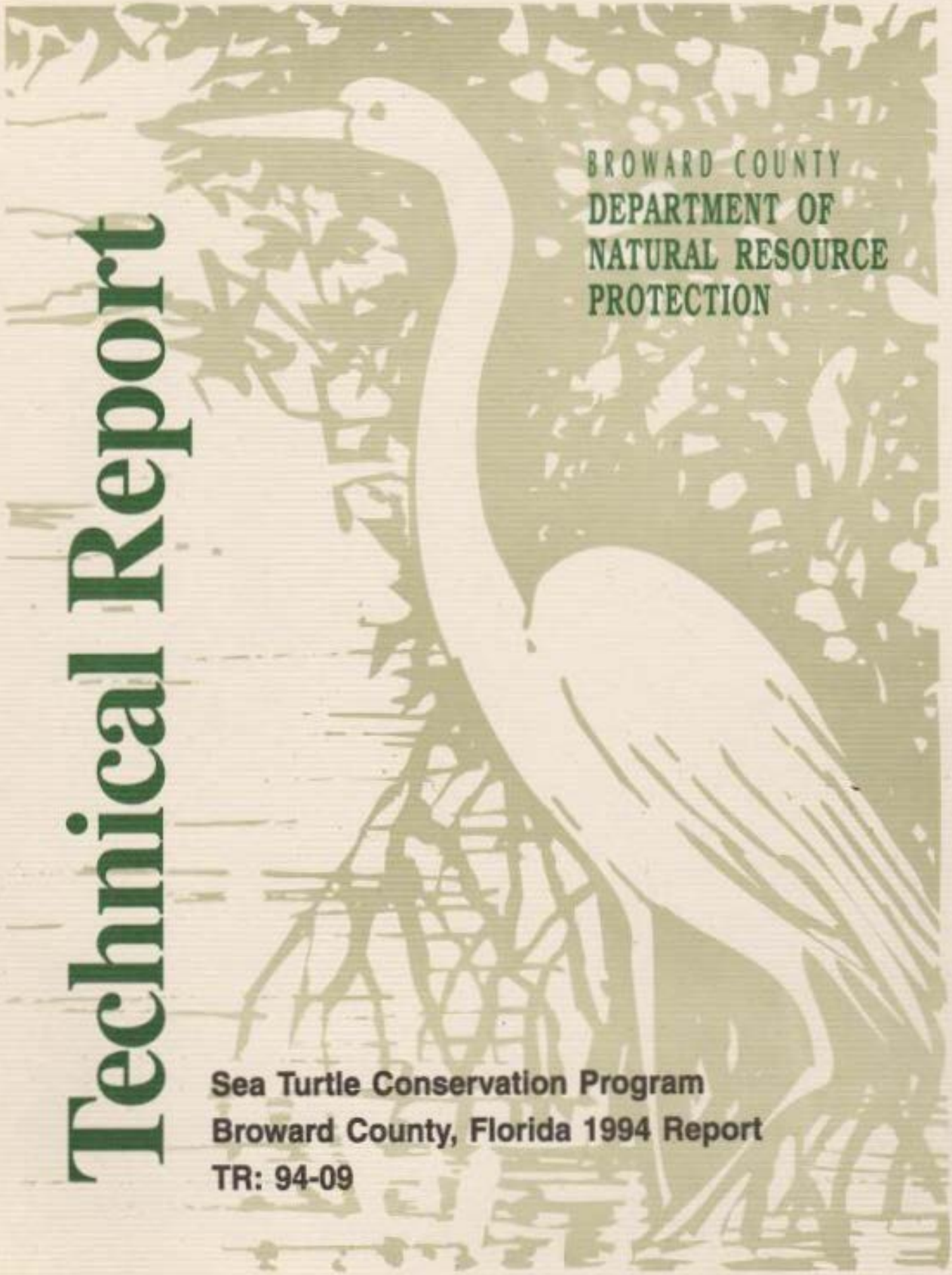

# Technical Report

BROWARD COUNTY
DEPARTMENT OF
NATURAL RESOURCE
PROTECTION

**Sea Turtle Conservation Program**
**Broward County, Florida 1994 Report**
**TR: 94-09**

# Technical Report 94-09

# Sea Turtle Conservation Program
# Broward County, Florida
# 1994 Report


Submitted by:

Curtis Burney
and
William Margolis

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


For the:

Broward County Board of County Commissioners
Department of Natural Resource Protection
Biological Resources Division

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## ACKNOWLEDGEMENTS

We thank the **Marine Resources Section of the Biological Resources Division of the Broward County Department of Natural Resource Protection.**

We gratefully acknowledge the dedicated efforts of **Dan Anderegg, Heather Balchowski, Clay Beauregard, Pat Bellew, John Braker, Scott Byrnes, Ike Chase, Lisa Csuzdi, Lisa DeCarlo, Missy Dore, Joan Dorrian, Charles Featherstone, Chris Gudeman, Matt Herman, Judy Hicklin, Barbara Maloney, Cathy Mattison, Claire McGuire, Terri Schmidt, James Sulikowski, Dale Vicha, and Anne Wiley** who helped with the field surveys, night releases, evening patrols, stranded turtles, and/or hatchery sand replacement. Their dedication and hard work has made the project a success. Very special thanks goes to American Honda Corporation, especially **Mr. Willie Tokishi**, for the generous donation of five new all terrain vehicles. We gratefully thank the owner, Steve St.Clair, and Pat of **Competition Cycle, Dania, FL** who kept the older all-terrain vehicles running and provided help whenever a problem arose. We also acknowledge the park employees of the Broward County Parks and Recreation Division at **Hollywood North Beach Park** and the Rangers at **John U. Lloyd S.R.A.** who were always willing and able to offer assistance whenever we needed it. We would especially like to thank the following people for their assistance and cooperation:

**Paul Eaton, Ed Lampert** and the **Hollywood Beach Maint. Dept.**
**John Depp** and the **Hallandale Beach Maint. Dept.**
**Fort Lauderdale Beach Maint.** and **Public Works Dept.**
**Beach Rakers** of Pompano Beach, FL.
**Pompano Beach Maint. Dept.** and **Public Works Dept.**

We also acknowledge the following agencies and local governments for their cooperation in the completion of this project:

The Florida Department of Environmental Protection, Division of Recreation and Parks

The Florida Department of Environmental Protection, Florida Marine Patrol

The Florida Department of Environmental Protection, Institute of Marine Research

The Cities and Police Departments of Hallandale, Hollywood, Dania, Fort Lauderdale, Lauderdale-By-The-Sea, Pompano Beach, Deerfield Beach and the Town of Hillsboro Beach.

# 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: *Caretta caretta* (the loggerhead sea turtle), *Chelonia mydas* (the green sea turtle) and *Dermochelys coriacea* (the leatherback sea turtle). *C. caretta* is listed as a threatened species, while *C. mydas* and *D. coriacea* are listed as endangered under the U.S. Endangered Species Act, 1973, and Chapter 370, F.S. This year, there was one incidental nest of *Eretmochelys imbricata* (hawksbill sea turtle) deposited in Broward County. This species is also listed as endangered.

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 renourishment projects on shorelines and the offshore reefs. As part of this concern, the DNRP has maintained the sea turtle conservation program in non-renourishment years to provide a continu-

ous data base.

Operation of the program is competitively bid and a contract award is issued based on a selection committee review of submitted bids through a weighted point factor procedure. Nova Southeastern University was awarded the contract to conduct the 1994 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 determine any 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.

This year, the project was modified to support a Florida Atlantic University experiment (M. Salmon and J. Wyneken) to assess the possible impact of mass relocation sites on hatchling predation by fish. An additional study of the effectiveness of protecting individual nests with cages, as an alternative to relocation, was conducted on a section of Fort Lauderdale beach.

## 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 | LENGTH (km) | BOUNDARIES | DEP SURVEY MARKER # |
|---|---|---|---|
| Hillsboro-Deerfield | 7.0 | Palm Beach Co. line to Hillsboro Inlet | 1-24 |
| Pompano | 7.7 | Hillsboro Inlet to Commercial Blvd. | 25-50 |
| Ft.Lauderdale | 10.6 | Commercial Blvd to Port Everglades Inlet | 51-84 |
| Lloyd Park | 3.9 | Port Everglades Inlet to Dania Beach fence | 86-97 |
| Hollywood-Hallandale | 9.4 | Dania Beach fence to Dade Co. Line | 98-128 |

Daily surveys of Broward County beaches commenced on April 20th. All surveys continued through September 15th. Nest locations were referenced to FDEP beach survey bench marks numbered consecutively from 1 to 128 (N to S). Marker numbers corresponding to each beach area are listed above. Each nest was initially located relative to the nearest building, street, or other land mark. These locations were later cross referenced to the nearest survey marker.

The beach at John U. Lloyd State Recreation Area was surveyed by park personnel, who provided the data for that area. Due to the relative lack of land

marks in the park, four 1 km zones (zone 1 farthest north) were used for recording nest locations. This was also done to provide continuity with the data collected in Lloyd Park during the previous three years, to assess the effects of a completed beach renourishment project on nesting patterns.

Surveyors used four-wheeled all-terrain vehicles which can carry up to five turtle nests in plastic buckets per trip. 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 Hillsboro by car. When there were many nests requiring relocation, and no road support, 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 mean high water line,

2) a nest located in an area with a high level of pedestrian traffic,

3) 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,

4) a nest located in an area subject to beach renourishment,

5) a nest deposited directly in existing, dense vegetation where roots might interfere with successful emergence of the hatchlings.

Especially due to definition 3, all of the discovered nests at Pompano and Hollywood-Hallandale, and all but 37 nests in Fort Lauderdale beaches were considered to be in danger of negative impact and therefore were relocated to hatcheries or to one of three open beach locations on Hillsboro beach. Unlike past years, there were three open beach hatchery locations in Hillsboro. These were at the Hillsboro Club (designated HB1), and near the Diamond Head

(HB2) and Ocean Crest (HB3) condominiums. The Hillsboro Club is located immediately north of the Hillsboro Inlet and the addresses of the other locations were 1057 A1A and 1187 A1A, respectively. The use of three hatchery areas was designed to support a hatchling predation study (M. Salmon and J. Wyneken, Florida Atlantic Univ.). Nests deposited on Hillsboro beach, which were in danger of negative impacts, were relocated to less hazardous nearby locations on that beach (HB), not to the three hatchery areas listed above. Thirty seven nests were caged and left *in situ* on the primarily residential section of Fort Lauderdale beach. This was done to test the feasibility of nest caging as an alternative to mass relocation, and to support a hatchling misorientation study initiated by Dr. Blair Witherington of FDEP, Tequesta.

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, Lloyd Park and Fort Lauderdale beaches, were marked and left *in situ*. After hatching, 448 of these nests were excavated for post emergence examination. Almost all nests were left *in situ* at John Lloyd park, which accounts for the large number of *in situ* nests investigated. Hatching (actual emergence) success for *in situ* nests was defined as the number of spent shells minus the number of hatchlings found dead in the nest, expressed as a percentage of the sum of the spent shells, pipped eggs, and eggs with arrested or no visible development.

Hatchery Operations

As in previous years, eggs were transferred to one of three chain-link

fenced hatcheries located at Pompano beach near Atlantic Blvd., at the South Beach municipal parking lot in Fort Lauderdale, or at North Beach Park in Hollywood. The hatchery located in Lloyd Park was not used this year. The 7 relocated nests at Lloyd Park were moved to safer areas of the open beach. After hatching, all hatchery nests were dug, and counts of spent shells, dead hatchlings, pipped 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. After hatching commenced, the hatcheries were checked each night between 9:00 PM and midnight. Hatchlings were released that same night in dark sections of Fort Lauderdale, Hillsboro, Hollywood or Lloyd Park beaches by allowing them to crawl through the intertidal zone into the surf. Hatchlings discovered at dawn 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.

Because of the high nesting density early in the season and the high percentage of relocated nests, the Pompano and Fort Lauderdale hatcheries quickly filled. After May 16, nests from Fort Lauderdale and Pompano were relocated to Hillsboro Beach, for the remainder of the season. 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 was compiled, analyzed and plotted primarily with Quattro Pro software. County-wide yearly nesting densities from 1981 to 1994 for *C. caretta*, *C. mydas*, and *D. coriacea* were plotted and trends were assessed by linear regression and correlation analyses. Seasonal nesting patterns for *C. caretta* and *C. mydas* were plotted for each of the five beaches. Nesting densities were calculated per km for each beach and the data (except for *D. coriacea*) were compared using 1-way analysis of variance (ANOVA) and Student-Newman-Keuls (SNK) tests (at the .05 significance level) (Zar, 1974). 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 successes of *C. caretta* and *C. mydas* at each beach was compared by ANOVA and SNK analyses. The total nesting success in each beach segment for each species, was plotted versus its FDEP survey number.

The mean hatching successes of *C. caretta* and *C. mydas* nests deposited at the individual beaches and at the individual relocation sites were also compared using ANOVA and SNK analyses, as were the overall hatching success of relocated and *in situ* nests of the three sea turtle species.

The total number of relocated nests, eggs, lost or destroyed eggs and hatchlings released were tabulated and compared. An accounting of the status of all eggs from investigated *in situ* and relocated nests at each beach was prepared, with unsuccessful eggs listed as dead-in-nest (DIN), partially emerged hatchling (PIP), unhatched with visible development (VD) and eggs showing no visible development (NVD). The numbers of *in situ* and relocated eggs in each of these categories (also including successful eggs) were compared using a large-sample hypothesis test of population proportions (percent test) (Weiss and Hassett, 1991).

## RESULTS

Figure 1 gives the historical trend of total sea turtle nest counts in 1994. A total of 2,314 nests were counted in 1994. This was 133 more than in 1993 and only 71 fewer the record year, 1990. This was the fifth consecutive high nesting year. The mean nest count for 1990 thru 1994 (2,251) is 4 standard deviations above the mean of the previous 9 years. This is a very significant difference (t-test; t= 7.7, P<< .001). Figure 2 shows the nesting trends for the three species. The trend line for *C. caretta* still has a strongly positive slope, which is highly significant (P < .001). *C. mydas* nesting has shown alternating highs and lows for the past 5 years. The 123 *C. mydas* nests deposited in the county this year is the second highest number recorded. *D. coriacea* nesting was down slightly from last year, but the nest numbers are low and there is still no overall significant trend.

In addition, one hawksbill sea turtle (*Eretmochelys imbricata*) nested in Broward County in 1994. This was an incidental nesting, since South Florida is well north of the normal nesting range of this species.

Figure 3 gives the seasonal pattern of daily *C. caretta* nesting. The pattern was extraordinary because early season nesting densities were much higher than in previous years. If the early-season nesting pace had continued throughout the season, some 2700 nests could have been deposited. In actuality, the nesting rate decreased during the latter half of the season, and the final nest count was not much different than the previous 4 years.

Table 1 and Figure 4 give the total *C. caretta* nesting densities and seasonal patterns for the five beaches, respectively. Nesting densities were lowest at Hollywood-Hallandale beach and highest at Pompano and Hillsboro. Nesting densities at all beaches, except Hillsboro and Pompano, grouped

# SEA TURTLE NESTING HISTORY
## ALL SPECIES COMBINED

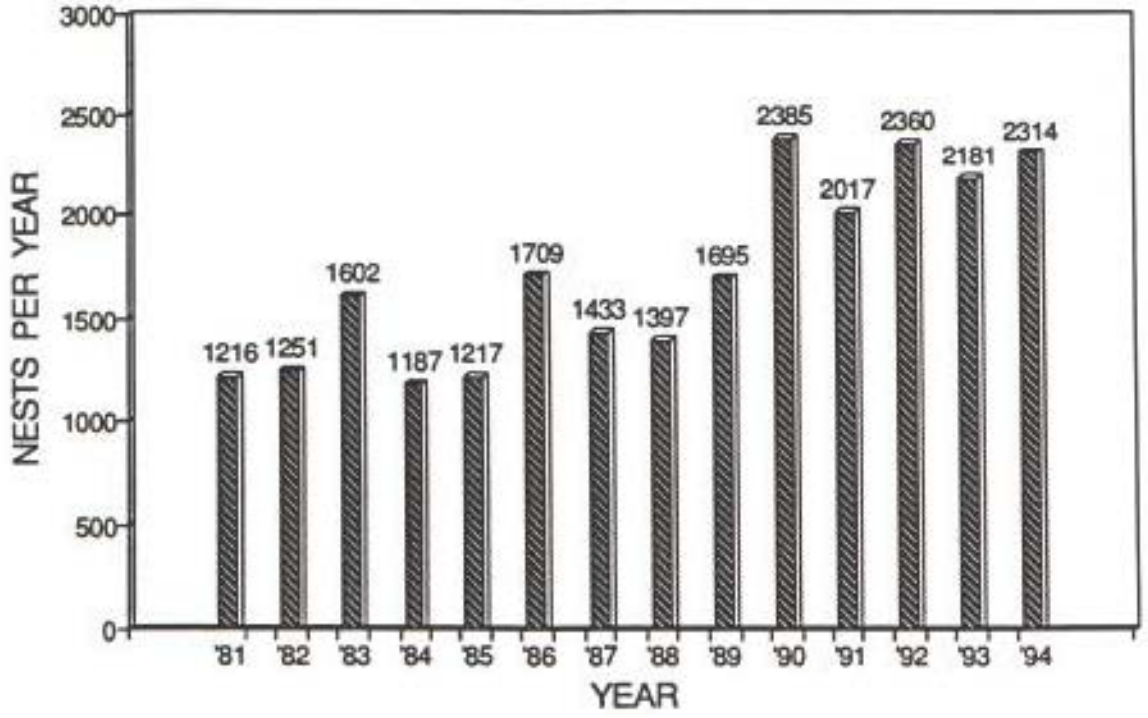
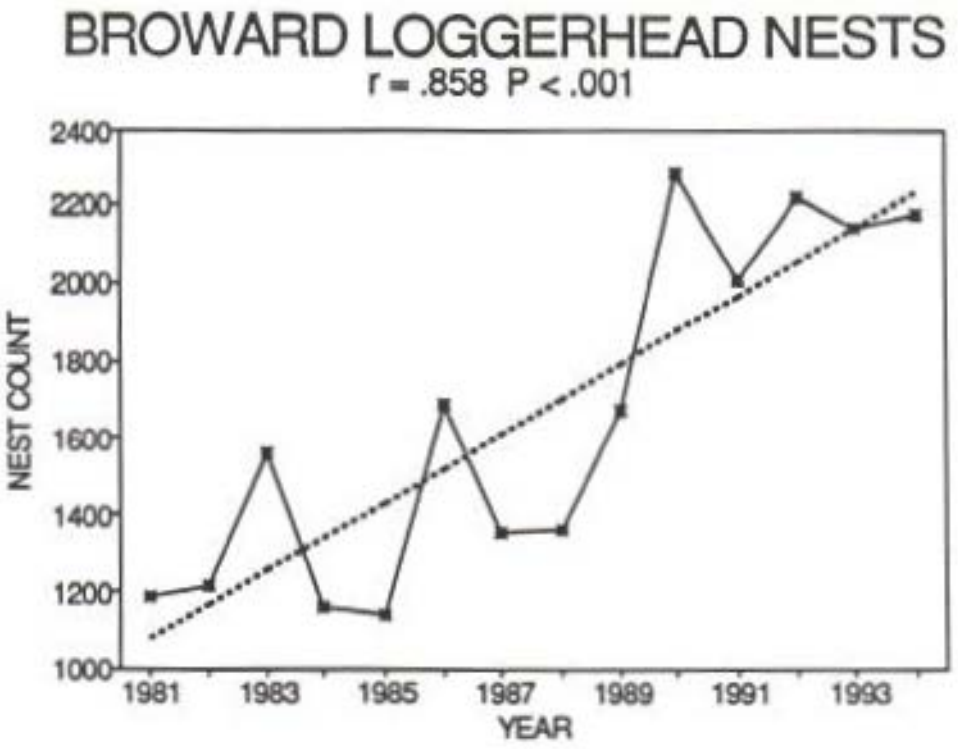



Figure 1: The historical pattern of total sea turtle nesting in Broward County, since full surveys commenced in 1981.



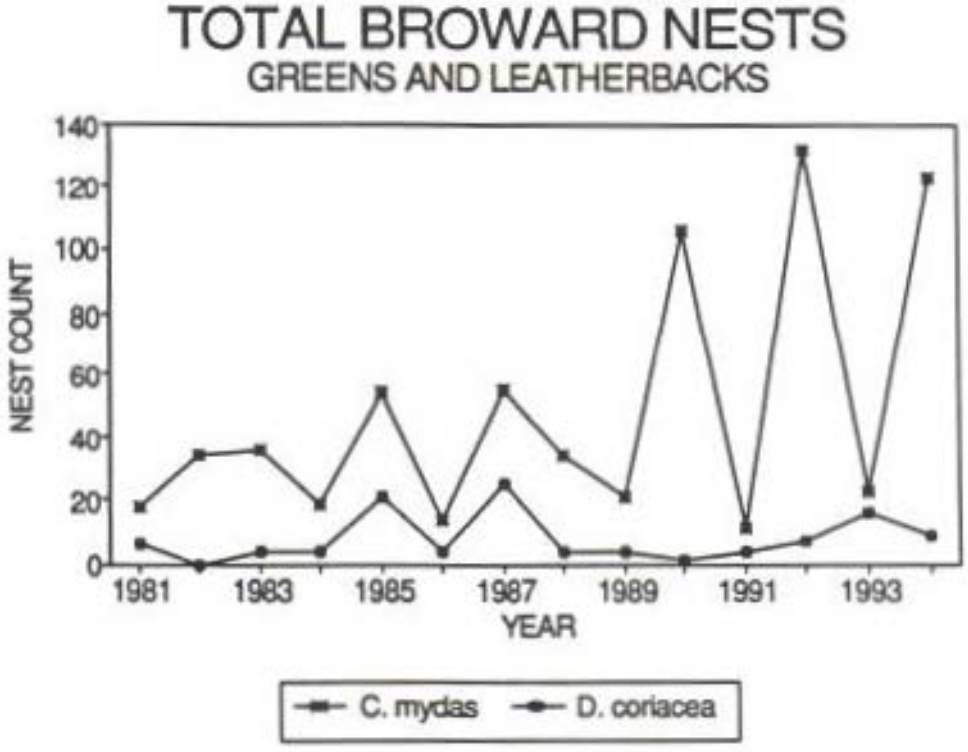




Figure 2: Historical nesting patterns of loggerhead, green, and leatherback sea turtles in Broward County since 1981.

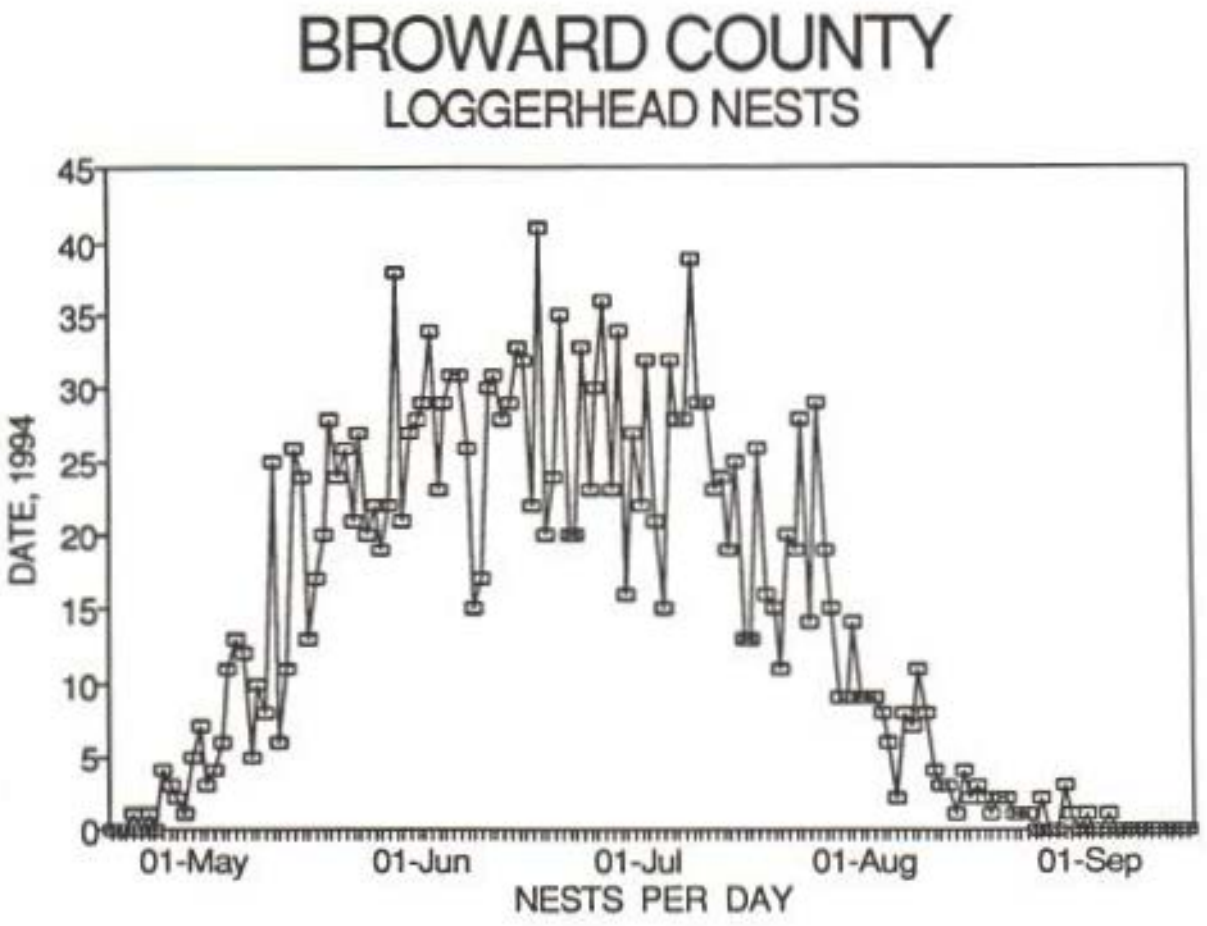
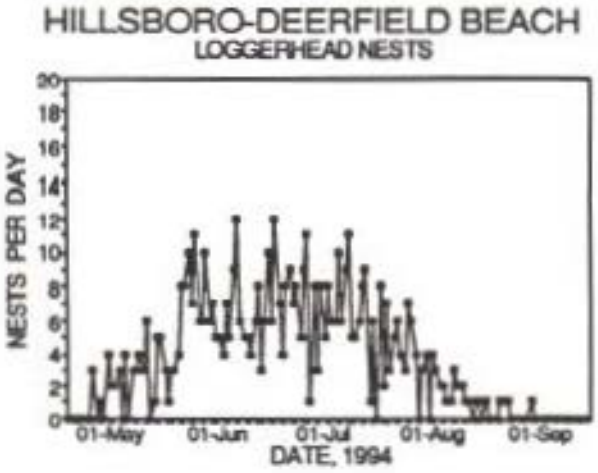
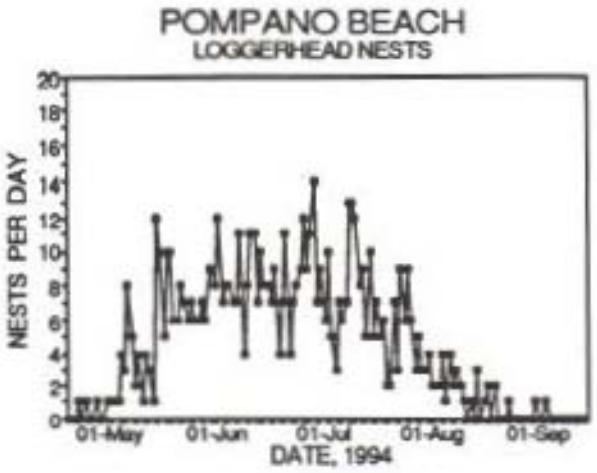


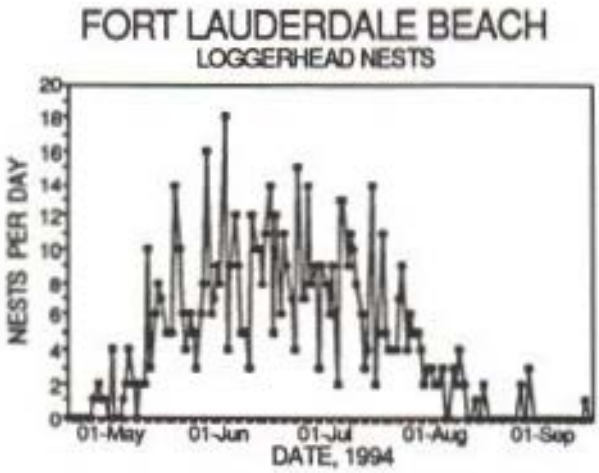

Figure 3: The seasonal pattern of daily loggerhead nesting in Broward County, 1994.

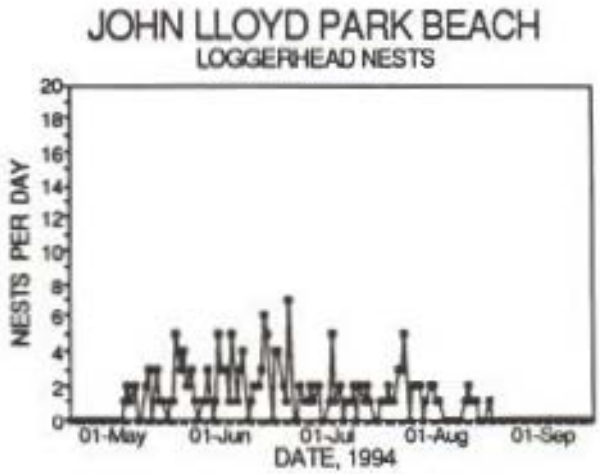
Table 1: Total *C.caretta* nests and nesting densities expressed as nests-per-kilometer for the 1994 season. Vertical lines at the right overlap groups where means were not distinguishable in a SNK test (alpha = .05) of mean daily nesting per km.

| BEACH | TOTAL NESTS | BEACH LENGTH (km) | NESTS per km | MEAN DAILY NESTS /km | |
|---|---|---|---|---|---|
| Hollywood-Hall. | 97 | 9.4 | 10.3 | .069 | I |
| Lloyd Park | 190 | 3.9 | 48.7 | .289 | I |
| Ft.Laud. | 668 | 10.6 | 63.0 | .419 | I |
| Hillsboro | 549 | 7.0 | 78.4 | .518 | I |
| Pompano | 677 | 7.7 | 87.9 | .583 | I |
| OVERALL | 2181 | 38.6 | 56.5 | .379 | |



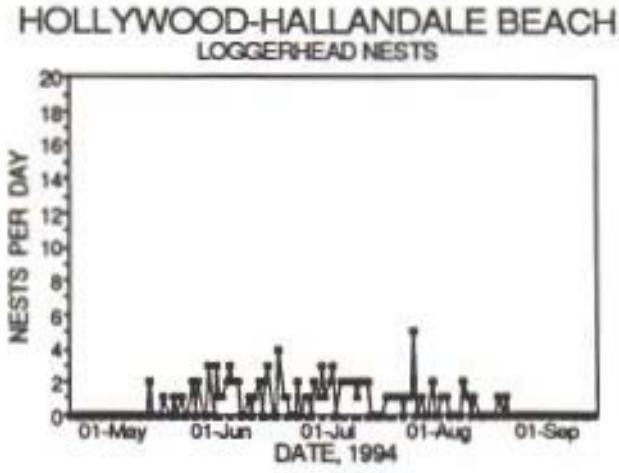




Figure 4: Comparison of the daily loggerhead nesting patterns on the five Broward County beaches in 1994.

separately in the SNK analysis (Table 1).

The county-wide seasonal nesting patterns for *C. mydas* and *D. coriacea* are shown in Figure 5 and for the individual beaches in Figure 6. The first *C. mydas* nest was deposited on June 2. This was similar to the other two high-nesting years (1990 and 1992), when nesting commenced in mid May or early June (Burney and Mattison, 1990, 1992). As in previous years, *D. coriacea* nested in the early part of the season, with the first nest deposited in Hillsboro on 24 March and a second on 12 April, before the start of the daily beach patrols. These two nests are not shown in Figure 5, but are included in the totals. Table 2 gives the nest counts, nests per km and nests per km per day for *C. mydas*. As in 1993, nesting densities were greatest on Hillsboro and Lloyd Park beaches, but daily nesting densities at Lloyd Park could not be statistically distinguished from those at Fort Lauderdale or Pompano beaches.

Table 3 gives the distribution of *D. coriacea* nesting. Seven of the 9 nests were deposited in Hillsboro. There were no *D. coriacea* nests deposited on Pompano or Hollywood-Hallandale beaches this year.

Figure 7 shows the horizontal distribution of *C. caretta*, *C. mydas*, and *D. coriacea* nesting. The *C. caretta* nesting pattern was similar to past years, except that the proportion of *C. caretta* nesting on Hillsboro beach was lower than in previous years. There were no *C. caretta* nests deposited in zone #6. The single *E. imbricata* nest was deposited in beach zone #78 (Fort Lauderdale) on September 14.

Figure 8 and Table 4 give the county-wide distribution of nesting success for the three species. There were no significant county-wide differences in nesting success except at Lloyd Park, where it was significantly lower than the rest of the county. This was also the case in 1993.

Table 5 gives the total numbers of nests for each species that were

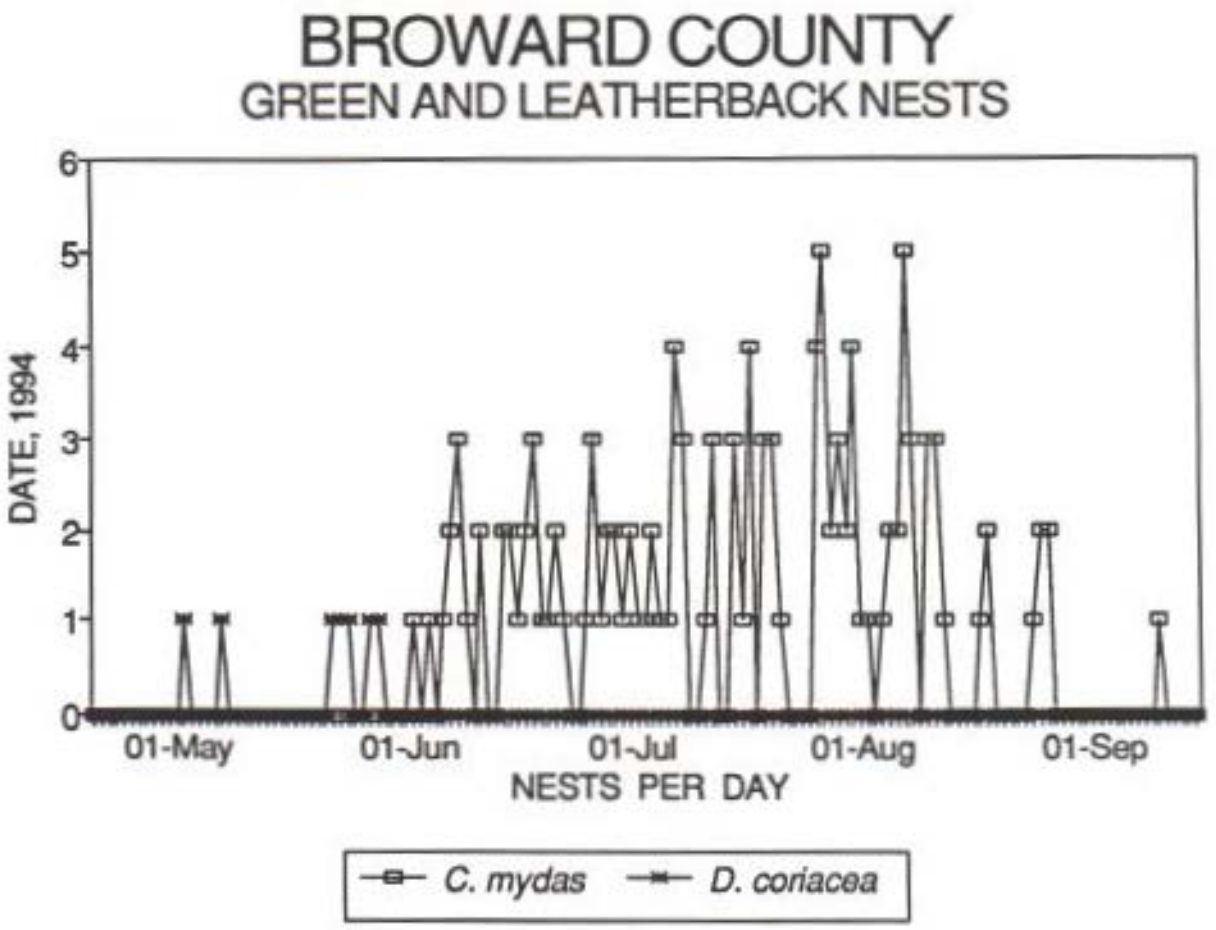
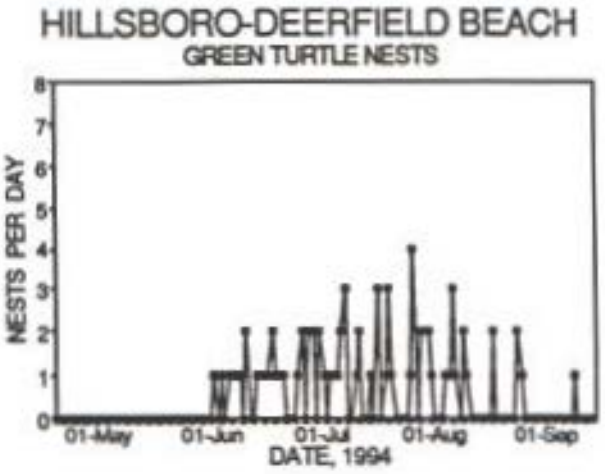
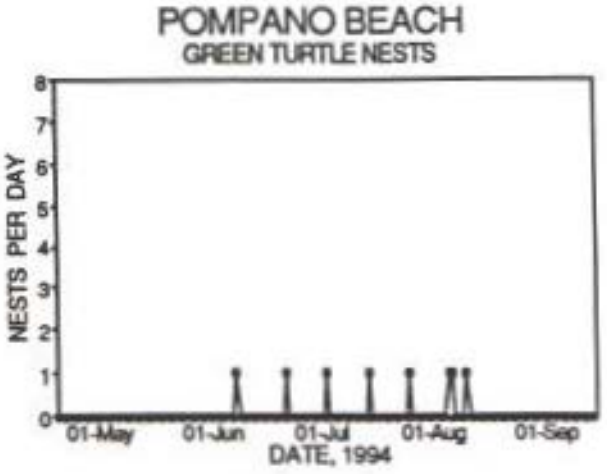
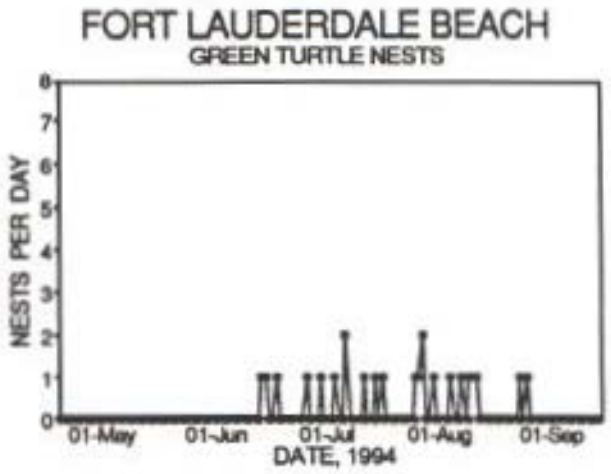
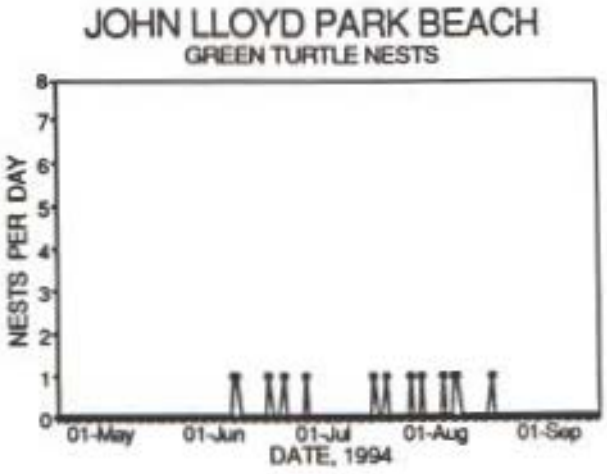



Figure 5: The seasonal patterns of daily green and leatherback nesting in Broward County, 1994



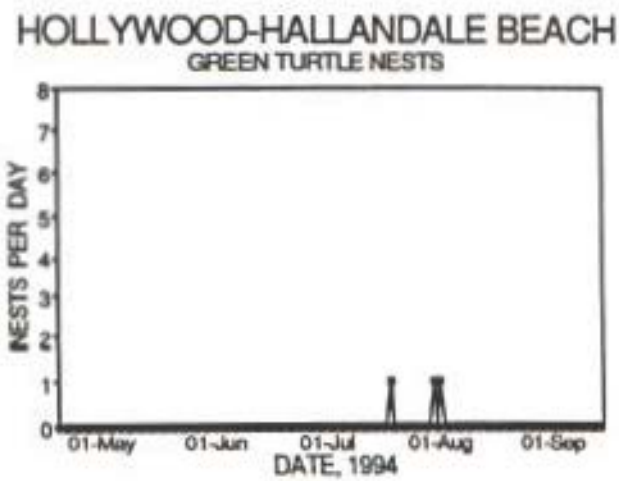



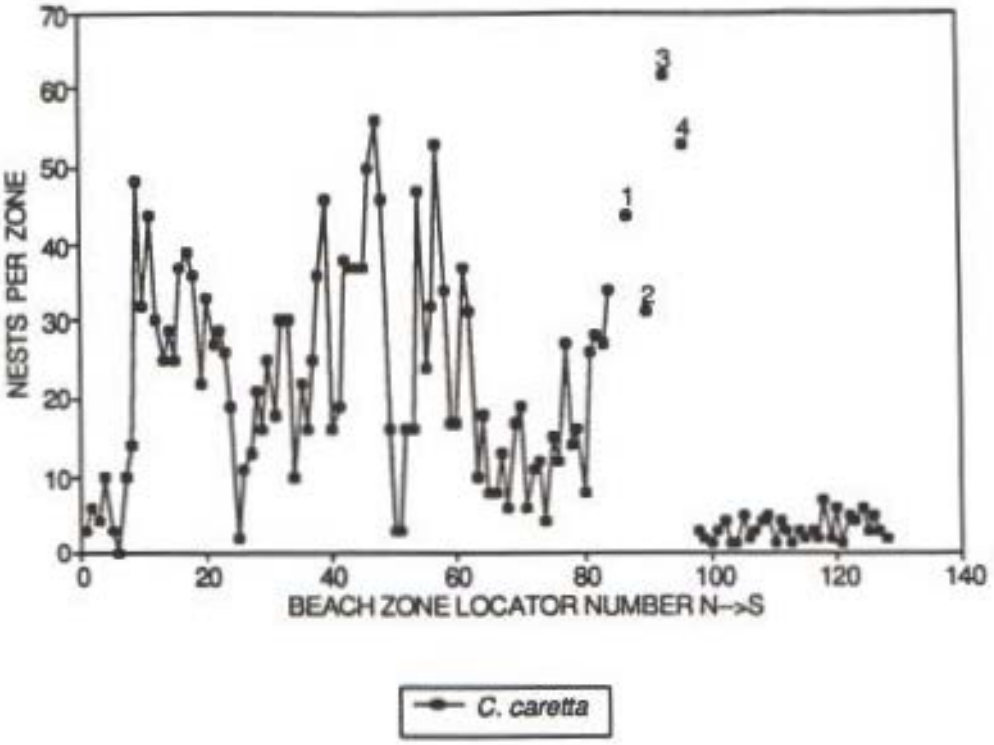

Figure 6: Comparison of the daily nesting patterns of the green sea turtle on the five Broward County beaches in 1994.

Table 2: Total *C.mydas* nests and nesting densities expressed as nests-per-kilometer for the 1994 season. Vertical lines at the right overlap groups where means were not distinguishable in a SNK test (alpha = .05) of mean daily nesting per km.

| BEACH | TOTAL NESTS | BEACH LENGTH (km) | NESTS per km | MEAN DAILY NESTS/km |
|---|---|---|---|---|
| Hollywood-Hall | 3 | 9.4 | 0.3 | .002 |
| Pompano | 8 | 7.7 | 1.0 | .007 |
| Ft. Laud. | 23 | 10.6 | 2.2 | .015 |
| Lloyd Park | 14 | 3.9 | 3.6 | .024 |
| Hillsboro | 75 | 7.0 | 10.7 | .072 |
| OVERALL | 123 | 38.6 | 3.2 | .021 |

Table 3: Total *D. coriacea* nests and nesting densities expressed as nests-per-kilometer for the 1994 season. Data were too few for a reliable SNK comparison of mean daily nesting densities.

| BEACH | TOTAL NESTS | BEACH LENGTH (km) | NESTS per km |
|---|---|---|---|
| Pompano | 0 | 7.7 | 0 |
| Lloyd Park | 1 | 3.9 | .26 |
| Ft. Laud. | 1 | 10.6 | .09 |
| Hollywood-Hall | 0 | 9.4 | 0 |
| Hillsboro | 7 | 7.7 | .91 |
| OVERALL | 9 | 38.6 | 0.23 |



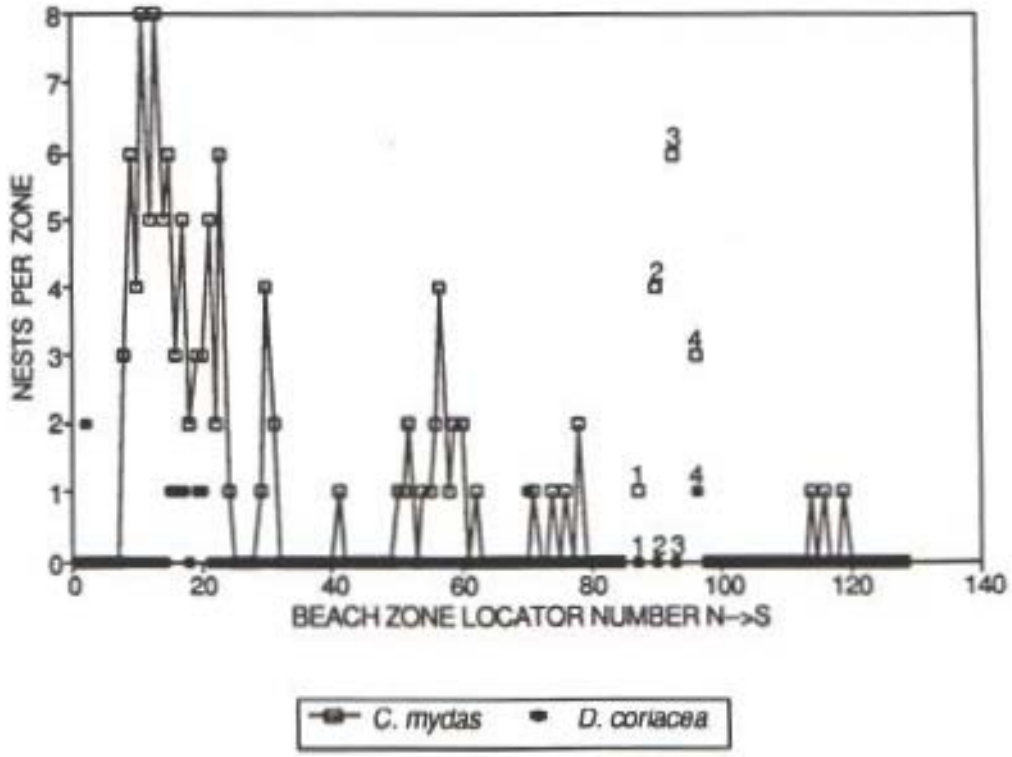
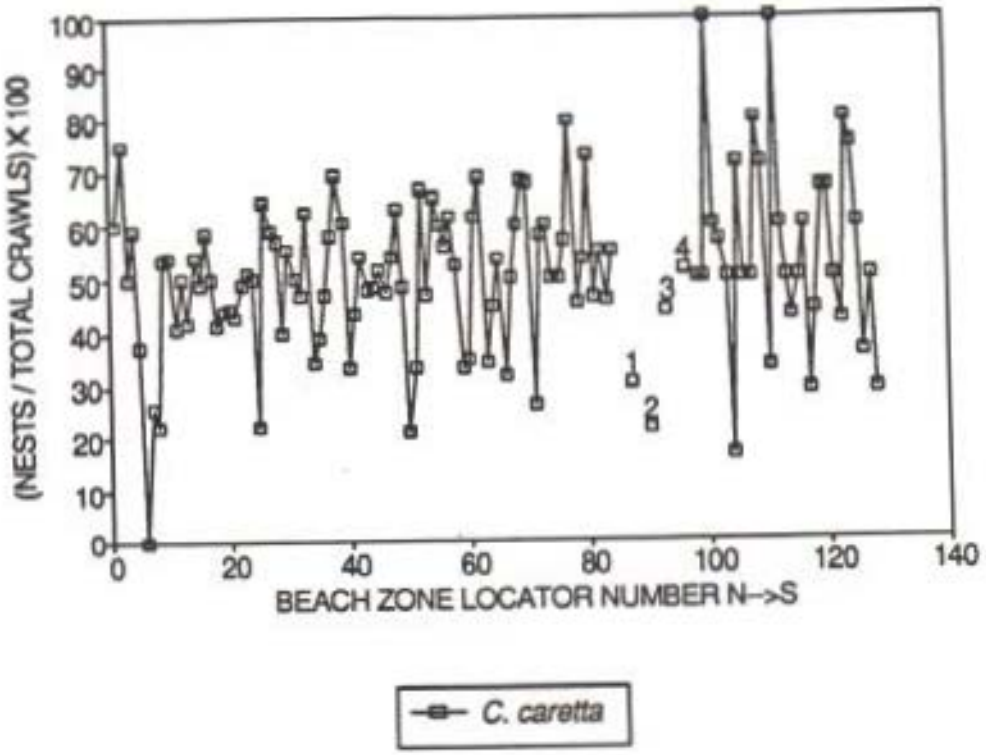




Figure 7: Locations of loggerhead, green, and leatherback nests in Broward County, 1994. Numbers 1-4 indicate the four zones of Lloyd Park.



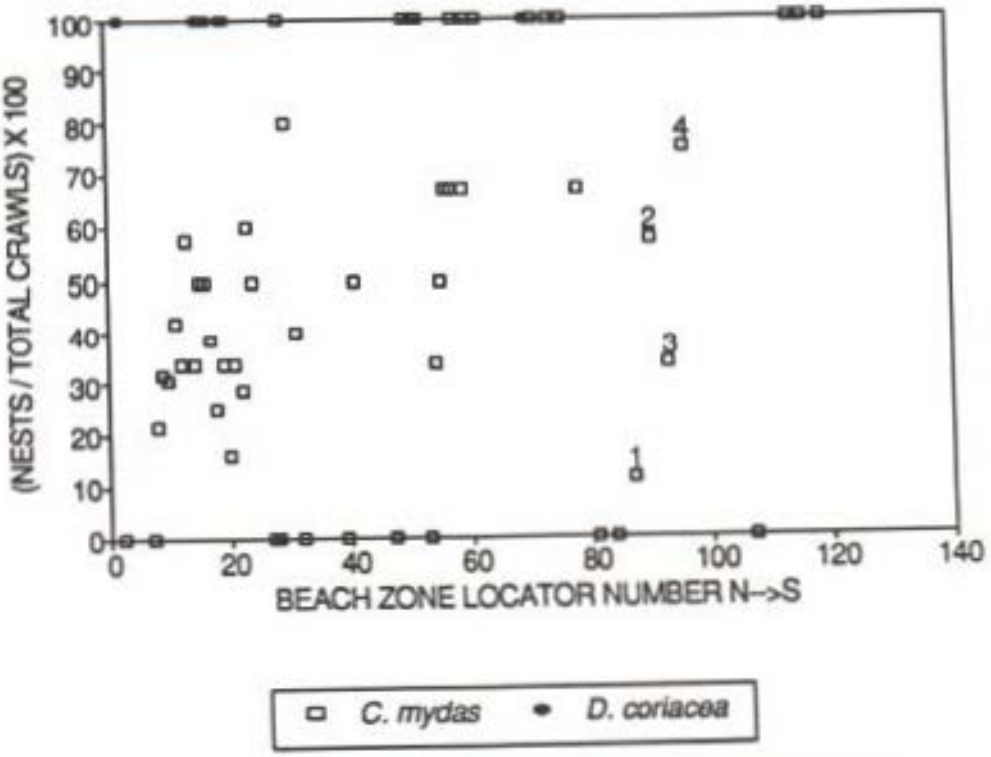




Figure 8: The horizontal distribution of mean daily nesting success for loggerhead, green, and leatherback sea turtles in 1994.

Table 4: Total nests, false crawls (FC) and percent nesting success (NS) for three sea turtle species in each of five Broward County beaches during 1994.Vertical lines for *C. caretta* overlap beaches where mean daily nesting successes were not distinguishable in a SNK test. ANOVA showed no significant differences in *C. mydas* nesting success. *D. coriacea* nesting was too sparse for reliable statistical comparisons.

| BEACH | *C.caretta* | | | *C.mydas* | | | *D.coriacea* | | |
|---|---|---|---|---|---|---|---|---|---|
| | NESTS | FC | NS | NESTS | FC | NS | NESTS | FC | NS |
| Lloyd Park | 190 | 343 | 35.6 | 14 | 24 | 36.8 | 1 | 0 | 100 |
| Hillsboro | 549 | 647 | 45.9 | 75 | 140 | 34.9 | 7 | 0 | 100 |
| Holly-Hall. | 97 | 87 | 52.7 | 3 | 1 | 75.0 | 0 | 0 | |
| Pompano | 677 | 646 | 51.2 | 8 | 12 | 40.0 | 0 | 0 | |
| Ft.Laud. | 668 | 583 | 53.4 | 23 | 12 | 65.7 | 1 | 0 | 100 |
| OVERALL | 2181 | 2306 | 48.6 | 123 | 189 | 39.4 | 9 | 0 | 100 |

relocated to Hillsboro Beach or fenced hatcheries, as well as the numbers and location of nests left *in situ*. Table 6 lists the total number of eggs, and the total number of emerged hatchlings from evaluated *in situ* and relocated nests of all species. The numbers of eggs from predated nests were not included in these totals and are listed at the bottom of Table 6. Many of these eggs from partially predated nests probably hatched successfully.

The hatching success of relocated nests of all species were higher than in 1993. The success of *C. mydas* and *D. coriacea* nests improved by 17.2 and 23.1 percent, respectively. However, the hatching rate of *C. caretta* nests was only 0.8 percent higher than last year. For *in situ* nests, *C. caretta* hatched at a slightly lower rate than in 1993 (7.0 percent), and *C. mydas* success increased by 0.4 percent. As in 1993 the *in situ* hatching success of *C. caretta* was significantly higher than for relocated nests, but the gap decreased in 1994, owing to the drop in *in situ* hatching success.

Figure 9 illustrates the seasonal patterns of *C. caretta* hatching success for relocated and *in situ* nests. Unlike past years (1989-1993) neither pattern shows a significant trend toward reduced hatching success as the season progressed. Figure 10 shows the *C. mydas* seasonal hatching success patterns. Hatching success appeared to increase later in the season. This trend was not quite significant for relocated nests (P=.116) but it was significant for *in situ* nests (P=.002). Figure 11 shows the historical patterns of the yearly hatching success of all species combined, since 1981.

Table 7 gives the post-hatching nest investigation data for all *in situ* and relocated *C. caretta* nests for all beaches. Table 8 and 9 show the same data for *C. mydas* and *D. coriacea*, respectively. Table 10 compares mean hatching success rates for *C. caretta* nests laid or relocated to Hillsboro Beach. The values are slightly different from those in Table 7 due to round-off errors. Table 10 shows that the hatch success of *in situ* nests was significantly greater than

Table 5: Total Number of *C.caretta*, *C. mydas* and *D. coriacea* nests relocated to Hillsboro beach or fenced hatcheries, or left *in situ*.

| | *C. caretta* | *C. mydas* | *D. coriacea* |
|---|---|---|---|
| **RELOCATED** | | | |
| Open Beach | | | |
| Hillsboro* | | | |
| HB | 224 | 28 | 1 |
| HB1 | 289 | 8 | 0 |
| HB2 | 687 | 14 | 1 |
| HB3 | 209 | 7 | 0 |
| Fort Lauderdale | 1 | 0 | 0 |
| Lloyd Park | 7 | 0 | 0 |
| Hatcheries | | | |
| Pompano | 57 | 0 | 0 |
| Ft.Lauderdale | 50 | 0 | 0 |
| Lloyd Park | 0 | 0 | 0 |
| Hollywood | 97 | 3 | 0 |
| Totals | 1621 | 60 | 2 |
| ***IN SITU*** | | | |
| Open Beach | | | |
| Hillsboro | 325 | 47 | 6 |
| Pompano | 8 | 0 | 0 |
| Fort Lauderdale | 42 | 2 | 0 |
| Lloyd Park | 183 | 14 | 1 |
| Totals | 558 | 63 | 7 |
| Totals | 2179* | 123 | 9 |

* HB - Hillsboro nests relocated to safer nearby beach locations
HB1- Hillsboro Club hatchery site
HB2- Diamond Head hatchery site
HB#- Ocean Crest hatchery site

* Total does not include one *C. caretta* nest which was poached and one nest sent to the Museum of Discovery and Science. One *E. imbricata* nest was deposited in Fort Lauderdale and relocated to HB1

Table 6: Total egg counts, released hatchlings and overall hatching successes for *in situ* and relocated nests of *C.caretta*, *C.mydas* and *D.coriacea* in 1994.

| Species | NUMBER OF EGGS | n* | NUMBER TURTLES RELEASED | HATCH SUCCESS PERCENT |
|---|---|---|---|---|
| **In Situ Nests** | | | | |
| *C. caretta* | 43481 | 407 | 31192 | 71.7 |
| *C. mydas* | 4637 | 39 | 3211 | 69.2 |
| *D. coriacea* | 226 | 2 | 175 | 77.4 |
| Total | 48344 | 448 | 34578 | 71.5 |
| **Relocated Nests#** | | | | |
| *C. caretta* | 156538 | 1423 | 96924 | 61.9 |
| *C. mydas* | 4989 | 43 | 2902 | 58.2 |
| *D. coriacea* | 246 | 2 | 144 | 58.5 |
| *E. imbricata* | 151 | 1 | 108 | 71.5 |
| Total | 161924 | 1469 | 100078 | 61.8 |
| **Overall** | | | | |
| *C. caretta* | 200019 | 1830 | 128116 | 64.1 |
| *C. mydas* | 9626 | 82 | 6113 | 63.5 |
| *D. coriacea* | 472 | 4 | 319 | 67.6 |
| *E. imbricata* | 151 | 1 | 108 | 71.5 |

* n = The number of nests actually investigated for hatching success percent.

# In addition, there were 18586 eggs from 157 partially predated *C. caretta* nests and 2110 eggs from 17 *C. mydas* nests, which were not included in the evaluated totals.

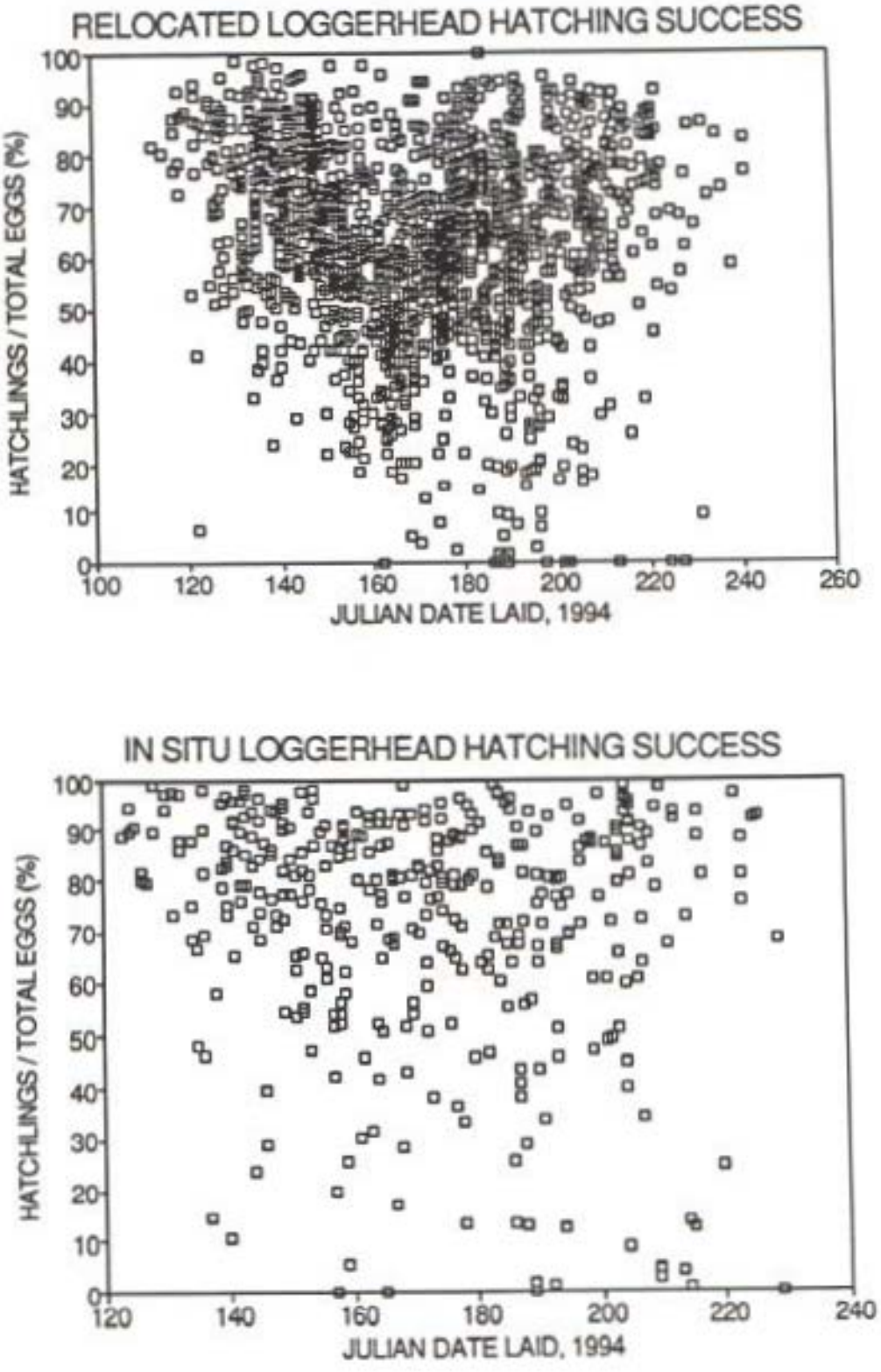
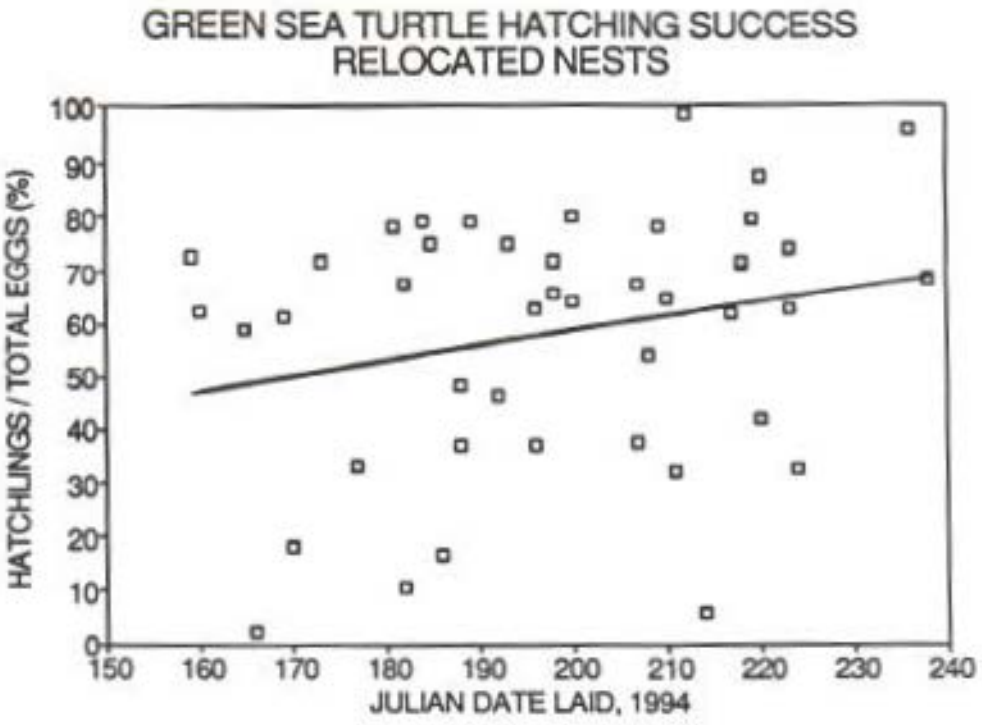



Figure 9: Comparison of the seasonal patterns of hatching success of relocated and in situ loggerhead nests during 1994.



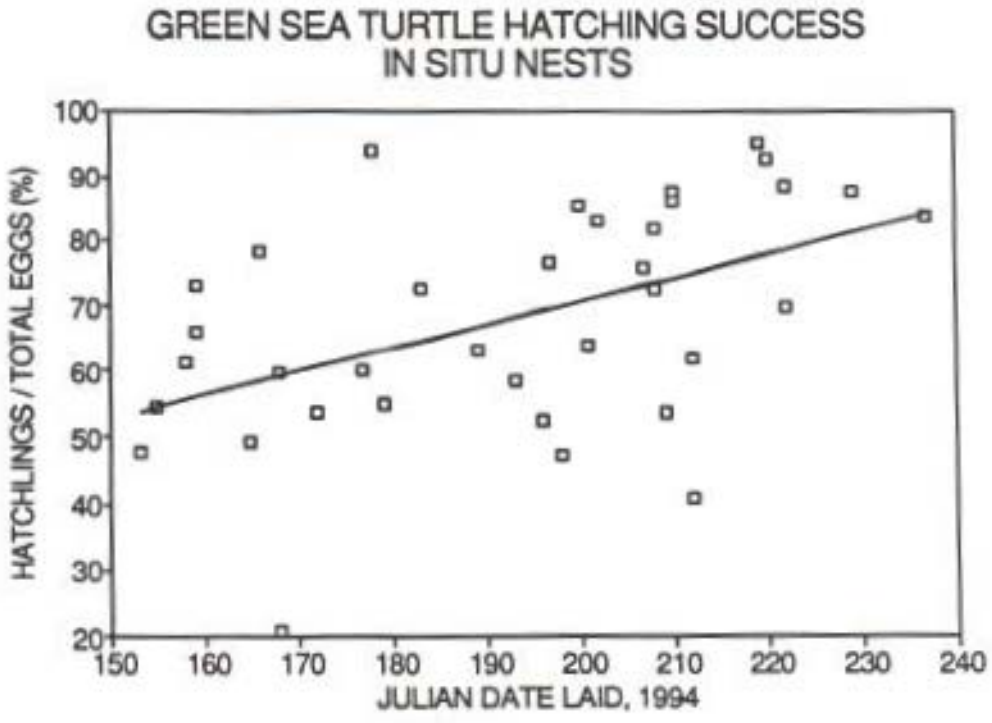




Figure 10: Comparison of the seasonal patterns of the hatching success of relocated and in situ green turtle nests during 1994.

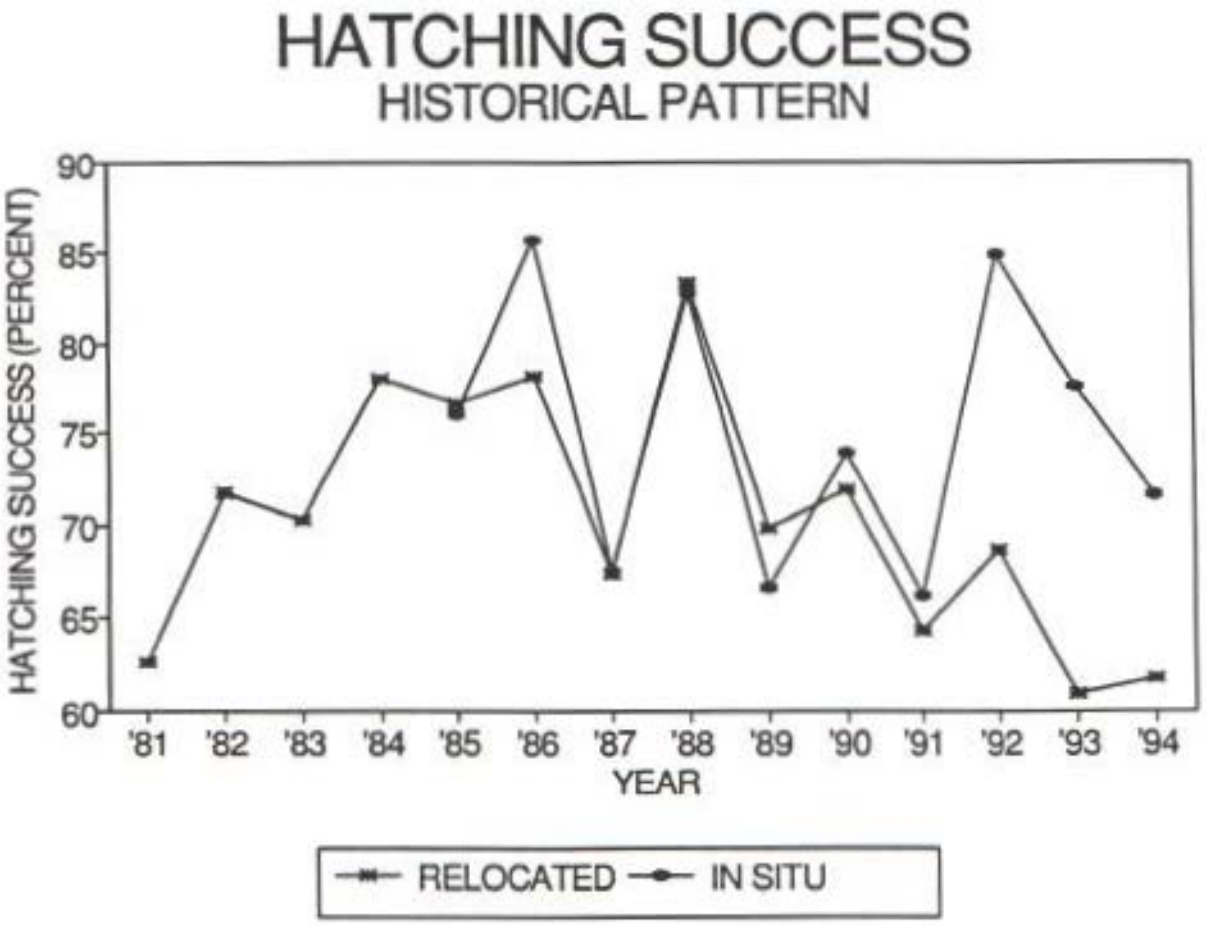



Figure 11: The historical patterns of yearly hatching success in all investigated relocated and in situ nests, since 1981.

Table 7: Accounting of the status of all hatched and unhatched eggs in investigated *in situ* and relocated *C. caretta* nests during 1994.

| Location | Total Eggs | Live Hatch % | DIN % | PIP % | VD % | NVD % | HL % |
|---|---|---|---|---|---|---|---|
| ***In Situ* Nests** | | | | | | | |
| Hillsboro | 25050 | 66.1 | 1.4 | 4.7 | 5.2 | 22.5 | n/a |
| Pompano | 850 | 89.1 | 2.5 | 1.7 | 2.2 | 4.6 | n/a |
| Fort Lauder. | 1625 | 72.2 | 13.5 | 3.8 | 2.6 | 7.9 | n/a |
| Lloyd Park | 15956 | 79.5 | 1.4 | 3.2 | • | 15.9 | n/a |
| **Relocated Nests** | | | | | | | |
| Hillsboro | | | | | | | |
| HB | 11504 | 56.9 | 2.1 | 7.7 | 5.2 | 27.7 | 0.1 |
| HB1 | 28893 | 58.9 | 2.7 | 12.6 | 7.7 | 17.7 | 0.4 |
| HB2 | 69841 | 59.0 | 2.6 | 13.2 | 9.6 | 15.3 | 0.3 |
| HB3 | 22604 | 68.2 | 1.7 | 11.1 | 5.0 | 13.8 | 0.3 |
| Pompano | 6664 | 67.9 | 1.8 | 12.2 | 5.0 | 12.9 | 0.2 |
| Ft. Lauderdale | 5675 | 77.9 | 0.9 | 10.0 | 1.5 | 9.6 | 0.1 |
| Lloyd Park | 717 | 69.5 | 2.1 | 6.0 | • | 22.4 | • |
| Hollywood | 10640 | 68.5 | 0.8 | 5.7 | 4.7 | 19.9 | 0.5 |

**Live Hatch** - All eggs which produced live hatchlings, including hatchlings found live in nest and live piped which were freed and released
**DIN** - Hatchlings found dead in the nest when it was excavated
**PIP** - Dead hatchlings which only partially succeeded in emerging from their eggs
**VD** - Unhatched eggs with signs of visible embryo development
**NVD** - Unhatched eggs with no signs of visible embryo development
**HL** - Eggs accidentally lost during relocation
* - See Table 5
• - Unreported category; all unhatched eggs listed as NVD

Table 8: Accounting of the status of all hatched and unhatched eggs in investigated *in situ* and relocated *C. mydas* nests during 1994. Notes and abbreviations as in Table 7.

| Location | Total Eggs | Live Hatch % | DIN % | PIP % | VD % | NVD % | HL % |
|---|---|---|---|---|---|---|---|
| ***In Situ* Nests** | | | | | | | |
| Hillsboro | 3034 | 64.7 | 0.8 | 4.5 | 4.5 | 25.4 | n/a |
| Fort Lauder. | 243 | 62.1 | 0.4 | 0.0 | 1.2 | 36.2 | n/a |
| Lloyd Park | 1360 | 80.6 | 0.5 | 1.5 | • | 17.4 | n/a |
| **Relocated Nests** | | | | | | | |
| Hillsboro | | | | | | | |
| HB | 1521 | 47.6 | 0.8 | 1.45 | 7.2 | 41.5 | 1.5 |
| HB1 | 818 | 68.7 | 1.0 | 1.6 | 4.6 | 23.0 | 1.1 |
| HB2 | 1567 | 57.6 | 1.7 | 5.4 | 9.3 | 25.3 | 0.8 |
| HB3 | 744 | 65.2 | 1.5 | 8.5 | 7.8 | 15.8 | 1.3 |
| Hollywood | 339 | 67.6 | 0.3 | 0.3 | 0.6 | 31.3 | 0.0 |

Table 9: Accounting of the status of all hatched and unhatched eggs in investigated *in situ* and relocated *D. coriacea* nests during 1994. Notes and abbreviations as in Table 7.

| Location | Total Eggs | Live Hatch % | DIN % | PIP % | VD % | NVD % | HL % |
|---|---|---|---|---|---|---|---|
| ***In Situ* Nests** | | | | | | | |
| Hillsboro | 226 | 77.4 | 0.4 | 0.4 | 0.4 | 21.2 | n/a |
| **Relocated Nests** | | | | | | | |
| Hillsboro | | | | | | | |
| HB | 147 | 69.4 | 0.7 | 0.0 | 8.8 | 21.1 | 0.0 |
| HB2 | 99 | 42.4 | 0.0 | 11.1 | 11.1 | 35.4 | 0.0 |

Table 10: Comparison of the mean hatching successes of relocated and *in-situ C. caretta* nests on Hillsboro Beach. Vertical lines at right overlap groups where means were not distinguishable in a SNK test (alpha-.05). Percentages are slightly different than in Table 7 due to round-off error.

| LOCATION | NESTS EVAL.* | MEAN HATCHING SUCCESS (%) | |
|---|---|---|---|
| HB-Reloc[1] | 105 | 57.6 | \| |
| HB2 | 642 | 59.8 | \| |
| HB1 | 262 | 60.8 | \| |
| HB-*In situ*[2] | 230 | 67.5 | \| |
| HB3 | 204 | 68.9 | \| |

* Number of nests dug for evaluation
[1] Nests relocated to other areas of Hillsboro beach; not hatcheries
[2] Hillsboro nests left *in situ*
Other designations as in Table 5.

that for Hillsboro nests relocated to other areas of that beach, and for Fort Lauderdale and Pompano nests moved to the HB1 and HB2 sites. However, the hatching success of nests moved to the HB3 site was not significantly different from that of *in situ* nests.

Table 11 gives a comparison of successful emergences and all categories of hatching or emergence failure for *in situ* and relocated nests at Hillsboro beach. All the differences are highly significant. There were higher proportions of dead-in-nest, pipped eggs, and unhatched eggs with visible embryo development in relocated nests, and a higher proportion of eggs showing no visible development in *in situ* nests. Table 12 compares the average number of pipped eggs per *C. caretta* nest for nests left *in situ* with those moved to Hillsboro beach (HB1, HB2 or HB3) or to the Hollywood hatchery.

## DISCUSSION

For the past five years, *C. caretta* nesting densities have been significantly higher than the 1981-1989 average. This clearly suggests that the population of nesting females has increased or that the individual females in the population have been nesting more frequently. This consistency continues to strengthen the argument against the hypotheses that higher nesting densities have resulted from the coincidental nesting of a large proportion of the female population in the same year. If this were the case, there would be alternating high and low nesting seasons (such as we see for *C. mydas*; Fig. 2), because individual sea turtles usually do not nest every year (Ehrhart, 1981). Whether the increased nesting is due to an increased number of newly mature females, augmentation from another population, or more frequent nesting of the individual females due to better nutrition (Wood and Wood, 1980) is impossible to determine without long-term tagging studies. The consistency in the density of

Table 11: Comparison of hatching and all categories of egg failure results for investigated *in situ* and relocated nests at Hillsboro Beach, using the large-sample hypothesis test for two population proportions (percent test). Percentages for each category are given in parentheses. Abbreviations as in Table 7.

| | IN SITU | RELOCATED | Z | P |
|---|---|---|---|---|
| Eggs | 25050 | 132842 | | |
| Live Hatch | 16570 (66.1) | 80194 (60.4) | 17.2 | $<<10^{-6}$ |
| DIN | 355 (1.4) | 3218 (2.4) | 9.8 | $<<10^{-6}$ |
| PIP | 1170 (4.7) | 16220 (12.2) | 35.0 | $<< 10^{-6}$ |
| VD | 1313 (5.2) | 10636 (8.0) | 15.1 | $<<10^{-6}$ |
| NVD | 5642 (22.5) | 22127 (16.7) | 31.2 | $<< 10^{-6}$ |

Table 12: Comparison of the average number of pipped eggs per *C. caretta* nest for nests left *in situ* at Hillsboro and Lloyd Park, and for relocation sites which were active for the entire season. Vertical lines at the right overlap groups where means were not distinguishable in a SNK test (alpha = .05).

| LOCATION | NESTS EVAL. n | MEAN NESTS PIPPED per nest | |
|---|---|---|---|
| Lloyd Park-in situ | 145 | 3.48 | I |
| Hillsboro-in situ | 230 | 5.09 | II |
| Hollywood Hatchery | 97 | 6.29 | II |
| Hillsboro-relocated | 105 | 8.47 | I |
| Ocean Crest (HB3) | 204 | 12.32 | I |
| Hillsboro Club (HB1) | 262 | 13.85 | I |
| Diamond Head (HB2) | 642 | 14.31 | I |

*C. caretta* nesting for the past 5 seasons (Fig. 2) strongly suggests that random processes are not the cause. This consistency also makes it uncertain whether the significant positive yearly trend in *C. caretta* nesting (Fig. 2) indicates an ongoing trend or is simply due to the large augmentation to the population in 1990, because there has been no significant positive trend in *C. caretta* nesting since then.

The status of *C. mydas* is much less clear, but a pattern seems to be developing. The alternating high-low patterns since 1989, and possibly from 1985 to 1987, (Fig. 2) are consistent with a population with a synchronized two-year nesting interval. *D. coriacea* nesting (Fig. 2) remains low and inconsistent.

The seasonal pattern of *C. caretta* nesting in 1994 was very unusual. Figure 12 compares the smoothed nesting patterns in 1993 and 1994. This year, nesting commenced at about the normal time, but the rate of increase during the early season was much faster than has been previously observed. This fast increase in May and early June was especially noticeable at Pompano Beach and Fort Lauderdale beaches (Fig. 4). Previously, the general shape of the seasonal nesting patterns had been very consistent, and similar to the 1993 pattern. Projections made in late May, based on the expectation of the usual shape of the seasonal pattern, predicted alarming numbers of nests, which would have overwhelmed our relocation efforts. In actuality, nesting fell off unusually fast in the last half of the season (Fig 12). Despite this abnormally fast start and slow finish, the seasonal pattern of sea turtle crawling activity (total crawls) still showed the usual fortnightly periodicity, with maximums near times when high tides occurred at about 10:00 PM. This has been observed and discussed previously (Burney and Mattison, 1989; Margolis, 1993; Margolis and Burney, 1994). The seasonal pattern of *C. mydas* nesting was similar to the other high-nesting years, 1990 and 1992 (Burney and Mattison,

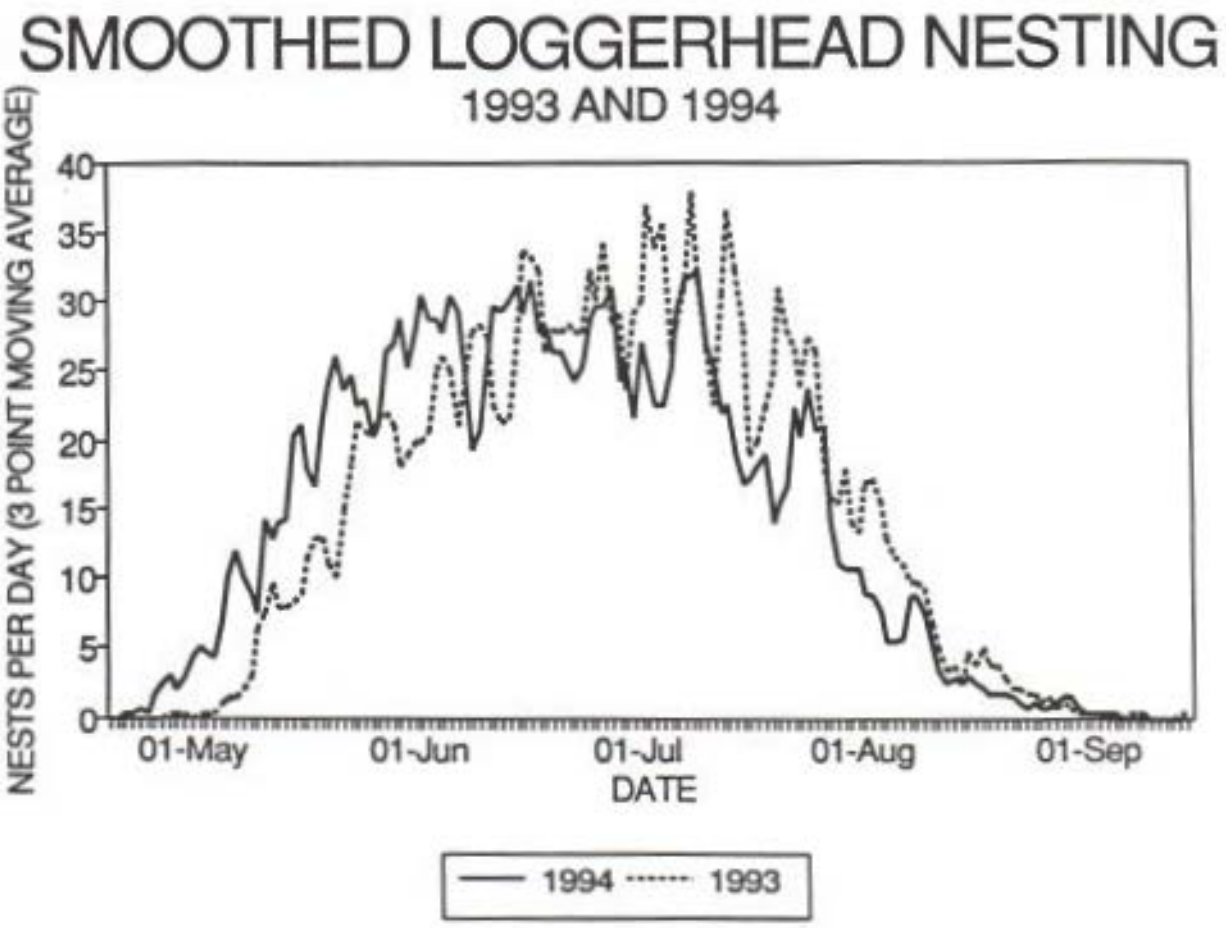



Figure 12: Comparison of loggerhead nesting in 1993 and 1994.

1990; 1992). *D. coriacea* again nested early, with the first nest deposited on March 24.

Unlike most recent years, the nesting density at Pompano Beach exceeded that at Hillsboro (Fig. 7), although the difference in mean daily nests per kilometer was insignificant (Table 1). There was a 21.5 percent reduction in *C. caretta* nesting (150 fewer nests) on Hillsboro beach compared to 1993. This was probably due to the severe erosion of some sections of this beach. *C. caretta* nesting at Pompano Beach was almost identical in 1993 and 1994, but there were 118 more nests deposited in Fort Lauderdale (21.5 percent increase) in 1994 than the previous year. This greatly added to the work load of the morning patrols, because these nests were all relocated to one of the three Hillsboro hatchery sites, or caged. Both the use of three relocation sites and the nest caging resulted in considerable additional time and effort for the beach workers. This was not offset by the reduction in nesting on Hillsboro beach, because nest relocation there did not involve long-distance transport and many nests were left *in situ*. Nesting in Lloyd Park increased by 70 nests (58.3 percent) compared to 1993, but the nest count for Hollywood-Hallandale for the two years was exactly the same.

As in the past, *C. mydas* appeared to prefer the relatively dark, undisturbed sections of Hillsboro Beach (Table 2; Fig 7). Lloyd Park beach also shares these characteristics, but nesting there was not statistically distinguishable from Fort Lauderdale or Pompano beaches. *D. coriacea* again nested primarily at Hillsboro Beach (Table 3; Fig. 7).

As in 1993, the nesting success of *C.caretta* was statistically uniform over the entire county (Fig. 8), except for Lloyd Park which was significantly lower (Table 4). This was probably not due to disturbance of emerging females as the park is closed at night. It may be due to beach erosion or unfavorable sand characteristics. *C. caretta* nesting success (Fig. 8) was lowest in the north

end of the Park (zones 1 and 2) which has the most eroded beach, due to the presence of the Port Everglades jetty. *C.mydas* nesting success was also lowest in zone 1 and highest in zone 4, which was the least eroded section. The nesting success of *C. mydas* was not statistically different throughout the county (Table 4).

The horizontal distribution of *C. caretta* nesting (Fig. 7) is also very similar to past years. The causes for the consistently higher and lower nested locations, involving the extent of beach-front lighting, pedestrian and vehicular traffic and development, have been discussed previously (Burney and Mattison 1990, 1991, 1992; Mattison, Burney and Fisher, 1993). As in past seasons, there was an extremely significant correlation ($r=.768$, $P< 10^{-6}$) between the horizontal distributions of nests (Fig. 7) and false crawls (not shown). This means that the zones with characteristically low nesting densities also have low numbers of false crawls, and vice versa. Lloyd Park appears to be the only exception. This is reflected in the general lack of trends in the horizontal nesting success pattern (Fig 8) and suggests that females generally select preferred nest sites before emergence, rather than by first emerging and then checking the sand, etc., for suitable conditions.

The overall hatching success of *C. caretta* nests (Table 6) again was significantly higher in *in situ* than in relocated nests ($P << .001$). This has been the case since 1991 (Fig 11). This was also the case with *C. mydas*. To assess this, analysis was focused on a comparison of *C. caretta* hatching success of nests deposited at Hillsboro beach and relocated there from Pompano and Fort Lauderdale. The hatching successes of *in situ* nests and those relocated to HB3 (Ocean Crest) were not statistically different (Table 10). However, the success of Hillsboro nests relocated to other areas of Hillsboro beach, HB1 (Hillsboro Club) and HB2 (Diamond Head) were significantly lower, and statistically indistinguishable from each other (Table 10). Hatching success can be reduced in

relocated nests due to rough handling or improper relocation technique, but the results are difficult to explain in these terms because the same group of people were involved in relocating the nests to all three Hillsboro relocation sites, and also to the Pompano and Fort Lauderdale hatcheries. It is reasonable to assume that the workers employed the same technique, regardless of the relocation site. The proportion of hatchlings found dead-in-nest was only slightly higher is relocated nests than in those left *in situ* (Table 11). This difference was significant, but it can not account for the overall difference in hatching percent. This suggests that the reduced hatching success of relocated nests was not primarily due to improper digging or filling of the artificial egg chambers, which might prevent hatchlings from emerging. The difference may have resulted from the non random assignment of personnel to the various hatcheries, but all workers worked at each of the three locations during the season, and they were assigned according to need, not a prearranged plan.

The differences in hatching success at the three sites may have been due to differences in conditions during incubation. The Ocean Crest (HB3) location was at a slightly lower elevation that the other sites, but there were no obvious differences in sand characteristics between the three areas. In a past report (Burney and Margolis, 1993), we speculated that the organic remains of old nests may have adversely affected hatching success at the Hillsboro Club. This could not have been the case this year, because the relocation site was moved away from the location used for the past five years.

Table 7 shows large variations in the percent of pipped eggs from *in situ* and relocated nests. An analysis of this showed that the average number of pipped eggs per nest at three Hillsboro hatcheries were statistically equivalent, but significantly greater than in undisturbed nests at Hillsboro and Lloyd Park and relocated nests at Hillsboro and Hollywood. It is also interesting that the hatching success of nests relocated to the Hollywood hatchery was higher than

for undisturbed nests at Hillsboro (Table 7), and there was a lower proportion of pipped eggs at Hollywood, which was statistically equivalent to *in situ* nests (Table 12). A possible explanation (hypothesis) is that the surveys of Hollywood-Hallandale beach were almost always finished by 7:30 AM or earlier, due to the low nesting densities, and the nests were exposed only in the early morning. Many nests relocated to Hillsboro Beach were excavated and relocated later in the morning, due to the heavy work load and transportation distance. These nests may have experienced more adverse environmental conditions during the relocation process than those moved to the Hollywood hatchery.

The seasonal hatching success patterns (Figs. 9-10) are unusual because the significant inverse relation of hatching success and the date of deposition (which has been observed since 1989) was not present this year. The increasing seasonal trends in both *in situ* and relocated *C. mydas* nests (Fig. 10) are even more unusual. This nesting season was unusually rainy. Rainfall in coastal Broward County was about 60 percent above normal in August and 30 percent above normal in September. Fort Lauderdale's total for September was twice the long-term average (Sun-Sentinel, Nov. 2, 1994). Much of this rain fell on the coastline in torrential downpours. This did not appear to adversely affect hatching success. Likewise, high tides over washed all the hatchery areas on Hillsboro Beach, sometimes several times, after September 9, but there is no noticeable decline in the hatching success of the later nests.

There is considerable uncertainty attached to the use of mass nest relocation as a management tool. If nest counts continue to increase, the cost of the project in terms of money and possibly decreased hatching success, will increase. There is also the very real possibility that continued erosion on Hillsboro beach might deprive us of suitable relocation sites. Nest caging, as an alternative to relocation was tried this year (details have been reported separately), with rather poor results. Of the 37 nests caged, only 17 remained

undisturbed until hatching. Table 7 shows an unusually high proportion of dead-in-nest hatchlings from Fort Lauderdale *in situ* nests. This was primarily due to one unmarked nest which contained 117 dead hatchlings. This nest may have been compacted by beach traffic. A comparison of the hatching successes and numbers of dead-in-nest hatchlings in nests which hatched from cages and in unmarked Fort Lauderdale *in situ* nests (many of which were probably nests from which cages were removed) showed no significant differences in either parameter (ANOVA). The caging was done on the least used section of Fort Lauderdale beach, but human tampering with the cages was severe, and in one case, possibly malicious. Cages were used for seats, tables, and two were turned upside down and used for trash cans during the Labor Day weekend. If caging was employed on more heavily used beaches, we can only assume the disturbance, and resulting confusion, would be much worse. It appears that the only viable long-term management solution must involve enactment and strict enforcement of beach-front lighting regulations, coupled with constructs, such as low retaining walls, which would keep any disoriented hatchlings on the beach, where they could be more easily rescued by morning patrols.

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APPENDIX 1: SUMMARY OF SEA TURTLE HOT-LINE, BEEPER & NOVA CALLS

| SUBJECT | HOT-LINE | NOVA |
|---|---|---|
| EMERGENCES: | | |
| Nesting | 8 | |
| Hatchlings | 3 | |
| NEST LOCATIONS | 120 | 3 |
| STRANDINGS | 12 | |
| POACHING | 2 | |
| VOLUNTEERS | 6 | 10 |
| OTHER ** | many | 30 |
| OVERALL | >151 | 43 |

** Including calls from the media, residents concerned about land turtles in pools, all-terrain vehicle breakdowns and repairs, and all other unclassified, requests for information, and multi reason calls.

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.

During July through mid August,a weekly sea turtle release and informational seminar was given by Bill Margolis or Dr. Dale Vicha, at Hollywood North Beach Park. These were well attended. At least two turtle lectures or talks were given at local schools.