



# Cape Hatteras National Seashore Sea Turtle Monitoring and Management Program

*2018 Annual Report*



ON THE COVER

Green sea turtle hatchling heading to sea at Cape Hatteras National Seashore  
Photography by NPS

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# Cape Hatteras National Seashore Sea Turtle Monitoring and Management Program

## *2018 Annual Report*

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# Abstract

Cape Hatteras National Seashore (Seashore), located on the Outer Banks of North Carolina from Nags Head, NC, to Ocracoke Inlet, contains many ecologically important habitats including those that support sea turtles. Sea turtle nesting activity is monitored annually on the Seashore from May through September. In 2018, 166 sea turtle nests (155 loggerhead, 6 Kemp's ridley, and 5 green) and 137 false crawls (135 loggerhead, 1 green, and 1 Kemp's ridley) were documented at the Seashore. The first documented nesting activity was documented on May 17 and the last was on August 30. The mean number of eggs per nest (clutch size) was 108.1. Mean hatch success for all nests was 58.6% while mean emergence success was 51.0%. Seashore staff found 0.8% of eggs depredated and 0.1% of the hatchlings lost. Significant storm and tide events resulted in 19 nests washed away, 8 complete nest failures and multiple partial nest failures. Pedestrian, off-road vehicle (ORV), and dog intrusions were documented in protected areas, but there was no evidence that these intrusions affected nest success. The Seashore documented 156 stranded sea turtles in 2018.

# Acknowledgments

We would like to thank David Hallac and Kristin Legg for reviewing this report. We also thank our partners, Matthew Godfrey and Sara Schweitzer, with the North Carolina Wildlife Resources Commission who provided technical assistance throughout the year.

# Introduction

## Sea Turtles

Cape Hatteras National Seashore (Seashore) was established to preserve significant segments of unspoiled barrier islands along the Outer Banks of North Carolina from Nags Head, NC, to Ocracoke Inlet. The Seashore's 67-mile long series of dynamic barrier islands face the Atlantic Ocean on the east side and the Pamlico sound on the west side. The Seashore contains ecologically important ecosystems including habitat for sea turtles. Five species of sea turtles nest on the Seashore's beaches: loggerhead (*Caretta caretta*), green (*Chelonia mydas*), leatherback (*Dermochelys coriacea*), hawksbill (*Eretmochelys imbricata*), and Kemp's ridley (*Lepidochelys kempii*). In the 1970s, under the Endangered species Act, the leatherback, Kemp's ridley, and hawksbill were listed as endangered, and the loggerhead and green were listed as threatened.

Non-breeding sea turtles of all five species can be found in the near-shore waters during much of the year (Epperly et al. 1995). The Seashore lies near the extreme northern limit of the nesting range for four of the five sea turtle species: the loggerhead, green, Kemp's ridley and leatherback. Hawksbill sea turtles are only known to exist on the Seashore through strandings and very rare nesting activity.

The Seashore has been monitoring sea turtle activity since 1987, and standard monitoring protocols have been developed during this time. Sea turtle monitoring and management at the Seashore follows management guidelines defined by the North Carolina Wildlife Resources Commission (NCWRC) in the Handbook for Sea Turtle Volunteers in North Carolina (NCWRC 2006), U.S. Fish & Wildlife Service (USFWS) species recovery plans (NMFS and USFWS 1991, 1992, 1993, 2008; NMFS, USFWS, and SEMARNAT 2011), and the Cape Hatteras National Seashore Off-Road Vehicle (ORV) Management Plan, as amended by the Review and Adjustment of Wildlife Protection Buffers Environmental Assessment (NPS 2010a, 2010b, 2015a, 2015b).

## Cape Hatteras National Seashore Off-Road Vehicle Management Plan

The ORV Management Plan protects resources, minimizes conflicts among users, and promotes visitor safety. This plan includes establishment of areas temporarily closed to public entry (such as protection areas around sea turtle nests) and requires that ORVs have a permit to drive on Seashore beaches. Developed from 2007 to 2010, the ORV Management Plan was accompanied by a special regulation



Loggerhead sea turtle nesting at Cape Hatteras National Seashore. NPS

detailing requirements for ORV use at the Seashore. [Copies of the plan and related documents are available at http://parkplanning.nps.gov/caha](http://parkplanning.nps.gov/caha).

The National Defense Authorization Act of 2014 directed the Seashore to conduct a review of established wildlife protection buffers and modify them, based on peer-reviewed science, to the shortest duration possible and the smallest area possible. The Seashore made a decision to implement modified buffers (NPS 2015b) in June 2015 and those buffers were partially implemented in 2015 and fully implemented in 2016.

### **Cooperating Agencies and Organizations**

The Seashore cooperates with the National Marine Fisheries Service, USFWS, and NCWRC on sea turtle protection. All nesting activity and stranding data are reported to the North Carolina Sea Turtle Program

Coordinator at NCWRC through the [seaturtle.org](http://seaturtle.org) website. An annual permit is issued to the Seashore by NCWRC under the authority of the USFWS for the possession and disposition of stranded marine turtles and relocation of nests. Seashore resource management staff cooperates with Hatteras Island Ocean Center and Nerds Without Borders to install remote nest sensors and collect and analyze data on an annual basis. The Network for Endangered Sea Turtles (N.E.S.T.) assists NPS staff with cold stun surveys and transportation of lethargic sea turtles. The Sea Turtle Assistance and Rehabilitation (STAR) center with the North Carolina Aquarium on Roanoke Island receives and rehabilitates live stranded sea turtles found on the Seashore. The University of Georgia analyzes and reports results of an ongoing genetic study within North Carolina, South Carolina, and Georgia looking at the overall demographics of the Northern Recovery Unit for loggerhead sea turtles.



# Methods

## Nest Monitoring and Management

Per the Cape Hatteras National Seashore Off-Road Vehicle (ORV) Management Plan, monitoring for sea turtle nest activities starts on May 1 annually, but in 2018, monitoring for sea turtle nests began on April 30 so staff could become familiar with shoreline features. Patrols were conducted in utility task vehicles (UTVs) or 4 X 4 trucks in the morning, beginning between 4:30 a.m. and 5:00 a.m. Staff searched the beach looking for characteristic crawl patterns indicating that sea turtles emerged from the ocean to attempt nesting. Each occurrence of nesting activity was recorded as either a false crawl or a nest. The location of each nest was recorded using Global Positioning System (GPS) devices and distances from the nearest ORV ramps and other beach access points (in miles rounding to the nearest tenth of a mile).

All nests were confirmed by locating eggs at the dig site; sediment was excavated to a depth of approximately 15–30 cm. One egg was taken from each clutch for DNA research purposes. If no eggs were laid, the nesting activity was considered a false crawl and recorded by collecting a GPS location at the apex of the crawl. In order to maximize sea turtle nest success, monitoring staff evaluated each nest to determine if relocation was advisable. Results of a 2018 annual habitat assessment, current

beach conditions, the North Carolina Wildlife Resources Commission (NCWRC) Handbook for Sea Turtle Volunteers in North Carolina, and guidance provided by North Carolina Sea Turtle Program Coordinator were all used to help make these decisions daily (NCWRC 2006, pp.14–16). Relocation methods recommended by NCWRC were used (Handbook for Sea Turtle Volunteers in North Carolina; NCWRC 2006). Sea turtle monitoring data were reported to NCWRC using the Sea Turtle Nest Monitoring System through the [seaturtle.org](http://seaturtle.org) website. Monitoring efforts to locate new nests ended September 29, more than two weeks after the last nesting activity was observed.

All nests were protected from human disturbance by installing a 10 x 10-m signed area around the nest site. Additionally, metal predator screens were installed over top of all nests found on Bodie Island in an effort to deter canid species from preying these nest sites. At days 50–55 of incubation, or earlier if hatch activity was observed, the protected area was expanded to 30 m wide (15 m on either side of a nest site) and extended to the water line. In addition, black filter fence was installed around each nest and extended just above the average high tide lines. The filter fence stands roughly 36 inches above the surface of the sand and reduces artificial light



Kemp's ridley sea turtle nesting at Cape Hatteras National Seashore. NPS





Hatchling crawls at Cape Hatteras National Seashore. NPS

pollution from housing, beach fires, ORV headlights, and flashlights in the immediate area. Ultimately the filter fencing shielded much of the artificial light produced and helped funnel hatchlings to the ocean unaided. These larger enclosed areas protected the nest site and potential hatching events from excessive human disturbance and allowed for a disturbance-free area for emerging turtles to reach the ocean. Each nest site was checked daily and any disturbance or hatching events were recorded.

Approximately three to five days after an initial hatching event, nests were excavated and the protection areas were removed. The remaining egg shells, unhatched eggs, and live/dead hatchlings were counted to determine hatch and emergence success for each nest excavated. Hatching success is the percentage of eggs in a nest that produce hatchlings. Mean hatch success rates were calculated by taking the mean of all the individual nest hatch successes. Emergence success is the total number of hatchlings that emerged unaided from the nest cavity relative to

the total number of eggs in the nest. Mean emergence success was calculated by taking the mean of all the individual nest emergence successes. Any hatchlings found during excavations were not considered to have emerged. Any nest that had an inventory date or was marked as lost was included in these calculations (Appendix A). Live hatchlings discovered during nest excavations were collected and released at or after dusk on the same day.

### ***Late Nest Management***

Any new nest discovered on or after August 21 in any year is considered a late laid nest. Following NCWRC recommendations, after 90 days of incubation, excavations began on any late laid nests (NCWRC 2006). If a viable embryo was observed, the excavation ended and the nest was left in place. If hatching activity was not observed after 100 days of incubation, the nest stayed in place and the protection area was reduced back to a 10 x 10-m area, thus eliminating any beach access issues. The eggs were checked approximately every 10 days for viability. Nests were fully excavated and protection areas were removed when no viable embryos were observed.

### ***Beach Nourishment***

In the 2017 nesting season, a beach nourishment project occurred that involved dredging sand from offshore and pumping it onto the shoreline. This project was contracted through Dare County to increase beach area in the Buxton Village area in order to protect Highway 12 from ocean overwash. The project area extended for approximately 2.9 miles. Due to the inherent risk to the eggs and hatchlings from heavy equipment operating on the beach, and large pipes blocking access to the ocean, all nests laid in the project area were relocated. During the 2018 nesting season, all construction and daily operations associated with the nourishment project had ended. Nests laid within the 2017 project zone were assessed as any other nests laid outside of the project zone. Contractors communicated with resource field staff periodically throughout the nesting season in order to plan site visits and conduct post nourishment beach surveys.

### ***ORV Corridors***

When ORV corridors could not be established behind nests on ORV beaches, and there were no alternative ORV access routes, ORV corridors were

established on the seaward side of nests. This is a modified sea turtle management action from the 2015 Environmental Assessment: Review and Adjustment of Wildlife Protection Buffers (NPS 2015a, 2015b). When nests meeting these conditions were located, Seashore staff and volunteers intensively monitored the nests and smoothed out ORV tire ruts (between 6 p.m. and 9 p.m. each night). Nests were monitored when their protected areas were expanded (at around 50–55 days of incubation) until the night before the nest was excavated.

### Depredation/Loss

NPS resource management staff documented sea turtle egg and hatchling loss as part of their routine monitoring efforts throughout the nesting/hatching season. Evidence of loss from humans, terrestrial mammals, and birds was documented when observed. In addition, staff monitored all protection areas for potential loss from predators, including first-hand sightings of predators and predator tracks/sign left behind.

### Storm, Tide, and Overwash

Seashore staff monitored nests for loss due to storms, tide, and overwash and recorded the loss as washed away, complete failure, or partial failure. Washed away is defined as a nest that no longer exists in the ground, and thus was unable to be inventoried. Complete failure is defined as a nest that shows 0%

hatch and 0% emergence upon inventory of the nest. Partial failure is a nest that produces a low percentage of emergence.

### Incidental Take/Human Disturbance

All species of sea turtles nesting at the Seashore are protected under the Endangered Species Act of 1973. Under this act, “take” is any human-induced threat to a listed species. Take is defined as “to harass, harm, pursue, hunt, shoot, wound, kill, capture or collect, or to attempt to engage in any such conduct.” Harm is further defined to include significant habitat modification or degradation that results in the death or injury of listed species by significantly impairing behavioral patterns such as breeding, feeding, or sheltering. Much of the Seashore’s shoreline remains open to pedestrians and Seashore staff is unable to monitor the entire shoreline for nesting turtles 24 hours a day. While it is difficult to determine whether human activities have disrupted or disturbed sea turtle nesting, Seashore staff minimized these potential effects by closing the shorelines to non-essential ORV use from 9:00 p.m. until 6:00 a.m. to provide for sea turtle protection.

### Protected Area Intrusions

Intrusions into sea turtle resource protection areas were documented whenever possible by Seashore staff. Protected area intrusions are defined as any direct or indirect observations of human activity



Sea turtle nest site closure area. NPS



within clearly marked protection areas and does not necessarily mean that any disturbance to nests or sea turtles occurred. Examples include pedestrians (on-foot), bicyclists, ORV traffic, and horses that could harm a turtle nest site inside of a protective, fenced area.

In addition ORV operation on oceanside beaches from May 1 to September 15 before 6:00–7:00 a.m. (depending on time of year/ramp location) and after 9:00 pm was prohibited in order to protect potential nesting habitat and reduce vehicle-related disturbances to nesting sea turtles. Park resource staff documented these violation instances each morning while on patrol and contacted park visitor and resource protection staff when resource damage or illegal acts occurred.

## Artificial Lighting

Artificial light is known to disturb nesting females and disorient hatchlings. Outdoor lights, beach fires, and headlights may deter nesting females from laying their nests along stretches of optimal beach. Hatchlings use natural light to navigate toward the water. When artificial lights are brighter than the natural light reflecting off the surface of the ocean, hatchlings will become disoriented and crawl away from the shoreline and toward these brighter lights and the

dunes. This causes hatchling mortality due to exhaustion and an increased chance of predation.

The Seashore continues to try and decrease the effects of artificial lighting on sea turtles. Since 2005, black silt fencing has been utilized around most turtle nests to decrease the amount of artificial light shone onto the beach, thereby decreasing the negative effects of light on hatchlings. In 2012, a Superintendent's Order was established that sets outdoor lighting guidelines within the Seashore boundaries. Since 2015, Seashore staff have continued their efforts to educate the public on artificial lighting by dispersing brochures to the public at sea turtle nests due to hatch or be excavated. Volunteer nest watchers pass out brochures so they can educate the public as they waited for nests to hatch in the evening in areas where light pollution occurs regularly. Efforts are also made by staff and volunteers to encourage vacationers at their rental homes to shut off all artificial lighting not being used during nighttime hours.

Night driving was not permitted from May 1 through September 15, 2018 from 9:00 p.m. to 6:00 a.m. On September 16, night driving was systematically reopened as nests were excavated and protected areas were removed. Since 2012, the Seashore has regulated ORV night driving because vehicle headlights can disturb nesting turtles and hatchlings.



Black silt fencing used to protect hatchlings from artificial light sources that can misorient them and prevent them from reaching the ocean. NPS

## Stranding Activity

A stranded turtle is a non-nesting turtle that comes to shore either sick, injured, or dead. Data were collected for each reported or observed stranding. In an attempt to discover cause of death, necropsies were performed on dead strandings when possible. Live stranded turtles were transported to the Sea Turtle Assistance and Rehabilitation Center at the North Carolina Aquarium on Roanoke Island for treatment and recovery. All data were reported to NCWRC using the Sea Turtle Rehabilitation and Necropsy Database (STRAND) through the [seaturtle.org website](http://seaturtle.org).

Based on cold weather patterns and average ocean-side and soundside water temperatures, an increased effort to locate stranded turtles began in late November 2018 and continued throughout the winter due to the increased chance of “cold stunned” turtles. Cold stunning refers to the hypothermic reaction that occurs when sea turtles are exposed to prolonged cold water temperatures. Initial symptoms include decreased heart rate, decreased circulation, and lethargy followed by shock, pneumonia and possibly death” (<https://www.greateratlantic.fisheries.noaa.gov/protected/stranding/overview/cold.html>). Searches for cold stunned turtles were emphasized on the soundside shorelines and inlets of the Seashore, where the majority of cold stunned turtles have been found in past years.

## Turtle Sensor Studies: Hatteras Island Ocean Center/ Nerds without Borders

In 2013, the Seashore began a collaboration with Samuel Wantman and David Hermeyer of Nerds Without Borders and Eric Kaplan of the Hatteras Island Ocean Center to develop a sensor that could monitor movement and temperature fluctuations in nests. The goal was to correlate these measurements with hatching and emergence events. The Seashore purchased the sensors and communication towers, and was responsible for implementing the project in the field during the 2013–2015 seasons. In the 2016–2018 seasons, Seashore resource staff worked directly with a researcher from Hampden-Sydney College, who helped install sensors, collected monitoring data, and collaborated with Hatteras Island Ocean Center and Nerds Without Borders. Hatching events were predicted using data from the sensors (detecting movement only) and nest-specific monitoring data.



Nest sensor in a sea turtle nest. NPS

## Genetic Study

Since 2010, the Seashore, along with all other North Carolina, South Carolina, and Georgia beaches, has participated in a genetic mark-recapture study of Northern Recovery Unit nesting female loggerheads using DNA derived from eggs. The study is coordinated by the Georgia Department of Natural Resources, the University of Georgia, and NCWRC. One egg from each nest was taken and sampled for maternal DNA each year. Loss due to collection of permitted research samples was recorded. The sample allows each nest from North Carolina, South Carolina, and Georgia to be “assigned” to a nesting female. The ultimate goal of the research is to answer questions about the total number of nesting females in the population, the number of nests each female lays per season, the distance between nests laid by individual females, and other information that is important to understanding the population dynamics of sea turtles. More information can be found at the [seaturtle.org nest genetics monitoring website](http://seaturtle.org/nestgeneticsmonitoringwebsite) (<http://www.seaturtle.org/nestdb/genetics.shtml>).

# Results

## Nest Monitoring and Management

A total of 166 nests (155 loggerhead, 6 Kemp's ridley, and 5 green) were observed at the Seashore in 2018 (Figure 1). Of the confirmed nests, six (3.6%) were found on Bodie Island, 119 (71.7%) on Hatteras Island, and 41 (24.7%) on Ocracoke Island (Appendix A and B). This was the fifth lowest number of nests recorded in a single nesting season in the last ten years at the Seashore (Figure 1). The first nest was observed on May 19 and the last nest was observed on August 30. Peak nesting occurred between June 17 and July 14 (Figure 2). Preliminary DNA results from the samples collected at each nest indicate a total of 84 females utilizing Seashore beaches to nest, resulting in an average of 1.98 nests laid per female with a mean inter-nesting period of 14.53 days (Table 1; Godfrey, n.d.).

## Nest Relocation

Of the 166 nests found in 2018, 61 (36.7%) were relocated (Appendix A). Most nests were moved due to natural factors including nests located at or below

daily high tide lines or nests that were laid in an area susceptible to high erosion and flooding.

## Late Nest Management

In 2018, two nests were laid after August 21, ranging from August 23 through August 30. Both late nests showed significant hatch activity, one at 52 days of incubation and the other at 56 days of incubation. Both nests exhibited 88% hatch success while emergence success varied, one being 83% and the other being 60.7%.

## False Crawls

During the 2018 breeding season, 137 false crawls or aborted nesting attempts were recorded. False crawls accounted for 45.2% of the 303 total turtle activities. Of the 137 false crawls, three (1.5%) were documented on Bodie Island, 83 (60.6%) on Hatteras Island, and 52 (37.9%) on Ocracoke Island (Appendix A and C). There was one Green, one Kemp's ridley, and 135 Loggerhead false crawls documented.

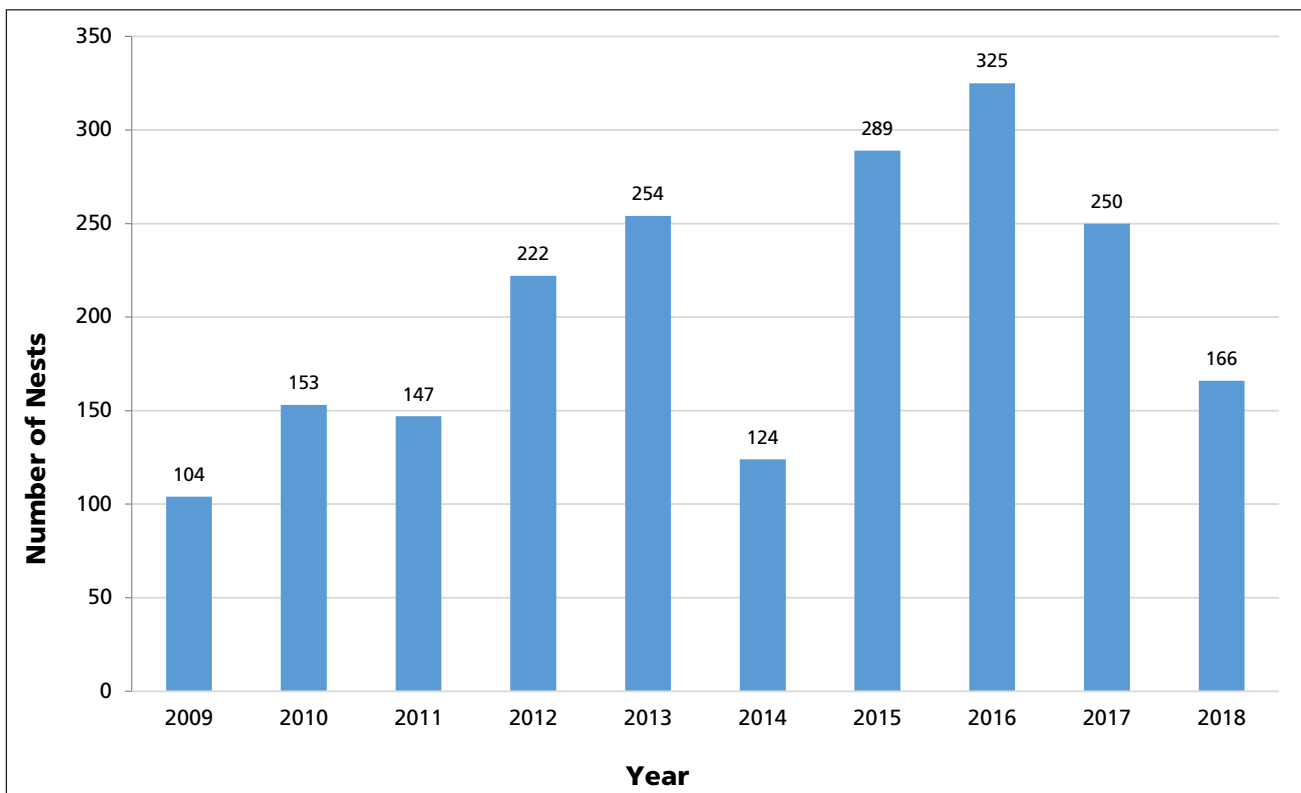
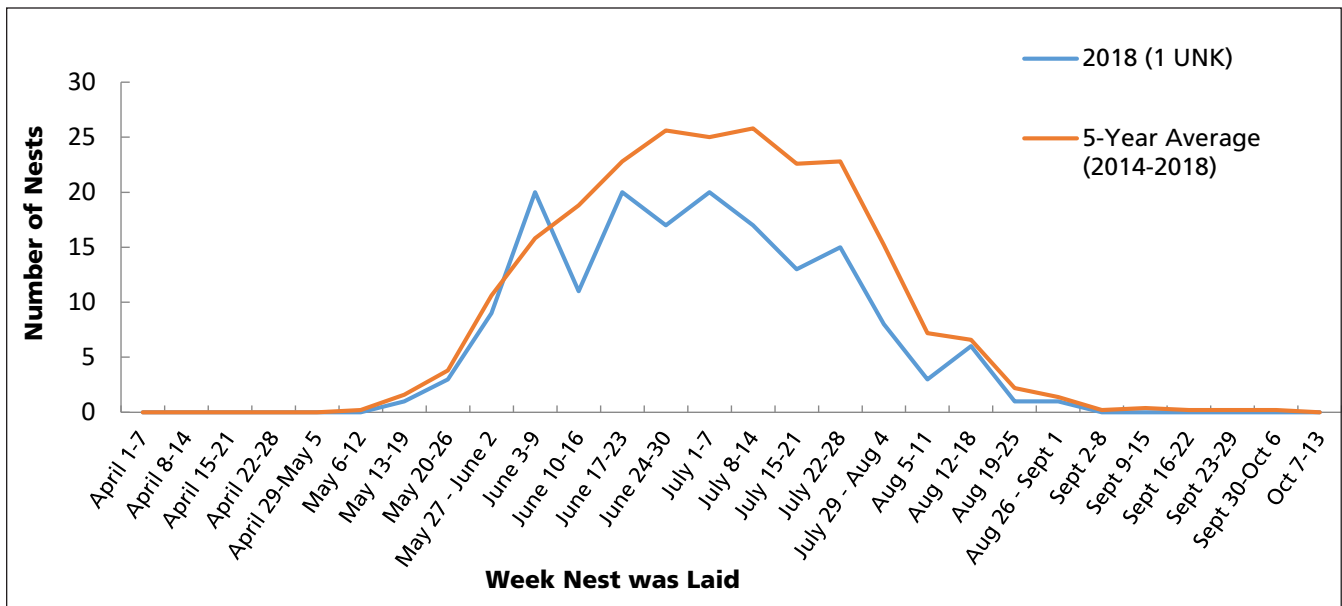


Figure 1. Sea turtle nests at Cape Hatteras National Seashore, 2009–2018.



**Figure 2.** Number of nests laid per week in 2018 and averages of the previous five years by week at Cape Hatteras National Seashore.

**Table 1.** Number of individual nesting sea turtles, number of nests per female, and mean inter-nesting periods based on DNA results, Cape Hatteras National Seashore (2010–2018).

Year	Individual Nesting Females	Nests per female	Mean Inter-nesting Period
2010	87	1.97	14.14
2011	77	2.23	14.52
2012	113	2.24	14.62
2013	126	2.24	15.22
2014	64	2.06	14.83
2015	131	2.52	14.5
2016	142	2.61	13.92
2017	105	2.80	14.81
2018*	84	1.98	14.53

\* DNA analysis for 2018 is not complete, entered on 02/21/2018; 86.7% complete.

### **Beach Nourishment**

Fifteen nests (12.6% of nests laid on Hatteras Island) were laid within the 2017 beach nourishment project site in the 2018 nesting season. Five of the 15 were relocated due to being laid at/or below the high tide line or within a historically high

erosion zone; these nests were relocated within the project site. The other 10 nests remained “in situ.” Overall hatch and emergence success rates of the 15 nests laid within the nourishment zone was 68.4% and 56.3%, respectively.



## Hatching

Mean clutch count was determined using total egg counts at the time of relocation from relocated nests only. The mean clutch count was 108.1 eggs per nest in 2018 (Table 2; Appendix A). Average incubation period of nests with known lay and emergence dates was 57.8 days. Incubation periods depend mostly upon sand temperature (Bustard and Greenham 1968); higher average temperatures during overall incubation decrease incubation periods while lower mean temperatures increase incubation periods. The 2018 mean incubation periods ranged from 52 to 64 days. All nests with known incubation days were organized by the week laid so a mean incubation period could be calculated and compared through the nesting season (Figure 3). The mean hatch success was 58.6% and the mean emergence success was 51.0% (Appendix A). Any hatchlings found during excavations, live or dead, were considered hatched but not emerged (Figure 4). Some emergences went undetected due to rain, wind, tides and storm events and were not included in these calculations.

## ORV Corridors

A total of 70 evenings/nights of intensive nest monitoring and ORV tire rut raking occurred for the 9 nests that were monitored. This increased the amount of beach that was accessible to vehicles from July 29, the date of the first nest with an ORV corridor, through September 7, the date of the last nest with an ORV corridor (41 calendar days).

## Depredation/Loss

Of the 16,282 estimated eggs produced in 2018, 20 eggs (0.1%) from four nests were observed to be depredated (Appendix A). In the 2016 breeding season, the first recorded sea turtle nest depredation by canids was recorded on the Seashore. Observations of canid predation were also recorded in the 2017 season. In the 2018 breeding season, canid presence around two newly discovered turtle nests on Bodie Island was observed but predation was never confirmed based on the disturbances that were left behind. Across the Seashore, ghost crabs depredated 20 eggs from 4 different nests prior to nest

**Table 2.** Sea turtle hatch summary, Cape Hatteras National Seashore (2001–2018).

Year	# of Nests	Avg. Clutch	Average Incubation (days)	Total Eggs	# Emerged	% Emergence
2001	75	111.7	64.5	6257	3402	54%
2002	99	108.7	58.6	10108	7201	71%
2003	87	115.7	69.1	4627	2708	58%
2004	43	103.4	58.5	2999	1609	53%
2005	73	114.6	58	6072	4142	68%
2006	76	114.8	62.9	7059	4444	63%
2007	82	112.1	60.7	9078	6075	58%
2008	112	109.0	59.7	11573	5965	52%
2009	104	114.9	65	11121	3430	31%
2010	152	110.9	57	16300	7843	48%
2011	147	116.2	58	13661	6483	48%
2012	222	105.3	60.1	24107	17965	73%
2013	254	116.9	62.3	28863	16860	56%
2014	124	105.3	62.2	12474	6172	45%
2015	289	116.5	56.9	30168	15960	49%
2016	325	118.6	53.6	34359	20385	54%
2017	250	112.8	59.5	27313	15365	54%
2018	166	108.1	57.8	16282	9062	51%

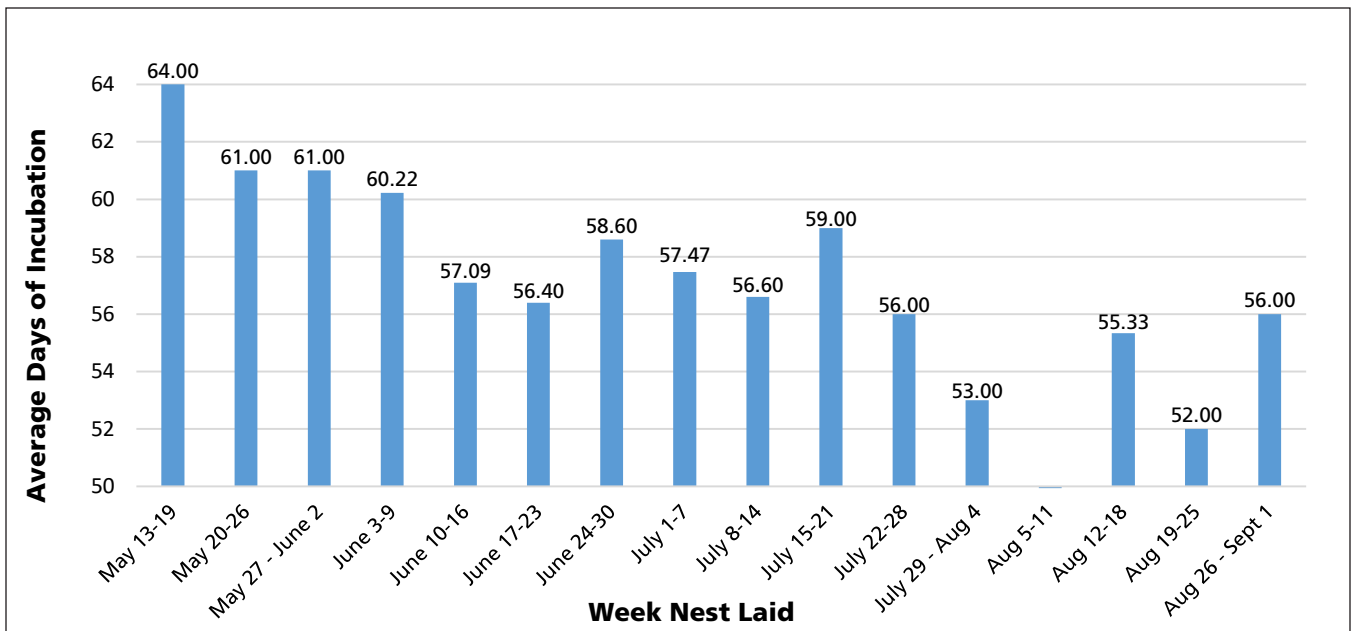


Figure 3. Mean incubation time (days) of sea turtle nests by week (2018) at Cape Hatteras National Seashore.

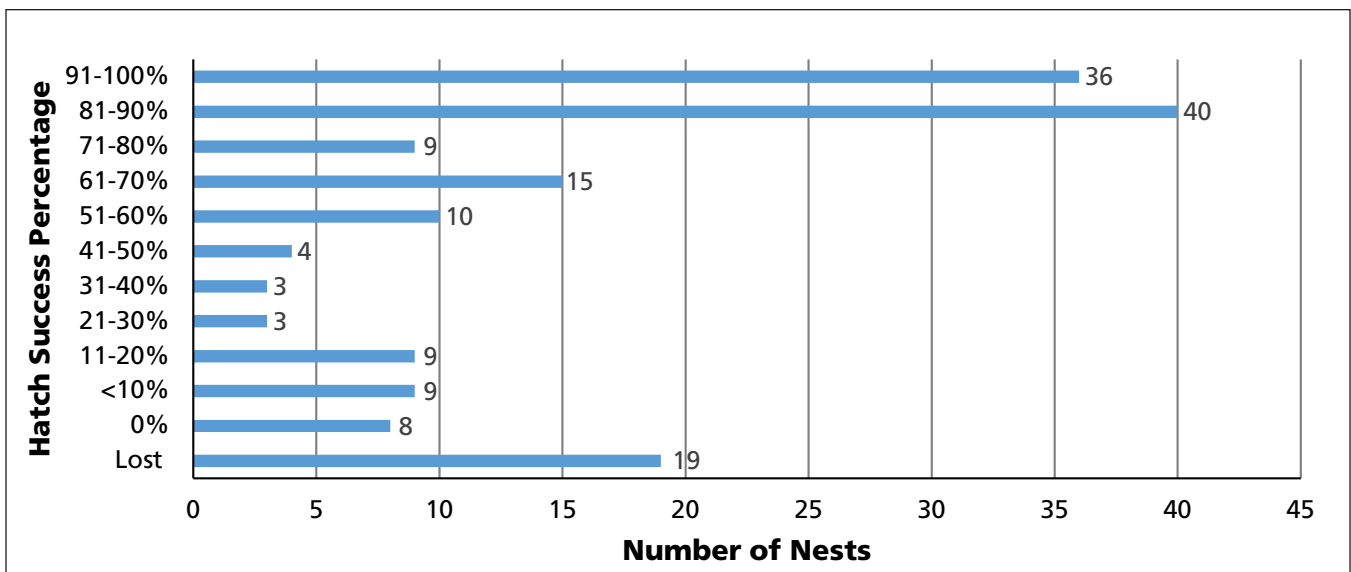


Figure 4. 2018 sea turtle nest hatch success at Cape Hatteras National Seashore.

excavations; this was usually observed by discovering eggshell fragments at the specific nest sites near known ghost crab burrows.

Of the 9,062 emerged hatchlings produced, 28 hatchlings (0.3%) were lost before reaching the water; these were not associated with disorientation events. Ghost crab depredation of 21 hatchlings from 10 nests was documented, but the full extent of hatchling depredation by ghost crabs is unknown. Observations were made of ghost crabs in the act of depredating hatchlings. These observations occurred

within nest cavities during excavations as well as after hatching events based on finding the hatchlings inside of ghost crab holes in the vicinity of the nest site. In addition to these confirmed hatchling loss accounts, 7 hatchlings from 5 separate nests were found deceased outside of the nest cavity between the nest and high tide line; no cause of death was apparent (Appendix A).

While on daily patrols, staff monitored all existing nest protection sites for any signs of potential predators through first-hand sightings and track

identification. In total, staff confirmed 19 cat, 56 domestic dog, 52 unknown canine species, 1 red fox, 1 mink, 1 raccoon, and 7 separate opossum intrusions within protected areas. Overall, there was no evidence that these intrusions affected nest success; often they were terrestrial mammals simply passing through the protected areas.

### **Storm, Tide and Over-wash Loss**

During the 2018 breeding season, 19 nests were completely washed away, 8 nests completely failed, and many others were partially affected due to significant storm systems producing excessive and prolonged wind, tide cycle, and erosion events. (Figure 4; Appendix A)

During these storm events, many nests were overwashed continually until the system passed, this mainly was due to extremely rough seas, storm surge, and abnormally high tide cycles. Significant overwash events may totally or partially inhibit embryonic development of entire nests or nests can fail to show any hatch activity due to severe sand compaction and/or inundation.

All 19 of the nests that were completely washed away were from the Hurricane Florence storm system (September 7–September 16). The estimated total

number of nests overwashed and/or inundated included 47 nests during Tropical Storm Chris (July 8–July 16), 56 nests during Hurricane Florence, and 6 nests during both storm events. Of the 47 nests overwashed during Tropical Storm Chris, 3 failed to result in any hatch activity, and 8 nests exhibited  $\leq 30\%$  hatch success. Of the 56 nests that were overwashed during Hurricane Florence, 5 nests failed completely, and 11 nests had  $\leq 30\%$  hatch success. Of the 6 nests that were overwashed by both storms, 4 nests exhibited  $\leq 30\%$  hatch success.

Many of the nests that completely failed were on beaches with very little slope, or in some instances on a back slope toward the dunes, which held water. Most partial nest failures were often located on areas of beach with steeper slope or located higher on the dune sides. Though these nests were still heavily overwashed, the slopes enabled the water to drain away more quickly and nests were less likely to be inundated.

### **Incidental Take/Human Disturbance**

Little is known about the extent to which human activities may have disrupted sea turtle nesting activities during the 2018 nesting season. People on the beach at night can disturb female turtles during



Loggerhead sea turtle hatchlings leaving a nest at Cape Hatteras National Seashore. NPS



the egg laying process. From the time a female exits the surf until she has begun covering her nest, she is highly vulnerable to disturbance, especially prior to and during the early stages of egg-laying.

### Protected Area Intrusions

Intrusions into sea turtle resource protection areas were monitored daily throughout the breeding season. Intrusions were defined as direct or indirect observations of pedestrians (on-foot), bicycles, ORVs, and horses within clearly marked protection areas. A total of 252 pedestrian, 3 bicycle, 6 ORV, and 0 horse intrusions into these protection areas were documented based on first-hand observations and/or evidence left behind. Of the recorded intrusions, none of them resulted in any direct resource damage.

A total of 220 ORVs were documented as operating on oceanside beaches before and/or after the allowable hours: 12 ORV violations were on Bodie Island, 169 ORV violations were on Hatteras Island, and 39 ORV violations were on Ocracoke Island. The most popular ramps to gain beach access related to these violations were Ramp 4 on Bodie Island (10 violations); Ramp 38 (52 violations), Ramp 44 (26 violations), and R55 (50 violations) on Hatteras Island; and Ramp 70 (16 violations), and R72 (20 violations) on Ocracoke Island. None of these violations appeared to directly impact sea turtle nesting efforts or hatching and emergence rates.

Overall, there was no evidence that intrusions affected nest success; they were simply human intrusions into clearly signed areas, temporarily prohibiting access. Little is known about the extent of disturbance after normal working hours since many areas of beach are open to pedestrian use 24 hours per day.

### Artificial Lighting

In 2018, misorientation (directed movement of a hatchling towards an inappropriate object or goal) or disorientation (lack of directed movement towards a specific area or goal) was documented at 42 nests, totaling approximately 488 hatchlings (5.4% of the 9,062 emerged hatchlings) or hatchling tracks observed to be affected (Appendix A). In most situations, hatchling tracks were the only evidence to show hatchlings were being disrupted from their normal movement to the ocean. Little is known about the fate of these hatchlings because, in most cases, they were never recovered. In some instances, hatchling tracks were observed eventually making it to the edge of waterline indicating they successfully made it to the ocean. Since the majority of nests are not observed during hatching events, the extent of hatchling loss due to artificial lighting at the Seashore is largely unknown.

### Strandings

In the 2018 calendar year, 156 stranded sea turtles were documented within the Seashore: 42 (26.9%) loggerhead, 41 (26.4%) Kemp’s ridley, 69 (44.2%) green, 1 (0.6 %) leatherback, and 3 (1.9%) unknown species were documented (Table 3). Volunteers with The Network for Endangered Sea Turtles assisted resource management staff by reporting and sometimes responding to observed strandings. Of the 156 strandings, 34 (21.8%) were found alive and were transferred to the North Carolina Aquarium Sea Turtle Assistance and Rehabilitation Center on Roanoke Island or a similar facility for rehabilitation. Of the 34 live turtles, 22 (64.7%) were treated and released, 5 (14.7%) have remained in rehabilitation at the Sea Turtle Assistance and Rehabilitation Center, 2 (5.9%) were transferred to other rehabilitation centers, 3 (8.8%) died of their ailments, and 2 (5.9%) have unknown status.

**Table 3.** Sea turtle yearly stranding totals by species at Cape Hatteras National Seashore (2014–2018).

Year	Stranding Total	Loggerhead	Kemp’s Ridley	Green	Leatherback	Hawksbill	Unk.
2014	219	50	61	104	1	0	3
2015	286	44	39	198	3	0	2
2016	637	45	49	541	1	0	1
2017	280	56	53	168	1	0	2
2018	156	42	41	69	1	0	3

Efforts were made to necropsy dead strandings to determine possible cause of death, gender, and any abnormalities, and to collect requested tissue samples for ongoing research. Gender was determined in 43 strandings (13 male, 30 female). Samples collected during necropsies (i.e., eyes, flippers, muscle, foreign debris, and tags) were provided to cooperating researchers. Probable cause of death, when possible, was determined by the North Carolina Wildlife Resources Commission (NCWRC; Table 4). During periods of cold water temperatures (7–10°C), sea turtles are most prone to cold stunning (stranding due to hypothermia; Spotilla 2004).

### **Turtle Sensor Studies: Hatteras Island Ocean Center/Nerds without Borders**

In 2018, the sixth year of the turtle sensor study, 11 sensors from Nerds Without Borders and the Hatteras Island Ocean Center were deployed in nests. Of those 11 nests, seven had hatchling emergence success. The sensors successfully detected movement from these seven nests leading up to initial

emergence evidence. Due to weather forecasting ahead of Hurricane Florence, the remaining four sensors were removed before hatching occurred in order to save the equipment from being damaged and/or washed away. Post Hurricane Florence, two of the four nests with equipment removed earlier were completely washed away and the remaining two survived the storm but showed poor hatch and emergence success.

### **Genetic Study**

In 2018, 162 eggs were taken specifically for DNA analysis out of the 166 total nests. In the remaining 4 nests, DNA was obtained from “spacer” eggs (irregularly small/infertile eggs), old broken eggs upon post-hatch excavations, or from dead hatchlings in wild nests (nests that were undetected until after hatching). The results are being analyzed by our partners at NCWRC. The analysis is in progress and results are pending.

**Table 4.** Sea turtle strandings and possible causes at Cape Hatteras National Seashore, 2018 calendar year.

Month	No Apparent Injuries	Cold Stun	Other/UNK	Watercraft	Entanglement	Pollution / Debris	Disease	Shark	Unable to Assess	Total
January	11	14	1	2	0	0	1	0	0	29
February	8	10	0	0	0	0	0	0	8	26
March	4	4	0	0	0	0	0	0	2	10
April	3	0	0	0	0	0	0	0	2	5
May	3	0	4	3	0	1	0	0	1	12
June	5	0	0	3	0	0	2	0	4	14
July	2	0	0	2	2	0	0	0	0	6
August	0	0	0	1	0	0	0	0	0	1
September	0	0	0	0	1	0	0	0	0	1
October	1	0	0	0	0	0	0	0	0	1
November	20	11	0	2	0	0	0	0	2	35
December	3	5	2	0	1	0	0	0	5	16
<b>Total: (Calendar Year 2018)</b>	<b>60</b>	<b>44</b>	<b>7</b>	<b>13</b>	<b>4</b>	<b>1</b>	<b>3</b>	<b>0</b>	<b>24</b>	<b>156</b>



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# Appendix A. 2018 Sea Turtle Nest Monitoring Project Summaries

**Table A-1.** 2018 sea turtle monitoring details and results at Cape Hatteras National seashore. The north boundary of the sea turtle surveying/monitoring is Ramp 1, Bodie Island (excludes Pea Island National Wildlife Refuge). The south boundary is South Point on Ocracoke Island.

Metric	Result
Length of Daily Survey (km; km = miles x 1.6)	99.8 km (62. mi)
Total Length Surveyed (km)	14,670.6 km
Total Days Surveyed	147
Days per Week Surveyed	7
Time of Day Surveyed	Morning
Number of Participants	23
Date Surveys Began <sup>a</sup>	4/30/2018
Date Surveys Ended <sup>a</sup>	9/29/2018
Date of First Crawl	5/17/2018
Date of Last Crawl	8/30/2018
Date of First Nest	5/19/2018
Date of Last Nest	8/30/2018
Total Nests	166
Total Nests Undetected by Staff	1
Total Crawls	303
Nesting density (nests/km)	1.67
In Situ Nests (not relocated)	105
Relocated Nests	61 (36.7%)
False Crawls	137
Disoriented/Misoriented (nests)	41
Nests Washed Away Tide/Storm	19
Nests Depradated	14
Unknown Nests <sup>b</sup>	1
Mean Clutch Count	108.1
Mean Incubation Duration (All)	57.8
Mean Incubation Duration (In Situ)	58.4
Mean Incubation Duration (Relocated)	56.8
Hatchlings Produced	10,390
Hatchlings Emerged	9,062

<sup>a</sup> Surveys were conducted from 4/30/18–9/10/18 and 9/17/18–9/29/18. Patrols were not conducted from 9/11/18–9/16/18 due to Hurricane Florence impacting Outer Banks, NC.

<sup>b</sup> Unknown nests are excluded from mean hatch and emergence success rates and overall nest and beach success. Unknown nests indicates the fate of the nest is unknown due to overwash and lack of data on how many eggs hatched prior to the overwash.

**Table A-2. 2018 sea turtle success rates at Cape Hatteras National Seashore.**

Metric	All Nests	In Situ Nests	Relocated Nests
Mean Hatch Success	58.56%	53.7%	66.8%
Mean Emergence Success	51.0%	47.9%	56.2%
Nest Success	72.7%	68.2%	80.3%
Overall Beach Success*	54.7%	–	–

\* Number of nests laid vs. number of crawls.

**Table A-3. 2018 sea turtle egg loss summary, Cape Hatteras National Seashore.**

Cause of Egg Loss	Number of Eggs Lost
Research <sup>a</sup>	162
Ghost Crab	20
Tide/Storm <sup>b</sup>	350
Other <sup>c</sup>	2
Total Egg Loss (All Causes)	534

<sup>a</sup> One egg was taken for DNA research from 162 of the 166 nests laid. DNA samples were taken using spacer eggs (eggs with no yolk) from 2 of the 4 remaining nests (NH018, NH062). A DNA sample was taken using old eggs' shells and a dead hatchling from 1 nest site (NH096). A DNA sample was not collected for 1 unknown nest site (NBH23).

<sup>b</sup> Tide/Storm Egg Loss: 19 total nests resulted in a known egg loss of 350 eggs. Four of 19 nests were relocated and accurate egg losses were recorded; 350 eggs lost in these 4 nests. This is a significant underestimate of eggs lost. 15 of 19 nests were "in situ" and total eggs in each clutch were unknown. One of the 15 "in situ" nests was partially excavated before tide/storm events resulting in 86 eggs and/or hatchlings being inventoried and/or released. On average, 80–120 eggs are laid in each nest.

Estimated egg loss ranges from 1,464–2,064 based on the average eggs laid per nest (80–120), the known egg loss (350 from 4 relocated nests), and the known eggs/hatchlings inventoried/released before the tide/storm event (86).

- (15 nests x 80 to 120 eggs = 1,200 to 1,800 estimated eggs lost)
- (1,200 - 86 = 1,114; 1,114 + 350 = 1,464)
- (1,800 - 86 = 1,714; 1,714 + 350 = 2,064)

<sup>c</sup> Egg loss defined as "other" includes 1 nest (NH011) that was checked for viability after heavy sand accumulation and being overwashed ~32 separate times. Two eggs were opened, 1 with a dead and 1 with a live, late stage embryo observed.

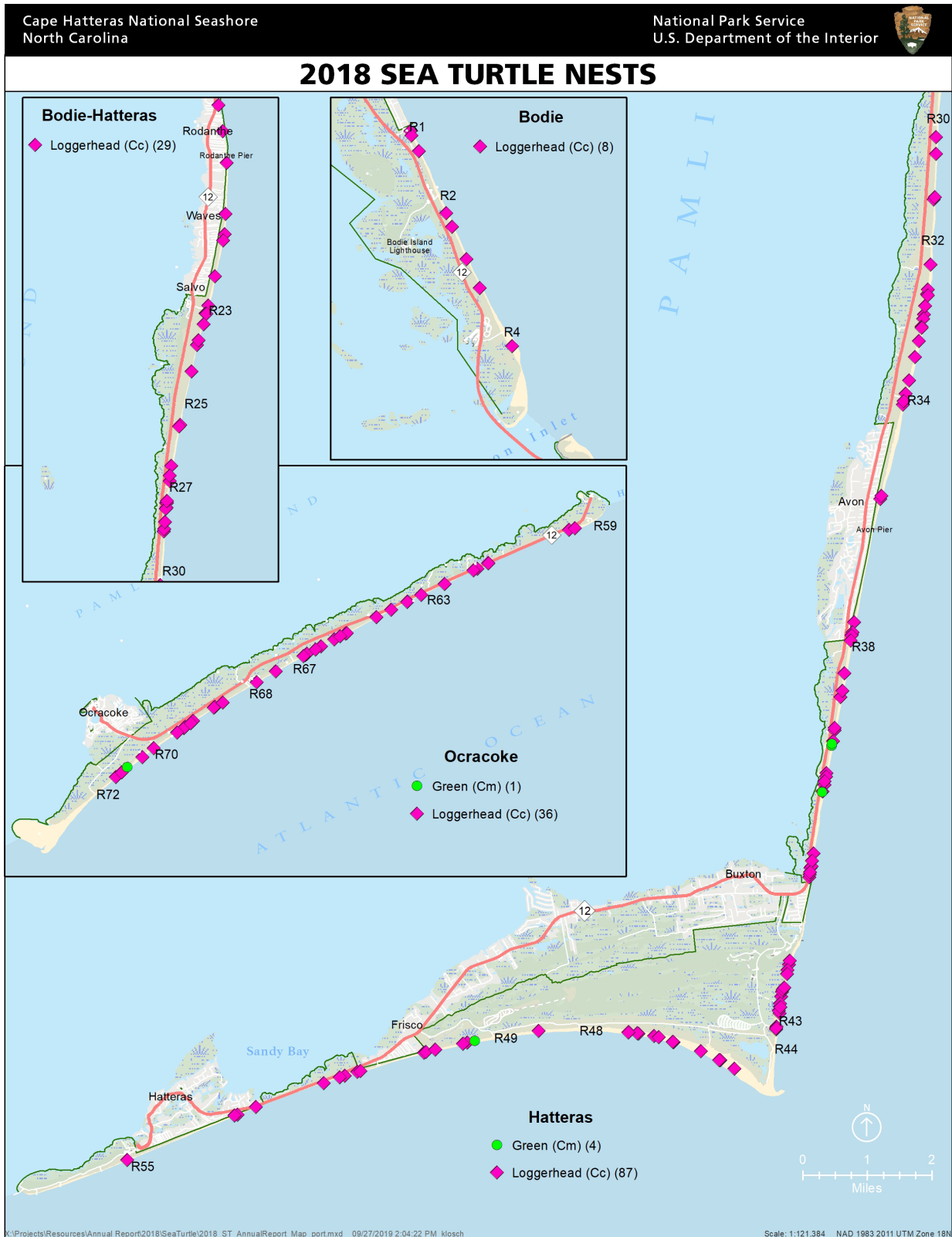
**Table A-4. 2018 sea turtle hatchling loss summary, Cape Hatteras National Seashore.**

Cause of Hatchling Loss	Number of Hatchlings Lost
Ghost Crab	21
Misorientation/Disorientation <sup>a</sup>	488
Other <sup>b</sup>	7
Total Hatchling Loss (All Causes)	516

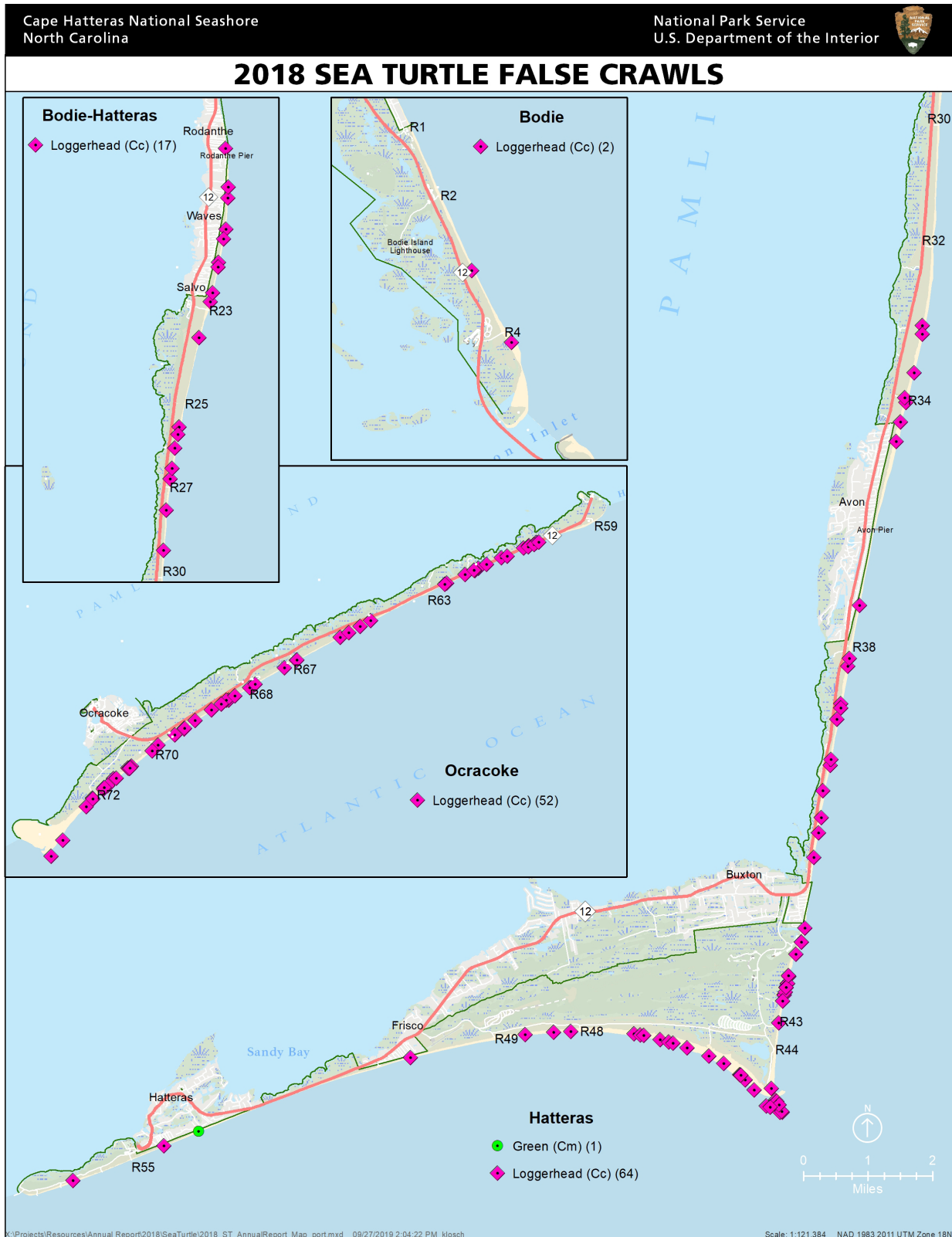
<sup>a</sup> The number of hatchlings lost due to Misorientation/Disorientation is from 42 separate nests. This total includes physical hatchlings observed as well as estimates of hatchling tracks left behind. Note: not all of these hatchlings are confirmed as dead, these are the number tracks/hatchlings observed to be mis/disorientated; some showed evidence making it to the ocean, others did not.

<sup>b</sup> Hatchling loss defined as "other" includes 5 separate nests. Two nests lost 2 hatchlings each; the remaining 3 nests lost 1 hatchling each for unknown reasons. Lack of evidence was the reason for the unknown losses.

# Appendix B. Sea Turtle Nesting Activity Maps

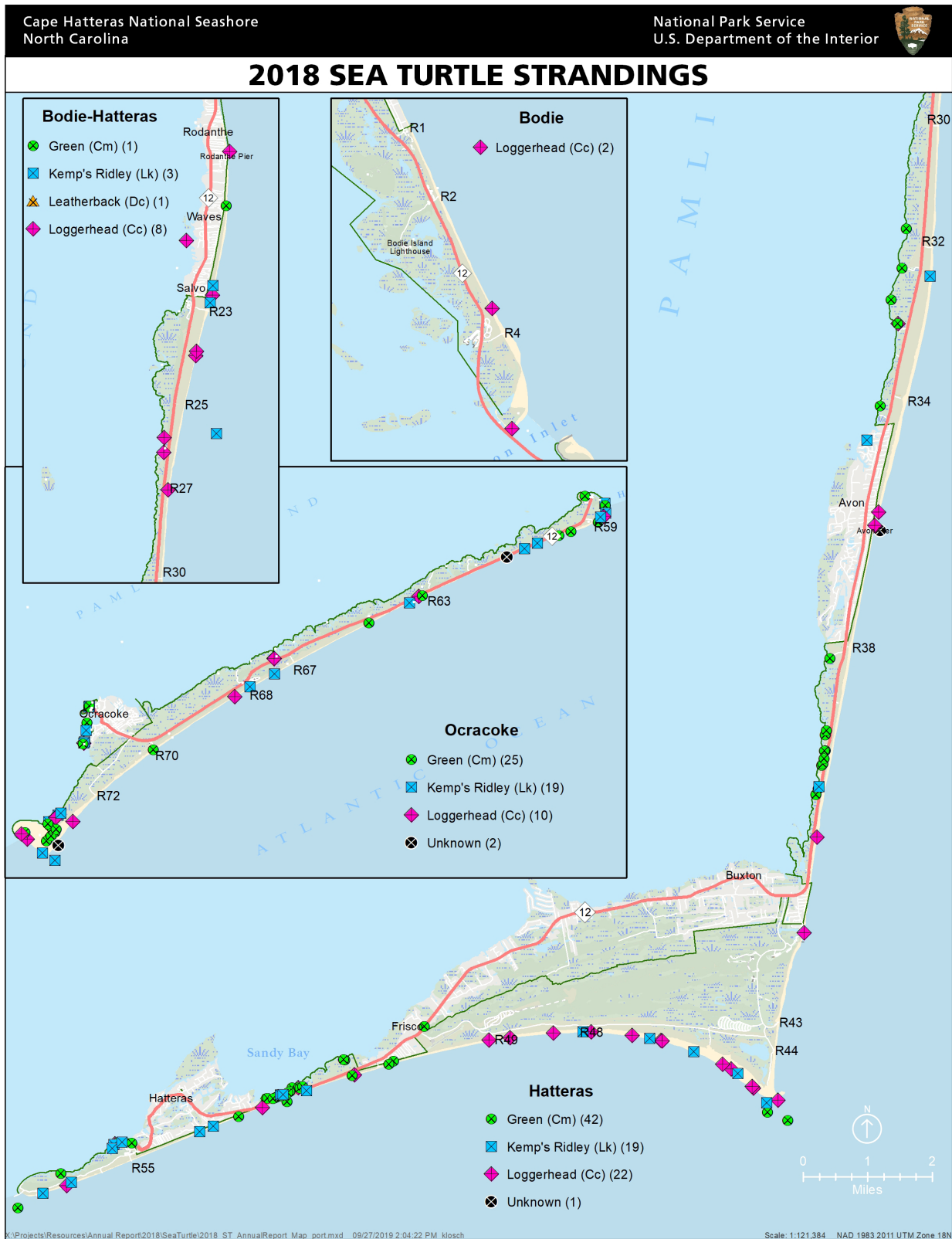


# Appendix C. Sea Turtle False Crawl Activity Maps



Map C-1. Sea turtle false crawls at Cape Hatteras National Seashore in 2018.

# Appendix D. Sea Turtle Stranding Maps







**National Park Service**  
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**Cape Hatteras National Seashore**

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