SECTION 5.0 - ENVIRONMENTAL CONSEQUENCES

5.1 ALTERNATIVES ELIMINATED FROM FURTHER CONSIDERATION

As indicated in Section 3.0 of the DEIS, a range of alternatives were developed in consultation with the Project Review Team (PRT). The range of alternatives includes considerations of various options that meet the purpose and need for this project. One alternative has been eliminated from the alternatives analysis: construction of a terminal groin without beach nourishment. The reason that this alternative has been eliminated from further consideration is that it is not compliant with current state statute as ratified in Senate Bill 110 which requires the placement of a concurrent beach fillet.

5.2 DESCRIPTION OF PREDICTED PHYSICAL EFFECTS

5.2.1 Shoreline Conditions

A. Methodology

The prediction of potential post-construction shoreline locations associated with each of the six (6) alternatives under consideration is primarily based upon numerical modeling of each alternative over a nine (9) year period. Within that time frame, the Wilmington Harbor Sand Management Plan (SMP) is assumed to occur on an average 3-year interval for Bald Head Island disposal except for identified "gaps" in the cycle when the SMP calls for placement on Oak Island. Though the current SMP anticipates disposal on adjacent beaches on two-year

intervals, federal funding and other considerations may impact the timing and occurrence of maintenance and disposal events. To that end, the model assumes that actual disposal would occur in a manner similar to the past decade with placement occurring on an average three-year interval. The use of a 3-year interval vs. a 2-year interval would not reflect any large-scale differences in the comparative nature of the modeling results, particularly over a nine-year analysis. In addition, the same annualized sand disposal volumes would be used, irrespective of the disposal interval, further dampening any difference in model results.

Note that the Delft 3D modeling does not account for sea-level rise. Relative sea-level rise (RSL) varies as a function of latitude on the NC coast with higher rates of rise documented in the northern part of the state and lower rates in south (NCCRC 2010). While different studies predict varied rates of sea-level rise in the future, use of a predicted accelerated rate in the Delft 3D model would not appreciably affect model results. This is due primarily to the length of analysis considered in the model runs (i.e. up to nine years). Over a nine-year period, the range of potential sea level rise and corresponding influence on numerical morphological modeling is negligible. 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. If the future rise of local water level accelerates, then the effects would be observed across alternatives and the relative differences between alternatives would be expected to be the same.

In each model run, beach fill is assumed to be placed on Bald Head Island at time zero. Therefore, the analysis of each alternative assumes the same “improved” condition (i.e. 1.2 Mcy of sand fill placed along a portion of South Beach) at time zero. In the same way, period of analysis for each alternative ends at Year 9 prior to the next scheduled sand disposal

event. The description of each of the six alternatives is provided in Section 3.2 of this document.

For each of the six alternatives considered, the initial modeled bathymetry comprising the nearshore zone and navigation channel were set to reflect conditions in spring 2011. The nearshore bathymetry and upland were described by physical monitoring survey data measured in May 2011. Input conditions within the navigation channel used in the Delft 3D model are based upon U.S. Army Corps of Engineers (USACE) condition surveys performed in February 2011. Combined, these surveys describe a generally eroded South Beach, an unimproved West Beach, and a shoaled navigation channel, particularly in the Bald Head Shoal I and II reaches.

A distribution of dredged material which reflects the current ratio of the division of sand pursuant to the SMP was taken into consideration in the model. However, in keeping with recent experience, the applicant's engineer chose to model dredging and sand fill projects on an average three year interval within the 9-year model simulation. *For all alternatives, a fill placement is specified to occur at model startup, at time zero.* A second dredge/fill event with disposal onto Bald Head Island occurs at year 3 in the model for all alternatives. For alternatives that consider a Village-sponsored nourishment event (during the period when sand from the federal navigation project is placed on Oak Island), a third fill is placed onto Bald Head Island at Year 6 (reflecting a Village-sponsored project). Alternatives without Village action place no "additional" material after Year 3 during the 9-year simulation. In either case, federal dredging events continue on a 3-year schedule throughout the period of simulation. As noted previously, the Year 9 prediction for each alternative therefore simulates a pre-disposal condition.

All fill placement events specify a volume of 1.2Mcy. The limits of fill for Alternatives 1 through 4 remain constant with placement occurring between Stations 46+00 and 168+00 on South Beach (refer to Appendix K for station location map). The western limit of fill was

established at the westernmost sand tube groin no. 16. The eastern limit of fill is based on prior federal disposal projects completed in 2001, 2005, and 2007. The limits of fill for Alternatives 5 and 6 specify placement between the terminal groin and Station 152+00 (+/-). The eastern limit of fill for these two alternatives was moved westward relative to non-terminal groin alternatives in order to accommodate the additional fill required to construct a fillet eastward of the terminal groin, as required by SB 151. Note that for alternatives considering a terminal groin structure, the applicant proposes that construction of the groin would be concurrent with, and following, a federal beach disposal with the limits of federal disposal occurring no further west than the proposed groin location (see Appendix E) .

B. Findings

The predicted approximate location of the mean lower low water (MLLW) shoreline at the end of each 9-year simulation for each of the alternatives is plotted in Figure 5.1. Note that for reference, the six alternatives are outlined in Table 5.1 below. As depicted in Figure 5.1, substantial seabed erosion and shoreline recession is predicted for Alternative 1 (No-Action), Alternative 2 (Retreat), and Alternative 4 (beach fill without sand tube groins). For each of these alternatives, erosion is predicted to extend well into the seaward limit of existing development on Bald Head Island. Alternative 3 (existing sand tube groins, SMP disposal, and Village beach fill), Alternative 5 (terminal groin, federal beach disposal, and existing sand tube groins), and Alternative 6 (terminal groin, federal beach disposal, without the existing sand tube groins) do not exhibit as pronounced a change in shoreline position as those identified above. For purposes of assisting in the interpretation the predicted MLLW line locations presented by Figure 5.1, Figures 5.2 – 5.7 portray cumulative erosion/sedimentation patterns for each of the six alternatives over the 9-year period of analysis. In each figure, red/yellow shading represents seabed or beach deflation (erosion) while blue shading reflects sedimentation (accretion). The bold black dashed line in each figure represents the approximate digitized seaward limit of development (homes, roads, etc.).

Table 5.1. List of Project Alternatives

Alternative #1	**No-Action (includes component of Status-Quo)**
Alternative #2	**Retreat**
Alternative #3	**Beach Nourishment/Disposal with Existing Sand Tube Groinfield to Remain in Place**
Alternative #4	**Beach Nourishment/Beach Disposal and Sand Tube Groinfield Removal**
Alternative #5	**Terminal Groin with Beach Nourishment/Beach Disposal (Sand Tube Groinfield Remaining)**
Alternative #6	**Terminal Groin with Beach Nourishment/Disposal (Removal of Sand Tube Groinfield)**

It should be noted that for Alternative 3 the cumulative erosion patterns predicted in the model indicates erosional stress along discrete areas of shoreline west and north of the westernmost sand-filled tube groin (refer to Figure 5.4). This result is consistent with actual recent events on western Bald Head, whereby additional emergency shore protection measures were required in 2011 westward of the sand tube groin field (several years after two SMP disposals and a Village-sponsored nourishment project). Additionally, the predicted erosion immediately adjacent to the westernmost sand-filled tube groin indicates structural failure of at least one tube groin and the existing sandbag revetment that lie westward thereof (which was not included in the model). If left unmitigated, sand tube failure would transfer to adjacent sand tubes resulting in increased erosion and land/property loss. As a result of the potential for this risk, the westernmost five (5) sand tube groins were replaced in the spring of 2013.

The MLLW analysis for Alternatives 5 and 6 (reference Figure 5.1) similarly demonstrates protection of existing upland development near the Point. The applicant's investigation of the complete model results for Alternative 6 indicates to its engineer that while erosion did not directly impact upland infrastructure nearest the Point, it does occur near areas which have previously been historically highly vulnerable to storm induced upland erosion (specifically along Bald Head Wynd on South Beach across from the Bald Head Island Club) (Olsen 2013).

The terminal groin is designed to allow for the ability to control sediment loss rates, thereby reducing end losses experienced with reoccurring sand placement projects. The structure's permeability is predicted to reduce downdrift impacts associated with the terminal groin by allowing some degree of controlled sand transport through and over the rock structure. As discussed in Section 3.0, the proposed structure for Alternative #5 and Alternative #6 would be constructed in two phases. The first phase would consist of a 1,300 lf groin that would require a smaller sand volume for the updrift fillet and result in a more rapid activation of downdrift transport to West Beach.

The MHHW shoreline position for each alternative is predicted by calculating composite intertidal beach widths derived from historical beach profiles. The resulting MHHW shoreline estimates for the six alternatives under consideration are shown in Figure 5.8. The applicant's engineer has calibrated and verified the Delft3D model and indicates that it provides excellent predictive ability relative to measured and observed physical processes within the study area. The results of the modeling described herein, however, are *not* intended to be a precise prediction of future shoreline or bathymetric conditions given computational limitations and uncertainties surrounding the future local meteorology, oceanographic conditions, sediment characteristics, non-project related anthropogenic works, etc.

The estimated MHHW shorelines resulting from Alternative 5 and Alternative 6 (both terminal groin alternatives) depict a relatively stable Point feature albeit at a more northerly location along with the continued erosion of the West Beach shoreline due to its current directional migration (as documented through USACE and Village surveys). The estimated post-project MHHW contours for both alternatives coincide with the existing bluff escarpment indicated in the aerial photography. The estimation is conservative as the initial shoreline condition modeled along West Beach reflects eroded conditions without beach improvements (i.e., sand placement) which have been historically necessary along this reach

and are expected to continue into the future. The most recent West Beach Sand Placement fill occurred in February of 2013 as a result of federal channel disposal by the Wilmington District, USACE at the request of VBHI.

5.2.2 Beach Conditions

The calibrated Delft3D model was used to describe the physical performance of sand placement operations for the six alternatives. The model predicts the relative volumetric changes three years following construction of each project alternative. Refer to Section 3.0 for a detailed description of the alternatives under consideration.

For alternatives without a terminal groin, the initial bathymetry used as model input included a 1.2 Mcy beach fill extending eastward from the Point to just east of Station 162+00. Project berm widths were roughly similar to those constructed in 2009/10; however, because the 2009 project volume was larger than that which was simulated, the eastern extent of the fill was truncated in order to simulate placement of 1.2 Mcy. The latter volume is more consistent with that placed in 2005 and what is conservatively expected to result on average from routine maintenance dredging (on an average 3-year basis).

For alternatives with a terminal groin, the initial bathymetry used as model input also included a similarly sized 1.2 Mcy beach fill. Because the terminal groin (i.e., fillet) was "pre-filled" with a portion of this material, it was necessary to adjust the spatial limits of the fill for the post-groin construction simulation. The initial sand placement extended from the terminal groin eastward to about Station 126+00. This station is still well east of the predicted nodal point in sediment transport and coincides with the eastern limit of sand fill that was placed for the 2004/05 beach disposal project.

The sand-filled tube groins along South Beach were included in the hydrodynamic model in their existing (2013) locations and simulated as thin dams, which are numerically considered infinitely high and impermeable to flow and sediment transport. The tube groins are not

permitted to fail due to erosion in the model. The terminal groin was described in the model using porous plates, which are also infinitely high but are permeable. That is, they allow through-flow and sediment transport. The permeability of porous plates is numerically controlled by a friction term which was set to roughly represent a level of permeability between about 10 and 30 percent.

For each alternative, two comparative computations were made with respect to the predicted changes within the project area: (1) gross volume change within the limits of the placed beach nourishment and (2) net volume change within an area representing the limits of the placed beach nourishment and the nearshore equilibration area. The latter area describes sand that remains in the littoral system (i.e., nearshore bar, etc.), but has been transported offshore during equilibration of the construction beach. Volume changes in the immediate vicinity of the navigation channel were not included because these sediments are effectively removed from the Bald Head Island littoral system once they are transported beyond the Point. An example of these computation areas is shown graphically in Figure 5.9 for the sand-filled tube groin scenario. Similar computation limits were applied to all the alternatives. In the figure, the red shading denotes areas of predicted erosion while blue shading denotes areas of predicted net accretion throughout the model run.

The model predicts that the presence of the semi-permeable terminal groin has the potential to retain approximately 33 to 39 percent more sand over three years within the littoral system relative to a tube-groin only alternative (see Table 5.2). This comparison suggests net benefit for the construction of a terminal groin in combination with the existing tube groin field. In terms of minimizing gross and net volume loss along South Beach, the terminal groin with tube groins (Alternative 5) performs the best while the fill only condition (Alternative 4) experiences the largest volume losses after three years. In all instances, the addition of the sand-filled tube groins tends to reduce volume losses relative to a comparable no sand tube groin scenario.

Relative terminal groin performance was also viewed in the context of the total fill placement volume for all alternatives. The results shown in Table 5.3 indicate the following:

- Within the fill placement area, volumetric losses exceed the initial placement volume by about 11 percent under the sand tube groin with fill only (Alternatives 1 and 3) scenario. Consideration of expected equilibration indicates that approximately 35 percent of the placed fill remains within the nearshore littoral system.
- Omission of all structures on Bald Head (Alternatives 2 and 4) suggests that losses within the fill area exceed the placement volume by about 62 percent. The nearshore littoral system is predicted to experience a net deficit of about 17 percent after three years.
- With the terminal groin and tube groins (Alternative 5), more than ¼ of the placed fill volume remains within the placement limits after three years. Consideration of expected equilibration indicates that approximately 61 percent of the placed fill remains within the nearshore littoral system.
- With the terminal groin only (Alternative 6), approximately 8 percent of the placed fill remains within the fill limits after three years. Consideration of expected equilibration indicates that approximately 44 percent of the placed fill remains within the nearshore littoral system.

Table 5.2: Predicted Volumetric Changes in the Project Area after Three Years.

	Gross Loss Within Fill Limits, "Area 1" (cy)	Net Change Including Nearshore, "Area 2" (cy)
Alts 1 and 3 – Tube Groins w/Fill	-1,332,800	-776,000
Alts 2 and 4 – Fill Only	-1,944,500	-1,398,900
Alt 5 – Terminal Groin, Fill, & Tube Groins	-883,000	-467,000
Alt 6 – Terminal Groin and Fill Only	-1,110,000	-667,500

Table 5.3: Predicted Percentage of Initial Fill Volume Remaining after Three Years.

	Within Fill Limits, "Area 1" (%)	Within Nearshore, "Area 2" (%)
Alts 1 and 3 – Tube Groins w/Fill	-11.1	35.3
Alts 2 and 4 – Fill Only	-62.0	-16.6
Alt 5 – Terminal Groin, Fill, & Tube Groins	26.4	61.1
Alt 6 – Terminal Groin and Fill Only	7.5	43.5

Similar volumetric analysis was carried out along the westernmost one mile of Bald Head Island (the shoreline west of about Station 102+00). This reach presently experiences the highest volume losses on Bald Head Island. Approximately 760,300 cy of initial fill were placed along this reach under the tube groin only scenario. Under the terminal groin plus tube groin scenario, about 990,230 cy of initial fill were placed along this reach. (The latter volume is higher due to the requirement to initially pre-fill the terminal groin fillet.) The model results are presented in Table 5.4 for the shoreline reaches west of Station 102+00. The results indicate the following:

- Less than 10 percent of the initial nourishment volume remains within the placement limits for the tube-groin only condition (Alternatives 1 and 3).
- The beach fill only conditions (Alternatives 2 and 4) experience severe sediment deficits west of Station 102+00 which well exceed the sand volume historically placed along this reach.
- For the terminal groin with tubes condition (Alternative 5), about 41 percent of the initial fill placement remains within the fill limits after three years over the same reach. The relative difference between Alternatives 3 and 4 is not as dramatic when including equilibrated material mobilized into the nearshore zone. Nevertheless, addition of the terminal groin with tube groins alternative is predicted to result in an approximate 19 percent increase in initial fill material remaining within the littoral zone relative to the tube-groin only alternative; that is, 65% remaining with the terminal groin versus only 46 percent remaining with the tube-groin only alternative.

- The terminal groin with beach fill only condition (Alternative 6) performs approximately 10 percent better than the sand tube groin with fill only alternatives (Alternatives 1 and 3) with respect to the percent volume remaining within the limits of fill, west of Sta. 102+00. Within the overall nearshore littoral area, the performance of this alternative is effectively the same as that of the tube groin only condition, with about 46 percent of the fill remaining.

Table 5.4: Predicted Percentage of Fill Remaining West of Station 102+00 after Three Years.

	Within Fill Limits, "Area 1" (%)	Within Nearshore, "Area 2" (%)
Alts 1 and 3 – Tube Groins w/Fill	9.6	46.0
Alts 2 and 4 – Fill Only	-69.3	-33.0
Alt 5 – Terminal Groin, Fill, & Tube Groins	41.1	64.6
Alt 6 – Terminal Groin and Fill Only	19.5	45.7

The results discussed above are predictions based on average annual wave, wind and, tide conditions. Storm impacts are not explicitly included in these estimations and actual volumetric performance is expected to vary[1]. Although the model has been calibrated and verified with respect to its ability to predict sediment transport along Bald Head Island, the results discussed in this document are not intended to serve as a definitive prediction of future project performance – particularly given the uncertainty associated with predicting future oceanographic conditions. Rather, these model simulations are intended for use in *relative* comparisons between the predicted performances of differing project alternatives under the same environmental conditions.

[1] Note that the engineer has completed an analysis of the effects of a hypothetical tropical storm event (conditions on a level comparable to Hurricane Bertha in 1996) for simulated conditions with and without a groin. The findings of this analysis are provided in Appendix P.

Within this context, extrapolation of these outcomes to longer term project performance may be instructional for planning purposes. The model results indicate that even with the best performing terminal groin and tube groin alternative, periodic sand placement at South Beach would likely be required. Under Alternatives 3 through 6 (those accounting for Village-sponsored nourishment), it is anticipated that nourishment would occur 3 years post-construction and then on roughly nine-year intervals thereafter. However, non-groin alternatives would be expected to require larger volumes of nourishment and would be susceptible to greater sand losses over time. As a result, there would be increased incidence of critically-eroded conditions which would in turn increase the likelihood of emergency-level responses (i.e. sand-bags, beach scraping, or smaller-scale nourishment) by property owners or the Village.

Figure 5.10 compares hypothetical long-term cumulative volume changes within the fill areas for the modeled alternatives. Year zero in the figure is assumed to represent post-construction conditions and identical fill volumes are added every three years. For each alternative, this analysis assumes a constant project volume, beach response, and typical average annual wave conditions. Under Alternatives 3 and 4, the analysis suggests that erosion creates a sand deficit which theoretically grows over time without additional (supplemental) sand placement volumes. Such a condition would likely grow exponentially more severe at hot spots as beach morphology would become progressively more conducive to continued erosion requiring greater renourishment volumes. Such is the present case along western Bald Head (i.e., rollback of the shoreline along western Bald Head).

Under Alternative 5 and Alternative 6, a fraction of material placed by the previous nourishment may remain within the fill placement area.

5.2.3 Duneline Conditions

Along the westernmost segment of South Beach, as well as the Point and the West Beach shorelines, the primary dune crest varies in elevation from approximately +10 ft NGVD to +20 ft NGVD. In most places the duneline averages +15 ft (NGVD). Figure 5.11 plots the maximum apparent dune elevation between survey baseline STA 0+00 (the northeasternmost extent of West Beach) and STA 106+00 (just westward of the terminus of the sand tube groinfield). Portions of the existing duneline are natural, whereas others are manmade. For example, dune features eastward of STA 47+00 extending to STA 97+00 (more or less) have been substantially enhanced or replaced since 2000 concurrent with, or following sand placement projects. As of this date, on average this duneline continues to increase in height annually due to continued beach disposal as well as comprehensive revegetation and sand fencing programs implemented by the Village. The landward limit of most existing primary dune formations lie in close proximity to (*i.e.* immediately seaward of) residential structures or infrastructure (i.e. Bald Head Wynd).

The present duneline provides an added element of storm protection to upland properties, but is highly vulnerable to loss due to large scale morphological changes which are predicted to occur for several of the stabilization alternatives under consideration, and due to the development of the areas behind the dunes which limit the duneline's ability to naturally retreat. For example, the predicted MHWL location at Year-9 (see Figure 5.1) would suggest that Alternative 2 and Alternative 4 would result in the loss of oceanfront dune resources between STAs 34+00 and STA 79+00 (more or less) as well as STA 30+00 through STA 106+00, respectively. The principal cause for these predicted dune losses is the removal of the existing fill berm presently supported by the sand tube groinfield (in the absence of a terminal structure) and the ensuing destabilization of the end of the island which would be expected to eventually occur.

Similarly, the modeling predictions indicate that Alternative 1 results in large scale dune loss between STA 73+00 and STA 28+00, (more or less) in accordance with the 9-year prediction

depicted by Figure 5.1. Alternative 3 does not result in large scale primary dune losses over a 9-year period; however, beyond 9 years, the existing trend of shoreline adjustment immediately westward of groin no. 16 is expected to continue into the future. Since Alternative 3 best reflects the series of cumulative actions taken over the last 10 years, it has been well monitored. As a result, the 9-year erosional response reflected by the numerical modeling is very much in keeping with what has been documented by survey for Alternative 3. This includes the migration of the Point northward over the last decade.

Alternative 5 and Alternative 6 (which address the installation of a terminal groin pursuant to SB 151) do not have a predicted downdrift impact on the primary duneline to the north. This is due to the design requirement for some level of sand transmissivity over, or through, the groin. It is predicted however that Alternative 6, which stipulates the removal of the sand tube groinfield, will have an impact on the existing South Beach dunes located eastward of STA 61+00 (more or less). Dune (and beach) recession would be expected to occur along a section of Bald Head Wynd where the upland was severely damaged and overtopped in 2002 prior to the reconstruction of the sand tube groinfield. Due to the orientation of the shoreline at that location, it is an area of high erosional stress due to wave energy concentration, particularly during storms. Removal of the sand tube groins at this location may release sand retained between tubes which presently support a protective beach berm thereby potentially making some portions of the duneline subject to sand loss at/or near the end of each 3-year sand placement operation. As discussed previously, the direct updrift benefits associated with the proposed terminal structure do not extend throughout the length of the sand tube groinfield in its entirety.

5.2.4 Sand Volume Requirements and Borrow Sites

As described in Section 3.0, Alternative #1 (No Action/Status Quo) and Alternative #2 (Retreat) preclude the use of any large scale Village-sponsored nourishment and the associated need for a sand source site. Each of the remaining four alternatives would have varying sand volume requirements depending upon the predicted (and monitored) condition

of the beachfront relative to the stated project purpose and goals. Based upon the predicted beach performance under Alternatives #3 through #6 (as described in Section 5.2.2 above), the project engineer has identified both the volume requirement and the frequency of nourishment for each of these alternatives over a 30-year planning horizon (see Table 5.5).

Table 5.5. Predicted Sand Volume Requirements by Alternative (cy)

Year	ALT 3	ALT 4	ALT 5	ALT 6
0[(1)]	--	--	0.25 M[(2)]	0.25 M[(2)]
3[(3)]	1.5 M	2.0 M[(4)]	1.25 M[(5)]	1.75 M[(4) (5)]
12	1.5 M	2.0 M	1.0 M	1.5 M
21	1.5 M	2.0 M	1.0 M	1.5 M
30	1.5 M	2.0 M	1.0 M	1.5 M
TOTAL	6.0 M	8.0 M	4.5 M	6.5 M

[(1)] Federal beach disposal event
[(2)] Assumes phased approach with the construction of an initial 1,300-ft groin. Note that this is a conservative estimate in the event a supplemental volume is necessary to augment the fillet.
[(3)] Village sand placement pursuant to assumptions of federal disposal (channel maintenance assumed on an average three-year interval).
[(4)] Additional 0.5 Mcy sand placement requirement due to sand tube groinfield removal.
[(5)] Assumes construction of Phase II groin (up to 1,900 lf).

As depicted in Table 5.5, it is assumed that a federal beach disposal occurs at time zero (presently estimated to be spring 2015). For Alternative #5 and #6, it is assumed that the 1,300-lf Phase I groin will be constructed at time zero with a contingent volume (0.25 Mcy) of sand identified to augment the fillet, if needed. It is anticipated that under each of the four alternatives nourishment would be required at Year 3, Year 12, Year 21, and Year 30. Alternative #4 would require the greatest volumes of sand for each nourishment event and cumulatively over the 30-year horizon. Alternative #5 would require the least amount of sand at each interval and thus cumulatively over the 30-year horizon.

The applicant's prefrerred sand source for the four alternatives identified above is the Jay Bird Shoals borrow site that was previously authorized on June 18, 2009 for a one-time use as part of a beach nourishment project. . At that time, project construction was sequenced in such a way that left an undisturbed quadrant of the originally permitted borrow area. This unused portion of the borrow site is approximately 106 acres (not including the Cultural Resources Exclusion Area) and consists entirely of subtidal sandy bottom ranging in depth from – 7 ft NGVD29 to -18 ft NGVD29. According to the Applicant's engineer, approximately 1.5 Mcy of beach compatible sand (verified through geotechnical investigations performed in 2007) is present within the remaining borrow area limits developed for the 2009 Village-sponsored beach nourishment project (refer to Sheets 13 through 16 of Appendix E).

Based upon the engineer's estimation of volume requirements for each alternative (Table 5.5 above), the sand volumes remaining within the Jay Bird Shoals borrow site would satisfactorily address sand needs for Alternative #3 and Alternative #5 through Year 3. After Year 3 (and before Year 12 at the latest), it is predicted that an alternate sand source site within Frying Pan Shoals would be developed (with requisite environmental documentation, geotechnical investigations, and cultural resource assessments performed). Implementation of Alternative #4 or #6 would exhaust the sand volumes present within the Jay Bird Shoals site and would necessitate the use of an additional borrow site much sooner.

Smaller sand volume requirements associated with periodic maintenance of the beachfront along West Beach[2]; sand fillet renewal needs; and "emergency" responses to critically eroded areas (e.g. post-storm condition) may be addressed through the use of either (1) the proposed borrow area adjacent to, and immediately north of, the mouth of Bald Head Creek or (2) portions of the authorized federal navigation channel that are shoaled (and contain beach quality sand), but that are not routinely dredged for navigation purposes.

[2] Note that the engineer has cited the need for continued sand placement on West Beach due to documented, recurring erosion and that such need exists with or without the construction of a terminal structure on the west end of South Beach.

The proposed borrow site for Bald Head Creek Shoals consists of an approximate 65-acre area ranging in depth from +3.9 ft NGVD29 to -8 ft NGVD29. The design dredge depth would be -7.8 ft NGVD (or -6 ft. MLW) (with +1 ft dredging tolerance). As a result, the dredging will result in a direct effect to the existing bathymetry of the borrow site. The existing and proposed plan views and cross-section profiles of the Bald Head Creek borrow site are provided in Appendix E (Sheets 18 and 19).

As described in Section 4.0, sediment transport processes at the mouth of Bald Head Creek result in continual spit formation and shoaling. The accretion of the shoal is accelerated by the routine and continual sand bypassing operation of Bald Head Island Marina. This work involves repeated hydraulic dredging of the marina entrance and its immediate southern shoreline and the pumping of material to the timber groin field of Row Boat Row. From that location, sand is transported through alongshore drift northward toward the creek where it is deposited as part of the spit and associated ebb tidal shoal feature. As a result, it is expected that potential excavation within the identified borrow site will not appreciably affect the sediment composition of the substrate subsequent to dredging. Such a result has been documented in post-construction monitoring for the 100,000 cy dredge area excavated in January 2012. For that particular project, sediment composition has been demonstrated to be uniform both pre- and post dredging as well as between the post-dredge borrow site and the reference site (LMG 2013).

The potential effects to natural resources associated with the use of borrow sites for Alternatives #3 through #6 are described further in Section 5.5.3 and 5.6 below.

5.3 GENERAL ENVIRONMENTAL CONSEQUENCES

General environmental consequences are summarized for each alternative below. An alternatives matrix is provided to depict these general findings (refer to Appendix L). Note that more detailed information is provided in the following subsections for specific resource categories located within and adjacent to the identified project area. In addition, economic benefits and costs are evaluated in Section 5.14.

5.3.1 No Action/Status Quo (Alternative #1)

Based upon modeling results, the No Action/Status Quo scenario would result in continued, acute shoreline recession of the western end of South Beach, the Point, and West Beach. The resultant condition would create an unstable beach profile prone to episodic sand losses and associated effects to natural resources (e.g. nesting sea turtle habitat and dune habitat). While federal sand disposal (in accordance with the SMP[3]) would likely occur (pending federal funding), larger-scale Village-sponsored projects would not occur. The conditions that arise from this scenario were previously documented in an Environmental Assessment (EA) prepared by the Village of Bald Head Island in support of obtaining federal and state permit authorizations for the 2009/2010 beach restoration project. Under this alternative, emergency-level responses would be required, but likely untenable over any significant duration (i.e. greater than 5 years). Emergency-level actions would include beach scraping/bulldozing and sandbag revetments.

The calibrated Delft3D model was also used to predict long-term morphological changes along the western end of Bald Head Island under the assumption of the continued maintenance of the existing sand-filled tube groinfield in conjunction with the periodic disposal of sand on South Beach via federal navigation maintenance with beach disposal. The tube groins were not permitted to fail during the model simulation. Beach nourishment

was prescribed to occur every three years (which has tended to be the average interval of federal disposal since the inception of the SMP) with a constant, assumed volume of 1.2 Mcy of sand placed each cycle.

The DELFT3D model results indicate that the sand from the SMP events every three years is not sufficient to maintain the shoreline downdrift (west and north) of the sand tube groinfield. It is predicted that within nine years, there would be shoreline recession and deflation that would impact beach and dune resources. Based upon erosion patterns over the last ten years, it can be reasonably expected that the sand tube groinfield would become susceptible to an increased risk of failure. While failure was not permitted in the model simulation, the actual performance of the groinfield could be compromised to an extent that groinfield maintenance becomes either impracticable or not feasible. If not mitigated, such structure failure would be expected to propagate erosion pressures eastward potentially leading to subsequent groin failures.

The predicted physical consequences resulting from Alternative #1 would primarily affect the following resources: dry beach, dunes, and interdunal wetlands. In addition, several federally and state listed species that utilize these habitats may be adversely affected. It is likely that the extent of relatively stable dry beach which provides nesting habitat for sea turtles would be reduced along western South Beach and the Point. In addition, habitat suitable for the establishment and propagation of seabach amaranth would also be likely compromised. Frontal and primary dunes would be subject to loss from erosion (particularly in the vicinity of the Point). The associated storm protection functions and foraging and nesting habitat afforded by dunes would also be lost.

[3] Note that federal sand disposal under the current SMP is anticipated to occur on a six-year cycle with disposal occurring on two-year intervals. Under each cycle, disposal is anticipated to occur on Bald Head two out of the three channel maintenance events. As such, there is a minimum 4-year hiatus of sand disposal on the island.

5.3.2 Retreat (Alternative #2)

The physical and environmental effects of the Retreat Alternative have been predicted utilizing Delft3D model simulations. Since this alternative would ultimately include the systematic removal or abandonment of the sand tube groinfield, there would be no stabilizing structures in place to reduce the rate of sand losses, and thus shoreline recession would likely occur at a more rapid pace. Furthermore, the lack of any stabilizing structures would result in a shoreline configuration affecting a much wider area of western South Beach. The applicant's models predict that within nine years, the shoreline will recede in approximately 1,100 lf landward (in the vicinity of western South Beach) from its current position.

The following habitat types are subject to indirect impact as a result of the implementation of Alternative #2: dry beach, dune, interdunal wetland, and maritime thicket/forest. Based upon prior shoreline monitoring during periods of rapid erosion, it is expected that the beach profile would be nearly vertical from upland dune to the mean high water line and thus offer very little (if any) habitat for species that utilize the dry beach. This condition would adversely affect nesting sea turtles and nesting shorebirds and waterbirds (including the Wilson's plover and the American oystercatcher). Foraging habitat for federally and state listed species would also be compromised as a result of acute erosion along much of western South Beach, the Point, and West Beach.

As the shoreline migrated landward, areas suitable for the establishment and growth of seabeach amaranth would be converted to intertidal or subtidal bottom. In addition, it is predicted that nearly all of the frontal dunes and primary dunes mapped within the area of study would be lost to erosion. Interdunal wetlands in the vicinity of South Bald Head Wynd would become inundated and eventually lost to open water. It can be reasonably expected that intertidal beach would migrate with the shoreline such that this type of habitat would not be adversely affected. In areas around the vicinity of the Point, intertidal beachfront could potentially expand.

5.3.3 Beach Nourishment/Disposal with Existing Sand Tube Groinfield to Remain in Place (Alternative #3)

Alternative #3 would result in similar conditions to those identified under the No Action Alternative with the exception of a shoreline loss that is periodically mitigated through a Village-sponsored nourishment action.

The increased frequency of nourishment required under this alternative would result in more frequent disturbance at both the dredge site and at the nourishment site. Use of the federal navigation channel as a source site for the sand would help to minimize any adverse environmental impacts at the dredge site. Use of an offshore or nearshore borrow site would result in direct, short-term impacts to benthos and associated foraging habitat for fish. In addition, disturbance at the nourishment site would occur at a relatively high level of frequency and potentially affect benthic infaunal recruitment and community assemblages. This in turn could influence the occurrence and distribution of species utilizing the beachfront for foraging.

Seabed deflation and shoreline recession would be offset to some degree (relative to the No Action Alternative), thus resulting in the delay of impacts to natural resources. Dune overwash areas and vegetated supratidal areas in the vicinity of the Point would be susceptible to conversion to open water. However, this is a dynamic area that is continually reworked and modified by wind and wave action. It is predicted that this feature would migrate north (consistent with recent observations) and thus the net loss of this type of habitat would be minimal.

Based upon the predicted morphological response of the shoreline to the implementation of Alternative #3, dry beach and frontal dunes would be the primary habitats subject to impact. As such, some effect to nesting sea turtles and seabeach amaranth would be anticipated. However, given the relatively limited extent of predicted physical effects and the dynamic nature of these habitats, potential adverse impacts would not be considered significant.

5.3.4 Beach Nourishment/Beach Disposal and Sand Tube Groinfield Removal

(Alternative #4)

The residual shoreline after groin removal would be subject to littoral transport rates unaffected by stabilizing structures. In light of current inlet hydraulics and incident wave energy, the resultant condition of Alternative #4 would more closely resemble that of the Retreat Alternative identified above. The difference under this alternative would be the implementation of Village-sponsored nourishment events to help mitigate sand losses. The volume of sand required to offset these losses would necessitate Village-sponsored nourishment events of greater size and frequency than that identified under Alternative #3. Increased frequency of nourishment events would have an adverse effect on benthic assemblages of subtidal bottom of the dredge site as well as the benthos of the wet and dry beach of the nourishment site. Benthic recruitment and assemblages available as prey items for foraging birds and surf zone fishes would likely be adversely affected by the need for more frequent nourishment to offset sand losses from the beachfront.

Based upon a three-year schedule of implementation of the SMP used in this analysis and a Village-sponsored nourishment of approximately 1.5 Mcy, it is anticipated that by Year 9 of the Delft 3D simulation that the shoreline would recede nearly 1,000 lf landward (in the vicinity of western South Beach) of its current position. As a result, the following habitat categories would be affected to an extent similar to that described for Alternative #2: dry beach, dune, interdunal wetlands, and maritime thicket/forest. Similar consequences to federally and state listed species are anticipated. In particular, the area of dry beach potentially suitable for nesting sea turtles, nesting shorebirds (in sparsely vegetated areas), and seabeach amaranth would be reduced. Foraging and nesting habitat of vegetated dunes would likewise be lost to erosion. Interdunal wetlands and maritime thicket/forest habitats would be converted to open water. Areas interior of the predicted 9-year shoreline position would be susceptible to shifts in vegetative composition due to increased exposure to coastal processes, including wind and wave energy and potential overwash (particularly during storm events).

5.3.5 Terminal Groin with Beach Nourishment/Beach Disposal (Sand Tube Groinfield Remaining) (Alternative #5)

Installation of a terminal groin structure, nourishment of the updrift field (i.e. placement of a corresponding fillet), and on-going maintenance of the existing sand tube groinfield would afford the highest level of stability and retention of sand along South Beach among the alternatives considered. Since the groin would be designed to allow sand transmissivity both through and over the structure, passage of sand would be expected continue to its lee side to some degree. As a result, habitats of the project area would be subject to decreased loss from erosion compared to the current condition.

Overall, it is anticipated that implementation of Alternative #5 would result in more stable dry beach habitats considered more favorable for sea turtle nesting. However, the footprint of the rock structure (combined phases) would replace approximately 0.1 acres of dry beach, 0.5 acres of wet beach, and 2.0 acres of marine subtidal bottom. In addition, proposed construction of the structure would necessitate work within the sea turtle moratorium. Work within the sea turtle moratorium would be reduced via the proposed phasing of the project. It is presently estimated that a Phase I (1,300 ft. long) terminal groin, constructed without the need for a hydraulically placed fillet, could theoretically begin in November or December of the construction season but would in all probability extend approximately three months past the May 1 start date of the moratorium. While sea turtle nest monitoring would be on-going throughout construction, there may be temporal disturbance to these nesting habitats as a result of the construction practices.

Installation of the groin could also influence the behavior of foraging birds. Construction practices and burial of benthic prey items may result in the need for some birds (including federally and state-listed species) to move to other parts of the beach not influenced by project construction. The location and extent of the Phase I structure relative to the expected beach condition subsequent to federal disposal is depicted in Sheet 9 of Appendix

E. It is likely that a Phase I groin construction operation can benefit from the creation of sand work pads on the structure's updrift side with the source of sand being the federal disposal berm. The purpose of the work pads is to minimize, or ideally eliminate, the need for a construction trestle. Any work pad sand placement likewise beneficially contributes to the expedited formation of an updrift fillet.

Installation of the groin structure is not anticipated to adversely affect larval fish transport into the Cape Fear River Estuary given the size of the structure relative to the large tidal hydraulic field of the river mouth. Olsen Associates utilized the Delft3D numerical model to analyze the potential differences in hydraulic pathways of particulates (hypothetical fish larvae) resulting from (1) beach fill and (2) beach fill with a semi-permeable terminal groin. The predicted alterations to tidal flow are not expected to significantly hinder the ability of suspended biota or fish larvae from nearshore waters to reach the inlet en route to the interior estuary system. The findings of the larval transport modeling conducted for this analysis are presented in Appendix M of this document.

If implemented concurrent with the federal disposal, it is likely that Phase I would not require any additional sand from a supplemental source site (i.e. Jay Bird Shoals). At the least, a Phase I structure would both reduce the volume of sand required, as well as potentially the timing of updrift fillet enhancement (if necessary) by approximately six months to one year. Direct impact and mortality to benthic infauna of the borrow site will occur from the cutter-suction dredge. However, these impacts would be considered temporary since the benthic assemblages of depositional features (i.e. shoals) tend to be adapted to disturbance and can recruit rather quickly from adjacent undisturbed sites.

5.3.6 Terminal Groin with Beach Nourishment/Disposal and Removal of Sand Tube Groinfield (Alternative #6)

Implementation of Alternative #6 would have similar consequences to natural resources of the study area as those identified above for Alternative #5. The predicted shoreline

positions of the two alternatives are similar based upon Delft 3D modeling. However, based upon volumetric analyses, Alternative #6 retains less sand within the modeled nearshore area than Alternative #5. Deflation of the beach would result in the increased risk of sand losses in areas identified as susceptible to erosion (i.e. "hot spots") of western South Beach. Increased erosion would influence the profile and width of dry beach habitat suitable for nesting sea turtles and would expose recently established frontal dunes to overwash during storm events.

5.4 THREATENED AND ENDANGERED SPECIES

5.4.1 Alternative #1: No Action/Status Quo

A. Mammals

(1) Direct Impacts

State and/or federally protected mammals known to occur within the project area include the right whale, the humpback whale, and the West Indian manatee. In-water work associated with the No-Action alternative includes dredging from the adjacent Wilmington Harbor Entrance Channel as part of on-going navigation maintenance and in conjunction with the SMP.

According to the Biological Assessment (BA) prepared for the Preconstruction Modifications of Authorized Improvements for the Wilmington Harbor Project, no direct impacts to these species are anticipated as a result of maintenance dredging and disposal events (USACE 2000). Since the dredge vessel is nearly stationary during operation, there is minimal collision threat. Additionally, a daytime whale observer is present when dredging occurs between December 1 and March 31 in accordance with previous biological opinions issued by NMFS (NMFS, 1997). Since these species do not encounter the surf zone, no impacts would occur from sand disposal on the beachfront.

The No-Action Alternative also considers the use of short-term stabilization measures (such as beach scraping and sand bag revetments) as have been employed by the Village in previous years. Since these actions are specific to the beachfront, no impacts would occur to state or federally-listed mammal species. Furthermore, maintenance of the groinfield (including reconstruction and/or minor reconfiguration) would not affect listed mammal species.

(2) Indirect Impacts

There are no indirect effects to manatee, humpback whale, or right whale resulting from maintenance dredging of the navigation channel (USACE 2000). Productivity of the nearshore ocean would not be diminished by the proposed dredging. Therefore, the food supply of federally-protected whale species would be unaffected. The diet of the West Indian manatee consists primarily of vascular plants of interior creeks. Proposed dredging of the entrance channels as part of the SMP has no effect to the physical habitat of the estuary, and overall estuarine and nearshore productivity would remain high throughout the project area (USACE 2000). Therefore, potential food resources of the manatee would not be impacted.

(3) Cumulative Impacts

Maintenance dredging and disposal of material derived from maintenance dredging of the Wilmington Harbor navigation channel onto Bald Head Island occurs per the terms of the SMP. Given the absence of any direct or indirect effects associated with these actions, there are no cumulative effects to federally-listed marine mammals when evaluated in the context of past, present, and reasonably foreseeable future projects.

B. Birds

(1) Direct Impacts

Disposal activities associated with the SMP would occur during winter months and would not affect nesting birds. Likewise it would be anticipated that other stabilization efforts that are

evaluated in the context of the status quo condition (such as sand tube maintenance, installation of sand bag revetments for imminently threatened structures, and beach bulldozing/scraping) would occur during winter months and outside of the nesting season of federally and state listed birds. However, all of these actions have the potential for the temporary disturbance of feeding activities of resident and migratory birds, including the federally-listed piping plover. The Wilmington Harbor Project BA determined that beach disposal may temporarily disrupt nesting that may be attempted along the eroded beach front (USACE 2000). However, that BA evaluated a much larger project area that included Oak Island and Holden Beach. No piping plovers have been documented nesting in the vicinity of the project area on Bald Head Island. Generally, the piping plover prefers the upper edges of overwash areas adjacent to inlets. Given the instability of the western end of South Beach and lack of documented nests, disposal events on Bald Head Island have no effect on piping plover nesting.

(2) Indirect Impacts

The 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 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. 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). However, material from the entrance channel reaches have been demonstrated to be compatible as evidenced through several SMP events. As a result, risk of these latter effects is considered to be minimal.

Levisen and Van Dolah (1996) reported rapid recovery of beach infauna (less than 60 days) including species abundance and diversity of the overall faunal complex following beach bulldozing. This study supports similar research indicating quick recovery of invertebrate fauna with no long term changes to species composition subsequent to beach scraping (ASMFC 2002). Additionally, 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. The Wilmington Harbor Project BA determined that beach disposal may temporarily impact foraging habitat.

The American oystercatcher, least tern, and Wilson's plover (all state-listed as Species of Concern), have been documented nesting in the dry beach at Bald Head Island. These species tend to nest above the high tide line on bare sand and shell in sparsely vegetated areas of the upper beach or between smaller dunes (Johnsgard 1981; Tompkins 1944). DELFT 3D model results indicate that, under the No Action alternative, disposal events from the SMP (combined with regular maintenance of the existing sand tube groinfield) would not be able to keep pace with predicted sediment losses from western South Beach and the Point. Erosion is anticipated to be most severe at the Point. This feature currently consists of expansive areas of unvegetated and sparsely vegetated supratidal habitat suitable for nesting habitat. Loss of these areas is predicted by Year 9 of the Delft 3D simulation (see Figure 5.1 and Figure 5.2). Refer to Table 5.6 for a summary of predicted area loss or gain (acres) by habitat type.

(3) Cumulative Impacts

The temporal separation between channel maintenance events has allowed and would continue to allow for recovery of the benthos prior to subsequent dredge events. Therefore, no cumulative impacts are anticipated.

Table 5.6. Predicted Losses or Gains by Habitat Type and Alternative.

Habitat Type	Existing Quantity	Alt 1		Alt 2		Alt 3		Alt 4		Alt 5		Alt 6	
	acres	Predicted Acreage	Δ (+/-)	Predicted Acreage	Δ (+/-)	Predicted Acreage	Δ (+/-)	Predicted Acreage	Δ (+/-)	Predicted Acreage	Δ (+/-)	Predicted Acreage	Δ (+/-)
Subtidal Bottom	186.9	219.7	32.8	283.1	96.2	194.1	7.2	256.9	70.0	176.4	-10.5	183.3	-3.6
Wet Beach	20.8	21.3	0.5	18.9	-1.9	21.8	1.0	19.6	-1.2	23.5	2.7	23.1	2.3
Dry Beach	30.5	8.7	-21.8	7.1	-23.4	24.6	-5.9	11.0	-19.5	38.6	8.1	32.2	1.7
Dunes	21.1	12.6	-8.5	5.0	-16.1	18.8	-2.3	8.6	-12.5	20.9	-0.2	20.7	-0.4
Interdunal Wetlands	3.9	3.9	0.0	1.9	-2.0	3.9	0.0	1.9	-2.0	3.9	0.0	3.9	0.0
Maritime Thicket/Forest	13.7	13.7	0.0	6.6	-7.1	13.7	0.0	9.4	-4.3	13.7	0.0	13.7	0.0
Total Acres in Evaluation Area	276.9												

*Note habitat gains and losses are based upon predicted shoreline positions at Year 9 of Delft 3D model simulation

C. Reptiles

(1) Direct Impacts

The proposed dredging of the navigation channel would be performed with a cutter suction dredge with sand pumped by submerged pipeline to the shoreline. Because the operation of the dredge plant to be used is almost stationary, no direct impacts to foraging sea turtles are anticipated. The BA for the Wilmington Harbor Project determined that the dredging and disposal related to the maintenance of the navigation channel may adversely affect the loggerhead, Kemp's ridley, and green sea turtles because of the possibility of missing a nest where beach disposal is scheduled to occur and because survival of moved eggs may be reduced compared to undisturbed nests (USACE 2000). In consideration of the dredge and disposal windows typically adhered to and the intensive monitoring of nests conducted by BHIC, potential impacts associated with disposal events are minimized.

(2) Indirect Impacts

As described above, the No Action/Status Quo scenario would result in continued shoreline recession of West Beach and the western end of South Beach[4]. The critically-eroded area would likely produce a nearly vertical profile from upland dune to the mean high water line. Unless relocated, loggerhead and green sea turtle nests that have already been laid may be lost to erosion. The Bald Head Island Conservancy (BHIC) currently monitors the beach for nesting sea turtles and relocates nests that are laid in eroded areas. Under the No-Action alternative, these relocation efforts would continue and may need to extend further east along South Beach as erosion progresses.

Based upon Delft 3D modeling, nearly all of the dry beach at the Point and the extreme west end of South Beach will be converted to intertidal wet beach or subtidal bottom by Year 9 of the simulation. As a result, it is predicted that nearly 22 acres of dry beach will be lost to

[4] Though the current SMP anticipates the disposal on adjacent beaches on two-year intervals, federal funding and other considerations may impact the timing and occurrence of maintenance and disposal events. To that end, the model assumes that actual disposal would occur in a manner similar to the past decade with placement occurring on an average three-year interval.

erosion within nine years of the implementation of Alternative #1. Additionally, deflation and recession of the shoreline would result in increase risk of inundation of nests.

In addition to the loss of habitat, physical conditions of the shoreline would likely result in additional indirect effects. Steeper beach profiles and the formation of escarpments would likely restrict access to suitable nesting areas and result in increased energy expenditure of the adult female. Eroding steep beach escarpments as well as other physical barriers often cause mature female sea turtles to select poor nesting sites at the dune toes which causes higher nestling mortality rates (Ernest & Martin 1999; NMFS 2008).

Sea turtle nesting habitat may also be indirectly affected by disposal events occurring under the SMP. However, the disposal events would occur outside of the sea turtle nesting season and only beach quality sand (suitable for sea turtle nesting, successful incubation, and hatchling emergence) would be disposed on the beach. Furthermore, sand of similar grain size and composition to that of the existing beach would be used to reduce any changes in physical characteristics of the beach that may affect nest survival.

(3) Cumulative Impacts

The continuation of the SMP and other short-term stabilization measures implemented by the Village are not anticipated to result in any cumulative effects.

D. Fish

(1) Direct Impacts

The federally-listed shortnose and Atlantic sturgeon are known to occur in the project area. Any individuals present would be non-spawning adults or juveniles. Under the SMP, sand would continue to be dredged from open water areas within the Wilmington Harbor during winter months. The proposed excavation work would be performed with a cutter suction dredge with sand pumped by submerged pipeline to the shoreline. Because the operation of

the dredge plant to be used would be almost stationary, no direct impacts to the shortnose or Atlantic sturgeon are anticipated.

(2) Indirect Impacts

The BA prepared for the Wilmington Harbor project determined that the food supply of the shortnose sturgeon would not be affected by the proposed schedule, location, and footprint of dredging of the Wilmington Harbor Deepening Project. While juveniles tend to feed on the bottom of deep water areas of the river, existing benthic assemblages would remain largely unchanged as a result of the implementation of the deepening and realignment project (USACE 2000). Although impacts to the Atlantic sturgeon were not evaluated in the BA (the species was not federally protected until 2012), it feeds on similar food resources as the shortnose sturgeon. Therefore, no indirect effects to either species are anticipated as a result of the on-going maintenance dredging and beach disposal .

Other short-term stabilization measures (e.g. beach scraping and sand bag revetments) and the maintenance of the existing sand tube groinfield are confined to the beachfront and surf zone area. These actions would not result in any indirect effects to the shortnose sturgeon or the Atlantic sturgeon.

(3) Cumulative Impacts

No cumulative impacts to these protected species are anticipated as a result of the implementation of the No-Action Alternative.

E. <u>Plants</u>

(1) Direct Impacts

Direct effects to seabeach amaranth could potentially result from the supplemental short-term stabilization measures considered under the No-Action or Status-Quo Alternative. Beach scraping and sand bag revetments can potentially impact plants and cover seeds which would reduce the opportunity for germination and growth of these plants.

While habitat conditions tend to improve as a result of beach disposal or nourishment, the BA for the Wilmington Harbor project stated that disposal events that occur during the growing season may slow population recovery over the short term. However, federal disposal events on Bald Head tend to occur during the winter months when the plants have not germinated. Placement of sand on the beach under the SMP may deeply bury existing seabeach amaranth seeds located on the upper beach of the project area, which could negatively affect the population in later seasons.

(2) Indirect Impacts

Based upon Delft 3D modeling, it is predicted that nearly 22 acres of dry beach would be lost to erosion within nine years of the implementation of this alternative. It is likely that the accelerated erosion would result in steep profiles of the shoreline from the upland dune to MHW. Therefore, seabeach amaranth habitat along West Beach and along the western part of South Beach would be either substantially degraded or lost. This loss would be offset by continued federal disposal events associated with the SMP. Disposal on western South Beach would likely enhance the habitat requirements for seabeach amaranth. According to the USACE (2000), "new populations have been observed to follow sand placement on other beaches where sand has been disposed by the Corps of Engineers."

(3) Cumulative Impacts

While some level of impact to seabeach amaranth habitat will occur as a result of the predicted shoreline response, cumulative impacts are not anticipated as a result of the implementation of the No-Action Alternative.

5.4.2 Alternative #2: Retreat

A. Mammals

(1) Direct Impacts

In-water work associated with the Retreat alternative is essentially the same as Alternative 1 and includes dredging from the adjacent Wilmington Harbor Entrance Channel as part of on-

going navigation maintenance and resulting beach disposal. Other measures employed as part of a planned shoreline retreat (including the removal of the sand tube groinfield) will not affect listed mammal species. As a result, no direct impacts to federally-protected mammals would occur under this scenario.

(2) Indirect Impacts

As described above for the no-action alternative, no indirect impacts to whales or manatees are anticipated to take place.

(3) Cumulative Impacts

Given the absence of any direct or indirect effects associated with the maintenance of the Wilmington Harbor Entrance Channel and the planned retreat measures, no cumulative effects to federally-listed marine mammals would occur.

B. Birds

(1) Direct Impacts

Direct impacts to state and federally-listed birds under the Retreat Alternative are not anticipated. While continued disposal resulting from the maintenance of the federal navigation channel may continue to occur, it is likely that the USACE would shift its disposal footprint further east on South Beach so as to minimize direct loss of sand back into the channel (in the absence of any stabilization measures along western South Beach). Continued disposal events under the SMP are not expected to have direct effects on state and federally-listed species.

(2) Indirect Impacts

The Retreat Alternative would include the removal or abandonment of the sand tube groinfield. Without these stabilizing structures, shoreline recession would occur at a more rapid pace than Alternative #1. Furthermore, the lack of any stabilizing structures would result in a shoreline configuration affecting a much wider area of western South Beach.

Under this alternative, the shoreline along western South Beach is predicted to recede in excess of 1,100 lf landward from its current position. In addition, rapid erosion into uplands would result in a nearly vertical profile from upland to MHW. While some level of equilibration and profile flattening would be expected over time, there will be loss of dry beach habitat. Over a nine-year term, model simulations predict the loss of nearly 2 acres of intertidal beach, 23 acres of dry beach, 16 acres of dunes, and 2 acres of interdunal wetlands, and 7 acres of maritime thicket/forest (refer to Table 5.6). Within a natural inlet and shoal system, it would be expected that these habitat types would reform as the system equilibrated. However, the routine dredging of the federal navigation channel changes natural sand transport processes and influences the predicted conditions ensuing from the Retreat Alternative. Just as importantly, the developed nature of the adjacent upland areas of Bald Head Island prevents migration of these habitats into other portions of the Island, as they moved in the decades before island development. As a result, loss of both foraging and nesting habitat for state and federally-listed species is expected under this scenario.

As indicated above, much of the shoreline of western South Beach and the Point (including intertidal, dry beach, and foredune habitats) would be converted to subtidal bottom. Foraging habitat would be degraded or lost as a result of these changes. While benthic assemblages of the shoreline tend to be adapted to disturbance-prone conditions, habitat losses would reduce the abundance and composition of benthic assemblages available for foraging birds. Short-term protection measures (e.g. temporary sandbag revetments) could potentially influence foraging behavior. In addition, demolition, removal, or relocation of structures, roads, and utilities in close proximity to the receding shoreline could influence foraging behavior for brief periods.

The extent of erosion predicted under Alternative #2 would result in the loss of mapped maritime thicket/forest areas of the interior hind-dunes of the Island. Additional stress from wind and salt spray would likely alter the vegetative assemblage of other areas not directly

lost. Birds known to occur in this community type, including the eastern painted bunting, may be affected.

(3) Cumulative Impacts

While current bird foraging and nesting habitat is subject to loss from acute erosion, these losses are expected to be offset over time as some level of equilibrium is achieved and areas of new intertidal and dry beach habitat form. The developed nature of the island in combination with the proximity of the deep-draft navigation channel, exert considerable influence over 'natural' barrier island processes. Nonetheless, this area of shoreline is highly dynamic and it is likely that foraging, roosting, and nesting habitat will continue to exist even with the extent of erosion predicted. As a result, no cumulative impacts to state and federally-listed bird species are expected.

C. Reptiles

(1) Direct Impacts

Direct impacts to state and federally-listed reptile species are not anticipated under Alternative #2. While federal channel maintenance and disposal is expected to continue to occur, these actions do not directly impact listed species. Removal of the sand-filled geotextile tubes and associated underlayments would require excavation with heavy machinery and sand tube clearing via hydraulic means (*i.e.* washing of sand from each tube structure). Geotube removal would likely occur only subsequent to a beach fill operation in order to ensure a sandy shorefront immediately upon removal. Removal of sand tubes may affect foraging and roosting of bird species, though any disturbance would be temporal. Other retreat measures (e.g. demolition and relocation of structures) would occur landward of the dry beach and thus would not affect nesting sea turtles.

(2) Indirect Impacts

As with Alternative #1, the rapid erosion predicted in this alternative could cause the loss of loggerhead and green sea turtle nests that have already been laid, unless such nests are

relocated. Under this alternative, relocation efforts currently conducted by the BHI Conservancy would continue and would likely need to extend further along South Beach as erosion is predicted to affect a much wider area of western South Beach. These efforts would help reduce the scope of potential adverse effects. However, given the extent of predicted shoreline recession and loss of dry beach habitat, impacts to sea turtle nesting would likely be unavoidable.

Loss or degradation of nearly 22 acres of dry beach habitat along western South Beach and the Point would likely influence sea turtle nesting behavior and success. Eroding steep beach escarpments as well as other physical barriers often cause mature female sea turtles to select poor nesting sites at the dune toes which causes higher nestling mortality rates (Ernest & Martin 1999; NMFS 2008). As with Alternative #1, turtle nesting habitat along West Beach and the point would likely deteriorate, however at a more rapid rate than Alternative #1.

Removal of the sand tube groinfield has a potential beneficial effect on adult female and hatchling behavior. 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). Failure or flanking of sand tubes can exacerbate erosion and result in steep escarpments between groins. Any indirect positive effects resulting from removal of the sand tube groinfield would need to be considered in the context of the likelihood of increased erosion and loss of dry beach habitat. Given the extent of dry beach losses predicted under the Retreat Alternative, the net effect of groinfield removal on nesting sea turtles is likely negative.

The extent of erosion predicted under this alternative would likely result in increased salt spray to the back dune and interdunal communities. Increased incidence of overwash has the potential for creating hypersaline conditions within interdunal wetlands or ponds. These conditions would influence the distribution and behavior of less salt-tolerant species, including the American alligator. Additionally, predicted erosion may expose maritime forest habitat to increased wind and salt spray, which can influence community composition. Several state listed reptiles, including coachwhip, southern hognose snake, and the eastern coral snake, are associated with this habitat type and may be negatively affected.

(3) Cumulative Impacts

While the predicted extent of habitat losses under this scenario are considerable, the western end of South Beach has been an area susceptible to acute erosion for many years and thus does not present high quality nesting habitat for sea turtles. Given the relatively low abundance of nests and the current practice of nest relocation for the far western portion of South Beach, implementation of the Retreat Alternative would likely not result in cumulative impacts to federally-listed turtle species. In addition, the potential indirect effects to other listed reptile species are not of a magnitude to generate cumulative impacts.

D. Fish

(1) Direct Impacts

In-water activities for the Retreat Alternative would be the same as those described for Alternative #1. As with Alternative #1, no direct impacts to the shortnose or Atlantic sturgeon are anticipated to occur.

(2) Indirect Impacts

Some food resources of sturgeons may be initially affected by dredging associated with maintenance of the Wilmington Harbor navigation channel. However, existing benthic assemblages of the maintained entrance channel are likely adapted to frequent disturbance (given the repeated shoaling and dredging characteristic of these portions of the entrance

channel). Taxa that are present are anticipated to be opportunistic in nature and would thus recruit rather quickly into the affected area (Van Dolah et al. 1984). Sturgeon habitat will not be modified and feeding areas will remain largely unchanged as a result of the continuation of the channel maintenance. Furthermore, both species are mobile and would likely avoid the operation of a hydraulic cutter-suction dredge.

(3) Cumulative Impacts

No cumulative effects to listed sturgeon species are anticipated as a result of the implementation of the Retreat Alternative.

E. Plants

(1) Direct Impacts

Disposal activities that would continue to be conducted as part of the SMP may bury existing seabeach amaranth seeds located on the upper beach of the project area, which could negatively affect the population in later seasons. However, disposal along western South Beach would likely have minimal impact on seabeach amaranth due to the high erosion rates and associated instability of the existing beach profile (USACE 2000).

(2) Indirect Impacts

Under this alternative, shoreline recession would occur at a more rapid pace than Alternative #1 and would affect a much wider area of the Point and western South Beach. Modeling predicts the net loss of over 23 acres of dry beach and 16 acres dunes (Table 5.6). Beach profiles would be expected to be nearly vertical from upland dune to the mean high water line along many areas of the receding shoreline. The resultant condition would thus offer very little habitat for species that utilize the dry beach. Therefore, this alternative would cause the loss of seabeach amaranth habitat and likely cause the loss of plants and/or seeds located along the dry beach.

Several state listed plants, including dune bluecurls, four-angled flatsedge and tough bumelia, grow within maritime forest habitat. Erosion predicted to occur under this alternative would likely expose this habitat type to increased wind and salt spray, which can influence community composition and ultimately affected these species.

(3) Cumulative Impacts

No cumulative impacts to seabeach amaranth are anticipated to occur under this alternative.

5.4.3 Alternative #3: Beach Nourishment/Beach Disposal with Existing Sand Tube Groinfield to Remain in Place

A. Mammals

(1) Direct Impacts

Alternative #3 would be similar to the No-Action Alternative with the exception of a shoreline loss that is periodically mitigated through a Village-sponsored nourishment action in addition to the regular disposal of sand from Federal navigation channel maintenance. It is anticipated that beach nourishment events for Alternative #3 would occur three years after the next scheduled federal disposal event and re-occur on nine year intervals through the life of the project (30 years); as noted before, this assumption does not track planned federal disposal activities, but rather assumes that actual disposal would occur in a manner similar to the past decade. For the SMP disposal, sand would be dredged from open water areas within the Wilmington Harbor Entrance Channel. For Village-sponsored events, sand would be dredged from offshore or nearshore borrow sites including (1) reaches of the Wilmington Harbor entrance channels, (2) Jay Bird Shoals, (3) Bald Head Creek, and/or (4) Frying Pan Shoals. As described under previous alternatives, because the proposed excavation work would be performed with a cutter suction dredge with sand pumped by submerged pipeline to the shoreline, no direct impacts to whales or manatees are anticipated.

(2) Indirect Impacts

Dredging of any one of the prospective sand source sites would result in the mortality of benthos that existed within the dredge area at the time of the work. Since manatees generally feed on aquatic vegetation of protected bays and estuaries (USFWS, 2001), no impacts to their foraging behavior or source of food would occur. The entrance channels of Wilmington Harbor are prone to disturbance from deposition and from subsequent channel maintenance. In addition, active shoals are dynamic features and similarly support disturbance-prone benthic taxa. Therefore, any benthic assemblage would likely include opportunistic species that would recruit rather quickly into the dredged site (Van Dolah et al. 1984). As a result, no indirect impacts are anticipated to the right whale or humpback whale.

(3) Cumulative Impacts

Given the absence of any direct or indirect effects associated with this alternative, no cumulative effects to federally-listed marine mammals are anticipated under this alternative.

B. Birds

(1) Direct Impacts

Disposal activities associated with the SMP and Village-sponsored events would occur during winter months and would not directly affect nesting birds. Nourishment would occur along eroded segments of western South Beach and West Beach. Any overwintering birds that may be present in the nourishment area can readily move to adjacent beachfront.

(2) Indirect Impacts

Based on modeling of the shoreline over a nine year period, foraging habitat for birds such as overwash areas and vegetated supratidal areas in the vicinity of the Point would be susceptible to conversion to open water. However, this is a dynamic area that is continually reworked and modified by wind and wave action. It is predicted that the Point would

migrate north (consistent with recent observations) and thus the net loss of this type of habitat would be minimal.

Disturbance at the nourishment site would occur at a higher level of frequency than previous alternatives since this alternative would include disposal from SMP events *and* supplemental Village-sponsored nourishment. The combined actions would result in more frequent burial of benthic infauna of the beachfront and could influence species assemblages. However, the Village-sponsored events would be spaced over nine-year intervals and would thus allow greater periods for recovery even when evaluated in the context of recurring SMP events. Moving sand to nourish the shoreline may bury intertidal macrofauna and reduce the available food resource to birds in this area, including the piping plover and other state-listed species. In general, beachfront fill placement results in short-term declines in species abundance, biomass, and taxa richness. 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. As stated previously, the Wilmington Harbor Project BA determined that the beach disposal associated with the SMP may temporarily impact foraging habitat and disrupt nesting that may be attempted along the eroded beach front. However, no piping plovers have been documented nesting within the project area.

Dredging at any of the prospective sand source sites is not anticipated to result in any indirect effects to state or federally-listed bird species. Proposed borrow site boundaries would avoid intertidal flats within or adjacent to the sand source site. Borrow area conditions generally consist of subtidal bottom ranging from shallow (e.g. – 1 ft MLW at Bald Head Creek) to deep water (e.g. – 40 ft +/- within shoaled areas of the federal navigation channel). Thus, potential impacts to foraging and roosting areas would be minimized or avoided entirely.

(3) Cumulative Impacts

In consideration of past, present, and reasonably foreseeable future projects, cumulative effects to state and federally-listed bird species are not anticipated. While some time crowding of disposal and nourishment events could potentially occur, it is believed that there would be sufficient time between these actions to allow for recovery of beachfront benthos. Some level of indirect effects may occur to foraging and roosting areas; however, these effects are not expected to result in additive or interactive stressors that would result in cumulative impacts.

C. Reptiles

(1) Direct Impacts

Dredging and disposal events associated with the Wilmington Harbor navigation channel are expected to continue to occur on average every three years. Village-sponsored nourishment is anticipated to occur three years after the 2014 SMP disposal and continue on approximately nine-year intervals for the remaining term of the 30-year Department of Army (DA) permit. No direct impacts to sea turtles would be anticipated to occur from the dredging activities since they would take place during winter months and would utilize a hydraulic cutter suction dredge. Nourishment events would be conducted outside of the sea turtle nesting season and would not directly impact these species.

Based upon the predicted morphological response of the shoreline to the implementation of Alternative #3, dry beach and frontal dunes would be the primary habitats subject to impact. Therefore, some loss of nesting sea turtle habitat would be anticipated. However, given the relatively limited extent of predicted physical effects and the dynamic nature of these habitats, potential direct, adverse impacts would not be considered significant.

(2) Indirect Impacts

Based upon the predicted morphological response of the shoreline to the implementation of Alternative #3, dry beach and frontal dunes would be the primary habitats subject to impact. Therefore, some loss of nesting sea turtle habitat would be anticipated. However, given the relatively limited extent of predicted physical effects and the dynamic nature of these habitats, potential adverse impacts would not be considered significant.

Sea turtle nesting habitat may be indirectly affected by periodic nourishment events if beach characteristics are altered. As with previous disposal and nourishment events, only sand suitable for sea turtle nesting, successful incubation, and hatchling emergence would be used. Furthermore, sand of similar grain size and composition to that of the existing beach would be used to reduce any changes in physical characteristics of the beach that may affect nest survival. Ultimately, nourishment would replenish the eroded beach and ultimately expand habitat for nesting sea turtles.

(3) Cumulative Impacts

In consideration of past, present, and reasonably foreseeable future actions, implementation of Alternative #3 is not anticipated to result in cumulative impacts to listed sea turtle species.

D. Fish

(1) Direct Impacts

Village-sponsored nourishment would require the use of sand source site(s) consisting of subtidal bottom within either a depositional reach of the federal channel or within a natural depositional feature (i.e. shoal). Dredging would represent direct, temporal impact to subtidal bottom. Use of the federal navigation channel as a source site would help to minimize any potential adverse effects since the channel is already a highly manipulated area subject to recurring deposition and dredging. Use of an offshore or nearshore borrow site would result in direct, short-term impacts to benthos and associated foraging habitat for

fish, including sturgeon. However, the proposed excavation work would be performed with a hydraulic cutter suction dredge during acceptable environmental windows and sand would be pumped by submerged pipeline to the shoreline. Since the operation of the dredge to be used would be nearly stationary, no direct impacts to the shortnose or Atlantic sturgeon are anticipated. Sturgeon are mobile and would likely avoid the cutter head and suction mouth.

Nourishment activities would occur above the mean low water level and would not affect these species.

(2) Indirect Impacts

Some food resources of sturgeons may be initially affected by periodic dredging activities. However, given the anticipated intervals between prospective Village-sponsored nourishment, there will be sufficient time for benthic species recovery at the dredge site. As evidenced for other projects, including the Village's recent Jay Bird Shoals dredge and nourishment project, species abundance and taxa richness return to pre-construction levels and are similar to reference shoal sites within two years of dredging (LMG 2012). In general, benthos of depositional environments tend to be adapted to disturbance and can quickly reestablish via recruitment from adjacent undisturbed areas (Van Dolah et al. 1984).

(3) Cumulative Impacts

Maintenance dredging of the Wilmington Harbor navigation channel in this area has been determined to have no effect to sturgeon (USACE 2000). Village-sponsored dredge and nourishment is sufficiently spaced and not of a magnitude to yield additive or interactive stressors to sturgeon. In the context of past, present, and reasonably foreseeable future actions, cumulative impacts are not expected as a result of the implementation of Alternative #3.

E. Plants

(1) Direct Impacts

Periodic dredging activities would occur in open water, offshore, or nearshore areas and would not affect seabeach amaranth. Nourishment activities would occur during winter months after seabeach amaranth plants have released their seeds. The placement of sand via federal disposal and Village-sponsored nourishment may deeply bury existing seeds located on the upper beach of the project area. However, the seeds are likely to remain viable and may germinate when the imported sand washes away (Benjamin 2012). As a result, no direct impacts to seabeach amaranth are expected.

(2) Indirect Impacts

Delft 3D modeling conducted for Alternative #3 predicts a loss of dry beach and frontal dunes, principally along western South Beach and the Point. Shoreline recession and deflation would be most prominent at the current location of the Point. This feature would likely migrate north. By year 9 of the model simulation, a net loss of 5.9 acres of dry beach and 2.3 acres of dune is predicted. While not all of these areas represent suitable habitat for seabeach amaranth, some areas considered suitable for the germination and growth of seabeach amaranth would expected to be lost or degraded.

(3) Cumulative Impacts

Implementation of Alternative #3 is not expected to result in cumulative impacts to the federally-protected seabeach amaranth.

5.4.4 Alternative #4: Beach Nourishment/Beach Disposal and Sand Tube Groinfield Removal

A. Mammals

(1) Direct Impacts

Alternative #4 considers Village-sponsored nourishment and the removal of the sand tube groinfield. With the removal of these sand-stabilizing structures, the frequency and extent

of Village-sponsored sand placement events will be significantly greater than that of Alternative #3 (as substantiated by Delft 3D modeling results discussed in Section 5.0). The potential sand sources required for this alternative are the same as those identified under Alternative #3. As with previous alternatives, the proposed excavation work would be performed with a cutter suction dredge and no direct impacts to whales or manatees would be anticipated.

Increased volumes of sand required under Alternative #4 would likely require the use of a large sand source site (i.e. Frying Pan Shoals) rather than the use of Jay Bird Shoals and reaches of the federal channel which contain limited sand volumes relative to predicted need. As a result, more frequent dredging of Frying Pan Shoals would be expected. If a suitable source site exists 3 nautical miles offshore on Frying Pan Shoals, a hopper dredge would need to be used. Use of the hopper dredge could result in some increased risk of collision with protected cetaceans.

(2) Indirect Impacts

Increased frequency of dredging events would have an adverse effect on benthic assemblages of subtidal bottom of the sand source site(s). However, it is unlikely this would significantly affect the food resources of marine mammals including whale species.

(3) Cumulative Impacts

No cumulative effects to protected marine mammals would occur as a result of the implementation of Alternative #4.

B. Birds

(1) Direct Impacts

Impacts from disposal activities associated with the SMP and Village-sponsored nourishment events would occur in winter months and would not directly affect nesting birds.

Removal of the sand-filled geotextile tubes and associated underlayments would require excavation with heavy machinery and sand tube clearing via hydraulic means (*i.e.* washing of sand from each tube structure). Geotube removal would likely occur only subsequent to a beach fill operation in order to ensure a sandy shorefront immediately upon removal. Removal of sand tubes may affect foraging and roosting of bird species, though any disturbance would be temporal.

(2) Indirect Impacts

Based upon a three-year schedule of implementation of the SMP and a Village-sponsored nourishment of approximately 1.5 Mcy, it is anticipated that by Year 9 of the Delft 3D simulation that the shoreline of western South Beach would recede nearly 1,000 lf landward of its current position. The predicted extent of recession and deflation of the shoreline along western South Beach and the Point would result in the net loss of nearly 20 acres of dry beach and over 12 acres of dune within the nine-year period. Though some losses would be mitigated via Village-nourishment, accelerated erosion would likely impact state-listed bird species (including American oystercatchers and Wilson's plovers) that nest in the upper dry beach.

Increased frequency of nourishment events predicted to occur under this alternative would have an adverse effect on the benthos of the wet and dry beach of the nourishment site. Benthic recruitment and assemblages available as prey items for foraging birds would likely be adversely affected by the need for more frequent nourishment to offset sand losses from the beachfront.

Similar to Alternative #2 above, areas of maritime thicket and maritime forest habitat would be either lost or subject to alteration via increased exposure to inundation, wind, and salt spray. Birds known to occur in this community type, including the eastern painted bunting, may be negatively affected.

(3)Cumulative Impacts

While the extent of erosion predicted as a result of the implementation of Alternative #4 would have considerable impact to dry beach and dune habitat, some level of shoreline equilibrium would be anticipated over time. Natural barrier island processes are largely prohibited due to the developed nature of the island and the proximity of the deep-draft navigation channel. Nonetheless, it is expected that these habitats would likely continue to exist to some degree along this area of shoreline and provide functional benefits to state and federally-listed species. As a result, no cumulative impacts are expected.

C. <u>Reptiles</u>

(1) Direct Impacts

Alternative #4 would include SMP and Village-sponsored disposal/nourishment events at a greater frequency than Alternative #3. However, no direct impacts to foraging and migrating sea turtles are anticipated to occur from the dredging of sand since it would take place during winter months and a slow moving cutter suction dredge would be used.

(2) Indirect Impacts

Largely as a result of any stabilizing structure, modeling predicts that western South Beach and the Point would experience rapid erosion similar to the Retreat Alternative. Alternative #4 would result in a rapid loss of dry beach and interdunal wetlands community types along the western end of South Beach and the Point. Unless relocated, sea turtle nests that have been laid in erosion prone areas would be susceptible to loss. It is anticipated that BHIC would continue to monitor the beach for nesting sea turtles and relocate nests that are laid in eroded areas.

Eroding steep beach escarpments as well as other physical barriers often cause mature female sea turtles to select poor nesting sites at the dune toes which causes higher nestling mortality rates. Therefore, turtle nesting habitat along western South Beach would continue to deteriorate.

Sea turtle nesting habitat may also be indirectly affected by periodic nourishment events. However, the nourishment events would occur during winter months outside of the sea turtle nesting season. Additionally, only beach quality sand suitable for sea turtle nesting, successful incubation, and hatchling emergence shall be used for beach nourishment at the project site. Furthermore, sand of similar grain size and composition to that of the existing beach will be used to reduce any changes in physical characteristics of the beach that may affect nest survival.

Similar to Alternative #2, sand tube removal in, and of itself, could be considered a benefit by reducing predator concentration and by removing the risk of adult female false crawls and false nests. In addition, removal of the sand tubes would eliminate the risk of interference with hatchling emergence into nearshore waters. Furthermore, failure of the sand tubes can result in intensive, localized erosion and the development of escarpments. As indicated previously, these conditions can increase energy expenditure for adult females and create unfavorable nest conditions. However, any potential benefit of groinfield removal would need to be considered in context of the increase in overall erosion rates and loss of dry beach habitat along this segment of shoreline.

The rapid erosion predicted under this alternative would likely result in increased incidence of dune overwash and salt spray to the back dune and interdunal communities. Increased salinities of depressions and ponded areas would influence the distribution and behavior of less salt-tolerant species, including the American alligator. Additionally, predicted erosion may expose maritime forest habitat to increased wind and salt spray, which can influence community composition. Several state listed reptiles, including coachwhip, southern hognose snake, and the eastern coral snake, are associated with this habitat type and may be negatively affected.

(3) Cumulative Impacts

As described above, the implementation of Alternative #4 would result in the loss of dry beach habitat. However, the western end of South Beach has been an area susceptible to acute erosion for many years and thus does not present high quality nesting habitat for sea turtles. Given the recurring compromised condition of nesting habitat, the relatively low abundance of documented nests, and the current practice of nest relocation for the far western portion of South Beach, implementation of Alternative #4 would likely not result in cumulative impacts to federally-listed turtle species. In addition, the potential indirect effects to other listed reptile species are not of a magnitude to generate cumulative impacts.

D. Fish

(1) Direct Impacts

More frequent disturbance at prospective dredge site(s) could alter bottom habitat and would result in temporal impacts to benthos. Since the dredge vessel, ladder, and cutter suction head are nearly stationary, there would be minimal collision threat with shortnose and Atlantic sturgeon.

No direct effects are anticipated with nourishment activities on the beachfront. Similarly, removal of the sand tube groinfield would have no direct effect on these species.

(2) Indirect Impacts

Some food resources may be initially affected by the dredging of deeper subtidal bottom areas where sturgeon may reside. As indicated above, these effects would be considered temporal due to the opportunistic recruitment strategies of benthic communities in disturbance-prone areas.

(3) Cumulative Impacts

No cumulative effects to protected sturgeon species are anticipated as a result of the implementation of Alternative #4.

E. Plants

(1) Direct Impacts

Similar to each of the other alternatives considered, disposal and nourishment events could potentially bury existing seeds on the upper beach of the project area. However, the seeds are likely to remain viable and may germinate when the imported sand washes away (Benjamin 2012). As a result, no direct impacts to seabeach amaranth are expected.

(2) Indirect Impacts

Indirect impacts to seabeach amaranth are expected as a result of extensive loss of dry beach habitat along western South Beach and the Point. The increased rate and extent of erosion associated with this alternative would result in a largely prohibitive environment for the germination and establishment of seabeach amaranth plants.

Erosion predicted to occur under this alternative would erode areas of maritime forest habitat and likely expose other areas not lost to increased wind and salt spray, which can influence community composition. State listed plants known to occur within this habitat type (dune bluecurls, four-angled flatsedge and tough bumelia) may be affected.

(3) Cumulative Impacts

No cumulative impacts to seabeach amaranth are anticipated to occur under this alternative.

5.4.5 Alternative #5: Terminal Groin with Beach Nourishment/Beach Disposal (Sand Tube Groinfield Remaining)

A. Mammals

(1) Direct Impacts

With Alternative #5, disposal activities would continue to occur under the SMP. Any Village-sponsored nourishment would be limited to the initial fillet (if project timing does not allow for use of the federal SMP disposal) and to periodic maintenance of the fillet and West Beach. As such, the beach nourishment volume requirements would be less than that of

Alternative #3 and Alternative #4. As with prior alternatives, dredging and nourishment actions are not anticipated to have direct effects on protected marine mammals. Further, the installation of the terminal groin will not directly affect these species. Approximately 650 lf of the structure (Phase I and Phase II combined) would be constructed seaward of the current mean low water (MLW) shoreline position. Fillet formation and shoreline realignment resulting from the installation of the groin will further minimize the extent of the structure extending into open water. Construction would be spatially constrained and would pose minimal (if any) collision threat to migrating whales and/or manatees.

No direct impacts to whales or manatees are anticipated from dredging or terminal groin construction.

(2) Indirect Impacts

As described in the alternatives above, periodic dredging of the entrance channel and other nearshore or offshore borrow areas would not substantially affect food resources of the humpback whale, right whale or manatee. The applicant's preferred sand source for the fillet is the federal disposal associated with the SMP. Other borrow source sites include Jay Bird Shoals, Bald Head Creek Shoal, and reaches of the federal channel containing beach compatible sand. Mortality to benthic infauna of the borrow sites will occur from the cutter-suction dredge. However, these impacts would be considered temporary since the benthic assemblages of depositional features (i.e. shoals) tend to be adapted to disturbance and can recruit rather quickly from adjacent undisturbed sites.

(3) Cumulative Impacts

Given the absence of any direct or indirect effects associated with these actions, there are no cumulative effects to federally-listed marine mammals when evaluated in the context of past, present, and reasonably foreseeable future projects.

B. Birds

(1) Direct Impacts

The proposed placement of sand for the fillet would occur during winter months and would not directly impact nesting birds. Work associated with the construction of the terminal groin would be concurrent with a beach fill placement or possibly federal sand disposal for the fillet. However, it is expected that necessary project sequencing would require work to continue into June or beyond and thus extend into the nesting period for several species of shorebirds and colonial waterbirds. Approximately 250 to 300 lf of the groin structure would be constructed above the 2012 MHW position (in dry beach). As indicated above, there have been no documented nests of piping plovers in this area of the island over several years of monitoring by NC WRC and by BHIC. However, least tern, American oystercatcher, and Wilson's plover nests have been documented in the vicinity of the Point.

The site of the proposed terminal groin structure (at the extreme west end of South Beach) 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. Post-nourishment conditions provide some level of stability and more expansive dry beach for a relatively short period of time. Since construction of the groin would occur concurrent with, and subsequent to, sand placement, it is unlikely that nests would exist at the time of construction. Therefore, construction of the groin itself would not be anticipated to have direct effects on state or federally-listed birds.

(2) Indirect Impacts

a. Effects to Food Sources: Piping plovers, as well as other state-listed species, tend to prefer expansive sand and mud flats for foraging and resting. During low tide, sand flats are exposed at the Point (northwest of the project area). Within the project area itself, the intertidal surf zone provides foraging habitat for wintering or migrant birds. Dredging and nourishment activities would occur between November 16th and April 30th, which would

avoid the larval recruitment period of coquina clams (spring and summer) and mole crabs (early October) (Donoghue, 1999). 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.

Moving sand to construct the groin may bury intertidal macrofauna and reduce the available food resource to birds in this area. However, the groin would be constructed within a recently-placed sand fillet. Thus, the area of construction would likely not present favorable foraging habitat for listed species.

b. Effects to Behavior: 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 (in 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 suitable foraging and resting sites for both wintering and migrant piping plovers (Webster 2006).

c. Physical Effects to Habitats: The implementation of Alternative #5 would provide for a more stable and wider beach profile updrift of the proposed structure. The particular section of shoreline affected has been subject to chronic and pronounced erosion and thus

has not provided suitable nesting habitat for state or federally listed species of birds. In the absence of nourishment, the shoreline of western South Beach is characterized by steep and narrow zone of transition from upland dune to wet beach and subtidal, nearshore bottom. According to Delft 3D modeling, implementation of Alternative #5 is predicted to result in the net gain of 2.7 acres of wet beach and 8.1 acres of dry beach by Year 9 of the simulation. These predicted net gains are the highest net gains among the alternatives under consideration and would provide more expansive (wider and relatively low slope) dry beach area for nesting. However, more stable conditions can also favor the growth of upper beach or dune vegetation. Denser vegetation would provide increased predator habitat and would also limit restrict nesting of certain species including the American oystercatcher and the Wilson's plover (CRC 2010).

It should also be noted that a wider, more stable beachfront can provide increased recreational opportunities for residents and visitors to the Island. As a result, areas that may become suitable for nesting also have the potential for increased human interference.

The proposed groin will be porous and will 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 will 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 designed to allow sand to bypass has not prohibited sand accretion to downdrift areas. The expanding spit in this particular area has recently become a successful nesting site for black skimmers, least terns, and American oystercatchers.

(3) Cumulative Impacts

In light of the current eroded condition of western South Beach and the potential for increased dry beach nesting habitat, cumulative impacts to state and federally-listed birds are not anticipated.

C. <u>Reptiles</u>

(1) Direct Impacts

Dredging and disposal or nourishment for the sand fillet would occur between November 16th and April 30th and would thus avoid the sea turtle's migratory and nesting seasons. Activities proposed to occur offshore, such as pipeline dredging via a hydraulic dredge and groin construction below MLW, may adversely affect migrating sea turtles. However, dredging would occur during winter months and the movements of a cutter suction dredge would be limited to a spatially constrained borrow area to minimize any potential adverse impacts to sea turtles.

Groin construction would occur concurrent with and subsequent to the placement of the sand fillet. While phasing of the construction would reduce the period of time necessary to complete the construction of Phase I, it is expected the groin installation work would extend into the sea turtle nesting and migratory periods. Depending upon the specific timing of the placement of the fillet, groin work would likely continue into June or beyond. Construction would be spatially constrained and would not directly affect migrating turtles. Approximately 300 to 700 linear feet of the groin would be constructed above MLW, most of which would be within the recently nourished dry beach. The project area occurs within a segment of shoreline with historically lower number of nest sites relative to the more stable beach areas to the east (Appendix N). This is principally due to the narrow beach and chronic erosion within this area. Additionally, its proximity to the mouth of the Cape Fear River and associated tidal hydraulics of the inlet may influence an adult female's access to the beach. BHIC conducts nest monitoring of the beaches of Bald Head Island. If nests are laid within areas susceptible to imminent loss from erosion, BHIC staff often will relocate the

nests to more stable beachfront. Intensive monitoring during site construction and methods employed to reduce the footprint of construction activities (including clearly designated and marked construction corridors) would minimize potential encounters with adult females and nests. However, the presence of heavy equipment and trucks on the beach during groin construction would pose a potential risk to adult females and any nests within the project area that were not identified, marked, or relocated.

The footprint of the terminal groin above the 2012 MHW line will be approximately 250 ft to 300 ft long and approximately 18 ft wide (equivalent to 4,800 sf +/-). This section of the groin would constitute a loss of potential sea turtle nesting habitat. However, as indicated above, the current pre-nourishment condition of this area does not tend to support viable nesting habitat. In addition, this amount of area would be offset by a predicted increase of dry beach habitat of 8 acres over a nine-year model simulation.

(2) Indirect Impacts

Indirect impacts to nesting sea turtles could occur if nourishment and/or groin construction activities significantly alter 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, beach nourishment 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, stringent sediment standards and geotechnical investigations of the sand source site to be used will minimize any potential adverse effects of the sand nourishment. In addition, the combined effects of nourishment and the installation of a terminal structure would expand suitable nesting habitat.

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).

Overall, the presence of a terminal structure would help stabilize the shoreline of western South Beach. The result will be a wider and relatively low slope beach profile conducive to sea turtle nesting.

(3) Cumulative Impacts

The proposed action elements of Alternative #5 are not anticipated to generate additive or interactive adverse effects to federally-protected sea turtles. In consideration of past, present, and reasonably foreseeable future actions, no cumulative effects are anticipated.

D. Fish

(1) Direct Impacts

As described in previous alternatives, no direct impacts to the shortnose or Atlantic sturgeon are anticipated to occur from dredging associated with nourishment events. In addition, groin construction would be spatially constrained and should not directly affect sturgeons.

Approximately 1,100 lf of the terminal groin (total for Phase 1 and Phase 2) would be placed below the 2012 eroded MLW line (refer to Appendix E, Sheet 8). However, the groin will be constructed in concert with the federal disposal thus much of the groin will actually be installed in the newly formed dry beach. In addition, post-construction equilibrium

conditions will result in an extended shoreline position and reduce the net length of structure extending into open water.

No direct effects to protected sturgeon are anticipated as a result of the implementation of Alternative #5.

(2) Indirect Impacts

Some food resources of sturgeons may be initially affected by dredging of deeper channels or shoal areas where sturgeon may reside and feed. However, most invertebrates would quickly reestablish from adjacent unaffected areas or through recruitment processes (Van Dolah et al. 1984). Furthermore, the construction of the groin would help to stabilize the beach and may ultimately reduce the frequency and volume of borrow site dredging needed to offset sand losses along South Beach.

As indicated above, the head of the groin structure will be constructed within open water and may require the use of a temporary trestle for equipment and placement of rock. However, implementing the phased approach would reduce the likelihood for the need of a trestle. Sand from the federal disposal can be used to create temporary pads from which to construct the groin.

(3) Cumulative Impacts

Implementation of Alternative #5 is not expected to generate cumulative impacts to federally-protected sturgeon.

E. <u>Plants</u>

(1) Direct Impacts

No impacts to amaranth plants would occur from the proposed dredging associated with the fillet or with future maintenance events. Beach nourishment would take place no earlier than November 16th, when amaranth plants have already released seeds. 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.

(2) Indirect Impacts

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.

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.

(3) Cumulative Impacts

The beach nourishment and groin construction that is to take place along the coast of Bald Head Island will occur on areas suffering from erosion and should ultimately maintain or expand potential habitat for the plant species. No cumulative impacts are expected as a result of the implementation of Alternative #5.

5.4.6 Alternative #6: Terminal Groin with Beach Nourishment/Beach Disposal (Removal of Sand Tube Groinfield)

A. Mammals

(1) Direct Impacts

In-water work proposed for Alternative #6 is essentially the same as Alternative #5. Therefore, impacts to federally-protected mammals would be similar to those described under Alternative #5. No direct impacts to whales or manatees are anticipated from dredging, terminal groin construction, or from the removal of the sand tube groinfield.

(2) Indirect Impacts

No indirect impacts to whales and manatees are expected as a result of Alternative #6.

(3) Cumulative Impacts

Given the absence of any direct or indirect effects associated with these actions, no cumulative effects to federally-listed marine mammals are anticipated.

B. Birds

(1) Direct Impacts

Direct impacts to birds under this alternative would be the same as Alternative #5. Terminal groin construction would extend into the nesting season of several bird species. The construction itself would be a temporal condition. It is likely that potential nesting birds (including least terns, Wilson's plovers, and American oystercatchers) would favor suitable nesting habitat near the Point.

Removal of the sand tube groinfield is not anticipated to directly affect state or federally-listed species.

(2) Indirect Impacts

As described under Alternative #5, moving sand to construct the groin and nourish the shoreline may bury intertidal macrofauna and reduce the available food resource to birds in this area. Installation of the groin would also influence the behavior of foraging birds. Construction practices and burial of benthic prey items may result in the need for birds (including federally and state-listed species) to move to other parts of the beach not influenced by project construction.

Longer term changes to shoreline configuration and profile conditions could potentially result in indirect effects to state and federally-listed bird species. An expanded dry beach habitat updrift of the structure may provide more suitable nesting habitat for these species. Potential beneficial effects may be offset by the potential for the upper beach to become more densely vegetated. Dense vegetation would preclude the use of the area by nesting pairs and would increase the risk of predation on nests in closer proximity to the vegetated areas. Furthermore, any potential downdrift impacts to the morphology of the Point could adversely affect nest success in this area that has historically supported higher occurrences of shorebird and colonial waterbird nests.

Removal of the sand tube groinfield would result in unobstructed dry beach and intertidal surf zone suitable for nesting, foraging, and resting habitat. This component of the alternative would be viewed as an indirect benefit to state and federally-listed species.

(3) Cumulative Impacts

No cumulative impacts are expected as a result of the implementation of Alternative #6.

C. Reptiles

(1) Direct Impacts

Direct impacts to sea turtles from Alternative #6 would be similar to direct impacts described under Alternative #5.

(2) Indirect Impacts

Indirect impacts of Alternative #6 would be similar to those identified above for Alternative #5. The exception would be the indirect effects of the removal of the sand tube groinfield. Removal of the sand-filled geotextile tubes and associated underlayments would require excavation with heavy machinery and sand tube clearing via hydraulic means (*i.e.* washing of sand from each tube structure). Geotube removal should ideally occur only subsequent to a beach fill operation in order to ensure a sandy shorefront immediately upon removal. Similarly, excavation of the structures – essentially in the "dry" after a fill project – would also help ensure both complete and relatively cost-effective removal.

It is anticipated that removal of the sand tubes would result in a net benefit for adult females that approach the beach and lay nests along this segment of shoreline. In general, hardened structures may physically interfere with adult females and could potentially lead to false crawls or false digs. The removal of the groinfield would also reduce the risk of physical interference to emerging hatchlings and would reduce the potential of predator concentration on or adjacent to the sand tubes.

An adverse indirect effect of the removal of the groinfield would be the potential for decreased beach profile stability east of the influence of the terminal groin. Delft 3D modeling indicates moderate beach deflation along South Beach which could increase the risk of inundation and/or loss of nests in these areas.

(3) Cumulative Impacts

Implementation of Alternative #6 is not anticipated to result in cumulative impacts to migratory or nesting sea turtles.

D. Fish

(1) Direct Impacts

No direct effects to listed sturgeon are expected as a result of implementation of Alternative #6.

(2) Indirect Impacts

As with previous alternatives, dredging for the fillet or for subsequent maintenance may temporarily affect food resources of sturgeons. However, most invertebrates would quickly reestablish from adjacent unaffected areas or through recruitment processes (Van Dolah et al. 1984).

The removal of the sand tube groinfield will not result in any indirect effects to sturgeon.

(3) Cumulative Impacts

No cumulative effects to shortnose or Atlantic sturgeon are anticipated as a result of Alternative #6.

E. Plants

(1) Direct Impacts

Direct impacts to seabeach amaranth would be similar to impacts described under Alternative #5.

The removal of the sand tube groinfield is not expected to generate any other direct effects to seabeach amaranth.

(2) Indirect Impacts

Alternative #6 is anticipated to have similar indirect effects to seabeach amaranth as identified for Alternative #5. The exception would be that the removal of the sand tub groinfield may result in some level of increased erosion and shoreline deflation beyond the

updrift influence of the terminal groin. The resultant condition may influence the extent of suitable habitat for seabeach amaranth germination and growth.

(3) Cumulative Impacts

In consideration of past, present, and reasonably foreseeable future actions, implementation of Alternative #6 is not anticipated to result in cumulative impacts to populations of seabeach amaranth.

5.5 PERMIT AREA HABITATS

The environmental resources that characterize the project area and the anticipated impacts of the project to those resources were researched and evaluated through numerous site-specific field studies, Delft3D modeling, aerial photography and a review of environmental research available in the scientific literature. Guidance from the Project Review Team (PRT), including Federal, State, and local environmental agencies, science professionals and other interested persons and organizations was incorporated to this document in an effort to identify project alternatives which sufficiently minimized and mitigated potential adverse environmental impacts while achieving the applicants stated purpose and need. This section describes the anticipated impacts to environmental resources within the project study area resulting from the six identified alternatives. Quantification of predicted gains or losses of each major habitat category is provided in Table 5.6. Likewise, visual representations of existing and predicted habitat areas are included as Figures 5.12 – 5.24.

5.5.1 Estuarine

A. Salt Marsh

As indicated in Section 4.0 of this document, salt marsh habitat in the vicinity of the permit area is confined to the back-barrier island areas contiguous with Bald Head Creek (east of Bald Head Island Marina and Keelson Row) and consists of high marsh (e.g. supratidal)

(dominated by *Spartina patens*) and low marsh (e.g. intertidal) dominated by *Spartina alterniflora*. As a result, these areas tend to be protected from dredging and beach disposal/nourishment actions along western South Beach and West Beach.

Given the location of salt marsh relative to the permit area, no direct, indirect, or cumulative impacts are anticipated for any of the alternatives evaluated in the DEIS.

5.5.2 Coastal Beach and Dune Habitats

A. Wet Beach

The wet beach habitat of Bald Head Island (particularly South Beach and West Beach) is a highly dynamic zone exposed to extreme physical forces that result in high rates of erosion and shoreline recession. These particular shorelines are affected by episodic sand disposal and nourishment events. Benthic species along the ocean beachfront are adapted to coarser-grained substrates and high-energy environments. While infaunal assemblages are rather diverse, the larger macrofaunal community in the swash zone is generally characterized by low density and low abundance due to dynamic and active wave conditions (Posey et al. 1996). The benthic community represents an important food source for many shore birds and important recreational fish species such as flounders, pompanos, mullets and kingfish. The following provides a description of potential effects of each project alternative to wet beach habitat mapped in the study area.

(1) No Action/Status Quo (Alternative #1)

a. Direct Impacts: Placement of sand at the beach fill site will result in impacts to infaunal communities as the existing intertidal wet beach is converted to dry beach habitat. Species which are permanent residents of the intertidal surf zone will be more severely impacted during beach nourishment than species which migrate on and off the beach (Hurme and Pullen 1988).

Placement of sediment that closely matches the native beach sediment is vital in the minimization of adverse impacts to beach infauna. Some studies have suggested that changes in geomorphology and sediment characteristics may have a greater influence on the recovery rate of invertebrates in comparison to direct burial or mortality (NRC 1995). Prior federal channel maintenance and disposal events associated with the Wilmington Harbor navigation project have demonstrated compatibility of the disposal materials within the nourishment area of South Beach and West Beach. As indicated above, compatibility with the nourishment site will favor benthic recolonization.

Upland erosion is anticipated even in the presence of ongoing disposal events associated with the SMP. As such, short-term stabilization measures such as the placement of emergency sand-bags, maintenance of the existing sixteen sand-tube groinfield and/or beach scraping could occur on an as needed basis. The use of heavy machinery associated with soft stabilization methods can result in direct mortality of benthic macrofauna.

As noted previously, infauna living in a high-energy environment, especially the intertidal area, are well adapted to disturbances (Van Dolah et al. 1994, Levison and Van Dolah 1996). The opportunistic nature of benthic invertebrates common to this area, compatibility of dredge materials to the target beach and avoidance of peak periods of biological activity help facilitate post-construction recovery.

b. Indirect Impacts: Removal of the benthic forage base would indirectly impact higher trophic species such as fish, birds and marine mammals utilizing the benthos for prey. However, the magnitude of indirect impacts to higher level trophic species is mitigated by the large area of habitat available beyond the nourishment site. Furthermore, peak larval recruitment periods for most benthic species are avoided by federal disposal typically occurring during winter months.

Delft3D modeling of Alternative #1 suggests that there will be shoreline erosion and recession, especially in the vicinity of the Point, and a small degree of accretion along West Beach. It is anticipated that the wet beach would shift relative to the shoreline. Impacts to the resident adult infaunal stock and larval transport are not anticipated and, as such, the infaunal community should gradually colonize the newly established intertidal habitat.

c. Cumulative Impacts: The cumulative reduction in benthic invertebrate fauna from repetitive placement of sediment on Bald Head Island could negatively impact the benthos over time. As described above, benthic communities at the recipient site should recover to pre-nourishment levels of community composition and biomass quickly given the opportunistic nature of resident infauna. Temporal separation between maintenance events should allow for infaunal recovery prior to the next dredging event such that only the area most recently dredged is affected.

(2) Retreat (Alternative #2)

a. Direct Impacts: Under Alternative #2 direct impacts resulting from dredge disposal events associated with routine maintenance of the federal navigation channel per the SMP would be the same as those discussed under Alternative #1; the primary direct effect of dredge disposal to the wet beach being the burial of benthic infauna with limited to no mobility. A retreat scenario would include the removal of the existing sand tube groinfield and the planned abandonment or relocation of infrastructure and residences. The use of heavy machinery during removal of the sand tube groinfield may result in direct mortality to resident infauna and epifauna with limited mobility.

b. Indirect Impacts: Indirect impacts associated with dredge disposal under Alternative #2 would be comparable to those discussed above. Similar to Alternative #1, the Retreat alternative would result in a rather significant change in shoreline configuration. It is anticipated that the wet beach will gradually migrate with the shoreline such that would be no widespread gains or losses of this habitat.

c. Cumulative Impacts: Cumulative impacts associated with the SMP under Alternative #2 would be comparable to those identified above.

(3) Beach Nourishment with Maintenance of Groinfield (Alternative #3):

a. Direct Impacts: As previously discussed under Alternative #1, placement of sand at the beach fill site will directly impact infaunal communities as the existing intertidal wet beach is converted to dry beach habitat. Nourishment impacts 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.

Benthic regeneration of wet beach 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; Van Dolah et al. 1992). The recovery of the benthos at the recipient site would be reliant on immigration (active or passive) of organisms from adjacent undisturbed areas and larval recolonization from the water column.

Placement of sediment that closely matches the native beach sediment is vital in the minimization of adverse impacts to beach infauna (NRC 1995). Sediment that is either finer or coarser than the recipient beach may cause a marked degradation in habitat value and negative effects to benthic reestablishment. Recovery time for small infauna residing in the interstitial spaces between sand grains will take longer if the percentage of silt and clay is high (ASFMC 2002). Peterson et al. (2000) noted that mole crab abundances were reduced in nourished beaches in North Carolina that used finer grained sediment than the native beaches, likely attributed to burrowing and/or feeding effects. Van Dolah et al. (1992)

attributed rapid benthic recovery to the similarity of fill material to existing sediments, as well as placing the fill high on the beach, well above mean sea level.

Infaunal abundance is typically lower during winter months in comparison to other seasons (Van Dolah 1978). *Donax* spp. (i.e. coquina clams) and *Emerita talpoida* (mole crab) are common residents in the lower beach and display peak larval abundance in the summer months. Peterson et al. (2000) found that densities of mole crabs and Donax spp. were 86-99% lower on nourished beaches of Bogue Banks, NC five to ten weeks following nourishment activities likely due to a poor match in sediment grade. Another study from Bogue Banks, NC indicated that while there was a complete loss of mole crabs following nourishment activities lasting from December through June, the population density recovered by mid-June, one month after completion of the project (Reilly and Bellis 1983). In this study, Reilly and Bellis found that infaunal species recruiting from pelagic larval stocks will recover if beach nourishment activities end before larval recruitment begins in the spring. Completion of construction activities during late fall and winter months prior to the peak spring larval recruitment season and when infaunal densities are comparatively low would reduce the recovery time of the wet beach community.

The Village of Bald Head Island completed a biological monitoring program in conjunction with the 2009 Bald Head Island Beach Restoration Project to assess pre-construction and post-construction populations of mole crabs and coquina clams along the beachfront of the west and south-facing beaches of Bald Head Island. This nourishment project was implemented in November 2009 and utilized Jay Bird Shoals as the source site. Baseline monitoring was conducted in June and September 2009 prior to the initiation of nourishment activities. Beachfront monitoring continued for two years upon completion of the project. No statistically significant differences were found between pre-construction and post-construction densities of coquina clams. The monitoring project yielded significant differences between pre and post-construction mole crab densities. However, these differences were also observed within reference sites and thus were attributed to

seasonality (or other factors not evaluated in the study) rather than project-related nourishment activities (LMG 2010, 2011).

b. Indirect Impacts: The surf zone supports abundant fish resources comprised mainly of small species and serves as an important migratory area used by larval and juvenile fish moving in and out of inlets and estuarine nurseries as well as adults migrating parallel to the coast (Hackney et al. 1996). Fish populations in the surf zone are typically higher and more diverse in the summer and early fall. This type of intertidal habitat has been shown to support as many as 95 species within a given area (ASFMC 2002). A 1996 review by Hackney et al. found that the diets of surf zone fish may change with development stage and prey availability suggesting that surf fish are opportunistic and may be able to adapt to disturbance events such as beach nourishment.

A study conducted by Versar Inc. (working on behalf of the USACE Wilmington District) attempted to identify the effects of dredge disposal on benthic resources of Brunswick County beaches. In 2001 and 2002, the deepening and realignment of the entrance channel of the Wilmington Harbor Project resulted in the removal of 5.6 Mcy of material from the Cape Fear River navigation channel and the offshore navigation channel leading to the river entrance. This material was then disposed of on four Brunswick County beaches (including Bald Head Island) affected by erosion over the previous years. The findings of the study indicated that that were no immediate impacts in fish abundances and diversities among disturbed, undisturbed and reference stations (Versar 2004).

Based upon Delft3D modeling over a nine year period, Alternative #3 is predicted to result in continued shoreline recession at the Point, with accretion on West Beach to the north of the Point. As with previous alternatives, the wet beach is anticipated to gradually migrate with the shoreline such that would no widespread gains or losses of this habitat or resident infauna are expected.

c. Cumulative Impacts: Utilizing sand with similar sediment characteristics to the target beach is mandated by the State of North Carolina and is vital to the minimization of adverse impacts. In addition, dredge disposal and beach nourishment tend to occur during winter months avoiding peak larval recruitment periods for many benthic species. Regional implementation of federal navigation maintenance projects and Village-sponsored nourishment efforts could potentially coincide; however, the spatial separation between projects as well as the dynamic nature of the coastal inlet system should reduce the potential for cumulative impacts to the wet beach.

(4) Alternative #4: Beach Nourishment/Beach Disposal and Sand Tube Groinfield Removal

a. Direct Impacts: Direct impacts associated with beach disposal/beach nourishment under Alternative #4 are similar to those discussed under Alternative #3. The intensity of the impact would be dependent on the volume of sediment and the total length of impacted shoreline. Removal of the sand tube groinfield would necessitate Village-sponsored nourishment events of greater magnitude (estimated by the engineer to be 500,000 cy more per nourishment event) than that identified under Alternative #3. Mortality of benthic infauna due to sand burial and the use of heavy machinery during construction activities and sand tube groinfield removal is anticipated and largely unavoidable. However, many of the benthic organisms inhabiting these sites are relatively opportunistic, allowing them to recover quickly after disturbances such as changes to the composition of the sediment or the rate of sediment accretion/loss.

b. Indirect Impacts: Indirect impacts associated with dredge disposal under Alternative #4 would be comparable to those discussed above. Based on 9-year model simulations this alternative is predicted to reconfigure the shoreline with a significant shift landward along the westernmost segment of South Beach, West Beach and the Point. While sediment losses are predicted to be greater than sediment losses under Alternative #3, the wet beach habitat is anticipated to migrate with the shoreline such there will be no appreciable gains or losses to the community.

c. Cumulative Impacts: The volume of sand required to offset losses from removal of the sand tube groinfield would necessitate independently-sponsored nourishment events of greater magnitude (and potentially greater frequency) than that identified under Alternative #3. Repeat disposal on an annual cycle has been shown to reduce productivity of the impacted beach by preventing mole crabs and coquina clams from attaining larger sizes (Lindquist and Manning 2001). The cumulative reduction in benthic invertebrate fauna from repetitive placement of sediment on Bald Head Island could negatively impact the benthos over time.

(5) Terminal Groin with Beach Nourishment (Groinfield Remaining) (Alternative #5)

a. Direct Impacts: Under Alternative #5, direct impacts associated with dredge disposal, beach nourishment, placement of the sand fillet and maintenance of the sand tube groinfield would be comparable to those discussed above. Additional impacts to the wet beach community will result from construction of the terminal groin structure. The terminal groin structure, as proposed, would have a total length (for both Phase 1 and Phase 2) of 1,900 linear ft with approximately 450 lf (or 0.5 acres) occupying the wet beach zone. The structure would be constructed of relatively large granite armor rock of varying size which would be transported to Bald Head Island by barge. Placement of the foundation mattresses and rock is generally by crane from a barge, from the upland and/or from a temporary trestle or pier constructed in close proximity to the groin structure. Such a pier is typically pile-supported and necessitates the driving or jetting of steel pile which are later retracted and removed from the site once the rock structure is completed[5]. There will be permanent loss of benthic fauna incapable of horizontal movement in the immediate footprint of the terminal groin. Heavy machinery associated with construction of the terminal groin and temporary trestle or pier construction will also result in mortality to benthic species with limited to no mobility.

[5] Note that by phasing the project, the need for the use of a trestle may be avoided.

b. Indirect Impacts: As previously discussed, the surf zone serves as a nursery and feeding ground for a number of finfish species that prey upon these benthic invertebrates and, in turn, are preyed upon by shorebirds, waterbirds, diving birds and marine mammals. Given the highly mobile nature of fish assemblages found to utilize the intertidal wet beach, it is expected that demersal species will relocate to other unaffected soft bottom and nearshore habitats during the period of construction activities and subsequent benthic recovery period. Finfish will return to the project area within a short period of time taking the opportunity to forage upon suspended nutrients and benthic infauna as well as utilize the new structure for resting and prey avoidance (Cenci et al. 2010).

c. Cumulative Impacts: Construction of the terminal groin would contribute to the loss of resident infauna of the wet beach community. However, this adverse effect is not of a magnitude that would generate cumulative impacts to the habitat type (or resident/migratory inhabitants) when viewed on a regional basis.

(6) Terminal Groin with Beach Nourishment/ Removal of Sand Tube Groinfield (Alternative #6)

a. Direct Impacts: Under Alternative #6, direct impacts associated with dredge disposal, beach nourishment and placement of the sand fillet would be comparable to those discussed under Alternative #5. Direct impacts are largely attributed to burial by the terminal groin structure and during the placement of sand during dredge deposition and/or beach nourishment. Additional temporary impacts will result from heavy machinery use during removal of the sand tube groinfield and construction of the terminal groin structure. Removal of the sand tube groin field would result in a relatively small increase in wet beach (i.e. < 1 acre).

b. Indirect Impacts: Indirect impacts associated with Alternative #6 would be comparable to those previously discussed. Some level of benefit would be realized via the removal of the

sand tube groin field. Though relatively small, there would be an expanded area of wet beach available to species foraging in the surf zone.

c. Cumulative Impacts: Cumulative impacts to the wet beach community under Alternative #6 would be comparable to those identified above.

B. Dry Beach

Biological diversity of the dry beach zone is typically low and resident fauna primarily include burrowing species well adapted to a dynamic environment. Dynamic shorelines typically display reduced species diversity in comparison to protected beaches buffered from physical extremes. The dry beach of South Beach and West Beach is subject to continual morphological changes due to erosion. In addition to offering recreational benefits to residents of Bald Head Island and the general public, the dry beach is utilized by nesting and foraging shorebirds and waterbirds and provides a nesting ground for sea turtles. In addition, the federally-listed seabeach amaranth (*Amaranthus pumilus*) is documented to occur within the upper beach of Bald head Island (particularly in areas in the vicinity of the Point). The following provides a description of potential effects of each project alternative to dry beach habitat mapped in the study area.

(1) No Action/Status Quo (Alternative #1)

a. Direct Impacts: There are a number of potential effects associated with the placement of dredged materials on top of benthic communities in estuarine environments, the most immediate impact being burial (Hirsch et al. 1978). The extent and magnitude of burial effects are dependent on the thickness and composition of emplaced dredge material. Burial effects would be greatest for non-motile benthic faunal species and species displaying limited mobility. Motile benthic fauna will either migrate vertically to pre-existing sediment depths or migrate horizontally to un-impacted areas.

The ultimate recovery of benthic community is largely dependent upon the compatibility of the sediment with the target beach. Habitat modification can be a concern in instances where dredged material represents a sediment type significantly different from that of the existing beach (Mauer et al. 1978). Prior federal channel maintenance and disposal events associated with the Wilmington Harbor navigation project have demonstrated compatibility of the disposal materials with the nourishment area along Bald Head Island.

Under the No Action/Status Quo Alternative, upland erosion is anticipated even in the presence of ongoing disposal events associated with the SMP. As such, short-term stabilization measures such as the placement of emergency sand-bags, maintenance of the existing sixteen sand-tube groinfield and/or beach scraping could occur on an as needed basis. The use of heavy machinery associated with soft stabilization methods can result in direct mortality of benthic macrofauna and sand compaction.

Lindquist and Manning (2001) documented negative impacts to some species following soft beach stabilization efforts. During the study, the ghost crab population was significantly reduced for 6 to 8 months following beach bulldozing. These findings were similar to the findings of Peterson et al. 2000 in which the number of ghost crabs in the upper beach zone were reduced by 55-65% three months following beach bulldozing at Bogue Banks, NC and 86-99% lower than on nearby reference beaches. However, other studies reported rapid recovery of beach infauna (less than 60 days) including species abundance and diversity of the overall faunal complex following beach bulldozing and no long term changes to species composition subsequent to beach scraping (ASFMC 2002).

b. Indirect Impacts: The placement of dredge disposal materials along Bald Head Island will temporarily disturb breeding, nesting and feeding activities of resident and migratory birds. Birds may be displaced by dredges, pipeline and other construction equipment. Birds which are startled by construction activities on the beach are likely to temporarily leave the immediate project area. Dredge material placed on the beach has the potential to crush

nests, eggs and hatchlings. While there will be a direct loss of prey species for birds following placement of the dredge materials, additional foraging impacts could result if the disposal materials do 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 (ASFMC 2002).

Predictive results from Delft3D modeling indicate that the most pronounced seabed erosion and shoreline recession under Alternative #1 is in the vicinity of the Point with a small degree of sediment accretion along West Beach. It is expected that the beach profile from upland dune to the mean high water line in the vicinity of the Point would be unstable and comparatively steeper than the existing profile and would offer limited habitat for species that utilize the dry beach, including threatened and endangered flora and fauna. Based upon a predictive nine-year model simulation, implementation of Alternative #1 would result in a net loss of 22 acres of dry beach. Several state- and federally-listed species would be impacted by this loss, including but not limited to: least terns, American oystercatchers, Wilson's plovers, sea turtle species, and seabeach amaranth.

c. Cumulative Impacts: Disposal events conducted under the SMP would not result in cumulative impacts to dry beach. In addition, emergency-level stabilization measures under the status quo condition would not result in widespread effects and would not be long-lasting – thus additive and interactive effects would be unlikely. While the magnitude of predicted loss of dry beach under Alternative #1 is considerable, it is not likely to produce cumulative impacts to this habitat. This is due in large part to the extent of dry beach habitat that exists along the shorelines of Bald Head Island and adjacent beaches in the region. In addition, the dry beach of western South Beach, the Point, and West Beach is subject to continual disturbance resulting from recurring erosion and overwash from storms. In the context of past, present, and reasonably foreseeable future actions, cumulative impacts are not expected as a result of the implementation of the No Action/Status Quo Alternative.

(2) Retreat (Alternative #2)

a. Direct Impacts: Under Alternative #2 direct impacts resulting from dredge disposal events associated with routine maintenance of the federal navigation channel would be the same as those discussed under Alternative #1; the primary direct effect of dredge disposal to the dry beach being the burial of benthic infauna with limited to no mobility. Removal of the sand-filled geotextile tubes and associated underlayments would require excavation with heavy machinery and sand tube clearing via hydraulic means (*i.e.* washing of sand from each tube structure) in place. The use of heavy machinery during removal of the sand tube groinfield could result in direct mortality to resident infauna and epifauna with limited mobility. Geotube removal would likely occur subsequent to a beach fill operation thereby reducing direct impacts to the infaunal community.

b. Indirect Impacts: Indirect impacts associated with dredge disposal, beach nourishment and sand tube groinfield maintenance under Alternative #2 would be comparable to those discussed under Alternative #1. Ultimately, the placement of dredge disposal materials along Bald Head Island will temporarily disturb breeding, nesting and feeding activities of resident and migratory birds.

While dredge disposal activities pursuant to the SMP would continue, there would be no stabilizing structures in place to reduce the rate of sand losses. The Delft 3D model predicts rapid shoreline recession along the western end of South Beach to an extent that residences are susceptible to loss (if not relocated) within the first three years. Based upon modeling and prior shoreline monitoring, it is expected that the beach profile would be nearly vertical from upland dune to the mean high water line. By year nine of the model simulation, the shoreline would recede to an extent that would result in the loss of over 23 acres of dry beach. Impacts to this habitat type would in turn adversely affect several resident and migratory fauna. In addition, the federally-listed seabeach amaranth would be negatively impacted.

c. Cumulative Impacts: As with Alternative #1 above, the loss of dry beach habitat predicted via the implementation of the Retreat Alternative is substantial (23 acres over the nine-year simulation). However, much of the area of predicted loss exists in a chronically eroded condition. While the developed nature of the island precludes unabated migration of the shoreline, it is expected that some level of equilibrium of beach profiles will occur such that dry beach will form along segments of the shoreline under evaluation. In consideration of this, as well as the extent of existing dry beach habitat along the shorelines of Bald Head Island and other barrier islands in the region, it is expected that the implementation of the Retreat Alternative would not result in cumulative effects to this resource.

(3) Beach Nourishment with Maintenance of Groinfield (Alternative #3):

a. Direct Impacts: The temporal loss of infauna as a result of sand burial (from both federal disposal and Village-sponsored nourishment) and periodic use of heavy machinery associated with the maintenance of the groin field is anticipated and largely unavoidable. Larger, more mobile species will be able to temporary relocate to unaffected areas along Bald Head Island. Impacts will be most severe for permanent faunal residents which do not migrate on and off the beach (Hurme and Pullen 1988).

Physical impacts to dry beach habitat will vary during and after dredge disposal. Studies have shown that the nourished beach may be physically altered with respect to sand compaction, shear resistance, moisture content and grain size and shape even when the sediment is compatible with the target beach (NRC 1995). Placement of sediment that closely matches the native beach sediment is vital in the minimization of adverse impacts to beach infauna.

The amount of sand overburden will vary across the width of the beach and can range from several centimeters to more than a meter. Studies of burrowing abilities of sand-dwelling species are varied. Infaunal organisms have been observed to burrow through sand burdens up to 1 meter depending on grain size characteristics (NRC 1995). As the beach fill adjusts a

distinct scarp can form which can hinder or eliminate movement of macrofauna between the swash zone and the upper beach (Reilly and Bellis 1978).

Monitoring efforts conducted following the 2005 Folly Beach Nourishment Project in Folly Beach, SC indicate that nourishment activities had little effect on surficial sediment characteristics and burrowing macroinvertebrates on the beach. Overall ghost crab population size did not yield a substantial response to nourishment. While not significant, there was evidence of decreased ghost crab densities with increased beach width which was attributed to habitat fragmentation, increased risk of predator exposure and increased pedestrian traffic (Bergquist et al. 2008).

The Village of Bald Head Island completed a biological monitoring program in conjunction with the 2009 Bald Head Island Beach Restoration Project to assess pre-construction and post-construction ghost crab (*Ocypode quadrata*) populations along the beachfront of the west and south-facing beaches of Bald Head Island. The Village-sponsored nourishment project was implemented in November 2009 and utilized Jay Bird Shoals as the source site. Baseline monitoring was conducted in June and September 2009 prior to the initiation of nourishment activities. Beachfront monitoring continued for two years upon completion of the project. The monitoring project yielded significant differences between pre and post-construction ghost crab burrow hole densities. However, significant differences were also observed at reference sites – thus indicating the influence of non-project related factors including inter-year natural variability (LMG 2010, 2011, 2012).

b. Indirect Impacts: Indirect impacts associated with dredge disposal, beach nourishment and sand tube groinfield maintenance under Alternative #3 would be comparable to those discussed under Alternative #1. Ultimately, the placement of dredge disposal materials along Bald Head Island will temporarily disturb breeding, nesting and feeding activities of resident and migratory birds. Village-sponsored nourishment events would occur three years subsequent to the next federal disposal and continue on approximate nine-year

intervals for the remaining life of the project. As such, indirect impacts associated with Alternative #3 could occur with greater frequency than implementation of the SMP alone (Alternative #1).

Under Alternative #3, the cumulative erosion pattern predicted in the model indicates erosional stress along discrete areas of shoreline west and north of the sand tube groin field with sediment accretion north of the Point, along West Beach. The predicted effect is the net loss of six acres of dry beach by Year 9 of the model simulation. Infaunal species of the dry beach should respond to shoreline erosion and accretion by migrating as the shoreline shifts over time.

c. Cumulative Impacts: While the implementation of Alternative #3 has the potential to result in considerable loss of dry beach from erosion, it is expected that such loss will not necessarily produce cumulative effects to this habitat type. This determination is made in large part to the condition of the existing condition of the dry beach within the area of study. Much of western South Beach experiences the effects of acute and recurring erosion (e.g. steep beach profiles and the prevalence of escarpments). While predicted shoreline recession will result in dry beach losses, some level of equilibrium would be anticipated over the long-term (i.e. beyond nine years) such that some losses may be eventually offset by the formation of dry beach habitat along sections of the shoreline under evaluation. When viewed in the context of past, present, and reasonably foreseeable projects, it is expected that the loss of dry beach predicted under Alternative #3 will not result in cumulative impacts.

(4) Beach Nourishment/Beach Disposal and Sand Tube Groinfield Removal (Alternative #4)

a. Direct Impacts: Direct impacts associated with beach disposal/beach nourishment under Alternative #4 are similar to those discussed under Alternative #3. The intensity of the impact would be dependent on the volume of sediment and the total length of impacted shoreline. Removal of the sand tube groinfield would necessitate Village-sponsored

nourishment events of greater magnitude (and potentially greater frequency) than that identified under Alternative #3. Mortality of benthic infauna due to sand burial and the use of heavy machinery during sand tube groinfield removal is anticipated and largely unavoidable. In general, biological diversity of the dry beach zone is typically low and resident fauna primarily include burrowing species well adapted to a dynamic environment. Data collected on Bald Head Island following 2009 nourishment efforts indicate that fluctuations in benthic fauna (i.e. ghost crabs) inhabiting the dry beach are attributed to seasonality and other environmental factors rather than beach nourishment activities (LMG 2010, 2011, 2012). Removal of the sand tube groinfield, in and of itself, would expose dry beach that is currently covered or altered in some manner by the existing sand tubes. However, the net effect of removal would be the increased instability of the beach profile and ensuing erosion. By Year 9 of the Delft 3D model simulation for this alternative, approximately 19 acres of dry beach can be expected to be lost (converted principally to subtidal bottom).

b. Indirect Impacts: Indirect impacts associated with dredge disposal, beach nourishment and sand tube groinfield maintenance under Alternative #4 would be comparable to those discussed under Alternative #3 but could occur with greater frequency following removal of the sand tube groinfield. Ultimately, the placement of dredge disposal materials along Bald Head Island and the use of heavy machinery during removal of the sand tube groinfield will temporarily disturb breeding, nesting and feeding activities of resident and migratory birds.

While dredge disposal activities pursuant to the SMP and additional Village-sponsored nourishment events would continue, there would be no stabilizing structures in place to reduce the rate of sand losses. The model predicts shoreline recession and associated upland damage along a portion of South Beach in the vicinity of Bald Head Wynd within the 9-year simulation. The predicted erosion would result in the loss of dry beach and thus offer limited habitat for species that utilize these areas, including threatened and endangered flora and fauna. North of the Point, the predicted shoreline migrates west resulting in

sediment accretion on West Beach. However, the net effect over the first nine-year period would be a predicted net loss of 19 acres of dry beach.

c. Cumulative Impacts: As with the alternatives discussed above, no cumulative impacts are anticipated as a result of the implementation of Alternative #4. While considerable loss of dry beach habitat is predicted via erosion over a nine-year period and beyond, there is extensive acreage of this type of habitat on the remaining shoreline of Bald Head Island as well as along the shorelines of adjacent barrier islands. In addition, it is expected that some level of equilibrium will occur over the long-term that would produce conditions suitable for the formation of dry beach.

(5) Terminal Groin with Beach Nourishment (Groinfield Remaining) (Alternative #5)

a. Direct Impacts: Under Alternative #5, direct impacts associated with dredge disposal, beach nourishment and maintenance of the sand tube groinfield would be comparable to those discussed under Alternative #3. Mortality of benthic infauna due to sand burial and the use of heavy machinery during construction activities and sand tube groinfield maintenance is anticipated and largely unavoidable.

Additional impacts to the dry beach community will result from construction of the terminal groin structure. The terminal groin structure, as proposed, would have an overall length of 1,900 linear ft (for both Phase 1 and Phase 2) with approximately 250 to 300 lf (equivalent to 4,800 sf) extending above the 2012 MHW location. The structure would be constructed of relatively large granite armor rock of varying size which would be transported to Bald Head Island by barge. Placement of the foundation mattresses and rock is generally by crane from a barge, from the upland, and/or from a temporary trestle or pier constructed in close proximity to the groin structure.[6] Upland portions of the structure tieback necessitate excavation and backfilling of beach sand in order to place the groin foundation and rock at

[6] As indicated previously, the Phase I structure may not require the use of a temporary construction trestle. Rather much of the work can be completed via the use of sand pads formed from the fillet.

the necessary elevations (normally below existing grade). Based upon current design, approximately 350 lf of the groin will consist of the tie-back section.

There will be mortality of benthic fauna incapable of horizontal movement in the immediate footprint of the terminal groin. Heavy machinery associated with construction of the terminal groin will also result in mortality to benthic species with limited to no mobility. The majority of the terminal groin will be covered with sand upon completion thereby maintain the relative function of dry beach habitat.

b. Indirect Impacts: The installation of the terminal groin will provide for an expanded and more stable dry beach, particularly updrift of the structure. Since the groin is designed to allow for sediment transport to its lee side, any potential adverse effects to downdrift dry beach would be minimized. Based upon Delft 3D modeling, there will be a net increase of approximately 8 acres of dry beach by Year 9 of the simulation. More stable dry beach is considered more advantageous to resident and migratory fauna particularly in consideration of a chronically eroded shoreline and comparatively steep beach profiles prevalent along much of western South Beach over the last several years.

c. Cumulative Impacts: No cumulative impacts to dry beach habitat are expected as a result of the implementation of Alternative #5. While there would be a relatively small direct impact as a result of the construction of the groin, this would be offset by the predicted increase in dry beach resulting from the stabilized shoreline.

(6) Terminal Groin with Beach Nourishment/ Removal of Sand Tube Groinfield (Alternative #6)

a. Direct Impacts: Under Alternative #6, direct impacts associated with dredge disposal and beach nourishment would be comparable to those discussed under Alternative #3. Mortality of benthic infauna due to burial by sand during nourishment and burial by granite armor rock upon completion of the terminal groin structure is largely unavoidable. Similarly, there

will be direct impacts to benthic species with limited to no mobility as a result of the operation of heavy machinery necessary for removal of the sand tube groinfield and construction of the terminal groin structure. Operation of equipment would be confined to construction corridors to limit disturbance where feasible.

b. Indirect Impacts: Similar to Alternative #5, the Delft3D modeling of Alternative #6 predicts an expanded dry beach updrift of the terminal structure. The Point downdrift of the groin is believed to exist more or less in its present-day condition. With the removal of the sand tube groinfield, it is expected that areas of South Beach beyond the influence of the terminal groin will experience some level of deflation and thus be susceptible to increased risk of inundation and erosion. This would, in turn, affect those species inhabiting or utilizing the dry beach along this segment of shoreline.

Given the designed porosity and profile of the structure, sediment passage through and over the groin will help minimize potential adverse effects to downdrift dry beach. Delft 3D modeling indicates the net gain of 1.7 acres of dry beach at Year 9 of the model simulation.

c. Cumulative Impacts: As with Alternative #5 above, no cumulative impacts are expected as a result of the implementation of Alternative #6.

C. Dune

Dunes are dynamic features subject to alteration by natural erosion or accretion. While sufficiently stable to support various species of vegetation, dunes can be subject to significant impact or loss from episodic storm-induced waves and wind. Actions of humans similarly can affect the condition and stability of dunes. For instance, active management (via planting and sand fencing) can help to restore or build frontal dunes, while conversely human foot traffic or intensive recreational use has been cited to adversely effect dune vegetation and structure (Rogers and Nash 2003).

The following provides a description of potential effects of each project alternative to dune habitats mapped in the study area.

(1) No Action/Status Quo (Alternative #1)

a. Direct Impacts: Disposal occurring under the No Action/Status Quo alternative will not have a direct impact to dune habitat. Similarly, other short-term stabilization measures (such as sand bags and beach scraping) that have been employed to remedy localized erosion will not result in direct impacts to dune habitat. These actions tend to occur in the upper beach and avoid disturbance to dunes.

b. Indirect Impacts: Alternative #1 is predicted to have the most significant effect to the shoreline position of the Point. While some level of shoreline recession is predicted along western South Beach, sand deficits over time would have a pronounced adverse impact on the conditions of the Point. As described in earlier sections, the Point consists of the most expansive areas of lower foredunes (newly formed features consisting of relatively sparse vegetation). Landward of these areas are the large, primary dunes of Bald Head Island. Based upon the physical Delft 3D models, all of the Point and the associated dune habitat (including frontal and primary dune) as it currently exists would be loss to erosion by year 9 of the simulation.

Some level of impact is expected along recently stabilized frontal dunes of South Beach, particularly along South Bald Head Wynd in the vicinity of the Bald Head Island Club. Many of these dunes have been reestablished through an active management plan that included sand fencing and planting with sea oats (*Uniola paniculata*). As has been observed in the past, a status quo condition results in a net deficit of sand along this section of shoreline and can result in the breaching and loss of frontal dune. The Delft 3D modeling completed for the no-action or status quo condition depicts a similar condition by Year 9 of the simulation.

Cumulatively, over 8 acres of dune of the total, existing 21 acres mapped in the study would be lost (converted to intertidal or subtidal bottom) within the first nine years of implementation of Alternative #1.

Deflation and recession of the shoreline along western South Beach and the Point would result in a less stable beach profile condition. In addition to the predicted habitat loss from erosion, it is anticipated that increased exposure to wind and waves would likely result in a less stable environment. Ultimately, such conditions are not conducive for the establishment and growth of dune vegetation. As such, newly formed dunes would not be as prevalent. Current primary dunes landward of the predicted 9-year shoreline position would be susceptible to storm-induced erosion and the effects of increased exposure to wind, waves, and salt spray. Overall, the indirect effects of this alternative would compromise dune function, particularly with respect to storm protection.

c. Cumulative Impacts: While some level of direct and indirect impacts to dune habitat are predicted, regional cumulative impacts to the resource are not anticipated as a result of the implementation of Alternative #1.

(2) Retreat (Alternative #2)

a. Direct Impacts: Direct impacts to dune habitat under Alternative #2 would be associated with the temporary disturbance of the sand tube removal. However, the entire sand tube groinfield was replaced in the winter of 2009-2010, and thus any vegetated dune is the result of more recent stabilization. Excavation of the landward end of the tubes could result in an impact to recently vegetated portions of the dune. Any disturbance would be temporal and spatially confined to the footprint of the sand tubes (landward ends) and the areas required for the operation of the construction equipment. No other direct impacts to dune habitat are expected under the Retreat Alternative.

b. Indirect Impacts: Under the Retreat Alternative, a systematic removal of the sand tube groinfield and demolition and/or relocation of structures would occur. In the absence of shoreline stabilization and beach nourishment, significant erosion would result over much of western South Beach, the Point, and West Beach. Shorter term (i.e. over one to three years) impacts would result from more frequent overwash and inundation. Overwash of frontal dunes would result in direct impact by effectively 'flattening' these features. The eroded dunes would not be able to become reestablished as the shoreline is predicted to retreat by as much as 1,000 lf landward of its current position. The Retreat Alternative would impact the lee side slopes and interior flats of the dunes along western South Beach and the Point. Nearly all of the frontal dunes identified in the model study area would be lost by Year 9 of the simulation. However, littoral transport would result in the migration of sand to the northwest and ultimately cause a shift northward of the Point feature. While some level of accretion in this area could favor the development of dunes, the net predicted effect is the loss of 16.1 acres (equivalent to 76%) of dunes within the mapped study area.

As indicated for Alternative #1, the predicted physical effects of the Retreat Alternative would result in a less stable beachfront condition over the nine-year model period. Areas currently consisting of relatively high primary dunes would become beachfront features and thus subject to increased exposure to wind, waves, and salt spray. Such rigorous environmental conditions would alter species composition, decrease stability, and increase the risk of further loss to erosion over the 30-year project life.

c. Cumulative Impacts: Implementation of the Retreat Alternative is predicted to result in the indirect loss of over 16 acres of dune habitat over the nine-year model simulation. While the presence of the federally-maintained channel would continue to influence shoreline morphology and processes, it is expected that the system will achieve some level of equilibrium that will allow for the formation of dunes over the long term. As a result, no cumulative impacts are expected.

(3) Beach Nourishment with Maintenance of Groinfield (Alternative #3):

a. Direct Impacts: There are no direct impacts to dune habitat associated with the implementation of Alternative #3.

b. Indirect Impacts: Based upon the predicted physical consequences of implementing Alternative 3, there would be considerably less impact to dune habitat than that predicted for Alternative #1 and Alternative #2. The principal area of risk identified under Alternative #3 is the segment of shoreline just west and north of the sand tube #16 and along the southern extent of the current Point feature. While the Point is predicted to migrate north, there will be approximately 2.3 acres of net loss of dune habitat under this alternative by Year 9 of the Delft 3D model simulation. The predicted area of dune loss currently consists of lower, sparsely vegetated foredunes. Bare or sparsely vegetated areas of the upper beach and foredunes present suitable nesting habitat for willets, American oystercatchers, and Wilson's plovers. With the exception of this area, dunes are likely to be able to exist more or less in their current condition as a result of the implementation of Alternative #3.

Indirect effects of Alternative #3 would include the potential of dune instability or loss resulting from storm-induced erosion. In particular, sand losses in the vicinity of the Point may have an adverse impact on frontal dunes of the area. Acute erosion of the upper beach and dune transition zone would result in a steeper, and less stable, berm profile. Increased exposure to wind, waves, and salt spray could influence plant species growth and composition.

c. Cumulative Impacts: Implementation of Alternative #3 is not expected to result in cumulative impacts to dune habitats of the region.

(4) Beach Nourishment/Beach Disposal and Sand Tube Groinfield Removal (Alternative #4)

a. Direct Impacts: As with Alternative #2, direct impacts to dune habitat under Alternative #4 would be associated with the temporary disturbance associated with the excavation of

the landward ends of the sand tubes. Any disturbance would be temporary and would be spatially confined to the footprint of the sand tubes and the areas required for the operation of the construction equipment.

b. Indirect Impacts: Implementation of Alternative #4 would have the similar effects to dunes within the project area as that of Alternative #2. By Year 9 of the model simulation, 12.5 acres of the total dunes mapped in the study area would be lost via conversion to intertidal or subtidal bottom, equivalent to a 59% decrease. Recession of the shoreline would result in primary dunes (currently located within the interior, more protected areas of the Island) to be exposed to increased wind, waves, and salt spray. Together, with steeper berm profiles characteristic of eroded areas, these conditions would lead to a generally less stable environment. Overall, remaining dune structure and function would potentially be compromised.

c. Cumulative Impacts: The implementation of Alternative #4 will result in the loss of dune habitat of a magnitude and duration that has the potential to result in cumulative effects. In light of the developed nature of the island, the opportunity for dune formation as the shoreline recedes will be limited. When considered in the context of past, present, and reasonably foreseeable future actions (e.g. residential and commercial development of barrier islands), these losses may result in cumulative impacts.

(5) Terminal Groin with Beach Nourishment (Groinfield Remaining) (Alternative #5)

a. Direct Impacts: Frontal and primary dunes are not anticipated to be adversely affected as a result of the implementation of Alternative #5.

b. Indirect Impacts: Based upon Delft 3D modeling, no adverse, indirect impacts to dunes are anticipated as a result of the implementation of Alternative #5. As with other alternatives, there may be some change to the configuration and position of the Point feature. However, these shifts will not result in a direct impact to dunes. The installation of

the groin and associated fillet will expand the area of dry beach updrift of the structure. A more stable upper beach zone could potentially result in the establishment and growth of dune grasses (e.g. bitter panicum, sea oats, salt meadow hay, etc.), which would in turn promote increased sand trapping and the potential for dune formation.

c. Cumulative Impacts: Implementation of Alternative #5 is not expected to result in cumulative impacts to dune habitat.

(6) Terminal Groin with Beach Nourishment/ Removal of Sand Tube Groinfield (Alternative #6)

a. Direct Impacts: Direct impacts associated with this alternative would consist of temporary and relatively confined disturbance associated with the removal of the landward ends of the sand tubes.

b. Indirect Impacts: The indirect effects for Alternative #6 are predicted to be the same as those identified above for Alternative #5. A more stable beach condition updrift of the structure could potentially promote conditions suitable for plant species establishment and growth. In turn, plant stems tend to trap wind-borne sand. In the absence of any significant erosion, these areas could potentially form into smaller foredunes near the upper beach-dune transition zone.

Note that the removal of sand tubes east of the terminal structure may result in some level of decreased stability along the section of shoreline across from the Bald Head Island Club. The frontal dunes of this segment of shoreline are relatively low and narrow. With decreased stability comes a corresponding increase of risk of loss to erosion. While the Delft 3D model does not predict any direct loss during the nine-year simulation, beach deflation and instability would make the upper beach and frontal dune more susceptible to erosion, particularly during storms.

c. Cumulative Impacts: No cumulative impacts to dune habitat are expected as a result of the implementation of Alternative #6.

D. Interdunal Wetlands

As described in Section 4.0 of the document, interdunal wetlands occupy depressions within the dune complex of the island. Interdunal wetlands have been mapped in the study area and are depicted in Figure 5.12. Given the proximity of these features to the shoreline of South Beach, these wetland types may be susceptible to impact via overwash or loss to marine waters under the different alternatives considered. The following provides a description of potential effects of each alternative to interdunal wetlands mapped in the study area.

(1) No Action/Status Quo (Alternative #1)

a. Direct Impacts: No direct impacts are expected as a result of the implementation of Alternative #1.

b. Indirect Impacts: Under Alternative #1, much of the shoreline of South Beach would continue to exist along a similar position as it does today with the exception of documented areas of persistent, acute erosion (i.e. immediately adjacent to South Bald Head Wynd across from the Bald Head Island Club). Provided that the frequency and volume of federal disposal events are similar to that which has occurred over the last decade and that the performance of the existing groinfield is maintained, then the shoreline of South Beach updrift of Sand Tube #16 would not be subject to the degree of recession predicted for other alternatives (e.g. Alternative #2 and Alternative #4).

While there are no significant changes in shoreline configuration predicted for much of South Beach, some level of sediment loss and deflation is anticipated. Overwash of the primary dunes and tidal inundation in the vicinity of South Bald Head Wynd is anticipated during storm events. Increased susceptibility to overwash can alter substrate elevations

within interior wetland areas and modify the hydrologic regime of the wetland. In addition, floodwaters that do not recede can become hypersaline and result in shifts in the vegetative composition of the wetland. It is important to note that while some periodic overwash is not uncommon for these types of wetlands (depending upon proximity to the shoreline), increased frequency of duration of tidal inundation can result in indirect impacts to wetland structure and function. For instance refuge or foraging habitat for characteristic fauna may be lost or modified to an extent that may force certain species to relocate to interior wetlands on the Island. Species less tolerant of mesohaline or euhaline conditions (such as the American alligator) in particular would be susceptible to displacement.

Cumulative Impacts: In consideration of past, present, and reasonably foreseeable future projects in the region, no cumulative effects to interdunal wetlands are anticipated in conjunction with Alternative #1.

(2) Retreat (Alternative #2)

a. Direct Impacts: No direct impacts to interdunal wetlands are expected as a result of the implementation of Alternative #2.

b. Indirect Impacts: The Retreat Alternative would include the systematic removal of the sand tube groinfield and the demolition and/or relocation of structures. In the absence of shoreline stabilization and beach nourishment, significant erosion would result over much of western South Beach, the Point, and West Beach. Shorter term (i.e. over one to three years) impacts would result from more frequent overwash and inundation. Overwash of frontal dunes would result in the deposition within back dune depressions and wetlands. Similar to the effects identified above, saltwater inundation could create hypersaline conditions and result in the dieback of species of low to moderate salt tolerance. Shifts in both the hydrologic regime and species composition would be anticipated over the short-term.

Based upon Delft 3D modeling, the shoreline of western South Beach and the Point is anticipated to recede over 1000 lf by Year 9 of the model simulation. Shoreline recession to this extent would result in the direct loss of 2 acres (equivalent to 50%) of the interdunal wetlands mapped within the area of study. These areas would be converted to intertidal or subtidal areas within nine years of the implementation of this alternative. It is anticipated that some state of quasi-equilibrium would be reached over a longer term period, such that interdunal wetlands of the interior areas of Bald Head would likely remain unaffected.

As indicated above, some level of equilibrium would ultimately be reached under the Retreat Alternative. While indirect loss of current, interdunal wetlands is predicted, it is likely that other interdune swales and flats (that are not currently identified as wetlands) would develop. Overall, the dune and backdune areas of barrier islands are dynamic environments that shift in response to varying physical conditions, including erosion and accretion. While the location and extent of this community type would likely be altered, it is anticipated that losses would be offset to some degree by the inundation of other sloughs/depressions in the landscape.

Species less tolerant of mesohaline or euhaline conditions (such as the American alligator, green tree frog, squirrel tree frog, or various species of snakes) may be displaced. However, more mobile species would readily relocate to interior areas protected from periodic overwash.

c. Cumulative Impacts: The predicted loss of interdunal wetlands under Alternative #2 will be offset to a degree by the expansion of wetlands within lower elevation areas not presently considered jurisdictional wetlands. As a result, cumulative impacts are not expected.

(3) Beach Nourishment with Maintenance of Groinfield (Alternative #3):

a. Direct Impacts: Actions implemented under Alternative #3 would not have a direct effect on interdunal wetlands of the permit area.

b. Indirect Impacts: Based upon the predicted physical consequences of implementing Alternative 3, there will likely be no short-term impacts to interdunal wetlands in the vicinity of the project area. The combination of nourishment and maintenance of the existing groinfield would likely provide sufficient stabilization of the shoreline so as not to adversely affect backdune flats and wetlands in the near term. However, Delft 3D modeling predicts the deflation of the area around the Point by Year 9 of the simulation. If erosion and deflation is significant enough to result in more frequent inundation of backdune areas, then interdunal wetlands are susceptible to some change in hydrology and species composition (as described above for Alternative #1 and Alternative #2).

Indirect effects would be the result of the potential for greater frequency and amplitude of tidal inundation during storm events. As described above, such conditions would alter hydrology and salinity of interdunal wetlands and give rise to shifts in species composition. Given the dynamic nature of these environments, it is anticipated that such shifts would not significantly adverse the function of this community type.

c. Cumulative Impacts: No cumulative impacts to interdunal wetlands are expected as a result of the implementation of Alternative #3.

(4) Beach Nourishment/Beach Disposal and Sand Tube Groinfield Removal (Alternative #4)

a. Direct Impacts: Similar to the three alternatives above, no direct impacts to interdunal wetlands are expected as a result of the implementation of Alternative #4.

b. Indirect Impacts: Implementation of Alternative #4 would have similar indirect effects to interdunal wetlands as Alternative #2. By Year 9 of the model simulation, 2 acres (equivalent

to 50%) of the wetlands mapped in the study area would be lost via conversion to intertidal or subtidal bottom. Loss from erosion may be offset to a degree as other low areas of the interior dunes are subject to increased hydrologic input from overwash. Over time these areas may develop hydroperiods of sufficient duration to be considered wetlands.

c. Cumulative Impacts: Predicted impacts to interdunal wetlands would likely be offset to a degree by the expansion of wetlands resulting from erosion and inundation. Alternative #4 is not expected to generate additive or interactive effects that would result in cumulative impacts.

(5) Terminal Groin with Beach Nourishment (Groinfield Remaining) (Alternative #5)

a. Direct Impacts: The installation of the terminal groin and maintenance of the existing sand tube groinfield is not anticipated to result in any direct impacts to interdunal wetlands. As described in prior sections, this wetland type occupies depressions of the interior backdunes and flats.

b. Indirect Impacts: Given the general increased stability of the shoreline associated with Alternative #5, no indirect impacts to interdunal wetlands are anticipated.

c. Cumulative Impacts: In consideration of past, present, and reasonably foreseeable future actions, there are no cumulative impacts associated with the implementation of this alternative.

(6) Terminal Groin with Beach Nourishment/ Removal of Sand Tube Groinfield (Alternative #6)

a. Direct Impacts: The installation of the terminal groin and *removal* of the existing sand tube groinfield is not anticipated to result in any direct impacts to interdunal wetlands. Overall, the predicted consequences of this alternative to habitat types landward of the frontal dunes are the same as those of Alternative #5.

b. Indirect Impacts: Overall, there will be increased stability of the shoreline associated with Alternative #6. However, some level of beachfront deflation may occur as a result of the removal of the sand tube groinfield. This deflation increases the risk for overwash of frontal dunes along South Bald Head Wynd in front of the BHI Club. This has the potential to affect interdunal wetlands closer to the beachfront. The effects of such are considered relatively minor.

c. Cumulative Impacts: In consideration of past, present, and reasonably foreseeable future actions, there are no cumulative impacts associated with the implementation of this alternative.

E. Maritime Thicket/Forest

Maritime thicket and maritime forests[7] are prevalent within undeveloped areas of the interior hind-dunes of the Island. More mature canopy maritime forest exists well east of the Point, particularly in the vicinity of Muscadine Wynd and points east. Given that these areas exist within interior sections of the Island (generally 1,000 lf or greater landward of the beachfront), most of the alternatives under consideration pose no direct threat to this habitat type. Potential consequences (direct or indirect) for each alternative are described further below.

(1) No Action/Status Quo (Alternative #1)

a. Direct Impacts: There would be no direct impacts to maritime thicket/forest as a result of the No Action/Status Quo alternative. While significant dry beach and dune loss is anticipated in the vicinity of the Point, maritime thicket/forest habitat will not be directly affected.

[7]Due to the close association of these community types and overlapping species occurrence, maritime thicket and maritime forest have been grouped under one category for the purpose of this evaluation.

b. Indirect Impacts: Erosion into the primary dune along the western end of South Beach and the Point (as predicted by Year 9 of the Delft 3D model simulation) could potentially have indirect effects to maritime thicket/forest habitats. Erosion to this extent would likely expose this habitat to greater physical stresses, including increased wind and salt spray. Exposure to increased wind and salt spray can influence plant species growth and community composition. Shifts in community composition can in turn adversely affect habitat functions.

c. Cumulative Impacts: In conjunction with other past, present, or reasonably foreseeable future actions, there are no other cumulative impacts to maritime thicket/forest. Other than the indirect effects of the No Action/Status Quo alternative, there are no other known actions that would have any appreciable effect on this resource.

(2) Retreat (Alternative #2)

a. Direct Impacts*:* No direct impacts are anticipated as a result of the implementation of the Retreat Alternative.

b. Indirect Impacts: The extent of erosion predicted under Alternative #2 would result in the loss of mapped maritime thicket/forest areas of the interior hind-dunes of the Island. Based upon Delft 3D modeling and baseline resource mapping, it is anticipated that approximately 7.1 acres (of the total 13.7 acres mapped) of maritime thicket/forest would be lost to erosion by Year 9 post-project implementation via conversion to intertidal beach or subtidal bottom. Areas not converted to open water or intertidal beach would be susceptible to loss from storm-induced tides and waves.

During storm events, those hammock areas in closer proximity to the mean high water line (as a result of the extent shoreline recession and deflation) would be at risk of inundation during storm events. Inundation would alter the hydrologic regime and physiochemistry of the habitat and alter species composition. Inundation would also likely result in the

deposition of sand, altering the microtopography of the habitat. Furthermore, increase exposure to wind and salt spray would also influence the growth and survivorship of characteristic species. The combined effect of these stressors would be a shift in species composition from species (such as live oak) adapted to more protected and stable conditions, to species adapted to more dynamic dune conditions (such as wax myrtle, groundsel tree, greenbrier, and various sedges and grasses).

Since the Retreat Alternative includes the planned relocation of structures (e.g. roads, utilities, and residential/commercial properties), additional indirect effects to maritime thicket/forest habitat would be expected as a result of providing additional right-of-ways, easements, and building sites for the relocated structures. Much of the current, undeveloped property contains maritime communities of varying age and condition susceptible to disturbance through future development. Those residences that are relocated would be moved to existing, platted lots. Thus, these impacts would be expected either way at some point in the future. However, relocation of South Bald Head Wynd and other roads would likely require the acquisition of new right-of-ways not currently platted.

c. Cumulative Impacts: Maritime forest represents one of the most endangered habitat types of North Carolina (Schafale and Weakley 1990). The principal cause of loss is habitat fragmentation from barrier island residential and commercial development. Further loss or degradation resulting from erosion associated with Alternative #2 is of a magnitude and duration (i.e. long-lasting or permanent loss) that may result in cumulative effects to this resource and the species relying on the resource for foraging, nesting, or refuge. Given the current condition of this habitat type and the susceptibility to loss in coastal North Carolina, its capacity to sustain additional impacts is relatively low. Therefore, cumulative impacts would be expected.

(3) Beach Nourishment with Maintenance of Groinfield (Alternative #3):

a. Direct and Indirect Impacts: Based upon the predicted physical effects, there would be no direct or indirect impacts to maritime thicket/forest habitat resulting from Alternative #3. The combination of beach nourishment and the continued maintenance of the groinfield will provide sufficient protection as to avoid erosion to nearly all of the upland areas landward of the current shoreline position.

b. Cumulative Impacts: In conjunction with other past, present, or reasonably foreseeable future actions, there are no cumulative impacts to maritime thicket/forest resulting from the implementation of Alternative #3.

(4) Beach Nourishment/Beach Disposal and Sand Tube Groinfield Removal (Alternative #4)

a. Direct Impacts: As with each of the alternatives described above, no direct impacts to maritime thicket/forest are anticipated as a result of the implementation of Alternative #4.

b. Indirect Impacts: It is predicted that approximately 4.3 acres of mapped maritime thicket/forest is susceptible to loss from erosion (conversion to intertidal beach or open water). Many areas not lost to erosion would be subject to alteration via increased exposure to inundation, wind, and salt spray. The combined effects of these physical stressors would likely result in a shift in species composition from those adapted to more stable conditions to those adapted to dynamic conditions of the shoreline and its immediate environs. In other words, as the shoreline migrates, maritime thicket/forest once protected by primary dunes would now be directly exposed to the rigorous environment of the oceanfront.

c. Cumulative Impacts: The extent of predicted impacts to maritime forest/shrub habitat is of a magnitude and duration that may result in cumulative impacts. As stated for Alternative #2, this habitat type has relatively low capacity to sustain additional impacts in consideration of the threat of its loss from barrier island development. Therefore, any permanent losses

(as expected for Alternative #4) would result in additive effects when viewed in the context of other past, present, and reasonably foreseeable future actions in the region.

(5) Terminal Groin with Beach Nourishment (Groinfield Remaining) (Alternative #5)

a. Direct and Indirect Impacts: There would be no direct or indirect impacts to maritime thicket/forest resulting from Alternative #5.

b. Cumulative Impacts: In conjunction with other past, present, or reasonably foreseeable future actions, no other cumulative impacts to this habitat are anticipated.

(6) Terminal Groin with Beach Nourishment/ Removal of Sand Tube Groinfield (Alternative #6)

a. Direct and Indirect Impacts: There would be no direct or indirect impacts to maritime thicket/forest resulting from Alternative #5.

b. Cumulative Impacts: In conjunction with other past, present, or reasonably foreseeable future actions, no other cumulative impacts to this habitat are anticipated.

5.5.3 Marine Habitats

A. Soft Bottom Communities

Soft bottom is characterized by a number of physiochemical factors including sediment grain size and distribution, water depth, hydrography as well as water quality (dissolved oxygen and salinity). Specific habitats identified in the study area include subtidal bottom of the Cape Fear River and Atlantic Ocean and estuarine and marine intertidal flats and shoals. Soft bottom located upstream of the inlet complex (beyond the study area) and within semi-protected areas of the estuary are more stable and support a larger, more diverse benthic community. The dynamic nature of the Cape Fear River inlet system and the relative instability of sediment can create an inhospitable environment for the benthic community

and thus favors the occurrence and predominance of species adapted to disturbance-prone conditions.

Soft bottom habitat is an important component of primary nursery areas, anadromous fish spawning areas and anadromous nursery areas. Together, the benthic microalgal and invertebrate populations within subtidal bottom may serve as an important food source for many juvenile fish. Additionally, intertidal shoals provide important foraging and roosting habitat for a variety of shorebirds and waterbirds.

1. Soft Bottom Effects at Borrow Sites:

Since four of the six alternatives include sand volume requirements beyond that supplied by federal disposal of material dredged from the Wilmington Harbor navigation channel, a summary of borrow site impacts specific to soft bottom communities is presented below.

As described in Section 5.2.4, sand volume requirements are variable between alternatives with Alternative #4 requiring the greatest volume of sand (estimated to be 8 Mcy) over the 30-year project life. Conversely, Alternative #5 would require the least volume (estimated to be 4.5 Mcy) over the 30-year period. The applicant's preferred borrow source of sand for alternatives that include nourishment would be the undredged portion of the Jay Bird Shoals borrow site included within the permit limits for the Village-sponsored beach nourishment project constructed in the winter of 2009/2010. 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). While dredging of any of the identified sand source sites will result in direct physical effect to marine subtidal bottom, the biological impacts may vary depending upon the existing condition of the borrow site and the anticipated conditions post-dredging.

Alteration of wave dynamics and sediment transport mechanisms following dredge events can lead to physical changes in the geomorphology at the dredge site. Physical changes observed following dredging can include: decreased sand content, increased silt/clay content, greater variation in sediment grain size (poor sorting) and accumulation of fine sediment (ASFMC 2002). Changes in sediment characteristics are cited as a principle causal factor restricting benthic re-population (NRC 1995) as such changes may reduce the suitability for larval settlement and recruitment. Dredging can also expose anaerobic sediment that may alter the rate of nutrient exchange between the sediment and the water column thereby impacting benthic recolonization. In addition, the creation of a bathymetric depression following dredging can reduce light penetration resulting in depressed rates of primary production. 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.

Studies have reported a decrease in mean grain size and, in some cases, an increase in silt and clay following dredge events (Bergquist et al. 2008, NRC 1995, Van Dolah et al. 1994). In the dredged area used to nourish Folly Beach, SC in 1993, silt and clay increased from 3% to 10% (Van Dolah et al. 1994). Similar sediment trends were observed in the borrow area used to nourish Hilton Head Island, SC in 1990. Sand content declined 31% and silt and clay content increased post-dredge (Van Dolah et al. 1992; Jutte and Van Dolah 2000). In all of these studies fine grained sediment remained elevated at the borrow site for at least one year following dredging.

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). In South Carolina, borrow sites located in depositional shoals at the southern terminus of barrier islands represent more sustainable locations than borrow sites at the northern end due to the direction of the dominant longshore currents (ASFMC 2002). Another study evaluated

borrow area sediments located at the southern end of Myrtle Beach (South Carolina) that had been excavated with a hopper dredge and found that there was no change in sediment characteristics post-dredging. In addition, the borrow site refilled rapidly with infill rates estimated at 47-100% after two years. In comparison a borrow area centrally located along the coastline of Myrtle Beach that was excavated with a hydraulic pipeline dredge exhibited modified sediment characteristics upwards of two years post-dredging and refilled slowly with infill rates estimated at 0-16% after two years (ASFMC 2002).

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). 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, interannual variability contributed more to the observed differences in species abundance than the sediment removal effects (Posey and Alphin 2002). Saloman et al. (1982) concluded that faunal abundance of a dredge site recovered within three months subsequent to dredging. The authors also determined that species diversity and faunal composition had returned to pre-dredge conditions within nine months.

Bergquist et al. (2008) evaluated the physical and biological characteristics at beach and borrow areas following 2005 renourishment efforts in Folly Beach, SC. In the borrow area, neither the sediment characteristics nor the biological community recovered to pre-dredge conditions within the first 12 months following dredging. The sediment at the borrow site

shifted toward finer grained sediment post-dredging, silt/clay increased, and CaCo3 (shell and carbonate rock rubble typically) decreased. The overall benthic community structure shifted substantially at the borrow area, independent of any seasonal cycles. A similar phenomenon has been documented in other South Carolina based studies. These studies indicated that mollusks and "other taxa" failed to recover within 12-18 months at one borrow site and that higher taxonomic groups required approximately 19-28 months to recover at a second borrow area (ASFMC 2002).

Jay Bird Shoals and Bald Head Creek Shoal have both been utilized for previous Village-sponsored nourishment events. In conjuction with the Bald Head Island Beach Restoration Project (SAW-2007-2699), the Village of Bald Head Island intitiated a biological monitoring program to characterize the benthic macrofuanal communities inhabiting nearshore soft bottom habitat including, Jay Bird Shoals and assess the response and recovery of benthic populations at this subtidal borrow site. 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 (LMG 2013).

Similar benthic recolonization patterns have been reported subsequent to dredging of the Bald Head Creek Shoal in January 2012 (LMG 2013). As with Jay Bird Shoals, the borrow site

consisted of a sandy depositional environment. After dredging, the substrate continued to consist of sandy sediments (mean percent sand by weight = 96%) with no statistical difference in sediment texture between the dredged site and the reference site (LMG 2013). Benthic infaunal sampling and analyses indicated that the benthic communities inhabiting these sites are highly resilient. Diversity, richness, and mean total abundance at the borrow site did not differ significantly between pre-construction sampling and Year 1 post-construction sampling. Diversity and richness were both significantly greater at the borrow site than at the reference site during both monitoring events. Based upon pre- and post-construction monitoring to date, it appears as though there was no long-term adverse effect on benthic populations resulting from project dredging.

Based upon the information above, it is expected the excavation of sand from any one of the proposed borrow sites would not result in any long-term impacts to soft bottom communities. All four proposed sand source sites are highly depositional environments prone to disturbance. As such, the benthic communities tend to consist of opportunistic taxa. Undisturbed shoals in close proximity to each of the proposed borrow sites (particularly Jay Bird Shoals, Bald Head Creek Shoal, and Frying Pan Shoals) will provide a source for recolonization of the dredged areas.

Given the predicted interval of dredging required for each of the four alternatives that include Village-sponsored beach nourishment and favorable conditions for benthic recruitment, it is expected that benthic communities of each of the proposed borrow sites will recover rather quickly.

2. Soft Bottom Effects at Nourishment Site

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. The fecundity and opportunistic nature of benthic invertebrates common to this area and project avoidance of peak periods of biological activity help facilitate post-dredging recovery.

(1) No Action/Status Quo: Alternative #1

a. Direct Impacts*:* The impacts to soft bottom communities as described below are associated with federal maintenance of the Wilmington Harbor Entrance Channels and associated disposal in accordance with the SMP. These effects have been assessed in the Wilmington Harbor Deepening Project FEIS (USACE 1996) and the subsequent EA for pre-construction modifications to the alignment of the entrance channel (USACE 2000).

Ongoing channel maintenance operations of the harbor disturb benthic populations in the existing deep water channel and nearby side slopes. Benthic infauna (e.g. polychaete worms, amphipods, and mollusks) are subject to adverse impacts associated with the removal of sand and entrainment of infaunal and non-motile epibenthic organisms during maintenance operations. Impacts to sessile, slow moving taxa that cannot escape the suction field of the dredge are anticipated.

Disposal of sand at the beach fill site will bury benthic infauna as existing soft bottom habitat is converted to dry beach and wet beach habitat. The fecundity and opportunistic nature of benthic invertebrates common to this area and project avoidance of peak periods of biological activity help facilitate post-dredging recovery.

b. Indirect Impacts: Finfish inhabiting the soft bottom, such as black sea bass and summer flounder, would temporarily exit the disturbed area upon commencement of dredging, and would return shortly after dredging operations cease. It is possible that a small number of these fish will become entrained in the dredging equipment. In addition, a number of

benthic prey species inhabiting the sediment surface layer will be smothered during sand placement. Intertidal and subtidal soft bottom serves as a nursery and feeding ground for a number of finfish species that prey upon these benthic invertebrates and, in turn, are preyed upon by shorebirds, waterbirds, diving birds and marine mammals.

The physical consequences resulting from Alternative #1 include continued shoreline recession of the western end of South Beach, the Point and West Beach. The erosional losses of dry beach habitat resulting from landward migration of the shoreline would ultimately lead to the creation of subtidal bottom. Benthic infauna would gradually colonize the expanded soft bottom habitat.

c. Cumulative Impacts: The inlet system of the Cape Fear River and it adjacent beaches is a dynamic environment prone to both anthropogenic and natural disturbances. The opportunistic nature of species inhabiting this environment allows for rapid recolonization following a high frequency of disturbance events. The anticipated disposal interval associated with the SMP should allow for sufficient time for repopulation and succession of the soft bottom habitat. In addition, the alternative would result in the increase of soft-bottom habitat as beach and dune habitats are lost to erosion (particularly in the area of the Point). As a result, there are no cumulative impacts expected as a result of the implementation of Alternative #1.

(2) Retreat: Alternative #2

a. Direct Impacts: Under Alternative #2 direct impacts resulting from dredge and disposal events associated with routine maintenance of the federal navigation channel per the SMP would be the same as those discussed under Alternative #1. The primary direct effect of dredge activities is the removal of sand and entrainment of infaunal and non-motile epibenthic organisms and subsequent burial of benthic infauna during placement of the dredge materials.

b. Indirect Impacts: Under Alternative #2, indirect impacts to intertidal and subtidal soft bottom habitat associated with disposal of dredged material pursuant to the SMP would be similar to those described in Alternative #1. In addition, the extent of predicted shoreline recession associated with the retreat alternative would result in widespread increases in soft bottom habitat as other intertidal and supratidal habitats are lost to open water. Increase of soft bottom area would expand habitat suitable for colonization by benthic meoifauna and macrofauna.

c. Cumulative Impacts: In consideration of past, present, and reasonably foreseeable future actions, implementation of Alternative #2 is not expected to generate cumulative impacts.

(3) Beach Nourishment with Maintenance of Groinfield (Alternative #3):

a. Direct Impacts: As described at the beginning of this section, there will be direct impacts to soft bottom communities at the borrow sites. 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. Impacts to sessile, slow moving taxa that cannot escape the suction field of the dredge are anticipated. Removal of sediments will result in reduced abundance, diversity, and biomass of the resident benthic community. Studies along the East, Gulf and West Coasts of the United States document 84% to 90% decrease in the number of benthic organisms post-dredge (ASFMC 2002). The benthic assemblages characteristic of accreting subtidal bottom of the Cape Fear region (including the prospective sand source sites) tend to be dominated by opportunistic species prone to natural and/or anthropogenic disturbance. While populations of these species have been documented to recover rather quickly, later successional species may not fully recover for two to three years (Wilber and Stern 1992).

b. Indirect Impacts: The lower Cape Fear River and associated sandy shoals serve as a conduit for passage of larval, juvenile, and adult fish species as well as organisms of lower trophic levels (e.g. phytoplankton and zooplankton) between the open ocean environment

and the estuarine environment. The increased frequency of nourishment required under Alternative #3 would result in more frequent disturbance at the nourishment site which, in turn, could influence the occurrence and distribution of species utilizing the beachfront for foraging.

Alternative #3 would result in similar physical conditions to those identified under the No Action Alternative with the exception of a shoreline loss that is periodically mitigated through a Village-sponsored nourishment action. As discussed previously, the loss of dry beach would lead to the addition of soft bottom habitat.

c. Cumulative Impacts: Village-sponsored nourishment efforts on Bald Head Island considered under Alternative #3 would result in direct and indirect impacts to soft bottom communities at the borrow sites. However, these impacts represent a relatively small area of disturbance (106 acres and 65 acres for Jay Bird Shoals and Bald Head Creek Shoal, respectively) relative to the overall area of soft bottom habitat in the vicinity of the mouth of the Cape Fear River. In addition, the benthic communities of depositional shoals tend to be adapted to disturbance and recolonize over a relatively short period of time. 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 avoid the potential for cumulative effects. As a result, the implementation of Alternative #3 is not expected to generate cumulative impacts to soft bottom communities.

(4) Beach Nourishment/Beach Disposal and Sand Tube Groinfield Removal (Alternative #4)

a. Direct Impacts: The types of impacts to soft bottom habitat at the dredge and nourishment sites under Alternative #4 would be comparable to those identified for Alternative #3 above.

b. Indirect Impacts: Under Alternative #4, indirect impacts to soft bottom habitat would be the same as those described in Alternative #3.

c. Cumulative Impacts: No cumulative impacts to soft bottom communities are expected as a result of the implementation of Alternative #4.

(5) Terminal Groin with Beach Nourishment (Groinfield Remaining) (Alternative #5)

a. Direct Impacts: Under Alternative #5, direct impacts associated with dredging, beach nourishment (including the placement of the sand fillet), and maintenance of the sand tube groinfield would be comparable to those discussed under Alternative #3. Additional impacts to the wet beach community will result from construction of the terminal groin structure. The terminal groin structure, as proposed, would have an overall length (combined Phase I and Phase II) of 1,900 linear ft with approximately 1,600 lf (stem and head sections) occupying the nearshore soft bottom. Given the proposed length of these sections, approximately 2.0 acres of soft bottom habitat would be covered by the structure. There will be permanent loss of benthic fauna incapable of horizontal movement in the immediate footprint of the terminal groin.

The proposed groin would be constructed of relatively large granite armor rock of varying size placed on a geotextile foundation mattress. Rock would be placed either by crane from a barge, from sand pads (shaped from sand from the federal disposal), and/or from a temporary trestle or pier constructed in close proximity to the groin structure. Phasing of the structure would reduce the need for the temporary trestle as much of the work could be accomplished with equipment operating from temporary sand pads. Depending upon the construction method, there is a potential for additional disturbance to soft bottom in the immediate vicinity of the groin.

b. Indirect Impacts: As previously discussed, intertidal and shallow subtidal soft bottom serve as a nursery and feeding ground for a number of finfish species that prey upon these benthic invertebrates and, in turn, are preyed upon by shorebirds, waterbirds, diving birds and marine mammals. Given the highly mobile nature of fish assemblages that typically

utilize the subtidal areas of the prospective borrow sites and the nourishment site, it is expected that demersal species would relocate to other unaffected soft bottom and nearshore habitats during the period of construction activities and subsequent benthic recovery period. Finfish would likely return to the project area to forage upon suspended nutrients and benthic infauna as well as to utilize the proposed groin structure for resting and refuge (Cenci et al. 2010).

Installation of a terminal groin structure; nourishment of the updrift field (i.e. placement of a corresponding fillet); and on-going maintenance of the existing sand tube groinfield would afford the highest level of stability and retention of sand. Creation of a stable beachfront and the addition of the sand fillet would result in a loss of soft bottom habitat within the immediate project area. By Year 9 of the Delft 3D simulation, approximately 10.5 acres of subtidal bottom would be converted to intertidal surf zone or dry beach.

c. Cumulative Impacts: Soft bottom habitat along the seaward end of the rock terminal groin footprint would be filled by the proposed groin structure while the remainder of the structure footprint would be covered with sand. 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. The extent of existing soft bottom habitat in conjunction with its resilience to disturbance (either natural or anthropogenic) reduces the risk of cumulative impacts. As a result, Alternative #5 is not anticipated to generate cumulative impacts to soft bottom communities.

(6) Terminal Groin with Beach Nourishment/ Removal of Sand Tube Groinfield (Alternative #6)

a. Direct Impacts: Under Alternative #6, direct impacts to soft bottom habitat associated with the dredge and disposal/nourishment site and construction of the terminal groin would be the same as those described in Alternative #5. Removal of the sand tube groinfield has

the potential to decrease the anticipated maximum life of the project thereby creating the need for more frequent beach nourishment. Temporal spacing between maintenance/nourishment activities should, however, allow for full recovery of the benthos prior to subsequent events. The footprint of the sand tubes to be removed (albeit small) will result in the immediate expansion of soft bottom habitat.

b. Indirect Impacts: Indirect impacts to soft bottom habitat under Alternative #6 would be comparable to impacts described in Alternative #5. Implementation of Alternative #6 would also have similar physical consequences to habitat types of the study area as those identified above for Alternative #5 (i.e. expansion of a more stable dry beach), ultimately resulting in a net loss of soft bottom habitat.

c. Cumulative Impacts: No cumulative impacts are expected as a result of the implementation of Alternative #6.

B. Hardbottom Communities

Ocean-bottom surveys conducted by the USACE in the vicinity of the new channel alignment for the Wilmington Harbor Navigation Project did not indicate the presence of hard bottoms within the path of the federal channel (USACE 2000). However, hard bottoms have been identified near the seaward limit of the former federal navigation channel (approximately five miles offshore). Other hard bottom points have been identified greater than three miles west of Jay Bird Shoals (Deaton et al. 2010).

Given the lack of observed hard bottom near the study area, it is anticipated that implementation of any of the alternatives considered in this DEIS would not have any direct, indirect, or cumulative impacts to hard bottom communities.

5.6 WATER COLUMN

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.

1. Water Column Effects at Borrow Sites:

Since four of the six alternatives include sand volume requirements beyond that supplied by federal disposal pursuant to the SMP, a summary of water column effects for the borrow sites is presented below.

As described in prior sections (including Section 5.2.4), sand volume requirements are variable between alternatives with Alternative #4 requiring the greatest volume of sand (estimated to be 8 Mcy) over the 30-year project life. Conversely, Alternative #5 would require the least volume (estimated to be 4.5 Mcy) over the 30-year period. The applicant's preferred source of sand for alternatives that include nourishment would be the remaining portion of the Jay Bird Shoals borrow site previously permitted for the Village-sponsored beach nourishment project constructed in the winter of 2009/2010. Other borrow 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).

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.

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 demonstrated to utilize beach-compatible sand since much of the source material is derived from the adjacent beaches. 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).

(1) No Action/Status Quo (Alternative #1)

a. Direct Impacts: 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, development of the upland watershed and storm events lead to perturbations of the water column. Since its inception, the SMP has resulted in disposal of beach compatible sand on Bald Head Island and Oak Island.

Localized turbidity impacts will result during the placement of sand associated with federal disposal. However, these actions will be limited both temporally and spatially and are minimized by the use of material derived from the existing littoral system of the region. Fine-grained sediment content has been demonstrated to be below 10%. This material is compatible with the recipient beach since the adjacent beaches are the source of the sediment within these channel reaches (USACE 2000). Turbidity levels tend to decrease rapidly subsequent to dredging and disposal through simple mixing and dilution processes (associated with longshore and tidal currents, wind and surf).

Implementation of other components of this alternative, such as beach bulldozing and temporary sand bags, is not expected to result in any direct effects to the water column since these activities are conducted above the MHW line of the beachfront.

b. Indirect Impacts: While increased turbidity levels have the potential to influence fish behavior (including foraging) and distribution patterns, the extent of the effect will be localized and short-term.

c. Cumulative Impacts: 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. 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 expected as a result of the implementation of Alternative #1.

(2) Retreat (Alternative #2)

a. Direct and Indirect Impacts: Under Alternative #2, impacts to the water column associated with the dredging of the Wilmington Harbor channel and resulting beach disposal would be the same as those described in Alternative #1. The Village would additionally identify high-risk areas for the development and implementation of a managed shoreline retreat and provide for the demolition or relocation of residences, roads, and infrastructure, if land and funds are available, in advance of the shoreline recession. Thresholds would be identified to trigger the demolition or relocation of specific structures such that removal of anthropogenic debris (concrete, rubble, asphalt, steel, etc.) would be completed, primarily, above MHW thereby limiting potential impacts to the water column.

Due to the extent of predicted shoreline recession, the demolition and relocation of residences and infrastructure (including roads and sub-grade utilities) would be required. If the relocation efforts do not keep pace with erosion, then there is a potential for structural damage to homes and infrastructure with ensuing exposure of material debris, septic tanks, and sewer lines to open water. While the alternative assumes relocation, the predicted rate and extent of erosion would make these areas vulnerable to damage particularly during storm events and would increase the risk of impairments to the water column.

b. Cumulative Impacts: No cumulative impacts are expected as a result of Alternative #2.

(3) Beach Nourishment with Maintenance of Groinfield (Alternative #3):

a. Direct and Indirect Impacts: Impacts to the water column associated with federal maintenance dredging and Village-sponsored dredging of prospective sand source sites and subsequent nourishment of the beachfront are described above.

Prior to use of any sand source site by the Village, minimum state sediment compatibility standards must be met. Jay Bird Shoals, Bald Head Creek Shoals, and the entrance channel

reaches of the Wilmington Harbor Project have all been demonstrated to contain beach compatible sand (as evidenced through both geotechnical investigations and through beach placement and post-nourishment conditions on the beach). In addition, based on compatibility analysis criteria for percent silt content, percent shell content, and mean grain size, sediments sampled within Frying Pan Shoals have been demonstrated to be largely compatible with the native beach material (Catlin 2010).

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).

b. Cumulative Impacts: Implementation of Alternative #3 is not expected to result in any cumulative impacts to the water column.

(4) Beach Nourishment/Beach Disposal and Sand Tube Groinfield Removal (Alternative #4)

a. Direct and Indirect Impacts: Due to the removal of the sand tube groinfield and subsequent increased erosion of western South Beach, Alternative #4 would require greater volumes and frequency of dredge and nourishment actions by the Village. While the type of direct and indirect impacts to the water column would be similar to those discussed above, the frequency of occurrence of these effects would be greater under this alternative.

As described for Alternative #2, the predicted rate and extent of erosion would make residences and infrastructure vulnerable to damage from inundation and conversion to open water. While not specifically evaluated under a managed retreat, it is likely that the Village would implement a program to relocate structures, roads, and sub-grade utilities in advance of the erosion to minimize public safety concerns. However, under this alternative there is increased risk of exposure of structures (including septic tanks and sewer lines) and debris to the water column. The result would be the potential for localized water quality impairments and associated effects on resident and migratory fauna.

b. Cumulative Impacts: Given the capacity for the water column resource to accommodate localized stressors, no cumulative impacts are expected as a result of the implementation of Alternative #4.

(5) Terminal Groin with Beach Nourishment (Groinfield Remaining) (Alternative #5)

a. Direct Impacts: Impacts to the water column within and in the vicinity of the dredge and nourishment sites for Alternative #5 would result in similar localized effects as those described for Alternative #3.

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). It has been suggested that the presence of jetties may result in the deflection of larvae to an extent that would eliminate the opportunity for the larvae to be entrained into the estuary. 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 M. 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.

b. Indirect Impacts: 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).

c. Cumulative Impacts: Given the temporal and localized effects on the water column and the capacity for this habitat to accommodate these effects, cumulative impacts are not expected.

(6) Terminal Groin with Beach Nourishment/ Removal of Sand Tube Groinfield (Alternative #6)

a. Direct and Indirect Impacts: Direct and indirect impacts resulting from Alternative #6 would be comparable to those identified for Alternative #5.

b. Cumulative Impacts: No cumulative impacts are expected as a result of the implementation of Alternative #6.

5.7 WATER QUALITY

(1) No Action/Status Quo (Alternative #1)

a. Direct Impacts: 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. In accordance with the SMP, beach-compatible dredged material (sands) dredged from the ocean bar or river channel is 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).

b. Indirect Impacts: 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.

c. Cumulative Impacts: Disturbance activities associated with maintenance of the Wilmington Harbor navigation 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 resource impacts from Alternative #1 in combination with other regional navigation projects and water dependent development activities would be negligible.

(2) Retreat (Alternative #2)

a. Direct Impacts: The frequency of dredge disposal events under Alternative #2 are dependent upon funding and other considerations, but would be anticipated to occur generally as described in the SMP. The types of direct impacts to water quality associated with dredge disposal would be similar to those discussed under Alternative #1.

Under the Retreat Alternative, the Village would identify high-risk areas for the development and implementation of a managed shoreline retreat and provide for the demolition or relocation of residences, roads, and infrastructure, if land and funds are available, in advance of the shoreline recession. Thresholds would be identified to trigger the demolition or relocation of specific structures such that anthropogenic debris (concrete, rubble, asphalt, steel, etc.) and infrastructure (sanitary sewer) would not lead to degradation of water quality.

b. Indirect Impacts: Due to the extent of predicted shoreline recession, the demolition and relocation of residences and infrastructure (including roads and sub-grade utilities) would be required. If the relocation efforts do not keep pace with erosion, then there is a potential for structural damage to homes and infrastructure with ensuing exposure of material debris, septic tanks, and sewer lines to open water. While the alternative assumes relocation, the predicted rate and extent of erosion would make these areas vulnerable to damage particularly during storm events and would increase the risk of water quality impairments.

Alternative #2 is predicted to result in the loss of interdunal wetlands regulated under Section 404 of the Clean Water Act (CWA). Given the water quality functions (e.g. sediment retention and nutrient/contaminant uptake and transformation) ascribed to wetlands, some

level of impairment could potentially result from the loss of these habitats. However, as the shoreline recedes, it can be expected that other low-lying areas of the back-barrier dune system would be able to provide similar functions. As a result, any adverse effect resulting from wetland losses would be relatively minor.

c. Cumulative Impacts: No cumulative impacts to water quality are expected as a result of the implementation of Alternative #2.

(3) Beach Nourishment with Maintenance of Groinfield (Alternative #3):

a. Direct Impacts and Indirect Effects: Under Alternative #3, impacts to water quality would be comparable to Alternative #1 during dredging and sand placement activities. While this alternative includes periodic nourishment by the Village, water quality impairment of both the dredge site and the nourishment site would be localized and short-term.

b. Cumulative Impacts: No cumulative impacts are expected as a result of the implementation of Alternative #3.

(4) Beach Nourishment/Beach Disposal and Sand Tube Groinfield Removal (Alternative #4)

a. Direct Impacts: Under Alternative #4, water quality impacts would be comparable to Alternative #1 and Alternative #3 during dredging and sand placement activities. Given the increased need for beach nourishment events required under this alternative, there is an increased risk of water quality impairments. However, these effects would be localized and short-term as physical mixing and dilution would minimize the extent of turbidity and suspended sediment concentrations.

b. Indirect Impacts: As described for Alternative #2, the predicted rate and extent of erosion would make residences and infrastructure along western South Beach vulnerable to damage from inundation and conversion to open water. While not specifically evaluated under a managed retreat, it is likely that the Village would implement a program to relocate

structures, roads, and sub-grade utilities in advance of the erosion to minimize public safety concerns. However, under this alternative there is increased risk of exposure of structures (including septic tanks and sewer lines) and debris to the water column. The result would be the potential for localized water quality impairments and associated effects on resident and migratory fauna.

c. Cumulative Impacts: Given the capacity for nearshore waters to accommodate the type of stressors outlined above, no cumulative impacts to water quality are anticipated.

(5) Terminal Groin with Beach Nourishment (Groinfield Remaining) (Alternative #5)

a. Direct Impacts: Under Alternative #5, impacts to water quality would be comparable to Alternative #1 during dredging and sand placement activities. The construction of the terminal groin is proposed to take place concurrent with, and subsequent to, beach fill disposal. Placement of the armor stone would be accomplished via barge and crane or via land-based equipment operating on sand fill pads. Depending upon conditions at the time of construction, the use of a temporary pier structure constructed parallel to the terminal groin may be necessary. This is a piling-supported trestle utilizing steel pilings jetted into the substrate and removed once construction is complete. Localized, temporary impacts to the water quality would be expected through increased turbidity during construction, but these effects would dissipate rapidly and are considered relatively minor.

b. Indirect Impacts: Indirect impacts under Alternative #5 would be similar to impacts associated with Alternative #1 and Alternative #3.

c. Cumulative Impacts: No cumulative impacts to water quality are expected as a result of the implementation of Alternative #5.

(6) Terminal Groin with Beach Nourishment/ Removal of Sand Tube Groinfield (Alternative #6)

a. Direct Impacts: Under Alternative #6, water quality impacts would be comparable to Alternative #5 during dredging, sand placement activities and groin construction. Given the increased frequency of beach nourishment events under this alternative there is a greater potential for impacts to water quality. However, turbidity effects would be localized and relatively short-lived.

b. Indirect Impacts: Indirect impacts under Alternative #6 would be similar to impacts associated with Alternative #1, Alternative #3, and Alternative #5.

c. Cumulative Impacts: No cumulative impacts to water quality are expected for this alternative.

5.8 AIR QUALITY

(1) No Action/Status Quo (Alternative #1)

a. Direct and Indirect Impacts: Impacts to air quality associated with this alternative are present only during periods when heavy machinery is in use for maintenance of the federal channel, dredge disposal and sand tube groinfield maintenance. During channel maintenance and dredge disposal, diesel emissions would be generated from the barge during transit, dredging, pumping of sand to the beach and placement of fill material. Beach fill activities will require the use of a bulldozer for sand placement and additional heavy equipment would be utilized as necessary during maintenance of the sand tube groinfield. While there will be temporary and localized increases in pollutants to the ambient air during active construction, the concentration of emissions coupled with the short period of time (months) is not anticipated to affect compliance with the National Ambient Air Quality Standards (NAAQS).

b. Cumulative Impacts: Construction related activities associated with the SMP and soft stabilization methods on Bald Head Island (i.e. sand bags, beach scraping, maintenance of sand tube groinfield) are unlikely to lead to a violation of NAAQS. Cumulative emissions resulting from the SMP, soft stabilization on the island, and regional navigation and nourishment projects will be minimal and short-term and are not anticipated to appreciably affect local or regional air quality.

(2) Retreat (Alternative #2)

a. Direct and Indirect Impacts: Impacts associated with Alternative #2 would be similar to Alternative #1. In addition, implementation of a managed retreat would result in demolition of threatened structures and infrastructure. Diesel emissions would be generated from the use of demolition equipment (bulldozer, bobcat, etc.) as well haul-off equipment (dump truck, light truck, etc.). The demolition and haul-off process could also generate particulates such as dust. However, the posted speed limits throughout the VBHI would keep construction-related machinery at slow speeds thereby reducing the level of incident particulates during haul-off. The concentration of emissions associated with demolition and haul-off is not anticipated to affect compliance with the NAAQS.

b. Cumulative Impacts: No cumulative impacts to air quality are expected as a result of the implementation of Alternative #2.

(3) Beach Nourishment with Maintenance of Groinfield (Alternative #3):

a. Direct and Indirect Impacts: Impacts associated with Alternative #3 would be similar to similar to those identified for Alternative #1 and Alternative #2 above.

b. Cumulative Impacts: No cumulative impacts are expected as a result of the implementation of Alternative #3.

(4) Beach Nourishment/Beach Disposal and Sand Tube Groinfield Removal (Alternative #4)

a. Direct and Indirect Impacts: Impacts associated with Alternative #4 would be similar to Alternatives #1 through #3 above.

b. Cumulative Impacts: Implementation of Alternative #4 will not result in cumulative impacts to air quality.

(5) Terminal Groin with Beach Nourishment (Groinfield Remaining) (Alternative #5)

a. Direct and Indirect Impacts: Air quality impacts associated with Alternative #5 would be comparable to each of the alternatives discussed above.

b. Cumulative Impacts: Cumulative impacts to air quality are not expected as a result of the implementation of Alternative #5.

(6) Terminal Groin with Beach Nourishment/ Removal of Sand Tube Groinfield (Alternative #6)

a. Direct and Indirect Impacts: Air quality impacts associated with Alternative #6 would be comparable to those of all the other alternatives.

b. Cumulative Impacts: No cumulative effects to air quality are expected under Alternative #6.

5.9 PUBLIC SAFETY

(1) No Action/Status Quo (Alternative #1)

a. Direct, Indirect and Cumulative Impacts: Dredges, barges and associated marine craft would be on-site for several months during the maintenance of the Wilmington Harbor navigation channel and associated beach disposal. Placement of dredge materials would result in the use of dredge pipeline, bulldozers and associated vehicles. Recreational and

commercial boaters would need to use caution and maintain no wake speeds to assure safe passage while in the project work area. Use of heavy machinery during placement and grading of disposal materials would increase the potential for safety issues to beach pedestrians. It is likely that recreational access to the beach would be restricted within the active construction area. It should be noted that federal channel maintenance and other short-term stabilization measures are likely to occur during periods of the year when tourism and recreation in general is low thereby reducing the potential for impacts to public safety. No cumulative impacts are anticipated.

(2) Retreat (Alternative #2)

a. Direct, Indirect and Cumulative Impacts: Public safety concerns associated with the use of heavy machinery during dredging, placement of disposal materials and removal of the sand tube groinfield under Alternative #2 would be the same as those discussed under Alternative #1. There are additional public safety issues associated with heavy machinery use during relocation and/or demolition of residences and infrastructure and exposure of utilities including sanitary services and public water supply.

South Bald Head Wynd has been identified as a primary evacuation route for residents and guests of Bald Head Island. Unimpeded shoreline recession would compromise the integrity of existing roads and ultimately lead to demolition of a number of roadways, including South Bald Head Wynd. Removal of a primary evacuation route would increase the potential for public safety concerns as alternate roads could be overloaded and reduce evacuation efficiency during emergent situations. The Retreat Alternative would likely necessitate acquisition of replacement right-of-ways to preserve adequate emergency evacuation routes for Island residents and visitors.

(3) Beach Nourishment with Maintenance of Groinfield (Alternative #3):

a. Direct, Indirect and Cumulative Impacts: Impacts associated with Alternative #3 would be comparable to those for Alternative #1. No cumulative impacts are expected.

(4) Beach Nourishment/Beach Disposal and Sand Tube Groinfield Removal (Alternative #4)

a. Direct, Indirect and Cumulative Impacts: Impacts associated with Alternative #4 would be comparable to those for Alternative #2. The predicted extent of erosion along South Bald Head Wynd would present similar public safety concerns as the structural integrity of roads and sub-grade utilities would become compromised. In the absence of adequate planning and relocation efforts, the loss or exposure of these structures to open water would present a public safety and health hazard.

(5) Terminal Groin with Beach Nourishment (Groinfield Remaining) (Alternative #5)

a. Direct, Indirect and Cumulative Impacts: Impacts associated with Alternative #5 would be comparable to those identified above. Prior to initiation or construction of the terminal groin, the USACE to would coordinate with the US Coast Guard to assure that the new structure is placed on the appropriate maps and is equipped with appropriate navigation aids, as needed (NCDCM 2010).

(6) Terminal Groin with Beach Nourishment/ Removal of Sand Tube Groinfield (Alternative #6)

a. Direct, Indirect and Cumulative Impacts: Impacts associated with Alternative #6 would be comparable to those identified above.

5.10 AESTHETIC RESOURCES

(1) No Action/Status Quo (Alternative #1)

a. Direct, Indirect and Cumulative Impacts: The presence of construction equipment and personnel during disposal of material on the beach would temporarily detract from the aesthetics of the beach. Dredges, barges and associated marine craft would be on-site for several months during maintenance of the federal channel. Placement of dredge materials would result in the use of dredge pipeline, bulldozers and associated vehicles. The use of

water-dependent and land based heavy machinery would result in additional noise in the project area and would detract from the normal aesthetics of the beach. Federal channel maintenance is likely to occur during periods of the year when tourism and recreation in general is low. Upon completion of construction activities, increased beach area and restoration of the natural shoreline would result in an overall improved aesthetic quality.

(2) Retreat (Alternative #2)

a. Direct, Indirect and Cumulative Impacts: Impacts associated with dredge disposal activities under Alternative #2 would be comparable to those described for Alternative #1. There is also the potential for aesthetic depreciation associated with unabated beach erosion under Alternative #2. Reduced beach widths with steep, nearly vertical profiles may be considered an aesthetic detriment by some users. A retreat scenario would include the removal of the existing sand tube groinfield and the planned abandonment or relocation of infrastructure and residences. The presence of heavy machinery and personnel during relocation and/or demolition of residences and infrastructure would detract from the aesthetics of the area. In addition, erosion would be of a magnitude that will likely require the relocation of the Bald Head Island Clubhouse and some of the associated amenities. As the shoreline receded to a maximum extent, some level of equilibrium would be expected such that any adverse aesthetic effects would not be permanent.

(3) Beach Nourishment with Maintenance of Groinfield (Alternative #3):

a. Direct, Indirect and Cumulative Impacts: Impacts associated with Alternative #3 would be comparable to those identified under Alternative #1.

(4) Beach Nourishment/Beach Disposal and Sand Tube Groinfield Removal (Alternative #4)

b. Direct, Indirect and Cumulative Impacts: Impacts associated with Alternative #4 would be comparable to those identified above. In the absence of a planned demolition and relocation effort, the extent of erosion would compromise the structural integrity of roads and expose sub-grade utilities along western South Beach. Exposure of any infrastructure

due to erosion of the shoreline would diminish the aesthetic appeal of the beach. However, removal of the sand tubes would help to increase beach aesthetics.

(5) Terminal Groin with Beach Nourishment (Groinfield Remaining) (Alternative #5)

a. Direct, Indirect and Cumulative Impacts: Impacts associated dredge disposal and beach nourishment under Alternative #5 would be comparable to those identified above. Construction of the terminal groin could lead to reduced aesthetic appeal for property owners due to loss of unimpeded view corridor from shoreward- and waterward-facing perspectives. Properties with views of the associated area may have reduced amenity value relative to that which would exist with a natural shoreline as man-made features contrast with the natural features of the island. To the extent that the structure serves to attract recreationists, property owners in the vicinity may experience crowding and reduced aesthetic appeal. The terminal groin may also have an adverse effect of trapping floating debris and trash thereby creating an unwanted view.

(6) Terminal Groin with Beach Nourishment/ Removal of Sand Tube Groinfield (Alternative #6)

a. Direct, Indirect and Cumulative Impacts: Impacts associated with Alternative #6 would be comparable to those identified for Alternative #5.

5.11 RECREATIONAL RESOURCES

(1) No Action/Status Quo (Alternative #1)

a. Direct, Indirect and Cumulative Impacts: During dredge disposal, portions of the Bald Head Island beachfront will become an active construction area unavailable for daily recreational uses. Individuals seeking recreational opportunities along the beachfront will have to utilize unimpacted areas, principally eastern South Beach and East Beach which offers comparable beachfront. Daily recreational activities are expected to continue upon completion of dredge disposal and construction. In addition, federal channel maintenance

will take place during periods of the year when tourism and recreation in general is low. Immediately following dredge disposal, recreation is likely to be enhanced for a period of time as a larger, more stable beachfront will be established.

The lower Cape Fear River and nearshore waters of the Atlantic Ocean are popular recreational fishing areas. While active dredging is underway, recreational vessels would avoid the immediate area of excavation as well as the pipeline or barge receiving excavated materials. Weather permitting, the dredge will remain moored in the river until project completion. The vast expanse of waters in the lower Cape Fear River and Atlantic Ocean will remain unaffected during project implementation.

Delft3D modeling predicts deflation and recession of the shoreline along western South Beach and the Point resulting in less dry beach area. The loss of 22 acres of dry beach would reduce recreational opportunities of this public resource.

(2) Retreat (Alternative #2)

a. Direct, Indirect and Cumulative Impacts: Delft3D model predictions indicate that continued sand placement per the SMP will not be sufficient to prevent high rates of erosion and resultant shoreline recession. While construction-related impacts associated with federal channel maintenance (Alternative #1) would be comparable under this alternative, the loss of beachfront would also reduce recreational use of this public resource. In addition, the predicted extent of erosion would impact recreational uses of the Bald Head Island Club. In particular, tennis courts, swimming pools, and portions of the golf course would be loss to erosion. During the period of relocation, Club services would likely be interrupted or diminished in some capacity.

(3) Beach Nourishment with Maintenance of Groinfield (Alternative #3):

a. Direct, Indirect and Cumulative Impacts: Under Alternative #3, impacts to land-based and water-dependent recreation would be comparable to those discussed under Alternative #1.

The predicted physical effects of this alternative would also result in an unstable beachfront condition over the nine-year model period which would adversely affect beachfront recreation.

(4) Beach Nourishment/Beach Disposal and Sand Tube Groinfield Removal (Alternative #4)

a. Direct, Indirect and Cumulative Impacts: Under Alternative #4, impacts to land-based and water-dependent recreation would be comparable to those identified for Alternative #1 and Alternative #3 above.

(5) Terminal Groin with Beach Nourishment (Groinfield Remaining) (Alternative #5)

a. Direct, Indirect and Cumulative Impacts: Under Alternative #5, impacts to land-based and water-dependent recreation associated with dredge disposal and terminal groin construction would be comparable to Alternative #1, #3, and #4 above. Short-term adverse effects may include limiting or blocking access to the beachfront during project construction and subsequent nourishment and maintenance actions (NCDENR DCM 2010). Rock structures, such as terminal groins, jetties, etc. can provide ideal habitat for crustaceans and small fish which are commonly utilized as bait for recreational and commercial fishermen. The creation of hard structure in an area that is presently devoid of such habitat has the potential to enhance fishing opportunities around the terminal groin. Coupled with periodic nourishment, the terminal groin would likely expand beachfront suitable for a number of recreational uses.

(6) Terminal Groin with Beach Nourishment/ Removal of Sand Tube Groinfield (Alternative #6)

a. Direct, Indirect and Cumulative Impacts: Under Alternative #6, impacts to land-based and water-dependent recreation would be comparable to those discussed under Alternative #5.

5.12 NAVIGATION

5.12.1 Background

The Wilmington Harbor Navigation Project is authorized at a current design depth of -42 ft (MLLW) with two additional feet across the ocean bar. It extends from the Atlantic Ocean 38 miles up the Cape Fear River to the Port of Wilmington and beyond. Continuous maintenance of the harbor by the federal government began in 1870 and harbor dimensions have increased incrementally for over 100 years. Today, the Port of Wilmington is a major contributor to the economies of Brunswick and New Hanover Counties, moving some $6.4B in goods in 2010.

As expected, the navigation channel likewise serves local recreational and commercial fishing interests as well as small vessel traffic entering and exiting the Atlantic Intracoastal Waterway which passes through the lower reach of the Cape Fear River near the town of Southport.

The following analyses identify if any of the six (6) alternatives under consideration would adversely affect navigation of the Wilmington Harbor federal channel. Specifically, potential consequences to navigability resulting from major changes in currents, waves or shoaling from any of the alternatives are evaluated.

5.12.2 Waves

Of the six alternatives under consideration, only the two structural alternatives (which propose a barrier which could affect incident wave energy at/or near the western extremity of South Beach) would be capable of modifying wave climatology within the navigation channel. In that instance however, wave energy was actually reduced, thereby eliminating the potential for adverse impacts to vessels.

The predicted effects of each of the six alternatives considered are below:

- Alternative 1 – This alternative does not include the provision of a structure extending beyond the existing shoreline. Hence it will have no effect on localized wave climatology.
- Alternative 2 – Identical to Alternative No. 1.
- Alternative 3 – Identical to Alternative No. 1.
- Alternative 4 – Identical to Alternative No. 1.
- Alternative 5 – This alternative proposes the construction of a terminal structure which could potentially serve to modify wave energy along the abutting navigation project centerline. In that regard, the alternative is predicted to result in a small net reduction in local wave height to the west of the structure. This should be considered as net beneficial to navigation interests.
- Alternative 6 – Identical to Alternative No. 5.

5.12.3 Currents

Commercial vessels entering or exiting the Cape Fear River Entrance Channel are often faced with cross-currents and/or difficult turns associated with a varying channel alignment at, or immediately northward of Bald Head Island. Hence, the potential effect of any alternative on current speed or direction is of interest with respect to commercial vessel traffic passing Bald Head Island.

As quantified in Section 5.19, the only alternatives which could potentially alter current magnitude or direction are those which would construct an impediment to the existing flow regimen. That is to say, any such alternative would include placement of a structure extending into the present day inlet flow field, or any flow field serving the inlet's margins – such as the nearshore area seaward of Bald Head Island's westernmost segment of South Beach. Such is the case for Alternatives 5 and 6 which propose the installation of a terminal groin extending seaward of the existing shoreline. Any such groin would require sand fill which likewise artificially extends the shoreline seaward.

Figure 5.25 predicts that the construction of a terminal groin results in a modest decrease in *peak* ebb tidal velocities immediately offshore of a terminal structure's seaward end. No changes of consequence are noted within the navigation channel, per se.

Conversely, computer modeling of changes in *peak* flood tidal velocities and magnitudes under the "with terminal groin" conditions are somewhat greater than ebb effects. This is predominately due to (a) the reclamation of the shoreline updrift and eastward of a terminal groin, and (b) the physical reduction or modification of flood tidal flows by the structure's seaward tip. As shown by Figure 5.26, peak velocity increases, or decreases within the limits of the navigation channel are predicted to be .1m/sec., or less. Such an increase in *peak* velocity would result in minimal effects.

The predicted effects on hydrodynamics of each of the six alternatives considered, are as follows:

- Alternative 1 – This alternative does not include the provision of a structure extending beyond the existing shoreline. Hence, it will have no effect on inlet hydrodynamics.
- Alternative 2 – Identical to Alternative No. 1.
- Alternative 3 – Identical to Alternative No. 1.
- Alternative 4 – Identical to Alternative No. 1.
- Alternative 5 – This alternative proposes the construction of a physical impediment to the existing flow field bordering the inlet. As a result both ebb and flood current regimens are slightly modified. A comparison of before and after conditions for each tidal condition (peak ebb or peak flood) are presented by Figure 5.27. No changes to peak ebb tidal velocities are predicted within the navigation channel. Only minor changes in peak flood tidal velocities are computed, i.e. .1m/sec or less – within the navigation channel westward of the Point. As a result, no significant adverse

consequences to navigational interests are predicted to occur subsequent to alternative implementation.

- Alternative 6 – Identical to Alternative No. 5.

5.12.4 Shoaling

Shoaling within the innermost three segments of the Ocean Entrance channel of the Wilmington Harbor navigation project typically averages about 1 Mcy, mol. every two (2) years. Beach quality sand excavated from these three reaches is subject to beach disposal in accordance with the Wilmington Harbor Sand Management Plan. Although the preferred maintenance interval is biennial, dredging to restore the authorized navigable depths within the channel at this location has occurred closer to every three years on average since harbor deepening and realignment in 2000. The most recent channel maintenance occurred early in 2013 with the removal of over 1.617 Mcy of sediment from channel segments Bald Head Reaches 1 & 2 and the Smith Island Channel. Prior to the 2013 contract, the prior maintenance operation had occurred in 2009 – 4 years earlier. A small scale dredging of a portion of Bald Head Reach 2 was necessary in 2012 to ensure reliable commercial vessel passage at that location. The need for maintenance dredging in 2013 (at year 4) was approaching critical. Accordingly, as predictions regarding Congressional appropriations are difficult to make, we have elected to model the next nine years based upon the average disposal amounts and frequencies experienced over the past decade.

The predicted average annual volume of sand shoaling the federal navigation channel was quantified for each alternative over a 9-year modeling simulation. The residual shoreline locations for each alternative modeled over the subject 9-year period were previously presented by Figure 5.1. In all alternatives, channel shoaling is predicted to derive from sand moving off Bald Head Island, encroachment of the Point in some alternatives, as well as continued deflation of the ebb tidal platform seaward of Bald Head Island, known as Bald Head Shoals. Because the DEFLT 3D model is incapable of simulating avalanching side slopes of sediment within the channel cross section, it is not possible to predict the final destination

or particular morphological shape of channel shoals. Predicted channel shoaling patterns in each alternative reflect steep-banked, large-scale shoal features within the channel. In reality slope avalanching would likely cause shoaling to extend further west and be even more diffuse than what is indicated by the results. Even considering these inherent limitations of the model, there is no indication that any analyzed alternative produces a "pinch" point, or area of concentrated shoaling, within the channel. The model results indicate no significant change in the post-terminal groin distribution of shoaling material between dredge cuts. That is the distribution of material entering Baldhead Shoal Channel 1 and 2 remains relatively constant between simulations containing fill stabilization (i.e., Alt 3 vs. Alt 5). It should be noted that portions of the existing navigation channel have depths well exceeding the project design depth. Hence, any shoaling predicted to occur in those areas – associated with a specific alternative under consideration – may not result in the requirement for maintenance dredging.

Figure 5.28 plots the predicted cumulative shoaling volume within the limits of Bald Head Shoal 1 and 2 channel reaches. *Relative* comparison of the results suggests that channel shoaling is predicted to be lowest under Alternative 5 (terminal groin, existing tube groins, and beach fill). That is, the terminal groin with the existing tube groins is not expected to negatively alter the shoaling rates within the federal channel – over today's conditions. The model predicts that under Alternative 5, the channel adjustment to Bald Head Island will shoal with about 3.33 Mcy over 9 years. Conversely, Alternative 4, fill at years 0, 3 and 6 but the sand tube groinfield removed results in the highest rate of shoaling over the period of simulation. It should be noted that Alternative No. 3 as well as Alternative No. 6, rank closely and only slightly greater in magnitude than Alternatives 1 and 5.

For purposes of depicting *relative* merit, Figure 5.29 plots the percent change in shoaling within Baldhead Shoal Channels 1 and 2 relative to Alternative 5, the option with the lowest predicted value. From this depiction, the ranking of each alternative can be more easily derived. If one considers Alternative 3 to be the status quo over the last decade, then

judgments can be made regarding whether the other alternatives result in a net improvement – or a net impact over "existing conditions." Note that for modeling purposes, volume was directly placed into the fillet initially and at every disposal event until reaching a maximum berm elevation. Upon reaching a maximum berm elevation, remaining volume was then distributed evenly throughout the rest of the fill limits.

In summary, the predicted affects of each alternative on shoaling within the navigation channel closest to Bald Head Island (i.e. Bald Head Reaches 1 & 2) are as follows:

- Alternative 5 is predicted to result in the lowest rate of annual shoaling over a nine-year period of analysis.
- Alternative 1 is predicted to result in a modest increase (0.5%) in the rate of shoaling relative to Alternative 5.
- Alternative 3 is predicted to result in a 4.5% increase in the rate of shoaling relative to Alternative 5.
- Alternative 6 is predicted to have a 4.8% increase in the rate of shoaling relative to Alternative 5.
- Alternative 2 is predicted to have a 20% increase in the rate of shoaling relative to Alternative 5.
- Alternative 4 is predicted to have a 28% increase in the rate of shoaling relative to Alternative 5.

5.13 HISTORIC PROPERTIES AND CULTURAL RESOURCES

(1) No Action/Status Quo (Alternative #1)

a. Direct and Indirect Impacts: The USACE Wilmington District investigated the Wilmington Harbor entrance channel and the Ocean Dredged Material Disposal Site (ODMDS) for potential cultural resources as part of the February 2000 Environmental Assessment of modifications to entrance channel and placement of dredged sand (USACE 2000). This effort

was completed in cooperation with the NC Division of Archives and History through the Underwater Archaeology Unit (UAU) and the State Historic Preservation Officer (SHPO). Remote sensing analysis performed during the investigation identified 113 magnetic and/or acoustic anomalies of which 35 were considered for potential association with a significant cultural resource. A diver survey of these anomalies confirmed one target as a shipwreck located on Jay Bird Shoal. The UAU has also investigated an additional shipwreck site, the Fort Caswell Steamer, located near Southport. Both of the identified shipwrecks are beyond the limits of the harbor channel. As such, it was determined during agency review of the Environmental Assessment there would be no direct impacts to existing historic properties and/or cultural resources.

b. Cumulative Impacts: In conjunction with other past, present, or reasonably foreseeable future actions, there are no other cumulative impacts to historic properties and/or cultural resources resulting from Alternative #1.

(2) Retreat (Alternative #2)

a. Direct and Indirect Impacts: Given the lack of identified cultural resources within the footprint of the federal navigation channel it is anticipated that dredging and beach disposal activities associated with the maintenance of the Wilmington Harbor Channel will not adversely affect historic properties or cultural resources.

b. Cumulative Impacts: In conjunction with other past, present, or reasonably foreseeable future actions, there are no anticipated cumulative impacts to historic properties and/or cultural resources resulting from Alternative #2.

(3) Beach Nourishment with Maintenance of Groinfield (Alternative #3)

a. Direct and Indirect Impacts: It has been previously established that there are no direct impacts to cultural resources resulting from maintenance of the federal channel (USACE 2000). Three potential sand source sites have been evaluated in the event that the

Wilmington Harbor Entrance Channel is unavailable at the time of an independently-sponsored nourishment action. Potential source sites include; (1) Jay Bird Shoals; (2) Bald Head Creek Shoal; and (3) Frying Pan Shoals.

The VBHI contracted with Tidewater Atlantic Research, Inc. (TAR) to perform an archaeological survey and assessment of the Jay Bird Shoal borrow area as part of the Environmental Assessment for the 2009 beach nourishment event on Bald Head Island. TAR conducted magnetometer and side-scan surveys of the proposed borrow area within Jay Bird Shoal. Analysis of this data indicated a total of 49 magnetic anomalies. None of these anomalies had an associated acoustic signature. All but seven of these targets appear to have been generated by modern debris such as fish and crab traps, pipes, cable, chain, small boat anchors, etc. The remaining seven targets were investigated via diver reconnaissance. Five of these anomalies were associated with modern debris as well. The remaining two anomalies could not be located or identified by probing depths of up to 15 ft below the bottom surface. The signatures of these anomalies however were consistent with potential shipwreck material, and therefore, were avoided during excavation of the borrow site in 2009. There is the potential for direct impacts to the two aforementioned anomalies in the event that Jay Bird Shoal is utilized as a sand source for future beach nourishment efforts of the Island. However, it is anticipated that consultation with the UAU and SHPO would be required prior to excavation of Jay Bird Shoal such that there would be no impact to historical properties or cultural resources.

An archaeological survey of the Bald Head Creek Shoal borrow area was also performed by TAR as part of the Environmental Assessment (LMG 2010) for the January 2012 beach nourishment project. Background research gathered from the NC State Historic and Preservation Office (SHPO) indicated that there are no known resources listed or eligible for listing in the National Register of Historic Places in the vicinity of the Bald Head Creel borrow site. Analysis of remote-sensing data collected by TAR in the area identified 17 magnetic anomalies. A cluster of four magnetic anomalies and an associated acoustic signature were

created by a modern reinforced concrete range platform. Signatures of the remaining targets appear to have been generated by modern debris such as fish and crab traps, pipes, small diameter rods, cable, wire rope, chain, rebar or small boat anchors. No potentially significant anomalies were identified in the survey area (TAR 2009).

As previously discussed, the USACE has identified Frying Pan Shoals as a potential source site for the Brunswick County Beaches Coastal Storm Damage Reduction Project. An archeological study was completed as part of the environmental review process of the *Integrated General Reevaluation Report and Environmental Impact Statement for Brunswick County Beach, North Carolina* (in press). Three remote sensing targets were identified within the proposed Frying Pan Shoal borrow area with the use of side-scan sonar, marine magnetometer and sub-bottom profiler. One remote sensing target was identified during the extended hardbottom sonar survey, however, this target was located beyond the limits of the proposed borrow area. Identified targets were further analyzed by video, and surficial sediments we collected at each site. The Frying Pan Shoal borrow area identified for the Brunswick County Beaches Coastal Storm Damage Reduction Project appears to consist of fluvial sediment deposits. In addition, no hardbottom was recorded in the survey area or within 500 meters adjacent to the proposed borrow area (USACE pers. comm.).

b. Cumulative Impacts: In conjunction with other past, present, or reasonably foreseeable future actions, there are no other cumulative impacts to historic properties and/or cultural resources resulting from Alternative #3.

(4) Beach Nourishment/Beach Disposal and Sand Tube Groinfield Removal (Alternative #4)

a. Direct and Indirect Impacts: The impacts and consultation discussed under Alternative #4 would be the same under Alternative #3.

b. Cumulative Impacts: In conjunction with other past, present, or reasonably foreseeable future actions, there are no other cumulative impacts to historic properties and/or cultural resources resulting from Alternative #4.

(5) Terminal Groin with Beach Nourishment (Groinfield Remaining) (Alternative #5)

a. Direct and Indirect Impacts: A 2012 marine remote-sensing survey conducted in the coastal waters near Bald Head Island and the mouth of the Cape Fear River identified the remains of a 160- to 190-ft sailing vessel within the VBHI Shoreline Protection Project Study area. Historical research indicates that three documented vessels remains could be candidates for association with the wreck, the most-likely being 639-ton schooner *Charles H. Valentine* which wrecked off Bald Head Point on Smith Island in 1911. Based upon consultation with NC SHPO, the groin structure is designed to create a minimum of 150 ft of clearance from the identified vessel remains. During construction, the contractor would be made aware of the location of the wreck and would be required that vessels engaged in construction of the groin will not infringe on the 150ft buffer created to preserve the surviving vessel remains. The groin structure, as proposed, would result in accretion of sediment along the southwestern shoreline of Bald Head Island. It is likely that the wreck remains would be covered by several feet of sediment. Burial of the remains would offer protection from further degradation thereby resulting in a positive impact to the archeological site. Annual physical monitoring of the area would confirm burial of the remains over the life of the project. Consultation with the SHPO to identify proper contingency measures would be initiated should the remains of the wreck become exposed.

b. Cumulative Impacts: In conjunction with other past, present, or reasonably foreseeable future actions, there are no cumulative impacts to historic properties and/or cultural resources resulting from Alternative #5.

(6) Terminal Groin with Beach Nourishment/ Removal of Sand Tube Groinfield (Alternative #6)

Alternative #6 would involve the construction of a single, low-profile terminal groin as described in Alternative #5 above. However, upon completion of the installation of the terminal groin, the Village would begin the systematic removal of the existing sand-tube groinfield on South Beach. Sand placement via Village-sponsored nourishment projects and federal beach disposal would continue on periodic intervals (potentially on a greater frequency then would occur under Alternative #5).

a. Direct and Indirect Impacts: The impacts and consultation discussed under Alternative #5 would be the same under Alternative #6.

b. Cumulative Impacts: In conjunction with other past, present, or reasonably foreseeable future actions, there are no cumulative impacts to historic properties and/or cultural resources resulting from Alternative #6.

5.14 SOCIO-ECONOMIC CONSIDERATIONS[8]

5.14.1 Introduction

Alternative actions for the Village of Bald Head Island Shoreline Protection Project each create a unique array of costs and benefits. These include market costs, such as any construction or engineering costs associated with active mitigation, potential economic losses associated with upland damage to coastal real estate and infrastructure, as well as non-market costs and benefits, such as those associated with effects on the natural environment, aesthetic appeal, habitats and species.

[8] Note that Section 5.14 was prepared for the USACE by Dr. Peter Schuhmann. Construction and maintenance costs for the economic analysis were provided by the applicant's engineer, Olsen Associates, Inc.

The purpose of this section is to describe the potential scope of these values for each of the six alternative actions under consideration for the Bald Head Shoreline Protection Project. Monetary measures for values are provided that are readily identifiable and measurable based on existing data, such as construction and maintenance costs for the alternatives that involve nourishment or a terminal groin as well as assessed tax values of at-risk properties. These values should not be considered definitive and should not be used as the sole basis for choice or ranking of alternatives.

It is important to note that this section should not be considered a formal cost-benefit analysis. There is no attempt to monetize all aspects of the range of non-market costs and benefits that are associated with alternative actions such as those associated with aesthetics, opportunities for recreation or services provided by the natural environment. Based on results in the literature, these values are known to be substantial. However, in the absence of formal valuation efforts, their magnitude remains unknown. As such, the select monetary values that are provided herein should not be considered to be a representation of the true economic worth associated with the alternatives. Given the lack of formal valuation and the inherent uncertainties regarding specific performance of alternatives over a 30-year project horizon, providing an estimate of total costs, total benefits or net gains is not possible. Further, ranking of the alternatives based on their relative economic values is not possible.

In many cases, the benefits associated with alternatives that mitigate the effects of erosion can be considered costs of alternatives that do not mitigate erosion. For example, the benefits of shoreline stabilization via nourishment or hardened structures include maintaining the integrity of the Bald Head Island shoreline and the associated real estate. These economic values may be partially or wholly sacrificed in the absence of active measures to offset erosion. Hence, the costs of retreat should account for declinations in the economic value of associated real estate due to lost shoreline integrity as well as losses associated with effects on use and non-use values associated with recreation and tourism on

Bald Head Island. Likewise, the benefits of inaction may include values associated with maintenance of environmental conditions that would be subject to alteration by active shoreline protection measures. It is important to note however, that in the case of Bald Head Island, it is likely that inaction or retreat will have additional adverse effects on environmental conditions. That is, strategies that do not protect the shoreline from continued erosion are not expected to maintain environmental conditions in the study area, and the developed nature of the island does not allow for the landward migration of biological communities.

Cost and benefit values described below include explicit and implicit values. Affected stakeholders include employees of VBHI, Bald Head Island Limited, property owners, business owners, visitors, taxpayers of North Carolina and individuals who value coastal species and ecosystems and existence of the current character of Bald Head Island. The incidence of costs and benefits across these stakeholder groups will vary across the alternatives. As noted in Landry and Hindsley (2011), stakeholders can be expected to have different perceptions of the effectiveness of natural and man-made storm and erosion buffers and variable evaluations of beach characteristics in terms of aesthetics, recreation, and leisure. Hence, the alternative actions can be expected to convey net economic gains to some user groups and impose economic losses on others.

Explicit costs associated with alternative actions include physical construction costs associated with shoreline nourishment activities, construction of a terminal groin, maintenance costs associated with the existing sand tube groinfield, and costs associated with destruction and/or removal of existing properties and infrastructure. Implicit costs include losses to the economic value to coastal property and public infrastructure associated with degradation of the character of the shoreline and proximate coastal and marine ecosystems, as well as reductions in use and non-use values associated with recreation, aesthetics and changes in the quantity and quality of habitats and species.

Construction and maintenance costs detailed herein are those incurred by VBHI and are based on estimates provided by the applicant's agent, Erik J. Olsen, P.E., as part of an engineering analysis of project alternatives (Olsen 2013). These estimates were constructed using a 30-year time horizon beginning in year 2015 and a 4.125 discount rate to current dollar value expenditures in order to provide cost estimates in discounted present value terms. It is important to note that due to the current low interest rate environment, a discount rate of 4.125 percent may be perceived as an overestimate of the opportunity cost of public funds. Indeed, at the time of this writing, long-term rates on U.S. Treasury Bills are lower than 2 percent. However, because the public is generally risk-averse with regard to spending on projects with uncertain outcomes, it can be argued that higher discount rates are more appropriate. Therefore, the present value of future expenditures associated with the alternatives are also examined using discount rates of 2 percent, 4.125 percent and 6 percent. Lower discount rates result in higher estimated present values for future expenditures, and causes alternatives that involve more future outlays to appear less favorable. Likewise, higher discount rates result in lower present values for future expenditures.

Cost estimates are based upon recent project experience associated with sand tube maintenance and locally sponsored beach fill construction at Bald Head Island as follows:

- Sand Tube Groinfield (16 Structures)
    - Removal - $250K
    - Replacement - $2M
    - Maintenance - $130K + $115K/sand tube groin (per maintenance event)

      Note – each action must occur subsequent to a beach fill project.
- Terminal Groin Construction
    - Initial Cost - $8M (AE&D included)
- Beach Fill by Village
    - $2M + $8.00/cy + AE&D: Fills greater than 1 Mcy
    - $1M + $10.00/cy + AE&D: Fills less than 1 Mcy; greater than 0.5 Mcy

Sand placement on Bald Head Island via the Wilmington Harbor Sand Management Plan (SMP) is assumed on a three-year interval for two events.[9] A six-year gap is then assumed prior to the next disposal event.[10] Alternatives that include the construction of a terminal groin involve large initial costs associated with construction, but considerably lower costs associated with beach nourishment. This cost saving is due to the smaller quantity of sand that would be placed during each episode, rather than a decreased frequency of episodes.

In the case of alternatives that are projected to provide some level of shoreline stabilization (i.e. Alternative Nos. 1, 3, 5 and 6), benefits include the maintenance/protection or enhancement of coastal real estate, which may include values associated with residential, commercial and infrastructure assets. These values can also be interpreted as representing potential costs of Alternative Nos. 2 and 4, which involve a projection of extensive upland losses to erosion.

To understand the relative scope of potential impacts on coastal property, the most recent (2011) assessed tax values for at-risk properties are used. It is important to note that the current assessed tax values may not be reflective of current market values. To the extent that risk of future erosion is known to market participants, market values could be considerably lower than assessed tax value. Given the dynamic nature of the shoreline in recent years and uncertainty regarding the potential for mitigating action, it seems logical that current market values for at-risk properties on Bald Head Island will have capitalized a sense of future risk. More generally, changes in the real estate market that have transpired since the most recent assessment may affect market values. These changes include general market trends as well as modifications to insurance rates specific to properties in the coastal zone. While the general market trend since 2011 seems upward, such enhancements are

[9] The 3-year interval represents roughly the average interval that disposal events have actually taken place on Bald Head Island in the past, and can be considered a conservative estimate of disposal timing. Federal disposal cannot be assumed or relied upon by the Village for stabilization purposes, as stabilization of the Bald Head shoreline is not the intent or objective of the Wilmington Harbor Sand Management Plan.

not homogenous across locations and may not be conferred upon properties at risk of erosion. Recent trends in insurance rates as part of the N.C. Beach Plan have been generally unfavorable for properties in the coastal zone. Expected or realized additional costs may decrease demand for coastal properties offsetting some of the general market improvements experienced in recent months. Moreover, it can be argued that the appropriate values to be used in understanding the possible effects of alternative shoreline management actions are the values that exist at the time of the associated environmental change. As noted above, and with the important exception of acute change due to damage from storms, anticipated changes in coastal environments are likely to be capitalized into the market value of real estate far in advance of actual change (Landry and Hindsley, 2011; Landry, 2011).

In the absence of contemporaneous sales data for at risk properties and without a formal hedonic study for the properties in the subject area, an appropriate means of determining the true market value of at-risk real estate is lacking. The assessed tax values of at-risk properties should therefore be used only as a means of appreciating the relative magnitude of the management alternatives, rather than the absolute value that is at risk. Even in terms of their relative magnitudes, these values should be used with caution. As noted in Landry and Hindsley (2011), if active mitigation creates an expectation of improved conditions over time, value estimates should be interpreted as lower bounds on true value. If instead, conditions are expected to degrade, value estimates should be interpreted as upper bounds on true value.

It should also be noted that impending property loss due to erosion may result in some structures being demolished and some being moved further inland. There is no attempt to monetize the value of the transition losses associated with destruction or location of property, nor is there an attempt to monetize the gains in value that will be realized by

[10] As noted in Landry (2011), the fixed costs associated with beach replenishment can be significant (e.g. costs of mobilizing and demobilizing dredging equipment).

currently unimproved parcels that are subsequently improved when structures are relocated. While it is important to acknowledge that such effects will transpire in the case of some alternatives, forecasting the magnitude, timing and location of such transitions is beyond the scope of this report.

As described in Section 3.0 of Appendix O, economic value extends beyond the prices and quantities of goods and services traded in markets. An extensive body of literature is associated with the definition and estimation of non-market and non-use values. Portions of this literature that are germane to shoreline change are reviewed in Appendix O. Recognition of these values suggests that alternatives that induce long term enhancements to beach width or beach quality will convey additional economic benefits associated with tourism, recreation and aesthetics. Stabilized shorelines may also convey additional use and non-use values associated with protecting coastal habitats and species. Non-use values such as existence values, option values and bequest values may also accrue to past and potential visitors to Bald Head Island who derive benefits from maintenance of favorable conditions at the site. Actions that involve the construction of a terminal groin (i.e. Alternative Nos. 5 and 6) may create economic benefits in terms of enhanced recreational fishing opportunities, though these gains may be more than offset by diminished aesthetic appeal and/or any unforeseen adverse environmental effects produced by permanent physical alteration of the shoreline. Alternatives that maintain the existing sand tube groin field (i.e. Alternative Nos. 1, 3, and 5) are also likely to involve loss of aesthetic appeal (particularly as sand tubes become exposed) as well as diminished recreation value due to the physical constraints that the structures impose on beach activities, especially at low tide.

Alternative No. 2 (retreat) may produce economic benefits to a set of individuals who place economic value on unimpeded ecosystem function and change. These values are probably best described as non-use values, though some use value losses may also transpire. A critical assumption with regard to these values is that baseline environmental conditions are naturally occurring. This assumption seems unlikely in the case of Bald Head Island, given the

highly modified conditions of the study area that have resulted from long-term and short-term anthropogenic alterations of the coastal area. Without formal valuation studies directed at estimating these values, it is impossible to form conclusions regarding net gains or losses in economic value.

5.14.2 Cost Considerations of Alternative Actions[11]

(1) No Action (Alternative #1)

The "No Action" alternative entails sand placement associated with the SMP and maintenance of the existing 16 structure sand-tube groinfield by VBHI. Larger-scale projects sponsored by VBHI would not occur under this alternative. The resultant condition would create an unstable beach profile prone to sand losses, necessitating short term emergency-level responses such as beach scraping/bulldozing and sandbag revetments.

a. Costs: Construction and maintenance costs of this alternative are expected to total $9.7 million under a 3-year interval scenario over a 30-year planning horizon. Discounted present values of these expenditures are approximately $7.33 million, $5.63 million and $4.59 million assuming discount rates of 2 percent, 4.125 percent and 6 percent respectively.

The "no action" alternative is expected to adversely affect the market value of several properties near the Point. Seventeen (17) parcels are projected to be at risk using 9-year simulations of the projected mean higher high water (MHHW) shoreline position (refer to Figures 5.30 and 5.31). Of these parcels, 15 (88 percent) are improved. Most recent (2011)

[11] Note that the following narrative includes an analysis of at-risk lots under each alternative considered. For the purpose of this analysis, a lot is considered at risk if any portion of the lot is within 20 ft of the predicted MHHW line at the end of a nine-year model simulation. Given the inherent limitations of the numerical modeling, the total values of at-risk lots should not be considered absolute but are presented rather as a means to provide a relative comparison between alternatives. The total lot values at risk do not necessarily equate to a loss, since the position of the MHHW line at the edge of a lot would not necessarily render a lot useless and thus devoid of value. In addition, this analysis does not account for any beach stabilization measures (i.e. supplemental nourishment or use of sandbags) for protection of property other than those measures defined in each project alternative.

assessed tax values for these properties range from approximately $518,000 to $1.8 million for the improved parcels and from $350,000 to $560,000 for the unimproved parcels. The total assessed tax value of these properties is approximately $18.2 million.

A portion of this market value can be expected to transfer to properties currently located further inland as newly beachfront properties realize value improvements. However, to the extent that the "no action" alternative conveys a sense of future erosion risk to market participants, this additional value may be limited to temporary proximity value rather than long term improvements in market value. Even with partial or complete relocation of physical property, or the continued use for those properties not lost entirely, the decrease in value associated with these 17 parcels can be expected to have a net adverse effect on the tax base of the Island, *ceteris paribus*[12].

The "no action" alternative is expected to result in moderate near term loss of beach volume near the Point. While it seems logical to conclude that recreation opportunities will be diminished as a result of this volumetric loss, the total length of shoreline and area of beach available for recreation may remain unchanged. Hence, this alternative may fit the case discussed by Parsons and Powell (2001), where the shoreline is relocated further inland with no meaningful changes to other beach characteristics. If this is the case, total welfare derived from recreationists under Alternative No. 1 may be unchanged relative to status quo conditions. An important caveat here is that the recreational value of the Point is of the same magnitude as other beach areas in the vicinity. The Point is currently the most expansive area of dry beach available to beachgoers in the vicinity of western South Beach and West Beach. Its anticipated wholesale loss would likely result in a more direct impact to recreation than loss of beach between existing sand tubes. Another important caveat pertains to the potential loss of dune structure or function in the vicinity of the Point, which

[12] *Ceteris paribus* is a Latin phrase translated to "holding other things constant" and is typically rendered in English as "all else being equal". In economics, the term is used as a way of indicating the effect of one economic variable on another, holding constant all other variables.

may result in additional loss of beach width and/or volume. If dune function is compromised, recreational values may modestly diminish relative to status quo conditions. The risk of dune loss is heightened by the probability of progressive groinfield failure, the occurrence of which was not accounted for in model simulations.

In terms of environmental values, calibrated Delft3D modeling of Alternative No. 1 suggests that there will be considerable shoreline recession and deflation within nine years, directly impacting dry beach, dunes and interdunal wetlands. In addition to a reduction in the storm protection function of dunes, several federally and state listed species that utilize these habitats may be adversely affected, including sea turtles and seabeach amaranth. Estimating the economic value of these changes is beyond the scope of this report. However, it should be noted that use and non-use values associated with the protection of habitats have been shown to be large, as highlighted in Appendix O.

b. Benefits: The benefits of Alternative No. 1 can in large part be construed as maintenance of the current stock and flow of market and non-market goods and services, subject to caveats noted above. It should also be noted that potential adverse effects that result from the use of a hardened structure will be avoided. These effects include the possibility of environmental damages to adjacent or proximate shorelines, aesthetic disamenity to coastal property owners and recreationists and economic value realized by the segment of the population that values unfettered ecosystem function.

(2) Retreat (Alternative #2)

The "Retreat" alternative involves continuation of federal beach disposal activities, but does not include maintenance of the existing sand tube groinfield, or large scale shore protection projects by the Village of Bald Head Island. Shoreline recession is expected to occur at a more rapid pace, with the shoreline moving up to 1,100 feet landward from its current position along western South Beach within nine years (refer to Figure 5.1).

Considerable upland losses are expected due to erosion along the westernmost segment of South Beach, West Beach and the Point. A large volumetric reduction in beach area is expected, with a moderate improvement in beach width along a small section of West Beach as the Point feature migrates northward. Dune habitat losses are expected to be noteworthy.

a. Costs: Excluding transition costs associated with relocation of structures and infrastructure (discussed below), construction and maintenance costs associated with this alternative are expected to be negligible. Contemporaneous costs associated with removal of the sand tube field are expected to be approximately $250,000.

The expected reconfiguration of Bald Head Island's shorefront associated with this alternative involves a major shift landward, with notable upland impacts on existing properties and infrastructure. As a result of the extent of shoreline recession and deflation associated with this alternative, substantial adverse effects to habitats are predicted as described elsewhere in this section. These include effects on dry beach, dunes, interdunal wetlands and maritime thicket/forest habitats. Existing interdunal wetlands are expected to be inundated, altering species composition and wetland function. The beach profile is expected to be nearly vertical from upland dune to the mean high water line. This new profile is expected to adversely impact available habitat for species that utilize the dry beach as well as diminishing nesting area for sea turtles, shorebirds and waterbirds. Areas currently suitable for seabeach amaranth are expected to be converted to intertidal or subtidal bottom. While estimating the change in economic value associated with such impacts is beyond the scope of this report, an extensive literature search suggests that adverse changes to ecosystems, habitats and species can be expected to result in the loss of economic value associated with use and non-use benefits derived from these amenities. Examples of such values are detailed in Appendix O.

Under this alternative, it is predicted that nearly all of the frontal dunes and primary dunes mapped within the area of study would be lost to erosion. Unlike wet and dry beach habitat, it is not expected that dune habitat will naturally relocate or regenerate in the near term. In addition to important loss of habitat function, the protection service provided by dunes is expected to be seriously compromised under this alternative. As described in Appendix O, the shoreline protection services afforded by dunes and other coastal habitats convey real economic value by preventing damage to coastal land and property. While non-market valuation techniques could be applied to estimate these values, such analysis is beyond the scope of this report.

The upland losses associated with the retreat strategy are expected to adversely affect the market value of numerous private properties near the Point. Up to 95 parcels are projected to be impacted using 9-year simulations of the projected mean high water line. Of these 95 parcels, 65 (68 percent) are improved (Brunswick County GIS 2013). Current tax assessed values for these properties range from $334,000 to $4.9 million for the improved parcels and from $150,000 to $643,000 for the unimproved parcels. The total assessed tax value of these properties is approximately $63.4 million. As noted in Landry (2011), as the market capitalizes the expectation of continued shoreline erosion into the value of these properties, market values may be driven toward zero. Inland relocation of structures will offset some of these losses but will involve nontrivial transition costs. Again, it is reasonable to expect that a portion of the lost market value will transfer to properties currently located further inland. However, a strategy of retreat is likely to convey an expectation of risk from future erosion losses to shoreline properties. Newly beachfront properties might reasonably be considered newly at-risk properties. The market capitalization of this additional risk may offset much of the gains in amenity value. While proximity benefits associated with recreation and aesthetics will likely accrue to property owners in the near term, it seems unlikely that such values will be capitalized into market values due to long term uncertainty and risk.

Additional costs will be associated with relocation or demolition and removal of existing properties as acute loss to erosion becomes imminent. There is no attempt to estimate the monetary value of these transition costs, but it should be noted that in addition to physical costs associated with the removal and transport of materials[13], aesthetic costs associated with noise, equipment and congestion can be expected as part of this alternative. These additional costs will temporarily impact specific locations - largely be concentrated around the Point - as individual structures are removed. Physical removal of materials from the Island may involve substantial transport costs. Generally, these adverse effects can be expected to persist for the duration of the landward shift of the shoreline.

In addition to loss of private property, the predicted landward shift of the shoreline associated with this alternative is also expected to result in a large physical loss of land and property currently contained within the 151 acres of the Bald Head Island Club and golf course (as shown in Figure 5.16). In addition to physical capital (Club House facility, pools, tennis courts), at least two holes of the golf course are projected to be inundated under this alternative. There is no attempt to monetize the magnitude of the economic costs associated with these losses, but it should be recognized that the current economic impact of the Bald Head Island Club is considerable. The Club generates $10M in revenue annually and, as a not-for-profit entity, spends approximately the same amount each year.

In addition to a championship golf course, the Club houses a pool, fitness facility, tennis courts and two restaurants. Because the Club serves as the foundation for recreation and social activity island wide, the gross domestic product (GDP) of the Island is strongly associated with the Club, its associated activities, and the resultant effect on home purchases and rentals on the Island. On average, twenty-thousand rounds of golf are played each year on the Club's championship eighteen-hole golf course. A majority of these rounds (63%) are played by non-members that rent Island residences. It is estimated that 500

[13] Such transition costs can be expected to be higher than those encountered on the mainland, because Bald Head Island is accessible only by boat, ferry or barge.

homes are rented each year (equivalent to $5,700 weekly in rental income) as a direct result of the amenities offered by the Club. Over 81,000 full meals were served at the club in 2011, totaling roughly $3 million in food and beverage sales. All of the Club's seafood and produce are locally sourced. The Club is also the single largest employer on the Island, employing 151 people during the summer and 75 people during the off-season. None of the Club's employees are Island residents. The Club's largest expense is payroll (accounting for an average of 57% of accounts payable) in most years. The Club is also the largest source of tax revenue for the Village. The current economic impact of the Club is not known, but clearly extends to surrounding municipalities.

It seems logical to assume that the Club will relocate all displaced amenities further inland should the retreat strategy be adopted. Hence, it would be erroneous to conclude that the economic impact and economic value of the Club will be lost in their entirety under a strategy of retreat. However, such relocation efforts would involve considerably transition costs, similar in nature to those described above for private properties, but likely considerably larger in scope given the existing footprint of the Club and the amount of standing physical capital that is at risk. Revenue losses should also be expected during the period of relocation. The extent to which relocation might affect the ability of the Club to provide the same level and quality of amenities is unknown.

The major landward shift of the shoreline associated with alternative No. 2 will also result in loss of existing Island subgrade infrastructure, including roadways, water lines, sewer lines, fire suppression, power and communications. Nine-year modeling of the affected shorelines suggests that approximately 3500 linear feet of road, water, sewer and power lines (including portions of W. Bald Head Wynd and Cape Fear Trail) will be lost (as shown in Figure 5.16). It is reasonable to assume that a portion of the economic value associated with this infrastructure has been capitalized into the value of the properties that rely on it for support. Some of the infrastructure value, however, accrues to the public that uses the roads to gain access to beaches. Moreover, the at-risk infrastructure that runs below Bald

Head Wynd provides utility service that is ultimately distributed throughout other (inland) areas of the Island. Bald Head Wynd is also the primary route for evacuation and emergency vehicles. Hence, relocation of the physical capital that provides these service flows will be necessary in the case of loss as predicted under this alternative. A lower bound[14] on the value of this infrastructure can be provided using the replacement cost method. The estimation is based on NCCRC (2010a), and value at risk infrastructure using construction costs of $568 per foot for roads, $55 per foot for water lines and $150 per foot for sewer lines, assuming that the length of affected water and sewer lines is coincident with affected length of road.[15] Applying these values to the 3500 linear feet of anticipated infrastructure impact under Alternative No. 2 suggests a replacement cost of approximately $2.7 million over the nine year simulation period. This estimate does not include infrastructure associated with power and communications and does not include costs associated with land acquisition for ROW.

The predicted large scale increase in beach erosion associated with the affected shoreline segments under this alternative is also expected to increase the volume of sand entering the Wilmington Harbor Entrance channel. As a result, there are expected to be additional channel maintenance costs associated with this alternative. The Applicant's engineer has predicted the percent change in shoaling within the federal channel relative to Alternative No. 5. Comparison of the results suggests that channel shoaling is predicted to be 20% higher for Alternative No. 2 relative to Alternative No. 5 (refer to Section 5.12.4 and Figure 5.28). In addition, cumulative sedimentation and erosion changes have been modeled and

[14] These estimates are considered a lower bound on value for several reasons. First, as noted in the review above, the cost associated with new construction is likely smaller than the discounted present value of the benefits flowing from the intact infrastructure over its lifetime. Second, transport of materials and labor to an island only reachable by boat will involve additional costs not included in standard replacement costs calculations. Finally, additional costs associated with the physical removed and off-site transport of the materials that comprise the at-risk infrastructure will create additional transition costs.

[15] The replacement cost estimate for roads is based North Carolina Department of Transportation Construction Cost Estimates for 2008. Water and sewer construction costs are based on estimates from the Cape Fear Public Utility Authority and Wrightsville Beach public works department (NCCRC 2010a). It is not known whether acquisition, engineering, permitting costs are accounted for in the NCCRC estimation.

graphically depicted in Figures 5.30 through 5.36 for each alternative. A more detailed analysis is provided within the Engineering Report (Olsen 2013).

While there is no attempt to quantify the monetary value of losses under this or any alternative, it seems clear that this alternative involves the greatest scope of foreseeable market and non-market costs. Market losses include land loss, capital (structure) loss, proximity loss, and transition loss affecting both privately held real estate and real estate owned by VBHI. Non-market losses include the use and non-use values associated with affected species and habitats, most notably, dune habitat and species nesting areas.

b. Benefits: The retreat alternative can be construed as the alternative where "natural processes" are permitted to continue unimpeded by human activity or intervention. As noted in Judge, Osborne and Smith (1995), some individuals have preference for non-interventionist approaches that allow unimpeded erosion to take place. These individuals may derive real economic value from the existence of unfettered coastal ecosystems. As noted above, a critical assumption with regard to these values is that baseline environmental conditions are naturally occurring. This assumption seems unlikely in this case, given the highly modified conditions of the study area that have resulted from long-term maintenance of the adjacent federal channel. Such activities (continued dredging and disposal) will continue even with a strategy of retreat. Hence, without a thorough (non-market) valuation study directed at understanding the scope and magnitude of these benefits it is difficult to characterize their nature or extent. It should be noted that in a sample of North Carolina beachgoers, Whitehead et al. (2008) found that a majority of respondents favored beach nourishment as a means of maintaining beach width, and 18 percent felt that beach width should not be altered by people.

Because this alternative involves the removal of the existing sand tube groin field, improved aesthetic appeal as well as enhanced recreation value may also be created. However, it is

unknown whether removal of the aesthetic disamenity and physical constraints associated with the groin field will be offset by losses associated with reduced beach width.

(3) Beach Nourishment with Maintenance of Groinfield (Alternative #3)

Alternative #3 is predicted to result in continued beach erosion at the Point, with potential accretion on the shoreline to the north of the Point. Conditions similar to those identified under the Alternative No. 1 are predicted, with the exception of shoreline loss that is periodically mitigated through a Village-sponsored renourishment. Nine-year modeling of projected changes under this alternative suggests a net increase in total volume over a 9-year time period in the vicinity of the Point.

a. Costs: Alternative No. 3 is expected to involve construction and maintenance costs totaling $72.9 million under a 3-year interval scenario over a 30-year planning horizon. Assuming 6, 4.125 percent and 2 percent discount rates, the discounted present values of these expenditures are $33.04 million, $40.71 million $53.72 million respectively.

Under this alternative, continued diminished beach width at the Point will likely have an adverse impact on the market value of a limited number of properties. Based upon the 9-year model simulation, one improved parcel (Parcel ID No. 2641D026) would be directly affected by land loss and potential capital (structure) loss. The total assessed value of this parcel is $518,532. Other neighboring parcels (along Sandpiper Trail) would be subject to increased risk of impact from erosion under this alternative as well. Failure of any one or more of the geotextile sand tubes protecting this segment of shoreline (e.g. during a storm) would immediately place additional lots at risk.

Parcels in the immediate vicinity of the Point will likely suffer losses due to decreased aesthetic appeal and loss of recreational values as beach width in that area is diminished over time. As with other alternatives, it is reasonable to expect that with shoreline erosion a portion of the lost proximity value currently capitalized into at-risk properties will transfer to

properties currently located further inland. That is, newly beachfront properties will realize value improvements due to enhanced proximity values, including those associated with recreation and aesthetics. However, to the extent that this alternative is viewed as a temporary measure, continued perceptions of risk to shoreline properties may diminish the extent to which this value can be realized in the marketplace. Indeed, given the dynamic nature of beaches near the Point in recent history, it seems likely that such risks are currently capitalized into existing, at-risk shorefront properties. If this is the case, private recreation and aesthetic values will likely accrue to some property owners in the near term, but it seems unlikely that such values will be capitalized into market values due to long term uncertainty and risk.

Public recreational values may be affected under this alternative to the extent that the northward sand accretion affects recreation around the Point. Based on 9-year simulations, the volume/width will be transferred only a short distance to an area with similar characteristics. Hence, it seems likely that public recreation values will be largely unaffected by this alternative. Maintenance of the existing sand tube groin field may also create recreation losses due to diminished aesthetic appeal and physical constraints on recreation activities, especially at low tide.

This alternative is expected to result in a modest increase (4% increase relative to the no-action alternative) in shoaling volume within the maintained federal navigation channel. Thus, there may be some additional costs associated with channel maintenance.

The increased frequency of nourishment required under this alternative is expected to result in more frequent environmental disturbance at both the dredge site and at the nourishment site relative to Alternative No. 1. Short-term impacts on foraging habitat for fish are expected at the dredge site, though these effects may be mitigated by using the federal navigation channel as a sand source. Estimating the economic value of such changes to commercial and recreational fisheries is beyond the scope of this report. The occurrence and

distribution of species that utilize wet and dry beach for foraging may be temporarily impacted at the nourishment site, which may diminish the value of associated recreation. Potential adverse effects to dry beach and frontal dune habitats are expected to be relatively minor.

b. Benefits: As with Alternative No. 1, the benefits of Alternative No. 3 can be construed as maintenance of the current stock and flow of market and non-market goods and services. Accretion on beaches to the north of the Point will confer some benefits on property values in the immediate vicinity. Other benefits include the avoidance of adverse effects resulting from the use of a hardened structure. These effects include potential environmental damages to immediately adjacent or proximate downdrift shorelines, aesthetic disamenity to coastal property owners and recreationists and economic value realized by the segment of the population that values unfettered ecosystem function.

(4) Beach Nourishment/Beach Disposal and Sand Tube Groinfield Removal (Alternative #4)

Removal of the sand tube groinfield under Alternative No. 4 is expected to necessitate the implementation of larger scale Village-sponsored nourishment events to help mitigate sand losses. Sediment losses on South Beach are expected to be larger than Alternative No. 3 due to the absence of the stabilizing effects of the sand tube groinfield. Based on the 9-year simulations, alternative No. 4 is expected to result in a reconfiguration of Bald Head Island's shorefront with a shift landward along the westernmost segment of South Beach, West Beach and the Point. Assuming a three-year schedule of implementation of the SMP coupled with Village-sponsored nourishment of approximately 1.5 Mcy, the Delft 3D simulation predicts that by Year 9 the shoreline will have receded approximately 1,000 feet landward of its current position.

a. Costs: Alternative No. 4 is expected to involve construction and maintenance costs associated with beach nourishment and disposal totaling approximately $79.45 million under a 3-year interval over a 30-year planning horizon. The discounted present values of

these costs are $35.99 million, $44.34 million and $58.51 million using discount rates of 6 percent, 4.125 percent and 2 percent respectively. These estimates include costs associated with removal of the sand tube field in the initial year, expected to total approximately $250,000.

Resulting upland losses under this alternative are expected to be considerable, involving loss or degradation of 71 parcels, of which 46 (approximately 65 percent) are improved (see Figure 5.34). Current assessed values of these properties range from $350,000 to $4.9 million for the improved parcels and from $150,000 to $643,000 for the unimproved parcels. Total value of these lots (both improved and unimproved) is $49.2 million.

As is the case with Alternative No. 2, to the extent that projected shoreline erosion is anticipated by market participants, the near term market value of these properties may be driven toward zero. Again, due to the realization or expectation of enhanced proximity values, it is reasonable to expect that a portion of this market value will transfer to properties located further inland. However, similar to the retreat strategy, a strategy involving the removal of the groinfield is likely to convey an expectation of additional future risk of loss from erosion, potentially offsetting long term gains in amenity value.

Additional costs of this alternative will be associated with relocation or demolition and removal of existing properties. Physical costs associated with the removal and transport of materials, aesthetic costs associated with noise, equipment and congestion can be expected as part of this alternative. As above, an estimate of the monetary value of such costs is not attempted. These adverse effects can be expected to persist for the duration of the landward shift of the shoreline.

In addition to loss of private property, alternative No. 4 is expected to result in physical loss of land and property currently occupied by the Bald Head Island Club and golf course, though the total land loss under this alternative is less severe than that which is expected

under Alternative No. 2. As stated previously, estimating the economic impact of the land and property loss associated with this alternative is beyond the scope of this report, and it is safe to assume that the Club will relocate affected amenities. Nonetheless, given the economic importance of the Club to the Island and surrounding communities, it is safe to assume that transition losses will be considerable.

Based upon DELFT 3D model simulations, a considerable volumetric reduction in beach area is expected under this alternative, with a moderate improvement in beach width along a small section of West Beach as the Point migrates northward. As a result of the extent of shoreline recession and deflation associated with this alternative, and similar to the effects described for Alternative #2, adverse effects to dry beach, dune, interdunal wetlands, and maritime thicket/forest habitats are predicted. Existing interdunal wetlands and maritime thicket/forest habitats would likely be inundated, altering species composition. Impacts on federally and state listed species are anticipated. The area of dry beach available for nesting sea turtles, shorebirds and seabeach amaranth are expected to be reduced, potentially creating economic losses associated with diminished aesthetics and recreation opportunities, as well as non-use value losses. The increased frequency of nourishment events necessitated by this alternative is expected to have adverse effects at the dredge site and the nourishment site. These effects are likely to reduce economic values associated with direct and indirect uses as well as non-use values associated with these species and habitats. While estimation of the magnitudes of the associated economic losses is beyond the scope of this report, an extensive literature (reviewed in Appendix O) suggests that such economic values are likely to be considerable.

As with Alternative No. 2, the landward shift of the shoreline associated with alternative No. 4 will result in loss of existing Island infrastructure, including roads, water lines and sewer lines. Nine-year modeling of the affected shorelines suggests that approximately 3050 linear feet of road, water lines and sewer lines (including portions of W. Bald Head Wynd and Cape Fear Trail) will be lost, resulting in economic costs associated with removal and transport of

the materials that comprise this infrastructure (see Figure 5.21). Again, because the at-risk infrastructure that runs below Bald Head Wynd provides utility service that is distributed throughout the Island, relocation of the physical capital that provides these service flows will be necessary in the case of loss. A lower bound on the value of this infrastructure can be provided using the replacement cost method. Following the estimation used by NCCRC (2010a), and assuming that the length of affected water and sewer lines is coincident with affected length of road, the 3050 linear feet of predicted infrastructure impact under Alternative No. 4 suggests a replacement cost of approximately $2.36 million. This does not include infrastructure associated with power and communications and does not account for additional costs associated with transporting materials and labor to Bald Head Island.

Beach erosion under this alternative is also expected to increase the volume of sand entering the inlet by approximately 28% than the no-action alternative. As a result, there may be increased channel maintenance costs associated with this alternative relative to current 'baseline' conditions.

b. Benefits: Similar to Alternative No. 2, alternative No. 4 can be construed as allowing natural processes to continue largely unimpeded by human activity or intervention. As such, the portion of the population that values dynamic but unobstructed beaches will derive economic value from this alternative. Further, under this alternative, any adverse effects that result from the use of the sandtube groinfield and terminal groin structure will be avoided.

Because this alternative involves the removal of the existing sand tube groin field, improved aesthetic appeal as well as enhanced recreation value would also be created. It is unknown whether removal of the aesthetic disamenity and physical constraints associated with the groin field will be offset by losses associated with reduced beach width.

(5) Terminal Groin with Beach Nourishment (Groinfield Remaining) (Alternative #5)

The terminal structure associated with Alternative No. 5 is expected to reorient the westernmost segment of the South Beach shoreline in a manner that reduces annualized sand losses following beach fill placement operations. It is predicted that overall beach stabilization will be enhanced with some level of sand tube groinfield remaining functional, particularly those sand tubes that are beyond the effective footprint of the terminal structure's fillet of sand.

a. Costs: It is currently assumed that the westernmost 3 to 6 sand tube groins would be candidates for eventual removal under this Alternative. Costs associated with removal of these sand tubes are expected to be approximately $100,000.

Over a 30 year planning horizon, other construction and maintenance costs associated with Alternative No. 5 are expected to total approximately $63.10 million under the 3-year interval scenario. The discounted present values of these costs are $37.3 million using a 6 percent discount rate, $42.29 million using a 4.125 percent discount rate and $50.72 million using a 2 percent discount rate. These values include an expected cost of $8 million for construction of the terminal structure in the initial year.

Based upon the 9-year model simulation and prediction of the MHHW location, marginally diminished beach width along West Beach could potentially affect the market value of two (improved) parcels (Parcel ID Nos. 2604F004 and 2604F006). The current assessed value of these parcels is approximately $3.4 million. Based upon the requirements of the state terminal groin legislation, mitigation action (e.g. nourishment along West Beach) would limit any potential for future loss of use or value should these lots be threatened. Parcels in the immediate vicinity of the Point may suffer losses due to decreased aesthetic appeal and loss of recreational values as beach width in that area fluctuates over time.

During construction of the terminal structure, reduced recreation value and aesthetic appeal is anticipated due to the presence of construction equipment and associated noise and disruption. To the extent that the terminal structure itself may be viewed as aesthetically lacking, properties with views of the associated area may have reduced amenity value relative to that which would exist with a natural and stable shoreline. Further, to the extent that the structure serves to attract recreationists (i.e. fishermen), property owners in the vicinity may suffer economic losses due to crowding and reduced aesthetic appeal. Shoreward-facing visual impacts should also be anticipated. Maintenance of the existing sand tube groin field may also create recreation additional losses due to diminished aesthetic appeal and physical constraints on recreation activities, especially at low tide.

Construction of the terminal groin and accompanying nourishment has the potential to create short-term and long-term impacts on the natural environment, including effects caused by dredging, sediment transfer, physical contact, physical barriers and placement of material (NCCRC 2010a). Adverse effects are to be expected for some species and habitats, while other species and habitats may be promoted or restored. Adverse impacts will include those induced by volumetric losses to beaches on the lee side of the structure and benthic habitat losses in the footprint of the structure and from the introduction of rocky bottom material (NCCRC 2010a). Disturbance to the nesting habitat of sea turtles may result during construction of the groin. Groin Installation is also expected to temporarily influence the behavior of foraging birds, including federally and state-listed species. Dredging associated with obtaining sand for the groin fillet may result in adverse habitat effects as well as direct mortality to benthic species at the borrow site. As suggested by an extensive body of literature (reviewed in Appendix O), changes to the quantity, quality or character of species, ecosystems and habitats result in real changes in economic value and human wellbeing. As such, these adverse effects can be expected to result in real economic losses associated with diminished use and non-use values. Understanding the magnitude of these losses would require the application of non-market valuation methods, which is beyond the scope of this report.

The use of a hardened structure to mitigate erosion will confer economic losses on the segment of the population that values unfettered ecosystem function. Even if harmful effects on proximate or adjacent coastlines are never realized, it is safe to conclude that some people may remain opposed to the use of hardened structures for erosion control. In the case of the proposed terminal groin on Bald Head Island, such sentiments may be partially mitigated by the understanding that the terminal groin is designed to minimize the potential of adverse effects to navigation in the adjacent channel. In addition, the projected need to nourish will be reduced, resulting in fewer of the environmental consequences associated with dredging and sand placement in general.[16]

In the event of unanticipated negative impacts to the coastal and marine environment, removal of the groin structure may be necessary. Initial estimates for the physical costs associated with groin removal are $3.1 million (Erik J. Olsen, P.E., personal communication). Additional costs will include reduced recreation, diminished aesthetic appeal and habitat disturbance during the removal process. It should be noted that 100 percent removal of the proposed rock structure may not be feasible or desirable given the nature of the marine environment and substrate.

b. Benefits: As noted in NCCRC (2010a) the use of a terminal groin in concert with a shoreline protection plan may provide a host of benefits, including long-term infrastructure protection, enhanced beach width and volume, and enhanced recreation opportunities for the public. The principle benefit associated with Alternative No. 5 is the anticipated stability and reduced erosion potential along the western sections of South Beach and the Point, relative to existing conditions and relative to that which would result under Alternative Nos. 2 and 4. Similarly, it is expected that Alternative No. 5 would reduce shoaling within the

[16] As noted in NCCRC (2010a), inlet dredging can have large effects on neighboring beach volume and behavior, as the channel cuts through bar formations and alters sediment flow and transport. This concern seems particularly germane to the case of BHI, as channel maintenance has occurred for over 150 years at mouth of the Cape Fear River.

adjacent federal navigation channel and thus reduce channel maintenance costs. According to the Applicant's engineer, implementation of Alternative No. 5 is predicted to result in the lowest rate of potential annualized shoaling of all the alternatives considered (4.5% less than Alternative 3, 20% less than Alternative 2, and 28% less than Alternative 4). Refer to Section 5.12.4 for additional information regarding predicted shoaling by alternative.

To the extent that the public views the terminal structure as reducing the risk of future erosion, this added stability should serve to enhance property values along these stretches of the Island. An estimate of the magnitude of these benefits is not attempted in this assessment, but based on the associated literature it is reasonable to expect that property values will be enhanced as far as 300 meters inland. Associated benefits are likely to include increased rental revenues and higher tax revenues.

As noted in Parsons and Powell (2001), active mitigation efforts such as beach armoring may also serve to encourage additional use and/or development. Such additional development can reasonably be anticipated in the case of the Bald Head Island Club, in the form of a planned $6 million expansion which is unlikely to transpire absent a hardened structure solution to the chronic erosion that characterizes South Beach. Provided that such development does not compromise the integrity and value of the adjacent beaches, this expansion is expected to generate additional economic impacts relative to the status quo in the form of increased tourism demand, employment and spending.

The terminal groin may create enhanced recreation values as a result of (predicted) gains in beach width and stability as well as the creation of rocky bottom area that may increase species diversity and enhance the quality of recreational fishing near the structure. Indirect and non-use values may also be created, enhanced or preserved as a result of reduced erosion. In particular, a more stable dry beach habitat eastward of the groin would be expected to create conditions considered more favorable for sea turtle nesting (footprint of the structure notwithstanding). It is important to note that benefits may be offset to varying

degrees by potential adverse effects including: increased risk of interference with nesting females (resulting in the potential for increased energy expenditure and false crawls); increased risk of interference with hatchling egress to nearshore waters; and increased predator concentration (both birds and fish).

(6) Terminal Groin with Beach Nourishment/ Removal of Sand Tube Groinfield (Alternative #6)

As with Alternative No. 5, the terminal structure associated with Alternative No. 6 is expected to reduce annualized sand losses nearest the Point following beach fill placement operations. However, without the added stability associated with the easternmost segment of the sand tube groinfield, the maximum extent of benefit of the terminal groin will be diminished, resulting in increased sediment losses and beach recession along the segment of South Beach that is not within the structure's permanent fillet.

a. Costs: Over a 30 year planning horizon, projected construction and maintenance costs are expected to be $77.6 million under the 3-year interval scenario, with discounted present values of $43.79 million, $50.29 million $61.32 million assuming discount rates of 6 percent, 4.125 percent and 2 percent respectively. These values include initial year cost of $8 million for construction of the terminal groin structure and $250,000 associated with the removal of sand tubes outside of the structure's fillet.

As is the case with alternative No. 5, alternative No. 6 is expected to result in marginally diminished beach width along West Beach. Subsequent erosion has the potential to impact the market value of three (improved) parcels (Parcel Nos. 2604F006, 2604F004, 2641D026) due to land loss and potential capital (structure) loss. The current assessed value of these parcels is approximately $3.9 million. Similar to Alternative No. 6, mitigation action (e.g. nourishment along West Beach) as required by state legislation would limit any potential for future loss of use or value. Again, other parcels in the immediate vicinity of the Point will

likely suffer losses due to decreased aesthetic appeal and loss of recreational values as beach width in that area is diminished over time.

Environmental effects of this alternative are expected to be similar to those described for Alternative No. 5. Exceptions include an anticipation of increased erosion that may adversely affect the profile and width of dry beach habitat suitable for nesting sea turtles and expose frontal dunes to impact and overwash during storm events. Further, removal of the sand tube groins may alter or diminish nesting benefits associated with a more stable beach. However, to the extent that the presence of the sand tubes may currently be affecting nesting behavior, or inducing anthropogenic relocation of sea turtle nests their removal may induce benefits.

Construction of the terminal structure will induce temporarily reduced recreation value and aesthetic appeal due to the presence of construction equipment and associated noise and congestion. The aesthetic quality of the structure itself may also impact property values in the area. Further, to the extent that the structure serves to attract recreationists, property owners in the vicinity may suffer losses associated with crowding and reduced aesthetic appeal.

The negative effect on the segment of shorefront from removal of stabilizing sand tube structures outside of the terminal groin's fillet is expected to increase both beach fill requirements and littoral transport westward, toward the navigation channel. Hence, some level of additional shoaling within the navigation project could potentially result as a result of this alternative. The project engineer has quantified volumes of sand retained on the beaches adjacent to the federal channel by alternative over the first three years (refer to Section 5.2). These relative volumes are proportional to the volume of sand that may shoal into the navigation channel (refer to Section 5.12.4). In addition, cumulative sedimentation and erosion changes have been modeled and graphically depicted in Figures 5.30 through 5.36 for each alternative. Based upon the engineer's analysis, Alternative No. 6 is expected

to result in a 4.8% increase in shoaling relative to Alternative No. 5. A more detailed analysis is provided within the Engineering Report (Olsen 2013).

Relative to alternative No. 4, Alternative No. 6 is expected to result in less erosion and associated adverse effects. However, based upon engineering assessments, the shoreline beyond the limits of the updrift benefits of the terminal groin would be susceptible to increased instability and erosion - compromising beach profile and beach widths - and potentially compromising dune habitats.

If unanticipated negative impacts to the coastal and marine environment necessitate groin removal, physical costs will total approximately $3.1 million (Erik J. Olsen, P.E., personal communication). Additional temporary costs due to reduced recreation and aesthetic appeal should also be anticipated.

b. Benefits: As is the case with Alternative No. 5, the use of a terminal groin coupled with a shoreline protection plan is expected to provide long-term infrastructure protection, enhanced beach width and volume, enhanced recreation opportunities, and increased rental and tax revenues nearest the Point. These benefits are not expected to be as large without the additional stabilizing function provided by the sand tube groinfield. However, the removal of the existing sand tube groin field can be expected to improve aesthetic appeal as well as enhance recreation value due to removal of the physical constraints imposed by the structures.

Further, given the location of the Club relative to the existing footprint of the groinfield, it is not known whether the proposed future expansion will take place under Alternative No. 6.
As with Alternative No. 5, the terminal groin could result in a small net reduction in local wave height and energy to the west of the structure. Such a modification to wave climatology would be expected to be result in aggregate net benefits to commercial and recreational vessels.

5.14.3 Summary of Economic Analysis

This economic analysis has outlined the nature, scope and complexities associated with the costs and benefits of the proposed alternatives for the Bald Head Shoreline Stabilization Project. Table 5.7 below provides a conceptual framework for understanding the scope of the alternatives.

Each alternative action creates a unique set of costs and benefits. Consideration of these values conveys an obvious sense that no matter the choice, tradeoffs are unavoidable. Complicating the analysis of the available alternatives is the fact that many important outcomes are highly unpredictable. Alternatives that involve the construction of a terminal groin provide an improved probability of shoreline stability, enhanced property values and associated economic impacts and cost savings due to reduced future need for nourishment. However, the terminal groin may result in unanticipated deleterious effects on adjacent or proximate shorelines of Bald Head Island. Absent the terminal groin, there will be a great deal of uncertainty pertaining to the future economic condition of physical capital on Bald Head Island and an array of associated economic value and activity.

5.15 LAND USE

Though remaining under the general planning authority of the Brunswick County Land Use Plan, the Village has adopted its own policies regarding planning and resource management. Bald Head Island policies have been incorporated into the Brunswick County Land Use Plan. These policies promote natural resource protection and management and guide responsible development. The Village supports state and federal laws designed to manage development in Ocean Hazard Areas of Environmental Concern and Estuarine Shoreline Areas of Environmental Concern (AECs).

Table 5.7: Scope of Costs and Benefits by Alternative.

Costs (*ceteris paribus*,)						
Alternative	1	2	3	4	5	6
Construction and Maintenance (NPV[17])	$4.59 – $7.33 M	$250,000	$33.04 - $53.72 M	$35.99 - $58.51 M	$37.3 – $50.72 M	$43.79 - $61.32 M
Additional channel maintenance	Low	High	Intermediate	Highest	Low	Intermediate
Reduction in tax base	Intermediate	Highest	Low	High	Low	Low
Parcels affected	17	95	1[18]	64	2	3
Transition costs	Intermediate	Highest	Low	High	None	None
Diminished recreation value	Intermediate[a]	High[b]	Intermediate[a]	High[b]	Intermediate[a]	Low[a]
Diminished aesthetic value	Intermediate[c]	High[b]	Intermediate[c]	High[b]	High[c,d]	Intermediate[d]
Environmental damage	Range of potential beneficial and adverse effects for each alternative described in DEIS. Relative effect determination pending completion of NEPA analysis.					
Public non-use value losses (nature)	Low	Intermediate	Low	High	Highest	High
Public non-use value losses (BHI)	Intermediate	Highest	Low	High	Low	Low
Benefits (*ceteris paribus*, relative to status quo)						
Alternative	1	2	3	4	5	6
Reduction in future nourishment expense	Intermediate	N/A	Low	Low	Highest	High
Enhanced property value	None	None	Intermediate	None	High	High
Enhanced Recreation value	None	Low	None	Low	High	Highest
Environmental condition	See Table 5.6 and Appendix L					
Public non-use value (nature)	Intermediate	Highest	Intermediate	High	Intermediate	Low

[17] Lower value in range corresponds to discounted present value of current and future costs calculated using a 6 percent discount rate. Higher value corresponds to 2 percent discount rate.

[18] Assumes that sand tubes are not allowed to fail. If any one of the sand tubes does fail (e.g during a storm) then several other neighboring lots are placed at risk.

Specific upland uses within the project study include low- and medium- residential, recreational, government, Association Owned Property (AOP) and a few properties acquired by the Smith Island Land Trust (SILT). The Conservation Trust of North Carolina has placed conservation easements on SILT properties.

(1) No Action/Status Quo (Alternative #1)

a. Direct, Indirect and Cumulative Impacts: The Village supports the efforts of the US Army Corps of Engineers in its efforts to dispose of sand in accordance with the SMP (VBHI 2006). As such construction activities associated with the SMP would be in compliance with the Village's Land Use Plan.

Predictive results from Delft3D modeling indicate that the most pronounced seabed erosion and shoreline recession under Alternative #1 is in the vicinity of the Point with a small degree of sediment accretion along West Beach. The implementation of this alternative adversely impacts residential uses located immediately eastward of the Point.

(2) Retreat (Alternative #2)

a. Direct, Indirect and Cumulative Impacts: The anticipated shoreline recession rates predicted under the Retreat alternative would result in significant upland losses and direct impacts to land use. There will be a loss of a number of residential homes, thereby impacting residential uses, and AOP owned property. There will also be a loss of recreational uses associated with Bald Head Island Club and golf course. The Village supports the relocation of structures endangered by erosion given that all relocated structures are in compliance with designated use policies and regulations, including the flood plain ordinance.

(3) Beach Nourishment with Maintenance of Groinfield (Alternative #3)

a. Direct, Indirect and Cumulative Impacts: Alternative #3 would result in similar conditions to those identified under the No Action Alternative with the exception of a shoreline loss

that is periodically mitigated through a Village-sponsored nourishment action. While there would be endangerment of several residential structures fronting the Point by Year 9 of the model simulation, there are no direct impacts to existing upland uses.

(4) Beach Nourishment/Beach Disposal and Sand Tube Groinfield Removal (Alternative #4)

a. Direct, Indirect and Cumulative Impacts: It is the Village's intention to conserve and maintain shorelines, floodplains, major dune ridges and other coastal features for natural storm protection functions and natural resources giving recognition to public health, safety and welfare issues (VBHI 2006). As such, beach disposal or fill (either through federal SMP disposal or through Village-sponsored action) would be in compliance with the local land use ordinances.

Similar to the Retreat Alternative, Alternative #4 Delft3D modeling results predict that within nine years, there would be substantial shoreline recession which would directly impact upland uses including residential uses, recreational uses, and AOP properties. Relocation efforts would be supported given that all relocated structures and infrastructure are in compliance with the designated land use of that area.

(5) Terminal Groin with Beach Nourishment (Groinfield Remaining) (Alternative #5)

a. Direct, Indirect and Cumulative Impacts: Similar to above, beach nourishment/beach disposal and terminal groin construction would aid the Village in its effort to conserve and maintain shorelines, floodplains, major dune ridges and other coastal features for natural storm protection functions and natural resources. Installation of a terminal groin would ultimately serve to maintain existing upland uses. Alternative #5 results in no predicted impacts to local land use.

(6) Terminal Groin with Beach Nourishment/ Removal of Sand Tube Groinfield (Alternative #6)

a. Direct, Indirect and Cumulative Impacts: Impacts to land use resulting from Alternatives #6 would be comparable to those identified above (Alternative #5).

5.16 HYDRODYNAMICS

Refer to Section 5.12 (Navigation) for a discussion of predicted hydrodynamic conditions under each alternative.

5.17 INFRASTRUCTURE

5.17.1 Background

The present day array of commonly owned (i.e. "public") infrastructure potentially affected by beach erosion and associated shoreline recession at Bald Head Island in proximity to the Cape Fear River is comprised of roadways and sub-grade utilities including sewer, water distribution, fire suppression, power, communications, and stormwater ponds. Note that there are 16 groundwater well sites that, in combination with Brunswick County water main line, provide the Island residents and visitors with potable water. In addition, there are privately held infrastructure components associated with the facilities at the Bald Head Island (BHI) Club. While wastewater is primarily collected via sewer and treated by a package treatment system, there are few individual septic tanks for single-family residences that are still in existence. In particular, there are privately-owned and operated septic tanks and attendant lines for four homes on Cape Fear Trail (located within the permit study area and in close proximity to the Point). Figure 5.37 depicts the location and extent of the existing road, sewer line, and water line network on the Island. The locations of the 16 groundwater wells are also depicted.

Most major utilities run below, or immediately abutting, the primary thoroughfares utilized for daily commuting or work vehicles known as "Wynds" (i.e. North Bald Head Wynd, or South Bald Head Wynd, or West Bald Head Wynd). Utilities are ultimately distributed throughout a network of secondary thoroughfares that are residential hard-surfaced streets, or "trails." Similarly, privately-owned infrastructure endangered by erosional processes is principally associated with major habitable structures, furnishings, pools, outbuildings, over-walks, pavilions, etc. It should be noted that South Bald Head Wynd (SBHW), West Bald Head Wynd (WBHW), and North Bald Head Wynd (NBHW) are the primary evacuation routes, as well as emergency services routes, for portions of the oceanfront and riverfront residential properties.

5.17.2 Predicted Effects to Infrastructure

The principal source of predicted future effects of shoreline change on existing infrastructure is the 9-year numerical simulation of future MHHW location(s) presented in Section 5.2.1 (ref. Figure 5.8). Based upon these results, the predicted relative effects for each of the six alternatives are described below.

(1) No Action/Status Quo (Alternative #1)

The implementation of this alternative adversely impacts numerous residential structures located immediately eastward of the Point as it exists today. It is predicted that the Point's present-day configuration would be lost to erosion by Year 9 of the simulation. As a result, Cape Fear Trail and associated sub-grade utilities would be subject to loss. Without action and capital expense by the Village to remove and relocate these utilities, sewer lines and water lines could become exposed to open water. In addition, all four of the existing private septic tanks would become exposed due as a result of the extent of erosion predicted along this area of shoreline.

(2) Retreat (Alternative #2)

The predicted effects of Alternative #2 over the 9-year period of numerical analysis result in a large-scale land loss of 48.6 acres of existing uplands located along western South Beach, the Point, and West Beach. The associated impacts would include the loss of over one mile of roadways, including portions (or all of) the following streets: Water Thrush Court, Royal Tern Court, Cape Fear Trail, Sandpiper Trail, SBHW, and NBHW. Under this alternative, the Village would implement a management plan to relocate critical right-of-ways and utilities. Other secondary streets would likely be removed in advance of the erosion and not relocated. For instance, Sandpiper Trail, Water Thrush Court, and portions of Cape Fear Trail and Royal Tern Court would likely be removed at an expense to the Village. SBHW and NBHW would likely need to be relocated a significant distance landward of the predicted nine-year shoreline position. To do so would necessitate the acquisition of right-of-way corridors on land currently owned and utilized by the BHI Club. New right-of-way corridors would also need to provide the necessary easement areas for new utility lines.

In addition to roads and utility lines, the relocation or demolition of several single-family homes and boardwalks would be required as part of this alternative. Furthermore, at least four septic tanks and attendant lines (for homes located on Cape Fear Trail) would need to be removed in advance of erosion.

Amenities and utilities owned by BHI Club are also subject to direct loss via erosion within the nine-year simulation. These features include a swimming pool, tennis courts, ingress and egress roads, parking lots, the Club facility itself, golf course greens and fairways, and permitted stormwater ponds.

(3) Beach Nourishment with Maintenance of Groinfield (Alternative #3)

For the period of analysis modeled, implementation of Alternative #3 would not cause any direct impact to infrastructure. However, as evidenced in prior years, Village-sponsored nourishment would not be able to keep pace with sand deficits along western South Beach.

The net result would be the endangerment of several residential structures fronting the Point by Year 9 of the model simulation. In addition, deflation of the beach profile in front of BHI Club would place this segment of SBHW at risk of inundation and loss during storm events. Associated utility lines may likewise be susceptible to damage or loss at this location during storms.

(4) Beach Nourishment/Beach Disposal and Sand Tube Groinfield Removal (Alternative #4)

Alternative #4 would result in large-scale upland losses with accompanying major damage to private and public infrastructure. The extent and nature of infrastructure losses associated with this alternative would be very similar (and only slight less) than those associated with Alternative #2. For instance, for Alternative #4 would result in the loss of nearly 5,000 lf of right-of-ways (approximately 930 lf less than that predicted for Alternative #2). Much of the critical infrastructure and amenities for the BHI Club would not be subject to direct loss (at least within the first nine years of the model simulation). However, portions of one stormwater pond would likely be converted to subtidal bottom as a result of the extent of shoreline erosion. Furthermore, deflation of the beach profile would likely result in more frequent overwash, inundation, and subsequent indirect impact to permitted stormwater ponds of the Club.

(5) Terminal Groin with Beach Nourishment (Groinfield Remaining) (Alternative #5)

Alternative #5 results in no predicted or imminent loss of private or public infrastructure.

(6) Terminal Groin with Beach Nourishment/ Removal of Sand Tube Groinfield (Alternative #6)

Alternative #6 likewise results in no numerically *predicted* impacts to private or public infrastructure over the period of analysis. However, beyond Year 9 of the model it should be assumed that the segment of SBHW and any abutting sub-grade utilities, would be endangered in the area lying southward of the BHI Club facility. Simplistically, those impacts would be experienced sometime beyond year 9 due to the removal of the sand tube

groinfield which artificially stabilizes the shoreline segment of predicted impact. The latter coincides with a point of inflection in shoreline orientation which lies eastward of the zone of predicted benefit associated with a terminal structure. As such, the subject section of South Beach shorefront is an area of documented high erosional stress.

5.18 URBAN QUALITY

The location of the project study area is within the Cape Fear River estuary and nearshore waters of the Atlantic Ocean. There are no urban quality impacts associated with implementation of any of the six alternatives considered for the Village of Bald Head Island Shoreline Protection Project.

5.19 SOLID WASTE

Project alternatives evaluated as part of this DEIS would be limited to open waters of the Cape Fear River estuary and the immediate beachfront of Bald Head Island. Disposal of any solid waste material into area waters will not be permitted. However, implementation of Alternative #2 (Retreat) would require demolition of infrastructure and residences as the shoreline recedes into existing developed uplands. The demolition and transport of these materials to an approved solid waste facility would require a solid waste disposal plan in advance of the eroding shoreline. Furthermore, implementation of Alternative #4 (which is predicted to result in considerable upland erosion without planned retreat) would pose a risk of solid waste coming into contact with surface waters as structures (including homes, decking, roads, sub-grade utilities, etc.) become susceptible to loss from acute erosion.

5.20 DRINKING WATER

(1) No Action/Status Quo (Alternative #1)

a. Direct, Indirect and Cumulative Impacts: Maintenance of the Wilmington Harbor navigation channel would be limited to open waters of the Cape Fear River estuary and the immediate beachfront of Bald Head Island. Municipal and private water supplies are not located within the limits of the SMP impact area therefore; drinking water would not be impacted by construction activities associated with the SMP.

(2) Retreat (Alternative #2)

a. Direct, Indirect and Cumulative Impacts: The predicted approximate location of the MLLW shoreline at the end of a nine-year simulation of Alternative #2 indicates that seabed erosion will extend into the existing infrastructure along West Beach and South Beach. The potable water is supplied to Bald Head Island through a forced water main from mainland Brunswick County as well as a series of state approved groundwater supply wells. It is anticipated that threatened utility services, including potable water lines, would be relocated or removed in advance of erosional losses to prevent contamination of the VBHI drinking water supply. Likewise, the Village's groundwater wells are beyond the limits of the nine-year simulated impact area and will therefore likely remain unaffected.

(3) Beach Nourishment with Maintenance of Groinfield (Alternative #3)

a. Direct, Indirect and Cumulative Impacts: Both implementation of the SMP and beach nourishment associated with an independently-sponsored nourishment project would be limited to open waters of the Cape Fear River estuary, nearshore waters of the Atlantic Ocean and the immediate beachfront of Bald Head Island. Municipal and private water supplies are not located within the limits of the SMP impact area therefore; drinking water would not be impacted by construction activities associated with the SMP.

(4) Beach Nourishment/Beach Disposal and Sand Tube Groinfield Removal (Alternative #4)

a. Direct, Indirect and Cumulative Impacts: Implementation of Alternative #4 would not result in the direct impact to the drinking water supply on the island. However, several potable water lines within existing right-of-ways in proximity to South Beach and the Point would be susceptible to erosion-related impact over the nine-year simulation and beyond. These lines would need to be removed and relocated as the shoreline receded. Given the fact that these lines supply water to several residences that may remain unaffected by erosion, some disruption to the drinking water supply is possible during the period that lines are repaired or replaced. In the context of past, present, and reasonably foreseeable future projects, no cumulative impacts to the drinking water supply is expected.

(5) Terminal Groin with Beach Nourishment (Groinfield Remaining) (Alternative #5)

Construction of the terminal groin structure would be limited to open waters of the Cape Fear River estuary and the immediate beachfront of Bald Head Island. In addition, concurrent placement of a sand fillet utilizing either derived materials from maintenance of the federal channel or a nearshore borrow area would be limited to open waters of the Cape Fear River estuary, the Atlantic Ocean and the immediate beachfront of Bald Head Island. No direct, indirect, or cumulative impacts are expected as a result of the implementation of Alternative #5.

(6) Terminal Groin with Beach Nourishment/ Removal of Sand Tube Groinfield (Alternative #6)

No direct, indirect, or cumulative impacts are expected as a result of the implementation of Alternative #6.

5.21 NON-RELEVANT RESOURCES

5.21.1 Hazardous, Toxic and Radioactive Waste

There are no known hazardous, toxic or radioactive wastes in the project study area. There is a potential for hydrocarbon spills from heavy machinery associated with construction and/or demolition activities associated with each of the alternatives. Implementation of Best Management Practices for equipment fueling and maintenance as well as established spill prevention and control measures within the contract specifications would reduce the potential for hydrocarbon spills.

For Alternative #2, it is anticipated that threatened residences and infrastructure (including sub-grade utilities) would be relocated or removed in advance of erosion to reduce the potential for releases of hazardous wastes.

For Alternative #4 (which is predicted to result in acute erosion to South Beach and the Point without planned retreat), residences and infrastructure (including remaining septic tanks) would become susceptible to loss and exposure to open water. As a result, there is potential for the release of hazardous waste under this alternative.

No other adverse effects related to hazardous, toxic, and radioactive waste are predicted for the remaining alternatives.

5.21.2 Noise

Under each of the alternatives considered, there would be temporary increases in noise levels associated with the operation of heavy equipment during dredging, disposal/nourishment, and associated construction work (including demolition and relocation work for Alternative #2). Noise levels should not exceed those of a typical construction site or passing commercial vessel (including daily-operated ferries that arrive and leave from the Bald Head Island Marina). Noise levels would return to ambient levels

upon project completion. Baseline underwater sound levels at the dredge site would temporarily increase during active dredge operations.

5.22 COMPLIANCE WITH ENVIRONMENTAL REQUIREMENTS

The Applicant will comply with all applicable federal and state laws (refer to Section 1.0 for summaries of laws applicable to the proposed action). No construction will occur until such time a Record of Decision (ROD) and Department of Army (DA) permit has been issued for work in Section 10 and Section 404 regulated waters of the United States. The DA permit will also include a Section 404(b)(1) evaluation. A separate Section 401 Water Quality Certification will be required from the North Carolina Division of Water Quality (DWQ). A CAMA Major Permit application will be submitted to the NC Division of Coastal Management (DCM) to ensure compliance with the NC Coastal Area Management Act and the NC Dredge and Fill Law. Furthermore, the Applicant will comply with the requirements of SB 151. These requirements are outlined in Section 1.0 of the DEIS. A copy of the entire legislation is provided in Appendix A. In response to these requirements, the Applicant and its engineered have developed an Inlet Management Plan (refer to Appendix B). No work will be conducted until such time all applicable federal and state authorizations have been issued.