MID-CURRITUCK BRIDGE STUDY

ESSENTIAL FISH HABITAT TECHNICAL REPORT

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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 Final Environmental Impact Statement (FEIS) to evaluate proposed improvements in the Currituck Sound area. The proposed action is included in NCDOT's 2009 to 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 project's Preferred Alternative, which includes a Mid-Currituck Bridge, as well as associated US 158 and NC 12 road widening. 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 of Commerce on all actions, or proposed actions, authorized, funded, or undertaken by the agency that might adversely affect EFH.

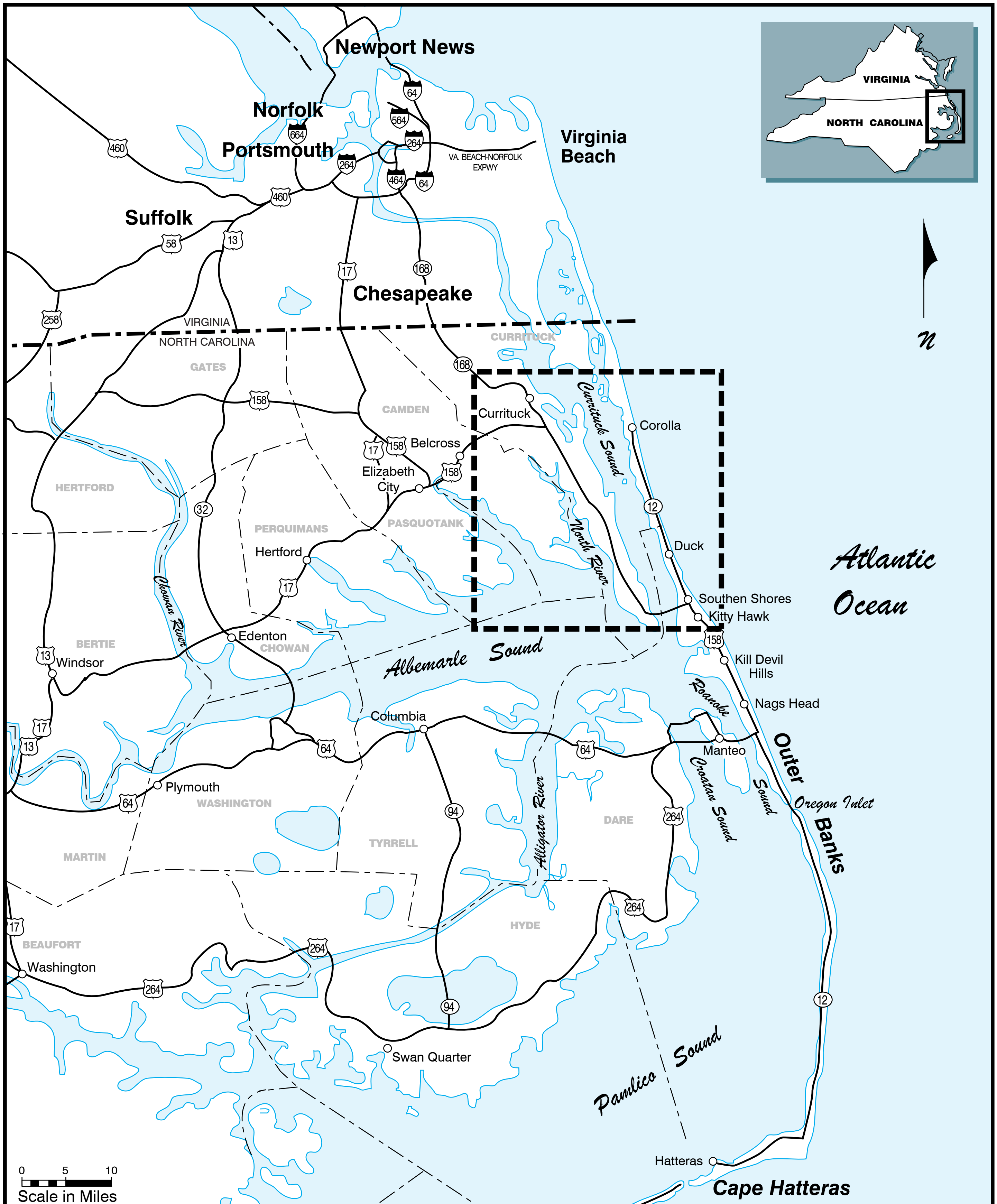
All EFH is defined as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity" (16 USC 1802(10)). "Waters" include aquatic areas and their associated physical, chemical, and biological properties that are used by fish and can include aquatic areas historically 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. The designation of EFH is 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 its junction with 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. The primary north-south route on the mainland is US 158, and 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 evaluated in the *Draft Environmental Impact Statement* (DEIS). The DEIS detailed study alternatives identified are ER2, MCB2, and MCB4. MCB2 and MCB4 also include two bridge corridor alternatives across Currituck Sound, C1 and C2, as well as two options for the portion of the bridge through Maple Swamp between US 158 and Currituck Sound, Option A and Option B. 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. Along the western side of the project area, US 158 is located along a well drained ridge. 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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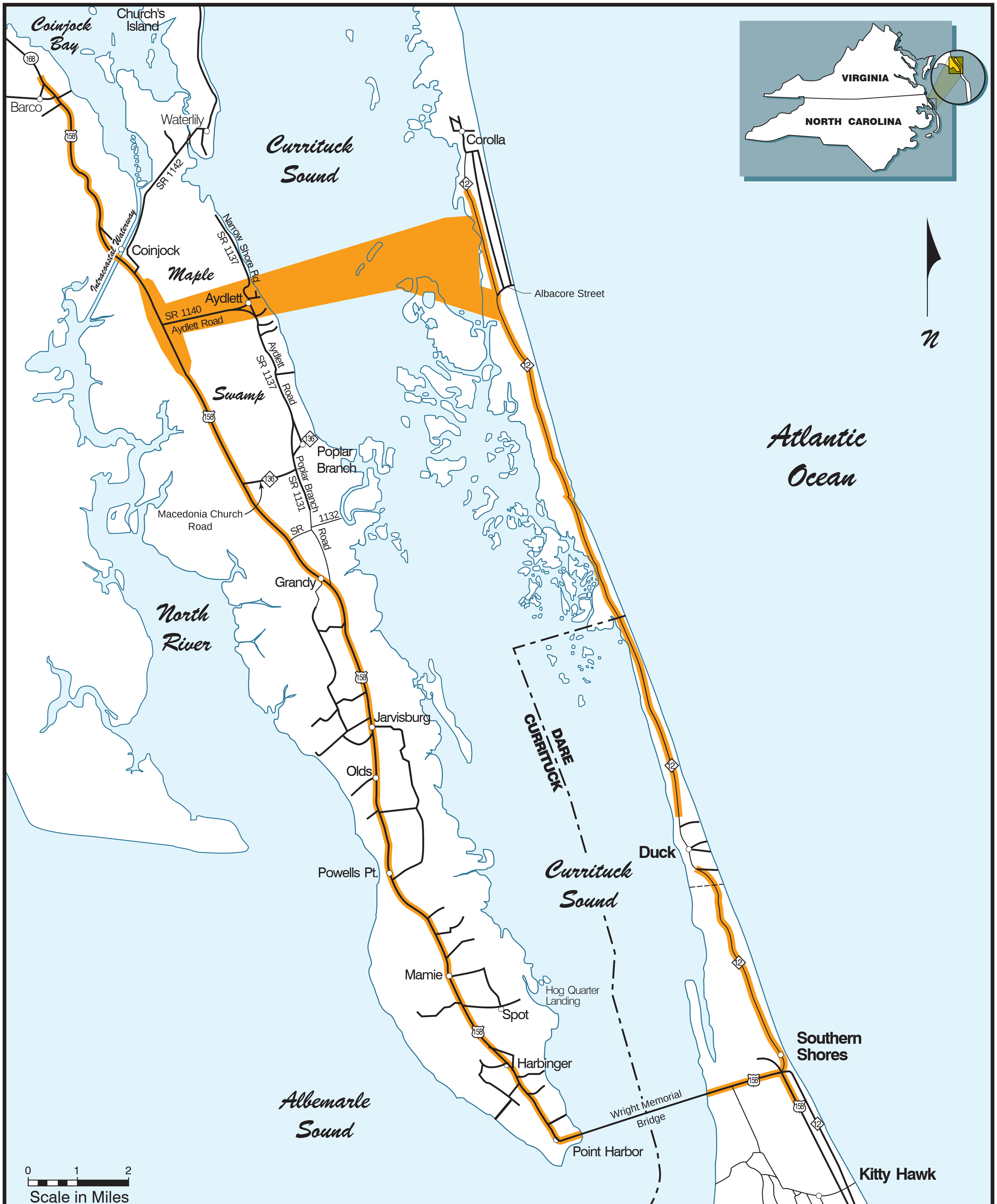
Project Vicinity

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:

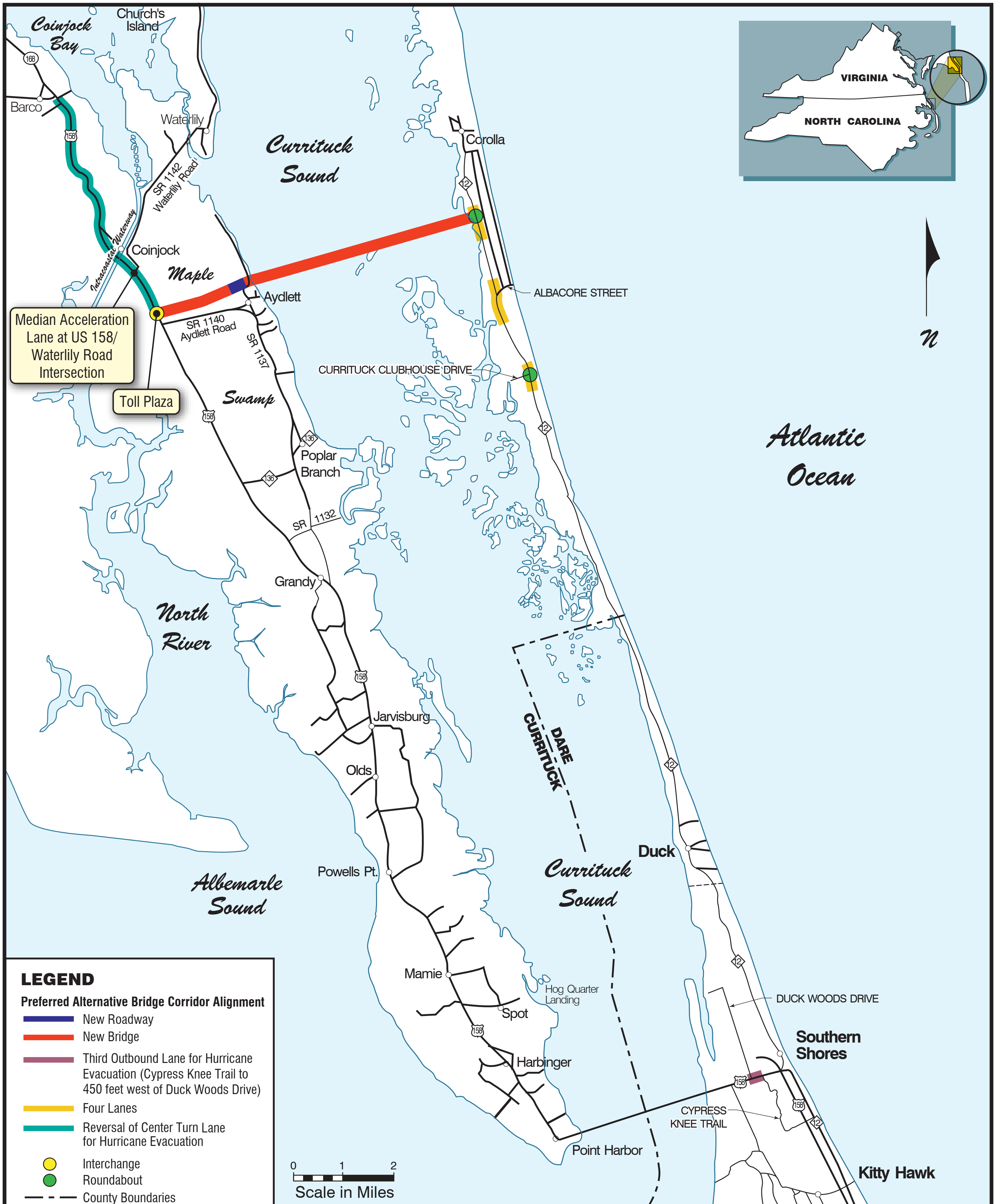
- The project area's main thoroughfares (US 158 and NC 12) are becoming increasingly congested and congestion will become even more severe in the future.
- Increasing congestion is causing travel time between the Currituck County mainland and the Currituck County Outer Banks to increase, especially during 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 DEIS along with the No-Build Alternative. After publication of the DEIS and input from private and government groups and citizens, a Preferred Alternative was selected for consideration and is included (along with the DEIS detailed study alternatives) in the FEIS.

3.1 Preferred Alternative

The Preferred Alternative is a refined version of DEIS detailed study alternative MCB4/C1 with Option A. (See Figure 3.) This revised EFH report focuses on impacts resulting from the Preferred Alternative. The Preferred Alternative also includes several design refinements to reduce impacts, in response to government agency and public input and comments. These refinements include:

- Provision of a median acceleration lane at Waterlily Road. This safety feature would allow left turns to continue to be made at Waterlily Road and US 158. Bulb-outs for u-turning vehicles also would be provided at the re-aligned US 158/Aydlett Road intersection and the US 158/Worth Guard Road intersection to provide greater flexibility for local traffic in turning to and from existing side streets near the US 158/ Mid-Currituck Bridge interchange.
- Reducing the amount of four-lane widening along NC 12 from that with MCB4/C1 from approximately 4 miles to approximately 2.1 miles, plus left turn lanes at two additional locations over approximately 0.5 mile. The 2.1 miles of NC 12 widening



Preferred Alternative

Figure 3

would be concentrated at three locations: the bridge terminus, the commercial area surrounding Albacore Street, and Currituck Clubhouse Drive.

- Constructing roundabouts on NC 12 instead of signalized intersections at the bridge terminus and Currituck Clubhouse Drive.
- Terminating the bridge in a roundabout at NC 12 also allowed the C1 bridge alignment to be adjusted to remove curves and thereby reduced its length across Currituck Sound by approximately 250 feet (from approximately 24,950 feet [4.7 miles] to 24,700 feet).
- Provision of marked pedestrian crossings along NC 12 where it would be widened. They would be placed at locations identified by Currituck County plans (Albacore Street, Orion's Way, and Currituck Clubhouse Drive are under consideration for inclusion in the next Currituck County thoroughfare plan), as well as at North Harbor View Drive and the bridge terminus (one across NC 12 and one across the bridge approach road).

For hurricane evacuation, the Preferred Alternative includes:

- On the mainland, reversing the center turn lane on US 158 between the US 158/Mid-Currituck Bridge interchange and NC 168 to provide additional road capacity during a hurricane evacuation and reduce clearance times.
- On the Outer Banks, adding approximately 1,600 feet of new third outbound lane to the west of the NC 12/US 158 intersection to provide additional road capacity during a hurricane evacuation. The additional lane would start at the US 158/Cypress Knee Trail/Market Place Shopping Center intersection and end approximately 450 feet west of the Duck Woods Drive intersection, a total distance of approximately 1,600 feet. From this point, the new lane would merge back into the existing US 158 westbound lanes over a distance of approximately 300 feet.

3.2 Mid-Currituck Bridge Construction

NCTA is currently proposing the construction methodologies described below for construction of the bridge over Currituck Sound to minimize construction-related water quality impacts to Currituck Sound and other jurisdictional waters, as practicable. If a Mid-Currituck Bridge is included in the alternative selected for implementation, NCTA would continue to work with environmental resource and regulatory agencies as the project progresses into final design and permit application to refine this approach. Construction methodologies proposed for building a Mid-Currituck Bridge include:

- A combination of work trestle and barges, including:

- An approximately 1,900-foot-long work trestle extending from the western shoreline. Based on the limited presence and sparse coverage of submerged aquatic vegetation (SAV) found only along the shoreline in the western portion of Currituck Sound, an open trestle would not be necessary. This closed surface work trestle is envisioned to be approximately 50 feet wide. Its footprint would allow a parked crane and a small lane to allow necessary materials to pass the crane for loading onto barges. The bridge in this area of the sound would be constructed from the work trestle. The barge method would be used east of the trestle. A barge loading area would be located at the eastern end of the trestle.

- Remaining construction from small, low draft barges for approximately 20,000 feet or 3.8 miles. The barges would be launched from the trestle extending off the shoreline from Narrow Shore Road in Aydlett.

- On the eastern side, use of a temporary construction trestle for approximately 4,500 feet or 0.9 mile (over SAV habitat [including existing beds] = 3,000 feet and over shallow water = 1,500 feet). Bridge erection equipment would operate on the trestle to place the components of the bridge foundation and spans. An open trestle would be used to minimize the shading of SAV habitat during construction. Marine industry standard pans attached to equipment would be used to capture any accidental release of petroleum products from equipment.

- Construction from land for approximately 400 feet total.

- Construction duration of 52 months.

- Driving of bridge piles with no jetting (using pressurized water to wash out a hole for a pile to set in).

- The bridge would likely be built beginning at both ends simultaneously. Construction also could begin in a third location, at the eastern-most point of construction from barges.

State and federal environmental resource and regulatory agencies at the time of the release of this report have concerns with impacts to SAV habitat (including existing beds) associated with bridge shading and driving piles. In response to this concern, NCTA would follow the protocols discussed in Section 5.1 and continue to work with environmental resource and regulatory agencies as the project progresses into final design and permit application to refine this approach.

3.3 Stormwater Management

NCTA would comply with NC Session Law 2008-211 (An Act to Provide for Improvements in the Management of Stormwater in the Coastal Counties in Order to Protect Water Quality) to the maximum extent practicable for the additional impervious surface area that would be created by the construction of the Preferred Alternative if it is selected for implementation.

Of the approximately 71.5 acres of additional impervious surface area (new built upon area with the Preferred Alternative), about 28 acres would be associated with the bridge over Currituck Sound and 11 acres with the bridge over Maple Swamp. The remaining approximately 33 acres would be associated with US 158 improvements, interchange ramps/bridges, toll facilities, local road connections, parking areas, and NC 12 widening. In addition, there are about 18 acres of existing roadway impervious surface area in the project area associated with existing US 158 and the portions of existing NC 12 to be widened.

Compliance with NC Session Law 2008-211's requirement for new development to capture and treat the first 1.5 inches of runoff from additional impervious surface areas would be met, to the maximum extent practicable, through a combination of pollutant source control and capture and treatment. Source control would be through the use of pavement sweeping and vacuuming on bridge decks. Capture and treatment would be through the use of bridge closed drainage systems, stormwater wetlands, wet detention basins, rooftop rainwater harvesting, and other traditional roadway Best Management Practices (BMPs), to the maximum extent practicable. Capture and treatment would occur for 56 of the 71.5 acres of new impervious surface area.

The following paragraphs describe how stormwater would be managed with the Preferred Alternative. Similar approaches, as applicable, would have been used with the other detailed study alternatives if one of them had been selected as the Preferred Alternative. A final stormwater management plan for minimizing the potential impact of project pollutants would be developed in association with the North Carolina Department of Environment and Natural Resources, Division of Water Quality (NCDENR-DWQ), as well as other appropriate state and federal environmental resource and regulatory agencies, during final design and permitting of the Preferred Alternative.

3.3.1 Stormwater Management for Uplands on the Mainland and the Outer Banks

In uplands areas on the mainland and the Outer Banks, stormwater capture and treatment would be through typical roadway BMPs using infiltration trenches and basins. To the maximum extent practicable, all 33 acres of non-bridge additional impervious surface area, plus all 18 acres of existing roadway impervious surface in the project's area of affect, would have the first 1.5 inches of runoff captured and either treated or used in the project site. Additionally, a rooftop runoff system may be used for buildings and/or toll plaza awnings to capture and use water on site or to infiltrate it. Alternative pavement materials, such as pervious pavements, also may be used in parking areas associated with the toll plaza.

With the Preferred Alternative, there would be no outfalls from NC 12 to Currituck Sound or the Atlantic Ocean. The accommodation of drainage on NC 12 was a focus in developing the preliminary designs along NC 12, both because a wider NC 12 would generate more runoff and because road flooding would continue to occur on NC 12 during storm events without improvement.

Much of NC 12 within the project area is in a topographic (rise and fall of the land) depression. To the east, the dune area along the coastline forms a ridge line. Similarly, to the west, the land generally rises near Currituck Sound. As a result, NC 12 is in a topographic "bathtub." In addition, there are no streams providing for water discharge, or other outlets for runoff, except in those locations where NC 12 is adjacent to Currituck Sound. Under existing conditions, stormwater runoff makes its way to low areas and eventually infiltrates into the ground. In some places the road itself is the low point, and thus there are parts of NC 12 that experience chronic flooding problems. Other complicating factors include the groundwater elevation, which is near the surface (in some places within 2 feet), and the extensive land development that has occurred along NC 12, particularly in the towns of Southern Shores and Duck.

The preliminary designs for NC 12 with the detailed study alternatives, including the Preferred Alternative, generally use infiltration strategies for the majority of the project, along with a limited number of outfalls to Currituck Sound in the case of MCB2 and ER2. Infiltration strategies involve locations for water to be absorbed into the ground rather than be transported to and released into a water body like Currituck Sound. The infiltration strategies would include infiltration basins and linear infiltration strips (roadside ditches). Infiltration basins and linear infiltration strips would remain dry except during and after storms. These volume-based BMPs would be sized to store temporarily the runoff from a 10-year storm. The infiltration strategies closely replicate existing drainage patterns, while improving storage capacity during the infiltration process. The specific approach to be taken varies along the roadway corridor for the NC 12 widening alternatives.

3.3.2 Stormwater Management for Maple Swamp and Currituck Sound

The stormwater management plan for the Maple Swamp and Currituck Sound bridges with the Preferred Alternative would have the following components:

- Source Control. Source control would be used on both the Maple Swamp and Currituck Sound bridges. Source control would be provided by frequent deck cleaning using state of the art, multi-function cleaning equipment that employs mechanical, vacuum, and regenerative air systems. Weather conditions would be monitored on site and additional deck cleaning would be done in advance of anticipated significant storm events. Source control through deck cleaning would be a contractual element of the agreement between NCTA and the concessionaire operating and maintaining the toll bridge. Failure by the concessionaire to comply with contractual terms could result in a financial penalty.

Modern pavement sweeping and vacuuming technology has been shown to remove effectively upwards of 97.5 percent of materials that cause pollution from the bridge deck (Real World Street Cleaner Pickup Performance Testing, Roger C. Sutherland, PE, Pacific Water Resources, Inc., July 2008). Even when graduated by particle size, this technology removes over 90 percent of the smallest particles and nearly all of the larger particles. Use of this technology prior to a storm event would remove the vast majority of the pollutants from the bridge runoff, thereby substantially improving the water quality of the runoff reaching the sound. Therefore, the sweeping approach is a pre-treatment method.

- <u>Stormwater Capture at the Ends of the Maple Swamp Bridge</u>. For the bridge over Maple Swamp, stormwater would be captured from each end of the bridge (for 500 feet) and piped to infiltration basins for treatment. The remaining length of this 1.5-mile-long bridge would have pre-treated discharge (via frequent vacuum/sweeping deck cleaning) through scuppers to the Maple Swamp wetland system. The height of the scuppers over Maple Swamp would vary because of the grade on the bridge and the ground elevations in Maple Swamp. Based on current plans, the bottom of the scuppers would be between 7 feet and 18 feet above the ground of Maple Swamp. If the energy of the water exiting the scuppers is determined to be a problem, dissipation would be provided either at the scupper pipe outlet or on the ground.

- <u>Stormwater Capture over SAV Habitat (including Existing Beds) at the Eastern End of the Currituck Sound Bridge</u>. For the bridge over Currituck Sound, the first 1.5 inches of stormwater runoff would be captured from the eastern end of the bridge for a distance of 4,000 feet to prevent direct discharge into SAV habitat (including existing beds) along the eastern shore of the sound. The runoff would be piped to the end of the bridge for treatment to either a stormwater wetland or a wet detention basin. The bridge stormwater collection system would be subject to:

  - Regular pipe inspections and maintenance (including debris and litter removal); and

  - Periodic removal and disposal of accumulated sediments in the wet detention basin.

  The remaining length of this 4.7-mile-long bridge would have no stormwater capture and would have pre-treated discharge (via frequent vacuum/sweeping deck cleaning) through bridge scuppers into Currituck Sound. According to FHWA research (Design of Bridge Deck Drainage, HEC 21, May 1993), stormwater from bridge scuppers that are 25 feet or greater above the ground has no erosive force. Instead, because of wind and other normal conditions encountered during rain and storm events, this water returns to a state similar to rain. For the bridge over Currituck Sound, the scupper height would be approximately 22 feet above the water. Therefore, impacts to SAV habitat (including existing beds) and potential

SAV habitat because of stormwater concentrations discharging from scuppers would be minimal. In addition, NCTA would ensure the stability of the sound is not affected by erosion as a result of stormwater discharge from scuppers by an annual inspection.

- Treatment of Existing Impervious Road Surface Where the Project Improves Those Roads. The water capture and treatment program proposed for the two bridges would result in an uncaptured bridge area of 24 acres on the bridge over Currituck Sound and 10 acres on the bridge over Maple Swamp. Stormwater in these areas would directly discharge into their receiving bodies; however, greater than 90 percent (possibly as high as 97.5 percent) of the pollutants would have already been removed (i.e., pre-treated) through frequent deck cleaning via sweeping and vacuuming.

  As indicated above, to the maximum extent practicable, all 33 acres of non-bridge additional impervious surface area, plus all 18 acres of existing roadway impervious surface area in the project's construction limits, would have the first 1.5 inches of runoff captured and either treated or used in the project site. The net effect of this approach would be to offset the 34 acres of uncaptured (yet greater than 90 percent treated) bridge area with the 18 acres of treatment for existing roadway impervious surface area. This results in a net of 16 acres of uncaptured (yet greater than 90 percent treated) new impervious surface area. Traditional bridge collection and stormwater wetland treatment systems are thought to achieve about 85 percent removal of Total Suspended Solids and 40 percent removal of Total Nitrogen and Total Phosphorus. This results in 15 to 60 percent of the pollutants being discharged into receiving waters even with treatment.

- Water Quality Monitoring and Research. A water quality monitoring program would be conducted as a part of bridge operations. It would monitor the effectiveness of the bridge deck cleaning program so adjustments to the program could be made as needed. The monitoring program would first establish (test) existing water quality levels, including turbidity levels. Research also could be supported for better understanding of the effect of bridge deck cleaning and/or the effect of bridge deck stormwater runoff on SAV habitat (including existing beds) and potential SAV habitat receiving waters.

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 SAFMC and MAFMC have defined several habitats to be EFH for managed species (SAFMC, 2008; MAFMC, 2008). In general, EFH areas affected by the Preferred Alternative include habitats and wetlands associated with Currituck Sound. There are no palustrine forested or emergent wetlands (that are considered EFH) that are affected by the Preferred Alternative. A list of EFH habitat types and their presence or absence in the project area is 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 in Currituck Sound within the Preferred Alternative bridge corridor, as well as within the DEIS C1 and C2 bridge corridors. The waters of Currituck Sound are classified as both estuarine water column and aquatic bed. Aquatic bed is broken down into confirmed SAV and various water depths and their potential for supporting SAV. Intertidal mudflats are irregularly present and variable, thus are unable to be accurately mapped.

Table 1. EFH Types Potentially 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 (Relict)
• 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.

Essential Fish Habitats

Figure 4

4.1.1 Submerged Aquatic Vegetation (SAV)

The shallow waters (6 feet deep or less) of Currituck Sound provide habitat and potential habitat for extensive beds of SAV. Habitat for SAV as defined by NCMFC is currently vegetated with one or more appropriate SAV species or has been vegetated by one or more species within the past 10 annual growing seasons, as well as meets the average growing conditions needed (water depth of 6 feet or less, average light availability [Secchi depth of one foot or more], and limited wave exposure).

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 roles include stabilization of sediment, nutrient cycling, reduction of wave energy, and provision of organic matter that supports complex food webs (North Carolina Wildlife Resources Commission [NCWRC], 2005). For these reasons, SAV habitat is considered Habitat Areas of Particular Concern (HAPC) for several managed fish species. The distribution and composition of SAV habitat is 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).

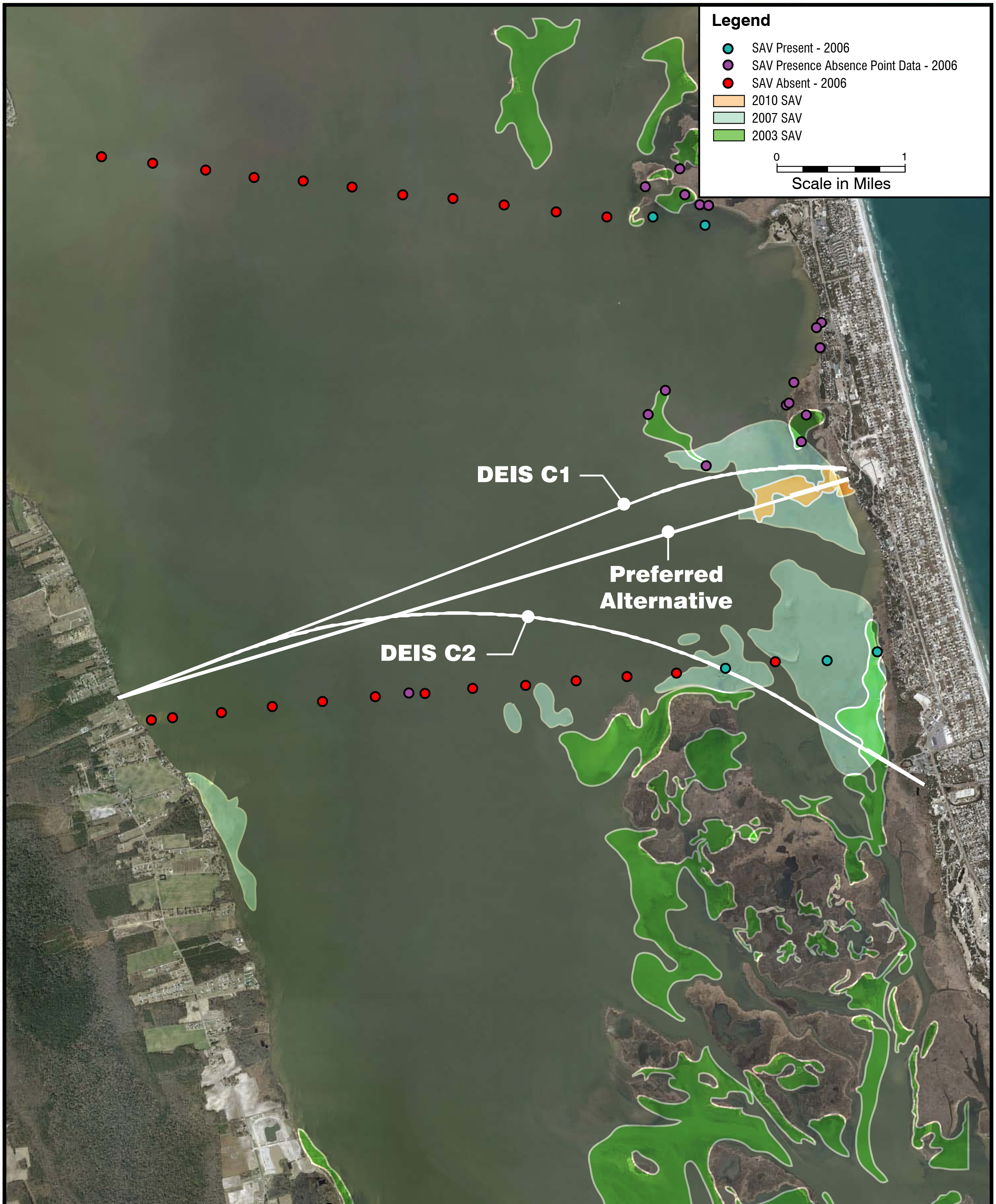
Species composition and biomass of SAV beds in Currituck Sound have varied greatly over the past 70 years (US Army Corps of Engineers [USACE], 2010; Davis and Brinson, 1983; Davis and Carey, 1981). The abundance of many native SAV species declined in the 1960s, likely a result of increased salinity and/or dredging, while Eurasian water milfoil (*Myriophyllum spicatum*) increased. In the late 1970s, SAV beds also decreased again. Possible causes for the decline were changes in salinity and inorganic nutrients, epiphytic growth and siltation on plants, and storms that increased turbidity and turbulence, and caused unusual temperatures and damage to plants (USACE, 2010). No exact cause for the decline could be determined, but it is likely a combination of the above factors.

The reduced amount of SAV beds has generally continued into this century with occasional scattered episodes of increased growth in localized areas (Deaton et al., 2010). Highly sensitive to changes in water quality, SAV is affected by weather, site conditions, and human activity (Deaton et al., 2010). The erosion of some marsh islands in the sound has increased the wind fetch, creating more wave energy that can re-suspend particles in the water, increasing turbidity (USACE, 2010). Recent trends indicate a decrease in Eurasian water milfoil and an increase in formerly more common, native species such as widgeon grass (*Ruppia maritima*) and wild celery (freshwater eelgrass) (*Vallisneria americana*) (USACE, 2010; Ferguson and Wood, 1994; Davis and Brinson, 1989). This trend mainly reflects a change in species composition, not necessarily an increase in abundance. Other submersed rooted vascular species occurring in the 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. Available data since 2000 (from 2003, 2006, 2007, and 2010) on the presence of SAV communities (existing and past beds) within the project area were compiled into one figure to show the historical extent of SAV communities (Figure 5).

Noble and Mohr (2008) conducted a SAV survey of Currituck Sound and Back Bay (southeastern Virginia) in 2006. They surveyed along transects established by earlier studies in the 1960s to compare historical data with current status and found a significant decline from historical numbers. One transect was located within the Mid-Currituck Bridge project area and showed existing SAV beds in the eastern portion of the sound, near areas that were found to have existing SAV beds in the following two surveys.

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

East Carolina University (ECU) conducted a survey for SAV in October 2010 in the revised C1 bridge corridor included in the Preferred Alternative (Luczkovich, 2010). The team used sonar and ground-truthing methods to systematically search for existing SAV beds along, and within 300 feet of, the revised C1 bridge corridor, which was a smaller survey area than the 2007 USACE survey. Significant stands of existing SAV beds with greater than 50 percent cover were found near the eastern landing of the bridge. The total area of existing SAV beds found in the eastern area of the proposed corridor was 48 acres, and it appeared the boundaries of the existing SAV beds in the area experienced a reduction since the 2007 USACE survey. However, it is not unusual for the edges of existing SAV beds to expand and contract annually. In the western portion of Currituck Sound, SAV was only found along the immediate western shoreline and coverage was estimated at less than 10 percent in an area less than 2 acres. Species of SAV found included freshwater eelgrass, widgeon grass, Eurasian water mil-foil, and sago pondweed.



SAV Data from 2003, 2006, 2007 and 2010

Figure

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

SAV Presence/Likelihood of Occurrence	Water Depth in Feet	Approximate Acreage in Project Area
• Confirmed existing SAV beds present	0.0 - 5.0[1]	710.9
• Probable SAV habitat[2]	< 4.0	1,129.0
• Potential SAV habitat	4.0 - 6.0	1,008.2
• Unsuitable SAV habitat	> 6.0	1,050.3
Total Open Waters of Currituck Sound		3,898.4

Source: USACE, 2007 and analysis of associated GIS data.

[1] Approximately 98 percent (697 acres) of existing SAV beds were found at water depths less than 4 feet. Approximately 2 percent (14 acres) of existing SAV beds were found at water depths between 4 and 5 feet.

[2] Includes Jean Guite Creek and other open water areas of Currituck Sound not included 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. Living oyster reefs are not known to occur in the sound because of low salinity levels (personal communication, Clay Caroon, NCDENR-DMF, May 7, 2008). The optimum salinity range for oysters is 10 to 30 parts per thousand (ppt) (NCDENR-DMF, 2001), which does not occur in the project area. In the recent survey by USACE, evidence of relict 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 near the project area is determined by local topography and tidal amplitude, which is primarily influenced by wind. These factors vary over time, resulting in a habitat that is irregularly present and variable, thus it is unable to be accurately mapped and to have impacts quantified.

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 wetland 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. Palustrine forested wetlands are irregularly flooded and used as foraging habitat by small fish and invertebrates and also provide a source of detritus and protection to other EFH areas.

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 primarily provided by riverine sources and transported via primarily wind influenced effects in addition to 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 3.1ppt and 1.7 ppt in 2006 and 2007, respectively (U.S. Geological Survey [USGS], 2009). Distinct zones within the water column can be defined by several parameters such as salinity, temperature, and dissolved oxygen. Water column zonation continually fluctuates 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 the upper reaches of streams which are used by marine and estuarine fishes and invertebrates during early development. Secondary nursery areas occur in the lower reaches of streams and bays. Nursery areas are designated and regulated by NCDENR-DMF and 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 typically 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 state-designated PNA within the project boundaries, but it would not be impacted by the Preferred Alternative. Jean Guite Creek drains into Kitty Hawk Bay, which is a state-designated Secondary Nursery Area approximately 3 miles south of the project area. In addition, portions of Currituck Sound function as a secondary nursery area for diadromous fish species (fish that use both marine and freshwater habitats) that utilize the area, but no state-designated Secondary Nursery Areas are crossed by the Preferred Alternative

4.2 Managed Species

4.2.1 SAFMC and MAFMC Managed Species

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 in 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

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	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 (*Penaeus* sp. and *Sicyonia* sp.)	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
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 MAFMC is located in the project area; however, black sea bass are included in the snapper grouper management unit under SAFMC.

[2] No EFH or HAPC designated for butterfish by 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.

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 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 (NCDENR-DMF, unpublished commercial fishing data, 1994 to 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. 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 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 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 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 (NCDENR-DMF, unpublished commercial fishing data, 1994 to 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 MAFMC. This species is not considered over-fished by 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. 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 (NCDENR-DMF, unpublished commercial fishing data, 1994 to 2008). No HAPC has been designated by 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. 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 MAFMC. This species is considered over-fished by MAFMC.

4.2.1.5 Penaeid and Rock Shrimp (Penaeus **sp.** *and Sicyonia* **sp.***)*

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 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 (NCDENR-DMF, 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 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 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 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 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.

4.2.1.7 Atlantic Spadefish (Chaetodipterus faber)

Atlantic spadefish are opportunistic bottom feeders found from Massachusetts to Brazil. They utilize a 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 (NCDENR-DMF, 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, Atlantic spadefish are considered part of the Snapper Grouper Management Unit by 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 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 SAFMC. The stock status of Atlantic spadefish in North Carolina has not been determined.

4.2.1.8 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 (NCDENR-DMF, 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 several other species, Spanish mackerel are considered part of the Coastal Migratory Pelagics Management Unit by 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 SAFMC. There are no HAPCs designated by SAFMC for Spanish mackerel near 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 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 NCDENR-DMF Managed Species

Under the Fisheries Reform Act of 1997 (FRA), NCDENR-DMF 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 (NCDENR-DMF, unpublished commercial fishing data, 1994 to 2008). Based on NCDENR-DMF 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 stressors to fish and EFH communities in Currituck Sound have occurred as a result of increased fishing pressure and natural and anthropogenic fluctuations in nutrient loading, turbidity, and salinity (USACE, 2010). The sound has become more saline since the late 1980s, and data from 1998 and 1999 suggest that there was a net inflow of salt into the sound (Caldwell, 2001). Data collected by Caldwell (2001) suggest 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 suggest 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 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 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 bottom disturbing fishing gear, construction of docks/piers/marinas, storms, shoreline erosion, dredging, boating, sedimentation, and runoff can create unfavorable conditions for SAV survival. The biomass and area of existing SAV beds has significantly declined from historical abundances (USACE, 2010; Deaton et al., 2010). Davis and Brinson (1983) suggested that the historic decline of existing SAV beds in Currituck Sound may have been the result of channel dredging associated with the Albemarle and Chesapeake Canal, which began in 1914. Additional declines of existing SAV beds in the 1960s were attributed to extensive dredging and filling in Back Bay, Virginia during 1963 (Sincock, 1966). Changes in water quality also contributed to the decline.

The North Carolina portion of the North Landing River was dredged in 1946 and again in 1965 with the spoil 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 deposited in shallow waters along the channel. The study concluded that erosion of the dredged materials has contributed to increased turbidity in

Currituck Sound, with possible negative effects on SAV habitat (including existing beds).

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 NCDEM 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.

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 stating "some of the highest values for suspended solids for the entire Albemarle-Pamlico estuarine system have been recorded in Currituck Sound." However, data collected by USGS show 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 affect permanently the turbidity of Currituck Sound.

5.1 Short-Term and Temporary Impacts

Mid-Currituck Bridge construction associated with the Preferred Alternative would take place over Currituck Sound. Bridge construction would include use of temporary work trestles and low draft barges to drive piles and add sections of bridge deck. Turbidity curtains and sediment shrouds would be used to confine turbidity impacts while driving piles in areas of SAV habitat (including existing beds) as defined by NCMFC and when necessary in potential SAV habitat areas of the sound 6 feet deep or less that have a suitable substrate. The over-water construction activities associated with the Preferred Alternative would produce noise, turbidity, and siltation, thereby creating localized, short-term impacts to EFH (including existing SAV beds, estuarine water column, aquatic beds, and oyster reefs and shell banks), as shown in Table 4.

The temporary effects of bridge pile placement and other bottom disturbance would include short-term increases 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). However, the Hanson report mostly documented activities in deep fresh waters in California, as well as some salt waters, in seismic conditions, and addressed large piles. The report

Table 4. Potential Impacts to EFH Resulting from the Preferred Alternative

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 (relict)[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.
• Aquatic bed (tidal freshwater)	Temporary turbidity and siltation	Shading; run-off from roadway; permanent loss of habitat from piles.
• Estuarine water column[3]	Temporary increase in turbidity, noise, and siltation; decline in dissolved oxygen	Shading; run-off from roadway; permanent loss of habitat from piles; and potential for degradation from turbidity and siltation.

[1]Also HAPC for summer flounder, 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 relict shell hash.
[3]Currituck Sound is also HAPC for Penaeid shrimp and red drum.

does state that noise from vibratory pile driving is less invasive than large impact hammers. In addition, many of the mobile organisms would be able to escape the area during construction. Also, an anticipated agency-required, bottom disturbing in-water work moratorium (from approximately February 15-September 30, with slight variations possible based on water temperatures) in SAV habitat should help reduce noise/vibration impacts from pile placement to listed species as well as other anadromous fish using SAV habitat for foraging. In addition, current plans include both impact and vibratory pile driving. Vibratory pile driving (when appropriate for the subsurface geology) results in less noise, thus reducing the effect on marine organisms.

At the ecosystem level, increased turbidity would result in a reduction in ecosystem productivity (i.e., ability of the system to produce and export energy) and nursery value by elimination of organisms that cannot readily move, and displacement of 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 could 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, but would likely return once construction ceased and pre-construction conditions returned. However, non-mobile shellfish, such as clams, could suffer long-term impacts from construction-related siltation if minimization techniques failed, or from direct impacts of pile driving. Benthic organisms are expected to recover rapidly after construction ceases, as most soft bottom benthic communities are resilient and likely to recolonize quickly after short-term impacts. If the habitat returned to favorable conditions, and favorable weather occurred, SAV habitat (including existing beds) affected by turbidity and siltation only would likely begin to recover within one growing season after construction (Ellis, 2009).

Bridge construction techniques would be evaluated during final design to determine the most appropriate technique for constructing structures in Currituck Sound. Final construction methods would be selected as part of the permitting process. Current proposals are described in Section 3.0. In addition, to minimize construction impacts to SAV by in-water work with the Preferred Alternative, NCTA would follow the following protocols to protect SAV habitat (including existing beds) and potential SAV habitat:

- No dredging in any part of Currituck Sound.
- No bottom disturbing in-water work in SAV habitat (including existing beds) during a moratorium period from February 15 to September 30, which may be adjusted based on water temperature. In-water work consists of bottom disturbing activities like temporary trestle pile placement and removal and driving permanent piles. Working above the water, including barge operations (non-bottom disturbing), installation and removal of temporary trestle beams and decking, and installation of Mid-Currituck Bridge pile caps, beams, and decking, would occur up to 365 days a year at the discretion of NCTA.
- Use of an open (i.e., beams only to support a crane) temporary construction trestle to minimize shading impacts while the trestle is in place. Marine industry standard pans would be placed under construction equipment operating on the open trestle to capture any accidental spills of oil and lubricants.
- The eastern side of the sound is the only location that includes SAV habitat (including existing beds) that meets NCMFC's criteria. In this area of the sound, NCTA would install temporary piling and temporary open work trestle for approximately 4,500 linear feet and would, outside of the moratorium dates, drive piles for both the permanent bridge and the temporary trestle within SAV habitat (including existing beds).
- In SAV habitat (including existing beds) as defined by NCMFC, as well as potential SAV habitat when necessary, turbidity curtains would be used during pile installation (permanent and temporary bridges) and pile removal (temporary bridge). Turbidity curtains would capture any silt from migrating outside the

curtain perimeter. These are common and proven turbidity control techniques. Pile installation would be performed both by vibratory and impact hammers, with no jetting of piles.

On the eastern side of Currituck Sound, limiting pile placement to times outside the moratorium period is expected to result in the following construction sequence over the SAV habitat (including existing beds) present there:

- Construction Season 1. The October 1 to February 14 non-moratorium window would allow installation of approximately 35 percent of both work trestle and permanent bridge pilings along with deck construction.

- Construction Seasons 2 and 3. During these two seasons, the remaining temporary work trestle and permanent bridge construction would be completed.

- Construction Season 4. During this season, the temporary work trestle would be removed/dismantled.

If surveys following construction operations reveal that additional permanent impacts to SAV beds have occurred, additional permanent impact mitigation would be provided using one or more of the options described in Section 5.2.4.

Minimization of potential impacts to potential SAV habitat (areas of the sound 6 feet deep or less that have a suitable substrate) would be accomplished through no dredging anywhere in Currituck Sound, use of turbidity curtains during pile installation when necessary, and by pile installation using both vibratory and impact hammers, with no jetting of piles.

There is no specific statute or regulation that designates or references the waters of Currituck Sound as subject to the construction moratorium noted above. However, there is a possibility that a moratorium could be imposed on the project related to bottom disturbing in-water work in SAV habitat (including existing beds), as defined by NCMFC, via a permit condition during the USACE Section 404 and CAMA permitting review processes. The only state-designated fish nursery/spawning area (primary, secondary, or anadromous spawning area) in the project area is Jean Guite Creek, which is a PNA, but it would not be affected by the Preferred Alternative.

Construction associated with the road widening portions could result in increased turbidity and sedimentation within Currituck Sound as a result of runoff from these construction areas. Runoff during and after construction could contain varying amounts of particulates, organic compounds, nutrients, and heavy metals, all of which could temporarily degrade water quality and impact aquatic organisms. However, these effects would cease after natural re-vegetation from the seed bank and surrounding vegetation, and these areas would be expected to return to previous conditions. Best Management Practices (BMPs) would be used to minimize sedimentation and 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 and permitting in coordination with environmental resource and regulatory agencies. The Preferred Alternative would result in no temporary impact to wetlands or coastal marsh (Coastal Area Management Act [CAMA] Areas of Environmental Concern [AEC]).

5.2 Permanent and Long-Term Impacts

Permanent loss or alteration of SAV habitat (including existing beds), subtidal and intertidal flats, and estuarine waters would result directly from shading in water 6 feet deep or less and pile placement associated with bridge construction across Currituck Sound with the Preferred Alternative. Direct impacts to EFH resulting from construction of the Preferred Alternative are presented in Table 5. Final EFH impacts would be determined during the final design of the alternative selected for implementation.

Based on the most recent SAV mapping (Luczkovich, 2010; USACE, 2007; Noble and Mohr, 2008; Hall, 2005), the C1 bridge corridor revised for the Preferred Alternative would shade less SAV habitat as defined by NCMFC (4.8 acres) than the original C1 (4.9 acres) or C2 corridors (6.5 acres), but would result in approximately the same amount of piling impact (0.1 acre of aquatic bottom habitat). In addition to permanent loss of habitat resulting from pile placement, the Preferred Alternative could generate several other 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.

The aquatic bed/substrate could be slow to recover, depending on the 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 permanently EFH, but runoff as described in Sections 5.1 and 5.2.1 could be a source of additional pollutants. These potential impacts to EFH resulting from the Preferred Alternative are presented in Table 4.

Although the proposed bridge construction and resulting bridge would alter existing EFH, for the reasons described below and in the conclusions section, substantial adverse impacts to EFH and managed species are unlikely to occur. There would be no dredging of Currituck Sound and bottom disturbing in-water construction activity would not occur during the established moratorium period in SAV habitat (including existing beds) as defined by NCMFC. Permanent impacts to water quality would be minimal as a result of the stormwater management plan described below. Existing patterns of water flow through Currituck Sound are expected to be minimally affected by the presence of bridge pilings, and the pilings could provide additional habitat for

Table 5. Permanent Impacts to Essential Fish Habitat Areas by the Preferred Alternative

Community[1]	Fill	Pilings	Shading	Clearing
Palustrine forested wetland (acres)	0.0	0.0	0.0	0.0
Palustrine emergent wetland (acres)	0.0	0.0	0.0	0.0
Aquatic bottom (tidal freshwater) (total[2]/≤6 feet) (acres)	0.0/0.0	0.1/0.0	27.8/8.7	0.0/0.0
TOTAL EFH IMPACT[3] (acres)	0.0	0.1	27.8	0.0
Primary nursery areas[4] (acres/linear feet)	0.0/0.0	0.0/0.0	0.0/0.0	0.0/0.0
SAV Communities				
• SAV beds (existing)[5] (acres)	0.0	0.0	3.8	0.0
• Areas <4 feet deep (potential SAV habitat) (acres)	0.0	0.0	2.0	0.0
• Areas 4 to 6 feet deep (potential SAV habitat) (acres)	0.0	0.0	2.9	0.0
• Areas >6 feet deep (unsuitable SAV habitat) (acres)	0.0	0.1	19.1	0.0
SAV Habitat[6] (acres)	0.0	0.0	4.8	0.0

[1]Communities that have not been mapped include intertidal flats and oyster reef/shell bank.
[2]Includes all SAV community sub-categories and is equivalent to estuarine water column (volume not calculated).
[3]Includes palustrine forested wetland, palustrine emergent wetland, and aquatic bottom.
[4]Jean Guite Creek is the only state-designated fish nursery/spawning area (primary, secondary, or anadromous spawning area) in the project area, but it is not crossed by the Preferred Alternative.
[5]Based on Luczkovich, 2010.
[6]SAV habitat as defined by NCMFC is currently vegetated with one or more appropriate SAV species, or has been vegetated by one or more species within the past 10 annual growing seasons, and meets the average growing conditions needed (water depth of 6 feet or less, average light availability [Secchi depth of 1 foot or more], and limited wave exposure). Available data for 2000 to 2010 is from 2003, 2006, 2007, and 2010 (see Figure 5).

some species. Shading would potentially affect the managed species in small areas of SAV habitat (including existing beds), subtidal and intertidal flats, and estuarine waters found in the project area, but shading impacts would be mitigated, likely with SAV habitat restoration in nearby areas.

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 water bodies 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 near 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 areas with better circulation.

The amount of runoff and associated impacts to water quality are dependent upon the method implemented to manage bridge runoff. NCTA would comply with NC Session Law 2008-11 (An Act to Provide for Improvements in the Management of Stormwater in the Coastal Counties in Order to Protect Water Quality) to the maximum extent practicable for the additional impervious surface area created by this project. The currently proposed stormwater management plan to minimize the impacts of bridge runoff is described in Section 3.3. The long-term consequences the bridge might contribute to the area near the bridge because of bridge run-off are not expected to be substantial, in part because of the implementation of that plan. A final stormwater management plan for minimizing the potential impact of project pollutants would be developed in association with NCDENR-DWQ, as well as other appropriate state and federal environmental resource and regulatory agencies, during final design and permitting of the Preferred Alternative.

5.2.2 Water Flow

The presence of bridge pilings is not anticipated 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). 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 by wind tides. 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 is 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 de-stratified upon flowing past the bridge, the effects were minimal a short distance away. The extent of pile-induced de-stratification varied with factors such as current direction and energy, but de-stratification 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 Preferred Alternative would affect SAV habitat (including existing beds), 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 habitat (including existing beds). In addition to macrophytes, shading could potentially reduce the high productivity and community of microalgal species that dominate non-vegetated areas such as subtidal and intertidal flats and tidal freshwater aquatic beds.

The height/width ratio of a bridge structure over marsh communities and SAV habitat is one indicator of the potential shading impacts of the structure to these communities. Based on the approximate 16-foot vertical clearance of the proposed Mid-Currituck Bridge over the water surface of Currituck Sound, as well as the proposed width of the structure of 47 feet, the height/width ratio of the bridge is 0.34. A study of the effects of shading on marsh communities (Broome et al., 2005) reported that no significant adverse effects to marsh productivity (i.e., above- and below-ground biomass of macrophytes and abundance of benthic invertebrates) resulted from bridges with a height/width ratio greater than 0.7. Based on the findings of this study, the 0.34 ratio with the proposed Mid-Currituck Bridge could indicate potential adverse affects with vegetation productivity under the bridge. Current design specifications for the proposed bridge propose a height/width ratio greater than 0.7 only for a small portion of the bridge within the raised portion at the location of the navigation span.

USACE dock and pier guidelines for Florida and Puerto Rico require a minimum height to width ratio of 1.25 (Shafer et al., 2008). Docks and piers adhering to that ratio or higher had more SAV growth under and near the structure than those with lower ratios. However, SAV was found under docks and piers with ratios less than that, although the amount of SAV was less than 30 percent. A few docks and piers in Puerto Rico had small amounts of SAV (less than 20 percent) growing under structures with an average ratio of 0.3, but docks and piers in Indian River Lagoon did not have any SAV growing under structures with an average ratio of 1.3.

The Jackson Marine Laboratory with the University of New Hampshire has developed a model/calculator to evaluate the potential effects of shade from structures over eelgrass (*Zostera marina*) communities (Short et al., 2009). Using this "dock eelgrass calculator," the Preferred Alternative design results in a value of 7, between a range of 0 (no suitable eelgrass habitat) and 9 (healthy eelgrass). Although this model was developed primarily for docks less than 6.8 feet in height and for a saline SAV species in New Hampshire, the model provides some insight to the tolerance of eelgrass based on the design of the Preferred Alternative, for conditions in New Hampshire. In North Carolina, eelgrass occurs primarily in lower turbidity, saline conditions compared to the primarily freshwater and more shade-tolerant species found in Currituck Sound. Application of this information suggests that the Preferred Alternative may not result in entirely unsuitable conditions for SAV habitat under the bridge.

Shading could affect managed species through habitat alteration and diminished vegetative growth near the proposed bridge 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 of some species 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. Thus, shading would potentially affect the managed species in small areas of SAV habitat (including existing beds), subtidal and intertidal flats, and estuarine waters found in the project area.

5.2.4 Discussion of Potential Long-Term Impacts

The changes in vegetative, sedimentary, and hydrologic features discussed in Sections 0 to 5.2.3 would affect EFH areas. However, it is difficult to assess the direct and indirect long-term impacts of these changes on EFH and managed species.

There are few studies on the biological impacts of inshore urban and/or bridge structures. 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 those 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 higher rates of predation. This issue is particularly important considering the presence of extensive SAV beds and HAPC for summer flounder, penaeid shrimp, 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 similar to 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 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. The Mid-Currituck Bridge would likely provide currently present species, such as sessile invertebrates, with additional habitat and may help to increase the populations of structure-oriented species already present within, or utilizing, the project area. The piles would not function as a typical reef in open water because of the shallow depths and low salinity.

While increasing habitat complexity, introduction of piles and associated loss of SAV habitat (including existing beds) 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 amount of larval fish found in freshwater SAV beds has been found to be 160 times higher than adjacent open water, and the fish were concentrated in the interior of the beds (Deaton et al., 2010). Deaton et al. (2010) also reported that clams, pink shrimp, and blue crab (all juveniles) were more abundant in large or continuous SAV beds. However, the opposite was true for adult pink shrimp and adult grass shrimp.

Impacts to SAV habitat (including existing beds) associated with the Preferred Alternative have been minimized via selection of the corridor across the sound and by construction techniques and timing. There appears to be an undetermined threshold for SAV area and density below which SAV survival is in jeopardy (Deaton et al., 2010). The edges of SAV beds are more vulnerable than the interior to disturbances and if more edges result from project construction activities and/or the completed project, existing SAV beds could become more vulnerable to disturbance (Shafer et al., 2008). However, SAV has been known to occur naturally as sparse, occasional individual plants outside of dense beds.

Growth of SAV is affected by salinity, wave exposure, nutrient concentrations, light, and turbidity. The project is not expected to impact salinity or wave exposure. Runoff could affect nutrient concentration and turbidity/light exposure. High nutrient concentrations could encourage nuisance algal growth, which could smother SAV and/or reduce light availability. However, increased nutrients are more of a concern in runoff from land, not from a bridge. Turbidity/light exposure could be affected by suspension in the water column of solids flushed from the bridge, and those solids could adhere to SAV surfaces or reduce the amount of light able to penetrate the water column to reach SAV leaves.

Shading impacts from the proposed bridge deck were discussed in Section 5.2.3. NCTA would mitigate permanent impacts to SAV habitat (including existing beds), as defined by NCMFC, resulting from Mid-Currituck Bridge shading and pile placement with the Preferred Alternative. Available options for this mitigation include:

- In-kind restoration in the project area at a suitable site at a 2:1 ratio (if feasible). This restoration activity would follow the currently adopted SAV protocols in North Carolina and best practices from recent successful SAV restoration efforts. These efforts could be performed by others such as Elizabeth City State University or East Carolina University.

- Efforts to improve conditions for SAV propagation and survival within Currituck Sound. This option would involve: protection and establishment of riparian buffers; contribution of funds to promote agricultural BMPs; stormwater management improvement projects; acquisition of properties identified as important for the protection of water quality (as reported in the November 2006 *Countywide Land Parcel Prioritization Strategy for Water Quality Enhancement*); and other measures that would reduce the turbidity of water in Currituck Sound.

- Support for SAV research.

- Participation in the Currituck Sound Ecosystem Restoration Project coordinated by USACE.

Efforts to improve conditions for SAV propagation and survival within Currituck Sound, support for SAV research, and participation in the Currituck Sound Ecosystem Restoration Project also are options for mitigating the shading of portions of Currituck Sound in potential SAV habitat (areas of the sound 6 feet deep or less that have a suitable substrate and do not meet NCMFC's definition of SAV habitat).

Regarding potential stormwater runoff impacts, the stormwater management plan proposed for the Preferred Alternative is described in Section 3.3.2. NCTA would comply with NC Session Law 2008-211 (An Act to Provide for Improvements in the Management of Stormwater in the Coastal Counties in Order to Protect Water Quality) to the maximum extent practicable for the additional impervious surface area created by this project. With regard to mitigation of potential impacts to SAV, the first 1.5 inches of stormwater runoff would be captured/treated from the eastern end of the Currituck Sound bridge for a distance of 4,000 feet to prevent direct discharge into the SAV habitat (including existing beds) areas along the eastern shore of the sound, the only location they occur. The runoff would be piped to the end of the bridge for treatment to either a stormwater wetland or a wet detention basin. Source control also would be used. Source control would be provided by frequent deck cleaning using state of the art, multi-function cleaning equipment that employs mechanical, vacuum, and regenerative air systems.

A final stormwater management plan for minimizing the potential impact of project pollutants would be developed in association with NCDENR-DWQ and other state and federal environmental resource and regulatory agencies during final design of the alternative selected for implementation and in the process of obtaining related permits.

Long-term change in bottom habitat is not anticipated from the proposed construction methods, except in the footprint of the pilings. However, the aquatic substrate could be slow to recover after temporary construction impacts, and long-term effects would vary depending on the characteristics of areas disturbed and resulting sediment composition. Fine sand sediments, such as those in Currituck Sound, typically recover from disturbance faster than other sediment types (Dernie et al., 2003). Dernie et al. (2003) also found that opportunistic benthic species did not rapidly recolonize impacted areas as expected. As a result of the variability at each site because of specific conditions, such as local weather and time of disturbance, as well as variability in other studies, it is difficult to predict the recovery of a benthic community at a given location (Dernie et al., 2003).

There has been some recent interest in the effects of bridges on aquatic systems by NCDOT. Preliminary investigations by NCDOT in 2010 and data from collections of benthic invertebrates associated with the Wright Memorial Bridge and Virginia Dare

Bridge did not detect substantial differences between areas under the influence of the bridge and nearby areas apparently not under the influence of and adjacent to the bridge (NCDOT, 2010 unpublished data; CZR, 2010).

5.3 Potential Impacts to Individual Species

Potential short-term and permanent/long-term impacts to EFH present in the project area are found in Table 4. Acreages of EFH impacts for the Preferred 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.

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 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 hard bottom; therefore, the proposed project could provide habitat for black sea bass.

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

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="8">Short-term displacement and habitat disturbance from noise, turbidity, and siltation.

Potential short-term direct mortality from construction in Currituck Sound.</td><td rowspan="8">Short-term displacement and habitat disturbance from noise, turbidity, and siltation.

Potential short-term direct mortality from construction in Currituck Sound.</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 (Penaeus sp.)</td><td>N/A</td></tr>
<tr><td>Bluefish (Pomatomus saltatrix)</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="7">Limited potential disruption of dispersion through Currituck Sound.

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

Decreased abundance of autotrophic and planktonic food sources as a result of lower light levels.</td><td colspan="2" rowspan="8">Permanent loss and/or alteration of foraging habitat and refuge from predators.

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

Potential attraction 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
(Penaeus sp.)</td><td>N/A</td></tr>
<tr><td>Bluefish
(Pomatomus saltatrix)</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.

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 from shore. Larvae and juveniles use estuaries as nurseries, and both life stages could be found near 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. Pile placement associated with the Preferred Alternative would affect an estimated 0.1 acre of aquatic bottom within Currituck Sound, and the bridge deck would permanently shade 4.8 acres of SAV habitat (including existing beds).

Summer flounder eggs are generally found in ocean waters and 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 (*Penaeus* sp.)

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. Pile placement associated with the Preferred Alternative would affect an estimated 0.1 acre of aquatic bottom within Currituck Sound, and the bridge deck would permanently shade 4.8 acres of SAV habitat (including existing beds).

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 egg 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 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, because of the rarity of this species in the area, disruption of larval transport likely would be minimal. The bridge 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.

5.3.7 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 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 near the bridge structure as discussed in Sections 5.1 and 5.2.

5.3.8 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, because of 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.

5.3.9 Additional Species

The State of North Carolina has developed, 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 flounder are addressed above. Potential impacts to red drum, kingfish, river herring, striped bass, hard clams, bay scallops, oysters, blue crabs, and striped mullet are addressed below.

The red drum is an estuarine-dependent species with important foraging areas in Currituck Sound. As adults and subadults, red drum is commonly found in the sound. Typically, red drum arrives in Currituck Sound in late April, with a second peak in abundance during fall as fish begin migrating south from the Mid-Atlantic states. 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 enters Currituck Sound as free-swimming juveniles. While they are bottom feeders that favor structure and could be attracted to bridge pilings, the Mid-Currituck Bridge could adversely affect adult life stages if there is a permanent decrease in the abundance of benthic invertebrate food resources near the bridge.

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 Currituck Sound may be used by spawning fish, no state-designated Anadromous Fish Spawning Areas (AFSA) would be crossed by the Preferred Alternative. 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. Open water and marsh communities are habitat for hard clams and impacts to these habitats resulting from the Mid-Currituck Bridge are described in Section 5.2. (The Preferred Alternative does not directly affect marsh.) Potential short-term disturbance and permanent loss of some benthic habitat for hard clams 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.

Salinity levels in Currituck Sound are too low to support oysters and bay scallops and their occurrence in the project area is extremely unlikely. Thus, impacts to these particular 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 near 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.

Species that managed species feed on, such as minnows, silversides, killifish, perch, and anchovy, could also be affected by the project for many of the same reasons their predators might be affected. Forage species utilize SAV habitat (including existing beds) for many reasons and if SAV habitat is reduced or eliminated, forage species might experience a decline in population or move to other areas to find more suitable habitat. If SAV habitat recovered quickly, and there was enough of a source population, the forage species would also be able to recover quickly after construction. Increased turbidity and siltation would impede the forage species' ability to evade predators and limit their ability to function normally. This also would likely be a temporary impact.

6.0 Findings and Conclusion

6.1 Findings

The Preferred Alternative would avoid sound-fringing wetlands at both the mainland and Outer Banks landing sites. Permanent loss or alteration of SAV habitat (including existing beds), intertidal flats, and tidal freshwater aquatic bed would result directly from shading and/or pile placement. Permanent loss from pile impacts to EFH would total 0.1 acre. The bridge would shade 3.8 acres of existing SAV beds present in 2010, as defined by NCMFC, and 4.8 acres of SAV habitat (including the 3.8 acres of existing beds). It would also shade an additional 4.9 acres of potential SAV habitat based on water depth of 6 feet or less (see Table 5).

The presence of the bridge and pile placement could result in potential permanent impacts, including changes to light levels, habitat structure, and water quality of the area associated with the bridge. The effect on water flow would be minimal and insignificant. 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. The Mid-Currituck Bridge would likely provide currently present species, such as sessile invertebrates, with additional habitat and may help to increase the populations of structure-oriented species already present within, or utilizing, the project area. The piles would not function as a typical reef in open water because of the shallow depths and low salinity. 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.

The temporary effects to EFH of bridge pile placement and other bottom disturbance 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, 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 temporary construction impacts persist and adverse affects would vary depending on areas disturbed and post-construction sediment composition. Construction activities associated with permanent drainage easements and road-widening for the Preferred Alternative 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 (e.g., silt fences), thus greatly reducing runoff (and associated increases in turbidity and sedimentation) into EFH areas. Turbidity and siltation would be minimized for in-water work with the planned use of turbidity curtains and shrouds in SAV habitat (including existing beds) as defined by NCMFC, as well as potential SAV habitat when necessary. Also, piles would be driven, not jetted, which is more precise and generates less disturbance than jetting. Finally, no in-water work (bottom-disturbing activities) in SAV habitat (including existing beds) would occur from approximately February 15 through September 30 as a result of an anticipated agency-required moratorium.

6.2 Conclusion

The Preferred Alternative likely would result in short-term and possibly long-term adverse effects to EFH and managed species, but measures under consideration would keep those impacts to a minimum. Consequently, the Preferred Alternative would not have a *substantia*l long-term adverse impact on EFH or managed species for the following reasons:

- Pile impacts resulting in the permanent loss of EFH would be 0.1 acre. In addition, there would be no impacts to EFH from fill or clearing activities.

- A Mid-Currituck Bridge would shade a total of 27.8 acres of aquatic bottom in Currituck Sound, but this area includes only 3.8 acres of existing SAV beds, as defined by NCMFC, and 4.8 acres of SAV habitat (including the 3.8 acres of existing beds) (see Table 5). It would also shade an additional 4.9 acres of potential SAV habitat based on water depth of 6 feet or less. However, most of the shading would occur over deeper waters (greater than 6 feet), 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. Mitigation is planned for shading impacts (see Section 5.2.4). Possible forms of mitigation include: coordination of NCTA efforts with the Currituck Sound Ecosystem Restoration Project led by USACE Wilmington District; in-kind restoration of SAV habitat in the project area by planting SAV (at a 2:1 ratio) and/or improvement of habitat; and restoration, enhancement, or preservation of aquatic and terrestrial wetland and upland habitats adjacent to the sound which function as buffers that help to filter pollutants from runoff before they enter the sound. The most likely mitigation that NCTA would pursue for shading impacts to SAV habitat (including existing beds) is SAV restoration.

  Options for mitigating the shading of portions of Currituck Sound in potential SAV habitat (areas of the sound 6 feet deep or less that have a suitable substrate and do not meet NCMFC's definition of SAV habitat) and buffer restoration/enhancement/ preservation include efforts to improve conditions for SAV propagation and survival within Currituck Sound, support for SAV research, and participation in the Currituck Sound Ecosystem Restoration Project.

- 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 in primarily bottom disturbance and associated re-suspension 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. Currently planned construction techniques for the Mid-Currituck Bridge as a whole are described in Section 3.0. Specific plans to minimize construction impact in SAV habitat (including existing beds) are described in Section 5.1.

The Mid-Currituck Bridge would introduce a new source of pollution (via bridge runoff) into Currituck Sound. Pollutants discharged into Currituck Sound near the bridge may dissipate slowly because of poor water circulation and could result in higher sediment pollutant levels and bioaccumulation near the bridge. The components of the currently proposed stormwater management plan are presented in Section 3.3. NCTA would comply with NC Session Law 2008-211 (An Act to Provide for Improvements in the Management of Stormwater in the Coastal Counties in Order to Protect Water Quality) to the maximum extent practicable for the additional impervious surface area that would be created by the construction of the Preferred Alternative if it is selected for implementation.

Final construction and stormwater management plans for minimizing impacts to EFH would be developed in association with appropriate state and federal environmental resource and regulatory agencies during final design and permitting of the Preferred Alternative.

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.* NC 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*. US Fish and Wildlife Service FWS/OBS-79/31, Washington, D.C.

CZR Incorporated. 2010. *Taxonomic Identification and General Evaluation of Aquatic Macroinvertebrate Samples associated with: Virginia Dare Bridge - Croatan Sound, Wright Memorial Bridge - Currituck Sound, and Proposed Mid Currituck Bridge Alignments - Currituck Sound*. Prepared for: URS Corporation and the NC Department of Transportation.

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.

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

Dernie, K.M, M.J, Kaiser, and R.M. Warwick. 2003. "Recovery rates of benthic communities following physical disturbance." *Journal of Animal Ecology*. 72: 1043-1056.

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.

Ellis, B.O. 2009. "Year Five (Final) Submersed Aquatic Vegetation Survey, Currituck Sound, Whalehead Bay-Currituck Heritage Park." Memorandum to John Hennessy, Environmental Supervisor, National Park Service, Assistance and Compliance Oversight Unit.

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.

Hawkins, A. 2005. "Assessing the Impact of Pile-Driving Upon Fish," Chapter 2 of *Proceedings of the International Conference on Ecology and Transportation.* Available: http://www.icoet.net/ICOET_2005/05proceedings_directory.asp.

Hall, K. June 2005. "SAV Habitat from Duck to Corolla," map. Elizabeth City State University, Department of Geological, Environmental, and Marine Sciences, Remote Sensing Program.

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.

Luczkovich, J.J. 2010. *Survey of the Submerged Aquatic Vegetation in the Proposed Alignment for the Mid-Currituck Bridge*. A report to the North Carolina Turnpike Authority.

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, Florida.

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, Maryland.

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, Maryland.

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.

North Carolina Coastal Land Trust. November 2006. *Countywide Land Parcel Prioritization Strategy for Water Quality Enhancement, Currituck County, North Carolina*. Prepared for the North Carolina Clean Water Management Fund, North Carolina Coastal Federation, and North Carolina Coastal Land Trust.

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 NC Department of Environment and Natural Resources, Division of Water Quality). Unpublished Report.

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

Noble, E.B and K.A. Mohr. 2008. *Currituck Sound Restoration Project Submerged Aquatic Vegetation Transect Field Surveys in Currituck Sound, North Carolina and Back Bay, Virginia*. Elizabeth City State University, Marine Environmental Science Program.

Parsons Brinckerhoff. 2009. *Alternatives Screening 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.

Shafer, D.J., J Karazsia, L. Carrubba, C. Martin. 2008. *Evaluation of Regulatory Guidelines to Minimize Impacts to Seagrasses from Single-Family Residential Dock Structures in Florida and Puerto Rico.* US Army Corps of Engineers Document ERCD/EL TR-08-41.

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. 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, North Carolina. 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.

Sutherland, Roger C. PE. July 2008. *Real World Street Cleaner Pickup Performance Testing.* Pacific Water Resources, Inc.,

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

US Army Corps of Engineers. 2010. *Currituck Sound, North Carolina Ecosystem Restoration Feasibility Study, Feasibility Scoping Meeting Report*. Available: http://www.saw.usace.army.mil/Currituck/FSM/Currituck%20Sound%20FSM%20Report_February%202010_FINAL.pdf.

US Department of Transportation. 2003. *Woodrow Wilson Bridge Project Shortnose Sturgeon Biological Assessment Supplement*. Prepared by Potomac Crossing Consultants, Alexandria, Virginia, for the Federal Highway Administration, Baltimore, Maryland.

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

7.2 Personal Communications

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

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

Short, F.T., Burdick, B.M., and Moore, G.E. 2009. Impacts of Marine Docks on Eelgrass in New England: A Spreadsheet-Based Model. Jackson Estuarine Laboratory. University of New Hampshire. Available: http://marine.unh.edu/jel/faculty/fred2/seagrass-tools.htm. Accessed: February, 2011.

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. 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.