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 every 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

expand by ~1.3 acres, but would be displaced seaward of its pre-nourishment position. The areas of nearshore and offshore bottom are expected to remain nearly equal to existing conditions but be displaced seaward by the width of the dry beach (Fig 4.1).

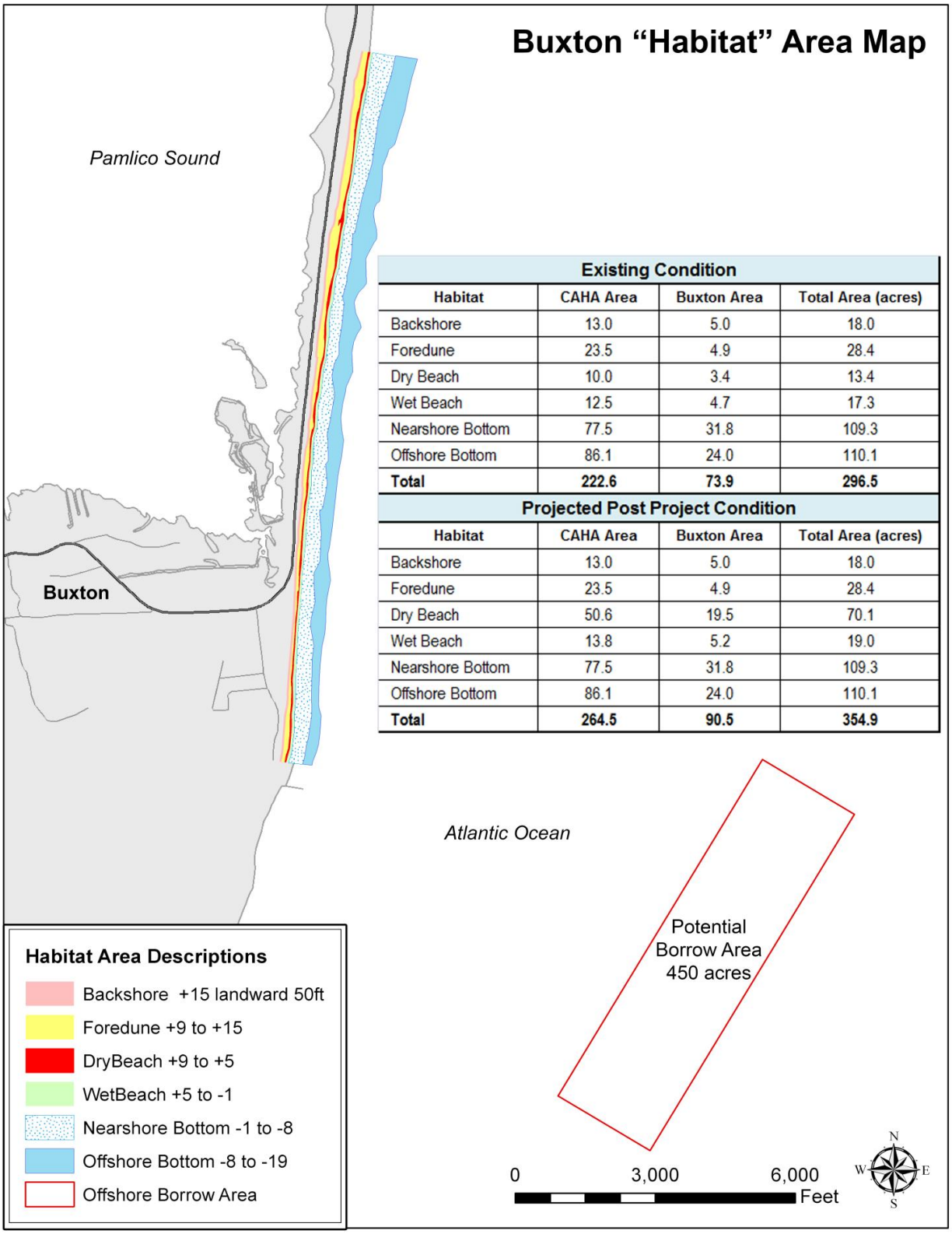
The overall shape and morphology of the beach after nourishment and adjustment is expected to be similar to natural profiles along Hatteras Island. As wave energy varies through the year, the nourished beach is expected to respond in much the same way as a natural beach. The visible beach would widen during low wave conditions in the summer and narrow during high waves in winter. Alternative 3–Summer Construction would provide roughly twice the volume of sand compared with Alternative 2–Winter Construction, thereby leaving a broader beach area to dissipate wave energy before reaching the foredune. The greater beach width is expected to provide longer duration, storm-damage reduction benefits and more extensive and improved nesting habitat along the upper beach.

Dredging efficiency under Alternative 3–Summer Construction is expected to be much greater than Alternative 2–Winter Construction and comparable to efficiencies achieved at Nags Head (CSE 2012). Daily production at Nags Head (2011) averaged ~42,000 cubic yards per day during the first three months of construction (24 May–27 August). One hopper dredge operating for three months and one suction cutterhead dredge operating for ~1.5 months accomplished ~3.8 million cubic yards under similar distances between the borrow area and the beach (CSE 2012).

The Applicant anticipates that Alternative 3–Summer Construction would be constructed during an ~2.5 month period using some combination of hopper and suction cutterhead dredges depending on dredge availability and the contractor's plan for most efficient construction. The borrow area is sufficiently large to accommodate two dredges, particularly hopper dredges which alternate excavations and pump out. Assuming two dredges are used and average daily production is ~42,000 cubic yards per day (counting ~20% downtime for weather and mechanical delays), 2.6 million cubic yards could be placed in ~62 days. As previously discussed in Chapter 2, work would proceed in sections from two landing points, with ~200–300 feet completed per day.

Sand placement operations by hopper or suction cutterhead dredge involve the same methods and impacts along the beach. A large-diameter (~30 inch), submerged pipe would cross the surf zone and connect to elbows and valves at the edge of the beach. After an initial platform of sand is pumped into place and shaped by bulldozers, lengths of steel shore pipe (typically 40 feet long; 30 inches in diameter) would be rammed into the connectors and run parallel to the beach. A splitter placed at the end of the pipe would spread the slurry allowing a cone of sand to fall out. Water and fines would drain back to the surf.

In projects where the borrow material is fine sand with significant proportions of silt, training dikes are sometimes used to confine the discharge and reduce the extent of turbidity plumes. Training dikes consist of sand pushed up along the seaward edge of the nourishment template, leaving a shallow basin in between the existing beach and the dike. This channels the slurry, confines turbidity, and helps retain sandy material. As sand accumulates near the pipe end, bulldozers continually shape the mound to the grades and slopes specified in the project design.



Existing Condition			
Habitat	**CAHA Area**	**Buxton Area**	**Total Area (acres)**
Backshore	13.0	5.0	18.0
Foredune	23.5	4.9	28.4
Dry Beach	10.0	3.4	13.4
Wet Beach	12.5	4.7	17.3
Nearshore Bottom	77.5	31.8	109.3
Offshore Bottom	86.1	24.0	110.1
Total	**222.6**	**73.9**	**296.5**

Projected Post Project Condition			
Habitat	**CAHA Area**	**Buxton Area**	**Total Area (acres)**
Backshore	13.0	5.0	18.0
Foredune	23.5	4.9	28.4
Dry Beach	50.6	19.5	70.1
Wet Beach	13.8	5.2	19.0
Nearshore Bottom	77.5	31.8	109.3
Offshore Bottom	86.1	24.0	110.1
Total	**264.5**	**90.5**	**354.9**

FIGURE 4.1 Map of Proposed action area around Buxton. Inset table lists existing areas in acres between the indicated contours according to the key. The actual borrow area would be ~300 acres of the ~450-acre potential borrow area. Parts of the borrow area would be buffered to avoid bottom debris (See Appendix F – *Cultural Resources*). Post nourishment habitats would initially increase over the dry and wet beach. More seaward habitats would maintain the same area, but be displaced offshore. Post-project condition is projected prior to foredune build up by wind. CSE data shown is based on latest survey (October 2014) of Proposed Action Area. It is overlain on NOAA map, which reflects an earlier shoreline condition.

When a nourishment section is determined to contain the design volume, another length of shore pipe is added, shifting the pumpout point ~40 feet. Projects which involve coarse sand free of muddy material can be built efficiently with negligible sand losses and little turbidity without training dikes (Great Lakes Dredge & Dock Co, B. Hansen, Vice-President, pers. comm., March 2011). The 2011 Nags Head project did not use training dikes (CSE 2012). However, at the direction of USFWS, training dikes may be used for the Buxton project.

Some sections of the proposed project would involve initial berm widths >300 feet wide at placement. For these areas, the discharge pipe would be split using Y-valves and more than one pumpout point would be used across the section. For example, three pipes connected to the primary discharge line may be used in the active work zone with the inner line building the first ~100-foot width, the second working a middle section, and a third working the outer section of the nourishment berm. Pumpout would be alternated among the two or three pipes until the full section is complete. As work progresses alongshore, the Y-valves would be moved with the active work zone leaving a single pipe along the completed sections. This trunk line would be left in place while the rest of the reach (~25 % of the project length) is being constructed. The active work zone where multiple lengths of pipe occur across the beach typically extends ~600–800 feet. The active pumping zone typically extends ~300 feet alongshore. On a given day, between 200 and 300 feet of nourished beach would be completed.

The active work zone would be cordoned off for safety but unnourished sections of beach within ~200 feet ahead of the work area would remain open for public use and would be free of equipment. As soon as a nourished section is completed and the safety fence is moved to the next work area, the nourished beach would be opened to the public. That section of beach would have a single pipe (trunk line) running the length of the section back to the landing pipe from offshore. Sand ramps would be constructed across the pipe every 100–200 feet to provide ingress and egress for equipment and the public. The pipe connection points would remain uncovered to allow daily inspection for leaks and to provide access to plug leaks using gaskets and wedges.

Assuming the proposed project is constructed from two pipe landing points in four discrete sections (i.e. four ~4,000-foot-long beach segments to accomplish 15,500 feet), the length of exposed trunk line along completed sections open to the public would range from a few hundred feet to ~3,500 feet. If two dredges are used, two active work zones may be operating at the same time from each landing point. While this is unlikely during the majority of the project duration, it may be necessary to maintain efficiency or shift the active work zone away from areas where nesting activities are occurring. Shifts of the active work zone would be coordinated with NPS officials to minimize impacts where threatened or endangered species may be present.

Upon completion of a project reach and confirmation of nourishment volumes in place, all pipe and equipment would be shifted to the next reach. The nourished reach (~4,000 feet long) would be final graded to remove tire tracks, mounds, depressions, and escarpments. Under Alternative 3–Summer Construction, a 4,000-foot reach would be completed in ~2–3 weeks and would involve average placement volume of ~650,000 cubic yards.

The Applicant proposes to vary the nourishment volumes and constructed beach width systematically as illustrated in Figures 4.2 and 4.3. Figure 4.2 is a conceptual diagram representing a generic length of beach where a central reach like the Proposed Action Area has a major sand deficit. The critically eroded area would receive a volume to replace the sand deficit plus additional volume to serve as advance nourishment. This latter volume provides a reservoir to accommodate average annual erosion losses (~115,000–130,000 cubic yards per year) for a number of years before the deficit volume is impacted. As Figure 4.2 implies, the nourishment would be expected to spread laterally toward

unnourished areas where the profiles have more sand. Some volume would also be expected to shift downcoast (south) each year under normal transport processes (Appendix A).

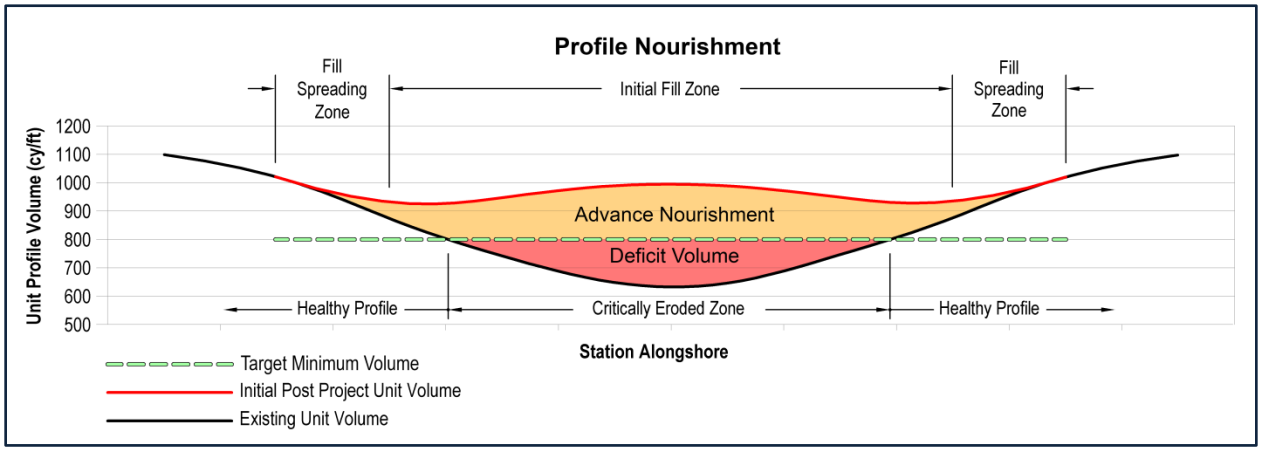


Figure 4.2. Formulation of alternative nourishment plans for Buxton was based on the general concept of replacing a deficit volume (in red) along critically eroded sections to achieve a target minimum volume (green dashed line corresponding to 800 cubic yards/foot) everywhere plus an advance nourishment volume (in tan) to accommodate average annual losses. The shoreline salient (bulge produced by nourishment) is expected to erode and feed sand to adjacent unnourished sections of beach. The diagram shows the unit profile volume (cubic yards/foot) on the y axis versus the alongshore position on the x axis. The bottom line represents the critically eroded section of beach with unit volume minima (i.e. maximum deficit) in the middle of the graph. The upper line shows the target volume (smoothed) after nourishment with a portion of the new sand (in red) representing the deficit and the other portion (in tan) representing advance nourishment. Over time, the nourishment sand is expected to migrate north and south, away from the critically eroded zone.

The Applicant's design analyses, using volumetric data and computer modeling, indicate the optimal nourishment configuration for the Proposed Action Area should include large volumes along the Seashore (Appendix A–*Littoral Processes*). By placing sand upcoast of the most critically eroded area, project longevity would be greater. Figure 4.3 shows the proposed nourishment plan for Buxton with diminishing volumes (width) at the ends of the project and maximum volumes generally near the boundary between the Seashore and Buxton Village. Thus, the proposed fill configuration would provide end tapers and gradual transitions between the existing beach and the nourished area. The variation in section volumes is similar to the design approach at Nags Head and the 2014 emergency nourishment at Pea Island/Mirlo Beach (Rodanthe) under the direction of the USACE (2013a).

Under Alternative 3–Summer Construction, the advance nourishment volume would be much greater than Alternative 2–Winter Construction. Assuming 2.6 million cubic yards can be accomplished under the Applicant's available budget, up to 1.7 million cubic yards would be available to offset annual erosion losses before the Proposed Action Area returns to a deficit volume condition (Appendix A). The Applicant projects that Alternative 3–Summer Construction would provide up to 10 years of erosion protection (assumes average losses totaling 170,000 cubic yards per year which is 20–50% higher than the estimated historical erosion rates). The Applicant plans to track nourishment performance and loss rates by annual surveys and sand volume calculations during the life of the project.

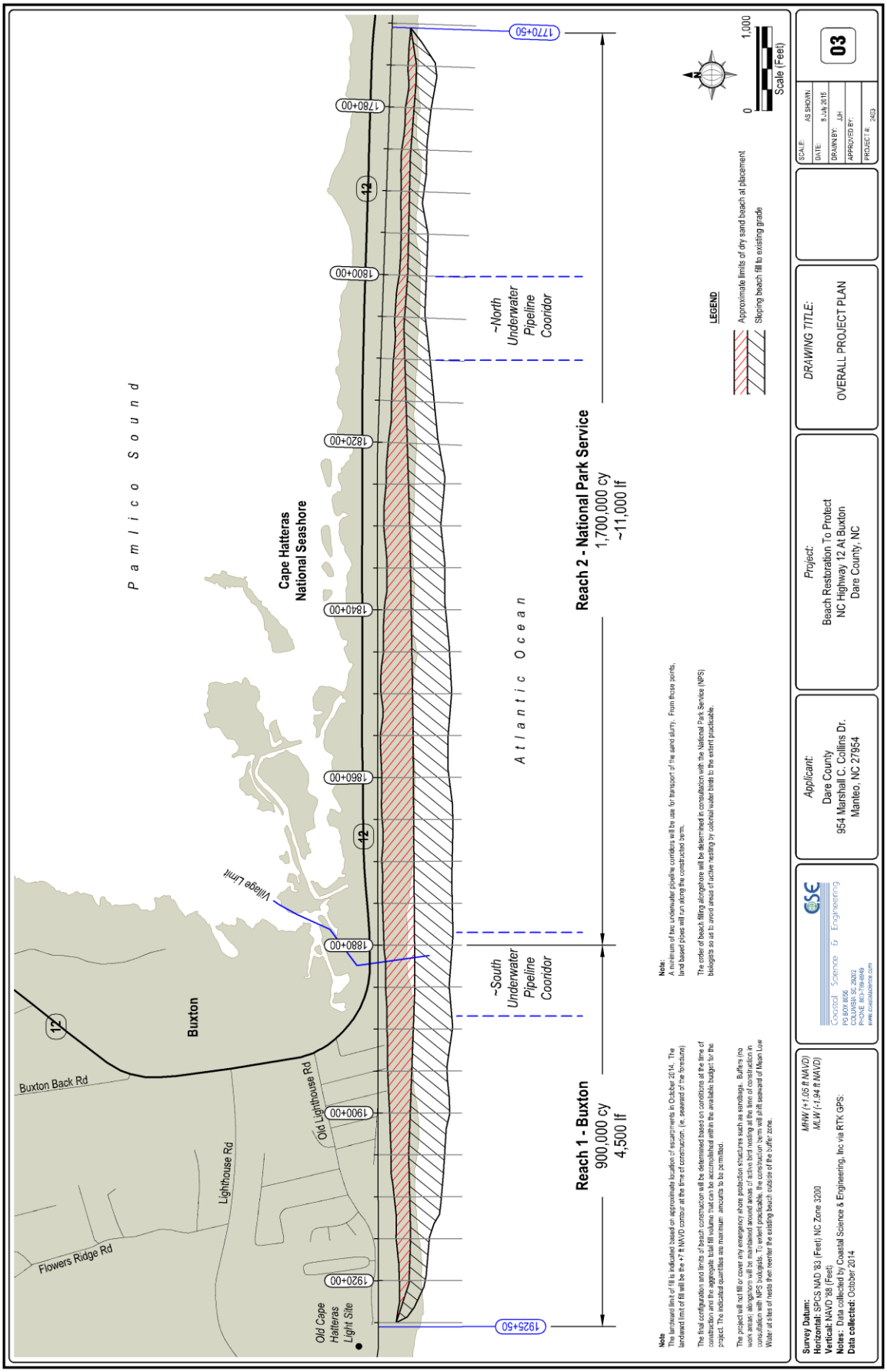


Figure 4.3. Proposed nourishment plan for the Buxton beach restoration project — Alternative 3–Summer Construction. The map shows approximate limits and width of the dry-sand beach at placement (red-hatched area) and the sloping seaward edge to existing grade underwater. This is the area on which initial estimates of impact areas are based. The plan references two reaches extending along undeveloped sections of the Seashore (Reach 2) and the Village of Buxton (Reach 1). Total volume planned under Alternative 3 is 2.6 million cubic yards. Two landing points for the submerged dredge pipe would be used, pumping sand in either direction to build the beach in four sections.

Excavations in the borrow area would impact a similar amount of shoal habitat (~300 acres) as Alternative 2–Winter Construction, but the average excavation depth would be ~5.5 feet to accomplish ~2.6 million cubic yards. Maximum dredging depth would be 7 feet with some areas left undisturbed, particularly areas which may contain cables or other obstructions. Alternative 3–Summer Construction would impact about 25% of the shoal area and increase the depth over excavated sections by ~5.5 feet. The range of depths in the borrow area are presently ~32–45 feet compared with surrounding areas that are > 50 feet. After dredging, the range of depths would be ~37–50 feet (average) where excavations have occurred. Remaining high spots over the shoal are expected to slough toward the dredged areas and gradually even out under wave action. The overall morphology of the borrow area would be similar to pre-project conditions after dredging and shoal adjustment.

Alternative 3 would produce short-term and localized adverse impacts of dredging in the offshore borrow area. However, the proportion of sediment removed would be substantially less than the total volume in the shoal. Overall shoal morphology and relief would remain similar to existing conditions; however, impacts would be greater than Alternative 2 because the volume removed would be roughly two times greater.

Analyses of waves and littoral sand transport indicate Alternative 3–Summer Construction would have a negligible impact at the borrow area and along the beach in the Proposed Action Area (Appendix A). Under the range of applicable wave-approach directions, wave heights would incrementally change under a few directions. The resulting energy at the beach in the Proposed Action Area would be similar, with minor to negligible increases or decreases in sand transport, depending on wave approach direction (Appendix A). For example, net transport under Alternative 3–Summer Construction varies by hundreds of cubic yards per year compared with existing annual rates totaling in the range 115,000–130,000 cubic yards per year. Net transport would continue to be southerly, with losses from the Buxton Proposed Action Area adding sand volume to Cape Point and Diamond Shoals.

Alternative 3 would produce direct, long-term, local benefits in the form of a wider beach within the action area for upwards of one decade, depending on the volume of nourishment and post-construction erosion rate. As the project erodes and the profile adjusts, naturally transported sand would produce indirect, local, long-term benefits through volume additions to the foredune in the action area and downcoast beaches and shoals, particularly Cape Point and Diamond Shoals.

Summary of Alternative 3 Construction Mitigation Measures

Summer construction would involve impacts to threatened and endangered species. Detailed mitigation measures are provided in Appendix G. The following bulleted lists highlight some of the construction methods, mitigation, and monitoring measures that would be implemented under Alternative 3–Summer Construction. Additional mitigation measures specific to certain species are discussed in the applicable section of this chapter.

At the borrow area:

- Dredging would leave buffers around obstructions such as underwater cable, providing undisturbed areas in close proximity to excavated areas.
- Dredging would cease, and the dredge would be relocated to other parts of the borrow area if incompatible material or cultural resources are encountered.

- Dredge track lines would be monitored via the USACE Dredge Quality Management (DQM) System so as to ensure excavations are within the permitted boundaries of the borrow area.
- The submerged pipeline to the beach would be monitored for leaks and repaired immediately so as to avoid accidental slurry discharges in unauthorized bottom areas.

At the beach:

- Sand placement would occur in approximately four reaches extending ~4,000 feet in either direction from two landing points.
- Fill placement activities would be confined to one reach before proceeding to another area, with direct impacts of construction lasting ~2–3 weeks in each reach. [Note: If two dredges are utilized, there may be limited periods of time when it is necessary to work from two areas for purposes of efficiency or avoidance of active nesting areas.]
- Numerous sand ramps would be placed over the trunk line as sections are completed to allow access for beach patrol vehicles and the public.
- The schedule for completion of each reach would be coordinated with NPS officials to postpone operations as long as practicable where active bird nests are being monitored.
- The nourishment berm would be modified if necessary to increase the separation between an active bird nest on the upper beach and the fill placement area along the lower beach. This may include nourishing a limited length of the project seaward of mean low water as outlined in Figure 2.3 (i.e. fill placement option no. 2).
- No nourishment would be placed on existing sand bags, beach vegetation, or the foredune.
- A continuous no-work buffer would be maintained along the backbeach between the toe of the foredune and the active fill area.
- Irregular mounds would be smoothed out as the project progresses and as soon as pipe is removed from completed sections.
- Escarpments formed during construction would be eliminated by scraping to gentle slopes similar to the natural swash zone slope.

Coastal Resources Impact Summary

Alternative 1–No-Action would allow erosion to continue and would lead to dune breaches, a possible barrier-island breach, and emergency measures such as sand scraping and sand bags to protect development and NC 12. It would likely foster further manipulation of the barrier-island profile and would result in moderate adverse impacts on coastal resources.

Alternative 2–Winter Construction would add up to 30 acres of beachfront area and would provide a new source of sand to the littoral system. The sand would move under normal coastal processes adding some volume to the foredune after nourishment and feeding sand to downcoast areas, particularly Cape Point and Diamond Shoals. It would reduce the possibility of a dune breach or barrier-island breach for several years and would produce direct, local, and long-term benefits for several years.

Alternative 3–Summer Construction would add up to 60 acres of beachfront area and would provide a new source of sand to the littoral system. The sand would move under normal coastal processes adding some volume to the foredune after construction and feeding sand to downcoast areas. It would reduce

the possibility of a dune breach or barrier-island breach and produce direct, local, and long-term benefits for up to one decade.

Cumulative Impacts on Coastal Resources

Hatteras Island and other Dare County beaches are parts of a continuous barrier-island system extending along the 326-mile-long North Carolina coast. Barrier islands exist through the buildup of sand by waves. Therefore, actions which add new sand to the beach system help maintain the integrity of the islands. Over long geologic time scales, barrier islands would tend to migrate landward or disintegrate under rising sea levels (Swift 1975). However, if the rate of sediment supply exceeds the rate of sediment losses (erosion), and sea level fluctuates at low rates, barrier islands would be preserved and even build seaward in some areas (Hayes & Michel 2008). If no new sediment is gained along barrier islands and sea level rises, the volume of sediment on the visible portion of the barrier island would diminish.

It can be shown that addition of ~1 cubic yard of non-littoral sand to the beach system creates ~1 square foot of beach area (CERC 1984). Beach nourishment is typically implemented along erosional beaches where development and infrastructure are at risk to erosion. The volume added would generally not remain in the action area indefinitely, but it would be conserved locally or regionally, moving to other segments of beach, into the dunes, or into inlets and shoals. The three alternatives evaluated for Buxton would add zero square feet, ~1.3 million square feet, or ~2.6 million square feet of beach area. Alternative 2 would provide ~30 acres and Alternative 3 would provide ~60 acres of new beach front area. Alternative 1 has no impact on littoral sand supply.

Other nourishment projects executed or planned for the 70-mile-long Dare County shoreline north of Cape Point between 2010 and 2020 include Nags Head (2011, 4.6 million cubic yards), Rodanthe (2014, 1.7 million cubic yards), Duck (planned 2016, 1.06 million cubic yards), Kitty Hawk (planned 2016, 1.91 million cubic yards) and Kill Devil Hills (planned 2016, 0.915 million cubic yards). Combined, these projects potentially add ~10.2 million square feet (~234 acres) of beachfront area north of Cape Point. At placement, projects completed or planned from 2010 to 2020 would impact a total of ~19.9 miles. The Buxton project (Alternative 3–Summer Construction) would increase these totals by ~60 acres and 2.9 miles. Therefore, all executed or planned projects in Dare County north of Cape Point between 2010 and 2020 would impact ~22.8 miles (33%) of the 70-mile-long shoreline and add up to 12.8 million cubic yards to the littoral sand budget. If the added sand eventually spread evenly over the 70 miles of shoreline by natural processes, it would advance the shoreline by ~35 feet and offset erosion losses of that magnitude.

The majority of impacted shoreline would occur north of Oregon Inlet. The two projects south of Oregon Inlet (Rodanthe and Buxton) would impact ~4.8 miles of ~38 miles (~13%) along Hatteras Island. These two sites are separated by ~20 miles. The Rodanthe project (2014) and the Buxton project (2016) would be separated in time and space. Sand added along Rodanthe in 2014 is expected to erode and move downcoast in the littoral system, incrementally offsetting erosion in other areas over time. Such additions of sand would augment the littoral sand budget, provide a volume of sand to feed the dune system, and add protection to development and habitats. This would produce a noticeable beneficial impact on coastal resources with negligible impact on regional littoral processes.

Beach widening by nourishment would provide a sand source for dune growth. Dune growth reduces the chance of a barrier breach or washover formation during storms. From the perspective of maintenance of the integrity of the barrier island, nourishment would provide a noticeable beneficial impact. However, from the perspective of maintaining or promoting erosional processes, dune

breaches, barrier island breaches, and washovers, nourishment would produce a noticeable negative impact. The degree of impact to coastal resources would be directly proportional to the volume of sand added to the beach system by each project in Dare County.

Washover barrier islands provide important habitat as discussed under Biological Resources. Currently, a substantial proportion of Dare County beaches north of Cape Point are being considered for nourishment for purposes of protecting existing infrastructure and development. However, nearly 50 miles remains of undeveloped erosional barrier islands immediately southwest of Cape Point, including Core Banks and Portsmouth Island, two washover barrier islands in the Cape Lookout National Seashore. Therefore, the Rodanthe project and the proposed Buxton action would impact a small fraction of the barrier-island shoreline between Oregon Inlet and Cape Lookout, leaving a spectrum of barrier island conditions ranging from accreting sites with high dunes to eroding sites with low dunes and active washovers.

Combined with the foreseeable future actions, including erosion elsewhere along Dare County Beaches, the No-Action Alternative would contribute a noticeable adverse increment to a long-term, regional, cumulative, adverse impact. Alternatives 2 and 3 would contribute a noticeable beneficial increment to a long-term regional, cumulative, adverse impact. Benefits from Alternative 2 would last for several years, whereas benefits from Alternative 3 would extend up to one decade.

SAND RESOURCES

Methodology

NPS guidelines and North Carolina rules for beach nourishment sediment quality (15A NCAC 07H.0312) call for use of sand that is similar in color, texture and grain size to the existing native sediment (NPS 2012a). The impact analysis and conclusions for possible impacts to sand resources are based on a detailed investigation of beach and offshore sand deposits in the Buxton Action Area, a review of existing literature and studies, experience with similar projects and professional judgment. Details of sand resource investigations are given in Appendix C (*Geotechnical Data*) of this EA. Predictions about short-and long-term impacts are based on similar projects in the Hatteras Island and Bodie Island setting.

Impacts of Alternative 1– No-Action

Under Alternative 1–No-Action, sand resources along the Buxton Proposed Action Area would diminish. As erosion continues, infrastructure and development including NC 12 would be periodically damaged. Erosion has forced emergency protection measures including sand scraping, emergency sand bags, and dune reconstruction. These actions have altered the sediment size distribution in the dunes, leading to coarser grain sizes in comparison with unaltered sections of Hatteras Island. For example, mean grain size in the foredune along the Proposed Action Area is 0.515 millimeter (ten stations ranging from means of 0.373 to 0.682 millimeter) (Appendix C– *Geotechnical Data*). By comparison, dune samples along other beaches of the Outer Banks are typically 0.3–0.35 millimeter (USACE 2010). Continued erosion under Alternative 1–No-Action would lead to further scraping and manipulation of the profile and introduction of more coarse sediment in the dune.

Coarser sediments in the dune increase drainage and modify freshwater retention, which interferes with natural propagation of dune vegetation. Coarser sediments in the Proposed Action Area compared with other Hatteras Island beaches, combined with emergency sand bags, have produced a steeper profile

and have led to higher wave runup relative to runup over wide beaches (McNinch et al. 2012). The narrow, dry-sand and wet-sand beach in the central part of the Proposed Action Area around the Seashore/Buxton Village boundary is a zone of chronic wave overtopping and flooding of NC 12 and developed property. Such flooding would continue at increased frequency. Minor storm events would carry coarse granular sediments from the lower beach face to the backshore, changing the character of sediments across the profile relative to unmanipulated segments of Hatteras Island.

Alternative 1–No-Action would have a moderate adverse impact on the sand resources in the Proposed Action Area and would continue to modify the character of the sediment distribution across the profile due to emergency manipulations in comparison with unmanipulated reaches of Hatteras Island. Because of the potential loss of beach area, continued manipulation of the foredune to restore access along NC 12 after storms, and the likelihood of more emergency sand bags to protect threatened structures, Alternative 1–No-Action would result in moderate, long-term adverse impact on sand resources in the Proposed Action Area. While erosion would likely result from natural processes, it would induce further emergency actions to protect property and infrastructure including NC 12.

Impacts of Alternative 2–Winter Construction

Under Alternative 2–Winter Construction, up to 1.3 million cubic yards of non-littoral sand would be removed from an offshore shoal and added to the beach zone within the Proposed Action Area. A high density of borings (~1 per 12 acres) in the borrow area, yielding over 120 sediment samples in the upper 8–9 feet of substrate, indicate general vertical and horizontal consistency in sediment quality (Appendix C–*Geotechnical Data*). Color, mean grain size, percent gravel, and percent shell are relatively uniform within the portion of the sand search area targeted for excavations (see Fig 3.10). Composite samples to 4, 6, and 8 feet of section show vertical homogeneity, which means excavations to a range of depths (not to exceed 7 feet of substrate) would leave similar underlying sediments. The color of sediments in nearly all cores is similar to native beach sediments and characteristic of well-oxygenated waters. Fines, such as clays and silts, are generally absent or found only in trace amounts in the core samples. The general lack of mud or organics is reflected in sediment color, lack of flaser bedding (Reineck & Singh 1976), or other indicators of cyclic sedimentation during quiescent periods. The borrow area is exposed to high waves which naturally winnow fine-grained material from the deposit and limit natural turbidity.

Winter dredging operations would likely be limited to ocean-certified hopper dredges because of high wave conditions between December 1 and March 31. Hopper dredges typically would lower two drag arms to the bottom along either side of the vessel. Each drag arm contains a suction head and piping which jets water into the substrate to liquefy the sediments. Suction pumps then draw slurry into the hopper of the vessel. The sediment-water slurry fills the hold during the initial 10–15 minutes of excavation then water and any fine-grained material that is present begin to overflow through scuppers. During the remainder of each hopper loading (~30–60 minutes), water and fines continue to discharge overboard while coarser material settles in the hopper. The net result is an incrementally coarser grain size in the hopper relative to the in-situ sediments excavated. Material in the hopper is what ultimately is pumped to the beach.

Because the borrow area is generally free of mud, the majority of sediments lost overboard during excavation is likely to be in the coarse silt to very fine sand range (i.e. <0.1 millimeter diameter). The composite characteristics of the borrow sediments are expected to be in the narrow ranges of 0.45–0.47 millimeter (mean diameter), 2.3–2.8% gravel (defined as mean size >2 millimeters), and 14.2–15.1% shell for composites to 4, 6, and 8 feet or all samples (see Table 3.2 and Appendix C).

Borrow sand would be discharged along the seaward edge of the dry-sand beach. The visible beach in the Proposed Action Area tested 0.44 millimeter mean diameter in August 2013 (24 samples) and 0.58 millimeter mean diameter in October 2014 (Appendix C). The borrow area would provide sediments similar to conditions observed on the visible beach in summer within the Proposed Action Area but somewhat finer than fall post-storm conditions. Nearshore sediments in the Proposed Action Area are generally <0.3 millimeter mean diameter from the outer bar to –24 feet NAVD. However, sediments in the trough presently test >2 millimeters mean diameter. The borrow sediments would be much finer than the native trough samples but coarser than the nearshore samples.

The borrow sediments, after mixing with native sediments across the littoral profile in the Proposed Action Area, are expected to incrementally reduce the variation in grain sizes from the foredune to deep water. Finer sands within the size distribution are expected to be sorted by wind and naturally shift to the toe of the foredune or move offshore. The net result after profile adjustment would be coarser sediment on the berm and wet-sand beach similar to existing conditions. Sorting and mixing of native and borrow sediments would preserve similar variations in grain size across the profile but incrementally shift sizes closer to those of other Hatteras Island beaches. The Applicant proposes to track the evolution of sand sizes via post-project sampling using state standards for beach nourishment sediment sampling.

Alternative 2 would produce a moderate, long-term, adverse impact in the borrow area by removing up to 1.3 million cubic yards of sand resources. The impact area would be ~300 acres and involve a reduction in average shoal elevation (increased depth) of ~2.5-3 feet within the excavation boundaries. This volume represents ~10–15% of the shoal volume in the upper ~8 feet of substrate. Alternative 2 would produce a minor, long-term (several years), beneficial impact along the beach by addition of up to 1.3 million cubic yards of beach quality sand. Upon mixing with native sediment and adjustment of the profile, the sediment quality in the beach-dune system within the action area is expected to change incrementally and become more similar to that of unmanipulated profiles along Hatteras Island. The added sand resources along the beach would provide long-term, indirect benefits downcoast, as new sand in the action area erodes and is transported toward Cape Point and Diamond Shoals.

Impacts of Alternative 3 (Preferred Alternative) Summer Construction

Under Alternative 3 (Preferred Alternative) Summer Construction, up to 2.6 million cubic yards of non-littoral sand from the offshore borrow area would be added to the beach zone within the Buxton Proposed Action Area. Impacts to sand resources would be similar but greater than Alternative 2–Winter Construction based on higher volumes. A total of 37 borings were obtained in and around an ~450-acre, sand search area 1.7 miles seaward of Cape Hatteras Lighthouse (see Fig 3.10). A total of 33 cores are situated in the sand search area (1 per 13.6 acres). Following cultural resources surveys (Appendix F, *Cultural Resources*), an ~300-acre subarea within the sand search box was defined, leaving no-work buffers around magnetic anomalies which may represent debris and cables on the ocean floor. This subarea (Fig 4.4) would be the maximum area of impact. It is represented by 28 borings (1 per ~11 acres).

Appendix C (*Geotechnical Data*) provides detailed sediment quality for all borings. As Figure 3.10 illustrated, general spatial and vertical uniformity of sediment exists within the proposed borrow area. Excavations to variable depths (not to exceed 7 feet below existing grade) would leave similar sediments exposed on the bottom. Based on the consistency of sediment quality in and around the borrow area and negligible mud in the shoal deposit, sediments which infill depressions after dredging are expected to be similar in size, color, and shell content as the pre-dredging conditions.

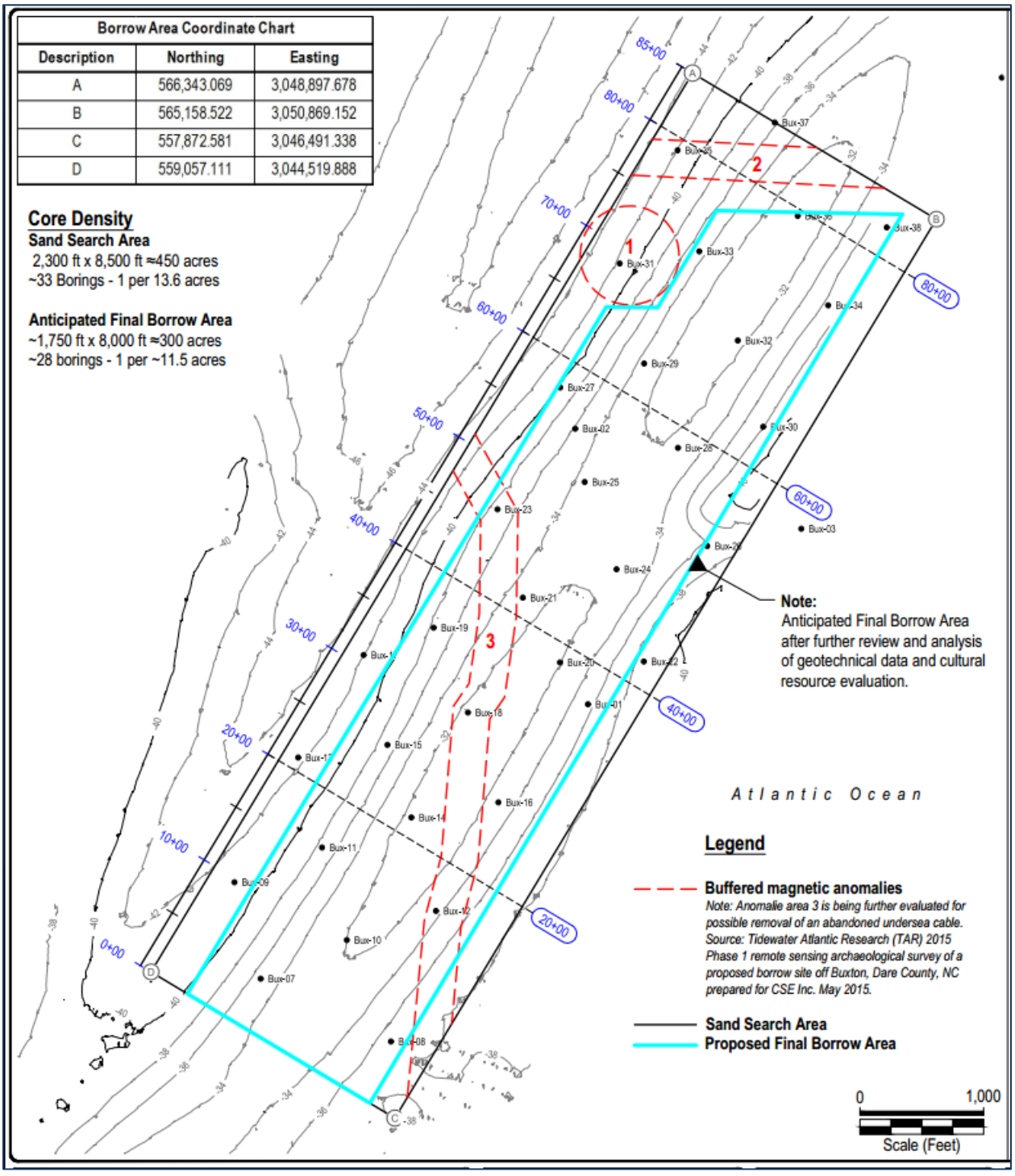


Figure 4.4. Map of the Buxton (NC) sand search area 1.7 miles seaward of Cape Hatteras Lighthouse. Dashed lines show proposed no-work areas around magnetic anomalies. Anomaly #3 is believed to be an abandoned communication cable which may be removed prior to dredging. The proposed final borrow area (blue border) is ~300 acres and contains 28 borings for sediment quality.

The proposed borrow area is located in similar water depths and distance offshore as the borrow areas used in the 2011 Nags Head project. Information on pre- and post-project sediment quality at that site is contained in Appendix E (*Biological Monitoring*). The Nags Head borrow area showed non-significant differences in sediment quality in nearly all post-project samples obtained during eight seasonal sampling events relative to nearby control stations. Based on similarities in sediment quality between the proposed borrow area and the Nags Head borrow area, post-project sediments are expected to show negligible differences after dredging and equilibration of the bottom.

Alternative 3–Summer Construction would approximately double the volume of new sand added to the beach in the Proposed Action Area compared with Alternative 2–Winter Construction. The additional volume would increase longevity of the project and serve as a larger source of sand to feed downcoast areas of the Seashore. Natural sorting of grain sizes would involve the same processes as described for Alternative 2–Winter Construction. However, the volume of new sand shifted into the backbeach and foredune would be greater and thereby would provide longer term benefits of beach restoration.

Alternative 3–Summer Construction would reduce the volume of sand in the targeted offshore shoal by ~25%. This depletion of offshore sand resources would be balanced by the increase in beach volume within the project beach. The proposed, shoal-borrow area represents ~2% of similar shoal areas off Hatteras Island inside the 3–mile limit (i.e. state waters). Because the project would remove <25% of the shoal volume, the impact on shoal sand resources is expected to be <0.5% of the total shoal volume in the region.

USACE (2000) identified a 7-mile-long shoal in state waters off Nags Head and estimated it contained ~100 million cubic yards of beach-quality sand. The 2011 Nags Head project removed ~4.6 million cubic yards (~4.6%) from the shoal. Byrnes et al (2013) located a similar shoal in federal waters off Nags Head and estimated that deposit also contained ~100 million cubic yards of beach-quality sediment. The shoal areas off Nags Head, combined, are smaller than Diamond Shoals, providing a measure of potential sand resources remaining in the vicinity of the Proposed Action Area. Offshore shoals like the proposed borrow area are relict deposits accumulated during lower stands of sea level. They are generally positioned too far offshore and in water too deep for natural exchange with the beach at decadal-to-century time scales.

Alternative 3–Summer Construction would have a moderate, long-term, adverse impact on the sand resources in the borrow area by removing up to 2.6 million cubic yards of sand resources. It would have a moderate beneficial impact on the sand resources along the beach. Based on the sediment quality in the borrow area, nearly all material pumped to the beach is expected to remain in the littoral zone for decades, thereby feeding sand to the downcoast beach (i.e. Cape Point area) and Diamond Shoals as erosion continues in the Proposed Action Area.

Sand Resources Impact Summary

Alternative 1–No-Action would have no impact on offshore sand resources. However, continued erosion would have a minor adverse impact on sand resources along the beach within the Proposed Action Area.

Alternative 2–Winter Construction would have a moderate adverse impact on sand resources in the borrow area. This would be balanced by a long-term (several years) beneficial impact on sand resources along the beach in the Proposed Action Area. Sand resources added to the beach zone would ultimately contribute by natural processes to dune growth and downcoast accumulation with the majority of the nourishment sand eventually shifting to Cape Point and Diamond Shoals.

Alternative 3–Summer Construction would provide approximately twice the impacts of Alternative 2, because of a doubling of the sand resources involved. Otherwise, adverse and beneficial impacts would be similar.

Cumulative Impacts on Sand Resources

Nourishment projects executed or planned in Dare County north of Cape Point between 2010 and 2020 would potentially impact ~2,880 acres of offshore bottom and remove up to 12.8 million cubic yards. Two borrow areas in state waters totaling 480 acres (out of 575 acres permitted) were impacted during the 2011 Nags Head project (CSE 2012). The Rodanthe Project impacted <400 acres of offshore bottom, and the Duck, Kitty Hawk, and Kill Devil Hills projects are anticipated to impact much less than the ~1,700 acres of federal offshore bottom which is being proposed for future excavation (CPE 2015). The proposed Buxton Project would impact up to 300 acres. These areas, though imprecise, represent ~2% of the ocean bottom within state waters of Dare County north of Cape Point, or 1% of the ocean bottom out to a distance of ~6 miles offshore. The Duck, Kitty Hawk, and Kill Devil Hills projects are proposing borrow areas in federal waters ~4–6 miles offshore (CPE 2015). There are ~420 square miles (~270,000 acres) of ocean bottom out to 6 miles off Dare County north of Cape Point.

USACE (2000) and Byrnes et al (2003) identified potential, beach-quality sand resources off Dare County north of Oregon Inlet totaling ~200 million cubic yards. The projects north of Oregon Inlet between 2010 and 2020 would remove up to ~8.5 million cubic yards (~4.3%) of the estimated sand resources from those areas. The completed or planned nourishment projects along Dare County north of Cape Point between 2010 and 2020 would remove a small fraction of the available offshore sand resources. Placement of sand along the beach would add up to 12.8 million cubic yards to the littoral budget. The majority of projects completed or planned would be north of Oregon Inlet. No projects are anticipated to occur between 2010 and 2020 between Cape Point and Cape Lookout. If implemented at the maximum sand volume under Alternative 3–Summer Construction, the Buxton project would produce a noticeable but incremental reduction in offshore sand resources within state and federal waters off Dare County and would produce a noticeable but incremental increase in beach sand sources along Hatteras Island.

Other impacts to sand resources along the beach in Dare County during the 2010-2020 decade would likely include minor additions of sand from inland sources, including potentially Hatteras and Bodie Island deposits on NC 12 after storms. Such import of sand from inland to repair roads or fill breaches, as well as volumes transferred from storm deposits on NC 12 back to the dune, would likely be a small fraction of the planned or executed nourishment projects. Sand transfers from the road back to the beach after storms would potentially introduce non-beach-compatible material—a noticeable adverse increment to the overall cumulative impacts to beach sand resources along Dare County Beaches north of Cape Point. Alternative 2 and 3 would contribute a noticeable adverse increment to the overall cumulative impact to offshore sand resources, with Alternative 3 producing roughly twice the increment of Alternative 2. Alternative 2 and 3 would contribute a proportionally noticeable beneficial increment to the overall cumulative impact of beach sand resources.

WATER QUALITY

Methodology

The analysis of water quality within the study area is based on review of existing data and literature for the project area.

Impacts of Alternative 1–No-Action

Under Alternative 1–No-Action, ongoing erosion in the Proposed Action Area would periodically encroach on development and NC 12. These natural actions would release contaminants like oil and grease from the highway, or create debris from buildings which would enter the surf zone, contributing to non-point-source pollution (NPS). These events would be small-scale and episodic, and have a negligible to minor adverse impact on water quality in the Proposed Action Area. The frequency of such events would likely increase under Alternative 1–No-Action as erosion worsens, but would not produce adverse long-term impacts on water quality due to rapid dilution and low concentration of contaminants in the surf zone. The overall water quality along the Proposed Action Area would remain within historical limits and the normal range of conditions between storms and fair-weather periods. Turbidity levels would remain a function of wave action and natural runoff during rain storms.

Impacts of Alternative 2–Winter Construction

Under Alternative 2–Winter Construction, beach nourishment would produce turbidity in the offshore borrow area and in the area of active beach filling. Dredging mobilizes unconsolidated sediments and places them in suspension in the water column, which can have detrimental effects on marine organisms present in the area (Michel et al 2013). Sediment suspensions in the surf zone or over high-energy shoals, such as the proposed borrow area, tend to be intermittent with rapid settling of sandy material (Komar 1998). Settling velocities of sand-sized particles (~0.1–2 millimeter diameter) are roughly in the range 1–20 centimeters per second in quiet water. Thus, settling occurs in seconds to minutes for sand-sized particles in the range of depths typical of the Proposed Action Area including the borrow area.

Fine-grained material (e.g. silts and clays) has much slower settling velocities and may remain in suspension for hours or indefinitely under conditions of natural vertical mixing and resuspension (Adriaanse & Coosen 1991). Suspended particles may interfere with biological processes including respiration and reproduction. Filter-feeding organisms typical of the nearshore, such as polychaete worms, mollusks, and amphipods, may be adversely impacted by high turbidity. Turbid waters also diminish light penetration and can adversely impact photosynthesis and the activity of phytoplankton.

Hopper dredging produces sediment plumes associated with the operation of drag heads as well as overflow during loading operations (Herbich 1975). Plumes at drag heads are typically localized at the bottom and do not extend through the water column to the surface (LaSalle et al 1991). Plumes associated with overflow may extend further because of the greater fall distances to the bed, as well as the continuous motion of the ship. Plumes have been reported to extend 1,600–4,000 feet from the dredge (Hitchcock et al 1998). The length and shape of the plume depends on the currents and waves as well as the sediment grain size.

For the proposed project, expected levels of turbidity are indicated by the background conditions and natural variations between storm and calm sea conditions. No riverine sources of fine-grained sediment have been identified in the Cape Hatteras area. Detritus, such as dead *Spartina* grass and clays, flushed out of Pamlico Sound via Oregon Inlet and Hatteras Inlet may be transported into the Proposed Action Area during storms. However, the general lack of fine-grained material in the littoral zone or in the borrow area (based on available cores) suggests existing conditions prevent accumulations of the type of material that is likely to remain in suspension for extended periods. The color of sediments in the proposed borrow area is similar to native beach sediments and further support this observation. While turbidity is likely to be elevated locally at the dredge during excavations and loading, the plume associated with the action is expected to be limited in extent and short-lived. Sediments released into the water column are expected to be >99% sand-sized material, or coarser, based on the available

sediment cores (Appendix C). The predominance of sandy material in the proposed borrow area and oxygen-rich conditions indicate the Proposed Action would have negligible impact on dissolved oxygen, pH, or temperature.

The coarse texture of proposed borrow sediment would minimize the spatial and temporal extent of sediment plumes around the dredge or at beach discharge points. The impact would be highly localized and temporary, returning to ambient conditions within minutes to hours of cessation of pumping. Sediment discharges would not elevate turbidity levels beyond the range of levels that occur during storm events.

Alternative 2 would produce minor, localized short-term adverse impacts on turbidity in the borrow area and at the active discharge point along the beach. It would produce imperceptible, local, short-term changes in dissolved oxygen, temperature, pH or salinity in the water column during construction.

Impacts of Alternative 3 (Preferred Alternative) Summer Construction

Under Alternative 3–Summer Construction, beach nourishment would produce similar impacts as Alternative 2. The greater volume involved with Alternative 3 means that a greater amount of fine-grained material would enter the water column, even if the concentrations of silt and clays are the same as Alternative 2. Higher daily production under Alternative 3 would produce incrementally larger suspensions. However, settling would be rapid, and the extent of plumes would be localized around the dredge and discharge point(s). At Nags Head, sediment plumes associated with the discharge were visible a few hundred yards in either direction alongshore (CSE 2012). The plumes were generally confined to the inner littoral zones inside the bar. At the cessation of dredging or between hopper loads, turbidity became more localized around the bulldozer work at the edge of the fill.

One indicator of fine-grained material in borrow sediments would be a thin deposit of mud in depressions or tire tracks on the nourishment berm. These form where pools of slurry flow into an isolated swale before running into the surf zone. There were negligible puddles of mud on the Nags Head nourishment berm in 2011 (CSE 2012). Based on the similarity of borrow areas and sediment quality, mud lenses are not expected to accumulate at Buxton or produce long-term impacts such as cementation of sediments. Thin mud drapes over isolated depressions in the nourishment berm are more common where temporary dikes are used to contain the nourishment material and direct the flow parallel to shore. Where dikes are not used, the slurry tends to drain efficiently into the surf zone carrying fines away from the berm. The low fraction of fine-grained materials in the borrow area is expected to prevent any noticeable accumulations of mud or produce conditions whereby sediment compaction, cementation or quality varies substantially from ambient conditions.

Under Alternative 3–Summer Construction, the course texture of proposed borrow sediments is expected to produce negligible adverse impacts on turbidity and water quality within the Proposed Action Area. The impacts would be highly localized and temporary, returning to ambient conditions within minutes to hours of cessation of pumping and beach grading operations. Sediment discharges would not elevate turbidity levels beyond the range of levels that occur during and after storm events.

Like Alternative 2, Alternative 3 would produce minor, localized short-term adverse impacts on turbidity in the borrow area and at the active discharge point along the beach. It would produce imperceptible, local, short-term changes in dissolved oxygen, temperature, pH or salinity in the water column during construction. Impacts of Alternative 3 would be incrementally greater than Alternative 2 because of the large borrow and nourishment volume.

Cumulative Impacts on Water Quality

Water quality along the beaches of the Seashore and Dare County is considered to be high. Beach nourishment activities completed or planned for the period 2010 to 2020 involve offshore deposits which are predominantly beach quality sand. The deposits used at Nags Head (CSE 2012) and Rodanthe (USACE 2013a) did not result in extensive turbid plumes during construction and conditions returned to normal after cessation of dredging. The sediment in the proposed borrow areas for Buxton, Duck, Kitty Hawk, and Kill Devil Hills is predominantly sand-sized material with low concentration of mud; therefore, turbidity levels are not expected to remain elevated over extensive areas or time during or after dredging. Natural erosion along Dare County beaches north of Cape Point is expected to continue into the future with certain limited reaches, such as Kitty Hawk (~3 miles), south Nags Head (~2 miles), Pea Island (~5 miles), Rodanthe (~3 miles) and east Buxton (~2miles), exhibiting more rapid changes (NCDENR 2012). These erosion hot spots among others tend to be sites of dune breaches, washovers into NC 12, breach inlets during major storms, or encroachment on development. Ad hoc repairs and protection measures such as sand bags are likely to continue into the foreseeable future for purposes of maintaining vehicle access along NC 12 or protecting existing structures. Such events and emergency measures produce negligible to minor adverse impacts on water quality by releasing contaminants from roads or building materials as repairs are made. The No-Action Alternative would contribute an imperceptible adverse increment to long-term, negligible adverse cumulative impacts. If implemented at the maximum sand volume under Alternative 3, the Buxton project would produce an imperceptible, adverse increment to long-term, negligible adverse cumulative impacts on turbidity levels and water quality along Dare County beaches or the offshore zone. The impacts of Alternative 2 and 3 would be indistinguishable from the normal fluctuations in turbidity associated with natural events.

ESSENTIAL FISH HABITAT AND HABITAT AREAS OF PARTICULAR CONCERN

Methodology

The Sustainable Fisheries Act of 1996 identified the contribution of habitat loss and degradation on fishery declines and amended the Magnuson-Stevens Act to create a program to protect essential fish habitat (EFH). The Magnuson-Stevens Fisheries Conservation and Management Act [Section 305(b)(2)] mandates that all federal agencies consider the potential impacts of their activities on Essential Fish Habitat (EFH). Certain areas or zones within EFH categories are also considered to be Habitat Areas of Particular Concern (HAPC).These EFHs and HAPCs are discussed and evaluated in detail in Appendix D (*Essential Fish Habitat*), prepared for the proposed Buxton project. The Buxton EFH assessment analyzed effects of the proposed action, Alternative 3–Summer Construction, as that alternative would have the most effects on EFH/HAPC and on the species found in those habitats. For the purpose of analysis, the project vicinity is within 2 miles and the project area and Proposed Action Area is the area directly impacted by either the dredge activity or sand placement activity.

Within the project vicinity, ten EFH categories and four geographically defined HAPC can be found. Of the ten EFHs, six are estuarine (emergent wetlands, submerged aquatic vegetation [SAV], oyster reefs and shell banks, intertidal flats, estuarine water column and seagrass) and four are marine (unconsolidated/shallow subtidal bottom, artificial man-made reefs, *Sargassum,* and water column and high-salinity surf zones). Of the HAPC, three are considered area-wide (*Sargassum* habitat, state-designated areas of importance for managed species [PNAs or primary nursery areas], and submerged aquatic vegetation) and one is specific to North Carolina (Cape Hatteras sandy shoals). See Table 4.1.

Within the project area/action area three EFHs (no estuarine, but marine unconsolidated/shallow subtidal bottom, *Sargassum*, and marine water column and high salinity surf zones) and two HAPC (*Sargassum* habitat and Cape Hatteras sandy shoals) are found. The potential impacts to EFH/HAPC were evaluated through review of the literature and related data from similar projects. The thresholds of change for the intensity of an impact and duration are described earlier in document (see pg 120).

Impacts of Alternative 1–No-Action

Under Alternative 1–No-Action, conditions in the action area would be impacted in incremental and usually minor ways by ongoing erosion and emergency protection measures. The NC Department of Transportation would continue to manage NC 12 repairs as necessary following overwash events and inlet breaches as they occur. In overwash events, NCDOT most often bulldozes overwash sands from the highway and shapes the sand into dunes along the east edge of NC 12—an activity which would have no effect on Essential Fish Habitat or Habitat Areas of Particular Concern in the Proposed Action Area. However, an inlet breach could be considered a larger impact/change. Depending on the scale and dynamics of the breach, newly formed EFH could become stabilized and used by fish and/or their prey before the emergency solution could be permitted. Examples of solutions would be a temporary bridge or emergency beach nourishment, as was completed in 2014 at the Rodanthe breach. New EFH could be impacted by either solution.

Under Alternative 1–No-Action, the Buxton Village property owners would continue to apply for permits to add sand bags in front of threatened structures. The area currently sandbagged (~1,500 ft) may expand in length in the future under this alternative. Sand bags reduce the area of inner surf zone substrate for benthic organisms, and continued erosion tends to concentrate coarser sediments in the beach zone. This has the potential to modify the marine unconsolidated/shallow subtidal bottom EFH and change the conditions for benthic fauna to propagate and maintain similar population assemblages.

Alternative 1–No-Action would have no direct effects on NPS management of EFH, as no specific current NPS management activities are occurring in these EFH-identified habitats. However, part of the NPS mandate is to protect the natural resources within any park boundary, which would include some of the EFH found on the west side of NC 12. As the Seashore western boundary is usually considered to include 150 feet of Pamlico Sound, these back-barrier EFH resources under NPS protection could include emergent wetlands, submerged aquatic vegetation (SAV), oyster reefs and shell banks, intertidal flats, estuarine water column, and seagrass. Alternative 1–No-Action and the NPS approach to protection of these resources would allow natural processes such as overwash or inlet breaches to alter, bury, or bisect some of these back-barrier EFH.

Alternative 1-No-Action would have indirect, site-specific to local, long-term, minor adverse impacts to nearshore EFH/HAPC, but no impact on offshore EFH or HAPC.

Table 4.1 Listing of EFH categories and geographic HAPCs within the project vicinity, indicating four categories of EFH that would be impacted by dredging operations and one that would be impacted by sand placement activities. Of these impacts, all but one would be within acceptable limits. Unconsolidated, shallow, subtidal bottom (i.e. the borrow area) is the principal EFH that may be the most impacted. [W = within acceptable limits]

	PROXIMITY		IMPACT ACTIVITY	
ESSENTIAL FISH HABITAT	**Project Vicinity**	**Project Impact Area**	**Dredge Operations**	**Sand Placement**
Estuarine				
Emergent wetlands	Y	N	N	N
Estuarine scrub/shrub mangroves	N	N	N	N
Submerged aquatic vegetation (SAV)	Y	N	N	N
Oyster reefs and shell banks	Y	N	N	N
Intertidal flats	Y	N	N	N
Aquatic beds	N	N	N	N
Estuarine water column	Y	N	N	N
Seagrass	Y	N	N	N
Creeks	N	N	N	N
Mud bottom	N	N	N	N
Marine				
Emergent wetlands	N	N	N	N
Unconsolidated/shallow subtidal bottom	Y	Y	Y	Y
Live/hard bottoms	N	N	N	N
Coral and coral reefs	N	N	N	N
Artificial/man-made reefs	Y	N	N	N
Sargassum	Y	Y	W	N
Water column & high salinity surf zones	Y	Y	W	W
GEOGRAPHICALLY DEFINED HAPC	**PROXIMITY**		**IMPACT ACTIVITY**	
Area-wide				
Council-designated artificial reef special management zones	N	N	N	N
Hermatypic (reef-forming) coral habitat and reefs	N	N	N	N
Hard bottoms	N	N	N	N
Hoyt Hills	N	N	N	N
Sargassum habitat	Y	Y	W	N
State-designated areas of importance for managed species (PNAs)	Y	N	N	N
Submerged aquatic vegetation (SAV)	Y	N	N	N
North Carolina				
Big Rock	N	N	N	N
Bogue Sound	N	N	N	N
Pamlico Sound at Hatteras/Ocracoke Islands	N	N	N	N
Cape Fear sandy shoals	N	N	N	N
Cape Hatteras sandy shoals	Y	Y	W	N
Cape Lookout sandy shoals	N	N	N	N
New River	N	N	N	N
The Ten Fathom Ledge	N	N	N	N
The Point	N	N	N	N

Impacts of Alternative 2–Winter Construction

Alternative 2–Winter Construction would have direct, site-specific, short-term minor to moderate impact on benthic organisms, the fish which prey upon those benthos, and other fish higher in the food chain which may be present in the three EFH and two HAPC categories found in the Proposed Action Area (marine water column and high-salinity surf zone EFH, the unconsolidated/shallow subtidal bottom EFH, *Sargassum* EFH, *Sargassum* habitat HAPC, and the 20–30-foot high Cape Hatteras sandy shoals HAPC (borrow area). The same three EFH's along the same ~3 miles of beach as Alternative 3–Summer Construction would be impacted although impacts to the offshore HAPC (Cape Hatteras sandy shoals) would be about 50% less than Alternative 3–Summer Construction (average dredge depth 2.5–3 feet with Alternative 2–Winter Construction).

Dredging of any kind would result in the direct removal of benthic habitat along with the infaunal and epifaunal organisms with limited motility in that habitat. Habitat removal would reduce both the number of individuals, number of taxa, and the biomass. This alternative would impact EFH/HAPC by modification of the HAPC bottom at the offshore borrow area (Cape Hatteras sandy shoal), burial of prey organisms for certain fish species in the surf zone EFH (marine unconsolidated/shallow subtidal bottom) during placement of up to 1.3 million cubic yards of sand, and introduction of more turbidity into the water column which would affect EFH (*Sargassum* and marine water column and high salinity surf zones) and HAPC (*Sargassum* habitat and Cape Hatteras sandy shoals).

At any given time, only 600–800 feet of beach would experience active impacts and the intertidal zone EFH within the 200–300 linear feet of sand placement completed per day would become immediately available for benthic recruitment and use by fish. Additionally, areas in the borrow area untouched by the dredge would serve as refugia and recruitment sources. For the shoal, dredging would not impact the entire borrow area at once, and undisturbed area would be available for benthic recruitment as operations continued, helping the impact area to recover and provide habitat for fish use. These minor to moderate adverse impacts to the EFH/HAPC in the Proposed Action Area (beach and offshore) are expected to be short-lived, based on recovery rates for similar projects (Burlas et al. 2001, CZR/CSE 2014 Appendix E) and expected conservation measures.

Based on multiple studies of similar borrow areas and benthic populations recovery cited in Michel et al (2013), the effect of Alternative 2–Winter Construction on EFH/HAPC would likely be minor and short-lived because (1) areas of offshore sandy substrates like the proposed borrow area typically recover more quickly, and (2) areas of the borrow shoal would be left undisturbed which would serve as refugia and recolonization sources, and (3) mitigation measures during dredging would avoid creation of pits which could infill with finer sediments and help prevent rapid colonization by less desirable, successional benthic species. Geotechnical data (Appendix C) also indicate that underlying sediments remaining after excavation are likely to be similar in size, texture, and color as the existing substrate. Geotechnical data also indicate the dredged material proposed for placement on the Buxton beach is similar in size, texture, and color to the native beach which also helps to ensure benthic population recovery (Deaton et al 2010). Thus recruitment of a similar suite of benthic organisms is expected offshore and on the beach (see Appendix E–*Biological Monitoring*). Results from similar projects along with the similarity between native beach sands, borrow sands, and underlying sands in the borrow area, support the expectation that recolonization would be rapid (2–6.5 months for beach) (NMFS 2012).

Compared to Alternative 1–No Action, winter construction would provide a wider dry-sand beach and restore a normal surf-zone profile along segments of the project area that have been modified by emergency sand bags (with ~1.3 acres of intertidal area added seaward of sand bags) for ~3 years (beneficial direct, site-specific, long-term impact). This would increase the area of marine unconsolidated/shallow

subtidal bottom EFH for benthic organisms compared with existing conditions along ~15% of the project length. Another beneficial, direct, site-specific, long-term impact to the marine unconsolidated/ shallow subtidal bottom EFH would be a less steep profile which would tend to increase the habitat and distance of wave runup.

Offshore dredging would alter the Cape Hatteras sandy shoal HAPC, but dredging in winter when benthic populations are lower in the offshore zone of Dare County (see Appendix E) and removal of ~1.3 million cubic yards (~50% less than summer construction) would have reduced impacts to the 20–30-foot high Cape Hatteras sandy shoal HAPC compared to Alternative 3–Summer Construction (average dredge depth would be ~2.5–3 feet with Alternative 2–Winter Construction). No more than 300 acres or ~25% of the offshore shoal would be disturbed with Alternative 2–Winter Construction if hopper dredges were used (cutterhead dredge would dredge deeper in a smaller acreage, but would not likely be able to operate in the winter due to wave climate). There would be a potential beneficial impact for fish which may aggregate over the HAPC shoal as the surface of the borrow area would likely have a more complex surface topography post-dredging and post-equilibration which may provide more diverse food and shelter for both prey and predator.

The following list of considerations to minimize impacts to EFH/HAPC was developed in coordination with the NCDMF and NOAA-NMFS during early project planning for the 2014 emergency project at Rodanthe. These would be implemented to the maximum extent practicable for either Alternative 2–Winter Construction or Alternative 3–Summer Construction:

1) Promote quick benthic recovery through shallow borrow area excavation.
2) Use topographic highs and/or areas of high sediment mobility within the borrow area.
3) Encourage dredge operations that leave behind unimpacted ridges to allow for recovery.
4) Avoidance of hard bottom resources (within the nearshore toe of fill and offshore borrow area). There are no indications of hard bottom in close proximity to any portion of the Proposed Action Area.
5) Construction of a temporary sand dike* along the seaward edge of the slurry discharge to contain the sand and minimize turbidity.

[A temporary sand dike is considered when the borrow material contains a significant proportion of fines, and it is necessary to reduce handling losses. However, such conditions also lead to greater accumulation of fines in the beach fill, which may bind deposited sediments and increase compaction. For borrow material that has only trace amounts of mud, temporary sand dikes may be counter-productive. Decisions on the use of sand dikes to contain the slurry would be made at the time of construction. They would be implemented if it is deemed beneficial to controlling the fill placement or to reducing turbidity.]

The five Rodanthe EFH considerations listed above would be applied to the Buxton project, integrated into planning, and eventually into the Buxton project construction process under either Alternative 2–Winter Construction or Alternative 3–Summer Construction. This would be implemented to minimize physical and biological impacts to EFH and to assure that any adverse effects are short-term and localized on both an individual and cumulative effects basis.

Alternative 2-Winter Construction would have direct, site-specific, short-term, minor to moderate adverse impacts to EFH/HAPC in the borrow area during dredging and in the surf zone during sand placement. Indirect, long-term impacts to surf-zone EFH would be beneficial compared to Alternative 1–No-Action and would also have potential beneficial impact to Cape Hatteras sandy shoal HAPC by the addition of post-project habitat complexity.

Impacts of Alternative 3 (Preferred Alternative) Summer Construction

The potential adverse impacts of Alternative 3– Summer Construction on EFH/HAPC in the Proposed Action Area would be direct, site-specific, short-term, minor to moderate, and were summarized in Table 4.1. Only those habitats which would have the potential to be impacted (either a Y or W shown in the Impact Activity columns of Table 4.1) were discussed in further detail in Section 6.0 of the Buxton EFH assessment (Appendix D).

Alternative 3–Summer Construction would impact the same three EFHs and two HAPCs as identified previously in Alternative 2–Winter Construction but over a slightly wider distance in the case of the surf zone EFH (~150 feet). The marine water column EFH and HAPC in the offshore area would be ~4–5 feet deeper over the shoal post-removal of the sediment (average dredge depth of 5.5 feet) and like Alternative 2–Winter Construction, ~75% of the offshore shoal would remain undisturbed if hopper dredges are used. However, in the summer, the dredge operator may elect to use some combination of hopper dredge and cutterhead dredge. The latter would dredge up to a maximum of 7 feet over an incrementally smaller footprint, leaving more of the shoal area undisturbed. As this alternative would provide approximately twice as much sand volume and would result in the widest beach in the Proposed Action Area, it would also produce greater impacts on the organisms in EFH/HAPC found within the Proposed Action Area. Active impacts on the surf zone EFH and borrow area HAPC would be as described in Alternative 2-Winter Construction.

Since construction would occur in the late spring-summer timeframe (i.e. May–September) when benthic population densities and recruitment tend to be greater, more organisms would be present, and since the footprint is 50% greater along the beach than Alternative 2–Winter Construction, mortality and disruptions to organisms within these EFH/HAPCs would be higher than either of the other two alternatives under consideration. There would be a potential site-specific, moderate, beneficial impact for fish which may aggregate near the shoal as the surface of the borrow area shoal would likely have a more complex surface topography post-dredging which may provide more food and shelter for both prey and predator. Following construction and equilibration of the nourished beach, Alternative 3–Summer Construction would provide site-specific, long-term, moderate, beneficial effects to species which use the EFH along the beach (both predators and prey) for ~10 years. A reduced rate of erosion over the project life would provide more desirable nesting and foraging habitat for some species and allow for increased usage of those habitats.

The same five minimization measures listed for Alternative 2 above would be applied to and integrated into Alternative 3–Summer Construction.

Alternative 3-Summer Construction would have direct, site-specific, short-term, minor to moderate adverse impacts to nearshore (similar to Alternative 2-Winter Construction in footprint-length and construction practices, but less biological impact due to seasonal differences) and offshore EFH/HAPC (about twice the amount of excavation and additional beach width compared to Alternative 2-Winter Construction) . Indirect, long-term impacts to surf-zone EFH would be beneficial compared to the other two alternatives and would also have potential beneficial impact to Cape Hatteras sandy shoal HAPC by the addition of post-project habitat complexity.

Cumulative Impacts on EFH/HAPC

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. Various dredging operations have occurred or are being planned in the vicinity of the Seashore or the Outer Banks, including:

- Dredging of the federally authorized navigation channel at Oregon Inlet (every 4–5 years for major dredging efforts; maintenance dredging occurs on a more frequent basis) with disposal near Oregon Inlet along Pea Island;
- Recent emergency beach nourishment at Rodanthe in 2014 (Oregon Inlet sands were dredged and passed onto Pea Island in the vicinity of a recent inlet breach); and
- Beach nourishment planned for three northern Outer Banks communities: Duck, Kill Devil Hills, and Kitty Hawk.

According to the USACE Wilmington District website, batched EA and EFH documents have been submitted for review by the communities' consultant. Nourishment at northern Outer Banks towns would also involve three offshore borrow sources and placement of ~4 million cubic yards of sand along the beach north of Oregon Inlet. More specific project details on the Outer Banks beach nourishment are not known at the time of this EA preparation but necessary documents to evaluate the impacts and submit the permit application are in process by consultant(s) hired by the towns.

During the past five years, two large-scale beach nourishment projects were conducted: Nags Head 2011 (10 miles) and Rodanthe-Pea Island 2014 (~2 miles). Several 2-mile-long, dredge-disposal projects at Oregon Inlet were also conducted. These recent nourishments represent ~20% of the Dare County oceanfront north of Cape Hatteras within the littoral cell (70 miles). Planned or proposed projects north of Buxton encompass portions of Duck (2016 pending, ~1.6 miles, tapers included), Kitty Hawk (2016–2017 pending, ~3.8 miles, tapers included), and Kill Devil Hills (~2.6 miles, tapers included) (CBI, Ken Willson, pers. comm., 24 July 2015). Combined with either Alternative 2–Winter Construction (~3 miles) or Alternative 3–Summer Construction (~3 miles), a total of ~23 miles (~33%) of the Dare County shoreline north of Cape Hatteras has already received or is likely to receive nourishment over the 10-year period 2010–2020. The majority of shoreline that has or may be nourished is developed.

Each nourishment project contemplated for Dare County contributes an incremental short-term, adverse impact to the beach ecosystem and offshore borrow areas. The amount of shoreline that may be impacted by nourishment along Dare County north of Cape Hatteras (same primary littoral cell) is likely to be 30–33% of the ocean coast over one decade. Twenty-three miles of shoreline (of 70 miles) is likely to be nourished or receive dredge disposal during this time period. Of this length, less than 7 miles (10%) would impact undeveloped Seashore beaches. The majority of projects would front developed property. Additions of sand increase beach width, expand potential nesting areas for threatened and endangered species, and reduce the pressure for structured shore-protection measures for a period of time directly proportional to the nourishment volume.

All of the dredging associated with these future projects, either in Oregon Inlet or offshore, and sand placement during future disposal of Oregon Inlet dredged material, or beach nourishment activities for Dare County beaches, would impact marine unconsolidated/shallow subtidal bottom EFH (removal and/or burial of the bottom and the associated fauna), *Sargassum* EFH (entrainment from the water column during dredge operations or burial during sand placement), and marine water column and high-salinity surf zones EFH (increased turbidity). These activities could also impact *Sargassum* habitat HAPC.

Numerous actions around fisheries activities (e.g. legal and illegal bottom disturbing fishing gear) within state waters would continue, and potential future actions (offshore wind projects, offshore oil and gas seismic testing and drilling) all have the potential to adversely affect EFH/HAPC.

If nourishment for the northern Outer Banks communities' projects (i.e., Duck, Kitty Hawk, and Kill Devil Hills) occur entirely in summer 2016 and Alternative 2–Winter Construction for Buxton also occurs in 2016, ~11 miles of the 70-mile shoreline (or 16%) would be impacted in 2016 by nourishment activities which would affect not only the EFH/HAPC in the Buxton Action Area but also EFH/HAPC associated with the northern Outer Banks projects. If the northern Outer Banks beach nourishment projects are permitted as proposed (summer 2016), it would not occur at the same time as Alternative 2–Winter Construction which would ameliorate cumulative temporal effects.

If Alternative 3–Summer Construction and the three proposed northern Outer Banks projects occur entirely in summer 2016, the same 3 miles of Buxton beach and the same ~11 miles within the 70-mile shoreline would experience short-term minor to moderate impacts as during Alternative 2–Winter Construction. However, the projects would occur during peak productivity for many species that use the affected EFH/HAPC. These 11 miles of potential beach nourishment would be slightly longer than the 10-mile Nags Head project permitted in summer 2011. However, while there is no separation between the Kitty Hawk and Kill Devil Hills portions (6.35 miles total length) of the proposed northern Outer Banks nourishment projects, there is a 6.11 mile gap between the northern taper limit for Kitty Hawk and the beginning of Duck project and an ~55 mile gap between Kitty Hawk/Kill Devil Hills project and the proposed Buxton project end (northern taper).

The effects of the three proposed northern Outer Banks nourishment projects, replacement of the Bonner Bridge, and continued use of bottom disturbing fishing gear when added to any of the three evaluated alternatives would cause imperceptible cumulative impacts.

Conclusion

Alternative 1–No-Action would allow erosion to continue which would result in future modification of the beach profile and surf-zone substrate. The impact on benthic fauna assemblages would be gradual over an extended period of time and would require scientific measurements to confirm. While Alternative 1 could have short-term minor to moderate effects to some back-barrier EFH categories in the vicinity of Buxton, these effects would be minor in light of the large amount of adjacent similar EFH available and could also be beneficial. Overall, Alternative 1–No-Action would not likely adversely affect any EFH or HAPC long-term due to the large amount of similar or same EFH/HAPC available nearby. Therefore, Alternative 1-No Action would have indirect, site-specific to local, long-term, minor adverse impacts to nearshore EFH/HAPC but no impact on offshore EFH or HAPC and would contribute an imperceptible to noticeable, adverse increment to long-term, adverse cumulative impacts.

Under Alternative 2–Winter Construction, while short-term minor to moderate effects from construction would occur, these impacts would be outside of either their recruitment window in the case of benthic organisms, or their growth and reproduction window in the case of some fish, or the migratory window in the case of many other fish present in other seasons. Under Alternative 2, the resultant wider beach would reduce the likelihood of overwash events and or an inlet breach compared to Alternative 1. The wider beach post-construction would likely eliminate or reduce potential impacts to the back-barrier EFH mentioned in discussion of Alternative 1. However, as beach nourishment would occur under Alternative 2, benthic organisms and fish present in the previously mentioned three EFHs and two HAPCs found in the Proposed Action Area would experience short-term, moderate

adverse effects (burial/mortality of non-motile organisms or forage disruptions from turbidity) by dredging in the borrow area and placement of those dredged sands on the beach.

Therefore, Alternative 2–Winter Construction would have direct, site-specific, short-term, minor to moderate adverse impacts to EFH/HAPC offshore and nearshore. Indirect, long-term impacts to surf-zone EFH and borrow area HAPC would be beneficial. Alternative 2-Winter Construction would contribute an imperceptible to noticeable adverse increment during construction to long-term, minor, adverse cumulative impacts of offshore sand borrow excavations and beach placement of excavated materials, replacement of the Bonner Bridge, and periodic Oregon Inlet dredging. It would contribute an imperceptible increment to noticeable long-term cumulative beneficial impacts associated with stable beaches.

Alternative 3–Summer Construction would have similar comparisons to Alternative 1–No-Action as mentioned in Alternative 2–Winter Construction and the same benthic recovery expectations from sediment quality and dredge operation measures as described in Alternative 2 would apply. However, depending on which month the ~2.5-month-long summer construction began under Alternative 3–Summer Construction, short-term minor to moderate effects from construction would potentially occur during peak benthic recruitment (late summer) and high productivity (growth and reproduction) windows for various fish species which use the EFH/HAPC in the Proposed Action Area (beach and offshore). Coordination with representatives of the National Marine Fisheries Service (NMFS) and the North Carolina Division of Marine Fisheries (NCDMF) would continue throughout the life of the project in order to ensure that all parties are aware of any fisheries impacts. Additionally, both NMFS and NCDMF would be provided with information from any required project surveys, and development of detailed borrow area use plans would be coordinated with both agencies.

Therefore, Alternative 3–Summer Construction would have direct, site-specific, short-term, minor to moderate adverse impacts to nearshore and offshore EFH/HAPC. Indirect, long-term impacts to surf-zone EFH would be beneficial and offshore HAPC could also have indirect, long-term beneficial impacts. Alternative 3-Summer Construction would contribute an imperceptible to noticeable adverse increment to cumulative noticeable short-term adverse impacts of other offshore sand borrow excavations and beach placement of excavated materials, replacement of the Bonner Bridge, and periodic Oregon Inlet dredging. It would contribute an imperceptible increment to noticeable long-term cumulative beneficial impacts associated with stable beaches.

BIOLOGICAL RESOURCES

General Methodology

The Endangered Species Act (ESA) (16 USC 1531 et. Seq.) mandates that all federal agencies consider the potential impacts of action on federal lands on the species listed as threatened or endangered. If the National Park Service or USACE determine that an action may adversely impact a federally listed species, consultation with the USFWS is required under Section 7 of the ESA to ensure that the action would not jeopardize the continued existence of the species, or result in the destruction or adverse modification of critical habitat. NPS Management Policies (NPS 2006) state that potential impacts of actions on federal lands would also be considered on state or locally listed species.

The Applicant obtained a list of rare, threatened, and endangered species and designated critical habitat in close proximity to the Buxton Action Area. Information on these species and habitats was provided in Chapter 3 and discussed in greater detail in Appendix B (*Biological Assessment*). The evaluated

alternatives could cause potential adverse impacts within the action area, including possible continued reduction of habitat due to erosion and emergency repairs, protection of existing structures from potential direct impacts, and disruption of nesting species during construction. The principal impacts are related to turtle nesting and colonial water fowl nesting.

The summer dredging of Alternative 3 would involve greater risks to threatened and endangered species than the winter dredging of Alternative 2. Hopper dredges have taken sea turtles while operating, including numerous takes at the mouth of the Chesapeake Bay (NMFS 2003, USACE 2007, USFWS 2007). The nature of channel dredging at confined entrances and the unavoidable concentration of sea turtles in tidal entrances increases opportunities for chance dredge and turtle encounters. These are greater than activities in open-ocean and offshore borrow areas, such as the proposed sand source for Buxton. The 2011 Nags Head nourishment project involved hopper dredge operations between May and October, without a turtle take by the dredges.

Per recommendations of USFWS, trawling ahead of operating dredges was a special condition of the Nags Head project permits. Several turtles were caught and relocated by certified endangered species monitors without adverse incident (CSE 2012). The Applicant would implement monitoring and mitigation measures under Alternative 3 as prescribed by resource and regulatory agencies. In general, if dredges cannot operate under moderate to high wave conditions, neither can trawlers equipped to trap and relocate sea turtles ahead of dredges.

Beach fill operations have potential to disrupt infauna and surf fisheries in the active work area and impact sea turtle or bird nesting activities at that time of year. This section discusses the potential environmental consequences to biological resources based on review of the literature, experience with similar projects, and mitigation measures recommended by US Fish and Wildlife Service for protection of species of concern. The thresholds of change for the intensity of an impact and duration are described earlier in the document (see pg 120).

The following information was used to assess impacts on all listed species from each of the three alternative actions:

1) Species found in areas likely to be affected by actions described in the alternatives.
2) Habitat loss or alteration caused by the alternatives.
3) Displacement and disturbance potential of the actions and the species' potential to be affected by the activities.

According to the Endangered Species Act (ESA), the term take means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct.

Specific methodologies and assumptions pertaining to the species are described under the relevant descriptions in the following text. To provide the public with additional information on the intensity of impacts, the NEPA thresholds for each species were defined and used throughout the analysis. The ESA defines the terminology used to assess impacts to listed species as follows.

No effect	When a proposed action and its interrelated and interdependent actions would not directly or indirectly affect listed species or destroy or adversely modify designated critical habitat. Formal Section 7 consultation is not required when the no effect conclusion is reached.
Not likely to adversely affect	When a proposed action occurs in suitable habitat or results in indirect impacts on the species, but the impact on the species is likely to be entirely beneficial, discountable, or insignificant. Beneficial effects are contemporaneous positive

	effects without any adverse effects to the species. Insignificant effects relate to the size of the impact and should never reach the scale where take occurs. Discountable effects are those extremely unlikely to occur. Based on best judgment, a person would not (1) be able to meaningfully measure, detect, or evaluate insignificant effects, or (2) expect discountable effects to occur.
Likely to adversely affect	When any adverse effect to listed species or critical habitat may occur as a direct or indirect result of the proposed action or its interrelated or interdependent actions, and the effect is not discountable or insignificant. If the overall effect of the proposed action is beneficial to the listed species or critical habitat, but may also cause some adverse effects on individuals or segments of critical habitat, then proposed action is likely to adversely affect the listed species. If incidental take is anticipated to occur as a result of the proposed action, then it is likely to adversely affect the species. Incidental take is the take of a listed species that results from, but is not the purpose of, carrying out an otherwise lawful activity. Such a determination requires formal Section 7 consultation.
Likely to jeopardize species/ adversely modify critical habitat	The appropriate conclusion when analysis or Section 7 consultation identifies an adverse effect that could jeopardize the continued existence of a species or destroy or adversely modify critical habitat of a species within or outside project boundaries.

Using the terms previously described for analysis, and the three alternatives, a summary matrix of potential impacts on federal- and state-protected species expected within the project area is provided in Table 4.2. Under the NEPA thresholds, Table 4.3 shows the effects determination of Alternative 3–Summer Construction (Preferred Alternative) for the species with ESA protection. While effects of only the proposed action on all the ESA-protected species are evaluated in the BA (Appendix B), effects of the other two alternatives for those ESA species are summarized below. For the species not evaluated in the BA, effects from each alternative on all species with the potential to occur are also summarized below.

Impacts on Federally Listed Threatened or Endangered Species

Study Area. The study area for assessment of the alternatives is the Proposed Action Area (offshore and beach). The study area for the cumulative effects analysis is the Seashore and the region.

Critical Habitat. No critical habitat for the piping plover is within the Proposed Action Area, but critical wintering habitat has been designated at four locations on the Outer Banks, the closest of which is Unit NC-2 Cape Hatteras Point. The northern boundary of Unit NC-2 is 468 feet south of the southernmost taper of the pro-posed action (same distance for both Alternative 2–Winter Construction and Alternative 3–Summer Construction).

For the Constructed Migratory Corridor Critical Habitat for the northwest Atlantic Ocean loggerhead turtle DPS (Fig 3.12), dredging and sand placement activities could present obstructions to loggerhead sea turtles in transit through either the surf zone or the offshore borrow area. But as stated in the final rule (CFR #15725 on 7.10.2014, Comments on Constructed Migratory Corridors, response to comment 73),... many of the possible impacts associated with dredging and or disposal activities are not expected to occur, or to occur at a level that would affect or modify the essential features of the critical habitat. The need for additional conservation measures to avoid impacts to this designated corridor are not likely, beyond those measures that are typical for projects of this type and which would be in place to protect the species itself.

No other critical habitat for any protected species is within or adjacent to the Proposed Action Area.

Table 4.2. Impact matrix under the three alternatives addressed in this EA for state and/or federally protected species with the potential to occur and proposed mitigation to offset impacts.

Resource	No-Action Alternative	Alternative 2 Winter Construction	Preferred Alternative 3 Summer Construction
PIPING PLOVER Present year round on NC Outer Banks; nests in Seashore near tidal inlets or overwash areas; no nests in project area.	No impact to breeding, foraging, or resting habitat. Potential beneficial effect should a breach occur and new tidal inlet habitat form. Potential beneficial effect if future overwash events build new breeding, foraging, or resting habitat. No adverse effect to critical wintering habitat.	Temporary to short-term, negligible impact from disruption of foraging areas, but not likely to adversely affect. Foraging habitat could be impacted, although historically project area has limited foraging habitat. Any plovers resting in the project area during construction would be temporarily displaced. No adverse effect to critical wintering habitat. Potential beneficial long-term impact to resting habitat (wider dry beach) and foraging habitat (lower slope intertidal beach) and critical wintering habitat by downcoast migration of nourishment sediment.	Temporary to short-term, negligible impact from disruption of foraging areas, but not likely to adversely affect. Foraging habitat could be impacted, although historically project area has limited foraging habitat. No nests have been reported within the project area. Any plovers resting in the project area during construction would be temporarily displaced. No adverse effect to critical wintering habitat. Potential beneficial long-term impact to resting habitat (wider dry beach) and foraging habitat (lower slope intertidal beach) and critical wintering habitat by downcoast migration of nourishment sediment. ***MITIGATION:*** *Prescribed NPS surveys for use of the beach by piping plovers will occur into mid-August and include the project area. No construction will occur within any NPS established buffers.*
ROSEATE TERN No nesting habitat or breeding occurs at Seashore; rare visitor during migration May through September. July records within Seashore.	No impact to breeding or nesting habitat. Negligible impact to resting habitat.	No impact to breeding or nesting habitat; direct, temporary to short-term negligible impact to resting habitat. Beneficial short-term impact to resting habitat (wider dry beach).	No impact to breeding or nesting habitat. Temporary to short-term, negligible impact from disruption of resting and foraging areas for the rare visitor, but not likely to adversely affect. Any birds resting in the project area during construction would be temporarily displaced. Beneficial long-term impact to resting habitat (wider dry beach).
PEREGRINE FALCON No nesting along NC coast; uncommon May to August; more common in October. Winter resident.	No impact to breeding, foraging, or resting habitat.	Temporary to short-term, negligible adverse impact from disruption of foraging areas. Beneficial long-term impacts to foraging and resting habitat (wider dry beach).	Temporary to short-term, negligible adverse impact from disruption of foraging areas. Beneficial long-term impact to foraging and resting habitat (wider dry beach).
BALD EAGLE No nests in project area; birds observed all months in Seashore, but more common in winter.	No impact to breeding, foraging, or resting habitat.	Temporary to short-term, negligible adverse impact from disruption of foraging and resting areas	Temporary to short-term, negligible adverse impact from disruption of foraging and resting areas.
RUFA RED KNOT No nesting in North Carolina; birds have been observed in all months in Seashore with highest numbers during peak migration in April-May and August-September.	No impact to foraging or resting habitat.	Temporary, negligible impact, but not likely to adversely affect. Foraging habitat could be impacted, although historically project area has limited foraging habitat. Beneficial long-term impact to resting habitat (wider dry beach) and foraging habitat (lower slope intertidal beach).	Temporary, negligible, minor adverse impact, but not likely to adversely affect. Foraging habitat could be impacted, although historically project area has limited foraging habitat. Beneficial long-term impact to resting habitat (wider dry beach) and foraging habitat (lower slope intertidal beach).

Table 4.2 (continued)

Resource	No-Action Alternative	Alternative 2 Winter Construction	Preferred Alternative 3 Summer Construction
AMERICAN OYSTERCATCHER Common in Dare County all year with low numbers in winter months. Nests and breeds in Seashore.	Long-term, moderate adverse impact to nesting habitat. Beach would eventually become too narrow to support nesting.	No impact. Species not normally present in this area during winter. Beneficial long-term impact to nesting habitat (wider beach).	Temporary to short-term, negligible to minor adverse impact to nesting birds, and foraging and resting areas. Beneficial long-term impact to nesting habitat (wider beach). ***MITIGATION:*** *No construction within 300 meters of active nests or chicks.*
COLONIAL WATERBIRDS (includes gull-billed tern, common tern, least tern, and black skimmer) All nest on NC beaches including Seashore and within project area. As a group, can be in project area from March to November.	Long-term, moderate adverse impact to nesting habitat. Beach would eventually become too narrow to support nesting.	No impact. Birds not normally present in winter. Beneficial long-term impact to nesting habitat (wider beach).	Temporary to short-term, negligible to minor adverse impact to nesting birds and disruption of foraging and resting areas. Beneficial long-term impact to nesting habitat (wider beach). ***MITIGATION:*** *No construction within 300 meters of active colonies.*
WILSON'S PLOVER Rare nester in Seashore; present March to October with occasional January or November occurrence.	Long-term, moderate adverse impact to nesting habitat. Beach would eventually become too narrow to support nesting. No nests in project area but a few nests have been documented elsewhere at Seashore.	Temporary to short-term, impact with negligible disruption of foraging and resting areas.	Temporary, negligible, minor adverse impact. Foraging habitat could be impacted; historically, project area is low quality foraging habitat. Beneficial long-term impact to resting habitat (wider dry beach) and foraging habitat (lower slope intertidal beach).
SEA TURTLES (includes green, hawksbill, Kemp's ridley, leatherback, and loggerhead) Some commonly nest in Seashore; others never to rarely, but may be present in project vicinity waters.	Long-term, moderate adverse impacts to nesting habitat. Beach would eventually become too narrow to support nesting. Regular overwash would decrease nest success. Potential beneficial short-term impact if breach occurred which would allow new temporary access to back barrier habitats until the breach closed. A potential NCDOT solution to a breach may include a temporary bridge which may have short-term adverse impact to turtles in the area during construction. No adverse effect on critical migratory habitat.	No effect during construction. Project would occur outside of the sea turtle nesting season. No adverse effect on critical migratory habitat. Nesting beaches would have long-term beneficial impact (wider beach and lower slope).	Temporary, negligible to minor impacts and likely to adversely affect. Nesting females could be disturbed during construction activities within the project area. No adverse effect on critical migratory habitat. Nesting beaches would have short-term negligible impact, but beneficial long-term impacts (wider beach and lower slope). ***MITIGATION:*** *No night work or night work using turtle friendly lighting; night-time monitors must survey the beach area to be affected on any given night before the daily survey which must occur before 9 am. Nesting surveys initiated by 15 April for leatherback and 1 May for others. Surveys would continue during project, conducted by personnel with prior experience and training, duly authorized and permitted by USFWS or NCWRC. Construction would not begin until the daily survey is completed in any given area. All nests in project area to be relocated by NPS personnel as soon as possible after discovery, but no later than 9:00 am to location which ensures hatch success. Nests discovered after project completion in an area will not be relocated if laid in location conducive to hatch.* *(Continued next page.)*

Table 4.2 (continued)

Resource	No-Action Alternative	Alternative 2 Winter Construction	Preferred Alternative 3 Summer Construction
SEA TURTLES (continued)FF			*All nests (in situ or relocated) must be marked with stakes which delimit a 10-foot buffer zone around the nest and two on-beach markers and must be monitored daily. Qualified NMFS/PRD-approved endangered species observer on dredge at all times would follow standard reporting procedures and would have authority to stop dredge operations if turtle observed in area of danger or in dredge screen, skimmer funnels, or drag heads.*
ATLANTIC STURGEON Documented in project vicinity waters most all year; moves to freshwaters inshor to spawn in spring.	No adverse impact. Potential beneficial impact if inlet breach opens new access to Pamlico Soun habitats. Duration of benefit would depend on NCDOT response or length of time inlet remained open.	Temporary, negligible to minor impact and likely to adversely affect due to potential disruption in early spring during inshore migration. ***MITIGATION:*** *Conservation measures to minimize impacts or disruption provided by NMFS during consultation will be followed. Qualified NMFS/PRD-approved endangered species observer on dredge at all times who will follow standard reporting procedures and has authority to stop dredge operations if Atlantic sturgeon observed in area of danger or in dredge screen, skimmer funnels, or drag heads.*	Temporary, negligible to minor impact and likely to adversely affect, due to potential disruption in late spring during inshore migration. ***MITIGATION:*** *Conservation measures to minimize impacts or disruption provided by NMFS consultation will be followed. Qualified NMFS/PRD-approved endangered species observer on dredge at all times would follow standard reporting procedures and would have authority to stop dredge operations if Atlantic sturgeon observed in area of danger or in dredge screen, skimmer funnels,or drag heads.*
SHORTNOSE STURGEON Move to freshwater from late winter to early spring; remains in estuarine and nearshore waters remainder of year. One (1) record from Pamlico Sound.	No impacts. Potential beneficial impact if inlet breach opens new access to Pamlico Sound habitats. Benefit duration depends on NCDOT response and how long inlet remains open.	Temporary, negligible to minor impact and likely to adversely affect, due to likely disruption in late winter or early spring during migration to fresh and estuarine waters.	Temporary, negligible to minor impact, but not likely to adversely affect, due to unlikely potential disruption in nearshore waters.
SEABEACH AMARANTH No plants documented in the Seashore since 2005; no records from project area.	Long-term, moderate adverse impacts to potential habitat. Beach would eventually become too narrow to support; alternatively, regular overwash would increase potential habitat, a beneficial impact.	No impact. Potential beneficial long-term impact (wider beach above wrack line). ***MITIGATION:*** *NPS biologists survey for the plant each year and if found, steps to avoid the plant(s) would be identified by NPS manager in coordination with USFWS.*	No impact. Potential beneficial long-term impact (wider beach above wrack line). ***MITIGATION:*** *NPS biologists survey for the plant each year and if found, steps to avoid the plant(s) would be identified by NPS manager in coordination with USFWS.*
WHALES Finback and humpback migrate through in winter; North Atlantic right migrate through in spring and are found closer to shore in spring, but can be in project vicinity throughout the winter months.	No impacts.	Temporary, negligible to minor impact, but not likely to adversely affect. Noise avoidance could affect behavior of north Atlantic right whale, depending on presence of prey species; could affect finback and humpback during winter migration. ***MITIGATION:*** *Qualified NMFS/PRD-approved endangered species observer on dredge at all times would follow standard reporting procedures and has authority to stop dredge operations if a whale is spotted in area of danger.*	Temporary, negligible to minor impact, but not likely to adversely affect. Noise avoidance could affect behavior, depending on presence of prey species. ***MITIGATION:*** *Qualified NMFS/PRD-approved endangered species observer on dredge at all times would follow standard reporting procedures and has authority to stop dredge operations if a whale is spotted in area of danger.*

Table 4.2. (continued) Impact matrix under the three alternatives addressed in this EA for state and/or federally protected species with the potential to occur and proposed mitigation to offset impacts.

SPECIES WITH STATE PROTECTION ONLY			
Resource	**No-Action Alternative**	**Alternative 2 Winter Construction**	**Preferred Alternative 3 Summer Construction**
DIAMOND BACK TERRAPIN Nests and forages in marsh or back dune areas; hibernates in back-barrier muds. No record from within project area.	Long-term, unpredictable, moderate adverse impact to existing potential habitat. Overwash could bury nests, young, or adults and habitats, but may increase and build habitats further into the sound over time which could be beneficial. A breach may destroy habitat if inlet became permanent. NCDOT post-overwash maintenance activities (road scraping and dune building) may have adverse impact to a turtle trying to cross the road.	No impact.	Temporary, negligible to minor adverse impact due to potential disruption when crossing NC 12; such disruptions already occur from existing traffic. Project related traffic would be temporary and mostly confined to the beach where the turtle is not found.
SEABEACH KNOTWEED Unpredictable colonizer species found between wrack line and foredunes and overwash fans. No record from within project footprint, but documented in project vicinity (near the Cape Hatteras lighthouse).	Long-term, unpredictable, moderate, adverse impact to existing potential back-barrier habitat (existing foredune habitat not suitable). Overwash could bury seeds and habitats, but may increase brackish and back barrier habitat or assist in seed dispersal which could be beneficial.	No impact. Potential beneficial long-term impact (wider beach). ***MITIGATION:*** *NPS biologists survey for the plant each year and will notify if found prior to construction; proper steps to avoid would be coordinated with NCNHP.*	No impact. Potential beneficial long-term impact (wider beach). ***MITIGATION:*** *NPS biologists survey for the plant each year and will notify if found prior to construction; proper steps to avoid would be coordinated with NCNHP.*

Table 4.3 Summary effects determination of Alternative 3–Preferred Alternative–Summer Construction, using offshore borrow area on species with ESA protection with potential to occur in project area or vicinity (from Appendix B–*Biological Assessment* – prepared for project).

SPECIES COMMON (*SCIENTIFIC NAME*)	FEDERAL STATUS	DETERMINATION
BIRDS		
Piping plover (*Charadrius melodus*)	T	MAY AFFECT, NOT LIKELY TO ADVERSELY AFFECT
Roseate tern (*Sterna dougallii dougallii*)	E	MAY AFFECT, NOT LIKELY TO ADVERSELY AFFECT
Rufa red knot (*Calidris canuta rufa*)	T	MAY AFFECT, NOT LIKELY TO ADVERSELY AFFECT
FISHES		
Atlantic sturgeon (*Acipenser oxyrinchus*)	E	MAY AFFECT, LIKELY TO ADVERSELY AFFECT
Shortnose sturgeon (*Acipenser brevirostrum*)	E	MAY AFFECT, NOT LIKELY TO ADVERSELY AFFECT
FLOWERING PLANTS		
Seabeach amaranth (*Amaranthus pumilus*)	T	NO EFFECT
MAMMALS		
Finback whale (*Balaenoptera physalus*)	E	MAY AFFECT, NOT LIKELY TO ADVERSELY AFFECT
Humpback whale (*Megaptera novaeangliae*)	E	MAY AFFECT, NOT LIKELY TO ADVERSELY AFFECT
North Atlantic right whale (*Eubalaena glacialis*)	E	MAY AFFECT, NOT LIKELY TO ADVERSELY AFFECT
REPTILES		
Green sea turtle (*Chelonia mydas*)	T	MAY AFFECT, LIKELY TO ADVERSELY AFFECT
Hawksbill sea turtle (*Eretmochelys imbricata)*	E	MAY AFFECT, LIKELY TO ADVERSELY AFFECT
Kemp's ridley sea turtle (*Lepidochelys kempii*)	E	MAY AFFECT, LIKELY TO ADVERSELY AFFECT
Leatherback sea turtle (*Dermochelys coriacea*)	E	MAY AFFECT, LIKELY TO ADVERSELY AFFECT
Loggerhead sea turtle (*Caretta caretta*)	T	MAY AFFECT, LIKELY TO ADVERSELY AFFECT

Piping Plover

Impacts of Alternative 1–No-Action. While the closest nest is 1.5 miles south of the action area, one non-breeding plover has been observed immediately north of the northern project boundary (one of the NPS migratory bird transects overlaps the northern project boundary). Although it is likely that the project area may be used by this species during migration or foraging, the Cape Hatteras National Seashore field data has not documented this use; no breeding activity has ever been recorded in the project area since the July–May weekly migratory bird surveys began in 2010 (Cape Hatteras National Seashore, Randy Swilling, Natural Resource Program Manager, pers. comm., 4 June 2015). However, should new overwash fans or a new inlet form in the action area as a result of continued erosion or a storm event, piping plover would likely make use of the expanded habitat which would be a short-term beneficial impact.

Under Alternative 1–No-Action, continued routine maintenance activities and emergency repairs by NC Department of Transportation would occur as needed. Routine road maintenance activities would occur outside of designated critical wintering habitat and would not directly disturb any plover habitat, but depending on scale and timing, could have indirect, local, short-term negligible to minor adverse impacts to birds in the vicinity. The likelihood of a large storm event to cause major road damage, or an inlet breach, is greatest under Alternative 1. Depending on scale, type, and timing, NCDOT's emergency solutions to storm damage could require construction work outside the existing roadway and near nesting birds, potentially causing unavoidable short-term minor adverse impacts from disturbance.

Alternative1 would include indirect, site-specific, long-term impacts to breeding, foraging, or resting habitat for the piping plover as erosion would continue. However, as a breach is considered a likely but unpredictable future event with this alternative, if an inlet formed and remained open, new tidal inlet habitat would be available and quickly used by these birds, which would be an indirect, site-specific, beneficial impact of unknown duration. Without a breach, continued erosion and overwash would likely attract piping plovers which then may occupy new nesting, foraging, or resting habitats.

Mitigation and protection measures similar to the action alternatives would be carried out to avoid indirect impacts to nesting birds and their nearby critical wintering habitat during any maintenance or repair activity conducted by NCDOT (e.g. as dictated by associated permit conditions). Mitigation would include avoidance of routine maintenance work near nesting and feeding sites during the breeding season and mitigation to protect the birds during any emergency work would be carried out to the extent feasible. The Applicant for the proposed Buxton beach restoration project has no authority over the nature of emergency repairs to NC 12 in the event of a partial or complete breach of the roadway.

Impacts of Alternative 2–Winter Construction. Alternative 2–Winter Construction would have direct, site-specific, short-term, moderate impacts on existing foraging and resting habitat, but no nesting habitat is currently found within the action area. Post-project there would be potential direct, site-specific, long-term beneficial impacts to piping plover resting habitat (wider dry beach) and foraging habitat (lower-sloped, intertidal beach). Birds in the area during construction may be disrupted and displaced to other nearby areas, a direct, site-specific, short-term, minor impact. Since birds would not be nesting, Alternative 2 would have no impacts on nesting adults, chicks or fledglings. This alternative would have no adverse effect on critical wintering habitat Unit NC-2, but downcoast migration of nourishment sediments may have beneficial effect by addition of sediment to the area.

Impacts of Alternative 3 (Preferred Alternative) Summer Construction. Alternative 3–Summer Construction would have the highest potential for direct, site-specific, short-term, minor impacts to individual piping plover in the area during construction, as birds may be disrupted and displaced to other nearby foraging or resting areas. These impacts would be staggered along a ~600-800 foot length of active construction on the beach at any given time, with ~200-300 feet completed per day under normal conditions. Birds in the vicinity in the summer may be nesting (closest documented nest to project area is ~1.5 miles to south). The long-term recovery of piping plover is dependent upon the protection of existing breeding and feeding habitat. The closest designated critical habitat is ~450 feet south of the southern taper of the sand placement footprint. Since the weekly NPS surveys began in 2010, no birds have been documented in the sand placement footprint.

Construction noise would be a possible project-specific, short-term adverse impact on any birds that may be near the project area during the summer period (one non-breeding plover has been observed immediately north of the Proposed Action Area since 2010). However, Park biologists would monitor the project vicinity for piping plover, and if found near a work area, the project manager would restrict work within prescribed buffers as necessary under current NPS management policy.

Beneficial direct, site-specific, long-term impacts post-project and post- beach equilibration, would include improved resting habitat (~140 feet more beach; ~40 more acres of dry beach) and improved foraging habitat (lower slope to intertidal wet beach; ~1.3 more acres). This alternative would have no adverse effect on critical wintering habitat Unit NC-2, but downcoast migration of nourishment sediments may have beneficial effect by addition of sediment to the area.

Cumulative Impacts on Piping Plover. Please refer to the Cumulative Impacts on EFH/HAPC section of this document for a description of past, present, and reasonable foreseeable future actions (pg 114).

The replacement of the Herbert C. Bonner Bridge would occur within the Seashore and in the vicinity of designated critical wintering habitat for the piping plover (Unit NC-1 including Bodie Island Spit). An EIS and Biological Opinion for this project found that, the proposed replacement of the Bonner Bridge… as proposed, is not likely to jeopardize the continued existence of these species (including piping plover), and is not likely to destroy or adversely modify proposed critical wintering habitat for the piping plover.

Additionally, while the Proposed Action Area would likely revert to the pre-project deficit condition within ~3 years under Alternative 2–Winter Construction and ~10 years under Alternative 3–Summer Construction, sand that migrates from the nourished beach downdrift within the littoral current would feed the existing piping plover nesting, foraging, and roosting habitat south of Buxton at Cape Point, including designated critical wintering habitat Unit NC-2.

Habitat loss or degradation due to human activities associated with recreation or coastal development actions elsewhere in Dare County would continue.

Conclusion – Piping Plover. Alternative 1–No-Action would have indirect, site-specific, long-term impacts to breeding, foraging, or resting habitat on the intertidal portions of the beach as the beach would become progressively steeper and narrower. Conversely, short-term beneficial impacts to piping plovers could occur if overwash events or an inlet breach produced more preferred habitat. Emergency repairs to fix damage caused by storms that may occur with continued erosion may adversely affect piping plovers, depending on season of repairs. Overall, continued routine maintenance activities under Alternative 1–No-Action are not likely to adversely affect piping plovers or their critical wintering habitat.

Alternative 2–Winter Construction would result in direct, site-specific, short-term, negligible, and potentially adverse effects to existing piping plover roosting or foraging habitat on the intertidal portions of the beach during sand placement and individual birds which may be foraging would be disturbed; however, no nesting or breeding birds would be in the area during this season. Conversely, direct, site-specific, long-term beneficial impacts to piping plovers could occur post-project, as the nourished beach intertidal foraging habitat would be less steep and roosting habitat may be up to 70 feet wider until the beach reverts back to a deficit condition. Overall, Alternative 2–Winter Construction is not likely to adversely affect piping plover or their critical wintering habitat.

Alternative 3–Summer Construction would have similar levels of effects during sand placement as Alternative 2 but would have the additional potential for short-term adverse effects on individuals which may be breeding or nesting in the vicinity and be disturbed from an activity. All pre-nest closures would be avoided and work would occur only outside of any NPS-established buffers (for nests or chicks) to minimize these potential effects during construction. Additionally, the order of beach sections to be filled and placement options would be selected to further minimize effects. Conversely, long-term beneficial impacts to piping plovers could occur post-project until the beach reverts back to a deficit condition. Therefore, Alternative 3–Summer Construction is not likely to adversely affect piping plover or their critical wintering habitat.

The incremental adverse impacts to piping plover of any of the three evaluated alternatives are imperceptible when added to the cumulative adverse effects of the three proposed northern Outer Banks nourishment projects, replacement of the Bonner Bridge, periodic Oregon Inlet dredging, and continued development in Dare County.

Roseate Tern

Impacts of Alternative 1–No-Action. The No-Action alternative would have negligible, adverse impacts to potential resting habitat and would not likely adversely affect the roseate tern, as no nesting or breeding habitat occurs in the Seashore or the action area, and it is a rare visitor.

Impacts of Alternative 2–Winter Construction. Alternative 1–Winter Construction would occur outside of the migration window of roseate tern (May–September) and would have direct, site-specific, short-term, negligible, adverse impacts on potential resting habitat, but would not likely adversely affect the species. Impacts would occur in a staggered manner as construction progresses over the sand placement area (~600-800 feet under active construction at any given time with ~200–300 feet completed/day). Beneficial direct, site-specific, long-term impacts to potential resting habitat would include a wider dry beach post-project after beach equilibrated (~70 more feet of dry beach for up to three years until sand deficit returns).

Impacts of Alternative 3–Summer Construction. Migration for the roseate tern is from May to September, and records of this tern in the Seashore have been reported for July. In the summer, an individual bird would be disrupted if it tried to rest or forage during construction activities, but this would be considered a direct, site-specific, short-term, minor, adverse impact. Alternative 3 would have beneficial, site-specific, long-term impacts (~10 years) to roseate tern resting habitat due to ~150 feet more beach (~40 more acres dry beach) post-equilibration. Due to the rarity of its occurrence, Alternative 3 would not be likely to have adverse effects on the roseate tern.

Cumulative Impacts on Roseate Tern. Please refer to the Cumulative Impacts on EFH/HAPC section of this document for a description of past, present, and reasonable foreseeable future actions (pg 114).

Additionally, the action area would likely revert to the pre-project deficit condition within ~three years under Alternative 2–Winter Construction and ~10 years under Alternative 3. Sand that migrates from the nourished beach downdrift within the littoral current would feed the existing foraging and roosting habitat for other colonial water birds south of Buxton at Cape Point where the common tern occurs, a species often affiliated with roseate tern.

Habitat loss or degradation due to human activities associated with recreation or development elsewhere in Dare County would continue.

Conclusion – Roseate Tern. Alternative 1–No-Action would have negligible impact on potential resting habitat and no effect on roseate tern due to rarity of occurrence and lack of nesting/breeding habitat. While Alternative 3–Summer Construction would occur during its migration window, both Alternative 2–Winter Construction and Alternative 3 would have direct, site-specific, short-term, and negligible to minor impact on potential resting habitat, but would not likely adversely affect roseate tern, due to rarity of occurrence and lack of preferred habitat in the Proposed Action Area. Beneficial site-specific long-term impacts for both Alternative 2 and Alternative 3 would include a wider beach and increased resting habitat. The incremental adverse impacts to roseate tern for any of the three evaluated alternatives are imperceptible when added to the cumulative adverse effects of the three proposed northern Outer Banks nourishment projects, replacement of the Bonner Bridge, periodic Oregon Inlet dredging, and continued development in Dare County.

Rufa Red Knot

Impacts of Alternative 1–No-Action. Under Alternative 1–No-Action, existing foraging and resting habitat of the rufa red knot would have indirect, site-specific, long-term, adverse impacts from continued erosion and increased sand deficit which contribute to poor quality of the existing habitat. Park biologists indicate that the action area has historically provided limited foraging area (narrow dry beach for resting and steep narrow slope of intertidal area for foraging) and is not preferred or rarely used by rufa red knots in the area. Erosional processes which contribute to the lower quality of these habitats would continue unabated. Birds in the vicinity would likely continue to prefer adjacent beaches.

Impacts of Alternative 2–Winter Construction. Existing low quality foraging and resting habitat would have direct, site-specific, short-term, negligible to minor adverse impacts in a staggered manner as construction progresses over the sand placement area (~600-800 feet under active construction at any given time with ~200–300 feet completed/day under normal conditions). Park biologists indicate the project area has historically provided limited foraging habitat for this species (see Alternative 1 above). Beneficial, direct, site-specific, long-term impacts would include a lower slope to the intertidal zone (1.3 acres of improved foraging habitat) and an additional ~70 feet of dry beach (improved resting habitat) post-project equilibration.

Park biologists would conduct their non-breeding bird surveys from July through May, and should rufa red knot be present in the active work zone, NPS resource managers would follow either already established management policy or would coordinate proper response through USFWS. A bird in the area would be deterred by construction noise, but this scenario is unlikely to occur within the active work zone, given the current lack of use; however, should it occur in the construction area, impacts would be short-term and minor.

Alternative 2–Winter Construction would not likely adversely affect rufa red knot, as they would be present in comparatively low numbers during the construction window, the buried foraging habitat would recover rather quickly with an improved slope, and abundant adjacent habitat would be available.

Impacts of Alternative 3–Summer Construction. Foraging and resting habitat would have direct, site-specific, short-term, negligible to minor adverse impacts during construction, although NPS biologists indicate the project area has historically provided limited foraging habitat for this species (see Alternative 1 above). Surveys for the rufa red knot would be conducted by Park biologists throughout the action area during construction in conjunction with other prescribed beach bird surveys (non-breeding survey from July through May) and would be noted during other daily surveys for other species which may have closures or established buffers. A bird in the area would be deterred by construction noise, but this scenario is unlikely to occur within the active work zone given the current lack of use; however, should it occur in the construction area, impacts would be short-term and minor. As the rufa red knot does not nest in North Carolina, no pre-nesting surveys or closures would be expected for this bird.

Also, studies have shown that depending on species, recolonization of beach benthos can begin as soon as 2–6.5 months, if borrow sediments are similar in grain size to the target beach as is the case for the proposed Buxton project (Burlas et al 2001, Appendix E–*Biological Monitoring*–CZR/CSE 2014). Because active construction shifts along the beach, the earliest sections nourished would potentially show evidence of beach benthos recovery before completion of the last section of the project. Beneficial, direct, site-specific, long-term impacts would include a lower slope to the entire intertidal zone (including an additional 1.3 acres of improved foraging habitat along the beach seaward of the sandbags in Buxton) and an additional ~140 feet of dry beach (additional 40 acres of improved resting

habitat) post-project equilibration. Potential adverse effects would be avoided and minimized as dictated by current NPS resource management policy or coordination with USFWS.

Cumulative Impacts on Rufa Red Knot. Please refer to the Cumulative Impacts on EFH/HAPC section of this document for a description of past, present, and reasonable foreseeable future actions (pg 114). Additionally, while the action area would likely revert to the pre-project deficit condition within ~3 years under Alternative 2–Winter Construction and ~10 years under Alternative 3–Summer Construction, sand that migrates from the nourished beach downdrift within the littoral current would feed the existing better quality foraging and roosting habitat south of Buxton at Cape Point. In the final rule on threatened status of the rufa red knot, the USFWS acknowledged that beach nourishment may benefit red knot under circumstances of rapid erosion and land loss due to accelerating sea level rise, locally or regionally exacerbated by limited sediment inputs (USFWS 2014). Habitat loss or degradation due to human activities associated with recreation or development elsewhere in Dare County would continue.

Conclusion – Rufa Red Knot. While Alternative 1–No-Action would allow continued erosion to occur which would contribute to continued degradation of potential foraging and resting habitat, this alternative is not likely to adversely affect rufa red knot, as the action area is relatively short compared to miles of other adjacent and better quality resting and foraging areas. Both Alternative 2-Winter Construction and Alternative 3-Summer Construction would have direct, site-specific, short-term, negligible to minor adverse impacts on existing potential foraging, roosting/resting habitat during construction. Long-term beneficial impacts to potential roosting/resting habitat (wider dry beach) and potential foraging habitat (lower sloped intertidal beach) for the rufa red knot would occur for ~3 years under Alternative 2 and ~10 years under Alternative 3. Overall, Alternative 2–Winter Construction or Alternative 3–Summer Construction are not likely to adversely affect rufa red knot. The incremental adverse impacts to rufa red knot of any of the three evaluated alternatives are imperceptible when added to the cumulative effects of the three proposed northern Outer Banks nourishment projects, replacement of the Bonner Bridge, periodic Oregon Inlet dredging, and continued development in Dare County.

Sturgeon (Atlantic and Shortnose)

Impacts of Alternative 1–No-Action. Alternative 1–No-Action would allow continued erosion to occur and would provide indirect, site-specific, short- or long-term beneficial effect for both the Atlantic and shortnose sturgeon, if a future breach occurs and is deep enough to allow access into Pamlico Sound. A breach would be a likely future event if current erosion and sea level rise rates continue or accelerate. A new inlet would provide a beneficial impact with new access into Pamlico Sound for both species as they move inshore to fresh water to spawn. It would provide the shortnose sturgeon with another ingress/egress location as it moves back and forth from nearshore to estuarine waters at other times of the year. The length of the benefit would depend on whether or how fast the breach closed and whether it was bridged. These impacts are not likely to adversely affect either sturgeon species.

Impacts of Alternative 2–Winter Construction. Under Alternative 2–Winter Construction, sturgeon in the area during dredging would experience direct, site-specific, short-term, negligible to minor adverse impacts from noise, disruption of active foraging, or interruption to other behaviors in early or late spring during sturgeon inshore migration (dependent upon actual months project may occur), although the 12–mile distance to the nearest inlet likely reduces the chance of an encounter (Stein et al 2004, referenced in Laney 2007). Both species may be in the project vicinity all year, but winter construction would have the potential to disrupt the shortnose in late winter or early spring as it moves to estuarine waters. Recent acoustic data from the vicinity (Atlantic Cooperative Telemetry Network data referenced in CPE 2015) indicate that Atlantic sturgeon are present offshore in higher numbers in November and March.

Removal of the sediments from the borrow shoal offshore would have direct, site-specific, short-term, adverse minor impacts on sturgeon by temporary removal of benthic fauna food source in those

sediments. An indirect, long-term, local beneficial impact would potentially occur for bottom feeders, such as sturgeon, as the surface topography of the borrow area shoal could be more complex or diverse post-dredging. This may provide more food and shelter for both prey and predator before equilibration of the sediment. Potential also exists for moderate, direct adverse impacts if, for example, an individual sturgeon were entrained by the hopper dredge or struck by a vessel in transit from the dredge to the pump-out.

As sturgeons are a mobile species not generally found at the surface, these events are not considered likely. The average incidental take of Atlantic sturgeon during all USACE-authorized dredging projects on the southeast Atlantic coast since 1995 is 0.7 per year and most of those incidental takes associated with dredging occured in inlets or harbors, not offshore (USACE Southeast Division HQ, David Bauman, Regional Environmental Specialist, pers. comm. 4 September 2015). While National Marine Fisheries Service and the US Army Corps of Engineers remain in consultation about inclusion of the Atlantic sturgeon under an updated South Atlantic Regional Biological Opinion for hopper dredging in the southeast Atlantic, the USACE has determined that such dredging will not jeopardize the continued existence of Atlantic sturgeon and NMFS has not disagreed (USACE Southeast Division HQ, David Bauman, Regional Environmental Specialist, pers. comm. 4 September 2015).

Mitigation measures would be coordinated with NMFS/Protected Resource Division (PRD) during consultation and would require a NMFS/PRD-qualified and approved endangered species observer to be on the dredge at all times. The observer would follow all appropriate agency mandated actions (reporting, measurements, stop-work authority) should a sturgeon be found in the dredge screen, skimmer funnels, or drag heads. Therefore, Alternative 2–Winter Construction would have the potential to likely adversely affect both species of sturgeon.

Impacts of Alternative 3–Summer Construction. Under Alternative 3–Summer Construction, adverse impacts would be direct, site-specific, short-term, and negligible to minor in early or late spring during their inshore migration, depending upon actual months the project may occur. A summer construction window does not coincide with elevated Atlantic sturgeon numbers in North Carolina waters as referenced in CPE (2015). Deaton et al (2010) showed no capture of Atlantic sturgeon in North Carolina waters during their summer surveys despite numerous tows; nonetheless, their behavior is not completely understood and not all months were sampled.

Therefore, Atlantic sturgeon could be in the area during dredging and would likely be adversely affected by noise, disruption of active foraging, or interruption to other behaviors such as resting. Shortnose sturgeon are less likely to be in the project area as they are more common nearshore in the vicinity of inlets and the closest inlet is 12 miles away. Removing sediments from the borrow shoal offshore would also impact Atlantic sturgeon by removal of benthic fauna food source in those sediments (~twice as much sediment as Alternative 2). Despite the rarity of incidental take documented by the USACE, and the mobility of sturgeon, an individual sturgeon could potentially be entrained in hopper dredge equipment or collide with a project vessel. Therefore, Alternative 3–Summer Construction would have the potential to likely adversely affect Atlantic sturgeon.

However, mitigation measures would be coordinated with the National Marine Fisheries Service/ Protected Resource Division (NMFS/PRD) during consultation and would require an NMFS/PRD-qualified and approved endangered species observer to be on the dredge at all times. The observer would follow all appropriate agency mandated actions (reporting, measurements, stop-work authority) should a sturgeon be found in dredge screen, skimmer funnels, or drag heads. In addition, if recommended by resource agencies and given as a condition of the permits, non-capture trawling ahead

of the dredge would be implemented during dredging operations. Such trawling would be intended to mobilize any sturgeon at or near the bottom in the borrow area before contact with the dredge.

Cumulative Impacts on Sturgeon (Atlantic and Shortnose). Please refer to the Cumulative Impacts on EFH/HAPC section of this document for a description of past, present, and reasonable foreseeable future actions (pg 114). In addition, likely future actions which include activities known to affect, suspected to affect, or may affect sturgeon, such as offshore wind project development, offshore seismic testing and drilling, and military maneuvers that include sonar or blasting, would continue in both state and federal waters off North Carolina and the region.

Conclusion – Sturgeon. Alternative 1–No-Action would have no adverse effect on either sturgeon species. Alternative 2–Winter Construction would have direct, site-specific, short-term, and negligible to minor adverse impacts during dredging and would likely adversely affect both species of sturgeon. Alternative 3–Summer Construction would also have direct, site-specific, short-term, and negligible to minor impacts during dredging and would not likely adversely affect shortnose sturgeon but would likely adversely affect Atlantic sturgeon. The incremental adverse impacts to Atlantic sturgeon or shortnose sturgeon of any of the three evaluated alternatives are imperceptible when added to the cumulative adverse effects of the three proposed northern Outer Banks nourishment projects, replacement of the Bonner Bridge, periodic Oregon Inlet dredging, sonar testing and blasting, and offshore exploration for oil and gas.

Mammals – Whales (Finback, Humpback, Atlantic Right)

Impacts of Alternative 1–No-Action. Alternative 1–No-Action would have no impact on the finback, humpback, or North Atlantic right whale.

Impacts of Alternative 2–Winter Construction. Alternative 2–Winter Construction impacts would include direct, local, short-term, negligible to minor disruptions during dredging from noise avoidance behaviors. These behaviors may drive a whale away from suitable prey or potentially cause them to collide with project vessels. The North Atlantic right whale would more likely be in the area in spring or winter, and the finback and humpback whales migrate through the area in the winter, so Alternative 2 would have a slightly higher likelihood of a whale encounter than Alternative 3. A National Marine Fisheries Service/ Protected Resource Division (NMFS/PRD)-qualified and approved endangered species observer would be stationed on the dredge at all times and would follow standard reporting and notification protocols should a whale be observed in the vicinity (within 2.2 miles)(NMFS 2012). To avoid adverse impacts, the standard NMFS/PRD mitigation measure of turning off pumps until the whale is beyond 2.2–mile limit would be followed.

Impacts of Alternative 3–Summer Construction. Alternative 3–Summer Construction adverse impacts would include direct, local, short-term, negligible disruptions during dredging from noise avoidance behaviors, which may drive a whale away from suitable prey species and create potential for them to collide with project vessels. Whales are fewer in number and less likely to be in the offshore waters and project vicinity during the summer. Individuals in the area could be impacted by noise, depending on the presence of prey species in the vicinity or vessel collision. As mentioned above, an NMFS/PRD observer would be stationed on the dredge to ensure that required NMFS whale protection measures would be carried out.

Cumulative Impacts on Whales. Please refer to the Cumulative Impacts on EFH/HAPC section of this document for a description of past, present, and reasonable foreseeable future actions (pg 114). In addition, likely future actions which include activities known to affect, suspected to affect, or may affect whales, such as offshore wind project development, offshore seismic testing and drilling, and military maneuvers that include sonar or blasting, would continue in both state and federal waters off North Carolina and the region.

Conclusion – Whales. Alternative 1–No-Action would have no effect on whales. Both Alternative 2–Winter Construction and Alternative 3–Summer Construction would have direct, local, short-term, negligible to minor disrup-tions to whales during dredging from noise avoidance behaviors. Both have the potential to affect whales, but are not likely to have adverse effects. Since whales are more likely to be in the vicinity during the winter or fall, Alternative 2 is more likely to impact whales, but effects would be minimized by the presence of a NMFS/PRD-qualified and approved endangered species observer on the dredge at all times under either Alternative 2 or Alternative 3 operations. The incremental adverse impacts to whales of any of the three evaluated alternatives are imperceptible when added to the cumulative adverse effects of the three proposed northern Outer Banks nourishment projects, replacement of the Bonner Bridge, periodic Oregon Inlet dredging, noise from and collisions with ocean-going vessels, and offshore exploration for oil and gas.

Sea Turtles

Impacts of Alternative 1–No-Action on Sea Turtles. Alternative 1–No-Action would allow erosion to continue which would continue to narrow and steepen the beach and continue to degrade or even decrease potential sea turtle nesting habitat in the action area. Overwash events would increase which could decrease nest success, should nests be laid and not relocated by NPS biologists in time. These impacts would be indirect, site-specific, and long-term adverse impacts. A future breach could provide a temporary beneficial impact as it would offer new access to back-barrier habitats frequented in summer for some sea turtles, most commonly loggerheads, but also green and Kemp's ridley.

Impacts of Alternative 2–Winter Construction on Sea Turtles. Alternative 2–Winter Construction would be completed by 31 March and occur outside of seasonal windows for turtle nesting and migration (April to December) and avoid adverse impacts. Long-term, site-specific, beneficial impacts to potential nesting habitat would include less steep slope in the intertidal zone and ~70 feet more of dry beach post-project equilibration.

The nourishment berm would be tested for compaction using protocols established by the US Fish and Wildlife Service (USFWS). If the nourished beach exhibits semi-cemented or compacted sediments exceeding USFWS criteria of 500 psi, the beach would be tilled to 36 inches at the direction of USFWS and NPS officials. Tilling may be waived at the discretion of the USFWS, if natural control beaches fail compaction tests.

Impacts of Alternative 3–Summer Construction on Sea Turtles. Under Alternative 3–Summer Construction, swimming turtles and nesting females would have direct, site-specific, short-term, minor to moderate adverse impacts during construction activities either in the borrow area or on the beach. In the borrow area, foraging behaviors may be impacted by the dredge operations (either a disruption by the equipment itself or by disruptions to prey species and increased turbidity by the activity itself). Entrainment during the dredge operation could occur; most likely to a loggerhead as it is a bottom forager and is the most common turtle in the Proposed Action Area. Measures to minimize adverse impacts include (see Appendix G–*Monitoring and Mitigation Measures*–for more detail):

- Non-capture turtle trawler used before and during hopper dredge operations.
- NMFS/PRD-qualified and approved endangered species observer would be on the dredge at all times and follow all standard reporting and avoidance procedures as required.
- Sea turtle-friendly lighting, should work occur at night.
- Nightly turtle monitors would patrol the active work zone and pipeline to detect any turtles that may cross the pipe or become stranded or disorientated, and would have the authority to stop work while wildlife officials are contacted about each incident and resolution is complete.

- Timely and proper relocation of all nests discovered in the active action area by trained volunteers and/or NPS biologists.
- Compaction tests post-completion as required.

On any given day, 600–800 feet of beach would be under active construction, and 200–300 feet of nourishment would be completed per day under normal conditions. Nesting turtles which come ashore in the completion area would be able to build their nests in improved habitat should they find it acceptable. While it would be unlikely for a turtle to be trapped between the pipe and the dunes, nightly patrols would be conducted along the active 4,000-foot segment of trunk line on both sides. If a turtle were found trapped behind the pipe, work would stop until the proper authority could be notified and procedures followed to free the trapped turtle. Existing USFWS/NPS protocols for nest relocation would be strictly followed. Per recommendations of US Fish and Wildlife Services and North Carolina Water Resources Commission, all turtle nests laid before or during construction would be relocated to areas outside of the Proposed Action Area.

Potential, direct, site-specific, short-term, moderate beneficial impacts would include improved potential nesting habitat in the action area with ~150 feet more of dry beach post-project equilibration and a less steep slope to the intertidal area.

Cumulative Impacts on Sea Turtles. Please refer to the Cumulative Impacts on EFH/HAPC section of this document for a description of past, present, and reasonable foreseeable future actions (pg 114). Additional cumulative impacts on sea turtles would include long-line fisheries and trawling bycatch. Beneficial impacts would include improved nesting habitat (wider dry beach) and would be in place for ~3 years under Alternative 2–Winter Construction and ~10 years under Alternative 3–Summer Construction. Other future actions would include continued coastal development and its associated artificial lighting, offshore wind projects, and offshore oil and gas development.

Conclusion – Sea Turtles. While erosion would reduce and continue to degrade existing nesting habitat, Alternative 1–No- Action would not likely have adverse effects in the long-term, as there is abundant nearby nesting habitat. Alternative 2–Winter Construction would have long-term beneficial impacts, with improved nesting habitat and less slope to the intertidal zone, but no adverse impacts as it would not occur during nesting season. Alternative 3–Summer Construction would have direct, site-specific, short-term, minor to moderate adverse impacts and would be likely to adversely affect sea turtles during construction activities either in the borrow area or on the beach. Dredging may disturb or entrain a turtle in the area and sand placement on the beach would affect sea turtles that try to nest on the beach. Due to the use of the mitigation and conservation measures mentioned above those adverse impacts would be minimized to the extent possible. The incremental adverse impacts on sea turtles of any of the three evaluated alternatives are imperceptible when added to the cumulative adverse effects of the three proposed northern Outer Banks nourishment projects, replacement of the Bonner Bridge, periodic Oregon Inlet dredging, continued development in Dare County, and long-line fisheries and trawling bycatch. Incremental beneficial impacts of Alternative 2 and Alternative 3 would be noticeable and include a wider beach with increased nesting habitat.

Seabeach Amaranth

Impacts of Alternative 1–No-Action on Seabeach Amaranth. Alternative 1–No-Action would increase potential habitat for the seabeach amaranth, as overwash events may disperse dormant seeds into new suitable habitats formed by the overwash deposits– a short-term, indirect, site-specific impact. However, should the species colonize such a deposit, continued erosion and other overwash events may bury or eliminate the plants before a colony could become established–a short-term, indirect, site-specific, adverse impact.

Impacts of Alternative 2–Winter Construction on Seabeach Amaranth. Under Alternative 2–Winter Construction impacts would be unlikely as the species has not been documented in the project area historically and has not been seen in the Seashore since 2005. Beneficial, direct, site-specific, long-term impacts would include an increase in potential habitat due to ~70 more feet of dry beach post-project equilibration.

Impacts of Alternative 3–Summer Construction on Seabeach Amaranth. Under Alternative 3–Summer Construction, direct adverse impacts would be unlikely as the species has not been documented in the project area historically and has not been seen in the Seashore since 2005. Beneficial, site-specific, long-term impacts would include an increase in potential habitat by the gain of ~150 more feet of dry beach post-project equilibration.

Cumulative Impacts on Seabeach Amaranth. Please refer to the Cumulative Impacts on EFH/HAPC section of this document for a description of past, present, and reasonable foreseeable future actions (pg 114). Habitat loss or degradation due to coastal development elsewhere in Dare County would continue.

Conclusion – Seabeach Amaranth. Alternative 1–No-Action would have no effect on seabeach amaranth and may have short-term beneficial impacts by creation of new temporary potential habitat during storm overwash events. Overall, Alternative 2–Winter Construction and Alternative 3–Summer Construction would also have no effect on seabeach amaranth. Park biologists survey each year for this plant and would notify the applicant and/or the contractor should any be found and would work with USFWS for appropriate mitigation measures to be followed to avoid adverse impacts to the plant. The incremental adverse impacts on seabeach amaranth of any of the three evaluated alternatives are imperceptible when added to the cumulative adverse effects of the three proposed northern Outer Banks nourishment projects, replacement of the Bonner Bridge, periodic Oregon Inlet dredging, and continued development in Dare County.

Impacts on Species with Other Federal Protection

Marine Mammals

As indicated in Chapter 3, the Marine Mammal Protection Act (MMPA) of 1972, as amended, offers federal protection to marine mammals within the waters of the US. The MMPA prohibits marine mammal takes and enacts a moratorium on the import, export, and sale of any marine mammal, along with any marine mammal part or product within the US. The Act defines take as the act of hunting, killing, capture, and/or harassment of any marine mammal; or, the attempt at such. The MMPA defines harassment as any act of pursuit, torment or annoyance which has the potential to either: (1) injure a marine mammal in the wild; or (2) disturb a marine mammal by causing disruption of behavioral patterns, which includes, but is not limited to, migration, breathing, nursing, breeding, feeding, or sheltering.

Of the 37 marine mammals with the potential to occur in the action area (see Table 3.6), only four are considered common, uncommon/common, or common/abundant and the biology and distribution of these four were described in Chapter 3. Thirteen of the 37 are considered accidental/ causal or accidental/causal to rare, 11 are considered rare, and nine are considered uncommon or rare/ uncommon. Six of the 37 have federal protection under the ESA, and five of these were evaluated in the *Biological Assessment* (Appendix B). The sixth species is the West Indian manatee (*Trichechus manatus*) which was eliminated from analysis in the BA due to lack of habitat in the action area.

In the text below, when the term marine mammal is used, it does not include the marine mammal species with ESA protection addressed earlier in this EA.

Impacts of Alternative 1–No-Action on Marine Mammals. Alternative 1–No-Action would likely have no adverse effect on marine mammals. There is slight potential for indirect, long-term, minor, local benefit for the West Indian manatee and common bottlenose dolphin should a breach inlet form with the high rate of erosion expected to continue with no action. Although a very rare visitor in inland waters north of Cape Hatteras and also seldom in the NC ocean waters north of Carteret County, the West Indian manatee might be found in the vicinity of the inlet or use it to go from its preferred quieter back barrier habitats with vegetation to more saline ocean waters. The common bottlenose dolphin is the most abundant NC visitor among the 17 oceanic dolphins which may occur in NC waters and often will use inlets and river mouths to access estuaries.

Impacts of Alternative 2 and Alternative 3 on Marine Mammals. Of the four species of marine mammal common or abundant in North Carolina waters, three are found year round (Atlantic spotted dolphin, common bottlenose dolphin, and short-finned pilot whale) and one is found only during the winter or early spring (short-beaked common dolphin). With the exception of the four earless seals, all of which are rare or accidental/causal but also occur in shallower waters like the common bottlenose dolphin, most of the other marine mammals with potential occurrence in North Carolina waters are oceanic and found further offshore in deeper waters than the Proposed Action Area. As only the common bottlenose dolphin is abundant to common and can be found close to the beach and offshore, it is the only marine mammal likely to be impacted by both the dredge operation and sand placement activities under either alternative; winter construction may be more likely to affect pregnant or nursing females of this species than summer construction. Winter construction would also be more likely to have short-term direct impacts on short-beaked common dolphin during dredge operations compared to summer construction but this species is usually associated with deeper waters. Noise from the dredging under either alternative would be the source of potential adverse impact most likely to affect any marine mammals in the vicinity. Any of these potential adverse impacts would be considered direct, minor, local, and short-term.

NOAA guidelines define two levels of harassment for marine mammals: Level A based on a temporary threshold shift (190dB re 1μPa for pinnipeds and 180dB re 1μPa for cetaceans), and Level B harassment with the potential to disturb a marine mammal in the wild by a disruption to behavioral patterns such as migration, breeding, feeding, and sheltering (160dB re 1μPa for impulse noise such as pile driving and 120 dB re 1μPa for continuous noise such as vessel thrusters). There is new draft guidance on anthropogenic-sourced noise for temporary threshold shifts (TTS) and permanent threshold shifts (PTS) based on hearing sensitivities within certain marine mammal groups (http://www.nmfs.noaa.gov/pr/acoustics/draft%20acoustic%20guidance%20July%202015.pdf). Non-impulsive sources evaluated in the 2015 guidance do include drilling and dB thresholds (peak and cumulative) for non-impulsive activities range from 174 to 230 dB depending on whether the cetacean is considered susceptible to a low, medium, or high frequency range. However, dredging is not one of the activities evaluated and the new noise thresholds do not address behavioral effects. So in the interim, as discussed in Section 9.5 of the BA (Appendix B), noise associated with hydraulic cutterhead or hopper dredges operating in sandy substrates are unlikely to exceed either the Level A or Level B thresholds.

Cumulative Impacts on Marine Mammals. Please refer to the Cumulative Impacts on EFH/HAPC section of this document for a description of past, present, and reasonable foreseeable future actions (pg 114).

As the replacement of the Herbert C. Bonner Bridge by NCDOT would occur within the Seashore and not offshore, it would be unlikely to adversely affect marine mammals that are found only or usually in deeper water habitat. However, the construction noise (e.g. pile driving) or other construction activities

could disturb common bottle nose dolphin or West Indian manatee which may use Oregon Inlet to access Pamlico Sound.

All of the dredging associated with Hatteras Island future projects, either in Oregon Inlet or offshore, and sand placement during future disposal of Oregon Inlet dredged material, or beach nourishment activities for Dare County beaches, would possibly disturb marine mammals in the vicinity of the dredge and pumping operations (Atlantic spotted dolphin and common bottle nose dolphin primarily; other species are most often found in deeper waters). Sand placement activities would possibly disturb species found closer to shore in shallower water, e. g. the common bottle nose dolphin. Dredging work associated with Oregon Inlet would also possibly disturb West Indian manatee, although it is a very rare visitor to the ocean side of NC inlets.

Anthropogenic background sounds in the marine environment have steadily increased and are likely to continue to increase from shipping and other uses of the ocean and inland waters. Shipping is the dominant source of underwater noise below 300 Hz (Ross 1987, 1993 as referenced in USACE 2015). While this level is below 1 kHz, the potential exists that this sound can mask biologically important significant sounds from groups of marine mammals that produce and receive sounds in this band (e.g., pinnipeds and baleen whales such as finback and humpback). Numerous actions around fisheries activities (e.g., legal and illegal bottom-disturbing fishing gear) within state waters would continue and potential future actions (offshore wind projects, offshore oil and gas seismic testing and drilling), all have the potential to adversely affect marine mammals.

Conclusion – Marine Mammals. Alternative 1–No-Action would have no adverse impact on marine mammals and may have slight short-term beneficial effect for two marine mammal species (West Indian manatee and common bottlenose dolphin). Marine mammals in the offshore area during either Alternative 2–Winter Construction or Alternative 3–Summer Construction dredging activities may avoid the associated noise and turbidity which, depending on prey availability, might disrupt foraging behaviors or temporarily mask communication. However, with the exception of the common bottlenose dolphin, most of the marine mammals with the potential to occur are usually associated with waters deeper than the –25 feet to –50 feet found in the vicinity of the borrow area. Common bottlenose dolphin in the shallow waters closer to the beach during sand placement under either winter or summer construction may also experience direct, short-term adverse impacts during pumping operations or disturbance from other project-associated vessels, but being mobile they would be able to easily find nearby suitable habitat for foraging or other behaviors.

Overall, because both Alternative 2–Winter Construction or Alternative 3–Summer Construction have the potential to temporarily affect certain behaviors of some species, both alternatives may adversely impact marine mammals. The incremental adverse impacts to marine mammals of any of the three evaluated alternatives are imperceptible when added to the cumulative adverse effects of the three proposed northern Outer Banks nourishment projects, replacement of the Bonner Bridge, periodic Oregon Inlet dredging, noise from ocean-going vessels, and offshore exploration for oil and gas.

Colonial Waterbirds, Other Shorebirds, and Birds of Prey

Additional species of birds may occur in the project area/vicinity which are federally protected under the Migratory Bird Protection Act (MBTA); e.g., colonial waterbirds, other shorebirds, and birds of prey (bald eagle and peregrine falcon). For MBTA-protected species, there is no provision for incidental take related to dredging or filling or crushing by equipment. Take under the MBTA is defined as pursue, hunt, shoot, wound, kill, capture, or collect or attempt to pursue, hunt, shoot, wound, kill, capture, or

collect, per 50 CFR§10.12. Some of these birds also have state-level protection status as discussed in Chapter 3.

Impacts of Alternative 1–No-Action on Colonial Waterbirds (Gull-billed Tern, Common Tern, Least Tern, and Black Skimmer. Alternative 1–No-Action would include moderate, long-term impacts to colonial waterbird nesting habitat, as the beach would eventually become too narrow to support nesting. One beneficial effect of Alternative 1 would be the formation of additional foraging and resting habitat, if a breach occurred. The duration of this benefit would depend on whether the breach remained open or closed and whether it was bridged.

Impacts of Alternative 2–Winter Construction on Colonial Waterbirds (Gull-billed Tern, Common Tern, Least Tern, and Black Skimmer. Alternative 2–Winter Construction would have no adverse impact on nesting colonial waterbirds, but would have direct, site-specific, short-term, negligible to minor impacts to foraging or resting birds which may be in the area. These include black skimmer (present all year), common tern (could be present March to November), and gull-billed tern and least tern (not likely to be present). Birds would be disturbed by construction activities on the beach. Existing foraging and nesting habitat would also have short-term minor impacts during sand placement. These impacts would be staggered, however, and progress over a 600–800-foot active impact area of the beach at any given time as the sand is pumped and bulldozed. Approximately 200–300 feet of nourishment would be completed per day, which would become immediately available for use by birds in the area, based on their tolerance to disturbance and proximity to human activity.

Impacts of Alternative 3–Summer Construction on Colonial Waterbirds(Gull-billed Tern, Common Tern, Least Tern, and Black Skimmer). Impacts under Alternative 3–Summer Construction would be similar to Alternative 2, although all four species included in the colonial waterbirds category would be present. These disturbances would be minimized by the NPS shorebird surveys, which are conducted March to mid-August, depending on species presence. These would establish pre-nesting closures based on observed behaviors of target species and designated buffer distances around nests, unfledged chicks, or fledglings (modified buffer distances for species and activity type as described in recent environmental assessment for ORVs prepared by Cape Hatteras National Seashore) (NPS 2015). No construction would occur within the closures or buffers.

Cumulative Impacts on Colonial Waterbirds (Gull-billed Tern, Common Tern, Least Tern, and Black Skimmer). Please refer to the Cumulative Impacts on EFH/HAPC section of this document for a description of past, present, and reasonable foreseeable future actions (pg 114). Habitat loss or degradation due to human activities associated with recreation or development elsewhere in Dare County would continue. Alternative 2–Winter Construction would provide up to ~3 years of beneficial long-term impacts to nesting habitat (wider beach) and Alternative 3–Summer Construction would provide ~10 years.

Conclusion – Colonial Waterbirds. While the level of potential impact is slightly different between the three alternatives due to seasonal presence or absence of some species, each would be unlikely to adversely impact colonial waterbirds due to NPS-established monitoring surveys, closures, and buffers. Those NPS conservation activities and restrictions would minimize, reduce, or avoid adverse potential effects. When added to the cumulative effects of the three proposed northern Outer Banks nourishment projects, replacement of the Bonner Bridge, periodic Oregon Inlet dredging, and continued development in Dare County, the incremental adverse impact on colonial waterbirds of Alternative 1-No Action is imperceptible, and impacts are imperceptible to noticeable for Alternative 2 and Alternative 3.

Impacts of Alternative 1–No-Action on Wilson's Plover. Alternative 1–No-Action would allow erosion to continue in the action area which would have adverse, site-specific, long-term impacts to nesting habitat for the Wilson's plover, as the beach would eventually become too narrow to support nesting. However, currently, this plover rarely nests in the Seashore and only nested on Ocracoke Island in 2014.

The likelihood of an inlet breach would increase under Alternative 1, and should an inlet breach occur, additional foraging habitat (tidal mudflats and lagoons which support fiddler crabs, their favorite food) could result in a beneficial impact to the back barrier west of NC 12. The duration of the benefit would be temporary or short-term depending on how long the inlet breach remained open.

Impacts of Alternative 2–Winter Construction on Wilson's Plover. Wilson's plover could be in the area from March to October, so under Alternative 2–Winter Construction, not only would foraging and resting area habitats in the Proposed action area be adversely impacted during construction, but also any birds in the area could also be disrupted from feeding or resting (short-term and site-specific impacts). Long-term, site-specific, beneficial effects would include ~70 additional feet of dry beach for nesting and resting post-equilibration. Regular bird surveys conducted by NPS biologists begin in March for this bird, and all NPS protocols (buffer distances and closures as appropriate) would be followed in the unlikely event one was observed in the active work area.

Impacts of Alternative 3–Summer Construction on Wilson's Plover. This bird could be in the area from March to October, so under Alternative 3–Summer Construction, not only would foraging and resting area habitats in the Proposed action area be adversely impacted during construction (short-term), but also any birds in the area could also be disrupted from feeding or resting. Beneficial, site-specific, long-term effects would include ~150 additional feet of dry beach for nesting and resting post-equilibration. Regular bird surveys conducted by NPS biologists begin in March for this bird, and all NPS protocols (buffer distances and pre-nesting closures as appropriate) would be followed in the unlikely event one was observed in the active work area.

Cumulative Impacts on Wilson's Plover. Please refer to the Cumulative Impacts on EFH/HAPC section of this document for a description of past, present, and reasonable foreseeable future actions (pg 114). Habitat loss or degradation due to human activities associated with recreation or development elsewhere in Dare County would continue. Additionally, while the action area would likely revert to the pre-project deficit condition within ~3 years under Alternative 2–Winter Construction and ~10 years under Alternative 3–Summer Construction, sand that migrates from the nourished beach downdrift within the littoral current would feed the existing foraging and roosting habitat south of Buxton at Cape Point, a potential long-term benefit to the species.

Conclusion – Wilson's Plover. Under Alternative 1–No-Action, continued erosion in the action area would cause moderate and long-term adverse impacts to nesting habitat, but if an inlet breach occurred, it would provide additional short-term foraging habitat. Overall, this alternative would not likely adversely impact Wilson's plover. Under Alternative 2–Winter Construction and Alternative 3–Summer Construction, impacts to nesting and foraging habitat would occur and individual birds may be disturbed during construction, but these are considered negligible, temporary, and short-term and would not likely adversely impact Wilson's plover. The incremental adverse impacts on Wilson's plover of any of the three evaluated alternatives are imperceptible when added to the cumulative adverse effects of the three proposed northern Outer Banks nourishment projects, replacement of the Bonner Bridge, periodic Oregon Inlet dredging, and continued development in Dare County.

Impacts of Alternative 1–No-Action on American Oystercatcher. Alternative 1–No-Action would allow erosion to continue which would result in less nesting habitat as the beach would continue to steepen and narrow–an indirect, long-term, site-specific, adverse effect. One beneficial, indirect, site-specific

effect of this alternative would be the formation of additional foraging and resting habitat if a breach occurred. The duration of this benefit would depend on whether the breach remained open or closed or was temporarily bridged.

Impacts of Alternative 2 and Alternative 3 on American Oystercatcher. Both Alternative 2–Winter Construction and Alternative 3–Summer Construction would have short-term, minor impacts to American oystercatcher foraging and resting habitat in the action area during sand placement. As fewer oystercatchers are in Dare County in the winter, the likelihood of an encounter with the bird is lower with Alternative 2. Alternative 3 would also have short-term, minor, local impacts to nesting birds especially in the northern portion of the action area where nests have been documented since 2009. However, NPS biologists establish pre-nesting closures when breeding behaviors are noted and maintain a 495-foot buffer around active nests and a 660-foot buffer around unfledged chicks where no construction can occur; NPS established buffers would be strictly observed by the contractor. These buffers should help to minimize and avoid adverse impacts to American oystercatcher; in fact, NPS biologists can enlarge the buffers if individual birds appear disturbed at the shorter distances. Beneficial, site-specific, long-term, moderate effects would include ~70 additional feet (Alternative 2) and ~150 additional feet (Alternative 3) of dry beach for nesting and resting post-equilibration. Alternative 2 would have no adverse impact on nesting birds.

Cumulative Impacts on American Oystercatcher. Please refer to the Cumulative Impacts on EFH/HAPC section of this document for a description of past, present, and reasonable foreseeable future actions (pg 114). Additionally, while the Proposed Action Area would likely revert to the pre-project deficit condition within ~10 years, sand that migrates from the nourished beach downdrift within the littoral current would feed the existing foraging and roosting habitat south of Buxton at Cape Point, a potential long-term benefit to this species. Habitat loss or degradation due to human activities associated with recreation or development elsewhere in Dare County would continue.

Conclusion – American Oystercatcher. All three alternatives have short- to long-term beneficial impacts by the addition of, or expansion of, nesting, resting, or foraging habitat. Alternative 2 would have slightly less likelihood than Alternative 3 to impact individual birds, and Alternative 3 would have the potential to adversely impact nesting birds, but avoidance and conservation measures already in place would reduce the likelihood of any negative effect. Alternative 2 and Alternative 3 may provide beneficial, long-term impacts to nesting habitat due to a wider beach. Therefore, overall the American oystercatcher is not likely to be adversely impacted by any of the three evaluated alternatives. The incremental adverse impacts on American oystercatcher of any of the three evaluated alternatives are imperceptible when added to the cumulative effects of the three proposed northern Outer Banks nourishment projects, replacement of the Bonner Bridge, periodic Oregon Inlet dredging, and continued development in Dare County.

Impacts of Alternative 1–No-Action on Bald Eagle. Alternative 1–No-Action would have no impact on habitats commonly frequented by the bald eagle.

Impacts of Alternative 2 and Alternative 3 on Bald Eagle. Under Alternative 2–Winter Construction and Alternative 3–Summer Construction, bald eagle foraging and resting areas would be subject to short-term and negligible impact during sand placement. Alternative 2 may have a slightly higher likelihood of disturbance since the bald eagle is more common at the Seashore in the winter. Bald eagle nest locations have not been confirmed by NCWRC since 2011, and the six nests last known are not within the project vicinity. Neither beach nourishment nor dredging is specifically listed in the National Bald Eagle Management Guidelines (USFWS 2007). These guidelines provide buffer distances for activity categories based on type of activity, visibility of activity from an active eagle nest, or whether

similar activity exists within one mile. However, extremely loud intermittent noises within 0.5-mile of nests are discouraged, unless greater tolerance to the activity is demonstrated by eagles in the nesting area. Any impacts from noise, should they occur, would be considered site-specific and short-term.

Cumulative Impacts on Bald Eagle. Please refer to the Cumulative Impacts on EFH/HAPC section of this document for a description of past, present, and reasonable foreseeable future actions (pg 114). These cumulative effects are considered imperceptible to noticeable.

Conclusion – Bald Eagle. The bald eagle would experience no impact under Alternative 1 and would not likely be adversely impacted by either Alternative 2–Winter Construction or Alternative 3–Summer Construction. The incremental adverse impacts to bald eagle of any of the three evaluated alternatives are imperceptible when added to the cumulative adverse effects of the three proposed northern Outer Banks nourishment projects, replacement of the Bonner Bridge, periodic Oregon Inlet dredging, and continued development in Dare County.

Impacts of Alternative 1–No-Action on Peregrine Falcon. As there is no peregrine falcon nesting or breeding habitat in the Seashore or the Proposed Action Area, Alternative 1–No-Action would not affect this falcon.

Impacts of Alternative 2 and Alternative 3 on Peregrine Falcon. The peregrine falcon is uncommon from May to August, becoming slightly more common in October. During winter construction, a slightly higher likelihood of a visitor would occur, depending on the actual months of construction. Foraging habitat (near congregations of shorebirds) would have direct, site-specific, short-term, negligible to minor impacts from both Alternative 2–Winter Construction and Alternative 3–Summer Construction during sand placement activities. However, as stated above, the active zone of disturbance would range from 600-800 feet long on any given day, and extensive foraging habitat is otherwise available. Both these alternatives may have beneficial long-term impacts to foraging and resting habitat of the peregrine falcon, due to the wider dry beach which would be likely to attract shorebirds, preferred coastal falcon prey.

Cumulative Impacts on Peregrine Falcon. Please refer to the Cumulative Impacts on EFH/HAPC section of this document for a description of past, present, and reasonable foreseeable future actions (pg 114). Habitat loss or degradation due to human activities associated with recreation or development elsewhere in Dare County would continue. Long-term beneficial impacts of a wider dry beach would be ~3 years for Alternative 2–Winter Construction and ~10 years for Alternative 3–Summer Construction. A wider, dry beach equates to more potential use by shorebirds, which are prey for peregrine falcon.

Conclusion – Peregrine Falcon. Alternative 1-No Action would have no impact, and both Alternative 2-Winter Construction and Alternative 3-Summer Construction would have direct, site-specific, short-term, and negligible to minor impact. The incremental adverse impacts to peregrine falcon of any of the three evaluated alternatives are imperceptible when added to the cumulative effects of the three proposed northern Outer Banks nourishment projects, replacement of the Bonner Bridge, periodic Oregon Inlet dredging, and continued development in Dare County.

Impacts on Species with State Protection

One additional reptile, the diamondback terrapin, and one additional plant, the seabeach knotweed, have the potential to be affected by the alternatives addressed in this document. Both species are designated for state-level protection and are discussed in more detail in Chapter 3. Potential impacts to those species by each alternative are discussed below.

Impacts of Alternative 1–No-Action on Diamondback Terrapin. The diamondback terrapin has been documented by NPS biologists west of the Proposed Action Area on the west side of NC 12. Therefore, Alternative 1–No-Action may permanently affect some existing back-barrier habitats preferred by the diamondback terrapin, as erosion would continue under this alternative and increase the likelihood of overwash events or a breach in the future. While both overwash and a breach would be unpredictable in time and duration, a breach would remove back-barrier dune and marsh areas the terrapin may currently use for foraging, nesting, and hibernation. Overwash events would have the potential to bury either active or dormant individuals or preclude use of existing foraging or habitat. The duration of those effects would depend on whether or not the breach closed naturally or remained open and was temporarily bridged. Disturbance and disruptions from erosion and overwash would continue to affect the terrapin and its habitats. After some overwash events, some short periods of decreased traffic may occur before NCDOT could clear NC 12, or decreased traffic may occur over longer periods if NCDOT needs to conduct more extensive repairs to NC 12, or in the event of a breach. Post-storm maintenance activities conducted by NCDOT (road scraping and dune building) may have adverse impact to a terrapin if it attempted to cross the road during these activities. These impacts would be considered short-term and minor to moderate.

Impacts of Alternative 2–Winter Construction on Diamondback Terrapin. Under Alternative 2–Winter Construction, the diamondback terrapin would not likely be affected, as no suitable habitat exists for it within the Proposed Action Area. However, there is a chance that a project-associated support vehicle could encounter a terrapin as it crossed NC 12, but it would not likely be found on the ocean side of beach dunes where much of the project activities would occur, regardless of season. In addition, the species would be less active during the winter, which would also reduce the likelihood of an encounter with project vehicles on NC 12 during construction.

Impacts of Alternative 3–Summer Construction on Diamondback Terrapin. While this terrapin is not found on the ocean side of dunes in the summer, a project-associated vehicle en route from one beach access point to another could encounter a female diamondback terrapin crossing NC 12 on her way to or from the back barrier to a back-dune nest area. Although existing traffic is heaviest in the summer, which raises the potential for an encounter with any vehicle, the odds are somewhat remote that it would be a project-associated vehicle. Should an encounter occur, this type of impact would be considered short-term and moderate. Existing habitats for this terrapin west of the dune crest to the edge of Pamlico Sound would have no adverse impacts during summer construction and would have long-term beneficial impacts from a wider beach in front of the dunes.

Cumulative Impacts on Diamondback Terrapin. Please refer to the Cumulative Impacts on EFH/HAPC section of this document for a description of past, present, and reasonable foreseeable future actions (pg 114). Traffic is not expected to increase as a direct result of the any of the three alternatives; however, traffic on NC 12 in general may increase as it has historically and would likely continue with or without the project. An increase in traffic raises the likelihood that a diamondback terrapin would be killed as it crossed NC 12 between habitats. Alternative 2–Winter Construction would provide ~3 years of storm-surge protection to the preferred habitats of the diamondback terrapin. Alternative 3–Summer Construction would provide ~10 years of storm-surge protection. Habitat loss or degradation due to human activities associated with recreation or development elsewhere in Dare County would continue.

Conclusion – Diamondback Terrapin. Any of the three alternatives would not adversely impact the diamondback terrapin. However, Alternative 2–Winter Construction and Alternative 3–Summer Construction would have the potential beneficial impact of a wider beach better protected from storm surge and overwash. The incremental adverse impacts to diamond terrapin of any of the three evaluated

alternatives are imperceptible when added to the cumulative effects of the three proposed northern Outer Banks nourishment projects, replacement of the Bonner Bridge, periodic Oregon Inlet dredging, and continued development in Dare County..

Impacts of Alternative 1–No-Action on Seabeach Knotweed. Alternative 1–No-Action would allow erosion to continue which could increase habitat for the seabeach knotweed, as more frequent overwash events may disperse dormant seeds into new suitable habitats formed by the overwash deposits. The type of impact would be beneficial, indirect, site-specific, and short term to long term. However, should the species colonize such a deposit, continued erosion and other overwash events may bury or eliminate the pioneering plants which would be a short-term, adverse, moderate impact.

Impacts of Alternative 2 and Alternative 3 on Seabeach Knotweed. Under either Alternative 2–Winter Construction or Alternative 3–Summer Construction, no adverse effects are likely to occur as there is currently no known occurrence of the seabeach knotweed, and it has not historically been found in the Proposed Action Area. Occurrences of the seabeach knotweed has been documented south of the former location of the Cape Hatteras Lighthouse; however, not within the Proposed Action Area. The species was last documented during monthly visits between 1989 and October 1995 at the beach south of Buxton light (pre-1995 location) with no other details as to density of occurrence or more specific distances (NCNHP, Allison Weakley, Conservation Planner, pers. comm. 10 August 2015).

Since Park Service biologists conduct surveys for this plant each year along the Seashore, they would notify the Applicant and/or the nourishment contractor if any plants are found. Alternative 2–Winter Construction and Alternative 3–Summer Construction may have beneficial effects on the seabeach knotweed because the project is designed to widen the beach. As the nourished beach equilibrates over time to the additional sediment in the system, Aeolian processes may also enhance the species' preferred habitat between the wrack line and dune face. Therefore, the project under either alternative has the potential to provide more habitats for this pioneering species and is not likely to threaten its continued existence.

Cumulative Impacts on Seabeach Knotweed. Please refer to the Cumulative Impacts on EFH/HAPC section of this document for a description of past, present, and reasonable foreseeable future actions (pg 114). Habitat loss or degradation due to human activities associated with recreation or development elsewhere in Dare County would continue.

Conclusion – Seabeach Knotweed. While each of the three alternatives would have short-term minor effects on potential habitat for seabeach knotweed, only Alternative 1 has the potential for moderate effect. Each alternative has the potential for beneficial effect which differs in time (temporary overwash habitats with Alternative 1–No-Action, a wider more stable beach between the wrack line and dune toe for ~3 years with Alternative 2–Winter Construction, and ~10 years with Alternative 3–Summer Construction. Considering the lack of historic occurrence in the Proposed Action Area in conjunction with surveys performed prior to construction, it would be unlikely for seabeach knotweed to be adversely impacted by any of the three evaluated alternatives. The incremental adverse impacts to seabeach knotweed of any of the three evaluated alternatives are imperceptible when added to the cumulative effects of the three proposed northern Outer Banks nourishment projects, replacement of the Bonner Bridge, periodic Oregon Inlet dredging, and continued development in Dare County.

Impacts on State-Designated Natural Habitats

No state-designated natural areas or natural communities exist within the action area. While the North Carolina Natural Heritage Program (NCNHP) database shows two so-designated areas nearby, Turtle

Pond Registered Heritage Area (RHA) and Buxton Woods, neither would experience effects from the project activities of any of the three alternatives evaluated in this EA (see Fig 3.11).

CULTURAL RESOURCES

Methodology

The Applicant retained Tidewater Atlantic Research, Inc. (TAR) (Dr. Gordon Watts) to investigate existing and potential Cultural Resources in the Buxton Action Area. Results of the TAR studies and data collection are contained in Appendix F - *Cultural Resources*. The TAR report summarizes the cultural development of the Hatteras Island area from pre-European colonization to the present. Both onshore and offshore cultural resources were researched, with focus on offshore resources. Historical maps, literature and reports were reviewed, and methodology for the study complied with the National Historic Preservation Act of 1966 (Public Law 89-665), the National Environmental Policy Act of 1969 (Public Law 11–190), Executive Order 11593, the Advisory Council on Historic Preservation Procedures for the protection of historic and cultural properties (36 CFR Part 800), the updated guidelines described in 36 CFR 64 and 36 CFR 66, Archaeological Resource Protection Act (16 USC 470), Abandoned Shipwreck Law (North Carolina General Statute [NCGS] 121, article 3) and the North Carolina Archeological Resource Protection Act (NCGS 70, article 2).

TAR conducted remote-sensing surveys of the offshore sand search area using magnetic and acoustic imaging to detect submerged artifacts and potential remains of shipwrecks. A total of 123 magnetic anomalies were identified within the ~450-acre sand search area. With the exception of a cluster of 10 anomalies buffered for avoidance, all had signatures similar to those produced by deteriorated small pipe, old cable, or deteriorated wire. None of the 113 remaining magnetic signatures are suggestive of complex vessel remains. A search of shipwreck records indicated no known vessel remains are in the Proposed Action Area.

Impacts of Alternative 1–No-Action

Continued erosion is likely to occur in the Proposed Action Area with potential to uncover buried objects which are unknown at this time. Erosion at ~10 feet per year along portions of the beach-dune system in the Proposed Action Area would potentially expose up to 17 acres over an ~5-year period. Although there are no known shipwrecks, historic structures, or burial grounds near the beach-dune line in the Proposed Action Area, continued erosion could possibly expose cultural artifacts of importance. Therefore, Alternative 1 would generally have a negligible to minor adverse impact on Cultural Resources and would have no impact on the offshore borrow area.

Impacts of Alternative 2–Winter Construction

Beach fill operations in the Proposed Action Area would add new sand to an erosional beach, thereby lessening the chance of exposing undetected historical artifacts or shipwreck remains that are unknown at this time. Burial by an extra cover of sand is expected to have a negligible to minor beneficial impact on undetected artifacts or shipwreck remains at the shoreline.

Dredging operations in the offshore borrow area would possibly encounter undetected artifacts or shipwreck remains. The Applicant would avoid known or detected artifacts identified during surveys (Appendix F–*Cultural Resources*) by establishing no work buffers of at least 200 feet around the objects. If unknown artifacts are encountered during dredging, work would stop. The dredge would be

relocated to other parts of the borrow area until a determination could be made regarding the nature and historical importance of the material, in consultation with state and federal Historic Preservation officials. The string of magnetic anomalies that extends North-South through the middle of the offshore borrow area is being investigated further to determine whether it is an abandoned cable that can be removed before dredging. Any operation to remove the object which appears to be ~4,000 feet long (see Fig 4.4) would be performed in coordination with the North Carolina Historic Preservation Office (SHPO). If the object cannot be removed, the Applicant would establish a no work buffer around it and not utilize that portion of the borrow area.

Alternative 2 would have a beneficial impact on undetected cultural resources or artifacts that may occur in the Proposed Action Area along the beach-dune system. Additions of sand would bury such material for several years and lessen the chance of damage by erosion and wave action for the life of the project. Alternative 2 would have a negligible to minor adverse impact on undetected cultural resources or artifacts that may be encountered in the borrow area. The Applicant would cease operations and move the dredge to other parts of the borrow area should unknown artifacts be encountered during construction.

Impacts of Alternative 3 (Preferred Alternative) Summer Construction

Alternative 3 would place approximately twice the amount of nourishment along the beach in the Proposed Action Area. The impacts would be greater and longer lasting than Alternative 2. Burial of undetected artifacts would potentially extend by up to 10 years. The extra cover of sand is expected to have a beneficial impact on undetected artifacts at the shoreline. As sand erodes from the Proposed Action Area and shifts to other sections of Hatteras Island, it is expected to have beneficial impact on undetected artifacts in proximity to the Proposed Action Area.

The impacts of Alternative 3 in the offshore borrow area would be similar, but greater than Alternative 2. Deeper excavations would potentially encounter undetected artifacts or shipwreck remains. Similar to Alternative 2, if unknown artifacts are encountered during dredging, work would stop and the dredge would be relocated to other parts of the borrow area until a determination can be made regarding the nature and historical importance of the material, in consultation with state and federal historic preservation officials. See Alternative 2 for additional details on impacts and avoidance measures.

Alternative 3 would have a beneficial impact on undetected cultural resources or artifacts that may occur in the Proposed Action Area along the beach-dune system. Additions of sand would bury such material for up to 10 years and lessen the chance of damage by erosion and wave action. Alternative 3 would have a negligible to minor adverse impact on undetected cultural resources or artifacts that may be encountered in the borrow area. The applicant would cease operation and move the dredge to other parts of the borrow area should unknown artifacts be encountered during construction.

Cumulative Impacts on Cultural Resources

The principal cultural resources near the Buxton Action Area are the Cape Hatteras Lighthouse and a number of shipwrecks miles away. The only potential cultural resources in the borrow area are what appear to be abandoned cable or small pipe. The Applicant proposes to establish no-work buffers around these objects or remove them in consultation with federal and state officials prior to dredging. The other nourishment projects completed or planned along Dare County beaches between 2010 and 2020 have involved similar cultural resource surveys to avoid impacts to shipwrecks and other debris on the ocean floor. Each project is expected to avoid or minimize impacts because excavation on or around debris and wrecks would be counterproductive to dredging operations and result in unnecessary

expense associated with damages to dredges or work stoppages. Sand placement on beaches is generally considered to be beneficial to cultural resources at the shoreline because it provides additional cover to buried objects. This would reduce potential exposure of objects to erosion and damage while preserving them in situ for future research or recovery.

The No-Action Alternative would contribute a negligible to minor adverse increment to long-term, minor, adverse cumulative impacts to undetected cultural resources along eroding beaches of Dare County north of Cape Point. Alternatives 2 and 3 would contribute a beneficial increment to long-term beneficial cumulative impacts associated with additional burial by nourishment of detected or undetected cultural resources in the beach zone. Alternative 2 and 3 would contribute a noticeable adverse increment to overall cumulative impacts of dredging undetected cultural resources in offshore borrow areas.

SOCIOECONOMICS

Methodology

A primary goal of the proposed project is to widen the beach and reduce the chance of damage to NC 12, the principal access road along Hatteras Island and gateway to Park Service facilities, historic communities and structures, and the existing corridor for utilities. The economy of Dare County is tourism-based, and NC 12 accommodates far more visitors to the Seashore than would likely visit, if there was no vehicular access by road. The overall economic impact of Hatteras Island is >$200 million per year. Each road closure results in substantial economic impact, loss of access to hospitals, fire and police protection, loss of accommodations tax revenue and related devaluations of businesses and property.

The cost of the Proposed Action, though substantial, is weighed against these potentially much greater costs. Beach nourishment costs cannot be known with certainty in this setting until more systematic measurement and monitoring is performed. The Proposed Action would provide an opportunity for the County to evaluate objectively project performance, nourishment longevity, and degree of protection to infrastructure over an ~5–10-year period. With more accurate data in hand, the North Carolina Department of Transportation's alternative, long-term strategies for maintaining or relocating NC 12 could be better evaluated. The Applicant proposes to implement the project based on favorable economics and without impact to federal or state budgets. Under the terms of the permits, the Proposed Action would be a one-time event and any future nourishment activity would require another application.

Anticipated impacts on socioeconomics were analyzed using information from public records, previous studies, and similar project experience.

Impacts of Alternative 1–No-Action

Continued erosion along the action area would likely result in periodic damages to the foredune and NC 12 and force temporary road closures while emergency repairs to the road and utilities are completed. Erosion would also adversely impact developed property and lead to more emergency shore protection measures such as sand bags and beach scraping. This is expected to occur at increasing frequency as erosion proceeds at upwards of 10 feet per year in the action area. Each road closure would adversely impact economic activity on Hatteras Island, particularly the communities of Buxton, Frisco, and Hatteras Village.

When NC 12 is closed along the action area, all supplies to Buxton, Frisco, and Hatteras Village must be shipped in via temporary ferries from the north, or the existing state ferry system that operates at Ocracoke and Hatteras Inlet. Some supplies can arrive via small planes or helicopter to the municipal airport at Frisco which has a 3,000-foot runway. During periods of road closures, visitors cannot easily access the communities and businesses at the Cape. The ferry system has limited capacity to transport the numbers of visitors to the Seashore, motels, and private businesses each day, particularly in the high season tourist months of summer. Based on an economic impact of ~$200 million per year to the economy of Dare County, each day of road closure on Hatteras Island has a potential impact of hundreds of thousand dollars in lost business and tax revenues. Road closures increase the cost of basic supplies needed to support the communities. As a hub of business around Cape Hatteras, loss of access to Buxton impacts the local economy of Avon to the north or Frisco, Hatteras Village, and Ocracoke to the south. Avon also depends on Buxton for its water supply which is provided by way of a pipe paralleling NC 12. A breach of NC 12 would cut off water to Avon and impact infrastructure.

The No-Action Alternative would produce moderate adverse impacts on to the socioeconomics of Dare County and specifically Hatteras Island. The degree of the impact would be related to the timing and intensity of storm damages with greater impacts during high visitation summer months and lesser impacts during low-visitation winter months. A breach of the barrier would produce longer lasting and further reaching impacts by cutting the water supply to Avon. The Applicant has determined that the potential economic losses associated with closures of NC 12 and related damages to infrastructure and developed property would potentially be much greater than the cost of the action alternatives. Therefore, Alternative 1–No-Action is considered to have adverse, direct, regional, long-term impacts on socioeconomics.

Impacts of Alternative 2–Winter Construction

Beach nourishment in winter would provide a protective buffer between the ocean and existing infrastructure and development in the action area. Addition of ~1.3 million cubic yards would widen the beach by ~70 feet and offset annual erosion losses for several years. The number of years of protection from storm erosion would depend on the frequency and magnitude of future storms which is not predictable. Nevertheless, Alternative 2 would be expected to reduce the frequency and intensity of storm damages, breaches of the foredune and emergency closures of NC 12 in proportion to its scale. The duration of beneficial impacts would be <5 years based on projections of erosion losses after nourishment. Alternative 2 would produce beneficial impacts to the economics of Dare County and Hatteras Island with the degree of benefits proportional to the size (volume) of the project and intensity of future damaging storms. The beneficial impacts would be felt region-wide because of the dependence of Dare County on tourism and access to the Buxton area. The potential economic benefits of uninterrupted access along NC 12 over the life of Alternative 2 (~3–5 years) are expected to exceed the cost of the project.

Impacts of Alternative 3 (Preferred Alternative) Summer Construction

Impacts of Alternative 3 would be greater than Alternative 2 because the project scale would be about twice as large. Higher sand volume equates to increased project longevity and reduced probability of damages to infrastructure. Alternative 3 is expected to provide about one decade of erosion relief and economic benefits to the community. The potential economic benefits would be much greater than the cost of the project based on prior storm damage experience, the amount of economy at risk to road closures, and the accelerating values of barrier island property. Road closures along Hatteras Island

after Hurricanes *Irene* (2011) and *Sandy* (2012) forced cancellation of hotel and cottage rentals, and special events such as surfing and fishing tournaments.

Alternative 3 would produce beneficial impacts to the economics of Dare County and Hatteras Island for up to one decade. These benefits would be felt region wide because of the dependence of Dare County on tourism and access to the Buxton area. The potential economic benefits of uninterrupted access along NC 12 over the life of Alternative 3 (~10 years) are expected to exceed the cost of the project.

Cumulative Impacts on Socioeconomics

Hatteras Island is unique among east coast National Seashores in providing vehicular access over the length of the barrier island. This accounts for higher visitation rates than other National Seashores and additional major use by visitors to the area who may not be counted as park visitors. Emergency road closures have been a frequent occurrence along Hatteras Island particularly in the Rodanthe, Buxton and Hatteras Village area. The 2014 Rodanthe project was completed to widen the beach and protect NC 12 in an area of chronic erosion and emergency shore protection measures. The Buxton Project would similarly provide protection and reduce the threat of a breach of the dune or barrier island. The No-Action Alternative, combined with critical erosion areas and potential road closures along other parts of Hatteras Island, would produce an appreciable, adverse increment to long-term, cumulative, adverse impacts to the socioeconomics of Dare County.

Because the Buxton Action Area is one of the most vulnerable areas of Hatteras Island for barrier breaches, it is considered by the Applicant to be a high priority for beach restoration. The Applicant has no authority to relocate NC 12 and associated infrastructure so its options for reducing the probability of frequent road closures are limited to beach widening. Alternative 2–Winter Construction, like the 2014 Rodanthe nourishment project, would widen the beach and reduce the possibility of emergency road closures due to erosion for several years. Alternative 3–Summer Construction would provide similar benefits for up to 10 years. Other nourishment projects planned or anticipated to occur in Dare County north of Cape Point would add sand to the beach system, increasing the overall sand budget and incrementally reducing the probability of storm damages to NC 12, infrastructure, and development.

Alternatives 2 and 3 would contribute a noticeable, beneficial increment to long-term, cumulative impacts of reduced storm damages on the socioeconomics of Dare County.

VISITOR USE AND EXPERIENCE

Methodology

NPS Management Policies 2006 (NPS 2006) state that enjoyment of park resources and values by the people of the United States are part of the fundamental purpose of all parks and that the National Park Service is committed to providing appropriate, high-quality opportunities for the public to enjoy parks. Past planning documents, park statistics, and input from park staff provide background on visitor use and experience. Anticipated impacts on visitor use and experience were analyzed based on understanding of the construction processes associated with implementation of Alternatives 2 and 3.

Impacts of Alternative 1–No-Action

Under Alternative 1, the current opportunities for visitor use and experience would continue. Vistas along the beach would remain the same, including deteriorated conditions and emergency shore-

protection measures along the portion of the Seashore fronting Buxton Village. When damaging storms occur and NC 12 is blocked or closed for some period of time, visitor use and experience would diminish. This includes extended elimination of vehicle access to park facilities and reduction in the number of visitors.

Present conditions of the deteriorated oceanfront along Buxton Village produce relatively minor impacts to park visitors because the nearest beach accesses are either ~2 miles north of Buxton at the Haulover Day Use Parking Area, or are near the former site of the Cape Hatteras Lighthouse at the south end of the action area. However, temporary loss of road access by way of NC 12 would prevent many visitors from accessing the beach and amenities in the vicinity of Buxton, as well as traveling through Buxton. During road closures in the action area, visitor use and experience would be adversely impacted well beyond the immediate action area. Previous road closures have forced cancellation of reservations at area motels, guest cottages, and restaurants. Based on the likelihood of future periods of storm damage and extended road closures, the No-Action Alternative would have a moderate to major adverse impact on visitor use and experience. The impact would be regional whenever NC 12 is closed due to storm damages.

Impacts of Alternative 2–Winter Construction

Under Alternative 2, beach nourishment would be implemented during winter months when visitor use and experience are lowest. Construction activities along the beach would generally be hidden from view by the existing dune. Visitors on NC 12 would generally not be aware of activities on the beach unless they purposefully elected to use beach accesses near the ends of the project. Because construction would be focused along several hundred feet of beach on a given day and work would progress toward the ends of the project at different times, the duration of construction impacts on visitor use and experience would be relatively short.

Recreational fishing offshore may be adversely impacted during dredging operations over the borrow area and cause such activities to shift to other areas that may not be as productive. In some projects, dredging activities have been shown to increase or attract certain fish species because of nutrients and food sources released into the water column (Burlas et al 2001). The offshore borrow area is relatively large and would be able to accommodate recreational fishermen during dredging operations with some minor modification by users to maintain safe distances.

Upon completion of construction (4 months under Alternative 2), visitor use and experience would be expected to improve by way of a wider beach for recreational use and more natural vistas where shore-protection structures are removed under state regulations following nourishment. Alternative 2 would lessen the chance of road damage and closure or a breach of the barrier within the action area for several years. To the extent Alternative 2 prevents or delays additional damages and road closures, it would provide region-wide benefits to visitor access and use along the seashore.

Based on the foregoing analysis, the short-term impacts occurring during construction would be offset by the long-term (several years) beneficial impacts of the project. Therefore, Alternative 2 would have short-term, minor, adverse impact (local, construction-related) and long-term (several years), regional, beneficial impact on visitor use and experience.

Impacts of Alternative 3 (Preferred Alternative) Summer Construction

Alternative 3 would produce greater beneficial and adverse impacts than Alternative 2. The scale of Alternative 3 would be approximately twice as large as Alternative 2, thus prolonging post-construction

benefits of a wider beach and improved protection, including reduced frequency of road closures to NC 12. However, construction during summer months has more potential to impact visitor use and experience, albeit for a shorter duration (~2–3 months) because of higher visitor use during summer months. Otherwise, impacts of Alternative 3 are similar to Alternative 2.

During construction, a limited section of beach totaling ~800 feet would be cordoned off in the vicinity of the active work area. The beach north and south of the active work area would remain open and accessible. In addition, a narrow corridor would be maintained for public access between the foredune and active work area. The nourished beach would be available for public use within ~24 hours of fill placement as construction progresses.

Like Alternative 2, Alternative 3 would have short-term, minor, adverse impacts on visitor use and experience in the immediate area of construction and long-term (decade), regional, beneficial impacts on visitor use and experience.

Cumulative Impacts on Visitor Use and Experience

Beach nourishment projects completed or planned in Dare County adversely impact visitor use and experience during construction. However, upon completion, visitor use and experience is generally improved via wider beaches, better vistas, and reduced incidence of road closure.

Alternative 1–No-Action would contribute a noticeable to appreciable, adverse increment to appreciable, adverse, cumulative impacts of beach erosion and road closures on visitor use and experience in Dare County. Each closure of NC 12 results in loss of access to businesses and park facilities, cancellation of lodging reservations, and a decline of visitors.

Alternative 2–Winter Construction would contribute a noticeable, adverse increment to adverse, cumulative impact on visitor use and experience associated with nourishment construction. However, upon completion of construction, Alternative 2 would contribute a noticeable, beneficial increment to appreciable, beneficial, cumulative impacts associated with maintenance of road access for visitors. The post-construction impacts would provide noticeable benefits extending well beyond the limits of the action area, relating to conditions during emergency road closures. Impacts during construction would be less than Alternative 3 but add an increment to cumulative impacts associated with nourishment projects planned for Dare County previously referenced. Because Alternative 2 would be constructed in winter, when there are few visitors utilizing the Proposed Action Area, impacts on visitor use and experience would be imperceptible.

Alternative 3–Summer Construction would potentially occur at the same time as three other projects scheduled for completion along Dare County Beaches. The other three sites would be north of Oregon Inlet at least 50 miles north of the Buxton Action Area. Other Seashore beaches would remain open and available to the public. Within the action area, the maximum length of shoreline that would contain the active construction area or a length of pipeline along a completed section of beach would be ~4,000 feet. The remainder of the action area would be unobstructed by equipment or pipeline. Visitor use and experience following completion of Alterative 3 would be noticeably improved via wider beaches in Dare County for up to 10 years.

Alternative 3 would contribute a noticeable, adverse increment to adverse cumulative impacts on visitor use and experience associated with nourishment construction. However, upon completion of construction, Alternative 3 would contribute a noticeable, beneficial increment to appreciable, beneficial, cumulative impacts associated with maintenance of road access for visitors.

PUBLIC SAFETY

Methodology

Public safety was considered in the context of work conditions in the Proposed Action Area as well as safety to visitors and residents. NPS Management Policies states that the National Park Service would seek to provide a safe and healthful environment for visitors and employees (NPS 2006). This impact analysis identifies potential impacts to safety associated with each Alternative.

Impacts of Alternative 1–No-Action

Under Alternative 1, current public safety conditions within the Proposed Action Area would continue. In the context of the project, potential impacts to public safety would arise in response to appreciable shoreline erosion during coastal storm events, or unpredictable dune breaches unrelated to a discrete storm event, but still caused by continued erosion that was sustained at some previous time. Such events could cause partial or complete road closures and emergency repairs of NC 12. This may require temporary lane closures. Such closures may present enhanced risks for vehicular accidents via interaction with construction equipment and the presence of workers on or near the highway. Road closures would make it difficult to evacuate the critically ill to hospitals in Nags Head or elsewhere.

A catastrophic breach of the barrier island or loss of the road surface during a major storm also would present a potentially dangerous situation for users. Should passenger vehicles be traveling through the affected area at the time of such a failure, they may not have sufficient time to react to the changing conditions or damaged areas and, as a result, could suffer personal property damage and/or personal injury. As the section of NC 12 within the project area is unlit, reaction time may be further diminished. The frequency and occurrence of conditions which produce road closures is unknown. However, continued erosion at up to 10 feet per year along the action area increases the likelihood of storm impacts to the road and a potential breach of the barrier. This would reduce the level of safety to the public over time. Road closures prevent emergency responders from reaching residents and visitors who may have life threatening health issues and transporting them to hospitals in Nags Head or elsewhere.

Based on the foregoing analysis, Alternative 1 would have a long-term, moderate, adverse impact on public safety. This impact would be a result of the risks posed by ongoing or event-driven erosion, the emergency repairs conducted after erosion impacts infrastructure, and the restrictions on emergency access associated with road closures. The impacts would be regional and extend well beyond the boundaries of the action area.

Impacts of Alternative 2–Winter Construction

Under Alternative 2, beach nourishment would help absorb damaging storm waves and reduce the risk of erosion and closure of NC 12. Impacts on public safety would be accordingly improved under Alternative 2, as damages and extended closure of NC 12 would be diminished for several years. However, direct, site-specific, short- term impacts would occur during project construction. These would include the presence and activities of construction equipment on the beach and transport of heavy equipment via NC 12 to the project site. The potential for conflicts between construction equipment and recreational traffic may arise during mobilization and demobilization.

During construction, the area of impact would generally be away from NC 12 and would be cordoned off from beachgoers. Equipment staging would be in designated areas approved by Park Service officials and would be isolated from the public. Because much of the construction equipment required for beach

nourishment would access the action area from the water, there would be limited opportunity for visitor interaction. The construction site also would be cordoned off, and safety personnel would be stationed at either end of the active work area to alert the public to the restricted areas.

Safety to construction workers is a major consideration by the Applicant in its determination of the Preferred Alternative. Winter dredging operations in the action area pose unacceptable risks to dredging personnel operating offshore (Dredging Association of America, B. Holliday, Executive Director, pers. comm., March 2008). Average sea state in winter is > 6 feet beyond the normal operating conditions for ocean certified dredges. Storms occur at frequencies of 1 per 6 days forcing frequent evacuation of equipment and personnel to the nearest safe harbor over 110 miles away in the area of Norfolk, Virginia. Personnel remain at risk if they are delayed in vacating the action area. High winds and waves, common off Buxton, combined with low temperatures in winter, produce hazardous conditions onboard dredges. After each load of a hopper dredge, the vessel must hook up to the submerged pipe before it can pump sand to the beach. This operation cannot be performed when seas exceed ~5 feet (Great Lakes Ocean Dredging, B. Hanson, Vice President, pers. comm., March 2011). In some cases, loaded hopper dredges have had to pump their material over the side into unauthorized areas because they could not hook up to the submerged pipeline before moving to a safe harbor.

Based on the foregoing analysis, adverse impacts to public safety arising from Alternative 2 would be direct, local, short-term, and minor (construction-related). Impacts to construction personnel safety associated with Alternative 2 would be major and potentially involve bodily injury or death. Over the long-term (years), impacts of the proposed action would be beneficial (post-construction) in the form of reduced chances of road closures for several years.

Impacts of Alternative 3 (Preferred Alternative) Summer Construction

The impacts to public safety arising from the implementation of Alternative 3 (Preferred Alternative) would be similar as those discussed for Alternative 2, but would have longer lasting beneficial impacts because of the larger scale of the project. Protection of NC 12 would potentially be approximately one decade under Alternative 3. Like Alternative 2, adverse impacts to the public associated with construction would be localized and short-term, and offset by the beneficial impacts of the project. Safety to construction workers would be much greater under Alternative 3 because work would be performed during low wave months in summer when temperatures are more conducive for efficient work. Dredge production efficiency as well as worker efficiency during summer months is expected to be much better under Alternative 3 and lead to shorter duration of impacts on the beach.

Alternative 3 would have direct, local, short-term, minor, adverse impacts on public safety during construction. These impacts would be minimal, provided that appropriate access restrictions are carried out where visitors would otherwise be in close proximity to heavy equipment. Alternative 3 would have minor short-term adverse impacts on worker safety common to heavy marine construction. Following completion of construction, Alternative 3 would provide indirect, regional, long-term benefits to public safety by lessening the chance of a breach inlet or road closure in the Buxton Action Area.

Cumulative Impacts on Public Safety

A primary concern expressed by the Applicant is public safety. Each closure of NC 12 due to erosion and storm breaches reduces public safety. Breaches along Hatteras Island occurred in 2003 during Hurricane *Isabel* (Hatteras Village) and in 2011 during *Irene* (Pea Island and Mirlo Beach-Rodanthe). The 2014 nourishment at Rodanthe was implemented to protect NC 12 and help maintain access along Hatteras Island. When any part of the highway is closed, residents, workers, and visitors have no direct

access to supplies, emergency services or basic utilities in some cases. The Applicant has proposed nourishment as a way of safeguarding access along Hatteras Island. Other nourishment projects in planning or implemented since 2010 along Dare County beaches have been considered in response to public safety needs and maintenance of road access (e.g. Rodanthe, Kitty Hawk, and south Nags Head). Each of these projects is planning for summer construction due to worker safety considerations. Nags Head (2011) and Rodanthe (2014) were constructed during summer months. Projects at Duck, Kitty Hawk, and Kill Devil Hills are similarly being planned for summer construction (anticipated 2016).

Alternative 1–No-Action would not improve public safety because continued erosion would increase the chance of a breach and closure of NC 12 in the critically eroding action area. Alternative 1 would contribute a noticeable, adverse increment to long-term, appreciable, adverse cumulative impacts on Public Safety.

Alternative 2–Winter Construction would improve public safety for several years by lessening the chance of a breach and road closure of NC 12. The impact would be noticeable and extend well beyond the action area. Alternative 2 would produce appreciable risks to worker safety due to winter construction. Because of high wave conditions, frequency of storms and low temperatures during winter months of construction, dredging personnel offshore would be at high risk for injury or death with frequent work stoppages required while the dredge is moved to a safe harbor. Contractor safety and liability is a paramount concern in the selection of Alternative 3 as the Preferred Alternative. Alternative 2 would contribute a noticeable, adverse increment to short-term, appreciable, cumulative impacts during construction with respect to worker safety on ocean dredges. Alternative 2 would contribute a noticeable beneficial increment to long-term (years), appreciable, cumulative impacts on public safety, with respect to protection of NC 12.

Alternative 3–Summer Construction would improve public safety for up to 10 years by lessening the chance of a breach or road closure. The impact would be noticeable and extend well beyond the action area. Alternative 3 would produce fewer risks to worker safety associated with all offshore dredging work. During summer months, warmer temperatures pose fewer hazards to dredge personnel, and wave heights would generally be within normal operational limits during construction. Alternative 3 would contribute a noticeable, beneficial increment to long-term (decade) appreciable, cumulative impacts on public safety, with respect to protection of NC 12.

SUSTAINABILITY AND LONG-TERM MANAGEMENT

Methodology

Beach nourishment has been used to maintain beaches since the 1920s (CERC 1984). Its sustainability and applicability for long-term management is dependent on numerous factors, including the cost, longevity and value of the property at risk in relation to the cost and impacts of other alternatives. In general, the longevity of nourishment depends on the underlying, or background, erosion rate, and the project's scale. Longevity tends to increase geometrically with project length (NRC 1995).

The Buxton Action Area has been nourished previously in the 1960s and 1970s using sand sources from upland areas or Pamlico Sound. No projects have been performed since 1973 or have used an offshore borrow area. Further, no quantitative surveys of sand losses have been conducted to document accurately the performance of prior projects or track the annual erosion losses in the action area. As a result, uncertainty exists regarding how well the proposed action would perform, whether nourishment would be sustainable at costs commensurate with the benefits, and whether nourishment is an appropriate long-term (decades) management approach to erosion and protection of NC 12 infrastructure

and development. The Proposed Action would be a one-time event under the terms and conditions of the permits. Each nourishment event produces a short-term disruption of the natural system with associated biological impacts. Literature on beach nourishment suggests that frequent events (every few years) are likely to be more impactful than infrequent events (every decade or so). Greater longevity of individual projects is likely to make them more sustainable and apportion capital costs over more years.

Sustainability was evaluated based on the projected longevity, projected future sand losses, and projected annualized costs of each alternative.

Impacts of Alternative 1–No-Action

Erosion along certain sections of Hatteras Island, including the Proposed Action Area, has caused dune breaches and formation of new inlets, as well as damages to NC 12 and costly closures to the highway. Each closure produces adverse impacts to the economy of Dare County and disrupts Park operations and visitor enjoyment. Such impacts would continue under Alternative 1 and potentially worsen as erosion progresses in the Buxton area, leaving less sand in the littoral system seaward of NC 12, although washovers would build up back-barrier areas, an important process over the long term. Continued erosion, undermining of NC 12, extended road closures, and frequent emergency repairs are not deemed sustainable relative to the economy at risk.

Alternative 1–No-Action would continue the management approach of the past several decades in the Buxton area and produce a moderate, long-term, adverse impact. This alternative is not considered sustainable without major consequences to the economy and welfare of existing communities, jobs, and tourism on Hatteras Island. The potential impacts are not quantifiable and would depend on the frequency and magnitude of damaging storms. Breaches of the foredune and washovers onto NC 12 are generally short-term events of minor consequence until sand can be cleared and the highways reopened. However, a breach inlet in the action area would result in extended road closure and disruption to the economy for weeks or months. Alternative transportation arrangements would be required while repairs are made or a temporary bridge is installed. The March 1962 breach inlet was initially bridged but the emergency bridge washed out in late 1962. The breach inlet was closed by dredge in early 1963 after ~10 months of disruption to the local economy. Costs associated with a breach of the barrier island include the cost of repairs, increased costs of supplies, and the loss of tourism business among other factors.

Alternative 1–No-Action would have a long-term, moderate, adverse impact on sustainability and long-term management of the action area. The impacts would likely extend to the broader region of Hatteras Island and lead to more demands on limited financial resources of the County.

Impacts of Alternative 2–Winter Construction

Maintenance of NC 12 along certain erosion hotspots of Hatteras Island, including the Buxton Action Area, has been costly and the subject of considerable debate for decades (NCDOT 2008). The North Carolina Department of Transportation (NCDOT 2015 in prep) is evaluating the feasibility of short-term (5-years) and long-term (~50 years) alternatives for NC 12 in the Buxton area. Alternative 2 would offer a quantitative measure of performance and provide site-specific cost and performance data which are not available for the area at this time. Cost and performance data would help to establish whether nourishment using an offshore, borrow area is sustainable and cost-effective relative to other NCDOT alternatives for NC 12. The Applicant has no authority over NC 12 and cannot implement alternative transportation strategies. However, the Applicant bears certain costs or reduction in tax revenues associated with unplanned road closures.

The Applicant has proposed nourishment to mitigate erosion with negligible, long-term, adverse impacts on adjacent shorelines. Nourishment may be sustainable relative to the potential costs of future road closures and potential damages to the Dare County economy although the benefit is not quantifiable. Alternative 2 would provide several years of erosion relief and limited sustained benefits. The time frame over which Alternative 2 is projected to last is well below the planning scenarios for sea level rise (SLR). Local erosion processes rather than SLR are expected to control shoreline change for the foreseeable future in the Buxton Action Area.

Alternative 2 would have a long-term (years), beneficial impact on sustainability and long-term management of infrastructure and development in the action area by adding to the littoral sediment budget for the area. The Proposed Action is expected to mitigate erosion and to widen the beach for a period of several years before the beach returns to a deficit volume condition in the action area. Sand losses from the action area over time would contribute to sustainability of Cape Point beaches.

Impacts of Alternative 3 (Preferred Alternative) Summer Construction

The impact of Alternative 3 on sustainability and long-term management would be greater than Alternative 2, because of the larger scale of the project. Nourishment longevity would be upwards of 10 years in the action area, thus reducing average annual project costs by ~50%. Protection of NC 12 would be sustained longer at lower cost with negligible long-term adverse impacts. As sand erodes from the action area, it would migrate alongshore to other parts of the Seashore, providing indirect benefits for an extended period of time. Less frequent nourishment would provide more time for biological resources to return to normal or recover from short-term impacts of construction. Alternative 3 would facilitate long-term management of the action area if coastal resources are spared disruptions caused by chronic erosion, storm damages, dune losses, or barrier island breaches. Alternative 3 would have a long-term (decade), beneficial impact on sustainability and long-term management of development and infrastructure in the action area by adding to the littoral sediment budget for the area. The Proposed Action is expected to mitigate erosion and widen the beach for a period of about 10 years before the beach returns to a deficit volume condition in the action area. The beneficial impacts would extend to other parts of the Seashore and Dare County and reduce the need for emergency shore protection such as sand bags.

Cumulative Impacts on Sustainability and Long-Term Management

Other than dredge disposal projects from Oregon Inlet to a 2-mile length of Pea Island and some small-scale truck hauling projects in Dare County, there were no large scale nourishment events between 1973 and 2011. As a result there is relatively little recent experience with nourishment to develop cost information. Sustainability of completed and planned projects in Dare County would depend on: the underlying erosion rate and loss rate of the nourishment; the proximity of quality borrow areas to the beach segment considered for restoration; and the quality of the borrow material.

The 2011 Nags Head project involved ~4.6 million cubic yards at a cost of ~$32 million. The 2014 Rodanthe Project involved ~1.7 million cubic yards at a cost of ~$21 million. Unit costs of these projects were ~$6.70 per cubic yard and ~$12.30 per cubic yard (respectively). The Buxton Project has a projected cost of~$9.75 per cubic yard. This range of costs reflects various economies of scale and dredging distances which vary by project. The Buxton Project is projected to provide benefits for up to 10 years along an ~15,500 foot length of shoreline. Thus, on a unit basis, the average cost would equate to (~)$1,635 per foot or (~)$163 per foot per year for 10 years. Nags Head was a 10-mile-long project with lower unit costs equaling ~$610 per foot. If that project lasts 10 years as planned, the average

annual cost would ~$61 per foot per year. The higher unit cost estimated for Buxton reflects higher sand loss rates than Nags Head.

Previous dune breaches along Hatteras Island have been costly to the economy of Dare County. The Applicant estimates that each day NC 12 is closed has an economic impact in the range of $0.5-1 million. The amount varies with the season which is driven by tourism. Nevertheless a two month closure such as the period associated with the breach inlets near Rodanthe would be comparable to the cost of the 2014 Rodanthe project or the proposed action. For this reason, the Applicant has proposed Alternative 3 as a means of mitigating emergency expenditures to maintain access along Hatteras Island. It is part of a strategy by the Applicant to preemptively prevent damages to infrastructure along Dare County beaches.

Alternative 1–No-Action would not achieve the goals and objectives of the applicant and is not considered sustainable or consistent with the long-term management goals of maintaining access along Hatteras Island. It would contribute a noticeable increment to appreciable, adverse cumulative impacts on sustainability and long-term management along the critically eroding parts of Hatteras Island.

Alternative 2–Winter Construction would provide about half the nourishment volume at the same fixed budget of the Applicant. It therefore would provide a noticeable beneficial increment to long-term, adverse cumulative inputs of erosion on sustainability and long-term management of Dare County beaches. The unit cost per year would be more than twice Alternative 3 and thereby be less sustainable.

Alternative 3–Summer Construction would provide noticeable benefits for up to 10 years. As the first nourishment in the action area in over 40 years, it would provide more project experience which, when combined with other Dare County projects, would offer realistic measures of the cost of nourishment. Alternative 3 would therefore provide a noticeable, beneficial increment to long-term, adverse, cumulative impacts of erosion on sustainability and long-term management of Dare County beaches.

CHAPTER 5 – CONSULTATION AND COORDINATION

Federal regulations require the US Army Corps of Engineers (USACE) and the National Park Service (NPS) to involve the interested and affected public in a review and comment process under the National Environmental Policy Act of 1969 (NEPA). For the present Environmental Assessment, this was accomplished through several means as outlined below. A number of federal and state agencies were also consulted and solicited for input into the scoping and alternatives development process. This chapter documents the scoping process for the Proposed Action, identifies future compliance needs and permits, and includes a list of preparers for the document.

INTERNAL SCOPING

Because most of the Proposed Action would occur along oceanfront beach that is under the jurisdiction of the National Park Service, the Applicant (Dare County) met with NPS officials prior to developing plans for the Proposed Action. Meetings to discuss the general need and rationale for the Proposed Action were convened from December 2013 to July 2014 between the Applicant and NPS local, regional, and national offices. During this preliminary scoping period, the Applicant also met with representatives of the US Army Corps of Engineers, the US Fish and Wildlife Service (USFWS), the North Carolina Department of Environment and Natural Resources (NCDENR), North Carolina Wildlife Resources Commission (NCWRC), and the North Carolina Department of Transportation (NCDOT) to inform those agencies of a County plan for funding restoration of Dare County beaches along critically eroding areas. Emergency beach restoration work by NCDOT and US Army Corps of Engineers along the S-curve at Rodanthe informed the Applicant's decision to pursue a project along the critically eroding Buxton Action Area.

During 2014, the Applicant notified the public in regular Dare County Commission meetings of its regional, long-range strategy for funding and implementing beach restoration projects along critically eroding areas of the county. On 18 August 2014, the Dare County Board of Commissioners voted to proceed with planning and permitting of a beach restoration project at Buxton, authorizing the firms of Coastal Science & Engineering and CZR Incorporated to prepare the necessary documents under NEPA in support of a permit application. On 19 August 2014, Dare County convened the first agency consultation meeting involving NPS and NCDOT officials. A public forum was held that same night in Buxton to outline the Applicant's plan for beach restoration before the local community. The Applicant discussed a timetable, emphasizing the requirements for environmental review and comment by the National Park Service and other federal and state regulatory and resource agencies before any action could be taken.

AGENCY CONSULTATION

During fall 2014, meetings were convened at Dare County offices between the Applicant and the National Park Service (10 September, 9 October, 30 October, 13 November, and 4 December). These meetings were preparatory to formal scoping and public notices through the NPS Planning, Environment, and Public Comment (PEPC) website. NPS resource staff provided guidance to the Applicant on environmental protection measures that would be required if any action was conducted along NPS beaches. The Applicant submitted an application for a special use permit to the National Park Service on 5 November 2014.

In accordance with Section 102(2)(c) of the National Environmental Policy Act of 1969 (NEPA), the National Park Service published a notice in the federal register on 29 December 2014 informing the

public of its intent to prepare an Environmental Impact Statement (EIS) for beach nourishment proposed by Dare County along Seashore property in the Buxton, North Carolina, area. Comments were solicited from the public regarding the Proposed Action, and the PEPC website was activated to receive comments. The National Park Service also solicited and received comments by regular mail, e-mail, and hand delivery through 27 February 2015.

PRE-APPLICATION MEETINGS AND PREPARATION OF SUPPORTING DOCUMENTS

Three pre-application meetings were convened in Washington, North Carolina (22 October 2014, 8 January 2015, and 29 July 2015) with federal and state regulatory and resource agencies to outline the Applicant's proposed activity. Attendees included the National Park Service, US Army Corps of Engineers, US Fish and Wildlife Service (USFWS), and NC Department of Environment and Natural Resources. Other attendees included representatives from National Oceanic and Atmospheric Administration-National Marine Fisheries Service (NOAA-NMFS), North Carolina Department of Environment and Natural Resources' Division of Coastal Management (NCDCM), Division of Marine Fisheries (NCDMF), and the Wildlife and Resources Commission (NCWRC).

The Applicant prepared supporting technical documents in fall 2014 and winter 2015, including littoral processes, biological assessment, geotechnical data, essential fish habitat assessment, biological monitoring, cultural resources, and monitoring and mitigation measures. Each report was submitted in draft form for review by the National Park Service and the US Fish and Wildlife Service preliminary to placing the project on public notice under a permit application to US Army Corps of Engineers (September 2015).

Comments on the NPS special-use permit application were received on 27 February 2015 and were used by the Applicant to finalize the project purpose and need and to identify alternatives retained for detailed analysis in the environmental documents. The National Park Service received a total of 261 comments through the PEPC website, regular mail, e-mail, and hand delivery. The comments were summarized in Chapter 1 – *Purpose and Need for Action* of this document.

The US Army Corps of Engineers and the National Park Service reviewed draft documents describing the project and determined that an Environmental Assessment (EA) rather than an Environmental Impact Statement (EIS) would be required and that USACE would serve as the lead federal permitting agency. Accordingly, the National Park Service notified the public via the Federal Register on 17 June 2015 of the intent to terminate preparation of an EIS and instead prepare an EA for the project. The purpose of the EA remained the same, to assist the NPS in determining whether, where, and under what conditions the NPS would issue a Special Use Permit to Dare County for actions related to the protection of Highway 12 in the Buxton village area (CFR Vol. 80 (116) pp. 34691-34692).

Between January and August 2015, the Buxton project team convened regular weekly and biweekly meetings via conference call to review progress on document preparation. During the development of the environmental documents, an interdisciplinary team of technical experts within the National Park Service and US Army Corps of Engineers provided review and comments as well as guidance regarding protection of park resources.

OTHER CONSULTATION

During the preparation of the EA and supporting appendices, many agencies were contacted for information as documented in each report. These included North Carolina Department of Transportation, North Carolina Department of Environment and Natural Resources' Division of

Coastal Management, Division of Marine Fisheries, Water Resources Commission, and the Natural Heritage Program (NCNHP), NC State Historic Preservation Office (SHPO), National Oceanic and Atmospheric Administration-National Marine Fisheries Service, and USACE-Wilmington (Planning Section). There are no ethnographic or Indian Trust resources in the Action Area, so no tribal consultations were required.

SECTION 7 OF THE ENDANGERED SPECIES ACT

The Applicant's Preferred Alternative–Summer Construction would impact threatened or endangered species. Accordingly, the Applicant prepared a Biological Assessment (BA) in connection with the Proposed Action (Appendix B) and anticipates a request by US Army Corps of Engineers to US Fish and Wildlife (USFWS) and National Marine Fisheries Service (NMFS) for formal Section 7 consultation when the US Army Corps of Engineers' permit application is placed on public notice. Officials at USFWS and NMFS have been involved in pre-application meetings and have had opportunities to input prior to completion of the BA and EA.

MARINE MAMMAL PROTECTION ACT AND MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT

As a condition of any federal permits for the proposed project, the Applicant through the US Army Corps of Engineers must consult with the National Marine Fisheries Service under the Marine Mammal Protection Act and the Magnuson-Stevens Fishery Conservation and Management Act.

NATIONAL HISTORIC PRESERVATION ACT (NHPA)

As a condition of any federal and state permits for the proposed project, the Applicant through the US Army Corps of Engineers must consult with the North Carolina State Historic Preservation Office (SHPO) regarding potential cultural resources that may be present or impacted in the general vicinity of the project under Section 106 of the NHPA.

REQUIRED PERMITS AND APPROVALS

Clean Water Act Section 404

The Proposed Action impacts waters of the United States as defined by the Clean Water Act and is therefore subject to review by the US Army Corps of Engineers. The Clean Water Act Section 404 regulates the discharge of dredged or fill material into waters of the United States, and under Section 404, impacts to wetlands or aquatic habitats may be considered in compliance if the project is water dependent.

Rivers and Harbors Act Section 10

Section 10 of the Rivers and Harbors Act is administered by the US Army Corps of Engineers and regulates construction, filling, dredging, or excavation in navigable waters of the United States. The US Army Corps of Engineers would have to issue a major permit for the proposed action.

Clean Water Act Section 401 Certification

North Carolina Department of Environment and Natural Resources' Division of Water Resources (NCDWR) administers the Clean Water Act Section 401 Certification. The NCDWR must review the

proposed action and issue a 401 Certification prior to state or federal permits for construction involving dredge and fill in navigable waters of the US.

North Carolina Coastal Area Management Act (CAMA)

The North Carolina Department of Environment and Natural Resources' Division of Coastal Management (NCDCM) administers the North Carolina Coastal Area Management Act (CAMA) and must review the proposed action prior to issuance of a Major CAMA permit. NCDCM requires a permit application and supporting documents under NEPA in parallel with a federal permit application. NCDENR is the overall coordinating state agency responsible for soliciting review and comment on the proposed action from relevant state resource agencies or divisions of NCDENR, including the Division of Coastal Management (NCDCM), Division of Marine Fisheries (NCDMF), Division of Water Resources (NCDWR), and Wildlife Resources Commission (NCWRC). Other corresponding agencies are North Carolina Department of Transportation and the North Carolina Office of State Archaeology.

US Coast Guard

If any actions are approved and permitted which involve dredging in navigable waters of the United States, the Applicant or contractor will be required to contact the US Coast Guard so that a Notice to Mariners is published prior to mobilization of equipment or any operations. The Notice to Mariners would identify the equipment and potential obstructions that may be in the action area and the dates of the action.

FUTURE PUBLIC INVOLVEMENT

This document will be available for review and comment for 30 days. The Environmental Assessment and all appendices are available on the project website throught he NPS Planning, Environment and Public Comment system at http://parkplanning.nps.gov/BeachRestorationPermits. If you wish to comment on the Environmental Assessment, you may mail comments to:

Beach Restoration to Protect NC 12 Permits EA
US Army Corps of Engineers–Wilmington District
Washington Regulatory Field Office
2407 West Fifth Street
Washington, NC 27889
Attn: Raleigh W Bland, PWS

In addition, public forum(s) on the project will be convened prior to issuance of permits with press releases and notices published in local papers prior to each event. A public forum is scheduled for 29 September 2016 at the Fessenden Center, Buxton, North Carolina. Contact the National Park Service for times and dates of other forums (252-473-2111) or visit the above link to the project website.

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PUBLICATIONS

REFERENCES CITED

ASCE
1994. Coastal Groins and Nearshore Breakwaters. Technical Engineering and Design Guides as Adapted from the US Army Corps of Engineers, No 6, American Society of Civil Engineers, New York, NY, 87 pp.

Adriaanse, LA, and J Coosen
1991. Beach and dune nourishment and environmental aspects. Journal of Coastal Engineering, Vol 16, pp 129-146.

Bagnold, RA
1941. *The Physics of Blown Sand and Desert Dunes.* Chapman and Hall, London, UK, 265 pp.

Barth, MC, and JG Titus (eds)
1984. *Greenhouse Effect and Sea Level Rise: A Challenge for this Generation.* Van Nostrand Reinhold, New York, NY, 325 pp.

Bascom, WN
1954. Characteristics of natural beaches. In Proceedings 4th Conference on Coastal Engineering, ASCE, New York, NY, pp 163-180.

Birkemeier, WA
1985. Field data on seaward limit of profile change. Journal Waterway Port, Coastal and Ocean Engineering, Vol III(3), pp 598-602.

Booher, M, and L Ezell
2001. *Out of Harm's Way: Moving America's Lighthouse.* Eastwind Publishing Company, Annapolis, MD, 144 pp.

Bruun, P
1962. Sea-level rise as a cause of shore erosion. Journal Waterways and Harbor Division, ASCE, New York, NY, Vol 88(WW1), pp 117-132.

Bruun, P, and F Gerritsen
1959. Natural bypassing of sand at coastal inlets. Journal Waterways and Harbor Division, ASCE, New York, NY, Vol 85(WW4), pp 75-107.

Burlas, M, GL Ray, and DG Clarke
2001. The New York district's biological monitoring program for the Atlantic coast of New Jersey, Asbury Park to Manasquan Section beach erosion control project. Final Report. US Army Engineer District, New York, and US Army Engineer Research and Development Center, Waterways Experiment Station, Vicksburg, MS.

Byrnes, MR, RM Hammer, BA Vittor, SW Kelley, DB Snyder, JM Côté, JS Ramsey, TD Thibaut, NW Phillips, JD Wood, and JD Germano
2003. Collection of Environmental Data within Sand Resource Areas Offshore North Carolina and the Environmental Implications of Sand Removal for Coastal and Beach Restoration. Herndon, VA: US Dept Interior, MMS, Leasing Div, Sand and Gravel Unit; OCS Rept MMS 2000-056: I (main text) 256 pp; OCS Rept MMS 2000-056: II (appendices) 69 pp.

CERC
1984. *Shore Protection Manual.* 4th Edition, US Army Corps of Engineers, Coastal Engineering Research Center, Ft Belvoir, VA, US Government Printing Office, Washington, DC, 2 vols.

Church, JA, NJ White, CM Domingues, DP Mouselesan, and ER Miles
2013. Sea level and ocean heat content change. Journal of International Geophysics, Vol 103, Chapter 27, pp 697-725.

CHWA (Cape Hatteras Water Association)
1977. Environmental assessment: Buxton to Avon waterline: Cape Hatteras National Seashore, Dare County, North Carolina. EA by Cape Hatteras Water Association, Manuscript, 77 pp (accessed via NC Sea Grant Library, August 2013).

CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora)
2013. Sixteenth meeting of Congress of the Parties, Considerations of Proposals for Amendment of Appendices I and II. CoP16 Prop. XXX Bangkok (Thailand), March 3-14.

Cowardin, LM, V Carter, FC Golet, and ET LaRoe
1979. Classification of wetlands and deep water habitats of the United States. US Fish and Wildlife Service. FWS/OBS-79/31, Washington, DC, 85 pp.

CPE (Coastal Planning & Engineering)
2014. Draft environmental assessment. Town of Duck shoreline protection project. Wilmington, NC: Prepared for Town of Duck, NC. CPE., Wilmington, NC, November: 157 pp.
2015. Draft environmental assessment: Town of Kill Devil Hills shore protection project. Prepared for Town of Kill Devil Hills, North Carolina. CPE, Wilmington, NC, January: 158 pp.

CSE (Coastal Science & Engineering Inc)
2005a. Post-*Isabel* dune restoration project at Nags Head. Final Report for Town of Nags Head, NC. CSE, Columbia, SC, 12 pp + figures + 2 appendices.
2005b. Analysis of potential downdrift impacts – Hunting Island beach restoration project. Final Report for SCPRT, Columbia, SC. CSE, Columbia, SC, 82 pp + appendices.
2011. Coastal engineering & geotechnical analyses for beach nourishment, Nags Head, NC. Final Design Report for Town of Nags Head, NC. CSE, Columbia, SC, 163 pp.
2012. 2011 Nags Head beach nourishment project. Final Report for Town of Nags Head, NC. CSE, Columbia, SC, 167pp.
2013a (February). Monitoring and analyses of the 2011 Nags Head beach nourishment project. Year 1 (2012) beach monitoring report for Town of Nags Head, NC. CSE, Columbia (SC), 93 pp + appendices.
2013b (November). Shoreline erosion assessment and plan for beach restoration, Rodanthe and Buxton areas, Dare County, North Carolina. Feasibility Report for Dare County Board of Commissioners, Manteo, NC. CSE, Columbia (SC), 159 pp.
2014. Monitoring and Analysis of the 2011 Nags Head beach nourishment project: 2014 beach monitoring report. Prepared for the Town of Nags Head, Dare County, NC. CSE, Columbia (SC), 114 pp.
2014. 2013–2014 Sagaponack and Bridgehampton Beach Erosion Control Districts nourishment project, Southampton, Long Island, Suffolk County, NY. Final Report for Town of Southhampton, NY. CSE, Columbia (SC), 79 pp.

CRA (Coastal Research Associates)
1974. 1973 Buxton Beach Nourishment Project: An Annotated Photographic Atlas. Prepared for the Cape Hatteras National Seashore by Coastal Research Associates, Charlottesville, VA, February 1974, 44 pp.

Curray, JR
1964. Transgressions and regressions. In RL Miller (ed), Papers in Marine Geology (Shepard Commemorative Volume), MacMillan, NY, pp 175-203.

CZR/CSE (CZR Incorporated / Coastal Science & Engineering)
2014. Nags Head beach 2011 nourishment project. Post-Year 2 and Final Reports for Town of Nags Head, North Carolina. CZR (Wilmington NC) and CSE (Columbia SC), 65 pp plus appendices.

Dallas, K, J Eshleman, and R Beavers
2012. National Park Service beach nourishment guidance. Natural Resource Technical Report NPS/NRSS/GRD/NRTR-2012/581. National Park Service, Fort Collins, Colorado. September 2012.

Dallas, K, M Berry, and P Ruggiero
2013. Inventory of coastal engineering projects in Cape Hatteras National Seashore. Natural Resources Technical Report NPS/NRSS/GRD/NRTR-- 2013/713. National Park Service, Fort Collins, CO, 54 pp.

Davidson-Arnott, RGD and MN Law
1990. Seasonal patterns and control on sediment supply to coastal foredunes, Long Point, Lake Erie. In KF Nordstrom, NP Psuty, and RWG Carter (eds), *Coastal Dunes: Form and Process.* John Wiley & Sons, Chichester, UK, pp 177-200.

Dean, Robert G
2002. *Beach Nourishment: Theory and Practice*. World Scientific, New Jersey, 399 pp.

Dean, RG, and RA Dalrymple
2002. *Coastal Processes with Engineering Applications.* Cambridge University Press, Cambridge, UK, 475 pp.

Deaton, AS, WS Chappell, K Hart, J O'Neal, and B Boutin
2010. North Carolina coastal habitat protection plan. NCDENR, Division of Marine Fisheries, Morehead City, NC, 589 pp plus appendices.

Dickerson, D, C Theriot, M Wolters, C Slay, and T Bargo
2007. Effectiveness of relocation trawling during hopper dredging for reducing incidental take of sea turtles. In Proc. of the World Dredging Congress XVIII, Central Dredging Assoc. Lake Buena Vista, FL, 22 pp.

Dolan, RS
1972. Man's impact on the Outer Banks of North Carolina. Dune Stabilization Study, Report No 3, National Park Service, Department of the Interior, Washington, DC, 16 pp.

Dolan, R, and H Lins
1986. The Outer Banks of North Carolina. Reston, VA: Professional Paper 1177-B, Prepared in cooperation with the National Park Service, US Geological Survey. (1986): 49.

Dolan, R, PJ Godfrey, and WE Odum
1973. Man's impact on the barrier islands of North Carolina. American Scientist, Vol 61, pp 152-162.

Dolan, R., S Trossbach, and M Buckley
1990. New Shoreline Erosion Data for the Mid-Atlantic Coast. Journal of Coastal Research, Vol 6(2), pp 471-478.

Dolan, R, B Hayden, P Riddle, and J Ponton
1974. Buxton beach nourishment project. Annotated Photographic Atlas, NPS Contract CX50031059, Coastal Research Associates, Charlottesville, VA.

Douglass, SL
1997. Nearshore placement of sand. In Proc. 25th ICCE, ASCE 3 (286), New York, NY, pp 3708-3721.

Everts, CH
1985. Yearly maintenance requirements for fill material at Sandbridge, Virginia. Attachment 1 of Final Phase I General Design Memo for Beach Erosion Control and Hurricane Protection at Sandbridge Beach, Virginia Beach, USACE, Norfolk, VA, 15 pp + attachment + appendix.

Everts, CH, JP Battley, and PN Gibson
1983. Shoreline movements: Report 1: Cape Henry, Virginia, to Cape Hatteras, North Carolina, 1849–1980. Technical Report CERC-83-1, Coastal Engineering Research Center, US Army Engineer Waterways Experiment Station, Vicksburg, MS, 111 pp.

Fischetti, DC, OH Pilkey Jr, DM Bush, and BD Wilson
1987. *Move or Lose it! The case for Relocation of Cape Hatteras Lighthouse.* Prepared by Move the Lighthouse Committee, Cary NC, 87 pp.

Fisher, JJ
1962. Geomorphic expression of former inlets along the Outer Banks of North Carolina. MS Thesis, University of North Carolina.
1967. Development pattern of relict beach ridges, Outer Banks Barrier Chain, NC. PhD Dissertation, University of North Carolina.

Fisher, JS, W Felder, L Gulbrandsen, and J Ponton
1975. Cape Hatteras nourishment study post-pumping report: March 1974–February 1975. Department of Environmental Sciences, University of Virginia, Charlottesville, VA, 95 pp.

Folk, RL and WC Ward
1957. Brazos River bar: a study in significance of grain-size parameters. Journal of Sedimentary Petrology, Vol 27, pp 3-26.

Fussell, III, JO
1994. *A Birder's Guide to Coastal North Carolina*. University of North Carolina Press, 540 pp.

Galvin, Jr, CJ
1971. Inlets and wave direction: wave climate and coastal processes. In AT Ippen (ed), Proceedings of the Symposium on Water, Environment, and Human Needs (Massachusetts Institute of Technology, Cambridge), pp 44-78.

Gannon, M
1990. *Operation Drumbeat: The Dramatic True Story of Germany's First U-Board Attacks along the American Coast in World War II.* Harper & Row, New York. 490 pp

Godfrey. PJ
1972. An integrated management approach to dune stabilization programs in the national recreation areas of the United States East Coast. National Park Service, Office of Natural Science Studies, Washington, DC, 15 pp.

Godfrey. PJ, and MM Godfrey
1977. Barrier island ecology of Cape Lookout National Seashore and vicinity, North Carolina. National Park Service Science Monogram Series 9, 160 pp.

Guilfoyle, MA, and RA Fischer
2006. Summary of first regional workshop on dredging, beach nourishment, and birds on the south Atlantic coast. US Army Corps of Engineers, Dredging Operations and Environmental Research Program. ERDC/EL TR-06-10.

Hands, EB
1981. Predicting adjustments in shore and offshore sand profiles on the Great Lakes. CETA No. 81-4, USACE-CERC, Fort Belvoir, VA, 25 pp.

Hanson, H, and NC Kraus
1989. GENESIS, generalized model for simulating shoreline change. Tech Rept CERC 89-19, Coastal Engineering Research Center, US Army Corps of Engineers, Vicksburg, MS, 185 pp + appendices.

Hayes, Miles O
1979. Barrier island morphology as a function of tidal and wave regime. In S Leatherman (ed), *Barrier Islands*, Academic Press, New York, NY, pp 1-26.
1994. Georgia Bight. Chapter 7 in RA Davis, Jr (ed), *Geology of the Holocene Barrier Island System*, Springer-Verlag, Berlin, pp 233-304.

Hayes, MO, and JC Boothroyd
1969. Storms as modifying agents in the coastal environment. In *Guidebook Coastal Environments of NE Massachusetts and New Hampshire: Eastern Section.* Reprinted in RA Davis (ed), *Beach and Nearshore Sediments and Processes.* SEPM Reprint Series No. 12, Tulsa, OK, pp 25-39.

Hayes, MO, and J Michel
2008. *A Coast for All Seasons – A Naturalist's Guide to the Coast of South Carolina.* Pandion Books, Columbia, SC, 285 pp.

Herbich, JB
1975. *Coastal and Deep Ocean Dredging.* Gulf Publishing Company, Houston, TX, 622 pp.

Hitchcock, DR, RC Newell, and LJ Seiderer
1998. Investigation of benthic and surface plumes associated with marine aggregate mining in the United Kingdom. Final Report to US Department of Interior, Minerals Management Service, Washington, DC, 168 pp.

Houston, JR
1990. Discussion of Pilkey, OH (1990), A time to look back at beach replenishment (editorial), Journal Coastal Research, Vol 6(1), pp iii-vii; and Leonard, L, T Clayton, and Pilkey, OH (1990), An analysis of replenished beach design parameters on U.S. East Coast barrier islands, Journal Coastal Research, Vol 6(1), pp 15-36. Journal of Coastal Research, Vol 6(4), pp 1023-1036.
1995. The economic value of beaches. The *CERC*ular, Coastal Engineering Research Center, Waterways Experiment Station. Vol CERC-95-4, pp 1-4.
2002. The economic value of beaches – 2002 update. Shore & Beach, Vol 70(1), pp 9-12.
2013. The economic value of beaches – 2013 update. Shore & Beach, Vol 81(1), pp 1-9.

IPCC (Intergovernmental Panel on Climate Change)
2007. Climate Change 2007: Synthesis Report. IPCC, United Nations Environmental Program, Geneva, Switzerland, 103 pp.
2013a. Climate Change 2013: The Physical Science Basis. IPCC, Draft Report, 36th Session of the IPCC (26 September 2013), Stockholm, Sweden (publication foreseen in January 2014).
2013b. Annex II: Climate System Scenario Tables [M Prather, G Glato, P Friedlingstein, C Jones, J-F Lamarque, H Liao, and P Rasch (eds)]. In Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the IPCC {TF Stocker, D Qin, G-K Plattner, M Tignor, SK Allen, J Boschung, A Nauels, Y Xia, V Bex, and PM Midgley (eds)]. Cambridge University Press, Cambridge, UK, and New York, NY, USA. http://www.ipcc.ch/report/ar5.
2013c. Summary for Policy Makers. In Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the IPCC {TF Stocker, D Qin, G-K Plattner, M Tignor, SK Allen, J Boschung, A Nauels, Y Xia, V Bex, and PM Midgley (eds)]. Cambridge University Press, Cambridge, UK, and New York, NY, USA. http://www.ipcc.ch/report/ar5.

Inman, D, and R Dolan
1989. The Outer Banks of North Carolina: budget of sediment and inlet dynamics along a migrating barrier system. Journal of Coastal Research, Vol 5(2), pp 193-237.

Jarrett, J
1978. Coastal processes at Oregon Inlet, North Carolina. In Proceedings 16th Conf on Coastal Engineering, American Society of Civil Engineers, New York, NY.

Jutte, PC, RF Van Dolah, and PT Gayes
2002. Recovery of benthic communities following offshore dredging, Myrtle Beach, South Carolina. Journal Shore & Beach 70(3): 25-30.

Kaczkowski, HL, and TW Kana
2012. Final design of the Nags Head beach nourishment project using longshore and cross- shore numerical models. In Proceedings 33rd International Conference on Coastal Engineering (Santander, Spain), ICCE, 24 pp.

Kana, TW
2012. A brief history of beach nourishment in South Carolina. Shore & Beach, Vol 80(4), pp 1-13.

Kana, TW, and RK Mohan
1998. Analysis of nourished profile stability following the fifth Hunting Island (SC) beach nourishment project. Journal of Coastal Engineering, Vol 33. pp 117-136.

Kana, TW, HL Kaczkowski, and SB Traynum
2015. An empirical approach to beach nourishment formulation. Chapter 4 in YC Kim (ed), *Design of Coastal Structures and Sea Defenses*, Vol 2, Series on Coastal and Engineering Practice, World Scientific, pp 105-144.

Kana, TW, J Michel, MO Hayes, and JR Jensen
1984. The physical impact of sea-level rise in the area of Charleston, SC. In MC Barth and JG Titus (eds), *Greenhouse Effect and Sea Level Rise: A Challenge for this Generation*, Van Nostrand Reinhold Co, New York, NY, pp 105-150.

Kana, TW, HL Kaczkowski, SB Traynum, and PA McKee
2012. Impact of Hurricane *Irene* during the Nags Head Beach Nourishment Project. Shore & Beach 80(2), pp 6-18.

Kana, TW, SB Traynum, D Gaudiano, HL Kaczkowski, and T Hair
2013. The physical condition of South Carolina beaches: 1980–2010. Journal of Coastal Research, Special Issue 69, pp 61-82.

Komar, PD.
1998. *Beach Processes and Sedimentation.* Second Edition. Prentice-Hall, Inc, Simon & Schuster, Upper Saddle River, NJ, 544 pp.

Kraus, NC, and JD Rosati
1998. Estimation of uncertainty in coastal sediment budgets at inlets. Coastal Engineering Technical Note CETN-IV-16, USAE Waterways Experiment Station, Coastal and Hydraulics Laboratory, Vicksburg, MS, 12 pp.

Lane, B
2013. Hatteras Island economic impact. Report to Outer Banks Visitors Bureau, University of North Carolina, Chapel Hill, NC, 22 pp.

Laney, RW, JE Hightower, BR Versak, MF Mangold, WW Cole, Jr, and SE Winslow
2007. Distribution, habitat use, and size of Atlantic sturgeon captured during cooperative winter tagging cruises 1988–2006. American Fisheries Society Symposium, Vol 56, pp 167-182.

LaSalle, MW, DG Clarke, J Homziak, J Lunz, and TJ Fredette
1991. A framework for assessing the need for seasonal restrictions on dredging and disposal operations. US Army Waterways Experiment Station, Tech Rept D-91-1, Vicksburg, MS, 74 pp.

Leatherman, SP, K Zhang, and B Douglas
1999. Sea level rise shown to drive beach erosion. EOS, Vol 81, pp 55-57.

Leffler, M., C Baron, B Scarborough, K Hathaway, P Hodges, and C Townsend
1996. Annual data summary for 1994 CERC Field Research Facility (2 volumes). Tech Rept CERC-96-6, USACE-WES, Coastal Engineering Research Center, Vicksburg, MS.

Machemehl, JL
1973. Artificial beach saves Hatteras motels. Shore & Beach, Vol 41(1), pp 10–13.
1979. Damage and repairs to coastal structures. In Proceedings Coastal Structures '79, ASCE, New York, NY, pp 314–332.

McBride, RA, and MR Byrnes
1997. Regional variations in shore response along barrier island systems of the Mississippi River delta: historical change and future prediction. Journal of Coastal Research, Vol 13(3), pp 628-655.

McNinch, JE, KL Brodie, HM Wadman, KK Hathaway, RK Slocum, RP Mulligan, JL Hanson, and WA Birkemeier
2012. Observations of wave runup, shoreline hotspot erosion, and sound-side seiching during Hurricane *Irene* at the Field Research Facility. Shore & Beach 80(2) (2012): 19-37.

Michel, J, AC Bejarano, CH Peterson, and C Voss
2013. Review of biological and biophysical impacts of dredging and handling of offshore sand. OCS Study BOEM 2013-0119, US Department of the Interior, Bureau of Ocean Energy Management, 258pp.

Molina, KC, and RM Erwin
2006. The distribution and conservation status of the gull-billed tern (*Gelochelidon nilotica*) in North America. Waterbirds, Vol 29(3), pp271-295.

Morton, RA
1988. Interactions of storms, seawalls, and beaches of the Texas coast. NC Kraus and OH Pilkey (eds); CW Finkl, Editor-in-Chief. Journal of Coastal Research, The Coastal Education and Research Foundation SI4: Autumn, Charlottesville, VA, pp115-134.

Morton, RA and TL Miller
2005. National assessment of shoreline change: Part 2 – Historical shoreline changes and associated coastal landloss along the US Southeast Atlantic Coast. Open File Report 2005-1401. US Geological Survey, Center for Coastal and Watershed Studies, St Petersburg, FL, 35 pp.

Moslow, Thomas F, and S Duncan Heron
1994. The Outer Banks of North Carolina. Chapter 2 in RA Davis Jr (ed), *Geology of Holocene Barrier Island Systems*, Springer-Verlag, New York, NY, pp 47-74.

NCCRC (North Carolina Coastal Resources Commission)
2015. North Carolina sea-level rise assessment report. NCCRC, Science Panel, 31 March 2015 draft, Raleigh, NC, 34 pp.

NCDENR (North Carolina Department of Environment and Natural Resources)
2012. North Carolina 2011 long-term average annual oceanfront erosion rate update study methods report. NC Division of Coastal Management, Raleigh, NY, 125 pp.

NCDOT (North Carolina Department of Transportation)
2008a. Final environmental impact statement and Section 4(f) evaluation: NC 12 replacement of Herbert C Bonner Bridge. Volume 1, NCDOT TIP Project Number B-2500, Raleigh, NC, 670 pp plus appendices.
2008b. Final environmental impact statement: citizen's summary and user guide: NC 12 Bonner Bridge Replacement Project. Federal Highway Administration and NCDOT, NCDOT TIP Project Number B-2500, Raleigh, NC, 14 pp.
2010. Record of Decision: NC 12 Replacement of Herbert C. Bonner Bridge (Bridge No. 11 over Oregon Inlet). NCDOT, Federal Highway Administration. Dare County, NC, 31 pp with appendices.
2015 (in prep). Feasibility Report – NC 12 Evaluation in the Buxton Area (title uncertain until published). NCDOT, Raleigh, NC (anticipated November 2015).

NMFS (National Marine Fisheries Service0
1997. Regional biological opinion concerning the use of hopper dredges in channels and borrow areas along the southeast U.S. Atlantic coast. South Atlantic Regional Biological Opinion, NMFS, Silver Spring, MD, 16 pp.
2003. Biological opinion on the effects of the Army Corps of Engineers dredging in Cape Henry Channel, York Spit Channel, York River Entrance Channel, and Rappahannock Shoal Channel, Virginia on threatened and endangered species. NMFS, NE Region, Gloucester, MA, 101 pp plus.
2012. Biological opinion for the shoreline restoration and protection project - Joint Expeditionary Base Little Creek/Fort Story (F/NER/2012/02020). NMFS, Northeast Region, Gloucester, MA

NOAA (National Oceanic and Atmospheric Administration)
2015. Draft guidance for assessing the effects of anthropogenic sound on marine mammal hearing. NOAA, Draft Report for publication 23 July 2015, 18 pp.

NPS (National Park Service)
1980. *Cape Hatteras Lighthouse, Buxton, North Carolina*. Authors: MTMA Design Group, JL Machemehl, NPS, 139 pp.
2002. National Park Service Director's Order#28: Cultural Resource Management.
2006. *Management Policies: The Guide to Managing the National Park System*. US Department of Interior, NPS, US Government Printing Office,180 pp.
2007. The creation and establishment of Cape Hatteras National Seashore: The Great Depression through Mission 66: (written by C Binkley for NPS). Southeast Regional Office, Cultural Resource Division, NPS, 265 pp.
2011. Foundation Statement: Cape Hatteras National Seashore. US Department of the Interior, NPS, Washington, DC, 56 pp.
2012a. National Park Service beach nourishment guidance. Technical Report NOPS/NRSS/GRD/NRTR-2012/581, National Park Service, Fort Collins, CO, 59 pp.
2012b. Colonial National Historical Park: repair and stabilize the York River shoreline to protect the Colonial Parkway. Environmental Assessment Doc 333/1008000, PMIS No. 145520. NPS, 222 pp.
2013. Inventory of coastal engineering projects in Cape Hatteras National Seashore. See above Dallas et al. 2013.
2015. EA-review and adjustment of wildlife buffers, Cape Hatteras National Seashore. US Department of Interior, National Park Service. April.

NRC (National Research Council)
1988. *Saving Cape Hatteras Lighthouse from the Sea: Options and Policy Implications.* Committee on Options for Preserving Cape Hatteras Lighthouse, NRC, National Academy Press, National Academy of Sciences, Washington, DC, 150 pp.
1990. *Managing Coastal Erosion*. NRC, National Academy Press, Washington, DC, 182 pp.
1995. *Beach Nourishment and Protection.* Committee on Beach Nourishment and Protection, Marine Board, Commission on Engineering and Technical Systems, NRC, National Academy Press, National Academy of Sciences, . Washington, DC, 334 pp.

O'Brien, MP
1969. Equilibrium flow areas of inlets on sandy coasts. Journal Waterways and Harbors Division, ASCE 95, New York, NY, pp 43-52.

Overton, MF, and JS Fisher
2005. Bonner Bridge replacement: parallel bridge corridor with NC 12 maintenance: shoreline change and stabilization analysis. Prepared for URS Corporation–North Carolina and NCDOT, Task Orders 18 and 20, TPI No B-2500. FDH Engineering, Raleigh, NC, 39 pp.

Pendleton, EA, ER Thieler, and SJ Wiliams
2005. Coastal vulnerability assessment of Cape Hatteras National Seashore (CAHA) to sea-level rise. Open-File Report 2004-1064, US Geological Survey, Reston VA, 18 pp

Penland, S, SJ Williams, DW Davis, AH Sallenger Jr, and CG Groat
1992. Barrier island erosion and wetland loss in Louisiana. In Louisiana Barrier Island Erosion Study–Atlas of Barrier Shoreline Changes in Louisiana from 1853 to 1989. US Geological Survey Misc Investigations Series I-2150-A, pp 2-7.

Peterson, CH, and MJ Bishop
2005. Assessing the environmental impacts of beach nourishment. BioScience Vol 55(10), pp 887-896.

Peterson, CH, MJ Bishop, GA Johnson, IM D'Anna, and LM Manning
2006. Exploiting beach filling as an unaffordable experiment: benthic intertidal impacts propagating upwards to shorebirds. Journal of Experimental Marine Biology and Ecology, Vol 338, pp 205-221.

Pilkey, Jr, OH
1981. Saving the American beach: a position paper by concerned coastal geologists. Results of Skidaway Institute Conference on America's Eroding Beaches (March 1981), 12 pp.
1990. A time to look back at beach replenishment (editorial). Journal of Coastal Research, Vol 6(1), pp iii-vii.

Pilkey, OH, and ME Field
1972. Onshore transportation of continental shelf sediment: Atlantic Southeastern United States. In DJP Swift, DB Duane, and OH Pilkey (eds), *Shelf Sediment Transport: Process and Pattern.* Dowden, Hutchinson, and Ross, Stroudsberg, PA, pp 429-445.

Reine, KJ, D Clarke, C Dickerson, and G Wikel
2014. Characterization of underwater sounds produced by trailing suction hopper dredges during sand mining and pump-out operations. ERDC/EL TR 14-3, BOEM 2014-055, US Department of the Interior, Bureau of Ocean Energy Management and US Army Corps of Engineers, Herndon, VA.

Reineck, HE and IB Singh
1976. *Depositional Sedimentary Environments with Reference to Terrigenous Clastics*. Springer-Verlag. New York, NY, 551 pp.

Riggs, SR, and DV Ames
2003. Drowning the North Carolina coast: sea-level rise and estuarine dynamics. Tech Rept, NCDENR, and NC Sea Grant, Raleigh, 154 pp.

Riggs, SR, SJ Culver, DV Ames, DJ Mallinson, DR Corbett, and JP Walsh
2008. North Carolina's coasts in crisis: a vision for the future. Department of Geological Science White Paper, East Carolina University, Greenville, NC.

Riggs, SR, DV Ames, SJ Culver, DJ Mallinson, DR Corbett, and JP Walsh
2009. Eye of a human hurricane: Pea Island, Oregon Inlet, and Bodie Island, northern Outer Banks, North Carolina. In JT Kelley, OH Pilkey, and JAG Cooper (eds), *America's Most Vulnerable Coastal Communities*, Geological Society of America, Special Paper 460-04, pp 43-72.

Rosati, JD
2005. Concepts in sediment budgets. Journal of Coastal Research Vol 21(2), pp 307-322.

Rosati, JD, RG Dean, and TL Walton
2013. The modified Bruun rule extended for landward transport. Journal of Marine Geology Vol 340, pp 71-81.

Ross, DG
1987. *Mechanics of Underwater Noise*. Peninsula Publishing, Los Altos, CA.
1993. On ocean underwater ambient noise. Acoustics Bulletin, January/February, pp 5-8.

Schupp, CA, GP Bass, and WG Grosskopf
2007. Sand bypassing restores natural processes to Assateague Island, Maryland. In NC Kraus and JD Rosati (eds), Coastal Sediments '07, ASCE, New York, NY, pp 1340-1353.

Schweitzer, S
2012. Coast-wide survey of colonial-nesting waterbirds, May-July 2011. Conference Presentation. Hammocks Beach State Park, Swansboro, NC. 8 March 2012.

Schweitzer, S, and M Abraham
2014. American oystercatcher and Wilson's plover breeding distribution and abundance estimates – 2013. Conference Presentation, Hammocks Beach State Park, Swansboro, NC. 6 March 2014.

Seelig, WN, and RM Sorensen
1974. Factors controlling changes to an open coast beach. In Proceedings 14th Conference on Coastal Engineering, ASCE, New York, NY, pp 1149-1163.

Shirihai, H, and B Jarrett
2006. *Whales, Dolphins and Other Marine Mammals of the World.* Princeton, Princeton University Press. pp 192-194.

Shepard, FP
1950. Beach cycles in southern California. Technical Memorandum No 21, Beach Erosion Board, USACE, Washington, DC.
1963. Thirty-five thousand years of sea level. Essays in Marine Geology in honor of K.O. Emery. University of Southern California Press. Los Angeles, pp 1-10.

Smith, CG, SJ Culver, SR Riggs, D Ames, DR Corbett, and D Mallinson
2008. Geospatial analysis of barrier island width of two segments of the Outer Banks, North Carolina, USA: anthropogenic curtailment of natural self-sustaining processes. Journal of Coastal Research, Vol 24(1), pp 70-83.

Stein, AB, KB Friedland, and M Sutherland
2004. Sturgeon marine distribution and habitat use along the northeast coast of the United States. Transactions of the American Fisheries Society, Vol 133, pp 527-537.

Stratton, AC
1943. Reclaiming the North Carolina Banks. Shore & Beach, Vol 1, pp 25-27,32.
1957. Beach erosion control in the Cape Hatteras National Seashore recreational area. Shore & Beach, Vol 25(1), pp 4-8.

Swift, DJP
1975. Barrier island genesis: evidence from the Central Atlantic Shelf, Eastern USA. Sedimentary Geology. Vol 14, pp 1-43.

TAR (Tidewater Atlantic Research Inc)
2015. A Phase 1 remote-sensing archaeological survey of a proposed borrow site off Buxton, Dare County, North Carolina. Prepared for Dare County Board of Commissioners, Cultural Resources Report, Tidewater Atlantic Research Inc, 107 pp.

Thomson et al. 2009

Turner, I.L. and S.P. Leatherman
1997. Beach Dewatering as a 'Soft' Engineering Solution to Coastal Erosion – A History and Critical Review. Journal Coastal Research 13 (4) (1997) 1050-1063.

USACE (US Army Corps of Engineers)
1963. *Report on Operation Five High, Appendices 6-19: After Action Report on Public Law 875 Activities, Closure of Buxton Inlet, North Carolina*: 8.
1996. *Cape Hatteras Lighthouse, North Carolina, Fourth groin alternative: design report and environmental assessment*. Prepared for the National Park Service. U.S. Army Corps of Engineers, Wilmington District, NC: 73.
2000. (Sep) Final feasibility report and environmental impact statement on hurricane protection and beach erosion control: Dare County beaches (Bodie Island portion), Dare County, North Carolina. Vol I and Vol II, US Army Corps of Engineers, Wilmington District, South Atlantic Division, 99 pp + appendices.
2001. STWAVE: Steady-State Spectral Wave Model User's Manual for STWAVE, Version 3.0, ERDC/CHL SR-01-1, Coastal and Hydraulics Laboratory, USACE. 66 pages + appendices.
2008. *Coastal Engineering Manual: Coastal Project Planning and Design.* EM 1110-2-1100, Part V, Chapter 4, Beach Fill Design. US Army Corps of Engineers, Washington, DC, pp V-4-1 to V-4-109.
2010. *Final Environmental Impact Statement, Beach Nourishment Project, Town of Nags Head, North Carolina.* US Army Corps of Engineers, Wilmington District, Washington Regulatory Field Office, NC (Action ID SAW-2006-40282-182), May:164 + 15 Appendices.
2013a. *Final Environmental Assessment, Town of Rodanthe, North Carolina.* Wilmington, NC: US Army Corps of Engineers, Wilmington District, Washington Regulatory Field Office, NC.

2013b. Hurricane *Sandy* Coastal Projects Performance Evaluation Study: Disaster Relief Appropriations Act. Submitted by the Assistant Secretary of the Army for Civil Works, US Army Corps of Engineers: 74.
2015. *North Atlantic Coast Comprehensive Study: Resilient Adaptation to Increasing Risk: Main Report.* US Army Corps of Engineers (2015):116.
2015. Appendix G. Noise Assessment for Charleston Harbor Post 45 Final Integrated Feasibility Report and Environmental Impact Statement. June.

USFWS (US Fish and Wildlife Service)
2007. National Bald Eagle Management Guidelines. May, 14 pp.
2007. Loggerhead Sea Turtle Management (*Caretta caretta*) 5-year Review: Summary and Evaluation. US Fish and Wildlife Service, Jacksonville, FL, 65 pp.
2008. Birds of Conservation Concern. US Department of Interior, Division of Migratory Bird Management, Arlington, VA, 85 pp [online version available at http://www.fws.gov/migratorybirds/<].
2010. Status review and conservation recommendations for the Gull-billed Tern (*Gelochelidon nilotica*) in North America. Biological Technical Publication. BTP-R1013-2010.
2014. Final rule: endangered and threatened wildlife and plants; threatened species status for the rufa red knot. Department of Interior, Federal Register, Vol 79(238), 11 December 2014.
2014. Official species list of threatened and endangered species that may occur in proposed action location or be affected by proposed action (CTN: 04EN2000-2014-SLI-0473), 19 September 2014, 5 February 2015, and 29 June 2015.

Van Dolah, RF, RM Martore, AE Lynch, PH Wendt, MV Levisen, DJ Whitaker, and WD Anderson
1994. Environmental evaluation of the Folly Beach nourishment project. Final Report, USACE, Charleston District and the South Carolina Department of Natural Resources, Marine Resources Division, Charleston, SC, 101 pp.

Walmsley, TV, KK Hathaway, and M Wutkowski
2010. Hatteras Breach, North Carolina. ERDC Technical Note CHETN-VI-43,US Army Corps of Engineers, Vicksburg, MS, 23 pp.

Warraich, N, R Zambrano, and EA Wright.
2012. First records of least terns nesting on non-gravel roofs. Southeastern Naturalist, Vol 11 (4), pp 775-778.

Webster, W. David, James F. Parnell and Walter C. Biggs
1985. Mammals of the Carolinas, Virginia, and Maryland. The University of North Carolina Press. Chapel Hill and London. 255 pgs.

Webster, W. David, P.D. Goley, J. Pustis and J.A. Gouveia
1995. Seasonality in Cetacean Strandings Along the Coast of North Carolina. Brimleyana 23: 41-51.

Witham, R
1990. A Case Report on Beach Erosion, Beach Nourishment, and Sea Turtle Nesting. In Proceedings of the 10th Annual Workshop on Sea Turtle Biology and Conservation NOAA Technical Memorandum NMFS-SEFC-278. Washington, DC: National Oceanic and Atmospheric Administration (NOAA), pp 157-160.

Wutkowski, M
2004. Hatteras breach closure. Shore & Beach, Vol 72(2), pp 20-24.

Zdravkovic, MG
2013. Conservation plan for the Wilson's plover (*Charadrius wilsonia*). Version 1.0, Manomet Center for Conservation Sciences, Manomet, Massachusetts, USA.

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