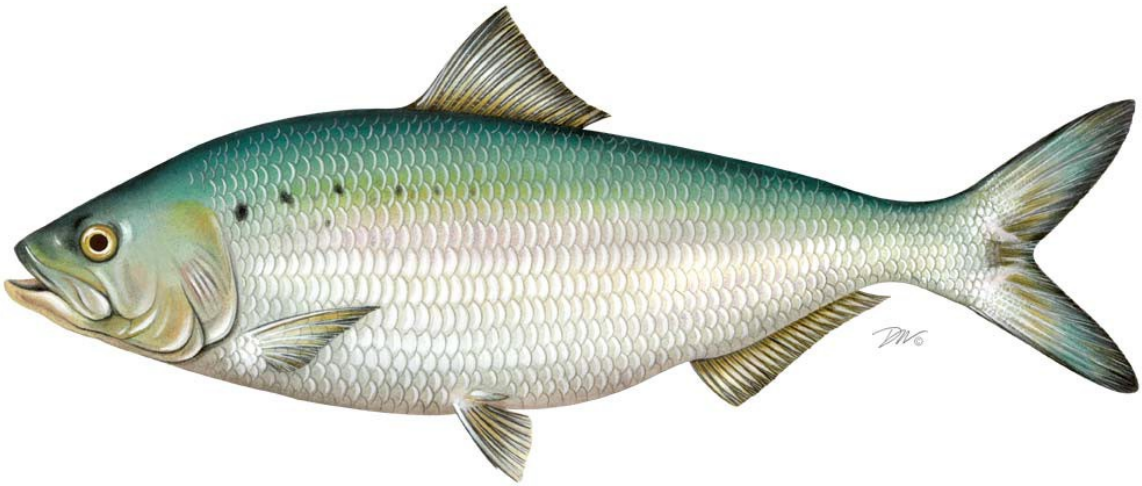
American Shad Habitat Plan for North Carolina



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Submitted to the Atlantic States Marine Fisheries Commission as a requirement of Amendment 3 to the Interstate Management Plan for Shad and River Herring

Approved February 2021

NORTH CAROLINA AMERICAN SHAD HABITAT PLAN

North Carolina Division of Marine Fisheries
North Carolina Wildlife Resources Commission

January 2021

Update Approved: February 2021

Introduction

Amendment 3 to the Atlantic States Marine Fisheries Commission (ASMFC) Interstate Fishery Management Plan required all states and jurisdictions to develop an Implementation Plan, which consists of two components: 1) a Sustainable Fishery Plan (for jurisdictions wishing to keep fisheries open) and 2) a Habitat Plan. The requirement for a Habitat Plan was in recognition of the fact that much of the decline in American shad stocks along the Atlantic coast is related to degradation of spawning and juvenile habitat from anthropogenic impacts such as upland development, stormwater runoff, and sewer discharges, as well as barriers to migration from dam construction and culverts. Restoration, protection, and enhancement of American shad habitat is a key component of rebuilding populations of this species to levels that will support their ecological, economic, and cultural roles.

The purpose of the Habitat Plan is to collate information regarding the status of and threats to American shad spawning, nursery, and juvenile habitats specific to a particular state or jurisdiction, and to develop restoration programs to address such threats. This document serves as North Carolina's American Shad Habitat Plan and as detailed below, draws heavily upon existing documents and efforts.

North Carolina Coastal Habitat Protection Plan (CHPP)

In recognition of the fact that protecting habitat was equally as important as preventing overfishing, the North Carolina General Assembly passed the Fisheries Reform Act in 1997. This law established the requirement to develop a Coastal Habitat Protection Plan (CHPP) to protect and enhance important coastal fisheries habitats. It also contains a directive to three major rulemaking commissions (Environmental Management, Coastal Resources and Marine Fisheries) to cooperate in the development and implementation of the plan. The NC Division of Marine Fisheries (NCDMF) and the Albemarle-Pamlico National Estuary Partnership (APNEP) were charged with writing the plan and serve as lead agencies within the NC Department of Environmental Quality (NCDEQ).

The initial version of the CHPP, approved by all three commissions in December 2004, detailed the status, trends and threats to six major fisheries habitats: the water column, submerged aquatic vegetation, wetlands, shell bottom, soft bottom and ocean hard bottom (Street et al 2005). The CHPP is reviewed and updated on a five-year schedule. The first review of the CHPP began in 2009, and the updated plan was published in 2010 (Deaton et al 2010). The last update was completed in 2016 (NCDEQ 2016) and the 2021 update is currently underway. Similar to the previous versions, the 2016 CHPP includes four overarching goals for protection of coastal fish habitat.

1) Improve effectiveness of existing rules and programs protecting coastal fish habitats
2) Identify and delineate strategic coastal habitats
3) Enhance habitat and protect it from physical impacts
4) Enhance and protect water quality

Because of the breadth and depth of data and information contained in the document, both state and federal agency staff have come to rely on the CHPP as a resource. Recommendations from the CHPP have been incorporated into several programs within state government as funding priorities.

To minimize duplication, the NC American Shad Habitat Plan (hereafter "Habitat Plan") relies heavily upon the extensive body of information and recommendations contained within the 2016 CHPP. As such, various sections of the CHPP are referred to in the sections of the Habitat Plan for more detailed and specific information. Because the 2016 CHPP is 475 pages (including appendices), it is not included as an appendix to this Habitat Plan. Individual chapters of the 2016 CHPP as well as the two year Implementation Plans can be found on the CHPP website (http://portal.ncdenr.org/web/mf/habitat/chpp/07-2020-chpp), and all documents related to Strategic Habitat Areas (referred to in the Habitat Assessment below) can be found on the Strategic Habitat Areas website (http://portal.ncdenr.org/web/mf/habitat/SHAs).

Previous versions of the CHPP have been accompanied by two year implementation plans. However, to improve efficacy of implementation, the 2021 CHPP update will focus on a five key priority habitat issues.

1. Environmental Rule Compliance to Protect Habitat
2. Habitat Monitoring to Assess Status and Regulatory Effectiveness
3. Submerged Aquatic Vegetation Protection and Restoration, with Focus on Water Quality Improvements
4. Wetland Protection and Enhancement, with Focus on Nature-Based Methods
5. Reducing Inflow and Infiltration associated with Wastewater Infrastructure to Improve Coastal Water Quality

Objectives and recommendations will be restructured to be actionable, with a focus on policy and rule development as needed. Non-regulatory measures can also be highly effective, given enough staff and monetary resources. Because the source document is comprehensive and remains relevant, it will be selectively updated as needed to support priority issues.

The Habitat Plan follows the suggested outline contained in Amendment 3, consisting of a Habitat Assessment, Threats Assessment, and Habitat Restoration Program.

Section 1: Habitat Assessment

American Shad Spawning and Nursery Area Habitat

American shad are an anadromous, pelagic, highly migratory schooling species (Colette and Klein-MacPhee 2002). They utilize a variety of habitats with variations in habitat preference due to location, season, and ontogenetic stage.

American shad are found in most habitats identified by the CHPP including water column, wetlands, submerged aquatic vegetation (SAV), soft bottom, hard bottom, and shell bottom. Each habitat is part of a larger habitat mosaic, which plays a vital role in the overall productivity and health of the coastal ecosystem. Although American shad are found in all of these habitats, the usage varies by habitat. Additionally, these habitats provide the appropriate physicochemical and biological conditions necessary to maintain and enhance the American shad population. Limburg and Waldman (2009) have shown that the loss of habitat contributes to the decline in anadromous fish stocks throughout the world. Therefore, the protection of each habitat type is critical to the sustainability of the American shad stock.

American shad ascend most coastal rivers in North Carolina (Figure 1). American shad are most abundant in the Roanoke, Chowan, Tar-Pamlico, Neuse, Northeast Cape Fear, and Cape Fear rivers as well as Albemarle and Pamlico sounds (Street *et al*. 1975; Marshall 1976a;

Sholar 1977; Fischer 1980; Hawkins 1980a; Hawkins 1980b; Johnson *et al*. 1981; Winslow *et al*. 1983; Winslow *et al*. 1985).

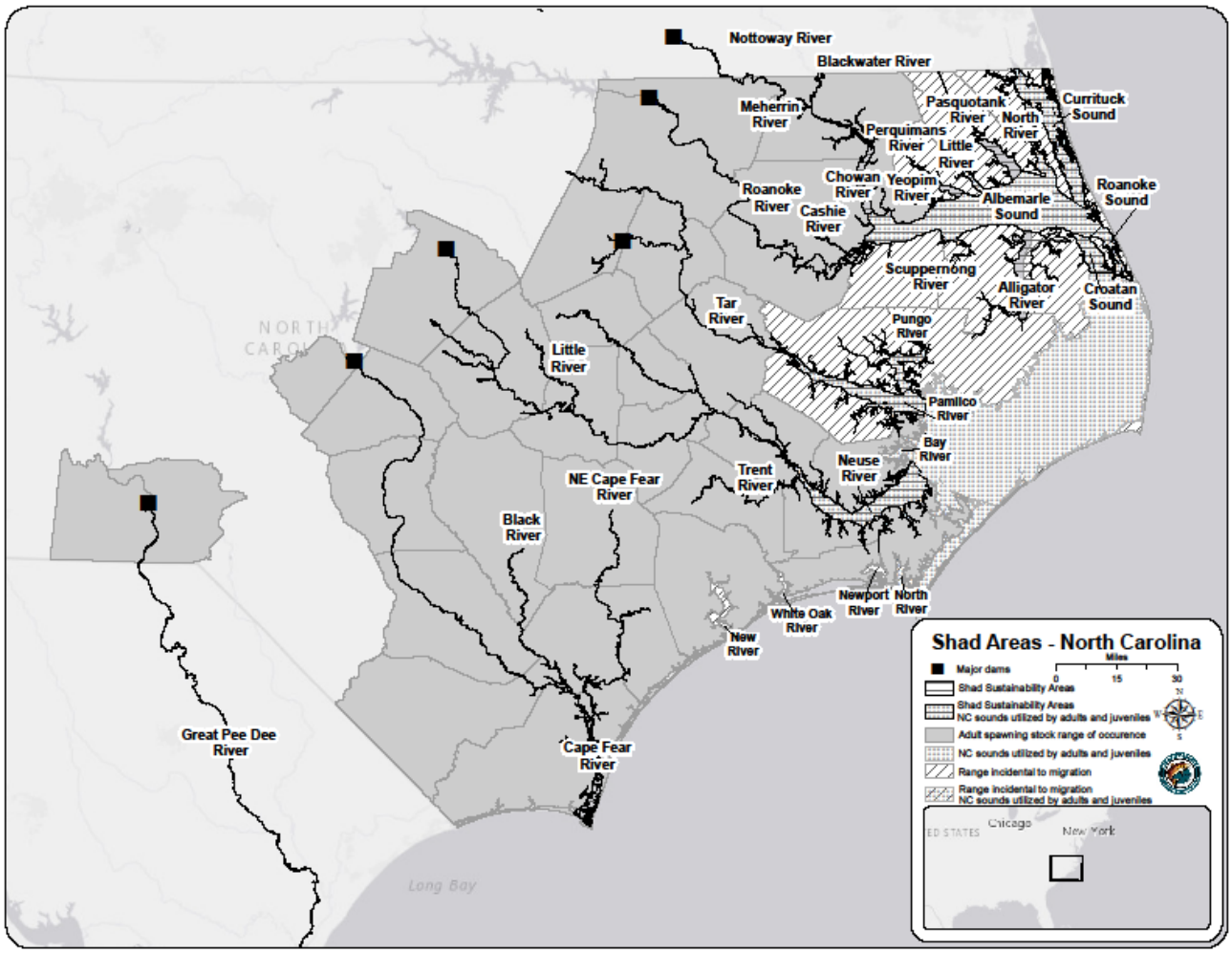

Figure 1. North Carolina river systems depicting the extent of American shad occurrence and habitat use.

The NCDMF conducted American shad spawning area surveys between 1973 and 1984 in the major coastal tributaries. Physical characteristics of the spawning grounds vary somewhat between systems. Shad may spawn anywhere within a given spawning area but prefer shallow flats composed of sand, gravel, or a combination of the two bordering the rivers (Smith 1907; Walburg and Nichols 1967; Beasley and Hightower 2000; Hightower and Sparks 2003). Water conditions may vary from clear to very turbid, water depth ranges from 3 to 30 ft, and temperatures may range from 8 to 26°C (Walburg and Nichols 1967; Winslow 1990).
Shad eggs are non-adhesive and slightly heavier than water, so they gradually sink and are carried along by currents (Ulrich *et al*. 1979). Sufficient water current is required to keep eggs suspended in the water column for successful development (Cheek 1968; Sholar 1977). Current velocity, increasing light and temperature are all important cues for anadromous spawning activity (Klauda et al. 1991; Orth and White 1993). Successful spawning of American shad coincides with water velocities between 2 and 3 ft/s (61-91 cm/s) (Fay et al. 1983; Mackenzie et

al. 1985; Hill et al. 1989). This requirement may explain why American shad spawning was found only in the Nottoway, Blackwater, Meherrin, Roanoke, Tar, Neuse and Cape Fear rivers, all of which have relatively strong currents compared to other coastal rivers in the state. During their spawning migration, anadromous fish actively avoid waters with low dissolved oxygen and extremely high turbidity (Steel 1991). All American shad spawning areas have been documented either by capture of eggs or larvae, or direct observation of spawning.

Nursery habitat for anadromous fishes is generally downstream from spawning locations but still within the freshwater low-salinity system. Juvenile American shad use the same general nursery areas as river herring, but the young shad prefer deeper pools away from the shoreline and occasionally move into shallow riffles (Funderburk et al. 1991). During summer, juvenile shad migrate from the bottom during the day to the surface at night (Loesch and Kriete 1984). A decrease in temperature during the fall and slight increases in river flow seem to trigger downstream movement of American shad (Funderburk et al. 1991). Nursery area surveys conducted by NCDMF noted decreased catch of juvenile shad in October on the Cape Fear River, Neuse River, and Albemarle Sound (Winslow 1990).

Albemarle Sound

The Albemarle Sound area includes Albemarle Sound, all of its tributaries, Currituck, Roanoke, and Croatan sounds, and all of their tributaries. The Albemarle Sound, including the tributaries, occupies more than 212,055 hectares (ha) of open water as well as extensive bordering swamps in northeastern North Carolina (Figure 1). The Albemarle Sound measures 88.5 km long by 4.8 to 22.5 kilometers (km) wide. Shoals generally extend 0.8 km from shore, sloping to a central basin 5.5 to 7.6 meters (m) depth. The bottom consists mostly of sand in the central basin with some mud and detritus on the shoals. The shoreline in eastern Albemarle Sound consists mostly of cypress swamps and a few small beaches, while beaches and low bluffs become more frequent to the west (Street *et al.* 1975). Croatan and Roanoke sounds are estuarine with salinities ranging from 1 part per thousand (ppt) to 28 ppt, depending on tide, wind, and rainfall. Salinities of 2 to 4 ppt sometimes occurred in eastern Albemarle Sound, while salinities of 1 to 2 ppt were occasionally recorded from the downstream portions of the North, Pasquotank, Alligator, and Little Rivers. North, Pasquotank, and Alligator Rivers and eastern Albemarle Sound serve as channels of the Atlantic Intracoastal Waterway (Street *et al.* 1975).

Currituck Sound joins the Albemarle Sound from the northeast, and Croatan and Roanoke sounds join from the southeast. Ten rivers drain into Albemarle Sound, which joins Pamlico Sound through Croatan and Roanoke sounds, and in turn, empties into the Atlantic Ocean via Oregon Inlet. Most of the rivers originate in coastal swamps and do not function as spawning areas for American shad. Moving across the Albemarle Sound drainage rivers from east to west, the North River joins the Albemarle Sound from the northeast. The North River originates in coastal swamps and occupies about 6,475 ha and is about 34 km in length (Baker and Smith 1965, as cited by Street *et al.* 1975, p. 7). The Pasquotank River, covering about 13,468 ha, is the main southern outlet for the Great Dismal Swamp, and is about 64 km in length (Baker and Smith 1965, as cited by Street *et al.* 1975, p. 7). The Little River originates in the Great Dismal Swamp, occupies about 2,849 ha, and flows approximately 30.6 km south to the Albemarle Sound (Baker and Smith 1965, as cited by Street *et al.* 1975, p. 8). The Perquimans River also originates in the Great Dismal Swamp and flows approximately 50 km to the Albemarle Sound and occupies about 5,180 ha (Baker and Smith 1965, as cited by Street *et al.* 1975, p. 8). The Yeopim River (including Yeopim Creek) originates in local swamps and is about 16 km long and occupies approximately 1,554 ha (Baker and Smith 1965, as cited by Street *et al.* 1975, p. 8). The Roanoke and Chowan Rivers are the principal tributaries of the Albemarle Sound, and areas of these rivers are known to function as American shad spawning areas (Street *et al.*

1975; Johnson *et al.* 1981; Winslow *et al*. 1983; Winslow *et al.* 1985; Hightower and Sparks 2003).

Chowan River
Chowan River occupies approximately 15,540 ha and extends 80.5 km from the North Carolina-Virginia border to the Albemarle Sound. Three rivers drain into the Chowan River: Meherrin, Nottoway, and Blackwater. The Meherrin and Nottoway rivers are the major tributaries of the Chowan and begin in the Piedmont Plateau of Virginia (Smith 1963, as cited by Street *et al.* 1975, p. 8). The Blackwater River, a smaller tributary, originates as a coastal plain swamp in Prince George County, Virginia (VDGIF 2019). All three rivers function as a spawning area for American shad.

Roanoke River (including Cashie River)
The Roanoke River and Cashie River join the Albemarle Sound from the west, via a shared delta. The Cashie River originates in local swamps, occupies approximately 777 ha, and flows 48.3 km to enter the Albemarle Sound (Carnes 1965, as cited by Street *et al.* 1975, p. 8). The Roanoke River flows 220.5 km from the Roanoke Rapids Dam (Roanoke Rapids, North Carolina) to the Albemarle Sound. The river begins in the foothills of Virginia's Blue Ridge Mountains and crosses the Fall Line just below Roanoke Rapids Dam (Carnes 1965, as cited by Street *et al.* 1975, p. 9). Near the North Carolina-Virginia border, John H. Kerr Reservoir, Lake Gaston, and Roanoke Rapids Lake impound the Roanoke River. The U.S. Army Corps of Engineers (USACE) and Dominion Energy operate these reservoirs for flood control and hydropower generation. A dam was constructed in 1955 on the River at Roanoke Rapids, North Carolina, 220.6 km (137 miles) from the mouth (Carnes 1965). This dam does not have facilities for fish passage and is therefore the upper limit of migration. Recent studies have shown that American shad accumulate in the Roanoke Rapids, NC and Weldon, NC areas, and newly-spawned American shad eggs have been collected there (Knutzen 1997; Hightower and Sparks 2003; Kornegay and Thomas 2004; Harris and Hightower 2007). Downstream of Roanoke Rapids Lake, flows in the Roanoke River are highly regulated by discharges from the dams. From the Roanoke Rapids Dam, the Roanoke River flows 221 km (137 miles) through an expansive area of bottomland hardwood wetlands to its confluence with Albemarle Sound. Major tributaries of this lower section of the Roanoke River include Broad Creek, Devil's Gut, Broad Neck Swamp, Conoho Neck Swamp, and the Cashie River.

Tar-Pamlico River
The Tar-Pamlico watershed is the fourth largest in North Carolina encompassing 14,090 square km (5,440 square miles). From its headwaters in Person County, the Tar-Pamlico watershed is drained by 3,790 km (2,355 miles) of tributaries along its 290 km (180 mile) main-channel length to Pamlico Sound near the confluence of the Pungo River (NCDWQ 1999; Figure 1). The river reach upstream of the City of Washington is designated as the Tar River and is primarily freshwater, while the reach below Washington, referred to as the Pamlico River, has characteristics of an upper estuary. Sixteen counties and six large municipalities (Greenville, Henderson, Oxford, Rocky Mount, Tarboro, and Washington) are represented within the basin. Major tributaries to the river include Fishing, Swift, and Tranters creeks, Cokey Swamp, and the Pungo River. Main stem headwater reaches, and tributaries are located within the outer piedmont physiographic region and are characterized by low flows during dry seasons due to minimal groundwater discharge (NCDWQ 1999). However, since the majority of the basin is located within the coastal plain, these waters are largely characterized by slow flowing, low gradient, brown and blackwater streams with extensive floodplains often comprised of bottomland hardwood forests and marshes.

From its headwaters in the North Carolina Piedmont the Tar River flows 288 km in a southeasterly direction before emptying into the Pamlico River at sea level. The Tar River drainage basin is approximately 802,893 ha. The principal tributaries of the Tar River, as it is ascended, are Tranters Creek, Town Creek, Fishing Creek, and Swift Creek. The Pamlico River is actually a continuation of the Tar River with the name change occurring at the US 17 bridge near Washington, North Carolina. It flows southeasterly about 53 km and empties into the Pamlico Sound about 51 km west of Ocracoke Inlet. The Pamlico River drainage basin is approximately 315,967 ha. The principal tributaries of the Pamlico River, in addition to the Tar River, include Pungo River, Rose Bay, Swanquarter Bay, Juniper Bay, Chocowinity Bay, Broad Creek, Bath Creek, Blount Creek, Durham Creek, North Creek, Goose Creek, South Creek, and Upper Goose Creek (Marshall 1976b).

Neuse River

The Neuse River is formed by the confluence of the Eno and Flat Rivers in the Piedmont region of North Carolina and flows in a southeasterly direction through the coastal lowlands discharging into Pamlico Sound 430 km from its origin (Hawkins 1980b; McMahon and Lloyd 1995; Figure 1). It resides entirely in North Carolina and has a drainage area of 1,449,869 ha. of land (Hawkins 1980b; McMahon and Lloyd 1995). The river flows in a southeasterly direction from its origin to below New Bern where it bends to flow in an easterly direction to the Pamlico Sound. Bay River, West Bay, and a portion of the western Pamlico Sound, and Core Sound from Ocracoke Inlet to Drum Inlet are also included in the basin (Marshall 1977).

The Neuse River and its tributaries drain all or a portion of 18 counties. The upper third of the river lies in the Piedmont Region of the state with the fall line occurring halfway between Raleigh and Smithfield, North Carolina. Flow regimes in the Neuse River downstream of Raleigh, North Carolina are regulated by Falls Lake Dam (rkm 370), which was built in 1983 by the USACE to create an impoundment for flood control, water supply, water quality, and recreational purposes. Spawning of American shad has been documented in the main stem Neuse River up to the first dam near Raleigh and in several tributaries: Contentnea Creek, Mill Creek, Little River, Swift Creek, and Crabtree Creek (Burdick and Hightower 2006). Principal tributaries of the Neuse River as it is ascended from its mouth to New Bern are: Broad Creek, Turnagain Bay, South River, Smith and Greens Creek at Oriental, Adams Creek, Dawson Creek, Clubfoot Creek, Hancock Creek, Beards Creek, Slocum Creek, Goose Creek, Upper Broad Creek, and the largest tributary, Trent River. The Trent River is quite large and has an important tributary, Brice Creek. All of these tributaries lie within 55 km of the mouth of the river and are within 93 km of Ocracoke Inlet. Between New Bern and Goldsboro, the principal tributaries are Bachelor Creek, Swift Creek, Cove Creek, and Contentnea Creek. These creeks are all within 103 km of the mouth, and Contentnea Creek at river mile 103 is the last major tributary until Little River is reached near Goldsboro, NC (rkm 261). Further upstream tributaries include: Thoroughfare Swamp, Mill Creek, Black Creek, Swift Creek, Marks Creek, Walnut Creek, Crabtree Creek, Perry Creek, and Smiths Creek. All other tributaries are located upstream of Falls Lake Dam, which represents the uppermost limit of American shad migration in the Neuse River Basin.

Cape Fear River

The Cape Fear River, the largest river system in the state, forms at the confluence of the Deep and Haw rivers in the Piedmont region of North Carolina and flows southeasterly for approximately 274 km to the City of Wilmington and from there, 40 km south to discharge into the Atlantic Ocean at Cape Fear, near Southport, North Carolina (Fischer 1980; Figure 1). The main river drainage area encompasses an area of 15,708 sq km with an additional 7,988 sq km included in the drainage areas of the Deep and Haw Rivers. It is the largest river basin lying completely within the state of North Carolina. The basin includes portions of 27 counties and

114 municipalities, and encompasses 9,984 km of freshwater streams and rivers, 36 lakes and reservoirs, and 15,864 ha of estuarine waters (NCDWQ 1995). The Cape Fear River has five major tributaries: Upper Little River, Lower Little River, Rockfish Creek, Black River, and Northeast Cape Fear River, which is the largest of the tributaries. The major tributaries which feed the Cape Fear River are dark, acidic, swamp-drainage streams; however, the waters of the Cape Fear River itself are usually very turbid (Fischer 1980).

Three navigational dams and locks were built between 1913 and 1934. The dams prevented fish from ascending the river above except during boat lockages or periods of high water. Although the dams were provided with fish ladders, anadromous fishes did not use them (Davis and Cheek 1967, as cited by Fischer 1980) and were prevented from accessing historic spawning habitat around Smiley Falls (rkm 290) and further upstream. However, through an agreement among NC Wildlife Resources Commission (NCWRC), USACE, and US Fish and Wildlife Service, fish are locked upstream through all three locks during the spawning run of anadromous fishes in the spring (Nichols and Louder 1970, as cited by Fischer 1980). In 2012, a rock arch fishway was constructed at the base of Lock and Dam 1 (rkm 97) to provide continuous, volitional fish passage, and USACE halted locking operations for fish passage at Lock and Dam 1 after the fishway was completed. Buckhorn Dam (rkm 316) prevents further migrations to potential upstream spawning habitat except during extreme flood events.

Pee Dee River

The Yadkin-Pee Dee River basin is the second largest basin in North Carolina and covers approximately 7,213 square miles in 21 counties (NCDWQ 2008). The Yadkin River originates in the Blue Ridge Mountains in Caldwell and Wilkes counties and flows through the Piedmont region until being joined by the Uwharrie River to form the Pee Dee River. The Pee Dee River continues its southeast course through North and South Carolina to Winyah Bay at the Atlantic Ocean. Other major tributaries in North Carolina, from downstream to upstream, include the Waccamaw River, Lumber River, and Rocky River. The Yadkin-Pee Dee River is heavily impacted by dams, and the most downstream dam, Blewett Falls Dam (rkm 303), prevents upstream migrations of American Shad. Prior to dam construction in the basin, American Shad were recorded as far upstream as Wilkesboro, NC (rkm 725; Stevenson 1897). Approximately 25 km of American Shad spawning habitat is located in the North Carolina portion of the Pee Dee River downstream of Blewett Falls Dam, while the remaining spawning habitat is in South Carolina. The Yadkin Pee Dee River is not covered in the CHPP because all waters in the North Carolina portion of the basin are designated as inland waters and are not under NCDMF jurisdiction.

Other Coastal Rivers

The North River (Carteret County), Newport River, White Oak River and New River are small coastal rivers located in southeastern North Carolina. These rivers are not presently known as American shad spawning or nursery habitat areas, but historical data has been collected on some (White Oak River and New River) that documents the presence on American shad.

Habitat Designations

There are several different designations used in North Carolina that identify, delineate, and designate functionally important habitat areas. Some of the key designations for anadromous species are nursery areas, anadromous fish spawning areas and strategic habitat areas. These designations are presented below and discussed in the 2016 CHPP.

Nursery areas: Those areas in which for reasons such as food, cover, bottom type, salinity, temperature and other factors, young finfish and crustaceans spend the major portion of their initial growing season [NCMFC rule 15A NCAC 03N .0102 (a)].

Primary nursery area (PNA): Those areas of the estuarine system where initial post-larval development takes place. These areas are located in the uppermost sections of a system where populations are uniformly very early juveniles [NCMFC rule 15A NCAC 03N .0102 (b)].

Secondary nursery areas (SNA): Those areas of the estuarine system where later juvenile development takes place. Populations are usually composed of developing sub-adults of similar size which have migrated from upstream primary nursery areas to the secondary nursery area located in the middle portion of the estuarine system [NCMFC rule 15A NCAC 03N .0102 (c)].

[Inland] primary nursery areas (IPNA): Those [inland] areas inhabited by the embryonic, larval, or juvenile life stages of marine or estuarine fish or crustacean species due to favorable physical, chemical or biological factors [NCWRC rule 15A NCAC 10C.0502].

Anadromous fish spawning areas (AFSA): Those areas where evidence of spawning of anadromous fish has been documented by direct observation of spawning, capture of running ripe females, or capture of eggs or early larvae [NCMFC rule 15A NCAC 03I .0101 (b) (20) (C)].

Anadromous fish nursery areas: Those areas in the riverine and estuarine systems utilized by post-larvae and later juvenile anadromous fish [NCMFC rule 15A NCAC 03I .0101 (b) (20) (D)].

Anadromous Fish Spawning Areas (AFSAs). Anadromous fish spawning areas are defined in NCMFC rule 15A NCAC 03N .0106 and NCWRC rule 15A 10C .0602 as those areas where evidence of spawning of anadromous fish has been documented through direct observation of spawning, capture of running ripe females or capture of eggs or early larvae. The areas are delineated in NCMFC rule 15A NCAC 03R .0115 and NCWRC rule 15A 10C .0603 (Figures 2-5). Anadromous fish spawning areas cover 17% of streams/shorelines and 10% of water bodies in coastal plain portions of CHPP regions. Most AFSAs (70%) are in CHPP Region 1-Albemarle and include the mainstem Roanoke River the Chowan River, and other smaller tributaries.

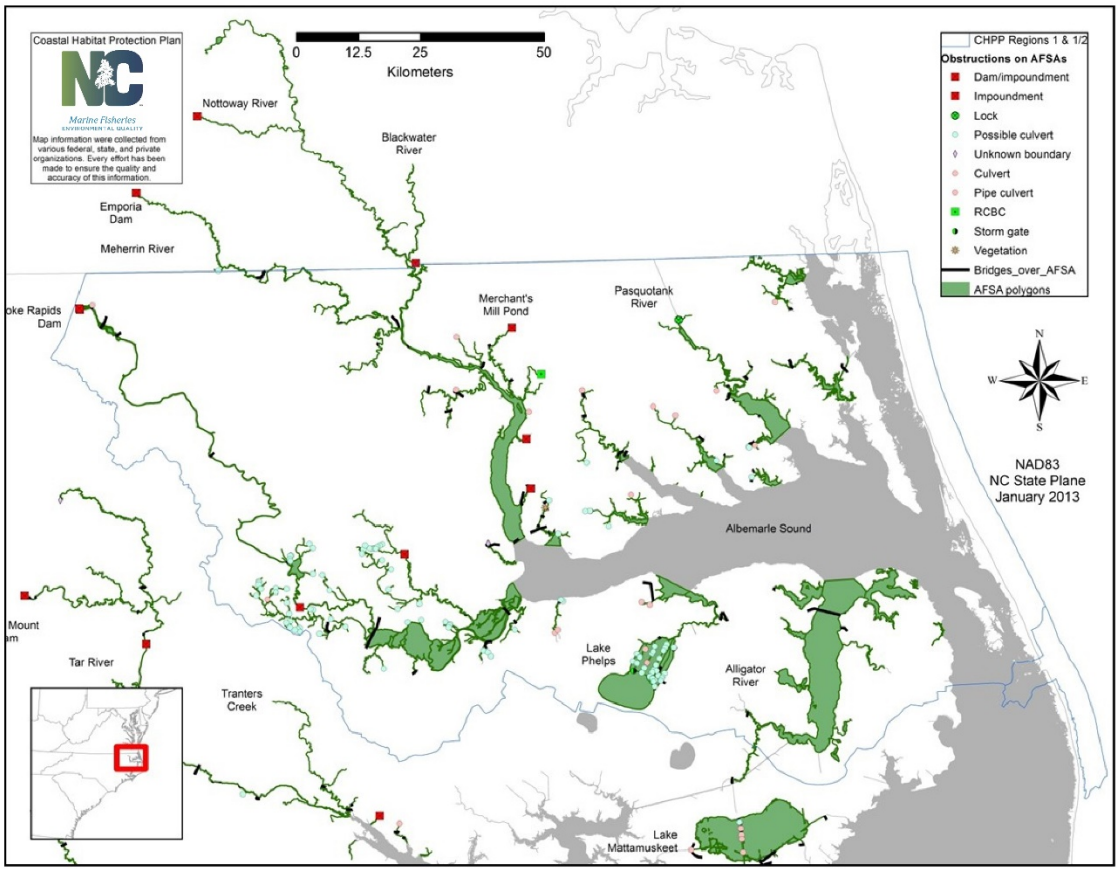

Figure 2. Anadromous fish spawning areas for CHPP Region 1-Albemarle (Albemarle, Currituck, and Roanoke sounds) and Region 1/2 (Oregon Inlet).

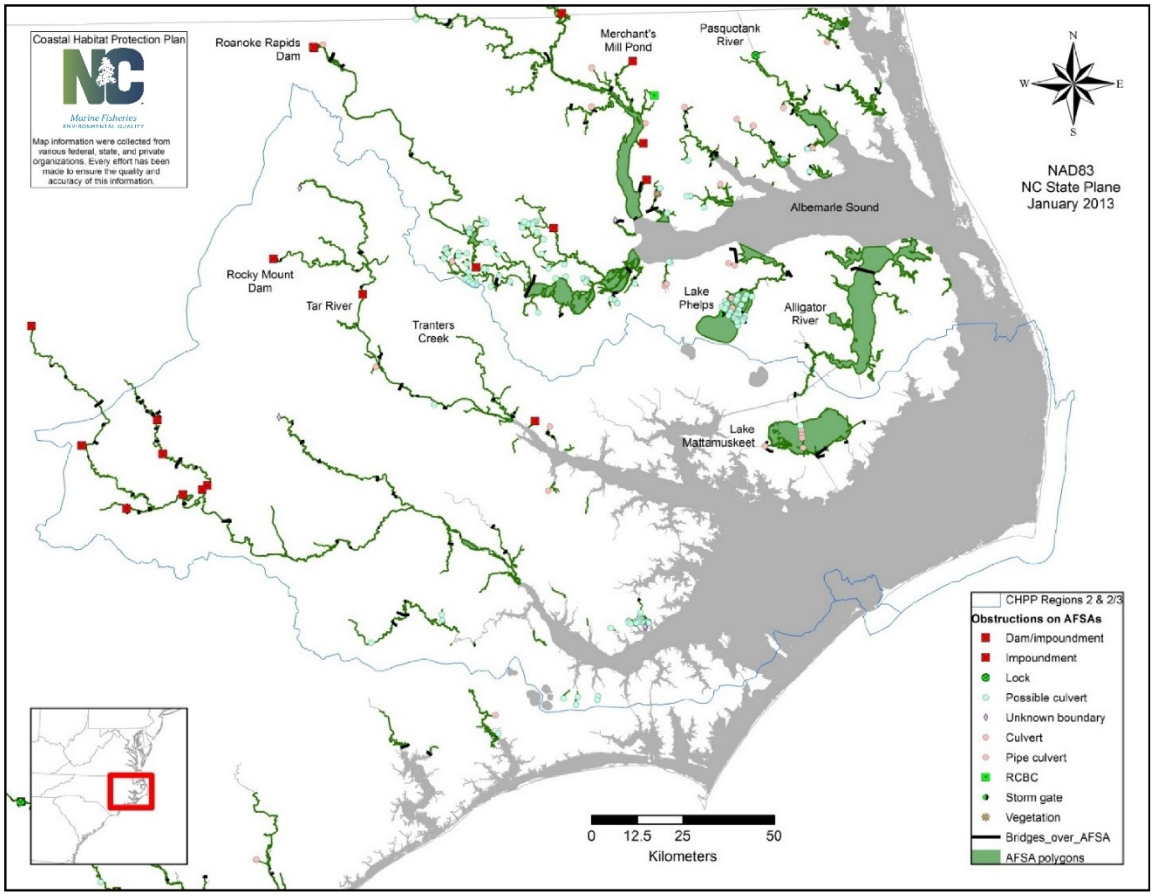

Figure 3. Anadromous fish spawning areas for CHPP Region 2-Pamlico (Pamlico Sound; Neuse and Tar-Pamlico rivers) and Region 2/3 (Ocracoke Inlet).

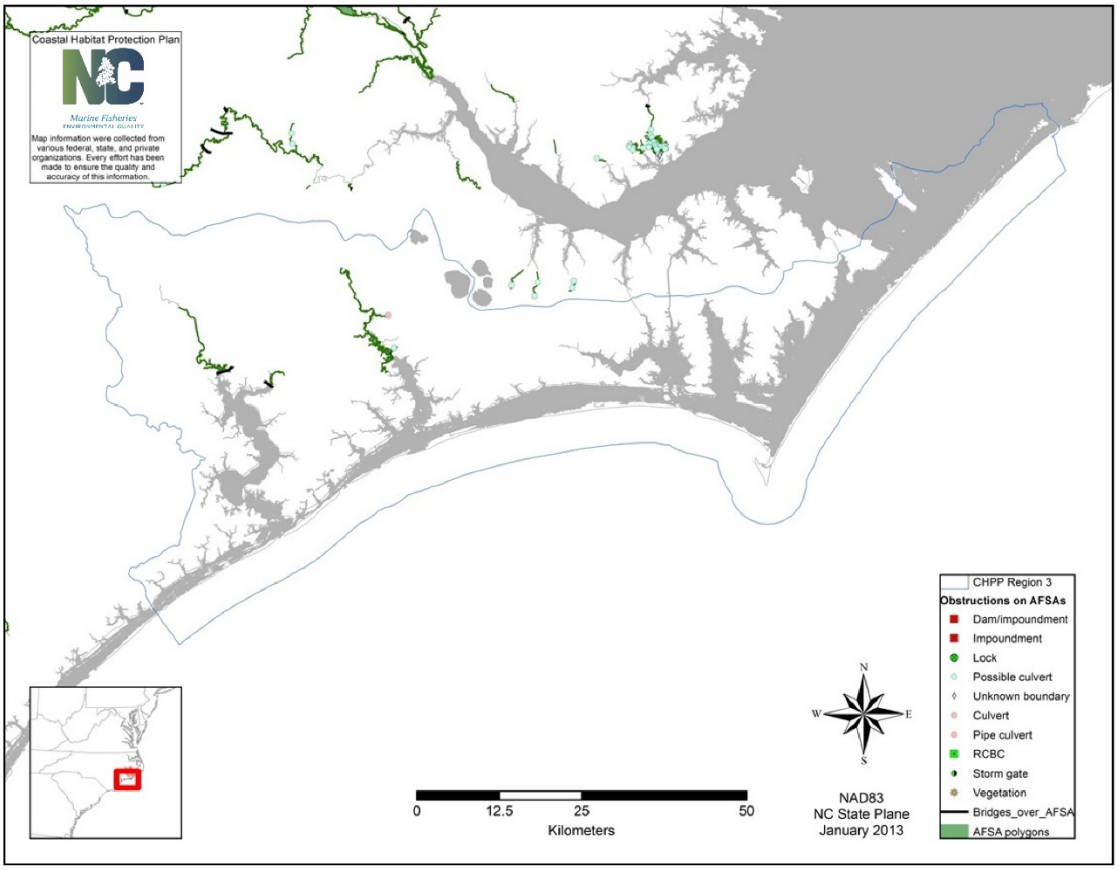

Figure 4. Anadromous fish spawning areas for CHPP Region 3-Core-Bogue (Core, Bogue, Stump Sounds; New and White Oak Rivers)

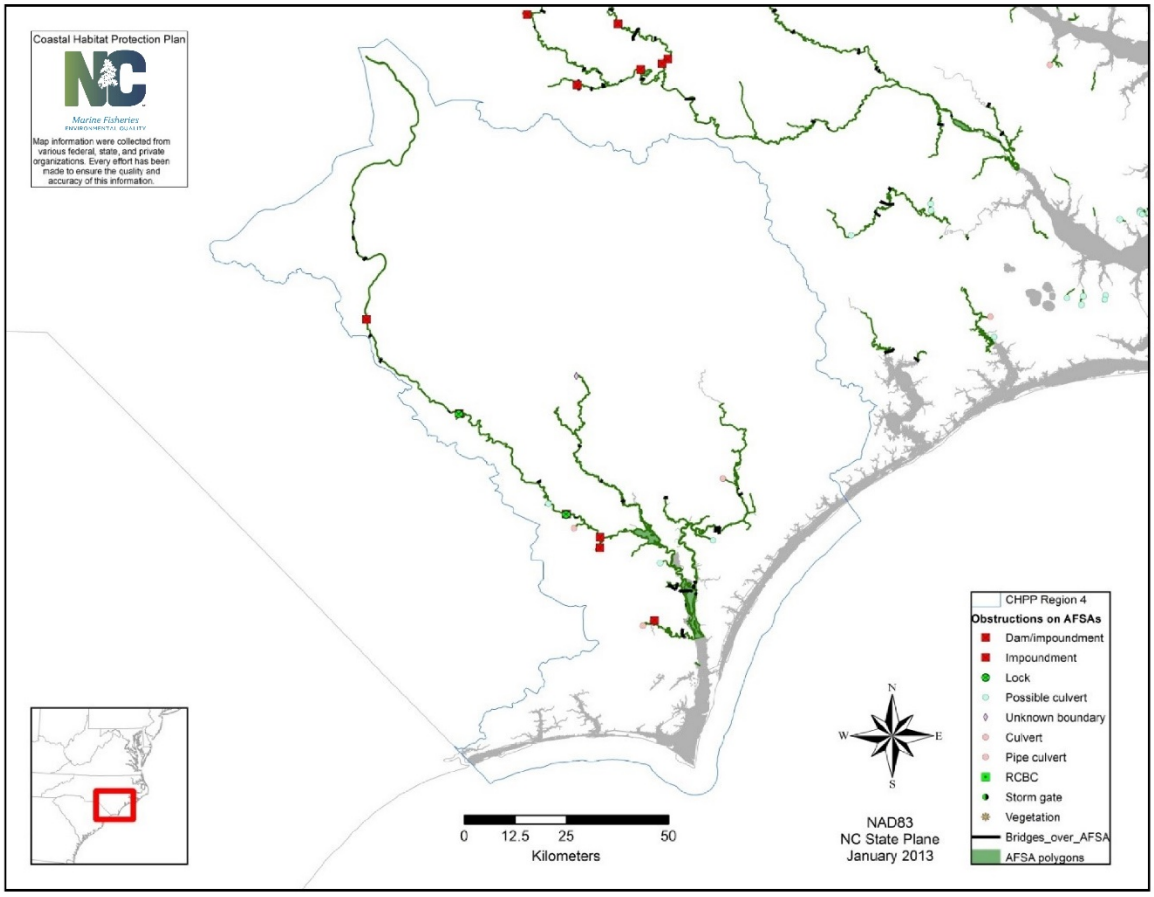

Figure 5. Anadromous fish spawning areas for CHPP Region 4-Cape Fear (Cape Fear River; tidal creeks and sounds, Northeast Cape Fear River, and Black River).

Nursery Areas

North Carolina Primary Nursery Areas, first designated by the NC Marine Fisheries Commission (NCMFC) in 1977, are similar in concept to Federal Habitat Areas of Particular Concern (HPAC). The NCMFC and NCWRC have designated tens of thousands of acres as nursery areas in North Carolina (see below). The state designations are well accepted by the various state and federal regulatory and permitting agencies, as well as by the public.

The NCMFC and NCWRC have designated nursery areas since 1977 and 1990, respectively, based on field sampling (Figures 6 and 7). Approximately 162,000 acres of Coastal Fishing Waters are currently designated by the NCMFC as Primary, Secondary, and Special Secondary Nursery Areas. About 10,000 acres of Inland Fishing Waters in the coastal area are designated as Inland Primary Nursery Areas (IPNA), as well as the following areas of the four main rivers draining to North Carolina's coast:

- Roanoke River, U.S. 258 bridge to Roanoke Rapids Dam (35.5 stream miles, 57.1 km)
- Tar-Pamlico River, railroad bridge at Washington to Rocky Mount Mill Dam (90.2 stream miles, 145.2 km)
- Neuse River, Pitchkettle Creek to Milburnie Dam (160.6 stream miles, 258.4 km)
- Cape Fear River, Lock and Dam #1 to Buckhorn Dam (126.7 stream miles, 203.9 km).

There are specific protections for designated nursery areas included in the rules of the NC

Environmental Management, Coastal Resources and Marine Fisheries commissions. There are relatively few primary nursery areas (PNA) in the Albemarle/Roanoke region, but a relatively large number of IPNAs. There are approximately 162,000 acres of PNA and secondary nursery area (SNA) in North Carolina Coastal Fishing Waters (including both water and wetlands).

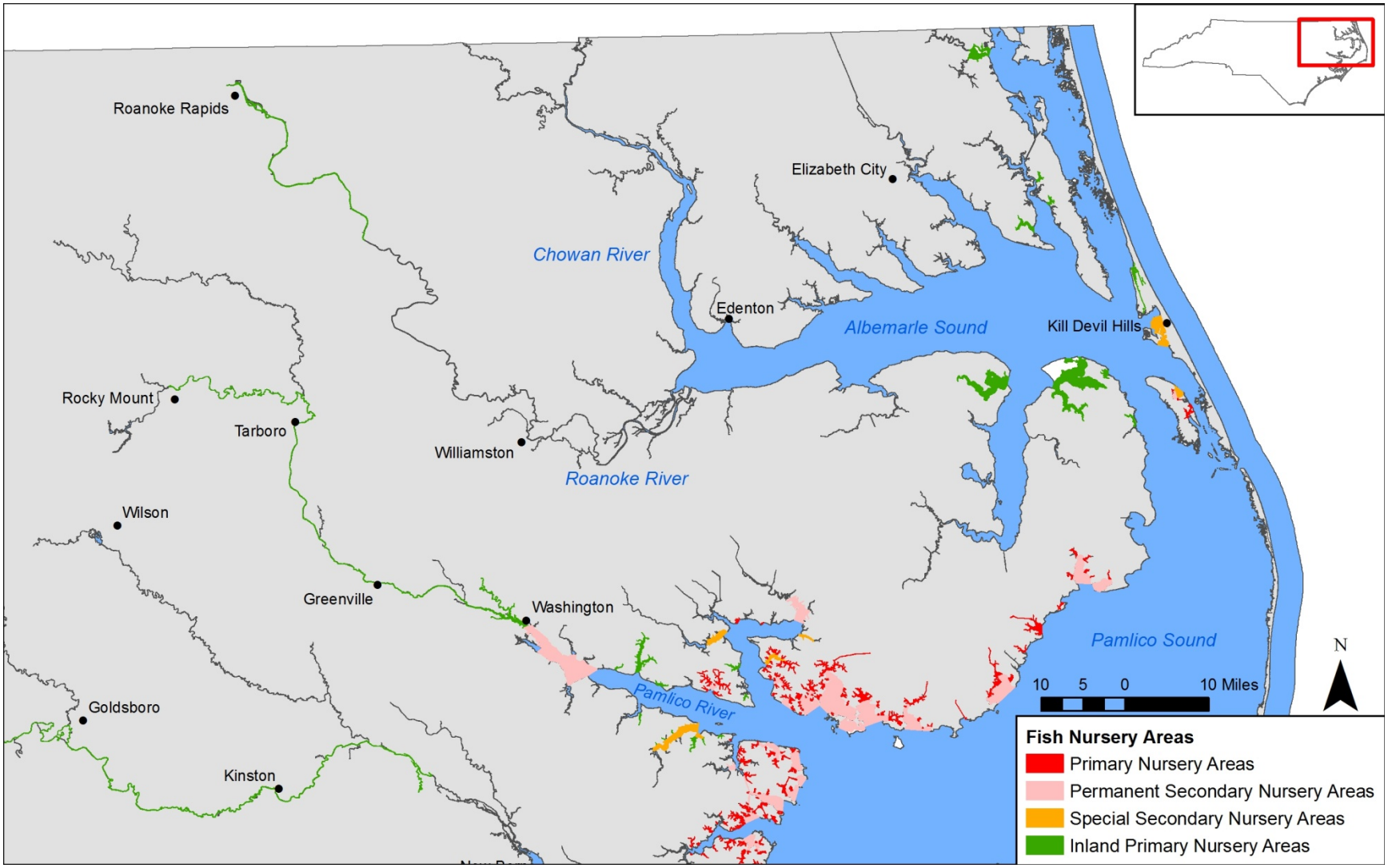

Figure 6. Nursery area designations in the Albemarle Sound and Tar-Pamlico River areas.

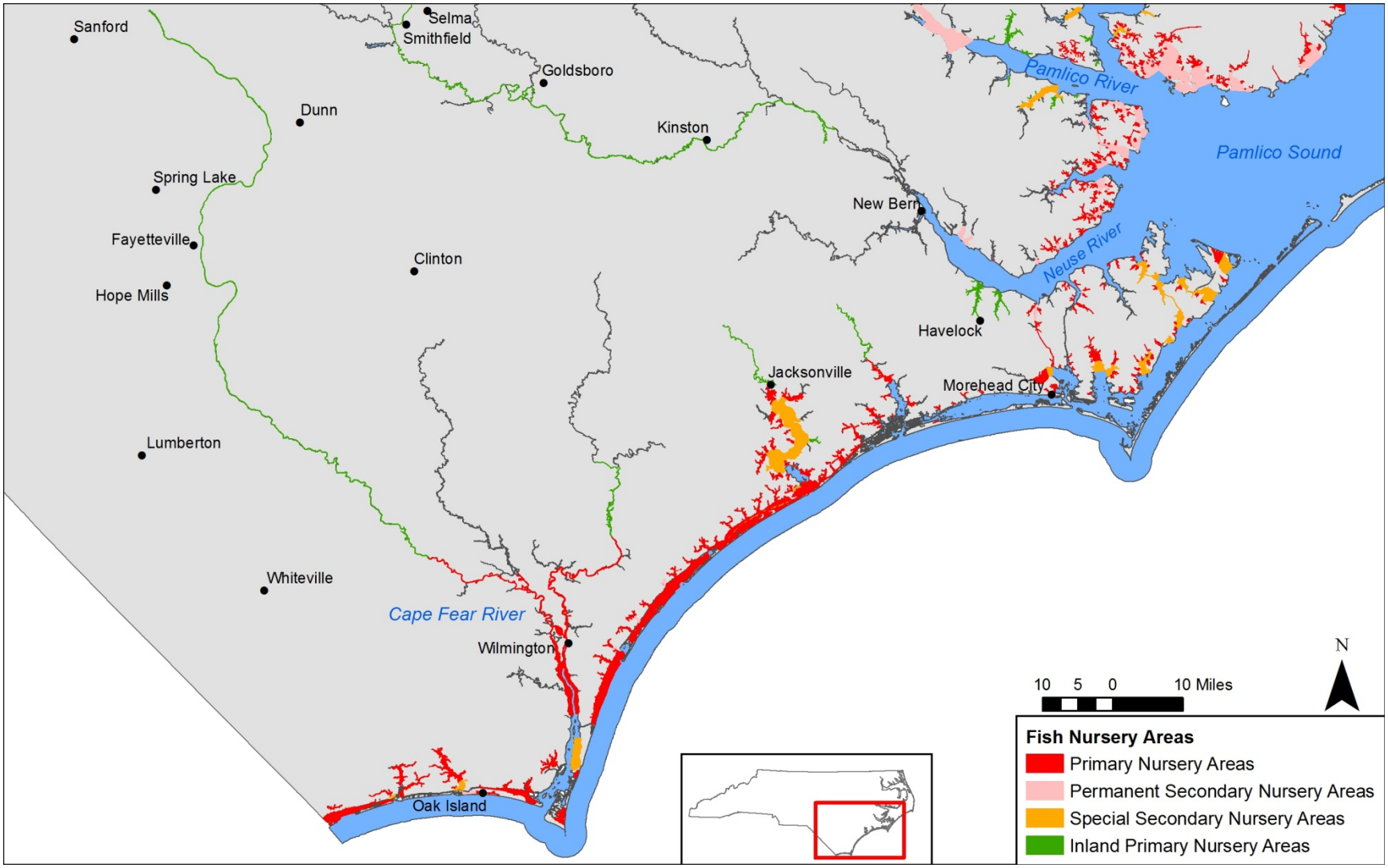

Figure 7. Nursery area designations in the Neuse River and Cape Fear River (including Northeast Cape Fear River, and Black River) areas.

Strategic Habitat Areas (SHAs) - CHPP Chapter 13.2

The identification and designation of Strategic Habitat Areas (SHAs) for marine and coastal fishery species is a critical component in the implementation of North Carolina's approved CHPP. Strategic Habitat Areas were defined in the CHPP as, "specific locations of individual fish habitat or systems of habitats that have been identified to provide exceptional habitat functions or that are particularly at risk due to imminent threats, vulnerability, or rarity" (Street *et al.* 2005). Criteria for identifying SHAs were developed by an advisory committee of the Marine Fisheries Commission established in summer 2005. The committee developed a scientifically based process for identifying candidate areas for designation using biological data and the consensus of a regional expert panel (regional advisory committee).

The identification of existing SHAs was conducted in a two step process: 1) using GIS-based habitat and alteration data in a computerized site-selection analysis, and 2) verifying and modifying information based on input from a scientific advisory committee. Staff and advisory committee specified representation levels for 42 habitat types, or natural resource targets. There were also 18 alteration factors that were represented geospatially (e.g., hydrologic alterations, water quality degradation). The site selection program MARXAN was used to select areas that met representation levels while also minimizing alteration. The scientific advisory committee then modified the computer results based on their unique knowledge and experience. The SHAs were corroborated with biological data, ecological designations, and specific knowledge of the area. The SHA nominations will be incorporated into conservation and restoration planning efforts.

SHA designations are based on regional analyses that identify optimally placed habitat areas of various ecological condition (exceptional or at risk). SHAs may include areas that have already been protected by other designations, as well as areas not currently recognized in any way. A network of designated SHAs providing habitat connections throughout North Carolina's coastal waters should ensure that the complex life history needs of all species are met. Once SHAs are designated in rule, resource managers may address gaps in existing management and take steps to prevent further alteration of the system as a whole. Thus, the necessary protections may go above and beyond current measures designed to protect habitat. Even before designation in rule, conservation agencies may incorporate candidate SHAs in their site selection process for acquisition, enhancement or restoration projects.

Four regions have been delineated for analysis and development of SHAs (Figure 8). As of May 2018, SHAs in all four regions have been identified and approved by the NCMFC. Regions 1, 2, 3, and 4 were presented and approved by the NCMFC in January 2009, November 2011, November 2014, and May 2018, respectively (Figure 9).

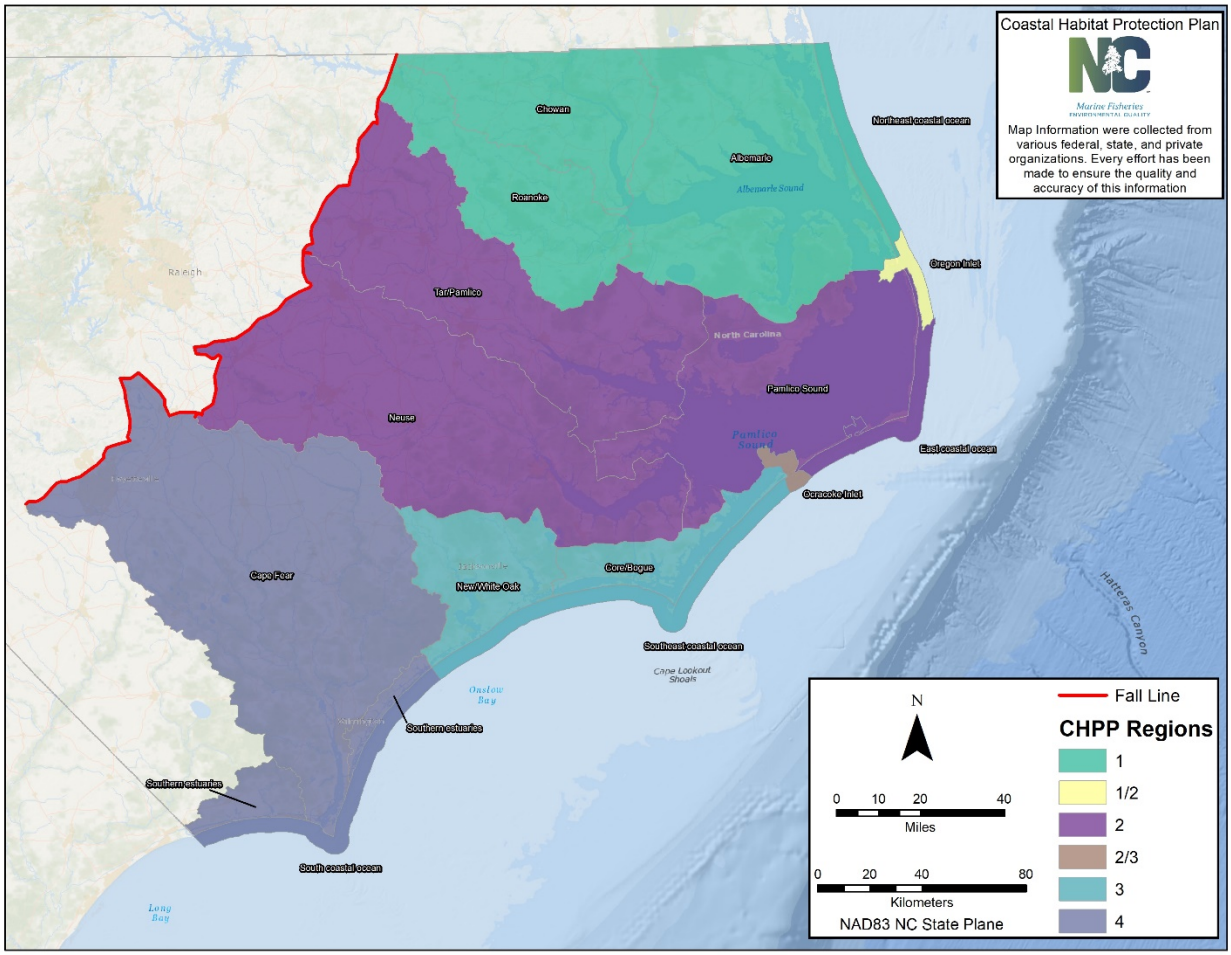

Figure 8. The CHPP region and subregion boundaries (based on USGS hydrologic units), along with the fall line separating Coastal Plains and Piedmont physiographic regions.

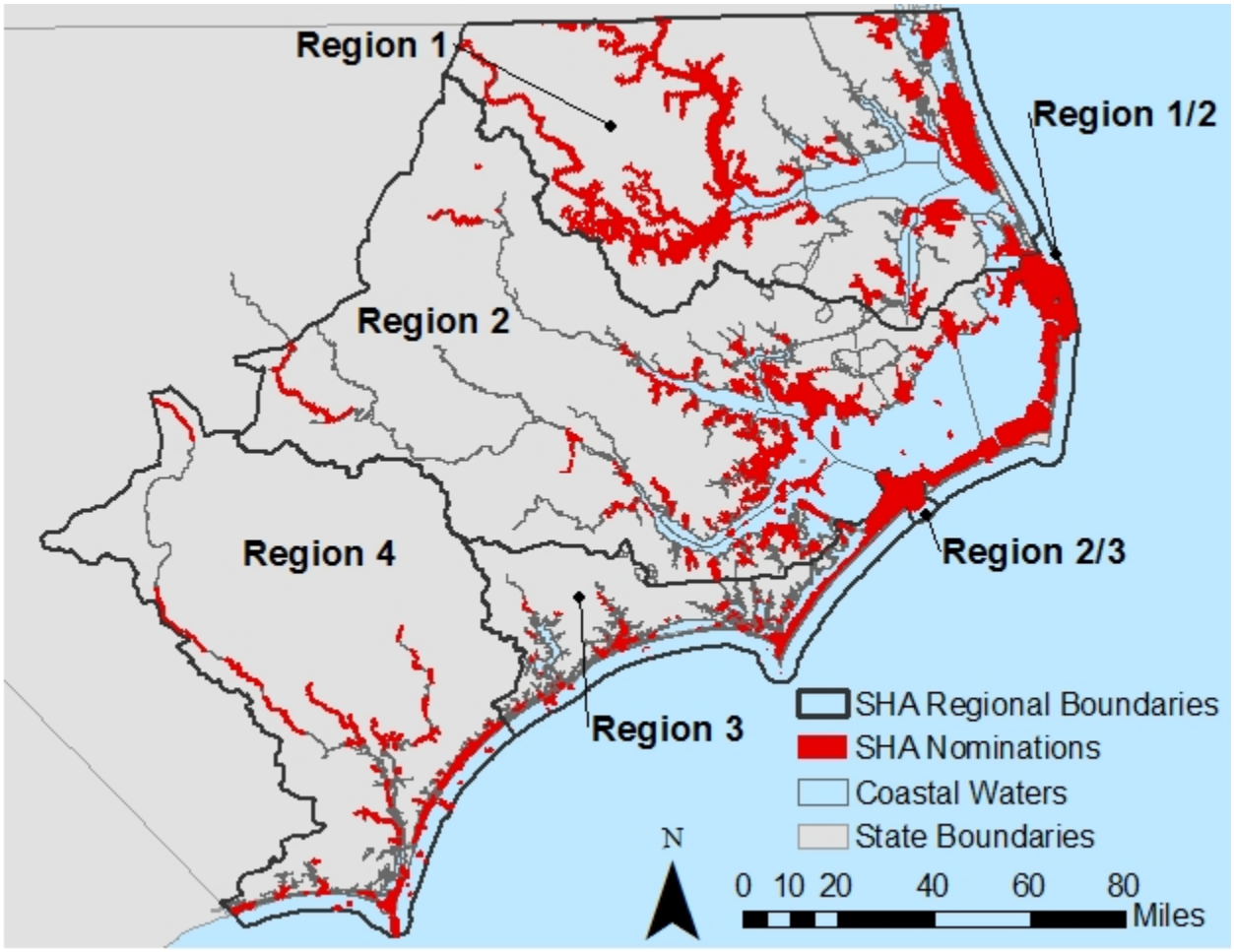

Figure 9. CHPP Regions 1, 2, 3, and 4 strategic habitat area nominations presented and approved by the Marine Fisheries Commission.

Section 2: Threats Assessment

Barriers to Migration Inventory and Assessment

The 2020 Atlantic States Marine Fisheries Commission's American Shad Stock Assessment and Peer Review Report provides an extensive review of available literature and discussion on the topic of fish passage (ASMFC 2020). Specifically, it highlights the issues with lack of evaluation and performance from decades-old approaches, facilities designs/operations that are not effective, and therefore cannot reasonably be expected to achieve management and restoration goals without significant changes. The Assessment Report also provides an important quantitative modeling approach examining shad habitat and passage barriers, and the need to address status quo fish passage performance. The impacts of these barriers and status quo passage are described and also modeled as effects on spawner population size under three scenarios, 1) no barriers, 2) first barrier with no passage, and 3) realistic fish passage performance measures applied to barriers (e.g., upstream passage efficiency of 50%).

The Assessment Report used standardized data and modelling approaches that quantified the impacts of barriers and fish passage as significant in all three management areas examined based on shad life history and habitat (New England, Mid-Atlantic, and South Atlantic). The

assessment determined that overall, dams completely or partly block nearly 40% of the total habitat once used by American Shad. The model results of the “no barriers” scenario yielded an estimated spawner production potential 1.7 times greater than that yielded by the scenario assuming no passage at the first barrier: 72.8 million versus 42.8 million fish. The results of the third model scenario, which applies “realistic” (i.e., current) fish passage efficiencies, resulted in a gain of less than 3 million fish. Conclusions include “losses in (spawner production) potential are significant in each state and region.” The Assessment Report provides a strong justification for the need and benefits of requiring improved fish passage performance measures. Additionally, meeting such improved passage performance standards is now an achievable goal given the current state of knowledge on fish behavior, swimming performance, and fish passage engineering expertise.

Dams - CHPP section 9.2.1; 9.2.2; 9.2.3; 9.2.5

The majority of dams in North Carolina occur in the upstream portions of estuaries, rivers, and streams. In the coastal plain, dams are most abundant in the upper reaches of the Cape Fear, Neuse, Tar-Pamlico, Roanoke, Chowan, and Yadkin-Pee Dee watersheds. These structures primarily impact anadromous fish and the catadromous American eel spawning migrations, (Figures 2-5). Eggs and larvae are less likely to survive if passage to their historical spawning areas is obstructed by dams or other alterations (Moser and Terra 1999).

In the coastal plains portion of CHPP Region 1, approximately 18% (2,369 miles) of National Hydrologic Dataset (NHD) streams (13,070 miles) appear blocked by an impoundment, based on strategic coastal habitat assessment results. The Chowan subregion of Region 1 had the largest percent of dam-obstructed streams at 38% (Table 1).

Table 1. Number of documented obstructions (e.g., dams, locks, culverts) in coastal plains portion of CHPP regions.

Data sources: Virginia Game and Inland Fisheries (1983 data), Collier and Odum (1989), Moser and Terra (1999), NCDOT (2003 data), NCDWR (2003 data), and USACE obstructions inventory (2009 data) 1.

CHPP Region	Subregion	Dam/impoundment	Beaver dam*	Lock*	Stormgate*	Vegetation*	Culvert (unspecified)	Pipe culvert	Box culvert**
1	Albemarle	2	0	1	4	2	33	39	3
	Chowan	95	1	0	0	0	25	46	5
	Roanoke	28	0	0	0	0	29	32	0
	TOTAL	125	1	1	4	2	87	117	8
2	Neuse	113	0	0	0	0	119	139	1
	Pamlico Sound	1	0	0	0	0	15	9	0
	Tar/Pamlico	73	0	0	0	0	95	68	0
	TOTAL	187	0	0	0	0	229	216	1
3	Core/Bogue	1	0	0	0	0	0	8	0
	New/White Oak	5	0	0	0	0	8	24	0
	TOTAL	6	0	0	0	0	8	32	0
4	Cape Fear	191	0	0	0	0	104	176	1
	Southern estuaries	3	0	0	0	0	1	6	0
	TOTAL	194	0	0	0	0	105	182	1
ALL	TOTAL	512	1	1	4	2	429	547	10

[1] Note: Structures duplicated in different datasets were consolidated into one dataset.

* Collier and Odum (1989) only

** Moser and Terra (1999) only

Additional information on aquatic barriers in North Carolina can be found using the Southeast Aquatic Barrier Prioritization Tool (https://connectivity.sarpdata.com/). The Southeast Aquatic Resources Partnership has compiled an inventory and living database of dams, culverts, and other road crossings and other road crossings for 14 states in the southeast. While the information on barriers is not complete or comprehensive across the region, a large portion of North Carolina's aquatic barriers have been inventoried. The inventory directly supports prioritization of barriers by including metrics that describe network connectivity, landscape condition, and presence of threatened and endangered aquatic organisms.

Other Physical Structures - CHPP section 9.2.4

Based on analysis of NCDEQ and NC Department of Transportation (NCDOT) records, it has been estimated that the state loses, on average, about 500 acres of wetlands per year, mostly from road construction (see "Culverts and Road Fill" section of the Hydrological Alterations chapter for more information). Road construction over rivers, streams, or wetlands often involves blockage of a portion of the original stream channel and floodplain. Bridges may cross over the water or culverts may be constructed under the road, depending on the size of stream and associated wetlands. In the past, bridges were constructed by filling the adjoining wetlands and creating a narrow channel for water passage.

Altered Water Quality and Quantity - CHPP section 10.2

Besides degrading water quality, modifications to normal flow conditions (e.g., stream blockages, water withdrawals, droughts, or discharges) can negatively impact anadromous fish migrations, including American shad.

Water Withdrawals Inventory and Assessment - CHPP Section 9.3.1

Water is withdrawn from surface and ground waters for multiple purposes. Surface water is withdrawn for industrial uses (such as cooling water for nuclear and fossil fuel power plants), municipal water supply, crop irrigation, and other uses. Thermoelectric power generation accounts for the greatest amount of surface water withdrawals followed by public water supply, irrigation, industrial, and aquaculture withdrawals in the CHPP regions.

Specific information regarding the type and quantity of water withdrawals for each basin is catalogued by the NC Division of Water Resources (NCDWR 2001).

Toxic and Thermal Discharges Inventory and Assessment - CHPP Section 10.2.2; 10.2.3; 10.2.4; 10.2.5

Both direct (point source) and indirect (non-point source) discharges occur in the river systems that support American shad, and can contain a variety of stressors that are generally dependent on adjacent land use. Common stressors contained in both point and non-point discharges are nutrients and toxins (e.g., chlorinated hydrocarbons).

Several of these major rivers flow into estuarine environments that are characterized by slowly moving, poorly flushed waters with high level of nutrients, which offer ideal conditions for various algae, fungi, and bacteria to thrive. Toxins can exist in the water column as well as adhere to bottom sediments. General information regarding discharges of nutrients and toxins is presented in the CHPP with specifics for each river basin. Additional information regarding North Carolina water quality data assessments and impaired waters list can be found on the NC Division of Water Resources (NCDWR) website (https://deq.nc.gov/about/divisions/water-resources/planning/modeling-assessment/water-quality-data-assessment/integrated-report-files).

Channelization and Dredging Inventory and Assessment - CHPP Section 9.3.2; 8.2.3

Water Column, wetlands, SAV, and soft bottom, all of which are critical to American shad stocks, are directly threatened by dredging and channelization. Not only will dredging directly affect American shad stocks, the sedimentation and turbidity associated with it will have adverse impacts on American shad.

Much of NC's estuarine waters are shallow and these shallow waters are where most structured habitats like wetlands, SAV, and shell bottom occur. Dredging can consist of deepening existing shallow water habitat or creating new waters from upland in the form of canals, boat basins, marinas, or ditches. This is generally done for the purpose of navigation or drainage for flood or mosquito control. The latter is no longer permitted.

Land Use Inventory and Assessment - CHPP Section 1.7.1; 10.1

Land use and land cover vary from North Carolina's oceanfront shoreline to the freshwater upstream limit of American shad in coastal river systems. Statewide the dominant land cover is forest, followed by agriculture, and developed land. In the flat and relatively low elevation of the coastal plain, marsh and forested wetlands are very abundant. Forest land can be upland or

wetland and can be managed (silvaculture) or natural (undisturbed). Forestry and agriculture are the biggest industries in terms of land cover in the coastal plain.

Land cover and water quality within a watershed are closely linked. The impact of land uses on fish habitat and water quality depends on the location of the land uses in the watershed as well as local weather conditions (rainfall, winds etc.). For additional information on land use change data please refer to the NOAA Coastal Change Analysis Program (C-CAP) 2016 Regional Land Cover and Change Data Set (https://coast.noaa.gov/digitalcoast/data/).

Atmospheric Deposition Inventory and Assessment - CHPP Section 10.3.3

The effect of atmospheric deposition on water quality is difficult to trace. Sources of atmospheric pollutants include vehicle exhaust, industrial emissions, and waste from animal operations (Walker et al. 2000; USGS 2003). Atmospheric deposition was the source implicated in 7.9% of impaired coastal draining streams in North Carolina (NCDWQ 2006). The greatest number of streams impaired from atmospheric deposition occurred in the Roanoke River Basin. A significant portion of nutrient pollution has also been attributed to atmospheric deposition.

Climate Change Inventory and Assessment

On October 29, 2018, North Carolina Governor Roy Cooper issued Executive Order No. 80 (EO80), which outlines North Carolina's commitment to addressing climate change and transition to a clean energy economy. The North Carolina Climate Science Report (NCCSR) supports Governor Cooper's EO80 by providing an independent peer-reviewed scientific contribution to the EO80. The NCCSR is a scientific assessment of historical climate trends and potential future climate change in North Carolina under increased greenhouse gas concentrations (https://ncics.org/programs/nccsr/). The report was prepared independently by North Carolina-based climate experts and an advisory panel was formed to provide oversight and review of the report. The report underwent several rounds of review and revision, including an anonymous peer review organized by NOAA's National Centers for Environmental Information (NCEI). The NCCSR was released in March 2020 and revised in September 2020 to enhance accessibility of the report.

The report found that large changes in North Carolina's climate are very likely to occur by the end of this century (Kunkel *et al* 2020). North Carolina annual average temperature has increased by about 1.0°F since 1895, less than global average (Kunkel *et al* 2020). However, 2009-2018 represent the warmest 10-year period on record in North Carolina, averaging about 0.6°F warmer than the warmest decade in the 20th century (1930-1939; Kunkel *et al* 2020). Sea level along the northeastern coast of North Carolina has risen about twice as fast as the southeastern coast, averaging 1.8 inches per decade since 1978 at Duck, NC, and 0.9 inches per decade since 1935 at Wilmington, NC (Kunkel *et al* 2020). The report predicted that by the end of the century all of the state's coast will experience disruptive coastal flooding. While the report found no long-term trend in annual total precipitation, there is an upward trend in the number of heavy rainfall events (3 inches or more in a day), from 2015-2018 (Kunkel *et al* 2020).

Competition and Predation by Invasive and Managed Species Inventory and Assessment - CHPP 11.1

There is widespread documentation that some non-native species can out-compete native species, altering the established ecosystem, habitat, and eventually water quality (Mallin *et al.* 2001, Burkholder *et al.* 2007).

The most troublesome submerged aquatic plant species in low-salinity estuarine waters are Eurasian watermilfoil (*Myriophyllum spicatum*) and hydrilla (*Hydrilla verticillata*). It is possible for Eurasian watermilfoil and hydrilla to become thick dense beds that will out compete native SAV species. The presence of these two species may remove critical habitat by "choking" out native species or fish kills may arise due to low dissolved oxygen levels. Hydrilla has been documented in many of the North Carolina coastal rivers and the Albemarle Sound.

The NCDEQ is charged with the regulation of noxious weeds in the Aquatic Weed Control Act of 1991 (Article 15 113A-220). By virtue of the regulations created following the act (T15A NCAC 02G .0600), NCDWR implements the Aquatic Weed Control Program (AWCP), which focuses primarily on non-native invasive species in freshwater lakes, ponds, and rivers. Weed control activities in coastal waters are primarily focused on Eurasian watermilfoil. Control activities target areas where native species are not the dominant species based on site assessments (R. Emens NCDWR, personal communication 2009).

Both the blue catfish (*Ictalurus furcatus*) and flathead catfish (*Pylodictis olivaris*) are nonnative catfish species in coastal North Carolina that are known to prey on native fishes including river herring and American shad. In North Carolina flathead catfish do not target native species, but they are opportunistic feeders eating whatever becomes available (Pine *et al.* 2005) but both species have been documented to consume river herring (Schloesser et al. 2011). At the current time, the blue catfish population is expanding in the Albemarle Sound and its tributaries but the extent of its effect on river herring and American shad is unknown. Flathead catfish have yet to be documented in the Albemarle Sound region, but they are present in all other river basins, including some coastal waters, in the state (NCDMF and NCWRC unpublished data). While the impact of blue catfish and flathead catfish predation on American shad in North Carolina is unknown, we assume American shad are just a vulnerable as river herring due to the opportunistic feeding behavior of these invasive species. Neither the NCDMF nor the NCWRC has regulations to restrict harvest of invasive catfishes in North Carolina coastal rivers and sounds in attempts to control their populations.

Section 3: Habitat Restoration Program

Barrier Removal and Fish Passage Program

Chowan Watershed

In the Chowan watershed, there is one hydropower dam on the Meherrin River, and one on the Nottaway River (Baskerville Mill Dam), both in Virginia. In addition to dams found on mainstem rivers, numerous smaller mill dams are found on creeks throughout eastern North Carolina. For example, Collier and Odom (1989) reported three such dams within the Chowan River basin on Bennetts, Indian, and Rockyhock creeks (Figure 2). The dams on mainstem and tributary portions of the Chowan drainage basin form the upstream boundaries of some documented anadromous fish spawning habitat in North Carolina and Virginia. Although there is a fish passage structure, the upstream boundaries include the Emporia Dam on the Meherrin River in Virginia (Collier and Odom 1989). The structure at the dam does not effectively pass fish upstream. Removing or bypassing these dams would open access to many miles of potential spawning habitat for anadromous species including American shad. Recent fish passage improvements in the Chowan watershed include fish ladders at Merchant's Millpond on Bennett's Creek and Dillard's Millpond on Indian Creek (Mike Wicker USFWS, personal communication, 2005), but these improvements are only beneficial for river herring.

Roanoke River

Currently, numerous large and small dams are present in the Roanoke River Basin. Roanoke Rapids Dam at river kilometer (rkm) 220 (river mile 137) is the lowermost dam on the mainstem of the river. Roanoke Rapids Dam impounds the river to Gaston Dam at rkm 233 (river mile 145). Gaston Dam impounds the river to rkm 274 (river mile 170), below Kerr Dam at rkm 288 (river mile 179). Kerr Dam impounds the river up the Dan River to rkm 332 (river mile 206), and up the Staunton River to rkm 341 (river mile 212; Laney et al. 2001). State and federal fisheries management agencies in North Carolina and Virginia finalized negotiations with Dominion/NC Power for relicensing of the Gaston and Roanoke Rapids lakes hydroelectric dams through the Federal Energy Regulatory Commission (FERC) in 2005. Among the mitigative measures required by relicensing was a long-term, well-funded, and coordinated program to restore American shad in the Roanoke River basin. Measures outlined in this effort included improvements in hatchery production of fry, continued intensive monitoring of fry stocking success upstream and downstream of the mainstem reservoirs, and an assessment of American shad population size, using hydroacoustic techniques, as it pertains to providing upstream passage facilities and fulfilling the prescription for fish ways provided by NMFS. The Diadromous Fishes Restoration Technical Advisory Committee (DFRTAC), comprised of Dominion staff and state and federal resource managers, advises implementation of Dominion's settlement agreement. Due to numerous studies showing ineffective downstream passage of stocked fish and continued low spawning population estimates, the DFRTAC has delayed the design and construction of American shad passage facilities at Roanoke Rapids Dam as prescribed in the settlement agreement. Nevertheless, the fish ways prescription and the settlement agreement established a process for providing American shad access to spawning habitat in the upper Roanoke River that can be implemented when conditions are appropriate.

Tar/Pamlico River

The Rocky Mount Mills Dam is the lowermost dam on the Tar River that obstructs migration of striped bass, American shad, Atlantic sturgeon, hickory shad, and blueback herring (Collier and Odom 1989). The dam was constructed on the Tar River near the City of Rocky Mount in approximately 1816. The dam provided power for gristmill, sawmill, and textile industries. In 1949, hydro-electric turbines were installed, and the dam produced electricity in addition to the textile manufacturing (GEO 2019). The textile mill closed in 1996, but the hydropower operation continued through approximately 2013 (EPA 2019). The current owners of the dam and associated hydropower facility plan to refurbish the turbines and resume power generation in the future. Operation for the benefit of fish spawning and providing fish passage will not be required because the dam is not regulated by FERC; however, the owners have been receptive to fish passage ideas and seem willing to cooperate with beneficial flows (Wilson Laney, USFWS ret., personal communication). Rocky Mount Mills Dam will continue to represent a barrier to American shad migration on the Tar River until its removal or development of fish passage.

Neuse River

The first blockage in the Neuse River is Falls of Neuse Dam at rkm 314 (river mile 195). A substantial amount of mainstem habitat was restored in 1998 with the removal of the Quaker Neck Dam near Goldsboro (Bowman and Hightower 2001). In 2017, the Milburnie Dam rkm 295 (river mile 183) was removed providing access to more than ten kilometers (six miles) of potential spawning habitat. Removal of Milburnie Dam also allows the USACE some latitude to provide a stable flow regime for the Neuse.

Little River, a Neuse River tributary, has had three low-head dams removed since 1998. Cherry Hospital Dam, Rain Mills Dam, and Lowell Mill Dam have been removed and have reconnected 82 river kilometers (51 river miles) of Little River to the Neuse River and 237 river kilometers (147 river miles) including Little River tributaries. Raabe and Hightower (2014) estimated that 24-31% of American shad and 45-49% of gizzard shad migrated past the former Lowell Mill dam site in 2009 and 2010. A partially removed dam, which provides for a back-up water intake structure for the city of Goldsboro, still exists just upstream of the former Cherry Hospital Dam. This remaining structure appears to impede the upstream migration of American shad and gizzard shad, blocking some individuals and delaying others (Raabe and Hightower 2014).

Cape Fear River

In the Cape Fear River, the lowermost obstructions to migration are the three locks and dams located within the Coastal Plain operated by the USACE. Above the final lock, Buckhorn Dam at rkm 316 (river mile 196) prevents further migrations to potential upstream spawning habitat except during extreme flood events. The Cape Fear River may provide the best opportunity for remediation of obstructions. In November 2012, the USACE completed construction on a rock ramp fish passage for the lower most lock and dam. State and federal natural resource agencies, along with university and non-governmental organizations, have partnered to develop a Cape Fear Basin Action Plan for Migratory Fish (http://www.habitat.noaa.gov/protection/capefear/pdf/CapeFearActionPlan.pdf).

Telemetry studies conducted to evaluate American shad usage of the rock arch fishway indicate American shad passage efficiency at the Lock and Dam 1 (LD-1) fishway ranged 53–65% and was consistent with prior estimates from locking procedures (Raabe et al. 2019). Electrofishing surveys corroborate the telemetry studies, as electrofishing catch rates have increased at the upper two locks and dams and decreased at LD-1 over the last five years. These results indicate American shad are readily passing LD-1. With presumed historic spawning grounds, upstream of Lock and Dam 3 (LD-3), substrate was strategically placed below Lock and Dam 2 (LD-2) in 2013 to increase the potential spawning habitat for anadromous fish that pass the rock arch fishway but fail to navigate the lockage system. Locking at LD-1 has ceased at this point but continues for LD-2 and LD-3 to facilitate fish passage. American shad spawning activity has been observed by Commission staff (Bennett Wynne, NCWRC retired, personal communication), and American shad eggs have been collected just downstream of LD-2 (Dawn York, Cape Fear River Partnership, personal communication). Therefore, fish that migrated to LD-2 but failed to migrate farther upstream could reproduce and benefit from the habitat enhancement efforts. In 2016, NCWRC staff documented higher egg densities below LD-3 compared to other locks and dams (Morgeson and Fisk 2018). The Cape Fear River Partnership, including local, state, and federal agencies, as well as private groups, continues to plan fish passage enhancement projects on the remaining locks and dams on the main stem Cape Fear River.

Following the construction of the fish passageway at LD-1, natural resource agencies have advocated for removal or construction of fish passage structures at LD-2 and LD-3. Restoration efforts through removal or modification of dam structures that impede migration of anadromous fish should remain a high priority to continue in North Carolina, focusing on the lowermost structures in rivers or streams, and advancing upstream. In particular, the Cape Fear system, LD-2 should be a high priority, since striped bass, shortnose sturgeon, and Atlantic sturgeon have not recovered. In late 2015, the North Carolina General Assembly approved $250,000 to be used towards the engineering and design of a fish passage at Lock and Dam 2. The funds require a 50/50 match of non-federal monies. Fundraising for the matching funds is currently

under way by the Cape Fear River Partnership. However, the USACE authorized a disposition study in 2019, and the fate of the dams, including continued ownership by the USACE and any future improvements, is in question pending the study.

Hatchery Product Supplementation Program

American shad fry reared at the USFWS Edenton National Fish Hatchery (ENFH) and at the NCWRC Watha State Fish Hatchery have been stocked annually into the Roanoke River since 1998. This restoration project was initiated by NCWRC, and although it was originally funded by the North Carolina Department of Transportation as mitigation for aquatic habitat damages resulting from highway bridge construction on the Roanoke River, continued American shad stocking efforts have primarily been funded by Sport Fish Restoration Funds and Dominion Energy through their FERC settlement agreement requirements. Annual production and stocking information can be found in North Carolina's annual Shad and River Herring Compliance reports. In 2019, however, NCWRC and other program partners decided to temporarily halt the Roanoke River restoration program for at least three years due to growing concerns about high hatchery contribution and decreasing genetic diversity without population growth. A similar, but smaller scale American Shad restoration program began in the Neuse River in 2012 to supplement the wild population by stocking fry produced from one spawning tank of approximately 100 broodfish each year. The Neuse River restoration program was also stopped in 2019.

Annual contribution of hatchery-origin American shad to the Roanoke River and Neuse River populations is evaluated for multiple cohorts of returning adults during the spring spawning run. Fin clips from adult American shad are collected during spawning stock surveys, and broodfish are also evaluated for potential hatchery contribution of stockings from previous years. Parentage-based tagging analysis using genetic, microsatellite markers has been used to examine adult and juvenile fin clips for hatchery origin since 2010, and OTC was used in prior years. Although stockings were halted in 2019, evaluation of previously stocked cohorts will continue.

Water Quality Improvement Program-CHPP 14

One of the four major goals of the CHPP is "Enhance and protect water quality" and significant cooperation among agencies has occurred in pursuit of this goal. The most recent CHPP Implementation Plan 2018-2020, as well as recent annual reports can be found on the CHPP website (http://portal.ncdenr.org/web/mf/habitat/chpp/07-2020-chpp). The implementation plans outline specific items regarding water quality while the annual reports provide details on progress on items contained in the Implementation Plan. A separate improvement plan for water quality is not needed because the implementation plans outline specific actions to address water quality.

In 2010, the North Carolina General Assembly directed the NCDEQ to develop basinwide hydrologic models for all 17 river basins in North Carolina (https://deq.nc.gov/about/divisions/water-resources/water-planning/modeling-assessment/basinwide-hydrologic-modeling). For long term planning, NCDEQ uses hydrologic models for evaluating potential impacts of proposed projects with new or increased water withdrawals within the basin as well as interbasin transfers. Local stakeholders as well as DEQ use these models to plan for increased water use due to growth and to evaluate the effects of operational and regulatory constraints during a drought condition. To date basinwide models have been completed for the Cape Fear-Neuse river (combined), Roanoke River, and Tar River.

The NCDWR is actively working to develop appropriate nutrient criteria for the waters of the state. The NCDWR's goal is to develop scientifically defensible criteria based primarily on the linkage between nutrient concentrations and protection of designated uses. The criteria for each water body will be coordinated with other water bodies to ensure consistency across the state and protect downstream uses. The nutrient criteria development plan for 2019 can be found on the NCDWR website (https://deq.nc.gov/about/divisions/water-resources/water-resources-data/water-sciences-home-page/nutrient-criteria-development-plan). Nutrient criteria development efforts will be directed to the three specific water body types: 1) reservoirs/lakes, 2) rivers/streams and 3) estuaries. Currently, the plan is using the Albemarle Sound as the pilot water body for estuaries. The timeline for development and adoption of nutrient criteria in the 2019 plan is 2025. Adoption of nutrient criteria statewide is anticipated by 2029.

Habitat Improvement Program-CHPP 14

Similar to the Water Quality Improvement Program, the CHPP Implementation Plan fills the role of a Habitat Improvement Program. Two of the four major CHPP goals are directly related to habitat protection and improvement: "Identify, designate and protect strategic habitat areas" and "Enhance habitat and protect it from physical impacts." The CHPP Implementation Plan 2018-2020 details the component of and progress towards several efforts aimed at improving fisheries habitat in North Carolina (http://portal.ncdenr.org/web/mf/habitat/chpp/07-2020-chpp). A separate improvement plan for habitat improvement is not needed because the implementation plans outline specific actions to address habitat concerns.

In 2010, American Rivers initiated a dam removal program in North Carolina. This organization has been working with state and federal agencies to prioritize which dams should and can be removed. While creating this list, American Rivers has been actively trying to obtain funding to remove dams. In partnership with the American Rivers organization and other state and federal councils and fish and wildlife agencies, the Southeast Aquatic Resources Partnership has been working with partners cross 14 southeast states to inventory aquatic barriers since 2013. Recently, the Southeast Aquatic Resources Partnership launched the Aquatic Barrier Prioritization Tool (https://connectivity.sarpdata.com/). This interactive tool contains a living database and GIS assessment of aquatic barriers in the southeast. This information allows partners to prioritize dams and road-stream crossings for potential removal or remediation based on ecological metrics. Researchers at NCDEQ, NCWRC and East Carolina University (R. Rulifson and J.P. Walsh) have contributed to the assessment in estimating the acreage of habitat gained by the removal of the first and second obstructions on North Carolina coastal rivers.

Additionally, staffs from NCDMF and NCWRC, as well as other federal and state agencies participate in several cooperative efforts to improve fish passage, including the ASMFC Fish Passage workgroup.

Project Permit/Licensing Review and Minimization Programs-CHPP 14

During the 2008-2009 fiscal year the NCDMF received approval for two grant funded position dedicated to NC Division of Coastal Management (NCDCM) permit review. NCDMF through NCDCM participates in an extensive permit review process on behalf of 15 federal and state agencies. NCDMF is specifically authorized by state statute to review and comment on permits that may impact public trust resources and has established a set of internal guidelines for staff in order to maintain a consistent review process. Dedicated staff conduct reviews on permits related to coastal development, while programmatic fisheries staff take the lead in reviewing federal permits for particular species.

In 2009, the NCMFC approved a compensatory mitigation policy that was incorporated into the "Policies for Protection and Restoration of Marine and Estuarine Resources and Environmental Permit Review and Commenting." Based on evolving understanding of the needs of compensatory mitigation to protect and enhance the quality of coastal waters and watersheds, the focus and goals of compensatory mitigation should allow an array of options to be applied. The NCMFC has delegated its permit commenting authority to its Habitat and Water Quality Standing Advisory Committee (Committee) for the sake of efficiency and effectiveness.

State and federal laws charge the NCWRC with protecting, managing and conserving aquatic, wetland and upland habitats for the benefit of fish and wildlife populations. The Habitat Conservation Program implements this mandate based upon the NCWRC's Policies and Guidelines for Conservation of Wetlands and Aquatic Habitats. The NCWRC Habitat and Conservation Program reviews proposed projects statewide and evaluates the potential environmental threats associated with each project. The program recommends project design modification to minimize adverse environmental impacts and recommends mitigation to compensate for unavoidable impacts. A large portion of the coastal region permit review is associated with shoreline stabilization, piers construction, marina development and small channel dredging.

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