interpretation of the law authorizing the Seashore and its amendments, since neither made specific reference to automobiles or how beach access would be provided. It only specified that commercial fishing by legal residents was to be allowed. One practice in use by local residents was "haul fishing," a technique whereby fisherman used a jeep or similar vehicle to drag a net from the sea to the beach. Vehicle use was integral to this practice and not merely a means for transportation. The NPS established beach access ramps to enable commercial fishermen to continue to use vehicles to fish from shore while mitigating damage to the barrier dunes by controlling the points of entry, but these ramps also allowed general visitors motorized access to the beach (NPS 2007f).

Within a decade of completion of the Bonner Bridge, the NPS was facing serious public complaints on two related fronts. The first concerned the presence of ORVs or "beach buggies," especially at Cape Point near the famous Cape Hatteras Lighthouse. Such vehicles, then mainly used by fishermen, concentrated near the best fishing sites in groups of up to fifty or so, leaving piles of beach trash and making it difficult for other visitors to enjoy the scenic vista. The problem may have existed for a while, but by 1972, as one writer informed Director George B. Hartzog, Jr., a person "literally could not take a photograph of the waves by themselves without two or three hip-booted intruders in the viewfinder." This visitor did not want a total ban on the buggies but did want some restrictions. He protested that the NPS mission was to leave the land "unimpaired" and noted that if there were fifty buggies this year, when would it stop? "You might as well call it the Hatteras Parking Lot," he concluded (NPS 2007f).

The stock NPS response was that "in contrast to natural areas, the recreation area is supposed to serve many needs." Indeed, according to Deputy Assistant Director Joseph C. Rumberg, Jr., "a closure of the cape to allow full aesthetic appreciation of the power and wonder of the ocean, at the expense of fishing and beach buggy use, would be a matter fraught with controversy." Nevertheless, Director Hartzog directed the Southeast Regional Office in Atlanta to arrange with the Superintendent to study the possibility of changes, limitations, or even the elimination of beach buggies. Hartzog hoped the study would develop recommendations that might provide the park with a better means of controlling vehicle use on the beach (NPS 2007f).

The problem was actually more serious than suggested by visitors annoyed over compromised scenic views. The Bonner Bridge had also brought increasing numbers of fishermen who were not residents of the Outer Banks but were bent on using more sophisticated means to exploit commercial opportunities. The basic issue involved fishermen using dories loaded with nets that were pulled along the beach by truck until a school of fish was located. Then, a boat was launched and part or all of the school was surrounded by the net tied to the truck onshore, which hauled in the line. According to the account of a sport-fishing newsletter, an existing practice became an acute problem by 1972. During the 1930s, only a half-dozen local residents practiced this technique, some using nets that were up to 200 yards long. Between 1936 and the early 1960s, the number of fishermen had remained fairly constant, and with up to ten such fishermen working, their nets were still no longer than 400 yards (NPS 2007f).

After the Bonner Bridge opened in 1964, however, commercial fishermen from elsewhere began participating in the fish harvest, some from as far away as New York. Now as many as twenty commercial fishermen were using nets up to sixteen hundred yards in length. This activity was wiping out striped bass because such huge nets took in 20- to 50-pound fish in catches weighing up to 10,000 pounds. Worse, non-commercial fish were merely left to die and rot on the beach. By 1972, the problem was acute, and local fishermen began to complain, noting that they brought in cash much needed by the villagers whereas outside commercial fishermen merely depleted the fishing stock. After several years of competition between these various groups of fishermen, the situation began to threaten violence, and calls for new legislation were voiced (NPS 2007f).

Beach driving 1933
Credit: NPS

In the coming years, many heated debates were to erupt between commercial, sports, environmental, and park-access groups. It should be noted, however, that between the 1930s until well into the 1960s, the public lodged few complaints about fishing, beach driving, or conflicts between vehicle-users and other beach-goers. At first, the few Outer Banks residents with vehicles, and occasional visitors, did not relish the notion of beach driving and did so simply because there were almost no roads on which to drive. After World War II, improved automotive technologies allowed more villagers and visitors to drive along the seashore, but without roads this activity still entailed the onerous rituals of deflating and re-inflating tires, digging out from occasional sandpits, and risking getting stuck. Such experiences were unpleasant but whether they bothered the typical "Hatterasman" as writer Ben Dixon MacNeill phrased it, was another question (NPS 2007f).

Outer Banks residents were by tradition and necessity a people of the sea and were adept at using it for transportation. They did not need roadways for their own transportation or lifestyle needs, rather an absence of roads limited economic growth. As their traditional life ways declined, Outer Banks residents increasingly sought the roads and bridges needed to sustain a tourist-based economy. A major reason the NPS began to reappraise its opposition to an island parkway was that random beach driving led to destruction of the artificial dunes and harmed native flora and fauna. Ironically, the very road that boosted tourism and was supposed to better protect the environment by eliminating the chore of beach driving was also what made commercial and recreational access to the beach ever more possible and brought those separate interests into conflict. However, some commercial fishermen used jeeps early on to operate shore-based fishing nets while the NPS set up ramps to help channel sport fishermen away from the more sensitive dune areas. These early ramps also gave access to increasing numbers of tourists. Still, such uses did not begin to elicit great controversy until after the Bonner Bridge opened in 1964. With the bottleneck at Oregon Inlet removed, there was no limit to the number of park visitors who in a day's span could drive down the banks and out onto the beach. Completion of the Bonner Bridge, therefore, marks a key demarcation point in the history of the first national seashore (NPS 2007f).

In brief, residents adopted the use of ORVs for commercial netting of fish, while sport fishermen used ORVs to pursue migrating schools of game fish and reach more productive areas, such as Cape Point or the inlets, often a mile or more from the nearest paved surface. Presently, ORVs are used to access the beach for activities such as commercial and recreational fishing, sightseeing, travel to and from swimming and surfing areas, and pleasure driving (NPS 2004b).

Today ORVs access the ocean beaches and sound shoreline via a system of "ramps" located off NC-12 and other paved roadways. The ramps began as an informal system of unimproved access points connecting the roadway to the sounds and beaches. Over time, this system was formalized and the oceanside ramps are now numbered, maintained, and identified on the Seashore's ORV route maps as official vehicle access 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

ORV Routes and Areas

Legend

- CAHA Boundary
- PINWR Boundary
- Villages
- Boat Ramps
- Campgrounds
- Existing Parking Lots
- Swim Beaches

ORV Ramps

- Oceanside Ramps
- Soundside Ramps

- US Hwy
- State Hwy
- Other
- Ferry Route

ORV Routes

- Open to ORV all year
- Seasonally open/closed

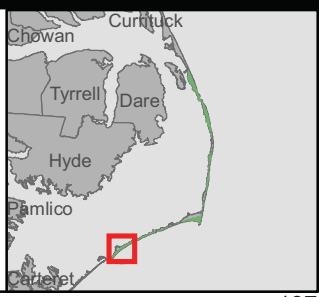
*Areas open to ORV are subject to temporary resource or safety closures.

Alternative F

Map 7 of 7

N

0 0.5 1 1.5 Miles



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). For the 2009 season there were a total of 54 pairs in the state (USFWS 2009b); in 2010, there were an estimated 51 pairs in the state (Schweitzer pers. comm. 2010).

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. 2010). Plovers from the endangered Great Lakes population have been observed in fall and spring migration and during the wintering period (Cohen et al. 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
2010[i]	—	—	—	51	—	—

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.

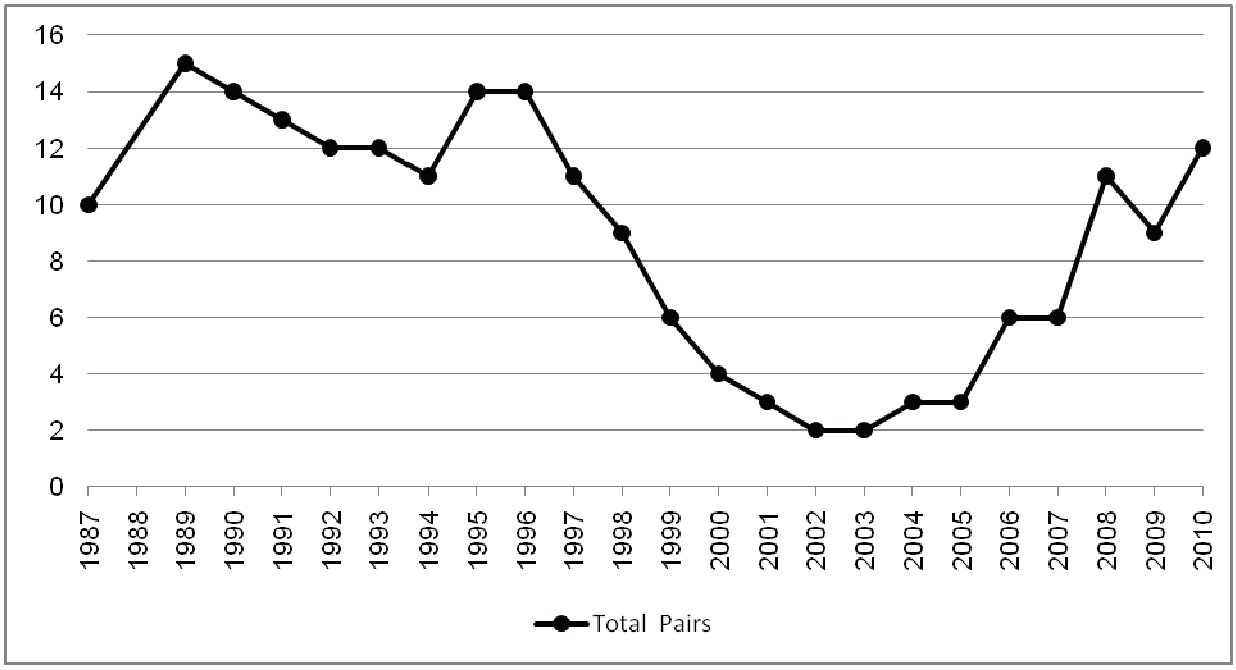
[g] USFWS 2008c. 2008 Preliminary Atlantic Coast Piping Plover Abundance and Productivity Estimates.

[h] USFWS 2009b. 2009 Preliminary Atlantic Coast Piping Plover Abundance and Productivity Estimates.

[I] Schweitzer pers. comm. 2010

— = No data available.

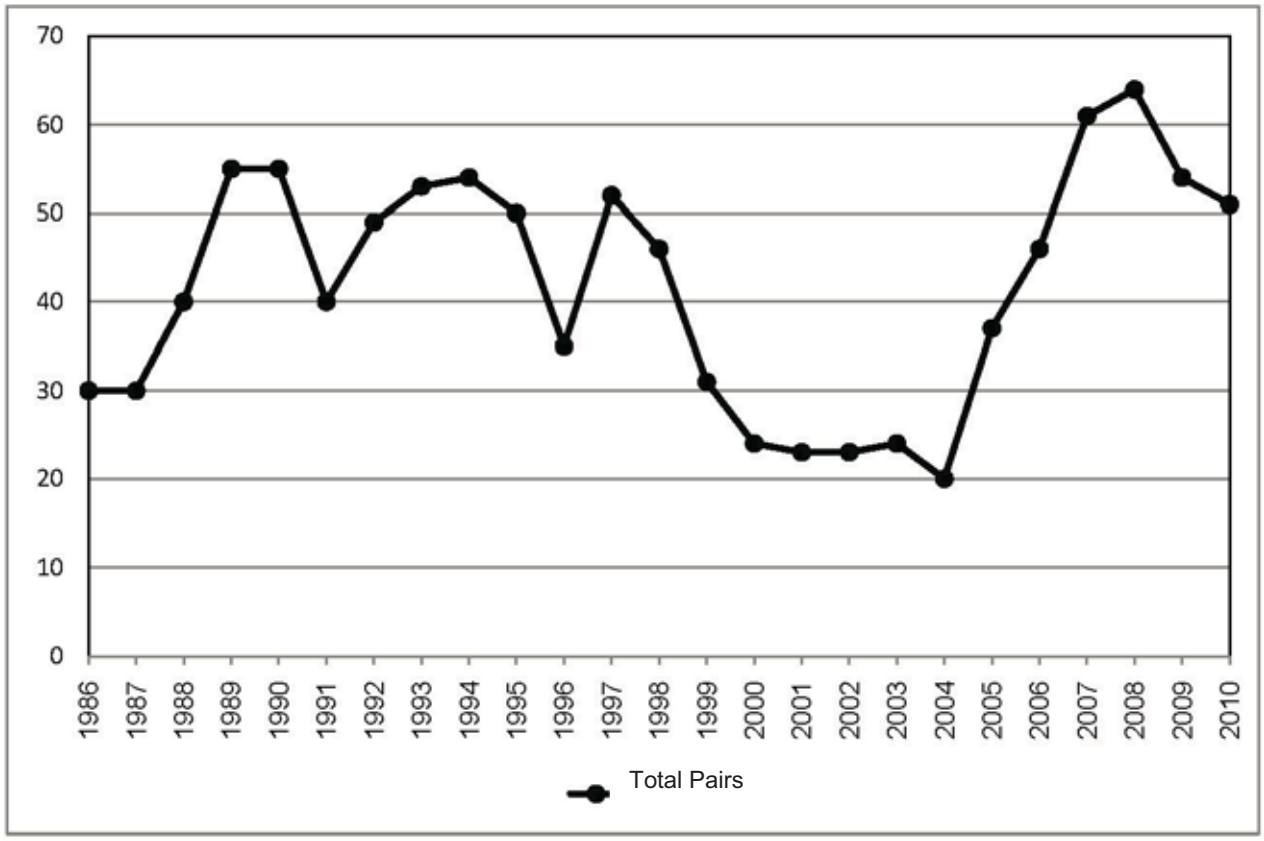
At the Seashore, four nests and one brood were observed in 1984, and five chicks were confirmed to have fledged that year. All four nests were located adjacent to least tern (*Sterna antillarum*) colonies on wide, open, sandy flats (Golder 1985). Nine pairs were counted in 1985 (Golder 1986), and 10 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, 1987–2010

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 end of season estimates indicated a total of 54 breeding pairs in the state in 2009 and 51 in 2010 (USFWS 2009b; Schweitzer pers. comm. 2010). 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).



Source: USFWS 2004a, 2004b, 2005a, 2006b, 2007c, 2008c; USFWS 2009b; Schweitzer pers. comm. 2010

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, 1986–2010

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. 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 (Federal Register (FR) notice 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.

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)).

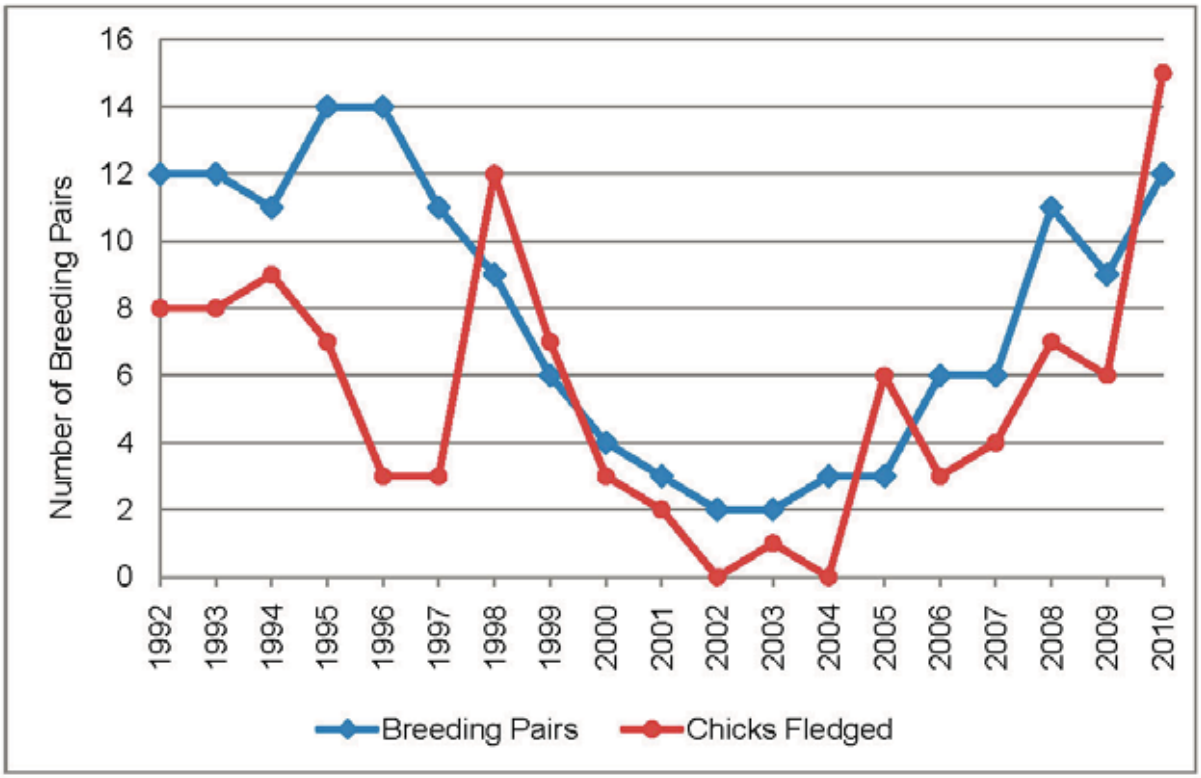
Of the 2,043 acres of designated critical habitat in Dare and Hyde counties, approximately 1,827 acres are located within the boundaries of the Seashore and are located at Bodie Island Spit, Cape Point, Hatteras Inlet Spit, Ocracoke Inlet Spit, and South Point (73 FR 62816).

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).

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; NPS 2010d; Muiznieks pers. comm. 2010a

FIGURE 5. NUMBERS OF PIPING PLOVER BREEDING PAIRS AND FLEDGED CHICKS AT CAPE HATTERAS NATIONAL SEASHORE, 1992–2010

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 2010. Average fledge rates[5] 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 in 2010 to be above the 1.50 goal set by the 1996 revised recovery plan. In 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.

[5] "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.

TABLE 17. PIPING PLOVER HATCHING AND FLEDGING SUCCESS AT BODIE ISLAND SPIT, 1992–2010

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	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 = 0.14										

Muiznieks pers. comm. 2010a

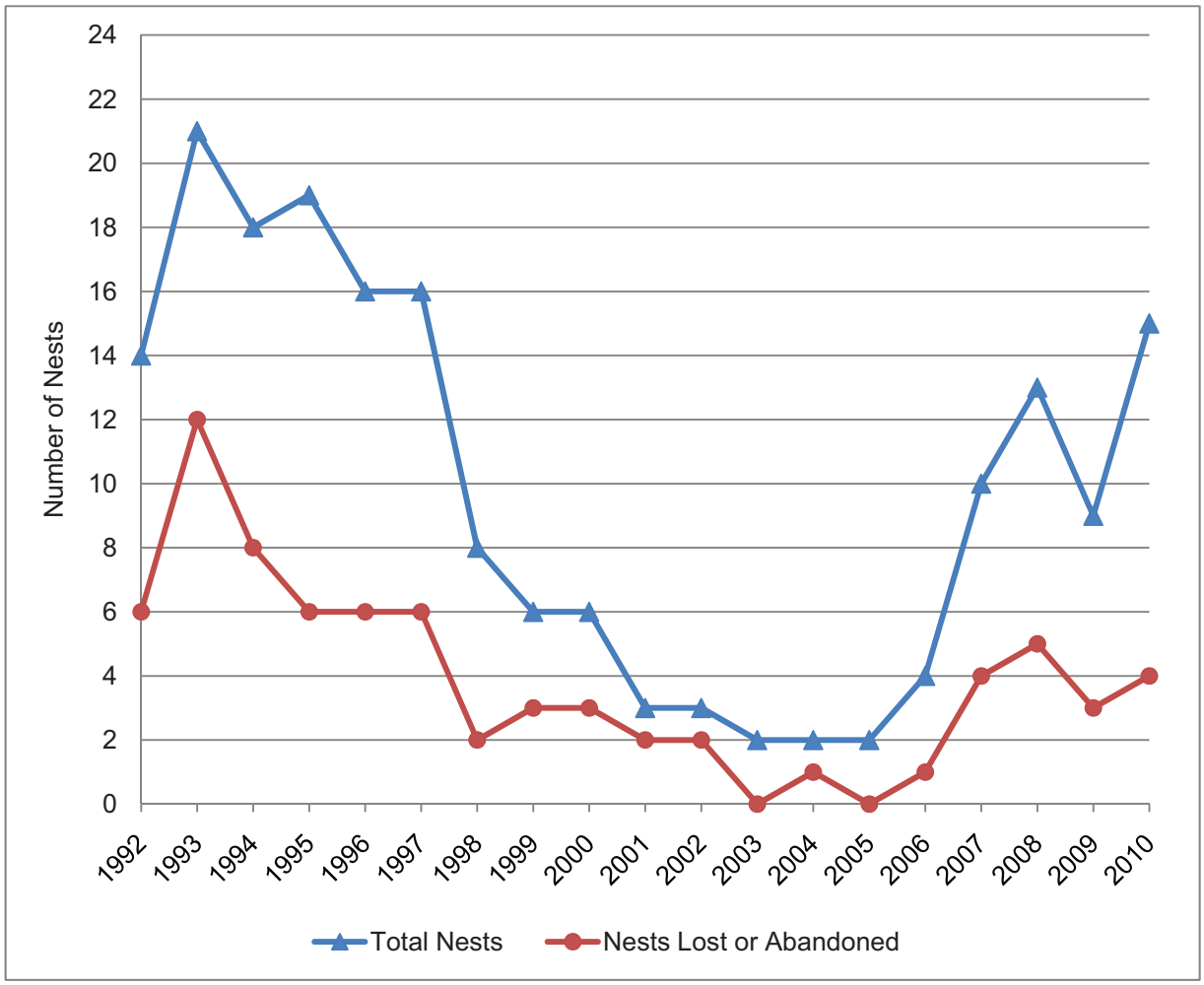
TABLE 22. PIPING PLOVER HATCHING AND FLEDGING SUCCESS AT SOUTH POINT, 1992–2010

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	22	3	42.9	8	36.4	0	0.0	0.00
Average Fledge Rate at South Point = 0.57										

Muiznieks pers. comm. 2010a

Nest Loss/Abandonment

Nest loss and abandonment have had significant impacts on piping plover reproduction at the Seashore. In the 19 seasons from 1992 through 2010, 40% of nests (of 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.



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

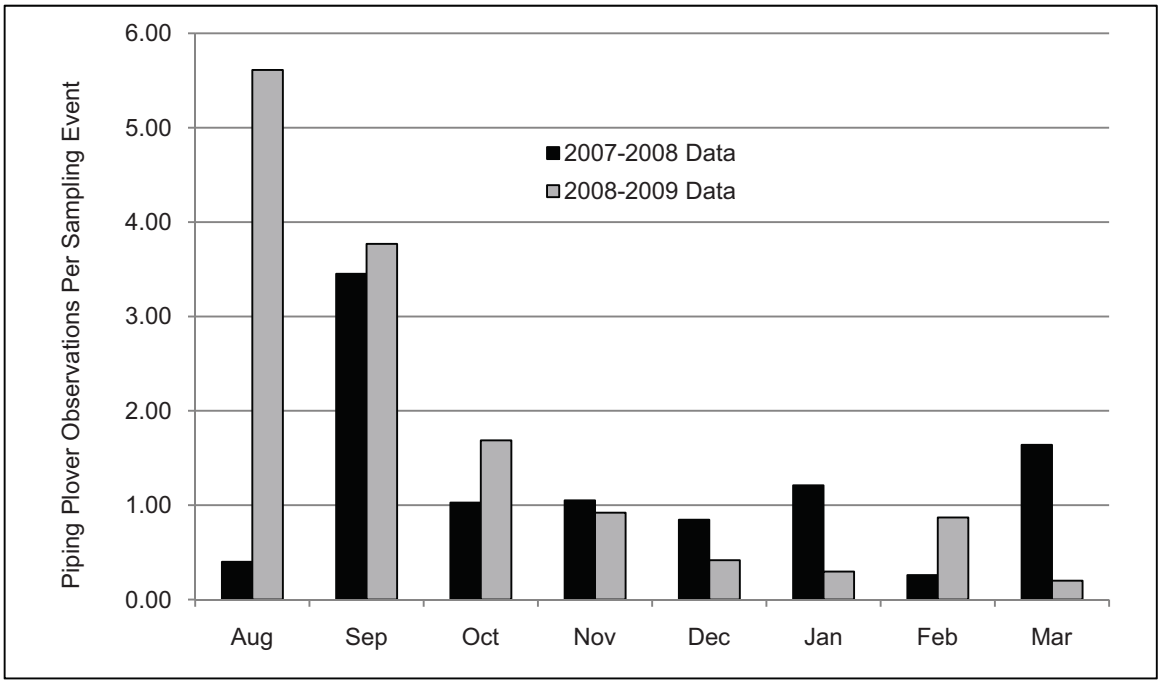
FIGURE 6. PIPING PLOVER NEST LOSS / ABANDONMENT AT CAPE HATTERAS NATIONAL SEASHORE, 1992–2010

Nonbreeding Population

In addition to supporting a local breeding population, the Seashore also hosts migrating and wintering piping plovers from the threatened Atlantic Coast population 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).

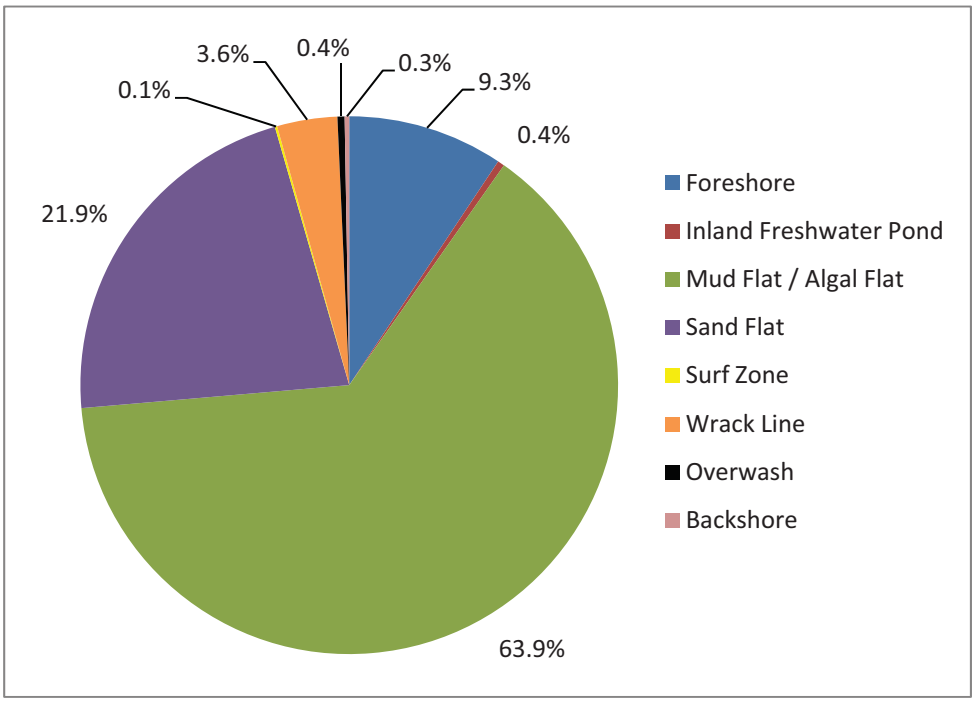
Wintering piping plovers on the Atlantic Coast select wide beaches in the vicinity of inlets that are associated with a high percentage of moist substrate habitat (Nicholls and Baldassarre 1990; Wilkinson and Spinks 1994). Because tidal regimes and fall and winter storm patterns often cause piping plovers to

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



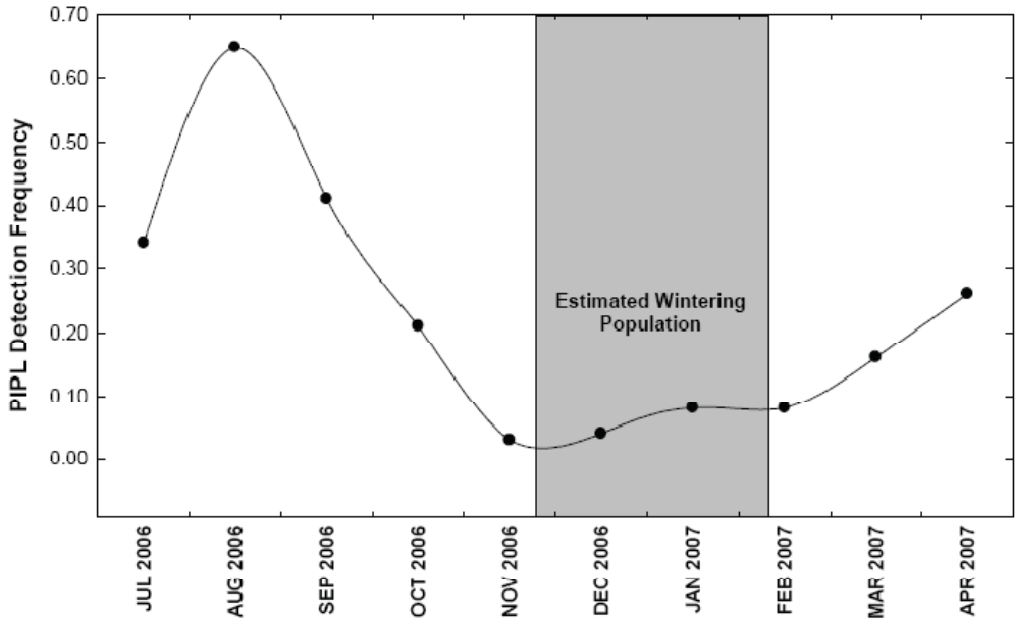
Source: Byrne et al. 2009

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



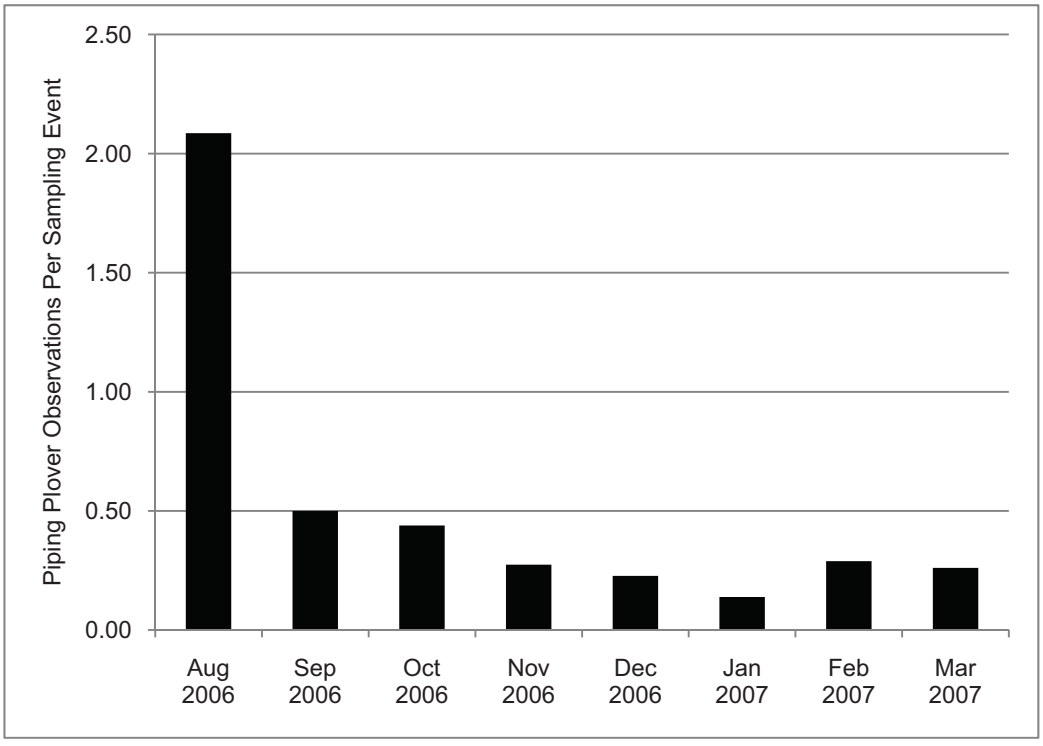
Source: NPS 2009b; Muiznieks pers. comm. 2009

FIGURE 8. WINTERING OBSERVATIONS OF PIPING PLOVER BY HABITAT TYPE



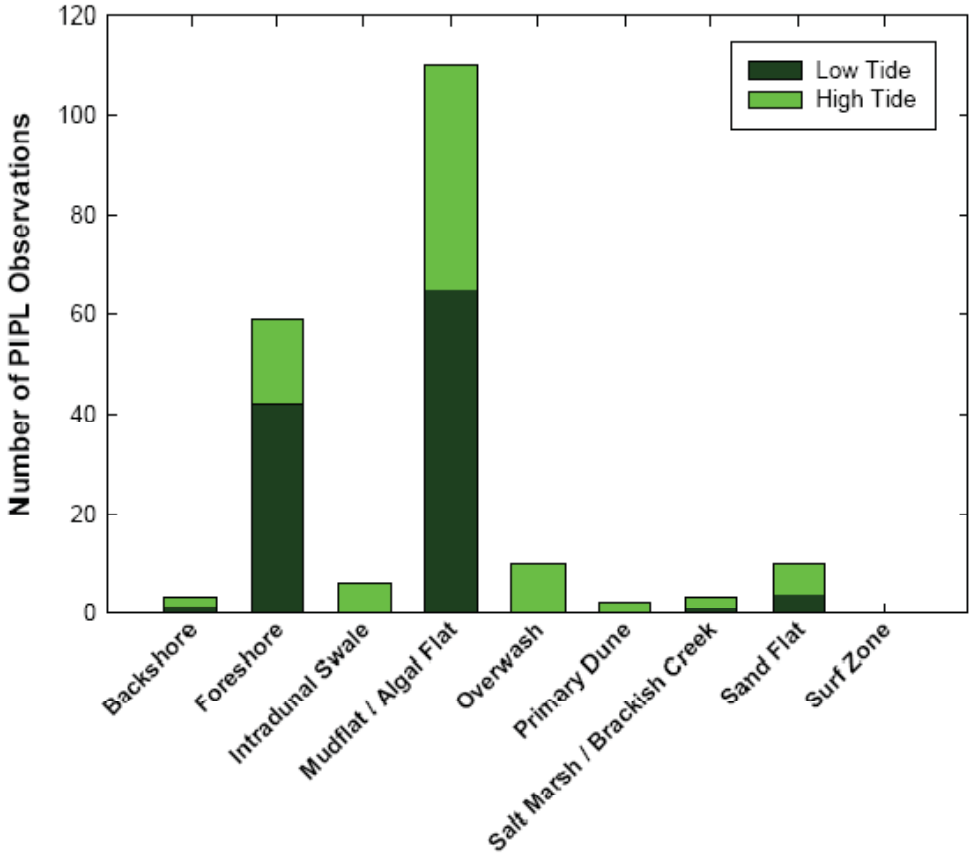
Source: Byrne et al. 2009

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



Source: Byrne et al. 2009

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

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. 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 coast (including one at the Seashore) and gulf coast 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). This type of disturbance also affects the energetic of migrating shorebirds, including piping plover and other migrating shorebirds at the Seashore. Shorebirds are some of the longest distance migratory birds and as such the energy demands of migration are extreme (Goss-Custard 1984; Harrington et al. 1991). During migration shorebirds use a variety of habitats to find food, to rest, and to avoid predators, and their survival is in part a function of the calories that individual shorebirds add by way of efficient foraging and the calories that shorebirds preserve during resting (Kersten and Piersma 1987). High quality shorebird "stop-over" habitats are those in which individual shorebirds are free to find high-quality food quickly as well as those where shorebirds can effectively rest and avoid predators between foraging bouts. Low quality habitats are those where prey items are low in density and/or where human or natural disturbance keeps birds from feeding and resting and especially where these key activities are replaced by energy-demanding avoidance behaviors such as flying and running. Disturbance to migrating shorebirds that results in the interruption of feeding and resting, combined with the energetically high-cost short flight fleeing behaviors, may impede shorebirds' ability to develop the necessary physiological condition to survive long migratory flights. Supporting this finding, comparing two beach plots open and closed to human traffic along North Carolina's Outer Banks, Collazo and others (1995) found that resting time of shorebirds was reduced by nearly 50 % in areas open to human activity.

Weather and Tides. Nine named hurricanes affected the Outer Banks between 1993 and 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 (NPS 2010d).

Hurricanes and other ocean storms can lead to unusually high tides, and subsequent flooding can overwash piping plover nests (Cohen et al. 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 (NPS 2010d). In 2010 there was an offshore weather event that flooded South Point resulting in the loss of a three egg nest on May 26 (Muiznieks pers. comm. 2010e).

Indeed, some piping plovers that nest too close to mean high tide may lose their nests on normal high tides (Cohen et al. 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 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*), 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. 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 (NPS 2010d). In 2010 the loss of three nests and one chick on South Point, Ocracoke, was attributed to ghost crabs (Muiznieks pers. comm. 2010e).

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*) 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 plovers 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 nonmotorized 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

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).

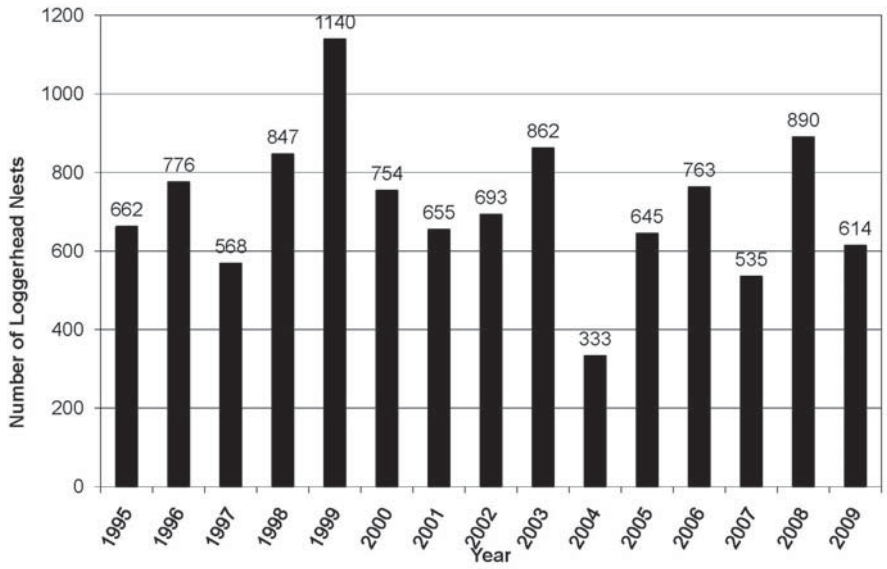
The Seashore staff has been consistently monitoring for sea turtle nests since 1987. However, over the years both monitoring and managing techniques have changed, making data comparison difficult; therefore, only nesting data from 2000 to 2010 are presented, for these data are known to be accurate. The number of nests recorded at the Seashore from 2000 to 2010 has fluctuated greatly, with only 43 nests recorded in 2004 and 153[6] nests recorded in 2010, which was the highest number on record (NPS 2010a; Muiznieks pers. comm. 2010b). Of the three species that nest at the Seashore, the loggerhead turtle is by far the most numerous, comprising approximately 95% of the known nests between 2000 and 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 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, 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).

Loggerhead Turtle

Loggerhead Turtle
Credit: NPS

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 2008). 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 2008). 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 729 nests from 1995 through 2009 (figure 12) (Godfrey pers. comm. 2005b, 2008, 2010a, 2010b).

[6] Turtle numbers for 2010 are current through October 5, 2010, with no additional nesting expected.



Source: Godfrey pers. comm. 2005b, 2008, 2010a, 2010b; seaturtle.org

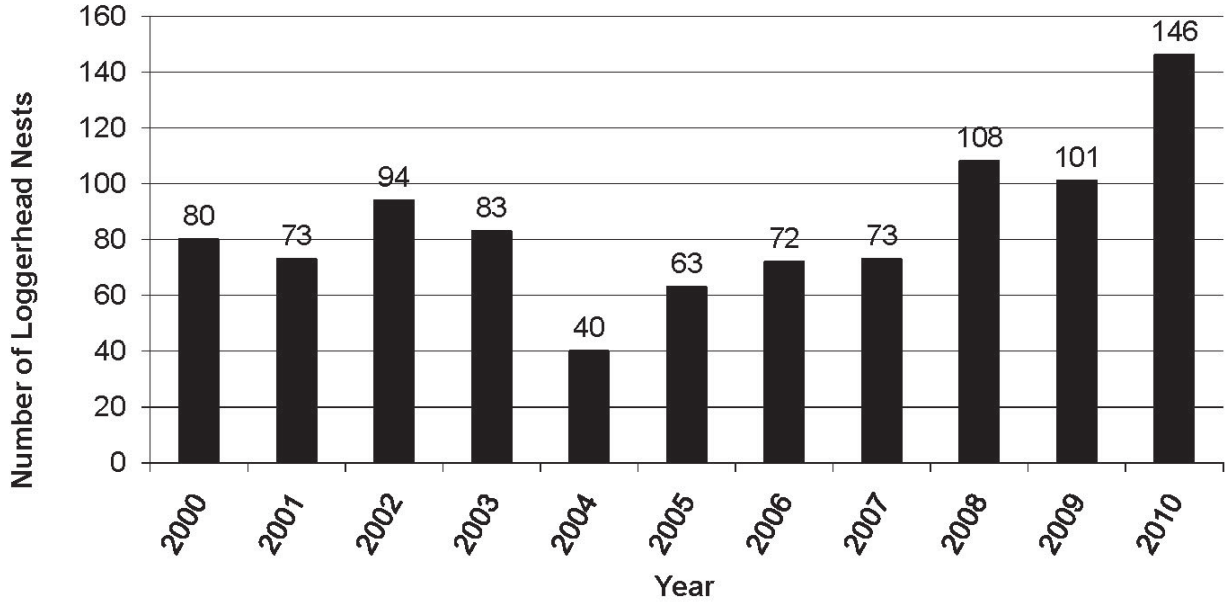
FIGURE 12. NUMBERS OF LOGGERHEAD TURTLE NESTS IN NORTH CAROLINA, 1995–2009[7]

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 146 loggerhead nests were laid at the Seashore (Muiznieks pers. comm. 2010b). 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, 2010a). Although three nests were found prior to May 15 (two of which were leatherback nests), and five 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 staff.

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).

[7] The NCRWC is reviewing their sea turtle database and updating the numbers with the coordinators for all North Carolina nest site locations. Many, but not all, site reviews have been completed and the numbers in this table and in the final EIS text have been updated consistent with the database revisions received from the NC Sea Turtle Coordinator at the time this final EIS was finalized. These totals reflect the best available data as of September 23, 2010. However, the North Carolina database may change slightly when the reviews of the remainder of the site locations are completed.



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

FIGURE 13. NUMBERS OF LOGGERHEAD TURTLE NESTS AT CAPE HATTERAS NATIONAL SEASHORE, 2000–2010

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% were relocated for natural causes (e.g., in areas prone to flooding [below the high tide line], in an area prone to erosion, etc.), 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 3% were moved during storm events later into incubation (Muiznieks pers. comm. 2010c).

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 2009 decreased to 21% of the nests found (NPS 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 2008). 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 2008). 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 2008). 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 2010, there was an annual average of 4.3 green turtle nests at the Seashore, with a peak of nine nests in 2005 (Baker pers. comm. 2009a). In 2010, seven green turtle nests were laid at the Seashore (Muiznieks pers. comm. 2010b).

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, 2004, 2007, and 2009, totaling seven nests since 2000 (NPS 2008a, 2010a; Baker pers. comm. 2009a). No leatherback nests were documented on the Seashore in 2010 (Muiznieks pers. comm. 2010b). 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

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.

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 11 years between 1999 and 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 2009, with 0 to 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 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 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. 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 of the 2007 nests appeared undamaged; however, four eggs were crushed in the second 2007 nest. In 2004, a total of ten hatchlings were killed by vehicles in two separate incidents.

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 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 turtle was hit by an ORV and dragged 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 incident is believed to be the first time documented that a nesting sea turtle has been killed by an ORV at the Seashore (NPS 2010b).

Nesting Female Loggerhead Killed by ORV in 2010

NPS photo of scene showing turtle carcass (between ORV tracks) and drag marks. Oval objects extending from the turtle are eggs.

Source NPS 2010b

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 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 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, turned around, and went back into the water, as noted in the annual report (NPS 2010a).

There have also been documented reports in 2000, 2001, 2007, 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. 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	1995
Number of seabeach amaranth	550	600	6,883	15,828	3,332	0	0	1
	1996	1997	1998	1999	2000	2001	2002	2003
Number of seabeach amaranth	98	81	265	8	2	51	93	30
	2004	2005	2006	2007	2008	2009	2010	
Number of seabeach amaranth	1	2	0	0	0	0	0	

Source: NPS 2009e; NPS 2010e; Broili pers. comm. 2010

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. 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. 2005). 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).

Breeding Biology

American Oystercatcher Chicks Near Wrack

Credit: Ted Simons

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.

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 2006, the number of nesting pairs declined 44% from 41 to 23 pairs on Ocracoke, Hatteras, Bodie, and Green islands (table 26).

From 1999 to 2010 on Ocracoke Island, there were a total of 94 nesting pairs, 133 nests, 60 hatched nests, 47 fledged chicks, and a fledge rate of 0.46. From 1999 to 2010 on Hatteras Island, there were a total of 207 nesting pairs, 273 nests, 120 hatched nests, 95 fledged chicks, and a fledge rate of 0.51. From 1999 through 2010 on Bodie Island, there were a total of 30 nesting pairs, 44 nests, 10 hatched nests, 6 fledged chicks, and a fledge rate of 0.20. From 2004 through 2010 on Green Island, there were a total of 15 nesting pairs, 19 nests, 11 hatched nests, 15 fledged chicks, and a fledge rate of 0.98 (Muiznieks pers. comm. 2010a; table 27).

American Oystercatcher Chick and Egg

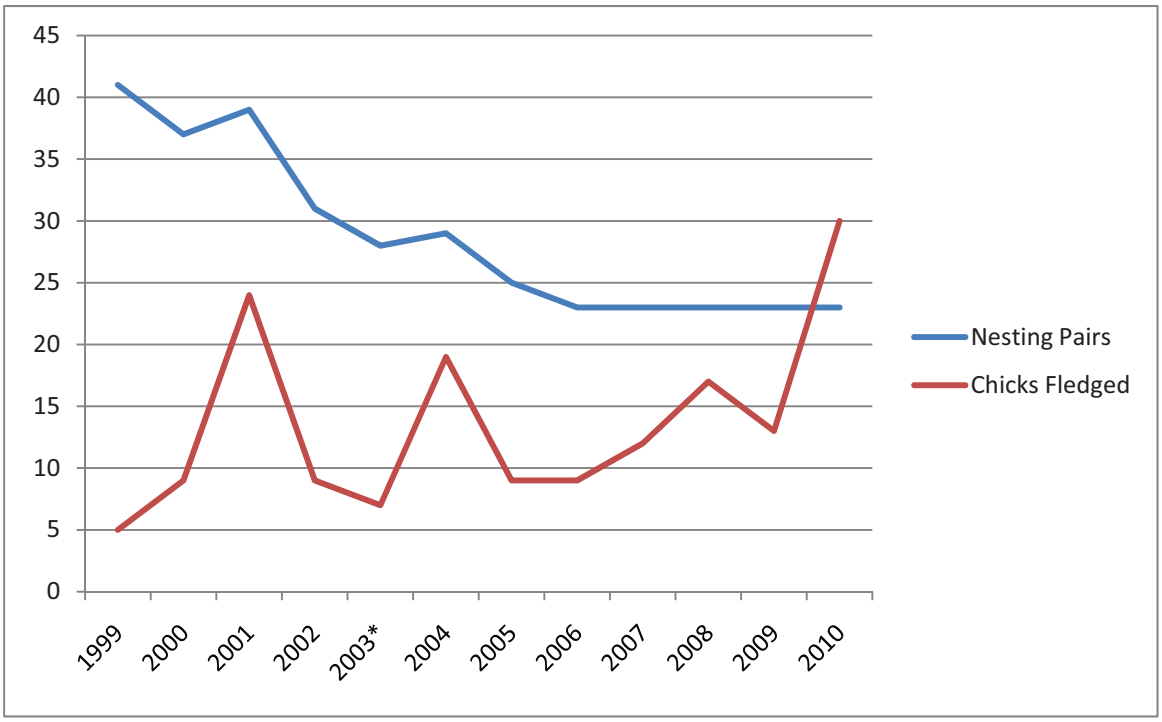
Credit: Ted Simons

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

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	207	30	15	346

Source: Muiznieks pers. comm. 2009 and 2010a, except [a]Simons and Schulte 2007, 2008
NOTE: Data available only for years listed.

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: NPS 2010f 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.

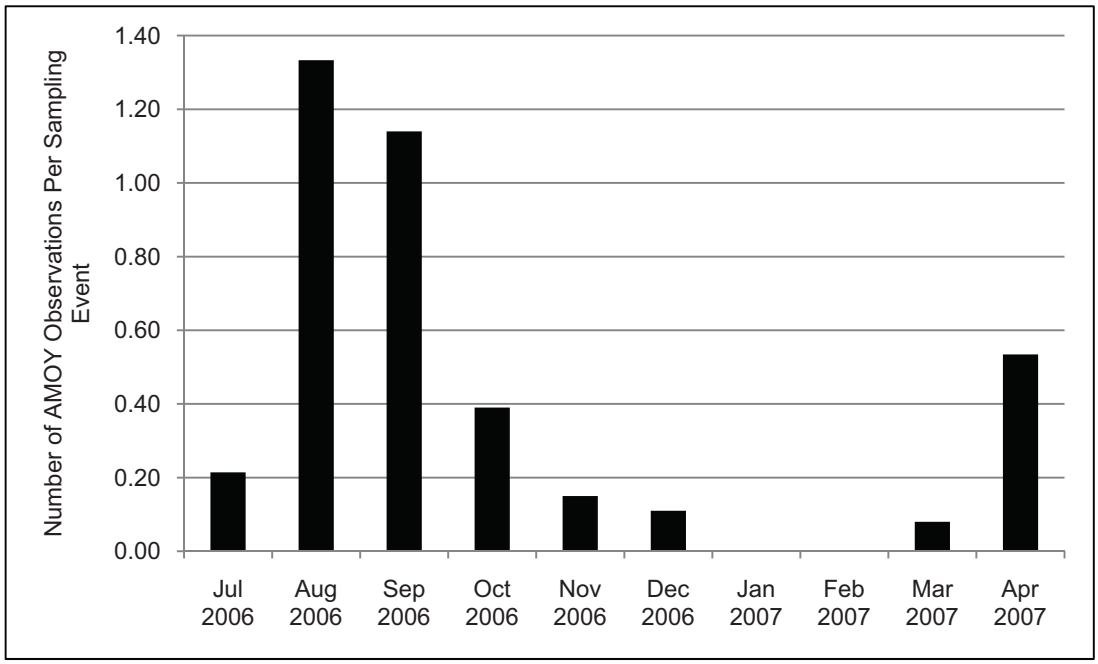
FIGURE 14. AMERICAN OYSTERCATCHER NESTING PAIRS AND CHICKS FLEDGED, CAPE HATTERAS NATIONAL SEASHORE, 1999–2010

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, which is shown in the American oystercatcher numbers between 2008 and 2010 (Muiznieks pers. comm. 2010e).

Studies in Europe on the European oystercatchers (*Haematopus ostralegus*), in the same genus as American oystercatcher and closely related, have shown reduced foraging 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).

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. 2010; see table 28).

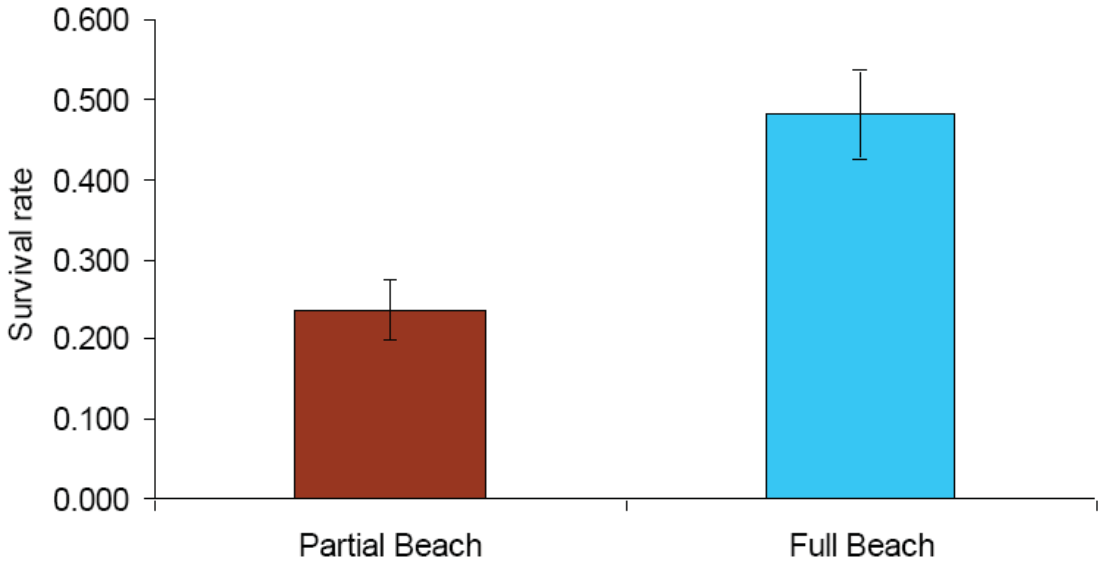
TABLE 28. BUFFER DISTANCES RECOMMENDED FOR AMERICAN OYSTERCATCHERS

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. 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.

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).



Source: Simons and Schulte 2008

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

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 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

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. None of these species is federally listed as threatened or endangered.

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

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 by the State of North Carolina.

Gull-Billed Tern and Chick
Credit: NPS

Common Tern

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 2008b).

Common Tern with Fish
Credit: Phylis Cooper / USFWS

Least Tern

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).

Least Tern and Chick
Credit: NPS

Black Skimmer

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

Black Skimmer
Credit: NPS

the USFWS 2008 Birds of Conservation Concern (USFWS 2008b), as well as being a North Carolina Species of Special Concern (NCWRC 2008b).

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. 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	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 2007

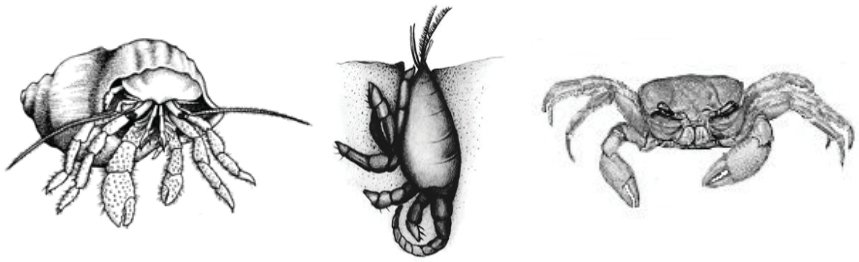
N/A = Not applicable.

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. 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. 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. 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. 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 (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).

Red Knot
Credit: USFWS

Another indication of conservation concern for the red knot is the fact that in August 2004, the U.S. Fish and Wildlife Service published its list of U.S. and Canadian shorebird populations that are considered highly imperiled or of high conservation concern (USFWS 2004c). 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).

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). When the Seashore took over monitoring from SECN staff, only the points and spits were surveyed to meet the migratory and wintering piping plover survey requirements of the USFWS biological opinion. At that time limited staffing in the winter months prohibited more extensive surveys. As the result of additional full-time staffing in the early part of 2010, resource management staff began surveying the entire shoreline for red knots along with other shorebirds on March 18, 2010. The protocol was revised to accommodate the increased staffing level and will provide a more comprehensive, standardized approach for determining use of the shoreline by selected shorebirds.

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 or 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*

For the 2010 survey, table 35-2 lists the weighted percent of the sampling population that selected each activity as their primary activity for the trip. Swimming, sunbathing, or enjoying the beach was the primary activity for 63.2% of visitors in the sampling population and surfing or kite-surfing was the primary activity for 6.9% of the sampling population. Beach fishing was the primary purpose of the trip for 22.8% of visitors, and driving on the beach was the primary purpose of the trip for 0.7% of visitors (RTI 2010a).

TABLE 35- 2. PRIMARY ACTIVITY FOR THE TRIP - MEAN ESTIMATE AND 95% CONFIDENCE INTERVAL

		95% Confidence Interval	
Activity	Mean	Lower Bound	Upper Bound
Beach fishing	22.8%	7.3%	38.2%
Swimming, sunbathing, or enjoying the beach	63.2%	48.8%	77.6%
Surfing or kite-surfing	6.9%	0.0%	16.5%
Visit the Cape Hatteras Lighthouse or Bodie Island Lighthouse	0.5%	0.0%	1.3%
Driving on the beach during the day	0.7%	0.0%	1.9%
Other	6.0%	0.0%	13.0%

Source: RTI 2010a

The 2010 survey also included questions regarding the current management of the Seashore. Table 35-3, shows that the awareness of beach driving among visitors to the Seashore was high, with 91.6% aware that some Seashore beaches are open to vehicles. Additionally, 58.7% of visitors were aware that some beaches previously open to vehicles are now closed at some point during the year. The uncertainty surrounding beach closures did not affect the planning of trips for 93.4% of visitors, however 4.2% of visitors reported making plans closer to time of the trip due to this uncertainty.

TABLE 35-3. KNOWLEDGE AND IMPACT OF CURRENT MANAGEMENT - MEAN ESTIMATE AND 95% CONFIDENCE INTERVAL

			95% Confidence Interval	
Question	Answer	Mean	Lower Bound	Upper Bound
Before you arrived at Cape Hatteras National Seashore for this trip, did you know that some beaches at Cape Hatteras National Seashore were open to vehicles?	Yes	91.6%	84.0%	99.3%
	No	8.1%	0.5%	15.8%
	Don't Know	0.2%	0.0%	0.6%
Before you arrived at Cape Hatteras National Seashore for this trip, did you know that certain parts of the Seashore that have been open to vehicles in the past are now closed to vehicles during parts of the spring, summer and fall?	Yes	58.7%	47.3%	70.0%
	No	40.1%	28.4%	51.9%
	Don't Know	1.2%	0.0%	2.7%
How would you say the uncertainty about whether specific parts of the Seashore would be open to vehicles affected when you started planning for this trip?	Didn't Affect	93.4%	88.1%	98.7%
	Farther in Advance	1.8%	0.0%	3.9%
	Made Plans Closer to the Time of the Trip	4.2%	0.2%	8.2%
	Don't Know	0.6%	0.0%	1.5%

Source: RTI 2010a

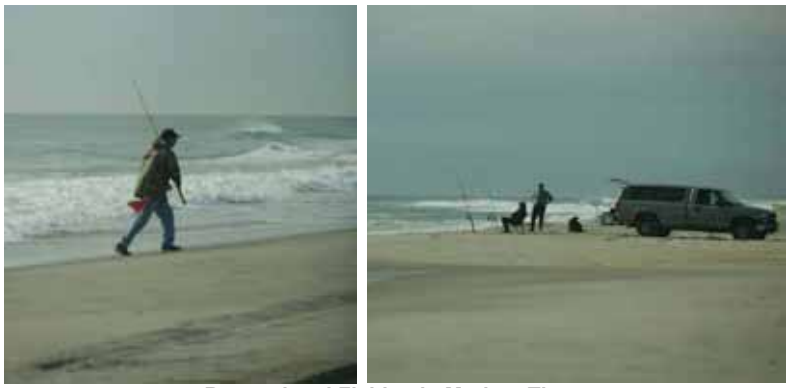
Recreational Fishing

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).

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
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	11/4/2004	600	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 11/2/2006 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; 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

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 recreational use 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

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

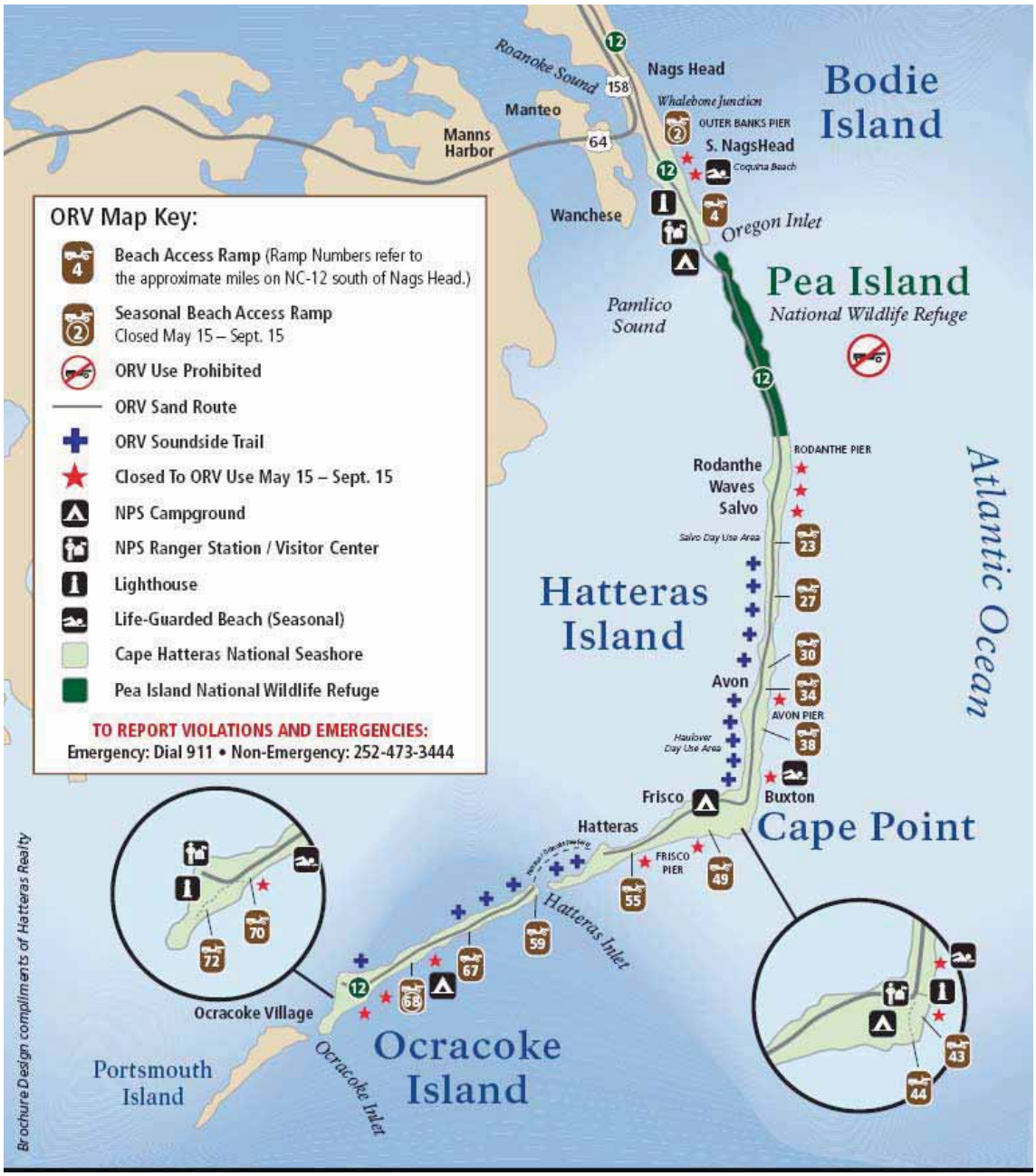


FIGURE 24. OFF-ROAD VEHICLE RAMPS AT CAPE HATTERAS NATIONAL SEASHORE

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. 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. 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 and the ramp counts in table 37-1 show the distribution of ORVs across these areas on Memorial Day and the Fourth of July in 2008.

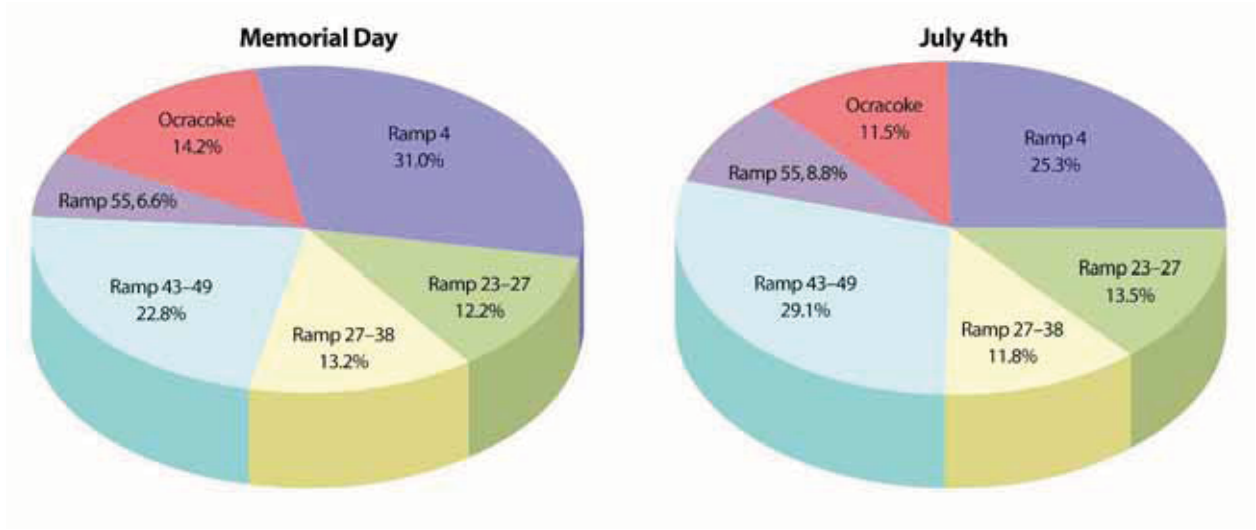


FIGURE 25. ORV DISTRIBUTION BASED ON AERIAL COUNTS, FOURTH OF JULY AND MEMORIAL DAY 2008

TABLE 37-1. RAMP COUNTS FOR MEMORIAL DAY AND FOURTH 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 27-38	191	Ramp 27-38	277
Ramp 43-49	471	Ramp 43-49	758
Ramp 55	137	Ramp 55	230
Ocracoke	293	Ocracoke	300
2008 Total Count	**2069**	**2008 Total Count**	**2579**

Trevino pers. comm. 2010

To supplement these counts, a survey was 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. NPS contracted with RTI to conduct a count of vehicles using the oceanside ORV beach access ramps over a 12-month period from April 2009 through March 2010. The primary goal of the vehicle counting survey was to estimate the total number of vehicle roundtrips on the 17 oceanside ORV 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 2010b). These vehicle counts provide an estimate of the total number of vehicle roundtrips to the beach. They are not directly comparable to the official number of recreational visitors to Cape Hatteras, because these numbers are determined by a traffic counter at Whalebone Junction. A single recreational visit, as counted by the Whalebone Junction counter, can include multiple vehicle roundtrips over an ORV ramp to the beach. Seventeen oceanside ORV access ramps currently operate in the Seashore. Two of the ramps are located on Bodie Island, ten are on Hatteras Island, and the remaining five are on Ocracoke Island. RTI field staff took 19 three-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 hours counting the number of vehicle roundtrips on each of two ORV ramps (the numbers of entrances and exits were added together and averaged to provide the estimated number of roundtrips since each vehicles that entered the beach through a vehicle access ramp also exited the beach, though not necessarily at the same ramp). The 57 days of counting resulted in a total sample of 114 clusters covering 228 two-hour vehicle counting opportunities and 456 beach counting opportunities (RTI 2010b).

To ensure that at least two counting trips were taken during the low winter season, RTI created two seasonal categories out of the 52 weeks. The two categories roughly correspond to low and medium/high visitation seasons at the Seashore. The lowest visitation category, which consisted 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 took place during the other 35 weeks from April 2009 through November 2009, which make up the medium and high visitation categories. The data from the counting trips was weighted based on the 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 ramp counts, the mean estimate is 499,802 vehicle roundtrips over an oceanside ramp onto the Seashore beaches 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 inside these vehicles with a 95% confidence interval of 654,961 to 1,334,247 passengers (table 37-2). As with the number of vehicle roundtrips, the estimated number of passengers is not directly comparable to the official statistics on recreational visitors to the Seashore. A visitor using the ramps could make several

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 prenesting closures. Table 37-4 details the prenesting closures or resource closures that have taken place under alternative A (2007) and alternative B (2008 – 2010), beginning in 2007, showing dates when the closure began and when the area reopened.

TABLE 37-4. RESOURCE CLOSURE DATES FOR POPULAR VISITOR SITES 2007-2010

2007 (Prenesting 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 10	2
North Ocracoke[3]	April 8	June 7	60
South Point Ocracoke (two events)	June 26[4]	June 28	2
	July 10[5]	July 11	1
2008 (Prenesting areas installed by March 15)			
Location	**Closed**	**Reopened**	**# of Days Closed**
Bodie Island Spit	May 5	August 26	113
Cape Point	May 5	July 22/29 (Pedestrian/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 (Prenesting 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

2010 (Prenesting 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

[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 prenesting 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.

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.

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

Typical Closure
Credit: NPS

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. The potential for accidents involving ORVs and pedestrians on beaches open to ORV use is well documented. For example, during 2010 in separate incidents in Volusia County, Florida, two children were run over and killed by ORV, one on New Smyrna Beach and one on Daytona Beach Shores (Cave 2010). Since 2005, 41 pedestrians have been hit by cars on the Volusia beaches (Hobson 2010). At the Seashore, law enforcement staff indicated in early 2009 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).

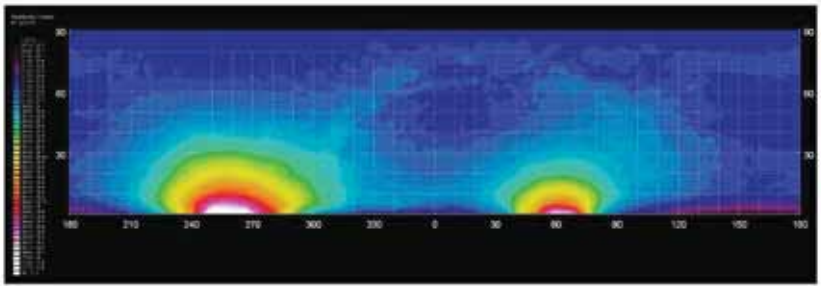
VISITOR SATISFACTION

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 three categories of facilities, services, and recreational opportunities taken together, was 95%. When asked about each component separately, 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

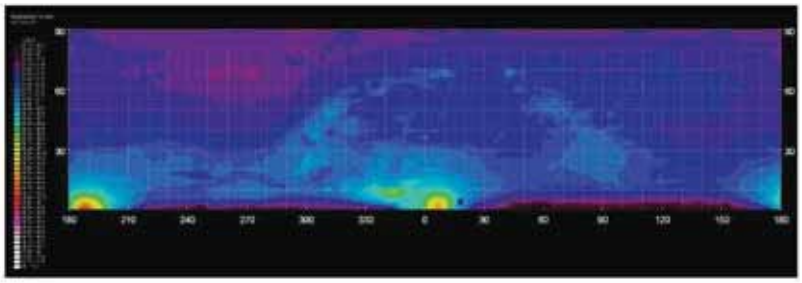
The NPS defines a natural lightscape as "a place or environment characterized by the natural rhythm of the sun and moon cycles, clean air, and of dark nights unperturbed by artificial light. Natural lightscapes, including dark night skies, are not only a resource unto themselves, but are an integral 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



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

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).



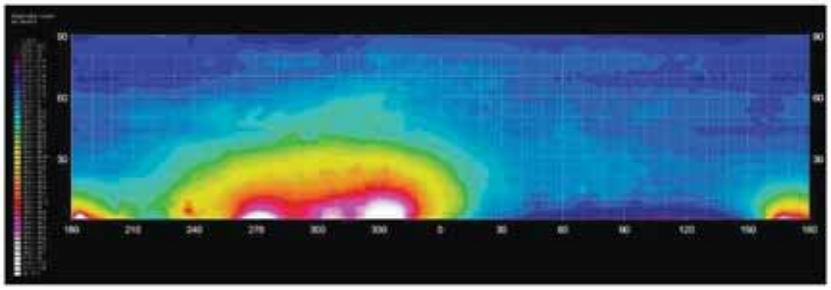
This picture was compiled from images captured on a boardwalk between Salvo and Avon. The combined light of Rodanthe, Salvo, and Waves can be seen at about 6º and Avon at 191º. Also note the presence of a few clouds reflecting the town lights at about 345º.

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).

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).



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

SOCIOECONOMIC RESOURCES

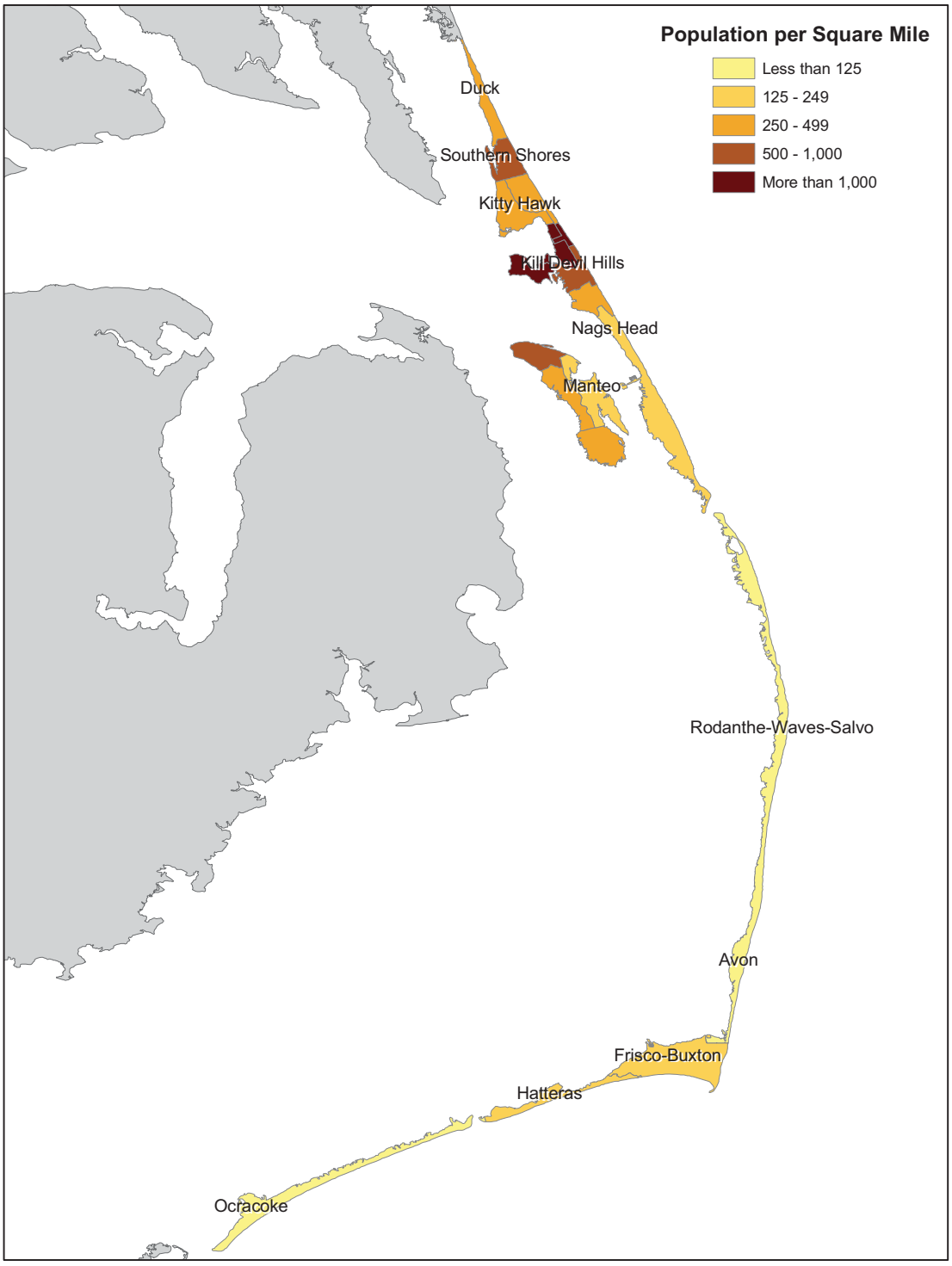
This section describes the social and economic environment that potentially would be affected by the proposed alternatives. The social and economic environment of a region is characterized by its demographic composition, the structure and size of its economy, and the types and levels of public services 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 thirteen zip codes, eighteen of the nineteen 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 experienced in the villages within the Seashore.

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.



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 2008a), 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 2000).

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 2000

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

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

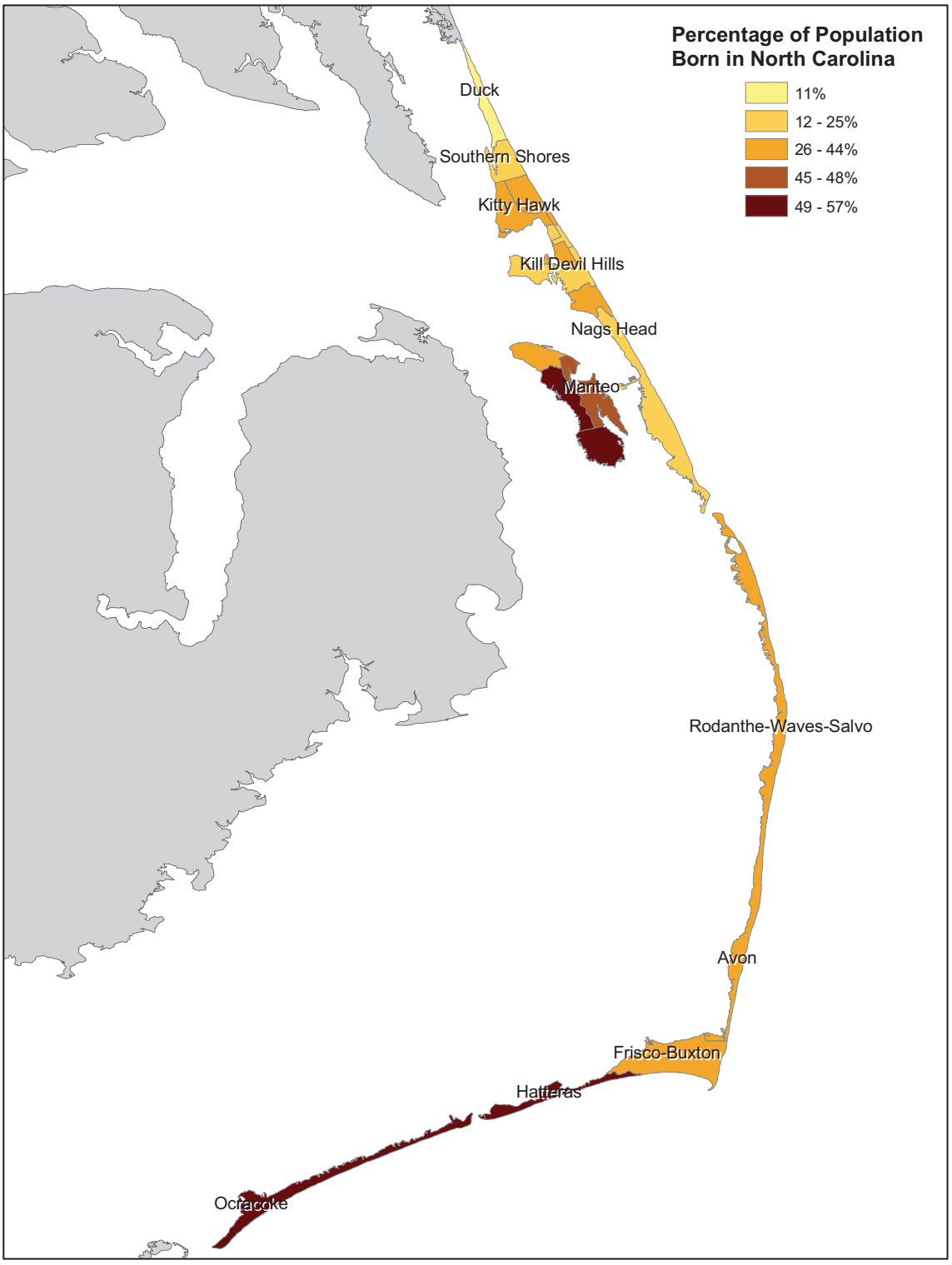
[d] The 18 Dare County block groups in the ROI

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

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).



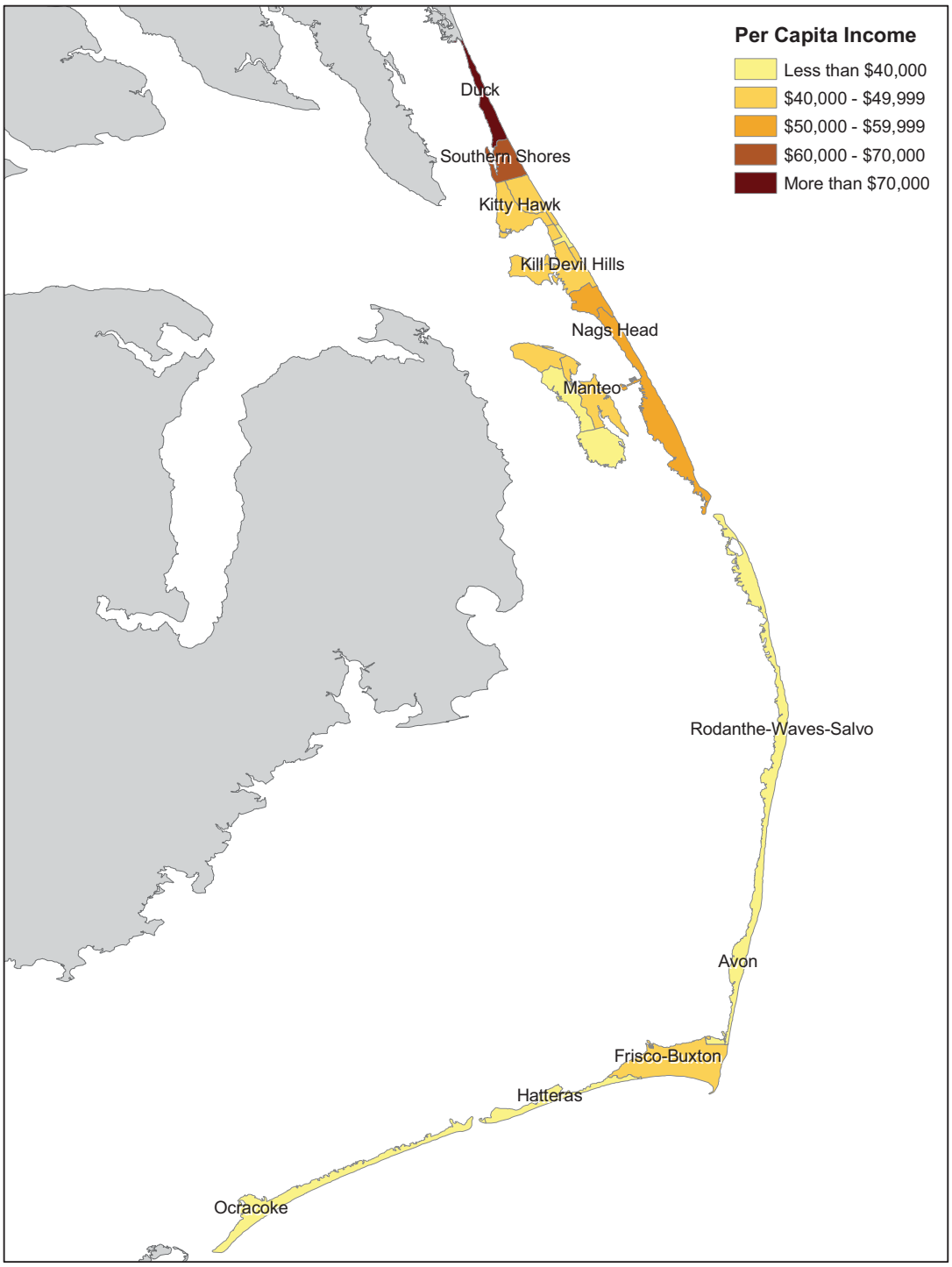
Source: U.S. Census Bureau 2000

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

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 2000



Source: U.S. Census Bureau 2000

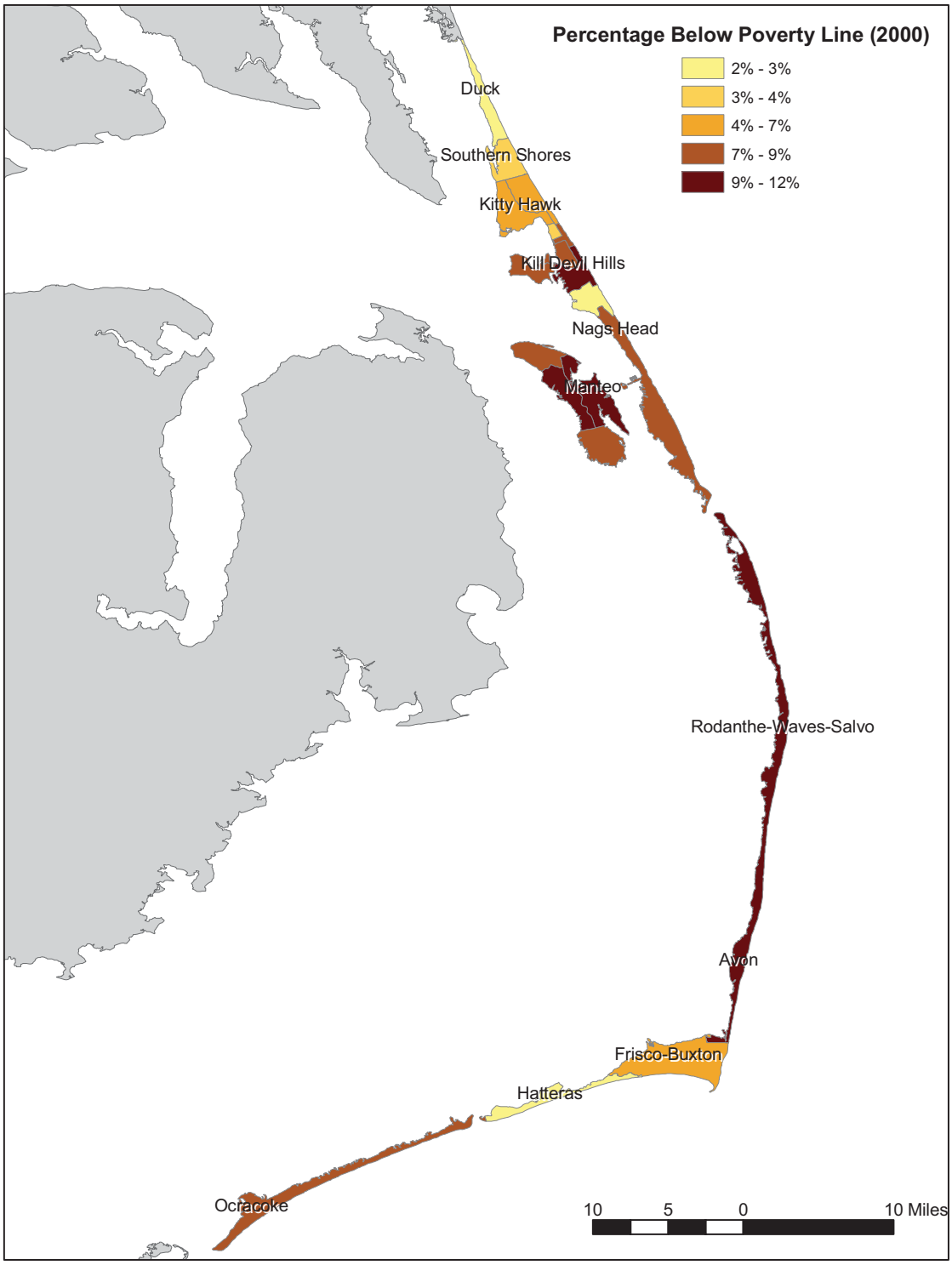
FIGURE 28. 1999 PER CAPITA INCOME BY BLOCK GROUP

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 2000



Source: U.S. Census Bureau 2000

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 2010).

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).

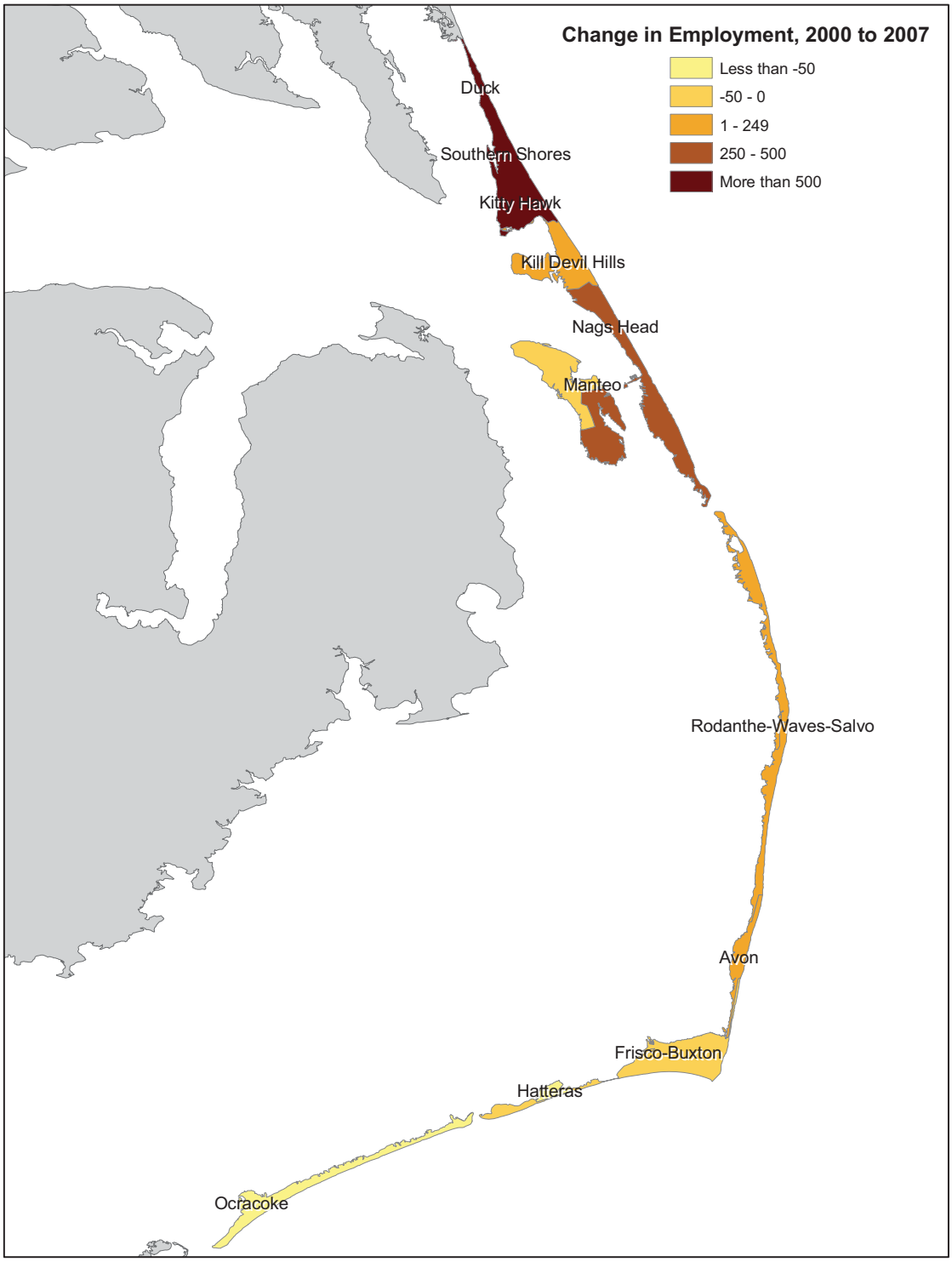
UNEMPLOYMENT

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, manufacturing, and retail trade 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, 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).

In North Carolina, 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).

[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."



Source: U.S. Census Bureau 2002a

FIGURE 30. CHANGE IN EMPLOYMENT BY ZIP CODE

TABLE 41. NONEMPLOYERS BY INDUSTRY, 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	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)

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 2010a

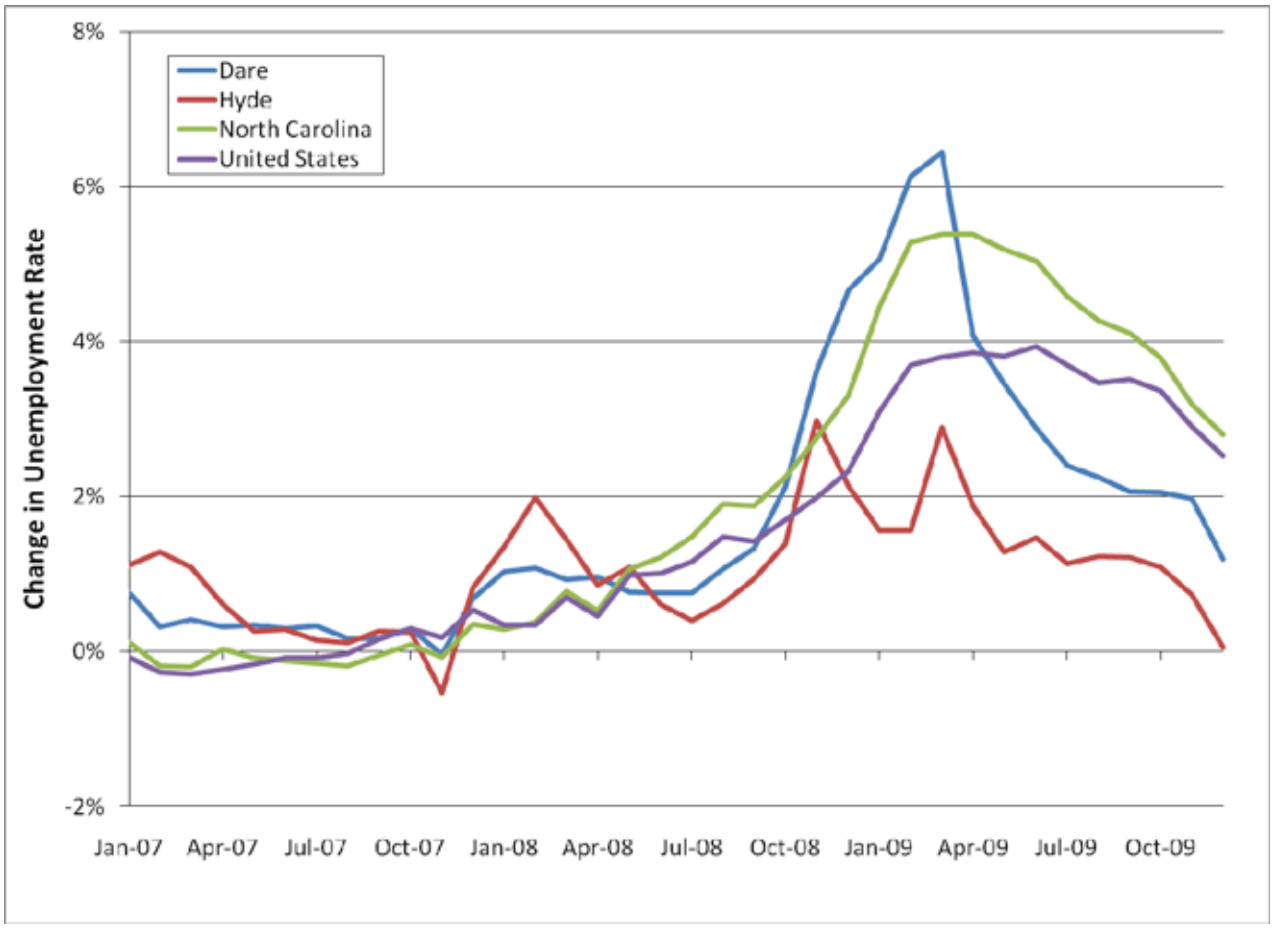
2000 UNEMPLOYMENT BY ZIP CODE

Using the 2000 census, one can calculate a measure of unemployment using information about labor force participation. Unemployment calculated with census data is somewhat different than the definition used by the Bureau of Labor Statistics. 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 (table 42-1 and figure 31). 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 in employment 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 2000



Source: Bureau of Labor Statistics 2010a

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

BUSINESS SURVEY

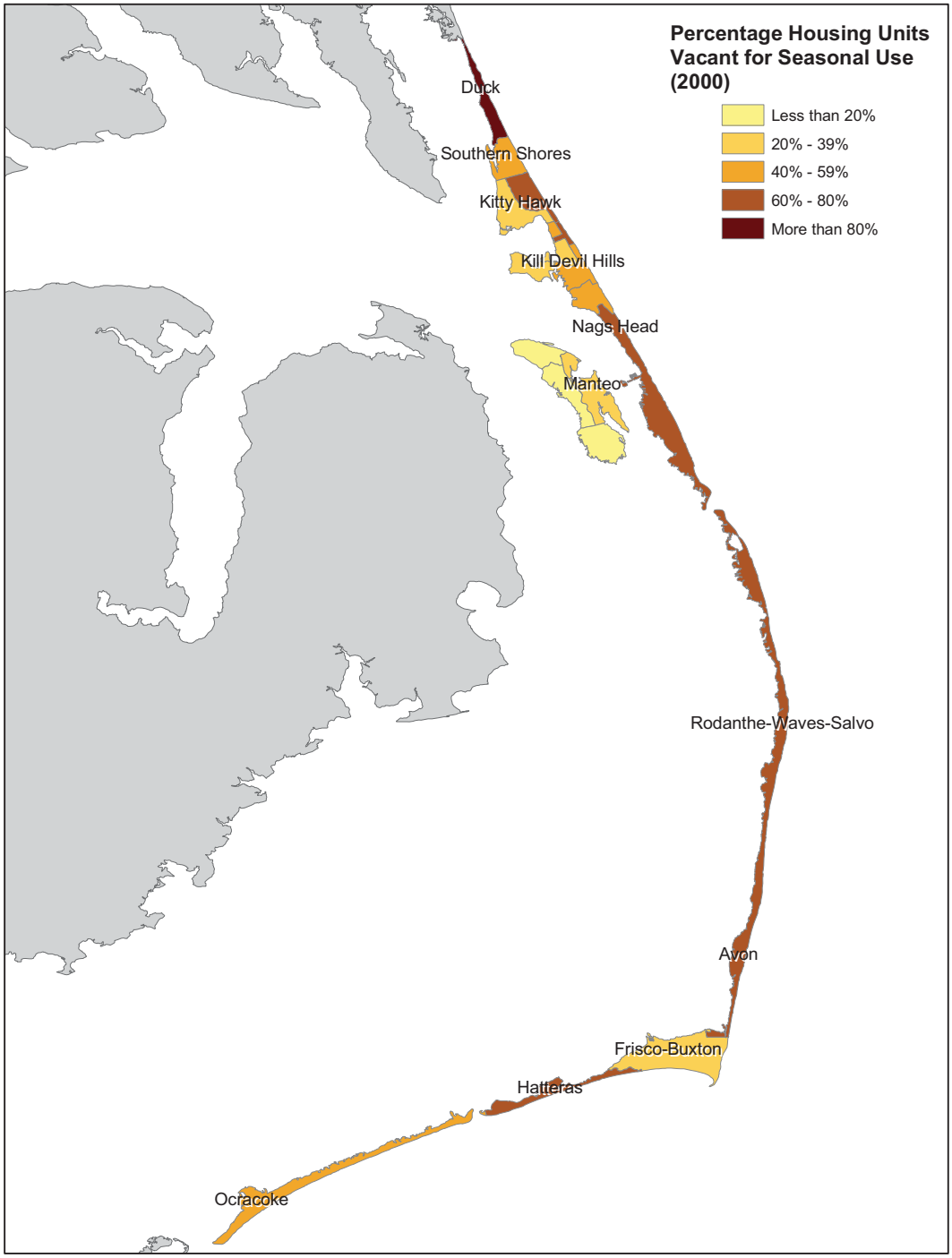
NPS contracted with RTI to conduct surveys of local businesses to provide additional information for the ORV planning process. The business survey (RTI 2010c) included questions about the characteristics and size of local businesses to assess the possible impacts of the action alternatives on revenue relative to the no-action alternatives, as discussed later in chapter 4. For the purposes of the survey, NPS divided businesses into two groups based on geographic location. The first group included businesses in the villages that directly border the Seashore, called the "Seashore villages" (Rodanthe, Waves, Salvo, Avon, Buxton, Frisco, Hatteras, and Ocracoke). These businesses depend heavily on tourists visiting the beaches on the Seashore. The second group included businesses located north of the Seashore boundary in the villages of Nags Head, Kill Devil Hills, and Kitty Hawk. These businesses serve tourists that visit the Seashore, but their customer base also includes visitors who use the beaches outside the Seashore on the Outer Banks.

Four primary industry categories were selected for interviewing: recreational supplies, rental homes, lodging excluding rental homes, and commercial fishermen. In addition to these four industry categories, several other industry categories serve tourists directly, which are addressed in the impact analysis (see chapter 4). These surveys all followed the same format, with appropriately worded questions for the

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 2000



Source: U.S. Census Bureau 2000

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