MID-CURRITUCK BRIDGE STUDY

ESSENTIAL FISH HABITAT TECHNICAL REPORT

WBS ELEMENT: 34470.1.TA1
STIP NO. R-2576
CURRITUCK COUNTY
DARE COUNTY

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1.0 Introduction

The North Carolina Turnpike Authority (NCTA), a division of the North Carolina Department of Transportation (NCDOT), in cooperation with the Federal Highway Administration (FHWA), is preparing a Draft Environmental Impact Statement (DEIS) to evaluate proposed improvements in the Currituck Sound area. The proposed action is included in NCDOT's 2009-2015 *State Transportation Improvement Program* (STIP), the North Carolina Intrastate System, the North Carolina Strategic Highway Corridor Plan, and the Thoroughfare Plan for Currituck County.

The purpose of this document is to assess impacts to essential fish habitat (EFH) resulting from the construction of the Mid-Currituck Bridge and associated US 158 and NC 12 road widening contained in the project's detailed study alternatives. The Magnuson-Stevens Fishery Conservation and Management Act (16 USC 1801 et seq.) requires the US Secretary of Commerce to develop guidelines assisting regional fisheries management councils in the identification and creation of management and conservation plans for EFH. Each council is required to amend existing fisheries management plans (FMPs) to include EFH designations and conservation requirements. The act also requires federal agencies to consult with the Secretary on all actions, or proposed actions, authorized, funded, or undertaken by the agency that might adversely affect EFH.

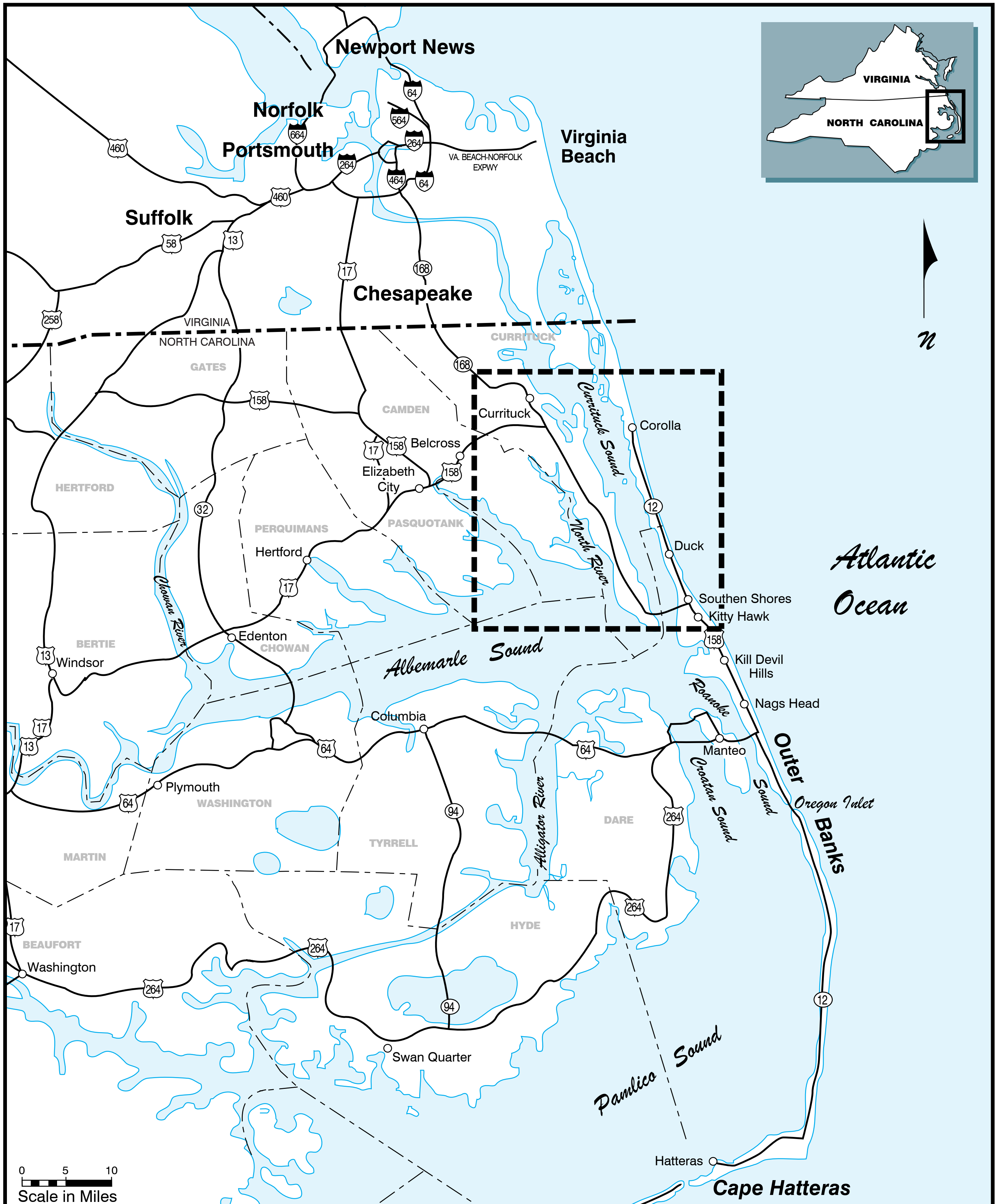
EFH is defined as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity" (16 USC 1802(10)). "Waters" include aquatic areas and their associated physical, chemical, and biological properties that are used by fish and can include aquatic areas historically used by fish where appropriate. "Substrate" includes sediment, hard bottom, structures underlying the waters, and associated biological communities. "Necessary" means the habitat is required to support a sustainable fishery and the managed species' contribution to a healthy ecosystem. "Spawning, breeding, feeding, or growth to maturity" covers a species' full life cycle. EFH designations are required only for species or species units for which councils have developed FMPs.

2.0 Project Area

Currituck and Dare counties are in northeastern North Carolina within the Tidewater Region of the Atlantic Coastal Plain physiographic province (Figure 1). Topography of the project area consists of nearly level and gently sloping land that drains primarily into Currituck Sound.

The project area is in northeastern North Carolina and includes the Currituck County peninsula on the mainland and its Outer Banks, as well as the Dare County Outer Banks north of Kitty Hawk (see Figure 2). The project area is south of the Virginia Beach-Norfolk, Virginia (Hampton Roads) metropolitan area. The project area encompasses two thoroughfares: US 158 from NC 168 to NC 12 (including the Wright Memorial Bridge) and NC 12 north of its intersection with US 158 to its terminus in Currituck County. US 158 is the primary north-south route on the mainland. NC 12 is the primary north-south route on the Outer Banks. The Wright Memorial Bridge connects the mainland (southern end of Currituck County) with the Dare County Outer Banks.

The survey area for the Section 404 jurisdictional delineation was used for the purpose of quantifying EFH habitats found in the project area that could be affected by the detailed study alternatives. Mainland portions of the project corridors traverse several distinctive landscapes. The eastern edge of Great Swamp occurs west of US 158 along the edge of the project area. Great Swamp is a low elevation wetland associated with the North River. US 158 follows a well drained ridge along the western side of the project area. In proximity to Aydlett Road, the project area continues east of this ridge crossing a broad, level, poorly drained, linear depression occupied primarily by Maple Swamp. Another well drained ridge occurs between Maple Swamp and Currituck Sound. Mainland development is concentrated along these upland ridges. The project area crosses Currituck Sound to the Outer Banks and crosses narrow bands of poorly drained sandy soils supporting marshes and swamp forest before reaching better drained sandy soils along NC 12. Elevations on the mainland range from near sea level to 20 feet above sea level, and elevations along the Outer Banks range from sea level to 10 feet above sea level.



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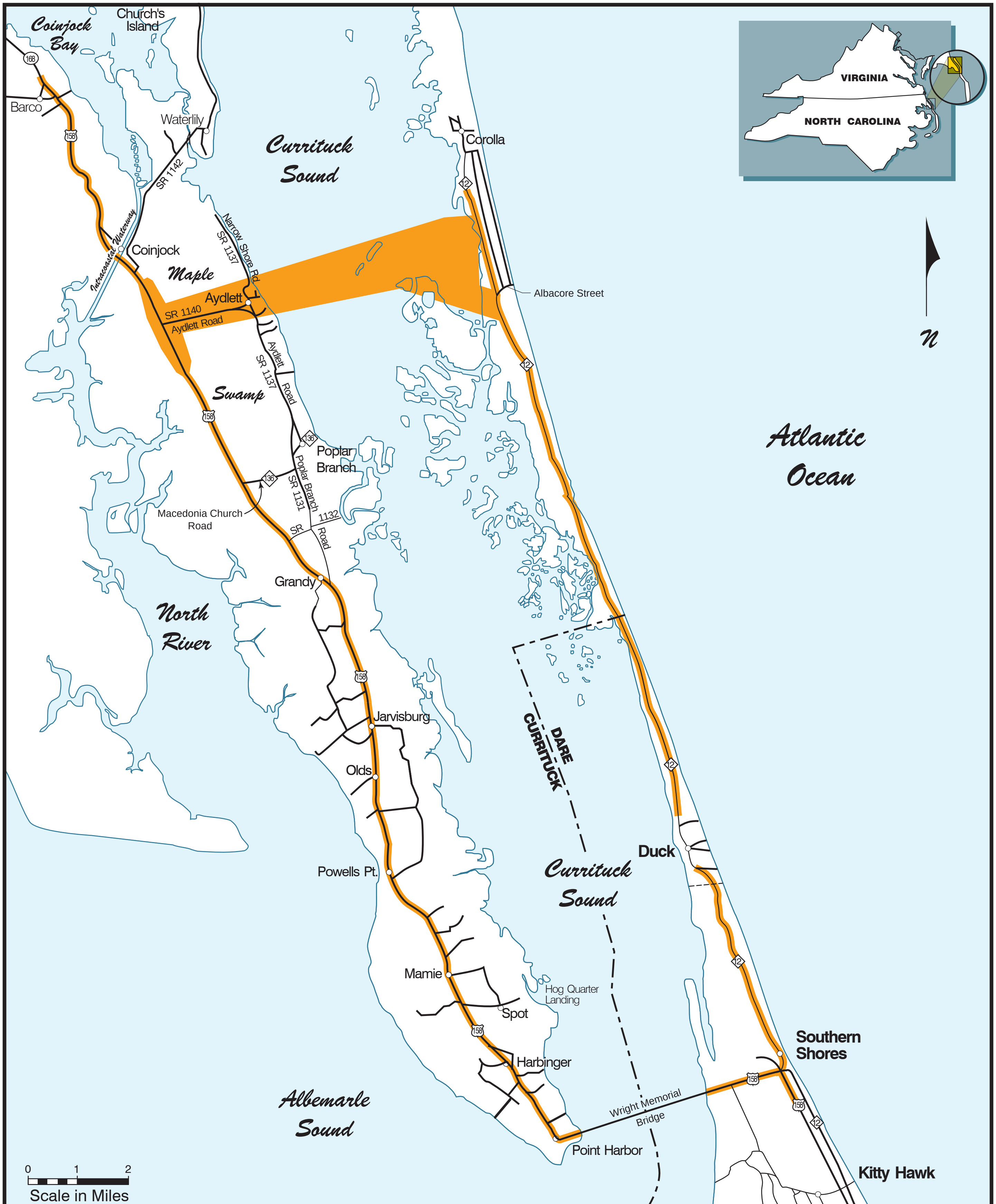
Project Vicinity

Vicinity Map

Figure

1



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— - — County Boundaries

Section 404 Survey Area

Project Area Map

Figure
2

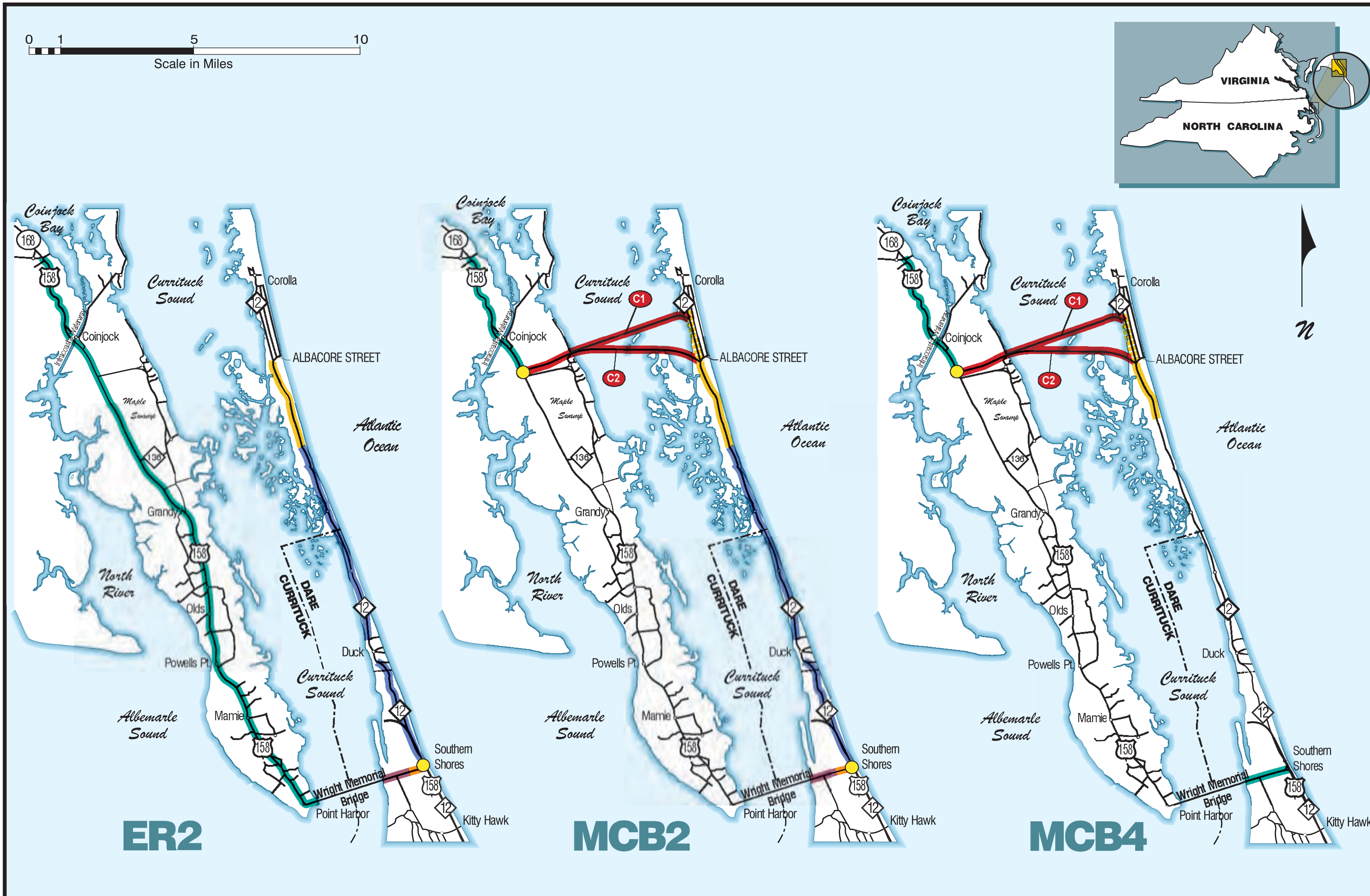
3.0 Project Description

The proposed action responds to three underlying needs in the project area. These needs are based on the following travel conditions:

- The project area's main thoroughfares (US 158 and NC 12) are becoming increasingly congested, and congestion will become even more severe in the future.
- Increasing congestion is causing travel time between the Currituck County mainland and the Currituck County Outer Banks to increase, especially during the summer.
- Evacuation times for residents and visitors who use US 158 and NC 168 as an evacuation route far exceed the State-designated standard of 18 hours.

An alternatives screening study was conducted for the project. Its findings were discussed with federal and state environmental resource and regulatory agencies in a series of Turnpike Environmental Agency Coordination (TEAC) meetings in 2006, 2007, 2008, and 2009. Based on discussions at TEAC meetings, and written comments received from the agencies and public, the *Alternatives Screening Report* (Parsons Brinckerhoff, 2009) for the proposed project identified three alternatives to be carried forward for detailed study in the Draft Environmental Impact Statement (DEIS) along with the No-Build Alternative. The detailed study alternatives identified are ER2, MCB2, and MCB4. The detailed study alternatives are shown on Figure 3 and described below:

- **ER2**
    - Adding for evacuation use only, a third outbound evacuation lane on US 158 between NC 168 and the Wright Memorial Bridge as a hurricane evacuation improvement or using the existing center turn lane as a third outbound evacuation lane; in either case one inbound lane on the Wright Memorial Bridge and on the Knapp (Intracoastal Waterway) Bridge would be used as a third outbound evacuation lane;
    - Widening US 158 to a six-lane super-street between the Wright Memorial Bridge and Cypress Knee Trail that widens to eight lanes between Cypress Knee Trail and the Home Depot driveway;
    - Constructing an interchange at the current intersection of US 158, NC 12, and the Aycock Brown Welcome Center entrance, including six through lanes on US 158 starting at the Home Depot driveway and returning to four lanes just south of Grissom Street; and



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- Eight Lanes (Super-street)
- Six Lanes (Super-street)
- Four Lanes
- Four Lanes (Only with C1)
- Three Lanes
- Mid-Currituck Bridge
- Third Outbound Lane (Contraflow of an existing lane is an option)
- C1 / C2 Bridge Corridor Alternatives
- Interchange

NOTE: Existing 3-lane segment of NC 12 in Duck is unchanged.

Detailed Study Alternatives

Figure

3

- Widening NC 12 to three lanes between US 158 and a point just north of Hunt Club Drive in Currituck County (except where NC 12 is already three lanes in Duck) and to four lanes with a median from just north of Hunt Club Drive to Albacore Street.

- **MCB2**
  - Constructing a two-lane toll bridge across Currituck Sound, as well as approach roads and/or bridges and an interchange at US 158;
  - Adding for evacuation use only, a third outbound evacuation lane on US 158 between NC 168 and the Mid-Currituck Bridge as a hurricane evacuation improvement or using the existing center turn lane as a third outbound evacuation lane; in either case one inbound lane on the Knapp (Intracoastal Waterway) Bridge would be used as a third outbound evacuation lane;
  - Widening US 158 to a six-lane super-street between the Wright Memorial Bridge and Cypress Knee Trail and an eight-lane super-street between Cypress Knee Trail and the Home Depot driveway;
  - Constructing an interchange at the intersection of US 158, NC 12, and the Aycock Brown Welcome Center entrance, including six through lanes on US 158 starting at the Home Depot driveway and returning to four lanes just south of Grissom Street; and
  - Widening NC 12 to three lanes between US 158 and a point just north of Hunt Club Drive in Currituck County (except where NC 12 is already three lanes in Duck) and to four lanes with a median from just north of Hunt Club Drive to NC 12's intersection with the Mid-Currituck Bridge.

- **MCB4**
  - Constructing a two-lane toll bridge across Currituck Sound, as well as approach roads and/or bridges and an interchange at US 158;
  - Adding for evacuation use only, a third outbound evacuation lane on US 158 between NC 168 and the Mid-Currituck Bridge as a hurricane evacuation improvement or using the existing center turn lane as a third outbound evacuation lane; in either case one inbound lane on the Knapp (Intracoastal Waterway) Bridge would be used as a third outbound evacuation lane;
  - Adding for evacuation use only, a third outbound evacuation lane on US 158 between the Wright Memorial Bridge and NC 12 as a hurricane evacuation improvement or using the existing center turn lane as a third outbound

evacuation lane; in either case one inbound lane on the Wright Memorial Bridge would be used as a third outbound evacuation lane; and

- Widening NC 12 in Currituck County to four lanes with a median from Seashell Lane to NC 12's intersection with the Mid-Currituck Bridge.

The unique characteristic of a super-street, included along US 158 east of the Wright Memorial Bridge with ER2 and MCB2, is the configuration of the intersections. Side-street traffic wishing to turn left or go straight must turn right onto the divided highway where it can make a U-turn through the median a short distance away from the intersection. After making the U-turn, drivers can then either go straight (having now accomplished the equivalent of an intended left turn) or make a right turn at their original intersection (having now accomplished the equivalent of an intention to drive straight through the intersection).

For MCB2 and MCB4, two design options are evaluated for the approach to the bridge over Currituck Sound, between US 158 and Currituck Sound. Option A would place a toll plaza within the US 158 interchange. The mainland approach road to the bridge over Currituck Sound would include a bridge over Maple Swamp. With Option B, the approach to the bridge over Currituck Sound would be a road placed on fill within Maple Swamp. Aydlett Road would be removed and the roadbed restored as a wetland. Traffic traveling between US 158 and Aydlett would use the new bridge approach road. A local connection would be provided between the bridge approach road and the local Aydlett street system. The toll plaza would be placed in Aydlett east of that local connection so that Aydlett traffic would not pass through the toll plaza when traveling between US 158 and Aydlett. No access to and from the Mid-Currituck Bridge would be provided at Aydlett.

Also, for MCB2 and MCB4, there are two variations of the proposed bridge corridor (see Figure 3) in terms of its terminus on the Outer Banks. Bridge corridor C1 would connect with NC 12 at an intersection approximately two miles north of the Albacore Street retail area, whereas bridge corridor C2 would connect with NC 12 approximately one-half mile south of this area. The length of the proposed Mid-Currituck Bridge would be approximately 7.0 miles with bridge corridor C1, whereas it would be approximately 7.5 miles with bridge corridor C2.

When impacts differ for the three alternatives (ER2, MCB2, and MCB4) between the mainland approach road design options (Option A and Option B) and/or the two bridge corridors (C1 and C2), the names of the alternatives are augmented with suffixes for the mainland approach road design option and/or the bridge corridor. For example, MCB2 with mainland design Option B and the C1 corridor is referred to as MCB2/B/C1. In situations where impacts differ between the bridge corridors but the design option on the mainland is not relevant to the comparison, only the corridor suffix is used (e.g., MCB2/C1). When differences are confined to the mainland design options, only the design option suffix is used (e.g., MCB2/A). If no suffix is provided (e.g., MCB2), then the reader can assume that impacts would be identical irrespective of the mainland design option or corridor terminus alternative used.

4.0 Essential Fish Habitat

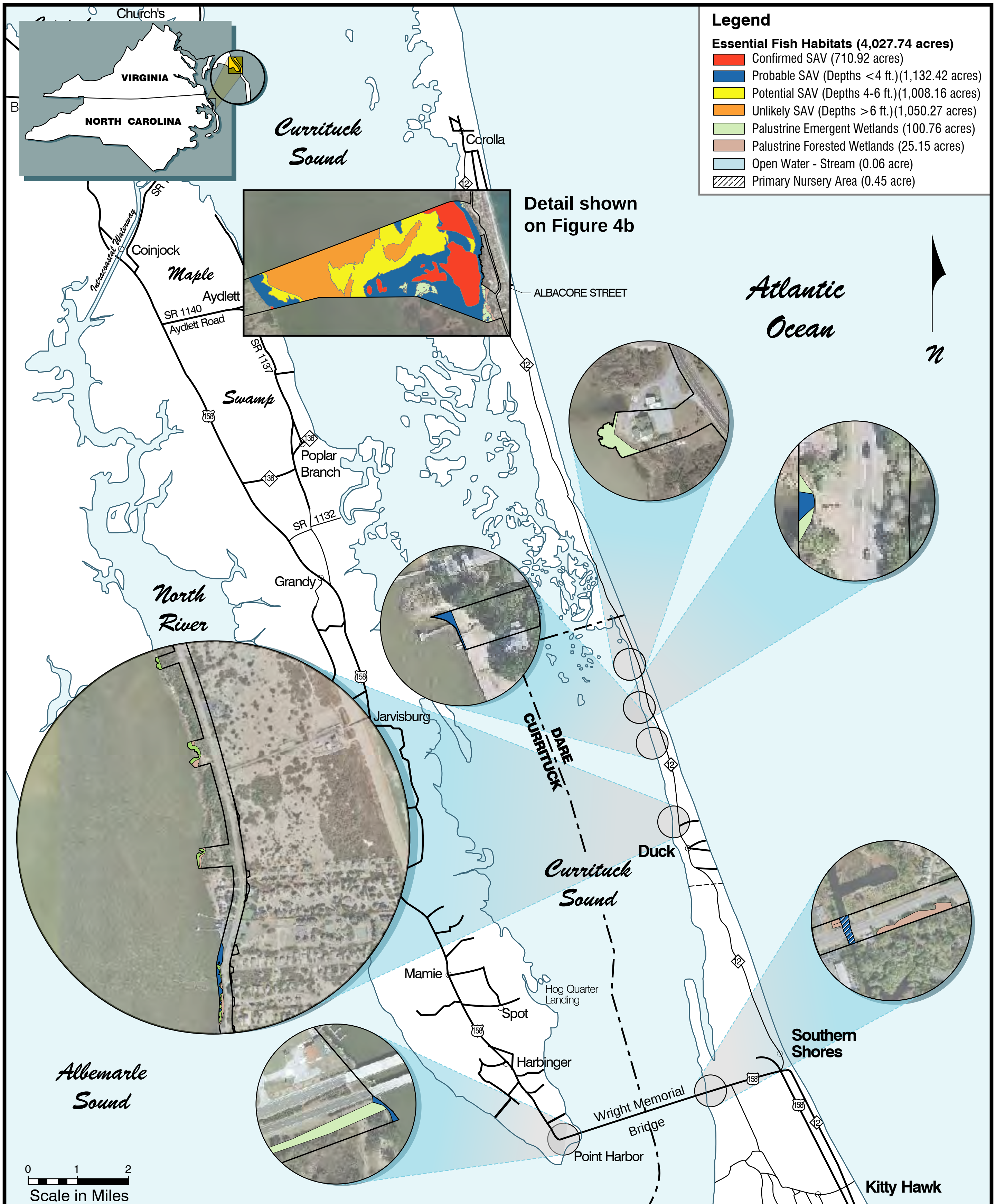
4.1 Habitat Elements

Managed species found in the project area fall under the joint responsibility of the South Atlantic Fisheries Management Council (SAFMC), the Mid-Atlantic Fisheries Management Council (MAFMC), and the National Marine Fisheries Service (NMFS). Both the SAFMC and MAFMC have defined several habitats to be EFH for managed species (SAFMC, 2008; MAFMC, 2008). In general, EFH areas affected by the detailed study alternatives include habitats and wetlands associated with the Currituck Sound. A list of EFH habitat types and their presence in the project area are provided in Table 1. Although Currituck Sound is oligohaline (classification within estuarine system [Cowardin et al., 1979]), the adjacent marshes are more characteristic of a palustrine community and so have been included within the palustrine emergent habitat category, and SAV has been included in both estuarine (SAV) and tidal freshwater (aquatic bed) habitat categories. Habitats are described in more detail in the following sections. Figure 4 depicts locations of EFH areas found within the project area; estuarine water column and aquatic bed are synonymous and broken down into SAV categories, and intertidal mudflats are unable to be accurately mapped.

Table 1. EFH Types Found in the Project Area

EFH Type	Found in Project Area
Inshore	
• Estuarine emergent and forested	No*
• Estuarine shrub/scrub (mangrove)	No
• Submerged aquatic vegetation (SAV)	Yes
• Oyster reef and shell bank	Yes (Relic)
• Intertidal flats/mud bottoms	Yes
• Palustrine emergent and forested (freshwater)	Yes
• Aquatic bed (tidal freshwater)	Yes
• Estuarine water column/creeks	Yes
Marine	
• Live/hard bottom	No
• Coral and coral reef	No
• Artificial/manmade reef	No
• Sargassum	No
• Water column	No

*Sound-fringing marshes are included within the freshwater/palustrine emergent category.



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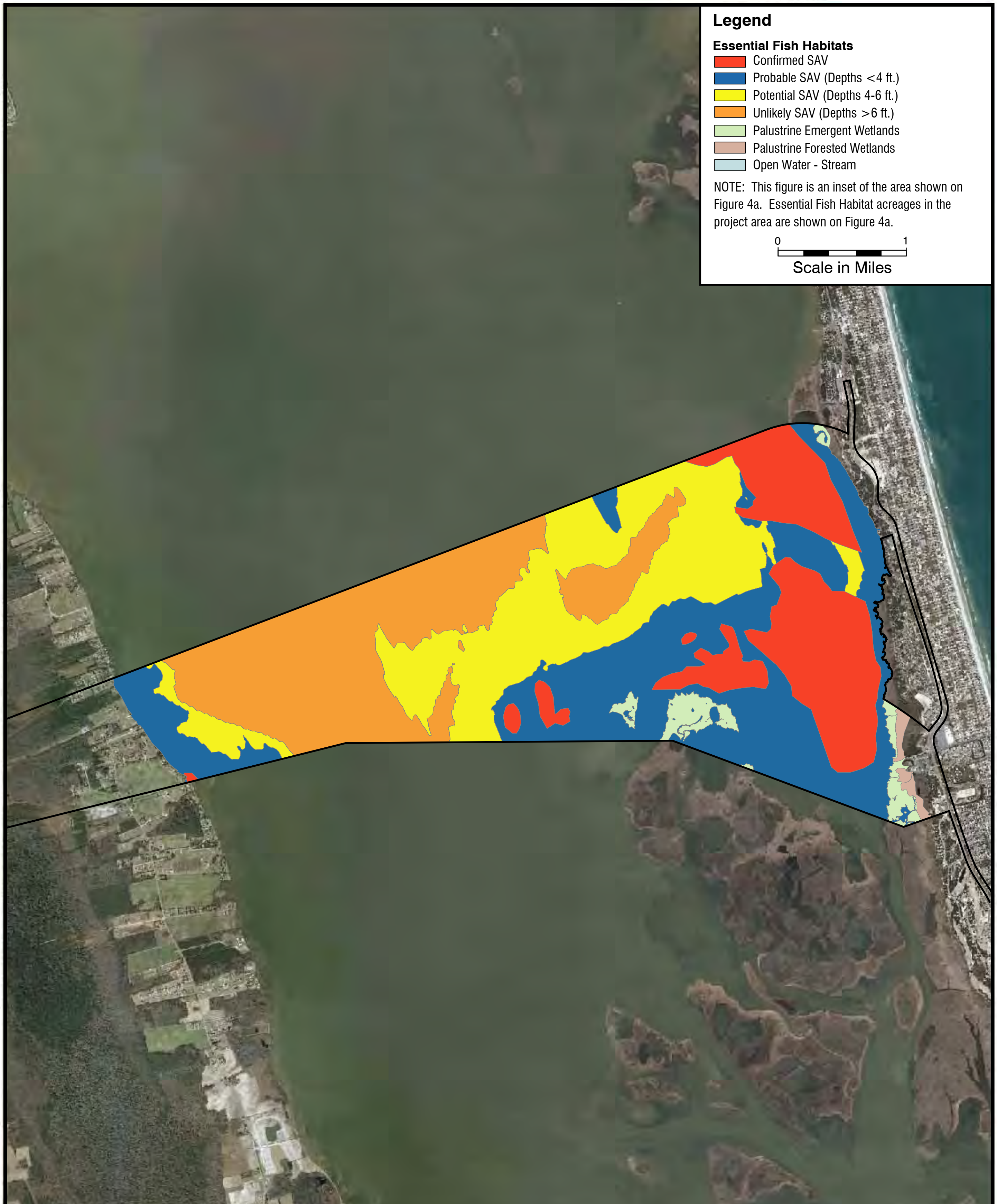
— - — County Boundaries

Essential Fish Habitats

Figure 4a



Essential Fish Habitats

Figure

4b

4.1.1 Submerged Aquatic Vegetation (SAV)

The shallow waters (less than 6 feet [2 meters] deep) of Currituck Sound provide habitat for beds of submerged aquatic vegetation (SAV). These SAV communities are included within the open water areas of the Currituck Sound. For many juvenile and adult fish, the structural complexity of SAV habitat provides refuge from predators. These habitats are also rich in invertebrates and, therefore, serve as important foraging areas. Other functions of SAV include stabilizing sediment, nutrient cycling, reducing wave energy, and providing organic matter that supports complex food webs (NCWRC, 2005). For these reasons, SAV communities are considered Habitat Areas of Particular Concern (HAPC) for several managed fish species. The distribution and composition of SAV communities are influenced by several factors; among the most important factors are light, salinity, wave action, and nutrient levels. Recent studies have referenced these systems as submersed rooted vascular (SRV) beds, which distinguishes rooted vegetation from primarily algae (Ferguson and Wood, 1994). Species composition and biomass of SAV in the Currituck Sound have varied greatly over the past 70 years (Davis and Carey, 1981; Davis and Brinson, 1983).

The abundance of many native SAV species declined in the 1960's with the invasion of Eurasian water milfoil (*Myriophyllum spicatum*). Recent trends indicate a decrease in Eurasian water milfoil and an increase in formerly more common, low salinity tolerant, native species such as widgeon grass (*Ruppia maritima*) and wild celery (*Vallisneria americana*) (Ferguson and Wood, 1994; Davis and Brinson, 1989). Other freshwater to low salinity tolerant SRV species predominately occurring as a result of the low salinity levels found in the project area of Currituck Sound include sago pondweed (*Potamogeton pectinatus*), redhead grass (*Potamogeton perfoliatus*), and bushy pondweed (*Najas guadalupensis*). Stoneworts, a type of macroscopic algae (*Chara* spp.), also have been important components of SAV communities.

Approximately 711 acres of SAV were confirmed within the project area in Currituck Sound during a survey (including side-scan sonar) conducted in 2007 by the US Army Corps of Engineers (USACE, 2007). Bathymetry data indicate approximately 1,008 additional acres of potential SAV habitat (waters 4 to 6 feet deep) and approximately 1,129 additional acres of probable SAV habitat (water less than 4 feet deep). The waters of Jean Guite Creek and other open water areas of Currituck Sound not included in the USACE survey area (westward extensions off of NC 12) comprise 1.1 acres of the probable SAV habitat within the project area (Table 2).

Table 2. Results of the SAV Survey of the Project Area in Currituck Sound Conducted by the USACE in September 2007

SAV Presence/Likelihood of Occurrence	Water Depth in Feet	Approximate Acreage in Project Area
• Confirmed SAV present	0.0 - 5.0[1]	710.9
• Probable SAV habitat[2]	0.0 - 4.0	1,129
• Potential SAV habitat	4.0 - 6.0	1,008.2
• Unlikely SAV habitat	> 6.0	1,050.3
Total Open Waters of Currituck Sound		3,898.3

Source: USACE, 2007 and analysis of associated GIS data.
[1] Approximately 98 percent (697 acres) of SAV was found at water depths less than 4 feet. Approximately 2 percent (14.0 acres) of SAV was found at water depths between 4 and 5 feet.
[2] Includes Jean Guite Creek and open water areas of Currituck Sound not found in the USACE survey area (1.1 acres).

4.1.2 Oyster Reef and Shell Bank

Oyster reefs and shell banks are intertidal or subtidal habitats composed of living shellfish or artifact shell material. Several species of specialized fish and invertebrates are associated with oyster reefs as these habitats provide food and cover. Living oyster populations are limited by, among other things, siltation, salinity, and substrate. Throughout their entire Atlantic range, oyster reefs have declined substantially in the last century because of anthropogenic and natural stressors. Oyster reefs are not likely to occur in the sound because of low salinity levels (Personal communication, Clay Caroon, NCDMF, 5-7-08). The optimum salinity range for oysters is 10 to 30 parts per thousand (ppt) (NCDMF, 2001), which does not occur in the project area. In the recent survey by the USACE, evidence of relic oyster beds was found typically at depths greater than 6 feet in the form of shell hash, which is a mixture of broken shells, sand, mud and/or gravel (USACE, 2007, Street et al., 2005).

4.1.3 Intertidal Flats

Intertidal flats are un-vegetated or sparsely vegetated, sandy or soft bottom areas and are found throughout the project area. These flats provide year round habitat for invertebrates and are important feeding areas for both resident fishes and seasonal migrants. Particularly important is the microhabitat known as the “marsh edge,” or the detritus-rich area where the flats interface with marsh vegetation. The spatial extent of intertidal flats is determined by local topography and tidal amplitude, which is primarily influenced by wind near the project area.

4.1.4 Palustrine Emergent Wetlands

Extensive areas of palustrine emergent wetlands exist on the sound side of the Outer Banks. These communities include tidal freshwater and oligohaline (estuarine) marshes that are nutrient-rich with high primary productivity, allowing these habitats to support a diversity of fish, invertebrates, and waterfowl. Managed fish species use these marshes during multiple life stages because they provide nursery habitat for juveniles and foraging areas for adults.

4.1.5 Palustrine Forested Wetlands

Palustrine forested areas are present within the maritime swamp communities that border the highly productive tidal marshes and open water on the sound side of the Outer Banks. These areas are frequently inundated by the waters of Currituck Sound as a result of wind-tides. This community also supports several types of fishery food sources including invertebrates and small fish. These areas provide support to other EFH types through the generation of detritus and sediment retention. Palustrine forested wetlands may not be as diverse or productive as other EFH areas, but are irregularly flooded and used as foraging habitat by small fish and invertebrates.

4.1.6 Aquatic Bed (Tidal Freshwater)

Aquatic bed habitats in the project area include the soft bottom substrate of Currituck Sound. It is comprised of sand as well as inorganic muds, organic rich muds, and peat. Nutrients are provided by riverine sources in addition to both wind and lunar tidal exchange. The abundance of benthic macroalgae in this habitat supports a high diversity of invertebrates that are an important fishery food source. In shallow areas (less than 6 feet), this type of substrate also supports SAV (Street et al., 2005).

4.1.7 Estuarine Water Column

The estuarine water column extends from the estuarine bottom to the surface waters. This habitat is characterized by the oligohaline (estuarine) waters present in Currituck Sound. Salinity levels vary in the sound seasonally with mean salinity levels of 3.1 parts per thousand (ppt) and 1.7 ppt in 2006 and 2007, respectively (USGS, 2009). Distinct zones within the water column can be defined by several parameters such as salinity, temperature, and dissolved oxygen. Water column zonation is continually fluctuating and is a function of tidal dynamics, season, nutrient levels, and proximity to the ocean. Fish and shellfish often exploit distinct resources within the water column based on species-specific diet, behavior, and morphology. For example, demersal fishes (bottom dwelling) and pelagic fishes (live higher in the water column) have adapted to take advantage of these different habitats, and favorable spawning/feeding conditions for these species can occur at varying locations at different times of the year. The condition of the water column is especially important as it directly affects all other estuarine aquatic habitats (NCWRC, 2005).

4.1.8 Primary Nursery Areas

Primary Nursery Areas (PNAs) are low salinity state-designated waters in streams which are used by marine and estuarine fishes and invertebrates during early development. Nursery areas are designated and regulated by the North Carolina Division of Marine Fisheries (NCDMF) and North Carolina Wildlife Resources Commission (NCWRC) in some areas. While not a single specific EFH type, PNAs are areas composed of several EFH types making them especially valuable. These areas are typical shallow waters with soft bottom substrate that are surrounded by marshes and wetlands. The abundance of refuge, foraging habitat, and food sources present in these areas result in the successful development of many sub-adult organisms (Beck et al., 2001). Nursery areas are considered HAPC for several managed fish species. Jean Guite Creek occurs in the southernmost portion of the project area and is the only designated PNA within project boundaries. Jean Guite Creek drains into Kitty Hawk Bay, which is a designated Secondary Nursery Area approximately 3 miles south of the project area.

4.2 Managed Species

4.2.1 SAFMC and MAFMC Managed Species

The SAFMC and MAFMC have developed FMPs for several species, or species units (SAFMC, 2008; MAFMC, 2008), although not all species are found in the project area. In addition, highly migratory species' FMPs and Atlantic billfish FMPs were developed by the Highly Migratory Species Management Unit, Office of Sustainable Fisheries, NMFS (NMFS, 1999a; NMFS, 1999b). As part of each FMP, the council designates not only EFH, but also HAPC, a subset of EFH that refers to specific locations required by a life stage(s) of that managed species. Table 3 presents the species or species units for which FMPs exist, occurrence of these species within the project area, and designated EFH and HAPC in the project area.

The sections that follow describe managed species that are found near the project area and associated EFH areas.

4.2.1.1 Black Sea Bass (Centropristis striata)

The black sea bass is a demersal species (bottom dwelling) found from Maine to Florida. They are opportunistic feeders and accept a wide variety of food sources. As juveniles and adults, this species is associated with submerged structures in estuarine and marine waters. Spawning occurs offshore from May to October along the continental shelf in an area extending from southern New England to North Carolina. Eggs are generally hatched on the continental shelf near large estuaries, but eggs have been found in bays as well. Larvae develop in coastal waters and estuaries, with highest concentrations

Table 3. Managed Fish Species or Species Units Listed by Manager

Species	Present in Project Area	Life Stages Present in Project Area	Designated EFH in Project Area	HAPC in Project Area
Mid-Atlantic Fisheries Management Council (MAFMC)				
Atlantic mackerel *(Scomber scombrus)*	No	None	None	None
Atlantic surfclam (*Spisula solidissima*)	No	None	None	None
Black sea bass[1] (*Centropristis striata*)	Yes	Larvae, juveniles, adults	None	None
Bluefish (*Pomatomus saltatrix*)	Yes	Larvae, juveniles, adults	Estuarine water column/creeks	None
Butterfish[2] (*Peprilus triacanthus*)	Yes	Eggs, larvae, juveniles, adults	Estuarine water column/creeks	None
Spiny dogfish (*Squalus acanthius*)	No	None	None	None
Longfin squid (*Loligo pealei*)	No	None	None	None
Monkfish (*Lophius americanus*)	No	None	None	None
Ocean quahog (*Artica islandica*)	No	None	None	None
Summer flounder (*Paralichthys dentatus*)	Yes	Larvae, juveniles, adults	Estuarine water column/creeks, tidal flats, SAV	Jean Guite Creek, SAV
Scup (*Stenotomus chrysops*)	No	None	None	None
Shortfin squid *(Illex illecebrosus)*	No	None	None	None
Tilefish (*Lopholatilus chamaeleonticeps*)	No	None	None	None
South Atlantic Fisheries Management Council (SAFMC)				
Penaeid and Rock Shrimp *(Farfantepenaeus* spp. and *Sicyonia* spp.)	Yes	Larvae, juveniles, adults	Estuarine water column/creeks, SAV, intertidal flats, aquatic beds, emergent/forested wetlands	Estuarine water column/creeks, Jean Guite Creek, intertidal flats, SAV

Table 3 (concluded). Managed Fish Species or Species Units Listed by Manager

Species	Present in Project Area	Life stages Present in Project Area	Designated EFH in Project Area	HAPC in Project Area
Red drum (*Sciaenops ocellatus*)	Yes	Juveniles, adults	Estuarine water column/creeks, intertidal flats, emergent/forested wetlands, aquatic beds, oyster reefs/shell banks, SAV	Estuarine water column/creeks, Jean Guite Creek, aquatic beds, SAV
Snapper grouper management unit	Yes[3]	Larvae, juveniles, adults	Estuarine water column/creeks, intertidal flats, emergent/forested wetlands, oyster reefs/shell banks, SAV	Jean Guite Creek, oyster reefs/shell banks, SAV
Golden crab (*Chaeceon fenneri*)	No	None	None	None
Spiny lobster (*Panulirus argus*)	No	None	None	None
Coastal migratory pelagic species	Yes[4]	Larvae, juvenile, adults	Estuarine water column/creeks, Jean Guite Creek	None
Sargassum (*Sargassum* sp.)	No	None	None	None
Calico scallop *(Agopecten gibbus)*	No	None	None	None
Coral, coral reef, and live/ hardbottom habitat	No	None	None	None
National Marine Fisheries Service (NMFS)				
Highly migratory species (sharks, tuna, swordfish)	No	None	None	None
Billfish	No	None	None	None

Source: MAFMC, 2008; SAFMC, 2008; NMFS, 1999a, 1999b.

[1] No EFH or HAPC designated for black sea bass by the MAFMC is located in the project area; however, black sea bass are included in the snapper grouper management unit under the SAFMC.

[2] No EFH or HAPC designated for butterfish by the MAFMC is located in the project area; however, because of catch records of butterfish, the estuarine waters of Currituck Sound are included as "inshore" EFH.

[3] Species from this management unit that have been recorded near the project area include black sea bass, red grouper, and Atlantic spadefish.

[4] Spanish mackerel is the only species from this management unit recorded in the vicinity of the project area.

from Virginia to New York. As juveniles, black sea bass enter estuaries during the late spring and summer to take advantage of seasonally abundant fish and invertebrate prey. While not typically found in oligohaline waters such as Currituck Sound, black sea bass have been documented in the area (NCDMF, unpublished commercial fishing data, 1994-2008). During the warmer months of the year, adults are most often found in coastal waters, but move to deeper areas in the fall and winter as temperatures decline. The MAFMC does not currently designate any EFH or HAPC areas for black sea bass within the project area. Along with over 70 other species, black sea bass are considered part of the Snapper Grouper Management Unit by the SAFMC, and all tidal palustrine and estuarine waters, including emergent and forested wetlands, subtidal/intertidal flats, SAV, and oyster reef and shell banks, within the project area are designated EFH by the SAFMC for this species. In addition, Jean Guite Creek (a designated PNA), oyster beds and shell banks, and the SAV beds of Currituck Sound are designated HAPC for black sea bass by the SAFMC. Total black sea bass landings have been relatively stable over the past decade, but there is concern about the current stock status because of possible overfishing.

4.2.1.2 Bluefish (Pomatomus saltatrix)

Bluefish are pelagic fish found in coastal waters from Nova Scotia to South America. Adults are piscivorous (fish-eating) and generally feed on small baitfish in inshore and estuarine habitats. This species makes long-distance migrations to the southeastern US during the fall and winter and migrates to waters off the northeastern US during the spring and summer. While not typically found in oligohaline waters such as Currituck Sound, bluefish do occur in the area (NCDMF, unpublished commercial fishing data, 1994-2008), most likely in the southern portions of the sound when southerly winds result in high salinity levels. Spawning takes place on the continental shelf at various times of the year depending on location. Bluefish eggs do not occur in estuarine waters. As larvae develop, they begin crossing the continental shelf to enter nearshore habitats and estuaries. The transport of larvae and juveniles across the shelf is by both active movement and wind driven surface flow.

There are currently no EFH areas designated in the project area for bluefish eggs and larva. The estuarine water column of Southern Currituck Sound has been identified as EFH for juvenile and adult bluefish. No HAPC for bluefish has been designated by the MAFMC. This species is not considered over-fished by the MAFMC.

4.2.1.3 Butterfish (Peprilus triacanthus)

Butterfish are opportunistic feeders found in coastal waters from Newfoundland to Florida. Spawning occurs offshore, but eggs and larvae can be found in the lower reaches of estuaries. All life stages may make use of estuaries during growth. Adults are seasonal migrants that winter in offshore waters or warm coastal waters near the southern states. The MAFMC has designated both inshore and offshore EFH for all life stages of butterfish. Inshore EFH is defined as the estuarine "mixing zone" where fresh and saline waters converge from Maine to Virginia and therefore there is no officially designated inshore EFH in North Carolina for the butterfish. Offshore EFH consists of pelagic waters typically greater than 33 feet in depth over the Continental Shelf from Maine to North Carolina; however, such depths do not occur within the project area. Even though the range of inshore EFH is designated as outside of North Carolina, the appropriate habitat (estuarine "mixing zone") is available in the project area and may potentially be used by butterfish. Butterfish have been documented in Currituck Sound (NCDMF, unpublished commercial fishing data, 1994-2008). No HAPC has been designated by the MAFMC. Based on the most recent NMFS assessment, the butterfish stock is neither over-fished nor approaching an over-fished condition (NMFS, 2001).

4.2.1.4 Summer Flounder (Paralichthys dentatus)

The summer flounder is an estuarine-dependent species found along the Atlantic coast from Maine to Florida. Spawning occurs from Cape Cod to Cape Hatteras between October and May along the continental shelf in waters 30 to 360 feet in depth. Larvae enter the estuaries in the late winter and spring where they develop into juveniles before migrating to the ocean during the fall. As adults, summer flounder continue to make seasonal use of estuaries. The MAFMC designates all tidal palustrine and estuarine waters, including emergent and forested wetlands, SAV, aquatic beds, and subtidal/intertidal flats, of Currituck Sound as EFH for larval, juvenile, and adult life stages. In addition, the SAV beds of Currituck Sound and Jean Guite Creek (a PNA) are designated HAPC by the MAFMC. This species is considered over-fished by the MAFMC.

4.2.1.5 Penaeid and Rock Shrimp (Farfantepenaeus **spp.** *and Sicyonia* **spp.***)*

Penaeid shrimp (white, pink, and brown shrimp) are estuarine dependent species of ecological and commercial importance. Penaeid shrimp spawn offshore where larval and postlarval development occurs. After currents carry postlarvae into estuaries, shrimp distribute themselves according to substrate and salinity preference. As shrimp grow, they migrate to deeper, high salinity waters before leaving for offshore spawning grounds. All tidal palustrine and estuarine waters, including emergent and forested wetlands, SAV, aquatic beds, and subtidal/intertidal flats, within the project area are designated penaeid shrimp EFH. Also, the shorelines and SAV beds of Currituck Sound, the "marsh edges" located within the subtidal/intertidal flats, and Jean Guite Creek (a PNA) are designated HAPCs for penaeid shrimp. There are no rock shrimp or associated EFH present in the project area. The status of penaeid shrimp varies with location. In North Carolina, the fishery is listed as viable, meaning the stock exhibits stable or increasing trends in average length and weight, catch per unit effort, spawning stock biomass, and juvenile abundance indexes.

4.2.1.6 Red Drum (Sciaenops ocellatus)

Red drum are found in the coastal waters, inlets, and estuaries of the Atlantic coast from Massachusetts to northern Mexico. Spawning occurs in shallow water along beaches and inlets after which eggs and larvae are carried into estuaries where juvenile development takes place. Juveniles feed and grow during the warmer months before moving into deep estuarine or oceanic waters. As adults, red drum make pronounced seasonal migrations along the coast, moving offshore or to southern waters in fall and back to more northern, inshore waters in the spring. Typically, red drum arrive in Currituck Sound in late April, with a second peak in abundance during fall as fish begin migrating south from the Mid-Atlantic states. All tidal palustrine and estuarine waters, including emergent and forested wetlands (including marsh edges), SAV, aquatic beds, subtidal/intertidal flats, and oyster reef and shell banks, within the project area are designated red drum EFH. The estuarine water column and SAV beds of the Currituck Sound, along with Jean Guite Creek (a PNA), are designated HAPCs for red drum. In North Carolina, red drum are listed as recovering and the FMP is currently under review.

4.2.1.7 Red Grouper and Gray Snapper (Epinephelus morio and Lutjanus griseus)

Red grouper are opportunistic demersal species found from Maine to Brazil. Spawning typically occurs from early winter to late spring. Eggs and larva are pelagic and settle in shallow nearshore reef environments. Major movements occur when juveniles move to deeper waters at sexual maturity and adult red grouper extensively migrate although movement patterns are unknown. While not typically found in oligohaline waters such as Currituck Sound, red grouper do occur in the area (NCDMF, unpublished commercial fishing data, 1994 to 2008), most likely in the southern portions of the sound when southerly winds result in high salinity levels. Along with over 70 other species, red grouper are considered part of the Snapper Grouper Management Unit by the SAFMC, and all tidal palustrine and estuarine waters, including emergent and forested wetlands, SAV, subtidal/intertidal flats, and oyster reef and shell banks, within the project area are designated EFH by the SAFMC for this species. In addition, Jean Guite Creek (a designated PNA), oyster beds and shell banks, and the SAV beds of Currituck Sound are designated HAPC for red grouper by the SAFMC. Red grouper are currently overfished and there is concern about the stock status. Gray snapper also fall under the Snapper Grouper Management Unit managed by the SAFMC and have similar life history to that of the red grouper. There are no records of gray snapper in Currituck Sound; however, juvenile and adult gray snapper are found in estuarine waters throughout North Carolina.

4.2.1.8 Atlantic Spadefish (Chaetodipterus faber)

Atlantic spadefish are opportunistic bottom feeders found from Massachusetts to Brazil. They utilize variety of brackish water and beach habitats at depths ranging from 3 to 33 feet. Spawning occurs from May to September. Juveniles are more commonly found in estuaries and adults are mostly found in near shore areas in large schools. While not typically found in oligohaline waters such as Currituck Sound, Atlantic spadefish do occur in the area (NCDMF, unpublished commercial fishing data, 1994-2008), most likely in the southern portions of the sound when southerly winds result in high salinity levels. Along with over 70 other species, Atlantic spadefish are considered part of the Snapper Grouper Management Unit by the SAFMC, and all tidal palustrine and estuarine waters, including emergent and forested wetlands, SAV, subtidal/intertidal flats, and oyster reef and shell banks, within the project area are designated EFH by the SAFMC for this species. In addition, Jean Guite Creek (a designated PNA), oyster beds and shell banks, and the SAV beds of Currituck Sound are designated HAPC for Atlantic spadefish by the SAFMC. The stock status of Atlantic spadefish in North Carolina has not been determined.

4.2.1.9 Spanish Mackerel (Scomberomorus maculatus)

Spanish mackerel are an epipelagic species found from Nova Scotia to the Gulf of Mexico. They are primarily a piscivorous species (fish-eating). Individuals in the northern portion of its range spawn from August to September. Eggs and larva are primarily pelagic and juveniles often utilize estuaries as nursery areas. Juveniles are also found in the surf zone and offshore with adults most commonly found in large schools at depths greater than 30 feet. Long-distance migrations occur southward in the fall and northward in the spring. While not typically found in oligohaline waters such as Currituck Sound, Spanish mackerel do occur in the area (NCDMF, unpublished commercial fishing data, 1994-2008), most likely in the southern portions of the Sound when southerly winds result in high salinity levels. Along with several other species, Spanish mackerel are considered part of the Coastal Migratory Pelagics Management Unit by the SAFMC. Estuarine habitats are designated as EFH by SAFMC in the management of this unit because prey items for species in this unit are typically estuarine dependent. Jean Guite Creek (a designated PNA) is also designated as EFH for Spanish mackerel by the SAFMC. There are no HAPCs found for Spanish mackerel designated by the SAFMC in the vicinity of the project area. In North Carolina, the stock status for Spanish mackerel is currently listed as viable.

4.2.2 ASMFC Managed Species

In addition to federally managed species, the Atlantic States Marine Fisheries Commission (ASMFC) serves as a deliberative body, coordinating the conservation and management of the states' shared nearshore fishery resources – marine, shell, and anadromous – for sustainable use. Member states are Maine, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Delaware, Maryland, Virginia, North Carolina, South Carolina, Georgia, and Florida. Species managed by the ASMFC that are found in the Currituck Sound and inshore coastal waters include: American eel (*Anguilla rostrata*), Atlantic croaker (*Micropogonias undulatus*), Atlantic menhaden (*Brevoortia tyrannus*), black sea bass, blueback herring (*Alosa aestivalis*), bluefish, red drum, spot (*Leiostomus xanthurus*), spotted sea trout (*Cynoscion nebulosus*), southern flounder (*Paralichthys lethostigma*), striped bass (*Morone saxatilis*), summer flounder, and weakfish (*Cynoscion regalis*).

4.2.3 NCDMF Managed Species

Under the Fisheries Reform Act of 1997 (FRA), the NC Division of Marine Fisheries (NCDMF) prepared FMPs for all commercially and recreationally important species or fisheries that comprise state marine or estuarine resources, with the goal of ensuring the long-term viability of these fisheries. The State of North Carolina has or is currently developing FMPs for several species. Species with management plans include: river herring [blueback herring (*Alosa aestivalis*) and alewife (*Alosa pseudoharengus*)], shrimp (*Penaeus* spp.), striped bass, southern flounder, blue crab (*Callinectes sapidus*), and striped mullet (*Mugil cephalus*). Currently under review are FMPs for red drum, oysters (*Crassostrea virginica*), and hard clams (*Mercenaria mercenaria*); and FMPs for bay scallop (*Argopecten irradians*) and kingfish (*Menticirrhus americanus*) are under development.

Several of the species mentioned above are among the most important fisheries on the east coast. Blue crabs, summer flounder, shrimp, bluefish, and croaker were the most commercially important fisheries in North Carolina, while striped bass and bluefish were among the most recreationally important (NCDMF, unpublished commercial fishing data, 1994-2008). Based on NCDMF statistics from 1990 to 2008, blue crabs and Paralichthid flounder are by far the most valuable commercial species in Currituck Sound. Also of commercial and recreational significance are catfish (*Ameiurus* spp. and *Ictalurus* spp.), American eel (*Anguilla rostrata)*, white perch, (*Morone americana*), yellow perch (*Perca flavescens*), and striped bass.

5.0 Potential Impacts to EFH

Historic and present stress to fish and EFH communities in Currituck Sound has occurred as a result of fluctuations in turbidity and salinity. The sound has become more saline since the late 1980's, and data from 1998 and 1999 suggested that there was a net inflow of salt into the sound (Caldwell, 2001). Data collected by Caldwell (2001) suggested that increased salinity in the northern portion of Currituck Sound may be a result of winds from the north driving water south from the Chesapeake Bay. These data also suggested that increased salinity in the southern portion of Currituck Sound may be a result of southerly winds driving water north from the Albemarle Sound (Caldwell, 2001).

A drought from 1985 to 1988 caused salinity levels to rise above 4 ppt, resulting in a decrease in aquatic vegetation and the near cessation of largemouth bass spawning. With the end of the drought in 1989, salinity levels dropped, and largemouth bass spawned successfully. Another dry year in 1991 coupled with ocean overwash during several storms increased salinity and slowed largemouth bass reproduction and recovery of submerged aquatic vegetation (SAV) (NCDEHNR, 1994). Continual increases in the salinity of Currituck Sound could result in shifts in the community structure of aquatic flora and fauna, and possibly increase EFH value for managed species and other estuarine dependent species. The proposed construction of the Mid-Currituck Bridge is not anticipated to affect the salinity of the Currituck Sound.

Turbidity is an important factor affecting the distribution and abundance of SAV (Davis and Carey, 1981; Davis and Brinson, 1983; Ferguson and Wood, 1994). Increased turbidity from shoreline erosion, dredging, boating, sedimentation, and runoff can all increase turbidity creating unfavorable conditions for SAV survival. Davis and Brinson (1983) suggested that the historic decline of SAV in the Currituck Sound may have been the result of channel dredging associated with the Albemarle and Chesapeake Canal, which began in 1914. Additional declines of SAV in the 1960s were attributed to extensive dredging and filling in Back Bay, Virginia during 1963 (Sincock, 1966).

The North Carolina portion of the North Landing River was dredged in 1946 and again in 1965 with the spoil being deposited in shallow waters along the navigation channel (Riggs et al., 1993). The Virginia portion of the river was dredged in the years 1984, 1986, and 1991 with the spoil also being deposited in shallow waters along the channel. The study concluded that erosion of the dredged materials has caused increased turbidity in Currituck Sound, with possible negative effects on SAV.

The NC Division of Environmental Management (NCDEM) reported that the sound has a large amount of material in suspension most of the time with turbidity being highest in the upper Sound, north of Waterlily (NCDEHNR, 1994). Four of 14 DEM sampling stations had turbidity levels that exceeded state standards (> 25 Nephelometric Turbidity Units [NTU]) between 1992, and 1993 (NCDEHNR, 1994). Nephelometric refers to the way the instrument, a nephelometer, measures how much light is scattered by suspended particles in the water. The greater the scattering, the higher the turbidity. Low NTU values indicate high water clarity, while high NTU values indicate low water clarity.

The NCDEM also concluded that wind-driven suspension of bottom sediments was not a significant contributor to decreased water clarity during 1992 and 1993. Holman (1993) summarized the water quality data for Currituck Sound by indicating that "some of the highest values for suspended solids for the entire Albemarle-Pamlico estuarine system have been recorded in the Currituck Sound." Data collected by the USGS shows that the yearly average turbidity in Currituck Sound was relatively low during 2006 and 2007, meeting standards for ORW designation (< 25 NTU). Currituck Sound has been denied ORW designation in the past as a result of high nutrient levels and resulting algal blooms (NCDEHNR, 1994). The proposed construction of the Mid-Currituck Bridge is not anticipated to permanently affect the turbidity of the Currituck Sound.

5.1 Short-term Impacts

Mid-Currituck Bridge construction associated with MCB2 and MCB4 alternatives would take place over Currituck Sound. The over water construction activities associated with these alternatives would produce noise, turbidity, and siltation, thereby creating localized, short-term impacts to EFH (including estuarine and palustrine forested and emergent wetlands, SAV beds, intertidal flats, estuarine water column, aquatic beds, and oyster reefs and shell banks), as shown in Table 4.

Construction of a Mid-Currituck Bridge could include use of a gantry, work bridge, launching truss (temporary truss attached to and extending out from completed foundations), and/or low draft barges with associated dredging in parts of Currituck Sound without existing SAV and less than 6 feet deep. Should dredging be used during Mid-Currituck Bridge construction, the bottom would be dredged to a depth of 6 feet. Dredging would occur parallel to the bridge. Dredging would primarily be along the west shore of Currituck Sound (2,000 feet for C1 or C2) and a section in the middle of the sound (5,100 feet for C1 and 2,600 feet for C2). The total dredging lengths would be approximately 7,100 feet for C1 (approximately 29 percent of the length of C1 over the sound) and 4,600 feet for C2 (approximately 17 percent of the length of C2 over the sound). The dredged area is anticipated to be 150 feet wide with roughly 3:1 side slopes beyond the dredged area to reach natural bottom. Given these assumptions, C1 would disturb approximately 25 acres of bottom area and C2 would disturb approximately 17 acres (probable and potential SAV habitat), but no known SAV would be disturbed by dredging. Additionally, a temporary materials delivery dock could be placed on the west side of the sound adjacent to the proposed bridge or north of the bridge at a suitable staging area. Dredging may be necessary to construct and operate this dock,

Table 4. Potential Impacts to EFH Resulting from the C1 and C2 Bridge Corridors with MCB2 and MCB4

EFH Type	Bridge Construction (short-term)	Bridge Construction (permanent and long-term)
• SAV[1]	Temporary turbidity and siltation	Shading; run-off from roadway; permanent loss of habitat from piles; potential for degradation from turbidity and siltation; increased fragmentation.
• Oyster reef and shell bank (relic)[2]	Temporary turbidity and siltation	None
• Intertidal flats	Temporary turbidity and siltation	Shading; run-off from roadway; permanent loss of habitat from piles; potential for degradation from turbidity and siltation.
• Palustrine emergent and forested wetlands	Temporary disturbance	Shading; run-off from roadway; permanent loss of habitat from piles and bridge maintenance corridors.
• Aquatic bed (tidal freshwater)	Temporary turbidity, siltation and loss of habitat if dredging is used during construction.	Shading; run-off from roadway; permanent loss of habitat from piles. Loss of habitat as a result of dredging would depend on whether the deeper bottom prevents re-establishment of the disturbed community and habitat.
• Estuarine water column[3]	Temporary increase in turbidity, noise and siltation; decline in dissolved oxygen, especially if dredging is used.	Shading; run-off from roadway; permanent loss of habitat from piles.

[1]Also HAPC for summer flounder, red drum, shrimp, and the snapper grouper management unit.
[2]Oyster reef and shell bank is also HAPC for the snapper grouper management unit; however, oyster reef and shell bank present in the project area is described as relic shell hash.
[3]Currituck Sound is also HAPC for Penaeid shrimp and red drum.

which would affect approximately 4 additional acres of bottom area. Dredging would not occur in areas of existing SAV.

The temporary effects of bridge pile placement and other bottom disturbance, such as dredging if it were used, with MCB2 and MCB4 would be a short-term increase in noise, turbidity, benthic disturbance, and siltation. Noise from open water construction activity would be a temporary, localized disturbance to fish. Construction related noise generated during pile driving can be of sufficient intensity to kill or injure marine organisms (reviewed in Hanson et al., 2004). At the ecosystem level, turbidity, especially if dredging occurs, would result in a reduction in ecosystem productivity (i.e., ability of the system to produce and export energy) and nursery value by eliminating organisms that cannot readily move, and displacing mobile organisms. For individual organisms, turbidity can impair visual predation success, impair predator avoidance, and impair oxygen uptake by clogging respiratory structures. Siltation could generate increased water column turbidity, as well as smother or alter benthic vegetative (SAV) and animal communities. These impacts are likely to be prolonged because of poor water circulation in the sound.

Because of the degraded habitat value, most mobile animals would avoid the area of construction for the duration of the construction phase, while non-mobile shellfish, such as clams, could suffer long-term impacts from construction-related siltation. Benthic organisms are expected to rapidly recover after construction ceases, as most soft bottom benthic communities are resilient and likely to recolonize quickly. NCTA would take measures to minimize turbidity generated during bridge construction.

For MCB2 and MCB4, bridge construction techniques would be evaluated during final design in order to determine the most appropriate technique for constructing structures in Currituck Sound. Final construction methods would be selected as part of the permitting process.

. There is no specific statute or regulation that designates or references the waters of Currituck Sound as subject to a construction moratorium. However, there is a possibility that a moratorium could be imposed on the project via a permit condition during the US Army Corps of Engineers (USACE) Section 404 of the Clean Water Act and CAMA permitting review processes. The only state-designated fish nursery/spawning area (primary, secondary, or anadromous spawning area) crossed by any of the detailed study alternatives is Jean Guite Creek, which is a primary nursery area (PNA) and would be crossed by the widening of US 158 with ER2 and MCB2, as well as third outbound lane hurricane evacuation improvements with MCB4. Although each project is reviewed on a case-by-case basis and coordinated with the NC Division of Marine Fisheries, the dates for a potential moratorium, depending on extent and type of impact, could range from February 15 through September 30.

Construction associated with the road widening portions for all detailed study alternatives could result in increased turbidity and sedimentation within Currituck Sound as a result of runoff from these construction areas, primarily on the mainland. Runoff may contain varying amounts of particulates, organic compounds, nutrients, and heavy metals, all of which can degrade water quality and impact aquatic organisms. However, these effects would cease after re-vegetation and these areas would be expected to return to previous conditions. Best Management Practices (BMPs) would be used to minimize sedimentation. The total temporary impact to wetland habitat within the existing NC 12 and US 158 temporary construction easements would be 2.2 acres with ER2, 1.7 acres with MCB2, and 2.1 acres with MCB4. CAMA areas would not be directly affected by these easements.

Bridge replacement and widening over Jean Guite Creek (a PNA) is proposed for all alternatives. Although some potential adverse impacts to EFH would occur during the construction phases, the impacts would be temporary and are not expected to result in substantial short-term effects on managed species.

BMPs would be implemented to manage pollutants associated with construction activities (see Section 5.2.1). The specific construction methods used in the construction of the proposed project would be determined during final design.

5.2 Permanent and Long-Term Impacts

Shading in less than 6 feet of water and pile placement resulting from bridge construction across Currituck Sound associated with MCB2 and MCB4 would result directly in the permanent loss or alteration of palustrine forested and emergent wetlands (palustrine/estuarine), SAV, subtidal and intertidal flats and estuarine waters. Direct impacts to EFH resulting from shading and pile placement are presented in Table 5. Final EFH impacts would be determined during the final design of the alternative selected for implementation.

Pile and fill impacts in the open water of Currituck Sound with MCB2 and MCB4 (including SAV) and marsh communities (big cordgrass, black needlerush, and intertidal flats) would affect EFH. As presented in Section 4.12 of the *Natural Resources Technical Report* (CZR Incorporated, 2009), the most fill, pile, and shading impacts (combined total of all three impacts) to EFH (wetlands and aquatic bottom areas) would occur with MCB2/C2 and MCB4/C2, and the least with ER2. The most fill and pile impacts to EFH areas would occur with MCB2 (both bridge alternatives), followed by ER2. The most shading impacts would occur with MCB2/C2 and MCB4/C2 and the least impacts would occur with ER2. Clearing of palustrine emergent and forested wetlands would occur with MCB2/C2 and MCB4/C2 (same amount for both alternatives); however, fill would be placed in those communities with MCB2/C1, MCB2/C2, and ER2 (same amount for all three alternatives).

Based on the most recent SAV mapping (USACE, 2007), the C1 bridge corridor would shade less known SAV habitat than the C2 corridor, but both bridge corridors would result in approximately the same amount of piling impact. The C2 bridge corridor would affect more wetland EFH habitats at its eastern landing on the Outer Banks compared to C1. ER2 would fill and/or shade the least amount of SAV habitat at approximately 0.2 acre of probable SAV habitat (area outside of USACE survey area and no known SAV area). If a third outbound lane is added for hurricane evacuation on US 158 over Jean Guite Creek (a PNA) with MCB4, a single piling would be installed in the creek and the existing bridge over the creek would be widened by 18 feet. With ER2 and MCB2, the bridge over Jean Guite Creek would be widened by 36 feet for the widening of US 158.

Table 5. Permanent Impacts to Essential Fish Habitat Areas by Detailed Study Alternative

Community[1]	ER2 (acres)				MCB2/C1 (acres)				MCB2/C2 (acres)				MCB4/C1 (acres)				MCB4/C2 (acres)			
	Fill	Pilings	Shading	Clearing	Fill	Pilings	Shading	Clearing	Fill	Pilings	Shading	Clearing	Fill	Pilings	Shading	Clearing	Fill	Pilings	Shading	Clearing
Palustrine forested wetland	1.0	0.0	0.0	0.0	1.0	0.0	0.2	0.0	1.0	0.0	0.9	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.6	1.8
Palustrine emergent wetland	0.7	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.7	0.0	0.6	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.9	1.4
Aquatic bottom (tidal freshwater) (total/<6 feet)[2]	0.1/ 0.1	0.0/ 0.0	0.1/ 0.1	0.0/ 0.0	0.1/ 0.1	0.1/ 0.1	28.2/ 14.5	0.0/ 0.0	0.1/ 0.1	0.2/ 0.1	28.2/ 17.8	0.0/ 0.0	0.0/ 0.0	0.1/ 0.1	28.1/ 14.5	0.0/ 0.0	0.0/ 0.0	0.2/ 0.1	29.1/ 17.8	0.0/ 0.0
TOTAL EFH IMPACT[3]	1.8	0.0	0.1	0.0	1.8	0.1	28.4	0.0	1.8	0.2	30.7	3.2	0.0	0.1	28.1	0.0	0.0	0.2	30.6	3.2
Primary nursery areas[4] Acres/linear ft	0.0/ 0.0	0.0/ 0.0	0.0 36.0	0.0/ 0.0	0.0/ 0.0	0.0/ 0.0	0.0/ 36.0	0.0/ 0.0	0.0/ 0.0	0.0/ 0.0	0.0/ 36.0	0.0/ 0.0	0.0/ 0.0	0.0/ 5.0	0.0/ 18.0	0.0/ 0.0	0.0/ 0.0	0.0/ 5.0	0.0/ 18.0	0.0/ 0.0
SAV																				
Confirmed SAV	0.0	0.0	0.0	0.0	0.0	0.0	4.3	0.0	0.0	0.0	5.5	0.0	0.0	0.0	4.3	0.0	0.0	0.0	5.5	0.0
Probable SAV habitat (<4 feet)	0.1	0.0	0.1	0.0	0.1	0.0	3.4	0.0	0.1	0.0	7.0	0.0	0.0	0.0	3.4	0.0	0.0	0.0	7.0	0.0
Potential SAV habitat (4-6 feet)	0.0	0.0	0.0	0.0	0.0	0.0	6.8	0.0	0.0	0.0	5.3	0.0	0.0	0.0	6.8	0.0	0.0	0.0	5.3	0.0
Unlikely SAV habitat (>6 feet)	0.0	0.0	0.0	0.0	0.0	0.1	13.7	0.0	0.0	0.1	11.3	0.0	0.0	0.1	13.7	0.0	0.0	0.1	11.3	0.0

[1] Communities that have not been mapped include intertidal flats and oyster reef/shell bank.
[2] Includes all SAV sub-categories ≤ 6ft and is equivalent to estuarine water column (volume not calculated).
[3] Includes palustrine and forested, emergent wetlands and aquatic bottom.
[4] Area in association with Jean Guite Creek and already included in probable SAV habitat totals. Total area is <0.05.
Note: Impacts are the same with and without the hurricane evacuation lane on mainland US 158 except for a minute amount of piling (<0.1) and shading (<0.1) impacts to Jean Guite Creek with MCB4.

In addition to permanent loss of habitat resulting from pile placement, the C1 and C2 bridge options could generate several other types of impacts, including changes in: water quality, water flow, and light levels of the area both underneath the bridge and for some distance surrounding the bridge. If construction dredging occurs, the aquatic bed/substrate could be slow to recover, depending on the post-construction water depths and areas disturbed. Generally, shallow water aquatic bottom habitat is more productive than deeper water, but varies depending upon light penetration and substrate composition. There are also the potential effects of altered/increased traffic and highway maintenance including runoff and noise. Noise is not anticipated to affect EFH, but runoff as described in Sections 5.1 and 5.2.1 could be a source of additional pollutants. These impacts to EFH resulting from the C1 and C2 bridge corridors are presented in Table 4.

Although these bridge alternatives would alter existing EFH, for the reasons described below, substantial adverse impacts to EFH and managed species are unlikely to occur.

5.2.1 Water Quality

Highway systems near water bodies may potentially contribute pollutants via stormwater runoff, road maintenance activity, litter, and atmospheric deposition. Without appropriate mitigation, the water quality in receiving waterbodies may be diminished, thereby increasing the potential for adverse impacts to managed species and their resources. The waters of Currituck Sound currently receive runoff from the Wright Memorial Bridge at the southern end of the project area. The construction, traffic, operations and maintenance, and runoff associated with the Mid-Currituck Bridge would introduce an additional source of pollution to the sound where none currently exists. These pollutants include, but are not limited to, particulates, organic compounds, nutrients, and heavy metals. Pollutants discharged into Currituck Sound in the vicinity of the bridge may not dissipate because of poor water circulation and could result in higher sediment pollutant levels and bioaccumulation near the bridge when compared to bridges over high-flow areas.

The amount of runoff and associated impacts to water quality are dependent upon the method implemented to manage bridge runoff. The preliminary designs used in this impact assessment assume that a bridge over Currituck Sound would drain directly into the sound. Drainage would not be captured and treated to remove or reduce motor vehicle pollutants. However, water from the Mid-Currituck Bridge could be captured and treated in one of three ways, as discussed below.

The first way to capture runoff would involve creating high points in the bridge over Currituck Sound. This would allow the bridge to drain to the bridge termini via a pipe system where runoff from the bridge deck could be directed to stormwater treatment Best Management Practices (BMPs), such as stormwater wetlands or wet detention basins. With a uniform minimum 0.3 percent slope, the Mid-Currituck Bridge would be 71 to 79 feet high at its highest point, compared to the current 20 feet of elevation.

Bridge runoff is transported through pipes to stormwater treatment Best Management Practices (BMPs) such as stormwater wetlands or dry infiltration basins located on the mainland and the Outer Banks. This option would replicate natural physical, chemical, and biological methods of runoff treatment.

The second way would treat runoff from the bridge deck using filter devices on the bridge itself rather than conveying runoff to the ends of the bridges on the mainland and Outer Banks. The bridge design would need to be modified to allow a minimum longitudinal slope of 0.3 percent so that bridge deck runoff would find its way to the regularly spaced filter units. This would introduce periodic high and low points in the bridge profile, rather than creating a single high point as in the first option.

The final approach would use the 0.5 percent slope of the bridge's Outer Banks approach span (i.e., the sloped bridge segment that brings the bridge down to grade) to allow bridge runoff over the palustrine wetlands on the Outer Banks (adjacent to the Currituck Sound shoreline) to be collected and transported to off-site treatment sites such as stormwater wetlands or wet detention basins. For C1, the palustrine wetlands crossed by the bridge corridor would be completely under the bridge's approximately 590-foot-long Outer Banks approach span, so a runoff collection pipe matching the slope of the bridge approach span could be hung from the bridge to collect runoff. For C2, the length of the Outer Banks approach span would be approximately 773 feet, so a substantial portion of the palustrine wetlands crossed by the bridge corridor would be under the sloped segment of the bridge where a runoff collection pipe matching the slope of the bridge could be used to collect the runoff. However, there is an additional approximately 452 feet of palustrine wetlands (between the shoreline and the start of the approach span) that would be under a flat segment of the bridge. To collect the runoff in this area, the runoff collection pipe could be hung from the bridge with a slight slope (i.e., the hangers on the western end of the pipe would be shorter than those on the eastern end) until the pipe ties into the sloped pipe within the approach span. For the balance of the bridge, bridge runoff would drop directly into Currituck Sound through bridge scuppers as is assumed in the preliminary design assessed in this report.

Capturing and treating runoff would involve additional cost. Further consideration of capturing and treating runoff would be accomplished when finalizing mitigation measures should MCB2 or MCB4 be selected for implementation. Details regarding the bridge runoff treatment options can be found in the *Assessment of Alternatives for Treating Bridge Runoff* (Parsons Brinckerhoff, 2009).

For the road widening portions of all alternatives, infiltration strips and ditch transport to wet detention basins will be implemented to treat highway runoff.

5.2.2 Water Flow

The presence of bridge pilings is not predicted to alter substantially the existing patterns of water flow through Currituck Sound. The sound generally has a slow southerly current, and water circulation and tidal action within the sound are primarily dependent on wind strength and direction. The presence of the piles in the water column may result in local increases in the turbulence and bed shear stresses around bridge piles because of pressure differentials between the upstream and downstream sides of individual piles (Sumer and Fredsoe, 2002). The changes in water flow could affect the settlement and transport of larval fish and invertebrates, many of which rely on water column stratification and discrete water masses for migration into estuarine nurseries (Abelson and Denny, 1997; Williams and Thom, 2001).

Although impacts to larval transport are possible, they are not likely to be substantial for several reasons. The primary mechanism for larval dispersion of managed fish species within the sound is through the tidal action caused by northerly winds. These wind tides do not generate excessive currents and proposed bridge pilings are widely spaced (approximately 130 feet between foundations is assumed in the preliminary design) and would not impede total water flow. Water turbulence would increase in the immediate vicinity of the bridge piles, but normal flow would reestablish rapidly a short distance from the piles. A conservative estimate for the areal extent of the disturbance for a single pile is 2.5 diameters upstream and on the sides and 4 diameters downstream of the pile (diameter of each pile in approximately 2.5 feet). In a study of water flow past the Chesapeake Bay Bridge, Miller and Valle-Levinson (1996) found that, while the water column was destratified upon flowing past the bridge, the effects were minimal a short distance away. The extent of pile-induced destratification varied with factors such as current direction and energy, but destratification because of the piles was much less than that caused by naturally occurring forces such as wind and bottom structure.

5.2.3 Bridge Shading

The Mid-Currituck Bridge would shade EFH areas (see Table 5). The detailed study alternatives would affect palustrine forested and emergent wetlands, SAV, subtidal and intertidal flats, and estuarine waters. In freshwater and estuarine systems, structures over water are known to alter and/or negatively impact vegetation, benthic invertebrates, and fish in shaded areas (reviewed in Able et al., 1999; Nightingale and Simenstad, 2001; Struck et al., 2004; Alexander and Robinson, 2006). Biological impacts within the shaded areas result from reduced light levels that change, disturb, or eliminate both photosynthetic communities and the consumer community that the primary producers support. Changes are most evident in macrophyte-dominated communities such as marshes and SAV beds. In addition to macrophytes, shading could potentially reduce the high productivity of microalgal species that dominate non-vegetated areas such as subtidal and intertidal flats and tidal freshwater aquatic beds. However, a study looking at the affects of shading on marsh communities (Broome, et al., 2005), reported that no adverse effects to marsh productivity resulted from bridges with a height/width ratio greater than 0.7. Current design specifications propose a height/width ratio greater than 0.7 only in the raised portion of the bridge at the location of the navigation span, but not near marshes and SAV beds.

Shading could affect managed species through habitat alteration and diminished vegetative growth near the project area by locally diminishing the primary producers on which the managed species rely for food and cover, thereby resulting in an overall reduction in local carrying capacity. Consequently, fish abundance and growth have been found to be lower beneath fishing piers when compared to adjacent waters (Able et al., 1998; Duffy-Anderson and Able, 1999). Shading impacts also could result from behavioral avoidance of low light conditions and the diminished visual abilities of fish to evade predators and capture prey (Nightingale and Simenstad, 2001; NMFS, 2004). However, when considering the large size of Currituck Sound, these impacts are expected to be minimal. Shading impacts for the Jean Guite Creek bridge replacement portion of each alternative would be greater for ER2 and MCB2 that propose a six-lane bridge (resulting in 0.1 acre of shading to open water and <0.1 acre of shading to palustrine forest) as opposed to adding a single additional lane proposed for MCB4 (adding <0.1 acre of shading and piling to open water only). In either case the impacts would be minimal at less than 0.1 acre.

Thus, shading associated with all detailed study alternatives would potentially affect the managed species in palustrine forested and emergent wetlands, SAV, subtidal and intertidal flats, and estuarine waters found in the project area. Although most of the research reviewed concerned docks and piers (Burdick and Short, 1999), the data suggest that shading effects may be mitigated by increasing bridge height and orienting the bridge to maximize sunlight exposure underneath, which is reinforced by studies looking at bridge/height ratios (Broome, et al., 2005). The C1 bridge corridor would cross Currituck Sound from the southwest to the northeast, providing hourly variation in the areas shaded by the bridge. This would allow more sunlight exposure than the C2 bridge corridor, which would cross the sound primarily east to west, resulting in only seasonal variation in shaded areas.

5.2.4 Discussion of Potential Long-Term Impacts

The changes in vegetative, sedimentary, and hydrologic features discussed in Sections 5.2.1 to 5.2.3 would affect EFH areas. If construction dredging occurs, the aquatic bed/substrate could be slow to recover. However, for many reasons, it is difficult to assess the direct and indirect effects of these changes on EFH and managed species.

There are few studies on the biological impacts of inshore urban and/or bridge structures. None have been conducted in the area of the Wright Memorial Bridge, the existing bridge that crosses the mouth of Currituck Sound. Because of the lack of data, the assessment of long-term bridge impacts will be based on studies of other pile supported man-made structures. Perhaps the most relevant studies concern oil and gas platforms and piers. On these structures, piles are typically colonized by a variety of sessile invertebrates such as mussels, barnacles, anemones, corals, bryozoans, and poriferans. This complex biogenic structure in turn attracts small mobile fish and invertebrates that attract larger consumers (Nelson, 2003; Clynick et al., 2007). Research at oil platforms clearly shows that piles serve as fish aggregating structures (Stanley and Wilson, 2000). Davis et al., (1982) found fish and invertebrate communities changed substantially after platform installation, with some species disappearing completely, and new species coming to dominate the assemblage. Similarly, in a study of off-shore artificial reefs constructed of piles in approximately 40 feet of water, Ambrose and Anderson (1990) found some fish and invertebrate species increased in abundance while others declined. The effects on larval stages of managed species are not clear. Ichthyoplankton are often found at high concentrations near artificial reefs, presumably because of local currents, habitat, and high food availability (Lindquist et al., 2005). However, larval and early juvenile stages of managed species that swim or drift to the proposed bridge may suffer high rates of predation. This issue is particularly important considering the presence of extensive SAV beds, a HAPC for summer flounder, penaeid shrimp, red drum, and the snapper-grouper complex (black sea bass, red grouper, Atlantic spadefish).

The introduction of bridge piles would alter sediment characteristics and provide a type of hard substrate previously unavailable in the estuarine water column, thereby increasing habitat complexity. In this way the bridge could act as an artificial reef (Williams and Thom, 2001) and, therefore, may represent a change in existing EFH and not a loss or degradation of EFH habitat. Glasby and Connell (1999) reviewed studies of piles as artificial reefs and concluded that piles increase local species richness by allowing the colonization of species not previously able to exist because of the lack of hard substrate. For example, structure-oriented managed fishes, such as red drum, are likely to congregate at the bridge piles. However, Glasby and Connell (1999) emphasize that piles do not always support the same communities as natural hard substrate and should not be considered functionally equivalent to natural reefs.

While increasing habitat complexity, introduction of piles and associated loss of SAV and marsh through fill and shading would possibly fragment and degrade the existing quality of these EFH areas. In brackish water systems, nekton (fishes and decapod crustaceans) have been shown to occur at greater densities with increasing SAV biomass (Kanouse, et al., 2006) and closer proximity to marsh edges (La Peyre, et al, 2007). The SAV beds and palustrine emergent (marsh) areas near the C2 corridor are more extensive and thus could be considered higher quality EFH when compared to the SAV and marsh areas found near the C1 corridor. The C2 corridor also contains more shallow water areas less than 4 feet deep, which are considered probable SAV habitat, where the C1 corridor occurs more in unlikely SAV habitat (greater than 6 feet deep). The C2 bridge corridor would cross larger SAV areas and would result in more SAV being lost from pilings and affected by shading when compared to the C1 bridge corridor, in addition to greater effects on marsh and palustrine forested wetlands from pile placement, shading, and permanent clearing.

Long-term change in bottom habitat as a result of dredging during construction (if used) would depend on whether the deeper bottom prevents re-establishment of the disturbed community and habitat. Dredging in Currituck Sound to allow construction from low-draft barges would affect the waters and aquatic bottom of 25 acres with C1 and 17 acres with C2. The aquatic substrate could be slow to recover after dredging, and long-term adverse affects would vary depending on the characteristics of areas disturbed and post-construction water depths and sediment composition.

The road widening portions of MCB2 and ER2 would result in larger areas of marsh areas being lost because of piling placement and/or fill when compared to MCB4, primarily through the construction of drainage easements at scattered locations on the Outer Banks between NC 12 and the Currituck Sound.

5.3 Species-Specific Potential Impacts

Short-term and permanent/long-term impacts to EFH present in the project area are found in Table 4. Acreages of EFH impacts for each detailed study alternative are found in Table 5. As discussed below, the Mid-Currituck Bridge could result in short-term adverse impacts to managed species. However, no substantial long-term adverse impacts to managed species are anticipated. Potential short-term and permanent/long-term impacts to life stages of individual managed species are found in Table 6 and Table 7 , respectively. No substantial impacts to individually managed species would occur with ER2, which would not involve the construction of a Mid-Currituck Bridge.

5.3.1 Black Sea Bass (*Centropristis striata*)

Estuarine waters designated as EFH for this species would be subject to temporary and permanent impacts from the Mid-Currituck Bridge, as described in Sections 5.1 and 5.2. Although unlikely to occur within the project area because of very low salinity, larval, juvenile, and adult life stages of the black sea bass could potentially be present in the future location of the Mid-Currituck Bridge. Bridge construction activities in Currituck Sound could result in a short-term increase in mortality to larvae, as this life stage is not mobile enough to avoid construction related turbidity, noise, and siltation. Juvenile and adult black sea bass would generally be able to avoid short-term construction disturbance. Black sea bass are estuarine dependent species, and larvae are commonly found in shallow estuarine waters. Therefore, long-term impacts from bridge piles in this environment may include increased mortality to larvae, as well as some potential disruption of their transport throughout Currituck Sound. However, as discussed in Section 5.2.2, disruption of larval transport would likely be minimal. The bridge alternatives could adversely affect adult life stages if there is a permanent decrease in the abundance of benthic invertebrate food resources near the piles. However, during the warmer months of the year, juveniles and adult black sea bass are commonly associated with structure or hardbottom; therefore, the proposed project could provide habitat for black sea bass.

Table 6. Potential Temporary and Short-Term Impacts to Managed Fish Species or Species Units Present in the Project Area

<table>
<tr><th>Species</th><th>Eggs</th><th>Larvae</th><th>Juveniles</th><th>Adults</th></tr>
<tr><td>Butterfish (Peprilus triacanthus)</td><td>Potential short-term direct mortality from construction in Currituck Sound.</td><td rowspan="7">Potential short-term direct mortality from construction in Currituck Sound.</td><td rowspan="9">Short-term displacement and habitat disturbance from noise, turbidity, and siltation.

Potential short-term direct mortality from construction in Currituck Sound.</td><td rowspan="9">Short-term displacement and habitat disturbance from noise, turbidity, and siltation.</td></tr>
<tr><td>Black sea bass (Centropristis striata)</td><td>N/A</td></tr>
<tr><td>Red grouper (Epinephelus morio)</td><td>N/A</td></tr>
<tr><td>Atlantic spadefish (Chaetodipterus faber)</td><td>N/A</td></tr>
<tr><td>Spanish mackerel (Scomberomorus faber)</td><td>N/A</td></tr>
<tr><td>Summer flounder (Paralichthys dentatus)</td><td>N/A</td></tr>
<tr><td>Penaeid Shrimp (Farfantepenaeus spp.)</td><td>N/A</td></tr>
<tr><td>Bluefish (Pomatomus saltatrix)</td><td>N/A</td><td>N/A</td></tr>
<tr><td>Red drum (Sciaenops ocellatus)</td><td>N/A</td><td>N/A</td></tr>
</table>

Note: Impact descriptions apply to all species unless specified as not applicable (N/A).

Table 7. Potential Permanent and Long-Term Impacts to Managed Fish Species or Species Units Present in the Project Area

<table>
<tr><th>Species</th><th>Eggs</th><th>Larvae</th><th>Juveniles</th><th>Adults</th></tr>
<tr><td>Butterfish (Peprilus triacanthus)</td><td>Low density in the project area, but limited potential disruption of dispersion through Currituck Sound.

Permanent loss of refuge from predators.</td><td rowspan="8">Limited potential disruption of dispersion through Currituck Sound.

Permanent loss and/or alteration of foraging habitat and refuge from predators.

Decreased abundance of autotrophic an planktonic food sources resulting from lower light levels.</td><td colspan="2" rowspan="10">Permanent loss and/or alteration of foraging habitat and refuge from predators.

Change in food web dynamics resulting from lower light levels and increased habitat complexity.

Possibly attracted to bridge as a reef structure.</td></tr>
<tr><td>Black sea bass (Centropristis striata)</td><td>N/A</td></tr>
<tr><td>Red grouper (Epinephelus morio)</td><td>N/A</td></tr>
<tr><td>Atlantic spadefish (Chaetodipterus faber)</td><td>N/A</td></tr>
<tr><td>Spanish mackerel (Scomberomorus faber)</td><td>N/A</td></tr>
<tr><td>Summer flounder (Paralichthys dentatus)</td><td>N/A</td></tr>
<tr><td>Penaeid Shrimp (Farfantpenaeus spp.)</td><td>N/A</td></tr>
<tr><td>Bluefish (Pomatomus saltatrix)</td><td>N/A</td><td>N/A</td></tr>
<tr><td>Red drum (Sciaenops ocellatus)</td><td>N/A</td><td>N/A</td></tr>
</table>

Note: Impact descriptions apply to all species unless specified as not applicable (N/A). Impacts to juveniles and adults are combined because of similarity.

5.3.2 Bluefish *(Pomatomus saltatrix)*

The waters of southern Currituck Sound are designated as EFH for this species and would be subject to temporary and permanent impacts from the proposed Mid-Currituck Bridge as described in Sections 5.1 and 5.2. While bluefish eggs and larvae occur across the entire shelf, most are concentrated in mid-shelf depths and would not occur in the low salinity environment of the proposed bridge (Shepherd and Packer, 2006). Although not common in the project area, juvenile and adult bluefish would generally be able to avoid short-term construction disturbance. Long-term impacts of bridge and pile placement are expected to be minor, as bluefish generally swim and feed in the water column and, therefore, would not be substantially disturbed by potential bridge related changes in the benthos.

5.3.3 Butterfish *(Peprilus triacanthus)*

The waters of Currituck Sound are considered appropriate inshore habitat (estuarine "mixing zone") for this species (but are not within the official EFH geographic range as determined by MAFMC) and would be subject to temporary and permanent impacts from the proposed Mid-Currituck Bridge as described in Sections 5.1 and 5.2. However, butterfish are unlikely to occur in the low salinity waters of the project area. Eggs and larvae occur across the entire shelf between the shoreline to greater than 6,000 feet (1,828.8 meters) from shore. Larvae and juveniles use estuaries as nurseries, and both life stages could be found in the vicinity of the proposed bridge. Bridge construction activities in Currituck Sound could result in a short-term increase in mortality to eggs and larvae as these life stages are not mobile enough to avoid construction related turbidity, noise, and siltation. Juvenile and adult butterfish would generally be able to avoid short-term construction disturbance. Long-term impacts from bridge piles in the nearshore environment may include increased egg and larval mortality and the disruption of larval transport throughout Currituck Sound. However, as discussed in Section 5.2.2, disruption of larval transport would likely be minimal. Long-term impacts of bridge and pile placement to juveniles and adults are expected to be minor as butterfish are generally pelagic feeders and, therefore, would not be substantially disturbed by potential bridge related changes in the benthos.

5.3.4 Summer Flounder *(Paralichthys dentatus)*

The waters of Currituck Sound are designated as EFH for summer flounder and would be subject to temporary and permanent impacts from the proposed Mid-Currituck Bridge as described in Sections 5.1 and 5.2. In addition, the extensive SAV beds of Currituck Sound and Jean Guite Creek (a PNA) are designated as HAPC for summer flounder. The C1 bridge corridor would affect an estimated <0.1 acre of SAV habitat from pile placement and permanently shade 4.3 acres of SAV. The C2 bridge corridor would affect an estimated <0.1 acre of SAV habitat from pile placement and permanently shade 5.5 acre of SAV. Widening of the bridge over Jean Guite Creek would also create additional shading with all of the detailed study alternatives.

Summer flounder eggs are generally found in ocean waters are not likely to be affected by project construction activities. Ocean-spawned larvae are transported into estuarine areas, such as Currituck Sound, where they develop into juveniles. During transport into the sound, short-term increases in mortality to larvae could occur as this life stage is not mobile enough to avoid construction related turbidity, noise, and siltation. Juvenile and adult summer flounder would be displaced and are mobile enough to avoid construction related disturbance. Thus long-term impacts to summer flounder from bridge piles in the sound may include increased mortality to larvae and the disruption of larval transport throughout Currituck Sound. However, as discussed in Section 5.2.2, disruption of larval transport would likely be minimal. The bridge could adversely affect the juvenile and adult life stages if there is a permanent decrease in the abundance of benthic invertebrate food resources near the piles.

5.3.5 Penaeid Shrimp (*Farfantepenaeus* spp.)

All tidal palustrine and estuarine waters, including emergent and forested wetlands, SAV, aquatic beds, and subtidal/intertidal flats, within the project area are designated penaeid shrimp EFH. As described in Sections 5.1 and 5.2, the waters of Currituck Sound would be subject to temporary and permanent impacts from the proposed Mid-Currituck Bridge. In addition to the shorelines and "marsh edges" of Currituck Sound, the extensive SAV beds found throughout Currituck Sound and Jean Guite Creek (a PNA) also are designated as HAPC for penaeid shrimp. The C1 bridge corridor would affect an estimated <0.1 acre of SAV habitat from pile placement and permanently shade 4.3 acres of SAV. The C2 bridge corridor would affect an estimated <0.1 acre of SAV habitat from pile placement and permanently shade 5.5 acre of SAV. Widening of the bridge over Jean Guite Creek also would create additional shading with all of the detailed study alternatives.

Except for eggs, all life stages of the penaeid shrimp are present near the proposed Mid-Currituck Bridge. Penaeid shrimp spawn offshore in greater than 30 feet of water and eggs would not be present near the proposed bridge, so mortality from bridge related construction would not be expected. Larvae are transported into Currituck Sound where they continue to develop. Thus, bridge construction activities could result in a short-term increase in mortality to larvae as this life stage is not mobile enough to avoid construction related turbidity, noise, and siltation. Juveniles and adults could be affected by short-term construction disturbance including mortality and displacement. Because penaeid shrimp are estuarine dependent and larvae are commonly found in shallow waters, long-term impacts from bridge piles in Currituck Sound could include increased mortality of early life stages and the disruption of their transport throughout Currituck Sound. However, as discussed in Section 5.2.2, disruption of larval transport likely would be minimal. For later life stages, long-term bridge impacts could include permanent displacement coincident with decreased abundance of benthic communities near the bridge.

5.3.6 Red Drum *(Sciaenops ocellatus)*

All tidal palustrine and estuarine waters, including emergent and forested wetlands, SAV, aquatic beds, subtidal/intertidal flats, marsh edges, and oyster reef and shell banks, within the project area are designated red drum EFH. Jean Guite Creek, SAV, aquatic beds, and the estuarine water column/creeks of Currituck Sound are designated HAPCs for red drum. As described in Sections 5.1 and 5.2, waters of the sound would be subject to temporary and permanent impacts from the proposed Mid-Currituck Bridge. The C1 bridge corridor would affect an estimated <0.1 acre of SAV habitat from pile placement and permanently shade 4.3 acres of SAV. The C2 bridge corridor would affect an estimated <0.1 acre of SAV habitat from pile placement and permanently shade 5.5 acre of SAV. Widening of the bridge over Jean Guite Creek would also create additional shading with all of the detailed study alternatives.

The red drum is an estuarine-dependent species with important foraging areas in Currituck Sound. Bridge construction activities in the sound should not result in a disturbance to eggs and larvae, as these life stages occur in higher salinity estuarine waters and inlets. Both juvenile and adult red drum that occur in the project area are mobile enough to avoid construction-related disturbance. Early juveniles enter Currituck Sound in winter and spring where they continue to develop. Disruption of larval transport should not occur, since red drum typically enter Currituck Sound as free-swimming juveniles. As adults and subadults, red drum are commonly found in the waters of Currituck Sound. They are bottom feeders that favor structure and could be attracted to bridge pilings, but the Mid-Currituck Bridge could adversely impact adult life stages if there is a permanent decrease in the abundance of benthic invertebrate food resources in the vicinity of the bridge.

5.3.7 Red Grouper (*Epinephelus morio*)

Estuarine waters designated as EFH for this species would be subject to temporary and permanent impacts from the proposed Mid-Currituck Bridge as described in Sections 5.1 and 5.2. Although unlikely to occur within the project area because of very low salinity, larval, juvenile life stages of the red grouper could potentially be present in the future location of the Mid-Currituck bridge. Adults reside in deeper offshore waters and are unlikely to be found in the project area. Bridge construction activities in Currituck Sound could result in a short-term increase in mortality to larvae, as this life stage is not mobile enough to avoid construction related turbidity, noise, and siltation. Juvenile red grouper would generally be able to avoid short-term construction disturbance. Red grouper occasionally utilize estuarine environments, and larvae could be found in these waters. Therefore, long-term impacts from bridge piles in this environment could include increased mortality to larvae, as well as some potential disruption of their transport throughout Currituck Sound. However, as discussed in Section 5.2.2 and the rarity of this species in the area, disruption of larval transport likely would be minimal. The bridge alternatives could adversely affect adult life stages if there is a permanent decrease in the abundance of benthic invertebrate food resources near the piles.

However, juvenile red grouper are commonly associated with structure or hardbottom; therefore, the proposed bridge could provide habitat for red grouper.

5.3.8 Atlantic Spadefish (*Chaetodipterus faber*)

Estuarine waters designated as EFH for this species would be subject to temporary and permanent impacts from the proposed Mid-Currituck Bridge as described in Sections 5.1 and 5.2. Although unlikely to occur within the project area because of very low salinity, larval, juvenile, and adult life stages of the Atlantic spadefish could potentially be present in the future location of the Mid-Currituck Bridge. Juvenile and adult Atlantic spadefish generally would be able to avoid short-term construction disturbance. Since they are found in a wide variety of estuarine and nearshore environments, spadefish larvae could be found in the waters of the project area. Therefore, long-term impacts from bridge piles in this environment may include increased mortality to larvae, as well as some potential disruption of their transport throughout Currituck Sound. However, as discussed in Section 5.2.2, disruption of larval transport would likely be minimal. The bridge alternatives could adversely affect adult life stages if there is a permanent decrease in the abundance of benthic invertebrate food resources near the piles. Atlantic spadefish are also known to frequent SAV beds and this habitat could be degraded in the project area near the bridge structure as discussed in Sections 5.1 and 5.2.

5.3.9 Spanish Mackerel (*Scomberomorus maculatus*)

Estuarine waters designated as EFH for this species would be subject to temporary and permanent impacts from the proposed Mid-Currituck Bridge as described in Sections 5.1 and 5.2. Although unlikely to occur within the project area because of very low salinity, larval, juvenile life stages of the Spanish mackerel could potentially be present in the future location of the Mid-Currituck Bridge. Adults reside in offshore waters and are unlikely to be found in the project area. Bridge construction activities in Currituck Sound could result in a short-term increase in mortality to larvae, as this life stage is not mobile enough to avoid construction related turbidity, noise, and siltation. Juvenile Spanish mackerel would generally be able to avoid short-term construction disturbance. Spanish mackerel are common in estuarine environments, and larvae could be found in these waters. Therefore, long-term impacts from bridge piles in this environment could include increased mortality to larvae, as well as some potential disruption of their transport throughout Currituck Sound. However, as discussed in Section 5.2.2 and the rarity of this species in the area, disruption of larval transport likely would be minimal. The bridge could adversely affect larval juvenile life stages if there is a permanent degradation of habitat for food resources near the bridge structure.

5.3.10 Additional Species

The State of North Carolina has, or is currently developing, FMPs for several species including red drum, southern flounder, striped bass, blue crab, striped mullet, hard clams, and kingfish. Impacts to red drum and flounder are addressed above. Potential impacts to kingfish, river herring, striped bass, hard clams, bay scallops, oysters, blue crabs, and striped mullet are addressed below.

Kingfish have a life history, diet, and habitat preference similar to other sciaenids, such as the red drum. However, kingfish are not likely to occur within Currituck Sound and bridge construction should not affect this species.

River herring and striped bass are anadromous fish whose adult life stages live in the lower estuaries and marine waters, moving to freshwater only to spawn. Although portions of the Currituck Sound may be used by spawning fish, no state-designated Anadromous Fish Spawning Areas (AFSA) would be crossed by any of the detailed study alternatives. Bridge construction activities in Currituck Sound could result in a short-term increase in mortality to eggs and larvae as these life stages are not mobile enough to avoid construction related turbidity, noise, and siltation. Juveniles and adults are mobile enough to avoid construction disturbance. The proposed Mid-Currituck Bridge could adversely affect juvenile and adult life stages if there is a permanent decrease in the abundance of benthic invertebrate food resources near bridge piles.

Hard clams are common throughout Currituck Sound. Potential short-term disturbance and permanent loss of some benthic habitat would result from the Mid-Currituck Bridge. Open water bridge construction in the sound would generate temporary turbidity and siltation that could clog the respiratory and feeding structures of hard clams and could lead to mortality. Clams are sessile and could be eliminated in the location of proposed piles. Open water and marsh communities are habitat for hard clams. Impacts to these habitats resulting from the Mid-Currituck Bridge are described in Section 5.2. Salinity levels in Currituck Sound are too low to support oysters and bay scallops and their occurrence to project area is extremely unlikely. Thus, impacts to these species resulting from bridge construction should not occur.

Blue crabs occupy marine and estuarine habitats at various stages of their life-cycle. Mating occurs in the estuary, followed by spawning near coastal inlets from April to June and August to September. Year-class strength is greatly influenced by weather and current conditions, proximity to inlets, alongshore northerly winds, and hours of dark flood tide. Mid-Currituck Bridge construction activities could result in a short-term increase in mortality to eggs and larvae from construction related turbidity, noise, and siltation. Long-term bridge impacts to juveniles and adults could include permanent displacement coincident with decreased abundance of benthic communities and associated food sources in the vicinity of the bridge. As discussed in Section 5.2.2, disruption of larval transport likely would be minimal and would not adversely affect this species.

Striped mullet are catadromous species that live in fresh and estuarine waters until moving to nearshore marine and high salinity estuarine waters to spawn in winter and spring. Larvae develop offshore and would not be present in Currituck Sound.

Immature striped mullet move into estuarine waters during the winter and generally occupy estuarine waters until spawning. Juveniles and adults could be present near the proposed Mid-Currituck bridge and could be disturbed by temporary construction related noise, turbidity, and siltation.

6.0 Findings and Conclusion

6.1 Findings

Four (MCB2/C1 and C2 and MCB4/C1 and C2) of the five detailed study alternatives would cross Currituck Sound with a new bridge via one of two different bridge corridors (C1 and C2) and would include different combinations of road widening. One (ER2) of the five detailed study alternatives excludes construction of a new bridge and involves only road widening.

MCB4 would avoid the construction of drainage easements in several EFH areas that are associated with road widening for ER 2 and MCB2. The temporary negative impacts to water quality associated with bridge construction would be somewhat reduced by the shorter length of the C1 bridge corridor (7.0 miles) when compared to the C2 bridge corridor (7.5 miles). For these reasons, MCB4/C1 would have the least potential for affecting EFH. When considering permanent loss (fill and pile impacts) of EFH with all five detailed study alternatives, the area affected from greatest to least would be: MCB2/C2 (2.0 acres), MCB2/C1 (1.9 acres), ER2 (1.8 acres), MCB4/C2 (0.2 acre), and MCB4/C1 (0.1 acre).

Permanent loss or alteration of palustrine emergent and forested areas, SAV, intertidal flats, and tidal freshwater aquatic bed would result directly from shading and pile placement and possible long-term sediment change could result if dredging occurs with the bridge structure associated with MCB2 and MCB4. In addition, ER2 and MCB2 would involve permanent loss of palustrine emergent and forested areas through the construction of permanent drainage easements at scattered locations on the Outer Banks between NC 12 and the Currituck Sound, and also result in increased shading of Jean Guite Creek (a PNA and probable SAV habitat). Addition of a hurricane evacuation lane across the existing Jean Guite Creek with MCB4 would result in less than 0.1 acre of shading and piling impact. If US 158 is widened across Jean Guite Creek with ER2 or MCB2, an even smaller amount of additional shading would occur.

The presence of the bridge and pile placement could also result in several additional impacts, including changes to water quality, water flow, and light levels of the area below the bridge and for some distance surrounding the bridge. Altered light levels and the introduction of piles as a hard substrate previously unavailable in the area would have multiple effects, thereby resulting in changes to the existing food web structure. Decreased autotrophic productivity (phytoplankton and aquatic vegetation) resulting from lower light levels could result in decreased abundances of aquatic vegetative habitat (including SAV), heterotrophic grazers, and predators (zooplankton, benthic invertebrates, and fish) near the Mid-Currituck Bridge. On the other hand, organisms could be attracted to bridge pilings as a reef structure. Shading likely would have less of an effect on EFH with the C1 bridge corridor than with the C2 bridge corridor because it is shorter and the orientation of the bridge structure (southwest to northeast) would allow more variability in sunlight exposure to areas under the bridge.

The temporary effects to EFH of bridge pile placement and other bottom disturbance, such as dredging if it were used, with MCB2 and MCB4 would be a short-term increase in noise, turbidity, benthic disturbance (including sediment removal), and siltation. Suspended fine sediments would settle and could result in burial of organisms and/or sediment drift, which depending on the currents, could spread outside the direct impact area. The result would be short-term adverse effects from bridge construction on biota and managed species that use benthic habitats. However, if dredging is not used, benthic organisms would be expected to recover after construction ceases and other organisms also are expected to re-colonize the area afterwards. The aquatic substrate could be slow to recover if dredging occurs, and adverse affects would vary depending on areas disturbed and post-construction water depths and sediment composition. Construction activities associated with permanent drainage easements and road-widening for all of the detailed study alternatives would result in similar temporary, short-term impacts as discussed above; however, they would occur at much lower levels. Preventative measures could be implemented in terrestrial construction areas, thus greatly reducing runoff (and associated increases in turbidity and sedimentation) into EFH areas.

6.2 Conclusion

The detailed study alternatives likely would result in short-term and long-term adverse effects to EFH and managed species and measures would be considered to minimize those effects. The detailed study alternatives would not have a substantial long-term adverse impact on EFH or managed species for the following reasons:

- With all detailed study alternatives, fill and pile impacts resulting in the permanent loss of EFH would be small at 0.1 to 2.0 acres. Clearing impacts also would be small at 0.0 to 3.2 acres.
- Shading impact with a Mid-Currituck Bridge would range from 28.1 to 30.7 acres. Most of the shading would occur over Currituck Sound, however, and Currituck Sound is large (97,920 acres) compared to the small area that would be affected by shading. Shading would not affect fish passage.
- With MCB2 and MCB4, the bridge pilings would increase habitat complexity and provide some hard structure that would potentially provide additional habitat for some managed species.
- Temporary impacts would occur during construction but the aquatic substrate generally would be expected to recover after construction. Impacts would result primarily bottom disturbance and associated raising of sediments, but most adult

fish are mobile and would actively avoid direct impacts. Some impairment of ability of EFH managed species to find prey items could occur, but this effect would be temporary and spatially limited to the immediate vicinity of construction activities. Although the direct impact on EFH managed species would be largely temporary, the extent of impact and length of the recovery time would be affected by how, when, and if dredging occurs. Dredging would not be used in areas of existing SAV habitat. Bridge construction techniques would be evaluated during final design in order to determine the most appropriate technique for constructing structures in Currituck Sound. Final construction methods would be selected as part of the permitting process.

- The bridge alternatives would introduce a new source of pollution (via bridge runoff) into Currituck Sound. Pollutants discharged into Currituck Sound near the bridge may not dissipate because of poor water circulation and could result in higher sediment pollutant levels and bioaccumulation near the bridge. NCTA would examine cost-effective options for treating the first inch of bridge runoff during development of a Mid-Currituck Bridge design if MCB2 or MCB4 is selected for implementation.

- Bridge replacement and/or widening of US 158 over Jean Guite Creek (a PNA) is proposed for all alternatives. Although some potential adverse impacts to EFH would occur during the construction phases, the impacts would be temporary and are not expected to result in substantial short-term effects on managed species because with ER2 and MCB2, a new US 158 bridge over the creek is expected to not place piles in the creek. The additional hurricane evacuation lane that could be associated with MCB4 is expected to duplicate the existing US 158's single pile foundation in the creek.

7.0 References/Literature Cited

7.1 Publications and Technical Reports

Able, K. W., J. P. Manderson, and A. Studholme. 1998. "The Distribution of Shallow Water Juvenile Fishes in an Urban Estuary: The Effects of Man-Made Structures in the Lower Hudson River." *Estuaries*, 21: 731-44.

Able, K. W., J. P. Manderson, and A. Studholme. 1999. "Habitat Quality for Shallow Water Fishes in an Urban Estuary: The Effects of Man-Made Structures on Growth." *Marine Ecology Progress Series*, 187: 227-235.

Ableson, A., and M. Denny. 1997. "Settlement of Marine Organisms in Flow." *Annual Review of Ecology and Systematics*, 28: 317-339.

Alexander, C., and M. Robinson. 2006. *Quantifying the Ecological Significance of Marsh Shading: Impact of Private Recreational Docks in Coastal Georgia*. Coastal Resources Division, Georgia Department of Natural Resources, Brunswick, Georgia.

Ambrose, R. F., and T. W. Anderson. 1990. "Influence of an Artificial Reef on the Surrounding Infaunal Community." *Marine Biology*, 107: 41-52.

Beck, M.W., K.L. Heck Jr., K.W. Able, D.L. Childers, D.B. Eggleston, B.M. Gillanders, B. Halpern, C.G. Hayes, K. Hoshino, T.J. Minello, R.J. Orth, P.F. Sheridan, and M.P. Weinstein. 2001. "The Identification, Conservation, and Management, of Estuarine and Marine Nurseries for Fish and Invertebrates." *Bioscience*. 51(8): 633-641.

Broome, S.W., C.B. Craft, S.D. Struck, M. SanClements. 2005. *Final Report: Effects of Shading from Bridges on Estuarine Wetlands.* N.C. State University Center for Transportation and the Environment/NCDOT Joint Research Program.

Burdick, D. M., and F. T. Short. 1999. "The Effects of Boat Docks on Eelgrass Beds in Coastal Waters off Massachusetts." *Environmental Management*, 23: 231-240.

Caldwell, William S. 2001. *Hydrologic and Salinity Characteristics of Currituck Sound and Selected Tributaries in North Carolina and Virginia, 1998-1999*. US Geological Survey, Water-Resources Investigations Report 01-4097.

Clynick, B. G., M. G. Chapman, and A. J. Underwood. 2007. "Effects of Epibiota on Assemblages of Fish Associated with Urban Structures." *Marine Ecology Progress Series*, 332: 201–210.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. *Classification of Wetlands and Deepwater Habitats of the United States*. U.S. Fish and Wildlife Service FWS/OBS-79/31, Washington, D.C.

CZR Incorporated. 2009. *Natural Resources Technical Report*. Prepared for PB Americas and the North Carolina Turnpike Authority.

Davis, N., G. R. Van Blaricom, and P. K. Dayton. 1982. "Man-Made Structures on Marine Sediments: Effects on Adjacent Benthic Communities." *Marine Biology*, 70: 295-303.

Davis, G. J. and D. F. Carey, Jr. 1981. "Trends in Submersed Macrophyte Communities of the Currituck Sound: 1977-1979." *J. Aquat. Plant Manage*. 19:3-8.

Davis, G. J. and M. M. Brinson. 1983. "Trends in Submersed Macrophyte Communities of the Currituck Sound: 1909-1979." *J. Aquat. Plant Manage*. 21:83-87.

Davis, G. J. and M. M. Brinson. 1989. *Submerged Aquatic Vegetation of the Currituck Sound and Western Albemarle-Pamlico Estuarine System*. Final Report to the Albemarle-Pamlico Estuarine Study.

Duffy-Anderson, J. T., and K. W. Able. 1999. "Effects of Municipal Piers on the Growth of Juvenile Fish in the Hudson River Estuary: A Study across the Pier Edge." *Marine Biology*, 133: 409-418.

Ferguson, R.L. and L.L. Wood. 1994. *Rooted Vascular Beds in the Albemarle-Pamlico Estuarine System*. US Environmental Protection Agency, National Estuary Program, NC Department of Environment, Health, and Natural Resources. Report No. 94-02.

Glasby, T. M., and S. D. Connell. 1999. "Urban Structures as Marine Habitats." *Ambio*, 28: 595-598.

Hanson, J., M. Helvey, and Russ Strach. 2004. *Non-Fishing Impacts to Essential Fish Habitat and Recommended Conservation Measures*. National Marine Fisheries Service (NOAA Fisheries), Version 1. Southwest Region, Long Beach, California.

Holman, R. E. 1993. *Evaluation of the Albemarle-Pamlico Estuarine Study Area Utilizing Population, Land Use, and Water Quality Information.* The University of North Carolina, Water Resources Research Institute, Special Report Series No. 11.

Kanouse, Sariai, Megan K. La Peyer, J. Andrew Nyman. 2006. "Nekton use of *Ruppia maritima* and non-vegetated bottom habitat types within brackish marsh ponds". *Mar. Ecol. Prog. Ser.* 327: 61-69.

La Peyre, Megan, Bryan Gossman, John A. Nyman. 2007. "Assessing functional equivalency of nekton habitat in enhanced habitats: Comparison or terraced and unterraced marsh ponds". *Estuaries and Coasts.* 30: 526-536.

Lindquist, D. C., R. F. Shaw, and F. J. Hernandez. 2005. "Distribution Patterns of Larval and Juvenile Fishes at Offshore Petroleum Platforms in the North-Central Gulf of Mexico." *Estuarine, Coastal and Shelf Science*, 62: 655-665.

Miller, J. L., and A. Valle-Levinson. 1996. "The Effect of Bridge Piles on Stratification in the Lower Chesapeake Bay." *Estuaries*, 19: 526-539.

National Marine Fisheries Service. 2001. *Report to Congress*. Status of Fisheries of the United States: Report on the Status of Fisheries of the United States. National Marine Fisheries Service, Silver Spring, Maryland.

National Marine Fisheries Service. 1999. *Essential fish habitat: A marine fish habitat conservation mandate for federal agencies*. Revised 08/04. NMFS, Habitat Conservation Division, Southeast Regional Office, St. Petersburg, FL.

National Marine Fisheries Service. 1999a. *Final fishery management plan for Atlantic tuna, swordfish, and sharks, including the revised final environmental impact statement, final regulatory impact review, the final regulatory flexibility analysis, and the final social impact assessment.* Highly Migratory Species Management Division, Office of Sustainable Fisheries, National Marine Fisheries Service, Silver Springs, MD.

National Marine Fisheries Service. 1999b. *Amendment 1 to the Atlantic billfish fishery management plan, including the revised final environmental impact statement, final regulatory impact review, the final regulatory flexibility analysis, and the final social impact assessment.* Highly Migratory Species Management Division, Office of Sustainable Fisheries, National Marine Fisheries Service, Silver Springs, MD.

National Marine Fisheries Service. 2004. *Non-Fishing Impacts to Essential Fish Habitat and Recommended Conservation Measures*. National Marine Fisheries Service and US Fish and Wildlife Service, Washington, D.C.

NC Department of Environment Health and Natural Resources. 1994. *Currituck Sound Outstanding Resource Water Evaluation.* NC Division of Environmental Management, (NCDEM), Water Quality Section (Now the N.C. Department of Environment and Natural Resources, Division of Water Quality). Unpublished Report.

NC Division of Marine Fisheries. 2001. *N.C. Oyster Fishery Management Plan*. N.C. Department of Environment and Natural Resources.

Nelson, Peter A. 2003. " Marine fish assemblages associated with fish aggregating devices (FADs): effects of fish removal, FAD size, fouling communities, and prior recruits." *Fishery Bulletin*, 101(4): 835–850.

Nightingale, B., and C. Simenstad. 2001. *Overwater Structures: Marine Issues*. Submitted to Washington Department of Fish and Wildlife, Washington Department of Ecology, and Washington Department of Transportation.

Parsons Brinckerhoff. 2009. *Alternatives Screening Report*. Prepared for the North Carolina Turnpike Authority.

Parsons Brinckerhoff. 2009. *Assessment of Alternatives for Treating Bridge Runoff.* Prepared for the North Carolina Turnpike Authority.

Parsons Brinckerhoff. 2009. *Indirect and Cumulative Effects Technical Report.* Prepared for the North Carolina Turnpike Authority.

Riggs, S. R., J. R. Bray, R. A. Wyrick, C. R. Klingman, J. C. Hamilton, D. V. Ames, and J. S. Watson. 1993. *Sedimentation and Sediment Quality in the North Landing River, Currituck County Estuarine System, North Carolina and Virginia.* US Environmental Protection Agency, National Estuary Program, NC Department of Environment, Health, and Natural Resources. Report No. 92-22.

Shepherd, G. R., and D. B. Packer. 2006. *Bluefish, Pomatomus Saltatrix, Life History and Habitat Characteristics*. Second Edition. NOAA Technical Memorandum NMFS-NE-198.

Sincock, J. L. 1966. *Back Bay-Currituck Sound Data Report.* Patuxent Wildlife Research Center.

Stanley, D. R., and C. A. Wilson. 2000. "Seasonal and Spatial Variation in the Biomass and Size Frequency Distribution of Fish Associated with Oil and Gas Platforms in the Northern Gulf of Mexico." *Fisheries, Reefs, and Offshore Development*. pp. 123-153. American Fisheries Society Symposium 36. Gulf of Mexico Fish and Fisheries Meeting, New Orleans, Louisiana (USA), October 24-26, 2000.

Street, M.W., A.S. Deaton, W.S. Chappell, and P.D. Mooreside. 2005. North Carolina Coastal Habitat Protection Plan. North Carolina Department of Environment and Natural Resources, Division of Marine Fisheries, Morehead City, NC. 656 pp.

Struck, S. D., C. B. Craft, S. W. Broome, M. D. Sanclements, and J. N. Sacco. 2004. "Effects of Bridge Shading on Estuarine Marsh Benthic Invertebrate Community Structure and Function." *Environmental Management*, 34: 99–111.

Sumer, B. M., and J. Fredsoe. 2002. *The Mechanics of Scour in the Marine Environment. Advanced Series on Ocean Engineering*. Volume 17. World Scientific.

US Army Corps of Engineers. 2007. *Currituck Sound Hydrographic and Submerged Aquatic Vegetation Survey*. Field Research Facility. Duck, NC.

Williams, G. D., and R. M. Thom. 2001. *Marine and Estuarine Shoreline Modification Issues*. Battalle Marine Sciences Laboratory. Pacific Northwest Laboratory, Washington, USA.

7.2 Personal Communications

Caroon, Clay. North Carolina Division of Marine Fisheries. May 7, 2008.

7.3 Web Sites

Mid-Atlantic Fishery Management Council. 2008. Fishery Management Plans. Available: http://www.mafmc.org/mid-atlantic/fmp/fmp.htm. Accessed: December and January, 2009.

NC Division of Coastal Management (NCDCM). 2007. CAMA Handbook for Development in Coastal North Carolina. N.C. Department of Environment and Natural Resources. Available: http://dcm2.enr.state.nc.us/Handbook/contents.htm. Accessed: May 22, 2008.

NC Wildlife Resources Commission (NCWRC). 2005. North Carolina Wildlife Action Plan. Raleigh, NC. Available: http://www.ncwildlife.org/pg07_WildlifeSpeciesCon/pg7c1_3.htm. Accessed: May 29, 2008.

South Atlantic Fishery Management Council. 2008. Fishery Management Plans. Available: http://www.safmc.net/Library/FisheryManagementPlansAmendments/tabid/395/Default.aspx. Accessed: December and January, 2009.

United States Geological Survey (USGS). 2009. USGS: Surface-water annual statistics for North Carolina. Upper Currituck Sound near Corolla, NC: Station #02043430. Available: http://waterdata.usgs.gov/nc/nwis/annual/?format=sites_selection_links&search_site_no=02043430&referred_module=sw. Accessed: June 2009.