 percent in Lloyd Park, 39 percent in Fort Lauderdale and 21 percent in Hillsboro Beach. Nesting declined by 6 percent in Pompano Beach. Loggerhead nesting was heaviest in Hillsboro Beach, (despite its generally eroded condition). The width of the beach above the high tide line has visibly declined over the last 7 to 8 years in at least two thirds of Hillsboro Beach.

Seasonal nesting patterns of green turtle nesting were very similar to previous high nesting years (Burney and Mattison, 1990, 1992; Burney and Margolis, 1994, 1996) with nesting beginning in late May and ending in early September. The record high temperatures did not seem to alter the seasonal pattern. The leatherback nesting season commenced later in 1998 (late April) than in 1997 (late February), but fewer nests were deposited in 1998.

As in previous years, green turtles nested most heavily at Hillsboro Beach and Lloyd Park (Table 2) with a strong preference for Hillsboro Beach, where green turtle densities were significantly higher than on other beaches. Compared to 1992 (previous record year) (Burney and Margolis, 1992) green nesting densities increased by 148 percent in Fort Lauderdale, 86 percent in Pompano Beach, 31 percent in Lloyd Park and 39 percent in Hillsboro Beach. Four green turtle nests were deposited in Hollywood in 1998 and there were none in 1992. The rank order of nesting densities on the five County beaches was identical in 1992 and 1998. Like greens, leatherbacks nested most densely at Hillsboro Beach and Lloyd Park (Table 3), possibly because of the lower levels of beachfront lighting and other nocturnal disturbance, but they nested on all beaches (Table 3, Figure 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) declined dramatically from 48.2 percent in 1997 to 39.4 percent in 1998. Nesting success was highest at Fort Lauderdale, but there was considerable statistical overlap between all the beaches. Nesting success was significantly lower between R6 and R12 which underwent nourishment just prior to the nesting season, compared to the region of Hillsboro Beach south of the project (R13 to R24). The effects of the nourishment

project on nesting and hatching success has been analyzed and reported separately (Burney and Margolis, submitted).

While beach characteristics and disturbance by humans and animals can affect nesting success (Dodd, 1988), sand temperature plays an important role in nest site selection as well as the decision to return to the sea without nesting (Nelson, 1986). Temperature gradients across the surface of the dry beach may provide the cues (Stoneburner and Richardson, 1981). No sand temperature data was collected in the present study but nesting success was depressed throughout the County and the early summer of 1998 was the hottest on record (Sterghos, 1998), it might be reasonable to hypothesize that high temperature was the primary reason for reduced nesting success (except possibly in the nourished zones).

Green turtle nesting success was statistically similar throughout the County, except in Fort Lauderdale which was significantly higher than the other beaches (Table 4). Countywide, the nesting success of greens was not much different in 1998 (43.0 percent) than in 1996 (43.9 percent).

Hatching success was also severely depressed in 1998 (Table 6, Figure 12) reaching the lowest levels since project inception. However, loggerhead hatching success was nearly equal in relocated and *in situ* nests (slightly higher in relocated nests) so it appears that environmental factors rather than relocation was the possible cause. The hatching success of the green and leatherback nests was lower in relocated nests, but relatively small numbers of relocated and *in situ* nests were evaluated in both species.

Incubation time is inversely correlated with nest temperature (Dodd, 1988). Figure 13 compares the incubation times of loggerhead nests in 1998 and 1997. In 1997, early nests had longer incubation times which declined until about 9 June and then leveled off. The 1997 seasonal average was 49.3 days. In 1998, incubation times were similar throughout the season (mean = 47.9 days), with only a hint of lengthening in the early season. The difference in means was extremely significant (t-test;  $P \ll .001$ ). The unusually high temperatures in early summer (Sterghos, 1998) appears to have affected the early nests. Figure 9 shows that loggerhead hatching success declined significantly throughout the season. The slopes of the regression lines for *in situ* and relocated nests were not significantly different ( $P = .65$ ) but were significantly ( $P \ll .001$ ) steeper when compared to 1997 data. There were apparent downward trends in green turtle hatching success (Figure 10) over the season but the trend was not significant for relocated or *in situ* nests. Greens appear to have tolerated the hot summer better than loggerheads.

Figure 11 also illustrates the poor hatching success of loggerhead nests in 1998. The hatch success mode was dramatically shifted to the left in 1998 compared to 1997. The frequency of nests hatching above 80 percent was strongly reduced in both relocated and *in situ* nests. This may be due to higher incubation temperatures early in the season when nests with high hatching success are ordinarily deposited (as seen in past years). This would be illustrated by the significantly shorter average incubation times in 1998 (Figure 13).

The post-hatching nest evaluation data (Tables 7-9) give the percentages of hatchlings which emerged from the nest without assistance. The percentage of live-in-nest (LIN) 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

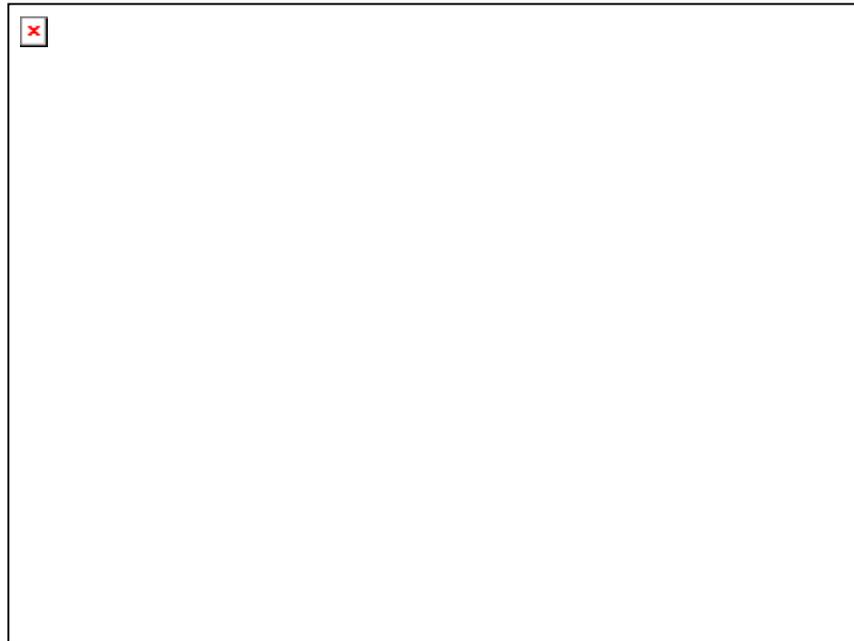


Figure 13: Comparison of seasonal loggerhead incubation times in 1997 and 1998.

some percentages are derived from very few nests and some locations such as BH3 and the Fort Lauderdale hatchery were only used early in the season. The emergence rate of *in situ* loggerheads at Hillsboro Beach was very similar to nests deposited on that beach which were moved to safer locations in the same general area (BH). Although the differences are statistically significant, the emergence rates of loggerheads relocated to all areas of Hillsboro Beach are very similar, except for the early nests at BH3. The higher emergence and hatchling success rates at BH3 on the recently nourished beach were not statistically different from those of early season nests relocated to natural sand in Hillsboro Beach (Burney and Margolis, submitted). The emergence and hatching success rates at the Hollywood hatchery were the highest of all the areas which received more than 100 nests and were used for the entire season. The nests left *in-situ* at Pompano Beach, Fort Lauderdale and Hollywood also emerged and hatched at relatively higher rates than did the Hillsboro Beach nests. Emergence and hatching percentages of green turtle eggs were significantly higher for *in situ* compared to relocated nests, but relatively small numbers of nests were evaluated (Table 8). The number of evaluated leatherback nests precludes meaningful comparisons of emergence and hatching rates (Table 9).

Overall, 1998 was a record year for sea turtle nesting activity but a poor year for recruitment. Since hatchling release rates were depressed for *in situ* and relocated nests, and the effect was county-wide, it is possible that the record high summer temperatures were to blame. The high temperature effect was implicated by comparing the significantly shorter incubation times and steeper seasonal declines in hatching success in 1998 to 1997.

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

SUBJECT	HOT-LINE
EMERGENCIES	
Nesting	3
Hatchlings	28
NEST LOCATIONS	71
STRANDINGS	15
POACHING	4
VOLUNTEERS	29
OTHER	NUMEROUS
OVERALL	> 150

## 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 placed in beach-front business establishments and some were 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 August 2 to Sept. 16 at the Anne Kolb Nature Center. These slide show presentations were followed by hatchling releases at Greene St. in Hollywood. Public talks and slide shows were given for the Nova Center Eisenhower Career Day, Riverside Elementary, New River Middle School, Stirling Elementary, Norcrest Elementary, Cooper City High School a Coral Springs street fair, and the Coral Ridge Yacht Club.

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

