Topic	Alternative 1: No-Action	Alternative 2: Winter Construction	Preferred Alternative 3: Summer Construction
Biological Resources	Existing conditions of moderate to high erosion would continue to degrade the beach, produce dune breaches, damage existing development and NC12 and force emergency repairs, including dune rebuilding, with less than ideal sediment and road debris. Emergency sand bags would eliminate nesting habitat for threatened birds or turtles. As erosion proceeds, greater lengths of shoreline would be considered for protection by sand bags, particularly ~3,000 feet within Reach 2 (Buxton Village) and the southernmost ~1,000 feet of Reach 1 along the Seashore where NC 12 is closest to present mean high water. Because the action area represents a relatively small portion of similar habitat in the Cape Hatteras and Cape Lookout National Seashores, the overall impact would be minor. Storms would increase overwash habitats preferred by some protected birds and plants. Following a major storm, there could be significant observable adverse impacts to existing habitats, particularly if the barrier is breached. A storm breach would also provide certain benefits in the form of locally increased tidal flushing in Pamlico Sound and the formation of new intertidal shoals, habitats preferred by some protected birds. A breach would also provide short-term benefit to both sturgeon species and sea turtles if it was deep enough to provide access to back barrier habitats. Length of benefit would depend on whether and how fast the breach closed and whether or not the breach was bridged. **Project Impact:** Mixed beneficial and adverse short-term and middle-term, indirect impacts associated with ongoing erosion processes, which reduce some preferred habitats or render others less desirable **Cumulative Impact:** Contributes a minor adverse increment to long-term, moderate adverse cumulative impacts associated with ongoing erosion processes.	Nourishment would produce short-term (~4 months) adverse impacts to biota in the action area, particularly benthic organisms. During winter, species abundance tends to be lower, and impacts would be less than construction activities in summer months. There would also be short-term impacts to nesting or roosting activities of colonial sea birds that may be using the back beach area. Sea turtles are not likely to be present on the beach during winter months, but if water temperatures rise sufficiently during a portion of the construction period, could be present, along with Atlantic sturgeon and shortnose sturgeon in the offshore borrow area. Additional sand mitigates erosion and expands the area of dry-sand beach for the benefit of species that thrive in that zone, including ghost crabs and sea beach amaranth. Over time, nourishment sand feeds the foredune and provides expanded dune habitat for several years. Nourishment sand eventually buries emergency shore protection devices or migrates to downcoast areas, augmenting the natural sand supply. Adverse impacts to benthic organisms are expected to be short-lived in relation to the particular life cycle of each species present. If the borrow sediments are similar to native beach sediments, rapid recruitment of new biota should occur in the expanded habitat created by the project.During construction, beneficial and adverse impacts would occur in the form of nutrients and biota dislodged in the borrow area and beach zone. This may attract predators as well as eliminate benthic organisms for a short period (weeks to months). Upon project completion, new habitat would be available (wider beach) for the benefit of some organisms and barrier island vegetation. **Project Impact:** Site-specific, short-term, adverse and beneficial impacts, depending on the species (e.g. Atlantic sturgeon, shortnose sturgeon, and whales) may be adversely affected during dredging, and benthic organisms would be excavated or buried during construction, but benthic foraging habitat and sea turtle nesting habitat would be beneficially affected post-construction). See Appendices B – *Biological Assessment*, D – *Essential Fish Habitat*, and E – *Biological Monitoring* for more detail. **Cumulative Impact:** Contributes an imperceptible, adverse increment to long-term, moderate, adverse, cumulative impacts (construction). Post-construction contributes an imperceptible to noticeable, beneficial increment (wider beach) to moderate, adverse, cumulative impacts associated with ongoing erosion processes, which reduce some preferred habitats or render others less desirable.	Alternative 3 would produce shortest term (~2-3 months) impacts during construction, but greater impacts than Alternative 2 to certain biological resources because of the season. Benthic populations in summer tend to exhibit much greater abundance than winter populations. Sea turtles and certain colonial seabirds are more likely to be nesting or otherwise using the action area in summer. Therefore, shorter duration impacts under Alternative 3 would affect much greater biological activity during summer months. Adverse impacts during construction would include burial of benthic organisms and disruption of turtle nesting activities, or colonial seabird nesting and roosting activities. Following construction, Alternative 3 potentially produces much longer (decade) beneficial impacts in the form of expanded beach habitat. Duration of beneficial impacts would be a function of the scale and longevity of the project, but upwards of twice that of Alternative 2. During construction, beneficial and adverse impacts would occur in the form of nutrients and biota dislodged in the borrow area and beach zone. This may attract predators as well as eliminate benthic organisms for a short period (weeks to months). Upon project completion, new habitat would be available (wider beach) for the benefit of some organisms and barrier island vegetation. **Project Impact:** Site-specific, short-term, adverse and beneficial impacts, depending on species. Atlantic sturgeon may likely be adversely affected by dredging, and adverse impact would likely occur to sea turtles that may be trying to nest (particularly to loggerhead and greens) and less likely to Kemp's ridley) and to benthic organisms, which would be excavated or buried during construction (offshore and beach). All sea turtle nests in the project area would be relocated during construction; post-construction-nesting beach will be wider. Benthic foraging habitats would be increased post-construction, as would overwash habitats preferred by some protected plants and protected birds for nesting, foraging, and roosting. See Appendices B, D, and E for more detail. **Cumulative Impact:** Contributes an imperceptible, adverse increment to long-term, moderate, adverse, cumulative impacts (construction). Contributes an imperceptible to noticeable, beneficial increment (wider beach) to moderate, adverse, cumulative impacts associated with ongoing erosion processes, which reduce some preferred habitats or render others less desirable.

Topic	Alternative 1: No-Action	Alternative 2: Winter Construction	Preferred Alternative 3: Summer Construction
Cultural Resources	No shipwrecks are known to be in the area. However, continued shoreline recession potentially exposes remains of undetected, cultural artifacts buried along the barrier island. **Project Impact:** Negligible to minor, long-term, adverse impact to undetected cultural resources along the beach-dune system due to continued erosion. No impact at the borrow area. **Cumulative Impact:** Contributes an imperceptible, adverse increment to long-term, adverse impacts of erosion on undetected or detected, cultural resources along Dare County beaches.	Nourishment lessens the chance of undetected cultural artifacts being exposed on the beach. At the borrow site, cultural resources such as potential remains of shipwrecks would be avoided by placing no work buffers around any objects that may have historical value. Possibility of encountering and damaging undetected objects would be reduced by suspending operations and moving the dredge to other areas of the borrow site. **Project Impact:** Long-term (several years) beneficial impact along the beach and negligible to minor, adverse impact at the borrow site. **Cumulative Impact:** Contributes a beneficial increment to long-term, beneficial impacts associated with additional burial of undetected or detected cultural resources in the beach zone. Contributes a noticeable, adverse increment to overall cumulative impacts of encountering undetected cultural resources in offshore borrow areas.	Same as Alternative 2 with greater potential to expose undetected cultural resources in the borrow area. **Project Impact:** Long-term (decade), beneficial impact along the beach and negligible to minor, adverse impact at the borrow site. **Cumulative Impact:** Contributes a beneficial increment to long-term, beneficial impacts associated with additional burial of undetected or detected cultural resources in the beach zone. Contributes a noticeable, adverse increment to overall cumulative impacts of encountering undetected cultural resources in offshore borrow areas.
Socio-Economics	Developed property and NC 12 would sustain substantial socio-economic impacts in the form of road closures, loss of business, decline in visitation, and increased cost of supplies and emergency response. A breach of the barrier beach would necessitate costly emergency repairs such as construction of a temporary bridge, closure of the channel and restoration of the beach. The economic cost of road closures is high in the Hatteras communities because of their dependence on tourism. Road closures result in loss of business and tax revenues, inability of tourists to reach their destination, and substitute forms of transportation required to supply the community and safeguard life and property. **Project Impact:** Long-term, moderate, adverse impacts, depending on season, frequency, and magnitude of storms during the period. **Cumulative Impact:** Contributes an appreciable adverse increment to long-term, adverse cumulative impacts.	Reduces the frequency and magnitude of damages to NC 12, developed property and existing homes and businesses along the Buxton east coast, with associated substantial socio-economic benefits. Offsets costs of road closures and emergency repairs over the life of the project (several years) and preserves property values and the tax base within the community. Visitation and use of park facilities is maintained with negligible interruption. **Project Impact:** Long-term (several years), beneficial impacts over the life of the project. **Cumulative Impact:** Contributes a noticeable to appreciable, beneficial increment to long-term, beneficial, cumulative impacts.	The Preferred Alternative increases the duration of socioeconomic benefits to the project longevity (~1 decade). Benefits are otherwise the same as Alternative 2. The wider beach that is possible under Alternative 3 provides a significantly greater reservoir of sand to feed the dune system and reduces damaging wave runup at existing structures. Property damages would be reduced or minimized for the project's duration. The potential economic benefits in the form of reduced property damage, less frequent NC12 repairs, preservation of access for visitors, and preservation of the tax base and property values are likely to be an order of magnitude greater than the cost of the project over a decade. **Project Impact:** Long-term (decade), beneficial impacts over the project's life. **Cumulative Impact:** Contributes a noticeable, beneficial increment to long-term, beneficial, cumulative impacts.
Visitor Use & Experience	The No-Action Alternative would produce continued adverse impacts on visitor use and experience along the action area. Ongoing erosion would increase the frequency of dune breaches and road closures. Loss of beach along Buxton Village and installation of more emergency sand bags would inhibit or prevent direct beach access. Road damage and repairs would result in minor to major inconvenience for visitors and likely alter travel plans. Visitors to the Seashore and villages along Cape Hatteras are attracted to the area by the natural beauty, wildlife, and vistas of the coast. This experience would continue to be degraded by ongoing erosion and emergency road repairs and property protection measures. (continued next page)	Beach nourishment would produce short-term (months) adverse impacts to visitor use and experience during the period of construction due to dredge pipelines and equipment on the beach. Upon project completion, visitor experience would improve for several years by way of a wider recreational beach, less exposure of emergency sand bags, and less frequent dune breaches and road closures. **Project Impact:** Short-term, minor, adverse impacts in the active construction area, followed by long-term (years) beneficial impacts due to a wider beach and less frequent road closures. With fewer visitors in winter, fewer would be impacted by construction. (continued next page)	Similar impacts as Alternative 2, but would affect more people because visitation is highest during summer months. Post-construction benefits would last longer than Alternative 2. **Project Impact:** Short-term, adverse impacts in the active construction area, followed by long-term (decade) beneficial impacts due to a wider beach and less frequent road closures. With more people in summer, more people would be impacted by construction. **Cumulative Impact:** Contributes a noticeable increment to adverse, cumulative impacts during construction and beneficial impacts after construction for a decade. (continued next page)

Topic	Alternative 1: No-Action	Alternative 2: Winter Construction	Preferred Alternative 3: Summer Construction
Visitor Use & Experience (continued)	**Project Impact:** Moderate to major, adverse impact associated with road closures and emergency shore protection along Buxton Village properties. **Cumulative Impact:** Contributes an appreciable adverse increment to long-term adverse cumulative impacts.	**Cumulative Impact:** Contributes a noticeable increment to adverse, cumulative impacts during construction and beneficial impacts after construction for several years.	See above.
Public Safety	Current conditions within the action area would continue with increasing frequency of road closures as erosion continues. Road closures impact public safety, affecting emergency services, inhibiting evacuation of residents, and preventing patient transfers to regional hospitals. A potential breach of the barrier would produce extended adverse impacts over weeks to months as demonstrated by the breach events due to Hurricane *Irene* (2011). **Project Impact:** Regional, long-term, moderate, adverse impacts. **Cumulative Impact:** Contributes a noticeable, adverse increment to long-term appreciable, adverse cumulative impacts.	Reduces the frequency of road closures or the threat of a barrier breach and helps maintain unimpeded access via NC 12 during medical and other emergencies. Fire, police, and park service operations are favorably impacted for several years. **Project Impact:** Long-term (years), beneficial impacts in relation to the longevity of the project. Produces major, adverse impacts to worker safety associated with winter construction offshore. **Cumulative Impact:** Contributes a noticeable, beneficial increment to long-term, appreciable, cumulative impacts on public safety, with respect to maintenance of NC 12.	Produces the same benefits as Alternative 2 but for up to one decade in relation to the scale and longevity of the project. **Project Impact:** Long-term (decade) beneficial impacts in relation to the longevity of the project. Produces much lower adverse impacts to worker safety associated with summer construction compared with Alternative 2. **Cumulative Impact:** Contributes a noticeable, beneficial increment to long-term, appreciable, cumulative impacts on public safety, with respect to maintenance of NC 12.
Sustainability and Long-Term Management	NCDOT reports spending more money per mile maintaining NC 12 than any other road in the state. Maintenance is focused on several segments of the road where erosion has degraded the beach and encroached on the road. These erosion hotspots are limited in extent, but are a cause of frequent emergency actions to maintain the road. NCDOT is evaluating long-term (50-year) alternatives for the Buxton Canadian Hole hotspot. Until a plan can be agreed on and implemented, damages and emergency repairs would continue at increasing frequency. Existing conditions are neither sustainable nor practical for long-term management. **Project Impact:** Long-term, moderate, adverse impacts with the likelihood of increased frequency of emergency repairs and more difficult management of road closures and beach erosion. A breach of the barrier greatly magnifies the adverse impacts and management requirements associated with alternative transportation routes and methods. No-Action would indirectly, adversely impact the region. **Cumulative Impact:** Contributes an appreciable adverse increment to long-term adverse impacts of erosion.	Beach nourishment is sustainable at decadal scales in many areas provided there is a cost-effective source of beach-quality sand nearby and erosion rates are moderate. The action area was nourished between 1962 and 1973. Local observers report that those projects provided benefits due to better property protection and few road closures for ~2 decades. No nourishment has occurred in over 40 years. Alternative 2 would provide a sand volume of ~1.3 million cy, which would be comparable to the 1973 project. Alternative 2 is predicted to provide 3-5 years of erosion relief, due to the lower sand volume that a winter project would allow. The project would include performance monitoring to quantify nourishment longevity. Such information is needed to determine objectively whether nourishment is sustainable and cost-effective, relative to other shore protection or long-term (decades) property abandonment. **Project Impact:** Long-term (years) beneficial impacts. Project would provide site-specific performance data for evaluation of cost and sustainability. **Cumulative Impact:** Contributes an appreciable, beneficial increment to long-term, adverse, cumulative impacts of erosion.	The Preferred Alternative provides benefits similar to Alternative 2, but for at least twice as long in relation to the scale of the project. Alternative 3 would nourish the beach using up to ~2.6 million cy of sand, compared to Alternative 2 at ~1.3 million cy. Economies of scale make Alternative 3 more sustainable and cost-effective than Alternative 2. **Project Impact:** Long-term (decade) beneficial impacts. Project would provide site-specific, quantitative performance data for evaluation of cost and sustainability. **Cumulative Impact:** Contributes an appreciable, beneficial increment to long-term, adverse cumulative impacts of erosion.

ENVIRONMENTALLY PREFERABLE ALTERNATIVE

In accordance with Section 404b1(CFR 40 Part 230), the US Army Corps of Engineers must identify the Least Environmentally Damaging Practicable Alternative (LEDPA) before it can issue a permit. The National Park Service must also identify the environmentally preferable alternative in its NEPA documents for public review and comment [Sect. 4.5E (9)]. The LEDPA is the alternative that causes the least damage to the biological and physical environment and provides protection that best preserves and enhances historical, cultural, and natural resources. The LEDPA is identified by the Responsible Officer after weighing long-term environmental impacts against short-term impacts when evaluating and considering what is the best protection of the resources. In the case of beach nourishment in high-energy sites such as the Buxton Action Area, the environmentally preferred alternative (e.g. winter dredging) may not be the alternative under which the US Army Corps of Engineers or the National Park Service issues its permits, considering such other factors as safety.

Under Alternative 1–No Action, emergency measures are likely to be implemented with increasing frequency while the remaining beach would diminish in width. Alternative 1–No-Action is unlikely to provide a solution to the problem of ongoing erosion and does not address the urgency of the comments expressed to PEPC.

Alternative 2–Winter Construction and Alternative 3 (Preferred Alternative)–Summer Construction are beach nourishment projects designed to mimic the natural processes of accretion, which also occur along Hatteras Island within Seashore boundaries. Additions of sand by artificial means are generally more impactful than natural additions, mainly because of scale and rates of change to the profile. The added sand, if similar in texture to native sand, should be indistinguishable after equilibration of the beach.

The environmental impacts of Alternative 2–Winter Construction would be less than Alternative 3–Summer Construction because of the season of construction and the smaller scale. During Alternative 3–summer construction, the applicant acknowledges that disruptions to the environment would occur and the implementation of certain environmental protection measures would be needed. However, upon completion of construction, the environmental benefits of Alternative 2–Winter Construction would be less than Alternative 3–Summer Construction due to the project's shorter longevity and smaller volume of sand.

By comparison to Alternative 2, Alternative 3–Summer Construction would provide greater project longevity and environmental benefits resulting from a wider, longer-lasting beach. Until the NC Department of Transportation, the National Park Service, and other stakeholders can reach consensus on a long-term strategy for NC 12, Alternative 3–Summer Construction is considered to provide the most environmentally beneficial remedy for chronic erosion and the narrow beach in the high-energy coastal setting at Buxton. Therefore, Alternative 3–Summer Construction is the environmentally preferable alternative for the Proposed Action Area.

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CHAPTER 3 – AFFECTED ENVIRONMENT – EXISTING CONDITIONS

The Affected Environment describes existing conditions for those elements of the natural and cultural environments that would be affected by the implementation of the actions considered in this EA. Impacts for each of these topics are analyzed in Chapter 4: Environmental Consequences. The topics addressed include coastal resources (including littoral processes), sand resources, water quality, essential fish habitat, biological resources, cultural resources, socioeconomics, visitor use and experience, public safety, and sustainability and long-term management. The section on coastal resources offers additional background on barrier islands and erosion because the Proposed Action has not been widely applied within the Cape Hatteras and Cape Lookout National Seashores, and beach nourishment continues to be debated as a method to restore erosional beaches (Pilkey 1990, Houston 1990).

COASTAL RESOURCES (INCLUDING LITTORAL PROCESSES)

The Cape Hatteras and Cape Lookout National Seashores encompass a contiguous string of barrier islands and spits extending from north of Oregon Inlet to Beaufort Inlet along the northern coast of North Carolina. This coastline includes ~130 miles of ocean beaches, two cuspate forelands (Cape Hatteras and Cape Lookout), and six unstabilized tidal inlets. The Cape Hatteras National Seashore itself begins at the south boundary of Nags Head (on Bodie Island) and terminates at the village of south of Buxton. The Seashore provides direct vehicle access to ~73 miles of oceanfront, which is mostly undeveloped beach open to public use. In contrast, the ~56 miles of outer beaches of Cape Lookout National Seashore south of Cape Hatteras largely function as a wildlife preserve, having limited vehicle access by ferry and none by road.

The coastline north of Cape Lookout is commonly called the Outer Banks. The Outer Banks is a classic micro-tidal, wave-dominated coast (Hayes 1994) in which littoral sands (ie sand in the beach zone) of the inner continental shelf have been shaped into elongate barrier islands miles from the mainland. They provide shelter to sounds and tidal rivers extending tens of miles inland across the coastal plain of North Carolina. A characteristic of wave-dominated barrier islands is their tendency to be long and narrow with widely separated inlets. Over a 400-year period, up to 30 inlets of varying longevity have been documented along the Cape Hatteras National Seashore. Only three—Oregon Inlet, Hatteras Inlet, and Ocracoke Inlet—have persisted for many decades. The others either closed naturally after a brief life or were closed artificially (Everts et al. 1983).

Hurricane *Irene* (August 2011) produced several breach inlets—one adjacent to Oregon Inlet and another along Pea Island, which closed naturally within weeks to a couple of months of the event. A breach at Rodanthe was closed artificially soon after the hurricane. Prior to *Irene*, breaches occurred ~1 mile north of Buxton in 1962 (USACE 1963) and near Hatteras Village (west of Buxton) during Hurricane *Isabel* in 2003 (Wutkowski 2004, Walmsley et al. 2010). Both breaches were closed artificially within a year to restore vehicle access to the area and to rebuild NC 12, the only road through the Seashore. Breach inlets, although infrequent, typically occur where the barrier island is narrowest and lacks high dunes.

Of the ~73 miles of Cape Hatteras National Seashore shoreline, the Proposed Action Area, also called the Buxton Action Area in this Environmental Assessment, encompasses a total of ~3 miles of shoreline, which includes ~2.2 miles of undeveloped beaches within the Seashore and ~0.8 mile of developed beach along the east shoreline of Buxton. This represents ~4% of the ocean shoreline within the boundaries of the Seashore, or ~2.3% of the ocean shoreline within the Cape Lookout and Cape Hatteras National Seashores combined.

The Proposed Action Area is an East-facing beach near the downcoast terminus of a primary littoral cell extending from the Virginia Capes at the entrance of the Chesapeake Bay to Cape Hatteras, a foreland that marks a prominent turn in the shoreline. Beaches within the primary littoral cell are exposed to similar waves from the northeast and experience the highest waves along the US East Coast (Leffler et al. 1996). During Hurricane *Irene* (2011) and *Sandy* (2012), peak wave heights about 1 mile off Duck and Nags Head, North Carolina, exceeded 27 feet (McNinch et al. 2012, CSE 2013a). These localities are ~45–60 miles north of the Buxton Proposed Action Area. While hurricane waves often propagate and drive sand to the north, more frequent northeast waves produce net southerly transport in the Proposed Action Area (Inman & Dolan 1989). Sand moving north to south accounts for the extension of Cape Point (see Fig 2.5). West of Cape Hatteras, the ocean shoreline is sheltered from northeast waves, allowing southerly waves to dominate and also drive sand toward Cape Point. Thus, Cape Hatteras and Diamond Shoals are a convergence zone for sand moving along the Seashore. Mean monthly wave heights in the Proposed Action Area are ~3.7 feet in July and ~5.7 feet in January (see Fig 2.2). Mean tide range is 2.99 feet and spring tide range is 3.46 feet (source: NOAA). SEA level has risen during the 20th century with the recent tide gauge record showing a 4.3-inch rise over 30 years at Oregon Inlet, North Carolina (NCCRC 2015).

For purposes of analyzing cumulative impacts, the principal study area (littoral cell) is about 96 miles long and is considered to encompass the North Carolina outer coast from Cape Hatteras to Virginia. Net sand transport reverses along southern Virginia beaches and is directed north into the Chesapeake Bight (USACE 2010). Detailed analysis of littoral processes (Appendix A- *Littoral Processes*) focuses on the ~6-mile-long ocean beach extending from about 1.5 miles north of the NPS Haulover Day Use Area to Cape Point. The seaward boundary for detailed analysis is ~3 miles offshore and encompasses the proposed borrow area. The principal littoral cell referenced in this EA contains one permanent and maintained entrance channel at Oregon Inlet about 36 miles north of the Proposed Action Area and one ephemeral breach inlet, which opened during Hurricane *Irene* (27 August 2011) along Pea Island, ~30 miles north of the Proposed Action Area. The Pea Island inlet remains closed most of the time (source: Google Earth).

Hatteras Island beaches exhibit the full spectrum of conditions from accreting segments (e.g. Waves, Salvo, and south Buxton/Cape Point) to retreating erosional segments (e.g. Pea Island, Rodanthe, and East Buxton) (Morton & Miller 2005, NCDENR 2012). At decadal to century time scales, littoral sand along Hatteras Island is generally conserved, but shifts from segment to segment. Along some high-erosion segments, shoreline recession rates exceed 12 feet per year (NCDENR 2012). Accreting segments such as Waves and Salvo appear to be widening by >5 feet per year (see Fig 1.4).

Everts et al. (1983) prepared a detailed analysis of shoreline change for the Outer Banks which researched measurements of ocean and sound shoreline changes between the 1850s and 1980s and reviewed earlier maps and charts. This analysis was a cooperative study conducted by the Coastal Engineering Research Center (CERC) and National Ocean Service (NOS) within the US Army Corps of Engineers (USACE), and the National Oceanic & Atmospheric Administration (NOAA) (respectively). Everts et al. found that the Outer Banks, on average, was narrowing by ~0.9 meter, or ~3 feet per year, with the majority of the recession occurring along the oceanfront (~0.8 meter per year average). The study found that the sound shoreline was stable with a net recession of 0.1 meter per year (~0.3 foot per year) on average. The Everts et al. study theorized that the principal losses of sand along the Outer Banks are associated with inlets, particularly the deposits of sand into the sound (Everts et al. 1983).

Best-available, historical shoreline data (Everts et al. 1983, Morton & Miller 2005, NCDENR 2012) indicate that Hatteras Island is drowning in place on average with shoreline recession occurring along the ocean and sound shorelines. Some segments of Hatteras Island, including parts of Pea Island, Rodanthe, and Buxton, have likely retreated over 1,000 feet in the past century, while other areas have widened by hundreds of feet. Erosion and accretion rates exhibit high variability along the island relative to the island-wide averages (NCDENR 2012) (see Appendix A - *Littoral Processes*). The average width of Hatteras Island is ~1,800 feet. Some narrow areas, such as the Buxton Action Area and Pea Island, have segments <600 feet wide.

Previous Shore-Protection Measures

Previous shore-protection measures along the Buxton Action Area include dune reconstruction, emergency breach closures and shoreline armoring, groin construction, and beach nourishment to protect Cape Hatteras Lighthouse (NPS 2013). These previous measures have modified the natural system along this segment of Hatteras Island.

Dune Reconstruction and Management

The Works Progress Administration (WPA) in 1935 built up a protective dune line along the Outer Banks to reduce the threat of breaching along the barrier islands (Stratton 1957, pg 4). Brush panels were installed over a denuded landscape to trap sand and establish a dune line. A.C. Stratton was the field supervisor with the National Park Service during the dune restoration efforts. His reports (Stratton 1943, 1957) described the degraded condition of the Outer Banks in the 1930s compared with conditions in the late 1800s. Stratton (1943) attributed the denudation of Hatteras Island in the early part of the 20th century to overgrazing, mostly by hogs, and to timber removal by commercial interests. Stratton (1957) reported that the effort from the 1930s project remained in place 20 years later. The work was credited with reducing erosion and saving the Cape Hatteras Lighthouse, which had been abandoned in 1936 (www.ncsu.edu/coast/chl/timeline.html, accessed 31 October 2013). Stratton (1957) described a rehabilitation program planned by the National Park Service (Mission 66) to repair damaged dunes over a ten-year period and restore them to the condition they were in following the 1930s project.

By the 1970s, some researchers (e.g. Dolan 1972, Godfrey 1972, Dolan et al.1973, Godfrey & Godfrey 1977) questioned the wisdom of dune reconstruction, seeing such efforts as countering the natural sequence of overwash and beach repair. A number of researchers have theorized that washovers and breach inlets maintain barrier island width and are therefore the natural mode of barrier island evolution and sustainability (Riggs & Ames 2003, Smith et al. 2008, Riggs et al. 2009). Other researchers have documented the collapse and drowning of barrier islands under the processes of washover breach inlet formations and sea-level rise (Penland et al. 1992, McBride & Byrnes 1997).

In the case of the northern North Carolina coast, islands that are classified as washover barriers, such as Core Banks and Portsmouth Island in Cape Lookout National Seashore, tend to be much narrower than Hatteras Island where high dunes are common. Some researchers assert that the presence of high dunes helps preserve littoral sand budgets and reduces net recession rates, because less sand is lost to washovers and breach inlets (Kraus & Rosati 1998, Rosati 2005, Rosati et al. 2013). When storms impact beaches backed by high broad dunes and bluffs, the profile is likely to adjust by dune scarping and offshore transport. A majority of the eroded sand may be retained within the littoral zone and, therefore, may be available to rebuild the beach under normal processes (Shepard 1950, Bascom 1954, Hayes & Boothroyd 1969, Seelig & Sorensen 1974).

Historical aerial images for the past 50 years indicate there is a general lack of active washovers along nearly all of Hatteras Island and Bodie Island in comparison with many segments of the Seashore (e.g. Core Banks and Portsmouth Island). In the spectrum of barrier-island types (Hayes 1979), most of Hatteras Island would be classified as a positionally stable beach ridge barrier. The highly eroding segments, such as Rodanthe and the Buxton Proposed Action Area, have been the focus of plans for remedial restoration.

Previous Beach Nourishment

Several nourishment projects were conducted in the Buxton Action Area in the 1960s and 1970s. The first was in early 1963 in conjunction with closure of the March 1962 breach inlet (see Fig 1.7). In 1966, 312,000 cubic yards were pumped from Pamlico Sound onto the beach along the Buxton motel area and the US Naval Facility north of the lighthouse (NPS 1980, USACE 1996, NPS 2013). This NPS-sanctioned project was intended to restore sand losses and help protect the lighthouse and supplement nourishment after the March 1962 (Ash Wednesday) northeaster of record breached Hatteras Island just north of Buxton. The National Park Service (1980) reported that the *borrow material . . . was too fine and did not remain on the subaerial beach* (pg 48).

A destructive northeaster on 24 October 1970 caused severe erosion near the Hatteras Court Motel (adjacent to the Seashore at the north edge of the Village of Buxton). A total of ~2,300 cubic yards was placed in an emergency berm, using sand from an inland stockpile. Severe erosion in 1970 led the National Park Service to plan for another nourishment in 1971 (NPS 1980). That project reportedly involved pumping ~200,000 cubic yards* from an inland pit on Cape Point to the critically eroding area of the Village of Buxton and the lighthouse. The National Park Service stated that the . . . *sand . . . remained for a longer period of time than 1966. However, the quantity of borrow material proved insufficient to have any significant impact on the beach or on the inshore bar system* (NPS 1980, pg 48).

> [**Machemehl (1973) reported the volume as 300,000 cubic yards obtained from a man-made lake at Cape Point and pumped via 14-inch cutter head dredge owned by J.A. LaPort Dredging Company with the aid of a booster station a total distance of ~3.5 miles. The sand slurry was discharged near Hatteras Court Motel and allowed to move south from there via normal littoral currents.*]

Continued erosion after the 1971 project resulted in a decision to implement the third nourishment in 1973. That project reportedly involved 1,300,000 cubic yards** obtained from an interior borrow area within the Cape Point accreted lands (NPS 1980, pg 48). [***USACE (1996) reported the volume as 1,250,000 cubic yards.*] The basin for the borrow area is visible on aerial images as a zone of altered vegetation. A 16-inch dredge with three booster pumps discharged the sand slurry a few miles north in the vicinity of Hatteras Court Motel. Over a 5,000-foot reach, the beach was widened by ~500 feet and the horizontal berm (i.e. dry-sand beach) was widened by 70 feet (NPS 1980).

Fisher et al. (1975) tracked the project using profiles across the visible beach (but not underwater) before and after pumping and found a net gain of ~608,480 cubic yards above mean sea level. They reported a net loss of 771,003 cubic yards between September 1972 and February 1973 (presumed period of construction). They projected that ~25% of the fill would be retained at the end of four years under favorable conditions (NPS 1980, pg 49). Fisher et al. (1975) reported *large losses of material in the fill area and north end and large gains on the point and Diamond shoals.*

The Applicant could not find any recoverable surveys from the 1970s which incorporated the entire active profile to the outer bar. Therefore, it is not possible to confirm the fate of the 1973 nourishment material. The Fisher et al. (1975) quantities for the visible beach and timing of their surveys suggest that their measurements reflect initial profile adjustment, rather than net erosion across the entire profile.

While no other monitoring reports were found for prior Buxton projects, some local observers believe the 1973 project yielded benefits for many years because of the lack of emergency-protection measures needed until recently (Lighthouse View Motel, J. Hooper, former Dare County Commissioner, pers. comm., April 2013). Good performance may also be due to the limited number of hurricanes impacting the North Carolina coast from the mid 1970s to the mid 1990s (NC Sea Grant, S. Rogers, Coastal Engineering Specialist, pers. comm., September 2013).

Groins

Persistent erosion in the vicinity of Cape Hatteras Lighthouse and the adjacent US Naval Facility has led to various shore-protection measures in the past 50 years. Following the breach closure in 1963 and small-scale nourishment in 1966, the US Navy installed sand bags along 1,100 feet of shoreline in 1967. These geotextile bags deteriorated rapidly and proved short-lived (NPS 1980). The Navy then installed a field of three groins to stabilize the beach along their facilities (Machemehl 1979, USACE 1996). The groins reportedly slowed the erosion rate updrift of the structures and, for a time, accretion occurred along the US Naval Facility. This was likely aided by the 1973 nourishment along the Village of Buxton. Dolan et al. (1974) reported the positive impact of the 1973 nourishment extending to the Cape Hatteras Lighthouse. In their analysis, the US Army Corps of Engineers (1996) suggested ... *the impact of the fill is believed to be minor compared to that of the groins, which have been influencing the shoreline for more than 25 years* (pgs 3–10). The downcoast area of Cape Point continued to erode with the resulting shoreline forming a salient in the vicinity of the lighthouse (USACE 1996) (see Fig 2.6). During the 1980s, erosion around groin no.3 (fronting the lighthouse) was threatening to flank the groin, although a sheet-pile wall (groin extension) had been installed around the lighthouse to check the erosion (USACE 1996). The present conditions of the Hatteras groins were illustrated in Figure 2.6.

Lighthouse Protection and Relocation

The original Cape Hatteras Lighthouse, completed in 1802 and positioned ~1 mile inland, was deemed inadequate because of its limited height and setback from the ocean (NPS 1980, NRC 1988). A new lighthouse—the tallest in the United States—was completed in 1870, at which time it was positioned ~1,500 feet from the ocean. According to NPS records, by 1919, the ocean was within 300 feet of the structure. By 1936, the US Coast Guard abandoned the lighthouse due to erosion, and ownership was transferred to the National Park Service. The National Park Service reported that the ocean had advanced to within 100 feet of the lighthouse by 1935. This anecdotal information implies that, between 1870 and 1919, the shoreline eroded ~1,200 feet (~25 ft/yr), but erosion slowed between 1919 and 1935 to a rate of ~12.5 feet per year. [Note: The high rate of retreat between 1870 and 1919 could also reflect inaccuracies of early surveys which were made difficult by the remoteness of Hatteras Island from control monuments on the mainland.] Erosion apparently lessened or reversed between 1936 and 1950 when the US Coast Guard reactivated the lighthouse (NPS 1980). Shore-protection measures to protect the lighthouse resumed in the 1960s as previously described.

During the 1980s, the US Army Corps of Engineers evaluated a number of protection alternatives for the lighthouse. At the urging of a private group, the Move the Lighthouse Committee (Fischetti et al. 1987), the National Park Service contracted with the National Academy of Sciences for an independent review of all protection alternatives (NRC 1988). The Academy committee recommended moving the lighthouse. After the USACE completed a series of emergency repairs to the groins and sandbag revetment during the 1990s, funds were finally acquired, and the lighthouse was moved ~2,900 feet southwest in 1999 (completion September 14, 1999) (Booher & Ezell 2001).

Highway NC 12

Prior to the 1950s, NC 12 was an intermittent paved road and unpaved trail between Oregon Inlet and Buxton. In 1952, a fully paved, two-lane highway was completed. Shortly thereafter (1953), Congress established the Cape Hatteras National Seashore to be administered by the National Park Service. Certain sections of NC 12 along Hatteras Island have been subject to erosion, washovers, and inlet breaching from the beginning (Riggs et al. 2009). Three hurricanes in 1955 (*Connie*, August 12; *Diane,* August 17; *Ione,* September 19) resulted in severe erosion and damages to NC 12 between Buxton and Oregon Inlet (USACE 1996). The Ash Wednesday northeaster of record (March 1962) in the Middle Atlantic states breached the barrier island between Buxton and Avon (CHWA 1977), causing emergency repairs to close the channel and rebuild the highway. In 1973, the Lincoln's Birthday Storm (NPS 1980) produced considerable erosion, including severe overwash into Pamlico Sound just north of Buxton. *Oceanfront motels at Buxton and beach cottages north of the lighthouse were significantly damaged* (NPS 1980, pg 32).

Over the past decade, NC Department of Transportation has conducted extensive reviews of alternatives for the protection of NC 12 in the Rodanthe area (NCDOT 2008a, 2008b). While alternatives are being debated publically, NCDOT, with assistance from USACE (2013a), implemented a remedial nourishment north of Rodanthe in response to critical erosion within the Pea Island National Wildlife Refuge section of the Seashore. In 2014, ~1.7 million cubic yards were pumped from offshore borrow areas and placed along ~2.1 miles of oceanfront in the refuge. This was the first nourishment project along Hatteras Island to use offshore borrow areas (USACE-Wilmington District, R. Keistler, Project Manager, pers. comm., August 2013).

Recognizing the need for a long-term strategy for NC 12 in the Buxton Canadian Hole area, the NC Department of Transportation conducted a feasibility study (August 2015) that evaluated short-term (5-year) and long-term (50-year) alternatives for road maintenance (NCDOT, J Jennings, District Engineer, pers. comm., August 2014). The Applicant (Dare County) for the proposed project evaluated in this Environmental Assessment has coordinated closely with NCDOT and has selected the Proposed Action (Alternative 3 – Summer Construction) for two primary reasons:

- To respond proactively to the existing degraded condition of the beach before another storm forces closure and costly repairs of NC 12.
- To implement a project similar in scale to the Rodanthe nourishment and to provide 5–10 years of erosion relief until a long-term strategy for NC 12 can be implemented.

Summary of Previous Shore-Protection Measures

The NPS policy of the 1930s through the 1960s called for active dune building and revegetation efforts along the Seashore. However, by the 1970s, the policy was reversed, allowing the beach and dunes to evolve without stabilization measures. Because erosion along Hatteras Island has not been uniform during the past century (NCDENR 2012), a spectrum of conditions exists today. In some places, segments of beach are relatively stable, and high dunes are maintained by natural processes. In other places, like the Proposed Action Area, erosion has encroached on the dunes and pushed washovers into NC 12, other parts of the Seashore, and adjacent communities. Manipulating the dune line to maintain NC 12 has been ongoing for the past 40 years (NCDOT 2008a), irrespective of present NPS policy.

What remains uncertain, due to the lack of projects performed, is how much sand is lost or gained along Hatteras Island at decadal scales, and what the impact and longevity of adding sand in critically eroded areas would be. Overton and Fisher (2005) provided nourishment estimates for Oregon Inlet to Rodanthe before large-scale nourishment had been conducted. In the absence of site-specific surveys and project construction experience, such aspects as volume erosion rates and nourishment longevity and costs have been approximations. After two recently completed projects at Nags Head (CSE 2012) and Rodanthe (USACE 2013a), it is now possible to develop more realistic estimates of nourishment cost and longevity for the area.

Appendix A – *Littoral Processes* of this Environmental Assessment reviews the present condition of the beach and provides the technical basis for the Proposed Action. The following summarizes the findings.

Condition Survey, Sand Deficit, and Annual Erosion Rates

To prepare Appendix A - *Littoral Processes*, the Applicant completed condition surveys of Buxton beach in August 2013 and October 2014. The surveys confirmed volumes of sand in the foredune, on the visible beach, and in the near shore zone out to a depth >40 feet (Fig 3.1). A project baseline was established extending from the Oregon Inlet jetty to Cape Hatteras. The study area of interest around Buxton is represented by stations 1700+00 to 1980+00 (28,000 ft or ~5 mi). Details of the condition surveys are given in Appendix A. Over 50 profile lines into deep water were used to compute a standard reference volume between the foredune and the –24-ft depth contour (Fig 3.2). This analysis confirmed which segments of beach are critically eroded and provided a measure of sand deficits with respect to a normal stable beach (Fig 3.3).

A similar analysis was made with respect to NC 12 and existing structures. A target minimum profile volume was determined based on the site-specific field data. Using objective criteria, a contiguous ~8,000-ft reach along the Seashore and the Village of Buxton was determined to have a sand deficit totaling ~900,000 cubic yards (Appendix A – *Littoral Processes*). This volume constitutes the initial nourishment requirement to restore the beach to a condition similar to adjacent stable areas. It is analogous to the US Army Corps of Engineers first cost volume for federal projects (USACE 2008).

Annual volume erosion rates were extrapolated from official NCDENR Division of Coastal Management (DCM) setback factors (which are based on long-term linear erosion rates) and applied section-by-section alongshore to derive historical average annual erosion losses (Appendix A – *Littoral Processes*). Figure 3.4 illustrates the systematic variations in linear erosion rates along the Buxton Action Area based on NC Department of Environment &Natural Resources (2012) data. The graphs in Figure 3.4 show erosion rates for three time periods. The earlier period (1925/46 to 1970/88) shows highest erosion rates in the area between stations 1790 and 1830. The more recent period (1970/88 to 2012) shows highest erosion rates between stations 1820 and 1860. This implies there has been southerly movement of the zone of maximum erosion during the past 50–80 years. Long-term erosion rates continue to exhibit systematic variation in the Buxton Action Area with a well-defined zone of maximum erosion.

The results, converted to equivalent volume rates, show the Buxton Proposed Action Area has lost from ~115,000 to 130,000 cubic yards per year along the project area. These volumes constitute the average annual advance nourishment that would be required to keep pace with erosion (USACE 2008). While the sand deficits and average erosion rates are high within the critically eroding areas of Buxton, nearby areas are generally stable and eroding at much lower rates, with some sections accreting.

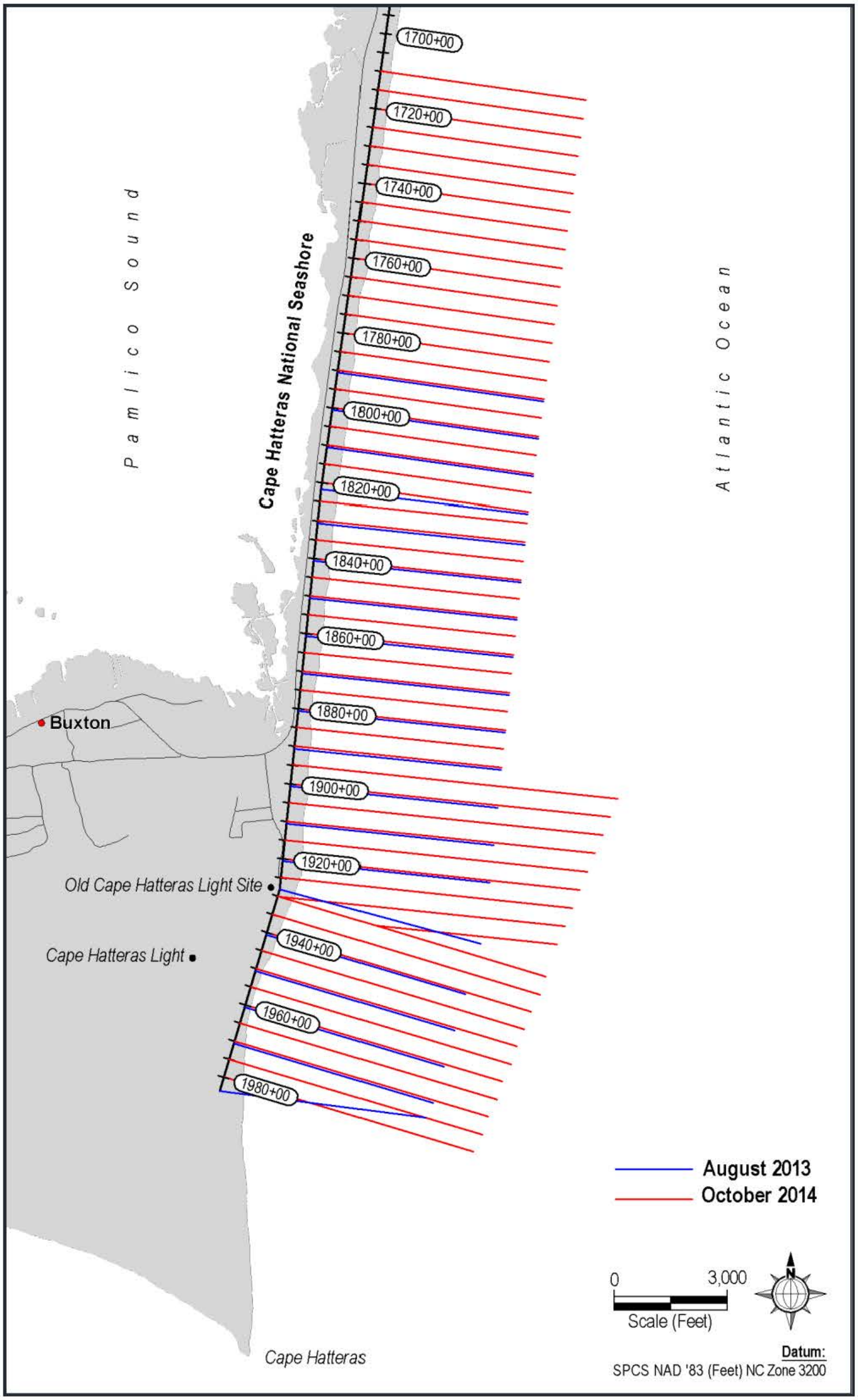


Figure 3.1. Map of the Buxton Action Area showing locations and azimuths of ~50 profile lines numbered in engineering nomenclature from north to south. The northern project limit is around station 1770+50, and the southern project limit at station 1925+50 is near the former site of the Cape Hatteras Lighthouse. Stations reference a project baseline extending from Oregon Inlet (0+00) to Cape Hatteras (~2000+00). Profiles extend from backshore structures and dunes to ~40-foot depths. (See Appendix A - *Littoral Processes*)

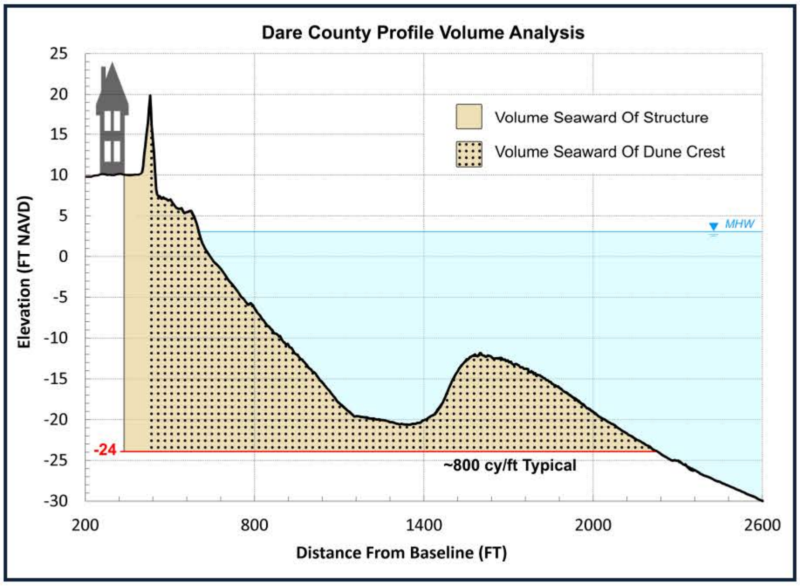
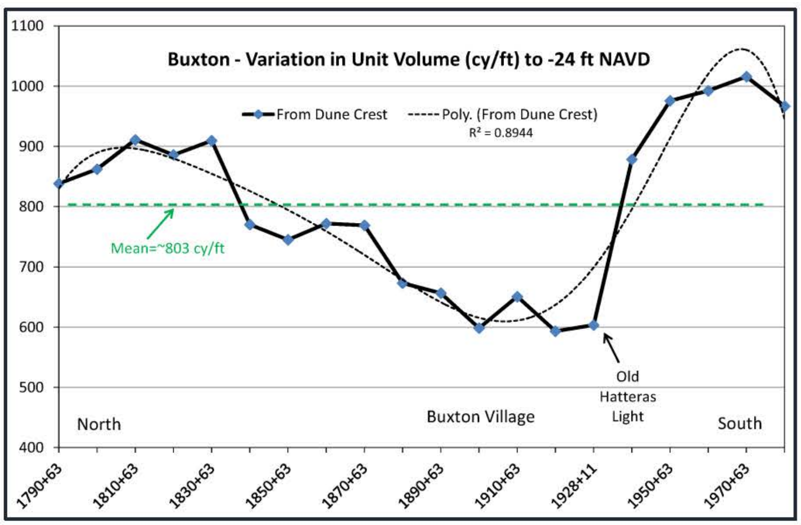


Figure 3.2.

Diagram showing a cutaway cross-section of the dune, beach, and inshore zone illustrating two area calculation lenses. The area under the beach profile to a reference depth of −24 ft NAVD (i.e. ~24 feet below mean sea level) is converted to an equivalent volume of sand contained in a 1-foot length of beach. The first volume quantifies sand contained between the approximate foredune crest and −24-feet NAVD. The second calculates the volume between the seaward most structure in the vicinity of the profile and −24-feet NAVD.

Based on typical dimensions in the project area, the hatched cross-section (referencing the dune crest) shown here has a 2-D area of ~21,600 square feet. This is equivalent to a unit volume of 800 cubic yards/foot (i.e. 800 cubic yards are contained in a 1-foot section of beach).



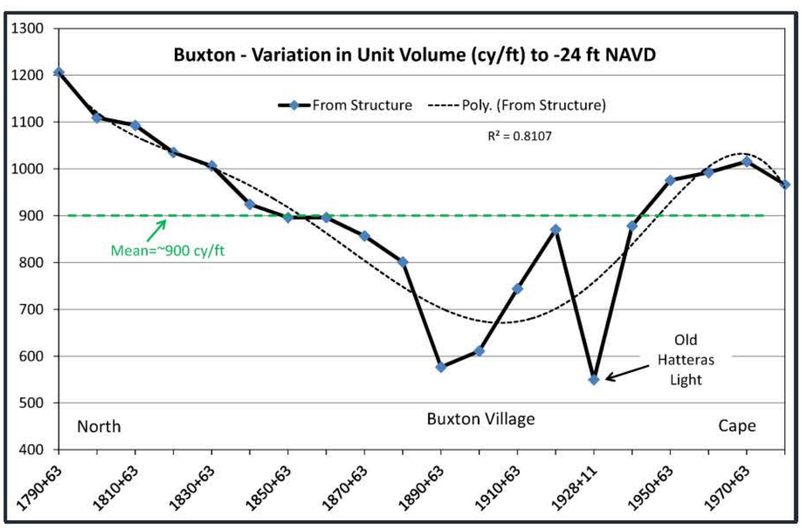


Figure 3.3.

Two graphs showing the unit profile volume in cubic yards/foot by station with respect to the dune crest (upper graph) and the nearest structure (lower graph).

The volumes decrease significantly toward the center of the Buxton Action Area. A dashed green horizontal line on each graph marks reference minimum target volumes of 800 and 900 cubic yards/foot seaward of the dune crest and the structure, respectively.

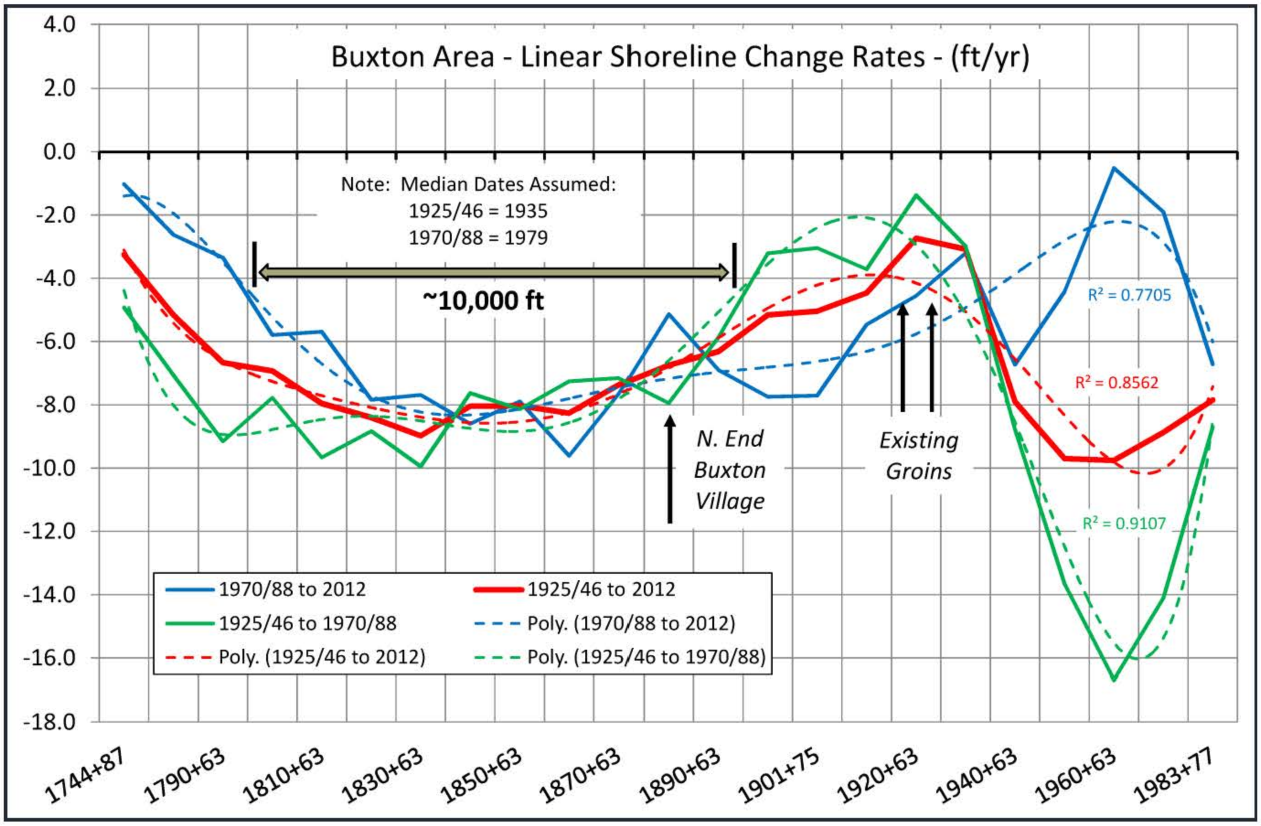


Figure 3.4. Graph showing average annual shoreline change rates (feet per year) at CSE stations derived from historical shorelines 1920s to 2009, digitized by the State of North Carolina (source: NCDENR 2012). The 2012 shoreline was digitized by CSE from 2012 imagery. Solid lines show reported rates by station for representative periods with erosion maxima centered along Seashore stations ~1820 to 1890. Dashed lines represent a best-fit line (complex polynomial) for each data set. Blue lines represent 1970 to 2012; green lines represent 1925 to 1970; red lines represent 1925 to 2012. Each line shows similar form and erosion maxima. (After CSE 2013b) [Source: ESRI ArcGIS World Imagery]

Littoral Processes

The Proposed Action Area is subject to naturally occurring littoral processes including onshore/offshore transport and longshore transport. These wave-generated processes account for the seasonal buildup of the visible beach in summer and narrowing of the dry-sand beach in fall and winter (Komar 1998). Based on the systematic variation in erosion rates along the beach in the Proposed Action Area, as well as the general morphology of Cape Hatteras and Diamond Shoals, net transport is southerly in the Buxton area. Everts (1985) and Inman and Dolan (1989) concluded that net longshore transport along Hatteras Island is southerly. Some early estimates of net transport rates were as high as 1 million cubic yards per year (Jarrett 1978, Inman & Dolan 1989).

However, a number of recent studies for the Nags Head, North Carolina area have documented net northerly transport for some years based on wave records in the range of 100,000–200,000 cubic yards per year (e.g. Byrnes et al. 2003, USACE 2010). Morphological indicators, such as spit growth at Oregon Inlet and accumulation of sand on Cape Point, prove southerly transport is the dominant trend, but temporary reversals indicate the magnitude of longshore transport is likely to be much lower than some earlier estimates. Longshore transport in the Proposed Action Area is analyzed in more detail in Appendix A – *Littoral Processes*. Waves reaching the beach along the Proposed Action Area originate from northerly, easterly, and southerly directions, undergoing transformation over the irregular bottom topography. A primary feature paralleling the beach is a longshore bar situated about 1,000–1,200 feet offshore (see Fig 3.2). Other isolated shoals (including the proposed borrow area ~1.7 miles offshore) in deeper water also modify waves in the Proposed Action Area.

As part of the Buxton project planning, the Applicant analyzed the potential impact on waves of borrowing offshore sand and modifying the underwater contours (Appendix A - *Littoral Processes*). Changes in wave heights, approach directions, and longshore transport potential were evaluated with the aid of numerical models. Details of the analysis are given in Appendix A. The applicable models used for the analysis were USACE-approved STWAVE (USACE 2001) and GENESIS (Hanson & Kraus 1989). Input deep-water waves were obtained using NOAA Real-Time Wave Buoy Station 41025 (12-year record of 2003–2014) off Diamond Shoals and hindcast waves for USACE Wave Information Study (WIS) Station 63230 situated ~10 miles east of the Buxton Proposed Action Area. This provided a 20 plus-year record. Predominant waves at Buxton originate from northeast to south-southeast quadrants.

STWAVE allows calculations of wave fields within defined boundaries of interest. For the Buxton Action Area, the study grid extended ~6.3 miles alongshore and ~3.2 miles offshore centered on the proposed 15,500-foot long shoreline of the Proposed Action Area. This grid encompasses the offshore borrow area. Wave modeling under existing bathymetry and post-dredging bathymetry was implemented, and then the differences were compared. The differences provided a measure of how much the waves at the coast would be altered due to the proposed action.

GENESIS is a shoreline change model which allows calculation of gradients in longshore transport in the presence of nourishment or coastal structures such as groins. It uses the results of STWAVE to evaluate changes in the wave component that drives sediment transport. The results (Appendix A – Littoral *Processes*) show that under existing conditions, longshore transport rates vary along the beach, which helps to account for higher erosion rates within portions of the Proposed Action Area. The models were used to evaluate potential changes in wave energy and sediment transport under each alternative. (Chapter 4 includes results of the models and predicted impact of each alternative on littoral processes.)

SAND RESOURCES

The Proposed Action calls for excavation of up to ~1.3 million cubic yards of offshore sediment in winter under Alternative 2–Winter Construction or up to 2.6 million cubic yards in summer under Alternative 3–Summer Construction. The offshore borrow area is an isolated submarine ridge which extends from water depths of ~32 feet to >45 feet along the crest and is situated about 1.7 miles due east of the old Cape Hatteras Lighthouse site. This is a relict shoal that may once have been part of the barrier island system when sea level was lower. The offshore zone around Hatteras Island contains many larger submarine ridges including Wimble Shoals, Platt Shoals, Kinakeet Shoals, and Diamond Shoals. These areas provide habitat for certain species of fish and sustain communities of benthic organisms as detailed in other sections of this EA (Appendix D - *Essential Fish Habitat*).

The proposed borrow area is roughly 2,250 feet by 8,500 feet, an area of ~440 acres (Fig 3.5). To provide 2.6 million cubic yards, the borrow area would have to be excavated an average of ~4 feet, thus lowering the substrate incrementally from existing conditions. The Applicant proposes to excavate a smaller area to a deeper depth for operational reasons related to dredging efficiency and cultural resources protection. Thus, the final impact area is expected to be smaller (order of ~300 acres) and deeper (order of 6 ft). The area of impact is <2% of the area of similar shoals off Hatteras Island within state waters.

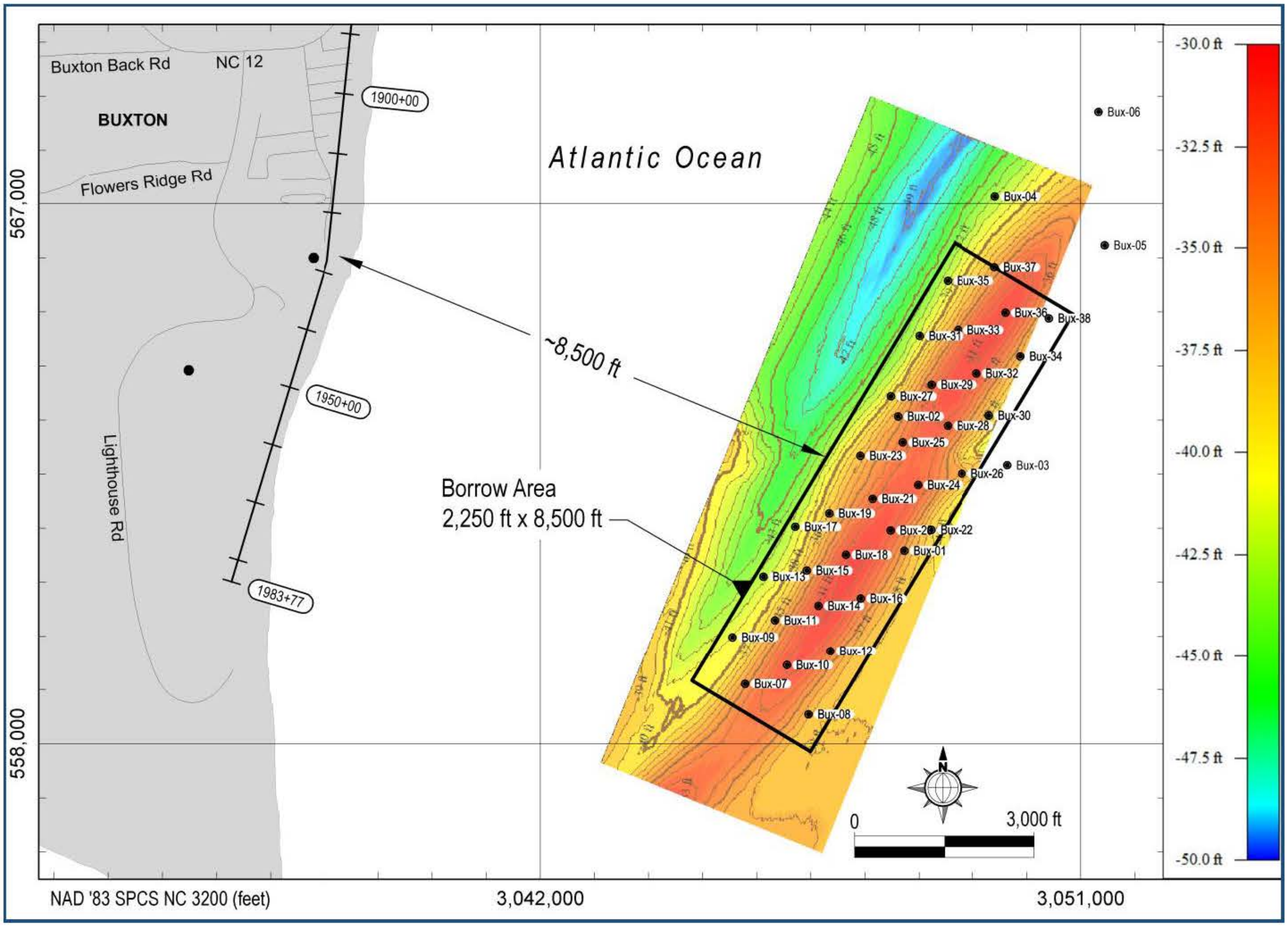


FIGURE 3.5. Map showing color-coded bathymetry, contours, and location of borings in an offshore sand search area. The proposed borrow area (inset box) is roughly 2,250 feet by 8,500 feet (~440 acres) and follows the orientation of an isolated ridge, trending northeast-southwest in water depths between ~32 feet and 45 feet, and situated ~8,500 feet offshore. The final designated borrow area for the Proposed Action will be a smaller area totaling ~300 acres within the sand search Area, so as to avoid impacting potential cultural resources (see Appendix F – *Cultural Resources*).

Beach nourishment performance and impacts are related to the similarity between borrow sediment and the native beach sediment. If the borrow material closely matches the texture and size distribution of native material, it should respond similarly to beach building and erosional processes. Additionally, it should provide similar habitat for beach organisms.

Borrow sediments that are significantly finer than the native beach would tend to be unstable and shift offshore into deeper water leaving gentler slopes (Dean 2002). Sediment that is much coarser than the native beach would alter the profile and produce steeper slopes at the coast. The Applicant seeks to use sand that closely matches the native beach sediment in the wider Buxton area. Appendix C – *Geotechnical Data* contains detailed sediment data for the project area and proposed borrow area. Following is a summary of findings.

Native Beach Sediments

To prepare Appendix C – *Geotechnical Data*, the Applicant obtained 140 samples between stations 1760+00 and 1980+00 (~4.2 miles) in the Buxton Action Area in October 2014. Ten transects with 14 samples per transect were obtained between the foredune and the −24-foot NAVD depth contour. Sample positions were as prescribed under state of North Carolina rules and standards for beach fill projects (re: 15A NCAC 07H.0312). The summary graphs of Figures 3.6 and 3.7 show the results for mean grain size. Figure 3.6 shows mean grain size by sample position (cross-shore position) and station. Figure 3.7 shows the mean grain size by cross-shore position. The results indicate a wide range of grain sizes between the foredune and underwater area seaward of the bar at Buxton. The visible beach is predominantly ~0.5–0.6 millimeter sand, whereas the offshore zone is dominated by ~0.25 millimeter sand.

Samples near the low watermark (wave plunge point) and in the trough between the shoreline and longshore bar contain very coarse sediments averaging a mean diameter of ~1.2–2.3 millimeters. This highly variable size distribution makes it more difficult to select a target native size. The Applicant elected to compute several representative mean grain sizes for the Buxton Action Area using select groups of samples. Table 3.1 gives results for four groups of samples (weighted):

Comp 140 – all samples
Comp 130 – all but the trough samples
Comp 120 – all but the trough and mean low water samples
Comp 60 – all the subaerial samples above mean low water

The designation comp is the abbreviation for the composite results, and the numeric value corresponds with the applicable number of samples. The results are weighted (rather than arithmetic) by combining the results of all laboratory sample splits (see Appendix C – *Geotechnical Data*). This is analogous to combining and mixing the applicable number of physical samples, then testing them for sediment size distribution by mechanical sieving.

As Table 3.1 indicates, the mean of all samples (Comp 140) is 0.465 millimeter. Elimination of the outlier samples of the trough and mean low water yields mean grain sizes of 0.411 millimeter (Comp 130) and 0.380 millimeter (Comp 120). The subaerial samples alone (Comp 60) have a mean grain size of 0.582 millimeter (October 2014 conditions). In an earlier sampling in August 2013, Coastal Science & Engineering (2013b) found the sub aerial mean grain size was 0.435 millimeter (based on 24 samples). The difference in mean size for the visible beach between August 2013 and October 2014 likely reflects seasonal exchange of finer sediments from offshore. In high-energy fall and winter months, the finer sand naturally tends to shift toward the ocean bar, leaving coarser sediments in place. The Applicant used the range of mean grain sizes along Buxton to compare with the borrow sediments.

Borrow Samples

The Applicant obtained 37 three-inch borings in an offshore sand search grid (see Fig 3.5). Core spacing was ~1,000 feet; core lengths averaged around 8 feet. The density of cores is ~1 per 11.5 acres within the sand search area, and the cores exhibited lateral and vertical consistency. The majority of the cores were determined to meet or exceed state standards for beach-fill sediment quality based on grain size, gravel, shell, and mud content. Figures 3.8 and 3.9 illustrate one representative core from the east center of the proposed borrow area. Its texture and color were found to be similar to Buxton beach with no layers of mud, cemented sediment, or coarse shell material. Details for all borings and subsamples are given in Appendix C (*Geotechnical Data*).

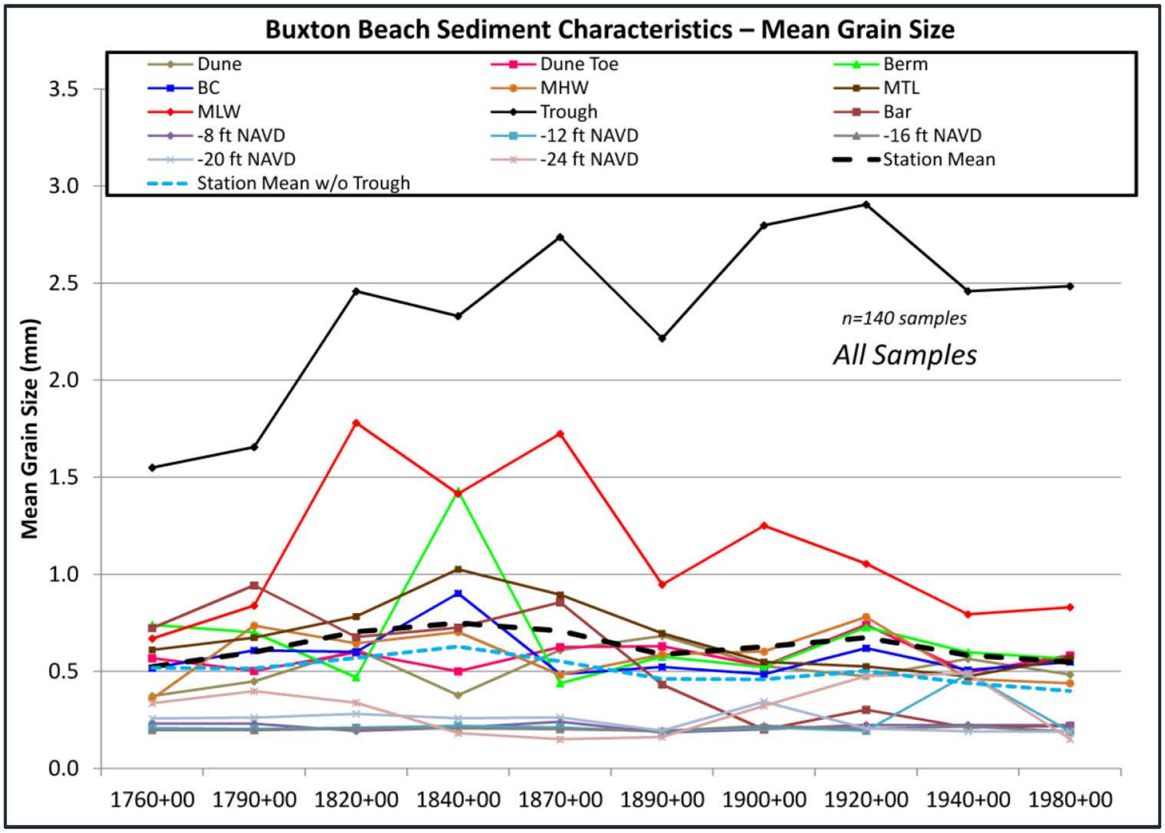


Figure 3.6. Graph showing mean grain size in millimeters (y-axis) by station for all beach samples along the Buxton Action Area. Results represent ten transects with 14 samples per transect between the foredune and the −24-foot depth contour. Samples were obtained in October 2014. Note outlier coarse sample results (grain size ~1–3 millimeters, typical) for the trough area (between the beach and the bar). The mean low-water (MLW) samples also tested much coarser than the remaining samples. [BC – berm crest. MTL – mean tide level. NAVD – North American Vertical Datum of 1988.]

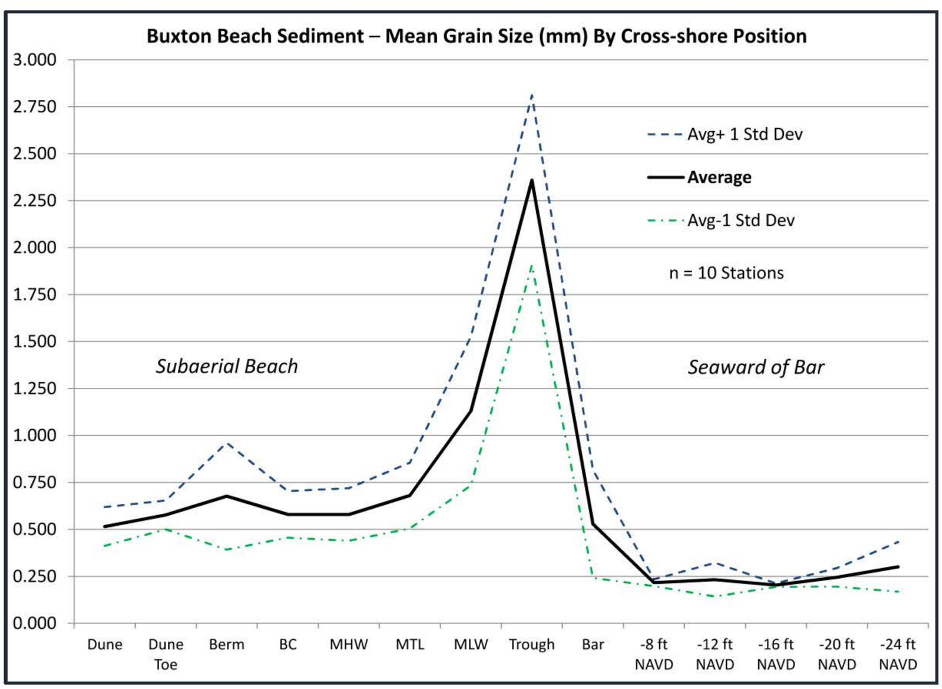


Figure 3.7.

Arithmetic mean grain size by sample position based on ten samples per station.

The visible (subaerial) beach samples were typically 0.5–0.6 millimeter in October 2014.

The underwater samples (i.e. at −8 feet, −12 feet, etc.) averaged ~0.25 millimeter. Outlier samples from the trough averaged ~2.5 millimeters.

Table 3.1. Tables showing native mean grain size for Buxton. Results are for selected groups of samples. The results in bold are considered most representative of the beach, consistent with size distributions for other Outer Banks localities (Birkemeier et al. 1985, USACE 2010). Upper table gives phi and millimeter results using the method of moments; the second table down gives the results based on the Folk and Ward (1957) graphical method using phi units; the bottom two tables are Unified Soil Classification System (USCS) sand classification and the Wentworth description. [UW = underwater samples]

Buxton Beach Sediment Characteristics		Method of Moments					
		Mean	STD	Mean	STD	Skew	Kurt
		mm	mm	phi			
All Sta-Comp140	All X-Shore Samples	0.465	0.413	1.104	1.277	-0.612	3.164
All Sta-Comp130	**Exclude Trough**	**0.411**	**0.464**	**1.284**	**1.108**	**-0.391**	**2.807**
All Sta-Comp120	Exclude MLW & Trough	0.380	0.485	1.395	1.043	-0.344	2.672
All Sta-Comp60	Exclude All UW Samples	0.582	0.598	0.780	0.743	-0.256	3.349

Buxton Beach Sediment Characteristics		Folk Graphical Method				
		Mean	STD	ISTD	Skew	Kurt
		phi				
All Sta-Comp140	All X-Shore Samples	1.028	1.273	1.280	-0.146	0.949
All Sta-Comp130	**Exclude Trough**	**1.190**	**1.118**	**1.093**	**-0.076**	**0.842**
All Sta-Comp120	Exclude MLW & Trough	1.288	1.050	1.026	-0.084	0.826
All Sta-Comp60	Exclude All UW Samples	0.655	0.723	0.730	-0.029	1.029

Sample	Interval	USCS Description		
All Sta-Comp140	All X-Shore Samples	SP	Medium Sand	Poorly Graded
All Sta-Comp130	**Exclude Trough**	**SP**	**Fine Sand**	**Poorly Graded**
All Sta-Comp120	Exclude MLW & Trough	SP	Fine Sand	Poorly Graded
All Sta-Comp60	Exclude All UW Samples	SP	Medium Sand	Poorly Graded

Sample	Interval	Wentworth Description			
All Sta-Comp140	All X-Shore Samples	Medium Sand	Poorly Sorted	Coarse Skewed	Mesokurtic
All Sta-Comp130	**Exclude Trough**	**Medium Sand**	**Poorly Sorted**	**Symmetrical**	**Mesokurtic**
All Sta-Comp120	Exclude MLW & Trough	Medium Sand	Poorly Sorted	Symmetrical	Mesokurtic
All Sta-Comp60	Exclude All UW Samples	Coarse Sand	Moderately Sorted	Symmetrical	Mesokurtic

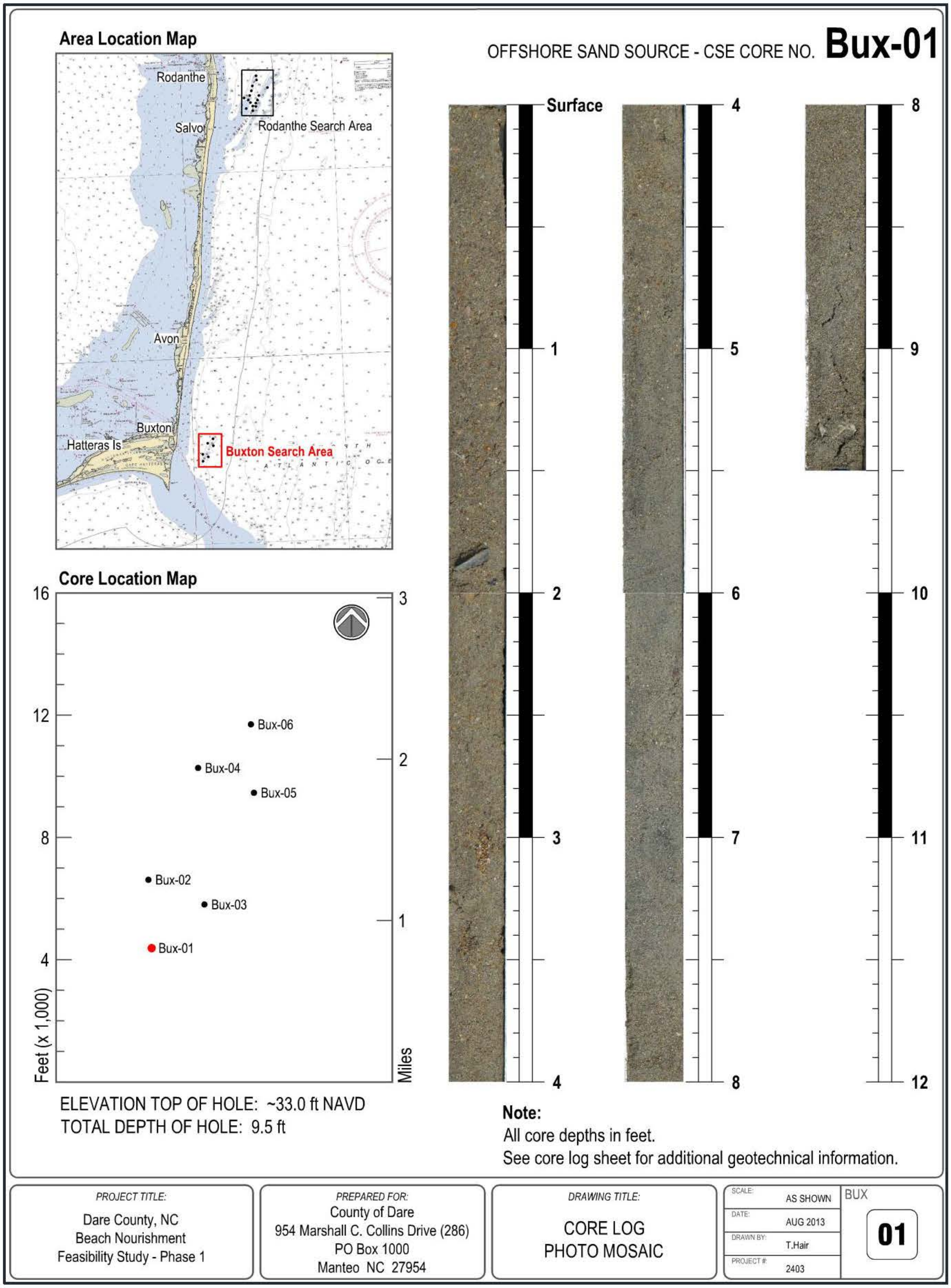


Figure 3.8. Example core photo log for BUX-01 obtained by CSE in August 2013 in water depths of ~33 feet. Core Bux-01 is situated near the outer (east) boundary in the center of the proposed borrow area. Initial cores Bux-03, Bux-04, Bux-05 and Bux-06 were found to be poor quality. Those sand search areas were eliminated from consideration, leaving 33 out of 37 cores within the primary borrow area (See Fig 3.5).

CORE LOG	Coastal Science & Engineering			Sheet 1 of 1
PROJECT:	2403 - Dare County	COORDINATES: Northing: 561226.750 Easting: 3048052.106 Grid Datum: NAD '83		HOLE NUMBER: Bux-1 (as shown on title drawing and file no.)
LOCALITY:	Buxton - Offshore			

DATE:	2013-Jul-09	TOP ELEVATION:	-33.00 ft. NAVD '88	DEVICE DESIGNATION:	Coastal Science & Engineering
BORE ANGLE:	90.00°				
BURDEN THICKNESS:	9.5 ft.	BOTTOM ELEVATION:	-42.50 ft. NAVD '88	BARREL SIZE/TYPE:	3 in. Aluminum
CORE RECOVERY:	9.5 ft. (100.0%)	WATER DEPTH:	(operational note only)	GEOLOGIST: FIELD TEAM:	TWK - NC #1752 DG, ST, TH

Depth	Lithology	Classification Of Materials (Description)	Sample #	Remarks
0–2		0.0 to 2.0 ft: Medium Sand / Coarse Sand mix - Mixed, clean, lt tan with minor shell -- 1.8 ft: Small Scallop - 4 cm fragment	S1	S1: 0.0 ft. to 2.0 ft. Mean Grain Size: 0.428mm
2–4		2.0 to 4.0 ft: Medium Sand / Coarse Sand mix - Mixed, clean, lt tan with minor shell. 3 cm mollusk fragment @ 2.2'. Scattered large shell clasts eg. 4-6 cm scallops	S2	S2: 2.0 ft. to 4.0 ft. Mean Grain Size: 0.402mm
4–6		4.0 to 6.0 ft: Medium Sand - Clean, lt tan	S3	S3: 4.0 ft. to 6.0 ft. Mean Grain Size: 0.374mm
6–7.5		6.0 to 7.5 ft: Medium Sand - Mixed, clean, greyish lt tan	S4	S4: 6.0 ft. to 7.5 ft. Mean Grain Size: 0.375mm
7.5–9.5		7.5 to 9.5 ft: Medium Sand / Coarse Sand mix - Mixed, clean, lt tan Sand dollar fragment	S5	S5: 7.5 ft. to 9.5 ft. Mean Grain Size: 0.440mm
10				

Figure 3.9. Core log for BUX-01 showing the lithology, sample intervals, and mean grain sizes. Sediments classify as medium-coarse sand with isolated shell class as indicated on the graphic.

Figure 3.10 summarizes key statistics for each core in the offshore borrows area. Weighted composites to 4 feet, 6 feet, and 8 feet of core section were developed from random-length, individual samples. These data provide an indication of the degree of similarity between the upper and lower layers of each core. One of the environmental concerns of using offshore borrow areas is the possibility that underlying sediments after excavation would be dissimilar and would not provide the same substrate for recolonization by benthic organisms (USACE 2010, NPS 2012). The Buxton borings exhibit highly similar mean sizes, shell content, and gravel percentages in each vertical composite. This is also confirmed via color-coded isopach maps of the sets of composites (see Appendix C, Figs 4.5–4.7).

Figure 3.10. Maps of the core locations within the proposed borrow area (three panels) showing mean grain size, percent shell, and percent gravel for core composite samples to 4 feet and 8 feet in the Buxton offshore sand search area based on borings obtained in October 2014. Bux-13 was attempted but not recovered. Composite results to 6 feet (not shown) fall between the results for 4 feet and 8 feet.

Geotechnical studies for the Buxton project (Appendix C – *Geotechnical Data*) indicate that the visible beach contains medium-coarse sand in the 0.4–0.6 millimeter mean size range with some seasonal variation. By comparison, the underwater portion of the profile is dominated by fairly uniform, fine sand (~0.25 millimeter), but includes localized concentrations of coarse material in the trough. Similar mixtures across the littoral profile occur at Duck, North Carolina (Birkemeier et al. 1985) (see Appendix C, Fig 1.3). For the present project, the Applicant sought borrow sand that is a relatively close match in size to the visible beach. Table 3.2 summarizes the mean grain size, shell percent, and gravel percent for the available offshore cores. The mean sizes fall between the measured native mean sizes on the subaerial beach in August 2013 and October 2014. As Table 3.2 indicates, the mean size, shell percent, and gravel percent are relatively constant for the indicated composite depths in the borrow area.

TABLE 3.2. Average arithmetic mean grain size, standard deviation, shell percentage, and gravel percentage for 37 borings (135 samples) off Buxton (All Samples). Composites are weighted by applicable length of individual samples for the upper 4 feet of core (Comp 4), the upper 6 feet of core (Comp 6), and the upper 8 feet of core (Comp 8). Composite statistics are based on 33 cores within the box shown in Figure 3.10. Standard deviation for shell and gravel percentages is given in parentheses.

Core Samples	Mean Size (mm)	Std Deviation (mm)	Shell (percent)	Gravel (percent)
All Samples	0.446	0.615	15.1 (7.5)	2.8 (5.2)
Comp 4 feet	0.466	0.609	14.8 (5.9)	2.5 (1.7)
Comp 6 feet	0.455	0.604	14.2 (4.8)	2.3 (1.4)
Comp 8 feet	0.447	0.605	14.5 (5.1)	2.5 (1.5)

WATER QUALITY

Water quality is generally evaluated by a number of parameters including water chemistry, turbidity, and light attenuation. Water chemistry is affected by runoff and pollutants moved into an area from a source. Along ocean beaches well removed from inlets and rivers, such as the Buxton Action Area, constant mixing and exchange occur under the natural processes of wave breaking and currents. The dominant sediments are sand-sized with negligible fine-grained material. Sandy sediments do not absorb and retain pollutants the way muddy sediments do. In addition, suspended sediment in the surf zone tends to involve short, intermittent suspensions under the wave-breaking process with sands settling quickly. The amount of sediment in suspension is directly proportional to the energy of waves with storm conditions producing more turbidity (Komar 1998).

State sediment-quality standards for borrow areas allow sources to contain up to 5% fines over ambient conditions. This standard is applied so as to allow recycling of some harbor sediments and dredge disposal material back to beaches (NCDENR, J. Warren, Coastal Management Specialist, pers. comm., January 2007). A project involving 1 million cubic yards could, therefore, introduce up to 50,000 cubic yards of fine-grained material like clays and silts into the surf zone under existing state regulations. To protect public health, the federal Beaches Environmental Assessment and Coastal Health Act (BEACH) helps states and local governments develop monitoring programs. Through these programs, local officials test beach water for bacteria and issue closings or advisories when bacterial levels exceed a certain threshold.

The US Environmental Protection Agency recently issued a new Beach Action Value [BAV or 60 enterococcus bacteria colony forming units (cfu) per 100 ml marine or estuarine water in a single sample]. This is a more protective threshold than the national allowable bacteria levels used in previous years to trigger beach advisories. The EPA considers the BAV to be a conservative, precautionary tool for making beach notification decisions. While the use of the BAV is currently optional, the EPA's proposed *National Beach Guidance and Required Performance Criteria for Grants* would require states receiving BEACH Act funding to use the BAV to trigger beach notifications.

According to the Natural Resources Defense Council, in 2013 North Carolina beaches ranked fifth out of 30 states in beach water quality. The beach at Cape Hatteras Lighthouse was among the four beaches in North Carolina rated as a Super Star beach; all four beaches have had 0%of samples exceed the BAV in 2013 or the national standard from 2009 to 2012.

However, as of the 2012 reporting year, all water bodies of North Carolina were designated impaired for aquatic life harvesting of certain species of freshwater or ocean fish, including the Atlantic Ocean Waterbody ID NC99-(7)i that the Buxton project area falls within and the Pamlico Sound Waterbody NC30-22f adjacent to Buxton. This was due to concentrations of methylmercury in their tissues. [USEPA website (http://ofmpub.epa.gov/waters10/attains_watershed.control?p_state=NC&p_ huc= 03020105&p_cycle=2012&p_report_type=), NCDENR 2012]. In addition to the mercury impairment, Pamlico Sound is also impaired for shellfish growing due to pathogens.

No quantitative turbidity data are available for the Buxton Action Area, including the offshore borrow Area. Anecdotal information from divers obtained during geotechnical surveys offshore indicated variable visibility over the shoal, ranging from 5-30 feet (typical) near the bottom (Coastal Science & Engineering, Inc., unpublished field notes, 2014). A low-concentration silty layer roughly four feet thick was observed at the bottom at some localities. All stations samples (n = 33) exhibited rippled sand beds with no mud drapes in ripple troughs (a common feature where high turbidity waters occur, such as off Charleston, South Carolina). The anecdotal information on turbidity in the action area suggests suspended sediment concentrations are low and patchy. Variations in wave energy likely control turbidity levels at the borrow area as well as the surf zone.

One public supply wellfield is designated a Public Water Supply Area of Environmental Concern (AEC) by the NC Coastal Resources Commission to protect it from pollutants associated with development. That particular wellfield is on Hatteras Island and supplies Buxton Village with its drinking water. As a water supply held in rapidly draining sands from the earth's surface to a shallow water table, the AEC wellfield is particularly susceptible to contaminants from pavement and rooftop runoff.

Nearby ponds and wetlands also warrant monitoring. Open Pond, a large pond ~300 meters long and 100 meters wide, is located in the southern portion of Buxton Woods. Extensive wetlands are located south of Buxton Woods in the Cape Point area. Some are drained through a large pond area into the ocean, while some of the wetlands on the south side of the island are drained through a gated culvert operated by the National Park Service, with a range of 0–37,800 cubic meters per day (0–10 million gallons per day), ~1 mile from the Proposed Action Area. In 2003 and 2004, water samples taken by NC Shellfish Sanitation from the beach near the gated culvert that drains wetlands showed several excessive counts of enterococcus bacteria. This resulted in posted warning signs and beach closures in the area. Any water-quality issues from the drainage, such as high concentrations of fecal microbes or enterococcus bacteria, could impact the beach (the Seashore Water Certification Authority) and therefore should be included in monitoring activities.

ESSENTIAL FISH HABITAT (EFH)

The Magnuson-Stevens Act defines Essential Fish Habitat as all waters and substrates necessary to fish for spawning, breeding, feeding, or growth to maturity and may include habitat for individual species or an assemblage of species so designated by regional fishery management councils. The Act also requires these regional councils to develop a Fishery Management Plan (FMP) for each resource or species and to identify any Habitat Areas of Particular Concern (HAPC) within an EFH. The FMPs are periodically amended. The HAPC must meet one of four criteria based on either ecological function, habitat sensitivity to human degradation, human development activities stresses, or rarity.

On behalf of Dare County (via email dated 1 October 2014), the National Oceanic and Atmospheric Administration (NOAA) Southeast Regional Office (SERO) was notified about the proposed Buxton project and informed that an *Essential Fish Habitat Assessment (*Appendix D) was in preparation. The notification arrived via the Endangered Species Act (ESA) consultation email address on the Southeast Regional Office's website. The Southeast Regional Office's webpage also was used to generate the list of species to evaluate. Additional email correspondence to the National Marine Fisheries Service personnel occurred on 1 October 2014 and 29 January 2015. Although both the South Atlantic Fisheries Management Council (SAFMC) and the Mid Atlantic Fisheries Management Council (MAFMC) manage numerous fish stocks, only those which have a federal Fishery Management Plan have designated Essential Fish Habitat.

While no official coordination is required with the Atlantic States Marine Fisheries Commission (ASMFC), since 1942 it has been the deliberative body of the Atlantic coastal states and coordinates the management and conservation of 25 nearshore fish species. Some of these 25 species are also managed by either the South Atlantic Fisheries Management Council or the Mid Atlantic Fisheries Management Council, and many also use the Essential Fish Habitat and/or Habitat Areas of Particular Concern (HAPC) addressed in the *Buxton Essential Fish Habitat Assessment.*

Dare County would continue the coordination required to receive concurrence on the effects of analysis of Essential Fish Habitat and the conservation/mitigation recommendations included in Appendix D - *Essential Fish Habitat Assessment.* The County would address agency concerns and comments during the permitting phase of the selected Action. Pertinent summary information from the *Buxton Essential Fish Habitat Assessment* is included below, and the complete *Essential Fish Habitat Assessment* is included in Appendix D of this Environmental Assessment.

The Fishery Management Plan amendments of South Atlantic Fisheries Management Council and Mid Atlantic Fisheries Management Council identify numerous categories of Essential Fish Habitat and multiple Habitat Areas of Particular Concern for the south Atlantic area, which are listed in Table 3.3. The Habitat Areas of Particular Concern are subsets of Essential Fish Habitat which are rare, particularly susceptible to human-induced degradation, especially ecologically important, or located in an environmentally stressed area. In general, HAPC include high value intertidal and estuarine habitats, offshore areas of high habitat value or vertical relief, and habitats used for migration, spawning, and rearing of fish and shellfish. Due to characteristics of the proposed project location where only estuarine and marine environments occur, palustrine and freshwater EFH are not included in other tables or in additional analyses.

The habitats and HAPC for species managed by the Atlantic States Fishery Management Council (ASFMC) and EFH and HAPC for SAFMC-managed species are shown in Table 3.4. These are shown along with the species for which a fishery management plan (FMP) has been developed and the species assigned Atlantic States Fishery Management Council strategies and management goals.

Table 3.3 Categories of Essential Fish Habitat (EFH) and Habitat Areas of Particular Concern (HAPC) defined in the south Atlantic region and in North Carolina in the vicinity of the Buxton Action Area.

NOTES: EFH areas are identified in FMP Amendments for SAFMC and MAFMC. Geographically defined HAPC are identified in FMP Amendments affecting the south Atlantic area. The EFH for species managed under NMFS Billfish and Highly Migratory Species generally falls within the marine and estuarine water column habitats designated by the Councils. Information in this table was derived from Appendices 4 and 5 of NMFS 2010 and SAFMC EFH and HAPC designations from http://www.safmc.net/ecosystem-management/essential-fish-habitat).

EFH	GEOGRAPHICALLY DEFINED HAPC
Palustrine Areas	**Area - Wide**
Unconsolidated bottom/aquatic beds	*Sargassum* habitat (pelagic and benthic)
Tidal forest	Hard bottoms
Tidal freshwater	Hoyt Hills
Estuarine Areas	State-designated Areas of Importance to Managed Species
Subtidal and intertidal non-vegetated flats	All coastal inlets
Emergent wetlands	Council-designated Artificial Reef Special Management Zones
Estuarine scrub / shrub (mangroves)	Hermatypic coral habitat and reefs
Water column	
State-designated PNAs and SNAs	
Unconsolidated bottom	
Oyster reefs and shell banks	
Submerged aquatic vegetation (SAV)	
Coastal inlets	
Marine Areas	**North Carolina**
Unconsolidated bottom/aquatic beds	Bogue Sound
Artificial / manmade reefs	Pamlico Sound at Hatteras/ islands
Coral reefs	New River
Live/hard bottom	The Ten Fathom Ledge
Sargassum	Big Rock
Water column	Sandy shoals at capes (Hatteras, Lookout, Fear)
Emergent wetlands	The Point
Submerged aquatic vegetation (SAV)	
Continental shelf currents/Gulf Stream	
Ocean high salinity surf zones	
Sandy shoals of capes and offshore bars	
Coastal inlets	

Table 3.4 Habitat type and Habitats of Particular Concern (HAPC) within the project vicinity or impact area and for which potential impacts may occur for ASFMC-managed species and SAFMC EFH or HAPC as shown in Table 3.3 and the protected resource designated to that habitat under a fishery management plan developed for Each protected resource. (* indicates ASMFC habitat, ASMFC HAPC, or SAFMC EFH; ** indicates SAFMC HAPC). (Table 5.3 from Appendix D – EFHA)

HABITAT TYPE	FMP	ASMFC
Unconsolidated bottom*	Red drum, snapper grouper, spiny lobster	Red drum, horseshoe crab, scup, spiny dogfish, summer flounder
Offshore marine habitats used for spawning and growth to maturity*	Shrimp, snapper grouper	Atlantic menhaden, Atlantic striped bass, Atlantic sturgeon, bluefish, alewife, American shad, blueback herring, hickory shad, Spanish mackerel, spiny dogfish, spot, spotted sea trout, weakfish, Atlantic coastal sharks
Ocean high salinity surf zones*	Red drum, coastal migratory pelagics	Red drum, Atlantic striped bass, bluefish, spotted sea trout, Atlantic coastal sharks
Live/hardbottom*	Snapper grouper, spiny lobster	Black sea bass, scup
Spawning area in the water column above the adult habitat and the additional pelagic environment, including sargassum; Sargasso Sea*	Snapper grouper, coastal migratory pelagics	American eel
Barrier island ocean side waters from the surf to shelf break zone but shoreward of the Gulf Stream*	Coastal migratory pelagics	Horseshoe crab
All state-designated nursery habitats of particular importance (all PNAs and SNAs in North Carolina)*	Coastal migratory pelagics, shrimp	Atlantic croaker, American eel, Atlantic herring, black sea bass, Atlantic sturgeon, scup, alewife, American shad, hickory shad, Spanish mackerel, spiny dogfish, spot, spotted sea trout, summer flounder, weakfish, Atlantic coastal sharks
Shallow subtidal bottom*	Spiny lobster	Horseshoe crab, scup
Pelagic sargassum habitat**	For dolphin under coastal migratory pelagics	
Sandy shoals of Cape Hatteras from shore to the ends, but shoreward of the Gulf Stream**	Coastal migratory pelagics	Red drum, horseshoe crab, scup, bluefish, summer flounder

BIOLOGICAL RESOURCES

Vegetation

Plant species identified for the Seashore number 1,072 that are definitely present (not including varieties or subspecies) and three additional species that are probably present. Harsh conditions such as wave and wind exposures affect the amount of vegetation cover on the beach and dunes. The upper beach of the Seashore is sparsely covered with American sea rocket (*Cakile edentula*) and possibly seabeach amaranth (*Amaranthus pumilus*), a federally-listed species. Dune slopes are sparsely to densely covered in patches of species such as firewheel (*Gallardia pulchella*), largeleaf pennywort (*Hydrocotyle bonariensis*), prickly pear cactus (*Opuntia pusilla*), shore little bluestem (*Schizachyrium littorale*), lanceleaf greenbriar (*Smilax smalli*), salt meadow cordgrass (*Spartina patens*), and sea oats (*Uniola paniculata*) (NPS 2014).

Terrestrial and Marine Wildlife

The Seashore is a permanent and temporary home to a great variety of terrestrial and aquatic life, including threatened, endangered, and other protected species. These species depend on the special habitats resulting from the transition between the northern and southern habitat zones and the dynamic nature of the barrier islands. Special-status species are discussed in further detail in the section following.

The Seashore, a Globally Important Bird Area (GIBA), is a critical natural landform along the Atlantic Flyway, serving as major resting and feeding grounds for migratory birds throughout the year. The barrier island ecosystem is also important to several species of shorebirds that use the Seashore as nesting grounds. Shorebirds are most abundant from late spring through the summer months. There are 365 species of birds documented at the Seashore, with an additional four species that are probably present.

The Seashore also provides habitat for a variety of reptiles, amphibians, mammals, and fish. Thirty-two (32) species of reptiles have been documented at the Seashore, including one alligator species, 14 snake species, five lizard species, and 12 turtle species. Twelve (12) species of amphibians are present, including nine species of frogs and three species of salamanders. There are 26 species of mammals documented and 8 marine mammals that are probably present. Fish species number 60 that are present, with 236 species that are probably present.

Special-Status Species

Species listed as threatened or endangered by the US Fish & Wildlife Service or National Marine Fisheries Service are afforded federal protection under the Endangered Species Act of 1973 as amended. In North Carolina, animal species designated by the NCDENR Wildlife Resources Commission (NCWRC) and the NCDENR Natural Heritage Program (NCNHP) as threatened, endangered, or species of concern are afforded legal protection by the Endangered Species Act (Article 25, Chapter 113, General Statutes 1987). Plant species in North Carolina determined by the Plant Conservation Program (NC Department of Agriculture) and the NC Natural Heritage Program as threatened, endangered, or special concern are protected by the Plant Protection and Conservation Act of 1979. During the preparation of the *Biological Assessment* (Appendix B), 19 species with special status were excluded from evaluation, as they were deemed not likely to occur within the project area or vicinity. These 19 species are shown in Table 3.5. Species listed only by the state and not federally-listed as threatened or endangered are discussed in the section State-Protected Species.

Table 3.5 Threatened, endangered, and candidate/proposed species with the potential to occur within the action/ analysis area as determined by state and/or federal agencies with jurisdictional authority. The species lists were obtained from appropriate agencies (USFWS, NMFS, NCNHP) and reviewed; species without the potential to occur were excluded from further review with a no-effect determination based on the rationale codes as shown below.

[1] **Status Codes**: **E/E**= federally and state listed endangered; **E***=state listed endangered; **T/T**=federally and state listed threatened; **T***=state listed threatened; **SC**= state listed special concern; **V**=state listed vulnerable; **P**= federally proposed for listing; **Exp**=experimental population, non-essential

[2] **Exclusion Rationale Codes**: **HAB**=no habitat present in analysis area

SPECIES COMMON & SCIENTIFIC NAME	STATUS[1]	POTENTIAL TO OCCUR	RATIONALE FOR EXCLUSION[2]	HABITAT DESCRIPTION AND RANGE
BIRDS				
Red-cockaded woodpecker (*Picoides borealis*)	E	No	HAB	Mature pine forests with an open understory
Little blue heron (*Egretta cerulean*)	SC	No	HAB	Forests or thickets on maritime islands
Snowy egret (*Egretta thula*)	SC	No	HAB	Forests or thickets on maritime islands
Tricolored heron (*Egretta tricolor*)	SC	No	HAB	Forests or thickets on maritime islands
Least bittern (*Ixobrychus exilis*)	SC	No	HAB	Fresh or brackish marshes
Black rail (*Laterallus jamaicensis*)	SC	No	HAB	Brackish marshes, rarely freshwater marshes
Glossy ibis (*Plegadis falcinellus*)	SC	No	HAB	Forests or thickets on maritime islands
FLOWERING PLANTS				
Georgia sunrose (*Crocanthemum georgianum*)	E*	No	HAB	Maritime forests
Gulfcoast spikerush (*Eleocharis cellulosa*)	E*	No	HAB	Brackish marsh
Lanceleaf seedbox (*Ludwigia lanceolata*)	E*	No	HAB	Brackish marsh
Florida adder's mouth (*Malaxis spicata*)	SC-V	No	HAB	Swamps, low woods, streambanks
Four angled flatedge (*Cyperus tetragonus*)	SC-V	No	HAB	Open woods, thickets, barrier islands
MAMMALS				
West Indian manatee (*Trichetus manatus*)	E	Yes	HAB	Florida coast and Caribbean; rare visitor to NC waters and further north; 5 NC strandings 1997-2008 all inshore, 2 in Alternative 3–Summer Construction window (July, August)
Red wolf (*Canis rufus*)	Exp	No	HAB	NC's Albemarle peninsula, species found from agricultural lands to pocosins in areas of low human density, a wetland soil type, and distance from roads.
Buxton Woods white-footed deermouse (*Peromyscus leucopus buxtoni*)	SC	No	HAB	Only found in maritime forest of Buxton Woods
REPTILES[1]				
Carolina watersnake (*Nerodia sipedon williamengelsi*)	SC	No	HAB	Salt or brackish marshes
Outer Banks king snake (*Lampropeltis getula sticticeps*)	SC	No	HAB	Maritime forests, thickets, and grasslands of the Outer Banks
Timber rattlesnake (*Crotalus horridus*)	SC	No	HAB	Wetland forests in the coastal plain.

Federally Protected Species

The *Biological Assessment* (Appendix B) prepared for this project evaluated 14 species which had the potential to occur in the action area or vicinity and were protected under the Endangered Species Act of 1973. These 14 species included three birds, two fish, five sea turtles, three whales, and one plant. The northern long-eared bat (*Myotis septentrionalis*) was proposed by the US Fish & Wildlife Service to be listed as endangered under the ESA on 2 October 2013. During the Biological Assessment evaluation, the USFWS agreed that habitat for the northern long-eared bat does not exist within the Proposed Action Area. Therefore, the species was not evaluated within Appendix B, and is not included in Table 3.5.

Marine Mammals. The US Marine Mammal Protection Act (MMPA) of 1972 (amended 1994) protects all marine mammals, including cetaceans (whales, dolphins, and porpoises), pinnipeds (seals and sea lions), sirenians (manatees, dugongs), sea otters, and polar bears within the waters of the United States. It was the first act the US Congress passed to specifically call for an ecosystem approach to natural resource management and conservation. The MMPA prohibits marine mammal take, and enacts a moratorium on the import, export, and sale of any marine mammal, any marine mammal part or product within the United States. The Act defines take as the act of hunting, killing, capture, and/or harassment of any marine mammal; or, the attempt at such. It defines harassment as any act of pursuit, torment or annoyance which has the potential to either: a) injure a marine mammal in the wild, or b) disturb a marine mammal by causing disruption of behavioral patterns, which includes, but is not limited to, migration, breathing, nursing, breeding, feeding, or sheltering.

The Marine Mammal Protection Act provides for enforcement of its prohibitions, and for the issuance of regulations to implement its legislative goals. The US Fish & Wildlife Service was given the authority to ensure protection of sea otters and marine otters, walruses, polar bears, three species of manatees and dugongs; the National Oceanic Atmospheric Administration was given responsibility to conserve and manage pinnipeds, including seals, sea lions, and cetaceans such as whales and dolphins.

As shown in Table 3.6, four species of earless seal, 17 species of oceanic dolphin, one porpoise species, three sperm whale species, five species of beaked whales, five species of rorquals, one species of right whale, and one manatee species have the potential to occur in North Carolina waters. Of these 37 species, six species have additional federal protection under the ESA and are addressed in detail in Appendix B – *Biological Assessment*. Five of the six ESA species are under the protection of the National Marine Fisheries Service, and one is under US Fish & Wildlife Service. The four species in Table 3.6 shown as common or abundant are described below.

Atlantic Spotted Dolphin (*Stenella frontalis*)

Due to uncertainties about population status and trends, the Atlantic spotted dolphin is considered as Data Deficient by the International Union for Conservation of Nature (IUCN). It occurs throughout the warm temperate, subtropical, and tropical waters of the Atlantic Ocean. They have a widespread distribution that ranges from the US East Coast (Gulf of Mexico to Cape Cod, Massachusetts), the Azores and Canary Islands, to Gabon, and Brazil. Distribution is suspected to be affected by warm currents such as the Gulf Stream. A long-term resident population is well known in the sand flats of the Bahamas.

Table 3.6 Marine mammals which may occur in North Carolina waters. Only bottlenose dolphins are known to be abundant.

[Occurrences from http://www.dpr.ncparks.gov/mammals/accounts.php and range limits per Webster et al. 1985.]
A = abundant C = common U = uncommon R = rare X = accidental/causal
*northern limit of range **southern limit of range

PHOCIDAE (Earless seals)		
Hooded seal	*Cystophora cristata*	X
Harbor seal	*Phoca vitulina*	R/U
Harp seal	*Pagophilus groenlandicus*	X/R
Gray seal	*Halichoerus grypus*	R
DELPHINIDAE (oceanic dolphins)		
Killer whale	*Orcinus orca*	X/R
Rough-toothed dolphin	*Steno bredanensis*	R
Striped dolphin	*Stenella coeruleoalba*	R/U
Atlantic spotted dolphin	*Stenella frontalis*	C
Spinner dolphin	*Stenella longirostris*	X/R*
Clymene dolphin	*Stenella clymene*	R
Pantropical spotted dolphin	*Stenella attenuata*	X/R*
Short-beaked common dolphin	*Delphinus delphis*	U/C
Common bottlenose dolphin	*Turciops truncatus*	C/A
Fraser's dolphin	*Lagenodelphis hosei*	X
Atlantic white-sided dolphin	*Lagenorhynchus acutus*	R
False killer whale	*Pseudorca crassidens*	R
Risso's dolphin	*Grampus griseus*	U
Long-finned pilot whale	*Globicephala melas*	R**
Short-finned pilot whale	*Globicephala macorhynchus*	C*
Pygmy killer whale	*Feresa attentuata*	X
Melon-headed whale	*Peponocephala electra*	X
PHOCOENIDAE (porpoises)		
Harbor porpoise	*Phocoena phocoena*	U
PHYSTERIDAE (sperm whales)		
Sperm whale	*Physeter macrocephalus*	U
ZIPHIIDAE (beaked whales)		
Gervais; beaked whale	*Mesoplodon europaeus*	R/U
Blainville's beaked whale	*Mesoplodon densirostris*	R
True's beaked whale	*Mesoplodon mirus*	X/R
Northern bottlenose whale	*Hyperoodon ampullatus*	X/R
Cuvier's beaked whale	*Ziphius cavirostris*	U
BALAENOPTERIDAE (rorquals)		
Fin whale	*Balaenoptera physalus*	R
Sei whale	*Balaenoptera borealis*	X
Common minke whale	*Balaenoptera acutorostrata*	X/R
Bryde's whale	*Balaenoptera edeni*	X
Humpback whale	*Megaptera novaengliae*	U
BALAENIDAE (bowhead and right whales)		
North Atlantic right whale	*Eubalaena glacialis*	R
KOGIIDAE (small sperm whales)		
Pygmy sperm whale	*Kogia breviceps*	R/U
Dwarf sperm whale	*Kogia simus*	R
TRICHECHIDAE (manatees)		
West Indian manatee	*Trichechus manatus*	R

A common to abundant dolphin in its range, and equally common to at times very common off the North Carolina coast, this dolphin is found mainly in warmer waters of the Gulf Stream, less so farther offshore. It is present in North Carolina waters year-round, as it is not seasonally migratory. It is often more frequently seen than the common bottlenose dolphin on boat trips, though the latter is the most abundant cetacean in North Carolina waters.

The Smithsonian National Museum of Natural History mammal collections lists 45 stranding records for North Carolina (http://collections.nmnh.si.edu/search/mammals/). As of 1995, twenty-five (25) strandings had occurred along the North Carolina coast (Webster et al., 1995), covering most months of the year. The 45 strandings reported in the National Museum of Natural History database also are fairly well spread out across the year.

Unlike most of the dolphins in North Carolina waters, this species prefers the shallower inshore waters, mainly over the continental shelf. Its status beyond the continental slope is not well known, and perhaps the majority of the spotted dolphins at these depths are pantropical spotted dolphin (*Stenella attenuata*) (http://www.dpr.ncparks.gov/mammals/reference.php). A medium-build dolphin, it is quite agile and frequently is seen leaving the water for its dives (more so than does the bottlenose dolphin). They are about 5-7.5 feet long and weigh 220-315 pounds. They have a robust or chunky body with a tall, falcate dorsal fin located midway down their back. The rounded melon is separated from the moderately long beak by a distinct crease. (Photo courtesy of NOAA Southeast Fisheries Science Center.) Their shape is often described as an intermediate between a bottlenose and pantropical spotted dolphin (Shirihai & Jarrett 2006 referenced at the National Marine Fisheries Service website http://www.nmfs.noaa.gov/pr/species/mammals/cetacEAns/spotteddolphin_atlantic.htm).

The coloration and patterns vary with age, lifestage, and geographic location. Calves and immature animals have an unspotted three-part muted coloration pattern consisting of a dark gray cape and lighter flanks with a pale white underside giving it a counter-shading effect. As animals age and mature, they gradually become darker and more heavily spotted, especially on the dorsal area. It also often comes to boats to bow-ride, where observers can see the spots and the pale blaze or wedge below the dorsal fin. It travels in smaller groups than most other dolphins, mainly 10-25 individuals. The two spotted dolphin species—Pantropical and Atlantic—are easily confused, as the amount of spotting is quite variable; some Atlantics can look spotless. On many trips to the Gulf Stream, observers can expect to see a few individuals of species, and often a few dozen or more can be seen (http://www.dpr.ncparks.gov/mammals/reference.php). For management purposes, Atlantic spotted dolphins inhabiting U.S. waters have been divided into two stocks: the Northern Gulf of Mexico Stock and the Western North Atlantic Stock. The northern Gulf of Mexico stock is estimated at 24,500-31,000 animals, while the population in the western North Atlantic is estimated at 36,000-51,000 animals. There are insufficient data available on current population trends.

Atlantic spotted dolphins have been incidentally taken as bycatch in fisheries such as gillnets and purse seines. This species has been observed interacting with various fishing vessels, often following and feeding on discarded catch. A few animals have been harpooned in the Caribbean, South America (e.g. Brazil), West Africa, and other offshore islands for food and bait.

Short-beaked Common Dolphin (*Delphinus delphis*)

Short-beaked common dolphins prefer warm tropical to cool temperate waters (52-88° F or 10-28° C) that are primarily oceanic and offshore, but still along the continental slope in waters 650-6,500 feet (200-2,000 m) deep. Short-beaked common dolphins also prefer areas where upwelling occurs. Though this species is found worldwide in temperate and tropical waters, in the Atlantic off the East coast of the

United States, it seems to prefer the more temperate zone. It is seen more often from Cape Hatteras northward than it is off the southern half of the North Carolina coast and is seen much less often than common bottlenose dolphins and Atlantic spotted dolphins. The southernmost stranding record is for Carteret County, with none at all along the southern 40% of the coastline. In the western North Atlantic, they are often associated with the Gulf Stream, although in the waters off North Carolina, it seems to favor deeper, temperate (cooler) water and is not often seen in the warm Gulf Stream waters or close to shore.

Short-beaked common dolphins are small dolphins under 9 feet long and weigh about 440 pounds. As adults, males are slightly larger than females. They have a rounded melon, moderately long beak, and a sleek but robust body with a tall, pointed, triangular, falcate dorsal fin located in the middle of the back. This species can be identified by its distinct bright coloration and patterns. A dark gray cape extends along the back from the beak and creates a V just below the dorsal fin on either side of the body. A yellow/tan panel appears along the flank, between the dark cape and white ventral patch, forward of the dorsal fin. This bold coloration forms a crisscrossing hourglass pattern. A narrow dark stripe extends from the lower jaw to the flipper. There is also a complex color pattern on the facial area and beak that includes a dark eye patch. The coloration and patterns of young and juvenile dolphins are muted and pale, but become more distinguishable and bolder as they mature into adulthood. These morphologies can be variable and distinct based on different geographic and regional populations. (Photo courtesy Howard Goldstein, NOAA.)

This is a very active and lively species, often coming to boats to bow-ride, and individuals are often seen leaping completely out of the water, so that the hourglass pattern and amber-colored patch on the side of the animal can be seen. Short-beaked dolphins are usually found in large social groups, averaging hundreds of individuals, but have occasionally been seen in larger herds consisting of thousands of animals (up to at least 10,000), known as mega-pods. These large schools are thought to consist of sub-groups of 20-30 individuals that are possibly related or separated by age and/or sex. Groups of several dozen dolphins are normal off North Carolina, and winter boat trips seem to offer more opportunities to see them than trips in warmer months. At times, 100 or more can be seen on a single boat trip.

Short-beaked dolphin is common within its overall range; however, in North Carolina waters, fairly common to at times common, and at that, mainly north of Cape Hatteras. It is rare in the warmer months and in warmer waters. The Smithsonian National Museum of Natural History mammal collections (2014 http://collections.nmnh.si.edu/search/mammals/) lists 47 stranding records for North Carolina, all from Carteret County northward, and all between November and June, with the great majority from February to April. Thus, in North Carolina waters, it is very rare to nearly absent in summer and most of the fall, and present mainly in the latter part of winter into early spring.

The short-beaked common dolphin is still abundant in most oceans with the exception of depleted populations in the Mediterranean and Black Sea. Threats include incidental take in a number of fisheries in the Atlantic Ocean, with several types of fishing gear, including longlines, driftnets, gillnets, and trawls. Hunting for their meat and oil also pose threats in Russia, Japan, and by nations bordering the Black Sea and Mediterranean Sea.

Common Bottlenose Dolphin (*Tursiops truncatus*)

Found worldwide in temperate and tropical waters ranging from latitudes of 45°N to 45°S, the bottlenose dolphin is one of the most well-known species of marine mammals in North America. It occurs in the Atlantic all along the coastline and far offshore and at times enters estuaries and river mouths.

They have a robust body and a short, thick beak. Their coloration ranges from light gray to black with lighter coloration on the belly. Inshore and offshore individuals vary in color and size. Inshore animals are smaller and lighter in color, while offshore animals are larger, darker in coloration and have smaller flippers. Bottlenose dolphins can sometimes be confused with the rough toothed dolphins (*Steno bredanensis*), Risso's dolphins (*Grampus griseus*), and Atlantic spotted dolphins in regions of overlapping distributions. (Photo courtesy of NOAA Southwest Fisheries Science Center. Pictured: female with calf.)

Bottlenose dolphins range in lengths from 6.0 to 12.5 feet with males slightly larger than females. Adults weigh from 300-1,400 pounds. This is a long-lived dolphin species with a lifespan of 40-45 years for males and more than 50 years for females. Sexual maturity varies by population and ranges from 5-13 years for females and 9-14 years for males. Calves are born after a 12-month gestation period and are weaned at 18 to 20 months. On average, calving occurs every 3 to 6 years. Females as old as 45 years-old have given birth (http://www.nmfs.noaa.gov/pr/species/mammals/dolphins/bottlenose-dolphin.html).

Bottlenose dolphins are generalists and feed on a variety of prey items endemic to their habitat, foraging individually and cooperatively. Like other dolphins, bottlenose dolphins use high frequency echolocation to locate and capture prey. Coastal animals prey on benthic invertebrates and fish, and offshore animals feed on pelagic squid and fish. Bottlenose dolphins employ multiple feeding strategies, including fish whacking, where they strike a fish with their flukes and knock it out of the water. Bottlenose dolphins are commonly found in groups of 2-15 individuals in North Carolina waters instead of many dozens to hundreds like those in other genera, but offshore herds can sometimes have several hundred individuals. This species is often associated with pilot whales and other cetacean species.

By far the most widely distributed cetacean in North Carolina waters from the continental shelf to the coastline, and the only dolphin species likely to be seen from shore. Bottlenose dolphins are quite active, though they are not quite as agile as some species, because they are somewhat stocky. Leaps completely out of the water are not as frequent as with many other dolphins. On offshore North Carolina boat trips, numbers can be matched or exceeded by Atlantic spotted dolphins, but bottlenose dolphins are typically seen on most trips. Separate populations/forms are found inshore and offshore, with an apparent gap between them; few biologists believe that the two populations or forms might represent separate species, but most probably do not share that belief (http://www.dpr.ncparks.gov/mammals/reference.php).

The Smithsonian National Museum of Natural History mammal collections (2014 http://collections.nmnh.si.edu/sEArch/mammals/) lists approximately 1,718 stranding records for North Carolina, by far the most for any cetacean species. Bottlenose dolphin can occur year-round in North Carolina waters. Numerous stranding records are reported for all 12 months, with more in the winter, perhaps owing to pregnant or nursing females or young with females at that time of year. Threats include incidental injury and mortality from fishing gear, such as gillnet, seine, trawl, and longline commercial and recreational operations, exposure to pollutants and biotoxins, viral outbreaks, and direct harvest in Japan and Taiwan. In 2006, the National Marine Fisheries Service implemented the Bottlenose Dolphin Take Reduction Plan (BDTRP) to reduce the serious injury and mortality of Western North Atlantic coastal bottlenose dolphins incidental to nine commercial fisheries in the United States. In addition to multiple non-regulatory provisions for research and education, the BDTRP requires modifications of fishing practices for small, medium, and large-mesh gillnet fisheries from New York to Florida. The BDTRP also established seasonal closures for certain commercial fisheries in state waters. The International Union for Conservation of Nature classifies bottlenose dolphin as Data Deficient.

Short-finned Pilot Whale (*Globicephala macrorhynchus*)

Short-finned pilot whales are found primarily in deep waters throughout tropical and subtropical areas of the world. Four stocks are recognized in the United States: West Coast, Hawaii, Northern Gulf of Mexico, and Western North Atlantic. They prefer warmer tropical and temperate waters and can be found at varying distances from shore, but typically in deeper waters. Areas with a high density of squid are their primary foraging habitats, but they may also feed on octopus and fish, all from moderately deep water of 1,000 feet or more. When they are swimming and probably looking for food, pilot whales form ranks that can be more than 0.5-mile long.

Short-finned pilot whales are larger members of the dolphin group reaching average lengths of 12 feet for females and 18 feet for males with maximum male size of 24 feet. Adult weight is 2,200 to 6,600 pounds. They have a bulbous melon head with no discernible beak. Their dorsal fin is located far forward on the body and has a relatively long base. Body color is black or dark brown with a large gray saddle behind the dorsal fin. They are polygynous (males have more than one mate) and are often found in groups with a ratio of one mature male to about every eight mature females.

Males generally leave their birth school, while females may remain in theirs for their entire lifetime. Gestation lasts approximately 15 months while lactation lasts for at least two years. The last calf born to a mother may be nursed for as long as 15 years. The calving interval is 5-8 years, but older females do not give birth as often as younger females. Maturity occurs around 10 years of age and maximum longevity is 45 years for males and 60 years for females. Sluggish for a fairly small cetacean, it does not emerge far out of the water like some smaller species, but is seen mostly moving slowly, in pods of 20 or more, fairly horizontally at and near the water surface. The species is easily confused with the closely related long-finned pilot whale (*Globicephala melas*), which favors cooler waters.

It is numerically common throughout North Carolina waters offshore, though mainly in warmer waters, and thus perhaps scarce in inshore waters north of Cape Hatteras (in the Labrador Current). The species is one of the more numerous cetaceans off the North Carolina coastline, exceeded in numbers by the common bottlenose dolphin, but perhaps as numerous or more so than Atlantic spotted dolphin.

The Smithsonian National Museum of Natural History mammal collections (2014 http://collections.nmnh.si.edu/search/mammals/) lists 68 stranding records for North Carolina. Webster et al. (1995) found a statistical difference in seasonal strandings of the species along the North Carolina coast, with more in the cooler months; of the 18 stranded, all but three were between December and May. The National Museum of Natural History strandings (68) are from most months of the year, except none for August and September. However, these stranding dates seem odd, as the species is frequently seen offshore in the warmer months. Likely, the species is probably resident all year in North Carolina waters, as it is not known to be strongly migratory (http://www.dpr.ncparks.gov/mammals/reference.php).

Bycatch in fishing gear is the primary threat to pilot whales. Several types of commercial fishing gear, including gillnets, longlines, and trawls, incidentally take short-finned pilot whales. Short-finned pilot whales have been documented entangled, hooked, and captured in these various types of fishing gear. In addition, drive fisheries that specifically target pilot whales exist in Japan and the Lesser Antilles. Ship strikes may also pose a threat in Hawaii as propeller scarred whales have been documented. The IUCN Red List classifies the short-finned pilot whale as Lower Risk-Conservation Dependent (http://www.nmfs.noaa.gov/pr/species/mammals/cetacEAns/pilotwhale_shortfinned.htm).

Colonial Waterbirds, Other Shorebirds, and Birds of Prey

Details for each ESA-protected species are contained in the Biological Assessment. Bird species not included in Appendix B - *Biological Assessment*, but which are federally protected under the Migratory Bird Treaty Act (MBTA) or Bald Eagle and Golden Eagle Act, are evaluated in more detail below. These other birds with federal protection include some species which are also listed by the State of North Carolina as threatened or endangered. Species that have only state level protection are discussed in the section State-Protected Species.

NPS staff provided general locations of Colonial Waterbird colonies in the action area based on surveys between 2007 and 2015 (National Park Service, R. Swilling, Natural Resources Program Manager, pers. comm., August 2015). During that timeframe, several colonies of Colonial Waterbirds were reported to have occurred near the Haulover Day Use beach access. These colonies were observed within the northern-most one-mile of oceanfront of the 2.9 miles of the Proposed Action Area. No colonies were reported to have occurred along the remaining ~two miles going south within the Proposed Action Area since 2007, although individual birds have been observed using the entire action area.

Gull-billed Tern

The gull-billed tern (*Gelochelidon niloctia*) is state listed as threatened in North Carolina (2005) and Virginia, endangered in Maryland, and has various other legal statuses in South Carolina, Alabama, California, Louisiana, and Michigan. It also has federal protection under the Migratory Bird Treaty Act. It is included in the US Fish &Wildlife Service's *Birds of Conservation Concern* (2008) for the US southeastern coastal plain. If conservation actions are not taken, the species could become a candidate for listing under the Endangered Species Act.

This medium-sized tern has light gray wings with some black in the tips, a thick, black bill, and black legs. Their tails are short and notched and have a light gray to white body. During the winter, they have white heads with some black around their eyes. In the summer, when they are breeding, they have a black cap that extends from their beak back to the nape of their neck. Juveniles look similar to winter adults (http://www.allaboutbirds.org). They have a wingspan of about 35 inches and are approximately 14 inches in length (https://www.audubon.org/field-guide). (Photo courtesy of Glen Fergus)

Gull-billed terns are year-long residents in parts of southern California and the western coast of Mexico, the Gulf coast, the Caribbean Islands, the northeast coast of South America, and parts of Argentina. Some terns spend the winter months along the coasts of Central America, Columbia, and Venezuela (http://www.allaboutbirds.org – Gull-billed Tern).

Breeding occurs during the summer months along the Gulf coast from Mexico to Florida and from Florida to New Jersey along the Atlantic coast (https://www.audubon.org/field-guide – Gull-billed Tern). Most Atlantic hatching occurs in June (USFWS 2010). It is not abundant in any part of its North American range, and by 2006, Texas was thought to contain over 60% of the eastern subspecies (*G. niloctia arena*). The subspecies was probably extirpated in Maryland with declines in population numbers in Virginia, North Carolina, Florida, and possibly Georgia (Molina & Erwin 2006). Although breeding pair numbers in North Carolina have declined from 1977 levels, it was rather stable (200–250 pairs) from 2000 to 2010. However, recent North Carolina census data indicate a reduction in the number of North Carolina colony sites and a center abundance shift from the Cape Fear River area to the northeastern part of the state (USFWS 2010). The species has a tendency to nest in relatively, small, scattered and often ephemeral colonies (Molina & Erwin 2006). Terns make their nests on sandy exposed beaches and dredge spoil sites with usually sparse vegetation and feed over mudflats, marshes, and dunes (Georgia Wildlife 2010 – http://www.georgiawildlife.com/sites/default/files/uploads/wildlife/nongame/pdf/accounts/birds/gelochelidon_nilotica.pdf – 24 October 2014, USFWS 2010).

Gull-billed terns are common in Dare County during mid-May through July where they breed, build nests, and hatch their young. Beginning in August, the terns begin to migrate south, and by September, very few are left. By November, the terns have departed from the North Carolina coast and begin to return the next year by the end of March (eBird 2014 Bird Observations North Carolina and Dare County). An NPS nesting survey conducted in 2013 for its annual Seashore colonial waterbird study found six gull-billed tern nests during the first part of June (NPS 2013c). This number is lower than the previous years, with 15 nests counted in 2011 and 43 nests counted in 2012 (NPS 2013c). Lower nest numbers in 2013 are likely due to habitat changes caused by Hurricane *Sandy* fall 2012 and extreme winds and high tides caused by Tropical Storm **Andrea** which washed out nesting sites in early June 2013 (NPS 2013c). The gull-billed terns are one of the less common nesters on the Seashore (NPS 2013c).

Human disturbance at nesting sites is perhaps the biggest threat to gull-billed terns. Eggs and young in nests can be crushed by vehicles, people, and pets (Georgia Wildlife 2010). Other losses include elimination of natural nest sites to beach erosion or perturbations to estuarine functions, development or modification of upland habitats important for foraging near breeding areas, and feral predation (Molina & Erwin 2006). Gull-billed terns are considered to be more susceptible to disturbance than other terns. Constant disturbance of gull-billed tern nesting sites can upset important activities that are essential for species survival and can even cause terns to abandon nesting sites. According to Molina and Erwin (2006), this species often nests on man-made substrates, which suggests it could be responsive to management of breeding sites.

Least Tern

While the least tern (*Sternula antillarum*) is not federally protected under the Endangered Species Act, it is protected under the Migratory Bird Treaty Act. The least tern is listed as Special Concern in North Carolina due to continued disturbance of nesting sites along the coast. In fact, most states along the Atlantic coast list the tern as endangered, threatened, or special concern due to loss of nesting habitat (http://www.allaboutbirds.org – Least Tern). Interior and California populations are federally listed as endangered. Additionally, it is included in the Birds of Conservation Concern (USFWS 2008) for the US southeastern coastal plain. If conservation actions are not taken, the species could become a candidate for listing under the ESA for this region.

The smallest of the American terns, least terns are ~9 inches in length, with their long, narrow wings reaching a 20-inch wingspan (http://www.allaboutbirds.org). Breeding plumage of least terns includes a black cap; white forehead; a short, white eyestripe; grayish-white back; white underside; short, notched tail; yellow legs; and a yellow bill with a black tip. During nonbreeding season, they have a black eyestripe that extends to the back of the head, a white cap, and a black bill. Males and females look alike and immature terns appear similar to wintering adults (https://www.audubon.org/field-guide). (Photo courtesy Dick Daniels, carolinabirds.org)

Least terns build their nests on sandy or gravelly beaches or along wide, sandy river banks and lake shores and also may even use flat gravel rooftops as nesting sites. Guilfoyle and Fischer (2006) estimated that of the 50% of all coastal pairs nesting on rooftops, 90% occur from Florida (both coasts) north to North Carolina. Eastern populations occur all along the Atlantic US and Gulf Coasts and in the Caribbean during breeding season. In Dare County, least terns begin to arrive in early April and are abundant May through August. By the end of September, very few may remain until the beginning of October (eBird 2014 Bird Observations North Carolina and Dare County). By November, all have flown south to coastal areas along Central and South America for the winter. The Seashore is a traditional nesting site for the least tern, and in 2013, Cape Point had the largest colony along the Seashore with 329 nests out of the 802 total observed. The 2013 total is only slightly lower than the 832 nests observed in 2012 (NPS 2013c). Since 2007, the highest number was in 2011 with 1,063 nests, much higher than the 381 nests observed in 2010 (NPS 2013c).

The biggest threat to the least tern, and many other shore birds that use sandy beaches for nesting and foraging, is human disturbance. Recreational use, residential development, and water diversion are hazardous to the least tern's survival (http://www.allaboutbirds.org – Least Tern). As gravel rooftops are being phased out due to storm safety concerns and energy efficiency, the loss of this alternate nesting habitat further threatens this species. Although there were two instances in Florida in 2010 where least terns were documented nesting on roofs other than gravel, this is not considered a long-term alternate choice for the bird (Warraich et al. 2012). (The two roofs had been gravel and were previously used by nesting terns.) Despite increased development over the years, the least tern population has steadily increased since 1997, with the largest colonies found on inlets (Schweitzer 2012).

Common Tern

Common terns (*Sternula hirundo*) are the most widespread tern species of North America. This tern species was once a common nester in North Carolina, however breeding populations along the coast have severely decreased within the last 40 years due to loss or disturbance of nesting habitats (*Birds of North Carolina* 2014 Common Tern'). The common tern is listed as a special concern species in North Carolina and has been listed as threatened, endangered, or special concern in other states (*Birds of North Carolina* 2014 Common Tern). It is not federally protected under the Endangered Species Act, but is protected under the Migratory Bird Treaty Act.

Common terns are considered medium-sized at 12 inches long with a 30-inch wingspan. Male and females look similar with black caps and wingtips, grayish-white bodies, red legs and bills with a black tip, and long deeply forked tails during the breeding season (https://www.audubon.org/field-guide). Nonbreeding and immature terns have only a partial cap, and juveniles have a brownish head and brown stripes across their backs (http://www.allaboutbirds.org). (Photo courtesy Jeff Lewis, Carolina Bird Club)

Breeding areas for common terns include Canada, US states bordering Canada, and beaches along the Atlantic coast from Canada to North Carolina. Guilfoyle and Fischer (2006) estimated that less than 1% of the world population breeds along the coast of North Carolina. In North Carolina, common terns use bare sand islands, dredge islands, and sandy beaches as nesting sites (Birds of North Carolina 2014 Common Tern). They build nests on the ground in shallow depressions or scrapes, sometimes with dead vegetation and shells (http://www.allaboutbirds.org – Common Tern). During migrations, they may also be found around lakes and marshes.

Common tern sightings have been documented in North Carolina during winter months, but it is believed that these may be misidentifications, and that common terns are absent from North Carolina in November, December, and January (Birds of North Carolina 2014 Common Tern). In 2011, the largest colonies of common terns were found on Big Foot Island, Clark Reef, Cape Hatteras, and Cape Lookout National Seashore along the North Carolina coast, and approximately one-fourth of nests were built on dredged material (Schweitzer 2012). In Dare County, these terns are commonly seen April through October (eBird 2014 Bird Observations North Carolina and Dare County 2014). They appear in April during spring migration and while some remain to breed in the action area, others continue further north to breed. Local breeders begin to leave in the fall joined by northern breeders on their way south for the winter in South America. The Seashore is a traditional nesting site for the common tern. From 2007 to 2013, the lowest number of nests observed was 19 (2008) and the highest number was 218 (2012), followed by a substantial decrease to 34 nests in 2013 (NPS 2013c). Lower nest numbers in 2013 are likely due to habitat changes caused by Hurricane *Sandy* in the fall of 2012 and extreme winds and high tides caused by Tropical Storm Andrea that washed out nesting sites in early June 2013 (NPS 2013c).

Predation, competing gulls, pets, loss of nesting habitat, human disturbance at nesting sites, weather, and rising sea levels are all factors that threaten breeding populations of common tern along the Atlantic coast (https://www.audubon.org/field-guide – Common Tern). The common tern is one of the most rapidly declining beach-nesting species.

Black Skimmer

Although black skimmers (*Rhynchops niger*) are not protected under the Endangered Species Act, they are federally protected under the Migratory Bird Treaty Act. In some states, the skimmer is listed as an endangered (New Jersey), threatened (New York), or special concern (Florida, North Carolina) species (https://www.audubon.org/field-guide – Black Skimmer).

There is no mistaking this bird with its unique red and black bill and short, red legs. The black skimmer's bill is thin with a longer lower mandible used to skim the water for fish as it flies. Black skimmers are medium to large-sized waterbirds (18 inches long with a 44-inch wingspan) (http://www.allaboutbirds.org). They have long, pointed wings and a short, white tail (https://www.audubon.org/field-guide). The top of the head, back, and wings are black and the forehead and underparts are white. Skimmers have thin vertical pupils that reduce glare from the sand and water; a trait that is highly unusual in birds. Males and females are similar in appearance and immature skimmers have mottled brown caps and backs (http://www.allaboutbirds.org). (Photo courtesy Lindsay Addison, Audubon)

Of the three races of the black skimmer, the North American race is mainly coastal with the exception of some large inland lakes in Florida and the Salton Sea in California (https://www.audubon.org/field-guide – Black Skimmer). During breeding season, black skimmers occupy areas ranging from Massachusetts to Texas and areas in Central and South America. Guilfoyle and Fischer (2006) estimated that as much as 20% of the world's population of the black skimmer breeds in the southeast US where they are found year-round.

During winter months, skimmers are not found any further north than North Carolina (https://www.audubon.org/field-guide – Black Skimmer). Skimmers may move inland to the North Carolina piedmont during hurricanes (Birds of North Carolina 2014 Black Skimmer). Black skimmers use open sandy beaches, dredge spoil islands, sparsely vegetated shell or gravel bars, and mats of sea wrack in salt marshes as nesting habitats. In some instances, nests are built on rooftops (http://www. allaboutbirds.org – Black Skimmer). They nest in groups and share nesting areas with laughing gulls and common, least, and gull-billed tern colonies. In 2011, one-third of observed black skimmer nests built along North Carolina coast were on dredged material (Schweitzer 2012).

In Dare County, black skimmers can be spotted year-round, commonly April through October (breeding season), but rarely seen December through February (eBird 2014 Bird Observations North Carolina and Dare County 2014). The Seashore is a traditional nesting site for the black skimmer, with the number of nests increasing between 2007 and 2012. From 2007 to 2010, low numbers of nests were observed, ranging from 4 in 2008 to 61 in 2009; 99 and 119 nests were observed in 2011 and 2013, respectively; and the highest number of nests was 221 in 2012 (NPS 2013c). Lower nest numbers in 2013 was likely due to habitat changes caused by Hurricane *Sandy* in the fall of 2012 and extreme winds and high tides caused by Tropical Storm Andrea that washed out nesting sites in early June 2013 (NPS 2013c).

Black skimmers are under the same types of threats as gulls and terns. Loss of habitat due to human development and disturbance of nesting sites due to human recreational use of beaches are the main risks to their survival.

American Oystercatcher

American oystercatchers (*Haematopus palliates*) are listed as endangered, threatened, or of special concern in almost every state along the Atlantic Coast; in North Carolina, they are listed as a special concern species (nc.audubon.org). This species is included in the USFWS (2008) Birds of Conservation Concern for the US southeastern coastal plain, and if conservation actions are not taken, the species could become a candidate for listing under the Endangered Species Act. Currently, oystercatchers have federal protection under the Migratory Bird Treaty Act.

American oystercatchers are unlikely to be confused with other shorebirds due to their bold coloring and size. With long, sharp bright red bills and stout, pale-pinkish legs, black heads, brown backs, and white bellies, they are distinctive birds. At 18 inches in length, with a 32-inch wingspan, they are one of the largest shorebird species in North America (https://www.audubon.org/field-guide). Young oystercatchers look very similar to adults except for duller bill color and the feathers on their backs impart a flecked look. As their common name indicates, they feed almost entirely on shellfish, including oysters, limpets, clams, mussels, crabs, starfish, sea urchins and worms (http://www.allaboutbirds.org). (Photo courtesy Planetofbirds.com)

These unique birds are strictly coastal and use large, open sandy areas, sand dunes, and tidal marshes as habitat. During summer months, the American oystercatcher can be seen along the Atlantic Coast from New England to the Gulf Coast, Mexico, and Central America, parts of South America, and the Caribbean. Oystercatchers are typically considered non-migratory; however, most all birds from New England to Maryland head south for the winter around late September. Approximately 12% of the global population of American oystercatchers inhabits the United States, with one third of that population wintering in South Carolina alone. Virginia through the Carolinas has the largest concentration of wintering populations along the Atlantic Coast (https://www.audubon.org/field-guide – American Oystercatcher).

American oystercatchers are commonly seen in Dare County throughout the year; however, numbers are lower during winter months (eBird 2014 Bird Observations North Carolina and Dare County 2014). Guilfoyle and Fischer (2006) estimated about 1,875 breeding pairs along both the Atlantic and Gulf coasts, with 1,200 pairs estimated from Florida to North Carolina. Recent surveys from NCWRC have shown an increase in American oystercatcher counts in the state from a total of 701 in 2004 to 822 in 2013. Since the last survey in 2010, observed pairs went from 369 to 374 in 2013 and observed singles from 25 to 74. Along the Seashore, 27 total breeding pairs were documented in 2013 (Schweitzer & Abraham 2014). The same number of breeding pairs (27) was also documented in 2014, with 14 of them documented on Hatteras Island (Cape Hatteras resource field summary August 20, 2014). The Hatteras Island nests (22) had seven of the nine documented fledglings for 2014.

Like many other shorebirds, loss of habitat and nesting sites, human disturbance, and predators pose the biggest threat to the survival of American oystercatchers. This species is particularly sensitive to disturbance and is more vulnerable because on average a pair may take up to four years to successfully fledge one young (Guilfoyle & Fischer 2006). One human activity that has been beneficial is the creation of sand islands from dredging spoils. These islands are good nesting sites because they are often high in elevation and fairly isolated from people and predators like raccoons and skunks (http://www.allaboutbirds.org).

Wilson's Plover

Wilson's plover (*Charadrius wilsonia wilsonia*) is not listed under the Endangered Species Act, but is federally protected under the Migratory Bird Treaty Act (MBTA) and listed by southeastern coastal states and a few bird groups. They are listed as special concern in North Carolina, rare in Georgia, threatened in South Carolina, and endangered in Virginia. They are considered a Bird of Conservation Concern by the US Fish & Wildlife Service and High Concern by the US Shorebird Conservation Plan and Southeast Coastal Plain – Caribbean Region. The Audubon Watch List has given them a Moderately High Priority status. After a recent reevaluation of estimated American shorebird populations, the Wilson's plover population was designated as in Apparent Decline (Zdravkovic 2013).

Three subspecies of Wilson's plover have been identified, with only one occurring on the US Atlantic coast, *C. wilsonia wilsonia* (Zdravkovic 2013). This coastal subspecies breed from Virginia to Florida, along the Gulf Coast from Florida to Mexico, and in parts of the Caribbean and Central and South America.

They spend the winter months along the Atlantic and Gulf Coasts from Florida to Texas and south to parts of South America. The Wilson's plover is not considered a completely migratory bird because some birds stay on nesting beaches year long. Birds in the more northern reaches of their breeding range would migrate short distances (*All About Birds* 2015 Wilson's Plover). (photo courtesy of Wikimedia commons)

Wilson's plovers can be found on sparsely vegetated coastal areas, including beaches, sand bars, barrier and dredge spoil islands, lagoons, tidal mudflats, and river mouths where fiddler crabs, their main food source, can be found (All About Birds 2015 Wilson's Plover). A recent study in North Carolina found 83% of breeding Wilson's plovers on barrier islands (Cameron 2008). They build nests in areas with varying vegetation ground cover from open to dense, but they prefer to build nests on sparsely vegetated sites (Zdravkovic 2013). Wilson's plovers nest in pairs or small groups and often return to the same nesting site (http://www.allaboutbirds.org – 2015 – Wilson's Plover).

Guilfoyle and Fischer (2006) estimated about 1,500 breeding pairs are present on the US Southeast coastal plain and peninsular Florida. More recent estimates put the total population of *C. wilsonia wilsonia* from 13,550 to 14,650 breeding adults—of those adults, about 2,000–2,220 comprise the US Atlantic Coast population (Zdravkovic 2013).

In a comprehensive study (Cameron 2008), the coastal North Carolina population was estimated to range from 245 to 270 breeding pairs. A more recent North Carolina study documented nest success rates of 46% for 20 nests in 2008 and 44% for 26 nests in 2009; the hatched survival rates in this study were 45% in 2008 and 50% in 2009 (Zdravkovic 2013). The numbers of nesting pairs on Hatteras Spit on Hatteras Island and Ocracoke Island have decreased, and Oregon Inlet no longer has nesting plovers (Fussell 1994; Zdravkovic 2013).

In 2014, three nests occurred in the Seashore, all on Island, and no fledglings were documented (Cape Hatteras Resource Management Field Summary 20 August 2014). In Dare County, the plover is not an abundant species, but can be spotted from March to October. There have been a few sightings documented in the first week of November and January (eBird 2014 Bird Observations North Carolina and Dare County).

The biggest threat to the survival of Wilson's plover is human disturbance. This includes coastal development that diminishes or alters habitat and human disturbances to nesting areas. Sometimes nests and chicks have been run over by four-wheelers driven by sea turtle biologists (Guilfoyle & Fischer 2006).

Bald Eagle

In August of 2007, the bald Eagle (*Haliaeetus leucoephalus*) was removed from the federal list of species protected under the Endangered Species Act (ESA). However, the species remains federally protected under the Bald and Golden Eagle Protection Act and the Migratory Bird Treaty Act (MBTA). In addition, the bald Eagle has threatened status in the State of North Carolina and is on the USFWS (2008) Birds of Conservation Concern for the US southeastern coastal plain.

The national bird, the bald Eagle is easily recognizable due to its white head and tail feathers that contrast with its dark brown body and wings, with a bright yellow beak and feet. Juvenile bald eagles have a dark head and tail feathers and are mottled with white on their underside. They acquire adult plumage after about five years (http://www.allaboutbirds.org). Female bald eagles can weigh up to 14 pounds and have a wingspan of about 8 feet while male bald eagles are smaller, weighing up to 10 pounds with a wingspan of about 6 feet (USFWS 2014). (Photo courtesy NCWRC)

Bald eagles take up permanent residence in areas along the coast from Alaska to northern California, the Rocky Mountains, the Great Lakes, the Mississippi River, and along the Gulf and southeast US coasts (https://www.audubon.org/field-guide – Bald Eagle). They can be seen all over the United States during winter months and migration for breeding. Breeding hotspots include two areas: Canada and the northern US near the Great Lakes and Florida and the southeastern US coast (http://www.allaboutbirds.org – Bald Eagle). Bald Eagles can be found near bodies of water such as lakes, rivers, marshes, and coastlines to feed on their preferred food, fish, but would also eat birds, reptiles, crabs, and small mammals (http://www.allaboutbirds.org – Bald Eagle).

In Dare County, bald eagles are common to abundant from November through April and less common May through September (eBird 2014 Bird Observations North Carolina and Dare County). Nests are usually built in tall trees in forested areas near large bodies of water (http://www.allaboutbirds.org – Bald Eagle). NCWRC bald Eagle nest data identifies six nests in Dare County, none of which are within the project area vicinity. These nests have not been verified by North Carolina Water Resources Commission since 2011 (NCWRC, David Allen, NCWRC biologist, pers. comm., December 18, 2014). In the south, eagles typically breed from late September through November and lay eggs from November through January (Bald Eagle Info 2014).

Increasingly common in North Carolina since their historic low numbers, bald eagles can be seen perching, fishing, or soaring near the back barrier portion of the action area but are less likely to be seen over the beach itself or over near shore ocean waters. Much like peregrine falcons, threats to bald eagles include habitat destruction, poisoning, shooting, theft of eggs or young, electrocution by power lines, and collision with moving vehicles (USFWS Species Profile 2014).

Peregrine Falcon

The peregrine falcon (*Falco peregrinus*) does not have federal protection under the Endangered Species Act, but it does have federal protection under the Migratory Bird Treaty Act and appears on the USFWS Birds of Conservation Concern (2008) for the southeastern coastal plain of the US. The peregrine falcon is also listed as an endangered species by the State of North Carolina. After being listed as an endangered species under the ESA for 29 years, the peregrine falcon was removed on 25 August 1999. The post-delisting monitoring plan calls for monitoring by various agencies and biologists for five times at three year intervals beginning in 2003 and ending in 2015.

The peregrine falcon is a crow-sized bird with a wing span of about 3 feet, with long, pointed wings and a long tail (USFWS 2014, http://www.allaboutbirds.org). Adult peregrine falcons have a dark gray back and hood that extends down their face on either side of their beak. They have a pale chest with dark horizontal bars and spots on their abdomens and legs. Juvenile falcons have brown backs and many brown vertical stripes covering their pale underside. Males are smaller than females, but are otherwise identical in appearance (USFWS 2014). (Photo courtesy Jeff Lewis, Carolina Bird Club)

In North America, common areas with year-round falcon residents include the western North American coast from Alaska to Mexico, Utah, Arizona, western Colorado, around the Great Lakes, and the northeastern portion of the US coast (USFWS Species Profile 2014, https://www.audubon.org/field-guide – Peregrine Falcon). They typically breed in the summer months in Alaska and northern Canada, the Rocky and Appalachian Mountains, and the southern portion of South America. They build nests on cliffs, bluffs, or tall buildings in the city. Rebounding populations are expanding breeding and nesting areas across North America. One of the migration routes taken by peregrine falcons includes the Atlantic coastal areas (USFWS Species Profile 2014).

In Dare County, peregrine falcons are more common from September through mid-April with highest numbers sighted in October. Around May, sightings decrease and are not spotted again until July. Peregrine falcon numbers remain low until September (eBird 2014 Bird Observations North Carolina and Dare County). Preferred habitats for peregrine falcons include open areas, along lakes, river and stream banks, mudflats, coastal areas, and even in cities where they can perch on tall structures (USFWS Species Profile 2014). Peregrine falcons rely on shorelines, mudflats, and areas near open water to prey on waterfowl and shorebirds. The peregrine falcon is common in the action area during its migrations in spring (January–April) and fall (mid September to early November) with more abundance in October than during earlier months.

The major contributing factor to peregrine falcon decline was the pesticide DDT. Since banning the use of DDT (31 December 1972), population recovery programs have helped establish a self-sustaining population of peregrine falcons in the eastern US (USFWS Species Profile 2014). Humans now pose the greatest threat, with habitat destruction being the most detrimental action. Poisoning, shooting, theft of eggs or young, electrocution by power lines, and collisions with moving vehicles are also threats to this species (USFWS Species Profile 2014).

State-Protected Species

The two species discussed here represent the species with the potential to occur in the action area which have only state level protection. Within North Carolina, endangered, threatened and special concern species have legal protection status. Other state-protected species which also have federal protection (although sometimes with a different status) were previously discussed in the section Federally Protected Species.

Diamondback Terrapin

The diamondback terrapin (*Malaclemys terrapin*) is protected by the State of North Carolina with special concern status and although it lacks federal protection, it does have federal status as a species of concern, which indicates not enough is known to determine whether or not it should be considered as a candidate for federal listing. Native to coastal states from Cape Cod, Massachusetts, to Corpus Christi, Texas, it is the only species of turtle in the temperate zone adapted to life in the salt marsh. It is found in brackish coastal waters in habitats including coastal swamps, mangrove swamps, salt marshes, lagoons, and estuarine tidal creeks.

The females of this medium-sized hard shell turtle grow to a much larger size than males. Females reach a maximum of 25 centimeters (9.8 inches) while males reach only 14 centimeters (5.5 inches). Coloration is highly variable, although adult terrapin carapaces (top shells) are generally a shade of grey with lighter colored concentric rings (circles inside of circles). Heads and limbs are also a shade of grey, with variable spots or blotches. Orange rings with a grey or greenish background may appear on shells, but there is a wide variety of patterns and colors in the species, sometimes even within single populations. Feet are webbed for strong swimming (Photo courtesy ncpedia.org).

There is also a separate small breeding subpopulation on the east end of Bermuda. It needs periodic access to nearby freshwater for long-term health and often skims the water surface after a rain to obtain freshwater. Cape Hatteras marks the interbreeding fulcrum between the ranges of two of the seven subspecies of this reptile; the two subspecies compose the entire east coast population. The more northern subspecies *M. terrapin terrapin* intergrades with the more southern subspecies *M. terrapin centrata* in the Cape Hatteras region. Although these seven subspecies are recognized, these designations do not correspond well with genetic data (CITES 2013). A long-lived species (~40 years), the turtle is also known for its high site fidelity which means it stays in the same area its entire life. In North Carolina, it was once so abundant, it was considered a nuisance.

Threats to the species include habitat degradation and loss from urbanization since the 1700s, collision with vehicles particularly adult females crossing to and from nest areas in dunes to the back barrier sound marshes, raccoon predation of unprotected nests, international pet trade, sea level rise, beach development, and incidental drowning in blue crab pots (CITES 2013).

Seabeach Knotweed

The State of North Carolina considers the seabeach knotweed (*Polygonum glaucum*) endangered, but it is not afforded any federal protection. It is found in maritime coastal habitats from Florida to Massachusetts, which are often subject to both natural and anthropogenic disruptions and disturbances. An annual prostrate member of the buckwheat family, the small narrow foliage of seabeach knotweed is bluish green with a waxy coating (glaucous) on sprawling fleshy stems growing from a central taproot. The leaves have inrolled margins. On beaches, it is found seaward of dunes, above the wrack line or high spring tide zone, and often forms interwoven mats when growing conditions allow. It is also often found on the margins of salt ponds in the back barrier environment and interdune swales. Flowers form from May to October and fruits from June to September. (Photo courtesy of Rhode Island Department of Environmental Management, Fish & Wildlife Division)

Often subject to overwash which may aid in seed dispersal, the seabeach knotweed is considered a pioneer colonizer species in these dynamic conditions, although little is known about the biology of this plant. This species was known in North Carolina from nearby Chicamacomico (~20 miles to the north of Buxton) prior to initiation of dune stabilization projects in that area, but has not been seen in recent years. This species has also been documented south of the former location of the Cape Hatteras Lighthouse (NC Natural Heritage Program, Allison Weakley, Conservation Planner, pers. comm., 8 October 2014). Known threats to the species are from vehicle traffic and dune stabilization projects.

Habitats

The Cape Hatteras National Seashore is characteristic of the ecological habitats normally associated with barrier-island systems, including wet and dry beach, dunes, maritime forest, inlets, freshwater wetlands, salt marshes, and tidal flats. The ocean side of the Seashore, where the project area is located, consists of wet and dry beach and dunes. On the sound side near the project, maritime forests, shallow bays, temporary ponds, salt marshes and tidal flats occur.

State Natural Areas

The Turtle Pond and Cape Hatteras Lighthouse natural area is a Registered Natural Heritage Area (RHA) under an agreement between the National Park Service and NC Department of Environment & Natural Resources. Within the Turtle Pond RHA an Interdune Pond natural community has been documented. The Buxton Woods Natural area is located just west and southwest of the Turtle Pond RHA and a portion of the Woods is also an RHA. The following natural communities have also been documented within the Buxton Woods Natural Area: Interdune Marsh, Interdune Pond, Maritime Evergreen Forest (Mid-Atlantic Subtype), Maritime Shrub Swamp (Dogwood Subtype), and Maritime Swamp Forest (Typic Subtype). These Natural Heritage Areas are depicted on Figure 3.11.

Figure 3.11. Map of Buxton–Cape Hatteras area showing the approximate boundaries of the Buxton Woods Coastal Reserve and Turtle Ponds, the two Natural Heritage sites located about 1 mile from the Proposed Action Area.

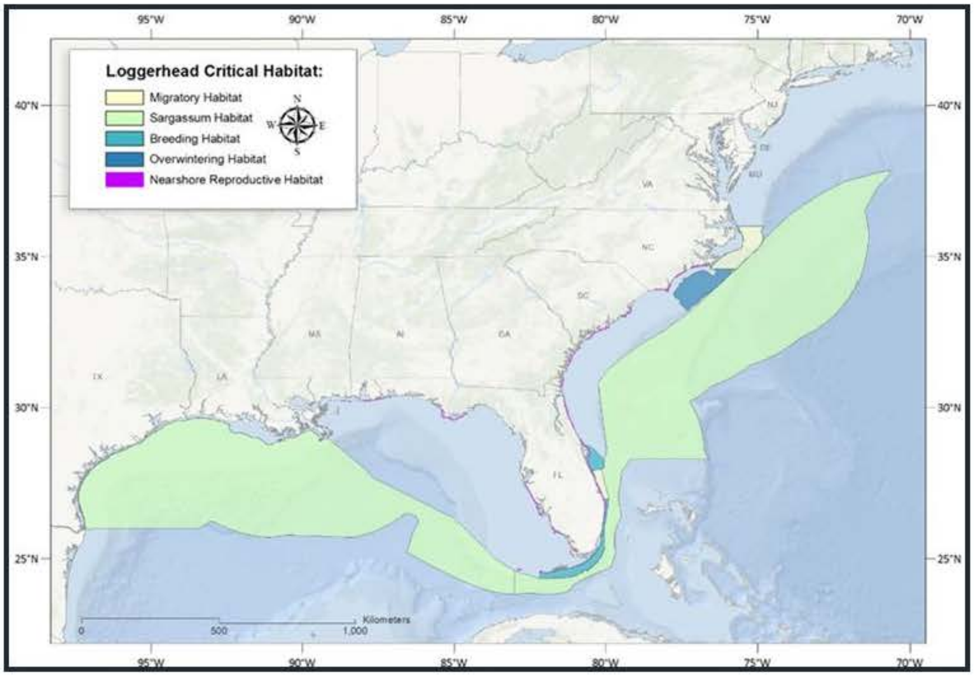
Critical Habitat

The National Marine Fisheries Service designated Constricted Migratory Corridor Critical Habitat for the northwest Atlantic Ocean loggerhead turtle Designated Population Segment (DPS) in July 2014. This habitat is designated primarily because of its high use and constricted narrow width (land to west and Gulf Stream to east). The corridor is used by juvenile and adult loggerheads migrating between nesting, breeding, and foraging areas (Fig 3.12). Because of the corridor's high use and narrow passageway, the loggerheads are more subject to perturbation. No other critical habitat for any species is found within the project area or vicinity.

CULTURAL RESOURCES

Due to abundant natural resources and strategic coastal positioning, the Outer Banks has attracted human habitation and visitors throughout its known history. Within the Seashore in Dare County, 28 sites are listed on the National Register of Historic Places, with two listed for Buxton.

The first listed is the Cape Hatteras Lighthouse (original structure built in 1802; replacement built in 1870), currently the tallest brick lighthouse structure in the United States. Now managed by the National Park Service, the lighthouse, visitor's center and museum attract about 2 million visitors a year to the Cape Hatteras National Seashore. In 1999, the lighthouse was relocated inland, away from erosion and advancing seas. (www.//en.wikipedia.org/ wiki/Cape_Hatteras_Light).



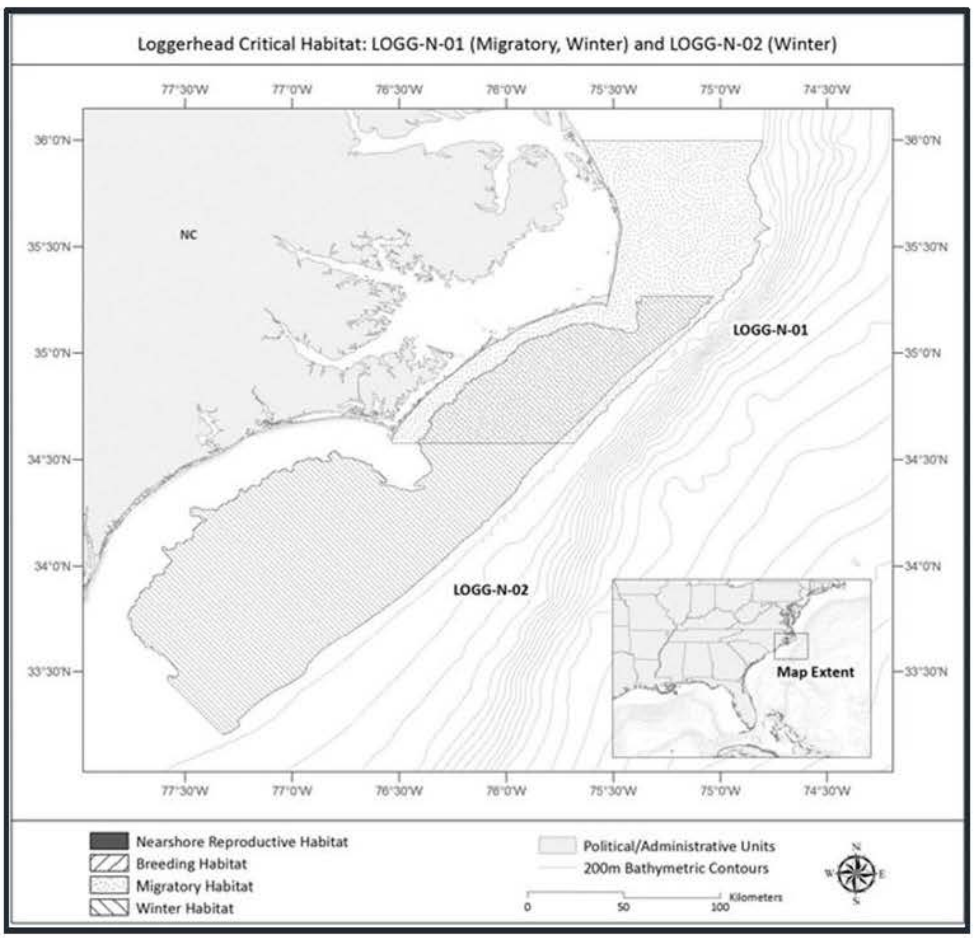


Figure 3.12. **[UPPER]** Map of the Atlantic and Gulf Coasts of the United States showing critical migratory habitat for the loggerhead sea turtle. A narrow corridor (in yellow) occurs between the North Carolina Outer Banks and the Gulf Stream. **[LOWER]** Map showing critical migratory habitat designated units for the loggerhead sea turtle off the capes of North Carolina.

The second Register listing is the offshore S.S. Lansing shipwreck, the remains of a whale factory vessel, sunk by a German U-boat in 1942. Neither the Lighthouse facilities nor the S.S. Lansing are located in the Buxton Action Area (www.//en.wikipedia.org/wiki/National_Register_of_Historic_Places_listings_in_Dare_County_North_Carolina). In accordance with Section 106 of the National Historic Preservation Act (NHPA) (36 CFR Part 800 Protection of Historic Properties), cultural resources in the vicinity of the Buxton Action Area and the offshore borrow area were researched.

Tidewater Atlantic Research (TAR) of Washington, North Carolina published the results of its study in, *A Phase I Remote Sensing Archeological Survey of a Proposed Borrow Site off Buxton, Dare County, North Carolina (*TAR 2015) (see Appendix F - *Cultural Resources*). The study's goal was to determine whether resources of significance existed in the areas that would be directly impacted by the Proposed Action.

The TAR (2015) assessment methodology was developed to comply with the requirements of the following laws:

- National Historic Preservation Act of 1966 (Public Law 89-665)
- National Environmental Policy Act of 1969 (Public Law 91-190)
- Executive Order 11593
- Advisory Council on Historic Preservation Procedures for the Protection of Historic and Cultural Properties (36 CFR Part 800)
- Updated guidelines of Archeological and Historic Preservation Act (54 USC. 3000101 et seq.)
- Abandoned Shipwreck Law [NC General Statute (NCGS) 121, Article 3]
- North Carolina Archeological Resources Protection Act (NCGS 70, Article 2).

In addition to geophysical surveys of the borrow area, the TAR study provides a summary of human habitation along Hatteras Island and detailed lists of documented shipwrecks and their general locations. It includes excerpts of historical charts and maps depicting lands and inlets of Cape Hatteras over the past four centuries. The research focused on submerged cultural resources in the study area.

Cultural surveys conducted by Tidewater Atlantic Research (Appendix F) yielded no evidence of human artifacts such as projectile points or pottery fragments in the action area. However, it is recognized that in such an historically rich area, occupied for example by Native Indians, European explorer-traders, colonial settlers, and Civil War soldiers, archaeological remains or objects may be uncovered by erosion or exposed on the beach prior to or during the Proposed Action. No shipwrecks are known on or near the beach in the Proposed Action Area. Appendix F – *Cultural Resources* provides a list of shipwrecks known to have occurred in the general area of the Seashore.

Offshore

Offshore investigations were completed during December 2014 and January 2015 by Tidewater Atlantic Research (TAR, Washington, NC) and are detailed in Appendix F - *Cultural Resources*.

Just offshore of the Outer Banks is a region of the ocean known as The Graveyard of the Atlantic, where some 3,000 shipwrecks have been documented. Cape Hatteras itself marks a major turn in the coastline. The cape promontory has led to numerous shipwrecks, with the earliest reported around 1740. Two hundred years later, German U-boats were sinking merchant vessels offshore of the cape (Gannon 1990). Contributing to an extensive number of shipwrecks in the area is Diamond Shoals, an area of shallow water extending over 10 miles south of Cape Point. While many shipwrecks have been reported in the vicinity of Cape Hatteras, records indicate that only three are in the vicinity of the Buxton project area: the USS Monitor, a federal gunboat sunk 30 December 1862, 16 miles south-southeast of the Cape

Hatteras Lighthouse in 225 feet of water; the Empire Gem, tanker sunk 23 January 1942; the E.M. Clark, tanker sunk 18 March 1942. There are no known vessel remains in the Proposed Action Area.

The TAR *Cultural Resources* study (Appendix F) utilized magnetic and acoustic data to locate underwater objects within the proposed borrow area. A total of 123 magnetic anomalies were identified within the ~500-acre search grid (Fig 3.13). With the exception of a cluster of ten anomalies buffered for avoidance, all the anomalies have signatures similar to those produced by deteriorated small pipe, old cable, or deteriorated wire. The cluster of ten anomalies occurs at the northern end of the grid (circled group in Fig. 3.13), and many anomalies cross the northern boundary of the proposed borrow area.

The long band of anomalies, running north to south diagonally across the southern half of the sand search area, appear to be an underwater cable. Historical research suggests that the source of this anomaly could be associated with telegraph or a post-World War II acoustic transducer. None of the signatures are suggestive of complex vessel remains. Six acoustic target images were identified within the borrow site, of which one long linear object resembles cable, wire, or small-diameter pipe. The others may represent concreted cable or wire and a cluster of small rectangular objects.

During the Cold War-era, the US Naval Facility mentioned above collected classified data, which included underwater acoustic surveillance via the Sound Surveillance System (SOSUS). Several sites in the United States maintained underwater cable arrays as part of this system, including Cape Hatteras. This evidence suggests some of the anomalies running across the proposed borrow area may be relict cables from that system no longer used by the federal government.

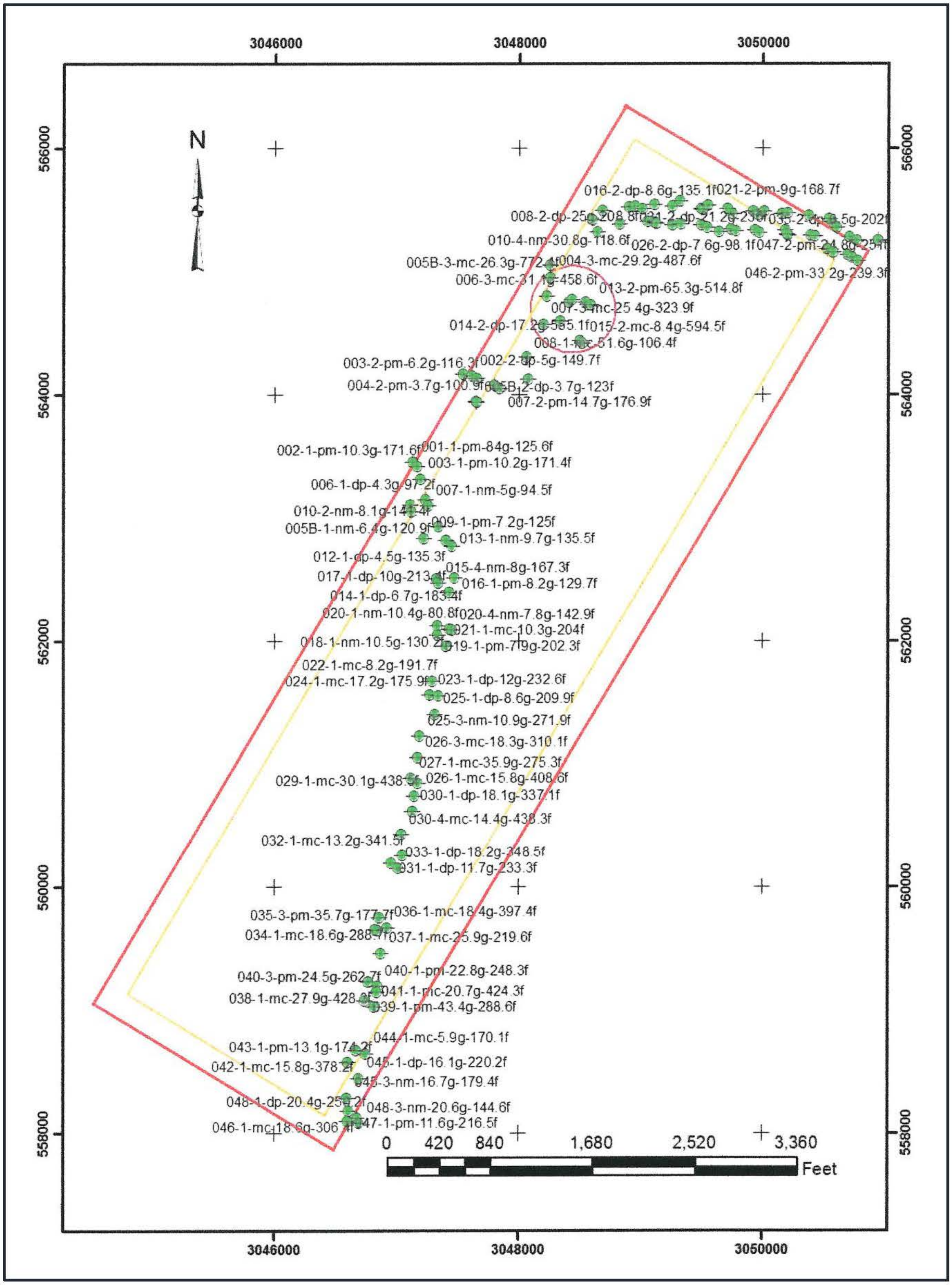


Figure 3.13. Map of the offshore sand search area showing magnetic anomalies (green dots) identified by Tidewater Atlantic Research (2015) in the Proposed Action Area. The majority of anomalies have an acoustic signature that is representative of cable, wire, or small-diameter pipe, except for the 10 anomalies circled near the northern end of the grid. See Appendix F – *Cultural Resources* for details.

SOCIOECONOMICS

The economy of Dare County is highly dependent on tourism, and Hatteras Island accounts for a significant portion of County assets and revenues. The NC Department of Commerce estimated that tourism in Dare County produced an annual economic impact of $877 million in 2011 (Lane 2013). The most recent figures from the state commerce department show this total rising to $953 million in 2013 and $1.02 billion in 2014. The communities and businesses on Hatteras Island account for roughly 20% of the Dare County total. While the permanent population of Rodanthe, Waves, Salvo, Avon, Buxton, Frisco, and Hatteras Village has remained relatively constant around 3,814 (1990) to 4,322 (2010 US Census), these communities support upward of 50,000 visitors per day during the peak tourist season.

The Hatteras Island economy generates economic activity through home rentals, hotel visitation, food and beverage services, recreational fishing and water-sports charters, commercial fishing, and associated support services. Dare County collects a 5% Occupancy Tax on gross receipts derived from room rentals, lodging, and campsite rentals. It also collects tax on food and beverages at the many restaurants that serve visitors. Real-estate taxes also generate a substantial amount of revenue to the County which is used toward emergency services, fire, and police protection.

In 2013, there were 8,572 real-estate parcels valued at approximately $2.1 billion on Hatteras Island (Lane 2013). Property taxes totaled more than $9 million per year to Dare County. Occupancy receipts totaled approximately $106 million in 2011, despite a two-month closure of road access on NC 12 between August 27 and the end of October, due to Hurricane Irene. The occupancy tax earned $2.1 million for Dare County.

Buxton, Frisco, and Hatteras Village contain almost 50% of the real-estate parcels on Hatteras Island and, therefore, a large percentage of the property tax base of the island. Island property values declined during the recent national recession from upward of $3 billion around 2005, but are expected to rebound as the overall economy improves (Lane 2013). An extended closure of NC 12 due to storms produces a ripple effect through the economy, including substantial lost tourism revenues and taxes. Repeated closures at an increasing frequency would compound the problem and potentially undermine property values and the property tax base in addition to jeopardizing many of the businesses on the island.

Tourism is estimated to account for at least 11,260 jobs in Dare County (Lane 2013) with 2,618 jobs (~23.2%) on Hatteras Island. These jobs represent an estimated payroll of $41 million which adds to the total state and local taxes generated. The Hatteras Island tourism economy contributed $10.3 million to state and $9.4 million to local taxes in 2011.

NC 12 has been damaged by erosion and breaches of the dune numerous times since it was built. According to NC Department of Transportation records (NCDOT, J. Jennings, District Engineer, August 2014), the segment of road between Oregon Inlet and Village has required in excess of $104 million for maintenance and repairs between 2003 and 2013. Repairs have been most extensive in the Pea Island section between Oregon Inlet and Rodanthe. However, the Buxton Action Area also required dune rebuilding, road resurfacing, and related maintenance. Assuming the Buxton section of NC 12 only represents 10% of NCDOT expenditures, it equates to approximately $1 million per year.

The Applicant has a fixed budget for the Proposed Action which is expected to provide benefits in the form of a wider beach and better protection to Buxton Village and NC 12 for a variable number of years depending on which alternative is implemented. There would be indirect and direct costs to the Applicant under each alternative.

VISITOR USE AND EXPERIENCE

NPS Management Policies (NPS 2006) state that a fundamental purpose of all parks is for enjoyment of park resources and their values by the people of the United States. The policies continue to state that the National Park Service is committed to providing appropriate, high-quality opportunities for visitors to national parks.

Visitors to the Seashore exceed 2.1 million people annually, where they may access over 50 miles of undeveloped ocean beaches between Bodie Island and Ocracoke, plus long sections of Seashore beaches which front the historic communities on Hatteras Island. Designated parking areas help control ingress and egress over the dunes. At Buxton, the artificial dune protecting NC 12 provides a naturalized buffer between passing vehicles and the beach.

The Proposed Action would occur along ~2.2 miles of undeveloped Seashore beach and ~0.8 mile of developed beach at Buxton. The main public access to the undeveloped segment is the Haulover Day Use Parking Area situated near station 1770 +00. This places public access very close to the northern boundary of the planned project (station 1770+50). The other existing public parking and access within the Proposed Action Area is adjacent to the former site of the Cape Hatteras Lighthouse near the south end of the proposed project. Within the ~0.8-mile area in Buxton, pedestrian access is provided via easements between some private properties. The beach within the entire Proposed Action Area is open to the public and accessible at all tides, except where emergency sand bags armor an ~1,500-foot length of beach at Buxton (see Fig 1.3). Those who visit the beach in or near the Proposed Action Area at Buxton enjoy day activities, such as sunbathing, beach combing, surfing, wildlife viewing, and photography.

PUBLIC SAFETY

A purpose of the Proposed Action is to widen the beach and thereby protect the park environs and infrastructure of NC 12, which is a critical lifeline for the communities of Hatteras Island. When storms breach the foredune and wash out the road, temporary or extended closures create hardship. Emergency access to hospitals in Nags Head and Manteo are blocked and other disruptions to fire and police impact the safety of the community. NC 12 is the primary artery for supplies, service personnel, visitors, and government business. When NC 12 is closed, food, water, transportation, and shelter are affected within the communities of Hatteras Island. Prior breaches in the Buxton Action Area have cut off water supplies to other communities on Hatteras Island. Road closures have produced hardships that may explain why a large number of respondents during the public scoping for the Proposed Action voiced support for some action to protect NC 12.

The Proposed Action involves work offshore and in the active beach zone. Offshore dredging is high-hazard work subject to Occupational Safety and Health Administration (OSHA) laws and regulations. Many beach nourishment projects have been completed successfully without incident. However, there have been accidents in which lives were lost. For example, a tug associated with a winter dredging operation offshore of Long Island, New York was driven ashore during a storm resulting in the loss of two men. A hopper dredge seeking shelter at the Oregon Inlet entrance dragged anchor and was driven through Bonner Bridge during a storm (www.outerbanks.com/ herbert-c-bonner-bridge.html, accessed June 2015). As a result of these and other incidents, the offshore dredging industry has adopted extensive safety rules for its personnel and visitors to job sites which exceed OSHA requirements in some cases (Great Lakes Dredge & Dock Company, W Hanson, Vice President, pers. comm., February 2011). Of the approximately five dredging companies that are legally certified to operate in US open waters, all consider the safety of placing their personnel offshore and the conditions they would face during normal operations prior to bidding a project. The Dredging Association of America (B. Holliday, Executive Director, pers. comm., March 2008) has asserted on behalf of the dredging industry that work offshore of Hatteras Island and Bodie Island is not safe and would jeopardize personnel during winter months because of the high frequency of storms and waves which severely restrict normal dredging operations.

SUSTAINABILITY AND LONG-TERM MANAGEMENT

Beach nourishment has been implemented along many recreational beaches to counteract erosion and widen the area of usable beach (National Research Council 1995). Some of the earliest projects in North Carolina were at Wrightsville Beach, where the US Army Corps of Engineers (USACE) has periodically added sand over the past 50 years (USACE 2008). While the overall condition of Wrightsville Beach appears to be better than it was before nourishment, the project has generated debate because of the frequency of renourishment at typically 3–4-year intervals (CERC 1984). Hunting Island, South Carolina is another site where frequent nourishment has brought criticism regarding its sustainability (Pilkey 1990). Other beaches have been maintained by nourishment at lower frequencies of action, including Coney Island, New York (four nourishment events in 75 years, USACE 2008) and Myrtle Beach, South Carolina (four nourishment events in 30 years, Kana 2012).

The mixed experience with nourishment relates to many factors, but the principal reasons appear to be the site-specific rate of erosion, the length of the project, the volume of sand, and the quality of the sediment relative to the native beach (NRC 1995, Dean 2002). Hunting Island has exhibited historical erosion at rates exceeding 20 feet per year, whereas Myrtle Beach erodes at about 2 feet per year (Kana et al. 2013). Thus, additions of sand to these two beaches should not be expected to perform equally.

NRC (1995) has determined that beach nourishment can provide protection from storm and flooding damage when viewed in human time scales (decades not centuries), provided that:

- Site specific erosion rates are incorporated into the design, and
- Projects are maintained according to design with periodic infusions of sand.

Beach nourishment is the only engineered shore protection alternative that directly addresses the problem of a sand budget deficit (NRC 1995, pp 1-2). Therefore, a key prerequisite to sustainability is knowledge of how much sand is in the littoral zone and what the sand deficit is at a site. In practice, relatively few beaches are tracked systematically by volumetric surveys to make this determination (NRC 1995). Surveys that encompass the active littoral zone from the dune to some limiting depth offshore are the most objective means of measuring the beach condition at any time.

In the case of the Buxton Action Area, the Applicant is working with a minimal amount of historic data for projects of this type. It lacks information both from comprehensive surveys following the 1960s and 1970s nourishment projects and from a systematic tracking of littoral sand volumes along Hatteras Island during the past few decades. However, based on the information it has gathered to date, the Applicant has developed estimates of the sand deficit with respect to a minimum stable beach and calculated volumetric erosion rates along the action area. This provides relatively objective criteria for estimating the longevity of each alternative.

A similar design approach was used in the recent project at Nags Head, ~45 miles north of the Buxton Action Area on Bodie Island (USACE 2010). The 2011 Nags Head nourishment project was the first large-scale nourishment in the northern Outer Banks and the first to use an offshore borrow area (CSE 2012). In terms of volume, it represents nearly 60% of all the sand that has been placed on Dare County beaches in the past 50 years (NPS 2013). The 10-mile-long project involved placement of 4.6 million cubic yards, equivalent to 86 cubic yards per foot. It is still early in its design life, but surveys of Nags Head indicate ~90% sand retention in the project area after the first three years (CSE 2014). About 20% of the project length situated at south Nags Head has lost ~30% of its nourishment volume, while the remaining 80% of the project length has been stable with negligible losses.

In comparison with Nags Head, the Buxton Action Area is 3 miles long with the Applicant's design goal totaling 2.6 million cubic yards, equivalent to 168 cubic yards per foot (maximum possible volume under Alternative 3 (Preferred Alternative) –Summer Construction, but not Alternative 2–Winter Construction). The higher average volume density in Alternative 3 is related to Buxton's shorter length, but higher sand loss rate (CSE 2013b). Whether nourishment is sustainable at Buxton would depend on performance and the economies of other alternative strategies for property development and maintaining NC 12 (NCDOT 2015, in prep). Periodic beach condition surveys are a key method of tracking performance and objectively verifying sand-retention rates (NRC 1995).

The Applicant has indicated a desire to complete annual measurements of Buxton beach and use such performance data to determine whether or not to pursue future nourishment or to elect alternate beach-management strategies in the Buxton Action Area. Regardless of the outcome of post-project monitoring, the Preferred Alternative would be a one-time event under the terms and conditions of federal and state permits. Any future nourishment activities would require another permit application and its attendant environmental review. The findings and experience following the Proposed Action would inform decisions regarding sustainability and long-term management alternatives in the Buxton Area.

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CHAPTER 4 – ENVIRONMENTAL CONSEQUENCES

This chapter describes the environmental consequences associated with the alternatives presented in Chapter 2: Alternatives. It is organized by impact topic, which summarizes the issues and concerns. US Army Corps of Engineers (USACE) regulatory reviews of proposed projects seek to integrate National Environmental Policy Act (NEPA) requirements with the Public Interest and Section 404b1 requirements. Each alternative should be addressed equivalently with the degree of analysis commensurate with the levels of impact. Under NEPA and 404b1, alternative analyses and impacts must include consideration of the proposed action, geographic options, different layouts and scales of the action, and the no-action alternative. With respect to the Public Interest, the level of concern drives the level of review and considers both practicability and reasonability of the action. NPS Directors Order DO-12 requires consideration of context, intensity, and duration of adverse and beneficial impacts (direct, indirect, and cumulative) and measures to mitigate for impacts.

GENERAL METHODOLOGY FOR ASSESSING IMPACTS

The Council on Environmental Quality (CEQ) regulations that implement NEPA require assessment of impacts to the human environment, which includes natural and cultural resources. As required by NEPA, potential impacts are described in terms of type (beneficial or adverse), context (site-specific, local, or regional), duration, and level of intensity (negligible, minor, moderate, or major). Both indirect and direct impacts are described; however, they may not be identified specifically as direct or indirect. These terms are defined below. Overall, these impact analyses and conclusions were based on the review of existing literature and studies, information provided by on-site experts and other government agencies, professional judgments, and park staff insight.

Type of Impact

Impacts can be beneficial or adverse. Beneficial impacts would improve resource conditions, while adverse impacts would deplete or negatively alter resources.

Beneficial: A positive change in the condition or appearance of the resource or a change that moves the resource toward a desired condition.

Adverse: A change that moves the resource away from a desired condition or detracts from its appearance or condition.

Direct: An impact that is caused by an action and occurs at the same time and place

Indirect: An impact that is caused by an action, but is later in time or farther removed in distance, but still reasonably foreseeable.

Context

Context is the setting within which an impact occurs and can be site specific, local, park-wide in the case of national parks, or region-wide. Site-specific impacts would occur at the location of the action; local impacts would occur within the general vicinity of the project area; parkwide impacts would affect a great portion outside the project area yet within the park; and regionwide impacts would extend well beyond the Proposed Action Area.

Site-specific: The impact would occur within project site.

Local: The impact would occur within the general vicinity of the project area.

Park-wide: The impact would affect a greater portion outside the project area yet within the park.

Regional: The impact would affect surrounding localities, cities, or towns in the region.

Duration

Impacts can be either short-term or long-term. A short-term impact would be temporary in duration and would be associated with the construction process. Depending on the resource, impacts would last as long as construction was taking place, or up to one year after construction is completed. Long-term impacts last beyond the construction period, and the resources may need more than one year after construction to resume their preconstruction condition. Impact duration for each resource may differ and is presented for each resource topic, where applicable.

Short-term: Impacts that occur only during construction or last less than one year.

Long-term: Impacts that last longer than one year.

Level of Intensity

Impact intensity is the degree to which a resource would be adversely affected. Level of intensity (negligible, minor, moderate, major) may vary by resource, but the following descriptions are representative under these levels.

Negligible: An action that would have a very small impact on the resource and be below easily measured thresholds.

Minor: An action that would produce measureable but subtle impacts on the resource that is likely to be difficult to distinguish without rigorous measurement after implementation of the action.

Moderate: An action that would produce a noticeable and easily measured impact on the resource that is likely to remain distinguishable for some extended time, but not produce a permanent change after implementation of the action.

Major: An action that would produce a verifiable and easily measured impact on the resource that is likely to be distinguishable for a long time (decades) or permanently after implementation of the action.

The general levels of impacts defined above may be modified for certain resources as noted under each topic retained for analysis. Following discussion of impacts by topic in this EA, cumulative impacts are consolidated and discussed for each alternative by topic. A number of mitigation and protection measures are discussed as applicable under each topic retained for analysis, then summarized at the back of the chapter and outlined in detail in Appendix G (*Monitoring and Mitigation Measures*). The protection measures serve as recommended conditions to be placed on any action authorized following the NEPA review process. These measures are based on previous project experience and input from US Fish and Wildlife Service, the National Marine Fisheries Service, the National Park Service, North Carolina Department of Environment and Natural Resources, and the corresponding state resource agencies.

CUMULATIVE IMPACT METHODOLOGY

Cumulative impacts are defined as impacts which result when the impact of the proposed action is added to the impacts of past, other present, and reasonably foreseeable future actions, regardless of what agency (federal or nonfederal) or person undertakes such other actions (40 CFR 1508.7).

Cumulative Impact Scenario

To determine the potential cumulative impacts, existing and anticipated future similar projects in the vicinity of the action area were considered. Potential projects identified as cumulative actions include planning or construction of beach nourishment projects that have been completed in the recent past, are currently being implemented, or are expected to be constructed in the near future. The shoreline referenced for cumulative impacts is the Dare County ocean beach north of Cape Point. This ~70-mile barrier-island coast is part of the Cape Henry to Cape Hatteras littoral cell (~120 miles) with similar wave climate and coastal processes.

During the past decade, two large-scale beach nourishment projects were conducted: Nags Head 2011 (10 miles) and Rodanthe-Pea Island 2014 (~2 miles). Several dredge disposal projects at Oregon Inlet impacting ~2 miles were also conducted. This represents about 20% of the Dare County oceanfront within the littoral cell. At the time of this Environmental Assessment's preparation, other projects are in planning and permitting phases. These encompass portions of Duck (2016 pending, 1.6 miles), Kitty Hawk (2016 pending, 3.8 miles), and Kill Devil Hills (2016 pending, 2.6 miles). Combined with the proposed action at Buxton of 2.94 miles, a total of ~23 miles (~33%) of the Dare County shoreline north of Cape Hatteras is likely to receive nourishment over the 10-year period 2010–2020. An additional ~2 miles of Pea Island south of Oregon Inlet is likely to receive additions of dredge-material disposal during the period. The majority of shoreline (18 miles out of 25 miles) that has or may receive additions of sand is developed and situated north of Oregon Inlet.

Cumulative Impact Contribution Methodology

In defining the contribution of each alternative to cumulative impacts, the following terminology is used:

Imperceptible: The effect contributed by the alternative to the overall cumulative impact is such a small increment that it is impossible or extremely difficult to discern.

Noticeable: The effect contributed by the alternative, while evident and observable, is still relatively small in proportion to the overall cumulative impact.

Appreciable: The effect contributed by the alternative constitutes a large portion of the overall cumulative impact.

COASTAL RESOURCES (INCLUDING LITTORAL PROCESSES)

Methodology

The analysis of coastal resources and littoral processes within the study area is based on a review of existing data for the project area and shorelines in similar geomorphic settings and recent scientific literature.

Impacts of Alternative 1–No-Action

Under Alternative 1–No-Action Alternative, beach erosion would continue at historical rates over the next decade or so. Existing rates exceed 10 feet per year along portions of the Proposed Action Area. An estimated 115,000-130,000 cubic yards per year (~1.15–1.3 million cubic yards over 10 years) would be eroded from the Proposed Action Area. This quantity of sand loss would add to the existing sand deficit for the area (~900,000 cubic yards). Sand losses of this magnitude would result in the following:

- further narrowing of the beach,
- direct encroachment on the foredune, and
- damage to NC 12, existing property, and infrastructure.

The beach profile seaward of the foredune would become narrower and provide less wave attenuation, making the dune more vulnerable to breaching. Minor storms would be increasingly damaging to the foredune and increase the likelihood of a full breach of the barrier island and severe damage to NC 12 and infrastructure. A breach of the barrier would cut off vehicle access to residents and businesses. Developed properties along Buxton Village at the downcoast end of the Proposed Action Area would likely sustain repeated damages and continue to install protection in the form of emergency sand bags. Wave runup heights along a steepening beach seaward of sand bags would increase and lead to more frequent flooding of developed property and sections of NC 12.

The erosion losses and damages described would be the result of natural processes that are protected by NPS Management Policies (NPS 2006). Accordingly, they do not necessarily represent an adverse impact on coastal resources and littoral processes. As described in Chapter 2: Alternatives, interference with natural processes is generally prohibited, with the exception of certain circumstances, such as sites which have been previously altered or manipulated by non-natural means. Portions of the Proposed Action Area have been modified by sand scraping, dune reconstruction, breach closures, shoreline stabilization via groins, and emergency armoring via sand bags. Such modifications are expected to continue adhoc into the near future under the need to protect infrastructure and access to the area for the benefit of residents and visitors.

Under Alternative 1–No-Action, an increasingly narrow beach would reduce the area of suitable habitat for sea-turtle and shorebird nesting. Nests produced in spring or early summer would be increasingly vulnerable to overwash and erosion. The NC Department of Transportation has been evaluating long-term (50-years) alternatives for NC 12 in the Buxton area that will be published in a report (NCDOT 2015, in prep.). Once the report of possible alternatives is published, approval and implementation of a plan is likely to require a substantial number of years. In the interim, conditions at the Proposed Action Area would continue to deteriorate at a reasonably predictable rate.

Alternative 1–No-Action would have a minor, but not negligible, impact on existing littoral processes. As erosion progresses, local, direct, and long-term impacts would occur, including: the increasing sand deficit would drive the use of emergency sand bags, which then would reduce or eliminate a portion of the sand supply in the beach or foredunes. As a result, less sand would be available to feed downcoast areas — a local, long-term indirect impact. The eroded and armored beach in the south half of the action area would continue to steepen, thus modifying the breaker type (Galvin 1971) and general character of the surf zone. Therefore, Alternative 1–No-Action would result in moderate adverse impacts on coastal resources.

Impacts of Alternative 2–Winter Construction

Under Alternative 2–Winter Construction, the beach in the Proposed Action Area would be widened by an average of ~70 feet following equilibration of the profile. Assuming ~1.3 million cubic yards can be placed along ~15,500 feet during a four-month environmental window (1 December through 31 March) prescribed for hopper dredging in the South Atlantic Region (NMFS 1997), the initial visible beach width would be ~150 feet wider than the existing with all nourishment placed seaward of the +7-foot NAVD contour. The initial slope along the seaward edge would be ~1 on 10 to 1 on 12 based on the range of existing slopes of the intertidal beach and inner surf zone. The impact area would be ~42 acres above mean high water and ~62 acres below mean high water. As Figure 2.1 illustrated, the nourished beach would be expected to adjust rapidly under high wave conditions. During winter storms, wave runup would overtop the nourishment berm and shift some sand landward in forms similar to natural washover deposits. Following storms, the backbeach area would provide expanded dry beach habitat and serve as a reservoir of sand to feed the foredune.

Profile adjustment after construction would include erosion of the seaward edge of the nourishment with a concomitant shift of sand to the inshore zone and outer bar. The net result during the first six months is expected to be natural enhancement of the upper beach and formation of inshore bars and runnels across the surf zone.

The shape and morphology of the beach after adjustment is expected to be similar to natural profiles along Hatteras Island. If sea level rises during the life of the project as projected by IPCC (2013a), the nourished beach is expected to adjust rapidly to elevated water levels and incrementally recede by a small fraction of the added beach width as discussed in Anticipated Sea Level Rise(see pg 21). As wave energy varies through the year, the nourished beach would respond like a natural beach. Summer wave conditions would promote natural widening of the dry-sand beach, whereas winter wave conditions would reduce beach width and shift sand offshore. A goal of the Applicant is to have a wider beach, on average, after the Proposed Action so that normal seasonal changes in the beach profile may occur without adverse impact to the foredune, NC 12, and other infrastructure. Any additional protection to existing infrastructure would occur via added beach width and the post-construction adjustment of the profile. This general approach to nourishment and storm damage reduction is similar to the approach used by the Town of Nags Head during a project in 2011 (USACE 2010). Post project surveys at Nags Head indicate that ~20% of the nourishment volume shifted naturally into the upper beach and foredune during the first two years (CSE 2014), adding nesting habitat and improving storm protection.

Alternative 2–Winter Construction would involve numerous work stoppages to move the dredge(s) to a safe harbor during storms and high-wave events. This would lengthen the time pipe and equipment is exposed on the beach. During major storms, shore pipe would have to be removed from the active construction area and stored temporarily at upland staging sites. The Applicant projects that dredge efficiency under Alternative 2–Winter Construction would be less than 50% (USACE 2000, 2010). To accomplish up to 1.3 million cubic yards, average production at 50% efficiency would have to exceed 20,000 cubic yards per day within the four-month winter period prescribed for hopper dredging under the South Atlantic Regional Biological Opinion (SARBO) (NMFS 1997).

The maximum volume that could be accomplished under Alternative 2–Winter Construction is ~400,000 cubic yards greater than the present sand deficit of ~900,000 cubic yards in the Proposed Action Area. The extra sand above the deficit volume would offset average yearly erosion losses for ~3 years (Appendix A, *Littoral Processes*). After that time, the beach would be in deficit and therefore, provide diminishing protection. Once in deficit, the narrower beach would not buffer the foredune from winter waves, and dune escarpments would occur with increasing frequency. Storm damages to infrastructure and development would resume.

Under Alternative 2–Winter Construction, sand would be placed along up to 2.94 miles of ocean beach on the Seashore in anticipation of net southerly transport. Nourishment longevity increases geometrically with project length, so longer projects help sustain benefits (NRC 1995, Dean 2002). A large portion of the nourishment would be placed north of the Buxton village line to widen the beach and protect NC 12, as well as provide excess sand to shift south over time. The Applicant projects that Alternative 2–Winter Construction would provide erosion relief for several years, but would not meet the goals and objectives of beach widening and protection of infrastructure for up to one decade. The addition of ~1.3 million cubic yards from a non-littoral sand source would augment the sand budget of Hatteras Island, ultimately contributing to growth of Cape Point and accumulation of more sand on Diamond Shoals.

Littoral processes would be negligibly modified under Alternative 2–Winter Construction (Appendix A). The offshore borrow area (~300 acres in 32–45-foot water depths) would be excavated an average of <3 feet. Water depths would remain similar over the shoal and would remain markedly shallower than surrounding bottom depths which are >50 feet. Winter dredging would likely involve hopper dredges and preclude suction cutterhead dredges for operational reasons. Hopper dredges take shallow, narrow cuts while leaving undisturbed areas.

The borrow area is part of an isolated shoal which extends beyond the sand search boundaries for the proposed project (see Figs 3.5 and 3.10) and contains >5 million cubic yards in the upper ~7 feet of substrate. Under Alternative 2–Winter Construction, <25% of the upper shoal volume would be removed leaving the overall shoal morphology intact. Since it is the contractor's decision to make regarding which section of the borrow area would be dredged for the project, the analysis of wave transformation and sediment transport considered the worst case scenario (ie – the scenario that 7 feet of material are removed from <u>every</u> section of the borrow area—Appendix A). This would yield over 5 million cubic yards of sand which is much more than the volumes required under Alternatives 2 and 3.

The USACE-approved numerical models, STWAVE and GENESIS, were used in this study to simulate wave patterns and longshore sediment transport rates before and after the proposed project. The STWAVE model results show that borrow-area dredging would not cause any measurable, wave-pattern changes at the beach in the project area, and the impact would be concentrated within the dredged area and its immediately adjacent area. The borrow area is 10–30 feet deeper than the estimated Depth of Closure in this setting, and therefore well beyond any expected zone of normal exchange of sediment with the beach. The wave modeling results indicate that sand transport would not be significantly modified over the borrow area after dredging, and that onshore and offshore sand transport would not be interrupted.

The GENESIS results yielded 117,500 to 122,000 cubic yards per year annual net sediment transport rates, which are in close agreement with the estimated rates of 115,000 to 130,000 cubic yards per year (Appendix A). The model simulation for potential after-project longshore transport indicates less than 1% changes compared to the before-project condition under all wave approach directions applicable to the Proposed Action Area. The transport rates would change locally where beach fill is conducted, but there would be no changes ~0.5 mile north or south of the fill area.

High wave conditions are expected to persist over the borrow area after dredging and provide energy at the bottom which would mix sediments and maintain oxygenated conditions. Ridges and furrows left by dredging action are expected to gradually smooth out by waves and yield comparable substrate and morphology as pre-dredging conditions. During Hurricanes *Irene* and *Sandy*, wave heights 2 miles offshore at Duck and Nags Head exceeded 25 feet (McNinch et al. 2012, Kana et al 2012). The borrow area for Buxton, ~45 miles south of Nags Head, is expected to sustain comparable wave heights in storms after the project. High waves would help maintain similar sediment quality at the borrow area after dredging. Alternative 2 would produce short-term and localized adverse impacts of dredging in the offshore borrow area. However, the proportion of sediment removed would be small, leaving substantial volume and similar shoal morphology and relief relative to surrounding bottom depths.

Placement of sand along the Buxton Action Area is expected to reduce the possibility of a breach inlet forming. This would yield a long-term beneficial impact over the life of the project with respect to storm-damage reduction, protection of property and infrastructure including NC 12, and the economy of Hatteras Island and Dare County. A wider beach would increase the area available for nesting, foraging, and roosting of threatened and endangered species. Restoration of the beach would preclude/forestall the tendency for future breach inlet formation and would lessen overwash events for several years. Alternative 2 would produce direct, long-term, local benefits in the form of a wider beach within the action area for several years related to the post-construction erosion rate. As the project erodes, transported sand would produce indirect, local, long-term benefits to downcoast beaches and shoals, specifically the areas of Cape Point and Diamond Shoals.

Impacts of Alternative 3 (Preferred Alternative) Summer Construction

Under Alternative 3 (Preferred Alternative) Summer Construction, the beach in the Proposed Action Area would be widened by an average of ~150 feet following equilibration of the profile. Up to 2.6 million cubic yards would be placed along 15,500 feet during an ~2.5 month construction period. The Applicant has requested permits to allow dredging during summer when average wave conditions are within operational limits for hopper dredging (i.e. < 5 feet). Wave conditions are within operational limits for suction cutterhead dredging ~35-40% of the time during June, July, and August (Appendix A). The period during which average waves are within safe operation limits for hopper dredges spans roughly late May to early September (~110 days).

The initial visible beach width would average ~300 feet wider than existing with all nourishment placed seaward of the +7-foot NAVD contour. The initial slope along the seaward edge would be ~1 on 10 to 1 on 12 based on the range of existing slopes of the intertidal beach and inner surf zone. The impact area would be ~84 acres above mean high water and ~123 acres below mean high water. Figure 2.1 illustrated generally how the nourished beach would be expected to adjust under high wave conditions. During winter storms, wave runup would overtop the nourishment berm and shift some sand landward in forms similar to natural washover deposits. Following storms, the backbeach area would provide expanded beach habitat at higher elevations and serve as a natural reservoir of sand to feed the foredune.

Dune growth by wind is a function of wind speed and the width of the dry sand beach (Bagnold 1941, Davidson-Arnott & Law 1990). Therefore, post-project dune growth under Alternative 3–Summer Construction is expected to be more rapid and greater than Alternative 2–Winter Construction. Following the 2011 Nags Head nourishment project, winter storms built up the backbeach and foredune above the +6-foot NAVD contour by ~4 cubic yards per foot per year (CSE 2014). After three years, this was equivalent to a cross-sectional area >300 square feet, or about the size of a dune 7 feet high with a 50-foot base fronted by a 50-foot-wide storm berm ~2 feet higher than the nourishment berm. Wind and wave conditions at Buxton are comparable to the Nags Head area (Appendix A).

Profile adjustment after construction would include relatively rapid erosion of the seaward edge of the nourishment berm with a concomitant shift of sand to the inshore zone and outer bar. The net result of profile adjustment during the first six months after construction is expected to be natural development and enhancement of the upper beach and formation of inshore bars and runnels across the active surf zone. Compared with existing conditions along portions of the Proposed Action Area where emergency sand bags exist, the area of intertidal and shallow subtidal habitat is expected to increase as shown in Figure 4.1. Initially, the backshore and foredune habitat areas would remain the same after nourishment. The dry-beach area would expand by ~40 acres and the wet-sand beach area would