# APPENDIX D – EFH ASSESSMENT

**US ARMY CORPS OF ENGINEERS**

**US DEPARTMENT OF INTERIOR**
**NATIONAL PARK SERVICE**

**CAPE HATTERAS NATIONAL SEASHORE**
**NORTH CAROLINA**

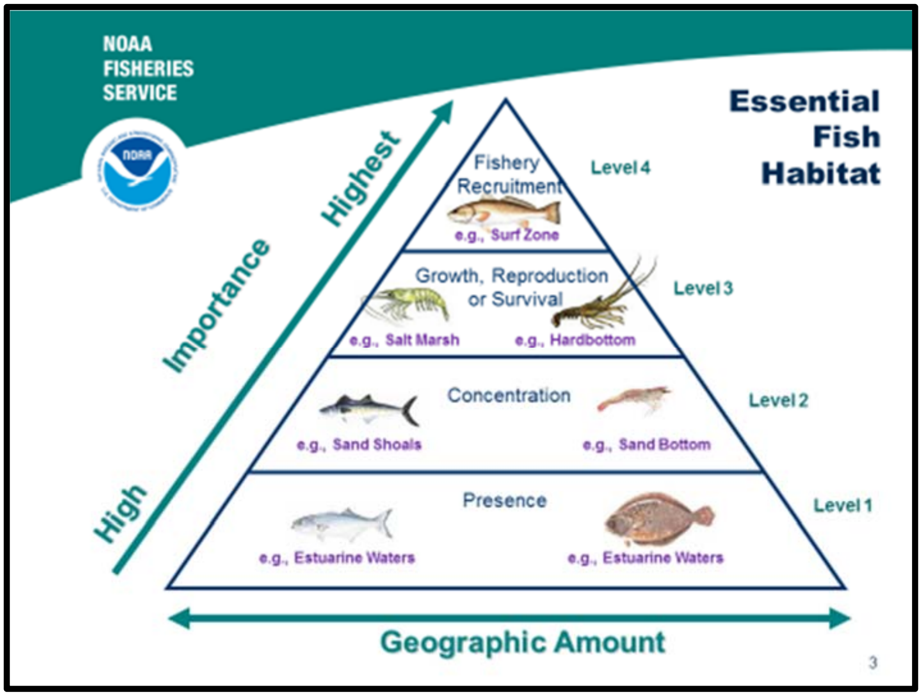
# ENVIRONMENTAL ASSESSMENT

## BEACH RESTORATION TO PROTECT NC HIGHWAY 12
## CLEAN WATER ACT 404 AND NPS SPECIAL USE PERMITS
### AT BUXTON, DARE COUNTY, NORTH CAROLINA

**SEPTEMBER 2015**

# ESSENTIAL FISH HABITAT ASSESSMENT
## in support of the NEPA documents prepared for

## BEACH RESTORATION TO PROTECT NC HIGHWAY 12 AT BUXTON, DARE COUNTY, NC




Prepared for:

Dare County Commissioners
US Army Corps of Engineers
National Park Service - Cape Hatteras National Seashore

For review by:

National Marine Fisheries Service
NC Division of Marine Fisheries

Prepared by:
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Columbia, SC 29202

April 2015

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# BEACH RESTORATION TO PROTECT NC HIGHWAY 12 AT BUXTON, DARE COUNTY, NC

## 1.0 INTRODUCTION AND PROJECT SETTING

In compliance with Section 305(b) (2) of the Magnuson-Stevens Fishery Conservation and Management Act (reauthorized by 1996 amendments), Dare County, the National Park Service (NPS), and the US Army Corps of Engineers (USACE) provides this National Marine Fisheries Service (NMFS) assessment of Essential Fish Habitat (EFH) in regards to the proposed project, Beach Restoration to Protect NC Highway 12 at Buxton, Dare County, NC. The proposed project will affect lands within and waters adjacent to the Cape Hatteras National Seashore and Dare County has been in regular communication and coordination with the National Park Service (NPS) about all aspects of the project. Dare County has requested a special use permit from the National Park Service to authorize beach restoration activities within the Cape Hatteras National Seashore and a Clean Water Act Section 404 permit from the USACE for the associated dredge and fill activities. The federal actions include decisions whether or not, and under what conditions, to issue the county the permits it has requested. Dare County contracted with Coastal Science & Engineering, Inc. (CSE) of Columbia, SC for the design and engineering. Two consultants will assist CSE: Tidewater Atlantic Research, Inc. (TAR) of Washington, NC for geotechnical field surveys and CZR Incorporated (CZR) of Wilmington, NC for preparation of and assistance with required NEPA documents and agency permits.

In order to assess potential impacts of the project and determine whether or not a Special Use Permit can be issued to Dare County to complete the project on Seashore property, an Environmental Assessment is under preparation per National Environmental Policy Act (NEPA) requirements. Dare County, or their authorized agent, is responsible for all coordination required to obtain State and other Federal authorizations for the proposed project.

Along the Outer Banks of North Carolina, NC Highway 12 connects all communities on Hatteras and Ocracoke Islands and serves as the only land-based evacuation route for all permanent and temporary island residents when the predicted approach of severe weather determines an evacuation is necessary. NC Highway 12 is also used by emergency services to access mainland hospitals and by waste collection services for mainland waste disposal.

Low lying and/or narrow portions of NC Highway 12 unprotected by substantial dunes are often affected by overwash events during large storms and hurricanes which leave behind sand deposits over portions of the road or cause actual degradation of the road surface making the road impassable. In these conditions, the NC Department of Transportation initiates emergency repairs in order to alleviate the hardship imposed by closure of NC Highway 12 and NC Highway 12 is continually repaired and maintained to prevent permanent loss of access on Hatteras Island.

The narrow isthmus within Cape Hatteras National Seashore (National Seashore) immediately north of Buxton Village has breached in the recent past under storms like Hurricane Irene (27 August 2011) and Hurricane Sandy (28 October 2012), which caused emergency closure of NC 12 at those breaches. This narrow isthmus is the target of the proposed project.

## 2.0 FISHERIES COORDINATION

On behalf of Dare County, via email dated 1 October 2014, CZR notified the National Oceanic and Atmospheric Administration (NOAA) Southeast Regional Office (SERO) via the SERO website's Endangered Species Act (ESA) consultation email address about the proposed project and that an EFH was in preparation. The SERO webpage also was used to generate the list of species to evaluate. Additional email correspondence from CZR to NMFS personnel occurred on 1 October 2014 and 29 January 2015. Dare County will continue coordination required to receive concurrence on the effects analysis on essential fish habitat (EFH) and conservation/mitigation recommendations included in this assessment. Although both the South Atlantic Fisheries Management Council (SAFMC) and the Mid Atlantic Fisheries Management Council (MAFMC) manage numerous fish stocks, only those which have a federal Fishery Management Plan (FMP) have designated EFH.

While no official coordination is required with The Atlantic States Marine Fisheries Commission (ASMFC), since 1942 it has been the deliberative body of the Atlantic coastal states and coordinates the management and conservation of 25 nearshore fish species. Some of these 25 species are also managed by either SAFMC or MAFMC and many also utilize the EFH and/or HAPC addressed in this document.

## 3.0 DESCRIPTION OF ALTERNATIVES AND PROPOSED ACTION

Eight potential alternatives are under consideration at the time this document was prepared and a complete suite of alternatives will be evaluated in detail in the concurrent EA in preparation. Of the eight, two were dismissed because the applicant does not have the authority to execute them (e.g. realignment of NC 12, structure abandonment), two were dismissed because they would not be allowed under existing North Carolina regulations for the northern coast (e.g. sand-retaining structures, seawalls), and one was dismissed due to environmental impacts, sediment quality, or economics (e.g., non-off shore borrow source). Three potential alternatives were fully evaluated:

1. No Action,
2. Beach Nourishment with Offshore Sand and Winter Construction, and
3. Beach Nourishment with Offshore Sand and Summer Construction (Applicant Preferred Alternative and proposed action).

Preliminary alternatives analysis indicates that the No Action alternative would have the least impact on the EFH which are the subject of this assessment, but the most impact on the human environment (private structures and NC12 would continue to be damaged and breaches would occur), and would not meet the purpose and need. The second alternative would meet the purpose and need and have minimal impact on the EFH addressed in this assessment as construction would occur outside of either their recruitment window (e.g., benthos), or their growth and reproduction window (e.g. some fish), or the migratory window of many others. However, due to normal winter wave climate and frequency of winter storms along the Outer Banks, the winter construction window is likely to prove too dangerous and too costly. Without a nearby safe harbor, the dredge operations would have to demobilize repeatedly to Virginia Beach (closest safe harbor for ocean going dredges) under the threat of storms or when the wave climate becomes unsafe; the normal wave heights can become unsafe for the ocean dredges even on a clear sunny day. These conditions would render the winter season alternative impracticable from both a safety and an economic perspective. Therefore, preliminary alternatives analysis indicates the Preferred Alternative is likely to be most practicable alternative that also meets the purpose and need and it is what is described in detail in this assessment. It also has the highest likelihood of EFH impacts among the eight potential alternatives.

The proposed action, Beach Restoration to Protect NC Highway 12 at Buxton, Dare County NC, is planned to begin by June 2016 with project completion by September 2016. The proposed action (fig 3.1) includes the following items:

1. Placement of up to 2.6 million cubic yards (cy) of beach compatible sediment (≥90% sand) along up to 2.94 miles of ocean front beach beginning near Mile Post 59 in the Seashore and extending south to the approximate former location of the Cape Hatteras Lighthouse at Buxton Village. The beach nourishment project design specifies the majority of the sand placement within a ~13,000-foot zone within the Seashore and the balance within the Village of Buxton. The design beach width throughout the planned nourishment area will average up to ~140 feet (ft) wide after normal adjustment. The north and south ends of the project will taper gradually back to the existing shoreline over a minimum distance of 500 ft. Sand will be placed in a normal configuration which closely matches the grades and slopes of the native dry sand beach between the toe of the fore dune and mean high water line. The maximum design berm elevation will be ~7 ft NAVD. The native dry beach elevation for the area is typically ~9 ft NAVD at the toe of the fore dune sloping gently to ~+5 ft at the berm crest. Natural profiles vary seasonally around a range of berm elevations. Figure 3.2 shows a typical beach fill template prior to natural fill adjustment. No sediment will be placed directly on the existing fore dune or toe of dune such that a minimum buffer of ~50 ft remains between the active construction area and the edge of vegetation. No sediment will be placed over existing structures, emergency sand bags, or existing ingress and egress points along the project area.

2. All sediment placed on the Buxton project beach adjacent to NC Highway 12 will be compatible with the native beach. Table 3.1 lists typical mean grain sizes for the subaerial beach in the project area (August 2013 conditions). The beach fill sand will be dredged from the proposed Borrow Area C located about 1.7 miles offshore of Buxton from within an unnamed sand ridge (fig 3.3). Geotechnical investigations were conducted in August 2013 and October and December 2014 within the proposed borrow area to identify sufficient quantities of beach compatible material (≥90% sand) and determine presence of cultural resources or hard grounds. Figure 3.4 shows an example core photo log and core log from the center of the proposed borrow area. Figure 3.5 shows a preliminary comparison of the grain size distribution along the subaerial beach and borrow area (composited samples in the upper 7 ft of section). The proposed borrow area is a shoal exposed to high wave energy in water depths between 30 to 45 ft with negligible fine grained material present (e.g., mud or organics) (CSE 2013).

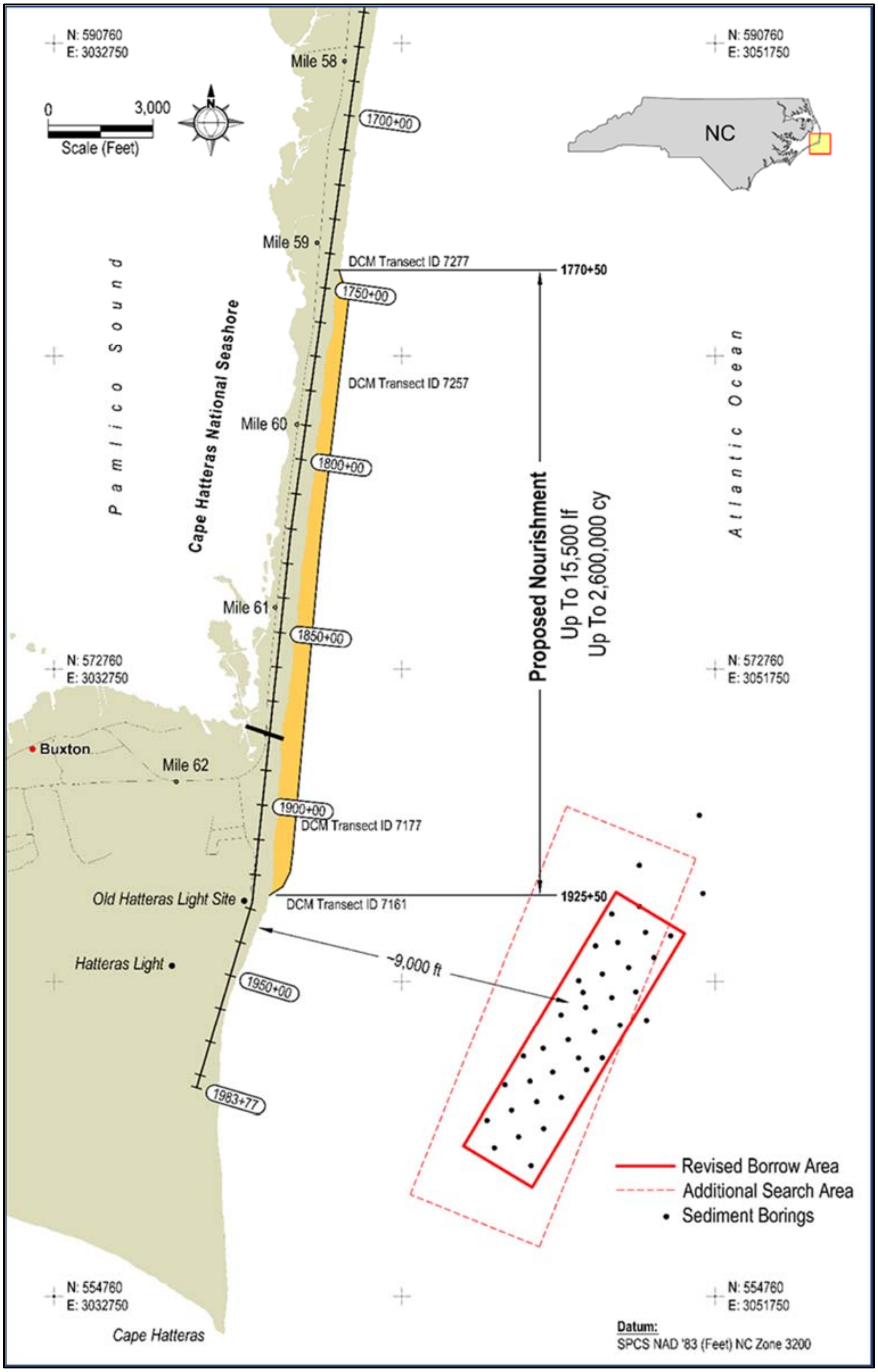



**FIGURE 3.1.** The project area for beach restoration to protect NC Highway 12 at Buxton, Dare County (NC), showing maximum limit of beach nourishment and proposed offshore borrow area within state waters near Cape Hatteras.

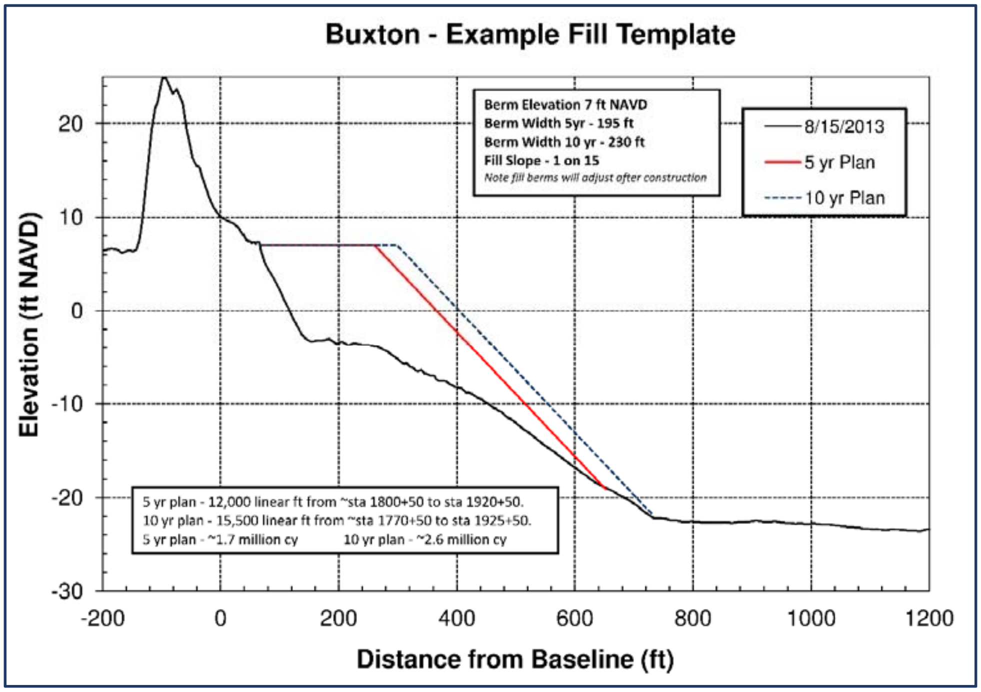



**FIGURE 3.2.** Representative beach nourishment fill template superimposed on a representative profile before profile adjustment. Highway NC 12 is positioned immediately adjacent to the foredune which was pushed up after the dunes breached in some areas during Hurricane *Irene* (27 August 2011) and Hurricane *Sandy* (27 October 2013). The average dry beach width after adjustment will be ~80 to 140 ft, depending on the section and final volume placed (constrained by fixed budget). No sand will be placed above +7ft NAVD, on the upper beach fore dune, or on any sand bags in place at the time of construction.

**TABLE 3.1.** Native beach sediment sample mean grain-size by station and position across the subaerial beach (sampling in August 2013) (after CSE 2013).

| **BUXTON – Cape Hatteras National Seashore** | | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Mean Grain-Size Distribution (mm)** | | | | | | |
| **Station** | **Dune Toe** | **Berm Middle** | **Beach Face** | **Low Tide Terrace** | **Averages All** | **% Shell (Average)** | **% Gravel (Average)** |
| | | | | | | | |
| 1790+63 | 0.469 | 0.469 | 0.373 | 0.461 | **0.443** | 5.2 | 1.9 |
| 1840+63 | 0.397 | 0.345 | 0.459 | 0.222 | **0.356** | 3.4 | 0.3 |
| 1890+63 | 0.613 | 0.352 | 0.464 | 0.540 | **0.492** | 11.8 | 4.4 |
| 1900+63 | 0.666 | 0.425 | 0.352 | 0.643 | **0.522** | 16.9 | 5.5 |
| 1940+63 | 0.368 | 0.442 | 0.277 | 0.347 | **0.359** | 14.0 | 0.9 |
| 1980+63 | 0.469 | 0.508 | 0.278 | 0.491 | **0.437** | 9.3 | 1.1 |
| **Averages** | **0.497** | **0.424** | **0.367** | **0.451** | **0.435** | **10.1** | **2.4** |

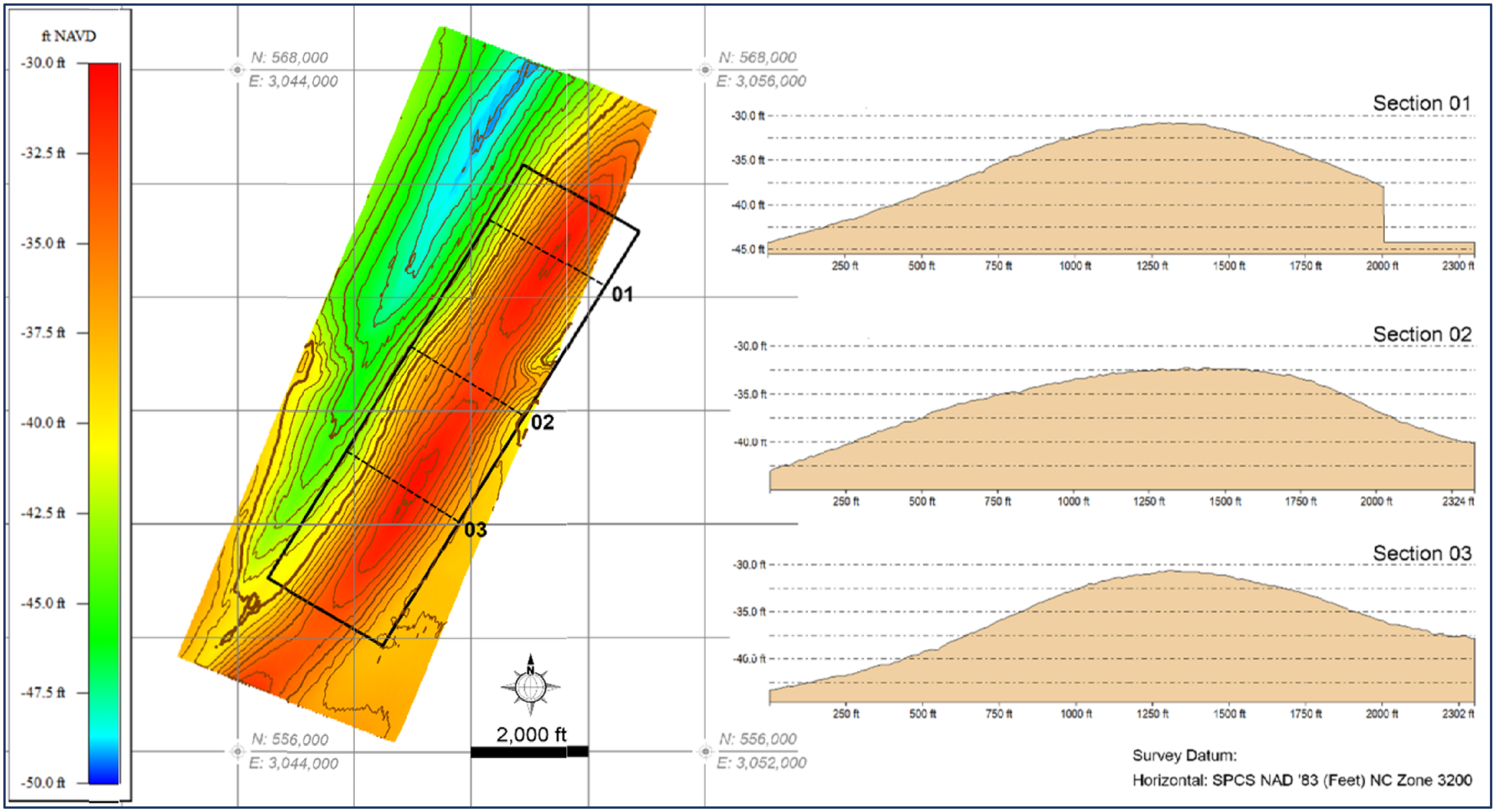



**FIGURE 3.3.** Bathymetry and cross sections (September 2014) through the proposed borrow area (black outline) (offshore of Buxton) based on field data collection by CSE in August 2013 and October 2014. (See fig. 3.1 for location of sand search area.)

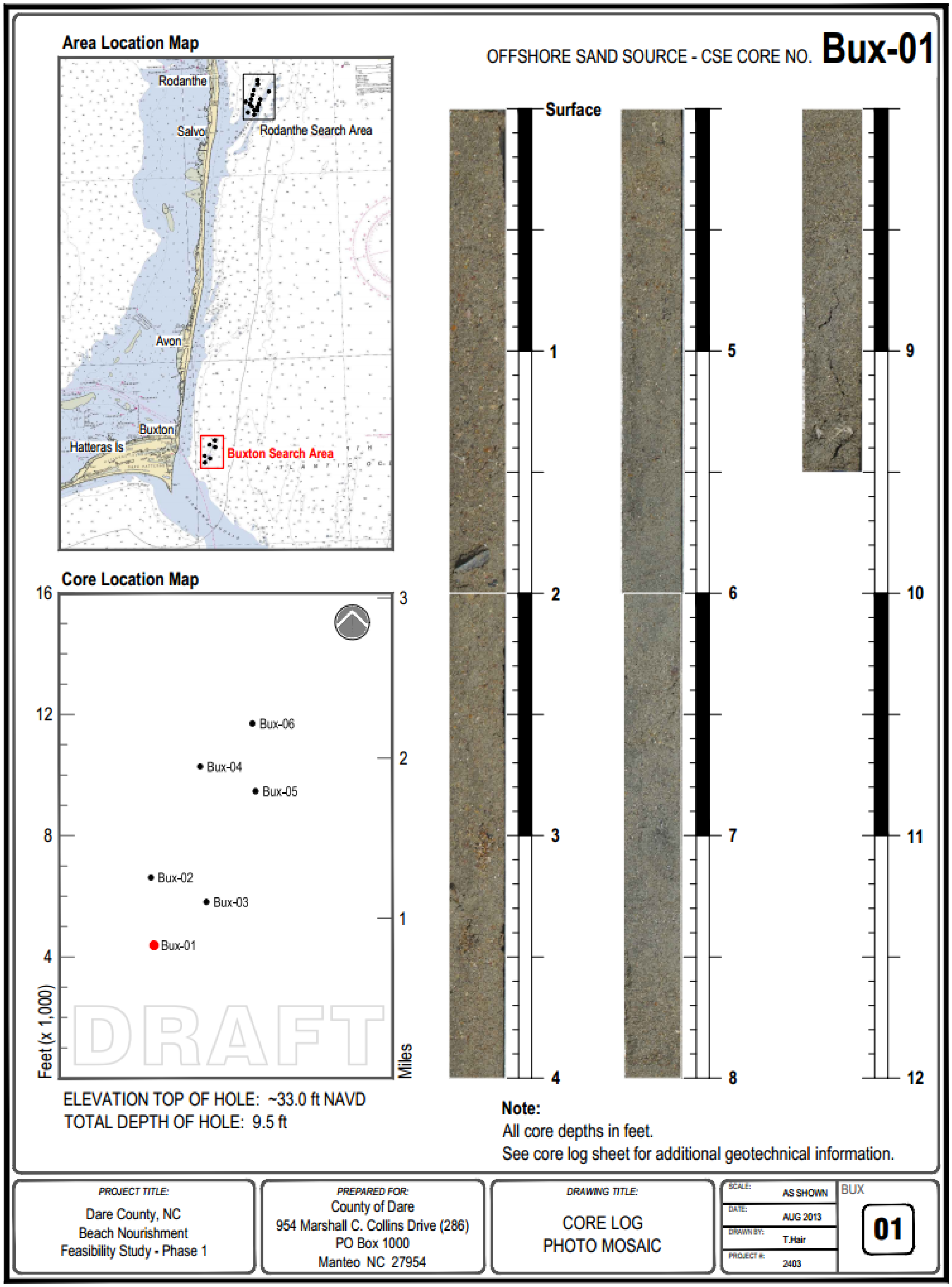



**Figure 3.4a.** Representative core photo log from Boring Bux-01 in the center east edge of the proposed borrow area.

| CORE LOG | Coastal Science & Engineering | | | | Sheet 1 of 1 |
|---|---|---|---|---|---|
| PROJECT: | 2403 - Dare County | COORDINATES: Northing: 561226.750 Easting: 3048052.106 Grid Datum: NAD '83 | | HOLE NUMBER: | Bux-1 (as shown on title drawing and file no.) |
| LOCALITY: | Buxton - Offshore | | | | |
| DATE: | 2013-Jul-09 | TOP ELEVATION: | -33.00 ft. NAVD '88 | DEVICE DESIGNATION: | Coastal Science & Engineering |
| BORE ANGLE: | 90.00° | | | | |
| BURDEN THICKNESS: | 9.5 ft. | BOTTOM ELEVATION: | -42.50 ft. NAVD '88 | BARREL SIZE/TYPE: | 3 in. Aluminum |
| CORE RECOVERY: | 9.5 ft. (100.0%) | WATER DEPTH: | (operational note only) | GEOLOGIST: FIELD TEAM: | TWK - NC #1752 DG, ST, TH |

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

**FIGURE 3.4b.** Representative core log from Bux-1 showing lithology and mean grain size by core section illustrated in Figure 3.4a.

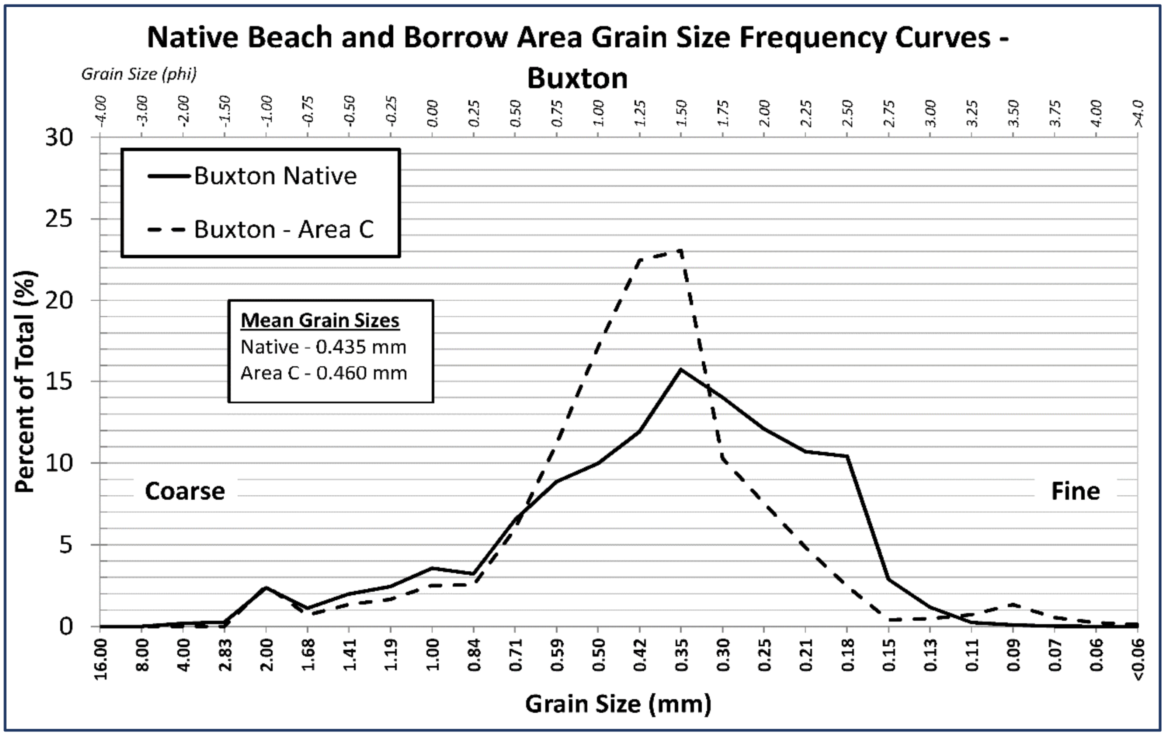



**FIGURE 3.5.** Preliminary comparison of mean grains size distributions for Buxton native beach sand and the proposed borrow area. Results composited from Phase 1 samples (CSE 2013). Note: detailed results of Phase 2 sampling are contained in the Geotechnical Data Report (CSE 2015) included as an appendix to the EA for the project.

3. The proposed work will use either an ocean certified hopper dredge (with pump-ashore capabilities) and/or a hydraulic pipeline cutterhead dredge to excavate and pump the material from the proposed offshore Borrow Area C to the sand placement area (fig 3.6). The most feasible and safe method for excavation is anticipated to be via hopper dredge during summer months when wave energy at the borrow site is within threshold criteria for safest and most optimal operations (fig 3.7). The project area is exposed to the highest waves along the East Coast (Leffler et al 1996) and is situated approximately 105 miles from the nearest safe harbor at Little Creek Virginia. Ocean-going dredges, which can legally operate offshore generally have drafts which exceed the navigation channel depth or actual depth at Oregon Inlet (~45 miles away) or Hatteras Inlet (~20 miles away, not counting the extra steaming required around Diamond Shoals for safe passage).

4. Once sand has been pumped to the site, heavy equipment typically used in beach fill placement operations (i.e., bulldozers, front end loaders, excavators) will be used to build the design beach profile in addition to other support vehicles (i.e., ATVs, trucks) (fig.3.8). Operations at the active beach construction site will be around the clock seven days a week until completion, the active beach discharge point will be fenced to protect public safety, and land based personnel will work within the beach construction zone to assure compliance with conditions and restrictions of the applicable state and federal permits. Staging areas will be used to store additional shore pipe, fuel, mobile on-site office, and other necessary equipment. Locations of any staging areas and two anticipated access points for support vehicles and heavier equipment will be coordinated with NPS personnel and the Village of Buxton.

**FIGURE 3.6.** Three hopper dredges and one suction cutterhead dredge were used to construct the Nags Head (NC) beach nourishment project (24 May to 27 October 2011). Nourishment construction in progress working south to north toward Outer Banks Pier in south Nags Head. [Photos by CSE and Great Lakes Dredge & Dock Co]

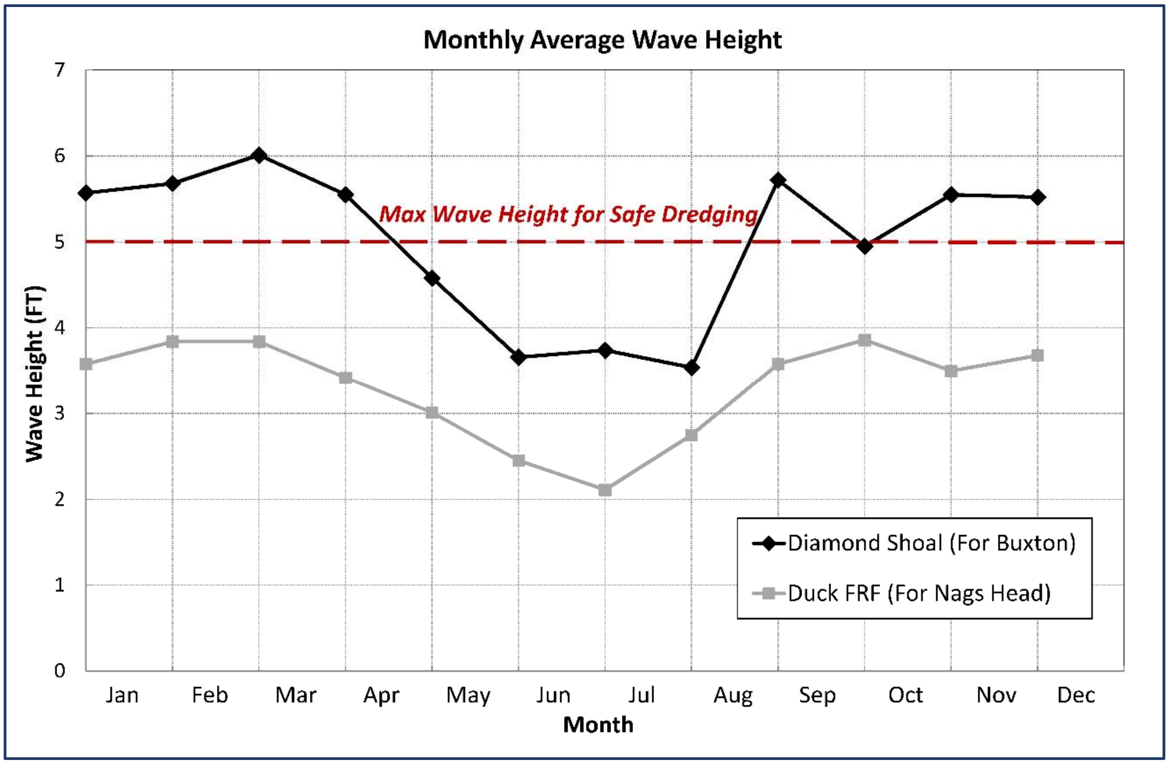



**FIGURE 3.7.** Monthly average wave climate from 2003 through 2013 at NDBC wave buoy Station 41025 at Diamond Shoals (NC) compared with wave climate at the USACE-FRF at Duck (NC). The criteria for safe dredging apply to hopper dredge operations using ocean-certified equipment per informal guidance by dredging companies. Operations decisions involve numerous additional factors: wave period, sea state, pumping distance, size of dredge, and sediment characteristics. Suction cutterhead dredges generally cannot operate safely in waves >3 ft (USACE 2010). [Source: NDBC]

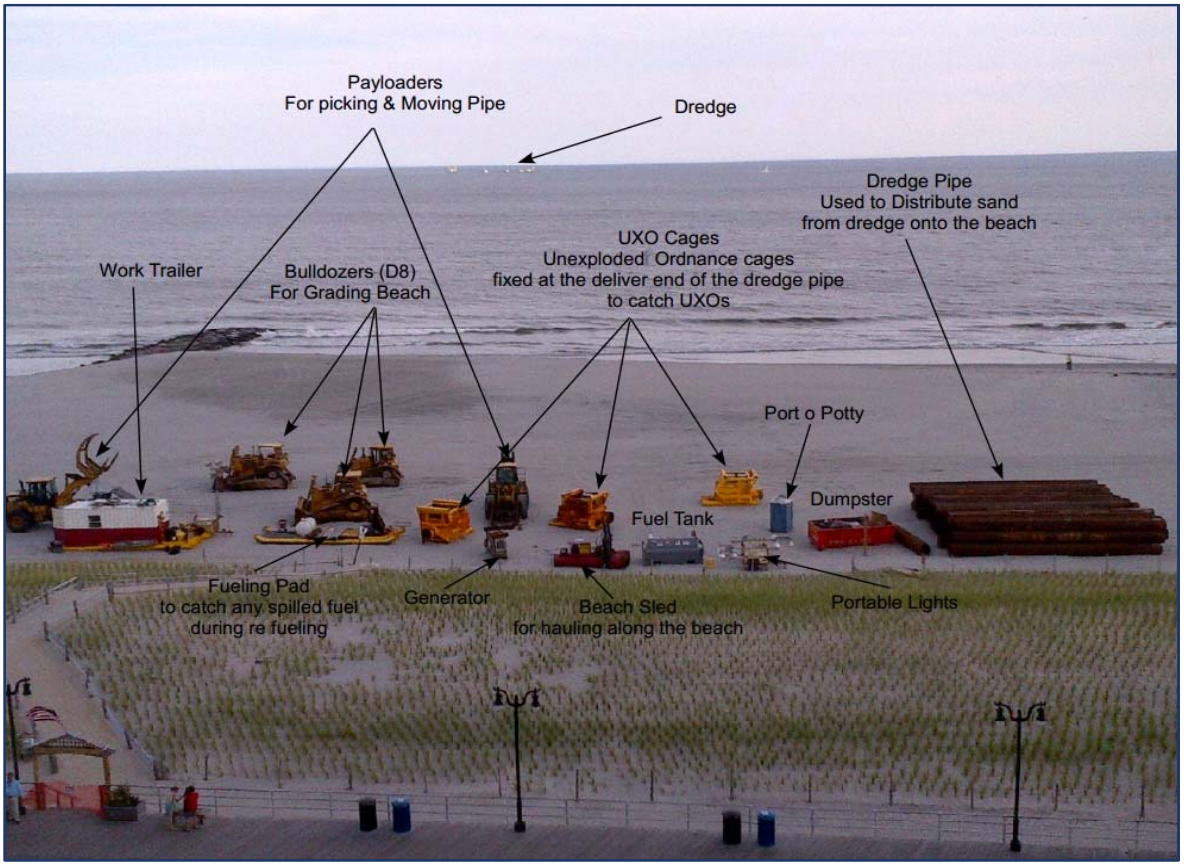



**FIGURE 3.8.** Types of land-based support equipment generally required for construction of beach nourishment. [Photo annotations courtesy of J Lignelli and First Coastal Corp, New York]

5. The duration of construction is expected to be ~2 months assuming operations are permitted during summer months. Production for a 4.6 million cy project at Nags Head NC (~50-60 miles north of the Buxton project site) was ~3.8 million cy in three months between 27 May and 27 August 2011 using one large hopper dredge (~6,000 cy capacity) and one suction cutterhead dredge (for ~1.5 months), and ~0.8 million cy in two months between 27 August and 27 October using two smaller hopper dredges (~3,000 cy capacity each) (CSE 2012). Low production rates for the latter 20% of the Nags Head project reflect a high frequency of no-work days associated with high wave events in September and October. Hurricane *Irene* impacted the Nags Head project on 27 August 2011.

6. On a given day, the typical impact area along the beach in the project area will average ~1,000 linear feet. Project areas outside the active work area will remain open to the public, subject to NPS natural resource protection, management, and policy. As sections of the project are completed, the nourished area will be reopened immediately to the public as appropriate. Sections of shore pipeline extending up to ~4,000 linear feet along the beach will be left in place along the completed berm. Sand ramps will be placed over the pipeline for vehicle and pedestrian access. The pipeline will be monitored nightly while in place to detect any turtle

activity in the project area and to insure no turtles are stranded landward of the pipeline. Upon completion of a section of the project (over ~ two weeks), the shore pipeline will be removed and relocated to a new pump-out point and shore pipe extended along the beach as the subsequent sections are completed. Thus, the shore length over which pipe extends during construction will vary from <100 ft to ~4,000 ft. Resource closure areas designated by NPS biologists before or during construction will be bypassed or avoided by shifting construction as far seaward as practicable to minimize impacts and maintain acceptable no work buffers near closure areas. Close coordination between NPS personnel and contractors will be maintained throughout the construction of the project.

7. Loaders will remove and relocate the pipeline and bulldozers will shape the nourishment berm into its final grades and slopes above mean high water. The seaward slope cannot be controlled accurately, but the likely intertidal beach slope for the nourished beach at the time of construction will be ~1 on 15 based on experience in similar settings. The constructed berm is expected to adjust rapidly to slopes and morphology typical of the surf zone, including low-tide bars and troughs formed within weeks in response to varying wave action. During fall months, the project area is subject to frequent high energy wave events associated with minor extra-tropical storms ("northeasters"). The berm elevation of the nourished beach is expected to be lower than the typical wave uprush limit during northeasters and be overtopped periodically within months of project completion. Washover deposits will shift sand landward to higher elevations near the fore dune and shift sand into shallow water. Figure 3.9 illustrates a sequence of profile changes at one station along the Nags Head project area during and shortly after construction (from CSE 2012). Figure 3.10 shows natural buildup of the fore dune over sand fencing placed at the toe of the fore dune one year and three years after construction of the Nags Head project.

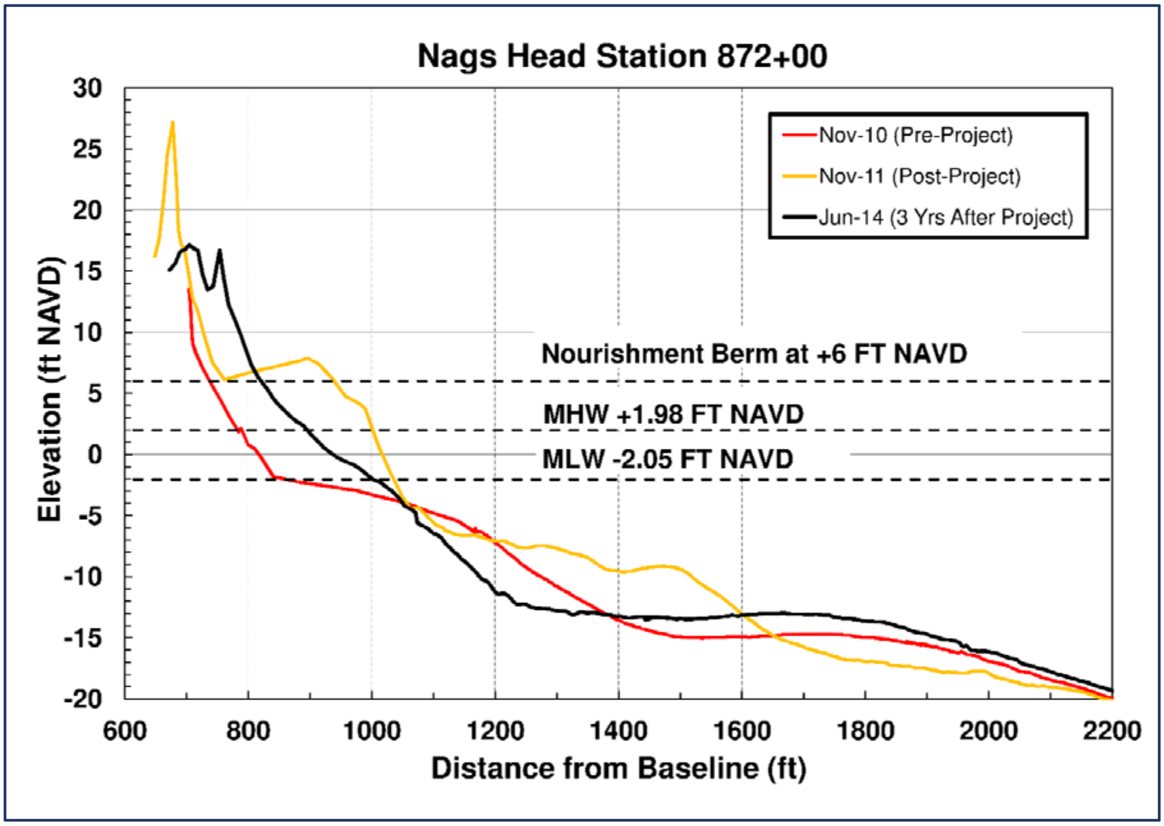



**FIGURE 3.9.** Pre- and post-nourishment profiles from a station in south Hags Head ~900 ft south of Jennette's Pier (Whalebone Junction) showing fill adjustment after three years. Note ~20:1 vertical exaggeration. No sand was placed above the +7ft NAVD contour. Natural profile adjustment by Year 3 has included a large shift of sand from the nourishment berm to the fore dune as well as a buildup of sand offshore. The buildup of the fore dune since nourishment is due to natural processes (from CSE 2014). The profile changes include impacts from Hurricane *Irene* (2011) and Hurricane *Sandy* (2012).

**Figure 3.10**. Natural dune regrowth along south Nags Head (NH Station 855+00) after the 2011 nourishment project. [UPPER] 11 June 2012 locality in Nags Head (NC) seven months after nourishment. [LOWER] 5 June 2014, same locality two years and seven months after nourishment.

8. The offshore borrow area will be excavated to a maximum depth of ~7 ft below existing grade. If hopper dredges are used, excavations will leave undisturbed areas in close proximity to dredged corridors and each pass of the dredge will remove ~1 to 2 ft of substrate within two 8 to 10 ft corridors flanking the vessel. High wave energy is expected to rapidly eliminate irregularities in the borrow area topography and promote mixing of exposed sands which underlie the removed sediments. The anticipated borrow area contains potential sand resources totaling >5 million cy. The maximum project volume to be removed will be less than 50% of the sand resources in the designated area. Upon adjustment, the average depth over the designated borrow area is expected to increase by ~3 ft to an average depth in the range ~35-45 ft below mean sea level. The excavations over a natural ridge are not expected to leave deep holes. An adjacent trough within 1,000 ft west of the proposed borrow area contains natural water depths >50 ft (see fig 3.1). For detailed analysis of sediment quality in the borrow area, see CSE (2015).

## 4.0 RESOURCE SURVEYS AND COORDINATION

Coastal Science and Engineering conducted baseline, control, inshore geotechnical surveys, and sediment compatibility analyses; TAR conducted geophysical investigations (magnometer and shallow seismic profiles) and cultural resource analyses within the proposed Borrow Area C. These surveys confirm a general uniformity of sediment quality and compatibility with the beach and ensure that the proposed project will not adversely encounter or impact hard bottom or cultural resources. Data from these surveys will be coordinated with all appropriate agencies (e.g., NMFS, USFWS, USACE, NCDMF, NCDCM, and NCWRC). Cultural resource survey results are detailed in TAR 2015 and indicate at least one limited area to be avoided via buffers in the northwest corner of the borrow area. Additional surveys of target cultural resources objects are planned for summer 2015 (phase 2 of cultural resource sampling).

Prior to any construction of the proposed project, the National Park Service will determine whether or not to grant a Special Use Permit (SUP) from the US Department of the Interior for the placement of sand on the beach and if so, Dare County will then coordinate with state and federal agencies to obtain the following authorizations:

1. North Carolina Division of Coastal Management (CAMA) Major Development Permit and North Carolina Division of Water Resources (NCDWR) Section 401 of the Clean Water Act Certificate (PL 92-500).

2. Department of the Army Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbor Act of 1899 permits. These USACE permits will ensure that the proposed action complies with Section 7 of the Endangered Species Act of 1973 (PL 93-205), as amended, Magnuson-Stevens Fishery Conservation and Management Act (MFCMA), Section 106 of the National Historic Preservation Act (i.e., cultural resources), Coastal Zone Management Act (CZMA), Coastal Barrier Resources Act (CBRA), and other NEPA/environmental requirements.

No work will be initiated until these state and federal authorizations have been issued.
The permitted project will be performed in compliance with all conditions and restrictions found within these permits.

## 5.0 EFH AND HABITAT AREAS OF PARTICULAR CONCERN (HAPC) WITHIN PROPOSED PROJECT AREA OR VICINITY

The Magnuson-Stevens Act defines EFH as "all waters and substrates necessary to fish for spawning, breeding, feeding, or growth to maturity" and may include habitat for individual species or an assemblage of species so designated by regional fishery management councils. The Act also requires these regional councils to develop a Fishery Management Plan (FMP) for each resource or species and to identify any Habitat Areas of Particular Concern (HAPC) within an EFH. The FMPs are periodically amended. The HAPC must meet one of four criteria based on either ecological function, habitat sensitivity to human degradation, human development activities stresses, or rarity. The FMP amendments of SAFMC and MAFMC identify numerous categories of EFH and multiple Habitat Areas of Particular Concern (HAPC), which are listed in Table 5.1. Those fish species managed by the SAFMC/MAFMC and their association with the categories of EFH and HAPC shown in Table 5.1 are identified in Table 5.2.

On a state level, as mandated by a 1997 state law, the North Carolina Marine Fisheries, Environmental Management, and Coastal Resources Commissions adopted the *North Carolina Coastal Habitat Protection Plan* (CHPP) in December 2004 and published the document in January 2005 (Street et al 2005). The purpose of the CHPP was long-term enhancement of coastal fisheries associated with coastal habitats. It provided a framework to protect and restore habitats deemed critical to North Carolina coastal fisheries. The CHPP identifies six types of these habitats: shell bottom, sea grasses, wetlands, hard bottoms, soft bottoms, and the water column. In December 2010, with the addition of a fourth commission (North Carolina Wildlife Resources) the second iteration of the CHPP was published to update the latest scientific information on the condition, threats, and function of these habitats (Deaton et al 2010). The CHPP habitats also occur within, or overlap, EFH habitats.

While all the EFH habitat categories occur in waters of the southeastern United States, and many occur in North Carolina waters, only a few occur in the immediate project vicinity (within 2 miles) or the project area itself (maximum footprint of sand placement area = ~175 acres; maximum footprint of Borrow Area C and pipeline distribution area = ~325 acres; combined footprint of project area = ~500 acres). The entire ~500-acre project area includes the dry beach, intertidal and subtidal surf zone, nearshore area, and the entire marine water column between the borrow area and the intertidal beach.

Table 5.1 shows the categories of EFH and Habitat Areas of Particular Concern (HAPC) for managed species that were identified in the FMP Amendments affecting the South Atlantic area. The HAPC are subsets of EFH which are rare, particularly susceptible to human-induced degradation, especially ecologically important, or located in an environmentally stressed area. In general, HAPC include high value intertidal and estuarine habitats, offshore areas of high habitat value or vertical relief, and habitats used for migration, spawning, and rearing of fish and shellfish. Due to characteristics of proposed project location where only estuarine and marine environments occur, palustrine and freshwater EFH are not included in other tables or in additional analyses.

**TABLE 5.1.** Categories of Essential Fish Habitat (EFH) and Habitat Areas of Particular Concern (HAPC) defined in the south Atlantic region and in North Carolina in the vicinity of project area.

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

Table 5.1 Notes:
EFH areas are identified in FMP Amendments for SAFMC and MAFMC. Geographically defined HAPC are identified in FMP Amendments affecting the south Atlantic area. The EFH for species managed under NMFS Billfish and Highly Migratory Species generally falls within the marine and estuarine water column habitats designated by the Councils. Information in this table was derived from Appendices 4 and 5 of NMFS 2010 and SAFMC EFH and HAPC designations from http://www.safmc.net/ecosystem-management/essential-fish-habitat).

Table 5.2 lists the federally managed fish species for which Fishery Management Plans (FMPs) have been developed by the South Atlantic Fishery Management Council (SAFMC) and/or the Mid-Atlantic Fishery Management Council (MAFMC) and which may occur in the project area waters. In addition, the table shows EFH by fish life stage and type for those species that have designated EFH (marine species which spend no portion of their lifecycle in local estuarine waters are indicated with N/A). Fish species which utilize habitats shown in Table 5.1 and occur in the water bodies of NC shown in Table 5.2 require special consideration to promote their viability and sustainability. The habitats and HAPC for species managed by the Atlantic States Fishery Management Council (ASFMC) and EFH and HAPC for SAFMC-managed species are shown in Table 5.3 along with the species for which a fishery management plan (FMP) has been developed and the species with ASFMC strategies and management goals. The potential effects of the proposed project on those fish and habitats are summarized in Table 5.4; for the purposes of this analysis, project vicinity is within 2 miles. Only those habitats or species which have the potential to be affected by the proposed project (either a Y or W shown in the Impact Activity column of Table 5.4) are discussed in further detail in Section 6.0 of this document.

Figure 5.1 shows the hard bottom, possible hard bottom, shipwrecks, and artificial reefs in state and federal waters of the North Carolina coast in the vicinity of Cape Hatteras as depicted in Deaton et al (2010). The red dot south of Buxton indicated as "hard bottom – point" represents the existing groins installed in the 1970s under the direction of the US Navy to protect a facility adjacent to Cape Hatteras Lighthouse and to hold sand along the beach around the lighthouse. No sand will be placed directly on the existing groins. Geotechnical studies of the proposed borrow area including ~35 borings up to 10 ft long and geophysical surveys for the project by TAR confirm there is no hard bottom in the borrow area. Previous surveys conducted or reviewed as part of the NOAA Southeast Area Monitoring and Assessment Program (SEAMAP) indicate that the nearest offshore hardbottom habitat is ~10 miles east of the proposed project area. Figure 5.2 shows the SAFMC designated EFH and HAPC in the vicinity of Cape Hatteras as well as hardbottom mapped by The Nature Conservancy as part of the South Atlantic Bight Marine Assessment. Prior to any placement of sand on the targeted beach at Buxton, remote sensing (i.e., shallow seismic, magnetometer and side scan surveys) will be used to delineate any potential cultural resources such as wrecks and their associated habitat. All interim and final survey data will be coordinated and provided to representatives of the NMFS and North Carolina Division of Marine Fisheries (NC DMF). If any hardbottom features, or cultural resources are identified within the project area, they will be mapped, these areas will be avoided, and appropriate buffers will be incorporated.

**TABLE 5.2.** EFH SAFMC and or MAFMC* species found in major North Carolina water bodies (as shown in USACE 2013).

| Life stage and species | North Carolina waterbody | | | | |
|---|---|---|---|---|---|
| E – eggs<br>L = larval<br>J = juvenile<br>A = adult<br>N/A = not found | Roanoke Sound | Croatan Sound | Pamlico Sound | Oregon Inlet | Hatteras Inlet |
| **COASTAL DEMERSALS** | | | | | |
| Red drum | E L J A | E L J A | E L J A | E L J A | E L J A |
| Bluefish | J A | J A | J A | J A | J A |
| Summer flounder | L J A | L J A | L J A | L J A | L J A |
| **INVERTEBRATES** | | | | | |
| Brown shrimp | L J A | L J A | L J A | E L J A | E L J A |
| Pink shrimp | L J A | L J A | L J A | E L J A | E L J A |
| White shrimp | L J A | L J A | L J A | E L J A | E L J A |
| Calico shrimp | N/A | N/A | N/A | N/A | N/A |
| **COASTAL PELAGICS** | | | | | |
| Dolphinfish | N/A | N/A | J | J A | J A |
| Cobia | J A | J A | J A | L J A | L J A |
| King mackerel | J A | J A | J A | L J A | L J A |
| Spanish mackerel | J A | J A | J A | L J A | L J A |
| **HIGHLY MIGRATORY** | | | | | |
| Bigeye tuna | N/A | N/A | N/A | N/A | JA |
| Bluefin tuna | N/A | N/A | N/A | N/A | JA |
| Skipjack tuna | N/A | N/A | N/A | N/A | JA |
| Yellowfin tuna | N/A | N/A | N/A | N/A | JA |
| Swordfish | N/A | N/A | N/A | N/A | N/A |
| Blue marlin | N/A | N/A | N/A | N/A | N/A |
| White marlin | N/A | N/A | N/A | N/A | N/A |
| Sailfish | N/A | N/A | N/A | N/A | N/A |
| Little tunny | N/A | N/A | N/A | N/A | N/A |
| **SHARKS** | | | | | |
| Spiny dogfish | J A | J A | J | J A | J A |
| Smooth dogfish | J A | J A | J A | J A | J A |
| Small coastal sharks | J A | J A | J A | J A | J A |
| Large coastal sharks | J A | J A | J A | J A | J A |
| Pelagic sharks | N/A | N/A | N/A | N/A | N/A |
| Prohibited research sharks | N/A | N/A | J A | J A | J A |
| **SNAPPER/GROUPER** | | | | | |
| Black sea bass | L J A | L J A | L J A | L J A | L J A |
| Bank sea bass | N/A | N/A | N/A | N/A | N/A |
| Rock sea bass | J | J | J | J | J |
| Gag | J | J | J | J A | J A |
| Graysby | N/A | N/A | N/A | N/A | N/A |
| Speckled hind | N/A | N/A | N/A | N/A | N/A |
| Yellowedge grouper | N/A | N/A | N/A | N/A | N/A |
| Coney | N/A | N/A | N/A | N/A | N/A |
| Red hind | N/A | N/A | N/A | N/A | N/A |
| Goliath grouper | N/A | N/A | N/A | N/A | N/A |
| Red grouper | N/A | N/A | N/A | N/A | N/A |
| Misty grouper | N/A | N/A | N/A | N/A | N/A |
| Warsaw grouper | N/A | N/A | N/A | N/A | N/A |
| Snowy grouper | N/A | N/A | N/A | N/A | N/A |
| Yellowmouth grouper | N/A | N/A | N/A | N/A | N/A |
| Black grouper | N/A | N/A | N/A | N/A | N/A |
| Scamp | N/A | N/A | N/A | N/A | N/A |
| Blackfin snapper | N/A | N/A | N/A | N/A | N/A |
| Red snapper | N/A | N/A | N/A | N/A | N/A |
| Cubera snapper | N/A | N/A | N/A | N/A | N/A |
| Lane snapper | J | J | N/A | N/A | N/A |
| Silk snapper | N/A | N/A | N/A | N/A | N/A |
| Vermillion snapper | N/A | N/A | N/A | N/A | N/A |
| Mutton snapper | N/A | N/A | N/A | N/A | N/A |
| Gray snapper | J | J | J | J | J |
| Gray triggerfish | N/A | N/A | N/A | N/A | N/A |
| Yellow jack | N/A | N/A | J | J | J |
| Blue runner | J | J | J | J | J |
| Crevalle jack | J | J | J | J | J |
| Bar jack | N/A | N/A | J | J | J |
| Greater amberjack | N/A | N/A | N/A | N/A | N/A |
| Almaco jack | N/A | N/A | N/A | N/A | N/A |
| Banded rudderfish | N/A | N/A | N/A | N/A | N/A |
| Atlantic spadefish | J | J | J | J | J |
| White grunt | N/A | N/A | N/A | N/A | N/A |
| Tomtate | N/A | N/A | N/A | N/A | N/A |
| Hogfish | N/A | N/A | N/A | N/A | N/A |
| Puddingwife | N/A | N/A | N/A | N/A | N/A |
| Sheepshead | J | J A | J A | J A | J A |
| Red porgy | N/A | N/A | N/A | N/A | N/A |
| Longspine porgy | N/A | N/A | N/A | N/A | N/A |
| Scup | N/A | N/A | N/A | N/A | N/A |
| Blueline tilefish | N/A | N/A | N/A | N/A | N/A |
| Sand tilefish | N/A | N/A | N/A | N/A | N/A |

| | |
|---|---|
| **SMALL COASTAL SHARKS** | **PROHIBITED SHARKS** |
| Atlantic sharpnose shark | Sand tiger shark |
| Finetooth shark | Bigeye sand tiger shark |
| Blacknose shark | Whale shark |
| Bonnethead | Basking shark |
| **LARGE COASTAL SHARKS** | White shark |
| Silky shark | Dusky shark |
| Tiger shark | Bignose shark |
| Blacktip shark | Galapogos shark |
| Spinner shark | Night shark |
| Bull shark | Reef shark |
| Lemon shark | Narrowtooth shark |
| Nurse shark | Carribean sharpnose shark |
| Scalloped hammerhead | Smalltail shark |
| Great hammerhead | Atlantic angel shark |
| Smooth hammerhead | Longfin mako shark |
| **PELAGIC SHARKS** | Bigeye thresher shark |
| Shortfin mako shark | Sharpnose sevengill shark |
| Porbeagle | Bluntnose sixgill shark |
| Thresher shark | Bigeye sixgill shark |
| Oceanic whitetip shark | **RESEARCH SHARK** |
| Blue shark | Sandbar shark |

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

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

**TABLE 5.4.** EFH categories and geographically defined HAPCs within project vicinity or area and potential impacts of proposed project by activity (Y = yes; N = no; W =within acceptable limits). Refer to Section 5.0 and 6.0 for details.

| | PROXIMITY | | IMPACT ACTIVITY | |
|---|---|---|---|---|
| **ESSENTIAL FISH HABITAT** | **Project vicinity** | **Project impact area** | **Dredge operation** | **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** | | | | |
| **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 |

**Table 5.4** (continued)

| | PROXIMITY | | IMPACT ACTIVITY | |
|---|---|---|---|---|
| **ESSENTIAL FISH HABITAT** | **Project vicinity** | **Project impact area** | **Dredge operation** | **Sand placement** |
| 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 |

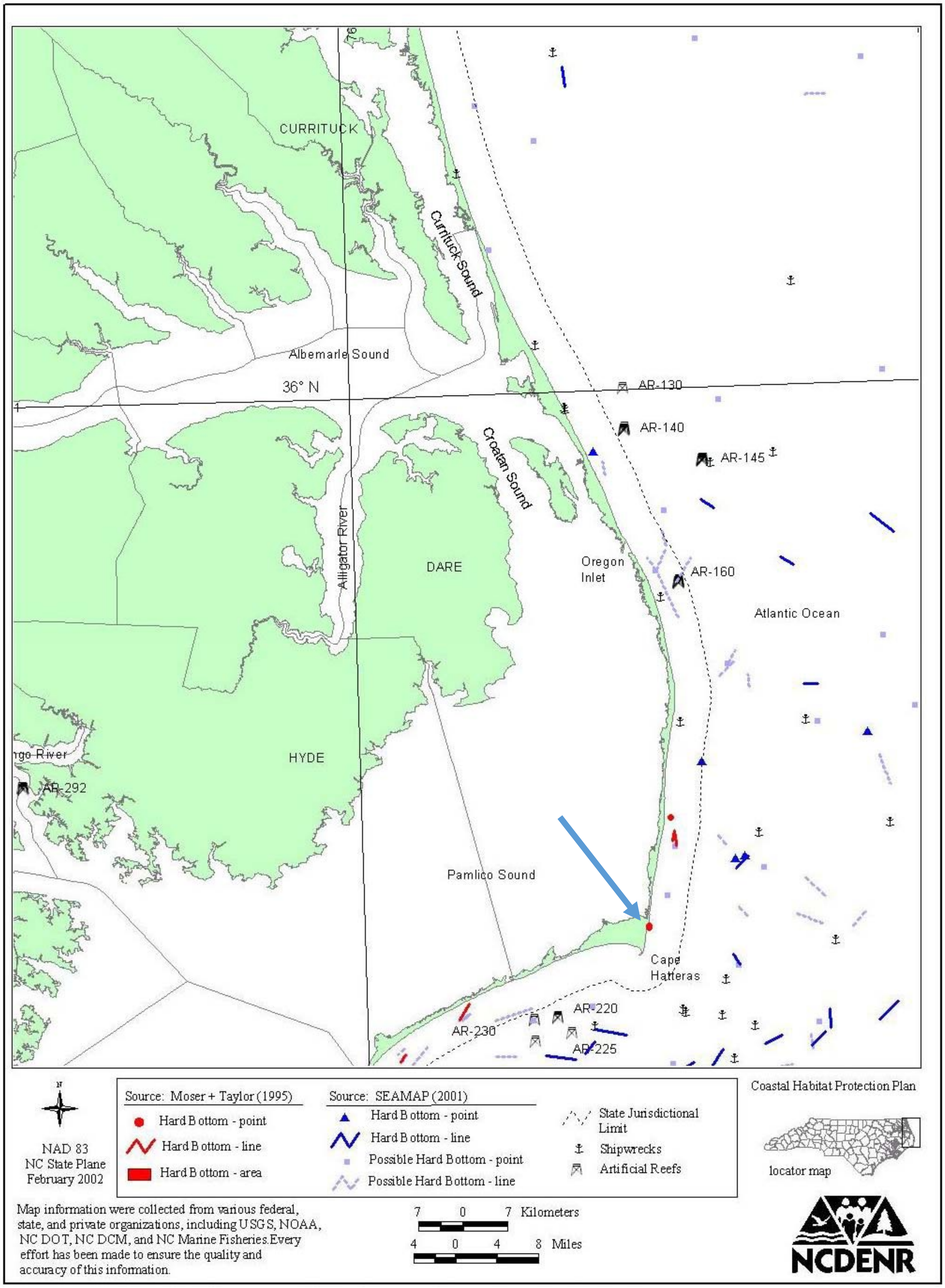



**FIGURE 5.1.** Location of hard bottom, possible hard bottom, shipwrecks, and artificial reefs in state and federal waters off North Carolina- northern coast (from Deaton et al 2010, Map 7.1.a). Blue arrow points to the old groins south of Buxton Village indicated as "Hard Bottom – point."

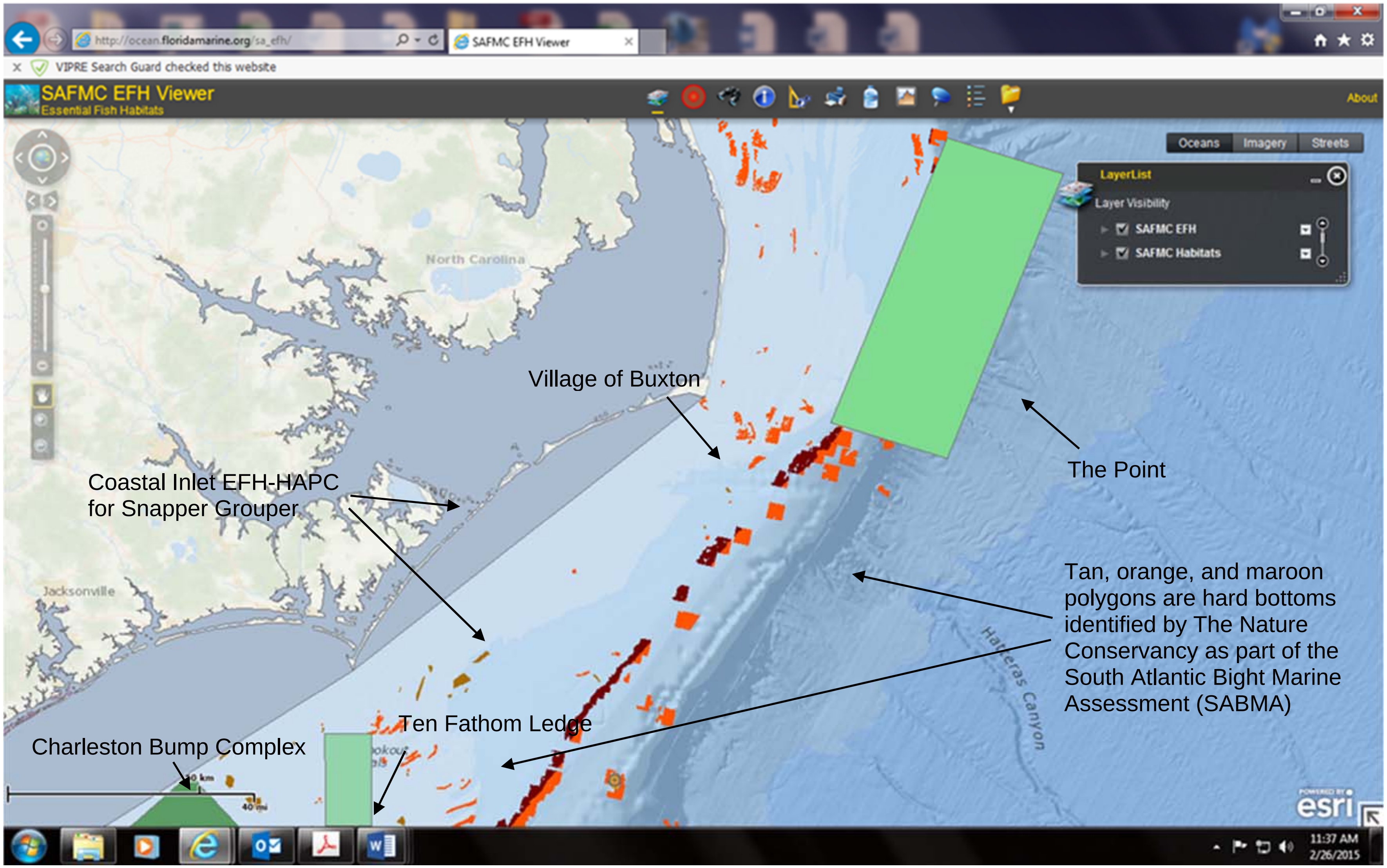



**FIGURE 5.2.** A screen shot of SAFMC designated EFH and HAPC near proposed project (SAFMC EFH Viewer webpage accessed 26 February 2015). The Point EFH-HAPC for coastal migratory pelagics is located approximately 25 miles offshore from Cape Hatteras and the proposed project area.

The potential pipeline corridors for a cutterhead dredge operation or a hopper dredge operation have not been determined at this time. It is anticipated that the project will be constructed via ocean-certified hopper dredge so as to maintain flexibility and safety during temporary demobilization to a safe harbor in rough sea conditions. Offshore hopper dredging operations do not require a continuous pipeline from the borrow area to the beach instead, utilizing a relatively short segment of submerged pipe extending from safe water depths to the shoreline. The anticipated submerged line will be ~2,000 ft and be placed along the bottom more or less normal to the shoreline azimuth. Multiple pumpout points are anticipated for the project (likely a maximum of three corridors). Additional surveys will be conducted once the borrow area and parameters for corridor spacing are confirmed with prospective dredging companies (requirements vary with the size of dredges assigned to the project). All information associated with additional surveys, data analysis, mapping of corridors and proposed buffers will be coordinated with resource agencies prior to construction so as to avoid or minimize resource impacts. Final pipeline corridors also cannot be determined until the time of construction because of the need to avoid designated resource closure areas.

The nearshore zone of impact of the beach fill will be a function of the normal annual to decadal depth of active profile change (i.e., Depth of Closure – DOC) along the foreshore, which for the Buxton and northern Outer Banks area is in the approximate range -19 ft NAVD to -30 ft NAVD (Birkemeier 1985; USACE 2010; CSE 2013). During construction, all nourishment along Nags Head was placed landward of the −12 ft contour. This was confirmed by pre- and post-nourishment construction surveys and post-storm surveys after Hurricane Irene after 85% of the nourishment was in place (CSE 2013). Subsequently, over a three year period, sand from the nourishment project shifted seaward to the approximate −19 ft NAVD contour with additional evidence of minor profile change between the −19 and −30 ft NAVD depth contours. Thus, the zone of impact is initially smaller than the subsequent area receiving inputs of sand. The post-construction adjustment of the profile tends to be rapid (order of weeks to months along the Outer Banks) in the surf zone, but relatively slow and event-driven in deeper water. Available data to date indicate there are no hard-bottom areas along the project shoreline out to a water depth of ~30 ft NAVD.

### 5.1 Potential EFH or HAPC within Project Impact Area and Fish Species which Utilize Them

This section expands upon the EFH or HAPC with the potential to occur within the project vicinity (within 2 miles of project area) or project area (project footprint) shown in Table 5.4. Fish utilization is described in more detail for only those EFH or HAPC found within both the project vicinity and the project area.

5.1.1 Submerged Aquatic Vegetation (SAV) and Seagrass – these shallow estuarine or marine EFHs perform many critical ecological functions and are highly productive for multiple protected and managed species. These species, along with other recreationally important shellfish and invertebrates, utilize the complex SAV habitat for spawning, nurseries, feeding, and refugia. Both the patches of SAV itself (stems, roots, rhizomes, leaves and propagules) and the area between patches are considered SAV habitat. High salinity SAV habitat in NC waters is generally dominated by three species of seagrass, shoal grass (*Halodule wrightii*), widgeon grass (*Ruppia maritima*), and saltwater eelgrass (*Zostera marina*). Siltation, damage from boat props and wakes, and other changes in water quality or substrate affect ability of SAV to thrive and extend coverage. While SAV habitat is extensive in some areas and patchy in other areas of NC waters, the nearest SAV is located in Pamlico Sound, directly across Highway NC 12 to the west, in the back barrier environment. Shown in Kenworthy et al (2012) as covered densely with high salinity SAV, this closest SAV area lies within the project vicinity but outside the project area and the nearest inlet which could transport any waters or sediment from the project area is ~12 miles southwest. **Therefore, this EFH is not evaluated further in this document.**

5.1.2 Oyster Reef and Shell Banks - Oyster reefs and shell banks are intertidal or subtidal estuarine habitats composed of living shellfish or artifact shell material. Several species of specialized fish and invertebrates are associated with oyster reefs as these habitats provide food and cover. Living oyster populations are limited by, among other things, siltation, salinity, and substrate. Throughout their entire Atlantic range, oyster reefs have declined substantially in the last century because of natural and anthropogenic stressors. Efforts currently are underway to regenerate oyster reefs in many states, including NC. Habitat for and likely patches of oyster reef or shell bank are found within the project vicinity in the back barrier environments of Pamlico Sound but none are found within the project area. As mentioned for SAV, the nearest inlet which could transport any waters or sediment from the project area is ~12 miles southwest. **Therefore, this EFH is not evaluated further in this document.**

5.1.3 Estuarine Intertidal Flats – this EFH is extensive throughout Pamlico Sound and is an important component of primary and secondary nursery areas and is considered a soft bottom habitat per Deaton et al (2010). Described by SAFMC as dynamic areas that change and respond to shifts in sediment supply based on patterns of erosion and deposition, this EFH provides habitat for numerous benthic organisms which comprise important dietary components of many managed species and recreationally important fish species. As described for SAV and oyster reef/shell banks, the nearest estuarine intertidal flats lie in Pamlico Sound to the west of NC 12, in the project vicinity but not in the project area. **Therefore, this EFH is not evaluated further in this document.**

5.1.4 *Sargassum* and *Sargassum* Habitat – *Sargassum filipendula* is a benthic brown algae found along the Atlantic coast of the Americas in shallow subtidal zones attached to rocks or shells, but is also found in deeper waters of 80 to 100 ft. In North Carolina, this algae is found predominantly south of Cape Hatteras often growing on jetties near stabilized inlets. As it has larger floats than other species of *Sargassum* and weaker holdfasts, rough weather will often dislocate the holdfasts and it is often carried out to the open ocean where it joins other species of seaweed and *Sargassum* in the Sargasso Sea. Positively buoyant, the larger floats of *S. filipendula* keep it on top of the large floating mats of seaweed common to the Sargasso Sea. Of the 150 species worldwide, two other free-floating species of *Sargassum* are found in the Atlantic, *S nutans* and *S fluitans*. *Sargassum* can occur in large floating mats in the waters of the continental shelf, in the Sargasso Sea, and in the Gulf Stream and can appear as concentrations of small patches (Fig 5.3), large mats, or often miles-long weed lines along current convergence boundaries in the open or coastal ocean (Deaton et al 2010). It circulates primarily between 20° and 40° N latitudes and 30° W longitude and the western edge of the Florida Current/Gulf Stream. Masses of *Sargassum* provide a mobile home for over 100 species of fish, fungi, and micro- and macro-epiphytes, at least 145 species of invertebrates, five species of sea turtles, and numerous marine birds. Roughly 2M square miles in area, surrounded by a ring of currents that rotate a large eddy in a clockwise circulation, the Sargasso Sea receives little wind or rain. The rotation keeps the masses of *Sargassum* and other seaweed in the Sargasso Sea from dispersing into other parts of the ocean.

Legally, SAFMC considers the *Sargassum* vegetation as both EFH and as a "fish" under the Magnuson Stevens Act. Designated EFH or HAPC for Snapper/Grouper and Coastal Migratory Pelagics, it is also the area to which all American and European eels are thought to congregate for spawning. It is a major source of biological productivity in nutrient-poor regions of the ocean; however, unregulated commercial harvest of *Sargassum* for traditional medicines, fertilizer, livestock feed, and the cosmetics industry has prompted concerns over the potential loss of this important resource. Under certain wind conditions, relatively small masses of

**FIGURE 5.3.** Floating mat of *Sargassum* with associated small triggerfish and filefish. (Courtesy of NOAA Ocean Explorer Gallery)

*Sargassum* may wash ashore from the Gulf Stream or outer continental shelf waters and it can also be found occasionally in nearshore waters.

5.1.5 Water column – the water column is the medium which connects all aquatic habitats, provides a basic ecological role for all organisms within it, and performs an essential corridor function for species which depend on more than one habitat for various life stages (Deaton et al 2010). Either or both the estuarine and marine water column are EFH for all managed species and, as shown in Table 5.2, life stages of many of the species are found in the nearby estuarine waters of the North Carolina back-barrier sounds (Roanoke, Pamlico, and Croatan Sounds) and/or nearest inlets (Oregon Inlet is ~30 miles to the north and Hatteras Inlet is ~12 miles to the southwest). Many other managed species can be found in the nearshore marine waters of the proposed borrow area or in the surf zone in the vicinity of proposed sand placement.

5.1.5.1 Estuarine water column – EFH for multiple managed species under various FMPs: coastal demersals (red drum, bluefish, summer flounder), invertebrates (shrimp species), coastal pelagics (e.g., cobia, both mackerels), some sharks, and the snapper grouper complex (e.g., black and rock sea bass, Lane and grey snapper, sheepshead). While the nearest waters of Pamlico Sound are within 1,000 ft or less of the proposed sand placement area, the dry beach, the dunes (where they exist), NC Highway 12, and vegetated and unvegetated habitats separate the project area from the estuarine water column. The distance to the nearest inlet which could connect the project area marine water column to the estuarine water column is ~12 miles to the southwest, therefore this EFH is not evaluated further in this document.

<u>5.1.5.2 Marine water column</u> -– this broad EFH also includes ocean high salinity surf zones EFH for red drum and coastal migratory pelagics, barrier island ocean-side waters from surf to shelf break zone and from Gulf Stream shoreward EFH for coastal migratory pelagics, and spawning area above adult habitat and additional pelagic environment EFH for snapper grouper and shrimp under various FMPs. Additionally, the marine water column is utilized by various life stages of ASMFC species including Atlantic menhaden, shad, spotted seatrout, spiny dogfish, and Atlantic coastal sharks among others. The coastal and nearshore Atlantic Ocean waters of North Carolina occupy a unique location in that the colder southerly Labrador Current (a portion of the North Atlantic gyre) intersects with the warmer northerly Gulf Stream in the vicinity of Cape Hatteras, which also is a biogeographic boundary and is the closest point of land to the Gulf Stream along the mid-Atlantic coast. This collision of currents generally decreases the marine water column temperatures north of Cape Hatteras and increases temperatures south of Cape Hatteras. The collision generates offshore frontal mixing zones which, combined with the varied winds and shifting bottom topography characteristic of Cape Hatteras shoals, causes nutrient-rich upwelling. This upwelling supports a large diversity of larval to adult stages of managed fish, including Highly Migratory Species and results in the HAPC called The Point (as shown in Fig 5.2). These waters concentrate pelagic fauna relatively close to shore from the temperate biogeographic region to the north and tropical to sub-tropical biogeographic region to the south.

Laney et al (2007) indicated that juvenile Atlantic sturgeon (*Acipenser oxyrinchus*) were consistently captured in January - February bottom trawls from 1988 to 2006 in the shallow nearshore waters of North Carolina north of Cape Hatteras, including captures near the Buxton project vicinity. However, most of the captures were concentrated north of Oregon Inlet (Fig 3 of Laney et al, pg 175). An index of the estimated Atlantic coast population abundance for Atlantic sturgeon was developed from the Northeast Fisheries Observer Program (NEFOP) during 2006 to 2011(Kocik et al 2013). The Kocik et al report (2013) includes a map of the capture locations along the North Carolina coast (Fig 1, pg 26) which indicates that Atlantic sturgeon were not captured within the Buxton project area itself but were captured both to the north and south; an absence potentially linked to the distances to an inlet.

The NCDMF (Personal communication, Alan Bianchi, Trip Ticket Coordinator, License and Statistics Section, 15 October 2014) provided summary data for commercial landings in the ocean up to 3 miles off the beach from north of Cape Hatteras to the Virginia border from 2000-2013. Figure 5.4 shows the dominant species by tonnage and the list below provides additional information from the NCDMF summary data:

- Total taxa richness = 108 (2000-2007 = 92; 2008-2013 =89)
- Total sample = 20,377 tons
- Managed species comprised 34.3% of total as follows:
  Coastal demersals = 15.8%
  Sharks = 14.5%
  Coastal pelagics = 3.4%
  Snapper/grouper = 0.3%

Highly migratory = 0.2%
Invertebrates = <0.1%

- Top fish species taken was Atlantic croaker (*Micropogonias undulatus*) = 43.1%
- Other top fish species taken were less than 10% of total as follows:

Spiny dogfish (*Squalus acanthias*) = 9.3%
Bluefish (*Pomatomus saltatrix*) = 9.1%
Flounders (*Paralichthid*) = 6.7%
Striped bass (*Morone saxatilis*) = 6.6%
Menhaden bait (*BRevoortia tyrannus*) = 4.3%
Gray trout (*Cynoscion regalis*) = 3.9%

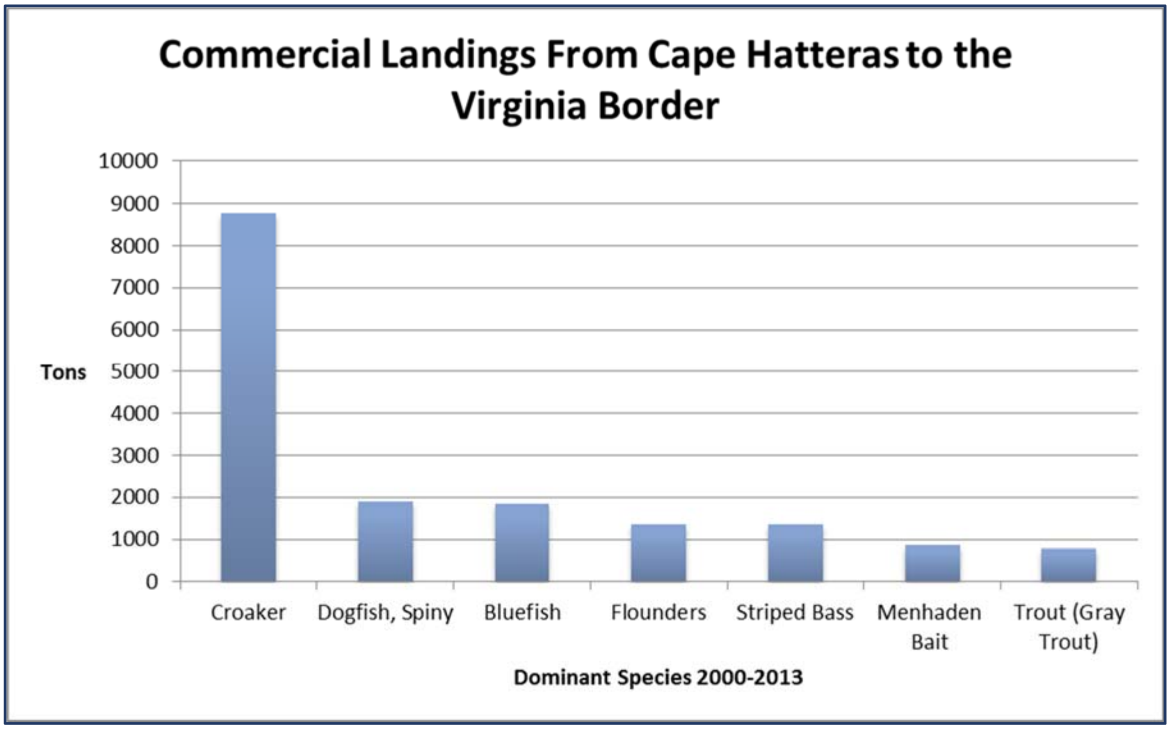



**FIGURE 5.4.** Dominant fish species caught in commercial landings from 2000-2013 per NCDMF.

Summary data for recreational landings (beach and up to 3 miles offshore) at Buxton access sites from 2004-2013 was also provided by NCDMF (Personal communication, Chris Wilson, Biologist II, License and Statistics Section, 23 January 2015). These data were collected by interception of anglers and catch observation at different fishing access locations in the Buxton project area (beach and various marinas). Unlike the commercial landings data, these data are not separated by year and summarize total observed catch by species for the entire period. Figure 5.5 shows the dominant species by total catch (individuals) and the list below provides additional information from the summary recreational NCDMF data:

- Total taxa richness = 50 (2004-2013)
- Total sample = 22,648 individuals
- Managed species comprised 39.6% of total as follows:
  - Coastal demersals = 29.5%
  - Coastal pelagics = 7.3%
  - Sharks = 1.7%
  - Snapper/grouper = 0.9%
  - Highly migratory = 0.2%
- Top fish species taken was bluefish = 26.6%
- Other top species taken were as follows:
  - Spot (*Leiostomus xanthurus*) = 19.6%
  - Spanish mackerel (*Scomberomorus maculatus*) = 7%
  - Southern kingfish (*Menticirrhus americanus)* = 6.8%
  - *Unidentified kingfish (Menticirrhus* spp.*)* = 4.8%
  - *Spotted seatrout (Cynoscion nebulosus*) = 4.5%
  - Northern kingfish (*Menticirrhus saxatilis*) = 3.1%

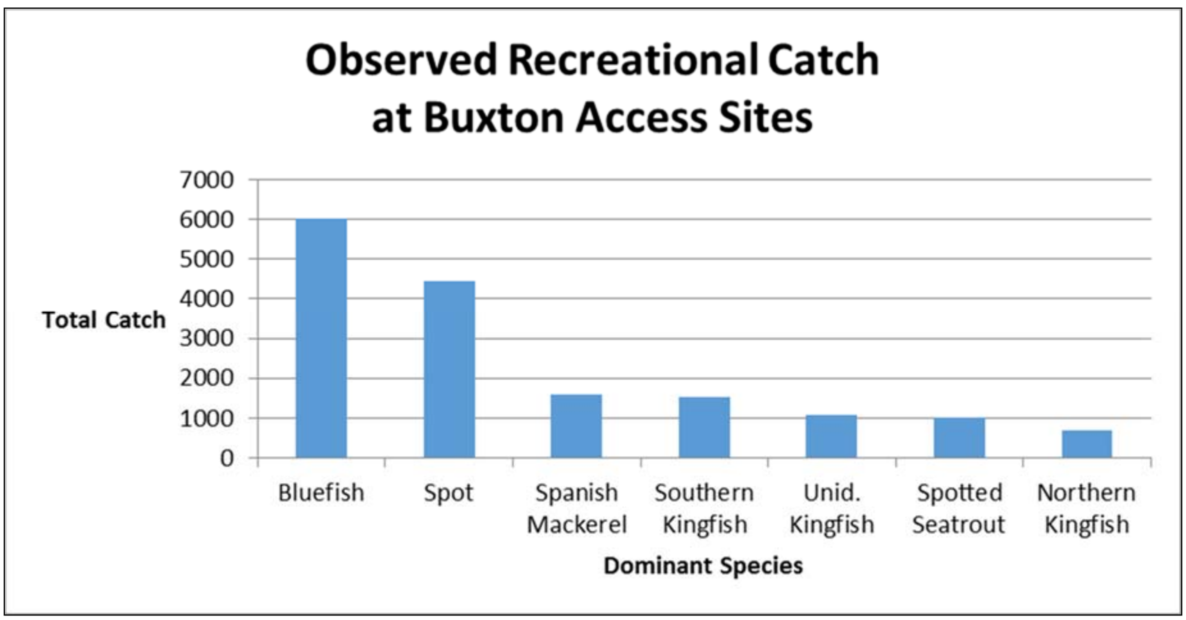



**FIGURE 5.5.** Dominant fish species observed during recreational angler intercepts from 2004-2013 per NCDMF.

5.1.6 Artificial/man-made reefs – used for centuries to enhance fishery resources prior to their designation as EFH, these areas serve many of the same functions as natural reefs whether they are a natural shipwreck, a deliberately sunken ship, or other man-made structure (e.g., jetty, groin, reef ball). As a fishery management tool, properly constructed and strategically sited artificial reefs help offset the loss or damage of natural reef habitat to bottom-fishing gear and pollution and rebuild reef-associated fish stocks (NOAA 2007). In North Carolina, the NCDMF Artificial Reef Program manages four reefs offshore which are shown on Figure 5.1 (AR-130, AR-140, AR-145, and AR-160). All four of these sites are outside of the project vicinity. Dredging in Borrow Area C and placement of material associated with proposed project would not be expected to adversely affect artificial reef sites managed by the Artificial Reef Program. **Therefore, this EFH is not evaluated further in this document.**

5.1.7 Primary and Secondary Nursery Areas (PNAs/SNAs) – these EFH/HAPC areas are designated as areas of importance for managed fish by the North Carolina Marine Fisheries Commission and are defined by North Carolina as tidal saltwaters that provide essential habitat for the early development of commercially important fish and shellfish (http://www.ncfisheries.net/rules.htm, 15 NC Administrative Code 3B .1405). These habitats are also of particular importance to multiple species important to North Carolina fisheries as identified in NC Coastal Habitat Protection Plan (CHPP) (Deaton et al 2010) and various life stages of numerous ASFMC-managed species as shown in Table 5.4. All PNAs/SNAs serve as EFH for egg, larval, and juvenile life stages of coastal migratory pelagics and shrimp, as can be inferred from listed species in Table 5.2; however, the closest designated nursery habitat occurs ~29 miles away on the mainland in western Pamlico Sound (tributaries to Pains Bay and Long Shoal River) and the nearest inlet which could transport fish to those PNAs is ~12 miles to southwest of the project area. **Therefore, this EFH/HAPC is not evaluated further in this document.**

5.1.8 Unconsolidated/shallow subtidal bottom – this EFH consists of soft estuarine or marine sediments inhabited by a diverse assemblage of invertebrates that serve as prey to demersal fishes. Typically very mobile in response to wave and current conditions, these sediments lack stable surfaces for extensive vegetation or animal attachment. Changes in type or amount of sediment supply, energy of wave and currents, and changes in water quality chemistry drive the biodiversity within this EFH. In the project vicinity, this EFH is found beneath both estuarine and marine waters, but for the same reasons given for other estuarine EFHs above, only the marine sediments of this EFH will be evaluated further. The offshore component of this EFH is typically more taxa rich than the surf zone and nearshore components because of differences in sediment transport forces and the dynamics of breaking waves in the surf zone. Marine EFH of this type is found both within the project vicinity (within 2 miles of project area) and within the project area itself (Borrow Area C and Buxton beach intertidal beach/surf zone).

5.1.9 Cape Hatteras shoals – these shoals are part of the sandy shoals of capes and offshore bars EFH for coastal migratory pelagics and summer flounder and a habitat of concern for red drum. Such shoals include the marine soft bottom community identified and discussed in the CHPP (Deaton et al 2010). Diamond Shoals at Cape

Hatteras are a major sink in the coastal sediment transport system and are formed by convergent waves and longshore currents associated with cuspate forelands (Moslow and Heron 1994). The shoals are fed by sand moving south along the north segment of Hatteras Island under predominant northeast winds and waves, and sand moving east along the southern arm of Hatteras Island under prevailing southwest winds and waves. Diamond Shoals encompass over 15,000 acres of shoal habitat (an area approximately 7 by 2.5 nautical miles extending southeast from Cape Point beginning ~12,000 ft south of the project area. A continuous supply of sand from adjacent beaches feeds Diamond Shoals and maintains them as an underwater extension of the coastline (Armstrong et al 2013). Diamond Shoals contains roughly 100 times the volume of sediment in the proposed borrow area within the upper ~ 8ft of substrate.

Cape Hatteras also marks a convergence zone where southerly Labrador Current meets the northerly flowing Gulf Stream. This dynamic mixing zone of oceanic waters marks a distinct transition between warmer Gulf Stream waters and cooler waters to the north with associated changes in dominant species. For example, in a 4 February 2015 email to the author, Randy Swilling (Acting Division Chief, Resource Management at Cape Hatteras National Seashore) indicated that turtle nesting numbers per mile of shoreline decline north of Cape Point. Cape Hatteras shoals represent the northern and the southern terminus of the range of numerous species and results in a diverse biological assemblage. These shoal habitats support seasonal congregations of bait fish which are then preyed upon by numerous managed species (e.g., red drum and Spanish mackerel), often serve as staging areas for other coastal migratory species, and the larger shoals north of Cape Hatteras (Wimble and Kinnakeet) serve as spawning habitat for summer flounder aggregations (Deaton et al 2010). Nearshore ocean waters and subtidal bottom habitat also serve as important pupping areas for several species of small coastal sharks (e.g., Atlantic sharpnose, bonnethead, blacknose shark); larger coastal sharks pup in these areas to a lesser extent. While not considered to be within the nearby Kinnakeet Shoals found north of the project area, the smaller shoal targeted within Borrow Area C does appear to be oriented along a similar axis as Kinnakeet and likely formed under similar dynamics and performs similar functions (fig 5.5).

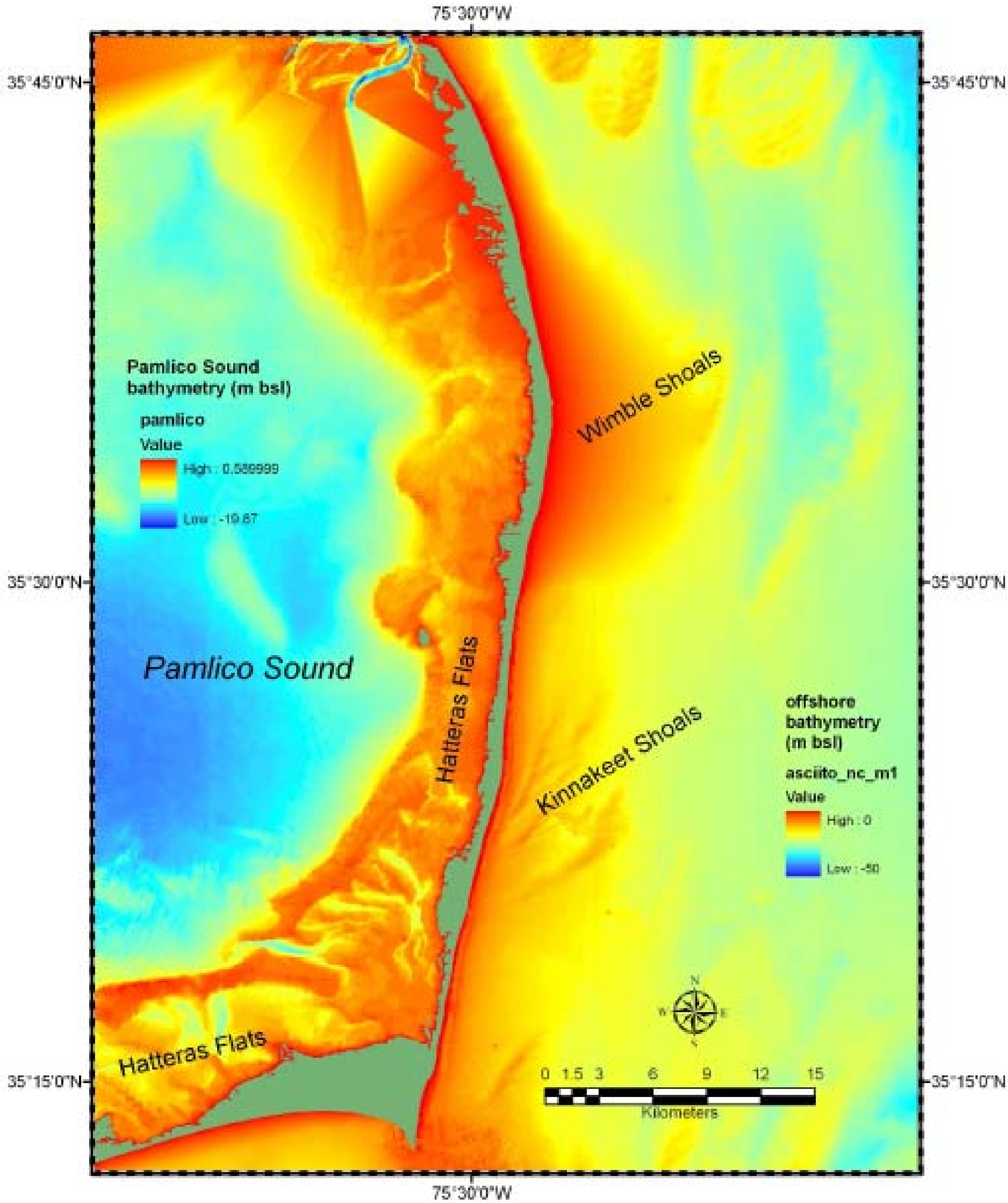



**FIGURE 5.6.** From Mallinson et. al., 2009, which shows Wimble and Kinnakeet Shoals to the north; the smaller ridge feature to the immediate west end of the map scale is the ridge of Borrow Area C.

## 6.0 POTENTIAL EFFECTS TO EFH, HAPC, OR LIFE STAGES OF ASSOCIATED MANAGED FISH

Increased development of barrier islands and increased erosion of low-lying barrier island segments without adequate dunes have resulted in dredging (both inlet maintenance and excavation of offshore sites) and beach placement of dredged sediments as common practices in coastal North Carolina. Out of 326 miles of ocean shoreline in North Carolina, 86 miles (~26%) have been nourished at least one time and an estimated total of 163 miles (50%) have either received nourishment or are being considered for nourishment sometime in the future (NCDENR, unpublished data, 2014). The average renourishment interval has been 4.4 years for North Carolina projects. This means that in a given year, ~6% of the North Carolina coast has been subject to beach reconstruction over the past several decades. If renourishment intervals remain the same, potential additional areas considered for nourishment may increase the proportion of beaches being actively nourished in a given year to ~11%. The construction duration of nourishment for any single project is typically ~3 months. Potential effects to marine resources (including food sources and various life stages) or their habitats from dredging or placement of sediments may include some or all of the following: reduced food availability, direct habitat removal or burial, increased water column turbidity, dissolved oxygen reduction, contaminant and nutrient release, character changes in benthic sediment, character changes in benthic composition of infauna, suspension and dispersion of infauna, and entrainment. The potential effect varies from project to project and is dependent on methods, frequency, season, location, and the marine resources present in the project area.

Over the past few decades, improved dredging methods, equipment, and techniques, improved project design, sustained interagency collaboration and coordination, establishment of sediment criteria, regional planning, and specific permit conditions have all contributed to the minimization of these potential effects. Largely due to these improvements and collaboration, for their NEPA process and permitting, the Wilmington District Corps of Engineers has determined that most beach nourishment projects in North Carolina can now be properly evaluated with a detailed Environmental Assessment/Finding of No Significant Impact (EA/FONSI) instead of an environmental impact statement (Personal communication, Raleigh Bland, Dare County regulatory representative, Wilmington District).

### 6.1 EFH and HAPC

Table 5.4 lists the EFH categories and geographically defined HAPCs within the project area or vicinity and only those categories/features in the Impact Activity columns in this table which have designations other than N (for No potential impact) are discussed below with emphasis on the SAFMC resource specifically designated to that EFH or HAPC as shown in Table 5.3. Appendix A contains descriptions of both cutterhead and hopper dredge equipment, potential sedimentation and turbidity effects from their operation, and a summary table of minimization measures extracted from the final EFH Assessment for the Emergency Beach Fill Along NC Highway 12 in Rodanthe, Dare County, North Carolina (Sections 13.1 and 13.2 and Table 4 from USACE 2013).

For additional details on differences between dredge types and the summary of various methods to reduce impacts, please refer to Appendix A (CSE edits are shown in italics).

6.1.1 Sargassum - pelagic *Sargassum* is positively buoyant and, depending on the prevailing surface currents, remains in waters of the continental shelf for extended periods or can be cast ashore when storm currents and wind allow such onshore/nearshore transport. Therefore, pelagic *Sargassum* species could drift through the vicinity of the dredge operation in Borrow Area C or, depending on wind and currents, could drift into the nearshore or surf zone. Because it occurs in the upper few feet of the water column, it is not subject to direct effects from dredging, although sediment placement activities associated with the proposed project could introduce temporary turbidity in the shallow water column during sand placement. However, this turbidity is short-lived and will likely duplicate storm conditions; thus, no impacts are expected to this EFH or its associated managed fish species. If floating mats are encountered during dredging or are washed ashore during sand placement and are buried, these mats would represent a very small portion of the EFH or HAPC available. Since *Sargassum* occurs in the upper few feet of the water column and is not commonly found in the project area, **the project is not expected to have any impact on this EFH or HAPC or the life stages of managed species which utilize them; any impacts that may occur are expected to be minor and within acceptable limits.**

6.1.2 Marine water column - Dredging and sand placement activities conducted during project construction will occur in the marine water column in the immediate vicinity of the borrow area and the target beach which have the potential to impact nearshore and intertidal surf zone resources of both larval, juvenile, and/or adult life stages. These impacts may include minor and short-term sediment plumes (and related turbidity) as well as the release of trace constituents from the sediment. Marine sediments can be sinks/reservoirs for various pollutants most typically sourced to atmospheric or riverine deposition. Trace constituents found in the sediments which may be released into the water column during dredging or sand placement activities in connection with beach nourishment projects are usually associated with source sediment having proximity to either an active or old port, wastewater treatment facilities, effluents from industries, or undocumented spill of pollutants. Additionally, nutrients can accumulate in various soft bottom sediments and be reintroduced into the water column when disturbed. Although it could possibly contain constituents from an unknown spill, Borrow Area C is a naturally formed, high energy shoal located at considerable distance from a port, inlet, or known effluent source so it is unlikely to release harmful contaminants or nutrients during dredging or placement activities. The borrow area is regularly exposed to waves greater than 10 ft and generally exhibits only trace amounts of fine-grained clays to which contaminants can adsorb.

Other effects from turbidity in the water column would include changes in light penetration and visibility which may be either beneficial or problematic (whether predator or prey) and can interfere with nutrient availability for filter-feeders. Because the proposed borrow area consists of >99% sandy or gravelly material, settling of sediments placed into suspension during dredging operations is expected to be rapid and measured in minutes, returning the borrow area to ambient conditions soon after cessation of operations.

Turbidity in the water column from beach placement of sand may create localized stressful habitat conditions and may result in the temporary displacement of fish and other biota. Given the high-energy offshore environment and the coarse sediment composition, the turbidity plume created is expected to be short-lived. Coarse sediments have much higher settling velocities than finer material (Table 6.1). Fine-grained sediments (such as silts and clays) produce greater and longer lasting turbidity plumes, which can impact large areas of the sea floor more than coarser, sand-sized material (USACE 2002). Suspended sediments settle at predicted rates depending on grain size as shown in Table 6.1 below. The time necessary for sediments in the turbidity plume to settle whether in suspension from dredge activity, in the slurry itself, or resuspended during manipulation is also affected by current and wave climate in the borrow area during dredge activity and in the intertidal zone during placement and manipulation. While turbidity plumes associated with dredging are often short-lived and may affect relatively small areas, subsequent resuspension and redispersal of dredged sediments can be propagated beyond the dredged area for extended periods in certain wave climates (CSA International et al 2010). However, these affects are minimal in sandier offshore areas like Borrow Area C.

**TABLE 6.1.** Sediment settling velocities. [$d_S$- sieve diameter. $d_V$- volume sphere diameter. $d_F$- sedimentation diameter. *Wentworth Classification.]

| ds (mm) | dv (mm) | df (mm) | @ 10°C (m/sec) | @ 20°C (m/sec) | *Sand Classification |
|---|---|---|---|---|---|
| 0.089 | 0.10 | 0.1 | 0.005 | 0.007 | vf |
| 0.126 | 0.14 | 0.14 | 0.010 | 0.013 | vf-f |
| 0.147 | 0.17 | 0.16 | 0.013 | 0.016 | f |
| 0.208 | 0.22 | 0.22 | 0.023 | 0.028 | f |
| 0.25 | 0.25 | 0.25 | 0.028 | 0.033 | f-m |
| 0.29 | 0.30 | 0.29 | 0.033 | 0.039 | m |
| 0.42 | 0.46 | 0.40 | 0.05 | 0.058 | m |
| 0.59 | 0.64 | 0.55 | 0.077 | 0.084 | c |
| 0.76 | 0.80 | 0.70 | 0.100 | 0.110 | c |
| 1.25 | 1.40 | 1.00 | 0.15 | 0.160 | vc |
| 1.8 | 1.90 | 1.20 | 0.17 | 0.170 | vc |

The impacts associated with this project from turbidity may be similar, on a smaller scale, to the effects of storms. Storm effects also generally include increased turbidity and suspended sediment load in the water column and, in some cases, changes in fish community structure (Hackney et al 1996). Severe storms have been associated with fish kills, but such situations are not associated with beach disposal of dredged sand. Turbidity will be most noticeable in proximity to the slurry discharged from the pipe head which operates ahead of the beach building activities. The section of beach affected per day will vary from 800 to 1,000 ft in length with 400 ft per day as the estimated completion rate. Elevated turbidity levels were detected within up to ~500 ft down-current of the discharge point along Nags Head during the 2011 project (CSE 2012). The discharge plume was generally not detectable at greater distances.

Van Dolah et al (1994) assessed turbidity conditions associated with a beach nourishment project at Folly Beach (SC), where native mean grain size is ~0.2 mm, and drew the following conclusion:

> Although dredge effluent does increase turbidity levels in the immediate vicinity of the outfall, there are many other factors such as local weather and wave energy that will also produce this effect. The turbidity levels at Folly Beach during nourishment and the dispersal of the sediment plume were not considered unusual or severe relative to normal fluctuations and background levels.

As mentioned in USACE (2014) in their Environmental Report on the Use of Federal Offshore Sand Resources for Beach and Coastal Restoration in New Jersey, Maryland, Delaware and Virginia (MMS 1999), the U.S. Department of Interior BOEM (previously MMS) provided the following assessment:

> In order to assess if turbidity causes an impact to the ecosystem, it is essential that the predicted turbidity levels be evaluated in light of conditions such as during storms. Storms on the Mid-Atlantic shelf may generate suspended matter concentrations of several hundred mg/L (e.g., Styles and Glenn 1999). Concentrations in plumes decrease rapidly during dispersion. Neff (1981, 1985) reported that solids concentrations of 1000 ppm two minutes after discharge decreased to 10 ppm within one hour. Poopetch (1982) showed that the initial concentration in the hopper overflow of 3,500 mg/L decreased rapidly to 500 mg/L within 50 m. For this reason, the impact of the settling particles from the turbidity plume is expected to be minimal beyond the immediate zone of dredging.

Burlas et al (USACE 2001) found that certain fish species (e,g., kingfish) were attracted to higher turbidity waters, whereas other species (e.g., bluefish) avoided high turbidity water around the discharge pipe during a major nourishment project along the central New Jersey coast. This study indicates that fish may seek as well as avoid locally turbid water associated with beach nourishment and that the presence of elevated turbidity can repel, or even attract, certain species dependent upon their particular adaptive behavior. In addition to USACE 2001, other studies have also found insignificant impact or even a temporary increase in surf zone fish populations associated with nourishment projects as possibly attributed to:

1) release of nutrients and infauna during dredging,
2) wide-foraging nature of surf zone fish, or

3) short term stay of migratory fish in the project area (Deaton et al 2010).

So while highly migratory managed species such as bigeye, bluefin, skipjack, and yellowfin tuna all have been documented as juvenile and adults in Hatteras Inlet and presumed to be in the waters near Buxton, it is unlikely these species will be affected by the associated turbidity of the proposed project.

Fish larvae in the ocean waters near Oregon Inlet generally travel westward until they encounter the shoreline then migrate along the shoreline until they encounter the inlet (USACE 2002b). As stated in the EFH assessment prepared for the recent Rodanthe project by the USACE (2014), results from larval ingress and egress studies suggest that larval transport from offshore shelves to estuarine nursery habitats occurs in three stages: offshore spawning grounds to nearshore, nearshore to the locality of an inlet or estuary mouth, and from the mouth into the estuary (Boehlert and Mundy 1988). Results from the Hettler and Hare 1998 study suggest two bottlenecks for offshore-spawning fishes with estuarine juveniles: the transport of larvae into the nearshore zone and the transport of larvae into the estuary from the nearshore zone. While the methods fish larvae use to cover large distances over the open ocean and find the inlets to their estuarine nurseries is uncertain, both passive and active methods of movement are suspected along with use of environmental cues such as salinity, depth, temperature, swells, etc. Various studies have hypothesized passive wind and depth-varying current dispersal and active horizontal swimming transport. However, data is limited regarding larval distribution in the nearshore area. As indicated in USACE (2014), population level calculations of larval entrainment from hydraulic dredging activities were *insignificant* within a representative high concentration *inlet bottleneck* at Beaufort Inlet, North Carolina. Therefore, the risk of larval entrainment from dredging activities in the offshore Borrow Area C associated with this project would likely be even less. However, some larvae in the marine water column adjacent to the beach could be buried or injured during sand placement activities but not in numbers that would have a long-term effect at the species level. Diamond Shoals lies between the Buxton project area and Hatteras Inlet (the nearest inlet). Currents and waves associated with these shoals act as a barrier to longshore transport which naturally converges toward Diamond Shoals (Deaton et al 2010) and therefore likely divert seaward a component of larvae drifting in the littoral current in the Buxton vicinity.

Very few peer-reviewed papers have discussed responses of fish larvae or eggs to man-made sounds and while many other factors may be at play in responses of juveniles and adults to man-made noise or to any long-term consequences, one of the most important will be largely determined by presence or absence of a gas bladder (Popper et al 2014). Gas bladders, along with their location within the body, make fish more susceptible to pressure-mediated injury to the ears and other tissues than those without and allow fish to detect a broader frequency range and at greater distances (Popper et al 2014). Most bony fishes have gas bladders while the more primitive cartilaginous fishes (sharks and rays) do not. Despite recent interest and increased concern, wide information gaps make it very difficult to draw conclusions about the nature and levels of man-made sounds and their potential to cause harm on fish, turtles, or invertebrates (Hawkins et al 2014).

For the reasons described above, marine water column EFH will experience temporary turbidity from both the dredge operation and the sand placement activity along with the potential for some fish or benthos larval death and/or injury from turbidity; however, mobile juvenile and adult fish species have the ability to locate away from the most disruptive activities. Noise levels may result in avoidance behaviors in some mobile fish species but levels are not expected to cause hearing damage. Feeding activities of fish that predate on the benthic invertebrates may be temporarily interrupted but these interruptions are considered minor. **These effects are not expected to be long-lasting or cause significant impact to this EFH or the life stages of managed species which are found within this habitat.**

<u>6.1.3 Unconsolidated/shallow subtidal bottom (marine only)</u> – this EFH is extensive and includes all areas of submerged or intertidal bottom seaward of the beach not considered hard bottom. This EFH provides large areas of nursery and foraging grounds for managed fish and invertebrates. Dredging of sediments in Borrow Area C will disturb and dislodge benthic organisms and either cause mortality from burial or entrainment or disrupt their normal behaviors during the disturbance window. Beach disposal of the dredged sediments can affect fishery resources through burial of intertidal and surf zone resources that managed fish may utilize. However, some demersal fish species are sometimes attracted to this type of disturbance and feed on the numerous fauna that may be suspended in the water column from the dredging or disposal activity. Other more sensitive demersal species can opt to move away to adjacent feeding areas. While Deaton et al (2010, page 364) acknowledge "the relative quick recovery on intertidal and shallow subtidal benthic communities" associated with soft stabilization projects on oceanfront shorelines, without adequate best management practices known to enhance biological recovery, recovery rates in mined areas are usually longer.

While not specifically designated as EFH, HAPC, Primary Nursery Areas (PNAs) or Strategic Habitat Areas, Rippled Scoured Depressions (RSDs) and Rippled Channel Depressions (RCDs), are recognized as important soft bottom habitat and such features provide a diversity of structure for fish and benthos in the nearshore environment (Deaton et al 2010). As a nourished beach equilibrates, sediment placed in the targeted nourishment zone could gradually move within these nearshore RSD/RCD features which shift seasonally in response to wave action. However, as stated in USACE (2014), Thieler et al (1999 and 2001) demonstrated it is likely that the features would be maintained through the self-reinforcing pattern in response to both along- and across-shore flows independent of beach nourishment activities. Therefore, benthic organisms normally associated with fine- and coarse-grained sediments in the nearshore component of this EFH are not likely to be significantly altered by the project.

Managed species, whether piscivorous or not, are attracted to this EFH largely due to its use by their preferred food, a process driven by the dynamics of a typical food web which is built from the bottom to the top and largely dependent on the benthic community in the unconsolidated sediments. Spatial and temporal variation in the benthic community prey species can therefore affect growth, survival, population levels of predators and all higher trophic level species (Normandeau Associates 2014). The annual and seasonal variability in the benthic community of this EFH is well documented and when subject to storms during a monitoring period (hurricanes or northeasters common to the Outer Banks) project effects can be difficult to discern with confidence (Deaton et al 2010). However, known factors which maximize benthic biological recovery rates in the offshore portion of this EFH include use of hopper dredges, shallow excavation, use of topographic highs, and rate of sand movement. In US Gulf and Atlantic sandy borrow areas studied within BOEM jurisdiction, general faunal recovery (total abundance and biomass) has been shown to vary from 3 months to 2.5 years; however, paucity of long term studies suggest that diversity and dominants composition may take 3.5 years (Michel et al 2013). Those factors which maximize recovery in the beach intertidal zone include grain size (similarity between native beach and borrow source is considered the most important factor), season of nourishment (winter placement avoids peak recruitment periods), frequency of nourishment (allow for growth to maturity across years), location of sediment placement (maintain stable geomorphology across the normal beach seasonal profile to ensure sand remains in the system as long as possible), and rate of longshore transport (upstream recruitment opportunity). No infilling fines in the borrow area and accurate placement of properly sized sediment at Nags Head Beach in 2011 allowed a full suite of species similar to the native beach and offshore zone to recolonize the impact areas within one season and by the second year taxa richness and abundances were similar to controls (CZR 2014).

In such environments frequently disturbed by natural events, infauna are well adapted to such perturbations by being small bodied, short lived, with a maximum rate of fecundity, efficient dispersal mechanisms, dense settlement, and rapid growth rates. Burial or temporary exposure from dredging could also be beneficial or problematic depending on species and niche (a more mobile fauna may be able to dig vertically to the new surface and avoid burial and less mobile prey species temporarily exposed may provide more available food source for predator species). However, it is recognized that tube dwellers and permanent burrow dwellers are most susceptible to these types of disturbances compared to more mobile organisms. On a spatial scale which far exceeds the Borrow Area C shoal itself, another system driver which can affect both speed and diversity of biological recovery of a post-disturbance benthic assemblage is variability in supply, transport, and settlement of larvae for some species (CSA International et al 2010). **While some disturbance, mortality, and burial will occur with dredging and sand placement activities, these effects are not expected to be long-lasting or cause significant impact to this EFH or the life stages of managed species which are found within this habitat.**

6.1.4 Cape Hatteras shoals – the Cape Hatteras sandy shoals (a.k.a., Diamond Shoals) are located directly south of the project area off Buxton and extend for up to 14 miles. These unconsolidated shoals are equivalent to soft bottom habitat as described in Deaton et al (2010; Chapter 6). Borrow Area C is a small isolated ridge oblique to the axis of the main complex of Diamond Shoals which is located ~2 miles to the south. Geotechnical data (CSE 2015) confirm there is uniformity of sediment size and type within the full section of the proposed dredge cut, with similar quality surficial sediments expected to be left in place after excavations of overlying material. These mobile soft sediments with various topographies serve as congregation areas and secondary nurseries for many managed and commercially important fish species that feed on benthic fauna [e.g., per Deaton et al (2010)–spiny dogfish, striped bass, and juvenile Atlantic sturgeon] are known to aggregate off the Outer Banks in the winter. Of potential interest, recent satellite tagging data on spiny dogfish indicate that benthic trawl data may not accurately represent the status of the species as unexpected movement patterns shown by the tagged fish demonstrates that spiny dogfish utilize more of the water column than previously thought making them less available to benthic gear (Carlson et al 2014).

Compared to larger named complexes like Kinnakeet Shoal, Wimble Shoals, or even the cape-associated Diamond Shoals, Borrow Area C is a small somewhat isolated ridge; however, the ridge and nearby flatter habitat provide complexity for some species of fish and invertebrates. Site specific information about the fish and invertebrates found within Borrow Area C was not located, but biological resources which may be common in the area can be inferred. Any vertical relief can provide refugia for an abundance of potential prey which then affords more suitable foraging ground and likely attracts more predators. A deeper understanding and appreciation for the diversity of demersal and pelagic fishes associated with shoal complexes has been gained with recent studies in the Mid-Atlantic Bight (predominantly north of Maryland) and support their designation as EFH (e.g., pelagics such as bay anchovy, Atlantic menhaden, Atlantic mackerel, butterfish, striped bass). Potential feeding, spawning, and maturation can take place in these habitats during fall and spring migrations of numerous managed and unmanaged fish species, especially those behaviorally and morphologically adapted to bottom feeding in sedimentary environments (skates, scups, drums, searobins, black seabass, flounders) CSA International 2010).

The water depth in shallowest portion of Borrow Area C proposed to be dredged ranges from about 30 to 35 ft (9 to 11 meters) at the top of the ridge to about 40 to 45 ft (12 to 14 meters) in the flatter topography on either side of the gentle slopes of the ridge. As described in the EFH assessment for the 2014 nearby Rodanthe beach nourishment project, modeling performed for that project showed that for shoals in water depths like Borrow Area C, waves more likely influence their formation rather than currents (USACE 2013). However, Borrow Area C depths are at the shallower end of the 10 to 30 m range of the model range. Another model suggests that post-dredge infill of borrow areas is largely dependent on whether or not the ridge is active, whether or not there is sand available for refilling, and the actual dredging location within the ridge (CSA International et al 2010). This model suggests that the best location for dredging on a shoal or ridge, at least from a physical standpoint, is the leading, down-drift edge as the borrow scour area can then be fed by ongoing physical (wave) processes which if active, are presumed to quickly refill the borrowed area. The ridge crest would be the second best, followed by the trailing edge. If the ridge is not active, only larger scale processes, e.g., major storms will rebuild the ridge. The Dibajnia and Nairn (2011) model referred to in the Rodanthe EFH assessment also tested various dredging methodologies and subsequent reformation scenarios in order to suggest ways to dredge offshore that would protect and maintain the morphologic integrity of ridge and shoal features; thereby also affording protection of or reestablishment of benthos and fish habitat.

Only coarse grain sediment (≥90% sand) will be placed on the ocean beach strand in Buxton and any turbidity with this placement is not expected to extend to the Cape Hatteras sandy shoals. However, turbidity associated with the removal of sediment from the offshore Borrow Area C (in an unnamed shoal adjacent to the larger shoal) will have short term impacts on the water column in the immediate vicinity and potentially allow some settlement of fines to the bottom. However, the associated turbidity effects from dredging in Borrow Area C and from sand placement on the Buxton beach will not adversely impact the Cape Hatteras Sandy Shoals with altered longshore currents or altered tidal climate.

Dredge operations on the unnamed shoal in Borrow Area C will alter the geometry of the existing sand feature which can alter benthic species recruitment patterns, especially if the area refills with finer grained sediments. However, effects of these alterations will be minimized by the method and location of targeted cutting such that portions of the habitat structure unique to the feature and important to resource use will be maintained. A combination of physical and environmental variables (e.g., temperature, depth, current facing versus lee side) as well as differences in sampling season or gear type bias (otter trawl versus beam trawl) all contribute to differences in cross-shelf species assemblage distributions among research studies of shoals. Studies of shoals in the Mid-Atlantic Bight show most diversity, taxa richness, and abundance documented from the flats adjacent to shoals and according to Slacum et al 2010, winter was the period of lowest finfish and invertebrate use of shoal habitat (Diaz et al 2004, Slacum et al 2010, and Normandeau Associates 2014). Vasslides and Noble (2008) evaluated shoreface sand ridges as habitat for fishes of the northeast coast and noted that shoreface sand ridges may have a distinct influence on fish abundance and assemblages. Contrary to other studies which found higher species richness and abundance in the surrounding inner shelf habitat (Diaz et al 2004 and Slacum et al 2010), Vasslides and Noble noted highest species abundance and richness on either side of the sand ridge with distinct recreationally and commercially important species assemblages. The fish found at the top of the ridge were typical prey species (sand lances, anchovies, smallmouth flounder) favored by both resident and transient piscivores in the Mid-Atlantic Bight (Chao and Musick 1977; Chase 2002; Walter et al 2003; Gartland et al 2006) and thus sand ridges may influence the distribution of these economically important piscivores (Vasslides and Noble 2008).

Use of the topographic high within Borrow Area C, overall shallow excavation depth of the hopper dredge, and the borrow site's location in an area of high sand movement are important factors that will maximize biological recovery rates (Deaton et al 2010). Further, the area of the proposed borrow excavations represents less than 1% of the extant similar habitat available nearby in Diamond Shoals and Kinnakeet Shoals. **Therefore, the project is not expected to pose a threat to this EFH or the life stages of managed species which are found within this habitat; any impacts that may occur are within reasonable limits.**

### 6.2 Potential Cumulative Effects of Proposed Project on EFH and HAPC

To protect the Cape Hatteras lighthouse from erosion, in the 1970s three groins were placed in the surf zone south of Buxton Village but these groins have not been maintained. With the exception of sand bags permitted to be placed in front of 14 parcels in north Buxton Village in 2013, this highly eroding segment of Hatteras Island has received no recent soft or hard stabilization. The most recent nearby nourishment project was NC DOT's 2014 Rodanthe emergency nourishment which occurred 25 miles to the north of the Buxton project. Depending on how time-crowded or space-crowded future offshore dredging and beach placement operations were, cumulative effects could be harmful to managed fishes and their habitats (marine water column, Sargassum, Cape Hatteras shoals) within the borrow area and/or the surf zone.

While NCDOT will mobilize to protect NC12 in emergency situations such as that which occurred at the Rodanthe "S Curves" and which could occur at Buxton, Dare County officials would prefer to not wait for an emergency at Buxton. Dare County government does have a long-range beach nourishment plan that will eventually schedule and coordinate beach segments in need of sand into a five-year rotation to ensure a more equitable use of available County funds. Such a staggered and coordinated approach should eliminate the negative cumulative effects of multiple projects which occur in close proximity, either spatially or temporally.

As post-nourishment beach invertebrate population recovery is most subject to similarity between native and introduced sediments, NC recently adopted sediment criteria for beach nourishment projects in the state. Geological models of shoal formation offshore have shown that as long the sea floor irregularity remains on which to reform a ridge, dominant shelf processes will reconstruct these features as predicted by the shelf ridge process models despite repeated dredge episodes from the most the crest, leading edge, or trailing edge (CSA International et al 2010).

Along with strict adherence to NC sediment criteria, additional offshore dredging and sand placement mitigative practices for beach nourishment projects as shown in Table 4 of Appendix A will also minimize the potential of cumulative effects to the EFH and HAPC. **With the high quality of the sediment selected for sand placement, little to no interruption to longshore or cross shore sediment transport dynamics, one-time only strategic removal of shoal sands from Borrow Area C, and the small amount of soft bottom, marine water column, or sandy shoal in the action area relative to the amount of available other similar EFH or HAPC at any time, the proposed activity would not be expected to pose a significant cumulative threat.**

## 7.0 EFH CONSIDERATIONS SUMMARY

Construction is expected to occur in the late spring -summer timeframe (i.e., May-September). The following EFH considerations were developed in coordination with the NCDMF and NOAA Fisheries during early project planning for the 2014 emergency project at Rodanthe and will be implemented for the proposed Buxton project to the maximum extent practicable:

1) promote quick benthic recovery through shallow borrow area excavation,
2) use topographic highs and/or areas of high sand movement within Borrow Area C,
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), and
5) construction of a temporary berm during placement on the beach strand in order to minimize turbidity.

## 8.0 EFH IMPACT SUMMARY

The proposed Buxton project would not be expected to cause any significant adverse impacts to EFH or HAPC for those species managed by the SAFMC and MAFMC.

Coordination with representatives of NMFS and NCDMF will 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 will be provided with information from any required project surveys and development of detailed borrow area use plans will be coordinated with both agencies.

The five Rodanthe EFH considerations listed in Section 7.0 will be integrated into the planning and eventually into the Buxton project construction process in order 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.

## REFERENCES

Armstrong, B. N., J.C. Warner, George Voulgaris, J.H. List, E. R. Thieler, M.A. Martini, E. Montgomery, Jesse McNinch, J. W. Book, and Kevin Haas. 2013. Carolinas coastal change processes project data report for nearshore observations at Cape Hatteras, North Carolina, February 2010: U.S. Geological Survey Open-File Report 2012–1219, http://pubs.usgs.gov/of/2012/1219/.

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

CSA International, Inc., Applied Coastal Research and Engineering, Inc., Barry A. Vittor & Associates, Inc., C.F. Bean, L.L.C., and Florida Institute of Technology. 2009. *Analysis of Potential Biological and Physical Impacts of Dredging on Offshore Ridge and Shoal Features*. Prepared by CSA International, Inc. in cooperation with Applied Coastal Research and Engineering, Inc., Barry A. Vittor & Associates, Inc., C.F. Bean, L.L.C., and the Florida Institute of Technology for the U.S. Department of the Interior, Minerals Management Service, Leasing Division, Marine Minerals Branch, Herndon, VA. OCS Study MMS 2010-010. 160 pp. + apps.

CSE. 2012. 2011 Nags Head beach nourishment project. Final Report for Town of Nags Head, NC. CSE, Columbia (SC), 167 pp + appendices.

CSE. 2013. 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 with synopsis plus appendices.

CSE. 2014. Monitoring and analyses of the 2011 Nags Head beach nourishment project. Year 3 (2014) beach monitoring report for Town of Nags Head, NC. CSE, Columbia (SC), 128 pp + appendices.

CSE. 2015. Geotechnical Data Report. Assessment. Beach Restoration to Protect NC Highway 12, Buxton NC. Prepared for Dare County Board of Commissioners. Coastal Science & Engineering Inc. Columbia SC. 78 pp + Attachments

CZR Incorporated. 2014. Post-Y2 and final report, Nags Head Beach 2011 nourishment project. Unpublished final monitoring report submitted to NC Division of Coastal Management on behalf of the Town of Nags Head.

Carlson, Amy E., Eric R. Hoffmayer, Cindy A. Tribuzio, and James Sulikowski. 2014. The use of satellite tags to redefine movement patterns of spiny dogfish (*Squalus acanthias*) along the US east coast: implications for fisheries management. PLoS One 9 (7): e103384 doi: 101371/journalpone 013384

Chao, L.N. and J.A. Musick. 1977. Life history, feeding habits, and functional morphology of juvenile sciaenid fishes in the York River estuary, Virginia. Fish. Bull. 75: 657-702.

Chase B.C. 2002.Differences in diet of Atlantic Bluefin tuna (*Thunnus thynnus*) at five seasonal feeding grounds on the New England continental shelf. Fish. Bull. 100:168-180.

Deaton, A.S., W.S. Chappell, K. Hart, J. O'Neal, B. Boutin. 2010. North Carolina Coastal Habitat Protection Plan. North Carolina Department of Environment and Natural Resources. Division of Marine Fisheries, NC. 639 pp.

Diaz R.J., Cutter G.R. Jr., and Hobbs C.H. III. 2004. Potential Impacts of Sand Mining Offshore of Maryland and Delaware: Part 2 – Biological Considerations. Journal of Coastal Reasearch. Vol 20 (1); pgs. 61-69.

Dibajnia, M. and R. B. Nairn. 2011. *Investigation of Dredging Guidelines to Maintain and Protect the Geomorphic Integrity of Offshore Ridge and Shoal Regimes*, U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Regulation and Enforcement, Leasing Division. OCS Study BOEMRE 2011-025. 150 pp. + appendices.

Gartland, J., R. J. Latour, A.D. Halvorson, and H.M. Austin. 2006. Diet composition of young-of-the-year bluefish in the lower Chesapeake Bay and coastal Virginia. Trans. Am. Fish. Soc. 135: 371-378.

Hackney, C.T., M.H. Posey, S.W. Ross, and A.R. Norris. 1996. *A Review and Synthesis of Data on Surf Zone Fishes and Invertebrates in the South Atlantic Bight and the Potential Impacts from Beach Nourishment*. Prepared for the U.S. Army Corps of Engineers, Wilmington, NC.

Hawkins, A.D., A. E. Pembroke, and A.N. Popper. 2014. Information gaps in understanding the effects of noise on fish and invertebrates. Reviews in Fish Biology and Fisheries. DOI 10.1007/s11160-014-9369-3. Published online 12 September.

Kenworthy, W. Judson, Christine A. Buckel, Dean E. Eggleston, Don Field, Cecilia S. Krahforst, Joseph J. Luczkovich, and Gayle R. Plaia. 2012. Development of Submerged Aquatic Monitoring Protocols in North Carolina. NC Coastal Recreational Fishing License Program report.

Kocik J, Lipsky C, Miller T, Rago P, Shepherd G. 2013. An Atlantic Sturgeon Population Index for ESA Management Analysis. US Dept Commerce, Northeast Fish Sci Cent Ref Doc. 13-06; 36 p. Available from: National Marine Fisheries Service, 166 Water Street, Woods Hole, MA 02543-1026, or online at http://www.nefsc.noaa.gov/nefsc/ publications/

Laney, R.W., J. E. Hightower, B.R. Versak, M.F. Mangold, W.W. Cole, Jr., and S.E. Winslow. 2007. Distribution, Habitat Use, and Size of Atlantic Sturgeon Captured during Cooperative Winter Tagging Cruises, 1988–2006.

MMS (Minerals Management Service formerly, now Bureau of Ocean Energy Management or BOEM). 1999. Environmental Report on the Use of Federal Offshore Sand Resources for Beach and Coastal Restoration in New Jersey, Maryland, Delaware and Virginia. OCS Study – MMS 990036. http://www.boem.gov/Non-Energy-Minerals/1999-036.aspx

Mallinson, J. M., S.R. Riggs, S.J. Culver, and D. Ames. 2009. The North Carolina Outer Banks Barrier Islands: A Field Trip Guide to the Geology, Geomorphology, and Process.

Moslow, T.F., and S.D. Heron, Jr. 1994. Chapter 2. The outer banks of North Carolina. In R.A. Davis, Jr. (ed) Geology of Holocene Barrier Island Systems. Springer-Verlag. New York. pp 47-74.

Michel, J., A.C. Bejarano, C.H. Peterson, and C. Voss. 2013. Review of Biological and Biophysical Impacts of Dredging and Handling of Offshore Sand. US Department of the Interior, Bureau of Ocean Energy Management. OCS Study BOEM 2013-0119. 258pp.

NMFS. 2010. Essential Fish Habitat. A Marine Fish Habitat Conservation Mandate for Federal Agencies. Southeast Regional Office.

NOAA. 2007. National artificial reef plan (as amended): guidelines for siting, construction, development, and assessment of artificial reefs. US Department of Commerce. February.

Neff, J.F. 1985. Biological effects of drilling fluids, drill cuttings, and produced waters. In: The long-term effects of offshore oil and gas development: An assessment and research strategy, ed. D.F. Boesch and N.N. Rabalais. Elsevier Applied Science.

Neff, J.F. 1981. Fate and biological effects of oil well drilling fluids in the marine environment. In: *Final Technical Report to the USEPA*.

Normandeau Associates, Inc. 2014. Understanding the Habitat Value and Function of Shoal/Ridge/Trough Complexes to Fish and Fisheries on the Atlantic and Gulf of Mexico Outer Continental Shelf. Draft Literature Synthesis for the US Dept. of Interior. BOEM.

Popper, A.N., A. E. Hawkins, R.R. Fay, D. Mann, S. Bartol, T. Carlson, S. Coombs, W. T. Ellison, R. Gentry, M.B. Halvorsen, S. Lokkeborg, P. Rogers, B. L. Southall, D. G. Zeddies, and W.N. Tavolga. 2014. Sound Exposure Guidelines for Fishes and Sea Turtles: A Technical Report prepared by ANSI-Accredited Standards Committee S3/SC1 and registered with ANSI. ASA S3/SC1.4 TR-2014 XVI, 76 p. 64 illus., 53 illus. in color.

Poopetch, T. 1982. Potential effects of offshore tin mining on marine ecology. *Proceedings of the Working Group Meeting on Environmental Management in Mineral Resource Development,* Series No. 49, p. 70-73.

Slacum, W. H. Jr., W.H. Burton, and E.T. Methratta. 2010. Assemblage Structure in Shoal and Flat-Bottom Habitats on the Inner Continental Shelf of the Middle

Atlantic Bight, USA. Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science. 2:277-298.

Street, M.W., A.S. Deaton, W.S. Chappell, and P.D. Mooreside. 2005. North Carolina Coastal Habitat Protection Plan (CHPP). North Carolina Department of Environment and Natural Resources, Division of Marine Fisheries, Morehead City, NC.

Styles R. and S. M. Glenn. 1999. Modeling stratified wave and current bottom boundary layers in the continental shelf. J. of Geophysical Research (submitted). Published in 2000, 105, 24119-24139.

TAR. 2015. A phase I remote-sensing archaeological survey of a proposed borrow site off Buxton, Dare County, NC. Submitted to CSE by Tidewater Atlantic Research, Inc. Washington, NC 31 March, 74 pp + attachments.

Thieler, E.R., P.T. Gayes, W.C. Schwab, and M.S. Harris. 1999. Tracing sediment dispersal on nourished beaches: two case studies. *Coastal Sediments*. New York, ASCE, p. 2118–2136.

Thieler, E.R., O.H. Pilkey Jr., W.J. Cleary, and W.C. Schwab. 2001. Modern sedimentation on the shoreface and inner continental shelf at Wrightsville Beach, North Carolina, USA. *Journal of Sedimentary Research* 71(6):958–970.

USACE (Burlas et al). 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 Corps of Engineers, Waterways Experiment Station, Vicksburg, MS, 11 chapters.

USACE. 2002a. *Coastal Engineering Manual*. Engineer Manual 1110-2-1100 (in 6 volumes). U.S. Army Corps of Engineers, Washington, DC.

USACE. 2002b. Environmental Assessment and Finding of No Significant Impact, Manteo Shallowbag Bay Project, Maintenance of Oregon Inlet Bar Channel and Channel Widner, Dare County, North Carolina. Dated June 2002. US Army Corps of Engineers, Wilmington District, NC.

USACE. 2010 (MAY). 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), 164 pp+ executive summary, references, and appendices.

USACE. 2013. Essential Fish Habitat Assessment for the Emergency Beach Fill along NC Highway 12, in Rodanthe, Dare County, NC.

USACE. 2014. Final Integrated Feasibility Report and Environmental Impact Statement, Coastal Storm Damage Reduction, Bogue Banks, Carteret County, NC. August.

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

Vasslides, J.M. and K.W. Able. 2008. Importance of shoreface sand ridges as habitat for fishes off the northeast coast of the United States. Fishery Bulletin. 106(1); pgs. 93-107.

Walter, J.S. III, A.S. Overton, K.H. Ferry, M.E. Mather. 2003. Atlantic coast feeding habits of striped bass: a synthesis supporting a coast-wide understanding of trophic biology. Fish. Manag. Ecol. 10: 349-360.

**APPENDIX A**

**HOPPER DREDGE AND CUTTERHEAD DREDGE INFORMATION
AND MITIGATION MEASURES
EXTRACTED FROM THE FINAL EFH ASSESSMENT
FOR
EMERGENCY BEACH FILL ALONG NC HIGHWAY 12,
IN RODANTHE, DARE COUNTY, NC
3 JULY 2013**

**NOTE: additional text added by CSE is shown in *italics***

## 13.1 Cutterhead Hydraulic Pipeline Dredge - Sedimentation and Turbidity

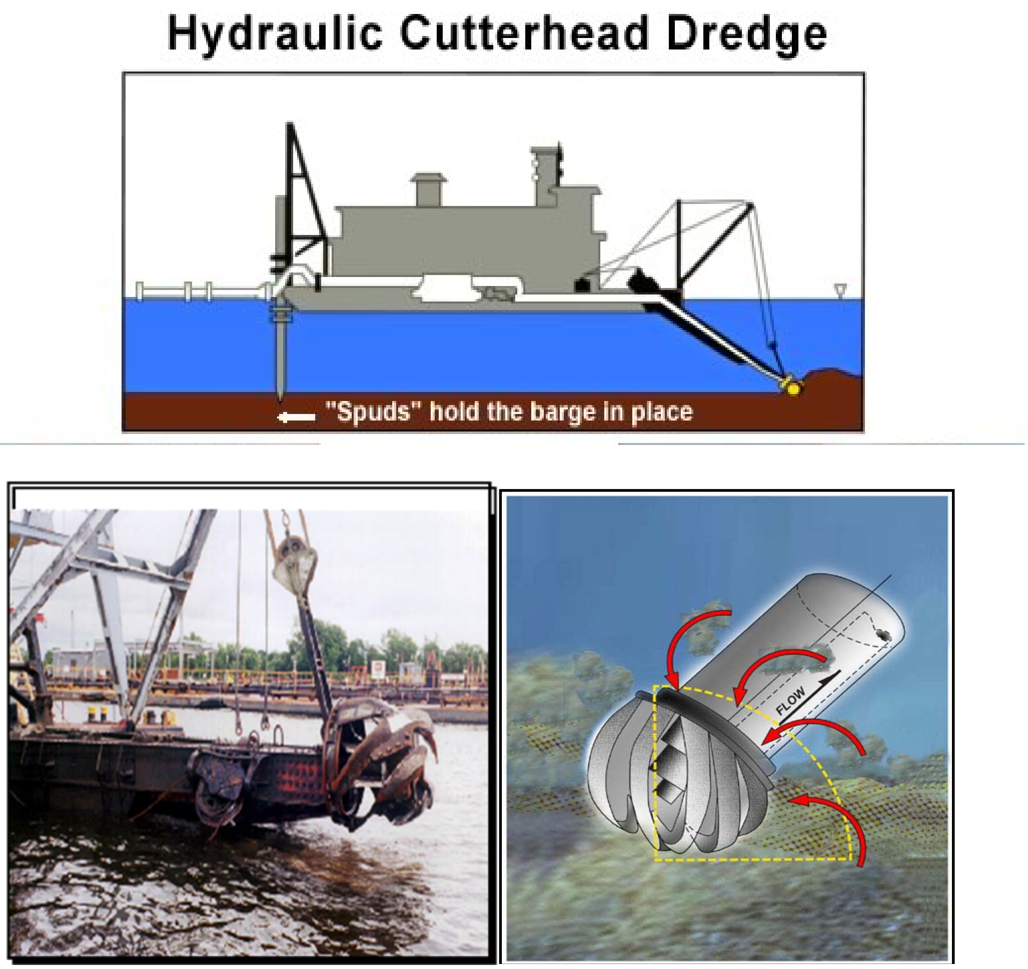
Cutterhead hydraulic pipeline dredges are designed to handle a wide range of materials including clay, hardpan, silts, sands, gravel, and some types of rock formations without blasting. They are used for new work and maintenance in projects where suitable placement/disposal areas are available and operate in an almost continuous dredging cycle resulting in maximum production, economy, and efficiency. Cutterhead dredges are capable of dredging in shallow or deep water and have accurate bottom and side slope cutting capability. Limitations of cutterhead suction dredges include relative lack of mobility, long mobilization and demobilization, inability to work in high wave action and currents, and are impractical in high traffic areas. However, the dredging industry has shown itself to be capable of developing innovative methodologies to work around some of these constraints.

Cutterhead dredges are rarely self-propelled and; therefore, must be transported to and from the dredge site. Cutterhead dredge size is based on the inside diameter of the discharge pipe which commonly ranges from 6" to 36." They require an extensive array of support equipment including pipeline (floating, shore, and submerged), boats (crew, work, survey), barges, and pipe handling equipment. A cutterhead is located on the suction end of the dredge and is a mechanical device that has rotating teeth to break up or loosen the bottom material so that it can be sucked through the dredge (Fig 7, below).

During the dredging operation a cutterhead suction dredge is held in position by two spuds at the stern of the dredge, only one of which can be on the bottom while the dredge swings, *or an anchor-cabling system that serves a similar purpose. The dredge swings around one spud or stern cable position as it works the bottom.* There are two swing anchors some distance from either side of the dredge, which are connected by wire rope to the swing wenches. The dredge swings to port and starboard alternately, passing the cutter through the bottom material until the proper depth is achieved. The dredge advances by "walking" itself forward on the spuds. This is accomplished by swinging the dredge to the port, using the port spud and appropriate distance, then the starboard spud is dropped and the port spud raised. The dredge is then swung an equal distance to the starboard and the port spud is dropped and the starboard spud raised. *For ocean borrow areas, a cable bridle system is generally preferred over a spud system to allow better seakeeping as work progresses.*

Moving cutterhead suction dredges is a slow process; therefore, efficiency is maximized by dredging in localized areas with deeper dredge cut volumes where the cutterhead is buried in the bottom. A cutterhead removes dredged material through an intake pipe and then pushes it out the discharge pipeline directly into the placement/disposal site. Most, but not all, cutterhead dredging operations involve upland placement/disposal of the dredged material. Therefore, the discharge end of the pipeline is connected to shore pipe. When effective pumping distances to the placement/disposal site become too long, a booster pump is added to the pipeline to increase the efficiency of the dredging operation.

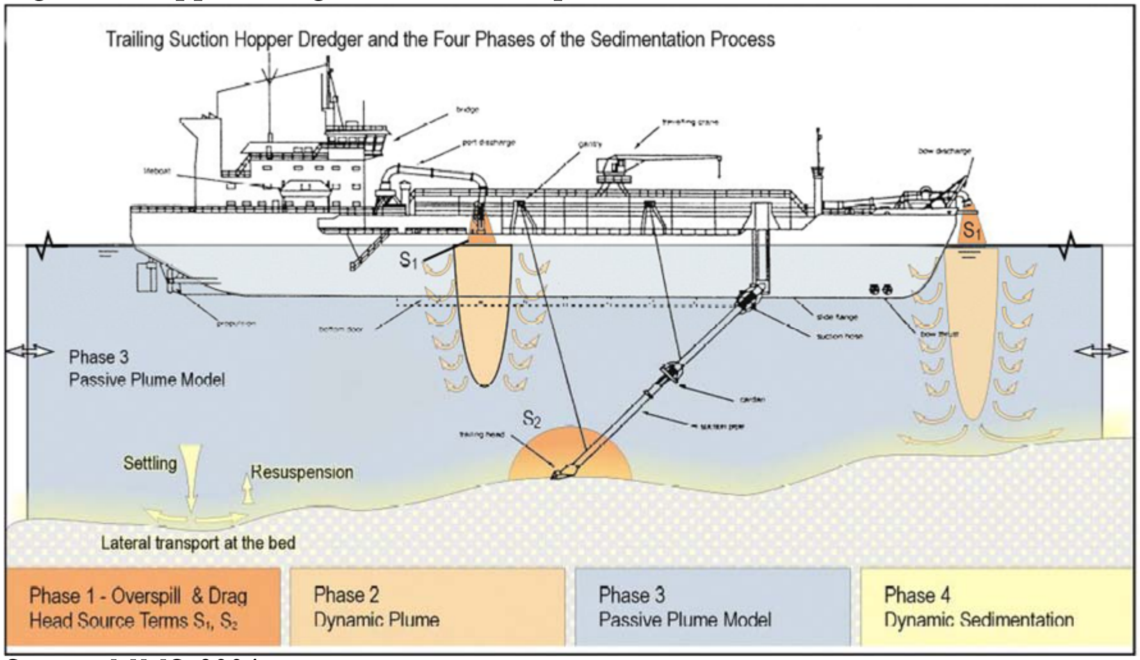
**Figure 7**. Cutterhead suction dredge schematic and representative close-up photographs. (Video of cutterhead dredge: http://el.erdc.usace.army.mil/dots/doer/anima/cutterfront.avi; http://el.erdc.usace.army.mil/dots/doer/anima/cutterside.avi)




## 13.2 Hopper Dredge—Sedimentation and Turbidity

During dredging operations, marine resources within the vicinity of offshore borrow areas can be affected by turbidity and sediment plumes generated from filling and overflow of hopper dredges depending on the characteristics and suspension time of the sediment being dredged. The discharge of overflow associated with hopper dredges to achieve economic loading releases sediment into the water column. Cutterhead dredge operations are confined to the benthic environment and associated turbidity is more confined. Hopper dredge suction dragheads hydraulically remove sediment from the sand bottom and discharge the material into the storage hoppers on the dredge. The screened sandy material fills the hopper until an economic load is achieved for transit and subsequent pumpout to the beach placement location. As illustrated in Figure 8 the operation has two types of sedimentation and turbidity sources: S1 from the overflow (which for most U.S. dredges now is through the bottom of the hull) and S2 associated with suspension of sediment at the draghead. During filling of the hopper, any fine sediment (primarily silt, clays, and fine-sands) are washed overboard through *overflow* ports (i.e., S1) either over the side of the vessel or through *weirs* that release the slurry through the hull of the vessel. Such *washing* of the dredged material is the predominant source of turbidity plumes and sedimentation generated by the hopper dredge; however, the *washing* effect also makes the hopper load for pumpout to the beach coarser. Some turbidity would be expected from the physical interaction of the draghead with the bottom substrate (i.e., S2) during the dredging operation, however, it would not be expected to be significant considering most of the disturbed sediments would be confined to the suction field of the hopper dredge dragheads and would be dredged and disposed into the hopper. Sediment discharged overboard from the hopper overflow moves faster than would be anticipated from simple Gaussian models because of the settlement velocity of component particles. That is because of high sediment concentration and discharge rate of the overflowed material, factors that lead to the development of a density current that moves through the water column in a *dynamic phase* of settlement, at least initially. Sediment is stripped away as the dynamic plume moves through the water column forming a passive plume that is advected and dispersed by ambient currents, with the particles settling according to Gaussian models (MMS, 2004).

**Figure 8. Hopper dredge sedimentation processes.**




Source: MMS, 2004

Note: This figure shows two S1 sources at overflows from a screening operation, in almost all U.S. dredges, the S1 source is through the bottom of the hull.
Hitchcock and Drucker (1996) summarized values for material lost through the overflow process on a typical 4,500 ton hopper dredge operating in United Kingdom (U.K.) waters. Results from the study indicate that during an average loading time of 290 minutes, 4,185 tons of dry solids are retained as cargo, while 7,973 tons of dry solids are returned overboard from overflow. *Such high proportions of returned sediments are not expected for the Buxton borrow area which contains similar sediemtns as the borrow areas used at Nags Head (CSE 2012). Post-dredging surveys at Nags Head showed nearly equal excavation and placement volumes on the beach. This implies only minor losses of excavated material at Nags Head. The ~5,500 cy capacity hopper dredge used at Nags Head filled in a typical time of less than 1 hour, which is much more rapid that the filling rate for the UK study*. Sand-sized particles fall directly to the seabed and are reduced to background levels over a distance of 200–500 m (656–1,640 ft.) and smaller, silt-sized particles have a typical settling velocity of 0.1 to 1.0 mm/s and are reduced to background values of 2–5 milligrams per liter (mg/L) over a similar distance. According to Neff (1981, 1985), concentrations of 1,000 mg/L immediately after discharge decreased to 10 mg/L within one hour. The minimal effect of settling particles from hopper dredge turbidity plumes was further supported by a study from Poopetch (1982), which found that the initial hopper dredge overflow concentrations of 3,500 mg/L were reduced to 500 mg/L within 50 m (164 ft.).

The distance that sediment plumes can extend depends on the type of dredge, how it is operated, currents, and the nature of the sediments in the dredged area. Only beach-compatible, sandy sediments would be used for this project consisting of no less than 90% sand. Dredging of sandy sediments would minimize the amount of turbidity associated with the dredging operation and would reduce the suspension time and advection distance of overflow sediments. A study performed by Newell and Siederer (2003) in the U.K. (high-current velocities) showed that, in most cases, coarse material up to sand-size particles settles within 200 m (656 ft.) to 600 m (1,968 ft.) of the point source of discharge, depending on depth of water, tidal velocity, and the velocity of flow from the discharge pipe. During hopper dredging operations in the Baltic's, Gajewski and Uscinowicz (1993) noted that the main deposition of sand from hopper dredge overflow was confined to distances within 150 m (492 ft.) on each side of the dredge. The study further supported that the initial sedimentation associated with overflow material behaves like a density current where particles are held together by cohesion during the initial phase of the sedimentation process and are mainly confined to a zone of a few hundred meters from the discharge chutes. According to a plume dispersion model developed by Whiteside et al (1995) (based on field study measurements obtained while hopper dredging in Hong Kong waters), the contours for sediment deposition remain as a narrow band extending for approximately 100 m (328 ft.) on each side of the vessel, consistent with that recorded by Gajewski and Uscinowicz.

Though elevated turbidity levels could occur from hopper dredge overflow, the overflow process occurs only during the physical dredging operation and the elevated turbidity values are short term and confined. Because maximum load efficiency would be attained before transit to the pumpout location, overflow of material would not be expected to occur once the dredging process is complete. Once at the pumpout location, all turbid water generated by the hopper dredge slurry for pumpout would be retained in the hopper.

Overall water quality impacts of the proposed action would be expected to be short-term and minor. The various life stages of fish species associated with marine and estuarine resources dependent on good water quality would likely move out of the impact area and are not expected to experience significant adverse effects from water quality changes. Therefore, the proposed action is not anticipated to adversely impact the marine water column either in the offshore borrow area and/or the ocean beach strand.

**TABLE 4.** Recommendations identified by the environmental resource agencies as well as the current literature for shoal borrow area design and dredging considerations to minimize physical and biological impacts.

| **Source** | **Recommendation** | **Considered in Borrow Area Design and Dredging** | | | **Comments** ***updated for Buxton as applicable in italics*** |
|---|---|---|---|---|---|
| | | ***Yes*** | ***Partial*** | ***No*** | |
| *Dibajnia and Nairn (2011)* | Avoid shoals in waters deeper than 30 meter (m) which show a decrease in height with increasing depth representing a possible Shoal Height Decrease Zone beyond 30 m depth | X | | | *The shallowest portion of Borrow Area C proposed to be dredged (i.e., top of ridge) ranges between 20 - 25 ft deep and the deepest areas along the gently sloping sides of the ridge ranges between 40 - 45 ft deep.* |
| | Consider ridge and shoal dredging scenarios which minimize impacts to overall shoal integrity and protect habitat for benthos and fish | X | | | *Borrow Area C* use plans will be developed in accordance with dredging guidelines to the maximum extent practicable to minimize morphologic shoal response provided by Dibajnia and Nairn (2011). The proposed volume of sediment to be dredged relative to the overall Wimble Shoals complex is small; thus, no adverse effects to overall shoal integrity are expected. *Geotechnical data (CSE 2015) confirm there is uniformity of sediment size and type within the full section of the proposed dredge cut, with similar quality surficial sediments expected to be left in place after excavations of overlying material.* |
| *CSA International Inc et al (2009)* | Priority locations for shoal dredging to minimize physical impacts is the leading edge due to net long-term deposition and faster infilling rates, followed by the crest and the trailing edge | | X | | *Use of the topographic high within Borrow Area C, overall shallow excavation depth of the hopper dredge, and the borrow site's location in an area of high sand movement are important factors that will maximize biological recovery rates.* According to Mallinson et al (2009) analysis of high resolution seismic and side scan sonar data suggest that Wimble Shoals are relict erosional features and not constructive depositional sand bars as inferred by Swift et al (1973). However once the proposed borrow area surveys have been completed, coordination with appropriate State and Federal Agencies will occur to avoid impacts to existing high valued biological resources associated with specific shoal features. |
| | Innovative dredging methodologies utilizing "striped" dredging pattern appear to support a more timely and uniform recovery | X | | | Hopper dredges are the proposed primary dredging method. Hopper dredging operations typically dredge in a "striped" pattern to maximize production over long expansive portions of the borrow area leaving portions of the borrow area unimpacted. |
| | Shallow dredging over large areas rather than excavating small but deep pits may be preferred | X | | | The current borrow area design and borrow area use plan supports this recommendation. Hopper dredges operate most efficiently dredging shallow cuts over a large surface area rather than excavating small deep pits. The usable dredge depths will be determined once the surveys have been completed. |
| | Dredging in a striped pattern to leave sediment sources adjacent to and interspersed throughout target areas, leading to a more uniformly distributed infilling process | X | | | Hopper dredging operations typically dredge in a "striped" pattern to maximize production over long expansive portions of the borrow area leaving portions of the borrow area unimpacted to support infilling processes |
| Discussions with NMFS and NCDMF | Borrow area design should consider a wider and shallower cuts rather than deep dredge holes | X | | | *Geotechnical data (CSE 2015) within the proposed borrow area confirm the sediments are beach compatible and exceed North Carolina state standards for similarity with the native beach. A high density of 33 borings (~1 per 11 acres) demonstrates general uniformity of sediments in the upper 8 ft of substrate. The potential beach quality sand reserves total >5 million cubic yards within an ~440 acre area if dredged to 8 ft. Shallower cuts over a smaller area are therefore feasible. The final borrow area layout and dredge plan will be prepared in consultation with resource agencies pending results of cultural resource studies. If a suction cutterhead dredge is used, the minimum and maximum excavation depth will be in the range 6-8 ft due to operational considerations for large ocean-certified dredges. If a hopper dredge is used, the cut depths will vary between ~2 ft and 8 ft according to the number of passes over a given area.* |

| | | | | | |
|---|---|---|---|---|---|
| | Review published literature and integrate significant information or lessons learned from dredging of other shoal features throughout the region into borrow area use planning for this project | X | | | Relevant literature pertaining to the physical and biological activities associated with sand ridge features as well as potential dredging related impacts have been integrated into this impact evaluation |
| | Consider leaving a segment of un-dredged sediment to allow for recovery and recolonization into impacted areas. | X | | | Hopper dredges will likely be the primary dredging methodology for this project. As a result of the operating characteristics of the hopper dredging, it is likely that un-dredged ridges will be left behind allowing for recolonization from un-impacted areas. Additionally, it is anticipated that the dynamic nature of the borrow area will result in infilling of the impacted areas with adjacent sediments |

**Table 4.** (continued)

| Source | Recommendation | Considered in Borrow Area Design and Dredging | | | Comments *updated for Buxton as applicable in italics* |
|---|---|---|---|---|---|
| | | *Yes* | *Partial* | *No* | |
| Diaz et al (2004) and Slacum et al (2010) | Shoals should be only partially dredged to facilitate post dredging re-colonization from un-impacted refuge areas | X | | | The proposed borrow areas and associated quantity of sediment to be dredged is small relative to (1) the overall size of *shoals off Hatteras Island, including Platt, Wimble, Kinnakeet, and Diamond Shoals* |
| | Limiting the distance between the remaining patches of shoal habitat would reduce the distance and time a shoal-associating species would have to travel between patches | X | | | *The Borrow Area C shoal is ~ 2 miles north of the large expansive area of Diamond Shoals and is a rather small component within the overall complex of available habitat.* Considering the nearness of similar adjacent habitat types no adverse impacts to shoal associated species are anticipated |
| | Shoals with less relief should be targeted for mining instead of steeper shoals when the option is available | X | | | *The* borrow area use plan will be developed that maximizes opportunity to dredge along the relatively flat and gradual sloped transition towards the shoal crest in order to minimize shoal impacts to higher relief shoal features. |
| | Dredging should be avoided when demersal finfish are using the inner continental shelf as a nursery ground | | | X | *Dredging for the proposed beach nourishment to protect NC 12 at Buxton is proposed to occur in summer 2016 and is anticipated to be completed in two months (anticipated to begin between May-July).* |
| | Sand could be mined at night, when some species migrate vertically into the water column to reduce the direct injury to fish that can result from mining activities | | | X | Dredging activities will not be confined to nighttime activities due to efficiency constraints |
| | Shoals should be mined in rotation to allow shoal-associated assemblages to recover between mining events; this should be done in consideration of the rate at which sand accumulates at the particular shoal where sand is being harvested | | X | | The proposed *project to protect* NC 12 *at Buxton* is a one-time only event *which will provide needed site-specific data on the performance of nourishment for purposes of evaluating long-term strategies for protecting and maintaining a transportation corridor along this section of Hatteras Island. The proposed borrow area is not expected to be used again given its limited size* and benthic *communities* should recover quickly. |

## REFERENCES FOR APPENDIX A NOT CITED PREVIOUSLY


Gajewski, L.S., and S. Uscinowicz. 1993. Hydrologic and sedimentologic aspects of mining marine aggregate from the Slupsk Bank (Baltic Sea). *Marine Georesources and Geotechnology* 11:229–244.

Hitchcock, D.R., and B.R. Drucker. 1996. Investigation of benthic and surface plumes associated with marine aggregates mining in the UK. In *Conference Proceedings Oceanology International '96. Volume 2*. ISBN: 0 90025412 2. pp. 220-234.

Newell, R.C. and L.J. Seiderer. 2003. Ecological Impacts of Marine Aggregate Dredging on Seabed Resources. In *Review of Existing and Emerging Environmentally Friendly Offshore Dredging Technologies*. Prepared for the U.S. Department of Interior, Leasing Division, Sand and Gravel Unit Minerals Management Service, Herndon, VA.

U.S. Department of Interior, Minerals Management Service (MMS). 2004. Review of Existing and Emerging Environmentally Friendly Offshore Dredging Technologies. Prepared by W.F. Baird and Associates, Ltd. and research Planning, Inc. for the MMS Leasing Division, Sand and Gravel Unit.

Whiteside, P.G.D., K. Ooms, and G.M. Postma. 1995. Generation and decay of sediment plumes from sand dredging overflow. In *Proceedings of the 14th World Dredging Conference Amsterdam*, The Netherlands. pp. 877–892.