

TECHNICAL REPORT

SEA TURTLE CONSERVATION PROGRAM BROWARD COUNTY, FLORIDA 2013 REPORT

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For the:



BROWARD COUNTY
BOARD OF COUNTY COMMISSIONERS

TABLE OF CONTENTS

LIST OF TABLES	3
LIST OF FIGURES	4
ACKNOWLEDGEMENTS	5
EXECUTIVE SUMMARY	7
INTRODUCTION	8
MATERIALS AND METHODS	10
RESULTS	15
Yearly Nesting Trends	15
Seasonal Nesting Patterns and Densities	16
Countywide Nest Distribution and Shoreline Protection Projects	17
Nesting Success	17
Relocated and <i>In Situ</i> Nests	18
Live Hatchlings Released	18
Post Hatch Evaluation Results	19
Hatchling Disorientation Events	20
DISCUSSION	20
Yearly Nesting Trends	20
Seasonal Nesting Patterns	22
Countywide Nest Distribution	23
Nesting Success	24
Hatchling Productivity	24
Post-Emergence Analysis	25
Hatchling Disorientation	26
REFERENCES	49
APPENDICES	
1. Summary of Emergency Cell Phone Calls	51
2. Summary of Educational Activities	52
3. Sea Turtle Nest Marker Sign	53

LIST OF TABLES

Table 1: Broward County survey areas.	27
Table 2: Destinations for Relocated Nests in Pompano, Lauderdale-by-the-Sea and Fort Lauderdale.	27
Table 3: Destinations for relocated nests in Dania, Hollywood and Hallandale.	28
Table 4: Total loggerhead nests and nesting densities expressed as nests-per-kilometer for 2013.	28
Table 5: Total green sea turtle nests and nesting densities expressed as nests-per-kilometer for 2013.	29
Table 6: Total leatherback nests and nesting densities expressed as nests-per-kilometer for 2013.	29
Table 7: Total nests, false crawls and percent nesting success for three sea turtle species in each of five Broward County beach areas during 2013.	30
Table 8: The total number of nests relocated or left <i>in situ</i> .	31
Table 9: Total egg counts, released hatchlings and overall hatching production for <i>in situ</i> and relocated nests of all species in 2013.	32
Table 10: Accounting of all categories of hatched and unhatched loggerhead eggs from relocated and <i>in situ</i> nests, for each beach during 2013.	33
Table 11: Accounting of all categories of hatched and unhatched green turtle eggs from relocated and <i>in situ</i> nests, for each beach during 2013.	34
Table 12: Accounting of all categories of hatched and unhatched leatherback eggs from relocated and <i>in situ</i> nests, for each beach during 2013.	34

LIST OF FIGURES

Figure 1: Site location map of Broward County.	35-37
Figure 2: The historical sea turtle nesting pattern in Broward County since full surveys began in 1981	37
Figure 3: Historical nesting patterns of loggerheads, greens and leatherbacks in Broward County, 1981-2013.	38
Figure 4: The seasonal pattern of daily loggerhead nest counts in Broward County, 2013.	39
Figure 5: Comparison of the daily loggerhead nesting patterns on the five Broward County beaches during 2013.	40
Figure 6: The seasonal patterns of daily green and leatherback nest counts in Broward County, 2013.	41
Figure 7: Comparison of the daily nesting patterns of greens and leatherbacks on the Broward County beaches, 2013.	42
Figure 8: Locations of loggerhead, green and leatherback nests in Broward County, 2013, listed by DEP locator number.	43
Figure 9: The horizontal distribution of average loggerhead, green and leatherback nesting success plotted by the DEP survey markers.	44
Figure 10: Yearly loggerhead nesting success trends since 2000.	45
Figure 11: The historical patterns of yearly hatchling release success in all investigated relocated and <i>in situ</i> nests since 1981.	46
Figure 12: The seasonal patterns of loggerhead hatchling release success in relocated and <i>in situ</i> nests during 2013.	47
Figure 13: Hatchling release success frequencies for relocated and <i>in situ</i> loggerhead nests in 2013.	48

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Executive Summary

Sea turtle patrols were conducted each morning, beginning at dawn on all Broward County beaches except John Lloyd State Park, from March 1 through September 30, 2013. Nests of loggerhead, green and leatherback sea turtles were identified, marked and located with GPS. A total of 2459 loggerhead nests were deposited in the County, which was 825 (25.1%) fewer than last year, but was still the second highest count since surveys began in 1981. Loggerhead nesting has increased overall since 1981, but there was a sharp decline from 2000 to 2007. Since 2007 there has been a significant positive trend ($P = 0.019$) in loggerhead nesting. Loggerhead nesting densities ranged from 108 nests per km in Hillsboro Beach to 16.9 nests per km in Hollywood and Hallandale Beach. Green sea turtles deposited a record number of 495 nests throughout the County, exceeding the previous record of 272 set in 2008 by 82%. Hillsboro and Fort Lauderdale account for 87.4% of the total green nesting. Leatherbacks laid only 18 nests this year, which was down from last year's record of 46, but was still slightly above the 33-year average of 15.2 nests per year. Hillsboro Beach accounted for 61% of the leatherback nesting this year.

Loggerhead nesting in 128 R-zones, designated by FDEP survey markers set at approximately 1000 foot intervals along the beach, showed a general pattern of high and low nested zones which has been very consistent for 25 years. This pattern was related to fixed beach structures and features and was characterized by lower nesting near inlets and piers, the Fort Lauderdale strip and in Hollywood and Hallandale Beach. Greens and leatherbacks nested preferentially in Hillsboro Beach, probably due to lower beach front lighting and lower nocturnal human activity.

Nesting successes (nests / total emergences) averaged 50% for loggerheads, 59.3% for greens and 91.7% for leatherbacks. Compared to 2012, green nesting success increased 17.4%, while loggerheads and leatherbacks successes changed very slightly.

The production of live hatchlings from 1720 evaluated loggerhead nests that incubated in place (*in-situ*) was extremely high at 88.3%, which indicates that incubation conditions were very good this year. The hatchling production rate of 115 loggerhead nests that were relocated to protect them from seawater inundation or disorientation due to beach lighting was slightly lower at 81.9%, probably due to the relocation process. The live hatchling production of 336 evaluated green and 11 leatherback nests were 89.7% and 69.5%, respectively. Overall live hatchling production rates were near historical maxima.

This season surveyed two active beach protection projects and one ongoing sand bypass project. The A1A Emergency Beach Restoration

Project conducted in March and April, 2013 in Fort Lauderdale (R64-67) was finished in the early nesting season. No sea turtle nests required relocation from the construction area. There were 50 loggerhead and 5 green turtle nests deposited on the filled sand during the nesting season. Loggerhead nesting success in the nourishment area declined from 53.2% in 2012 to 41.7%, possibly due to the sand placement. This is normal after nourishment projects and nesting success usually returns to normal in following years. Sea turtle monitoring was conducted for the Flood Control and Coastal Emergency Beach Erosion Control Project in R26-R53 in Pompano Beach. One green turtle nest was relocated from R40 to R59 in Fort Lauderdale on August 31. It hatched on October 21. There were no additional nests that required relocation during the extended monitoring period from October 1 through November 15. Only 4 loggerhead nests were deposited in the area directly impacted by the Hillsboro Inlet sand bypass (R25-26) compared to 18 and 21 nests in R27 and R28, respectively. Nesting has been historically low in R25-26. This could be due to the sand bypass or also to the higher tidal currents around the adjacent inlet.

INTRODUCTION

Since 1978, the Broward County Natural Resources Planning and Management Division (BCNRPMD) has provided for the conservation of endangered and threatened sea turtle species within Broward County. 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 Florida's Marine Turtle Protection Act (379.2431, Florida Statutes).

Since these statutes strictly forbid any disturbance of sea turtles and their nests, conservation activities involving the relocation of nests from hazardous locations require permitting by the U.S. Fish and Wildlife Service (USFWS). In Florida, this permit is issued to the Florida Fish and Wildlife

Conservation Commission (FFWCC), Imperiled Species Management Section, Tallahassee, Florida. This project was administered by the BCNRPMD and conducted by the Nova Southeastern University Oceanographic Center under Marine Turtle Permit #108 issued to Laura Wright by the FFWCC.

The BCNRPMD is especially concerned with any environmental effects of intermittent beach nourishment projects on shorelines and the offshore reefs. As a result, the BCNRPMD has maintained the sea turtle conservation program in non-nourishment years to provide a continuous database and for monitoring of completed nourishment projects. Two small renourishment projects: the A1A Emergency Restoration Project in Fort Lauderdale and the Flood Control and Coastal Emergency Beach Erosion Control (FCCE) Project in Pompano Beach. Sand was also placed in R25-26 by the Hillsboro Inlet sand bypass project. In addition to fulfilling the requirements of the U.S. Endangered Species Act and Florida's Marine Turtle Protection Act (379.2431, Florida Statutes, the purposes of the project include:

- 1) to relocate eggs from nests deposited in sites threatened by natural processes or human activities and thus maximize hatchling survival,
- 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 in terms of nesting success, hatching success and total live hatchling production,

- 4) to dispose of turtle carcasses, respond to strandings and other emergencies and maintain a 24-hour emergency cell phone 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 one half hour before sunrise. For survey purposes the County was divided as follows:

Daily surveys of Deerfield Beach, Hillsboro Beach, Pompano Beach, Lauderdale-by-the-Sea, Fort Lauderdale, Dania Beach, Hollywood Beach, and Hallandale Beach commenced on March 1, 2013. Surveys continued through September 30 for the majority of the County and through October 31 to satisfy permit obligations for beach cleaning activities in Fort Lauderdale and a beach renourishment project in Hollywood. The beach at John U. Lloyd State Park (JUL) was patrolled by park personnel who provided the data from that area. Except in Lloyd Park, nest locations were referenced to Florida Department of Environmental Protection (FDEP) beach survey monuments numbered consecutively from R1 to R128 (North to South). Marker numbers corresponding to each beach section are listed in Table 1. 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. Nest and non-nesting (false) crawl locations were also recorded using Nexus 7 tablets with the VJGames GPS Coordinates Application. This system uses GPS, Wi-Fi and mobile networks

to determine locations. Its accuracy is usually within 3 meters, which is sufficient for locating previously marked nests. All false crawls were recorded, but those that did not reach the previous high tide line were listed separately.

Surveyors used four-wheeled all-terrain vehicles (ATVs) that could carry up to six turtle egg clutches per trip in plastic buckets if needed. When relocation was necessary, nests and false crawls were marked and recorded on the first pass along the beach. Nests in danger of negative impacts were dug and transported to relocation sites on the return pass. Nests were relocated to adjacent “safe zones” or “recipient sites” in a random manner to avoid clustering nests within the recipient zones, in accordance with FFWCC instructions. After recording all pertinent information, the crawl marks were obliterated to avoid duplication.

Nests in danger of negative impacts were defined as follows:

- 1) a nest located at or below the previous evening’s wrack line or,
- 2) a nest located in a “donor zone”, which was pre-determined by the FFWCC and located in a highly illuminated area.

Nests located in Fort Lauderdale, Lauderdale-by-the-Sea, and Pompano were relocated if they were deposited in a donor site or at or below the previous evening’s wrack line. Donor sites for these beaches were designated by FFWCC and included zones R85, R54-53, R50, R35-32, and 2300 Bay Drive north to the Hillsboro Inlet. All other zones were designated recipient and *in situ* only sites.

In Fort Lauderdale, Lauderdale-by-the-Sea, and Pompano recipient and *in situ* only sites included zones R31-25 (referred to as BP1), R41-36 (BP2), R49-42 (BP3), R84-55, and R52-51. All nests that were relocated from zones R54-53 were alternately moved to zones R52-51 and R63-58. Nests that were relocated from R85 were moved to R83-80. Nests needing to be

relocated from zones R50 were relocated to R49-42 (BP3, Lauderdale-by-the-Sea). All relocated nests from zones R35-33 were moved to R41-39 and R37-36 (BP2) and R32 were moved to R31-25 (BP1). Zones R79-69 were designated as *in situ* only with caging encouraged. This protocol was mandated by FFWCC. Donor zones and their associated recipient zones are summarized in Table 2.

Nests in danger of negative impacts at Hillsboro Beach were individually relocated to safer nearby locations (designated BH) or they were moved to open beach locations adjacent to homes with house numbers in the 900s through the 1100s on Highway A1A. These locations were designated BH900s, BH1000s, BH1100s and DB (in Deerfield Beach), respectively. The locations of the most southerly and northerly limits of this area (BH900s and BH1100s, respectively) are shown in Figure 1B.

Hollywood Beach was divided into donor and recipient/*in situ* only sites. Donor sites included zones R122-107 and R101-100. Nests relocated from zones R101-100 were moved to R106-102. Nests relocated from zones R114-R107 were moved to R106-102, and nests from R122-115 were moved to R128-124. These donor and recipient zones are summarized in Table 3. By FFWCC directive, all green and leatherback nests were left *in situ* except for those deposited at or below the previous evening's wrack line. Only 3 green turtle nests were relocated, while 468 were left in place. One leatherback nests was relocated and 16 remained *in situ*.

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

was taken to maintain the natural orientation of each egg, to minimize possible injury to the embryos. These relocated nests were marked off on the beach using one signed stake and two unsigned stakes forming a triangle around the egg chamber. A total of 124 nests were relocated. Of these, 120 were loggerhead nests that were relocated due to their location below the wrack line (29) or in areas with high intensity beach lighting (91). After hatching, 115 of these nests were evaluated. The 5 unevaluated nests were totally predated or washed out. In addition, 2 green and 1 leatherback nests below the wrack line were relocated to prevent certain washout and 1 green nest was relocated from the FCCE beach renourishment area in Pompano Beach.

A total of 2646 nests that were located in FFWCC designated recipient sites were marked with stakes bearing yellow 5.5" X 8.8" sea turtle nest warning signs (Appendix 3), surrounded by a minimum of four additional stakes and a 6 foot diameter circle of caution tape and left *in situ*.

At least three days after emergence, 2067 *in situ* nests (78%) were excavated for post emergence evaluation. The number of hatchlings released from each nest was determined as the total number of eggs minus the number of hatchlings found dead in the nest (DIN), dead piped eggs with partially emerged hatchlings (DPIP), and unhatched eggs showing visible (VD) or no visible development (NVD). The number of hatchlings alive in the nest (LIN) and live piped eggs (LPIP) were included in the number of hatchlings released but were subtracted from this number to determine the number which naturally emerged from each nest. Live hatchling production success was defined as the number of released hatchlings divided by the total number of eggs.

Workers also located, assessed, and recorded hatchling disorientation events and sent a Marine Turtle Hatchling Disorientation Incident Report Form for each event to FFWCC.

Data Analysis

The data were compiled, analyzed and plotted with Quattro Pro, version 8 (Corel Corp. Ltd.) and Statistica, release 6 (StatSoft, Inc.). The countywide yearly nesting densities from 1981 to 2013 for the three species were plotted and trends were assessed by linear regression and correlation analyses to keep consistent with historical methods of analysis. Seasonal nesting densities (nests per km) were calculated for each beach and compared using 1-way analysis of variance (ANOVA) and Newman-Keuls (NK) tests at the 0.05 significance level. The total number of nests deposited by each species in the beach segments corresponding to each FDEP survey marker were tabulated and plotted. GPS positions for nests were also plotted on the Broward County Coastline Aerial Shore Line Map using the ArcMap Geographic Information System (GIS).

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 were compared using 1-way ANOVA and NK analyses. The average nesting success in each zone was also plotted versus its FDEP survey number. The numbers of eggs and live hatchlings (emerged, LIN and LPIP) of each species in relocated and evaluated *in situ* nests were recorded and the hatchling release successes were determined. The overall hatchling release successes of all eggs from relocated and *in situ* nests were plotted from 1981 through 2013. The frequency distribution of the hatching success of relocated and *in situ* loggerhead nests were plotted and compared with the

Mann-Whitney U-test. The mean hatching percentages and proportions of the post-hatching egg categories (LIN, LPIP, DIN, DPIP, VD and NVD) were tabulated by species from nests deposited or relocated at each of the individual beaches or relocation sites.

RESULTS

Yearly Nesting Trends

Figure 2 shows the historical trend in the total number of sea turtle nests deposited in Broward County since 1981. A total of 2972 nests were recorded in 2013, which was 567 (16%) fewer than in 2012 but was still the second highest count on record and 685 nests above the average of the previous 10 years.

Figure 3 shows the yearly nesting trends of loggerhead, green and leatherback sea turtles. Loggerheads deposited 2459 nests in 2013, which was 825 (25.1%) less than 2012 but exceeded the previous 10-year mean by 384 nests. The overall loggerhead nesting trend is still strongly positive ($P < 0.001$), with a slope indicating an average increase of 30.7 nests per year since 1981. The upward trend since 2007 is still significantly positive ($P = 0.019$), with a slope of 201 nests per year. Green turtles deposited an astonishing 495 nests in the County this year (Fig. 3), which was 82% higher than the previous record of 272 set in 2008 and 4 standard deviations above the previous 10-year average of 190 nests. The slope of the trend line since 1981 is significantly greater than zero ($P < 0.001$), and indicates an average increase of 8.5 nests per year. Leatherbacks made 18 nests this year which was 28 below last year's record of 46, and 4 nests less than the average of the previous 10 years, but close to the 33-year average of 15.2. The overall

trend is significantly positive ($P < 0.002$), suggesting a gradual increase of 0.7 nests per year.

Seasonal Nesting Patterns and Densities

Figure 4 shows the countywide loggerhead seasonal nesting pattern. The first nest was deposited on April 20 in Hillsboro Beach and the last was in Fort Lauderdale on September 2. Table 4 and Figure 5 give the total loggerhead nesting densities and seasonal patterns for the five beaches. Nesting densities (mean daily nests/km) were the highest by far in Hillsboro Beach, followed by Fort Lauderdale, Pompano Beach, Lloyd Park and Hollywood.

The countywide seasonal nesting patterns of greens and leatherbacks are shown in Figure 6 and for the individual beaches in Figure 7. The first and last leatherback nests were deposited on March 18 and August 19, in Pompano Beach and Hillsboro Beach, respectively. The first green turtle nest was laid on May 27 in Lloyd Park and the last was on September 25 in Fort Lauderdale. Nesting densities for greens and leatherbacks are shown in Tables 5 and 6, respectively. The Newman-Keuls test showed that the nesting density of green turtles per kilometer was significantly highest in Hillsboro Beach, while the other beaches were much lower and statistically equivalent.

Hillsboro Beach accounted for almost 65% of the total green nests deposited in the entire County. Leatherbacks also nested most densely in Hillsboro Beach, which accounted for 61% of total county nesting for this species. Leatherbacks nested on all beaches in 2013. One nest was deposited in Lloyd Park, after a 2-year absence.

Countywide Nest Distributions and Shoreline Protection Projects

Figure 8 gives nest counts for each species in each approximately 1000-foot beach zone (3280 ft zones in Lloyd Park) during 2013. There were 50 loggerhead and 5 green nests deposited in the A1A Emergency Restoration Project beach renourishment area (R 64-67) and 4 loggerhead nests in the area receiving sand from the Hillsboro Inlet sand bypass project (R25-26).

Nesting Success

Figure 9 and Table 7 show the countywide nesting successes of the three species. As found in the two previous years, there were no significant overall between-beach differences for loggerheads and leatherbacks. The nesting success of green turtles was significantly lower in Hollywood than on the other beaches, which were not significantly different from each other (Table 7). North of R96, loggerhead nesting success was highest (69.4%) in R23 in southern Hillsboro Beach and lowest (20.0%) in R26 in the sand bypass area just south of the Hillsboro inlet in Pompano Beach. As in previous years, the higher variability in loggerhead nesting successes south of R96 was due to the relatively lower number of nests and false crawls in this area. There was no significant overall north-to-south trend in loggerhead nesting success in zones R1-96 (Fig. 9a). Zones farther south were excluded from this analysis because of the high variability, due to low nesting. Loggerhead nesting success was 41.7% in the A1A Emergency Restoration Project area (R64-67) and 25% in the area impacted by the Hillsboro Inlet sand bypass (R25-26).

Figure 10 shows the trends in loggerhead nesting success for the 5 beaches since 2000. Prior to 2004, false crawls were counted only if they

extended above the previous high tide line. Since then, false crawls that did not reach the previous high tide line were also counted, but were listed separately. The closed symbols give the nesting success with these crawls included.

Relocated and *In Situ* Nests

Table 8 gives the number of nests for each species that were relocated or left *in situ*, not including John U. Lloyd Park. Overall, 120 loggerhead nests were relocated and 2162 were left *in situ*. Because of the FFWCC directive to leave all green and leatherback nests *in situ* unless they faced certain destruction, only 2 green and 1 leatherback nests that were deposited below the previous evening's wrack line were relocated. One additional green nest with 121 eggs was relocated on August 31 from R 40 in Pompano Beach to R-59 in Fort Lauderdale because of the impending FCCE beach renourishment project. This nest hatched on October 21 and produced 112 live hatchlings.

Live Hatchlings Released

Table 9 lists the number of eggs and released hatchlings from evaluated *in situ* and relocated nests. The hatchling release success (live hatchlings/total eggs) of relocated loggerhead nests this year was 81.9% compared to 80.0% last year. The success of *in situ* loggerhead nests increased from 84.3% in 2012 to 88.3% this year.

The live hatchling production rates for *in situ* and relocated green nests of 89.7% and 82.7%, respectively, compared to respective values of 86.4% and 76.6% in 2012. The 12 evaluated *in situ* leatherback nests produced live

hatchlings at a rate of 69.5% while the single relocated nest had a yield of 58.0%.

Figure 11 illustrates the historical patterns of yearly release success for all evaluated *in situ* and relocated sea turtle nests since 1981. This year's percentages were near or slightly above their historical maxima.

Figure 12 shows the live hatchling production percentages for *in situ* and relocated loggerhead nests plotted versus Julian date of deposition in 2013. This year, the inclusion of small numbers of live hatchlings from partially predated nests could have caused the mean success rates to be inflated since the spreadsheet calculated 100% for these nests. Therefore, 142 partially predated *in situ* nests and 7 partially predated relocated nests were removed from the analysis in Figure 13. The average hatching successes of 88.5% and 80.5% of *in situ* and relocated nests was very similar to the rates calculated from the total number of eggs and released hatchlings in Table 9.

Figure 13 shows the frequencies (percentages) of relocated and *in situ* nests that produced from 0 to 100 percent live released hatchlings in 2013. A Mann-Whitney U Test showed that the medians of 93.5% for *in situ* and 86.5% for relocated nests were significantly different ($P < 0.001$).

Post Hatch Evaluation Results

Table 10 compares emergence success and the percentages of hatchlings and eggs in the post-hatching evaluation categories for relocated and *in situ* loggerhead nests. No post-hatching data were obtained for Lloyd Park. The park staff reports these data separately. Tables 11 and 12 give the same results for greens and leatherbacks, respectively. In Tables 10-12, emergence success is the percentage of hatchlings that emerged from the

nests on their own, and should not be confused with live hatchling production success, [hatchling production success = (emerged +LIN+LPIP)/total eggs] in Table 9 and Figures 11-13.

Hatchling Disorientation Events

The morning patrols reported a total of 155 nests that experienced disorientation in 2013, including 5 in Deerfield Beach, 19 in Hillsboro Beach, 48 in Pompano, 15 in Lauderdale-by-the-Sea, 54 in Fort Lauderdale 13 in Hollywood and 1 in Hallandale. There were 130 reports in 2012. From 2006 through 2013, this number has ranged from 110 to 385, with this year's total near the low end of the range. Another group which monitors nests at night to rescue disoriented hatchlings known as Sea Turtle Oversight Protection (STOP) reported about 20,500 disoriented hatchlings from approximately 657 nests in 2012 and 30,639 disoriented hatchlings from approximately 669 nests in 2013. In 2011, this group reported about 14,000 disoriented hatchlings from about 350 nests.

DISCUSSION

Yearly Nesting Trends

The number of loggerhead nests deposited in Broward County this year was 25% lower than last year's record, but it was still the second highest number since project inception (Fig. 3). The upward trend since 2007 is still positive. Figure 3 shows that this year's total plotted very close to the trend line from 2007 through 2010. This trend was significant (P = 0.006) even with the 2012 point excluded. Loggerhead nesting on the Florida Index Beaches also declined this year, but not enough to interrupt the upward

trend since 2007 (Fish and Wildlife Research Institute, 2013a). As we pointed out last year (Burney and Wright, 2013), if the record increase in 2012 was due to the nesting of an unusually large percentage of the established adult female population, 2013 should be a non nesting year for a many of these turtles and this year's count should have declined dramatically. This was not the case. Nesting did decline, but it remained in line with the slower increase established from 2007 to 2010.

Green turtles established a new nesting record this year, posting a nest count more than double that of 2012 and exceeding the previous record year by 82%. If this increase was due to new females entering the nesting population, then next year may be a non-nesting year for them and next year's count might be closer to last year's number. Based on the alternating pattern of nesting and non-nesting years established during the 1990's (Fig 3) and the fact that nesting remained high relatively high from 2010 to 2012, we expected this year to be a non-nesting year for most of the population (Burney and Wright, 2013). The decidedly opposite result may indicate the recruitment of new females to the nesting population. Green turtles also nested in record numbers on the core index beaches statewide, more than doubling the number in the next highest year (Fish and Wildlife Research Institute, 2013b).

Leatherback nesting was down from last year's record but still near the 33-year average. Nesting also declined on the core index beaches (Fish and Wildlife Research Institute, 2013b). Although there is still a significantly positive nesting trend in Broward County, it is not as dramatic as the statewide up trend. Leatherback nesting continues to be highly variable but the species has not failed to nest in the County since 1982.

Seasonal Nesting Patterns

The seasonal loggerhead-nesting pattern (Fig. 4) was quite similar in shape and duration to 2012 (Burney and Wright, 2013), with a rather symmetrical overall shape and a midpoint in late June. The highest daily count of 53 nests was recorded on June 24, at mid season. There was nothing unusual about the seasonal nesting at the individual beaches (Fig. 5) except for Fort Lauderdale, which showed an unusual saw-tooth pattern of 3 or 4-day increases and declines, with a frequency of six to seven days. The cause of such a nesting pattern is unknown. Loggerhead nesting densities throughout Broward County were again highest in Hillsboro Beach and generally declined toward the south (Table 4), with lower but statistically equivalent nesting in Fort Lauderdale and Pompano Beach and still lower nesting in Lloyd Park and Hollywood.

Green turtle nesting (Fig. 6) started 15 days later than in 2012 but both seasons ended on the same day (Sept. 25). Daily nest counts fluctuated widely. The maximum number of 18 nests was recorded on July 22, but only 1 nest was laid on the following day. The leatherback nesting season was highly unusual this year. Although the first nest was deposited on March 18, which is not unusual, there were two extremely late nests laid in Hillsboro Beach on August 9 and August 19. The first of these was deposited in R-13 and the second was laid nearby in R-11, quite possibly by the same turtle. Eckert et al. (1989) reported a leatherback clutch frequency interval of 9 days. The earlier nest failed to hatch and the later nest produced only 2 naturally emerged and 3 live-in-nest hatchlings.

Green turtles have always favored Hillsboro Beach over the more southerly beaches (Fig 7, Table 5). Hillsboro accounted for almost 65% of the

total County nesting. Nesting densities on other beaches were much lower and all statistically indistinguishable.

Countywide Nest Distribution

The distribution of loggerhead nests in the 128 survey zones (Fig. 8) was extremely similar to last year's pattern (Burney and Wright, 2013) and continues to correlate with shoreline features identifiable since 1981. As in previous years, there was lower nesting in zones R1-4, R24-26, R33-34 and R50, near the Deerfield Beach Pier, the Hillsboro Inlet, the Pompano Beach Pier and the Commercial Boulevard pier, respectively. The beach along the Fort Lauderdale strip (R65 to R79) and the entire beach south of R107 also received relatively light nesting. The beach renourishment project in R 64-67 was in one of the traditionally low-nested areas on the Fort Lauderdale strip. In the project area loggerhead nesting declined from 74 nests in 2012 to 50 this year (32.4%) from 2012, but county-wide loggerhead nesting also declined 25.1%.

Correlation of loggerhead nest counts in the 85 zones north of Lloyd Park over the last 10 years yielded correlation coefficients ranging from 0.59 to 0.89. All of these were statistically significant ($P < 0.001$) demonstrating historical consistency of the nesting pattern. This pattern has been discussed previously (Burney and Mattison, 1992; Mattison et al., 1993). Low nested zones are generally characterized by high levels of artificial lighting and nocturnal human activity (Mattison, 2002). Green turtles again demonstrated their preference for nesting at Hillsboro Beach, which has darker beaches and less public access (Fig. 8).

Nesting Success

As in 2012, there was no significant countywide north-south trend in loggerhead nesting success per zone (Fig. 9) and no statistical differences between the 5 beach survey areas, except that the nesting success of greens was significantly lower in Hollywood (Table 7). The overall nesting success rates for loggerheads, greens and leatherbacks were 50.0%, 64.5% and 91.7% respectively. Loggerhead nesting success in the R 64-67 renourishment area declined from 53.2% in 2012 to 41.7%, possibly due to the sand placement. A proportions test (Statistica 6.0) showed that this difference was significant ($P = 0.033$). Decreased nesting success is common in the first season after a project but typically returns to normal success rates in following years (Crain et al.1995). The lower nesting success of 25.0% in the Hillsboro Inlet sand bypass area (R25-26) compared to 45.9% in R27-28 may have also been due to sand placement, but the difference in these proportions was not significant ($P = 0.062$).

Figure 10 shows very small changes from 2012 to 2013 in the yearly loggerhead nesting success rates in Hillsboro Beach, Pompano Beach and Fort Lauderdale. Lloyd Park showed a substantial decline, after a similar increase in 2012 and Hollywood experienced a large increase. While the decrease in Lloyd Park may be due to erosion, nesting success is still well above the average since 2000. There appears to be no obvious reason for the increased nesting success in Hollywood.

Hatchling Productivity

The production rate of live loggerhead hatchlings increased slightly from the high levels in 2012 and now stands above 80% or higher for total relocated and *in situ* nests (Fig. 11, Table 9). Because of the increased

success, the total number of live loggerhead hatchlings was 2608 higher than in 2012, in spite of the larger total number of nests last year. Kawana (2013) found a significant inverse correlation between the mean daily hatching success of *in situ* loggerheads and the mean monthly air temperature in July at Fort Lauderdale Beach from 1999 through 2010. Extending that analysis through 2013 yielded a significant ($P = 0.001$) inverse relation with an R^2 value of 0.514, indicating that mean July air temperatures accounted for over 50% of the variance in overall loggerhead hatching success. This year's mean July air temperature was tied for the third coolest since 1999 and there were no major storms. Unlike previous years, there were no seasonal declines in the live hatchling production rates of relocated or *in situ* nests this year (Fig. 12), further attesting to the favorable incubation conditions that prevailed throughout the season.

Post Emergence Analysis

The overall loggerhead hatchling emergence rate (on their own) for *in situ* nests was 87.6% (Table 10), up 4.3 percentage points from 2012, with most of the remainder accounted for by unhatched eggs with visible (VD) or no visible development (NVD). Unemerged hatchlings and piped eggs totaled only 4.0%. For relocated nests, the overall natural emergence rate increased slightly from 74.3% in 2012 to 75.1% this year. Unemerged hatchlings and piped eggs accounted for a total of 12.7% and the remaining 12.2% was unhatched eggs. As in previous years, there were slightly higher percentages of LIN and LPIP in relocated nests when compared to *in situ* nests.

Table 11 shows that an average of 87.2% of *in situ* green hatchlings emerged on their own in 2013, which was up from 82.7% last year. Most of the remainder of the eggs were unhatched VD or NVD. The emergence rate

was 72.1% for the two relocated green nests that were evaluated. *In situ* leatherbacks emerged at a rate of 65.25%, including the low-hatching nest deposited in Hillsboro Beach on August 19. Such late leatherback nesting is unprecedented in Broward County. One leatherback nest that was relocated due to its proximity to the high tide line produced 58% live hatchlings and 39.5% of the eggs showed no visible development.

Hatchling Disorientation

Our morning patrols reported 155 disorientation events, which was 25 more than in 2012 but the numbers of disoriented hatchlings could not be determined for two reasons. The new FFWCC Marine Turtle Disorientation Report forms have new hatchling ranges making number comparisons difficult. Additionally, STOP's monitoring effort varies from year to year, and targets nests where hatchlings are more likely to disorient. Therefore, it is difficult to compare hatchling disorientation and the status of artificial coastal lighting over the last few years. Monthly lighting surveys were conducted from March through September and submitted to local code enforcement, per contract requirement.

Table 1: Broward County Survey Areas.

BEACH	BEACH LENGTH (km)	BOUNDARIES	FDEP SURVEY MARKER #
Hillsboro-Deerfield Beach	7.0	Palm Beach Co. line to Hillsboro Inlet	R1-24
Pompano Beach Including Lauderdale-by-the-Sea	7.7	Hillsboro Inlet to Commercial Blvd.	R25-50
Fort Lauderdale	10.6	Commercial Blvd. to Port Everglades Inlet	R51-85
John U. Lloyd Park	3.9	Port Everglades Inlet to Dania Beach fence	R86-96
Hollywood-Hallandale Including Dania	9.4	Dania Beach fence to Miami Dade Co. line	R97-128

Table 2: Destinations for Relocated Nests in Pompano, Lauderdale-by-the-Sea, and Fort Lauderdale. March 1-Oct. 31

Donor Zones	Recipient Zones
R85	R83-80
R54-53	R52-51 & R63-58,
R50	R49-42
R35-33	R41-39 & R37-36
R32	R31-25

Table 3: Destinations for Relocated Nests in Dania, Hollywood, and Hallandale. March 1-Oct 31

Donor Zones	Recipient Zones
R122-115	R128-124
R114-107	R106-102
R101-100	R106-102

Table 4: Total loggerhead nests and nesting densities expressed as nests-per-kilometer for the 2013 season. Beaches with the same NK designation letters were not significantly different in a Newman-Keuls test ($\alpha = .05$) of mean daily nesting per km (1 Apr-15 Sep). Beaches with different NK letters had significantly different nesting densities.

Beach	Total Nests	Beach Length (km)	Nests per km	Mean Daily Nests per km with NK Designation Letter
Hillsboro Beach	757	7.0	108.1	0.644 A
Ft. Lauderdale	802	10.6	75.7	0.450 B
Pompano Beach	564	7.7	73.2	0.436 B
Lloyd Park	177	3.9	45.4	0.270 C
Hollywood	159	9.4	16.9	0.101 D
OVERALL	2459	38.6	63.7	

Table 5: Total green turtle nests and nesting densities expressed as nests-per-kilometer for the 2013 season. Beaches with the same NK designation letters were not significantly different in a Newman-Keuls test (alpha = .05) of mean daily nesting per km (1 May-30 Sep). Beaches with different NK letters had significantly different nesting densities.

Beach	Total Nests	Beach Length (km)	Nests per km	Mean Daily Nests per km with NK Designation Letter
Hillsboro Beach	320	7.0	45.7	0.299 A
Ft. Lauderdale	113	10.6	10.7	0.070 B
Lloyd Park	24	3.9	6.2	0.040 B
Pompano Beach	32	7.7	4.2	0.027 B
Hollywood	6	9.4	0.6	0.004 B
OVERALL	495	38.6	12.8	

Table 6: Total leatherback nests and nesting densities expressed as nests-per-kilometer for the 2013 season. Beaches with the same NK designation letters were not significantly different in a Newman-Keuls test (alpha = .05) of mean daily nesting per km (1 March-15 Sep). Beaches with different NK letters had significantly different nesting densities.

Beach	Total Nests	Beach Length (km)	Nests per km	Mean Daily Nests per km
Hillsboro Beach	11	7.0	1.6	0.008 A
Pompano Beach	4	7.7	0.5	0.003 B
Lloyd Park	1	3.9	0.3	0.001 B
Hollywood	1	9.4	0.1	0.001 B
Ft. Lauderdale	1	10.6	0.1	0.001 B
OVERALL	18	38.6	0.5	

Table 7: Total nests, false crawls (FC) and percent nesting success (Nest Succ.) for three sea turtle species on each of five Broward County beaches during 2013. NK tests detected no significant differences in mean nesting successes of loggerheads, greens or leatherbacks throughout the County, except for lower success in Hollywood*.

Beach	Loggerheads		
	Nests	False Crawls	Nest Succ.
Hillsboro	757	679	52.7
Pompano	564	624	47.5
Ft. Lauderdale	802	820	49.4
Lloyd Park	177	204	46.5
Hollywood	159	135	54.1
Overall	2459	2462	50.0
	Greens		
	Nests	False Crawls	Nest Succ.
Hillsboro	320	176	64.5
Pompano	32	28	53.3
Ft. Lauderdale	113	93	54.9
Lloyd Park	24	29	45.3
Hollywood	6	14	30.0*
Overall	495	340	59.3
	Leatherbacks		
	Nests	False Crawls	Nest Succ.
Hillsboro	11	1	91.7
Pompano	4	0	100
Ft. Lauderdale	1	0	100
Lloyd Park	1	0	100
Hollywood	1	1	50.0
Overall	18	2	90.0

Table 8: Total Number of loggerheads, greens, and leatherback nests relocated or left *in situ* in 2013. Individually relocated nests in Deerfield Beach, Hillsboro Beach, Pompano Beach, Fort Lauderdale and Hollywood are listed as DB, BH, BP, BFT and BHo, respectively.

	Loggerheads	Greens	Leatherbacks	Totals
RELOCATED				
Open Beach				
Hillsboro Beach				
DB	1	0	0	1
BH	0	0	0	0
BH900s	6	1	0	7
BH1000s	4	0	0	4
BH1100s	4	1	0	5
Pompano Beach				
BP	1	0	0	1
BP1	11	0	1	12
BP2	10	0	0	10
BP3	3	0	0	3
Fort Lauderdale				
Strip	1	0	0	1
BFT	5	0	0	5
BFTN	26	1	0	27
BFTS	2	0	0	2
Hollywood Beach				
BHo	1	0	0	1
BHoN	23	0	0	23
BHoS	22	0	0	22
TOTALS	120	3	1	124
IN SITU				
Hillsboro Beach	742	318	11	1071
Pompano Beach	539	31	3	573
Ft. Lauderdale				
BFT	768	113	1	882
Hollywood Beach	113	6	1	120
TOTALS	2162	468	16	2646
GRAND TOTALS	2282	471	17	2770

Table 9: Total egg counts, released hatchlings and overall release successes for *in situ* and relocated nests of loggerheads, greens and leatherbacks in 2013, with the numbers of unevaluated nests.

Species	Number of Eggs	Eval. Nests	Hatchlings Released	Release Success Percent	Uneval. Nests
<i>In situ</i>					
Loggerhead	174869	1720	154471	88.3	442
Green	37665	336	33794	89.7	132
Leatherback	921	11	640	69.5	5
Total	213455	2067	188905	88.5	579
Relocated					
Loggerhead	12328	115	10096	81.9	5
Green	243	2	201	82.7	1
Leatherback	81	1	47	58.0	0
Total	12652	118	10344	81.8	6
Overall					
Loggerhead	187197	1835	164567	87.9	447
Green	37908	338	33995	89.7	133
Leatherback	1002	12	687	68.6	5
TOTAL	226107	2185	199249	88.1	585

Table 10: Accounting of the status of all hatched and unhatched eggs in evaluated *in situ* and relocated loggerhead nests during 2013.

Location	Total Eggs	Total Eval. Nests	Emerged (%)	LIN (%)	DIN (%)	PIP Live (%)	PIP Dead (%)	VD (%)	NVD (%)
<i>In situ</i> Nests									
Hillsboro Beach	44140	509	84.3	1.8	1.2	0.2	2.1	3.0	7.4
Pompano Beach	46984	434	87.5	1.5	1.0	0.2	1.2	1.7	6.8
Ft. Lauderdale									
BFT	73032	675	87.9	1.3	0.9	0.2	1.4	1.7	6.6
BFTN	166	2	79.5	1.8	0	1.2	0.6	5.4	11.4
BFTS	271	2	84.1	4.4	0	4.4	3.3	1.1	2.6
Hollywood Beach									
BHo	10166	98	84.1	1.3	1.3	0.1	0.8	2.1	10.2
<i>Overall In situ</i>	174759	1720	87.6	1.5	0.9	0.2	1.4	1.9	6.5
<i>Relocated</i> Nests									
<u>Hillsboro Beach</u>									
DB	144	1	84.7	5.6	0	0	2.1	2.1	5.6
BH900s	329	5	76.0	11.2	2.4	2.1	6.1	0.3	1.8
BH1000s	422	4	74.2	3.3	0.9	0.7	0.2	0.5	20.1
BH1100s	297	3	92.3	1.7	1.0	0.7	1.7	2.0	0.7
<i>Overall Hillsboro</i>	1192	13	80.5	5.4	1.2	1.0	2.4	1.0	8.5
<u>Pompano Beach</u>									
BP	128	1	58.6	1.6	0	0	0.8	3.9	35.2
BP1	973	10	87.6	1.7	0.5	0.2	1.6	1.6	6.3
BP2	991	10	75.5	5.7	1.1	1.5	4.6	2.6	9.0
BP3	339	3	75.5	2.1	0	0.9	8.0	3.5	10.0
<i>Overall Pompano</i>	2431	24	79.5	3.4	0.6	0.8	3.7	2.4	9.4
<u>Fort Lauderdale</u>									
BFT	518	5	75.7	2.3	1.4	0.2	6.2	2.3	12.0
BFTN	2913	26	76.0	6.4	1.1	1.3	4.7	2.4	7.9
BFTS	200	2	50.0	10.0	6.0	4.0	26.0	1.5	2.0
STRIP	125	1	64.0	21.6	0	4.0	3.2	6.4	0.8
<i>Overall Ft. Laud.</i>	3756	34	74.2	6.5	1.4	1.4	6.0	2.5	7.9
<u>Hollywood Beach</u>									
BHo	83	1	84.3	3.6	3.6	1.2	1.2	0	6
BHoN	2432	22	74.6	4.4	1.8	0.8	3.6	2.5	12.3
BHoS	2434	22	69.7	7.1	1.7	2.3	5.1	4.4	9.6
<i>Overall Hollywood</i>	4949	45	72.4	5.7	1.8	1.5	4.3	3.4	10.9
<i>Overall</i>	12328	116	75.1	5.5	1.4	1.3	4.5	2.7	9.5

Table 11: Accounting of the status of all hatched and unhatched eggs in investigated *in situ* and relocated green sea turtle nests during 2013.

Location	Total Eggs	Total Eval. Nests	Emerg ed (%)	LIN (%)	DIN (%)	PIP Live (%)	PIP Dead (%)	VD (%)	NVD (%)
<i>In situ</i> Nests									
Hillsboro Beach	24110	220	85.6	2.9	0.6	0.1	1.4	2.9	6.4
Pompano Beach	3042	26	93.5	0.7	0.4	0	0.4	1.4	3.6
Ft. Lauderdale									
BFT	9861	84	89.5	1.8	0.8	0.2	0.7	2.1	4.9
BFTS	108	1	59.3	0.9	1.9	0	0	8.3	29.6
Hollywood Beach	544	5	84.2	1.1	1.5	0	0.7	2.8	9.7
Overall <i>In situ</i>	37665	336	87.2	2.4	0.7	0.1	1.1	2.6	5.9
Relocated Nests									
Hillsboro Beach									
BH1100s	122	1	64.8	7.4	0.8	0.8	1.6	1.6	23.0
Fort Lauderdale									
BFTN	121	1	79.4	9.9	0.8	3.3	0	2.5	4.1
Overall Reloc.	243	2	72.1	8.6	0.8	2.0	0.8	2.0	13.6

Table 12: Accounting of the status of all hatched and unhatched eggs in investigated *in situ* and relocated leatherback nests during 2013.

Location	Total Eggs	Total Eval. Nest	Emerg ed (%)	LIN (%)	DIN (%)	PIP Live (%)	PIP Dead (%)	VD (%)	NVD (%)
<i>In situ</i> Nests									
Hillsboro Beach	565	7	66.7	1.6	3.2	0	0.2	6.2	22.1
Pompano Beach	267	3	77.4	9.1	3.2	0	1.6	1.1	7.5
Ft. Lauderdale	93	1	30.1	10.8	50.5	0	1.1	1.1	6.5
Hollywood Beach	77	1	67.5	3.9	2.6	0	0	13.0	13.0
Overall <i>In situ</i>	921	11	65.2	4.2	7.9	0.0	0.6	5.2	16.8
Relocated Nests									
Pompano Beach									
BP1	81	1	58.0	0	0	0	2.5	0	39.5

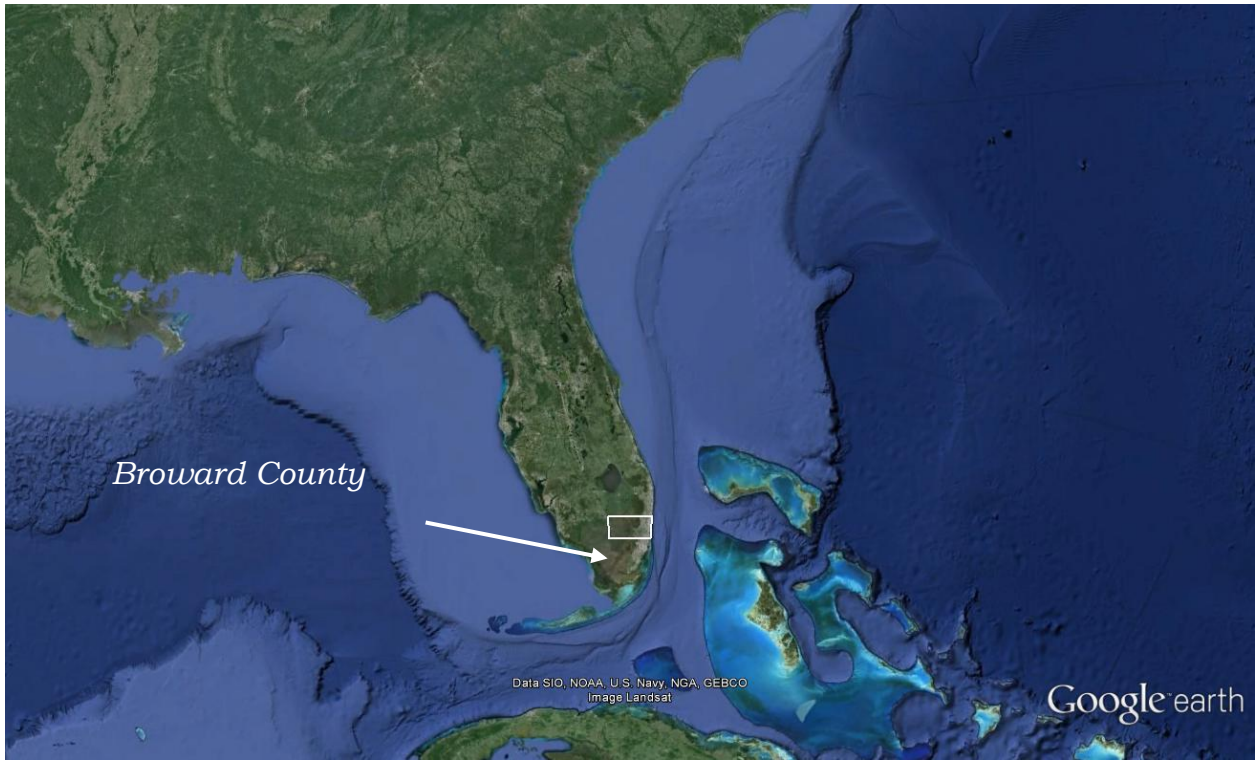


Figure 1A: The location of Broward County Florida



Figure 1B: Northern Broward County

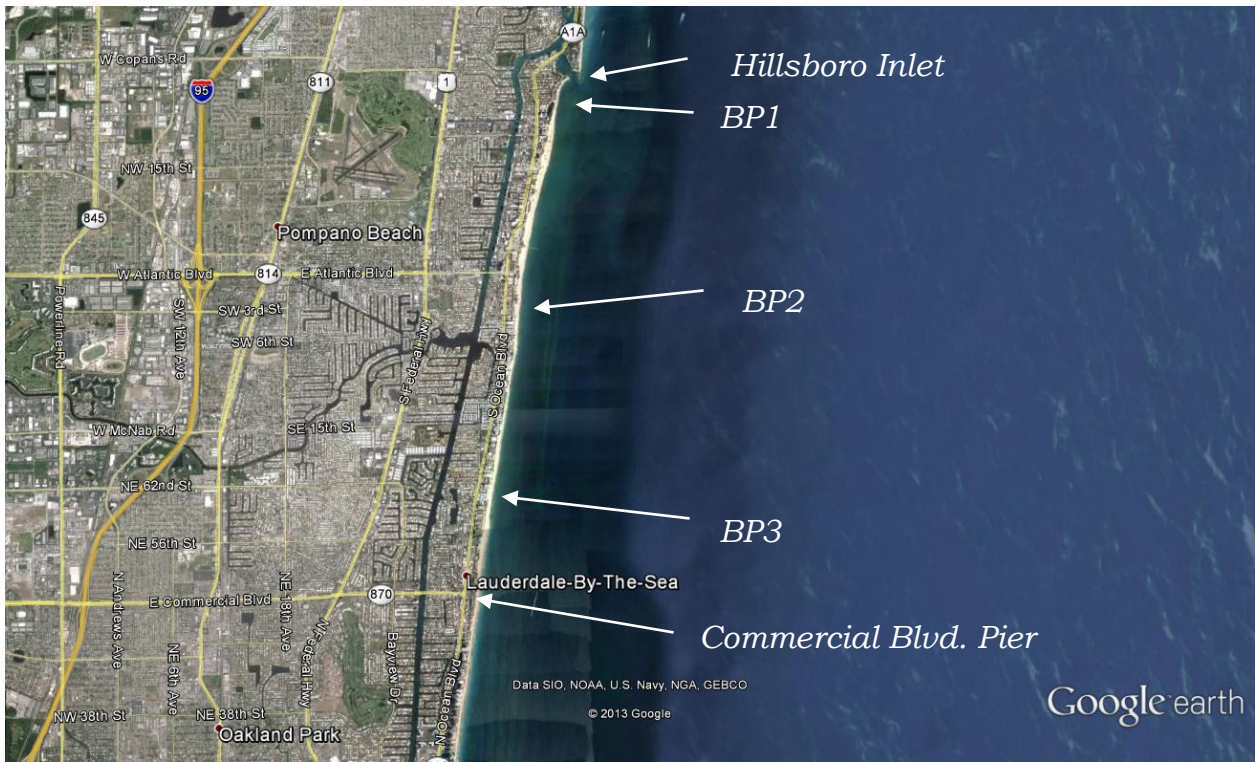


Figure 1C: North Central Broward County

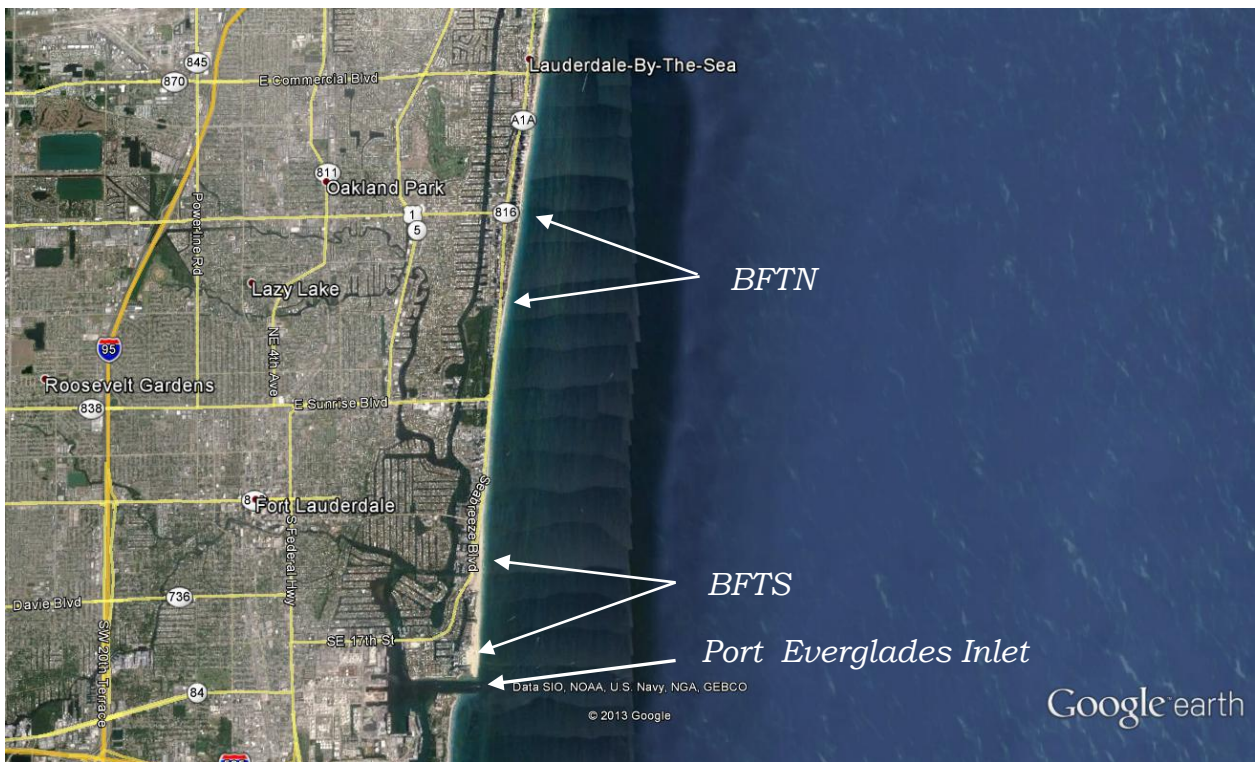


Figure 1D: Central Broward County

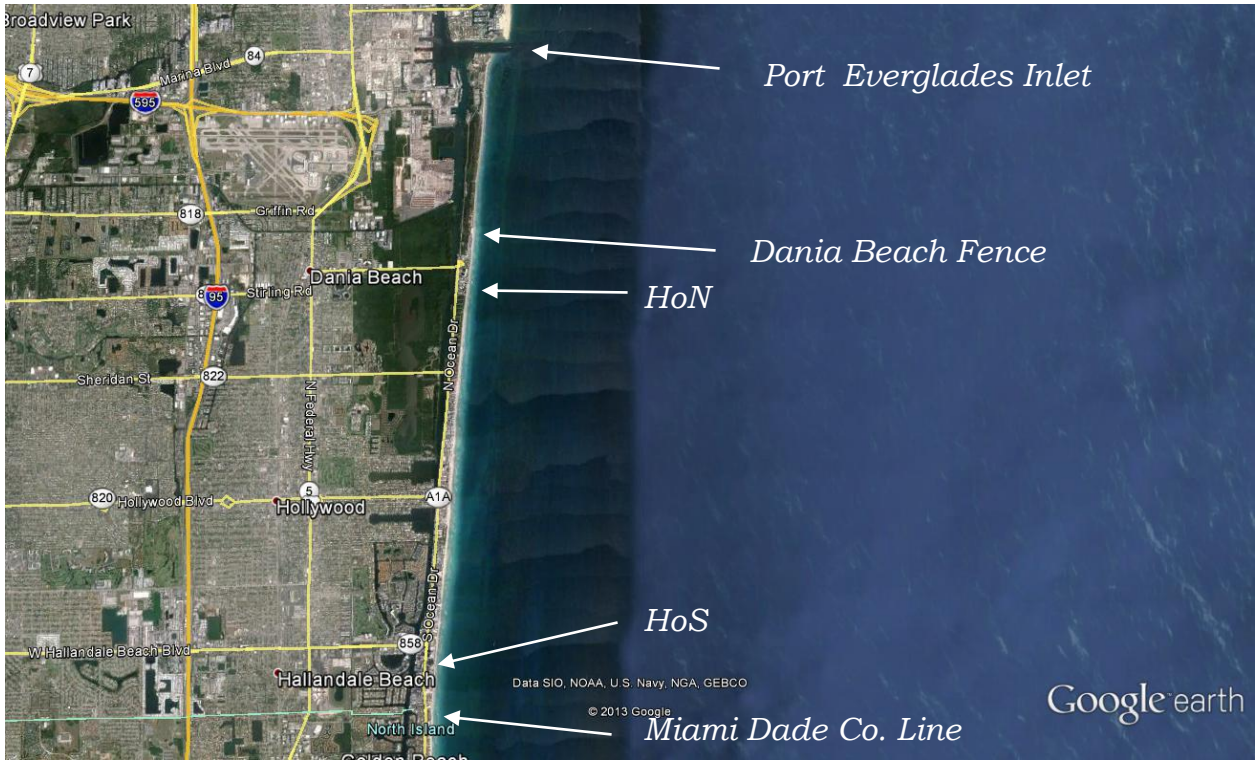


Figure 1E: Southern Broward County

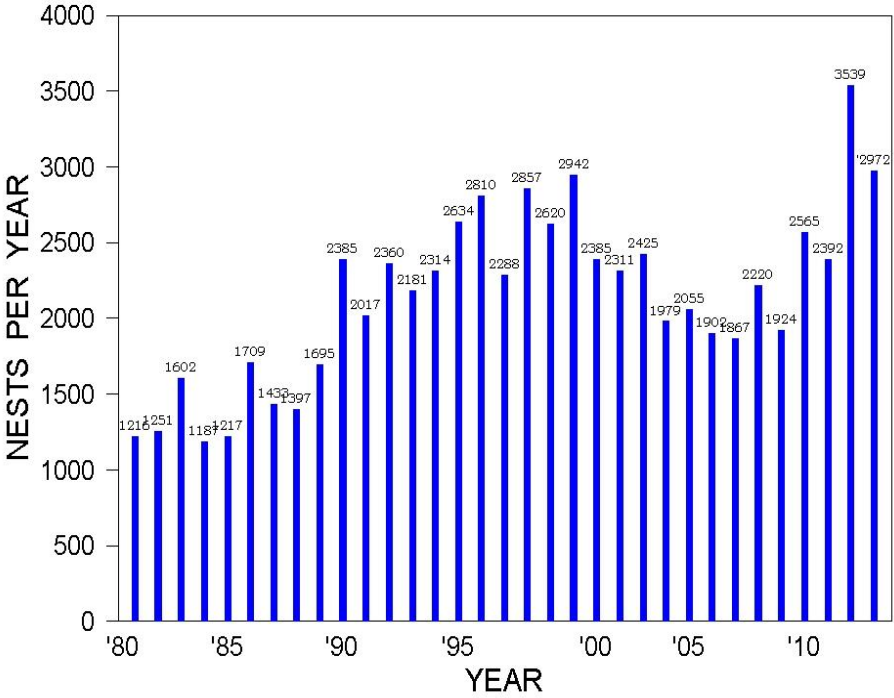
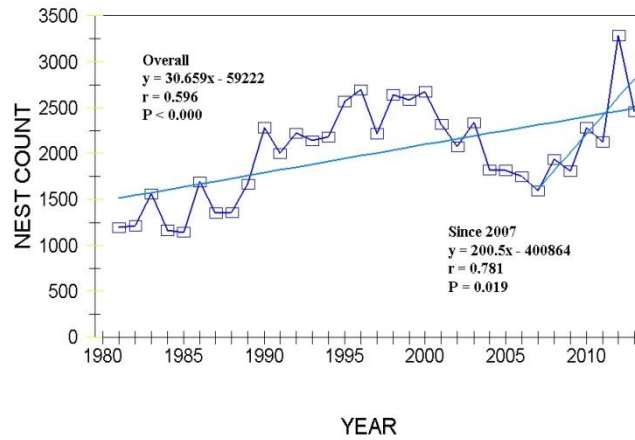


Figure 2: Yearly sea turtle nesting in Broward County since full surveys began in 1981. All species combined.

BROWARD LOGGERHEAD NESTS



GREENS AND LEATHERBACK NESTS

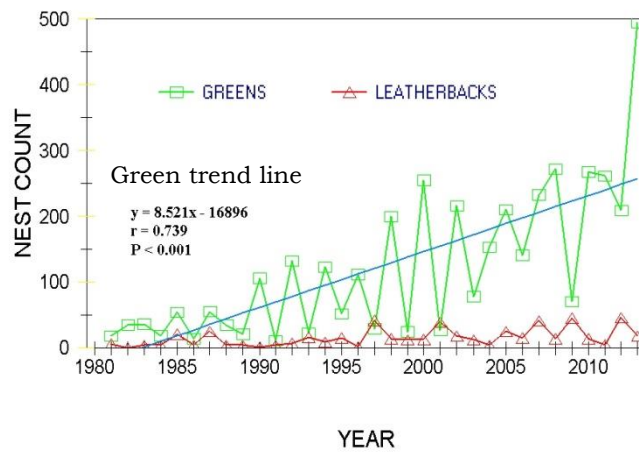


Figure 3: Historical nesting patterns of loggerhead, green and leatherback sea turtles since 1981. Overall trends for loggerheads and greens and the loggerhead trend since 2007 are shown.

LOGGERHEAD NESTS

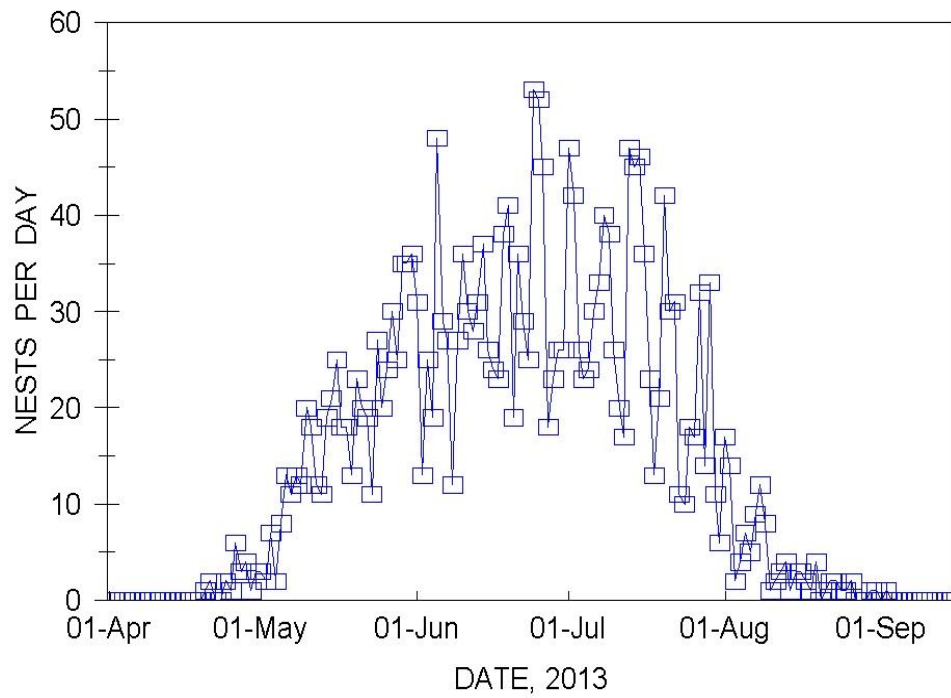


Figure 4: Daily loggerhead nesting during the 2013 season.

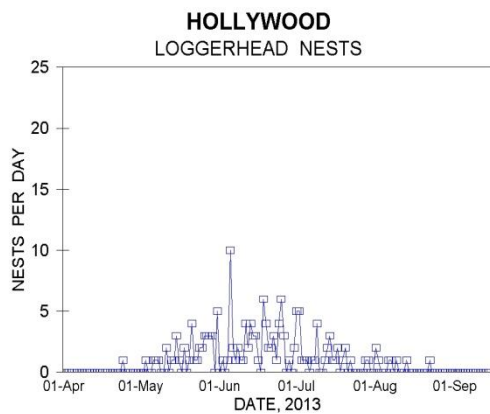
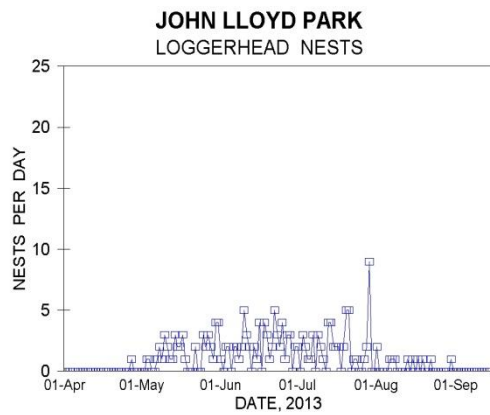
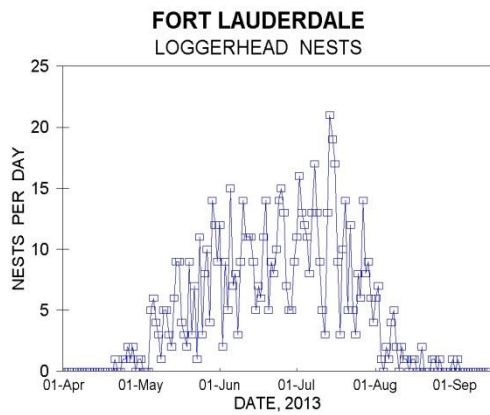
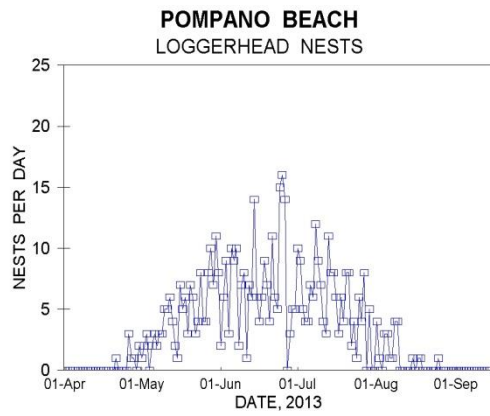
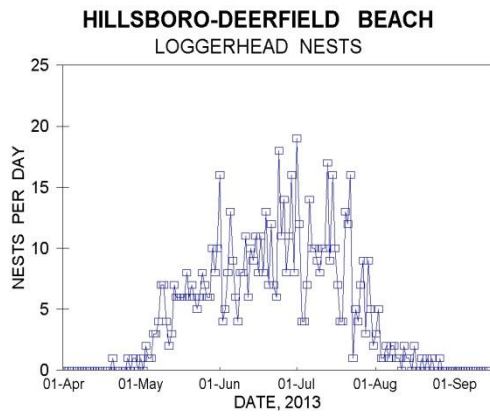


Figure 5: Comparison of the daily loggerhead nesting patterns on the five Broward County beaches in 2013.

GREEN AND LEATHERBACK NESTS

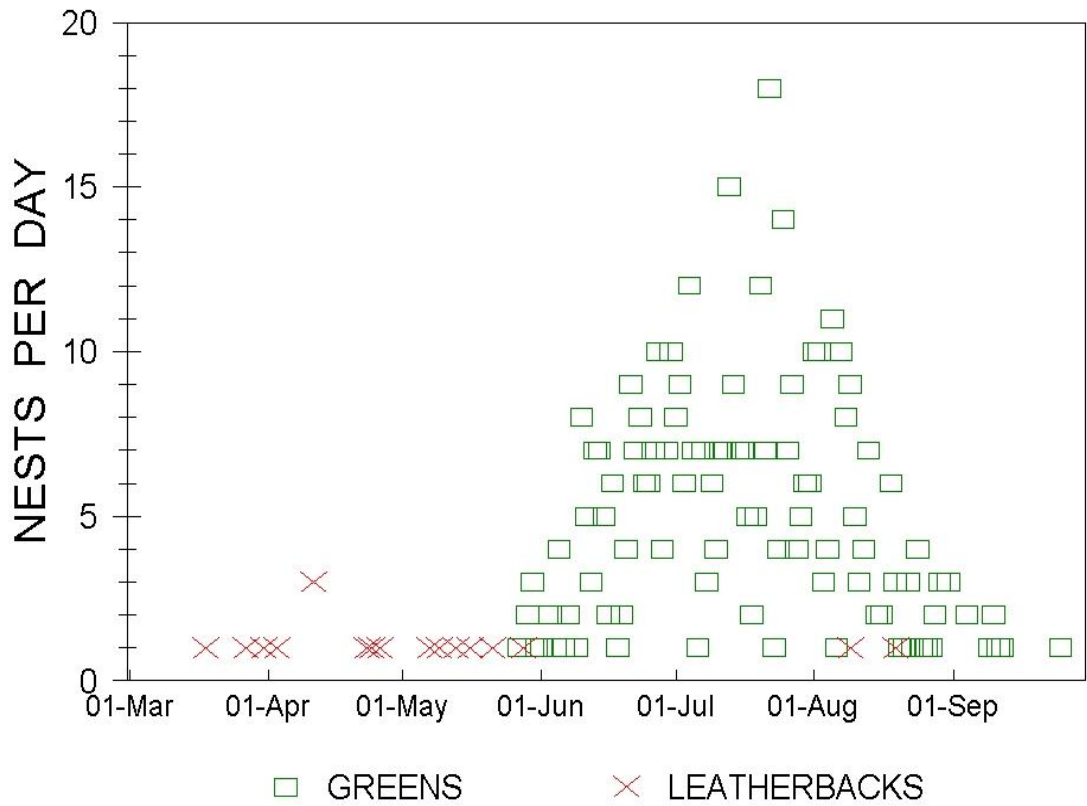


Figure 6: Daily green and leatherback nesting during 2013.

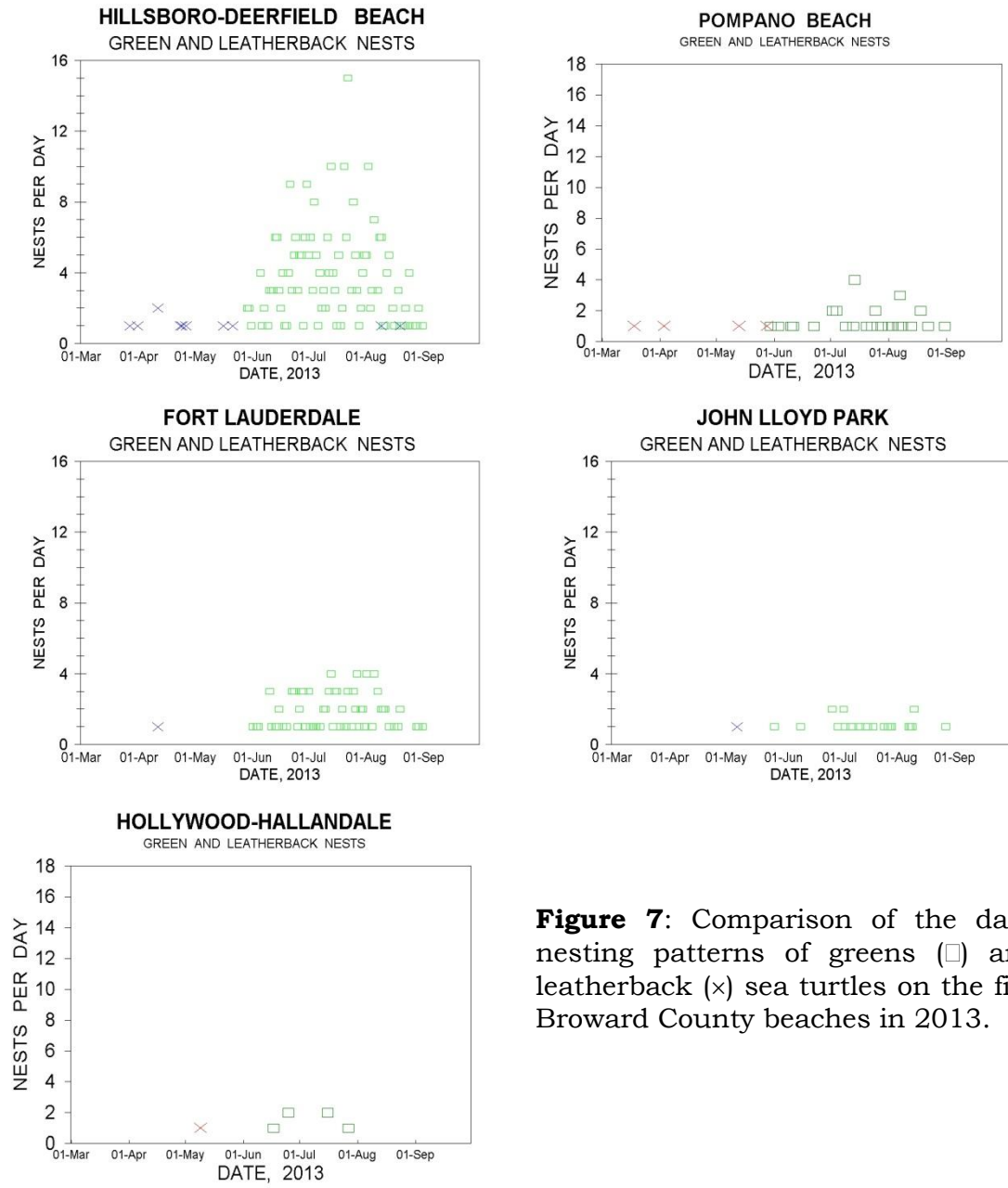


Figure 7: Comparison of the daily nesting patterns of greens (□) and leatherback (×) sea turtles on the five Broward County beaches in 2013.

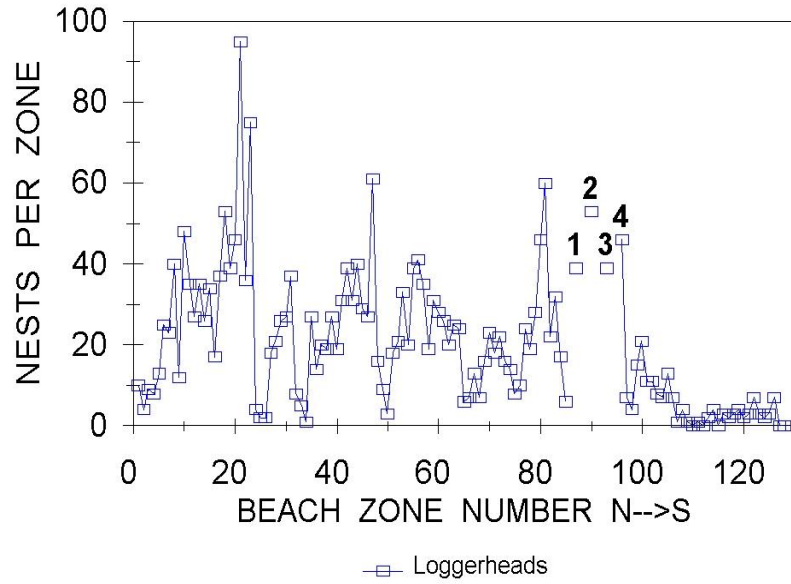


Figure 8a: Locations of loggerhead nests in Broward County in 2013. Numbers 1-4 indicate the four beach zones of John Lloyd Park.

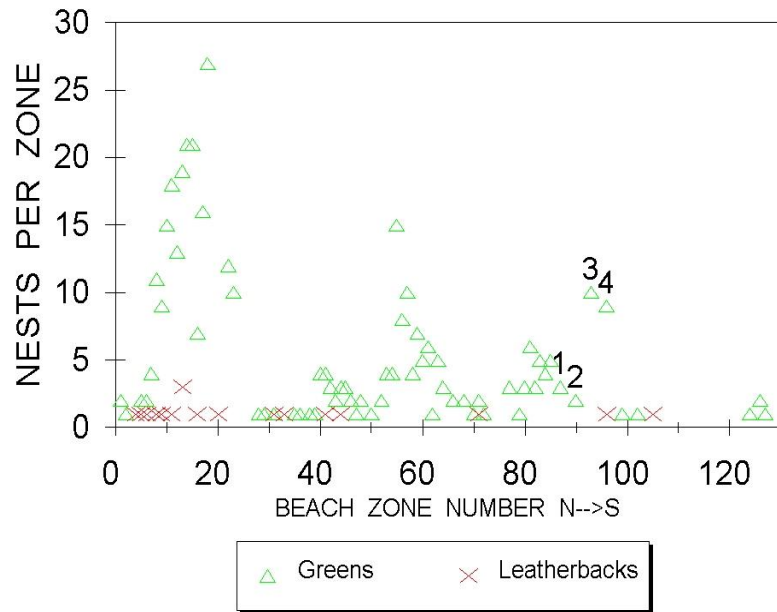


Figure 8b: Locations of green and leatherback nests in Broward County in 2013

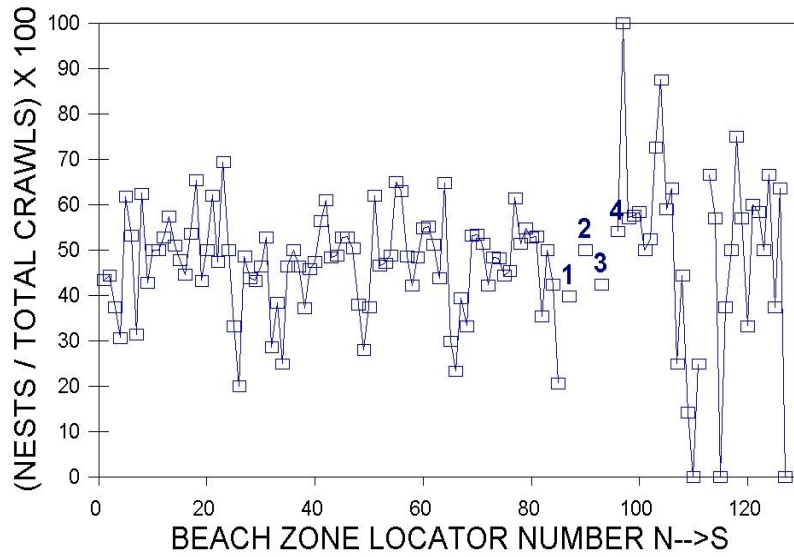


Figure 9a: Loggerhead nesting success across Broward County in 2013 classified by FDEP R Monument zones from North to South. Numbers 1-4 indicate the four beach zones of John Lloyd Park.

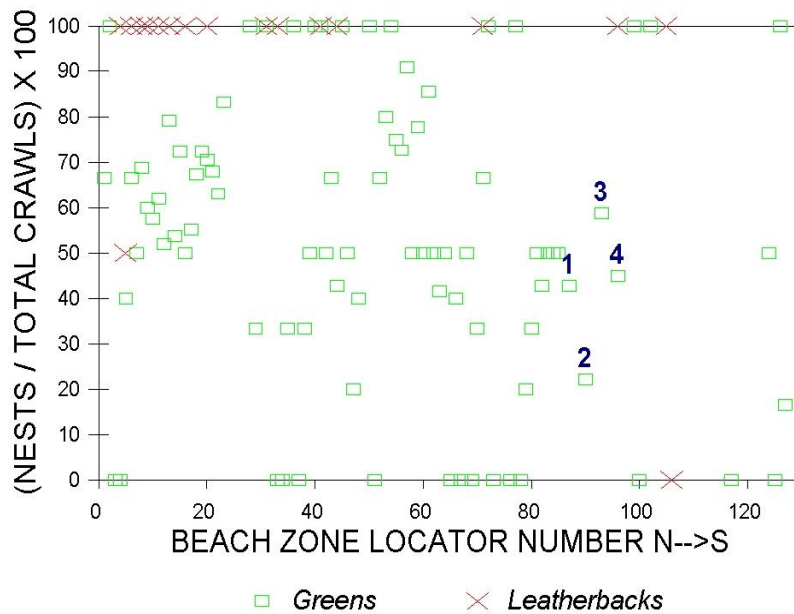


Figure 9b: Green and leatherback nesting success across Broward County in 2013.

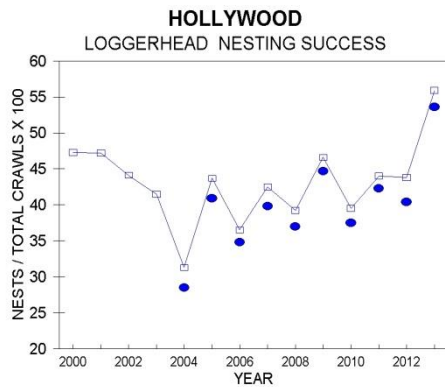
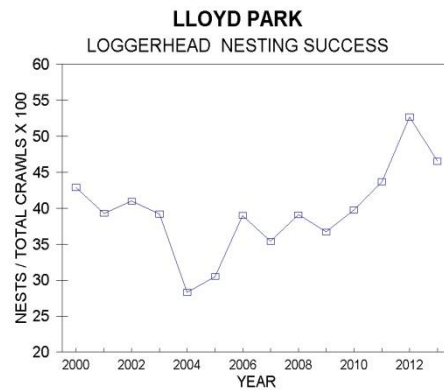
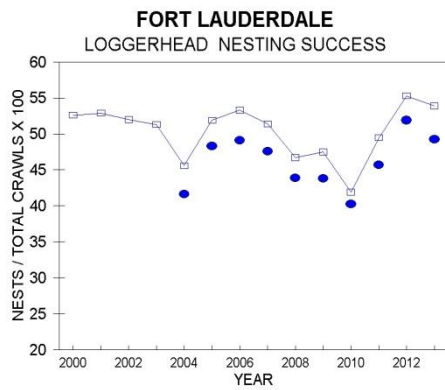
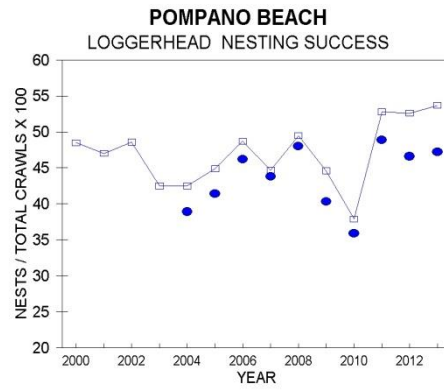
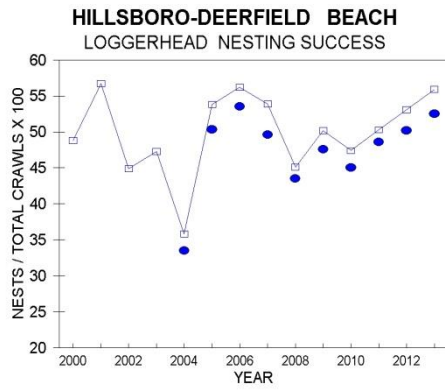


Figure 10: Loggerhead nesting success trends since 2000. Open symbols; nests / total crawls that extended above the high tide line. Closed symbols include false crawls that did not extend above the high tide line.

HATCHING RELEASE SUCCESS HISTORICAL PATTERN

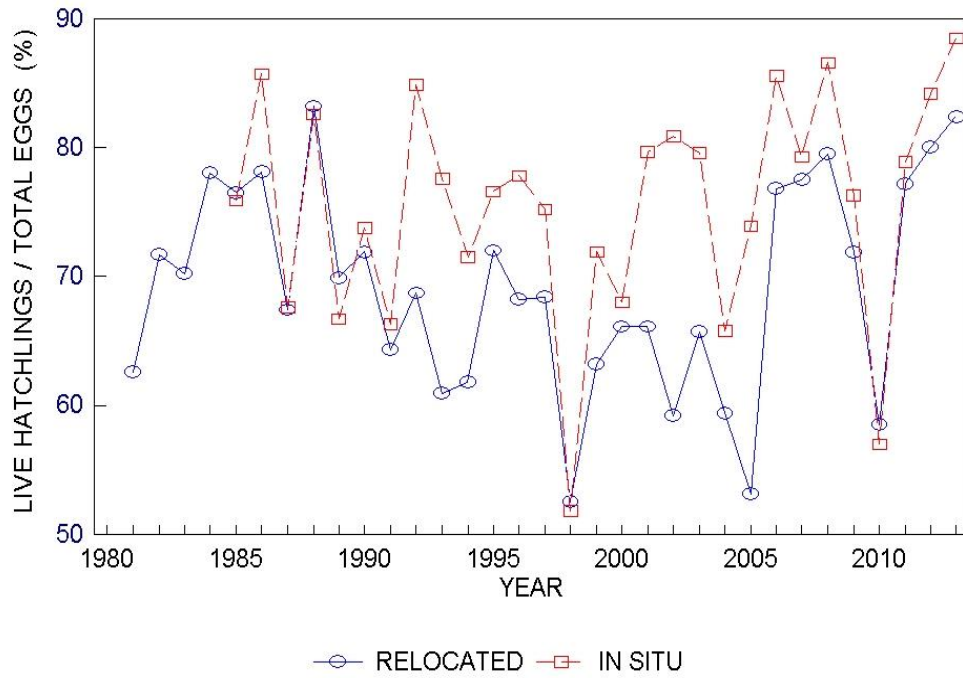


Figure 11: The historical patterns of yearly hatching release success for all evaluated *in situ* and relocated nests, since 1981

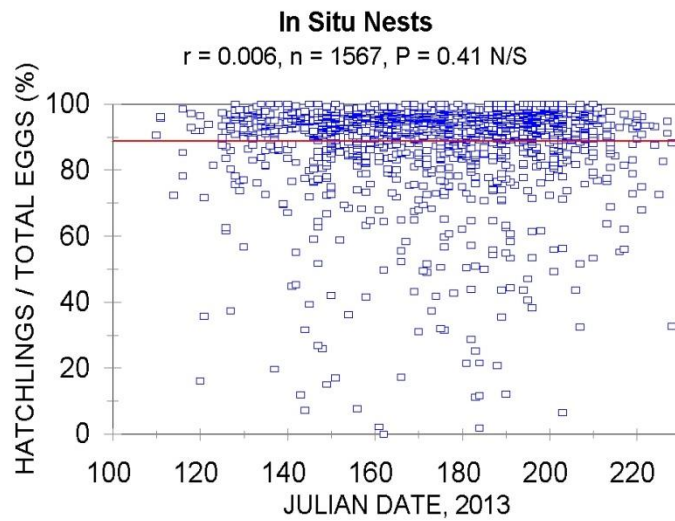
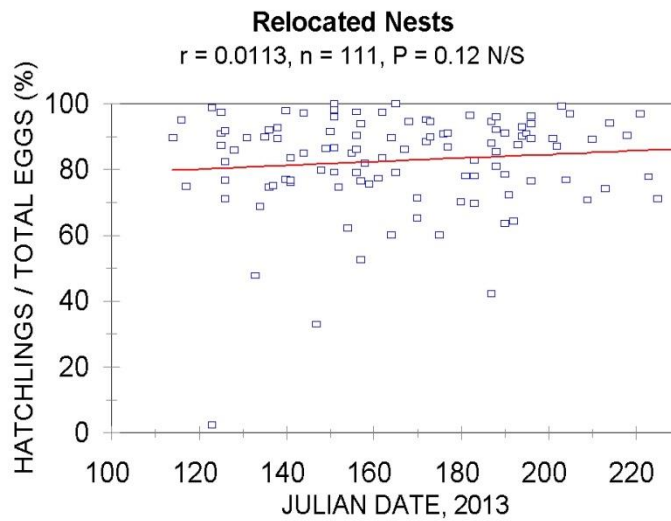


Figure 12: Comparison of seasonal hatchling production rates for relocated and *in situ* loggerhead nests.

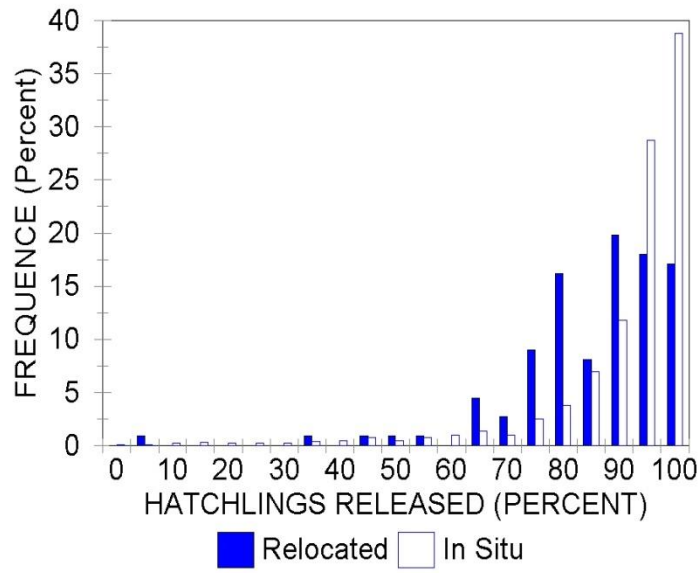


Figure 13: Frequencies of relocated and *in situ* nests producing 0 to 100 percent live hatchlings.

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APPENDIX 1: Summary of sea turtle emergency cell phone calls.

SUBJECT	EMERGENCY LINE
LIVE STRANDINGS	30
TOTAL STRANDINGS	150
DISORIENTATIONS	65
NEST LOCATIONS	100
POACHING	20
OTHER	<700
OVERALL	<1000

APPENDIX 2: Summary of Educational/Public Information Activities

Flyers were distributed on the beach, primarily to people with questions, at the turtle talks, and at school visitations.

The 2013 Presentation Team conducted a total of 48 public education talks from July 3 to September 7 at Anne Kolb Nature Center, Saltwater Studies, Boy Scouts of America, Florida Marine Aquarium Society, Hollywood Beach Maintenance, Girl Scouts of America, Sawgrass Springs M.S., NSU Nature Club, home school groups, University School, Community Christian Church, and John U Lloyd State Park. These PowerPoint presentations were followed by hatchling releases.

Turtle talks were also given at the following locations:

- 1) Driftwood M.S. (Jan 10)
- 2) Royal Palm Elementary (May 10)
- 3) Driftwood M.S. (May 17)
- 4) Widdon Rogers Education Center (May 31)
- 5) Westin Beach Resort & Spa (June 5)
- 6) Broward County Parks & Rec (June 21)
- 7) City of Miami Beach Aquatic Life & Nature Camp (June 10, July 8 & 15)
- 8) Sherman Library Summer Program (July 9 & 10)
- 9) Northwest Regional Library Summer Program (July 18)
- 10) Southwest Regional Library (July 22)
- 11) National Wildlife Federation Habitat Steward Training (Aug 1)
- 12) Roosevelt Gardens Park (Aug 2)
- 13) Camp Wild, Sawgrass Nature Center (Aug 9)
- 14) Museum of Discovery (Aug 17 & 18)
- 15) Orange Brook Elementary (Sep 4)
- 16) North Broward Prep School (Sep 20)
- 17) Driftwood M.S. (Oct 4)
- 18) Dania Beach Ocean Rescue (Nov 1)

Tables with specimens, informational handouts, brochures, door hangers, table tents and activity books were provided at the following events.

- 1) Gumbo Limbo Sea Turtle Day (March 2)
- 2) Cosmo International (April 26)
- 3) Royal Palm Elementary (Oct 17)

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

