Essential Fish Habitat Assessment

for Maintenance Dredging and Open Water Placement at Hilton Head Island, South Carolina

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Table of Contents

List of Tables

List of Figures

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List of Appendices

Executive Summary

The South Island Dredging Association (SIDA) seeks to dredge and dispose of approximately 300,000 cubic yards of uncontaminated silt, clay, and sand materials, placing them at the southern end of the mouth of Calibogue Sound. Proposed dredge areas include Harbour Town Marina, Gull Point Marina, South Beach Marina, community docks at Portside and Port Villas, Baynard Cove Creek's Community Dock, and channels to and near these areas. The dredging is needed because shoaling of these areas and the existing shallow depths prevent navigation of recreational and commercial vessels in many areas during much of the tidal cycle. SIDA proposes to place the material at a near-shore open water site almost a mile south of Hilton Head Island's shoreline. This is the only practicable and feasible alternative (GEL, 2012).

This report provides information for the National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service (NMFS) regarding effects of the proposed project on federally managed fish and essential fish habitat in accordance with the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act). Potential project effects include effects to fish communities and habitats from dredging in the creeks and discharge of dredged material at the placement site. The potential project effects were evaluated based on available data and a site inspection of the areas to be dredged. This analysis includes the following elements:

- Description of the proposed action;
- Summary of the alternatives considered for the project;
- Literature review of previous site-specific studies describing the project area environment, as well as literature review of studies on the effects of dredged material placement in open water in South Carolina and the US;
- Estimates of essential fish habitat impacts in the dredging action area;
- Estimates of essential fish habitat impacts in the placement action area;
- A description of managed fisheries in the action area;
- Estimates of effects on federally managed fish species; and
- Descriptions of avoidance, minimization and mitigation for the project.

The proposed maintenance dredging will remove sediments from previously disturbed areas, and the project will not include dredging of new areas or at depths beyond those previously permitted and dredged (i.e., there is no "new work" material to be dredged). The proposed dredging will affect the areas of dredging and placement by increasing turbidity during dredging and deepening shallow and intertidal habitats (but not beyond depths previously permitted and dredged). The potential effects on managed fish and fish habitat from the proposed project include:

- Temporary suspension of sediments in the water column which may abrade gills and affects foraging;
- Temporary burial of various portions of up to 56 acres of benthic biota and sand bottom habitat at the placement area;

- Sediments suspended by the dredge cutterhead may settle on creek bottom habitat in adjacent areas;
- Deepening of 50.5 acres in marina basins and creeks from intertidal and shallow benthic soft bottom communities to shallow subtidal habitats; and
- Dredge entrainment and mortality of benthic infaunal organisms.

The potential effects specific to Essential Fish Habitat (EFH) from the proposed project are burial of foraging habitat in the placement area, temporary suspension of sediment in the water column at the placement area, temporary removal of benthic soft bottom communities in the placement area (via burial) and dredging areas, and loss of shallow and intertidal flat habitat in the dredging areas. The area buried by the deposited sediment is small as compared to the size of Calibogue Sound. Also, the project is small as compared to other permitted open water placement projects in the vicinity (e.g., the Port Royal ODMDS is more than ten times larger [960 acres], and the recent Hilton Head beach nourishment at the south end of the island was 670 acres). Although the proposed project is not directly comparable to an ocean site such as the ODMDS or a beach nourishment project, it is helpful to compare these acreages to put the scale of the proposed project in context with other dredging related projects in the region. Species will recolonize disturbed sediment in areas affected by the dredging. The recovery speed of the benthic community in dredged areas varies between a few weeks to 6 months (Clarke, D., and Miller-Way, T., 1992, Van Dolah et al., 1984).

The potential effects to managed fish species are related to temporary turbidity and suspended sediment effects in the water column, removal of shallow habitat, and temporary habitat burial in the placement area. Managed fish species expected to be affected include summer flounder and penaeid shrimp. Coastal sharks, particularly spiny dogfish and Atlantic sharpnose sharks, snapper and grouper species, and Spanish mackerel may experience minor impacts.

The proposed avoidance, minimization, and mitigation measures will significantly reduce the impacts and measure (via monitoring) those impacts which are unavoidable. Table ES-1 summarizes the effects of the proposed project on EFH and federally managed fish species. In short, the dredging project will cause limited and temporary adverse impacts. A temporary benefit would be enhanced feeding opportunities for turbidity tolerant fishes at the dredged material placement site due to transported fauna released from the dredge pipe.

Table ES-1. Summary of potential effects from the proposed project on EFH and managed species.

EFH Type	Effects Summary
Estuarine Emergent (Saltmarsh/Brackish Marsh)	Deepening of area within sand spit to be removed. Potential for indirect effects due to bank slumping.
Estuarine Unconsolidated Substrate	Temporary burial of various portions of up to 56 acres of sandy bottom in the placement area. No long term effects.
Estuarine Scrub Shrub	No effects. Not in impact area.
Seagrass/SAV)	No effects. Not in impact area.
Oyster Reef and Shell Bank	Adjacent to dredging area, may be temporarily affected by suspended sediments.
Tidal Flats	Channel areas dredged to increase depth.
Freshwater Wetlands	No effects. Not in impact area.
Water Column - Tidal Creek	Temporary suspended sediments during dredging.
Water Column - Calibogue Sound	Temporary suspended sediments during dredged material placement.
Coral	Sea whips in hard bottom areas north of dredged material placement area may be temporarily affected by low levels of suspended sediments from the placement area.
Coral Reefs	No effects. Not in impact area.
Live/Hard Bottom	Areas north of dredged material placement area may be temporarily affected by low levels of suspended sediments from the placement area.
Artificial Reefs	No effects. Not in impact area, nearest are north of Sound near Port Royal ODMDS.
Sargassum	No effects. Not in impact area, floating *Sargassum* will not be affected by subsurface turbidity.
MANAGED FISHES	
Bluefish	No effects. Not common in area during season of dredge activity.
Summer flounder	Deepening of foraging habitat in creeks, temporary sediment impacts to larvae and eggs, deepening of shallow nursery habitat in creeks, temporary disturbance of creek habitat during dredging.
Snapper and grouper species	Deepening of shallow nursery habitats in creeks, temporary sediment impacts to larvae and eggs in nearshore habitat during placement.
Dolphin	No effects. Not common in impact area.
Cobia	No effects. Not common in area during season of dredge activity.
Spanish mackerel	Temporary turbidity interference with foraging, sediment interference with prey distribution.
Coastal sharks	Temporary turbidity interference with foraging, sediment interference with prey distribution.
Brown, pink, and white shrimp	Deepening of shallow habitats in creeks, temporary sediment impacts to all life stages in nearshore habitat during placement.

1 Proposed Action

The South Island Dredging Association (SIDA) has requested a permit to conduct maintenance dredging in Baynard Creek, Braddock Creek and Harbour Town Yacht Basin on the south end of Hilton Head Island, South Carolina (Figure 1-1). This maintenance dredging will remove sediments that have settled in these navigation channels, and the project will not include dredging of new areas or at depths beyond those previously permitted and dredged (i.e., there is no "new work" material to be dredged). The project dredge areas and proposed dredge depths are summarized in Table 1-1. SIDA proposes to place approximately 300,000 cubic yards of dredged materials at the mouth of Calibogue Sound. The project dredge and placement areas are shown in Figure 1-2. The placement site is within the inland waters of Calibogue Sound. As shown by Figure 1-2, the site is on the landward side of the baseline points and tangents from which the territorial sea is measured. "Ocean waters" are defined as the waters of the open seas lying seaward of the baseline.

Table 1-1. Dredge areas and depth for each site

Location		Acres	Depth (MLW)
Harbour Town Marina			
	Entrance Channel	6.5	-8
	Marina	8.3	-8
Braddock Cove Creek			
	Entrance Channel to South Beach Marina, including Gull Point Marina	12.6	-8
	South Beach Marina	2.1	-8
	Upcreek of S. Beach Marina to Port Villas	2.6	-6
Baynard Cove Creek			
	Entrance Channel	13.6	-8
	Community Dock	1.5	-5
	Creek	3.3	-6
	TOTAL	50.5	

Because of the quantity of material to be dredged, and the fact that only a shallow draft small dredge can navigate the creeks to excavate the material (which limits the production rate of the dredge), the project will require up to 6 months to complete. The proposed project would start in the month of November and continue through the winter and spring months, ending as late as the end of April. Dredging would be conducted continuously, except when repositioning the dredge or conducting equipment repair or maintenance. The duration of the impact for the tidal creeks will be weeks for the creeks, and months for the open water areas.

Based on a review of geotechnical data collected by Applied Technology and Management (ATM) (1999) and by GEL Engineering (GEL) (2008), the maintenance material is mostly silt and clay with a variable fraction of sand. Material composition and sediment grain size depends upon the location from which it is extracted. Table 1-2 summarizes the 2008 grain size analysis data for the dredge sites.

The project proposes to use a small hydraulic dredge with a maximum intake diameter of 16 inches (although a 10-inch dredge will most likely used), and transport the materials via a pipe to Placement Site 5 (Figure 1-2). Site 5 is located in an area with rippled sand bottom habitat. The location of the proposed pipeline discharge at Placement Site 5 is approximately 4,600 feet from the shoreline of Hilton Head Island and approximately 8,100 feet from the shoreline of Daufuskie Island. Figure 1-3 also shows an alternative dredged material placement site (Site 2) that is discussed in this report. Site 2 is an alternative placement site that was considered previously, but it was removed from consideration in order to reduce the potential project impacts. The dredging footprint ranges from 35 to 50 feet wide in the channels, depending upon the channel's width and distance from oyster reefs and saltmarsh.

Table 1-2. Summary of grain size distribution at dredge sites

Sample	Site Description	Sand	Coarse silt	Fine silt	Clay
HT-2	Harbour Town Marina – entrance	8	12	38	42
HT-3	Harbour Town Marina - center of basin	22	16	28	34
Gull PT-1	Gull Point Marina in Braddock Cove Creek	5	15	38	42
S. Beach-1	South Beach Marina in Braddock Cove Creek	5	21	46	28
Brad-2	Middle of Braddock Cove Creek	8	18	34	40
Bay-2	Middle of Baynard Cove Creek	6	26	30	38
CD-1	Community dock in Baynard Cove Creek	7	25	31	37
Average		9	19	35	37
Standard Deviation		6.0	5.2	6.2	5.0

The discharge pipeline would also be a maximum of 16 inches in diameter or less, and it would lead from the dredge site along the shoreline in water depths sufficient for it to remain off the bottom and convey materials to the chosen site for placement. The pipelines would be floated at the surface except when crossing channels, where they would need to be submerged and anchored (using heavy chains with weights on the ends) so that it does not create a navigation impediment.

For the purposes of this report, the Project Action Area includes the marina and creek dredge areas (listed in Table 1-1), the pipeline route to the placement area, and the Site 5 placement area. These Action Area elements are included in Figure 1-4.

Environmental concerns surrounding the project include the effects to the creek channel bottom from dredging, as well as effects to fish communities and habitats at the placement sites. This report provides information for the National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries

Service (NMFS) regarding effects on federally managed fish and essential fish habitat in accordance with the Magnuson-Stevens Act Fishery Conservation and Management Act (Magnuson-Stevens Act).

GEL Engineering (2012) and ATM (2000a) conducted detailed evaluations of the alternative designs for the proposed project, including potential alternative placement sites for the dredged materials (e.g., upland sites and ocean sites). The proposed project evaluated in this report is the only practicable and feasible project identified by GEL Engineering (2012).

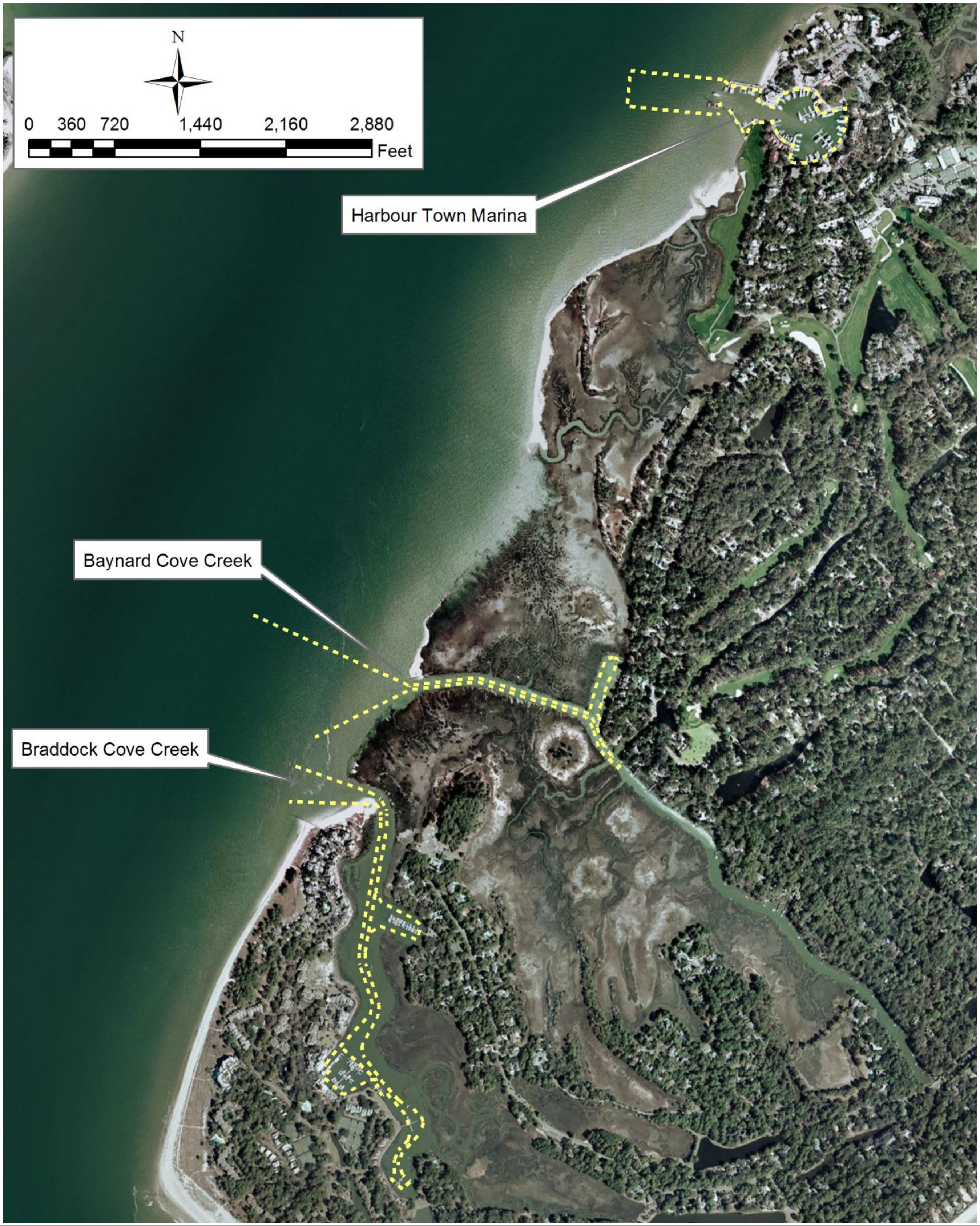

Figure 1-1. Overall proposed areas to be dredged.

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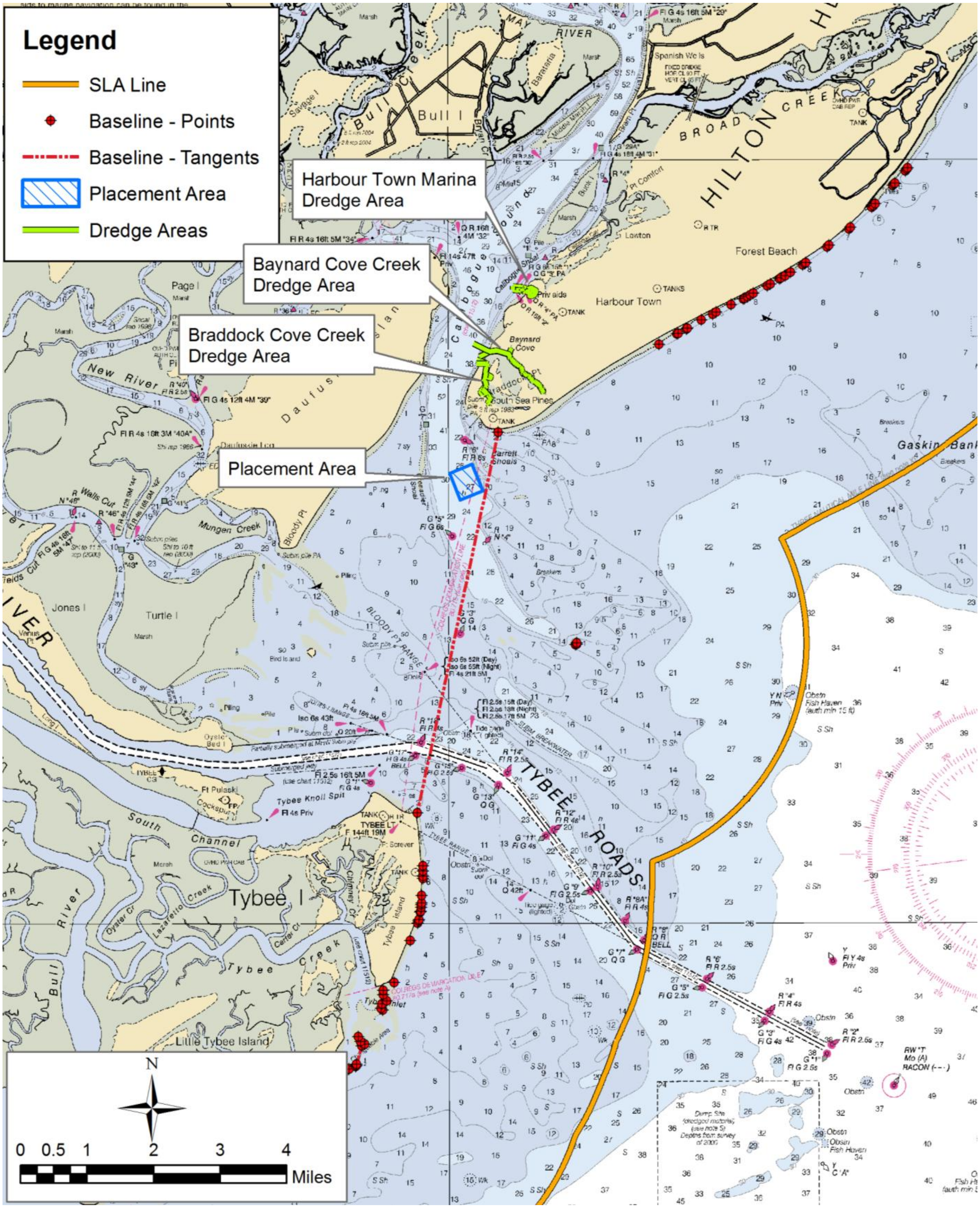

Figure 1-2. Project location map.

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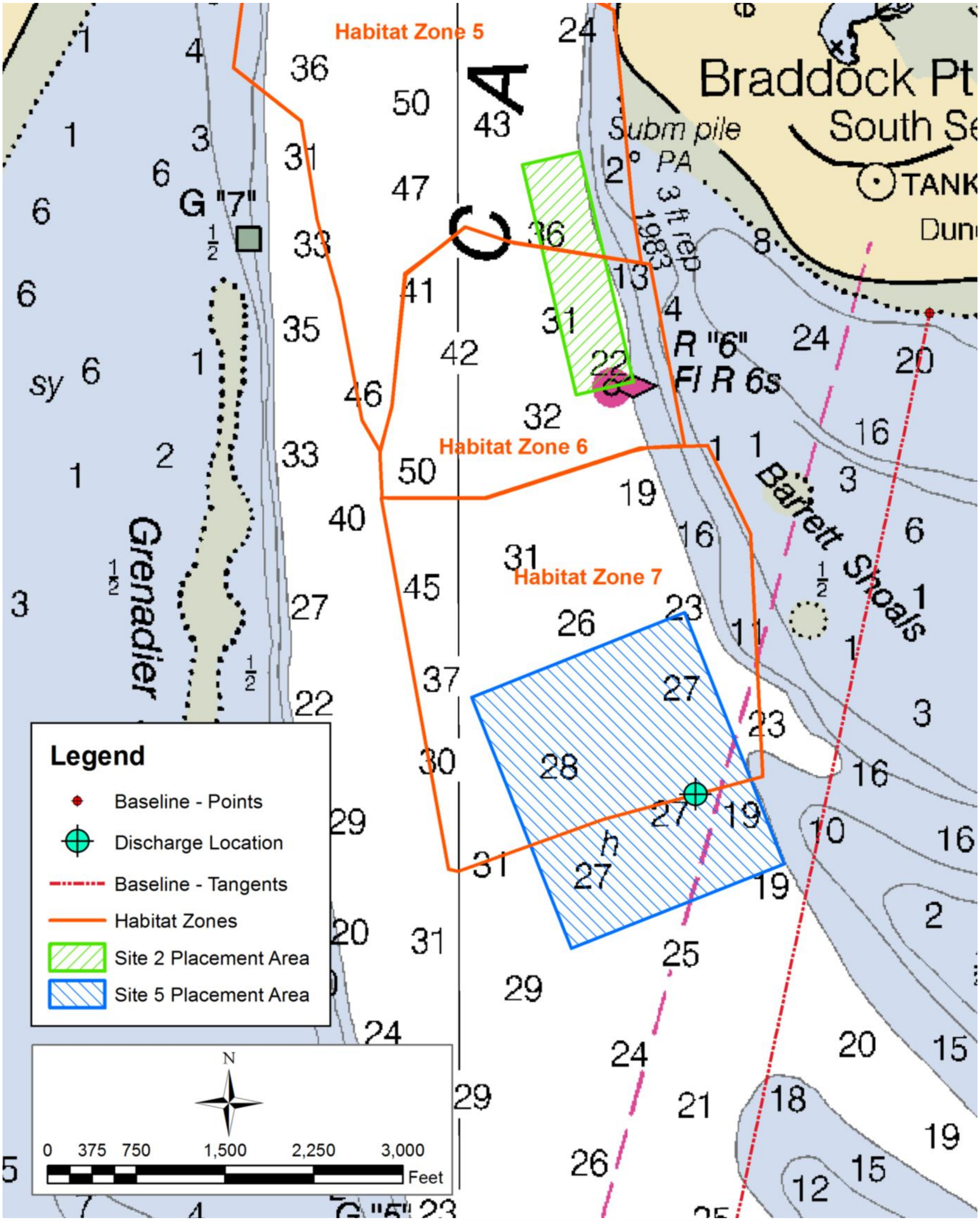

Figure 1-3 Dredged material placement area alternatives, including proposed Sites 5 and earlier alternative Site 2. Included are habitat zones identified by ATM (2000a).

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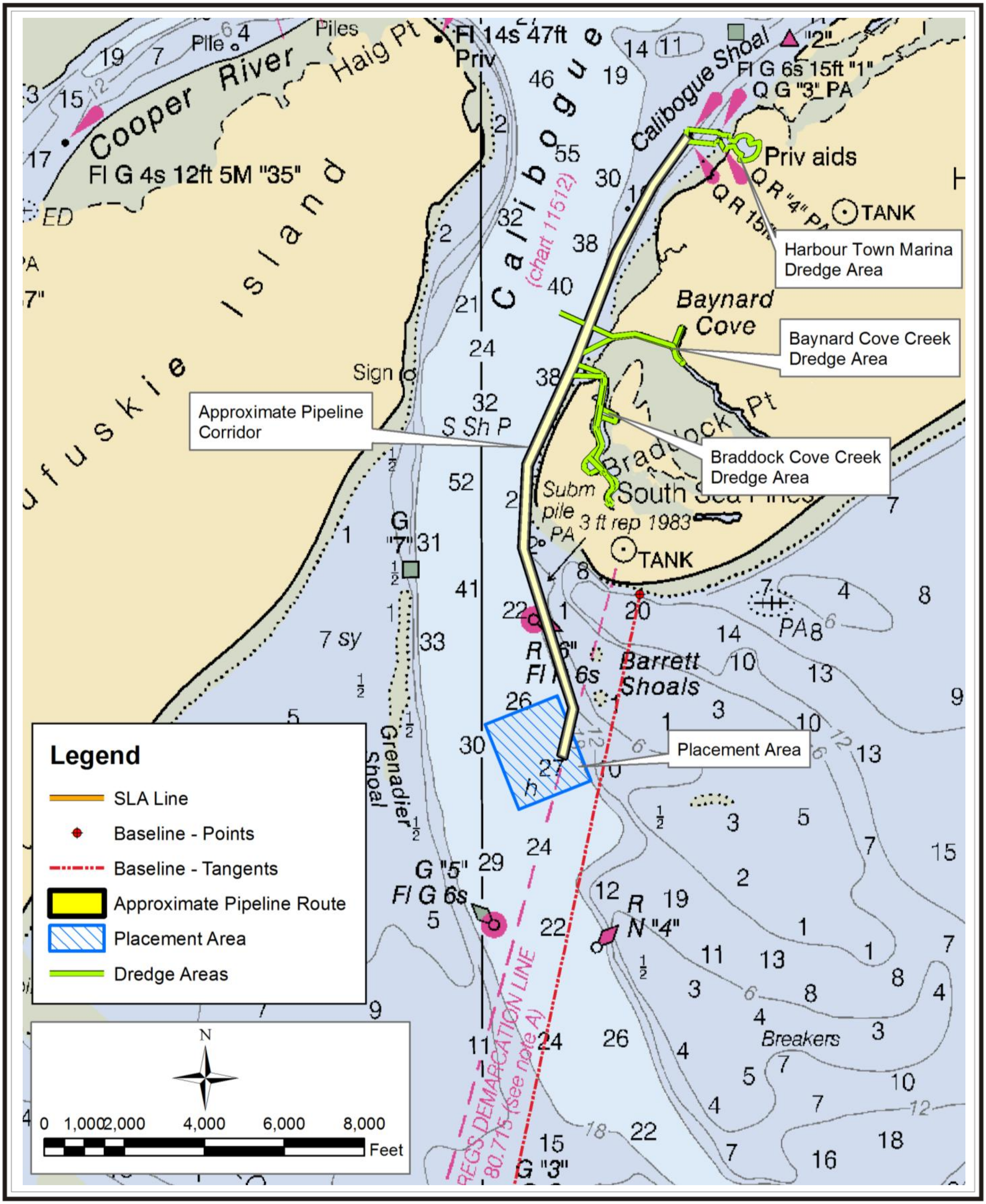

Figure 1-4. Project action area map.

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2 Literature Review

Literature reviewed for the proposed project include the benthic survey of the proposed inshore and nearshore placement sites in Calibogue Sound conducted by Barry Vittor & Associates (BVA) in 2000, engineering and environmental studies prepared by ATM for the 2000 permit application, and studies by SC Department of Health and Environmental Control (SCDHEC), SC Department of Natural Resources (SCDNR), joint public notices, and other unpublished literature. It also included review of literature on the effects of dredged material placement in open water in South Carolina and the US (Van Dolah et al. 1984, Newcombe and MacDonald 1991, Clarke and Miller-Way 1992, Nightingale and Simenstad 2001, Wilber et al. 2005).

2.1 Dredging Areas

Because of the lack of detailed information in the literature specific to the creeks and tributaries around Hilton Head Island (including those areas proposed to be dredged), documents describing adjacent areas were reviewed. To the east of the area to be dredged are the mouths of Broad Creek and May River, both of which have management plans (Town of Hilton Head 2002, OCRM and Hilton Head 2008). The May River is an Outstanding Resource Water meaning its surface waters provide outstanding recreational opportunities, support valuable fisheries and wildlife habitat, have good water quality, and are not significantly impacted by human activities. No project-related effects, positive or negative, were identified from reviewing the plans for the May River or Broad Creek.

2.2 Dredged Material Placement Area

The effects of dredging vary, and much depends on the type of habitat that the dredged material is placed upon, with similar grain sizes being the best match. In terms of the fish community, the egg and larval life stages are the most vulnerable to physiological effects and habitat changes. With these parameters in mind, understanding the details of the affected coastal habitat is critical.

BVA's 2000 study provides the best available information on the area proposed for dredged material placement. In this study, habitat maps were created using a combination of techniques. Side-scan sonar previously conducted by ATM was complemented by a rigorous collection effort using dredge and grab methods to confirm mapped bottom types and characterize the benthic and epibenthic communities. These data are used to characterize the existing conditions at the open water placement site, as described in Section 3.6.

The recommendations of BVA were that hard bottom habitats (e.g., rock outcrops or scoured rock) identified in Calibogue Sound should be avoided. While soft substrates contain a diverse community within their sediments, the species living there are more able to recolonize following burial and, consequently, are more resilient in the long term. BVA (2000) provided a detailed description of the succession processes in soft sediment communities following burial, and reviewed available literature on recruitment and recovery of areas affected by dredge material placement.

Other habitat characterizations of the shallow coastal zone near Hilton Head Island include ongoing work by the SCDNR and studies conducted for the permitting of dredged material placement and beach renourishment. The South East Regional Taxonomic Center (SERTC) of SCDNR conducted a research cruise to survey the hard bottom areas on the continental shelf near Hilton Head Island. The cruise did not include a survey of the proposed dredged material placement area (Site 5); however, it located "suspected" hard bottom areas east of Hilton Head Island, as shown in Figure 2-1.

2.3 Water Quality in Calibogue Sound

Calibogue Sound has been investigated in the greatest level of detail for the upper reaches, which are Outstanding Resource Waters. Therefore, water quality monitoring data from SCDHEC's four sampling stations in Calibogue Sound were reviewed. These monitoring sites are located immediately upstream from the proposed dredge areas. The study found that "aquatic life and recreational uses are fully supported at all sites and a significant decreasing trend in fecal coliform bacteria suggests improving conditions for this parameter."

2.4 Fisheries and EFH in Calibogue Sound

Efforts also were made to gather available fisheries information for Calibogue Sound through personal communications with researchers at SCDNR, University of South Carolina-Beaufort, Coastal Carolina University, College of Charleston, and among the fishing charter captains at Broad Creek Marina on Hilton Head Island. The finding was that hydroacoustic studies of spawning fish and marine mammal activities are underway by the University of South Carolina-Beaufort (Montie, personal communication, 2012), and a few other studies are being conducted on fisheries. However, no project work is underway in the areas affected by the proposed dredging project. Adjacent to Barrett Shoals, fishing captains indicated that the area is used for charter boats to fish for various species, including sharks, rays, and other fishes (Roth, Majers and Hughes, personal communications, 2012).

The Port Royal ODMDS Environmental Impact Statement (EIS) (USACE 2004) contains details that are relevant for comparing the effects to fisheries from this proposed project with the previously permitted project. The permitting of the 1.5 square mile ocean site included solicitations from resource agencies and the general public. Implementation of the proposed project impacted approximately 1.5 square miles of marine water column (average depth 36 feet) and non-vegetated bottoms utilized by various life stages of species comprising the red drum, shrimp, and snapper-grouper, coastal migratory pelagic fishes, spiny lobster and calico scallop management complexes.

The EIS synthesized previous studies to describe the ocean waters affected by the ODMDS selection. The area's common finfish included all life stages of the following families: Clupeidae (herring, shads, sardines, or menhaden), Sciaenidae (drums or croakers), Bothidae (flounders), Gadidae (cod, haddock, whiting, or pollock), Carangidae (jacks, pompanos, jack mackerels, or scads), Mugilidae (mullet), and Triglidae (sea robins). Commercially important species of shellfish in the Port Royal Sound area included shrimps, crabs, whelks, and oysters. The area was identified as important for whelk fisheries. The studies did not address commercial shrimping, which occurs primarily 3 miles seaward of shore in South Carolina. With the absence of structures such as piers and reefs in the proposed ODMDS placement area, no threat was identified to finfish.

While the area was used for whelk, mackerel, and other types of commercial, sport-fishing and charter businesses, the project was found to have no substantial individual or cumulative impacts on managed EFH or fisheries (p. 101 of EIS citing letter dated October 23, 2003 by NMFS). The project was also determined by the Protected Species Division of NMFS to have no effect on listed species or critical habitat protected by the ESA under NOAA Fisheries purview (p. 101 citing letter dated December 10, 2003 by NMFS).

In 2005, another study conducted by the US Army Corps of Engineers (USACE) during the permitting of the Hilton Island Beach Renourishment Project assessed the area of Barrett Shoals likely to be affected by inland open water placement. The renourishment project used Barrett Shoals as a sand source for beach fill that affected 670 acres of estuarine substrates and emergent wetlands utilized by several managed fisheries. The area around South Beach was renourished during this project and is immediately east of the proposed placement area. The contours and bathymetry collected for this project updates those that were used for the previous studies in 1999 and 2000 by ATM. For this project, the determination by the USACE was that the proposed project would not have a substantial individual or cumulative adverse impact on EFH or federally managed fisheries, including the mining of Barrett Shoals. However, they determined the project was likely to have an adverse effect on loggerhead sea turtle critical habitat as well as piping plover critical habitat due to the beach fill (USACE 2005). Documents for the permit application for Calibogue Cay to dredge its creek and place the material in an upland disposal site were also reviewed. In its Joint Public Notice for this project, the USACE noted that the proposed project would impact 13.77 acres of estuarine substrates and emergent wetlands utilized by red drum, shrimp, and the snapper-grouper management complexes. Their determination was that the proposed project would not have a substantial individual or cumulative adverse impact on EFH or federally managed fisheries (USACE 2008b).

The SCDNR dredging advisory summarizes vulnerability and seasonal abundance of select species for the three habitat types present in the project area: smaller inlet entrances, high salinity bay or sound, and high salinity creeks (Van Dolah and Berquist 2009). Species considered include the brown, white, and pink shrimp (*Penaeus aztecus*, *P. setiferus*, and *P. duorarum*, respectively), red drum (*Sciaenops ocellatus*), spotted seatrout (*Cynoscion nebulosus*), flounder (*Paralichthys* spp.), shad (*Alosa sapidissima*), shortnose sturgeon (*Acipenser brevirostrum*), Atlantic sturgeon (*Acipenser oxyrhynchus*), American eel (*Anguilla rostrata*), oysters (Ostreidae spp.), hard clams (Mercenaria *mercenaria)*, and sea turtles (Cheloniidae and Dermochelyidae spp.). The resulting tabular matrix (provided in Appendix A) not only provides a useful reference, but it illustrates the tradeoffs and conflicts inherent in determining when to conduct such projects in the marine and estuarine environment.

Based on the above literature and data review, there is sufficient information to characterize existing EFH in the area proposed for dredged material placement (Site 5). Additional information on the proposed areas to be dredged was obtained during a field visit in March 2012. Descriptions of these sites are provided in the following section.

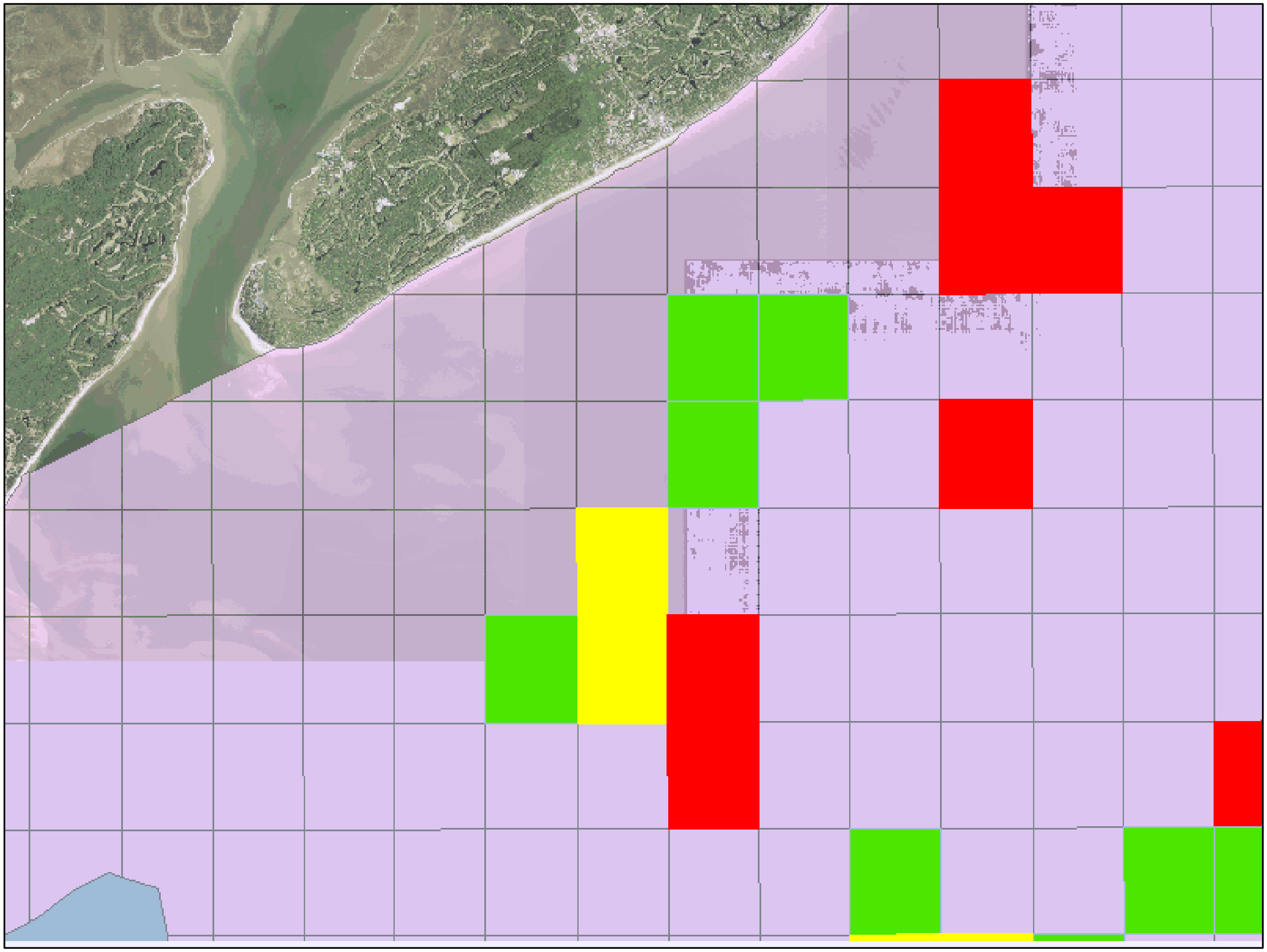

Figure 2-1. Survey of Hard Bottom Areas on the Continental Shelf. Red is evidence of hard bottom reef in that area, yellow is probable hard bottom, and green is no evidence of hard bottom (SCDNR 2012.)

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3 Existing Conditions

The area proposed for dredging was reviewed during a field visit on March 23, 2012 by Bridget Lussier, a senior biologist with MG Associates (MGA), and Tom Hutto, a professional geologist and principal with GEL Engineering. Prior to field deployment, the following information was reviewed: detailed recent aerial photographs, proposed project plans overlain on the aerials, defined “area of influence”, list of protected species and species of concern known to inhabit the site, agency comments on the proposed scope of work, and the outline of information for the EFH Assessment and Biological Assessment (BA).

During the site visit, the project impact areas and adjacent areas were documented. The dredged material placement areas were not investigated. The sites were viewed at high tide in the morning (8:55) and low tide (2:35) in the afternoon. The overall habitat quality of the proposed dredging areas was evaluated during and following the site visit. The proposed areas to be dredged have been previously dredged, and no pristine or undisturbed habitats will be affected.

The following sections describe each site from the north end of the project area to south, and individual sites are described from Calibogue Sound to the upper reaches.

3.1 Harbour Town Marina

Harbour Town Marina is located at the northeastern end of the Action Area. Harbour Town is economically important to the marine, sport-fishing, tourism, and golf industries of Hilton Head, particularly for the Heritage Golf Tournament. Shallow-draft vessels that are docked in the neck area of the marina, which is in most need of dredging, are commercial charter vessels. The basin was last dredged in 2003. Figure 3-1 shows the proposed dredge footprint at Harbour Town. Site photographs 1-6 illustrate the conditions during the March 23, 2012 site visit.

The inner basin is bulk-headed with steep sides all around and no natural intertidal habitat, except from fouling communities on the bulkhead and docks. In the neck of the harbor, toward the mouth, there are two areas of tidal flats. These areas have shoaled just inside of the entrance channel east of the mouth and are proposed to be dredged. The southern tidal flat is wedge-shaped and approximately 45 feet long on each side. The northern one is also wedge-shaped, and approximately 25 feet long on either side. The entrance channel in Calibogue Sound is also proposed to be dredged. The substrate throughout the action area is a combination of sand, silt and clay.

The area was viewed within an hour and a half of low tide and no oyster reefs, salt marsh, or emergent habitats – other than small areas of tidal flat noted above – were identified. A salt marsh restoration project was noted to the south of the seawall in the golf course area. However, this project is outside of the area of influence and would not be affected by the proposed dredging.

The pipe conveying dredged material from the harbor will run along the shallow subtidal area of the shoreline, off the bottom of the Sound and away from intertidal and subtidal habitats. There are beaches to the north of the seawall, but they are not expected to be affected by the proposed dredging. The pipeline will be submerged where necessary to avoid blocking navigation.

Marine birds that were observed during the visit included brown pelicans (*Pelecanus occidentalis*), herring gulls (*Larus argentatus*), and laughing gulls (*Larus atricilla*). Apart from cannonball jellies (*Stomolophus meleagris*), no other marine life was observed.

3.2 Baynard Cove Creek

Baynard Cove Creek (Baynard) is a tidal creek of approximately 125 feet in width that extends from Calibogue Sound southeast to a culvert along the road. Approximately 1,500 linear feet upstream from its mouth is a side channel that forks to the north, and at the head of that is the Community Dock. The area at the head of the creek, dock, and the approaches were viewed during the site visit at high and low tide. Figure 4-2 shows the proposed dredging area for Baynard Cove Creek's mouth and the Community Dock. Site photographs 7 through 17 portray the area proposed for dredging, as well as upper Baynard areas that are no longer under consideration for the proposed project.

The creek banks from the mouth to the northern side channel consist of salt marsh and maritime scrub wetlands. The existing channel contains intertidal and subtidal unconsolidated substrates of clay, silt and sand. From the aerial photographs, it appeared that the channel dredging would primarily affect subtidal and intertidal mudflat; however, some areas of oyster reef are present, particularly upstream of the north channel where the Community Dock is located. Field surveys confirmed that the middle and upper reaches of Baynard have oyster reefs near the proposed impact areas. The proposed project design will provide a 10 foot buffer from oyster reefs or emergent marsh when the proposed channel is dredged such that these resources will not be affected.

The previously permitted project included dredging the upper reaches of Baynard beyond the north channel leading to the Community Dock. The upper reach of Baynard has not been dredged for approximately 40 years. During this time, substantial oyster reefs have developed along the creek's banks. After noting the presence of this established tidal creek habitat, the project extent was reduced to avoid the upper reaches of Baynard, so that a 10-foot buffer between oyster reefs and the area affected by dredging could be maintained. Thus the upper two-thirds of Baynard are no longer proposed for dredging under this project. The new extent of dredging will be to the second dock upstream from the northern side creek where the Community Dock is located. By extending just past the side creek, the mouth of that creek will not refill after dredging as quickly. Further, the width of the creek in this area is adequate to protect oyster reef resources along the banks.

Wildlife noted during the survey included two tri-colored herons (*Egretta tricolor*) and a great egret (*Ardea alba*) at the Community Dock, a snowy egret (*Egretta thula*) at the head of the creek, unidentified fish under 1 inch long in the shallow waters of the creek, and numerous cannonball jellies.

The dredge pipe will be floated along the creek and will be submerged at the mouth of the creek to allow boat access. No resource uses were noted during the survey; however, all docks observed had small motor vessels and many had kayaks. The Community Dock had a kayak rack as well. Existing impacts noted included the docks, most of which rested on the mud during the low tide portion of the survey.

3.3 Braddock Cove Creek

Braddock Cove Creek (Braddock) is a much larger tidal system than Baynard Creek, with a narrow entrance (approximately 100 feet wide) opening to an approximate bank width of 250-350 feet. The proposed dredge area in the mouth of Braddock Cove Creek to just from Gull Point Marina is shown in Figure 3-3. As shown, there is a small area of accreting sand spit at the inlet which is proposed for removal. Site photographs 18-27 illustrate conditions in the mouth of Braddock Creek during the March 23, 2012 site visit.

Travelling from the mouth, Gull Point Marina is positioned first in a side channel on the east bank, then a large cut basin holds the South Beach Marina on the west bank, followed by five small docks along both banks. Three of these docks are on the west bank are community docks: one set of docks for the six Portside homes and two sets for the Port Villas condominiums. There is also one dock each for two individual homes on the east bank. Most of the west bank is bulk-headed and much of it has a rock revetment. Along the east bank, most of the shoreline is not reinforced and is densely vegetated by cordgrass species (*Spartina alterniflora, S. cynosuroides,* and *S. patens*), depending on the elevation.

The greatest diversity of fauna was noted at the mouth of the creek, where wildlife observed included two bottlenose dolphin (*Tursiops truncatus*), two osprey (*Pandion haliaetus*), cormorants (*Phalacrocorax auritus*), and laughing gulls. The following marine species were found washed up on the sandy beach or seen in the water: spider crab (*Libinia emarginata*), polychaetes (*Nereis* spp.) in a spawning swarm, ghost crab holes (*Ocypode quadrata*), stone crab (*Menippe mercenaria*), fragments of sand dollar (*Mellita isometra*), channeled whelk (*Busycotpus canaliculatus*), pen shell (*Atrina seminuda*), oyster (*Crassostrea virginica*), numerous sea whips (*Leptogorgia virgulata*), and unidentified calcareous alga (*Penicillis* spp.) On the accreting spit, vegetation included sea rocket (*Cakile harkeri*), dune grass (*Distychlis spicata*), sandspurs (*Cenchrus tribuloides*), pennywort (*Hydrocotyle bonariensis*), beach croton (*Croton punctatus*), and dried *Sargassum* spp. In the high dune above the area proposed for removal, dense sea oats (*Uniola paniculata*), sea oxeye daisy (*Borrichia fruescens*), marsh elder (*Iva frutescens*), beach croton, occasional yucca (*Yucca aloifolia*), prickly pear (*Opuntia compressa*), and sandspurs were noted. A bulkhead separates the residential properties from the dune.

The area is frequented by boaters, including commercial kayak charters and small private and charter vessels. Existing impacts included erosion along the beach and a 1-2 foot beach scarp created by wave action. A long rock revetment was built in 2010 to prevent erosion and has caused considerable shoreline accretion to the south of the project area. This groin will likely help reduce additional sediment accretion in the mouth of the creek, once the dredging project has been conducted.

Careful inspection of the sand spit was conducted to check for the presence of seabeach amaranth (*Amaranthus pumilus*), which is a federally threatened species that can be found on sand spit habitats and is a dune pioneer species. No amaranth was noted, and because it has difficulty competing with other beach plants, it is unlikely to occur here. However, surveys later in the growing season (i.e., May) will be conducted to ensure that this species is not present in the area affected by dredging. This species is discussed further in Section 5.1.5.

3.4 Gull Point Marina

Gull Point Marina is located approximately 1,000 feet from the mouth of Braddock, in a cut side channel on the east bank. The sides of the channel are natural and consist of *Spartina alterniflora* and intertidal mudflat. Along the south shore of the channel there are some oyster reefs that have developed outside of the proposed dredge footprint. The marina is completely intertidal as shown by the site photographs. During mid-tide conditions (not shown), 20 snowy egrets and a great blue heron (*Ardea herodius*) were observed foraging for small fish in the shallows. Dense concentrations of mud snails (*Littorina* sp.) and hermit crabs (*Paguridae* sp.) occupy the shallow intertidal mudflats. Site photographs 28-32 portray the Gull Point Marina conditions.

The marina includes 36 slips and serves the property owners of Gull Point. All the vessels at the marina are shallow draft and can only access Braddock Creek within 2 hours of high tide.

3.5 South Beach Marina and Upper Braddock Cove Creek

South Beach Marina is located approximately 2,000 feet from the mouth of Braddock, on the west bank. It is a cut basin from the creek and contains a large number of docks as well as a busy commercial center of restaurants and gift shops. The entire basin is bulk-headed and much of it also has a rock revetment. Along the southwestern side of the bulkhead, the slope has oyster reef with approximately 30 percent cover. This area is outside of the dredge footprint and will not be affected by the proposed project. Wildlife noted during the South Beach Marina survey included laughing gulls, herring gulls, and brown pelicans at the marina.

The proposed dredge footprint includes the existing marina and access channels, as well as the channel up to the head of the creek, as shown on Figure 3-4. Site photographs 33-27 portray South Beach Marina. Above South Beach Marina, Braddock Creek continues for an additional approximate 1,000 feet in a predominantly bulk-headed channel. On the west side of the channel are Portside homes and Port Villas condominiums. On the east side is Wren Point. There are three community docks on the west side that would be served by the proposed dredging project: one for the Portside homes and two dock trees for the Port Villas condominiums. There are two docks on Wren Point that will benefit from the proposed dredging. On the west side, the channel is bulk-headed for its entire length, while on the east side, it appears to be more natural without reinforcement. Site photographs 38-42 portray upper Braddock Cove Creek above South Beach Marina.

Four snowy egrets were observed perched on a log on the east shore of Braddock Creek and slightly upstream from the marina. Brown pelicans were observed on docks. Mullet (*Mugil* sp.) were observed jumping in the creek during high tide. In some areas, there are oyster mounds near shore as well as oyster reefs along the shore. These habitats will be avoided by dredging ten feet or more away from any marsh grass or oyster reefs.

3.6 Open Water Placement Area

The proposed open water placement area is located in waters of the United States as regulated by the Clean Water Act, or simply Calibogue Sound. The proposed discharge location is approximately 4,600 feet south southwest of Hilton Head Island. The estuarine bottom at the site is relatively flat, with depths ranging between 26 and 28 feet Mean Lower Low Water (MLLW).

The bottom habitat at the proposed placement area is characterized by BVA's 2000 study. In this study, habitat maps were created using a combination of techniques. Side-scan sonar previously conducted by ATM (2000) was complemented by a rigorous collection effort using dredge and grab methods to confirm mapped bottom types and characterize the benthic and epibenthic communities. Grab and dredge samples were collected and species were identified and enumerated. The resulting combination of species richness for a given location and habitat mapping throughout the mouth of Calibogue Sound was used to characterize the benthic habitats and avoid impacts due to dredged material placement. A summary of the habitat map and sediment composition findings is shown in Figure 3-5.

Trawls conducted by BVA in 2000 were not performed in a discrete area, but ran along an escarpment in the northern sites and ended at Placement Site 5. Figure 3-6 shows the location of the trawls. Figure 3-7 presents the catch of Trawl 6. In general, the trawls yielded Hauff's Alcyonidium (*Alcyonidium hauffi)*, sponges (*Porifera*), and whelks (*Busycon* sp.). While sea whips are not listed in the trawl catch, they are shown in the photographs and preliminarily identified as *Leptogorgia* sp. Therefore, it appears that there are sea whip and sponge communities in adjacent hard bottom areas to the north of Site 5.

In total, BVA identified 6,702 organisms representing 243 taxa. The project report emphasized that the results show presence and absence, not abundance, as the methods used (trawl and grab) can miss concentrations of individuals. The dominant taxa are shown in BVA's report for each station. In the report's detailed species list, the catch for all stations was composited, rather than listed separately.

The proposed placement area at Site 5 was characterized as containing a rippled sand bottom. Species observed within the area include those collected at stations 7-17, 18, 45, 65, 67, 82, and 83. The sediment and faunal characteristics for Site 5 are presented in Table 3-1 below.

Table 3-1. Site 5 sediment and faunal characteristics (from BVA, 2000)

Station	Percent Gravel /Sand/Clay	Dominant Taxa	Subdominant Taxa
7-17	16/84/0.3	70 percent Annelida	Mollusca, Arthropoda, Echinodermata
7-18	11/88/0.6	88 percent Annelida	Arthropoda
7-45	12/88/0.3	66 percent Annelida	Mollusca, Arthropoda, Echinodermata
7-65	33/50/17	59 percent Annelida	Mollusca, Echinodermata, Arthropoda
7-82	34/53/13	53 percent Annelida	Mollusca, Arthropoda, Echinodermata
7-83	13/86/0.7	60 percent Annelida	Arthropoda, Mollusca, Echinodermata

Grab samples yielded primarily annelids, with polychaetes dominating the catch, as well as molluscs, arthropods, echinoderms, and unidentified taxa. Of the species listed in BVA's report (2000), unidentified penaeid shrimp, which includes the federally managed species of brown (*Penaeus aztecus*), pink (*P. duorarum*), and white shrimp (*P. setiferus*), were found at one station and represented 0.01 percent of the catch.

Based on the species list composited by BVA (2000), no golden crab (*Chaceon fenneri*), calico scallop (*Argopecten gibbus*), spiny lobster (*Panulirus* argus*)*, or other species of managed shrimp (royal red [*Pleoticus robustu*], rock [*Sicyonia brevirostris*], or seabob [*Xiphopenaeus kroyeri*]) were observed. The bryozoan, *Alcyonidium,* noted above as being found during trawls is listed as a species of conservation concern by the South Carolina Department of Natural Resources (SCDNR). However, no federal or state protection is conferred by this distinction.

Figure 3-1. Harbour Town Marina Dredge Area

MGA
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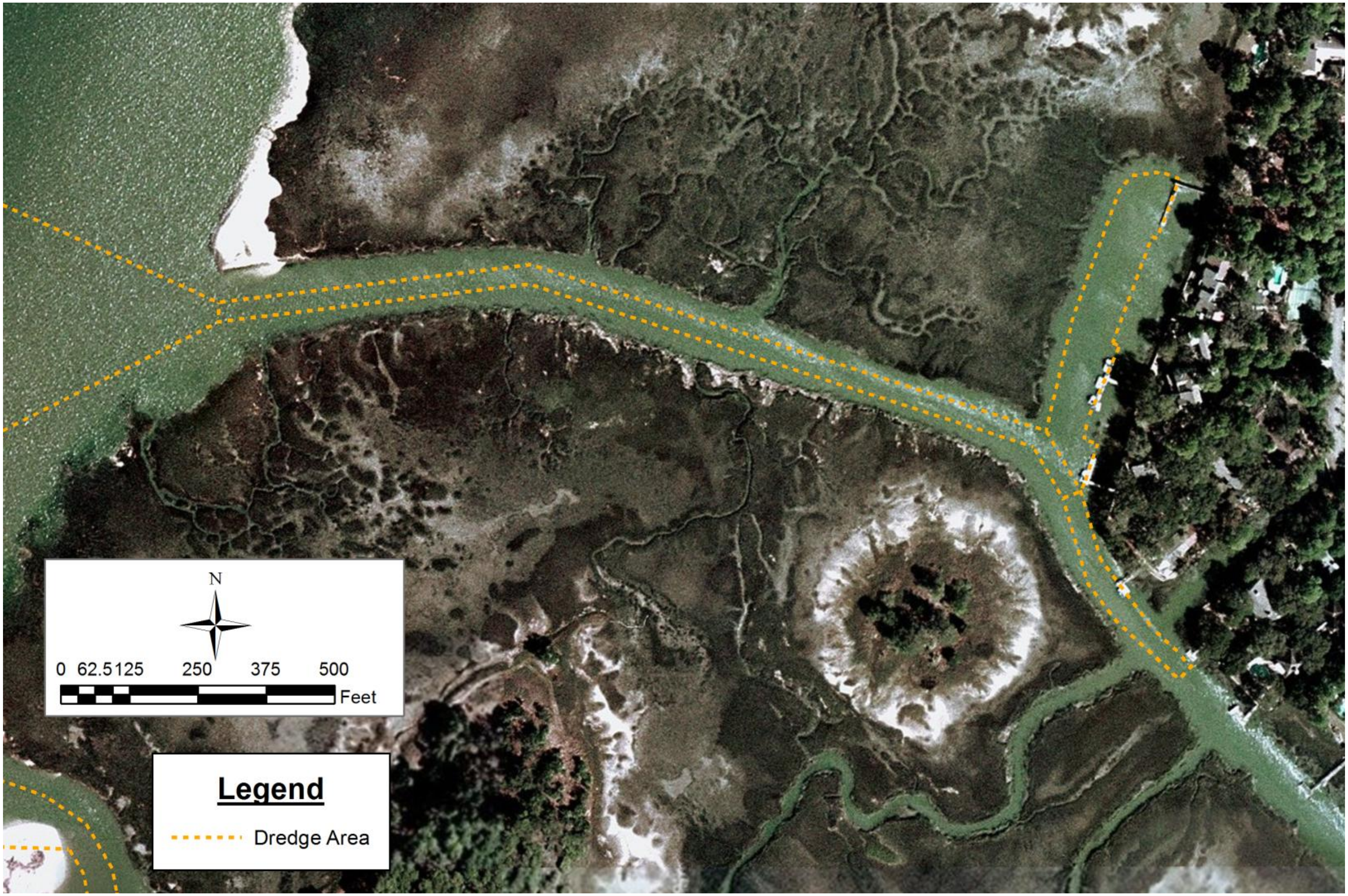

Figure 3-2. Baynard Cove Creek Mouth and Community Dock Dredge Area.

MGA
www.mgassociates.us

Figure 3-3 Braddock Cove Creek Mouth and Gull Point Marina areas to be dredged.

MGA
www.mgassociates.us

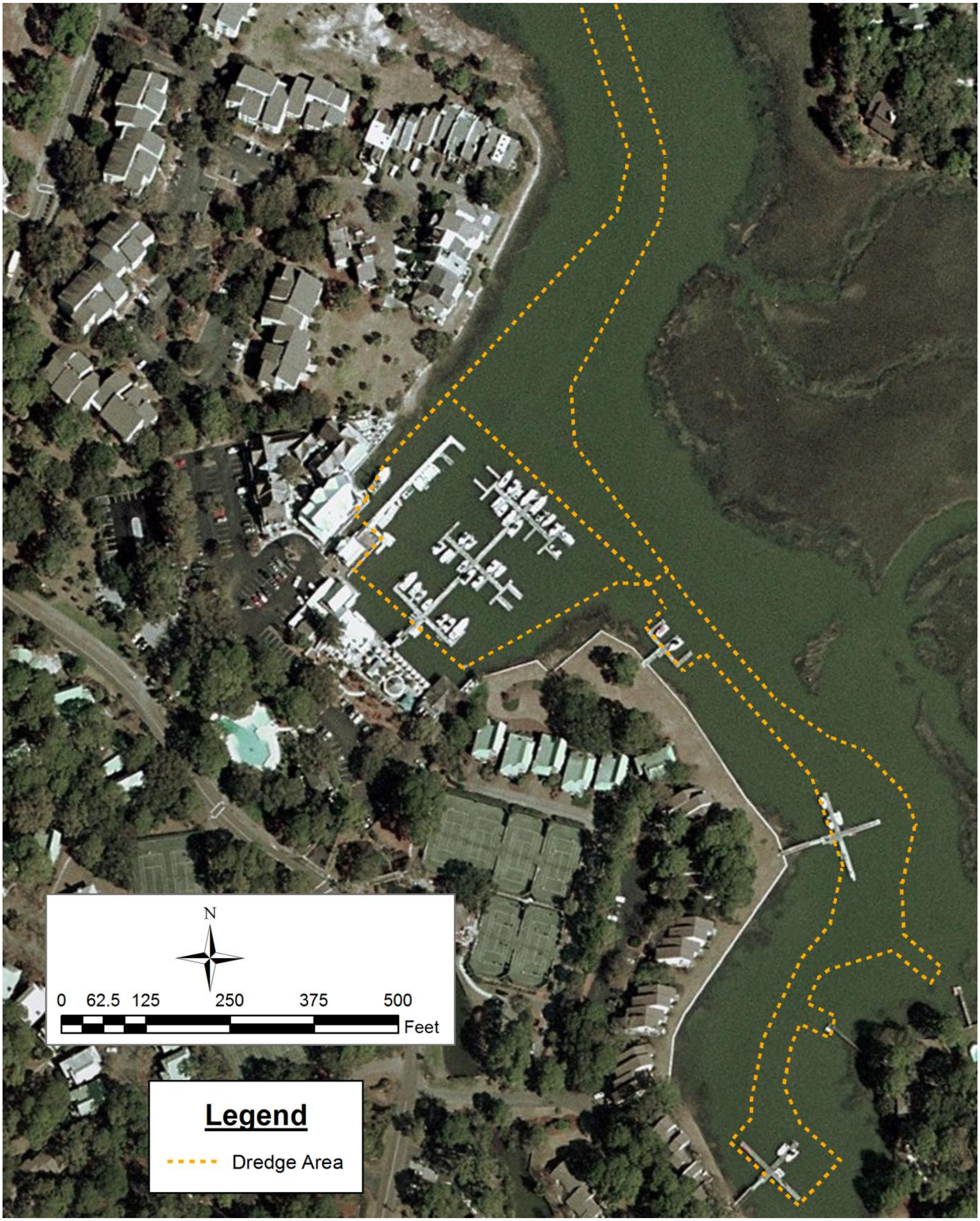

Figure 3-4 Braddock Cove Creek and South Beach Marina areas to be dredged.

MGA
www.mgassociates.us

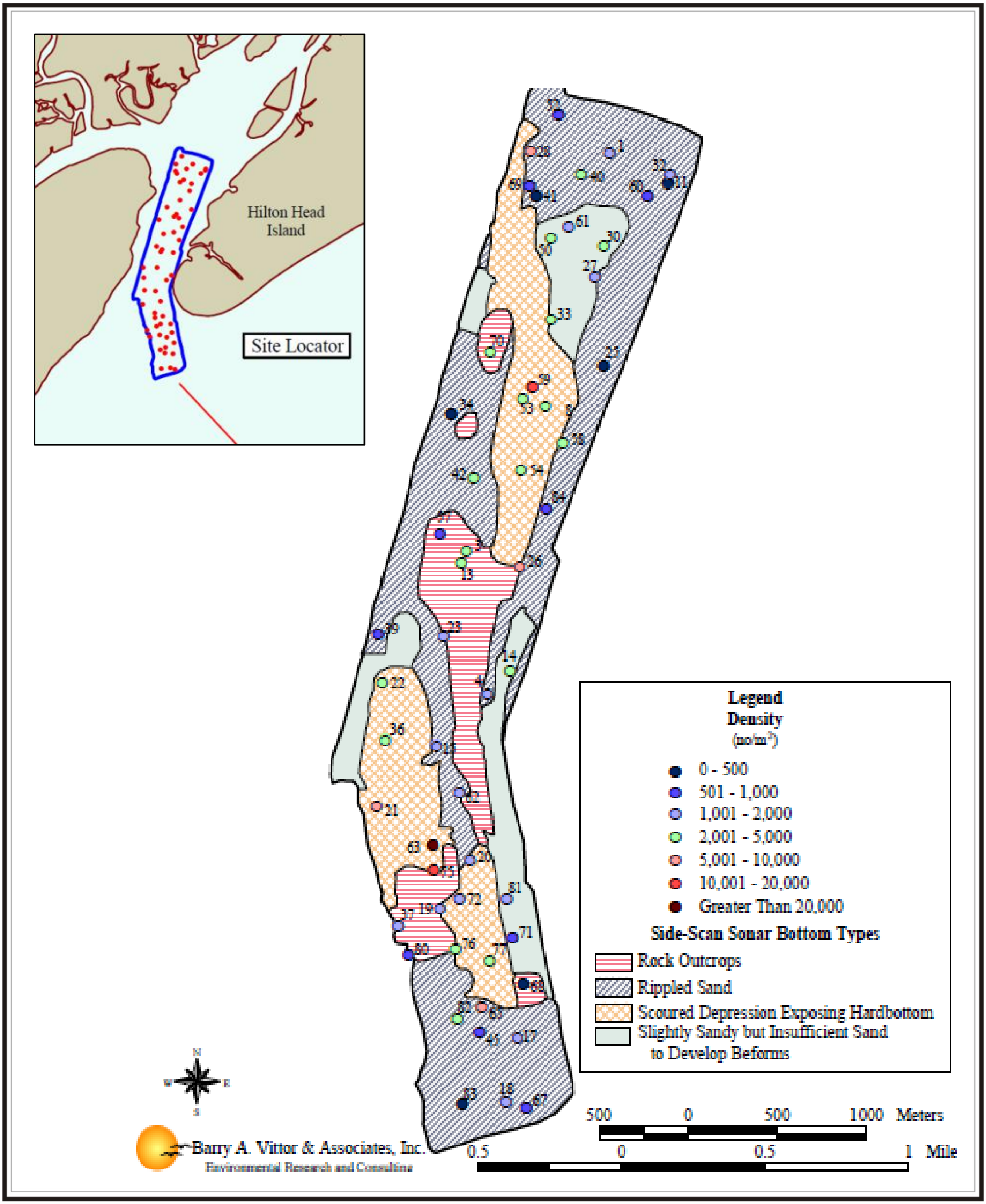

Figure 3-5 Benthic habitat map and sampling locations by BVA in July 2000.

www.mgassociates.us

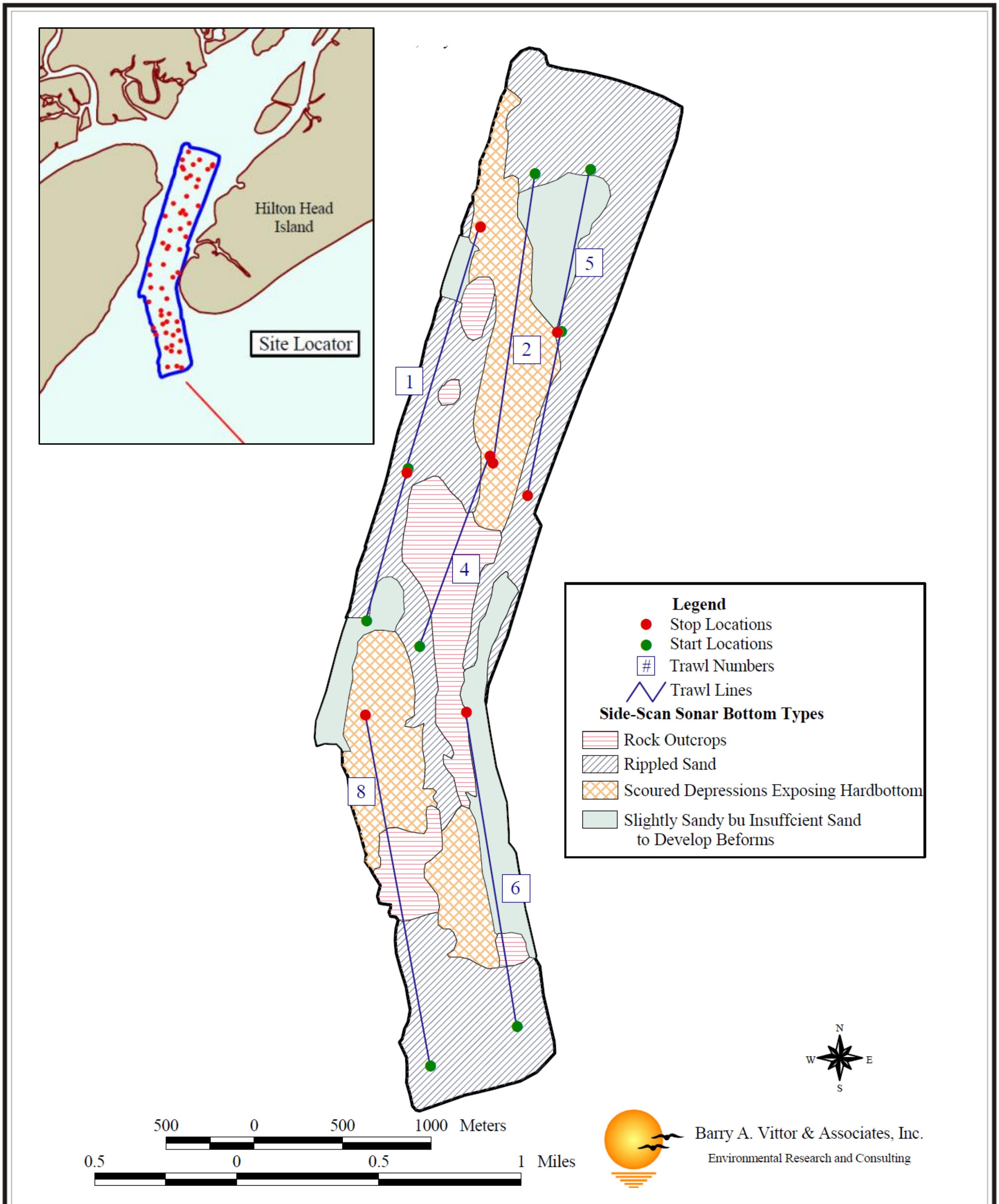

Figure 3-6. Trawl locations conducted by BVA in July 2000.

MGA
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Figure 3-7. Echinoderms and shells (top) and whelks, sponges, and sea whips captured in Trawl 6 by BVA (2000).

MGA
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Harbour Town Site Photographs 1-4 showing inner basin and shoaling in quiescent areas.

MGA
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Harbour Town Site Photographs 5 & 6 (top) showing inner basin and entrance channel with pilings showing dredge channel wiidth. Baynard Cove Site Photographs 7 & 8 (bottom) showing northwest above proposed upstream limit of dredging just upstream of north channel containing community dock. Photo on the left faces downstream, and the photo on the right faces upstream.

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Site Photographs 9-12 of Baynard Cove Creek. Top pictures show the upper area not to be dredged, and the lower two photographs show the areas to be dredged, including the end of the dock downstream of the community dock.

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Site Photographs 13-16 of the community dock area on Baynard Cove Creek. Top pictures show the north channel of this creek, including the community dock and the area between the main channel and north channel (top right). Lower pictures show the community dock.

MGA
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Site Photograph 17 (top left)-of upper Baynard Cove Creek, which was removed from the proposed dredge area. Photograph 18 (top right) is the mouth of Braddock Cove Creek on Calibogue Sound. Lower left is Photograph 19 showing the accreted spit in the dredge footprint of the mouth of Braddock Cove Creek. The lower right (Photograph 20) shows the tidal flat at the mouth of Braddock Cove Creek, facing east.

MGA
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Site Photographs 21-24 showing the mouth of Braddock Cove Creek from the rock groin (top left), facing west from the beach (top right), facing west (lower left), and facing southeast (lower right) with small patch of cordgrass in the background that is within the dredge footprint.

MGA
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Site Photographs 25-27 of the mouth of Braddock Cove Creek (top) facing the mouth and facing upstream (right). Dune vegetation on the upper mouth of Braddock Cove Creek (bottom left). Photograph 28 of Gull Point Marina's north side, facing east (bottom right.)

MGA
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Site Photographs 29 through 32 of Gull Point Marina: top left is the mouth, top right is the north side, bottom left is the south side, facing west, and the bottom right is the north side, facing west.

MGA
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Site Photographs 33 through 36 of South Beach Marina. Top shows the outer marina facing the main channel of Braddock Cove Creek, and the top right and bottom photographs show the inner basin of South Beach Marina, including oyster habitat along the bulkhead which will be avoided during dredging.

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Site Photograph 38 showing the west side of South Beach Marina to be dredged to the pilings at the left (top left). Site photographs 39-41 show Braddock Cove Creek upstream of South Beach Marina facing north (top right), facing southeast (bottom left) and facing east (bottom right.)

MGA
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Site Photographs 42-45 showing upper Braddock Cove Creek at low tide (top photographs) and high tide (bottom photographs).

MGA
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4 Essential Fish Habitat Impacts in Dredging Action Area

This section describes the potential project impacts within the area proposed for dredging to Essential Fish Habitat (EFH), including salt marsh, oyster reefs, tidal flats, estuarine water column, and estuarine unconsolidated substrate.

4.1 Salt Marsh

Throughout the dredge footprint, a ten foot buffer from salt marsh will be maintained except at the mouth of Braddock as noted below. With side slopes at a ratio of three (horizontal) to one (vertical), slumping is unlikely. The proposed project will not cause any direct loss of salt marsh. While it is possible that wave action and wakes from boat traffic may result in loss of edge marsh habitat, indirect loss of salt marsh is considered unlikely given the slow vessel speeds in these areas.

At the mouth of Braddock Cove Creek, there is a sand spit that is proposed to be removed to ensure that the creek mouth does not quickly refill with sediments following dredging. The salt marsh grass at the site is sparse and above the tide line, so it does not function as fish habitat. It may, however, serve to stabilize the sand spit. Site photographs 24 and 25 show that within the dredge footprint there was approximately 150 square feet (0.003 acre) of sparse *Spartina* on the sand spit in March 2012.

4.2 Oyster Reefs

As with salt marsh habitat, the applicant will maintain a ten foot buffer from oyster reefs and mounds present along the waterways proposed for dredging. During field surveys, no unavoidable areas of oyster reef within the dredge footprint were noted. However, it is recommended that PVC stakes be used to mark any oyster mounds near the dredge footprint immediately prior to the dredging project so that dredge operators can clearly see the demarcation of the buffer areas. This is not assumed to be needed for salt marsh because it is more conspicuous during all tide conditions, whereas oyster mounds may not be visible during mid and high tides when dredging will occur.

Despite avoidance measures, some indirect impacts from suspended sediments may occur during dredging. As described by Barnard (1978), water column turbidity generated by dredging operations involving fine-grained material is usually restricted to the vicinity of the operation and decreases rapidly with increasing distance from the operation. Elevated levels of suspended solids around cutterhead dredges are restricted to the immediate vicinity of the cutter, where concentrations may be as high as a few tens of grams per liter within 3 meters of the cutter (Barnard 1978). Therefore, oyster reefs in close proximity to the dredging may be affected by elevated suspended sediment concentrations, which is a temporary minor impact. However, it should be noted that vessel traffic and storm events also cause episodic increases in suspended sediment concentrations. Overall, potential project effects to oyster reefs are expected to be acceptable minor temporary impacts.

4.3 Tidal Flats

The project includes deepening of 50.5 acres in marina basins and creeks from intertidal and shallow benthic soft bottom communities to shallow subtidal habitats. The majority of this area is shallow tidal flats. Because the goal of the project is to maintain depths to allow normal navigation, the areas within Baynard and Braddock Cove Creeks, and a small area described above in Harbour Town Marina's entrance will be converted from tidal flat to subtidal habitat. The total area of tidal flat habitat to be affected by this project was considerably reduced by removing the upper portion of Baynard Cove Creek from the proposed dredging area. This narrow channel did not allow for a ten foot buffer between oyster reef and salt marsh habitats, and therefore the reach of the creek (approximately 66% of the total area within Baynard Cove Creek originally proposed for dredging) was removed from the project.

4.4 Estuarine Water Column

The water column serves as EFH for several managed species and their prey, at various life stages, by providing habitat for spawning, breeding, feeding, and growth. Species (and life stages) for which the water column of seawater and the mixing zone of estuaries has been designated as EFH include post-larval and juvenile penaeid shrimp; larval and juvenile snapper-grouper species complex (such as black sea bass (*Centropristis striata*) and gray snapper (*Lutjanus griseus*)); juvenile cobia and Spanish mackerel (*Rachycentron canadum* and *Scomberomorus maculatus*, respectively); juvenile and adult bluefish (*Pomatomus saltatrix*); larval, juvenile, and adult summer flounder (*Paralichthys dentatus)*; and juvenile coastal and inshore sharks (such as the Atlantic sharpnose shark [*Rhizoprionodon terraenovae*]).

This section describes potential impacts to the EFH species and each relevant life stage, including but not limited to temporary increases in suspended sediment concentrations during dredging, and other effects on benthic habitats and benthic species from dredging.

The South Atlantic Fishery Management Council (SAFMC) outlined the potential impacts to EFH from navigation; dredged material placement, disposal of contaminated sediments, filling of wetlands, and the conversion of shallow water to deep water (SAFMC 1998). Subtidal impacts will be of a temporary nature. However, after dredging, the benthic community will probably consist of early succession stage organisms with a high tolerance for sedimentation, such as polychaete worms. At the site of dredging, any resident community would be removed; however, new organisms could colonize the site within six months based on studies of other sites in Georgia, South Carolina, and Alabama (Clarke, D., and Miller-Way, T., 1992, Van Dolah et al., 1984).

The proposed project will have localized and temporary water quality effects on the estuarine water column during construction by re-suspension of sediments and discharge of sediments in the ocean water column. For these impacts, the effects will be most intense near the bottom. The biological effect of these water quality changes depends upon exposure magnitude, frequency, and duration, as well as environmental parameters (mainly temperature and salinity), and the species' tolerance. Life stage affects vulnerability as well. For example, an adult fish can avoid harmful impacts by leaving the area immediately affected. Larvae, eggs, and some juveniles, however, are planktonic or weak swimmers and may not escape effects of dredging. The proposed dredging will occur over a period up to six months in duration, and the water quality effects will be monitored during the dredging activity. Apart from deepening the bottom elevation in the dredged areas, the project will cause limited and temporary impacts to fish in the water column habitat.

4.5 Estuarine Unconsolidated Substrate

Estuarine subtidal unconsolidated substrate ranges in grain size from sand to fine mud. Unconsolidated substrates support many benthic and epibenthic fauna, including but not limited to hermit crabs, blue crabs (*Callinectes sapidus*), spider crabs, penaeid shrimp (*Penaeus* spp.), grass shrimp (*Palaemonetes paludosus*), mantis shrimp (Lysiosquillidae spp.), snapping shrimp (Alpheidae spp.), ghost shrimp (*Palaemonetes* spp.*)*, mud shrimp (Thalassinidea spp.), and many species of amphipods, polychaetes, and other invertebrates. These species reside within the sediments of the estuarine intertidal and subtidal unconsolidated substrates. Deepening of this habitat temporarily reduces the quality of foraging habitat for managed fishes.

Entrainment of organisms from the benthic habitat will occur, particularly the infaunal species. Infauna are those organisms living below the surface, such as most clams, burrowing crustaceans, and worms. Epifaunal benthic organisms include penaeid shrimp, blue crab, mummichogs (*Fundulus heteroclitus*), silversides (*Menidia menidia*), and flatfish such as flounder.

The affected benthic community will go through stages of succession during the recovery process after the dredging event. Succession in this community type depends upon established burrowing communities that aerate the otherwise anoxic sediments. The soft sediment community develops over time and increases in biological productivity. The dredging effects are temporary, as pioneer species will recolonize disturbed sediment in areas affected by the dredging. The recovery speed of the benthic community depends on the availability of larvae for new settlement and other factors, but studies of other sites in Georgia, South Carolina, and Alabama indicate that the early succession stage community can recover within a few weeks to six months (Clarke, D., and Miller-Way, T., 1992, Van Dolah et al., 1984). By leaving large undisturbed areas along the margins of the channel and leaving the side slope habitats as a source of larvae and other life stages to recolonize the dredged area, no significant permanent adverse effects to the unconsolidated substrate community in the creeks or marina basins are expected.

5 Essential Fish Habitat Impacts in Dredged Material Placement Action Area

As discussed in Section 1, the Site 5 placement area is proposed as the open water placement site for this project. An earlier site considered as an alternative (Site 2) was eliminated given its proximity to hard bottom habitat. A primary goal in selecting the placement site is to avoid impacts to hard bottom habitats (e.g., rock outcropping or scoured rock) and the fisheries that depend on them. Other considerations include avoidance of impacts to oyster reefs and other fisheries in Calibogue Sound.

As described in Section 1 of this report (Proposed Action), the material will be discharged from a pipeline continuously during dredge operations over a period up to six months in duration. The end of the pipeline will be located at the estuarine bottom in approximately 25 feet of water (MLLW). Locating the discharge at the bottom of Placement Site 5 will minimize the turbidity plume in the water column.

As described by MGA (2012), approximately 99 percent of the discharged material will initially descend to the bottom as a fluid mud layer within the proposed boundaries of the placement area. This fluid mud will spread and flow along the bottom as an underflow (Figure 5-1). MGA (2012) used the CORMIX model to estimate the initial mixing of the discharge jet, and used the PDFATE sediment transport model developed by the USACE to estimate the characteristics of the underflow. Based on the results of the CORMIX and PDFATE models, sediments will deposit from this underflow on the bottom within a radius extending 410 meters (1,350 feet) from the discharge location. The underflow is a density current that will flow in a down-slope direction (even against the ambient currents), and the path of the flow will change over time as sediments are deposited on the bottom. Based on the model results, up to 52 percent of the material will be deposited on the bottom. The maximum bottom area potentially affected by the underflow is approximately 56 acres of existing sandy bottom. The area of 56 acres is based on conservative model inputs, and the actual area may be smaller. Regardless, it will not cover any of the identified hard bottom areas in Calibogue Sound.

Following deposition of the sediments on the bottom from the underflow, the tidal currents will begin to erode the sediments. MGA (2012) used the EFDC-SEDZLJ sediment transport model to evaluate the long-term stability of the deposited sediments at the placement site. Given the high tidal current velocities at the site and the low density of the sediments, the placement site is dispersive. This means that the tidal currents will then erode this deposited sediment from the bottom and incorporate the material in to the natural sediment transport system. This erosion process will occur continuously throughout the 6-month project, and the sediments will be completely eroded from the placement site within weeks after the project is completed. Therefore, the proposed placement site is a dispersive site, and the project will not cause any permanent or long-term changes to the bottom.

The sediments entrained into the water column and carried away by the currents will create a plume of suspended sediments. The contributions from three sources are included in estimates of the sediment plume concentrations: entrainment at the pipe outfall; entrainment along the underflow surface; and erosion of sediments recently deposited on the bottom. MGA (2012) estimated the plume concentrations using the equations given by Kuo et al. (1985) that describe a dredging induced turbidity plume model. The Kuo et al. far-field plume model is used in the USACE's DREDGE model (Hayes and Je, 2000). The estimated suspended sediment plume concentrations *above the ambient concentrations* are shown in Figures 6-3 through 6-6. The suspended sediment plumes plots include both peak ebb and peak flood tidal current conditions, as well as half-speed conditions representative of intermediate tidal currents that occur in between slack and peak current conditions. Concentrations at elevations of 3 feet and 6 feet above the bottom are provided in the plots.

The resulting increase in water column suspended sediment concentrations are relatively minor because the underflow of fluid mud is spread along the bottom, and therefore the source of entrained sediments is spread over an area on the bottom. The peak ebb and flood currents cause temporary increases in suspended sediment concentrations up to 11 mg/L above ambient background concentrations at 3 feet above the bottom over a localized area downstream from the underflow. For reference, Applied Technology and Management (ATM) measured a background concentration of 68 mg/L in 1999 (ATM, 2000a). There is no explicit South Carolina water quality standard for TSS. However, the South Carolina water quality standard for turbidity of 25 NTU is approximately equivalent to a TSS concentration of about 37 mg/L. Therefore, the natural ambient concentrations routinely exceed the water quality standard for turbidity at this location. The 11 mg/L TSS plume concentrations are equivalent to 16 percent of the observed background concentration, and approximately 30 percent of the concentration equivalent to the turbidity water quality standard.

Figures 6-3 through 6-6 show estimated suspended sediment concentrations at two elevations: 3 feet and 6 feet above the bottom. Concentrations exceeding 10 mg/L above the background concentration would extend a maximum distance of 1,900 feet from the discharge point at 3 feet above the bottom. As shown by these results, most of the suspended sediment plume effects are limited to the bottom half of the water column. The concentrations 3 feet above the bottom show the highest concentrations, whereas the concentrations 6 feet above the bottom are much lower. Concentrations at elevations more than 6 feet above the bottom are minimal. No effects on suspended sediments would be detectable at the water surface.

As shown in Figures 6-3 and 6-5, the predicted plume concentrations are greater during peak ebb and peak flood current conditions because the higher currents entrain more sediment from the underflow area. For currents equal to half of the peak current speed, the entrainment rate from the underflow area is minimal, and the predicted plume is caused primarily by entrainment from the surface of the underflow. Beyond the plume areas shown in these figures, the sediment concentrations would be indistinguishable from the natural background concentrations in the water column.

Sediments suspended into the water column will ultimately settle in quiescent areas with low current velocities. The concentrations in these areas caused by the project would be very small (i.e., less than 1 mg/L), and therefore, the deposition thickness of these sediments in quiescent areas would be indistinguishable from the deposition caused by ambient sediments in the environment. These sediments will not cause appreciable deposition in the vicinity of the disposal area, Calibogue Sound inlet or Barrett Shoals because the high current speeds in the area will keep these fine sediments in suspension.

The following subsections describe the project effects on the EFH types present in the dredge material placement action area. South Carolina has two dominant natural bottom habitat types off its coast: sand and hard bottom. There are also gradients between the two, with higher proportions of shell hash within the sand creating more coarse sediment and increased interstitial volume. The effects to these habitat types (subtidal unconsolidated habitat, water column, and octocoral and hard bottom) are described below, as well as effects to the water column.

Some EFH types are not described in this section because they are not affected by the proposed project. There will be no effects on the following types of EFH, because they do not occur in the dredging footprint, placement area, or immediate areas indirectly affected by the project: estuarine scrub shrub, seagrass/submerged aquatic vegetation, freshwater wetlands, artificial reefs, and Sargassum.

5.1 Subtidal Unconsolidated Habitat

The bottom habitat in the vicinity of the dredged material placement area for the proposed project (Site 5) is characterized by the BVA 2000 study as rippled sand. As discussed in the literature review (Section 3 of this report), BVA relied on dredge and grab sampling methods, in combination with side scan sonar data to characterize the bottom types. Due to the strong currents and high natural turbidity in the placement area, SCUBA transects and photography of the bottom types is not practical and will not likely yield information on the bottom habitats. Visibility is less than 1 foot in the nearshore areas, as is shown in the existing plumes visible on aerial photography. Therefore, grab and dredge sampling, as used by BVA, is suitable to confirm bottom types. Furthermore, this is proximal to the area previously dredged for sand for renourishment which provides additional confirmation of the bottom type.

The Site 5 placement area is located southwest of Barrett Shoals (Figure 1-2). The sediments in this area range in sediment particle distribution from 11-34 percent gravel or shell hash, 50-88 percent sand, and 0.3-17 percent clay (BVA 2000). The bottom is relatively flat in the placement area, with depths ranging from 26 to 28 feet, as shown in Figure 6-2. The proposed project will cause temporary burial of up to 56 acres of this sandy bottom habitat. The deposited dredged material will contain a higher percentage of fine grained sediments than the existing sediments at this site. However, as explained above, the deposited sediments will be continuously eroded throughout the 6-month project, and the sediments will be completely eroded from the placement site within weeks after the project is completed. Therefore, the proposed placement site is a dispersive site, and the project will not cause any permanent or long-term changes to the bottom.

To the east of Site 5, Barrett Shoals is used for beach sand mining for beach renourishment. Barrett Shoals will experience negligible impacts from placement of dredged material at Site 5. The discharged sediments will not directly settle on Barrett Shoals. Fine grained sediments carried away from the placement site by the ebbing currents flowing towards the southeast will not settle on the bottom on Barrett Shoals because of the swift currents that flow over this feature.

5.2 Water Column

The proposed sediment placement area is turbid due to the naturally-occurring suspended materials in Calibogue Sound. Suspended sediment ranges for the area of Calibogue Sound proposed for dredged material placement were measured in December 1999 and found to be 68 mg/L at mid-depth application (ATM, 2000b). As summarized by ATM (2000b), Browkaw and Oertel (1977) collected and analyzed suspended sediment data from the nearshore waters of Georgia. The report found that the band of turbid water is widest adjacent to the Savannah River entrance and attenuates towards the south near Jacksonville, Florida and towards the north near Cape Romain, South Carolina. The report also concluded that concentrations are highest near the shoreline and lowest offshore. As part of the study, suspended sediment concentrations were measured in the Calibogue Sound ebb channel south of Hilton Head Island in water depth of 9.1 meters on November 11, 1974. The surface measurement was 19.3 mg/l and the measurement 1 meter above the bottom was 61.0 mg/l. Aerial images showing high turbidity naturally occurring in the area are shown in Figure 5-7.

The water column in the vicinity of the dredged material placement area will be temporarily affected by turbidity and increased suspended sediment load during dredging and placement. As described above, the placement will cause localized increases in suspended sediment concentrations, primarily limited to the bottom 6 feet of the water column. These effects will be temporary during the dredging activity, and water column concentrations will return to normal concentrations within days to weeks following completion of the project. Levels of turbidity from the proposed project are not expected to exceed background levels caused during storm events or other natural turbidity-inducing events.

5.3 Octocoral and Hard Bottom

While coral reefs do not occur in the placement area, there are some areas of hard bottom habitat that support the octocoral that were identified during the surveys in 2000 by BVA. That study shows that to the north of Site 5, the throat of the Calibogue Sound inlet has various bottom types, including slightly sandy areas, rock outcrops, rippled sand areas, and scoured depressions exposing hard bottom. Unidentified sponges were also noted in the trawls conducted during that study. The presence of dead sea whip specimens during the March 2012 site visit along the beach at the mouth of Braddock Creek indicates this species is present in nearby hard bottom habitats. While not in the immediate dredge material placement area, it is possible some suspended sediment from the turbid disposal plume may reach sea whip and hard bottom habitats. Therefore, the proposed placement site was located sufficiently far enough to the south to avoid these hard bottom areas from being affected by high suspended sediment concentrations from the disposal. Furthermore, the sea whip is found in turbid environments (such as the existing turbid environment in Calibogue Sound) and is unlikely to suffer mortality from turbidity. Also, given the high current speeds in this area, the fine grained material from the disposal will not settle in these hard bottom areas or cause significant accretion. Therefore, any impacts that may occur are considered minor.

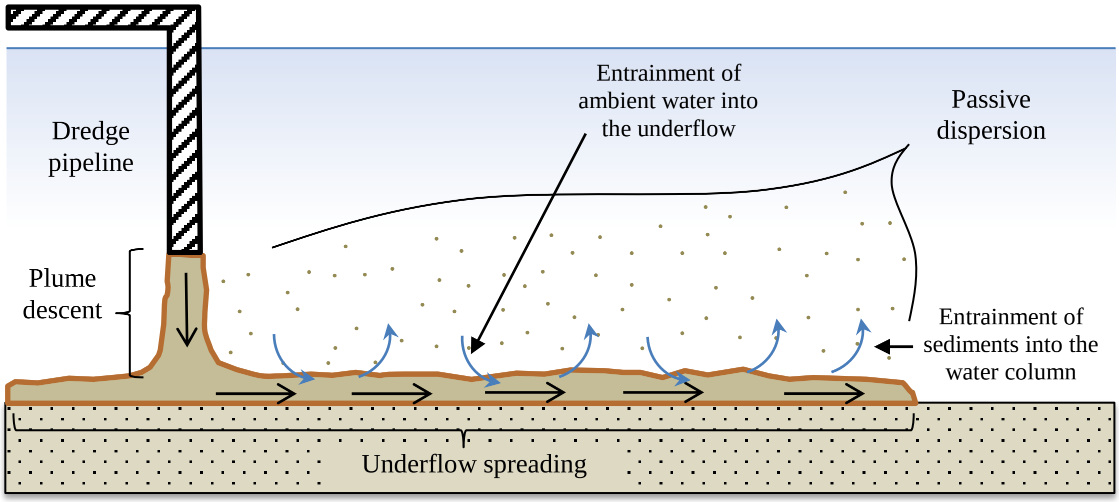

Figure 5-1. Dispersion phases of discharge from a pipeline (adapted from Teeter, in Thovenot et al., 1992).

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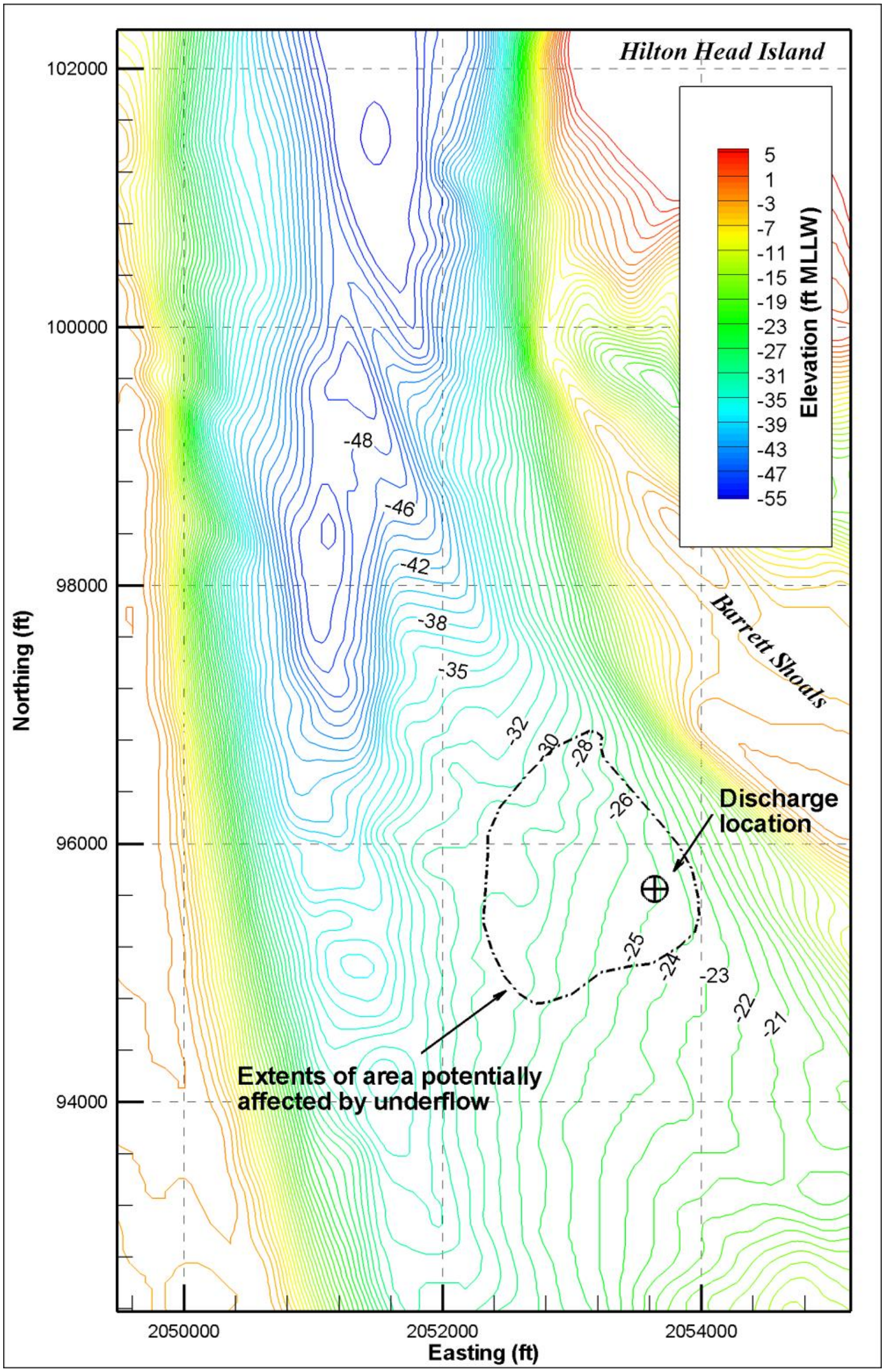

Figure 5-2 Existing depths and estimated maximum extent of area affected by underflow.

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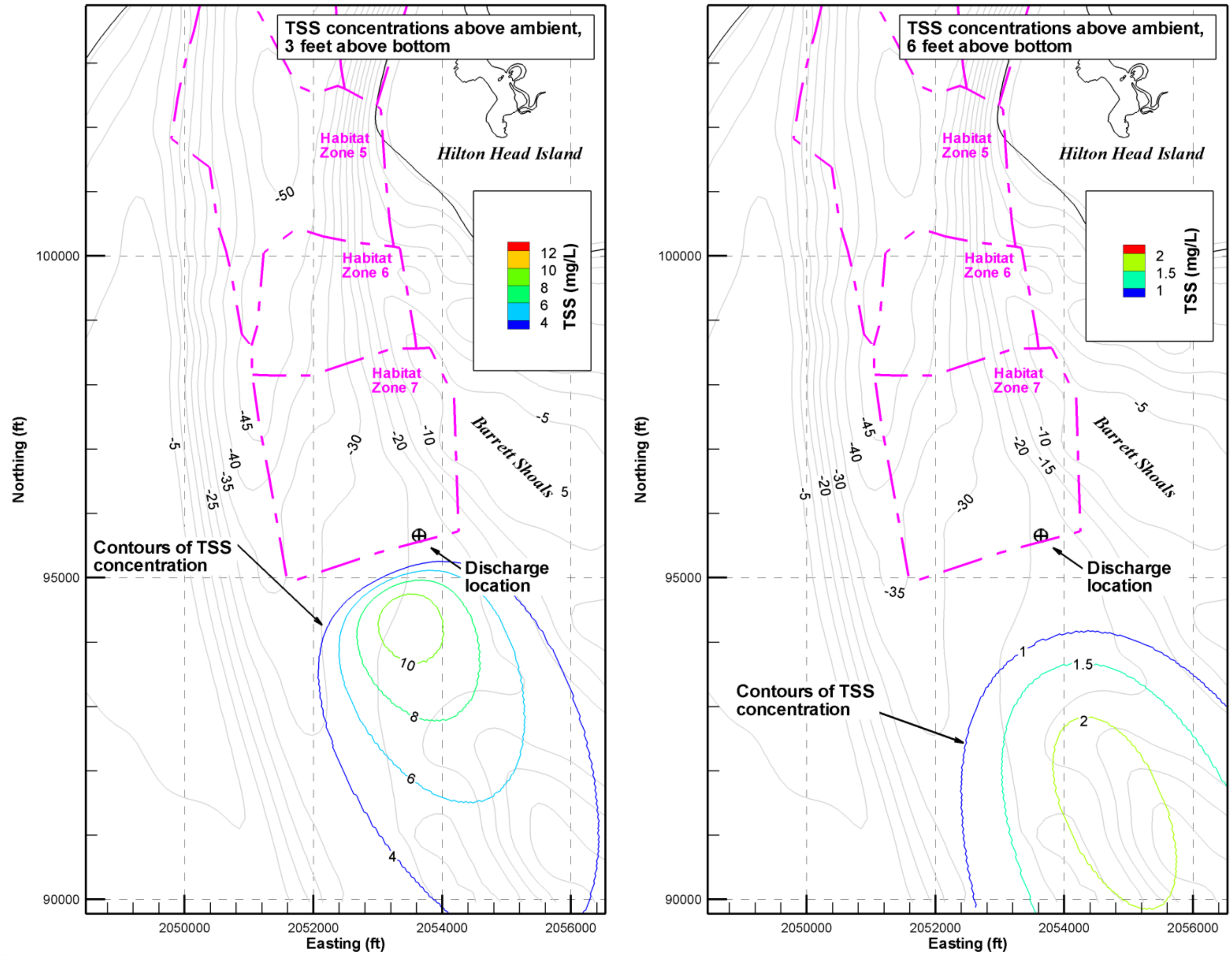

Figure 5-3. Predicted suspended sediment concentrations above ambient during peak ebb current conditions, 3 feet and 6 feet above the bottom

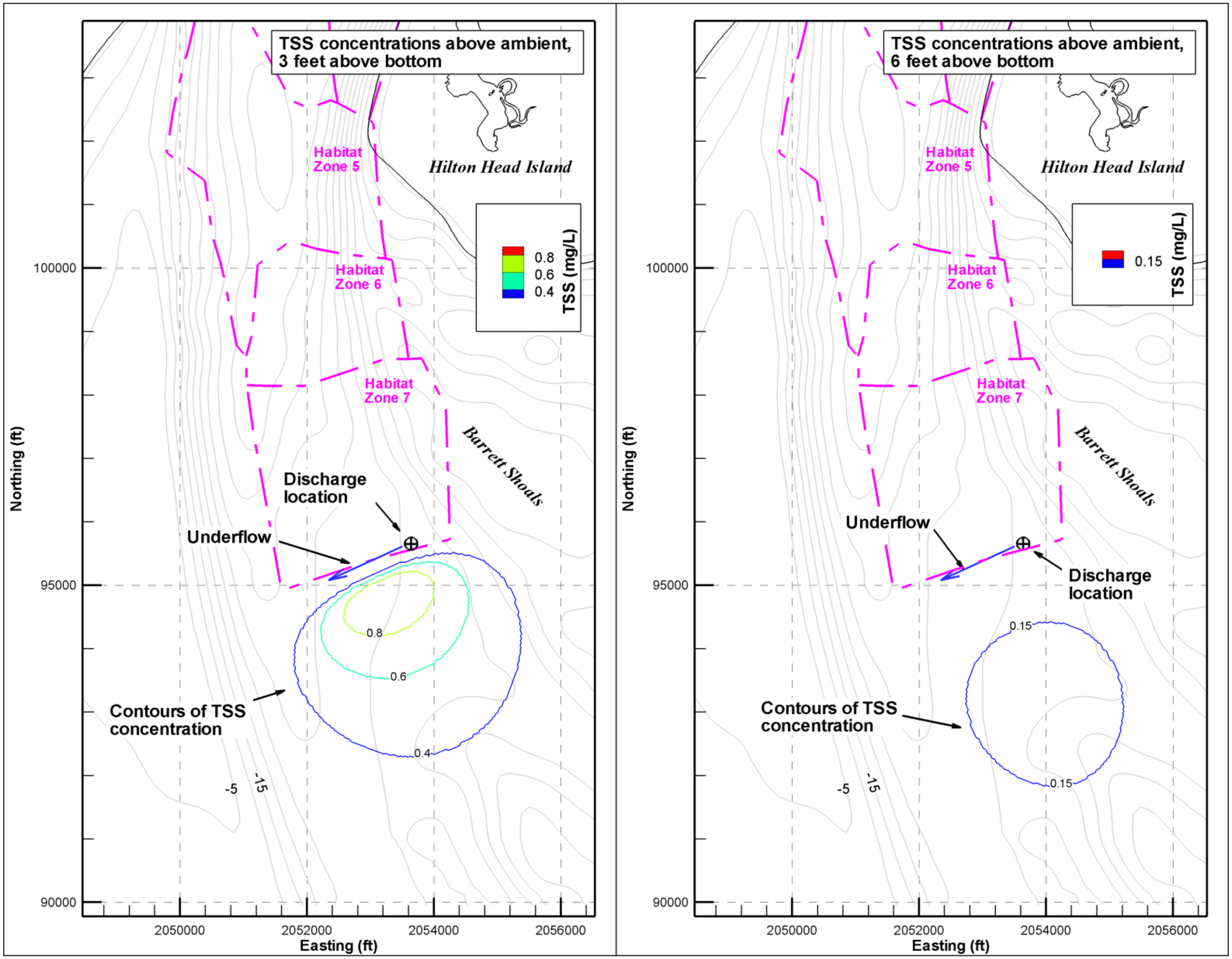

Figure 5-4. Predicted suspended sediment concentrations above ambient during half peak ebb current conditions, 3 feet and 6 feet above the bottom.

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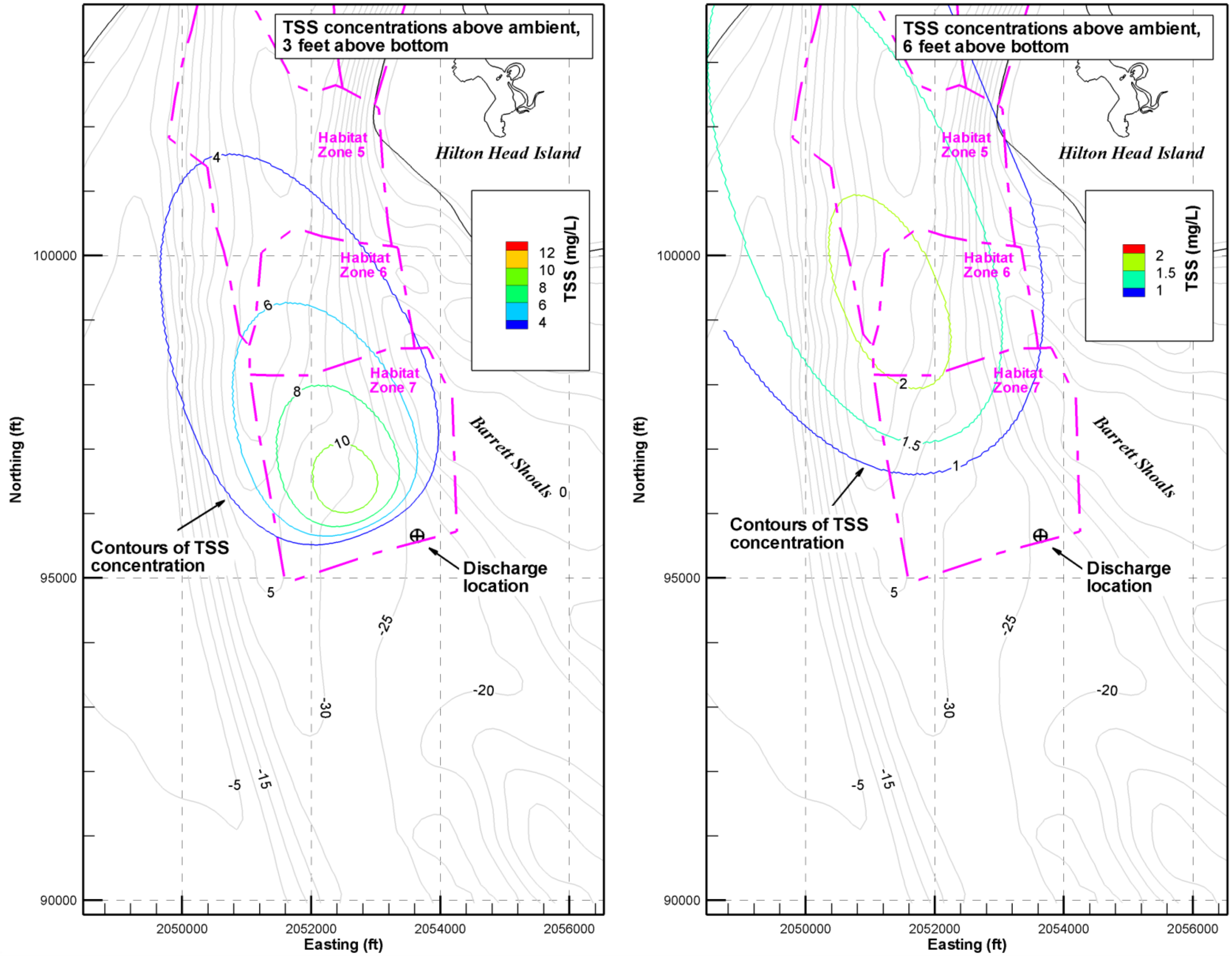

Figure 5-5. Predicted suspended sediment concentrations above ambient during peak flood current conditions, 3 feet and 6 feet above the bottom.

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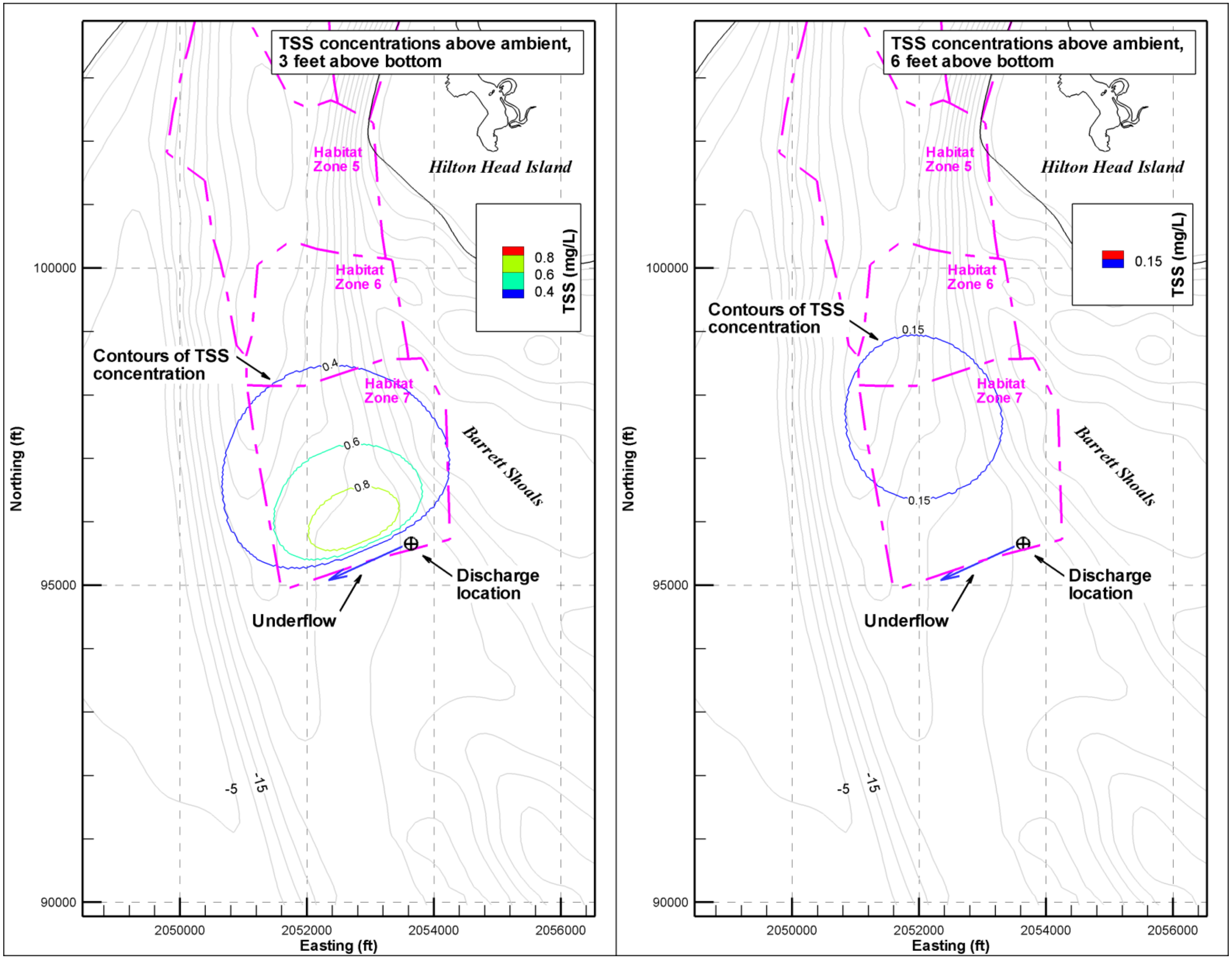

Figure 5-6. Predicted suspended sediment concentrations above ambient during half peak flood current conditions, 3 feet and 6 feet above the bottom.

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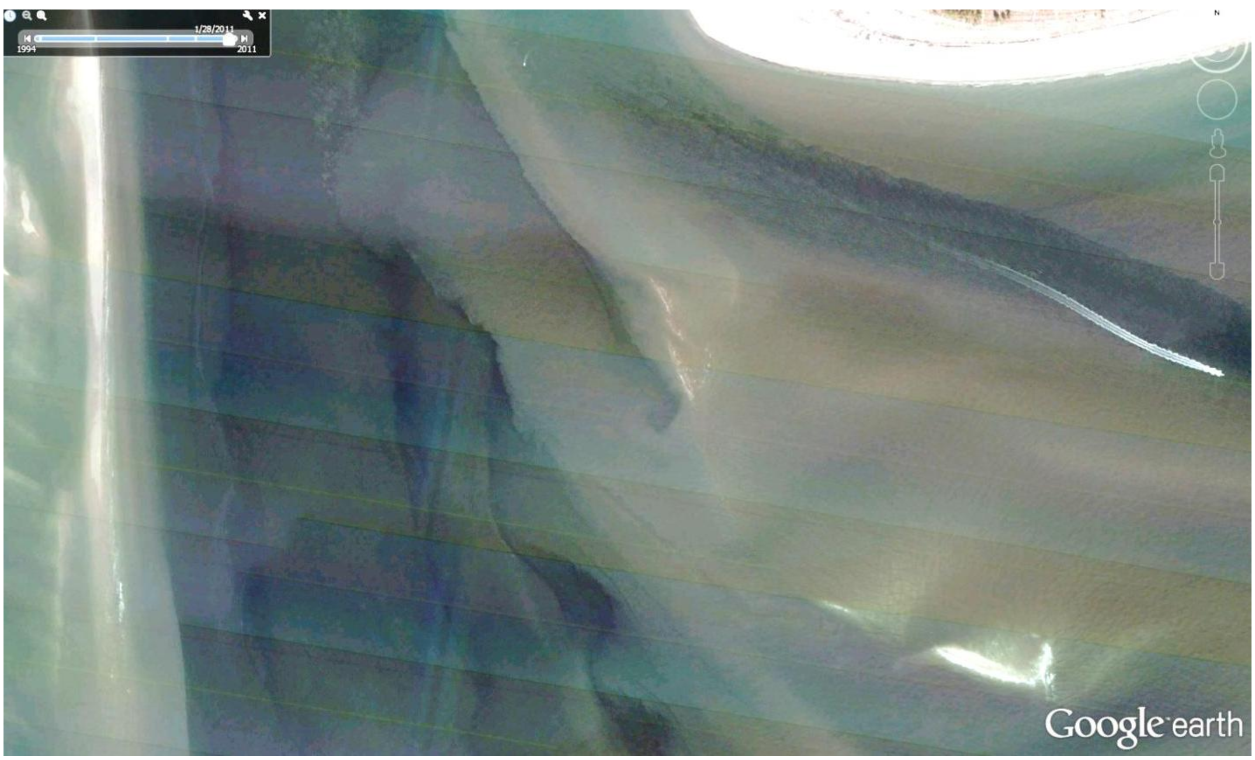

Figure 5-7 Aerial imagery showing high turbidity conditions in the vicinity of Barrett Shoals and the proposed placement area (source: Google Earth, January 28, 2011 image; bottom image brightness increased 40%).

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6 Managed Fishes in Action Area

This section describes the life history characteristics and life stages of the EFH species with the potential to occur in the vicinity of the project area. Calibogue Sound has been designated as EFH for the following species managed by the South Atlantic and Mid Atlantic Fishery Management Councils (SAFMC and MAFMC) and NMFS:

- bluefish (*Pomatomus saltatrix*)
- summer flounder (*Paralichthys dentatus*)
- snapper and grouper complex species such as black sea bass (*Centropristis striata*) and gray snapper (*Lutjanus griseus*)
- dolphin (*Coryphaena hippurus*)
- cobia (*Rachycentron canadum*)
- king mackerel (*Scomberomorus cavalla*)
- Spanish mackerel (*S. maculatus*)
- coastal and inshore sharks such as the Atlantic sharpnose shark (*Rhizoprionodon terraenovae*)
- brown shrimp (*Penaeus aztecus*)
- pink shrimp (*Penaeus duorarum*)
- white shrimp (*Penaeus setiferus*)

These species and their presence in the action areas will be described in the following sections. Floating *Sargassum* communities are not found in the areas affected by the project. The attached form of this brown alga is part of the hard bottom habitat community. It is possible that attached *Sargassum* occurs on stable surfaces in the hard bottom habitats described above, but it was not observed by BVA in the benthic surveys conducted in 2000. The light requirements for photosynthesis and the turbid conditions at the inlet suggest it would not be present.

6.1 Bluefish

Adult bluefish (*Pomatomus saltatrix*) migrate vast distances and are distributed over the continental shelf from Cape Cod to Key West (Fahay, 1998). EFH for this species includes the mixing and seawater zones of all major estuaries between Maine and north Florida from March through December for juveniles, and May through January for adults (MAFMC et al., 1998). This is based on the time frame that bluefish in any southeastern estuary may enter brackish water. No HAPC's have been identified for this species due to a lack of information on their life history.

During the summer and fall, juveniles in South Carolina and Georgia use high salinity tidal creeks and rivers for nursery areas (Shipman, personal communication in MAFMC et al., 1998). Adults and juveniles seek prey such as Atlantic menhaden (*Brevoortia tyrannus*) during the summer and fall in the estuary, as well as near beach areas. Fishing charters based on Hilton Head target bluefish in the spring months. As the project will not be conducted during the summer and fall, it is unlikely that it will result in impacts to bluefish.

6.2 Summer Flounder

Summer flounder (*Paralichthys dentatus*) are benthic dwellers whose EFH includes the mixing and seawater zones of the Calibogue Sound for the larval, juvenile and adult life stages. This species lies motionless on the bottom and surprises its prey. As with many opportunistic feeders, prey size increases with body size and the adults graduate to eating fish such as bay anchovies (*Anchoa mitchilli*) and mummichogs as their size increases (Wenner et al., 1990). Grass shrimp, mysids, copepods, and polychaetes make up a large portion of the juveniles' prey (Wenner et al., 1990, Reichert and van der Veer, 1991).

Flounder inhabit Calibogue Sound in larval through adult life stages, in all seasons. They begin life during the winter in the coastal spawning areas. The larvae and juveniles make their way into the estuary in January through March using tidal currents, the Gulf Stream, and weak swimming abilities. The juveniles settle in tidal creeks and in the shallows near the brackish and salt marsh edges. The flounder leave the tidal creek habitats when they reach adult size (20-25 cm) and move into other benthic habitats in the estuary where they spend their first year. The following year, adult flounder move out into the ocean after a sharp drop in the fall water temperature (around September). After spawning in the ocean, they will re-enter the estuary in the spring when the water temperature rises.

Flounder are expected to receive some adverse effects from this project due to disturbance of foraging areas from dredging of creek habitats. Coastal fishing charters in Hilton Head target this species during the fall months. Adverse impacts may also occur from dredged material placement on the sandy foraging habitats at placement Site 5. Impacts to larvae and eggs from turbidity in coastal spawning areas may also occur. Due to the benthic nature of this species and the potential disturbance of prey, adverse effects to this species are possible. Effects include temporary disturbance from dredging and placement, as well as permanent impacts from deepening of foraging habitat in the dredged creek areas.

6.3 Snapper-Grouper Species Complex

The snapper-grouper species complex (SGSC) includes 73 species, some of which spend part of their juvenile life stage in estuaries, such as the gray snapper (*Lutjanus griseus*). This group includes the snappers, groupers, porgys, triggerfish, jacks, tilefishes, grunts, spadefishes, wrasses, and sea basses.

The majority of these species live their adult life in the ocean. However, while snapper and grouper spawn in the ocean during March, the larvae and juveniles use estuaries for rearing and feeding. In addition, gray snapper adults also use the estuaries. Because of that habitat linkage to the reefs, EFH for this assemblage includes brackish and salt marshes and unconsolidated bottom habitats. These habitats are also considered Habitat Areas of Particular Concern (HAPC's) for the SGSC. Unconsolidated bottoms are HAPC's for this group because juvenile snapper eat crustaceans, fish, mollusks, and other invertebrates, while the adults eat mostly fish, shrimp, and crabs. These prey species are reliant on unconsolidated substrates as well as salt marsh habitats.

While the project is not expected to cause impacts to the Calibogue Sound tributaries other than the proposed dredge areas, two tributaries to the sound are designated as Outstanding Resource Waters

(ORW): the May River and the Cooper River. The May River is shown near the top of Figure 1-2; the Cooper River is shown near the top of Figure 1-4. All ORW's in South Carolina are designated as nursery habitat under the HAPC guidelines for the snapper-grouper complex, as well as penaeid shrimp and coastal migratory pelagic species (NOAA and SAFMC 2011).

Fishing charter captains in Hilton Head report they catch the following species from the SGSC on reefs nearshore off Hilton Head: red snapper (*Lutjanus campechanus*), pigfish (*Orthopristis chrysoptera*), triggerfish (Balistidae spp.), jacks (Carangidae spp.), black sea bass (*Centropristis striata*), spadefish (Ephippidae spp.), and sheepshead (*Archosargus probatocephalus*) (Roth, Majers and Hughes, personal communications, 2012). Many of these fish are targeted during the summer; however, sheepshead and black sea bass are commonly caught during the winter and may be temporarily affected by the proposed project. Direct impacts may include temporary effects to eggs, larvae and juveniles from suspended sediments.

6.4 Coastal Migratory Species: Dolphin, Cobia, and Mackerels

The coastal migratory species assemblage found in the area includes mahi-mahi or dolphin (*Coryphaena hippurus*), cobia (*Rachycentron canadum*), king mackerel (*Scomberomorus cavalla*), and Spanish mackerel (*S. maculates*), which spend their adult life in the coastal and open ocean. Of these, the dolphin is primarily found near and in the Gulf Stream, 70 miles away, and is unlikely to be affected by the proposed project.

EFH for this group found in the placement area includes sandy shoals and bars, and the ocean side waters of barrier islands from the surf zone to the shelf break. EFH for cobia also includes high salinity bays such as Calibogue Sound, and the Broad River is a HAPC for cobia adults and juveniles from May to July where the salinity is 26 parts per thousand (ppt) or more (NOAA and SAFMC 2011).

Cobia is of particular concern as it is a major recreational fishery in the spring in Beaufort County. The state record, an 87 pound cobia, was caught in Port Royal Sound in 2004. They are found primarily in the Calibogue Sound and its mouth during the spring and summer months. Based on research from North Carolina, it appears cobia spawn in high salinity inlets and possibly in the sounds in the summer. Juveniles may be found in the estuary during the fall as well, although the exact time of their departure from the estuaries in not known (Hammond, D.L. 2001). Based on the planned dredging time, the dredging activities should result in no interference with cobia.

Fishing charter captains in Hilton Head report that Spanish mackerel are most common in the spring and summer, when they can be caught in the nearshore areas (Roth, Majers and Hughes, personal communications, 2012). Adults of this species may be negatively temporarily affected by suspended sediments and turbidity, which can interfere with predation and cause the fish to avoid or leave the area to seek more fruitful feeding grounds. However, because project effects on turbidity are localized and small compared to the total Calibogue Sound area, this avoidance is not considered an unacceptable impact.

In summary, for all of the coastal migratory species, their larval and juvenile life stages use estuaries as nursery grounds, and many of their prey species are also estuarine dependent. To protect them, all estuaries within the species' latitudinal range are considered EFH for coastal pelagic species. Protection of water quality within the estuary is important for vulnerable larval and juvenile life stages. The proposed project is not expected to affect cobia at any life stage.

6.5 Highly Migratory Species

To illustrate what is meant by "highly migratory", a sandbar shark (*Carcharinus plumbeus)* tagged in Chesapeake Bay in 1998 was caught in Calibogue Sound in May two years later, while another shark tagged in Chesapeake Bay was recaptured in the Gulf of Mexico (Grubbs et al. 2005). Calibogue Sound is 830 km from the tagging location.

In addition to twenty-five species of shark, five species of tuna and five species of billfish (marlin, sailfish, swordfish, etc.) are protected under the Highly Migratory Species Management Plan. While bonito (skipjack) tuna (*Sarda sarda*) may be found close to shore, it is unusual. Most of this group, including marlin (*Makaira nigricans*), swordfish (*Xiphias gladius*), and tunas (*Thunnus* spp.) are found far from the project area, near the Gulf Stream, which is 70 miles from the Hilton Head shoreline. Bluefin tuna (*Thunnus thynnus*) are known to migrate off the shore of Hilton Head from December through February, and in 2006, a state record blue fin tuna was caught off of the island. While they are most commonly found in deep water, they may enter waters as shallow as 50 feet. Due to their tendency to remain in the ocean (not in the area of project effects), it is not anticipated that the billfish or tuna will be affected by the proposed project.

Effects are possible for the sharks, however. Many species of shark use Calibogue Sound during their juvenile life stage, particularly in the summer, and the area proposed for dredged material placement during adult and juvenile life stages (NMFS, 1999). Juvenile sharks of less than three feet are commonly hooked in the Sound and inlet during the summer.

Sharks are most common in the inshore areas affected by dredge material placement from May to October. However, they may occur year round. Sharks' abundance, sportfishing appeal, and ease of capture near shore have contributed to a large recreational fishery for Hilton Head waters. There are approximately forty species of sharks found in South Carolina. Sharks commonly caught near Calibogue Sound include hammerheads and bonnetheads (*Sphyma* spp.) and black tip (*Carcharhinus limbatus*). Occasionally, lemon (*Negaprion brevirostris*), bull (*Carcharhinus leucas*), tiger (*Galeocerdo cuvier*), blue (*Prionace glauca*), and mako sharks (*Isurus* spp.) are also caught.

As an example of the fully mature sharks found in the area, in 2010 a state record lemon shark was caught a half a mile from shore off Hilton Head, and in the same year a state record black tip shark was caught further off the island. In June 2011, a twelve foot tiger shark was caught (and released) less than a mile from the south end of Hilton Head. For most conscientious anglers, only a record-maker is kept; others are released. For tiger sharks, the state record is a sixteen foot specimen caught from a pier in Myrtle Beach. Large (over ten feet) hammerhead sharks are hooked in the nearshore area during the summer, but the average sharks are six feet or less. In the summer of 2006, two shark attacks were recorded in shallow water on the beach, and another attack in the summer of 2007 was also reported. Based on fisheries data from SCDNR and anecdotal sources, many species of sharks, in all life stages, are abundant in the waters off Hilton Head. Based on anecdotal discussions with captains and fishermen from Hilton Head, the areas adjacent to Barrett Shoals are a popular location for recreational shark fishing. While most sharks are caught during the summer, the Atlantic sharpnose shark (*Rhizoprionodon terraenovae*), smooth dogfish (*Mustelis canis*) and spiny dogfish (*Squalis acanthias*) are targeted by fishermen in the nearshore habitats during the winter, as well. Sharks feed in turbid areas and the increased turbidity in the placement area may negatively affect their foraging opportunities if their prey depart from the area seeking less turbid environments. Further, if the placed materials bury the habitats where prey fish forage, the sharks will also leave the area in search of prey. However, the levels of turbidity from the proposed project are not expected to exceed background levels caused during storm events or other natural turbidity-inducing events. Therefore, the proposed project is expected to cause only temporary and limited impacts to sharks.

6.6 Penaeid Shrimp

The proposed project is located in an area identified as EFH for the commercially and recreationally valuable penaeid shrimp (Shrimp Fishery Management Plan, SAFMC, 1998). For the three species – brown, pink, and white shrimp (*Penaeus azecus, P. duorarum,* and *P. setiferus*, respectively) – all inshore nursery areas, brackish and salt marshes (especially the edges), unvegetated unconsolidated bottoms, and intertidal flats are the affected EFH for post larval and juvenile shrimp. These habitats are important for this group because shrimp eat a variety of other invertebrates, decaying plant matter, and other types of organic debris. While they spend their fastest growth phase during the spring and summer in estuarine waters, the adults migrate to ocean waters to grow and spawn. Adults are least common in estuarine waters, therefore, in the fall and early winter after this migration occurs.

The three species share a life history pattern, with variations in the timing, salinity, and benthic habitat preference. All penaeid shrimp spawn in the ocean, then the larvae enter estuaries where they grow, and then they return to the ocean to spawn the following year. White shrimp spawn in the spring and summer, and the planktonic larvae recruit to estuaries from May to September. They remain in the estuaries through the winter, but prefer areas with mid-range salinities, from 8-15 ppt. In the spring, they migrate out to sea once again. Brown shrimp spawn in the ocean in the fall and spring, and enter the estuaries in March and April. They can be found in a wide range of salinities. Pink shrimp spawn in the ocean in the spring and summer (Wenner 2004). They are less common than brown and white shrimp in South Carolina and the least likely to be affected by the project. Brown shrimp are the most likely species to be affected by this project.

Dredging the tidal creeks and channels will cause short-term temporary localized impacts to adult and juvenile penaeid shrimp. Dredged material placement may cause short-term temporary localized impacts to spawning shrimp.

7 Effects to Federally Managed Fish Species

As discussed above, effects on managed fish from dredging and dredged material placement for this project include temporary increased turbidity and total suspended solids, deepening of habitat, temporary burial of habitat, and temporary interference with predation and foraging. Managed species most likely to be negatively affected include summer flounder and penaeid shrimp. The primary impact is from temporary increases in turbidity and total suspended solids, as well as deepening of shallow and intertidal habitat and disturbance to subtidal habitats in the creeks and placement areas. Spanish mackerel and coastal sharks may experience minor impacts due to temporary increases in turbidity in foraging areas and temporary changes in prey distribution due to turbidity and suspended sediment. A synthesis of the literature on the effects of these water quality parameters is provided in the following sections.

7.1 Effects on Fish Due to Increased Total Suspended Solids and Turbidity

Because it was specifically requested in the NMFS comments on the study plan for this EFH Assessment, the effect of increasing total suspended solids and turbidity is discussed herein. While no regulatory criteria have been established for TSS levels in warm-water estuarine communities, a qualitative assessment can be based on how much the additional TSS exceeds normal background levels. Calibogue Sound is a shellfish harvesting water and the turbidity criteria are “not to exceed 25 NTUs provided existing uses are maintained” (SCDHEC OCRM 2006).

The background TSS in the area measured by ATM for the 2000 permitting effort was approximately 68 mg/L. Turbidity was not measured. The relationship between TSS and tubidity was developed by MGA for the Savannah River (MGA, 2011). Concurrent measurements of TSS and turbidity fit by a polynomial relationship ($TSS = 0.0118 * (turbidity)^2 + 1.1711 * turbidity$) resulted in a high correlation between the two variables in the Front River ($r^2 = 0.98$). Site specific data in Calibogue Sound are not available to determine a site specific relationship at the project site. However, given the close proximity of the Savannah River to the project site, it is reasonable to assume that the Lower Savannah River relationship gives a reasonable estimate of the relationship between TSS and turbidity at the project site. Using this relationship, a TSS concentration of 68 mg/L corresponds to a turbidity of 41 NTU. Therefore, the background natural conditions in the area already exceed the water quality standard of 25 NTU. Using the same relationship, the water quality standard of 25 NTU corresponds to a TSS concentration of only 37 mg/l. Aerial photographs of the project area confirm that the water is already naturally turbid. For example, Google Earth imagery from January 2011 in the vicinity of the proposed placement area shows high turbidity water moving from Barrett Shoals into the Calibogue Sound inlet on a flood tide (Figure 5-7). Increased turbidity is associated with storm events and spring tide conditions which resuspend bottom sediments into the water column.

Increased TSS increases the turbidity of the water column, but there is not a direct correlation between the two metrics. TSS is the measure of suspended solids, filtered from the water column and dried, and is usually expressed as mg/L of sieved and dried solids in the water. Turbidity is the scattering of light by particles or substances in the water column, and measures the depth of light penetration. It is often measured in nephelometric turbidity units (NTU). Because measuring TSS is laborious, and turbidity can be measured instantaneously, turbidity is often used as a proxy measurement for TSS. Turbidity fluctuates with suspended sediment, as well as dissolved organic matter and plankton. Increased turbidity is correlated with rainfall, tidal input to the estuary, algae blooms, as well as dredging and other human activities.

TSS can interfere with growth because the fish has to clear its gills of the sediment, and this can reduce growth and health. Turbidity limits fish vision, which affects behavior, foraging, and predator avoidance. Turbidity can reduce predation on larvae and juveniles by making it harder for predators to see them. At some levels, however, turbidity may make the contrast of prey against a turbid background more sharp, thus increasing the success of visual predators. In the Pacific Northwest, the effect of water control structures that decrease the turbidity have resulted in increased predation on white sturgeon, for example. Turbidity augmentation experiments are proposed for some areas to increase turbidity and protect the vulnerable juvenile sturgeon from predators (British Columbia Hydro, 2009).

One TSS effect can be reduced feeding ability, as many fish find prey by sight. For example, Breitburg (1988) found that striped bass (*Morone saxatilis*) larvae feeding on copepods, (a small type of zooplankton common in the Savannah River), ate 60% less in TSS levels of 200-500 mg/L. However, many juvenile stages use the estuary as a nursery because the lowered visibility may help them avoid predation from larger piscivorous fish. For example, Buck (1956) found that channel and flathead catfish (*Ictalurus punctatus* and *Pylodictis olivaris*, respectively) survive well in turbid conditions, partially because they can more easily avoid predation by striped bass. Boerlert and Morgan (1985) found that larval Pacific herring (*Clupea pallasii*), a clupeid species similar to Atlantic menhaden and blueback herring (*Alosa aestivalis*), take advantage of turbid conditions in estuaries and can feed well in sediment concentrations of 500 to 1000 mg/L. This effect was also observed in cod (*Gadus* spp.), which did not avoid turbidity and may use it to their advantage for foraging (Meager, 2007). Therefore, a temporary benefit would be enhanced feeding opportunities for turbidity tolerant fishes as they are exposed to enhanced feeding opportunities due to transported fauna released from the dredge pipe.

Migration can be affected by turbidity because some fish may avoid sediment plumes. For example, Matthews (1984) found that larval shad (genus *Dorosoma*, not the genus *Alossa* occurring in Georgia), move towards the surface in response to turbidity. This study and others addressing the effects of sedimentation on fish focused on chronic effects.

In general, bottom dwelling fish are less sensitive to TSS than those inhabiting the rest of the water column, and filter feeders are the most sensitive. Many species of adult fish and shellfish are very tolerant, but eggs and larvae are more sensitive than adults, and larvae are more sensitive than eggs. Vulnerability depends upon the sediment particle’s size and angularity, with large and angular particles being more abrasive and thus more damaging to sensitive tissues (Appleby and Scarratt, 1989, in Kerr 1995.) Gill abrasion and damage are the most threatening physical impacts to fish from TSS (Nightingale and Simenstad, 2001).

Results of laboratory tests on sublethal and lethal effects of TSS are available for the following species: spot (*Leiostomus xanthurus*), menhaden, bay anchovy, Atlantic silversides, croaker, weakfish (*Cynoscion regalis*, closely related to spotted seatrout (*Cynoscion nebulosus*), bluefish, toadfish (Batrachoididae spp.), hogchoker (*Trinectes maculatus*), and striped bass (O'Connor et al., 1976). O'Connor et al. found that the sublethal and lethal thresholds for these species exceed that which the fish in the dredge's sediment plume will experience.

One key to understanding the relationship between turbidity and a potentially harmful impact is the type of particle that causes the turbidity. If the turbidity is due to phytoplankton in the water column, high turbidity can correlate with high day time dissolved oxygen levels. If plankton die in an enclosed environment, the resulting biological oxygen demand can reduce dissolved oxygen levels. If the turbidity is due to anoxic mud churned from the bottom, the mixing of interstitial anoxic water with the water column can increase turbidity and decrease dissolved oxygen. However, in environments that have naturally low turbidity, increased turbidity can decrease light penetration and hence photosynthesis, thus reducing the amount of oxygen produced by phytoplankton, algae, and submerged aquatic vegetation.

During dredging and placement, turbidity levels and total suspended solids are temporarily increased in the water column and are spatially limited. The effect may be observed for the duration of the dredging project (up to 6 months), and egg, larval, or small juvenile life stages may suffer minimal impacts. The biological effect of these water quality changes depends upon the exposure magnitude, frequency, and duration, as well as environmental parameters (mainly temperature and salinity), and the species' tolerance. Life stage affects vulnerability as well. Adult and juvenile fish can avoid harmful impacts by leaving the area, but larvae and eggs are planktonic or weak swimmers and may not escape negative effects caused by dredging. Eggs, larvae, and small juveniles are more physiologically vulnerable to the TSS increase from dredging as well.

7.2 Effects on Fish Due to Decreased Dissolved Oxygen

For dredge activities conducted during the summer time, when dissolved oxygen (DO) conditions are low, the combined stress of low DO and dredging related impacts, such as increased TSS and turbidity, can be a concern. However, because the placement site for this project is in open waters in close proximity to the ocean, and these waters are typically agitated by wind waves and near saturation concentrations, low dissolved oxygen conditions at the placement site are unlikely. Some oxygen reduction may occur during dredging operations in the creeks. However, analysis of bottom sampling data upstream and downstream from a large hydraulic cutterhead dredge found a very weak relationship between decreasing DO and increasing turbidity (Clarke, 2009). The proposed project is not expected to cause a negative dissolved oxygen effect on managed fish.

7.3 Effects on Fish Due to Contaminants

Another concern is the exposure to contaminants released by dredging. ATM (2000d) evaluated quality of the sediments to be dredged. The sediments were sampled according to the procedures set forth in the Inland Testing Manual (USEPA/USACE, 1998) and the local USACE Charleston District testing protocols set forth in the 17 June 1998 Draft Sampling and Analysis Plan (CESAC, 1998). The assessment concludes that the proposed dredged material is acceptable for open water placement with no special management provisions.

Sediment quality testing by GEL Engineering (2008) found that the bulk sediment chemistry was very similar to the samples collected for the ATM study (2000d), demonstrating that there has been no potentially significant change in sediment quality. GEL Engineering (2008) concluded that the sediment quality remains acceptable for placement in the Port Royal ODMDS. Therefore, no adverse effects on fish are expected from contaminants in the dredged material.

8 Avoidance, Minimization, and Mitigation Measures

Maintenance dredging of harbors, marinas and entrance channels is necessary to allow for navigation. However, during dredging and placement operations, there is potential for unacceptable environmental impacts to coastal resources. During the process of planning the proposed dredging and disposal operations, the applicant has sought means to reduce identified impacts and preserve the abundant aquatic life in Calibogue Sound, its watershed, and the adjacent coastal waters. In a recent study comparing dredged and un-dredged creeks, it was determined that preserving marshes, reducing dredge depth, and restricting dredging to the winter period moderated the impacts of dredging and development (Bilkovic, 2010). Timing, duration, design, methodology, and monitoring approaches have been proven to reduce the negative impacts associated with dredging. To further avoid, minimize, and mitigate the unavoidable impacts of the proposed project, the applicant will commit to the measures discussed in the following paragraphs.

Permit conditions typically restrict project dredging to the period from November 1 to March 31. Because of the quantity of material to be dredged (300,000 CY), and the fact that only a small dredge can navigate the creeks to excavate the material, the project will require up to 6 months to complete. Therefore, the project will require up to 6 months duration during late fall, winter and early spring seasonal conditions. This project timing will avoid summer season impacts to many species, including those that are federally protected.

Selecting the least-damaging methodology will reduce impacts to all aquatic life. There are several dredge methodologies available for this site. The chosen hydraulic cutterhead dredge method will result in less sedimentation to creek habitats and less suspension, also less water column entrainment than from using a hopper or clamshell dredge. The reduced risk of entrainment will protect more aquatic life than if other methodologies were employed. Because hydraulic dredging will be used, materials will be transported by pipeline, which will have fewer potential impacts than multiple barge or scow trips through the estuary. No marine mammal ship strike or collision risks are present that could result in mortality to whales or turtles. The footprint of the conveyance and outfall pipe will be along the shoreline, but in adequate depth to avoid impacts to the benthic environment. The applicant will place the pipeline over unconsolidated surfaces that will not suffer shading effects, thus avoiding impacts to intertidal or subtidal resources. The dredge pipeline will be positioned with chain and floatation that does not present entanglement risks for animals. The surface-level dredge pipe will also be more easily monitored for debris or damage.

The primary potential impacts to wildlife are the conversion of tidal flat foraging habitat to subtidal habitat in the dredged creek areas. Site specific modification of the dredge footprint has been used to minimize aquatic impacts. The extent of the dredge area has changed since the previously approved application in 2008, which included the full length of Baynard Cove Creek. Site surveys of the area noted that the narrow channel of upper Baynard would not allow for avoidance of sensitive habitats, including oyster reefs and salt marsh. As a result, the area to be dredged has been minimized and no dredging will occur in upper Baynard Cove Creek. This modification represents an approximately 3,400 foot reduction in the length of Baynard Creek channel to be dredged. Furthermore, this loss of tidal flat foraging habitat is insignificant compared to the available habitat.

To further reduce impacts to prey populations and foraging habitat, the applicant and their contractors will maintain a ten foot wide buffer from salt marsh and oyster reefs and mounds during the dredging effort. To ensure this buffer is maintained, the applicant will mark the dredge corridor with PVC stakes in areas where oyster reefs may be obscured by water.

To further avoid impacts to the creeks, the applicant minimized the channel width to 35 feet in most areas with a maximum width of 50 feet. The narrow width will allow for 3:1 side slopes which will maximize channel stability and reduce slumping and erosion of the adjacent banks. To accommodate the gentle side slopes, the areas will be dredged to the minimum depth necessary to allow navigation for relatively small recreational craft in most areas, except South Beach and Harbour Town Marinas, which serve commercial vessels with deeper draft requirements. To meet these requirements, the project includes maximum depths of 6-8 feet MLW plus 1 foot allowable over-dredge.

Selecting the least-damaging methodology will reduce impacts to all aquatic life. There are several dredge methodologies available for this site, and the chosen hydraulic cutterhead dredge method results in less sedimentation lost to creek habitats and less suspension, also less entrainment than from using a hopper or clamshell dredge. The reduced risk of entrainment will protect more aquatic life than if other methodologies were employed.

Because hydraulic dredging will be used, materials will be removed by pipeline, which will have fewer impacts than multiple barge or scow trips through the estuary. The footprint of the conveyance and outfall pipe will be along the shoreline, but in adequate depth to avoid impacts to the benthic environment. The applicant will place the pipeline over unconsolidated surfaces that will not suffer shading effects, thus avoiding impacts to intertidal or subtidal resources. To avoid impacts to the bottom-dwelling prey species and habitats, the applicant will suspend the dredge pipe above the bottom rather than anchor it directly on the bottom as proposed in previous applications. The pipeline will be anchored with heavy chains with weights on the ends that do not pose an entanglement risk to animals, and the project will not include use of any ropes or cables that are light enough to pose a potential entanglement risk.

The site chosen during the prior 2000 application process for dredged material placement (Placement Site 2) consists of sand; however, hard bottom resources were located with the potential area of turbidity effects. To avoid turbidity effects or migration of sediments to hard bottom communities, the dredged material placement site was relocated further south (to Placement Site 5). This measure helps ensure that the project avoids hard bottom habitats.

To demonstrate that the project has a minimum effect on the aquatic resources of concern, the applicant will conduct biological and water quality monitoring in association with the dredging. A specific dredging and monitoring plan will be submitted for review and approval prior to dredging. To quantify the effects of turbidity, suspended sediment, and dissolved oxygen changes due to dredging and placement, the applicant will monitor benthic habitat and water quality parameters before, during, immediately after, and periodically after dredging. The outcome of each monitoring event will be reported in a report to permitting and commenting natural resource agencies. These measures will quantify and qualify the level and duration of impacts from the project, and compare or confirm them to the predicted effects described in this report.

9 Conclusions

The proposed maintenance dredging will remove sediments from previously disturbed areas, and the project will not include dredging of new areas or at depths beyond that previously permitted and dredged (i.e., there is no "new work" material to be dredged). The proposed dredging will affect the areas of dredging and dredged material placement by temporarily increasing turbidity during dredging and deepening shallow and intertidal habitats (but not beyond depths previously permitted and dredged). The potential effects on managed fish and fish habitat from the proposed project include:

- Temporary suspension of sediments in the water column which may abrade gills and may affect foraging;
- Temporary burial of various portions of up to 56 acres of benthic biota and sand bottom habitat at the placement site;
- Sediments suspended by the dredge cutterhead may settle on creek bottom habitat in adjacent areas;
- Deepening of 50.5 acres in marina basins and creeks from intertidal and shallow benthic soft bottom communities to shallow subtidal habitats; and
- Entrainment and mortality of benthic infaunal organisms.

The primary concerns regarding effects to EFH from the proposed project are burial of foraging habitat in the placement site, temporary suspension of sediment in the water column at the placement site, temporary removal of benthic sandy bottom communities in the placement area (via burial) and dredging areas, and loss of shallow and intertidal flat habitat in the dredging areas. The area buried by the deposited sediment is small as compared to the size of Calibogue Sound. Also, the project is small as compared to other open water placement projects in the vicinity (e.g., the Port Royal ODMDS is more than ten times larger [960 acres], and the recent Hilton Head beach nourishment at the south end of the island was 670 acres). Although the proposed project is not directly comparable to an ocean site such as the ODMDS or a beach nourishment project, it is helpful to compare these acreages to put the scale of the proposed project in context with other dredging related projects in the region. Species will recolonize disturbed sediment in areas affected by the dredging. The recovery speed of the benthic community varies between a few weeks to 6 months (Clarke, D., and Miller-Way, T., 1992, Van Dolah et al., 1984).

The primary effects to managed fish species are related to temporary turbidity and suspended sediment effects in the water column, removal of shallow habitat, and temporary habitat burial in the placement area. Managed fish species expected to be affected include summer flounder and penaeid shrimp. Coastal sharks, particularly spiny dogfish and Atlantic sharpnose sharks, snapper and grouper species, and Spanish mackerel may experience minor impacts. The proposed avoidance, minimization, and mitigation measures will significantly reduce the impacts and measure (via monitoring) those impacts which are unavoidable. Table 10-1 summarizes the effects of the proposed project on EFH and federally managed fish species. Apart from the deepening of the bottom elevation of the dredged areas, the dredging and dredged material placement will cause only temporary and limited adverse impacts as discussed above. A temporary benefit would be enhanced feeding opportunities for turbidity tolerant fishes at the dredged material placement site due to transported fauna released from the dredge pipe.

Table 9-1. Summary of potential effects from the proposed project on EFH and managed species.

EFH Type	Effects Summary
Estuarine Emergent (Saltmarsh/Brackish Marsh)	Deepening of area within sand spit to be removed. Potential for indirect effects due to bank slumping.
Estuarine Unconsolidated Substrate	Temporary burial of various portions of up to 56 acres of sandy bottom in the placement area. No long term effects.
Estuarine Scrub Shrub	No effects. Not in impact area.
Seagrass/SAV)	No effects. Not in impact area.
Oyster Reef and Shell Bank	Adjacent to dredging area, may be temporarily affected by suspended sediments.
Tidal Flats	Channel areas dredged to increase depth.
Freshwater Wetlands	No effects. Not in impact area.
Water Column - Tidal Creek	Temporary suspended sediments during dredging.
Water Column - Calibogue Sound	Temporary suspended sediments during dredged material placement.
Coral	Sea whips in hard bottom areas north of dredged material placement area may be temporarily affected by low levels of suspended sediments from the placement area.
Coral Reefs	No effects. Not in impact area.
Live/Hard Bottom	Areas north of dredged material placement area may be temporarily affected by low levels of suspended sediments from the placement area.
Artificial Reefs	No effects. Not in impact area, nearest are north of Sound near Port Royal ODMDS.
Sargassum	No effects. Not in impact area, floating *Sargassum* will not be affected by subsurface turbidity.
MANAGED FISHES	
Bluefish	No effects. Not common in area during season of dredge activity.
Summer flounder	Deepening of foraging habitat in creeks, temporary sediment impacts to larvae and eggs, deepening of shallow nursery habitat in creeks, temporary disturbance of creek habitat during dredging.
Snapper and grouper species	Deepening of shallow nursery habitats in creeks, temporary sediment impacts to larvae and eggs in nearshore habitat during placement.
Dolphin	No effects. Not common in impact area.
Cobia	No effects. Not common in area during season of dredge activity.
Spanish mackerel	Temporary turbidity interference with foraging, sediment interference with prey distribution.
Coastal sharks	Temporary turbidity interference with foraging, sediment interference with prey distribution.
Brown, pink, and white shrimp	Deepening of shallow habitats in creeks, temporary sediment impacts to all life stages in nearshore habitat during placement.

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Appendix A – South Carolina Dredging Advisory (Van Dolah and Berquist, 2009)

South Carolina Department of Natural Resources

Advisory Regarding Dredging and Natural Resources

Problem: Many estuarine and marine water bodies are routinely dredged in order to ensure safe and efficient transportation between the open ocean and land-based infrastructure. Estuaries also provide habitat and nursery grounds for a wide range of commercially and recreationally important invertebrates (shrimp, crabs, oysters, etc.) and finfish (flounder, red drum, etc) as well as threatened and endangered species (sturgeon, sea turtles, etc.). Many of these species have both inshore and offshore life stages involving ingress and egress through channels, either as post-larval or juvenile organisms, or as adults. As a result, resource managers are placed in the position of balancing navigation channel maintenance with the potential impact of those activities on these natural resources. Central to this decision-making process is a clear identification of the resources potentially at risk as well as when and where those resources and dredging are likely to coincide.

Development of Ranking System: In order to provide guidance on these issues, a panel of SCDNR resource specialists was assembled and asked to develop spatially and temporally explicit distributions of important estuarine, diadromous, and marine species. This list included various crustacean, finfish, mollusk and sea turtle species that are either of commercial-recreational value and/or that are protected by state or federal law (Table 1). The estuarine/marine environment was divided into eight habitats, based on ocean proximity, water body size, and salinity, that could be dredged (Table 2). The likelihood of each species coinciding with dredging in each habitat was then ranked for each half-month increment throughout the calendar year. The ranking system had four levels describing the probability of a species' presence in an area impacted by dredging:

- white—little if any probability of occurrence,
- yellow—low probability of occurrence,
- orange—moderate probability of occurrence,
- red—high probability of occurrence.

Table 1. Species ranked for occurrence in estuarine habitats.

Crustaceans
Brown Shrimp, White Shrimp, Blue Crab
Finfish
Red Drum, Spotted Sea Trout, Flounder, Shad, Shortnose Sturgeon, Atlantic Sturgeon, American Eel
Molluscs
American Oyster, Hard Clam
Sea Turtles
Loggerhead, Kemp's Ridley, Green, Leatherback

In addition to the species rankings, hopper dredging is restricted in state waters to the period of December through March. As a result, the April through November period was given a"red" ranking for hopper dredging in those environments where it could be used. The rankings were compiled into spreadsheets (Tables 3-10) that allow rapid identification of time periods during which few or many species may be affected by dredging.

Table 2. Estuarine habitats that potentially face dredging

Habitat	Definition
Major Estuary Entrance Channel	Connection of major bays and sounds to open ocean
Smaller Inlet Entrances	Connection of tidal rivers and creeks to open ocean.
High Salinity Bay/ Sound	Open water body with salinity > 18 ppt
Mesohaline River	Channelized water body > 100 m bank to bank and salinity 5-18 ppt
Oligohaline River	Channelized water body > 100 m bank to bank and salinity 0-5 ppt
High Salinity Creek	Channelized water body < 100 m bank to bank and salinity > 18 ppt
Mesohaline Creek	Channelized water body < 100 m bank to bank and salinity 5-18 ppt
Oligohaline Creek	Channelized water body < 100 m bank to bank and salinity 0-5 ppt

Prepared by - South Carolina Department of Natural Resources - 2009

The decision to base the rankings on occurrence rather than risk reflected a need to provide an objective tool for resource managers, whereas to adequately assess risk for the various species typically requires detailed information about a particular project . More specifically, the time-specific rankings were not developed to measure the risk of dredging to individual species' populations (for example: will entrainment of larvae by a dredge negatively impact shrimp populations?) or the relative risk among different species (for example: will the loss of one sturgeon have more impact that the loss of one flounder). Drawing these kinds of conclusions without the needed information would have resulted in an overly subjective series of rankings that force trading impacts to one species against another. The goal with the ranking spreadsheets was to provide additional critical information and to leave decision-making to the experience and judgment of resource managers.

Reading the Rankings Spreadsheets: Each spreadsheet shows the occurrence rankings for the target species for each half-month time period in one of the estuarine/marine habitats. The temporal patterns of occurrence generally reflect the life cycles of the species in South Carolina. For example, brown shrimp, *Farfantepenaeus aztecus,* spawn offshore and larvae enter estuaries during spring, take up residence in mesohaline tidal creeks and rivers, and then exit to the ocean during the summer. The ranking tables for probability of their occurrence in major estuary entrance channels (Table 3) and smaller inlet entrances (Table 4) during February and March (larval ingress) and May through mid-August (adult egress) and high probabilities of occurrence in mesohaline rivers and creeks (Tables 6 and 9) and bays and sounds (Table 5) in between ingress and egress (nursery stage). This species may also take up residence in oligohaline environments and higher salinity creeks, but less often and in lower numbers, thus their probability of occurrence in these environments are shown as low to moderate (Tables 7, 8 and 10).

Example Applications of Spreadsheets:

Example 1—Proposed Dredging of a Major Estuary Entrance Channel (Table 3). Dredging in this habitat illustrates decisions that may be made among the conflicting needs of various protected species. Hopper dredging is only allowed from December 1 through March 31 due to dangers of this form of dredging to sea turtles. However, the threatened shortnose and Atlantic sturgeon have a high probability of occurrence in entrance channels and numerous other species are also entering and exiting the estuary during that period. To minimize the chances of impacts to estuarine/marine resources, hydraulic dredging between April 1 and August 31 would be recommended. If this is not enough time, that window could be expanded through September when the likelihood of sturgeon occurrence is low (yellow). If still more time is needed, the window could be extended into March and October when occurrence probabilities are moderate. Dredging would likely not be permitted in this habitat between November and February.

Example 2—Proposed Dredging of a Mesohaline Creek (Table 9). Dredging in this habitat illustrates decisions that may be made in a weight-of-evidence manner. These habitats are most heavily used by crustaceans, mollusks and finfish of commercial and/or recreational value with peak occurrences between February and October. Dredging may be recommended between November 1 and January 31 to avoid that time period. If more time is needed for the project, that window may be expanded into spring and early fall in such a way as to affect the fewest species possible. Although oysters will be present year-round, they occur almost exclusively in the intertidal zone in South Carolina. If significant oyster resources are present in a creek, dredging will likely be restricted to subtidal areas and to a design not likely to cause the loss of oyster habitat due to slumping.

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Table 3. Major estuary entrances channels

	January		February		March		April		May		June		July		August		September		October		November		December	
Species	1-15	16-31	1-15	16-28	1-15	16-31	1-15	16-30	1-15	16-31	1-15	16-30	1-15	16-31	1-15	16-31	1-15	16-30	1-15	16-31	1-15	16-30	1-15	16-31
Crustaceans																								
Brown Shrimp																								
White Shrimp																								
Blue Crab																								
Finfish																								
Red Drum																								
Spotted Trout																								
Flounder																								
Shad																								
Shortnose Sturgeon																								
Atlantic Sturgeon																								
American Eel																								
Mollusks																								
Oysters																								
Hard Clams																								
Turtles																								
Loggerhead																								
Kemp's ridley																								
Green																								
Leatherback																								
OCRM Regs For Hopper Dredges																								

Table 4. Smaller inlet entrances

	January		February		March		April		May		June		July		August		September		October		November		December	
Species	1-15	16-31	1-15	16-28	1-15	16-31	1-15	16-30	1-15	16-31	1-15	16-30	1-15	16-31	1-15	16-31	1-15	16-30	1-15	16-31	1-15	16-30	1-15	16-31
Crustaceans																								
Brown Shrimp																								
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Oysters																								
Hard Clams																								
Turtles																								
Loggerhead																								
Kemp's ridley																								
Green																								
Leatherback																								
OCRM Regs For Hopper Dredges																								

little if any probability of occurrence

low probability of occurrence

moderate probability of occurrence

high probability of occurrence

Table 5. High salinity bay or sound

Species	January		February		March		April		May		June		July		August		September		October		November		December	
	1-15	16-31	1-15	16-28	1-15	16-31	1-15	16-30	1-15	16-31	1-15	16-30	1-15	16-31	1-15	16-31	1-15	16-30	1-15	16-31	1-15	16-30	1-15	16-31
Crustaceans																								
Brown Shrimp																								
White Shrimp																								
Blue Crab																								
Finfish																								
Red Drum																								
Spotted Trout																								
Founder																								
Shad																								
Shortnose Sturgeon																								
Atlantic Sturgeon																								
American Eel																								
Mollusks																								
Oysters																								
Hard Clams																								
Turtles																								
Loggerhead																								
Kemp's ridley																								
Green																								
Leatherback																								
OCRM Regs for Hopper Dredges																								

Table 6. Mesohaline rivers

Species	January		February		March		April		May		June		July		August		September		October		November		December	
	1-15	16-31	1-15	16-28	1-15	16-31	1-15	16-30	1-15	16-31	1-15	16-30	1-15	16-31	1-15	16-31	1-15	16-30	1-15	16-31	1-15	16-30	1-15	16-31
Crustaceans																								
Brown Shrimp																								
White Shrimp																								
Blue Crab																								
Finfish																								
Red Drum																								
Spotted Trout																								
Flounder																								
Shad																								
Shortnose Sturgeon																								
Atlantic Sturgeon																								
American Eel (Elvers)																								
Mollusks																								
Oysters																								
Hard Clams																								
Turtles																								
Loggerhead																								
Kemp's ridley																								
Green																								
Leatherback																								
OCRM Regs For Hopper Dredges																								

little if any probability of occurrence

low probability of occurrence

moderate probability of occurrence

high probability of occurrence

Prepared by - South Carolina Department of Natural Resources - 2009

Table 7. Oligohaline rivers

Species	January 1-15	January 16-31	February 1-15	February 16-28	March 1-15	March 16-31	April 1-15	April 16-30	May 1-15	May 16-31	June 1-15	June 16-30	July 1-15	July 16-31	August 1-15	August 16-31	September 1-15	September 16-30	October 1-15	October 16-31	November 1-15	November 16-30	December 1-15	December 16-31
Crustaceans																								
Brown Shrimp									M	M	M													
White Shrimp									H	H	H	M	M											
Blue Crab										M	M	M	M	H	H	H	H	H	H					
Finfish																								
Red Drum	L	L	L	L															L	L	L	L	L	L
Spotted Trout	L	L	L	L			L	L	L	L	L	L	L	L	L	L	L	L						
Flounder	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L						
Shad	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L				
Shortnose Sturgeon	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	M	M	L	L	L	L
Atlantic Sturgeon			L	L	H	H	H	H	H	H	H	H	H	H	L	L	L	L	M	M				
American Eel (Elvers)	M	M	M	M	H	H	H	H	H	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
Mollusks																								
Oysters																								
Hard Clams																								
Turtles																								
Loggerhead																								
Kemp's ridley																								
Green																								
Leatherback																								
OCRM Regs For Hopper Dredges																								

Table 8. High salinity creeks

Species	January 1-15	January 16-31	February 1-15	February 16-28	March 1-15	March 16-31	April 1-15	April 16-30	May 1-15	May 16-31	June 1-15	June 16-30	July 1-15	July 16-31	August 1-15	August 16-31	September 1-15	September 16-30	October 1-15	October 16-31	November 1-15	November 16-30	December 1-15	December 16-31
Crustaceans																								
Brown Shrimp			M	M	M	M	M	M	M	M														
White Shrimp									M	M	M	M	M	M	M	M	M	M						
Blue Crab							M	M	M	M	M	M	M	M	M	M	M	M	M	M				
Finfish																								
Red Drum																	M	M	M	M	M	M	M	M
Spotted Trout							M	M	M	M	M	M	M	M	M	M	M	M						
Flounder					H	H	H	H	L	L	L	L	L	L	L	L								
Shad																								
Shortnose Sturgeon																								
Atlantic Sturgeon																								
American Eel																								
Mollusks																								
Oysters	M	M	M	M	M	M	M	M	H	H	H	H	H	H	H	H	H	H	M	M	M	M	M	M
Hard Clams	M	M	M	M	M	M	M	M	H	H	H	H	H	H	H	H	H	H	M	M	M	M	M	M
Turtles																								
Loggerhead																								
Kemp's ridley																								
Green																								
Leatherback																								
OCRM Regs For Hopper Dredges																								

(blank/white) little if any probability of occurrence
(L/yellow) low probability of occurrence
(M/orange) moderate probability of occurrence
(H/red) high probability of occurrence

Table 9. Mesohaline creeks

Species	January		February		March		April		May		June		July		August		September		October		November		December	
	1-15	16-31	1-15	16-28	1-15	16-31	1-15	16-30	1-15	16-31	1-15	16-30	1-15	16-31	1-15	16-31	1-15	16-30	1-15	16-31	1-15	16-30	1-15	16-31
Crustaceans																								
Brown Shrimp			Moderate	High	High	High	High	High	High	High	High	High	Moderate											
White Shrimp									Moderate	High	High	High	High	High	High	High	High	Moderate	Moderate	Low	Low			
Blue Crab	Low	Low	Low	Low	Low	High	High	High	High	High	High	High	High	High	High	High	High	High	High	High				
Finfish																								
Red Drum																	High	High	High	High	High	High	High	High
Spotted Trout							Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Low	Low	Low	Low	Low	Low
Flounder					High	High	High	High	Low	Low	Low	Low	Low	Low	Low	Low								
Shad																								
Shortnose Sturgeon																								
Atlantic Sturgeon																								
American Eel (Elvers)																								
Mollusks																								
Oysters	Low	Low	Low	Low	Low	Low	Low	Low	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Low	Low	Low	Low	Low	Low
Hard Clams	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
Turtles																								
Loggerhead																								
Kemp's ridley																								
Green																								
Leatherback																								
OCRM Regs For Hopper Dredges																								

Table 10. Oligohaline creeks

Species	January		February		March		April		May		June		July		August		September		October		November		December	
	1-15	16-31	1-15	16-28	1-15	16-31	1-15	16-30	1-15	16-31	1-15	16-30	1-15	16-31	1-15	16-31	1-15	16-30	1-15	16-31	1-15	16-30	1-15	16-31
Crustaceans																								
Brown Shrimp							Low	Low	Low	Low	Low	Low	Low	Low										
White Shrimp									Moderate	Moderate	High	High	High	High	High	High	High	High						
Blue Crab											Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate				
Finfish																								
Red Drum	Low	Low	Low	Low															Low	Low	Low	Low	Low	Low
Spotted Trout	Low	Low	Low	Low			Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low						
Flounder	Low	Low	Low	Low	High	High	High	High	High	High	Low	Low	Low	Low	Low	Low								
Shad																								
Shortnose Sturgeon																								
Atlantic Sturgeon																								
American Eel (Elvers)	Moderate	Moderate	High	High	High	High	High	High	High	High	Moderate	Moderate	Low	Low										
Mollusks																								
Oysters																								
Hard Clams																								
Turtles																								
Loggerhead																								
Kemp's ridley																								
Green																								
Leatherback																								
OCRM Regs For Hopper Dredges																								

- little if any probability of occurrence
- low probability of occurrence
- moderate probability of occurrence
- high probability of occurrence