APPENDIX Q

CUMULATIVE EFFECTS ANALYSIS

Village of Bald Head Island Shoreline Protection Project
Cumulative Effects Analysis

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1.0 INTRODUCTION

The purpose of the cumulative effects analysis is to ensure that regulatory agencies consider the full range of consequences (i.e. cumulative effects) on specific resources, ecosystems, and human communities as a result of private, state, or federal projects reviewed under the provisions of the National Environmental Policy Act (NEPA). The Council on Environmental Quality's (CEQ) regulations for implementing NEPA defines cumulative effects as;

> "*the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-federal) or person undertakes such actions (40 CFR §1508.7)*".

The cumulative effects analysis is composed of three principle components with corresponding steps as outlined in Table 1.

2.0 SCOPING

2.1 Cumulative Effects Issues

Depending upon specific project location and design, beach disposal/nourishment projects and hardened structures have the potential to beneficially or adversely affect the following resources, ecosystems, and communities:

(1) shorebirds and waterbirds (including the federally-protected piping plover and its critical habitat);
(2) seabeach amaranth (Amaranthus pumilus);
(3) sea turtles;
(4) intertidal and subtidal soft bottom (including benthic assemblages)
(5) water column (including federally-managed species)
(6) water quality; and
(7) human communities.

Table 1. Steps in the Cumulative Effects Analysis (CEA) (as adapted from CEQ 1997)

Environmental Impact Assessment Components	CEA Steps
I. Scoping	a. Identify the significant cumulative effects issues associated with the proposed action and define the assessment goals b. Establish the geographic scope for the analysis c. Establish the time frame for the analysis d. Identify other actions affecting the resources, ecosystems, and human communities of concern
II. Describing the Affected Environment	a. Characterize the resources, ecosystems, and human communities identified in scoping in terms of their response to change and capacity to withstand stresses b. Characterize the stresses affecting these resources, ecosystems, and human communities and their relation to regulatory thresholds c. Define a baseline condition for the resources, ecosystems, and human communities
III. Determining the Environmental Consequences	a. Identify the important cause-and-effect relationships between human activities and resources, ecosystems, and human communities b. Determine the magnitude and significance of the cumulative effects c. Modify or add alternatives to avoid, minimize, or mitigate significant cumulative effects d. Monitor the cumulative effects of the selected alternative and adapt management

These resources may be affected via the interactive or additive effects of a single project or of multiple projects occurring within an identified geographic and temporal scope. Examples of cumulative effects include time crowding (i.e. frequent and repetitive effects), space crowding (high abundance of stressors in a given spatial extent), or compounding effects. Each of the resources identified above will have different exposures and tolerance levels for actions associated with the type of project proposed.

Cumulative effects may arise from various stressors or impacts including: loss or disturbance to habitat; disturbance from mechanical operations of the dredge equipment and heavy machinery; indirect effects associated with short-term elevation of turbidity levels; expansion of supratidal beachfront; and structural impediments resulting from the installation of a terminal groin. These effects (and others) are evaluated in Section 5.0 of the DEIS.

2.2 Geographic and Temporal Scope

The cumulative effects analysis takes into consideration coincident effects (adverse or beneficial) of the proposed project as well as all related actions occurring within specified spatial and temporal boundaries. The project impact zone is the area potentially affected by the proposed action. Environmental resources of the river mouth, nearshore subtidal zone, and beachfront area may be affected by the VBHI Shoreline Protection Project. For the purpose of this cumulative impact assessment, the identified geographic region evaluated encompasses all beachfront and nearshore coastal areas of Onslow Bay and Long Bay. This constitutes 141 miles of shoreline.

This analysis considers known past, present, and reasonably foreseeable future (RFF) dredge and disposal/nourishment projects within the project vicinity over a thirty-five year period (1980 to 2015). The time period was selected to include the increase in the number of federal disposal projects in the early 1980s and was extended to 2015 because this date represents a reasonably foreseeable future. The majority of remaining beaches that could reasonably be expected to have federal projects implemented is included in this analysis.

3.0 ACTIONS AFFECTING RESOURCES

Cumulative effects analysis not only considers the impacts of past, present and RFF actions on the identified resources, but also the impacts from unrelated actions occurring in the vicinity of the project area including regional beach nourishment/beach disposal projects, hardened structures along the North Carolina coast, storms and sea-level rise.

Table 2 lists similar dredge and beach nourishment/disposal projects occurring within the geographic scope of this analysis and approximate distance from the proposed project. These projects are applicable for this evaluation given the type of activity and the potential for disturbance to identified resources. The cumulative direct and/or indirect effects of these projects have been evaluated in the context of each resource type. The compilation of projects represents those recent, current, and RFF projects that are either federally-funded or are sponsored via local initiatives.

3.1 Dredging & Beach Nourishment/Disposal

For the purpose of this assessment, intertidal and shallow subtidal shoal habitats have been mapped from available GIS data of tidal inlets and interpretation of aerial photography. Based upon this mapping effort, there are approximately 11,500 total acres of flood and ebb tide delta shoals (intertidal and shallow subtidal bottom habitat) extending from Barden Inlet (at Cape Lookout) to Little River Inlet. Expansive, undisturbed shoal habitat (as part of Frying Pan Shoals) also exists east of the project area. Frying Pan Shoals extend southeastward from Cape Fear approximately 20 miles into the Atlantic Ocean. Most maintenance dredging and navigation projects affect a relatively small percentage of the total intertidal and subtidal habitat occurring within a coastal inlet. Cumulatively, twelve (12) of the fifteen (15) active inlets within the assessment area have been recently, or are currently authorized to be, dredged for navigational improvements. Of these inlet areas, it is estimated that there are over

Table 2. Summary of Recent, Current, and RFF Projects (Onslow Bay and Long Bay) and Proximity to Bald Head Island Project Area

Project	Source of Sand for Nourishment	Beachfront Nourished	Approximate Volume of Material and/or Length of Shoreline	Approximate Dates of Occurrence	Distance to Bald Head Island Project Area
Section 933 Project (Outer Harbor)	Beaufort Inlet Outer Harbor	Indian Beach, Salter Path, and portions of Pine Knoll Shores	7 miles	Feb/March 2004 Jan-April 2007	75 miles north
Emerald Isle FEMA Project	USACE ODMDS – Morehead City Port Shipping Channel	Emerald Isle	3.8 miles	Mar-04	75 miles north
Emerald Isle Post-Isabel, Ophelia, and Irene Projects (FEMA)	ODMDS	Eastern Emerald Isle, Indian Beach, Pine Knoll Shores	156,000 cy; 1.23 Mcy; 992,000 cy	2004, 2007, 2012	75 miles north
Bogue Banks FEMA Project	USACE ODMDS – Morehead City Port Shipping Channel	Emerald Isle (2 segments), Indian Beach, Salter Path, Pine Knoll Shores	13 miles (cumulatively)	Jan/Feb 2007	75 miles north
USACE Dredge Disposal to Eastern Bogue Banks (Federal)	Beaufort Inlet Inner Harbor and Brandt Island Pumpout	Fort Macon and Atlantic Beach	Varies (180,000 cy to 4.67 Mcy)	1978, 1986, 1994, 2002, 2005, 2007	75 miles north
Bogue Banks Shore Protection Project (Federal)	Offshore Borrow Sites	Communities of Bogue Banks	24 miles	2009-2011	75 miles north
Bogue Banks Restoration Project – Phase I – PKS/IB Joint Restoration	Offshore Borrow Areas	Pine Knoll Shores and Indian Beach	7.4 miles	Winter 2001/2002	75 miles north
Bogue Banks Restoration Project – Phase II – Eastern EI	Offshore Borrow Areas	Indian Beach and Emerald Isle	5.9 miles	Winter 2002/2003	75 miles north
Bogue Banks Restoration Project – Phase III– Bogue Inlet Channel Realignment Project	Bogue Inlet Channel	Western Emerald Isle	4.5 miles	March-05	72 miles north
AIWW Section 1 – Tangent B (Federal)	AIWW shoaling directly north of Pine Knoll Shores	Eastern limit of Pine Knoll Shores	2,000 lf	Jan-March 2008	75 miles north
Inlet Crossing at Bogue Inlet (Federal)	Bogue Inlet – ocean bar to AIWW via connecting channel	Western Emerald Isle	0.66 miles (38,000 cy per event)	Summer 2006 (anticipated frequency 1 to 3 years)	70 miles north
North Topsail Beach Nourishment (Federal)	New River Inlet Dredging	Surf City and North Topsail	11.1 miles	Maintenance dredging every four years	52 miles north
North Topsail Dune Restoration (Town of North Topsail Beach)	Upland borrow source near Town of Wallace, NC	North Topsail Beach	47,300 cy	2006	52 miles north
North Topsail Beach Shoreline Protection Project	New River Inlet Realignment and Offshore Borrow Area	Topsail Island	5 phases totaling 11 miles	Phase 1-5 occurring every other year 2009-2017 (subject to regulatory approval)	52 miles north
Topsail Island Beach Nourishment (Federal)	New Topsail Inlet	Topsail Island	Varies	Maintenance dredging	40 miles north
Figure Eight Island	Banks Channel and Nixon Channel	North & South Sections	2.5 miles	Winter 2005/2006	35 miles north
Figure Eight Island - Terminal Groin and Beach Nourishment		Figure Eight Island		TBD	35 miles north
Mason Inlet Relocation Project	Mason Inlet (new channel) and Mason Creek	North end of Wrightsville Beach and south end of Figure Eight Island	1.9 miles	Jan-March 2002 (smaller maintenance events of inlet throat, sedimentation basin, and AIWW on as needed basis)	30 miles north
Wrightsville Beach (Federal)	Masonboro Inlet	Wrightsville Beach	2.84 miles	4-year cycle: Winter 2004/2005 Proposed 2013/2014	25 miles north
Carolina Beach (Federal)	Carolina Beach Inlet	Carolina Beach	2.0 miles	3-year cycle: Dec 2006 – Feb 2007; winter 2012/2013	15 miles north
Kure Beach (Federal)	Wilmington Harbor CDF Area 4	Kure Beach	2.0 miles	3-year cycle: Dec 2006 - Feb 2007; February 2013	10 miles north
Wilmington Harbor Deepening (933 Project) Sand Management Plan	Wilmington Harbor Ocean Entrance Channels	Bald Head Island, Caswell Beach, Oak Island	Varies (2 to 4 miles)	6-year cycle: Winter 2001/2002; 2005/2007; 2012/2013	0 miles to 10 miles west
Brunswick County Beaches Project	Nearshore and Offshore Borrow Areas	Caswell Beach, Yaupon Beach, Long Beach, Holden Beach	30 miles +/-	Notice of Intent to Prepare EIS issued May 2012	0 miles to 20 miles west
Oak Island Section 1135 - Sea Turtle Haibtat Restoration	Upland Borrow Area - Yellow Banks	Oak Island	2 miles	Winter/Spring 2001	5 to 10 miles west
Bald Head Island Creek Project (non-federal)	Bald Head Creek	South Beach	1,800 lf	Winter 2006	0 miles
Bald Head Island Beach Nourishment	Jay Bird Shoals	West and South Beach	4 miles	Winter 2009/2010	0 miles
Bald Head Island Creek Project (non-federal)	Bald Head Creek	Western South Beach	140,000 cy	March 2012	0 miles
Bald Head Island Shoreline Protection Project	Wilmington Harbor Ocean Entrance Channels	West and South Beach	0.25 Mcy	TBD; anticipated winter 2015	0 miles
Holden Beach (933 Project)	Wilmington Harbor Ocean Entrance Channels	Holden Beach	1.9 miles	March-April 2002	16 miles west
Holden Beach East & West (sponsored by Town)	Upland truck hauling	Extension of 933 Project	160,000 cy	March-April 2002	16 miles west
Holden Beach East & West	Upland truck hauling	Extension of 933 Project	200,000 cy	December-03	16 miles west
Holden Beach - Terminal Groin and Beach Nourishment	TBD	Holden Beach within vicinity of Lockwood Folly Inlet	TBD	TBD	16 miles west
Holden Beach – AIWW 400-ft Widener (GP 2878)	AIWW at Lockwood Folly Inlet Crossing	East end of Holden Beach	100,000 cy	Winter 2014	16 miles west
Lockwood Folly Inlet Crossing (Federal)	Inlet crossing of AIWW	Long Beach and East end of Holden Beach	80,000 to 165,000 cy each event	November 2001 - April 2006	10 to 20 miles west
Shallotte Inlet (Federal)	Inlet crossing of AIWW	Ocean Isle Beach	5.3 miles in '01 48,000 cy in 06	Winter 2001 and 2006	26 miles west
Ocean Isle - Terminal Groin and Beach Nourishment	TBD	OIB within vicinity of Shallotte Inlet	TBD	TBD	26 miles west

9,000 acres of ebb tide and flood tide shoals. Most inlet navigational projects affect a relatively small percentage of the total shoal habitat associated with an inlet. Considering that these areas are actively changing due to natural physical processes, the alteration from dredging is considered a temporal disturbance.

For the VBHI Shoreline Protection Project, it is the applicant's proposal that sand for the required groin fillet (estimated at 0.25 Mcy of material) would be principally derived from the next maintenance event of the Wilmington Harbor federal navigation project. Additional sand source sites identified by the applicant to augment the fillet or for maintenance and future Village-sponsored nourishment are: (1) Jay Bird Shoals; (2) reaches of the Wilmington Harbor Channel demonstrated to contain beach-compatible material (i.e. Baldhead Shoal Channel 1, Baldhead Shoal Channel 2, and Smith Island Channel); (3) Bald Head Creek Shoal; and (4) Frying Pan Shoals.

Within the geographic scope of this analysis (141 miles of shoreline), there are ten (10) authorized and/or active inlet projects (federal and non-federal actions) and eleven (11) nourishment projects affecting approximately 50 miles of beachfront. Thus recent, current, and/or authorized beach nourishment projects affect approximately 35% of the total length of shoreline of Onslow Bay and Long Bay. On a broader geographic scale, North Carolina has 320 miles of shoreline. According to a recent cumulative impact assessment prepared by the USACE for the Bogue Banks Coastal Storm Damage Reduction Project (USACE 2013), existing or proposed federal projects total approximately 122 miles of beach or 38% of North Carolina beaches. Considering all existing and proposed federal and non-federal nourishment projects, and taking into consideration that some of the project footprints overlap, approximately 112 miles or 35% of the North Carolina coast could have beach nourishment or sand disposal projects by 2015.

The VBHI Shoreline Protection Project may affect up to 13,000 total linear feet of beachfront (South Beach and West Beach, combined). This represents approximately 0.8% of the 320 miles of beachfront in North Carolina and 1.7% of beachfront in the assessment area of Long Bay and Onslow Bay. There are approximately 8.5 miles of remaining undisturbed beach along eastern South Beach and East Beach of Bald Head Island. Therefore, the potential extent of nourished beach for this project represents approximately 22% of the beachfront on Bald Head Island.

Frequency of nourishment events can vary dramatically pending a number of project-specific factors including funding, need (i.e. sediment losses), and the identified source of beach-compatible sand. Some level of maintenance is typically authorized over the life-span of a permit (often 30-year or 50-year periods). The proposed schedule for nourishment and/or maintenance events is commonly affected due to physical responses in the project area and funding issues. In addition, nourishment projects of a single beachfront may be the result of multiple initiatives through federal, municipal, or private entities. Therefore, determining specific interval frequencies is difficult. However, a review of available documents indicates that nourishment projects may range from one-time events to more frequent intervals of 2 to 4 years. In general, the frequency of occurrence has been such that biological recovery is likely over most stretches of shoreline. Cumulative effects (positive or negative) are discussed for each identified resource in Section 6.0 of this document.

3.1.1 Dredging and Disposal Actions associated with the Wilmington Harbor Project (Past, Present, and RFF)

In addition to spatial considerations, repeating actions may present additive effects of disturbance to affected resources. The Cape Fear River ocean bar channel has been maintained by the federal government for over 100 years. Over this time period, the width and depth of the navigational channel has been increased several times to accommodate larger vessels. By 1945, the federal channel had been deepened to 32 feet. In 1964, the US Army Corps of Engineers (USACE) initiated deepening of the main harbor channel to 38 feet to accommodate 34-foot-draft (26,000 deadweight ton) vessels to call at any tide. This project was completed in 1970. Since the 1970s, vessel sizes increased significantly. By the 1990s, approximately 50% of the ocean-going ships exceeded the 26,000 deadweight ton (DWT) design vessel. As such, these vessels could enter or leave Wilmington Harbor only at high tide or only when light-loaded (USACE 1996). The resultant increased shipping costs prompted the more recent Wilmington Harbor Deepening Project in 2001. The channel modifications included realignment of the ocean bar channel (30-degree southern shift); deepening of the ocean bar channel and entrance channel to 44 feet; and deepening of the 24.3-mile river reach (from Battery Island Channel to the Cape Fear Memorial Bridge) to 42 feet (USACE 2008).

Prior to channel entrance modifications in 2001, maintenance of the entrance channel required annual removal of between 500,000 and 1,000,000 cubic yards of material. Much of the material removed was placed in the Wilmington Ocean Dredge Material Disposal Site (ODMDS) located three (3) nautical miles offshore. The ODMDS was the primary disposal site for material dredged from three principal zones of the river: (1) ocean bar channels; (2) the navigation channel to Wilmington (excluding the ocean bar and reaches above the Lower Brunswick channel); and (3) Military Ocean Terminal at Sunny Point (MOTSU). Between 1976 and 2004, approximately 49 Mcy of material were placed in the Wilmington Harbor ODMDS. In 2000, the Sand Management Plan (SMP) for disposal of material derived from maintenance of the ocean entrance channels and other portions of the harbor was implemented. One of the goals of the SMP is to return beach-quality dredged material to the active littoral system when feasible. A new offshore ODMDS is still utilized for placement of non-compatible material high in silt and clay content or material consisting of woody debris. The Wilmington Harbor Dredge Material Management Plan (DMMP) provides more specific information related to dredge quantities and subsequent placement within the former and current ODMDS sites.

The Wilmington Harbor project, historically, did not provide for the placement of littoral sands on barrier island beachfronts due in large part to dredging technology and the lack of understanding for coastal processes (particularly with respect to the sand sharing system associated with tidal inlets and adjacent beaches) (USACE 2000). Over time, it has become well recognized that littoral material should be conserved (when practicable and economically feasible) via deposition directly on adjacent beaches or appropriate nearshore placement areas. As a result, the Wilmington Harbor SMP was developed and implemented as part of the larger Wilmington Harbor deepening project in 2000. Subsequent to the development of this plan, approximately 4.8 Mcy of ocean-derived sediments were dredged as part of the new alignment of the ocean entrance channel (USACE 2004). The beach-quality dredged material was distributed on Bald Head Island, East Oak Island-Caswell Beach, West Oak Island, and Holden Beach. Shoaling of the new entrance channel results, in part, from the combined effect of the eastward movement of Jay Bird Shoals; erosion from western South Beach; and the westward movement of Bald Head Shoal into the channel gorge. Based upon sediment transport analyses conducted by the USACE, approximately 66% of the sediment shoaling the channel is derived from the Bald Head Island side of the channel while 34% is derived from the Caswell Beach side (USACE 2000). In order to redistribute this material, sand is currently disposed on the shoreline of Bald Head Island in Year 2 and Year 4 of each six-year disposal cycle and on Oak Island-Caswell Beach during the sixth year of the cycle subject to availability of funding and dependent upon navigation priorities.

The USACE has identified Frying Pan Shoal as the sand source for the Brunswick County Beaches (BCB) Coastal Storm Damage Reduction Project. The USACE is in the process of preparing an Integrated General Reevaluation Report (GRR) and Draft Environmental Impact Statement (DEIS) for the project in accordance with Corps' Planning Guidance and NEPA. Actual implementation of the Federal BCB project (if implemented at all) is likely to be at a much later date than the VBHI Shoreline Protection Project. As such, time crowding of actions and associated additive impacts would become less of an issue. Given the size of the shoal feature relative to any prospective borrow sites, spatial crowding effects are likewise to be minimal. As a result, cumulative impacts potentially affecting this resource are not anticipated.

3.1.2 Dredging and Nourishment Actions specific to Bald Head Island (Past, Present, and RFF)

Sand placement activities constructed at Bald Head Island since 1991 are summarized in Table 3. The three small scale disposal projects constructed between 1991 and 1997 were cost-shared or paid for by the Village of Bald Head Island. The 2001 disposal operation was constructed as an element of the Wilmington Harbor Deepening Project. The disposal sand was placed as a designed berm along 15,500 ft of shoreline on South Beach. In Year 2 of the SMP cycle, approximately 1.2 Mcy was placed on South Beach between November 3004 and January 2005. A small scale non-federal West Beach sand disposal project was constructed by the Village in 2006 as a by-product of the dredging to the entrance of Bald Head Creek. In response to erosion of the western end of South Beach, the Village designed and implemented a larger beach restoration project that resulted in the placement of 1.85 Mcy of beach sand during the 2009/2010 dredge and nourishment window. The sand source site for this project was approximately 158 acres of the distal, subtidal portions of Jay Bird Shoals.

Sand losses subsequent to the 1.85 Mcy project in 2010 prompted the Village to identify and permit the use of an approximate 21-acre sand source site at the mouth of Bald Head Creek. The purpose of the project was to provide supplemental sand to an eroded segment of western South Beach. In March 2012, the Village completed the dredge and placement of 140,000 cy. Most recently (during the Winter and early Spring of 2013), the maintenance dredging of the Federal channel has resulted in the disposal of approximately 1.8 Mcy along South Beach and a portion of West Beach.

Table 3: Beach disposal activities at Bald Head Island since 1991.

Year	Volume
1991	0.35 Mcy
1996	0.70± Mcy
1997	0.45 Mcy
2001	1.849± Mcy
2005	1.217 Mcy
2006	47,800 cy
2007	0.9785 Mcy
2010	1.85 Mcy
2012	102,000 cy
2013	1.8 Mcy

3.2 Hardened Structures

3.2.1 Hard Stabilization Actions in the State of North Carolina)(Past, Present, and RFF)

Until recently, it has been the State's policy to limit the use of hardened erosion control structures on oceanfront shorelines. Seawalls and similar structures were banned by the Coastal Resources Commission in 1985. In 2003, the CRC's prohibition of hardened structures was placed into law with House Bill 1028 which amended the NC Coastal Area Management Act (CAMA). The few engineered structures existing in the State are largely limited to structures which protect important transportation corridors, existing commercial navigation channels of regional importance, and locations of historical significance. Existing hardened structure include the following (NCCRC 2010);

- jetty and weir jetty - Masonboro Inlet
- rock revetment - Carolina Beach
- rock revetment – near Fort Fisher
- groins – Cape Hatteras Lighthouse and Coast Guard Station
- terminal groin – Pea Island and Oregon Inlet
- terminal groin – Fort Macon (Beaufort Inlet)

In June 2011, the General Assembly of North Carolina ratified Senate Bill 110 *("An Act To Authorize The Permitting And Construction Of Up To Four Terminal Groins at Inlets Under Certain Conditions*"). The legislation included various requirements that must be met prior to issuance of a CAMA Major Permit for a terminal groin. In July 2013, SB 151 ("*An Act to Amend Marine Fisheries Laws; Amend the Laws Governing the Construction of Terminal Groins, and Clarify that Cities May Enforce Ordinances within the State's Public Trust Areas*") was ratified by the NC General Assembly and subsequently approved as law in August 2013 (Session Law 2013-384). SB 151 reduced some of the requirements placed upon applicants seeking authorization to construct terminal groins. The specific provisions of SB 151 are discussed in the DEIS. Currently, four proposed terminal groin projects (Figure Eight Island, Bald Head Island, Holden Beach, and Ocean Isle Beach) are under review for authorization in North Carolina. Under the existing law, this is the maximum number of terminal groins that can be authorized in North Carolina.

3.2.2 Hardened Structures specific to Bald Head Island (Past, Present, and RFF)

A. Sand Tube Groinfield

Presently, the 5,300 ft westernmost segment of South Beach of Bald Head Island is quasi-stabilized by a sixteen (16) structure sand tube groinfield originally constructed in 1995 and subsequently replaced in its entirety in both 2005 and 2010. With the last two reconstruction programs, minor design changes to groin location, groin length, and (most importantly) geotextile materials comprising the individual tube structures have occurred in accordance with the original design precepts. The sand tube groinfield was authorized by CAMA Major Permit No. 9-95 (USACE Action ID No. SAW-1994-04687).

The current location, individual lengths and spacing of the sixteen (16) sand tube groins is depicted by Figure 1.3 of the DEIS. The structures currently exist along South Beach between survey baseline Station 47+50 (on the west) and Station 100+00 (on the east). The groin tubes vary in length from 250 ft. to 350 ft. Each geotube is tapered and varies in height from 5.7 ft to approximately 4.0 ft at its seaward tip. For purposes of installation, the beach is excavated to elevation +2 ft. NGVD. Each tube is then filled within the excavated beach (*i.e.* in a trench) which is subsequently backfilled. During each beach fill operation, the groins are essentially buried (*i.e.* overfilled) by design and therefore remain inactive until the fill berm equilibrates to the point that the tubes are exposed to wave energy. Their effectiveness in reducing littoral transport and maintaining a protective beach berm within each groin cell (located between any two groins) varies over time depending on their level of interaction with waves.

B. Sand Bag Revetment

In July 2011, the North Carolina Division of Coastal Management (NCDCM) and the U.S. Army Corps of Engineers (USACE) granted a minor modification of existing CAMA Permit No. 9-95 and USACE Action ID SAW-1994-04687, respectively, thereby authorizing the construction of a 350 lf sandbag revetment beginning at sand tube groin No. 16 and extending in a general northwesterly alignment. The purpose of the temporary structure was to address chronic inlet-related beach and dune erosion and recession occurring westward of the last sand tube groin. Subsequently, in 2012 a second minor permit modification was issued to the Village which allowed for the placement of up to 1,200 cy of sand to be placed on top of the sand bag revetment. The source of the sand was the 2009-2010 Village beach fill project berm located to the east of the revetment. The selection of borrow areas was based upon existing dry beach width. All of the area subject to temporary borrowing was subsequently filled as a result of a large scale (1.8 Mcy) federal navigation maintenance project with beach disposal undertaken in the spring of 2013.

3.3 Storms

Major storms, such as hurricanes and northeasters, have been acknowledged as significant events that can affect the form of barrier islands. Storm tides associated with oceanic storm surges are extremely important to shoreline dynamics. Damage from wind, salt toxicity, and overwash, combined with shore retreat, can severely impact the biological integrity of the island. Hurricanes making landfall in the project area as well as winter storms with sustained northeasterly winds have been shown to exacerbate shoreline erosion and resultant biological impacts on the island. The NOAA National Weather Service maintains a database of hurricanes impacting the Atlantic Coast. Table 4 provides a summary of hurricanes which have impacted Bald Head Island since 1996.

3.4 Sea-level Rise

According to the NC Coastal Resource Commission Science Panel on Coastal Hazards, historical tide gauge data and geologic evidence obtained over the last several centuries provide evidence that sea level is steadily rising in the state of North Carolina. Additionally, data collected from scientific studies within the state suggest that relative sea level (RSL) change varies as a function of latitude along the North Carolina coast. RSL change is higher in the northern part of the state with lower documented rates in the south and varies from 2.04 mm/yr to 4.27 mm/yr (NCCRC 2010b).

NOAA maintains a detailed record of sea level trends at stations around the United States. The nearest such station to the study area is at Southport, immediately inside Cape Fear Inlet (Station 8659084). The measured data at Southport cover the period between 1933 and 2006 and suggest that the local water level rises approximately 2.08 mm/year, or about 0.21 meters (0.69 feet) per 100 years, on average.

Table 4: Hurricanes impacting Bald Head Island since 1996.

Hurricane	Year
Irene	2011
Hanna	2008
Ophelia	2005
Charley	2004
Irene	1999
Floyd	1999
Bonnie	1998
Fran	1996
Bertha	1996

Riggs and Ames (2003) predicted increased rates of sea-level rise will adversely impact the North Carolina coast in the following ways: accelerated rates of coastal erosion and land loss; increased economic losses due to flooding and storm damage; increased loss of urban infrastructure; collapse of some barrier island segments; and increased loss of estuarine wetlands and other coastal habitats. Sea-level rise has the potential to increase the volume of sand required for beach nourishment projects region-wide.

4.0 RESOURCE CAPACITY TO WITHSTAND STRESS AND REGULATORY THRESHOLDS

In 1972, Congress passed the Coastal Zone Management Act, which encouraged states to keep the coasts healthy by establishing programs to manage, protect, and promote the country's fragile coastal resources. Two years later, the North Carolina General

Assembly passed the landmark Coastal Area Management Act (CAMA). CAMA established the Coastal Resources Commission, required local land use planning in 20 coastal counties, and provided for a program for regulating development. The North Carolina Coastal Management Program was federally approved in 1978 by NOAA.

Demands placed on lands and waters of the coastal zone from economic development and population growth require that new projects or actions be carefully planned in order to avoid stress on the coastal zone. This planning involves a review of state enforceable policies, which are designed to provide effective protection and use of land and water resources of the coastal zone. Under CAMA, the proposed work cannot cause significant damage to one or more of the historic, cultural, scientific, environmental or scenic values or natural systems identified in Areas of Environmental Concern (AECs). In addition, significant cumulative effects cannot result from a development project.

5.0 RESOURCE BASELINE CONDITIONS

The resources potentially affected by past, present, and RFF dredging; beach nourishment and sand disposal activities; and terminal groin construction are listed above in Section 2.0 above. Baseline conditions such as status of populations, life histories, stressors (both natural and anthropogenic), and ability to adapt to stressors for each of these resources are described in corresponding sections of the project DEIS (Section 4.0 and 5.0), the Essential Fish Habitat (EFH) report, and the project Biological Assessment (BA). Information pertaining to human communities in the context of the cumulative effects issues is provided below.

Development pressures along the coast of North Carolina have significantly increased over the years with the influx of people wanting to live near the water. The State's position regarding beach ownership is that the public has always enjoyed the right to use the dry sand beach located above the normal high water line until the growth of vegetation or dune line occurs. The preservation of a stable beachfront is a critical aspect of the State's tourist industry.

Development of Bald Head Island began in 1972 with the construction of an inn and 18-hole golf course. The developer, Bald Head Island Limited, designed the phased plan development of the Island which encompasses 2,000 acres. With increasing build-out and anticipated increase of both permanent and part-time residents, along with the inherent advantages of municipal form of government for achieving the planned community goals, the Village of Bald Head Island was incorporated as a municipality in 1988.

The island is accessible to the public by means of a passenger ferry which operates between Southport, NC and Bald Head Island Marina. The Village exists primarily as a second home community and is a well-known tourist and seasonal destination. Commercial activity is primarily limited to retail trade including: grocery, hardware and restaurants. Other than retail trade, the only other non-residential construction activity involves the marina, country club, multifamily common areas, Bald Head Island Conservancy, office space, and town-owned facilities.

While there is a relatively small population of permanent, year-round residents (approximately 220), Bald Head Island serves the public (including residents of North Carolina and visitors from others state and countries), with its beachfront being among its principal draws. There are on average 5,000 visitors to the Island during a typical summer weekend day. Water-related activities along Bald Head Island include, boating, diving, sailing, windsurfing, surfing, kite surfing, stand-up paddle boarding and canoeing. Numerous beach accesses are maintained to support the daily public demands. The Bald Head Island Conservancy offers organized hikes, nature walks and kayak tours to permanent residents, guests and the general public. An eighteen-hole golf course is also available at the Bald Head Island Club. The golf course is open to member guests and is available with rental properties that have memberships.

The project area, located at the confluence of the Cape Fear River and Atlantic Ocean, is public and provides unique and important public beach resources and access, as do all of Bald Head Island's beaches. Maintenance of the beachfront for recreational use is a critical component of the Island tourism. The beachfront has been nourished via federal sand disposal and Village-sponsored projects over the last decade. The net beneficial effect of these soft stabilization measures for the Bald Head Island community has been the protection of properties and infrastructure as well as the use of a more expansive and stable beachfront.

6.0 DETERMINATION OF MAGNITUDE AND SIGNIFICANCE OF CUMULATIVE EFFECTS

The following is a qualitative assessment of the potentially beneficial, adverse, or neutral cumulative effects of the proposed action and similar past, present, or reasonably foreseeable future actions on identified resources.

6.1 Shorebirds and Waterbirds

The federally-protected piping plover and a variety of other shorebirds and colonial waterbirds are known to forage within the surf zone along Bald Head Island throughout the year. Moving sand to nourish or dispose of on the shoreline as well as short-term beach stabilization methods may bury intertidal macrofauna and reduce the available food resource to birds in this area. In general, beachfront fill placement results in short-term declines in species abundance, biomass, and taxa richness. Studies have shown that intertidal macrofauna can recolonize a nourished area within one or two seasons (Ross and Lancaster, 1996; National Research Council, 1995; Van Dolah et al. 1984; Reilly and Bellis, 1978). Directly after impacts to macrofauna have occurred and numbers of these species are depressed, birds that prey upon these invertebrates, including plovers, would likely move to adjacent undisturbed beach areas or tidal flats for the temporary period of population re-establishment.

While there will be a direct loss of prey species (i.e. crabs and worms) for birds following placement of the dredged sand, additional foraging impacts could result if the disposal material does not closely match the recipient beach. Sediment that is too coarse and/or contains high shell content can inhibit a bird's ability to extract food particles from the sand (ASMFC 2002). Material from the entrance channel reaches have been demonstrated to be compatible as evidenced through several federal disposal events. Likewise, in the event the VBHI utilizes one of the four prospective sand source sites, all beach fill material would comply with the State of North Carolina Technical Standards for Beach Fill Projects (15A NCAC 07H .0312). As a result, risk of these latter effects is considered to be minimal.

Dredge operations and sand placement projects are generally confined to the period of the year between November 15th and April 1st thereby avoiding the larval recruitment period of coquina clams (spring and summer) and mole crabs (early October) (Donoghue, 1999). As such, cumulative effects are manifested more likely from a spatial crowding of disturbance rather than temporal effects. If significant expanses of intertidal shoal and mudflat habitat are being excavated along a stretch of shoreline, then shorebirds and waterbirds are not only impacted by diminished food resources but by loss of habitat utilization as well. Shorebirds and waterbirds will preferentially seek suitable areas for foraging and roosting readily available outside of the project area.

Nourishment and associated construction activities within the intertidal surf zone could influence foraging and resting winter residents and spring migrants. For the Mason Inlet Relocation Project (which involved the backfilling of a small tidal inlet and its relocation 3,000 ft north), piping plover spring migrants were documented to pass over the Mason

Inlet shoals during construction (2002) and instead favor Rich Inlet to the north for foraging and resting. Likewise, fall migrants avoided Mason Inlet later in the year, stopping again at Rich Inlet before continuing southward of the study area. Since that time, expansive mud flats have developed on the backside of the relocated inlet. These areas have become a favored foraging and resting site for both wintering and migrant piping plovers (Webster 2006).

The terminal groin as currently proposed by the Village of Bald Head Island would be porous and would thus allow for sediment passage both through and over the structure. Inlet-directed sediment losses (i.e. shoaling of the adjacent federal channel) would continue to occur. In addition, the Point is expected to continue to migrate north as has been documented over the last several years. While sediment transport rates will be reduced, the Point feature will continue to exist. As a result, the intertidal and supratidal areas associated with this feature should continue to provide foraging, resting, and nesting habitat for shorebirds and colonial waterbirds. As has been observed on the south end of Wrightsville Beach, the presence of a low-profile structure does not prohibit sand accretion to downdrift areas. Indeed, the expanding spit in this particular area has recently become a viable nesting site for least terns and American oystercatchers.

Other regional projects have incorporated mitigative measures that have resulted in a net benefit to shorebird and waterbird populations. The Mason Inlet project included creation of the Mason Inlet Waterbird Management Area that serves as a sanctuary for nesting birds. Audubon North Carolina (in cooperation with New Hanover County and the Town of Wrightsville Beach) has assumed the responsibility of monitoring and maintaining this area. In addition, Audubon offers conservation and educational programs for the public. Audubon has documented nesting species to include least terns, black skimmers, common terns, and Wilson's plovers within the Inlet Management Area.

Previous federal projects associated with maintenance of Wilmington Harbor have also resulted in the creation of colonial waterbird nesting islands within the Cape Fear River. These islands have been documented successful nesting sites for gulls, terns, and waders in the estuary (Parnell et al. 1997). The islands are suitable locations because they tend to be relatively stable, extend well above the high-tide line, and support appropriate vegetation. Additionally, many of these islands are surrounded by open water and are relatively inaccessible to mammalian predators.

Additional cumulative effects may manifest from increased human disturbance via habitat encroachment. Continued beach nourishment projects could favor the increase of humans along the beachfront. However, beaches of developed barrier islands already have an established human presence. Shorebird and waterbird populations have already been subject to this type of disturbance to some degree. While potentially detrimental, human encroachment and disturbance is not expected to be incrementally worse with multiple projects. Additionally, with awareness and educational programs through the Bald Head Island Conservancy, any potential adverse effects of human activity along the BHI beachfront can be mitigated.

The southern and western-facing beaches of Bald Head Island have been the site of periodic nourishment and sand disposal in the past either through federal navigation disposal or Village-sponsored projects. Since 1991, there have been 10 sand placement events of varying size, which equates to one event every 2.3 years. Several of these projects have been small in scale and affected only a small section of the shoreline. Other projects have been much larger. However, all of the projects left an unaffected adjacent beachfront (specifically East Beach) and birds are presumably able to move to these areas to forage during and immediately after construction. Furthermore, benthic infaunal species have been demonstrated to re-populate nourished beaches over a relatively short period of time.

The site of the proposed terminal groin is an area characterized by chronic erosion and instability. In the absence of nourishment, the beach profile tends to slope steeply from upland dunes to wet beach. As a result, the existing condition provides little opportunity for suitable bird nesting habitat. The installation of the groin coupled with periodic nourishment would promote a more stable dry beach with the potential for increased nesting. However, more stable conditions can also favor the growth of upper beach or dune vegetation. Denser vegetation would provide increased cover for predators and would also restrict nesting of certain species including the American oystercatcher and the Wilson's plover.

As stated above, the BHI project would affect approximately 1.7% of the total length of shoreline of Onslow Bay and Long Bay. All recent, current, and/or authorized beach nourishment projects combined affect approximately 35% of the shoreline. When considering all of these projects, a large portion of the assessment area will have beach placement activities in the foreseeable future, which could affect benthic infauna populations. However, given funding constraints of these projects and the limited availability of dredging equipment, it is improbable that all or even most of these proposed projects would be constructed at once. Further, most of these projects will leave adjacent unaffected portions of beach that will be available habitat for food resources of shorebirds and waterbirds during and immediately following construction. Thus, cumulative effects from projects in the assessment area are considered neutral.

6.2 <u>Seabeach Amaranth</u>

Seabeach amaranth is an annual herb that occurs on beaches, lower foredunes, and overwash flats (Fussell, 1996). Historically, seabeach amaranth was found from Massachusetts to South Carolina. The species is currently found in New York, New Jersey, Delaware, Maryland, Virginia, North Carolina, and South Carolina. The decline of this species is a result of beach stabilization efforts, storm-related erosion, and human recreational use of its habitat (USFWS, 1996). Weakley (1986) found that in North Carolina the plant is most common on overwash flats on accreting ends of barrier islands. This species occupies elevations ranging from 0.2 to 1.5 m above mean high tide (Weakley and Bucher, 1992). Since dredging of the borrow area will be performed within open waters of the Cape Fear River or nearshore waters of the Atlantic Ocean in the event that the federal navigation channel is unavailable at the time of project implementation, no impacts to amaranth plants will occur from this action. Project-related beach nourishment would take place no earlier than November 16th, when amaranth plants have already released seeds. Deeply burying existing seeds via nourishment could negatively affect the amaranth population in later seasons. Assuming that seeds are located in the general position of former parent plants observed in past surveys, sediment placed on the beach may bury seeds and delay germination the following year.

Groin construction would extend into the summer months. Construction actions (including the excavation and reworking of recently nourished sand) could have an effect on amaranth germination. However, the site of the proposed groin is within a chronically and severely eroded condition that is not well-suited for the occurrence of seabeach amaranth. Studies have found that groins have mixed effects on seabeach amaranth (USFWS, 1996). Immediately updrift from a groin, accretion sometimes provides or maintains habitat suitable for seabeach amaranth. Immediately downdrift of a groin, seabeach amaranth habitat may become degraded if the area is sediment-starved. However, in 1991 Long Island’s (New York) largest population occurred along a groin field. Furthermore, the porous design will allow for sand passage through and over the proposed structure to minimize any potential downdrift impacts to the upper beach. It should be noted that updrift stabilization of the dry beach could potentially expand areas suitable for perennial vegetation that can outcompete seabeach amaranth. Overall, it is likely that a more expansive dry beach area would result in a net benefit to seabeach amaranth.

Research on the consequences of beach nourishment to amaranth seeds is inconclusive. The U.S. Army Corps of Engineers (1995) found that amaranth at Masonboro Inlet was more abundant in areas that recently received dredged material. Dredging activities could uncover buried seeds and allow them to germinate in deposited areas. (This benefit is unlikely to occur during this project if dredged material is supplied from areas offshore that do not contain amaranth seeds.) In contrast, Hancock (1995) concluded that amaranth seedlings generally do not emerge from depths of sand greater than 1 cm and beach nourishment may be detrimental if placed on top of seeds.

Although the proposed project will ultimately enhance seabeach amaranth habitat, the disposal of sand may initially bury seeds and slow germination. Therefore, the proposed project may affect but is not likely to adversely affect seabeach amaranth.

As stated above, the BHI project would affect approximately 1.7% of the total length of shoreline of Onslow Bay and Long Bay. Given funding and logistical constraints of these projects, it is improbable that all or even most of these projects would be constructed at once. Assuming these projects follow avoidance measures, adjacent unaffected portions of beach will be available for germination of this plant while nourishment activities in other areas potentially expand its habitat for germination in later seasons. For these reasons, cumulative effects to seabeach amaranth would be neutral.

6.3 Sea Turtles

In North Carolina, the Kemp's ridley sea turtle is known to occur in estuarine and oceanic waters, whereas the hawksbill and leatherback are found primarily in oceanic waters (Schwartz 1977, Epperly et al. 1995). These species are found in North Carolina waters all year but can be present in inshore waters April through December (Epperly et al. 1995). The hawksbill sea turtle and Kemp's ridley sea turtle are not known to nest along the Brunswick County beaches. The leatherback sea turtle primarily nests on beaches in the tropics, but is occasionally observed nesting in areas north of Florida (Rabon et al. 2003). In 2010, one leatherback sea turtle laid a nest on East Beach on Bald Head Island. Prior to that, the closest known leatherback nesting sites to the project area were in Georgetown County, SC and Carteret County, NC.

In North Carolina, the loggerhead and green sea turtles are found in North Carolina waters all year but can be present in inshore waters April through December (Epperly et al. 1995). Both species are known to frequently use coastal waters as travel corridors and have been observed migrating along the North Carolina coast (Epperly et al. 1995). Loggerhead turtles are known to regularly nest at Bald Head Island. Staff of the Bald Head Island Conservancy (BHIC) patrol the beach front daily during the nesting season to document and monitor sea turtle nests. Between 1980 and 2011, an average of 97.4 nests per year was recorded on Bald Head Island, with the majority of the nests occurring along South Beach and East Beach (BHIC sea turtle data). Between 2007 and 2011 an average of 19 nests per year were noted within the project area. In 2006, one green sea turtle nest successfully hatched from the south-facing beach of the project area (Dewire, personal communication.). In 2011, three nests successfully hatched from the south-facing beach of the project area. Since green sea turtles appear to have strong nesting site fidelity and often lay eggs on the same beach on which they hatched (USFWS 1992, Carr et al. 1978), surviving female green sea turtles will likely return to Bald Head Island for future nesting habitat.

In March 2013, the U.S. Fish and Wildlife Service proposed the designation of 739.3 miles of shoreline, 84% of all known nesting area, in the states of North Carolina, South Carolina, Georgia, Florida, Alabama, and Mississippi as critical habitat for the Northwest Atlantic Ocean Distinct Population Segment (DPS) of the loggerhead sea turtle. Bald Head Island is included in this proposed critical habitat protection area. Likewise, the National Marine Fisheries Service (NMFS), proposed critical habitat for this DPS of the loggerhead within the Atlantic Ocean and the Gulf of Mexico. Specific areas proposed for designation by NMFS include 36 occupied marine areas within the range of the Northwest Atlantic Ocean DPS. These areas contain one or a combination of nearshore reproductive habitat, winter area, breeding areas, and migratory corridors.

While dredge and project-related nourishment activities would be scheduled to occur between November 16th and April 30th, groin construction would likely extend into the sea turtle nesting and migratory periods. The proposed project could potentially affect loggerhead and green sea turtles in three ways. First, dredging activities proposed to occur offshore may occur in areas used by migrating juveniles. The act of dredging material may adversely affect juvenile turtles. However, the movements of a cutter suction dredge would be limited to the spatially constrained borrow area and should therefore pose substantially less collision threat to migrating sea turtles than normal commercial ship traffic. Second, nourishing the beach with the fill material may affect nesting activities by altering nesting habitat. If the beach becomes too hard through the compaction of deposited nourishment sediments by construction equipment, it could present a physical barrier to turtle nest digging. Furthermore, placement of sand on beaches may influence physical characteristics of beaches such as sand-grain size and shape, silt-clay content, sand compaction, moisture content, porosity/water retention, gas diffusion rates, and color of sand grains which could alter the temperature of the beach. These factors could reduce reproductive success of nests laid in nourished areas (Crain et al., 1995; Ackerman, 1996). However, more stringent sediment compatibility standards and well-established mitigation measures will help to avoid or reduce any potentially adverse cumulative effects. Third, the terminal groin and continued maintenance and occurrence of the sand tube groinfield may result in indirect effects to both adult nesting females and emerging hatchlings. Hardened structures exposed above the beach or buried by accreting sand have the potential to adversely affect nesting turtles during nest site selection or during nest digging (resulting in false crawls or false digs). Groin structures may also concentrate predators (either birds or fish) and present physical impediments to hatchlings. Resultant increased energy expenditure by hatchlings can affect their ability to reach offshore developmental areas (Davis et al., 2002).

The proposed project and other beach nourishment projects of its kind are designed to offset the erosive loss of sand. The net result of a widened, more stable beachfront has been cited to facilitate turtle nesting. Beach nourishment projects have been most abundant (both in numbers and length of shoreline) in Florida, a state with a documented upward trend in turtle nesting sites. North Carolina provides vast beachfront area considered suitable for nesting of the five species of sea turtles. Overall, the actual number of sea turtle nesting sites occurring in North Carolina is relatively small compared to the entire southeastern coast (i.e. beaches of Florida, Georgia, South Carolina, and North Carolina, combined). In light of these factors, it is believed that that the cumulative effects of multiple actions would be considered neutral in the net.

6.4 Intertidal and Subtidal Soft bottom Habitat (including shoals)

Benthic infauna (e.g. polychaete worms, amphipods, and mollusks) will be subject to immediate adverse impacts associated with the removal of sand and entrainment of infaunal and non-motile epibenthic organisms. Physical removal of sediments from a borrow site removes benthic habitat, along with resident infauna and epifauna incapable of avoiding the dredge head, and can yield pronounced population effects to the benthos (USFWS 2000). Studies along the east, gulf and west coasts of the United States document similar trends of 84% to 90% decrease in the number of benthic organisms post-dredge (ASFMC 2002). Continual maintenance of Wilmington Harbor began in 1870 and harbor dimensions have been increased incrementally for over 100 years. Ongoing channel maintenance operations of the harbor routinely disturb benthic populations in the existing deep water channel and nearby side slopes. The benthic assemblages characteristic of the Cape Fear River and nearshore ocean (including the prospective sand source sites) are dominated by opportunistic species which recover quickly from environmental disturbances.

Potential physical effects of dredging typically include alteration of wave dynamics and sediment transport mechanisms; shoal deflation; and exposure of sediments with different physical characteristics (grain size, chemical composition, etc.). The rate of sediment recovery will fluctuate based on location, time of dredging, volume of sediment removed, sediment transport rate and storm characteristics following dredge events. In high energy sandy environments, the effects of sediment alteration are often minimized (Saloman et al. 1982, Pullen and Naqvi 1983). Studies have documented recovery of sediment characteristics within several months (Bowen and Marsh 1988).

While species abundances has been shown to return to pre-dredging conditions rather quickly, species composition and diversity indices may remain altered for a period of time subsequent to excavation. Posey and Alphin (2002) concluded that the rapid infilling of a borrow site (resulting from strong water currents and dynamic sand movement) contributed to a relatively quick species recovery. Based upon the results of this study, inter-annual variability contributed more to the observed differences in species abundance than the sediment removal effects (Posey and Alphin 2002). Similar benthic recovery trends were documented during biological monitoring efforts initiated by VBHI following excavation of Jay Bird Shoals in 2010. Data collected over the four year course of study indicate that the benthic community inhabiting the Jay Bird Shoals borrow site recovered quickly from any potential deleterious effects of project activities (LMG 2011, 2012, 2013). During pre-construction and post-construction monitoring, Jay Bird Shoals was dominated by amphipods, particularly *Protohaustorius wigley*, and other taxa which are adapted to life in environments prone to natural disturbance. These taxa presumably recolonized quickly after project construction and were joined by other taxa that may have capitalized on the reduced competition for space associated with recently disturbed habitats. While there were noticeable dominance patterns throughout the course of study, there was some deviation in the species present between years, likely a reflection of natural inter-annual variability typical of benthic infaunal communities. The rapid re-colonization of Jay Bird Shoals resulted in a relatively stable benthic community assemblage which persisted during subsequent monitoring events.

The recovery of the benthos at the recipient site would be reliant on immigration (active or passive) of organisms from the adjacent undisturbed areas and larval recolonization from the water column. A number of studies have indicated relatively rapid recolonization and recovery of the benthos subsequent to dredging operations provided that the post-dredge environment is favorable for colonization and peak periods of larval recruitment are avoided (Pullen and Naqvi 1983; NRC 1995; Hackney et al. 1996; Schaffner et al. 1996; Bergquist et al. 2008).

Placement of sand at the beach fill site will bury the majority of benthic infauna as existing soft bottom habitat is converted to dry beach and wet beach habitat. Nourishment impacts on the target beach would be most severe for small, relatively immobile species that are unable to burrow through the new sediment. Larger, more mobile organisms will burrow through the newly placed sediment or avoid the area of disturbance by migrating to neighboring unaffected areas. As a result of the dredge and pump processes, it is likely that disposal materials will be devoid of live benthic species. Benthic regeneration within soft bottom habitat will vary depending upon the magnitude of the disturbance, the character of the new sediment interface, rate of sediment recovery duration and timing of the dredging, the type of equipment used to extract the sediment, life history characteristics of colonizing species and water quality (Pullen and Naqvi 1983; NRC 1995). Areas that are slow to return to pre-nourishment conditions may never fully recover before subsequent nourishment events. However, relatively small, opportunistic species of polychaetes and amphipods tend to be the numerically dominant benthic macrofauna of intertidal and subtidal flats. In addition, implementation of the state sediment criteria would ensure the use of beach compatible sediment for present and future nourishment/disposal projects facilitating a favorable environment for recovery of the benthos.

Federal dredge disposal and Village-sponsored nourishment efforts on Bald Head Island would contribute to the removal of subtidal bottom and/or sandy shoals of the area, which in turn, has the potential to result in cumulative impacts to benthic communities residing within these habitats. However, the cumulative amount of sediment removed for disposal and nourishment efforts on Bald Head Island reflects a small percentage of the overall soft bottom and sandy shoal habitat identified in the region. Any impact to soft bottom habitat would be offset to a degree by the predicted increase in soft bottom resulting from erosion of upland habitats. Furthermore, the extent of the potential adverse impact relative to the amount of soft bottom habitat on a regional scale, in conjunction with the capacity of this type of habitat to accommodate additive effects, would minimize the risk of any cumulative impacts.

The USACE has identified Frying Pan Shoal as the sand source for the Brunswick County Beaches Coastal Storm Damage Reduction Project. The USACE is in the process of preparing a DEIS for the project in accordance with NEPA. Actual implementation of the project is likely to be at a much later date (if implemented at all) than the VBHI Shoreline Protection Project. As such, time crowding of actions and associated additive impacts would become less of an issue. Given the size of the shoal feature relative to any prospective borrow sites, spatial crowding effects are likewise to be minimal. As a result, cumulative impacts potentially affecting this resource are not anticipated.

Construction of the terminal groin would permanently replace part of the beach with granite armor rock. Benthic infauna incapable of horizontal movement would be permanently lost and eventually replaced with species capable of inhabiting rock substrate and interstitial spaces between the rocks. While construction of the terminal groin would contribute to the loss of benthos, the cumulative loss of benthic infauna associated with construction of hard structures is offset by the amount of undisturbed soft bottom along the coast of the Cape Fear region. As previously noted, the extent of existing soft bottom habitat in conjunction with its resilience to disturbance (either natural or anthropogenic) reduces the risk of cumulative impacts.

6.5 <u>Water Column (including federally-managed species)</u>

The water column provides a basic ecological role in the assimilation of energy and nutrients at the base of the food chain through primary productivity, largely by phytoplankton, and benthic-pelagic coupling. The water column also serves as habitat for pelagic species in varying life stages while providing a corridor for numerous anadromous and catadromous species.

6.5.1 Water Column Effects at Borrow Sites

It is the applicant's proposal that the sand fillet for the proposed terminal groin be augmented by the disposal of the next federal navigation channel maintenance event. Supplemental sand (as needed) would be sourced from either Jay Bird Shoals or Bald Head Creek Shoals. The proposed Jay Bird Shoals borrow area is located within the undredged portions of the borrow site that had been previously authorized for the Village-sponsored beach nourishment project constructed in the winter of 2009/2010[1]. Other sources of sand for fillet maintenance and maintenance of West Beach include the federal navigation channel and the ebb tidal shoal of Bald Head Creek. Frying Pan Shoals has been identified as a future borrow source for nourishment beyond Year 3 (particularly for anticipated nourishment needs in Year 12, 21, and 30).

[1] The previous authorization for use of the Jay Bird Shoals borrow site was for the specific action completed in 2010 and has no bearing on permit decisions for future proposed actions.

Impacts to the water column associated with dredging are associated principally with the entrainment of infauna, epifauna, and demersal species. Mortality of organisms (i.e. plankton, pelagic eggs and larvae to pre-flexion stage individuals) within the water column that lack the ability to escape the suction field of an operating dredge and subsequent entrainment in the flow of water and sediment passing through its pumping equipment is likely. However, the effect is believed to be negligible based upon: (1) the very small volumes of water pumped by dredges relative to the total amount of water in the water in the vicinity of the operating dredge; (2) the extremely large numbers of larvae that are produced by most estuarine-dependent species; and (3) the high natural mortality rate for early life stages of many fish species (USACE 2000). The risk of entrainment has been evaluated for the Cape Fear River mouth itself. The USACE (2000) estimated that the amount of water intercepted by the largest operating hydraulic dredge (30-inch diameter pipe) is less than 8/10ths of 1% of the average daily river flow. Motile organisms, including most fish assemblages capable of escaping the suction field will likely relocate to other areas while dredging activities take place.

Localized turbidity impacts are anticipated by the removal of substrate from the borrow site as well as overspill associated with the dewatering of dredge sediment. While the identified borrow sites are characterized as high-energy, sandy environments, background turbidity levels are expected to increase during project implementation. However, these effects are expected to be localized and short-term. Turbidity levels in waters outside of the immediate vicinity of the operating dredge should be less than 25 NTUs (USACE 2000).

Pullen and Naqvi (1983) found that motile animals were the least affected by dredging and concluded that benthic and fish utilization likely depends upon water quality of the dredge area. Provided the dredge area does not form an anaerobic pit of organic-laden sediment, biological communities may be restored rather quickly. In addition, multiple studies have indicated rapid recovery of fish utilization at locations with high water and sediment dynamics such as tidal channels (Pullen and Naqvi 1983; Van Der Veer et al. 1985; Musick 1998; Schaffer et al. 1996). The prospective sand source sites considered for Village-sponsored nourishment are sandy, depositional features and thus should not be susceptible to water column impairments nor to the subsequent secondary effects on benthic and fish resources.

6.5.2 Water Column Effects at Nourishment Site

The potential effects to water column in the littoral zone during nourishment are minimized through the use of beach-compatible sediments consisting of more than 90% sand (USACE 1997). In general, the spatial scale of elevated turbidity related to beachfront disposal is very small (USACE 2001). Federal disposal actions have been demonstrated to utilize beach-compatible sand since much of the source material is derived from the adjacent beaches and shoals. Prior to use of any sand source site by the Village, minimum state sediment compatibility standards must be met. Available sediment data from each of the four prospective sites indicate the presence of beach-compatible sand in sufficient volumes for nourishment. Each of the sites consists of sediments characterized by a high percentage of sand by percent weight and low percentage of fines (see Olsen 2007, Athena Technologies 2009, Catlin 2010, and LMG 2013). Thus, effects to the water column from nourishment are expected to be spatially confined and temporal.

The indirect impact of turbidity on mortality, growth, and spawning behavior for surf zone fish is not well documented but is likely not significant since most adult fish are mobile enough to avoid areas of highest turbidity. Given the avoidance behavior of mobile species, nourishment is expected to influence fish distribution. However, many surf zone species are adapted to relatively high ambient turbidity levels and it is largely inferred in the literature that impacts to fish are more closely related to changes in and/or loss of benthic prey resources than temporary changes in water column characteristics (USACE 2001; Hackney et al. 1996). Ross and Lancaster (2002) reported that species (such as pompano and kingfish) that utilize the surf zone for nursery areas exhibit high site fidelity and are therefore more vulnerable to localized effects to benthic assemblages (Ross and Lancaster 2002). Increases in suspended sediments may also adversely affect the feeding behavior of visually-orienting fish (Wilber et al. 2003).

The construction of the terminal groin is proposed to take place concurrent with, and subsequent to, the placement of the fillet. A portion of the stem section and all of the head section will likely be constructed in open water. Placement of the armor stone would be accomplished using a barge and crane or potentially through the use of a temporary trestle structure constructed parallel to the terminal groin. The trestle would be supported by steel pilings jetted into the substrate and removed once construction is complete. However, phasing of the project would reduce the need for the use of a trestle. Depending upon conditions at the time of the groin installation, it is likely that equipment will be able to be operated from sand pads formed from the fillet. Any effects to the water column as a result of increased turbidity from construction would be expected to be localized and short-lived.

Due to their mobility and range, surf zone fishes utilizing the project area to forage upon benthic macrofauna (e.g. mole crabs and coquina clams) would move to adjacent undisturbed beach areas and other suitable feeding zones for the temporary period of construction. Surf zone conditions would resume a pre-construction mode relatively quickly.

It has been reported that shore-perpendicular structures such as groins or jetties have the potential to impede longshore transport of larvae and natural passage into estuaries or sounds and thus negatively impact recruitment success (Blanton et al. 1999; Hare et al. 1999). In particular, the presence of jetties has the potential to deflect larvae to an extent that would eliminate the opportunity for the larvae to be entrained into the estuary (particularly for relatively small coastal inlets). For the Oregon Inlet project, it was asserted that construction of duel jetties would result in the reduction of ocean-spawned larvae from reaching estuarine nursery areas (USACE 1999).

While a dual jetty system of an inlet presents a vastly different set of physical and biological conditions than that of the proposed terminal groin on Bald Head Island near the mouth of the Cape Fear River, hypothetical particle ingress into the Cape Fear River estuary was nonetheless simulated via Delft 3D modeling by Olsen Associates. The drogue simulations were intended to represent larval fish pathways into the estuary under two scenarios: (1) ingress with beach fill; and (2) ingress with beach fill and a terminal groin in place. The presence of the terminal groin appears to have no significant limiting influence on the ability of particles (hypothetical larval fish) to enter the estuary. The complete model report of findings is provided in Appendix J of the DEIS. The size of the structure relative to the hydraulic field of the Cape Fear River mouth is negligible. As a result, larval entrainment into the Cape Fear River estuary will remain unaffected. In addition, the post-construction template would result in a shoreline configuration that effectively extends the shoreline to the waterward extent of the structure. Given these considerations, it is believed that the post-construction condition would be conducive for unimpeded passage of fish and larvae into the Cape Fear River estuary.

The terminal structure will likely provide foraging and shelter opportunities for surf zone fishes thus adding to species abundance and richness to the soft bottom community (Peters and Nelson 1987; Clark et al. 1996). Cenci et al.'s (2010) study focused on installation of shoreline stabilization structures in areas characterized by soft bottom habitats. The data collected on fish populations indicates that during the early stages following new groin construction, species diversity and richness increased dramatically. These new structures become fish "producers" by providing habitat for local and transient fish assemblages. However, introduction of artificial structures may also be viewed as a habitat trade-off in which species assemblages may be altered. In addition, hardened structures have been cited as being susceptible to invasion by non-native species (Bulleri and Chapman 2010).

The hydrodynamics of the lower Cape Fear Estuary create a dynamic environment. The water column is subject to wind and current-induced mixing and daily tidal exchange with the Atlantic Ocean. Additionally, the presence of the terminal groin appears to have no significant limiting influence on the ability of particles (hypothetical larval fish) to enter the estuary. In consideration of other past, present, and reasonably foreseeable future actions in the coastal Cape Fear region, no cumulative impacts to the water column are anticipated.

6.6 Water Quality

Marine and estuarine waters may experience elevated, localized turbidity as a result of the placement of disposal materials on the beach as well as dredging activities in the channel. As part of the federal navigation project, beach-compatible dredged material (sands) dredged from the ocean bar or river channel is regularly placed on the recipient beach. Turbidity effects from fill placement are directly related to grain size. The high percentage of sand in the dredged material will allow for more rapid settling of sediment following placement activities. In addition, the tidal currents and hydrodynamics of the Cape Fear River estuary provide a means for water mixing and dilution. Turbidity created by the disposal operation normally does not persist beyond more than one or two tidal cycles (12 to 24 hours) following the cessation of the disposal operation (USACE 2000).

Dredging and associated suspended sediment plumes can have short-term and localized effects on water quality. These include chemical transformations resulting from the oxidation of sulfides and of ferrous iron (Fe^{2+}) which in turn can lead to reductions in dissolved oxygen (DO). Oxidation of sulfides can also lead to localized reduction in pH levels in the water column (Jabusch et al. 2008). DO levels over the dredge site can also be suppressed via the release of oxygen-demanding material (e.g. organics). However, bottom sediments of the proposed borrow sites exhibit a high percentage of sand by weight with low percent organic matter. In addition, the waters at the mouth of the Cape Fear River tend to be well-oxygenated (Mallin et al. 2012) and thus less susceptible to impairment from any localized increases in DO.

Disturbance activities associated with federal maintenance of the channel (i.e. dredging and dredge disposal) would occur within the open waters of the Cape Fear River estuary where hydrodynamics of the water column are subject to semi-diurnal tidal exchange as well as wind and current induced mixing. Elevated turbidity levels would be localized and temporary due to mixing and dilution. The incremental contribution to cumulative water quality impacts from the proposed action in combination with other regional navigation projects and water dependent development activities would be negligible.

6.7. Human Communities

The net beneficial effect of soft stabilization measures (i.e. beach nourishment) and engineered structures is the protection of properties and infrastructure as well as the use of a more expansive and stable beachfront. Since Bald Head Island is a planned unit development, efforts to widen and stabilize the beachfront protect existing platted lots, constructed residences, and existing infrastructure. Beach restoration will not allow for additional development or the recordation of new lots on the Island. The cumulative benefit to the human community is protection of existing structures/infrastructure and enhanced recreational use. These benefits are realized by permanent residents, part-time residents, vacationers, and visitors to the Island.

Stabilization measures along the coast of North Carolina help to protect a significant property tax base to local municipalities. In addition, protection of existing structures, infrastructure, and recreational beach ensures a viable and critical tourist industry for the State. Thus, multiple projects occurring in a single location (e.g. Bald Head Island) or in multiple locations (e.g. beachfront communities of North Carolina) are considered cumulatively beneficial to the human community resource.

7.0 ACTIONS TO REDUCE CUMULATIVE IMPACTS

Cumulative effects are not anticipated from the Village of Bald Head Island Shoreline Protection Project. Over the course of the last few years, the applicant has evaluated numerous alternatives and implemented various measures in an effort to mitigate environmental impacts potentially resulting from nourishment activities. Section 6.0 of the DEIS describes the mitigative measures to be employed by the Village of Bald Head Island. Detailed monitoring and mitigation efforts associated with construction of the terminal groin are also included within the Inlet Management Plan (Appendix B of the DEIS). Collectively, monitoring and mitigative measures will reduce the potential for cumulative impacts related to proposed dredging, nourishment, and terminal groin construction.

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