HOBE SOUND NATIONAL WILDLIFE REFUGE

RESULTS OF 2005 SEA TURTLE MONITORING

Prepared by

Ecological Associates, Inc.
Post Office Box 405
Jensen Beach, Florida 34958

May 2006

EXECUTIVE SUMMARY

Since its establishment in 1969, the primary objective of the Hobe Sound National Wildlife Refuge (HSNWR) has been to protect and maintain suitable nesting habitat for threatened and endangered species of sea turtles. For over 30 years, HSNWR has monitored the nesting activity and reproductive success of loggerhead turtles (*Caretta caretta*), green turtles (*Chelonia mydas*), and leatherback turtles (*Dermochelys coriacea*) nesting on Refuge shores. During these monitoring activities, depredation rates of sea turtle nests by such predators as raccoons (*Procyon lotor*) and armadillos (*Dasypus novemcinctus*) were also recorded. With the inception of its sea turtle monitoring program, HSNWR also implemented an on-going predator removal program geared towards controlling the populations of those animals responsible for the greatest depredation of sea turtle nests within the Refuge.

During the 2005 sea turtle nesting season, 1,007 loggerhead, 120 green, and 47 leatherback turtle nests were recorded within HSNWR. When compared to annual data since 1973, this represents below average nesting for loggerhead turtles and high nesting for green and leatherback turtles. Regression analyses indicate that nesting data for all three species exhibit significantly increasing trends between 1973 and 2005. The distribution of loggerhead nests within the Refuge during 2005 was similar to previous years; nesting was relatively high in the southern sections and low in the northern sections. This season, loggerhead nesting success was lowest in Section 5 and highest in Section 8. Overall nesting success for the Refuge during 2005 was low when compared to the previous seven years. Low nesting success was attributed to changes in beach topography associated with two hurricanes that passed through the area in September 2004.

The primary factor impacting sea turtle nests during 2005 was predation. Predators (primarily armadillos) destroyed 15.8 percent of the sea turtle nests in the Refuge during 2005. The predation rate during 2005 was lower than during 2004 when predator control activities had to be terminated early.

When compared to data since 1997, loggerhead turtle hatchling productivity during 2005 (51,135 hatchlings) was below average (59,709 hatchlings), but considerably higher than productivity in 2004 (38,890 hatchlings). The most effective management option for maximizing hatchling production in the Refuge is to maintain an effective predator control program throughout the sea turtle nesting and hatching season.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

Location

Located approximately 20 miles north of West Palm Beach, Florida, Hobe Sound National Wildlife Refuge (HSNWR) is composed of 967 acres of land within Martin County. Broken into two tracts separated by the Intracoastal Waterway, the Refuge includes 735 acres on Jupiter Island, and 232 acres along the mainland. Established in 1969, the primary objective of the Refuge is to protect and maintain suitable nesting habitat for endangered green turtles (*Chelonia mydas*) and leatherback turtles (*Dermochelys coriacea*), as well as for threatened loggerhead turtles (*Caretta caretta*) nesting along HSNWR shores (USFWS, 1996). The Refuge also serves to protect over 27 other endangered or threatened plant and animal species and their habitats.

The HSNWR beach is 5.4 km long and is located north of the Town of Jupiter Island's municipal beaches (Figure 1). Beginning at the northern boundary of the municipal beaches, the refuge runs north to the St. Lucie Inlet State Park. The beaches of the State Park continue north to the St. Lucie Inlet between Jupiter and Hutchinson Islands. With the exception of a parking lot located near the southern boundary of HSNWR, both the Refuge and Park are accessible only by foot from the municipal beaches, or by boat.

Physical and vegetative features of HSNWR beach

For management purposes, the Refuge beach is divided into 13 sections (Figure 1). These sections are approximately 0.4 km in length and run sequentially from south to north (Table 1). Beach Sections 1 through 4 and Section 9 receive moderate public use (fishing, sunbathing, swimming, surfing, and shelling). Public accesses are located in Section 2 where dune crossovers connect the beach to the Refuge parking lot, and Section 9 where boaters may access the beach from Peck Lake. The only artificial structures found on the refuge beach are a private house built on a riprap foundation extending onto the beach midway through Section 1, and two dune crossovers in Section 2.

Various portions of the Refuge have received sand from renourishment and sand transfer projects since 1996 (see EAI, 2003). Shoreline erosion has caused the beach to migrate west towards what was once coastal strand and wetland communities, as evidenced by the presence of black mangrove (*Avicennia germinans*), red mangrove (*Rhizophora mangle*) and cabbage palm (*Sabal palmetto*) immediately landward of the dune. Stumps of dead mangrove and Australian pine (*Casuarina equisetifolia*) are found on the beach within several sections.

Very little shade exists along the beach. Sea oats (*Uniola paniculata*) and coastal panic grass (*Panicum amarum*) are the most widespread grasses in the frontal zone. Sea grape (*Cocoloba uvifera*) forms shrubby thickets in both the fore and backdune. Other species

of native dune vegetation include marsh elder (*Iva imbricata*), saw palmetto (*Serenoa repens*), bay cedar (*Suriana maritima*), sea purslane (*Sesuvium portulacastrum*), and inkberry (*Scaevola plumieri*). Scrambling vines are also common, particularly railroad vine (*Ipomoea pes-caprae*), coin vine (*Dalbergia ecastophyllum*) and beach bean (*Canavalia maritima*). Invasive exotic species occurring among the dune vegetation include half-flower (*Scaevola frutescens*) and Brazilian pepper (*Schinus terebinthifolius*).

Previous sea turtle research

Three species of sea turtles regularly nest on Florida's beaches: the loggerhead, green and leatherback turtles. Of these, the loggerhead turtle nests in the greatest numbers (Meylan et al., 1995). The Florida coast from Brevard to Broward County represents the center of loggerhead nesting activity in the United States, the second most important concentration for this species worldwide. Green and leatherback turtles also nest in substantial numbers within this area. Although suffering from extensive anthropogenic impact, this region of Florida continues to harbor loggerhead, green and leatherback turtle nesting populations of worldwide significance.

Sea turtles nest throughout Martin County along the shores of Jupiter and Hutchinson Islands. In 2005, 10.6 percent of all sea turtle nests recorded in Florida occurred in Martin County (11.1 percent of all loggerhead, 6.1 percent of all green, and 29.4 percent of all leatherback turtle nests; Florida Fish and Wildlife Conservation Commission, 2006). Based on the number of sea turtle nests documented by county from 1988 through 2005, Martin County ranks third among Florida counties with respect to sea turtle nesting.

Monitoring of sea turtle nesting activity along HSNWR beaches began in 1972 (Bain et al., 1997). However, consistent methods of data collection were not implemented until 1973. Since then, annual loggerhead, green and leatherback turtle nest counts within the Refuge have ranged from 889-1857, 0-143 and 0-58, respectively (Bain et al., 1997; Kemp, 1996; EAI, 1997, 1999, 2000, 2001, 2002, 2003, 2004, 2005).

Management concerns

Prior to 1986, exotic Australian pines dominated dune vegetation along Refuge beaches. These trees tend to alter dune development, exclude native vegetation, and adversely affect sea turtle nesting activity (Schmelz and Mezich, 1988). Since 1983, managers have worked towards the restoration of native dune habitat. Through the removal of exotic species, such as Australian pines, native vegetation has largely been restored along the coastline.

Raccoons (*Procyon lotor*) have been responsible for causing substantial to nearly complete destruction of nests on numerous sea turtle nesting beaches throughout the southeastern United States (Stancyk, 1982). Raccoons have been documented as being responsible for the depredation of nests within the Refuge since sea turtle nesting surveys began in 1972 (Bain et al., 1997). Instances of nine-banded armadillos (*Dasypus*

novemcinctus) invading turtle nests were first recorded in 1988 (Drennan et al., 1989). Very little documentation of armadillos depredating sea turtle nests in Florida exists. HSNWR, Merritt Island National Wildlife Refuge in Brevard County, and beaches monitored by Mote Marine Laboratory near Sarasota, Florida, are among the first to record significant levels of armadillo depredation (Drennen et al., 1989; Kemp et al., 1998; Foote et al., 2000). On HSNWR, a trapping program has been in place since 1972 to reduce depredation by both raccoons and, more recently, armadillos (Bain et al., 1997; DuBall, 1998, 1999; Engeman et al., 2003; Lawrence, 1999; USDA, 2000; Woolard, 2002, 2003, 2004, 2005).

At one time vehicles were driven on Refuge beaches and poaching of sea turtle nests by humans was a problem. However, improved management including limited entry to the beaches and improved law enforcement has helped reduce these types of impacts. The Refuge is open daily from sunrise to sunset. With nighttime use prohibited, disturbance to nesting turtles by curious beach walkers is limited. High levels of protection of these beaches in conjunction with active management programs help ensure the preservation of nesting habitat within HSNWR.

METHODS

Personnel

During the 2005 sea turtle nesting season, HSNWR beaches were monitored daily by personnel from Ecological Associates, Inc. (EAI) of Jensen Beach, Florida. The following personnel participated in the surveys:

- Carrie K. Crady (Staff Biologist)
- Niki Desjardin (Staff Biologist)
- Matt Goff (Senior Ecologist)
- R. Erik Martin (Scientific Director)
- Mark Mohlmann (Senior Scientist)
- Barbara L. Stadden (Field Technician)

Nesting Surveys

Beginning March 15, HSNWR beaches were monitored periodically by EAI to locate leatherback nests deposited early in the season. Daily surveys were conducted along the entire length of the HSNWR beaches from 12 April to 16 September 2005. After 16 September, portions of the Refuge beach were surveyed two to three times a week until the last marked nest was evaluated on 14 November 2005. The beach surveys began early in the morning (0630-0730) and continued through late morning (0930-noon). Surveys were performed via all terrain vehicles (ATV).

All turtle activity evident from the previous night was recorded. Emergences (crawls) of turtles onto the beach were interpreted to determine which species came ashore and whether or not they nested. The numbers of nesting and non-nesting emergences (false crawls) were recorded by species and beach section (1 through 13). An attempt was also made to map the location of each nest and false crawl using a hand-held GPS unit. The location of the crawl in relation to the previous high tide line was also recorded. In accordance with Florida Fish and Wildlife Conservation Commission (FWC) Index Nesting Beach Survey protocols, only those crawls observed above the previous high tide line were included in the analyses. After a crawl was recorded, an ATV was driven over the turtle tracks so they would not be counted on subsequent surveys.

Nesting success (percentage of crawls resulting in nests) was determined by dividing the total number of nests observed by the total number of crawls (nests plus false crawls), and multiplying by 100 percent. Nesting success was determined per species and beach section.

Marking of nest sub-sample

All green and leatherback turtle nests were marked for future reproductive success analysis. Every eighth loggerhead nest encountered was marked. This resulted in approximately twelve percent of all loggerhead nests being sampled for evaluation of reproductive success.

When a nest was selected for evaluation, the nest mound was carefully excavated by hand to locate the clutch. Upon location of the egg chamber, digging and disturbance to the nest site ceased and the excavated hole was covered. A 120-cm-long wooden stake labeled with the date of observation, the species, and beach section was driven into the ground exactly 60 cm north or south of the clutch. The height of this stake above the beach surface was recorded. Additionally, two 60-cm-long stakes (also labeled with the date of observation, the species, and beach section) were placed on the opposite side of the clutch to form a triangle. The three stakes were then connected with orange surveyor's tape, creating a small barrier around the egg chamber. If the eggs in a leatherback or green turtle nest could not be located within a few digging attempts, or without causing significant disturbance to the nest site, the entire nest mound was staked off. If the eggs could not be located in a loggerhead nest after several digging attempts, then the next nest encountered during the survey was marked. All nests were left *in situ*.

Monitoring of marked nests

All marked nests were added to a nest inventory that listed each nest in the geographic order of occurrence (from south to north) along the beach. Marked nests were monitored daily for signs of hatchling emergence, tidal overwash, nest depredation, erosion, or other signs of disturbance. If all stakes surrounding the nest were washed away, the nest was presumed to have been completely washed out.

Nest depredation was characterized by a hole excavated in the vicinity of the marked clutch, predator tracks found at the disturbance site, and the presence of broken eggshells. Predators were identified by the tracks left at the site of disturbance. During previous years, an attempt was made to determine the reproductive success of marked nests that were partially depredated (i.e., some undamaged eggs were left in the nest after depredation). If a marked nest was partially depredated, the damaged eggs were removed from the egg chamber and the remaining eggs covered with sand. This procedure was repeated every time a depredation event occurred (many nests were depredated on more than one occasion). However, it was determined that these procedures may have artificially increased the reproductive success of those nests compared to unmarked nests that were not manipulated. In the absence of human interference, broken eggs (which promote bacterial growth and attract additional predators) would have remained in the clutch and the egg chamber would have been exposed to harsh environmental conditions. Under these conditions, it is unlikely that any eggs left undamaged by the initial depredation event would have survived. Therefore, the overall productivity of nests in the Refuge is more accurately reflected by assuming that no hatchlings are produced from nests that have been depredated.

Nest fate and reproductive data

The fate of each marked nest was determined and assigned to one the following categories:

Hatched with signs of emergence - nest hatched, hatchling tracks or emergence depression observed.

Hatched with no signs of emergence - nest hatched (based on evaluation of clutch contents), but no signs of hatchling emergence were observed.

Depredated - clutch partially or completely destroyed by predators.

Washed out - clutch destroyed by wave or tidal action.

Did not hatch - clutch located, no hatched eggs found.

Clutch not located - clutch not located and no signs of hatchling emergence observed.

Nested on by another turtle - clutch disturbed by another nesting female prior to hatchling emergence.

Scavenged - clutch disturbed by armadillo or raccoon after hatchling emergence, but before nest was evaluated.

Vandalized - all nest markers removed by vandals, clutch could not be located

Hatched, not analyzed - clutch contents could not be evaluated after hatchling emergence because the contents were washed out, decomposed, disturbed by another turtle, or could not be located.

Three full days after the first observed hatchling emergence, marked nests were excavated to determine reproductive success. Loggerhead and green turtle nests that exhibited no signs of hatchling emergence were excavated after a period of 70 days. Leatherback nests showing no signs of emergence were excavated after 80 days. Nest excavation was occasionally delayed for nests exposed to cooler temperatures (e.g., shaded locations) to provide all viable hatchlings an opportunity to emerge without human intervention. Prior to excavation, a final measurement was taken from the top of the 120-cm-long stake to the beach surface. This value, when subtracted from the initial stake height, yielded net sand shift over the nest during the incubation period.

All nests were excavated by hand, and clutch contents removed. Care was taken not to excavate beyond the depth of the egg chamber and to maintain one side of the cavity at ambient beach level. When all nest contents had been removed, a stake was placed across the portion of the cavity maintained at ambient beach level, and a measurement

was taken from the bottom edge of the stake to the deepest point in the egg chamber. This provided final clutch depth. Initial clutch depth, the depth to which the egg chamber was originally dug, was calculated for each nest by subtracting net sand shift from final clutch depth.

The numbers of hatched eggs, unhatched eggs, live and dead hatchlings, and live and dead embryos in pipped eggs were recorded. All live hatchlings were handled and released in accordance with FWC Sea Turtle Conservation Guidelines. Mean clutch size, hatching success, emerging success, and mean incubation period were determined for marked nests using the following formulae:

1) Clutch Size (total number of eggs in nest) = number of hatched eggs + number of unhatched eggs + number of pipped eggs.

2) Hatching Success (percentage of eggs in the clutch that completely extricated themselves from their eggshells) = (number of hatched eggs / clutch size) ∗ 100 percent.

3) Emerging Success (percentage of eggs in the clutch that produced hatchlings that successfully emerged from the nest) = {(number of hatched eggs – number of live and dead hatchlings) / (clutch size)} ∗ 100 percent.

4) Incubation Period = inclusive period (days) from the date of egg deposition until the first sign of hatchling emergence.

Loggerhead hatchling productivity estimates

The total number of loggerhead turtle hatchlings that emerged from nests (hatchling productivity) on the Refuge beach was estimated by extrapolating the results from the marked sub-sample of nests to the entire population of loggerhead nests in the Refuge. The following formula was used to estimate the total number of loggerhead hatchlings that emerged from all nests laid on the HSNWR beach during 2005:

$$\text{Hatchling Productivity} = \sum_{s=1}^{13} [(ES_s) * (CS)] * [(N_s) - (N_s * PR_s)]$$

Where: ES_s = mean emerging success (including washed out nests) calculated for beach Section *s*.

CS = mean clutch size for all non-depredated, marked nests in the Refuge.

N_s = total number of loggerhead nests in beach Section *s*.
PR_s = depredation rate for beach Section *s* (= number of marked nests depredated in Section *s* / total number of marked nests in Section *s*).

The maximum potential productivity of loggerhead nests within the refuge was also determined for each beach section. Maximum potential productivity is calculated by multiplying the total number of loggerhead nests laid within a section by the average loggerhead clutch size for the Refuge. This value serves as a means of comparison between the estimated number of hatchlings that actually emerged versus the maximum number that could have emerged had all eggs produced hatchlings that successfully emerged from their nests.

Predator control program

During 2005, all predator control activities were conducted by U.S. Department of Agriculture (USDA)-Animal and Plant Health Inspection Service (APHIS) Wildlife Services personnel. The USDA-APHIS predator control program consisted of nighttime hunting and trapping activities targeted at raccoons and armadillos.

RESULTS

NESTING DATA

Refuge overview

A total of 2,833 sea turtle crawls were recorded within HSNWR during the 2005 nesting season. Of these, 1,174 resulted in nests yielding an overall refuge nesting success of 41.4 percent for all species combined. Nesting occurred throughout all beach sections, with the greatest number of nests occurring within Sections 1 through 4.

Species overview

Of the sea turtle crawls recorded within HSNWR, 2,333 (82.4 percent) were identified as loggerhead, 440 (15.5 percent) as green turtle, 60 (2.1 percent) as leatherback, and 1 (0.04 percent) as Kemp's ridley. A total of 1,007 loggerhead crawls resulted in nests (Table 2). This is below the annual average of 1,263 nests for the period 1973-2004 (Bain et al., 1997; Kemp, 1996; EAI, 1997, 1999, 2000, 2001, 2002, 2003, 2004, 2005). The largest number of loggerhead nests (1,857) was documented in 1991. The overall nesting success for loggerhead turtles during 2005 was 43.2 percent.

From 1989 through 2002, green turtle nesting in the Refuge and throughout Florida was relatively low during odd years and relatively high during even years (Bain et al., 1997; Kemp, 1996; EAI, 1997, 1999, 2000, 2001, 2002, 2003; Witherington and Koeppel, 2000). In 2003, nesting was intermediate within the Refuge and throughout Florida when compared to the previous four years, and did not fit into the pattern of alternating "high" and "low" years (EAI, 2004; FWC, unpublished data). Green turtle nesting in the Refuge increased in 2004 (101 nests) but statewide nesting was again moderate. The number of green turtle nests increased both in the Refuge and statewide in 2005. In the Refuge, 120 green turtle nests were recorded (Table 3), making it the third highest number recorded since 1973; the highest number of green turtle nests (143) was recorded during 2002. An overall nesting success of 27.3 percent was recorded for green turtles in the Refuge during 2005.

Of the 60 leatherback crawls this season, 47 were nests (Table 4). This was a relatively high year for nesting by leatherbacks with the total number of nests for 2005 considerably greater than the annual average (11.0 nests) for the period 1973-2004 (Bain et al., 1997; Kemp, 1996; EAI, 1997, 1999, 2000, 2001, 2002, 2003, 2004, 2005). The largest number of leatherback nests (58) was recorded in 2001. Overall nesting success for leatherback turtles during 2005 was 78.3 percent.

Average nesting densities within HSNWR during 2005 were 186.5, 22.2, and 8.7 nests per kilometer for loggerhead, green and leatherback turtles, respectively.

For the second time since sea turtle monitoring began in 1972, a Kemp's ridley was documented emerging in the Refuge. During 2005, a Kemp's ridley was observed to emerge on the morning of May 18 but returned to the ocean without nesting in the Refuge. This same individual emerged numerous other times in the adjacent St. Lucie Inlet State park and ultimately nested there on June 3.

Spatial distribution of nesting activity

Loggerhead nesting occurred within every beach section, with the highest nest densities (nests per kilometer) recorded in Section 3 (Table 2; Figure 2). Nesting by this species was relatively low in the northern area of the Refuge (Sections 11-13). Nesting success was highest in Section 8 and lowest in Section 5 (Table 2; Figure 3). The approximate locations of individual loggerhead nests and false crawls are shown in Figure 4.

Green turtle nesting occurred in all beach sections except Section 12 with highest nest densities occurring primarily along the southern portion of the Refuge in Sections 1-4 (Table 3). As with loggerheads, green turtle nesting was relatively low in the northern sections. Green turtle nesting success varied considerably from section to section within the Refuge with the highest value in Section 10 and the lowest in Section 12. The approximate locations of individual green turtle nests and false crawls are shown in Figure 5.

Leatherback nesting occurred in all beach sections (Table 4). Nesting was highest in Sections 1 and 2 and lowest in the northern sections. There were too few crawls for meaningful analysis of nesting success. The approximate locations of individual leatherback nests and false crawls are shown in Figure 5.

The single Kemp's ridley false crawl occurred at the north end of the Refuge in Section 13. The approximate location of this false crawl is shown in Figure 5.

Monthly distribution of nesting activity

Table 5 illustrates the monthly distribution of all sea turtle nesting activity within HSNWR. Nesting activity began on 15 March 2005 with the emergence of a leatherback turtle on the Refuge beach. The majority of the recorded leatherback nests were observed during May, with the last nest being recorded on 3 July 2005.

Loggerhead nesting activity occurred from 30 April through 3 September, with activity peaking during June (Table 5). There was some temporal variability in overall loggerhead nesting success with the lowest nesting success recorded during August and the highest during May (Figure 6).

Green turtles were the last species to begin nesting within the refuge with the first nest recorded on 4 June. Green turtle nesting activity continued well into September, with most activity occurring during July and August (Table 5). The last green turtle nest was observed on 19 September.

REPRODUCTIVE SUCCESS

Refuge overview

During the 2005 nesting season, 284 nests (all species combined) were marked for reproductive success evaluation (Table 6). This represents 24.2 percent of the total nests recorded within the Refuge. Table 7 details the fate of all marked nests. Nests could not be evaluated and were excluded from analyses of reproductive success if the clutch could not be located (33 nests with no signs of hatchling emergence and 6 nests with signs of hatchling emergence), the clutch was disturbed by another nesting turtle (6 nests before and 1 nest after hatchling emergence), nest contents were too decomposed to be evaluated (4 nests), nest contents were disturbed by scavengers after hatchling emergence (4 nests), the nest contents were washed out after hatchling emergence (1 nest), or the nest markers were vandalized (1 nest).

A total of 30 marked nests (10.6 percent) were completely washed out by heavy surf and beach erosion during 2005 (Table 8). Washed out nests were assumed to have reproductive success values of zero and were included in calculations of hatching and emerging success.

Of the 284 marked nests, 45 (15.8 percent) were depredated (Table 9). Most of the nests were depredated by armadillos. Other predators included raccoons, bobcats, skunks, and dogs. All depredated nests were assumed to have reproductive success values of zero and were included in calculations of loggerhead hatchling productivity estimates and overall refuge reproductive success.

An overall hatching success of 57.0 percent and an overall emerging success of 54.2 percent were recorded for non-depredated nests within HSNWR (N = 183; Table 10). Including depredated nests in calculations resulted in an overall hatching success of 45.7 percent and an overall emerging success of 43.5 percent (N = 229; Table 11).

Species overview

Of the 124 marked loggerhead nests, 23 (18.5 percent) were depredated and 15 (12.1 percent) were washed out (Table 7). Two nests were disturbed by other turtles (one before and one after hatchling emergence), nest markers for one nest were vandalized, one nest was washed out after hatchling emergence but before excavation/evaluation, the clutch could not be located in one nest, and the contents of one nest were too decomposed to be evaluated. The remaining 80 nests had an average initial clutch depth of 57.4 cm and a mean clutch size of 111.2 eggs (Table 10). The 70 loggerhead nests that showed signs of emergence had a mean incubation period of 52.2 days. Overall mean hatching and emerging success for non-depredated loggerhead nests (including washed out nests) was 58.3 percent and 56.1 percent, respectively (N = 95). When depredated nests were included, hatching and emerging success values for loggerhead nests were reduced to 47.0 and 45.2 percent, respectively (N = 118; Table 11).

A total of 113 green turtle nests were marked. Nineteen of these (16.8 percent) were depredated and 11 (9.73 percent) were washed out (Table 7). The clutch could not be located in 25 nests (2 with signs of hatchling emergence and 23 without), four nests were disturbed by other turtles, nest contents in two nests were disturbed by scavengers after hatchling emergence, and the contents of one nest were too decomposed to be evaluated. The remaining 51 nests had an average initial clutch depth of 79.2 cm and a mean clutch size of 123.7 eggs (Table 10). The average incubation period for the 51 nests that showed signs of hatchling emergence was 49.9 days. Non-depredated green turtle nests (including washed-out nests) had mean hatching and emerging success values of 59.6 percent and 56.8 percent, respectively (N = 62). Including depredated nests in calculations resulted in a mean hatching success of 45.5 percent and a mean emerging success of 43.3 percent (N = 81; Table 11).

Of the 47 leatherback turtle nests that were marked, three (6.4 percent) were depredated and four (8.5 percent) were washed out (Table 7). Additionally, the clutch could not be located in 13 nests (4 with signs of hatchling emergence and 9 without), one nest was disturbed by another turtle, the contents of two nests were disturbed by scavengers after hatchling emergence, and the contents of two nests were too decomposed to evaluate. The remaining 22 nests had a mean initial clutch depth of 76.3 cm and an average clutch size of 75.4 eggs (Table 10). The average incubation period for the 29 nests that showed signs of emergence was 69.0 days. Overall hatching and emerging success for non-depredated leatherback turtle nests (including washed-out nests) was 44.0 percent and 39.8 percent, respectively (N = 26). When depredated nests were included, hatching and emerging success values were reduced to 39.4 and 35.7 percent, respectively (N = 29; Table 11).

NEST DEPREDATION

Refuge overview

A total of 45 sea turtle nests (all species combined) were depredated during 2005 (Table 9). This represents 15.8 percent of all marked nests (N = 284) within the Refuge. Armadillos were responsible for 77.8 percent of recorded depredation. Raccoons alone were responsible for 8.9 percent of the total predation, while raccoons acted in conjunction with armadillos in 4.4 percent of the cases. One nest depredated by a skunk accounted for 2.2 percent of total documented predation and two nests depredated by bobcats accounted for 4.4 percent.

Nests were depredated throughout incubation with the greatest number of nests (11 nests; 24.4 percent) depredated after 41 to 50 days of incubation (Figure 7). The average incubation period for the 150 sea turtle nests that showed signs of emergence was 54.7 days (range = 45-92 days).

Species overview

Of the 124 marked loggerhead nests, 23 (18.5 percent) were depredated during the course of their incubation (Table 7). In comparison, 19 (16.8 percent) of the green turtle nests and 3 (6.4 percent) of the leatherback nests were depredated during 2005.

Spatial distribution of depredated nests

Marked nests were depredated in small numbers throughout the Refuge (Figure 8). The highest rates of depredation occurred in Sections 7, 8, 9 and 13 and the lowest in Section 2 (Table 9). Armadillos were responsible for the greatest number of depredations within the Refuge (35; 12.3% of all marked nests). Marked nests in every beach section (with the exception of Section 12) were damaged by armadillos. Raccoons alone were responsible for only four predation events; one each in Sections 4, 7, 8, and 12. Only 1.4 percent of the marked sea turtle nests were destroyed by raccoons. Other nest predators included skunks (1 depredation in Section 5), bobcats (2 depredations in Section 9), and dogs (1 depredation in Section 8).

LOGGERHEAD HATCHLING PRODUCTIVITY ESTIMATES

The estimated number of loggerhead hatchlings that emerged on the HSNWR beach this year was 51,135 out of a potential 111,928 (Table 12). Based on calculated productivity per kilometer, loggerhead productivity was highest in Section 3, primarily due to the high nest densities in this section. A comparison of hatchling productivity estimates among sections using numbers of hatchlings per kilometer revealed that Section 3 was the most productive (Figure 9). Hatchling productivity was lowest in Sections 5, 7, 12, and 13 due to relatively low nesting and (in Sections 5, 7, and 12) high depredation rates.

PREDATOR CONTROL PROGRAM

During 2005, the USDA-APHIS predator control program resulted in the removal of four raccoons, two armadillos, and two opossums from the Refuge (Woolard, 2006). Raccoons were removed from Sections 6, 8, and 9, armadillos were removed from Sections 2 and 7, and opossums were removed from Section 2.

DISCUSSION

During 2005, nesting by all species increased from 2004. Despite this increase, nesting success was the lowest since 1997 (41.4 percent; Figure 10). Nesting success is an index that relates the number of nests to the number of false crawls and is useful in assessing the post-emergence suitability of a nesting beach. Low nesting success during 2005 may be related to changes in beach topography associated with the passage of Hurricanes Frances and Jeanne during September 2004. These changes in beach topography persisted during the 2005 nesting season and may have reduced the suitability of Refuge beaches for sea turtle nesting. When nesting success values since 1997 were analyzed using regression analysis, no statistically significant trend was indicated ($r^2 = 0.0005$, $P = 0.96$).

Loggerhead turtles nested in relatively low numbers in the Refuge during 2005. During the thirty-three year period of record (1973-2005), there have been considerable fluctuations in loggerhead nesting in the Refuge. Since 1991 there has been an apparent trend towards decreasing nesting by this species. However, linear regression analysis applied to loggerhead nesting data for the entire period of record indicated a significant, though very weak, trend towards increased nesting ($r^2 = 0.13$, $P < 0.05$).

Green turtles nested in high numbers in the Refuge during 2005 and the long-term trend has been towards increased nesting (Figure 12). Regression analysis indicates that this trend is highly significant ($r^2 = 0.45$, $P < 0.0001$). As with green turtles, leatherback nesting during 2005 was high and the long-term trend is towards increased nesting (Figure 13). This trend was also found to be highly significant when tested with regression analysis ($r^2 = 0.66$, $P < 0.0001$).

As in previous years, the primary factor impacting sea turtle nests during the 2005 sea turtle nesting season was predation. The loss of turtle nests to depredation is a problem recorded by HSNWR researchers since sea turtle nesting surveys began in 1972. During the first 15 years of research, raccoons were documented as being the only major predator of sea turtle eggs within the Refuge. However, during recent years, armadillos have become an increasing problem (EAI, 1997, 1999, 2000, 2001, 2002, 2003, 2004, 2005).

Armadillo depredation of sea turtle nests in the Refuge was first documented in 1988 (Drennen et al., 1989). During the first few years of armadillo depredation, it was observed that the armadillos would generally depredate a nest only after a raccoon had initially invaded the clutch. However, during the last nine years (1997-2005) armadillos have been solely responsible for 43-78 percent of the depredation occurring within the Refuge each year (EAI, 1997, 1999, 2000, 2001, 2002, 2003, 2004, 2005; Figure 14). During this same period up to 45 percent of the annual depredation was attributed to a combination of raccoons and armadillos. During 2005, 77.8 percent of the depredation in the Refuge was due solely to armadillos and an additional 4.4 percent was due to a combination of armadillos and raccoons.

Very little documentation exists of armadillos depredating sea turtle nests on other nesting beaches in Florida. Armadillos are known to shift feeding patterns seasonally (Sikes et al., 1989; Wirtz et al., 1985). Although the majority of food items consumed by these animals are soft-bodied invertebrates (Breece and Dusi, 1985), Florida armadillo populations have been observed to excavate and consume reptile eggs (Wirtz et al., 1985; Breece and Dusi, 1985). Significant levels of armadillo depredation on sea turtle nests have only been reported for a few areas. These include HSNWR and other Jupiter Island beaches, Merritt Island National Wildlife Refuge in Brevard County and beaches monitored by Mote Marine Laboratory near Sarasota, Florida (Drennen et al., 1989; EAI, 1997, 1999, 2000, 2001, 2002, 2003, 2004, 2005; Foote et al., 2000; Kemp et al., 1998).

A predator trapping program has been ongoing at the Refuge since 1972 (Bain et al., 1997). In the past, armadillos have been difficult to trap within the refuge and up until 1998, efforts to control armadillos focused only on trapping. In 1998, Refuge personnel supplemented the trapping program with some nighttime hunting (DuBall, 1998). The combined hunting and trapping program resulted in the elimination of seven armadillos during 1998. Every year since 1999, USDA-APHIS personnel have conducted more intensive nighttime hunting and trapping program to target this species (Lawrence 1999; USDA, 2000; Woolard, 2002; Woolard, 2003, 2004, 2005). Through the combined efforts of USDA-APHIS and Refuge personnel, 42 armadillos have been removed during the last seven years (1999-2005).

The increased efforts to trap and hunt armadillos and raccoons since 1998 has apparently been responsible for the recent trend towards decreasing mammal predation on sea turtle nests in the Refuge (Figure 15). This nine-year trend towards decreasing predation was found to be statistically significant ($r^2 = 0.78$, $P < 0.01$).

Probably the best overall gauge of sea turtle reproductive success on the Refuge is hatchling productivity. This measure takes into account the number of nests deposited, the average number of eggs per nest, the number of nests lost to predation and erosion, and the emerging success of the remaining nests. Loggerhead turtle hatchling productivity at the Refuge has been calculated in a consistent manner every year since 1997 (EAI, 1997, 1999, 2000, 2001, 2002, 2003, 2004, 2005). Though there has been considerable variability in annual productivity from 1997 through 2005 (Figure 16), no significant trend towards increasing or decreasing productivity is indicated by linear regression analysis ($r^2 = 0.02$, $P = 0.75$).

When compared to data since 1997, loggerhead turtle hatchling productivity during 2005 (51,135 hatchlings) was below average (59,709 hatchlings), but considerably higher than productivity in 2004 (38,890 hatchlings; Figure 16). Low productivity during 2004 was primarily attributed to low nesting and a record high nest wash-out rate (22.1 percent) caused by Hurricane Frances which passed through the area in early September. During 2005, loggerhead nest numbers were only slightly higher than those in 2004. Although Hurricane Wilma passed through the area in late October 2005, all loggerhead nests had already hatched and thus it did not affect loggerhead productivity. Nest-loss due to erosion during 2005 (12.1 percent) was about average and considerably lower than in

2004. Also, the predation rate was lower during 2005 (18.5 percent) than during 2004 (25.4 percent). Higher predation during 2004 was attributed to the premature termination of the predator control program that year. During 2005, predator control continued throughout the sea turtle nesting and hatching season and was successful in limiting predation on turtle nests. Clearly, the predator control program is the most effective management option for increasing sea turtle productivity in the Refuge.

LITERATURE CITED

Bain, R., S. D. Jewell, J. Schwagerl, and B. S. Neely, Jr. 1997. Sea turtle nesting and reproductive success at the Hobe Sound National Wildlife Refuge (Florida): 1972-1995. Report to U.S. Fish and Wildlife Service, ARM Loxahatchee NWR.

Breece, G. A. and J. L. Dusi. 1985. Food habits and ranges of the common long-nosed armadillo *Dasypus novemcinctus* in Alabama. Pages 419-427 in Montgomery, G.E. (editor). The evolution and ecology of armadillos, sloths, and vermilinguas. Smithsonian Inst. Press, Washington, D. C.

Drennen, D., D. Cooley, and J. E. Devore. 1989. Armadillo predation on loggerhead turtle eggs at two national wildlife refuges in Florida, USA. Mar. Turt. News. 45:7-8.

DuBall, R. 1998. Predator Control Program, 1998, Hobe Sound National Wildlife Refuge. Report to U.S. Fish and Wildlife Service, ARM Loxahatchee NWR.

_____. 1999. Predator Control Program, 1999, Hobe Sound National Wildlife Refuge. Report to U.S. Fish and Wildlife Service, ARM Loxahatchee NWR.

EAI (Ecological Associates, Inc.). 1997. Hobe Sound National Wildlife Refuge, 1997 Sea Turtle Nesting Report. Report to U.S. Fish and Wildlife Service, ARM Loxahatchee NWR.

_____. 1999. Hobe Sound National Wildlife Refuge, Results of 1998 Sea Turtle Monitoring. Report to U.S. Fish and Wildlife Service, ARM Loxahatchee NWR.

_____. 2000. Hobe Sound National Wildlife Refuge, Results of 1999 Sea Turtle Monitoring. Report to U.S. Fish and Wildlife Service, ARM Loxahatchee NWR.

_____. 2001. Hobe Sound National Wildlife Refuge, Results of 2000 Sea Turtle Monitoring. Report to U.S. Fish and Wildlife Service, ARM Loxahatchee NWR.

_____. 2002. Hobe Sound National Wildlife Refuge, Results of 2001 Sea Turtle Monitoring. Report to U.S. Fish and Wildlife Service, ARM Loxahatchee NWR.

_____. 2003. Hobe Sound National Wildlife Refuge, Results of 2002 Sea Turtle Monitoring. Report to U.S. Fish and Wildlife Service, ARM Loxahatchee NWR.

_____. 2004. Hobe Sound National Wildlife Refuge, Results of 2003 Sea Turtle Monitoring. Report to U.S. Fish and Wildlife Service, ARM Loxahatchee NWR.

_____. 2005. Hobe Sound National Wildlife Refuge, Results of 2004 Sea Turtle Monitoring. Report to U.S. Fish and Wildlife Service, ARM Loxahatchee NWR.

Engeman, R.M., R.E. Martin, B. Constantin, R. Noel, and J. Woolard. 2003. Monitoring predators to optimize their management for marine turtle nest protection. Biological Conservation 113:171-178.

Florida Fish and Wildlife Conservation Commission. 2006. Florida Statewide Nesting Beach Survey Data. http://research.myfwc.com/ February 28, 2006.

Foote, J. J., J. L. Floyd, T. L. Mueller, M. Salmon, and J. Sprinkel. 2000. Changes in loggerhead nest predation patterns on west central Florida beaches. Pages 189-190 in Abreu-Grobois, F.A., R. Briseno, R. Marquez, and L. Sarti (compilers). Proceedings of the eighteenth international sea turtle symposium. NOAA Tech. Mem. MFS-SEFSC-436.

Kemp, S. J. 1996. Hobe Sound National Wildlife Refuge: 1996 Sea Turtle Nesting Report. 51 pp.

_____, S. Jewell, and B. S. Neely. 1998. Predation of loggerhead sea turtle (*Caretta caretta*) nests by armadillos (*Dasypus novemcinctus*) at Hobe Sound National Wildlife Refuge, Florida. Pages 212-213 in Epperly, S.P. and J. Braun. Proceedings of the Seventeenth Annual Sea Turtle Symposium. NOAA Tech. Mem. NMFS-SEFSC-415.

Lawrence, E. W. L. 1999. Hobe Sound Sea Turtle Nest Predator Control Report. Report to U.S. Fish and Wildlife Service, ARM Loxahatchee NWR.

Meylan, A., B. Schroeder, and A. Mosier. 1995. Sea turtle nesting activity in the state of Florida, 1979-1992. Fla. Mar. Res. Publ. No. 52.

Schmelz, G.W., and R. R. Mezich. 1988. A preliminary investigation of the potential impact of Australian pines on the nesting activities of the loggerhead turtle. Pages 63-66 in Schroeder, B. A. (compiler). Proceedings of the Eighth Annual Workshop on Sea Turtle Conservation and Biology. NOAA Tech. Mem. NMFS-SEFC-214.

Sikes, R. S., G. A. Heidt, and D. A. Elrod. 1989. Seasonal diets of the nine-banded armadillo (*Dasypus novemcinctus*) in a northern part of its range. Am. Midl. Nat. 123: 383- 389.

Stancyk, S. E. 1982. Non-human predators of sea turtles and their control. Pages 139-152 in Bjorndal, K. A. (editor). Biology and Conservation of Sea Turtles. Smithsonian Inst. Press, Washington, D. C.

USDA (U.S. Department of Agriculture). 2000. Hobe Sound National Wildlife Refuge/Saint Lucie Inlet State Park Sea Turtle Nest Predator Control Project. Prepared by U.S. Department of Agriculture, Animal and Plant Health Service, Wildlife Services for Hobe Sound National Wildlife Refuge. 2pp.

USFWS (U.S. Fish and Wildlife Service). 1996. Hobe Sound National Wildlife Refuge. Department of the Interior and U.S. Fish and Wildlife Service publication RF-41561, September, 1996.

Wirtz, W. O., D. H. Austin, and G. W. Dekle. 1985. Food habits of the common long-nosed armadillo *Dasypus novemcinctus* in Florida, 1960-61. Pages 439-450 in Montgomery, G.E. (editor). The evolution and ecology of armadillos, sloths, and vermilinguas. Smithsonian Inst. Press, Washington D. C.

Witherington, B.E. and C.M. Koeppel. 2000. Sea turtle nesting in Florida, USA, during the decade 1989-1998: an analysis of trends. Pages 94-96 in Kalb, H. and T. Wibbels (compilers). Proceedings of the Nineteenth Annual Symposium on Sea Turtle Conservation and Biology. NOAA Tech. Mem. NMFS-SEFSC-443.

Woolard, J. 2002. Hobe Sound National Wildlife Refuge/Saint Lucie Inlet State Park Sea Turtle Nest Predator Control Report. Prepared by U.S. Department of Agriculture, Animal and Plant Health Service, Wildlife Services for Hobe Sound National Wildlife Refuge. 3pp.

Woolard, J. 2003. Hobe Sound National Wildlife Refuge & Saint Lucie Inlet State Park: Sea Turtle Nest Predator Totals, 2002. Prepared by U.S. Department of Agriculture, Animal and Plant Health Service, Wildlife Services for Hobe Sound National Wildlife Refuge. 1p.

Woolard, J. 2004. Hobe Sound National Wildlife Refuge & Saint Lucie Inlet State Park: Sea Turtle Nest Predator Totals, 2003. Prepared by U.S. Department of Agriculture, Animal and Plant Health Service, Wildlife Services for Hobe Sound National Wildlife Refuge. 1p.

Woolard, J. 2005. Hobe Sound National Wildlife Refuge & Saint Lucie Inlet State Park: Sea Turtle Nest Predator Totals, 2004. Prepared by U.S. Department of Agriculture, Animal and Plant Health Service, Wildlife Services for Hobe Sound National Wildlife Refuge. 1p.

Woolard, J. 2006. Hobe Sound National Wildlife Refuge & Saint Lucie Inlet State Park: Sea Turtle Nest Predator Totals, 2005. Prepared by U.S. Department of Agriculture, Animal and Plant Health Service, Wildlife Services for Hobe Sound National Wildlife Refuge. 1p.

Table 1. Length of Hobe Sound National Wildlife Refuge Beach Sections 1 Through 13, including latitude and longitude of section borders, as determined by Hobe Sound National Wildlife Refuge personnel, 11 April 2002.

Beach Section	Length (km)	Latitude	Longitude
Start of 1	N/A	27.08637° N	80.12481° W
1	.422	27.08960° N	80.12708° W
2	.409	27.09278° N	80.12918° W
3	.352	27.09565° N	80.13073° W
4	.563	27.10023° N	80.13322° W
5	.383	27.10332° N	80.13496° W
6	.433	27.10685° N	80.13686° W
7	.365	27.10983° N	80.13844° W
8	.404	27.11317° N	80.14008° W
9	.456	27.11713° N	80.14135° W
10	.449	27.12092° N	80.14292° W
11	.401	27.12448° N	80.14375° W
12	.311	27.12725° N	80.14427° W
13	.406	27.13075° N	80.14552° W

Table 2. Loggerhead turtle (*Caretta caretta*) crawl activity and nesting success per beach section, Hobe Sound National Wildlife Refuge, 2005. Includes only crawls above the previous high tide line. Numbers in parentheses are calculated crawls per kilometer.

Beach Section	Total Crawls	Total Nests	Total False Crawls	Nesting Success Per Section[1]
1	224 (531)	89 (211)	135 (320)	39.73%
2	205 (501)	93 (227)	112 (274)	45.37%
3	259 (735)	130 (369)	129 (366)	50.19%
4	294 (522)	130 (231)	164 (291)	44.22%
5	162 (423)	48 (125)	114 (298)	29.63%
6	227 (524)	80 (185)	147 (339)	35.24%
7	149 (409)	67 (184)	82 (225)	44.97%
8	153 (378)	81 (200)	72 (178)	52.94%
9	201 (440)	100 (219)	101 (221)	49.75%
10	157 (350)	75 (167)	82 (183)	47.77%
11	123 (307)	43 (107)	80 (200)	34.96%
12	76 (244)	25 (80)	51 (164)	32.89%
13	103 (254)	46 (113)	57 (140)	44.66%
Total	**2,333 (432)**	**1,007 (186)**	**1,326 (246)**	**43.16%**

[1]Nesting Success = (number of nests /number of crawls) x 100 percent.

Table 3. Green turtle (*Chelonia mydas*) crawl activity and nesting success per beach section, Hobe Sound National Wildlife Refuge, 2005. Includes only crawls above the previous high tide line. Numbers in parentheses are calculated crawls per kilometer.

Beach Section	Total Crawls	Total Nests	Total False Crawls	Nesting Success Per Section[1]
1	55 (130)	15 (36)	40 (95)	27.27%
2	47 (115)	15 (37)	32 (78)	31.91%
3	62 (176)	20 (57)	42 (119)	32.26%
4	61 (108)	20 (36)	41 (73)	32.79%
5	38 (99)	6 (16)	32 (84)	15.79%
6	47 (109)	8 (18)	39 (90)	17.02%
7	20 (55)	7 (19)	13 (36)	35.00%
8	28 (69)	9 (22)	19 (47)	32.14%
9	25 (55)	6 (13)	19 (42)	24.00%
10	23 (51)	9 (20)	14 (31)	39.13%
11	12 (30)	3 (7)	9 (22)	25.00%
12	12 (39)	0 (0)	12 (39)	0.00%
13	10 (25)	2 (5)	8 (20)	20.00%
Total	**440 (81)**	**120 (22)**	**320 (59)**	**27.27%**

[1]Nesting Success = (number of nests /number of crawls) x 100 percent.

Table 4. Leatherback turtle (*Dermochelys coriacea*) crawl activity and nesting success per beach section, Hobe Sound National Wildlife Refuge, 2005. Includes only crawls above the previous high tide line. Numbers in parentheses are calculated crawls per kilometer.

Beach Section	Total Crawls	Total Nests	Total False Crawls	Nesting Success Per Section[1]
1	11 (26)	10 (24)	1 (2)	90.91%
2	13 (32)	9 (22)	4 (10)	69.23%
3	3 (9)	3 (9)	0 (0)	100.00%
4	9 (16)	7 (12)	2 (4)	77.78%
5	6 (16)	3 (8)	3 (8)	50.00%
6	4 (9)	2 (5)	2 (5)	50.00%
7	3 (8)	2 (5)	1 (3)	66.67%
8	3 (7)	3 (7)	0 (0)	100.00%
9	3 (7)	3 (7)	0 (0)	100.00%
10	1 (2)	1 (2)	0 (0)	100.00%
11	1 (2)	1 (2)	0 (0)	100.00%
12	2 (6)	2 (6)	0 (0)	100.00%
13	1 (2)	1 (2)	0 (0)	100.00%
Total	**60 (11)**	**47 (9)**	**13 (2)**	**78.33%**

[1]Nesting Success = (number of nests /number of crawls) x 100 percent.

Table 5. Monthly distribution of sea turtle nests summarized by species, Hobe Sound National Wildlife Refuge, 2005. Includes only nests above the previous high tide line.

Month	Loggerhead Nests	Green Nests	Leatherback Nests	Refuge Total
March	0	0	4	4
April	0	0	7	7
May	163	0	22	185
June	420	15	11	446
July	365	62	3	430
August	58	41	0	99
September	1	2	0	3
October	0	0	0	0
Total	**1,007**	**120**	**47**	**1,174**

Table 6. Number of marked sea turtle nests summarized by species and beach section, Hobe Sound National Wildlife Refuge, 2005.

Beach Section	Loggerhead	Green Turtle	Leatherback	Total
1	9	15	10	34
2	11	15	9	35
3	13	19	3	35
4	18	20	7	45
5	2	5	3	10
6	12	7	2	21
7	7	7	2	16
8	12	8	3	23
9	16	6	3	25
10	9	9	1	19
11	6	0	1	7
12	4	0	2	6
13	5	2	1	8
Total	**124**	**113**	**47**	**284**

Table 7. Fates of all marked sea turtle nests summarized by species, Hobe Sound National Wildlife Refuge, 2005.

	Fate	Loggerhead	Green Turtle	Leatherback
Evaluated	Hatched with signs of emergence	67	46	21
	Hatched with no signs of emergence	7	2	0
	Did not hatch	6	3	1
	Total Evaluated	**80**	**51**	**22**
Not Evaluated	Depredated	23	19	3
	Washed Out	15	11	4
	Stakes Vandalized	1	0	0
	Nested on by another turtle	1	4	1
	Clutch not located[1]	1	23	9
	Hatched, Not Analyzed[2]	3	3	6
	Scavenged	0	2	2
	Total Not Evaluated	**44**	**62**	**25**
Total Marked		**124**	**113**	**47**

[1]No hatchling emergence noted, clutch not located upon excavation.

[2]The contents of one loggerhead nest were washed out after hatchling emergence, but before excavation/evaluation. Contents of two leatherback nests, one green turtle nest and one loggerhead nest were too decomposed to enumerate and evaluate. One loggerhead nest could not be evaluated because another loggerhead disturbed the clutch after hatchling emergence but before excavation/evaluation. The contents of two green turtle nests and four leatherback nests showed signs of hatchling emergence, but the clutch could not be located at the time of excavation.

Table 8. Numbers and percentages of marked sea turtle nests that were washed out during incubation, summarized by species and beach section, Hobe Sound National Wildlife Refuge, 2005.

Beach Section	Loggerhead	Green Turtle	Leatherback	Total
1	0 (0.0%)	3 (20.0%)	1 (10.0%)	4 (11.8%)
2	0 (0.0%)	3 (20.0%)	0 (0.0%)	3 (8.6%)
3	3 (23.1%)	2 (10.5%)	0 (0.0%)	5 (14.3%)
4	2 (11.1%)	1 (5.0%)	1 (14.3%)	4 (8.9%)
5	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
6	2 (16.7%)	0 (0.0%)	0 (0.0%)	2 (9.5%)
7	1 (14.3%)	1 (14.3%)	0 (0.0%)	2 (12.5%)
8	4 (33.3%)	0 (0.0%)	1 (33.3%)	5 (21.7%)
9	1 (6.3%)	0 (0.0%)	0 (0.0%)	1 (4.0%)
10	0 (0.0%)	1 (11.1%)	0 (0.0%)	1 (5.3%)
11	1 (16.7%)	0 (0.0%)	0 (0.0%)	1 (14.3%)
12	1 (25.0%)	0 (0.0%)	1 (50.0%)	2 (16.7%)
13	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
Total	**15 (12.1%)**	**11 (9.7%)**	**4 (8.5%)**	**30 (10.6%)**

Table 9. Numbers of marked sea turtle nests depredated by each predator species summarized by beach section, Hobe Sound National Wildlife Refuge, 2005. AD = depredated by armadillo only, RD = depredated by raccoon only, ARD = depredated by raccoon and armadillo, SD = depredated by skunk only, BD = depredated by bobcat only, and DD = depredated by dog only.

Beach Section	AD	RD	ARD	SD	BD	DD	Section Totals	#Nests Marked	Rate of Depredation
1	2	0	0	0	0	0	2	34	5.9%
2	1	0	0	0	0	0	1	35	2.9%
3	6	0	1	0	0	0	7	35	20.0%
4	5	1	0	0	0	0	6	45	13.3%
5	1	0	0	1	0	0	2	10	20.0%
6	2	0	0	0	0	0	2	21	9.5%
7	5	1	0	0	0	0	6	16	37.5%
8	4	1	0	0	0	1	6	23	26.1%
9	4	0	0	0	2	0	6	25	24.0%
10	1	0	0	0	0	0	1	19	5.3%
11	1	0	0	0	0	0	1	7	14.3%
12	0	1	0	0	0	0	1	6	16.7%
13	3	0	1	0	0	0	4	8	50.0%
Total	**35**	**4**	**2**	**1**	**2**	**1**	**45**	**284**	**15.8%**

Table 10. Reproductive success data (mean values) for all non-depredated, marked sea turtle nests summarized by species, Hobe Sound National Wildlife Refuge, 2005. Calculations of hatching and emerging success include washed-out nests.

Reproductive Success Variable	Loggerhead Nests	Green Turtle Nests	Leatherback Nests	Total
Initial Clutch Depth (cm)	57.4 (N=80)	79.2 (N=51)	76.3 (N=22)	67.4 (N=153)
Clutch Size	111.2 (N=80)	123.7 (N=51)	75.4 (N=22)	110.2 (N=153)
Incubation Period (days)	52.2 (N=70)	49.9 (N=51)	69.0 (N=29)	54.7 (N=150)
Hatching Success	58.3% (N=95)	59.6% (N=62)	44.0% (N=26)	57.0 (N=183)
Emerging Success	56.1% (N=95)	56.8% (N=62)	39.8% (N=26)	54.2 (N=183)

Table 11. Mean hatching and emerging success values for all marked sea turtle nests summarized by species, Hobe Sound National Wildlife Refuge, 2005. Calculations include washed-out and depredated nests.

Reproductive Success Variable	Loggerhead (N=118)	Green Turtle (N=81)	Leatherback (N=29)	Total (N=229)
Hatching Success	47.0%	45.5%	39.4%	45.7%
Emerging Success	45.2%	43.3%	35.7%	43.5%

Table 12. Loggerhead turtle (*Caretta caretta*) hatchling productivity estimates summarized by beach section, Hobe Sound National Wildlife Refuge, 2005. Emerging success values are means for non-depredated marked nests. For the purposes of calculating productivity estimates, the mean clutch size (111.15) for all marked loggerhead nests was used. Numbers in parentheses are calculated productivity and maximum potential productivity per kilometer.

Beach Section	# of Nests	Emerging Success	Predation Rate	Hatchling Productivity[1]	Max. Potential Productivity[2]	Percent of Maximum
1	89	47.63%	22.22%	3,665 (8,685)	9,892 (23,442)	37.05%
2	93	64.28%	0.00%	6,645 (16,247)	10,337 (25,274)	64.28%
3	130	50.27%	7.69%	6,705 (19,048)	14,450 (41,050)	46.40%
4	130	55.66%	11.11%	7,150 (12,699)	14,450 (25,665)	49.48%
5	48	NA[3]	100.00%	0 (0)	5,335 (13,930)	0.00%
6	80	61.09%	8.33%	4,979 (11,500)	8,892 (20,536)	56.00%
7	67	44.12%	71.43%	939 (2,572)	7,447 (20,403)	12.60%
8	81	35.44%	25.00%	2,393 (5,923)	9,003 (22,285)	26.58%
9	100	66.27%	31.25%	5,064 (11,105)	11,115 (24,375)	45.56%
10	75	75.23%	0.00%	6,271 (13,968)	8,336 (18,566)	75.23%
11	43	66.08%	0.00%	3,158 (7,876)	4,779 (11,919)	66.08%
12	25	30.02%	0.00%	834 (2,682)	2,779 (8,935)	30.02%
13	46	39.12%	40.00%	1,200 (2,956)	5,113 (12,593)	23.47%
Total	1007	56.09%	18.55%	51,135 (9,551)	111,928 (20,906)	45.69%

[1] Calculations of Hatchling Productivity are based on a formula presented in the text.

[2] The maximum number of hatchlings that could be produced if all eggs produced hatchlings that emerged (total number of nests x mean clutch size).

[3] Two nests were marked in Section 5 and both were depredated so a mean emerging success value for non-depredated nests is not available.

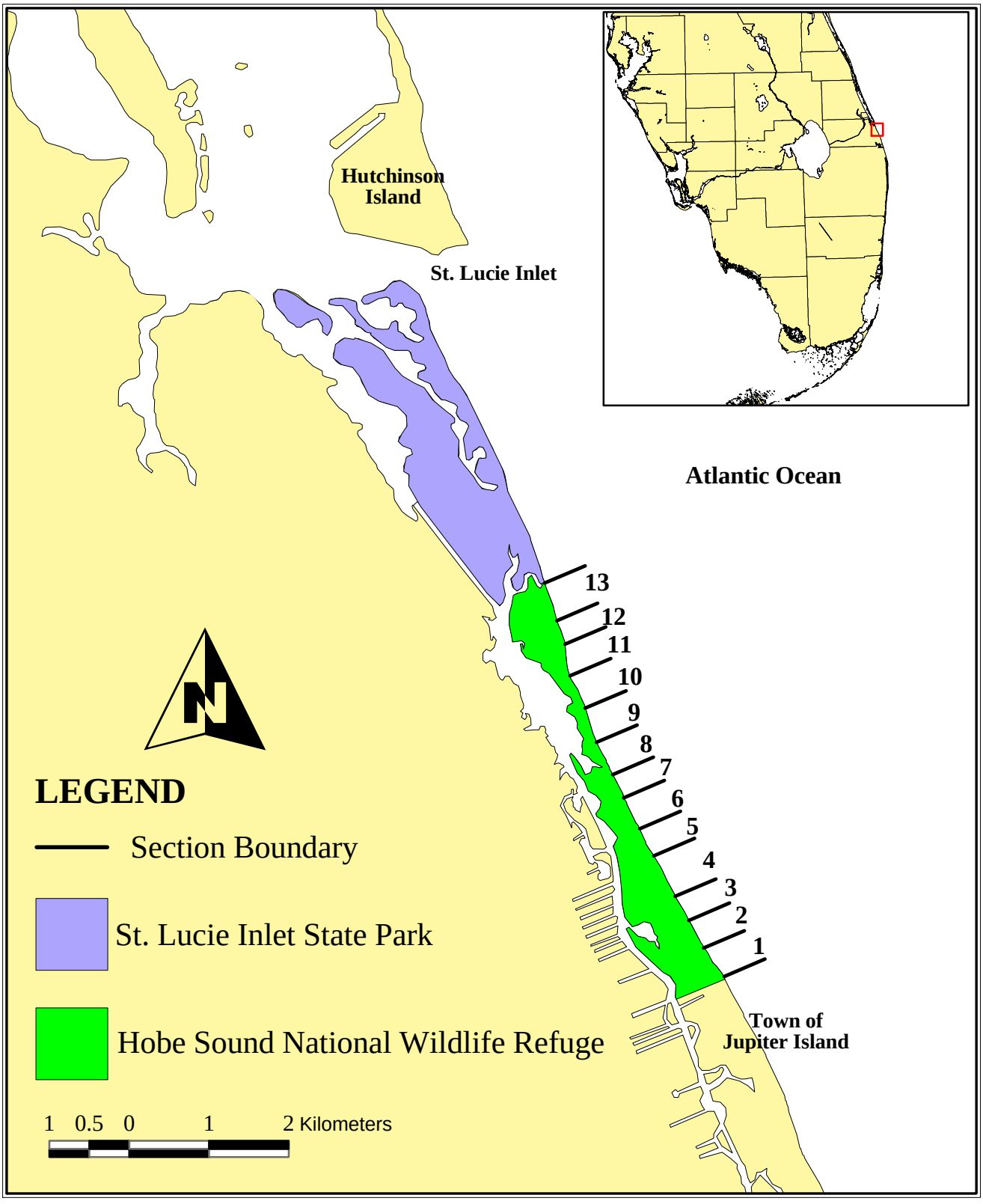


Figure 1. Location of Beach Sections 1-13 used to monitor sea turtle nesting activities within the Hobe Sound National Wildlife Refuge on Jupiter Island, Florida.

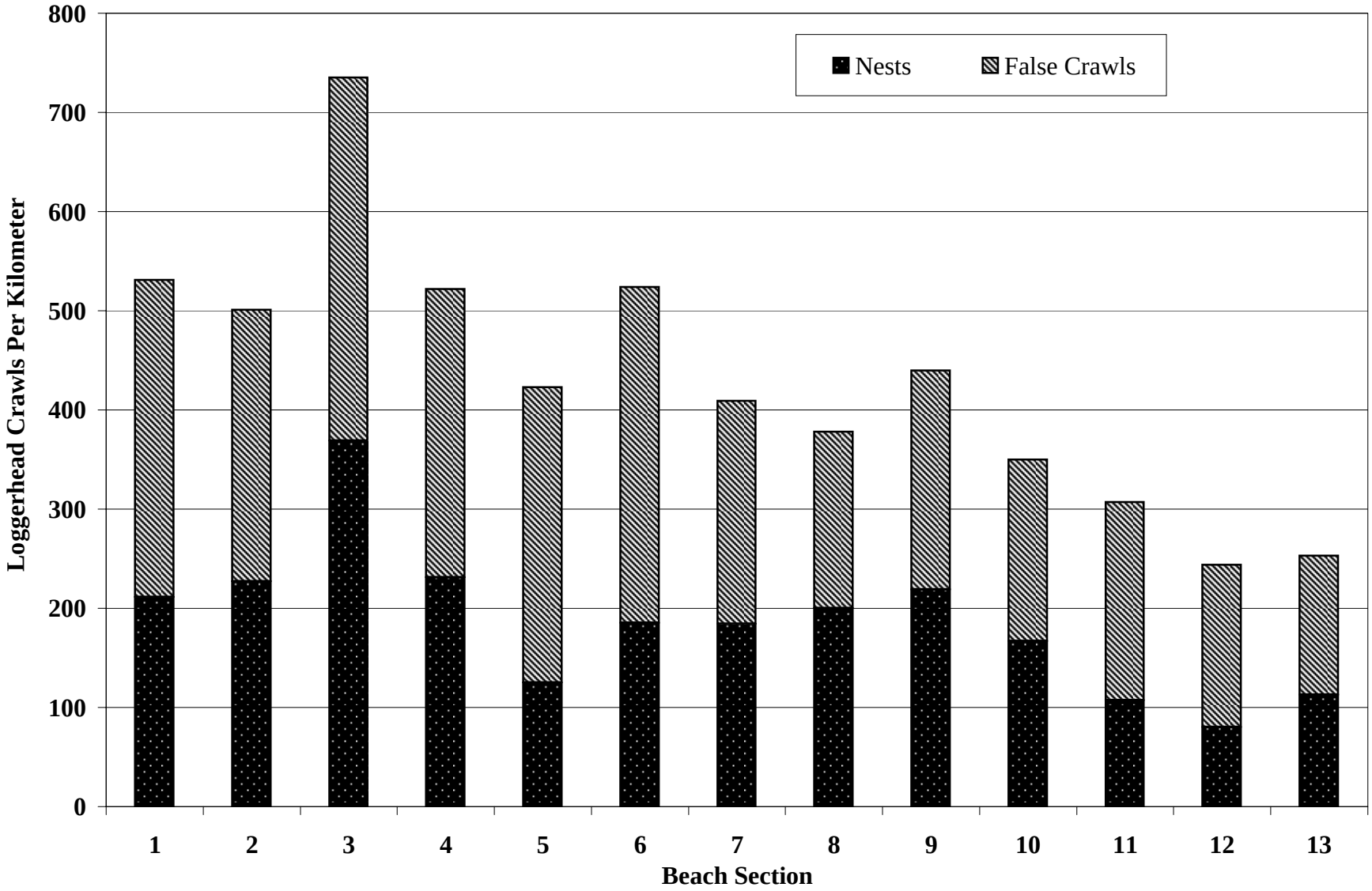


Figure 2. Loggerhead turtle *(Caretta caretta)* crawl activity per beach section, Hobe Sound National Wildlife Refuge, 2005. Note: Because all sections are not the same length (see Table 1), the numbers of nests and false crawls per section have been converted to numbers per kilometer so comparisons may be made among sections.

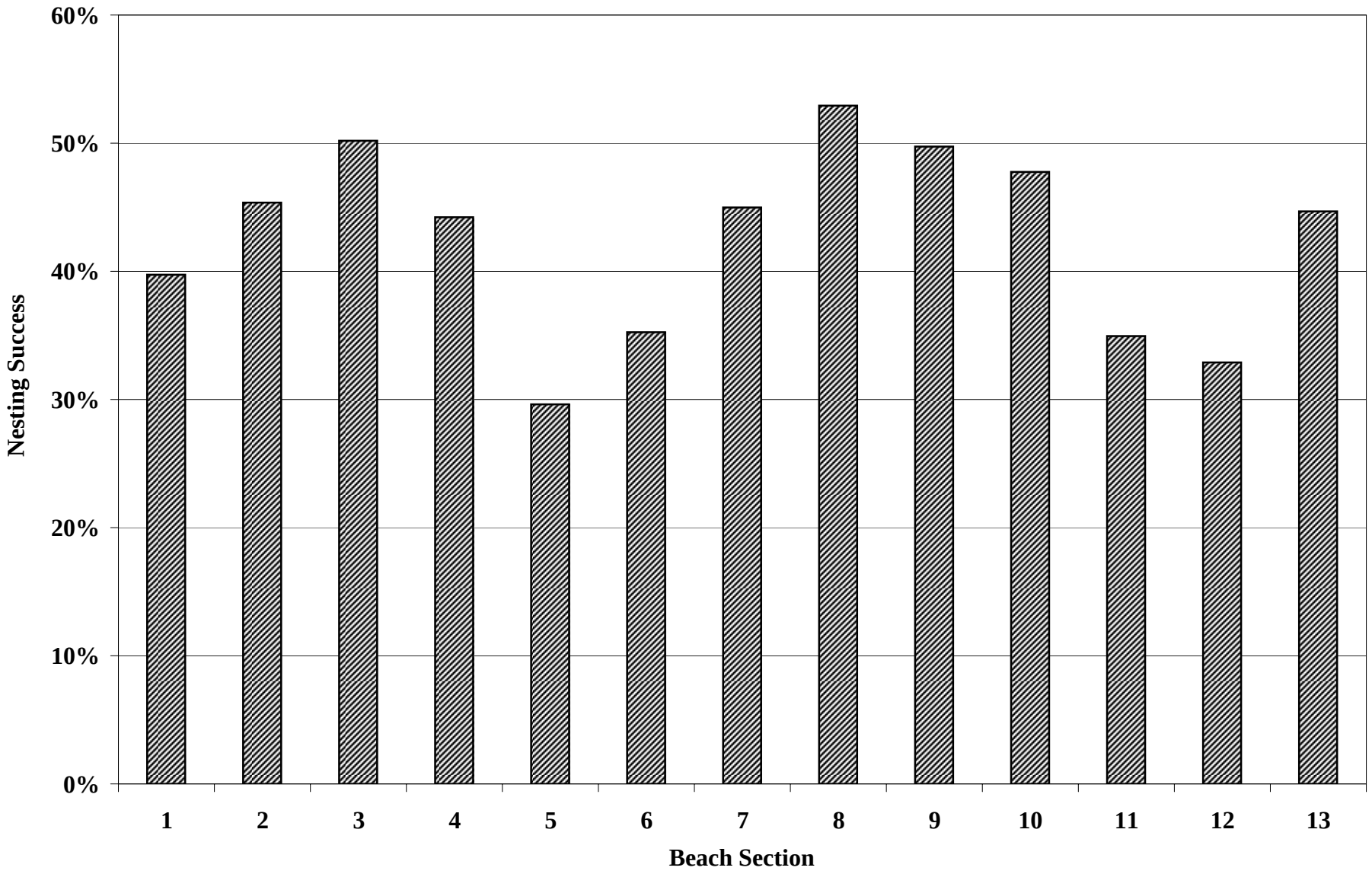
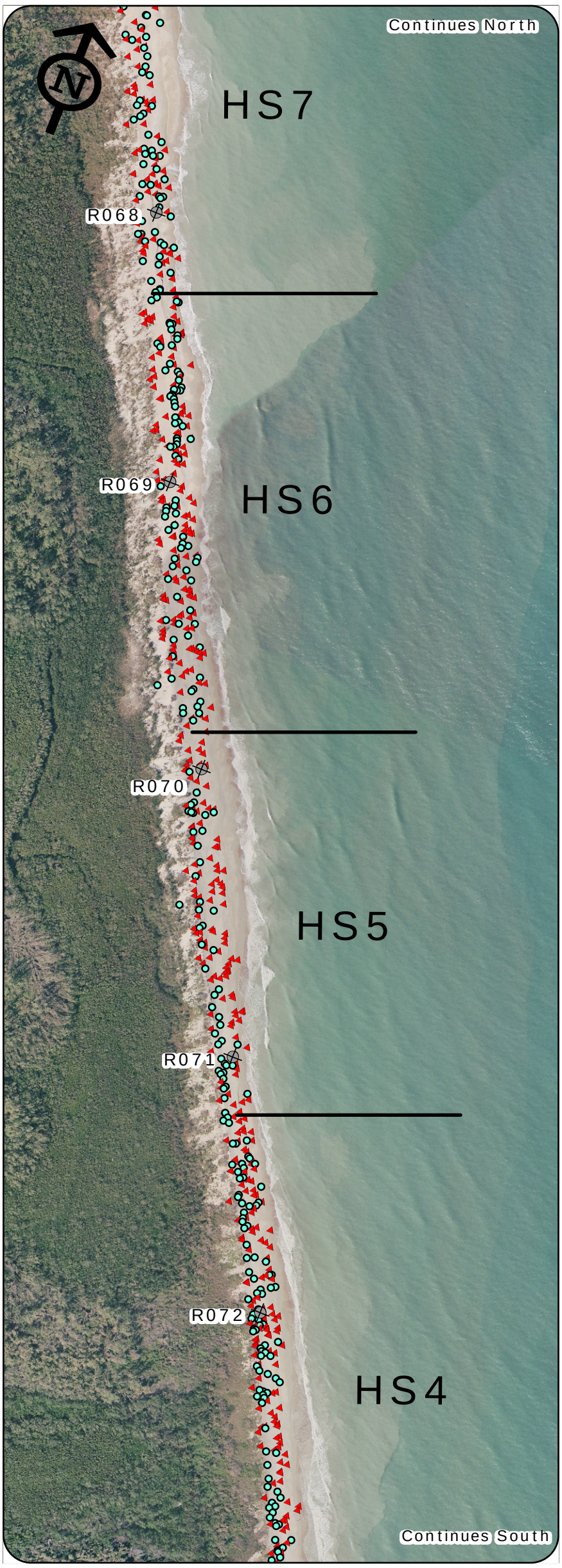
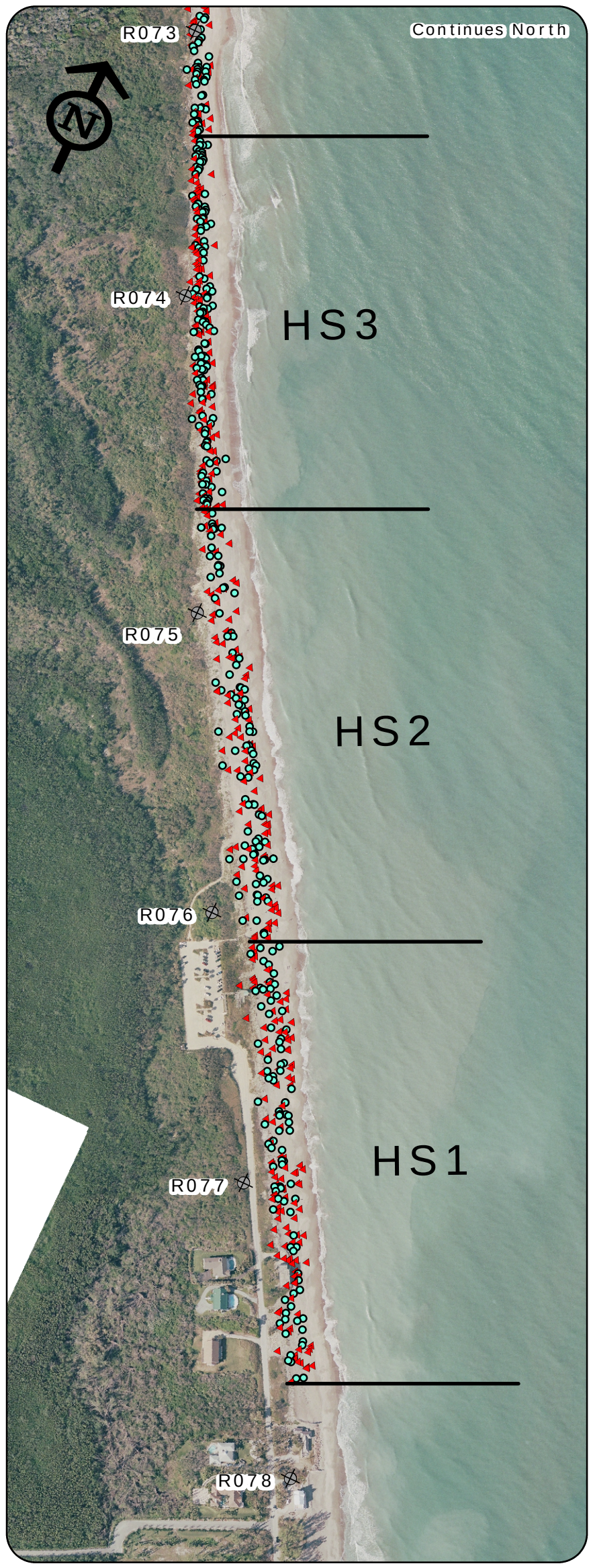


Figure 3. Loggerhead turtle *(Caretta caretta)* nesting success per beach section, Hobe Sound National Wildlife Refuge, 2005.





Legend

Loggerhead

Nest

False Crawl

FDEP Reference Monument

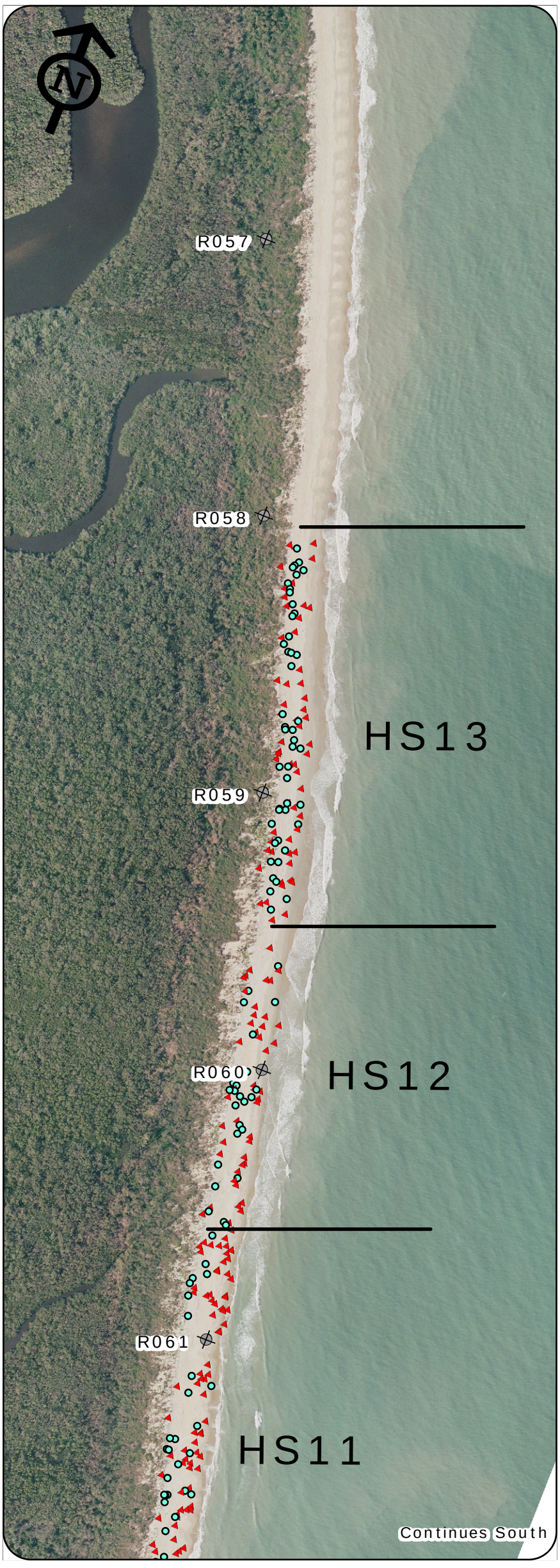
Note:

Reliable GPS Data Not Available for 6 loggerhead nests and 12 false crawls.

0 400 800 1,600 Feet

Figure 4A	Location of 2005 Loggerhead Sea Turtle Crawls	Photo: Martin County Information Technology Services, January 2005
	Hobe Sound National Wildlife Refuge Jupiter Island, Martin County, FL	Scale: 1" = 400'

EAI ECOLOGICAL ASSOCIATES, INC.



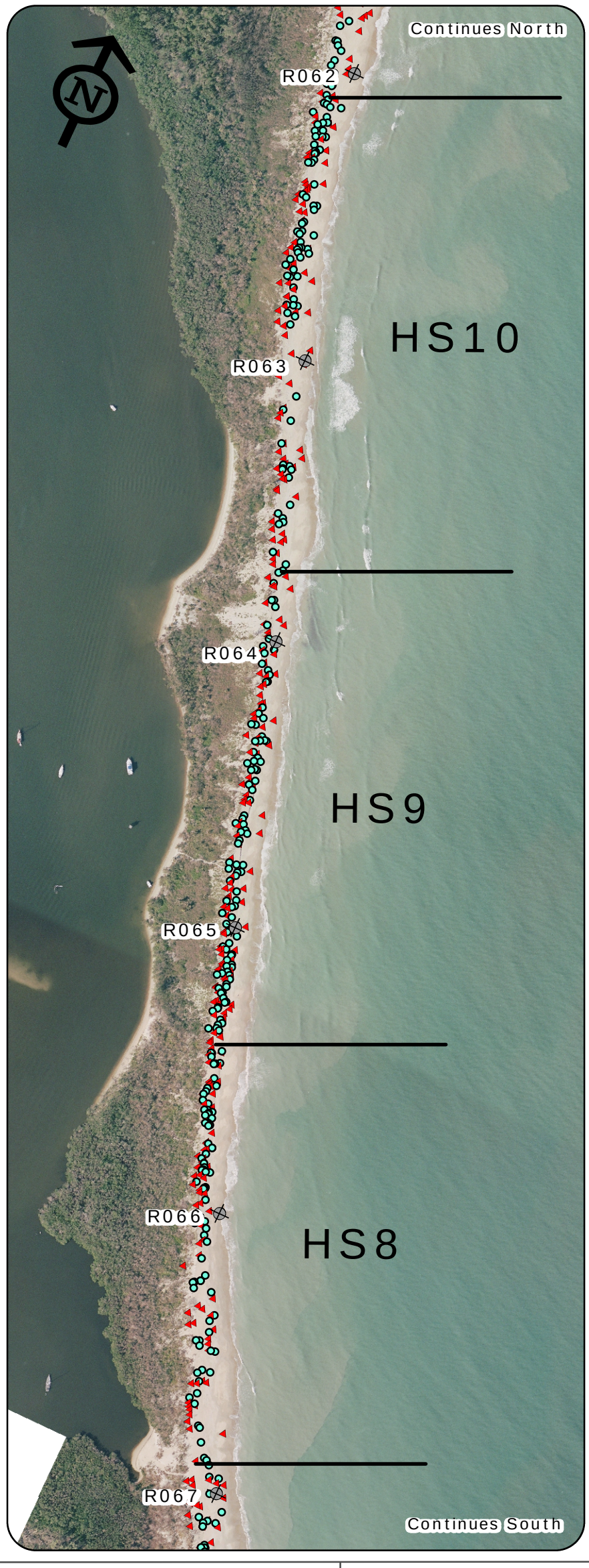
Legend

Loggerhead

Nest

False Crawl

FDEP Reference Monument

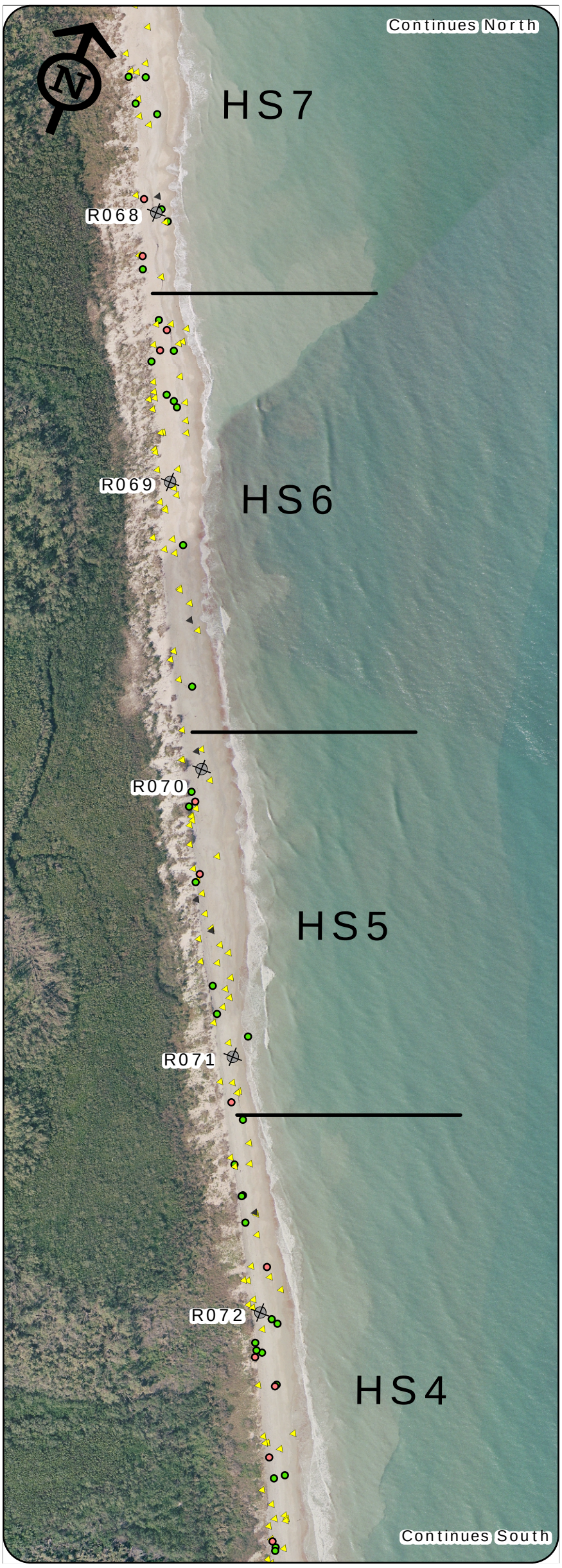


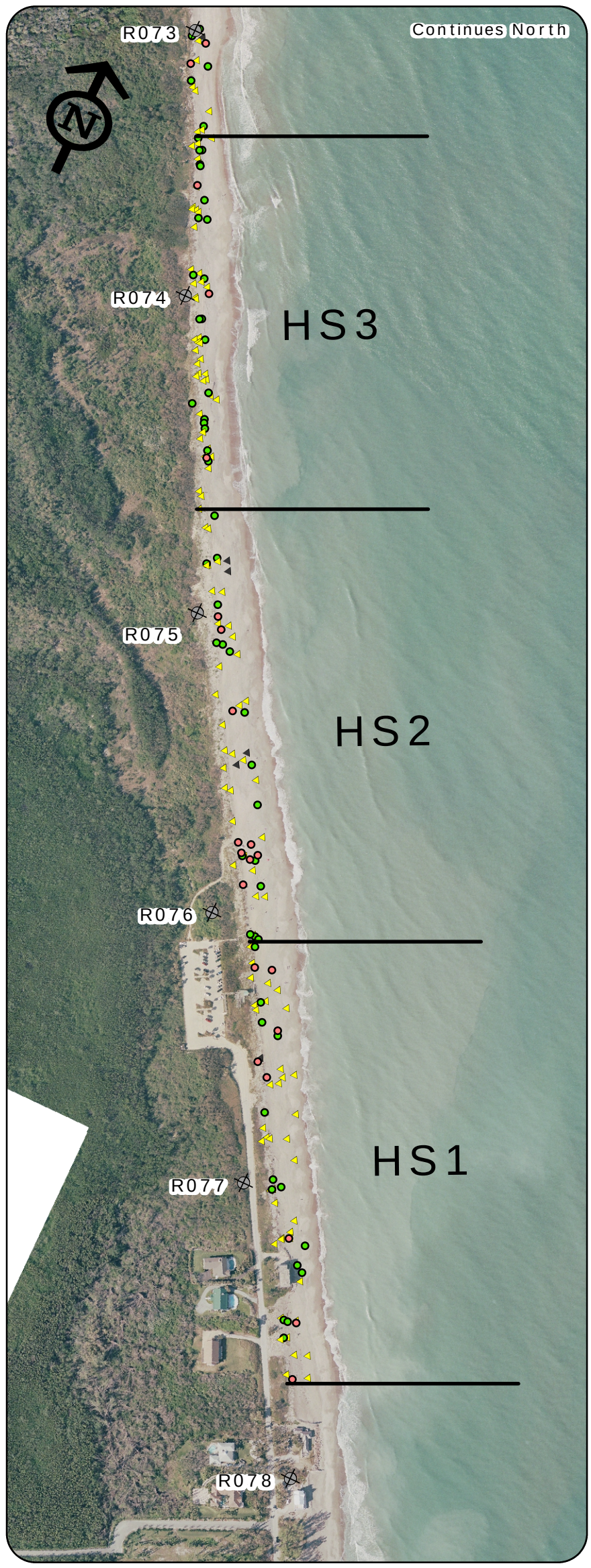
Note:

Reliable GPS Data Not Available for 6 loggerhead nests and 12 false crawls.

0 400 800 1,600 Feet

Figure 4B	Location of 2005 Loggerhead Sea Turtle Crawls	Photo: Martin County Information Technology Services, January 2005	EAI ECOLOGICAL ASSOCIATES, INC.
	Hobe Sound National Wildlife Refuge Jupiter Island, Martin County, FL	Scale: 1" = 400'	





Legend

FDEP Reference Monument

Green Turtle

Nest

False Crawl

Leatherback

Nest

False Crawl

Note:

Reliable GPS Data Not Available for:
1 green turtle nest
1 green turtle false crawl
2 leatherback nests
1 leatherback false crawl

0 400 800 1,600 Feet

Figure 5A	Location of 2005 Green, Leatherback, and Kemp's Ridley Sea Turtle Crawls	Photo: Martin County Information Technology Services, January 2005
	Hobe Sound National Wildlife Refuge Jupiter Island, Martin County, FL	Scale: 1" = 400'

EAI ECOLOGICAL ASSOCIATES, INC.

Legend

FDEP Reference Monument

Green Turtle

Nest

False Crawl

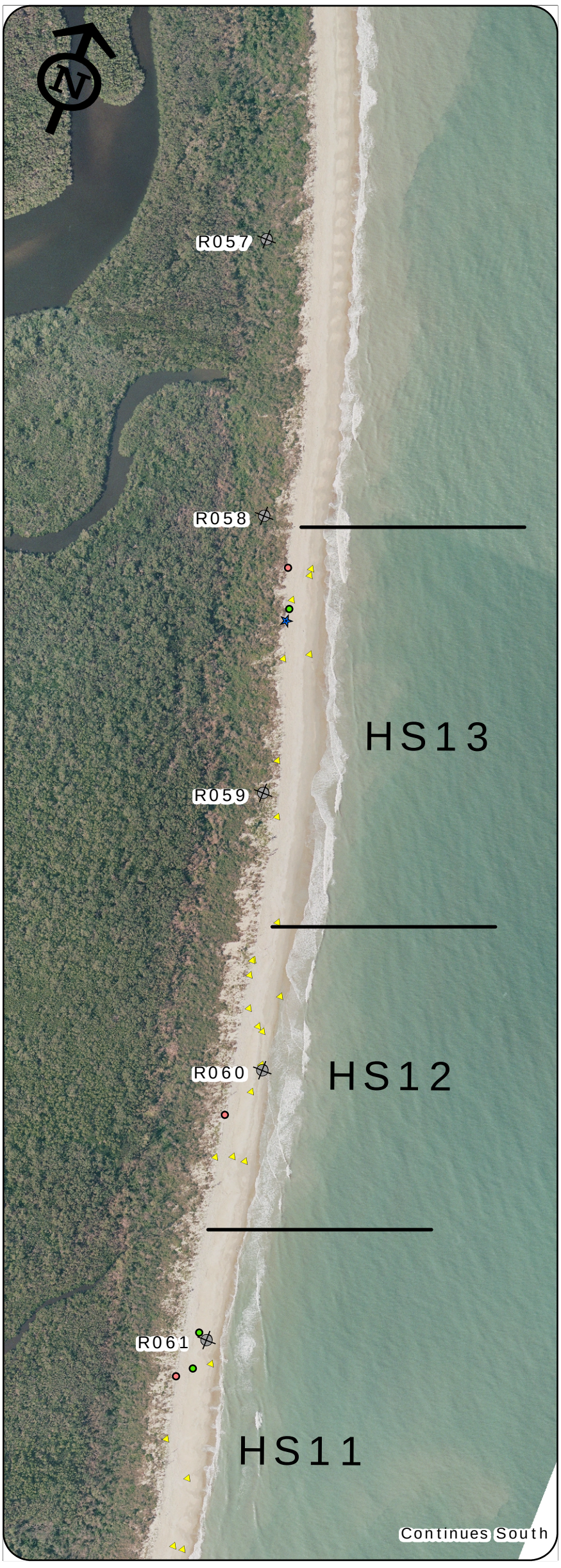
Leatherback

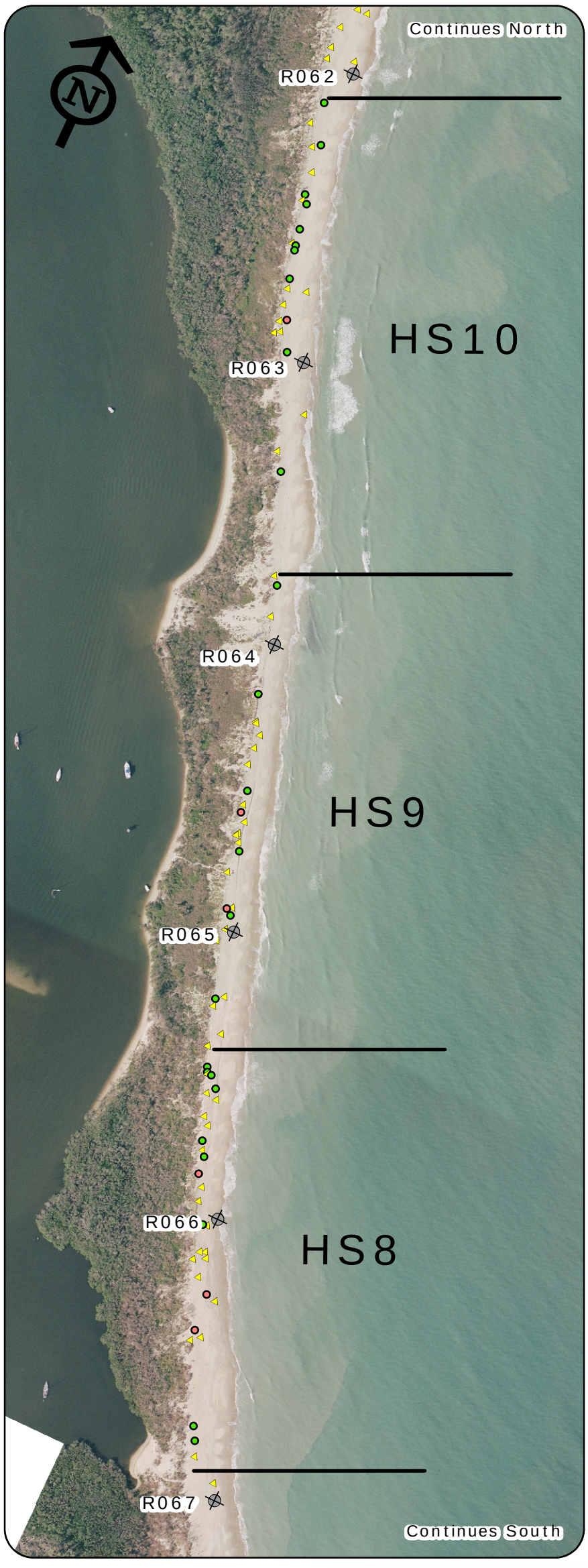
Nest

False Crawl

Kemp's ridley

False Crawl





Note:

Reliable GPS Data Not Available for:
1 green turtle nest
1 green turtle false crawl
2 leatherback nests
1 leatherback false crawl

0 400 800 1,600 Feet

Figure 5B	Location of 2005 Green, Leatherback, and Kemp's Ridley Sea Turtle Crawls	Photo: Martin County Information Technology Services, January 2005
	Hobe Sound National Wildlife Refuge Jupiter Island, Martin County, FL	Scale: 1" = 400'

EAI ECOLOGICAL ASSOCIATES, INC.

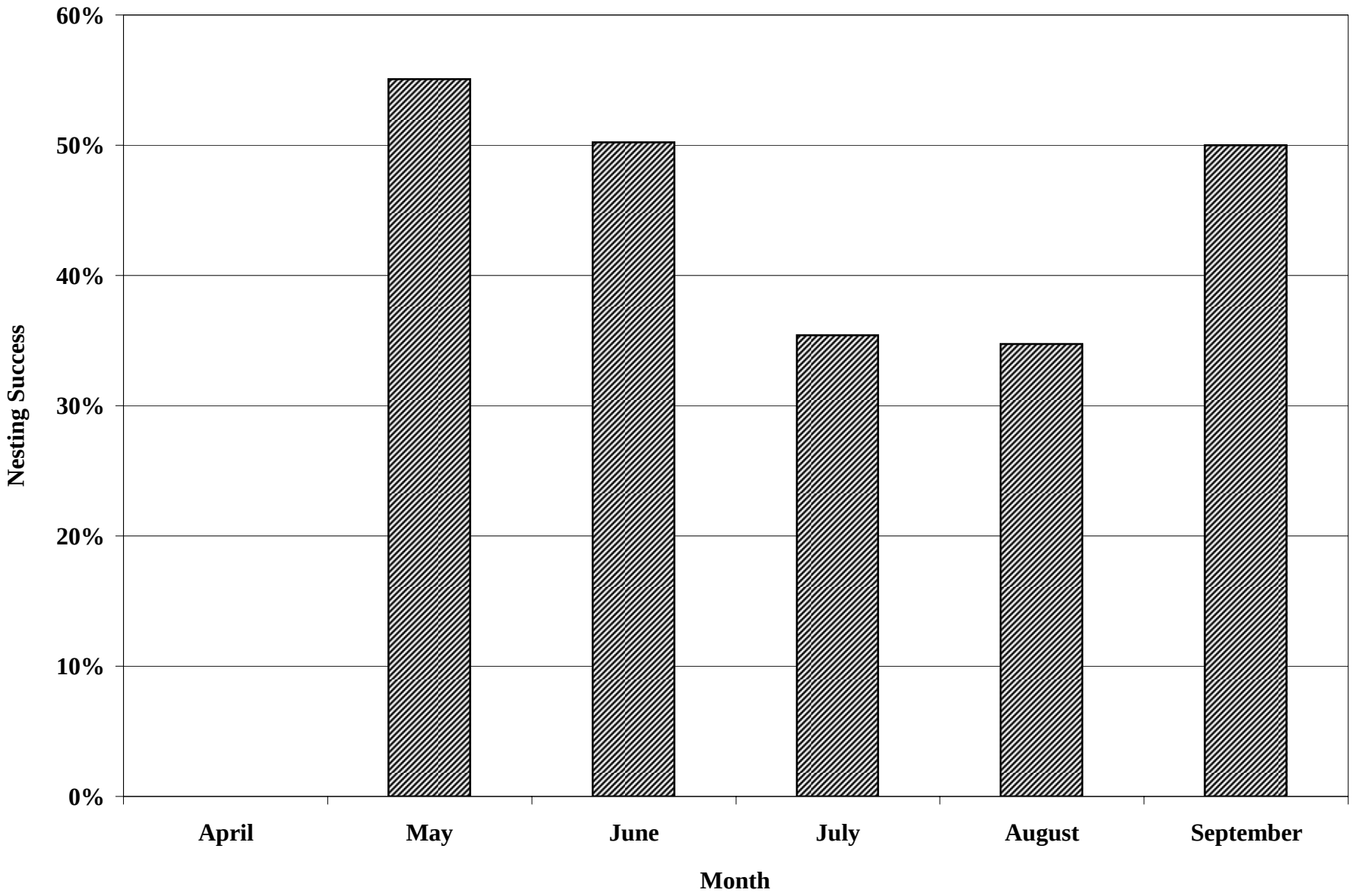


Figure 6. Monthly distribution of loggerhead turtle *(Caretta caretta)* nesting success, Hobe Sound National Wildlife Refuge, 2005

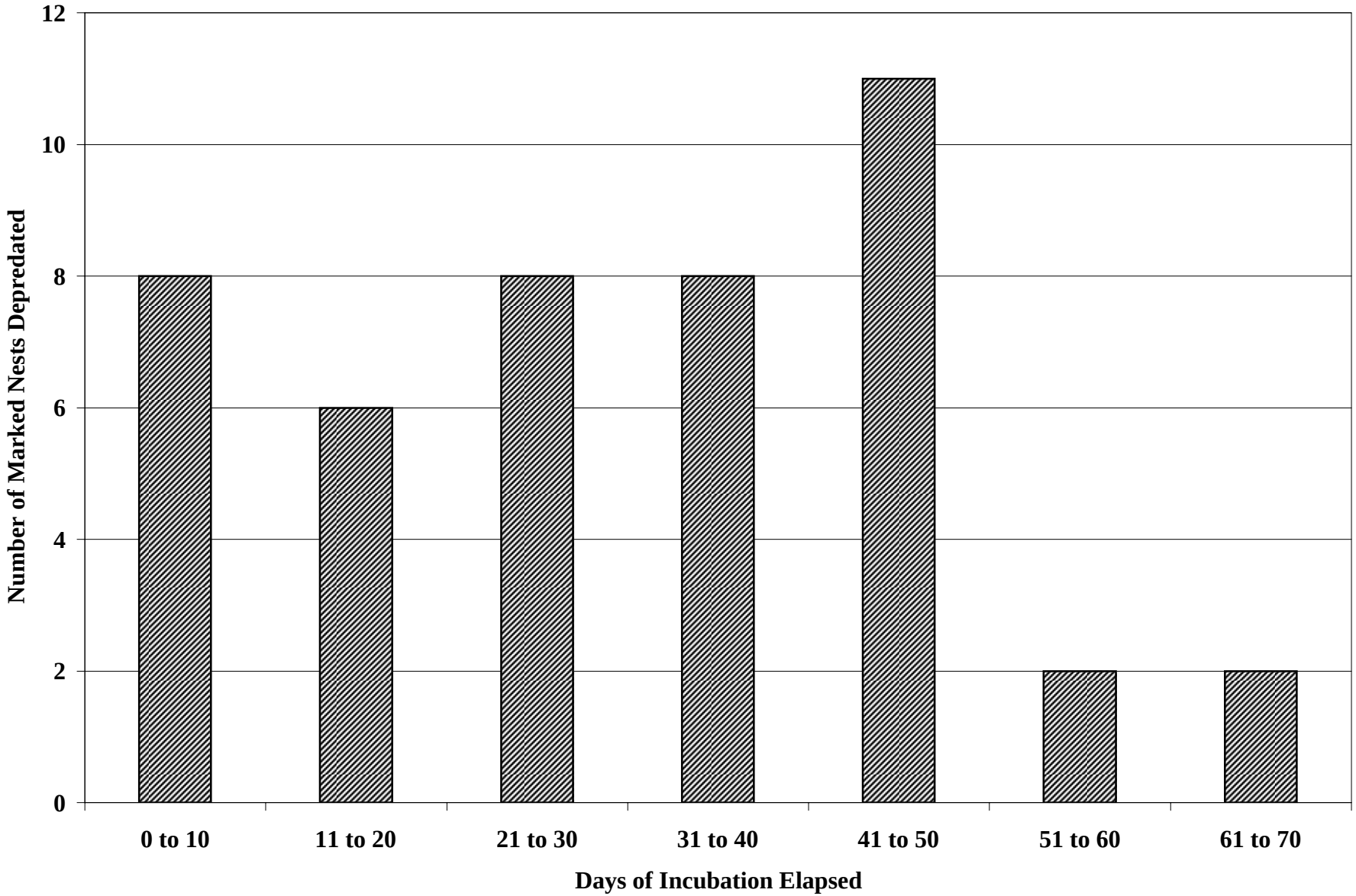


Figure 7. Period of incubation during which marked sea turtle nests were depredated (N=45), Hobe Sound National Wildlife Refuge, 2005.

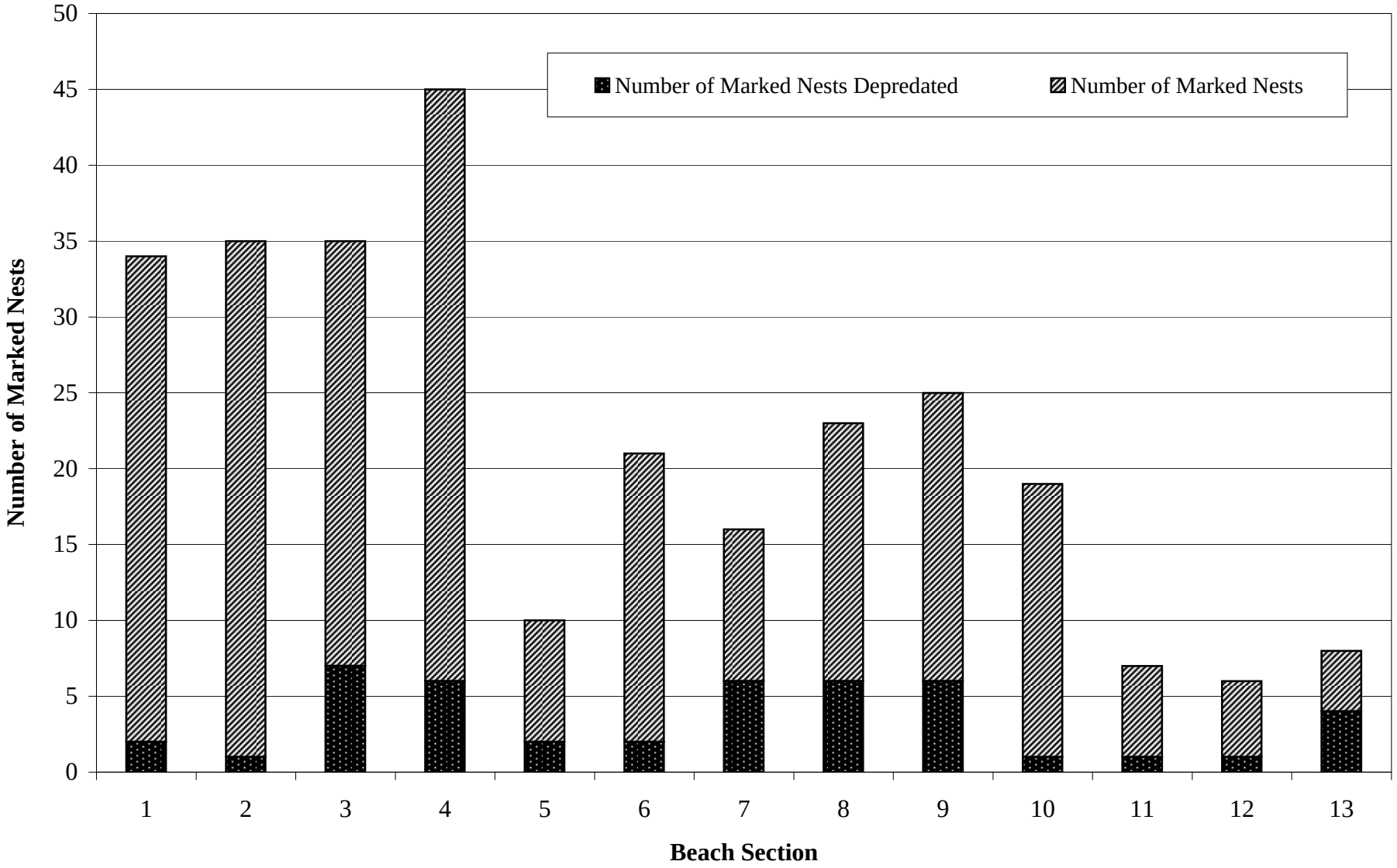


Figure 8. Number of marked sea turtle nests depredated per beach section, Hobe Sound National Wildlife Refuge, 2005.

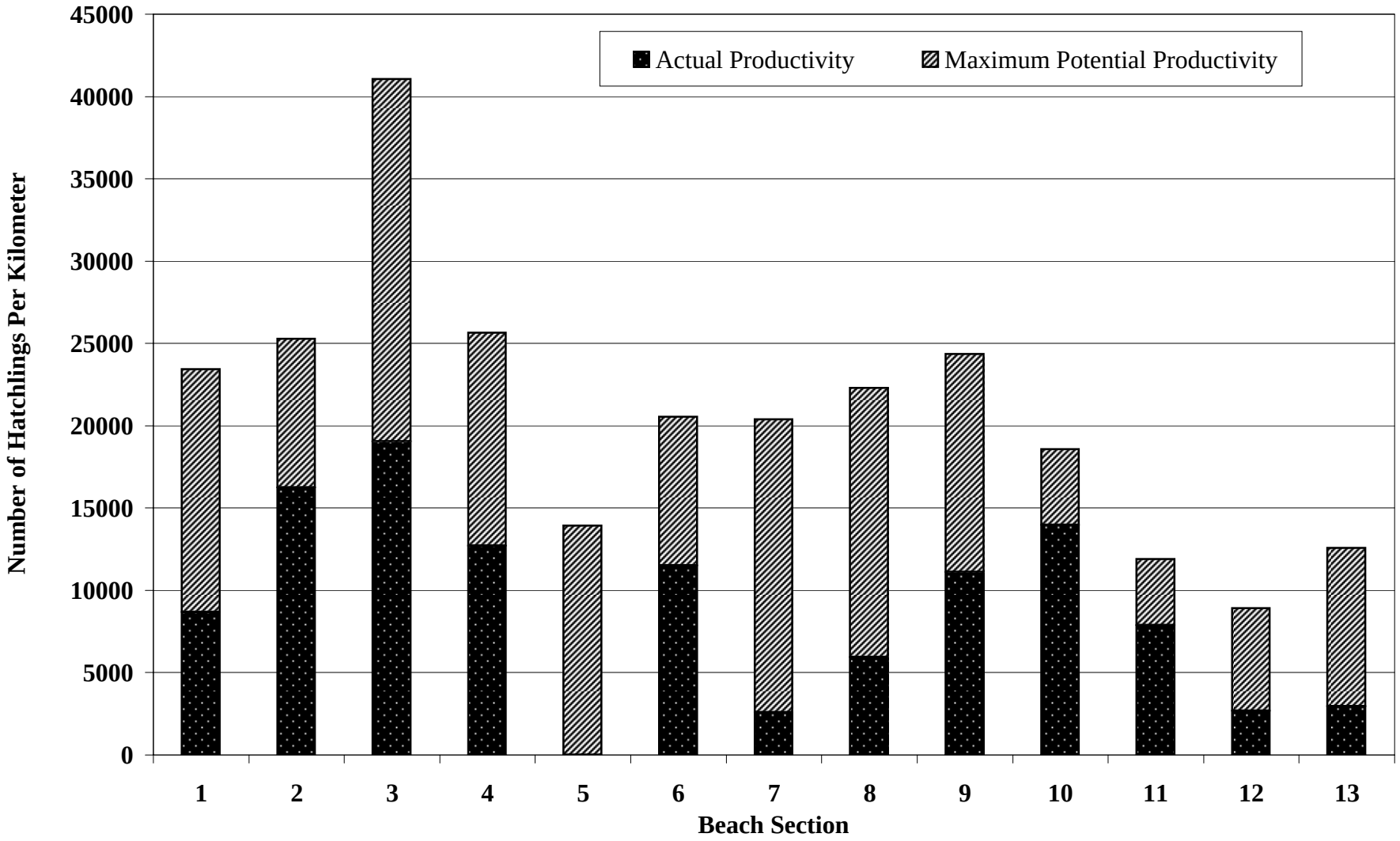


Figure 9. Loggerhead turtle *(Caretta caretta)* hatchling productivity estimates per beach section, Hobe Sound National Wildlife Refuge, 2005. Note: Because all sections are not the same length (see Table 1), the numbers of hatchlings per section have been converted to numbers per kilometer so comparisons may be made among sections.

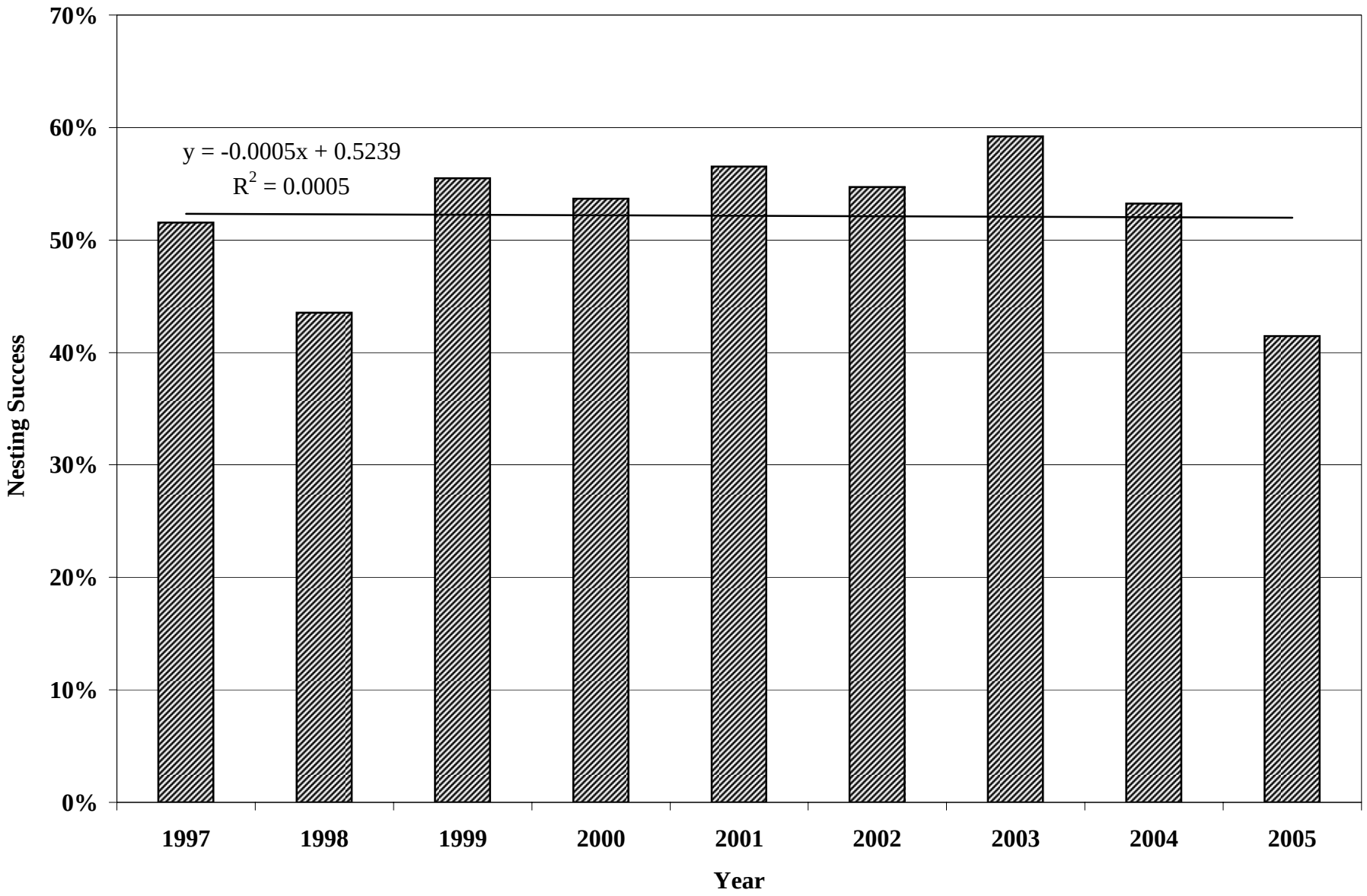


Figure 10. Annual nesting success (all species combined), Hobe Sound National Wildlife Refuge, 1997-2005.

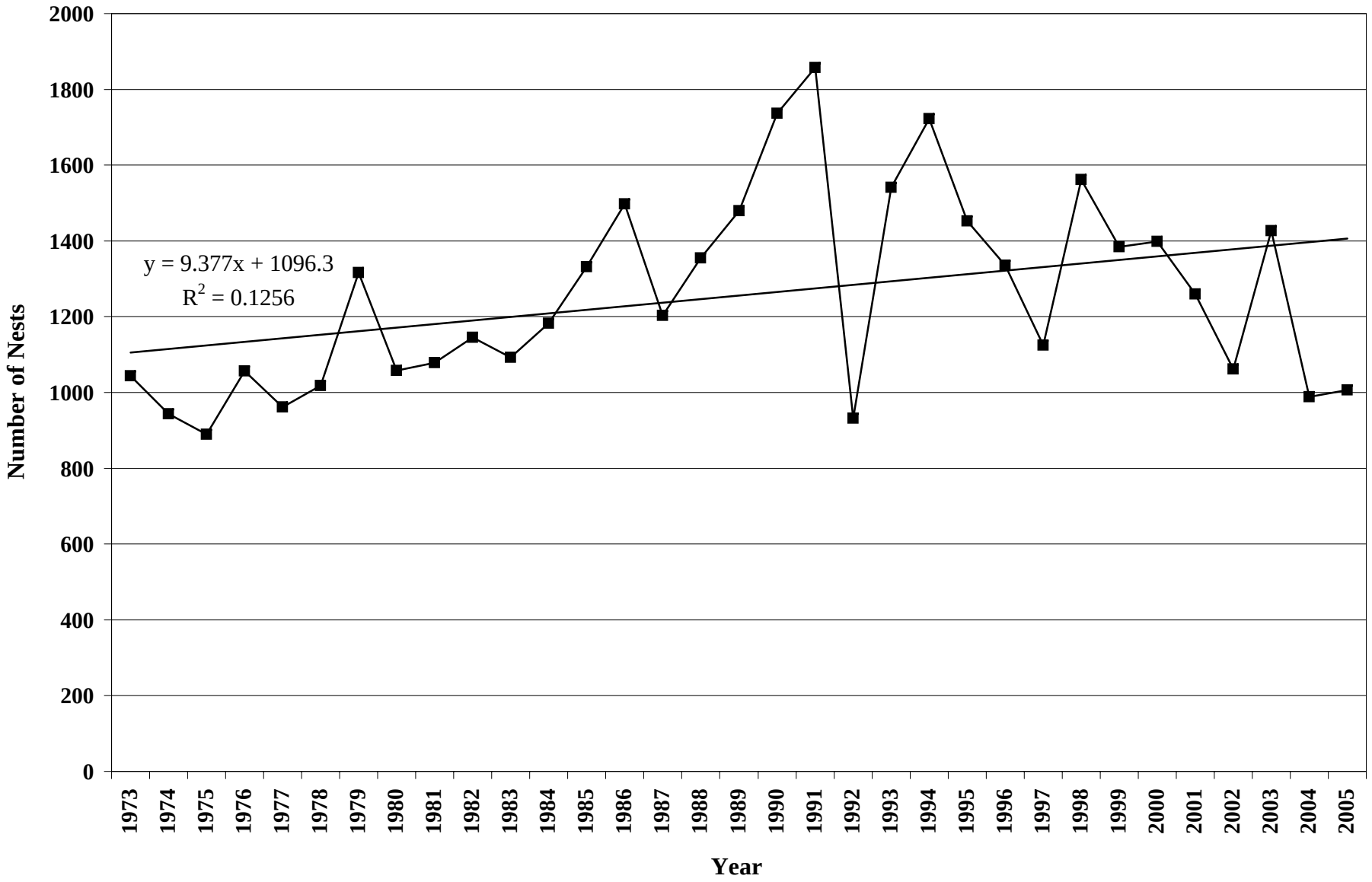


Figure 11. Annual number of loggerhead turtle (*Caretta caretta*) nests, Hobe Sound National Wildlife Refuge, 1973-2005.

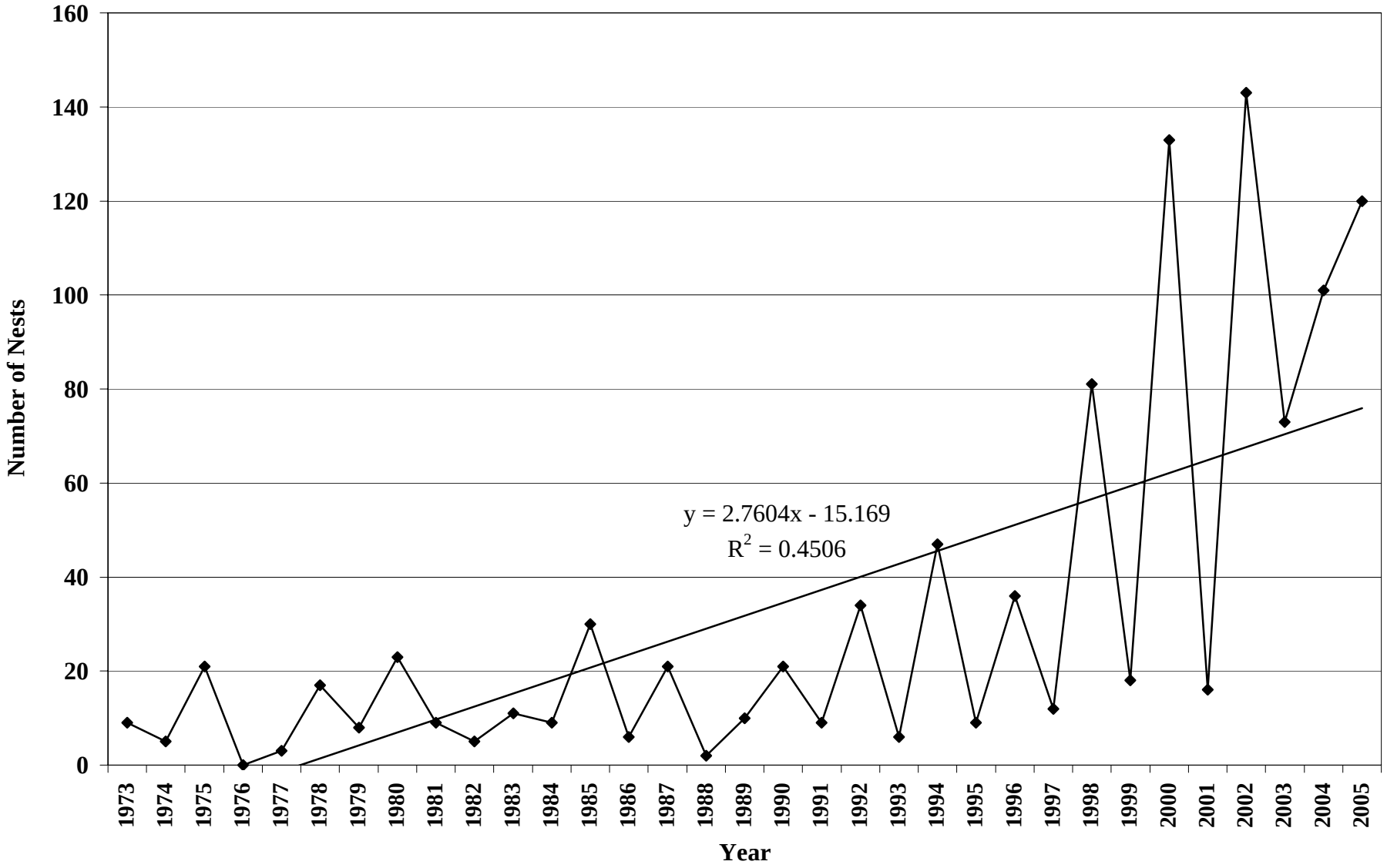


Figure 12. Annual number of green turtle (*Chelonia mydas*) nests, Hobe Sound National Wildlife Refuge, 1973-2005.

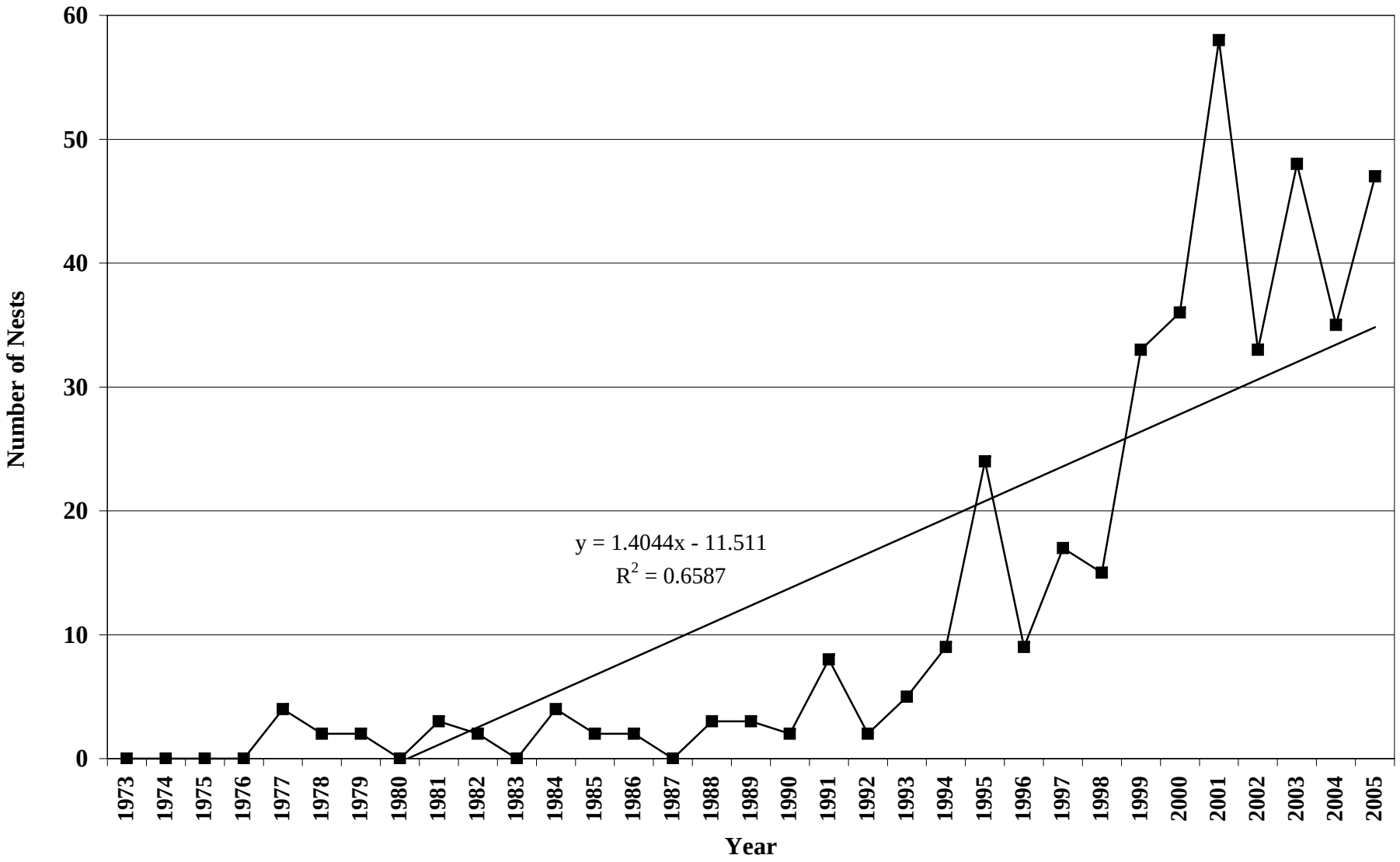


Figure 13. Annual number of leatherback turtle (*Dermochelys coriacea*) nests, Hobe Sound National Wildlife Refuge, 1973-2005.

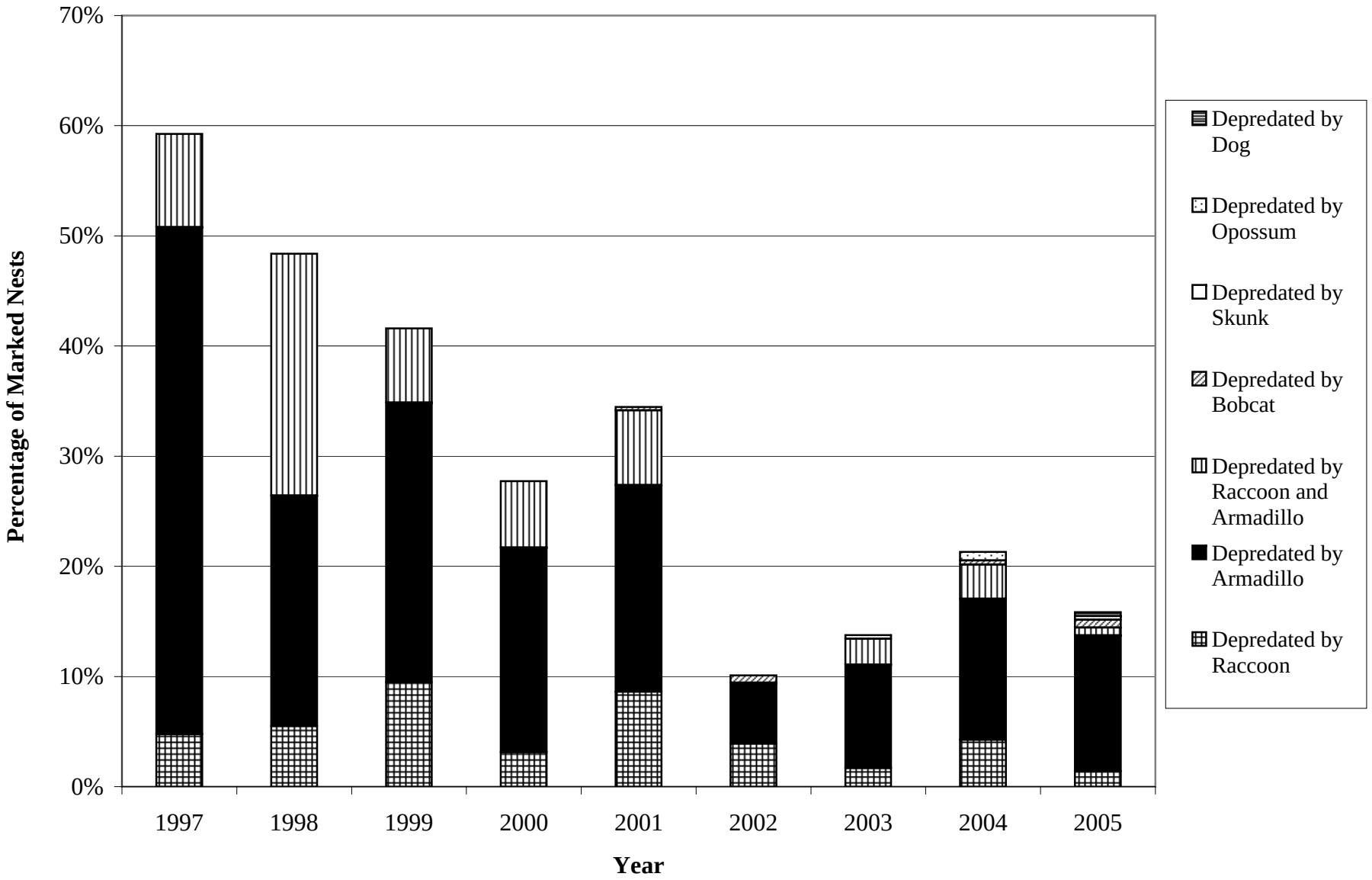


Figure 14. Percentage of marked sea turtle nests depredated by each species of predator annually, Hobe Sound National Wildlife Refuge, 1997-2005.

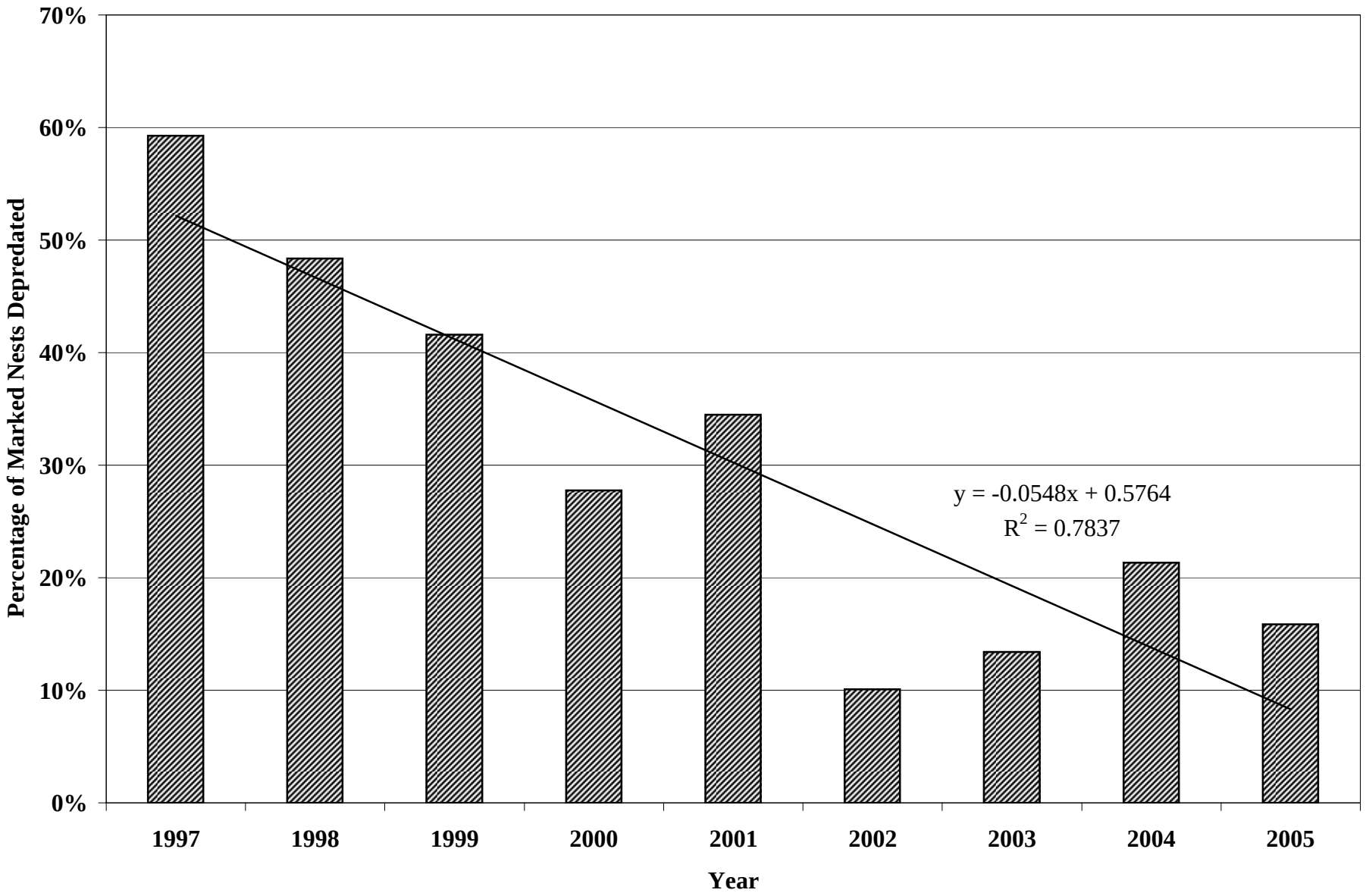


Figure 15. Percentage of marked sea turtle nests depredated annually, Hobe Sound National Wildlife Refuge, 1997-2005.

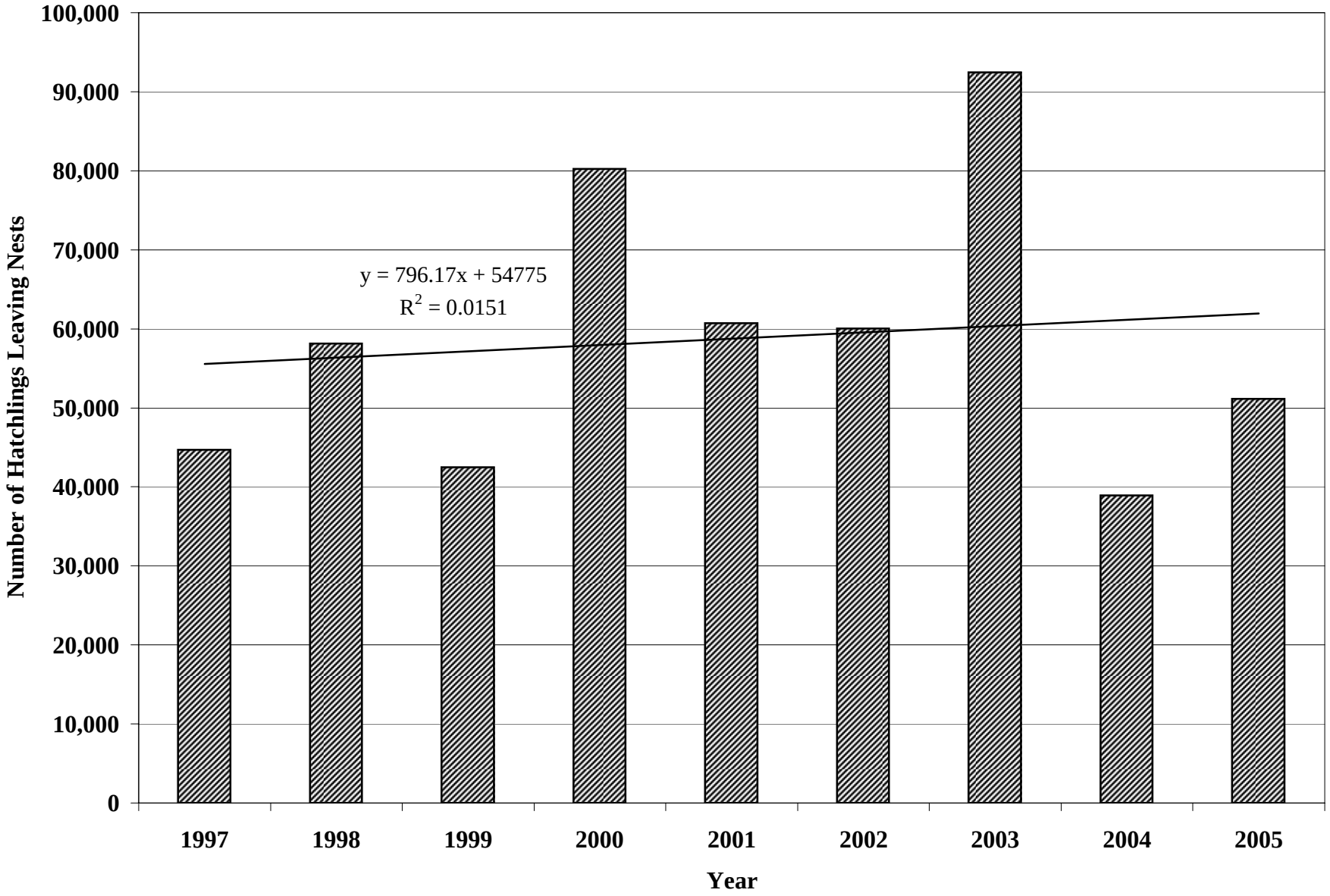


Figure 16. Annual loggerhead turtle (*Caretta caretta*) hatchling productivity, Hobe Sound National Wildlife Refuge, 1997-2005.