SEA TURTLE NESTING ACTIVITY ALONG EGLIN AIR FORCE BASE ON CAPE SAN BLAS AND SANTA ROSA ISLAND, FLORIDA FROM 1994 TO 1997.

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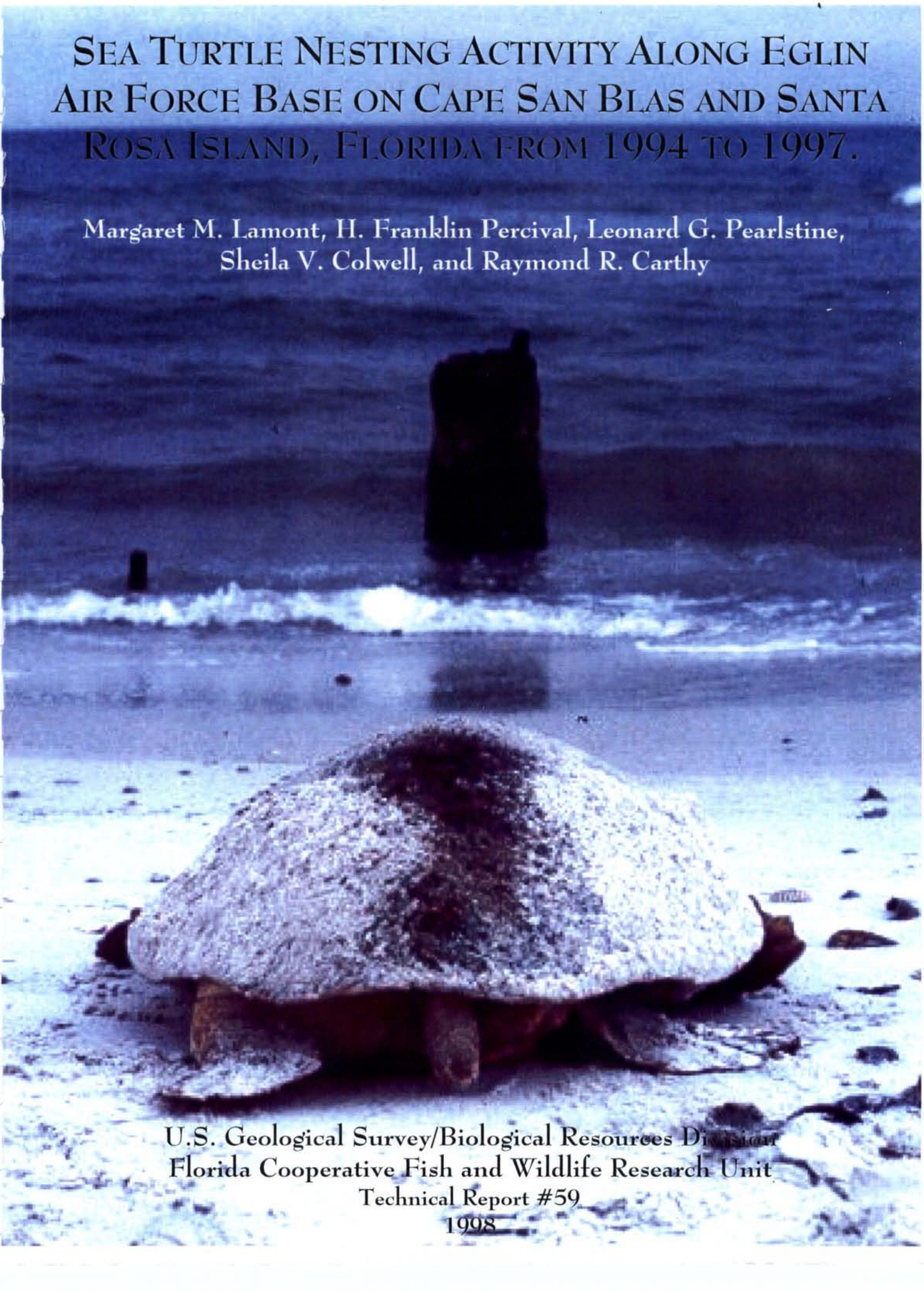

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Adult sea turtles are unevenly distributed throughout the tropical and subtropical seas (Miller 1997). Although foraging ranges are generally large and may extend beyond the tropics, nesting areas are more specific and are located almost exclusively within the tropical and subtropical region. The only exception to this is the loggerhead turtle (*Caretta caretta*) which nests primarily in warm temperate and subtropical areas (Miller 1997). Included in the nesting range of the loggerhead turtle is the northern Gulf of Mexico coast, including barrier islands along the Florida panhandle. In addition to loggerhead turtles, endangered Green turtles (*Chelonia mydas*) and Leatherback turtles (*Dermochelys coriacea*) have been documented along the northwest Florida coast, indicating this area may provide essential nesting habitat for threatened and endangered sea turtles.

The places and conditions under which sea turtles nest are similar among species (Miller 1997). Nesting females nest predominantly during the warmer months on beaches that are above high tide and have deep, loose sand (Miller 1997). In addition to similarities in nesting conditions, sea turtle species share behavioral characteristics. Hatchling sea turtles move from their natal beaches into the open ocean, often taking refuge in gyres (Lohmann and Lohmann 1996). The juveniles and sub-adults reside in coastal feeding areas located hundreds or thousands of miles away from the beaches where they were hatched. After becoming sexually mature, adult turtles migrate from their foraging areas to breed at mating areas close to their nesting region. At the end of the mating period, males return to their foraging grounds and females move to their nesting sites (Lohmann and Lohmann 1996). This pattern defines three important areas for sea turtle survival: foraging grounds, mating areas, and nesting beaches. Within each stage, sea turtles are challenged by natural and human induced disturbances. Because foraging and mating occur at sea and nesting occurs along beaches, the stage often greatly influenced by human disturbance is the nesting period.

Sea turtles must survive a variety of challenges throughout each stage of their life. Nesting female sea turtles are threatened by human activity such as poaching and habitat destruction, and natural disturbances including tropical storms and beach erosion. Turtle fishing and importation continued in the United States until 1975 when the U.S. signed the CITES (Convention on International Trade in Endangered Species of Wild Flora and Fauna) which banned trade in sea turtle products (Johnson and Barber 1990). In addition, several native peoples throughout the world gather sea turtle eggs for subsistence or cultural beliefs. Hunting and egg-poaching continue to present a significant threat to sea turtle populations throughout the world.

Humans also influence nesting sea turtles through destruction of habitat. Beaches are valuable property for human development. Construction, maintenance, and human use along these areas may disturb sea turtle nesting in a variety of ways. Building on the beach directly destroys nesting habitat. In addition, the human presence introduced by the new development increases potential disturbances to nesting females and allows for greater human use of the sensitive beach habitat. Increased human use also raises the economic potential of the beach, which often results in strong political pressure to restore and maintain beaches (Ackerman 1997). Beaches are typically restored through beach renourishment which involves locating a suitable source of sand offshore, pumping the sand onto the beach, and mechanically shaping the beach platform (Ackerman 1997). This is often a short-term repair to the beach and may greatly influence nesting sea turtles by altering the substrate into which they build their nest and deposit their eggs. In addition, additional human use increases activities such as beach driving and beach cleaning which may directly destroy nests and alter the nesting habitat.

Sea turtles must also endure natural disturbances. Peak tropical storm activity in the southeastern United States, June through November, coincides with sea turtle nesting. Tropical storms often cause severe beach erosion, flooding, and abnormally high water tables. Sea turtle nests may be washed away or inundated, thus destroying the clutch. Consistent beach erosion in some locations also greatly influences nesting sea turtles. Recent projections based on estimates of climate warming indicated the ocean level may rise about one foot by 2100, therefore submerging many beaches (Ackerman 1997). Increased global warming may allow this change in sea level to occur very rapidly which may accelerate beach erosion (Ackerman 1997). This may be especially severe along dynamic coasts, such as barrier islands.

There is an extensive chain of barrier islands along the Atlantic and Gulf of Mexico coasts in the southeastern United States. The Gulf of Mexico coast is more dynamic and unstable because it experiences smaller tidal ranges and has a lower wave energy regime (Johnson and Barbour 1990). One of the greatest erosional rates in Florida occurs on Cape San Blas, a barrier island located along the northern Gulf of Mexico coast (Fig. 1; Johnson and Barbour 1990). The dynamics of this barrier island present a severe threat to the loggerhead sea turtles that nest along this beach. In addition to severe erosion, sea turtles nesting along Cape San Blas must also cope with the vehicular traffic that is permitted along these beaches and with predators such as raccoons and coyotes that are present along Cape San Blas. The dynamics of this barrier island present unique challenges to the sea turtles nesting on Cape San Blas.

Along EAFB on Cape San Blas, the only sea turtle species nest observed has been the loggerhead turtle. The first green turtle nest documented along the Florida panhandle coast was observed on EAFB property, however (D. Atencio, EAFB, pers. comm). Santa Rosa Island, located approximately 150 miles west of Cape San Blas supports a small but consistent, group of nesting green turtles (Fig. 2). Although erosion is not as severe along Santa Rosa Island as it is on Cape San Blas, and vehicular traffic is not permitted, sea turtles nesting on this barrier island must survive severe tropical storms, predation, and artificial lighting to be successful. Because this area supports a rare group of nesting green turtles and is disturbed by intense artificial lighting from Air Force missions and adjacent resort towns, continued monitoring is necessary. The sea turtle species that nest along this barrier island, and the human activities that disturb those sea turtles present unique circumstances for management of this area. Protection of the significant nesting populations of sea turtles on EAFB properties on Cape San Blas and Santa Rosa Island requires yearly monitoring of the nesting activity and the natural and human disturbances influencing the nesting females.

The objectives of this study were to monitor sea turtle nesting along EAFB on Cape San Blas to determine number of nests and hatching success, assess disturbances, and determine proper management to ensure successful nesting and hatching.

Methods

From 1994 to 1997, the beaches along EAFB on Cape San Blas and Santa Rosa Island, Florida were monitored for nesting sea turtles. Every morning from May 15 through October 1, personnel traveled the beach on foot or all-terrain vehicle. When sea turtle tracks were observed, data were collected on the crawl and personnel determined whether it was a nesting or non-nesting (false) crawl. If it was determined to be a nesting crawl, the nest was located and different protocol were followed according to geographic location. At both locations, data collected included width and length of crawl, height of crawl above mean high water, height of dunes at mean high water, distance mean high water to dunes, time crawl/nest was located, whether it was a nesting or false crawl, whether the nest was relocated or left *in situ*, and number of eggs in the clutch (if available). Each nest was marked with a number corresponding to when it was located and the date on which it was located.

Cape San Blas

On Cape San Blas, because of severe erosion and inundation nests often required relocated, and due to severe predation, nests were typically screened. Eggs were always located in nests along Cape San Blas because screens had to be placed over the clutch or eggs required relocation. Nests left *in situ* were screened with a three foot by three foot square piece of two inch by four inch screening placed over the clutch. Screens were held in place by wooden stakes pounded into each corner of the screen. Neon orange flagging was placed around the stakes to mark the nest, and a sign identifying it as a sea turtle nest and explaining disciplinary actions taken for disturbing it was nailed to one of the wooden stakes. During relocation, eggs were found, removed individually from the nest and placed in a black bucket. Relatively moist sand from the original nest site was placed in the bottom of the bucket. Special care was taken to maintain the original orientation of each egg during relocation. After all eggs were placed in the bucket they were transported to a more stable location. At the relocation site, the surface sand was scraped away. A post-hole digger was used to dig an egg-chamber similar in size and shape to the original egg-chamber. Eggs were placed into the artificial egg-chamber in the same order they were laid (eggs laid in the bottom of the original clutch were placed in the bottom of the artificial nest, those on top remained on top, etc.). The artificial chamber was filled in with sand, screened, staked, and flagged.

The beach along EAFB was separated into three areas; east, cape, and north. Mile markers were placed in front of the dune line every 0.1 miles along the entire beach. The area between mile marker 0.0 to 0.99 was designated east beach, 1.0 to 1.99 was the cape beach, and 2.0 to 2.99 was called north beach (Fig. 1).

Santa Rosa Island

On Santa Rosa Island, nests were rarely relocated because erosion and inundation were not as severe as along Cape San Blas. Nests were identified, however, eggs in the clutch were not located unless relocation or screening were required. Nests were only screened after predation attempts occurred during incubation. Most nests were left *in situ*, with wooden stakes and flagging placed around the entire body pit. A sea turtle sign was also placed on each nest.

Results

Cape San Blas

1994

One-hundred and thirty loggerhead turtle crawls were located along EAFB property on Cape San Blas in 1994 (Table 1a). Of those, 77 were false crawls and 53 were nesting crawls (Fig. 3). Most false crawls were located on north beach (40; 51.9%), the second greatest (31; 40.3%) on cape beach, and the fewest (6; 7.79%) on east beach. The earliest crawl was observed on May 19 and the latest on August 12, with the earliest being a false crawl and the latest a nesting crawl. Most false crawls were observed in July (30; 39.0%), the second greatest number were located in June (29; 37.7%), and the fewest in August (18; 23.4%). No false crawls were observed in May.

Nests

The earliest of the 53 loggerhead nests located on Cape San Blas in 1994 was observed on May 19 and the latest on August 12 (Table 2). Most nests (54.7%) were laid in July, the second greatest number (24.5%) were located in June, third greatest (7.55%) in August, and the fewest (3.77%) in May. The greatest number of nests were laid on the cape beach (23;43.4%), second greatest on east beach (18; 34%), and the fewest on north beach (12; 22.6%). Of all nests laid, nineteen (35.8%) were relocated, and 34 (64.2%) remained *in situ* (Table 4a). Thirty-three (62.3%) nests were destroyed by erosion, and four (7.55%) were partially or completely depredated (Table 5a). Of all eggs laid, 313 were lost to predators and 835 were destroyed by erosion. Primary predators were raccoons (*Procyon loctor*) and ghost crabs (*Ocyopode quadrata*).

Of all nests, clutch size of 23 (43.4%) nests was known. The average clutch size for those 23 nests was 102.7 eggs, with the largest clutch containing 168 eggs and the smallest numbering 40 eggs. The total number of eggs in those nests of known clutch size was 2,361.

Hatching Success

Average hatching success for all 53 nests was 5.73% (Fig. 4). Of all nests laid, 10 (18.9%) hatched at least one egg and of those, average incubation length was 64.7 days. The longest incubation period was 75 days and the shortest was 54 days. Of all eggs laid, 356 hatched and hatchlings emerged, 186 showed no development, 212 were addled, 338 experienced arrested development, and 126 hatched but hatchlings were dead in the nest.

In situ versus relocated

Average hatching success for all nests left *in situ* was (7.12%) and for all relocated nests was (3.23%). Of the 34 nests left *in situ*, 7 (20.6%) produced at least one hatchling, whereas three (15.8%) of the 19 relocated nests had at least one hatchling emerge. Of those nests that produced at least one hatchling, average incubation length for *in situ* nests was 64.1 days and for relocated nests was 66 days. From the 522 eggs located in the five *in situ* nests of known clutch size, 268 (51.3%) hatchlings emerged, whereas 84 (4.68%) hatchlings emerged from the 1,839 relocated eggs located in the 18 nests of known clutch size. Average number of eggs in the five *in situ* nests of known clutch size was 104.4, whereas for the 18 relocated nests, average clutch size was 102.17 eggs.

1995

In 1995, 181 loggerhead turtle crawls were located along Cape San Blas. Sixty of those were nesting crawls and 121 were false crawls (Table 1a). The greatest number of false crawls were located on north beach (56; 46.3%), second greatest on cape beach (43; 35.5%), and the fewest on east beach (22; 18.2%). The earliest crawl was observed on May 16 and the latest on August 22, with both being false crawls. Most false crawls were observed in July (55; 45.5%), the second greatest number were located in June (49; 40.5%), third greatest in May (10; 8.3%), and the fewest in August (7; 5.8%).

Nests

In 1995, of the 60 nests located the greatest number were laid in July (37; 61.7%), the second greatest in June (18; 30%), third greatest in May (3; 5.00%), and fewest in August (2; 3.33%; Table 2). The earliest nest was observed on May 25 and the latest on August 18. Most nests were located on cape beach (34; 56.7%), the second greatest number on north beach (16; 26.7%), and the fewest on east beach (10; 16.7%). Thirty-six nests (60%) were relocated in 1995, and 24 (40%) remained *in situ* (Table 4a). Of all nests laid, 27 (45%) were completely or partially destroyed by predators, and 17 (28.3%) were influenced by erosion (Table 5a). Primary predators were coyotes (*Canis latrans*) and ghost crabs.

Of all nests, clutch size of 52 (86.7%) nests was known. The average clutch size for those 52 nests was 89.1 eggs, with the largest clutch containing 140 eggs and the smallest numbering 25 eggs. The total number of eggs in those nests of known clutch size was 4,633.

Hatching Success

Average hatching success was 9.54% for all nests. Of all nests laid, 11 (18.3%) hatched at least one egg, and of those, average incubation length was 55.9 days. The longest incubation period was 63 days and shortest was 52 days. Of all eggs laid, 470 hatched and hatchlings emerged, 110 showed no development, 260 were addled, 324 experienced arrested development, and 93 hatched but hatchlings were dead in the nest.

In situ versus relocated

Average hatching success for all nests left *in situ* was 9.94% and for all relocated nests was 9.28%. Of the 24 nests left *in situ*, 5 (20.8%) produced at least one hatchling, whereas 10 (27.8%) of the 36 relocated nests had at least one hatchling emerge. Of those nests, average incubation length for all nests left *in situ* was 56.2 days and for all relocated nests was 56.5 days. From the 1,369 eggs located in the 18 *in situ* nests of known clutch size, 248 (18.1%) hatchlings emerged, whereas 227 (6.95%) hatchlings emerged from 3,264 eggs located in the 34 relocated nests of known clutch size. Average number of eggs in the 18 *in situ* nests was 76.1 eggs, whereas the average clutch size for the 34 relocated nests was 96.0 eggs.

1996

In 1996, 70 loggerhead turtle crawls were located, 25 of which were nesting crawls and 45 were false crawls (Table 1a). Most false crawls were located on the cape beach (17; 37.8%), second greatest on north beach (15; 33.3%), and the fewest on east beach (13; 28.9%). The earliest crawl was observed on May 27 and was a false crawl. The latest crawl was also a false crawl and was observed on August 15. Most false crawls were located in June (24; 53.3%), the second greatest number were observed in July (16; 35.6%), third greatest in August (4; 8.9%), and the fewest in May (1; 2.2%).

Nests

In 1996, the greatest number of nests were located in June (13; 52%), the second greatest in July (10; 40%), and the fewest in August (2; 8%; Table 2). No nests were observed in May. The greatest number of nests were located on the north beach (12; 48%), second greatest on the cape beach (8; 32%), and fewest on the east beach (5; 20%). The earliest nest was located on June 7 and the latest on August 10. Fifteen (60%) nests were relocated in 1996, and 10 (40%) remained *in situ* (Table 4a). Of all nests laid, 14 (56%) were partially or completely depredated and none were lost to erosion or tropical storm damage (Table 5a). The primary predators were coyotes and ghost crabs.

Of all nests, clutch size was determined. The average clutch size was 96.24, with the largest clutch containing 127 eggs and the smallest numbering 67 eggs. The total number of eggs was 2,406.

Hatching Success

Average hatching success for all nests was 26.9%. Of all nests laid, at least one hatchling emerged from 11 (44.0%) nests, and of those, average incubation length was 64.2 days. The longest incubation period was 70 days and shortest was 62 days. Of the 2,406 eggs observed in sea turtle nests, 717 (29.8%) hatched and hatchlings emerged, 244 (9.93%) showed no development, 142 (5.8%) were addled, 278 (11.24%) experienced arrested development, and 1,007 (41.9%) hatched but hatchlings were dead in the nest.

In situ versus relocated

Average hatching success for all nests left *in situ* was 0.0% and for all relocated nests was 44.9%. Of all *in situ* nests, none hatched, whereas at least one egg hatched in 10 (66.7%) of all 15 relocated nests. Average incubation length for *in situ* nest was zero days, whereas for the 9 relocated nests of known incubation length it was 64.2 days. From the 790 eggs left *in situ*, none hatched, whereas 717 (44.4%) hatchlings emerged from the 1,616 relocated eggs. Average number of eggs in *in situ* nests was 79.0, whereas average clutch size for relocated nests was 107.7 eggs.

1997

In 1997, 109 loggerhead turtle crawls were located, 54 of which were nesting crawls and 55 were false crawls (Table 1a). Most false crawls were located on north beach (26; 47.3%), second greatest on cape beach (17; 30.9%), and the fewest on east beach (12; 21.8%). The earliest crawl was a false crawl located on May 15, and the latest was also a false crawl observed on August 12. Most false crawls were observed in July (25; 45.5%), the second greatest number were located in June (20; 36.4%), third greatest in May (6; 10.9%), and the fewest in August (4; 7.3%).

Nests

In 1997, the greatest number of nests were located in June (27; 50%), the second greatest in July (22; 40.7%), the third greatest in May (3; 5.6%), and the fewest in August (2; 3.7%; Table 2). The greatest number of nests were located along north beach (36; 66.7), second greatest along cape beach with 10 (18.5%), and fewest along east beach (8; 14.8). The earliest nest was located on May 19 and the latest on August 11. Forty-three

(79.6%) nests were relocated in 1997, and 11 (20.4%) remained *in situ* (Table 4a). Of all nests laid, 12 (22.2%) were partially or completely depredated and none were lost to erosion or tropical storms (Table 5a). The primary predators were ghost crabs and fire ants (*Solenopsis invictus*).

Clutch size was determined for all nests. Average clutch size was 112.37, with the largest clutch containing 159 eggs, and the smallest numbering 75 eggs. The total number of eggs was 6,068.

Hatching Success

Average hatching success for all nests was 64.3%. Of all nests laid, at least one hatchling emerged from 47 (87.0%) nests, and of those, average incubation length was 63.5 days. The longest incubation was 72 days and the shortest was 56 days. Of the 6,068 eggs laid, hatchlings emerged from 3,949 (65.1%), 140 showed no development, 846 (13.9%) were addled, 1, 012 (16.7%) experienced arrested development, and 43 (0.71%) hatched but hatchlings were dead in the nest.

In situ versus relocated

Average hatching success for all nests left *in situ* was 33.78%, whereas for relocated nests it was 72.2%. Of all *in situ* nests, at least one hatchling emerge from 6 (54.5%) nests, and of all relocated nests, at least one hatchling emerged from 41 (75.9%) nests. Average incubation length for *in situ* nests was 53 days and for relocated nests was 62.2 days. From the 1,242 eggs left *in situ*, 449 (36.2%) hatchlings emerged, and from the 4,826 eggs relocated, hatchlings emerged from 3,499 (72.5%). Average number of eggs left *in situ* was 112.9 whereas, average clutch size for relocated nests was 112.2 eggs.

Santa Rosa Island

1994

Crawls

In 1994, 106 sea turtle crawls were located on Santa Rosa Island (Table 1b). Forty-eight were nesting crawls and 58 were false crawls (54.7%). The earliest and latest crawls were both false and were observed on May 23 and August 23. Forty-four (75.9%) of the false crawls were loggerhead crawls and 14 (24.1%) were green turtle crawls. Most false crawls were observed in July (20; 34.5%), the second greatest number were observed in June (19; 32.8%), the third greatest in August (12; 20.7%), and the fewest in May (7; 12.1%).

Nests

Total

Forty-eight sea turtle nests were located along Santa Rosa Island in 1994, 32 of which were loggerhead turtle nests and 16 were green turtle nests (Table 3). Most nests were laid in July (22; 45.8%), the second greatest number were laid in June (19; 39.6%), third in August (5; 10.4%), and the fewest were laid in May (2; 4.2%). The earliest nest was located on May 25 and the latest on August 7. Five (10.4%) nests were relocated (Table 4b). Of all nests, 16 (33.3%) were destroyed by storms and 8 (16.7%) were partially or completely depredated by a variety of predatory species including ghost crabs, fire ants, and raccoons (Table 5b).

Loggerheads

Most loggerhead nests were laid in June (15; 46.9%), the second greatest number were laid in July (12; 37.5%), third greatest in August (3; 9.4%), and the fewest in May (2; 6.3%). The earliest loggerhead nest was observed on May 25 and the latest on August 7. Of all loggerhead nests, 5 were relocated (15.6%), 14 (43.8%) were influenced by storms, and 6 (18.8%) were partially or completely depredated.

Greens

Most green turtle nests were laid in July (10; 62.5%), the second greatest number in June (4; 25%), third greatest in August (2; 12.5%), and the fewest in May (0). The earliest green turtle nest was located on June 2 and the latest on August 5. Of all green turtle nests, none were relocated, 2 (12.5%) were influenced by storms, and 2 (12.5%) were partially or completely depredated by raccoons.

Hatching Success

Total

Hatching success for all 48 nests was 30.8%. Of all nests laid, at least one egg hatched in 20 (41.7%) nests, and of those, average incubation length was 71 days. The longest incubation was 82 days and the shortest was 65 days. Clutch size was known for 22 nests (45.8%) which contained 2,596 eggs, and averaged 118 eggs per nest. The largest clutch held 141 eggs and the smallest contained 67 eggs. Of all eggs in all nests, 1,652 hatchlings emerged, 413 experienced no development, 108 were addled, 99 were in arrested development, and 365 hatched but hatchlings were dead in the nest.

Loggerheads

Hatching success for all 32 loggerhead nests was 24.97%. Of all nests laid, at least one egg hatched in 11 (34.4%) nests, and of those, average incubation length was 70.2 days. The longest incubation was 76 days and the shortest was 65 days. Clutch size was known for 10 nests which contained 1,291 eggs, and averaged 129.1 eggs per nest. The largest clutch held 136 eggs and the smallest contained 67 eggs. Of all eggs in all nests, 982 hatchlings emerged, 99 experienced no development, 108 were addled, 85 were in arrested development, and 146 hatched but were dead in the nest.

Greens

Hatching success for all 16 green turtle nests was 42.4%. Of all nests laid, at least one egg hatched in 10 (62.5%) nests, and of those, average incubation length was 64.8 days. The longest incubation period was 82 days and the shortest was 66 days. Clutch size was known for 12 (75.0%) nests which contained 1,305 eggs and averaged 108.8 eggs per nest. The largest clutch held 141 eggs and the smallest contained 74 eggs. Of all eggs in all nests, 670 hatchlings emerged, 314 experienced no development, none were addled, 14 were in arrested development, and 219 hatched but hatchlings were dead in the nest.

In situ versus relocated

All five nests relocated in 1994 were loggerhead nests. Of all relocated nests, at least one egg hatched in two (40%) nests, whereas at least one egg hatched in 9 (33.3%) in situ nests. Of those that hatched, average incubation length for relocated nests was 73 days and 69.6 days for in situ nests. Clutch size was known for two (40.0%) relocated nests and average 107.5 eggs per nest whereas for in situ nests, clutch size was known for

8 nests that contained 1,076 eggs and averaged 134.5 eggs per nest. Average hatching success for relocated nests was 16.8% and for in situ nests was 26.5%.

1995

Crawls

Twenty-eight crawls were located in 1995, 10 (35.7%) of which were false crawls and 19 (67.9%) were nesting crawls (Table 1b). The earliest and latest crawls were both nesting crawls and were observed on May 25 and August 8. All crawls located in 1995 were produced by loggerhead turtles. Most false crawls were observed in June (5; 50%) and the second greatest in May (2; 20%) and July (2; 20.0%).

Nests

Total

Eighteen loggerhead sea turtle nests were located along Santa Rosa Island in 1995 (Table 3). Most nests were laid in June (9; 50.0%), the second greatest number were laid in July (7; 38.9%), and the fewest nests were laid in May (1; 5.56%) and August (1; 5.56%). The earliest nest was located on May 25 and the latest on August 8. Four (22.2%) nests were relocated (Table 4b). Of all nests, 17 (94.4%) were destroyed by storms and 5 (27.8%) were partially or completely depredated prior to being destroyed by storm activity (Table 5b). The remaining nest (5.56%) not lost to storms was completely depredated. Predatory species included raccoons and unidentified canids (either fox or coyote).

Hatching Success

None of the nests laid on Santa Rosa Island in 1995 hatched, therefore hatching success was 0.0%. Clutch size was known for 4 nests (22.2%) which contained 460 eggs, and averaged 115 eggs per nest. The largest clutch held 138 eggs and the smallest contained 99 eggs.

1996

Crawls

Eighty-eight crawls were located on Santa Rosa Island in 1996. Forty-two were nesting crawls and 46 (52.3%) were false crawls (Table 1b). The earliest crawl, a false crawl, was located on May 27 and the latest, a nesting crawl, on August 17. Thirty-four (73.9%) of the false crawls were loggerhead crawls and 12 (13.6%) were green turtle crawls. Most false crawls were observed in June (19;41.3%) and July (19; 41.3%), the second greatest number were located in August (6; 13.0%), and the fewest occurred in May (4; 8.70%).

Nests

Total

Forty-two sea turtle nests were located along Santa Rosa Island in 1996, 28 (66.7%) of which were loggerhead turtle nests and 14 (33.3%) were green turtle nests (Table 3). Most nests were laid in July (21; 50.0%), the second greatest number were laid in June (16; 38.1%), and the fewest were laid in August (5; 11.9%). No nests were laid in May. The earliest nest was located on June 7 and the latest on August 17, and both were green turtle nests. Sixteen (38.1%) nests were relocated (Table 4b). Of all nests, one

(2.38%) was destroyed by storms and 25 (59.5%) were partially or completely depredated by a variety of predatory species including ghost crabs, raccoons, fox, and coyotes (Table 5b).

Loggerheads

Most loggerhead nests were laid in June (17; 60.7%), the second greatest number were laid in July (9; 32.1%), and the fewest were laid in August (2; 7.1%). The earliest loggerhead nest was observed on June 9 and the latest on August 8. Of all loggerhead nests, 15 (53.6%) were relocated, 1 (2.38%) was influenced by storms, and 14 (50.0%) were partially or competely depredated.

Greens

Most green turtle nests were laid in July (7; 50.0%), the second greatest number in June (4; 28.6%), and the fewest in August (2; 14.3%). The earliest green turtle nest was located on June 7 and the latest on August 17. Of all green turtle nests, one (7.1%) was relocated, none were influenced by storms, and 11 (39.3%) were partially or completely depredated by raccoons.

Hatching Success

Total

Hatching success for all 42 nests was 25.0%. Of all nests laid, at least one egg hatched in 24 (57.1%) of nests, and of those, average incubation length was 71.1 days. The shortest incubation duration was 57 days and the longest was 81 days. Clutch size was known for 40 nests which contained 3,118 eggs and averaged 78.0 eggs per nest. The largest clutch held 194 eggs and the smallest contained 61 eggs. Of all eggs in all nests, 936 hatchlings emerged, 194 experienced no development, 768 were addled, 551 showed arrested development, and 84 hatched but hatchlings were dead in the nest.

Loggerheads

Hatching success for all 28 loggerhead turtle nests was 31.6%. Of all nests laid, at least one egg hatched in 19 (67.9%) of nests, and of those, average incubation length was 1.0 days. The longest incubation duration was 77 days and the shortest was 57 days. Clutch size was known in 27 (96.4%) nests which contained 3,046 eggs and averaged 121.8 eggs per nest. The largest clutch held 159 eggs and the smallest contained 72 eggs. Of all eggs in all nests, 1004 hatchlings emerged, 46 experienced no development, 332 were addled, 332 showed arrested development, and 83 hatched but hatchlings were dead in the nest.

Greens

Hatching success for all 14 green turtle nests was 14.7%. Of all nests laid, at least one egg hatched in 5 (35.7%) of nests, and of those, average incubation length was 73.4 days. The longest incubation duration was 81 days and the shortest was 66 days. Clutch size was known for 13 nests which contained 1.421 eggs and averaged 109.3 eggs per nest. The largest clutch held 194 eggs and the smallest contained 61 eggs. Of all eggs in all nests, 252 hatchlings emerged, 146 showed no development, 311 were addled, 219 experienced arrested development, and one hatched but the hatchling was dead in the nest.

In situ versus relocated

Loggerheads

Fifteen (53.6%) loggerhead nests were relocated in 1996 and 13 (42.3%) were left in situ. Of all relocated loggerhead nests, 11 (73.3%) hatched at least one egg, and of those, average incubation length was 67.2 days. Of all in situ nests, 8 (61.5%) hatched at least on egg and of those average incubation length was 73.3 days. Average hatching success for relocated nests was 39.2% and for in situ nests was 22.9%. From the 1,798 eggs in the 15 relocated nests, 684 (38%) hatchlings emerged, whereas 320 (25.6%) hatchlings emerged from the 1,248 eggs in the 12 in situ nests of known clutch size. Average number of eggs in the relocated nests was 119.9 eggs per nest, and in *in situ* nests was 104.0 eggs per nest.

Greens

One (6.3%) green turtle nest was relocated in 1996 and 13 (92.9%) were left in situ. None of the 101 eggs laid in the one relocated nest hatched.

1997

Crawls

Forty-seven crawls were located on Santa Rosa Island in 1997 (Table 1b). Twenty-two were nesting crawls and 25 (53.2%) were false crawls. The earliest crawl, a false crawl, was located on May 28 and the latest, a nesting crawl, on August 14. All crawls were loggerhead turtle crawls. Most false crawls were observed in June (11;44.0%) and July (8; 32.0%), the second greatest number were located in May (4; 16.0%), and the fewest occurred in May (2;8.00%).

Nests

Total

Twenty-two sea turtle nests were located along Santa Rosa Island in 1997, all of which were loggerhead turtle nests (Table 3). Most nests were laid in June (13; 59.1%), the second greatest number were laid in July (5; 22.7%), third greatest in August (3; 13.6%), and the fewest were laid in May (1; 4.55%). The earliest nest was located on May 29 and the latest on August 14. One (4.55%) nest was relocated (Table 4b). Of all nests, four (18.2%) were destroyed by storms and 12 (54.5%) were partially or completely depredated by a variety of predatory species including ghost crabs, raccoons, and canids (Table 5b).

Hatching Success

Total

Hatching success for all 22 nests was 27.2%. Of all nests laid, at least one egg hatched in 15 (68.2%) nests. Incubation period was known for 7 nests, and average incubation length for those nests was 75.7 days. The longest incubation period was 90 days and the shortest was 67 days. Clutch size was known for 15 nests that contained 1,443 eggs and averaged 96.2 eggs per clutch. Of all eggs laid, 780 hatchlings emerged, 128 exhibited no development, 108 were addled, 387 were in arrested development, and one hatched but the hatchling was dead in the nest.

In situ versus relocated

One loggerhead turtle nest was relocated on Santa Rosa Island in 1997. This nest contained 142 eggs and was partially depredated (8 eggs) by ghost crabs. Of the 141 eggs, 51 (35.9%) hatchlings emerged. Incubation length was 74 days. The remaining 21 nests were left *in situ*. These nests contained 1,301 eggs and had an average clutch size of 92.9 eggs per nest. Average hatching success for all *in situ nests* was 26.8%. Of all *in situ* nests, at least one egg hatched in 14 (66.7%) nests. Clutch size was known for 14 nests, and from those, 729 (56%) hatchlings emerged.

Discussion

The timing and density of sea turtle crawls and nests along Cape San Blas and Santa Rosa Island fluctuated between 1994 and 1997, however they remained within the typical range of sea turtle nesting along the Florida panhandle. Much of the inconsistency in numbers along Santa Rosa Island reflected a biyearly nesting of green turtles along this island. On Cape San Blas, however, the fluctuations in numbers primarily reflected changes in the number of false crawls. In 1995, nearly 67% of all crawls observed along Cape San Blas were false crawls, whereas in 1996, only 36% were false crawls. This may be due to a variety of factors, including beach conditions or nesting behavior of the sea turtles.

Perhaps disturbances along the beach in 1995 caused turtles to abandon nesting attempts. Debris and other disturbances may cause the nesting female to change direction or even abandon the nesting effort (Miller 1997). A large number of sea turtle nests were depredated by coyotes in 1995. Possibly, coyotes were roaming the beach at night in search of prey. If a coyote came upon a turtle attempting to find an appropriate nesting site, the turtle may have abandoned the effort, recognizing the threat of depredation the coyote posed. The percentage of nests depredated increased and the number of false crawls decreased in 1996 however, which indicated the presence of coyotes on the beach may not have been the primary cause of the increased number of false crawls observed in 1995.

Coyotes are opportunistic feeders however, and may shift their primary prey items when necessary (MacCracken and Uresk 1984). Coyotes did not depredate many sea turtle nests in 1994, therefore perhaps coyotes first recognized sea turtle nests as an appropriate food source in 1995 and were required to spend more time in search of nests while they "learned" to use this resource. While looking for sea turtle nests, coyotes may have roamed the beach more often than normal thereby disturbing many female turtles attempting to nest. In 1996, coyotes may have been more adept at depredating sea turtle nests, thus they were able to spend less time in search of nests which would have resulted in fewer disturbed nesting sea turtles. Coyotes were also depredating sea turtle nests along Santa Rosa Island, and an increase in false crawls was not apparent, which would appear to suggest that coyotes were not influencing the number of false crawls along Cape San Blas. Santa Rosa Island is a much larger area than Cape San Blas (26 miles versus three miles). Perhaps, coyotes on Santa Rosa Island do not roam the entire area in search of prey, thus they would effect only a fraction of the turtles nesting in this area. It is, therefore, possible that coyotes along Cape San Blas influenced the number of false crawls observed along this beach in 1995.

Additional disturbances may have also influenced sea turtles attempting to nest along Cape San Blas in 1995. Vehicular traffic is allowed along this beach. Perhaps a larger number of vehicles and people were using the beach at night in 1995 than in 1994 or 1996. More vehicles and people may have created more disturbances to nesting sea turtles and resulted in a greater number of false crawls. Vehicular traffic is not allowed on Santa Rosa Island, therefore changes in the number of false crawls would not be expected due to this disturbance.

The fluctuation in the number of false crawls may have been a natural fluctuation in the sea turtles nesting along Cape San Blas between 1994 and 1997. Different turtles may have been nesting in this area in 1995 than in 1994 or 1996, and fluctuations in nesting behavior would be expected among different groups of turtles. Changes in the beach or offshore environment may also have resulted in the inconsistency in numbers of false crawls. Possibly, sea turtles use cues on the beach to identify appropriate nesting sites. If changes in the beach occurred between 1994 and 1995, sea turtles may have had greater difficulty locating appropriate nesting sites thus increasing the number of false crawls.

Although the number of crawls fluctuated, the number of sea turtle nests laid along Eglin Air Force Base on Cape San Blas and Santa Rosa Island, Florida remained relatively stable from 1994 to 1997. There was a decrease in the number of nests observed along Cape San Blas in 1996, however in the following season, the number increased again to more a typical nesting density. Along Santa Rosa Island, a pattern was observed of fewer nests in odd years than even years. This was due to biyearly nesting of green turtles that occurs along Santa Rosa Island (16 in 1994, 14 in 1996). In even years, the number of loggerhead turtle nests remained relatively stable.

The decrease in the number of nests observed along Cape San Blas in 1996 may have been due to a natural fluctuation in sea turtle nesting. In general, female sea turtles do not reproduce every year (Miller 1997). The mean interval between laying for female sea turtles varies among species, and ranges from one to 9 years (Miller 1997). For the loggerhead turtle, the average interval among nesting years is 2.59 years (Miller 1997). Possibly, the turtles that nest in successive years along Cape San Blas are not a consistent group, therefore fluctuations in numbers would be expected.

Sea turtles nesting along both locations, nested within the typical season for the loggerhead and green turtle in Florida. The earliest nests were most often observed during the last week in May and the latest nests during the first week in August. On Cape San Blas the greatest average percentage of nests laid per year occurred in June (45.0%) and July (45.2%) whereas on Santa Rosa Island the greatest percentage were laid in June (46.7%) and the second greatest in July (39.4%). The average percentage of nests laid in May (approximately 4%) and August (approximately 10%) in both locations was similar. The loggerhead turtle typically nests in Florida from late April to early September (Van Meter 1992). Peak nesting along Cape San Blas and Santa Rosa Island are encompassed within this time span. The difference in nesting percentage between June and July along Santa Rosa Island is most likely a natural fluctuation in the nesting pattern of the sea turtle group nesting along this island.

In 1994 and 1995 along Cape San Blas, the greatest number of nests were laid in July, whereas in 1996 and 1997 the greatest number were laid in June. This may indicate that separate groups of turtles are nesting along Cape San Blas from year to year, following the typical 2 year internesting period exhibited by most loggerhead turtles (Miller 1997). These fluctuations may also reflect environmental variations along Cape San Blas that may influence timing of nesting of these turtles. Hurricane Opal severely influenced this area in 1995. Possibly, this storm altered the offshore or onshore environment along Cape San Blas, which resulted in turtles nesting earlier than in the previous years. Santa Rosa Island was also greatly influenced by Hurricane Opal, however and this pattern was not evident. This indicates the fluctuations in timing of nesting along Cape San Blas were most likely a natural pattern within the sea turtle group laying along this beach.

The three miles of beach along Cape San Blas are extraordinarily dynamic. The north beach erodes severely while the east beach accretes (see erosion chapter). Sea turtles nesting along Cape San Blas typically laid along the eroding cape or north beach rather than the accreting east beach. In 1994 and 1995, most nests were laid on the cape beach (43.4% and 56.7%), whereas in 1996 and 1997 most nests were laid along north beach (48% and 66.7%). Fewer than 25% of nests were laid along east beach throughout each year of the study. This may reflect changes in the sea turtle group nesting along Cape San Blas, or alterations in the offshore or onshore environment of this area.

Possibly, sea turtles nesting in 1994 and 1995 represented different individuals than those nesting in 1996 and 1997. Variations in nesting behavior throughout this may be due to these changes. The location of mating grounds of the loggerhead turtles nesting along the Florida panhandle is unknown. If turtles are mating in the western gulf, and then moving towards their nesting beaches along the panhandle, they may be approaching their nesting beaches from the west. If this occurred off Cape San Blas, the turtles moving along the coastline would be forced to cross the Cape San Blas spit to nest along the east beach. The Cape San Blas spit extends approximately 15 miles into the Gulf of Mexico and presents a barrier between the east and north beaches of Cape San Blas. Sea turtles may primarily nest along the cape and north beach because of their direction of approach to the island, and the barrier presented by the Cape San Blas spit.

Sea turtle nests laid along Cape San Blas and Santa Rosa Island encountered several challenges to survival between 1994 and 1997. A severe storm season in 1995 influenced many nests along Cape San Blas and destroyed all but one nest along Santa Rosa Island. Storm damage also affected both locations in 1994, however a mild season in 1996 and 1997 helped minimize losses to water inundation and erosion caused by tropical storms.

In addition to storms, predators greatly influenced sea turtle nests along Cape San Blas and Santa Rosa Island from 1994 to 1997. The number of nests along Cape San Blas lost to predators in 1994 increased from 7.55% to 56.0% in 1996. This pattern was also evident along Santa Rosa Island. Predators claimed 16.7% of nests in 1994 and 59.5% in 1996. These increases were due primarily to an increase in coyote depredation of sea turtle nests in both areas.

Several activities were initiated in 1995 to assist in reducing losses to storm and depredation. Along Cape San Blas, an increased number of nests were relocated from 1995 to 1997 than in 1994. Nests laid along the north beach are greatly influenced by erosion and a high water table. In 1994, 35.8% of nests were relocated. This increased to 60% in 1995 and 1996, and 79.6% in 1997. A greater number of nests were relocated between 1995 to 1997 because of the increased awareness of the threat of erosion and depredation along Cape San Blas beaches, and due to the increased number of nests laid along the cape and north beaches.

On Santa Rosa Island, erosion was not as severe as along Cape San Blas, therefore fewer nests required relocation due to inundation or erosion. Nests were relocated, however, when influenced by predators. On Santa Rosa Island, a nest was relocated only after an initial attempt at depredation occurred. The number of depredated nests increased from 1994 to 1996, therefore a greater number of nests were relocated in 1995 and 1996 than in 1994. Fewer nests were relocated on Santa Rosa Island than on Cape San Blas.

In addition to relocation of nests, coyote control was conducted in the state park adjacent EAFB on Cape San Blas in 1996 in an attempt to reduce losses of sea turtle nests to coyotes. These methods appeared to be successful for the entire St. Joseph Peninsula. The number of nests depredated along Cape San Blas decreased to 22.2% in 1997. Continued trapping of coyotes within the state park may assist in protecting sea turtle nests along EAFB on Cape San Blas.

Hatching success along Cape San Blas and Santa Rosa Island reflected numbers of nests influenced by storms and depredation, and the numbers relocated. Hatching success and the number of nests that hatched at least one egg increased along Cape San Blas from 1994 to 1997. This is most likely a result of a decreased number of nests lost to storms (62.3% in 1994 vs 0% in 1997) and an increased number of nests relocated (35.0% in 1994 and 79.6% in 1997).

Along Santa Rosa Island, hatching success and the number of nests that hatched at least one egg decreased sharply in 1995, but then increased in 1996 and 1997. The sharp decrease in 1995 is the result of a severe storm season that destroyed 94.4% of nests laid that season. Although a greater number of nests were depredated along Santa Rosa Island in 1996, more nests were also relocated, therefore hatching success and hatching per nest were also able to increase. Losses from depredation and storms decreased in 1997, therefore hatching success was again able to increase. Less depredation and storm activity also allowed for relocation of fewer nests in 1997.

It appears relocating nests along Cape San Blas and Santa Rosa Island from 1994 to 1997 promoted increased success of sea turtle nests laid along in areas. Along Cape San Blas, the number of nests that hatched at least one egg was greater for relocated than *in situ* nests during every year of the study. In 1994 and 1995, hatching success was slightly less for relocated than *in situ* nests, but in 1996 and 1997 it was substantially greater for relocated than for *in situ* nests. The severe storms that influenced Cape San Blas during 1994 and 1995 most likely contributed to the decreased success of relocated nests in those years. Total hatching success was also less in 1994 and 1995 than in 1996 and 1997. With an increase in total hatching success in 1996 and 1997, an increase in success of relocated nests was also observed.

Similar trends were observed along Santa Rosa Island. Hatching success and the number of nests that hatched at least one egg were less for relocated than *in situ* nests in 1994. In 1995, no nests hatched, but in 1996 and 1997, both measures of hatching success were greater for relocated than for *in situ* nests. Again, total success was less in 1994 than in 1996 and 1997, most likely due to the severe storm season of 1994. When total success increased, success of relocated nests also increased. This indicates that along Cape San Blas and Santa Rosa Island, relocating nests may have resulted in increased hatching success of nests.

Development among those eggs that did not hatch, varied from no development to arrested development. When laid, the egg shell is creamy-white. Shortly after being laid, the top of the egg turns white, and this process continues for approximately 10 days, until the entire egg is white. Eggs that do not turn white are most likely infertile or the embryo died before attaching to the shell membrane (Miller 1997). Those eggs that showed no development or addled conditions when examined may have been infertile when laid, or may have been influenced by external factors, such as environmental factors or disturbances. Excessive rain may cause inundation of eggs thereby drowning embryos before they are able to develop. In addition, disturbances to the egg chamber may destroy conditions necessary for successful development. Predators may invade the chamber and, in addition to direct death of eggs, they may result in cessation of development. Movement of eggs during relocation may also cause enough disturbance to cease development of embryos.

Management Recommendations

Cape San Blas

The natural and human disturbances that influence Cape San Blas also effect the sea turtles that rely on its beaches for survival. The severe erosion that occurs along north beach threatens the majority of nests laid on that beach. In 1994, three nests were left *in situ* along north beach. In 1995, one nest was left *in situ*, and in 1996 five nests remained *in situ* along north beach. Of these nests, none of the eggs hatched. In 1997, 8 nests were left *in situ*, and of those, five nests experienced some degree of hatching. Of the 436 eggs in those nests, 229 hatched (52.5%). Average hatching success among all four years was 13.1%, indicating that nests left *in situ* along north beach have a small chance of success. From 1994 to 1997, the number of nests laid along north beach increased, therefore threatening the survival of more nests. It is impossible to stop the natural erosional forces influencing this area, therefore continued monitoring and protection of sea turtle nests is necessary to preserve successful hatching of nests laid along Cape San Blas beaches.

1. Continued monitoring of sea turtle nests laid along EAFB on Cape San Blas is recommended. In addition to monitoring, relocating nests severely threatened by erosion and inundation is advised, however, only those nests in immediate danger should be moved. Moving approximately 25% or fewer of nests laid in highly eroding areas (north and cape beaches) is suggested.

In addition to storms, predators have also greatly influenced sea turtle nesting success along Cape San Blas. It would be difficult to remove all predators from the Cape San Blas area, therefore continued protection of sea turtle nests from predators is necessary. Reduction of the coyote population through control may decrease the number of coyotes depredating sea turtle nests, however if may increase raccoon predation. Coyotes often decrease populations of additional predators, such as raccoons or foxes through competition, therefore, an increase in the number of coyotes in an area may help decrease the raccoon or fox depredation, however it may also result in depredation of sea turtle nests by coyotes. On Cape San Blas, from 1994 to 1997, coyotes did not depredate nests once the nests had been screened. All coyote depredation occurred before nests had been located during morning surveys. Therefore, surveying at night for nesting turtles, or starting morning surveys earlier may reduce the number of nests influenced by coyotes. Coyote control would assist in decreasing the coyotes population, however it may also allow for an increase in the raccoon population. Raccoons depredate sea turtle nests throughout incubation and are able to reach through screens to remove eggs, therefore they are more difficult to manage for than coyotes. Using coyotes to control the raccoon population and then managing for coyotes may be the most efficient way to manage for these predators.

There are additional predators that influence sea turtle nests, including ghost crabs and fire ants. Ghost crabs are an abundant and important species among most southeastern beach systems, therefore their removal would be difficult and would most likely adversely effect the beach habitat (Ruppert and Fox 1988). Because they depredate such a few number of sea turtle eggs per season, it may be unnecessary to attempt control of these predators.

Fire ants, however, may require control along Cape San Blas in the future. No eggs were lost to fire ants in 1994, however, since then the number of nests affected by these predators has increased. Red imported fire ants were introduced into the United States in the 1930's and have now spread to most of the southeastern U.S. (Allen et al. in press). Fire ants tend to invade an area in extremely high densities and then population numbers stabilize or slowly increase (Allen et al. in press). They typically favor disturbed areas, such as pastures, yards, clear-cut forests, or plowed fields. They are excellent and aggressive colonizers that can readily out compete native species, therefore they are not limited to disturbed sites, but are also known to invade undisturbed areas, such as the Marquesas Keys, west of Key West, Florida. General habitat requirements for red imported fire ants include high sun exposure and adequate moisture, both of which are readily available along Cape San Blas. Fire ants are capable of depredating species much larger than themselves, including bobwhite quail, alligators, and box turtles (*Terrapene carolina triunguis*; Allen et al. in press, Montgomery 1996). Fire ants are attracted to proteins, sugar, and moisture. A readily available source of these are egg contents and newborn young of vertebrates, as well as insects. Waterbird nest mortality was as high as 100% on fire ant infested barrier islands (Drees 1994), and Moulis (1996) documented a 15% decrease in hatchling release rate for loggerhead sea turtles emerging from nests infested with fire ants as compared to uninfested nests. Because of the increase in numbers of nests along Cape San Blas affected by fire ants from 1994 to 1997, it is apparent fire ants have immigrated to Cape San Blas.

It is difficult to protect sea turtle eggs from fire ant depredation. Use of pesticides near sea turtle nests may be harmful to the incubating eggs. Continued monitoring of fire ant depredation of sea turtle nests is necessary to determine the extent of the threat these species pose to nests along Cape San Blas. If their depredation rates increase, protection efforts, such as Amdro, may be necessary.

2. Continued screening of sea turtle nests is recommended for protection from coyotes and raccoons. Further research into fire ant removal will help provide safe methods for protecting nests without harming eggs or the surrounding wildlife.

In addition to natural threats, sea turtles nesting along Cape San Blas must also survive human disturbances. Vehicular traffic is permitted along EAFB on Cape San Blas. The affects of this activity on the beach habitat is not completely known, however it may contribute to the erosion that occurs in this area (see erosion chapter). Erosion on this barrier island occurs primarily due to natural forces, therefore restricting vehicles on Cape San Blas may not eliminate this threat to nesting sea turtles. Sea turtles also typically nest at night, therefore driving along the beach during the day may not disturb nesting females. Driving during the day may, however, greatly influence nests and hatchlings, and night-time driving may severely disturb nesting females, nests, and hatchlings. Therefore, although beach driving may not affect sea turtle nests by causing erosion, it may greatly influence nesting sea turtles, particularly at night.

Day-time driving along the beach may cause injury primarily to nests and hatchlings. Sea turtles often lay below the dune line. Nests laid close to or below mean high water are often relocated by sea turtle nest monitors during morning surveys. Occasionally, however, vehicles driven on the beach before sea turtle surveys have been completed, ride over nests laid seaward of the dune line. This may disturb or destroy a nest, particularly if the nest was laid in soft, wet sand that could not support the weight of the vehicle.

Driving on the beach during the day may also influence hatchling sea turtles. Vehicles often leave ruts in the beach, especially in dry sand. Hatchling sea turtles attempting to make their way seaward after emergence often get caught in vehicle tire ruts and are either unable to escape or become more obvious prey for predators. In addition to increasing the risk of death while traveling down the beach, hatchlings may also use more energy attempting to escape tire ruts. This may deplete much of their energy reserves, which may increase their risk of death once they reach the water.

Vehicles may also influence hatchling sea turtles more directly. Hatchlings typically emerge when sand temperatures are cool, which often occurs after the sun has set (Miller 1997). Because sand temperature is the primary cue for hatchling emergence, hatchlings also emerge occasionally at dawn or during a daytime rainstorm when sand temperatures have decreased (Miller 1997). Vehicles driving on the beach during an emergence may drive over hatchlings attempting to reach the water. Both directly and indirectly, daytime vehicular traffic along Cape San Blas beaches represents a potentially destructive disturbance to sea turtles, especially to their nests and hatchlings. Because daytime emergences and nests laid below mean high water are rare, however, daytime traffic may be possible if intense public education occurs and specific driving restrictions are observed.

3. Driving vehicles on the beach during daylight hours (0600 to 2200 hours) may continue to occur, however close monitoring of nesting and hatching should continue.

Driving along the beach at night, however, poses a much more serious threat to sea turtles including, nesting females, nests, and hatchlings. Vehicles traveling on the beach at night provide a variety of hazards to nesting sea turtles, including direct death, lighting disorientation, and nest abandonment. Because females come ashore to nest at night, drivers traveling on the beach after dark may have difficulty seeing a turtle on the beach, and may crush her beneath the vehicle's tires. Driving without lights increases the chances of running over a turtle, whereas driving with headlights may severely disorient and disturb a female attempting to nest. Vehicles driven at night may also effect sea turtle nests by traveling over a newly laid nest, which may damage or destroy the eggs. Vehicles traveling on the beach at night during sea turtle nesting season represent a serious threat to nesting females and the nests they are laying.

Hatchlings may be at the greatest risk from vehicles driven at night both directly and indirectly. Hatchling sea turtles often emerge from the nest at night in a group, therefore a vehicle driven along the beach during an emergence may not crush only one hatchling but a large group of hatchlings (Miller 1997). Sea turtle hatchlings are small, approximately 20 g in total weight, and dark colored. A driver operating a vehicle would have an extremely difficult time observing hatchlings moving down the beach at night. If drivers use their headlights they would be able to see the hatchlings, however headlights would cause severe hatchling disorientation and would indirectly threaten hatchling survival as much as the vehicles themselves. Hatchling sea turtles orient themselves to the water using several cues (Salmon and Wyneken 1994). They typically move downhill and away from the darkest part of the horizon and towards the lightest region (Salmon and Wyneken 1994). Artificial lights on the beach result in significant disorientation of sea turtle hatchlings (Witherington and Bjorndal 1989). Lights such as vehicle headlights, porch lights, spot lights, flashlights, and bonfires cause hatchlings to become disoriented (pers. obs).

Because EAFB property on Cape San Blas is contiguous with adjacent beaches, it would be difficult to restrict driving on EAFB property. A fence or gate would have to be placed vertically along the beach to prevent drivers from entering the property. This would be logistically difficult, if not impossible, because wave action and sand movement would quickly destroy the structure. A more effective method of restricting traffic on EAFB property is to limit driving along the entire beach from Indian Pass to St. Joseph State Park. Limitations have already been placed on drivers using the beach north of EAFB property, therefore control would only be necessary along Indian Pass and EAFB property. There are no vehicle entry points along EAFB property, therefore, access to this beach is limited to entry points east of EAFB property to Indian Pass. Blocking illegal access roads and limiting access to legal entry points would effectively control vehicular traffic on EAFB property during sea turtle season. This requires cooperation with the

Gulf County Sheriff's Department. Official and illegal access roads would have to be monitored by deputies to enforce proper use and to close the roads when driving is restricted. Minimal effort is required, however, for this to be effective.

4. Vehicles and bonfires should be restricted on EAFB beaches on Cape San Blas from June 15 through October 15 during night-time hours (2200 hours to 0600 hours). CONTROL OF ACCESS ROADS FROM INDIAN PASS TO EAFB PROPERTY AND COOPERATION WITH THE GULF COUNTY SHERIFF'S DEPARTMENT WILL ALLOW RESTRICTIONS TO BE EFFECTIVE.

Santa Rosa Island

Variations in the number of nests laid along Santa Rosa Island appear to be the result of a biyearly pattern of green turtle nesting that occurs on this barrier island. Green turtles typically nest on large dunes, therefore Santa Rosa Island offers suitable nesting habitat for green turtles. Destruction of this dune system may prevent green turtles from nesting in this area. In 1995, however, Hurricane Opal destroyed much of Santa Rosa Island's dune system, yet 14 (33%) green turtle nests were laid in 1996. This indicates that even after severe damage, the dune habitat along Santa Rosa Island provides appropriate nesting sites for green turtles. Protection of these dunes by planting of dune vegetation, may assist in protecting this habitat.

1. Planting of dune vegetation may assist in protecting this habitat for green turtle nesting.

Two forces influencing sea turtle nests along Santa Rosa Island cause the greatest amount of destruction to the success of these nests. Hurricanes have detrimentally affected the success of sea turtle nesting along this portion of Eglin Air Force Base since sea turtle monitoring by the University of Florida began in 1994. The affect of predators, however, appears to have increased since 1994, insinuating an increase in the number of predators located on this island.

Hurricanes are natural forces therefore it is difficult to create management plans for these disturbances. Sea turtle nests laid near or below mean high water appeared to be at greatest risk during the minor storms that influenced this area between 1994 and 1997, therefore relocating nests laid in this area may assist in protecting them during minor tropical systems. Major storms, such as Hurricanes Erin and Opal, however, caused severe damage to all nests, therefore management actions, such as relocating nests, appear to be futile against these severe forces.

2. Although hurricanes cause severe damage to sea turtle nests, it is difficult to prevent this destruction. Relocation of nests above mean high water may protect nests during minor tropical storms.

Management actions against depredation of nests may be more successful, however. On Santa Rosa Island, sea turtle nests are not screened until evidence of depredation appears. Typically, some damage to nests occurs before screens are used. Earlier placement of screens, such as when nests are laid, may assist in preventing this initial depredation.

After initial depredation, screens appear to reduce coyote depredation, however they do not seem to reduce raccoon or fox depredation (M. Lamont, pers. obs.). Fox and raccoons are able to fit their paws through the screening and pull eggs or hatchlings out of the egg chamber, or to dig under the screen (M. Lamont, per. obs.). To assist with these more dextrous predators, wire cages were developed that protect the egg chamber from above and along the sides. The cages rest approximately one foot above the nest thereby preventing raccoons from reaching through the cage and into the egg chamber. The cage is buried at least 6 inches in a trench surrounding the nest to prevent foxes from digging into the egg chamber from the side. Use of these cages from the day a nest is laid may prevent depredation of nests by coyotes, fox, and raccoons. If additional depredation occurs after cages have been put in place, predator control along the island may be necessary.

3. Caging nests upon deposition should assist in preventing depredation by coyotes, raccoons, and foxes. If nests continue to be depredated, predator control should be implemented.

Variations in hatching success along Santa Rosa Island have occurred primarily due to storms and depredation. Management of these forces may stabilize or increase hatching success of sea turtle nests along Eglin Air Force Base on Santa Rosa Island.

Increasing hatching success may allow for more hatchlings to be produced along Santa Rosa Island, however more hatchlings emerging may simply result in more disoriented hatchlings. Hatchlings emerging along Santa Rosa Island often disorient towards lights on Air Force buildings or the glow of surrounding cities such as Destin and Fort Walton Beach. In the past, the dune system shielded the beach from these lights, however destruction of these dunes by Hurricane Opal allowed for direct illumination of the beach and increased hatchling disorientation. Lights on Air Force buildings should be shut off at night, or replaced by low sodium vapor lights that may reduce the chance of disorientation. It is more difficult, however to shut off all the lights of Destin or to replace them all with low sodium vapor bulbs. It may be possible, however, to shield the beach from these lights with backdrops. Several days before a nest is scheduled to hatch, a large shield may be placed at the dune line, landward of the hatching nest. When hatchlings emerge, this shield may block the glow of lights from surrounding cities and allow for hatchlings to properly orient themselves. This may be logistically difficult however. Therefore, if a backdrop is not possible, volunteers may monitor hatching at night, and relocate emerged hatchlings to darker areas of the beach. Non-releasing cages may also be used which would allow for hatchlings to emerge naturally, however, they would not be able to escape the cage. Volunteers or technicians may then move the hatchlings to a darker area and allow to crawl to the sea. If cages are monitored frequently (at least late each evening and early each morning), hatchlings may successfully emerge and not become disoriented.

4. Turning off Air Force lights or replacing Air Force light bulbs with low sodium vapor bulbs may assist in decreasing hatchling disorientation. In addition, non-releasing cages should be used, which would allow hatchlings to emerge naturally and then be relocated to darker areas.

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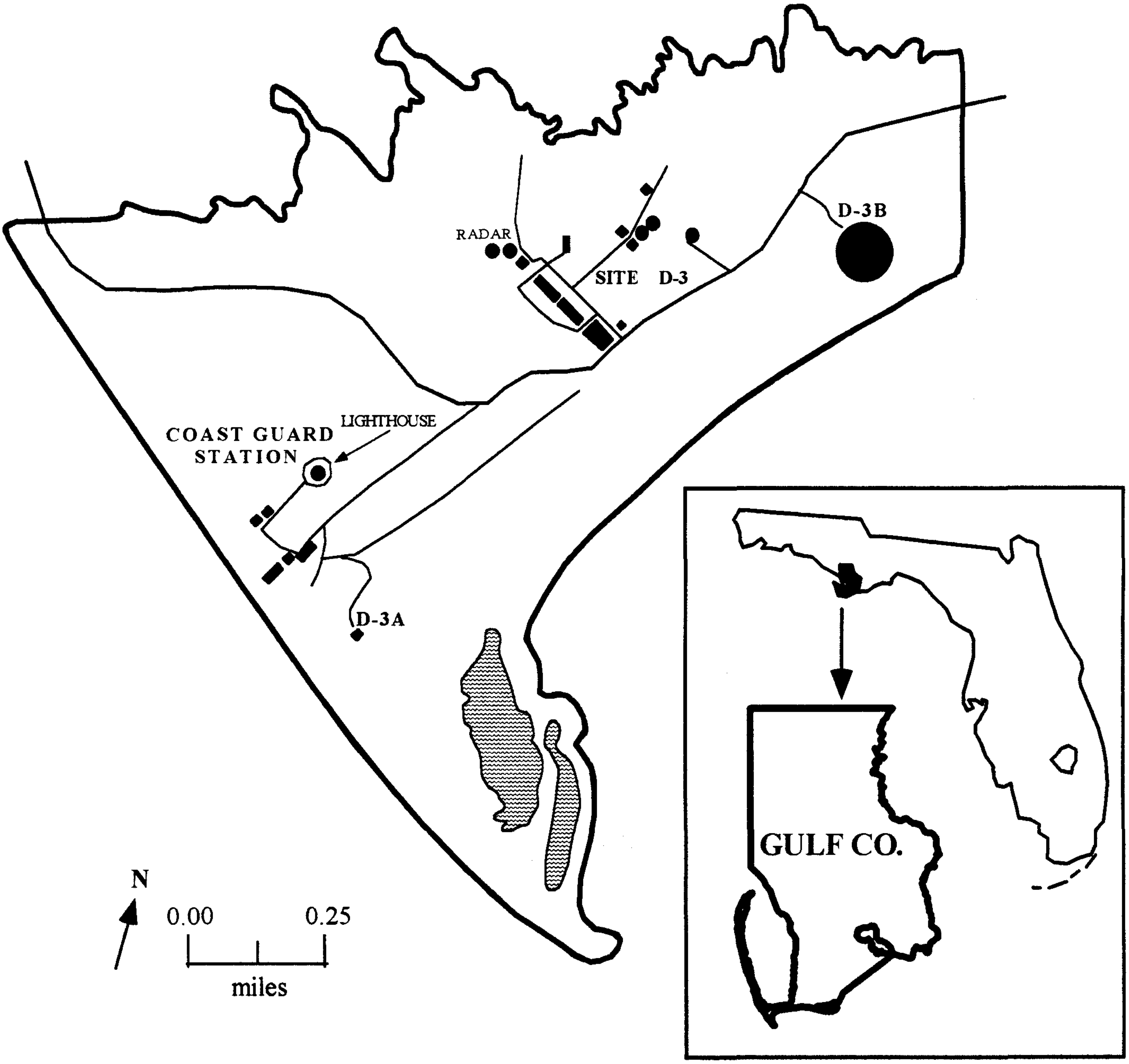

Figure 1. Eglin Air Force Base on Cape San Blas, Florida where sea turtle nesting activity was monitored from 1994 to 1997.

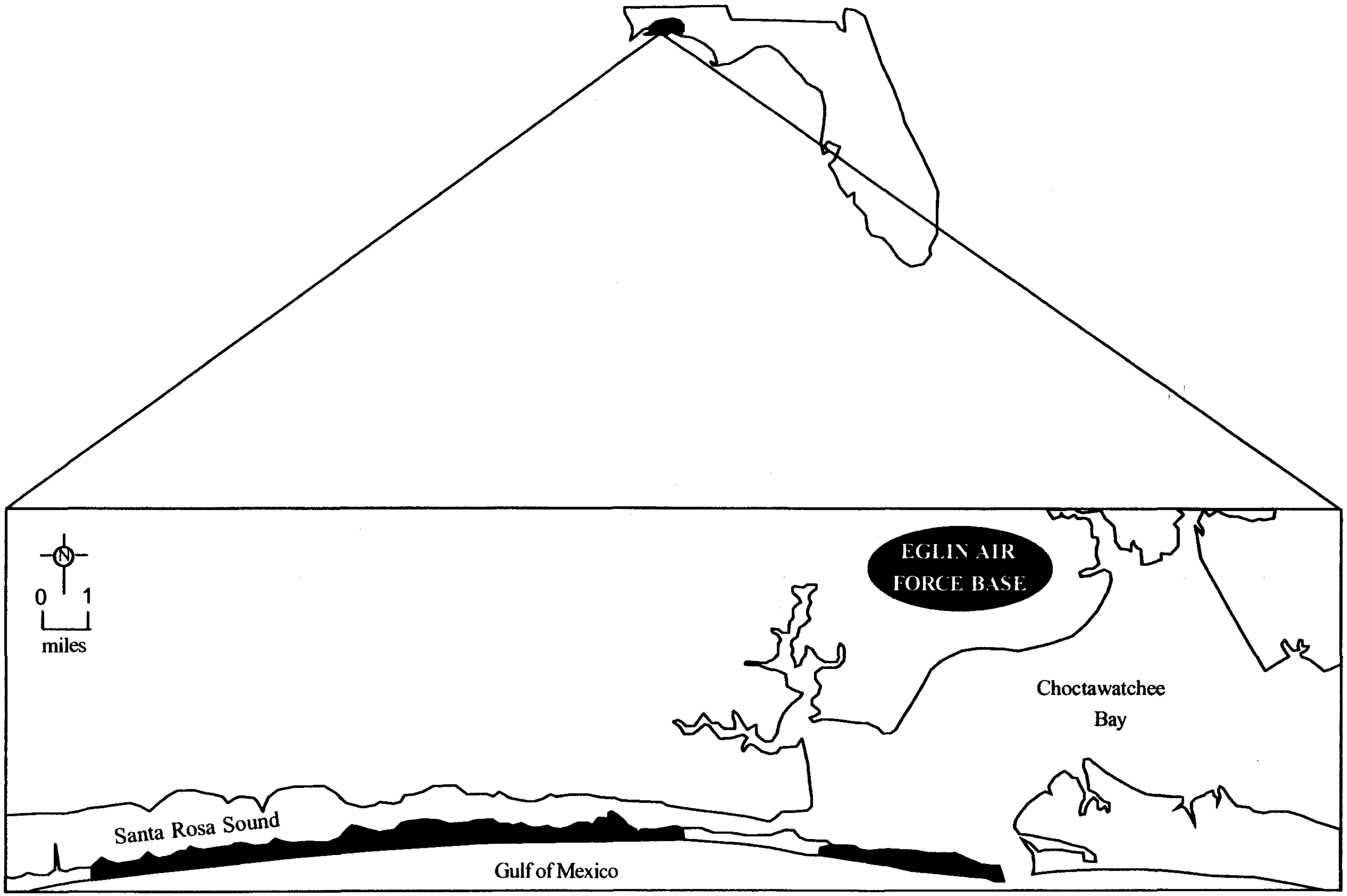

Figure 2. Eglin Air Force Base, including property owned on Santa Rosa Island where sea turtle nesting surveys were conducted from 1994 to 1997.

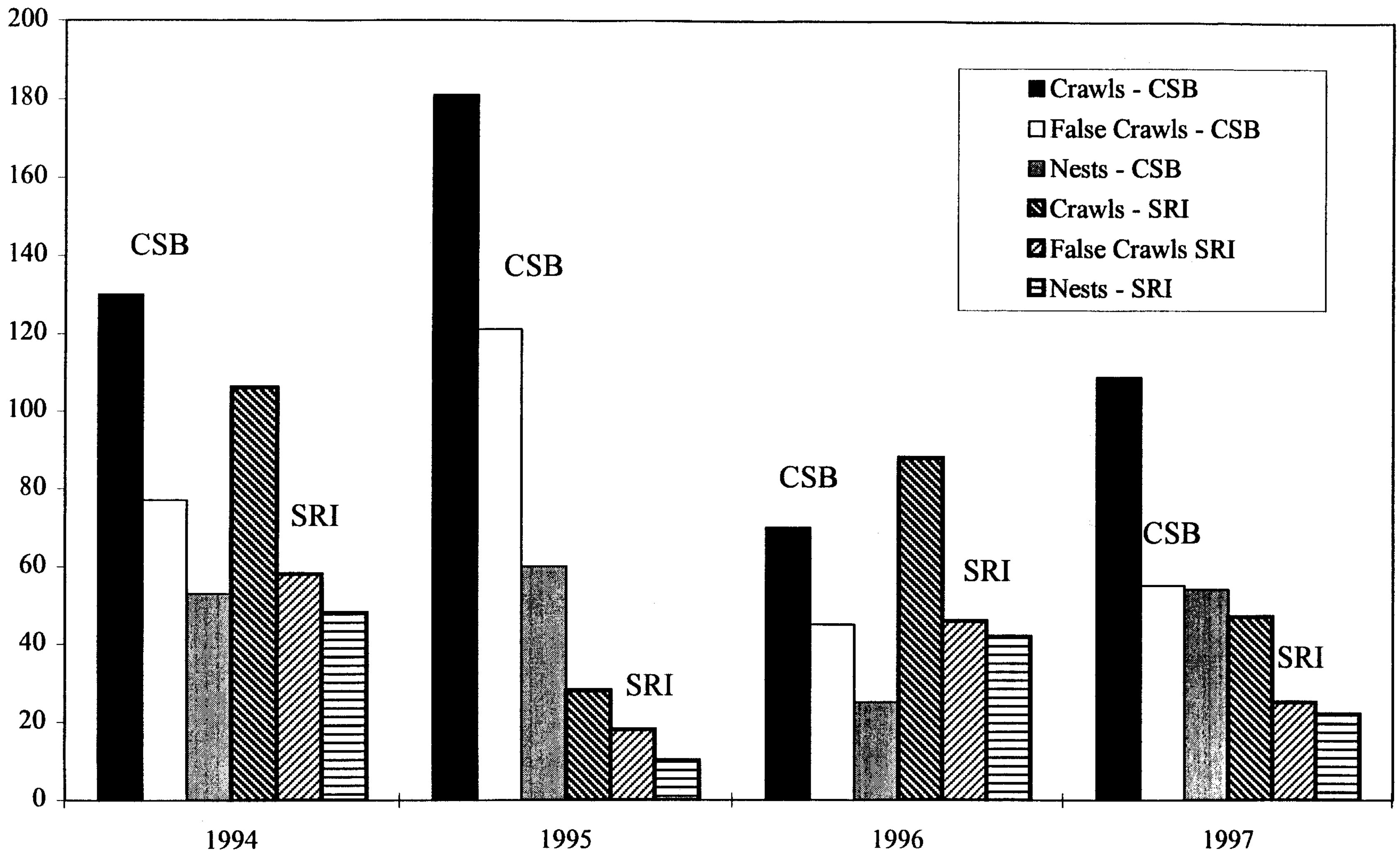

Figure 3. Number of sea turtle crawls, false crawls and nests along Eglin Air Force Base on Cape San Blas and Santa Rosa Island, Florida from 1994 to 1997

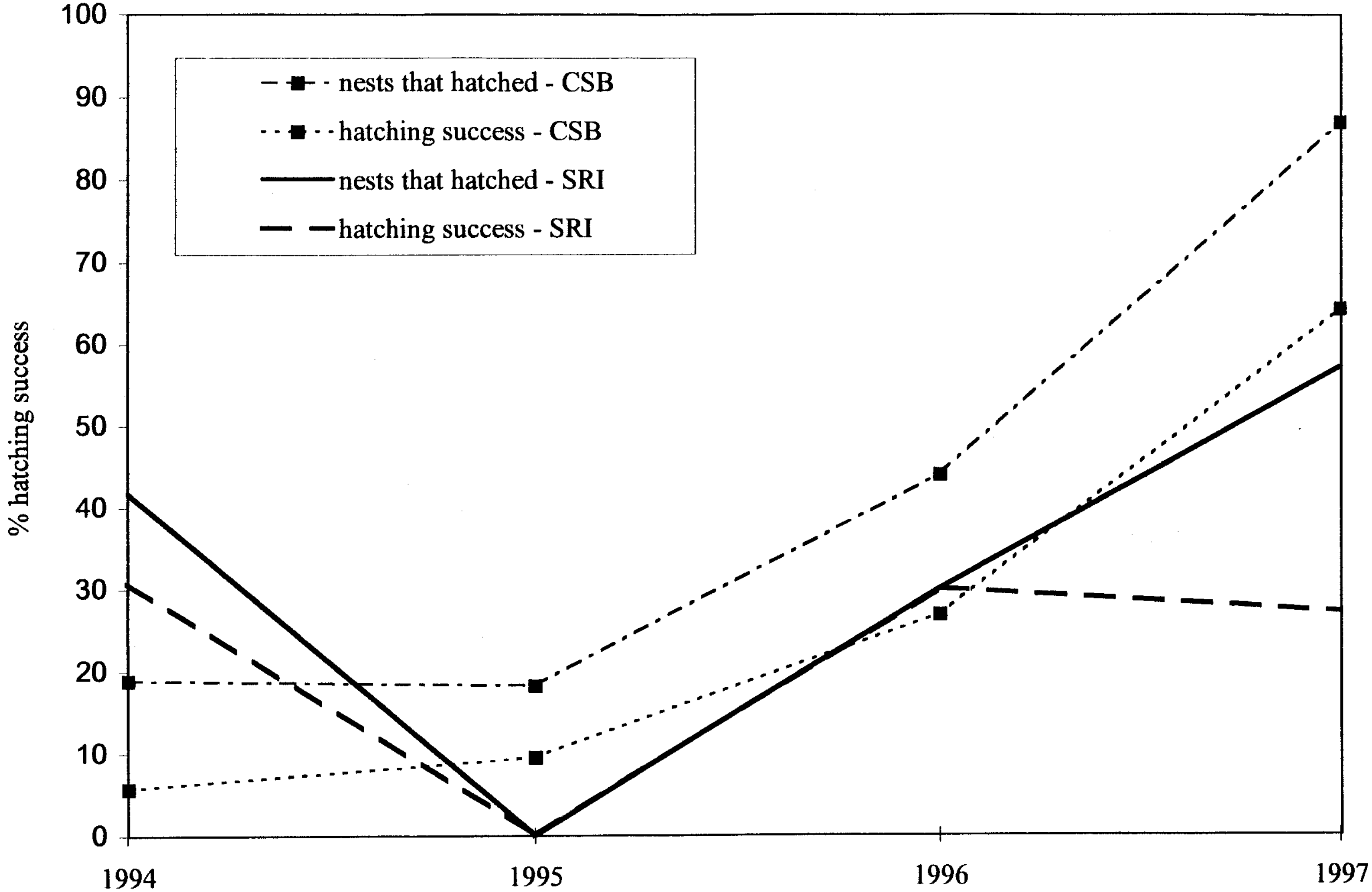

Figure 4. Hatching success and percent nests that hatched at least one egg along Eglin Air Force Base on Cape San Blas and Santa Rosa Island, Florida from 1994 to 1997

Table 1. A summary of the sea turtle crawls that occurred along Eglin Air Force Base on Cape San Blas (a.) and Santa Rosa Island (b.), Florida from 1994 to 1997.

a.

	1994	1995	1996	1997
Total # Crawls	131	181	70	109
Total # False Crawls	77	121	45	55
Earliest	May 19	May 16	May 27	May 15
Latest	Aug. 13 (N)	Aug. 22	Aug. 15	Aug. 12
May	0 (0.00%)	10 (8.30%)	1 (2.20%)	6 (10.9%)
June	29 (37.7%)	49 (40.5%)	24 (53.3%)	21 (38.2%)
July	30 (39.0%)	55 (45.5%)	16 (35.6%)	24 (43.6%)
August	18 (23.4%)	7 (5.80%)	4 (8.90%)	4 (7.30%)
North	40 (51.9%)	56 (46.3%)	17 (37.8%)	26 (47.3%)
Cape	31 (40.3%)	43 (35.5%)	15 (33.3%)	17 (30.9%)
East	6 (7.79%)	22 (18.2%)	13 (28.9%)	12 (21.8%)

b.

	1994	1995	1996	1997
Total # Crawls	106	28	88	47
Total # False Crawls	58	10	46	25
# Loggerhead	44 (75.9%)	28 (100%)	34 (73.9%)	47 (100%)
# Green	14 (24.1%)	0 (0.00%)	12 (13.6%)	0 (0.00%)
Earliest	May 23	May 25 (N)	May 27	May 28
Latest	Aug. 23	Aug. 8 (N)	Aug. 17 (N)	Aug. 14 (N)
May	7 (12.1%)	2 (20.0%)	4 (8.70%)	4 (16.0%)
June	19 (32.8%)	5 (50.0%)	19 (41.3%)	11 (44.0%)
July	20 (34.5%)	2 (20.0%)	19 (41.3%)	8 (32.0%)
August	12 (20.7%)	0 (0.00%)	6 (13.0%)	2 (8.00%)

Table 2. A summary of the sea turtle nests laid along Eglin Air Force Base on Cape San Blas and from 1994 to 1997.

	1994	1995	1996	1997
Total # nests	53	60	25	54
Earliest	May 19	May 25	June 7	May 19
Latest	Aug. 12	Aug. 18	Aug. 10	Aug. 11
May	2 (3.77%)	3 (5.00%)	0 (0.00%)	3 (5.60%)
June	13 (24.5%)	18 (30.0%)	13 (52.0%)	27 (50.0%)
July	29 (54.7%)	37 (61.7%)	10 (40.0%)	22 (40.7%)
August	4 (7.55%)	2 (3.33%)	2 (8.00%)	2 (3.70%)
North	12 (22.6%)	16 (26.7%)	21 (48.0%)	36 (66.7%)
Cape	23 (43.4%)	34 (56.7%)	8 (32.0%)	10 (18.5%)
East	18 (34.0%)	10 (16.7%)	5 (20.0%)	8 (14.8%)
Avg. clutch size	102.7	89.1	96.2	112.4
Hatching success	5.73%	9.54%	26.9%	64.3%
# nests hatched at least 1 egg	10 (18.9%)	11 (18.3%)	11 (44.0%)	47 (87.0%)
Avg. incub. length	64.7	55.9	64.2	

Table 3. A summary of sea turtle nesting activity along Eglin Air Force Base on Santa Rosa Island, Florida from 1994 to 1997.

	1994		1995		1996		1997	
	L	G	L	G	L	G	L	G
Total # nests	32	16	18	0	28	14	22	0
Earliest	May 25	June 2	May 25	--	June 9	June 7	May 29	--
Latest	Aug. 7	Aug. 5	Aug. 8	--	Aug. 8	Aug. 17	Aug. 14	--
May	2 (6.3%)	0 (0.00%)	1 (5.56%)	--	0 (0.00%)	0 (0.00%)	1 (4.55%)	--
June	15 (46.9%)	4 (25.0%)	9 (50.0%)	--	16 (38.1%)	4 (28.6%)	13 (59.1%)	--
July	12 (37.4%)	10 (62.5%)	7 (38.9%)	--	9 (32.1%)	7 (50.0%)	5 (22.7%)	--
August	3 (9.4%)	2 (12.5%)	1 (5.56%)	--	2 (7.10%)	2 (14.3%)	3 (13.6%)	--
Avg. clutch size	129.1	108.8	115	--	121.8	109.3	96.2	--
Hatching success	25.0%	42.4%	0.00%	--	31.6%	14.7%	27.2%	--
# nests hatched at least 1 egg	11 (34.4%)	10 (62.5%)	0	--	19 (67.9%)	5 (35.7%)	15 (68.2%)	--
Avg. incub. length	70.2	64.8	0	--	70.0	73.4	75.7	--

Table 4. Summary of relocated sea turtle nests along Eglin Air Force Base on Cape San Blas (a) and Santa Rosa Island (b), Florida from 1994 to 1997.

a.

	1994	1995	1996	1997
# relocated nests	19 (35.8%)	36 (60.0%)	15 (60%)	43 (79.6%)
Hatching success - rel.	3.23%	9.28%	44.9%	72.2%
in situ	7.12%	9.94%	0.00%	33.8%
at least one hatchling - rel	7 (20.6%)	10 (27.8%)	10 (66.7%)	41 (75.9%)
in situ	3 (15.8%)	5 (20.8%)	0 (0.00%)	6 (54.5%)
Incubation length - rel.	66.0 days	56.5 days	64.2 days	62.2 days
in situ	64.1	56.2	0	53
Avg. clutch size - rel.	102.2 eggs	96 eggs	107.7 eggs	112.2 eggs
in situ	104.4	76.1	79.0	112.9

b.

	1994		1995		1996		1997	
	L	G	L	G	L	G	L	G
# relocated nests	5	0	4 (22.2%)	0	15 (53.6%)	1 (6.30%)	1 (4.50%)	0
Hatching success - rel.	16.8%	--	0.00%	--	39.2%	0.00%	35.9%	-
in situ	26.5%	--	0.00%	--	22.9%	15.9%	26.8%	-
At least one hatchling - rel	2 (40%)	--	0 (0.00%)	--	11 (73.3%)	0 (0.00%)	1 (100%)	-
in situ	9 (33.3%)	--	0 (0.00%)	--	8 (61.5%)	5 (38.5%)	14 (66.7%)	-
Incubation length - rel.	73 days	--	--	--	67.2 days	--	74.0 days	-
in situ	69.6 days	--	--	--	73.3 days	73.4 days	75.9 days	-
Avg. clutch size - rel.	107.5 eggs	--	N/A	--	119.9 eggs	101 eggs	142 eggs	-
in situ	134.5 eggs	--	N/A	--	104.0 eggs	109.9 eggs	92.9 eggs	-

Table 5. Summary of storm and predator damage to sea turtle nests along Eglin Air Force Base on Cape San Blas (a.) and Santa Rosa Island (b.), Florida from 1994 to 1997.

a.

	1994	1995	1996	1997
# lost to erosion	33 (62.3%)	17 (28.3%)	0 (0.00%)	0 (0.00%)
# depredated	4 (7.55%)	27 (45.0%)	14 (56.0%)	12 (22.2%)
coyotes	4	27	14	--
raccoons	--	--	--	--
ghost crabs	--	1 partial	--	9 partial
fire ants	--	--	--	4 partial
unknown	--	--	--	2 partial

b.

	1994	1995	1996	1997
# lost to erosion	16 (33.3%)	17 (94.4%)	1 (2.38%)	4 (18.2%)
# depredated	8 (16.7%)	1 (5.60%)	25 (59.5%)	12 (54.5%)
coyotes	--	--	14	--
raccoons	5	--	1 partial	--
foxes	--	1 partial	16	12
ghost crabs	1 partial	1 partial	3 partial	6 partial
fire ants	1 partial	--	--	--
unknown	1	--	--	--