

BROWARD COUNTY SEA TURTLE CONSERVATION PROGRAM

2019 Technical Report



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Finally, we would like to thank all of the individuals and groups that participated in our education and outreach efforts this year, making another great season for the BCSTCP and for Broward County's sea turtles!

Executive Summary

The BCSTCP is funded and administered by the Broward County Board of County Commissioners through the Environmental Planning and Community Resilience Division (EPCRD) and carried out by Nova Southeastern University (NSU) to conduct sea turtle nesting surveys daily from March 1–October 31, 2019 for all Broward County beaches excluding Dr. Von D. Mizell-Eula Johnson State Park (Mizell-Eula State Park; monitored by Park staff). All loggerhead, green and leatherback turtle crawls (nests and false crawls) were identified to species and recorded by Geographic Positioning System (GPS). All nests were marked using wooden stakes and Red-Glo flagging tape and monitored throughout the season until they hatched or reached a maximum incubation time determined by FWC guidelines.

A total of 3,647 (2,813 loggerhead, 788 green, 43 leatherback, and 3 unknown species) nests were deposited in Broward County from March 9 to September 22, 2019. This was a record-setting nesting season with 60 more nests than the 2017 season, which was the previous record high nesting season since the BCSTCP's inception in 1981. Loggerhead turtles led the nesting again this year with 2,813 nests, which is 80 more nests than last year. Loggerheads fell a little short of the five-year average of 2,916 nests per season. Green turtles laid a record setting 788 nests, which were 652 nests above last year and 123 more than the previous high record green turtle nest season in 2017. A high nesting year was anticipated since the local population of green turtles appears to have a biennial reproductive cycle where an individual may only return to nest every two years in most cases. The 2018 season was a low nesting year for green turtles, and so high green turtle nesting was expected in 2019. This season was much higher than the five-year average of 437 green turtle nests. Leatherback turtles are the least common nesters in Broward County, laying 43 nests in 2019. This season, leatherback nesting was well above the five-year average of 27 nests.

Nesting success (nests/(nests + false crawls)) averaged 47.56% for all species combined, 3.13% higher than the 2018 season and about 3% higher than the five-year average of 44.46%. Loggerhead nesting success was 45.46%, slightly higher than 2018 (43.87%), and about 2% higher than the five-year average of 43.15%. Green turtle nesting success was 55.10%, about 1.5% higher than 2018 (53.54%) and slightly higher than the five-year average of 52.26%. Leatherbacks showed a decreased nesting success of 91.49%, compared to the 2018 season at 100% and fell about 2% below the five-year average of 93.08%.

Reproductive success was investigated for 2,310 nests after hatch-out (2,172 *in situ*, 67 relocated, and 71 restraining cage nests). Emergence success for *in situ* loggerhead nests in 2019 (77.56%) was very similar compared to 2018 (77.72%). Emergence success for *in situ* green nests in 2019 was 81.30%, which was about 6% higher than 2018. Emergence success for *in situ* leatherback nests rose considerably from 57.00% in 2018 to 64.52% in 2019.

The Hillsboro Beach survey zone had the most nesting in Broward County with an average of 355.58 nests/mile (218.43 nests/km; all species combined). The Hollywood Beach survey zone had the lowest nesting density with an average of 31.90 nests/mile (19.68 nests/km; all species combined).

The BCSTCP monitored sea turtle nesting activity relative to three renourishment projects in recent years and one active maintenance/bypass projects:

- Hillsboro/Deerfield Beach Nourishment Project (FDEP Permit No. 0289706-001 JC) placed approximately 37,285 cubic yards of sand from R6+750 feet south to R9. Sand placement concluded on April 1, 2018.
- Hillsboro Inlet Maintenance Dredging and Sand Bypass Project (FDEP Permit No. 0229394-001-JC) to place sand from R25 to R26+150 feet south. Sand placement is ongoing
- Broward County Segment II Beach Renourishment and Restoration Project (FDEP Permit No. 0314535-001-JC) placed approximately 710,300 cubic yards of sand from R36 to R41+300 feet south and R51 to R72). Sand placement concluded on December 28, 2016.
- FCCE Broward County Shore Protection Project Segment III (FDEP Permit No. 0135660-001-JC) placed approximately 134,810 cubic yards of sand from R98+400 feet south to R101 and R102 to R128+675 feet south. Sand placement concluded on May 10, 2019, and environmental monitoring concluded on May 16, 2019.

Introduction

Since 1978, the EPCRD and Broward County Board of County Commissioners have provided for the conservation of endangered and threatened sea turtles in Broward County, Florida. Florida's coastline experiences the densest sea turtle nesting in the United States. Broward County is classified by FWC as a medium-density nesting area in Florida and is in the normal nesting ranges of three species of sea turtles: loggerhead (*Caretta caretta*), green (*Chelonia mydas*), and leatherback (*Dermochelys coriacea*) turtles. In the coastal waters around Broward County, Kemp's ridley (*Lepidochelys kempii*) and hawksbill (*Eretmochelys imbricata*) sea turtles can also be found, but do not nest regularly in the area.

The leatherback is categorized as endangered in this region, while the loggerhead and green turtles are listed as threatened. The North Atlantic distinct population segment of green turtles (including Florida) was recently down-listed from endangered to threatened in 2016. All species of sea turtles in U.S. waters are protected under the U.S. Endangered Species Act of 1973 and Florida's Marine Turtle Protection Act (379.2431, Florida Statutes). These statutes protect all life history stages of sea turtles and therefore all conservation, monitoring, or research efforts require permitting by FWC. Permitting is administered by the U.S. Fish and Wildlife Service for sea turtles on land and the National Oceanic and Atmospheric Association (NOAA) protects all in-water turtles. All monitoring and conservation efforts for this program were administered and supported by the Broward County EPCRD and conducted by NSU as part of the BCSTCP.

Beach Renourishment Projects

Coastal development alters the natural accumulation and loss of sand on natural beaches. Broward County's highly developed and armored coastline calls for needed maintenance of beach profiles, beach width, and dune structures. To help mitigate erosion along sections of Broward County beaches, intermittent beach renourishment projects have been established in some areas of the County to ensure the continuation of coastal preservation, beach recreation and infrastructure protection. The EPCRD has maintained the sea turtle conservation and monitoring program in years with and without sand placement projects, to better understand the long- and short-term impacts of sand placement projects on nesting sea turtles. There have been four renourishment projects in recent years:

- Hillsboro/Deerfield Beach Nourishment Project (FDEP Permit No. 0289706-001 JC) placed approximately 37,285 cubic yards of sand from R6+750 feet south to R9. Sand placement concluded on April 1, 2018.
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Program Goals

The BCSTCP goals in 2019 were to:

- 1) Conduct daily sea turtle nesting surveys and beach monitoring for mechanical beach cleaning and various permitted projects and beach events.
- 2) Relocate or protect imperiled sea turtle nests to maximize hatchling survival.
- 3) Conduct nest evaluations to examine hatching success.
- 4) Conduct stranding and salvage activities and maintain a 24-hour sea turtle emergency hotline.
- 5) Inform and educate the public through educational seminars, public hatchling releases, and table events about sea turtles and sea turtle conservation/management.
- 6) Provide accurate and timely reporting.

Materials and Methods

Personnel

The BCSTCP works with protected species, therefore all sea turtle monitoring and work is authorized by FWC's Imperiled Species Management section (ISM) and was conducted by permitted individuals under Marine Turtle Permits #214, #215, #148 issued to Curtis Slagle (January 1–December 31, 2019). The FWC Marine Turtle Permit, FWC Marine Turtle Conservation Handbook, and the contract with Broward County were used to set procedures for all monitoring, stranding, and survey protocols for this program.

2019 BCSTCP Senior Staff

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Sea Turtle Nesting Surveys

Daily sea turtle nesting surveys were conducted by BCSTCP staff from March 1–October 31, 2019 for all Broward County beaches (24 miles) excluding Mizell-Eula State Park (previously John U. Lloyd State Park; 2.4 miles; Figure 1). Mizell-Eula State Park is an FWC Index Beach that is used by researchers following a standardized set of survey protocols and specific beaches to monitor the long-term nesting trends of marine turtles in Florida. Survey protocols and data collected on FWC Index Beaches are slightly different from the data that are collected throughout the rest of Broward’s beaches, so some information may not be recorded in this area and therefore will be left out of parts of this technical report. Park rangers carried out surveys in Mizell-Eula State Park and they provided all data for this survey area.

Surveys began 30 minutes before sunrise each day and were conducted using ATVs (Honda Rancher 420, Honda Pioneer 500 Side x Side). For survey purposes, Broward County was divided into five survey zones: Hillsboro and Deerfield Beaches (Hillsboro), Pompano Beach including Lauderdale-By-The-Sea (Pompano), Fort Lauderdale, Mizell-Eula State Park, and Hollywood and Hallandale Beaches including Dania Beach (Hollywood; Table 1; Figure 2). For all survey zones, except Mizell-Eula State Park, nest locations were referenced to Florida Department of Environmental Protection (FDEP) range monuments (R-zone) numbered consecutively (north to south) from R1-R128.

Data Collection, Management, and Analysis

All nesting and non-nesting emergences (false crawls) were recorded and locations marked by GPS when they were first encountered on the survey. Data were recorded on paper data sheets and electronically using a Sonim XP-7 device with the VJGames GPS Coordinates and ZohoForms applications in the field. The VJGames GPS Coordinate application uses GPS, Wi-Fi, and mobile networks to determine location. All nests were additionally marked with a Trimble GeoExplorer 6000 Series or Trimble GeoExplorer 2008 Series (<1 m accuracy) to allow for precise nest reestablishment throughout the season if necessary (stakes lost, nest washout, vandalism, etc.). Nest GPS was taken over the center of the clutch when it was verified, the approximate clutch location when it was not known, or at the apex of a false crawl. To ensure crawls were not double counted, after all data were collected from a crawl and it was marked accordingly, the tracks (not the nest site) were driven over with an ATV to indicate they have already been documented.

The following information was recorded for each crawl:

- 1) Survey zone referenced to nearest property and R-zone monument marker
- 2) Crawl type (nest or false crawl)
- 3) A unique identifying number (generated using beach code and nest or false crawl number)
- 4) Date crawl was discovered
- 5) Species identification
- 6) Measurement from nest or apex of false crawl to the previous night's high tide line
- 7) Crawl characteristics (e.g. crawl width, number of body pits or abandoned egg chambers, etc.)
- 8) Final nest treatment (*in situ*, relocation, restraining cage)
- 9) If the turtle encountered an obstruction (ONA)
- 10) If the turtle disoriented

The Data Manager entered data daily into an Excel spreadsheet, all field data sheets were photocopied, and originals were held until all analysis and reporting requirements were complete. All data were verified by at least one additional senior staff member after being entered and before analysis. Data analyzed and presented in this report were compiled using Microsoft Excel 2008 for Mac and JMP Pro 12. All maps were constructed in ESRI ArcGIS 10.6.1 (GCS North American NAD 1983 projection). Historical nesting, nesting success, hatching success trends, and reproductive success were analyzed using analysis of variance for linear regression.

Treatment Zones

Survey zones were further broken down into treatment zones based on different management tools/strategies to minimize unwanted natural and anthropogenic influences in the area. Treatment zones were broken down into "donor," "*in situ* & recipient," "restraining cage," or "*in situ*" categories (Table 2, Figure 3).

All nests classified as "*in situ*" (did not undergo nest relocation) were marked with a minimum of four stakes (one signed stake [see Appendix 1 for example of nest sign], at least three non-signed stakes) with a circle of Red-Glo flagging tape with a radius of at least three feet centered on the clutch. The top of the signed stake was painted white to facilitate clear data recording on the stake. For sites where a clear dig sight could not be identified, the whole area of disturbed sand was encircled with flagging tape. If during the season the nest markers were lost, washed away, vandalized, etc. the nest was reestablished using the Trimble sub-meter GPS units. Upon reestablishment, nests were marked with a circle of Red-Glo flagging tape with at least a five feet radius centered on the nest site.

Nest Relocation

Nests deposited in areas that were deemed “donor zones” by FWC or that were laid below the previous night’s high tide line were relocated to the nearest “recipient zone” or west of the original nest location, respectfully, to ensure the highest possible hatching success. All nests were relocated before 9 am the morning after they were deposited. Each nest was carefully dug by hand and the eggs were transported in buckets containing damp sand from the original nest chamber. Special care was taken to leave eggs in their natural orientation (how they were sitting in the original chamber created by the nesting mother) to minimize mortality of the embryos during transportation. A new “nest chamber” was dug by hand to the same depth/width/shape as the original nest chamber, eggs were placed in the chamber and reburied following the FWC Marine Turtle Conservation Handbook (2016).

Relocated nests were marked with three stakes (one signed stake, two unsigned stakes) in a triangle with the egg chamber in the middle and surrounded with Red-Glo flagging tape. All relocated nests were evaluated post-hatching for hatching success unless extenuating circumstances (washout, vandalism, etc.) made post-hatching analysis impossible.

Restraining Cages

Restraining cages were used as a temporary management tool for zones of high artificial lighting trespass on the beach, as specified by the FWC permit (Figure 3). In all “restraining cage” zones, egg chambers were located for each nest during the daily survey and nests were marked as per standard procedures for “*in situ*” nests. Restraining cages were constructed for every other loggerhead nest in the “restraining cage” zones, as per the FWC permit. Cages were deployed at 45 days (the beginning of the hatch out window) and monitored until at least 72 hours post-emergence or until the nest reached 70 days incubation time.

Cages were constructed of a thick plastic mesh ($\frac{3}{4}$ inch x $\frac{3}{4}$ inch) lined with window screen on the inside of the cage to minimize hatchling entanglement in the cage and protect hatchlings from predators that may reach through the mesh. Cages were a cylinder (24-inch diameter and height), with a flat mesh top secured in place and an access hatch in the top to facilitate hatchling retrieval. Additionally, a door was cut into the eastern side of the cage that was opened during the day so hatchlings that may emerge during the day could escape and not desiccate in the cage during the heat of the day (Appendix 2a). An informative sign was affixed to the outside of the cage with the pertinent response phone numbers if a turtle was found in the cage (Appendix 2b).

For cage construction, the enclosure was placed centered over the top of the egg chamber, a trench was dug around the base of the cage, and the base of the cage was buried in the ground 4-6 inches and then secured to stakes to hold it in place. Daily cage monitoring consisted of closing the eastern door at sunset each day, checking the

cage for hatchling activity at least once between 23:00 and 01:00 each night (any hatchlings encountered were removed from the cage and released), and opening the eastern door at sunrise each morning.

Reproductive Success Evaluations

When possible, nests were excavated and assessed for reproductive success at least 72 hours post-hatchout. If a hatchout was not observed, nests were excavated and assessed after a 70-day incubation period for green and loggerhead nests and 80 days for leatherback turtles; after this time the nests are no longer considered viable (FWC Handbook, 2016). Each nest was carefully dug by hand.

The following data were collected for each inventoried nest:

- 1) Hatched eggs
- 2) Live hatchlings in nest (LIN)
- 3) Dead hatchlings in nest (DIN)
- 4) Live pipped hatchlings (LPIP)
- 5) Dead pipped hatchlings (DPIP)
- 6) Whole, unhatched eggs

Clutch size was calculated as: Hatched eggs, plus LPIP, plus DPIP.

Emergence success for each nest was calculated as: Hatched eggs, minus LIN, plus DIN; divided by clutch size.

Hatchlings released for each nest was calculated as: Hatched eggs, minus DIN, plus LPIP.

Lighting Surveys

Surveys for artificial lighting on Broward County beaches were conducted once each month from March–September 2019 for all survey zones. Surveyors walked each section of beach after dark (commencing between 22:00 and 00:00) to document light fixtures that were not in compliance with local lighting ordinances. A small lighting survey team worked the same sections of beach each month to allow the highest level of familiarity with the properties surveyed, minimizing human error and discretion thus providing better long-term tracking of lighting non-compliance throughout the season. Survey protocols followed standard techniques as described by the FWC Technical Report: Understanding, Assessing, and Resolving Light-Pollution Problems on Sea Turtle Nesting Beaches (Witherington et al., 2014) and Chapter 62B-55, Florida Administrative Code Model Ordinance for Marine Turtle Protection; both documents identify compliant and noncompliant fixtures/bulbs depending on fixture type, bulb type, light wavelength, etc. Properties that exhibited potentially impactful lighting were photographed to better track individual property lighting throughout the season. All lights/fixtures that may impact sea turtle nesting or hatchling behavior were documented

on a standardized “BCSTCP Lighting Survey Data Sheet” which is broken down by light/fixture type and property/address. Each coastal municipality in Broward County has adopted and enforces their local Sea Turtle-Friendly Lighting Ordinance. These ordinances vary slightly, but follow the general recommendations outlined in the Model Ordinance. A list of common lighting types found in Broward County can be found in Appendix 3 and are more fully outlined in the Broward County Sea Turtle Conservation Program Lighting Survey 2019 Summary Report (Broward County, 2019).

Lighting survey reports were submitted to the Broward County Contract Administrator and FWC ISM staff monthly. These reports were ultimately sent to code enforcers in each Broward County coastal municipality for targeted rectification and enforcement actions if necessary.

Strandings

A Sea Turtle Emergency Line is monitored year-round 24 hours a day in Broward County and most members of the BCSTCP are trained in sea turtle stranding response. The emergency line receives many calls throughout the year (Appendix 4), including turtle stranding calls. When a stranding call is received on the emergency line, a member of the sea turtle stranding team is dispatched with a stranding kit, which contains all of the necessary equipment (tag reader, measuring tape, data sheets, knife, pens/pencils, spray paint, trash bags, gloves, etc.) to document the event. Each stranding event is documented using a standardized form from FWC, and similar information is collected whether the animal is alive or deceased. Some of these data include species, sex (if mature), morphometrics, injuries, presence of tags, etc. Each stranding event is reported to the FWC Sea Turtle Stranding and Salvage Network Coordinator within 24 hours; depending on the state of the turtle, instructions are given on transportation to a rehabilitation facility (live stranding) or salvage/burial (deceased). If possible, deceased turtles are marked with spray paint to indicate that the animal has been documented and then are buried on or off the beach. A summary of the BCSTCP stranding responses in 2019 can be found in Appendix 5.

Disorientation Events and Obstructed Nesting Attempts

Three volunteer organizations: STOP, SFAS, and STARS had a strong presence on Broward County beaches again this year. These programs monitored nest hatch outs at night and reported disorientation events separately from the BCSTCP. A disorientation event is defined as either an adult or hatchling sea turtle that does not orient or travel toward the sea, but instead travels in a direction that is more than 45 degrees from the beach-ocean interface. Most of these events can be tied to a bright anthropogenic light source that may be misleading from what would naturally be the brightest point on the horizon (how the nesting mothers and hatchlings typically orient themselves). Historically, the brightest point on the horizon was the moon and stars over the ocean.

The STOP, SFAS, and STARS groups monitor most County beaches; however, their efforts are focused in the areas most impacted by anthropogenic lighting.

When an organization (BCSTCP, STOP, SFAS, or STARS) observed a hatchling disorientation event, the nest was marked with the date of hatch out on colored flagging tape to avoid report duplication among groups. In addition, each event was documented using a Marine Turtle Disorientation Report Form and logged into the FWC Online Disorientation Report mobile app. Analyses were conducted using BCSTCP data only as well as all disorientation reports logged by all groups in Broward County. Adult disorientations were observed and reported only by the BCSTCP; Disorientation Forms were filed for these instances, but no analysis was performed on these data.

When a nesting female encountered an obstruction (escarpment, beach furniture, sea wall, rocks, etc.) that impacted her nesting attempt, a Marine Turtle Obstructed Nesting Report (ONA) Form was submitted to FWC as well as recorded using the FWC ONA Reporting mobile app. An impact to the female's nesting attempt was characterized by the obstruction causing her to change direction, become entangled, etc.

Education and Outreach Initiatives

One of the leading missions of the BCSTCP is community outreach and education. In 2019, a total of 102 education and outreach events were held. Each event educated residents and visitors of Broward County about sea turtles. With all these events, the BCSTCP was able to reach out to over 48,670 individuals (Appendix 6).

Results

Sea Turtle Nesting Surveys

The 2019 sea turtle nesting surveys in Broward County started on March 1, 2019, and the first crawl of the season was a leatherback nest discovered on March 9, 2019. A total of 7,668 emergences were documented for all of Broward County resulting in a record-setting 3,647 nests and 4,021 false crawls (Figure 4) or a 47.56% nesting success for all species (Figure 5). This is slightly above last year's nesting success at 44.43% and above the five-year average nesting success for all species of 44.46%.

Following the general trend, leatherback turtles were the first species to nest in Broward County in 2019 (Figure 6a), followed by loggerhead turtles (Figure 6b), and then green turtles (Figure 6c).

Leatherback Sea Turtles (*Dermochelys coriacea*)

Overall Nesting Activity

Leatherback turtles are historically the least frequent nesting species in Broward County. This trend continued again for the 2019 season. A total of 47 crawls were

recorded in all of Broward County resulting in 43 nests and 4 false crawls for a County-wide nesting success for leatherback turtles of 91.49% (Table 3a). This represents an 8.51% decrease in nesting success compared to 2018 and is 1.59% lower than the five-year average leatherback nesting success of 93.08% (Figure 7a). Leatherback nesting has experienced a significant increase over the life of the Program with an average increase of 0.68 nests per year from 1981-2019. Regression shows a highly significant positive trend ($F(1,37) = 16.56, P < 0.001$; Figure 8a).

Temporal Patterns

The first leatherback nest was deposited on March 9, 2019 and the first leatherback false crawl was documented on March 25, 2019 for the 2019 season. March 31, April 5, 30, May 1, 3, 9, 10, and 19 each saw 2 leatherback nests each day. The last leatherback nest was deposited on June 7, 2019 (Figure 6).

Spatial Patterns

Leatherback crawls were recorded in all survey zones except Mizell-Eula State Park. County-wide, leatherback turtles laid an average of 1.80 nests/mile (1.11 nests/km). The highest leatherback nesting density was seen in Hillsboro with 4.42 nests/mile (2.71 nests/km) and was lowest in Mizell-Eula State Park where no leatherback nests were documented (Table 4a).

Incubation Periods

Incubation periods were determined for 32 leatherback nests left *in situ* on Broward County beaches (excluding Mizell-Eula State Park) in 2019. The overall 2019 season incubation periods for leatherbacks ranged from 55-79 days with a mean incubation period of 62.94 days.

Reproductive Success

Reproductive success was assessed for 33 leatherback nests left *in situ* in Broward County. The 33 nests resulted in 3055 eggs were laid and 1,971 hatchlings released for an emergence success of 64.52% (Table 5a). This represents a 7.52% higher emergence success than was observed in 2018 (57.00%).

The highest emergence success for *in situ* nests was found on Ft Lauderdale Beach at 72.38% (10 nests evaluated). The lowest emergence success of *in situ* nests was 41.01% (7 nests evaluated), observed in Pompano (Table 6a).

Loggerhead Sea Turtles (*Caretta caretta*)

Overall Nesting Activity

Loggerhead nesting made up the majority of the nesting activity in Broward County in 2019. A total of 6,188 crawls were recorded for loggerhead turtles in all of Broward County: 2,813 nests and 3,375 false crawls, which resulted in a nesting success of 45.46% (Table 3b). This is slightly higher than the loggerhead nesting success from last year (43.87%) and is ~2% higher than the five-year average of 43.15% (Figure 7b). Loggerhead nesting has experienced a significant increase over the life of the program with an average increase of 35.93 nests per year from 1981-2019. Regression shows a highly significant positive trend ($F(1,37) = 35.98, P < 0.001$; Figure 8b).

Temporal Patterns

The first loggerhead nest was deposited on April 13, 2019 and the first loggerhead false crawl was documented on April 15, 2019. Highest daily nesting was recorded on June 15, 2019 when 82 loggerhead nests were discovered in Broward County. The last loggerhead nest was deposited on September 5, 2019, and the last false crawl was recorded on August 28, 2019 (Figure 6b).

Spatial Patterns

Loggerhead nests and false crawls were recorded in all survey zones with an average of 117.70 nests/mile (73.14 nests/km) across the entire survey area. Hillsboro experienced the highest loggerhead nesting with 216.05 nests/mile (132.71 nests/km) and Hollywood showed the lowest loggerhead nesting density with 28.97 nests/mile (17.87 nests/km; Table 4b).

Incubation Periods

Incubation periods were determined for 1,750 loggerhead nests left *in situ* on Broward County Beaches (excluding Mizell-Eula State Park) in 2019. Incubation periods ranged from 46-68 days with a mean incubation period of 50.45 days.

Reproductive Success

Reproductive success was investigated in 1,744 *in situ* loggerhead nests across Broward County (excluding Mizell-Eula State Park) in 2019. In these evaluated nests 182,156 eggs were laid resulting in 141,281 hatchlings released for an emergence success of 77.56% (Table 5a). This is very similar to the *in situ* loggerhead emergence success from the 2018 season (77.72%).

The highest emergence success in nests left *in situ* were those evaluated in Hollywood Beach with an emergence success of 86.17%; the lowest emergence success of *in situ* nests was in Hillsboro Beach at 68.99% (Table 7a).

Reproductive success was investigated in 57 relocated loggerhead nests across Broward County (excluding Mizell-Eula State Park) in 2019. In these evaluated nests 5,321 eggs were laid resulting in 3,340 hatchlings released for an emergence success of 62.77% (Table 7b). This was 2.86% higher than the relocated loggerhead emergence success from the 2018 season (59.91%).

Reproductive success was investigated in 71 caged loggerhead nests across Broward County (excluding Mizell-Eula State Park) in 2019. In these evaluated nests 7,327 eggs were laid resulting in 5,817 hatchlings released for an emergence success of 79.39% (Table 7c). This was 1.75% higher than the caged loggerhead emergence success from the 2018 season (77.64%).

Green Sea Turtles (*Chelonia mydas*)

Overall Nesting Activity

Green turtles are historically the second most frequent nesters in Broward County. This trend continued again for the 2019 nesting season. A total of 1,430 crawls were recorded for green turtles in all of Broward County. A record-setting total of 788 nests and 642 false crawls resulted in a County-wide green turtle nesting success of 55.10% (Table 3c). This represents a 2% increase in nesting success compared to 2018 and is 2.84% higher than the five-year average green turtle nesting success of 52.26% (Figure 7c). Like the other species, green nesting has experienced a significant increase over the life of the program with an average increase of 10.70 nests per year from 1981-2019. Regression shows a highly significant positive trend ($F(1,37) = 34.17$, $P < 0.001$; Figure 8c).

Temporal Patterns

The first green turtle nest was deposited on May 9, 2019 and the first green turtle false crawl was documented on May 18, 2019. Highest daily nesting was recorded on July 19, 2019 when 25 green nests were discovered that morning in Broward County. The last green turtle nest was deposited on September 22, 2019 and the last green false crawl was deposited on September 18, 2019 (Figure 6c).

Spatial Patterns

Green turtle nests and false crawls were recorded in all survey zones resulting in a County-wide green turtle average nesting density of 32.97 nests/mile (38.60 nests/km). The highest green nesting density was in Hillsboro Beach with 135.35 nests/mile (84.10

nests/km), and the lowest was in Hollywood Beach with 2.07 nests/mile (1.28 nests/km; Table 4c).

Incubation Periods

Incubation periods were determined for 412 green turtle nests left *in situ* on Broward County Beaches (excluding Mizell-Eula State Park) in 2019. Incubation periods ranged from 44-69 days with a mean incubation period of 51.31 days.

Reproductive Success

Reproductive success was evaluated for 394 green turtle nests that were left *in situ* in 2019. There were 43,567 eggs deposited in the evaluated nests resulting in 35,418 hatchlings released for an emergence success of 81.30% (Table 5a). The 2019 season had more nests evaluated than 2018, and the emergence success was about 5.51% higher than that recorded in 2018 (75.79%).

The highest emergence success for *in situ* nests was found on Pompano Beach at 91.02% (24 nests evaluated). The lowest emergence success of *in situ* nests was 77.46% (284 nests evaluated), observed in Hillsboro Beach (Table 8a).

Reproductive success was investigated in 9 relocated green nests across Broward County (excluding Mizell-Eula State Park) in 2019. In these evaluated nests 780 eggs were laid resulting in 449 hatchlings released for an emergence success of 57.56% (Table 8b). This was 14.64% lower than the relocated loggerhead emergence success from the 2018 season (72.20%).

Beach Renourishment Projects

Hillsboro/Deerfield Beach Nourishment Project

The Hillsboro/Deerfield Beach Nourishment Project (R6-R8) was a small renourishment project that placed approximately 375,000 cubic yards of sand across 7,175 linear feet of shoreline miles. This project concluded on April 11, 2011 but in 2015, an amendment to this project permitted the placement of an additional 50,000 cubic yards of truck haul fill from Broward County Borrow Area 1 in the same 7,175 linear feet of shoreline. Now in 2018 (FDEP Permit No. 0289706-001 JC) placed approximately 37,285 cubic yards of sand from R6+750 feet south to R9. Sand placement concluded on April 1, 2018.

Nesting Success

The Hillsboro/Deerfield Beach Nourishment Project accounted for 1 leatherback nest and no false crawls in the project area (Table 9a). Loggerheads laid 115 nests and 166 false crawls for a nesting success of 40.93% (Table 9b). There were 65 green turtle nests laid and 70 false crawls in the project area for a nesting success of 48.15% (Table 9c).

Reproductive Success

The Hillsboro/Deerfield Beach Nourishment Project had one leatherback nest was evaluated for reproductive success with 103 eggs and 79 hatchlings released for an emergence success of 76.70% in the project area. There were 71 loggerhead nests that were evaluated for reproductive success. The 71 nests resulted in 7,019 eggs with 5,102 hatchlings released for an emergence success of 72.69%. There were 26 green nests evaluated for reproductive success resulting in 2792 eggs with 1,979 hatchlings released for an emergence success of 70.88% (Table 10a).

Hillsboro Inlet Maintenance and Sand Bypass Project

The Hillsboro Inlet Maintenance and Sand Bypass Project in Hillsboro Beach (R25-R26) is a small maintenance and sand bypass project at the Hillsboro Inlet and moves sand as necessary across a 0.21 mile stretch of beach.

Nesting Success

The Hillsboro Inlet Maintenance and Sand Bypass Project saw no leatherback crawls in the area this season (Table 9a). However, 8 loggerhead nests and 8 false crawls were documented in the project area, resulting in a loggerhead nesting success in this project area of 50% (Table 9b). Green turtles laid 0 nests in the project area and 1 false crawls for a nesting success of 0.00% (Table 9c).

Reproductive Success

The Hillsboro Inlet Maintenance and Sand Bypass Project had 8 loggerhead nests evaluated for reproductive success. These nests resulted in 745 eggs and 531 hatchlings released for an emergence success of 71.28% (Table 10b).

Broward County Segment II Beach Renourishment and Restoration Project

The Broward County Segment II Project (R36-R41; R51-R72) placed approximately 607,000 cubic yards of upland sourced sand from January–April 2016. More sand was placed in November–December 2016 to reach the goal of placing 706,700 cubic yards of sand across 4.9 miles of beach.

Nesting Success

Within the project area, there were 11 leatherback nests and 1 false crawl for a nesting success of 91.67% (Table 9a). Loggerheads laid 547 nests and 660 false crawls for a nesting success rate of 45.32% (Table 9b). Green turtles laid 118 nests in the fill area and 112 false crawls for a nesting success of 51.30% (Table 9c).

Reproductive Success

The Broward County Segment II Project had 418 loggerhead nests that were evaluated for reproductive success. These nests resulted in 44,703 eggs laid and 36,517 hatchlings released for an emergence success of 81.69%. There were 84 green turtle nests evaluated resulting in 9,827 eggs and 8,935 hatchlings released for an emergence success of 90.92%. There were 10 leatherback nests evaluated resulting in 995 eggs and 651 hatchlings released for an emergence success of 65.43% (Table 10c).

FCCE Broward County Shore Protection Project Segment III

The FCCE Broward County Shore Protection Project Segment III (FDEP Permit No. 0135660-001-JC) placed approximately 134,810 cubic yards of sand from R98+400 feet south to R101 and R102 to R128+675 feet south. Sand placement concluded on May 10, 2019, and environmental monitoring concluded on May 16, 2019.

Nesting Success

The fill area had 5 leatherback nests and had no false crawls resulting in a nesting success of 100.00% (Table 9a). Loggerheads laid 157 nests and 248 false crawls for a loggerhead nesting success in the fill zone of 38.77% (Table 9b). Green turtles laid 12 nests and 18 false crawls for a nesting success of 40.00% (Table 9c).

Reproductive Success

The FCCE Broward County Shore Protection Project Segment III had 5 leatherback nests evaluated for reproductive success resulting in 534 eggs and 349 hatchlings released for an emergence success of 65.36% in the project area for the 2019 season. There were 130 loggerhead nests evaluated for reproductive success. These nests resulted in 13,035 eggs and 11,003 hatchlings released for an emergence success of 84.41%. There were 7 green nests evaluated for reproductive success resulting in 913 eggs and 763 hatchlings released for a reproductive success of 83.57% (Table 10d).

Relocation

A total of 71 nests (60 loggerhead, 10 green, 1 leatherback) were relocated throughout the 2019 nesting season. This accounted for 2.09% of all nests laid in Broward County (Figure 9). Of these 71 nests, 28 were relocated mid-incubation due to nest chamber washout or egg exposure, 8 were relocated because they were laid below the high tide line; of the remaining 35 nests, 31 were relocated because they were laid in a “donor” zone as specified by FWC and 4 were relocated as part of the FCCE Broward County Shore Protection Project Segment III during a period of active sand deposition.

Incubation Period

Incubation periods were determined for 51 relocated loggerhead nests. Relocated loggerhead nests had an incubation range of 45-59 days with a mean incubation period of 50.47 days. Incubation periods were calculated for 8 relocated green nests. Incubation periods for greens ranged from 45-60 days with an average of 50.00 days. Incubation period was calculated for 1 relocated leatherback nest that incubated for 63 days.

Reproductive Success

Reproductive success was calculated for 67 relocated nests (57 loggerhead, 9 green, and 1 leatherback). The 1 leatherback nest resulted in 114 eggs with 87 hatchlings released for an emergence success of 76.32% (Table 6b). The 57 loggerhead nests resulted in 5,321 eggs with 3,340 hatchlings released for an emergence success of 62.77%. The 9 green turtle nests resulted in 780 eggs with 449 hatchlings released for an emergence success of 57.56% (Table 5b).

Disorientation Events

The BCSTCP surveyors reported 143 (12 adult, 131 hatchling) disorientation events across Broward County on morning surveys (Figure 10). Fifty of these disoriented nests were in the Fort Lauderdale municipality and an additional 32 disoriented nests were in the Town of Lauderdale-By-The-Sea. Together these two municipalities accounted for 57.34% of all disorientation events reported by BCSTCP staff this season. The 2019 season saw nearly 6 fewer disorientation events than the 2018 season and was lower than the five-year Broward County average of 169.8 events (Figure 10).

To gain a more comprehensive understanding of the number of hatchling disorientation events in the entire County, all disorientation reports submitted to FWC by all sea turtle monitoring/volunteer groups (BCSTCP, STOP, SFAS, STARS) in Broward County (except Mizell-Eula State Park) were examined. A total of 889 nests experienced hatchling disorientation events out of 2049 nests where a hatch out was observed, yielding a 43.39% disorientation rate (Table 11); however, variation existed among beaches within the County. Fort Lauderdale experienced the highest hatchling disorientation rate at 71.35% (538 nests disoriented out of 754 observed hatch outs). Additionally, Lauderdale-By-The-Sea/Sea Ranch Lakes, and Pompano experienced at least 50% disorientation rates or higher. Dania and Hillsboro had the lowest hatchling disorientation rates with 0.00% (0 nests disoriented out of 4 observed hatchouts) and 2.25% (15 nests disoriented out of 666 observed hatchouts respectively (Table 11, Figure 11).

Predation and Poaching

In 2019, 42 nests (or 1.23% of all nests) in Broward County (excluding Mizell-Eula State Park) experienced predation. This is slightly higher than the 2018 season that had an overall predation rate of 0.26% and is 2.27% lower than the five-year predation average percentage of 3.5% (Figure 12). Broward County has seen relatively low predation rates from 2005-2017, reaching an all-time low in 2018 with only a slight increase again in 2019. A slight increase in predation in the 2013 and 2014 seasons was not continued during the 2015, 2016, or 2017 seasons, but fluctuating numbers suggest that continued monitoring of predation rates in this area would be beneficial. Traditionally, foxes are the primary predators of turtle nests in Broward County, however in 2019 raccoons showed the highest rates of predation and several unknown bird species were also documented preying on nests. The Hollywood survey zone experienced the lowest predation impact with one predation event. The Hillsboro survey zone experienced the highest predation rate with 2.42% of nests experiencing predation (Figure 13). This is slightly higher than the 2018 predation rate of 0.59% in Hillsboro but is still greatly reduced from the 2017 season, which saw a 10.76% predation rate and is still considerably lower than the 25% predation rate documented in Hillsboro in 2014.

In addition to predation impacts, 3 nests in Broward County were impacted by human disturbance/poaching/vandalism (0.09% of all nests laid). This is down from the 2018 season, which saw 0.17% of nests impacted due to human disturbance.

Restraining Cages

In the designated “restraining cage” zones, a total of 75 restraining cages were constructed on loggerhead turtle nests: 47 in Fort Lauderdale, 28 in Hollywood.

Incubation Period

Incubation period for caged nests ranged from 46 days to 60 days with a mean incubation period of 50.96 days. This is very similar to the wider dataset of *in situ* loggerhead nests, which had incubation periods ranging from 46-68 days with a mean incubation period of 50.47 days in 2019.

Reproductive Success

Seventy-one caged nests were excavated and analyzed for reproductive success. Four of the 75 caged nests could not be excavated due to washout and/or loss of cage/stakes that required reestablishment (egg chambers ultimately could not be located). A total of 7,327 eggs were deposited with 5,817 hatchlings released for an emergence success rate of 79.39% across all inventoried caged nests (Tables 5c and 7c).

Washover and Washout Events

A total of 1,087 nests were impacted by washover (excluding Mizell-Eula State Park). Of these nests, 288 were washed out completely (clutch completely lost). A total of 31.95% of all nests throughout Broward County (excluding Mizell-Eula State Park) experienced washover at some point over the 2019 season. This is similar to the rate of washover that was experienced in the 2018 season, which had 803 (30.23% of nests) nests impacted; this year was slightly lower than the five-year average of 34.38% of nests impacted (Figure 14). Hurricanes Dorian and Humberto, and the King Tides were responsible for 34.31% (n=373) of the washover and 86.11% (n=248) of the washout events in 2019.

Strandings

There were 56 marine turtle strandings events reported for Broward County, and the BCSTCP responded to 44 from January 1–December 31, 2019 (the remaining 11 were handled by Gumbo Limbo Nature Center). Of these, 24 were live strandings and 32 were dead stranded turtles (Appendix 5). Stranding numbers increased by 27 in 2019 compared to the 2018 season (Appendix 7).

Of the 56 strandings, 14 were affected by fishing hooks (13 were live and able to be transported to a rehabilitation facility to remove the hooks and fishing line).

Obstructed Nesting Attempts

Morning surveys documented 504 ONAs: 301 were loggerhead crawls, 199 green turtle crawls, and 4 leatherback crawls. Of the 504 ONAs, 252 resulted in false crawls and 252 resulted in nests. Turtles encountered various obstructions (sometimes multiple obstructions) including escarpments (88), beach furniture (191), seawalls (65), rock revetments (50), dune crossovers (9), rock outcroppings (9), boats (9), cabanas (9), umbrellas (6), special events equipment (2), marine debris (1), and sand bags (1). Turtles also encountered fences, garbage cans, lifeguard stands, posts, stairs, signs, pier pylons, sprinklers, wheelchair access mat, benches, storage bins, roads, pipes, kayak racks, etc. (combined total of 104 interactions).

Discussion

Yearly Nesting Trends

All three species of nesting turtles in Broward County have shown significant increases in nest deposition over the history of the BCSTCP starting in 1981. Nesting trends between seasons is not demonstrated historically among nesting loggerhead and leatherback populations in Broward County. However, green turtle nesting trends in Broward County historically follow an annual oscillation between high nesting seasons and low nesting seasons. Leatherback nesting is following an increasing historical trend

(Figure 8a). Broward County experienced four years of declining leatherback nest numbers from 2014-2017, however a slight increase in leatherback nesting was observed in 2018 followed by the most nests since 2012 laid in 2019. Similar nesting patterns have been documented in Broward County between seasons 2002 to 2005 and 2010 to 2012. Loggerheads are on an increasing trend of +35.93 nests per year since 1981; however, there was a 10-year period of decline from 1997-2007. Since 2007, there has been an increase in loggerhead nesting activity and the rate of increase is higher than the overall program trend. The 2019 season experienced a slight increase in loggerhead nesting numbers relative to the 2018 nesting season (Figure 8b). A large increase was observed in 2016, with a decrease in 2017, a slight decrease in 2018, and a slight increase in 2019. Green turtle nesting has exhibited a steady positive historic trend in Broward County. Green sea turtles demonstrate extreme oscillation between high and low nesting seasons. The 2018 season experienced a low nesting season for greens, followed by a record-setting year in green nests in the 2019 season (Figure 8c), suggesting that 2020 will be a low green nesting season.

Seasonal Nesting Patterns

The seasonal nesting pattern was consistent with what is normally found in Broward County: the first nesters to arrive were the leatherbacks, followed by the loggerheads and then the green turtles. Nest deposition over the season followed a normal distribution with the height of the season falling in June and July, which is similar to historic nesting patterns.

Green turtle nesting in 2019 was considerably higher than in 2018 and set a record for highest number of nests in the County. Green turtle nesting started considerably earlier but also ended earlier than the 2018 season. The first green nest was deposited on May 9 this year compared to June 9 in 2018. The last nest was deposited on September 22 this year compared to October 24 in 2018.

Countywide Nest Distribution

Nest distributions this season closely resembled patterns that have been seen in Broward County for many years with the highest nesting densities in the Hillsboro survey zone, followed by Fort Lauderdale Beach, Pompano Beach, Mizell-Eula State Park and the lowest nesting activity was documented in the Hollywood survey zone. In addition, there was very little crawl/nest activity directly adjacent to most jetties and inlets. These types of beach armoring constructions disrupt the natural water flow and sand movement and often result in increased beach erosion near the structures, impacting sea turtle nesting (Mosier and Witherington, 2000; Rizkalla and Savage, 2011).

This nesting distribution could be influenced by a number of factors. Hillsboro Beach has one of the lowest human population densities and some of the lowest amount of artificial lighting of any of Broward County's beaches (Broward County, 2019).

Additionally, a sea turtle hatchery facility was once located near the Hillsboro Beach Club. The hatchery was maintained through the 2005 nesting season and received nests from “donor” zones that were brightly lit by artificial lighting (Burney and Ouellette, 2005). These factors may play some role in the current high-density nesting observed on Hillsboro Beach (Brothers and Lohmann, 2015; Lohmann et al., 1997). However, the reason still remains unknown. Hollywood Beach was a long time “donor” zone since it is one of the brightest areas in Broward County, and therefore nests have historically been relocated out of Hollywood Beach. Female sea turtles return to their natal beaches when they are ready to deposit nests of their own (Lohmann et al., 1997), which may explain the underutilization of Hollywood beaches for sea turtle nesting in recent years. Additionally, Florida’s east coast exhibits a general nesting trend of increasing nesting densities moving south to north from Miami to Brevard Counties. The same trend might be occurring within Broward County, as Hollywood is the southernmost zone while Hillsboro is the northernmost zone. Both historical relocations into hatcheries and the south-north nesting trend may influence the nest distributions seen in Broward County.

Nest Relocation

Hatcheries were historically used quite extensively in Broward County as a management tool to protect marine turtles. An active hatchery facility was maintained near the Hillsboro Beach Club until 2005 (Burney and Ouellette, 2005). Hatchery facilities provide a sound management tool in heavily impacted coastal communities where nests left *in situ* will likely experience very high rates of disorientation, predation, washout, etc. However, the hatchery model is not without complications. The sex of marine turtle hatchlings is dependent on sand temperature during incubation (Standora and Spotila, 1985). A beach with all nests left *in situ* will experience a range of temperatures due to variation in nest placement in relation to the high tide line, shading from dune vegetation, etc.; likewise, different nest chamber depths will likely experience different temperatures during development (Abella et al., 2008, Van et al., 2006). When all or most nests are relocated into a hatchery facility, this may eliminate some of the natural temperature variation found when nests are left *in situ*. Also, when nests are packed densely together in a hatchery facility, they become more vulnerable to disease and disease transmission, predation, and storm events (Izadjoo et al., 1987). In 2004, Hurricanes Frances and Jeanne had significant negative impacts on the hatchery nest facilities in Broward County (Burney and Ouellette, 2004).

Relocated sea turtle nests generally experience lower emergence success than *in situ* nests because the eggs are moved and placed into an artificial chamber and some eggs/embryos may be damaged in transport/handling (Moody, 1996). This was demonstrated in 2019 as the *in-situ* loggerhead emergence success (77.56%) was higher than the relocated loggerhead emergence success of 62.77%. In a hatchery system, some nests may travel a long distance in buckets before they are placed in their new man-made nests, increasing the likelihood of damage to the embryos. The final year of the hatchery facilities in Broward County resulted in loggerhead nests with an

emergence success of 41.6% for relocated nests (N = 1151; Burney and Ouellette, 2005). Broward County has moved towards a more “hands-off” management strategy, relocating less nests due to non-compliant lighting. The final year of the hatchery facilities in the County relocated 56.04% of all nests, compared to just 2.09% in 2019 (Figure 9). The five-year average for nest relocation is currently 2.29%. As lighting compliance improves in Broward County, the more “hands-off” management strategy is strongly recommended. Future nesting, relocation, and reproductive success data will help determine the most effective suite of management tools for the dynamic and highly utilized beaches of Broward County.

Restraining Cages

Restraining cages were found to be an effective short-term mitigation action in areas of bright anthropogenic beachfront lighting to minimize loss of sea turtle hatchlings that would likely disorient in these areas. The cages also provided an effective educational tool in the field with signage and allowed the BCSTCP team to speak to beachgoers about turtle friendly lighting and why the restraining cages were being used in certain areas. While effective as a temporary mitigation action, restraining cages are logistically difficult (time and labor) for Program staff to ensure hatchlings are not restrained for too long. Considering these challenges, working towards rectifying the underlying lighting issues at the source is recommended as a long-term management solution in these areas.

Disorientation Reports

Disorientation reports provide a mechanism to document nests that experience adult or hatchling disorientation. Broward County has four organizations documenting these events each season: the BCSTCP, STOP, SFAS, and STARS. Recent innovations in disorientation reporting technology from FWC has improved the standardization of documenting disorientation events among all organizations in Broward County. However, all hatchling disorientation reports filed in Broward County this year were used to provide a more succinct and complete look at the impact of coastal lighting on hatchling sea turtles.

The trends in disorientation reports are similar this season to previous years. Ft Lauderdale beach has some of the highest rates of disorientation annually and Hillsboro and Deerfield show some of the lowest rates of disorientation. County wide, disorientation rates were 10% higher in 2018 (45.39%) than the 2017 season (35.03%). These disorientation reports and monthly lighting reports show a negative correlation between sea turtle nesting activities and non-compliant anthropogenic lighting. The results of this comprehensive analysis are being used to target future outreach efforts.

Predation and Poaching

Drastic decreases in nest predation in the 2018 and 2019 seasons is a very positive sign. Since Hillsboro hosts the highest nesting density in Broward County and typically sees the highest nest predation rates in the County, maintaining these low predation rates is significant. Continued monitoring is needed to ensure predation stays low in this area, otherwise this area may warrant some degree of nest protection in future years.

Challenges Encountered

Both the nesting and hatching success of Broward County sea turtle nests were impacted by weather driven factors such as Hurricane Dorian and Hurricane Humberto as well as King Tide events. Broward County beaches sustained some flooding/sand erosion with these events resulting in the loss of 248 nests (with an additional 373 nests that experienced wash over).

A small degree of vandalism was observed throughout the season that resulted in damage to nest stakes/perimeters of 3 nests, but no poaching events were documented in 2019.

Conclusions and Recommendations

Management of endangered nesting sea turtles in Florida is a monumental task. The current “hands-off” approach recommended by FWC is working very well to provide the highest nesting and hatching success for the beaches in Broward County. Hopefully as nest numbers continue to rise in this area, this approach will be even more effective and result in less overall impact on the local nesting female population and hatchlings.

The restraining cages currently being used in some zones in Broward County provide a good short-term management strategy for addressing areas of high concern with regard to artificial lighting and light fixtures. These areas experience high rates of hatchling disorientation and the cages help mitigate the negative impacts by allowing sea turtle professionals to ensure the hatchlings safely enter the water; however, this is not a feasible long-term solution to these issues. Continued efforts working with code enforcement in each municipality to generate targeted education and enforcement efforts with regard to turtle friendly lighting should be of the utmost priority.

This season documented record high nesting for total number of nests (all species) and for green turtles over the life of the Program. Nesting numbers in Broward County this year and recent nesting trends indicate an overall positive trend, leaving local scientists cautiously optimistic about the status of the local nesting sea turtle populations in Broward County.

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Tables and Figures

Table 1: Summary of the sea turtle nesting beach survey zones in Broward County, Florida, USA.

Beach	Beach Length (miles)	Boundaries	FDEP Survey Marker
Hillsboro- Deerfield	4.3	Palm Beach County line to Hillsboro Inlet	R1-24
Pompano Beach including Lauderdale-By- The-Sea	4.8	Hillsboro Inlet to Commercial Blvd.	R25-50
Fort Lauderdale	6.6	Commercial Blvd. to Port Everglades Inlet	R51-85
Dr. Von D. Mizell- Eula Johnson State Park	2.4	Port Everglades Inlet to Dania Beach fence	R86-96
Hollywood- Hallandale including Dania	5.8	Dania Beach fence to Miami-Dade County line	R97-128

Table 2: Summary of treatment zones by R-monument.

	Donor	<i>In Situ</i> & Recipient	<i>In Situ</i> Only	Restraining Cage
Description	All nests were relocated from this area to the nearest “recipient” zones.	All nests left in place; nests from “donor” zones may be relocated to this area. Cages were not used.	All nests left in place; nests from “donor” zones may not be relocated in these zones.	All nests left in place; a restraining cage was installed on every other nest.
R-Monuments	R24 – Hillsboro Inlet R85 – Port Everglades	R6-R24 R26-R34 R39-R50 R51-R53 R58-R64 R80-R84 R102-R107 R124-R128	R1-R6 R25-R26 R34-R39 R50-R51 R53-R58 R64-R74 R78-R80 R84-R84.7 R97.5-R102	R74-R78 R107-R124

Table 3a: A summary of the total nests, false crawls (FC), and nesting success (NS) of all leatherback crawls by beach.

Beach	Nests	FC	NS (%)
Hillsboro	19	2	90.48
Pompano	8	1	88.89
Fort Lauderdale	11	1	91.67
Mizell-Eula	0	0	N/A
Hollywood	5	0	N/A
Overall	43	4	91.49

Table 3b: A summary of the total nests, false crawls (FC), and nesting success (NS) of all loggerhead crawls by beach.

Beach	Nests	FC	NS (%)
Hillsboro	929	950	49.44
Pompano	538	648	45.36
Fort Lauderdale	973	1202	44.74
Mizell-Eula	205	309	39.88
Hollywood	168	266	38.71
Overall	2813	3375	45.46

Table 3c: A summary of the total nests, false crawls (FC), and nesting success (NS) of all green turtle crawls by beach.

Beach	Nests	FC	NS (%)
Hillsboro	582	399	59.33
Pompano	29	55	34.52
Fort Lauderdale	125	132	48.64
Mizell-Eula	40	36	52.63
Hollywood	12	20	37.50
Overall	788	642	55.10

Table 4a: A summary of the total leatherback nests laid and nesting densities by beach.

Beach	Total Nests	Beach Length	Nests per Mile
Hillsboro	19	4.3	4.42
Pompano	8	4.8	1.67
Fort Lauderdale	11	6.6	1.67
Mizell-Eula	0	2.4	0.00
Hollywood	5	5.8	0.86
Overall	43	23.9	1.80

Table 4b: A summary of the total loggerhead nests laid and nesting densities by beach.

Beach	Total Nests	Beach Length	Nests per Mile
Hillsboro	929	4.3	216.05
Pompano	538	4.8	112.08
Fort Lauderdale	973	6.6	147.42
Mizell-Eula	205	2.4	85.42
Hollywood	168	5.8	28.97
Overall	2813	23.9	117.70

Table 4c: A summary of the total green turtle nests laid and nesting densities by beach.

Beach	Total Nests	Beach Length	Nests per Mile
Hillsboro	582	4.3	135.35
Pompano	29	4.8	6.04
Fort Lauderdale	125	6.6	18.94
Mizell-Eula	40	2.4	16.67
Hollywood	12	5.8	2.07
Overall	788	23.9	32.97

Table 5a: Emergence success for all *in situ* nests by species.

Species	Evaluated Nests	Unevaluated Nests	Total Eggs	Hatchlings Released	Emergence Success (%)
Leatherback	33	9	3055	1971	64.52
Loggerhead	1744	728	182156	141281	77.56
Green Turtle	394	338	43567	35418	81.30
Total	2171	1075	228778	178670	78.10

Table 5b: Emergence success for all relocated nests by species.

Species	Evaluated Nests	Unevaluated Nests	Total Eggs	Hatchlings Released	Emergence Success (%)
Leatherback	1	0	114	87	76.32
Loggerhead	57	3	5321	3340	62.77
Green Turtle	9	1	780	449	57.56
Total	67	4	6215	3876	62.37

Table 5c: Emergence success for all restraining cage nests by species.

Species	Evaluated Nests	Unevaluated Nests	Total Eggs	Hatchlings Released	Emergence Success (%)
Loggerhead	71	4	7327	5817	79.39
Total	71	4	7327	5817	79.39

Table 6a: Excavation information for all *in situ* leatherback nests by beach. See text for details.

Beach	Evaluated Nests	Total Eggs	Emerged (%)	LIN (%)	DIN (%)	Live Pipped (%)	Dead Pipped (%)
Hillsboro	12	1070	70.65	2.52	5.42	0.00	5.33
Pompano	7	573	41.01	4.89	23.04	0.17	8.73
Fort Lauderdale	10	992	72.38	2.72	2.52	0.20	1.92
Hollywood	4	420	62.38	2.14	4.05	0.00	12.14
Overall	33	3055	64.52	2.98	7.59	0.10	5.79

Table 6b: Excavation information for all relocated leatherback nests by beach. See text for details.

Beach	Evaluated Nests	Total Eggs	Emerged (%)	LIN (%)	DIN (%)	Live Pipped (%)	Dead Pipped (%)
Hollywood	1	114	76.32	4.39	1.75	0.00	0.00
Overall	1	114	76.32	4.39	1.75	0.00	0.00

Table 7a: Excavation information for all *in situ* loggerhead nests by beach. See text for details.

Beach	Evaluated Nests	Total Eggs	Emerged (%)	LIN (%)	DIN (%)	Live Pipped (%)	Dead Pipped (%)
Hillsboro	583	60401	68.99	1.85	1.89	0.16	4.56
Pompano	379	38431	80.30	1.44	1.64	0.17	3.34
Fort Lauderdale	677	72730	81.98	1.01	1.34	0.13	2.71
Hollywood	105	10594	86.17	0.42	0.64	0.06	1.41
Overall	1744	182156	77.56	1.34	1.54	0.14	3.38

Table 7b: Excavation information for all relocated loggerhead nests by beach. See text for details.

Beach	Evaluated Nests	Total Eggs	Emerged (%)	LIN (%)	DIN (%)	Live Pipped (%)	Dead Pipped (%)
Hillsboro	12	1092	53.94	7.05	1.83	1.92	9.52
Pompano	8	707	66.90	3.96	1.13	0.57	6.65
Fort Lauderdale	31	2924	62.69	4.10	3.01	1.37	7.52
Hollywood	6	598	74.41	5.18	1.34	0.84	5.02
Overall	57	5321	62.77	4.81	2.33	1.32	7.54

Table 7c: Excavation information for all caged loggerhead nests by beach. See text for details.

Beach	Evaluated Nests	Total Eggs	Emerged (%)	LIN (%)	DIN (%)	Live Pipped (%)	Dead Pipped (%)
Fort Lauderdale	44	4712	77.82	2.27	1.19	0.85	8.11
Hollywood	27	2615	82.22	0.42	0.27	0.00	1.07
Overall	71	7327	79.39	1.61	0.86	0.55	5.60

Table 8a: Excavation information for all *in situ* green turtle nests by beach. See text for details.

Beach	Evaluated Nests	Total Eggs	Emerged (%)	LIN (%)	DIN (%)	Live Pipped (%)	Dead Pipped (%)
Hillsboro	284	30645	77.46	2.17	1.62	0.35	2.99
Pompano	24	2685	91.02	1.27	0.15	0.11	0.60
Fort Lauderdale	79	9324	90.87	1.24	0.69	0.12	1.40
Hollywood	7	913	83.57	1.97	2.08	0.44	0.66
Overall	394	43567	81.30	1.91	1.34	0.29	2.45

Table 8b: Excavation information for all relocated green turtle nests by beach. See text for details.

Beach	Evaluated Nests	Total Eggs	Emerged (%)	LIN (%)	DIN (%)	Live Pipped (%)	Dead Pipped (%)
Hillsboro	2	204	29.41	0.49	0.00	0.00	0.00
Pompano	1	59	13.56	3.39	0.00	0.00	1.69
Fort Lauderdale	6	517	73.69	16.05	1.55	2.71	7.16
Overall	9	780	57.56	14.66	1.38	2.41	6.55

Table 9a: A summary of the nests, false crawls (FC), and nesting success (NS) for leatherbacks in relation to County-sponsored beach renourishment projects.

Project	Nests	FC	NS (%)
Deerfield	1	0	100.00
Hillsboro Inlet Bypass	0	0	N/A
Hollywood	5	0	100.00
Segment II	11	1	91.67
Overall	17	1	94.44

Table 9b: A summary of the nests, false crawls (FC), and nesting success (NS) for loggerheads in relation to County-sponsored beach renourishment projects.

Project	Nests	FC	NS (%)
Deerfield	115	166	40.93
Hillsboro Inlet Bypass	8	8	50.00
Hollywood	157	248	38.77
Segment II	547	660	45.32
Overall	827	1082	43.32

Table 9c: A summary of the nests, false crawls (FC), and nesting success (NS) for green turtles in relation to County-sponsored beach renourishment projects.

Project	Nests	FC	NS (%)
Deerfield	65	70	48.15
Hillsboro Inlet Bypass	0	1	0.00
Hollywood	12	18	40.00
Segment II	118	112	51.30
Overall	195	201	49.24

Table 10a: Reproductive success of leatherback, loggerhead, and green turtles in relation to the Hillsboro/Deerfield Beach Nourishment Project.

Species	Evaluated Nests	Unevaluated Nests	Number of Eggs Laid	Hatchlings Released	Emerged (%)
Leatherback	1	0	103	79	76.70
Loggerhead	71	44	7019	5102	72.69
Green Turtle	26	37	2792	1979	70.88

Table 10b: Reproductive success of leatherback, loggerhead, and green turtles in relation to the Hillsboro Inlet Maintenance Dredging and Sand Bypass Project.

Species	Evaluated Nests	Unevaluated Nests	Number of Eggs Laid	Hatchlings Released	Emerged (%)
Leatherback	0	0	N/A	N/A	N/A
Loggerhead	8	0	745	531	71.28
Green Turtle	0	0	N/A	N/A	N/A

Table 10c: Reproductive success of leatherback, loggerhead, and green turtles in relation to the Broward County Segment II Beach Renourishment and Restoration Project.

Species	Evaluated Nests	Unevaluated Nests	Number of Eggs Laid	Hatchlings Released	Emerged (%)
Leatherback	10	1	995	651	65.43
Loggerhead	418	129	44703	36517	81.69
Green Turtle	84	33	9827	8935	90.92

Table 10d: Reproductive success of leatherback, loggerhead, and green turtles in relation to the FCCE Broward County Shore Protection Project Segment III .

Species	Evaluated Nests	Unevaluated Nests	Number of Eggs Laid	Hatchlings Released	Emerged (%)
Leatherback	5	0	534	349	65.36
Loggerhead	130	27	13035	11003	84.41
Green Turtle	7	5	913	763	83.57

Table 11: A summary of the hatchling disorientation (DIS) reports by municipality as reported by BCSTCP, STOP, SFAS, and STARS.

Municipality	Hatch DIS	Hatch Total	% Hatch DIS
Deerfield	21	44	47.73
Hillsboro	15	666	2.25
Pompano	141	270	52.22
Lauderdale-By-The-Sea and Sea Ranch Lakes	139	214	64.95
Fort Lauderdale	538	754	71.35
Dania	0	4	0.00
Hollywood	29	79	36.71
Hallandale	6	18	33.33
Total (excludes State Park)	889	2049	43.39

Figure 1: Location of Broward County, Florida, USA.



Figure 2: Boundaries of the 2019 Sea Turtle Survey Zones.



Figure 2: Boundaries of the 2019 Sea Turtle Survey Zones.

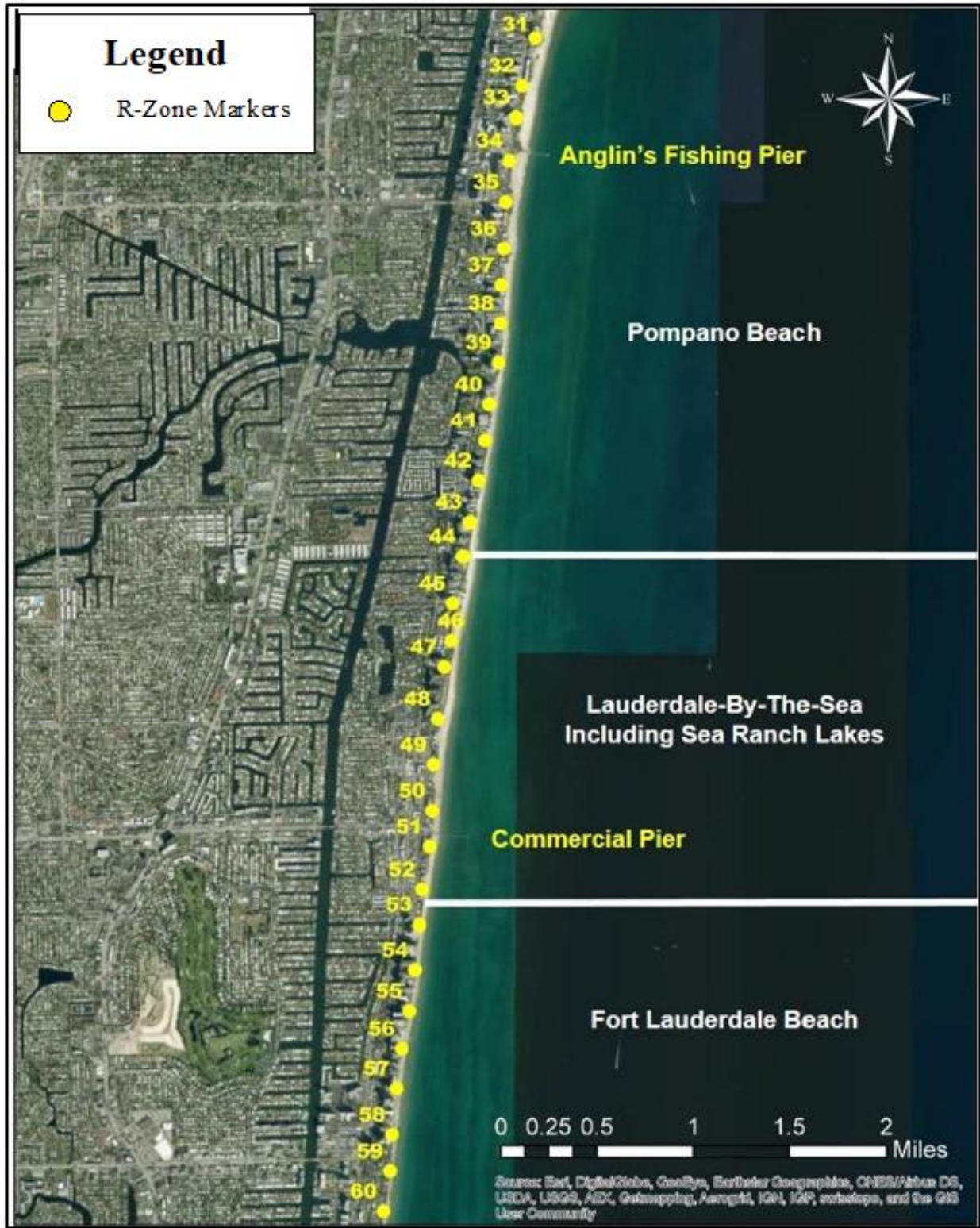


Figure 2: Boundaries of the 2019 Sea Turtle Survey Zones.



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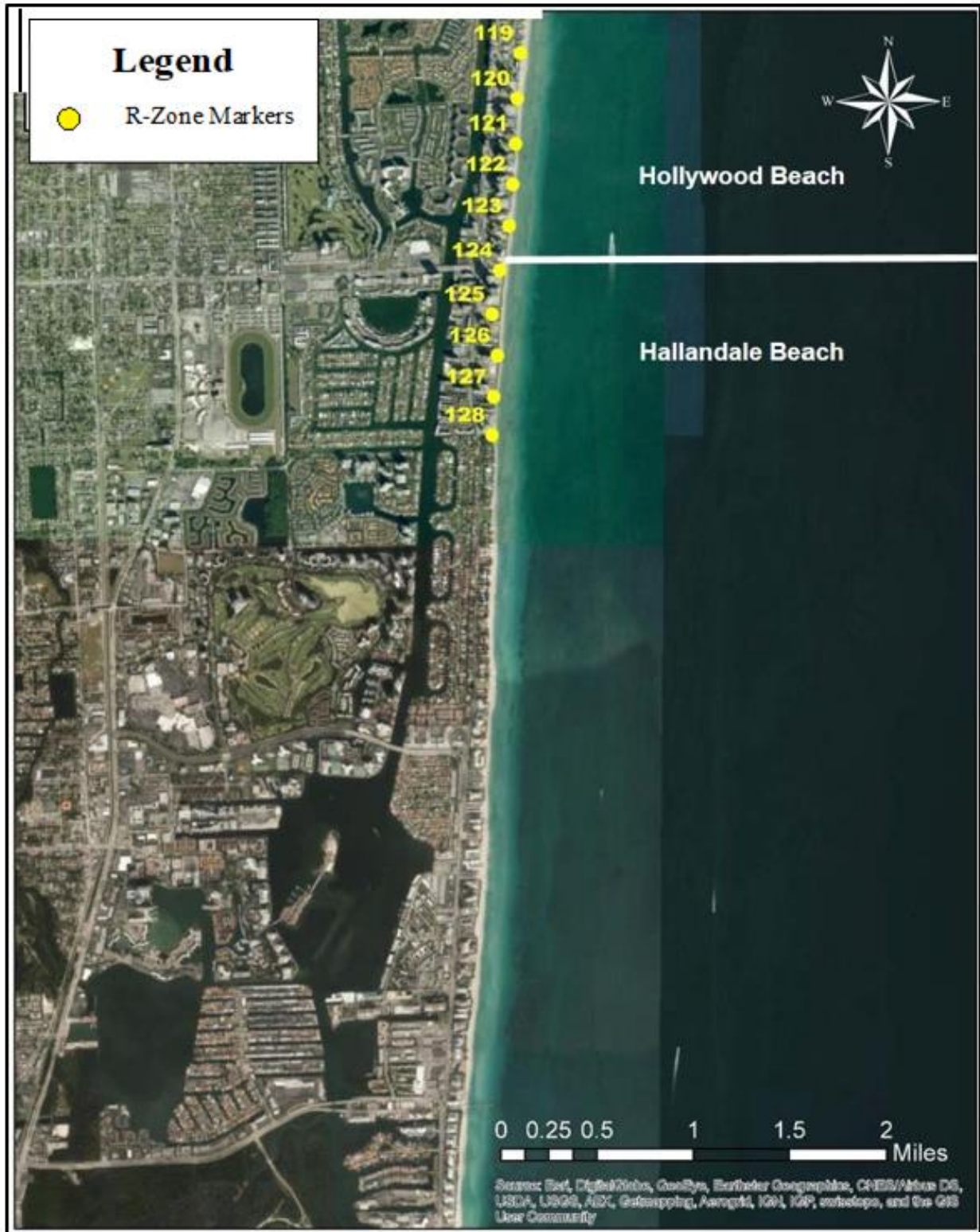


Figure 3: Locations of 2019 Turtle Crawls and Treatment Zones.

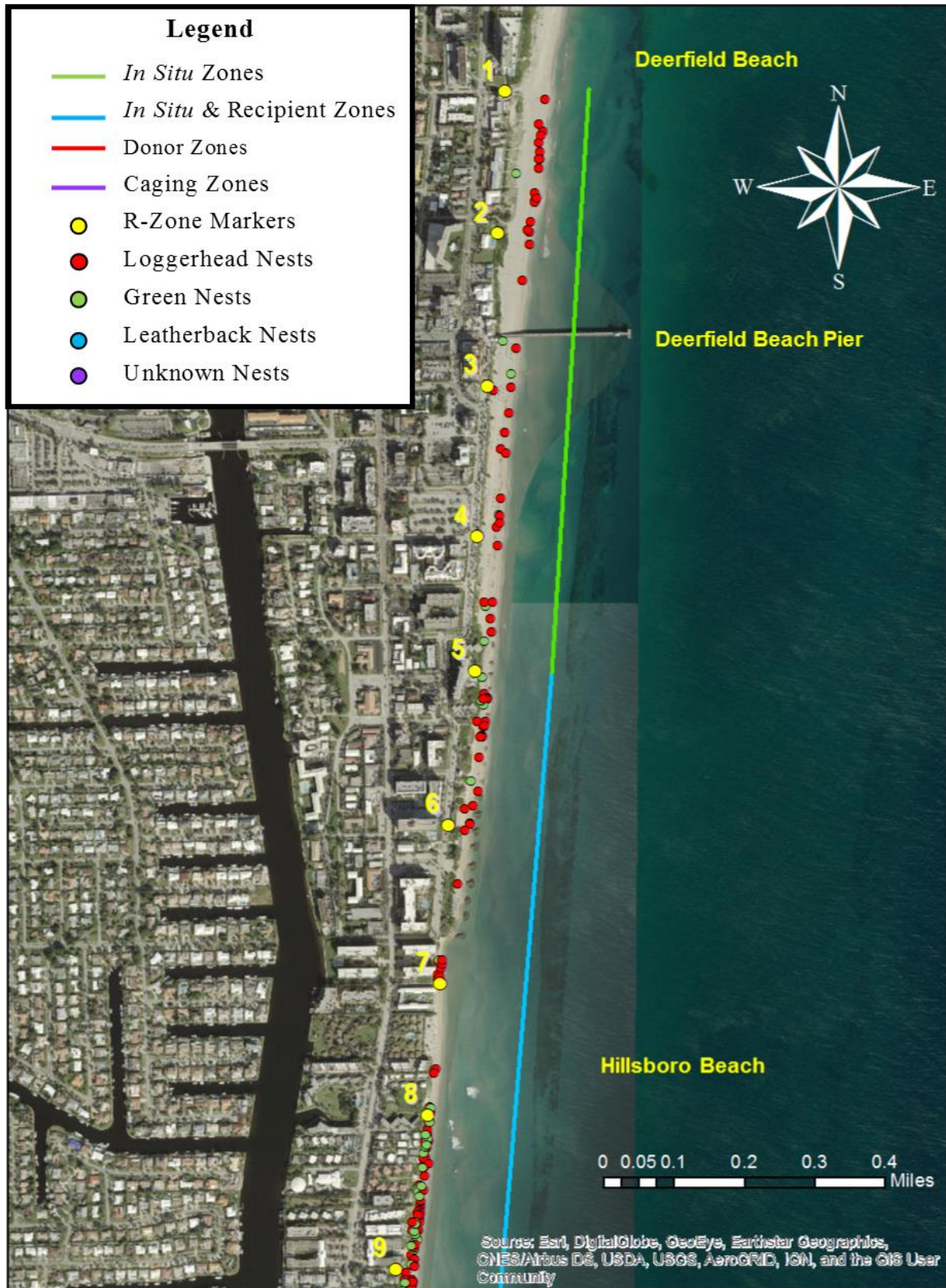


Figure 3: Locations of 2019 Turtle Crawls and Treatment Zones.

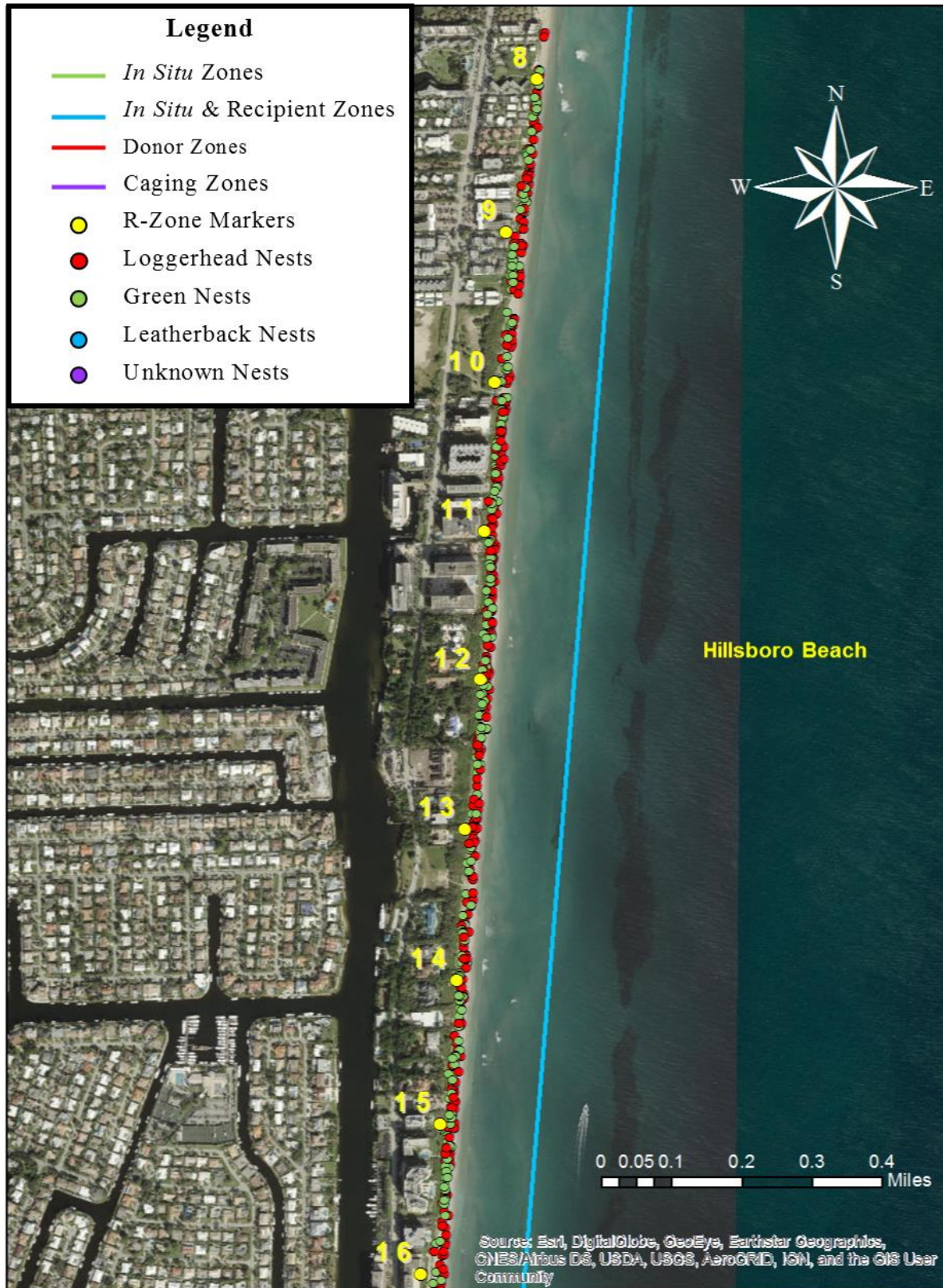


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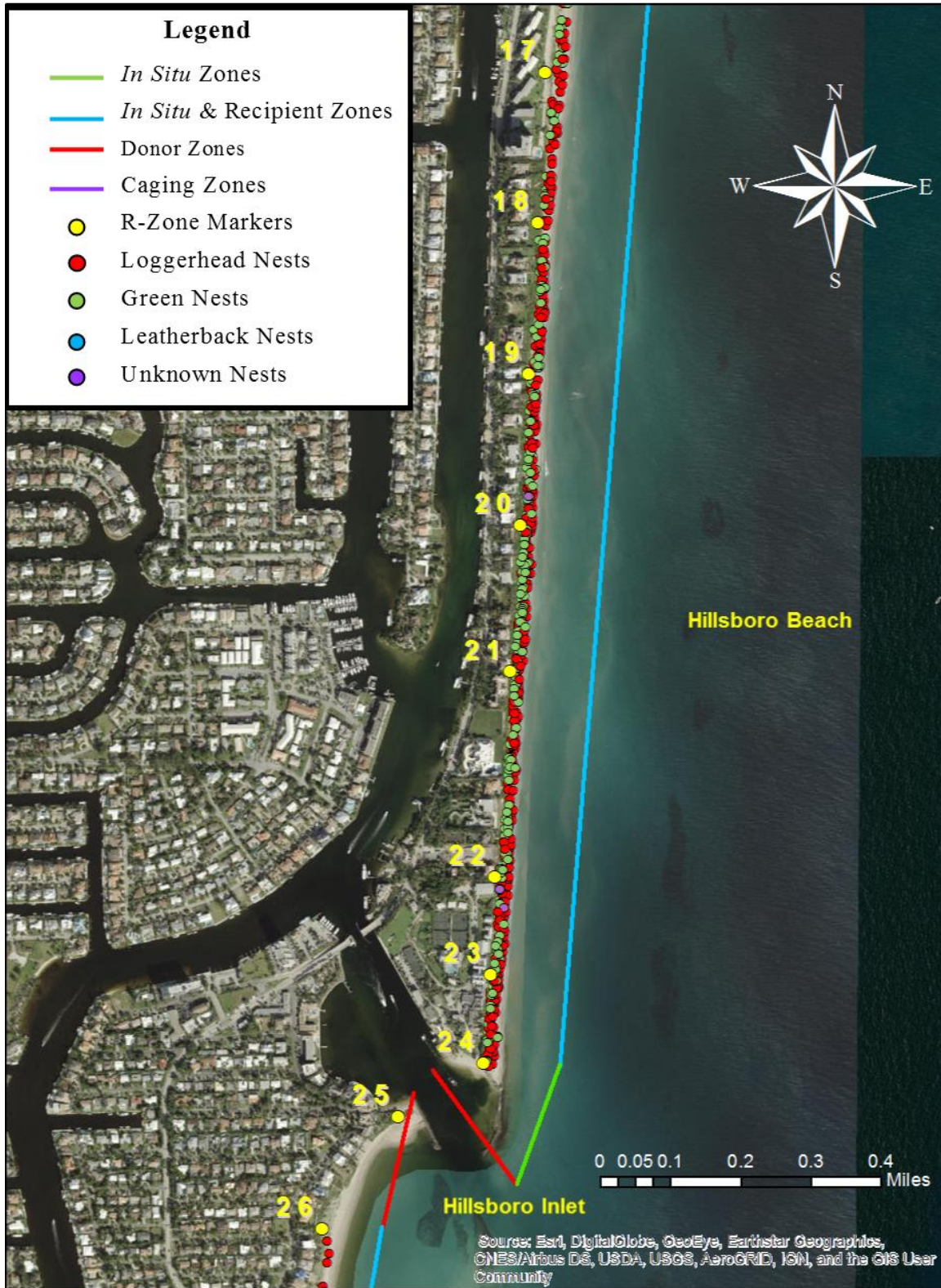


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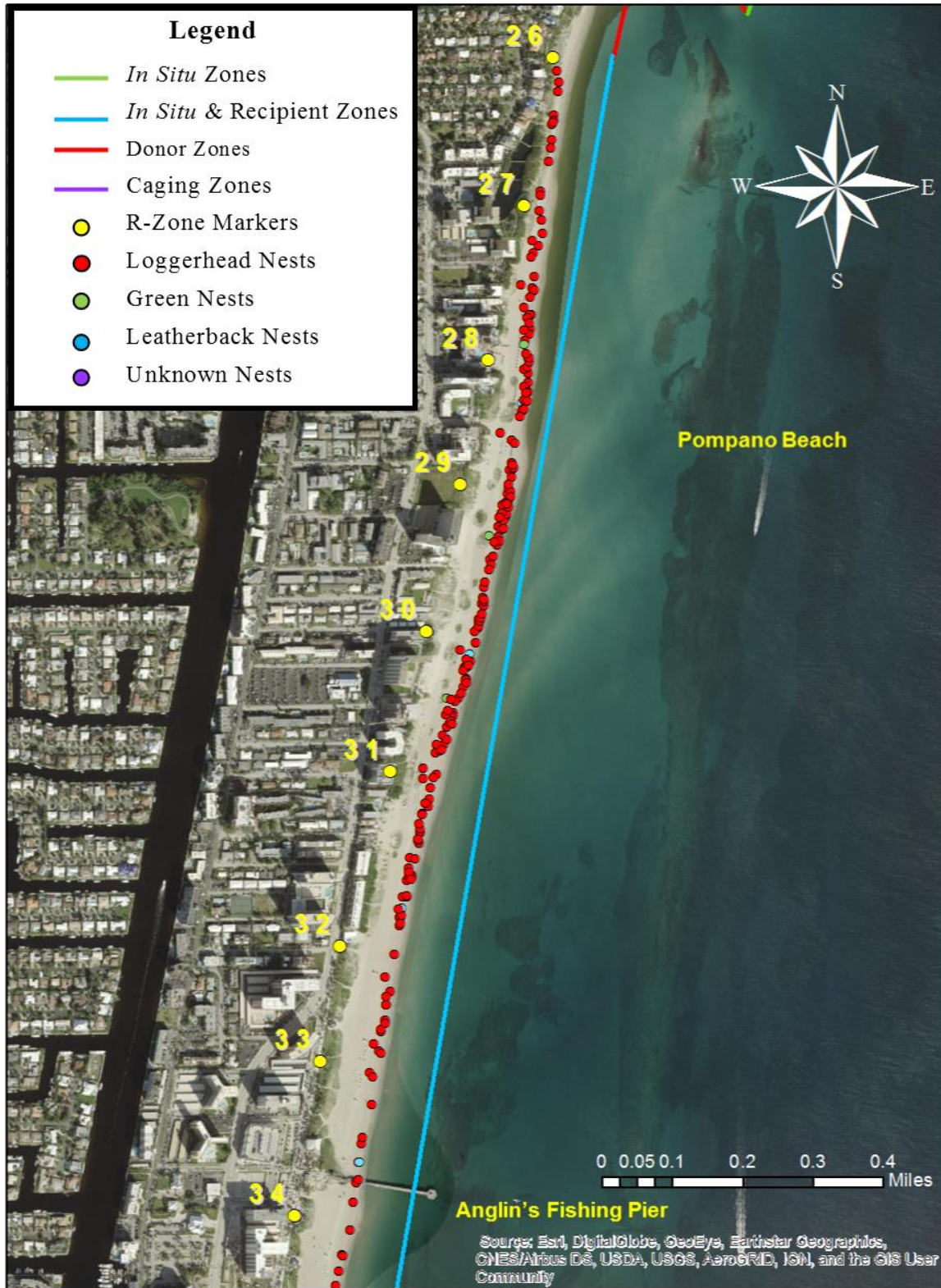


Figure 3: Locations of 2019 Turtle Crawls and Treatment Zones.

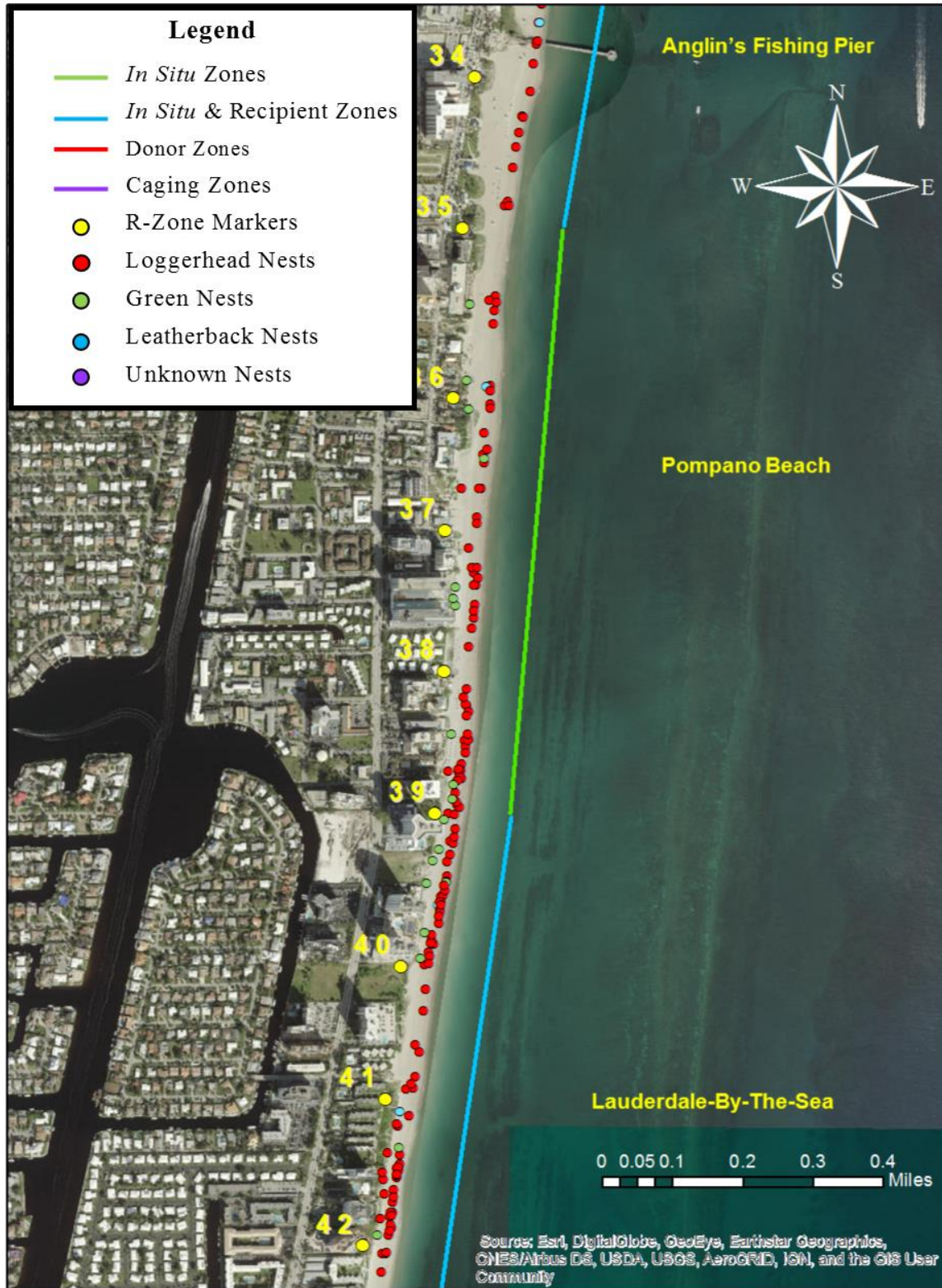


Figure 3: Locations of 2019 Turtle Crawls and Treatment Zones.

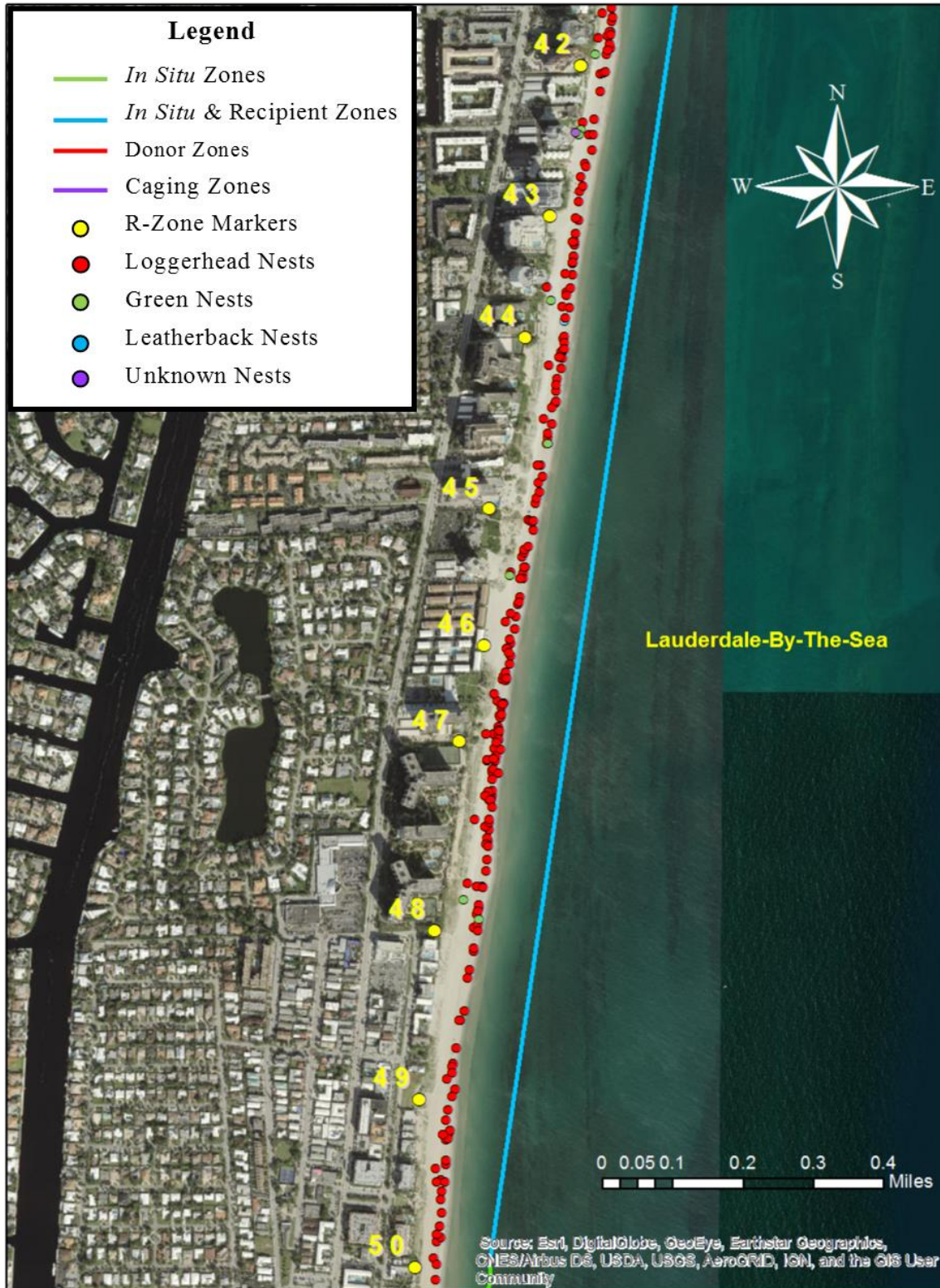


Figure 3: Locations of 2019 Turtle Crawls and Treatment Zones.

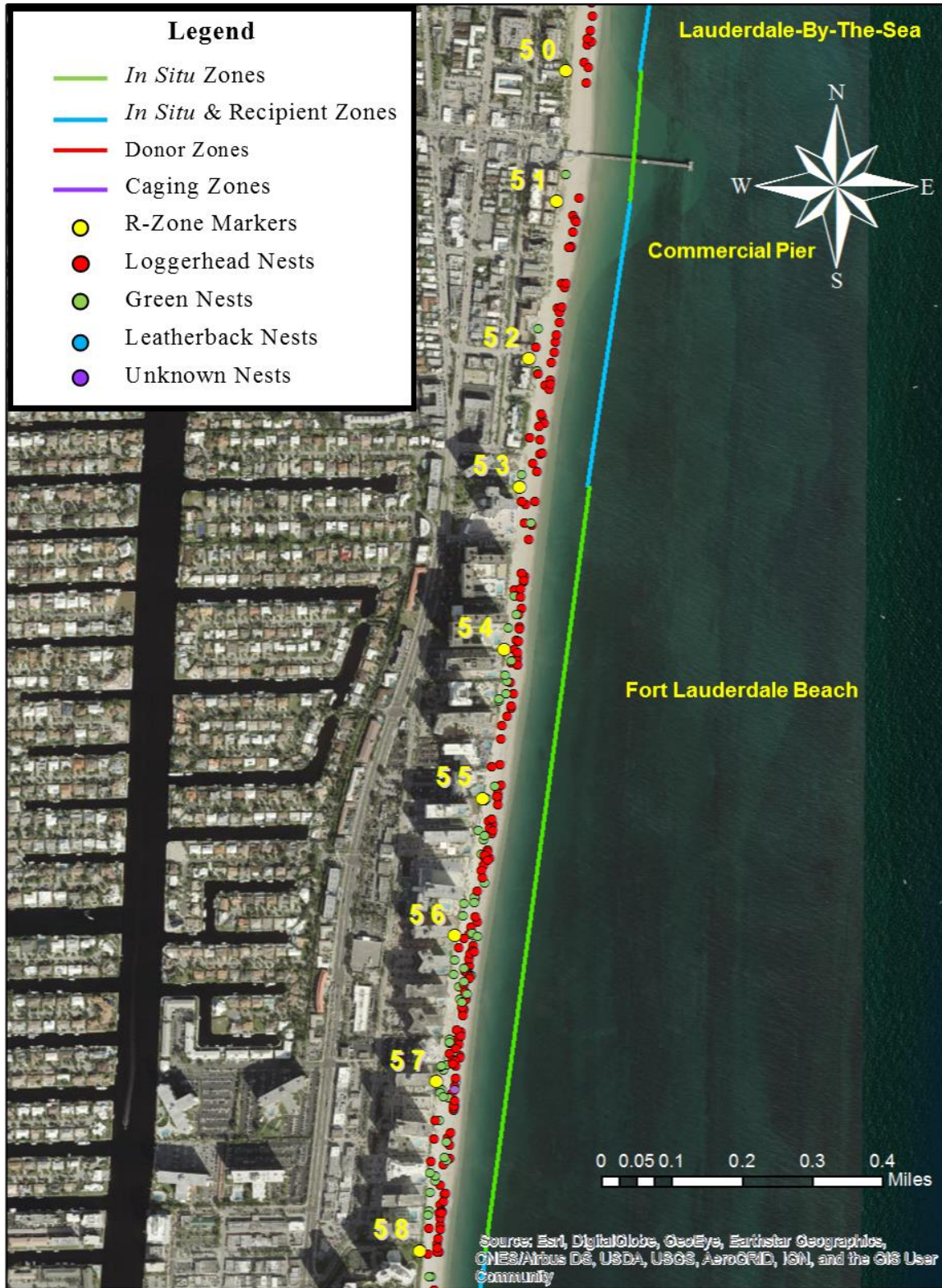


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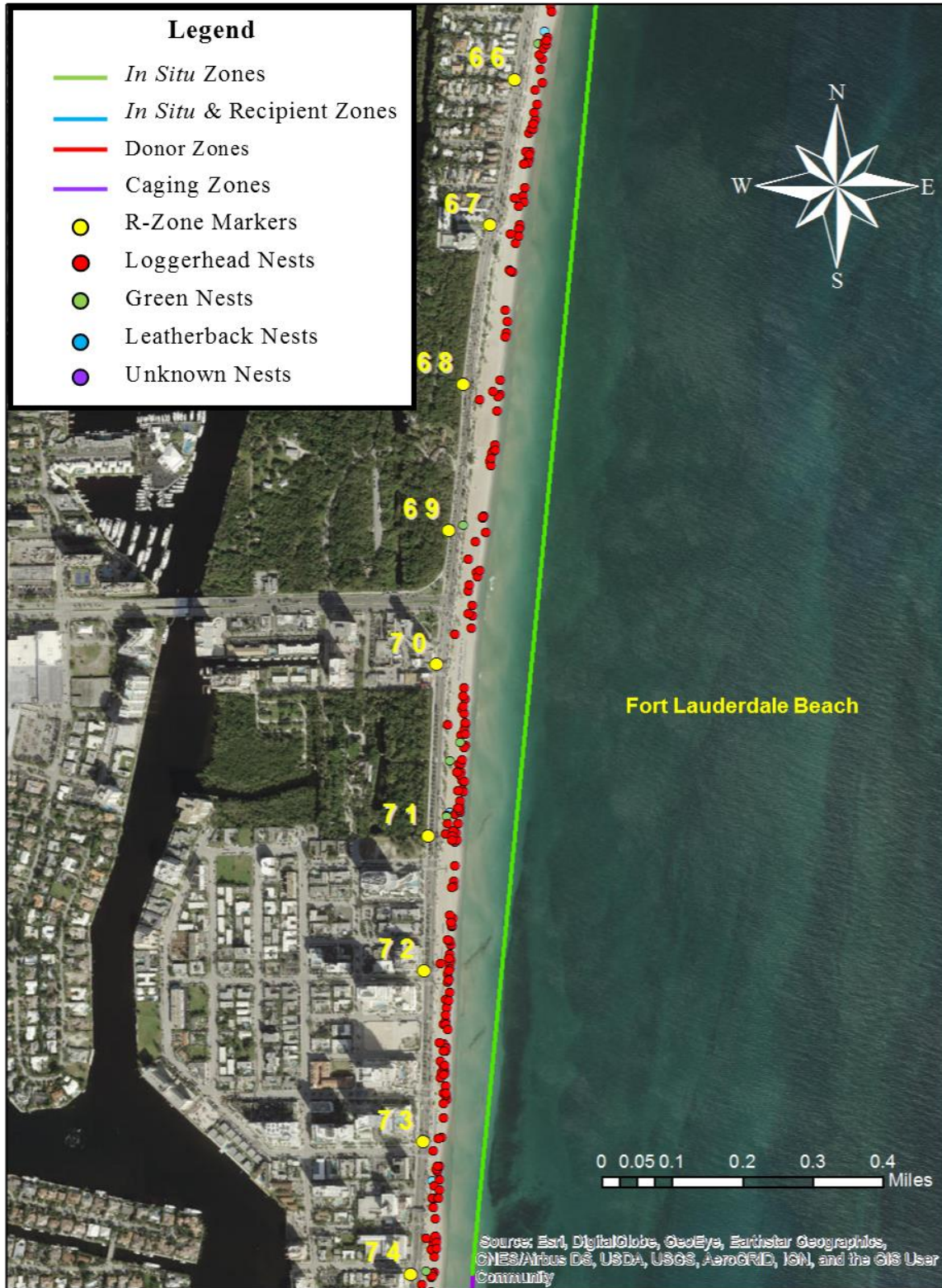


Figure 3: Locations of 2019 Turtle Crawls and Treatment Zones.

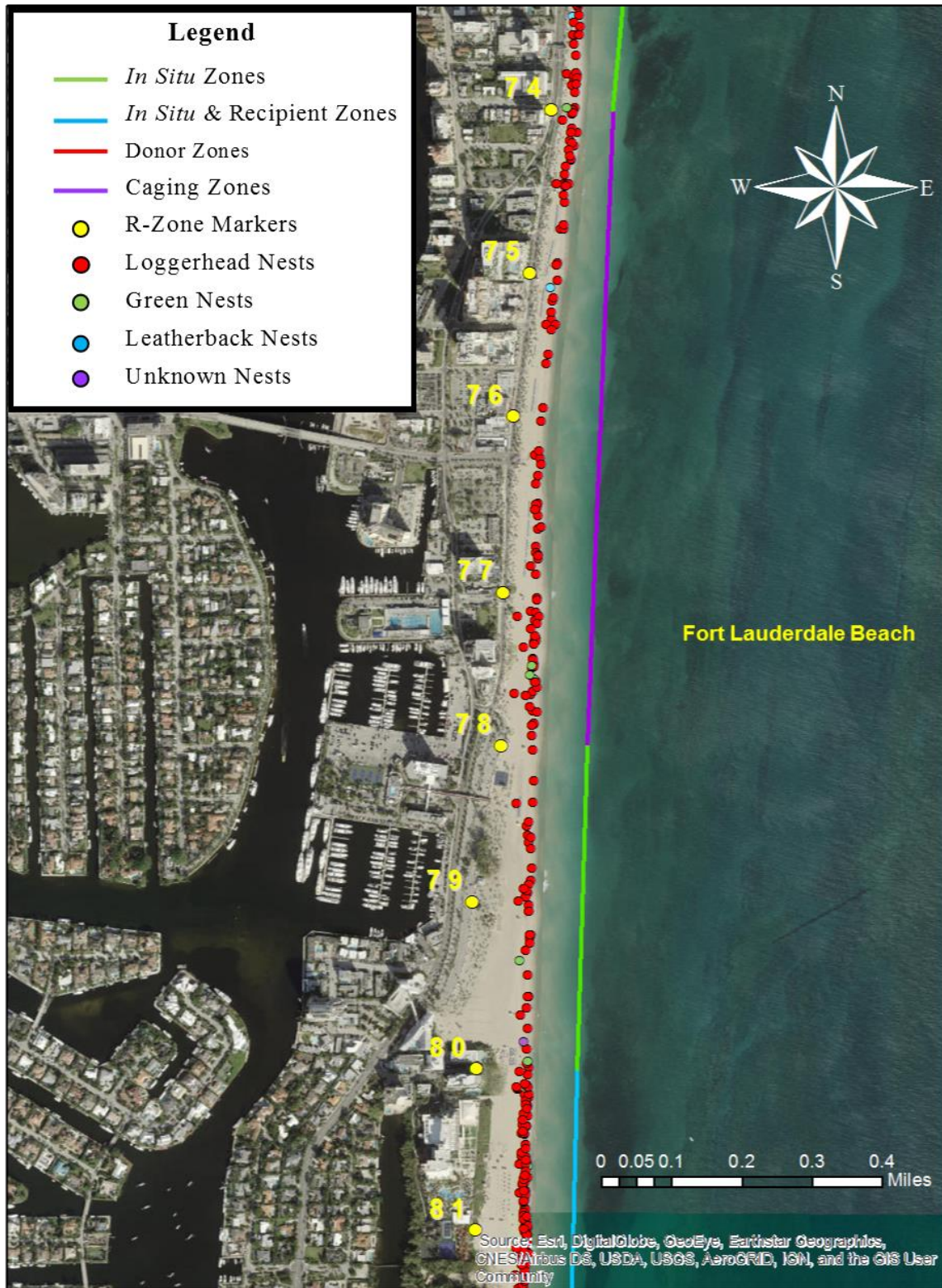


Figure 3: Locations of 2019 Turtle Crawls and Treatment Zones.



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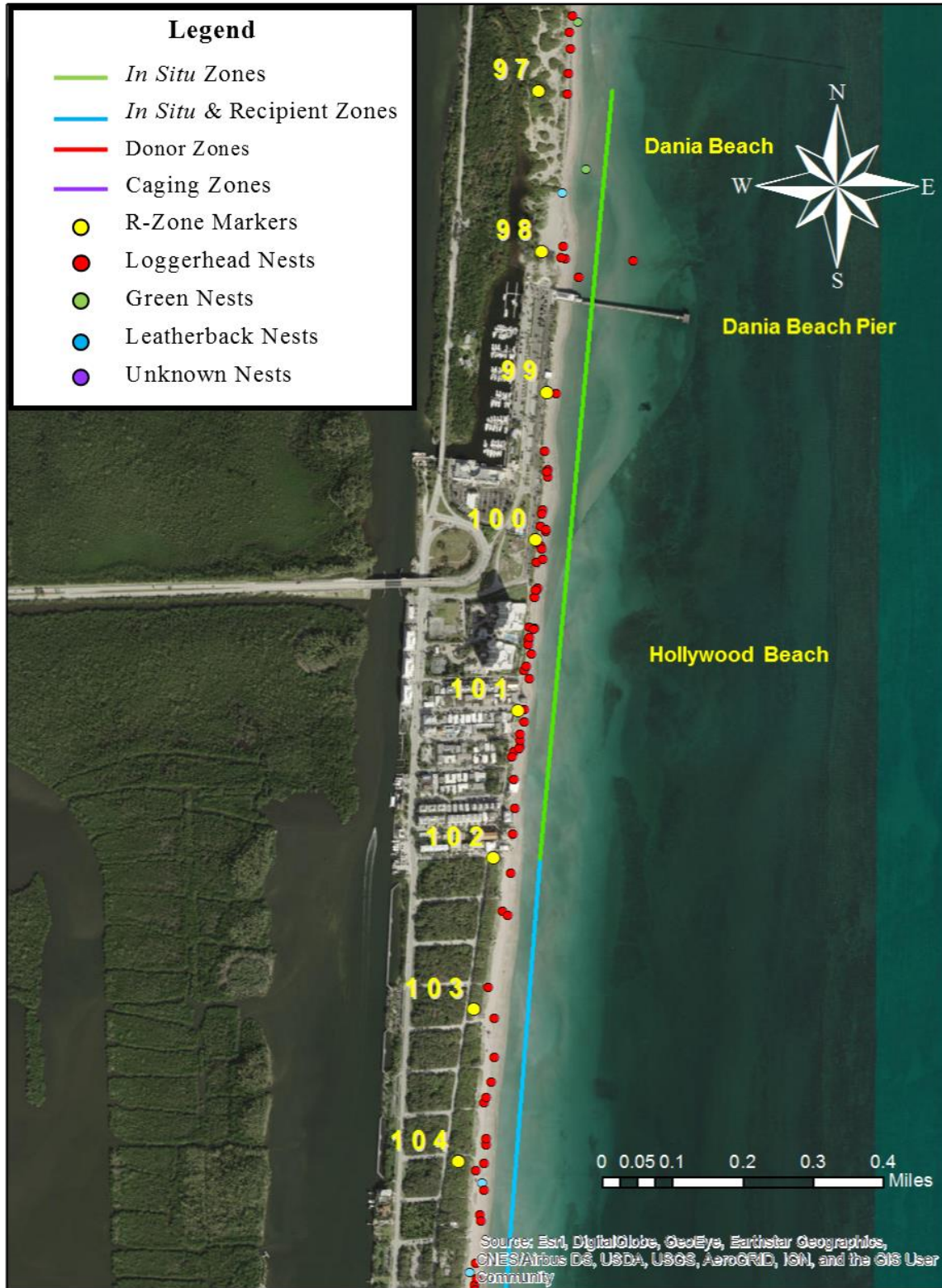


Figure 3: Locations of 2019 Turtle Crawls and Treatment Zones.

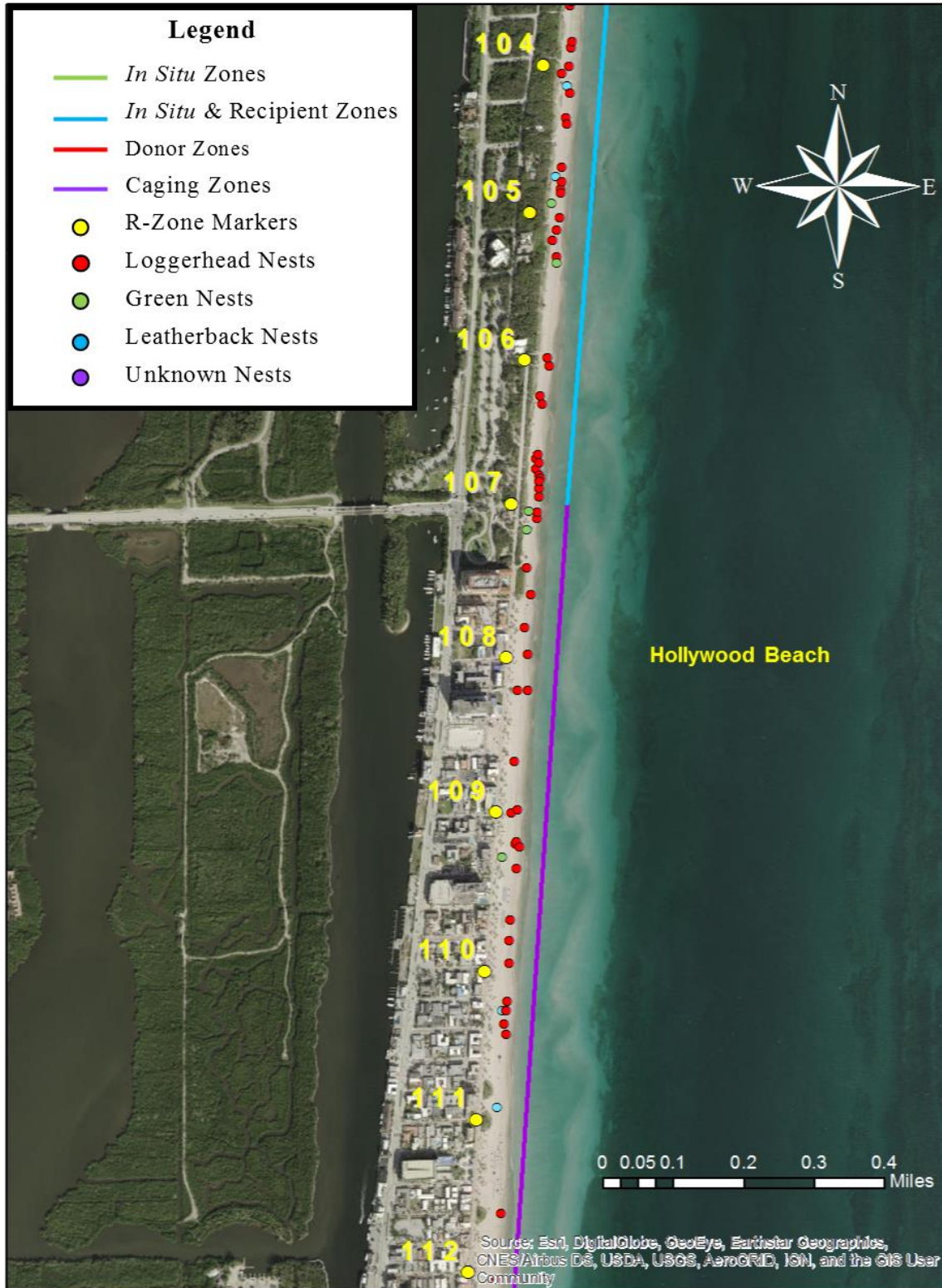


Figure 3: Locations of 2019 Turtle Crawls and Treatment Zones.

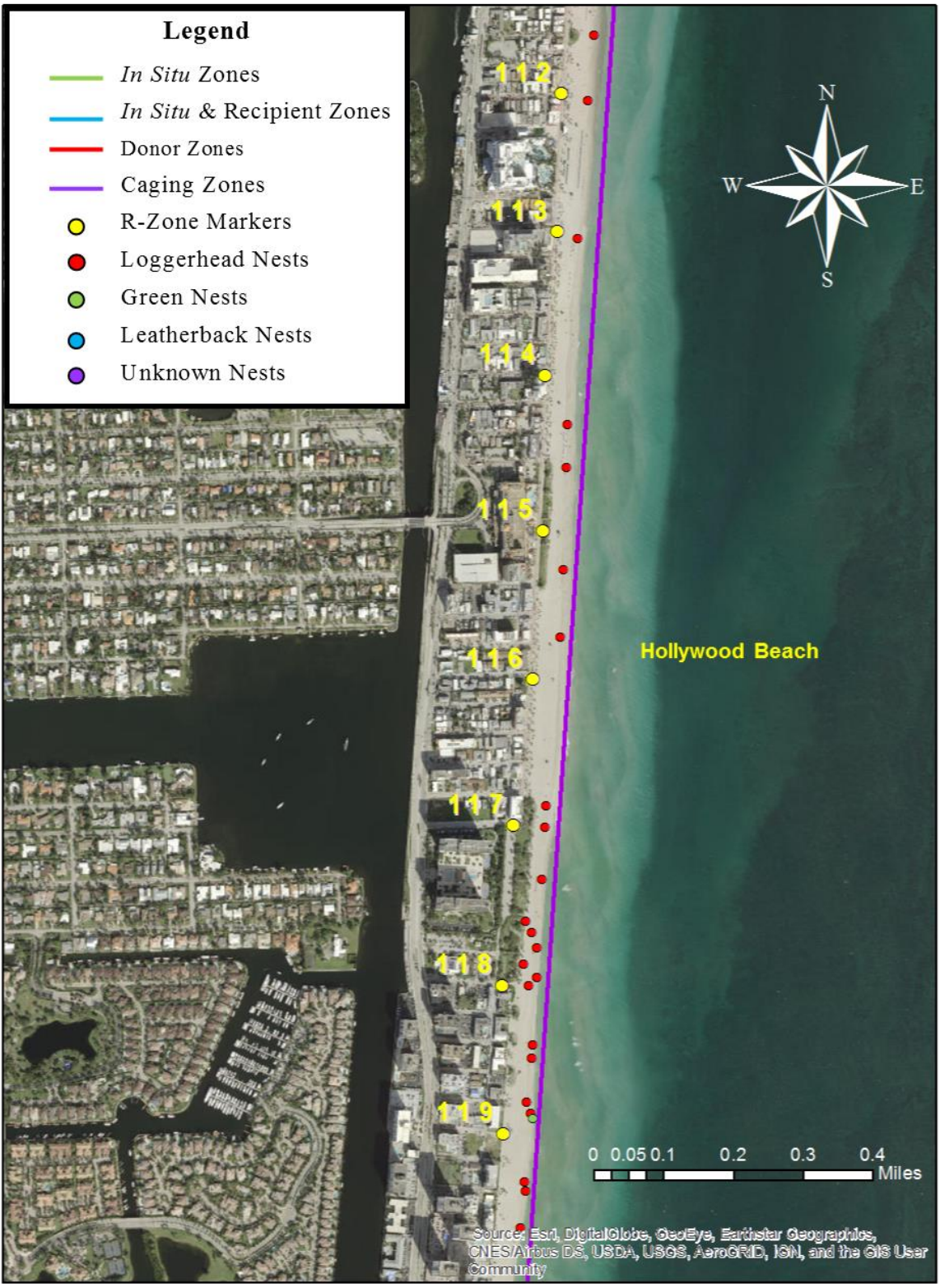


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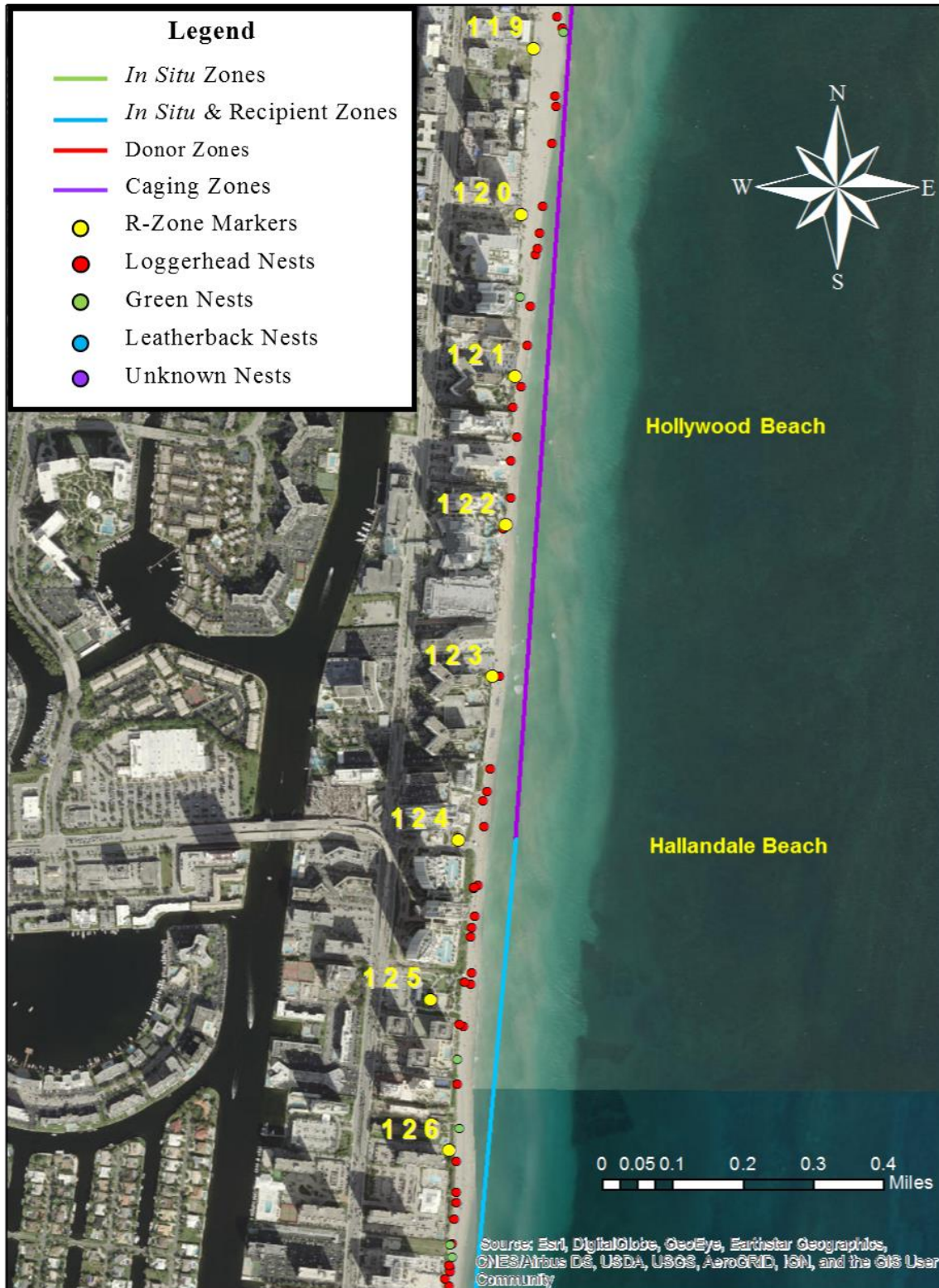


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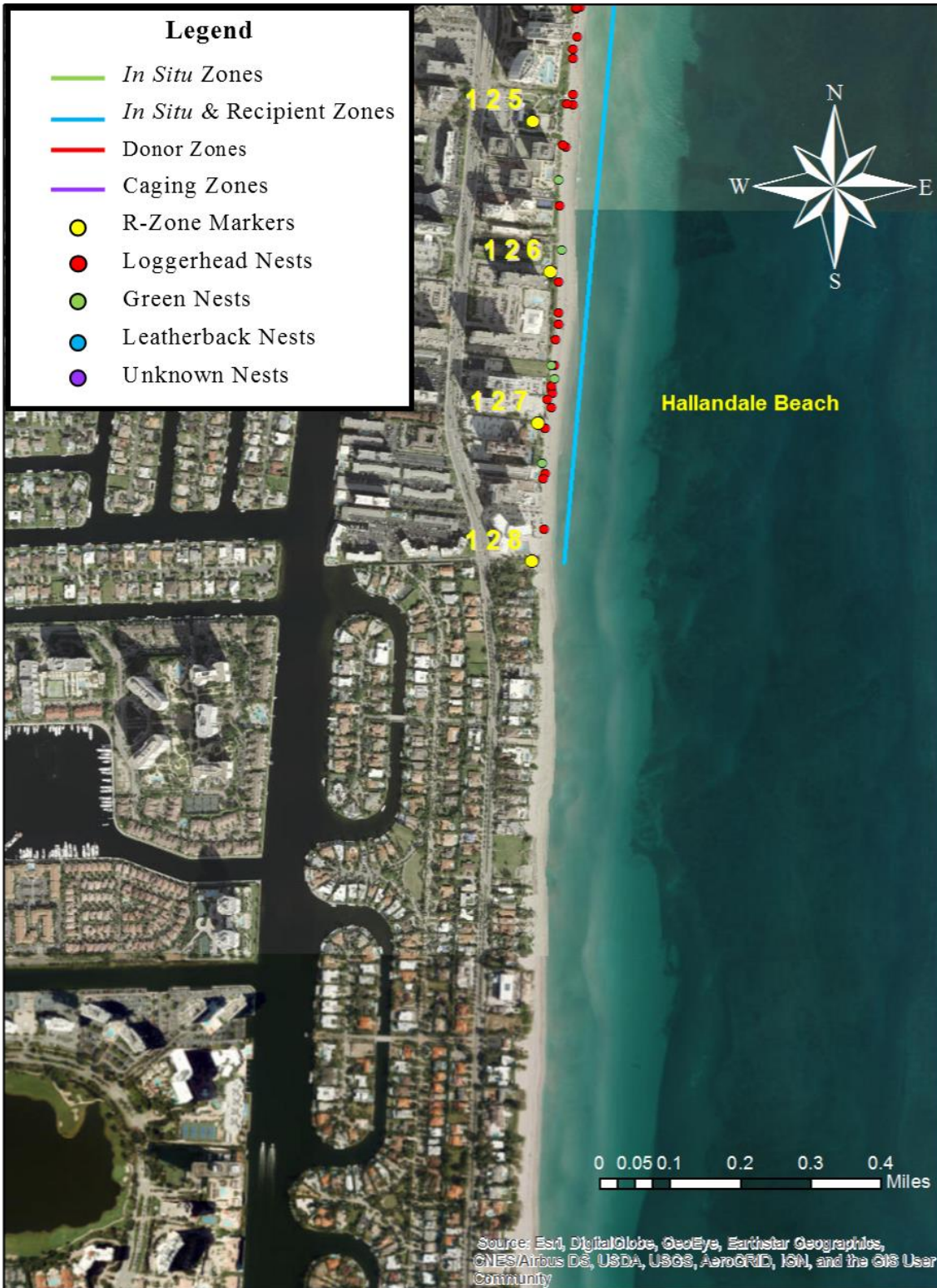


Figure 4: Historical crawl totals for all species combined for Broward County (2000-2019). Nests are designated by blue bars and false crawls are designated by red bars. Solid lines indicate trend lines for nesting (blue) and false crawls (red).

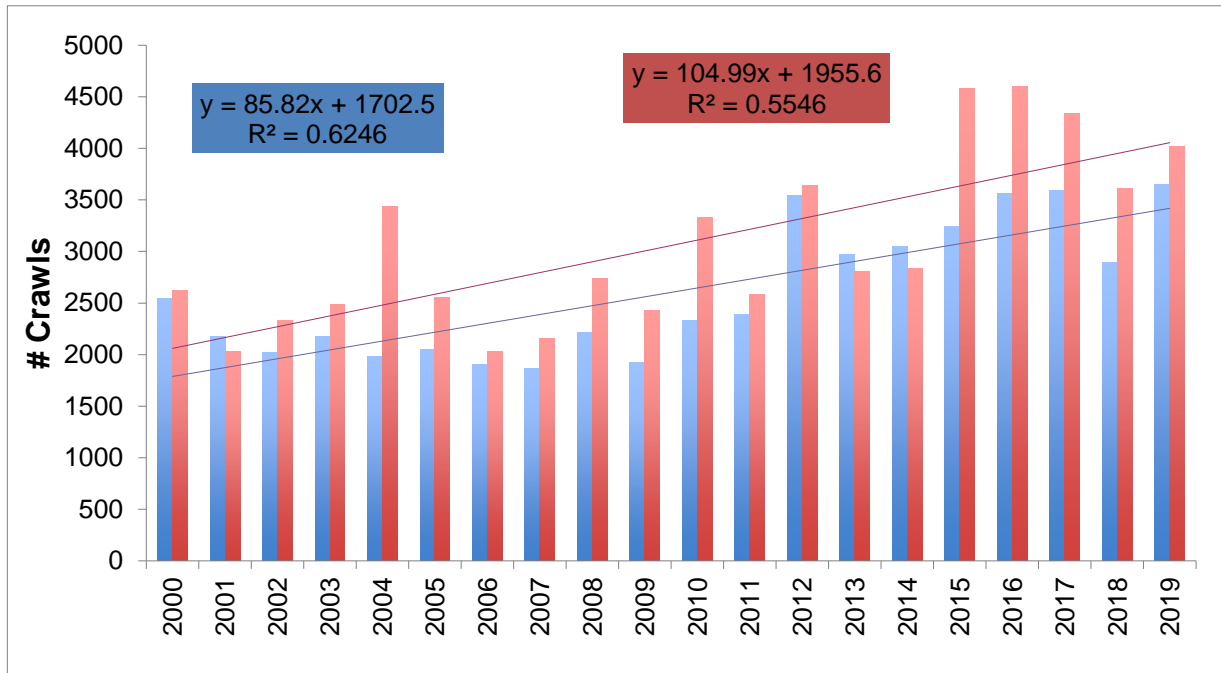


Figure 5: Historical nesting success, all species combined for Broward County (2000-2019). Five-year average is indicated by the solid black line.

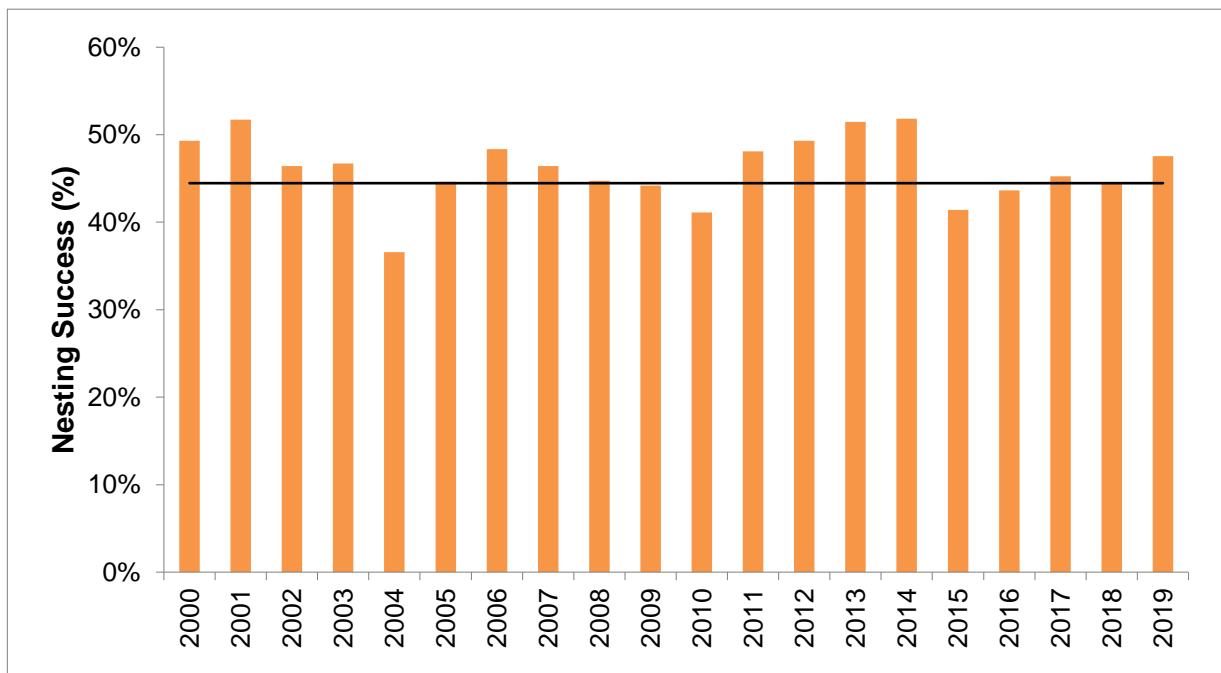


Figure 6a: Number of leatherback nests laid per day in Broward County.

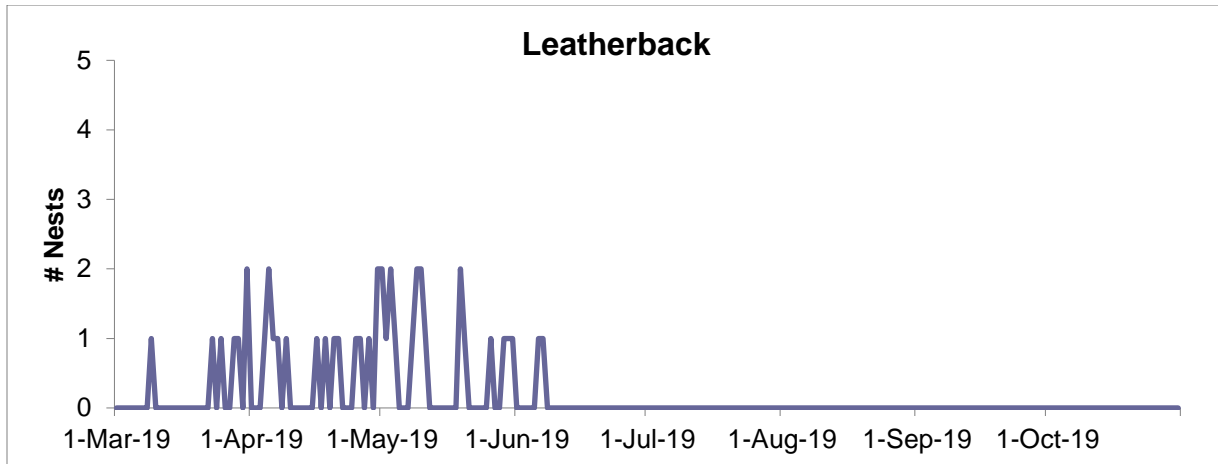


Figure 6b: Number of loggerhead nests laid per day in Broward County.

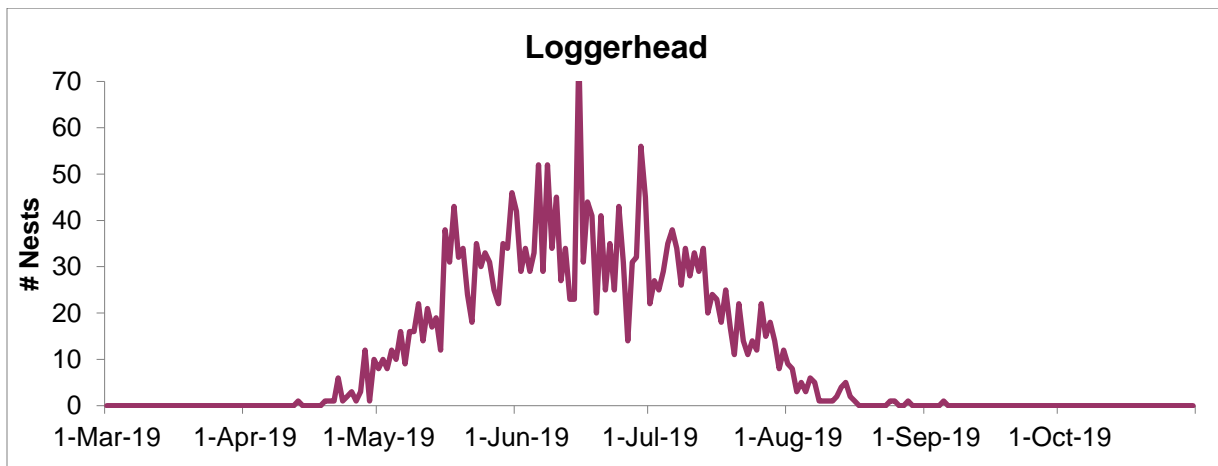


Figure 6c: Number of green turtle nests laid per day in Broward County.

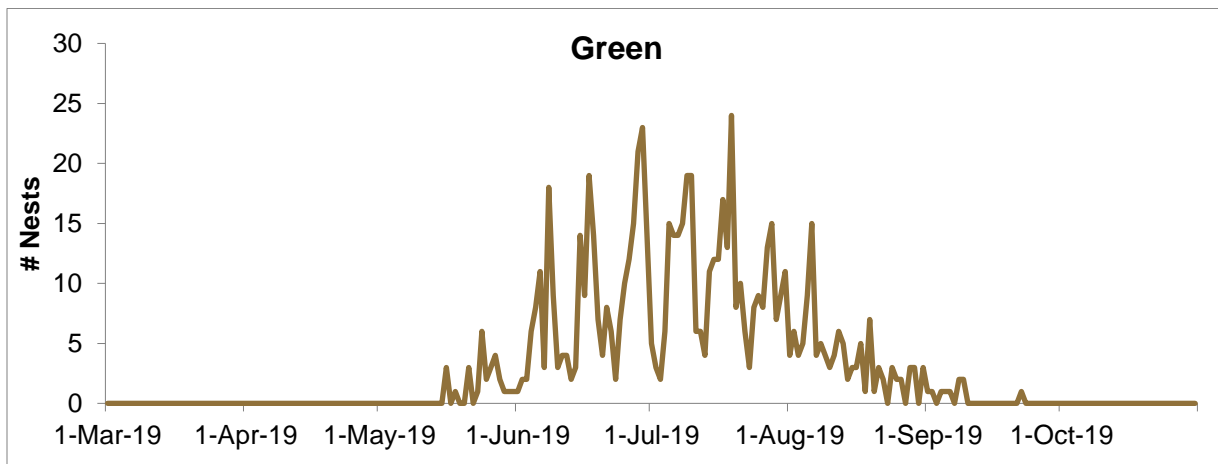


Figure 7a: Historical nesting success for leatherbacks in Broward County from 2000-2019. Five-year average is indicated by the solid black line.

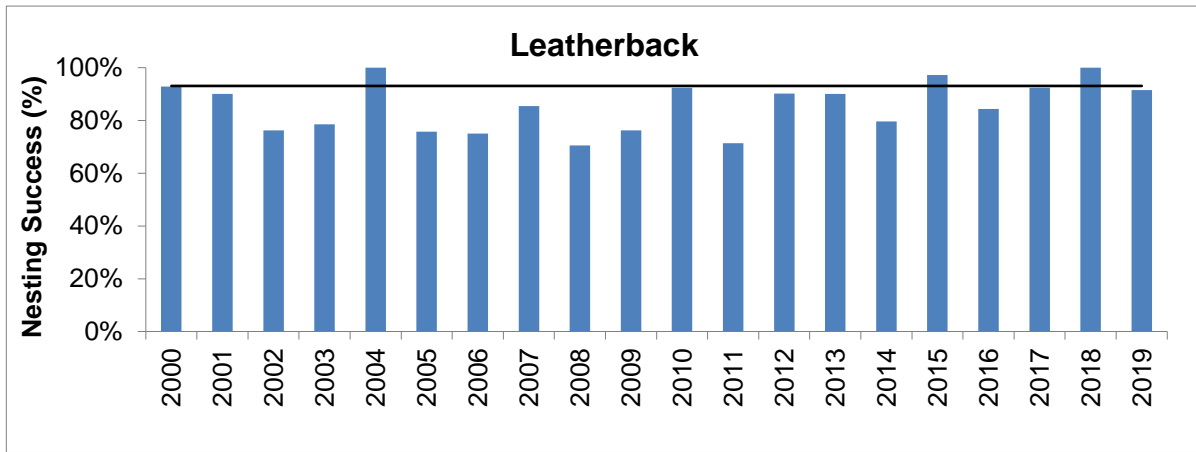


Figure 7b: Historical nesting success for loggerheads in Broward County from 2000-2019. Five-year average is indicated by the solid black line.

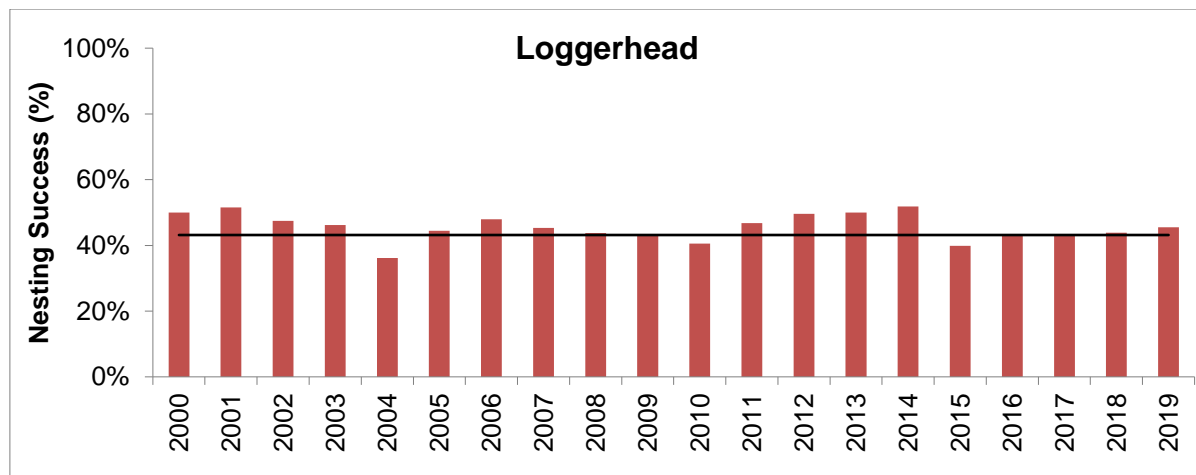


Figure 7c: Historical nesting success for green turtles in Broward County from 2000-2019. Five-year average is indicated by the solid black line.

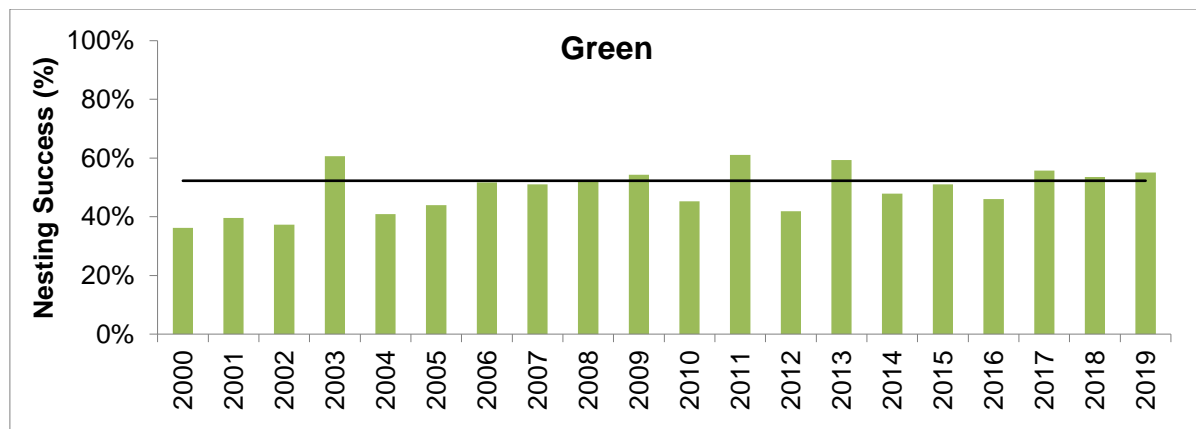


Figure 8a: Historical leatherback nest activity (number of nests) in Broward County from 1981-2019. Solid black line indicates linear trend line of nest activity.

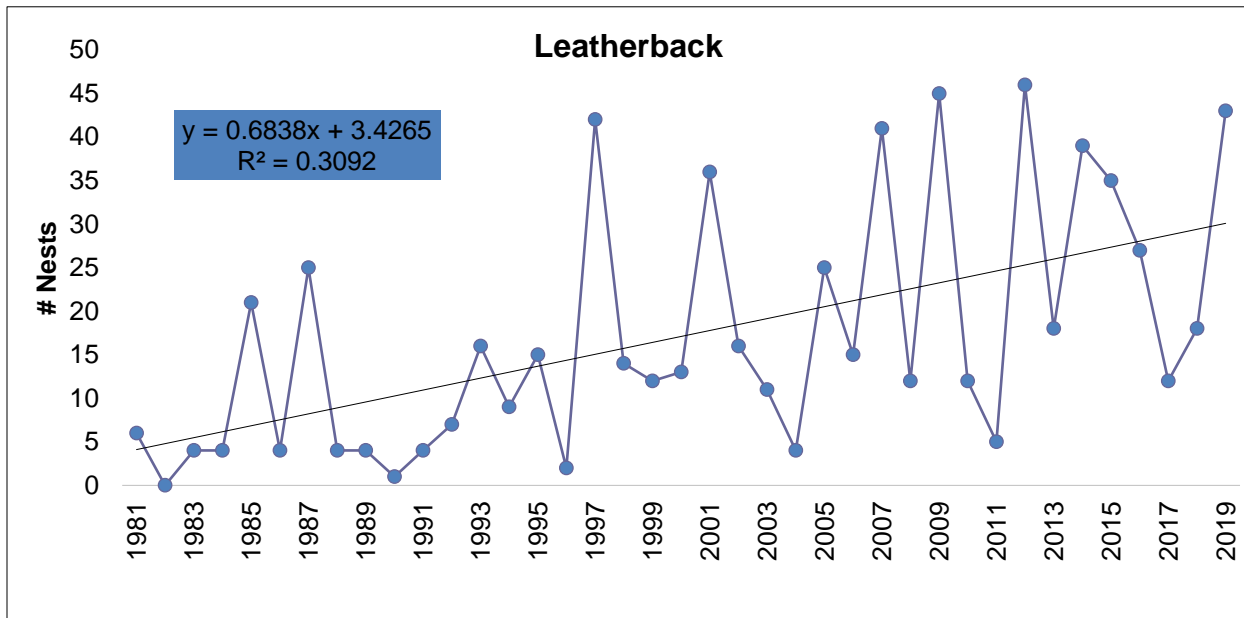


Figure 8b: Historical loggerhead nest activity (number of nests) in Broward County from 1981-2019. Solid black line indicates linear trend line of nest activity.

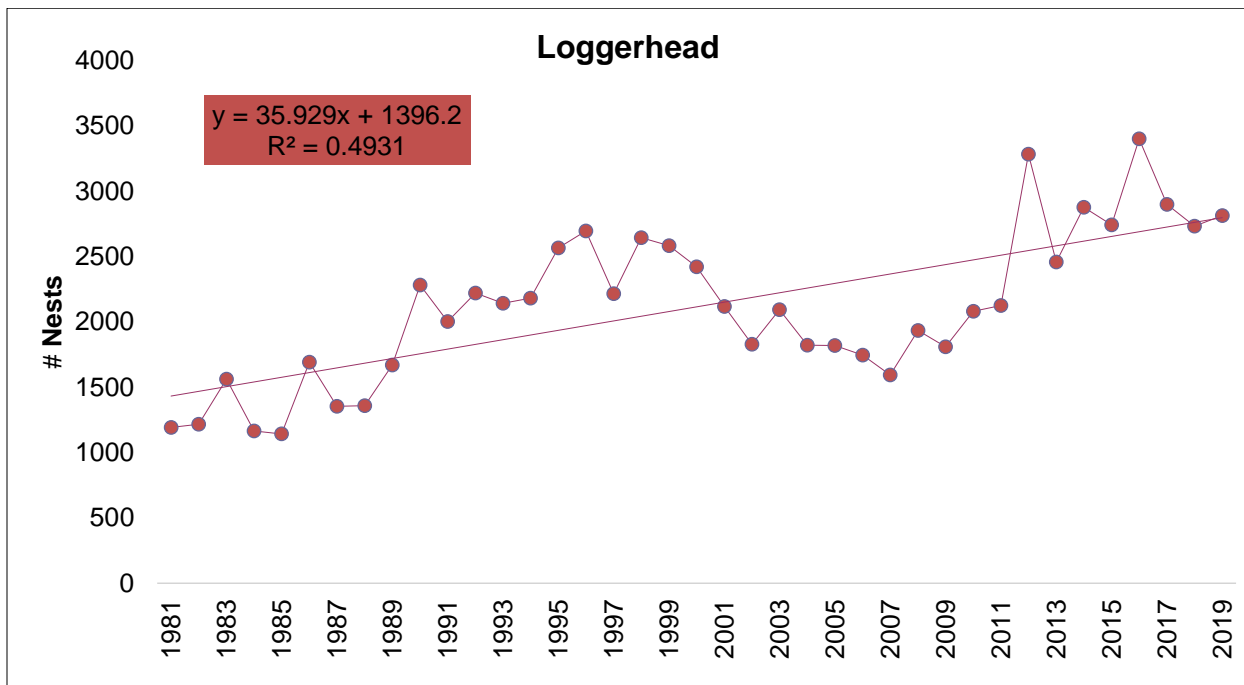


Figure 8c: Historical green turtle nest activity (number of nests) in Broward County from 1981-2019. Solid black line indicates linear trend line of nest activity.

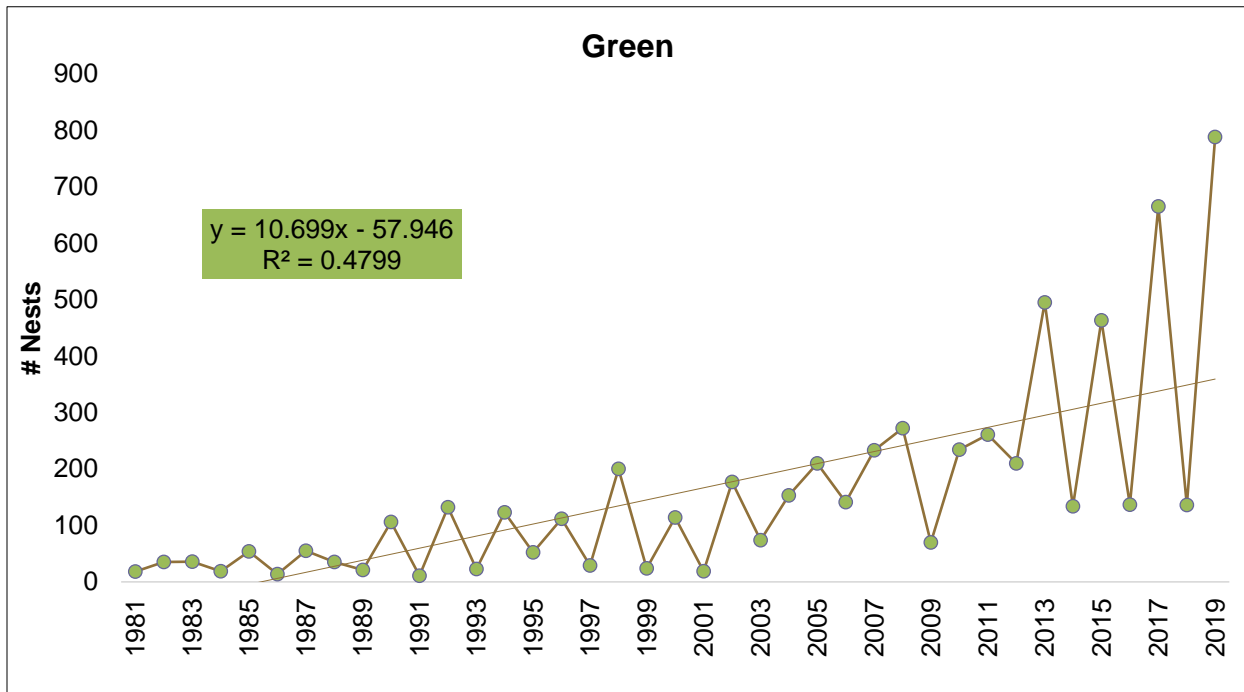


Figure 9: Historical nest relocation activity in Broward County (excluding Mizell-Eula State Park) from 2005-2019. Solid black line indicates linear trend line of nest relocations.

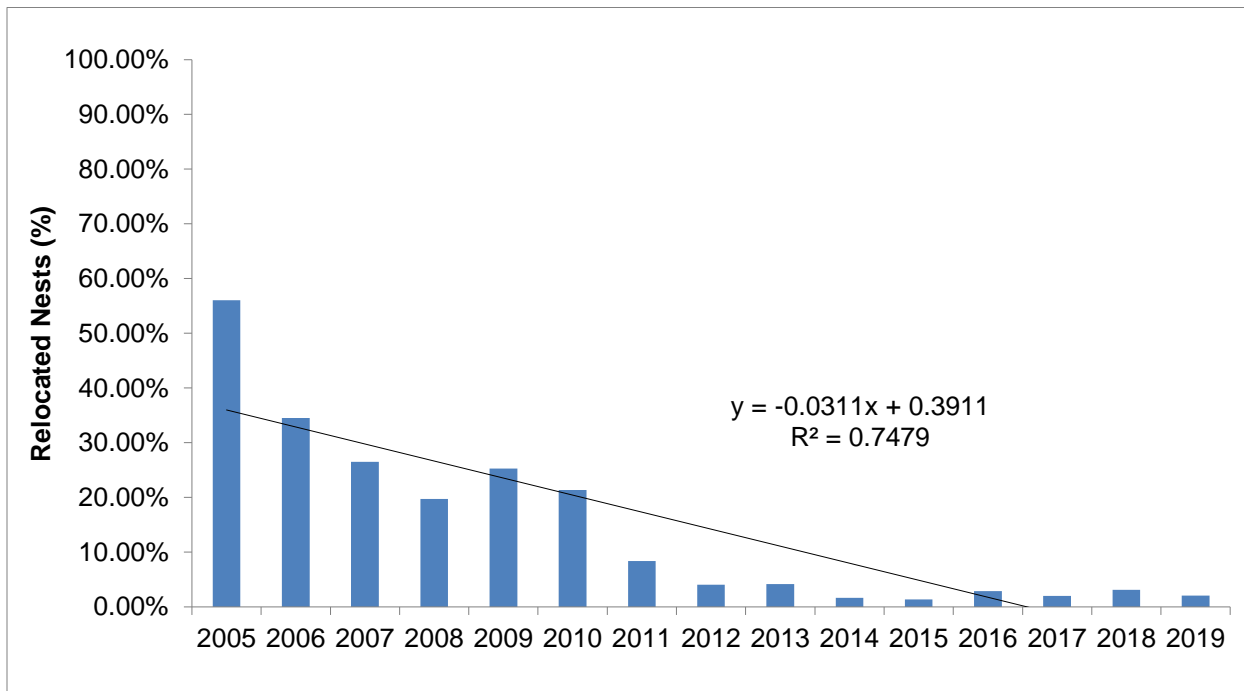


Figure 10: Historical disorientation reporting (adult and hatchling disorientations) by the BCSTCP in Broward County (excluding Mizell-Eula State Park) in 2009-2019. Five-year average is indicated by the solid black line.

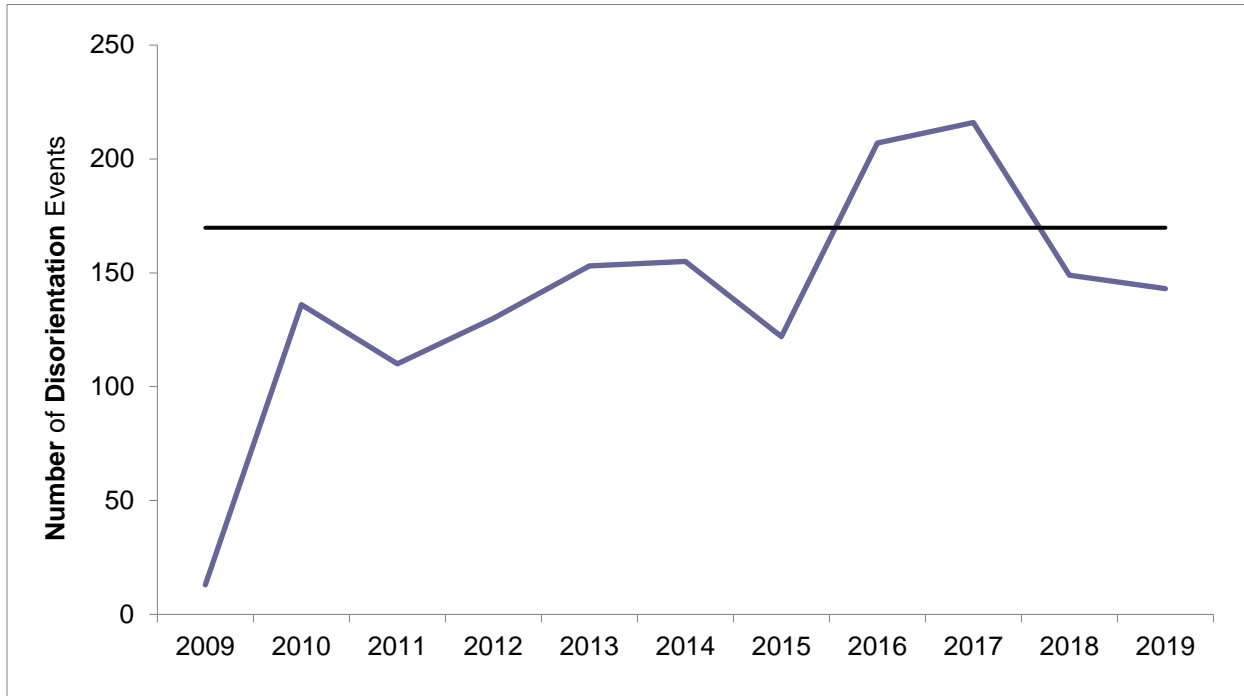


Figure 11: All hatchling disorientation reports by municipality recorded in 2019, as reported by BCSTCP, STOP, SFAS, and STARS.

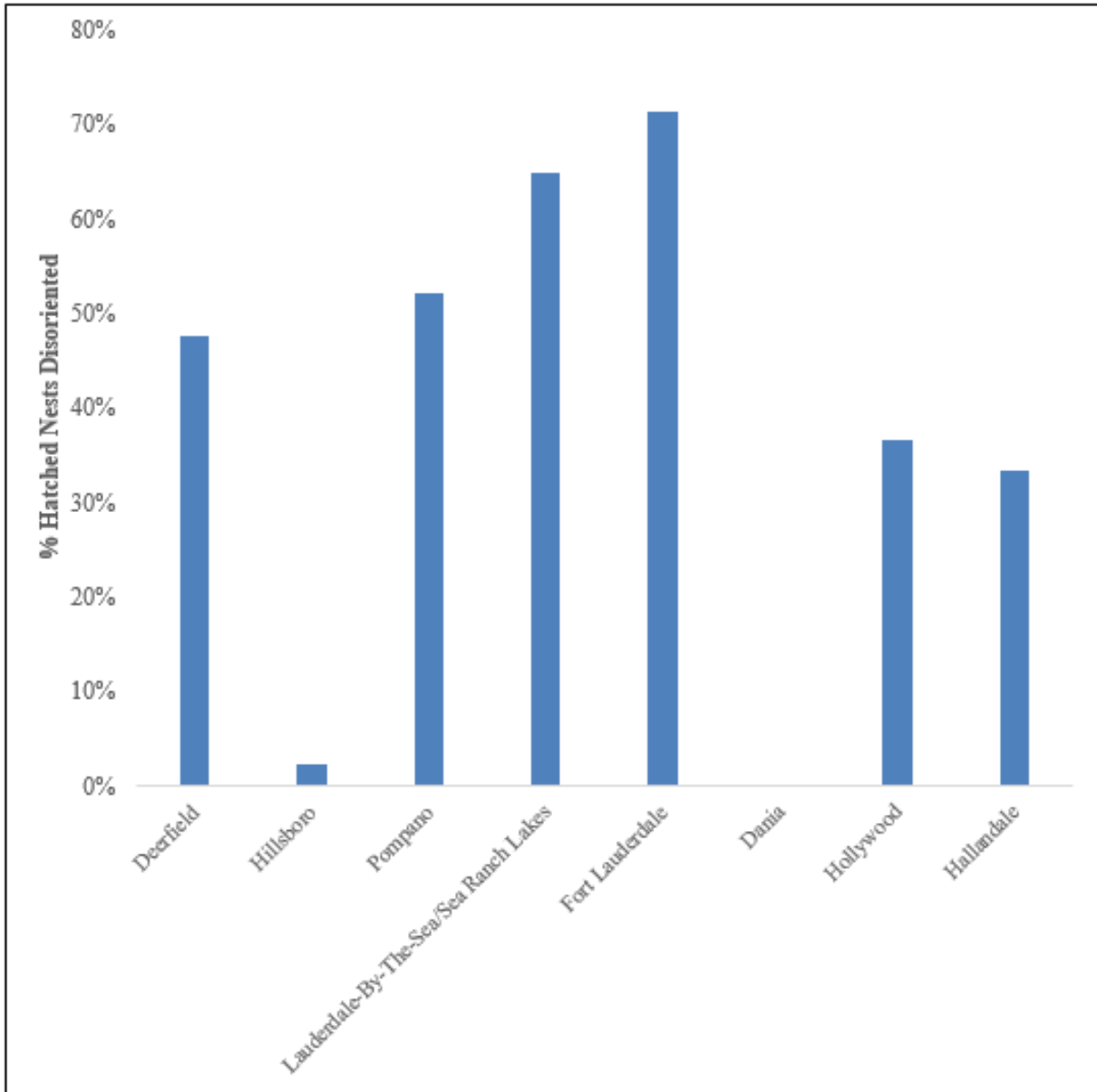


Figure 12: Percentage of nests that experienced predation in Broward County, all species and survey zones combined, 2005-2019. Solid black line indicates trend line of nest predation.

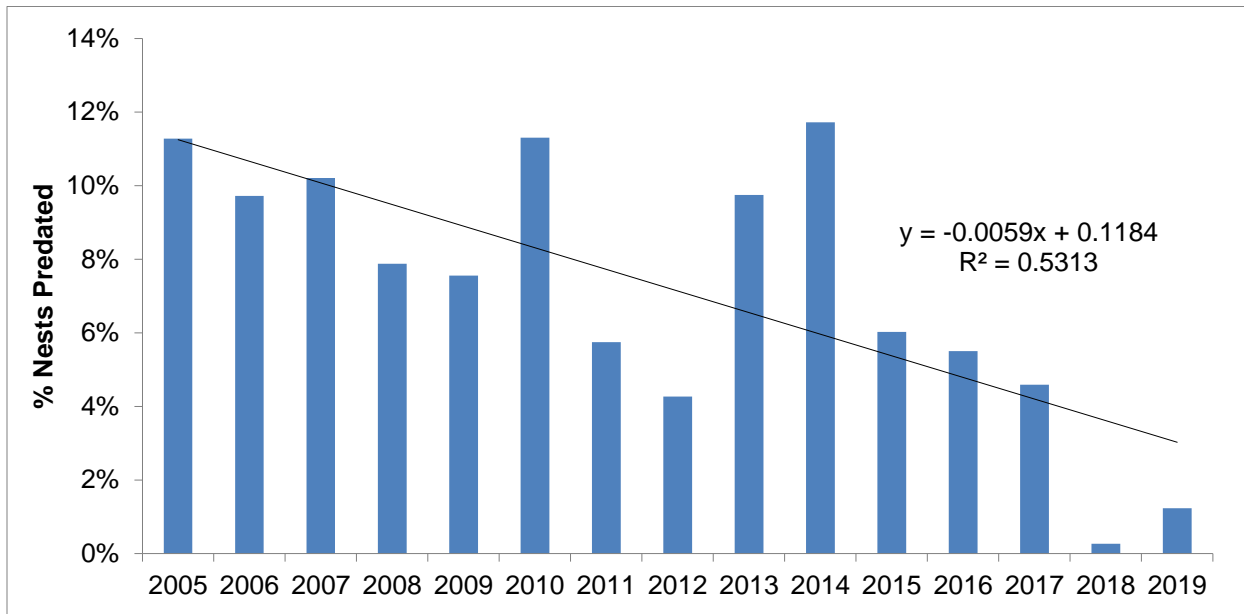


Figure 13: Percentage of nests that experienced predation in the Hillsboro survey zone, all species combined, 2005-2019. Solid black line indicates trend line of nest predation.

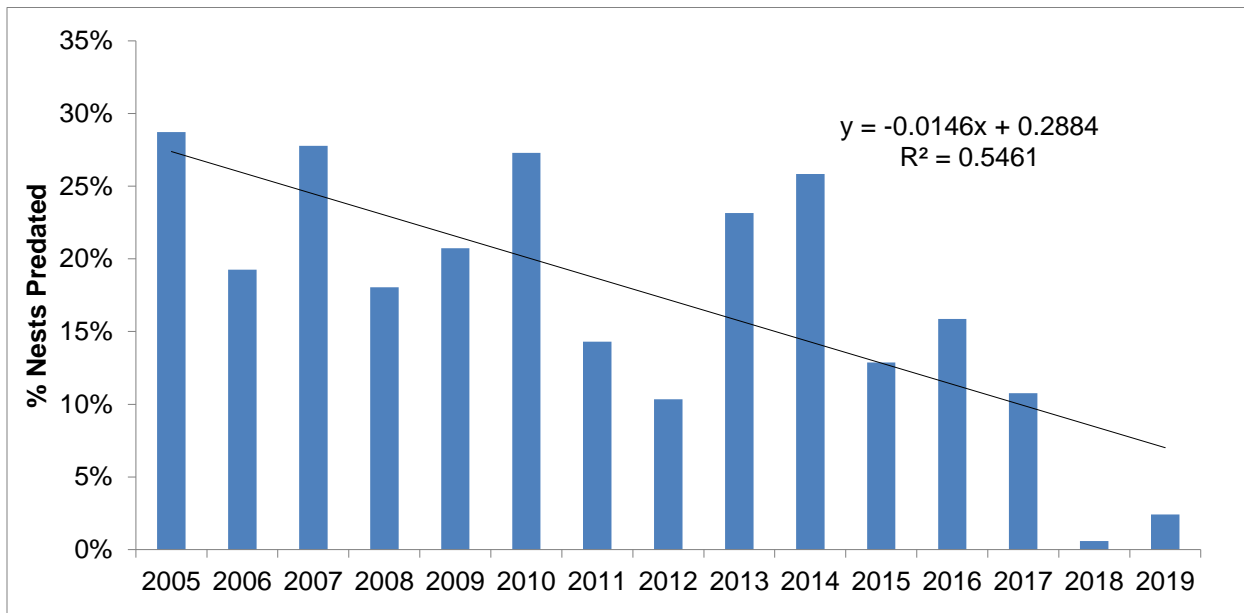
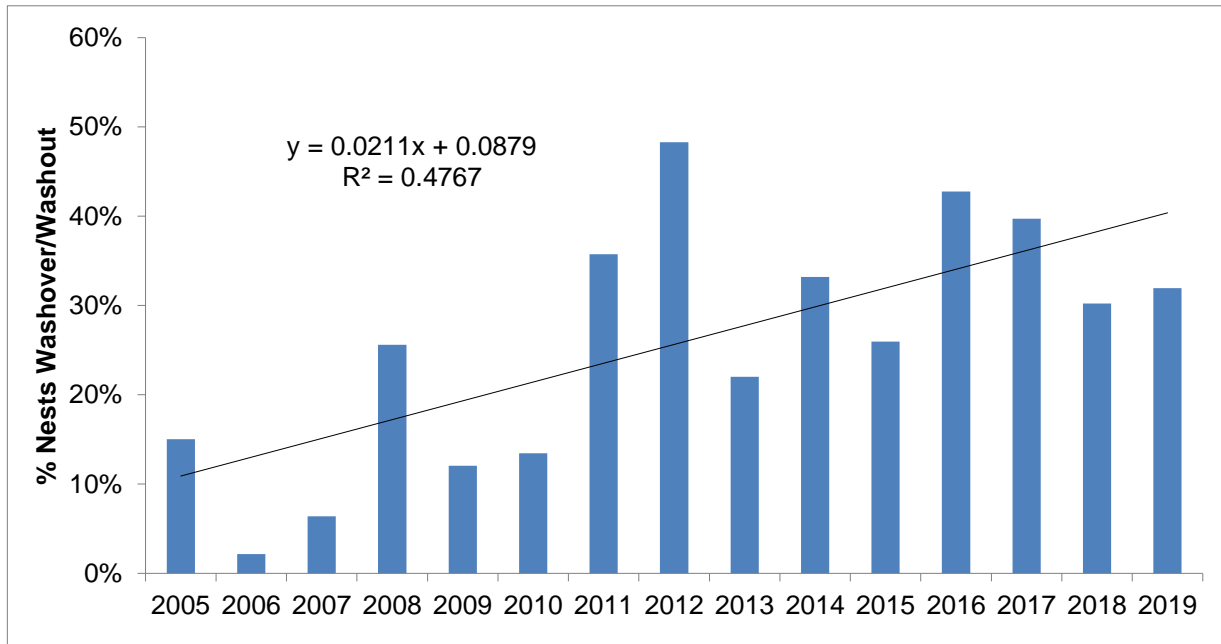


Figure 14: Historical nest washover/inundation in Broward County (excluding Mizell-Eula State Park), all species combined, 2005-2019. Solid black line indicates trend line of nest washover/inundation.



Appendix 1: Sea turtle nest sign. Size: 5.5 inches by 8.5 inches.



Appendix 2a: Sea turtle hatchling restraining cage design with escape door. Size: ~24 inches height by 24 inches diameter.





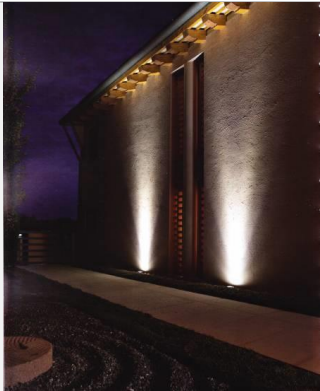
Appendix 2b: Restraining cage informational sign. Size: 8.5 inches by 11 inches.









Appendix 3: Examples of light types commonly observed on lighting surveys.




Light Fixture Type	Description	Example
Cobra	Streetlights that look like a snake head.	
Acorn	Streetlights that resemble acorns.	
Floodlight	Lights that are typically attached to corners of buildings and illuminate a broad area.	




Light Fixture Type	Description	Example
Globe	Circular, posted lights. May be “shielded” on one side with black paint, canvas, or inside the fixture.	
Bell	Pole-mounted lights with a bell-shaped fixture.	
Wall Mount	A light fixture that is mounted to a wall that is not described elsewhere.	


Light Fixture Type	Description	Example
Ceiling Mount	A light fixture that is mounted to a ceiling that is not described elsewhere.	
NEMA	Streetlight with a circular covering and open bottom.	
Up Lighting	Lights that are directed upward.	

Light Fixture Type	Description	Example
Bollards	Lighting that is inside posts attached to ground; usually less than 4 feet in height.	
Landscape	Lighting that illuminates trees or other vegetation.	
Spotlights	Lighting that is directed toward something specific.	

Light Fixture Type	Description	Example
Interior	Lights that are located inside a property and turned on.	
Rope	Multiple small lights attached to a rope.	
Posted	Any other lights on a pole not previously described.	

Light Fixture Type	Description	Example
UFO	Streetlights with round, saucer-like fixtures.	
Pool Lighting	Lights that are found underwater in swimming pools.	
Neon	True neon lighting of various colors (e.g., blue, green, purple, etc.).	

Light Fixture Type	Description	Example
Signage	Signs that are illuminated internally.	
Fluorescent	Long tube lights that are typically seen in parking garages.	
Walkway	Lights that illuminate a pathway.	

Light Fixture Type	Description	Example
Step Lights	Lights that illuminate stairs.	

Appendix 4: Summary of 2019 sea turtle emergency line use.

Call Subject	Number of Calls
Caging Inquires	1
Dead Strandings	46
Disorientations	3
Exposed Eggs	1
Hatchling Pick-up	26
Lighting Concerns	11
Live Strandings	15*
Hatchout	12
Nest/crawl Locations	26
Non-emergency Sea Turtle Inquires	67
Other Wildlife Non-emergencies	27
Potential Poaching/Vandalism/Digging	6
Spam	221
Strandings Outside Broward	4
Wrong Number	38
Overall	504

*includes events responded to by Gumbo Limbo Nature Center

Appendix 5: Summary of sea turtle strandings.

There were 56 marine turtle strandings events reported for Broward County, BCSTCP responded to 44 from January 1–December 31, 2019 (the remaining 12 were handled by Gumbo Limbo Nature Center). Of the 56 stranding events, 32 turtles were dead upon arrival (24 *Chelonia mydas*, 8 *Caretta caretta*). Of the dead stranding responses, 9 turtles suffered from boat strikes, 3 from entanglement, 4 from a predator attack, 1 was caught on shark fishing line and subsequently drowned, and 15 unknown cause of death. Twenty-four strandings were in response to live turtles (3 *Caretta caretta*, 20

Chelonia mydas, and 1 *Dermochelys coriacea*). Thirteen live turtles were accidentally hooked by fishermen (one was released on site), 5 were washbacks, 3 were removed from an FPL intake canal, 1 was a juvenile found on the beach with most of its left front flipper missing (healed), 1 fell into an empty pool on a construction site while attempting to nest, and 1 was caught under pier fencing while nesting. Twenty of the live turtles were transported to Gumbo Limbo Nature Center in Boca Raton, Florida and 1 was transported to Miami Seaquarium for treatment and rehabilitation. One live turtle that was accidentally hooked was released on site. The two turtles that stranded while attempting to nest did not sustain any injuries and each one was released immediately.

Appendix 6: Summary of education and outreach activities.

One of the goals of the BCSTCP is to provide engaging educational/outreach opportunities to the general public and students. In doing so, the program brings awareness to individuals, businesses, beach users, and coastal residents and nurtures stewardship towards a more suitable environment for these important animals. Educational flyers were distributed throughout the season to interested parties on the beach, at turtle talks, classroom/school visits, and hatchling releases.

In 2019, the BCSTCP conducted a total of 102 education/outreach events connecting with over 48,670 individuals.

- Turtle talks (16 presentations, ~1,495 participants)
 - Abraham S. Fischler College of Education
 - Alvin Sherman Library–STEM for Tweens
 - American Heritage Elementary
 - Church by the Glades Preschool
 - Coconut Palm Elementary Career Day
 - Eagle Point Elementary School Career Day
 - Glades Christian Academy
 - Green Children's House Montessori Preschool
 - Hollywood Academy of Arts & Science Career Day
 - Hollywood Women's Club
 - Kiwanis Club of Cooper City
 - NSU First Year Experience Course
 - Riverland World Languages Magnet Elementary School Career Day
 - South Broward High School Career Day
- Turtle talks followed by public hatchling release (62 presentations; ~2,266 participants)
 - Anne Kolb Nature Center
 - Beaux Arts–Fort Lauderdale
 - Big Dog Tackle
 - Bombshell Productions
 - Free Our Seas

- General Public
- Girl Scout Troop 14222
- Girl Scout Troop 660
- Hillsboro Club
- Hillsboro Police Department
- LauderAle Brewery
- Marine Environmental Education Center–Donor Appreciation
- Marine Environmental Education Center–Volunteer Appreciation
- Marine Environmental Education Center–Volunteer Appreciation
- Marjorie Stoneman Douglas High School
- Melissa DeMayo Charity Guild
- National Save the Sea Turtle Foundation
- NSU Alumni Association
- NSU Ambassador's Board
- NSU Leadership Florida Gold Coast Chapter
- NSU President's Associates
- NSU-Fellow's Society
- Pompano Dive Center
- South Florida Association of Environmental Professionals
- University School Homecoming Spirit Auction Winner
- Weston Training Center
- Women's International Shipping & Trading Association
- Table events (20 events, ~42,900 participants)
 - 18th Annual Hispanic Women of Distinction Charity Awards Luncheon
 - Anne Kolb Nature Center Oceanfest
 - Free Our Seas Art Rubber JellyFish Movie Premier
 - Free Our Seas Environmental Art Festival
 - Free Our Seas H2O Art Festival
 - Free Our Seas International Coastal Cleanup Table Event
 - Gumbo Limbo Nature Center Sea Turtle Day
 - Hollywood Cardboard Boat Race
 - Hollywood Funtastic Fridays Earth/Arbor Day
 - LauderAle Brewery–Turtle Season Kickoff
 - LauderAle Brewery–Hatchling Season Kickoff
 - LauderAle Brewery–Turtle Season Celebration
 - Loggerhead Marinelife Center TurtleFest
 - Montessori Children's House of Miami Lakes
 - Museum of Discovery and Science World Ocean's Day
 - Nova Southeastern University
 - NSU Green Sharks Earth Day
 - Stoked on Salt Ocean Conservation Day/Winterfest Family Fun Day
 - Tortuga Music Festival

- Tri-Rail's Rail Fun Day
- Excavation demonstrations (1 demonstration, 6 participants)
 - Sea Turtle Oversight Protection Youth Camp
- Ride-along tours (1 tour, 3 participants)

Appendix 7: Historical sea turtle strandings in Broward County, 2004-2019. Solid bars indicate dead strandings and open bars indicate live strandings.

