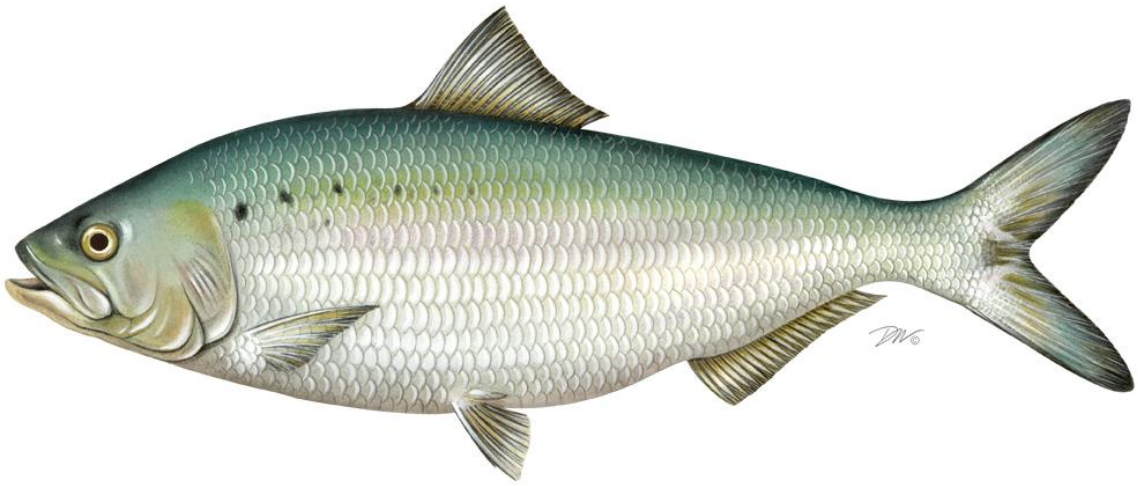
North Carolina Division of Marine Fisheries

North Carolina Wildlife Resources Commission

American Shad Habitat Plan



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 6, 2014

NORTH CAROLINA AMERICAN SHAD HABITAT PLAN

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January 2014

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 to protect and enhance important coastal fisheries habitats. It also contains a directive to three major rulemaking commissions (Environmental Management Commission, Coastal Resources Commission and Marine Fisheries Commission) to cooperate in the development and implementation of the plan. The NC Division of Marine Fisheries (NCDMF) was charged with writing the plan.

The initial version of the CHPP was approved by all three commissions in December 2004, and 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. A Steering Committee comprised of two commissioners from each of the three rulemaking commissions provided guidance and policy oversight, while NCDMF staff wrote the plan with assistance of the CHPP Development Team – staff from the Divisions of Water Quality, Coastal Management, Environmental Health and the Wildlife Resources Commission (NCWRC). A number of state and federal agency staff external to the development of the CHPP provided review of the individual chapters of the plan. Additionally, two-year Implementation Plans were developed to guide agency activities and progress towards the goals, objectives and recommendations of the CHPP.

The CHPP is reviewed and updated on a five-year schedule, with the last update completed in 2010. A process similar to that described above was employed in the review and update of information, goals, objectives and recommendations. During this update, two commissioners from the NCWRC were added to the Steering Committee in recognition of the increasing role of this commission in Implementation Plan items. 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.

In an effort 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 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 CHPP is 638 pages (including appendices), it is not included as an appendix to this Habitat Plan (Deaton et al 2010).

Individual chapters of the CHPP (both 2004 and 2010 versions) as well as Implementation Plans and all documents related to Strategic Habitat Areas (referred to in the Habitat Assessment below) can be found within the CHPP document (Deaton et al 2010).

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 North Carolina Coastal Habitat Protection Plan (CHPP) including: water column, wetlands, submerged aquatic vegetation (SAV), soft bottom, hard bottom, and shell bottom (Deaton et al. 2010). 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 all coastal rivers in North Carolina and 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 1976; Sholar 1977; Fischer 1980; Hawkins 1980; Johnson *et al*. 1981; Winslow *et al*. 1983; Winslow *et al*. 1985) (Figure 1).

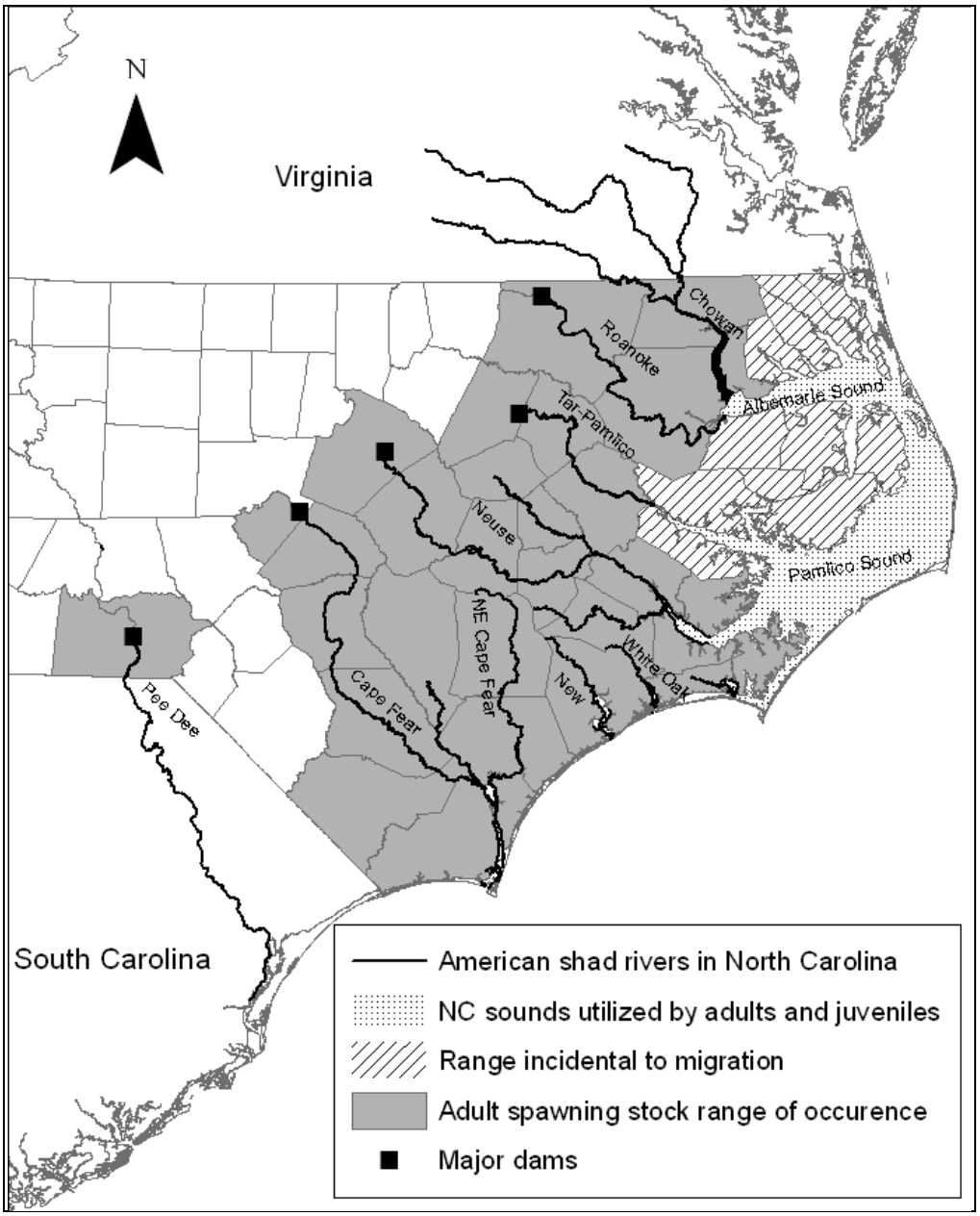

Figure 1. North Carolina river systems depicting the extent of American shad occurrence and habitat use.

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. Albemarle Sound, located in the northeastern portion of North Carolina, is a shallow estuary extending 88.5 km in an east-west direction averaging 11.3 km wide and .9–6.1 m deep. 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. Currituck Sound joins Albemarle Sound from the northeast. Although the headwaters of the Roanoke River are located in the Appalachian foothills of Virginia, most of the tributaries to the Sound originate in extensive coastal swamps. The Roanoke and Chowan Rivers are the principal tributaries, 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). American shad spawning occurs in the Chowan River system in Virginia where the River divides into the Blackwater and Nottoway Rivers. The upper Meherrin River, a tributary of the Chowan River, also functions as a spawning area in North Carolina and Virginia. Spawning also occurs in the Roanoke River near Weldon and Roanoke Rapids.

Roanoke River

The Roanoke River is a relatively narrow stream that follows a winding course to its mouth below Plymouth, where it enters western Albemarle Sound. The Roanoke River watershed arises in the mountains of Virginia and covers 25,035 square km (8,893 square miles); only 9,081 square km (3,506 square miles) of the basin lies within North Carolina (NCDWQ 2001). Fifteen counties and 42 large municipalities (e.g., Greensboro, Winston-Salem, High Point, Roanoke Rapids, Williamston, Plymouth) are represented within the North Carolina portion of the basin. 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 (USACOE) and Dominion/NC Power Company 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 area, 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). River reaches upstream of the City of Washington are designated as the Tar River and are 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.

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 (267 miles) from its origin (Hawkins 1980b; McMahon and Lloyd 1995). Through the Piedmont, the Neuse River has a relatively high gradient, and substrates tend to be rocky (McMahon and Lloyd 1995). As the river passes through the fall line into the coastal lowlands, it widens and slows with the reduced gradient. Downstream of the fall line, substrate is dominated by sand and silt (McMahon and Lloyd 1995). The Neuse River resides entirely within North Carolina and drains approximately 14,500 square km (5,598 square miles) of land, which is composed of approximately 48% forest, 30% agriculture, 9% wetlands, 6% developed lands, and 5% water (Hawkins 1980b; McMahon and Lloyd 1995). Flow regimes in the Neuse River downstream of Raleigh, North Carolina are controlled by Falls Lake Dam (river km 370; river mile 230), which was built in 1983 by the USACOE 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).

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 where it discharges into the Atlantic Ocean at Cape Fear, near Southport, North Carolina (Figure 13.1). The basin lies entirely within the state, 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).

Major tributaries include the Upper and Lower Little Rivers in Harnett County, the Black River in Bladen, Pender, and Sampson counties, and the Northeast Cape Fear River in Duplin, Pender, and New Hanover counties.

Habitat Designations

There are several different existing 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 2010 NCDMF 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 (Figures 2 and 3). The areas are delineated in NCMFC rule 15A NCAC 03R .0115 and NCWRC rule 15A 10C .0603. Anadromous fish spawning areas cover 17% and 10% of streams/shorelines and water bodies, respectively, in coastal plain portions of CHPP regions. Most AFSAs are located in the Albemarle region (70%) and include the mainstem Roanoke River, Chowan River, Alligator River, and Phelps Lake.

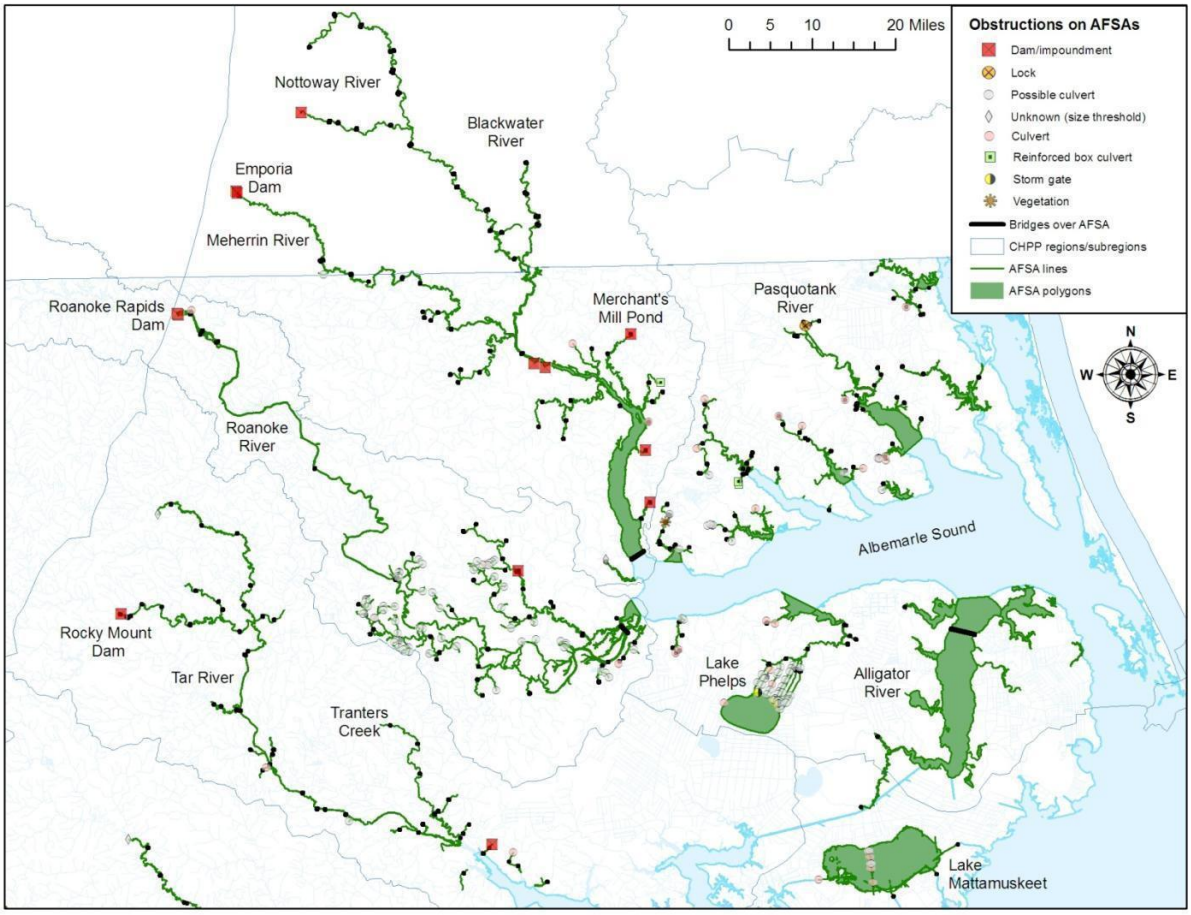

Figure 2. Anadromous fish spawning areas in the Albemarle Sound and Tar River areas.

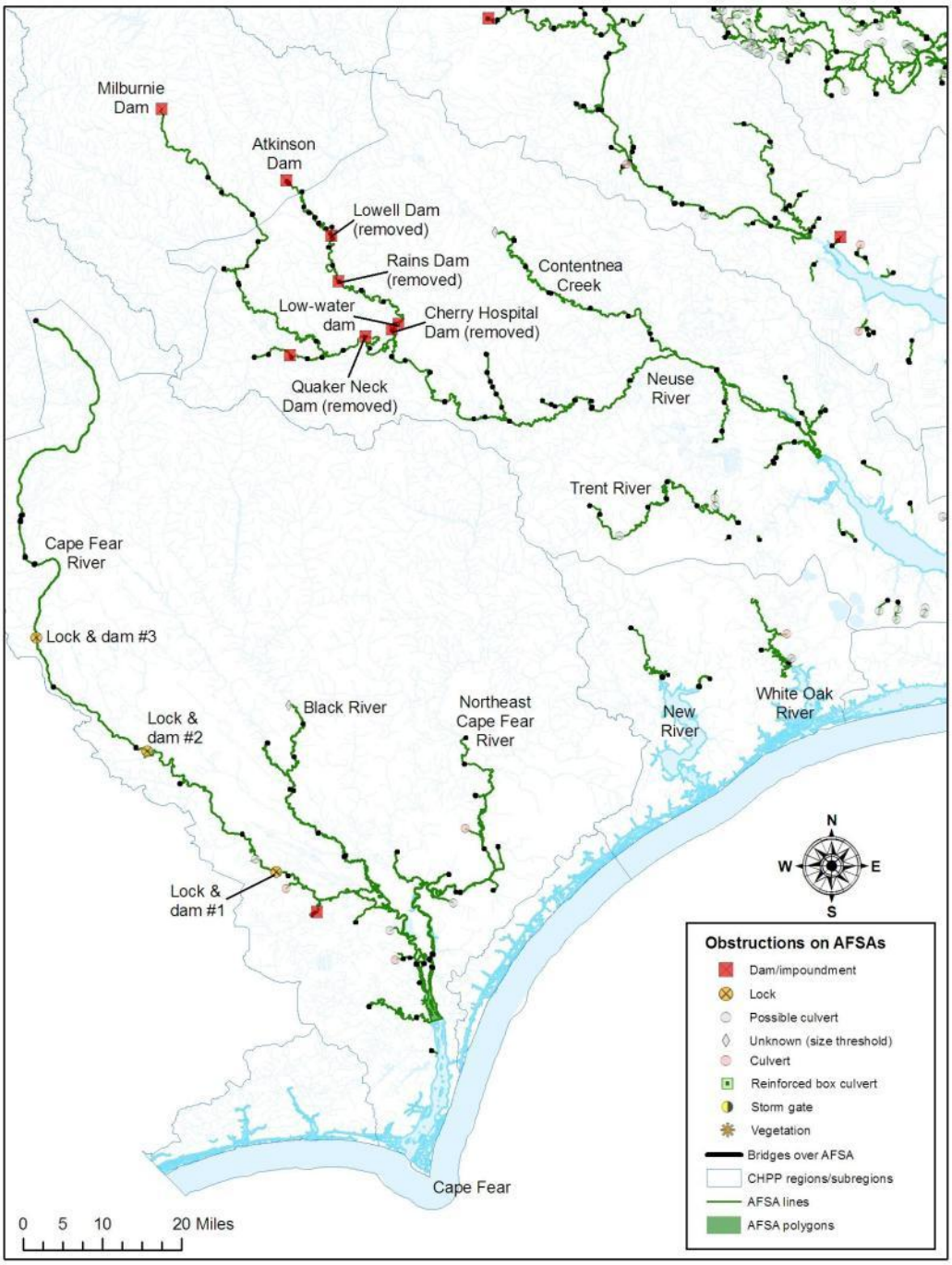

Figure 3. Anadromous fish spawning areas in the Neuse River and Cape Fear River areas.

Nursery Areas

North Carolina Primary Nursery Areas, first designated by the NCMFC in 1977, are similar in concept to Federal Habitat Areas of Particular Concern (HPAC). However, the NMFS has designated very few HAPCs (none in North Carolina), while the NCMFC/NCDMF 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 4 and 5). 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, 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 PNAs in the Albemarle/Roanoke region, but a relatively large number of IPNAs. There are approximately 162,000 acres of PNA and SNAs (Permanent and Special) in North Carolina Coastal Fishing Waters (including both water and wetlands).

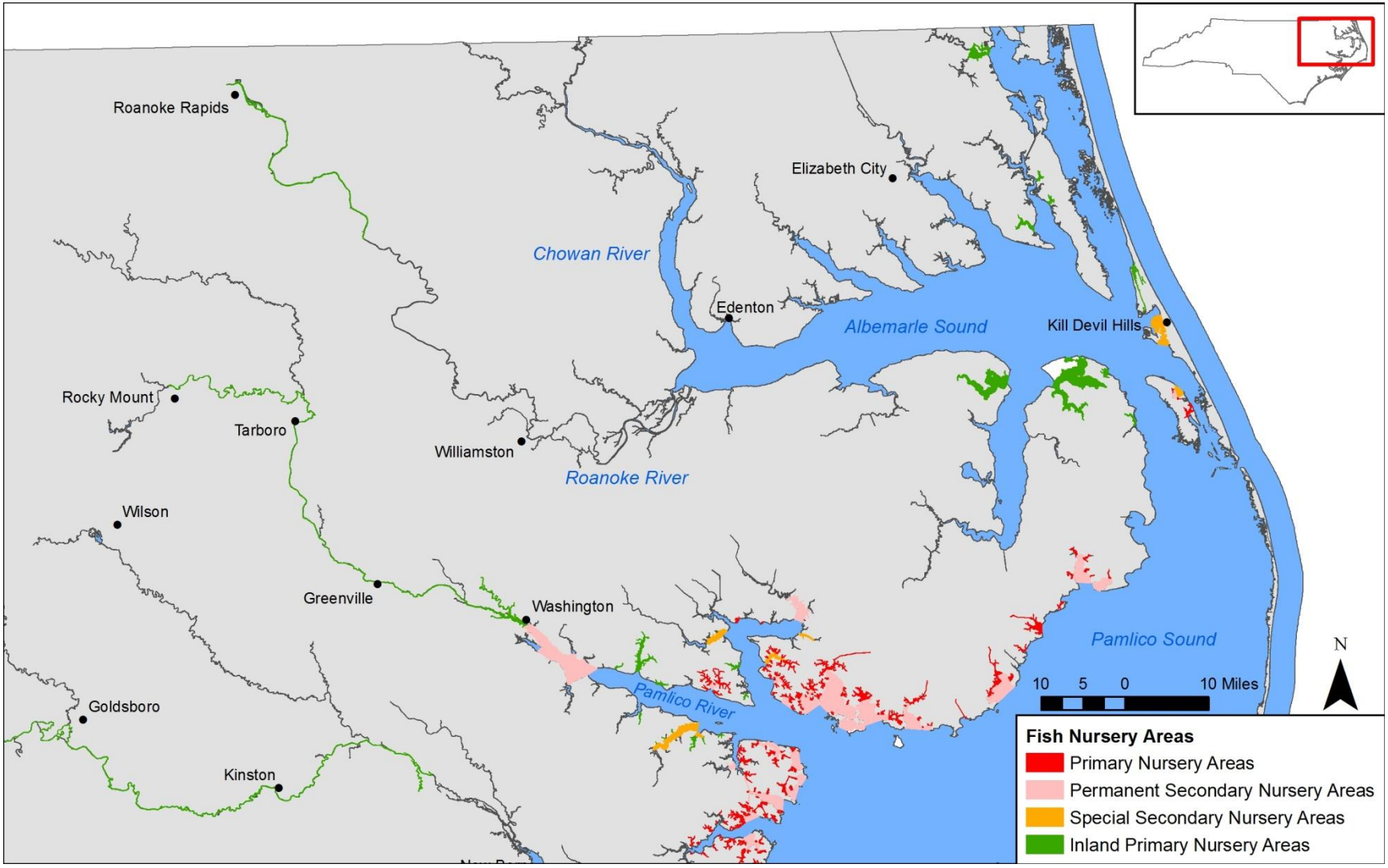

Figure 4. Nursery area designations in the Albemarle Sound and Pamlico River areas.

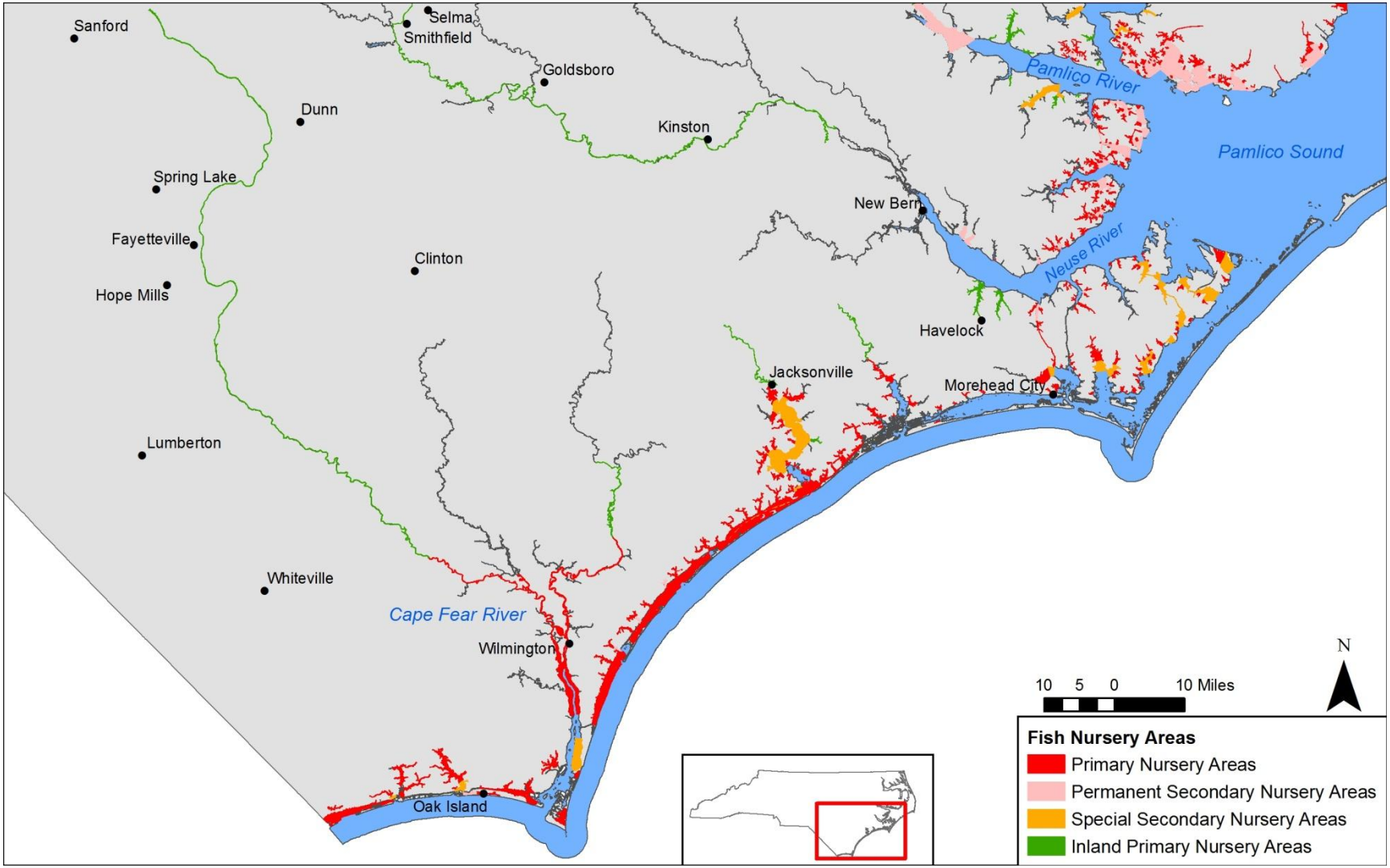

Figure 5. Nursery area designations in the Neuse River and Cape Fear River areas.

Strategic Habitat Areas (SHAs) - CHPP Chapter 8

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 6). SHAs have been identified in Region 1 and 2 (Figures 7 and 8, respectively). SHA identification is currently underway for Region 3.

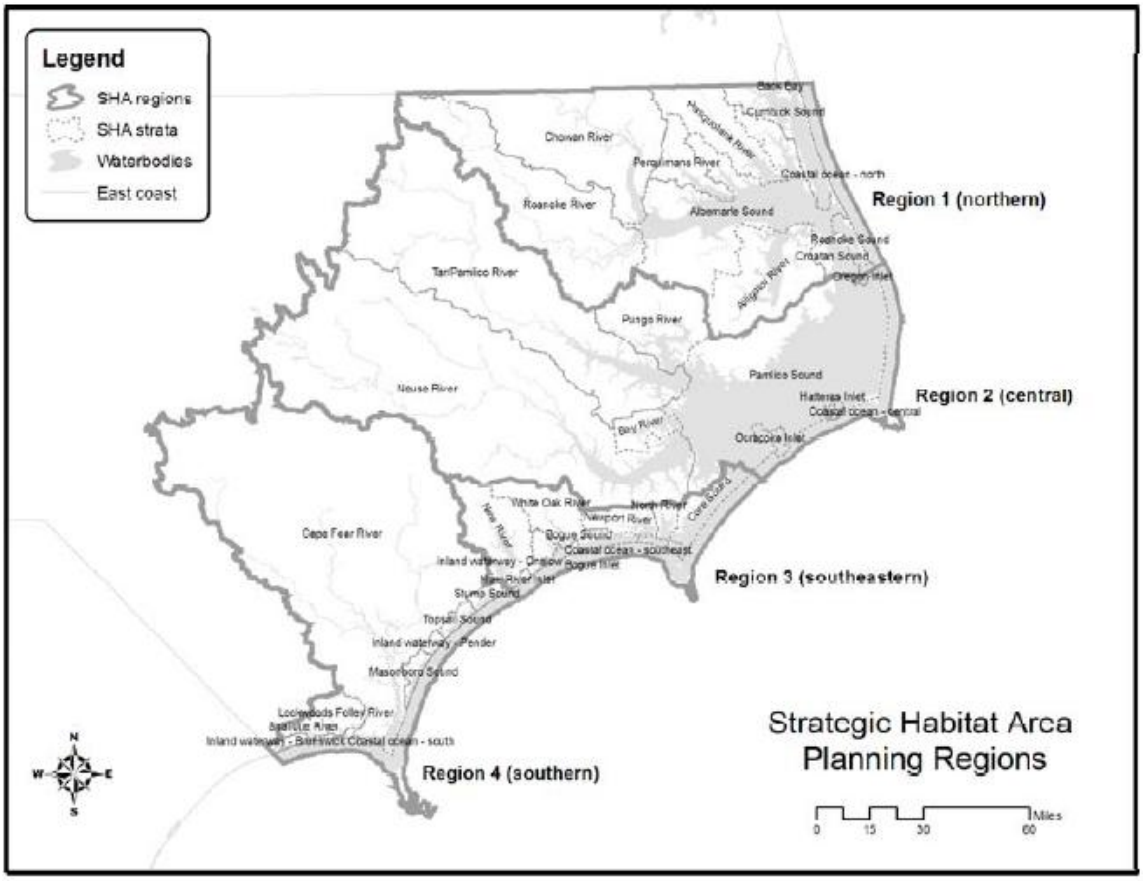

Figure 6. Geographic areas for Strategic Habitat Area (SHA) analysis.

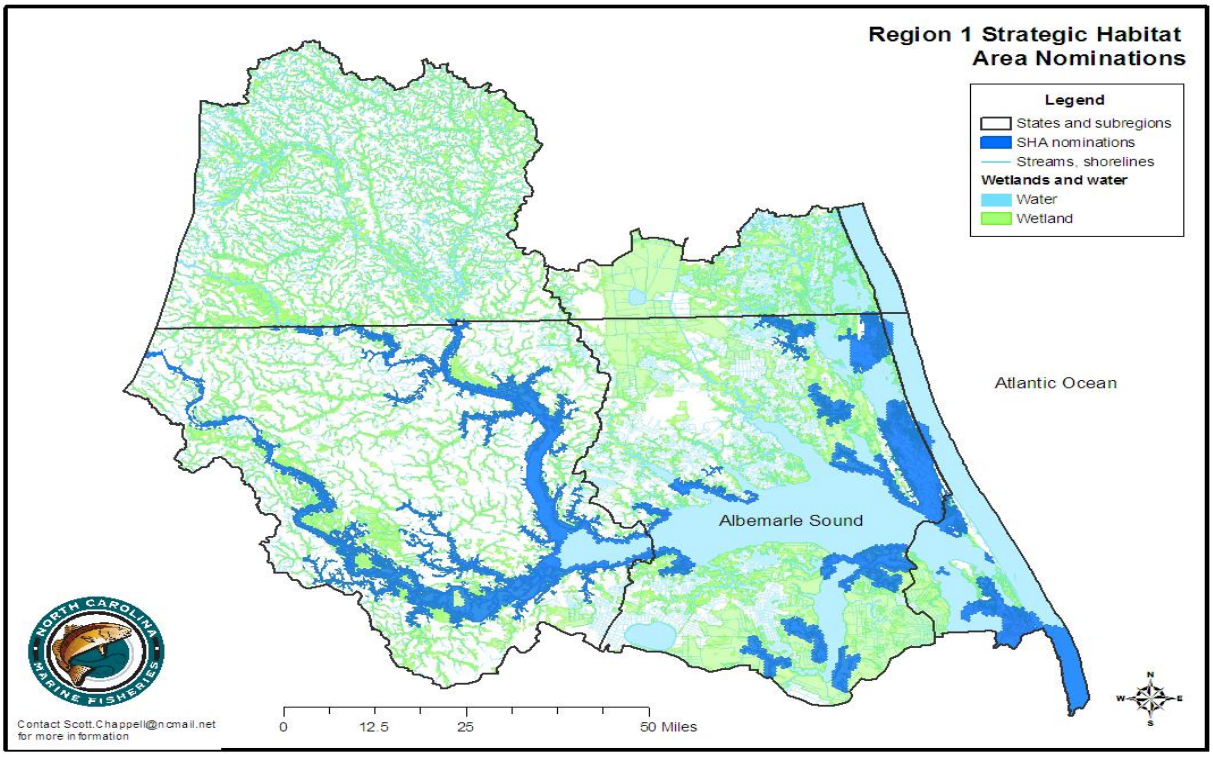

Figure 7. Region 1 strategic habitat area nominations.

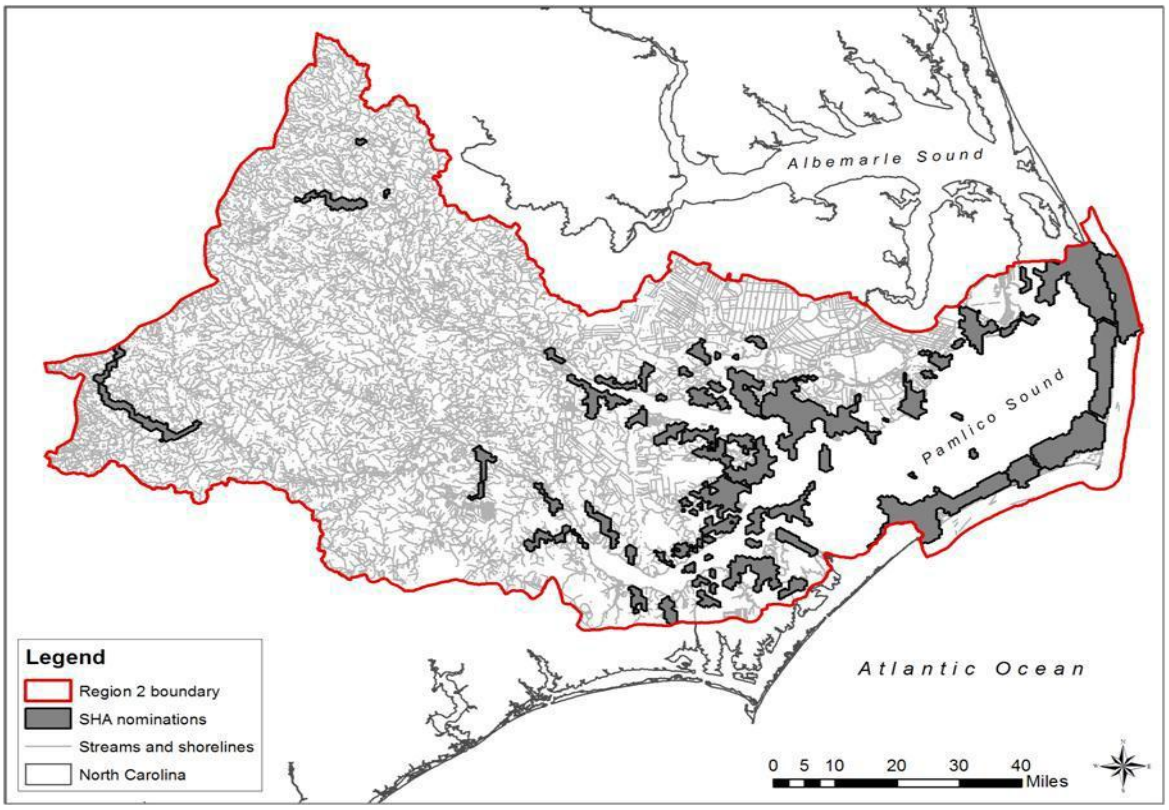

Figure 8. Region 2 strategic habitat area nominations.

Section 2: Threats Assessment

Barriers to Migration Inventory and Assessment

Dams- CHPP section 2.4.1.1

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, and Chowan watersheds. These structures primarily impact anadromous fish and the catadromous American eel spawning migrations, maps 2.5a-b in the CHPP (Deaton et al 2010). 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 SHA Assessment results (see "Ecosystem management and Strategic Habitat Areas" chapter for more information; Pg. 446). The Chowan subregion of Region 1 had the largest percent of dam-obstructed streams at 38%. CHPP Table 2.21 tallies the number of dams, locks, and culverts in CHPP regions and subregions.

Other Physical Structures- CHPP section 2.4.1.2;5.4.1.5

Based on analysis of NC DENR and NC DOT records, it has been estimated that the state loses, on average, about 500 acres of wetlands per year, mostly from road construction (see "Status and trends" section of the Wetlands 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 2.4.2

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 2.4.1.1

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 (Table 2.22). Documented water use in the state has risen from 9,286 to 10,863mgd from 1995-2008 (an increase of 1,577 mgd in 13 years).

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 2.4.2.1; 2.4.2.3;4.4.2.2

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.

Channelization and Dredging Inventory and Assessment - CHPP Section 2.4.1.3; 2.4.1.4; 4.4.1.1;5.4.1.4

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 1.5.1; 2.4.2.3

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 (Figure 1). 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.).

Atmospheric Deposition Inventory and Assessment - CHPP Section 2.4.3.3

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 - CHPP Section 2.4.5;4.4.5;5.4.4

Rising sea level is a major threat to coastal and riparian wetlands in North Carolina. Analyses of data from tide gauge stations in Hampton, Virginia, and Charleston, South Carolina, from 1921 to 2000 (Riggs 2001), show sea level rising along the Atlantic coast by about 3.35 mm per year (1.1 ft per 100 years). Gauge data specific to North Carolina are available only for 20 years, but suggest a slightly greater rate of approximately 4.57 mm per year (1.5 ft per 100 years).

The specific effects of climate change, including warming water, increased drought severity, and loss of flood plain spawning habitat should be further investigated.

Competition and Predation by Invasive and Managed Species Inventory and Assessment - CHPP 2.4.4; 4.4.3;5.4.3

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).

For aquatic plants the most troublesome species in low-salinity estuarine waters are Eurasian water milfoil and hydrilla. It is possible for water milfoil 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 DO levels. Weed control activities in coastal waters are primarily focused on these species. Control activities target areas where native species are not the dominant species based on site assessments (R. Emens DWR, 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 is unknown. Flathead catfish do not appear to be an issue in the Albemarle Sound region but they have been collected by NCDMF throughout coastal waters (NCDMF unpublished data). The NCDMF has no regulations for the taking of invasive catfish in NC. With no regulations present it will help to keep these catfish populations low.

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 9.4). 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 on at the dam does not effectively pass fish upstream. Removing or bypassing these dams would open access to many miles of potential spawning habitat. Recent fish passage in the Chowan watershed includes only the Bennett's Creek dam creating Merchant's Mill Pond (Mike Wicker USFWS, personal communication, 2005). The effectiveness of dam removal/bypassing in river herring recovery will depend on whether the runs have been extirpated from the entire stream reach impounded.

Roanoke River

Currently, numerous large and small dams are present in the Roanoke River Basin. Roanoke Rapids Dam at river mile 137 is the lowermost dam on the mainstem of the river. Roanoke Rapids Dam impounds the river to Gaston Dam at river mile 145. Gaston Dam impounds the river to river mile 170, below Kerr Dam at river mile 179. Kerr Dam impounds the river up the Dan River to river mile 206, and up the Staunton River to river mile 212 (Laney et al. 2001). Currently the Mid-East Resource Conservation and Development Council are working with APNEP and the NCWRC to restore river herring passage and habitat at the Hoggard Mill Pond in the headwaters of the Cashie River (J. Hawhee, APNEP, personal communication 2013).

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 Rocky Mount Mills Dam is a small hydro-dam that conducts peaking operations to produce electricity. Removal of the dam is unlikely due to the fact that the City of Rocky Mount has a water supply intake just above the dam and the dam is listed as a state historical site. However, discussions with the current owner, Capitol Broadcasting, Inc., are ongoing regarding the possibility of improving water flows downstream, and providing upstream passage for American shad. If water flows can be improved, this would be beneficial for all species using the Tar River, including river herring. Two other Tar River dams further upstream are considered to be within the range of anadromous fish migration, but are not currently accessible (Collier and Odom 1989).

Neuse River

The first blockage in the Neuse River is Milburnie Dam at river mile 183. The next obstruction is Falls of Neuse Dam at 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).

Removal of Milburnie Dam would allow the United States Army Corps of Engineers (USACE) some latitude to provide a stable flow regime for the Neuse and provide access to another 10-20 miles of riverine habitat for spawning. The owner of the dam has expressed an interest in removing the dam. The NCDWQ has expressed concern over removal of Milburnie Dam, due to possible loss of wetlands associated with the dam. In March 2010, the USACE received a prospectus to utilize the 29,000 linear feet of the Neuse River above the Milburnie Dam as a mitigation bank for state and federal permits. The applicant hopes to begin a phased removal of the dam in the fall 2013.

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 51 river miles of Little River to the Neuse River and 147 river miles including Little River tributaries. Near Goldsboro there is the water withdrawal and treatment structure but it has been breached. This structure may still impede striped bass migrations during low flow years (W. Laney, USFWS, personal communication 2010). Full removal of this dam is not an option since it is the City of Goldsboro back up water intake structure so American Rivers has been working with the City to develop fish passage at this location.

The highest priorities for dam removal are Milburnie Dam on the mainstem Neuse River and the remaining dam on the Little River near Goldsboro (Atkinson Mill Dam), in the Neuse subregion (M. Wicker/USFWS, pers. com., March 2010).

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. The Cape Fear River may provide the best opportunity for remediation of obstructions. The Corps constructed a rock ramp fish passage for the lower most lock and dam, and is in discussions with resource agencies to design and construct fish passages on the other two locks and dams. There are water supply intakes above all three dams which prevents them from being removed.

Hatchery Product Supplementation Program

State and federal fisheries management agencies in North Carolina and Virginia finalized negotiations with Dominion/N.C. Power with regards to relicensing of the Gaston and Roanoke Rapids lakes hydroelectric dams through the Federal Energy Regulatory Commission (FERC). 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.

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 funded by the North Carolina Department of Transportation as mitigation for aquatic habitat damages resulting from highway bridge construction on the Roanoke River. Annual production and stocking information can be found in North Carolina's annual Shad and River Herring Compliance reports.

Water Quality Improvement Program

As noted in the Introduction, two-year Implementation Plans are developed by the staffs of the NC Division of Water Quality, NC Division of Coastal Management, NCDMF and NC WRC, in conjunction with the CHPP Steering Committee, detailing specific steps towards achieving CHPP goals and objectives. One of the four major goals of the CHPP is "Protect and enhance water quality" and significant cooperation among agencies has occurred in pursuit of this goal. Appendix 1 contains the most recent Implementation Plan (2011-2013), and outlines specific items regarding water quality, while Appendix 2 contains the most recent CHPP Annual Report, which details progress on items contained in the Implementation Plan.

The North Carolina General Assembly also recognized the importance of water quality to habitat integrity, as illustrated by its creation of the Clean Water Management Trust Fund (CWMTF) in 1996. The original purpose of the fund was to provide grant assistance for projects and land purchases that would specifically improve water quality. Previously, the CWMTF had a budget of up to $100,000,000, but in the past two years (2011 and 2012), the budget has been dramatically reduced to less than $50,000,000.

In 2010, the North Carolina General Assembly directed the NCDENR to develop hydrologic models for each river basin in N.C. An important part of this bill requires the department to determine the flows needed to maintain ecological integrity in surface waters. The bill further authorized the creation of a Science Advisory Board (SAB) to assist the department in assessing these ecological flows. Members of the SAB include staff from the NCDMF, NCWRC,

USGS, and NMFS as well as several other government agencies and non-government organizations. The SAB is expected to make their recommendations by the end of 2013.

Habitat Improvement Program

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 documents contained in Appendices 1 and 2 detail the components of and progress towards several efforts aimed at improving fisheries habitat in North Carolina.

In addition to the water quality goals noted in the previous section, the CWMTF has monies available to buy existing dams or have them opened for fish passage. The CWMTF receives input from both NCDMF and NCWRC on where fisheries priorities exist in the state. 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. The Southeast Aquatic Resources Partnership is partnering with the Nature Conservancy to perform a GIS assessment that will prioritize barriers to aquatic resources movement for removal. This assessment, the Southeast Aquatic Connectivity Assessment Project, will prioritize on both the regional and state scales. Researchers at East Carolina University (R. Rulifson and J.P. Walsh) are in the process of 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

NCDMF participates in an extensive permit review process that is coordinated by the NC Division of Coastal Management on behalf of15 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.

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