From: Doug Wetmore
To: lfox@louisberger.com
Cc: Sandra Hamilton/DENVER/NPS@NPS
Subject: Caha ch 3
Date: 09/16/2010 03:57 PM
Attachments: 03_Chapter-3_1st_dw_sh.doc

Hi Lori.

Here's chapter 3, in 2 parts:

EQD's comments in one file, and Mike's comments in another.

We're still waiting on Britta's.  03_Chapter-3_1st_dw_sh.doc

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0028302

From: Doug Wetmore
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Cc: Sandra Hamilton/DENVER/NPS@NPS
Subject: caha ch 3 (mike murray)
Date: 09/16/2010 03:57 PM
Attachments: 03_Chapter-3_1st_Draft_EIS_090310_compressed[1].mbm.doc

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03_Chapter-3_1st_Draft_EIS_090310_compressed[1].mbm.doc

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CHAPTER 3: AFFECTED ENVIRONMENT

The "Affected Environment" describes existing conditions for those elements of the natural and cultural environments that would be affected by the implementation of the actions considered in this plan/EIS. The natural environment components addressed include wetlands and floodplains; ~~rare, unique,~~federally listed threatened~~,~~ or endangered species; state-listed and special status species; wildlife and wildlife habitats (with a focus on birds and invertebrate species that could be affected by ORV use or management); soundscapes; visitor use and experience (including night skies); socioeconomic resources; and Seashore management and operations. Impacts for each of these topics are analyzed in "Chapter 4: Environmental Consequences."

WETLANDS AND FLOODPLAINS

WETLANDS

Wetlands include areas inundated or saturated by surface or groundwater for a sufficient length of time during the growing season to develop and support characteristic soils and vegetation. The NPS classifies wetlands based on the USFWS Classification of Wetlands and Deepwater Habitats of the United States (the Cowardin classification system). Based on this classification system, a wetland must have one or more of the following attributes:

- The habitat at least periodically supports predominantly hydrophytic (wetland) vegetation.
- The substrate is predominantly undrained hydric soil.
- The substrate is nonsoil and saturated with water, or is covered by shallow water at some time during the growing season (Cowardin et al. 1979).

The majority of the undeveloped acreage within the Seashore can be classified as a wetland. The predominant wetland types at the Seashore are marine and estuarine. Marine wetlands occur along the beaches on the oceanside of the Seashore, and estuarine wetlands generally occur along the soundside, adjacent to the many tidal creeks that are prevalent along the islands. Non-wetland or "upland" areas of the Seashore include areas landward of the dune line, areas around NC-12, and other developed areas such as those in and around villages and Seashore facilities.

Marine wetlands at the Seashore are located in the intertidal zone (from extreme high tide to extreme low tide) and in the subtidal zone, which includes areas permanently submerged below coastal waters (Cowardin et al. 1979). Generally, areas of the Seashore's beaches between the toe of the dune and the extreme low tide water line are considered intertidal marine wetlands. Marine wetlands are found along the entire length of the ocean shoreline and are typical of a sandy beach environment, subject to high wind and wave energy. Estuarine wetlands consist of deepwater and adjacent tidal wetland areas that are often partially enclosed by land but are influenced by marine waters and freshwater runoff from adjacent uplands (Cowardin et al. 1979). Estuarine wetlands at the Seashore typically fall into two classes: emergent or scrub–shrub. Emergent wetlands, also referred to as tidal marshes, are characterized by herbaceous perennial vegetation such as saltmarsh cordgrass (*Spartina alterniflora*), black needlerush (*Juncus roemerianus*), bulrush (*Scirpus* spp.), and cattail (*Typha* spp.) (NCDENR 2008a). Scrub–shrub wetlands are typically dominated by woody vegetation less than 20 feet tall. Typical vegetation species found in these wetlands include wax myrtle (*Myrica cerifera*) and eastern red cedar (*Juniperus virginiana*) (Sutter 1999). Although most wetlands at the Seashore are tidal, there are also some areas of nontidal wetlands, located primarily on Hatteras Island near the village of Buxton and Buxton Woods

Coastal Reserve. These wetland areas include forested and emergent wetlands and are predominantly freshwater swamps and marshes that are not influenced by the tides.

Wetland areas provide substantial environmental and economic benefits to the Seashore and surrounding areas of coastal North Carolina. For example, wetlands trap sediment and pollutants from stormwater runoff and provide a natural filter before this runoff can enter local waterways. Wetlands also store large volumes of water and function like sponges to reduce the likelihood of flooding during storm events. Wetlands also protect the shoreline from erosion and provide excellent habitat for fish and wildlife species, many of which are threatened or endangered (NCDENR 2008b).

FLOODPLAINS

North Carolina's barrier islands have historically been and continue to be affected by coastal forces and flooding events. The barrier islands that comprise the Seashore are flat and narrow and lie adjacent to the shallow and wide Pamlico Sound. The widest part of the Seashore islands is near Cape Point, between Buxton and Frisco (Pendleton et al. 2005). According to Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps, most of the Seashore is within the 100-year floodplain, with the exception of some areas within the 500-year floodplain (Shaded X Zone) located at the Navy tower site on Bodie Island and a larger area near Buxton.

Generally, lands along the ocean beaches and adjacent to the sound (at wide points) are in flood zone "VE," which is the flood insurance rate zone that corresponds to 100-year coastal floodplains that have additional hazards associated with storm waves. Zone "VE" is also referred to as the "Coastal High Hazard Area." The remainder of the Seashore that is located within the 100-year floodplain and not directly adjacent to the ocean or sound lies within the "AE" zone, which is subject to waves less than 3 feet high (NCDCCPS 2008).

Because the Seashore is almost entirely within the 100-year floodplain and is subject to high water table conditions and high wave action, many areas are subject to drainage and flooding problems that often result from storm events. Areas near Buxton Woods and Cape Point Campground have been documented as historically flood-prone and are examples of popular Seashore destinations that experience flooding during times of above-average precipitation events (Martin pers. comm. 2003).

~~RARE, UNIQUE,~~ FEDERALLY LISTED THREATENED~~,~~ OR ENDANGERED SPECIES

This section addresses species present at the Seashore that are listed by the USFWS as either endangered or threatened. In some cases, the species may also be listed by the State of North Carolina. These species include the federally and state-listed piping plover (*Charadrius melodus*); federally and state-listed loggerhead (*Caretta caretta*), green (*Chelonia mydas*), and leatherback (*Dermochelys coriacea*) sea turtles; and federally and state-listed seabeach amaranth (*Amaranthus pumilus*).

Species listed only by the state, and not federally listed as threatened and endangered, are discussed in the "State-Listed and Special Status Species" section of this chapter.

PIPING PLOVER

The piping plover is a small (6 to 7 inches long, weighing 1.5 to 2.2 ounces), highly camouflaged, sand-colored shorebird endemic to North America. The USFWS recognizes three distinct piping plover population segments: (1) the Atlantic Coast (from the Maritime Provinces of Canada to the Outer Banks

of North Carolina); (2) the Great Lakes (along Lake Superior and Lake Michigan); and (3) the Great Plains (from southern, prairie Canada to Nebraska).

Piping Plover
Credit: Gene Neiminen / USFWS

Wintering populations are found on the Atlantic Coast from North Carolina to Florida, on the Gulf Coast from Florida to Mexico, and in the Caribbean, with the greatest number of wintering birds found in Texas. Fewer than 3,000 breeding pairs of piping plovers were detected in the United States and Canada in 2001, although the most recent breeding census estimated breeding pairs in excess of 3,500 (Elliott-Smith et al. 2009). Piping plovers were common along the Atlantic Coast during much of the 19th century, but nearly disappeared due to excessive hunting for decorative feathers. Following passage of the MBTA in 1918, plover numbers recovered to a 20th century peak in the 1940s. Increased development and beach recreation after World War II caused a population decline that led to federal protection for the plover (USFWS 2007b). Habitat loss caused by human development and recreation, and low reproductive rates caused by disturbance and predation, were considered to be the primary causes of the decline (Elliot-Smith and Haig 2004). The Atlantic Coast population was federally listed in 1986 as threatened (FR 1985). At the time of listing, there were approximately 790 Atlantic Coast pairs, and the species was in decline. Therefore, a recovery target of 2,000 pairs was established in the 1996 Revised Recovery Plan for the Atlantic Coast population (USFWS 1996a). Disturbance and predation were intensively managed after the listing, and the Atlantic Coast population rose to 1,890 pairs by 2007 (USFWS 2007c), but was still short of the recovery goal of 2,000 pairs (USFWS 1996a; Hecht pers. comm. 2008; USFWS 2009a).

The population for the Atlantic Coast Southern Region (or Recovery Unit), which comprises the states of Delaware, Maryland, Virginia, and North Carolina, was estimated at 333 pairs in 2007, which was the highest since 1986, but still short of the regional goal of 400 pairs (table 14). North Carolina experienced more than a 50% decline in breeding pairs from 1989 (55 pairs) to 2004 (20 pairs) (USFWS 2004a) for reasons discussed in the "Risk Factors" section later in this chapter; however, the number of breeding pairs was estimated at 64 pairs in 2008, which represents the highest number recorded in North Carolina in the years that complete surveys have been conducted (1989–2008) (NCWRC 2008a). ~~Estimates for the~~For the 2009 season ~~indicated~~ there were a total of 54 pairs in the state (~~Hecht pers. comm. 2009~~USFWS 2009b); ~~and~~ in 2010, there were an~~d~~ estimated XXX pairs in the state.

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Piping Plover in North Carolina

North Carolina is currently the only state on the Atlantic Coast that hosts piping plovers during all phases of their annual cycle, including the establishment and holding of territories, courtship and copulation, nest scraping and nest building, egg laying and incubation, chick rearing and fledging, and migration and wintering (Cohen et al. ~~in press~~2010). ~~Band sightings indicate that plovers from all three North American breeding populations depend on Cape Hatteras during migration and/or the winter.~~ Plovers from the endangered Great Lakes population have been observed in fall and spring migration and during the wintering period (Cohen et al. ~~in press~~2008). Early nesting records indicate that plovers were nesting at Pea Island in 1901 and 1902 (Golder 1986). The first published account of breeding piping plovers in North Carolina is from 1960, when a young bird was photographed in early June on Ocracoke Island (Golder 1985).

TABLE 14. SOUTHERN REGION (INCLUDING NORTH CAROLINA) PIPING PLOVER POPULATION TRENDS, NUMBERS OF BREEDING PAIRS

	Delaware	Maryland	Virginia	North Carolina	South Carolina	Southern Region Total
1986	8	17	100	30[a]	3	158
1987	7	23	100	30[b]	—	160
1988	3	25	103	40	—	171
1989	3	20	121	55[a]	—	199
1990	6	14	125	55	1	201
1991	5	17	131	40	1	194
1992	2	24	97	49	—	172
1993	2	19	106	53	1	181
1994	4	32	96	54	—	186
1995	5	44	118	50	—	217
1996	6	61	87	35	0	189
1997	4	60	88	52	—	204
1998	6	56	95	46	—	203
1999	4	58	89	31	—	182
2000	3	60	96	24	—	183
2001	6	60	119	23	0	208
2002	6	60	120	23	—	209
2003	6	59	114	24	—	203
2004[c]	7	66	152	20	—	245
2005[d]	8	63	192	37	—	300
2006[e]	9	64	202	46	—	321
2007[f]	9	64	199	61	—	333
2008[g]	10	49	208	64	—	331
2009[h]	—10	—45	—193	54	—	—302

Source of 1986–2001 data is USFWS 2002

Source of 2002–2003 data is USFWS 2004a

[a] The recovery team believes that the apparent 1986–1989 increase in the North Carolina population was because of an intensified survey effort.

[b] No actual surveys were made in 1987; estimate is that from 1986.

[c] USFWS 2004b, Preliminary 2004 Atlantic Coast Piping Plover Abundance and Productivity Estimates (Updated March 2007); Figures are preliminary estimates.

[d] USFWS 2005a. Preliminary 2005 Atlantic Coast Piping Plover Abundance and Productivity Estimates.

[e] USFWS 2006c. 2006 Atlantic Coast Piping Plover Abundance and Productivity Estimates.

[f] USFWS 2007c. 2007 Atlantic Coast Piping Plover Abundance and Productivity Estimates.

[g] USFWS 2008c. 2008 Preliminary Atlantic Coast Piping Plover Abundance and Productivity Estimates.

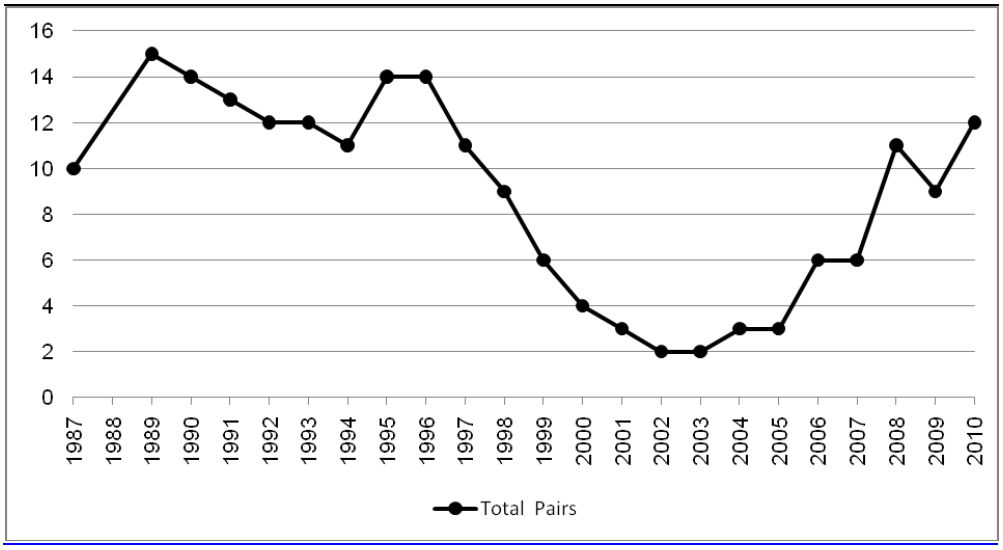
[h] ~~Hecht pers. comm. 2009~~USFWS 2009. 2009 Preliminary Atlantic Coast Piping Plover Abundance and Productivity Estimates.

— = No data available.

Comment [l2]: Update for 2010 if available by publication

Comment [dw3]: Should be 2009b

At the Seashore, four nests and one brood were observed in 1984, and five chicks were confirmed to have fledged that year. All four nests were located adjacent to least tern (*Sterna antillarum*) colonies on wide, open, sandy flats (Golder 1985). Nine pairs were counted in 1985 (Golder 1986), and 10 pairs in the summer of 1987 (Cooper 1990). The piping plover population reached a high of 15 pairs at the Seashore in 1989, and subsequently varied between 11 and 14 pairs through 1996, after which a sharp decline began (see figure 3). The population at the Seashore reached a low of two breeding pairs in 2002 and 2003, with only three breeding pairs reported in 2004 and 2005 (NPS 2009b). The population increased to 6 pairs in 2006 and 2007 and to 11 pairs by 2008 (NPS 2009b). The Seashore recorded nine piping plover breeding pairs during the 2009 season and 12 breeding pairs in the 2010 season (Muiznieks pers. comm. 2009; Muiznieks pers. comm. 2010a).

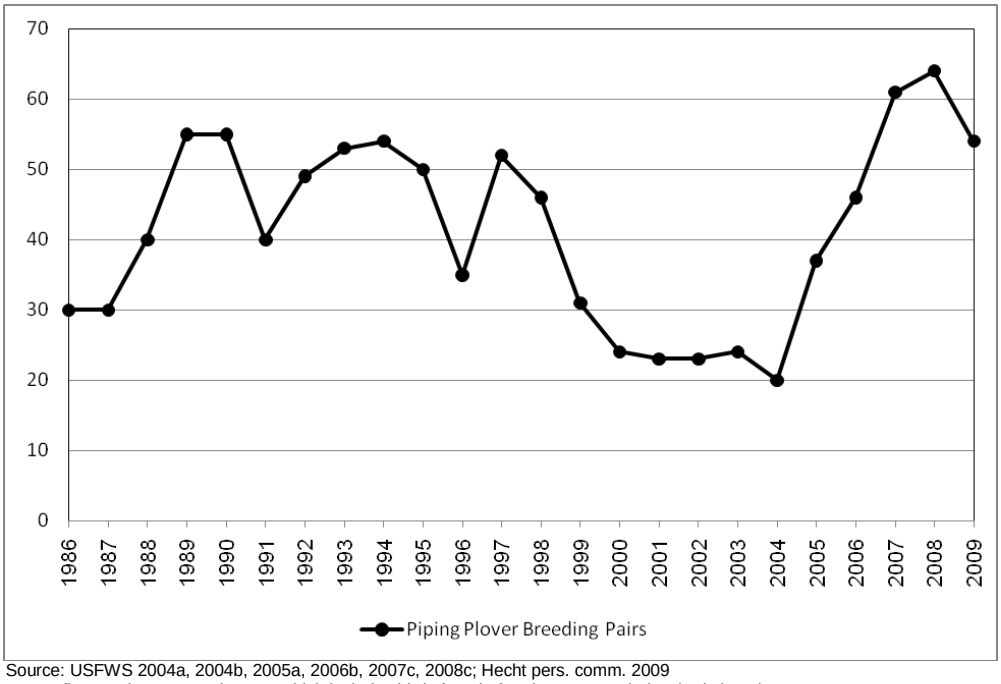


Source: NPS 2009b; Muiznieks pers. comm. 2009; Muiznieks pers. comm. 2010a

FIGURE 3. NUMBERS OF PIPING PLOVER BREEDING PAIRS, CAPE HATTERAS NATIONAL SEASHORE, 1987–~~2009~~2010

NCWRC staff conducted a piping plover breeding census along the coast of North Carolina during the June 1 through June 9, 2008, census window. The census included all suitable habitat on ocean and inlet beaches with the exception of Browns Island, which lies within a military live-fire training range. Sixty pairs and seven individual birds were counted during the census window. The end-of-season best estimate, which includes pairs discovered after the census window, was 64 pairs and 5 individuals, which was a 5% increase from the 2007 estimate of 61 pairs and is the highest number recorded in North Carolina in the years that complete surveys have been conducted (1986–2008; see figure 4). However, the 2009 end of season estimates indicated a total of 54 breeding pairs in the state (~~Hecht pers. comm.~~USFWS 2009b). Statewide, the distribution of piping plovers in 2008 was similar to previous years, with the majority of nesting pairs found at Cape Lookout National Seashore (NCWRC 2008a).

Comment [I4]: Update to 2010 if possible by publication



Source: USFWS 2004a, 2004b, 2005a, 2006b, 2007c, 2008c; Hecht pers. comm. 2009
Data reflect total season estimates, which includes birds found after the census window had closed

FIGURE 4. NUMBERS OF PIPING PLOVER BREEDING PAIRS IN NORTH CAROLINA, 1986–2009

Comment [I5]: Update to 2010 if possible by publication

Habitat Description

Plover Habitat
Credit: NPS

On the Atlantic Coast, piping plovers nest in sand, gravel, or cobble substrates in backshore, dune, interdune blowout, overwash fan, and barrier flat zones of open or sparsely vegetated beaches. Nest sites may have little or no slope (Cairns 1982; Burger 1987), although nesting does occur on lower-elevation dunes (Cairns 1982). On wide beaches, piping plovers nest in the open to maintain a wide field of view, but on narrower beaches nests can be established under clumps of vegetation (Cairns 1982; USFWS 1996a). Where beaches are wide, piping plovers tend to nest far from the tide line to reduce risk of nest overwash, but this can place nests closer to vegetated dunes where the risk of predation is higher (Burger 1987). Piping plovers have also been observed nesting within least tern colonies, which could provide an added defense against predators due to the antipredator behavior of least terns (Burger 1987).

In the winter and on migration, piping plovers tend to be found in areas with wide beaches and inlet habitats, foraging in moist, substrate habitat that includes both low- and high-wave-energy intertidal zones, mudflats, moist sand flats, ephemeral pools, shores, and brackish ponds (Cohen et al. ~~in press~~2010; Elliot-Smith and Haig 2004; Nicholls and Baldassarre 1990; Wilkinson and Spinks 1994; USFWS 2009a). During winter distribution surveys on the Atlantic Coast from 1986 to 1987, piping plovers were

almost always found associated with other species of shorebirds, such as sanderlings (*Calidris alba*), least sandpipers (*C. minutilla*), or western sandpipers (*C. mauri*), in addition to other piping plovers (Nicholls and Baldassarre 1990).

Critical Habitat Designation

Piping Plover Nest Site

Credit: NPS

All piping plover breeding sites at the Seashore were designated as critical habitat for wintering birds, as defined by the federal ESA (FR 2001) until 2004, when a court decision vacated the designation for Oregon Inlet, Cape Point, Hatteras Inlet, and Ocracoke Island (*Cape Hatteras National Seashore Access Preservation Alliance versus U.S. Dept. of the Interior*, 344 F. Supp. 2d 108 [D.D.C. 2004]). A rule to revise designated critical habitat for the wintering population of the piping plover in North Carolina was proposed in 2006 (71 FR 33703). That proposed rule described four coastal areas (named Units NC-1, NC-2, NC-4, and NC-5), totaling approximately 739 hectares (1,827 acres) entirely within the Seashore, as critical habitat for the wintering population of the piping plover. The USFWS also proposed to add 87 hectares (215 acres) of critical habitat to two previously proposed units. As a result, the proposed revised critical habitat designation for the species now includes four revised critical habitat units totaling approximately 826 hectares (2,042 acres). The final rule for the revised critical habitat designation became effective on November 20, 2008 (73 FR 62816). On February 6, 2009, Cape Hatteras Access Preservation Alliance and Dare and Hyde Counties, North Carolina filed a legal challenge to the revised designation. On August 18, 2010, a U.S. District Court granted the government's motion for summary judgment and dismissed the case with prejudice, and the critical habitat designation for these four units remains in effect.

Comment [dw6]: Need to clarify what this is. I added it to the acronym list.

Critical habitat identifies specific areas that are essential to the conservation of a listed species, or that contain physical and biological features that are essential to the species and that may require special management considerations or protection. Approximately 2,043 acres in Dare and Hyde counties are designated as critical habitat for the wintering population of the piping plover (73 FR 62816).

Section 7 of the ESA requires federal agencies to ensure that actions they authorize, fund, or carry out are not likely to destroy or adversely modify designated critical habitat. Activities that may destroy or adversely modify critical habitat include those that alter the primary constituent elements (PCEs) to an extent that the value of critical habitat for both the survival and recovery of the species is appreciably reduced (65 FR 41793).

The PCEs for the wintering population of the piping plover are the habitat components that support foraging, roosting, and sheltering and the physical features necessary for maintaining the natural processes that support these habitat components. Specifically, the PCEs are

(1) Intertidal sand beaches (including sand flats) or mud flats (between the mean lower low water line and annual high tide) with no or very sparse emergent vegetation for feeding. In some cases, these flats may be covered or partially covered by a mat of blue-green algae.

(2) Unvegetated or sparsely vegetated sand, mud, or algal flats above annual high tide for roosting. Such sites may have debris or detritus and may have micro-topographic relief (less than 20 inches (50 centimeters) above substrate surface) offering refuge from high winds and cold weather.

(3) Surf-cast algae for feeding.

(4) Sparsely vegetated backbeach, which is the beach area above mean high tide seaward of the dune line, or in cases where no dunes exist, seaward of a delineating feature such as a vegetation line, structure, or road. Backbeach is used by plovers for roosting and refuge during storms.

(5) Spits, especially sand, running into water for foraging and roosting.

(6) Salterns, or bare sand flats in the center of mangrove ecosystems that are found above mean high water and are only irregularly flushed with sea water.

(7) Unvegetated washover areas with little or no topographic relief for feeding and roosting. Washover areas are formed and maintained by the action of hurricanes, storm surges, or other extreme wave actions.

(8) Natural conditions of sparse vegetation and little or no topographic relief mimicked in artificial habitat types (e.g., dredge spoil sites).

Critical habitat does not include manmade structures (such as buildings, aqueducts, runways, roads, and other paved areas) and the land on which they are located existing within the legal boundaries as of November 20, 2008 (50 CR 17.95 b (1)(2)).

Of the 2,043 acres of designated critical habitat in Dare and Hyde counties, approximately 1,827 acres are located within the boundaries of the Seashore and are located at Bodie Island Spit, Cape Point, Hatteras Inlet Spit, Ocracoke Inlet Spit, and South Point (73 FR 62816).

The four units of designated critical habitat that include acreage within the Seashore are described below:

NC-1: This unit extends from the southern portion of Bodie Island through Oregon Inlet to the northern portion of Pea Island. It begins at ramp 4 near the Oregon Inlet Fishing Center on Bodie Island and extends approximately 7.6 kilometers (4.7 miles) south to the intersection of NC-12 and Salt Flats Wildlife Trail on Pea Island. The unit is bounded by the Atlantic Ocean on the east and Pamlico Sound on the west and includes lands from the MLLW (mean lower low water) on the Atlantic Ocean shoreline to the line of stable, densely vegetated dune habitat (which is not used by piping plovers and where PCEs do not occur) and from the MLLW on the Pamlico Sound side to the line of stable, densely vegetated habitat, or (where a line of stable, densely vegetated dune habitat does not exist) lands from MLLW on the Atlantic Ocean shoreline to the MLLW on the Pamlico Sound side. Any emergent sandbars south and west of Oregon Inlet, including Green Island and lands owned by the State of North Carolina are included.

NC-2: This unit is entirely within the Seashore and encompasses Cape Point. The unit extends south approximately 4.5 kilometers (2.8 miles) from the ocean groin near the old location of the Cape Hatteras Lighthouse to the point of Cape Hatteras, and then extends west 7.6 km (4.7 miles) along South Beach to the edge of ramp 49 near the Frisco Campground. The unit includes lands from the MLLW on the Atlantic Ocean to the line of stable, densely vegetated dune habitat (which is not used by the piping plover and where PCEs do not occur).

NC-4: This unit extends from the western end of Hatteras Island to the eastern end of Ocracoke Island. The unit extends approximately 7.6 kilometers (4.7 miles) southwest from the first beach access point at the edge of ramp 55 at the end of NC-12 near the Graveyard of the Atlantic Museum on the western end of Hatteras Island to the edge of the beach access at the ocean-side

parking lot (approximately 0.1 mile south of ramp 59) on NC-12, approximately 1.25 kilometers (0.78 miles) southwest of the ferry terminal on the northeastern end of Ocracoke Island. The unit includes lands from the MLLW on the Atlantic Ocean shoreline to the line of stable, densely vegetated dune habitat (which is not used by the piping plover and where PCEs do not occur) and from the MLLW on the Pamlico Sound side to the line of stable, densely vegetated habitat, or (where a line of stable, densely vegetated dune habitat does not exist) lands from MLLW on the Atlantic Ocean shoreline to the MLLW on the Pamlico Sound side. All emergent sandbars within Hatteras Inlet between Hatteras Island and Ocracoke Island, including lands owned by the State of North Carolina are included.

NC-5: This unit is entirely within the Seashore and includes the western portion of Ocracoke Island beginning at the beach access point at the edge of ramp 72, extending west approximately 3.4 kilometers (2.1 miles) to South Point and then back east on the Pamlico Sound side to a point where stable, densely-vegetated dune habitat meets the water. This unit includes lands from the MLLW on the Atlantic Ocean shoreline to the line of stable, densely-vegetated dune habitat (which is not used by the piping plover and where PCEs do not occur) and from the MLLW on the Pamlico Sound side to the line of stable, densely vegetated habitat, or (where a line of stable, densely vegetated dune habitat does not exist) lands from MLLW on the Atlantic Ocean shoreline to the MLLW on the Pamlico Sound side. All emergent sandbars within Ocracoke Inlet are also included.

Diet

Piping plovers feed primarily on freshwater, marine, terrestrial, and benthic invertebrates (Elliot-Smith and Haig 2004) such as marine worms, fly larvae, beetles, crustaceans, or mollusks (USFWS 1996a, 2009a). Adults forage both day and night (Staine and Burger 1994), but young chicks are brooded during the night and therefore feed by day (Wolcott and Wolcott 1999). During territory establishment, foraging adults exhibit a preference for a moist substrate habitat that particularly includes mudflats, sand flats, ephemeral pools, and shores of brackish ponds and excludes the high-wave-energy intertidal zone (Cohen et al. ~~in press~~2010). Broods forage primarily on damp sand flats or moist substrate habitat, where the abundance of prey is much higher than in other habitats (Kuklinski et al. 1996).

Piping Plovers Foraging along Shoreline
Credit: Gene Nieminen / USFWS

Chicks with access to moist substrate habitat survived better than chicks without such access in Virginia (Loegering and Fraser 1995) and Rhode Island (Goldin and Regosin 1998). A study in New York in 1992 and 1993 found that piping plover broods had higher foraging rates in areas with ephemeral pools and tidal flats, which suggested that these habitats were superior. This study also documented higher incidences of arthropods in the moist substrate habitat, which could explain the increased plover numbers and survival rates in these habitat types. Management implications of this study include conserving a variety of foraging habitat (Elias et al. 2000). Burger (1994) found that when broods had access to a diversity of foraging habitat zones, the impact of human disturbance was reduced because chicks had opportunities to escape disturbances and still forage.

Breeding Biology

On the Atlantic Coast, breeding territory establishment and courtship generally begin in late March, the first nests are initiated in late April, and the brood-rearing period extends from late May to mid-August (Cohen 2005). On beaches with more birds in the northern end of the Atlantic Coast breeding range, most pairs establish breeding territory within a day or two of the birds' arrival in early spring, whereas pairs on sites with fewer birds can take several days or weeks longer to become established (Elliot-Smith and Haig 2004).

Piping plovers are primarily monogamous during the breeding season but often change mates between seasons. The nest is built by the male and consists of a shallow scrape in sandy substrate that may or may not be lined with pebbles and shell fragments.

Piping Plover Chicks
Credit: Mary Hake / NPS – Cape Cod National Seashore

The normal clutch size is four (USFWS 2007b, 2009a), and the average duration for egg laying is six days (Elliot-Smith and Haig 2004). Replacement of lost or destroyed eggs has not been reported. If one or more eggs are lost, the pair continues to incubate the remaining eggs. Incubation is shared by males and females and typically commences the day of clutch completion, but sometimes occurs when the next-to-last egg is laid (Elliott-Smith and Haig 2004).

The length of incubation ranges from 25 to 29 days, and a pair will re-nest multiple times if successive clutches are destroyed, but re-nesting after the chicks hatch is rare (Elliott-Smith and Haig 2004). Chicks leave the nest scrape within a few hours of hatching, except when a nest hatches at night, and they never return (Wolcott and Wolcott 1999). Broods may move hundreds of meters away from the nest site during the first week after hatching (USFWS 1996a, 2009a). Chicks are vulnerable soon after hatching, and survival rates are lower if the brood is forced to move. Members of a breeding pair share brood-rearing duties, though some females desert broods within 5 to 17 days (Elliott-Smith and Haig 2004). Although chicks follow adults to a foraging habitat, chicks forage for themselves. Fledging time ranges from 25 to 35 days (USFWS 1996a, 2009a), and most adults and young depart the breeding grounds between mid-July and early September (Cohen et al. ~~in press~~2010).

Breeding Chronology and Performance at Cape Hatteras National Seashore

Locally breeding piping plovers arrive at the Seashore in mid-March, begin courting and pairing in April, and begin to scrape and/or build nests by the third week of April. Bodie Island Spit, Cape Point, South Beach, Hatteras Inlet Spit, North Ocracoke Spit, and South Point Ocracoke (South Point) all contain potential nesting habitat. Nesting has occurred in all but one of these areas~~ in the last 10 years~~. Although breeding pairs had not been identified on the north end of ~~Ocaracoke~~Ocracoke Island since 1996, resource management staff members continued monitoring this area for potential plover activity and identified one breeding pair in 2010~~Although there has not been a breeding pair on the north end of Ocracoke Island since 1996, resource management staff members continue to monitor this area for potential plover activity~~. Under the Interim Strategy, Seashore personnel would generally begin monitoring for piping plover arrival and prenesting behavior in late March and early April. Monitoring and surveys of these sites were conducted a minimum of three times per week. However, the 2008 consent decree required staff to begin monitoring these sites on March 15, and monitor every two days from March 15 to April 15, and daily from April 16 to July 15. Bodie Island Spit had to be monitored daily from March 15 to July 15.

All known nests are protected by predator exclosures, which have been in use at the Seashore since 1994. Once nests are located, they are briefly approached once a week to inspect the exclosure, count eggs, and search for predator tracks. Morning and evening observations begin when clutches are expected to hatch. Monitors observe from a distance for evidence of hatching or chicks. After hatching, in areas not open to ORV use, the broods are monitored a few hours in the morning and a few hours in the afternoon until the chicks have fledged or are lost. Seashore personnel document brood status, behavior, individual bird and/or brood movements, human disturbance, predator interactions, and other significant environmental events.

Table 15 shows the numbers of breeding pairs of piping plovers at the six known nesting sites from 1987 to 20~~0~~10~~9~~. Table 16 provides data on piping plover hatching and fledging success at the Seashore from 1992 through 2010~~09~~. The 11 breeding ~~nesting~~ pairs identified in 2008 marks an 83% increase from the 6 pairs identified in ~~2009~~2007, and the 12 breeding ~~nesting~~ pairs identified in 2010 marks a 100% increase (NCWRC 2008a; Muiznieks, pers. comm. 2010a). In 2010, 15 piping plover chicks successfully fledged, which represents the greatest number of fledged plover chicks ever documented at the Seashore.

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TABLE 15. NUMBERS OF PIPING PLOVER BREEDING PAIRS BY SITE, CAPE HATTERAS NATIONAL SEASHORE, 1987–20~~09~~10

Year	Bodie Island Spit	Cape Point	South Beach	Hatteras Inlet Spit	North Ocracoke Spit	South Point	Total Pairs
1987	0	4	0	4	1	1	10
1989	—	—	—	—	—	—	15
1990	0	8	0	4	2	0	14
1991	0	5	0	3	5	0	13
1992	0	4	0	4	4	0	12
1993	0	5	1	3	3	0	12
1994	0	5	1	3	2	0	11
1995	0	6	1	4	2	1	14
1996	1	5	1	5	1	1	14
1997	1	4	1	3	0	2	11
1998	0	4	1	3	0	1	9
1999	0	3	1	1	0	1	6
2000	0	2	0	2	0	0	4
2001	1	1	0	1	0	0	3
2002	1	0	0	1	0	0	2
2003	0	0	0	1	0	1	2
2004	1	0	0	1	0	1	3
2005	0	0	1	1	0	1	3
2006	1	2	1	1	0	1	6
2007	1	4	0	0	0	1	6
2008	1	5	1	0	0	4	11
2009	0	5	0	0	0	4	9
2010	0	6	1	0	1	4	12
Total (% of total pairs)	8 (4.3~~4.6~~[a])	78~~72~~ (41.7(~~41.1~~[a])	~~10~~11 (5.9~~5.7~~[a])	45 (24.1~~25.7~~[a])	20~~2~~1 (11.2~~11.4~~[a])	20~~2~~4 (12.8~~11.4~~[a])	190202 (100)

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Year	Bodie Island Spit	Cape Point	South Beach	Hatteras Inlet Spit	North Ocracoke Spit	South Point	Total Pairs

Source: NPS 2009b, Muiznieks, pers. comm., 2010a

[a] Total number of pairs was ~~190~~202, but locations were not available in 1989. Therefore, percentages from the specific sites are based on the ~~175~~ 187 nests that were recorded at one of the six specific nesting areas.

— = No data available.

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TABLE 16. PIPING PLOVER HATCHING AND FLEDGING SUCCESS AT CAPE HATTERAS NATIONAL SEASHORE, 1992–2009109

Year	# Total Pairs	# Nests	# Eggs	Nests Hatched		Eggs Hatched		Chicks Fledged		Fledge Rate[b]
				#	%	#	%[a]	#	%	
1992	12	14	49[c]	8	57.1	17	34.7	8	47.1	0.67
1993	12	21	69	9	42.9	27	39.1	8	29.6	0.67
1994	11	18	65[d]	10	55.6	32[e]	49.2	9	28.1	0.82
1995	14	19	63	13	68.4	30	47.6	7	23.3	0.50
1996	14	16	56[f]	10	62.5	30	53.6	3	10.0	0.21
1997	11	16	47[f]	10	62.5	32	68.1	3	9.4	0.27
1998	9	8	31	6	75.0	20	64.5	12	60.0	1.33
1999	6	6	23	3	50.0	11	47.8	7	63.6	1.17
2000	4	6	23	3	50.0	10	43.5	3	30.0	0.75
2001	3	3	10	1	33.3	3	30.0	2	66.7	0.67
2002	2	3	8	1	33.3	1	12.5	0	0.0	0.00
2003	2	2	5[f]	2	100.0	5[f]	100.0	1	20.0	0.50
2004	3	2	6	1	50.0	4	66.7	0	0.0	0.00
2005	3	2	8	2	100.0	8	100.0	6	75.0	2.00
2006	6	4	15	3	75.0	9	60.0	3	33.3	0.50
2007	6	10[g]	29	6	60.0	17	58.6	4	23.5	0.67
2008	11	13	43	8	61.5	22	51.2	7	31.8	0.64
2009	9	9	34	6	66.7	22	64.7	6	27.3	0.67
2010	12	15	XX	11	73.3	31	XX	15	48.4	1.25
Average Fledge Rate at Cape Hatteras National Seashore = 0.6470										

Source: NPS 2009b; Muizniek~~s~~; pers. comm., 2010a

[a] Percentage of all known eggs.

[b] Fledge rate is defined as the number of fledged chicks per breeding pair (number of total pairs).

[c] Assumes three eggs from a brood whose nest was not found.

[d] Assumes two eggs from a brood whose nest was not found.

[e] Includes those presumed hatched.

[f] Assumes one egg from a brood whose nest was not found.

[g] Based on consultation with USFWS, it was determined that Nest 1 and Nest 2 were a single nesting attempt.

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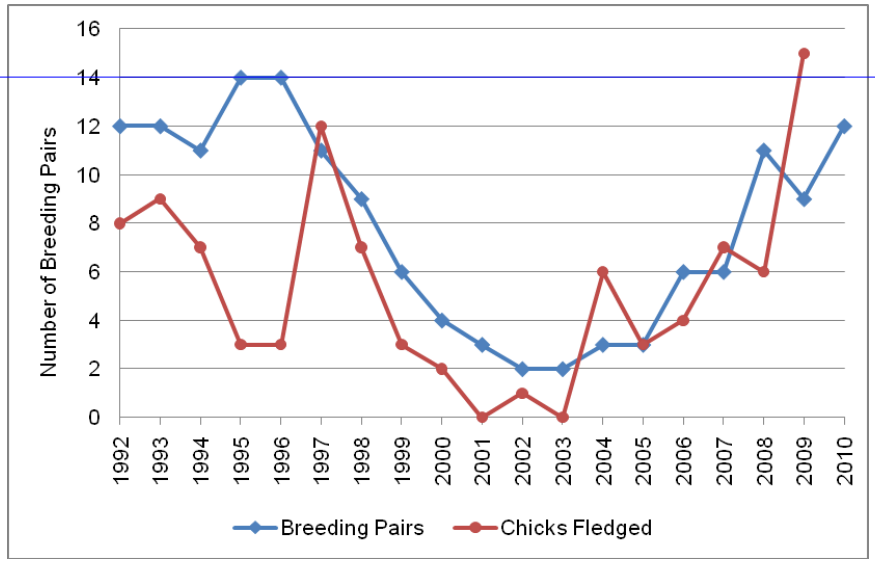
Fledge rate (or reproductive rate) is defined as the number of chicks that survive until fledging age per breeding pair. Since 1989, reproductive rates at the Seashore have ranged from 0.00 to 2.00 chicks per breeding pair, with an average rate over the ~~18~~ 19 years from 1992 to 2010~~09~~ of 0.70~~64~~ chicks per breeding pair (NPS 2009b; Muizniek~~s~~, pers. comm. 2010a). During 2009, a total of 9 breeding pairs fledged 6 chicks, which is ~~(~~a rate of 0.67 chicks per pair~~)~~ (Muizniek~~s~~ pers. comm. 2009). However, a rate of 1.25 fledged chicks per breeding pair annually would be needed to sustain the population (USFWS 1996a), and the recovery goal set by the USFWS is 1.50 fledged chicks per breeding pair. Although ~~A~~a fledge rate of 1.25 ~~fledged~~ chicks per breeding pair was achieved at the Seashore in 2010, ~~. Hence,~~ the fledge rate at the Seashore has averaged less than half the recovery goal since 1992~~, but in 2010 was at the level needed to sustain the population~~.

The decline in the local breeding population (figure 5) from 1995 to 2003 is likely a reflection of the low reproductive rate (NPS 2005a) and resultant lack of recruitment. However, the increase in the numbers of piping plover breeding pairs since 2003 is encouraging.



Source: NPS 2009b; Muiznieks pers. comm. 2009, Muiznieks pers. comm. 2010a

FIGURE 5. NUMBERS OF PIPING PLOVER BREEDING PAIRS AND FLEDGED CHICKS AT CAPE HATTERAS NATIONAL SEASHORE, 1992–201009

Hatching and Fledging Success at Primary Nesting Sites

The following tables (table 17 through table 22) provide a summary of hatching and fledging success at each of the individual primary breeding sites from the early 1990s through 201009. Average fledge rates[3] across the six breeding sites ranged from 0.13 at Bodie Island Spit to 0.90 at South Beach. In 2010, Cape Point achieved a 2.50 average fledge rate, the only site to be above the , and each site has a fledge rate below the 1.50 goal set by the 1996 revised recovery plan since 1992. HoweverIn addition, there were eight instances of years when one or more sites did meet or exceed this goal, indicating that despite poor Seashore-wide recruitment, some primary nesting sites performed at or above this expectation in some years.

Nest Loss/Abandonment

Nest loss and abandonment have had significant impacts on piping plover reproduction at the Seashore. In the 18 19 seasons from 1992 through 201009, 4041% of nests (of 172 187 discovered) were lost or abandoned (figure 6). Factors contributing to nest loss and abandonment include weather, predation, and human disturbance, which are discussed in detail under the "Risk Factors" section later in this chapter.

[3] "Annual fledge rate" is defined as the number of chicks fledged per breeding pair. "Average fledge rate" is the average of the annual fledge rates for years when there was at least one breeding pair.

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TABLE 17. PIPING PLOVER HATCHING AND FLEDGING SUCCESS AT BODIE ISLAND SPIT, 1992–201009

Year	Total Pairs	# Nests	# Eggs	Nests Hatched		Eggs Hatched		Chicks Fledged		Fledge Rate
				#	%	#	%	#	%	
1992	0	0	0	0	0.0	0	0.0	0	0.0	N/A
1993	0	0	0	0	0.0	0	0.0	0	0.0	N/A
1994	0	0	0	0	0.0	0	0.0	0	0.0	N/A
1995	0	0	0	0	0.0	0	0.0	0	0.0	N/A
1996	1	1	4	1	100.0	3	75.0	0	0.0	0.00
1997	1	2	6	0	0.0	0	0.0	0	0.0	0.00
1998	0	0	0	0	0.0	0	0.0	0	0.0	N/A
1999	0	0	0	0	0.0	0	0.0	0	0.0	N/A
2000	0	0	0	0	0.0	0	0.0	0	0.0	N/A
2001	1	1	3	0	0.0	0	0.0	0	0.0	0.00
2002	1	1	3	1	100.0	1	33.3	0	0.0	0.00
2003	0	0	0	0	0.0	0	0.0	0	0.0	N/A
2004	1	1	2	0	0.0	0	0.0	0	0.0	0.00
2005	0	0	0	0	0.0	0	0.0	0	0.0	N/A
2006	1	0	0	0	0.0	0	0.0	0	0.0	N/A
2007	1	1	3	1	100.0	3	100.0	1	33.3	1.00
2008	1	1	3	0	0.0	0	0.0	0	0.0	0.00
2009	0	0	0	0	0.0	0	0.0	0	0.0	N/A
2010	0	0	0	0	0.0	0	0.0	0	0.0	N/A

Average Fledge Rate at Bodie Island Spit = 0.13

Muiznieks pers. comm. 2010a

TABLE 18. PIPING PLOVER HATCHING AND FLEDGING SUCCESS AT CAPE POINT, 1992–20101099

Year	Total Pairs	# Nests	# Eggs	Nests Hatched		Eggs Hatched		Chicks Fledged		Fledge Rate
				#	%	#	%	#	%	
1992	4	5	19	4	80.0	11	57.9	4	36.4	1.00
1993	5	6	23	5	83.3	15	65.2	3	20.0	0.60
1994	5	6	24	5	83.3	16	66.7	5	31.3	1.00
1995	6	9	33	5	55.6	15	45.5	2	13.3	0.33
1996	5	5	16	3	60.0	7	43.8	3	42.9	0.60
1997	4	6	18	5	83.3	15	83.3	3	20.0	0.75
1998	4	5	19	3	60.0	10	52.6	6	60.0	1.50
1999	3	3	12	2	66.7	7	58.3	5	71.4	1.67
2000	2	3	11	2	66.7	6	54.5	2	33.3	1.00
2001	1	1	3	0	0.0	0	0.0	0	0.0	0.00
2002	0	0	0	0	0.0	0	0.0	0	0.0	N/A
2003	0	0	0	0	0.0	0	0.0	0	0.0	N/A
2004	0	0	0	0	0.0	0	0.0	0	0.0	N/A
2005	0	0	0	0	0.0	0	0.0	0	0.0	N/A
2006	2	2	7	2	100.0	6	85.7	3	50.0	1.50
2007	4	8	22	4	50.0	10	45.5	3	30.0	0.75
2008	5	6	22	4	66.7	12	54.5	4	33.3	0.80
2009	5	5	20	5	100.0	19	95.0	4	21.1	0.80
2010	6	6	XX	6	100.0	XX	XX	15	71.4	2.50

Average Fledge Rate at Cape Point = 0.8899

Muiznieks pers. comm. 2010a

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TABLE 19. PIPING PLOVER HATCHING AND FLEDGING SUCCESS AT SOUTH BEACH, 1992–~~2009~~2010

Year	Total Pairs	# Nests	# Eggs	Nests Hatched		Eggs Hatched		Chicks Fledged		Fledge Rate
				#	%	#	%	#	%	
1992	0	0	0	0	0.0	0	0.0	0	0.0	N/A
1993	1	2	7	1	50.0	4	57.1	0	0.0	0.00
1994	1	1	2	1	100.0	2	100.0	1	50.0	1.00
1995	1	1	3	1	100.0	1	33.3	1	100.0	1.00
1996	1	1	3	1	100.0	2	66.7	0	0.0	0.00
1997	1	2	8	2	100.0	7	87.5	0	0.0	0.00
1998	1	1	4	1	100.0	4	100.0	2	50.0	2.00
1999	1	1	4	1	100.0	4	100.0	2	50.0	2.00
2000	0	0	0	0	0.0	0	0.0	0	0.0	N/A
2001	0	0	0	0	0.0	0	0.0	0	0.0	N/A
2002	0	0	0	0	0.0	0	0.0	0	0.0	N/A
2003	0	0	0	0	0.0	0	0.0	0	0.0	N/A
2004	0	0	0	0	0.0	0	0.0	0	0.0	N/A
2005	1	1	4	1	100.0	4	100.0	3	75.0	3.00
2006	1	1	4	0	0.0	0	0.0	0	0.0	0.00
2007	0	0	0	0	0.0	0	0.0	0	0.0	N/A
2008	1	1	4	1	100.0	2	50.0	0	0.0	0.00
2009	0	0	0	0	0.0	0	0.0	0	0.0	N/A
2010	1	1	XX	1	100.00	XX	XX	0	0	0.00

Average Fledge Rate at South Beach = 0.~~90~~82

Muiznieks pers. comm. 2010a

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TABLE 20. PIPING PLOVER HATCHING AND FLEDGING SUCCESS AT HATTERAS INLET SPIT, 1992–~~2009~~2010

Year	Total Pairs	# Nests	# Eggs	Nests Hatched		Eggs Hatched		Chicks Fledged		Fledge Rate
				#	%	#	%	#	%	
1992	4	5	16	2	40.0	5	31.3	2	40.0	0.50
1993	3	4	16	2	50.0	7	43.8	4	57.1	1.33
1994	3	6	24	3	50.0	10	41.7	3	30.0	1.00
1995	4	6	17	5	83.3	11	64.7	3	27.3	0.75
1996	5	7	26	4	57.1	14	53.8	0	0.0	0.00
1997	3	4	8	1	25.0	4	50.0	0	0.0	0.00
1998	3	1	4	1	100.0	2	50.0	0	0.0	0.00
1999	1	1	4	0	0.0	0	0.0	0	0.0	0.00
2000	2	3	12	1	33.3	4	33.3	1	25.0	0.50
2001	1	1	4	1	100.0	3	75.0	2	66.7	2.00
2002	1	2	5	0	0.0	0	0.0	0	0.0	0.00
2003	1	1	4	1	100.0	4	100.0	0	0.0	0.00
2004	1	1	4	1	100.0	4	100.0	0	0.0	0.00
2005	1	1	4	1	100.0	4	100.0	3	75.0	3.00
2006	1	0	0	0	0.0	0	0.0	0	0.0	N/A
2007	0	0	0	0	0.0	0	0.0	0	0.0	N/A
2008	0	0	0	0	0.0	0	0.0	0	0.0	N/A
2009	0	0	0	0	0.0	0	0.0	0	0.0	N/A
2010	0	0	0	0	0.0	0	0.0	0	0.0	N/A

Average Fledge Rate at Hatteras Inlet Spit = 0.61

Muiznieks pers. comm. 2010a

TABLE 21. PIPING PLOVER HATCHING AND FLEDGING SUCCESS AT NORTH OCRACOKE SPIT, 1992–~~2009~~2010

Year	Total Pairs	# Nests	# Eggs	Nests Hatched		Eggs Hatched		Chicks Fledged		Fledge Rate
				#	%	#	%	#	%	
1992	4	4	14	2	50.0	5	35.7	2	40.0	0.50
1993	3	9	23	1	11.1	1	4.3	1	100.0	0.33
1994	2	5	15	1	20.0	4	26.7	0	0.0	0.00
1995	2	2	6	2	100.0	3	50.0	1	33.3	0.50
1996	1	1	3	0	0.0	0	0.0	0	0.0	0.00
1997	0	0	0	0	0.0	0	0.0	0	0.0	N/A
1998	0	0	0	0	0.0	0	0.0	0	0.0	N/A
1999	0	0	0	0	0.0	0	0.0	0	0.0	N/A
2000	0	0	0	0	0.0	0	0.0	0	0.0	N/A
2001	0	0	0	0	0.0	0	0.0	0	0.0	N/A
2002	0	0	0	0	0.0	0	0.0	0	0.0	N/A
2003	0	0	0	0	0.0	0	0.0	0	0.0	N/A
2004	0	0	0	0	0.0	0	0.0	0	0.0	N/A
2005	0	0	0	0	0.0	0	0.0	0	0.0	N/A
2006	0	0	0	0	0.0	0	0.0	0	0.0	N/A
2007	0	0	0	0	0.0	0	0.0	0	0.0	N/A
2008	0	0	0	0	0.0	0	0.0	0	0.0	N/A
2009	0	0	0	0	0.0	0	0.0	0	0.0	N/A
2010	1	1	XX	1	100.0	XX	XX	0	0.0	0.00

Average Fledge Rate at North Ocracoke Spit = 0.~~27~~22

Muiznieks pers. comm. 2010a

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TABLE 22. PIPING PLOVER HATCHING AND FLEDGING SUCCESS AT SOUTH POINT, 1992–~~2009~~2010

Year	Total Pairs	# Nests	# Eggs	Nests Hatched		Eggs Hatched		Chicks Fledged		Fledge Rate
				#	%	#	%	#	%	
1992	0	0	0	0	0.0	0	0.0	0	0.0	N/A
1993	0	0	0	0	0.0	0	0.0	0	0.0	N/A
1994	0	0	0	0	0.0	0	0.0	0	0.0	N/A
1995	1	1	4	0	0.0	0	0.0	0	0.0	0.00
1996	1	1	4	1	100.0	4	100.0	0	0.0	0.00
1997	2	2	7	2	100.0	6	85.7	0	0.0	0.00
1998	1	1	4	1	100.0	4	100.0	4	100.0	4.00
1999	1	1	3	0	0.0	0	0.0	0	0.0	0.00
2000	0	0	0	0	0.0	0	0.0	0	0.0	N/A
2001	0	0	0	0	0.0	0	0.0	0	0.0	N/A
2002	0	0	0	0	0.0	0	0.0	0	0.0	N/A
2003	1	1	1	1	100.0	1	100.0	1	100.0	1.00
2004	1	0	0	0	0.0	0	0.0	0	0.0	N/A
2005	1	0	0	0	0.0	0	0.0	0	0.0	N/A
2006	1	1	4	1	100.0	3	75.0	0	0.0	0.00
2007	1	1	4	1	100.0	4	100.0	0	0.0	0.00
2008	4	5	14	3	60.0	8	57.1	3	37.5	0.75
2009	4	4	14	1	25.0~~%~~	3	21.0	2	66.7	0.50
2010	4	7	XX	3	42.9	XX	XX	0	0.0	0.00

Average Fledge Rate at South Point = 0.~~52~~48

Muiznieks pers. comm. 2010a

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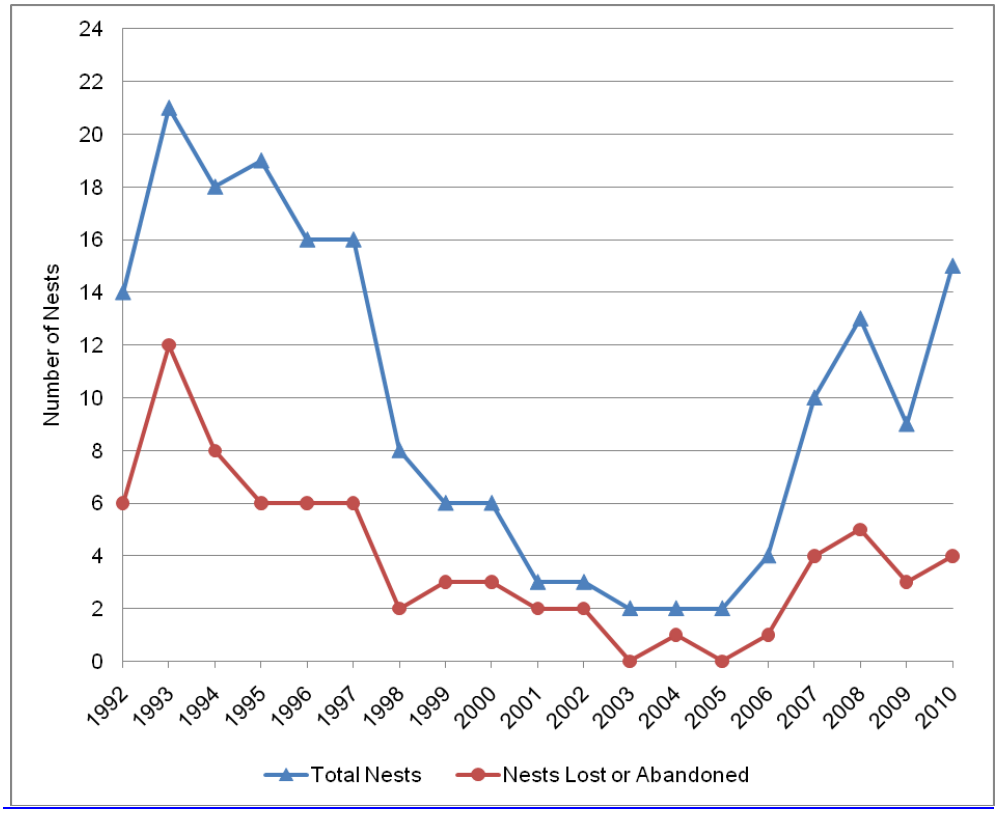


Source: NPS 2009b; Muiznieks pers. comm. 2009; Muiznieks pers. comm. 2010a

FIGURE 6. PIPING PLOVER NEST LOSS / ABANDONMENT AT CAPE HATTERAS NATIONAL SEASHORE, 1992–~~2009~~2010

Nonbreeding Population

In addition to supporting a local breeding population, the Seashore also hosts migrating and wintering piping plovers from ~~all three of the North American breeding populations (~~the threatened Atlantic Coast ~~and Great Plains~~ population~~s~~ and the endangered Great Lakes population). The Outer Banks is an important stopover area for migrating shorebirds along the Atlantic Coast. Fall migrants arrive at the Outer Banks in July, peak in August and September, and depart by November (Dinsmore et al. 1998). The distribution and abundance of nonbreeding populations at the Seashore are less well documented than the local breeding population. Documenting and protecting nonbreeding piping plovers and their habitats are priorities articulated in the recovery plans for all three North American breeding populations (USFWS 1988; 1996a; 2003, 2009a). Recognizing the importance of the Outer Banks to wintering piping plovers, the USFWS designated 2,043 acres of critical habitat in Dare and Hyde counties in November 2008 (FR 2008).

Wintering piping plovers on the Atlantic Coast select wide beaches in the vicinity of inlets that are associated with a high percentage of moist substrate habitat (Nicholls and Baldassarre 1990; Wilkinson

and Spinks 1994). Because tidal regimes and fall and winter storm patterns often cause piping plovers to move among habitat patches, a diversity of habitat patches may be important to wintering populations (Burger 1994; Nicholls and Baldassarre 1990).

Cohen and others (~~in press~~2010) studied nonbreeding piping plovers at the Seashore from 2000 to 2005. The results of this study indicated that the greatest number of nonbreeding piping plovers at the Seashore occurs during the fall migration, which begins in July and peaks between July and September (see table 23). The fall migration counts were highest at South Point, followed by Oregon Inlet (Bodie Island Spit, Pea Island NWR, and, formerly, Green Island, which is now largely unusable for plovers because of vegetation growth), then Hatteras Inlet Spit, and finally Cape Point (Cohen et al. ~~in press~~2010).

TABLE 23. MONTHLY MEDIAN AND MAXIMUM NONBREEDING BIRDS SEEN DURING FALL, WINTER, AND SPRING SURVEYS, SELECTED SITES AT CAPE HATTERAS NATIONAL SEASHORE, 2000–2005

	Month	Bodie Island Spit	Cape Point / South Beach	Hatteras Inlet Spit	South Point	All Sites
Median	Jul	0.49	0.18	0.45	2.21	5.7
	Aug	0.68	0.31	0.13	3.76	6.4
	Sep	0.66	0.07	0.38	4.22	5.7
	Oct	0.36	0.00	0.86	1.81	3.3
	Nov	0.82	0.00	0.07	1.00	4.2
	Dec	0.77	0.00	0.00	2.07	2.9
	Jan	0.25	0.00	0.00	1.00	1.2
	Feb	3.33	0.00	0.00	1.00	4.3
	Mar	1.25	0.00	0.00	0.75	2.8
	Apr	1.89	0.00	0.62	1.31	3.6
Maximum	Jul	32	5	21	56	56
	Aug	34	6	14	72	72
	Sep	16	5	4	37	37
	Oct	12	1	28	31	31
	Nov	15	0	8	12	15
	Dec	17	0	7	15	17
	Jan	18	0	1	11	18
	Feb	14	0	0	18	18
	Mar	12	3	4	8	12
	Apr	25	3	7	11	25

Source: Cohen et al. ~~in press~~2010

NOTE: Not all sites were surveyed during the designated survey days (typically, only one or two sites were surveyed on a given survey day), so the numbers in the table provide only a rough idea of the total size of the nonbreeding population.

During this time, the first banded winter residents appeared in August; however, other wintering birds could have arrived in July. Cohen suggested that the nonbreeding population from December to January probably consisted entirely of winter residents and estimated that although the size of the resident wintering population at the Seashore was not precisely known, it may be on the order of 20 to 35 birds (Cohen et al. ~~in press~~2010). In the winter of 2004–2005, the maximum numbers seen were about 50% of

the recent norm; however, whether this observed difference was because of a difference in survey methodology is unknown. The highest counts of wintering residents were at Bodie Island Spit and South Point. Based on a sample of banded birds, winter residents can be present until April (Cohen et al. ~~in press~~2010). Spring piping plover migrants first appear in February or early March, and their numbers peak in late March or April (table 23). Sites at Bodie Island Spit have had the highest abundance of spring migrants, followed by South Point, with fewer at Hatteras Inlet Spit and Cape Point / South Beach (Cohen et al. ~~in press~~2010).

NPS staff documented nonbreeding piping plovers' use of the Seashore throughout 2006. Migratory birds appeared to peak in August and September, with a high count of 93 birds at South Point on August 10 (table 24). South Point revealed the highest counts during fall migration. Three surveys at South Point were coordinated with Seashore surveys on North Core Banks to investigate bird abundance around Ocracoke Inlet (table 24).

TABLE 24. COUNTS OF PIPING PLOVER ON BOTH SIDES OF OCRACOKE INLET DURING FALL MIGRATION, 2006

Date	South Point	North Core Banks	Total	Tide
Aug 10, 2006	93	7	100	Mid
Aug 14, 2006	69	16	85	Low
Oct 2, 2006	15	16	31	Low

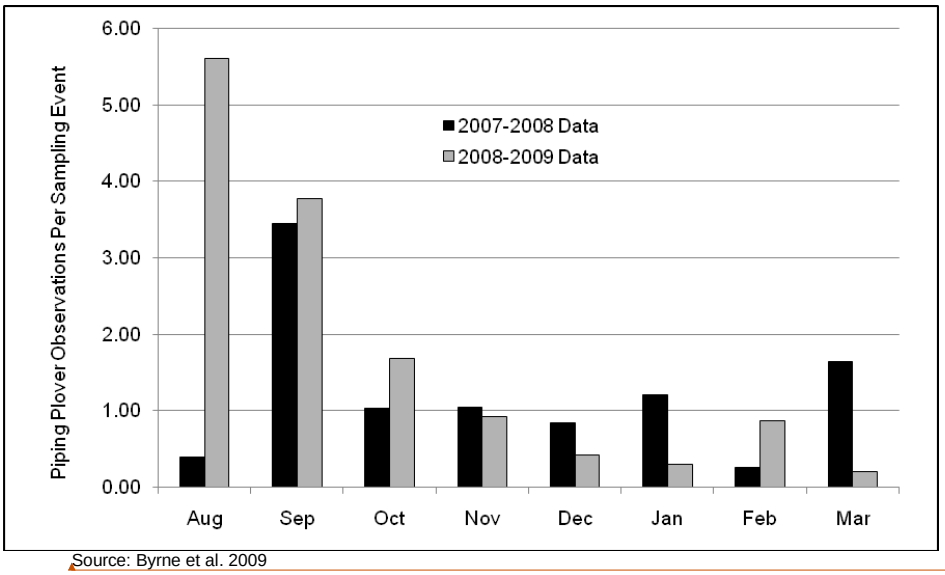
Source: NPS 2007c

Seashore staff also documented nonbreeding plovers' use of the Seashore beginning at the end of the breeding season in August 2007 through March 2008 and from August 2008 to March 2009 (see figure 7), although surveys were limited to the points and spits. Figure 7 indicates the number of piping plover observations recorded per sampling event (or unit of effort), which is also referred to as "normalized" data, which were used as a means to control a varying level or effort across sampling units. In 2007, migratory birds peaked in September, with a high of 33 counted on September 7, 2007, on South Point (NPS 2009b). After the migrants passed through the area in September 2007, plover numbers appeared to stabilize over the winter months except in February 2008, when there was an unexplained drop in numbers. In 2008, the number of migratory plovers peaked in August and numbers declined in September to a level similar to the previous year. The number of birds at the Seashore continued to decline until February 2009, when the migrants started passing through the Seashore again (figure 7).

Seashore staff documented the habitat type in which migratory and wintering piping plovers were observed from August 2007 to March 2008 and from August 2008 to March 2009 (figure 8). Of the 717 observations, 458 were in mudflat / algal flat, 157 were in sand flat, 67 were in foreshore, and 26 were in wrack line habitat (NPS 2009b; Muiznieks pers. comm. 2009).

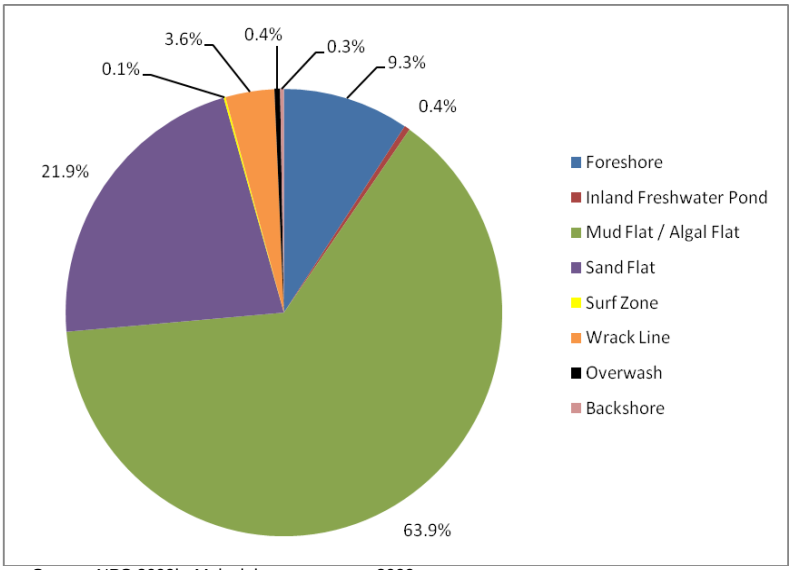
In addition to the monitoring being conducted by Cohen and others (~~in press~~2010) and Seashore staff, the Southeast Coast Network (SECN) Inventory and Monitoring Program conducted a comprehensive study on wintering shorebirds at the Seashore. Pilot implementation of a long-term shorebird monitoring protocol began in mid-July 2006 and the first report was published in March 2009. The study found that the fall migration appeared to peak in August (figure 9) and the spring migration likely peaked in May, but nest initiation by piping plover and logistical issues precluded consistent sampling later than April in any given year. The three highest single-day counts during the pilot study (for sampled areas only) were 24 in July 2006, 50 in August 2006, and 14 in April 2007. Monthly normalized counts (number of birds observed per 30-minute sampling event) are shown on figure 10.

The SECN study found that the majority of piping plover observations occurred in mudflat / algal flat and foreshore habitat types (figure 11).



Source: Byrne et al. 2009

FIGURE 7. MONTHLY OBSERVATIONS OF PIPING PLOVERS PER SAMPLING EVENT FROM AUGUST TO MARCH 2007–2009



Source: NPS 2009b; Muiznieks pers. comm. 2009

FIGURE 8. WINTERING OBSERVATIONS OF PIPING PLOVER BY HABITAT TYPE

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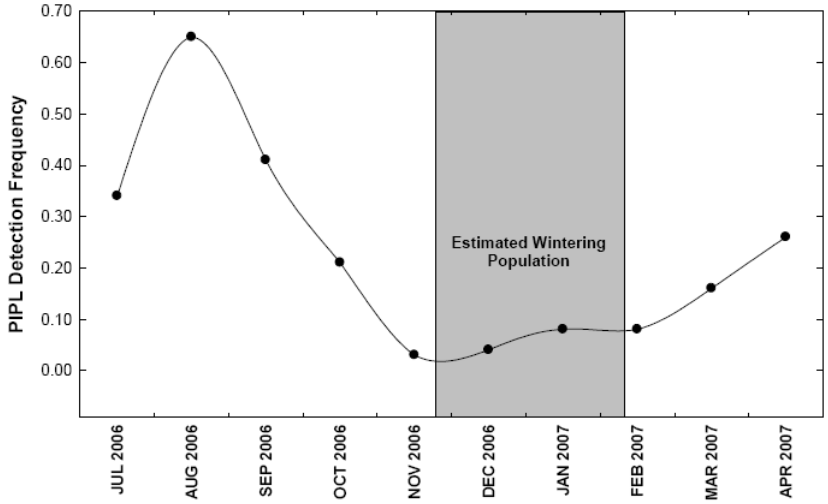

Source: Byrne et al. 2009

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FIGURE 9. DETECTION FREQUENCY FOR PIPING PLOVER (PIPL) AT BODIE ISLAND SPIT, CAPE POINT, HATTERAS INLET SPIT, NORTH OCRACOKE SPIT, AND SOUTH POINT—CAPE HATTERAS NATIONAL SEASHORE, 2006–2007

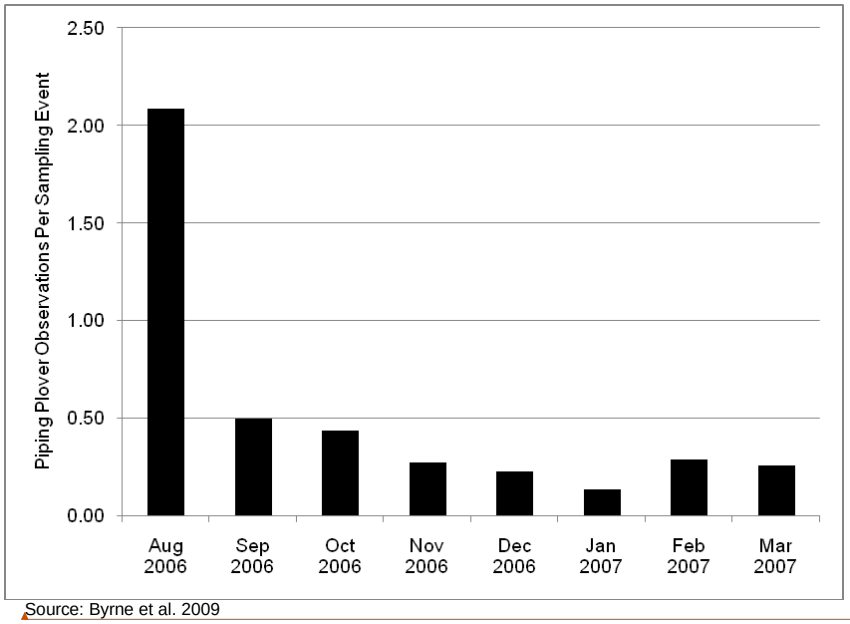

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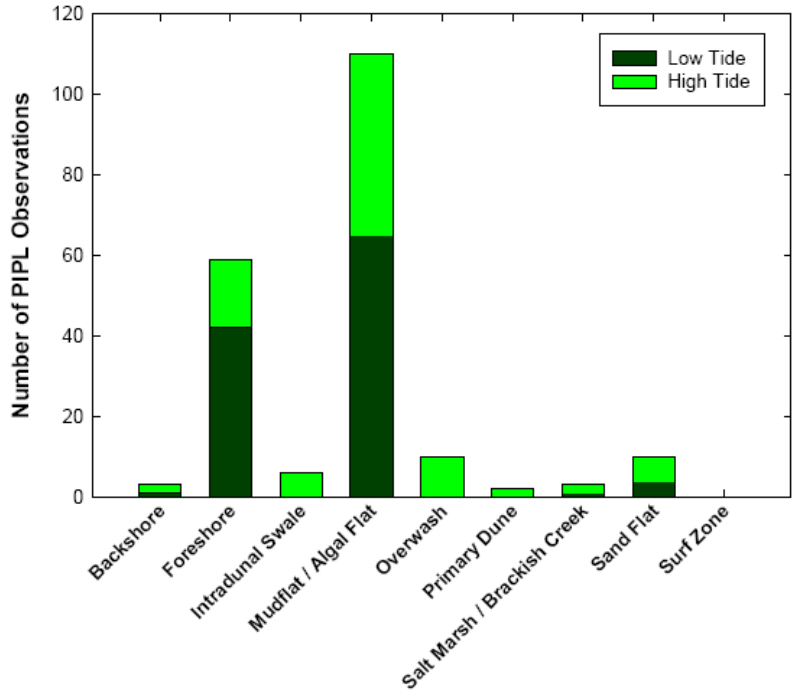
FIGURE 10. MONTHLY OBSERVATIONS OF PIPING PLOVER PER SAMPLING EVENT AT CAPE HATTERAS NATIONAL SEASHORE, 2006–2007



Source: Byrne et al. 2009

FIGURE 11. NUMBERS OF NONBREEDING PIPING PLOVER (PIPL) OBSERVATIONS BY HABITAT TYPE AND TIDE STAGE AT CAPE HATTERAS NATIONAL SEASHORE, 2006–2007

The results of the SECN study were consistent with previous studies that found that the moist substrate habitat type is thought to play a vital role in the survival of nonbreeding piping plovers. It was also noted that migratory and wintering piping plovers occurred more frequently in accreted areas (i.e., the points and spits), which are popular spots for recreational ORV use at the Seashore (Byrne et al. 2009). The importance of protecting nonbreeding piping plovers was demonstrated in a research program by the Canadian Wildlife Service between 1998 and 2003, which primarily tracked migration patterns and survival rates of the Eastern Canada population of piping plovers. Individuals from this population were identified migrating and wintering at points along the east coast of the United States, including North Carolina (Amirault et al. 2006). The analysis of this research identified adult survival as the single most important factor influencing the population trends of this piping plover population and showed that expanding protection of nonbreeding habitat was an important factor in the recovery of the species (Amirault et al. 2006). Seashore staff will continue to monitor the abundance of nonbreeding piping plovers at the Seashore and use the data to make management decisions as to where the winter closures need to be placed.

Risk Factors

Small populations such as the Atlantic Coast piping plover populations face a heightened risk of extinction compared to large populations because they are more vulnerable to the following: (1) random

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environmental variations, such as storms; (2) reduction in genetic variations that limit a species' ability to adapt to local conditions; (3) sudden, random drops in birth and death rates; and (4) an impaired ability to find suitable mates (Lande 1988).

Given the vulnerability of the small piping plover populations in North America to random events, the persistence of the populations will depend increasingly on controlling sources of mortality to adults, eggs, and chicks throughout their range. Predators, human disturbance, and limited or blocked access to foraging habitat have been identified in past research as contributing to impaired reproductive success for plovers using the Seashore (Kuklinski et al. 1996). Thus, providing a disturbance-free environment early in the season may help piping plovers to establish territories and attract mates (Cohen 2005).

Rates and sources of mortality and disturbance, and the responses of piping plovers to disturbance in the nonbreeding season, have not been specifically assessed at the Seashore. However, it is known that piping plover foraging and roosting habitats at Cape Hatteras are used by pedestrians and ORVs outside of the breeding season (Cohen et al. ~~in press~~2010). Where such activity is allowed, studies conducted at several beaches in Massachusetts and New York have shown that there is the potential for piping plovers to be killed by being run over by ORVs (Melvin et al. 1994) or taken by domestic pets. Studies along the Atlantic and gulf coasts (including one at the Seashore) have shown that the density of wintering plovers is higher in areas with limited human presence or disturbance (Cohen et al. 2008; Nicholls and Baldassarre 1990). Furthermore, disturbance to roosting and foraging birds by ORVs, unleashed pets, and pedestrians may reduce foraging efficiency or alter habitat use, thereby increasing the risk of nutritional or thermal stress (Zonick 2000; Burger et al. 2004).

Weather and Tides. Nine named hurricanes affected the Outer Banks between 1993 and ~~2008~~ 2009 (NOAA 2009). Hurricane Isabel, which hit the coast in September 2003, renewed piping plover habitat on portions of the Seashore and may have resulted in a reduction in predator populations (NCWRC 2008a). In the years immediately following the storm, piping plover numbers and productivity increased. However, there have been no significant storms since that time, and much of the created habitat is now deteriorating due to revegetation (NCWRC 2008a). No significant weather events, such as hurricanes or tropical storms, occurred during the 2006 breeding season. However, smaller, localized events may have affected nesting. Nest 4 on South Point was partially buried by high wind and blowing sand. One egg was buried by sand, and the nest was a deep cup rather than a scrape (June 29). One adult remained hunkered down on the nest during the strong winds, and the buried egg was visible again during the nest check. A strong thunderstorm was noted on the night before Nest 2 on South Beach was discovered lost; however, the loss is characterized as "unknown" because it cannot be shown conclusively that weather was the cause. Five nests were lost to weather, predation, or abandonment during the 2007 breeding season. Nest 1, a two-egg nest on Cape Point, was lost during a Nor'easter storm. It is unknown if the eggs were blown out of the nest scrape in the 50- to 60-mile-per-hour winds, buried under the sand, or taken by a predator. In 2008, a series of sandstorms with wind gusts over 35 mph may have caused the pair from Nest 1 (Cape Point) to abandon the nest. A nest on Ocracoke was buried during a Nor'easter prior to the nest being located by resource management staff. One egg was found when compacted sand was removed from a scrape that had been maintained prior to the arrival of the storm (NPS 2009b). In 2009 there were high winds and rain prior to a single egg (first egg of a clutch) disappearing at Cape Point (Muiznieks pers. comm. 2009).

Hurricanes and other ocean storms can lead to unusually high tides, and subsequent flooding can overwash piping plover nests (Cohen et al. ~~in press~~2010). In May 2000, a 3-day storm produced high winds, heavy rain, and ocean overwash. One clutch at Cape Point was buried under windblown sand and abandoned, while a second was lost to flooding at Hatteras Inlet Spit (NPS 2001b). Wave action and erosion caused the abandonment of a nest in 2002 when waves undermined a protective dune, resulting in the nest being flooded by ocean overwash. The eggs were scattered from the nest and the adults did not

return to them (NPS 2003d). In 2009 a four-egg nest discovered on June 8 on South Point, Ocracoke, was overwashed by spring tides on June 23 (Muiznieks pers. comm. 2009).

Indeed, some piping plovers that nest too close to mean high tide may lose their nests on normal high tides (Cohen et al. ~~in press~~2010). Storms can also result in widespread mortality of chicks (Houghton 2005). Besides these direct effects of storms on piping plover nests, flooding from extreme high tides or storm surges may alter habitat enough to render it unsuitable for nesting. This may lead to the abandonment of habitat within or between breeding seasons (Haig and Oring 1988).

Predation. Predation, especially by mammalian predators, continues to be a major factor affecting the reproductive success of the piping plover (Elliot-Smith and Haig 2004). Predators of eggs, chicks, and/or adults include such predators as mink (*Mustela vison*), gray fox (*Urocyon cinereoargenteus*), red fox (*Vulpes vulpes*), opossum (*Didelphis virginiana*), raccoon (*Procyon lotor*), domestic dogs (*Canis lupus familiaris*), feral and domestic cats (*Felis catus*), crows (*Corvus brachyrhynchos*), gulls (*Larus* spp.) (NPS 2008c), and birds of prey (Murphy et al. 2003). The impact of predation has been postulated to be greater on beaches with high human use because the presence of pets and trash (which may attract wild predators) is correlated with the presence of humans (USFWS 1996a, 2009a).

Foxes outside a Piping Plover Nest Exclosure
Credit: Richard Kuzminski / USFWS

Fox activity was recorded at all active plover nesting areas in 2001 and one late nest initiation and two nest abandonments were linked to this activity (NPS 2002b). No direct evidence of predation of chicks or eggs was recorded from 2001 through 2006, although the presence or tracks of crows, grackles (*Quiscalus* spp.), gulls, ghost crabs (*Ocypode quadrata*), Virginia opossum, mink, raccoon, red fox, gray fox, and domestic cats and dogs were documented within many plover breeding territories. A fox den was discovered within the Bodie Island Spit bird closure in June 2006 (NPS 2007c). During the 2007 season, eggs were missing from a plover nest at Cape Point. Staff observed both raccoon and opossum tracks in the area of the nest scrape (NPS 2008c). Predators or high winds generated by a Nor'easter storm are thought to be responsible for missing eggs and eggs observed eight feet from scrapes (NPS 2008c). In 2008, Seashore staff documented the loss of two plover chicks at Cape Point due to avian predation. One chick was taken by a gull and another by a crow. Staff also documented the presence or tracks of crows, ghost crabs, grackles, gulls, opossum, mink, raccoon, red fox, gray fox, and feral cats within many of the piping plover breeding territories (NPS 2009b). In 2009, two chicks at Cape Point were lost to suspected opossum predation on day three (Muiznieks pers. comm. 2009). In addition to causing direct mortality, predators in piping plover habitat can also lead to piping plovers' abandoning territories within and between breeding seasons (Cohen 2005).

Ghost crabs have occasionally been implicated in the loss of nests (Watts and Bradshaw 1995) and chicks (Loegering et al. 1995). Research on ghost crabs conducted in the lab and at a breeding site at Assateague Island in Virginia suggests that crab predation is generally uncommon. However, this study indicated that the presence of ghost crabs could have a more indirect effect on plover survival. For example, adult plovers may shepherd their broods away from the foreshore, where the best forage normally exists, due to the abundance of ghost crabs at that location (Wolcott and Wolcott 1999). Poor forage was found to be a more likely contributor to chick mortality than predation by ghost crabs (Wolcott and Wolcott 1999). However, anecdotal records indicate that ghost crabs may be more of a problem in North Carolina than at sites farther north (Cohen et al. ~~in press~~2010). In 2007, one egg in an exclosed nest was lost to a ghost crab (NPS 2008c) and in 2008, ghost crab predation was suspected in the loss of three piping plover nests because ghost crab holes were found inside and around the nests and predator exclosures (NPS 2009b). In

2009, a two–egg nest discovered on May 22 on South Point, Ocracoke, was incubated well past its expected hatch date and was eventually predated by ghost crabs (Muiznieks pers. comm. 2009).

Human Activity. Human disturbance, both direct and indirect, can adversely affect piping plovers at the Seashore. Studies on piping plovers have demonstrated that reproductive success is lower in areas with high human disturbance (Burger 1991, 1994). Research has shown that piping plover and snowy plover (*Charadrius alexandrinus*) ~~plover~~ behavior is altered by the presence of humans, which ultimately results in chicks exhibiting less time feeding, brooding, and conserving energy (Lafferty 2001a, 2001b; Page et al. 2009). Piping p~~P~~lovers that are subject to human disturbance spend less than 50% of their foraging time searching for prey and feeding, where undisturbed plovers can spend up to 90% of that time feeding (Burger 1994). These human-caused behavioral changes result in depleted energy reserves (Nudds and Bryant 2000), which could leave chicks more susceptible to predation or other stresses (Flemming et al. 1988; Loegering and Fraser 1995; Lafferty 2001a, 2001b; Page et al. 2009; Thomas et al. 2002). At other sites, it was documented that fledging success did not differ between areas with and without recreational ORV use (Patterson et al. 1991), although pedestrians caused a decrease in brood-foraging behavior in New Jersey (Burger 1994).

Pedestrian and non-motorized recreational activities can be a source of both direct mortality and harassment of piping plovers. Potential pedestrians on the beach include those individuals driving and subsequently parking on the beach, those originating from off-beach parking areas (hotels, motels, commercial facilities, beachside parks, etc.), and those from beachfront and nearby residences. Vehicle impacts can extend to remote stretches of beach where human disturbance would be very slight if access were limited to pedestrians only (USFWS 1996a, 2009a).

Symbolic Fencing—Posts with string tied between them intended to signify that an area has been closed to protect resources.

Even with resource closures in place, protected species are still at risk. Approximately 50 to 60 occurrences of ORVs entering protected areas at the Seashore were recorded each year from 2000 to 2002. In 2003, 13 bird closure posts/signs were driven over by an ORV, and several instances of ORVs within the protected area were observed (NPS 2003d, 2004e, 2005a). A total of 105 occurrences of ORVs entering posted bird closures were recorded in 2003. This number represents a substantial increase as compared to 52 recorded in 2001 and 63 in 2002 (NPS 2004e). In 2004, 227 pedestrians and 65 vehicle tracks were reported within posted bird resource closures, including those for piping plovers. However, no plover nests were known to be disturbed, and no plover chicks were known to be lost, although four other bird species were killed by ORVs in 2004 (NPS 2005a). In 2005, 135 pedestrian, 57 ORV, and 13 illegal dog entries into posted bird closures were recorded (NPS 2006d). In 2006 resource staff recorded 255 pedestrian, 47 ORV, 22 dog, and 5 horse violations of bird closures (NPS 2007c). In 2007, resource staff recorded 249 pedestrian, 25 ORV, 17 dog, and 1 horse violation of bird closures (NPS 2008c). During the 2008 breeding season, resource staff recorded 80 pedestrian, 11 ORV, 5 dog, and 1 boat violation of nesting plover closures (NPS 2009b). During the 2009 breeding season, resource staff documented 192 pedestrian, 8 ORV, 19 dog, 3 horse and 3 boat violations in the prenesting closures (Muiznieks pers. comm. 2009). Most illegal entries were not witnessed but documented based on vehicle, pedestrian, or dog tracks left behind.

Disturbance from vehicles, pedestrians, and pets can cause incubating ~~birds~~ shorebirds to be flushed from their nests and in some cases pets elicited a stronger response than people (Lafferty 2001a, 2001b; Thomas 2002; Peters and Otis 2006). Flushing can affect plover behavior and viability in a number of ways (Hoopes 1993; Peters and Otis 2006). Flushing of incubating plovers from nests can expose eggs to avian predators or excessive temperatures (Hoopes 1993). Repeated exposure of eggs to direct sunlight on hot days can cause overheating, which can kill avian embryos (Bergstrom 1989). In Texas, piping plovers

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avoided foraging on sand flats close to areas of high human use (Drake et al. 2001). Zonick (2000) found that the number of piping plovers was lower on disturbed bayside flats than on undisturbed flats, and piping plovers experienced lower foraging efficiency when disturbed. Hoopes (1993) documented a relationship between human recreation and piping plover foraging and chick survival. Other published (Smith 2007; Lott et al. 2009) and unpublished data (Houghton 2005) support the assertion that ~~winter~~ non-breeding habitat selection is negatively correlated with human activities and development ~~(Houghton 2005)~~. In New York, the response of incubating adults to the presence of humans near the nest was found to be highly variable, and average nest success was unrelated to the number of disturbance sources observed within 100 meters (328 feet) of nests (Houghton 2005). Other studies on the effect of human disturbance on incubating piping plovers documented highly variable flushing distances ranging anywhere between 20 and 200 meters (66 to 656 feet) (USFWS 1996a). However, piping plovers may be more sensitive to disturbance in the Atlantic Coast southern recovery unit, as evidenced by longer flush distances in response to disturbance sources at Assateague Island National Seashore (Loegering 1992). The study on Assateague Island found that on average, incubating plovers flushed from their nests at a distance of 78 meters (256 feet), although some birds flushed when researchers were as far as 174 meters (571 feet) away, indicating a much larger flushing distance than was documented by other studies.

Canid—The biological family of carnivorous and omnivorous mammals that includes the wolves, foxes, jackals, coyotes, and the domestic dog.

Unleashed pets have the potential to flush piping plovers, and these flushing events may be more prolonged than those associated with pedestrians or pedestrians with dogs on leash. For example, a study conducted on Cape Cod, Massachusetts, found that the average distance at which piping plovers were disturbed by pets was 46 meters (151 feet), compared with 23 meters (75 feet) for pedestrians. Birds flushed by pets moved farther (an average of 57 meters [187 feet]) than plovers reacting to pedestrians (an average of 25 meters [82 feet]). Duration of observed disturbance behaviors stimulated by pets was significantly greater than that caused by pedestrians (USFWS 1996a, 2009a). In 2002, there was evidence that a dog may have been responsible for the loss of a piping plover chick at Bodie Island. When a plover brood could not be found, large canid tracks were documented in the area where the brood was often seen foraging and resting. A professional trapper with the U.S. Department of Agriculture examined the prints and verified them as domestic dog tracks. The tracks were found running in a sharp turning pattern, seeming to indicate that the dog had been engaged in a chase. Scrape marks where the dog had clawed in the sand were also evident. The chick was not observed at the site thereafter (NPS 2004e).

Vehicles have been documented running over nests (Patterson et al. 1991) and birds on Assateague Island in Maryland and Virginia. In Massachusetts and New York, biologists found that 18 chicks and 2 adults were killed by vehicles between 1989 and 1993, even on beaches with only five to ten vehicles passes per day (Melvin et al. 1994). Piping plover chicks often move from the foredune area to forage along the wrack line and intertidal zone, which places them in the paths of vehicles. Chicks can end up in or near tire ruts, and sometimes have difficulty crossing or climbing out of them. The normal response of plover chicks to disturbance could increase their vulnerability to vehicles. Chicks sometimes stand motionless or crouch as vehicles approach, and their lack of rapid movement could lead to mortality (USFWS 1996a).

ORV use may also affect the beach through sand displacement and compaction (Anders and Leatherman 1987), which may lead to steeper dune profiles. This, in turn, may prove less suitable for piping plover nesting. Degradation of the wrack line is possible from as little as one vehicle pass (Leatherman and Godfrey 1979), and may negatively impact reproductive success due to the loss of important habitat used by foraging plovers (Hoopes 1993). Also, the wrack line provides habitat for many beach invertebrates, which are a staple of the plover diet.

Beach and dune renourishment projects can alter the profile of beaches, causing increased erosion and habitat loss (Leatherman 1985). Important dune-creation projects have been carried out along most of the Seashore, beginning in the 1930s. These may be affecting the ability of the Seashore to support piping plovers (Harrison and Trick pers. comm. 2005). A recent study theorized that beach nourishment projects may negatively impact plover habitat because the resulting dredge spoil is often fine-grained, reducing the availability of pebbles and cobbles, which are a preferred substrate for nesting plovers (Cohen, Wunker, and Fraser 2008). Furthermore, beach stabilization prevents normal storm processes, such as overwash fan formation, thereby leading to long-term loss of moist substrate habitat and to accelerated vegetative succession in potential nesting habitat (Dolan et al. 1973). Construction of artificial structures on beaches eliminates breeding territories and may result in an increased level of predation on and human disturbance of remaining pairs (Houghton 2005).

Research, surveying, and even protective management activities can sometimes expose piping plovers to a risk of disturbance at breeding sites. For example, adult birds may be more vulnerable to predation within exclosures (Murphy et al. 2003), depending on the local predator pool and the type of exclosure used. Adults may also abandon exclosed nests more frequently (Elliot-Smith and Haig 2004).

SEA TURTLES

Sea turtles are large marine reptiles found in subtropical, tropical, and temperate oceans, as well as subarctic areas. They spend the majority of their time in ocean waters, with females coming ashore only to nest on sandy beaches. Five of the seven sea turtle species existing in the world today occur in the coastal waters of North Carolina and the Seashore, and all are listed as either federally threatened or endangered. These five species are the loggerhead sea turtle, the green sea turtle, the Kemp's ridley sea turtle, the leatherback sea turtle, and the hawksbill sea turtle. Of the five species, only three are known to nest at the Seashore: the loggerhead, green, and leatherback sea turtles. The other two species, Kemp's ridley and hawksbill, are known to occur on the beaches of the Seashore only through occasional stranding, usually either due to death or incapacitation due to hypothermia, and are therefore not discussed further.

In 1978, the loggerhead turtle was federally listed as threatened (NMFS and USFWS 2008a). The NMFS and the USFWS are currently considering petitions to reclassify the loggerheads in the Northwest Atlantic as endangered. Also in 1978, the green turtle was federally listed as threatened, except for the breeding populations in Florida and on the Pacific Coast of Mexico, which were listed as endangered (NMFS and USFWS 1991). The leatherback turtle was listed as federally endangered in 1970 (NMFS and USFWS 1992a). All three species carry the same state listings as their federal listings (NCWRC 2008b).

The Seashore staff has been consistently monitoring for sea turtle nests since 1987. However, over the years both monitoring and managing techniques have changed, making data comparison difficult; therefore, only nesting data from 2000 to ~~2009~~ 2010 are presented, for these data are known to be accurate. The number of nests recorded at the Seashore from 2000 to ~~2009~~ 2010 has fluctuated greatly, with only ~~43~~43 nests recorded in 2004 and ~~112~~ 154[4] nests recorded in ~~2008~~2010, which was the highest number on record (NPS 2010a; Muiznieks pers. ~~Comm~~comm. 2010b~~2008a~~). ~~In 2009, there were 104 seas turtle nests recorded at the Seashore (Baker pers. comm. 2009a).~~ Of the three species that nest at the Seashore, the loggerhead turtle is by far the most numerous, comprising approximately ~~94~~95% of the known nests between 2000 and ~~2008~~2010 (NPS 2005c, 2007e, 2008a; 2009c; 2010a; Baker pers. comm. 2009a; Muiznieks pers. comm. 2010c). Green turtles and leatherbacks breed primarily in the tropics, with

[4] Turtle numbers for 2010 are current through August 27~~th~~ 2010; however, as of that date the nesting season is still ongoing and final numbers for 2010 may differ.

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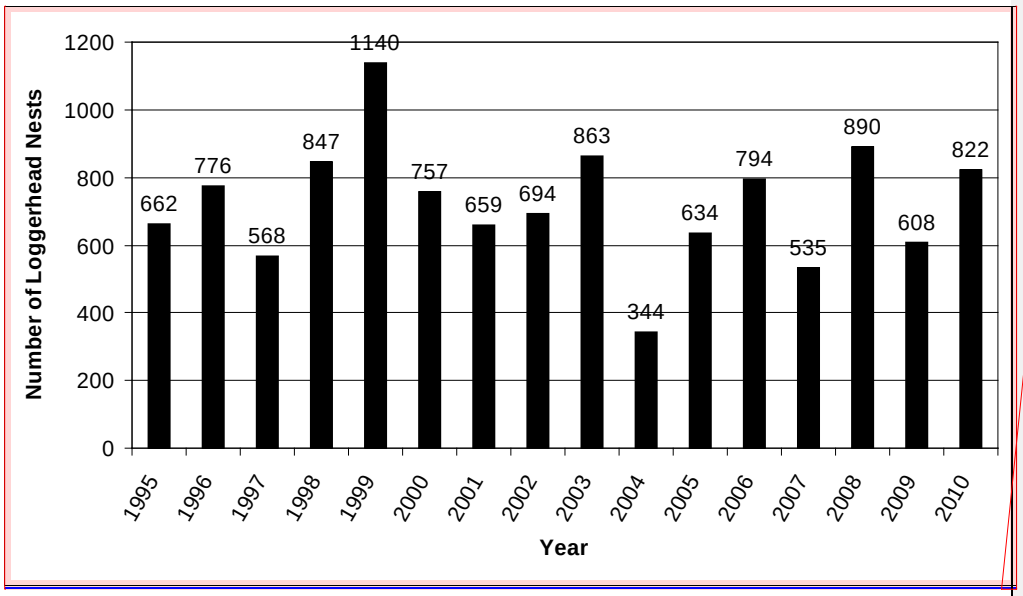
only small numbers nesting at higher latitudes. Green turtles have nested regularly at Cape Hatteras, but in fewer numbers, comprising only about 5% of the nests between 2000 and 2010~~2008~~, while leatherback turtles have nested infrequently at the Seashore, comprising only about 1% of the nests (NPS 2005c, 2007e, 2008a; 2009c; 2010a; Baker pers. comm. 2009a; Muiznieks pers. comm. 2010b). The vast majority of sea turtle nests occur on Hatteras and Ocracoke islands, with turtles occasionally nesting on Bodie Island (NPS 2000b, 2001c, 2002c, 2003e, 2005c, 2006e, 2007e, 2008a, 2009c, 2010a~~Baker pers. comm. 2009a~~).

Loggerhead Turtle

The loggerhead sea turtle occurs throughout the temperate and tropical regions of the Atlantic, Pacific, and Indian oceans. However, the two largest nesting rookeries occur along the western rims of the Atlantic and Indian oceans. Within the United States, the loggerhead turtle nests from Texas to Virginia, with the primary nesting concentrations found on the coastal islands of North Carolina, South Carolina, and Georgia, and on the Atlantic and Gulf coasts of Florida (NMFS and USFWS 2008a). Over the last decade, the total estimated nesting in the United States has fluctuated between 47,000 and 90,000 nests per year, with about 80% of the loggerhead nesting activity occurring in six counties in the state of Florida (NMFS and USFWS 2008a). Within the northern recovery unit as defined in the Loggerhead Recovery Plan (Florida/Georgia border to southern Virginia), studies of annual nest totals in South Carolina and Georgia have documented a decline in the number of nests (Ehrhart et al. 2003). However, since standardized surveying began in North Carolina in the mid-1990s, the number of loggerhead nests per season has remained fairly stable, averaging ~~724~~ 729 nests from 1995 through ~~2008~~ 2010 (figure 12) (Godfrey pers. comm. 2005b, 2008, 2010a, 2010b; seaturtle.org 2010~~Godfrey pers. comm. 2005b, 2008; Muiznieks pers. com. 2009~~).

Loggerhead Turtle
Credit: NPS



Source: Godfrey pers. comm. 2005b, 2008, 2010a, 2010b; seaturtle.orgGodfrey pers. comm. 2005b, 2008; Muiznieks pers. comm. 2009

FIGURE 12. NUMBERS OF LOGGERHEAD TURTLE NESTS IN NORTH CAROLINA, 1995–2008[5]2010[5]

Between 2000 and 2009 the average number of loggerhead nests at the Seashore was 79, with the lowest number of nests occurring in 2004 and the highest number of nests occurring in 2008 (figure 13) (NPS 2007e, 2008a, 2009c, 2010a; Baker pers. comm. 2009a). However, in 2010 a record-breaking high number of 150 loggerhead nests were laid at the Seashore (Muiznieks pers. comm. 2010b)[6]While only 40 loggerhead nests were laid at Cape Hatteras in 2004, it was a poor nesting year for the entire southeast Atlantic Coast (NPS 2005c).

Loggerhead turtles spend the majority of their life at sea, with only mature females coming ashore to nest every two to three years, on average (Schroeder et al. 2003). The first turtle nests (all turtle species included) typically begin to appear at Cape Hatteras in mid-May, and the last nests are usually deposited in late August (NPS 2000b, 2001c, 2002c, 2003e, 2005c, 2006e, 2007e, 2008a, 2009c, 2010aBaker pers. comm. 2009a). Although three nests were found prior to May 15 (two of which were leatherback nests), and 4 nests have been found after September 1, it is important to note that prior to 2008, nest patrols were conducted only from June 1 through August 31 (2001–2005), or May 15 through September 15 (2006 and 2007). Any nests laid outside of that timeframe had a greater likelihood of not being found and protected by resource management staffwere unlikely to be found and protected by resource management staff (Baker pers. comm. 2009a).

[5] North Carolina turtle nest countsnumbers for 2010 were obtained from seaturtle.org on August 30, 2010. However, there is sometimes a lag of several days for data entry, so the date may not completely reflect all of the nests in North Carolina as of August 30, 2010. Also, as of that date, the nesting season is still ongoing, and the final number of loggerhead nests in North Carolina for 2010 may differ.

[6] Turtle nest numbers for the Seashore in 2010 are current through August 27, 2010; however, as of that date the nesting season is still ongoing, and the final number of loggerhead nests for 2010 may differ.

Comment [dw13]: Numbers look fuzzy

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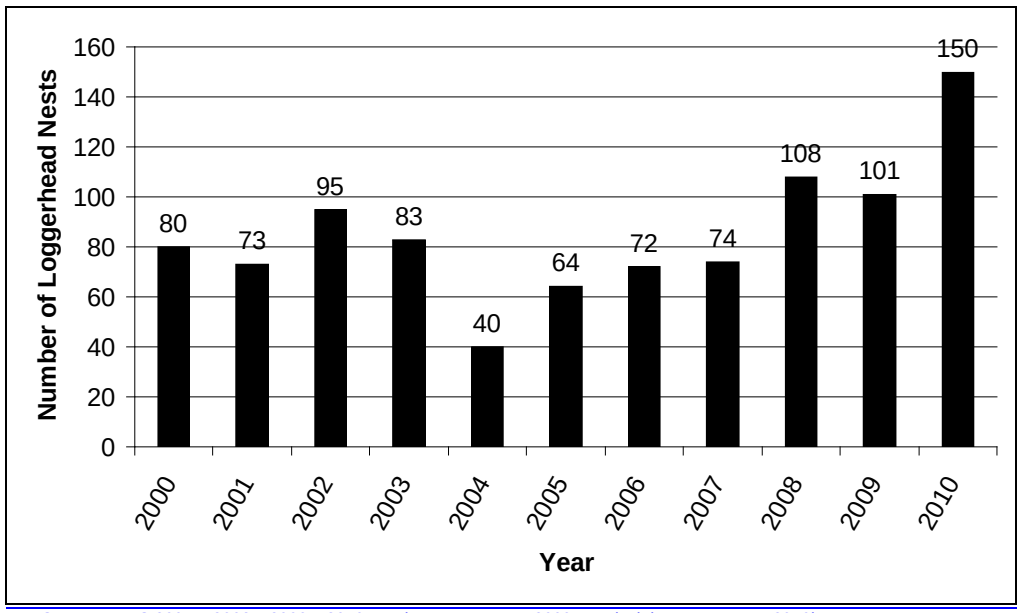
Typical nesting areas for loggerheads tend to be sandy, wide, open beaches, backed by low dunes (Miller et al. 2003). Some factors that have been found to determine nest selection include beach slope, temperature, distance to the ocean, sand type, and moisture, though results were occasionally contradictory (Miller et al. 2003).



Sources: NPS 2007e; 2008c; 2009c, 2010a; Baker pers. comm. 2009a; Muiznieks pers. comm. 2010b

~~Sources: NPS 2006b; 2008c; 2009c; Baker pers. comm. 2009a.~~

Figure 13. Numbers of Loggerhead Turtle Nests at Cape Hatteras National Seashore, 2000–~~2009~~2010

Comment [dw14]: FONT

Although the process of nest site selection is not well understood, a successful nest must be laid in a low salinity, high humidity, well-ventilated substrate that is not prone to flooding or burying because of tides and storms and where temperatures are optimal for development (Miller et al. 2003).

At the Seashore, between 2000 and 2009 (excluding 2005 relocation data that cannot be verified), on average, 25% of the nests found (all turtle species included) were relocated from their original location by Seashore staff. Of those nests, 81~~82~~% were relocated for natural causes (e.g., in areas prone to flooding [below the high tide line], in an area prone to erosion, etc.), ~~14~~13% were relocated because of potential human disturbance, primarily because they were within one mile of a lighted fishing pier, 3% were relocated due to both environment and human disturbance issues, and ~~4~~3% were moved during storm events later into incubation (~~Baker pers. comm. 2009a~~Muiznieks pers. comm. 2010c).

Comment [dw15]: Why were these numbers changed? Was 2005 data removed? Was 2010 data added?

~~Of those nests, 79% were relocated for natural causes (e.g., in areas prone to flooding [below the high tide line], in an area prone to erosion, etc.), while the rest were relocated because of potential human~~

~~disturbance, primarily because they were within one mile of a lighted fishing pier (NPS 2001c, 2002c, 2003c, 2005c, 2006c, 2008a, 2009c; Sayles pers. comm. 2005).~~ The practice of relocating nests for recreation or lighting issues is not encouraged by the USFWS; therefore, beginning in 2006 nests were no longer relocated for recreational access issues and starting in 2007 nests were no longer relocated based on distance to a lighted fishing pier. As a result, the average number of nests relocated each year from 2006 to ~~2008~~ 2009 decreased to ~~18~~21% of the nests found (NPS ~~2006c~~2007e, 2008a, 2009c, 2010a).

Loggerheads are nocturnal nesters. Females emerge from the ocean and crawl toward the dune line until they encounter a suitable nest site. The female clears away surface debris with her front flippers, creating a "body pit," and then excavates a flask-shaped nest cavity with her hind flippers. Loggerheads throughout the southeastern United States lay an average of 100 to 126 eggs per nest (NMFS and USFWS 2008a). After laying her eggs, the female covers the nest with sand, and she crawls back to the sea.

Individual females may nest one to six times per nesting season, at an average interval of 12 to 15 days (NMFS and USFWS 2008a). Loggerheads do not produce clutches in successive years very often with nesting years typically separated by two to three years of foraging in between (NMFS and USFWS 2008a). The nest incubation period (from laying to hatching) depends on temperature and ranges from 49 to 68 days in North Carolina with an average of about 55 days (USFWS n.d.). The sex ratio of hatchlings also depends on temperature during incubation. Below 84.6°F, more males are produced than females, and above that temperature, more females are produced (Mrosovsky 1988). For this reason, the northern part of the U.S. Atlantic population, which includes North Carolina, apparently provides a disproportionate number of males to the larger population, which is important for the stability of the population as a whole (Mrosovsky et al. 1984; Hanson et al. 1998).

Hatchling emergence occurs almost exclusively at night (Mrosovsky 1968; Witherington et al. 1990) and may occur over several nights. Upon emerging from the nest, hatchlings primarily use light cues to find and move toward the sea (Witherington and Martin 1996). Once in the water, they swim incessantly out to sea to offshore habitats where they will spend the next phase of their life history.

Green Turtle

The green turtle is a circumglobal species in tropical and subtropical waters. The major green turtle nesting colonies in the Atlantic Ocean occur on Ascension Island, Aves Island, Costa Rica, and Surinam (NMFS and USFWS 1991). Nesting in the United States occurs in small numbers in the U.S. Virgin Islands and on Puerto Rico and in larger numbers along the east coast of Florida, particularly in Brevard, Indian River, St. Lucie, Martin, Palm Beach, and Broward counties. North Carolina is near the northern limits of its nesting area.

Green Turtle
Credit: Michael Lusk / USFWS

Nesting habits for the green turtle are very similar to those of the loggerhead turtle, with only slight differences. Average clutch sizes range from 110 to 115 eggs, although this varies by population, and females produce clutches in successive years only occasionally. Usually two to four years or more occur between breeding seasons (NMFS and USFWS 1991).

From 2000 to 2009, there was an annual average of four green turtle nests at the Seashore, with a peak of nine nests in 2005 (Baker pers. comm. 2009a).~~.~~ In 2010, four~~4~~ green turtle nests were laid at the Seashore (Muiznieks pers. comm. 2010b).[7]

Leatherback Turtle

Leatherback nesting grounds are distributed circumglobally, with the largest known nesting area occurring on the Pacific Coast of southern Mexico. Nesting in the United States occurs primarily in Puerto Rico, the U.S. Virgin Islands, and southeastern Florida (NMFS and USFWS 1992a).

Leatherback Turtle
Credit: USFWS

Leatherback nesting at the Seashore was first documented in 1998 and has subsequently been documented in 2000, 2002, 2007, and 2009, totaling six nests since 2000 (~~NPS 2001c;~~ NPS 2008a, 2010a~~, 2009c~~; Baker pers. comm. 2009a). No leatherback nests were documented in 2010 (Muiznieks pers. comm. 2010b).[8] Since the species has a minimum of two years between nesting cycles, it is not known if more than one female of the species uses the Seashore as a nesting ground. Until 2009 the Seashore was the northernmost nesting location on record for this species (Rabon et al. 2003). However, in 2009 a leatherback nested in Kill Devil Hills, North Carolina, which currently represents the northernmost nest ever found from this species (Baker pers. comm. 2009c~~a~~).

Leatherback nesting habits are very similar to those of the loggerhead turtle, although they tend to begin and end nesting earlier in the year than the loggerhead (NMFS and USFWS 1992a). Since 1999, the only two nests laid in April at the Seashore have been leatherbacks (NPS 2000b, 2008a). Leatherbacks are thought to migrate to their nesting beach about every two to three years (NMFS and USFWS 1992a; Miller 1997). Clutch size averages 116 eggs, and the incubation period averages 55 to 75 days. It is also reported that leatherback turtles nest an average of five to seven times per year, with an average interval of nine to ten days between nesting (NMFS and USFWS 1992a).

Potential Threats

Threats to the loggerhead turtle on nesting grounds, as outlined in their recovery plan (NMFS and USFWS 2008a), are representative of those also faced by green and leatherback turtles. The following discussion of threats to sea turtles is taken from the 2008 revised Loggerhead Sea Turtle Recovery Plan, which has been updated with more recent research on potential threats to these species that, in some cases, was not available at the time of the 1991 recovery plan.

Human Presence. The greatest threat posed by humans on the beach at night is disturbance of female turtles before they have finished nesting. 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. Females that abort a nesting attempt may attempt to nest again at or near the same location or select a new site later that night or the following night. However, repeated interruption of nesting

[7] Turtle nest numbers for the Seashore in 2010 are current through August 27, 2010; however, as of that date the nesting season is still ongoing, and the final number of green turtle nests for 2010 may differ.
[8] Turtle nest numbers for the Seashore in 2010 are current through August 27, 2010; however, as of that date the nesting season is still ongoing, and the final number of leatherback turtle nests for 2010 may differ.

attempts may cause a turtle to construct her nest in a sub-optimum incubation environment, postpone nesting for several days, prompt movement many kilometers from the originally chosen nesting site, or result in the shedding of eggs at sea. Direct harassment may also cause adult turtles to reduce the time spent covering the nest. Visitors using flashlights or lanterns or lighting campfires on the beach at night during the nesting season may deter nesting females from coming ashore and may disorient hatchlings. In addition, heavy pedestrian traffic may compact sand over unmarked nests, although the effect of this compaction has not been determined and may be negligible. Depending on the nesting substrate, pedestrian traffic over nests near the time of emergence can cause nests to collapse and result in hatchling mortality. A study in Japan found loggerhead nests laid in beach areas with pedestrian access had higher rates of dead pipped hatchlings than nests laid in restricted beach zones (USFWS and NMFS 2008).

Recreational Beach Equipment. The use and storage of lounge chairs, cabanas, umbrellas, catamarans, and other types of recreational equipment on the beach can hamper or deter nesting by adult females and trap or impede hatchlings during their nest-to-sea migration. The documentation of non-nesting emergences (also referred to as false crawls) at these obstacles is becoming increasingly common as more recreational beach equipment is left on the beach at night. Nesting turtles have been documented being deterred by wooden lounge chairs that prevented access to the upper beach. Additionally, there are documented reports of nesting females being trapped under heavy wooden lounge chairs and cabanas, eggs being destroyed by equipment (e.g., beach umbrellas penetrating the egg chamber), and hatchlings being hampered during emergence by equipment inadvertently placed on top of the nest (USFWS and NMFS 2008).

Beach Vehicular Driving. Operating privately owned vehicles on nesting beaches for recreational purposes or beach access is allowed on certain beaches in northeast Florida (Nassau, Duval, St. Johns, and Volusia counties), northwest Florida (Walton and Gulf counties), Georgia (Cumberland, Little Cumberland, and Sapelo islands), North Carolina (Fort Fisher State Recreation Area, Carolina Beach, Freeman Park, Onslow Beach, Emerald Isle, Indian Beach / Salter Path, Pine Knoll Shores, Atlantic Beach, Cape Lookout National Seashore, Cape Hatteras National Seashore, Nags Head, Kill Devil Hills, town of Duck, and Currituck Banks), Virginia (Chincoteague NWR and Wallops Island), and Texas (the majority of beaches except for a highly developed section of South Padre Island and Padre Island National Seashore, San Jose Island, Matagorda Island, and Matagorda Peninsula where driving is not allowed or is limited to agency personnel, land owners, and/or researchers). Operating vehicles to conduct scientific research and management is generally allowed throughout the loggerhead's nesting range. The presence of vehicles on the beach has the potential to negatively impact sea turtles by running over nesting females, hatchlings, stranded turtles that have washed ashore, and nests. In addition, the ruts left by vehicles in the sand may prevent or impede hatchlings from reaching the ocean following emergence from the nest. Hatchlings impeded by vehicle ruts are at greater risk of death from predation, fatigue, desiccation, and being crushed by additional vehicle traffic. Vehicle lights and vehicle movement on the beach after dark can deter females from nesting and disorient hatchlings. Sand compaction due to vehicles on the beach may hinder nest construction and hatchling emergence from nests. Driving directly above incubating egg clutches can cause sand compaction, which may decrease hatching success and directly kill pre-emergent hatchlings. Additionally, vehicle traffic on nesting beaches may contribute to erosion, especially during high tides or on narrow beaches where driving is concentrated on the high beach and foredune (USFWS and NMFS 2008).

Research and Conservation Management Activities. Research and conservation management activities (e.g., nesting surveys, tagging of nesting females, nest manipulation) are tools to advance the recovery of the loggerhead; however, they have the potential to adversely affect nesting females, hatchlings, and developing embryos if not properly conducted. Research and conservation management activities should be carefully evaluated to determine their potential risks and conservation benefits. The States, in cooperation with the USFWS, have established permitting programs to ensure that proposed research and

conservation activities are necessary for recovery, carried out by appropriately trained persons, non-duplicative, the least manipulative possible, and carried out in such a way to minimize chances of mortality. A low level of lethal take is authorized annually for research and conservation purposes. Under conditions where the conservation benefits (e.g., embryo survivorship, hatchling survivorship, conservation knowledge gained) are forecast to substantially outweigh the potential conservation risks, certain activities can be considered beneficial to loggerhead recovery. Most research and conservation management activities are likely to have minimal effects on nesting turtles, hatchlings, and developing embryos when conducted in accordance with established protocols designed to minimize disturbance and risk. On many beaches, surveyors use small 4-wheeled ATVs with low-pressure (<5 psi) tires that minimally impact nesting habitat. In addition, almost all surveys to count nests are conducted after sunrise when encounters with nesting turtles and emergent hatchlings are unlikely. Research activities, such as flipper and pit tagging, blood sampling, skin sampling, satellite and radio transmitter attachment, and hatchling orientation surveys, have a minimal effect on individual turtles when conducted according to established guidelines (e.g., Florida Fish and Wildlife Conservation Commission Marine Turtle Conservation Guidelines). Potential benefits from this research include important insight into population structure, species health, habitat use, and other important aspects of loggerhead biology and ecology. Nest relocation is a management technique for protecting nests that are predicted to be destroyed by environmental factors, such as erosion or repeated tidal inundation, or permitted human activities, such as beach nourishment during the nesting season. However, the unnecessary relocation of nests may result in negative impacts to eggs and hatchlings. Historically, the relocation of sea turtle nests to higher beach elevations or into hatcheries was a regularly recommended conservation management activity throughout the southeast United States. However, advances in our knowledge of the incubation environment have provided important information to guide nest management practices. Nests located where there are threats from beachfront lighting, foot traffic, and mammalian predators can be effectively managed by addressing the threat directly or by protecting the nest in situ rather than by moving the nest. In situ protection, which addresses the root causes of egg and hatchling mortality, is in keeping with Frazer's (1992) call to move away from "halfway technology." Increased understanding of the potential adverse effects associated with nest relocation, restraint of hatchlings, and concentrated hatchling releases has resulted in less manipulative management strategies to protect nests and hatchlings. The Florida Fish and Wildlife Conservation Commission's sea turtle conservation guidelines consider nest relocation to be a management technique of last resort. At training workshops, nest monitors are advised to relocate nests only if they are certain that the nest will otherwise be lost, and if this certainty is based on extensive experience at the specific beach. Recovery Action 6111 describes development of protocols by which managers could identify threatened nests with greater precision, thereby minimizing the number of nests that are relocated (USFWS and NMFS 2008).

Beach Erosion and Accretion. Natural beach erosion events may influence the quality of nesting habitat. Nesting females may deposit eggs at the base of an escarpment formed during an erosion event where they are more susceptible to repeated tidal inundation. Erosion, frequent or prolonged tidal inundation, and accretion can negatively affect incubating egg clutches. Short-term erosion events (e.g., atmospheric fronts, Nor'easter storms, tropical storms, and hurricanes) are common phenomena throughout the loggerhead nesting range and may vary considerably from year to year. Sea turtles have evolved a strategy to offset these natural events by laying large numbers of eggs and by distributing their nests both spatially and temporally. Thus, the total annual hatchling production is never fully affected by storm-generated beach erosion and inundation, although local effects may be high. For example, storm-induced mortality in the Dry Tortugas Recovery Unit has been high during years of high tropical storm activity and may limit recovery. However, human activities along coastlines can accelerate erosion rates, interrupt natural shoreline migration, and reduce both the quantity and quality of available nesting habitat. During erosion events, some nests may be uncovered or completely washed away. Nests that are not washed away may suffer reduced reproductive success as the result of frequent or prolonged tidal inundation. Eggs saturated with seawater are susceptible to embryonic mortality. However, in spite of the potential

for reduced hatching success, loggerhead eggs can successfully survive periodic tidal inundation. Studies have shown that although frequent or prolonged tidal inundation resulted in fewer emergent hatchlings, occasional overwash of nests appeared to have minimal effect on reproductive success. Accretion of sand above incubating nests may also result in egg and hatchling mortality (USFWS and NMFS 2008).

Light Pollution. Both nesting and hatchling sea turtles are adversely affected by the presence of artificial lighting on or near the beach. Experimental studies have shown that artificial lighting deters adult female turtles from emerging from the ocean to nest. A 1986 study noted that loggerheads aborted nesting attempts at a greater frequency in lighted areas. Because adult females rely on visual brightness cues to find their way back to the ocean after nesting, those turtles that nest on lighted beaches may become disoriented (unable to maintain constant directional movement) or misoriented (able to maintain constant directional movement but in the wrong direction) by artificial lighting and have difficulty finding their way back to the ocean. In some cases, misdirected nesting females have crawled onto coastal highways and have been struck and killed by vehicles. Hatchlings exhibit a robust sea-finding behavior guided by visual cues, and direct and timely migration from the nest to sea is critical to their survivorship. Although the mechanism involved in sea-finding is complex, involving cues from both brightness and shape, it is clear that strong brightness stimuli can override other competing cues. Hatchlings have a tendency to orient toward the brightest direction as integrated over a broad horizontal area. On natural undeveloped beaches, the brightest direction is commonly away from elevated shapes (e.g., dune, vegetation, etc.) and their silhouettes and toward the broad open horizon of the sea. On developed beaches, the brightest direction is often away from the ocean and toward lighted structures. Hatchlings unable to find the ocean, or delayed in reaching it, are likely to incur high mortality from dehydration, exhaustion, or predation. Hatchlings lured into lighted parking lots or toward streetlights are often crushed by passing vehicles. Uncommonly intense artificial lighting can draw hatchlings back out of the surf. Although the attributes that can make a light source harmful to sea turtles are complex, a simple rule has proven useful in identifying lights that pose potential problems for sea turtles. Researchers propose that artificial light sources are “likely to cause problems for sea turtles if light from the source can be seen by an observer standing anywhere on the beach.” This visible light can come directly from any glowing portion of a luminaire, including the lamp, globe, or reflector, or indirectly by reflection from buildings or trees that are visible from the beach. Bright or numerous light sources, especially those directed upward, will illuminate sea mist and low clouds, creating a distinct sky glow visible from the beach. Field research suggests hatchling orientation can be disrupted by the sky glow from heavily lighted coastal areas even when no direct lighting is visible. The ephemeral nature of evidence from hatchling disorientation and mortality makes it difficult to accurately assess how many hatchlings are misdirected and killed by artificial lighting. Reports of hatchling disorientation events in Florida describe several hundred nests each year and are likely to involve tens of thousands of hatchlings. However, this number calculated from disorientation reports is likely a vast underestimate. Independent of these reports, researchers surveyed hatchling orientation at nests located at 23 representative beaches in six counties around Florida in 1993 and 1994 and found that, by county, approximately 10 to 30% of nests showed evidence of hatchlings disoriented by lighting. From this survey and from measures of hatchling production, the number of hatchlings disoriented by lighting in Florida is calculated in the range of hundreds of thousands per year (USFWS and NMFS 2008).

Beach Debris. Hatchlings often must navigate through a variety of obstacles before reaching the ocean. These include natural and human-made debris. Debris on the beach may interfere with a hatchling’s progress toward the ocean. Research has shown that travel times of hatchlings from the nest to the water may be extended when traversing areas of heavy foot traffic or vehicular ruts; the same is true of debris on the beach. Hatchlings may be upended and spend both time and energy in righting themselves. Some beach debris may have the potential to trap hatchlings and prevent them from successfully reaching the ocean. In addition, debris over the tops of nests may impede or prevent hatchling emergence.

Natural Catastrophes. Periodic, short-term, weather-related erosion events (e.g., atmospheric fronts, Nor'easter storms, tropical storms, and hurricanes) are common phenomena throughout the loggerhead nesting range and may vary considerably from year to year. It was reported that 24.5% of all loggerhead nests laid on Deerfield Beach, Florida, in 1992 were lost or destroyed by Hurricane Andrew as a result of storm surge (NMFS and USFWS 2008a). Similarly, Martin (1996) reported a 22.7% loss of total loggerhead nest production on the southern portion of Hutchinson Island, Florida, during the passage of Hurricane Erin in 1995. Ehrhart and Witherington (1987) reported a 19% loss of loggerhead nests at Melbourne Beach, Florida, after a 5-day Nor'easter storm in 1985. In Georgia, 16% of loggerhead nests were lost to tropical storm systems in 2001; nest loss was particularly high on Sapelo (54%) and Little Cumberland islands (28%). On Fisher Island in Florida, it was reported that hatchling emerging success decreased significantly following Hurricane Andrew in 1992 (NMFS and USFWS 2008a). They found that hatchlings were unable to emerge from nests where sand had accreted in large quantities and that these hatchlings probably died from asphyxiation or exhaustion while struggling to emerge from the nests. Sea turtles have evolved a strategy to offset these natural events by laying large numbers of eggs and by distributing their nests both spatially and temporally.

Threat Occurrences at Cape Hatteras National Seashore. The following data and discussions are from the Seashore's annual sea turtle reports, 1999 to 2009, and include all turtle species (NPS 2000b, 2001c, 2002c, 2003e, 2005c, 2006e, 2007e, 2008a, 2009c, 2010a; Sayles pers. comm. 2005).

The majority of turtle nest losses at the Seashore from 1999 to 2009 were weather related, particularly due to hurricanes and other non-tropical storms. Nest losses resulted from storms washing them away, burying them under feet of sand, or drowning them in the flooding tides. ~~Nest losses due to storms are the result of them being completely washed away due to erosion, being buried under feet of sand, or drowned by flooding tides.~~ During this time period, seven hurricanes made landfall and impacted nests. In 2003, 34 of 87 nests hatched before Hurricane Isabel hit. Afterward, none of the remaining 52 nests (60%) could be found, and the water and sand movement along the beaches left no evidence of their previous existence. In 2006, 30% of the nests (23 of 76 nests) were either lost to heavy seas or drowned by flooding tides. In 2007, five nests (6%) were lost; in 2008, six nests (5%) were lost and another 16 nests experienced decreased nest success due to two tropical storms. In 2009, six nests (6%) were lost to storms and another 25 experienced a severe decrease in nest success due to individual storms. Additionally, many other nests over the years have experienced reduced hatching success due to storm overwash that could not be correlated to any one particular storm event.~~During this time period, seven hurricanes made landfall and caused impacts to nests. As an example of the impacts storms have, in 2003, Hurricane Isabel destroyed 52 of the 87 nests (60%) (34 had hatched before the storm), and there was so much water and sand movement along the beaches that no evidence of any nests could be found afterward. In 2006, 30% of the nests (23 of 76 nests) were either physically lost to heavy seas or drowned by flooding tides. In 2007, 5 nests (6%) were lost, in 2008 6 nests (5%) were lost and another 16 nests saw a severe decrease in nest success due to two tropical storms. In 2009 6 nests (6%) were lost to storms with another 25 nests experiencing a severe decrease in nests success due to individual storms. Additionally, many other nests over the years have experienced reduced hatching success due to storm overwash that could not be correlated to any one particular storm event.~~

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~~The majority of turtle nest losses at the Seashore from 1999 to 2007 were weather related, particularly due to hurricanes and other storms. During this time, six hurricanes caused impacts to nests. In 2003, Hurricane Isabel destroyed 52 of the 87 nests (34 had hatched before the storm); there was so much water~~

~~and sand movement along the beaches that no evidence of any nests could be found afterward. The Seashore also felt the effects of numerous tropical storms and hurricanes as they passed by offshore.~~

Foxes were first seen at the Seashore in 1999 and on Hatteras Island in the winter of 2001–2002. Foxes disturbed or destroyed turtle nests in 5 of the ~~10~~ 11 years between 1999 and ~~2008~~2009, with the number of nests disturbed or destroyed ranging from one to nine nests per year. Ghost crab predation has been reported sporadically from 1999 to ~~2008~~2009, with 0 to ~~26~~ 27 nests per year recorded as having either ghost crab holes burrowed deep into the nest cavity and/or eggshell fragments found on top of the sand in association with crab tracks.

Pedestrian tracks have been recorded inside closures, with counts ranging from 8 to 92 intrusions per year. Pedestrians disturbed or destroyed two to six nests per year from 1999 to ~~2008~~ 2009 by digging at the nest site; however, no pedestrian disturbances occurred in 2003, and no data were available for 2005.

Many, but not all, ORV users respect sea turtle nest protection areas. Since 1999, recorded violations of sea turtle nest protection areas by ORVs have ranged annually from 13 to 45 sets of tracks inside closures, though a total of 130 sets of tracks were documented in 2000 and 102 sets of tracks were documented in 2001. Most, but not all, of these ORV violations occurred when ORVs drove in front of nest areas during periods of low tide. Incidents of ORVs causing property damage to signs, posts, and twine marking the sea turtle nest protection areas have also been documented. From 1999 to ~~2008~~2009, the number of incidents where ORVs caused property damage generally ranged from 3 to 9 incidents annually, although a total of 28 incidents were recorded in 2000 and a total of 146 incidents were recorded in 2001. ORVs drove over four to five nests per year from 2000 to 2002; however, the nests survived. ~~In 2007, two nests~~Two nests in 2007 and one nest in 2008 were known to have been run over by ORVs before they were found during the morning turtle patrol and fenced off. Of these three nests, the 2008 nest and ~~One~~ ~~O~~one of the~~in~~ 2007 nests~~and the nest in 2008~~ ~~nest~~ appeared undamaged; however,~~, but~~ four eggs were crushed in the second 2007 nest. In 2004, a total of ten hatchlings were killed by vehicles in two separate incidents.

Comment [dw16]: Only change specific words/numbers that need updating. Wholesale replacement of text should not occur unless absolutely necessary.

Comment [dw17]: Don't change this.

A consent decree exists at the Seashore, prohibiting night driving (between 10:00 p.m. and 6:00 a.m.) from May 1 to November 15. In 2009, despite operating under the consent decree, requiring expanded buffers be implemented after acts of deliberate closure violations/vandalism, two occurrences of deliberate violations were recorded (NPS ~~2009d~~2010a). In 2010, an ORV driving on the beach at night, in violation of the consent decree, struck and killed a nesting female loggerhead turtle during the nighttime hours between June 23 and June 24. The turtle had crawled out of the ocean and attempted to lay a nest between Ramps 70 and 72 on Ocracoke Island. -The ORV hit the turtle ~~was hit by an ORV~~ and dragged her approximately 12 feet, causing fatal injuries ~~to the turtle~~. -The turtle was found dead by NPS turtle patrol at 6:10 a.m. on June 24. This particular incidence ~~and it~~ is believed to be the first time documented that a nesting sea turtle has been killed by an ORV at the Seashore (NPS 2010b). ~~The consent decree~~

Comment [seh18]: Do not add this new sentence. It's awkward not needed here.

Comment [seh19]: Leave it the way you had it first.

~~prohibits night driving between the hours of 10:00 p.m. and 6:00 a.m. from May 1 to November 15.~~

Source: NPS 2010b. Nesting Female Loggerhead Killed by ORV in 2010. NPS photo of scene showing turtle carcass (between ORV tracks) and drag marks

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Comment [dw20]: Use other photo from press release.

Dogs disturbed or destroyed two nests in 2000, and 5 to 60 sets of dog tracks per year have been recorded inside closures. In 2008, cats were documented ~~predating~~ preying on emerging hatchlings at several nests, all within the villages. This was the first year in which this was documented; however, 10 to 50 sets of cat tracks per year were counted inside turtle closures from 2000 to ~~2002,~~2002 and in 2009 cat tracks were found within at least 20 turtle closures, most commonly in the village areas.

The total number of pedestrian, vehicle, and pet violations are conservative estimates, for often the actual numbers could not be determined. Footprints and tracks are often recorded as a single violation, when an undeterminable number of tracks through an area may actually represent multiple violations. Also, tracks below the expanded nest closures are often washed out by the tide before being discovered by the turtle patrol.

Documented beach fires totaled 174 in 2000 and 773 in 2001. Such fires may misdirect adults and emergent hatchlings. In 2006, an adult turtle crawl was discovered going into the coals of a beach fire, and in 2007, a turtle approached a beach fire, which visitors quickly extinguished prior to the turtle laying her nest about 2 feet from the fire site. In 2008, several hatchlings were found entering a fire and were recovered and released. It was unknown how many died prior to the hatchlings being noticed. Hatchlings being misdirected by lights from villages and other human structures is a common occurrence at the Seashore. In 2009, the NPS documented tracks which indicated that a nesting female sea turtle crawled up to a still--warm fire pit, ~~at which point the animal~~ turned around, and went back into the water.

Comment [dw21]: Is she "nesting" if she didn't lay a nest?

Comment [dw22]: How do we know it was warm when the turtle was there?

There have also been documented reports in 2000, 2001, 2007, ~~and~~ 2008, and 2009 and an unconfirmed report in 2006, of adult turtles aborting nesting attempts when visitors approached the turtles with flashlights, vehicle lights, or flash photography. Because the beaches are not patrolled 24 hours a day, it is likely that more disturbances of this nature occur but go undocumented.

Since 2001, Seashore staff members have been tying notices to personal property found on the beach after dawn, advising owners of the threats to nesting sea turtles, and then removing the items, when possible, if they remain on the beach 24 hours after tagging (NPS 2008a).

SEABEACH AMARANTH

Seabeach Amaranth

Credit: Gene Nieminen / USFWS

Seabeach amaranth is an annual plant native to barrier-island beaches along the U.S. Atlantic Coast, including those within the Seashore. Historically, seabeach amaranth was found in nine states, from Massachusetts to South Carolina. It was federally listed as threatened by the USFWS in 1993 because of its vulnerability to human and natural impacts and the fact that it had been eliminated from two-thirds of its historic range (USFWS 1996b). Since its listing, seabeach amaranth has reappeared in several states and is currently found in New York, New Jersey, Delaware, Maryland, Virginia, North Carolina, and South Carolina. Despite its reappearance in several states, the plant remains highly vulnerable to the threats that caused its listing, and in some states, populations continue to decline (USFWS 2005b).

This species is listed as threatened by the State of North Carolina (NCNHP 2006). Within North Carolina, from 2002 to 2003, the number of plants increased from 5,700 to 9,300 along 112 miles of beach (Cohen et al. ~~in press~~2010), only a fraction of the approximately 40,000 plants reported in the late 1980s and 1995 (Suiter pers. comm. 2005). Within the Seashore, seabeach amaranth numbers ranged from 550 to nearly 16,000 plants between 1985 and 1990 (table 25). However, in the last 10 years a maximum of only 93 plants was observed in 2002. More recently, only one plant was found in 2004 and two plants in 2005. Since 2005, no plants have been found within the Seashore.

TABLE 25. NUMBERS OF NATURALLY OCCURRING PLANTS OF SEABEACH AMARANTH AT CAPE HATTERAS NATIONAL SEASHORE, 1985–2008

	1985	1986	1987	1988	1990	1993	1994
Number of seabeach amaranth	550	600	6,883	15,828	3,332	0	0

	1995	1996	1997	1998	1999	2000	2001
Number of seabeach amaranth	1	98	81	265	8	2	51

	2002	2003	2004	2005	2006	2007	2008
Number of seabeach amaranth	93	30	1	2	0	0	0

Source: NPS 2009e

Seabeach amaranth is a low-growing annual, with stems that trail along the ground but do not root. The stems are reddish in color, fleshy, grow to 4 to 24 inches in length, and have round, fleshy, dark green leaves (0.4 to 0.6 inches long) clustered near the tips. Plants must recruit annually from seed banks, either in place or from other source populations dispersed by wind, water, or sediments distributed by anthropogenic (human) factors, such as beach renourishment (Jolls et al. 2004). Seeds must be scarified (the seed coat broken by nicking or abrasion) or cold stratified (chilling for weeks) before germination can occur (Cohen et al. ~~in press~~2010). Germination takes place from April through July; initially, a small sprig forms, which soon begins to branch into a clump. At the Seashore, seedlings are usually visibly detectable beginning in June (Lyons pers. comm. 2005b). Plants are typically 10 to 12 inches in diameter, consisting of 5 to 20 branches, though occasionally a clump may get as large 3 feet or more across, with more than 100 branches (USFWS 1993; NJDEP 2005).

Flowering begins when plants are of sufficient size, often in June but more typically in July, and continues until the plants die in late fall or early winter. The species is a prolific seed producer, with seed production beginning in July or August and usually reaching a peak in September. Seed production continues until the plant dies. The seeds are relatively large (0.1 inch), believed to be viable for long periods of time (decades), and contained in indehiscent utricles (a fruit pouch that does not split open spontaneously at maturity to release its seed). Though the utricles are normally indehiscent, it is not unusual to see them splitting open, either before or after their detachment from the plant. Splitting or fragmentation of the utricle occurs under conditions of agitation (by wind), abrasion (by sand), or simple loss of integrity over time (USFWS 1996b).

Seed dispersal may occur by wind or water, and naked seeds do not disperse nearly as far from the parent plants as seeds retained in utricles. Seeds may also be dispersed by human activities, such as beach replenishment programs. Many utricles remain attached to the plant and never disperse, allowing seeds and fruit to pile up around the bases of the parent plants. This primarily occurs at the end of the growing season when the plant dies (USFWS 1996b).

Seabeach amaranth occupies a fairly narrow habitat niche. It is found on sandy ocean beaches, where its primary habitat consists of overwash flats at accreting ends of islands, and at the sparsely vegetated zone between the high-tide line and the toe of the primary dune on non-eroding beaches. It is intolerant of competition and does not occur on well-vegetated sites. It is also intolerant of even occasional flooding or overwash. Populations are occasionally found in other habitats, including back dunes, soundside beaches, blowouts in foredunes, and beach-replenishment areas, but these populations tend to be small and temporary (USFWS 1996b; NJDEP 2005). In general, in order to survive, this species needs extensive areas of barrier island beaches and inlets, functioning in a relatively natural and dynamic manner, to allow it to move around in the landscape, occupying suitable habitat as it becomes available (USFWS 1993).

Since 2000, locations where seabeach amaranth has been found within the Seashore include the upper, dry-sand flats at Cape Hatteras Point (Cape Point and South Beach), in a line of small dunes adjacent to the flats at Hatteras Inlet Spit, at Bodie Island Spit, and at the base of dunes on the beach on the northern half of Ocracoke Island. Most areas where the plants have been found were either in established bird closures or other areas closed to vehicular traffic (NPS 2001d, 2001b, 2005a). Despite continuous protection (through the establishment of summer and winter resource closures) of the area on Bodie Island Spit where the plants were found in 2004 and 2005, as well as the area on Cape Point where the

plant was historically found, no plants have been found in the Seashore since 2005. Additionally, large portions of the historic range of the plant at Hatteras Inlet Spit no longer exist due to continued erosion. While it is thought that the plant may possibly be extirpated from the Seashore (NPS 2009e), 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 2007d).

The predominant threat to seabeach amaranth is the destruction or alteration of suitable habitat, primarily because of beach stabilization efforts and storm-related erosion (USFWS 1993). Other important threats to the plant include beach grooming and some forms of "soft" beach stabilization, such as sand fencing and planting of beach-grasses; vehicular traffic, which can easily break or crush the fleshy plant and bury seeds below depths from which they can germinate; and predation by webworms (caterpillars of small moths) (USFWS 1993). Webworms feed on the leaves of the plant and can defoliate the plants to the point of either killing them or at least reducing their seed production. Beach vitex (*Vitex rotundifolia*) is another threat to seabeach amaranth, as it is an aggressive, invasive, woody plant that can occupy habitat similar to seabeach amaranth and outcompete it (ISSG 2009).

STATE-LISTED AND SPECIAL STATUS SPECIES

This section addresses the habitat, diet, reproduction, population trends, and impacts on several species of shorebirds that are listed or recognized as special status species by the State of North Carolina but are not federally listed as endangered or threatened. Most of these species breed on Cape Hatteras, as well as in other areas of North Carolina. Species described include American oystercatcher; four species of colonial waterbirds, including gull-billed terns, least terns, common terns, and black skimmers; Wilson's plover; and red knots. The latter species breeds in the Arctic and uses the Seashore as a stopover during its annual migration. The Seashore was designated a Globally Important Bird Area by the American Bird Conservancy (American Bird Conservancy 2005). This designation recognizes those areas with populations and habitat important at the global level, but this designation does not carry any regulatory obligations.

Comment [seh23]: Is there a place earlier in the document such as CH 1 where we're discussing the significance of the Seashore where this would fit better. I suggest making deleting "but this designation does not carry any regulatory obligations, or making it a footnote. If we're keeping as part of the sentence, don't repeat "this designation" a second time on line 25.

AMERICAN OYSTERCATCHER

The American oystercatcher is a large (16–18 inches long, 14–24 ounces) and conspicuous shorebird with long pink legs and a long, bright reddish-orange bill. The upper body is covered with black feathers that contrast with white feathers on the breast and sides. The sexes are similar in appearance, although females are slightly larger than males.

American Oystercatcher
Credit: Steven J. Dinsmore

Oystercatchers are restricted to the coastal zone throughout the year, where they inhabit saltmarshes and coastal islands along the southeastern United States coast (Schulte et al. 2007; Nol et al. 2000). They feed primarily on bivalves, mollusks, worms, and other marine invertebrates that inhabit intertidal areas (Nol and Humphrey 1994; Cohen et al. ~~in press~~2010). This specialized diet is the reason that American oystercatchers are primarily found in coastal areas that support intertidal shellfish beds (Schulte et al. 2007).

Oystercatchers form pair bonds in February and early March. Courtship takes place in saltmarshes and on dunes, beaches, dredge spoils, and oyster bars. They breed from March to August along the Atlantic Coast, from Massachusetts to Florida, in relatively high, open, sandy areas with sparse to no vegetation

(Nol and Humphrey 1994; Cohen et al. ~~in press~~2010). They also breed along the Gulf Coast from Florida to Mexico and winter from central New Jersey south to the Gulf of Mexico (Simons and Schulte 2008).

American Oystercatcher in North Carolina

A 2007 breeding season survey estimated North Carolina's summer American oystercatcher population at 717 individuals, with 339 breeding pairs (Simons and Schulte 2008), and a 2005 survey estimated a winter population of oystercatchers in North Carolina at 647 birds (Brown et al. 2005). Cape Lookout and Cape Hatteras national seashores are estimated to support 90 breeding pairs (Simons and Schulte 2008), or 27% of the state's breeding oystercatchers. Barrier islands continue to be an important habitat, and supported 43% of the oystercatchers in North Carolina in 2007. Most of the barrier island nesters were found on undeveloped islands, although inlet spits on many developed islands continued to support nesting birds (NCWRC 2008b). Oystercatcher reproductive success in North Carolina has been extremely low, as studies conducted between 1995 and 2008 demonstrated an average of 0.31 chicks per nesting pair surviving to fledge (Simons and Schulte 2008). Other studies conducted at Cape Lookout National Seashore between 1997 and 1999 documented fledge rates ranging from as low as 0.04 to 0.15 (Davis et al. 2001). The American oystercatcher is classified as a Species of High Concern in the U.S. Shorebird Conservation Plan because of its small population (11,000 individuals), widespread habitat loss, and the threats it faces both during the breeding and nonbreeding seasons (Schulte et al. 2007). The oystercatcher was designated as a Species of Special Concern in North Carolina on May 1, 2008 (Pipkin pers. comm. 2009), and is listed on the USFWS 2008 Birds of Conservation Concern (USFWS 2008b), ~~but is not listed on the 1995 list of Non-game Birds of Management Concern (USFWS 1995).~~.

Habitat Description

In North Carolina, oystercatchers generally nest on sandy sites characterized by open substrate and little vegetation, far from the water, and slightly elevated to afford at least a 180° view (Nol and Humphrey 1994; Shields and Parnell 1990; Cohen et al. ~~in press~~2010). However, there is evidence that oystercatchers have begun to use less traditional nesting habitats such as dredge spoil islands and vegetated marshes (McGowan et al. 2005; Traut et al. 2006). A breeding season study in Virginia documented that over half of the oystercatcher breeding pairs were located on storm-deposited shell rakes (Wilke et al. 2005). Elevation of nest habitat and distance to the water are both important to nest success because nests can be destroyed by tidal flooding (Lauro and Burger 1989). Oystercatchers are more common in habitat with few predators or no terrestrial predators (e.g., feral or domestic predators) (Nol and Humphrey 1994). Oystercatcher foraging habitats include oyster and mussel bars and intertidal sand flats and mudflats. Winter and summer foraging habitats are similar (Nol and Humphrey 1994; Nol et al. 2000).

Foraging and Nesting Habitat

Credit: NPS – Cape Hatteras National Seashore

Sand Flats

Credit: NPS – Cape Hatteras National Seashore

Diet

The elongated and laterally compressed bill of the oystercatcher is especially suited to allow the bird to prey upon and open marine bivalves (class Bivalvia), including oysters (family Ostreidae), soft-shell clams (*Mya arenaria*), razor clams (*Ensis directus*), stout razor clams (*Tagelus plebeius*), and ribbed mussels (*Geukensia demissa*). Other items the oystercatcher consumes include marine worms (phylum Platyhelminthes), mole crabs (*Emerita talpoida*), sandworms (*Nereis virens*), limpets (order Patellogastropoda), jellyfish (phylum Cnidaria), sea urchins (phylum Echinoderma), and crabs (order Decapoda) (Bent 1929; Johnsgard 1981; Nol 1989; Nol and Humphrey 1994).

Breeding Biology

The major stages of the oystercatcher nesting cycle include the following: establishment and holding of nesting territories, courtship and copulation, nest scraping and nest building, egg laying and incubation, chick rearing, and fledging. Breeding pairs of oystercatchers begin nesting in late February and early March by establishing and holding a nesting territory and then scraping multiple shallow depressions in the sand. Eventually, they choose one scrape to build a nest (Nol and Humphrey 1994; McGowan et al. 2005). Nests are 1.5–2.5 inches deep and 7.0–8.0 inches across. They may contain shell fragments, dead plants, small stones, and beach debris (Baicich and Harrison 1997). Oystercatchers are typically monogamous and may mate for life (Nol and Humphrey 1994). Oystercatchers can nest in proximity to colonial waterbirds, including but not limited to common tern, least tern, and black skimmer.

American Oystercatcher Chicks along Wrackline

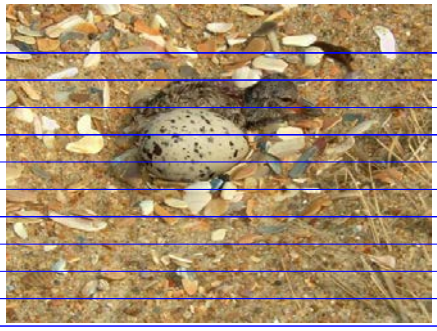
Credit: Ted Simons

Both sexes incubate three eggs (rarely two or four) for 24–28 days, and incubation may begin after the second egg is laid (Nol and Humphrey 1994) or after the last egg (Baicich and Harrison 1997). Oystercatchers will re-nest if eggs or nestlings are lost early in the season. Both adults brood nestlings, which crouch motionless when alarmed, making them difficult to see. Nestlings remain in the nest for 1–2 days and then move with adults within their nesting territory or into nearby foraging areas, which can be 150 to 600 feet away, depending on the habitat. Chicks fledge in about 35 days, but fledglings rely on adults almost entirely until they are 60 days old (Nol and Humphrey 1994).

American Oystercatcher Breeding Performance at Cape Hatteras National Seashore

At the Seashore, the oystercatcher population has experienced declines in numbers of breeding pairs since the 1990s. As seen in table 26 and figure 14, from 1999 to ~~2009~~2010, the number of nesting pairs declined 44% from 41 to 23 pairs on Ocracoke, Hatteras, Bodie, and Green islands (table 26).

From 1999 to ~~2009~~ 2010 on Ocracoke Island, there were a total of ~~90~~ 94 nesting pairs, ~~127~~ 133 nests, ~~55~~ 60 hatched nests, ~~44~~ 47 fledged chicks, and a fledge rate of 0.~~44~~46. From 1999 to ~~2009~~ 2010 on Hatteras Island, there were a total of 207~~192~~ nesting pairs, ~~256~~ 273 nests, ~~107~~ 120 hatched nests, ~~72~~ 95 fledged chicks, and a fledge rate of 0.51~~41~~. From 1999 through ~~2009~~ 2010 on Bodie Island, there were a total of ~~29~~ 30 nesting pairs, ~~42~~ 44 nests, 10~~9~~ hatched nests, 6 fledged chicks, and a fledge rate of 0.~~22~~20. From 2004 through ~~2009~~ 2010 on Green Island, there were a total of ~~12~~ 15 nesting pairs, ~~16~~ 19 nests, ~~9~~ 11 hatched nests, ~~11~~ 15 fledged chicks, and a fledge rate of 0.~~98~~92 (Muiznieks pers. comm. 20~~10a09~~; table 27).



American Oystercatcher Chick and Egg

Credit: Ted Simons

Of all known breeding sites at the Seashore, chicks on Green Island have the greatest chances of surviving until fledging, with an average fledge rate of 0.~~92~~98, which is ~~more than~~approximately double the fledge rate on Ocracoke or Hatteras islands and more than four times the fledge rate on Bodie Island. The percentage of nests that survived and successfully hatched has also been substantially lower on Bodie Island when compared to nest survival on the other three islands (table 27). However, since 2007, the number of nesting pairs increased from two to four on Bodie Island and 2008 marked the first time an oystercatcher chick fledged since 2002. In 2010, these numbers declined with only one nesting pair and no fledged chicks on Bodie Island (table 27).

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TABLE 26. OYSTERCATCHER NESTING PAIR COUNT COMPARISON, CAPE HATTERAS NATIONAL SEASHORE, 1999–~~2009~~2010

Year	Ocracoke Island	Hatteras Island	Bodie Island	Green Island	Total
1999[a]	15	24	2	—	41
2000	12	23	2	—	37
2001	13	24	2	—	39
2002	12	17	2	—	31
2003	8	16	5	—	29
2004	9	15	3	2	29
2005	5	16	2	2	25
2006	5	14	2	2	23
2007	4	15	2	2	23
2008	3	15	3	2	23
2009	4	13	4	2	23
2010	4	15	1	3	23
Total	94~~90~~	207~~192~~	30~~29~~	15~~12~~	346~~323~~

Source: Muiznieks pers. comm. 2009 and~~&~~ Muiznieks pers. comm. 2010a, except [a]Simons and Schulte 2007; 2008

NOTE: Data available only for years listed.

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TABLE 27. OYSTERCATCHER BREEDING DATA BY SITE, CAPE HATTERAS NATIONAL SEASHORE, 1999–~~2009~~2010

Year	Nesting Pairs	Nests	Nests Hatched	Nest Survival (%)	Chicks Fledged	Fledge Rate
Ocracoke Island						
1999[a]	15	17	7	41.2	2	0.13
2000	12	17	6	35.3	7	0.58
2001	13	15	11	73.3	17	1.31
2002	12	18	6	33.3	3	0.25
2003	8	12	4	33.3	1	0.13
2004	9	11	7	63.6	8	0.89
2005	5	10	3	30.0	1	0.20
2006	5	8	5	62.5	2	0.40
2007	4	10	3	30.0	1	0.25
2008	3	3	1	33.3	2	0.67
2009	4	6	2	33.3	0	0.00
2010	**4**	**6**	**5**	**83.3**	**3**	**0.75**
Total / [b]average	~~9~~40	~~12~~7133	~~5~~560	~~43.3~~45.1	~~4~~447	**0.~~4~~644[b]**
Hatteras Island						
1999[a]	24	31	7	22.6	3	0.13
2000	23	29	10	34.5	2	0.09
2001	24	28	10	35.7	6	0.25
2002	17	25	3	12.0	4	0.24
2003	16	23	10	43.5	6	0.38
2004	15	18	14	77.8	9	0.60
2005	16	23	12	52.2	8	0.50
2006	14	19	11	57.9	5	0.36
2007	15	21	10	47.6	9	0.60
2008	15	20	9	45.0	11	0.73
2009	13	19	11	57.9	9	0.69
2010	**15**	**17**	**13**	**76.5**	**23**	**1.53**
Total / [b]average	**~~192~~207**	**~~256~~273**	**120~~107~~**	**44.0~~41.8~~[b]**	**~~72~~95**	**0.5~~1~~41[b]**
Bodie Island						
1999[a]	2	3	0	0.0	0	0.00
2000	2	3	0	0.0	0	0.00
2001	2	3	1	33.3	1	0.50
2002	2	5	1	20.0	2	1.00

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Year	Nesting Pairs	Nests	Nests Hatched	Nest Survival (%)	Chicks Fledged	Fledge Rate
2003	5	5	1	20.0	0	0.00
2004	3	7	0	0.0	0	0.00
2005	2	3	1	33.3	0	0.00
2006	2	2	1	50.0	0	0.00
2007	2	2	1	50.0	0	0.00
2008	3	5	2	40.0	2	0.67
2009	4	4	1	25.0	1	0.25
2010	1	2	1	50.0	0	0
Total / [b]average	**2930**	**4244**	**910**	**22.721.4[b]**	**6**	**0.2022[b]**
Green Island						
2004	2	3	2	66.7	2	1.00
2005	1	3	2	66.7	0	0.00
2006	2	2	2	100.0	2	1.00
2007	2	2	1	50.0	2	1.00
2008	2	4	1	25.0	2	1.00
2009	2	2	1	50.0	3	1.50
2010	3	3	2	66.7	4	1.33
Total / [b]average	**1215**	**1619**	**911**	**56.357.9[b]**	**1115**	**0.92[b]98[b]**

Source: Muiznieks pers. comm. 2009 &and Muiznieks pers. comm. 2010a, except [a]Simons and Schulte 2007 and 2008

NOTE: Data available only for years listed.

[b] = Average.

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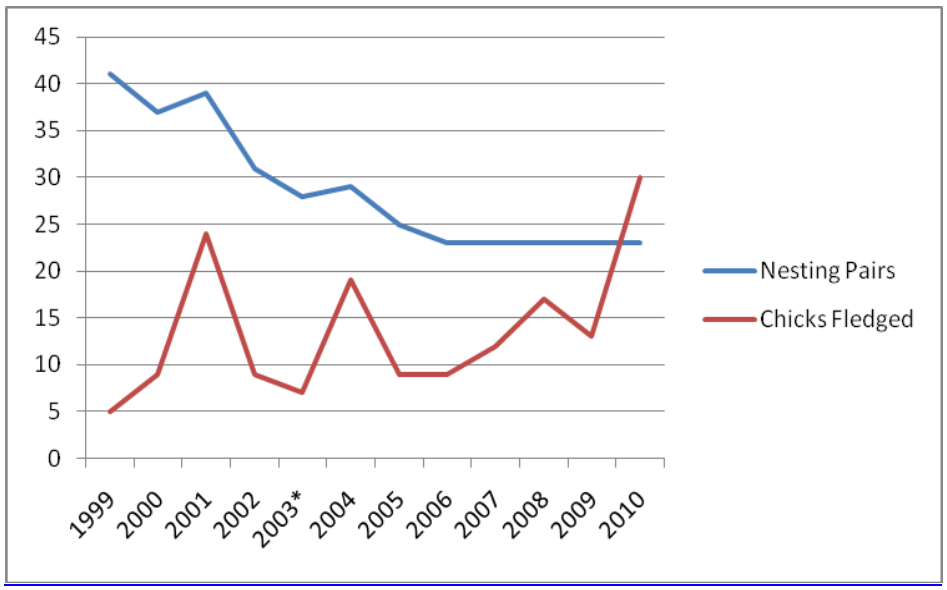
Since 1999, the number of nesting pairs at the Seashore has generally declined but has remained stable at 23 nesting pairs for the last four five years (see figure 14). The annual number of fledged chicks has ranged from a low of 5 in 1999 to a high of 24 30 in 201001. The rapid decrease in chick survival in 2002 is thought to correspond to the arrival of the fox as a predator on Hatteras Island. The advent of predator control efforts at the Seashore in 2003 is thought to be a contributing factor to the noticeable increase in chick survival between the 2003 and 2004 seasons (Simons and Schulte 2008). However, in the absence of hurricane events (which sometimes provide improved habitat), a recent demographic model projected a rapid decline for oystercatchers in North Carolina in the next 50 years (Simons and Schulte 2008).



Source: Muiznieks pers. comm. 2009 and& Muiznieks pers. comm. 2010a

Note: Data for Green Island for 2003 were unreliable and were not included in this figure. Data for Green Island prior to 2003 were not available.

FIGURE 14. AMERICAN OYSTERCATCHER NESTING PAIRS AND CHICKS FLEDGED, CAPE HATTERAS NATIONAL SEASHORE, 1999–20102009

Comment [dw24]: We should be showing the tables that we deleted from the DEIS.

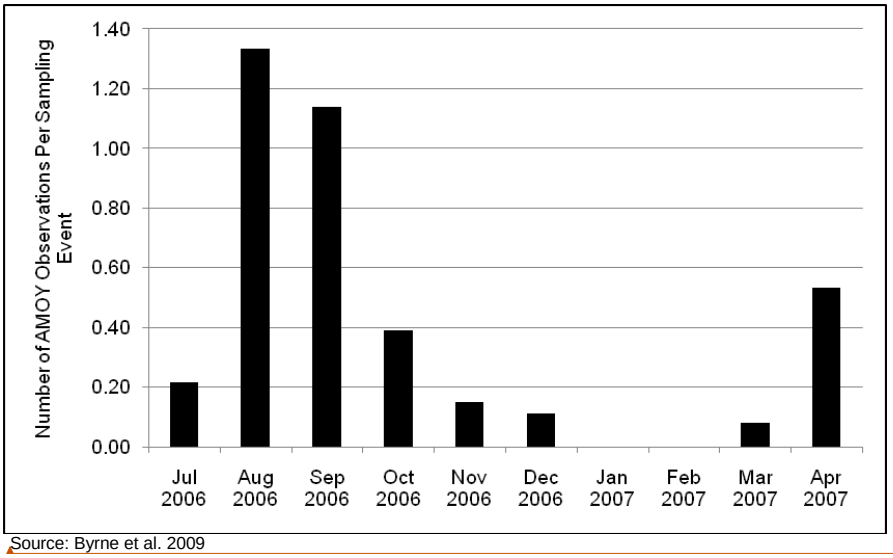
Comment [dw25]: The significance of these lines crossing should be noted in the text above the table. This represents the first time there was a fledge rate greater than 1.0 at the Seashore.

Nonbreeding Oystercatchers

American oystercatcher migration generally begins at the end of August and continues through November. American oystercatchers are short-distance, partial migrants and generally winter along the southeast coast of the United States (Schulte et al. 2007; Nol et al. 2000).

Winter and migratory habitat appear to be similar to breeding habitat, although additional research is needed to determine preferred habitat in the winter, especially for birds on migration. Limited observations indicate that winter birds roost on open ground without vegetation in areas near foraging habitat (Nol and Humphrey 1994). A study conducted during the winter of 2002–2003 found that oystercatchers commonly use shell rakes as winter roost sites (Brown et al. 2005). Other habitat types used by wintering oystercatchers include sand islands, inlet beaches, sand spits, edges and interior mudflats on marsh islands, and occasionally docks and jetties (Brown et al. 2005; Schulte et al. 2007).

The NPS SECN Winter Monitoring Program conducted a more comprehensive study on wintering shorebirds. Pilot implementation of this SECN shorebird monitoring protocol at the Seashore began in mid-July 2006. Results for the oystercatcher, which are depicted on figure 15, are discussed below.



Source: Byrne et al. 2009

FIGURE 15. MONTHLY OBSERVATIONS OF AMERICAN OYSTERCATCHERS (AMOY) PER 30-MINUTE SAMPLING EVENT AT CAPE HATTERAS NATIONAL SEASHORE, 2006–2007

From July 2006 through April 2007, the majority of American oystercatchers were observed in foreshore and mudflat / algal flat habitat types (figure 16). American oystercatchers appeared to use the foreshore during both tidal extremes and used the mudflat / algal flat habitat primarily during high tide. The highest numbers of birds appeared to occur in August, and the data from the first year of pilot study show that the Seashore does not appear to have a wintering population of oystercatchers.

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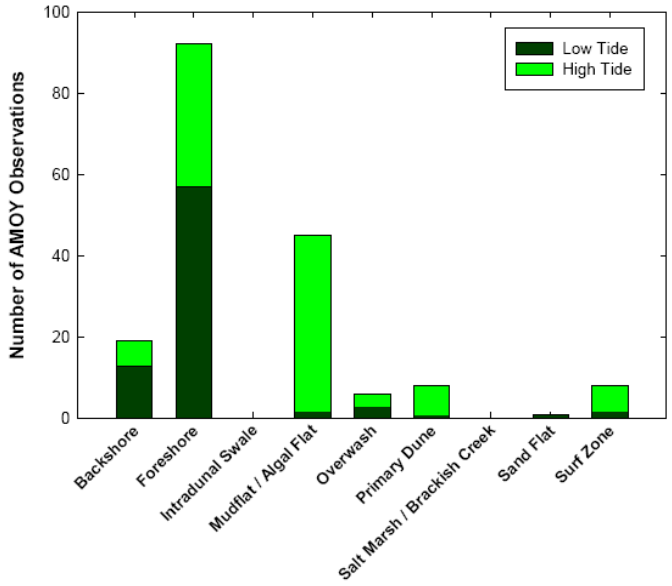
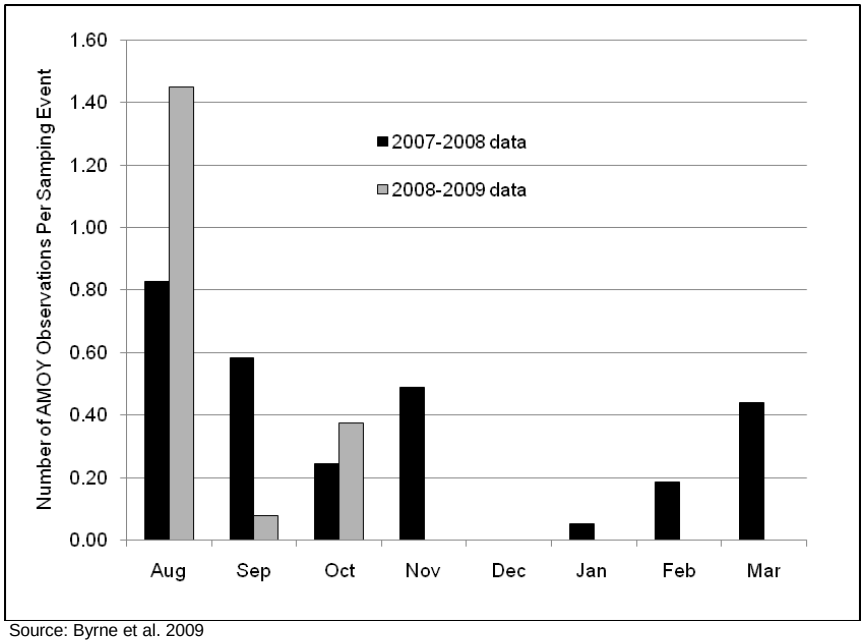


FIGURE 16. NUMBERS OF AMERICAN OYSTERCATCHER (AMOY) OBSERVATIONS BY HABITAT TYPE AND TIDAL STAGE AT CAPE HATTERAS NATIONAL SEASHORE, 2006–2007

Subsequent monitoring of oystercatchers between August and April 2007–2009 by Seashore staff indicated similar results, with very few birds observed from December through February (see figure 17). Figure 17 may be misleading in that the surveys conducted by Seashore staff were only conducted at the points and spits to comply with monitoring requirements for the piping plover. Oystercatchers will forage along the entire shoreline without preference for the points or spits and are therefore probably underestimates of the numbers occurring on the Seashore during the months represented.



Source: Byrne et al. 2009

Note: Data represented in this figure were only collected at the points and spits and most likely underestimate the number of oystercatchers present at the Seashore during these months.

FIGURE 17. MONTHLY OBSERVATIONS OF AMERICAN OYSTERCATCHERS (AMOY) PER SAMPLING EVENT AT CAPE HATTERAS NATIONAL SEASHORE, 2007–2009

Risk Factors to American Oystercatchers

In addition to direct habitat loss, the American oystercatcher faces pressure from recreational disturbance, increases in predators, potential contamination of food resources, and alteration of habitat through beach stabilization (Schulte et al. 2007). Causes of American oystercatcher nest failure on the Outer Banks from 1998 through 2008 could not be determined for 49% of nest failures. However, the causes of failure that could be determined were mammalian predation (54%), ghost crab predation (3%), avian predation (4%), direct human disturbance (4%), abandonment (6%), and overwash (29%) (Simons and Schulte 2008).

American Oystercatcher Chick in ORV Tracks
Credit: Ted Simons

Human Activity. Oystercatchers need large, undisturbed beach areas for successful nesting. Research has shown that disturbance by pedestrians, kayakers, vehicles, and unleashed pets can cause the abandonment of nest habitat as well as direct loss of eggs and chicks (Cohen et al. ~~in press~~2010; Sabine et al. 2006, 2008; Toland 1999; Hodgson et al. 2008). Studies of the effects of humans and vehicles on American oystercatchers have indicated lower nest survival and higher chick mortality in places with higher levels of disturbance (McGowan 2004; Sabine 2005; Simons and Schulte 2008). Studies in Europe on the European oystercatchers (*Haematopus ostralegus*) have shown reduced foraging

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efficiency and lower rates of chick feeding in disturbed versus undisturbed habitats (Verhulst et al. 2001). In the winter, disturbance caused European oystercatchers to reduce foraging, although the behavioral response of avoidance lessened as the winter progressed (Stillman and Goss-Custard 2002). A study at Cape Lookout National Seashore documented lower nesting success for oystercatchers in areas where human disturbance was higher and also noted that oystercatchers avoided nesting in areas with high levels of human activity (Davis 1999). Another study in North Carolina found evidence that oystercatcher nests that were frequently disturbed by beach vehicles suffered higher rates of nest predation (McGowan and Simons 2006).

Comment [dw26]: We made a point to avoid discussing the European or Black oystercatchers. Is this OK?

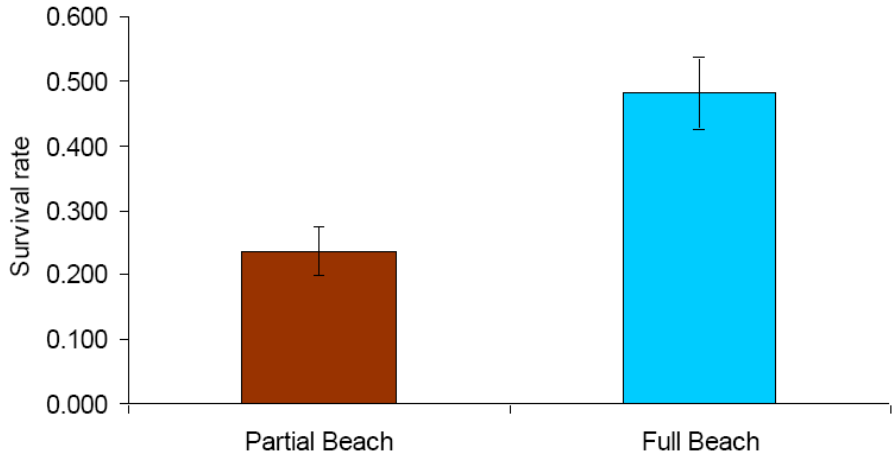
In addition to direct impacts or mortality, reasons for lower reproductive success in areas of high disturbance may include reduced time spent foraging (Sabine et al. 2008; Verhulst et al. 2001; Stillman and Goss-Custard 2002), thermal stress to eggs caused by a lack of incubation when reacting to disturbance (Sabine 2006; Verhulst et al. 2001), and expenditure of energy reserves during flushing or defensive displays (Toland 1999; Nudds and Bryant 2000; Stillman and Goss-Custard 2002). Studies at Cumberland Island National Seashore in Georgia found that foraging behavior was lower in the presence of vehicular activity, which could alter chick provisioning and ultimately affect chick survival. Researchers recommended prohibiting beach driving in oystercatcher territories when chicks are present (Sabine 2005). Research on flush responses of oystercatchers to human disturbance indicates that protection of this species requires a buffer distance of up to 656 feet from nesting areas (Cohen et al. ~~in press~~2010; see table 28).

TABLE 28. BUFFER DISTANCES RECOMMENDED FOR AMERICAN OYSTERCATCHERS

Buffer Distance	Source	Disturbance Types	Behavior/Location	Region
450 feet (137 meters)	Sabine 2005	Pedestrians, ORVs / other vehicles, boats, pets	Nesting	Cumberland Island National Seashore, Georgia
492 feet (150 meters)	Sabine 2005	Pedestrians, ORVs / other vehicles, boats, pets	Brood rearing	Cumberland Island National Seashore, Georgia
100 feet (30 meters)	Maine Department of Environmental Protection 2009	Development, vegetation removal	Feeding Area[a]	Maine
250 feet (76 meters)	Maine Department of Environmental Protection 2009	Development, vegetation removal	Roosting Area[b]	Maine
338 feet (103 meters)	Rodgers and Schwikert 2002	Personal watercraft	Nonbreeding adult foraging and loafing	West and east coasts of Florida
656 feet (200 meters)	Cohen et al. ~~in press~~2010	All human disturbance	Nesting	Cape Hatteras National Seashore

[a] Shorebird feeding areas include the intertidal zone and a 100-foot adjacent buffer area.

[b] Shorebird roosting areas include the intertidal zone, the roosting area, and a 250-foot area adjacent buffer area.



Source: Simons and Schulte 2008

FIGURE 18. AMERICAN OYSTERCATCHER CHICK SURVIVAL BY CLOSURE TYPE AT CAPE HATTERAS NATIONAL SEASHORE, 1999–2008

The reproductive success of oystercatchers at Cape Hatteras has been impacted by vehicle and pedestrian disturbance. From 1999 to 2008, 48% of chicks in full beach closures on Cape Hatteras survived to fledging, while only 24% survived when the beach had an open lane for vehicles and pedestrians (Simons and Schulte 2008; see figure 18). Seashore staff also documented that the highest hatching rate (87%) was found at sites that did not have ORV use or concentrated pedestrian use (NPS 2005e).

Direct mortality of oystercatcher chicks from vehicles has been documented since 1995, when three chicks were found crushed in a set of vehicle tracks at the Seashore (Simons and Schulte 2008). Similar events have been documented at neighboring Cape Lookout National Seashore, where studies documented five chick deaths related to vehicles in 1995 (Davis et al. 1999), and one chick and two clutches lost in 1997 when they were run over by vehicles (Davis et al. 2001). Three oystercatcher chicks were killed during the 2003 and 2004 breeding seasons at Cape Hatteras by being run over by vehicles (NPS 2004f, 2005e), as documented by Seashore resource protection staff. A recent radio telemetry study conducted at Cape Hatteras and Cape Lookout national seashores identified human activity as the source of 16% of known chick mortality from 2005 through 2007 (Simons and Schulte 2008), with 8% of that related to vehicle collisions and 8% to other human disturbance.

Weather and Tides. Nine named hurricanes have affected the Outer Banks between 1993 and ~~2008~~ 2009 (NOAA 2009). Storms and associated high tides during breeding season can reduce nesting success. Overwash and other weather-related events accounted for 29% of documented nest failures at Cape Hatteras from 1999 through 2008. However, periodic hurricanes (outside the breeding season) can benefit oystercatcher nesting success in the long term through the creation of new habitat and the reduction of predators. For example, on Cape Lookout National Seashore, nests lost to predators dropped significantly after Hurricane Isabel flooded the island in September 2003. This drop was attributed to the reduction of the predator population due to hurricane-related flooding (Simons and Schulte 2008).

Predation. Numerous studies and reports have identified nest predation as a major source of oystercatcher nest failure (Davis et al. 2001; Sabine et al. 2006; McGowan et al. 2005; McGowan 2004;

Hodgson et al. 2008; Traut et al. 2006; Wilke et al. 2007). Mammalian predation was the major identifiable cause of nest failure for study sites in North Carolina from 1998 through 2008 (Simons and Shulte 2008). Predators include gray fox, red fox, raccoon, mink, dogs, cats, American crows, and gulls (Nol and Humphrey 1994). More recently, video nest recordings have documented raccoon, bobcat (*Lynx rufus*), and ghost crab predation of oystercatcher eggs and chicks at Cumberland Island National Seashore, Georgia (Sabine et al. 2006). Oystercatchers may lay another clutch if their eggs are lost or destroyed (Nol and Humphrey 1994).

As previously discussed, predation of oystercatchers is thought to be associated with human activities such as ORV use and pedestrian recreation (McGowan and Simons 2006; Simons and Schulte 2007; Sabine et al. 2008). McGowan and Simons (2006) hypothesized that human recreation might increase the activity of incubating oystercatchers, thereby leading to increased predation rates. Their research found a clear association between recreation and incubation behavior at Cape Hatteras and Cape Lookout during the 2002 and 2003 breeding seasons (McGowan and Simons 2006). The presence of ATV traffic was associated with increased numbers of trips parents made back and forth to nests and a decrease in duration of incubation. Recreational activities such as truck use and pedestrian traffic showed a weaker association with nesting behaviors, although the proximity of the disturbance to the nest was a factor. Evidence points to a reduction of nest success as the result of an alteration of incubation behavior due to recreational disturbance. McGowan and Simons (2006) hypothesized that mammals, which were found to be the main nest predators during this study (Davis et al. 2001), can better locate disturbed nests because adults leave a scent trail when going back and forth to nests. Human behavior and actions may also result in higher predator populations. For example, raccoon sightings and signs were greater in areas of increased human activity at Cape Lookout (Davis et al. 2001), and raccoon and bobcat signs appeared to be more abundant around areas of frequent human activity at Cumberland Island National Seashore, Georgia (Sabine et al. 2006).

In areas of frequent human activity, pedestrians were commonly observed in close proximity to nests, causing oystercatchers to leave their nests and exposing eggs and chicks to temperature extremes and greater risk of predators (Sabine et al. 2006).

COLONIAL WATERBIRDS

Comment [I27]: All CWB numbers to be updated for next draft.

Colonial waterbirds at the Seashore include gull-billed terns, common terns, least terns, and black skimmers. The listing status of each of these species at the state level is described below. ~~Gull-billed terns are considered to be threatened in North Carolina, while the other three are listed as Species of Special Concern by the NCWRC and the NPS (Cohen et al. in press).~~ None of these species is federally listed.

~~The Seashore was designated a Globally Important Bird Area by the American Bird Conservancy (American Bird Conservancy 2005). This designation recognizes those areas with populations and habitat important at the global level but does not carry any regulatory obligations.~~ Ground-nesting colonial waterbirds breed along the Seashore beaches, which also host nesting sites for other birds, as well as a range of recreational activities for humans. Studies have documented that populations of some species of colonial waterbirds are declining. Beach nesters such as common terns, gull-billed terns, and black skimmers have shown the most significant declines. Coastal development, disturbances by humans, and increased nest predation all contribute to the decline in numbers of colonial waterbirds (NCWRC 2005).

Colonial Waterbirds—Descriptions

Gull-Billed Tern

Gull-Billed Tern and Chick
Credit: NPS

The gull-billed tern is a medium-sized (13 to 15 inches long, weighing about 5.6 to 7.0 ounces), black-capped waterbird found widely in Eurasia, the Mediterranean, northern Europe, and the United States. In the United States, it occurs as two subspecies, with the Atlantic Coast and Gulf subspecies being designated *Sterna nilotica aranea* and the *S. n. vanrossemi* subspecies occurring from the Salton Sea in California south to western Mexico (Parnell et al. 1995). The gull-billed tern is listed on the USFWS 2008 Birds of Conservation Concern (USFWS 2008b) and is listed as threatened ~~in~~by the State of North Carolina~~, but is not on the 1995 list of Non-game Birds of Management Concern (USFWS 1995).~~

Common Tern

Common Tern with Fish
Credit: Phylis Cooper / USFWS

The common tern can be found across the temperate region of the northern hemisphere. It also occurs in Bermuda and the southern Caribbean region (Nisbet 2002). It is one of the medium-sized, black-capped terns (12 to 14 inches long, weighing 3.8 to 5.1 ounces) (Nisbet 2002). In North America, it is distributed along the Atlantic Coast, the St. Lawrence River, and in most of the Great Lakes (Nisbet 2002). The common tern is listed on the USFWS 1995 list of Non-game Birds of Management Concern (USFWS 1995) and the 2008 Birds of Conservation Concern (USFWS 2008b), as well as being a North Carolina Species of Special Concern (NCWRC 2008).

Least Tern

Least Tern and Chick
Credit: NPS

The least tern is the smallest of the black-capped terns in North America. Five races are recognized in North America, although there are few differences genetically or morphologically among them (Thompson et al. 1997). The least tern weighs only about 1.7 ounces, on average, and is only 8 to 9 inches in length (Thompson et al. 1997). The least tern is listed on the USFWS 1995 list of Non-game Birds of Management Concern (USFWS 2005) and the 2008 Birds of Conservation Concern (USFWS 2008b), as well as being a North Carolina Species of Special Concern (NCWRC 2008b).

Black Skimmer

Black Skimmer
Credit: NPS

Black skimmers are the only waterbirds on the Atlantic Coast that feed by skimming along the surface of the water with their lower jaw. They are also unique in that males are on average 35% to 40% larger than females, and both exhibit a high degree of nocturnal behavior. Females average about 9.3 ounces and are 16 to 24 inches long, while

males average about 13 ounces and are 19 to 24 inches long (Gochfeld and Burger 1994). The black skimmer is listed on the USFWS 2008 Birds of Conservation Concern (USFWS 2008b), as well as being a North Carolina Species of Special Concern (NCWRC 2008b)~~, but is not listed on the 1995 list of Non-game Birds of Management Concern (USFWS 1995).~~

Black Skimmers with Gull-Billed Terns and Chick

Credit: NPS

Beach-Nesting Colonial Waterbirds in North Carolina

The Outer Banks region of North Carolina supports a large number of colonial waterbird species that depend upon its extensive sounds and the nearshore waters for feeding, and its relatively undisturbed islands for nesting. Most species of colonial waterbirds are in jeopardy in North Carolina (Parnell and Committee 1977) because of a decline in numbers over the past 20 to 30 years. During the period from 1977 to 2007, the number of gull-billed tern nests declined from approximately 268 to only 90, common tern nests from 2,761 to 498, and black skimmer nests from 976 to 555. The number of least tern nests, however, increased from 1,925 to 2,827 (NCWRC 2008b). Numbers of most breeding, colonially nesting shorebirds within North Carolina have declined over the past 20 to 30 years (Cohen et al. ~~in press~~2010; see table 29). For example, from 1977 to 2007, colonial waterbird nesting declined 30%, from 7,068 to 5,004 nests (table 29). Barrier island beaches provide important habitat for gull-billed terns, common terns, least terns, and black skimmers. Many of these beaches are severely degraded due to coastal development and associated increases in human disturbance and in predation by overabundant species. These factors have most likely contributed to the decline in colonial waterbird numbers in North Carolina (Cameron and Allen 2008).

TABLE 29. NUMBERS OF COLONIAL WATERBIRD NESTS IN NORTH CAROLINA, 1977–2007

Species	1977	1983	1988	1993	1995	1997	~~Species~~1999	2001	2004	2007	Average
Gull-billed tern	268	233	161	155	249	137	154	258	99	90	180.4
Common tern	2,761	2,247	2,618	2,122	1,699	952	888	1,131	570	498	1,548.6
Least tern	1,925	1,653	1,528	2,188	1,993	882	1,271	1,742	2,408	2,827	1,841.7
Black skimmer	976	797	743	1,084	819	570	681	594	623	555	744.2
Total	5,930	4,930	5,050	5,549	4,760	2,541	2,994	3,725	3,700	3,970	N/A

Source: NCWRC 200~~7~~8

N/A = Not applicable.

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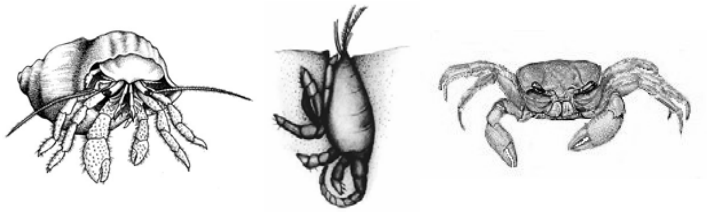
Descriptions of Breeding, Foraging, and Nonbreeding Habitats

Gull-Billed Tern

Breeding Habitat. Gull-billed terns typically nest among other tern and skimmer species on open, sandy shell beaches, on large barrier islands, on dredge-spoil islands, or on overwash fans (also used by piping plovers) that are mostly devoid of vegetation. They also nest on elevated-shell ridges ("rakes") along the edges of marsh islands, which they share with American oystercatchers and common terns (Erwin et al. 1998; Cohen et al. ~~in press~~2010; Molina et al. 2009).

Foraging Habitat. In contrast to other terns, gull-billed terns do not feed primarily on fish but are opportunistic, taking insects on the wing and feeding on a variety of invertebrates, including fiddler crabs (*Uca* spp.), decapods, marine worms, and clams, as well as small marsh fish (Cohen et al. ~~in press~~2010; Molina et al. 2009). Consequently, gull-billed terns can be seen feeding over marshes and creeks and along ocean and bay beaches, as well as over agricultural fields many miles from their nesting sites (Cohen et al. ~~in press~~2010; Molina et al. 2009).



Hermit Crab **Mole Crab** **Ghost Crab**

Drawings of Decapods

Credit: NPS

Nonbreeding Habitat. North American birds winter along the Gulf Coast, the Pacific Coast of Mexico, and into Central and South America. Little is known of gull-billed tern use of habitat while migrating, except that the habitat is generally considered similar to nesting habitat (i.e., open beach, sand spits) (Cohen et al. ~~in press~~2010). Nonbreeding gull-billed turns can be found in coastal ponds, lagoons, mudflats, and flooded inland fields (Molina et al. 2009).

Sand Spit / Coastal Pond **Mudflats**

Photos of Gull Billed Tern Habitat

Credit: NPS

Common Tern

Breeding Habitat. Common terns typically nest on open, sandy shell beaches on ocean coastal islands, as well as at inland island sites in freshwater lakes, or, as in Europe, on rivers (Nisbet 2002). However, they also nest in saltmarshes, either on shell or on wrack, especially where human disturbance along the beaches is significant, and even on man-made structures, including large rooftops in urban areas (Erwin 1980).

Foraging Habitat. Common terns prey on small fish and shrimp in inlets and along the coast, often within a few miles of their breeding colonies. They are also known to feed on aquatic or terrestrial

invertebrates such as crustaceans or insects~~, occasionally on squid, but rarely on other invertebrates~~ (Nisbet 2002).

Nonbreeding Habitat. There is little information on habitats used by migrating common terns. However, most continue to feed close to shore. Migration staging areas are known at large sandy spits and bars at a number of North Atlantic sites, with concentrations numbering in the thousands at some places (Nisbet 2002). In winter, common terns migrate to the Caribbean and South America; both coasts of Africa; coasts and islands in the Indian Ocean; and the western Pacific from Japan to the Solomon Islands, New Guinea, and Australia (Nisbet 2002), where they often concentrate in large numbers in coastal lagoons (Nisbet 2002).

Least Tern

Breeding Habitat. Least terns typically select the barest sand- and shell-covered substrates available on coastal, riverine, or dredge-spoil islands (Thompson et al. 1997). They also nest on rooftops in a number of coastal areas, where pea gravel is used as part of the roofing material (Thompson et al. 1997). On coastal barrier islands, they often select colony sites either adjacent to inlets or in overwash areas that are often interspersed among piping plover nests. Unlike common terns, least terns are typically found in small single-species colonies, where their nests are often widely spaced (Thompson et al. 1997). In New Jersey, inter-nest distance ranged from 2 to 66 meters (6 to 216 feet) at the time of egg laying and from 1 to 60 meters (3 to 197 feet) at the end of incubation (Burger and Gochfeld 1990).

Foraging Habitat. Least tern foraging habitat is similar to that of common terns, except that least terns seldom feed in large flocks.

Nonbreeding Habitat. Least terns migrate from the Outer Banks in August and September, with migration flocks staging at certain sandy island sites (Thompson et al. 1997). In late July or August, remote sandbars or sandy spits serve as roost sites. Least terns winter from Florida through the Caribbean and into Central and South America (Thompson et al. 1997).

Black Skimmer

Breeding Habitat. Black skimmers prefer to nest on open, sandy substrates on barrier and dredge-spoil islands or at the tips of barrier islands (Gochfeld and Burger 1994). They invariably nest with other tern species along the Atlantic Coast (Erwin 1977; Cohen et al. ~~in press~~2010). Black skimmers occasionally nest on wrack or on shell ridges in saltmarshes and even on rooftops with least terns (Gochfeld and Burger 1994).

Foraging Habitat. Black skimmers feed on small fish, shrimp, and other invertebrates that they capture by skimming the surface with their lower jaws just below the surface of the water. They typically feed very close to their nesting colonies and prefer quiet waters in saltmarsh creeks, lagoons, or protected coves and inlets near barrier islands. The black skimmer is reportedly a nocturnal forager~~,~~ but feeds regularly in daytime at the appropriate tide cycle, especially when feeding young (Erwin 1977; Cohen et al. ~~in press~~2010; Gochfeld and Burger 1994).

Nonbreeding Habitat. Black skimmers migrate from the Outer Banks region from September to November, forming very large concentrations on sandy spits and sandbars (Gochfeld and Burger 1994). They winter from Florida through the Caribbean and South America (Cohen et al. ~~in press~~2010; Gochfeld and Burger 1994).

Breeding Biology

Gull-Billed Tern

Birds arrive in North Carolina by mid-April. The mating system is monogamous, and like many other waterbirds, gull-bills probably have long-lasting pair bonds. Nest-site establishment and egg laying usually occur in mid- to late May. The nests consist of a shell-lined scrape in the sand or sometimes on wrack in saltmarshes. Nests contain from two to three brownish-blotched eggs (in the United States, the mean is around 2.2 eggs per nest [Molina et al. 2009]) that are incubated for 22 to 23 days. Members of a pair share incubation duties, but females take the dominant role. Gull-billed terns appear to be less tolerant of disturbance and less faithful to nest sites than other Sterna terns (Molina et al. 2009). Both parents share brooding duties, and both feed the young, often for an extended period after fledging occurs (birds generally fledge at 26 to 30 days of age). The chicks are highly camouflaged and more precocial (mobile and independent) than either common tern or black skimmer chicks, with which they coexist. The young may leave the immediate area of the nest within a few days if disturbance is high. Pairs may re-nest if a nest is lost early in the breeding season (Cohen et al. ~~in press~~2010).

Common Tern

Birds arrive in North Carolina in late April to early May and begin nesting most years from mid-May to early June (Nisbet 2002). The mating system is monogamous, and like many other waterbirds, common terns probably have long-lasting pair bonds. Clutch sizes vary, but three medium-dark-brown-mottled eggs are the norm. The eggs are incubated for 22 to 23 days. Both sexes incubate and feed the brood. As in other terns, feeding of the young occurs after fledging and can continue into the fall migration. Upon hatching, the young remain near the nest (unless disturbed) for the entire pre-fledging period. Re-nesting may occur if early nests fail. Fledging ranges from about 25 to 30 days. Common terns appear to serve as a social locus for mixed-species colony formation, possibly because of their aggressively protective nature (Erwin 1979; Cohen et al. ~~in press~~2010; Nisbet 2002). Hence, gull-billed terns and black skimmers often nest among common terns (Cohen et al. ~~in press~~2010).

Least Tern

Birds arrive in North Carolina from late March to mid-April. Unlike most other Outer Banks terns, least terns usually nest in single-species colonies, with nests often spread far apart. Courtship lasts for two to three weeks in April and May, and egg laying occurs from late May until June. Clutch sizes range from one to three eggs, with two being the norm in North Carolina. Eggs are highly camouflaged, with the background color beige to light olive-brown. Members of a pair share incubation duties, but females take the dominant role. Incubation lasts for 21 to 22 days, and the highly mobile young move from the nest within a few days. They are able to fly at about 20 days of age. Post-fledging parental feeding can occur for several weeks away from the colony (Thompson et al. 1997; Cohen et al. ~~in press~~2010).

Black Skimmer

Birds arrive in North Carolina from late April to mid-May, and nest building and egg laying usually occur from late May to mid-June (Erwin 1977; Cohen et al. ~~in press~~2010; Gochfeld and Burger 1994). Clutch sizes range from two to four eggs (Erwin 1977). Eggs are light buff with black blotches, and are laid and hatch at different times. Both sexes incubate the eggs, brood, and feed the young. Incubation ranges from 22 to 25 days. The young remain near the nest (unless disturbed) for most of the pre-fledging period of 28 to 30 days (Erwin 1977). As with other waterbirds, if nests fail early in the season, skimmers will re-nest (sometimes several times). Skimmers are sometimes seen incubating eggs as late as August in the mid-Atlantic region (Burger and Gochfeld 1990). Fledged young are fed by their parents, often right up until

migration (Erwin 1977; Cohen et al. ~~in press~~2010). Human disturbance can seriously affect the breeding success of black skimmers (Gochfeld and Burger 1994). Pre-laying skimmers have been known to abandon a colony that is frequently disturbed (Erwin 1980; Safina and Burger 1983). Research has indicated that disturbed subcolonies of black skimmers had lower nest density, later nesting dates, and lower hatching and fledging success (Safina and Burger 1983).

Breeding Performance at Cape Hatteras National Seashore

The beaches of the Seashore have been important in providing suitable habitat for these colonial nesters. In 2004, more than half of all nesting black skimmers and common terns in North Carolina were found at the Seashore, as well as one-third of the state's gull-billed terns (see tables 29 and 30).

Colonial waterbird breeding at Cape Hatteras generally occurs between the beginning of May and the middle of August. In many cases, colonial waterbirds use areas that were colonized in previous seasons, which include areas protected as prenesting closures for piping plovers. Colonies are commonly composed of small groups of least terns, but more diverse colonies sometimes occur.

Although different survey protocols have been used at the Seashore between 1977 and 2009, recent estimates of colonial waterbird nests at the Seashore are clearly much lower than they were 30 years ago (see table 30). Common terns, gull-billed terns, and black skimmers have shown the greatest declines over the last 30 years, both statewide and at the Seashore. These species are early nesters that require habitats of bare sand or shell with little or no vegetation for nesting. Historically, these species have nested primarily on barrier island beaches and have suffered declines most likely due to habitat loss and degradation (Cameron and Allen 2008). Other reasons for the decline in North Carolina's colonial waterbirds include mammal and bird predation, human development, beach stabilization, recreational disturbance, and perhaps, impacts on the wintering grounds (Parnell et al. 1995; Cohen et al. ~~in press~~2010). Recommended methods for colonial waterbird conservation include continued monitoring and management, habitat protection and restoration, predator management, and protection from human disturbance (Cameron and Allen 2008; Burger et al. 2004).

Within the Seashore, six gull-billed tern nests were recorded in 2007 on Green Island and none were found in 2008 or 2009, representing a decline from the Seashore's average of approximately 32 nests during surveys between 1977 and 2009. In 2010, one gull-billed tern nest was documented at Cape Point, but was lost before hatching. A total of 19 common tern nests were documented at the Seashore in 2008, although that number rose to 53 nests for the 2009 season. The number of least tern nests rose dramatically at the Seashore in 2009, when 577 were documented by resource management staff. Black skimmer nest numbers have sharply declined at the Seashore, with only 11 nests in 2007 and 4 nests counted in 2008. However, 61 black skimmer nests were documented in 2009 (table 30). The number of nests recorded in 2007 for three of the four species was the lowest in the history of waterbird surveys in North Carolina (Cameron and Allen 2008). With the exception of the gull-billed tern, colonial waterbird numbers at the Seashore showed substantial increases during the 2009 breeding season (table 30).

TABLE 30. NUMBERS OF COLONIAL WATERBIRD NESTS AT CAPE HATTERAS NATIONAL SEASHORE, 1977–2009

Species	1977[a]	1983[a]	1988[a]	1992[a]	1993[a]	1995	1997	1998	1999	2000	2001	2004[b]	2007[b]	2008	2009	Avg.
Gull-billed tern	27	7	26	0	12	58	84	21	103	3	108	31	6	0	0	32.4
Common tern	802	763	678	278	422	503	718	715	440	129	573[c]	376	109	19	53	438.5
Least tern	121	508	450	454	761	342	278	173	355	184	202	212	194	232	577	336.2
Black skimmer	286	296	144	30	226	139	454	366	306	149	193	342	11	4	61	200.5

Species	1977[a]	1983[a]	1988[a]	1992[a]	1993[a]	1995	1997	1998	1999	2000	2001	2004[b]	2007[b]	2008	2009	Avg.
Total	1,236	1,574	1,298	762	1,421	1,042	1,534	1,275	1,204	465	1,076[c]	961	320	255	691	N/A

Source of 1977–2004 data is NPS 2007a

Source of 2007–2009 data is Muiznieks pers. comm. 2009

[a] Surveys conducted by J. Parnell, University of North Carolina, Wilmington.

[b] Surveys conducted by NCWRC using non-NPS protocol.

[c] Updated from 2001 report to include nests found on Green Island at Oregon Inlet, which is now included in the Seashore boundary.

N/A = Not applicable.

Nonbreeding

Gull-Billed Tern

Fledged young and adults usually leave North Carolina's colonies by August, moving north for a short period before turning south for the fall and winter. Little is known of concentration areas during migration or winter, although wintering birds are known in Florida and the Gulf coastal region, from western Florida all the way south to Honduras and to Panama on the west coast. The gull-billed tern occasionally winters along the Atlantic Coast of North America as far north as North Carolina (Parnell et al. 1995; Cohen et al. ~~in press~~2010).

Common Tern

Fledged young and adults usually leave North Carolina's colonies in late July to August. They often move north before staging at sandbars near inlets in September and then heading south. Little information is known about winter range, but they are known from Florida south through the Caribbean to Peru and southern Brazil, where tens of thousands have been recorded in late winter (Nisbet 2002).

Least Tern

Fledged young and adults usually leave North Carolina's colonies in late July to August after breeding and also move northward into the New York to New England region before turning south to South America and the Caribbean. However, data are very limited on winter ranges (Thompson et al. 1997). Like other terns, least terns tend to congregate at staging areas along the Gulf Coast in August before departing for the winter (Thompson et al. 1997; Cohen et al. ~~in press~~2010).

Black Skimmer

Fledged young and adults usually leave North Carolina's colonies by early August and disperse northward before heading south. Large flocks congregate at staging areas, often with terns. Adults may remain with their young during fall migration. Most birds from the mid-Atlantic region winter from southern North Carolina to Florida, the Caribbean, and into Central and South America (Gochfeld and Burger 1994; Cohen et al. ~~in press~~2010).

Risk Factors

Human Activity. Ground-nesting colonial waterbirds are particularly vulnerable to impacts from human disturbance from ORVs, pedestrians, photographers, wildlife managers, and scientists because of the birds' usually high colony density and co-occurrence with human recreation (Erwin 1980; Cohen et al. ~~in press~~2010; Rodgers and Smith 1995; Rodgers and Schwikert 2002). Disturbances affect the birds' ability to feed, rest, and breed by evoking a flush response (Rodgers and Smith 1995; Rodgers and Schwikert 2002). Adverse effects from disturbance include egg and chick mortality, premature fledging, and reduced body mass (Rodgers and Smith 1995). Human activities that have indirect effects on bird behavior include sonic booms from military operations, aircraft disturbances, the presence of pets, and the leaving of garbage that subsequently attracts both avian and mammalian predators. Early in the spring, when the birds are first arriving and prospecting for breeding sites, even modest disturbances can be highly disruptive to colonial species (Buckley and Buckley 1976). Studies indicate that buffer distances between nesting areas and sources of human disturbances should be between 328 feet (100 meters) and 984 feet (300 meters), depending on the species and the particular behavior or reproductive stage (Rodgers and Smith 1995; Erwin 1989; Cohen et al. ~~in press~~2010). Recommended buffer distances from human disturbance are shown in table 31.

Human disturbance to waterbirds is frequently documented at the Seashore. At Cape Hatteras, four least tern chicks between ramps 23 and 30 and seven black skimmer chicks at Ocracoke Inlet were found dead or dying in ORV tracks during the 2003 breeding season. In all cases, the chicks were found adjacent to, but outside of, posted closures (NPS 2004g). Chicks become mobile after hatching, increasing their vulnerability. Colonial waterbird chick mortality from beach vehicles was documented every season from 2001 through 2004. Several chicks were killed by vehicles in 2001, 6 were killed in 2002, 11 were killed in 2003, and 6 were killed in 2004 (NPS 2002e, 2003b, 2004g, 2005d). Although no colonial waterbird deaths were directly attributed to impacts of human activity, instances of human disturbance to birds were reported in each colonial waterbird annual report from 2005 through 2008 (NPS 2006g, 2007g, 2008d, 2009k). Although informational signs are posted around all resource closures (including those for colonial waterbirds), violations by pedestrians, ORVs, and dogs are common at the Seashore. In 2008, there were several violations involving vehicles in colonial waterbird closures, including one that resulted in the crushing of a least tern egg by an ATV (NPS 2008h).

Least Tern Egg Crushed by Unauthorized ATV Use

Credit: NPS – Cape Hatteras National Seashore

TABLE 31. RECOMMENDED BUFFER DISTANCES FOR COLONIALLY NESTING WATERBIRDS

Species	Buffer Distance	Disturbance Type	Behavior/Stage	Source	Location
Mixed tern / skimmer colonies	591 feet (180 m)	Pedestrians and motor boats	Incubating and brooding adults	Rodgers and Smith 1995	Florida
Black skimmer	328 feet (100 m)	Pedestrian, ATV, ORV, boats	Adult foraging and loafing	Rodgers and Smith 1997	Florida
Least tern	328 feet (100 m)	All human disturbance	Established colonies post egg laying	Erwin 1989	Virginia, North Carolina

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Species	Buffer Distance	Disturbance Type	Behavior/Stage	Source	Location
Common tern Black skimmer	656 feet (200 m)	All human disturbance	Established colonies, post egg laying	Erwin 1989	Virginia, North Carolina
Common tern Least tern	150 feet[a] (50 yds)	All human disturbance	Nesting	Blodget and Melvin 1996	Massachusetts
Common tern Least tern	300 feet (100 yds)	All human disturbance	Chicks	Blodget and Melvin 1996	Massachusetts
Least tern	656 feet (200 m)	All human disturbance	Courtship/nesting	Erwin 1989	Virginia, North Carolina
Common tern Black skimmer	984 feet (300 m)	All human disturbance	Courtship/nesting	Erwin 1989	Virginia, North Carolina
All colonial waterbirds	1000 feet (305 m)	All human disturbance	Established colonies	Buckley and Buckley 1976	New York New England
Least tern	328 feet (100 m)	All human disturbance	Buffer entire colony after nesting	Cohen et al. ~~in press~~2010	Cape Hatteras National Seashore
Black skimmer Common tern Gull-billed tern	200 m	All human disturbance	Buffer entire colony after nesting	Cohen et al. ~~in press~~2010	Cape Hatteras National Seashore
Least tern	282 feet (86 m)	Personal watercraft	Foraging and loafing	Rodgers and Schwikert 2002	Florida
Common terns	328 feet (100m)	Personal watercraft	Nesting	Burger 1998	New Jersey

[a] Buffer should be expanded as needed to prevent disturbance to incubating birds.

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Weather and Tides. Nine named hurricanes affected the Outer Banks between 1993 and ~~2007~~ 2009 (NOAA 2009). Flooding and high winds from storms can result in nest loss or failure, which was demonstrated in 1999 when Hurricane Dennis hit the North Carolina coast. Impacts from the hurricane flooded the entire Ocracoke Inlet colony, resulting in the loss of all chicks and eggs (NPS 2000c). Winter storms can also impact shorebirds. High mortality of many coastal bird species was noted after a snowstorm swept the entire North Carolina coast in 1989 (USFWS 1996a). Storms can also result in beneficial impacts to shorebirds, as seen in 2003 when Hurricane Isabel's passing resulted in the creation of a great deal of suitable beach nesting habitat (NPS 2004g).

Predation. Resource Management staff at the Seashore is of the opinion that the leading cause of colonial waterbird nest and brood failure is predation (NPS 2009k). Predators of colonial waterbirds include red fox, gray fox, mink, opossum, dogs, cats, American crows, gulls, and raccoon. Foxes, raccoons, opossum, and feral cats have increased in recent years as human populations have grown in coastal regions (Buckley and Buckley 1976; Erwin et al. 2001; Cohen et al. ~~in press~~2010). The result of this predation has been poor reproduction or major redistributions of species such as gull-billed terns, common terns, least terns, and black skimmers (Erwin et al. 2001, 2003; Cohen et al. ~~in press~~2010). In addition, gulls are often predators of terns (Nisbet 2002). These include great black-backed gulls (*Larus marinus*), herring gulls (*Larus argentatus*), and the smaller laughing gulls (*Leucophaeus atricilla*). In addition, in certain areas other bird species may prey on terns and skimmers (or their eggs), such as peregrine falcons (*Falco peregrinus*), great-horned owls (*Bubo virginianus*), fish crows (*Corvus ossifragus*), and others (Cohen et al. ~~in press~~2010). In 2008, the Seashore modified the existing predator trapping program to provide a

more sustained trapping effort than occurred in previous seasons. The trapping program focused on depredation in the vicinity of shorebird nesting areas in an effort to reduce localized populations of raccoons, opossums, feral cats, red and gray foxes, and mink, which are all known predators of colonial waterbirds. However, raccoons at the Cape Point colony and mink at the South Ocracoke colonies severely hampered waterbird breeding success in those areas during the 2008 season (NPS 2009k).

WILSON'S PLOVER

Wilson's Plover

Credit: Terry Hartley / Due South Photography

Wilson's plover is a medium-sized, ringed plover of coastal habitats. Its overall length is 6.5 to 7.5 inches, and its weight ranges between 2 and 2.5 ounces. At all times of the year and in all plumages, its bill is entirely black, large, and heavy; its upperparts are generally grayish to grayish brown, and its underparts are white, with a black-to-brownish breast-band. Its legs and feet are flesh-colored to pinkish. It is readily distinguished from other, similar, ringed plovers by its larger size; by its large, heavy, all-black bill; and by its flesh-colored legs. The piping plover is smaller than Wilson's plover, having obviously paler upperparts, orange legs, and a much smaller, stubbier, two-toned bill that has an orange-yellow base and a black tip (Corbat and Bergstrom 2000; Hayman et al. 1986; Howell and Webb 1995). Wilson's plover has no federal protection status in the United States; however, it was classified as a species of conservation concern by the USFWS in 2002. Birds that appear on this list are those that, without additional conservation actions, are likely to become candidates for listing under the ESA (USFWS 2002; 16 USC 1531–1544). Brown et al. (2001) list Wilson's plover as a species of high concern in their prioritization of shorebird species according to relative conservation status and risk. Wilson's plover is listed as endangered in Virginia and Maryland, threatened in South Carolina, rare in Georgia, state protected in Alabama (~~National Audubon Society 2005~~Corbat and Bergstrom 2000), and as a species of special concern in North Carolina (NCAC 10I.0105, Subchapter 101 15A).

Distribution

Breeding. Wilson's plover is distributed locally along the Atlantic Coast, from Virginia south to southern Florida, including the Florida Keys, and from southern Florida west along the Gulf Coast to Veracruz, Mexico, the Yucatán, and Belize (Stevenson and Anderson 1994). Breeding locations are uncertain farther south along the Caribbean Coast of Central America.

In South America, Wilson's plover breeds locally along the Atlantic Coast, from Colombia south to Brazil, and includes the islands of Trinidad, Aruba, Bonaire, Margarita, and Curaçao, located off the coast of Venezuela (Meyer de Schauensee and Phelps 1978). In the West Indies, it breeds throughout the Bahamas, the Greater Antilles, the Virgin Islands, the Lesser Antilles, and in the Grenadines (Raffaele et al. 1998).

Along the Pacific Coast, Wilson's plover breeds locally along the west coast of Baja California, and from the Gulf of California south to Nayarit, Mexico (Howell and Webb 1995). Farther south along the Pacific Coast, it breeds from Mexico to Ecuador and Peru (Hilty and Brown 1986).

Wilson's Plover Chick
Credit: NPS

Nonbreeding. Wintering occurs mainly in northeast and central Florida (Corbat and Bergstrom 2000), as well as in west Louisiana and south Texas throughout the remainder of the breeding range (see above), to northern South America (Hayman et al. 1986).

Wilson's Plover in North Carolina and at Cape Hatteras National Seashore

A 2004 survey of the entire coast of North Carolina yielded 232 pairs of Wilson's plover. Of those, the Seashore supported two pairs of Wilson's plover on Ocracoke Island. In contrast, in 2004, Cape Lookout National Seashore supported 61 pairs and two individuals, which represented 26% of North Carolina's population of Wilson's plover (Cameron pers. comm. 2005). Wilson's plovers are often seen by Seashore staff during their piping plover observations, but no indications of nesting had been documented until 2009 when a three-egg nest was found in June. The nest hatched in July and produced one chick. The chick was not observed during subsequent observations and is not believed to have fledged (Muiznieks pers. comm. 2009).During the 2010 breeding season, two nests on Ocracoke Island fledged two chicks (Muiznieks per. c~~C~~omm~~.~~. 2010)

More comprehensive surveying of wintering shorebirds is being conducted per the NPS SECN Winter Monitoring Program. Implementation of the SECN Migratory, Wintering, and Beached Shorebird Monitoring Protocol at Cape Hatteras began in mid-July 2006. Only a few Wilson's plovers were observed at the Seashore from July to early December, and all birds were seen in foreshore habitat at low tide. SECN staff attributed the low numbers to insufficient training of field staff on the proper identification of Wilson's plover (Byrne et al. 2009). Seashore staff have not completed a comprehensive survey of nonbreeding Wilson's plovers, so it is not known if the Seashore supports wintering populations.

Wilson's plover is listed on the USFWS 1995 list of Non-game Birds of Management Concern (USFWS 1995) and the 2008 Birds of Conservation Concern (USFWS 2008b), ~~as well as being~~and is a North Carolina Species of Special Concern (NCWRC 2008b).

Habitat Description

Wilson's plovers are typically associated with coastal areas of high salinity and sparse vegetation, including salt flats, coastal lagoons, sand dunes, foredunes, and overwash areas above the high-tide line (Tomkins 1944; Hayman et al. 1986; Corbat and Bergstrom 2000). At the Seashore, Wilson's plover breeding sites have only been known to occur within piping plover closures. Hence, all closures, and much of the management of piping plovers, also apply indirectly to Wilson's plover.

Diet

Wilson's plover is a visual feeder on crustaceans, particularly fiddler crabs, and some insects (Strauch and Abele 1979; Morrier and McNeil 1991; Thibault and McNeil 1994), which they prey upon at intertidal

mudflats, sand flats, ephemeral pools, and shores of brackish ponds. They usually forage at low tide on intertidal mudflats (Strauch and Abele 1979; Thibault and McNeil 1994; Corbat and Bergstrom 2000).

Breeding Biology

Before territories are established in mid-March to early April (Tomkins 1944; Corbat and Bergstrom 2000), Wilson's plovers form pairs, and most breeding territories are established by mid-April. As with the piping plover, the nest is a scrape in sand that requires little construction (Bergstrom 1988). Egg laying peaks from late April through late May (Bergstrom 1988). Re-nesting after failure of a first nest can continue through the end of June. The estimated time required to complete a clutch of three eggs is four to six days (Bergstrom 1988; Corbat and Bergstrom 2000).

Reproductive Success at Cape Hatteras National Seashore

There are no data pertaining to Wilson's plover reproductive success at the Seashore.

Risk Factors

Because Wilson's plovers commonly nest on beaches with wide berms, which are also favored by birds like piping plovers, Wilson's plovers are subject to disturbances at their nests and roosts by the same factors as those that affect the piping plover, including beachgoers, pets, and ORV traffic on beaches. Wilson's plovers leave their nests when disturbed and are extremely reluctant to return when intruders are anywhere near, a practice that exposes eggs to predation and overheating (Corbat and Bergstrom 2000).

RED KNOT

The red knot is a shorebird that breeds in the Canadian Arctic and is known to visit North Carolina, the Outer Banks, and the Seashore, as well as the entire eastern seaboard of the United States, only as a migrant and an occasional winter resident (Harrington 2001). There are five subspecies currently recognized (*Calidris canutus canutus*, *C.c. rufa*, *C.c. islandica*, *C.c. rogersi*, *C.c. roselaari*) (Harrington 2001). Two of these (*C.c. rufa* and *C.c. roselaari*) are found in the United States but only during migration and in the winter. Southward migration of *C.c. rufa* and *C.c. roselaari* begins in mid-July, with staging occurring along the United States Atlantic Coast (Harrington 2001). Only those aspects of the red knot's life pertinent to its management and conservation in North Carolina, the Outer Banks, and the Seashore are covered in this section. The red knot is not listed as threatened or endangered by the USFWS, but it is a federal candidate species. The red knot does not carry state status in North Carolina ~~and is not on the USFWS 1995 list of Non-game Birds of Management Concern (USFWS 1995) or the 2008 Birds of Conservation Concern (USFWS 2008b)~~ .

Emergency Endangered Listing and Taxonomy

On August 1, 2005, in response to the 80% decline in red knot population over the past 10 years, leading conservation groups filed an emergency petition asking the USFWS to list the red knot as an endangered species under the ESA. The listing request came from an alliance of wildlife groups, including Defenders of Wildlife, New Jersey Audubon Society, American Bird Conservancy, the National Audubon Society, Delaware Audubon Society, Citizens Campaign for the Environment, Audubon New York, Audubon Maryland–DC, and the Virginia Audubon Council. On September 12, 2006, the USFWS announced that it had designated the red knot as a candidate for ESA protection. On February 27, 2008, conservation groups again petitioned the Department of the Interior to list as endangered the *rufa* subspecies of the red knot, and a broader taxon comprising both the *rufa* subspecies and the *roselaari* subspecies.

Red Knot
Credit: USFWS

Another indication of conservation concern for the red knot is the fact that in August 2004, the U.S. Shorebird Conservation Plan (2004) published its list of U.S. and Canadian shorebird populations that are considered highly imperiled or of high conservation concern. The Canadian Arctic–Atlantic Coast population of the red knot was one of eight taxa classified as Highly Imperiled. In 2008, the USFWS, which proposes candidates for listing under the ESA, determined that the ranking for the red knot should be raised from 6 to 3. The species' listing priority dictates the relative order in which proposed listing rules are prepared, with the species at greatest risk (listing priority 1 through 3) being proposed first (American Bird Conservancy 2008).

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Description

The red knot is characteristically found along the east coast of the United States, with its greatest population staging on Delaware Bay (Tsipoura and Burger 1999) on its migration from its breeding ground in the Canadian Arctic to the Tierra del Fuego region of Chile and Argentina in South America. It is this subspecies that is the subject of the emergency petition.

Males in breeding plumage have a dark red or salmon breast, throat, and flanks, with a white belly. Their crowns and backs are flecked with gray and salmon (Harrington 1996, 2001; Paulson 1993). Female coloration is similar to that of males but is typically less intense. Nonbreeding plumage is a plain gray on the head and back, with light fringes of gray and white along the wings, giving an appearance of a white line running the length of the wing when in flight. The breast is white, mottled with gray, and the belly is dull white. For both male and female, the bill is black (year-round), and the legs are dark gray to black (Harrington 1996, 2001). The average weight of the red knot is 5 ounces (which varies considerably through the year), with a body length between 9 and 10 inches.

Range and Migration

Red knots are found in the Arctic regions of Canada during the breeding season, which is mid-June through mid-August. They winter from November to mid-February primarily in two separate areas in South America—Tierra del Fuego in Chile and Argentina, and in Maranhão, northern Brazil (American Bird Conservancy 2005). Additional, smaller numbers of red knots also winter farther northwest in French Guiana and in the coastal, southeastern United States, including North Carolina, the Outer Banks, and the Seashore.

Red knots have one of the longest migrations of any shorebirds. Those individuals that winter in southern South America embark on their northern migration in February, with peak numbers leaving Argentina and southern Chile in mid-March to mid-April (Harrington 1996, 2001). The first stopover is along the coast of southern Brazil (Vooren and Chiaradia 1990), and the final stopover is the Delaware Bay. Their southward migration from the Canadian Arctic begins in mid-July. They arrive in South America along the coast of the Guianas in mid- to late August (Spaans 1978). From the Guianas, red knots continue to move southward along the Atlantic coastline of South America, and the greater part of the population will continue on to Tierra del Fuego to winter (Morrison et al. 2004).

These long-distance migrations can only occur when the birds have access to productive refueling stops, particularly on their northern migrations, which involve fewer stops than the southern ones. For red knots on the eastern seaboard of the United States, Delaware Bay is the most crucial spring stopover because it is the primary final stop at which the birds can refuel in preparation for their nonstop leg to the Arctic.

When they arrive at their final destination, weather conditions can be harsh, and food is scarce. Their fat reserves from the Delaware Bay must sustain them not only during their 2,400-kilometer (1,488-mile) final flight, but also upon arrival in the Arctic until food resources become more plentiful (Baker et al. 2004).

Red knots do not breed at the Seashore, but use it in the winter and during spring and fall migration.

Nonbreeding Habitat

Harrington (1996, 2001) describes how, during the winter, the red knot frequents intertidal habitats, notably along ocean coasts and large bays. Both areas usually display high waves or strong currents while supplying a sandy habitat. These areas are selectively chosen in South America, with the most abundant population on the island of Tierra del Fuego in Argentina and Chile (Morrison and Ross 1989).

On migration, the red knot principally uses marine habitats in both North and South America. Coastal habitats along the mouths of bays and estuaries are preferred, providing sandy beaches on which to forage (Harrington 1996, 2001). Niles et al. (2007) suggested that red knots consistently use coastal areas of North Carolina during spring and fall migration and indicated that approximately 1,000 red knots were observed on Ocracoke Island in early May 2005. Red knots are also known to use tidal flats in more sheltered bays or lagoons in search of benthic invertebrates or horseshoe crab eggs (Harrington 1996, 2001; Tsipoura and Burger 1999). In some cases, beach habitats are preferred because of high densities of benthic bivalves (Harrington 1996). Red knots also use tidal flats in more sheltered bays or lagoons, where they hunt for benthic invertebrates (Harrington 2001) or for special foods, such as horseshoe crab eggs (Harrington 1996; Tsipoura and Burger 1999). Delaware Bay hosts the largest number of spawning horseshoe crabs (a primary food source for the red knot) in the United States. At Delaware Bay, the red knots feed and put on weight needed for winter migration. The increasing human harvest of the horseshoe crab has reduced this food source for red knots, and this dearth is believed to be contributing to the red knot's failure to reach its needed threshold departure weight of 6.3 to 7.0 ounces. Hence, there has been a systematic reduction in the body weight of red knots leaving Delaware Bay for the Arctic, which negatively impacts their ability to survive and breed (Baker et al. 2004). Since 1999, reductions in commercial harvesting of horseshoe crabs in New Jersey and Delaware have been substantial, although the effect on horseshoe crab populations is not yet known. Preliminary 2009 information indicated that red knots were able to attain threshold departure weights and left the Delaware Bay stopover in good condition. However, it remains to be seen if this will become a long-term trend (FR 2009).

Nonbreeding Observations at Cape Hatteras National Seashore

During their wintering shorebird study, SECN staff observed red knots at the Seashore from August 2006 through February 2007. Monthly counts were highly variable with the two highest single-day counts in November 2006 and February 2007. Almost all red knots documented during this time were located in the foreshore habitat type (Byrne et al. 2009). Resource management staff at the Seashore have not yet begun surveying the entire Seashore for red knots, which are known to use areas outside the points and spits.

Risks

Red knots are highly vulnerable to degradation of the resources on which they depend to accomplish their migrations. Morrison et al. (2004) have identified four factors that cause this vulnerability: (1) a tendency to concentrate in a limited number of locations during migration and on the wintering grounds so that deleterious changes can affect a large proportion of the population at once; (2) a limited reproductive output, subject to vagaries of weather and predator cycles in the Arctic, which, in conjunction with a long lifespan, suggests slow recovery from population declines; (3) a migration schedule closely timed to

seasonally abundant food resources, such as horseshoe crab eggs during spring migration in Delaware Bay (Tsipoura and Burger 1999), suggesting that there may be limited flexibility in migration routes or schedules; and (4) occupation and use of coastal wetland habitats that are affected by a wide variety of human activities and developments (Bildstein et al. 1991).

WILDLIFE AND WILDLIFE HABITATS

In addition to the federally listed threatened and endangered species and other protected species detailed in previous sections of this chapter, other wildlife species depend on the habitats within the Seashore. This section describes those invertebrate species and other bird species that could be found in the study area and could be affected by ORV management alternatives.

Coquina Clam Shells

Credit: NPS

Limpet Shells

Credit: NPS

OTHER BIRD SPECIES

The Outer Banks of North Carolina provide a critical link in the migratory path of several shorebird species. The barrier island ecosystems at the Seashore provide habitat for large numbers of migratory and nesting bird species, and coastal marshes are critical to wintering populations of many waterbirds. Nearly 400 species of birds have been sighted within the Seashore and its surrounding waters (Fussell et al. 1990). Migration routes for many raptor species include southeastern barrier islands. Thousands of migrating shorebirds use the barrier islands as a stopover point to rest, forage, or spend the winter (Manning 2004). In 1999, the American Bird Conservancy designated Cape Hatteras National Seashore as a Globally Important Bird Area in recognition of the Seashore's value in bird migration, breeding, and wintering (American Bird Conservancy 2005).

Marbled Godwit

Credit: Lee Karney / USFWS

Studies have recorded 21 species of shorebirds (table 32) on the beaches of the Outer Banks of North Carolina, such as whimbrels (*Numenius phaeopus*), willets (*Catoptrophorus semipalmatus*), and sanderlings (*Calidris alba*). These shorebirds are most abundant in May and August. Least terns, common terns, gull-billed terns, black skimmers, piping plovers, Wilson's plovers, willets, and American oystercatchers can all be found nesting on North Carolina beaches (North Carolina Audubon 2008). Several of these species are designated as state-listed and/or federally listed threatened or endangered species and are discussed in a previous section of this chapter. However, nonlisted shorebirds such as willets have similar nesting and foraging habitats to those of state- and federally listed species. The eastern willet, for instance, breeds in coastal saltmarshes and nests on the ground, often in colonies, usually in well-hidden locations in short grass. These birds forage on mudflats or in shallow water, probing or picking up food by sight. Their diet consists of insects, crustaceans, and marine worms, as well as some plant material. Although not state-listed or federally listed, several of the shorebirds found at the Seashore appear on the USFWS Birds of Conservation Concern list, which identifies migratory birds that, without additional conservation actions, are likely to become candidates for listing under the ESA

(USFWS 2008b). Other waterbirds found at the Seashore include gulls, pelicans (*Pelecanus* spp.), terns, and egrets (family Ardeidae) (NCWRC 2005).

TABLE 32. SHOREBIRDS ON THE OUTER BANKS OF NORTH CAROLINA, 1992–1993

Scientific Name	Common Name
Pluvialis squatarola	Black-bellied plover
Charadrius wilsonia	Wilson's plover
Charadrius semipalmatus	Semipalmated plover
Charadrius melodus	Piping plover
Haematopus palliates	American oystercatcher
Catoptrophorus semipalmatus	Willet
Numenius phaeopus	Whimbrel
Limosa fedoa	Marbled godwit
Arenaria interpres	Ruddy turnstone
Calidris canutus	Red knot
Calidris alba	Sanderling
Calidris pusilla	Semipalmated sandpiper
Calidris mauri	Western sandpiper
Calidris minutilla	Least sandpiper
Calidris alpine	Dunlin
Limnodromus griseus	Short-billed dowitcher
Charadrius vociferous	Killdeer
Tringa melanoleuca	Greater yellowlegs
Tringa flavipes	Lesser yellowlegs
Actitis macularia	Spotted sandpiper
Calidris fuscicollis	White-rumped sandpiper

Source: Dinsmore et al. 1998

Migratory birds are often found at the Seashore throughout the year. During the winter months, the common loon (*Gavia immer*), pied-billed grebe (*Podilymbus podiceps*), northern gannet (*Morus bassanus*), tundra swan (*Cygnus columbianus*), and Canada goose (*Branta canadensis*) are common sights at the Seashore. During the summer migratory season, several varieties of herons (*Ardea* spp.), Audubon's shearwater (*Puffinus lherminieri*), and the barn swallow (*Hirundo rustica*) populate the Cape Hatteras shores. While less frequently sighted, grebes (*Podiceps auritus*), mallard ducks (*Anas platyrhynchos*), hawks (genus Accipiter), bald eagles (*Haliaeetus leucocephalus*), peregrine falcons, and various species of sandpipers also inhabit the Seashore at one point or another throughout the year. Studies have demonstrated the importance of the Outer Banks as a staging area for piping plovers, whimbrels, and sanderlings when compared to other areas along the Atlantic Coast and confirmed that the area provides a critical link in the migratory path of several shorebird species (Dinsmore et al.1998).

INVERTEBRATES

The Seashore beach ecosystem is home to a vast quantity of invertebrates, which form a valuable link in the coastal food chain. Many of the protected bird species found within the Seashore, including the piping plover, Wilson's plover, red knot, American oystercatcher, and gull-billed tern, feed on invertebrates in areas that are open to ORV use, such as the intertidal zone and the wrack line. High-energy, intertidal beaches in the southeastern United States generally support approximately 20 to 30 types of invertebrate species (Ruppert and Fox 1988), with the most identifiable being mole crabs, ghost crabs, and coquina clams (*Donax variabilis*). Both mole crabs and coquina clams are a primary prey base for fish, crabs, and shorebirds, and the population density of some predators may actually be dependent on the availability these invertebrate species (Greene 2002). Other invertebrates within the Seashore beach ecosystem include clamworms (*Nereis succinea*), limpets (*Patella vulgata*), which can be found in the intertidal zone, and varieties of jellyfish sea urchins and sea stars (class Asteroidea), all of which spend their entire lives in the water.

Ghost Crab

Credit: George Harrison / USFWS

Ghost crabs are sand-colored, terrestrial animals with square-shaped bodies, which are generally no more than 2 to 3 inches wide (Lippson and Lippson 1997). Ghost crabs are a top predator of the beach ecosystem and can be used as an indicator species to analyze the health of the beach ecosystem due to their prominence and high susceptibility to anthropogenic disturbances (Hobbs et al. 2008). They are primarily nocturnal and create burrows for shelter from heat and desiccation (drying) stress during the warmer afternoon periods. Burrows are usually 0.6 to 1.2 meters in length and are generally located in an area from the high-tide line landward up to 400 meters. Ghost crabs emerge from their burrows at night to feed in the intertidal zone, and travel up to 300 meters while foraging (Hobbs et al. 2008). Ghost crabs retreat deep into their burrows during the winter months (Lippson and Lippson 1997).

Like ghost crabs, mole crabs are a common inhabitant of the high-energy, exposed beach environment. In contrast to other species of crabs, they do not have claws or pincers. Mole crabs are generally less than 2 inches in length and have egg-shaped bodies that allow for rapid digging in wet sand (Ruppert and Fox 1988). Mole crabs are filter feeders that burrow and anchor themselves into the sands within the swash zone, collecting organic matter that they trap within their feeding antennae when water recedes over the buried crabs. Unlike ghost crabs, mole crabs move off the beach to deeper offshore waters during the winter (Lippson and Lippson 1997).

Marine bivalves such as oysters (*Crassostrea virginica*), razor clams, coquina clams, and ribbed mussels (*Geukensia demissa*) also inhabit the Seashore, forming the diet for many birds. Clams characteristically lie buried just beneath the surface of the sand, although they can burrow to greater depths as necessary. Much like the mole crab, coquina clams are filter feeders and migrate up and down the ocean beach in the intertidal area during the spring and summer (Ruppert and Fox 1988). Due to its importance in food webs, the coquina clam is considered an indicator species for the sandy beach oceanfront habitat. It feeds on small particles such as unicellular algae and detritus and in turn, is consumed by fish and birds (SCDNR 2009).

In addition to the intertidal zone, another important habitat for invertebrates is the wrack line. A wrack line is a line of stranded debris along a beach face marking the point of maximum run-up during a previous high tide. The wrack line is often composed of drying seaweed, tidal marsh plant debris, decaying marine animals, shells, and miscellaneous debris washed up and deposited on the beach. The wrack line provides a habitat suitable for many invertebrates such as amphipods, beetles, mites, flies, and spiders. Studies have demonstrated that ORV use in and around the wrack line reduces the density of invertebrates in beach environments.

Intertidal Zone
Credit: NPS

A 3-year study on Cape Cod and Fire Island, New York (Kluft and Ginsberg 2009), found that the shrimp-like crustaceans called amphipods are particularly vulnerable to drying out in immature stages, and use the wrack line as cover. Several species of flies also use the site to lay their eggs, and wolf spiders (family Lycosidae) migrate back and forth from the beach grass to the wrack line to feed on these amphipods. The study observed that higher ORV traffic resulted in dispersal and desiccation of the wrack line, thereby reducing the populations of invertebrates in these areas.

SOUNDSCAPES

According to the NPS, the acoustical environment is comprised of a combination of acoustic resources, including natural, cultural, and historical sounds. A soundscape is defined as the way in which humans perceive this acoustic environment (NPS 2009g). Specifically, the natural soundscape encompass all of the natural sounds that occur in parks, including the physical capacity for transmitting those natural sounds and the interrelationships among park natural sounds of different frequencies and volumes (NPS *Management Policies 2006* [NPS 2006c, sec 4.9]). Natural sounds may range from bird and bat calls and insect chirps, to sounds produced by physical processes like wind rushing through leaves on trees, thunder, and rushing and falling water through rivers, creeks and streams within a park. According to the NPS, 72% of visitors indicate that a crucial reason for the need to preserve national parks is that parks provide opportunities to experience natural peace and the sound of nature (NPS 2009g). Therefore, the NPS works to preserve, to the greatest extent possible, the natural soundscapes of parks.

NOISE FUNDAMENTALS

According to the NPS, "although noise has been used as a synonym for sound, it is essentially the negative evaluation of sound by people, is extraneous, or undesired. Humans perceive sound as an auditory sensation created by pressure variations that move through a medium such as water or air and is measured in terms of amplitude and frequency" (NPS 2009g). Sources of noise within national parks are dependent upon the particular park and may include vehicular sources (cars, buses, or other vehicles) used for tours and access to trails and campgrounds, aircraft overflights from planes, helicopters and military jets along with airport development, snowmobiles and watercraft, park operations and energy development (NPS 2009i).

The magnitude of noise is usually described by its sound pressure. Since the range of sound pressure varies greatly, a logarithmic scale is used to relate sound pressures to some common reference level, usually the decibel (dB). Sound pressures described in decibels are called sound pressure levels and are often defined in terms of frequency-weighted scales (A, B, C, or D).

The A-weighted decibel scale is commonly used to describe noise levels because it reflects the frequency range to which the human ear is most sensitive (1,000–5,000 Hertz) (Caltrans 1998). Sound levels

measured using an A-weighted decibel scale are generally expressed as dBA. Throughout this section, all noise levels are expressed in dBA. Several examples of sound pressure levels in the A-weighted (dBA) scale are listed in table 33, while table 34 presents examples of sound pressure levels measured in national parks.

TABLE 33. EXAMPLES OF COMMON SOUNDS

A-weighted Sound Level (dBA)	Overall Level	Noise Environment
120	Uncomfortably loud (32 times as loud as 70 dBA)	Military jet airplane takeoff at 50 feet
100	Very loud (8 times as loud as 70 dBA)	Jet flyover at 1,000 feet Locomotive pass-by at 100 feet
80	Loud (2 times as loud as 70 dBA)	Propeller plane flyover at 1,000 feet. Diesel truck 40 mph at 50 feet
70	Moderately loud	Freeway at 50 feet from pavement edge at 10:00 a.m. Vacuum cleaner (indoor)
60	Relatively quiet (one-half as loud as 70 dBA)	Air condition unit at 100 feet. Dishwasher at 10 feet (indoor)
50	Quiet (1/4 as loud as 70 dBA)	Large transformers Small private office (indoor)
40	Very quiet (1/8 as loud as 70 dBA)	Birds calls. Lowest limit of urban ambient sound
10	Extremely quiet	Just audible (1/64 as loud as 70 dBA)
0	Threshold of hearing	Quietest sound detectible by a healthy human ear

Source: FICN 1992
Modified by: The Louis Berger Group, Inc., October 1998.

TABLE 34. SOUND PRESSURE LEVELS MEASURED IN NATIONAL PARKS

Sound	dBA
Threshold of human hearing	0
Haleakala National Park: Volcano crater	10
Canyonlands National Park: Leaves rustling	20
Zion National Park: Crickets (5 meters)	40
Whitman Mission: Conversational speech (5 meters)	60
Yellowstone National Park: Snowcoach (30 meters)	80
Arches National Park: Thunder	100
Yukon-Charley Rivers National Park: Military jet (100 meters above ground level)	120

Source: NPS 2009h

Human and Wildlife Response to Changes in Noise Levels

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Noise may have adverse effects on the human population in a variety of ways. Noise may interfere with human activities, such as sleep, speech communication, and tasks requiring concentration or coordination. At a physiological level, noise may also cause annoyance, hearing damage, and other health-related problems. The degree of disturbance from unwanted sound depends essentially on (1) the amount and nature of the intruding noise; and (2) the type of activity occurring where the noise is heard. In considering the first of these factors, it is important to note that individuals have different sensitivity to noise. Loud noises bother some people more than others, and some patterns of noise also affect a person's perception of whether or not a noise is offensive. With regard to the second factor, individuals tend to judge the annoyance of noise relative to the natural sounds (i.e., without the intruding noise source) and activities occurring where the noise is heard. For example, if regions of a park are dedicated to enjoying the tranquility and serenity of the natural environment, sounds from motor boating and hunting would be distracting to the visitor experience. However, if these activities are consistent with the purpose of a particular region of the park, these sounds would be considered appropriate. Therefore, noise is a subjective term, and it is important to characterize the activities essential to the park's purpose (NPS 2000a).

It is widely accepted that the average healthy ear can barely perceive noise level changes of 3 dBA or less. A change of 5 dBA is readily perceptible and an increase or decrease of 10 dBA is perceived as being twice or half as loud, respectively (see table 35).

Table 35. Decibel Changes, Loudness and Energy Loss

Sound Level Change	Relative Loudness	Acoustic Energy Loss
0 dBA	Reference	0.0%
- 3 dBA	Barely perceptible change	50.0%
- 5 dBA	Readily perceptible change	67.0%
- 10 dBA	Half as loud	90.0%
- 20 dBA	1/4 as loud	99.0%
- 30 dBA	1/8 as loud	99.9%

Source: FHWA 1995

NOTE: This table underestimates changes in perceived loudness for low frequency noise, including transportation noise, which falls within the frequency range of 100 Hz to 1 kHz.

Wildlife are very sensitive to sound, as animals often depend on auditory cues for hunting, predator awareness, sexual communication, defense of territory, and habitat quality assessment (Barber et al. 2010). The consequences of higher ambient sound levels due to human noise, along with sound events associated with human activities (motorists, snowmobiles, hikers), have been observed in many species (Frid and Dill 2002; Landon et al 2003; Habib et al. 2007).

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Birds are especially susceptible to human-associated environmental sounds as they rely heavily on auditory cues for identifying and attracting suitable mates, pair bonding, communication among and between species, and detection of predator alerts or warning signals (Francis et al. 2009). Similar to physical degradation of the habitat caused by development, or other human activities, the low frequency, high amplitude, nearly omnipresent sound produced by roads, vehicles, airports, and mechanical equipment has been found to result in a decline in species diversity, abundance, and breeding success (Rheindt 2003).

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Researchers found that the presence of low-frequency mechanical noise limits communication between members of the same species, often reducing nesting success (Habib et al. 2007). For example, females zebra finches, exposed to high-amplitude, low-frequency sounds, such as those produced by traffic or other motor vehicles, showed less preference for their pair-bonded male. As the amplitude of ambient, low-frequency sounds increased, the strength of pair bonds decreased. Masking or distortion caused by ambient human-associated noise levels, likely reduced the clarity of the male's bonding call. When the female zebra finch was unable to detect the bonding call associated with her bonded mate, it appeared that she was unable to identify her mate, or found him less attractive (Swaddle and Page 2007). As a result, zebra finch females showed more interest in males other than their pair-bonded mate. This type of behavior may reduce pairing success, disrupt the strength of sexual selection, and affect the overall genetic structure of a population of birds nesting and seeking mates in the vicinity of roadways or in other areas exposed to high-amplitude mechanical noise (Swaddle and Page 2007).

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Many bird species' diversity and population decreases in locations closer to ~~the road,~~roads or sources of mechanized sound, described as the 'road effect' (Francis 2009). This effect is often attributed to mechanical noise levels, rather than to decreased habitat quality or direct mortality caused by vehicle collisions (Reijnen et al. 1995; Rheindt 2003). Certain species suffer more negative effects than others. Researchers have found ~~that~~ this is due, in part, to a greater difference between a bird's song frequency and the low-frequency sound produced by motorized vehicles. That is, birds with higher-frequency songs may have greater density and reproductive success than those with songs in ~~the low~~lower frequencies. This is because these high-frequency songs are not as strongly masked, and are perceived more clearly by birds, thus increasinges communication between bonded pairs. Some birds adapt to the presence of motorized sounds by increasing the amplitude of their song, singing earlier in the morning when motorized sound are generally lower, or using mainly higher-pitched calls (Rheindt 2003).

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Predation risk ~~on~~for ~~both birds~~ adult and nestlings birds increases in areas with high-amplitude, low-frequency mechanical sounds (Lima 2009). Direct predator risk may increase because nesting birds are unable to ~~both~~ detect auditory cues made by the predators ~~themselves~~ (such as a redtail hawk scream, or the cawing of a crow), ~~or/and~~and/or because they are unable to detect the warning calls of members of their own species or other birds in the area (e.g., the warning calls of a sparrow about a circling hawk). These impacts are due to masking or distortion of the natural sounds in the environments by mechanical or human-associated sounds. Additionally, human-caused sounds may themselves ~~may~~ be considered a predation risk, and birds have been found to respond in areas of high-amplitude human-associated sounds in similar ways that they might respond ~~to~~in areas with high numbers of predators such as~~(eg.~~ rodents or raptors~~)~~ (Lima 2009). Birds may respond with avoidance of such habitat, that may reduce the availability of prime nesting habitat containing the best cover and food sources. Birds may also respond by foregoing breeding altogether or reducing personal risk of predation by providing poorer quality care to fledglings (Lima 2009). Other risk-avoidance behaviors ~~risk~~ include active flight, decreased foraging and increased vigilance, and a reduction in overall fitness levels. Wildlife exposed to frequent sound events would also likely increase the intensity of ~~wildlife~~ their responses to all perceived predation threats (Rabin et al. 2006). Both direct and perceived or indirect predator risk may decrease overall reproductive success for birds and other species of wildlife.

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Alternatively, certain species, especially those considered 'urban adapted' like pigeons, may benefit from the disruption caused by human-associated noise. Researchers found that, when all other factors (habitat quality) were equal, mechanical noise alone reduced nesting species diversity, resulting in changes to the natural bird communities in these areas. A controlled experiment provided strong evidence that noise alone negatively influences bird population levels and species diversity, in much the same way as the physical destruction of, or altering of a natural habitat (Francis 2009). This effect is likely due to the masking of natural sounds by mechanical noise, which prevents many species of birds from successfully nesting in such areas. Increased mechanical sound levels altered species interactions, along with predator-prey interactions. Alternatively, certain species appeared to thrive in areas with

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increased sound levels, benefitting with decreased direct predation levels, and increased reproductive success. This observation may explain why certain bird species (pigeons, sparrows, starlings), thrive in heavily human influenced environments, and why species diversity in urban environments is very low (Francis 2009).

These examples demonstrate that low-frequency, mechanized noise may negatively impact bird species' reproductive success, by limiting auditory cues necessary for nesting and pair bonding; altering genetic preferences; masking natural auditory cues provided by other members of the same species, predators, or other bird species; and increasing perceived predation, or actual predation risk (Swaddle and Page 2006; Lima 2009; Habib 2007). However, such effects may be species specific, as certain factors, including a higher song frequency (Rheindt 2003), and ability to nest near mechanized sound sources without increased stress or predation risk (Francis 2009), may actually increase reproductive success of certain species. Birds have also shown ability to adapt certain behaviors, or ecological traits, when exposed to predation risk, decreasing the negative impacts of mechanized noise perceived as predator risk (Lima 2009).

Negative health impacts have been associated with high sound levels in humans, and such impacts likely also occur in animals (Jarup et al. 2008). Human noise also serves to mask other sounds; that is, it reduces the capacity to detect a sound of interest due to the presence of high ambient sound levels or anthropogenic sounds (Barber et al. 2010).

~~In addition to its effect on humans, studies have shown that intrusive and other human-induced noises can result in adverse physiological and behavioral changes in wildlife communities; however, the severity of impacts is dependent upon the particular species. For example, some sound sources have been associated with increased stress levels, as well as suppression of the immune system in wildlife. Additionally, increases in ambient noise levels may interrupt important communication networks for survival and reproduction between insects, birds, and mammals. Specifically, wildlife communications may signify mating calls, danger from predators, and territorial claims (NPS 2009j). An increase in ambient noise levels from the presence of intrusive noise sources may also reduce the listening area over which predators can hear their prey, as well as reduce the distance at which prey can begin to hear their predators (California State Lands Commission 2005).~~

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EXISTING SOUND LEVELS

The presence of millions of visitors to the Seashore engaging in various activities, coupled with the vehicular traffic through this Seashore along NC-12 and associated ramps, including ORV usage on the beaches, serve as sources of unnatural sounds within this Seashore. However, these sources are also considered to be consistent with the Seashore's purpose.

In order to determine the natural ambient sound levels within the Seashore and characterize the natural soundscape, the NPS Natural Sounds Program assisted the Seashore conduct acoustical monitoring within the Seashore. The sound level data collected by the Natural Sounds Program will facilitate the estimation of noise impacts from the use of ORV, serving as a comparative baseline condition to ORV noise.

A summary report of the sound level measurements, known as an "Acoustical Monitoring Snapshot," was developed by the NPS Natural Sounds Program and includes the locations of two representative sites where measurements were conducted, as well as a brief vegetative description for the sites and measured sound levels. The measured sound levels represent exceedance levels (L_x) that describe the measurement data in terms of the decibel level that is exceeded x percent of the time during a given measurement period (i.e., an L_{10} value of 55 dBA indicates that the sound level is 55 dBA for 90% of the measurement and exceeds this level 10% of the measurement period). As the NPS is required to protect the natural soundscape, impact assessment is based on comparisons against the natural ambient sound levels. Natural

ambient sound levels represent the natural environment, absent human-caused sounds, and may be well estimated based on the L_{90} metric. The L_{90} metric represents the sound level exceeded 90 percent of the time.

Sound level measurements were conducted at two sites over a period of 31 days between May 2008 and June 2008. Sound level data were collected during a daytime (7:00 a.m. to 7:00 p.m.) and a nighttime (7:00 p.m. to 7:00 a.m.) period. Monitors were placed in secure locations, away from traffic and the beaches. Site one, labeled CH1 (figure 19), was located on Bodie Island Bone Yard just north of the fishing center and west of NC-12 on the side of the island near the sound. The site is composed of woody wetlands and mixed forest. Daytime existing L_{90} sound levels are 33.6 dBA while nighttime L_{90} sound levels are 33.8 dBA. Site CH2 (figure 20) is located at Cape Point on the ocean side within woody wetlands and shrublands. Existing L_{90} sound levels are 33.4 dBA during the daytime and 41.0 dBA during the nighttime period.

NPS protocols for acoustic monitoring at national parks (NPS 2006c) were followed in the collection of acoustic data at Cape Hatteras National Seashore to determine ambient conditions. The protocols attempt to capture spatial and temporal variability within the Seashore. Therefore, monitors are typically not placed near sound sources that would dominate and mask other acoustic resources (i.e., birds, insects). As noise from the surf is a predominant natural sound source along the beaches within this Seashore, the NPS Natural Sounds Program also provided published information on surf sounds to further characterize the natural soundscape within the Seashore.

Sounds from the surf vary, depending on how active the surf is (i.e., during high tide or stormy conditions the surf has more acoustic energy), and therefore sound levels may range between 20 dBA during less active periods and 55 dBA during more active periods (California State Lands Commission 2005). Additionally, surf noise is predominant on the beaches, but diminishes with increasing distance from the beaches, where vehicular noise sources may prevail from NC-12 and associated ramps and smaller feeder roadways. Acoustic conditions at the surf were extrapolated using the collected data. The results of the extrapolation were verified and corroborated by published sources (*Disposition of Offshore Cooling Water Conduits SONGS Unit 1 EIR*) and the experiences of Seashore managers.

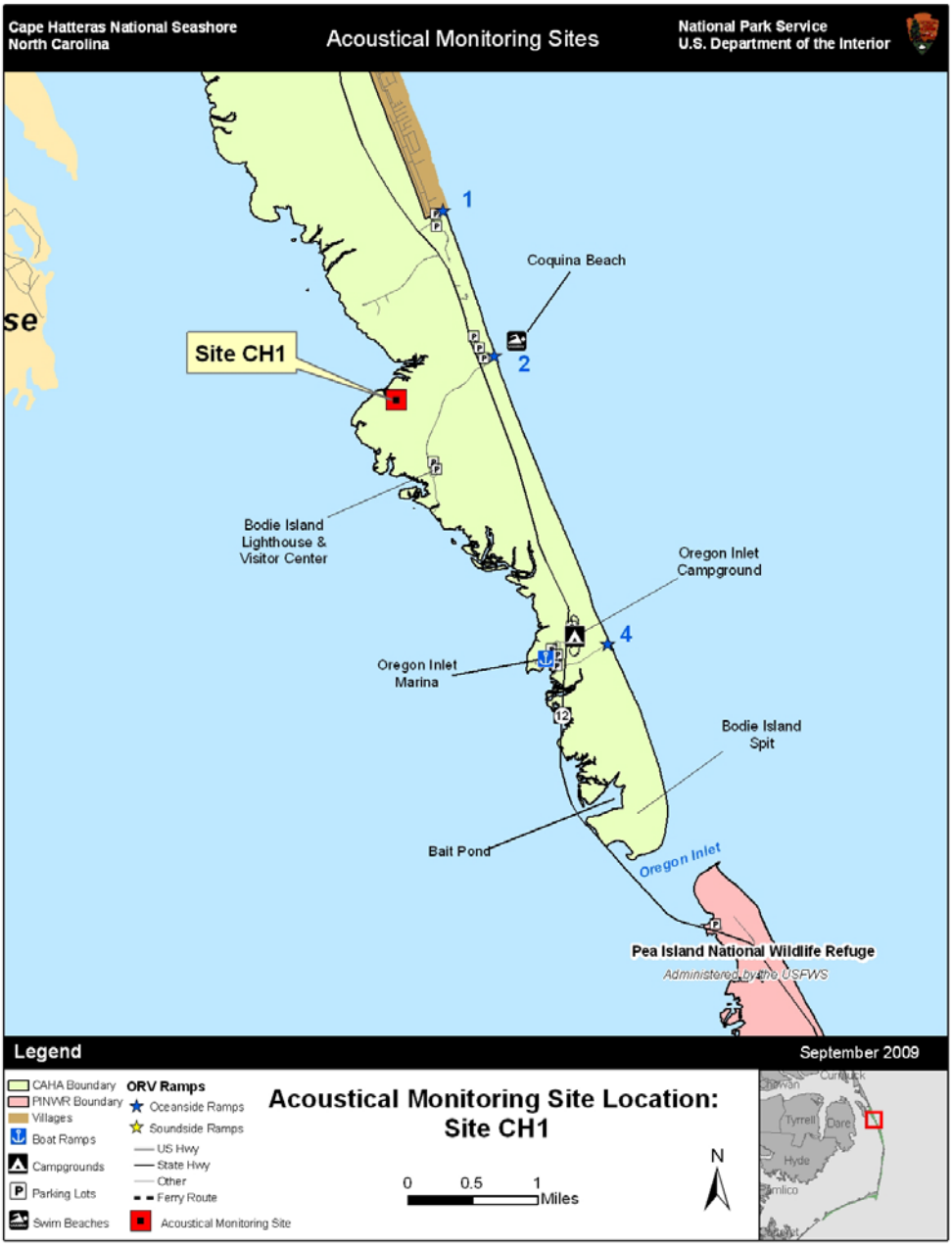
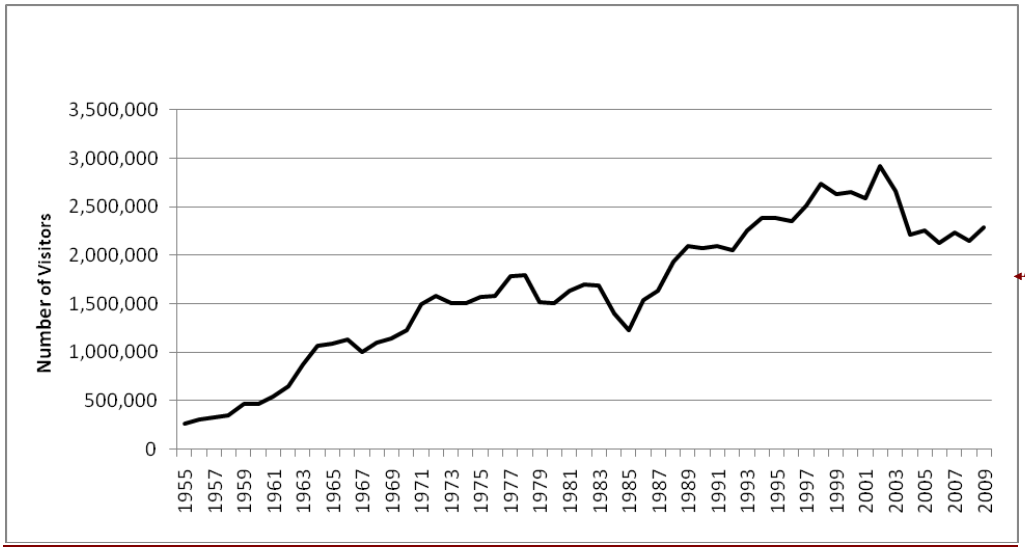


FIGURE 19. ACOUSTICAL MONITORING SITE LOCATION FOR CH1

FIGURE 20. ACOUSTICAL MONITORING SITE LOCATION FOR CH2

VISITOR USE AND EXPERIENCE

Visitation to the Seashore has shown a relatively steady increase, with occasional dips, particularly in the mid-1980s and recently from 2003 to the present. More than 2 million visitors have recreated at the Seashore every year since 1990 (see figure 21). Figure 22 illustrates visitor use data for 2005 through ~~November 2009~~July 2010, which indicate that highest use occurs during June, July, and August; this accounts for approximately 4~~7~~6% of the annual recreation visits (based on 200~~7~~9 data). Another 2~~1~~0% of annual visitation occurs during the fall (September, October, and November), 2~~5~~4% in the spring (March, April, and May), and ~~7~~9% in the winter (December through February) (NPS 2008e). Overall, visitation at the Seashore in 2009 has been higher than 2008, with July 2009 visitation of 407,754 being the highest since 2003 (Murray pers. comm. 2009b).



Source: NPS 2008e

FIGURE 21. ANNUAL RECREATIONAL VISITATION AT CAPE HATTERAS NATIONAL SEASHORE, 1955–~~2008~~2009

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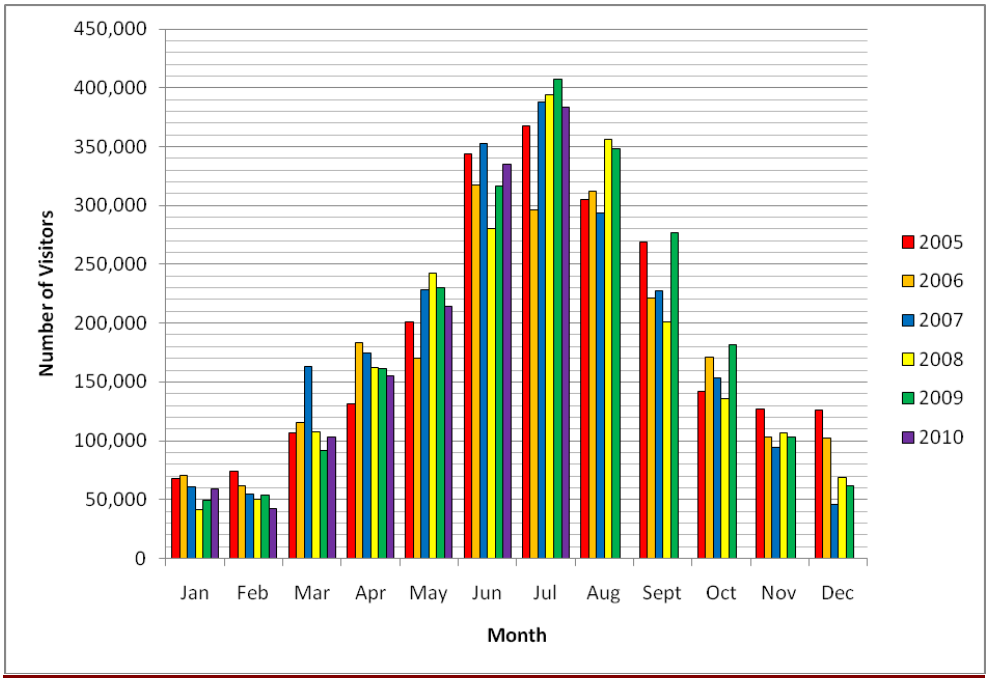

Source: NPS 2008e; Broili pers. comm. 2009

FIGURE 22. MONTHLY RECREATIONAL VISITATION AT CAPE HATTERAS NATIONAL SEASHORE, JANUARY 2005–~~NOVEMBER 2009~~JULY 2010

VISITOR CHARACTERISTICS

A study conducted by the University of Idaho during 1 week in July 2002 showed that many visitors (44%) were from North Carolina and Virginia, approximately 10% were from Ohio, and smaller proportions of visitors came from 29 other states and Washington DC. Over 50% of visitors were between 30 and 50 years of age (University of Idaho 2003).

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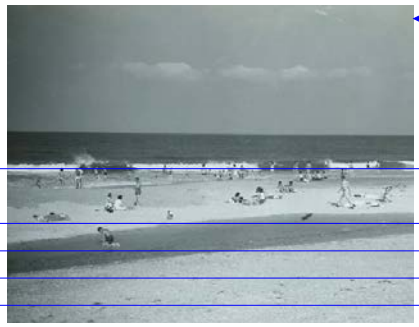
RECREATIONAL OPPORTUNITIES AND USE AT CAPE HATTERAS NATIONAL SEASHORE

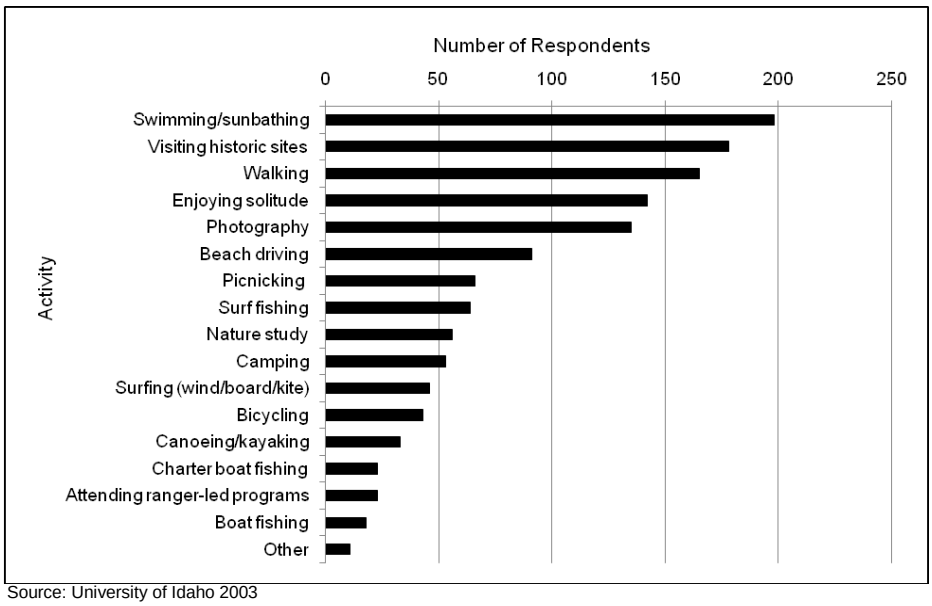
The Seashore provides a diverse range of recreational opportunities including auto touring, biking, bird watching, boating, camping, fishing, hiking, hunting, kayaking, taking nature walks, horseback riding, stargazing, swimming, wildlife viewing, surfing, kite boarding, and wind surfing. Materials submitted to the negotiated rulemaking committee by Cape Hatteras Business Allies mentioned the following recreational activities sought by visitors: bird watching and wildlife viewing, fishing, horseback riding, shelling, sea glass collecting, swimming, water sports (kayaking, kite boarding, paddle boarding, skim boarding, surfing, and windsurfing). (Cape Hatteras Business Allies 2009; ~~MI~~ (NPS 2009m]).



Historic Photo of Recreating at the Seashore

Credit: NPS

-According to the study conducted by the University of Idaho in 2002, the three most important reasons mentioned by visitors for visiting the Seashore were the lighthouses, the beach/beachcombing, and fishing. Historical significance and swimming followed closely (University of Idaho 2003). This study also asked visitor groups to list the activities in which they participated during their visit to the Seashore. The results are displayed in figure 23. Other activities that respondents participated in included family time / reunions, clamming/crabbing, shelling, shopping, and history study.



Source: University of Idaho 2003

FIGURE 23. VISITOR ACTIVITIES SURVEY RESULTS

Major developed facilities, such as visitor centers and campgrounds, as well as more informal visitor use areas at the Seashore that provide for these recreational activities, are shown on the Seashore map in chapter 1 of this document. Visitor centers are located on each island in association with Ocracoke, Cape

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Hatteras, and Bodie Island lighthouses, and campgrounds include Ocracoke, Frisco, Cape Point, and Oregon Inlet. Fishing piers are located near Frisco and at Avon and Rodanthe on Hatteras Island, and a major marina is located at Oregon Inlet on Bodie Island. Bathhouses and/or designated swimming beaches are available near Frisco on Cape Hatteras Island, Coquina Beach on Bodie Island, and on Ocracoke Island north of the village. Information stations, day use areas, and informal recreation opportunities, such as nature trails, are also found throughout the Seashore.

Recreational Fishing

Historic Photo of Recreational Fishing

Credit: NPS

The cold Labrador Current and the warm waters of the Gulf Stream meet adjacent to the Outer Banks of North Carolina. The waters off the Seashore are known throughout the world as highly productive fishing areas. The fish that congregate in the waters off the Outer Banks attract anglers from throughout the region, but largely from North Carolina and Virginia. In the spring and fall, when bluefish (*Pomatomus saltatrix*), spotted sea trout (*Cynoscion nebulosus*), red drum (*Sciaenops ocellatus*), and other species are present in offshore waters, surf fishermen line the beaches to cast their baits and lures over the incoming breakers and into the schooling fish. Most of the beach and sound are open to fishing as are the fishing piers in the villages of Rodanthe, Frisco, and Avon. NPS boat ramps are located at the Oregon Inlet Marina and near the ferry office in Ocracoke Village. Charters and head-boat services (boats that carry a large number of anglers who pay by the person) are available at local marinas.

Particularly productive and high-demand fishing areas include Ocracoke, Hatteras, and Oregon inlets and Cape Point, which are often accessed via ORVs. ORV counts at ramps accessing these inlets exceeded those of other beach access ramps. This use is discussed in the "Visitor Access and Off-road Vehicle Use" section that follows below.

Recreational Fishing in Modern Times

Credit: NPS

Typically, fishing tournaments occur in the spring and fall in locations throughout the Seashore, as shown in table 36. Tournament data from 2001 to 2008 indicate that, normally, about eight or nine fishing tournaments occur annually (Thompson pers. comm. 2008). While data are not available for actual attendance, the events are well attended. For 2005, estimates indicate that more than 720 people participated in one event that lasted for 2 days. Some tournaments may only have 25 participants, depending on the availability of fish and weather. Restrictions are placed upon the events as to location and times to ensure the availability of recreational areas for other Seashore visitors. These restrictions change from time to time depending on the time of the year, seasonal visitation figures, past experience with the sponsors, and how the proposed event is structured. Typically, Seashore beaches 0.5 mile on either side of Cape Point and 0.5 mile on either side of an inlet are closed to tournament fishing.

Like other Seashore visitors, tournament participants are not allowed in any resource closure areas. Tournaments take place in the designated ORV corridor, which has presented conflict with recreational anglers during the tournaments on a few occasions (NPS 2007e).

Visitor Access and Off-road Vehicle Use

As noted in chapter 1 of this document, before 1954, local residents and visitors used the beaches and sound trails for vehicular transportation purposes because there were few formal roads in this remote area. With the paving of NC-12, the completion of the Bonner Bridge connecting Bodie and Hatteras islands, and the introduction of the NCDOT Ferry System to Ocracoke Island, improved visitor access to the islands resulted in increased ~~vehicle~~ recreational use ~~on beaches for recreational purposes~~of the Seashore in general, as well as increased vehicle use on the beaches for recreational purposes. ORVs were used by residents to facilitate commercial netting of fish, and sport fishermen used ORVs to pursue migrating schools of game fish and to reach more productive areas such as Cape Point or the inlets, which are often a mile or more from the nearest paved surface. ORVs are currently used at the Seashore for commercial and recreational fishing, sightseeing, travel to and from swimming and watersport areas, and pleasure driving (NPS 2004b). On the other hand, Seashore visitors choose to access the Seashore by foot for swimming, sunbathing, birdwatching, fishing, enjoying scenic ocean views, and other recreational activities.

Beach Driving at the Seashore

Credit: NPS

TABLE 36. FISHING TOURNAMENTS, 2004–2008

Applicant/Event	Tournament Date	# People Authorized	Tournament Location within the Seashore
4 Plus Four Wheel Drive Club	Late April from 2004 to 2008	600	Ocean beaches excluding 0.5 mile either side of Cape Point, 0.5 mile from Hatteras Inlet and Ocracoke Inlet, and 0.5 mile on the north side of Oregon Inlet
Ocracoke Invitational Surf Fishing Tournament	Late April / early May from 2004 to 2008	240	Ocean beach between ramps 68 and 72
Outer Banks Association of Realtors	5/20/2005	150	Ocean beach from Coquina Beach to ramp 4
Hatteras Village Invitational	Early September from 2006 to 2008	540	Hatteras Island
Hatteras Village Civic Association	9/10/2004 9/9/2005	240	Ocean beaches on Hatteras Island open to 4×4 vehicles from ramp 43 south and west to 0.5 mile from Hatteras Inlet, but excluding 0.5 mile either side of Cape Point
Salt Water Grill	9/28/2008	120	Bodie Island
Nags Head Surf Tournament	Early October from 2004 to 2008	240	Ocean beach from Coquina Beach to ramp 4
FFFF Tournament	Early October from 2006 to 2008	120	Bodie Island

Applicant/Event	Tournament Date	# People Authorized	Tournament Location within the Seashore
Capitol City Four Wheelers	Mid-October from 2004 to 2008	600	Ocean beaches excluding 0.5 mile either side of Cape Point, 0.5 mile from Hatteras Inlet, and all areas closed to vehicular access including ramps temporarily closed due to flooding
Outer Banks Association of Realtors	Mid-October from 2006 to 2008	240	Bodie Island
Red Drum Tournament	10/24/2007 10/22/2008	600	Parkwide
Cape Hatteras Anglers Club~~Cape Hatteras Anglers Club~~	11/4/2004 ~~11/3/2005~~	600 ~~in 2004~~ ~~720 in 2005~~	Public ocean beaches excluding 0.5 mile either side of Cape Point, 0.5 mile from Hatteras Inlet and Ocracoke Inlet, and 0.5 mile on the north side of Oregon Inlet; ~~also excluding 0.2 mile on either side of ramps 1, 4, 23, 27, 30, 34, 43, 49, and 55, and the beaches of Pea Island NWR~~
~~Cape Hatteras Anglers Club~~	~~11/4-5/2006~~	~~720~~	~~Public ocean beaches excluding 0.5 mile either side of Cape Point, 0.5 mile from Hatteras Inlet and Ocracoke Inlet, and 0.5 mile on the north side of Oregon Inlet;~~
Cape Hatteras Anglers Club	11/3/2005 11/~~24-5/2005~~2006 11/8/2007 11/6/2008	720	Public ocean beaches excluding 0.5 mile either side of Cape Point, 0.5 mile from Hatteras Inlet and Ocracoke Inlet, and 0.5 mile on the north side of Oregon Inlet; ~~Hatteras Island~~ also excluding 0.2 mile on either side of ramps 1, 4, 23, 27, 30, 34, 43, 49, and 55
Outer Banks Angler	11/30/2007 12/5/2008	600	Parkwide
Surf Fishing Info.	12/2/2005	240	Ocean beaches excluding 0.5 mile either side of Cape Point, 0.5 mile from Hatteras Inlet and Ocracoke Inlet, 0.5 mile on the north side of Oregon Inlet, and other closures ordered by the Seashore

Source: Thompson pers. comm. 2008

Comment [dw34]: What was this change?

Comment [dw35]: Why is this showing up as a deletion when it was never in the DEIS?

Comment [dw36]: Why is this listed twice?

Comment [dw37]: Starts on a Thursday, so should be 11/2/2006. May need to change in concern response report.

ORVs Accessing the Beach using a Ramp
Credit: NPS

ORVs access the beach via a system of ramps located off NC-12. This vehicular beach access ramp system provides controlled entry and exit to beach areas. Originally, planks were placed on the dune crossing site, hence the name "ramp," to prevent the sand from moving and to prevent the dune from being further breached. The ramps began as an informal system of unimproved access points connecting the roadway to the beaches. Over time, this system was formalized and ramps are now numbered, maintained, and identified on the Seashore's ORV route maps as official vehicle routes for beach access. In 1978, there were 28 identified ramps, 22 of which were located on NPS lands. Although the NPS opened a new ramp to the public in 1998, the number of ramps has decreased since 1978 as some were lost to erosion and others were closed to the public and are now used for administrative vehicle access only (NPS 2004a). The NPS currently has 17 oceanside access ramps available for public ORV use. These ramps are listed on table 37. Each ramp number on the map (figure 24) refers to the approximate mile on NC-12 south of Nags Head on Bodie Island.

TABLE 37. OCEAN BEACH ACCESS

Ramp	Open to Public Use
Ramp 2 (Coquina)	Seasonal
Ramp 4	Year-round
Ramp 23	Year-round
Ramp 27	Year-round
Ramp 30	Year-round
Ramp 34	Year-round
Ramp 38	Year-round
Ramp 43	Year-round
Ramp 44	Year-round
Ramp 45	Year-round
Ramp 49	Year-round
Ramp 55	Year-round
Ramp 59	Year-round
Ramp 67	Year-round
Ramp 68	Seasonal
Ramp 70	Year-round
Ramp 72 (South Point Road)	Year-round

Source: NPS 2008g

FIGURE 24. OFF-ROAD VEHICLE RAMPS AT CAPE HATTERAS NATIONAL SEASHORE

Number and Distribution of ORVs at the Seashore

From 2007–2008, the Seashore installed infrared counters at ORV ramps to determine the number of ORVs using the Seashore, as well as their distribution in the Seashore. However, in addition to counting ORVs, the counters were found to count anything that breaks the infrared beam, including pedestrians, rain, and untrimmed plants. The counters also failed to register some counts and must be properly aligned to count. Testing showed that the ramp counters overestimated the number of ORVs substantially and that pedestrian crossings often added to the inaccurate counts. For these reasons, the data from the ramp

counters were deemed not reliable for constructing estimates of ORV use at the seashore (RTI pers. comm. 2009a).

On Memorial Day and the Fourth of July, the Seashore counts the number of ORVs on the beach by an aerial survey. Research Triangle Institute, International (RTI) (RTI pers. comm. 2009a) used this information, along with assumptions based on rental occupancy and patterns of use, to create a range of estimates for the total number of ORVs using the Seashore in a year. Although there are some data from various sources about the number of vehicles on the beach, none of the sources have the scope or reliability to provide a robust annual estimate of vehicles on the beach. A survey is being conducted according to a random sampling plan to provide an estimate of the number of vehicles on the beach between April 1, 2009, and March 30, 2010, with a 95% confidence interval. Data collection will be completed in March 2010.

The data from the aerial counts were used to provide counts for ORVs at the following locations, which include some of the most popular ramps leading to the points and spits:

- Ramp 4: Includes Bodie Island Spit.
- Ramp 23 to ramp 27: Approximately 4-mile area directly south of Salvo.
- Ramp 27 to ramp 38: Approximately 11 mile area including Avon.
- Ramp 43 to ramp 49: Includes Cape Point.
- Ramp 55: Includes Hatteras Inlet Spit.
- Ocracoke: All of Ocracoke Island.

Figure 25, as well as the provided ramp counts, shows the distribution of ORVs across these areas on Memorial Day and the Fourth of July in 2008. About 75% of the ORVs counted on those days occurred at ramps ~~were~~ located around the points and spits (including all of Ocracoke ramps as one count); over half of the ORVs were located around Cape Point and the Bodie Island Spit, even though the point and spot proper were temporarily closed at the time to protect park resources.

Comment [dw38]: I still disagree with the way this ended up. I would much rather delete this sentence.

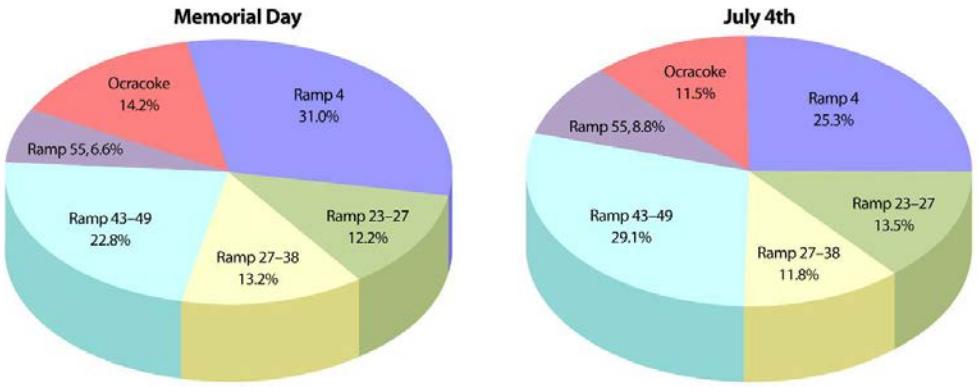

FIGURE 25. ORV DISTRIBUTION BASED ON AERIAL COUNTS, FOURTH OF JULY AND MEMORIAL DAY 2008

TABLE XX: Ramp Counts for Memorial Day and Fourth 4th of July, 2008

Memorial Day, 2008		Fourth of July, 2008	
Ramp	Count	Ramp	Count
Ramp 4	641	Ramp 4	661
Ramp 23-27	336	Ramp 23-27	353
Ramp 30-34	58	Ramp 30-34	54
Ramp 38	133	Ramp 38	223
Ramp 43-45	42	Ramp 43-45	67
Ramp 49	429	Ramp 49	691
Ramp 55	137	Ramp 55	230
Ramp 59-72	293	Ramp 59-72	300
2008 Total Count	2069	2008 Total Count	2579

Comment [dw39]: Need to provide source. Mike Trevino email Sept 2010

Comment [dw40]: Why is this entire table and heading not showing as track changes? It's all new, correct?

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Comment [dw41]: Recommend using same breaks as above pie chart. I checked the numbers and they work out.

Closures. A number of areas throughout the Seashore have been closed to ORV travel over the years, either due to safety issues or for resource protection purposes. Temporary closures to ORVs also occur along the beaches to protect sea turtle nests and bird species such as piping plovers, American oystercatchers, and colonial waterbirds. The Seashore contains approximately ~~68~~ 67 miles of shoreline that are available for public use, when not closed for resource or safety concerns. The 13 miles of beach that comprise Pea Island NWR are within the Seashore boundary and are managed separately and under a different regulatory framework by the USFWS; ORVs are not permitted on Pea Island beaches.

Currently, all the Seashore beaches are potentially open to ORV use during the winter, except a section near the Cape Hatteras Lighthouse (which is closed year-round), and those beaches under a safety closure. Some beaches are also closed to ORV use if they become too narrow. During the summer months, the amount of Seashore beach open can vary depending on resource closures and seasonal ORV closures of village beaches, as detailed in chapter 2 of this document. On the soundside, 18 access points are publicly available to ORVs. However, vehicular access is typically limited to short distances along sandy portions of the sound shoreline because the Seashore prohibits ORV use on vegetated areas, and most of the soundside areas have vegetation. Closures vary from year to year depending on a range of management considerations.

Following Hurricane Isabel, ORV use areas (restrictions) were put in place in March 2004 to protect sensitive habitat that opened up as a result of dune destruction and to provide for more consistent management of breeding and nesting bird closures. These closures did not significantly decrease the sum total of shoreline miles open to ORV access and public recreation nor did it impact the number of ramps open to allow ORV access to Seashore beaches. White posts were placed 150 feet landward from the average, normal high-tide line, or, if existing, at the vegetation or remnant dune line. Beach areas landward of the post line, although not open to ORV use, were open to pedestrian use (NPS 2004b).

Temporary resource closures are established throughout the Seashore, including within areas of ORV and pedestrian use, to comply with protection measures afforded nesting sea turtles and protected shorebirds. These closures are implemented at crucial periods during the life of these species. During these closures, the NPS routes ORV beach traffic around the temporary resource closure when possible. Temporary resource closures apply to both ORV and pedestrian use, although occasionally pedestrian access can be provided in pedestrian corridors. These closures include pre-nesting closures. Table 37-1 details the pre-nesting closures that have taken place under ~~the~~ alterantive A (2007) and alternatative B (2008 – 2010)~~conscent decree~~, beginning in 2007, showing dates when the closure began and when the area reopened.

TABLE 37-1. RESOURCE CLOSURE DATES FOR POPULAR VISITOR SITES 2007-2010~~, UNDER THE CONSCENT DECREE~~

2007 (Pre-nesting areas installed by April 1)			
Location	**Closed**	**Reopened**	**# of Days Closed**
Bodie Island Spit	July 15	August 16	32
Cape Point[1]	n/a	n/a	0
Hatteras Inlet "rip"[2]	May 8	May 20	2
North Ocracoke[3]	April 8	June 7	60

Comment [seh42]: Not needed and not correct because 2007 was under the FONSI

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Comment [seh43]: Is this correct, seems like May 8 to May 20 is longer than 2 days

South Point Ocracoke (two events)	June 26[4]	June 28	2
	July 10[5]	July 11	1
~~2007~~ 2008 (Pre-nesting areas installed by ~~April 1~~March 15)			
Location	**Closed**	**Reopened**	**# of Days Closed**
Bodie Island Spit	May 5	August 26	113
Cape Point[1]	May 5	July 22/29 (ORV/Pedestrian)	78/85
Hatteras Inlet "rip"[2]	April 9	July 24	75
North Ocracoke[3]	June 5	July 11	37
South Point Ocracoke	May 5	August 18	105
~~2007~~ 2009 (Pre-nesting areas installed by March 15)			
Location	**Closed**	**Reopened**	**# of Days Closed**
Bodie Island Spit	March 23	August 6	136
Cape Point	April 14	July 17/29 (Pedestrian/ORV)	101/113
Hatteras Inlet "rip"	March 11	July 15	125
North Ocracoke	May 9	August 28	111
South Point Ocracoke	May 22	August 9	80
20010 (Pre-nesting areas installed by March 15)			
Location	**Closed**	**Reopened**	**# of Days Closed**
Bodie Island Spit	May 9	August 23	106
Cape Point	May 13	July 7/July 21 (Pedestrian/ORV)	55/69
Hatteras Inlet "rip"	March 11	July 15	126
North Ocracoke	April 28	August 25	119
South Point Ocracoke	April 20	August 27	129

2007 Dates that Popular Sites Closed and Re-opened (pre-nesting areas installed by April 1)

Location	Closed	Re-opened	# Days Closed
Bodie Island Spit	July 15	August 16	32
Cape Point[1]	n/a	n/a	0
Hatteras Inlet "rip"[2]	May 8	May 10	2
North Ocracoke[3]	April 8	June 7	60
South Point Ocracoke	two closure periods for total of 3 days		3
	June 26[4]	June 28	(2)
	July 10[5]	July 11	(1)

[1] Open to ORVs/pedestrians from east side, but not from west side

[2] Open to pedestrians only from soundside (south of terminus of Spur Road). Pole Road safety closure after a storm prevented access to Spur Road May 8-9. Ocean shoreline approximately 0.3 mile south of Pole Road closed to ORVs and pedestrians as pre-nesting area on March 28, then reopened on June 30 (94 days closed).

[3] Open to ORVs and pedestrian North of Ramp 59 approximately to the inlet.

[4] Closed to access on June 26 (PIPL chicks); re-opened for daytime access on June 28; and re-opened to 24-hour access on July 2.

[5] Closed to access on evening of July 9 (AMOY chick); re-opened for daytime access on July 11; and re-opened for 24-hour access on July 16.

2008 Dates that Popular Sites Closed and Re-opened (pre-nesting areas installed by March 15)

Location	Closed	Re-opened	# Days Closed
Bodie Island Spit	May 5	August 26	113
Cape Point	May 5	Jul 22/29 (ped/ORV)	78/85
Hatteras Inlet "rip"	April 9	July 24	75
North Ocracoke	June 5	July 11	37
South Point Ocracoke	May 5	August 18	105

2009 Dates that Popular Sites Closed and Re-opened (pre-nesting areas installed by March 15)

Location	Closed	Re-opened	# Days Closed
Bodie Island Spit	March 23	August 6	136
Cape Point	April 14	July 17/29 (ped/ORV)	101/113
Hatteras Inlet "rip"	March 11	July 15	125
North Ocracoke	May 9	August 28	111
South Pt. Ocracoke	May 22	August 9	80

~~2010 Dates that Popular Sites Closed and Re-opened (pre-nesting areas installed by March 15)~~

~~Location~~	~~Closed~~	~~Re-opened~~	~~# Days Closed~~
~~Bodie Island Spit~~	~~May 9~~	~~August 23~~	~~106~~
~~Cape Point~~	~~May 13~~	~~July 7/July 21 (ped/ORV)~~	~~55/69~~
~~Hatteras Inlet "rip"~~	~~March 11~~	~~July 15~~	~~126~~
~~North Ocracoke~~	~~April 28~~	~~August 25~~	~~119~~
~~South Pt. Ocracoke~~	~~April 20~~	~~August 27~~	~~129~~

Comment [dw44]: Why is this in track-changes? It was never in the DEIS. See Sandy's GLOBAL COMMENTS on what the final product must look like.

Bird Closures. The open sand flats near the three inlets in the Seashore (Oregon, Hatteras, and Ocracoke) and Cape Point are used by protected bird species and are also favorite fishing areas that visitors access in ORVs. Piping plover, American oystercatcher, and colonial waterbird breeding activity has been documented on and near the ocean beach in all of these locations.

In 2005, temporary resource closures occurred at multiple beach locations (including popular recreational fishing areas at the points and spits) to protect piping plovers, American oystercatchers, and colonial waterbirds from ORV and pedestrian use. These closures occurred on all three islands but were most concentrated on Hatteras Island, followed by Ocracoke. The Interim Strategy was published in January 2006 and finalized by a FONSI in July 2007 (NPS 2007a). The Interim Strategy presented a multifaceted approach that included the establishment of prenesting closures, species protection buffers, wintering habitat protection, and temporary resource closures. Although for the most part the Interim Strategy established specific distances for species buffers, it allowed for the reduction or expansion of buffers based on professional judgment of the resource management staff. Species and ORV management under the Interim Strategy resulted in beach closures similar to those that occurred in previous years. Management and resource closures were altered by a lawsuit in 2007 and subsequent consent decree in 2008.

Typical Closure

Credit: NPS

In October 2007, Defenders of Wildlife and the National Audubon Society filed a lawsuit against the NPS alleging inadequacies in the management of protected species at the Seashore under the Interim Strategy and failure of the Seashore to comply with the requirements of the ORV executive order and NPS regulations regarding ORV use. On December 18, 2007, the Dare County Commissioners, Hyde County Commissioners, and the board of the Cape Hatteras Access Preservation Alliance were allowed to join the lawsuit as intervenor-defendants. However, a consent decree was filed on April 16, 2008, in U.S. District Court (signed on April 30, 2008), whereby the parties involved in the lawsuit agreed to a settlement of the case. The consent decree resulted in larger buffers than those prescribed in the Interim Strategy being established during portions of the spring and summer around bird breeding and nesting areas; this included creating a 1,000-meter (3,280-foot) vehicle buffer and a 300-meter (984-foot) pedestrian buffer around piping plover chicks until they have fledged. From May 15 through August 21, 2008, an average of 10 miles of oceanfront beach at the Seashore was

closed to both pedestrians and ORVs. The largest amount of beach closures was reported on May 29, 2008, when 12.8 miles of beach were closed to all recreational use to protect piping plovers exhibiting breeding, nesting, and/or foraging behavior. The consent decree also established a prohibition on night driving on beaches between the hours of 10:00 p.m. and 6:00 a.m. from May 1 through September 15, with night driving allowed from September 16 through November 15 under the conditions of a permit.

Sea Turtle Closures. Temporary resource closures, which apply to ORVs and pedestrians, are implemented during nesting and hatching activities for all three sea turtle species that are known to nest at the Seashore. Generally, ORVs and pedestrians can negotiate around these posted closures for sea turtle nests. However, when the turtle eggs are ready to hatch, the NPS implements a beach closure with fencing from the nest to the water's edge. If sufficient room exists, ORVs and pedestrians can go around the landward side of the fence. In some cases, a full beach closure must be implemented because of the location of a nest relative to a dune or vegetation, preventing ORV and pedestrian access through the area. As mentioned previously, the consent decree signed in April 2008 included a prohibition on night driving to protect nesting sea turtles. The consent decree also contains provisions for full beach closures in the fall to allow existing turtle nests to hatch safely.

Safety Closures. Areas normally open to ORVs may close for safety reasons. Adverse weather conditions can result in narrow beach areas or flooded conditions, among other hazards, necessitating closures to vehicles. In November 2005, safety closures included 1.6 miles on Bodie Island, 22.8 miles on Hatteras Island, and 6.5 miles on Ocracoke Island (Stevens pers. comm. 2005). However, from May 15 through August 21, 2008, safety closures throughout the season consistently included a total of 11.1 miles of beach (NPS 2008m). Under current management, village beaches are closed to ORVs to protect pedestrians during the busy summer season.

CROWDING, VISITOR ENCOUNTERS, AND VISITOR SAFETY

A University of Idaho study indicated that one of the reasons people visited the Seashore was to escape crowds and seek solitude. When asked about crowding, 27% of visitors said they felt "crowded" to "extremely crowded," while 43% of visitors felt "somewhat crowded." Thirty percent of visitors surveyed indicated that they felt "not at all crowded." Many visitor groups (49%) reported that crowding "detracted from" their park experience (University of Idaho 2003).

As part of the visitor experience, visitor safety is also considered. During public scoping for this plan/EIS, comments were received that indicated that some visitors felt that there was a potential for conflicts between visitors on foot and visitors using ORVs. In early 2009, Seashore law enforcement staff indicated that in the prior 10 years, there were no known case incident reports documenting pedestrians being struck by ORVs on Seashore beaches; however, public comment indicated a concern about the speed of ORVs on the beach and how close they are to other Seashore users. On September 27, 2009, a 7-year-old boy was accidentally hit by an ORV that was backing up on the beach in front of ramp 38. While the boy's parents and other family members were swimming and playing in the ocean, the boy decided to play on the beach digging holes and making sand castles with his hands. The driver of the vehicle that struck the boy had driven onto the beach to see if he and his passenger would surf at this location. The individuals decided not to surf at this location and turned around to exit the beach. The beach is sloped from the ramp down to the water and the sand is soft in this area. The vehicle driver was having difficulty driving his vehicle up the slope and was backing up and going forward to try to get up the slope, (they had not reduced air pressure in their tires). While backing up, the driver did not see the boy playing in the sand. The vehicle struck the boy with the right rear bumper and tire. Neither of the boy's parents had observed the actual incident but had observed the vehicle maneuvering on the beach prior to the accident. They did not believe the vehicle was being operated carelessly or too fast. The boy was transported to the

Outer Banks Hospital for examination and was released. Injuries included bruising to the arm and leg. The ORV operator was not charged with any violation (Murray pers. comm. 2009a).

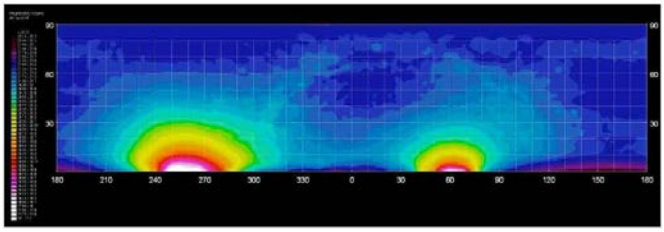
VISITOR SATISFACTION

A visitor survey was conducted by the University of Idaho Park Studies Unit for units of the NPS in 2008. The survey was developed to measure each park unit's performance related to NPS *Government Performance Results Act* (GPRA) Goals IIa1 (visitor satisfaction) and IIb1 (visitor understanding and appreciation). Survey cards were distributed at the Seashore to a random sample of visitors from July 1 to July 31, 2008. The report included three categories of data: park facilities (which included visitor centers, exhibits, restrooms, walkways/trails/roads, and campgrounds / picnic areas), visitor services (assistance from park employees, park maps/brochures, ranger programs, and commercial services), and recreational opportunities (nature/history/cultural learning and outdoor recreation). Overall, the percentage of Seashore visitors satisfied with the facilities, services, and recreational opportunities was 95%. Individually, 93% of visitors were satisfied with park facilities, 85% of visitors were satisfied with visitor services, and 89% were satisfied with recreational opportunities (University of Idaho 2008).

In the 2002 University of Idaho study, the researchers solicited visitor opinions about selected factors that affect visitor experience. As would be expected, vehicles on the beach were perceived very differently by different visitors, but most stated that the use of vehicles on the beach did not detract from their visitor experience. The factors receiving the highest proportion of "no effect" ratings were airplane overflights (50% of those surveyed), dogs off leash (35%), vehicles on the beach (34%), and visitors drinking alcohol (33%). Factors receiving the highest proportion of "added to my experience" ratings included vehicles on the beach (20%) and fires on the beach (16%), while those receiving the highest "detracted from my experience" ratings were litter (40%) and vehicles on the beach (18%). About 29% of those surveyed did not experience vehicles on the beach (University of Idaho 2003).

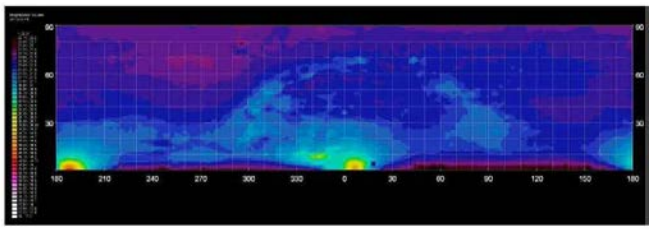
Night Skies

The NPS defines a natural lightscape as "a place or environment characterized by the natural rhythm of the sun and moon cycles, clean air, and of dark nights unperturbed by artificial light. Natural lightscapes, including dark night skies, are not only a resource unto themselves, but are an integral component of countless park experiences" (NPS 2007b). The NPS created the Night Sky Team in 1999 to address increasing alarm over the loss of night sky quality throughout the network of national parks. The Night Sky Team functions as a center of expertise that provides advice, guidance, and technical support in characterizing and preserving park lightscapes (NPS 2007b). According to the Night Sky Team, the Seashore is one of only a handful of sites in the eastern United States with a nearly natural regimen of light and dark, where light patterns are made up primarily of the dark sky, moon, and stars (NPS 2008f).



This picture was compiled from images captured on a boardwalk between Frisco and Hatteras. Frisco lies at about 60º azimuth and Hatteras at about 260º azimuth.

Credit: Night Sky Team Visit Report

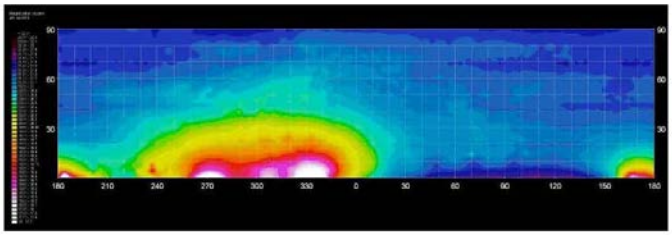


This picture was compiled from images captured on a boardwalk between Salvo and Avon. The combined light of Rodanthe, Salvo, and Waves can be seen at about 6º and Avon at 191º. Also note the presence of a few clouds reflecting the town lights at about 345º.

Credit: Night Sky Team Visit Report

In November 2007, the NPS Night Sky Team visited the Seashore to record preliminary measurements of night sky quality from three sites: the Bodie Island Maintenance Facility (Bodie Island); the boardwalk at ramp 27 (Hatteras Island); and the boardwalk south of Frisco (Hatteras Island) (NPS 2008f). During this visit, the team concluded that the Seashore has better night sky quality as compared to most other NPS units east of the Mississippi River. Furthermore, measurements showed that light pollution sources beyond the Seashore boundary illustrated the need to be aware of the easily impacted night skies (NPS 2008f).

Measurements of the night sky at the Seashore were taken with a charge-coupled device (CCD) camera (a scientific-grade digital camera) that captures the known magnitude (a measure of stellar brightness) of known stars as an index to determine the ambient brightness of the nighttime sky. These measurements are influenced by atmospheric conditions, which affect how light travels through the sky. To account for these changes, multiple measurements are taken over a period of time. The initial measurements at the Seashore occurred over two nights, with more planned in the future (NPS 2008f).



This picture was compiled from images on Bodie Island, just south of the maintenance facility. A number of light domes are evident in this image, including the combined light from Harbor, Rodanthe, and Salvo between 165º and 168º; the lighthouse at 184º; Wanchese at 267º; and the combined light from Manteo, Kill Devil Hills, Nags Head, and Kitty Hawk between 304º and 333º. A considerable amount of light scattering occurs in this picture due to high humidity.

Credit: Night Sky Team Visit Report

Results from the November 2007 measurements found that sky brightness ranged from approaching a natural level of darkness to significantly light polluted, with the potential to threaten the ecological health of the coastal environment in some areas (NPS 2008f). To address those areas where there are high levels of light pollution, the Night Sky Team recommended retrofitting or swapping existing light fixtures in favor of turtle-friendly and night-sky-friendly fixtures, as well as working with park neighbors to enact night sky measures such as lighting ordinances (NPS 2008f).

SOCIOECONOMIC RESOURCES

This section describes the social and economic environment that potentially would be affected by the proposed alternatives. The social and economic environment of a region is characterized by its demographic composition, the structure and size of its economy, and the types and levels of public services available to its citizens.

The socioeconomic environment evaluated for this plan/EIS encompasses the Outer Banks portion of two counties in North Carolina—Dare and Hyde. Hatteras and Bodie islands are part of Dare County while Ocracoke Island is within Hyde County. This area contains 13~~thirteen~~ zip codes, ~~eighteen~~18 of the ~~nineteen~~19 block groups in Dare County, and one of the four block groups in Hyde County. Data not available at the block group or zip code level will be reported at the county level. The Outer Banks portion of Dare and Hyde counties forms the economic region of influence (ROI) and defines the geographic area in which the predominant social and economic impacts from the proposed alternatives are likely to take place. The largest towns within the ROI include Nags Head, Kill Devil Hills, and Kitty Hawk, which are located on Bodie Island north of the Seashore. The villages of Ocracoke, Hatteras, Frisco, Buxton, Avon, Salvo, Waves, and Rodanthe would be most affected by the proposed actions because they are located within the Seashore and depend most directly on tourists visiting the Seashore for their livelihood. As discussed in the following sections, the northern part of the ROI, which is not adjacent to the Seashore, has a larger population and a larger business community~~.~~. Although the relative impact of changes in visitation to the Seashore will be greater for the villages located within the Seashore, the economic base is larger in the part of the ROI north of the Seashore. The result is that smaller relative changes to businesses north of the park could generate similar total revenue changes to the changes experience in the villages within the Seashore.

~~The socioeconomic environment evaluated for this plan/EIS encompasses the Outer Banks portion of two counties in North Carolina—Dare and Hyde. Hatteras and Bodie islands are part of Dare County while Ocracoke Island is within Hyde County. This area contains thirteen zip codes, eighteen of the nineteen block groups in Dare County, and one of the four block groups in Hyde County.~~

~~The Outer Banks portion of Dare and Hyde counties forms the economic region of influence (ROI) and defines the geographic area in which the predominant social and economic impacts from the proposed alternatives are likely to take place. The villages of Ocracoke, Hatteras, Frisco, Buxton, Avon, Salvo, Waves, and Rodanthe would be most affected by the proposed actions because they are located within the Seashore. The largest towns within the ROI include Nags Head, Kill Devil Hills, and Kitty Hawk, which are located on Bodie Island north of the Seashore. Data not available at the block group or zip code level will be reported at the county level.~~

DEMOGRAPHICS

The economic ROI is primarily rural in character, although portions of Dare County, especially in the north, are developed with large tracts of vacation homes and small businesses that support the area's robust tourism industry. Much of Dare County's permanent population also resides in this area, the most densely populated portion of the ROI (figure 26). Note that data presented are often taken from the U.S. Census Bureau. The census places people according to "usual residence" guidelines, so people are counted where they live most of the year.

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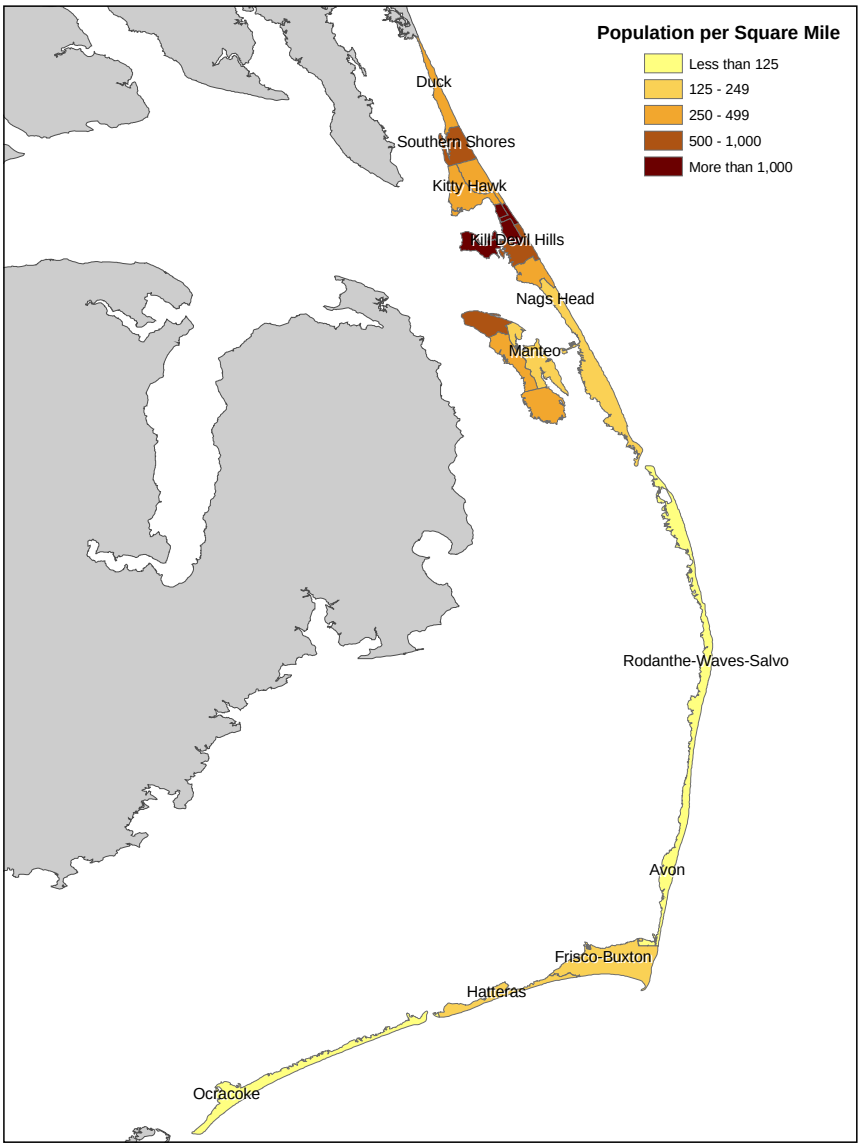

Source: Environmental Systems Research Institute, Inc. 2002

FIGURE 26. 2000 POPULATION DENSITY BY BLOCK GROUP

In recent years, population trends have differed substantially for Dare and Hyde counties. Table 38 provides population statistics for the state of North Carolina, Dare and Hyde counties, and the Dare and Hyde County block groups located on the Outer Banks. Between 2000 and 2008, Dare County's population grew 12%, from 29,967 to 33,584. This is a slightly lower percentage change in population than the state of North Carolina as a whole. However, the portion of the state population occupying Dare County remained 0.4%. During this same time period, the population of Hyde County decreased by 11%, from 5,826 to 5,181 (U.S. Census Bureau 2008), lowering the portion of the state population occupying Hyde County from 0.07% to 0.06%. The Dare County block groups within the ROI account for 96% of Dare County's population, while Hyde County block group represents only 13% of Hyde County's population (U.S. Census Bureau 2000a).

TABLE 38. POPULATION STATISTICS

Geographic Area	2000[a]	2007[b]	2015[c]	2029[c]	Percent Change, 2000–2007	Percent Change, 2000–2029
North Carolina	8,049,313	9,222,414	10,429,282	12,769,797	15%	59%
Dare County	29,967	33,584	31,225	26,053	12%	-13%
Dare County block groups[d]	28,798	—	—	—	—	—
Hyde County	5,826	5,181	5,256	4,717	-11%	-19%
Hyde County block group[e]	730	—	—	—	—	—

Sources:

[a] U.S. Census Bureau 2000a

[b] Population Division, U.S. Census Bureau 2009a

[c] Office of State Budget and Management, North Carolina 2009

[d] The 18 Dare County block groups in the ROI

[e] The one Hyde County block group in the ROI

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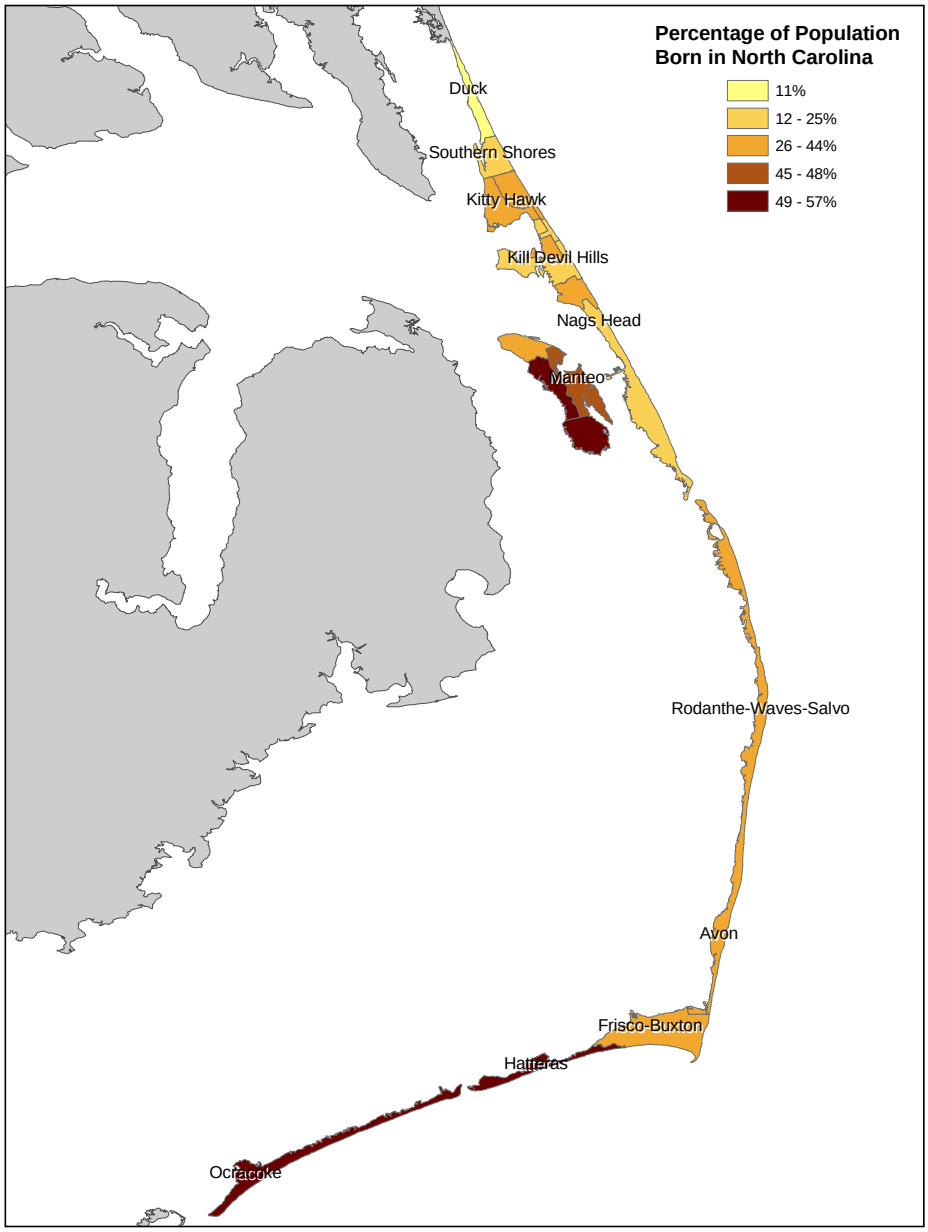
According to population projections published by the North Carolina Office of State Budget and Management's State Demographics unit, the state and Hyde County population trends are expected to continue into the foreseeable future, while Dare County is projected to lose residents. By 2029, the population in Dare County is projected to decrease to 26,053, a 13% reduction relative to 2000. The population of Hyde County is expected to fall further to 4,717, a 19% decrease relative to 2000 (Office of State Budget and Management North Carolina 2009).

Demographic and economic trends during the last three decades have contributed to growing differences in the population characteristics and income levels in the different areas of the ROI. The rate of change is especially rapid in northern Dare County, where a smaller percentage of residents were born in North Carolina, shown in figure 27.

In 1999, the areas within the ROI had a 13% greater per capita income than North Carolina as a whole, and 6% greater than the country as a whole (table 39). This distribution varies across the ROI. Ocracoke, southern Dare County, and portions of Roanoke Island all had a lower per capita income than the more densely populated block groups in the northern part of the ROI (figure 28).



Source: U.S. Census Bureau 2000a

FIGURE 27. PERCENTAGE OF RESIDENTS BORN IN NORTH CAROLINA BY BLOCK GROUP, 2000

1 **TABLE 39. EMPLOYMENT BY SECTOR, 2000**

	Number of Employees	Percentage			Difference	
Industry	ROI	ROI	NC	US	ROI-NC	ROI-US
Construction	2,102	14%	8%	7%	5%	7%
Accommodation and food services	1,857	12%	6%	6%	6%	6%
Real estate, rental and leasing	1,078	7%	2%	2%	5%	5%
Retail trade	2,296	15%	12%	12%	3%	3%
Agriculture; forestry; fishing and hunting	491	3%	1%	1%	2%	2%
Public administration	992	6%	4%	5%	2%	2%
Arts; entertainment; and recreation	453	3%	1%	2%	2%	1%
Utilities	162	1%	1%	1%	0%	0%
Management of companies and enterprises	0	0%	0%	0%	0%	0%
Other services (except public administration)	714	5%	5%	5%	0%	0%
Mining	4	0%	0%	0%	0%	0%
Administrative and support and waste management services	432	3%	3%	3%	0%	-1%
Information	379	2%	2%	3%	0%	-1%
Wholesale trade	414	3%	3%	4%	-1%	-1%
Professional; scientific; and technical services	688	4%	5%	6%	0%	-1%
Transportation and warehousing	365	2%	4%	4%	-1%	-2%
Educational services	986	6%	8%	9%	-2%	-2%
Finance and insurance	365	2%	4%	5%	-2%	-3%
Health care and social assistance	890	6%	11%	11%	-5%	-5%
Manufacturing	764	5%	20%	14%	-15%	-9%

Source: U.S. Census Bureau 2000a

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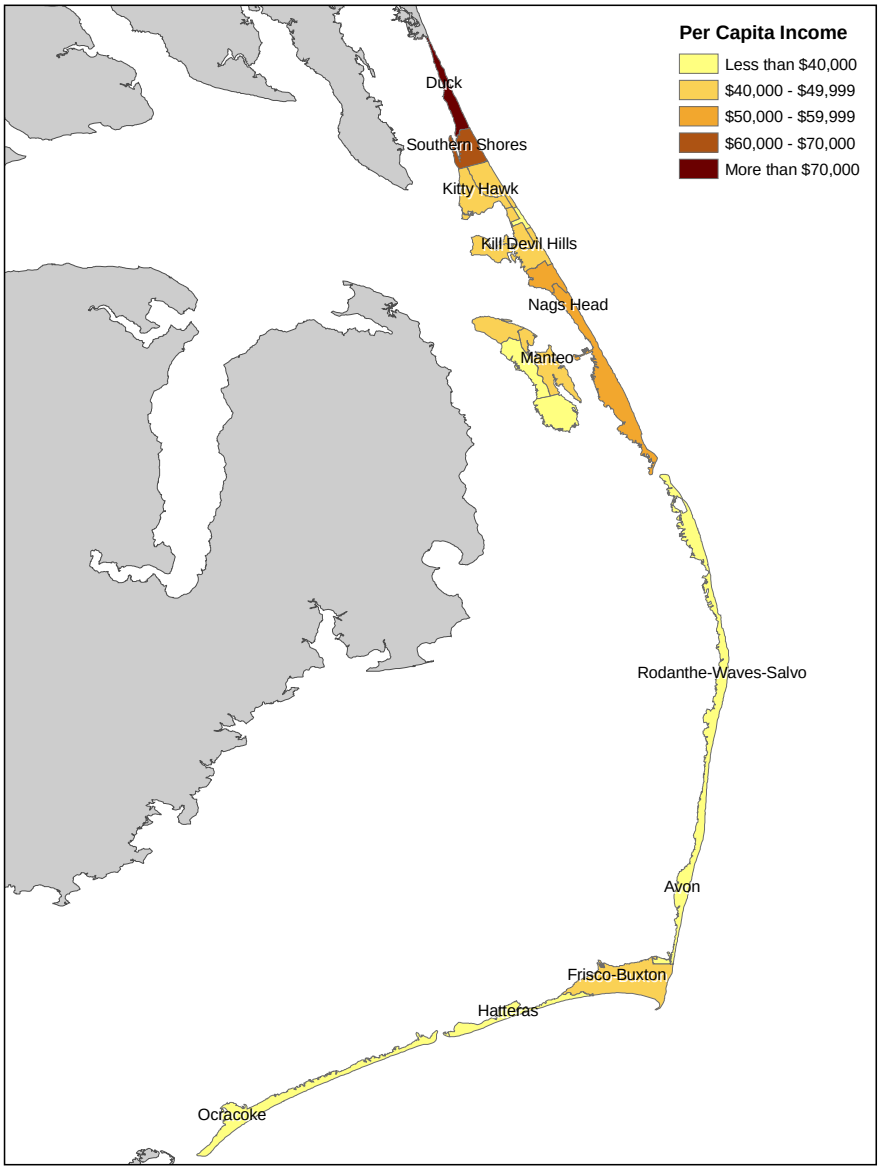


Source: U.S. Census Bureau 2000a

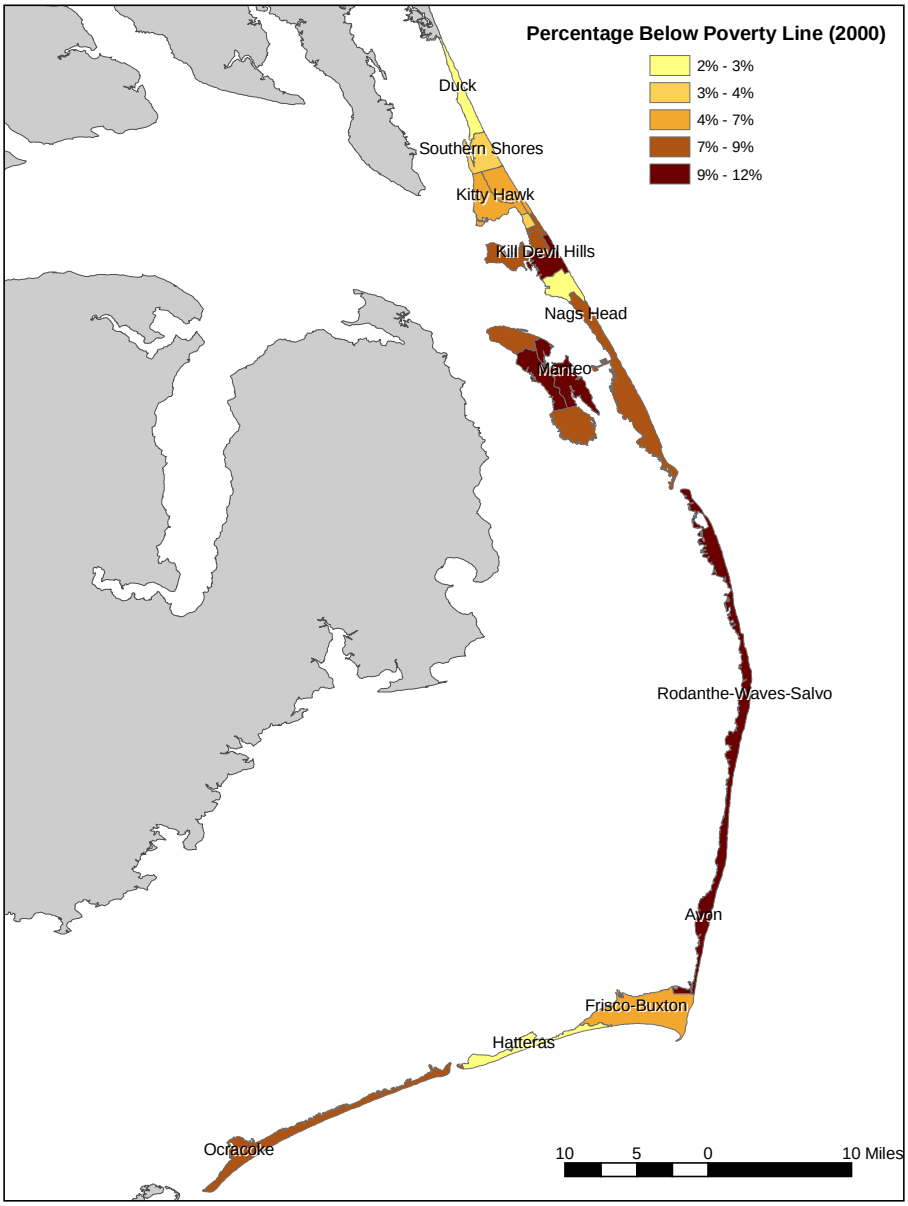
FIGURE 28. 1999 PER CAPITA INCOME BY BLOCK GROUP

In 2000, the ROI had a minority population of only 6% of the total (table 40). This is less than in North Carolina and the U.S. as a whole, which had 30% and 31% minority populations respectively. The ROI also had a lower percentage of individuals below the poverty level and a lower percentage of individuals without high school diplomas. The distribution of poverty rates by block groups is shown in figure 29.

TABLE 40. ENVIRONMENTAL JUSTICE STATISTICS, 2000

Geographic Area	Per Capita Income	Percent of Population		
		Minority	Below the Poverty Level	Without High School Diploma
United States	$41,994	31%	12%	20%
North Carolina	$39,184	30%	12%	22%
ROI	$44,462	6%	8%	11%

Source: U.S. Census Bureau 2000a



Source: U.S. Census Bureau 2000a

FIGURE 29. PERCENTAGE OF POPULATION BELOW THE POVERTY LINE BY BLOCK GROUP, 2000

EMPLOYMENT

As noted above, with the exception of the northern portion of Dare County, the ROI is primarily rural. There are no military bases, major federal facilities, state prisons, commercial airports, or four-year colleges in the ROI.

Within the ROI, much of the employment caters to tourists visiting the area. The sectors of construction; accommodation and food services; real estate, rental and leasing; and the retail trade accounted for 47.52% of the total employment within the ROI and 49.98% within the Hatteras block groups in 2000. These sectors only account for 26.50% of employment in the United States as a whole (table 39).

The majority of businesses within the ROI are located in the northern three zip codes of Dare County, encompassing the towns of Duck, Southern Shores, Kitty Hawk, Kill Devil Hills, and Nags Head. This area accounts for 64.8% of establishments and 69.6% of employment within the ROI in 2007 and has seen robust employment growth since 2000. Other areas of the ROI have experienced smaller gains or reductions in employment (figure 30). In 2007, Hatteras and Ocracoke islands contained 13.1% of the employees within the ROI. Small businesses are especially important within the ROI, with 1,713 of 2,104 establishments (81.42%) in the ROI operating with fewer than 10 employees in 2007, compared to 73.37% nationwide (Population Division, U.S. Census Bureau 2009).In addition to these employees, Dare and Hyde counties had 5,470 ~~of~~ self-employed individuals in 2008. The construction, real estate, rental and leasing, and agriculture, forestry, fishing and hunting (of which 93% are commercial fishermen) industries comprise 47% of all nonemployers[9] in the two counties (table 41).

Comment [dw45]: A, b, or c?

~~The majority of businesses within the ROI are located in the northern three zip codes of Dare County, encompassing the towns of Duck, Southern Shores, Kitty Hawk, Kill Devil Hills, and Nags Head. This area accounts for 64.8% of establishments and 69.6% of employment within the ROI in 2007 and has seen robust employment growth since 2000. Other areas of the ROI have experienced smaller gains or reductions in employment (figure 30). In 2007, Hatteras and Ocracoke islands contained 13.1% of the employees within the ROI. Small businesses are especially important within the ROI, with 1,713 of 2,104 establishments (81.42%) in the ROI operating with fewer than 10 employees in 2007, compared to 73.37% nationwide (Population Division, U.S. Census Bureau 2009).~~

~~In addition to these employees, Dare and Hyde counties had 5,764 of self-employed individuals in 2007. The construction, real estate, rental and leasing, and agriculture, forestry, fishing and hunting (of which 61% are commercial fishermen) industries comprise 49% of all nonemployers[10] in the two counties (table 41).~~

UNEMPLOYMENT

In 2008, an average of 6.5% of the civilian labor force in Dare County was unemployed (1,437 individuals) and 7.1% in Hyde County (187 individuals, compared with an unemployment rate of 6.3% for North Carolina as a whole) (table 42). For June 2009, the North Carolina (seasonally unadjusted)

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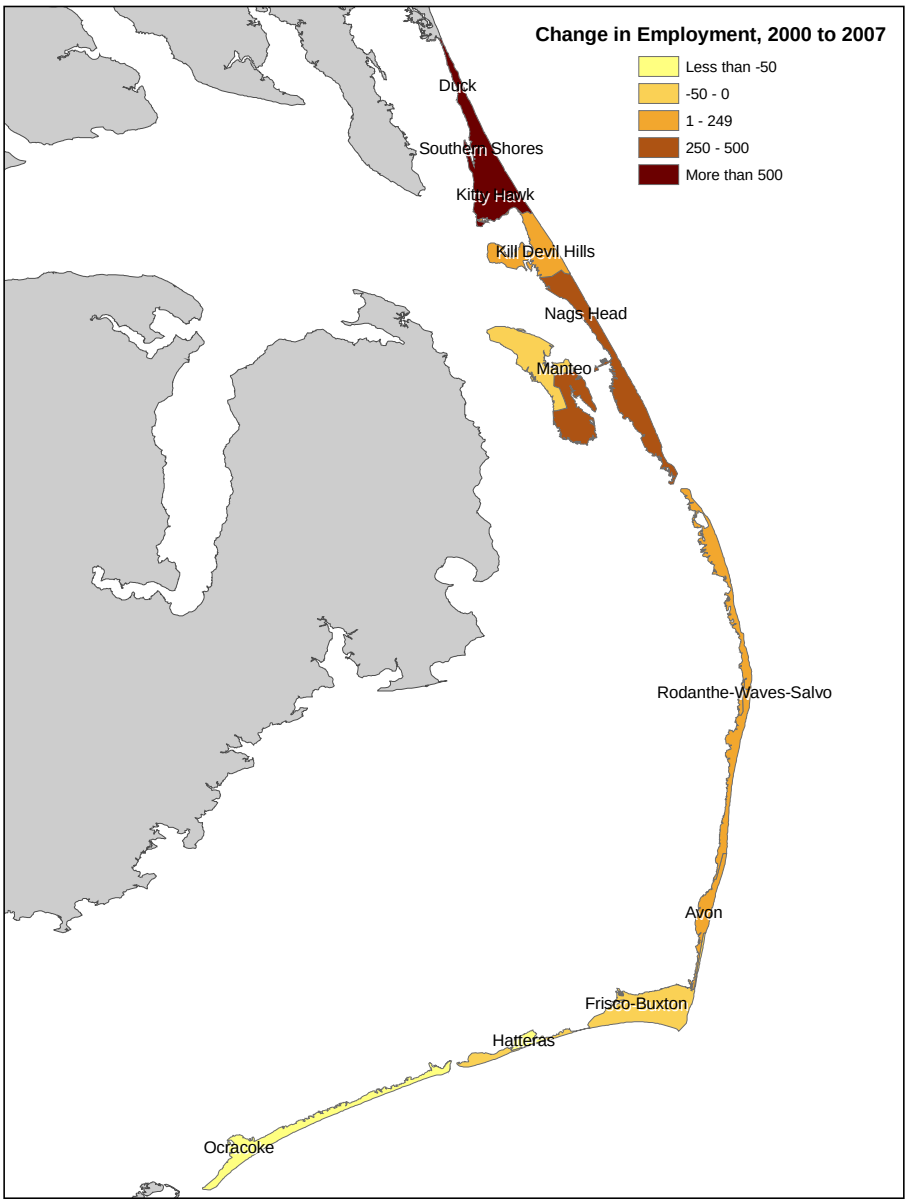
[9] From http://www.census.gov/econ/nonemployer/intro.htm : "Nonemployers are typically self-employed individuals operating very small businesses, which may or may not be the owner's principal source of income…Data are primarily comprised of sole proprietorship businesses filing IRS Form 1040, Schedule C, although some of the data is derived from filers of partnership and corporation tax returns that report no paid employees."

~~[10] oprietorship businesses filing IRS Form 1040, Schedule C, although some of the data is derived from filers of partnership and corporation tax returns that report no paid employees."~~

unemployment rate has risen to 11.1%, higher than Dare and Hyde counties (6.7% and 5.5%, respectively).

Within Dare County, establishments in construction, manufacturing, and retail trade industries accounted for the majority of private job losses from 2007 to 2008. Within the retail trade, job losses in furniture and home furnishings stores; building material and garden equipment and supplies dealers; food and beverage stores; and health and personal care stores were partially offset by employment gains in clothing and clothing accessories stores; gasoline stations; and sporting goods, hobby, and musical instrument stores.

Unemployment rates in North Carolina, Dare, and Hyde counties remain elevated relative to their 2004–2006 average in the summer of 2009. Dare and Hyde counties have recovered slightly since the winter of 2008/2009 (figure 31).



Sources: U.S. Census Bureau 2002

FIGURE 30. CHANGE IN EMPLOYMENT BY ZIP CODE

TABLE 41. NONEMPLOYERS BY INDUSTRY, ~~2007~~2008

	Number of Nonemployers	Percentage			Difference	
Industry	Dare and Hyde Counties	Dare and Hyde Counties	NC	US	Counties - NC	Counties - US
Agriculture, forestry, fishing and hunting	619	11%	1%	1%	10%	10%
Construction	1,115	20%	15%	12%	6%	9%
Real estate and rental and leasing	859	16%	11%	10%	5%	6%
Administrative and Support and Waste Management and Remediation Services~~vs~~	503	9%	10%	9%	-1%	1%
Accommodation and food services	110	2%	1%	1%	1%	1%
Utilities	4	0%	0%	0%	0%	0%
Manufacturing	68	1%	1%	1%	0%	0%
Mining, quarrying, and oil and gas extraction	>0	0%	0%	1%	0%	-1%
Information	>46	1%	1%	1%	0%	-1%
Wholesale trade	64	1%	2%	2%	-1%	-1%
Arts, entertainment, and recreation	238	4%	5%	5%	0%	-1%
Educational services	76	1%	3%	3%	-1%	-1%
Finance and insurance	>96	2%	3%	3%	-1%	-2%
Retail trade	317	6%	9%	9%	-3%	-3%
Transportation and warehousing	>78	1%	4%	5%	-3%	-3%
Other services (except public administration)	582	11%	16%	14%	-5%	-4%
Health care and social assistance	190	3%	7%	8%	-3%	-5%
Professional, scientific, and technical services	477	9%	12%	14%	-3%	-5%
Total for all sectors	5,470	100%	100%	100%	0%	0%

Source: U.S. Census Bureau; generated by RTI International; using American FactFinder; "Sector 00: NS0800A2: 2008 Nonemployer Statistics: Geographic Area Series: Nonemployer Statistics for the US." <http://factfinder.census.gov>; (1 September, 2010)

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-	Number of Nonemployers	Percentage			Difference	
Industry	Dare and Hyde Counties	Dare and Hyde Counties	NC	US	Counties - NC	Counties - US
Agriculture, forestry, fishing and hunting	667	12%	1%	1%	10%	10%
Construction	1,262	22%	16%	12%	6%	10%
Real estate and rental and leasing	912	16%	11%	11%	5%	5%
Administrative and Support and Waste Management and Remediation Services	520	9%	10%	8%	-1%	1%
Accommodation and food services	109	2%	1%	1%	1%	0%
Utilities	3	0%	0%	0%	0%	0%
Manufacturing	>67	1%	2%	2%	0%	0%
Mining, quarrying, and oil and gas extraction	0	0%	0%	0%	0%	0%
Wholesale trade	72	1%	2%	2%	0%	-1%
Information	>37	1%	1%	1%	-1%	-1%
Educational services	80	1%	2%	2%	-1%	-1%
Arts, entertainment, and recreation	234	4%	4%	5%	0%	-1%
Finance and insurance	>99	2%	3%	4%	-1%	-2%
Other services (except public administration)	611	11%	15%	14%	-5%	-3%
Transportation and warehousing	>86	1%	4%	5%	-3%	-3%
Retail trade	309	5%	9%	9%	-4%	-4%
Health care and social assistance	195	3%	6%	8%	-3%	-5%

~~PROFESSIONAL, SCIENTIFIC, AND TECHNICAL SERVICES~~	~~461~~	~~8%~~	~~12%~~	~~14%~~	~~-4%~~	~~-6%~~
~~TOTAL FOR ALL SECTORS~~	~~5,764~~	~~100%~~	~~100%~~	~~100%~~	-	-

UNEMPLOYMENT

In 2009, an average of 9.6% of the civilian labor force in Dare County was unemployed (2,179 individuals) and 8.3% in Hyde County (229 individuals), compared with an unemployment rate of 10.6% for North Carolina as a whole (table 42).

Within Dare County, establishments in construction and manufacturing industries accounted for 54% of private employment losses from 2007 to 2009~~.~~. The retail trade and wholesale industries accounted for an additional 30% of private jobs. Within the retail trade industry, 53% of those job losses occurred in building material and garden equipment and supplies dealers and furniture and home furnishings stores~~.~~. Sporting goods store employment declined 2.6% between 2007 and 2009. (Bureau of Labor Statistics 2010b).

~~Unemployment rates I~~In ~~the nation as a whole,~~ North Carolina, ~~and~~Dare and Hyde counties, and in the nation as a whole, unemployment rates began increasing in 2008 and continued to increase in 2009. Dare County's year~~-~~over~~-~~year unemployment change (change from the same month in the previous year) was greater than that for the state of North Carolina as a whole between November 2008 and March 2009 and lower than the state's unemployment change for the rest of 2009~~.~~ (figure 31).

Comment [dw46]: Why is this showing up as new text? Should only be updating to 2009 data.

TABLE 42. EMPLOYMENT CHARACTERISTICS, 2009

	North Carolina	Dare County	Hyde County
Labor Force	4,544,622	22,591	2,768
Employment	4,060,764	20,412	2,539
Unemployment	483,858	2,179	229
Unemployment Rate	10.6%	9.6%	8.3%

Source: Bureau of Labor Statistics 2010

Comment [dw47]: A or B?

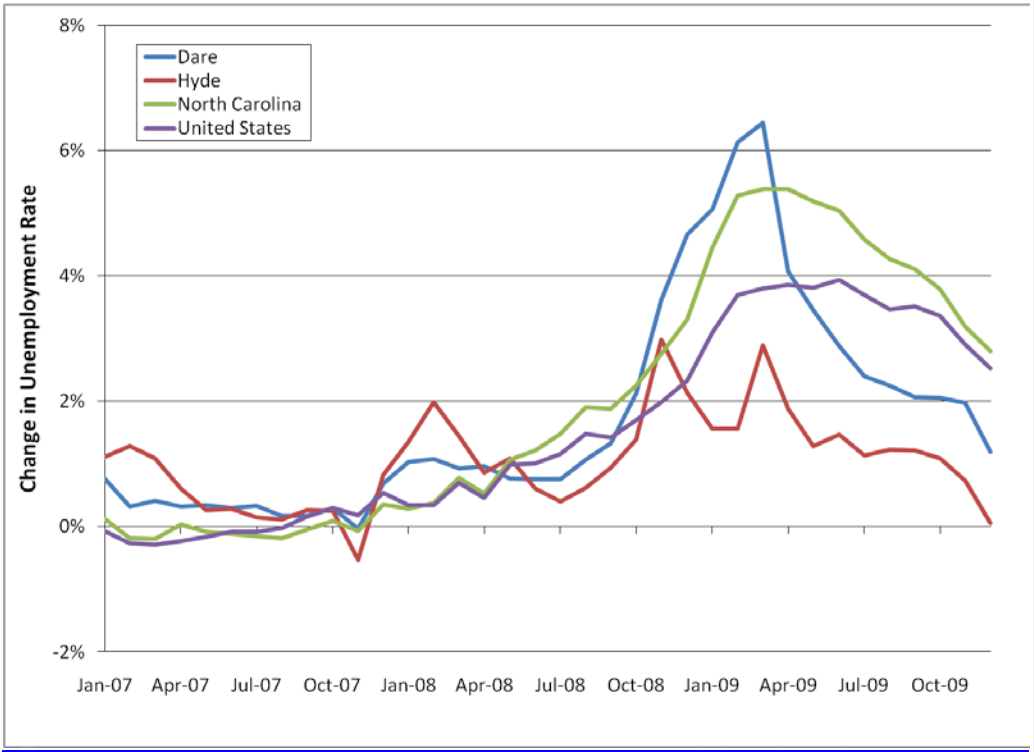
2000 UNEMPLOYMENT BY ZIP CODE

Using the 2000 Census, one can calculate a measure of unemployment using information ~~from the Census forms~~ about labor force participation~~.~~. Unemployment calculated with Census data is somewhat different than the definition used by the Bureau of Labor Statistics ~~(BLS)~~. Within the ROI, the unemployment rate in 2000 varied between a low of 0% in the Waves and Frisco zip codes to a high of 21.6% in the Salvo zip code (t~~T~~able 42-1)~~.~~. The Employment Security Commission of North Carolina's Labor Market Information Division estimates zip code level unemployment data for 2010 by multiplying the current Bureau of Labor Statistics county unemployment estimate by the ratio of unemployment by zip code to unemployment within the entire county based on the 2000 Census data~~.~~. The differences unemployment in 2000 does not provide information on how recent ORV regulations have impacted the ROI, but it does highlight how employment varied across the island in 2000.

Table 42-1. Labor Force and Unemployment in 2000 by Zip Code

Geographic Area	Zip Code	Labor Force	Unemployed	Unemployment Rate
Dare County		16,504	808	4.9%
Avon	27915	483	27	5.6%
Buxton	27920	882	108	12.2%
Frisco	27936	186	0	0.0%
Hatteras	27943	325	11	3.4%
Kill Devil Hills	27948	5,391	206	3.8%
Kitty Hawk	27949	3,033	114	3.8%
Manteo	27954	2,802	158	5.6%
Nags Head	27959	1,558	66	4.2%
Rodanthe	27968	186	17	9.1%
Salvo	27972	139	30	21.6%
Wanchese	27981	815	22	2.7%
Waves	27982	40	0	0.0%
Hyde County		2,360	124	5.3%
Ocracoke	27960	358	7	2.0%

Source: U.S. Census Bureau 2000a



Source: Bureau of Labor Statistics 2010

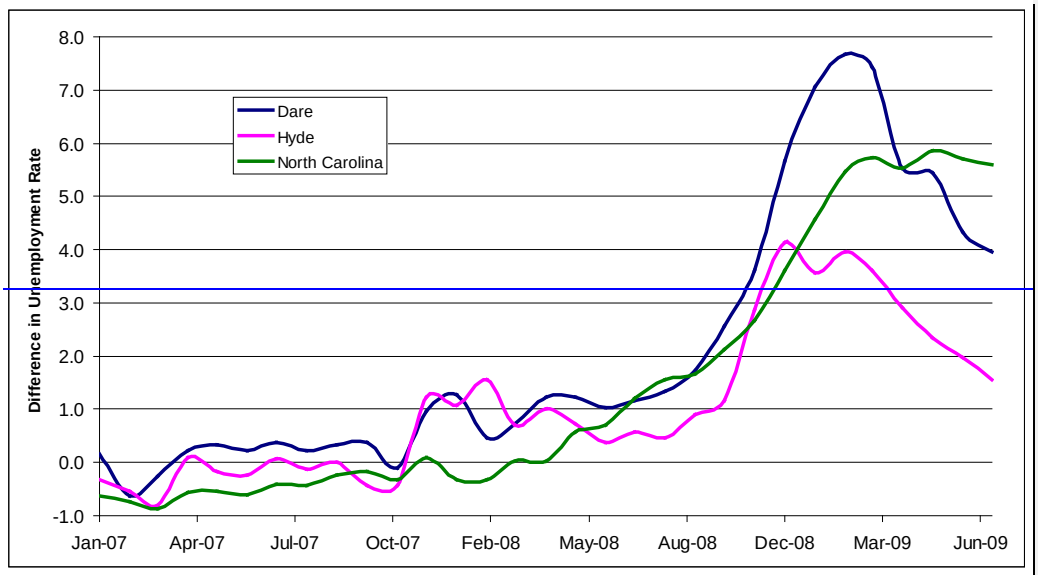
Comment [dw48]: A or B?

FIGURE 31. CHANGE IN UNEMPLOYMENT RATE FROM SAME MONTH IN PREVIOUS YEAR

~~TABLE 42. EMPLOYMENT CHARACTERISTICS, 2008~~

-	~~North Carolina~~	~~Dare County~~	~~Hyde County~~
~~Labor Force~~	~~4,543,754~~	~~22,087~~	~~2,644~~
~~Employment~~	~~4,256,815~~	~~20,650~~	~~2,457~~
~~Unemployment~~	~~286,939~~	~~1,437~~	~~187~~
~~Unemployment Rate~~	~~6.3%~~	~~6.5%~~	~~7.1%~~

~~Source: Bureau of Labor Statistics 2009~~



Source: Bureau of Labor Statistics 2009

FIGURE 31. DIFFERENCE IN UNEMPLOYMENT RATE FROM 2004–2006 MONTHLY AVERAGE

TOURISM CONTRIBUTIONS TO THE ECONOMY

The economy of the ROI is largely driven by the region's tourist draw, mainly during the summer months. As estimated by the North Carolina Department of Commerce, travel expenditures in Dare County have increased faster than those for the state as a whole (table 43); however, travel expenditures in Hyde County have decreased since 2000. In 2008, the Department of Commerce estimated that tourism was responsible for 11,250 jobs in Dare County and 370 jobs in Hyde County (North Carolina Department of Commerce 2009).

REGIONAL DISTRIBUTION OF TAX RECEIPTS WITHIN DARE COUNTY

The Outer Banks Visitors Bureau posts monthly data on gross tax receipts from lodging and meals (http://www.outerbanks.org/about_us/visitors_bureau/). Over the years, the county has made changes to the tax rate and the items that are taxed, so it is difficult to directly compare tax receipts across years. The data are provided for Dare County as a whole and the Seashore villages. Although year-to-year totals cannot be directly compared, assuming that taxes are consistent across the entire county, the percentage of tax receipts for all of Dare County generated by the Seashore villages provides one measure of how the tourism economy of the Seashore villages compares over time with the whole of Dare County. The Seashore villages contributed between 22% and 38% of the gross occupancy receipts in Dare County from March through November in the years 2006 through 2009. The Seashore village contribution is higher in the spring and fall, and has been consistent over the years. For gross meal receipts, however, the Seashore villages contribute between 8% and 15% of the receipts in Dare County, with their contribution higher in the summer. The gross meal receipts have also been consistent over the years.

Comment [dw49]: Is this 2010a or 2010 b? Should probably just cite OBVB here and put the web address in the references section.

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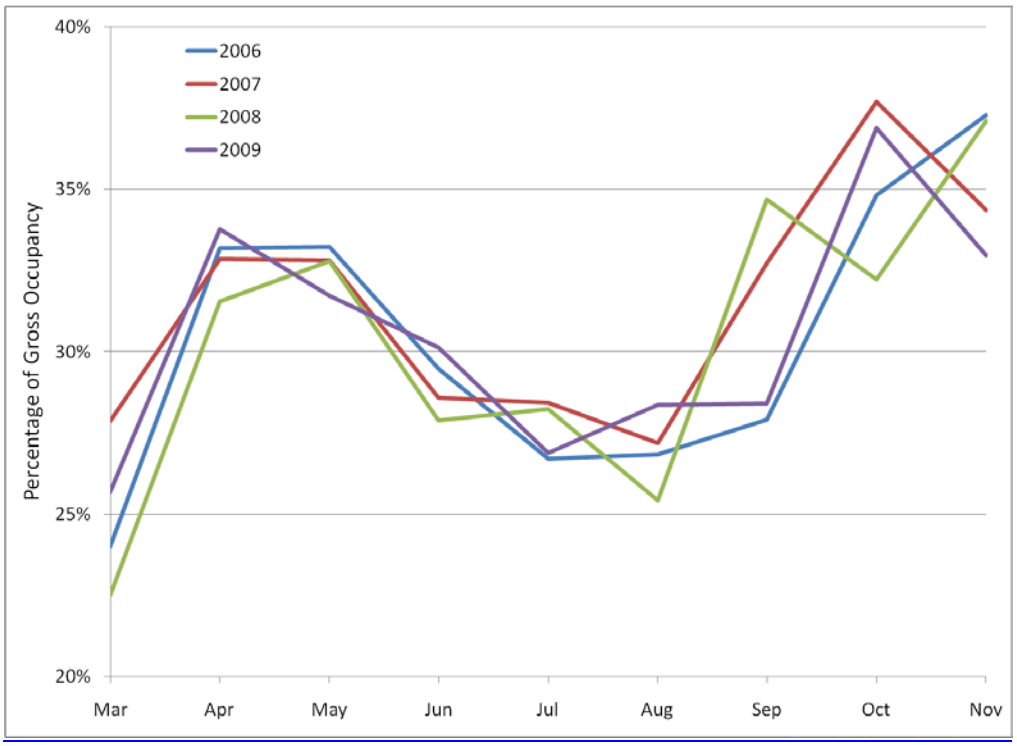

FIGURE 31-1. TAX RECEIPTS FROM THE SEASHORE VILLAGES AS A PERCENTAGE OF TOTAL TAX RECEIPTS FOR DARE COUNTY FOR LODGING

Comment [dw50]: Source?

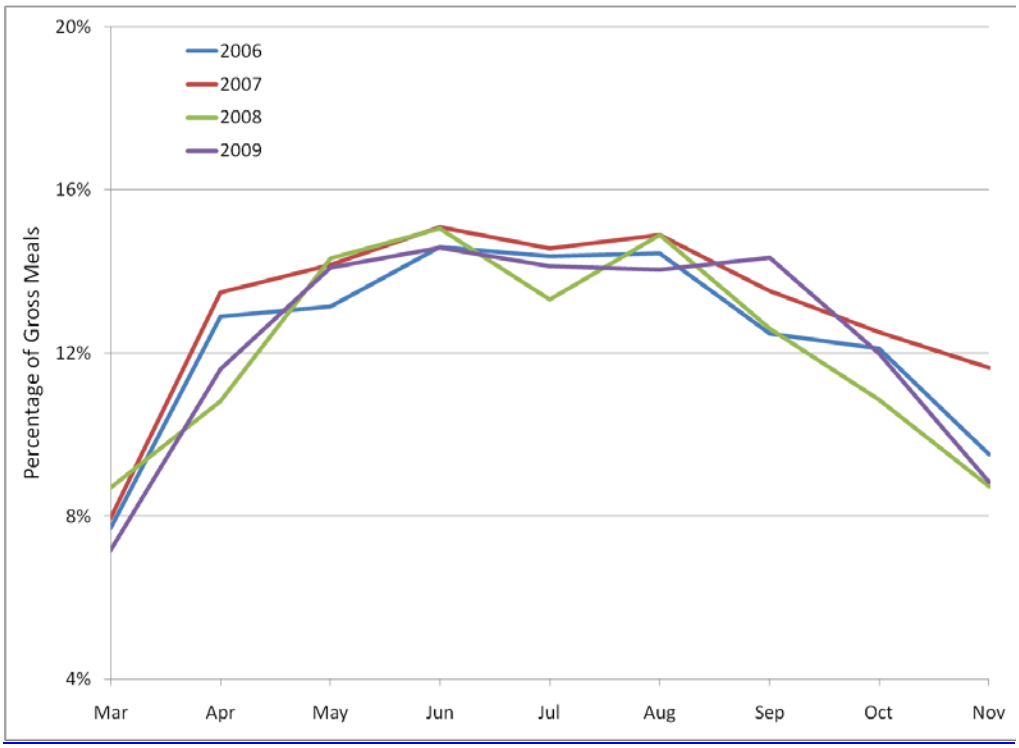

FIGURE 33-2. TAX RECEIPTS FROM THE SEASHORE VILLAGES AS A PERCENTAGE OF TOTAL TAX RECEIPTS FOR DARE COUNTY FOR MEALS

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TABLE 43. ESTIMATED DOMESTIC TRAVEL EXPENDITURES IN 2009 (IN MILLIONS)

Geographic Area	1991	2000	2008	2000 to 2008 CAGR
North Carolina	$11,092.58	$15,089.89	$16,864.60	1.6%
Dare County	$377.40	$624.14	$777.41	3.2%
Hyde County	$17.93	$29.58	$28.11	-0.7%

Source: North Carolina Department of Commerce 2009

~~TABLE 43. ESTIMATED DOMESTIC TRAVEL EXPENDITURES ($2008 MILLIONS)~~

~~Geographic Area~~	~~1991~~	~~2000~~	~~2008~~	~~2000 to 2008 CAGR~~
~~North Carolina~~	~~$11,092.58~~	~~$15,089.89~~	~~$16,864.60~~	~~1.6%~~
~~Dare County~~	~~$377.40~~	~~$624.14~~	~~$777.41~~	~~3.2%~~
~~Hyde County~~	~~$17.93~~	~~$29.58~~	~~$28.11~~	~~-0.7%~~

Source: North Carolina Department of Commerce 2009

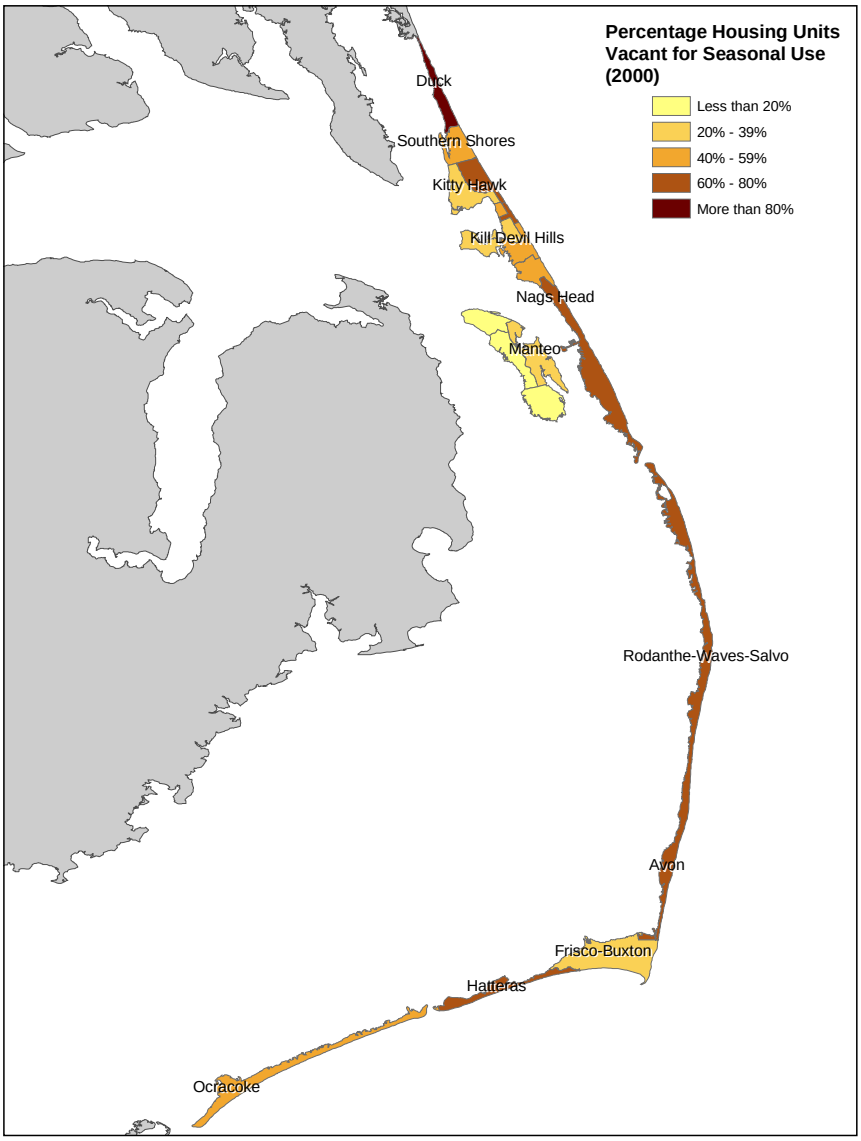
Housing

In 2000, the ROI had a total of 26,891 housing units, with 97% of these located in the Dare County block groups. The ROI's housing is roughly 54% urban and 46% rural, with 100% of the urban housing units being located in Dare County block groups. Over 50% of the housing units in the ROI are for seasonal, recreational, or occasional use (table 44). The distribution of vacant housing units for seasonal, recreational, or occasional use is shown in figure 32. This is further evidence of the importance of tourism's contributions to the region's economy.

TABLE 44. HOUSING UNIT STATISTICS, 2000

	United States	North Carolina	ROI
Total	115,904,641	3,523,944	26,891
Urban	89,966,555	2,080,729	14,578
% of Total	78%	59%	54%
Occupied	105,480,101	3,132,013	12,588
Vacant	10,424,540	391,931	14,303
For seasonal, recreational, or occasional use	3,872,468	147,087	13,771
% of Total	3%	4%	51%

Source: U.S. Census Bureau 2000a



Source: U.S. Census Bureau 2000a

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FIGURE 32. PERCENTAGE OF HOUSING UNITS VACANT FOR SEASONAL, RECREATIONAL, OR OCCASIONAL USE BY BLOCK GROUP, 2000

Since 2000, Dare County has experienced a 21% increase in the number of housing units, relative to a 14% change state wide (table 45). However, in October of 2008, Dare County had the fifth highest foreclosure rate of any county in North Carolina, with one in every 679 housing units in foreclosure (RealtyTrac.com 2008).

TABLE 45. CHANGE IN HOUSING UNITS

Geographic Area	2000	2008	Percent Change 2000–2008
United States	115,904,641	129,065,264	11%
North Carolina	3,523,944	4,201,378	19%
Dare County	26,671	32,749	21%
Hyde County	3,302	3,495	5%

Source: Population Division, U.S. Census Bureau 2009b, 2009c

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Quality of Life

Quality of life encompasses those attributes of resources (man-made or naturally occurring) of a region that contribute to the well-being of its residents. The relative importance of these attributes to a person's well-being is subjective (e.g., some individuals consider outdoor recreational opportunities essential to their well-being, others require access to cultural institutions essential to their quality of life, and still others may hold public safety as their primary quality-of-life concern). Quality-of-life analyses typically address issues relating to potential impacts of the proposed action on the availability of public services and leisure activities that contribute to the quality of life of an affected ROI's inhabitants. For the purpose of this study, the quality-of-life affected environment includes the natural environment, public schools, law enforcement, medical facilities, and fire protection services.

The natural environment, including beaches and wildlife, provide the primary basis for quality of life on the Outer Banks. As discussed above, beach-related tourism drives the economy of the area. Local residents also receive significant recreational benefits from the area's natural assets. In addition to the Seashore, the ROI includes Jockey's Ridge State Park and Pea Island NWR (Outer Banks Chamber of Commerce 2008). There are also public beaches, marinas, piers, and other recreational outlets. Two categories of outdoor recreation pertinent to the assessment of alternative management plans, recreational fishing and bird watching, are discussed further below using data from the National Survey of Fishing, Hunting, and Wildlife-Associated Recreation.

Fishing

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North Carolina is the sixth most popular state for fishing, with an estimated 1,263,000 residents and nonresidents participating in 2006 (U.S. Department of the Interior et al. 2008). Recreational fishing is a significant part of North Carolina's economy, attracting spending from both local and out-of-state anglers. Approximately 519,000 anglers in North Carolina engaged in saltwater fishing in 2006 (table 46). Expenditures from fishing trips totaled an estimated $692,977,000 in 2006, with $450,313,000 coming from saltwater anglers. While only 40% of anglers report participating in saltwater fishing, nearly 65% of all trip-related expenditures go toward this activity.

TABLE 46. RECREATIONAL FISHING IN NORTH CAROLINA, BY RESIDENTS AND NONRESIDENTS

	Resident	Nonresident	Total
Total participants	868,000	395,000	1,263,000
% Total participants	69%	31%	100%
# Saltwater	253,000	266,000	519,000
% Saltwater	49%	51%	100%
Total trip-related expenditures	$395,296,000	$297,681,000	$692,977,000
Average trip-related expenditures per participant	$456	$753	$549

Source: U.S. Department of the Interior et al. 2008

Nonresident angler expenditures are important to regional economic impacts, as they represent an addition to area wealth rather than a change in the mix of spending by residents. Nonresidents make up only 31% of all anglers in North Carolina but comprise 51% of saltwater anglers. Nonresidents, who often must pay greater lodging and transportation fees, spend an average of 65% more than residents for trip-related expenditures over all types of fishing.

Separate expenditure data for residents and nonresidents on saltwater fishing were not available. However, trip-related expenditures (including food, lodging, transportation, ice, bait, guide and usage fees, rental equipment, and other items, but excluding the cost of purchased equipment) are much higher for saltwater anglers than for all anglers combined, averaging $754 per person for both residents and nonresidents, compared to $549 per person for all fishing. Saltwater fishermen spend more per angler on food and lodging, transportation, and other trip costs, but spend proportionally less on transportation and slightly more on food, lodging, and other costs. Overall, saltwater fishing such as that on Cape Hatteras attracted a greater percentage of out-of-state residents and averaged 56% greater trip-related expenditures than all types of fishing combined.

Dare and Hyde counties sold 40% of coastal recreational fishing licenses sold within the eight coastal counties in North Carolina and 18% of all coastal recreational fishing licenses sold in 2008. Dare County ranks first among all North Carolina counties in coastal recreational fishing license sales (table 47).

Wildlife Watching

Among all states, North Carolina ranks nineteenth for number of wildlife watchers, with 2,641,000 participants in 2006. Wildlife watching is classified as activities for which wildlife watching is the primary purpose, and does not include trips to zoos or museums or accidental observation of wildlife. Wildlife watchers may be feeding, photographing, or observing wildlife. Approximately 15% of wildlife watchers in North Carolina were nonresidents in 2006.

TABLE 47. NUMBER OF COASTAL RECREATIONAL FISHING LICENSES SOLD BY NORTH CAROLINA COUNTY OF SALE (LOCATION WHERE LICENSE SALES AGENT RESIDES), EXCLUDING BLANKET COASTAL RECREATIONAL FISHING LICENSES, BY CALENDAR YEAR

County	2007	2008
Dare	93,225	82,635
Hyde	6,322	5,358
Brunswick	38,721	33,303
Carteret	46,813	38,456
Currituck	2,660	2,435
New Hanover	34,556	28,558
Onslow	16,098	15,185
Pender	17,462	14,733
Total	469,521	411,886

Source: NCWRC 2008a

Away-from-home wildlife watching is defined as wildlife observation occurring at least one mile away from home. Table 48 presents information about away-from-home wildlife watching in North Carolina. Among away-from-home wildlife watchers in North Carolina, approximately 56% are nonresidents. Away-from-home bird watchers made up 620,000 or 90% of all away-from-home wildlife watchers. Of these, 50% reported watching "other waterbirds." This category includes shorebirds, cranes, herons, and all other waterbirds not classified as waterfowl and serves as the best representation of birds on Cape Hatteras. Among wildlife watchers observing "other waterbirds," nonresidents made up 69% of participants. Thus, wildlife watching for birds like those on Cape Hatteras is far more likely to be participated in by nonresidents than other wildlife watching.

TABLE 48. AWAY-FROM-HOME WILDLIFE WATCHING IN NORTH CAROLINA, BY RESIDENT AND NONRESIDENT

	Resident	Nonresident	Total
Total away-from-home participants	300,000	386,000	686,000
Percent of total participants	44%	56%	100%
Total away-from-home birders	284,000	336,000	620,000
Total birders	46%	54%	100%
Away-from-home "other waterbird" observers	95,000	215,000	310,000
Percent of "other waterbird" observers	31%	69%	100%
Total trip-related expenditures	$84,245,000	$162,662,000	$246,906,000
Average trip-related expenditure per participant	$281	$421	$360

Source: U.S. Department of the Interior et al. 2008

Wildlife watchers in North Carolina spent a total of $246,906,000 in trip-related costs in 2006. This number includes food, lodging, transportation, rented equipment, and guide or permit fees, but not expenditures on purchased equipment. Away-from-home resident wildlife watchers spent an average of

$281 per person per trip, while nonresident participants spent $421. Although separate expenditure data for other waterbird watchers were not available, other waterbirds such as shorebirds are more likely to attract out-of-state wildlife watchers, who then spend on average 50% more than resident wildlife watchers.

Beach Driving

To ~~support~~ provide additional information for the required analyses and to collect information relevant to park management, NPS contracted with RTI International to conduct a count of vehicles using the ocean-side beach access ramps over a 12-month period from April 2009 ~~and~~ through March 2010~~.~~. The primary goal of the vehicle counting survey was to estimate ~~of~~ the total number of vehicles using the 16 ocean-side ramps during a 12-month period between 6 a.m. and 10 p.m.~~.~~. The details of the study are described in the final report (RTI 2010)~~.~~.

~~.~~Sixteen ocean-side ORV access ramps currently operate in the Seashore~~CAHA~~. Two of the ramps are located on Bodie Island, nine are on Hatteras Island, and the remaining five are on Ocracoke Island. Field staff took 19 three~~3~~-day trips to the Seashore to count at beaches and ramps, for a total of 57 days of counting. Each selected day, field staff traveled to two randomly selected clusters of ramps and beaches and spent two~~2~~ hours counting vehicles at each of the two ORV ramps and two~~2~~ hours counting beach visitors at the four beach segments in the cluster. The 57 days of counting resulted in a total sample of 114 clusters covering 228 two~~2~~-hour ramp-counting opportunities and 456 beach-counting opportunities.

To ensure that we had at least two counting trips taken during the low winter season, we created two seasonal strata out of the 52 weeks. The two strata roughly correspond to low and medium/high visitation seasons at the Seashore. The lowest visitation stratum~~a~~, which consists of the 17 weeks from the beginning of December 2009 through the end of March 2010, was assigned two 3-day trips. The remaining 17 trips will take place in the other 35 weeks from April 2009 through November 2009, which~~that~~ make up the medium and high visitation strata.

The data from the counting trips was weighted based on sampling design and the probability that a ramp was selected for counting at a certain time or a certain day. Based on the data from the vehicle counts, the mean estimate is 499,802 vehicle trips onto the Seashore beaches accessed by the ocean-side ramps between April 2009 and March 2010, with a 95% confidence interval of 276,946 to 722,659~~.~~. An estimated mean of 994,604 passengers were involved with these vehicle trips with a 95% confidence interval of 654,961 to 1,334,247 passengers (table 48-1).

The increased sampling coverage between April and November (49% of the weeks as opposed to 12% of the weeks between December and March), resulted in narrower confidence intervals around the April and November estimates~~.~~. Between April and November, the 95% confidence interval is +/-17% of our point estimate of 344,999 vehicle trips~~.~~. Between December and March, the 95% confidence interval is +/-151% (table 48-1)~~.~~. In addition, the geographic distribution of ORV use in the Seashore~~CAHA~~ could not be determined between December and March due to the lack of sampling coverage~~.~~. April through November captures the majority of trips that would be affected by the proposed management alternatives, providing the best estimates.

TABLE 48-1. ESTIMATES AND 95% CONFIDENCE INTERVALS FOR NUMBER OF VEHICLES AND PASSENGERS BY TIME STRATA

-	Vehicle Trips			Passengers		
Time Interval	Estimate	Lower Bound	Upper Bound	Estimate	Lower Bound	Upper Bound

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April 2009 to November 2009	344,999	284,696	405,302	768,948	625,928	911,968
December 2009 to March 2010	154,803	0	392,594	225,656	0	567,185
52 week total	499,802	276,946	722,659	994,604	654,961	1,334,247

Table 48-2 reports the estimates broken down by clusters of ramps for the period of April to November 2009. The most popular ORV ramp cluster between April and November were Ramps 2 and 4 on Bodie Island. Fifty-eight percent of ORV trips took place on the various ramps through Hatteras Island, 19% on Ocracoke Island, and 23% on Bodie Island (Table 48-2). Confidence intervals for the ramp cluster estimates range from +/-55% for Ramps 2 and 4 to +/-79% for ramps 59 and 67.

TABLE 48-2. ESTIMATES AND 95% CONFIDENCE INTERVALS FOR FOR NUMBER OF VEHICLES AND PASSENGERS CLUSTERS OF RAMPS (APRIL TO NOVEMBER 2009)

	Vehicle Trips			Passengers		
Ramps	Estimate	Lower Bound	Upper Bound	Estimate	Lower Bound	Upper Bound
2, 4	78,550	35,149	121,950	174,949	77,174	272,725
23, 27, 30	49,273	16,596	81,950	112,702	39,863	185,542
34, 38	48,778	13,214	84,341	103,171	30,092	176,250
43, 44, 45	51,277	11,277	91,277	117,030	17,262	216,797
49, 55	52,318	13,358	91,278	123,355	26,888	219,822
59, 67	20,447	4,356	36,538	45,152	9,824	80,480
68, 70, 72	44,358	14,090	74,625	92,588	29,933	155,243

Preservation and Nonuse Values

Preservation or nonuse impacts represent a category of values held by people independent of their use of the resources that also includes existence value and bequest value. The main assumption underlying the concept of nonuse values is that individuals' welfare can be enhanced simply by the *knowledge* that specific ecosystems are being protected or improved. As the name implies, individuals receive these types of services without any specific use of or interaction with the ecosystems. For example, nonuse values from preserving a natural area may come from the knowledge that future generations are more likely to experience and enjoy the area (i.e., "bequest values").

Economic theory recognizes that individuals can hold value for the Cape Hatteras National Seashore and the ecosystems contained within its boundaries because they want future generations to enjoy the area, because they value the protected species supported by the area, or because they feel the natural communities contained within the National Seashore have intrinsic value separate from the value they provide to visitors.

Measuring values for these "nonuse" services is more difficult and involves more uncertainty than for recreational and aesthetic services. Nevertheless, a variety of studies demonstrate that nonuse values exist

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and may be quite large depending on the resource in question. Loomis and White (1996) synthesized key results from 20 threatened and endangered species valuation studies using meta-analysis methods. They were able to identify variables that explain the observed variation in estimated willingness-to-pay (WTP) values for threatened and endangered species and examine how per-household benefit estimates compare with cost estimates for protection. In their meta-analysis, Loomis and White reviewed 20 contingent value studies coming from both the published and gray literature. They found that annual WTP estimates range from a low of $8 for the Striped Shiner fish to a high of $124 for the Northern Spotted Owl. Using these 20 studies, they applied regression based methods to combine valuation findings and to identify statistically significant determinants of estimated values for threatened and endangered species. Some of their key findings include statistically significant effects on WTP of (1) the size of the change in a species population; (2) whether those expressing values for the species are users of the affected resource; and (3) whether the species is a marine mammal or bird. Loomis and White also used the meta-analysis results to conduct a rough benefit-cost analysis. They noted that even in supposedly "high cost" cases, such as the Northern Spotted Owl, costs per household are relatively low and are well below the benefits found in WTP studies.

SEASHORE OPERATIONS AND MANAGEMENT

Management of ORV use at the Seashore, and implementation of the related administrative activities and field operations, involves all five NPS operational divisions, as well as the Superintendent's Office (Park Management). The baseline for Seashore operations and management will be discussed both in terms of pre-consent decree (under the Interim Strategy) (before 2008) and post-consent decree (2008).

Management and Administration. Management and administrative staff members at the Seashore have a variety of responsibilities related to ORV management, including compiling and sending out weekly access and resource updates, managing payroll for the Seashore, fielding questions from visitors regarding ORV management, fulfilling human resources functions and supervisory roles, and providing information technology and other technical support, in addition to the superintendent's role in ORV management. Administrative costs address the need to provide technical assistance to the approximately 25 field and administrative staff members associated with ORV management. Administrative support related to ORV management required approximately 4.75 full-time equivalent (FTE) ($428,750) under the Interim Strategy. This number increased to 5.35 ($480,950) plus approximately $3,000 of direct materials costs (total cost $483,950) in 2008 with the implementation of measures under the consent decree. The increased level of effort for administration is primarily related to the increased need for information technology support as the use of technology was increased to inform the public about areas open for ORV use or closed for species protection.

Visitor Protection. Law enforcement officers at the Seashore are responsible for enforcing all applicable regulations, including those related to ORV and species management. In relation to ORV management, duties of law enforcement include patrolling the Seashore, as well as providing on–the-spot interpretation to visitors as to the reason for certain ORV regulations and species management efforts. Other duties include responding to violations and conducting investigations. Support (or materials) costs for these Seashore staff members include vehicles, fuel, training, travel, field supplies, and radio support. Visitor protection support related to ORV management required approximately 13 FTE ($1,047,500) and $100,000 in support costs (total cost approximately $1,147,500) under the Interim Strategy. This number increased to 16.5 FTE ($1,321,500) and $160,000 in support costs (total cost approximately $1,481,000) in 2008 with the implementation of measures under the consent decree. This increased level of effort for law enforcement is primarily related to the increased amount of time patrol rangers are devoting to ORV management, such as addressing the night-driving restrictions under the consent decree.

Resources Management. Resources management staff members at the Seashore are responsible for all monitoring and surveying of species at the Seashore, as well as establishing and changing the required resource closures once state- or federally listed species are found at the Seashore. This staff includes supervisory roles as well as full- and part-time field staff to implement species management measures. Support (or materials) costs for these Seashore staff members include vehicles (such as four-wheel drive vehicles, ATVs/Utility Terrain Vehicles [UTVs]), fuel, training, field supplies (such as signs, string, flagging, and rope), monitoring supplies, and travel. Resources management efforts at the Seashore required approximately 9.5 FTE ($423,500) and $85,000 in support costs (total cost approximately $508,500) under the Interim Strategy. This number increased to 15 FTE ($778,000) and $35,000 in support costs (total cost approximately $813,000) in 2008 with the implementation of measures under the consent decree. This increased level of effort for resource management staff is primarily related to the need for additional field staff and Geographic Information Systems (GIS) staff to address the closure requirements and to be able to provide weekly reports and mapping of the closures to keep the public informed of their activities. Resources management staff is also responsible for preparation of all required annual reports for protected species, research on protected species or factors that affect the species, predator control activities, and coordination of regulatory and scientific activities with other entities such as the USFWS and NCWRC.

Interpretation. Interpretation staff members at the Seashore are responsible for providing information programs to Seashore visitors, specifically on the subject of species management. Support (or materials) costs for these Seashore staff include printing newsletters and brochures, and obtaining materials for visitor programs. Interpretation efforts at the Seashore required approximately 1.5 FTE ($58,500) and $10,000 in support costs (total cost approximately $68,500) under the Interim Strategy. This number increased to 3.0 FTE ($181,500) and $12,000 in support costs (total cost approximately $193,000) in 2008 with the implementation of measures under the consent decree. This increased level of effort for interpretation staff is primarily related to the increased level of programs and information provided to the public regarding areas available for ORV use, as well as providing information about why certain ORV and species management measures are being implemented at the Seashore. With the increase in programs, the number of staff members devoted to ORV management issues has also increased.

Facility Management. Facility management staff members at the Seashore are responsible for providing maintenance and repairs for beach ramps and parking lots, as well as installation of informational signs along the beach. This division of the Seashore is also responsible for maintaining and repairing the vehicles used by all other divisions of the Seashore, including those used for law enforcement and resource management patrols. Support (or materials) costs for these Seashore staff members include ramp fill material, vehicle parts, and vehicle maintenance supplies. Facility management efforts required approximately 0.6 FTE ($46,500) and $10,000 in support costs (total cost approximately 56,500) under the Interim Strategy. This number increased to 3.6 FTE ($158,600) and $20,000 in support costs (total cost approximately $178,600) in 2008 under the implementation of the consent decree. This increased level of effort for facility management staff is primarily related to the need to increase the number of maintenance workers and laborers. The increase in both law enforcement and resource management staff results in an increased number of vehicles that need to be maintained. The additional signage and educational requirements require more staff and effort to install, and an increased level of effort.

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