CAPE HATTERAS NATIONAL SEASHORE
NATURAL RESOURCES
2016 ANNUAL REPORT

Loggerhead Sea Turtle Photo credit: NPS Staff

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EXECUTIVE SUMMARY

Cape Hatteras National Seashore (CAHA) is located on the Outer Banks of North Carolina from Nags Head, NC to Ocracoke Inlet. The seashore is divided into four islands; Green, Bodie, Hatteras, and Ocracoke Islands.

The beaches of CAHA provide traditional nesting habitat for several species of special concern and state-listed shorebirds, including the piping plover (PIPL) (*Charadrius melodus*), American oystercatcher (AMOY) (*Haematopus palliatus*), Wilson's plover (WIPL) (*Charadrius wilsonia*) common tern (COTE) (*Sterna hirundo*), least tern (LETE) (*Sterna antillarum*), and black skimmer (BLSK) (*Rynchops niger*). Less common nesters include the gull-billed tern (GBTE) (*Gelochelidon nilotica*) and Forster's tern (FOTE) (*Sterna forsteri*). Daily monitoring for these species begins every year in March and concludes two weeks after the last chick is fledged (Tables 1-5).

Monitoring for sea turtle nesting activity begins on April 30th each year. Patrols are conducted in the morning, beginning approximately at dawn. Each nesting activity is recorded as either a false crawl or nest. All nests are confirmed by locating eggs at the nest site. The decision to relocate the nest or for the nest to remain in situ is made at the time of nest discovery. If no eggs were laid, the nesting activity is considered a false crawl (Figure 9).

A stranded turtle is a non-nesting turtle that comes to shore either sick, injured, or dead. Data is collected for each reported or observed stranding. Whenever possible, further data is collected by performing a necropsy on dead turtles. Live stranded turtles are transported to a facility for treatment and recovery (Table 6).

Seabeach amaranth (*Amaranthus pumilus*) is a federally threatened plant species found in barrier island beach environments, where it grows in overwash flats at accreting ends of islands and at the foot of frontal dunes. Surveys for seabeach amaranth are ideally conducted in July-September when the plants are sufficiently large to locate and document. CAHA staff begins surveying for plants in mid-July, usually starting where seasonal resource closures for nesting shorebirds are being removed. (Table 7).

Table 1. 2016 Piping Plover Reproductive Success

Breeding Pairs	Total Nests	Nests Hatched	Total Eggs	Total Eggs Hatched	Total Chicks Fledged	Total Chicks Lost	Fledge Rate
11	13	4	43	11	3	8	0.27

Figure 1. Piping plover historic fledge rate (chicks per pair)

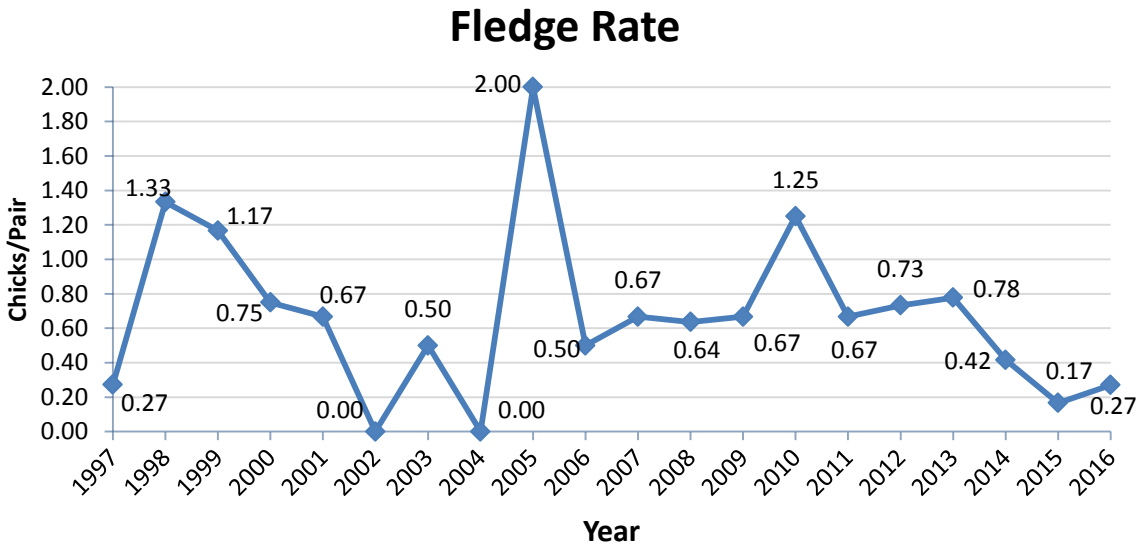


Table 2. 2016 American Oystercatcher Reproductive Success

Breeding Pairs	Total Nests	Nests Hatched	Successful Pairs (at least 1 chick fledged)	Number of Chicks Fledged	Fledge Rate
26	41	13	9	12	0.46

Figure 2. American oystercatcher historic fledge rate

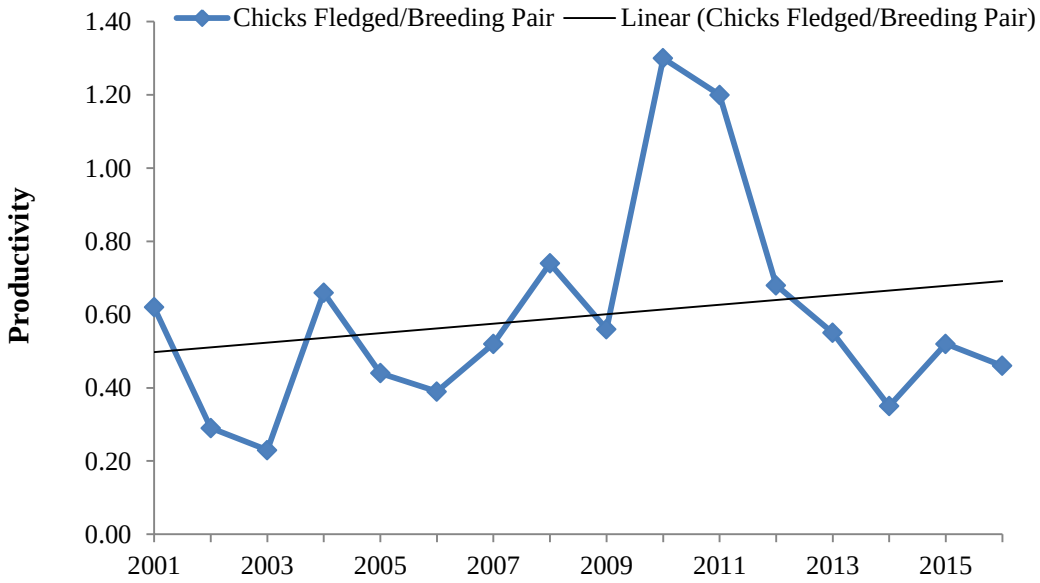


Table 3. 2016 Colonial Waterbird Colonies observed

	Observed Colonies	**Colonies Containing >10 Nests**
Bodie Island	3	1
Green Island	1	1
Hatteras Island	13	5
Ocracoke Island	3	3
Total	**20**	**10**

Table 4. 2016 Colonial Waterbird nests, eggs, and chicks documented per species during peak nesting surveys

	Nests	**Eggs**	**Chicks**
LETE	295	446	30
COTE	91	184	42
GBTE	23	40	3
FOTE	0	0	0
BLSK	169	318	26

Figure 3. Historic LETE Peak Nest Counts.

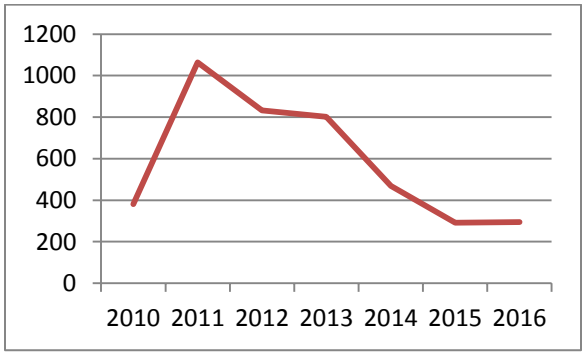


Figure 4. Historic COTE Peak Nest Counts.

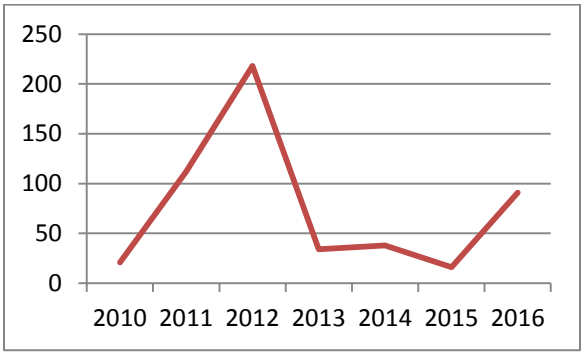


Figure 5. Historic GBTE Peak Nest Counts.

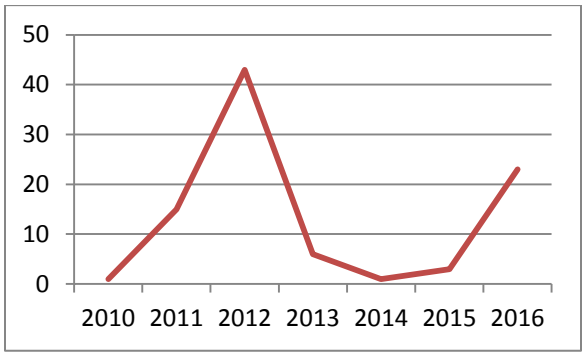


Figure 6. Historic FOTE Peak Nest Counts.

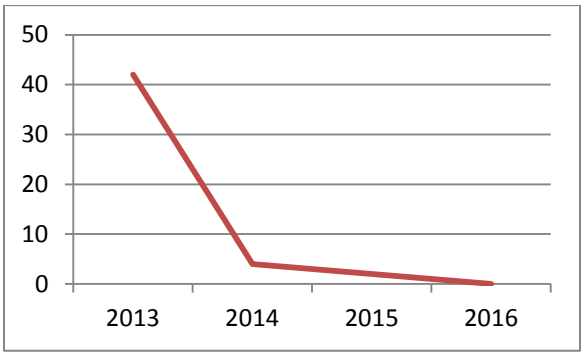


Figure 7. Historic BLSK Peak Nest Counts.

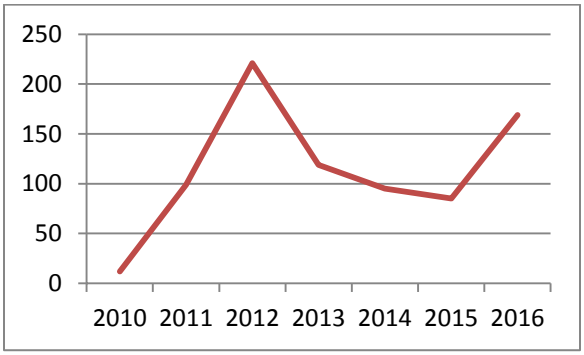


Table 5. 2016 Wilson's Plover Reproductive Success

Breeding Pairs	Total Nests	Nests Hatched	Successful Pairs (at least 1 chick fledged)	Number of Chicks Fledged	Fledge Rate
3	3	2	0	0	0

Figure 8. Wilson's plover historic fledge rate

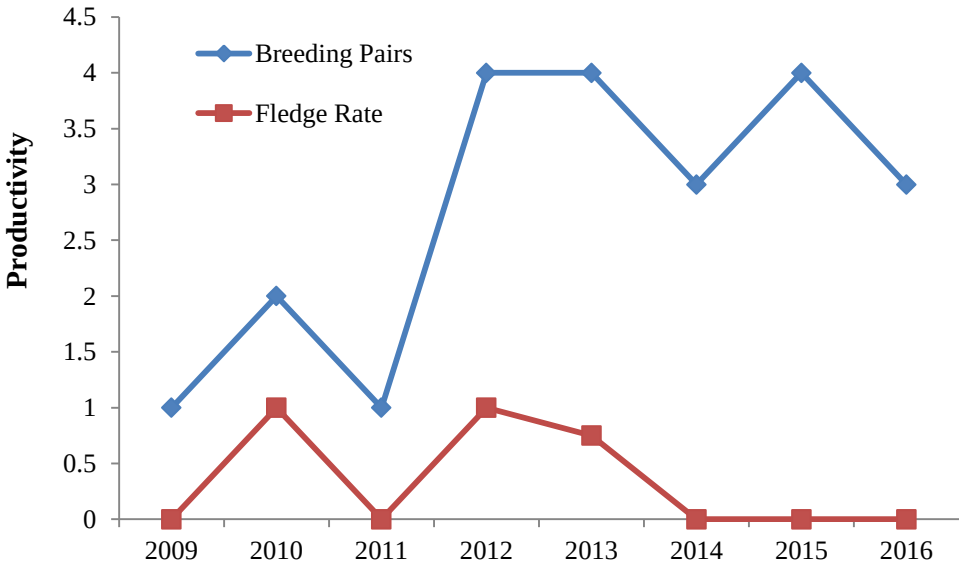


Figure 9. CAHA sea turtle nests 2008–2016.

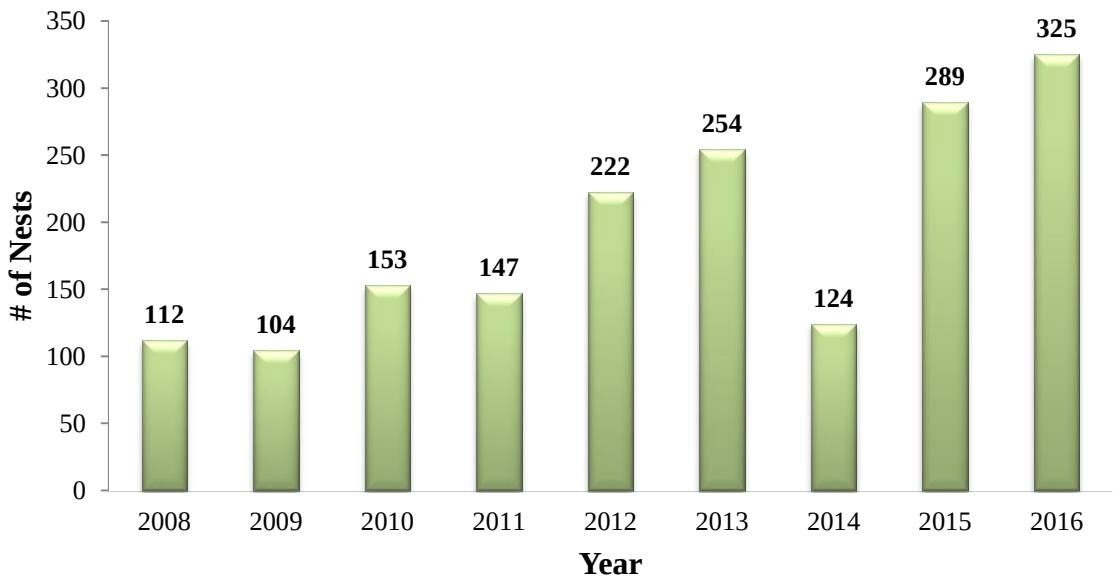


Table 6. Sea turtle strandings at CAHA by species, (2010–2016.)

Year[1]	Stranding Totals	Species Composition					
		Loggerhead	Kemp's Ridley	Green	Leatherback	Hawksbill	Unk.
2010	444	100	108	235	0	0	1
2011	148	50	46	49	0	0	3
2012	126	34	32	50	2	0	8
2013	189	38	52	94	1	0	4
2014	219	50	61	104	1	0	3
2015	286	44	39	198	3	0	2
2016	637	45	49	541	1	0	1

[1]Total stranding numbers for 2008-2011 include some strandings that occurred outside of CAHA boundaries

Table 7. 2016 Sea Beach Amaranth Surveys

Staff Hours	**Miles of Beach Habitat Surveyed**	**Number of Plants Found**
61	42	0

CAPE HATTERAS NATIONAL SEASHORE OFF-ROAD VEHICLE MANAGEMENT PLAN AND SPECIAL REGULATION

On February 15, 2012 the Cape Hatteras National Seashore Off-Road Vehicle Management Plan and Special Regulation (ORV Management Plan) was enacted. It was developed from 2007-2012 and was accompanied by a special regulation detailing requirements for off-road vehicle (ORV) use at CAHA. A copy of the ORV Management Plan and other related documents are available electronically at *http://parkplanning.nps.gov/caha*. The ORV Management Plan includes establishment of pre-nesting areas (areas temporarily closed to public entry) and buffer requirements for nesting birds, chicks, and sea turtles as well as the requirement for an ORV permit to drive on CAHA beaches. This is the fifth year the ORV Management Plan has guided the management of protected species at CAHA.

The National Defense Authorization Act of 2014 directed CAHA to conduct a review of established wildlife buffers and modify them, based on peer-reviewed science, to the shortest duration possible and the smallest area possible. The Environmental Assessment (NPS, 2015) was signed in June of 2015 and implemented at the beginning of the field season in 2016.

RESOURCE PROTECTION AREAS

Pre-nesting resource protection areas protect all potential shorebird breeding habitat and are installed in anticipation of breeding activity. These areas are temporarily closed to public entry during the shorebird nesting season. The PIPL, WIPL, and AMOY protection areas were installed by March 15, 2016 and the CWB protection areas were installed by April 15, 2016. The resource protection areas protect suitable nesting habitat and where nesting had occurred in more than one of the past five years.

While pre-nesting areas minimize disturbance in potential breeding areas, they also enable birds to establish territories and nest in their preferred habitat. An annual habitat assessment was conducted from February 22 - February 29, 2016, prior to the onset of the breeding season. This assessment, along with maps of historic nesting locations, was used to determine the boundaries for the pre-nesting areas (Appendices A-F).

HUMAN DISTURBANCE

Human disturbance, direct or indirect, can lead to the abandonment of nests or loss of chicks. Throughout the 2016 season, resource management staff documented 150 pedestrian, 20 ORV, and 34 dog, boat or horse intrusions in resource protection areas. These numbers are conservative since sites are not monitored continuously, weather erases tracks, and staff does not disturb incubating pairs or young in order to document disturbance. It is important to note that most of the resource protection areas contained multiple species, including AMOY, colonial waterbirds, piping plovers, and sea turtles. Most human violations in resource protection areas were not witnessed, but documented based on vehicle, pedestrian, or dog tracks left in the sand. Pedestrian entry most often required visitors to lift or stoop under the string that connected all posted signs, while vehicular entry required visitors to drive through or around a sign boundary. Visitors' unleashed dogs are also a threat to protected species and continue to be an issue of significant concern.

PREDATOR OBSERVATIONS

Depredation by mammals has the potential to affect the success of a nest or brood, thus predator control continues to be a tool in aiding with the success of breeding shorebirds. During the 2016 breeding season, trapping at CAHA was not implemented due to the lack of a trained trapper on staff. Shorebird nests and broods were allowed to progress with naturally occurring predators in their presence. When field staff walked through and surveyed areas, they documented any natural signs (e.g. track or scat) of predators for future reference and to determine if predator pressure may have affected the status of the nest or brood. Mammalian predation events can be difficult to assess as there are rarely remains that would indicate the type of predator. The constantly shifting sands often obliterate tracks, and when tracks are present, soft sands can make determining species problematic. Avian predation is also difficult to detect due to the lack of physical signs available to observe.

CAPE HATTERAS NATIONAL SEASHORE
PIPING PLOVER (*CHARADRIUS MELODUS)* MONITORING
2016 ANNUAL REPORT

ABSTRACT

In 2016, 11 pairs of piping plover (PIPL) nested at Cape Hatteras National Seashore (CAHA). A total of 13 nests were identified in the park which includes re-nests from pairs with failed nest attempts. The first nest was found on April 22nd and the last active nest was lost on July 13th. Of these nests, four hatched and produced a total of 11 chicks. Three chicks successfully fledged from two separate broods resulting in a fledge rate of 0.27 chicks per breeding pair. Since 1997, fledge rates have ranged from 0.0 to 2.0 chicks per pair at CAHA. The mean rate from 1997-2014 was 0.67 chicks per pair.

INTRODUCTION

Piping plover are small shorebirds that prefer to nest in wide, flat, sandy beaches with very little vegetation. They typically lay 3 to 4 eggs in a shallow scrape in the sand. Upon competition of the clutch, the pair incubates the nest for 27-30 days (Cairn 1982). Within hours of hatching, chicks are able to move about and feed on their own (Cairn 1982). Routine monitoring of PIPL at CAHA began in 1985. The Atlantic population was listed as threatened under the Endangered Species Act in 1986. Monitoring focuses on locating and protecting breeding territories to aid in determining nest and brood success.

METHODS

Resource Protection Areas

As per the modified regulation, PIPL buffers are 50m for breeding behavior scraping, territorial, courtship, or mating) and for nests. When unfledged chicks were present, this buffer was expanded to 200-500m in ORV areas and to 100m in pedestrian only areas.

Monitoring

Seasonal monitoring for PIPL began in early March. Predator exclosures, which have been used at CAHA since 1994 to reduce predatory pressure on PIPL nests and nesting adults, were constructed around nests when clutches reached three or more eggs. The circular exclosures (approximately ten feet in diameter), consisted of two inch by four inch welded-wire fence anchored by steel rebar and topped with a three-quarter inch mesh netting to dissuade avian predators. Exclosures were installed following the guidelines established in the USFWS' Piping Plover Recovery Plan (USFWS 1996, Appendix F). Thereafter, the nest was briefly approached once weekly to inspect the exclosure, verify the number of eggs, and check for signs of predators.

Daily nest monitoring occurred from an adequate distance to avoid disturbance to incubating birds but close enough to be able to document incubation, nest abandonment and abnormal

behavior. Morning and evening monitoring began five to seven days prior to the expected hatch date. During ORV access hours, brood monitoring was not continuous at Cape Point; however, broods were monitored regularly in the mornings and up until 7:00 PM. Flooding created a natural barrier between chicks and any open ORV areas. Observers documented brood status, behavior, individual bird and brood movements, human disturbance, predator interactions, and significant environmental events. An established grid system with points located 75 meters apart was utilized to aid staff in obtaining more accurate locations for individual birds and chick movement from a distance without disrupting their regular behavior patterns.

Migrating and Wintering Piping Plovers

Survey protocols adapted from the Southeast Coast Inventory Monitoring Network's Migratory and Wintering Shorebird Monitoring Study (Byrne *et al*, 2009) were implemented irregularly from April 2015 through March 2016. Not all survey dates were met due to limited staffing. Surveys were not conducted in June when all the PIPL present were assumed to be breeders and not migrants. Transect sampling consisted of a two-tiered approach comprised of high-intensity and low-intensity sampling units. High-intensity sites were sampled on a weekly basis whereas the low-intensity sampling units were sampled on a monthly basis. Semi-permanent transect locations have been established along the entire ocean shoreline. The majority of transects were one mile in length and were numbered Park Mile 0 through Park Mile 74. Some transects at the spits and Cape Point, varied in length due to the constantly changing shorelines. The spits and Cape Point also required more than one transect due to a larger topographical area. All target species including PIPL, AMOY, WIPL, red knots, black-necked stilts, whimbrels, and sanderlings were documented during surveys.

From 7/22/2016 through 8/26/2016, a volunteer conducted six weekly plover counts during fall migration. Plovers were counted utilizing a spotting scope and individuals were recorded as banded, not scanned, or unbanded. If the observer was not able to clearly see above and below the joint for color bands/flags on both legs the bird was counted as "not scanned." Band combination and a GPS location for each banded PIPL were recorded. For large groups of PIPL, mostly found on South Point, the count and band survey were divided into separate tasks. A total count would be taken and then the area would be visually divided into smaller areas demarcated by landmarks. The observer would spend approximately eight to ten hours scanning the smaller areas and identifying as many bands as possible.

Winter Shorebird Management Areas

In the fall, and to a lesser degree in the spring, large numbers of PIPL migrate through CAHA. Winter resource protection areas are established to provide protection for migrating and wintering PIPL that utilize CAHA as foraging grounds. The protection areas are placed in locations that encompass the primary foraging habitat preferred by PIPL. Winter protection areas that restrict both ORV and pedestrian access were established upon removal of the pre-nesting closures at Bodie Spit and South Point.

In addition to the winter protection areas, permanent Vehicle Free Areas (VFA), especially those at Cape Point, South Beach and North Ocracoke, also provide relatively undisturbed areas for migratory and wintering PIPL.

RESULTS AND DISCUSSION

Productivity

In 2016, nesting was identified at four sites: Bodie Island Spit on Bodie Island, Cape Point on Hatteras Island, North Ocracoke and South Point on Ocracoke Island (Appendix A, Maps 1, 2, 3 and 4 respectively). The first nests of the 2016 breeding season were discovered on April 22nd and the last active nest was lost on July 13th.

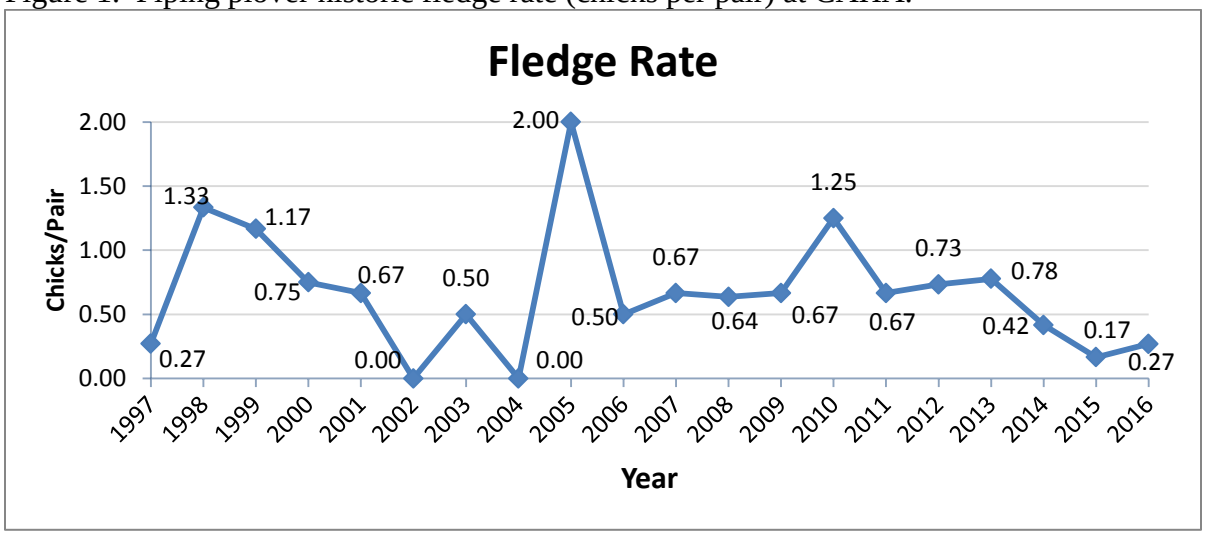
Eleven breeding pairs were observed which produced 13 known nests. The movement of one breeding individual between Cape Point and Bodie Island was documented when one banded individual attempted to nest at Cape Point and then, after the nesting attempt failed was observed with a new mate attempting to nest on Bodie Spit. Four nests successfully hatched at least one chick. A total of 43 eggs were documented, of which 11 hatched for a hatch rate of 25% (Table 1). The average incubation period was 28.7 days and ranged from 27 to 30 days (this calculation excludes nests found at full clutch).

Nine nests (69%) were lost prior to hatching and eight chicks (73%) were lost prior to fledging. Four out of 13 nests produced chicks. A total of three chicks fledged from two separate broods/nests (Table 1). The age at fledging was 30 days for both broods. Three chicks fledged from 11 breeding pairs yielding a fledge rate of 0.27 chicks fledged per breeding pair (Figure 1).

Table 1. Piping Plover Nest and Chick Success at CAHA in 2016.

Location	Breeding Pairs	Total Nests	Nests Hatched	Nests Lost/ Abandoned	Total Eggs	Total Eggs Hatched	Total Chicks Fledged	Total Chicks Lost
Bodie Island Spit	2	2	0	2	7	0 (0%)	0	0
Cape Point	6	7	4	3	26	11 (42%)	3	8
South Beach	0	0	0	0	0	0 (0%)	0	0
North Ocracoke	1	1	0	1	3	0 (0%)	0	0
South Point	2	3	0	3	7	0 (0%)	0	0
TOTAL:	11	13	4	9	43	11 (25%)	3	8

Figure 1. Piping plover historic fledge rate (chicks per pair) at CAHA.



Since 1997, fledge rates have ranged from 0.0 to 2.0 chicks per pair at CAHA. The mean rate from 1997-2014 was 0.67 chicks per pair. The fledge rate for 2016 was 0.27 chicks/pair. Chick loss, as in previous years, was difficult to document. The majority of chick mortality occurred soon after hatching with an average of 7.4 days (loss ranges were one to 15 days). Two nesting attempts occurred on Bodie Spit; both of which were lost prior to hatching. Two eggs were lost to ghost crabs and five eggs were abandoned. Cape Point, the only area within the Seashore that consistently fledges chicks, fledged three chicks and had a 42% hatch rate. Two complete nests were lost to flooding and one nest was lost to ghost crab and red fox predation. Three additional eggs were lost to unknown causes and one additional egg was lost to ghost crabs. Seven chicks were lost to unknown causes and one chick was lost to a ghost crab. No nesting attempts occurred on South Beach in 2016. Four nesting attempts occurred on Ocracoke Island this year (one on the north end and three on South Point); none of which produced any chicks. Of the ten eggs laid, five were lost to unknown causes, three were lost to ghost crabs, and two were lost to an unidentified mammal.

Chick Movement

During daily observations, field technicians documented foraging locations for PIPL chicks. Since chicks were not observed continuously from dawn to dusk or during the night, actual territories may be larger than depicted. When chicks were lost soon after hatching, no foraging territory outside the immediate vicinity of the nest could be established. An established grid system at the historical breeding territories (with points located 75 meters apart) was utilized by staff to obtain accurate locations for chicks. When chicks were observed, their locations were recorded relative to the grid points. The individual brood foraging areas designate the area in which the brood was observed on any given day until they fledged or were determined to be lost. The furthest distance traveled by the two broods this season from their respective nests was 560 m and 900 m. The estimated size of the foraging areas for the broods was calculated at 11.4 to 12.1 hectares.

Migrating and Wintering Piping Plovers

From April 2015 through March 2016 (excluding the month of May), 130 surveys were conducted for migratory and wintering piping plovers following the Southeast Coast Network

protocols. Very few surveys were conducted on Ocracoke during this time period and are therefore excluded from this analysis.

Surveys were conducted at five of the high intensity sites (PM 4, 5, 45, 46, and 58) and at 33 of the low intensity sites. Out of a potential 220 surveys, 50 surveys (23%) were completed at the high intensity sites. Out of 440 potential surveys, 80 surveys (18%) were completed at the low intensity sites. A total of 20 piping plover were counted during all surveys and all observed piping plovers were inside protected areas (VFAs, pre-nesting closures, or wintering closures). Eighteen of the plovers were observed in high intensity sites and 2 were observed in low intensity sites. Thirteen of the 20 piping plover were observed on the same transect during a survey of Bodie Spit during spring migration.

Although no documented Southeast Coast Network surveys were conducted on Ocracoke, a volunteer for the Seashore conducted a total of six weekly plover counts during fall migration from 7/22/16 through 8/26/16. The lowest piping plover count during the survey period was 155 individuals and the highest count was 188 individuals. Banded PIPL were also documented during these counts (Table 2). The importance of the South Point area on Ocracoke Island as a fall migration stopover site for piping plovers should not be underestimated and may be the only site on the Atlantic coast where such large numbers can be observed during migration.

Table 2. South Point Fall Migration Piping Plover Counts.

Date	Total Number	# Banded
7/22/2016	164	18
7/29/2016	182	25
8/5/2016	166	30
8/12/2016	155	30
8/19/2016	162	24
8/26/2016	188	28

Banded piping plovers documented included 11 different Atlantic Canada birds; three Great Lakes birds (two banded in Ontario); numerous birds from MA, RI, NY, NJ (and one from Assateague so either MD or VA); two banded on their wintering grounds in the US and one banded on the wintering grounds in the Bahamas. At least five of the birds were banded during the breeding season on Portsmouth and 1 on the north end of Ocracoke. Two of the birds observed on Ocracoke were birds that wintered last year at Oregon Inlet (one of which was at Oregon Inlet for two successive winters). Multiple birds stayed on Ocracoke for two, three or four weeks (S. Maddock, pers. comm.).

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APPENDIX A: MAPS

Map 1: Bodie Island Spit PIPL Nesting Activity, 2012-2016
Map 2: Cape Point PIPL Nesting Activity, 2012-2016
Map 3: North Ocracoke PIPL Nesting Activity, 2012-2016
Map 4: South Point PIPL Nesting Activity, 2012-2016

CAPE HATTERAS NATIONAL SEASHORE
AMERICAN OYSTERCATCHER (*HAEMATOPUS PALLIATUS*) MONITORING
2016 ANNUAL REPORT

ABSTRACT

In 2016, 26 pairs of American oystercatchers (AMOY) nested at Cape Hatteras National Seashore (CAHA). A total of 41 nests were identified in the park which includes re-nests from pairs with failed nest attempts. The first nest was found on April 4th and the last chick was fledged on August 9th. Of these nests, 13 hatched and produced a total of 24 chicks. Nine pairs of AMOY were successful in fledging 12 chicks which represents a 0.46 fledge rate per pair. Since 2001, fledge rates have ranged from 1.3 to 0.35 chicks per pair at CAHA. The mean rate from 2010-2015 is 0.66 fledge per pair.

INTRODUCTION

The AMOY is a ground-nesting shorebird native to North Carolina. As with many shorebirds, AMOY numbers have been in sharp decline over the past 20 years. The AMOY is designated as a Special Concern Species by the North Carolina Wildlife Resources Commission and a Species of High Concern in the U.S. Shorebird Conservation Plan (Brown et al 2001). Habitat loss and fragmentation due to beach development has resulted in nesting attempts in marginal habitat. Nesting attempts in marginal habitat is thought to lead to an increased number of unsuccessful breeding attempts. Off-road-vehicle (ORV) use on the beach can lead to direct mortality of chicks and eggs and pedestrian disturbance can indirectly cause loss of nests or chicks. The main cause of direct mortality of chicks and eggs is believed to be mammalian predators.

METHODS

Resource Protection Areas

As per the modified regulation, AMOY buffers are 150m for breeding behavior (scrapes or nests) and 200m for unfledged chicks. As chicks commenced their movement away from the nest sites the protection areas were expanded when necessary to ensure adequate buffers.

Monitoring

Breeding pairs of AMOY were located by surveying potential habitat including ocean-side beaches and sound-side beaches. Birds were monitored closely for nesting when observed regularly at the same location or when demonstrating territorial or breeding displays. If nests or scrapes were found, observers marked the location with a handheld GPS unit. Protection areas were installed (or modified) as necessary to maintain the required buffer distance(s).

Incubating pairs with nests were monitored daily and observed closely for signs of chicks near expected hatch dates. Expected hatch dates were calculated from an average nest incubation period for AMOY as 29 days from first egg laid or 24 days from last egg laid (Baicich and Harrison 1997). If an incubating bird was not observed on the nest, the nest was checked for the presence of eggs and, if the eggs were missing, the area was inspected for signs of predators.

Once chicks hatched, staff attempted to observe each chick daily.

Nonbreeding AMOY Surveys
Three surveys were conducted in all park districts from June 2 to June 6 to account for nonbreeding AMOY. Nonbreeding AMOY are lone birds and pairs of birds, both unbanded and banded, unassociated with nests at CAHA. Surveys were conducted on the same dates in all park districts and a GPS point was taken for each AMOY observed. After the conclusion of the breeding season the highest daily number of nonbreeding AMOY for the seashore over the three survey dates was recorded.

Banding
In addition to carrying out actions required by the ORV Management Plan, resource management staff banded AMOY chicks under North Carolina State University's (NCSU) banding permit. Banding aids in tracking survival of individuals, determining breeding success of individual pairs, documenting movement of young birds to other areas, and aids in determining breeding site fidelity. Being able to identify individual birds has also allowed NCSU and CAHA staff to coordinate data with scientists from other states to examine genetics, migration patterns, and long-term survival rates of the AMOY population.

RESULTS AND DISCUSSION

Productivity
In 2016, 26 pairs of AMOY nested at CAHA. One pair was found on Bodie Island, 14 were found on Hatteras Island, ten were found on Ocracoke Island, and one was found on Green Island. Twenty-three AMOY breeding pairs held territories within the pre-nesting areas and 37 of the 41 AMOY nesting attempts occurred inside the pre-nesting areas (Appendix B; Maps 1-6).

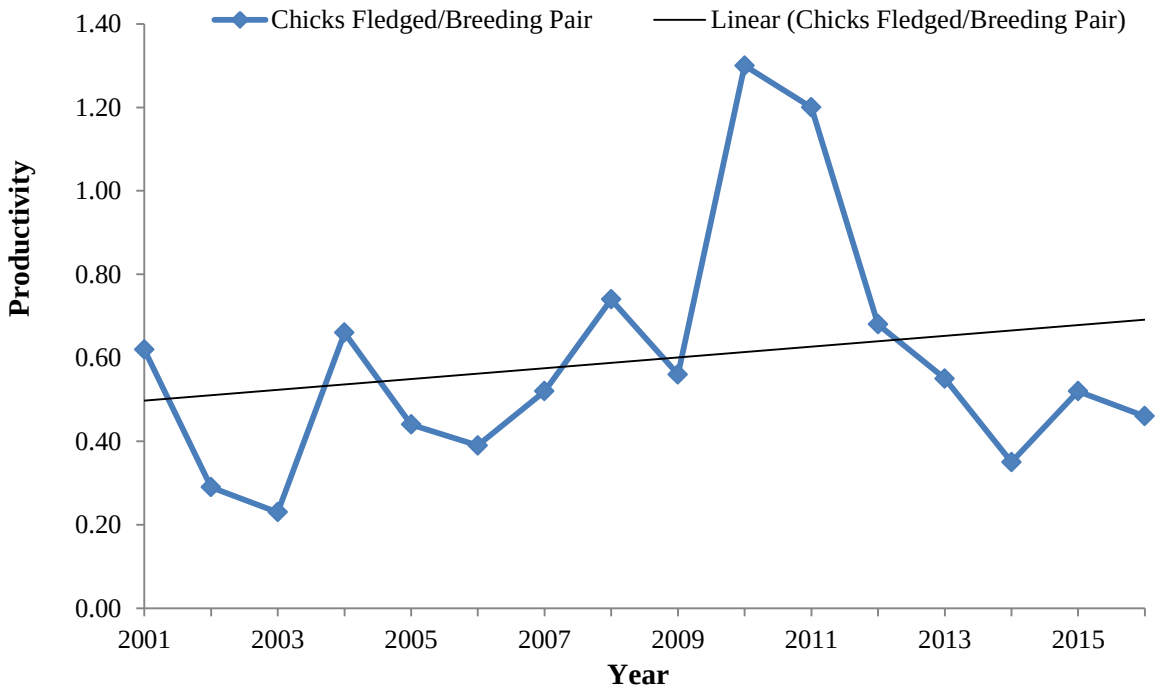
Altogether, these pairs produced a total of 41 nests, including re-nests, of which 13 nests hatched. Nine pairs were successful in fledging 12 chicks which represents a 0.46 fledge rate per pair (Table 1). This is a decrease from previous years nesting success (Figure 1).

Table 1. Summary of AMOY Reproductive Success 2010 – 2016.

Year	Breeding Pairs	Total Nests	Nests Hatched	Successful Pairs (at least 1 chick fledged)	Number of Chicks Fledged	Fledge Rate
2010	23	28	21	15	30	1.3
2011	23	26	22	17	28	1.2
2012	22	30	18	11	15	0.68
2013	27[1]	42	19	10	15	0.55
2014	26	38	18	8	9	0.35
2015	25	43	19	11	13	0.52
2016	26	41	13	9	12	0.46

[1] Could also be calculated as 26 pairs. One male AMOY nested twice, each time with a different female.

Figure 1. Fledge Rate and Trend for AMOY Breeding at CAHA from 2001-2016.



The first nest of the season was found on April 4, 2016 and the last nest was found on June 6, 2016. For the 13 nests with known start dates, the average incubation period was 31 days. For the nine broods which fledged chicks, the average age of chicks when they fledged was 41 days old. This average does not include separate dates for individuals within a brood but is based on the date of the first chick to fledge from each brood.

Increased mammalian predation is attributed to the low hatch and fledge rate. The high number of predation incidents could also be responsible for the increased number of nests. Of the 26 pairs with known nesting dates, 13 pairs re-nested at least once after their nest was lost.

Nest Failures and Chick Mortality

Twenty-eight nests were lost in 2016 breeding season. Four nests were lost to overwash, two nests were abandoned, 13 nests were lost to predation, and nine were lost to unknown causes. Of the 13 nests lost to predation four were taken by coyotes, one by avian predators, two by red foxes, two by canid species, and four by feral cats. Mammalian, ghost crab or avian predators are believed to be responsible for the other nine nests lost to unknown causes.

Determining cause of chick loss is even more difficult than determining cause of nest loss. In the 2016 season there were four complete brood failures and three partial brood failures. Thirteen chicks were lost to unknown causes. Chicks can move large distances and it is sometimes difficult to locate them. Environmental conditions surrounding the brood site may obscure evidence of predation and searches for missing chicks may be intentionally delayed since many different types of disturbances may cause the chicks to hide out of view from the observers.

Nonbreeding AMOY Surveys

Three surveys were conducted in all park districts on June 2, 4, and 6, 2016 to account for nonbreeding AMOY. A GPS point was taken for each AMOY observed and breeding pairs were identified after the breeding season concluded. Eleven nonbreeding AMOY were observed on June 2, and 4, 2016. One was observed on Bodie Island, four on Hatteras Island, and six on Ocracoke Island. The age of many of the banded birds is known and some were of age to nest in 2016, but did not, either due to their inability to find, establish and hold a territory, or inability to find a mate of breeding age. Other observed birds will first come into breeding age in 2017.

Banded AMOY

In 2016, ten new AMOY pairs and four new individuals joined the CAHA breeding population for a total of 26 AMOY pairs. Of the ten new pairs, five pairs were known breeding AMOY but choose a different mate in 2016.

A total of 217 AMOY have been banded at CAHA since 2002 consisting of 48 adults and 169 chicks. No AMOY were banded in 2016. As the result of this long term cooperative banding project with NCSU, CAHA has begun to document banded chicks surviving to adulthood and joining the breeding population. Banded birds enabled staff to identify breeding pairs and unpaired individuals with confidence.

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APPENDIX B: MAPS

CAPE HATTERAS NATIONAL SEASHORE
COLONIAL WATERBIRD MONITORING
2016 ANNUAL REPORT

ABSTRACT

A total of 20 colonies containing 2 or more nests within 200m (as defined by the seashore's Colonial Waterbird Management protocol) were documented in 2016. Hatteras Island contained thirteen colonies, Bodie Island and Ocracoke Island each had three colonies while Green Island contained one colony. In 2016, park totals of 295 LETE nests, 91 COTE nests, 169 BLSK nests, 23 GBTE nests, and 0 FOTE nests were documented. The total estimated number of nests for least terns (LETE), common terns (COTE), gull-billed terns (GBTE) and black skimmers (BLSK) was higher in 2016 than 2015; however, there were no Forster's tern (FOTE) nests. There were three multi-species colonies within CAHA; located at Green Island, Cape Point on Hatteras Island, and South Point on Ocracoke. The largest Colonial Waterbird (CWB) colony occurred on Ocracoke Island Spit (South Point) and consisted of 137 BLSK nests, 35 COTE nests, 12 LETE nests, and 23 GBTE nest. The largest LETE colony, 124 nests and 23 chicks, occurred on Hatteras Island at Cape Point.

INTRODUCTION

Colonial waterbird refers to those species of birds that nest in large groups or colonies and obtain their food from the water. Terns, gulls, pelicans, skimmers, and cormorants are all examples of CWB. The beaches of CAHA provide traditional nesting habitat for several species of special concern and state-listed colonial-nesting waterbirds, including the common tern (*Sterna hirundo*), least tern (*Sterna antillarum*), and black skimmer (*Rynchops niger*). Less common nesters include the gull-billed tern (*Gelochelidon nilotica*) and Forster's tern (*Sterna forsteri*).

METHODS

Resource Protection Areas

As per the modified regulation, LETE buffers are 100m for breeding behavior (scrapes or nests) and unfledged chicks. Other protected CWB species received a 180m buffer for all breeding activity and unfledged chicks (Table 1). Protection areas were modified as the colonies expanded to maintain the required buffer sizes from the outer-most nest or chicks in the colony. When multiple species were present, the greatest applicable buffer distance was applied.

Table 1. Modified colonial waterbird (CWB) nesting and chick buffers at CAHA, effective 2016.

	Breeding Behavior and Nest Buffer (m)	**Unfledged Chick Buffer (m)**
LETE	100	100
Other Protected CWB	180	180

Monitoring

Monitoring of CWB at CAHA focuses on identifying nesting habitat, protecting nesting areas and chicks, and monitoring colony activity. In addition to established pre-nesting areas, technicians were responsible for locating additional areas where active colonies may begin to form. This involved observing CWB for courtship, copulation, and scraping behaviors. Initialization of data collection began when scraping behavior or physical scrapes were observed and a protection area (with applicable buffers) was installed around the area. Once a protection area was established, the area was observed at least once daily from either outside the protection area or inside the protection area at the shoreline by resource management field staff. Efforts were made to minimize entry into colonies to minimize colony disturbance.

A minimum of two walk-through nest-abundance surveys were performed for each colony to more accurately count nests and determine the size of the colony. The highest nest count was reported as the nesting peak. The estimated peak nesting for CAHA is generally within the first part of June, but this may be advanced or delayed based on the start date and progression of the colony. If chicks have been observed prior to the first week of June then it is acceptable to perform a walk-through survey. The distance from the outer most nests or chicks to the resource protection boundary were checked during observation periods to ensure all nests or chicks were within the required buffer.

RESULTS AND DISCUSSION

Observed Colonies

The ORV Management Plan does not specify what parameters constitute an active CWB colony. Based on the current protocol Colonial Waterbird (CWB) Management at Cape Hatteras National Seashore, "Each distinct group of nesting CWB will be considered a colony and receive a name designation if there are 2 or more nests within 200m or less of one other." Also, activity that triggers a resource protection area must include physical evidence of established breeding such as a scrape or a nest; behavior alone (e.g. copulation or fish-flashing) will not suffice. A total of 20 colonies (Table 2) with 2 or more nests within 200m were observed within CAHA during the 2016 breeding season. If not already present, a protection area with proper buffering was installed to provide the colony with protection. Under the ORV Management Plan, locations of colonies containing more than 10 CWB nests will be considered for future placement of pre-nesting areas.

Table 2. Summary of colonies observed during the 2016 breeding season.

	Observed Colonies	**Colonies Containing >10 Nests**
Bodie Island	3	1
Green Island	1	1
Hatteras Island	13	5
Ocracoke Island	3	3
Total	**20**	**10**

Nest Observations and Counts

Similar to previous years, individual colony walk-throughs occurred during the peak nesting period for each colony. The walk-throughs were conducted a minimum of two times during peak nesting and potentially a third time if circumstances necessitate. A third survey was likely if either a colony start date is early or delayed, if there is predator influence, if storms/weather significantly impact colony sites, or if the colony has grown and more accurate information regarding breeding estimates can be obtained.

Table 3. Nests, eggs, and chicks documented per species during peak nesting surveys; 2016.

	Nests	**Eggs**	**Chicks**
LETE	295	446	30
COTE	91	184	42
GBTE	23	40	3
FOTE	0	0	0
BLSK	169	318	26

Peak nest surveys (Table 3) produced a park total of 295 LETE nests with 30 observed chicks, 91 COTE nests with 42 observed chicks, 23 GBTE nests with 3 observed chicks, 0 FOTE nests, and 169 BLSK nests with 26 observed chicks. The multi-species colony on Ocracoke, 15CWBOI02, was the most species-diverse and highest nest-producing colony on the seashore, containing nests from LETE, COTE, GBTE, and BLSK. The multi-species colony on Green Island (GI), 16CWBGI01, was reached by way of boat courtesy of NCDOT; active COTE and BLSK nesting behavior was unexpectedly observed later in the season (late June). Adult BLSK had not been observed nesting on GI since the 2013 field season. A third multi-species colony (LETE, COTE, and BLSK) was also documented at Cape Point.

Six CWB breeding locations were established and lost before colony status could officially be identified prior to the walk-through survey dates.

- 16-CWB-BH07 on Hatteras Island was active (one LETE nest) from July 15 – August 3. The lack of a colonial effort late in the season may have caused this single-nesting adult to abandon its nest.

- 16-CWB-HI07 on Hatteras Island was active (LETE scrapes only) from May 31 – June 5. Heavy rains from Tropical Storm Colin flooded the potential nesting site from 6/5-6/7; adults not observed thereafter.
- 16-CWB-HI08 on Hatteras Island was active (LETE scrapes only) from June 11 – June 13. Nest site abandoned for unknown reasons.

- 16-CWB-HI10 on Hatteras Island was active (one LETE nest) from June 23 – June 29. Nest site abandoned for unknown reasons, potentially merged into a nearby colony.

- 16-CWB-HI11 on Hatteras Island was active (one LETE nest) from June 25 – July 10. Breeding adult observed incubating consistently for three days. The number of

nonbreeding adults observed fluctuated greatly – nest likely abandoned; unknown reasons.

- 16-CWB-OI04 on Ocracoke Island was active (LETE scrapes only) from June 16 – June 20. Colony failure attributed to adverse weather conditions soon after the scraping process.

Historical Comparison

The total number of documented nests for all but one species in CAHA increased in 2016 (Figures 1-5). The LETE nesting activity, even though minimally higher, still maintains low numbers in the park. Quality of habitat is likely one of the factors causing low LETE numbers. For example, one key LETE nesting area, Bodie spit, continues to build a stabilized dune system where traditional LETE habitat previously existed. There were three multi-species colonies at CAHA this season that helped increase overall nest numbers for COTE and BLSK. Aside from Ocracoke, additional COTE and BLSK nests were observed at Green Island (BLSK last nested there in 2013) and Cape Point. Large numbers of laughing gulls (*Leucophaeus atricilla*) continue to nest on Green Island, which may have displaced the FOTE (adults and nests not observed). The seashore's only GBTE nesting continues to be on Ocracoke's South Point; this season produced the greatest nest numbers (23 nests) since 2012.

Figure 1. Historic LETE Peak Nest Counts.

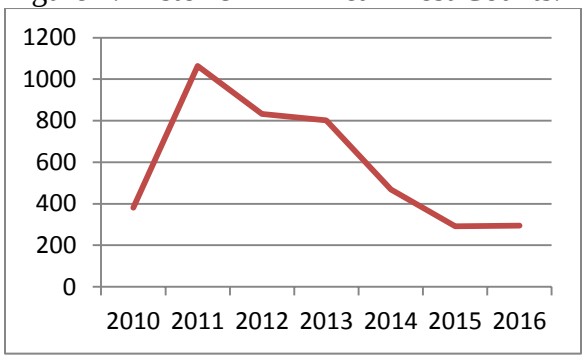


Figure 2. Historic COTE Peak Nest Counts.

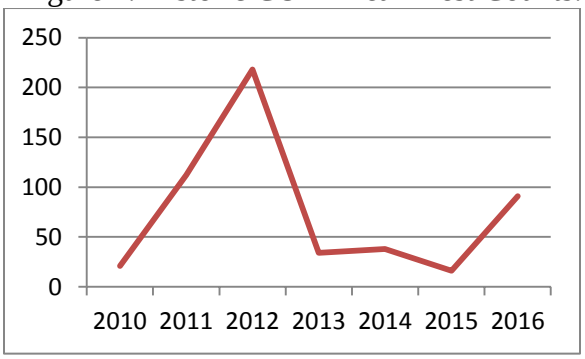


Figure 3. Historic GBTE Peak Nest Counts.

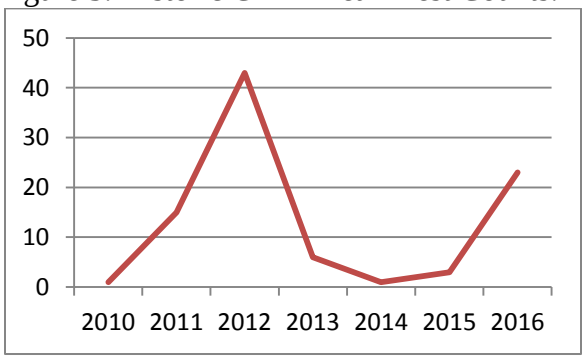


Figure 4. Historic FOTE Peak Nest Counts.

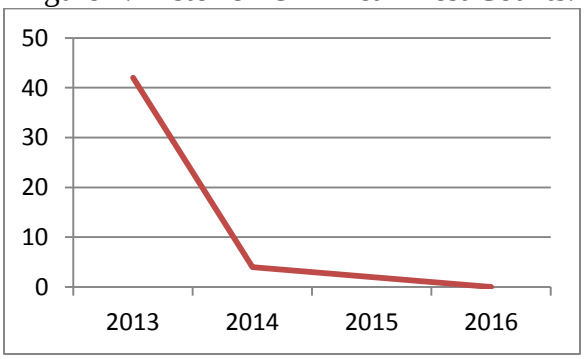
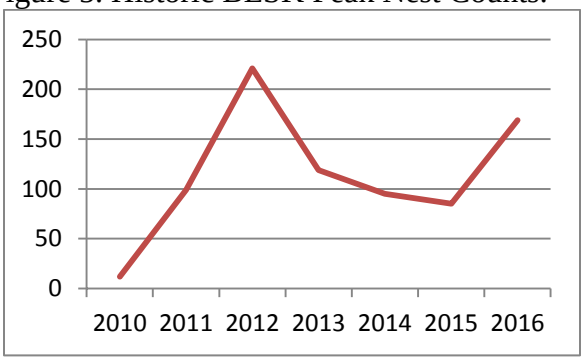


Figure 5. Historic BLSK Peak Nest Counts.



Productivity

Productivity in unmarked CWB colonies is very difficult to determine. While it is certain multiple colonies fledged chicks, there are no definitive numbers for CWB productivity at CAHA. The uncertainty remains as to whether or not the fledged chicks observed are from a particular colony or just passing through from elsewhere. Of the 20 documented colonies, CWB fledges were observed in 6 colonies. Four colonies contained LETE fledges while BLSK fledges were observed on Ocracoke's South Point (~200 fledges) and Green Island (9 fledges). Given the isolated congregation of breeding individuals on Green Island, it is likely that these 9 individual fledges were a product of the Green Island colony as many older chicks were previously observed.

Two walk-through nest-abundance surveys were performed during peak breeding during the 2016 nesting season. These surveys were performed for each colony to aid in refining nest counts and to more accurately classify colonies. Resource Management staff has made a greater effort to quantify birds documented in incubating posture as an alternative to conducting more frequent walk-through counts outside of peak nesting. Although we are losing some accuracy by relying solely on observational skills, nesting shorebirds have benefited from less obtrusive methods of monitoring.

Nest Failures and Chick Mortality

Three factors at CAHA are thought to contribute to the loss of nests or chicks on a yearly basis: predator disturbance, abandonment, and weather. On multiple occasions, more than one factor may occur. Predator interactions were documented in 13 of the 20 observed colonies; documented predators include coyote (37 interactions), unknown fox (3 interactions), gray fox (1 interaction), domestic dog (2 interactions), gulls (3 interactions), fish crow (1 interaction), nutria (2 interactions) and unknown predator (3 interactions). Perpetual predators that affect localized colonies include coyote disturbance on Bodie Island spit, and mink on Ocracoke Island. Constant pressure from predators has proven to lead to colony abandonment in the past. During the 2016 CWB breeding season, there was one significant weather event, Tropical Storm Colin (June 5-7), that may have negatively affect nesting or chicks at Cape Hatteras National Seashore.

Discussion

The 2016 CWB nesting season resulted in greater nest numbers in four of the five species that were documented to nest at CAHA. Even though five additional LETE colonies were

documented than the previous year, overall nest numbers for the species remains low. Habitat loss plays a key role in decreasing nesting numbers for LETE, much of the traditional habitat at the points/spits has given way to expanding dune systems - thus eliminating the sandy shellbeds that this species keys-in on for nesting. Significant weather events (i.e. hurricanes) have been absent in recent years or have failed to wash-over the dunes and re-establish the important shellbed habitat. The installation of yearly pre-nest areas and maintenance of appropriate buffers may have had a positive influence on the number of CWB pairs nesting at CAHA by providing less human pressure within nesting habitat.

APPENDIX C: MAPS

CAPE HATTERAS NATIONAL SEASHORE
WILSON'S PLOVER (*CHARADRIUS WILSONIA*) MONITORING
2016 REPORT

ABSTRACT

In 2016, three WIPL pairs and three nests were identified; one nest per pair. All nests were found on South Point, Ocracoke Island. The first nest was found on May 1st and the last chick was lost on July 6th. Two nests hatched a maximum of five chicks; three chicks from one nest and two chicks from the second nest. No chicks were fledged. Unfortunately, this is consistent with recent years of WIPL nesting at CAHA. Nest losses have been attributed to predation or overwash events but the cause for chick mortality is almost always unknown.

INTRODUCTION

The WIPL is a ground-nesting shorebird native to North Carolina. The preferred nesting habitat is vulnerable to destruction from development, erosion, and weather events (tropical storms, extreme high tides). Disturbance from recreational activities can cause plovers to abandon their nests leaving their eggs exposed to predation and overheating. The WIPL is listed as a Species of Special Concern in North Carolina.

Wilson's plovers generally lay two to three eggs in a small, shallow depression or scrape. The pair can take up to five days from the laying of the first egg to completion of the clutch (Bergstrom 1988). Upon completion of the clutch, the pair incubates the nest for 23-27 days until hatching. Both the eggs and chicks are cryptic in coloration which makes them difficult to locate. Chicks are precocial and follow the adults to locations where they forage for crustaceans, particularly fiddler crabs, and insects found in and on the sand.

METHODS

Resource Protection Areas

As per the modified regulation, WIPL buffers are 50m for breeding behavior (scrapes or nests) and 100m for unfledged chicks. As chicks commenced their movement away from the nest sites the protection areas were expanded when necessary to ensure adequate buffers.

Monitoring

Field staff began monitoring for WIPL arrival and breeding behavior in early March. Predator exclosures, which have been used at CAHA since 1994 to reduce predatory pressure on PIPL nests and nesting adults, were constructed around nests when clutches reached three or more eggs. The circular exclosures (approximately ten feet in diameter), consisted of two inch by four inch welded-wire fence anchored by steel rebar and topped with a three-quarter inch mesh netting to dissuade avian predators. Exclosures were installed following the guidelines established in the USFWS' Piping Plover Recovery Plan (USFWS 1996, Appendix F).

Thereafter, the nest was briefly approached once weekly to inspect the exclosure, verify the number of eggs, and check for signs of predators.

Daily nest monitoring occurred from an adequate distance to avoid disturbance to incubating birds but close enough to be able to document incubation, nest abandonment and abnormal behavior. Due to the alert and protective nature of WIPL adults, the pairs were rarely observed incubating but were documented outside the exclosure. Observation times were minimized to reduce disturbance to the nesting pair.

After hatching, staff attempted to monitor the broods daily. Adult WIPL prefer to forage with their chicks in vegetated intertidal mudflats where the chicks can easily be concealed for safety. Broods were assumed to be in areas where adult WIPL were documented being territorial with other shorebirds. Staff monitored chicks until day 35, at which time they are considered fledged (CAHA 2010).

RESULTS AND DISCUSSION

Productivity

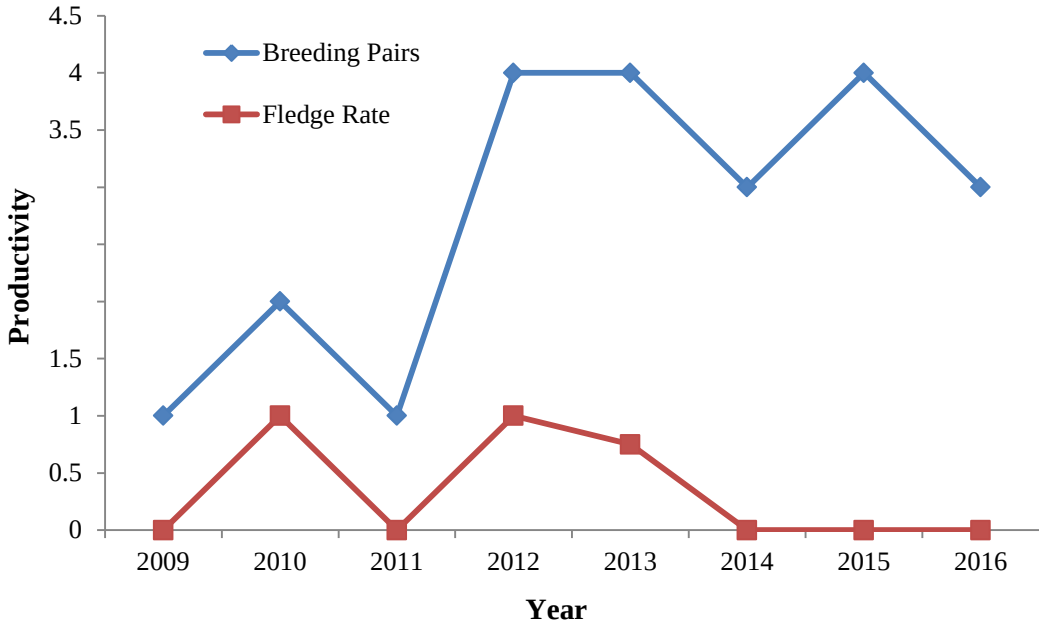
In 2016, three WIPL pairs and three nests were identified; one nest per pair. All nests were found on South Point, Ocracoke Island. Two nests hatched a maximum of five chicks; three chicks from one nest and two chicks from the second nest. No chicks were fledged (Table 1). Due to the evasive behavior and mobility of the broods, an exact number of chicks hatched is unknown. The earliest nest was discovered on May 1, 2016 and the latest nest was found on June 1, 2016. The average time to hatch was 30 days.

Since 2009, six pairs of WIPL fledged nine chicks which represents a 0.67 fledge rate per pair (Figure 1). The average time to fledge for the three broods with known fledge dates was 28 days. Three of the six broods were not observed with fledged chicks until more than 35 days after hatching.

Table 1. Summary of WIPL Reproductive Success 2009 – 2016.

Year	Breeding Pairs	Total Nests	Nests Hatched	Successful Pairs (at least 1 chick fledged)	Number of Chicks Fledged	Fledge Rate
2009	1	1	1	0	0	0
2010	2	2	2	1	2	1.0
2011	1	1	1	0	0	0
2012	4	4	2	2	4	1.0
2013	4	4	3	3	3	0.75
2014	3	3	2	0	0	0
2015	4	3	2	0	0	0
2016	3	3	2	0	0	0

Figure 1. WIPL Reproductive Success 2009-2016.



Nest Failures and Chick Mortality

In 2016, one WIPL nest was lost to overwash. Of the five chicks assumed to be hatched, all were lost prior to fledging and all losses were attributed to unknown causes. Determining the cause of chick mortality is difficult due to the tendency of WIPL broods to spend most of their time within vegetation. Mammalian, ghost crab and avian predators are believed to be responsible for the losses.

Banded WIPL

While CAHA does not participate in banding WIPL, there are several projects throughout the southeastern United States banding WIPL with unique color band combinations. Scientists study the banded birds to gain a better understand of movement patterns related to migration, nesting, wintering, foraging, etc. Since 2012, there have been nine individual WIPL with color bands observed at CAHA. Five individuals have been attributed to four separate nests at CAHA since 2012. The banded birds enable staff to identify pairs, broods and unpaired individuals with confidence. No banded WIPL nested at CAHA in 2016.

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APPENDIX D: MAPS

Map 1. South Point WIPL Nesting Activity, 2012-2016

CAPE HATTERAS NATIONAL SEASHORE
SEA TURTLE MONITORING
2016 ANNUAL REPORT

ABSTRACT

In 2016, 325 sea turtle nests (313 loggerhead, 11 green, and 1 Kemp's ridley nests) and 329 false crawls (320 loggerhead, and 9 green crawls) were documented at Cape Hatteras National Seashore (CAHA). The first nesting activity was documented on May 18 and the last nesting activity was documented on September 24. Mean hatch success for all nests was 62.3% while mean emergence success was 53.9%. A total of 775 stranded sea turtles have been documented within CAHA in the 2016 fiscal year (Oct. 1, 2015 – Sept. 30, 2016). A total of 637 stranded sea turtles have been documented within CAHA in the 2016 calendar year.

INTRODUCTION

Five species of sea turtles nest on CAHA beaches– the loggerhead (*Caretta caretta*), green (*Chelonia mydas*), leatherback (*Dermochelys coriacea)*, hawksbill (*Eretmochelys imbricata*), and Kemp's ridley (*Lepidochelys kempii*). In the 1970's, the leatherback, Kemp's ridley, and hawksbill were listed under the Endangered Species Act (ESA) as endangered and the loggerhead and green as threatened.

Non-breeding sea turtles of all five species can be found in the near-shore waters during much of the year (Epperly 1995). Cape Hatteras lies near the extreme northern limit of the nesting range for four of the five sea turtle species, including the loggerhead, green, Kemp's ridley and leatherback. Hawksbill sea turtles, in the past, were not known to nest at CAHA, but are known to occur here through strandings on beaches.

Cape Hatteras National Seashore has been monitoring sea turtle activity since 1987, and standard operating procedures have been developed during this time. CAHA follows management guidelines defined by the North Carolina Wildlife Resources Commission (NCWRC) in the *Handbook for Sea Turtle Volunteers in North Carolina*, United States Fish and Wildlife Service (USFWS) species recovery plans, and the Cape Hatteras National Seashore Off-Road Vehicle Management Plan and Special Regulation (ORVMP).

Cooperating Agencies

The Seashore cooperates with the National Marine Fisheries Service (NMFS), USFWS, and NCWRC on sea turtle protection. All nesting activity and stranding reports are reported to the North Carolina Sea Turtle Program Coordinator at NCWRC through the seaturtle.org website. An annual permit is issued to CAHA by NCWRC under the authority of the USFWS for the possession and disposition of stranded marine turtles and relocation of nests.

METHODS

Nesting Activity

Monitoring for sea turtle nesting activity began on April 30, 2016. Patrols utilizing UTVs (or 4X4 trucks during inclement weather) were conducted in the morning, beginning approximately at dawn. Each occurrence of nesting activity was recorded as either a false crawl or nest. All nests were confirmed by locating eggs at the nest site. One egg was taken from each clutch for DNA research purposes. The decision to relocate the nest or for the nest to remain in situ was made at the time of nest discovery. If no eggs were laid, the nesting activity was considered a false crawl and recorded by collecting a GPS point at the apex of the crawl. Sea turtle monitoring data were reported to NCWRC using the Sea Turtle Nest Monitoring System (STNMS) through the Seaturtle.org website.

All nests were protected from human disturbance by installing a 10m x 10m signed area around the nest site. At day 50-55 of incubation, or earlier if hatch activity is observed, the protected area is expanded to 30m wide and extended to the water line. This enclosed area protects the nest site and hatchling from human disturbance during hatching events. Each nest site is checked daily and any disturbances or hatching events are recorded.

Approximately three to five days after an initial hatching event, nests were excavated and the protected area markers and signs were removed. The remaining egg shells, unhatched eggs, and live/dead hatchlings were counted to determine hatch and emergence success for each nest excavation. Mean emergence success was calculated by taking the mean of all the individual nest emergence 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. Any hatchlings found during excavations were not considered to have emerged. Mean hatch success was calculated by taking the mean of all the individual nest hatch successes. Hatching success is the percentage of eggs in a nest that produce hatchlings.

Live hatchlings discovered upon excavation of the nest were collected and released at or after dusk the same day. Monitoring efforts to locate new nests ended October 8, 2016; two weeks after the last nesting activity was observed.

Late Nest Management

Following NCWRC recommendations, after 90 days of incubation, an excavation would begin on any late laid nests. If a viable embryo was observed, the excavation would be stopped and the nest would be left in place. If hatching activity was not observed after 100 days of incubation, the nest site would remain protected by a reduced sized protected area. The eggs would then be checked approximately every 10 days for viability. Nests would be fully excavated, and protected areas removed, when no viable embryos are observed.

Depredation

National Park Service resource management staff documented sea turtle egg and hatchling loss as part of their routine monitoring efforts throughout the nesting/hatchling season. Loss from research samples, humans, terrestrial mammals, bird species, and other organisms were identified and documented whenever observed.

Stranding Activity
A stranded turtle is a non-nesting turtle that comes to shore either sick, injured, or dead. Data was collected for each reported or observed stranding. Whenever possible, further data was collected by performing a necropsy on dead strandings. Live stranded turtles were transported to a facility for treatment and recovery. All data was reported to NCWRC using the Sea Turtle Rehabilitation and Necropsy Database (STRAND) through the Seaturtle.org website.

An increased effort to locate stranded turtles began in early November and continued throughout the winter due to the increased chance of "cold stunned" turtles. Searches for cold stunned turtles were emphasized on CAHA's sound side shorelines, where the majority of cold stunned turtles have been found in the past. Cold stunning refers to the hypothermic reaction that occurs when sea turtles are exposed to prolonged cold water temperatures. Initial symptoms include a decreased heart rate, decreased circulation, and lethargy followed by shock, pneumonia and possibly death (http://www.nero.noaa.gov/prot_res/stranding/cold.html).

RESULTS

Nesting
A total of 325 nests (313 loggerhead, 11 green, and 1 Kemp's ridley nests) were observed at CAHA in 2016 (Figure 1). Of the confirmed nests, 11 (3.4%) were found on Bodie Island, 218 (67.1%) on Hatteras Island, and 96 (29.5%) on Ocracoke Island (Appendix B, Maps 1–4). This was the greatest number of nests recorded at CAHA in a single nesting season since monitoring began at the Seashore (Figure 1). The first recorded nest occurred on May 18 and the last nest was recorded on September 24. While nesting occurred throughout this period, peak nesting occurred from July 1 to July 7, 2016 (Figure 2). Preliminary DNA results from one egg sampled from each nest shows a total of 82 nesting females have used CAHA beaches to nest, resulting in an average of 2.55 nests laid per female with a mean inter-nesting period of 13.61 days (Table 1).

Figure 1. CAHA sea turtle nests 2008–2016.

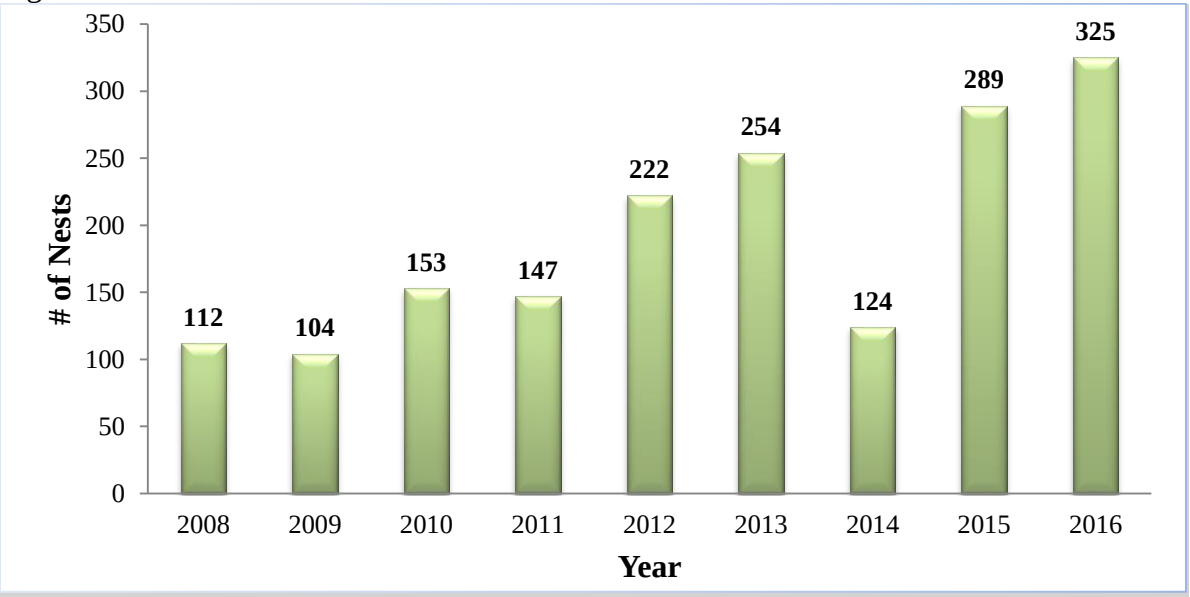


Figure 2. Number of nests by lay date for 2016 and average of previous five years.

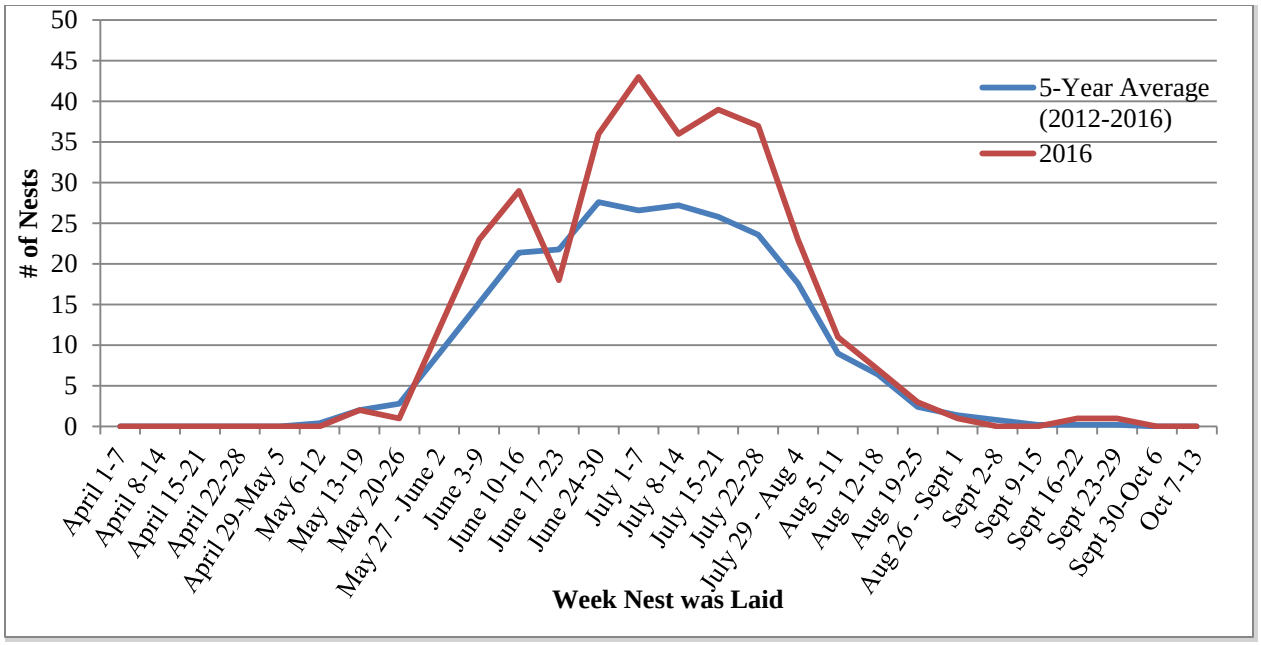


Table 1. Individual nesting sea turtles at CAHA, DNA analysis results (2010-2016)

Year	Individual Nesting Females	Mean Nests per female	Mean Inter-nesting Period (days)
2010	87	1.95	14.14
2011	77	2.23	14.52
2012	111	2.28	14.6
2013	127	2.22	15.22
2014	63	2.1	14.83
2015	125	2.58	14.54
2016[1]	82	2.55	13.61

[1] DNA analysis for 2016 has yet to be complete

Nest Relocation

Of the 325 nests, 85 (26.1%) were relocated (Appendix A). Most nests were moved due to natural factors including location of nest at or below high tide line or the nest was laid in an area susceptible to erosion. Relocation methods recommended by NCWRC, found in the *Handbook for Sea Turtle Volunteers in North Carolina* (2006), were followed.

False Crawls

During the 2016 breeding season, 329 false crawls or aborted nesting attempts were recorded. False crawls accounted for 50.3% of the 654 total turtle activities. Of the 329 false crawls, 10 (3.0%) were documented on Bodie Island, 172 (52.3%) on Hatteras Island, and 147 (44.7%) on Ocracoke Island (Appendix C, Maps 5–8). There were nine documented green, and 300 documented loggerhead sea turtle false crawls.

Hatching

In 2016, the mean clutch count was 118.6 eggs per nest (Table 2; Appendix A). The mean clutch count was determined using total egg counts at the time of relocation from relocated nests only. Average incubation period of nests with known lay and emergence dates was 53.6 days. The 2016 season marks the lowest average incubation rate since 2001. This is likely due to a larger sample size and an overall warmer summer during the nest incubation months (June–August). Incubation periods depend mostly upon sand temperature (Bustard and Greenham 1968), higher average temperatures during overall incubation decreases incubation periods while lower mean temperatures during overall incubation increases incubation periods. This season mean incubation periods ranged from 48.8 days to 68 days. All nests with known incubation days were organized by the week they were laid so a mean incubation period could be calculated and compared through the nesting season (Figure 3). Some emergences went undetected due to rain, wind, tides and storm events and were not counted in these calculations. Mean emergence success was 53.9% (Appendix A). Any hatchlings found during excavations, live or dead, were considered hatched (Figure 4). Mean hatch success was 62.3% (Appendix A).

Table 2. Sea turtle hatch summary 2001-2016.

Year	Nests	Avg. Clutch	Average Incubation (days)	Total Eggs	# Emerged	EMR%
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	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	53.4	34122	20380	54%

Figure 3. Mean incubation time (days) of nests by week (2016).

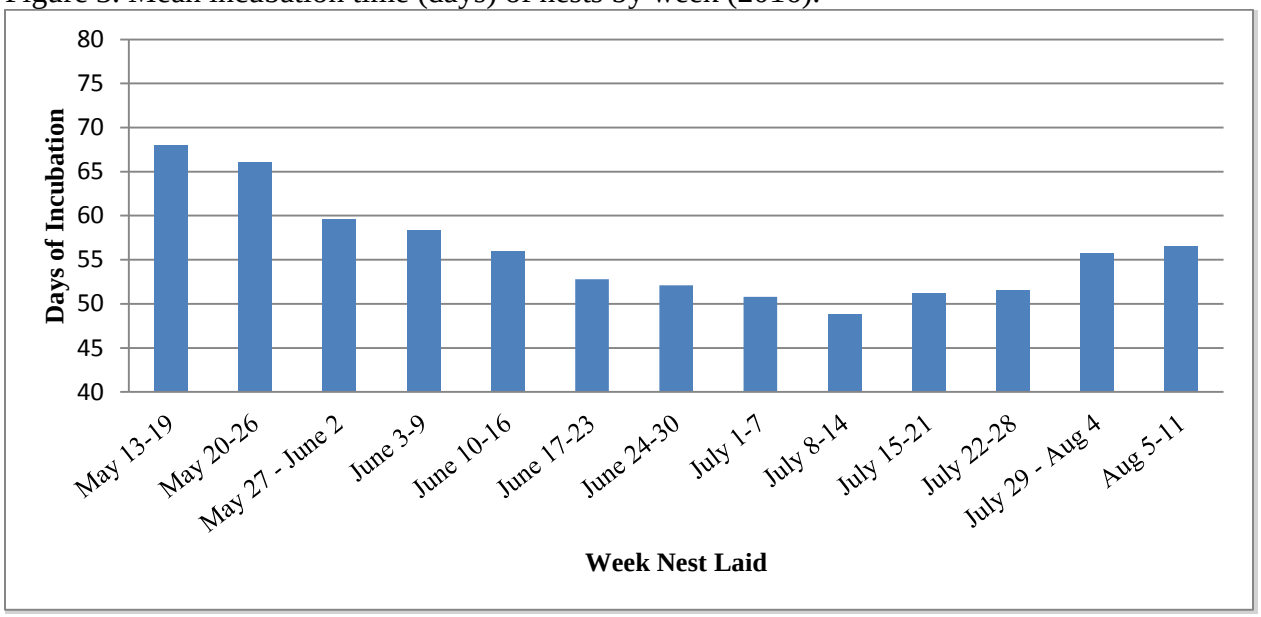
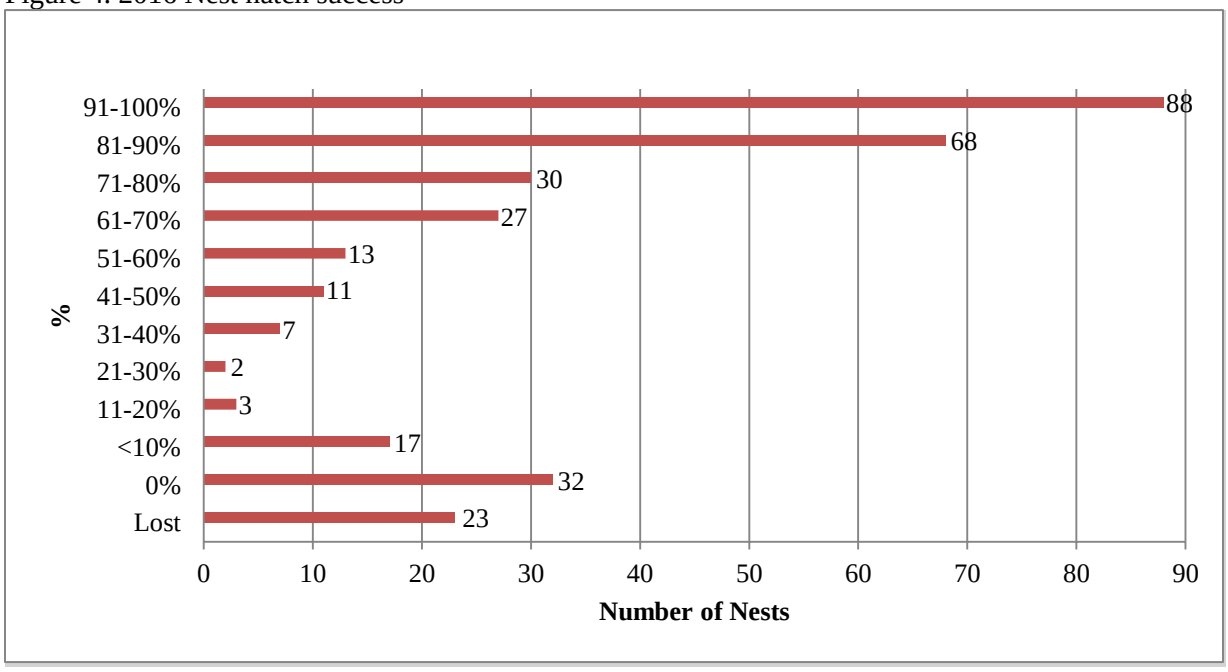


Figure 4. 2016 Nest hatch success



Nests laid on ORV beaches where no ORV corridors could be accommodated behind nest sites, and have no alternative ORV access routes, were candidates for the installation of an ORV corridor ocean-ward of the nest, a modified sea turtle management action from the 2015 Environmental Assessment: Review and Adjustment of Wildlife Protection Buffers document. A total of 47 nests met these parameters with staff and volunteers available to intensively monitor and smooth out ORV tire ruts (6 p.m.–9 p.m. each night). Nests were monitored when their

protected areas were expanded (50 – 55 days) until the night before the nest was excavated. A total of 235 evenings/nights of intensive nest monitoring and ORV tire rut raking occurred for the 47 nests that were monitored. This increased the amount of beach that was accessible to vehicles from July 24, date of the first nest with an ORV corridor, through October 3, date of the last nest with an ORV corridor (72 calendar days).

Storm, Tide and Over-wash Loss

During the 2016 sea turtle nesting season, 23 nests were completely lost or washed away by significant storm and tide events (Figure 4; Appendix A). Lost is defined as a nest that is still in the ground but not recovered. Washed away is defined as a nest that no longer exists in the ground.

A combination of above average Southeast swell and Southeast winds >25 mph from Tropical Depression #8 and Tropical Storm Hermine (August 29 – September 7) washed away or lost 22 nests. Hurricane Matthew's above average SE/ESE swell and SE/E/NE winds >30 mph contributed to the wash away or loss of one other nest. Severe beach erosion and high seas contributed to the loss of one other nest in the late season.

In addition to these storm and high tide events, the Seashore also experienced above average full moon tides in August, along with NE winds > 25 mph from August 3 through August 4 which also contributed to lower nest success for nests in specific areas prone to flooding. Twenty-seven of thirty-two nests with a hatch/emergence success rate of 0% (not including lost nests) that were recovered and inventoried were significantly impacted by these storms. Thirteen of twenty two nests with a hatch success of <10% - 30% were also directly impacted by storms based on their poor emergence success (Figure 4).

Five other nests with a range of 45% - 95.7% hatch success were impacted by storms based on their 0% - 30% emergence success. In these cases hatchlings likely were trapped in their nest cavities by heightened tides and never emerged. Excessive water inundation, over-washes, sand accretion, and sand loss over the top of these nests were contributing factors to the poor hatch and emergence successes.

Strandings

In the 2016 calendar year, 637 stranded sea turtles were documented within CAHA (Table 3a). In the 2016 fiscal year (October 15' – September 16'), 775 stranded sea turtles have been documented within CAHA (Table 3b). Volunteers associated with The Network for Endangered Sea Turtles (N.E.S.T.) assisted resource management staff by reporting and sometimes responding to observed strandings.

Of the 760 strandings in the fiscal year, 287 (37.8%) were found alive. Of the 287 alive, 260 were transferred to the North Carolina Aquarium Sea Turtle Assistance and Rehabilitation Center (STAR) on Roanoke Island or a similar facility for rehabilitation. Twenty-seven (9.4%) of the 287 live turtles were not transported for rehabilitation. One green was euthanized on site due to severe injuries from an ORV strike, one loggerhead was entangled in fishing gear at the Avon Pier and successfully disentangled and released on site, and 25 cold stunned turtles were left at their stranding sites in January 2016 due to overcrowded rehabilitation centers.

Table 3a. Sea turtle strandings at CAHA by species, (2010–2016.)

Year[1]	Stranding Totals	Species Composition					
		Loggerhead	Kemp's ridley	Green	Leatherback	Hawksbill	Unk.
2010	444	100	108	235	0	0	1
2011	148	50	46	49	0	0	3
2012	126	34	32	50	2	0	8
2013	189	38	52	94	1	0	4
2014	219	50	61	104	1	0	3
2015	286	44	39	198	3	0	2
2016	637	45	49	541	1	0	1

[1]Total stranding numbers for 2008-2011 include some strandings that occurred outside of CAHA boundaries

Table 3b. Sea turtle strandings at CAHA by species, (Fiscal Year 2016, Oct 15'- Sept 16')

Year	Stranding Totals	Species Composition					
		Loggerhead	Kemp's ridley	Green	Leatherback	Hawksbill	Unk.
2016	775	50	46	675	2	0	2

Efforts were made to necropsy dead strandings to determine possible cause of death, gender, any abnormalities, and to collect requested samples for ongoing research. Gender was determined in 161 strandings (81 male, 80 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 NCWRC (Table 3). During periods of cold water temperatures (7-10° C), sea turtles are most prone to stranding due to hypothermia (Spotilla 2004), which is often referred to as "cold stunning." In the month of January 2016, a fast moving, multi-day cold front caused the Pamlico Sound to drop in temperature rapidly; this along with strong north winds forced 450 "cold stunned" turtles to mass strand in select locations on CAHA.

Table 4. Probable cause of sea turtle strandings at CAHA by month, 2016 fiscal year.

Month (Oct 15' – Dec 16')	**No Apparent Injuries**	**Cold Stun**	**Other**	**Water-craft**	**Entangle-ment**	**Pollution/ Debris**	**Disease**	**Shark**	**Unable to Assess**	**Total**
Oct 15'	15	0	0	1	1	1	0	0	3	**21**
Nov 15'	35	0	3	4	0	1	0	0	3	**46**
Dec 15'	121	0	4	3	0	0	0	0	2	**130**
Jan 16'	10	450	0	0	0	0	0	0	1	**461**
Feb16'	23	25	0	1	0	0	0	0	1	**50**
March 16'	3	0	0	0	0	0	0	0	11	**14**
April 16'	3	0	0	0	0	0	0	0	7	**10**
May 16'	13	0	0	1	0	1	0	0	0	**15**
June 16'	4	0	0	0	0	0	0	0	4	**8**
July 16'	0	0	2	0	2	0	1	0	2	**7**
August 16'	1	0	1	2	2	0	1	0	0	**7**
Sept 16'	4	0	0	0	0	0	0	0	2	**6**
Oct16'	2	0	0	0	0	0	0	0	4	**6**
Nov 16'	11	0	0	2	0	0	0	0	1	**14**
Dec 16'	22	7	0	1	0	0	0	0	9	**39**
Total: Fiscal Year	**232**	**475**	**10**	**12**	**5**	**3**	**2**	**0**	**36**	**775**
Total: Calendar Year	**96**	**482**	**3**	**7**	**4**	**1**	**2**	**0**	**42**	**637**

DISCUSSION

Turtle Sensor Studies: Hatteras Island Ocean Center/ Nerds without Boarders

Cape Hatteras National Seashore collaborated with Samuel Wantman and David Hermeyer (Nerds Without Borders-NWB) and Eric Kaplan (Hatteras Island Ocean Center-HIOC) for the fourth year, to develop a sensor that is placed in turtle nests to monitor movement and temperature fluctuations. The hope is to be able to correlate the measurements with hatching and emergence events. The Seashore purchased the sensors and communication towers and was responsible for implementing the project in the field (2013–2015). In 2016, CAHA research staff worked directly with one researcher from Hampden-Sydney College who helped install sensors, collect monitoring data, and collaborated with HIOC and NWB to make implications from the results observed.

In 2016, the fourth year of the study, eleven sensors from NWB and HIOC were deployed. Seven of the eleven sensors successfully predicted hatching events, while three of the eleven nests never hatched due to significant storm events resulting in a high frequency of over-wash and standing water on top of nest sites. One of the eleven sensors and communication towers was washed away completely during a storm event.

Turtle Sensor Studies: Fleet Analytics Contractors

In the 2015 -2016 off-season CAHA management purchased 8 new sensors from Fleet Analytics, a new contractor with a different configuration than HIOC and NWB's sensor design for further analysis of sea turtle

hatchling movement in CAHA's nests. Three sensors were deployed but due to issues with the functionality of the sensors, specifically, maintaining the battery life of each unit, data was only collected on 2 of the 3 sensors installed for approximately 2-3 days. We did not receive any motion or temperature data during an actual sea turtle hatching event during the 2016 nesting season. Battery life, lack of weather resistance materials, height of the device when installed, and overall sturdiness of the communication towers were all contributing factors to the sensors failure.

Genetic Study

Since 2010, CAHA, 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 is taken and sampled for maternal DNA. This allows each nest from North Carolina, South Carolina, and Georgia to be "assigned" to a nesting female. This research ultimately will answer questions about the total number of nesting females in the population, the number of nests each female lays per season, distance between nests laid by individual females, and other information that is important to understanding the population dynamics of sea turtles. In 2016, 308 eggs were taken specifically for DNA analysis out of the 325 total nests that were observed on the Seashore.

Predation

Coyote and other canine species sightings on Bodie Island during this breeding season were more frequent than recent past breeding seasons based on staff's daily observations of the patrolled area. Staff, volunteers, and the public all have come forward and presented photos and evidence of these sightings. Also, at least one litter of multiple coyote pups has been observed by CAHA staff in the Bodie Island area. Evidence left behind revealed one nest located within this area was dug into and roughly 40 of the 98 eggs laid were likely predated by an unknown canine species. In addition, one other nest showed evidence of a canine species digging at the nest site but no eggs were destroyed. This is likely the first documented case of a sea turtle nest being depredated by a canine species in recent times at CAHA. Although no other nests were documented to be depredated by mammalian predators (feral cat, dog, raccoon, opossum, etc.), tracks and sign were observed at nest sites on mornings following hatching events throughout the Seashore. Birds depredated six eggs from one nest, likely due to exposed eggs at the surface of the sand, in the Ocracoke District.

Ghost crabs depredated 133 eggs from 34 different nests prior to nest excavations; this was usually observed by discovering eggshell fragments at the specific nest sites near known ghost crab burrows. Ghost crab depredation of 45 hatchlings from 27 nests was also documented, but the full extent of hatchling depredation by ghost crabs is unknown. Observations were made of ghost crabs in the act of predating hatchlings. These observations occurred within nest cavities during excavations as well as after hatching events inside of ghost crab holes in the vicinity of the nest site. Ants in nest cavities of two nests contributed to the loss of eight hatchlings. In addition to these confirmed predator hatchling loss accounts, nine hatchlings from six nests were found deceased outside of the nest cavity between the nest and high tide line, no cause of death was apparent (Appendix A).

Late Nest Management

In 2016, 5 nests were laid after August 20, ranging from August 22 through September 24. One nest was lost to severe erosion, and three nests hatched at day 65, 66, and 82 days of incubation. One nest incubated for 131 days but did not survive the colder winter temperatures.

Nesting Activity on Private Property Adjacent to CAHA

Superintendent's Order #25 was effective beginning in May, 2013. This order established CAHA protocols which personnel implemented when sea turtle nesting activity was observed on private property. In these instances, property owners were contacted in order to request access to their property for data collection and to carry out possible protection measures. This season, no nests required management actions on private property.

Incidental Take / Human Disturbance
All species of sea turtles nesting at CAHA are protected under the ESA of 1973. Under the ESA, "take" is any human induced threat to a species that is listed. 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 to listed species by significantly impairing behavioral patterns such as breeding, feeding, or sheltering.

Park staff documented one nesting green sea turtle struck by an ORV on Hatteras Island. The female was discovered on her carapace while on routine turtle patrol on August 21. Upon further examination she was still alive and her carapace had been crushed by an ORV at an unknown time. The turtle was euthanized by park staff due to her severe injuries beyond rehabilitation. Multiple eggs were observed coming from her caved-in carapace; 172 eggs were salvaged from her reproductive tract and relocated to a man-made nest site. The nest site was monitored throughout its incubation period and at day 65 began to hatch. The overall hatch success of the nest was 34.3% with an emergence rate of 19.1%. The nest produced 59 total hatchlings, 33 of which emerged on their own. The remaining 26 were released after the nest site was excavated.

There is little known to what extent human activities disrupted sea turtle nesting activities during the 2016 nesting season. People on the beach at night can disturb female turtles during 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. Much of CAHA's shoreline remains open to pedestrians and CAHA staff is unable to monitor the entire shoreline for nesting turtles 24 hours a day. Staff minimized some of these effects by closing the shorelines to non-essential ORV use from 9:00 p.m. until 7:00 a.m. to provide for sea turtle protection.

Protected Area Intrusions
Protected area intrusions are documented whenever possible by resource management staff. A protected area intrusion is defined as, observations of human activity within protected areas, examples include; pedestrians, ORV traffic, and pets that could harm a turtle nest site inside of protective symbolic fencing areas. A total of 309 pedestrian intrusions (135 instances) and 4 ORV violations (4 instances) of sea turtle protected areas were documented. In addition, 38 cat (38 instances), 63 domestic dog (55 instances), 55 coyote (30 instances), 30 unknown canine species (27 instances), and 2 opossum (2 instances) intrusions of sea turtle protected areas were also documented.

Artificial Lighting
This year, mis-orientation (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 31 nests, totaling approximately 483 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 is unknown. 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 increased chance of predation.

Cape Hatteras National 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 Seashores boundaries. In the 2015 and current season, CAHA staff 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. Staff also passed on brochures to volunteer nest watchers so they could educate the public as they waited for nests to hatch in the evening in areas where light pollution occurs regularly. Efforts were 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.

The CAHA ORV Management Plan regulates off-road night driving, which has the potential to decrease disturbance from headlights on nesting female turtles and hatchlings. Night driving was not permitted from May 1 through September 15 from 9:00 p.m. to 7:00 a.m. As of September 16, night driving was systematically re-opened as nests were excavated and protected areas removed.

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APPENDIX E. SEA TURTLE NESTING ACTIVITY MAPS
APPENDIX F. SEA TURTLE FALSE CRAWL ACTIVITY MAPS
APPENDIX G. SEA TURTLE STRANDING MAPS
APPENDIX H. SEA TURTLE NEST MONITORING SYSTEM PROJECT SUMMARY REPORT

Survey N Boundary	Ramp 1, Bodie Island (excludes Pea Island NWR)		
Survey S Boundary	South Point, Ocracoke		
Length of Daily Survey (km) *km = miles x 1.6*	~101 km (~62.8 mi)	Total Kilometers Surveyed	16,362 km
Total Days Surveyed	162	Days per Week Surveyed	7
Time of Day Surveyed	Morning	Number of Participants	24
Date Surveys Began	4/30/2016	Date Surveys Ended	10/08/2016
Date of First Crawl	5/14/2016	Date of Last Crawl	10/07/2016
Date of First Nest	5/18/2016	Date of Last Nest	9/24/2016
Total Nests	325	Undetected	2
Nesting Density (nests/km)	3.22	Disoriented/Misoriented	13 (nests)
In Situ	240	Washed Away Tide/Storm	24
Relocated	85 (26.1%)	Depredated	72
False Crawls	329	Unknown	0
Mean Clutch Count	118.6	Incubation Duration (All)	53.6
Hatchlings Produced	23541	Incubation Duration (*In situ*)	54.2
Hatchlings Emerged	20385	Incubation Duration (Relocated)	52.2

MEAN HATCH SUCCESS		MEAN EMERGENCE SUCCESS		NEST SUCCESS		BEACH SUCCESS	
62.30%		53.9%		73.7%		49.6%	
59.3%	70.5%	52.3%	58.3%	68.2%	89.4%	325	654
IN SITU	*RELOCATED*	*IN SITU*	*RELOCATED*	*IN SITU*	*RELOCATED*	TOTAL NESTS	TOTAL CRAWLS

Eggs Lost (Total Eggs Lost = 505)			
Research	308	Ghost Crab	133
Canine/Coyote	40	Broken eggs	10
Birds	6	Finger	14
Human	2		
Hatchling Loss (Total Hatchling Loss = 62)			
Mis/Disorientation	13 (nests), 235 (tracks or hatchlings)	Ghost Crab	45
Ants	8	Other (UNK Loss)	9

[1]Three out of the 325 total nests have not been inventoried. Success rates and losses will change after inventories are completed.

CAPE HATTERAS NATIONAL SEASHORE
SEABEACH AMARANTH (*AMARANTHUS PUMILUS*) SURVEYS
2016 ANNUAL REPORT

INTRODUCTION

Seabeach amaranth (*Amaranthus pumilus*) is a federally threatened plant species found in barrier island beach environments, where it grows in overwash flats at accreting ends of islands and at the foot of frontal dunes. The species is intolerant of competition and thus is limited to highly dynamic areas that are marginally conducive to plant growth. It survives in these habitats as a "fugitive" or "pioneer" species, continually moving around in the landscape to occupy suitable habitat as it becomes available. Amaranth must recruit annually either from existing seed bank or from seeds dispersed by wind, water, or anthropogenic factors (i.e., dredging, beach nourishment) (Jolls 2004). Dormant seeds may remain viable for many years, possibly decades (Jolls 2004). Populations can therefore be highly variable from year to year in any given area.

The natural habit of seabeach amaranth makes it vulnerable to both man-made and natural disturbances. The primary threat to the species is habitat destruction. Man-made beach-stabilizing structures (i.e., bulkheads, jetties, continuous barrier dunes) and off-road vehicle and pedestrian traffic on beaches have contributed to major habitat loss (USFWS 1996). Barrier islands are extremely dynamic in nature and are constantly being shaped by hurricanes and storm events, resulting in the rapid creation and elimination of potential amaranth habitat. Other threats to amaranth include herbivory by insects and mammals, competition from non-native, invasive plants, and sea level rise.

In 1993, *Amaranthus pumilus* was listed as federally threatened with extinction under authority of the Endangered Species Act (USFWS 1993). At the time of its listing, the species had been eliminated from two-thirds of its historic range that extended from Massachusetts to South Carolina (USFWS 1996). Cape Hatteras National Seashore (CAHA) was once heavily populated with amaranth, hosting three to fifteen thousand individuals per year in the late 1980s. Seabeach amaranth has since been in decline at CAHA, and was last documented here in 2005. Since populations can be highly variable, park staff continues to survey for the species annually.

METHODS

Some notable research in the past several decades has assessed the life history and habitat requirements of seabeach amaranth (Bucher and Weakley 1990, Johnson 2004, Jolls *et al.* 2004, Sellars and Jolls 2004, Strand 2002). Compilation and review of these studies, many of which address the crucial habitat characteristics that determine likelihood of amaranth occurrence (i.e., elevation, overwash disturbance potential, and competition), have provided a baseline for the selection of survey locations and methods at CAHA. Locations of historic amaranth occurrences at CAHA are also taken into consideration. Specific habitats surveyed include high beach (between the wrackline and foredune), sandflats on accreting ends of the islands, and large dune blowouts. State-listed rare plants encountered during amaranth surveys are also documented, including *Ipomoea imperati*, *Polygonum glaucum*, and *Yucca gloriosa*.

Surveys for seabeach amaranth are ideally conducted in July-September when the plants are sufficiently large to locate and document. CAHA staff begins surveying for plants in mid-July, usually starting where seasonal resource protection areas for nesting shorebirds are being removed. These are areas where off-road vehicle and pedestrian traffic has been excluded for the growing season. Historically at CAHA, when plants were found, they were typically located in vehicle-free areas, often the same areas protected for nesting birds. In the case that plants are found, the location of all individual plants or plant clusters are recorded with a GPS device with

sub-meter accuracy. The diameter (mm) is recorded and whether it is located in an area open or closed to pedestrian and/or ORV traffic. Any evidence of these uses (e.g., footprints or tire tracks) within 20 feet is also recorded. In areas where plants are observed, a follow-up monitoring survey in late September is recommended to examine survivorship and seed production (Marion 2005).

Beginning in the 2014 season, all spatial and tabular data associated with amaranth surveys and state-listed rare plant occurrences are housed in the Cape Hatteras National Seashore Vegetation Monitoring Database (Veg DB). The Veg DB is an ArcSDE relational geospatial database and web service housed on the Federated Enterprise Mapping Program (FEMP), Insidemapservices.nps.gov (internal ArcGIS Server), and Arcgisonline.com (public-facing ArcGIS Server). Tabular data included with the survey transects include: protocol followed, date of monitoring, observer(s), individual person minutes, habitat type(s), and survey results.

RESULTS AND DISCUSSION

Plant surveys were conducted from mid-July through mid-September 2016 in areas of the Seashore that contain potential habitat for seabeach amaranth. Staff spent approximately 61 hours surveying specifically for amaranth, covering roughly 42 lineal miles of potential beach habitat by foot. More hours were actually spent in potential habitat than was actually recorded, as other field work required staff to be in the historical and potential habitat. No amaranth was found anywhere within the survey areas.

At CAHA, seabeach amaranth populations fluctuated greatly from 1985 to 2004 (Table 1). No plants have been observed since 2005 and the plant is currently thought to possibly be extirpated from CAHA. The area on Bodie Island spit where amaranth had been located in 2004 and 2005 has been continuously protected by shorebird habitat resource protection areas during both summer nesting seasons and winter migration seasons. At Cape Point, a portion of the area where amaranth was historically found has also been protected by shorebird habitat resource protection areas during summer shorebird nesting seasons. No plants were found within any of these protected areas. At Hatteras Inlet, large portions of the historic range are simply no longer present due to continued erosion. While it is thought that the plant may possibly be extirpated from CAHA, it should be noted that since plants are not evident every year, but may survive in the seed bank, populations of seabeach amaranth may still be present even though plants are not visible for several years (USFWS 2007).

Table 1. Population Estimates of *Amaranthus pumilus* at CAHA by Site.

Year	Bodie Is. Spit	Cape Pt. / South Beach	Hatteras Island Spit	Ocracoke Island	Total
1981				15	15
1984				1	1
1985	0	300-500	300-500	100	700-1100
1986	0	>200	>300	>100	>600
1987	0	5,200	274	1,409	6883
1988	0	800	1,718	13,310	15,828
1990	0	2,830	252	250	3332
1994			0	0	0
1996	0	6	82	10	98
1997	0	59	16	6	81
1998	0	55	210	0	265
1999	0	3	5	0	8
2000	0	1	1	0	2
2001	0	27	16	8	51
2002	0	11	75	7	93
2003	0	16	3	11	30
2004	1	0	0	0	1
2005	1	0	0	1	2
2006	0	0	0	0	0
2007	0	0	0	0	0
2008	0	0	0	0	0
2009	0	0	0	0	0
2010	0	0	0	0	0
2011	0	0	0	0	0
2012	0	0	0	0	0
2013	0	0	0	0	0
2014	0	0	0	0	0
2015	0	0	0	0	0
2016	0	0	0	0	0

Population estimates by NC Natural Heritage Program, East Carolina Univ. and NPS

Nationwide, amaranth populations have similarly declined since 2000. Numbers have dropped from 249,261 plants observed in 2000 to 1320 plants in 2013, a 99.5 percent decline (Dale Suiter, *pers. comm.*). The species' recovery plan is due for a 5-year review by US Fish and Wildlife Service. The Service is trying to understand rapid species decline and is considering options for reintroduction attempts in suitable areas. CAHA has been discussed as a potential reintroduction site since the CAHA Off-Road Vehicle Management Plan calls for possible development of a restoration plan in suitable habitat (NPS 2010).

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End of Report