NORTH CAROLINA COASTAL BEACH SAND PLACEMENT

STATEWIDE PROGRAMMATIC BIOLOGICAL OPINION

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Prepared by: U.S. Fish and Wildlife Service

Signed by: ______________________ **Date:** 8/28/2017

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Acronyms

Act	Endangered Species Act
BA	Biological Assessment
BO	Biological Opinion
CAFF	Council Conservation of Arctic Flora and Fauna
CBRA	Coastal Barrier Resources Act
CFR	Code of Federal Regulations
CH	Critical Habitat
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
Corps	U.S. Army Corps of Engineers
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
CSDR	Coastal Storm Damage Reduction
DOI	U.S. Department of the Interior
DTRU	Dry Tortugas Recovery Unit
F	Fahrenheit
FAC	Florida Administrative Code
FDEP	Florida Department of Environmental Protection
FEIS	Final Environmental Impact Statement
FEMA	Federal Emergency Management Agency
FR	Federal Register
GCRU	Greater Caribbean Recovery Unit
HCP	Habitat Conservation Plan
IPCC	Intergovernmental Panel on Climate Change
ITP	Incidental Take Permit
LF	Linear Feet
MHW	Mean High Water
MHWL	Mean High Water Line
MLLW	Mean Low Low Water
MLW	Mean Low Water
mtDNA	Mitochondrial Deoxyribonucleic Acid
NCDCM	North Carolina Division of Coastal Management
NCWRC	North Carolina Wildlife Resources Commission
NGMRU	Northern Gulf of Mexico Recovery Unit
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NRU	Northern Recovery Unit
NWR	National Wildlife Refuge
PBF	Physical and Biological Feature
PCE	Primary Constituent Element
PFRU	Peninsular Florida Recovery Unit
SAJ	South Atlantic Jacksonville
SAM	South Atlantic Mobile
Service	U.S. Fish and Wildlife Service
SF	Square Feet

SNBS	Statewide Nesting Beach Survey
TED	Turtle Excluder Device
TEWG	Turtle Expert Working Group
U.S.C.	United States Code
U.S.	United States
USEPA	United States Environmental Protection Agency

CONSULTATION HISTORY

May 23, 2013 – The Service participated in a meeting organized by the North Carolina Division of Coastal Management (NCDCM) to discuss a potential programmatic approach to beach nourishment permitting. At the time, it was associated with proposal to develop 50-year projects for beach communities.

December 19, 2013 – The Service met with representatives of the Corps, NCDCM, and others to discuss the potential development of a Statewide Programmatic BO.

February 28, 2014 – The Service participated in a phone conference to plan for a scoping workshop to discuss the potential for a programmatic approach with North Carolina's beach communities. The scoping meeting took place on March 19, 2014.

June 11, 2014 – The Service met with the Corps, NCDCM, North Carolina Wildlife Resources Commission (NCWRC), and National Marine Fisheries Service (NMFS) to determine the scope of the Programmatic Biological Assessment (PBA) and a timeline for requesting proposals, awarding bids, and completing the PBA.

September 2014 through January 2015 - The Service participated in review of the Request for Proposals, proposals and bids for development of the PBA.

March 24, 2015 – The Service participated in a "kickoff" meeting to discuss the outline of the PBA.

June 30, 2015 – The Service participated in a meeting with the Corps, NCDCM, and the consultant concerning applicability of the PBO to regulatory and Civil Works projects.

October 2015 through September 2016 – The Service participated in reviews of the draft PBA and various phone calls with the consultant to discuss portions of the PBA.

October 7, 2016 – The Final PBA was submitted electronically to the Service by the consultant.

November 22, 2016 – The Corps requested initiation of formal Section 7 consultation. The Service received the letter on November 28, 2016.

February 2, 2017 – By email, the Service provided a draft of the Conservation Measures, Reasonable and Prudent Measures (RPM), Terms and Conditions, and Conservation Recommendations, along with draft Appendices to the Corps, BOEM, NCDCM, and NCWRC.

February 6, 2017 – The Service met with the Corps, BOEM, NCDCM, and NCWRC to discuss the draft RPMs and Terms and Conditions. By email, the Service requested comments to the draft by February 17, 2017.

February 16, 2017 – By email, the Corps requested an extension of time to March 10, 2017, to formulate comments and recommend revisions to the RPMs and Terms and Conditions. The Service concurred by email

March 10, 2017 – By email, the Corps provided comments and recommendations to the draft RPMs and Terms and Conditions. A conference call was scheduled to discuss the recommendations.

March 27, 2017 – By email, the Service provided a second draft of the Conservation Measures, Reasonable and Prudent Measures (RPM), Terms and Conditions, and Conservation Recommendations, along with draft Appendix D to the Corps, BOEM, NCDCM, and NCWRC.

March 31, 2017 – The Service, the Corps, BOEM, NCWRC, and NCDCM participated in a conference call to discuss the most recent draft of the RPMs and Terms and Conditions.

April 5, 2017 – By email, the Service provided a third draft of the Conservation Measures, Reasonable and Prudent Measures (RPM), Terms and Conditions, and Conservation Recommendations, along with draft Appendix D to the Corps, BOEM, NCDCM, and NCWRC.

May 1, 2017 – By email, the Corps provided final comments and recommendations to the third draft of the draft RPMs and Terms and Conditions.

May 2, 2017 – By Email, the Service provided a final draft of the SPBO and all of the Appendices to the Corps, BOEM, NCDCM, and NCWRC.

May 5, 2017 – By email, the Corps provided final comments and recommendations to the third draft SPBO.

BIOLOGICAL OPINION

INTRODUCTION

A biological opinion (BO) is the document that states the opinion of the U.S. Fish and Wildlife Service (Service) as to whether a federal action is likely to jeopardize the continued existence of listed species or result in the destruction or adverse modification of designated critical habitat. This BO addresses piping plover (*Charadrius melodus melodus*), red knot (*Calidris canutus rufa*), seabeach amaranth (*Amaranthus pumilus*), and the loggerhead (*Caretta caretta*), leatherback (*Dermochelys coriacea*), green (*Chelonia mydas*), hawksbill (*Eretmochelys imbricata*), and Kemp's ridley sea turtles (*Lepidochelys kempii*). Designated critical habitat for wintering piping plovers and terrestrial critical habitat for loggerhead sea turtles is also addressed. The BO evaluates the effects of the Action along with those resulting from interrelated and interdependent actions, and from non-federal actions unrelated to the proposed Action (cumulative effects), relative to the status of the species and the status of the critical habitat to arrive at a Service opinion that the proposed action is or isn't likely to jeopardize species or adversely modify critical habitat. Jeopardize the continued existence of means to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species (50 CFR §402.02). Destruction or adverse modification of designated critical habitat means a direct or indirect alteration that appreciably diminishes the value of critical habitat for the conservation of a listed species. Such alterations may include, but are not limited to, those that alter the physical or biological features essential to the conservation of a species or that preclude or significantly delay development of such features (50 CFR §402.02).

1. DESCRIPTION OF THE PROPOSED ACTION

This is a Statewide Programmatic Biological Opinion (SPBO). The proposed action includes all activities associated with the placement of compatible sediment on the oceanfront beaches of North Carolina, encompassing the entire range of the South Atlantic Wilmington (SAW) Corps Districts. This SPBO includes Corps Regulatory and Civil Works shore protection activities. Corps Regulatory activities may include the involvement of other Federal agencies, such as the Department of Defense (DoD), Bureau of Ocean Energy Management (BOEM), and the Federal Emergency Management Agency (FEMA). The sand placement activities covered in the SPBO encompass the following (when conducted between November 16 and April 30):

1. Sand placement on the sandy beach or dune by any non-federal public or private entity;
2. Sand placement as an associated authorization of sand extraction from the Outer Continental Shelf (OCS) by BOEM; and
3. Sand placement funded or conducted by a Federal agency, such as Coastal Storm Damage Reduction (CSDR) Projects, federal public assistance projects administered by FEMA or other federal agencies, and beach disposal from Operations and Maintenance (O&M) dredging of navigation channels (dredging is not included).

The history of shore protection activities in North Carolina is extensive and consists of a myriad of actions performed by local, State, and Federal entities. Future beach placement actions addressed in this SPBO may include maintenance of these existing projects or beaches that have not experienced a history of beach placement activities.

The Service and National Oceanic and Atmospheric Administration's (NOAA) National Marine Fisheries Service (NMFS) share Federal jurisdiction for sea turtles under the Act. The Service has responsibility for sea turtles on the nesting beach. The Service and the NMFS share Federal jurisdiction for sea turtles under the ESA. NMFS has jurisdiction for sea turtles in the marine environment. This SPBO only addresses activities that may impact nesting sea turtles, their nests and eggs, and hatchlings as they emerge from the nest and crawl to the sea. NMFS will assess and consult with the Corps concerning potential impacts to sea turtles in the marine environment, including updrift and downdrift nearshore areas affected by sand placement projects on the beach.

1.1 Action Area

The Service has described the action area to include sandy oceanfront beaches of North Carolina, for reasons that will be explained and discussed in the "EFFECTS OF THE ACTION" section of this consultation. The Programmatic Biological Assessment (PBA) defines currently managed shorelines in North Carolina as those that include active projects and those that are under study. The length of currently managed shoreline is 112 miles, but is anticipated to eventually grow to 163 miles. Based on the current length of managed shoreline in North Carolina, the BA anticipates that sand placement considered in this opinion will affect up to 25 miles of shoreline annually in North Carolina. However, after major storms, increases in the annual length of sand placement are expected. In years following major storm events, the BA states that a 250% increase in average annual sand placement can reasonably be expected. Therefore, in post-storm years (declared disaster or Congressional Order); a maximum length of annual sand placement is 62.5 miles (25 miles plus an additional 27.5 miles).

1.2. Conservation Measures: Corps Commitments as listed in the Final Programmatic Biological Assessment

The following language from the PBA lists the Conservation Measures proposed by the Corps. All sand placement projects would employ each of the following measures to reduce impacts on listed species and critical habitats:

Piping Plover and Red Knot

1) All sand placement activities will be completed between 16 November and 30 April; thereby avoiding the majority of the piping plover breeding season, a portion of the piping plover migration period, and the peak red knot migration period in NC.
2) As a means of minimizing the extent and/or duration of adverse effects on habitats and benthic prey resources, all material placed on the beach and in associated dune systems will consist of beach compatible sediment. Beach compatible material will consist of sediments that are similar in composition, grain size distribution, and color to the native sediments of the recipient beaches.

3) Construction staging areas and pipeline routes will be located to avoid high-value inlet complex habitats for piping plovers and red knots to the maximum extent practicable.
4) Temporary storage areas for construction equipment and pipelines will be located off the beach to the maximum extent practicable.

Sea Turtles

1) All sand placement activities will be completed between 16 November and 30 April; thereby avoiding the sea turtle nesting and hatching season in NC.
2) All material placed on the beach and in associated dune systems will consist of beach compatible sediment that is suitable for sea turtle nesting. Beach compatible material will consist of sediments that are similar in composition, grain size distribution, and color to the native sediments of the recipient beaches.
3) Immediately after construction and to the maximum extent practicable prior to 1 May, surveys for escarpments will be conducted within the limits of construction areas. Identified escarpments that that may interfere with sea turtle nesting (>18 inches in height and ≥ 100 ft in length) will be leveled to the natural beach profile. If it is determined that escarpment leveling is required during the nesting season, leveling activities would be coordinated with the USFWS or NCWRC.
4) Immediately after construction and to the maximum extent practicable prior to 1 May, the limits of construction areas will be evaluated for compaction in coordination with the USFWS and NCWRC. If it is determined that tilling is required for sea turtle nesting habitat suitability, the construction areas will be tilled to a depth of 36 inches. All tilling activity shall be completed prior to 1 May to the maximum extent practicable. In the case of projects that run until the 30 April nesting window cutoff, any tilling activities required after 1 May would be coordinated with the USFWS or NCWRC.
5) Post-construction monitoring of sea turtle nesting activities will be conducted in sand placement areas to assess effects on nesting. Monitoring will include daily surveys from 1 May until 15 September. Nesting data will be included in annual monitoring reports to be provided to the NCWRC.

Seabeach Amaranth

1) All sand placement activities will be completed between 16 November and 30 April; thereby avoiding the majority of the seabeach amaranth growing season in NC.

1.3. Project Timing and Duration

This SPBO encompasses sand placement activities that occur within the winter work window (November 16 through April 30).

2. PIPING PLOVER

2.1. Status of the Species

2.1.1. Species description

Listing: On January 10, 1986, the piping plover was listed as endangered in the Great Lakes watershed and threatened elsewhere within its range, including migratory routes outside of the Great Lakes watershed and wintering grounds (USFWS 1985). Piping plovers were listed principally because of habitat destruction and degradation, predation, and human disturbance. Protection of the species under the ESA reflects the species' precarious status range-wide.

Three separate breeding populations have been identified, each with its own recovery criteria: the Northern Great Plains (threatened), the Great Lakes (endangered), and the Atlantic Coast (threatened). Piping plovers that breed on the Atlantic Coast of the U.S. and Canada belong to the subspecies *C. m. melodus*. The second subspecies, *C. m. circumcinctus*, is comprised of two populations. One population breeds on the Northern Great Plains of the U.S. and Canada, while the other breeds on the Great Lakes. Each of these three entities is demographically independent. The piping plover winters in coastal areas of the U.S. from North Carolina to Texas, and along the coast of eastern Mexico and on Caribbean islands from Barbados to Cuba and the Bahamas (Haig and Elliott-Smith 2004) (**Figure 1)**.

Piping plovers in the Action Area include individuals from all three breeding populations. Piping plover subspecies are phenotypically indistinguishable, and most studies in the nonbreeding range report results without regard to breeding origin. Although a 2012 analysis shows strong patterns in the wintering distribution of piping plovers from different breeding populations (Gratto-Trevor et al. 2012), partitioning is not complete and major information gaps persist. This BO will consider each population separately.

North Carolina is the only state where the piping plover's breeding and wintering ranges overlap and the birds are present year-round. Piping plovers nest above the high tide line on coastal beaches; on sand flats at the ends of sand spits and barrier islands; on gently sloping foredunes; in blowout areas behind primary dunes (overwashes); in sparsely vegetated dunes; and in overwash areas cut into or between dunes. The species requires broad, open, sand flats for feeding, and undisturbed flats with low dunes and sparse dune grasses for nesting.

Figure 1. Distribution and range of piping plovers (base map from Haig and Elliott-Smith 2004). Conceptual presentation of subspecies and population ranges are not intended to convey precise boundaries.

Piping plovers from the federally endangered Great Lakes breeding population, as well birds from the threatened Atlantic Coast and Northern Great Plains breeding populations overwinter on North Carolina beaches. Piping plovers arrive on their breeding grounds in late March or early April. In the Great Lakes, arrival on the breeding grounds may be mid-April to early May. Following establishment of nesting territories and courtship rituals, the pair forms a depression in the sand, where the female lays her eggs. Some adults leave the breeding grounds as early as July. By early September both adults and young depart for their wintering areas.

2.1.2. Life history

The piping plover is a small, pale sand-colored shorebird, about seven inches long with a wingspan of about 15 inches (Palmer 1967). Cryptic coloration is a primary defense mechanism for piping plovers where nests, adults, and chicks all blend in with their typical beach surroundings.
Piping plovers live an average of 5 years, although studies have documented birds as old as 11 (Wilcox 1959) and 15 years. Plovers are known to begin breeding as early as one year of age (MacIvor 1990;

Haig 1992). In studies with large numbers of marked interior breeding piping plovers, Saunders et al. (2014) found that 56 percent of female Great Lakes piping plovers mated in their first season post-hatch, while 68 percent of female yearlings mated in Saskatchewan in 2001-2006 (Gratto-Trevor et al. 2010). Both studies found that probability of breeding in the first year was lower for males than females, but Great Lakes males that had not bred earlier were more likely than females to recruit into the breeding population in years two and three. Virtually all surviving Great Lakes piping plovers began breeding by year three (Saunders et al. 2014). Piping plover breeding activity begins in mid-March when birds begin returning to their nesting areas (Coutu et al. 1990; Cross 1990; Goldin et al. 1990; MacIvor 1990; Hake 1993). Piping plovers generally fledge only a single brood per season, but may re-nest several times if previous nests are lost. The reduction in suitable nesting habitat due to a number of factors is a major threat to the species, likely limiting reproductive success and future recruitment into the population (USFWS 2009a).

Plovers depart their breeding grounds for their wintering grounds between July and late August, but southward migration extends through November. More information about the three breeding populations of piping plovers can be found in the following documents:

a. Piping Plover, Atlantic Coast Population: 1996 Revised Recovery Plan (USFWS 1996a);
b. 2009 Piping Plover (*Charadrius melodus*) 5-Year Review: Summary and Evaluation (USFWS 2009a);
c. 2003 Recovery Plan for the Great Lakes Piping Plover (*Charadrius melodus*) (USFWS 2003a);
d. Questions and Answers about the Northern Great Plains population of Piping Plover (USFWS 2002).
e. 2016 Draft Revised Recovery Plan for the Northern Great Plains population of Piping Plover (USFWS 2015).

North Carolina is one of the only states in which piping plovers may be found year-round.
Piping plovers migrate through and winter in coastal areas of the U.S. from North Carolina to Texas and in portions of Mexico and the Caribbean. Data based on five rangewide mid-winter (late January to early February) population surveys, conducted at 5-year intervals starting in 1991, show that total numbers have fluctuated over time, with some areas experiencing increases and others decreases. Regional and local fluctuations may reflect the quantity and quality of suitable foraging and roosting habitat, which vary over time in response to natural coastal formation processes as well as anthropogenic habitat changes (e.g., inlet relocation, dredging of shoals and spits). Fluctuations may also represent localized weather conditions (especially wind) during surveys, or unequal survey coverage. Changes in wintering numbers may also be influenced by growth or decline in the particular breeding populations that concentrate their wintering distribution in a given area.

Breeding and wintering plovers feed on exposed wet sand in swash zones; intertidal ocean beach; wrack lines; washover passes; mud, sand, and algal flats; and shorelines of streams, ephemeral ponds, lagoons, and salt marshes by probing for invertebrates at or just below the surface (Coutu et al. 1990; USFWS 1996a). They use beaches adjacent to foraging areas for roosting and preening. Small sand dunes, debris, and sparse vegetation within adjacent beaches provide shelter from wind and extreme temperatures. Behavioral observations of piping plovers on the wintering grounds suggest that they spend the majority of their time foraging and roosting (Nicholls and Baldassarre 1990a; 1990b; Drake

1999a; 1999b, Maddock et al. 2009). Studies have shown that the relative importance of various feeding habitat types may vary by site (Gibbs 1986; Coutu et al. 1990; McConnaughey et al. 1990; Loegering 1992; Goldin 1993; Hoopes 1993). Feeding activities may occur during all hours of the day and night (Staine and Burger 1994; Zonick 1997), and at all stages in the tidal cycle (Goldin 1993; Hoopes 1993). Wintering plovers primarily feed on invertebrates such as polychaete marine worms, various crustaceans, fly larvae, beetles, and occasionally bivalve mollusks found on top of the soil or just beneath the surface (Bent 1929; Cairns 1977; Nicholls 1989; Zonick and Ryan 1996).

Piping plovers exhibit a high degree of intra- and interannual wintering site fidelity (Nicholls and Baldassarre 1990b; Drake et al. 2001; Noel and Chandler 2008; Stucker and Cuthbert 2006). However, local movements during winter are more common. In South Carolina, Maddock et al. (2009) documented many cross-inlet movements by wintering banded piping plovers as well as occasional movements of up to 11.2 mi by approximately 10 percent of the banded population. Larger movements within South Carolina were seen during fall and spring migration.

Atlantic Coast plovers nest on coastal beaches, sand flats at the ends of sand spits and barrier islands, gently-sloped foredunes, sparsely-vegetated dunes, and washover areas cut into or between dunes. Plovers arrive on the breeding grounds from mid-March through mid-May and remain for three to four months per year; the Atlantic Coast plover breeding activities begin in March in North Carolina with courtship and territorial establishment (Coutu et al. 1990; McConnaughey et al. 1990). Egg-laying begins around mid-April with nesting and brood rearing activities continuing through July. They lay three to four eggs in shallow, scraped depressions lined with light colored pebbles and shell fragments. The eggs are well camouflaged and blend extremely well with their surroundings. Chicks are precocial, often leaving the nest within hours of hatching, but are tended by adults who lead the chicks to and from feeding areas, shelter them from harsh weather, and protect the young from perceived predators. Chicks remain together with one or both parents until they fledge (are able to fly) at 25 to 35 days of age.

Atlantic and Gulf Coast studies highlighted the importance of inlets for nonbreeding piping plovers. Almost 90% of observations of roosting piping plovers at ten coastal sites in southwest Florida were on inlet shorelines (Lott et al. 2009b). In an evaluation of 361 International Shorebird Survey sites from North Carolina to Florida (Harrington 2008), piping plovers were among seven shorebird species found more often than expected ($p = 0.0004$; Wilcoxon Scores test) at inlet versus non-inlet locations. Wintering plovers on the Atlantic Coast prefer wide beaches in the vicinity of inlets (Nicholls and Baldassarre 1990b, Wilkinson and Spinks 1994). At inlets, foraging plovers are associated with moist substrate features such as intertidal flats, algal flats, and ephemeral pools (Nicholls and Baldassarre 1990a, Wilkinson and Spinks 1994, Dinsmore et al. 1998).

2.1.3. Population dynamics

The International Piping Plover Breeding Census is conducted throughout the breeding grounds every 5 years by the Great Lakes/Northern Great Plains Recovery Team of the U.S. Geological Survey (USGS). Although there are shortcomings in the census method, it is the largest known, complete avian species census. The 2011 survey documented 2,391 breeding pairs, with a total of 5,723 birds throughout Canada and the U.S. (Elliot-Smith et al. 2015).

The most consistent finding in the various population viability analyses conducted for piping plovers (Ryan et al. 1993; Melvin and Gibbs 1996; Plissner and Haig 2000; Amirault et al. 2005; Calvert et al. 2006; Brault 2007) indicates even small declines in adult and juvenile survival rates will cause increases in extinction risk. A banding study conducted between 1998 and 2004 in Atlantic Canada concluded lower return rates of juvenile (first year) birds to the breeding grounds than was documented for Massachusetts (Melvin and Gibbs 1996), Maryland (Loegering 1992), and Virginia (Cross 1996) breeding populations in the mid-1980s and very early 1990s. This is consistent with failure of the Atlantic Canada population to increase in abundance despite high productivity (relative to other breeding populations) and extremely low rates of dispersal to the U.S. over the last 15 plus years (Amirault et al. 2005). This suggests maximizing productivity does not ensure population increases. However, Drake et al. (2001) observed no mortality among 49 radio-marked piping plovers (total of 2,704 transmitter-days) in Texas in the 1990s. Cohen et al. (2008) also reported no mortality among a small sample (n=7) of radio-marked piping plovers at Oregon Inlet, North Carolina in 2005-2006.

The status of piping plovers on winter and migration grounds is difficult to assess, but threats to piping plover habitat used during winter and migration identified by the Service during its designation of critical habitat continue to affect the species. Unregulated motorized and pedestrian recreational use, inlet and shoreline stabilization projects, beach maintenance and nourishment, and pollution affect most winter and migration areas. Conservation efforts at some locations have likely resulted in the enhancement of wintering habitat.

2.1.3.1. Northern Great Plains breeding population

The Northern Great Plains plover breeds from Alberta to Manitoba, Canada and south to Nebraska; although some nesting has occurred in Oklahoma (Boyd 1991). Currently the most westerly breeding piping plovers in the U.S. occur in Montana and Colorado.

The decline of piping plovers on rivers in the Northern Great Plains has been largely attributed to the loss of sandbar island habitat and forage base due to dam construction and operation. Nesting occurs on sand flats or bare shorelines of rivers and lakes, including sandbar islands in the upper Missouri River system, and patches of sand, gravel, or pebbly-mud on the alkali lakes of the Northern Great Plains. Plovers do nest on shorelines of reservoirs created by the dams, but reproductive success is often low and reservoir habitat is not available in many years due to high water levels or vegetation. Dams operated with steady constant flows allow vegetation to grow on potential nesting islands, making these sites unsuitable for nesting. Population declines in alkali wetlands are attributed to wetland drainage, contaminants, and predation.

The Northern Great Plains breeding population is geographically widespread, with many birds in very remote places, especially in the U.S. and Canadian alkali lakes. Thus, determining the number of birds or even identifying a clear trend in the population is a difficult task. The IPPC was designed, in part, to help deal with this problem by instigating a large effort every five years in which an attempt is made to survey every area with known or potential piping plover breeding habitat during a two-week window (i.e., the first two weeks of June). The relatively short window is designed to minimize double counting if birds move from one area to another. Participation in the IPPC has been excellent on the Northern Great Plains, with a tremendous effort put forth to attempt to survey areas during the census window

(Elliot-Smith et al. 2009). The large area to be surveyed and sparse human population in the Northern Great Plains make annual surveys of the entire area impractical. Many areas are only surveyed during the IPPC years.

Figure 2 shows the number of adult plovers in the Northern Great Plains (U.S. and Canada) for all five IPPCs. The IPPC shows that the U.S. population decreased between 1991 and 1996, then increased in 2001 and 2006. Combined with the numbers from Canada, the IPPC numbers suggest that the population declined from 1991 through 2001, then increased almost 58% between 2001 and 2006 (Elliott-Smith et al. 2009). The 2011 breeding census count was substantially lower than the count in 2006 (over 4,500 birds in 2006 and 2,249 in 2011) (Elliott-Smith et al. 2015). It is unknown if the decrease in counts is an accurate accounting of the piping plover population numbers, or if birds were not counted due to displacement from flooding in the region that made traditional habitat unsuitable.

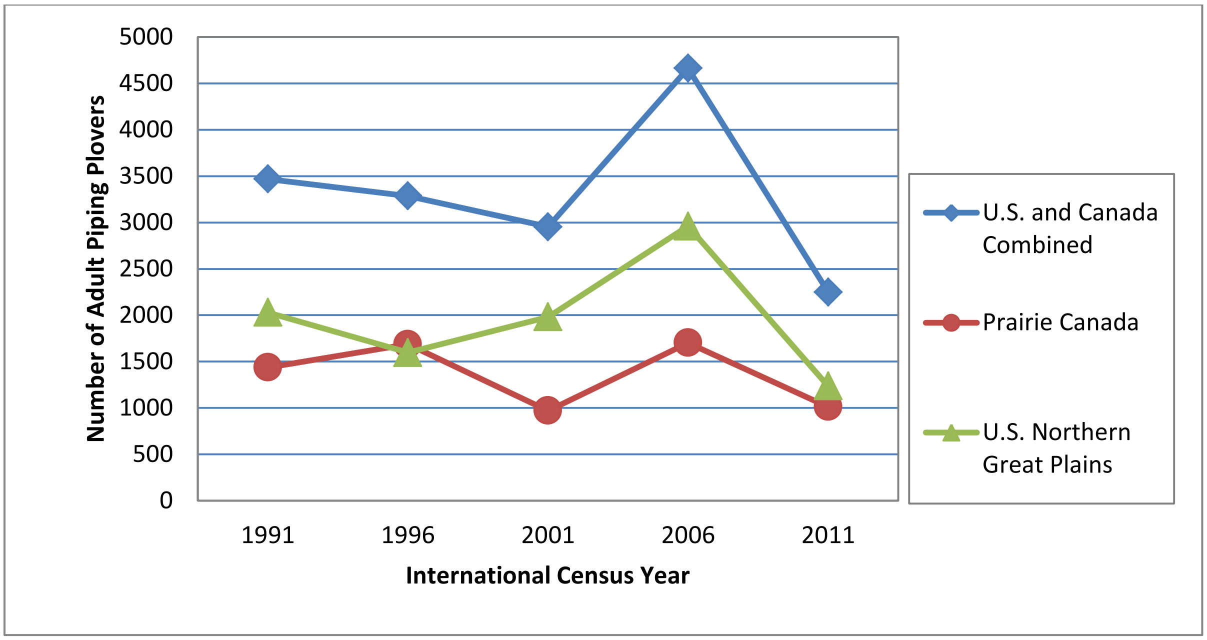

Figure 2. The number of adults reported for the U.S. and Canada Northern Great Plains breeding population during the International Censuses from 1991 to 2011. Data from Elliott-Smith et al. 2009, Elliott-Smith et al. 2015, Ferland and Haig 2002, Haig and Plissner 1993, Plissner and Haig 2000.

The increase in 2006 is likely due in large part to a multi-year drought across much of the region starting in 2001 that exposed thousands of acres of nesting habitat. The Corps ran low flows on the riverine stretches of the Missouri River for most of the years between censuses; allowing more habitat to be exposed and resulting in relatively high fledge ratios (USACE 2008). The Corps also began to construct habitat using mechanical means (dredging sand from the riverbed) on the Missouri River in 2004, providing some new nesting and foraging habitat. The drought also caused reservoir levels to drop on many reservoirs throughout the Northern Great Plains (e.g. Missouri River Reservoirs (ND, SD), Lake McConnaughey (NE)), providing shoreline habitat. The population increase may also be partially due to more intensive management activities on the alkali lakes, with increased management actions to improve habitat and reduce predation pressures. In 2011, the count was much lower, perhaps due to extreme flooding of nesting habitat.

While the IPPC provides an index to the piping plover population, the design does not always provide sufficient information to understand the population's dynamics. The five-year time interval between IPPC efforts may be too long to allow managers to get a clear picture of what the short-term population trends are and to respond accordingly if needed. As noted above, the first three IPPCs (1991, 1996, and 2001) showed a declining population, while the fourth (2006) indicated a dramatic population rebound of almost 58% for the combined U.S. and Canada Northern Great Plains breeding population between 2001 and 2006. The results for 2011 indicate a similar grand population total as 2006, but a declining population in the U.S. The larger overall population total in 2011 can be attributed to the larger numbers of plovers observed in the Bahamas. With only five data points over 20 years, it is impossible to determine if and to what extent the data reflects a real population trend versus error(s) in the 2011 census counts and/or a previous IPPC. The 2006 IPPC included a detectability component, in which a number of pre-selected sites were visited twice by the same observer(s) during the two-week window to get an estimate of error rate. This study found an approximately 76% detectability rate through the entire breeding area, with a range of between 39% to 78% detectability among habitat types in the Northern Great Plains.

2.1.3.2. Great Lakes breeding population

The Great Lakes plovers once nested on Great Lakes beaches in Illinois, Indiana, Michigan, Minnesota, New York, Ohio, Pennsylvania, Wisconsin, and Ontario. Great Lakes piping plovers nest on wide, flat, open, sandy or cobble shoreline with very little grass or other vegetation. Reproduction is adversely affected by human disturbance of nesting areas and predation by foxes, gulls, crows and other avian species. Shoreline development, such as the construction of marinas, breakwaters, and other navigation structures, has adversely affected nesting and brood rearing.

The Recovery Plan (USFWS 2003a) sets a population goal of at least 150 pairs (300 individuals), for at least 5 consecutive years, with at least 100 breeding pairs (200 individuals) in Michigan and 50 breeding pairs (100 individuals) distributed among sites in other Great Lakes states. The Great Lakes breeding population, which has been traditionally represented as the number of breeding pairs, has slowly increased after the completion of the recovery plan between 2003 and 2016 (**Figure 3**) (Cuthbert and Roche 2007; Cuthbert and Roche 2006; Westbrock et al. 2005; Stucker and Cuthbert 2004; Stucker et al. 2003; Cuthbert and Saunders 2013). The Great Lakes piping plover recovery plan documents the 2002 population at 51 breeding pairs (USFWS 2003a), and in 2016, 75 breeding pairs were estimated (Cavalieri pers. comm. 2016a). Monitoring efforts in years since have documented mostly increases with a few years of decreases. The Great Lakes annual monitoring program is an intensive survey effort with nearly daily monitoring of active breeding locations. Fluctuations in the number of breeding pairs between 2009 and 2016 may have been caused by weather conditions or merlin predation (Elliott-Smith et al. 2015).

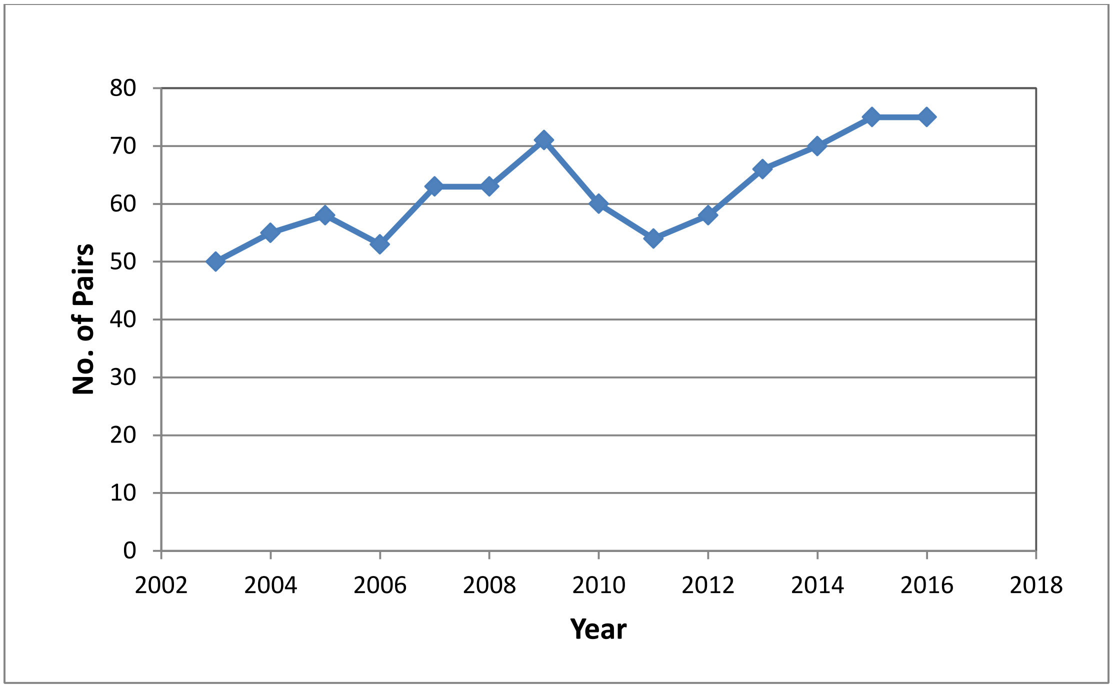

Figure 3. Annual Breeding Pair Estimates for Great Lakes Piping Plovers (2003-2016). Data from Cuthbert and Saunders 2013, Cavalieri pers. comm. 2016a; 2016c.

A single breeding pair discovered in 2007 in the Great Lakes region of Canada represented the first confirmed piping plover nest there in over 30 years. The number of nesting pairs in Canada increased to four in 2008, six in 2011, and 15 in 2016 (Cavalieri pers. comm. 2016a; 2016d). These 15 nesting pairs are included in the total population of 75 breeding pairs above.

The total fall population, including fledged chicks and captive-raised chicks was 310 in 2014. In 2015, the number was estimated at approximately 325. In fall of 2016, the number is currently estimated at approximately 330 (Cavalieri pers. comm.2016b). As winter approaches, this number is expected to be reduced rather quickly, as hatch-year mortality may be as high as 63% (Saunders et al. 2014; Saunders pers.comm. 2016).

Survival rates in general for Great Lakes piping plovers have declined over 20 percentage points since 1994 (**Table 1**) (Saunders pers. comm. 2016). The estimated annual survival rates in 1994 for males in the Great Lakes breeding population was 0.878 (or almost 88%), while the survival rate for females was a bit lower at 0.87. The survival rates have fallen steadily since then, and by 2012, the survival rate was 0.667 for males and 0.650 for females (Saunders pers. comm. 2016). During this time, adult predation by merlins (*Falco columbarius*) increased as a result of a general increase in merlin population numbers and a range expansion that began in the 1980s (Haas 2011; Cava et al. 2014). Management of merlin predation on the breeding grounds appears to have allowed the survival rate to stabilize (Roche et al. 2010a; Saunders pers. comm. 2016).

Table 1. Survival rates of adult male and female Great Lakes piping plovers, 1994 to 2012. Data from Saunders pers. comm. 2016.

Year	Male Survival Rate	Female Survival Rate
1994	0.878	0.870
1995	0.878	0.870
1996	0.811	0.799
1997	0.807	0.795
1998	0.827	0.816
1999	0.792	0.778
2000	0.737	0.721
2001	0.778	0.765
2002	0.761	0.746
2003	0.747	0.732
2004	0.790	0.776
2005	0.694	0.677
2006	0.639	0.621
2007	0.666	0.648
2008	0.677	0.660
2009	0.698	0.682
2010	0.713	0.697
2011	0.664	0.646
2012	0.667	0.650

2.1.3.3. Atlantic Coast Population

The Atlantic Coast piping plover breeds on coastal beaches from Newfoundland and southeastern Quebec to North Carolina. Historical population trends for the Atlantic Coast piping plover have been reconstructed from scattered, largely qualitative records. Nineteenth-century naturalists, such as Audubon and Wilson, described the piping plover as a common summer resident on Atlantic Coast beaches (Haig and Oring 1987). However, by the beginning of the 20th Century, egg collecting and uncontrolled hunting, primarily for the millinery trade, had greatly reduced the population, and in some areas along the Atlantic Coast, the piping plover was close to extirpation. Following passage of the Migratory Bird Treaty Act (MBTA) (40 Stat. 775; 16 U.S.C. 703-712) in 1918, and changes in the fashion industry that no longer exploited wild birds for feathers, piping plover numbers recovered to some extent (Haig and Oring 1985).

Available data suggest that the most recent population decline began in the late 1940s or early 1950s (Haig and Oring 1985). Reports of local or statewide declines between 1950 and 1985 are numerous, and many are summarized by Cairns and McLaren (1980) and Haig and Oring (1985). While Wilcox (1939) estimated more than 500 pairs of piping plovers on Long Island, New York, the 1989 population estimate was 191 pairs (see Table 4, USFWS 1996a). There was little focus on gathering quantitative data on piping plovers in Massachusetts through the late 1960s because the species was commonly observed and presumed to be secure. However, numbers of piping plover breeding pairs declined 50 to 100 percent at seven Massachusetts sites between the early 1970s and 1984 (Griffin and Melvin 1984). Piping plover surveys in the early years of the recovery effort found that counts of these cryptically-colored birds sometimes went up with increased census effort, suggesting that some historic counts of piping plovers by one or a few observers may have underestimated the piping plover population. Thus, the magnitude of the species decline may have been more severe than available numbers imply.

Annual estimates of breeding pairs of Atlantic Coast piping plovers are based on multiple surveys at most occupied sites. Sites that cannot be monitored repeatedly in May and June (primarily sites with few pairs or inconsistent occupancy) are surveyed at least once during a standard nine-day count period (Hecht and Melvin 2009). See **Tables 2 and 3** for unpublished data from the Service.

Table 2. Estimated abundance of Atlantic Coast piping plovers, 1986 to 2000. Unpublished data from the Service (2016).

State or Recovery Unit	**Number of pairs /year**														
	1986	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
Maine	15	12	20	16	17	18	24	32	35	40	60	47	60	56	50
New Hampshire												5	5	6	6
Massachusetts	139	126	134	137	140	160	213	289	352	441	454	483	495	501	496
Rhode Island	10	17	19	19	28	26	20	31	32	40	50	51	46	39	49
Connecticut	20	24	27	34	43	36	40	24	30	31	26	26	21	22	22
New York	106	135	172	191	197	191	187	193	209	249	256	256	245	243	289
New Jersey	102	93	105	128	126	126	134	127	124	132	127	115	93	107	112
Delaware	8	7	3	3	6	5	2	2	4	5	6	4	6	4	3
Maryland	17	23	25	20	14	17	24	19	32	44	61	60	56	58	60
Virginia	100	100	103	121	125	131	97	106	96	118	87	88	95	89	96
North Carolina	30	30	40	55	55	40	49	53	54	50	35	52	46	31	24
South Carolina	3		0		1	1		1			0				
U.S. Total	550	567	648	724	752	751	790	877	968	1150	1162	1187	1168	1156	1207
Eastern Canada	240	223	238	233	230	252	223	223	194	200	202	199	211	236	230
Atlantic Coast Total	790	790	886	957	982	1003	1013	1100	1162	1350	1364	1386	1379	1392	1437

Table 3. Estimated abundance of Atlantic Coast piping plovers, 2001 to 2014, with Preliminary data from 2015. Unpublished data from the Service (2016). *Numbers in parentheses are preliminary estimates, subject to revision.

State or Recovery Unit	**Number of pairs /year**														
	2001	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015***
Maine	55	66	61	55	49	40	35	24	27	30	33	42	44	50	62
New Hampshire	7	7	7	4	3	3	3	3	5	4	4	6	7	6	8
Massachusetts	495	538	511	488	467	482	558	566	593	591	656	676	666	663	687
Rhode Island	52	58	71	70	69	72	73	77	84	85	86	90	92	91	99
Connecticut	32	31	37	40	34	37	36	41	44	43	52	51	45	51	62
New York	309	369	386	384	374	422	457	443	437	390	318	342	289	268	(303)
New Jersey	122	138	144	135	111	116	129	111	105	108	111	121	108	92	108
Delaware	6	6	6	7	8	9	9	10	10	9	8	7	6	6	6
Maryland	60	60	59	66	63	64	64	49	45	44	36	41	45	38	36
Virginia	119	120	114	152	192	202	199	208	193	192	188	259	251	245	256
North Carolina	23	23	24	20	37	46	61	64	54	61	62	70	56	65	64
South Carolina	0						0								
U.S. Total	1280	1416	1420	1421	1407	1493	1624	1596	1597	1557	1554	1705	1609	1593	(1691)
Eastern Canada	250	274	256	237	217	256	266	253	252	225	209	179	184	186	179
Atlantic Coast Total	1530	1690	1676	1658	1624	1749	1890	1849	1849	1782	1763	1884	1793	1779	(1870)

Since its 1986 listing under the ESA, the Atlantic Coast population estimate increased from approximately 790 pairs to an estimated 1,870 pairs in 2015, and the U.S. portion of the population more than tripled, from approximately 550 pairs to an estimated 1,691 pairs (Hecht and Melvin 2009; Elliott-Smith et al. 2015; USFWS 2015). Even discounting apparent increases in New York, New Jersey, and North Carolina between 1986 and 1989, which likely were due in part to increased census effort (USFWS 1996a), the population nearly doubled between 1989 and 2008. The overall population growth pattern was tempered by periodic rapid declines in the Southern and Eastern Canada Recovery Units. The eastern Canada population decreased 21% in just three years (2002-2005), and the population in the southern half of the Southern Recovery Unit declined 68% in seven years (1995-2001). The 64% decline in the Maine population, from 66 pairs in 2002 to 24 pairs in 2008, following only a few years of decreased productivity, provides another example of the continuing risk of rapid and precipitous reversals in population growth (Hecht and Melvin 2009).

2.1.4. Status and distribution

Reason for Listing: Hunting during the 19th and early 20th centuries likely led to initial declines in the species; however, shooting piping plovers has been prohibited since 1918 pursuant to the provisions of the MBTA. Other human activities, such as habitat loss and degradation, disturbance from recreational pressure, contaminants, and predation are likely responsible for continued declines. These factors include development and shoreline stabilization. The 1985 final rule stated the number of piping plovers on the Gulf of Mexico coastal wintering grounds might be declining as indicated by preliminary analysis of the Christmas Bird Count data. Independent counts of piping plovers on the Alabama coast indicated a decline in numbers between the 1950s and early 1980s. At the time of listing, the Texas Parks and Wildlife Department stated 30 percent of wintering habitat in Texas had been lost over the previous 20 years. The final rule also stated, in addition to extensive breeding area problems, the loss and modification of wintering habitat was a significant threat to the piping plover.

Range-wide Trend: Five range-wide population surveys have been conducted for the piping plover; the 1991 (Haig and Plissner 1992), 1996 (Plissner and Haig 1997), 2001, 2006 (Elliott-Smith et al. 2009), and 2011 IPPCs. These surveys were completed to help determine the species distribution and to monitor progress toward recovery. Data from these surveys were provided in the previous pages.

Recovery Criteria

Delisting of the three piping plover populations may be considered when the following criteria are met:

Northern Great Plains Breeding Population (USFWS 1988, 1994)

1. Increase the number of birds in the U.S. Northern Great Plains states to 2,300 pairs (Service 1994).
2. Increase the number of birds in the prairie region of Canada to 2,500 adult piping plovers (Service 1988).
3. Secure long term protection of essential breeding and wintering habitat (Service 1994).

In 2016, the Service drafted new recovery criteria for the Northern Great Plains breeding population. The new criteria are expected to be finalized in the near future.

Great Lakes Breeding Population (USFWS 2003a)

1. At least 150 pairs (300 individuals), for at least 5 consecutive years, with at least 100 breeding pairs (200 individuals) in Michigan and 50 breeding pairs (100 individuals) distributed among sites in other Great Lakes states.
2. Five-year average fecundity within the range of 1.5-2.0 fledglings per pair, per year, across the breeding distribution, and ten-year population projections indicate the population is stable or continuing to grow above the recovery goal.
3. Protection and long-term maintenance of essential breeding and wintering habitat is ensured, sufficient in quantity, quality, and distribution to support the recovery goal of 150 pairs (300 individuals).
4. Genetic diversity within the population is deemed adequate for population persistence and can be maintained over the long-term.
5. Agreements and funding mechanisms are in place for long-term protection and management activities in essential breeding and wintering habitat.

Atlantic Coast Breeding Population (USFWS 1996a)

1. Increase and maintain for 5 years a total of 2,000 breeding pairs, distributed among 4 recovery units.

Recovery Unit	*Minimum Subpopulation*
Atlantic (eastern) Canada	*400 pairs*
New England	*625 pairs*
New York-New Jersey	*575 pairs*
Southern (DE-MD-VA-NC)	*400 pairs*

2. Verify the adequacy of a 2,000 pair population of piping plovers to maintain heterozygosity and allelic diversity over the long term.
3. Achieve a 5-year average productivity of 1.5 fledged chicks per pair in each of the 4 recovery units described in criterion 1, based on data from sites that collectively support at least 90% of the recovery unit's population.
4. Institute long-term agreements to assure protection and management sufficient to maintain the population targets and average productivity in each recovery unit.
5. Ensure long-term maintenance of wintering habitat, sufficient in quantity, quality, and distribution to maintain survival rates for a 2,000-pair population.

Conservation Recommendations

Nonbreeding Plovers from All Three Breeding Populations (USFWS 2012)

1. Maintain natural coastal processes that perpetuate wintering and coastal migration habitat.
2. Protect wintering and migrating piping plovers and their habitat from human disturbance.
3. Monitor nonbreeding plovers and their habitat.
4. Protect nonbreeding plovers and their habitats from contamination and degradation from oil or other chemical contaminants.
5. Assess predation as a potential limiting factor for piping plovers on wintering and migration sites.
6. Improve application or regulatory tools.
7. Develop mechanisms to provide long-term protection of nonbreeding plovers and their habitat.
8. Conduct scientific investigations to refine knowledge and inform conservation of migrating and wintering piping plovers.

Breeding Range

Northern Great Plains Breeding Population

The IPPC numbers indicate that the Northern Great Plains breeding population (including Canada) declined from 1991 through 2001, and then increased dramatically in 2006. This increase corresponded with a multi-year drought in the Missouri River basin that exposed a great deal of nesting habitat, suggesting that the population can respond fairly rapidly to changes in habitat quantity and quality. Despite this improvement, we do not consider the numeric, distributional, or temporal elements of the population recovery criteria achieved.

As the Missouri River basin emerged from drought and breeding habitat was inundated in subsequent years after 2006, the population declined (See **Figure 2**). The management activities carried out in many areas during drought conditions undoubtedly helped to maintain and increase the piping plover population, especially to mitigate for otherwise poor reproductive success during wet years when habitat is limited.

While the population increase seen between 2001 and 2006 demonstrates the possibility that the population can rebound from low population numbers, ongoing efforts are needed to maintain and increase the population. In the U.S., piping plover crews attempt to locate most piping plover nests and take steps to improve their success. This work has suffered from insufficient and unstable funding in most areas.

Emerging threats, such as energy development (particularly wind, oil and gas and associated infrastructure) and climate change are likely to impact piping plovers both on the breeding and wintering grounds. The potential impact of both of these threats is not well understood, and measures to mitigate for them are also uncertain at this time.

In the 2009 status review, the Service concluded that the Northern Great Plains breeding population remains vulnerable, especially due to management of river systems throughout the breeding range (USFWS 2009a). Many of the threats identified in the 1988 recovery plan, including those affecting Northern Great Plains breeding population during the two-thirds of its annual cycle spent in the wintering range, remain today or have intensified.

Great Lakes Breeding Population

Despite a declining annual survival rate, the population has shown significant growth, from approximately 17 pairs at the time of listing in 1986, to 75 pairs in 2015 and 2016. The total of 75 breeding pairs represents 50% of the current recovery goal of 150 breeding pairs for the Great Lakes breeding population. Productivity goals, as specified in the 2003 recovery plan, have been met over the past 5 years. During this time period the average annual fledging rate has varied, but averages about 1.7, well above the 1.5 fledglings per breeding pair recovery goal (Cavalieri pers. comm. 2016d). The total estimated population in 2016, including breeding pairs, non-breeding adults, and 2016 chicks, is approximately 330 individuals. Approximately 130 of those are 2016 chicks. However, that number may decline quickly over the next several months with the expected mortality of some hatch-year adults (Cavalieri pers. comm. 2016b). Survival of fledged hatch-year individuals has been estimated at approximately 37% (Roche et al. 2008; Saunders et al. 2014), so approximately 48 chicks of the 130 chicks are expected to survive until the 2017 breeding season. Analyses of banded piping plovers in the Great Lakes suggests that after-hatch year (adult) survival rates are declining, although management of merlin predation on the breeding grounds appears to have allowed the survival rate to stabilize (Roche et al. 2010; Saunders pers. comm. 2016). It is the productivity rate, or recruitment rate, that has continued to increase the overall population, despite considerable decreases in adult survival rates. Continued population growth will require the long-term maintenance of productivity goals concurrent with measures to sustain or improve important vital rates. Older birds are typically more successful breeders (Cavalieri pers.comm. 2016b), so after-hatch year survival rates may have a great effect on the overall population growth.

An additional factor in the number of breeding pairs is a sex ratio that is skewed towards males. Many of the non-breeding adults are males. There may be as many as 40 more males in the population each year than females, and males make up the majority of the non-breeding population. Females are more valuable individuals in part because of their reduced number compared to males (Cavalieri pers. comm. 2016b).

Several years of population growth is evidence of the effectiveness of the ongoing Great Lakes piping plover recovery program. However, the average annual growth of just less than 2.3% in this small population typically results in only 3 or 4 additional surviving individuals each year (Catlin pers. comm. 2016a). Most major threats, including habitat degradation, predation, and human disturbance remain persistent and pervasive. Severe threats from human disturbance and predation remain ubiquitous within the Great Lakes. Expensive labor-intensive management to minimize the effects of these continuing threats, as specified in recovery plan tasks, are implemented every year by a network of dedicated governmental and private partners. Because threats to Great Lakes piping plovers persist and annual gains are rather small, reversal of gains in abundance and productivity are expected to quickly follow if current protection efforts are reduced.

Habitat destruction and development have greatly reduced the amount of nesting habitat in all states in the Great Lakes region from which piping plovers are extirpated. Human disturbance and high predator densities compromise the quality of habitat that otherwise currently possesses physical characteristics suitable for piping plover foraging and breeding. Many physically suitable sites that are no longer occupied are distant from the current breeding area, potentially limiting opportunities for recolonization. Additionally, lake level fluctuations and winter storms periodically alter the quantity and quality of habitat at individual sites throughout the region (USFWS 2003a). Emerging potential threats to piping plovers in the Great Lakes basin include disease, increased predation by merlins on adults and chicks, wind turbine generators and, potentially, climate change. Type-E botulism in the Northern Lake Michigan basin has resulted in 15 to 20 piping plover mortalities since 2000 (USFWS 2013c), including at least 4 in 2016. Future outbreaks in areas that support a concentration of breeding piping plovers could impact survival rates and population abundance. Wind turbine projects, many of which are currently in the planning stages, need further study to determine potential risks to piping plovers and/or their habitat, as well as the need for specific protections to prevent or mitigate impacts. Climate change projections for the Great Lakes include the potential for significant water-level decreases. The degree to which this factor will impact piping plover habitat is unknown, but prolonged water-level decreases are likely to alter habitat condition and distribution.

In the 2009 status review, the Service concluded that the Great Lakes breeding population remains at considerable risk of extinction due to its small size, limited distribution and vulnerability to stochastic events, such as disease outbreak (USFWS 2009a). In addition, the factors that led to the piping plover's 1986 listing remain present.

Atlantic Coast Breeding Population

Substantial population growth, from approximately 790 pairs in 1986 to an estimated 1,870 pairs in 2015, has decreased the Atlantic Coast piping plover's vulnerability to extinction since ESA listing (**Tables 2 and 3**). Thus, considerable progress has been made towards the overall goal of 2,000 breeding pairs articulated in recovery criterion 1. As discussed in the 1996 revised recovery plan, however, the overall security of the Atlantic Coast piping plover is fundamentally dependent on even distribution of population growth, as specified in subpopulation targets, to protect a sparsely-distributed species with strict biological requirements from environmental variation (including catastrophes) and increase the likelihood of interchange among subpopulations. Population growth has been tempered by geographic and temporal variability. By far, the largest net population increase between 1989 and 2015 occurred in New England (445 percent). Net growth in the Southern Recovery Unit population was over 182 percent between 1989 and 2015, but the subpopulation target has not yet been attained. Preliminary estimates indicate abundance in the New York-New Jersey recovery unit experienced a net increase of 129 percent between 1989 and 2015. However, the population declined sharply from a peak of 586 pairs in 2007 and has still not recovered, with only 411 pairs in 2015. In Eastern Canada, where increases have often been quickly eroded in subsequent years, the population posted a 25-percent decline between 1989 and 2015.

Productivity goals (criterion 3) specified in the 1996 recovery plan must be revised to accommodate new information about latitudinal variation in productivity needed to maintain a stationary population. Population growth, particularly in the three U.S. recovery units, provides indirect evidence that adequate productivity has occurred in at least some years. However, overall security of a 2,000 pair population will require long-term maintenance of these revised recovery-unit-specific productivity goals concurrent with population numbers at or above abundance goals.

Twenty years of relatively steady population growth, driven by productivity gains, also evidences the efficacy of the ongoing Atlantic Coast piping plover recovery program. However, all of the major threats (habitat loss and degradation, predation, human disturbance, and inadequacy of other (non-ESA) regulatory mechanisms) identified in the 1986 ESA listing and 1996 revised recovery plan remain persistent and pervasive. Severe threats from human disturbance and predation remain ubiquitous along the Atlantic Coast. Expensive labor-intensive management to minimize the effects of these continuing threats, as specified in recovery plan tasks, are implemented every year by a network of dedicated governmental and private cooperators. Because threats to Atlantic Coast piping plovers persist (and in many cases have increased since listing), reversal of gains in abundance and productivity would quickly follow diminishment of current protection efforts.

Finally, two emerging potential threats, wind turbine generators and climate change (especially sea-level rise) are likely to affect Atlantic Coast piping plovers throughout their life cycle. These two threats must be evaluated to ascertain their effects on piping plovers and/or their habitat, as well as the need for specific protections to prevent or mitigate impacts that could otherwise increase overall risks to the species.

In the 2009 status review, the Service concluded that the Atlantic Coast piping plover remains vulnerable to low numbers in the Southern and Eastern Canada (and, to a lesser extent, the New

York-New Jersey) Recovery Units (USFWS 2009a). Furthermore, the factors that led to the piping plover's 1986 listing remain operative rangewide (including in New England), and many of these threats have increased. Interruption of costly, labor-intensive efforts to manage these threats would quickly lead to steep population declines.

Nonbreeding Range

Piping plovers spend up to 10 months of their life cycle on their migration and winter grounds, generally July 15 through as late as May 15. Piping plover migration routes and habitats overlap breeding and wintering habitats, and, unless banded, migrants passing through a site usually are indistinguishable from breeding or wintering piping plovers. Coastal migration stopovers by banded piping plovers from the Great Lakes region have been documented in New Jersey, Maryland, Virginia, North Carolina, South Carolina, and Georgia (Stucker et al. 2010). Migrating birds from eastern Canada have been observed in Massachusetts, New Jersey, New York, and North Carolina (Amirault et al. 2005). Piping plovers banded in the Bahamas have been sighted during migration in nine Atlantic Coast states and provinces between Florida and Nova Scotia (Gratto-Trevor pers. comm. 2012a). In general, the distance between stopover locations and the duration of stopovers throughout the coastal migration range remain poorly understood (USFWS, 2015).

Review of published records of piping plover sightings throughout North America by Pompei and Cuthbert (2004) found more than 3,400 fall and spring stopover records at 1,196 sites. Published reports indicated that piping plovers do not concentrate in large numbers at inland sites and that they seem to stop opportunistically. In most cases, reports of birds at inland sites were single individuals.

Piping plovers migrate through and winter in coastal areas of the U.S. from North Carolina to Texas and in portions of Mexico and the Caribbean. Gratto-Trevor et al. (2009) reported that six of 259 banded piping plovers observed more than once per winter moved across boundaries of the seven U.S. regions. This species exhibits a high degree of intra- and inter-annual wintering site fidelity (Noel and Chandler 2016; Cohen and Gratto-Trevor 2011; Gratto-Trevor et al. 2016; Drake et al. 2001; Noel et al. 2005; Stucker and Cuthbert 2006). Of 216 birds observed in different years, only eight changed regions between years, and several of these shifts were associated with late summer or early spring migration periods (Gratto-Trevor et al. 2009). Local movements are more common. In South Carolina, Maddock et al. (2009) documented many cross-inlet movements by wintering banded piping plovers as well as occasional movements of up to 18 km by approximately 10% of the banded population; larger movements within South Carolina were seen during fall and spring migration. Similarly, eight banded piping plovers that were observed in two locations during 2006-2007 surveys in Louisiana and Texas were all in close proximity to their original location, such as on the bay and ocean side of the same island or on adjoining islands (Maddock 2008). In Cape Lookout NS, wintering banded birds were surveyed along Shackleford Banks. Individual birds were always observed in the same general area over multiple seasons, indicating that the wintering birds are very site-specific and return to the same area in consecutive years (NPS 2003)

Gratto-Trevor et al. (2012) found strong patterns (but no exclusive partitioning) in winter distribution of uniquely banded piping plovers from four breeding populations (**Figure 4**). Resightings of more than 700 uniquely marked birds from 2001 to 2008 were used to analyze winter distributions along the Atlantic and Gulf Coasts. Plovers from eastern Canada and most Great Lakes birds wintered from North Carolina to Southwest Florida. However, eastern Canada birds were more heavily concentrated in North Carolina, while a larger proportion of Great Lakes piping plovers were found in South Carolina, Georgia, and Florida. This pattern is consistent with analysis of band sightings of Great Lakes plovers from 1995-2005 by Stucker et al. (2010). Gratto-Trevor et al. (2012) also found that Northern Great Plains breeding population were primarily seen farther west and south, especially on the Texas Gulf Coast.

The majority of birds from the Canadian Prairie were observed in Texas (particularly southern Texas), while individuals from the U.S. Great Plains were more widely distributed on the Gulf Coast from Texas to Florida. Seventy-nine percent of 57 piping plovers banded in the Bahamas in 2010 have been reported breeding on the Atlantic Coast; one has been resighted in the Northern Great Plains (Catlin pers. comm. 2013). Furthermore, consistent with patterns observed in other parts of the wintering range, a few individuals banded in the Great Lakes and Northern Great Plains breeding populations have been observed in the Bahamas (Gratto-Trevor pers. comm. 2012; Catlin pers. comm. 2012a). Collectively, these studies demonstrate an intermediate level of connectivity between breeding and wintering areas. Specific breeding populations will be disproportionately affected by habitat and threats occurring where they are most concentrated in the winter (USFWS 2015).

The findings of Gratto-Trevor et al. (2009; 2012) provide evidence of differences in the wintering distribution of piping plovers from these four breeding areas. However, the distribution of birds by breeding origin during migration remains largely unknown. Until recently, the wintering locations of the U.S. Atlantic Coast breeding population was relatively unknown, as was the breeding origin of piping plovers wintering on Caribbean islands. A 2010 banding effort in the Bahamas, led by Dr. Cheri Trevor-Gratto, indicated that the majority of piping plovers wintering in the Bahamas are from the Atlantic breeding population (Gratto-Trevor et al. 2016; AFWA 2015). A 2014/2015 winter census effort on five Bahamian islands located 657 piping plovers, 31 of which had bands identifying them as members of the U.S. or Canadian breeding population. Research efforts indicate that around half of the Atlantic population of piping plovers winter across the Bahamas for up to ten months each year. The majority (25%) of the plovers are in just three locations – Andros Island, Joulter Cays and the Berry Islands (AFWA 2015). In September 2015, the Bahamian government established the 113,920-acre Joulter Cays National Park. This large group of uninhabited islands and intertidal sand flats will continue to provide important wintering habitat for piping plovers, red knots, and other shorebirds (Audubon 2015; BNT 2015).

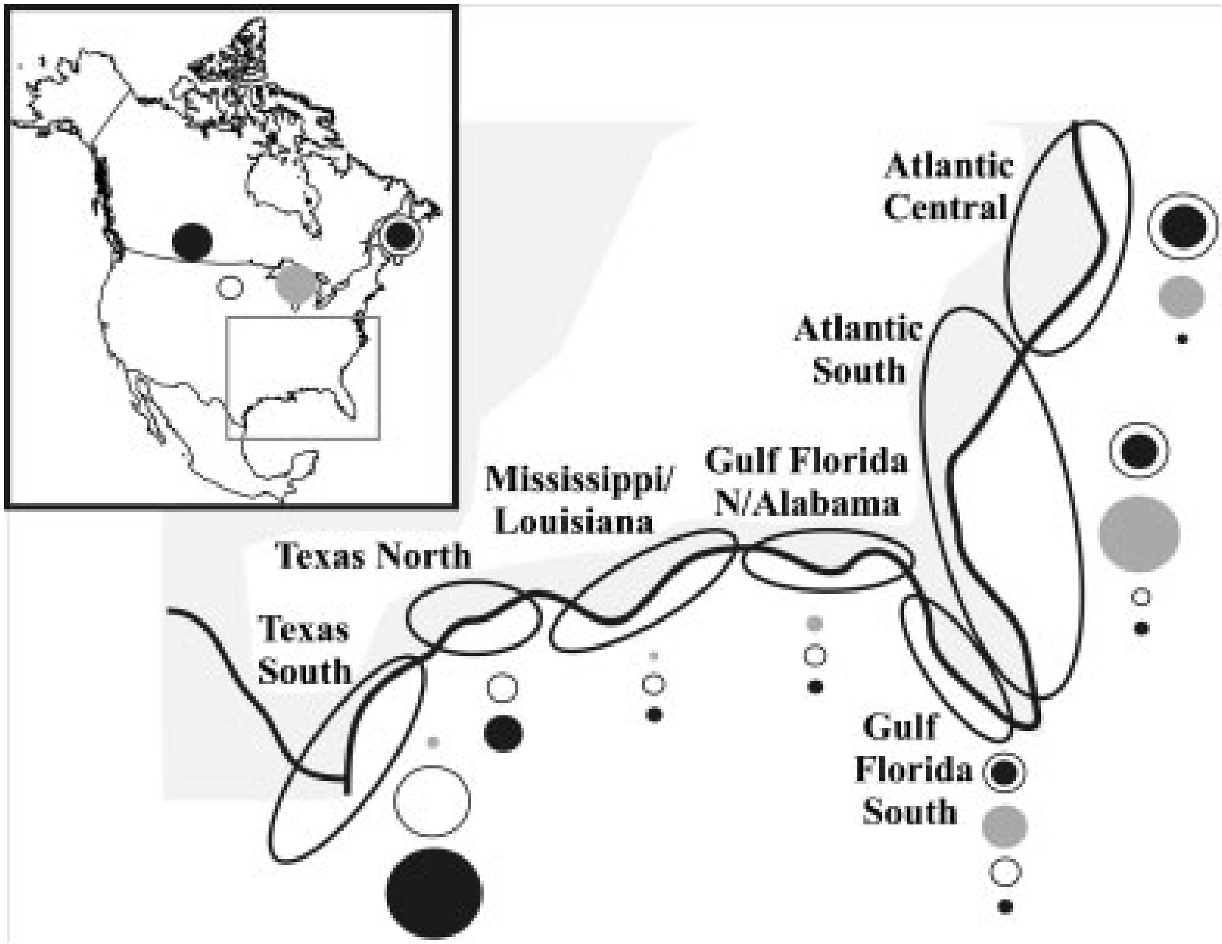

Figure 4. (From Gratto-Trevor et al. 2012, reproduced by permission). Four breeding locations (inset) included in Gratto-Trevor et al.'s (2012) study of wintering piping plovers in North America, 1998–2008, including eastern Canada (white circle with a large black spot in the center), Great Lakes (gray circle), Great Plains (white circle), and Prairie Canada (black circle). The North American wintering area is expanded to the right, divided into different wintering regions. The size of the adjacent circles relative to others represents the percentage of individual piping plovers from a specific breeding area reported in each wintering region up to December 2008.

Five rangewide mid-winter (late January to early February) IPPCs, conducted at five-year intervals starting in 1991, are summarized in **Table 4**. Total numbers have fluctuated over time, with some areas experiencing increases and others decreases. Regional and local fluctuations may reflect the quantity and quality of suitable foraging and roosting habitat, which vary over time in response to natural coastal formation processes as well as anthropogenic habitat changes (e.g., inlet relocation, dredging of shoals and spits). Fluctuations may also represent localized weather conditions (especially wind) during surveys, or unequal survey coverage. Changes in wintering numbers may also be influenced by growth or decline in the particular breeding populations that concentrate their wintering distribution in a given area.

Mid-winter surveys may substantially underestimate the abundance of nonbreeding piping plovers using a site or region during other months. In late September 2007, 104 piping plovers were counted at the south end of Ocracoke Island, North Carolina (NPS 2007), where none were seen during the 2006 International Piping Plover January Winter Census (Elliott-Smith et al. 2009). Noel et al. (2007) observed up to 100 piping plovers during peak migration at Little St. Simons Island, Georgia, where approximately 40 piping plovers wintered in 2003–2005. Differences among fall, winter, and spring counts in South Carolina were less pronounced, but inter-year fluctuations (e.g., 108 piping plovers in spring 2007 versus 174 piping plovers in spring 2008) at 28 sites were striking (Maddock et al. 2009). Even as far south as the Florida Panhandle, monthly counts at Phipps Preserve in Franklin County ranged from a mid-winter low of four piping plovers in December 2006 to peak counts of 47 in October 2006 and March 2007 (Smith 2007).

Local movements of nonbreeding piping plovers may also affect abundance estimates. At Deveaux Bank, one of South Carolina's most important piping plover sites, five counts at approximately 10-day intervals between August 27 and October 7, 2006, oscillated from 28 to 14 to 29 to 18 to 26 (Maddock et al. 2009). Noel and Chandler (2008) detected banded Great Lakes piping plovers known to be wintering on their Georgia study site in 73.8 $\pm$ 8.1 % of surveys over three years.

Abundance estimates for nonbreeding piping plovers may also be affected by the number of surveyor visits to the site. Preliminary analysis of detection rates by Maddock et al. (2009) found 87% detection during the mid-winter period on core sites surveyed three times a month during fall and spring and one time per month during winter, compared with 42% detection on sites surveyed three times per year (Cohen 2009 pers. communication).

Table 4. Results of the 1991, 1996, 2001, 2006, and 2011 International Piping Plover Winter Censuses (Haig and Plissner 1993; Plissner and Haig 2000; Ferland and Haig 2002; Haig et al. 2005; Elliott-Smith et al. 2009; Elliott-Smith et al. 2015).

Location	1991	1996	2001	2006	2011
Virginia	not surveyed (ns)	ns	ns	1	1
North Carolina	**20**	**50**	**87**	**84**	**43**
South Carolina	51	78	78	100	86
Georgia	37	124	111	212	63
Florida	551	375	416	454	306
-Atlantic	*70*	*31*	*111*	*133*	*83*
-Gulf	*481*	*344*	*305*	*321*	*223*
Alabama	12	31	30	29	38
Mississippi	59	27	18	78	88
Louisiana	750	398	511	226	86
Texas	1,904	1,333	1,042	2,090	2,145
Puerto Rico	0	0	6	2	2
U.S. Total	**3,384**	**2,416**	**2,299**	**3,357**	**2,858**
Mexico	27	16	ns	76	30
Bahamas	29	17	35	417	1,066
Cuba	11	66	55	89	19
Other Caribbean Islands	0	0	0	28	ns
GRAND TOTAL	**3,451**	**2,515**	**2,389**	**3,884**	**3,973**
Percent of Total International Piping Plover Breeding Census	62.9%	42.4%	40.2%	48.2%	69.4%

The 2004 and 2005 hurricane seasons affected a substantial amount of habitat along the Gulf Coast. Habitats such as those along Gulf Islands NS have benefited from increased washover events, which created optimal habitat conditions for piping plovers. Conversely, hard shoreline structures put into place following storms throughout the species range to prevent such shoreline migration prevent habitat creation (see *Factors Affecting Species Environment within the Action Area*).

2.1.5. Analysis of the Species Likely to be Affected

The three recovery plans stated that shoreline development throughout the wintering range poses a threat to all populations of piping plovers. The plans further stated that beach maintenance and nourishment, inlet dredging, and artificial structures, such as jetties, groins, and revetments, could eliminate wintering areas and alter sedimentation patterns leading to the loss of nearby habitat. Unregulated motorized and pedestrian recreational use, inlet and shoreline stabilization projects, beach maintenance and nourishment, and pollution affect most winter and migration areas. Data from studies at Hilton Head, Kiawah Island, and other locations in South Carolina and Georgia demonstrate that impacts from poor winter habitat conditions can be seen the following year on the breeding grounds (Saunders et al. 2014; Gibson et al. 2016). Piping plovers wintering at areas with fewer anthropogenic disturbances had higher survival, recruitment, and population growth rates than areas with greater disturbance.

Important components of ecologically sound barrier beach management include perpetuation of natural dynamic coastal formation processes. Structural development along the shoreline or manipulation of natural inlets upsets the dynamic processes and results in habitat loss or degradation (Melvin et al. 1991). Throughout the range of migrating and wintering piping plovers, inlet and shoreline stabilization, inlet dredging, beach maintenance and nourishment activities, and seawall installations continue to constrain natural coastal processes. Dredging of inlets can affect spit formation adjacent to inlets and directly remove or affect ebb and flood tidal shoal formation. Jetties, which stabilize an island, cause island widening and subsequent growth of vegetation on inlet shores. Seawalls restrict natural island movement and exacerbate erosion. As discussed in more detail below, all these efforts result in loss of piping plover habitat. Construction of these projects during months when piping plovers are present also causes disturbance that disrupts the birds' foraging efficiency and hinders their ability to build fat reserves over the winter and in preparation for migration, as well as their recuperation from migratory flights. In addition, up to 24 shorebird species migrate or winter along the Atlantic Coast and almost 40 species of shorebirds are present during migration and wintering periods in the Gulf of Mexico region (Helmers 1992). Continual degradation and loss of habitats used by wintering and migrating shorebirds may cause an increase in intra-specific and inter-specific competition for remaining food supplies and roosting habitats. The shrinking extent of shoreline that supports natural coastal formation processes concentrates foraging and roosting opportunities for all shorebird species, and forces some individuals into suboptimal habitats.

Thus, intra- and inter-specific competition most likely exacerbates threats from habitat loss and degradation.

Loss, modification, and degradation of habitat

The wide, flat, sparsely vegetated barrier beaches, spits, sandbars, and bayside flats preferred by piping plovers in the U.S. are formed and maintained by natural forces and are thus susceptible to degradation caused by development and shoreline stabilization efforts. As described below, barrier island and beachfront development, inlet and shoreline stabilization, inlet dredging, beach maintenance and nourishment activities, seawall installations, and mechanical beach grooming continue to alter natural coastal processes throughout the range of migrating and wintering piping plovers. Jetties stabilize inlets and cause island widening and subsequent vegetation growth on the updrift inlet shores; they also cause island narrowing and/or erosion on the downdrift inlet shores. Seawalls and revetments restrict natural island movement and exacerbate erosion. Although dredge and fill projects that place sand on beaches and dunes may restore lost or degraded habitat in some areas, in other areas these projects may degrade habitat quality by altering the natural sediment composition, depressing the invertebrate prey base, hindering habitat migration with sea level rise, and replacing the natural habitats of the dune-beach-nearshore system with artificial geomorphology. Construction of any of these projects during months when piping plovers are present also causes disturbance that disrupts the birds' foraging and roosting behaviors. These threats are exacerbated by accelerating sea level rise, which increases erosion and habitat loss where existing development and hardened stabilization structures prevent the natural migration of the beach and/or barrier island.

Development and Construction

Development and associated construction threaten the piping plover in its migration and wintering range by degrading, fragmenting, and eliminating habitat. Constructing buildings and infrastructure adjacent to the beach can eliminate roosting and loafing habitat within the development's footprint and degrade adjacent habitat by replacing sparsely vegetated dunes or back-barrier beach areas with landscaping, pools, fences, etc. In addition, bayside development can replace foraging habitat with finger canals, bulkheads, docks and lawns. High-value plover habitat becomes fragmented as lots are developed or coastal roads are built between oceanside and bayside habitats. Development activities can include lowering or removing natural dunes to improve views or grade building lots, planting vegetation to stabilize dunes, and erecting sand fencing to establish or stabilize continuous dunes in developed areas; these activities can further degrade, fragment, and eliminate sparsely vegetated and unvegetated habitats used by the piping plover and other wildlife. Development and construction of other infrastructure in close proximity to barrier beaches often creates economic and social incentives for subsequent shoreline stabilization projects, such as shoreline hardening and beach nourishment.

At present, there are approximately 2,119 miles of sandy beaches within the U.S. continental wintering range of the piping plover (**Table 5**). Approximately 40% (856 miles) of these sandy beaches are developed, with mainland Mississippi (80%), Florida (57%), Alabama (55%), South Carolina (51%), and North Carolina (49%) comprising the most developed coasts, and Mississippi barrier islands (0%), Louisiana (6%), Texas (14%) and Georgia (17%) the least developed (Rice 2012b). As discussed further below, developed beaches are highly vulnerable to further habitat loss because they cannot migrate in response to sea level rise.

Several studies highlight concerns about adverse effects of development and coastline stabilization on the quantity and quality of habitat for migrating and wintering piping plovers and other shorebirds. For example, Zdravkovic and Durkin (2011) observed fewer plovers on the developed portions of the Laguna and Gulf beach sides of South Padre Island than on undeveloped portions during both migratory and wintering surveys. Drake et al. (2001) observed that radio-tagged piping plovers overwintering along the southern Laguna Madre of Texas seldom used tidal flats adjacent to developed areas (five of 1,371 relocations of radio-marked individuals), suggesting that development and associated anthropogenic disturbances influence piping plover habitat use. Detections of piping plovers during repeated surveys of the upper Texas coast in 2008 were low in areas with significant beach development (Arvin 2009).

The development of bayside or estuarine shorelines with finger canals and their associated bulkheads, docks, buildings, and landscaping leads to direct loss and degradation of plover habitat. Finger canals are channels cut into a barrier island or peninsula from the soundside to increase the number of waterfront residential lots. Finger canals can lead to water pollution, fish kills, loss of aquatic nurseries, saltwater intrusion of groundwater, disruption of surface flows, island breaching due to the funneling of storm surge, and a perpetual need for dredging and disposal of dredged material in order to keep the canals navigable for property owners (Morris et al. 1978; Bush et al. 1996).

Rice (2012b) has identified over 900 miles (43%) of sandy beaches in the wintering range that are currently "preserved" through public ownership, ownership by non-governmental conservation organizations, or conservation easements (**Table 5**). These beaches may be subject to some erosion as they migrate in response to sea level rise or if sediment is removed from the coastal system, and they are vulnerable to recreational disturbance. However, they are the areas most likely to maintain the geomorphic characteristics of suitable piping plover habitat.

Table 5. **The lengths and percentages of sandy oceanfront beach in each state that are developed, undeveloped, and preserved as of December 2011 (**Rice 2012b**).**

State	Approximate Shoreline Beach Length (miles)	Approximate Miles of Beach Developed (percent of total shoreline length)	Approximate Miles of Beach Undeveloped (percent of total shoreline length)[a]	Approximate Miles of Beach Preserved (percent of total shoreline length)[b]
North Carolina	326	159 (49%)	167 (51%)	178.7 (55%)
South Carolina	182	93 (51%)	89 (49%)	84 (46%)
Georgia	90	15 (17%)	75 (83%)	68.6 (76%)
Florida	809	459 (57%)	351 (43%)	297.5 (37%)
-Atlantic	*372*	*236 (63%)*	*136 (37%)*	*132.4 (36%)*
-Gulf	*437*	*223 (51%)*	*215 (49%)*	*168.0. (38%)*
Alabama	46	25 (55%)	21 (45%)	11.2 (24%)
Mississippi barrier island coast	27	0 (0%)	27 (100%)	27 (100%)
Mississippi mainland coast	51[c]	41 (80%)	10 (20%)	12.6 (25%)
Louisiana	218	13 (6%)	205 (94%)	66.3 (30%)
Texas	370	51 (14%)	319 (86%)	152.7 (41%)
TOTAL	**2,119**	**856 (40%)**	**1,264 (60%)**	**901.5 (43%)**

[a] Beaches classified as "undeveloped" occasionally include a few scattered structures.

[b] Preserved beaches include public ownership, ownership by non-governmental conservation organizations, and conservation easements. The miles of shoreline that have been preserved generally overlap with the miles of undeveloped beach but may also include some areas (e.g., in North Carolina) that have been developed with recreational facilities or by private inholdings.

[c] The mainland Mississippi coast along Mississippi Sound includes 51.3 miles of sandy beach as of 2010-2011, out of approximately 80.7 total shoreline miles (the remaining portion is non-sandy, either marsh or armored coastline with no sand). See Rice 2012b for details.

In summary, approximately 40% of the sandy beach shoreline in the migration and wintering range is already developed, while 43% are largely preserved. This means, however, that the remaining 17% of shoreline habitat (that which is currently undeveloped but not preserved) is susceptible to future loss to development and the attendant threats from shoreline stabilization activities and sea level rise.

Dredging and Sand Mining

The dredging and mining of sediment from inlet complexes threatens the piping plover on its wintering grounds through habitat loss and degradation. The maintenance of navigation channels by dredging, especially deep shipping channels such as those in Alabama and Mississippi can significantly alter the natural coastal processes on inlet shorelines of nearby barrier islands, as described by Otvos (2006), Morton (2008), Otvos and Carter (2008), and Stockdon et al. (2010). Cialone and Stauble (1998) describe the impacts of mining ebb shoals within inlets as a source of beach fill material at eight locations and provide a recommended monitoring protocol for future mining events.

Forty-four percent of the tidal inlets within the U.S. wintering range of the piping plover have been or continue to be dredged, primarily for navigational purposes (**Table 6**). States where more than two-thirds of inlets have been dredged include Alabama (three of four), Mississippi (four of six), North Carolina (16 of 20), and Texas (13 of 18), and 16 of 21 along the Florida Atlantic coast. The dredging of navigation channels or relocation of inlet channels for erosion-control purposes contributes to the cumulative effects of inlet habitat modification by removing or redistributing the local and regional sediment supply; the maintenance dredging of deep shipping channels can convert a natural inlet that normally bypasses sediment from one shoreline to the other into a sediment sink, where sediment no longer bypasses the inlet.

Table 6. The number of open tidal inlets, inlet modifications, and artificially closed inlets in each state as of December 2011. Numbers for North Carolina are as of September 2016 (USFWS 2012; Rice 2012a; 2016).

State	Existing Inlets							Artificially closed
	Number of Inlets	Total Number of Modified Inlets	Habitat Modification Type					
			structures[a]	dredged	relocated	mined	artificially opened	
North Carolina	20	17 (85%)	7	16	5	10	4	13
South Carolina	47	21 (45%)	17	11	2	3	0	1
Georgia	23	6 (26%)	5	3	0	1	0	0
Florida *-Atlantic*	21	19 (90%)	19	16	0	3	10	0
Florida *-Gulf*	48	24 (50%)	20	22	0	6	7	1
Alabama	4	4 (100%)	4	3	0	0	0	2
Mississippi	6	4 (67%)	0	4	0	0	0	0
Louisiana	34	10 (29%)	7	9	1	2	0	46
Texas	18	14 (78%)	10	13	2	1	11	3
TOTAL	221	119 (54%)	89 (40%)	97 (44%)	8 (4%)	20 (9%)	30 (14%)	64 (N/A)

[a] Structures include jetties, terminal groins, groin fields, rock or sandbag revetments, seawalls, and offshore breakwaters.

Among the dredged inlets identified in Rice (2012a), dredging efforts began as early as the 1800s and continue to the present, generating long-term and even permanent effects on inlet habitat; at least 11 inlets were first dredged in the 19th century, with the Cape Fear River (North Carolina) being dredged as early as 1826 and Mobile Pass (Alabama) in 1857. Dredging can occur on an annual basis or every two to three years, resulting in continual perturbations and modifications to inlet and adjacent shoreline habitat. The volumes of sediment removed can be major, with 2.2 million cubic yards (mcy) of sediment removed on average every 1.9 years from the Galveston Bay Entrance (Texas) and 3.6 mcy of sediment removed from Sabine Pass (Texas) on average every 1.4 years (USACE 1992).

As sand sources for beach nourishment projects have become more limited, the mining of ebb tidal shoals for sediment has increased (Cialone and Stauble 1998). This is a problem because exposed ebb and flood tidal shoals and sandbars are prime roosting and foraging habitats for piping plovers. In general, such areas are only accessible by boat; and as a result, they tend to receive less human recreational use than nearby mainland beaches. Rice (2012a) found that the ebb shoal complexes of at least 20 inlets within the wintering range of the piping plover have been mined for beach fill. Ebb shoals are especially important because they act as "sand bridges" that connect beaches and islands by transporting sediment via longshore transport from one side (updrift) to the other (downdrift) side of an inlet. The mining of sediment from these shoals upsets the inlet system equilibrium and can lead to increased erosion of the adjacent inlet shorelines (Cialone and Stauble 1998). Rice (2012a) noted that this mining of material from inlet shoals for use as beach fill is not equivalent to the natural sediment bypassing that occurs at unmodified inlets for several reasons, most notably for the massive volumes involved that are "transported" virtually instantaneously instead of gradually and continuously and for the placement of the material outside of the immediate inlet vicinity, where it would naturally bypass. The mining of inlet shoals can remove massive amounts of sediment, with 1.98 mcy mined for beach fill from Longboat Pass (Florida) in 1998, 1.7 mcy from Shallotte Inlet (North Carolina) in 2001 and 1.6 mcy from Redfish Pass (Florida) in 1988 (Cialone and Stauble 1998; USACE 2004). Cialone and Stauble (1998) found that monitoring of the impacts of ebb shoal mining has been insufficient, and in one case the mining pit was only 66% recovered after five years; they conclude that the larger the volume of sediment mined from the shoals, the larger the perturbation to the system and the longer the recovery period.

Information is limited on the effects to piping plover habitat of the deposition of dredged material, and the available information is inconsistent. Drake et al. (2001) concluded that the conversion of bayshore tidal flats of southern Texas mainland to dredged material impoundments results in a net loss of habitat for wintering piping plovers because such impoundments eventually convert to upland habitat. Although Zdravkovic and Durkin (2011) found 200 piping plovers on the Mansfield Channel dredge material islands during a survey in late 2009, none were counted there in early 2011. By contrast, most of the sound islands where Cohen et al. (2008) found foraging piping plovers at Oregon Inlet, North Carolina were created by the U.S. Army Corps of Engineers from dredged material. Another example is Pelican Island, in Corpus Christi Bay, Texas, where dredged material is consistently used by piping plovers (Cobb pers. comm. 2012a). Research is needed to understand why piping plovers use some dredge material islands, but are not regularly found using many others.

In summary, the removal of sediment from inlet complexes via dredging and sand mining for beach fill has modified nearly half of the tidal inlets within the continental wintering range of the piping plover, leading to habitat loss and degradation. Many of these inlet habitat modifications have become permanent, existing for over 100 years. The expansion of several harbors and ports to accommodate deeper draft ships poses an increasing threat as more sediment is removed from the inlet system, causing larger perturbations and longer recovery times; maintenance dredging conducted annually or every few years may prevent full recovery of the inlet system. Sand removal or sediment starvation of shoals, sandbars and adjacent shoreline habitat has resulted in habitat loss and degradation, which may reduce the system's ability to maintain a full suite of inlet habitats as sea level continues to rise at an accelerating rate. Rice (2012a) noted that the adverse impacts of this threat to piping plovers may be mitigated, however, by eliminating dredging and mining activities in inlet complexes with high habitat value, extending the interval between dredging cycles, discharging dredged material in nearshore downdrift waters so that it can accrete more naturally than when placed on the subaerial beach, and designing dredged material islands to mimic natural shoals and flats.

Inlet Stabilization and Relocation

Many navigable tidal inlets along the Atlantic and Gulf coasts are stabilized with hard structures. A description of the different types of stabilization structures typically constructed at or adjacent to inlets – jetties, terminal groins, groins, seawalls, breakwaters and revetments – can be found in the *Manual for Coastal Hazard Mitigation* (Herrington 2003) and in *Living by the Rules of the Sea* (Bush et al. 1996).

The adverse direct and indirect impacts of hard stabilization structures at inlets and inlet relocations can be significant. The impacts of jetties on inlet and adjacent shoreline habitat have been described by Cleary and Marden (1999), Bush et al. (1996), Wamsley and Kraus (2005), USFWS (2009a), Thomas et al. (2011), and many others. The relocation of inlets or the creation of new inlets often leads to immediate widening of the new inlet and loss of adjacent habitat, among other impacts, as described by Mason and Sorenson (1971), Masterson et al. (1973), USACE (1992), Cleary and Marden (1999), Cleary and Fitzgerald (2003), Wamsley and Kraus (2005), and Kraus (2007).

Rice (2012a) found that, as of 2011, an estimated 54% of 221 mainland or barrier island tidal inlets in the U.S continental wintering range of the piping plover had been modified by some form of hardened structure, dredging, relocation, mining, or artificial opening or closure (**Table 6**). On the Atlantic Coast, 43% of the inlets have been stabilized with hard structures, whereas 37% were stabilized on the Gulf Coast. The Atlantic coast of Florida has 17 stabilized inlets adjacent to each other, extending between the St. John's River in Duval County and Norris Cut in Miami-Dade County, a distance of 341 miles. A shorebird would have to fly nearly 344 miles between unstabilized inlets along this stretch of coast.

The state with the highest proportion of natural, unmodified inlets is Georgia (74%). The highest number of adjacent unmodified, natural inlets is the 15 inlets found in Georgia between Little Tybee Slough at Little Tybee Island Nature Preserve and the entrance to Altamaha Sound at the south end of Wolf Island National Wildlife Refuge, a distance of approximately 54 miles. Another relatively long stretch of adjacent unstabilized inlets is in Louisiana, where 17 inlets between a complex of breaches on the West Belle Pass barrier headland (in Lafourche Parish) and Beach Prong (near the western boundary of the state Rockefeller Wildlife Refuge) have no stabilization structures; one of these inlets (the Freshwater Bayou Canal), however, is dredged (Rice 2012a).

Unstabilized inlets naturally migrate, reforming important habitat components over time, particularly during a period of rising sea level. Inlet stabilization with rock jetties and revetments alters the dynamics of longshore sediment transport and the natural movement and formation of inlet habitats such as shoals, unvegetated spits and flats. Once a barrier island becomes "stabilized" with hard structures at inlets, natural overwash and beach dynamics are restricted, allowing encroachment of new vegetation on the bayside that replaces the unvegetated (open) foraging and roosting habitats that plovers prefer. Rice (2012a) found that 40% (89 out of 221) of the inlets open in 2011 have been stabilized in some way, contributing to habitat loss and degradation throughout the wintering range. Accelerated erosion may compound future habitat loss, depending on the degree of sea level rise (Titus et al. 2009). Due to the complexity of impacts associated with projects such as jetties and groins, Harrington (2008) noted the need for a better understanding of potential effects of inlet-related projects, such as jetties, on bird habitats.

Relocation of tidal inlets also can cause loss and/or degradation of piping plover habitat. Although less permanent than construction of hard structures, the effects of inlet relocation can persist for years. For example, December-January surveys documented a continuing decline in wintering plover numbers from 20 birds pre-project (2005-2006) to three birds during the 2009 - 2011 seasons (SCDNR 2011). The subsequent decline in the wintering population on Kiawah is strongly correlated with the decline in polychaete worm densities, suggesting that plovers may have emigrated to other sites as foraging opportunities in these habitats became less profitable (SCDNR 2011). At least eight inlets in the migration and wintering range have been relocated; a new inlet was cut and the old inlet was closed with fill. In other cases, inlets have been relocated without the old channels being artificially filled (**Table 6**).

The artificial opening and closing of inlets typically creates very different habitats from those found at inlets that open or close naturally (Rice 2012a). Rice (2012a) found that 30 inlets have been artificially created within the migration and wintering range of the piping plover, including 10 of the 21 inlets along the eastern Florida coast (**Table 6**). These artificially created inlets tend to need hard structures to remain open or stable, with 20 of the 30 (67%) of them having hard structures at present. An even higher number of inlets (64) have been artificially closed, the majority in Louisiana (**Table 6**). One inlet in Texas was closed as part of the Ixtoc oil spill response efforts in 1979 and 32 were closed as part of Deepwater Horizon oil spill response efforts in 2010-2011. Of the latter, 29 were in Louisiana, two in Alabama and one in Florida. To date only one of these inlets, West (Little Lagoon) Pass in Gulf Shores, Alabama, has been reopened, and the rest remain closed with no plans to reopen any of those identified by Rice (2012a). Most other artificial inlet closures in Louisiana are part of barrier island restoration projects, because much of that state's barrier islands are disintegrating (Otvos 2006; Morton

2008; Otvos and Carter 2008). Inlets closed during coastal restoration projects in Louisiana are purposefully designed to approximate low, wide naturally closed inlets and to allow overwash in the future. By contrast, most artificially closed inlets have higher elevations and tend to have a constructed berm and dune system. Overwash may occur periodically at a naturally closed inlet but is prevented at an artificially closed inlet by the constructed dune ridge, hard structures, or sandbags (Rice 2012a).

The construction of jetties, groins, seawalls and revetments at inlets leads to habitat loss and both direct and indirect impacts to adjacent shorelines. Rice (2012a) found that these structures result in long-term effects, with at least 13 inlets across six of the eight states having hard structures initially constructed in the 19th century. The cumulative effects are ongoing and increasing in intensity, with hard structures built as recently as 2011 and others proposed for 2012. With sea level rising and global climate change altering storm dynamics, pressure to modify the remaining half of sandy tidal inlets in the range is likely to increase, notwithstanding that this would be counterproductive to the climate change adaptation strategies recommended by the USFWS (2010d), CCSP (2009), Williams (2013), Pilkey and Young (2009), and many others.

Groins

Groins pose an ongoing threat to piping plover beach habitat within the continental wintering range. Groins are hard structures built perpendicular to the shoreline (sometimes in a T-shape), designed to trap sediment traveling in the littoral drift and to slow erosion on a particular stretch of beach or near an inlet. "Leaky" groins, also known as permeable or porous groins, are low-crested structures built like typical groins but which allow some fraction of the littoral drift or longshore sediment transport to pass through the groin. They have been used as terminal groins near inlets or to hold beach fill in place for longer durations. Although groins can be individual structures, they are often clustered along the shoreline in "groin fields." Because they intentionally act as barriers to longshore sand transport, groins cause downdrift erosion, which degrades and fragments sandy beach habitat for the piping plover and other wildlife. The resulting beach typically becomes scalloped in shape, thereby fragmenting plover habitat over time.

Groins and groin fields are found throughout the southeastern Atlantic and Gulf Coasts and are present at 28 of 221 sandy tidal inlets (Rice 2012a). Leaky terminal groins have been installed at the south end of Amelia Island, Florida, the west end of Tybee Island, Georgia, and the north end of Hilton Head Island, South Carolina. Permeable or leaky groins have also been constructed on the beaches of Longboat Key and Naples, Florida, and terminal groins were approved in 2011 for use in up to four inlet locations in North Carolina (reversing a nearly 30-year prohibition on hard stabilization structures in that state).

Although most groins were in place before the piping plover's 1986 ESA listing, new groins continue to be installed, perpetuating the threat to migrating and wintering piping plovers. Two groins were built in South Carolina between 2006 and 2010, bringing the statewide total to 165 oceanfront groins (SC DHEC 2010). Eleven new groins were built in Florida between 2000 and 2009. The East Pass Navigation Project in Okaloosa County, Florida (USFWS 2009c) illustrates the negative impacts to plover habitat that can be associated with groins, which are often built as one component of a much larger shoreline or inlet stabilization project. The East Pass Navigation Project includes two converging jetties, one with a groin at the end, with dredged material placed on either side to stabilize the jetties; minimal piping plover foraging habitat remains due to changed inlet morphology. As sea level rises at an accelerating rate, the threat of habitat loss, fragmentation and degradation from groins and groin fields may increase as communities and beachfront property owners seek additional ways to protect infrastructure and property.

Seawalls and Revetments

Seawalls and revetments are hard vertical structures built parallel to the beach in front of buildings, roads, and other facilities. Although they are intended to protect human infrastructure from erosion, these armoring structures often accelerate erosion by causing scouring both in front of and downdrift from the structure, which can eliminate intertidal plover foraging and adjacent roosting habitat. Physical characteristics that determine microhabitats and biological communities can be altered after installation of a seawall or revetment, thereby depleting or changing composition of benthic communities that serve as the prey base for piping plovers. Dugan and Hubbard (2006) found in a California study that intertidal zones were narrower and fewer in the presence of armoring, armored beaches had significantly less macrophyte wrack, and shorebirds responded with significantly lower abundance (more than three times lower) and species richness (2.3 times lower) than on adjacent unarmored beaches. As sea level rises, seawalls will prevent the coastline from moving inland, causing loss of intertidal foraging habitat (Galbraith et al. 2002; Defeo et al. 2009). Geotubes (long cylindrical bags made of high-strength permeable fabric and filled with sand) are less permanent alternatives, but they prevent overwash and thus the natural production of sparsely vegetated habitat.

Rice (2012b) found that at least 230 miles of beach habitat has been armored with hard erosion-control structures. Data were not available for all areas, so this number is a minimum estimate of the length of habitat that has been directly modified by armoring. Out of 221 inlets surveyed, 89 were stabilized with some form of hard structure, of which 24 had revetments or seawalls along their shorelines. The Texas coast is armored with nearly 37 miles of seawalls, bulkheads and revetments, the mainland Mississippi coast has over 45 miles of armoring, the Florida Atlantic coast has at least 58 miles, and the Florida Gulf coast over 59 miles (Rice 2012b). Shoreline armoring has modified plover beachfront habitat in all states, but Alabama (4.7 miles), Georgia (10.5 miles) and Louisiana (15.9 miles) have the fewest miles of armored beaches.

Although North Carolina has prohibited the use of hard erosion-control structures or armoring since 1985 the “temporary” installation of sandbag revetments is allowed. As a result the precise length of armored sandy beaches in North Carolina is unknown, but at least 350 sandbag revetments have been constructed (Rice 2012b). South Carolina also limits the installation of some types of new armoring but already has 24 miles (27% of the developed shoreline or 13% of the entire shoreline) armored with some form of shore-parallel erosion-control structure (SC DHEC 2010).

The repair of existing armoring structures and installation of new structures continues to degrade, destroy, and fragment beachfront plover habitat throughout its continental wintering range. As sea level rises at an accelerating rate, the threat of habitat loss, fragmentation and degradation from hard erosion-control structures is likely to increase as communities and property owners seek to protect their beachfront development. As coastal roads become threatened by rising sea level and increasing storm damage, additional lengths of beachfront habitat may be modified by riprap, revetments, and seawalls.

Sand Placement Projects

Sand placement projects threaten the piping plover and its habitat by altering the natural, dynamic coastal processes that create and maintain beach strand and bayside habitats, including the habitat components that piping plovers rely upon. Although specific impacts vary depending on a range of factors, so-called "soft stabilization" projects may directly degrade or destroy roosting and foraging habitat in several ways. Beach habitat may be converted to an artificial berm that is densely planted in grass, which can in turn reduce the availability of roosting habitat. Over time, if the beach narrows due to erosion, additional roosting habitat between the berm and the water can be lost. Berms can also prevent or reduce the natural overwash that creates and maintains sparsely vegetated roosting habitats. The growth of vegetation resulting from impeding the natural overwash can also reduce the availability of bayside intertidal feeding habitats.

Overwash is an essential process, necessary to maintain the integrity of many barrier islands and to create new habitat (Donnelly et al. 2006). In a study on the Outer Banks of North Carolina, Smith et al. (2008) found that human "modifications to the barrier island, such as construction of barrier dune ridges, planting of stabilizing vegetation, and urban development, can curtail or even eliminate the natural, self-sustaining processes of overwash and inlet dynamics." They also found that such modifications led to island narrowing from both oceanside and bayside erosion. Lott et al. (2009b) found a strong negative correlation between ocean shoreline sand placement projects and the presence of piping and snowy plovers in the Panhandle and southwest Gulf Coast regions of Florida.

Sand placement projects threaten migration and wintering habitat of the piping plover in every state throughout the range (Rice 2012b, **Table 7**). At least 684.8 miles (32%) of sandy beach habitat in the continental wintering range of the piping plover have received artificial sand placement via dredge disposal activities, beach nourishment or restoration, dune restoration, emergency berms, inlet bypassing, inlet closure and relocation, and road reconstruction projects. In most areas, sand placement projects are in developed areas or adjacent to shoreline or inlet hard stabilization structures in order to address erosion, reduce storm damages, or ameliorate sediment deficits caused by inlet dredging and stabilization activities.

The beaches along the mainland coast of Mississippi are the most modified by sand placement activities with at least 85% affected (**Table 7**). Of the oceanfront beaches, the Atlantic coast of Florida has had the highest proportion (at least 51%) of beaches modified by sand placement activities. Approximately 47% of Florida's sandy beach coastline has received sand placement of some type, with many areas receiving fill multiple times from dredge disposal, emergency berms, beach nourishment, dune restoration and other modifications (Rice 2012b).

Table 7. Approximate shoreline miles of sandy beach that have been modified by sand placement activities for each state in the U.S. continental wintering range of the piping plover as of December 2011. These totals are minimum numbers, given missing data for some areas (Rice 2012b; USFWS 2012).

State	Known Approximate Miles of Beach Receiving Sand	Proportion of Modified Sandy Beach Shoreline
North Carolina	91.3	28%
South Carolina	67.6	37%
Georgia	5.5	6%
Florida Atlantic coast	189.7	51%
Florida Gulf coast	189.9	43%
Alabama	7.5	16%
Mississippi barrier island coast	1.1	4%
Mississippi mainland coast	43.5	85%
Louisiana	60.4	28%
Texas	28.3	8%
TOTAL	**684.8+**	**32%**

In Louisiana, the sustainability of the coastal ecosystem is threatened by the inability of the barrier islands to maintain geomorphologic functionality. The state's coastal systems are starved for sediment sources (USACE 2010). Consequently, most of the planned sediment placement projects in Louisiana are conducted as environmental restoration projects by various federal and state agencies because without the sediment many areas would erode below sea level. Several Louisiana Coastal Wetland Planning, Protection, and Restoration Act projects have been constructed on portions of undeveloped islands within the Terrebonne Basin to restore and maintain the diverse functions of those barrier island habitats (USFWS 2010b). Altogether over 60 miles of sandy beaches have been modified with sand placement projects in Louisiana, both through restoration projects and in response to the Deepwater Horizon oil spill (Rice 2012b).

Both the number and the size of sand projects along the Atlantic and Gulf coasts are increasing (Trembanis et al. 1999), and these projects are increasingly being chosen as a means to combat sea level rise and related beach erosion problems (Klein et al. 2001). Lott et al. (2009a) documented an increasing trend in sand placement events in Florida (**Figure 5**). In northwest Florida, the USFWS consulted on first-time sand placement projects along 46 miles of shoreline in 2007-2008. Much of this work was authorized on public lands (Gulf Islands National Seashore, portions of St. Joseph State Park, and at Eglin Air Force Base). Throughout the plover migration and wintering range, the number of sand placement events has increased every decade for which records are available, with at least 710 occurring between 1939 and 2007, and more than 75% occurring since 1980 (Trembanis et al. 1999). The cumulative volume of sand placed on East Coast beaches has risen exponentially since the 1920s (Trembanis et al. 1999). As a result, sand placement projects increasingly pose threats to plover habitat. As of 2011, at least 32% (~ 685 miles) of the sandy beaches in the continental wintering range have had one or more sand placement projects.

Loss of Macroinvertebrate Prey Base due to Shoreline Stabilization

Wintering and migrating piping plovers depend on the availability and abundance of macroinvertebrates as an important food item. Studies of invertebrate communities have found that communities are richer (greater total abundance and biomass) on protected (bay or lagoon) intertidal shorelines than on exposed ocean beach shorelines (Cohen et al. 2006; Defeo and McLachlan 2011). Polychaete worms comprise the majority of the shorebird diet (Tsipoura and Burger 1999; Verkuil et al. 2006); and of the piping plover diet in particular (Hoopes 1993; Nicholls 1989; Zonick and Ryan 1996).

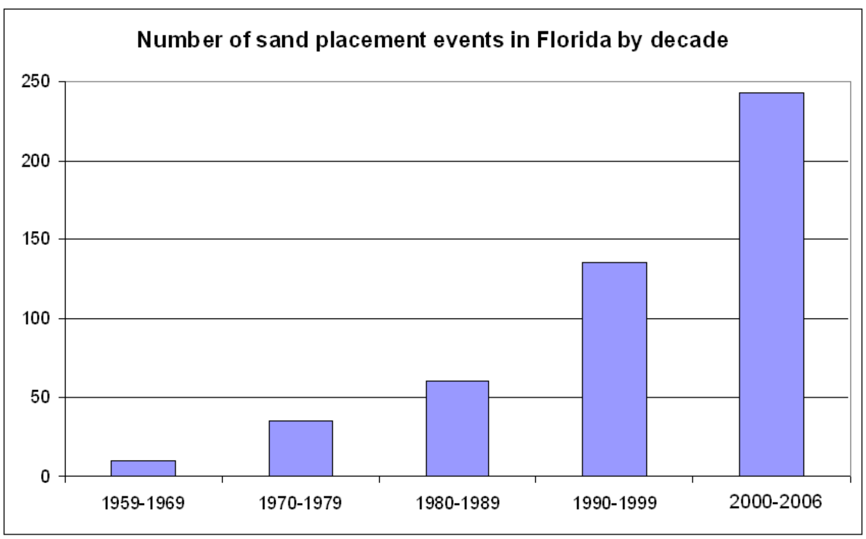

Figure 5. Number of sand placement events per decade in Florida between 1959-1999, and 2000-2006 **(**from Lott et al. 2009b).

The quality and quantity of the macroinvertebrate prey base is threatened by shoreline stabilization activities, including the approximately 685 miles of beaches that have received sand placement of various types. The addition of dredged sediment can temporarily affect the benthic fauna of intertidal systems. Invertebrates may be crushed or buried during project construction.

Although some benthic species can burrow through a thin layer of additional sediment (38-89 cm for different species), thicker layers (i.e., >1 meter) are likely to smother these sensitive benthic organisms (Greene 2002). Numerous studies of such effects indicate that the recovery of benthic fauna after beach nourishment or sediment placement projects can take anywhere from six months to two years, and possibly longer in extreme cases (Thrush et al. 1996; Bishop et al. 2006; Peterson et al. 2006).

Invertebrate communities may also be affected by changes in the physical environment resulting from shoreline stabilization activities that alter the sediment composition or degree of exposure. For example, SCDNR (2011) found the decline in piping plovers to be strongly correlated with a decline in polychaete densities on the east end of Kiawah Island, South Carolina, following an inlet relocation project in 2006. Similar results were documented on Bird Key, South Carolina, in 2006 when rapid habitat changes occurred within the sheltered lagoon habitat following dredge disposal activities, and piping plovers shifted to more exposed areas. Their diet also appeared to have shifted to haustoriid amphipods, based on analysis of fecal samples containing pieces of *Neohaustorius schmitzi*, *Lepidactylus dytiscus*, and *Acanthohaustorius* sp., which were also found during the invertebrate sampling in both locations (SCDNR 2011).

Shoreline armoring with hard stabilization structures such as seawalls and revetments can also alter the degree of exposure of the macroinvertebrate prey base by modifying the beach and intertidal geomorphology, or topography. Seawalls typically result in the narrowing and steepening of the beach and intertidal slope in front of the structure, eventually leading to complete loss of the dry and intertidal beach as sea level continues to rise (Pilkey and Wright 1988; Hall and Pilkey 1991; Dugan and Hubbard 2006; Defeo et al. 2009; Kim et al. 2011).

Sand placement projects bury the natural beach with up to millions of cubic yards of new sediment, and grade the new beach and intertidal zone with heavy equipment to conform to a predetermined topographic profile. This can lead to compaction of the sediment (Nelson et al. 1987; USACE 2008; Defeo et al. 2009). If the material used in a sand placement project does not closely match the native material on the beach, the sediment incompatibility may result in modifications to the macroinvertebrate community structure, because several species are sensitive to grain size and composition (Rakocinski et al. 1996; Peterson et al.2006; Peterson and Bishop 2005; Colosio et al. 2007; Defeo et al. 2009).

Delayed recovery of the benthic prey base or changes in their communities due to physical habitat changes may affect the quality of piping plover foraging habitat. The duration of the impact can adversely affect piping plovers because of their high site fidelity. Although recovery of invertebrate communities has been documented in many studies, sampling designs have typically been inadequate and have only been able to detect large-magnitude changes (Schoeman et al. 2000; Peterson and Bishop 2005). Therefore, uncertainty persists about the impacts of various projects to invertebrate communities and how these impacts affect shorebirds, particularly the piping plover. Rice (2009) has identified several conservation measures that can avoid and minimize some of the known impacts.

Invasive Vegetation

The spread of invasive plants into suitable wintering piping plover habitat is a relatively recently identified threat (USFWS 2009a). Such plants tend to reproduce and spread quickly and to exhibit dense growth habits, often outcompeting native plants. Uncontrolled invasive plants can shift habitat from open or sparsely vegetated sand to dense vegetation, resulting in the loss or degradation of piping plover roosting habitat, which is especially important during high tides and migration periods. The propensity of invasive species to spread, and their tenacity once established, make them a persistent threat that is only partially countered by increasing landowner awareness and willingness to undertake eradication activities.

Many invasive species are either currently affecting or have the potential to affect coastal beaches and thus plover habitat. Beach vitex (*Vitex rotundifolia*) is a woody vine introduced into the southeastern U.S. as a dune stabilization and ornamental plant which has spread to coastal communities throughout the southeastern U.S. from Virginia to Florida, and west to Texas (Westbrooks and Madsen 2006). Hundreds of beach vitex occurrences and targeted eradication efforts in North and South Carolina and a small number of known locations in Georgia and Florida are discussed in the 5-Year Review (USFWS 2009a). Crowfootgrass (*Dactyloctenium aegyptium*), which grows invasively along portions of the Florida coastline, forms thick bunches or mats that can change the vegetative structure of coastal plant communities and thus alter shorebird habitat (USFWS 2009a; Florida Exotic Pest Plant Council 2009). Australian pine (*Casuarina equisetifolia*) affects piping plovers and other shorebirds by encroaching on foraging and roosting habitat (Stibolt 2011); it may also provide perches for avian predators. Japanese sedge *(Carex kobomugi)*, which aggressively encroaches into sand beach habitats (USDA plant profile website), was documented in Currituck County, North Carolina, in the mid-1970s and as recently as 2003 on Currituck National Wildlife Refuge (Gramling pers. comm. 2011), at two sites where migrating piping plovers have also been documented.

Defeo et al. (2009) cite biological invasions of both plants and animals as global threats to sandy beaches, with the potential to alter the food web, nutrient cycling and invertebrate assemblages. Although the extent of the threat is uncertain, this may be due to poor survey coverage more than an absence of invasions.

Wrack Removal and Beach Cleaning

Wrack on beaches and baysides provides important foraging and roosting habitat for piping plovers (Drake 1999a; Smith 2007; Maddock et al. 2009; Lott et al. 2009b) and for many other shorebirds. Because shorebird numbers are positively correlated both with wrack cover and the biomass of their invertebrate prey that feed on wrack (Tarr and Tarr 1987; Hubbard and Dugan 2003; Dugan et al. 2003), beach grooming has been shown to decrease bird numbers (Defeo et al. 2009).

It is increasingly common for beach-front communities to carry out "beach cleaning" and "beach raking" activities. Beach cleaning is conducted on private beaches, where piping plover use is not well documented, and on some municipal or county beaches used by piping plovers. Most wrack removal on state and federal lands is limited to post-storm cleanup and does not occur regularly. Wrack removal and beach raking both occur on the Gulf beach side of the developed portion of South Padre Island in the Lower Laguna Madre in Texas, where plovers have been documented during both the migratory and wintering periods (Zdravkovic and Durkin 2011). Wrack removal and other forms of beach cleaning have been the subject of formal consultations between the U.S. Army Corps of Engineers, municipalities, and USFWS in Nueces County, Texas (USFWS 2008c, 2009c).

Although beach cleaning and raking machines effectively remove human-made debris, these efforts also remove accumulated wrack, topographic depressions, emergent foredunes and hummocks, and sparse vegetation nodes used by roosting and foraging piping plovers (Nordstrom 2000; Dugan and Hubbard 2010). Removal of wrack also reduces or eliminates natural sand-trapping, further destabilizing the beach. Furthermore, the sand adhering to seaweed and trapped in the cracks and crevices of wrack also is lost to the beach when the wrack is removed. Although the amount of sand lost during a single sweeping activity may be small, over a period of years this loss could be significant (Neal et al. 2007).

Tilling beaches to reduce soil compaction, which is sometimes required by the USFWS for sea turtle protection after beach nourishment activities, has similar impacts to those described above. In northwest Florida, tilling on public lands is currently conducted only if the land manager determines that it is necessary. Where tilling is needed, adverse effects are reduced by Florida USFWS sea turtle protection provisions that require tilling to be above the primary wrack line, rather than within it.

As of 2009, the Florida Department of Environmental Protection's Beaches and Coastal Management Systems section had issued 117 permits allowing multiple entities to conduct beach raking or cleaning operations. Beach cleaning along 45 miles of coastline in Nueces, Kleberg, and Cameron Counties in Texas was addressed in five USFWS biological opinions completed between 2008 and 2012 (Cobb pers. comm. 2012c).

Dugan and Hubbard (2010), studying beach grooming activities on the beaches and dunes of southern California, concluded that "beach grooming has contributed to widespread conversion of coastal strand ecosystems to unvegetated sand" by removing wrack cover, increasing the transport of windblown sediment, lowering the seed bank and the survival and reproduction of native plants, and decreasing native plant abundance and richness. They argue that conserving beach ecosystems by reducing beach grooming and raking activities "could help retain sediment, promote the formation of dunes, and maintain biodiversity, wildlife, and human use in the face of rising sea level (Dugan and Hubbard 2010)."

Accelerating sea level rise and other climate change impacts

Accelerating sea level rise poses a threat to piping plovers during the migration and wintering portions of their life cycle. As noted in the previous section, threats from sea level rise are tightly intertwined with artificial coastal stabilization activities that modify and degrade habitat. If climate change increases the frequency or magnitude of extreme temperatures, piping plover survival rates may be affected. Other potential adverse and beneficial climate change-related effects (e.g., changes in the composition or availability of prey, emergence of new diseases, fewer periods of severe cold weather) are poorly understood, but cannot be discounted.

Numerous studies have documented accelerating rise in sea levels worldwide (Rahmstorf et al. 2007; CCSP 2009; Pilkey and Young 2009; Vermeer and Rahmstorf 2009). Predictions include a sea level rise of between 50 and 200 cm above 1990 levels by the year 2100 (Rahmstorf 2007; Pfeffer et al. 2008; Vermeer and Rahmstorf 2009; Grinsted et al. 2010) and potential conversion of as much as 33% of the world's coastal wetlands to open water by 2080 (IPCC 2007; CCSP 2008). Potential effects of sea level rise on piping plover roosting and foraging habitats may vary regionally due to subsidence or uplift, the geological character of the coast and nearshore, and the influence of management measures such as beach nourishment, jetties, groins, and seawalls (CCSP 2009; Galbraith et al. 2002; Gutierrez et al. 2011). Sea level rise along the U.S. Gulf Coast exceeded the global average by 13-15 cm because coastal lands there are subsiding (EPA 2009). The rate of sea level rise in Louisiana is particularly high (Louisiana Coastal Wetlands Conservation and Restoration Task Force and the Wetlands Conservation and Restoration Authority 1998). Sediment compaction and oil and gas extraction compound tectonic subsidence along the Gulf of Mexico coastline (Penland and Ramsey 1990; Morton et al. 2003; Hopkinson et al. 2008).

Low elevations and proximity to the coast make all nonbreeding piping plover foraging and roosting habitats vulnerable to the effects of rising sea level. Areas with small tidal ranges are the most vulnerable to loss of intertidal wetlands and flats (EPA 2009). Sea level rise was cited as a contributing factor in the 68% decline in tidal flats and algal mats in the Corpus Christi, Texas region (i.e., Lamar Peninsula to Encinal Peninsula) between the 1950s and 2004 (Tremblay et al. 2008). Mapping by Titus and Richman (2001) showed that more than 80% of the lowest land along the Atlantic and Gulf coasts was in Louisiana, Florida, Texas, and North Carolina.

Gutierrez et al. (2011) found that along the Atlantic coast, the central and southern Florida coast is the most likely Atlantic portion of the wintering and migration range to experience moderate to severe erosion with sea level rise.

Inundation of piping plover habitat by rising seas could lead to permanent loss of habitat, especially if those shorelines are armored with hardened structures (Dugan and Hubbard 2006; Fish et al. 2008; Defeo et al. 2009). Overwash and sand migration are impeded on the developed portions of sandy ocean beaches (Smith et al. 2008) that comprise 40% of the U.S. nonbreeding range (Rice 2012b). As the sea level rises, the ocean-facing beaches erode and attempt to migrate inland. Buildings and artificial sand dunes then prevent sand from washing back toward the lagoons (i.e., bayside), and the lagoon side becomes increasingly submerged during extreme high tides (Scavia et al. 2002). Barrier beach shorebird habitat and natural features that protect mainland developments are both diminished as a result.

Modeling by Galbraith et al. (2002) for three sea level rise scenarios at five important U.S. shorebird staging and wintering sites predicted aggregate loss of 20-70% of current intertidal foraging habitat. The most severe losses were projected at sites where the coastline is unable to move inland due to steep topography or seawalls. Of five study sites, the model predicted the lowest loss of intertidal shorebird foraging habitat at Bolivar Flats, Texas (a designated piping plover critical habitat unit) by 2050 because the habitat at that site will be able to migrate inland in response to rising sea level. The potential for such barrier island migration with rising sea level is most likely in the 42% of plover's U.S. nonbreeding range that is currently preserved from development (Rice 2012b). Although habitat losses in some areas are likely to be offset by gains in other locations, Galbraith et al. (2002) noted that time lags between these losses and the creation of replacement habitat elsewhere may have serious adverse effects on shorebird populations. Furthermore, even if piping plovers are able to move their wintering locations in response to accelerated habitat changes, there could be adverse effects on the birds' survival rates or subsequent productivity.

In summary, the magnitude of threats from sea level rise is closely linked to threats from shoreline development and artificial stabilization. These threats will be perpetuated in places where damaged structures are repaired or replaced, exacerbated where the height and strength of structures are increased, and increased at locations where development and coastal stabilization is expanded. Sites that are able to adapt to sea level rise are likely to become more important to piping plovers as habitat at developed or stabilized sites degrades.

Weather events

Storm Events

Storms are an integral part of the natural processes that form coastal habitats used by migrating and wintering piping plovers, and positive effects of storm-induced overwash and vegetation removal have been noted in portions of the wintering range. For example, biologists reported piping plover use of newly created habitats at Gulf Islands National Seashore in Florida within six months of overwash events that occurred during the 2004 and 2005 hurricane seasons (Nicholas pers. comm. 2005). Hurricane Katrina created a new inlet and improved habitat conditions on some areas of Dauphin Island, Alabama, but subsequent localized storms contributed to habitat loss there (LeBlanc pers. comm. 2009) and the inlet was subsequently closed with a rock dike as part of Deepwater Horizon oil spill response efforts (Rice 2012a). Following Hurricane Ike in 2008, Arvin (2009) reported decreased numbers of piping plovers at some heavily eroded Texas beaches in the center of the storm impact area and increases in plover numbers at sites about 100 miles to the southwest. Piping plovers were observed later in the season using tidal lagoons and pools that Hurricane Ike created behind the eroded beaches (Arvin 2009).

Adverse effects attributed to storms alone are sometimes actually due to a combination of storms and other environmental changes or human use patterns. For example, four hurricanes between 2002 and 2005 are often cited in reference to rapid erosion of the Chandeleur Islands, a chain of low-lying islands in Louisiana where the 1991 International Piping Plover Winter Census (Haig and Plissner 1992) tallied more than 350 birds. Comparison of imagery taken three years before and again several days after Hurricane Katrina found that the Chandeleur Islands had lost 82% of their combined surface area (Sallenger 2010). A review of aerial photographs taken before the 2006 Census suggested that little piping plover habitat remained (Elliott-Smith et al. 2009). However, Sallenger et al. (2009) noted that habitat changes in the Chandeleur Islands stem not only from the effects of these storms, but rather from the combined effects of the storms, and more than a thousand years of diminishing sand supply and sea level rise. Although the Chandeleur Islands marsh platform continued to erode for 22 months post-Katrina, some sand was released from the marsh sediments which in turn created beaches, spits, and welded swash bars that advanced the shoreline seaward. Despite the effects of intense erosion, the Chandeleur Islands are still providing high quality shorebird habitat in the form of sand flats, spits, and beaches used by substantial numbers of piping plovers (Catlin et al. 2011), a scenario that could continue if restoration efforts are sustainable and successful from a shorebird perspective (USACE 2010).

Storm-induced adverse effects include post-storm acceleration of human activities such as beach nourishment, sand scraping, closure of new inlets, and berm and seawall construction. Such stabilization activities can result in the loss and degradation of feeding and resting habitats. Land managers sometimes face public pressure after big storm events to plant vegetation, install sandfences, and bulldoze artificial “dunes.” For example, national wildlife refuge managers sometimes receive pressure from local communities to “restore” the beach and dunes following blow-outs from storm surges that create the overwash foraging habitat preferred by plovers (Hunter pers. comm. 2011). At least 64 inlets have been artificially closed, the vast majority of them shortly after opening in storm events (see **Table 6, page 39**). Storms also can cause widespread deposition of debris along beaches. Subsequent removal of this debris often requires large machinery that in turn can cause extensive disturbance and adversely affect habitat elements such as wrack. Challenges associated with management of public use can grow when storms increase access (Gibson et. al. 2009; LeBlanc pers. comm. 2009).

Some available information indicates that birds may be resilient, even during major storms, and move to unaffected areas without harm. Other reports suggest that birds may perish in or following storm events. Noel and Chandler (2005) suspected that changes in habitat caused by multiple hurricanes along the Georgia coastline altered the spatial distribution of piping plovers and may have contributed to the winter mortality of three individuals. Wilkinson and Spinks (1994) suggested that low plover numbers in South Carolina in January 1990 could have been partially influenced by effects on habitat from Hurricane Hugo the previous fall, while Johnson and Baldassarre (1988) found a redistribution of piping plovers in Alabama following Hurricane Elena in 1985.

Climate change studies indicate a trend toward increasing numbers and intensity of hurricane events (Emanuel 2005; Webster et al. 2005). Combined with the predicted effects of sea level rise, this trend indicates potential for increased cumulative impact of future storms on habitat. Major storms can create or enhance piping plover habitat while causing localized losses elsewhere in the wintering and migration range.

Severe Cold Weather

Several sources suggest the potential for adverse effects of severe winter cold on survival of piping plovers. The Atlantic Coast piping plover recovery plan mentioned high mortality of coastal birds and a drop from approximately 30-40 to 15 piping plovers following an intense 1989 snowstorm along the North Carolina coast (Fussell 1990). A preliminary analysis of survival rates for Great Lakes piping plovers found that the highest variability in survival occurred in spring and correlated positively with minimum daily temperature (weighted mean based on proportion of the population wintering near five weather stations) during the preceding winter (Roche pers. comm. 2010; 2012). Catlin (pers. comm. 2012b) reported that the average mass of ten piping plovers captured in Georgia during unusually cold weather in December 2010 was 5.7 grams (g) less than the average for nine birds captured in October of the same year (46.6 g and 52.4 g, respectively; $p = 0.003$).

Disturbance from recreation activities

Increasing human disturbance is a major threat to piping plovers in their coastal migration and wintering range (USFWS 2009a). Intense human disturbance in shorebird winter habitat can be functionally equivalent to habitat loss if the disturbance prevents birds from using an area (Goss-Custard et al. 1996). Nicholls and Baldassarre (1990a) found less people and off-road vehicles at sites where nonbreeding piping plovers were present than at sites without piping plovers. Pfister et al. (1992) implicate anthropogenic disturbance as a factor in the long-term decline of migrating shorebirds at staging areas. Disturbance can cause shorebirds to spend less time roosting or foraging and more time in alert postures or fleeing from the disturbances (Burger 1991; 1994; Elliott and Teas 1996; Lafferty 2001a, 2001b; Thomas et al. 2003). Shorebirds that are repeatedly flushed in response to disturbance expend energy on costly short flights (Nudds and Bryant 2000).

Shorebirds are more likely to flush from the presence of dogs than people, and breeding and nonbreeding shorebirds react to dogs from farther distances than people (Lafferty 2001a, 2001b; Lord et al. 2001; Thomas et al. 2003). Hoopes (1993) found that dogs flush breeding piping plovers from further distances than people and that both the distance the plovers move and the duration of their response is greater. Foraging shorebirds at a migratory stopover on Delaware Bay, New Jersey responded most strongly to dogs compared with other disturbances; shorebirds often failed to return within ten minutes after the dog left the beach (Burger et al. 2007). Dogs off-leash were disproportionate sources of disturbance in several studies (Thomas et al. 2003; Lafferty 2001b), but leashed dogs also disturbed shorebirds. Pedestrians walking with dogs often go through flocks of foraging and roosting shorebirds; some even encourage their dogs to chase birds.

Off-road vehicles can disrupt piping plover's normal behavior patterns. The density of off-road vehicles negatively correlated with abundance of piping plovers on the ocean beach in Texas (Zonick 2000). Cohen et al. (2008) found that radio-tagged wintering piping plovers using ocean beach habitat at Oregon Inlet in North Carolina were far less likely to use the north side of the inlet where off-road vehicle use was allowed. Ninety-six percent of piping plover detections occurred on the south side of the inlet even though it was more than four times farther away from foraging sites, prompting a recommendation that controlled management experiments be conducted to determine if recreational disturbance drives roost site selection (Cohen et al. 2008). Zdravkovic and Durkin (2011) stated that Laguna Madre Gulf beaches are considered part of the Texas state highway system and are severely impacted by unrestricted public recreational off-road vehicle use.

In a study of migrating shorebirds in Maryland, Forgues (2010) found that shorebird abundance declined with increased off-road vehicle frequency, as did the number and size of roosts. Migrants spent less time foraging in the presence of vehicles. In a before-after control-impact experiment, densities of three focal species were significantly reduced after a vehicle closure was lifted, while densities outside the closure zone exhibited little change; densities of two other species also decreased more in the area where the closure was removed, but the difference was not significant (Forgues 2010). In North Carolina, a before-after control-impact experiment using the undisturbed plots as the controls found that vehicle disturbance decreased abundance of shorebirds and altered their habitat use during fall migration (Tarr 2008).

Recreational activities, especially off-road vehicles, may degrade piping plover habitat. Tires that crush wrack into the sand render it unavailable as a roosting habitat or foraging substrate (Goldin 1993; Hoopes 1993). At four study beaches in New York and Massachusetts, Kluft and

Ginsberg (2009) found that abundance of invertebrates in pitfall trap samples and abundance of wrack was higher on vehicle-free beaches, although invertebrate abundance in wrack clumps and cores taken below them did not show consistent differences between areas open and closed to vehicles. Off-road vehicles significantly lessened densities of invertebrates on intertidal flats on the Cape Cod National Seashore in Massachusetts (Wheeler 1979). In eastern Australia, off-road vehicles use has been documented as a significant cause of invertebrate mortality on beaches (Schlacher et al. 2008a; 2008b). Results of Schlacher and Thompson (2012) in eastern Australia also suggest that channeling major pedestrian access points away from key shorebird habitat may enhance protection of their prey base.

Various local and regional examples also illustrate threats from recreation. On a 12-kilometer stretch of Mustang Island in Texas, Foster et al. (2009) observed a 25% decline in piping plover abundance and a simultaneous five-fold increase in human use over a 29-year study period, 1979 – 2007. This trend was marginally significant, but declines in two other plover species were significant; declining shorebird abundance was attributed to a combination of human disturbance and overall declines in shorebird populations (Foster et al. 2009). In South Carolina, almost half of sites with five or more piping plovers had ten or more people present during surveys conducted in 2007-2008 and more than 60% allow dogs (Maddock and Bimbi unpubl. data). Zdravkovic and Durkin (2011) noted disturbance to piping plovers in Texas from kite-boarding, windsurfing, and horseback riding.

Oil spills and other contaminants

Piping plovers may accumulate contaminants from point and non-point sources at migratory and wintering sites. Depending on the type and degree of contact, contaminants can have lethal and sub-lethal effects on birds, including behavioral impairment, deformities, and impaired reproduction (Rand and Petrocelli 1985). Notwithstanding documented cases of lightly oiled piping plovers that have survived and successfully reproduced (Amirault-Langlais et al. 2007), contaminants have both the potential to cause direct toxicity to individual birds and to negatively impact their invertebrate prey base (Chapman 1984; Rattner and Ackerson 2008). Piping plovers' extensive use of the intertidal zone puts them in constant contact with coastal habitats likely to be contaminated by water-borne spills. Negative impacts can also occur during rehabilitation of oiled birds.

Oil Spills

Following the Ixtoc spill, which began on June 3, 1979 off the coast of Mexico, approximately 350 metric tons of oil accumulated on South Texas barrier beaches, resulting in a 79% decrease in the total number of infaunal organisms on contaminated portions of the beach (Kindinger 1981; Tunnell et al. 1982). Chapman (1984) collected pre- and post-spill data on the abundance, distribution, and habitat use of shorebirds on the beaches in the affected area and saw declines in the numbers of birds as well as shifts in the habitats used. Shorebirds avoided the intertidal area of the beach, occupying the backshore or moving to estuarine habitats when most of the beach was coated. Chapman surmised that the decline in infauna probably contributed to the observed shifts in habitats used. His observations indicated that all the shorebirds, including piping plovers, avoided the contaminated sediments and concentrated in oil-free areas. Amos, however, reported that piping plovers ranked second to sanderlings in the numbers of oiled birds he observed on the beach, although there was no recorded mortality of plovers due to oil (Amos pers. comm. 2009; 2012). Oiled birds were seen for a year or more following the initial spill, likely due to continued washing in of sunken tar; but there were only occasional subsequent observations of oiled or tarred plovers (Amos pers. comm. 2009).

According to government estimates, the 2010 Deepwater Horizon Mississippi Canyon Well #252 oil spill discharged more than 200 million gallons of oil into the Gulf of Mexico (U.S. Government 2010). Containment activities, recovery of oil-water mix, and controlled burning removed some oil, but additional impacts to natural resources may stem from the 1.84 million gallons of dispersant that were applied to the spill (U.S. Government 2010). At the end of July 2010, approximately 625 miles of Gulf of Mexico shoreline was oiled. This included approximately 360 miles in Louisiana, 105 miles in Mississippi, 66 miles in Alabama, and 94 miles in Florida (U.S. Government 2010). These numbers do not address cumulative impacts or include shoreline that was cleaned earlier. The U.S. Coast Guard, the states, and responsible parties that form the Unified Command (with advice from federal and state natural resource agencies) initiated protective measures and clean-up efforts as provided in contingency plans for each state's coastline. The contingency plans identified sensitive habitats, including all ESA-listed species' habitats, which received a higher priority for response actions.

Efforts to prevent shoreline oiling and cleanup response activities can disturb piping plovers and their habitat. Although most piping plovers were on their breeding grounds in May, June, and early July when the Deepwater well was discharging oil, oil was still washing onto Gulf beaches when the plovers began arriving back on the Gulf in mid-July. Ninety percent of piping plovers detected during the prior four years of surveys in Louisiana were in the Deepwater Horizon oil spill impact zone, and Louisiana's Department of Wildlife and Fisheries reported significant disturbance to birds and their habitat from response activities. Wrack lines were removed, and sand washing equipment "cleansed" beaches (Seymour pers. comm. 2011). Potential long-term adverse effects stem from the construction of sand berms and closing of at least 32 inlets (Rice 2012a). Implementation of prescribed best management practices reduced, but did not negate, disturbance to plovers (and to other beach-dependent wildlife) from cleanup personnel, all-terrain vehicles, helicopters, and other equipment. USFWS and state biologists present during cleanup operations provided information about breeding, migrating, and wintering birds and their habitat protection needs. However, high staff turnover during the extended spill response period necessitated continuous education and training of clean up personnel (Bimbi pers. comm. 2011). Limited clean-up operations were still on-going throughout the spill area in November 2012 (Herod pers. comm. 2012). Results of a natural resources damage assessment study to assess injury to piping plovers (Fraser et al. 2010) are not yet available.

More subtle but cumulatively damaging sources of oil and other contaminants are leaking vessels located offshore or within the bays on the Atlantic and Gulf coasts, offshore oil rigs and undersea pipelines in the Gulf of Mexico, pipelines buried under the bay bottoms, and onshore facilities such as petroleum refineries and petrochemical plants. In Louisiana, about 2,500-3,000 oil spills are reported in the Gulf region each year, ranging in size from very small to thousands of barrels (Carver pers. comm. 2011). Chronic spills of oil from rigs and pipelines and natural seeps in the Gulf of Mexico generally involve small quantities of oil. The oil from these smaller leaks and seeps, if they occur far enough from land, will tend to wash ashore as tar balls. In cases such as this, the impact is limited to discrete areas of the beach, whereas oil slicks from larger spills coat longer stretches of the shoreline (Rice pers. comm. 2009). In late July and early August 2009, for example, oil suspected to have originated from an offshore oil rig in Mexican waters was observed on plumage or legs of 14 piping plovers in south Texas (Cobb pers. comm. 2012b).

Pesticides and Other Contaminants

A piping plover was found among dead shorebirds discovered on a sandbar near Marco Island, Florida following the county's aerial application of the organophosphate pesticide Fenthion for mosquito control in 1997 (Pittman 2001; Williams 2001). Subsequent to further investigations of bird mortalities associated with pesticide applications and to a lawsuit being filed against the Environmental Protection Agency in 2002, the manufacturer withdrew Fenthion from the market, and Environmental Protection Agency banned all use after November 30, 2004 (American Bird Conservancy 2007). Absent identification of contaminated substrates or observation of direct mortality of shorebirds on a site used by migrating and wintering piping plovers, detection of contaminants threats is most likely to occur through analysis of unhatched eggs. Contaminants in eggs can originate from any point in the bird's annual cycle, and considerable effort may be required to ascertain where in the annual cycle exposure occurred.

There has been limited opportunistic testing of piping plover eggs. Polychlorinated biphenol (PCB) concentrations in several composites of Great Lakes piping plover eggs tested in the 1990s had potential to cause reproductive harm. Analysis of prey available to piping plovers at representative Michigan breeding sites indicated that breeding areas along the upper Great Lakes region were not likely the major source of contaminants to this population (Best pers. comm. 1999 in USFWS 2003a). Relatively high levels of PCB, dichloro diphenyl dichloroethylene (DDE), and polybrominated diphenyl ether (PBDE) were detected in one of two clutches of Ontario piping plover eggs analyzed in 2009 (Cavalieri pers. comm. 2011). Results of opportunistic egg analyses to date from Atlantic Coast piping plovers did not warrant follow-up investigation (Mierzykowski 2009; 2010; 2012; Mierzykowski pers. comm. 2012). No recent testing has been conducted for contaminants in the Northern Great Plains piping plover population.

Energy development

Land-based Oil and Gas Exploration and Development

Various oil and gas exploration and development activities occur along the Gulf Coast. Examples of conservation measures prescribed to avoid adverse effects on piping plovers and their habitats include conditions on driving on beaches and tidal flats, restrictions on discharging fresh water across unvegetated tidal flats, timing exploration activities during times when the plovers are not present, and use of directional drilling from adjacent upland areas (USFWS 2008d; Firmin pers. comm. 2012). With the implementation of appropriate conditions, threats to nonbreeding piping plovers from land-based oil and gas extraction are currently very low.

Wind Turbines

Wind turbines are a potential future threat to piping plovers in their coastal migration and wintering range. Relatively small single turbines have been constructed along the beachfront in at least a few locations (Caldwell pers. comm. 2012). Current risk to piping plovers from several wind farms located on the mainland north and west of several bays in southern Texas is deemed low during months of winter residency because the birds are not believed to traverse these areas in their daily movements (Newstead pers. comm. 2012a). To date, no piping plovers have been reported from post-construction carcass detection surveys at these sites (Clements pers. comm. 2012). However, Newstead (pers. comm. 2012a) has raised questions about collision risk during migration departure, as large numbers of piping plovers have been observed in areas of the Laguna Madre east of the wind farms during the late winter. Furthermore, there is concern that, as sea level rises, the intertidal zone (and potential piping plover activity) may move closer to these sites. Several off-shore wind farm proposals in South Carolina are in various stages of early scoping (Caldwell pers. comm. 2012).

In addition to uncertainty regarding the location and design (e.g., number and height of turbines) of future wind turbines, the magnitude of potential threats is difficult to assess without better information about piping plover movements and behaviors. For wind projects situated on barrier beaches, bay shorelines, or within bays, relevant information includes the flight routes of piping plovers moving among foraging and roosting sites, flight altitude, and avoidance rates under varying weather and light conditions. For off-shore wind projects, piping plover migration routes and altitude, as well as avoidance rates will be key determinants of threats.

Predation

The extent of predation on migrating or wintering piping plovers remains largely unknown and is difficult to document. Avian and mammalian predators are common throughout the species' wintering range. Human activities affect the types, numbers, and activity patterns of some predators, thereby exacerbating natural predation on breeding piping plovers (USFWS 1996).

One incident involving a cat observed stalking piping plovers was reported in Texas (NY Times 2007). It has been estimated that free-roaming cats kill over one billion birds every year in the U.S., representing one of the largest single sources of human-influenced mortality for small native wildlife (Sax and Gaines 2008).

Predatory birds, including peregrine falcons, merlin, and harriers, are present in the nonbreeding range. Newstead (pers. comm. 2012b) reported two cases of suspected avian depredation of piping plovers in a Texas telemetry study, but he also noted that red tide may have compromised the health of these plovers. It has been noted, however, that the behavioral response of crouching when in the presence of avian predators may minimize avian predation on piping plovers (Morrier and McNeil 1991; Drake 1999a; Drake et al. 2001). Drake (1999a) theorized that this piping plover behavior enhances concealment associated with roosting in depressions and debris in Texas.

Nonbreeding piping plovers may reap some collateral benefits from predator management conducted for the primary benefit of other species. Florida Keys Refuges National Wildlife Refuge (USFWS 2011a), for example, released a draft integrated predator management plan that targets predators, including cats, for the benefit of native fauna and flora. Other predator control programs are ongoing in North Carolina, South Carolina, Florida, and Texas beach ecosystems (USFWS 2009a).Although the extent of predation to nonbreeding piping plovers is unknown, it remains a potential threat.

Military operations

Five of the eleven coastal military bases located in the U.S. continental range of nonbreeding piping plovers have consulted with the USFWS about potential effects of military activities on plovers and their habitat (USFWS 2009a; USFWS 2010b). Formal consultation under section 7 of the ESA with Camp Lejeune, North Carolina in 2002 provided for year-round piping plover surveys, but restrictions on activities on Onslow Beach only pertain to the plover breeding season (Hammond, USFWS, pers. comm. 2012). Informal consultations with three Florida bases (Naval Station Mayport, Eglin Air Force Base, Tyndall Air Force Base) addressed training activities that included beach exercises and occasional use of motorized equipment on beaches and bayside habitats. Eglin Air Force Base conducts twice-monthly surveys for piping plovers, and habitats consistently used by piping plovers are posted with avoidance requirements to minimize direct disturbance from troop activities. Operations at Tyndall Air Force Base and Naval Station Mayport were determined to occur outside optimal piping plover habitats. A 2001 consultation with the Navy for one-time training operations on Peveto Beach in Louisiana concluded informally (USFWS 2010b). Current threats to wintering and migrating piping plovers posed by military activities appear minimal.

Disease

No instances of disease have been documented in piping plovers outside the breeding range. In the southeastern U.S., the cause of death of one piping plover received from Texas was emaciation (Acker pers. comm. 2009). Newstead (pers. comm. 2012b) reported circumstantial evidence that red tide weakened piping plovers in the vicinity of the Laguna Madre and Padre Island, Texas during the fall of 2011. Samples collected in Florida from two live piping plovers in 2006 both tested negative for avian influenza (Hines pers. comm. 2009). The 2009 5-Year Review concluded that West Nile virus and avian influenza remain minor threats to piping plovers on their wintering and migration grounds.

2.2. Environmental Baseline

North Carolina barrier beaches are part of a complex and dynamic coastal system that continually respond to inlets, tides, waves, erosion and deposition, longshore sediment transport, and depletion, fluctuations in sea level, and weather events. The location and shape of the coastline perpetually adjusts to these physical forces. Winds move sediment across the dry beach forming dunes and the island interior landscape. The natural communities contain plants and animals that are subject to shoreline erosion and deposition, salt spray, wind, drought conditions, and sandy soils. Vegetative communities include foredunes, primary and secondary dunes, interdunal swales, sand pine scrub, and maritime forests.

During storm events, overwash across the barrier islands is common, depositing sediments on the bayside, clearing vegetation and increasing the amount of open, sandflat habitat ideal for shoreline dependent shorebirds. However, the protection or persistence of these important natural land forms, processes, and wildlife resources is often in conflict with long-term beach stabilization projects and their indirect effects, i.e., increases in residential development, infrastructure, and public recreational uses, and preclusion of overwash which limits the creation of open sand flats preferred by piping plovers.

2.2.1. Status of the species within the Action Area

In North Carolina, piping plovers may be observed during every month of the year.

Breeding piping plovers

Nesting pairs are most likely to be seen on Cape Hatteras and Cape Lookout National Seashores (Seashores), where up to 97% of North Carolina's breeding individuals and breeding pairs have been recorded each year. One breeding pair nested at Rich Inlet on the north end of Figure Eight Island in 2014, 2015, and 2016, and one chick fledged at Rich Inlet in the summer of 2016. A nest with two eggs was documented on Topsail Beach in 2016, but no chicks fledged (Suiter pers. comm. 2016). In 2016, only three chicks fledged on Cape Hatteras and five fledged at

Cape Lookout National Seashores. South Carolina has historically been the most southern Atlantic state where piping plover nesting occurs. Nesting habitat for piping plovers is being lost incrementally in the Carolinas. In recent years, no piping plover nests have been observed in South Carolina. The nests on Figure Eight Island are not only the southernmost piping plover nests in recent years, but also the only North Carolina nests outside of the Seashores. Prior to 2010, breeding pairs and nests were also typically found on Lea-Hutaff Island, but chicks have not successfully fledged from those sites since 2008 (Schweitzer pers. comm. 2017). See **Table 8** for data on piping plover breeding pairs in North Carolina.

Between 2000 and 2016, successful nests (with fledged chicks) were recorded on Bodie Island, on the spit just north of Hatteras Inlet, Cape Point (Hatteras Island), several locations on Cape Lookout National Seashore (including Middle Core Banks, North Core Banks, Ophelia Island and South Core Banks), Lea-Hutaff Island, and Figure Eight Island. Locations where breeding pairs have been recorded, but no successful nests have been recorded, include Old Dump Island, Ocracoke Island, Bear Island, Bogue Inlet (East), New Topsail Inlet, Onslow Beach, Fort Fisher, Holden Beach, and Ocean Isle Beach (Schweitzer pers. comm. 2017).

The number of breeding pairs estimated from 2011 to 2016 in NC is only about 27% higher than the number of annual breeding pairs in the 1990s. Overall, there has been growth in numbers of breeding pairs in North Carolina, but the majority of growth for the Southern Recovery Unit has occurred in Virginia (**Tables 2 and 3**). The subpopulation target of 400 pairs has not yet been obtained, although numbers of breeding piping plovers in the Southern Recovery Unit have generally been above 300 for the past ten years (with the exception of 2011). The overall increase in the Southern Recovery Unit is due to population growth in Virginia, where recent storms have created and maintained habitat. However, the increase in Virginia was partially offset by the drop in productivity in North Carolina and a continuing decline in Maryland. Most of the Southern unit had cold, wet, and windy spring weather, which delayed breeding and was a major contributor to low productivity. Wind and flooding may also have contributed to the drop in abundance of breeding pairs in North Carolina, as several of the major breeding areas were completely flooded, and birds may have been unable to find territories (Hecht Pers. Comm. 2016). Annual productivity in North Carolina has varied wildly over the past 20 years, and does not show any trends in growth or decline (**Figure 6**). Productivity has been as low as 0.07 in 1991, when only three chicks fledged from 40 statewide pairs, to 0.96 in 2013, when 56 breeding pairs fledged 54 chicks.

Table 8. Piping plover breeding pairs and breeding success, 1986 to 2016. Data from the PBA and NCWRC (Schweitzer, pers. comm. 2017). NR = Not Reported

Year	# Pairs	Number of chicks fledged	Productivity rate
1986	36	NR	NR
1987	30	NR	NR
1988	40	NR	NR
1989	55	32	0.59
1990	55	24	0.43
1991	40	3	0.07
1992	49	21	0.42
1993	53	40	0.74
1994	54	20	0.36
1995	50	22	0.44
1996	35	30	0.86
1997	52	12	0.23
1998	46	28	0.61
1999	31	15	0.48
2000	24	13	0.54
2001	23	11	0.48
2002	23	3	0.17
2003	24	11	0.46
2004	20	13	0.65
2005	37	34	0.92
2006	46	40	0.87
2007	61	16	0.26
2008	64	19	0.3
2009	54	39	0.72
2010	61	47	0.77
2011	62	48	0.77
2012	70	41	0.59
2013	56	54	0.96
2014	65	14	0.22
2015	64	41	0.64
2016	53	9	0.17

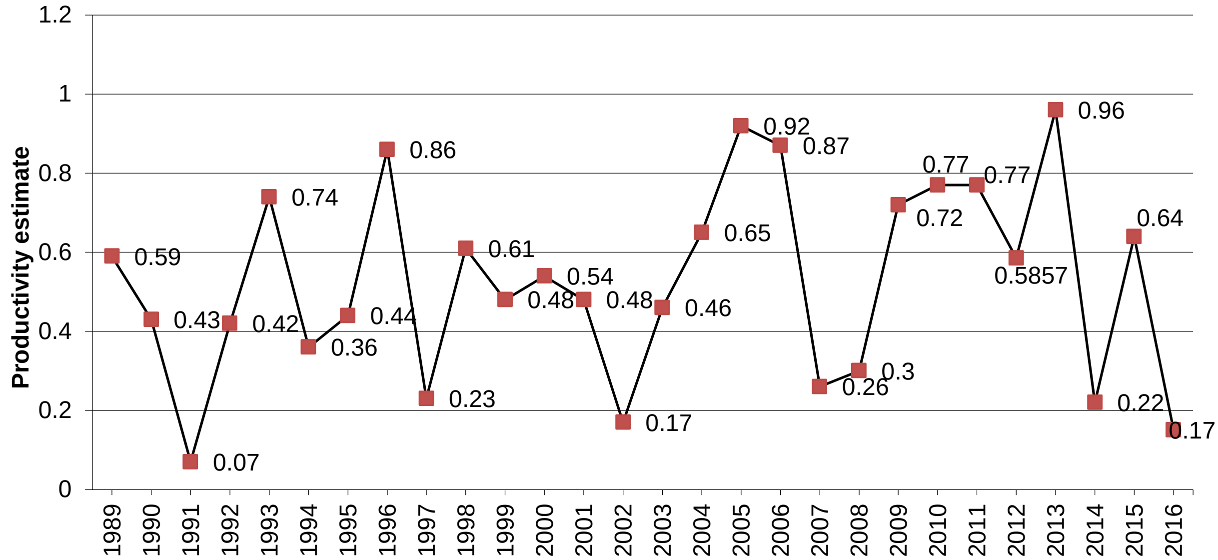

Figure 6. Annual reproductive productivity of piping plovers in North Carolina. Data from Schweitzer (Pers. comm. 2017).

Nonbreeding piping plovers

Surveys by multiple groups have documented many banded and unbanded piping plovers during migration and winter in North Carolina. The migrant population is larger than the winter population or nesting population. Piping plovers that winter at sites (meaning they spend the majority of their nonbreeding season at one location) can arrive at their winter site as early as August and depart as late as April (Maddock et al. 2009). However, the best winter population estimate cannot be determined until December and/or January. Results of a band re-sighting analysis for birds documented at sites in South Carolina showed zero immigration or emigration during the months of December and January (Cohen, pers. comm. 2009). Therefore, the Service determines the local winter population by using the single highest count of birds observed during surveys conducted between December 1 and January 31. Bird counts in other months are considered migrants or nesting individuals.

Piping plover observations during six rangewide mid-winter IPPCs, conducted at five-year intervals starting in 1991, are summarized for North Carolina, in **Table 9**. According to Schweitzer (pers. comm. 2017), 35 sites were surveyed in 2016, and a larger amount of habitat was surveyed than in 2011. The count of 101 observations in 2016 is the highest since surveys began. However, these mid-winter surveys appear to greatly underestimate the abundance of nonbreeding piping plovers using a site or region during other months, as discussed below.

Table 9. Results of the IPPC winter census in North Carolina. Data from Schweitzer (pers. comm. 2017).

Year	*Number of piping plovers*
1991	21
1996	50
2001	87
2006	84
2011	43
2016	101

Researchers from Virginia Tech (Virginia Tech Shorebird Program 2016) and others counted as many as 200 banded and unbanded piping plovers (on one date) on the south tip of Ocracoke Island between July 3 and August 26, 2017. The vast majority of the unbanded birds are expected to be from the Atlantic Coast population. Using models associated with Capture-Mark-Resighting (CMR) methods, Virginia Tech estimates that a total of approximately 533 (estimated range of 431—675) individual birds from the Atlantic Coast breeding population utilized the site as a migration stopover during this period, for an average length of at least 28 days. This represents approximately 20% of the entire Atlantic Breeding population of piping plover at this one site (Virginia Tech Shorebird Program 2016). Previous daily counts at this site were as high as 104 (NCWRC 2017).

Other North Carolina sites where greater than 10 piping plovers have been observed regularly since 2006 include other portions of Cape Hatteras National Seashore (including Bodie Island, Cape Point, Bird Shoal, Clam Shoal, and Hatteras Inlet), Cape Lookout National Seashore (including Core Banks, New Drum Inlet, and Shackleford Banks), Hammocks Beach State Park (on both Bogue Inlet and Bear Inlet), Onslow Beach, New River Inlet, New Topsail Inlet, Lea-Hutaff Island, Rich Inlet, Mason Inlet, and Masonboro Inlet. Most of these sites are undeveloped, or in the case of inlets, are undeveloped on at least one side. With the exception of New River, Mason and Masonboro Inlets, the inlets are also largely unmodified. The modified inlets and adjacent habitats support fewer piping plover in general, although on occasion larger numbers will be present. For example, since 2006, 10 piping plovers have been observed on two different dates on Onslow Beach, but during many surveys, fewer than one or two are observed (NCWRC 2017). Both Masonboro and Mason Inlets are relocated and mined regularly for sand, which is placed on the adjacent shoreline. Masonboro Inlet is also armored with jetties on either side.

Nine piping plovers were observed on the east end of Ocean Isle on March 31, 2011. The east end of Ocean Isle Beach on Lockwoods Folly Inlet supported four unbanded piping plovers during the winters of 2006 through 2008, and a breeding pair in 2007. However, the breeding habitat was not marked for protection until June that year, and the pair did not successfully nest (NCWRC 2017). Surveyors noted that beach traffic and development were likely affecting the individual birds. In 2017, the Town of Ocean Isle Beach received a Corps permit to construct a terminal groin along the shoreline near Lockwoods Folly Inlet.

Developed beaches and inlets that are regularly modified or disturbed are utilized by significantly fewer piping plovers. For example, Dare County north of Bodie Island, Emerald Isle, Oak Island, Holden Beach, and Sunset Beach have occasional piping plover observations, particularly during spring and fall migration. However, none of these areas have had more than five observations on a given date. The vast majority of surveys record no piping plovers or one individual.

Banded piping plovers in North Carolina

Unpublished data from NCWRC's PAWS database (NCWRC 2017) provide banded piping plover data for most coastal areas of North Carolina. The majority of banded piping plovers are recorded on Cape Hatteras and Cape Lookout National Seashores, and the islands and inlet complexes from Cape Lookout south to Masonboro Island. Only a few banded birds have been recorded in North Carolina south of Carolina Beach Inlet, in part because there are fewer records due to development of these areas, and also focus by the bird community on areas north. Banded piping plovers from all three breeding populations have been recorded on the National Seashores and south to Masonboro Inlet. This region of North Carolina, from Cape Lookout to Masonboro Inlet, is extremely important to the survival and recovery of the piping plover, particularly the Great Lakes piping plover (which is listed as endangered).

Since 2007, Audubon North Carolina has identified approximately 122 individually-banded piping plovers along the North Carolina coast from Topsail Island south to Masonboro Island (Addison Pers. Comm. 2016). This area encompasses four inlets and five islands: Topsail Island, New Topsail Inlet, Lea-Hutaff Island, Rich Inlet, Figure Eight Island, Mason Inlet, Wrightsville Beach, Masonboro Inlet, and Masonboro Island. 79 of these banded plovers are from the Great Lakes breeding population, 28 from the Atlantic Coast breeding population, and nine are from the Northern Great Plains population. Only 6 are from an unidentified population. The number or percentage of banded birds in each of the three populations depends on active banding projects. Virtually all of the Great Lakes individuals are banded, unlike individuals from the Atlantic Coast or Northern Great Plains breeding populations; the larger Atlantic Coast and Northern Great Plain populations only have banding projects at a few sites across their broad breeding ranges (Gratto-Trevor et al. 2012).

At least 52 banded piping plovers have been documented on either side of Rich Inlet or on Figure Eight Island since 2006, including at least 30 individuals from the endangered Great Lakes breeding population. The area has been monitored or surveyed by several different parties, and large numbers of banded and unbanded piping plovers have been observed throughout the migration and wintering season. For example, 40 piping plovers were observed on March 15, 2015 (including four banded birds), 31 were observed on August 1, 2015 (including seven banded birds), 11 were observed on October 6, 2013 (none with bands), and 10 were observed on December 28, 2013 (three with bands). The Great Lakes piping plovers migrating through and wintering in the Topsail/Rich/Mason/Masonboro Inlet complex have fledged 70 chicks since 2005, which is a significant contribution to the growth rate for this very small population.

Using a Jolly-Seber population model (Kery and Schaub 2012; Lyons et al. 2015), Virginia Tech estimated the total number of Great Lakes piping plovers that migrated through or overwintered at Rich Inlet and also those that migrated through or overwintered at Topsail, Rich, Mason, and Masonboro Inlets. Based on the number of banded individuals from the Great Lakes piping plover population, an average of approximately nine Great Lakes individuals, and as many as 12 are estimated to utilize Rich Inlet on a yearly basis. Considering the Masonboro to Topsail Inlet complex (including Masonboro Inlet, Mason Inlet, Rich Inlet and Topsail Inlet), an estimated 15 Great Lakes piping plovers utilize these inlets.

Because the vast majority of piping plovers from the Great Lakes breeding population are identifiable by bands, because they have high site fidelity for both overwintering and breeding sites, and because detection on the breeding grounds is near perfect, it is possible to estimate the average apparent survival of the piping plovers observed at various wintering sites. **Table 10** lists the average apparent survival of Great Lakes piping plovers between 2012 and 2016, at several inlets on the southeast coast. The average apparent survival rate of Great Lakes plovers at Rich Inlet was 0.822 for 2012-2016, one of the highest survival rates in the South Atlantic non-breeding grounds. The average apparent survival rate of Great Lakes plovers at (New) Topsail Inlet for the same time period is much lower (0.486), and is similar to more highly modified inlets in South Carolina and Georgia.

Table 10. Average Apparent Survival rates of Great Lakes piping plovers between 2012 and 2016, at several inlets in North Carolina, South Carolina, and Georgia. These numbers were derived from a model that constrained survival to be independent among sites, allowed for individuals to move to a new site (if seen), but constrained survival to be constant among years (Gibson pers. comm. 2016; 2017).

Site	Relative Disturbance	Average Apparent Survival (2012-2016)
Hilton Head, SC	High	0.534 (SE 0.078)
Kiawah/Seabrook Island, SC	Moderate	0.48 (SE 0.088)
Harbor Island, SC (2010-2015)	Low	0.700 (SE 0.089)
Deveaux Banks, SC (2010-2015)	Low	0.578 (SE 0.084)
Cumberland Island, GA (2010-2015)	Low	0.536 (SE 0.067)
Little Saint Simons Island, GA (2010-2015)	Low	0.576 (SE 0.044)
Rich Inlet, NC	Low	0.822 (SE 0.086)
Topsail Inlet, NC	Moderate	0.486 (SE 0.096)

2.2.2. Factors affecting the species environment within the Action Area

In accordance with the Act, the Service completes consultations with all federal agencies for actions that may adversely affect sea turtles. In North Carolina, consultations have included military missions and operations, beach nourishment and other shoreline protection, and actions related to protection of coastal development on sandy beaches of North Carolina's coast. A wide range of recent and on-going activities have altered the proposed Action Area and others are proposed along the coastline for the near future. Rice (2017) estimates that approximately 41% of North Carolina's sandy shoreline is developed. Activities are conducted along these shorelines to protect infrastructure and buildings from coastal erosion. Many miles of undeveloped sandy shorelines are also sporadically nourished, although it is not common for other types of shoreline protection actions to be conducted in undeveloped areas.

Beach Nourishment/ Sand Placement:

Appendix A (from the PBA) lists historical beach sand placement projects for the state of North Carolina. The beaches of North Carolina are regularly nourished with sand from the Corps and from locally-sponsored or private projects. Sand placement activities widen beaches, change their sedimentology and stratigraphy, alter coastal processes, and often plug dune gaps and remove overwash areas. The addition of dredged sediment can temporarily affect the benthic fauna of intertidal systems. Invertebrates may be crushed or buried during project construction. Although some benthic species can burrow through a thin layer of additional sediment (38-89 cm for different species), thicker layers (i.e., >1 meter) are likely to smother these sensitive benthic organisms (Greene 2002). Numerous studies of such effects indicate that the recovery of benthic fauna after beach nourishment or sediment placement projects can take anywhere from six months to two years, and possibly longer in extreme cases (Thrush et al. 1996; Bishop et al. 2006; Peterson et al. 2006). In North Carolina, the majority of sand placement projects are conducted during the migration and overwintering season for piping plovers, in an effort to avoid adverse effects to nesting sea turtles. Depending on the timing of the project, burial of prey items can have a significant adverse effect on migrating and overwintering birds.

Invertebrate communities may also be affected by changes in the physical environment resulting from shoreline stabilization activities that alter the sediment composition or degree of exposure. For example, SCDNR (2011) found the decline in piping plovers to be strongly correlated with a decline in polychaete densities on the east end of Kiawah Island, South Carolina, following an inlet relocation project in 2006. Similar results were documented on Bird Key, South Carolina, in 2006 when rapid habitat changes occurred within the sheltered lagoon habitat following dredge disposal activities, and piping plovers shifted to more exposed areas. Their diet also appeared to have shifted to haustoriid amphipods, based on analysis of fecal (SCDNR 2011). If the material used in a sand placement project does not closely match the native material on the beach, the sediment incompatibility may result in modifications to the macroinvertebrate community structure, because several species are sensitive to grain size and composition (Rakocinski et al. 1996; Peterson et al. 2006; Peterson and Bishop 2005; Colosio et al. 2007; Defeo et al. 2009).

Delayed recovery of the benthic prey base or changes in their communities due to physical habitat changes may affect the quality of piping plover foraging habitat. The duration of the impact can adversely affect piping plovers because of their high site fidelity. Although recovery of invertebrate communities has been documented in many studies, sampling designs have typically been inadequate and have only been able to detect large-magnitude changes (Schoeman et al. 2000; Peterson and Bishop 2005). Therefore, uncertainty persists about the impacts of various projects to invertebrate communities and how these impacts affect shorebirds, particularly the piping plover.

The PBA estimates that approximately 112 miles of Atlantic shoreline has been nourished in North Carolina. Rice (2017) estimates the length of nourished shoreline to be approximately 101 miles, with another 43 miles proposed. Within the states in the Atlantic Coast piping plover breeding range (Maine to North Carolina), this represents the largest length of modified shoreline. New Jersey is second with 78.43 miles of shoreline (Rice 2017). The first recorded sand placement project in North Carolina was on Wrightsville Beach in 1939, when sand was placed on 2.6 miles of shoreline. Sand placement did not occur again until the mid to late-1950's. Sand placement was generally intermittent and small in scope (less than 6 miles per year) until the late 1980's to 1990's, when the frequency of sand placement and miles of shoreline per year began to dramatically increase. Many of the beachfront communities have received sand on more than 10 occasions. Carolina Beach is listed in the PBA as having had 40 and placement events, while Wrightsville Beach has had 26, and Holden Beach 45. For most of these events, the sand source is navigation projects. Other sand sources include sediment mined from inlets, offshore borrow areas, and previously dredged material from upland disposal areas or existing material from an upland borrow area. Between 31% (Rice 2017) and 35% (PBA) of the North Carolina Shoreline has been modified by sediment placement as of 2015.

The Service is aware of many other activities conducted on the beaches during the past 10-20 years or more, such as terminal groins, jetties, beach scraping, sandbagging, beach cleaning, and beach driving. The Service consulted upon and concurred with many of these activities through informal and formal consultation. **Table 11** lists activities other than sand placement for which the Service has consulted between 2006 and 2017. This table is not inclusive of all informal consultations during that time period.

Table 11. Service consultations on North Carolina oceanfront shoreline activities other than sand placement, from 2006 to 2017.

Year	County	Project Name	Service Federal Activity Code	Project Location	Project Type	Anticipated Incidental Take (linear feet) or Affected Length of Beach
2017	Carteret	CLNS ORV Management Plan	04EN2000-2017-I-0127 04EN2000-2014-F-0255	Cape Lookout National Seashore	ORV use and access management – Cape Lookout National Seashore	56 miles
2016	Brunswick	Kay and David Picha	04EN2000-2016-F-0544	West end of Ocean Isle Beach	Extend existing sandbag revetment	468 lf
2016	Brunswick	Holden Beach Terminal Groin	04EN2000-2016-F-0283	East End of Holden Beach	Construction of terminal groin and sand fillet	4,000 lf
2016	Dare	NCDOT - Kitty Hawk NC12 Dune Repair	04EN2000-2016-I-0718	Kitty Hawk	Restore dune and extend sandbags along NC12	2,680 lf total, including sandbag revetments installed in 2003-2004 (Rice 2017)
2016	Dare	CHNS Frisco Pier Demolition	04EN2000-2016-I-0511	Frisco, NC	Demolish old pier	Less than 100 lf
2015	Brunswick	Ocean Isle Terminal Groin	04EN2000-2015-F-0201	East End of Ocean Isle Beach	Construction of terminal groin and sand fillet	24,500 lf
2015	Onslow	Camp Lejeune 2015-2020 INRMP	04EN2000-2015-F-0251	Camp Lejeune	Integrated Natural Resource Management Plan	11 miles
2015	Onslow	North Topsail Sandbag	04EN2000-2014-F-0495	North end of North Topsail	Construction of sandbag revetment	2,300 lf

		Revetment		Beach		
2014	New Hanover	Village of Bald Head Island Terminal Groin	04EN2000-2014-F-0204	West end of Bald Head Island	Construction of terminal groin and sand fillet	12,600 lf
2014	Dare	NCDOT Ocean Outfall #3	04EN2000-2014-I-0118-R001 04EN2000-2014-I-0118-R002	Nags Head Beach	Replacement of ocean outfall #3 pipe	Less than 100 lf
2012	Dare	NCDOT – NC 12 Repair	42420-2011-I-0334	Rodanthe and Pea Island NWR	Post-storm repair of NC-12 breaches	2,110 lf (Rice 2017)
2010	Dare, Hyde	CHNS Off-Road Vehicle Management Plan	04EN2000-2015-I-0362 42420-2010-F-0157	Cape Hatteras National Seashore – excluding Pea Island NWR	ORV use and access management – Cape Hatteras National Seashore	67 miles
2008	Brunswick	NCDOT East Second Street	42420-2008-TA-0118	E. Second St., Ocean Isle Beach	Replace sandbags	400 lf (1,885 lf total, including connecting Town and private landowner revetments) (Rice 2017)
2008	Dare	NCDOT - Herbert C. Bonner Bridge	42420-2006-F-0356-R001, R002, R003; 04EN2000-2013-F-0247-R001, R002; 04EN2000-2012-I-	Oregon Inlet, Bodie Island, Hatteras Island	Bridge replacement, road and new bridge construction	16.1 miles

			0153; 04EN2000-2013-F-0275			
2006	Dare, Hyde	CHNS Interim Protected Species Management Strategy	42420-2006-F-007	Cape Hatteras National Seashore	Management practices for recreational use and protection of species at CHNS until the ORV Management Plan was completed	56 miles
2006	Carteret	CLNS Interim Protected Species Management Strategy		Cape Lookout National Seashore	Management practices for recreational use and protection of species at CHNS until the Final Management Plan was completed	56 miles
2006	Onslow	Cape Lejeune 2007-2011 INRMP	42420-2006-I-0182 42420-2006-I-0009 04EN2000-2012-I-0154	Camp Lejeune	2006-2011 Integrated Natural Resource Management Plan	11 miles

Table 12 lists biological opinions since 2014 within the Raleigh Field Office geographic area that have been issued for adverse impacts to piping plovers. The BOs include those for beach renourishment, sandbag revetments, and terminal groin construction, all of which are included in the Environmental Baseline for this BO.

Table 12. BOs issued since 2014 within the Raleigh Field Office geographic area, for adverse impacts to piping plovers

OPINIONS	**PIPING PLOVER HABITAT**	
	Critical Habitat	**Habitat**
Fiscal Year 2014: 1 BO	n/a	12,600 lf (2.4 mi)
Fiscal Year 2015: 5 BOs	Approx. 33.49 acres, 2,200 lf	70,268 lf (13.3 mi)
Fiscal Year 2016: 8 BOs	9,696 lf (1.83 mi)	229,937 lf (43.54 mi)
Fiscal Year 2017 (to date): 1 BO	n/a	27,650 lf (5.24 mi)
Total: 15 BOs	**11,896 lf (2.25 mi) approx. 33.49 acres**	**340,455 lf (64.48 mi)**

Since the 1980s, development of the North Carolina coast has accelerated. Of the 20 currently open inlets, 16 are modified by man in some manner (Rice 2016). All 16 are dredged, and 7 have hardened structures (**Table 13).** Brown's Inlet, Bear Inlet, New Old Drum Inlet, and Ophelia Inlet are the only four that have not had some type of habitat modification, although the Corps dredges the AIWW crossing at Brown's Inlet, and other channels associated with Bear Inlet are dredged intermittently (e.g. Cow Channel).

Inlet dredging activities alter the sediment dynamics on adjacent shorelines and stabilize these dynamic environments; beach disposal of dredge material further alters the natural habitat adjacent to inlets. Estuarine dredging of navigational channels can alter water circulation patterns and sediment transport pathways, as well as increase the frequency and magnitude of boat wakes; sound-side sand or mud flats may be impacted by increased erosion rates as a result. Historically, there have been Federal navigation projects in the AIWW and in inlets along the North Carolina coast for decades. During hundreds of dredging events, the sediment has been placed on the adjacent beach using pipelines.

Table 13. Open tidal inlets from north to south along the North Carolina coast in 2015 with actual (X) and proposed (P) habitat modification(s) at each. Note that an X in the Jetties column indicates one jetty is present and a D indicates two (dual) jetties. Table from Rice (2016).

Order	Inlet	Type of Habitat Modification							
		Artificially created	Jetties	Terminal groins / groin field	Seawalls / revetment	Breakwaters	Dredging	Relocation of channel or	Mined for beach fill
1	Oregon Inlet1			X			X		X
2	Hatteras Inlet						X		
3	Ocracoke Inlet						X		
4	New Old Drum Inlet								
5	Ophelia Inlet								
6	Barden Inlet					X	X		X
7	Beaufort Inlet		X	X			X		
8	Bogue Inlet				X		X	X	X
9	Bear Inlet								
10	Brown's Inlet								
11	New River Inlet				X		X	X	X
12	New Topsail Inlet						X		X
13	Rich Inlet			P			X	P	X
14	Mason Inlet	X					X	X	X
15	Masonboro Inlet	X	D				X	X	X
16	Carolina Beach Inlet	X					X		X
17	Cape Fear River			X			X		
18	Lockwoods Folly Inlet			P			X		
19	Shallotte Inlet			P			X		X
20	Tubbs Inlet	X			X		X	X	

1 – The NCDOT mined ~33,000 cy of sediment from within Oregon Inlet to fill a scour hole adjacent to the Herbert C. Bonner Bridge across the inlet in December 2013, which had destabilized the bridge and led to its emergency closure.

Inlets associated with ports and other high-traffic areas typically have maintenance dredging conducted annually, if not more often. At four shallow-draft inlets (Bogue, Topsail, Carolina Beach, and Lockwoods Folly) the Corps has typically dredged the inlet on a quarterly basis, and maintained inlet crossings and connecting channels every one to two years (NCDENR, 2015).

Local governments have received authorization to also conduct maintenance dredging of these inlets on the same general schedule, with beach disposal during the winter work window. Inlets that are mined for Coastal Storm Damage Reduction (CSDR) projects (conducted by the Corps or local governments) are typically dredged on three-year intervals, with placement of the sand on the adjacent shoreline. Dredging may remove intertidal shoals and unvegetated sandy habitat on inlet shoulders. The average apparent survival rate of Great Lakes plovers at Topsail Inlet (**Table 10,** page 70) is similar to other inlets in the Southeast Atlantic where inlet dredging projects or other inlet modification projects are conducted. It is currently unclear how much of a role recreational use plays in the survival rate at these inlets.

Since 2012, several North Carolina tidal inlets have been dredged regularly for navigation purposes. Oregon Inlet continues to be dredged frequently for navigation and other purposes. In late 2015 the NC Department of Transportation (NCDOT) dredged a channel on the west side of Hatteras Inlet to maintain navigational access in and around Hatteras Inlet. The material was sidecast next to the dredged channel (USACE 2015a; Kozak 2016). Ocracoke Inlet was dredged by the Corps with a sidecast dredge in 2013 (Hinnant 2013). Portions of Beaufort Inlet are dredged yearly or more often than yearly, in order to maintain navigation access to the Morehead City State Port Terminal. Sediment disposal may be to Bogue Banks, to an upland disposal site, or to the Offshore Dredged Material Disposal Site (ODMDS). Beaufort Inlet was dredged in 2013, 2014, and 2017, with dredged sediment placed on Bogue Banks to the west in 2014 (Hibbs 2013, 2014). Similarly, portions of the Lower Cape Fear River are dredged each year to maintain navigation to Wilmington Harbor, with dredged material placed on adjacent beaches (Bald Head Island or Caswell and Oak Island Beaches) or the ODMDS. The Wilmington Harbor Inner Ocean Bar was dredged in 2017 with placement of sand on Caswell and Oak Island Beaches. Carolina Beach Inlet was dredged with a USACE sidecast dredge in 2013. In 2015 Carolina Beach Inlet was dredged by the Corps, state and New Hanover County, with the material placed in a nearshore disposal site off Carolina Beach (Hinnant 2013, Lane 2015). Lockwoods Folly Inlet was dredged by the Corps in 2013 (Hinnant 2013). The Town of Oak Island dredged Eastern Channel, part of the Lockwoods Folly Inlet complex, in 2015 and removed over 3 acres of emergent shoal habitat; the beach-compatible portion of the dredged material was placed on the beach of west Oak Island. The Corps dredged the AIWW and portions of Lockwoods Folly Inlet in 2016-2017 and placed the sand on Holden Beach (Hughes Pers. Comm. 2017). Cow Channel was dredged in early 2017 and the material placed on Bear Island within Hammocks Beach State Park (Corey Pers. Comm. 2017).

According to Rice (2016), at least 10 inlets have been mined for sediment for beach nourishment projects in North Carolina. Shallotte Inlet was mined in 2001 and 2014, Bogue Inlet in 2005, Barden Inlet in 2006, and Rich Inlet (or Nixon Channel) seven times between 1983 and 2011. More recently, Mason Inlet was mined in 2005, 2009, 2011, 2012-2013 and early 2016. Oregon Inlet was mined in 2013. New River Inlet was mined in 2012-13 as part of an inlet channel relocation project. New Topsail Inlet was mined in 2012 and 2015. The most recent project plans for the federal and local Carolina and Kure Beach CSDR Projects identify Carolina Beach Inlet as a primary sediment source; sediment dredged from the inlet has been placed periodically on Carolina Beach for storm damage reduction since the 1960s. Similarly, sediment removed from the inlet has been used as beach fill on Wrightsville Beach for storm damage reduction since the early 1960's.

Seven North Carolina inlets have been mined for beach sand in the past 5 years. Four of these are sites that have been mined previously, while three have not. The NCDOT mined approximately 33,000 cy of sediment from within Oregon Inlet in 2013 to provide sand to fill for a scour hole adjacent to the Herbert C. Bonner Bridge in another location of the inlet (USACE 2013). New Topsail Inlet was mined in 2012 and 2015 by the Town of Topsail Beach to provide sand for beach nourishment. In 2013, the inlet channel of New River Inlet was relocated, and the dredged material used to fill the beach on North Topsail Beach (USACE 2015b). In February 2017, the Town of North Topsail Beach received a modified permit to modify the ebb tide channel position within New River Inlet.

The four inlets that have been mined previously include Mason Inlet, Shallotte Inlet, Carolina Beach Inlet, and Masonboro Inlet. In many cases, these inlets are both managed for navigation and alternatively mined for sand for beach nourishment. Mason Inlet was mined in 2011, 2013, and 2016 to provide beach fill for Figure Eight Island and to maintain Mason Inlet within a specific inlet corridor. In 2014 and 2017, the Corps mined Shallotte Inlet to nourish adjacent Ocean Isle Beach, pursuant to the Corps' CSDR project (Ocean Isle Beach 2015; Hughes Pers. Comm. 2017). Carolina Beach Inlet was mined in 2013 and 2017 for beach fill on Carolina Beach. Masonboro Inlet was mined in 2014 for beach fill on Wrightsville Beach (USFWS 2016a; 2016b).

In some cases, sand has been dredged from the AIWW or inlets and placed within the sounds to improve habitat for migrating and nesting shorebirds. There are several "bird islands" along the sound shorelines which intermittently receive sand from navigation projects. In 2017, the Corps dredged Old House Channel to Oregon inlet and placed the sand on bird islands near Manteo (Hughes Pers. comm. 2017). Also in 2017, Carteret County dredged Wainwright Slough and placed the sand on the adjacent Wainwright Island. More such projects are planned in the near future, such as proposed placement of material dredged from the lower Cape Fear River on South Pelican and Ferry Slip Islands to restore these small islands for waterbird habitat.

Shoreline Stabilization and Armoring:

In 2017, there are 4 jetties and 34 groins along the North Carolina coast, and sandbags, sandbag revetments, groins, and jetties have been placed along at least 9.05 miles of North Carolina shoreline (Rice 2017). See **Table 14** for data from Rice (2017).

Sandbags on private properties provide stabilization to a significant portion of the North Carolina shoreline. Rice (2017) estimated 152 separate sandbag structures along the North Carolina beach shoreline. If multiple properties each had an individual seawall protecting their property and the seawalls were attached to each other with no gaps, then Rice (2017) counted the armoring as one structure (per Dallas et al. 2013) and measured the overall length.

Rice (2017) estimated that 24 of 37 North Carolina coastal communities have been modified by armor. In these communities, the proportion of armored sandy beach habitat was as high as 18%. Four communities exceed 10% of the shoreline armored: Kitty Hawk (18%), Bald Head Island (13%), Kure Beach (11%), and Ocean Isle Beach (10%).

In North Carolina, there are three currently existing terminal groins: along Oregon Inlet, at Fort Macon along Beaufort Inlet in Carteret County, and on Bald Head Island in New Hanover County. The terminal groin on Bald Head Island was installed in 2015, but the other two (Oregon Inlet and Fort Macon) were installed decades ago, and downdrift erosion has been severe at both, requiring frequent nourishment (Pietrafesa 2012; Riggs et al 2009). The Fort Macon groin is fronted by a larger structure that Rice (2016) refers to as jetty.

Table 14. Approximate number of each type of armoring visible on the oceanfront beach in each community in North Carolina visible on Google Earth imagery between 1993 and late 2015 / early 2016. Multiple seawalls, bulkheads or revetments are counted as one structure if they are continuous with no separations.

Community	Number of Groins	Number of Jetties	Number of Seawalls, Bulkheads and/or Revetments	Number of Breakwaters
Corolla	0	0	2	0
Duck	0	0	0	0
Southern Shores	0	0	0	0
Kitty Hawk	0	0	12	0
Kill Devil Hills	7	0	11	0
Nags Head	0	0	29	0
Rodanthe	1	0	4	0
Salvo	0	0	0	0
Avon	0	0	0	0
Buxton	3	0	1	0
Frisco	0	0	0	0
Hatteras	0	0	0	0
Ocracoke	0	0	0	0
Cape Lookout NS (Portsmouth Island to Shackleford Banks)[1]	0	1	0	1
Atlantic Beach[2]	0	1	10	0
Pine Knoll Shores	0	0	6	0
Indian Beach	0	0	0	0
Salter Path	0	0	0	0
Emerald Isle	0	0	4	0
Swansboro Township (Hammocks Beach SP)	0	0	0	0
Camp Lejeune	0	0	0	0
North Topsail Beach[3]	0	0	9	0
Surf City	0	0	10	0
Topsail Beach	0	0	14	0
Topsail Township (Lea-Hutaff Island)	0	0	0	0
Figure 8 Island[3]	0	0	3	0

Community	Number of Groins	Number of Jetties	Number of Seawalls, Bulkheads and/or Revetments	Number of Breakwaters
Wrightsville Beach	0	1	0	0
Masonboro Island	0	1	0	0
Carolina Beach	0	0	1	0
Kure Beach	0	0	2	0
Federal Point Township	0	0	0	0
Bald Head Island	23	0	1	0
Caswell Beach	0	0	1	0
Oak Island	0	0	17	0
Holden Beach[3]	0	0	5	0
Ocean Isle Beach[3]	0	0	10	0
Sunset Beach[4]	0	0	0	0
TOTAL	**34**	**4**	**152**	**1**

1 – A breakwater / jetty structure constructed in 1914-17 is present near Barden Inlet at Cape Lookout. A landlocked jetty / breakwater structure was constructed on the Beaufort Inlet shoreline of Shackleford Banks in 1882 but is currently landlocked (Coburn et al. 2010).

2 – The jetty at Fort Macon SP in Atlantic Beach is referred to as a terminal groin by some sources. One additional groin is located on the inlet shoreline of Fort Macon SP but was buried in 2015 and is not included here due to its location on the inlet shoreline, rather than the oceanfront shoreline.

3 – Terminal groins have been proposed or are under development for the inlet shorelines of North Topsail Beach, Figure 8 Island, Holden Beach and Ocean Isle Beach.

4 – One jetty at Little River Inlet is located on the southern tip of Bird Island / Sunset Beach, but is located within the state of South Carolina.

The Oregon Inlet and Fort Macon Groins are located on the updrift side of the island, but accretion in these areas is not significant due to scour. At Oregon Inlet, there is no sandy habitat on the inlet shoulder updrift of the groin and revetment, and there has not been for decades. There are two degraded groin/jetty structures in Dare County, adjacent to the old location of the Cape Hatteras lighthouse. The Service has issued BOs for the authorization of two other terminal groins (Towns of Ocean Isle Beach and Holden Beach), and the Figure "Eight" Homeowners Association is currently (2017) seeking authorization to construct a terminal groin on the north end of Figure Eight Island (south side of Rich Inlet). Also, in 2015, the North Carolina legislature revised state regulations to allow additional terminal groins to be constructed at New River Inlet and Bogue Inlet. However, it is unclear whether the local governments in the vicinity of these two inlets will propose the construction of a terminal groin. The south jetty along Masonboro Inlet was repaired by the Corps in 2013 and 2014 (USACE 2015c).

There are two existing rock revetments along the coast of North Carolina: one at Fort Fisher (approximately 3,040 lf), and another along Carolina Beach (approximately 2,050 lf). Sandbags and sandbag revetments have been placed along at least 1,800 lf of the eastern shoreline on Ocean Isle Beach, and the Tubbs Inlet shoreline on Ocean Isle Beach is completely lined with a sandbag revetment. A sandbag revetment at least 1,800 lf long (with a geotube in front of a portion) was constructed in 2015 at the north end of North Topsail Beach, and more sandbags were added in 2016 to protect a parking lot north of the revetment. In 2000 and 2001, sandbag revetments were installed on the north end of Figure Eight Island along Surf Court, Inlet Hook Road, and Comber Road.

Beach scraping can artificially steepen beaches, stabilize dune scarps, plug dune gaps, and redistribute sediment distribution patterns. Artificial dune building, often a product of beach scraping, removes low-lying overwash areas and dune gaps. As chronic erosion catches up to structures throughout the Action Area, artificial dune systems are constructed and maintained to protect beachfront structures either by sand fencing or fill placement. Beach scraping or bulldozing has become more frequent on North Carolina beaches in the past 20 years, in response to storms and the continuing retreat of the shoreline with rising sea level. From 2012 to 2015, Rice (2017) estimated that at least 4.84 miles of the North Carolina shoreline was impacted by beach scraping. These activities primarily occur during the winter months, when migrating and overwintering plovers may be present. Artificial dune or berm systems have been constructed and maintained in several areas. These dunes make the artificial dune ridge function like a seawall that blocks natural beach retreat, evolution, and overwash.

Beach raking and rock-picking: Man-made beach cleaning and raking machines effectively remove seaweed, fish, glass, syringes, plastic, cans, cigarettes, shells, stone, wood, and virtually any unwanted debris (Barber Beach Cleaning Equipment 2009). These efforts may remove accumulated wrack, topographic depressions, and sparse vegetation nodes used by roosting and foraging piping plovers. Removal of wrack also eliminates a beach's natural sand-trapping abilities, further destabilizing the beach. In addition, sand adhering to seaweed and trapped in the cracks and crevices of wrack is removed from the beach. Although the amount of sand lost due to single sweeping actions may be small, it adds up considerably over a period of years (Nordstrom et al. 2006; Neal et al. 2007). Beach cleaning or grooming can result in abnormally broad unvegetated zones that are inhospitable to dune formation or plant colonization, thereby enhancing the likelihood of erosion (Defreo et al. 2009). The Town of Carolina Beach rakes the beach front in Freeman Park at least twice per year, including areas in piping plover critical habitat unit NC-14. The Town of North Topsail Beach utilizes a rock-picker as needed, typically annually, to remove rocky material from the beach berm along portions of its shoreline.

Sand Fencing: Rice (2017) estimates that 62.69 miles (19%) of North Carolina's shoreline was modified with sand fencing between 2012 and 2015. This length represents approximately 25% of all of the sand fencing within the breeding range of the Atlantic Coast piping plover. Sand fencing modified more than 50% of the sandy beach habitat in 6 communities: Pine Knoll

Shores (97%), Kill Devil Hills (67%), Atlantic Beach (64%), Southern Shores (63%), Corolla (53%) and Nags Head (53%). In 14 other coastal communities, between 20 and 50% of the sandy beach habitat was modified by sand fencing between 2012 and early 2016. A total of 1,199 contiguous sections of sand fencing were identified on North Carolina's oceanfront beaches in the three years after Hurricane Sandy; only New Jersey had more contiguous sections of sand fencing (1,305), but had a slightly lower total length of sandy beach modified by fencing (60.26 miles, or 96.98 km) (Rice 2017). Sand fencing traps sand (typically lighter fine-grained sand) and may stabilize continuous dunes in developed areas, thereby also degrading, fragmenting, or eliminating sparsely vegetated and unvegetated habitats used by the piping plover and other wildlife. Sand fencing may create steeper slopes, and alter the surrounding area in a way that impedes shorebird nesting. For nesting, shorebirds typically prefer relatively flat dune areas with coarser sand. The fencing also is a physical barrier that can block unfledged chicks from getting from their nests to their food source, and the posts or stakes can serve as perches for hawks and other predators that feed on the chicks (USFWS 2015, Massachusetts Office of Coastal Management 2013).

Pedestrian Use of the Beach: There are a number of potential sources of pedestrians and pets on North Carolina beaches, including those individuals originating from beachfront or boat access points, public access points, and hotels, resorts, and residences. Elliott and Teas (1996) found a significant difference in actions between piping plovers encountering pedestrians and those not encountering pedestrians. Piping plovers encountering pedestrians spend proportionately more time in non-foraging behavior. This study suggests that interactions with pedestrians on beaches cause birds to shift their activities from calorie acquisition to calorie expenditure. In winter and migration sites, human disturbance continues to decrease the amount of undisturbed habitat and appears to limit local piping plover abundance (Zonick and Ryan 1996).

Disturbance also reduces the time migrating shorebirds spend foraging (Burger 1991). Pfister et al. (1992) implicate disturbance as a factor in the long-term decline of migrating shorebirds at staging areas. While piping plover migration patterns and needs remain poorly understood and occupancy of a particular habitat may involve shorter periods relative to wintering, information about the energetics of avian migration indicates that this might be a particularly critical time in the species' life cycle.

In many cases, dogs accompany pedestrians to the beach. Shorebirds are more likely to flush from the presence of dogs than people, and breeding and nonbreeding shorebirds react to dogs from farther distances than people (Lafferty 2001a, 2001b; Lord et al. 2001; Thomas et al. 2003). Hoopes (1993) found that dogs flush breeding piping plovers from further distances than people and that both the distance the plovers move and the duration of their response is greater. Foraging shorebirds at a migratory stopover on Delaware Bay, New Jersey responded most strongly to dogs compared with other disturbances; shorebirds often failed to return within ten minutes after the dog left the beach (Burger et al. 2007). Dogs off-leash were disproportionate sources of disturbance in several studies (Thomas et al. 2003; Lafferty 2001b), but leashed dogs also disturbed shorebirds. Pedestrians walking with dogs often go through flocks of foraging and roosting shorebirds; some even encourage their dogs to chase birds.

Horseback riding is allowed on North Carolina beaches including Emerald Isle, Hatteras Island, and Carolina Beach (Freeman Park). Horseback riding may cause adverse impacts to piping plover habitat, by causing compaction or erosion, trampling of wrack and vegetation, and flushing of birds. In general, a horse and rider may cause greater individual static ground pressure than cars, because of the small ground area over which the weight is spread (UK CEED 2000).

Off-Road Vehicles: Off-road vehicles can disrupt piping plover's normal behavior patterns. The density of off-road vehicles negatively correlated with abundance of piping plovers on the ocean beach in Texas (Zonick 2000). Cohen et al. (2008) found that radio-tagged wintering piping plovers using ocean beach habitat at Oregon Inlet in North Carolina were far less likely to use the north side of the inlet where off-road vehicle use was allowed. Ninety-six percent of piping plover detections occurred on the south side of the inlet even though it was more than four times farther away from foraging sites (Cohen et al. 2008). In a study of migrating shorebirds in Maryland, Forgues (2010) found that shorebird abundance declined with increased off-road vehicle frequency, as did the number and size of roosts. Migrants spent less time foraging in the presence of vehicles. In North Carolina, a before-after control-impact experiment using the undisturbed plots as the controls found that vehicle disturbance decreased abundance of shorebirds and altered their habitat use during fall migration (Tarr 2008). Recreational activities, especially off-road vehicles, may degrade piping plover habitat. Tires that crush wrack into the sand render it unavailable as a roosting habitat or foraging substrate (Goldin 1993; Hoopes 1993). Off-road vehicles are allowed on portions Cape Hatteras National Seashore (including Ocracoke Island) and Cape Lookout National Seashore for most if not all of the year. Driving is also allowed at Fort Fisher. Other communities which allow beach driving for at least portions of the year include Corolla, Duck, Nags Head, Kill Devil Hills, Atlantic Beach, Emerald Isle, Indian Beach, Salter Path, North Topsail Beach, Surf City, Topsail Beach, and Carolina Beach (Pippin 2013). Most of them only allow driving outside of the sea turtle nesting season (November to April).

Summary and synthesis of threats

A review of threats to piping plovers and their habitat in their migration and wintering range shows a continuing loss and degradation of habitat due to sand placement projects, inlet stabilization, sand mining, groins, seawalls and revetments, dredging of canal subdivisions, invasive vegetation, wrack removal, and recreational use. This cumulative habitat loss is, by itself, of major threat to piping plovers, as well as the many other shorebird species competing with them for foraging resources and roosting habitats in their nonbreeding range. However, artificial shoreline stabilization also impedes the processes by which coastal habitats adapt to storms and accelerating sea level rise, thus setting the stage for compounding future losses.

Furthermore, inadequate management of increasing numbers of beach recreationists reduces the functional suitability of coastal migration and wintering habitat and increases pressure on piping plovers and other shorebirds depending upon a shrinking habitat base. Experience during the Deepwater Horizon oil spill illustrates how, in addition to the direct threat of contamination, spill response activities can result in short- and long-term effects on habitat and disturb piping plovers and other shorebirds. If climate change increases the frequency and magnitude of severe weather events, this may pose an additional threat. The best available information indicates that other threats are currently low, but vigilance is warranted, especially in light of the potential to exacerbate or compound effects of very significant threats from habitat loss and degradation and from increasing human disturbance.

2.3. Effects of the Action

This section is an analysis of the beneficial, direct and indirect effects of the proposed action on migrating and wintering piping plovers within the Action Area. The analysis includes effects interrelated with and interdependent of the project activities. An interrelated activity is an activity that is part of a proposed action and depends on the proposed activity. An interdependent activity is an activity that has no independent utility apart from the action.

2.3.1. Factors to be considered

The proposed project will occur within habitat for migrating, wintering, and breeding piping plovers and construction will occur during a portion of the migration, winter, and breeding seasons. Long-term and permanent impacts could preclude the creation of new habitat and increase recreational disturbance. Short-term and temporary impacts to piping plovers could result from project work disturbing roosting plovers and degrading currently occupied adjacent foraging areas.

Proximity of the action: Sand placement would occur within and adjacent to foraging, roosting, and breeding habitats for migrating, wintering, or breeding piping plovers.

Distribution: Project construction activities that may impact migrating, wintering, or breeding piping plovers would occur along the North Carolina shoreline.

Timing: The timing of project construction could directly and indirectly impact migrating, wintering, and/or breeding piping plovers. Piping plovers may be present year-round in the Action Area.

Nature of the effect: The effects of the project construction include a long-term reduction in foraging, roosting, and nesting habitat, a long-term decreased rate of change that may preclude habitat creation. A decrease in the survival of piping plovers on the migration and winter grounds due to the lack of optimal habitat may contribute to decreased survival rates, decreased productivity on the breeding grounds, and increased vulnerability to the three populations. The Service expects the action will result in direct and indirect, long-term effects to piping plovers. The Service expects there may be morphological changes to adjacent piping plover habitat, including roosting, foraging, and nesting habitat. Activities that affect or alter the use of optimal habitat or increase disturbance to the species may decrease the survival and recovery potential of the piping plover.

Duration: These may be recurring activities, expected to last as long as five and a half months each time. Thus, the direct effects would be expected to be short-term in duration. Indirect effects from the activity may continue to impact migrating, wintering, and breeding piping plovers in subsequent seasons after sand placement.

Disturbance frequency: Disturbance from each event will be short term, lasting up to two years. However, sand placement activities may take place several times over the life of each project. In addition, several sand placement projects may be conducted in concurrent or consecutive years, including in adjacent foraging, roosting, and nesting habitats. Recreational disturbance may increase after project completion and have long-term impacts.

Disturbance intensity and severity: Project construction is anticipated to be conducted during portions of the piping plover migration, winter, and breeding seasons. Conservation measures have been incorporated into the project to minimize impacts. The Action Area encompasses an area in the nesting, migration, and wintering range of the piping plover. Plovers located within the Action Area are expected to move outside of the construction zone due to disturbance; therefore, no plovers are expected to be directly taken as a result of this action.

2.3.2. Analyses for effects of the action

Beneficial effects: For some highly eroded beaches, sand placement will have a beneficial effect on the habitat's ability to support wintering and nesting piping plovers. Narrow beaches that do not support a productive wrack line may see an improvement in foraging habitat available to piping plovers following sand placement. The addition of sand to the sediment budget may also increase a sand-starved beach's likelihood of developing habitat features valued by piping plovers, including washover fans and emergent nearshore sand bars. It is unclear whether this programmatic opinion will be utilized mostly on highly eroded beaches.

Direct effects: Direct effects are those direct or immediate effects of a project on the species or its habitat. The construction window will extend through the piping plover migration and winter season and into the beginning of the breeding season. Since piping plovers can be present on these beaches year-round, construction is likely to occur while this species is utilizing these beaches and associated habitats. Heavy machinery and equipment (e.g., trucks and bulldozers operating in Action Area) may adversely affect piping plovers in the Action Area by disturbance and disruption of normal activities such as roosting and foraging, and possibly forcing birds to expend valuable energy reserves to seek available habitat elsewhere. Burial and suffocation of invertebrate species will occur during the sand placement, and will affect up to 25 miles of shoreline annually in North Carolina. In years following major storm events, the PBA states that a 250% increase in average annual nourishment can reasonably be expected. Therefore, in post-storm years, a maximum length of nourishment may be 62.5 miles (25 miles plus the additional 27.5 miles).

Indirect effects: The proposed project includes placement of sand as a protective element against shoreline erosion to protect man-made infrastructure. Indirect effects include reducing the potential for the formation of optimal habitats. The proposed project may limit the creation of optimal foraging and roosting habitat, and may increase the attractiveness of these beaches for recreation, increasing recreational pressures within the Action Area. Recreational activities that potentially adversely affect plovers include disturbance by unleashed pets and increased pedestrian use.

2.3.3. Species' response to the proposed action

The Service anticipates potential adverse effects throughout the Action Area by limiting proximity to roosting, foraging, and nesting habitat and degrading occupied foraging, roosting and nesting habitat, and increasing disturbance from increased recreational use. Piping plovers have been documented foraging and roosting within the project area.

2.4. Cumulative Effects

This project may occur on federal or non-federal lands. Cumulative effects include the effects of future State, tribal, local, or private actions that are reasonably certain to occur in the Action Area considered in this biological opinion. Future Federal actions that are unrelated to the proposed action are not considered in this section, because they require separate consultation pursuant to section 7 of the Act. It is reasonable to expect continued shoreline stabilization, inlet dredging, sand placement projects, sand fencing, and beach scraping along the North Carolina shoreline in the future since erosion and sea-level rise increases would impact the existing beachfront development. However, with the exception of some of the above-listed project types, most of the future actions that are reasonable certain to occur will require a Clean Water Act (CWA) Section 404 permit, and thus will require separate consultation.

2.5 Conclusion

After reviewing the current status of the wintering piping plover populations from all three breeding populations, the environmental baseline for the Action Area, the effects of the proposed activities, the proposed Conservation Measures, and the cumulative effects, it is the Service's biological opinion that implementation of these actions, as proposed, is not likely to jeopardize the continued existence of the three breeding populations of piping plover.

- Construction will occur and/or will likely have an effect on up to 25 miles of shoreline annually during nonemergency years, and up to 62.5 miles of shoreline annually during emergency years.
- Piping plovers have been documented in the Action Area.
- Short-term and temporary impacts to piping plover activities could result from project work occurring on the beach that flushes birds from roosting, foraging, or nesting habitat.
- Long-term impacts could include a hindrance in the ability of migrating or wintering piping plovers to recuperate from their migratory flight from their breeding grounds, survive on their wintering areas, or to build fat reserves in preparation for migration.
- The survival and recovery of all breeding populations of piping plovers are fundamentally dependent on the continued availability of sufficient habitat in their coastal migration and wintering range.
- All piping plover populations are inherently vulnerable to even small declines in their most sensitive vital rates, i.e., survival of adults and fledged juveniles.

3. PIPING PLOVER WINTERING CRITICAL HABITAT

3.1. Status of the Critical Habitat

The Act defines critical habitat as the specific areas within the geographical area occupied by the species, at the time it is listed in accordance with the provisions of section 4 of the Act, on which are found those physical or biological features (1) essential to the conservation of the species and (2) which may require special management considerations or protection, as well as specific areas outside the geographical area occupied by the species at the time it is listed in accordance with the provisions of section 4 of the Act, upon a determination by the Secretary that such areas are essential for the conservation of the species (16 U.S.C. 1532(5)(A)).

This section summarizes the effects of all past human and natural activities or events that have led to the current status of designated critical habitat for the piping plover and are relevant to formulating the biological opinion about the proposed action.

3.1.1. Critical Habitat Description and Status

In 2001, critical habitat was designated for the breeding population in the Great Lakes region (USFWS 2001a), while a separate rule determined critical habitat for the U.S. portion of the Northern Great Plains breeding population in 2002 (USFWS 2002). No critical habitat has been proposed or designated for the Atlantic Coast breeding population, but the needs of all three breeding populations were considered in the 2001 critical habitat designation for wintering piping plovers (USFWS 2001b) and in subsequent re-designations (USFWS 2008b; 2009c). Critical habitat for wintering piping plovers currently comprises 141 units totaling 256,513 acres along the coasts of North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, and Texas. The original designation included 142 areas (the rule erroneously states

137 units) encompassing approximately 1,798 miles of mapped shoreline and 165,211 acres of mapped areas (USFWS 2001b). A revised designation for four North Carolina units was published in 2008 (USFWS 2008b). Eighteen revised Texas critical habitat units were designated in 2009, replacing 19 units that were vacated and remanded by a 2006 court order (USFWS 2009b). Designated areas include habitats that support roosting, foraging, and sheltering activities of piping plovers.

In North Carolina, there are 18 designated critical habitat units for wintering piping plover, from Oregon Inlet to Mad Inlet (**Figures 7-8**). See **Appendix B** for a figure and description of each critical habitat unit.

Critical Habitat Physical and Biological Features (PBFs)

In accordance with section 3(5)(A)(i) and 4(b)(1)(A) of the ESA and regulations at 50 CFR 424.12, in determining which areas within the geographical area occupied by the species at the time of listing to designate as critical habitat, the Service considers the physical or biological features (PBFs) that are essential to the conservation of the species and which may require special management considerations or protection.
These include, but are not limited to:

(1) Space for individual and population growth and for normal behavior;
(2) Food, water, air, light, minerals, or other nutritional or physiological requirements;
(3) Cover or shelter;
(4) Sites for breeding, reproduction, or rearing (or development) of offspring; and
(5) Habitats that are protected from disturbance or are representative of the historical, geographic, and ecological distributions of a species.

The term ‘‘primary constituent elements’’ was introduced in the critical habitat designation regulations (50 CFR 424.12) to describe aspects of the PBFs, which are referenced in the statutory definition of critical habitat; the Services have proposed to remove the term ‘‘primary constituent elements’’ and return to the statutory term ‘‘physical or biological features’’ for future listings of critical habitat. See 79 FR 27066, May 12, 2014 and 81 FR 7214.

Critical Habitat Primary Constituent Elements

The PCEs essential for the conservation of wintering piping plovers are those habitat components that support foraging, roosting, and sheltering and the physical features necessary for maintaining the natural processes that support these habitat components. The PCEs include intertidal beaches and flats (between annual low tide and annual high tide) and associated dune systems and flats above annual high tide. Important components of intertidal flats include sand and/or mud flats with no or very sparse emergent vegetation. In some cases, these flats may be covered or partially covered by a mat of blue-green algae. Adjacent non-or sparsely-vegetated sand, mud, or algal flats above high tide are also important, especially for roosting piping plovers, and are PCEs of piping plover wintering habitat. Such sites may have debris, detritus (decaying organic matter), or micro-topographic relief (less than 50 cm above substrate surface) offering refuge from high winds and cold weather. Important components of the beach/dune ecosystem include surf-cast algae, sparsely vegetated backbeach and salterns (beach area above mean high tide seaward of the permanent dune line, or in cases where no dunes exist, seaward of a delineating feature such as a vegetation line, structure, or road), spits, and washover areas. Washover areas are broad, unvegetated zones, with little or no topographic relief, that are formed and maintained by the action of hurricanes, storm surge, or other extreme wave action. The units designated as critical habitat are those areas that have consistent use by piping plovers and that best meet the biological needs of the species. The amount of wintering habitat included in the designation appears sufficient to support future recovered populations, and the existence of this habitat is essential to the conservation of the species. Additional information on each specific unit included in the designation can be found at 66 FR 36038 (USFWS 2001a).

Critical habitat does not include existing developed sites consisting of buildings, marinas, paved areas, boat ramps, exposed oil and gas pipelines and similar structures. Only those areas containing these PCEs within the designated boundaries are considered critical habitat. Although 141 units totaling 256,513 acres along the coasts of North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, and Texas have been designated, not all units are equally important depending on the presence, juxtaposition, and acreage of the PCEs and not all units are equally important to the three breeding populations. Piping plovers from the three breeding populations are not evenly distributed throughout their nonbreeding range (Gratto-Trevor et al. 2012).

Distribution of Breeding Populations within Designated Critical Habitat in the Non-breeding Range

Gratto-Trevor et al. (2012) emphasizes the significance of geographic differences between wintering locations for the three piping plover populations. Plovers from eastern Canada and most Great Lakes individuals wintered from North Carolina to Southwest Florida. However, eastern Canada birds were more heavily concentrated in North Carolina, while a larger proportion of Great Lakes piping plovers were found in South Carolina, Georgia, and Florida. Very few individuals from the Great Lakes breeding population were observed in winter on the Gulf Coast, west of Florida. Using information provided on inlets in Rice (2012a), the Service determined that there are 151 inlets in the non-breeding range of the Great Lakes piping plover population (including inlets from North Carolina to the Florida Gulf of Mexico shoreline). Based on Rice (2012a), 19% of the inlets in piping plover critical habitat in this region have been modified by dredging/mining, shoreline hardening, or relocation. Of these modified inlets, approximately 34% are within piping plover critical habitat. In North Carolina, 16 of the 20 (75%) existing inlets are modified in some manner, most often by dredging (**Table 13,** page 77)

(Rice 2016). This is higher than any other state in the non-breeding range of the Great Lakes piping plover population (Rice 2012a).

3.1.2. Analysis of the Critical Habitat Likely to be Affected

There are many man-made activities that degrade or remove PCEs of piping plover wintering critical habitat. Please see **Appendix A** (copied from the PBA) and **Table 11** (Page 73) for a list of activities conducted along the Atlantic Ocean shoreline in North Carolina.

Beach nourishment

At least 684 of 2,340 coastal shoreline mi (32% of beaches throughout the piping plover winter and migration range in the U.S.) are bermed, nourished, or renourished, generally for recreational purposes and to protect commercial and private infrastructure. The quantity and quality of piping plover prey may also be affected by the placement of sediment for beach nourishment or disposal of dredged material. Invertebrates may be crushed or buried during project construction. Although some benthic species can burrow through a thin layer of additional sediment, thicker layers (over 35 in (90 cm)) smother the benthic fauna (Greene 2002). By means of this vertical burrowing, recolonization from adjacent areas, or both, the benthic faunal communities typically recover. Recovery can take as little as 2 weeks or as long as 2 years, but usually averages 2 to 7 months (Greene 2002; Peterson and Manning 2001). Only a few percent of these impacts have occurred within critical habitat mainly because nourishment is most often conducted adjacent to infrastructure along the beachfront, rather than on the ends of islands near inlets.

Sand mining/dredging

Sand mining, the practice of extracting (dredging) sand from sand bars, shoals, and inlets in the nearshore zone, is a less expensive source of sand than obtaining sand from offshore shoals for beach nourishment. Sand bars and shoals are sand sources that move onshore over time and act as natural breakwaters. Inlet dredging reduces the formation of exposed ebb and flood tidal shoals considered to be primary or optimal piping plover roosting and foraging habitat. Removing these sand sources can alter depth contours and change wave refraction as well as cause localized erosion (Hayes and Michel 2008). Exposed shoals and sandbars are also valuable to piping plovers, as they tend to receive less human recreational use (because they are only accessible by boat) and therefore provide relatively less disturbed habitats for birds. Most jettied inlets need maintenance dredging, but non-hardened inlets are often dredged as well. According to Rice (2012; 2016), approximately 44% of the inlets in the non-breeding range have been dredged or mined.

Shoreline Stabilization

Many navigable mainland or barrier island tidal inlets along the Atlantic and Gulf of Mexico coasts are stabilized with jetties, groins, or by seawalls and/or adjacent industrial or residential development. This includes seawalls or adjacent development, which lock the inlets in place. Rice (2012a) created database of the inlets within the migration and wintering range of the piping plover, including identification of existing hard structures or other habitat modifications. Several studies highlight concerns about adverse effects of development and coastline stabilization on the quantity and quality of habitat for migrating and wintering piping plovers and other shorebirds. For example, Zdravkovic and Durkin (2011) observed fewer plovers on the developed portions of the Laguna and Gulf beach sides of South Padre Island than on undeveloped portions during both migratory and wintering surveys. Drake et al. (2001) observed that radio-tagged piping plovers overwintering along the southern Laguna Madre of Texas seldom used tidal flats adjacent to developed areas (five of 1,371 relocations of radio-marked individuals), suggesting that development and associated anthropogenic disturbances influence piping plover habitat use.

Groins (structures made of concrete, rip rap, wood, or metal built perpendicular to the beach in order to trap sand) are typically found on developed beaches with severe erosion. Although groins can be individual structures, they are often clustered along the shoreline. Groins can act as barriers to longshore sand transport and cause downdrift erosion (Hayes and Michel 2008), resulting in the loss of habitat and preventing future piping plover habitat creation by limiting sediment deposition and accretion. As sand fills the area updrift from the groin or jetty, some littoral drift and sand deposition on adjacent downdrift beaches may occur due to spillover. However, these groins and jetties often force the stream of sand into deeper offshore water where it is lost from the system (Kaufman and Pilkey 1979). The loss of sand from the inlet system can be exacerbated by inlet dredging and disposal outside of the inlet. Groins deflect longshore currents offshore. This aggravates downdrift erosion and erosion escarpments are common on the downdrift side of groins (Humiston and Moore 2001). Rice (2016) found that several inlets along the Atlantic Coast have hard stabilization structures such as jetties or groins along the entire inlet shoreline that have eliminated all sandy beach habitat from the inlet shoulders. Terminal groins along adjacent developed areas can alter erosion and accretion patterns and diminish the magnitude of the inlet cycle. As an example, the stabilization and dredging of Shinnecock Inlet on Long Island's South Shore in New York has directly negatively affected the inlet's ebb shoal equilibrium since construction in 1940. Buonaiuto et al. (2008) found that these impacts will persist for nearly 150 years and possibly longer. As of 2008, the ebb shoal had only reached approximately 60% of its estimated equilibrium volume and it is expected to take another 75 years to reach full equilibrium. If the ebb shoal is mined or dredged, the time for recovery will increase.

Seawalls and revetments are vertical hard structures built parallel to the beach in front of buildings, roads, and other facilities to protect them from erosion. However, these structures often accelerate erosion by causing scouring in front of and downdrift from the structure (Hayes and Michel 2008), which can eliminate intertidal foraging habitat and adjacent roosting habitat. Seawalls confine the wave energy and intensify the erosion by concentrating the sediment transport processes in an increasingly narrow zone. Eventually, the beach disappears, leaving the seawall directly exposed to the full force of the waves (Williams et al 1995). Physical characteristics that determine microhabitats and biological communities can be altered after installation of a seawall or revetment, thereby depleting or changing composition of benthic communities that serve as the prey base for piping plovers. Geotubes (long cylindrical bags made of high-strength permeable fabric and filled with sand) and sandbag revetments are softer alternatives, but act as barriers by preventing overwash. We did not find any sources that summarize the linear extent of seawall, revetment, and geotube installation projects that have occurred across the piping plover's wintering and migration habitat.

Inlet Relocation

Tidal inlet relocation can cause loss and/or degradation of piping plover habitat; although less permanent than construction of hard structures, effects can persist for years. Service biologists are aware of at least seven inlet relocation projects (two in North Carolina, three in South Carolina, two in Florida), but this number likely under-represents the extent of this activity.

The Mason Inlet Preservation Group (MIPG) has Corps authorization to conduct the Mason Inlet Relocation Project (MIRP) at the south end of Figure Eight Island. The inlet relocation project is conducted every 2-3 years, and may temporarily impact piping plover habitat, causing birds to select other sites (USFWS 2006a). Ongoing stabilization and growth of vegetation the north end of Wrightsville Beach due to the MIRP has led to a decline in the amount of suitable unvegetated intertidal habitat available in the Mason Inlet area. The acreage of unvegetated intertidal flats has significantly decreased, in part due to the lack of vegetation management in the Waterbird Management Area on North Wrightsville Beach. Approximately 50-60 acres of unvegetated intertidal flats was available within critical habitat unit NC-12 in 1998, prior to the project's initial construction (GoogleEarth©, accessed January 29, 2015). At that time, almost all available habitat was on the south end of Figure Eight Island. In October 2014, the approximate acreage of unvegetated intertidal flats in the same area was 22 to 28 acres (estimated from Google Earth, accessed on January 29, 2015). This represents a degradation of about half of the previously available intertidal flat habitat within piping plover critical habitat unit NC-12.

Exotic/invasive vegetation

The spread of coastal invasive plants is a threat to suitable piping plover habitat. Like most invasive species, coastal exotic plants reproduce and spread quickly and exhibit dense growth habits, often outcompeting native plant species. If left uncontrolled, invasive plants cause a habitat shift from open or sparsely vegetated sand to dense vegetation, resulting in the loss or degradation of piping plover roosting habitat, which is especially important during high tides and migration periods.

Beach vitex (*Vitex rotundifolia*) is a woody vine introduced into the southeastern U.S. as a dune stabilization and ornamental plant (Westbrooks and Madsen 2006). It currently occupies a very small percentage of its potential range in the U.S. The species has been found on beaches in all eight coastal counties in North Carolina and three counties in South Carolina. Small populations have been found in Maryland, Virginia, Georgia, Florida and Alabama. Task forces formed in North and South Carolina in 2004-2005 have made great strides to remove this plant from their coasts. To date, over 800 sites in North Carolina have been treated, with an additional 100 sites in need of treatment. Similar efforts are underway in South Carolina and several hundred sites have been treated there (Suiter pers. comm. 2015).

Unquantified amounts of crowfootgrass (*Dactyloctenium aegyptium*) grow invasively along portions of the Florida coastline. It forms thick bunches or mats that may change the vegetative structure of coastal plant communities and alter shorebird habitat. The Australian pine (*Casuarina equisetifolia*) changes the vegetative structure of the coastal community in south Florida and islands within the Bahamas. Shorebirds prefer foraging in open areas where they are able to see potential predators, and tall trees provide good perches for avian predators. Australian pines potentially impact shorebirds, including the piping plover, by reducing attractiveness of foraging habitat and/or increasing avian predation. The propensity of these exotic species to spread, and their tenacity once established, make them a persistent threat, partially countered by increasing landowner awareness and willingness to undertake eradication activities.

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Wrack removal and beach cleaning or rock-picking

Wrack on beaches and baysides provides important foraging and roosting habitat for piping plovers (Drake 1999a; Smith 2007; Maddock et al. 2009; Lott et al. 2009b) and many other shorebirds on their winter, breeding, and migration grounds. Because shorebird numbers are positively correlated with wrack cover and biomass of their invertebrate prey that feed on wrack (Tarr and Tarr 1987; Hubbard and Dugan 2003; Dugan et al. 2003), grooming will lower bird numbers (Defreo et al. 2009). There is increasing popularity in the Southeast, especially in

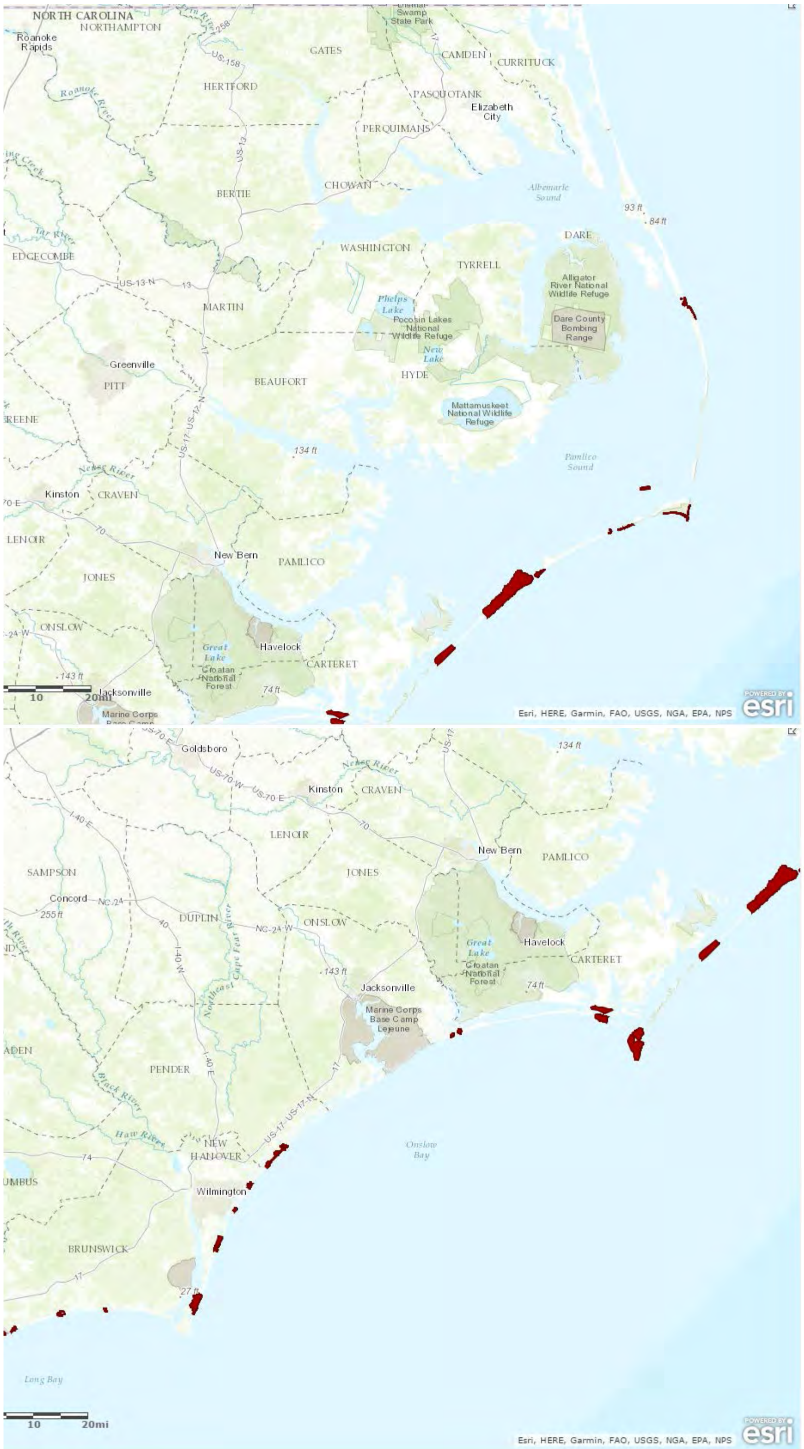
Florida, for beach communities to carry out "beach cleaning" and "beach raking" actions. Beach cleaning occurs on private beaches, where piping plover use is not well documented, and on some municipal or county beaches that are used by piping plovers. Most wrack removal on state and federal lands is limited to post-storm cleanup and does not occur regularly.

Man-made beach cleaning and raking machines effectively remove seaweed, fish, glass, syringes, plastic, cans, cigarettes, shells, stone, wood, and virtually any unwanted debris (Barber and Sons 2012). However, these efforts also remove accumulated wrack, topographic depressions, and sparse vegetation nodes used by roosting and foraging piping plovers. Removal of wrack also eliminates a beach's natural sand-trapping abilities, further destabilizing the beach. In addition, sand adhering to seaweed and trapped in the cracks and crevices of wrack is removed from the beach. Although the amount of sand lost due to single sweeping actions may be small, it adds up considerably over a period of years (Nordstrom et al. 2006; Neal et al. 2007). Beach cleaning or grooming can result in abnormally broad unvegetated zones that are inhospitable to dune formation or plant colonization, thereby enhancing the likelihood of erosion (Defreo et al. 2009). The Town of Carolina Beach rakes the beach front in Freeman Park at least twice per year, including areas in piping plover critical habitat unit NC-14. The Town of North Topsail Beach utilizes a rock-picker as needed, typically annually, to remove rocky material from the beach berm along portions of its shoreline.

3.2. Environmental Baseline

3.2.1. Status of Critical Habitat within the Action Area

The PCEs for piping plover critical habitat include intertidal beaches and flats, particularly those with no or very sparse emergent vegetation. Adjacent non-or sparsely-vegetated sand, mud, or algal flats above high tide are also important, especially for roosting. Important components of the beach/dune ecosystem include surf-cast algae, sparsely vegetated backbeach and salterns (beach area above mean high tide seaward of the permanent dune line, or in cases where no dunes exist, seaward of a delineating feature such as a vegetation line, structure, or road), spits, and washover areas.



Figures 7-8. Nonbreeding piping plover designated critical habitat units NC-1 through SC-2.

3.2.2. Factors Affecting Critical Habitat within the Action Area

Beach nourishment: North Carolina sandy beaches are regularly nourished with sand from the Corps, other federally-funded projects, and private activities. Nourishment activities widen beaches, change their sedimentology and stratigraphy, alter coastal processes and often plug dune gaps and remove overwash areas. Beach nourishment or disposal of dredged material typically crushes or buries invertebrate prey during project construction, suppressing prey populations for months. Although some benthic species can burrow through a thin layer of additional sediment, thicker layers (over 35 in (90 cm)) smother the benthic fauna (Greene 2002). Recovery can take as long as 2 years, but usually averages 2 to 7 months (Greene 2002; Peterson and Manning 2001).

Inlet dredging activities alter the sediment dynamics on adjacent shorelines and stabilize these dynamic environments; beach disposal of dredge material further alters the natural habitat adjacent to inlets. Estuarine dredging of navigational channels can alter water circulation patterns and sediment transport pathways, as well as increase the frequency and magnitude of boat wakes; sound-side sand or mud flats may be impacted by increased erosion rates as a result. Historically, there have been Federal navigation projects in the AIWW and in inlets along the North Carolina coast for decades. During hundreds of dredging events, the sediment has been placed on the adjacent beach using pipelines. Inlets associated with ports and other high-traffic areas typically have maintenance dredging conducted annually, if not more often. At four shallow-draft inlets within piping plover designated critical habitat (Bogue, Topsail, Carolina Beach, and Lockwoods Folly), the Corps has typically dredged the inlet on a quarterly basis, and maintained inlet crossings and connecting channels every one to two years (NCDENR, 2015). Local governments have received authorization to also conduct maintenance dredging of these inlets on the same general schedule, with beach disposal during the winter work window. Inlets that are mined for Coastal Storm Damage Reduction (CSDR) projects (conducted by the Corps or local governments) are typically dredged on three-year intervals, with placement of the sand on the adjacent shoreline. Dredging may remove intertidal shoals and unvegetated sandy habitat from critical habitat units.

Since 2012, several North Carolina tidal inlets within designated piping plover critical habitat have been dredged regularly for navigation purposes. Oregon Inlet continues to be dredged frequently for navigation and other purposes. In late 2015 the NC Department of Transportation (NCDOT) dredged a channel on the west side of Hatteras Inlet to maintain navigational access in and around Hatteras Inlet. The material was sidecast next to the dredged channel (USACE 2015a, Kozak 2016). Ocracoke Inlet was dredged by the Corps with a sidecast dredge in 2013 (Hinnant 2013). Carolina Beach Inlet was dredged with a USACE sidecast dredge in 2013. In 2015 Carolina Beach Inlet was dredged by the Corps, state and New Hanover County, with the material placed in a nearshore disposal site off Carolina Beach (Hinnant 2013, Lane 2015). Lockwoods Folly Inlet was dredged by the Corps in 2013 (Hinnant 2013). The Town of Oak Island dredged Eastern Channel, part of the Lockwoods Folly Inlet complex, in 2015 and removed over 3 acres of emergent shoal habitat within the critical habitat unit; the beach-compatible portion of the dredged material was placed on the beach of west Oak Island. The Corps dredged the AIWW and portions of Lockwoods Folly Inlet in 2016-2017 and placed the sand on Holden Beach (Hughes Pers. Comm. 2017).

According to Rice (2016), at least 10 inlets within designated critical habitat have been mined for sediment for beach nourishment projects in North Carolina. Shallotte Inlet was mined in 2001 and 2014, Bogue Inlet in 2005, Barden Inlet in 2006, and Rich Inlet (or Nixon Channel) seven times between 1983 and 2011. More recently, Mason Inlet was mined in 2005, 2009, 2011, 2012-2013 and early 2016. Oregon Inlet was mined in 2013. New River Inlet was mined in 2012-2013 as part of an inlet channel relocation project. New Topsail Inlet was mined in 2012 and 2015. The most recent project plans for the federal and local Carolina and Kure Beach CSDR Projects identify Carolina Beach Inlet as a primary sediment source; sediment dredged from the inlet has been placed periodically on Carolina Beach for storm damage reduction since the 1960s. Similarly, sediment removed from the inlet has been used as beach fill on Wrightsville Beach for storm damage reduction since the early 1960's.

Seven North Carolina inlets have been mined for beach sand in the past 5 years. Four of these are sites that have been mined previously, while three have not. The NCDOT mined approximately 33,000 cy of sediment from within Oregon Inlet in 2013 to provide sand to fill for a scour hole adjacent to the Herbert C. Bonner Bridge in another location of the inlet (USACE 2013). New Topsail Inlet was mined in 2012 and 2015 by the Town of Topsail Beach to provide sand for beach nourishment (Town of North Topsail Beach 2015).

The four inlets that have been mined previously include Mason Inlet, Shallotte Inlet, Carolina Beach Inlet, and Masonboro Inlet. In many cases, these inlets are both managed for navigation and alternatively mined for sand for beach nourishment. Mason Inlet was mined in 2011, 2013, and 2016 to provide beach fill for Figure Eight Island and to maintain Mason Inlet within a specific inlet corridor. In 2014 and 2017, the Corps mined Shallotte Inlet to nourish adjacent Ocean Isle Beach, pursuant to the Corps' CSDR project (Ocean Isle Beach 2015, Hughes Pers. Comm. 2017). Carolina Beach Inlet was mined in 2013 and 2017 for beach fill on Carolina Beach. Masonboro Inlet was mined in 2014 for beach fill on Wrightsville Beach (USFWS 2016b and 2016c).

Groins: In North Carolina, there are three currently existing terminal groins, along Oregon Inlet, at Fort Macon along Beaufort Inlet in Carteret County, and on Bald Head Island in New Hanover County. The terminal groin on Bald Head Island was installed only two years ago, but the other two (Oregon Inlet and Fort Macon) were installed decades ago, and downdrift erosion has been severe at both, requiring frequent nourishment (Pietrafesa 2012; Riggs et al 2009). The Oregon Inlet and Fort Macon Groins are located on the updrift side of the island, but accretion in these areas is not significant due to scour. At Oregon Inlet, there is no sandy habitat on the inlet shoulder updrift of the groin and revetment, and there has not been for decades. There are two degraded groin/jetty structures in Dare County, adjacent to the old location of the Cape Hatteras lighthouse. The Service has issued BOs for the authorization of two other terminal groins (Towns of Ocean Isle Beach and Holden Beach). Also, in 2015, the North Carolina legislature revised state regulations to allow additional terminal groins to be constructed at New River Inlet and Bogue Inlet. However, it is unclear whether the local governments in the vicinity of these two inlets will propose the construction of a terminal groin.

Recreational Use: There are a number of potential sources of pedestrians, pets, horses, and vehicles on North Carolina beaches. Pedestrians may originate from beachfront or boat access points, public access points, and hotels, resorts, and residences. Many of North Carolina inlets, particularly those near more populated areas, are regular gathering spots for boaters. It is common for boaters to park on the inlet shoulders or inlet shoals. In winter and migration sites, human disturbance continues to decrease the amount of undisturbed habitat and appears to limit local piping plover abundance (Zonick and Ryan 1996).

Horseback riding is allowed on North Carolina beaches including Emerald Isle, Hatteras Island, and Carolina Beach (Freeman Park). Horseback riding may cause adverse impacts to piping plover habitat, by causing compaction or erosion, and trampling of wrack and vegetation. In general, a horse and rider may cause greater individual static ground pressure than cars, because of the small ground area over which the weight is spread (UK CEED 2000).

Off-road vehicles can disrupt piping plover's normal behavior patterns. The density of off-road vehicles negatively correlated with abundance of piping plovers on the ocean beach in Texas (Zonick 2000). In addition, recreational activities, especially off-road vehicles, may degrade piping plover habitat. Tires that crush wrack into the sand render it unavailable as a roosting habitat or foraging substrate (Goldin 1993; Hoopes 1993). Off-road vehicles are allowed on portions Cape Hatteras National Seashore (including Ocracoke Island) and Cape Lookout National Seashore for most if not all of the year. Driving is also allowed at Fort Fisher. Other communities which allow beach driving for at least portions of the year include Corolla, Duck, Nags Head, Kill Devil Hills, Atlantic Beach, Emerald Isle, Indian Beach, Salter Path, North Topsail Beach, Surf City, Topsail Beach, and Carolina Beach (Pippin 2013).

3.3. Effects of the Action

This section is an analysis of the beneficial, direct and indirect effects of the proposed action on piping plover wintering critical habitat within the Action Area. Direct effects are caused by the Action and occur at the same time and place. Indirect effects are caused by the Action, but are later in time and reasonably certain to occur. The analysis includes effects interrelated and interdependent of the project activities.

3.3.1. Factors to be considered

The proposed projects may occur adjacent to or within piping plover critical habitat units, during a portion of the migration and winter seasons. Short-term and temporary impacts could result from project work degrading currently occupied foraging areas in the critical habitat unit. The direct effects from sand placement would be expected to be short-term in duration, until the benthic community reestablishes within the new beach profile.

3.3.2. Analyses for effects of the action

Beneficial effects: For some highly eroded beaches, sand placement will have a beneficial effect on the habitat's ability to support wintering and nesting piping plovers. Narrow beaches that do not support a productive wrack line may see an improvement in foraging habitat available to piping plovers following sand placement. The addition of sand to the sediment budget may also increase a sand-starved beach's likelihood of developing habitat features valued by piping plovers, including washover fans and emergent nearshore sand bars. It is unclear whether this programmatic opinion will be utilized mostly on highly eroded beaches.

Direct effects: Direct effects are those direct or immediate effects of a project on the species or its habitat. The construction window will extend through one or more piping plover migration and winter seasons. Since piping plovers can be present on these beaches year-round, construction is likely to occur while this species is utilizing these beaches and associated habitats. Direct effects include burial of invertebrate prey items and suppression of prey populations, resulting in degradation of foraging habitat.

Indirect effects: Indirect effects include reducing the potential for the formation of PCEs and foraging and roosting habitat, and increasing the attractiveness of these beaches for recreation, thereby increasing recreational pressures within the Action Area.

Interrelated and Interdependent Actions: An interrelated activity is an activity that is part of the proposed action and depends on the proposed action for its justification. An interdependent activity is an activity that has no independent utility apart from the action under consultation. The Service has addressed all interrelated and interdependent actions in the analysis of effects above. Therefore, there are no interdependent or interrelated actions associated with the proposed action that have not already been analyzed under the effects of the action, that are expected to affect wintering piping plover critical habitat.

3.4. Cumulative Effects

This project may occur on federal or non-federal lands. Cumulative effects include the effects of future State, tribal, local, or private actions that are reasonably certain to occur in the Action Area considered in this biological opinion. Future Federal actions that are unrelated to the proposed action are not considered in this section, because they require separate consultation pursuant to section 7 of the Act. It is reasonable to expect continued shoreline stabilization, inlet dredging, sand placement projects, sand fencing, and beach scraping along the North Carolina shoreline in the future since erosion and sea-level rise increases would impact the existing beachfront development. However, with the exception of some of the above-listed project types, most of the future actions that are reasonable certain to occur will require a Clean Water Act (CWA) Section 404 permit, and thus will require separate consultation.

3.5. Conclusion

After reviewing the current status of piping plover wintering critical habitat, the environmental baseline for the Action Area, the effects of the proposed activities, the proposed Conservation Measures, and the cumulative effects, it is the Service's biological opinion that the project is not likely to destroy or adversely modify designated critical habitat for wintering piping plovers.

- An unknown acreage of critical habitat included in the PCEs may be degraded due to burial of prey items.
- Approximately 19% of the inlets within critical habitat in the piping plover non-breeding range have been modified (Rice 2012a).
- Of all inlets modified in the piping plover non-breeding range, 34% is within a critical habitat unit (Rice 2012a).
- 40% of North Carolina's 20 inlets are currently modified with hard shoreline stabilization structures (groins, jetties, or revetments) (Rice 2016), and if the two proposed groins at Lockwoods Folly Inlet and Shallotte Inlet are built, the percentage will increase to 50%, resulting in fewer and fewer optimal habitats for migrating and wintering piping plovers.
- The modification of PCEs/PBFs in the action area will not cause an appreciable reduction in the conservation value provided by all designated CH for the species.

4. RED KNOT

4.1. Status of the Species/Critical Habitat

4.1.1. Species/critical habitat description

On December 11, 2014, the Service listed the rufa red knot (*Calidris canutus rufa*) (or red knot) as threatened throughout its range (79 FR 73706). The red knot is a medium-sized shorebird about 9 to 11 inches (in) (23 to 28 centimeters (cm)) in length. The red knot migrates annually between its breeding grounds in the Canadian Arctic and several wintering regions, including the Southeast U.S. (Southeast), the Northeast Gulf of Mexico, northern Brazil, and Tierra del Fuego at the southern tip of South America. During both the northbound (spring) and southbound (fall) migrations, red knots use key staging and stopover areas to rest and feed. Red knots migrate through and overwinter in North Carolina. The term "winter" is used to refer to the nonbreeding period of the red knot life cycle when the birds are not undertaking migratory movements. Red knots are most common in North Carolina during the migration season (mid-April through May and July to Mid-October), and may be present in the state throughout the year (Fussell 1994; Potter et al. 1980). Wintering areas for the red knot include the Atlantic coasts of Argentina and Chile, the north coast of Brazil, the Northwest Gulf of Mexico from the Mexican State of Tamaulipas through Texas to Louisiana, and the Southeast U.S. from Florida to North Carolina (Newstead et al. 2013; Niles et al. 2008). Smaller numbers of knots winter in the Caribbean, and along the central Gulf coast, the mid-Atlantic, and the Northeast U.S. Little information exists on where juvenile red knots spend the winter months (USFWS and Conserve Wildlife Foundation 2012), and there may be at least partial segregation of juvenile and adult red knots on the wintering grounds. There is currently no designation of critical habitat for red knot.

4.1.2. Life history

Each year red knots make one of the longest distance migrations known in the animal kingdom, traveling up to 19,000 miles (mi) (30,000 kilometers (km) annually between breeding grounds in the Arctic Circle and wintering grounds. Red knots undertake long flights that may span thousands of miles without stopping. As they prepare to depart on long migratory flights, they undergo several physiological changes. Before takeoff, the birds accumulate and store large amounts of fat to fuel migration and undergo substantial changes in metabolic rates. In addition, leg muscles, gizzard (a muscular organ used for grinding food), stomach, intestines, and liver all decrease in size, while pectoral (chest) muscles and heart increase in size. Due to these physiological changes, red knots arriving from lengthy migrations are not able to feed maximally until their digestive systems regenerate, a process that may take several days. Because stopovers are time-constrained, red knots require stopovers rich in easily-digested food to achieve adequate weight gain (Niles et al. 2008; van Gils et al. 2005a; van Gils et al. 2005b; Piersma et al. 1999) that fuels the next migratory flight and, upon arrival in the Arctic, fuels a body transformation to breeding condition (Morrison 2006). Red knots from different wintering areas appear to employ different migration strategies, including differences in timing, routes, and stopover areas. However, full segregation of migration strategies, routes, or stopover areas does not occur among red knots from different wintering areas (USFWS 2013a; USFWS 2013b).

Major spring stopover areas along the Mid- and South Atlantic coast include Río Gallegos, Península Valdés, and San Antonio Oeste (Patagonia, Argentina); Lagoa do Peixe (eastern Brazil, State of Rio Grande do Sul); Maranhão (northern Brazil); the Virginia barrier islands (U.S.); and Delaware Bay (Delaware and New Jersey, U.S.) (Cohen et al. 2009; Niles et al. 2008; González 2005). Important fall stopover sites include southwest Hudson Bay (including the Nelson River delta), James Bay, the north shore of the St. Lawrence River, the Mingan Archipelago, and the Bay of Fundy in Canada; the coasts of Massachusetts and New Jersey and the mouth of the Altamaha River in Georgia, U.S.; the Caribbean (especially Puerto Rico and the Lesser Antilles); and the northern coast of South America from Brazil to Guyana (Newstead et al. 2013; Niles 2012; Niles et al. 2010; Schneider and Winn 2010; Niles et al. 2008; Antas and Nascimento 1996; Morrison and Harrington 1992; Spaans 1978). However, large and small groups of red knots, sometimes numbering in the thousands, may occur in suitable habitats all along the Atlantic and Gulf coasts from Argentina to Canada during migration (Niles et al. 2008; USFWS 2013a; USFWS 2013b).

Some red knots wintering in the Southeastern U.S. and the Caribbean migrate north along the U.S. Atlantic coast before flying overland to central Canada from the mid-Atlantic, while others migrate overland directly to the Arctic from the Southeastern U.S. coast (Niles et al. 2012). These eastern red knots typically make a short stop at James Bay in Canada, but may also stop briefly along the Great Lakes, perhaps in response to weather conditions (Niles et al. 2008; Morrison and Harrington 1992). Red knots are restricted to the ocean coasts during winter, and occur primarily along the coasts during migration. However, small numbers of rufa red knots are reported annually across the interior U.S. (i.e., greater than 25 miles from the Gulf or Atlantic Coasts) during spring and fall migration—these reported sightings are concentrated along the Great Lakes, but multiple reports have been made from nearly every interior State (eBird.org 2012; USFWS 2013a).

Long-distance migrant shorebirds are highly dependent on the continued existence of quality habitat at a few key staging areas. These areas serve as stepping stones between wintering and breeding areas. Conditions or factors influencing shorebird populations on staging areas control much of the remainder of the annual cycle and survival of the birds (Skagen 2006; International Wader Study Group 2003). At some stages of migration, very high proportions of entire populations may use a single migration staging site to prepare for long flights. Red knots show some fidelity to particular migration staging areas between years (Duerr et al. 2011; Harrington 2001).

Habitats used by red knots in migration and wintering areas are similar in character, generally coastal marine and estuarine (partially enclosed tidal area where fresh and salt water mixes) habitats with large areas of exposed intertidal sediments. In North America, red knots are commonly found along sandy, gravel, or cobble beaches, tidal mudflats, salt marshes, shallow coastal impoundments and lagoons, and peat banks (Cohen et al. 2010; Cohen et al. 2009; Niles et al. 2008; Harrington 2001; Truitt et al. 2001). The supra-tidal (above the high tide) sandy habitats of inlets provide important areas for roosting, especially at higher tides when intertidal habitats are inundated (Harrington 2008; USFWS 2013a).

The red knot is a specialized molluscivore, eating hard-shelled mollusks, sometimes supplemented with easily accessed softer invertebrate prey, such as shrimp- and crab-like organisms, marine worms, and horseshoe crab (*Limulus polyphemus*) eggs (Piersma and van Gils 2011; Harrington 2001). Mollusk prey are swallowed whole and crushed in the gizzard (Piersma and van Gils 2011). Foraging activity is largely dictated by tidal conditions, as red knots rarely wade in water more than 0.8 to 1.2 in (2 to 3 cm) deep (Harrington 2001). Due to bill morphology, the red knot is limited to foraging on only shallow-buried prey, within the top 0.8 to 1.2 in (2 to 3 cm) of sediment (Gerasimov 2009; Zwarts and Blomert 1992).

The primary prey of the rufa red knot in non-breeding habitats include blue mussel (*Mytilus edulis*) spat (juveniles); *Donax* and *Darina* clams; snails (*Littorina spp*.), and other mollusks, with polychaete worms, insect larvae, and crustaceans also eaten in some locations. A prominent departure from typical prey items occurs each spring when red knots feed on the eggs of horseshoe crabs, particularly during the key migration stopover within the Delaware Bay of New Jersey and Delaware. Delaware Bay serves as the principal spring migration staging area for the red knot because of the availability of horseshoe crab eggs (Clark et al. 2009; Harrington 2001; Harrington 1996; Morrison and Harrington 1992), which provide a superabundant source of easily digestible food. In South Carolina, red knots appear to concentrate on *Donax spp*. as prey items, until horseshoe crab eggs become available, and then the horseshoe crab eggs become the main prey item (Melissa Bimbi pers. comm. 2015).

Red knots and other shorebirds that are long-distance migrants must take advantage of seasonally abundant food resources at intermediate stopovers to build up fat reserves for the next non-stop, long-distance flight (Clark et al. 1993). Although foraging red knots can be found widely distributed in small numbers within suitable habitats during the migration period, birds tend to concentrate in those areas where abundant food resources are consistently available from year to year (USFWS 2013a).

4.1.3. Population dynamics

In the U.S., red knot populations declined sharply in the late 1800s and early 1900s due to excessive sport and market hunting, followed by hunting restrictions and signs of population recovery by the mid-1900s (Urner and Storer 1949; Stone 1937; Bent 1927). However, it is unclear whether the red knot population fully recovered its historical numbers (Harrington 2001) following the period of unregulated hunting. More recently, long-term survey data from two key areas (Tierra del Fuego wintering area and Delaware Bay spring stopover site) both show a roughly 75 percent decline in red knot numbers since the 1980s (Dey et al. 2011; Clark et al. 2009; Morrison et al. 2004; Morrison and Ross 1989; Kochenberger 1983; Dunne et al. 1982; Wander and Dunne, 1982; USFWS 2013a).

For many portions of the knot's range, available survey data are patchy. Prior to the 1980s, numerous natural history accounts are available, but provide mainly qualitative or localized population estimates. No population information exists for the breeding range because, in breeding habitats, red knots are thinly distributed across a huge and remote area of the Arctic. Despite some localized survey efforts, (e.g., Niles et al. 2008), there are no regional or comprehensive estimates of breeding abundance, density, or productivity (Niles et al. 2008).

Counts in wintering areas are useful in estimating red knot populations and trends because the birds generally remain within a given wintering area for a longer period of time compared to the areas used during migration. This eliminates errors associated with turnover or double-counting that can occur during migration counts. Harrington et al. (1988) reported that the mean count of birds wintering in Florida was 6,300 birds (± 3,400, one standard deviation) based on 4 aerial surveys conducted from October to January in 1980 to 1982. Based on these surveys and other work, the Southeast wintering group was estimated at roughly 10,000 birds in the 1970s and 1980s (Harrington 2005a; USFWS 2013b).

Based on resightings of birds banded in South Carolina and Georgia from 1999 to 2002, the Southeast wintering population was estimated at 11,700 ± 1,000 (standard error) red knots. Although there appears to have been a gradual shift by some of the southeastern knots from the Florida Gulf coast to the Atlantic coasts of Georgia and South Carolina, population estimates for the Southeast region in the 2000s were at about the same level as during the 1980s (Harrington 2005a). Based on recent modeling using resightings of marked birds staging in Georgia in fall, as well as other evidence, the Southeast wintering group may number as high as 20,000 (Harrington pers. comm. 2012), but field survey data are not available to corroborate this estimate (USFWS 2013b).

Beginning in 2006, coordinated red knot surveys have been conducted from Florida to Delaware Bay during 2 consecutive days from May 20 to 24 (**Table 15**). This period is thought to represent the peak of the red knot migration. There has been variability in methods, observers, and areas covered. From 2006 to 2010, there was no change in counts that could not be attributed to varying geographic survey coverage (Dey et al. 2011); thus, we do not consider any apparent trends in these data before 2010.

Because red knot numbers peak earlier in the Southeast than in the mid-Atlantic (Bimbi pers. comm. 2013), the late-May coast-wide survey data likely reflect the movement of some birds north along the coast, and may miss other birds that depart for Canada from the Southeast along an interior (overland) route prior to the survey window. Thus, greater numbers of red knots may utilize Southeastern stopovers than suggested by the data in **Table 15**. For example, a peak count of over 8,000 red knots was documented in South Carolina during spring 2012 (South Carolina Department of Natural Resources 2012). Dinsmore et al. (1998) found a mean of 1,363 (±725) red knots in North Carolina during spring 1992 and 1993, with a peak count of 2,764 birds (USFWS 2013b).

Table 15. Red knot counts along the Atlantic coast of the U.S., May 20 to 24, 2006 to 2012 (Dey pers. comm. 2012; Dey et al. 2011).

<table>
<tr><th>State</th><th>2006</th><th>2007</th><th>2008</th><th>2009</th><th>2010</th><th>2011</th><th>2012</th></tr>
<tr><td>New Jersey</td><td>7,860</td><td>4,445</td><td>10,045</td><td rowspan="2">16,229</td><td>8,945</td><td>7,737</td><td>23,525</td></tr>
<tr><td>Delaware</td><td>820</td><td>2,950</td><td>5,350</td><td>5,530</td><td>5,067</td><td>3,433</td></tr>
<tr><td>Maryland</td><td>nr</td><td>nr</td><td>663</td><td>78</td><td>5</td><td>83</td><td>139</td></tr>
<tr><td>Virginia</td><td>5,783</td><td>5,939</td><td>7,802</td><td>3,261</td><td>8,214</td><td>6,236</td><td>8,482</td></tr>
<tr><td>North Carolina</td><td>235</td><td>304</td><td>1,137</td><td>1,466</td><td>1,113</td><td>1,868</td><td>2,832</td></tr>
<tr><td>South Carolina</td><td>nr</td><td>125</td><td>180</td><td>10</td><td>1,220</td><td>315</td><td>542</td></tr>
<tr><td>Georgia</td><td>796</td><td>2,155</td><td>1,487</td><td>nr</td><td>260</td><td>3,071</td><td>1,466</td></tr>
<tr><td>Florida</td><td>nr</td><td>nr</td><td>868</td><td>800</td><td>41</td><td></td><td>10</td></tr>
<tr><td>Total</td><td>15,494</td><td>15,918</td><td>27,532</td><td>21,844</td><td>25,328</td><td>24,377</td><td>40,429</td></tr>
</table>

nr = not reported

4.1.4. Status and Distribution

Reason for listing: The Service has determined that the rufa red knot is threatened due to loss of both breeding and nonbreeding habitat; potential for disruption of natural predator cycles on the breeding grounds; reduced prey availability throughout the nonbreeding range; and increasing frequency and severity of asynchronies (“mismatches”) in the timing of the birds’ annual migratory cycle relative to favorable food and weather conditions.

Range-Wide Trends:

Wintering areas for the red knot include the Southeast U.S. from Florida to North Carolina, the Atlantic coasts of Argentina and Chile, the north coast of Brazil, and the Northwest Gulf of Mexico from the Mexican State of Tamaulipas to Louisiana (Newstead et al. 2013; Patrick pers. comm. 2012; Niles et al. 2008). Smaller numbers of knots winter in the Caribbean, and along the central Gulf coast (Alabama, Mississippi), the mid-Atlantic, and the Northeast U.S. *Calidris canutus* is also known to winter in Central America and northwest South America, but it is not yet clear if all these birds are the *rufa* subspecies.

In some years, more red knots have been counted during a coordinated spring migration survey than can be accounted for at known wintering sites, suggesting there are unknown wintering areas. Indeed, geolocators have started revealing previously little-known wintering areas, particularly in the Caribbean (Niles et al. 2012; Niles pers. comm. 2013).

The core of the Southeast wintering area (i.e., that portion of this large region supporting the majority of birds) is thought to shift from year to year among Florida, Georgia, and South Carolina (Niles et al. 2008). However, the geographic limits of this wintering region are poorly defined. Although only small numbers are known, wintering knots extend along the Atlantic coast as far north as Virginia (Patrick pers. comm. 2012; Niles et al. 2006), Maryland (Burger et al. 2012), and New Jersey (BandedBirds.org 2012; Hanlon pers. comm. 2012; Dey pers. comm. 2012). Still smaller numbers of red knots have been reported between December and February from Long Island, New York, through Massachusetts and as far north as Nova Scotia, Canada (eBird.org 2012).

Recovery Criteria

A Recovery Plan for the red knot has not yet been completed. It will be developed, pursuant to Subsection 4(f) of the ESA, in the near future.

4.1.5. Analysis of the Species Likely to be Affected

Within the nonbreeding portion of the range, red knot habitat is primarily threatened by the highly interrelated effects of sea level rise, shoreline stabilization, and coastal development. Lesser threats to nonbreeding habitat include agriculture and aquaculture, invasive vegetation, and beach maintenance activities. Within the breeding portion of the range, the primary threat to red knot habitat is from climate change. With arctic warming, vegetation conditions in the breeding grounds are expected to change, causing the zone of nesting habitat to shift and perhaps contract. Arctic freshwater systems—foraging areas for red knots during the nesting season—are particularly sensitive to climate change.

Climate Change & Sea Level Rise

The natural history of Arctic-breeding shorebirds makes this group of species particularly vulnerable to global climate change (Meltofte et al. 2007; Piersma and Lindström 2004; Rehfisch and Crick 2003; Piersma and Baker 2000; Zöckler and Lysenko 2000; Lindström and Agrell 1999). Relatively low genetic diversity, which is thought to be a consequence of survival through past climate-driven population bottlenecks, may put shorebirds at more risk from human-induced climate variation than other avian taxa (Meltofte et al. 2007); low genetic diversity may result in reduced adaptive capacity as well as increased risks when population sizes drop to low levels.

In the short term, red knots may benefit if warmer temperatures result in fewer years of delayed horseshoe crab spawning in Delaware Bay (Smith and Michaels 2006) or fewer occurrences of late snow melt in the breeding grounds (Meltofte et al. 2007). However, there are indications that changes in the abundance and quality of red knot prey are already underway (Escudero et al. 2012; Jones et al. 2010), and prey species face ongoing climate-related threats from warmer temperatures (Jones et al. 2010; Philippart et al. 2003; Rehfisch and Crick 2003), ocean acidification (NRC 2010; Fabry et al. 2008), and possibly increased prevalence of disease and parasites (Ward and Lafferty 2004). In addition, red knots face imminent threats from loss of habitat caused by sea level rise (NRC 2010; Galbraith et al. 2002; Titus 1990), and increasing asynchronies ("mismatches") between the timing of their annual breeding, migration, and wintering cycles and the windows of peak food availability on which the birds depend (Smith et al. 2011; McGowan et al. 2011; Meltofte et al. 2007; van Gils et al. 2005a; Baker et al. 2004).

With arctic warming, vegetation conditions in the red knot's breeding grounds are expected to change, causing the zone of nesting habitat to shift and perhaps contract, but this process may take decades to unfold (Feng et al. 2012; Meltofte et al. 2007; Kaplan et al. 2003). Ecological shifts in the Arctic may appear sooner. High uncertainty exists about when and how changing interactions among vegetation, predators, competitors, prey, parasites, and pathogens may affect the red knot, but the impacts are potentially profound (Fraser et al. 2013; Schmidt et al. 2012; Meltofte et al. 2007; Ims and Fuglei 2005).

For most of the year, red knots live in or immediately adjacent to intertidal areas. These habitats are naturally dynamic, as shorelines are continually reshaped by tides, currents, wind, and storms. Coastal habitats are susceptible to both abrupt (storm-related) and long-term (sea level rise) changes. Outside of the breeding grounds, red knots rely entirely on these coastal areas to fulfill their roosting and foraging needs, making the birds vulnerable to the effects of habitat loss from rising sea levels. Because conditions in coastal habitats are also critical for building up nutrient and energy stores for the long migration to the breeding grounds, sea level rise affecting conditions on staging areas also has the potential to impact the red knot's ability to breed successfully in the Arctic (Meltofte et al. 2007).

According to the NRC (2010), the rate of global sea level rise has increased from about 0.02 in (0.6 mm) per year in the late 19th century to approximately 0.07 in (1.8 mm) per year in the last half of the 20th century. The rate of increase has accelerated, and over the past 15 years has been in excess of 0.12 in (3 mm) per year. In 2007, the IPCC estimated that sea level would "likely" rise by an additional 0.6 to 1.9 feet (ft) (0.18 to 0.59 meters (m)) by 2100 (NRC 2010). This projection was based largely on the observed rates of change in ice sheets and projected future thermal expansion of the oceans but did not include the possibility of changes in ice sheet dynamics (e.g., rates and patterns of ice sheet growth versus loss). Scientists are working to improve how ice dynamics can be resolved in climate models. Recent research suggests that sea levels could potentially rise another 2.5 to 6.5 ft (0.8 to 2 m) by 2100, which is several times larger than the 2007 IPCC estimates (NRC 2010; Pfeffer et al. 2008). However, projected rates of sea level rise estimates remain rather uncertain, due mainly to limits in scientific understanding of glacier and ice sheet dynamics (NRC 2010; Pfeffer et al. 2008). The amount of sea level change varies regionally because of different rates of settling (subsidence) or uplift of the land, and because of differences in ocean circulation (NRC 2010). In the last century, for example, sea level rise along the U.S. mid- Atlantic and Gulf coasts exceeded the global average by 5 to 6 in (13 to 15 cm) because coastal lands in these areas are subsiding (USEPA 2013). Land subsidence also occurs in some areas of the Northeast, at current rates of 0.02 to 0.04 in (0.5 to 1 mm) per year across this region (Ashton et al. 2007); primarily the result of slow, natural geologic processes (NOAA 2013). Due to regional differences, a 2-ft (0.6-m) rise in global sea level by the end of this century would result in a relative sea level rise of 2.3 ft (0.7 m) at New York City, 2.9 ft (0.9 m) at Hampton Roads, Virginia, and 3.5 ft (1.1 m) at Galveston, Texas (U.S. Global Change Research Program (USGCRP) 2009). **Table 16** shows that local rates of sea level rise in the range of the red knot over the second half of the 20th century were generally higher than the global rate of 0.07 in (1.8 mm) per year.

Table 16. Local sea level trends from within the range of the red knot (NOAA 2012)

Station	Mean Local Sea Level Trend (mm per year)	Data Period
Pointe-Au-Père, Canada	-0.36 ± 0.40	1900–1983
Woods Hole, Massachusetts	2.61 ± 0.20	1932–2006
Cape May, New Jersey	4.06 ± 0.74	1965–2006
Lewes, Delaware	3.20 ± 0.28	1919–2006
Chesapeake Bay Bridge Tunnel, Virginia	6.05 ± 1.14	1975–2006
Beaufort, North Carolina	2.57 ± 0.44	1953–2006
Clearwater Beach, Florida	2.43 ± 0.80	1973–2006
Padre Island, Texas	3.48 ± 0.75	1958–2006
Punto Deseado, Argentina	-0.06 ± 1.93	1970–2002

Data from along the U.S. Atlantic coast suggest a relationship between rates of sea level rise and long-term erosion rates; thus, long-term coastal erosion rates may increase as sea level rises (Florida Oceans and Coastal Council 2010). However, even if such a correlation is borne out, predicting the effect of sea level rise on beaches is more complex. Even if wetland or upland coastal lands are lost, sandy or muddy intertidal habitats can often migrate or reform. However, forecasting how such changes may unfold is complex and uncertain. Potential effects of sea level rise on beaches vary regionally due to subsidence or uplift of the land, as well as the geological character of the coast and nearshore (U.S. Climate Change Science Program (CCSP) 2009b; Galbraith et al. 2002). Precisely forecasting the effects of sea level rise on particular coastal habitats will require integration of diverse information on local rates of sea level rise, tidal ranges, subsurface and coastal topography, sediment accretion rates, coastal processes, and other factors that is beyond the capability of current models (CCSP 2009b; Frumhoff et al. 2007; Thieler and Hammar-Klose 2000; Thieler and Hammar-Klose 1999).

Because the majority of the Atlantic and Gulf coasts consist of sandy shores, inundation alone is unlikely to reflect the potential consequences of sea level rise. Instead, long-term shoreline changes will involve contributions from inundation and erosion, as well as changes to other coastal environments such as wetland losses. Most portions of the open coast of the U.S. will be subject to significant physical changes and erosion over the next century because the majority of coastlines consist of sandy beaches, which are highly mobile and in a state of continual change (CCSP 2009b).

By altering coastal geomorphology, sea level rise will cause significant and often dramatic changes to coastal landforms including barrier islands, beaches, and intertidal flats (CCSP 2009b; Rehfisch and Crick 2003), primary red knot habitats. Due to increasing sea levels, storm-surge-driven floods now qualifying as 100-year events are projected to occur as often as every 10 to 20 years along most of the U.S. Atlantic coast by 2050, with even higher frequencies of such large floods in certain localized areas (Tebaldi et al. 2012). Rising sea level not only increases the likelihood of coastal flooding, but also changes the template for waves and tides to sculpt the coast, which can lead to loss of land orders of magnitude greater than that from direct inundation alone (Ashton et al. 2007).

Red knot migration and wintering habitats in the U.S. generally consist of sandy beaches that are dynamic and subject to seasonal erosion and accretion. Sea level rise and shoreline erosion have reduced availability of intertidal habitat used for red knot foraging, and in some areas, roosting sites have also been affected (Niles et al. 2008). With moderately rising sea levels, red knot habitats in many portions of the U.S. would be expected to migrate or reform rather than be lost, except where they are constrained by coastal development or shoreline stabilization (Titus et al. 2009). However, if the sea rises more rapidly than the rate with which a particular coastal system can keep pace, it could fundamentally change the state of the coast (CCSP 2009b).

Climate change is also resulting in asynchronies during the annual cycle of the red knot. The successful annual migration and breeding of red knots is highly dependent on the timing of departures and arrivals to coincide with favorable food and weather conditions. The frequency and severity of asynchronies is likely to increase with climate change. In addition, stochastic encounters with unfavorable conditions are more likely to result in population-level effects for red knots now than when population sizes were larger, as reduced numbers may have reduced the resiliency of this subspecies to rebound from impacts.

For unknown reasons, more red knots arrived late in Delaware Bay in the early 2000s, which is generally accepted as a key causative factor (along with reduced supplies of horseshoe crab eggs) behind red knot population declines that were observed over this same timeframe. Thus, the red knot's sensitivity to timing asynchronies has been demonstrated through a population-level response. Both adequate supplies of horseshoe crab eggs and high-quality foraging habitat in Delaware Bay can serve to partially mitigate minor asynchronies at this key stopover site. However, the factors that caused delays in the spring migrations of red knots from Argentina and Chile are still unknown, and we have no information to indicate if this delay will reverse, persist, or intensify. Superimposed on this existing threat of late arrivals in Delaware Bay are new threats of asynchronies emerging due to climate change. Climate change is likely to affect the reproductive timing of horseshoe crabs in Delaware Bay, mollusk prey species at other stopover sites, or both, possibly pushing the peak seasonal availability of food outside of the windows when red knots rely on them. In addition, both field studies and modeling have shown strong links between the red knot's reproductive output and conditions in the Arctic including insect abundance and snow cover. Climate change may also cause shifts in the period of optimal arctic conditions relative to the time period when red knots currently breed.

Shoreline stabilization

Structural development along the shoreline and manipulation of natural inlets upset the naturally dynamic coastal processes and result in loss or degradation of beach habitat (Melvin et al. 1991). As beaches narrow, the reduced habitat can directly lower the diversity and abundance of biota (life forms), especially in the upper intertidal zone. Shorebirds may be impacted both by reduced habitat area for roosting and foraging, and by declining intertidal prey resources, as has been documented in California (Defeo et al. 2009; Dugan and Hubbard 2006). In Delaware Bay, hard structures also cause or accelerate loss of horseshoe crab spawning habitat (CCSP 2009b; Botton et al. in Shuster et al. 2003; Botton et al. 1988), and shorebird habitat has been, and may continue to be, lost where bulkheads have been built (Clark in Farrell and Martin 1997). In addition to directly eliminating red knot habitat, hard structures interfere with the creation of new shorebird habitats by interrupting the natural processes of overwash and inlet formation. Where hard stabilization is installed, the eventual loss of the beach and its associated habitats is virtually assured (Rice 2009), absent beach nourishment, which may also impact red knots. Where they are maintained, hard structures are likely to significantly increase the amount of red knot habitat lost as sea levels continue to rise.

In a few isolated locations, however, hard structures may enhance red knot habitat, or may provide artificial habitat. In Delaware Bay, for example, Botton et al. (1994) found that, in the same manner as natural shoreline discontinuities like creek mouths, jetties and other artificial obstructions can act to concentrate drifting horseshoe crab eggs and thereby attract shorebirds. Another example comes from the Delaware side of the bay, where a seawall and jetty at Mispillion Harbor protect the confluence of the Mispillion River and Cedar Creek. These structures create a low energy environment in the harbor, which seems to provide highly suitable conditions for horseshoe crab spawning over a wider variation of weather and sea conditions than anywhere else in the bay (Breese pers. comm. 2013). Horseshoe crab egg densities at Mispillion Harbor are consistently an order of magnitude higher than at other bay beaches (Dey et al. 2011), and this site consistently supports upwards of 15 to 20 percent of all the knots recorded in Delaware Bay (Lathrop 2005). Notwithstanding localized red knot use of artificial structures, and the isolated case of hard structures improving foraging habitat at Mispillion Harbor, the nearly universal effect of such structures is the degradation or loss of red knot habitat.

Sand Placement

Where shorebird habitat has been severely reduced or eliminated by hard stabilization structures, beach nourishment may be the only means available to replace any habitat for as long as the hard structures are maintained (Nordstrom and Mauriello 2001), although such habitat will persist only with regular nourishment episodes. In Delaware Bay, beach nourishment has been recommended to prevent loss of spawning habitat for horseshoe crabs (Kalasz 2008; Carter et al. in Guilfoyle et al. 2007; Atlantic States Marine Fisheries Commission (ASMFC) 1998), and is being pursued as a means of restoring shorebird habitat in Delaware Bay following Hurricane Sandy (Niles et al. 2013; USACE 2012). Beach nourishment was part of a 2009 project to maintain important shorebird foraging habitat at Mispillion Harbor, Delaware (Kalasz pers. comm. 2013; Siok and Wilson 2011). However, red knots may be directly disturbed if beach nourishment takes place while the birds are present. On New Jersey's Atlantic coast, beach nourishment has typically been scheduled for the fall, when red knots are present, because of various constraints at other times of year. In addition to causing disturbance during construction, beach nourishment often increases recreational use of the widened beaches that, without careful management, can increase disturbance of red knots. Beach nourishment can also temporarily depress, and sometimes permanently alter, the invertebrate prey base on which shorebirds depend. In addition to disturbing the birds and impacting the prey base, beach nourishment can affect the quality and quantity of red knot habitat (Bimbi pers. comm. 2012; Greene 2002). The artificial beach created by nourishment may provide only suboptimal habitat for red knots, as a steeper beach profile is created when sand is stacked on the beach during the nourishment process. In some cases, nourishment is accompanied by the planting of dense beach grasses, which can directly degrade habitat, as red knots require sparse vegetation to avoid predation. By precluding overwash and Aeolian transport, especially where large artificial dunes are constructed, beach nourishment can also lead to further erosion on the bayside and promote bayside vegetation growth, both of which can degrade the red knot's preferred foraging and roosting habitats (sparsely vegetated flats in or adjacent to intertidal areas). Preclusion of overwash also impedes the formation of new red knot habitats. Beach nourishment can also encourage further development, bringing further habitat impacts, reducing future alternative management options such as a retreat from the coast, and perpetuating the developed and stabilized conditions that may ultimately lead to inundation where beaches are prevented from migrating (Bimbi pers. comm. 2012; Greene 2002).

The quantity and quality of red knot prey may also be affected by the placement of sediment for beach nourishment or disposal of sand. Invertebrates may be crushed or buried during project construction. Although some benthic species can burrow through a thin layer of additional sediment, thicker layers (over 35 in (90 cm)) smother the benthic fauna (Greene 2002). By means of this vertical burrowing, recolonization from adjacent areas, or both, the benthic faunal communities typically recover. Recovery can take as little as 2 weeks or as long as 2 years, but usually averages 2 to 7 months (Greene 2002; Peterson and Manning 2001). Although many studies have concluded that invertebrate communities recovered following sand placement, study methods have often been insufficient to detect even large changes in abundance or species composition due to high natural variability and small sample sizes (Peterson and Bishop 2005). Peterson et al (2006) found that although *Emerita talpoida* abundance recovered relatively rapidly after beach nourishment on Bogue Banks, recovery of *Donax spp*. and amphipods was much longer. This is thought to be because *Emerita* is known to prefer relatively coarse sediments (Bowman and Dolan 1985). *Donax* is one of the preferred prey items of red knot. Uncertainty remains about the effects of sand placement on invertebrate communities and how these impacts may affect red knots.

Dredging/sand mining

Many inlets in the U.S. range of the red knot are routinely dredged and sometimes relocated. In addition, nearshore areas are routinely dredged ("mined") to obtain sand for beach nourishment. Regardless of the purpose, inlet and nearshore dredging can affect red knot habitats. Dredging often involves removal of sediment from sand bars, shoals, and inlets in the nearshore zone, directly impacting optimal red knot roosting and foraging habitats (Harrington in Guilfoyle et al. 2007; Winn and Harrington in Guilfoyle et al. 2006). These ephemeral habitats are even more valuable to red knots because they tend to receive less recreational use than the main beach strand. In addition to causing this direct habitat loss, the dredging of sand bars and shoals can preclude the creation and maintenance of red knot habitats by removing sand sources that would otherwise act as natural breakwaters and weld onto the shore over time (Hayes and Michel 2008; Morton 2003). Further, removing these sand features can cause or worsen localized erosion by altering depth contours and changing wave refraction (Hayes and Michel 2008), potentially degrading other nearby red knot habitats indirectly because inlet dynamics exert a strong influence on the adjacent shorelines. Studying barrier islands in Virginia and North Carolina, Fenster and Dolan (1996) found that inlet influences extend 3.4 to 8.1 mi (5.4 to 13.0 km), and that inlets dominate shoreline changes for up to 2.7 mi (4.3 km). Changing the location of dominant channels at inlets can create profound alterations to the adjacent shoreline (Nordstrom 2000).

Reduced food availability

Commercial harvest of horseshoe crabs has been implicated as a causal factor in the decline of the rufa red knot, by decreasing the availability of horseshoe crab eggs in the Delaware Bay stopover (Niles et al. 2008). Notwithstanding the importance of the horseshoe crab and Delaware Bay, other lines of evidence suggest that the rufa red knot also faces threats to its food resources throughout its range.

During most of the year, bivalves and other mollusks are the primary prey for the red knot. Mollusks in general are at risk from climate change-induced ocean acidification (Fabry et al. 2008). Oceans become more acidic as carbon dioxide emitted into the atmosphere dissolves in the ocean. The pH (percent hydrogen, a measure of acidity or alkalinity) level of the oceans has decreased by approximately 0.1 pH units since preindustrial times, which is equivalent to a 25 percent increase in acidity. By 2100, the pH level of the oceans is projected to decrease by an additional 0.3 to 0.4 units under the highest emissions scenarios (NRC 2010). As ocean acidification increases, the availability of calcium carbonate declines. Calcium carbonate is a key building block for the shells of many marine organisms, including bivalves and other mollusks (USEPA 2012; NRC 2010). Vulnerability to ocean acidification has been shown in bivalve species similar to those favored by red knots, including mussels (Gaylord et al. 2011; Bibby et al. 2008) and clams (Green et al. 2009). Reduced calcification rates and calcium metabolism are also expected to affect several mollusks and crustaceans that inhabit sandy beaches (Defeo et al. 2009), the primary nonbreeding habitat for red knots. Relevant to Tierra del Fuego-wintering knots, bivalves have also shown vulnerability to ocean acidification in Antarctic waters, which are predicted to be affected due to naturally low carbonate saturation levels in cold waters (Cummings et al. 2011).

Blue mussel spat is an important prey item for red knots in Virginia (Karpanty et al. 2012). The southern limit of adult blue mussels has contracted from North Carolina to Delaware since 1960 due to increasing air and water temperatures (Jones et al. 2010). Larvae have continued to recruit to southern locales (including Virginia) via currents, but those recruits die early in the summer due to water and air temperatures in excess of lethal physiological limits. Failure to recolonize southern regions will occur when reproducing populations at higher latitudes are beyond dispersal distance (Jones et al. 2010). Thus, this key prey resource may soon disappear from the red knot's Virginia spring stopover habitats (Karpanty et al. 2012).

Reduced food availability at the Delaware Bay stopover site due to commercial harvest and subsequent population decline of the horseshoe crab is considered a primary causal factor in the decline of the rufa subspecies in the 2000s (Escudero et al. 2012; McGowan et al. 2011; CAFF 2010; Niles et al. 2008; COSEWIC 2007; González et al. 2006; Baker et al. 2004; Morrison et al. 2004), although other possible causes or contributing factors have been postulated (Fraser et al. 2013; Schwarzer et al. 2012; Escudero et al. 2012; Espoz et al. 2008; Niles et al. 2008). Due to harvest restrictions and other conservation actions, horseshoe crab populations showed some signs of recovery in the early 2000s, with apparent signs of red knot stabilization (survey counts, rates of weight gain) occurring a few years later. Since about 2005, however, horseshoe crab population growth has stagnated for unknown reasons. Under the current management framework (known as Adaptive Resource Management, or ARM), the present horseshoe crab harvest is not considered a threat to the red knot because harvest levels are tied to red knot populations via scientific modeling. Most data suggest that the volume of horseshoe crab eggs is currently sufficient to support the Delaware Bay's stopover population of red knots at its present size. However, because of the uncertain trajectory of horseshoe crab population growth, it is not yet known if the egg resource will continue to adequately support red knot populations over the next 5 to 10 years. In addition, implementation of the ARM could be impeded by insufficient funding for the shorebird and horseshoe crab monitoring programs that are necessary for the functioning of the ARM models. Many studies have established that red knots stopping over in

Delaware Bay during spring migration achieve remarkable and important weight gains to complete their migrations to the breeding grounds by feeding almost exclusively on a superabundance of horseshoe crab eggs. A temporal correlation occurred between increased horseshoe crab harvests in the 1990s and declining red knot counts in both Delaware Bay and Tierra del Fuego by the 2000s. Other shorebird species that rely on Delaware Bay also declined over this period (Mizrahi and Peters in Tanacredi et al. 2009), although some shorebird declines began before the peak expansion of the horseshoe crab fishery (Botton et al. in Shuster et al. 2003).

Hunting

Legal and illegal sport and market hunting in the mid-Atlantic and Northeast U.S. substantially reduced red knot populations in the 1800s, and we do not know if the subspecies ever fully recovered to its former abundance or distribution. Neither legal nor illegal hunting are currently a threat to red knots in the U.S., but both occur in the Caribbean and parts of South America. Hunting pressure on red knots and other shorebirds in the northern Caribbean and on Trinidad is unknown. Hunting pressure on shorebirds in the Lesser Antilles (e.g., Barbados, Guadeloupe) is very high, but only small numbers of red knots have been documented on these islands, so past mortality may not have exceeded tens of birds per year. Red knots are no longer being targeted in Barbados or Guadeloupe, and other measures to regulate shorebird hunting on these islands are being negotiated. Much larger numbers (thousands) of red knots occur in the Guianas, where legal and illegal subsistence shorebird hunting is common. About 20 red knot mortalities have been documented in the Guianas, but total red knot hunting mortality in this region cannot be surmised. Subsistence shorebird hunting was also common in northern Brazil, but has decreased in recent decades. We have no evidence that hunting was a driving factor in red knot population declines in the 2000s, or that hunting pressure is increasing. In addition, catch limits, handling protocols, and studies on the effects of research activities on survival all indicate that overutilization for scientific purposes is not a threat to the red knot.

Threats to the red knot from overutilization for commercial, recreational, scientific, or educational purposes exist in parts of the Caribbean and South America. Specifically, legal and illegal hunting does occur. We expect mortality of individual knots from hunting to continue into the future, but at stable or decreasing levels due to the recent international attention to shorebird hunting.

Predation

In wintering and migration areas, the most common predators of red knots are peregrine falcons (*Falco peregrinus*), harriers (*Circus spp*.), accipiters (Family Accipitridae), merlins (*F. columbarius*), shorteared owls (*Asio flammeus*), and greater black-backed gulls (*Larus marinus*) (Niles et al. 2008). Other large are anecdotally known to prey on shorebirds (Breese 2010). In migration areas like Delaware Bay, terrestrial predators such as red foxes (*Vulpes vulpes*) and feral cats (*Felis catus*) may be a threat to red knots by causing disturbance, but direct mortality from these predators may be low (Niles et al. 2008).

Although little information is available from the breeding grounds, the long-tailed jaeger (*Stercorarius longicaudus*) is prominently mentioned as a predator of red knot chicks in most accounts. Other avian predators include parasitic jaeger (*S. parasiticus*), pomarine jaeger (*S. pomarinus*), herring gull and glaucous gulls, gyrfalcon (*Falcon rusticolus*), peregrine falcon, and snowy owl (*Bubo scandiacus*). Mammalian predators include arctic fox (*Alopex lagopus*) and sometimes arctic wolves (*Canis lupus arctos*) (Niles et al. 2008; COSEWIC 2007). Predation pressure on Arctic-nesting shorebird clutches varies widely regionally, interannually, and even within each nesting season, with nest losses to predators ranging from close to 0 percent to near 100 percent (Meltofte et al. 2007), depending on ecological factors. Abundance of arctic rodents, such as lemmings, is often cyclical, although less so in North America than in Eurasia. In the Arctic, 3- to 4-year lemming cycles give rise to similar cycles in the predation of shorebird nests. When lemmings are abundant, predators concentrate on the lemmings, and shorebirds breed successfully. When lemmings are in short supply, predators switch to shorebird eggs and chicks (Niles et al. 2008; COSEWIC 2007; Meltofte et al. 2007; USFWS 2003b; Blomqvist et al. 2002; Summers and Underhill 1987).

Recreational disturbance

In some wintering and stopover areas, red knots and recreational users (e.g., pedestrians, ORVs, dog walkers, boaters) are concentrated on the same beaches (Niles et al. 2008; Tarr 2008). Recreational activities affect red knots both directly and indirectly. These activities can cause habitat damage (Schlacher and Thompson 2008c; Anders and Leatherman 1987), cause shorebirds to abandon otherwise preferred habitats, and negatively affect the birds' energy balances. Effects to red knots from vehicle and pedestrian disturbance can also occur during construction of shoreline stabilization projects including beach nourishment. Red knots can also be disturbed by motorized and nonmotorized boats, fishing, kite surfing, aircraft, and research activities (Niles et al. 2008; Peters and Otis 2007; Harrington 2005b; Meyer et al. 1999; Burger 1986) and by beach raking or cleaning.

Table 17 lists biological opinions that have been issued for adverse impacts to red knots since 2014, within the Raleigh Field Office geographic area. Activities addressed by the BOs include inlet dredging, sand placement, construction of sandbag revetments, and terminal groin construction.

Table 17. BOs issued since 2014 within the Raleigh Field Office geographic area.

OPINIONS	**RED KNOT HABITAT**
Fiscal Year 2014: 1 BO	12,600 lf (2.4 mi)
Fiscal Year 2015: 5 BOs	70,268 lf (13.3 mi)
Fiscal Year 2016: 8 BOs	229,937 lf (43.54 mi)
Fiscal Year 2017: 1 BO (to date)	27,650 lf (5.24 mi)
Total: 15 BOs	**340,455 lf (64.48 mi)**

The proposed action has the potential to adversely affect wintering and migrating red knots and their habitat. Potential effects to red knots include disturbance during construction, degradation of foraging habitat and destruction of the prey base from sand placement, attraction of predators due to food waste from the construction crew, and disturbance due to increased recreational use. Like the piping plover, red knots face predation by avian and mammalian predators that are present year-round on the migration and wintering grounds.

4.2. Environmental Baseline

4.2.1. Status of the species within the Action Area

Aerial surveys for *rufa* red knots have been performed throughout the state and data from these surveys are maintained by NCWRC. Data is only currently available from 2006 to 2012. Data from the PBA and NCWRC (www.paws.org) are provided in **Table 18**.

Table 18. Number of red knots observed during aerial surveys from Bogue Banks to Sunset Beach, 2006-2012. Table (3.11) from the PBA, data from the PAWS database (NCWRC 2015).

	2006	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
Bogue Banks			24	345	0	37	33
Bear Island		0		34		0	25
Onslow Beach				336			
North Topsail Overwash					42	8	16
New Topsail Inlet					0	0	0
Lea-Hutaff Island	38	0	34	68	26	7	34
Rich Inlet				40	0		
Figure 8 Island	2	85		64	9	0	54
Mason Inlet			57		0		
Wrightsville Beach	6	0	1	72	5	0	0
Masonboro Island	111	30	1	27	15	22	58
Carolina Beach Inlet			36	11			
Carolina Beach		0	14		0		
Fort Fisher				81	4	20	8
Bald Head Island	78	67		21	5	26	40
Battery Island South			0		0		
Oak Island			0		0	22	0
Lockwood Folly Inlet		0	25	18			
Holden Beach					0	15	56
Ocean Isle Beach					0	23	112
Tubbs Inlet		0		11			
Sunset Beach				0	0	35	75
Bird Shoal (Rachael Carson)		40		0			
Total	**235**	**222**	**192**	**1128**	**106**	**215**	**511**

The National Park Service has surveyed red knots along North Core Banks (NCB) and South Core Banks (SCB) in Cape Lookout National Seashore (CALO) since 2006, conducting regular counts from March through October each year. NCB has much higher counts of red knots than SCB. The mean count along NCB for 2016 was 330 birds per count, while the mean along the SCB shoreline was 34 birds per count. Data from these counts clearly indicate a peak in red knot numbers during May for both NCB and SCB (NPS 2016) (**Table 19**).

Table 19. Red Knot Peak Counts and Relative Abundance (number of birds per kilometer of shoreline) on North Core Banks, 2006 – 2016. Data from NPS 2016.

Year	Peak Count	Date of Peak Count	Relative Abundance (# birds per km)
2006	618	May 5	20
2007	718	May 15	23
2008	1,287	April 15	42
2009	525	May 25	14
2010	927	May 15	26
2011	648	May 15	18
2012	1,370	April 25	46
2013	854	May 25	29
2014	2,666	May 15	89
2015	2,201	May 15	74
2016	2,124	May 15	71

The Service has conducted red knot monitoring along the shoreline of Pea Island National Wildlife Refuge (PINWR) since 1996. Numbers of red knots along PINWR are much lower than those at CALO, with peak numbers ranging from two on June 13, 1996 to 190 on June 6, 2006 (**Table 20**) (Harrison pers. comm. 2017). Red knots are present during every season of the year on PINWR.

Table 20. Peak numbers of red knots along PINWR (Harrison pers. comm. 2017).

Year	Peak Count	Date of Peak Count
1996	2	June 13
1997	5	September 23
1998	107	August 13
1999	44	August 2
2000	56	September 14
2001	74	October 5
2002	137	May 15
2003	34	May 28
2004	101	October 11
2005	36	June14
2006	190	June 6
2007	141	May 29
2008	42	December 3
2009	84	January 15
2010	18	November 17
2011	166	June 3
2012	31	June 5
2013	70	May 15
2014	18	May 28
2015	11	November 13
2016	13	May 26

4.2.2. Factors affecting the species environment within the Action Area

A wide range of recent and on-going beach disturbance activities have altered the North Carolina coastline, and many more are proposed along the coastline for the near future. **Appendix A** (copied from the PBA) and **Table 11** (page 73) list many of these activities.

Beach nourishment: **Appendix A** (from the PBA) lists historical beach sand placement projects for the state of North Carolina. The beaches of North Carolina are regularly nourished with sand from the Corps and from locally-sponsored or private projects. Sand placement activities widen beaches, change their sedimentology and stratigraphy, alter coastal processes, and often plug dune gaps and remove overwash areas. The addition of dredged sediment can temporarily affect the benthic fauna of intertidal systems. Invertebrates may be crushed or buried during project construction. In North Carolina, the majority of sand placement projects are conducted during the migrating or overwintering season for red knots, in an effort to avoid adverse effects to nesting sea turtles. Depending on the timing of the project, burial of prey items can have a significant adverse effect on migrating and overwintering birds.

Invertebrate communities may also be affected by changes in the physical environment resulting from shoreline stabilization activities that alter the sediment composition or degree of exposure. If the material used in a sand placement project does not closely match the native material on the beach, the sediment incompatibility may result in modifications to the macroinvertebrate community structure, because several species are sensitive to grain size and composition (Rakocinski et al. 1996; Peterson et al. 2006; Peterson and Bishop 2005; Colosio et al. 2007; Defeo et al. 2009).

Delayed recovery of the benthic prey base or changes in their communities due to physical habitat changes may affect the quality of red knot foraging habitat. Although recovery of invertebrate communities has been documented in many studies, sampling designs have typically been inadequate and have only been able to detect large-magnitude changes (Schoeman et al. 2000; Peterson and Bishop 2005). Therefore, uncertainty persists about the impacts of various projects to invertebrate communities and how these impacts red knots.

The PBA estimates that approximately 112 miles of Atlantic shoreline has been nourished in North Carolina. Rice (2017) estimates the length of nourished shoreline to be approximately 101 miles, with another 43 miles proposed. The first recorded sand placement project in North Carolina was on Wrightsville Beach in 1939, when sand was placed on 2.6 miles of shoreline. Sand placement did not occur again until the mid to late-1950’s. Sand placement was generally intermittent and small in scope (less than 6 miles per year) until the late 1980’s to 1990’s, when the frequency of sand placement and miles of shoreline per year began to dramatically increase. Many of the beachfront communities have received sand on more than 10 occasions. Carolina Beach is listed in the PBA as having had 40 and placement events, while Wrightsville Beach has had 26, and Holden Beach 45. For most of these events, the sand source is navigation projects. Other sand sources include sediment mined from inlets, offshore borrow areas, and previously dredged material from upland disposal areas or existing material from an upland borrow area. Between 31% (Rice 2017) and 35% (PBA) of the North Carolina Shoreline has been modified by sediment placement as of 2015.

Inlet dredging activities alter the sediment dynamics on adjacent shorelines and stabilize these dynamic environments; beach disposal of dredge material further alters the natural habitat adjacent to inlets. Estuarine dredging of navigational channels can alter water circulation patterns and sediment transport pathways, as well as increase the frequency and magnitude of boat wakes; sound-side sand or mud flats may be impacted by increased erosion rates as a result. Historically, there have been Federal navigation projects in the AIWW and in inlets along the North Carolina coast for decades. During hundreds of dredging events, the sediment has been placed on the adjacent beach using pipelines. Inlets associated with ports and other high-traffic areas typically have maintenance dredging conducted annually, if not more often. At four shallow-draft inlets (Bogue, Topsail, Carolina Beach, and Lockwoods Folly) the Corps has typically dredged the inlet on a quarterly basis, and maintained inlet crossings and connecting channels every one to two years (NCDENR, 2015). Local governments have received authorization to also conduct maintenance dredging of these inlets on the same general schedule, with beach disposal during the winter work window. Inlets that are mined for Coastal Storm Damage Reduction (CSDR) projects (conducted by the Corps or local governments) are typically dredged on three-year intervals, with placement of the sand on the adjacent shoreline. Dredging may remove intertidal shoals and unvegetated sandy habitat on inlet shoulders.

Since 2012, several North Carolina tidal inlets have been dredged regularly for navigation purposes. Oregon Inlet continues to be dredged frequently for navigation and other purposes. In late 2015 the NC Department of Transportation (NCDOT) dredged a channel on the west side of Hatteras Inlet to maintain navigational access in and around Hatteras Inlet. The material was sidecast next to the dredged channel (USACE 2015a, Kozak 2016). Ocracoke Inlet was dredged by the Corps with a sidecast dredge in 2013 (Hinnant 2013). Portions of Beaufort Inlet are dredged yearly or more often than yearly, in order to maintain navigation access to the Morehead City State Port Terminal. Sediment disposal may be to Bogue Banks, to an upland disposal site, or to the Offshore Dredged Material Disposal Site (ODMDS). Beaufort Inlet was dredged in 2013, 2014, and 2017, with dredged sediment placed on Bogue Banks to the west in 2014 (Hibbs 2013, 2014). Similarly, portions of the Lower Cape Fear River are dredged each year to maintain navigation to Wilmington Harbor, with dredged material placed on adjacent beaches (Bald Head Island or Caswell and Oak Island Beaches) or the ODMDS. The Wilmington Harbor Inner Ocean Bar was dredged in 2017 with placement of sand on Caswell and Oak Island Beaches. Carolina Beach Inlet was dredged with a USACE sidecast dredge in 2013. In 2015 Carolina Beach Inlet was dredged by the Corps, state and New Hanover County, with the material placed in a nearshore disposal site off Carolina Beach (Hinnant 2013, Lane 2015). Lockwoods Folly Inlet was dredged by the Corps in 2013 (Hinnant 2013). The Town of Oak Island dredged Eastern Channel, part of the Lockwoods Folly Inlet complex, in 2015 and removed over 3 acres of emergent shoal habitat; the beach-compatible portion of the dredged material was placed on the beach of west Oak Island. The Corps dredged the AIWW and portions of Lockwoods Folly Inlet in 2016-2017 and placed the sand on Holden Beach (Hughes Pers. Comm. 2017). Cow Channel was dredged in early 2017 and the material placed on Bear Island within Hammocks Beach State Park (Corey Pers. Comm. 2017).

According to Rice (2016), at least 10 inlets have been mined for sediment for beach nourishment projects in North Carolina. Shallotte Inlet was mined in 2001 and 2014, Bogue Inlet in 2005, Barden Inlet in 2006, and Rich Inlet (or Nixon Channel) seven times between 1983 and 2011. More recently, Mason Inlet was mined in 2005, 2009, 2011, 2012-2013 and early 2016. Oregon Inlet was mined in 2013. New River Inlet was mined in 2012-2013 as part of an inlet channel relocation project. New Topsail Inlet was mined in 2012 and 2015. The most recent project plans for the federal and local Carolina and Kure Beach CSDR Projects identify Carolina Beach Inlet as a primary sediment source; sediment dredged from the inlet has been placed periodically on Carolina Beach for storm damage reduction since the 1960s. Similarly, sediment removed from the inlet has been used as beach fill on Wrightsville Beach for storm damage reduction since the early 1960's.

Seven North Carolina inlets have been mined for beach sand in the past 5 years. Four of these are sites that have been mined previously, while three have not. The NCDOT mined approximately 33,000 cy of sediment from within Oregon Inlet in 2013 to provide sand to fill for a scour hole adjacent to the Herbert C. Bonner Bridge in another location of the inlet (USACE 2013). New Topsail Inlet was mined in 2012 and 2015 by the Town of Topsail Beach to provide sand for beach nourishment (Town of North Topsail Beach 2015). In 2013, the inlet channel of New River Inlet was relocated, and the dredged material used to fill the beach on North Topsail Beach (Town of North Topsail Beach 2015, USACE 2015b). In February 2017, the Town of North Topsail Beach received a modified permit to modify the ebb tide channel position within New River Inlet.

The four inlets that have been mined previously include Mason Inlet, Shallotte Inlet, Carolina Beach Inlet, and Masonboro Inlet. In many cases, these inlets are both managed for navigation and alternatively mined for sand for beach nourishment. Mason Inlet was mined in 2011, 2013, and 2016 to provide beach fill for Figure Eight Island and to maintain Mason Inlet within a specific inlet corridor. In 2014 and 2017, the Corps mined Shallotte Inlet to nourish adjacent Ocean Isle Beach, pursuant to the Corps' CSDR project (Ocean Isle Beach 2015, Hughes Pers. Comm. 2017). Carolina Beach Inlet was mined in 2013 and 2017 for beach fill on Carolina Beach. Masonboro Inlet was mined in 2014 for beach fill on Wrightsville Beach (USFWS 2016b and 2016c).

In some cases, sand has been dredged from the AIWW or inlets and placed within the sounds to improve habitat for migrating and nesting shorebirds. There are several "bird islands" along the sound shorelines which intermittently receive sand from navigation projects. In 2017, the Corps dredged Old House Channel to Oregon inlet and placed the sand on bird islands near Manteo (Hughes Pers. comm. 2017). Also in 2017, Carteret County dredged Wainwright Slough and placed the sand on the adjacent Wainwright Island. More such projects are planned in the near future, such as proposed placement of material dredged from the lower Cape Fear River on South Pelican and Ferry Slip Islands to restore these small islands for waterbird habitat.

Shoreline Stabilization and Armoring:

In 2017, there are 4 jetties and 34 groins along the North Carolina coast, and sandbags, sandbag revetments, groins, and jetties have been placed along at least 9.05 miles of North Carolina shoreline (Rice 2017). See **Table 14 (**page 81**)** for data from Rice (2017).

Sandbags on private properties provide stabilization to a significant portion of the North Carolina shoreline. Rice (2017) estimated 152 separate sandbag structures along the North Carolina beach shoreline. If multiple properties each had an individual seawall protecting their property and the seawalls were attached to each other with no gaps, then Rice (2017) counted the armoring as one structure (per Dallas et al. 2013) and measured the overall length.

Rice (2017) estimated that 24 of 37 North Carolina coastal communities have been modified by armor. In these communities, the proportion of armored sandy beach habitat was as high as 18%. Four communities exceed 10% of the shoreline armored: Kitty Hawk (18%), Bald Head Island (13%), Kure Beach (11%), and Ocean Isle Beach (10%).

In North Carolina, there are three currently existing terminal groins: along Oregon Inlet, at Fort Macon along Beaufort Inlet in Carteret County, and on Bald Head Island in New Hanover County. The terminal groin on Bald Head Island was installed in 2015, but the other two (Oregon Inlet and Fort Macon) were installed decades ago, and downdrift erosion has been severe at both, requiring frequent nourishment (Pietrafesa 2012; Riggs et al 2009). The Fort Macon groin is fronted by a larger structure that Rice (2016) refers to as jetty.

The Oregon Inlet and Fort Macon Groins are located on the updrift side of the island, but accretion in these areas is not significant due to scour. At Oregon Inlet, there is no sandy habitat on the inlet shoulder updrift of the groin and revetment, and there has not been for decades. There are two degraded groin/jetty structures in Dare County, adjacent to the old location of the Cape Hatteras lighthouse. The Service has issued BOs for the authorization of two other terminal groins (Towns of Ocean Isle Beach and Holden Beach), and the Figure "Eight" Homeowners Association is currently (2017) seeking authorization to construct a terminal groin on the north end of Figure Eight Island (south side of Rich Inlet). Also, in 2015, the North Carolina legislature revised state regulations to allow additional terminal groins to be constructed at New River Inlet and Bogue Inlet. However, it is unclear whether the local governments in the vicinity of these two inlets will propose the construction of a terminal groin. The south jetty along Masonboro Inlet was repaired by the Corps in 2013 and 2014 (USACE 2015c).

There are two existing rock revetments along the coast of North Carolina: one at Fort Fisher (approximately 3,040 lf), and another along Carolina Beach (approximately 2,050 lf). Sandbags and sandbag revetments have been placed along at least 1,800 lf of the eastern shoreline on Ocean Isle Beach, and the Tubbs Inlet shoreline on Ocean Isle Beach is completely lined with a sandbag revetment. A sandbag revetment at least 1,800 lf long (with a geotube in front of a portion) was constructed in 2015 at the north end of North Topsail Beach, and more sandbags were added in 2016 to protect a parking lot north of the revetment. In 2000 and 2001, sandbag revetments were installed on the north end of Figure Eight Island along Surf Court, Inlet Hook Road, and Comber Road.

Beach scraping can artificially steepen beaches, stabilize dune scarps, plug dune gaps, and redistribute sediment distribution patterns. Artificial dune building, often a product of beach scraping, removes low-lying overwash areas and dune gaps. As chronic erosion catches up to structures throughout the Action Area, artificial dune systems are constructed and maintained to protect beachfront structures either by sand fencing or fill placement. Beach scraping or bulldozing has become more frequent on North Carolina beaches in the past 20 years, in response to storms and the continuing retreat of the shoreline with rising sea level. From 2012 to 2015, Rice (2017) estimated that at least 4.84 miles of the North Carolina shoreline was impacted by beach scraping. These activities primarily occur during the winter months, when red knots may be present. Artificial dune or berm systems have been constructed and maintained in several areas. These dunes make the artificial dune ridge function like a seawall that blocks natural beach retreat, evolution, and overwash.

Beach raking and rock-picking: Man-made beach cleaning and raking machines effectively remove seaweed, fish, glass, syringes, plastic, cans, cigarettes, shells, stone, wood, and virtually any unwanted debris (Barber Beach Cleaning Equipment 2009). Removal of wrack also eliminates a beach's natural sand-trapping abilities, further destabilizing the beach. In addition, sand adhering to seaweed and trapped in the cracks and crevices of wrack is removed from the beach. Although the amount of sand lost due to single sweeping actions may be small, it adds up considerably over a period of years (Nordstrom et al. 2006; Neal et al. 2007). Beach cleaning or grooming can result in abnormally broad unvegetated zones that are inhospitable to dune formation or plant colonization, thereby enhancing the likelihood of erosion (Defreo et al. 2009). The Town of Carolina Beach rakes the beach front in Freeman Park at least twice per year. The Town of North Topsail Beach utilizes a rock-picker as needed, typically annually, to remove rocky material from the beach berm along portions of its shoreline.

Sand Fencing: Rice (2017) estimates that 62.69 miles (19%) of North Carolina's shoreline was modified with sand fencing between 2012 and 2015. Sand fencing modified more than 50% of the sandy beach habitat in 6 communities: Pine Knoll Shores (97%), Kill Devil Hills (67%), Atlantic Beach (64%), Southern Shores (63%), Corolla (53%) and Nags Head (53%). In 14 other coastal communities, between 20 and 50% of the sandy beach habitat was modified by sand fencing between 2012 and early 2016. A total of 1,199 contiguous sections of sand fencing were identified on North Carolina's oceanfront beaches in the three years after Hurricane Sandy; only New Jersey had more contiguous sections of sand fencing (1,305), but had a slightly lower total length of sandy beach modified by fencing (60.26 miles, or 96.98 km) (Rice 2017). Sand fencing traps sand (typically lighter fine-grained sand) and may stabilize continuous dunes in developed areas, thereby also degrading, fragmenting, or eliminating sparsely vegetated and unvegetated habitats used by the red knot.

Pedestrian Use of the Beach: There are a number of potential sources of pedestrians and pets on North Carolina beaches, including those individuals originating from beachfront or boat access points, public access points, and hotels, resorts, and residences.

Disturbance from recreational use reduces the time migrating shorebirds spend foraging (Burger 1991). Pfister et al. (1992) implicate disturbance as a factor in the long-term decline of migrating shorebirds at staging areas. In many cases, dogs accompany pedestrians to the beach. Shorebirds are more likely to flush from the presence of dogs than people, and breeding and nonbreeding shorebirds react to dogs from farther distances than people (Lafferty 2001a, 2001b; Lord et al. 2001; Thomas et al. 2003). Foraging shorebirds at a migratory stopover on Delaware Bay, New Jersey responded most strongly to dogs compared with other disturbances; shorebirds often failed to return within ten minutes after the dog left the beach (Burger et al. 2007). Dogs off-leash were disproportionate sources of disturbance in several studies (Thomas et al. 2003; Lafferty 2001b), but leashed dogs also disturbed shorebirds. Pedestrians walking with dogs often go through flocks of foraging and roosting shorebirds; some even encourage their dogs to chase birds.

Horseback riding is allowed on North Carolina beaches including Emerald Isle, Hatteras Island, and Carolina Beach (Freeman Park). Horseback riding may cause adverse impacts to red knot habitat, by causing compaction or erosion, trampling of wrack and vegetation, and flushing of birds. In general, a horse and rider may cause greater individual static ground pressure than cars, because of the small ground area over which the weight is spread (UK CEED 2000).

Off-Road Vehicles: Off-road vehicles can disrupt red knots' normal behavior patterns. In a study of migrating shorebirds in Maryland, Forgues (2010) found that shorebird abundance declined with increased off-road vehicle frequency, as did the number and size of roosts. Migrants spent less time foraging in the presence of vehicles. In North Carolina, a before-after control-impact experiment using the undisturbed plots as the controls found that vehicle disturbance decreased abundance of shorebirds and altered their habitat use during fall migration (Tarr 2008). Recreational activities, especially off-road vehicles, may degrade red knot habitat. Tires that crush wrack into the sand render it unavailable as a roosting habitat or foraging substrate (Goldin 1993; Hoopes 1993). Off-road vehicles are allowed on portions Cape Hatteras National Seashore (including Ocracoke Island) and Cape Lookout National Seashore for most if not all of the year. Driving is also allowed at Fort Fisher. Other communities which allow beach driving for at least portions of the year include Corolla, Duck, Nags Head, Kill Devil Hills, Atlantic Beach, Emerald Isle, Indian Beach, Salter Path, North Topsail Beach, Surf City, Topsail Beach, and Carolina Beach (Pippin 2013).

4.3. Effects of the Action

This section is an analysis of the beneficial, direct and indirect effects of the proposed action on migrating and wintering red knots within the Action Area. The analysis includes effects interrelated and interdependent of the project activities. An interrelated activity is an activity that is part of a proposed action and depends on the proposed activity. An interdependent activity is an activity that has no independent utility apart from the action.

4.3.1. Factors to be considered

The proposed project will occur within habitat used by red knots and construction will occur during a portion of the migration and winter seasons. Project impacts could include burial of prey items, degradation of foraging and roosting habitat, precluding the creation of new habitat, and increasing recreational disturbance. Short-term and temporary impacts to red knots could result from project work disturbing roosting red knots and degrading currently occupied foraging areas.

Proximity of action: Sand placement will occur within and adjacent to red knot roosting and foraging habitat.

Distribution: Project construction activities that may impact migrating and wintering red knots along the coastline of North Carolina would occur on the inlet shoulder and beach front.

Timing: The timing of project construction could directly and indirectly impact migrating and wintering red knots.

Nature of the effect: The effects of the project construction include a temporary reduction in foraging habitat, a long term decreased rate of change that may preclude habitat creation, and increased recreational disturbance. A decrease in the survival of red knots on the migration and winter grounds due to the lack of optimal habitat may contribute to decreased survival rates, decreased productivity on the breeding grounds, and increased vulnerability to the population.

Duration: These may be recurring activities, expected to last up to five and a half months each time. Thus, the direct effects would be expected to be short-term in duration. Indirect effects from the activity may continue to impact migrating and wintering red knots in subsequent seasons after sand placement.

Disturbance frequency: Disturbance from each event will be short term, lasting up to two years. However, sand placement activities may take place several times over the life of each project, or concurrently or consecutively on adjacent beaches. Recreational disturbance may increase after project completion and have long-term impacts.

Disturbance intensity and severity: Project construction is anticipated to be conducted during portions of the red knot migration and winter seasons. The Action Area encompasses an area in the migrating and wintering range of the red knot. Conservation measures have been incorporated into the project to minimize impacts. The severity is likely to be slight, as red knots located within the Action Area are expected to move outside of the construction zone due to disturbance; therefore, no red knots are expected to be directly taken as a result of this action.

4.3.2. Analyses for effects of the action

Beneficial effects: For some highly eroded beaches, sand placement with compatible sand may have a beneficial effect on the habitat's ability to support wintering or migrating red knots. The addition of compatible sand to the sediment budget may increase a sand-starved beach's likelihood of developing habitat features valued by red knots.

Direct effects: Direct effects are those direct or immediate effects of a project on the species or its habitat. The construction window will extend into one or more red knot migration and winter seasons. Heavy machinery and equipment (e.g., trucks and bulldozers operating on Action Area beaches, the placement of the dredge pipeline along the beach, and sand disposal) may adversely affect migrating and wintering red knots in the Action Area by disturbance and disruption of normal activities such as roosting and foraging, and possibly forcing birds to expend valuable energy reserves to seek available habitat elsewhere.

Burial and suffocation of invertebrate species will occur during the sand placement, and will affect up to 25 miles of shoreline annually in North Carolina. In years following major storm events, a maximum length of nourishment may be 62.5 miles (25 miles plus the additional 27.5 miles). Timeframes projected for benthic recruitment and re-establishment following beach nourishment are between 6 months to 2 years.

Indirect effects: The proposed project includes beach renourishment along up to 25 miles of shoreline annually in normal years, and up to 62.5 miles of shoreline in years following a major storm. Indirect effects include reducing the potential for the formation of optimal habitats (coastal marine and estuarine habitats with large areas of exposed intertidal sediments). The proposed project may limit the creation of optimal foraging and roosting habitat, and may increase the attractiveness of these beaches for recreation increasing recreational pressures within the Action Area. Recreational activities that potentially adversely affect red knots include disturbance by unleashed pets and increased pedestrian use.

4.3.3. Species' response to the proposed action

The proposed project will occur within habitat that is used by migrating and wintering red knots. Since red knots can be present on these beaches almost year-round, construction is likely to occur while this species is utilizing these beaches and associated habitats. Short-term and temporary impacts to red knot activities could result from project work occurring on the beach that flushes birds from roosting or foraging habitat. Long-term impacts could include a hindrance in the ability of migrating or wintering red knots to recuperate from their migratory flight from their breeding grounds, survive on their wintering areas, or to build fat reserves in preparation for migration. Long-term impacts may also result from changes in the physical characteristics of the beach from the placement of the sand material.

4.4. Cumulative Effects

This project may occur on federal or non-federal lands. Cumulative effects include the effects of future State, tribal, local, or private actions that are reasonably certain to occur in the Action Area considered in this biological opinion. Future Federal actions that are unrelated to the proposed action are not considered in this section, because they require separate consultation pursuant to section 7 of the Act. It is reasonable to expect continued shoreline stabilization, inlet dredging, sand placement projects, sand fencing, and beach scraping along the North Carolina shoreline in the future since erosion and sea-level rise increases would impact the existing beachfront development. However, with the exception of some of the above-listed project types, most of the future actions that are reasonable certain to occur will require a Clean Water Act (CWA) Section 404 permit, and thus will require separate consultation.

4.5 Conclusion

After reviewing the current status of the migrating and wintering red knot populations, the environmental baseline for the Action Area, the effects of the proposed activities, the proposed Conservation Measures, and the cumulative effects, it is the Service’s biological opinion that implementation of these actions, as proposed, is not likely to jeopardize the continued existence of the red knot.

- Construction will occur and/or will likely have an effect on up to 25 miles of North Carolina shoreline annually in normal years, and up to 62.5 miles of shoreline in years following a major storm.
- Red knots have been documented in the Action Area.
- Short-term and temporary impacts to red knot activities could result from project work occurring on the beach that flushes birds from roosting or foraging habitat.
- Long-term impacts could include a hindrance in the ability of migrating or wintering red knots to recuperate from their migratory flight from their breeding grounds, survive on their wintering areas, or to build fat reserves in preparation for migration.
- The survival and recovery of red knots is fundamentally dependent on the continued availability of sufficient habitat in their migration and wintering range.

5. SEABEACH AMARANTH

5.1. Status of the Species/Critical Habitat

5.1.1. Species/critical habitat description

Seabeach amaranth (*Amaranthus pumilus*) is an annual plant that grows on Atlantic barrier islands and ocean beaches currently ranging from South Carolina to New York. It was listed as threatened under the ESA on April 7, 1993 (58 FR 18035) 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). Seabeach amaranth stems are fleshy and pink-red or reddish, with small rounded leaves that are 0.5 to 1.0 inches in diameter. The green leaves, with indented veins, are clustered toward the tip of the stems, and have a small notch at the rounded tip. Flowers and fruits are relatively inconspicuous, borne in clusters along the stems. There is no designation of critical habitat for seabeach amaranth.

5.1.2. Life history

Seabeach amaranth is an annual plant. Germination of seabeach amaranth seeds occurs over a relatively long period, generally from April to July. Upon germinating, this plant initially forms a small unbranched sprig, but soon begins to branch profusely into a clump. This clump often reaches one foot in diameter and consists of five to 20 branches. Occasionally, a clump may get as large as three feet or more across, with 100 or more branches. Flowering begins as soon as plants have reached sufficient size, sometimes as early as June, but more typically commencing in July and continuing until the death of the plant in late fall. Seed production begins in July or August and peaks in September during most years, but continues until the death of the plant. Weather events, including rainfall, hurricanes, and temperature extremes, and predation by webworms have strong effects on the length of the reproductive season of seabeach amaranth. Because of one or more of these influences, the flowering and fruiting period can be terminated as early as June or July. Under favorable circumstances, however, the reproductive season may extend until January or sometimes later (Radford et al. 1968; Bucher and Weakley 1990; Weakley and Bucher1992).

5.1.3. Population dynamics

Within North Carolina and across its range, seabeach amaranth numbers vary from year to year. Data in North Carolina is available from 1987 to 2013. Recently, the number of plants across the entire state dwindled from a high of 19,978 in 2005 to 165 in 2013. This trend of decreasing numbers is seen throughout its range. 249,261 plants were found throughout the species' range in 2000. By 2013, those numbers had dwindled to 1,320 plants. In 2014, there was a slight increase in the number of plants to 2,829 (USFWS, unpublished data).

Seabeach amaranth is dependent on natural coastal processes to create and maintain habitat. However, high tides and storm surges from tropical systems can overwash, bury, or inundate seabeach amaranth plants or seeds, and seed dispersal may be affected by strong storm events. In September of 1989, Hurricane Hugo struck the Atlantic Coast near Charleston, South Carolina, causing extensive flooding and erosion north to the Cape Fear region of North Carolina, with less severe effects extending northward throughout the range of seabeach amaranth. This was followed by several severe storms that, while not as significant as Hurricane Hugo, caused substantial erosion of many barrier islands in the seabeach amaranth's range. Surveys for seabeach amaranth revealed that the effects of these climatic events were substantial (Weakley and Bucher 1992). In the Carolinas, populations of amaranth were severely reduced. In South Carolina, where the effects of Hurricane Hugo and subsequent dune reconstruction were extensive, amaranth numbers declined from 1,800 in 1988 to 188 in 1990, a reduction of 90 percent. A 74 percent reduction in amaranth numbers occurred in North Carolina, from 41,851 plants in 1988 to 10,898 in 1990. Although population numbers in New York increased in 1990, range-wide totals of seabeach amaranth were reduced 76 percent from 1988 (Weakley and Bucher 1992). The influence stochastic events have on long-term population trends of seabeach amaranth has not been assessed.

5.1.4. Status and distribution

The species historically occurred in nine states from Rhode Island to South Carolina (USFWS 2003c). By the late 1980s, habitat loss and other factors had reduced the range of this species to North and South Carolina. Since 1990, seabeach amaranth has reappeared in several states that had lost their populations in earlier decades. However, threats like habitat loss have not diminished, and populations are declining overall. It is currently found in New York, New Jersey, Delaware, Maryland, Virginia, North Carolina, and South Carolina. The typical habitat where this species is found includes the lower foredunes and upper beach strands on the ocean side of the primary sand dunes and overwash flats at accreting spits or ends of barrier islands. Seabeach amaranth has been and continues to be threatened by destruction or adverse alteration of its habitat. As a fugitive species dependent on a dynamic landscape and large-scale geophysical processes, it is extremely vulnerable to habitat fragmentation and isolation of small populations. Further, because this species is easily recognizable and accessible, it is vulnerable to taking, vandalism, and the incidental trampling by curiosity seekers. Seabeach amaranth is afforded legal protection in North Carolina by the General Statutes of North Carolina, Sections 106-202.15, 106- 202.19 (N.C. Gen. Stat. section 106 (Supp. 1991)), which provide for protection from intrastate trade (without a permit).

The most serious threats to the continued existence of seabeach amaranth are construction of beach stabilization structures, natural and man-induced beach erosion and tidal inundation, fungi (i.e., white wilt), beach grooming, herbivory by insects and mammals, and off-road vehicles. Herbivory by webworms, deer, feral horses, and rabbits is a major source of mortality and lowered fecundity for seabeach amaranth. However, the extent to which herbivory affects the species as a whole is unknown.

Potential effects to seabeach amaranth from vehicle use on the beaches include vehicles running over, crushing, burying, or breaking plants, burying seeds, degrading habitat through compaction of sand and the formation of seed sinks caused by tire ruts. Seed sinks occur when blowing seeds fall into tire ruts, then a vehicle comes along and buries them further into the sand preventing germination. If seeds are capable of germinating in the tire ruts, the plants are usually destroyed before they can reproduce by other vehicles following the tire ruts. Those seeds and their reproductive potential become lost from the population.

Pedestrians also can negatively affect seabeach amaranth plants. Seabeach amaranth occurs on the upper portion of the beach which is often traversed by pedestrians walking from parking lots, hotels, or vacation property to the ocean. This is also the area where beach chairs and umbrellas are often set up and/or stored. In addition, resorts, hotels, or other vacation rental establishments may set up volleyball courts or other sporting activity areas on the upper beach at the edge of the dunes. All of these activities can result in the trampling and destruction of plants. Pedestrians walking their dogs on the upper part of the beach, or dogs running freely on the upper part of the beach, may result in the trampling and destruction of seabeach amaranth plants.
The extent of the effects that dogs have on seabeach amaranth is not known.

Recovery Criteria

Seabeach amaranth will be considered for delisting when the species exists in at least six states within its historic range and when a minimum of 75 percent of the sites with suitable habitat within each state are occupied by populations for l0 consecutive years (USFWS 1996b). The recovery plan states that mechanisms must be in place to protect the plants from destructive habitat alterations, destruction or decimation by off-road vehicles or other beach uses, and protection of populations from debilitating webworm predation.

5.1.5. Analysis of the species likely to be affected

The predominant threat to seabeach amaranth is the destruction or alteration of suitable habitat, primarily because of beach stabilization efforts and storm-related erosion (USFWS 1993). Other important threats to the plant include beach grooming and vehicular traffic, which can easily break or crush the fleshy plant and bury seeds below depths from which they can germinate; and predation by webworms (caterpillars of small moths) (USFWS 1993). Webworms feed on the leaves of the plant and can defoliate the plants to the point of either killing them or at least reducing their seed production. Beach vitex (*Vitex rotundifulia*) is another threat to seabeach amaranth, as it is an aggressive, invasive, woody plant that can occupy habitat similar to seabeach amaranth and outcompete it (Invasive Species Specialist Group (ISSG) 2010).

The proposed action has the potential to adversely affect seabeach amaranth. Potential effects include burying, trampling, or injuring plants as a result of construction operations and/or sediment disposal activities; burying seeds to a depth that would prevent future germination as a result of construction operations and/or sediment disposal activities; and, destruction of plants by trampling or breaking as a result of increased recreational activities. Sand may be placed between November 16 and April 30, which includes portions of the growing season of seabeach amaranth. Therefore, there is also the potential for sand placement to adversely impact plants in the Action Area.

Table 21 lists biological opinions that have been issued for adverse impacts to seabeach amaranth since 2014, within the Raleigh Field Office geographic area. Activities addressed by the BOs include inlet dredging, sand placement, construction of sandbag revetments, and terminal groin construction.

Table 21. BOs issued since 2014 within the Raleigh Field Office geographic area.

OPINIONS	SEABEACH AMARANTH HABITAT
Fiscal Year 2014: 1 BO	12,600 lf (2.4 mi)
Fiscal Year 2015: 4 BOs	67,968 lf (12.9 mi)
Fiscal Year 2016: 5 BOs	169,250 lf (32.05 mi)
Fiscal Year 2017 (to date): 1 BO	27,650 lf (5.24 mi)
Total: 11 BOs	**277,468 lf (52.55 mi)**

5.2. Environmental Baseline

5.2.1. Status of the species within the Action Area

Since 1992, seabeach amaranth surveys have been conducted along much of the North Carolina shoreline. The numbers of seabeach amaranth vary widely from year to year. See **Table 22** for data from the Corps and the Service (unpublished). Seabeach amaranth has not typically been observed in Dare County, but there are records for all other beaches in the state. Since 1992, the statewide total number of seabeach amaranth records has varied from as few as 105 plants in the year 2000 to 33,514 plants in 1995. Over the past 12 years, the numbers of seabeach amaranth have declined dramatically across the state. It is unclear what is causing the decline in numbers of plants.

Table 22. Annual seabeach amaranth records in North Carolina, from 1987 to 2014. Data from various sources, collated by the Service.

Year	Dare Co.	Pea I. NWR	Cape Hatteras NS	Ocracoke	Core Banks	Shackleford Banks	Bogue Banks	Hammocks Beach SP	Camp LeJeune	Topsail Island	Lea Hutaff	Figure 8	Wrightsville Beach	Wrightsville Beach and Fig 8	Masonboro	Carolina Beach/Ft. Fisher	Bald Head Island	Oak Island	Holden Beach	Ocean Isle Beach	Sunset Beach	Brunswick County	Year Totals
1987			5474	1409	58	0	0		0					0								3337	**10278**
1988			2518	13310	900	2	0		0					0								3531	**20261**
1989					0	0	0		0					0								0	**0**
1990			3082	250	339	175	0		0					0								613	**4459**
1991					0	0	467	703	0					0					0	0		0	**1170**
1992					0	10	2556	407	0	22410			416	0	2	9	1	3148	21	5		3175	**32160**
1993					1290	975	3762	73	0	2089		1344	157	0	7	35	26	6103	52	15		6286	**22214**
1994			0	0	704	948	1181	3	0	135		1309	38	0	19	103	2	4409	239	112		4762	**13964**
1995			0	1	75	1155	14776		0	1925		3965	1323	0	295	579	1	4628	59	22		4710	**33514**
1996			88	10	1	3	0		0	1000		995	289	0		93	37	1983	99	819		3038	**8455**
1997			65	6	2	51	81		0	3			22	0		1	0	599	1	7		607	**1445**
1998			265	0	125	369	3946	1000	0	110			191	0	231	1	107	5367	32	11		0	**11755**
1999			8	0	2	9	218	1	0	39			1	0	6	0	24	15	268	5		0	**596**
2000			2	0	4	13	40		0	12			5	0	3		3	9	10	4			**105**
2001			43	8	51	126	451		0	4041			64	0	9		1	66	223	5			**5088**
2002			86	7	71	261	1983	50	0	413			104	72	51		0	542	702	45			**4387**
2003			19	11	206	1354	5270	66	0	1043			735	3	207		0	1267	843	206			**11230**
2004			1	0	79	58	5292	22	1797	1722			782	656	664	2	0	11	79	49			**11214**
2005			1	1	284	671	10711		1302	3416	1011		244	772	0	1	45	174	800	545			**19978**
2006			0	0	33	30	251	2		16	39			4		1	4	462	1954	337	118		**3251**
2007			0	0	2	125	130	6	5	160	21	0	9		0	0	0	116	281	20			**875**
2008		0	0	0	0	76	313		17	432	14	0	3		0	0	2	65	574	110			**1606**
2009		0	0	0	1	100	281	71	15	80	6	0	0		0	0	8	64	123	36			**785**
2010		0	0	0	6	28	70	187	32	215	18	4	0		0	0	0	1576	434	4			**2574**
2011		0	0	0	1	18	56	0	6	136	0	17	2		0	0	0	16	116	5			**373**
2012		0	0	0	0	7	5	1	4	83	2	0	0		NS	0	NS	5	46	1			**154**
2013		0	0	0	0	0	1	0	1	10	1	31	0		0	0	NS	1	108	1	12		**166**
2014					0	0	52	0	27	38	3		0		0	0	0	1	349	20	36		**526**
Site Totals	**0**	**0**	**11652**	**15013**	**4234**	**6564**	**51893**	**2592**	**3206**	**39528**	**1115**	**7665**	**4385**	**1507**	**1494**	**825**	**261**	**30627**	**7413**	**2384**	**166**	**30059**	**222583**
																							222583

5.2.2. Factors affecting the species environment within the Action Area

A wide range of recent and on-going beach disturbance activities have altered the North Carolina coastline, and many more are proposed along the coastline for the near future. **Appendix A** (copied from the PBA) and **Table 11** (page 73) list many of these activities.

Beach nourishment: The beaches of North Carolina are regularly nourished with sand from the Corps and locally-managed activities. Nourishment activities widen beaches, change their sedimentology and stratigraphy, alter coastal processes and often plug dune gaps and remove overwash areas.

Beach scraping can artificially steepen beaches, stabilize dune scarps, plug dune gaps, and redistribute sediment distribution patterns. Artificial dune building, often a product of beach scraping, removes low-lying overwash areas and dune gaps. As chronic erosion catches up to structures throughout the Action Area, artificial dune systems are constructed and maintained to protect beachfront structures either by sand fencing or fill placement. Beach scraping or bulldozing has become more frequent on North Carolina beaches in the past 20 years, in response to storms and the continuing retreat of the shoreline with rising sea level. These activities primarily occur during the winter months. Artificial dune or berm systems have been constructed and maintained in several areas. These dunes make the artificial dune ridge function like a seawall that blocks natural beach retreat, evolution, and overwash.

Beach raking and rock-picking: Man-made beach cleaning and raking machines effectively remove seaweed, plants, fish, glass, syringes, plastic, cans, cigarettes, shells, stone, wood, and virtually any unwanted debris (Barber Beach Cleaning Equipment 2009). These efforts may remove seabeach amaranth. Although the amount of sand lost due to single sweeping actions may be small, it adds up considerably over a period of years (Nordstrom et al. 2006; Neal et al. 2007). Beach cleaning or grooming can result in abnormally broad unvegetated zones that are inhospitable to dune formation or plant colonization, thereby enhancing the likelihood of erosion (Defreo et al. 2009).

Pedestrian Use of the Beach: There are a number of potential sources of pedestrians and pets on North Carolina beaches, including those individuals originating from beachfront, public access points, and nearby hotels, resorts, and residences.

Shoreline stabilization: Sandbags on private properties provide stabilization to the shoreline of North Carolina Beaches. Sandbags and sandbag revetments have been placed along at least 1,800 lf of the eastern shoreline on Ocean Isle Beach, and the Tubbs Inlet shoreline on Ocean Isle Beach is completely lined with a sandbag revetment. In 2014/2015, a sandbag revetment was constructed on over 1,800 lf of shoreline at the north end of Topsail Island. The intertidal areas and sand flats along the inlet were used as a sand source. The inlet shoreline downdrift of the sandbag revetment has eroded significantly since installation. A rock revetment was constructed several years ago in Carolina Beach (approximately 2,050 lf). In addition, the Town of Ocean Isle Beach has requested authorization for construction of a single, 1,050 lf terminal groin (300 lf landward, and 750 lf waterward of mean high water or MHW) on the east end of the island, placement of a concurrent 3,214 lf sand fillet, and the periodic placement of sand in the fillet from either scheduled federal disposal events and/or from locally-sponsored beach nourishment and disposal projects. The project is not yet constructed.

5.3. Effects of the Action

5.3.1. Factors to be considered

Proximity of action: Beach renourishment will occur within and adjacent to seabeach amaranth habitat.

Distribution: Project construction activities that may affect seabeach amaranth plants would occur along the North Carolina shoreline.

Timing: The timing of project construction could directly and indirectly impact seabeach amaranth. In warm years, seabeach amaranth plants may be present until January.

Nature of the effect: The effects of the project construction include burying, trampling, or injuring plants as a result of construction operations and/or sediment disposal activities; burying seeds to a depth that would prevent future germination as a result of construction operations and/or sediment disposal activities; and destruction of plants by trampling or breaking as a result of increased recreational activities.

Duration: These may be recurring activities, expected to last up to five and a half months each time. Thus, the direct effects would be expected to be short-term in duration. Indirect effects from the activity may continue to impact seabeach amaranth in subsequent seasons after sand placement.

Disturbance frequency: Disturbance from each event will be short term, lasting up to two years. However, sand placement activities may take place several times over the life of the project. Recreational disturbance may increase after project completion and have long-term impacts.

Disturbance intensity and severity: Project construction is anticipated to be conducted during portions of the seabeach amaranth growing and flowering season. Conservation measures have been incorporated into the project to minimize impacts.

5.3.2. Analyses for effects of the action

Beneficial Effects: The placement of beach-compatible sand may benefit this species by providing additional suitable habitat or by redistributing seed sources buried during past storm events, beach disposal activities, or natural barrier island migration. Disposal of sand may be compatible with seabeach amaranth provided the timing of beach disposal is appropriate and the material placed on the beach is compatible with the natural sand. Further studies are needed to determine the best methods of beach disposal in seabeach amaranth habitat (Weakley and Bucher 1992).

Direct Effects: Sand placement activities may bury or destroy existing plants, resulting in mortality, or bury seeds to a depth that would prevent future germination, resulting in reduced plant populations. Increased traffic from recreationists and their pets can also destroy existing plants by trampling or breaking the plants.

Indirect Effects: Future tilling on the beach may be necessary if beach compaction hinders sea turtle nesting activities. The placement of heavy machinery or associated tilling equipment on the beach may destroy or bury existing plants.

5.3.3. Species' response to the proposed action

The placement of sand in the Action Area could bury existing plants if work is conducted during the growing season. Sand placement at any time of year could also bury seeds to a depth that would prevent germination.

Sand placement on beaches could also have positive impacts on seabeach amaranth by creating additional habitat for the species, if the material is compatible. Although more study is needed before the long-term impacts can be accurately assessed, several populations are shown to have established themselves on beaches receiving dredged sediments, and have thrived through subsequent applications of dredged material (Weakley and Bucher 1992).

5.4. Cumulative Effects

This project may occur on federal or non-federal lands. Cumulative effects include the effects of future State, tribal, local, or private actions that are reasonably certain to occur in the Action Area considered in this biological opinion. Future Federal actions that are unrelated to the proposed action are not considered in this section, because they require separate consultation pursuant to section 7 of the Act. It is reasonable to expect continued shoreline stabilization, sand placement projects, sand fencing, and beach scraping along the North Carolina shoreline in the future since erosion and sea-level rise increases would impact the existing beachfront development. However, with the exception of some of the above-listed project types, most of the future actions that are reasonable certain to occur will require a Clean Water Act (CWA) Section 404 permit, and thus will require separate consultation.

5.5. Conclusion

After reviewing the current status of the seabeach amaranth population, the environmental baseline for the Action Area, the effects of the proposed activities, the proposed Conservation Measures, and the cumulative effects, it is the Service's biological opinion that implementation of these actions, as proposed, is not likely to jeopardize the continued existence of the seabeach amaranth.

- Construction will occur and/or will likely have an effect on up to 25 miles of North Carolina shoreline annually in normal years, and up to 62.5 miles of shoreline in years following a major storm.
- Seabeach amaranth has been documented in the Action Area.
- The placement of sand in the Action Area could bury existing plants and also bury seeds to a depth that would prevent germination.
- Increased traffic from recreationists and their pets can also destroy existing plants by trampling or breaking the plants.
- It is unclear whether the placement of sand would have positive impacts on seabeach amaranth by creating additional habitat for the species, or by exposing seeds that had previously buried.

6. LOGGERHEAD, GREEN, LEATHERBACK, HAWKSBILL, AND KEMP'S RIDLEY SEA TURTLES

6.1. Status of the Species/Critical Habitat

6.1.1. Species/critical habitat description

6.1.1.1. Species description – Loggerhead Sea Turtle

The loggerhead sea turtle, which occurs throughout the temperate and tropical regions of the Atlantic, Pacific, and Indian Oceans, was federally listed worldwide as a threatened species on July 28, 1978 (43 Federal Register (FR) 32800). On September 22, 2011, the loggerhead sea turtle's listing under the ESA was revised from a single threatened species to nine distinct population segments (DPS) listed as either threatened or endangered (79 FR 39755). The nine DPSs and their statuses are:

Northwest Atlantic Ocean DPS – threatened
Northeast Atlantic Ocean DPS – endangered
Mediterranean Sea DPS – endangered
South Atlantic Ocean DPS – threatened
North Pacific Ocean DPS – endangered
South Pacific Ocean DPS – endangered
North Indian Ocean DPS – endangered
Southwest Indian Ocean DPS – threatened
Southeast Indo-Pacific Ocean DPS – threatened

The loggerhead sea turtle grows to an average weight of about 200 pounds and is characterized by a large head with blunt jaws. Adults and subadults have a reddish-brown carapace. Scales on the top of the head and top of the flippers are also reddish-brown with yellow on the borders.

Hatchlings are a dull brown color (National Marine Fisheries Service (NMFS) 2009a). The loggerhead feeds on mollusks, crustaceans, fish, and other marine animals.

The loggerhead may be found hundreds of miles out to sea, as well as in inshore areas such as bays, lagoons, salt marshes, creeks, ship channels, and the mouths of large rivers. Coral reefs, rocky places, and ship wrecks are often used as feeding areas. Within the Northwest Atlantic, the majority of nesting activity occurs from April through September, with a peak in June and July (Williams-Walls et al. 1983; Dodd 1988; Weishampel et al. 2006). Nesting occurs within the Northwest Atlantic along the coasts of North America, Central America, northern South America, the Antilles, Bahamas, and Bermuda, but is concentrated in the southeastern U.S. and on the Yucatán Peninsula in Mexico on open beaches or along narrow bays having suitable sand (Sternberg 1981; Ehrhart 1989; Ehrhart et al. 2003; NMFS and USFWS 2008).

6.1.1.1.1. Critical Habitat Description - Designated critical habitat for the Northwest Atlantic (NWA) population of loggerhead sea turtles

The Act defines critical habitat as the specific areas within the geographical area occupied by the species, at the time it is listed in accordance with the provisions of section 4 of the Act, on which are found those physical or biological features (1) essential to the conservation of the species and (2) which may require special management considerations or protection, as well as specific areas outside the geographical area occupied by the species at the time it is listed in accordance with the provisions of section 4 of the Act, upon a determination by the Secretary that such areas are essential for the conservation of the species (16 U.S.C. 1532(5)(A)).

This section summarizes the effects of all past human and natural activities or events that have led to the current status of designated critical habitat for the piping plover and are relevant to formulating the biological opinion about the proposed action.

On July 10, 2014, the Service designated portions North Carolina beaches as critical habitat for the Northwest Atlantic (NWA) population of loggerhead sea turtles (79 FR 39756). See Appendix C for a description of the designated critical habitat units in North Carolina. North Carolina counties which include critical habitat for nesting loggerhead sea turtles include Carteret, Onslow, Pender, New Hanover, and Brunswick.
In total, 1,189.9 kilometers (km) (739.3 miles) of loggerhead sea turtle nesting beaches are designated critical habitat in the States of North Carolina, South Carolina, Georgia, Florida, Alabama, and Mississippi. These beaches account for 48 percent of an estimated 2,464 km (1,531 miles) of coastal beach shoreline, and account for approximately 84 percent of the documented nesting (numbers of nests) within these six States. The designated critical habitat has been identified by the recovery unit in which they are located. Recovery units are management subunits of a listed entity that are geographically or otherwise identifiable and essential to the recovery of the listed entity. Within the United States, four terrestrial recovery units have been designated for the Northwest Atlantic population of the loggerhead sea turtle: the

Northern Recovery Unit (NRU), Peninsular Florida Recovery Unit (PFRU), Dry Tortugas Recovery Unit (DTRU), and Northern Gulf of Mexico Recovery Unit (NGMRU). For the NRU, the Service has designated 393.7 km (244.7 miles) of Atlantic Ocean shoreline in North Carolina, South Carolina, and Georgia, encompassing approximately 86 percent of the documented nesting (numbers of nests) within the recovery unit. The eight critical habitat units in North Carolina total 96.1 miles (154.6 km) of beach. 15.1 miles (24.3 km) are located within state-owned lands, while 81 miles (130.3 km) are on land owned by private parties or others, such as counties and municipalities.

Under the Act and its implementing regulations, the Service is required to identify the physical or biological features (PBFs) essential to the conservation of the loggerhead sea turtle in areas occupied at the time of listing, focusing on the features' primary constituent elements (PCEs). The Service determined that the following PBFs are essential for the loggerhead sea turtle:

(1) PBF 1—Sites For Breeding, Reproduction, or Rearing (or Development) of Offspring.
To be successful, reproduction must occur when environmental conditions support adult activity (e.g., sufficient quality and quantity of food in the foraging area, suitable beach structure for digging, nearby inter-nesting habitat) (Georges et al. 1993). The environmental conditions of the nesting beach must favor embryonic development and survival (i.e., modest temperature fluctuation, low salinity, high humidity, well drained, well aerated) (Mortimer 1982; Mortimer 1990). Additionally, the hatchlings must emerge to onshore and offshore conditions that enhance their chances of survival (e.g., less than 100 percent depredation, appropriate offshore currents for dispersal) (Georges et al. 1993).

(2) PBF 2 - Natural Coastal Processes or Activities That Mimic These Natural Processes.
It is important that loggerhead nesting beaches are allowed to respond naturally to coastal dynamic processes of erosion and accretion or mimic these processes.

The Service considers PCEs to be those specific elements of the PBFs that provide for a species' life-history processes and are essential to the conservation of the species. Based on our current knowledge of the PBFs and habitat characteristics required to sustain the species' life-history processes, the terrestrial primary constituent elements specific to the Northwest Atlantic Ocean DPS of the loggerhead sea turtle are the extra-tidal or dry sandy beaches from the mean high-water line to the toe of the secondary dune, which are capable of supporting a high density of nests or serving as an expansion area for beaches with a high density of nests and that are well distributed within each State, or region within a State, and representative of total nesting, consisting of four components:

(1) PCE 1—Suitable nesting beach habitat that has (a) relatively unimpeded nearshore access from the ocean to the beach for nesting females and from the beach to the ocean for both post-nesting females and hatchlings and (b) is located above mean high water to avoid being inundated frequently by high tides.

(2) PCE 2—Sand that (a) allows for suitable nest construction, (b) is suitable for facilitating gas diffusion conducive to embryo development, and (c) is able to develop and maintain temperatures and moisture content conducive to embryo development.

(3) PCE 3—Suitable nesting beach habitat with sufficient darkness to ensure nesting turtles are not deterred from emerging onto the beach and hatchlings and post-nesting females orient to the sea.

(4) PCE 4—Natural coastal processes or artificially created or maintained habitat mimicking natural conditions. This includes artificial habitat types that mimic the natural conditions described in PCEs 1 to 3 above for beach access, nest site selection, nest construction, egg deposition and incubation, and hatchling emergence and movement to the sea.

The units in North Carolina contain all of the PBFs and PCEs. The PBFs in this unit may require special management considerations or protections to ameliorate the threats of recreational use, predation, beach sand placement activities, in-water and shoreline alterations, climate change, beach erosion, artificial lighting, human-caused disasters, and response to disasters.

6.1.1.2. Species/critical habitat description - Green Sea Turtle

The green sea turtle was federally listed on July 28, 1978 (43 FR 32800). On April 6, 2016, the NMFS and Service issued a final rule to list 11 DPSs of the green sea turtle. Three of the DPSs are endangered species (Central South Pacific, Central West Pacific, and Mediterranean Sea), and eight are threatened species (81 FR 20058). In North Carolina, the green sea turtle is part of the North Atlantic Ocean DPS, and is listed as threatened. The green sea turtle has a worldwide distribution in tropical and subtropical waters.

The green sea turtle grows to a maximum size of about 4 feet and a weight of 440 pounds. It has a heart-shaped shell, small head, and single-clawed flippers. The carapace is smooth and colored gray, green, brown, and black. Hatchlings are black on top and white on the bottom (NMFS 2009b). Hatchling green turtles eat a variety of plants and animals, but adults feed almost exclusively on seagrasses and marine algae.

Major green turtle nesting colonies in the Atlantic occur on Ascension Island, Aves Island, Costa Rica, and Surinam. Within the U.S., green turtles nest in small numbers in the U.S. Virgin Islands and 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 (NMFS and USFWS 1991). Nests have been documented, in smaller numbers, north of these Counties, from Volusia through Nassau Counties in Florida, as well as in Georgia, South Carolina, North Carolina, and as far north as Delaware in 2011. In 2015, 41 green sea turtle nests were documented in North Carolina. Nests have been documented in smaller numbers south of

Broward County in Miami-Dade. Nesting also has been documented along the Gulf coast of Florida from Escambia County through Franklin County in northwest Florida and from Pinellas County through Monroe County in southwest Florida (FWC/FWRI 2010b).

Green sea turtles are generally found in fairly shallow waters (except when migrating) inside reefs, bays, and inlets. The green turtle is attracted to lagoons and shoals with an abundance of marine grass and algae. Open beaches with a sloping platform and minimal disturbance are required for nesting.

Critical habitat for the green sea turtle has been designated for the waters surrounding Culebra Island, Puerto Rico, and its outlying keys (63 FR 46693). No designated critical habitat is present in the Action Area.

6.1.1.3. Species/critical habitat description - Leatherback Sea Turtle

The leatherback sea turtle was federally listed as an endangered species on June 2, 1970 (35 FR 8491). Leatherbacks have the widest distribution of the sea turtles with nonbreeding animals recorded as far north as the British Isles and the Maritime Provinces of Canada and as far south as Argentina and the Cape of Good Hope (Pritchard 1992). Foraging leatherback excursions have been documented into higher-latitude subpolar waters. They have evolved physiological and anatomical adaptations (Frair et al. 1972; Greer et al. 1973) that allow them to exploit waters far colder than any other sea turtle species would be capable of surviving.

The adult leatherback can reach 4 to 8 feet in length and weigh 500 to 2,000 pounds. The carapace is distinguished by a rubber-like texture, about 1.6 inches thick, made primarily of tough, oil-saturated connective tissue. Hatchlings are dorsally mostly black and are covered with tiny scales; the flippers are edged in white, and rows of white scales appear as stripes along the length of the back (NMFS 2009c). Jellyfish are the main staple of its diet, but it is also known to feed on sea urchins, squid, crustaceans, tunicates, fish, blue-green algae, and floating seaweed. This is the largest, deepest diving of all sea turtle species.

Leatherback turtle nesting grounds are distributed worldwide in the Atlantic, Pacific, and Indian Oceans on beaches in the tropics and subtropics. The Pacific Coast of Mexico historically supported the world’s largest known concentration of nesting leatherbacks. The leatherback turtle regularly nests in the U.S. Caribbean in Puerto Rico and the U.S. Virgin Islands. Along the U.S. Atlantic coast, most nesting occurs in Florida (NMFS and USFWS 1992). Nesting has also been reported in Georgia, South Carolina, and North Carolina (Rabon et al. 2003) and in Texas (Shaver 2008). Adult females require sandy nesting beaches backed with vegetation and sloped sufficiently so the distance to dry sand is limited. Their preferred beaches have proximity to deep water and generally rough seas.

Marine and terrestrial critical habitat for the leatherback sea turtle has been designated at Sandy Point on the western end of the island of St. Croix, U.S. Virgin Islands (44 FR 17710). There is no designated critical habitat in North Carolina.

6.1.1.4. Species/critical habitat description – Kemp's Ridley Sea Turtle

The Kemp's ridley sea turtle was federally listed as endangered on December 2, 1970 (35 FR 18320). The Kemp's ridley, along with the flatback sea turtle (*Natator depressus*), has the most geographically restricted distribution of any sea turtle species. The range of the Kemp's ridley includes the Gulf coasts of Mexico and the U.S., and the Atlantic coast of North America as far north as Nova Scotia and Newfoundland.

Adult Kemp's ridleys and olive ridleys are the smallest sea turtles in the world. The weight of an adult Kemp's ridley is generally between 70 to 108 pounds with a carapace measuring approximately 24 to 26 inches in length (Heppell et al. 2005). The carapace is almost as wide as it is long. The species' coloration changes significantly during development from the grey-black dorsum and plastron of hatchlings, a grey-black dorsum with a yellowish-white plastron as post-pelagic juveniles and then to the lighter grey-olive carapace and cream-white or yellowish plastron of adults. Their diet consists mainly of swimming crabs, but may also include fish, jellyfish, and an array of mollusks.

The Kemp's ridley has a restricted distribution. Nesting is essentially limited to the beaches of the western Gulf of Mexico, primarily in Tamaulipas, Mexico (NMFS et al. 2011). Nesting also occurs in Veracruz and a few historical records exist for Campeche, Mexico (Marquez-Millan 1994). Nesting also occurs regularly in Texas and infrequently in a few other U.S. states. However, historic nesting records in the U.S. are limited to south Texas (Werler 1951, Carr 1961, Hildebrand 1963).

Most Kemp's ridley nests located in the U.S. have been found in south Texas, especially Padre Island (Shaver and Caillouet 1998; Shaver 2002, 2005). Nests have been recorded elsewhere in Texas (Shaver 2005, 2006a, 2006b, 2007, 2008), and in Florida (Johnson et al. 1999, Foote and Mueller 2002, Hegna et al. 2006, FWC/FWRI 2010b), Alabama (J. Phillips, Service, personal communication, 2007 cited in NMFS et al. 2011; J. Isaacs, Service, personal communication, 2008 cited in NMFS et al. 2011), Georgia (Williams et al. 2006), South Carolina (Anonymous 1992), and North Carolina (Marquez et al. 1996), but these events are less frequent. Kemp's ridleys inhabit the Gulf of Mexico and the Northwest Atlantic Ocean, as far north as the Grand Banks (Watson et al. 2004) and Nova Scotia (Bleakney 1955). They occur near the Azores and eastern north Atlantic (Deraniyagala 1938, Brongersma 1972, Fontaine et al. 1989, Bolten and Martins 1990) and Mediterranean (Pritchard and Marquez 1973, Brongersma and Carr 1983, Tomas and Raga 2007, Insacco and Spadola 2010).

Juvenile Kemp's ridleys spend on average 2 years in the oceanic zone (NMFS SEFSC unpublished preliminary analysis, July 2004, as cited in NMFS et al. 2011) where they likely live and feed among floating algal communities. They remain here until they reach about 7.9 inches in length (approximately 2 years of age), at which size they enter coastal shallow water habitats (Ogren 1989); however, the time spent in the oceanic zone may vary from 1 to 4 years or perhaps more (Turtle Expert Working Group (TEWG) 2000, Baker and Higgins 2003, Dodge et al. 2003).

No critical habitat has been designated for the Kemp's ridley sea turtle.

6.1.1.5. Species/critical habitat description – Hawksbill Sea Turtle

The hawksbill sea turtle was Federally listed as endangered on June 2, 1970 (35 FR 8491). The hawksbill is found in tropical and subtropical seas of the Atlantic, Pacific, and Indian Oceans. The species is widely distributed in the Caribbean Sea and western Atlantic Ocean. Data collected in the Wider Caribbean reported that hawksbills typically weigh around 176 pounds or less; hatchlings average about 1.6 inches straight length and range in weight from 0.5 to 0.7 ounces. The carapace is heart shaped in young turtles, and becomes more elongated or egg-shaped with maturity. The top scutes are often richly patterned with irregularly radiating streaks of brown or black on an amber background. The head is elongated and tapers sharply to a point. The lower jaw is V-shaped (NMFS 2009d).

Within the continental U.S., hawksbill sea turtle nesting is rare, and nests are only known from Florida and North Carolina. Nesting in Florida is restricted to the southeastern coast of Florida (Volusia through Miami-Dade Counties) and the Florida Keys (Monroe County) (Meylan 1992; Meylan et al. 1995). Two nests have been recorded in North Carolina, both in 2015. Both nests, located on the Seashore, were originally thought to be loggerhead nests, but discovered to be hawksbill nests after DNA testing of eggshells. Hawksbill tracks are difficult to differentiate from those of loggerheads and may not be recognized by surveyors. Therefore, surveys in Florida and elsewhere in the southeastern U.S. likely underestimate actual hawksbill nesting numbers (Meylan et al. 1995). In the U.S. Caribbean, hawksbill nesting occurs on beaches throughout Puerto Rico and the U.S. Virgin Islands (NMFS and USFWS 1993).

Critical Habitat for the hawksbill sea turtle was designated on June 24, 1982 (47 FR 27295) and September 2, 1998 (63 FR 46693). Critical habitat for the hawksbill sea turtle has been designated for selected beaches and/or waters of Mona, Monito, Culebrita, and Culebra Islands, Puerto Rico. There is no designated critical habitat in North Carolina.

6.1.2. Life history

6.1.2.1. Life history – Loggerhead Sea Turtle

Loggerheads are long-lived, slow-growing animals that use multiple habitats across entire ocean basins throughout their life history. This complex life history encompasses terrestrial, nearshore, and open ocean habitats. The three basic ecosystems in which loggerheads live are the:

1. Terrestrial zone (supralittoral) - the nesting beach where both oviposition (egg laying) and embryonic development and hatching occur.

2. Neritic zone - the inshore marine environment (from the surface to the sea floor) where water depths do not exceed 656 feet. The neritic zone generally includes the continental shelf, but in areas where the continental shelf is very narrow or nonexistent, the neritic zone conventionally extends to areas where water depths are less than 656 feet.

3. Oceanic zone - the vast open ocean environment (from the surface to the sea floor) where water depths are greater than 656 feet.

Maximum intrinsic growth rates of sea turtles are limited by the extremely long duration of the juvenile stage and fecundity. Loggerheads require high survival rates in the juvenile and adult stages, common constraints critical to maintaining long-lived, slow-growing species, to achieve positive or stable long-term population growth (Congdon et al. 1993; Heppell 1998; Crouse 1999; Heppell et al. 1999; 2003; Musick 1999).

Numbers of nests and nesting females are often highly variable from year to year due to a number of factors including environmental stochasticity, periodicity in ocean conditions, anthropogenic effects, and density-dependent and density-independent factors affecting survival, somatic growth, and reproduction (Meylan 1982; Hays 2000; Chaloupka 2001; Solow et al. 2002). Despite these sources of variation, and because female turtles exhibit strong nest site fidelity, a nesting beach survey can provide a valuable assessment of changes in the adult female population, provided that the study is sufficiently long and effort and methods are standardized (Meylan 1982; Gerrodette and Brandon 2000; Reina et al. 2002). **Table 23** summarizes key life history characteristics for loggerheads nesting in the U.S.

Table 23. Typical values of life history parameters for loggerheads nesting in the U.S. (NMFS and USFWS 2008).

Life History Trait	**Data**
Clutch size (mean)	100-126 eggs[1]
Incubation duration (varies depending on time of year and latitude)	Range = 42-75 days[2,3]
Pivotal temperature (incubation temperature that produces an equal number of males and females)	84˚F[5]
Nest productivity (emerged hatchlings/total eggs) x 100 (varies depending on site specific factors)	45-70 percent[2,6]
Clutch frequency (number of nests/female/season)	3-4 nests[7]
Internesting interval (number of days between successive nests within a season)	12-15 days[8]
Juvenile (<34 inches Curved Carapace Length) sex ratio	65-70 percent female[4]
Remigration interval (number of years between successive nesting migrations)	2.5-3.7 years[9]
Nesting season	late April-early September
Hatching season	late June-early November
Age at sexual maturity	32-35 years[10]
Life span	>57 years[11]

[1] Dodd (1988).
[2] Dodd and Mackinnon (1999, 2000, 2001, 2002, 2003, 2004).
[3] Witherington (2006) (information based on nests monitored throughout Florida beaches in 2005, n = 865).
[4] NMFS (2001); Foley (2005).
[5] Mrosovsky (1988).
[6] Witherington (2006) (information based on nests monitored throughout Florida beaches in 2005, n = 1,680).
[7] Murphy and Hopkins (1984); Frazer and Richardson (1985); Hawkes *et al*. 2005; Scott 2006.
[8] Caldwell (1962), Dodd (1988).
[9] Richardson *et al.* (1978); Bjorndal *et al.* (1983).
[10] Snover (2005).
[11] Dahlen *et al.* (2000).

Loggerheads nest on ocean beaches and occasionally on estuarine shorelines with suitable sand. Nests are typically laid between the high tide line and the dune front (Routa 1968; Witherington 1986; Hailman and Elowson 1992). Wood and Bjorndal (2000) evaluated four environmental factors (slope, temperature, moisture, and salinity) and found that slope had the greatest influence on loggerhead nest-site selection on a beach in Florida. Loggerheads appear to prefer relatively narrow, steeply sloped, coarse-grained beaches, although nearshore contours may also play a role in nesting beach site selection (Provancha and Ehrhart 1987).

The warmer the sand surrounding the egg chamber, the faster the embryos develop (Mrosovsky and Yntema 1980). Sand temperatures prevailing during the middle third of the incubation period also determine the sex of hatchling sea turtles (Mrosovsky and Yntema 1980). Incubation temperatures near the upper end of the tolerable range produce only female hatchlings while incubation temperatures near the lower end of the tolerable range produce only male hatchlings.

Loggerhead hatchlings pip and escape from their eggs over a 1- to 3-day interval and move upward and out of the nest over a 2- to 4-day interval (Christens 1990). The time from pipping to emergence ranges from 4 to 7 days with an average of 4.1 days (Godfrey and Mrosovsky 1997). Hatchlings emerge from their nests en masse almost exclusively at night, and presumably using decreasing sand temperature as a cue (Hendrickson 1958; Mrosovsky 1968; Witherington et al. 1990). Moran et al. (1999) concluded that a lowering of sand temperatures below a critical threshold, which most typically occurs after nightfall, is the most probable trigger for hatchling emergence from a nest. After an initial emergence, there may be secondary emergences on subsequent nights (Carr and Ogren 1960; Witherington 1986; Ernest and Martin 1993; Houghton and Hays 2001).

Hatchlings use a progression of orientation cues to guide their movement from the nest to the marine environments where they spend their early years (Lohmann and Lohmann 2003). Hatchlings first use light cues to find the ocean. On naturally lighted beaches without artificial lighting, ambient light from the open sky creates a relatively bright horizon compared to the dark silhouette of the dune and vegetation landward of the nest. This contrast guides the hatchlings to the ocean (Daniel and Smith 1947; Limpus 1971; Salmon et al. 1992; Witherington and Martin 1996; Witherington 1997; Stewart and Wyneken 2004).

6.1.2.2. Life history - Green Sea Turtle

Green sea turtles deposit from one to nine clutches within a nesting season, but the overall average is about 3.3 nests. The interval between nesting events within a season varies around a mean of about 13 days (Hirth 1997). Mean clutch size varies widely among populations. Clutch size varies from 75 to 200 eggs with incubation requiring 48 to 70 days, depending on incubation temperatures. Only occasionally do females produce clutches in successive years. Usually two or more years intervene between breeding seasons (NMFS and USFWS 1991). Age at sexual maturity is believed to be 20 to 50 years (Hirth 1997).

6.1.2.3. Life history – Leatherback Sea Turtle

Leatherbacks nest an average of five to seven times within a nesting season, with an observed maximum of 11 nests (NMFS and USFWS 1992). The interval between nesting events within a season is about 9 to 10 days. Clutch size averages 80 to 85 yolked eggs, with the addition of usually a few dozen smaller, yolkless eggs, mostly laid toward the end of the clutch (Pritchard 1992). Nesting migration intervals of 2 to 3 years were observed in leatherbacks nesting on the Sandy Point National Wildlife Refuge, St. Croix, U.S. Virgin Islands (McDonald and Dutton 1996). Leatherbacks are believed to reach sexual maturity in 13 to 16 years (Dutton et al. 2005; Jones et al. 2011).

6.1.2.4. Life history – Kemp's Ridley Sea Turtle

Nesting occurs primarily from April into July. Nesting often occurs in synchronized emergences, known as "arribadas" or "arribazones," which may be triggered by high wind speeds, especially north winds, and changes in barometric pressure (Jimenez et al. 2005). Nesting occurs primarily during daylight hours. Clutch size averages 100 eggs and eggs typically take 45 to 58 days to hatch depending on incubation conditions, especially temperatures (Marquez-Millan 1994, Rostal 2007).

Females lay an average of 2.5 clutches within a season (TEWG 1998) and inter-nesting interval generally ranges from 14 to 28 days (Miller 1997; Donna Shaver, Padre Island National Seashore, personal communication, 2007 as cited in NMFS et al. 2011). The mean remigration interval for adult females is 2 years, although intervals of 1 and 3 years are not uncommon (Marquez et al. 1982; TEWG 1998, 2000). Males may not be reproductively active on an annual basis (Wibbels et al. 1991). Age at sexual maturity is believed to be between 10 to 17 years (Snover et al. 2007).

6.1.2.5. Life history – Hawksbill Sea Turtle

Hawksbills nest on average about 4.5 times per season at intervals of approximately 14 days (Corliss et al. 1989). In Florida and the U.S. Caribbean, clutch size is approximately 140 eggs, although several records exist of over 200 eggs per nest (NMFS and USFWS 1993). On the basis of limited information, nesting migration intervals of two to three years appear to predominate.

Hawksbills are recruited into the reef environment at about 14 inches in length and are believed to begin breeding about 30 years later. However, the time required to reach 14 inches in length is unknown and growth rates vary geographically. As a result, actual age at sexual maturity is unknown.

6.1.3. Population dynamics

6.1.3.1. Population dynamics – Loggerhead Sea Turtle

The loggerhead occurs throughout the temperate and tropical regions of the Atlantic, Pacific, and Indian Oceans (Dodd 1988). However, the majority of loggerhead nesting is at the western rims of the Atlantic and Indian Oceans. The most recent reviews show that only two loggerhead nesting beaches have greater than 10,000 females nesting per year (Baldwin et al. 2003; Ehrhart et al. 2003; Kamezaki et al. 2003; Limpus and Limpus 2003; Margaritoulis et al. 2003): Peninsular Florida (U.S.) and Masirah (Oman). Those beaches with 1,000 to 9,999 females nesting each year are Georgia through North Carolina (U.S.), Quintana Roo and Yucatán (Mexico), Cape Verde Islands (Cape Verde, eastern Atlantic off Africa), and Western Australia (Australia).

The major nesting concentrations in the U.S. are found in South Florida. However, loggerheads nest from Texas to Virginia. Since 2000, the annual number of loggerhead nests in NC has fluctuated between 333 in 2004 to 1,260 in 2013 (Godfrey, unpublished data). Total estimated nesting in the U.S. has fluctuated between 49,000 and 90,000 nests per year from 1999-2010 (NMFS and USFWS 2008; FWC/FWRI 2010a). Adult loggerheads are known to make considerable migrations between foraging areas and nesting beaches (Schroeder et al. 2003; Foley et al. 2008). During non-nesting years, adult females from U.S. beaches are distributed in waters off the eastern U.S. and throughout the Gulf of Mexico, Bahamas, Greater Antilles, and Yucatán.

From a global perspective, the U.S. nesting aggregation is of paramount importance to the survival of the species, as is the population that nests on islands in the Arabian Sea off Oman (Ross 1982; Ehrhart 1989; Baldwin et al. 2003).

6.1.3.2. Population dynamics - Green Sea Turtle

There are an estimated 150,000 females that nest each year in 46 sites throughout the world (NMFS and Service 2007a). In the U.S. Atlantic, the majority of nesting occurs along the coast of eastern central Florida, with an average of 10,377 each year from 2008 to 2012 (Witherington pers. comm. 2013). Years of coordinated conservation efforts, including protection of nesting beaches, reduction of bycatch in fisheries, and prohibitions on the direct harvest of sea turtles, have led to increasing numbers of turtles nesting in Florida and along the Pacific coast of Mexico. On April 6, 2016, NMFS and the Service reclassified the status of the two segments that include those breeding populations (North Atlantic Ocean DPS and East Pacific Ocean DPS) from endangered to threatened (81 FR 20058). In North Carolina, between 4 and 44 green sea turtle nests are laid annually (Godfrey, unpublished data). In the U.S. Pacific, over 90 percent of nesting throughout the Hawaiian archipelago occurs at the French Frigate Shoals, where about 200 to 700 females nest each year (NMFS and Service 1998a). Elsewhere in the U.S. Pacific, nesting takes place at scattered locations in the Commonwealth of the Northern Marianas, Guam, and American Samoa. In the western Pacific, the largest green turtle nesting aggregation in the world occurs on Raine Island, Australia, where thousands of females nest nightly in an average nesting season (Limpus et al. 1993). In the Indian Ocean, major nesting beaches occur in Oman where 30,000 females are reported to nest annually (Ross and Barwani 1995).

6.1.3.3. Population dynamics – Leatherback Sea Turtle

A dramatic drop in nesting numbers has been recorded on major nesting beaches in the Pacific. Spotila et al. (2000) have highlighted the dramatic decline and possible future extirpation of leatherbacks in the Pacific.

The East Pacific and Malaysia leatherback populations have collapsed. Spotila et al. (1996) estimated that only 34,500 females nested annually worldwide in 1995, which is a dramatic decline from the 115,000 estimated in 1980 (Pritchard 1982). In the eastern Pacific, the major nesting beaches occur in Costa Rica and Mexico. At Playa Grande, Costa Rica, considered the most important nesting beach in the eastern Pacific, numbers have dropped from 1,367 leatherbacks in 1988-1989 to an average of 188 females nesting between 2000-2001 and 2003-2004. In Pacific Mexico, 1982 aerial surveys of adult female leatherbacks indicated this area had become the most important leatherback nesting beach in the world. Tens of thousands of nests were laid on the beaches in 1980s, but during the 2003-2004 seasons a total of 120 nests were recorded. In the western Pacific, the major nesting beaches lie in Papua New Guinea, Papua, Indonesia, and the Solomon Islands. These are some of the last remaining significant nesting assemblages in the Pacific. Compiled nesting data estimated approximately 5,000 to 9,200 nests annually with 75 percent of the nests being laid in Papua, Indonesia.

However, the most recent population size estimate for the North Atlantic alone is a range of 34,000 to 94,000 adult leatherbacks (TEWG 2007). During recent years in Florida, the total number of leatherback nests counted as part of the SNBS program ranged from 540 to 1,797 from 2006-2010 (FWC/FWRI 2010a). Assuming a clutch frequency (number of nests/female/season) of 4.2 in Florida (Stewart 2007), these nests were produced by a range of 128 to 428 females in a given year. Nesting in North Carolina is sporadic. In 2010, two nests were reported in North Carolina, five were reported in 2012, and none were reported in 2013-2015.

Nesting in the Southern Caribbean occurs in the Guianas (Guyana, Suriname, and French Guiana), Trinidad, Dominica, and Venezuela. The largest nesting populations at present occur in the western Atlantic in French Guiana with nesting varying between a low of 5,029 nests in 1967 to a high of 63,294 nests in 2005, which represents a 92 percent increase since 1967 (TEWG 2007). Trinidad supports an estimated 6,000 leatherbacks nesting annually, which represents more than 80 percent of the nesting in the insular Caribbean Sea. Leatherback nesting along the Caribbean Central American coast takes place between Honduras and Colombia. In Atlantic

Costa Rica, at Tortuguero, the number of nests laid annually between 1995 and 2006 was estimated to range from 199 to 1,623. Modeling of the Atlantic Costa Rica data indicated that the nesting population has decreased by 67.8 percent over this time period.

In Puerto Rico, the main nesting areas are at Fajardo (Northeast Ecological Corridor) and Maunabo on the main island of Puerto Rico and on the islands of Culebra and Vieques. Between 1993 and 2010, the number of nests in the Fajardo area ranged from 51 to 456. In the Maunabo area, the number of nests recorded between 2001 and 2010 ranged from a low of 53 in 2002 to a high of 260 in 2009 (Diez 2011). On the island of Culebra, the number of nests ranged from a low 41 in 1996 to a high of 395 in 1997 (Diez 2011). On beaches managed by the Commonwealth of Puerto Rico on the island of Vieques, the Puerto Rico Department of Natural and Environmental Resources recorded annually 14-61 leatherback nests between 1991 and 2000; 145 nests in 2002; 24 in 2003; and 37 in 2005 (Diez 2011). The number of leatherback sea turtle nests recorded on Vieques Island beaches managed by the Service ranged between 13 and 163 during 2001-2010. Using the numbers of nests recorded in Puerto Rico between 1984 and 2005, the Turtle Expert Working Group (2007) estimated a population growth of approximately 10 percent per year. Recorded leatherback nesting on the Sandy Point National Wildlife Refuge on the island of St. Croix, U.S. Virgin Islands, between 1982 and 2010, ranged from a low of 82 in 1986 to a high of 1,008 in 2001 (Garner and Garner 2010). Using the number of observed females at Sandy Point from 1986 to 2004, the Turtle Expert Working Group (2007) estimated a population growth of approximately 10 percent per year. In the British Virgin Islands, annual nest numbers have increased in Tortola from zero to six nests per year in the late 1980s to 35 to 65 nests per year in the 2000s (TEWG 2007).

The most important nesting beach for leatherbacks in the eastern Atlantic lies in Gabon, Africa. It was estimated there were 30,000 nests along 60 miles of Mayumba Beach in southern Gabon during the 1999-2000 nesting season (Billes et al. 2000). Some nesting has been reported in Mauritania, Senegal, the Bijagos Archipelago of Guinea-Bissau, Turtle Islands and Sherbro Island of Sierra Leone, Liberia, Togo, Benin, Nigeria, Cameroon, Sao Tome and Principe, continental Equatorial Guinea, Islands of Corisco in the Gulf of Guinea and the Democratic Republic of the Congo, and Angola. In addition, a large nesting population is found on the island of Bioko (Equatorial Guinea) (Fretey et al. 2007). In North Carolina between the year 2000 and 2013, as many as 9 nests were laid per year (Godfrey, unpublished data).

6.1.3.4. Population dynamics – Kemp's Ridley Sea Turtle

Most Kemp's ridleys nest on the beaches of the western Gulf of Mexico, primarily in Tamaulipas, Mexico. Nesting also occurs in Veracruz and Campeche, Mexico, although a small number of Kemp's ridleys nest consistently along the Texas coast (NMFS et al. 2011). In addition, rare nesting events have been reported in Alabama, Florida, Georgia, South Carolina, and North Carolina. Historical information indicates that tens of thousands of ridleys nested near Rancho Nuevo, Mexico, during the late 1940s (Hildebrand 1963). The Kemp's ridley population experienced a devastating decline between the late 1940s and the mid-1980s. The total number of nests per nesting season at Rancho Nuevo remained below 1,000 throughout the 1980s, but gradually began to increase in the 1990s. In 2009, 16,273 nests were documented along the 18.6 miles of coastline patrolled at Rancho Nuevo, and the total number of nests documented for all the monitored beaches in Mexico was 21,144 (USFWS 2010). In 2011, a total of 20,570 nests were documented in Mexico, 81 percent of these nests were documented in the Rancho Nuevo beach (Burchfield and Peña 2011). In addition, 153 and 199 nests were recorded during 2010 and 2011, respectively, in the U.S., primarily in Texas.

6.1.3.5. Population dynamics - Hawksbill Sea Turtle

About 15,000 females are estimated to nest each year throughout the world with the Caribbean accounting for 20 to 30 percent of the world's hawksbill population. Only five regional populations remain with more than 1,000 females nesting annually (Seychelles, Mexico, Indonesia, and two in Australia) (Meylan and Donnelly 1999). Mexico is now the most important region for hawksbills in the Caribbean with about 3,000 nests per year (Meylan 1999). In the U.S. Pacific, hawksbills nest only on main island beaches in Hawaii, primarily along the east coast of the island of Hawaii. Hawksbill nesting has also been documented in American Samoa and Guam (NMFS and USFWS 1998b).

6.1.4. Status and distribution

Reason for Listing: There are many threats to sea turtles, including nest destruction from natural events, such as tidal surges and hurricanes, or eggs lost to predation by raccoons, foxes, ghost-crabs, and other animals. However, human activity has significantly contributed to the decline of sea turtle populations along the Atlantic Coast and in the Gulf of Mexico (NRC 1990). These factors include the modification, degradation, or loss of nesting habitat by coastal development, artificial lighting, beach driving, and marine pollution and debris. Furthermore, the overharvest of eggs for food, intentional killing of adults and immature turtles for their shells and skin, and accidental drowning in commercial fishing gear are primarily responsible for the worldwide decline in sea turtle populations.

6.1.4.1. Status and distribution – Loggerhead Sea Turtle

Range-wide Trend: Five recovery units have been identified in the Northwest Atlantic based on genetic differences and a combination of geographic distribution of nesting densities, geographic separation, and geopolitical boundaries (NMFS and USFWS 2008). Recovery units are subunits of a listed species that are geographically or otherwise identifiable and essential to the recovery of the species. Recovery units are individually necessary to conserve genetic robustness, demographic robustness, important life history stages, or some other feature necessary for long-term sustainability of the species. The five recovery units identified in the Northwest Atlantic are:

1. Northern Recovery Unit (NRU) - defined as loggerheads originating from nesting beaches from the Florida-Georgia border through southern Virginia (the northern extent of the nesting range);

2. Peninsula Florida Recovery Unit (PFRU) - defined as loggerheads originating from nesting beaches from the Florida-Georgia border through Pinellas County on the west coast of Florida, excluding the islands west of Key West, Florida;

3. Dry Tortugas Recovery Unit (DTRU) - defined as loggerheads originating from nesting beaches throughout the islands located west of Key West, Florida;

4. Northern Gulf of Mexico Recovery Unit (NGMRU) - defined as loggerheads originating from nesting beaches from Franklin County on the northwest Gulf coast of Florida through Texas; and

5. Greater Caribbean Recovery Unit (GCRU) - composed of loggerheads originating from all other nesting assemblages within the Greater Caribbean (Mexico through French Guiana, The Bahamas, Lesser Antilles, and Greater Antilles).

The mtDNA analyses show that there is limited exchange of females among these recovery units (Ehrhart 1989; Foote et al. 2000; NMFS 2001; Hawkes et al. 2005). Male-mediated gene flow appears to be keeping the subpopulations genetically similar on a nuclear DNA level (Francisco-Pearce 2001).

Historically, the literature has suggested that the northern U.S. nesting beaches (NRU and NGMRU) produce a relatively high percentage of males and the more southern nesting beaches (PFRU, DTRU, and GCRU) a relatively high percentage of females (e.g., Hanson et al. 1998; NMFS 2001; Mrosovsky and Provancha 1989). The NRU and NGMRU were believed to play an important role in providing males to mate with females from the more female-dominated subpopulations to the south. However, in 2002 and 2003, researchers studied loggerhead sex ratios for two of the U.S. nesting subpopulations, the northern and southern subpopulations (NGU and PFRU, respectively) (Blair 2005; Wyneken et al. 2005). The study produced interesting results. In 2002, the northern beaches produced more females and the southern beaches produced more males than previously believed. However, the opposite was true in 2003 with the northern beaches producing more males and the southern beaches producing more females in keeping with prior literature. Wyneken et al. (2005) speculated that the 2002 result may have been anomalous; however, the study did point out the potential for males to be produced on the southern beaches. Although this study revealed that more males may be produced on Southern Recovery Unit beaches than previously believed, the Service maintains that the NRU and NGMRU play an important role in the production of males to mate with females from the more Southern Recovery Units.

The NRU is the second largest loggerhead recovery unit within the Northwest Atlantic Ocean DPS. Annual nest totals from northern beaches averaged 5,446 nests from 2006 to 2011, a period of near-complete surveys of NRU nesting beaches, representing approximately 1,328 nesting females per year (4.1 nests per female, Murphy and Hopkins 1984) (NMFS and USFWS 2008). In 2008, nesting in Georgia reached what was a new record at that time (1,646 nests), with a downturn in 2009, followed by yet another record in 2011 (1,987 nests). South Carolina had the two highest years of nesting in the 2000s in 2009 (2,183 nests) and 2010 (3,141 nests). The previous high for that 11-year span was 1,433 nests in 2003. North Carolina had 1,252 nests in 2015. The Georgia, South Carolina, and North Carolina nesting data come from the seaturtle.org Sea Turtle Nest Monitoring System, which is populated with data input by the State agencies. The loggerhead nesting trend from daily beach surveys was declining significantly at 1.3 percent annually from 1983 to 2007 (NMFS and USFWS, 2008). Overall, there is strong statistical data to suggest the NRU has experienced a long-term decline (NMFS and USFWS 2008). Currently, however, nesting for the NRU is showing possible signs of stabilizing (76 FR 58868, September 22, 2011).

Recovery Criteria (only the Demographic Recovery Criteria are presented below; for the Listing Factor Recovery Criteria, see NMFS and USFWS 2008)

1. Number of Nests and Number of Nesting Females
   a. Northern Recovery Unit
      i. There is statistical confidence (95 percent) that the annual rate of increase over a generation time of 50 years is 2 percent or greater resulting in a total annual number of nests of 14,000 or greater for this recovery unit (approximate distribution of nests is North Carolina =14 percent [2,000 nests], South Carolina =66 percent [9,200 nests], and Georgia =20 percent [2,800 nests]); and
      ii. This increase in number of nests must be a result of corresponding increases in number of nesting females (estimated from nests, clutch frequency, and remigration interval).

   b. Peninsular Florida Recovery Unit
      i. There is statistical confidence (95 percent) that the annual rate of increase over a generation time of 50 years is statistically detectable (one percent) resulting in a total annual number of nests of 106,100 or greater for this recovery unit; and
      ii. This increase in number of nests must be a result of corresponding increases in number of nesting females (estimated from nests, clutch frequency, and remigration interval).

c. Dry Tortugas Recovery Unit
   i. There is statistical confidence (95 percent) that the annual rate of increase over a generation time of 50 years is three percent or greater resulting in a total annual number of nests of 1,100 or greater for this recovery unit; and
   ii. This increase in number of nests must be a result of corresponding increases in number of nesting females (estimated from nests, clutch frequency, and remigration interval).

d. Northern Gulf of Mexico Recovery Unit
   i. There is statistical confidence (95 percent) that the annual rate of increase over a generation time of 50 years is three percent or greater resulting in a total annual number of nests of 4,000 or greater for this recovery unit (approximate distribution of nests (2002-2007) is Florida= 92 percent [3,700 nests] and Alabama =8 percent [300 nests]); and
   ii. This increase in number of nests must be a result of corresponding increases in number of nesting females (estimated from nests, clutch frequency, and remigration interval).

e. Greater Caribbean Recovery Unit
   i. The total annual number of nests at a minimum of three nesting assemblages, averaging greater than 100 nests annually (e.g., Yucatán, Mexico; Cay Sal Bank, Bahamas) has increased over a generation time of 50 years; and
   ii. This increase in number of nests must be a result of corresponding increases in number of nesting females (estimated from nests, clutch frequency, and remigration interval).

2. Trends in Abundance on Foraging Grounds
   A network of in-water sites, both oceanic and neritic across the foraging range is established and monitoring is implemented to measure abundance. There is statistical confidence (95 percent) that a composite estimate of relative abundance from these sites is increasing for at least one generation.

3. Trends in Neritic Strandings Relative to In-water Abundance
   Stranding trends are not increasing at a rate greater than the trends in in-water relative abundance for similar age classes for at least one generation.

6.1.4.2. Status and distribution - Green Sea Turtle

Range-wide Trend: The North Atlantic Ocean DPS currently exhibits high nesting abundance, with an estimated total nester abundance of 167,424 females at 73 nesting sites. More than 100,000 females nest at Tortuguero, Costa Rica, and more than 10,000 females nest at Quintana Roo, Mexico. Nesting data indicate long-term increases at all major nesting sites. There is little genetic substructure within the DPS, and turtles from multiple nesting beaches share common foraging areas. Nesting is geographically widespread and occurs at a diversity of mainland and insular sites (81 FR 20058). Annual nest totals documented as part of the Florida SNBS program from 1989-2010 have ranged from 435 nests laid in 1993 to 13,225 in 2010. Nesting occurs in 26 counties with a peak along the east coast, from Volusia through Broward Counties. Although the SNBS program provides information on distribution and total abundance statewide, it cannot be used to assess trends because of variable survey effort. Therefore, green turtle nesting trends are best assessed using standardized nest counts made at INBS sites surveyed with constant effort over time (1989-2010). Green sea turtle nesting in Florida is increasing based on 22 years (1989-2010) of INBS data from throughout the state ((FWC/FWRI 2010b). The increase in nesting in Florida is likely a result of several factors, including: (1) a Florida statute enacted in the early 1970s that prohibited the killing of green turtles in Florida; (2) the species listing under the ESA afforded complete protection to eggs, juveniles, and adults in all U.S. waters; (3) the passage of Florida's constitutional net ban amendment in 1994 and its subsequent enactment, making it illegal to use any gillnets or other entangling nets in State waters; (4) the likelihood that the majority of Florida green turtles reside within Florida waters where they are fully protected; (5) the protections afforded Florida green turtles while they inhabit the waters of other nations that have enacted strong sea turtle conservation measures (e.g., Bermuda); and (6) the listing of the species on Appendix I of Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), which stopped international trade and reduced incentives for illegal trade from the U.S (NMFS and Service 2007a).

Recovery Criteria

The U.S. Atlantic population of green sea turtles can be considered for delisting if, over a period of 25 years, the following conditions are met:

1. The level of nesting in Florida has increased to an average of 5,000 nests per year for at least six years. Nesting data must be based on standardized surveys;

2. At least 25 percent (65 miles) of all available nesting beaches (260 miles) is in public ownership and encompasses at least 50 percent of the nesting activity;

3. A reduction in stage class mortality is reflected in higher counts of individuals on foraging grounds; and

4. All priority one tasks identified in the recovery plan have been successfully implemented.

6.1.4.3. Status and distribution - Leatherback Sea Turtle

Range-wide Trend: Pritchard (1982) estimated 115,000 nesting females worldwide, of which 60 percent nested along the Pacific coast of Mexico. Declines in leatherback nesting have occurred over the last two decades along the Pacific coasts of Mexico and Costa Rica. The Mexican leatherback nesting population, once considered to be the world's largest leatherback nesting population (historically estimated to be 65 percent of the worldwide population), is now less than 1 percent of its estimated size in 1980. Spotila et al. (1996) estimated the number of leatherback sea turtles nesting on 28 beaches throughout the world from the literature and from communications with investigators studying those beaches. The estimated worldwide population of leatherbacks in 1995 was about 34,500 females on these beaches with a lower limit of about 26,200, and an upper limit of about 42,900. This is less than one-third the 1980 estimate of 115,000. Leatherbacks are rare in the Indian Ocean and in very low numbers in the western Pacific Ocean. The most recent population size estimate for the North Atlantic is a range of 34,000 to 94,000 adult leatherbacks (TEWG 2007). The largest population is in the western Atlantic. Using an age-based demographic model, Spotila et al. (1996) determined that leatherback populations in the Indian Ocean and western Pacific Ocean cannot withstand even moderate levels of adult mortality and that the Atlantic populations are being exploited at a rate that cannot be sustained. They concluded that leatherbacks are on the road to extinction and further population declines can be expected unless action is taken to reduce adult mortality and increase survival of eggs and hatchlings.

In the western Atlantic, the U.S., nesting populations occur in Florida, Puerto Rico, and the U.S. Virgin Islands. In Florida, the SNBS program documented an increase in leatherback nesting numbers from 98 nests in 1989 to between 453 and 1,747 nests per season in the early 2000s (FWC 2009a; Stewart and Johnson 2006). Although the SNBS program provides information on distribution and total abundance statewide, it cannot be used to assess trends because of variable survey effort. Therefore, leatherback nesting trends are best assessed using standardized nest counts made at INBS sites surveyed with constant effort over time (1989-2010). Under the INBS program, approximately 30 percent of Florida's SNBS beach length is surveyed. The INBS nest counts represent approximately 34 percent of known leatherback nesting in Florida. An analysis of the INBS data has shown an exponential increase in leatherback sea turtle nesting in Florida since 1989. From 1989 through 2010, the annual number of leatherback sea turtle nests at the core set of index beaches ranged from 27 to 615 (FWC 2010b). Using the numbers of nests recorded from 1979 through 2009, Stewart et al. (2011) estimated a population growth of approximately 10.2 percent per year. In Puerto Rico, the main nesting areas are at Fajardo (Northeast Ecological Corridor) and Maunabo on the main island and on the islands of Culebra and Vieques. Nesting ranged from 51 to 456 nests between 2001 and 2010 (Diez 2011). In the U.S. Virgin Islands, leatherback nesting on Sandy Point National Wildlife Refuge on the island of St. Croix ranged from 143 to 1,008 nests between 1990 and 2005 (TEWG 2007; NMFS and USFWS 2007b).

Recovery Criteria

The U.S. Atlantic population of leatherbacks can be considered for delisting if the following conditions are met:

1. The adult female population increases over the next 25 years, as evidenced by a statistically significant trend in the number of nests at Culebra, Puerto Rico, St. Croix, U.S. Virgin Islands, and along the east coast of Florida;
2. Nesting habitat encompassing at least 75 percent of nesting activity in U.S. Virgin Islands, Puerto Rico, and Florida is in public ownership; and
3. All priority one tasks identified in the recovery plan have been successfully implemented.

6.1.4.4. Status and distribution – Kemp's Ridley Sea Turtle

Nesting aggregations of Kemp's ridleys at Rancho Nuevo were discovered in 1947, and the adult female population was estimated to be 40,000 or more individuals based on a film by Andres Herrera (Hildebrand 1963, Carr 1963). Within approximately 3 decades, the population had declined to 924 nests and reached the lowest recorded nest count of 702 nests in 1985. Since the mid-1980s, the number of nests observed at Rancho Nuevo and nearby beaches has increased 15 percent per year (Heppell et al. 2005), allowing cautious optimism that the population is on its way to recovery. This increase in nesting can be attributed to full protection of nesting females and their nests in Mexico resulting from a bi-national effort between Mexico and the U.S. to prevent the extinction of the Kemp's ridley, the requirement to use Turtle Excluder Devices (TEDs) in shrimp trawls both in the U.S. and Mexico, and decreased shrimping effort (NMFS et al. 2011, Heppell et al. 2005).

Recovery Criteria (only the Demographic Recovery Criteria are presented below; for the Listing Factor Recovery Criteria, see NMFS et al. 2011)

The recovery goal is to conserve and protect the Kemp's ridley sea turtle so that protections under the ESA are no longer necessary and the species can be removed from the List of Endangered and Threatened Wildlife. Biological recovery criteria form the basis from which to gauge whether the species should be reclassified to threatened (i.e., downlisted) or delisted, whereas the listing factor criteria ensure that the threats affecting the species are controlled or eliminated.

Downlisting Criteria

1. A population of at least 10,000 nesting females in a season (as estimated by clutch frequency per female per season) distributed at the primary nesting beaches (Rancho Nuevo, Tepehuajes, and Playa Dos) in Mexico is attained. Methodology and capacity to implement and ensure accurate nesting female counts have been developed.

2. Recruitment of at least 300,000 hatchlings to the marine environment per season at the three primary nesting beaches (Rancho Nuevo, Tepehuajes, and Playa Dos) in Mexico is attained to ensure a minimum level of known production through *in situ* incubation, incubation in corrals, or a combination of both.

Delisting Criteria

1. An average population of at least 40,000 nesting females per season (as measured by clutch frequency per female per season and annual nest counts) over a 6-year period distributed among nesting beaches in Mexico and the U.S. is attained. Methodology and capacity to ensure accurate nesting female counts have been developed and implemented.

2. Ensure average annual recruitment of hatchlings over a 6-year period from *in situ* nests and beach corrals is sufficient to maintain a population of at least 40,000 nesting females per nesting season distributed among nesting beaches in Mexico and the U.S into the future. This criterion may rely on massive synchronous nesting events (i.e., arribadas) that will swamp predators as well as rely on supplemental protection in corrals and facilities.

6.1.4.5. Status and distribution – Hawksbill Sea Turtle

The hawksbill sea turtle has experienced global population declines of 80 percent or more during the past century and continued declines are projected (Meylan and Donnelly 1999). Most populations are declining, depleted, or remnants of larger aggregations. Hawksbills were previously abundant, as evidenced by high-density nesting at a few remaining sites and by trade statistics.

Recovery Criteria

The U.S. Atlantic population of hawksbills can be considered for delisting if, over a period of 25 years, the following conditions are met:

1. The adult female population is increasing, as evidenced by a statistically significant trend in the annual number of nests on at least five index beaches, including Mona Island and Buck Island Reef National Monument;

2. Habitat for at least 50 percent of the nesting activity that occurs in the U.S. Virgin Islands and Puerto Rico is protected in perpetuity;

3. Numbers of adults, subadults, and juveniles are increasing, as evidenced by a statistically significant trend on at least five key foraging areas within Puerto Rico, U.S. Virgin Islands, and Florida; and

4. All priority one tasks identified in the recovery plan have been successfully implemented.

The Recovery Plan for the Hawksbill Turtle in the U.S. Caribbean, Atlantic, and Gulf of Mexico was signed in 1993 (NMFS and USFWS 1993), and the Recovery Plan for U.S. Pacific Populations of the Hawksbill Turtle was signed in 1998 (NMFS and USFWS 1998b).

6.1.5. Analysis of the species/critical habitat likely to be affected

Barrier islands and inlets are complex and dynamic coastal systems that are continually responding to sediment supply, waves, and fluctuations in sea level. The location and shape of the beaches of barrier islands perpetually adjusts to these physical forces. Waves that strike a barrier island at an angle, for instance, generate a longshore current that carries sediment along the shoreline. Cross-shore currents carry sediment perpendicular to the shoreline. Wind moves sediment across the dry beach, dunes and island interior. During storm events, overwash may breach the island at dune gaps or other weak spots, depositing sediments on the interior and back sides of islands, increasing island elevation and accreting the soundside shoreline.

Tidal inlets play a vital role in the dynamics and processes of barrier islands. Sediment is transferred across inlets from island to island via the tidal shoals or deltas. The longshore sediment transport often causes barrier spits to accrete, shifting inlets towards the neighboring island. Flood tidal shoals that are left behind by the migrating inlet are typically incorporated into the soundside shoreline and marshes of the island, widening it considerably. Many inlets have a cycle of inlet migration, breaching of the barrier spit during a storm, and closure of the old inlet with the new breach becoming the new inlet. Barrier spits tend to be low in elevation, sparse in vegetation, and repeatedly submerged by high and storm tides.

The proposed action has the potential to adversely affect nesting females, nests, and hatchlings on the beach within the proposed Action Area. Potential effects include destruction of nests deposited within the boundaries of the proposed project, harassment in the form of disturbing or interfering with female turtles attempting to nest within the construction area or on adjacent beaches as a result of construction activities, disorientation of hatchling turtles on beaches adjacent to the construction area as they emerge from the nest and crawl to the water as a result of project lighting or equipment on the beach, and behavior modification of nesting females during the nesting season resulting in false crawls or situations where they choose marginal or unsuitable nesting areas to deposit eggs within the Action Area, due to compaction or escarpments. The quality of the placed sand could affect the ability of female turtles to nest, the suitability of the nest incubation environment, and the ability of hatchlings to emerge from the nest.

Threats to Sea Turtle Species

Coastal Development

Loss of sea turtle nesting habitat related to coastal development has had the greatest impact on nesting sea turtles. Beachfront development not only causes the loss of suitable nesting habitat, but can result in the disruption of powerful coastal processes accelerating erosion and interrupting the natural shoreline migration (National Research Council 1990b). This may in turn cause the need to protect upland structures and infrastructure by armoring, groin placement, beach emergency berm construction and repair, and beach nourishment, all of which cause changes in, additional loss of, or impact to the remaining sea turtle habitat.

Hurricanes and Storms

Hurricanes and other large storms were probably responsible for maintaining coastal beach habitat upon which sea turtles depend through repeated cycles of destruction, alteration, and recovery of beach and dune habitat. Hurricanes and large storms generally produce damaging winds, storm tides and surges, and rain, which can result in severe erosion of the beach and dune systems. Overwash and blowouts are common on barrier islands.

Hurricanes and other storms can result in the direct loss of sea turtle nests, either by erosion or washing away of the nests by wave action and inundation or “drowning” of the eggs or pre-emergent hatchlings within the nest, or indirectly by causing the loss of nesting habitat. Depending on their frequency, storms can affect sea turtles on either a short-term basis (nests lost for one season and/or temporary loss of nesting habitat) or long term, if frequent (habitat unable to recover). The manner in which hurricanes affect sea turtle nesting also depends on their characteristics (winds, storm surge, rainfall), the time of year (within or outside of the nesting season), and where the northeast edge of the hurricane crosses land.

Because of the limited remaining nesting habitat in a natural state with no immediate development landward of the sandy beach, frequent or successive severe weather events could threaten the ability of certain sea turtle populations to survive and recover. Sea turtles evolved under natural coastal environmental events such as hurricanes. The extensive amount of predevelopment coastal beach and dune habitat allowed sea turtles to survive even the most severe hurricane events. It is only within the last 20 to 30 years that the combination of habitat loss to beachfront development and destruction of remaining habitat by hurricanes has increased the threat to sea turtle survival and recovery. On developed beaches, typically little space remains for sandy beaches to become reestablished after periodic storms. While the beach itself moves landward during such storms, reconstruction or persistence of structures at their pre-storm locations can result in a loss of nesting habitat.

Erosion

A critically eroded area is a segment of shoreline where natural processes or human activity have caused or contributed to erosion and recession of the beach or dune system to such a degree that upland development, recreational interests, wildlife habitat, or important cultural resources are threatened or lost. It is important to note that for erosion to be considered critical there must be an existing threat to or loss of one of those four specific interests listed.

Beachfront Lighting

Artificial lights along a beach can deter females from coming ashore to nest or misdirect females trying to return to the surf after a nesting event. A significant reduction in sea turtle nesting activity has been documented on beaches illuminated with artificial lights (Witherington 1992). Artificial beachfront lighting may also cause disorientation (loss of bearings) and misorientation (incorrect orientation) of sea turtle hatchlings. Visual signs are the primary sea-finding mechanism for hatchlings (Mrosovsky and Carr 1967; Mrosovsky and Shettleworth 1968; Dickerson and Nelson 1989; Witherington and Bjorndal 1991). Artificial beachfront lighting is a documented cause of hatchling disorientation and misorientation on nesting beaches (Philibosian 1976; Mann 1977; Witherington and Martin 1996). The emergence from the nest and crawl to the sea is one of the most critical periods of a sea turtle's life. Hatchlings that do not make it to the sea quickly become food for ghost crabs, birds, and other predators, or become dehydrated and may never reach the sea. In addition, research has documented significant reduction in sea turtle nesting activity on beaches illuminated with artificial lights (Witherington 1992). During the 2010 sea turtle nesting season in Florida, over 47,000 turtle hatchlings were documented as being disoriented (FWC/FWRI 2011).

Predation

Predation of sea turtle eggs and hatchlings by native and introduced species occurs on almost all nesting beaches. Predation by a variety of predators can considerably decrease sea turtle nest hatching success. The most common predators in the southeastern U.S. are ghost crabs (*Ocypode quadrata*), raccoons (*Procyon lotor*), feral hogs (*Sus scrofa*), foxes (*Urocyon cinereoargenteus* and *Vulpes vulpes*), coyotes (*Canis latrans*), armadillos (*Dasypus novemcinctus*), and fire ants (*Solenopsis invicta*) (Dodd 1988; Stancyk 1995). In the absence of nest protection programs in a number of locations throughout the southeast U.S., raccoons may depredate up to 96 percent of all nests deposited on a beach (Davis and Whiting 1977; Hopkins and Murphy 1980; Stancyk et al. 1980; Talbert et al. 1980; Schroeder 1981; Labisky et al. 1986).

Beach Driving

The operation of motor vehicles on the beach affects sea turtle nesting by interrupting or striking a female turtle on the beach, headlights disorienting or misorienting emergent hatchlings, vehicles running over hatchlings attempting to reach the ocean, and vehicle tracks traversing the beach that interfere with hatchlings crawling to the ocean. Hatchlings appear to become diverted not because they cannot physically climb out of the rut (Hughes and Caine 1994), but because the sides of the track cast a shadow and the hatchlings lose their line of sight to the ocean horizon (Mann 1977). The extended period of travel required to negotiate tire tracks and ruts may increase the susceptibility of hatchlings to dehydration and depredation during migration to the ocean (Hosier et al. 1981). Driving on the beach can cause sand compaction which may result in adverse impacts on nest site selection, digging behavior, clutch viability, and emergence by hatchlings, decreasing nest success and directly killing pre-emergent hatchlings (Mann 1977; Nelson and Dickerson 1987; Nelson 1988).

The physical changes and loss of plant cover caused by vehicles on dunes can lead to various degrees of instability, and therefore encourage dune migration. As vehicles move either up or down a slope, sand is displaced downward, lowering the trail. Since the vehicles also inhibit plant growth, and open the area to wind erosion, dunes may become unstable, and begin to migrate. Unvegetated sand dunes may continue to migrate across stable areas as long as vehicle traffic continues. Vehicular traffic through dune breaches or low dunes on an eroding beach may cause an accelerated rate of overwash and beach erosion (Godfrey et al. 1978). If driving is required, the area where the least amount of impact occurs is the beach between the low and high tide water lines. Vegetation on the dunes can quickly reestablish provided the mechanical impact is removed.

Climate Change

The varying and dynamic elements of climate science are inherently long term, complex, and interrelated. Regardless of the underlying causes of climate change, glacial melting and expansion of warming oceans are causing sea level rise, although its extent or rate cannot as yet be predicted with certainty. At present, the science is not exact enough to precisely predict when and where climate impacts will occur. Although we may know the direction of change, it may not be possible to predict its precise timing or magnitude. These impacts may take place gradually or episodically in major leaps.

Climate change is evident from observations of increases in average global air and ocean temperatures, widespread melting of snow and ice, and rising sea level, according to the Intergovernmental Panel on Climate Change Report (IPCC 2007a). The IPCC Report (2007a) describes changes in natural ecosystems with potential widespread effects on many organisms, including marine mammals and migratory birds. The potential for rapid climate change poses a significant challenge for fish and wildlife conservation. Species' abundance and distribution are dynamic, relative to a variety of factors, including climate. As climate changes, the abundance and distribution of fish and wildlife will also change. Highly specialized or endemic species are likely to be most susceptible to the stresses of changing climate. Based on these findings and other similar studies, the U.S. Department of the Interior (DOI) requires agencies under its direction to consider potential climate change effects as part of their long-range planning activities (Service 2007).

In the southeastern U.S., climatic change could amplify current land management challenges involving habitat fragmentation, urbanization, invasive species, disease, parasites, and water management. Global warming will be a particular challenge for endangered, threatened, and other "at risk" species. It is difficult to estimate, with any degree of precision, which species will be affected by climate change or exactly how they will be affected. The Service will use Strategic Habitat Conservation planning, an adaptive science-driven process that begins with explicit trust resource population objectives, as the framework for adjusting our management strategies in response to climate change (USFWS 2006). As the level of information increases relative to the effects of global climate change on sea turtles and its designated critical habitat, the Service will have a better basis to address the nature and magnitude of this potential threat and will more effectively evaluate these effects to the range-wide status of sea turtles. Temperatures are predicted to rise from 1.6°F to 9°F for North America by the end of this century (IPCC 2007a, b). Alterations of thermal sand characteristics could result in highly female-biased sex ratios because sea turtles exhibit temperature dependent sex determination (e.g., Glen and Mrosovsky 2004; Hawkes et al. 2008).

Along developed coastlines, and especially in areas where shoreline protection structures have been constructed to limit shoreline movement, rising sea levels will cause severe effects on nesting females and their eggs. Erosion control structures can result in the permanent loss of dry nesting beach or deter nesting females from reaching suitable nesting sites (National Research Council 1990a). Nesting females may deposit eggs seaward of the erosion control structures potentially subjecting them to repeated tidal inundation or washout by waves and tidal action.

Based on the present level of available information concerning the effects of global climate change on the status of sea turtles and their designated critical habitat, the Service acknowledges the potential for changes to occur in the Action Area, but presently has no basis to evaluate if or how these changes are affecting sea turtles. Nor does our present knowledge allow the Service to project what the future effects from global climate change may be or the magnitude of these potential effects.

Recreational Beach Use

Human presence on or adjacent to the beach at night during the nesting season, particularly recreational activities, can reduce the quality of nesting habitat by deterring or disturbing and causing nesting turtles to avoid otherwise suitable habitat. In addition, human foot traffic can make a beach less suitable for nesting and hatchling emergence by increasing sand compaction and creating obstacles to hatchlings attempting to reach the ocean (Hosier et al. 1981).

The use and storage of lounge chairs, cabanas, umbrellas, catamarans, and other types of recreational equipment on the beach at night can also make otherwise suitable nesting habitat unsuitable by hampering or deterring nesting by adult females and trapping or impeding hatchlings during their nest to sea migration. The documentation of non-nesting emergences (also referred to as false crawls) at these obstacles is becoming increasingly common as more recreational beach equipment is left on the beach at night. Sobel (2002) describes nesting turtles being deterred by wooden lounge chairs that prevented access to the upper beach.

Sand Placement

Sand placement projects may result in changes in sand density (compaction), beach shear resistance (hardness), beach moisture content, beach slope, sand color, sand grain size, sand grain shape, and sand grain mineral content if the placed sand is dissimilar from the original beach sand (Nelson and Dickerson 1988a). These changes could result in adverse impacts on sea turtle nest site selection, digging behavior, clutch viability, and hatchling emergence (Nelson and Dickerson 1987; Nelson 1988).

Beach nourishment projects create an elevated, wider, and unnatural flat slope berm. Sea turtles nest closer to the water the first few years after nourishment because of the altered profile (and perhaps unnatural sediment grain size distribution) (Ernest and Martin 1999; Trindell 2005)

Beach compaction and unnatural beach profiles resulting from beach nourishment activities could negatively impact sea turtles regardless of the timing of projects. Sand compaction may increase the length of time required for female sea turtles to excavate nests and cause increased physiological stress to the animals (Nelson and Dickerson 1988b). The placement of rocky material may have similar effects. These impacts can be minimized by using suitable sand.

A change in sediment color on a beach could change the natural incubation temperatures of sea turtle nests in an area, which, in turn, could alter natural sex ratios. To provide the most suitable sediment for nesting sea turtles, the color of the nourished sediments should resemble the natural beach sand in the area. Natural reworking of sediments and bleaching from exposure to the sun would help to lighten dark nourishment sediments; however, the timeframe for sediment mixing and bleaching to occur could be critical to a successful sea turtle nesting season.

In-water and Shoreline Alterations

Many navigable mainland or barrier island tidal inlets along the Atlantic and Gulf of Mexico coasts are stabilized with jetties or groins. Jetties are built perpendicular to the shoreline and extend through the entire nearshore zone and past the breaker zone to prevent or decrease sand deposition in the channel (Kaufman and Pilkey 1979). Groins are also shore-perpendicular structures that are designed to trap sand that would otherwise be transported by longshore currents and can cause downdrift erosion (Kaufman and Pilkey 1979).

These in-water structures have profound effects on adjacent beaches (Kaufman and Pilkey 1979). Jetties and groins placed to stabilize a beach or inlet prevent normal sand transport, resulting in accretion of sand on updrift beaches and acceleration of beach erosion downdrift of the structures (Komar 1983; Pilkey et al. 1984). Witherington et al. (2005) found a significant negative relationship between loggerhead nesting density and distance from the nearest of 17 ocean inlets on the Atlantic coast of Florida. The effect of inlets in lowering nesting density was observed both updrift and downdrift of the inlets, leading researchers to propose that beach instability from both erosion and accretion may discourage sea turtle nesting.

Following construction, the presence of groins and jetties may interfere with nesting turtle access to the beach, result in a change in beach profile and width (downdrift erosion, loss of sandy berms, and escarpment formation), trap hatchlings, and concentrate predatory fishes, resulting in higher probabilities of hatchling predation. In addition to decreasing nesting habitat suitability, construction or repair of groins and jetties during the nesting season may result in the destruction of nests, disturbance of females attempting to nest, and disorientation of emerging hatchlings from project lighting.

Threats to loggerhead sea turtle terrestrial habitat

Recreational beach use: beach cleaning, human presence (e.g., dog beach, special events, piers, and recreational beach equipment);

Beach driving: essential and nonessential off-road vehicles, all-terrain vehicles, and recreational access and use;

Predation: depredation of eggs and hatchlings by native and nonnative predators;

Beach sand placement activities: beach nourishment, beach restoration, inlet sand bypassing, dredge material disposal, dune construction, emergency sand placement after natural disaster, berm construction, and dune and berm planting;

In-water and shoreline alterations: artificial in-water and shoreline stabilization measures (e.g., in-water erosion control structures, such as groins, breakwaters, jetties), inlet relocation, inlet dredging, nearshore dredging, and dredging and deepening channels;

Coastal development: residential and commercial development and associated activities including beach armoring (e.g., sea walls, geotextile tubes, rock revetments, sandbags, emergency temporary armoring); and activities associated with construction, repair, and maintenance of upland structures, stormwater outfalls, and piers;

Artificial lighting: direct and indirect lighting, skyglow, and bonfires;

Beach erosion: erosion due to aperiodic, short-term weather-related erosion events, such as atmospheric fronts, northeasters, tropical storms, and hurricanes;

Climate change: includes sea level rise;

Habitat obstructions: tree stumps, fallen trees, and other debris on the beach; nearshore sand bars; and ponding along beachfront seaward of dry beach;

Human-caused disasters and response to natural and human-caused disasters: oil spills, oil spill response including beach cleaning and berm construction, and debris cleanup after natural disasters;

Military testing and training activities: troop presence, pyrotechnics and nighttime lighting, vehicles and amphibious watercraft usage on the beach, helicopter drops and extractions, live fire exercises, and placement and removal of objects on the beach.

Some individuals in a population are more "valuable" than others in terms of the number of offspring they are expected to produce. An individual's potential for contributing offspring to future generations is its reproductive value. Because of delayed sexual maturity, reproductive longevity, and low survivorship in early life stages, nesting females are of high value to a population. The loss of a nesting female in a small recovery unit would represent a significant loss to the recovery unit. The reproductive value for a nesting female has been estimated to be approximately 253 times greater than an egg or a hatchling (NMFS and USFWS 2008).
With regard to indirect loss of eggs and hatchlings, on most beaches, nesting success typically declines for the first year or two following sand placement, even though more nesting habitat is available for turtles (Trindell et al. 1998; Ernest and Martin 1999; Herren 1999). Reduced nesting success on constructed beaches has been attributed to increased sand compaction,

escarpment formation, and changes in beach profile (Nelson et al. 1987; Crain et al. 1995; Lutcavage et al. 1997; Steinitz et al. 1998; Ernest and Martin 1999; Rumbold et al. 2001). In addition, even though constructed beaches are wider, nests deposited there may experience higher rates of wash out than those on relatively narrow, steeply sloped beaches (Ernest and Martin 1999). This occurs because nests on constructed beaches are more broadly distributed than those on natural beaches, where they tend to be clustered near the base of the dune. Nests laid closest to the waterline on constructed beaches may be lost during the first year or two following construction as the beach undergoes an equilibration process during which seaward portions of the beach are lost to erosion. As a result, the project may be anticipated to result in decreased nesting and loss of nests that are laid within the Action Area for two subsequent nesting seasons following the completion of the proposed sand placement. However, it is unknown whether nests that would have been laid in an Action Area during the two subsequent nesting seasons had the project not occurred are actually lost from the population, or if nesting is simply displaced to adjacent beaches. Regardless, eggs and hatchlings have a low reproductive value; each egg or hatchling has been estimated to have only 0.004 percent of the value of a nesting female (NMFS and USFWS 2008). Thus, even if the majority of the eggs and hatchlings that would have been produced on the project beach are not realized for up to 2 years following project completion, the Service would not expect this loss to have a significant effect on the recovery and survival of the species, for the following reasons: 1) some nesting is likely just displaced to adjacent non-project beaches, 2) not all eggs will produce hatchlings, and 3) destruction and/or failure of nests will not always result from a sand placement project. A variety of natural and unknown factors negatively affect incubating egg clutches, including tidal inundation, storm events, and predation, accretion of sand, and erosional processes. The loss of all life stages of sea turtles including eggs are considered “take” and minimization measures are required to avoid and minimize all life stages. During project construction, predators of eggs and nestlings may be attracted to the Action Area due to food waste from the construction crew.

In the U.S., consultations with the Service have included military missions and operations, beach nourishment and other shoreline protection projects, and actions related to protection of coastal development on sandy beaches along the coast. Much of the Service’s section 7 consultation involves beach nourishment projects. A list of the Service’s consultations completed over the last two years in North Carolina is included in **Table 24**. The Act does not require entities conducting projects with no Federal nexus to apply for a section 10(a)(1)(B) permit. This is a voluntary process and is applicant driven. Section 10(a)(1)(A) permits are scientific permits that include activities that would enhance the survival and conservation of a listed species. Those permits are not listed as they are expected to benefit the species and are not expected to contribute to the cumulative take assessment.

Table 24. Biological opinions within the Raleigh Field Office geographic area that have been issued since 2014 for adverse impacts to sea turtle species. Activities addressed by the BOs include inlet dredging, sand placement, construction of sandbag revetments, and terminal groin construction.

OPINIONS	SPECIES	HABITAT	
		Critical Habitat (loggerhead)	**Habitat**
Fiscal Year 2014: 1 BO	Loggerhead, leatherback, green, and Kemp's ridley sea turtles	12,600 lf (2.4 mi)	12,600 lf (2.4 mi)
Fiscal Year 2015: 5 BOs	Loggerhead, leatherback, green, hawksbill, and Kemp's ridley sea turtles	50,268 lf (9.5 mi)	70,268 lf (13.3 mi)
Fiscal Year 2016: 7 BOs	Loggerhead, leatherback, green, hawksbill, and Kemp's ridley sea turtles	133,150 lf (25.22 mi)	229,469 lf (45.25 mi)
Fiscal Year 2017 (to date): 1 BO	Loggerhead, leatherback, green, hawksbill, and Kemp's ridley sea turtles	N/A	27,650 lf (5.24 mi)
Total: 14 BOs		**196,018 lf (37.12 mi)**	**339,987 lf (64.39 mi)**

6.2. ENVIRONMENTAL BASELINE

6.2.1. Status of sea turtle species within the Action Area

In general, sea turtle nesting has increased significantly in North Carolina between 2000 to 2016, although some years saw a substantial dip in the total number of nests. See **Table 25** for data on sea turtle nests in North Carolina from the year 2000 to 2016. Data from NCWRC (2014) and www.seaturtle.org (Accessed April 20, 2017). With the exception of hawksbill sea turtle, which has only been recorded (through DNA testing) nesting on Cape Hatteras, sea turtles species nest along the entire length of the North Carolina shoreline.

Table 25. Sea turtle nest totals for North Carolina, 2000 to 2016.

Year	Loggerhead	Green	Leatherback	Kemp's ridley	Hawksbill	Unknown	Total
2000	754	22	4	0		0	780
2001	655	9	0	0		0	664
2002	693	15	1	1		0	710
2003	862	4	0	1		0	871
2004	333	6	4	0		0	343
2005	645	14	7	0		0	666
2006	763	10	0	0		0	773
2007	534	21	9	0		1	565
2008	889	22	0	0		0	911
2009	614	4	3	0		1	622
2010	856	18	2	2		3	881
2011	950	16	0	1		0	967
2012	1074	24	5	2		0	1105
2013	1260	44	0	1		0	1305
2014	546	16	0	2		0	564
2015	1254	39	0	1	2	0	1296
2016	1622	24	0	4	0	0	1650

The loggerhead sea turtle nesting and hatching season for North Carolina beaches extends from May 1 through November 15. Incubation ranges from about 45 to 95 days. Loggerhead nesting has increased significantly since 2000. As few as 333 nests were recorded in 2004, but in 2016, 1,622 loggerhead nests were recorded across the state. Loggerhead nests have been recorded in every beach community in North Carolina.

The green sea turtle nesting and hatching season on North Carolina beaches extends from May 15 through November 15. Incubation ranges from about 45 to 75 days. Green sea turtles have nested in North Carolina every year since at least 2000, and nest numbers have increased over that time with some instances of significant dips in the annual number. Only four nests were recorded in 2003 and 2009, while as many as 29 were recorded in 2015 and 44 in 2013. Nests have been recorded from the northern outer banks to Brunswick County.

The Kemp's ridley sea turtle nesting and hatchling season on North Carolina beaches appears to be similar to other species. Incubation ranges from 45 to 58 days. Fifteen (15) Kemp's ridley sea turtle nests have been recorded along the North Carolina shoreline since 2000. Though typically only one or two nests may be laid each year (four were laid in 2016), the nests have been laid from the northern outer banks to New Hanover County.

The leatherback sea turtle nesting and hatching season on North Carolina beaches extends from April 15 through November 15. Incubation ranges from about 55 to 75 days. There have been 35 known leatherback nests laid on North Carolina Beaches since 2000. The nests have been laid in every area of the state, from the northern outer banks to Brunswick County.

The hawksbill sea turtle nesting and hatching season has not been determined on North Carolina beaches, but is assumed to be similar to other species. Two hawksbill nests were reported in 2015 at Cape Hatteras National Seashore south of Hatteras; the first records of hawksbill sea turtle nests in the state of North Carolina, and also the first outside the state of Florida. Both nests were north of the Action Area. One nest successfully hatched (hatching success of 64.5%); the other was destroyed by high surf from storms. The nest that successfully hatched had an incubation period of 59 days. It is currently unclear whether or not the hawksbill sea turtle may nest again in the Action Area. However, suitable nesting habitat is present throughout the Action Area.

6.2.2. Factors affecting the species environment within the Action Area

The Service and NMFS share Federal jurisdiction for sea turtles under the ESA. The Service has responsibility for sea turtles on the nesting beach. NMFS has jurisdiction for sea turtles in the marine environment. Activities proposed in this formal consultation would involve only impacts to sea turtles in the terrestrial environment, which includes the following life stages: nesting sea turtles, nests and eggs, and hatchlings as they emerge from the nest and crawl to the sea.

A wide range of recent and on-going beach disturbance activities have altered the proposed Action Area and, to a greater extent, the North Carolina coastline, and many more are proposed along the coastline for the near future. **Appendix A** (copied from the PBA) and **Table 11** (page 73) list many of these activities.

Beach nourishment: **Appendix A** (from the PBA) lists historical beach sand placement projects for the state of North Carolina. The beaches of North Carolina are regularly nourished with sand from the Corps and locally-managed activities. Nourishment activities widen beaches, change their sedimentology and stratigraphy, alter coastal processes and often plug dune gaps and remove overwash areas. The PBA estimates that approximately 112 miles of Atlantic shoreline has been nourished in North Carolina. Rice (2017) estimates the length of nourished shoreline to be approximately 101 miles, with another 43 miles proposed. The first recorded sand placement project in North Carolina was on Wrightsville Beach in 1939, when sand was placed on 2.6 miles of shoreline. Sand placement did not occur again until the mid to late-1950's. Sand placement was generally intermittent and small in scope (less than 6 miles per year) until the late 1980's to 1990's, when the frequency of sand placement and miles of shoreline per year began to dramatically increase. Many of the beachfront communities have received sand on more than 10 occasions. Carolina Beach is listed in the PBA as having had 40 and placement events, while Wrightsville Beach has had 26, and Holden Beach 45. For most of these events, the sand source is navigation projects. Other sand sources include sediment mined from inlets, offshore borrow areas, and previously dredged material from upland disposal areas or existing material from an upland borrow area. Between 31% (Rice 2017) and 35% (PBA) of the North Carolina Shoreline has been modified by sediment placement as of 2015.

Beach scraping can artificially steepen beaches, stabilize dune scarps, plug dune gaps, and redistribute sediment distribution patterns. Artificial dune building, often a product of beach scraping, removes low-lying overwash areas and dune gaps. As chronic erosion catches up to structures throughout the Action Area, artificial dune systems are constructed and maintained to protect beachfront structures either by sand fencing or fill placement. Beach scraping or bulldozing has become more frequent on North Carolina beaches in the past 20 years, in response to storms and the continuing retreat of the shoreline with rising sea level. These activities primarily occur during the winter months. Artificial dune or berm systems have been constructed and maintained in several areas. These dunes make the artificial dune ridge function like a seawall that blocks natural beach retreat, evolution, and overwash. From 2012 to 2015, Rice (2017) estimated that at least 4.84 miles of the North Carolina shoreline was impacted by beach scraping.

Beach raking and rock-picking: Man-made beach cleaning and raking machines effectively remove seaweed, plants, fish, glass, syringes, plastic, cans, cigarettes, shells, stone, wood, and virtually any unwanted debris (Barber Beach Cleaning Equipment 2009). Beach cleaning or grooming can result in abnormally broad unvegetated zones that are inhospitable to dune formation or plant colonization, thereby enhancing the likelihood of erosion (Defreo et al.

2009). Removal of wrack also eliminates a beach's natural sand-trapping abilities, further destabilizing the beach. Sand adhering to seaweed and trapped in the cracks and crevices of wrack is removed from the beach. Although the amount of sand lost due to single sweeping actions may be small, it adds up considerably over a period of years (Nordstrom et al. 2006; Neal et al. 2007). The Town of Carolina Beach rakes the beach front in Freeman Park at least twice per year, including areas in piping plover critical habitat unit NC-14. The Town of North Topsail Beach utilizes a rock-picker as needed, typically annually, to remove rocky material from the beach berm along portions of its shoreline.

Pedestrian Use of the Beach: There are a number of potential sources of pedestrians and pets on North Carolina beaches, including those individuals originating from beachfront, public access points, and nearby hotels, resorts, and residences.

Shoreline stabilization: In 2017, there are 4 jetties and 34 groins along the North Carolina coast, and sandbags, sandbag revetments, groins, and jetties have been placed along at least 9.05 miles of North Carolina shoreline (Rice 2017). See **Table 14 (**page 81**)** for data from Rice (2017).

Sandbags on private properties provide stabilization to a significant portion of the North Carolina shoreline. Rice (2017) estimated 152 separate sandbag structures along the North Carolina beach shoreline. If multiple properties each had an individual seawall protecting their property and the seawalls were attached to each other with no gaps, then Rice (2017) counted the armoring as one structure (per Dallas et al. 2013) and measured the overall length.

Rice (2017) estimated that 24 of 37 North Carolina coastal communities have been modified by armor. In these communities, the proportion of armored sandy beach habitat was as high as 18%. Four communities exceed 10% of the shoreline armored: Kitty Hawk (18%), Bald Head Island (13%)[1], Kure Beach (11%), and Ocean Isle Beach (10%).

Groins often result in accelerated beach erosion downdrift of the structures (Komar 1983; National Research Council 1987) and corresponding degradation of suitable sea turtle nesting habitat (NMFS and Service 1991; 1992). Initially, the greatest changes are observed close to the structures, but effects may eventually extend significant distances along the coast (Komar 1983). Groins operate by blocking the natural longshore transport of littoral drift (Kaufman and Pilkey 1979; Komar 1983). Conventional rubble mound groins control erosion by trapping sand and dissipating some wave energy. In general, except for terminal groins at the downdrift limit of a littoral cell, groins are not considered favorable erosion control alternatives because they usually impart stability to the updrift beach and transfer erosion to the downdrift side of the structure. In addition, groins deflect longshore currents offshore, and excess sand builds up on the updrift side

1 The proportion of Bald Head Island's sandy beach habitat that has been modified by armor is 13% when the Smithville Twp. portions of Zeke's Island Reserve and Bald Head Island State Natural Area are included. When only the Village of Bald Head Island is included, the proportion of sandy beach habitat modified by armor increases to 23% (Rice 2017).

of the structure which may be carried offshore by those currents. This aggravates downdrift erosion and erosion escarpments are common on the downdrift side of groins (Humiston and Moore 2001).

6.3. EFFECTS OF THE ACTION

6.3.1. Factors to be considered

Proximity of action: Sand placement activities would occur within and adjacent to nesting habitat for sea turtles and dune habitats that ensure the stability and integrity of the nesting beach. Specifically, the project would potentially impact loggerhead, green, leatherback, hawksbill, and Kemp's ridley nesting females, their nests, and hatchling sea turtles.

Distribution: Sand placement activities may impact nesting and hatchling sea turtles and sea turtle nests. The Service expects the proposed construction activities could directly and indirectly affect the availability and suitability of habitat for nesting and hatchling sea turtles.

Timing: The timing of the sand placement activities (between November 16 and April 30) could indirectly impact nesting females, their nests, and hatchling sea turtles.

Nature of the effect: The effects of sand placement activities may change the nesting behavior of adult female sea turtles, diminish nesting success, and cause reduced hatching and emerging success. Sand placement can also change the incubation conditions within the nest. Any decrease in productivity and/or survival rates would contribute to the vulnerability of the sea turtles nesting in the southeastern U.S. However, if portions of the area to be nourished are severely eroded, placement of sand may provide nesting habitat where it doesn't currently exist.

Duration: These may be recurring activities, lasting up to five and a half months each time. Thus, the direct effects would be expected to be short-term in duration. Indirect effects from the activity may continue to impact nesting and hatchling sea turtles and sea turtle nests in subsequent nesting seasons.

Disturbance frequency: Disturbance to the sediment from each event will be short term, lasting up to two years. However, sand placement activities may take place several times over the life of the project. Recreational disturbance may increase after project completion and have long-term impacts.

Disturbance intensity and severity: Project construction is anticipated to be conducted outside of the sea turtle nesting season. Conservation measures have been incorporated into the project to minimize impacts.

6.3.2. Analyses for effects of the action

The Action Area encompasses the entire shoreline on the Atlantic coast of North Carolina.

Beneficial Effects: The placement of sand on a beach with reduced dry foredune habitat may increase sea turtle nesting habitat if the placed sand is highly compatible (i.e., grain size, shape, color, etc.) with naturally occurring beach sediments in the area, and compaction and escarpment remediation measures are incorporated into the project. In addition, a nourished beach that is designed and constructed to mimic a natural beach system may benefit sea turtles more than an eroding beach it replaces.

Direct Effects: Although sand placement activities may increase the potential nesting area, significant negative impacts to sea turtles may result if protective measures are not incorporated during project construction.

a. Equipment during construction

The use of heavy machinery on beaches during a construction project may also have adverse effects on sea turtles. The physical changes and loss of plant cover caused by vehicles on vegetated areas or dunes can lead to various degrees of instability and cause dune migration. As vehicles move over the sand, sand is displaced downward, lowering the substrate. Since the vehicles also inhibit plant growth, and open the area to wind erosion, the beach and dunes may become unstable. Vehicular traffic on the beach or through dune breaches or low dunes may cause acceleration of overwash and erosion (Godfrey et al. 1978). Driving along the beachfront should be between the low and high tide water lines. To minimize the impacts to the beach, dunes, and dune vegetation, transport and access to the construction sites should be from the road to the maximum extent possible. However, if vehicular access to the beach is necessary, the areas for vehicle and equipment usage should be designated and marked.

b. Artificial lighting as a result of an unnatural beach slope on the adjacent beach

Visual cues are the primary sea-finding mechanism for hatchling sea turtles (Mrosovsky and Carr 1967; Mrosovsky and Shettleworth 1968; Dickerson and Nelson 1989; Witherington and Bjorndal 1991). When artificial lighting is present on or near the beach, it can misdirect hatchlings once they emerge from their nests and prevent them from reaching the ocean (Philibosian 1976; Mann 1977; FWC 2007). In addition, a significant reduction in sea turtle nesting activity has been documented on beaches illuminated with artificial lights (Witherington 1992). The unnatural sloped beach adjacent to the structure exposes sea turtles and their nests to lights that were less visible, or not visible, from nesting areas before the sand placement activity, leading to a higher mortality of hatchlings. Review of over 10 years of empirical information from beach nourishment projects indicates that the number of sea turtles impacted by lights increases on the post-construction berm. A review of selected nourished beaches in Florida (South Brevard, North Brevard, Captiva Island, Ocean Ridge, Boca Raton, Town of Palm Beach, Longboat Key, and Bonita Beach) indicated disorientation reporting increased by approximately 300 percent the first nesting season after project construction and up to 542 percent the second year compared to pre-nourishment reports (Trindell et al. 2005).

Specific examples of increased lighting disorientations after a sand placement project include Brevard and Palm Beach Counties, Florida. A sand placement project in Brevard County, completed in 2002, showed an increase of 130 percent in disorientations in the nourished area. Disorientations on beaches in the County that were not nourished remained constant (Trindell 2007). This same result was also documented in 2003 when another beach in Brevard County was nourished and the disorientations increased by 480 percent (Trindell 2007). Installing appropriate beachfront lighting is the most effective method to decrease the number of disorientations on any developed beach including nourished beaches. A shoreline protection project was constructed at Ocean Ridge in Palm Beach County, Florida, between August 1997 and April 1998. Lighting disorientation events increased after nourishment. In spite of continued aggressive efforts to identify and correct lighting violations in 1998 and 1999, 86 percent of the disorientation reports were in the nourished area in 1998 and 66 percent of the reports were in the nourished area in 1999 (Howard and Davis 1999).

Indirect Effects: Many of the direct effects of beach nourishment may persist over time and become indirect impacts. These indirect effects include increased susceptibility of relocated nests to catastrophic events, the consequences of potential increased beachfront development, changes in the physical characteristics of the beach, the formation of escarpments, and future sand migration.

a. Changes in the physical environment

Beach nourishment projects create an elevated, wider, and unnatural flat slope berm. Sea turtles nest closer to the water the first few years after nourishment because of the altered profile (and perhaps unnatural sediment grain size distribution) (Ernest and Martin 1999; Trindell 2005).

Beach compaction and unnatural beach profiles resulting from beach nourishment activities could negatively impact sea turtles regardless of the timing of projects. Very fine sand or the use of heavy machinery can cause sand compaction on nourished beaches (Nelson et al. 1987; Nelson and Dickerson 1988a). Significant reductions in nesting success (i.e., false crawls occurred more frequently) have been documented on severely compacted nourished beaches (Fletemeyer 1980; Raymond 1984; Nelson and Dickerson 1987; Nelson et al. 1987), and increased false crawls may result in increased physiological stress to nesting females. Sand compaction may increase the length of time required for female sea turtles to excavate nests and cause increased physiological stress to the animals (Nelson and Dickerson 1988b). Nelson and Dickerson (1988c) concluded that, in general, beaches nourished from offshore borrow sites are harder than natural beaches, and while some may soften over time through erosion and accretion of sand, others may remain hard for 10 years or more. The placement of rocky material on the beach may cause significant reductions in nesting success (i.e., increased frequency of false crawls), and may make it difficult for hatchlings to emerge from the nest.

These impacts can be minimized by using suitable sand and by tilling compacted sand and/or removing rock (minimum depth of 36 inches) after project completion. As the material is reworked by natural forces, the percentage of rock and gravel may increase.

A change in sediment color on a beach could change the natural incubation temperatures of nests in an area, which, in turn, could alter natural sex ratios. To provide the most suitable sediment for nesting sea turtles, the color of the nourished sediments should resemble the natural beach sand in the area. Natural reworking of sediments and bleaching from exposure to the sun would help to lighten dark nourishment sediments; however, the timeframe for sediment mixing and bleaching to occur could be critical to a successful sea turtle nesting season.

b. Escarpment formation

On nourished beaches, steep escarpments may develop along their water line interface as they adjust from an unnatural construction profile to a more natural beach profile (Coastal Engineering Research Center 1984; Nelson et al. 1987). Escarpments can hamper or prevent access to nesting sites (Nelson and Blihovde 1998). Researchers have shown that female sea turtles coming ashore to nest can be discouraged by the formation of an escarpment, leading to situations where they choose marginal or unsuitable nesting areas to deposit eggs (e.g., in front of the escarpments, which often results in failure of nests due to prolonged tidal inundation). This impact can be minimized by leveling any escarpments prior to the nesting season.

c. Increased susceptibility to catastrophic events

Nest relocation within a nesting season may concentrate eggs in an area making them more susceptible to catastrophic events. Hatchlings released from concentrated areas also may be subject to greater predation rates from both land and marine predators, because the predators learn where to concentrate their efforts (Glenn 1998; Wyneken et al. 1998).

d. Increased beachfront development

Pilkey and Dixon (1996) stated that beach replenishment frequently leads to more development in greater density within shorefront communities that are then left with a future of further replenishment or more drastic stabilization measures. Dean (1999) also noted that the very existence of a beach nourishment project can encourage more development in coastal areas. Following completion of a beach nourishment project in Miami during 1982, investment in new and updated facilities substantially increased tourism there (National Research Council 1995). Increased building density immediately adjacent to the beach often resulted as much larger buildings that accommodated more beach users replaced older buildings. Overall, shoreline management creates an upward spiral of initial protective measures resulting in more expensive development that leads to the need for more and larger protective measures. Increased shoreline development may adversely affect sea turtle nesting success. Greater development may support larger populations of mammalian predators, such as foxes and raccoons, than undeveloped areas (National Research Council 1990a), and can also result in greater adverse effects due to artificial lighting, as discussed above.

6.3.3 Species' response to the proposed action

The Service determined there is a potential for long-term adverse effects on sea turtles as a result of sand placement. An increase in sandy beach may not necessarily equate to an increase in suitable sea turtle nesting habitat.

The following summary illustrates sea turtle responses to and recovery from a nourishment project comprehensively studied by Ernest and Martin (1999). A significantly larger proportion of turtles emerging on nourished beaches abandoned their nesting attempts than turtles emerging on natural or pre-nourished beaches. This reduction in nesting success is most pronounced during the first year following project construction and is most likely the result of changes in physical beach characteristics associated with the nourishment project (e.g., beach profile, sediment grain size, beach compaction, frequency and extent of escarpments). During the first post-construction year, the time required for turtles to excavate an egg chamber on untilled, hard-packed sands increases significantly relative to natural conditions. However, tilling (minimum depth of 36 inches) is effective in reducing sediment compaction to levels that did not significantly prolong digging times. As natural processes reduced compaction levels on nourished beaches during the second post-construction year, digging times returned to natural levels (Ernest and Martin 1999).

During the first post-construction year, nests on nourished beaches are deposited significantly seaward of the toe of the dune and significantly landward of the tide line than nests on natural beaches. More nests are washed out on the wide, flat beaches of the nourished treatments than on the narrower steeply sloped natural beaches. This phenomenon may persist through the second post-construction year monitoring and result from the placement of nests near the seaward edge of the beach berm where dramatic profile changes, caused by erosion and scarping, occur as the beach equilibrates to a more natural contour.

The principal effect of beach nourishment on sea turtle reproduction is a reduction in nesting success during the first year following project construction. Although most studies have attributed this phenomenon to an increase in beach compaction and escarpment formation, Ernest and Martin (1999) indicated that changes in beach profile may be more important. Regardless, as a nourished beach is reworked by natural processes in subsequent years and adjusts from an unnatural construction profile to a natural beach profile, beach compaction and the frequency of escarpment formation decline, and nesting and nesting success return to levels found on natural beaches.

6.4. CUMULATIVE EFFECTS

This project may occur on federal or non-federal lands. Cumulative effects include the effects of future State, tribal, local, or private actions that are reasonably certain to occur in the Action Area considered in this biological opinion. Future Federal actions that are unrelated to the proposed action are not considered in this section, because they require separate consultation pursuant to section 7 of the Act. It is reasonable to expect continued shoreline stabilization, inlet dredging, sand placement projects, sand fencing, and beach scraping along the North Carolina shoreline in the future since erosion and sea-level rise increases would impact the existing beachfront development. However, with the exception of some of the above-listed project types, most of the future actions that are reasonable certain to occur will require a Clean Water Act (CWA) Section 404 permit, and thus will require separate consultation.

6.5. CONCLUSION

After reviewing the current status of the nesting loggerhead sea turtle, green sea turtle, leatherback sea turtle, hawksbill sea turtle, and Kemp’s ridley sea turtle, the environmental baseline for the Action Area, the effects of the proposed sand placement, the proposed Conservation Measures, and the cumulative effects, it is the Service's biological opinion that the placement of sand is not likely to jeopardize the continued existence of the loggerhead sea turtle, green sea turtle, leatherback sea turtle, hawksbill sea turtle, and Kemp’s ridley sea turtle. It is the Service’s biological opinion that the placement of sand is not likely to adversely modify terrestrial loggerhead critical habitat.

- The conservation of the five loggerhead recovery units in the Northwest Atlantic is essential to the recovery of the loggerhead sea turtle. Each individual recovery unit is necessary to conserve genetic and demographic robustness, or other features necessary for long-term sustainability of the entire population. Thus, maintenance of viable nesting in each recovery unit contributes to the overall population. The NRU, one of the five loggerhead recovery units in the Northwest Atlantic occurs within the Action Area. The NRU averages 5,215 nests per year (based on 1989-2008 nesting data). Of the available nesting habitat within the NRU, construction will occur and/or will likely have an effect on up to 25 miles of North Carolina shoreline annually in normal years, and up to 62.5 miles of shoreline in years following a major storm.

- Because of the programmatic nature of this BO, construction may occur and/or have an effect on up to 25 miles of loggerhead terrestrial critical habitat annually in normal years, and up to 62.5 miles of loggerhead terrestrial critical habitat in years following a major storm (although we acknowledge it is unlikely that all of the work would be conducted within critical habitat units), out of a total of 96.1 miles.
- Generally, green, leatherback, hawksbill, and Kemp's ridley sea turtle nesting overlaps with or occurs within the beaches where loggerhead sea turtles nest on both the Atlantic and Gulf of Mexico beaches. Thus, for green, leatherback, hawksbill, and Kemp's ridley sea turtles, sand placement activities will occur and/or will likely have an effect on up to 25 miles of North Carolina shoreline annually in normal years, and up to 62.5 miles of shoreline in years following a major storm.
- Research has shown that the principal effect of sand placement on sea turtle reproduction is a reduction in nesting success, and this reduction is most often limited to the first year or two following project construction. Research has also shown that the impacts of a typical sand nourishment project on sea turtle nesting habitat are short-term because a nourished beach will be reworked by natural processes in subsequent years, and beach compaction and the frequency of escarpment formation will decline.

7. INCIDENTAL TAKE STATEMENT

Section 9 of the ESA and Federal regulations pursuant to section 4(d) of the ESA prohibit the take of endangered or threatened species, respectively, without special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by the Service to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering. Harass is defined by the Service as intentional or negligent actions that create the likelihood of injury to listed species to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding, or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, carrying out an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited under the ESA, provided that such taking is in compliance with the terms and conditions of this incidental take statement.

The measures described below in Section 7.3 are non-discretionary, and must be implemented by the Corps so that they become binding conditions of any funding action or any grant or permit issued to the Applicant, as appropriate, for the exemption in section 7(o)(2) to apply. The Corps has a continuing duty to regulate the activity covered by this incidental take statement. If the Corps (1) fails to assume and implement the terms and conditions or (2) fails to require the Applicant to adhere to the terms and conditions of the incidental take statement through enforceable terms that are added to the permit or grant document, the protective coverage of section 7(o)(2) may lapse. In order to monitor the impact of incidental take, the Corps must report the progress of the action and its impacts on the species to the Service as specified in the incidental take statement [50 CFR §402.14(i)(3)].

Sections 7(b)(4) and 7(o)(2) of the ESA generally do not apply to listed plant species. However, limited protection of listed plants from take is provided to the extent that the ESA prohibits the removal and reduction to possession of Federally listed endangered plants or the malicious damage of such plants on areas under Federal jurisdiction, or the destruction of endangered plants on non-Federal areas in violation of state law or regulation, or in the course of any violation of a State criminal trespass law.

7.1. AMOUNT OR EXTENT OF TAKE

7.1.1. Amount or Extent of Take – Piping Plover

It is difficult for the Service to estimate the exact number of piping plovers that could be migrating through or wintering within the Action Area at any point in time and place during and after maintenance events. Disturbance to suitable habitat resulting from placement of sand would affect the ability of an undetermined number of piping plovers to find suitable foraging and roosting habitat for an unknown length of time after construction.

The Service anticipates that no more than 25 miles of highly eroded shoreline along the North Carolina coastline would receive sand placement per year during nonemergency years, with a maximum of 62.5 miles of shoreline receiving sand during or following an emergency event (declared disaster or Congressional Order) as a result of the Statewide Programmatic action. This represents 8% of the entire North Carolina shoreline per year during a nonemergency year, and 19% of the shoreline during an emergency year.

Therefore, directly and indirectly an unspecified amount of piping plovers along this length of shoreline, all at some point, potentially usable by piping plovers, could be taken in the form of harm, harassment, and/or habitat loss as a result of this proposed action; however, incidental take of piping plovers will be difficult to detect for the following reasons:

(1) harassment to the level of harm may only be apparent on the breeding grounds the following year; and
(2) dead plovers may be carried away by waves or predators.

The level of take of this species can be anticipated by the proposed activities because:

(1) piping plovers nest, migrate through and winter in the Action Area;
(2) the placement of the constructed beach is expected to affect the coastal morphology and prevent early successional stages, thereby precluding the maintenance and creation of additional recovery habitat;
(3) increased levels of pedestrian disturbance may be expected; and
(4) a temporary reduction of food base will occur.

The Service has reviewed the biological information and other information relevant to this action. The take is expected in the form of harm and harassment because of: (1) decreased fitness and survivorship of plovers due to loss and degradation of foraging and roosting habitat; and (2) decreased fitness and survivorship of plovers nesting or attempting to migrate to breeding grounds due to loss and degradation of nesting, foraging, and roosting habitat.

7.1.2. Amount or Extent of Take – Red Knot

It is difficult for the Service to estimate the exact number of red knots that could be migrating through or wintering within the Action Area at any one point in time and place during maintenance events. Disturbance to suitable habitat resulting from sand placement activities within the Action Area would affect the ability of an undetermined number of red knots to find suitable foraging and roosting habitat during any given year.

The Service anticipates that no more than 25 miles of highly eroded shoreline along the North Carolina coastline would receive sand placement per year during nonemergency years, with a maximum of 62.5 miles of shoreline receiving sand during or following an emergency event (declared disaster or Congressional Order) as a result of the Statewide Programmatic action. This represents 8% of the entire North Carolina shoreline per year during a nonemergency year, and 19% of the shoreline during an emergency year.

Therefore, directly and indirectly, an unspecified amount of red knots along this length of shoreline, all at some point, potentially usable by red knots, could be taken in the form of harm, harassment, and/or habitat loss as a result of this proposed action; however, incidental take of red knots will be difficult to detect for the following reasons:

(1) harassment to the level of harm may only be apparent on the breeding grounds the following year; and
(2) dead red knots may be carried away by waves or predators.

The level of take of this species can be anticipated by the proposed activities because:

(1) red knots migrate through and winter in the Action Area;
(2) the placement of the constructed beach is expected to affect the coastal morphology and prevent early successional stages, thereby precluding the maintenance and creation of additional recovery habitat;
(3) increased levels of pedestrian disturbance may be expected; and
(4) a temporary reduction of food base will occur.

The Service has reviewed the biological information and other information relevant to this action. The take is expected in the form of harm and harassment because of: (1) decreased fitness and survivorship of red knots due to loss and degradation of foraging and roosting habitat; and (2) decreased fitness and survivorship of red knots attempting to migrate to breeding grounds due to loss and degradation of foraging and roosting habitat.

7.1.3. Amount or Extent of Take – Loggerhead, Green, Leatherback, Hawksbill, and Kemp's Ridley Sea Turtles

The Service anticipates that no more than 25 miles of highly eroded shoreline along the North Carolina coastline would receive sand placement per year during nonemergency years, with a maximum of 62.5 miles of shoreline receiving sand during or following an emergency event (declared disaster or Congressional Order) as a result of the Statewide Programmatic action. This represents 8% of the entire North Carolina shoreline per year during a nonemergency year, and 19% of the shoreline during an emergency year.

Along this length of shoreline, take is expected to be in the form of: (1) destruction of all nests that may be constructed and eggs that may be deposited and missed by a nest survey, nest mark and avoidance program, or egg relocation program within the boundaries of the proposed project; (2) destruction of all nests deposited during the period when a nest survey, nest mark and avoidance, or egg relocation program is not required to be in place within the boundaries of the proposed project; (3) reduced hatching success due to egg mortality during relocation and adverse conditions at the relocation site; (4) harassment in the form of disturbing or interfering with female turtles attempting to nest within the construction area or on adjacent beaches as a result of construction activities; (5) misdirection of nesting and hatchling turtles on beaches adjacent to the sand placement or construction area as a result of project lighting; (6) behavior modification of nesting females due to escarpment formation within the Action Area during the nesting season, resulting in false crawls or situations where they choose marginal or unsuitable nesting areas to deposit eggs; (7) behavior modification of nesting females due to unsuitable material within the Action Area during the nesting season, resulting in false crawls or situations where they choose marginal or unsuitable nesting areas to deposit eggs; (8) reduced hatching or emergence success due to unsuitable nesting habitat, resulting in egg mortality or inability of hatchlings to emerge from the egg cavity; and (9) destruction of nests from escarpment leveling within a nesting season when such leveling has been approved by the Service.

Incidental take is anticipated for the 25 miles (nonemergency years) and 62.5 miles (emergency years) of beach that has been identified. The Service anticipates incidental take of sea turtles will be difficult to detect for the following reasons: (1) the turtles nest primarily at night and all nests are not found because [a] natural factors, such as rainfall, wind, and tides may obscure crawls and [b] human-caused factors, such as pedestrian and vehicular traffic, may obscure crawls, and result in nests being destroyed because they were missed during a nesting survey, nest mark and avoidance, or egg relocation program (2) the total number of hatchlings per undiscovered nest is unknown; (3) the reduction in percent hatching and emerging success per relocated nest over the natural nest site is unknown; (4) an unknown number of females may avoid the project beach and be forced to nest in a less than optimal area; (5) lights may misdirect an unknown number of hatchlings and cause death; and (6) escarpments may form and prevent an unknown number of females from accessing a suitable nesting site.

The incidental take of these species can be anticipated by the sand placement activities on suitable turtle nesting beach habitat because: (1) turtles nest within the Action Area; (2) the renourishment project will modify the incubation substrate, beach slope, and sand compaction; and (3) artificial lighting will deter and/or misdirect nesting hatchling turtles.

7.2. EFFECT OF THE TAKE

Piping Plovers

In the accompanying SPBO, the Service determined that this level of anticipated take is not likely to result in jeopardy to the Northern Great Plains, Great Lakes, or Atlantic Coast breeding populations of the piping plover. The Service determined that the proposed activities are not likely to result in adverse modification of wintering critical habitat for the piping plover.

Red Knot

In the accompanying biological opinion, the Service determined that this level of anticipated take is not likely to result in jeopardy to the red knot species.

Seabeach Amaranth

In the accompanying biological opinion, the Service determined that the potential of the project to damage or destroy seabeach amaranth is not likely to result in jeopardy to the seabeach amaranth species.

Loggerhead, Green, Leatherback, Hawksbill, and Kemp's Ridley Sea Turtles

In the accompanying biological opinion, the Service determined that this level of anticipated take is not likely to result in jeopardy to the loggerhead sea turtle, green sea turtle, leatherback sea turtle, hawksbill sea turtle, and Kemp's ridley sea turtle species. The Service determined that the proposed activities are not likely to result in adverse modification of loggerhead terrestrial critical habitat.

7.3. REASONABLE AND PRUDENT MEASURES *AND* TERMS AND CONDITIONS

The Service believes the following reasonable and prudent measures (RPMs) are necessary and appropriate to minimize take of piping plovers, red knots, seabeach amaranth, and sea turtles in the Action Area for the following sand placement activities:

A. Sand placement from beach nourishment activities; and

B. Sand placement from navigation channel maintenance.

If unable to comply with the RPMs and Terms and Conditions, the Corps, as the regulatory authority or construction agent may:

1. Inform the Service why the RPM or Term and Condition is not reasonable and prudent for the specific project or activity and request exception under the SPBO; or
2. Initiate consultation with the Service for the specific project or activity.

The Service may respond by either of the following:

1. Allowing an exception to the Terms and Conditions under the SPBO; or
2. Recommending or accepting initiation of consultation (if initiated by the Corps) for the specific project or activity.

REASONABLE AND PRUDENT MEASURES for:

A. Projects that include sand placement from beach nourishment activities, primarily for shore protection (these projects are usually larger scaled) shall include the following measures:

Post-construction requirements are listed in Reasonable and Prudent Measures A.13, A.16, A.17, A.18, A.19, and A.21. These post-construction requirements may be subject to congressional authorization and the allocation of funds. If the Corps or Permittee cannot fulfill these Reasonable and Prudent Measures, the Corps must reinitiate consultation.

RPMs – All Species

A.1. Conservation Measures included in the Corps' Programmatic Biological Assessment (PBA) that address protection of nesting sea turtles, piping plovers, red knots, and seabeach amaranth shall be implemented in the Corps federally authorized project or regulated activity. If a RPM and Term and Condition address the same requirement, the requirements of the RPM and Term and Condition take precedence over the Conservation Measure.

A.2. The Corps will notify the Service of the commencement of projects that utilize this SPBO for the purposes of tracking incidental take of all species.

A.3. For the life of the project, all sand placement activities above MHW must be conducted within the winter work window (November 16 to April 30).

A.4. Prior to sand placement, all derelict material, large amounts of rock, or other debris must be removed from the beach to the maximum extent possible.

A.5. During construction, trash and food items shall be disposed of properly either in predator-proof receptacles, or in receptacles that are emptied each night to minimize the potential for attracting predators of piping plovers, red knots, and sea turtles.

A.6. Pipeline placement must be coordinated with NCDCM, the Corps, the Service, and the NCWRC. Pipeline placement coordination may be accomplished through the permit application or Corps' contract processes utilizing appropriate GIS tools.

A.7. Access points for construction vehicles should be as close to the project site as possible. Construction vehicle travel down the beach should be limited to the maximum extent possible.

A.8. A meeting between representatives of the Permittee or Corps, the Service, NCWRC, and NCDCM, must be held prior to the commencement of work on each project.

A.9. The Corps shall facilitate an annual meeting with the Service to assess the effectiveness of the protection and minimization measures outlined in this SPBO.

RPMs - Piping Plovers and Red Knots

A.10. All personnel involved in the construction or sand placement process along the beach shall be aware of the potential presence of piping plovers and red knots. Before start of work each morning, a visual survey must be conducted in the area of work for that day, to determine if piping plovers and red knots are present.

A.11. If project-related activities will potentially adversely affect nesting shorebirds or active nesting habitat, the Corps or Permittee must coordinate with the Service and NCWRC prior to proceeding. If the project is ongoing and shorebirds begin territorial or other nesting behaviors within the project area, then the Corps or Permittee must contact the Service and NCWRC as soon as possible.

A.12. If project activities will be conducted in Optimal Piping Plover Areas (defined in Terms and Conditions A.13 and A.14), the Corps or the Permittee shall clearly delineate work areas within the Optimal Piping Plover Area such as pipeline corridors, travel corridors, and access points. Disturbance outside those delineated work areas must be limited to the maximum extent possible, thereby minimizing effects to sandy unvegetated habitat within the project footprint.

A.13. If project activities will be conducted in Optimal Piping Plover Areas (defined in Term and ConditionsA.13 and A.14), the Corps, the Permittee, or the local sponsor shall provide the mechanisms necessary to monitor impacts to the piping plovers from the project for two years post-construction.

RPMs – Loggerhead, Green, Leatherback, Hawksbill, and Kemp's Ridley Sea Turtles

A.14. Only beach quality sand suitable for sea turtle nesting, successful incubation, and hatchling emergence (defined in Term and Condition A.18) shall be used for sand placement.

A.15. During dredging operations, material placed on the beach shall be qualitatively inspected daily to ensure compatibility. If the inspection process finds that a significant amount of non-beach compatible material is on or has been placed on the beach, all work shall stop immediately and the NCDCM and the Corps will be notified by the Permittee or Corps to determine the appropriate plan of action.

A.16. Sea turtle nesting surveys must be conducted within the project area between May 1 and November 15 of each year, for at least two consecutive nesting seasons after completion, if the sand remains on the beach. Acquisition of readily available sea turtle nesting data from qualified sources (volunteer organizations, other agencies, etc.) is acceptable.

A.17. Visual surveys for escarpments along the Action Area must be made immediately after completion of sand placement, and within 30 days prior to May 1, for two subsequent years after any construction or sand placement event.

A.18. Sand compaction must be qualitatively evaluated at least twice after each sand placement event. Sand compaction must be inspected in the project area immediately after completion of any sand placement event and one time after project completion between October 1 and May 1.

A.19. A report describing the fate of observed sea turtle nests and hatchlings and any actions taken, must be submitted to the Service following completion of work for each year when a sand placement activity has occurred.

A.20. If a dune system is part of the project design, the placement and design of the dune must be coordinated with the Service.

RPMs – Seabeach Amaranth

A.21. The Corps Civil Works Program shall continue its annual seabeach amaranth monitoring program.

TERMS AND CONDITIONS FOR:

A. Sand placement from beach nourishment activities

All conservation measures described in the Corps' Programmatic Biological Assessment are hereby incorporated by reference as Terms and Conditions within this document pursuant to 50 CFR §402.14(I) with the addition of the following Terms and Conditions. In order to be exempt from the prohibitions of section 9 of the Act, the Corps shall comply with the following Terms and Conditions, which implement the Reasonable and Prudent Measures, described above and outline reporting/monitoring requirements. These terms and conditions are non-discretionary.

Post-construction requirements are listed in Terms and Conditions A.13, A.14, A.17, A.18, A.19, A.20, A.22, A.23, A.24, A.25, and A.26. These post-construction requirements may be subject to congressional authorization and the allocation of funds. If the Corps or Permittee cannot fulfill these Terms and Conditions, the Corps must reinitiate consultation.

Terms and Conditions – All Species

A.1. Conservation Measures included in the Corps' PBA that address protection of nesting sea turtles, piping plover, red knot, and seabeach amaranth listed on pages 10-11 of the SPBO shall be implemented in the Corps federally authorized project or regulated activity.

A.2. The Corps or the Permittee must provide the following information to the Service at least 10 business days prior to the commencement of work:

a) Project location (include latitude and longitude coordinates, as well as mile markers, cross streets, or street addresses if available);
b) Project description (including linear feet of beach, actual fill template, access points, and borrow areas); and
c) Anticipated date of commencement and anticipated duration of construction.

A.3. For the life of the permit/project, all sand placement activities above MHW must be conducted within the winter work window (November 16 to April 30), unless a variance is approved after additional consultation with the Service.

A.4. Prior to sand placement, all derelict material, large amounts of rock, or other debris must be removed from the beach to the maximum extent possible. If debris removal activities take place during shorebird breeding season (April 1– August 31), the work shall be conducted during daylight hours only.

A.5. During construction, trash and food items shall be disposed of properly either in predator-proof receptacles, or in receptacles that are emptied each night to minimize the potential for attracting predators of piping plovers, red knots, and sea turtles.

A.6. Pipeline placement must be coordinated with NCDCM, the Corps, the Service, and the NCWRC. This may be accomplished through the permit application or Corps' contract processes utilizing appropriate GIS tools.

A.7. Access points for construction vehicles should be as close to the project site as possible. Construction vehicle travel down the beach should be limited to the maximum extent possible.

A.8. A meeting between representatives of the contractor(s), the Corps, the Service, the NCWRC, and NCDCM, must be held prior to the commencement of work. Advance notice (of at least 5 business days) must be provided prior to conducting this meeting. The meeting will provide an opportunity for explanation and/or clarification of the Conservation Measures and Terms and Conditions, and will include the following:

a) Staging locations, and storing of equipment, including fuel stations;
b) Coordination with the surveyors on required species surveys;
c) Pipeline placement;
d) Minimization of driving within and around the Action Area;
e) Follow up coordination during construction and post construction;
f) Direction of the work including progression of sand placement along the beach;
g) Plans for compaction monitoring;
h) Plans for escarpment surveys and
i) Names and qualifications of personnel involved in any required species surveys.

A.9. Following the preconstruction meeting, the Corps shall provide the Service with specific anticipated shoreline lengths and anticipated duration of the project, using the form on the following web link: <https://www.fws.gov/northflorida/SeaTurtles/Docs/Corp%20of%20Engineers%20Sea%20Turtle%20Permit%20Information.pdf >. Only the following information should be filled out: Corps permit number, FWS Log Number, Project Location, Construction Activity, Duration of Project, and Actual Take (linear feet of beach). This form shall be emailed to the Service at <seaturtle@fws.gov>. The form should be filled out using information from the permit application or authorization. This form is in addition to the annual report, listed below.

A.10. The Corps shall meet with the Service, NCDCM, and NCWRC (and cooperating agencies such as BOEM, as appropriate) annually to discuss the effectiveness of the avoidance measures and additional measures to include for future projects. The agencies will also review the projects utilizing this SPBO the previous year to ensure that the reporting requirements for calculating the extent of take are adequate. This meeting will also explore:

a) The possibility of using dredged materials to enhance potential or existing piping plover habitat within and adjacent to the project area;
b) Methods for funding beneficial use opportunities for dredged materials that are not least-cost disposal to benefit piping plovers and their habitat;
c) The development of shore protection design guidelines that can be utilized during future project planning to protect and/or enhance piping plover habitat; and
d) Incorporating artificial lagoons or ephemeral pools into project designs adjacent to inlets where sand placement is proposed.

Terms and Conditions – Piping Plovers and Red Knots

A.11. All personnel involved in the construction or sand placement process along the beach shall be aware of the potential presence of piping plovers and red knots. Before start of work each morning, a visual survey must be conducted in the area of work for that day, to determine if piping plovers and red knots are present. If shorebirds are present in the work area, careful movement of equipment in the early morning hours should allow those individuals to move out of the area. Construction operations shall be carried out at all times in a manner as to avoid negatively impacting shorebirds and allowing them to exit the area.

A.12. If project-related activities will potentially adversely affect nesting shorebirds or active nesting habitat, the Corps or Permittee must coordinate with the Service and NCWRC prior to proceeding. If the project is ongoing and shorebirds begin territorial or other nesting behaviors within the project area, then the Corps or Permittee must contact the Service and NCWRC as soon as possible.

A.13. If project activities will be conducted in Optimal Piping Plover Areas, piping plover habitat (sandy unvegetated habitat) within the Optimal Piping Plover Area shall be avoided to the maximum extent practicable when staging equipment, establishing travel corridors, and aligning pipeline. The Corps or the Permittee, to the maximum extent practicable, shall clearly delineate work areas within the Optimal Piping Plover Area such as pipeline corridors, travel corridors, and access points. Disturbance outside those delineated work areas must be limited, thereby minimizing effects to sandy unvegetated habitat. Driving on the beach for construction shall be limited to the minimum necessary within the designated travel corridor. The delineation of work corridors and work areas in authorized project plans will be sufficient to meet this term and condition.
Optimal Piping Plover Areas are defined as having documented use by piping plovers, and they include coastal habitat features that function mostly unimpeded. Optimal Piping Plover Areas include:

a) Designated piping plover Critical Habitat Units (see **Appendix C**);
b) All Federal, State, and County publicly owned land where coastal processes are allowed to function, mostly unimpeded*, that have any of the following features in the Action Area:
    i. Located within 1 mile of an inlet;
    ii. Emergent nearshore sand bars;
    iii. Washover fans;
    iv. Emergent soundside and Ocean shoals and sand bars;
    v. Soundside mudflats, sand flats, and algal flats; or
    vi. Soundside shorelines.

[*Publicly owned land where coastal processes are allowed to function, mostly unimpeded, generally does not include public lands that are solely state-owned water bottoms, street ends, parking lots, piers, beach accesses, heavily-developed or highly-manipulated parks, or shoreline developed for commercial or residential purposes. It generally does include public lands consisting of undeveloped parks, preserves, and other natural undeveloped shoreline and dunes.]

A.14. If project related activities will be conducted in Optimal Piping Plover Areas, then the piping plover and red knot survey protocol in **Appendix D** must be followed. Two full years of post-construction monitoring is required. Optimal Piping Plover Areas include:

a) Designated piping plover Critical Habitat Units (see **Appendix C**);
b) All Federal, State, and County publicly owned land where coastal processes are allowed to function, mostly unimpeded*, that have any of the following features in the Action Area:
    i. Located within 1 mile of an inlet;
    ii. Emergent nearshore sand bars;
    iii. Washover fans;
    iv. Emergent soundside and Ocean shoals and sand bars;
    v. Soundside mudflats, sand flats, and algal flats; or
    vi. Soundside shorelines.

[*Publicly owned land where coastal processes are allowed to function, mostly unimpeded, generally does not include public lands that are solely state-owned water bottoms, street ends, parking lots, piers, beach accesses, heavily-developed or highly-manipulated parks, or shoreline developed for commercial or residential purposes. It generally does include public lands consisting of undeveloped parks, preserves, and other natural undeveloped shoreline and dunes.]

Terms and Conditions – Sea Turtles

A.15. Only beach compatible fill shall be placed on the beach or in any associated dune system. Beach compatible fill must be sand that is similar to a native beach in the vicinity of the site that has not been affected by prior sand placement activity. Beach compatible fill must be sand comprised solely of natural sediment and shell material, containing no construction debris, toxic material, large amounts of rock, or other foreign matter. The beach compatible fill must be similar in both color and grain size distribution (sand grain frequency, mean and median grain size and sorting coefficient) to the native material in the Action Area. Beach compatible fill is material that maintains the general character and functionality of the material occurring on the beach and in the adjacent dune and coastal system. In general, fill material that meets the requirements of the most recent version of the North Carolina Technical Standards for Beach Fill (15A NCAC 07H .0312) is considered compatible.

A.16. During dredging operations, material placed on the beach shall be qualitatively inspected daily to ensure compatibility. If the inspection process finds that a significant amount of non-beach compatible material is on or has been placed on the beach, all work shall stop immediately, and the NCDCM, Corps, and BOEM (as appropriate) will be notified by the permittee and/or its contractors to determine the appropriate plan of action. Required actions may include immediate removal of material and/or long-term remediation activities.

A.17. Daily sea turtle nesting surveys must be conducted within the project area between May 1 and November 15 of each year, for at least two consecutive nesting seasons after completion of sand placement (2 years post-construction monitoring). Acquisition of readily available sea turtle nesting data from qualified sources (volunteer organizations, other agencies, etc.) is acceptable. However, in the event that data from other sources cannot be acquired, the Corps or permittee will be responsible to collect the data. Data collected for each nest should include, at a minimum, the information in the table, below. This information will be provided to the Service in the annual report, and will be used to periodically assess the cumulative effects of these projects on sea turtle nesting and hatchling production and monitor suitability of post construction beaches for nesting. Please see REPORTING REQUIREMENTS, below.

Parameter	Measurement	Variable
Number of False Crawls	Visual Assessment of all false crawls	Number/location of false crawls in nourished areas; any interaction of turtles with obstructions, such as sand bags or scarps, should be noted.
False Crawl Type	Categorization of the stage at which nesting was abandoned	Number in each of the following categories: a) Emergence - no digging; b) Preliminary body pit; c) Abandoned egg chamber.
Nests	Number	The number of sea turtle nests in nourished areas should be noted. If possible, the location of all sea turtle nests should be marked on a project map, and approximate distance to scarps or sandbags measured in meters. Any abnormal cavity morphologies should be reported as well as whether turtle touched sandbags or scarps during nest excavation.
Nests	Lost Nests	The number of nests lost to inundation or erosion or the number with lost markers.
Nests	Relocated nests	The number of nests relocated and a map of the relocation area(s). The number of successfully hatched eggs per relocated nest.
Lighting Impacts	Disoriented sea turtles	The number of disoriented hatchlings and adults.

A.18. Visual surveys for escarpments along the Action Area must be made immediately after completion of sand placement, and within 30 days prior to May 1, for two subsequent years after any construction or sand placement event. Escarpments that interfere with sea turtle nesting or that exceed 18 inches in height for a distance of 100 feet must be leveled and the beach profile must be reconfigured to minimize scarp formation by the dates listed above. Any escarpment removal must be reported by location. The Service must be contacted immediately if subsequent reformation of escarpments that interfere with sea turtle nesting or that exceed 18 inches in height for a distance of 100 feet occurs during the nesting and hatching season to determine the appropriate action to be taken. If it is determined that escarpment leveling is required during the nesting or hatching season, the Service or NCWRC will provide a brief written authorization within 30 days that describes methods to be used to reduce the likelihood of impacting existing nests. An annual summary of escarpment surveys and actions taken must be submitted to the Service.

A.19. Sand compaction must be qualitatively evaluated at least twice after each sand placement event, once in the project area immediately after completion of any sand placement event and once after project completion between October 1 and May 1. Compaction monitoring and remediation are not required if the placed material no longer remains on the beach. Within 14 days of completion of sand placement and prior to any tilling (if needed), a field meeting shall be held with the Service, NCWRC, and the Corps to inspect the project area for compaction and determine whether tilling is needed.

a) If tilling is needed for sand suitability, the area must be tilled to a depth of 36 inches. All tilling activities shall be completed prior to May 1 of any year.
b) Tilling must occur landward of the wrack line and avoid all vegetated areas that are 3 square feet or greater, with a 3-foot buffer around all vegetation.
c) If tilling occurs during the shorebird nesting season or seabeach amaranth growing season (after April 1), shorebird surveys and/or seabeach amaranth surveys are required prior to tilling.
d) A summary of the compaction assessments and the actions taken shall be included in the annual report to NCDCM, the Corps, and the Service.
e) These conditions will be evaluated and may be modified if necessary to address and identify sand compaction problems.

A.20. A report describing the fate of observed sea turtle nests and hatchlings and any actions taken, must be submitted to the Service following completion of the proposed work for each year when a sand placement activity has occurred. Please see REPORTING REQUIREMENTS, below.

A.21. If a dune system is part of the project design, the placement and design of the dune must be coordinated with the Service.

Terms and Conditions – Seabeach Amaranth

A.22. The Corps Civil Works Program shall continue its annual seabeach amaranth monitoring program in accordance with April 19, 1993 Biological Opinion for various U.S. Army Corps of Engineers' projects and Terms and Conditions A.23 to A.26, below..

A.23. The Corps should survey beach sand placement areas for at least five years following each placement event, to determine the status of the seabeach amaranth populations in the project areas and the effects that beach disposal has on this species. Surveys should be conducted in August or September so that the number of plants reaching reproductive age can be determined.

A.24. Suitable habitat along shoreline reaches that have received sand within the previous five years should be surveyed for the occurrence of seabeach amaranth. Documentation for each seabeach amaranth plant should include location (using a handheld GPS unit), unique features, abnormalities, or other relevant information. If multiple plants are observed in an area, a single representative GPS point may be logged with accompanying notes describing total plants associated with that point.

A.25. A Corps report describing the seabeach amaranth survey and results should be submitted to Service, the North Carolina Natural Heritage Program, and the North Carolina Plant Conservation Program, by December 31 of each year. The report should include a map showing locations of seabeach amaranth populations and the numbers of plants, with separate figures for those in flower or fruit, found in the sand placement areas.

A.26. If tilling of the beach is required due to high compaction levels resulting from beach disposal, surveys should be conducted in advance of the tilling for seabeach amaranth (see sea turtle section - Reasonable and Prudent Measures). No tilling should be conducted in the immediate areas where seabeach amaranth plants are growing.

REASONABLE AND PRUDENT MEASURES for:

B. Projects that are navigation maintenance dredging with beach placement shall include the following measures:

Historically, sand placement events associated with navigation maintenance dredging projects have no local sponsor, are smaller-scaled, conducted at closer time intervals, and the sand often does not remain on the beach for an extended period of time.

Post-construction requirements are listed in Reasonable and Prudent Measures B.11, B.12, B.13, B.15, and B.16. These post-construction requirements may be subject to congressional authorization and the allocation of funds. If the Corps or Permittee cannot fulfill these Terms and Conditions, the Corps must reinitiate consultation.

B.1. Conservation Measures included in the Corps' PBA that address protection of piping plovers, red knots, nesting sea turtles, and seabeach amaranth shall be implemented in the Corps' federally authorized project or regulated activity.

B.2. The Corps will notify the Service of the commencement of projects that utilize this SPBO for the purposes of tracking incidental take of all species.

B.3. For the life of the project, all sand placement activities above MHW must be conducted within the winter work window (November 16 to April 30).

B.4. Prior to sand placement, all derelict material, large amounts of rock, or other debris must be removed from the beach to the maximum extent possible.

B.5. During construction, trash and food items shall be disposed of properly either in predator-proof receptacles, or in receptacles that are emptied each night to minimize the potential for attracting predators of piping plovers, red knots, and sea turtles.

B.6. Pipeline placement must be coordinated with NCDCM, the Corps, the Service, and the NCWRC.

B.7. Access points for construction vehicles should be as close to the project site as possible. Construction vehicle travel down the beach should be limited to the maximum extent possible.

B.8. Beach quality sand suitable for sea turtle nesting, successful incubation, and hatchling emergence shall be used for sand placement.

B.9. A meeting between representatives of the Corps, Service, NCWRC, and NCDCM shall be held prior to the commencement of work on this project.

B.10. During dredging operations, material placed on the beach shall be inspected daily to ensure compatibility. If the inspection process finds that non-beach compatible material, including large amounts of shell or rock, is or has been placed on the beach, all work shall stop immediately and the NCDCM and the Corps will be notified by the permittee and/or its contractors to determine the appropriate plan of action.

B.11. For navigation projects with placement of at least 200,000 cubic yards of sand on the beach, sea turtle nesting surveys must be conducted within the project area between May 1 and November 15 of each year, for at least two consecutive nesting seasons after completion, if the sand remains on the beach. Acquisition of readily available sea turtle nesting data from qualified sources (volunteer organization, other agencies, etc.) is acceptable.

B.12. Sand compaction shall be monitored and tilling shall be conducted if needed to reduce the likelihood of impacting sea turtle nesting and hatching activities.

B.13. Escarpment formation shall be monitored and leveling shall be conducted if needed to reduce the likelihood of impacting nesting and hatchling sea turtles.

B.14. Construction equipment and materials shall be stored in a manner that will minimize impacts to piping plovers, red knots, and nesting shorebirds.

B.15. A report describing the actions taken shall be submitted to the Service work for each year when the activity has occurred.

B.16. The Corps Civil Works Program shall continue its annual seabeach amaranth monitoring program.

TERMS AND CONDITIONS for:

B. Projects that are navigation maintenance dredging with beach placement, or Corps civil works project shall include the following measures:

Historically, sand placement events associated with navigation maintenance dredging projects have no local sponsor, are smaller-scaled, conducted at closer time intervals, and the sand often does not remain on the beach for an extended period of time.

All conservation measures described in the Corps' Programmatic Biological Assessment are hereby incorporated by reference as Terms and Conditions within this document pursuant to 50 CFR §402.14(I) with the addition of the following Terms and Conditions. In order to be exempt from the prohibitions of section 9 of the Act, the Corps shall comply with the following Terms and Conditions, which implement the Reasonable and Prudent Measures, described above and outline reporting/monitoring requirements. These terms and conditions are non-discretionary.

Post-construction requirements are listed in Terms and Conditions B.11, B.12, B.13, B.15, B.16, B.17, B.18, and B.19. These post-construction requirements may be subject to congressional authorization and the allocation of funds. If the Corps or Permittee cannot fulfill these Terms and Conditions, the Corps must reinitiate consultation.

B.1. Conservation Measures included in the Corps' PBA that address protection of nesting sea turtles, piping plover, red knot, and seabeach amaranth listed on pages 10-11 of the SPBO shall be implemented in the Corps federally authorized project or regulated activity.

B.2. The Corps or the Permittee must provide the following information to the Service at least 10 business days prior to the commencement of work:

a) Project location (include latitude and longitude coordinates, as well as mile markers, cross streets, or street addresses if available);
b) Project description (including linear feet of beach, actual fill template, access points, and borrow areas);
c) Anticipated date of commencement and anticipated duration of construction

B.3. For the life of the permit/project, all sand placement activities above MHW must be conducted within the winter work window (November 16 to April 30), unless allowed after additional consultation with the Service.

B.4. Prior to sand placement, all derelict material, large amounts of rock, or other debris must be removed from the beach to the maximum extent possible. If debris removal activities take place during shorebird breeding season (April 1– August 31), the work shall be conducted during daylight hours only.

B.5. During construction, trash and food items shall be disposed of properly either in predator-proof receptacles, or in receptacles that are emptied each night to minimize the potential for attracting predators of piping plovers, red knots, and sea turtles.

B.6. Pipeline placement must be coordinated with NCDCM, the Corps, the Service, and the NCWRC.

B.7. Access points for construction vehicles should be as close to the project site as possible. Construction vehicle travel down the beach should be limited to the maximum extent possible.

B.8. Only beach compatible fill shall be placed on the beach or in any associated dune system. Beach compatible fill must be sand that is similar to a native beach in the vicinity of the site that has not been affected by prior sand placement activity. Beach compatible fill must be sand comprised solely of natural sediment and shell material, containing no construction debris, toxic material, large amounts of rock, or other foreign matter. The beach compatible fill must be similar in both color and grain size distribution (sand grain frequency, mean and median grain size and sorting coefficient) to the native material in the Action Area. Beach compatible fill is material that maintains the general character and functionality of the material occurring on the beach and in the adjacent dune and coastal system. In general, fill material that meets the requirements of the most recent version of the North Carolina Technical Standards for Beach Fill (15A NCAC 07H .0312) is considered compatible.

B.9. The Service must be invited to any pre-construction meetings held prior to the commencement of work. Advance notice (of at least 5 business days) must be provided prior to conducting this meeting. The meeting will provide an opportunity for explanation and/or clarification of the Conservation Measures and Terms and Conditions, and will include the following:

a) Staging locations, storing equipment including fuel stations;
b) Coordination with the surveyors on required species surveys;
c) Pipeline placement (between 5 to 10 feet from dune);
d) Minimizing driving;
e) Follow up coordination during construction and post construction;
f) Direction of the project including progression of sand placement along the beach;
g) Plans for compaction monitoring;

h) Plans for escarpment surveys; and
i) Names and qualifications of personnel involved in any required surveys.

B.10. During dredging operations, material placed on the beach shall be inspected daily to ensure compatibility. If the inspection process finds that non-beach compatible material, including large amounts of shell or rock exceeding the state sediment criteria (15A NCAC 07H .0312), is or has been placed on the beach, all work shall stop immediately, and the NCDCM and the Corps will be notified by the permittee and/or its contractors to determine the appropriate plan of action.

B.11. For navigation projects with placement of at least 200,000 cubic yards of sand on the beach, sea turtle nesting surveys must be conducted within the project area between May 1 and November 15 of each year, for at least two consecutive nesting seasons after completion of sand placement (2 years post-construction monitoring). Acquisition of readily available sea turtle nesting data from qualified sources (volunteer organizations, other agencies, etc.) is acceptable. Data collected for each nest should include, at a minimum, the information in the table, below. This information will be provided to the Raleigh Field Office in the annual report, and will be used to periodically assess the cumulative effects of these projects on sea turtle nesting and hatchling production and monitor suitability of post construction beaches for nesting. Please see REPORTING REQUIREMENTS, below.

Parameter	**Measurement**	**Variable**
Number of False Crawls	Visual Assessment of all false crawls	Number/location of false crawls in nourished areas; any interaction of turtles with obstructions, such as sand bags or scarps, should be noted.
False Crawl Type	Categorization of the stage at which nesting was abandoned	Number in each of the following categories: a) Emergence - no digging; b) Preliminary body pit; c) Abandoned egg chamber.
Nests	Number	The number of sea turtle nests in nourished areas should be noted. If possible, the location of all sea turtle nests should be marked on a project map, and approximate distance to scarps or sandbags measured in meters. Any abnormal cavity morphologies should be reported as well as whether turtle touched sandbags or scarps during nest excavation.
Nests	Lost Nests	The number of nests lost to inundation or erosion or the number with lost markers.

Nests	Relocated nests	The number of nests relocated and a map of the relocation area(s). The number of successfully hatched eggs per relocated nest.
Lighting Impacts	Disoriented sea turtles	The number of disoriented hatchlings and adults.

B.12. Sand compaction must be qualitatively evaluated at least twice after each sand placement event, once in the project area immediately after completion of any sand placement event and once after project completion between October 1 and May 1. Compaction monitoring and remediation are not required if the placed material no longer remains on the beach. Within 14 days of completion of sand placement and prior to any tilling (if needed), a field meeting shall be held with the Service, NCWRC, and the Corps to inspect the project area for compaction and determine whether tilling is needed.

a) If tilling is needed for sand suitability, the area must be tilled to a depth of 36 inches. All tilling activities shall be completed prior to May 1 of any year.
b) Tilling must occur landward of the wrack line and avoid all vegetated areas that are 3 square feet or greater, with a 3-foot buffer around all vegetation.
c) If tilling occurs during the shorebird nesting season or seabeach amaranth growing season (after April 1), shorebird surveys and/or seabeach amaranth surveys are required prior to tilling.
d) A summary of the compaction assessments and the actions taken shall be included in the annual report to NCDCM, the Corps, and the Service.
e) These conditions will be evaluated and may be modified if necessary to address and identify sand compaction problems.

B.13. Visual surveys for escarpments along the Action Area must be made immediately after completion of sand placement, and within 30 days prior to May 1, for two subsequent years after any construction or sand placement event. Escarpments that interfere with sea turtle nesting or that exceed 18 inches in height for a distance of 100 feet must be leveled and the beach profile must be reconfigured to minimize scarp formation by the dates listed above. Any escarpment removal must be reported by location. The Service must be contacted immediately if subsequent reformation of escarpments that interfere with sea turtle nesting or that exceed 18 inches in height for a distance of 100 feet occurs during the nesting and hatching season to determine the appropriate action to be taken. If it is determined that escarpment leveling is required during the nesting or hatching season, the Service or NCWRC will provide a brief written authorization within 30 days that describes methods to be used to reduce the likelihood of impacting existing nests. An annual summary of escarpment surveys and actions taken must be submitted to the Service.

B.14. Piping plover habitat (sandy unvegetated habitat along inlet shoulders) shall be avoided to the maximum extent practicable when staging equipment, establishing travel corridors, and aligning pipeline.

B.15. A report describing the fate of observed sea turtle nests and hatchlings and any actions taken, must be submitted to the Service following completion of the proposed work for each year when a sand placement activity has occurred. Please see REPORTING REQUIREMENTS, below.

B.16. The Corps' annual seabeach amaranth monitoring program shall continue in accordance with April 19, 1993 Biological Opinion for various U.S. Army Corps of Engineers' projects.

B.17. The Corps should survey beach sand placement areas for at least five years following each placement event, to determine the status of the seabeach amaranth populations in the project areas and the effects that beach disposal has on this species. Surveys should be conducted in August or September so that the number of plants reaching reproductive age can be determined.

B.18. Suitable habitat along shoreline reaches that have received sand within the previous five years should be surveyed for the occurrence of seabeach amaranth. Documentation for each seabeach amaranth plant should include location (using a handheld GPS unit), unique features, abnormalities, or other relevant information. If multiple plants are observed in an area, a single representative GPS point may be logged with accompanying notes describing total plants associated with that point.

B.19. A Corps report describing the seabeach amaranth survey and results should be submitted to Service, the North Carolina Natural Heritage Program, and the North Carolina Plant Conservation Program, by December 31 of each year. The report should include a map showing locations of seabeach amaranth populations and the numbers of plants, with separate figures for those in flower or fruit, found in the sand placement areas.

7.4 REPORTING REQUIREMENTS

An annual report detailing the monitoring and survey data collected during the preceding year (required in the above Terms and Conditions) and summarizing all piping plover, red knot, shorebird, and sea turtle data must be provided to the Service's Raleigh Field Office by January 31 of each year for review and comment. In addition, any information or data related to a conservation measure or recommendation that is implemented should be included in the annual report. As in the past, the Corps should submit a separate annual monitoring report detailing seabeach amaranth monitoring and survey data for the preceding year. The contact for these reporting requirements is:

Pete Benjamin, Supervisor
Raleigh Field Office
U.S. Fish and Wildlife Service
Post Office Box 33726
Raleigh, North Carolina 27636-3726
(919) 856-4520

Upon locating a dead, injured, or sick individual of an endangered or threatened species, initial notification must be made to the Service's Law Enforcement Office below. Additional notification must be made to the Raleigh Ecological Services Field Office identified above and to the NCWRC at (252) 241-7367. Care should be taken in handling sick or injured individuals and in the preservation of specimens in the best possible state for later analysis of cause of death or injury.

Jason Keith
U.S. Fish and Wildlife Service
551-F Pylon Drive
Raleigh, NC 27606
(919) 856-4786, extension 34

7.5. COORDINATION OF INCIDENTAL TAKE STATEMENT WITH OTHER LAWS, REGULATIONS, AND POLICIES

The Service will not refer the incidental take of any migratory bird for prosecution under the Migratory Bird Treaty Act of 1918, as amended (16 USC S 703-712), if such take is in compliance with the terms and conditions specified herein. Take resulting from activities that are not in conformance with the Corps permit or this biological opinion (e.g. deliberate harassment of wildlife, etc.) are not considered part of the proposed action and are not covered by this incidental take statement and may be subject to enforcement action against the individual responsible for the act.

8. CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the ESA directs Federal agencies to utilize their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information.

The Service recommends the following Conservation Actions:

1. Construction activities for these projects and similar future projects should be planned to take place outside the shorebird nesting season (Prior to March 30).

2. The Permittee or the Corps should maintain suitable piping plover migrating and wintering habitat. Natural accretion at inlets should be allowed to remain. Accreting sand spits on barrier islands provide excellent foraging habitat for migrating and wintering plovers.

3. The Service encourages the Corps to work with local sponsors and/or applicants and permittees to develop local beach management plans that include protections for sea turtles, seabeach amaranth, piping plovers, red knots, and other shorebirds.

4. A conservation/education display sign at beach access points would be helpful in educating local beach users about the coastal beach ecosystem and associated rare species, including sea turtles, seabeach amaranth, piping plover, and red knot. The sign could highlight each species life history and basic biology and ways recreationists can assist in species protection efforts (e.g., keeping pets on a leash, removing trash to sealed refuse containers, etc.). The Service would be willing to assist the Corps or the Permittee in the development of such a sign, in cooperation with NCWRC.

5. The Service encourages continued investigation into opportunities for increasing monitoring for Civil Works operations and maintenance projects, including the potential development of a piping plover and red knot survey fund to assist in the management and monitoring of shorebirds in Optimal Piping Plover Areas.

6. If public driving is allowed on the project beach, and if the Corps has the authority, we recommend it exercise its discretionary authority to require the local sponsor or Permittee to have authorization from the Service for incidental take of piping plover, red knot, sea turtles, including nests and hatchlings (as appropriate), due to such driving or provide written documentation from the Service that no incidental take authorization is required. If required, the incidental take authorization for driving on the beach should be obtained prior to any subsequent sand placement events.

7. If the project area is within a local municipality that has not adopted a lighting ordinance, and lighting is shown to be an issue on a nourished beach, and if the Corps has the authority, we recommend it exercise its discretionary authority to require an ordinance be adopted prior to any subsequent sand placement event.

8. If the Corps has the authority, we recommend it exercise its discretionary authority to require that leash-laws and predator control programs (including education of pet owners and cat colony supporters) be implemented.

9. The Corps should work with local municipalities to identify and eradicate beach vitex, an invasive species. Beach vitex populations have been known to impact nesting sea turtles and shorebirds.

In order for the Service to be kept informed of actions minimizing or avoiding adverse effects or benefitting listed species or their habitats, the Service requests notification of the implementation of any conservation recommendations.

9. REINITIATION NOTICE – CLOSING STATEMENT

This concludes formal consultation on the action outlined in the request. As provided in 50 CFR §402.16, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded; (2) new information reveals effects of the Corps' action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion or the project has not been completed within five years of the issuance of this biological opinion; (3) the Corps' action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not considered in this opinion; or (4) a new species is listed or critical habitat designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, any operations causing such take must cease pending reinitiation.

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Appendix A

North Carolina
Historical Sand Placement Projects
(from the PBA)

Southern NC Region Historical Sand Placement Projects

Community	Year	Project Type	Volume (CY)	Shoreline Miles
Ocean Isle	1974	Navigation	82,831	0.16
	1976	Navigation	30,925	0.06
	1980	Navigation	37,325	0.07
	1983	Navigation	54,905	0.10
	1984	Navigation	38,880	0.07
	1986	Navigation	30,630	0.06
	1989	Navigation	48,614	0.09
	2001	Beach Nourishment	1,866,159	3.31
	2006	Navigation	497,367	1.33
	2007	Beach Nourishment	609,530	1.50
	2010	Beach Nourishment	575,040	2.30
	2011	Navigation	48,083	0.09
	2012	Navigation	41,961	0.08
	2014	Beach Nourishment	827,163	1.63
Subtotal			**4,789,413**	**10.85**
Holden Beach	1971	Navigation	108,802	0.21
	1973	Navigation	108,627	0.21
	1974	Navigation	92,774	0.18
	1975	Navigation	62,303	0.12
	1977	Navigation	76,149	0.14
	1981	Navigation	24,320	0.05
	1982	Navigation	177,606	0.34
	1983	Navigation	241,535	0.46
	1984	Navigation	199,386	0.38
	1985	Navigation	92,236	0.17
	1986	Navigation	150,757	0.29
	1987	Navigation	225,576	0.43
	1988	Navigation	59,411	0.11
	1990	Navigation	8,615	0.02
	1992	Navigation	55,665	0.11
	1993	Navigation	135,555	0.26
	1994	Navigation	80,505	0.15
	1995	Navigation	26,265	0.05
	1996	Navigation	4,370	0.01
	1997	Navigation	93,200	0.18
	1998	Beach Nourishment	39,125	0.76
	1999	Navigation	23,690	0.04
	2000	Navigation	45,535	0.09
	2001	Navigation	535,940	2.17
	2002	Navigation	160,945	1.29
	2003	Navigation	28,814	0.05
	2004	Navigation	113,230	0.21
	2005	Navigation	22,670	0.04
	2006	Beach Nourishment	45,200	1.04
	2009	Beach Nourishment	353,798	2.27
	2010	Navigation	167,938	0.66
Holden Beach (con't)	2011	Navigation	56,251	0.38
	2012	Navigation	15,493	0.19
	2014	Navigation	185,856	1.04
Subtotal			**3,818,142**	**14.10**
Oak Island	1986	Navigation	130,000	0.25
	1989	Navigation	104,803	0.20
	1993	Navigation	160,091	0.30
	2001	Habitat Restoration	4,968,400	10.31
	2009	Navigation	941,000	2.65
	2015	Navigation	221,773	0.55
Subtotal			**6,526,067**	**14.26**
Caswell	2001	Navigation	133,200	0.38
	2009	Navigation	123,400	0.66
Subtotal			**256,600**	**1.04**
Bald Head	1991	Navigation	400,000	1.89
	1992	Navigation	800,000	2.33
	1996	Navigation	715,000	2.46
	1997	Navigation	455,789	1.89
	2001	Navigation	1,849,000	3.10
	2005	Navigation	1,217,500	1.59
	2006	Beach Nourishment	47,800	0.00
	2007	Navigation	1,176,529	2.03
	2012	Beach Nourishment	140,000	0.00
	2013	Navigation	1,519,611	2.64
Subtotal			**8,321,229**	**17.93**
Kure Beach	1997	Beach Nourishment	3,384,854	3.41
	2001	Beach Nourishment	1,034,458	3.41
	2004	Beach Nourishment	460,000	1.65
	2007	Beach Nourishment	262,790	0.80
	2010	Beach Nourishment	446,967	1.55
	2013	Beach Nourishment	557,702	3.13
Subtotal			**6,146,771**	**13.95**
Carolina Beach	1955	Beach Nourishment	252,000	0.48
	1956	(Not Reported)	200,000	0.38
	1965	Beach Nourishment	2,632,000	2.65
	1967	Navigation	389,959	0.80
	1968	Navigation	97,000	0.18
	1970	Navigation	628,423	1.94
	1971	Navigation	734,140	2.20
	1972	Navigation	18,816	0.03
	1973	Navigation	30,547	0.06
	1974	Navigation	66,687	0.13

*The tables combine events occurring within the same calendar year.

Southern NC Region Historical Sand Placement Projects

Community	Year	Project Type	Volume (CY)	Shoreline Miles
Carolina Beach	1975	Navigation	40,804	0.08
	1976	Navigation	119,971	0.23
	1977	Navigation	62,066	0.12
	1979	Navigation	230,866	0.44
	1980	Navigation	38,075	0.07
	1981	Navigation	515,528	1.34
	1982	Beach Nourishment	3,662,181	2.70
	1983	Navigation	119,244	0.23
	1985	Navigation / Nourishment	792,429	1.19
	1988	Beach Nourishment	950,913	1.08
	1989	Navigation	98,843	0.19
	1991	Beach Nourishment	1,008,736	2.20
	1995	Beach Nourishment	1,157,742	2.20
	1996	Beach Nourishment	3,500,000	3.41
	1998	Beach Nourishment	1,204,646	2.28
	2001	Beach Nourishment	567,345	1.07
	2004	Navigation / Nourishment	844,270	1.60
	2007	Beach Nourishment	532,250	1.00
	2008	Navigation	115,269	0.22
	2010	Navigation / Nourishment	836,216	1.75
	2011	Navigation	40,739	0.08
	2012	Navigation	54,530	0.10
	2013	Navigation	1,085,428	2.08
		Subtotal	**22,627,663**	**34.51**
Masonboro Island	1986	Navigation	1,997,521	0.95
	1994	Navigation	362,009	0.45
	1998	Beach Nourishment	555,654	1.04
	2002	Beach Nourishment	518,826	1.14
	2006	Beach Nourishment	120,000	0.76
	2010	Beach Nourishment	579,269	1.61
		Subtotal	**4,133,279**	**5.95**
Wrightsville Beach	1939	(Type not reported)	700,000	2.60
	1955	(Type not reported)	38,000	0.07
	1956	(Type not reported)	35,000	0.07
	1957	(Type not reported)	304,000	0.58
	1959	(Type not reported)	100,000	1.50
	1965	Beach Nourishment	2,993,100	2.65
	1966	Beach Nourishment	362,108	2.27
	1970	Beach Nourishment	1,436,533	1.52
	1980	Navigation	576,823	1.57
	1981	Beach Nourishment	1,249,699	1.52
	1982	Navigation	124,533	0.24
	1983	Navigation	93,755	0.18
	1985	Navigation	19,399	0.04
	1986	Beach Nourishment	898,593	1.30
	1987	Navigation	76,556	0.14
	1989	Navigation	96,771	0.18
Wrightsville Beach (con't)	1991	Beach Nourishment	1,016,684	1.30
	1994	Beach Nourishment	619,031	1.21
	1998	Beach Nourishment	1,116,573	1.89
	2002	Beach Nourishment	783,690	1.72
	2005	Beach Nourishment	10,000	0.02
	2006	Beach Nourishment	560,000	1.61
	2010	Beach Nourishment	451,000	1.31
	2014	Beach Nourishment	756,164	1.61
		Subtotal	**14,418,012**	**27.09**
Figure Eight	1979	Navigation	181,949	0.34
	1983	Beach Nourishment	90,000	0.38
	1985	Beach Nourishment	166,300	0.76
	1986	Beach Nourishment	250,000	0.38
	1992	Beach Nourishment	703,000	2.69
	1993	Beach Nourishment	275,000	0.57
	1997	Beach Nourishment	250,000	0.00
	1998	Navigation	450,000	0.85
	1999	Navigation	400,000	1.70
	2002	Navigation	500,572	0.95
	2003	Navigation	90,000	0.17
	2005	igation / Beach Nourishm	791,235	1.50
	2006	Navigation	328,144	0.62
	2009	igation / Beach Nourishm	895,000	1.70
	2011	Beach Nourishment	275,000	0.52
	2013	Navigation	300,000	0.57
		Subtotal	**5,946,200**	**13.70**
Topsail Island	1982	Navigation	51,715	0.10
	1988	Navigation	151,017	0.29
	1992	Navigation	75,519	0.14
	1993	Navigation	80,162	0.15
	1995	Navigation	38,883	0.07
	2002	Navigation	280,000	0.53
	2004	Navigation	77,004	0.15
	2005	Navigation	58,000	0.11
	2006	Navigation	100,530	0.19
	2007	Navigation	160,000	0.76
	2008	Navigation	85,402	0.16
	2010	Navigation	1,181,356	5.08
	2011	Navigation	123,286	0.23
	2013	Beach Nourishment	683,404	1.68
	2015	Beach Nourishment	1,500,000	3.85
		Subtotal	**4,646,278**	**13.49**

*The tables combine events occurring within the same calendar year.

Southern NC Region Historical Sand Placement Projects

Community	Year	Project Type	Volume (CY)	Shoreline Miles
Onslow Beach	1990	Navigation	101,653	0.76
	2008	Navigation	123,382	0.23
	2010	Navigation	101,576	0.19
	2012	Navigation	79,218	0.15
		Subtotal	**405,829**	**1.33**
Emerald Isle	1984	Navigation	15,000	0.03
	1987	Navigation	30,000	0.06
	1989	Navigation	45,399	0.09
	1990	Navigation	56,000	0.11
	1993	Navigation	17,000	0.03
	1995	Navigation	33,000	0.06
	1996	Navigation	71,000	0.13
	1997	Navigation	39,000	0.07
	1999	Navigation	48,000	0.09
	2000	Navigation	16,000	0.03
	2003	Beach Nourishment	1,926,726	6.00
	2004	Beach Nourishment	156,000	2.37
	2005	Beach Nourishment	690,868	4.50
	2006	Navigation	76,732	0.15
	2007	Beach Nourishment	569,160	5.24
	2010	Navigation	63,953	0.12
	2013	Beach Nourishment	649,790	4.16
	2014	Navigation	48,454	0.09
		Subtotal	**4,552,082**	**23.33**
Indian Beach / Salter Path	2002	Beach Nourishment	456,994	0.87
	2004	Navigation	699,283	2.90
	2007	Beach Nourishment	289,604	2.54
		Subtotal	**1,445,881**	**6.31**
Pine Knoll Shores	2002	Beach Nourishment	1,276,586	7.40
	2004	Navigation	69,189	0.42
	2007	Navigation	1,159,796	6.58
	2008	Beach Nourishment	148,393	0.28
	2013	Beach Nourishment	315,221	2.44
		Subtotal	**2,969,185**	**17.12**
Atlantic Beach / Fort Macon	1961	Navigation	765,600	1.45
	1973	Navigation	504,266	0.96
	1978	Navigation	1,179,600	2.23
	1986	Navigation	4,168,600	7.41
	1994	Navigation	4,664,000	4.69
	2002	Navigation	209,348	0.40
	2005	Navigation	2,920,729	4.30
	2007	Navigation	211,000	0.40
	2011	Navigation	1,346,700	3.15
	2014	Navigation	792,354	1.50
		Subtotal	**16,762,197**	**26.48**

Community	Year	Volume (CY)	Volume Placed	Shoreline Miles
Cape Lookout	2006	Beach Nourishment	75,700	0.49
		Subtotal	**75,700**	**0.49**

Southern Region Project Summary

Community	Volume (CY)	Shoreline Miles
Ocean Isle	4,789,413	10.85
Holden Beach	3,818,142	14.10
Oak Island	6,526,067	14.26
Caswell	256,600	1.04
Bald Head Isl.	8,321,229	17.93
Kure Beach	6,146,771	13.95
Carolina Beach	22,627,663	34.51
Masonboro Isl.	4,133,279	5.95
Wrightsville Beach	14,418,012	27.09
Figure Eight Isl.	5,946,200	13.70
Topsail Isl.	4,646,278	13.49
Onslow Beach	405,829	1.33
Emerald Isle	4,552,082	23.33
Indian Beach / Salter Path	1,445,881	6.31
Pine Knoll Shores	2,969,185	17.12
Atlantic Beach / Fort Macon	16,762,197	26.48
Cape Lookout	75,700	0.49
Total	**107,840,528**	**241.94**

*The tables combine events occurring within the same calendar year.

Northern NC Region Historical Sand Placement Projects

Community	Year	Project Type	Volume (CY)	Shoreline Miles
Ocracoke Isl.	1986	Navigation	167,755	0.32
	1988	Navigation	90,773	0.17
	1989	Navigation	113,229	0.21
	1992	Navigation	100,000	0.19
	1995	Navigation	44,305	0.08
Subtotal			**516,062**	**0.97**
Hatteras Isl.	1974	Navigation	135,293	0.26
	1977	Navigation	97,029	0.18
	1984	Navigation	29,972	0.06
	1986	Navigation	90,114	0.17
	1988	Navigation	74,646	0.14
	1992	Navigation	18,147	0.03
	2003	(Not Reported)	442,600	0.28
Subtotal			**887,801**	**1.12**
Cape Hatteras	1966	Beach Nourishment	312,000	0.59
	1972	Beach Nourishment	200,000	0.38
	1973	Beach Nourishment	1,300,000	1.50
Subtotal			**1,812,000**	**2.47**
Pea Island	1990	Navigation	254,955	0.38
	1991	Navigation	282,600	0.47
	1992	Navigation	1,262,300	1.78
	1993	Navigation	433,235	0.47
	1995	Navigation	233,631	0.82
	1996	Navigation	771,221	1.46
	1997	Navigation	271,703	0.69
	1998	Navigation	260,183	0.66
	1999	Navigation	328,919	0.83
	2000	Navigation	663,750	1.26
	2001	Navigation	513,706	0.97
	2002	Navigation	732,852	1.34
	2003	Navigation	1,137,174	2.51
	2004	Navigation	616,448	1.56
	2005	Navigation	172,155	0.43
	2008	Navigation	791,829	1.50
	2009	Navigation	1,183,144	2.37
	2014	Beach Nourishment	1,618,083	2.03
Subtotal			**11,527,888**	**21.53**
Nags Head	2001	(Not Reported)	100,000	(Not Reported)
	2002	(Not Reported)	100,000	(Not Reported)
	2011	Beach Nourishment	4,600,000	10.00
Subtotal			**4,800,000**	**10.00**

Community	Year	Project Type	Volume (CY)	Shoreline Miles
Dare County	2004	Beach Nourishment	383,000	0.73
Subtotal			**383,000**	**0.73**

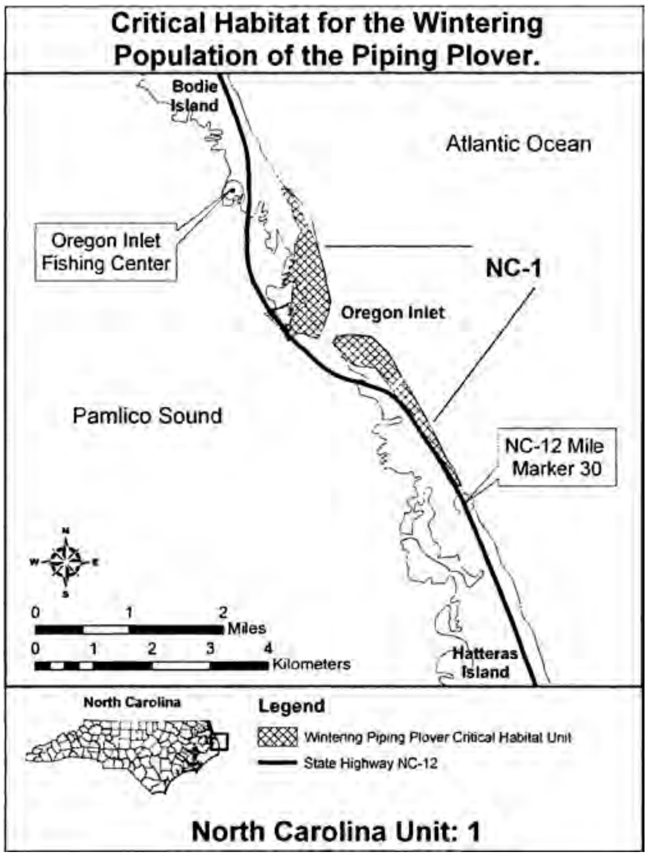
Northern Region Project Summary

Community	Volume (CY)	Shoreline Miles
Ocracoke Isl.	516,062	0.97
Hatteras Isl.	887,801	1.12
Cape Hatteras	1,812,000	2.47
Pea Island	11,527,888	21.53
Nags Head	4,800,000	10.00
Dare County	383,000	0.73
Total	**19,926,751**	**36.82**

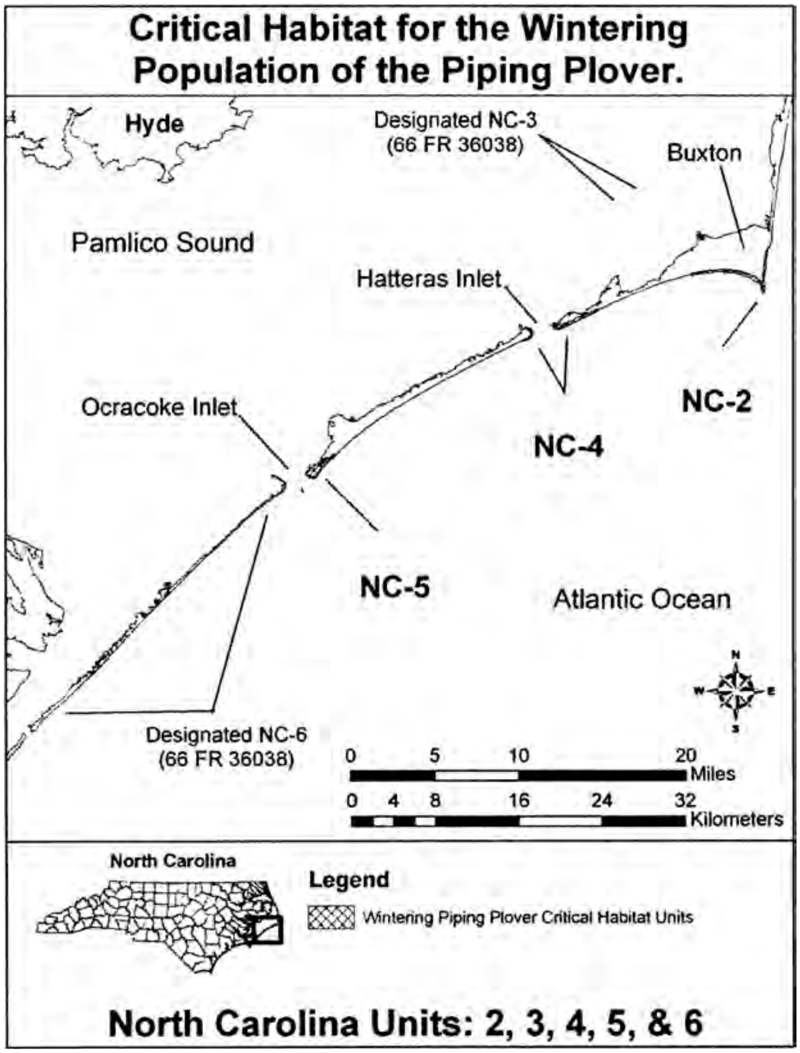
*The tables combine events occurring within the same calendar year.

APPENDIX B
North Carolina Critical Habitat Units
Piping Plover Wintering Critical Habitat

Critical habitat may be viewed at the following web site. An online map is available for viewing, as well as dowloadable GIS shapefiles and metadata:
https://ecos.fws.gov/ecp/report/table/critical-habitat.html



Unit NC-1 (Oregon Inlet): 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 4.7 mi (7.6 km) south to the intersection of NC Highway 12 and Salt Flats Wildlife Trail (near Mile Marker 30, NC Highway 12), approximately 2.9 mi (4.8 km) from the groin, 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, such as island DR–005–05 and DR–005– 06, are included (not shown on map). This unit does not include the Oregon Inlet Fishing Center, NC Highway 12 and the Bonner Bridge or its associated structures, the terminal groin, or the historic Pea Island Life-Saving Station, or any of their ancillary facilities (e.g., parking lots, out buildings).



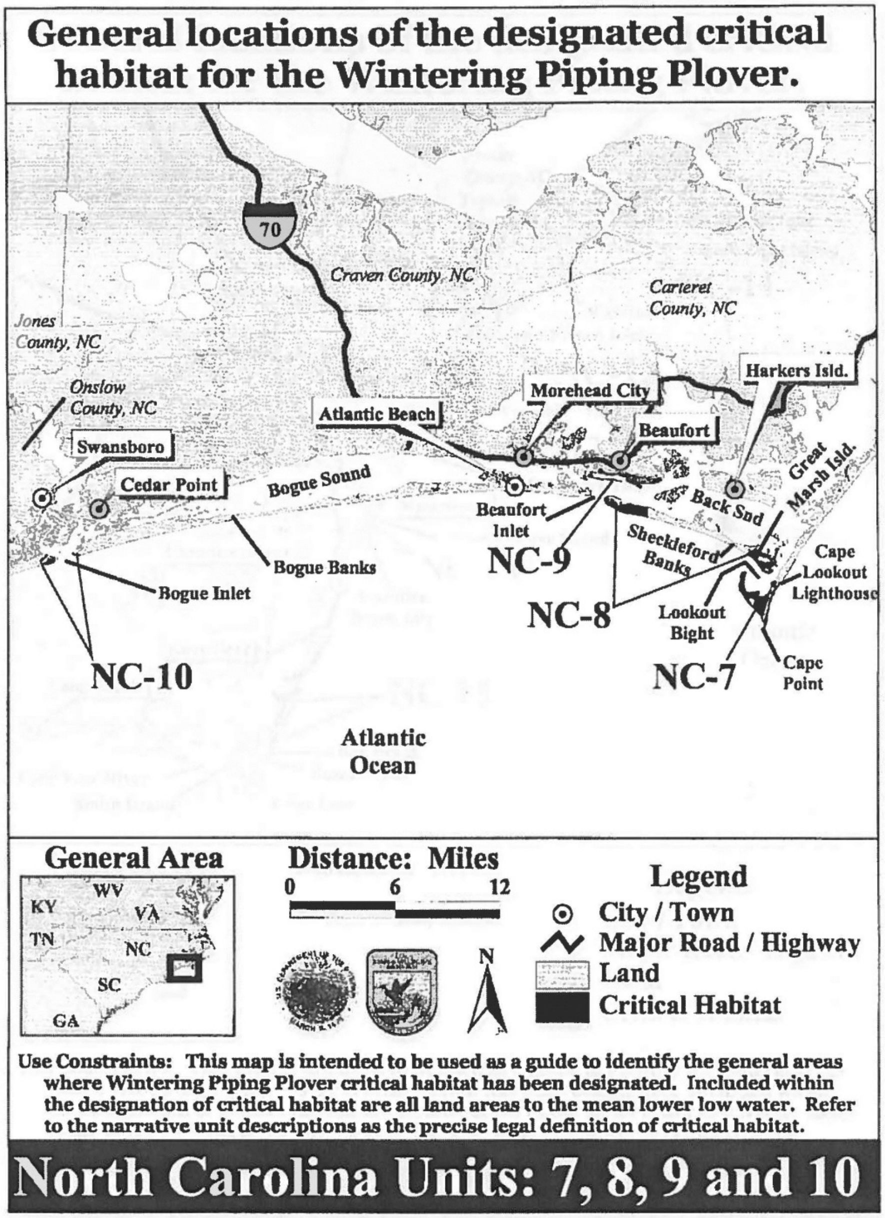
Unit NC-2 (Cape Hatteras Point): This unit is entirely within Cape Hatteras National Seashore and encompasses the point of Cape Hatteras (Cape Point). The unit extends south approximately 4.5 km (2.8 miles) from the ocean groin near the old location of the Cape Hatteras Lighthouse to the point of Cape Hatteras, and then extends west 7.6 km (4.7 miles) (straight-line distances) along Hatteras Cove shoreline(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). This unit does not include the ocean groin.

Unit NC-3 (Clam Shoals): The entire unit is owned by the State. This unit includes several island s in Pamlico Sounds known as Bird Islands. This unit includes lands on all islands to the MLLW.

Unit NC-4 (Hatteras Inlet): This unit extends from the western end of Hatteras Island to the eastern end of Ocracoke Island. The unit extends approximately 7.6 km (4.7 mi) southwest from the first beach access point at the edge of Ramp 55 at the end of NC Highway 12 near the Graveyard of the Atlantic Museum on the western end of Hatteras Island to the edge of the beach access at the ocean-side parking lot (approximately 0.1 mi south of Ramp 59) on NC Highway 12, approximately 1.25 km (0.78 mi) southwest (straightline distance) of the ferry terminal on the northeastern end of Ocracoke Island. The unit includes lands from the MLLW on the Atlantic Ocean shoreline to the line of stable, densely vegetated dune habitat (which is not used by the piping plover and where PCEs do not occur) and from the MLLW on the Pamlico Sound side to the line of stable, densely vegetated habitat, or (where a line of stable, densely vegetated dune habitat does not exist) lands from MLLW on the Atlantic Ocean shoreline to the MLLW on the Pamlico Sound side. All emergent sandbars within Hatteras Inlet between Hatteras Island and Ocracoke Island, including lands owned by the State of North Carolina such as Island DR–009– 03/04 (not shown on map), are included. The unit is adjacent to but does not include the Graveyard of the Atlantic Museum, the ferry terminal, the groin on Ocracoke Island, NC Highway 12, or their ancillary facilities (e.g., parking lots, out buildings).

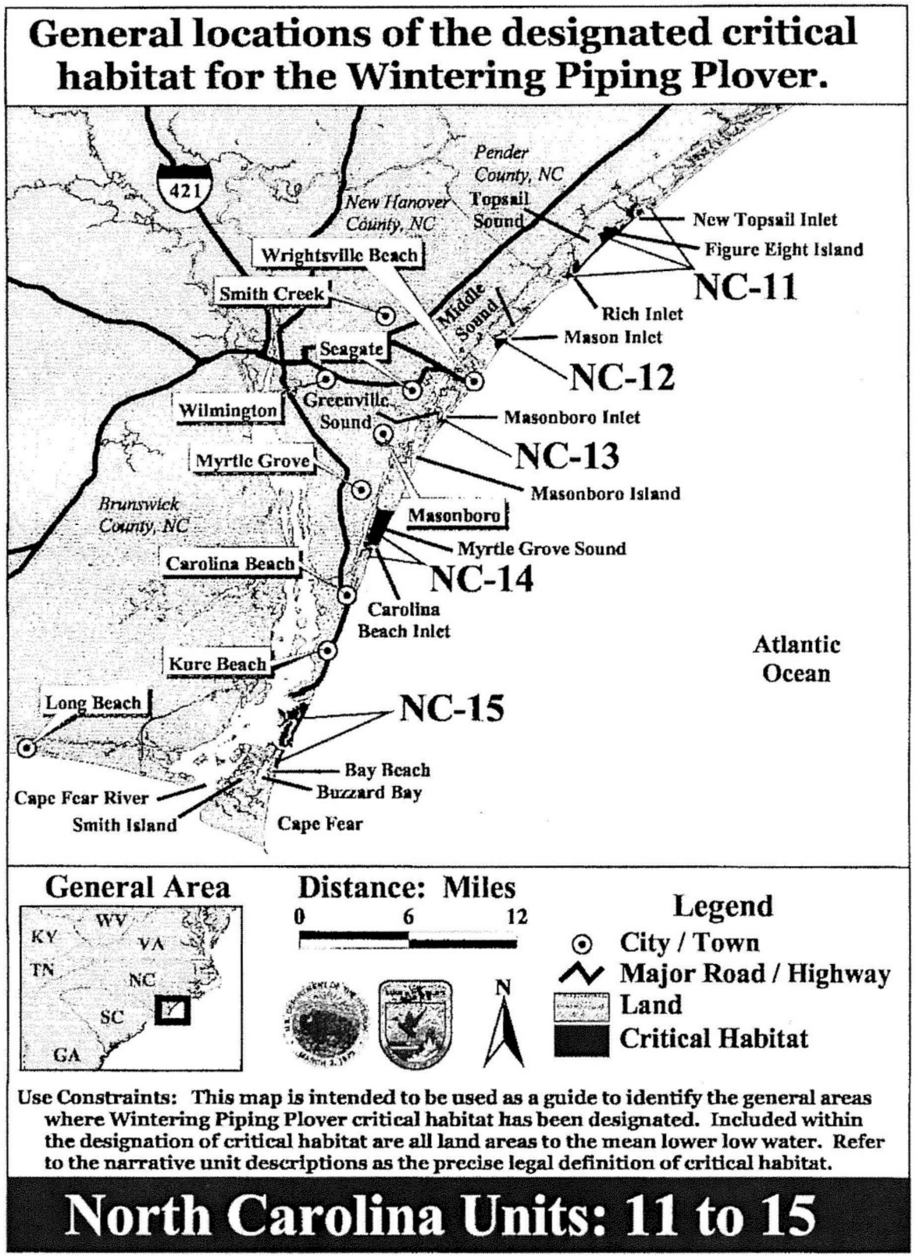
Unit NC-5 (Ocracoke Island): This unit is entirely within Cape Hatteras National Seashore and includes the western portion of Ocracoke Island beginning at the beach access point at the edge of Ramp 72 (South Point Road), extending west approximately 3.4 km (2.1 mi) to Ocracoke Inlet, and then back east on the Pamlico Sound side to a point where stable, densely-vegetated dune habitat meets the water. This unit includes lands from the MLLW on the Atlantic Ocean shoreline to the line of stable, densely-vegetated dune habitat (which is not used by the piping plover and where PCEs do not occur) and from the MLLW on the Pamlico Sound side to the line of stable, densely vegetated habitat, or (where a line of stable, densely vegetated dune habitat does not exist) lands from MLLW on the Atlantic Ocean shoreline to the MLLW on the Pamlico Sound side. All emergent sandbars within Ocracoke Inlet are also included. This unit does not include any portion of the maintained South Point Road, NC Highway 12, or any of their ancillary facilities.

Unit NC-6 (Portsmouth Island – Cape Lookout): The entire unit is within Cape Lookout National Seashore. This unit includes all land to MLLW on Atlantic Ocean to MLLW on Pamlico Sound, from Ocracoke Inlet extending west to the western end of the Pilontary Islands. This unit includes the islands of Casey, Sheep, Evergreen, Portsmouth, Whalebone, Kathryne Jane, and Merkle Hammock. This unit also extends west from the eastern side of Old Drum Inlet to 1.6 km (1.0 mi) west of the New Drum Inlet and includes all lands from MLLW on Atlantic Ocean to MLLW on Core Sound.



Unit NC-7 (South Core Banks): The entire unit is within Cape Lookout National Seashore. This unit extends south from Cape Lookout Lighthouse, along Cape Lookout, to Cape Point and northwest to the northwestern peninsula. All lands from MLLW on the Atlantic Ocean, Onslow Bay, and Lookout Bight up to where densely vegetated habitat, not used by the piping plover, begins and the constituent elements no longer occur are included.
Unit NC-8 (Shackleford Banks): The entire unit is within Cape Lookout National Seashore. This unit is in two parts: (1) The eastern end of Shackleford Banks from MLLW of

Barden Inlet extending west 2.4 km (1.5 mi), including Diamond City Hills, Great Marsh Island, and Blinds Hammock; and, (2) The western end of Shackleford Banks from MLLW extending east 3.2 km (2.0 mi) from Beaufort Inlet. The unit includes all land from MLLW to where densely vegetated habitat, not used by the piping plover, begins and where the constituent elements no longer occur and any emergent sandbars within Beaufort Inlet. This unit is bordered by Onslow Bay, Shackleford Slue, and Back Sound.
Unit NC–9 (Rachel Carson): The entire unit is within the Rachel Carson National Estuarine Research Reserve. This unit includes islands south of Beaufort including Horse Island, Carrot Island, and Lennox Point. This unit includes entire islands to MLLW.
Unit NC–10 (Bogue Inlet): The majority of the unit is privately owned, with the remainder falling within Hammocks Beach State Park. This unit includes contiguous land south, west, and north of Bogue Court to MLLW line of Bogue Inlet on the western end of Bogue Banks. It includes the sandy shoals north and adjacent to Bogue Banks and the land on Atlantic Ocean side to MLLW. This unit also extends 1.3 km (0.8 mi) west from MLLW of Bogue Inlet on the eastern portion of Bear Island.



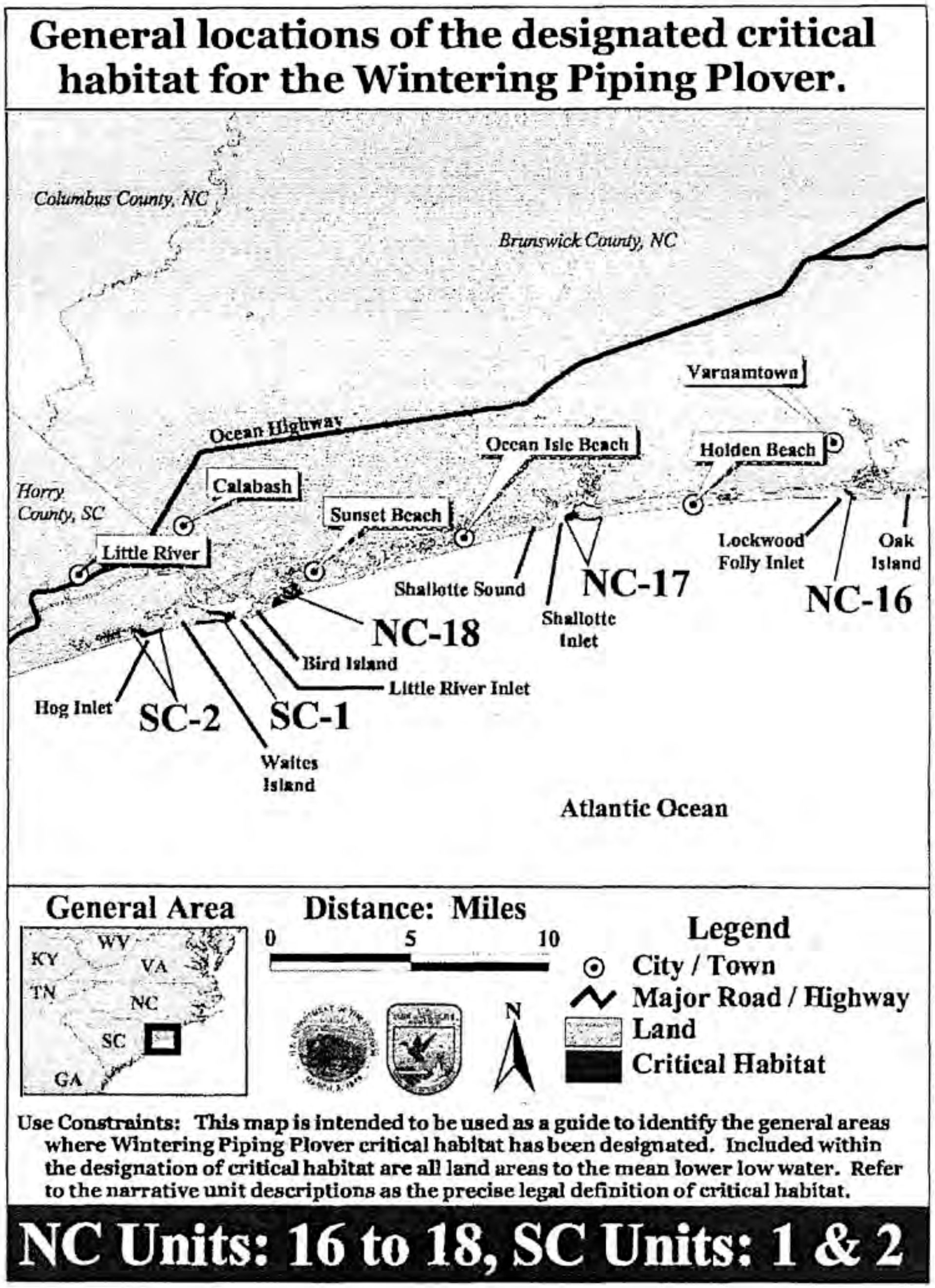
Unit NC–11 (Topsail): The entire area is privately owned. This unit extends southwest from 1.0 km (0.65 mi) northeast of MLLW of New Topsail Inlet on Topsail Island to 0.53 km (0.33 mi) southwest of MLLW of Rich Inlet on Figure Eight Island. It includes both Rich Inlet and New Topsail Inlet and the former Old Topsail Inlet. All land, including emergent sandbars, from MLLW on Atlantic Ocean and sound side to where densely vegetated habitat, not used by the piping plover, begins and where the constituent elements no longer occur. In Topsail Sound, the unit stops as the entrance to tidal creeks become narrow and channelized.

Unit NC–12 (Figure Eight Island): The majority of the unit is privately owned. This unit extends south from the western end of Beach Road on Figure Eight Island to the northern end of Highway 74 on Wrightsville Beach. The unit includes Mason Inlet and the sand and mudflats northwest of the inlet from MLLW on Atlantic Ocean to where densely vegetated habitat, not used by the piping plover, begins and where the constituent elements no longer occur.

Unit NC–13 (Masonboro): The entire unit is within the North Carolina National Estuarine Research Reserve. This unit extends 1.1 km (0.70 mi) south from the MLLW of Masonboro Inlet on Masonboro Island. This unit includes all lands along the Atlantic Ocean, Masonboro Inlet, and Masonboro Sound from MLLW to where densely vegetated habitat, not used by the piping plover, begins and where the constituent elements no longer occur.

Unit NC–14 (Carolina Beach Inlet): The majority of the unit is within Myrtle Grove Sound on Masonboro Island and is owned by the North Carolina National Estuarine Research Reserve. It extends 1.80 km (1.12 mi) west along the south shoreline of Wolf Island from the mouth of the Altamaja sound. This unit extends south from 3.2 km (2.0 mi) north of MLLW at Carolina Beach Inlet on Masonboro Island to 1.1 km (0.70 mi) south of MLLW at Carolina Beach Inlet on Carolina Beach. It includes land from MLLW on Atlantic Ocean across and including lands to MLLW on the western side of Masonboro Island, excluding existing dredge spoil piles. Emergent sand bars within Carolina Beach Inlet are also included.

Unit NC–15 (Ft. Fisher): This unit is within Ft. Fisher State Recreation Area and Zeke’s Island Estuarine Reserve. This unit extends south from Ft. Fisher Islands (from the rocks), south of the ferry terminal, to approximately 0.8 km (0.5 mi) south of MLLW at Corn Cake Inlet on Smith Island. It includes all land (including Zeke’s Island) from MLLW on Atlantic Ocean across to MLLW on the eastern side of the Cape Fear River.



Unit NC–16 (Lockwood Folly Inlet): The entire unit is on Oak Island (formerly known as the Town of Long Beach) and is privately owned. This unit extends from the end of West Beach Drive, west to MLLW at Lockwood Folly Inlet, including emergent sandbars south and adjacent to the island. This unit includes land from MLLW on Atlantic Ocean across to

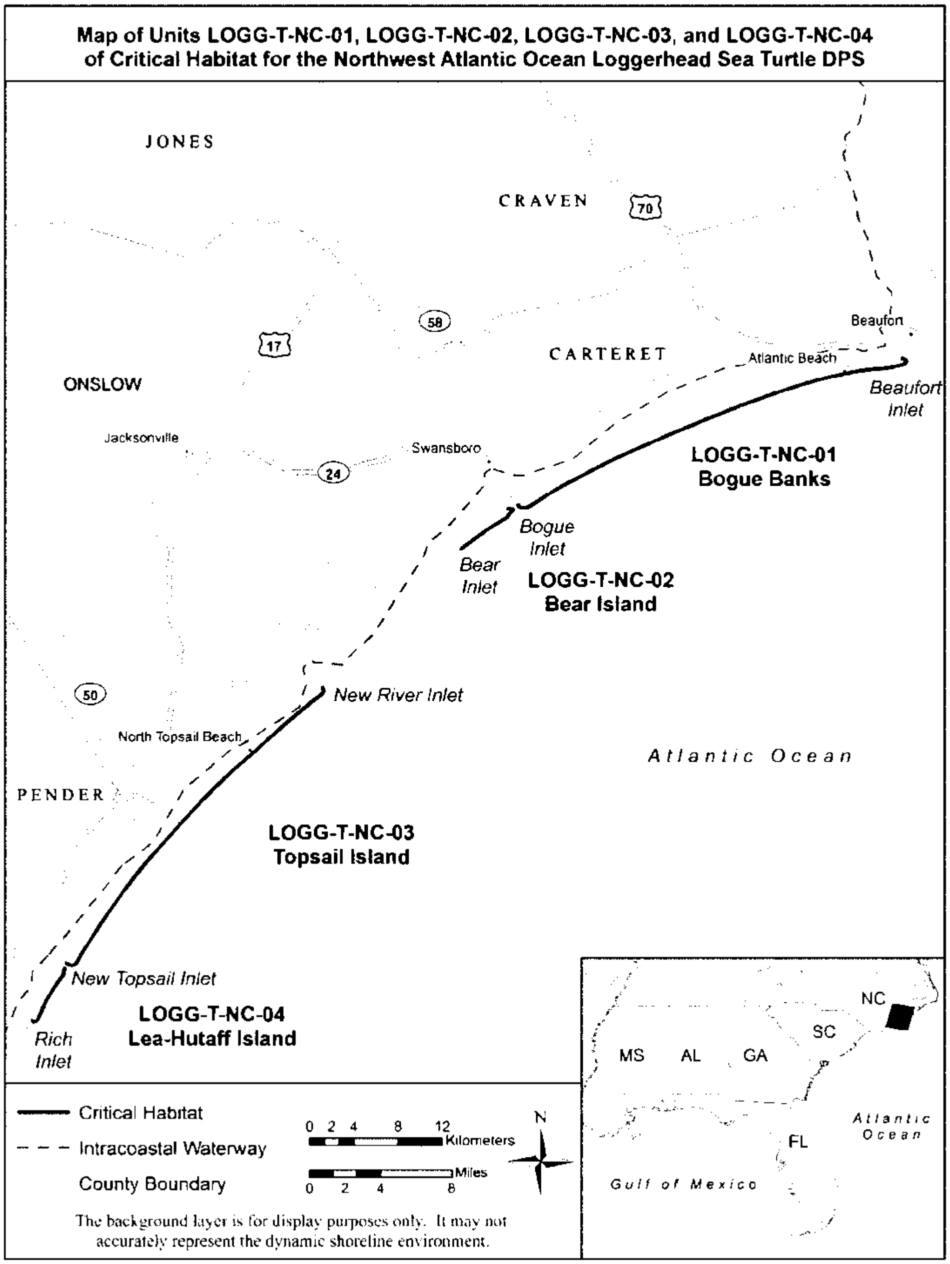
MLLW adjacent to the Eastern Channel and the Intracoastal Waterway.

Unit NC–17 (Shallotte Inlet): The entire unit is privately owned. This unit begins just west of Skimmer Court on the western end of Holden Beach. It includes land south of SR 1116, to where densely vegetated habitat, not used by the piping plover, begins and where the constituent elements no longer occur to the MLLW along the Atlantic Ocean. It includes the contiguous shoreline from MLLW to where densely vegetated habitat, not used by the piping plover, begins and where the constituent elements no longer occur along the Atlantic Ocean, Shallotte Inlet, and Intracoastal Waterway stopping north of Skimmer Court Road. The unnamed island and emergent sandbars to MLLW within Shallotte Inlet are also included.

Unit NC–18 (Mad Inlet): The entire unit is privately owned. This unit extends west 1.2 km (0.75 mi) from the end of Main Street (SR 1177) on western Sunset Beach to the eastern portion of Bird Island and includes the marsh areas north of western Sunset Beach shoreline. The shoreline area begins at MLLW on the Atlantic Ocean and continues landward to where densely vegetated habitat, not used by the piping plover, begins and where the constituent elements no longer occur.

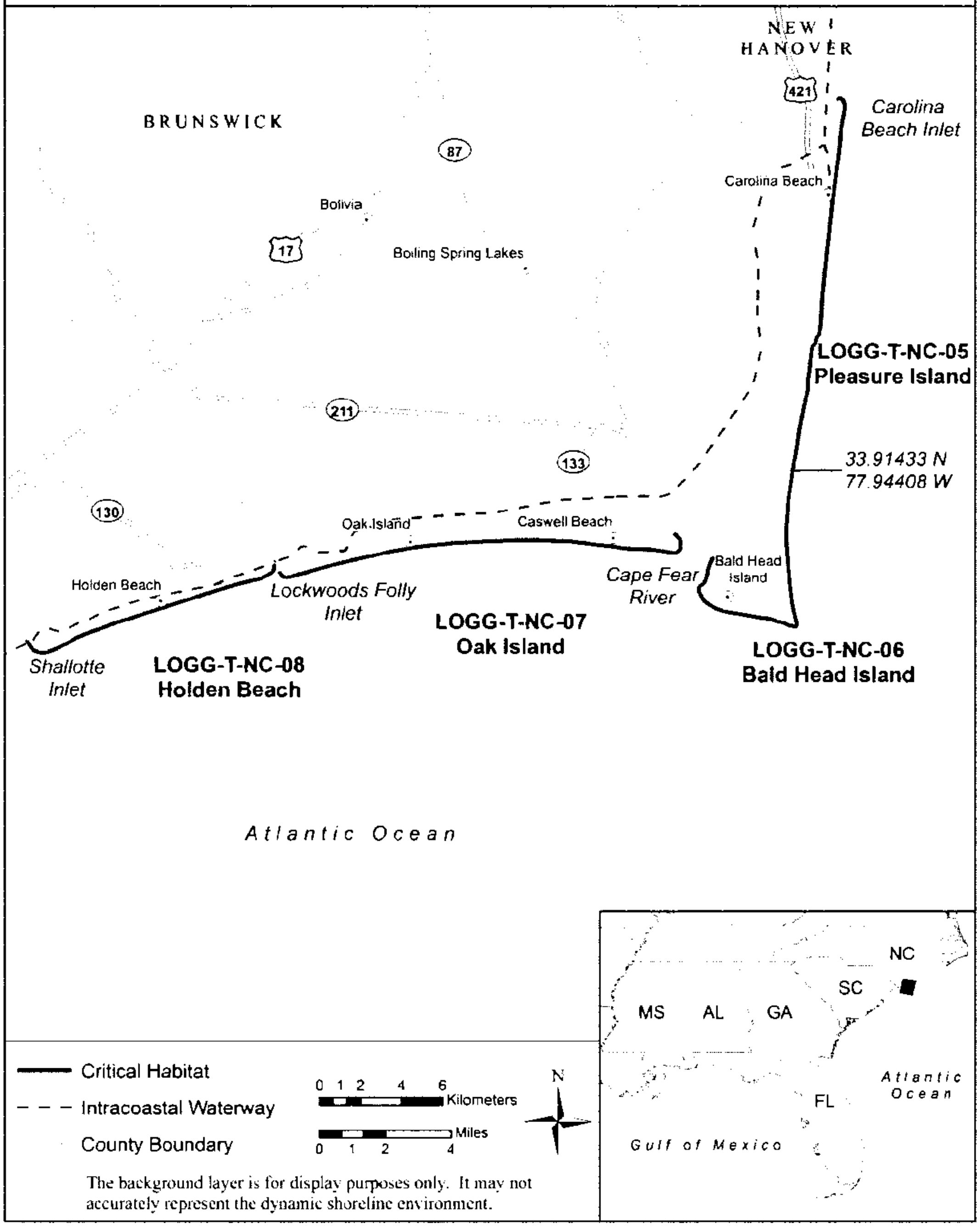
APPENDIX C
North Carolina Critical Habitat Units
NWA DPS of the Loggerhead Sea Turtle

Critical habitat may be viewed at the following web site. An online map is available for viewing, as well as dowloadable GIS shapefiles and metadata:
https://ecos.fws.gov/ecp/report/table/critical-habitat.html



Map of Units LOGG-T-NC-01, LOGG-T-NC-02, LOGG-T-NC-03, and LOGG-T-NC-04 of Critical Habitat for the Northwest Atlantic Ocean Loggerhead Sea Turtle DPS

Map of Units LOGG-T-NC-05, LOGG-T-NC-06, LOGG-T-NC-07, and LOGG-T-NC-08 of Critical Habitat for the Northwest Atlantic Ocean Loggerhead Sea Turtle DPS



Unit LOGG-T-NC-01 (Bogue Banks): This unit consists of 38.9 km (24.2 mi) of island shoreline along the Atlantic Ocean. The island is separated from the mainland by the Atlantic Intracoastal Waterway and Bogue Sound. The unit extends from Beaufort Inlet to Bogue Inlet. The unit includes lands from the MHW line landward to the toe of the secondary dune or developed structures. Land in this unit is in State and private ownership. The State portion is Fort Macon State Park, which is managed by the North Carolina Division of Parks and Recreation. This unit supports expansion of nesting from an adjacent unit (LOGG–T–NC–02) that has high-density nesting by loggerhead sea turtles in North Carolina.

Unit LOGG-T-NC-02 (Bear Island): This unit consists of 6.6 km (4.1 mi) of island shoreline along the Atlantic Ocean. The island is separated from the mainland by the Atlantic Intracoastal Waterway and salt marsh. The unit extends from Bogue Inlet to Bear Inlet. The unit includes lands from the MHW line landward to the toe of the secondary dune or developed structures. Land in this unit is in State ownership. The island is managed by the North Carolina Division of Parks and Recreation as Hammocks Beach State Park. This unit has high-density nesting by loggerhead sea turtles in North Carolina.

Unit LOGG-T-NC-03 (Topsail Island): This unit consists of 35.0 km (21.8 mi) of island shoreline along the Atlantic Ocean. The island is separated from the mainland by the Atlantic Intracoastal Waterway, Chadwick Bay, Alligator Bay, Goose Bay, Rogers Bay, Everett Bay, Spicer Bay, Waters Bay, Stump Sound, Banks Channel, and salt marsh. The unit extends from New River Inlet to New Topsail Inlet. The unit includes lands from the MHW line to the toe of the secondary dune or developed structures. Land in this unit is in private and other ownership. The local municipality portion is the North Topsail Beach Park, which is managed by the Town of North Topsail Beach. This unit has high-density nesting by loggerhead sea turtles in North Carolina.

Unit LOGG-T-NC-04 (Lea-Hutaff Island): This unit consists of 6.1 km (3.8 mi) of island shoreline along the Atlantic Ocean. Following the closure of Old Topsail Inlet in 1998, two islands, Lea Island and Hutaff Island, joined to form what is now a single island referred to as Lea-Hutaff Island. The island is separated from the mainland by the Atlantic Intracoastal Waterway, Topsail Sound, Eddy Sound, Long Point Channel, Green Channel, and salt marsh. The unit extends from New Topsail Inlet to Rich Inlet. The unit includes lands from the MHW line to the toe of the secondary dune or developed structures. Land in this unit is in State and private ownership. The State portion is part of the Lea Island State Natural Area, which includes most of the original Lea Island, and is owned by the North Carolina Division of Parks and Recreation and managed by Audubon North Carolina. The remainder of the original Lea Island is privately owned. The original Hutaff Island is entirely privately owned. This unit supports expansion of nesting from an adjacent unit (LOGG–T–NC–03) that has high-density nesting by loggerhead sea turtles in North Carolina.

Unit LOGG-T-NC-05: (Pleasure Island): This unit consists of 18.6 km (11.5 mi) of island shoreline along the Atlantic Ocean. The island is separated from the mainland by the Atlantic Intracoastal Waterway, Cape Fear River, Upper Midnight Channel Range, Lower Midnight Channel Range, Reaves Point Channel Range, Horseshoe Shoal Channel Range, Snow Marsh Channel Range, and The Basin (bay). The unit extends from Carolina Beach Inlet to

33.91433 N, 77.94408 W (historic location of Corncake Inlet). The unit includes lands from the MHW line to the toe of the secondary dune or developed structures. Land in this unit is in State, private, and other ownership. The State portion is Fort Fisher State Recreation Area, which is managed by the North Carolina Division of Parks and Recreation. The local municipality portion includes half of Freeman Park Recreation Area, which is managed by the Town of Carolina Beach. The County portion includes the other half of Freeman Park Recreation Area, which is also managed by the Town of Carolina Beach under an interlocal agreement with New Hanover County. This unit supports expansion of nesting from an adjacent unit (LOGG–T–NC–06) that has high-density nesting by loggerhead sea turtles in North Carolina.

Unit LOGG-T-NC-06 (Bald Head Island): This unit consists of 15.1 km (9.4 mi) of island shoreline along the Atlantic Ocean. The island is part of the Smith Island Complex, which is a barrier spit that includes Bald Head, Middle, and Bluff Islands. The island is separated from the mainland by the Atlantic Intracoastal Waterway, Cape Fear River, Battery Island Channel, Lower Swash Channel Range, Buzzard Bay, Smith Island Range, Southport Channel, and salt marsh. The unit extends from 33.91433N, 77.94408W (historic location of Corncake Inlet) to the mouth of the Cape Fear River. The unit includes lands from the MHW line to the toe of the secondary dune or developed structures. Land in this unit is in State and private and other ownership. The State portion is Bald Head State Natural Area. This unit has high-density nesting by loggerhead sea turtles in North Carolina.

Unit LOGG-T-NC-07 (Oak Island): This unit consists of 20.9 km (13.0 mi) of island shoreline along the Atlantic Ocean. The island is separated from the mainland by the Atlantic Intracoastal Waterway, Cape Fear River, Eastern Channel, and salt marsh. The unit extends from the mouth of the Cape Fear River to Lockwoods Folly Inlet. The unit includes lands from the MHW line to the toe of the secondary dune or developed structures. Land in this unit is in private and other ownership. This unit has high-density nesting by loggerhead sea turtles in North Carolina..

Unit LOGG-T-NC-08 (Holden Beach): This unit consists of 13.4 km (8.3 mi) of island shoreline along the Atlantic Ocean. The island is separated from the mainland by the Atlantic Intracoastal Waterway, Elizabeth River, Montgomery Slough, Boone Channel, and salt marsh. The unit extends from Lockwoods Folly Inlet to Shallotte Inlet. The unit includes lands from the MHW line to the toe of the secondary dune or developed structures. Land in this unit is in private and other ownership. This unit supports expansion of nesting from an adjacent unit (LOGG–T–NC–07) that has high-density nesting by loggerhead sea turtles in North Carolina.

APPENDIX D: USFWS Raleigh North Carolina Field Office Piping Plover and Red Knot Survey Minimum Survey Requirements To Document Site Abundance and Distribution

Required skills, training, and equipment for conducting surveys

1. Piping plover monitors must be capable of detecting and recording locations of roosting and foraging plovers, accurately reading and recording bands, and documenting observations in legible, complete field notes. Aptitude for monitoring includes keen powers of observation, familiarity with avian biology and behavior, experience observing birds or other wildlife for sustained periods, tolerance for adverse weather, experience in data collection and management, and patience. Monitors must also be able to captain a boat (if applicable) and walk long distances carrying field gear.

2. Binoculars, a GPS unit (set to record in decimal degrees in the WGS datum), a 10-60x spotting scope with a tripod, boat access (if applicable), and the RFO's datasheet must be used to conduct the surveys.

Piping plover survey methodology

3. Nonbreeding piping plover abundance and distribution must be determined through 6 surveys per season (2 during fall migration scheduled ≤3 days apart, 2 during winter scheduled ≤3 days apart, and 2 during spring migration scheduled ≤3 days apart). Suitable habitat must be surveyed by walking the survey area (weather and tide permitting, no surveys should be conducted if sustained winds exceed 20 mph) during the survey window (July 15 – May 15).

4. Surveys should be scheduled around the peak of migration (September in Fall and March in Spring) based on input from the RFO. Winter surveys must be conducted between December 1 and January 31. Surveys should be conducted around mid-tide when birds will still be foraging, making legs easier to see for re-sighting bands, but more concentrated.

5. All unbanded and banded piping plovers must be recorded on the RFO datasheet. Weather data must be collected at the beginning of each survey. The presence/absence of bands, GPS coordinate, plumage, behavior, and habitat type must be recorded for each piping plover.

6. Band resightings must be read and documented during each survey.

7. GPS coordinates must be collected in decimal degrees during each survey for each bird as close to the location of the bird as possible without causing a change in behavior (if the bird is spending most of its time watching the monitor instead of continuing the behavior it was exhibiting when it was first spotted).

8. Recreation and disturbance must be documented during the surveys. The number of people, dogs (on and off leash), bicycles, vehicles, etc. must be recorded during the

surveys. Additionally, any activity causing a disturbance (change in behavior, particularly if the disturbance flushes the birds) to roosting or foraging birds must be noted on the datasheet.

9. Survey data must be recorded in the field on the RFO datasheet and transcribed into the Microsoft Access database (provided by the RFO). Electronic hard copies of the datasheets and the database must be provided annually by June 15 to the RFO.

Red Knot

10. Red knots must be recorded during the piping plover surveys when both species are present. Additional surveys for red knots during their peak season must follow the same protocol outlined above. Band combinations, flag color and alphanumeric codes, and geolocators must be noted on the datasheet if applicable. All resightings must be reported on www.bandedbirds.org.

How To Resight and Report Banded Piping Plovers

Be careful not to disturb the bird. A slow, quiet approach avoids harassment and allows the observer to carefully scan the band combination. Using a spotting scope facilitates accurate observations from a distance.

Please record:

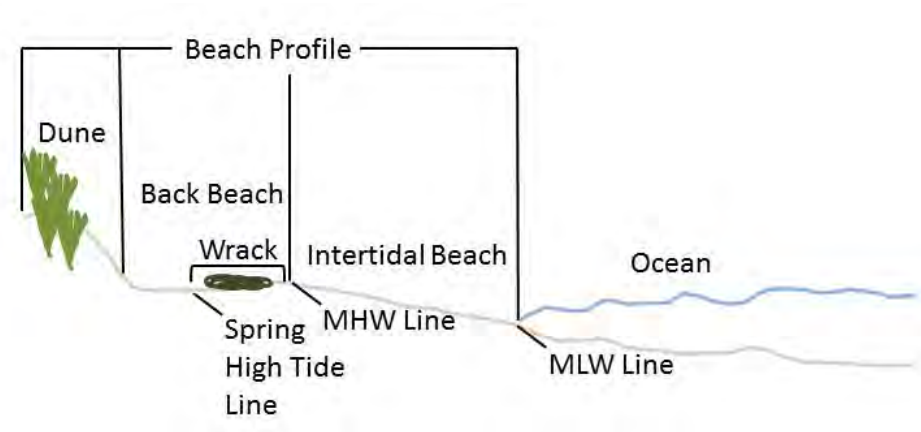
1. Location where the bird was seen (GPS coordinates are helpful).
2. Date when the bird was seen.
3. Any observations of the bird's behavior (e.g., roosting, foraging).
4. Band combination:
    a. Band combinations should be recorded in the following sequence: upper left (UL; above the "knee"), lower left (LL; below the "knee"), upper right (UR), lower right (LR). "Right" and "left" are from the bird's perspective, not the observer's (just like a person's right and left legs).
    b. Band types include flags (band with tab sticking out), metal, and color bands.
    c. Some bands may have alpha-numeric codes printed on the band or the flag (e.g., A1). The code, in addition to the color and location of the band or flag should be documented. Both the color of the band and the code (e.g., white writing on a green band) should be noted.
    d. Some bands are split (a single band with two colors; e.g., orange/blue) or triple split (a single band with three colors; e.g., blue/orange/blue).
    e. Sometimes two bands of the same color are placed over each other, appearing like one very tall band.
    f. Some piping plovers are banded on the upper legs only, and bands can be stacked (one above the other) on the upper leg.
    g. Record leg positions where bands are absent.
    h. Note if the color or type of any of the bands is uncertain or if some parts of a leg were not seen clearly.
    i. Recognize that band colors can fade over time.

Left Figure: This band combination below would be recorded as: metal (UL), dark blue (LL), black flag (UR), red over black (LR). The abbreviated band combination (refer to http://www.fws.gov/charleston/pdf/PIPL/20141205_usfws_pipl_survey_datasheet.pdf) would be recorded as: X,B:Lf,RL.
Middle Figure: Examples of alpha-numeric gray, black, and white flags.
Right Figure: Example in yellow circle shows use of an alpha-numeric code on a color band.

For banded piping plovers seen in North Carolina, please send this information along with the observer's contact information to melissa_bimbi@fws.gov. For more information about band resighting, please consult http://www.fws.gov/charleston/pdf/PIPL_Band_Identification_Training.pdf

Datasheet Habitat Descriptor Definitions

Back beach – dry sand, beach landward of the mean high water (MHW) line and seaward of the dune line.
Dune – A mound, hill, or ridge of wind-blown sand, either bare or covered with vegetation located landward of the back beach.
Ephemeral pool – a temporary water feature located on the beach.
Mudflat – intertidal area typically located behind sand spits adjacent to inlets. They appear darker in color than sand, and are soft and slick to walk on. The closest vegetation is typically *Spartina* sp.
Intertidal beach – wet, smooth sand; beach seaward of the MHW line and landward of the mean low water (MLW) line.
Sandflat – flat, rippled intertidal area along sound shorelines or around the mouth of an inlet. They are firm to walk on.
Dense vegetation – vegetation located on the back beach or dunes that provides >75% cover.
Washover – beach sand that has been transported landward of the beach/dune system by storm waves, areas where sand and shells become the top layer of once vegetated areas following a storm event.
Wrack – organic plant material deposited between the MHW line and the spring high tide line.


Beach Profile
Dune
Back Beach
Wrack
Intertidal Beach
Ocean
Spring
High Tide
Line
MHW Line
MLW Line

Nonbreeding PIPL/REKN Survey Data Sheet **Page___of___**

Date:_________**Location**: ____________________________________**Observer(s)**: ____

Survey #:_____**Survey Coverage**: (circle one): ALL NE SW **Survey Type**: (circle one): Population Foraging Roosting S/R

Start Time:______ **End Time**:______ **General weather** (circle one): Sunny Partly cloudy Cloudy Rain Fog Other (describe)

Temp:____°F **Wind Direction** (circle one): N NE E SE S SW W NW **Wind Speed** (circle one): 0-5 6-10 11-15 16-20 >21 MPH

Tidal stage at start of survey (circle one): Low Mid High (Rising/Falling)

Disturbance (#): Pedestrian(s)______Boat(s)_____Bicycle(s)_____ATV(s)_____ORV(s)_____Dog(s) On______Dog(s) Off______

PIPL/REKN #	ULU	ULL	LLU	LLL	URU	URL	LRU	LRL	Flag or band Code	Latitude	Longitude	Plumage	Behavior	Habitat	Notes

Abbreviation Key

Band Color		**Plumage**		**Behavior**		**Habitat**	
A	*Gray*	*B*	*Basic (nonbreeding)*	*D*	*Disturbed*	*M*	*Mudflats*
B	*Dark blue*	*A*	*Alternate (breeding)*	*FR*	*Foraging*	*S*	*Sandflats*
b	*Light blue*	*P*	*Partial (some breeding)*	*R*	*Roosting*	*B*	*Beach*
f	*Flag*			*L*	*Loafing*	*D*	*Dunes*
G	*Dark green*			*T*	*Territorial*	*WR*	*Wrack*
g	*Light green*			*O*	*Other*	*IT*	*Ocean intertidal*
L	*Black*					*WA*	*Washover*
N	*No band seen (leg position not visible)*					*VS*	*Vegetation sparse (<75%)*
O	*Orange*					*VT*	*Vegetation thick (>75%)*
P	*Pink*					*EP*	*Ephemeral pool*
R	*Red*					*O*	*Other*
U	*Purple*						
W	*White*						
X	*Metal*						
Y	*Yellow*						
-	*No band (no band on that leg position)*						
/	*Split band (color/color on one band)*						
//	*Triple split band (color/color/color on one band)*