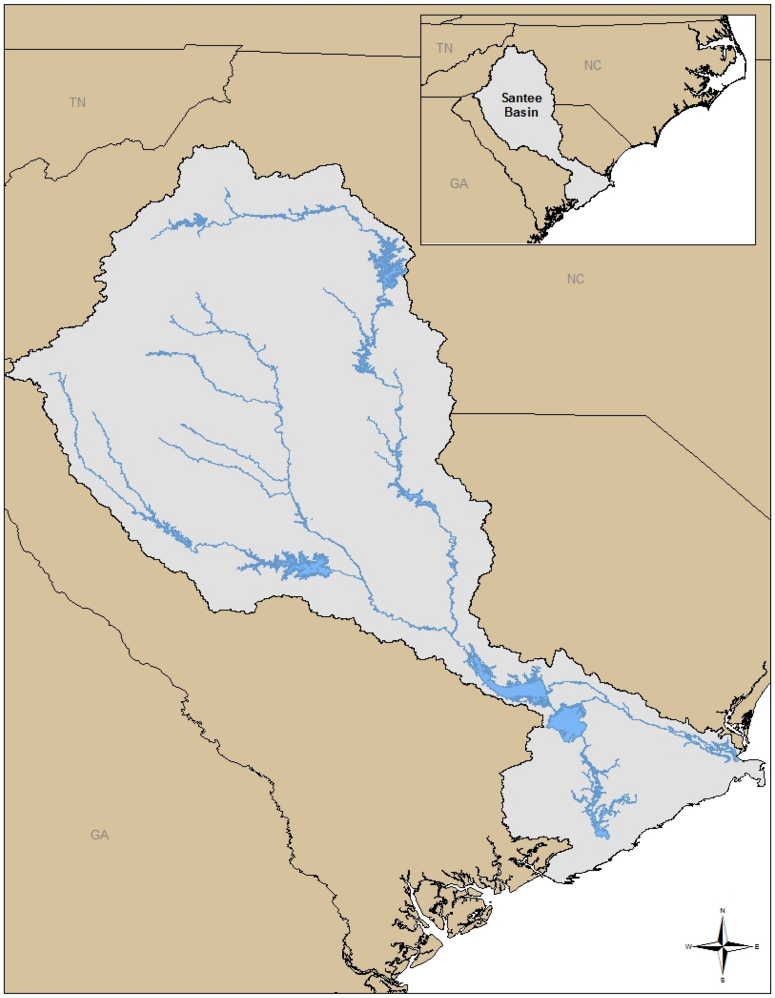
SANTEE BASIN

DIADROMOUS FISH RESTORATION PLAN



PREPARED BY:

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ACRONYMS AND ABBREVIATIONS

ASMFC	Atlantic States Marine Fisheries Commission
Accord	Santee River Basin Accord for the Protection, Restoration, and Enhancement of Diadromous Fish
CRA	Comprehensive Relicensing Agreement
CPUE	Catch per Unit Effort
Duke Energy	Duke Energy Carolinas, LLC
ESA	Endangered Species Act
FERC	Federal Energy Regulatory Commission
FWS	U.S. Fish and Wildlife Service
HEP	Habitat Enhancement Program
IFMP	Interstate Fisheries Management Plan
NCWRC	North Carolina Wildlife Resources Commission
NMFS	National Marine Fisheries Service
OTC	Oxy-tetracycline
Plan	*Santee Basin Diadromous Fish Restoration Plan*
ROR	Run-of-River
Santee Cooper	South Carolina Public Service Authority
Santee Basin	Santee River Basin
SCDHEC	South Carolina Department of Health and Environmental Control
SCDNR	South Carolina Department of Natural Resources
SCE&G	South Carolina Electric & Gas
USACE	U.S. Army Corps of Engineers
YOY	Young-of-the-Year

EXECUTIVE SUMMARY

This document updates and replaces the *Santee-Cooper Basin Diadromous Fish Passage Restoration Plan* developed by the U.S. Fish and Wildlife Service (FWS), National Marine Fisheries Service (NMFS), and South Carolina Department of Natural Resources (SCDNR) in 2001. Diadromous fishes have habitat needs in both freshwater and marine environments, and thus migrate between these environments. Diadromous species present in the Santee River Basin (Santee Basin) include Atlantic Sturgeon, Shortnose Sturgeon, American Eel, American Shad, Hickory Shad, and Blueback Herring. All of these species are listed as priority species, “species of greatest conservation need”, in the 2015 South Carolina State Wildlife Action Plan (SWAP).

The Santee Basin currently supports some of the largest populations of diadromous fishes on the east coast of the United States, yet population levels remain depleted compared to historical levels (ASMFC 2007a, 2012a, d). The most recent stock assessment of American Shad was conducted 10 years ago by the Atlantic States Marine Fisheries Commission (ASMFC) and reported stocks on the east coast of the United States were at all-time lows (ASMFC 2007a). This report identified the primary causes for stock declines as a combination of excessive total mortality, habitat loss and degradation, and impediments to spawning migrations and spawning habitat. The most recent stock assessments for American Eel (ASMFC 2012a), Blueback Herring (ASMFC 2012d), and Atlantic Sturgeon (Atlantic Sturgeon Status Review Team 1998), indicate populations of these species are also depleted or at all-time lows on the east coast of the US.

The 2001 edition of the *Santee-Cooper Basin Diadromous Fish Passage Restoration Plan* addressed the restoration of diadromous fishes by focusing primarily on restoring access to former spawning and maturation sites. A number of significant accomplishments resulted from the objectives of that plan, including construction of a fish ladder at the Columbia Diversion Dam (Columbia Fishway) to provide passage for American Shad and Blueback Herring to access about 24 miles of spawning habitat on the Broad River; establishment of science-based instream flows at five hydroprojects; and establishment and implementation of the Santee River Basin Accord for the Protection, Restoration, and Enhancement of Diadromous Fish (Accord) that created programs to conduct American Shad fry stocking and evaluate success; monitor juvenile American Shad recruitment and outmigration; identify spawning migration movement patterns of adult American Shad; identify critical spawning habitat of American Shad; monitor the spawning migrations and habitat utilization of Shortnose Sturgeon; identify presence of American Eel; and

collect life history information of diadromous fishes. As a "living" document, it is the intent of the FWS, NMFS, and SCDNR to periodically review and revise the Plan as needed. The current revision of the Plan is timely because a number of factors affecting the restoration of diadromous fishes have changed since 2001, including: 1) Federal Energy Regulatory Commission (FERC) relicensing of a number of hydroelectric projects in the Santee Basin, which afforded the opportunity to address fish passage and other diadromous fish restoration interests; 2) formation of the Accord in 2008, which formed a partnership with the primary objective of restoring and enhancing diadromous fish populations; 3) a significant amount of new information coming from the Accord addresses diadromous fish migrations within the basin, identifies spawning habitat, and furthers the understanding of the life histories of diadromous fishes to be considered in future management strategies; 4) stocking of American Shad fry in the Santee Basin; and 5) the 2012 NMFS listing of the Carolina Distinct Population segment of Atlantic Sturgeon as endangered and their 2016 proposed Critical Habitat.

The goal of the Santee Basin Diadromous Fish Restoration Plan (Plan) is to provide guidance and coordination to the resource agencies in protecting, enhancing, and restoring Santee Basin diadromous fish populations throughout the basin, compatible with established aquatic communities. The Plan identifies five objectives and recommends management measures to meet those objectives. Those objectives address 1) instream flows, 2) water quality, 3) habitat protection, 4) upstream and downstream fish passage, and 5) population enhancement and monitoring.

I. Introduction

Diadromous fishes migrate between fresh water and marine environments and include anadromous and catadromous species. Because of their freshwater and estuarine/marine habitat requirements, diadromous fishes are vulnerable to the many threats and potential sources of injury and mortality associated with these different habitats. Anadromous fishes spend most of their adult lives in marine environments and migrate to fresh water to spawn. Along the Atlantic Coast, these include Sea Lamprey (*Petromyzon marinus*), Atlantic Sturgeon (*Acipenser oxyrinchus*), Shortnose Sturgeon (*Acipenser brevirostrum*), American Shad (*Alosa sapidissima*), Hickory Shad (*Alosa mediocris*), Alewife (*Alosa pseudoharengus*), Blueback Herring (*Alosa aestivalis*), and Striped Bass (*Morone saxatilis*). Records of the Sea Lamprey and Alewife in the Santee River Basin (Santee Basin) are extremely scarce (Rohde et al. 2009, ASMFC 2012d). Striped Bass populations south of Cape Hatteras, North Carolina inhabit inshore waters throughout their lives and are considered to be potamodromous rather than anadromous and are managed as a reservoir species. For these reasons, Sea Lamprey, Alewife, and Striped Bass are not included in this Santee Basin Diadromous Fish Restoration Plan (Plan) as target species. Shortnose Sturgeon in the Santee Basin are estuarine anadromous, spending most of their adult lives in estuarine water and migrating to fresh water to spawn. However, a segment of the population is “dam-locked” spending its entire life cycle in the Santee Cooper lakes. Catadromous fishes spend most of their adult lives in fresh water and migrate to marine environments to spawn, and the only catadromous fish in the Santee Basin is the American Eel (*Anguilla rostrata*).

Diadromous fishes are important to North Carolina and South Carolina for a number of economical, ecological, and recreational reasons. Adult American Shad and Blueback Herring sustain commercial fisheries in the Santee Basin. They provide economic benefits from the direct sale of landings and indirectly from the purchase of items such as nets and other fishing supplies, boats, motor fuel, accommodations, and travel expenses. Both species provide ecological benefits by providing forage for fishes and birds residing in the system. The carcasses of American Shad provide marine-derived organic material, an ecologically significant mechanism of nutrient and energy transport from the marine ecosystem to fresh water (Garman 1992). American Shad and Blueback Herring support seasonal sport fisheries in the Santee Basin, which provides recreational and economic benefits, and American Shad are valued for their flesh and roe. Hickory Shad historically supported a commercial fishery in North Carolina, which is considered the center of abundance for this species on the East Coast (ASMFC 1999). They are targeted by recreational anglers in other states, but little information is available regarding their life history or population status in South Carolina (Rohde et al. 2009).

Diadromous fish populations on the East Coast are generally in a state of decline, based on the most recent stock assessments. The 2007 Atlantic States Marine Fisheries Commission (ASMFC) stock assessment for American Shad found that stocks were at all-time historical lows coast wide and did not appear to be recovering to acceptable levels (ASMFC 2007a). The primary causes for these declines were identified as a combination of excessive total mortality, habitat loss and degradation, and migration and habitat access impediments (ASMFC 2007a). Although improvement has been seen in a few American Shad stocks, many remain severely depleted compared to their historic levels (ASMFC 2007a).

Commercial landings of river herring, which include Blueback Herring and Alewife, have been monitored since colonial times. However, since Alewife and Blueback Herring are difficult to tell apart, commercial landings cannot be separated by species and are reported as “river herring.” A recent assessment of river herring stocks included historical landings back to 1887. According to that assessment, the reported commercial landings of river herring in most river systems peaked in 1965 and declined steadily and rapidly after that (ASMFC 2012e). In response to decreasing populations of river herring, Massachusetts, Rhode Island, Connecticut, Virginia, and North Carolina implemented moratoria on the commercial herring fishery. Virginia’s moratorium closed rivers that drain into North Carolina. In August 2011, the National Resources Defense Council petitioned the National Marine Fisheries Service (NMFS) to list river herring as threatened under the Endangered Species Act (ESA); however, following review of a comprehensive stock assessment conducted in 2012, NMFS determined that a listing was not warranted[1]. Although river herring are caught by recreational anglers, both as a target species and as bait for other gamefish like Striped Bass, there are very little data on recreational landings (ASMFC 2012e).

Both species of sturgeon found in the Santee Basin once supported a commercial fishery. However, due to pollution, overfishing, and habitat loss, the U.S. Fish and Wildlife Service

[1] 78 FR 48944; Aug 12, 2013

(FWS) listed Shortnose Sturgeon as endangered under the Endangered Species Preservation Act, the precursor to the ESA, in 1967[2] and NMFS listed two distinct population segments of Atlantic Sturgeon that spawn in the southeast as endangered in 2012[3].

Based on the most recent stock assessment, American Eel stocks are depleted on the east coast of the United States (ASMFC 2012a). According to that assessment, habitat loss from dams or urbanization; turbine mortality of adults associated with downstream migrations; mortality associated with infections of the nonnative swim-bladder parasite *Anguillicolla;* toxic pollutants; climate change; and fishing mortality have contributed to this decline. In 2010, the Center for Environmental Science Accuracy and Reliability petitioned the FWS to list American Eel as threatened under the ESA; however, following a comprehensive review of American Eel stocks, the FWS in coordination with NMFS determined a listing was not warranted[4].

Currently, the Santee Basin supports some of the largest populations of anadromous fishes on the east coast of the United States, yet population levels remain depleted compared to historical levels. Varying factors contribute to this decline. For example, hydrologic modification, which includes flow alterations, stream channelization or modification, and dam construction, can degrade water quality, reduce instream flows and habitat, increase streambank and shoreline erosion, impede upstream access to spawning or maturation habitats, and permanently inundate riverine spawning habitat. The Santee Basin has experienced a number of very large hydrologic modifications, including the Santee Cooper Power and Navigation Project, completed in 1942, and the Cooper River Rediversion Project, completed in 1985. Other large-scale modifications include hydropower projects in the Catawba-Wateree sub-basin, the Broad River sub-basin, and the Saluda River sub-basin. Completion of most of these projects occurred during the late 1800s through 1935.

Other factors potentially contributing to the decline of diadromous fishes along the East Coast include sedimentation; water quality issues (e.g., toxic and thermal wastewater discharges); low concentrations of dissolved oxygen; consumptive water withdrawals; competition and predation by invasive and managed species; illegal fisheries activities; and excessive harvest (ASMFC 2010). Furthermore, acid rain, atmospheric deposition of aluminum, climate change may

[2] 32 FR 4001; Mar. 11, 1967
[3] 77 FR 5914; Feb. 6, 2012
[4] 80 FR 60834; Oct. 8, 2014

adversely impact these fishes by increasing salinity in coastal rivers, reducing freshwater habitat, and increasing ocean temperatures (ASMFC 2010).

Progress has been made in addressing some of these factors in the Santee Basin. Water quality has generally improved since implementation of the Clean Water Act (1972)[5]. Best Management Practices established and implemented through the United States Department of Agriculture – Natural Resources Conservation Service and the North Carolina and South Carolina natural resource agencies have significantly reduced sedimentation due to agriculture and silviculture. In addition, access to upstream riverine spawning habitat for American Shad and Blueback Herring has improved due to the continued operation of the Pinopolis Navigation Lock and St. Stephen Fish Lock, and the construction and operation of the Columbia Fishway. A number of projects have enhanced instream flows, and information collected through the Santee Basin Accord for the Protection, Restoration, and Enhancement of Diadromous Fish (Accord) has led to a better understanding of life history, population dynamics, and habitat needs of several diadromous species. Finally, changes have been made to the South Carolina commercial fishery regulations, which included closure of the ocean intercept fishery for American Shad in 2005, followed by the implementation of ASMFC Sustainable Fishery Plans for both river herring (Blueback Herring) and American Shad in 2012 and 2013, and American Eel in 2013.

A. Need for a Plan

A Santee Basin Diadromous Fish Restoration Plan is useful for many reasons. Due to declines in population levels, diadromous fish restoration is a management interest of several agencies, including the FWS, NMFS, ASMFC, the North Carolina Wildlife Resources Commission (NCWRC), and the South Carolina Department of Natural Resources (SCDNR). However, the legislated authorities and responsibilities of these agencies differ, and there is a need to identify and communicate agency priorities, coordinate management responsibilities, and develop restoration goals that can be mutually endorsed and pursued.

NMFS currently oversees administration of the ESA for Atlantic Sturgeon and Shortnose Sturgeon. To maximize the benefits of any protection, restoration, or mitigation efforts for these species, all agencies and interested parties should participate in restoration planning.

Because the Santee Basin is a highly dynamic and modified system, diadromous fish

[5] 33 U.S.C. § 1251 et seq.

management activities should be coordinated and balanced with other freshwater and marine fisheries management programs. This will help to maximize the success of diadromous fish restoration efforts, minimize unintended consequences on other fisheries management programs, and maximize the available funding for these efforts.

This plan also provides an opportunity to summarize progress made in diadromous fish restoration since the publication of the 2001 Plan. Examples of progress include identification of new life history information, implementation of enhanced instream flows, hatchery augmentation of American Shad stocks, and construction of and planning for new fish passage facilities. The Plan also identifies a strategy for addressing restoration efforts for the next 10 - 15 years by identifying information needs (research) and potential resource enhancements, including instream flows, habitat protection, and fish passage. While the Resource Agencies are responsible for implementing this Plan, the establishment of an implementation team consisting of representation from interested utilities and NGO's is anticipated.

B. Santee Basin Description

The Santee Basin, originating in the Blue Ridge Mountains of North Carolina, is the second largest watershed on the East Coast (Hughes 1994), encompassing about 16,780 square miles (10,739,200 acres) which includes 12,000 square miles in South Carolina and 4,780 square miles in North Carolina (Figure 1) (Table 1) (SCDHEC 2007, NCDENR 2008, NCDENR 2010, SCDHEC 2012a, SCDHEC 2012b, SCDHEC 2013). The South Carolina Department of Health and Environmental Control (SCDHEC) recognizes five river sub-basins of the Santee Basin: the Catawba-Wateree River sub-basin, the Broad River sub-basin, the Saluda River sub-basin, the Congaree River sub-basin, and the Santee River sub-basin (Figure 2) (Wachob et al. 2009). While not considered a sub-basin of the Santee Basin, we have included the Cooper River sub-basin in this Plan because of its hydrological connection to the Santee Basin and importance to diadromous fish populations. With the completion of the Santee Cooper Diversion Project in 1942, dams and a diversion channel linked the Cooper River sub-basin to the Santee Basin.

Figure 1. The Santee Basin

Table 1. Watershed and land use properties of the sub-basins in the Santee Basin

Watershed Parameters												
Sub-basin	Catawba-Wateree			Broad				Saluda	Congaree	Santee	Cooper	
River system	Catawba	Wateree	Total	Broad	Tyger	Enoree	Total	Saluda	Congaree	Santee	Cooper	Total
Hydrologic units	03050101, 03050102, 03050103	3050104		03050105, 03050106	3050107	3050108		3050109	3050110	03050111, 03050112	3050201	
10-digit watersheds	27	4	31	23	5	5	33	14	4	5	7	94
NC	25*	0	25	13*	0	0	13	0	0	0	0	38*
SC	7*	4	11	17*	5	5	27	14	4	5	7	68*
Square miles	4,334	1,257	5,591	3,963	808	731	5,502	2,523	689	1,249	1,226	16,780
NC	3,267	0	3,267	1,513	0	0	1,513	0	0	0	0	4,780
SC	1,067	1,257	2,324	2,450	808	731	3,989	2,523	689	1,249	1,226	12,000
Stream miles	6,415	2,729	9,144	4,306	973	919	6,198	5,609	1,165	1,828	1,808	25,752
NC	3,005	0	3,005	1,508	0	0	1,508	0	0	0	0	4,513
SC	3,410	2,729	6,139	2,798	973	919	4,690	5,609	1,165	1,828	1,808	21,239
Lakes/ Impounded waters (square miles)	116	1,250	1,366	22.8	4.5	1.6	28.9	108	8	114	95	1,719.9
NC	94	0	94	0.0	0	0	0	0	0	0	0	94
SC	22	1,250	1,272	22.8	4.5	1.6	28.9	108	8	114	95	1,625.9
Estuarine areas (square miles)	0	0		0	0	0		0	0	8.5	33.3	41.8
NC	0	0		0	0	0		0	0	0	0	0
SC	0	0		0	0	0		0	0	8.5	33.3	41.8
Land Use												
% Agricultural (NC/SC)	19/22.9	0/18.1		23/23.8	0/25.7	0/22.3		0/26.1	0/26.6	0/15.8	0/6.1	
% Barren land	0/0.4	0/0.7		0/0.9	0/1.1	0/1.2		0/1.0	0/0.3	0/0.2	0/0.6	
% Developed (NC/SC)	21/14.2	0/6.8		9/9.8	0/12.9	0/14.2		0/12.9	0/17.9	0/0	0/15.2	
% Forested (NC/SC)	55/59.5	0/56.4		66/60.6	0/55.7	0/57.7		0/53.7	0/34.6	0/33.0	0/34.5	
% Forested wetland (NC/SC)	0/0.9	0/15.2		0/2.1	0/3.0	0/3.4		0/2.1	0/19.0	0/30.8	0/25.7	
% Non-forested wetland (NC/SC)	0/0	0/0.5		0/0	0/0	0/0		0/0	0/0.3	0/5.6	0/6.6	
% Scrub/shrub (NC/SC)	0/0	0/0		0/1.2	0/0.7	0/0.7		0/0	0/0	0/0	0/0	
% Scrub/shrub, grasslands, barren land (NC/SC)	4.5/0	0/0		0/0	0/0	0/0		0/0	0/0	0/0	0/0	
% Urban land (NC/SC)	0/0%	0/0		0/0	0/0	0/0		0/0	0/0	0/3.4	0/0	
% Water (NC/SC)	0/2.1	0/2.3		0/1.6	0/0.9	0/0.5		0/4.2	0/1.3	0/11.2	0/11.3	
% Wetland (NC/SC)	0.5/0	0/0		0/0	0/0	0/0		0/0	0/0	0/0	0/0	

*Some watersheds extend across both North Carolina and South Carolina

Figure 2. Sub-basins of the Santee Basin

A description of each of the river sub-basins follows:

Catawba-Wateree River Sub-basin: This sub-basin, along with the Broad River sub-basin, forms the headwaters of the Santee Basin and is subdivided into 31 10-digit watersheds within North Carolina and South Carolina (Figure 3). It encompasses the Catawba-Wateree River system covering approximately 5,591 square miles including 3,267 square miles in the Blue Ridge Mountains and North Carolina Piedmont and 2,324 square miles in the South Carolina Piedmont, Sandhills, and Upper Coastal Plain (Table 1) (NCDENR 2010, SCDHEC 2012a).

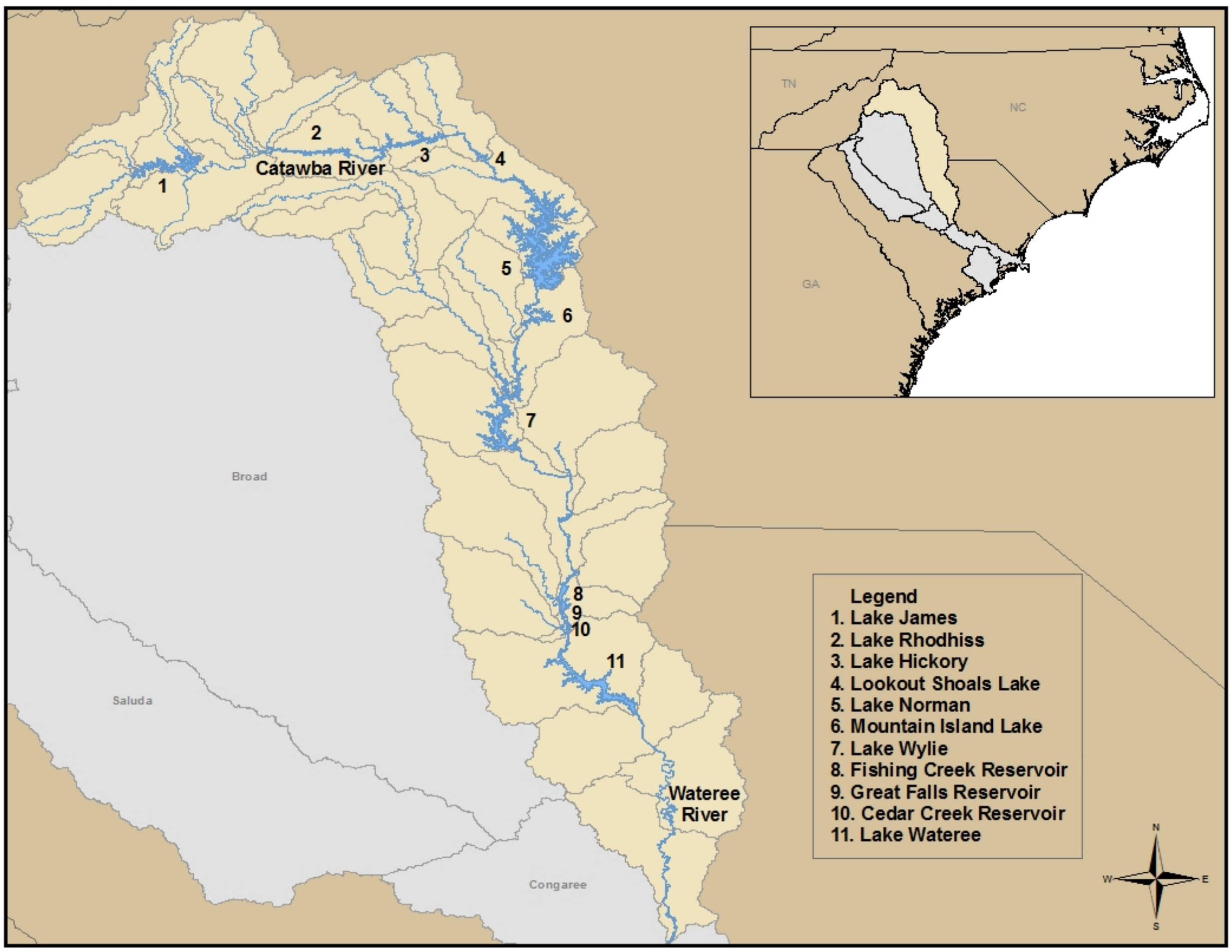

Figure 3. The major rivers, lakes, reservoirs, and 10-digit watersheds of the Catawba-Wateree River Sub-basin.

The Catawba River system (hydrologic units 03050101, 03050102, and 03050103) extends from the Blue Ridge Mountains of North Carolina to the South Carolina Piedmont. A series of hydropower reservoirs flowing through Lake James, Lake Rhodhiss, Lake Hickory, Lookout Shoals Lake, Lake Norman, Mountain Island Lake, Lake Wylie, Fishing Creek Reservoir, Great Falls Reservoir, and Cedar Creek Reservoir regulate the main stem of the Catawba River. Below Cedar Creek Reservoir, the Catawba River joins Big Wateree Creek to form the Wateree River and Lake Wateree. The Catawba River system encompasses 27 10-digit watersheds covering approximately 4,334 square miles (Table 1) (NCDENR 2010, SCDHEC 2012a). Several portions of the Catawba River system have been identified as waterbodies of significant importance including Wilson Creek in North Carolina, listed as a National Wild and Scenic River (NCDENR 2010), and a 30-mile section of the Catawba River beginning at the base of Lake Wylie Dam, designated as a South Carolina Scenic River (SCDHEC 2012a).

The Wateree River system (hydrologic unit 03050104) extends across the Piedmont, Sandhills, and Upper Coastal Plain portions of South Carolina. The Wateree River, formed where the Catawba River joins Big Wateree Creek, flows through Lake Wateree and merges with the Congaree River to form the Santee River. This system encompasses four 10-digit watersheds covering approximately 1,257 square miles (Table 1) (SCDHEC 2012a).

Historical diadromous fish habitat in the Catawba-Wateree River sub-basin extends into North Carolina (FWS et al. 2001), but based on the results of a number of studies conducted under the Accord, diadromous fish populations are presently much lower in this sub-basin than in the Broad, Congaree, Santee, and Cooper sub-basins.

Broad River Sub-basin: This sub-basin, along with the Catawba-Wateree River sub-basin, forms the headwaters of the Santee Basin. It is subdivided into 33 10-digit watersheds within North Carolina and South Carolina encompassing the Broad, Enoree, and Tyger River systems (Figure 4). It covers 5,502 square miles including 1,513 square miles in the Blue Ridge Mountains, Foothills, and Piedmont of North Carolina and 3,989 square miles in the Piedmont region of South Carolina (Table 1) (SCDHEC 2007, NCDENR 2008).

Figure 4. The major rivers, reservoirs, and 10-digit watersheds of the Broad River Sub-basin.

The Broad River system (hydrologic units 03050105 and 03050106), extending from the Blue Ridge Mountains in North Carolina, south-southeast through the foothills into the Piedmont region of South Carolina, accepts drainage from the Green, First Broad, Second Broad, Pacolet, Tyger, and Enoree rivers before converging with the Saluda River to form the Congaree River. It encompasses 23 10-digit watersheds covering approximately 3,963 square miles (Table 1) (SCDHEC 2007, NCDENR 2008). A portion of the Broad River, from Ninety-Nine Islands Dam to the confluence with the Pacolet River, is recognized as a South Carolina Scenic River (SCDHEC 2007).

The Tyger and Enoree River systems (hydrologic units 03050107 and 03050108, respectively) extend across the Piedmont region of South Carolina. The Tyger River system encompasses five

10-digit watersheds covering 808 square miles and the Enoree River system encompasses five 10-digit watersheds covering 731 square miles (Table 1) (SCDHEC 2007).

Diadromous species, including American Shad, American Eel, and one or both sturgeon species, historically used much of the Broad River sub-basin (FWS et al. 2001), but current usage is limited to the lower area of the sub-basin by American Shad and American Eel. American Shad can access the Broad River upstream to the Parr Shoals Dam, and do so in relatively low but increasing numbers based on fish passage at the Columbia Fishway (discussed in Section I.D). American Eel are also present in the lower Broad River, but numbers are thought to be very low (SCDNR 2017) (see Figure 12). Blueback Herring were collected from Lake Bowen on the South Pacolet River by the SCDNR during fisheries surveys conducted in the 1990s, however, the origin of these fish is unknown (SCDNR 1998).

Saluda River Sub-basin: The Saluda River sub-basin (hydrologic unit 03050109) lies fully within South Carolina extending from the Blue Ridge Mountains through the Piedmont and into the Sandhills (Figure 5). The principal tributaries of the Saluda River include the Little, Reedy, Bush, and Little Saluda rivers with the Little Saluda and Bush rivers joining the Saluda to form the headwaters of Lake Murray. Downstream of Lake Murray, the Saluda joins the Broad River to form the Congaree River. This system encompasses 14 10-digit watersheds covering 2,523 square miles (Table 1). Two portions of this system have been designated as South Carolina Scenic Rivers: a five-mile segment of the Middle Saluda River and a ten-mile segment of the lower Saluda River, from one mile below Lake Murray Dam to its confluence with the Broad River (SCDHEC 2012b). The Saluda River sub-basin historically supported fish migrations of sturgeons, American Eel, and American Shad (FWS et al. 2001), but presently supports only low numbers of American Eel.

Figure 5. The major rivers, lakes, and 10-digit watersheds of the Saluda River Sub-basin.

Congaree River Sub-basin: The Congaree River sub-basin (hydrologic unit 03050110), formed at the confluence of the Saluda and Broad rivers, extends across the Sandhills region of South Carolina, giving way to the Upper Coastal Plain region near the river's confluence with the Wateree River (Figure 6). It encompasses four 10-digit watersheds covering 689 square miles (Table 1). One section of the system, Cedar Creek, is classified as Outstanding National Resource Waters (SCDHEC 2012b). With the exception of Atlantic Sturgeon, all life stages of all diadromous fishes currently utilize the Congaree River sub-basin (Rohde et al. 2009). It provides important spawning habitat for the dam-locked population of Shortnose Sturgeon (Collins et al. 2003).

Figure 6. The major river and 10-digit watersheds of the Congaree River Sub-basin.

Santee River Sub-basin: The Santee River sub-basin (hydrologic units 03050111 and 03050112) extends through the Upper and Lower Coastal Plains of South Carolina (Figure 7). The confluence of the Congaree and Wateree rivers forms the Santee River, which flows into Lake Marion. Water flows out of Lake Marion through either a small hydropower unit or the floodgates at the Wilson Dam or out the Diversion Canal into Lake Moultrie. The water flowing through the Wilson Dam joins water exiting Lake Moultrie through a Rediversion Canal and continues to the Atlantic Ocean via the South Santee and North Santee rivers. This system encompasses five 10-digit watersheds covering 1,249 square miles (Table 1) (SCDHEC 2013). The Santee River sub-basin drains into the Atlantic Ocean near Georgetown and into the Atlantic Ocean in Charleston via the Cooper River. All diadromous fishes discussed in this plan historically and currently utilize the Santee River sub-basin.

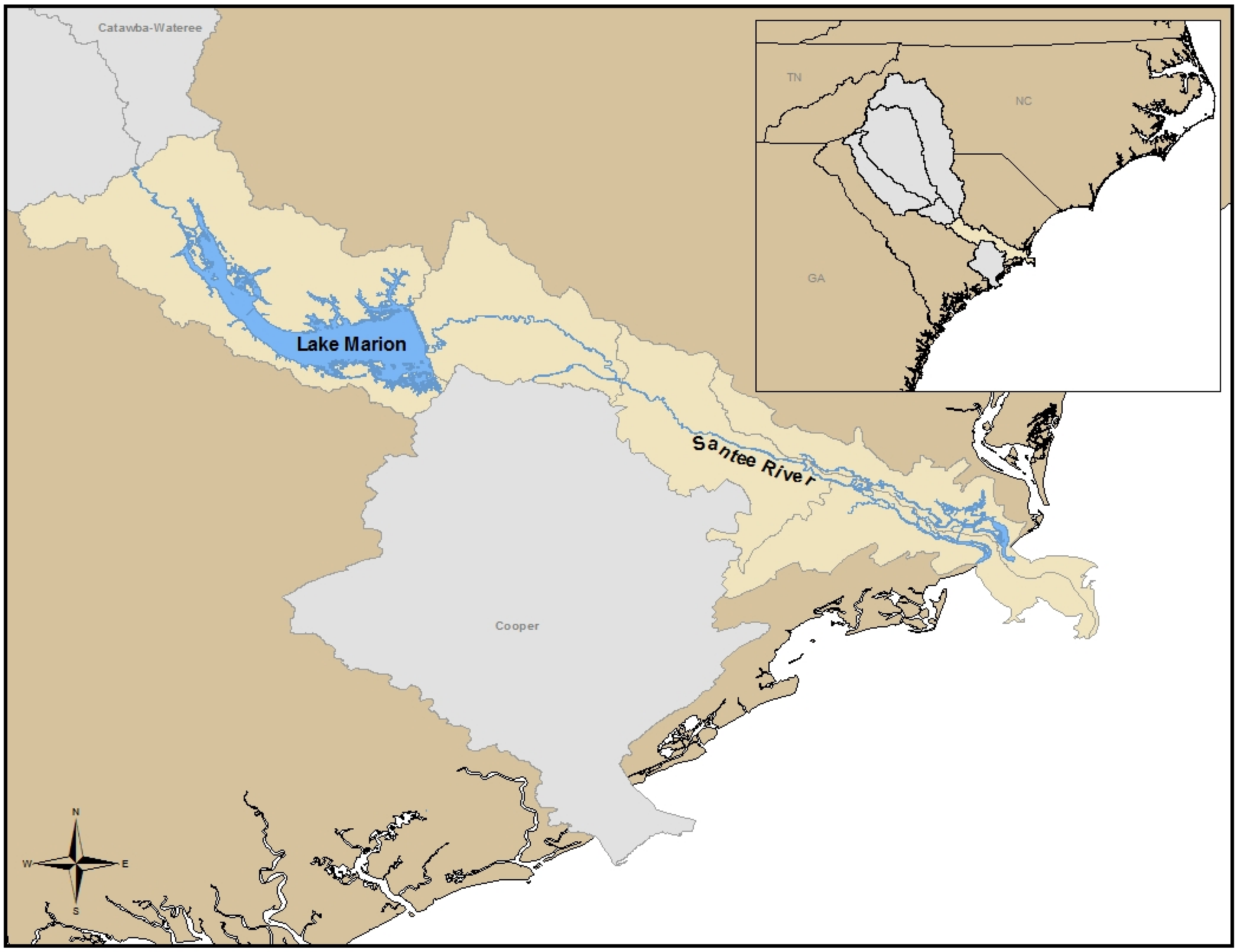

Figure 7. The major rivers, lakes, and 10-digit watersheds of the Santee River sub-basin.

Cooper River Sub-basin: Historically part of the Edisto-South Carolina Coastal Basin (HUC 030502), the completion of the Santee Cooper Diversion Project linked the Cooper River to the Santee Basin by way of the Pinopolis Dam and the diversion channel. The Cooper River sub-basin (hydrologic unit 03050201) extends across the Lower Coastal Plan and Coastal Zone regions of South Carolina (Figure 8). Diverted Santee River water flowing from Lake Moultrie through Pinopolis Dam forms the Cooper River, which then joins the Wando and Ashley rivers in Charleston Harbor and flows into the Atlantic Ocean. This system encompasses seven 10-digit watersheds covering 1,226 square miles (Table 1) (SCDHEC 2013). All life stages of diadromous fishes utilize the Cooper River.

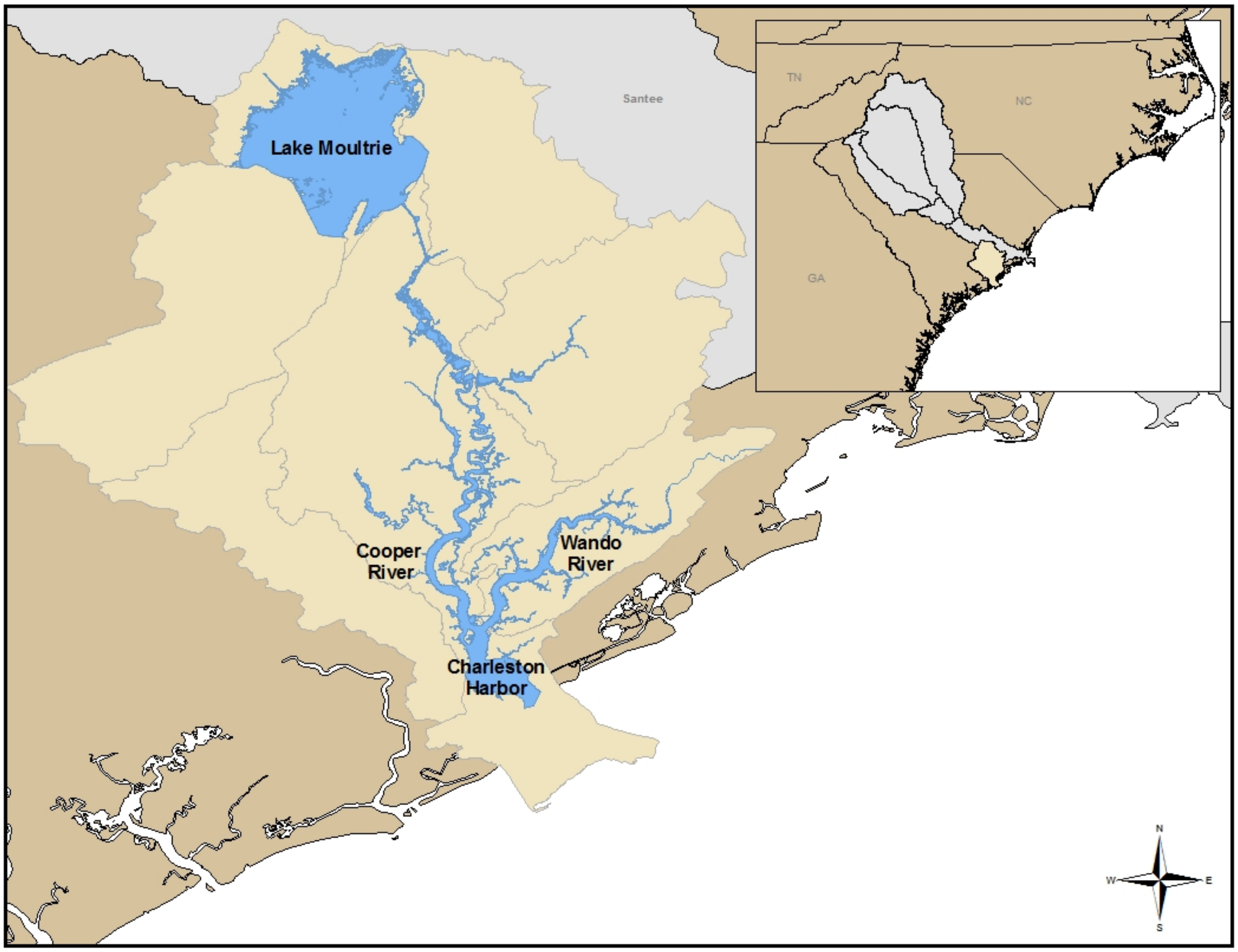

Figure 8. The major waterbodies and 10-digit watersheds of the Cooper River sub-basin.

C. Santee River Basin Historical Perspective

Prior to the late 19th century, many rivers in the Santee Basin supported large numbers of diadromous fishes. The alosines (American Shad, Hickory Shad, and Blueback Herring) and American Eel made extensive migrations into the Piedmont regions of North Carolina and South Carolina. American Shad were documented in the Wateree River up to Great Falls, the Congaree River to Columbia, and in the Broad River as far as the confluence of the Green River in North Carolina (Stevenson 1899). Mills (1826) reported the capture of American Shad in the Congaree, Wateree, Catawba, Broad, Pacolet, Tyger, and Enoree rivers. Jordan (1890) reported the presence of American Eel in Buck Creek, North Carolina, a tributary of the Catawba River. Sturgeon (not clear as to the species) were reported by Mills (1826) in the Broad and Wateree rivers, and Logan (1859) reported the presence of sturgeon in the Broad River.

In the late 1800s, the harvest of diadromous fishes, based on commercial fishery records, began to decline from previous years. A number of anthropogenic activities appear to correlate with this decline. These include increased sediment loading resulting from agriculture and other land use practices, possible degradation in water quality, overfishing, and dam construction that reduced access to riverine spawning and nursery habitat and seasonally altered flow regimes.

In the late 18th century, gristmills, the first dams in the Santee Basin, appeared on smaller tributaries in the upper Piedmont. Commercial anglers who foresaw loss of fish runs opposed the construction of these dams. In 1784, the South Carolina General Assembly passed an act to prohibit the blockage of fish passage on the Broad, Saluda, Pacolet, Tyger, and Enoree rivers (South Carolina et al. 1840). However, that law did not prevent the construction of a diversion dam and canal in 1824 on the Broad River in Columbia to provide for navigation around the Columbia Shoals. Hydroelectric dams were constructed at Great Falls on the Catawba River (1907), followed by the Parr Shoals Dam on the Broad River in 1914, and the Dreher Shoals Dam on the Saluda River in 1927. The Parr Shoals Dam had provisions for fish passage, but utilization apparently was very low. By 1930, most diadromous fish species lost access to riverine habitat in the upper Piedmont of South Carolina.

In 1942, the South Carolina Public Service Authority (Santee Cooper) completed the Santee Cooper Power and Navigation Project. This project consisted of the construction of two large reservoirs and a connecting canal (Diversion Canal) diverting almost all of the flow from the Santee River into the Cooper River (Figure 9b). During the 1950s, it was realized that Blueback Herring were moving upstream from the Cooper River into Lake Moultrie through the Pinopolis Navigation Lock, which was operated for boat passage. Also, it was determined that a dam-locked population of Striped Bass had established in Lakes Moultrie and Marion, and since herring are a popular prey item for Striped Bass, the navigation lock was operated to aid the upstream migration of herring (Scruggs and Fuller 1954, Stevens 1957).

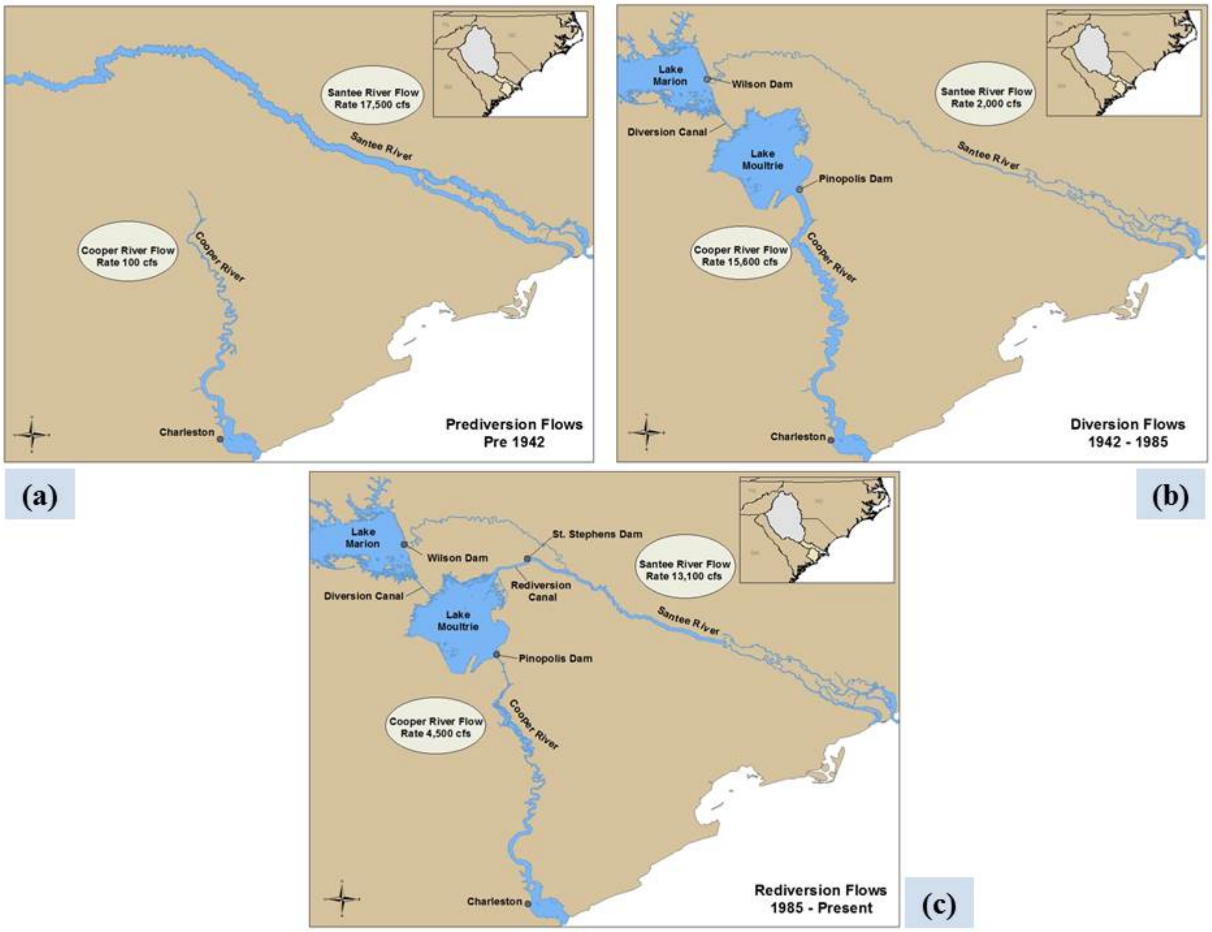

Figure 9. The Santee and Cooper Rivers from early the 1900s to the present. (a) shows the rivers prior to the completion of the Santee-Cooper Project while (b) and (c) show the change in hydrography and flow following the completion of the Santee-Cooper Project and Rediversion Canal respectively (map courtesy of USACE Charleston District).

In 1985, in order to reduce shoaling in navigable reaches of Charleston Harbor, flows were re-diverted into the Santee River near St. Stephen, South Carolina. This project created the “Rediversion Canal" between Lake Moultrie and the Santee River, and a new hydroelectric power generation facility to offset reductions in power production occurring at Pinopolis Dam when flows were re-diverted into the Santee River (Figure 9c). A fish lock designed to pass American Shad and Blueback Herring was built at the St. Stephen Dam to compensate for anticipated reductions in fish passage at the Pinopolis Navigation Lock. The Federal Energy Regulatory Commission (FERC) relicensing of a number of hydroelectric projects in the Santee Basin was initiated in the 1990s. These included the Columbia Diversion Dam (P-1895), Neal

Shoals (P-2315), Ninety-Nine Islands (P-2331), Lockhart (P-2620), and Gaston Shoals (P-2332), which all received new instream flow requirements. The FWS and NMFS reserved authority to prescribe fish passage at these projects, with the exception of the Columbia Diversion Dam, where they prescribed passage. Here, a vertical-slot fish ladder was operational in the spring of 2007 and the number of American Shad passed upstream has generally increased since its implementation (see Figure 14).

Relicensing of other hydroelectric projects in the Santee Basin, including Santee Cooper (P-199), Catawba-Wateree (P-2232), and Saluda (P-516), continued through the 2000s and addressed a number of diadromous fish issues. Passage for American Shad, American Eel, and Blueback Herring was prescribed at Catawba-Wateree while passage for Shortnose Sturgeon was reserved. Passage for American Shad, Blueback Herring, American Eel, and Shortnose Sturgeon has been prescribed at the Santee Cooper projects, and details of sturgeon passage, which will include the passage of Atlantic Sturgeon, are being refined through the ESA consultation. The FWS reserved authority to prescribe fish passage at the Saluda Project.

D. Santee Basin Diadromous Fish Accord

A concept presented in the 2001 Plan was development of a funding base to mitigate for impacts at sites where diadromous fish runs historically existed but reintroduction is not practical (not technically or economically feasible), such as the Saluda Hydroelectric Project. According to the 2001 Plan, "…proportional economic compensation should be provided to a designated restoration fund…" to assist restoration efforts of diadromous fishes in the Santee Basin (pg 46, FWS et al. 2001).

The Santee Accord, developed in 2008[6], is a cooperative agreement between Duke Energy Carolinas, LLC (Duke Energy), South Carolina Electric and Gas (SCE&G), the FWS, NCWRC, and SCDNR, establishing a workgroup and funding to protect, restore, and enhance diadromous fishes in the Santee Basin. Santee Cooper and NMFS participated in the development of the Accord and its studies, but are not members of the Accord. These entities and agencies developed the Accord to study diadromous fish issues on a basin-wide scale and to identify and address fish passage issues associated with FERC relicensing of several hydropower projects in the Santee Basin. Consistent with the Accord, the FWS established fish passage requirements

[6] U.S. Nuclear Regulatory Commission Final Administration and Policy Document Accession No. ML082830321

described below at the Wateree Development on the Wateree River and the Parr Shoals and Neal Shoals Hydroelectric projects on the Broad River. Fish passage at the Wateree Dam will be a trap, sort and transport facility operational by the spring of 2018, and adult American Shad and Blueback Herring will be relocated into Lake Wateree until the combined total of the target species equals or exceeds 10,000 fish. In all subsequent years, the target species will be relocated to upstream reaches of the Catawba River in South Carolina.

At the Parr Shoals and Neal Shoals hydroprojects, the initiation of planning (feasibility assessment) and construction of fish passage is based on numbers of American Shad or Blueback Herring passed at the Columbia Fishway. The FWS developed total restoration numbers and triggers for fishway construction from surface acreage calculations of the Broad River (including available tributaries) between the Columbia Dam and Parr Shoals Dam and between Parr Shoals Dam and Neal Shoals Dam. At Parr Shoals, a fish passage feasibility assessment will be initiated when the Columbia Fishway annually passes 46,400 American Shad or 185,600 Blueback Herring for any three years in a five-year period. Construction of a fishway will commence when the Columbia Fishway annually passes 69,600 American Shad or 348,000 Blueback Herring for any three years in a five-year period. Passage at the Parr Shoals Dam will provide access to almost 4,480 acres of habitat including the Broad, Enoree, and Tyger river systems. For the Neal Shoals Project, a fish passage feasibility study will begin when the Parr Shoals Project annually passes 64,075 American Shad or 320,325 Blueback herring in any three years of a five-year period. Construction of a fish passage facility will commence within one year after 96,112 American Shad or 480,562 Blueback Herring are passed for any three years in a five-year period (Figure 10). As of 2016, less than 4,000 American Shad are passed annually at the Columbia Fishway, but the numbers are generally increasing (Kleinschmidt 2016).

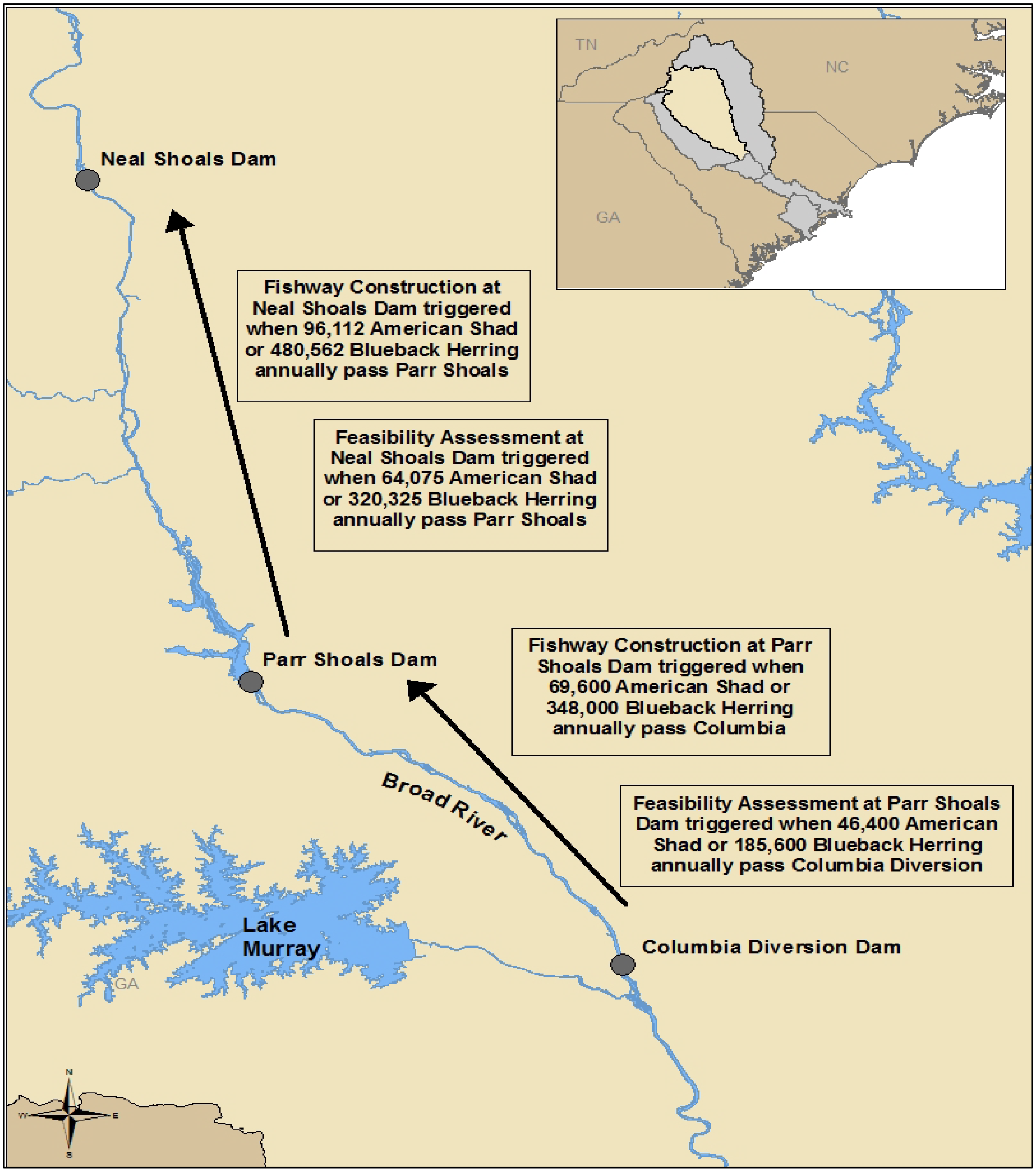

Figure 10. Fish passage requirements established in the "Santee River Basin Accord for Diadromous Fish Protection, Restoration, and Enhancement" for the Parr Shoals and Neal Shoals Hydropower projects. Passage of the specified numbers of American Shad or Blueback Herring annually for any three years in a five-year period at the specified dam will trigger a fish passage feasibility assessment or the construction of a fishway at the next upstream dam.

A number of restoration and monitoring activities have been conducted under the Accord. A summary of these activities follows:

American Shad culture and stocking: The American Shad stocking program is guided by the *Action Plan to Restore and Enhance Diadromous Fish Resources to the Santee Watershed*, developed under the Accord. The purpose of this program is to tank-spawn up to ten million larvae annually for stocking selected areas of the Broad and Wateree rivers in an effort to confirm suitability of nursery areas and to enhance restoration of this species in the upper basin. The SCDNR's Jack D. Bayless hatchery in St. Stephen, South Carolina, the Cohen Campbell Hatchery in Columbia, South Carolina, and the FWS's Orangeburg National Fish Hatchery in Orangeburg, South Carolina, have established hatchery production of American Shad. Brood stock from the St. Stephen Fish Lock and Tailrace are collected and transported to the hatcheries for holding. The facilities use hatching jars to incubate fertilized eggs, and three-day-old fry are marked with oxy-tetracycline (OTC) or are genetically tagged by parental tagging to determine their hatchery origin and stocked at various locations in the Broad and Wateree rivers. The hatcheries have stocked over 22 million shad fry since 2008 (Table 2). The Technical Committee established under the Accord will determine success based on the results of juvenile monitoring (see next section), fish counts conducted at the St. Stephen Fish Lock and the Columbia Fishway, and spring sampling conducted by Duke Energy in the Wateree River.

Table 2. Total number of American Shad fry stocked in the Broad and Wateree rivers from 2008 through 2016.

Year	Broad River	Wateree River	Annual Total
2008	24,000	249,643	273,643
2009	439,625	364,340	803,965
2010	2,543,218	824,927	3,368,145
2011	1,162,032	500,800	1,662,832
2012	1,025,808	334,302	1,360,110
2013	2,178,508	730,825	2,909,333
2014	2,565,516	877,485	3,443,001
2015	3,203,261	1,080,424	4,283,685
2016	3,328,107	1,058,900	4,387,007
Totals	16,470,075	6,021,646	22,491,721

Juvenile American Shad and river herring monitoring in nursery waters and determination of American Shad hatchery origin: The purpose of this study is to collect sufficient young-of-year (YOY) juvenile American Shad and river herring to determine abundance, distribution, growth rates, food habits, and out-migration timing. In addition, a separate study will determine the relative contribution of naturally produced versus hatchery-stocked American Shad juveniles.

SCDNR collected juvenile American Shad from the Santee Basin during 2009-2016 to evaluate the timing of outmigration and to attempt to determine the relative contribution of fry stocking to the total population. Electrofishing was used to collect juveniles during the late summer and fall from sampling locations on the Congaree, Wateree, and Santee rivers as well as Lake Marion, the Diversion Canal, and Lake Moultrie. Most (91%) of the fish were collected in upper Lake Marion, the upper Santee River, and the Congaree River. Few juveniles were collected from either the Broad or Wateree rivers. Based on an evaluation of otoliths, the majority of fish captured were wild. Hatchery-stocked fish, defined as having a distinguishable OTC mark on the otoliths, comprised less than 1% of the total number captured. However, there is some speculation that relative contribution of hatchery-produced fry may be underestimated due to factors such as a lack of OTC uptake into calcified structures during the marking period, unknown post-stocking mark retention rate, or other factors not yet clear, but which may hinder the detectability of a hatchery-produced fish.

American Eel studies: Abundance and distribution of American Eel along the spillways of the Columbia and Wateree dams were evaluated from 2010-2012 (Bulak and Bettinger 2013). Eel ramp traps were fished at up to four locations along each dam for a total effort of 4,890 ramp-days. Backpack electrofishing was conducted on 37 dates with a total electrofishing effort of 9 hours at each dam. During 2010 – 2012, 25 American Eels were captured, 12 at Wateree Dam and 13 at Columbia Dam. The low capture rates could be explained by 1) low capture efficiency and/or 2) low numbers of eels near the two dams during 2010 – 2012. Duke Energy has maintained eel passage at the Wateree Dam, with very limited results. Three elvers were collected in 2015, and a noticeable decline in capture has been observed since 2011. Eel assessment studies associated with other FERC relicensing projects resulted in no eels collected at the Saluda Project (2005) and three eel collected at the Parr Shoals Dam (1 in 2015 and 2 in 2016).

Sturgeon studies: SCDNR is studying Atlantic Sturgeon and Shortnose Sturgeon in the Santee

Basin. SCDNR has studied the Shortnose Sturgeon population residing in the upper portions of Lake Marion for a number of years. During 2012 - 2015, 86 Shortnose Sturgeon were tagged with transmitters and their movements were monitored throughout the Santee Basin (Post and Holbrook 2015). During that study period, two distinct patterns emerged. One group of sturgeon was recorded primarily in the Browns Lake/Upper Santee area. These fish were either not in spawning condition (i.e., did not make spawning runs) or their capture occurred well after the spawning season. The second group consisted of spawning animals observed utilizing areas previously verified as spawning habitat near Columbia, South Carolina; near the confluence of the Wateree/Congaree Rivers; and in the Browns Lake/Upper Santee area. This group included two tagged Shortnose Sturgeon that entered the Santee Cooper lake system from the Cooper River in March 2011, and after navigating through the lakes, were located in the Wateree River near the Hwy 1 Bridge downstream of Wateree Dam. Days later, both fish returned down river and subsequently entered the Congaree River where they proceeded to the known spawning location near Columbia. After several days, both fish traveled back down river to the Santee Cooper lake system. One fish remained in the Brown's Lake area of Lake Marion while the other fish was detected in the Cooper River in April 2011 presumably after exiting Lake Moultrie.

In 2016, two Shortnose Sturgeon passed through the turbines at Pinopolis and were residing in the Cooper River at the time of this publication. One of these fish passed upstream from the Cooper River through the Pinopolis Navigation Lock and was tracked upstream to the Congaree River spawning grounds before it returned to the Cooper River. The other fish had been previously captured and tagged in the Browns Lake area of Lake Marion, and migrated downstream into the Cooper River, where it still resides as of May 2017 (Post and Holbrook 2016, B. Post, personal communication).

Attempts to evaluate recent spawning of Shortnose Sturgeon in the Santee Basin have been met with limited success. Egg collectors were fished in 2013 and 2015 in the Congaree River but failed to collect any sturgeon eggs (Post and Holbrook 2015). Above average flows that silted over the egg collectors or below average flows that reduced boating access to the spawning grounds have hampered this effort. During 2012 - 2014, sampling for juvenile and YOY sturgeon was conducted using a Missouri trawl (Post and Holbrook 2015). During the three sampling seasons, 157 individual tows made over a total of 11 hours and 45 minutes (average time/tow was 4 minutes 29 seconds) near known spawning and nursery areas resulted in the capture of one juvenile Shortnose Sturgeon. Shortnose Sturgeon are known to spawn in the Congaree River in the vicinity of the I-77 Bridge (Collins et al. 2003).

E. Review of Migration Barriers

Obstruction of waterways has occurred in the Carolinas for centuries. Early colonial settlers constructed dams on small rivers and tributaries to power grist mills and for improvement of river navigation. During the Industrial Revolution, construction of larger dams to provide power for textile and industrial mills took over. Advancements in the generation of hydroelectric power around the turn of the 20th century led to the construction of much larger dams on nearly all of North Carolina and South Carolina's major rivers.

For the purposes of this Plan, we identified 66 dams in the Santee Basin as fish barriers on major rivers and streams, 48 in South Carolina and 18 in North Carolina (Figure 11) (Table 3). A number of other dams are present in the Santee Basin, but they are on smaller streams or in the upper portion of the Basin and do not appear to have immediate relevance to this Plan. Most (47) of these dams are current, former, or pending FERC, State-operated, or private hydropower facilities. The remaining 19 dams are old, non-operational mill dams or newer dams created to provide municipal drinking supply; one provides cooling water for the William States Lee steam plant.

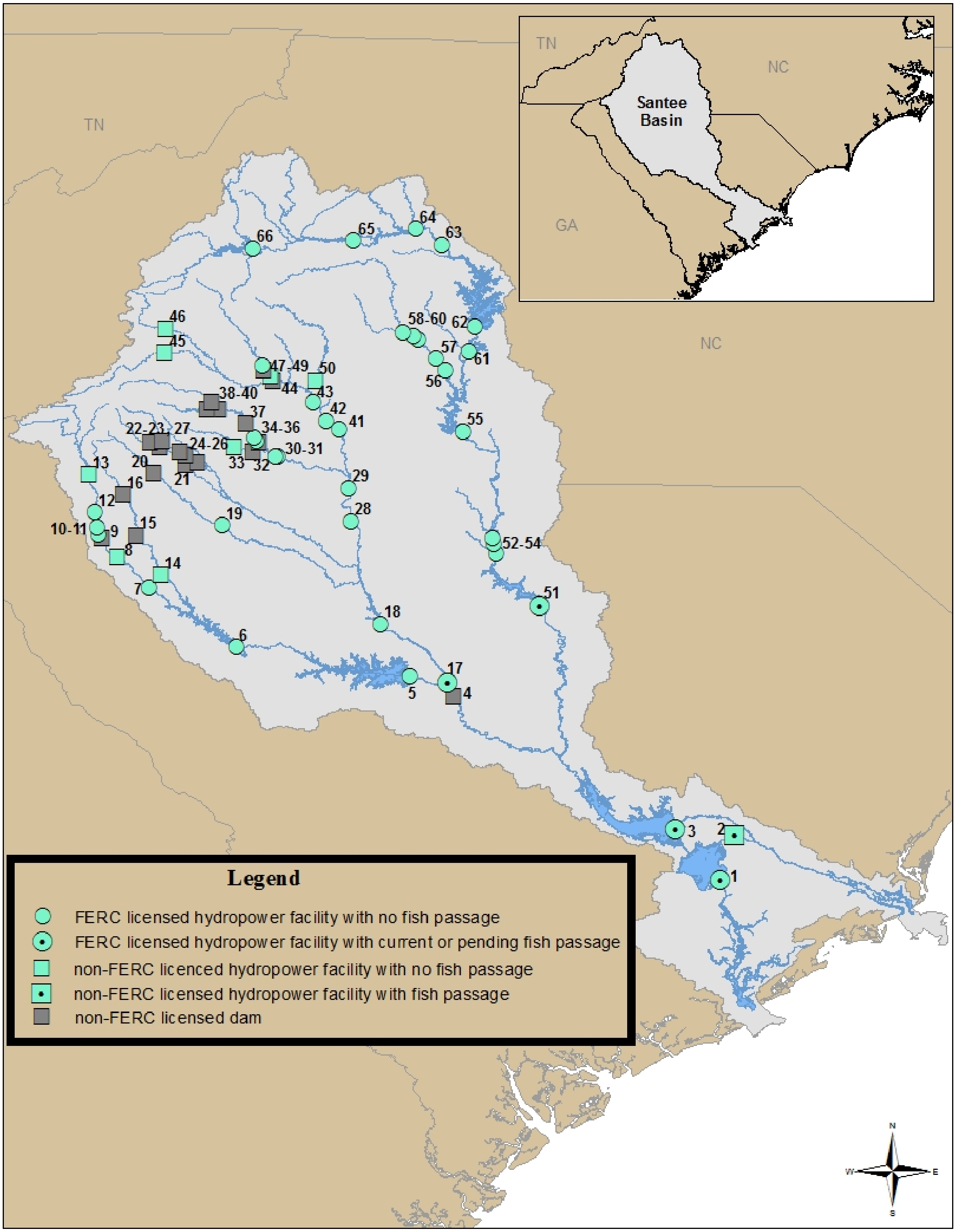

Figure 11. Existing dams in the Santee Basin. Circles represent facilities that fall under FERC jurisdiction. Squares represent non-FERC facilities (e.g., U.S. Army Corps of Engineers, State, Other). Hydropower facilities are in teal. Symbols with a dot indicate fish passage present or pending. Numbers correspond to dams listed in Table 3.

Table 3. Dams located in the Santee Basin that impede diadromous fish passage (Figure 11 & Appendix).

Number on Map	Project/Development (Other) Name	Waterway	HUC-8	Jurisdiction[a]	Hydropower	FERC Number	Generating Capacity (Megawatts)	Date Licensed	License Expiration Date	Plant Operating Mode[e]	Instream Flow Requirement	Fish Passage Requirement
					Cooper River Basin							
1	Santee Cooper/Cooper (Lake Moultrie, Pinopolis Dam, Jefferies Hydro)	Santee River, SC	3050201	FERC - L	Yes	P-199	132.6	5/6/1979	3/31/2006[d]	P	Yes	Yes
2	St. Stephen (Lake Moultrie)	Santee River, SC	3050201	USACE	Yes	---	84.0	---	---	---	No	Yes
					Santee River Basin							
3	Santee Cooper/Santee (Lake Marion, Wilson Dam)	Santee River, SC	3050111	FERC - L	Yes	P-199	1.9	5/6/1979	3/31/2006[d]	Continuous	Yes	Pending
					Congaree River Basin							
4	Granby Lock & Dam	Congaree River, SC	3050110	Other		---	---	---	---	---	No	No
					Saluda River Basin							
5	Saluda (Lake Murray, Dreher Shoals Dam)	Saluda River, SC	3050109	FERC - L	Yes	P-516	207.3	6/1/1984	8/31/2010[d]	R	Yes	No
6	Buzzards Roost (Greenwood)	Saluda River, SC	3050109	FERC - L	Yes	P-1267	15.0	12/18/1995	11/30/2035	P	Yes	No
7	Ware Shoals	Saluda River, SC	3050109	FERC - L	Yes	P-2416	6.2	4/4/2002	3/31/2032	ROR	Yes	No
8	Hollidays Bridge	Saluda River, SC	3050109	State	Yes	---	4	---	---	---		No
9	Lee Steam Diversion Weir	Saluda River, SC	3050109	Other		---	---	---	---	---	No	No
10	Pelzer Mills Dam - Lower	Saluda River, SC	3050109	FERC - L	Yes	P-10253	3.3	12/24/1987	11/30/2017	ROR	Yes	No
11	Pelzer Mills Dam - Upper	Saluda River, SC	3050109	FERC - L	Yes	P-10254	2.0	12/29/1987	11/30/2017	ROR	No	No
12	Piedmont	Saluda River, SC	3050109	FERC - L	Yes	P-2428	1.0	9/9/1986	12/31/2017	ROR	Yes	No
13	Saluda Dam	Saluda River, SC	3050109	State	Yes	---	2.4	---	---	---	No	No
14	Boyds Mill Dam	Reedy River, SC	3050109	State	Yes	---	1.4	---	---	---	No	No
15	Cedar Falls	Reedy River, SC	3050109	Other	No	---	---	---	---	---	No	No
16	Conestee	Reedy River, SC	3050109	Other	No	---	---	---	---	---	No	No
					Broad River Basin							
17	Columbia Diversion Dam	Congaree River, SC	3050106	FERC - L	Yes	P-1895	10.6	5/30/2002	4/30/2042	ROR	Yes	Yes
18	Parr Shoals	Broad River, SC	3050106	FERC - L	Yes	P-1894	14.9	8/28/1974	6/30/2020	P	Yes	No
19	Riverdale	Enoree River, SC	3050108	FERC - L	No	P-4362	---	Terminated	---	---	No	No
20	Pelham Mills	Enoree River, SC	3050108	Other		---	---	---	---	---	No	No
21	Berry Shoals Dam	S. Tyger River, SC	3050107	Other		---	---	---	---	---	No	No
22	Apalache Dam	S. Tyger River, SC	3050107	Other		---	---	---	---	---	No	No
23	Lake Cunningham	S. Tyger River, SC	3050107	Other		---	---	---	---	---	No	No
24	Fairmont	Middle Tyger River, SC	3050107	Other		---	---	---	---	---	No	No
25	Startex Mill (Tucapau)	Middle Tyger River, SC	3050107	Other		---	---	---	---	---	No	No
26	Lyman Dam	Middle Tyger River, SC	3050107	Other		---	---	---	---	---	No	No
27	Lake Lyman	Middle Tyger River, SC	3050107	Other		---	---	---	---	---	No	No
28	Neal Shoals	Broad River, SC	3050106	FERC - L	Yes	P-2315	4.4	6/17/1996	5/31/2036	P	Yes	No
29	Lockhart	Broad River, SC	3050106	FERC - L	Yes	P-2620	18	9/30/1999	3/31/2040	P	Yes	No
30	Pacolet Mills (Lower Pacolet)	Pacolet River, SC	3050105	FERC - L	Yes	P-2621	0.9	7/20/2011	2/1/2052	ROR	Yes	No
31	Upper Pacolet Mills	Pacolet River, SC	3050105	FERC - L	Yes	P-2621	1	7/20/2011	2/1/2052	ROR	No	No
32	Glendale Mills	Lawsons Fork Creek, SC	3050105	Other		---	---	---	---	---	No	No
33	Whitney Mills	Lawsons Fork Creek, SC	3050105	State	No	P-10881	---	Terminated	---	---	No	No

Table 3 cont. Dams located in the Santee Basin that impede diadromous fish passage (Figure 11 & Appendix).

Number on Map	Project/Development (Other) Name	Waterway	HUC-8	Jurisdiction[a]	Hydropower	FERC Number	Generating Capacity (Megawats)	Date Licensed	License Expiration Date	Plant Operating Mode	Instream Flow Requirement	Fish Passage Requirement
				Broad River Basin								
34	Clifton Dam #2	Pacolet River, SC	3050105	Other	No	---	---	---	---	---	No	No
35	Clifton Dam #1	Pacolet River, SC	3050105	FERC - L	No	P-4632	---	Decommissioned[b]	---	ROR	No	Yes
36	Clifton Dam #3	Pacolet River, SC	3050105	FERC - E	Yes	P-8185	1.3	10/1/1984	---	---	No	No
37	Lake Blalock	Pacolet River, SC	3050105	State	No	P-14338	---	Pending[c]	---	---	Yes (401 WQ)	No
38	South Pacolet River (Rainbow/Reservoir #1)	S. Pacolet River, SC	3050105	Other		---	---	---	---	---	No	No
39	Lake Bowen	S. Pacolet River, SC	3050105	Other	No	P-14361	---	Pending[c]	---	---	No	No
40	Fingerville	N. Pacolet River, SC	3050105	Other	No	P-14215	---	Pending[c]	---	---	No	No
41	Ninety-Nine Islands	Broad River, SC	3050105	FERC - L	Yes	P-2331	20	6/17/1996	5/31/2036	P	Yes	No
42	Cherokee Falls	Broad River, SC	3050105	FERC - L	Yes	P-2880	4.1	8/3/1981	7/31/2021	ROR	Yes (401 WQ)	No
43	Gaston Shoals - Lower	Broad River, SC	3050105	FERC - L	Yes	P-2332	8.5	6/12/1996	5/31/2036	P	Yes	No
44	Cliffside Steam Plant	Broad River, NC	3050105	Other	No	---	---	---	---	---	No	No
45	Turner Shoals (Lake Adger)	Green River, NC	3050105	State	Yes	---	---	---	---	---	No	No
46	Lake Lure	Broad River, NC	3050105	State	Yes	---	---	---	---	---	No	No
47	Cliffside (Cone Mills)	Second Broad River, NC	3050105	State	Yes	---	---	---	---	---	No	No
48	Henrietta Mills	Second Broad River, NC	3050105	Other	Inactive	---	---	---	---	---	No	No
49	Caroleen Mills (Second Broad, Burlington Mills)	Second Broad River, NC	3050105	FERC - E	Yes	P-7679	0.3	12/4/1984	---	---	No	No
50	Stice Shoals	First Broad River, NC	3050105	State	Yes	---	---	---	---	---	No	No
				Catawba-Wateree River Basin								
51	Catawba-Wateree/Wateree	Wateree River, SC	3050104	FERC - L	Yes	P-2232	82	11/25/2015	10/31/2055	P	Yes	Yes
52	Catawba-Wateree/Rocky Creek-Cedar Creek (Cedar Creek)	Catawba River, SC	3050103	FERC - L	Yes	P-2232	56.8	11/25/2015	10/31/2055	P	No	No
53	Catawba-Wateree/Great Falls-Dearborn (Great Falls)	Catawba River, SC	3050103	FERC - L	Yes	P-2232	54	11/25/2015	10/31/2055	P	No	No
54	Catawba-Wateree/Fishing Creek	Catawba River, SC	3050103	FERC - L	Yes	P-2232	48.1	11/25/2015	10/31/2055	P	No	No
55	Catawba-Wateree/Wylie	Catawba River, SC	3050103	FERC - L	Yes	P-2232	69	11/25/2015	10/31/2055	P	Yes	No
56	McAdenville (Stowe Mills)	S. Fork Catawba River, NC	3050102	FERC - E	Yes	P-4186	1.0	12/17/1982	---	ROR	No	No
57	Spencer Mountain	S. Fork Catawba River, NC	3050102	FERC - L	Yes	P-2607	0.6	7/12/1995	6/30/2025	ROR	Yes	No
58	Hardins	S. Fork Catawba River, NC	3050102	FERC - E	Yes	P-6492	0.7	12/8/1982	---	ROR	Yes	No
59	High Shoals	S. Fork Catawba River, NC	3050102	FERC - E	Yes	P-4827	1.7	11/10/1981	---	ROR	No	No
60	Long Shoals	S. Fork Catawba River, NC	3050102	FERC - E	Yes	P-7742	0.1	7/19/1984	---	ROR	Yes	No
61	Catawba-Wateree/Mountain Island	Catawba River, NC	3050101	FERC - L	Yes	P-2232	55.1	11/25/2015	10/31/2055	P	Yes	No
62	Catawba-Wateree/Cowans Ford (Lake Norman)	Catawba River, NC	3050101	FERC - L	Yes	P-2232	332.5	11/25/2015	10/31/2055	P	Yes	No
63	Catawba-Wateree/Lookout Shoals	Catawba River, NC	3050101	FERC - L	Yes	P-2232	25.7	11/25/2015	10/31/2055	P	Yes	No
64	Catawba-Wateree/Oxford (Lake Hickory)	Catawba River, NC	3050101	FERC - L	Yes	P-2232	35.9	11/25/2015	10/31/2055	P	Yes	No
65	Catawba-Wateree/Rhodhiss	Catawba River, NC	3050101	FERC - L	Yes	P-2232	32.2	11/25/2015	10/31/2055	P	Yes	No
66	Catawba-Wateree/Bridgewater (Lake James, Linville Dam)	Catawba River, NC	3050101	FERC - L	Yes	P-2232	27.9	11/25/2015	10/31/2055	P	Yes	No
						Total:	1368.4					

[a]Dams with jurisdiction type: "FERC - L" have been issued FERC licenses; "FERC - E" have an exemption issued by FERC; "Other" are old, non-operational mill dams or newer dams created to provide municipal drinking supply; Lee Steam Diversion Weir provides cooling water for the William States Lee steam plant.

[b]The FERC license for Cliffton Dam #1 was terminated. Licensee was requird to remove all Tainter gates, which allows ROR flows and un-impeded upstream and downstream fish passage.

[c]Fingerville, Lake Bowen, and Lake Blalock are being evaluated for hydropower. They have been assigned a FERC project number, but they do not have a FERC license or generate any power. Of these, it appears that Blalock has the most potential, but the applications for all three projects have been paused.

[d]At the time of writing of this plan, Santee Cooper/Cooper, Santee Cooper/Santee, and Saluda were waiting for issuance of a new license.

[e]Plant Operating Mode: P = Peaking, ROR = Run-of-River

II. Fishes Targeted for Restoration and Their Current Status

This Plan focuses on Atlantic Sturgeon, Shortnose Sturgeon, American Eel, American Shad, Hickory Shad, and Blueback Herring, which are species that are expected to benefit if fish passage and habitat in the Santee Basin are improved.

A. Atlantic Sturgeon

Atlantic Sturgeon, federally-listed as five distinct population segments under the ESA, can reach lengths of up to 14 feet (ft) (4.3 m) and weights up to 800 pounds (lbs) (363 kg). They have a life span approaching 50 years or greater (SCDNR 2015), spending most of their adult life at sea and migrating into rivers to spawn (Collins et al. 2000b). The capture of Atlantic Sturgeon in the Santee River in the 1990s suggests that a population still exists in this river (Collins and Smith 1997).

In South Carolina, females mature between the ages of 7 and 19 (Smith and Clugston 1997) and males between the ages of 5 and 13 (Atlantic Sturgeon Status Review Team 1998). In many South Carolina rivers, spawning occurs in the spring and fall around April and October (Collins et al. 2000b, Balazik and Musick 2015, Farrae et al. 2017). Spawning occurs repeatedly but not annually with females spawning every 3 - 5 years and males every 1 - 5 years (Smith 1985). Depending upon age, females spawn an estimated 400,000 - 8 million eggs per year (Borodin 1925, Smith et al. 1982, Van Eenennaam and Doroshov 1998, Dadswell 2006). After spawning, Atlantic Sturgeon return to ocean waters.

Spawning sites have not been identified in the Santee River, but in other rivers, have been reported to occur inland of the salt wedge (Bemis and Kynard 1997), at water temperatures between 13 - 24ºC (Greene et al. 2009), on substrates ranging from bedrock to cobble/gravel (Collins et al. 2000b, ASMFC 2012c), and in water depths of 5 - 42 ft (1.5-13 m) (Collins et al. 2000b). Moderate river flow is required for spawning and egg attachment, with optimal bottom velocities between 1.5 – 2 ft/sec (0.46 – 0.76 m/s) (Greene et al. 2009). While not critical for spawning success, the concentration of dissolved oxygen is very important for juvenile Atlantic Sturgeon, as they are extremely sensitive to hypoxic conditions. Secor and Niklitschek (2001) reported that YOY fish aged 30 to 200 days experienced a loss in growth in habitats with less than 60% oxygen saturation (4.3 mg/L to 4.7 mg/L at 22 - 27°C); and juvenile mortality was observed when dissolved oxygen concentrations were less than or equal to 3.3 mg/L (40%

oxygen saturation) at temperatures of 22 - 27°C. During the summer, Atlantic Sturgeon may aggregate in the lower portion of rivers, often in deep holes near the freshwater–saltwater interface, although the exact location can vary based on individual river characteristics and flow conditions (Collins et al. 2000a).

Atlantic Sturgeon populations in the Santee Basin are low, in part, due to overharvesting and potential bycatch (Collins et al. 1996). In addition, human actions have seriously impacted the quality of Atlantic Sturgeon habitat. Since European settlement, overfishing, habitat loss, and poor water quality have contributed to the coast-wide decline of Atlantic sturgeon stocks (Greene et al. 2009). Relatively low numbers of juvenile and adult Atlantic Sturgeon were captured in the Santee River during the mid-1990s (Collins and Smith 1997). A more recent side-scan sonar survey targeting Atlantic Sturgeon in their summer habitat was conducted at 30 sites, each 2 km long, near the freshwater-saltwater interface, but failed to detect any fish >1 m total length (Flowers and Hightower 2015). Post and Holbrook (2016) reported the capture of low numbers of adults and juveniles during ongoing sampling for telemetry surveys, but no adult Atlantic Sturgeon were captured (or tagged fish detected) in the Santee River during the spring or fall spawning season (B. Post, personal communication). Ongoing telemetry studies indicate stock mixing occurs frequently during the juvenile stage, but without genetic assignments for Atlantic Sturgeon captured in the Santee River, the true river of origin cannot be determined. However, tissue samples have been provided to NMFS, per permit requirements, and river of origin may be determined in the future. A reproducing population of Atlantic Sturgeon in the Cooper River has not been verified (Collins and Smith 1997, B. Post, personal communication). A reproducing population of Atlantic Sturgeon in the Santee Cooper lake systems is unlikely as only isolated reports of Atlantic Sturgeon upstream of the dams exist (Collins and Smith 1997).

Incidental catch or bycatch of Atlantic Sturgeon in the Santee River occurs in the commercial shad fishery below the St. Stephen and Wilson dams. There are no commercial shad fisheries in the Cooper River or upstream of the dams (i.e., Lakes Marion and Moultrie). In 2010, the ASMFC passed Amendment 3 to the Interstate Fishery Management Plan for Shad and River Herring (ASMFC 2010). This amendment established a coast-wide commercial and recreational moratorium for American Shad and River Herring, but allowed the fishery to remain open if the ASMFC prepared and approved an Implementation Plan. Additionally, NMFS encouraged SCDNR to consider the presence of both sturgeon species as the Implementation Plan was developed. As a result, for the Santee River, SCDNR implemented statewide gear restrictions, moved the start and ending dates of the season up two weeks, and reduced allowable gill nets from 10 to 5 per licensee (ASMFC 2012b) (Table 4), which appears to have resulted in a decline of sturgeon bycatch.

Table 4. Sturgeon encounters in the Santee River American Shad fishery 2001-2016. Gear restrictions and season changes highlighted in SC's Shad Sustainability Plan (Appendix I) were implemented in 2013.

Year	Shortnose Sturgeon	Atlantic Sturgeon	Year	Shortnose Sturgeon	Atlantic Sturgeon
2001	2	105	2009	11	175
2002	9	40	2010	2	9
2003	1	15	2011	3	173
2004	3	11	2012	12	77
2005	0	0	2013	1	7
2006	6	225	2014	1	10
2007	9	162	2015	0	7
2008	25	74	2016	8	15

B. Shortnose Sturgeon

Shortnose Sturgeon, a federally-listed endangered species, are smaller than Atlantic Sturgeon, reaching lengths of about 3 ft (1 m) and weights of about 50 lbs (24 kg) when fully grown. In South Carolina, Shortnose Sturgeon live 10 - 25 years with males reaching sexual maturity around 3 - 5 years and females around 6 years (Dadswell et al. 1984). Spawning occurs once per year in late winter/early spring at water temperatures of 9 - 15ºC (Kynard 1997) in areas of moderate river flow with average bottom velocities of 1 – 2 ft/sec (0.1-0.2 m/sec) (Hall et al. 1991, Kieffer and Kynard 1996). Spawning sites usually contain substrate of gravel, cobble, or large rocks located at river mile 125 or greater (Kynard 1997). Spawning periodicity varies between the sexes; males spawn at 1 - 2 year intervals while females typically spawn every 3 - 5 years (NMFS 1998). Females produce anywhere from 30,000 - 210,000 eggs per spawning event (Dadswell et al. 1984). After spawning, Shortnose Sturgeon appear to remain in freshwater or estuarine areas for most of the year, but recent studies demonstrate some fish use the ocean to migrate between coastal rivers (Post and Holbrook 2015).

In the Santee Basin, Shortnose Sturgeon occur in the Cooper River, Santee River, Lake Moultrie, Lake Marion, Wateree River, and Congaree River. In the Cooper River, upstream spawning migrations have been observed to the Pinopolis Dam (river mile 48) (Cooke and Leach 2004), and a few fish sonically tagged have been detected passing upstream through the navigation lock (Post and Holbrook 2015). Residence by spawning fish in the tailrace lasts on average 30 - 89 days suggesting the fish remain in the tailrace looking for upstream passage (Cooke et al. 2002, Cooke and Leach 2004). Viable Shortnose Sturgeon eggs have been collected in the tailrace below the dam; however, successful reproduction has not been confirmed as neither larvae nor juveniles have been collected (Cooke and Leach 2004, Post and Holbrook 2015). Reasons for unsuccessful reproduction may include unsuitable spawning substrate (dominated by barren hard bottom), excessive bottom water velocities (exceeding 3 feet (1 m)/sec), and increased water temperatures (18^{o}C) (Cooke and Leach 2004). The absence of early life stage Shortnose Sturgeon indicates that recruitment failure is occurring, as smaller fish are not present to grow and replace the reproducing adults. This led Cooke and Leach (2004) to conclude that the Cooper River subpopulation of Shortnose Sturgeon is recruitment limited. Based on population estimates, the population of adult Shortnose Sturgeon during the spawning season is believed to be between 100 and 300 individuals (Cooke et al. 2004), or between 100-238 individuals (Post and Holbrook 2016), falling well below the minimum viable population level of 1,000 adults suggested as ideal for vertebrates (Thompson 1991).

Results from a number of telemetry studies to evaluate the effectiveness of the Pinopolis Navigation Lock for upstream Shortnose Sturgeon passage indicate that Shortnose Sturgeon readily enter the Pinopolis Lock, but rarely pass upstream. Cooke et.al. (2002) tagged and tracked 72 spawning adult Shortnose Sturgeon in the Cooper River over a five-year period, and although many of them entered the navigation lock, none of them passed upstream. Timko et al. (2003) used a 3-D tracking system to study the effectiveness of the lock for passing Shortnose Sturgeon, and observed only one of 14 tagged Shortnose Sturgeon passed upstream into Lake Moultrie. In a study conducted in 2011 as part of the Santee Accord, two Shortnose Sturgeon were captured in the Cooper River and acoustically tagged and were detected as they passed upstream into Lake Moultrie through the Pinopolis Navigation Lock. One of these fish later passed safely downstream through the turbines at the Jeffries Power Station where it was tracked in the Cooper River (Post and Holbrook 2015).

Shortnose Sturgeon appear to be able to out-migrate from the Santee Cooper Project more effectively than they migrate upstream. In a study conducted by Cooke and Leach (2003a), 16 Shortnose Sturgeon were captured from the Cooper River, acoustically tagged and released into Lake Moultrie. Fifteen of the tagged fish exited the lakes, using several locations, including Wilson Dam (n=6) in Lake Marion, St. Stephen (n=8) on the Rediversion Canal, and Pinopolis Dam (n=l) in Lake Moultrie. Also, as previously stated, three acoustically-tagged Shortnose Sturgeon passed downstream through the Jefferies Power Plant in 2011(n=1) and 2016 (n=2).

In the Santee River, spawning migrations are blocked by Wilson Dam at river mile 89 and impeded by St. Stephen Dam on the Rediversion Canal at river mile 57 (Leach and Cooke 2005). Six Shortnose Sturgeon have been observed passing upstream at the St. Stephen Fish Lock since its construction in 1985 (Collins et al. 2003, Leach and Cooke 2005). Unlike in the Cooper River, no spawning has been observed in the Santee River below either of the dams (Shortnose Sturgeon Status Review Team 2010). However, in 2016 two YOY (412 and 432 mm fork length) were captured in the Santee River, but without genetic analysis, their river of origin remains unknown (Post and Holbrook 2016). Tissue samples have been provided to NMFS, per permit requirements, and river of origin may be determined in the future.

A dam-locked population of Shortnose Sturgeon is present in Lakes Marion and Moultrie. Based on the results of mark-recapture population studies conducted from 2012 through 2016, numbers of adult Shortnose Sturgeon estimated in the Browns Lake area of Lake Marion ranged from 207-286 individuals (Post and Holbrook 2016). This estimate is higher than the estimate obtained in an earlier population estimate conducted in 2005-2006 of 112 individuals, but that estimate was based on a small sample size (five recaptures from a marked population of 35); therefore, the estimate was derived with a large amount of uncertainty. The 2012-2016 study was more intensive and estimates were produced from a marked population of 142 and 75 recaptures and the 2016 estimate of 283 individuals is thought to be a more accurate representation of the population (Post and Holbrook 2016).

Other than areas near the confluence of the Wateree and Congaree rivers, utilization of the Wateree River by Shortnose Sturgeon appears to be rare and limited to the spring season (Post and Holbrook 2015). Over the course of a five-year migration study, 21 adults were detected in the Wateree River, but only one fish was observed spending any noticeable time as far as 11 miles upstream of the mouth of the Wateree River. Additionally, trawling was conducted in the Wateree River for juveniles, but no juveniles were collected and spawning has not been confirmed in the Wateree River (Post and Holbrook 2016).

A spawning site was identified in the Congaree River below Columbia but spawning has not been observed further upstream in the Broad River (Collins et al. 2003). No evidence of Shortnose Sturgeon in the lower Saluda River has been observed (Kleinschmidt 2007). In 2002, Finney et al. (2006) tracked two sexually mature Shortnose Sturgeon captured in the Cooper River and translocated into Lake Moultrie. Within a span of two weeks, both fish had traversed Lake Moultrie, the Diversion Canal, Lake Marion, and the Congaree River and were relocated in the Congaree River near Columbia, South Carolina (near river mile 100) where they remained for at least 14 days.

Despite some observations of fish passing from the Santee and Cooper rivers into the lakes, Collins et al. (2003) suggested that the lake population receives little genetic influx from either river due to size and condition differences, spawning site locations, and behavioral observations. However, more recent genetic analyses suggest the Lake Marion and Cooper River groups are not genetically discrete (Wirgin et al. 2010).

As discussed previously for Atlantic Sturgeon, one threat to the Shortnose Sturgeon populations in the Santee River has been bycatch associated with the commercial American Shad gillnet fishery. In recent years, significant changes in South Carolina legislation regulating the shad gillnet fishery have directly reduced numbers of sturgeon caught and affected by gill nets (Table 4).

C. American Eel

The American Eel is the only catadromous fish in the Santee Basin. As such, it spawns in the Atlantic Ocean migrating into river systems as juveniles (glass eels) that move into estuaries and tidal rivers in the late winter/early spring when water temperatures reach 10 - 12ºC (Greene et al. 2009). Glass eels and elvers (pigmented eels) migrate primarily at night while burrowing during the day in sand, mud, and plant mass (Greene et al. 2009). Juvenile eels are capable of climbing vertical walls, including low dams, as long as surfaces are damp and textured (SCDNR 2015). Elvers have difficulty swimming in river velocities exceeding about 0.8 ft (25 cm)/sec, so they rest in the stream substrate when velocities are not conducive to swimming (Jessop 2000).

The final inland resident stage is called the yellow eel and includes all eels greater than 4 inches (10 cm). Yellow eels may gradually move upstream over many years, with most movement occurring during spring and fall when water temperatures are moderate (SCDNR 2015). They inhabit a variety of habitats including estuaries, lakes, ponds, rivers, and streams and seem to prefer water with dissolved oxygen concentrations greater than 4 mg/L (Greene et al. 2009). During freshwater residency, they can grow to over 2 ft (60 cm) in length. At maturity, around 7 - 13 years, they stop feeding, take on a silvery cast and begin downstream migrations. Silver eels migrate to the Sargasso Sea region of the Atlantic Ocean during the fall where it is believed they die after spawning (Greene et al. 2009). The age and size at which migration begins varies geographically. American Eel in the northern part of the range exhibit slower growth and remain in freshwater and estuarine systems longer before migrating back to sea (Facey and Labar 1981). Various studies in Newfoundland, Lake Ontario, and Lake Champlain have shown that American Eel migrate back to sea after about 12 - 13 years, at a mean size of 27 inches (68 cm) (Gray and Andrews 1971, Hurley 1972, Facey and Labar 1981, McGrath et al. 2003). In the southern part of their range, American Eel begin migrating earlier than in the north (Hansen and Eversole 1984, Helfman et al. 1984, Owens and Greer 2003). Hansen and Eversole (1984) found that in the Cooper River, American Eel older than 7 and greater than 25 inches (65 cm) in length were sparse, suggesting that adults migrate at a younger age and smaller size. Based on the most recent stock assessment (ASMFC 2012a), American Eel stocks are depleted on the east coast of the United States. Reasons given to explain these declines in populations include habitat loss from dams or urbanization; turbine mortality of adults associated with downstream migrations; mortality associated with infections of the nonnative swim-bladder parasite *Anguillicolla;* toxic pollutants; climate change; and fishing mortality.

In the Santee Basin, American Eel numbers are likely well below those present prior to dam construction. Dams and causeways obstruct access to a diversity of habitats and can cause mortality during downstream passage. For American Eel migrating up the Santee and Cooper rivers, fish passage is thought to be non-existent at Wilson Dam and unknown at Pinopolis Dam. SCDNR maintains an eel ramp at the St. Stephen Dam on the re-diversion Canal, and passage from 2010-2016 ranged from 2,124 to 17,491 fish per year (Post and Holbrook 2016). Duke Energy has maintained American Eel passage at the Wateree Dam on the Wateree River since 2005, but annual passage exceeded 60 American Eels in only one (2008) of those years (Duke Energy 2016). Based on back-pack electrofishing catch rates, a higher abundance of American

Eel can be found in wadeable streams downstream of the Pinopolis and Wilson dams than below the Columbia and Wateree dams (Bulak et al. 2011), and based on SCDNR data, very low numbers of American Eel are present upstream of the fall line (SCDNR 2017) (Figure 12).

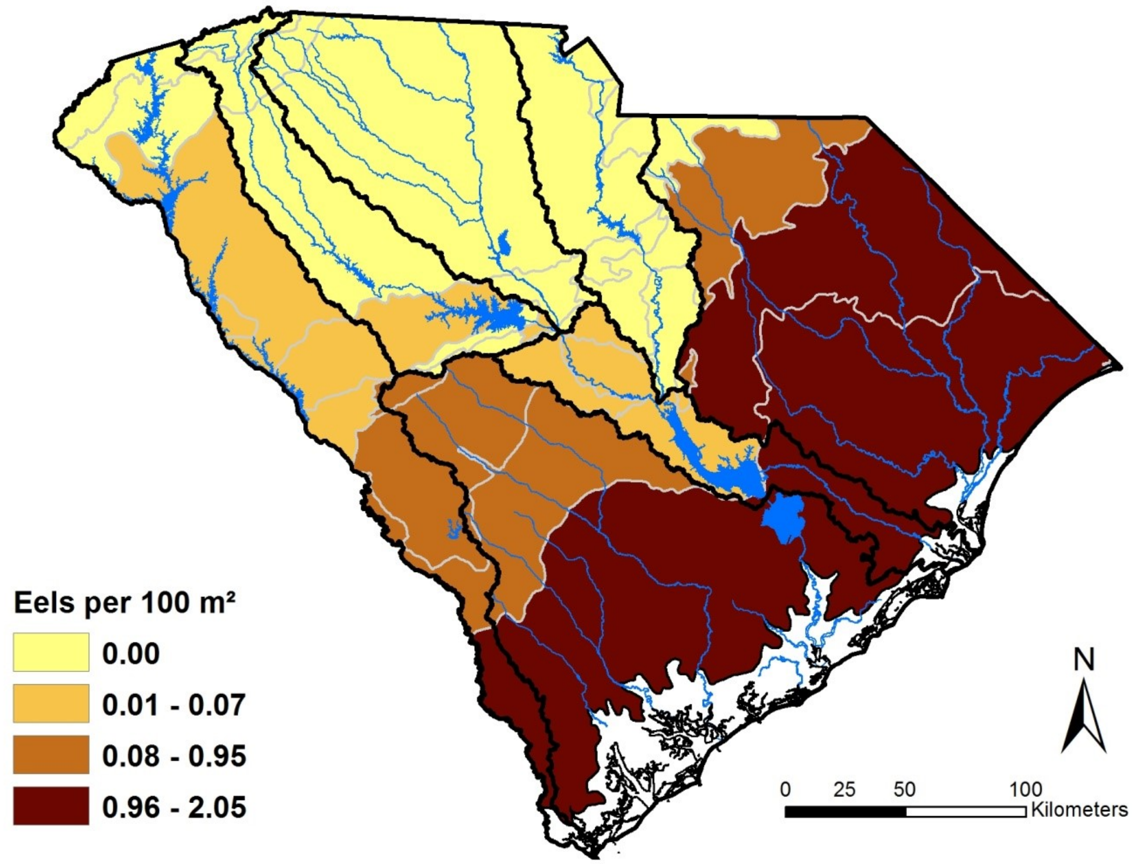

Figure 12. Density of American Eel in South Carolina ecobasins (SCDNR 2017).

Downstream passage of out-migrating American Eels is more problematic than upstream passage, as entrainment through a hydroelectric dam can result in injury and/or mortality of mature, fecund individuals. Data shows that the downstream mortality rate can be highly variable depending on the dam configuration, turbine type, and operational conditions (ASMFC 2015b). In general, larger fish are more likely to encounter turbine strikes than smaller fish, and thus the larger female silver American Eels are particularly vulnerable (ASMFC 2015a). Some studies have shown relatively high survival rates for silver eels and include: 66% (Normandeau Associates 2016), 73.5% (Normandeau Associates and Skalski 1998), and 97.9% (Normandeau

Associates 2016). However, Haro et al. (2000) reported that at large projects with high project flows, or intake openings that cannot be fitted with racks or screens with openings small enough to exclude American Eels, impingement and entrainment mortality of American Eels can be as high as 100%. Seasonal turbine shutdowns, based on environmental characteristics (e.g., flow, lunar phase, and temperature) and time of day, where practical, can be a used to successfully reduce eel mortality associated with downstream passage and outmigrations (ASMFC 2012a).

American Eel fisheries flourished well into the early 20th century. American eels were once an important food fish in the U.S., but today are mainly sold as bait or exported to Europe and Asia, where demand continues to be high. Declines in European and Asian eels drive the export fishery, and in particular, the export market for glass eels. From the 1970s to the mid-1980s, American Eel supported significant commercial fisheries, with coast-wide landings ranging from 2.5 -3.6 million lbs. Landings dropped to 1.6 million lbs in 1987 and have remained at low levels, ranging from 1.5 million to 700,000 lbs since then (ASMFC 2017).

The SCDNR annually monitors the relative abundance of glass eels/elvers in South Carolina, using techniques prescribed by the ASMFC, and maintains eel ladders at the St. Stephen and Goose Creek dams. However, basing the status of American Eel on abundance of elvers from a specific location is highly disputed because American Eels are considered to be a “panmictic” population segment. From a management perspective, this means that population levels of American Eels in other river basins and overall spawning success may heavily influence the success of efforts made to enhance American Eel populations in a river basin.

In 2000, an interstate fisheries management plan (IFMP) was developed for the American Eel, which provided recommendations for protecting or enhancing American Eel sub-populations by state and region (ASMFC 2000). The IFMP required the states to control and limit directed effort for commercial eel fisheries, and in 2001, states were required to collect and monitor catch and effort statistics for American Eel commercial fisheries and to limit effort to levels achieved in 2000.

In 2012, a benchmark population assessment conducted by ASMFC found that the American Eel population was depleted coast-wide, and in response to that assessment, Addendum III was added to the 2001 Management Plan. Addendum III established new measures for the commercial and recreational eel fishery. For South Carolina, a 1/8 inch non-stretchable mesh will be required to grade all captured glass eels immediately upon harvesting, which will reduce the harvest of pigmented eels. Furthermore, a small tolerance (maximum of 25 pigmented eels per pound of glass eel catch) of pigmented eels will be allowed. Finally, it is also recommended that all catch be graded on the boat or streamside and that any bycatch is immediately returned to the waters where the fish were harvested. As a result of these new recommendations, SCDNR capped the commercial glass eel fishery at 10 license holders, and since 2013, the glass eel fishery decreased from 2,270 lbs in 2013 to 205 lbs in 2014 and 132 pounds in 2015 (NMFS 2017).

In addition, Addendum III to the IFMP required states to limit recreational harvest through the establishment of several regulations: the possession limit is not to exceed 25 eels; the minimum size limit for the commercial eel fishery is 9 inches; and sale of American Eels is prohibited without a license (ASMFC 2015a).

D. Anadromous Clupeidae

Alosine fishes (American Shad, Hickory Shad, and Blueback Herring) have been the subject of numerous restoration efforts along the east coast of North America. Blueback Herring and Alewife are commonly referred to as river herring, but Alewife are encountered infrequently in South Carolina and are not thought to spawn in South Carolina rivers (Rohde et al. 2009). These fishes are an anadromous, pelagic, and highly migratory schooling species known for their stamina and ability to return to their natal rivers to spawn. Alosines are vital components of riverine, estuarine, and marine food webs, providing a major forage base for predacious fishes such as groundfishes, Striped Bass, Bluefish (*Pomatomus saltatrix*), and Red Drum (*Sciaenops ocellatus*) (Weiss-Glanz et al. 1986, Burke and Rohde 2015, McDermott et al. 2015). While alosine populations remain stable and relatively large in the Santee Basin as compared to other East Coast systems, additional increases in population numbers may be achievable through cooperative improvements to passage aspects, along with responsible management and enforcement actions that relate to other population limiting factors. A description of each of the alosine fishes in the Santee Basin follows.

American Shad: The American Shad is the largest member of the herring family averaging 17 inches (43 cm) in length when mature and weighing from about 2 - 7 lbs (1-3 kg). Sexual maturity is reached between the ages of 3 and 6 with males generally maturing a year earlier than females (SCDNR 2015). Melvin et al. (1986) provided evidence that American Shad show high levels of homing in a northern river. In coastal rivers south of Cape Hatteras, North Carolina, most American Shad are semelparous spawners, which means they die after one spawning season (SCDNR 2015). The reasons for this are thought to be related to physiological stresses associated with long spawning migrations and possibly higher water temperatures (Leggett 1969). Spawning in South Carolina occurs in main stem river areas from March - April when water temperatures reach 14 - 24.5ºC (Greene et al. 2009), between dusk and midnight (Harris and Hightower 2011) in water velocities of about 1 – 3 ft (0.3 – 0.9 m)/sec, and depths of about 5 – 20 ft (1.5- 6m) (Greene et al. 2009). Females will release anywhere from 100,000 - 600,000 eggs (Rohde et al. 2009), and southern stocks of American Shad produce more eggs per unit of body weight than northern populations, which may be an adaptation compensating for the lack of repeat spawning trips (Leggett and Carscadden 1978). Eggs require adequate water flow (generally 0.5 – 3 feet (0.15 – 0.9 m)/sec) and sufficiently low sediment loads to remain adrift until hatching (SCDNR 2015). Larval survival decreases if the suspended sediment concentration increases above 50 mg/L (SCDNR 2015).

Although historical population estimates are nonexistent, historical distribution records (FWS 2001) together with the commercial fisheries data indicate American Shad populations in South Carolina were declining prior to 1984 and the completion of the Cooper River Rediversion Project. American Shad historically ascended all of the sub-basins in the Santee Basin, well inland of the Fall Line and into North Carolina, and the current distribution of American Shad is now generally well downstream of the Fall Line (FWS 2001). The American Shad population in the Santee Basin has grown substantially since the Rediversion Canal was completed in 1985, and this population is among the largest on the Atlantic Coast, with the population likely approaching one million adults annually (McCord 2003, SCDNR 2015).

The commercial fishery was relatively undeveloped in the late 1800s, primarily due to the lack of transportation facilities and the limited population in the vicinity (Stevenson 1899, Walberg and Nichols 1967). Considerable numbers of shad were formerly taken further upstream in Columbia (McDonald 1884). Walberg and Nichols (1967) reported a Santee River American Shad harvest of 33,473 lbs (15,183 kg) in 1896, which increased to 54,255 lbs (24,610 kg) in 1960 but averaged only 5,460 lbs (2477 kg) from 1979-1984 (ASMFC 2007b). Since 1984, the commercial fishery has averaged 117,975 lbs (53,513 kg), and in 2013, landings of American

Shad in South Carolina accounted for 33% of the total commercial East Coast harvest of this species (ASMFC 2015d), of which the Santee River landings accounted for 62% of this total (there is no commercial fishery for American Shad in the Cooper River). The Santee River is the only river in South Carolina that has experienced a consistent increase in American Shad harvest over the last 100 years (ASMFC 2007b).

Because American Shad are highly sought by sport and commercial anglers for their roe and meat, and are prized by sport anglers for their hardy fight when hooked, seasonal sport and commercial fisheries for American Shad presently exist in the Santee River and a sport fishery exists in the Cooper River (ASMFC 2015d).

Hickory Shad: The Hickory Shad is intermediate in size between Blueback Herring and American Shad reaching a total length of 14 - 24 inches (30-40 cm) and a weight of about 2 – 4 lbs (1-2 kg). Spawning in South Carolina occurs within 50 miles of the ocean along channel edges of tidally-influenced freshwater reaches from February - early March when water temperatures reach 12 - 19°C (Greene et al. 2009, SCDNR 2015). Little information is available regarding other spawning requirements for Hickory Shad; however, water velocity and substrate may be important for successful spawning (Harris and Hightower 2011). Females produce between 100,000 - 400,000 eggs, which require adequate water flow (generally 0.5 - 3 feet (0.15 – 0.9 m)/sec) and sufficiently low sediment loads to remain adrift until hatching (SCDNR 2015). Larval survival decreases if the suspended sediment concentration increases above 50 mg/L (SCDNR 2015).

Like American Shad, Hickory Shad will strike at artificial lures and are a highly desirable sportfish along the East Coast (Mansueti 1962, Pate 1972, Rohde et al. 2009). While Hickory Shad are not sought commercially because the bony flesh is not considered to be as palatable as the other alosines (Whitehead 1985), some consider their roe to be more desirable than the other species (Nichols 1959). Juvenile Hickory Shad are important prey for other fish, including many species of commercial and recreational importance (B.M. Richardson, personal communication).

The Hickory Shad population status in South Carolina is poorly understood (Rohde et al. 2009); and the restoration need and potential is unknown. However, based on anecdotal observations, the Santee Cooper population is among the largest in the State, despite very low passage numbers recorded at the St. Stephen Fish Lock (Cooke and Leach 2003b).

Blueback Herring: The Blueback Herring is the smallest of the anadromous clupeids reaching a total length of about 12 - 14 inches (30 - 32 cm) and weight of less than 1 lb (0.5 kg). Blueback Herring can reach the age of 11, but the oldest fish seen in rivers today are six to eight years old (ASMFC 2012e). Spawning in South Carolina generally occurs nocturnally from March - April in water temperatures of 13 - 26ºC (Pardue 1983, Meador et al. 1984, Bozeman and Van Den Avyle 1989). Blueback Herring spawn in both lentic and lotic environments utilizing both swift-flowing, deeper stretches of rivers and streams with associated hard bottom and slow-flowing shallow tributaries with soft substrates covered with vegetation (Pardue 1983, Bozeman and Van Den Avyle 1989). While Blueback Herring generally spawn above the tidal influence, the distance they move upriver may be partly dependent upon the availability of suitable spawning habitat nearer the coast (SCDNR 2015). Females release as many as 250,000 eggs in shoreline areas where males fertilize them. Like American Shad and Hickory Shad, Blueback Herring larval survival decreases if the suspended sediments concentration increases above 50 mg/L (SCDNR 2015). Juveniles typically migrate out of the rivers into the ocean in the fall, where they spend the next three to five years of their lives. However, summer sampling events in the Santee Basin have captured several one-year-old fish, indicating some juveniles overwinter in the system. Blueback Herring are typically the most abundant of the Santee Basin's spring migrants, and they are capable of making long-distance migrations with some fish tagged in the Santee Basin collected as far away as the Bay of Fundy in Canada (FWS et al. 2001). Unlike American Shad, Blueback Herring do not die after spawning but will return to offshore areas to overwinter and may return to the same river to spawn several times over the course of their lives (Christie 1985).

A concern for the coast-wide decline in Blueback Herring populations has led to the closure of the fishery in many states along the east coast of the United States in 2012; only selected sustainable river herring fisheries in Maine, New York, New Hampshire, Rhode Island, and South Carolina remain open (Maryland Department of Natural Resources 2017). Blueback Herring are harvested commercially for human consumption, for cut-bait in American Eel pots, and as live-bait for Striped Bass anglers, and South Carolina accounted for 12% of the total coast-wide commercial harvest in 2013 (ASMFC 2015d). The majority of commercial fishing activity for Blueback Herring occurs in the tailraces of the Pinopolis, St. Stephen, and Wilson dams (ASMFC 2015c). It is one of the most important and closely-monitored commercial fisheries in the state.

The Cooper River Rediversion Project affected Blueback Herring populations in the Santee Basin in a two-fold manner. The Blueback Herring population in the Santee River had a positive response to increased flows with average annual population estimates increasing from 3.1 million fish pre-rediversion (1980 - 1984) to 6.6 million post-rediversion (1986 - 1990). However, the reduction in flows in the Cooper River negatively affected Blueback Herring populations in that river. Passage into the Santee Cooper Reservoirs via the Pinopolis Navigation Lock, which averaged 5.7 million annually and ranged from 2.1 to 10.7 million prior to the Rediversion Project (1975 - 1984), decreased to an annual average of 1.2 million and ranged from 160,000 to 3 million post-rediversion (1985 – 1990) (Cooke 1990). Cooke and Eversole (1994) attributed the decline in Cooper River Blueback Herring populations to a reduction in the amount, and perhaps quality, of spawning and nursery habitat.

Prior to rediversion, the commercial herring harvest from the Cooper River during 1969-1985 annually averaged about 206,000 lbs (93,440 kg). A commercial fishery was created on the Rediversion Canal, and the annual harvest during 1990-2015 averaged about 70,000 lbs. While the commercial harvest from the Santee River (and Rediversion Canal) increased after Rediversion, those increases are not large enough to offset the declines observed in the Cooper River harvest, and a net decline in the commercial fishery has occurred since Rediversion (Table 5).

Table 5. Commercial harvest of Blueback Herring from the Santee and Cooper rivers, 1969 – 2015.

Year	Cooper River Landings (kg)	Santee River Landings (kg)	Rediversion Canal Landings (kg)	Year	Cooper River Landings (kg)	Santee River Landings (kg)	Rediversion Canal Landings (kg)
1969	1111774	a	a	1993	4170	a	162977
1970	145379	a	a	1994	3047	a	116125
1971	629234	a	a	1995	472	a	186378
1972	448973	a	a	1996	a	a	238781
1973	164657	a	a	1997	a	a	128133
1974	40053	a	a	1998	a	a	180919
1975	8318	a	a	1999	a	a	118164
1976	11689	a	a	2000	a	a	120114
1977	13572	a	a	2001	550	a	24134
1978	15255	a	a	2002	a	a	0
1979	65341	a	a	2003	807	a	46665
1980	177444	31900	a	2004	3200	a	8040
1981	71392	101802	a	2005	a	a	10412
1982	93428	a	a	2006	a	a	6743
1983	262618	b	a	2007	a	a	50701
1984	251450	b	a	2008	3000	a	3600
1985	135926	9600	b	2009	a	a	71600
1986	66029	35200	b	2010	a	a	69600
1987	67988	a	b	2011	a	a	37600
1988	20133	a	b	2012	a	a	18900
1989	17791	a	b	2013	a	a	33500
1990	17846	a	1154	2014	a	a	52116
1991	7829	a	8859	2015	a	a	22521
1992	7723	a	82673				

a - indicates that harvest was not monitored and should not be assumed to be 0
b - commercial fishing was prohibited during these years

III. Other Migratory Species Benefiting from the Plan

Other migratory species (i.e. potomodromous or fish that migrate totally in fresh water), including suckers in the family Catostomidae, such as the Quillback (*Carpiodes cyprinus*), Highfin Carpsucker (*Carpiodes velifer*), Notchlip Redhorse (*Moxostoma collapsum*), V-lip Redhorse (*Moxostoma pappillosum*), and Robust Redhorse (*Moxostoma robustum*), may also benefit from the habitat and fish passage recommendations provided in the Plan. Suckers are an important component of the Santee Basin fish assemblage, accounting for more than 51% of the fish biomass in the Broad River alone (Bettinger et al. 2003, Coughlan et al. 2007). However, regionally they face a variety of threats including competition from invasive species, environmental contaminants, habitat degradation due to agricultural and urban development, hydropower projects, migration barriers, water diversions, eutrophication, and exploitation by commercial, recreational, and subsistence fishers (Cooke et al. 2005). Spawning aggregations are particularly vulnerable to migration barriers due to reproductive behavior typified by a spring migration upriver to spawning grounds in small tributaries (Curry and Spacie 1984, Cooke et al. 2005). Habitat degradation due to pollution and siltation, boat traffic and groundings, fishing pressure, and fluctuations in current velocities, water temperatures, and water levels caused by hydropower generation or water conservation at upstream reservoirs may also be problematic as many suckers require clean gravel deposits in shallow flowing water for successful spawning (Grabowski and Isely 2007). Therefore, the availability of suitable spawning habitat has the potential to be a major limiting factor in the conservation and long-term management of catostomid populations (Grabowski and Isely 2007). As such, the habitat and fish passage recommendations provided in this Plan may be beneficial to sucker populations.

IV. Previous Plan Accomplishments

The 2001 edition of the *Santee-Cooper Basin Diadromous Fish Passage Restoration Plan* established five objectives for restoring diadromous fishes within the Santee Basin: Upstream Passage, Downstream Passage, Instream Flows, Water Quality, and Habitat Protection. This section describes the progress made to date on these objectives.

A. Instream Flows

The 2001 Plan identified a need to restore flows at six riverine locations: the Santee River below the Santee (Wilson) Dam, the Wateree River below the Wateree Dam, the Catawba River at Great Falls Bypass and below the Lake Wylie Dam, the lower Saluda River below the Saluda (Lake Murray) Dam, and the Cooper River below the Pinopolis Dam. Progress has been made in enhancing instream flows for diadromous fishes at five of these sites. A description of instream flow enhancements at each of these locations follows:

Santee Cooper Hydroelectric Project: The Wilson Dam includes a small powerhouse that operates to provide a minimum flow into a 37-mile stretch downstream of the powerhouse to the confluence of the Rediversion Canal that has been bypassed since 1942. The current requirement for minimum instream flow at Wilson Dam is 500 cfs. Flows to benefit the aquatic community were negotiated in the relicensing settlement agreement signed by Santee Cooper, the FWS and SCDNR[7]. These flows will be initiated within three years from the time the new license is issued and will increase the instream flow requirements during May - January from 500 cfs to 1,200 cfs, and from February - April from 500 cfs to 2,400 cfs (FERC 2007).

[7] Relicensing Settlement Agreement for the Santee Cooper Project FERC No. 199

Catawba-Wateree Hydroelectric Project: Flows negotiated in the FERC license issued November 2015 include improvements in the Catawba River, Wateree River, and Great Falls Bypass (FERC 2015). The Wateree Development is the hydroelectric plant furthest downstream in the sub-basin, and the new FERC license requires implementation of seasonal instream flows developed with input from a site-specific instream flow study. The Wateree Dam has not delivered continuous flows since construction in 1919. However, flows prescribed in the FERC license increase from minimum average daily flows of 446 cfs to minimum continuous flows of 930 cfs from June - February 14, 2,400 cfs from February 15 - 29, 2,700 cfs from March - April, 2,400 cfs from May 1 - 15, and 1,250 cfs from May 16 - 31. This flow scenario should provide more than 97% of the maximum weighted useable area for American Shad during the March - May spawning period (FERC 2009). The new FERC license restores flows to the Great Falls Bypass. The long and short sections of the Bypass, when implemented, will split a total flow of 950 cfs from February 15 - May 15, and 550 cfs the remainder of the year.

While not identified in the 2001 Plan as needing inflow enhancement, the new FERC license established minimum average daily flows for the Fishing Creek Development (440 cfs) and the Rocky Creek-Cedar Creek Development (445 cfs), provided by a combination of leakage, spillage, and generation.

For the Lake Wylie Development, minimum flows will change from a minimum average daily flow of 411 cfs to a minimum continuous flow of 1,100 cfs. Furthermore, certain inflow criteria will trigger a 1,300 cfs spring flow to aid spawning conditions.

For the Lookout Shoals and Oxford developments, the new FERC license requires a year-round minimum continuous flow of 80 cfs and 150 cfs, respectively.

For the Bridgewater Development, the new FERC license requires seasonal minimum continuous flows of 145 cfs in the tailrace and 75 cfs in the bypass December - March, a minimum of 95 cfs in the tailrace and 75 cfs in the bypass April - June, a minimum of 95 cfs in the tailrace and 50 cfs in the bypass during July, and a minimum of 75 cfs in the tailrace and 50 cfs in the bypass August - November.

Also, the new FERC license for the project requires the implementation of a low-inflow protocol that establishes "critical flows" and utilizes reservoir storage to maintain instream flows in the entire basin during periods of drought (FERC 2015).

Saluda Hydroelectric Project: Flow enhancements are pending for the lower Saluda River below Lake Murray. The Settlement Agreement developed during the relicensing of this project, is expected to be included as a requirement of the new license. If this occurs, the operational mode of the hydroelectric project will change from peaking to reserve, which means the plant only operates to 1) provide backup power in the event of another plant going offline and 2) generate as needed to manage lake levels. This change in operations will result in less frequent daily variability and more stable stream flows in the ten-mile section of the lower Saluda River determined to be highly important and valuable aquatic habitat. In addition, continuous minimum flows will be increased from 500 cfs to 700 cfs during January - March and June - December; from 500 cfs to a minimum of 1000 cfs during April 1 - May 10, when the "Striped Bass" flows will be implemented; and 1,000 cfs from May 11 - 31. "Striped Bass" flows will range from 1,000 - 2,700 cfs, depending on the average daily flow reported at the U.S. Geological Survey Gage No. 0216100, located on the Broad River at Alston, South Carolina (Kleinschmidt 2009). The objective of these flows is to mimic the natural hydrograph, which is expected to increase spawning success of Striped Bass and anadromous species, such as American Shad and Shortnose Sturgeon, in the Congaree River. SCDNR determined that spawning conditions in the Congaree River are most favorable for Striped Bass at a flow of about 9,000 cfs (combined flow from the Broad and Saluda rivers). These flows should enhance migrations and spawning habitat for anadromous fishes in the Congaree River and other downstream locations in the Santee Basin.

In addition to the projects identified for instream flow improvements in the 2001 Plan, the Pacolet Project located on the Pacolet River, addressed instream flows. This plant operates in both Run-of-River (ROR) and peaking (P; up to 75 days per year) modes. The FWS, SCDNR, and licensee negotiated the flows required in the current license and they are part of an operational agreement. The project operates a minimum of 295 days in ROR mode, and during these ROR operations, the project headpond cannot fluctuate more than one foot below the full pond. Peaking operations are limited to 75 days per year. This operational mode results in more stable flow conditions in the reservoir and the river, which is advantageous to aquatic resources. Project instream flow includes the bypass flow, which varies from 22 - 49 cfs depending on the level of the headpond, and discharges from the hydroplant, to provide a minimum of 100 cfs below the confluence of the bypass. A seasonal flow regime was not required because the ROR operational mode and bypass flow will provide some seasonal variability. Based on field studies performed and operating conditions, instream flows appear to be consistent with the South Carolina State Water Plan.

B. Water Quality

The goal of this objective is to restore, maintain, and enhance water quality at levels needed to support all life stages of diadromous fish in the Basin. Based in part on work conducted through the Accord, the occurrence of juvenile and/or adult Blueback Herring, American Shad, American Eel and Shortnose Sturgeon has been detected throughout much of the lower Broad, Wateree, and Congaree rivers. It appears that water quality in those areas of the Basin accessible to these species is adequate to support all life stages.

Improvements in dissolved oxygen have occurred or are pending for several FERC hydroprojects. At the Catawba-Wateree projects, the issuance of the new FERC license in 2015 requires improvements to dissolved oxygen be addressed at a number of project dams in North Carolina and South Carolina. Provisions in South Carolina include the installation and operation of a new aerating turbine at each of the Wylie and Wateree projects, and the implementation of existing stay vanes, hub venting baffles, and /or vacuum breakers at Fishing Creek, Dearborn, and Cedar Creek. The lower Saluda River has experienced a history of periodic but infrequent problems in meeting State water quality standards for dissolved oxygen. Reasons for this include problems with wastewater discharge and the operation of the Saluda Hydroelectric Project. For the Saluda Hydroelectric Project, the issue has been the discharge of cool, hypolimnetic water that has little or no oxygen when operating above 10,000 cfs. Studies were initiated in the 1990s and continued through 2005 to evaluate the use of turbine venting and hub baffles on dissolved oxygen concentrations. The physical modifications made based on the study results, accompanied with operational changes, resulted in substantial improvements to dissolved oxygen concentrations, especially during the season diadromous fishes would be present. Operational adjustments are made annually.

Another issue for diadromous fishes is the coldwater discharge from the Saluda Hydroelectric Project, which appears to impact spawning anadromous fishes in both the lower Saluda River and the upper Congaree River. In the lower Saluda River, the hypolimnetic discharge is about the same temperature as ambient water temperatures during January and February; however, temperatures in the lower Saluda River do not warm up as quickly as in the Broad and Congaree rivers. Water temperatures measured in the lower Saluda River are very similar to those observed in the Broad River during the late winter and early spring (Jan – March) but the Broad River warms earlier than the lower Saluda River, and is 2 - 3 degrees (C) warmer in April 1 and 3 - 4 degrees warmer in May 1 (Bulak 2008). Whether this temperature differential is the reason American Shad continue upstream in the Broad River rather than the lower Saluda River is unknown. A second issue associated with the cold water discharged to the lower Saluda River is the reduction in water temperatures observed in the upper Congaree River, where a number of anadromous fishes are known to spawn. One objective of the Striped Bass spawning protocol, described in the previous section, is to reduce the effects of the Saluda discharge in lowering water temperatures in the upper Congaree River.

Based on the most recent Watershed Assessment Reports for the Santee, Saluda, Broad, and Catawba sub-basins (SCDHEC 2007, NCDENR 2008, NCDENR 2010, SCDHEC 2012a, SCDHEC 2012b, SCDHEC 2013), there are a number of areas in the Santee Basin where water quality is impaired and does not fully support aquatic life uses. For example, in Lake Marion, the SCDHEC monitors 14 water quality sampling stations and Santee Cooper monitors nine stations (SCDHEC 2013). Of these 23 monitoring sites, 11 sites (48%) fully supported aquatic life uses (Figure 13). Sites that did not fully support aquatic life generally had high nutrient levels of phosphorus and/or nitrogen, or pH excursions. At some of these stations, decreasing trends in pH or dissolved oxygen were observed (SCDHEC 2013). These same trends were observed in the Saluda, Broad, and Catawba systems.

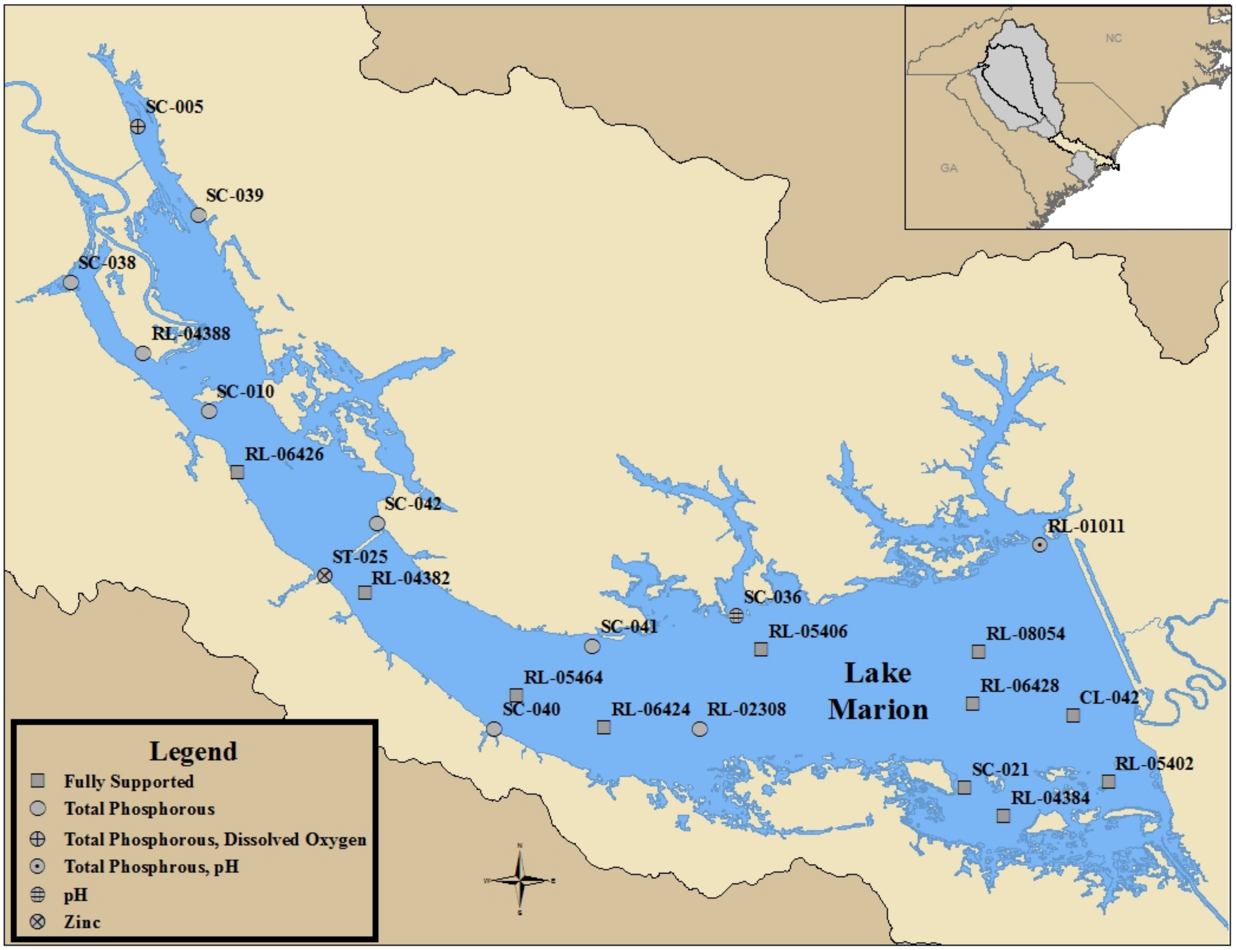

Figure 13. Water quality monitoring sites in Lake Marion. Squares represent sites fully supported for aquatic life uses. Circles represent sites not fully supported for aquatic life uses due to specicic water quality issues (e.g., total phosphorous, dissolved oxygen, pH, and zinc) (SCDHEC 2013).

In general, most of the sites that do not fully support aquatic life are located in tributaries and most of the larger water bodies (lakes and rivers) fully support aquatic life uses. Since many anadromous species utilize large water bodies to spawn, such as the Broad and Congaree rivers, the impacts of these tributary water quality issues may not be significant. In addition, the extent to which high nutrient levels and/or high pH may affect the various life stages is unknown. Until additional information is collected, any impacts to anadromous fish spawning habitat and/or success associated with water quality are unknown.

C. Habitat Protection and Enhancement

Riverine and associated wetland habitats in the Santee Basin have been altered for more than 200 years. The cumulative impact of this has been the loss and adverse modification of critically important habitats for diadromous fishes, and other fish and wildlife resources. Losses have occurred because of agriculture and silviculture practices, construction of impoundments, and the associated industrial, commercial, and residential development.

Impaired habitats include submerged and exposed riverine bottoms (especially those that support important structural or substrate features), shorelines, riparian zones, and associated wetlands that serve as habitat for fish, protect water quality, and provide other needed biological, ecological, and social functions such as food-chain production, flood protection, biodiversity, and recreational use. The goal is to protect, enhance, and increase the quality, quantity, and function of these habitats by preventing alteration of existing habitat, restoring and enhancing degraded habitat, and reintegrating habitats fragmented by physical barriers.

In 2006, Duke Energy implemented a Habitat Enhancement Program (HEP) on the Catawba-Wateree Project. This program, developed in consultation with the resource agencies, provides funding to enhance fish and wildlife habitat associated with the project. HEP funding cost shared with the Katawba Valley Land Trust to purchase a 228-acre tract of forested wetlands on Cane Creek, a large tributary of the Catawba River near Lancaster, South Carolina, and a 2,000-acre tract of riverfront property near Great Falls, South Carolina. In addition, as a component of the 2006 Catawba-Wateree Comprehensive Relicensing Agreement (CRA), Duke Energy agreed to establish conservation easements on 22 miles of shoreline along the Catawba, Johns, and Linville rivers in North Carolina and 5.5 miles of Catawba River shoreline in South Carolina. Other provisions of the CRA enabled the purchase in 2007 of about 2,800 acres of land along the Johns River in North Carolina, with an additional 2,600 acres planned for acquisition (FERC 2015). In 2015, the SCDNR completed the acquisition of several properties totaling about 8,000 acres, including approximately 17 miles of shoreline on Lake Wateree in Lancaster and Kershaw counties. Riparian lands on these properties will remain in an undeveloped state.

D. Upstream and Downstream Fish Passage

When the 2001 Plan was written, two facilities were operated in South Carolina to provide fish passage. These were the Pinopolis Navigation Lock on the Cooper River and the St. Stephen Fish Lock on the Rediversion Canal. Both facilities passed fish into Lake Moultrie. Currently, in addition to those facilities, fish passage is provided at the Columbia Diversion Dam on the Broad River and is planned for the Wilson Dam on the Santee River and the Wateree Dam on the Wateree River (passage for American Eel currently exists at the Wateree and St. Stephen Dams)

(Figure 11). A summary of fish passage at these facilities follows:

Pinopolis Navigation Lock: This facility is located at the Pinopolis (Jefferies) powerhouse on Lake Moultrie, which is part of the Santee Cooper Hydroelectric Project. To increase commerce between the Port of Charleston and Columbia, a large navigation lock was constructed to provide commercial ships and barges upstream and downstream access between the Cooper River and Lake Moultrie. An unanticipated result of the Diversion Project, which created Lakes Moultrie and Marion, was the creation of the country's first landlocked Striped Bass fishery and the previously mentioned dam-locked Shortnose Sturgeon population. To ensure an adequate supply of forage for this growing fishery, in the 1950s, state fisheries biologists requested Santee Cooper operate the locks on a daily basis for passing Blueback Herring into Lake Moultrie. Prior to 1985, large numbers of anadromous fishes concentrated at the base of Pinopolis Dam in pursuit of upstream migrations. These concentrations supported a robust commercial fishery for American Shad and Blueback Herring. SCDNR monitored the passage of anadromous fishes using hydroacoustic technology; however, the application of this technology in the lock was difficult to calibrate, and verifying species composition through time (season and years) was difficult and only undertaken a couple of times. In addition, because of inherent, unreliable data associated with this hydroacoustic technology, the SCDNR ceased deploying this gear in 2014. Alosines are thought to comprise the majority of fish (by number and weight) using the lock, but many other species have been captured in the lock (Curtis 1979). Shortnose Sturgeon can pass upstream through the lock, but the effectiveness of fish passage appears to be very low (Curtis 1979, Timko et al. 2003). SCDNR is currently experimenting with a new sonar fish counter to be installed in the Pinopolis Navigation Lock. It is hopeful this technology will provide a better estimate of the species and numbers of fishes currently passing through the lock.

St. Stephen Fish Lock: The St. Stephen Fish Lock has operated since 1985. Through 2016, the lock passed an average of 317,124 Blueback Herring (3,285 - 1,862,015) and an average of 235,735 American Shad (10,000 - 592,321) each spring (Table 6). Operational problems and/or high and low water years have affected passage success in some years (Post and Holbrook 2015). This facility was designed to pass American Shad and Blueback Herring, but six Shortnose Sturgeon have been observed passing through the facility.

Table 6. Annual American Shad and Blueback Herring passage for St. Stephen Fish Lock from 1985 - 2016.

Year	Blueback Herring	American Shad	Year	Blueback Herring	American Shad
1986	187,000	-	2002	421,459	140,398
1987	74,000	-	2003	86,909	298,902
1988	232,000	10,000	2004	35,545	145,201
1989	147,000	27,000	2005	175,184	215,428
1990	71,000	81,000	2006	105,129	283,225
1991	400,000	176,000	2007	49,342	328,828
1992	589,000	147,000	2008[a]	8,503	29,002
1993	345,000	159,000	2009	438,746	389,197
1994	298,000	212,000	2010	217,750	346,879
1995	561,000	445,000	2011	336,210	272,961
1996	1,452,285	477,047	2012[b]	37,117	150,082
1997	176,814	387,755	2013	113,860	336,728
1998	112,466	543,681	2014[b]	171,200	42,525
1999	182,798	306,493	2015	244,631	85,417
2000	695,586	592,321	2016	3,285	41,375
2001	1,862,015	165,875			

[a]Due to severe drought conditions, the St. Stephen Fish Lift did not operate during the full migratory season

[b]Due to a mechanical failure, the St. Stephen Fish Lift did not operate during the full migratory season

Wilson Dam Fishway: Wilson Dam is located on the Santee River, forms Lake Marion, and is part of the Santee Cooper Hydroelectric Project. As part of that relicensing, the FWS and NMFS prescribed fish passage for American Shad and Blueback Herring, and NMFS prescribed passage for sturgeon, at Wilson Dam, but the final design is pending the completion of the Section 7 ESA consultation. The fishway will initially be a trap-and-truck facility and is currently planned to be operational no sooner than six and no later than eight years after the issuing of the new license. The new license will also address upstream passage of American Eel.

Columbia Fishway: Lockhart Power currently operates this facility, operational since the spring of 2006, for the City of Columbia. It is located on the Broad River (river mile 183) at the Columbia Diversion Dam and provides access to 24 miles of river up to the Parr Shoals Dam. The facility is mainly operated for diadromous fish passage in the spring, but is left operational into the summer. The primary target species are American Shad and Blueback Herring. To evaluate effectiveness, consultants of the licensee monitor fish passage of the target species and all other species including American eel visually during March, April, and May, and all fish observed are identified and counted. The total number of shad and herring passed is calculated by computing a catch per unit effort (CPUE) (number per hour) based on the number of shad or herring observed during all of the daily counting periods, and expanding that CPUE to the number of hours in the passage season. Daily counts are conducted using a random schedule during daylight periods. During 2007 - 2016, visual counts of American Shad ranged from 7 – 899 fish per day, leading to passage estimates ranging from 102 - 3,733 individuals (Kleinschmidt 2016). No Blueback Herring or American eel have been observed to date. However, the number of American Shad passed has increased almost every year since inception (Figure 14).

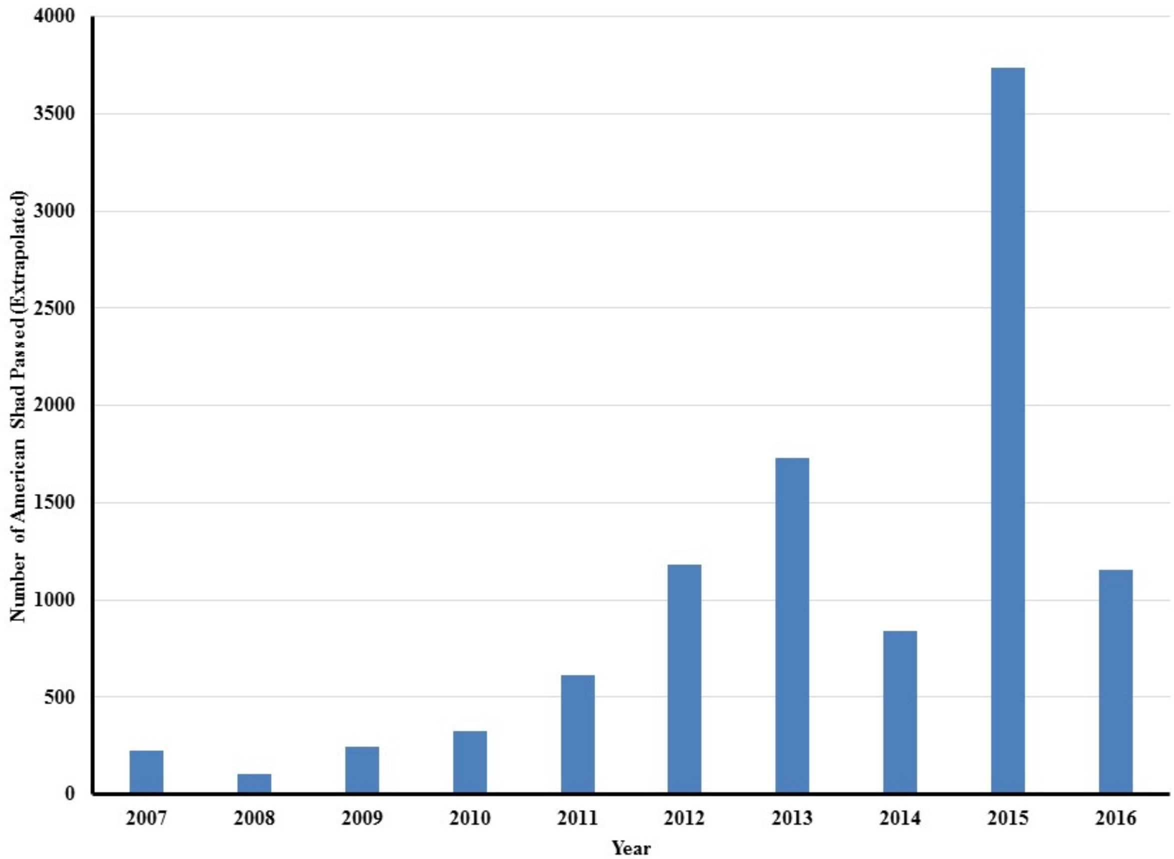

Figure 14. Passage of American Shad at the Columbia Fishway. Number of American Shad were estimated by dividing the total number of observed American shad by the total number of hours monitored in the field during each passage season then multiplying this rate by the total number of hours the Columbia Fishway was in operation during each fish passage season (March 16 - May 26). Note: Due to severe drought conditions in 2008, the St. Stephen Fish Lock did not operate during the full American Shad migratory season. Due to a failure of the St. Stephen Fish Lock during the peak of the shad run in 2012, data were not collected during the full American Shad migratory season. Due to mechanical failure in 2014, the St. Stephen Fish Lock did not operate during the full American Shad migratory season (Kleinshmidt 2015).

Wateree Dam Fishway: The Wateree Dam is the first (downstream) dam on the Wateree River that includes a series of 11 dams that comprise the Catawba-Wateree Hydroelectric Project. This project has recently undergone relicensing and, as part of that process, the FWS prescribed (NMFS reserved authority to prescribe) fish passage for American Shad and Blueback Herring, which was adopted in the Accord. According to the FERC license, the trap-and-truck facility will be operational by the spring of 2018 (FERC 2015). American Eel passage has been ongoing since 2005 and a five–year passage plan is under review by FERC.

V. Goal of the Plan

The goal of the Santee Basin Diadromous Fish Restoration Plan (Plan) is to provide guidance and coordination to the resource agencies in protecting, enhancing, and restoring Santee Basin diadromous fish populations throughout the basin, compatible with established aquatic communities. This may be accomplished by increasing population levels of diadromous species within their current range and/or by increasing their distribution throughout the Basin.

VI. Current Plan Objectives

A. Enhance Instream Flows

Expiring FERC licenses may provide opportunities to examine the need for implementing new or enhanced instream flows. FERC licenses for the Upper and Lower Pelzer projects, Piedmont, Parr Shoals, and Cherokee Falls projects in South Carolina and the Spencer Mountain Project in North Carolina will expire within the next ten years. Instream flow studies should be conducted in the bypasses of the ROR projects and the bypass and downstream riverine areas of the peaking plants. In lieu of conducting instream flow studies, the ROR projects should implement a seasonal bypass flow and the peaking projects should implement a seasonal project flow comprised of bypass and generation flows that are consistent with state plans and policies. A summary of the current instream flow requirements at these facilities follows:

1. Lower Pelzer Project: Located on the Saluda River, the license for this ROR project requires a continuous minimum flow of 140 cfs, which is released through a sluice gate on the dam. The FERC license for this project expires in 2017, and the project is currently (May 2017) undergoing relicensing.

2. Upper Pelzer Project: There is currently no instream flow requirement for this ROR project. The FERC license expires in 2017, and the project is currently undergoing relicensing. This project may benefit from implementation of a minimum flow in the bypass.

3. Piedmont Project: Located on the Saluda River, the license for this ROR project requires a continuous release of 15 cfs into the bypass, which is provided by a weir on the dam. The current instream flow was not developed based on a site-specific study and does not appear to comply with Water Plan recommendations. The license for this project expires in 2017 and is currently undergoing relicensing.

4. Parr Shoals Project: This plant operates in a modified ROR mode and the FERC license requires a 1,000 cfs minimum flow requirement during March - May and an 800 cfs minimum daily average with a 150 cfs absolute minimum during June - February. The FERC license for the Parr Shoals Hydroelectric Project expires in 2020, and an instream flow study is being conducted as part of the relicensing.

5. Cherokee Falls Project: This project has a minimum flow requirement and is operated so that when flow in the Broad River at Cherokee Falls is below 665 cfs (minimum turbine capacity plus the required minimum flow) both the main channel and the northern channel receive a portion of the flow. Approximately 75 percent of the flow goes to the main channel and the remaining flow goes into the north channel. The bypass is associated with the main channel, but the amount and quality of aquatic habitat provided during low flows (< 665 cfs) is presently unknown. When flow in the Broad River at Cherokee Falls is between 665 cfs and 3,525 cfs, 65 cfs of water is allowed to spill over the section of dam beginning at the south bank and extending 800 feet into the main channel of the river, which provides flow to the upper end of the bypass. This 65 cfs is in addition to any leakage through the flashboard riser system and the dam itself. This project is currently (May 2017) undergoing relicensing, and existing aquatic habitat in the bypass will be evaluated to determine if aquatic habitat would benefit from a different instream flow requirement.

6. Spencer Mountain Project: Located in North Carolina on the South Fork of the Catawba River, the license for this ROR project requires a continuous release of 76 cfs into the bypass. The license for this project expires in 2025.

In addition to reviewing instream flows associated with FERC hydroplants, there is a need to protect instream flows from excessive withdrawals or diversions of water. Authorities should also seek opportunities to establish and maintain instream flow standards to be protective of aquatic habitats in streams.

B. Improve Water Quality

Water quality should be adequate to support all life stages of diadromous fishes. There are a number of opportunities to improve water quality in the Basin. These include:

1. FERC relicensing provides an opportunity to examine water quality associated with FERC licensed hydroelectric projects. Water quality studies should be performed to assess impacts to water temperature, concentrations of dissolved oxygen, and turbidity (sedimentation). A low-inflow protocol should be developed to protect water quantity and quality during periods of extreme drought. In addition, the need to develop a new or update an existing sediment management plan can be determined. If needed, this plan can address intentional releases of sediment to minimize impacts to aquatic organisms and their habitat.

2. Other opportunities to protect water quality occur during the agency review of and consultation on 401 Water Quality Certifications and 404 Wetland Fill as part of the Clean Water Act, State and Federal Navigable Water Permits, Mining Permits, National Pollution Discharge Elimination System Permits, FERC projects, Nuclear Regulatory Commission projects, National Environmental Policy Act related projects, Natural Resource Damage Assessments related to oil spills and hazardous waste sites, and an assortment of small county projects. Permit applications should be thoroughly reviewed and comments should be provided to regulatory agencies. When environmental impacts are unavoidable, they should be assessed to ensure natural and cultural resources are mitigated appropriately.

3. Counties within the Santee Basin in South Carolina and North Carolina should be encouraged to adopt streamside buffer zones similar to those described in the SCDHEC publication *Vegetated Riparian Buffers and Buffer Ordinances* (SCDHEC-OCRM 2002).

4. Collaboration with utilities, state, county, and local authorities should occur to reduce nutrient concentrations and sediment loading, and improve dissolved oxygen concentrations throughout the basin.

C. Improve Habitat Quality

These habitats include submerged and exposed riverine bottoms (especially those that support important structural or substrate features), shorelines, riparian zones, and associated wetlands that serve as habitat for fish, protect water quality, and provide other needed biological, ecological, and social functions such as food-chain production, flood protection, biodiversity, and recreational use. The goal is to protect, enhance, and increase the linear distance, acreage, and function of these habitats by preventing alteration of existing habitat, restoring and enhancing degraded habitat, and reintegrating habitats fragmented by physical barriers.

1. Continue to seek opportunities under various authorities (e.g., Section 404 of the Clean Water Act, Farm Bill, Fish and Wildlife Coordination Act, critical habitat designation under the ESA, and the Federal Power Act) to address impacts that could affect important habitats. In connection with this, a sequential approach involving avoidance or minimization of impacts, and provision for mitigation of unavoidable impacts is needed.

2. Seek opportunities to use various funding sources (HEP, South Carolina Land Bank, etc.) to protect riparian lands.

D. Improve Fish Passage

There is no question that dams present significant obstacles for upstream and downstream fish migrations. When evaluating the need and practicality of fish passage, consideration should be given to a number of factors, including but not limited to, the historical range of a species, the presence of the target species in the project area, the availability and suitability of upstream spawning and/or nursery habitat (physical and chemical components), the consistency of fish passage with existing management objectives, the ecological consequences of passing non-target species, and the potential for unintended consequences such as range expansion for invasive species. In addition, the technical ability to address upstream and downstream passage should be considered.

For diadromous and native stream fishes to survive and recover, they must be able to access a variety of different habitats. The need to access these habitats may vary hourly, daily, or seasonally, but these areas must be connected and accessible. Fish passage is one way to provide access to habitats fragmented by dams. Adult anadromous fishes need access to suitable spawning habitats. With the exception of adult American Shad, the adults of all diadromous species need to be able to migrate safely back to estuarine or marine habitats, and the fry and juveniles need safe downstream passage. Immature American Eels need to access upstream maturation habitat and the adults need to return safely to the Atlantic Ocean to spawn. Native species need access to habitat that supports feeding, spawning, rearing, resting, and escape.

1. Implement fish passage for American Eel, American Shad, Blueback Herring, and sturgeon at the Santee Cooper Project (Pinopolis and Wilson dams) through the FERC-relicensing process. The FWS, NMFS, SCDNR, and Santee Cooper will work to accomplish this task.

2. Evaluate fish passage efficiency at the following Santee Basin facilities: the SCDNR and NMFS will evaluate American Shad passage efficiency at the Columbia Fishway; the SCDNR and the U.S. Army Corps of Engineers (USACE) will evaluate passage efficiency at the St. Stephen Fish Lock in consultation with the FWS and NMFS. Other facilities may be evaluated in the future.

3. Implement upstream eel passage at Wateree Dam and conduct effectiveness studies. The upstream passage at the Wateree Dam involves a proposed two-year siting study by Duke Energy followed by a four-year study of eel passage at the preferred site. Assuming FERC approval, and depending on the numbers of eels captured, work will begin on volitional passage either upstream or on a new siting study. A resource management team, composed of representatives from Duke Energy, the FWS, NMFS, NCWRC, and SCDNR, will determine siting for eel passage.

4. Evaluate the effectiveness of the Columbia Fishway for American Eel and determine if additional eel passage is warranted.

5. Identify when eel passage at Parr Shoals is appropriate and the type of facilities for upstream/downstream passage. The SCE&G, FWS, NMFS, and SCDNR will conduct this work.

6. Improve the species identification and enumeration of spring migrants, American Shad, Blueback Herring, and Shortnose Sturgeon, at the Pinopolis Lock. Santee Cooper and the SCDNR will conduct this work.

7. Identify and evaluate potential dam removal projects, such as Granby (Congaree River), Riverdale (Enoree River), and Whitney Mills (Lawson's Fork Creek, a tributary of the Pacolet River), that will provide access to spawning and nursery habitat. The FWS, NMFS, SCDNR and non-governmental organizations, such as American Rivers, will conduct this work.

8. Improve the reliability of the St. Stephen Fish Lock. The FWS, NMFS, and SCDNR should consult with the USACE to explore opportunities to improve the mechanical operation of this facility to reach a goal of having the fish lock operational for at least 95% of the passage season.

9. Assess the need for downstream fish passage at all dams where upstream access is provided. This assessment should include the determination of the need for species-specific outmigration facilities to include entrainment studies; the evaluation of changes in project operations such as pool levels, gate adjustments or flow; and siting studies to determine the best placement for outmigration facilities. The evaluation of outmigration success at the Santee Cooper Project is a high priority. This work will be accomplished by the FWS and NMFS under Section 18 Authority of the Federal Power Act, in consultation with the SCDNR and Santee Cooper.

E. Population Enhancement and Monitoring

1. Continue to stock American Shad fry in the Broad and Wateree rivers as recommended by the Accord Technical Committee. A goal established in the Accord was to stock up to 10 million shad fry per year. An annual average of about 2.5 million fry has been stocked to date. The FWS and SCDNR will conduct this work annually based on the recommendations of the Accord Technical Committee.

2. Evaluate the success of American Shad hatchery fry stockings based on the results of juvenile monitoring conducted in the Santee Basin and fish counts conducted at the St. Stephen Fish Lock and the Columbia Fishway. The SCDNR will conduct this work. Duke Energy may continue to conduct spring sampling in the Wateree River.

3. Develop a sampling program for American Shad to provide annual spawning stock and juvenile production assessment. Use these data to characterize annual stock status and stock response to management actions. The SCDNR will conduct this work in cooperation with the FWS and NMFS.

4. Continue to evaluate the use of genetics tools to determine the contribution of hatchery-stocked American Shad fry to the juvenile and adult shad population, and for other purposes as determined by the resource agencies and /or the Accord.

5. Monitor the movements of Atlantic Sturgeon, Shortnose Sturgeon, and American Shad in the Santee Basin. Santee Cooper (and potentially other utilities), the USACE, and the SCDNR will conduct this work.

6. Continue to analyze and summarize existing life history data for Shortnose and Atlantic Sturgeon, and collect additional data as needed, such as documenting fall spawning migrations for Atlantic Sturgeon. The SCDNR, in cooperation with Santee Cooper, the USACE, NMFS, ASMFC, and the Technical Committee of the Accord, will conduct this work.

VII. Implementation

This Plan will guide the restoration of diadromous fishes over the next 10-15 years in the Santee Basin and identifies objectives and management recommendations that may be beneficial in that endeavor. While the Resource Agencies are responsible for implementing this Plan, the establishment of an implementation team consisting of the resource Agencies and representation from interested utilities and NGO's is anticipated to guide the execution of the Plan. The team will track progress towards the goals established in the Plan, seek solutions to obstacles, and update the Plan as necessary. Team members and their respective agencies are limited to implementing actions within this Plan to the extent permitted by law and subject to the availability of resources, in accordance with their respective missions, policies, and regulations. The implementation team will also seek funding opportunities to implement the research and management recommendations identified in the Plan. The team will meet annually or as needed, and partners may be invited to attend the meeting at the discretion of the team.

The team's intent is to strongly advocate for the enhancement and restoration of the target species in this Plan, compatible with existing aquatic communities. The existence of this Plan may allow team members to seek opportunities to encourage cooperative funding and large scale/multi-project efforts, and identify and seek partners to support such efforts. Some examples of partnerships include the Accord and the Broad River Basin Fisheries Resource Enhancement Plan.

The Accord was described in detail earlier in this Plan. The Broad River Basin Fisheries Resource Enhancement Plan was established in 1996 to coordinate fisheries resource plans to address the turbine-induced impacts on fish of project operations for four FERC-licensed projects (Neal Shoals, Lockhart, Gaston Shoals, and Ninety-Nine Islands) under one plan. The three licensees, in consultation with the FWS and SCDNR, developed the 3rd segment of the

Broad River Basin Fisheries Resource Enhancement Plan for 2016 - 2025. This updated 10-year Plan was filed with FERC by the licensees in the final quarter of 2015. FERC issued an order approving the 10-year Plan on February 10, 2016. Consolidating planning and funds under one account for the four projects, the Broad River Fisheries Mitigation Trust Fund, allows for greater efficiency in conducting fisheries resource enhancement activities in the Basin.

VIII. Coordination with Other Management Plans

This Plan has made every effort to embrace the concepts, philosophies, and management guidelines of the following documents:

Amendment 2 to the Interstate Fishery Management Plan for Shad and River Herring (River Herring Management). 2009. Atlantic States Marine Fisheries Commission. 166 pp.

Amendment 3 to the Interstate Fishery Management Plan for Shad and River Herring (American Shad Management). 2010. Atlantic States Marine Fisheries Commission. 158 pp.

Atlantic Sturgeon stock assessment. 1998. Atlantic States Marine Fisheries Commission. 125 pp.

ASMFC American Shad Sustainable Fishing Plan for South Carolina. No Date. Atlantic States Marine Fisheries Commission. 30 pp.

Development of fishery management plan for selected anadromous fishes South Carolina/Georgia. G. Ulrich, N. Chipley, J.W. McCord, D. Cupka, and J.L. Music, Jr. SCDNR, GADNR. 135 pp.

Final recovery plan for the Shortnose Sturgeon. 1998. National Marine Fisheries Service. 104 pp.

Fisheries management plan for the anadromous alosid stocks of the Eastern United States: American Shad, Hickory Shad, Alewife, and Blueback Herring. 1985. Atlantic States Marine Fisheries Commission. 347 pp.

Fishery Management Report No. 35b of the Addendum I to Amendment 1 and Technical Addendum #1 to the Interstate Fishery Management Plan for Shad and River Herring. 2002. Atlantic States Marine Fisheries Commission. 10 pp.

Occurrences and distributions of the anadromous fish of South Carolina and Georgia. 1995. D.R. Spencer, National Marine Fisheries Service. Draft copy.

Reconnaissance planning aid report on Santee, Cooper and Congaree rivers. 1996. E.M. EuDaly, U.S. Fish and Wildlife Service. 34 pp.

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APPENDIX

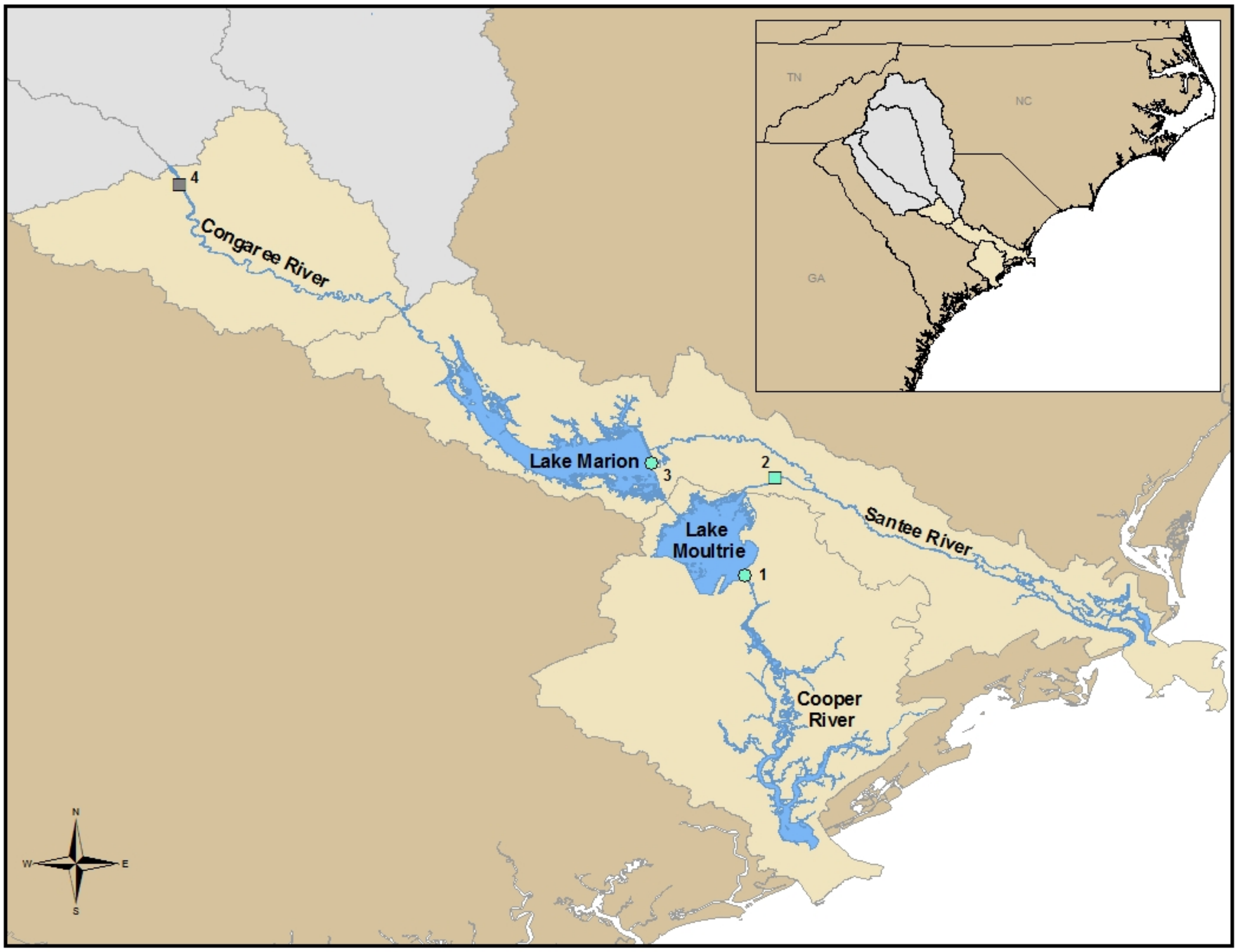

Figure 15. Existing dams in the Congaree, Cooper, and Santee River sub-basins. Circles represent facilities that fall under FERC jurisdiction. Squares represent non-FERC facilities (e.g., U.S. Army Corps of Engineers, State, Other). Hydropower facilities are in teal. Numbers refer to dams listed in Table 3.

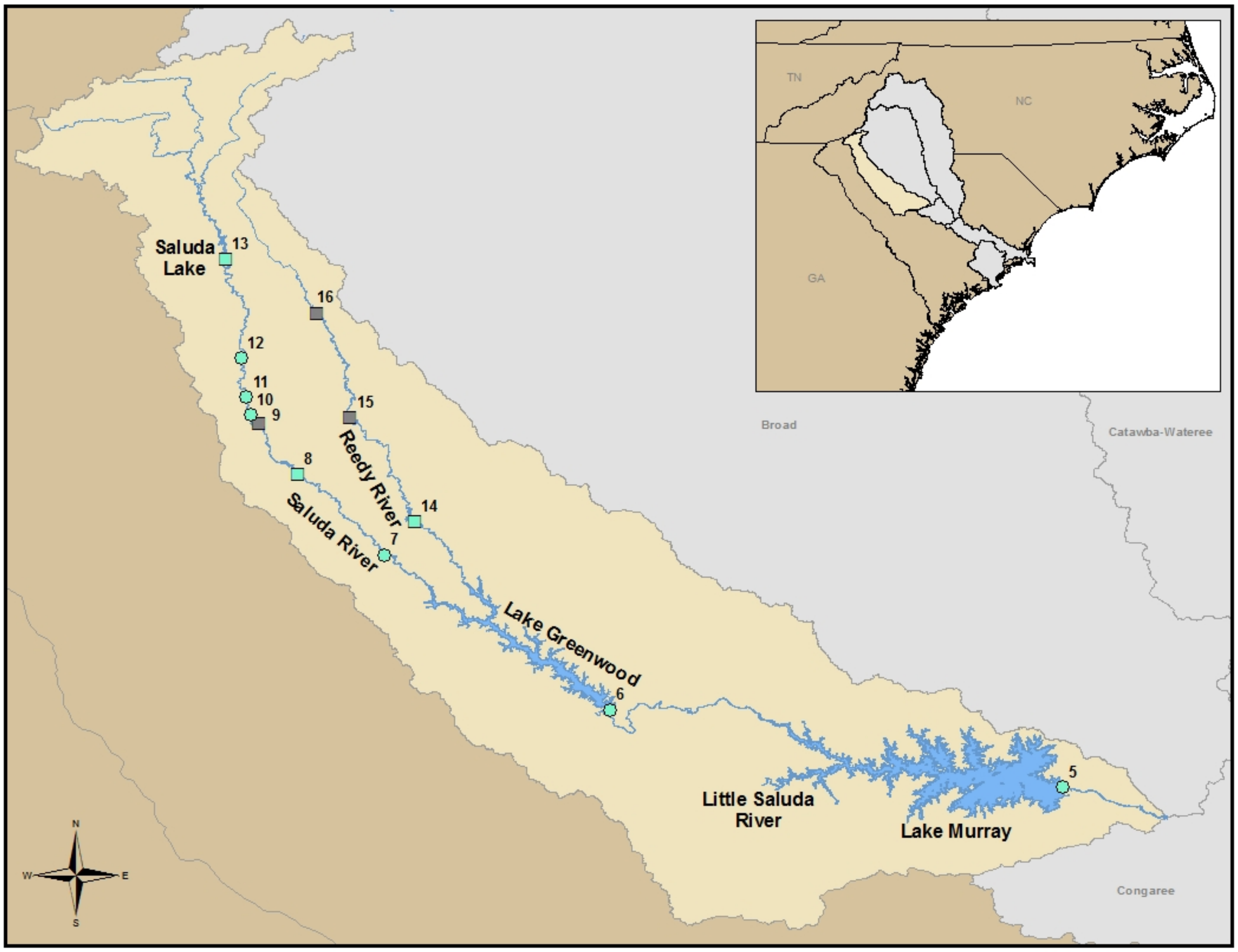

Figure 16. Existing dams in the Saluda River sub-basin. Circles represent facilities that fall under FERC jurisdiction. Squares represent non-FERC facilities (e.g., U.S. Army Corps of Engineers, State, Other). Hydropower facilities are in teal. Numbers refer to dams listed in Table 3.

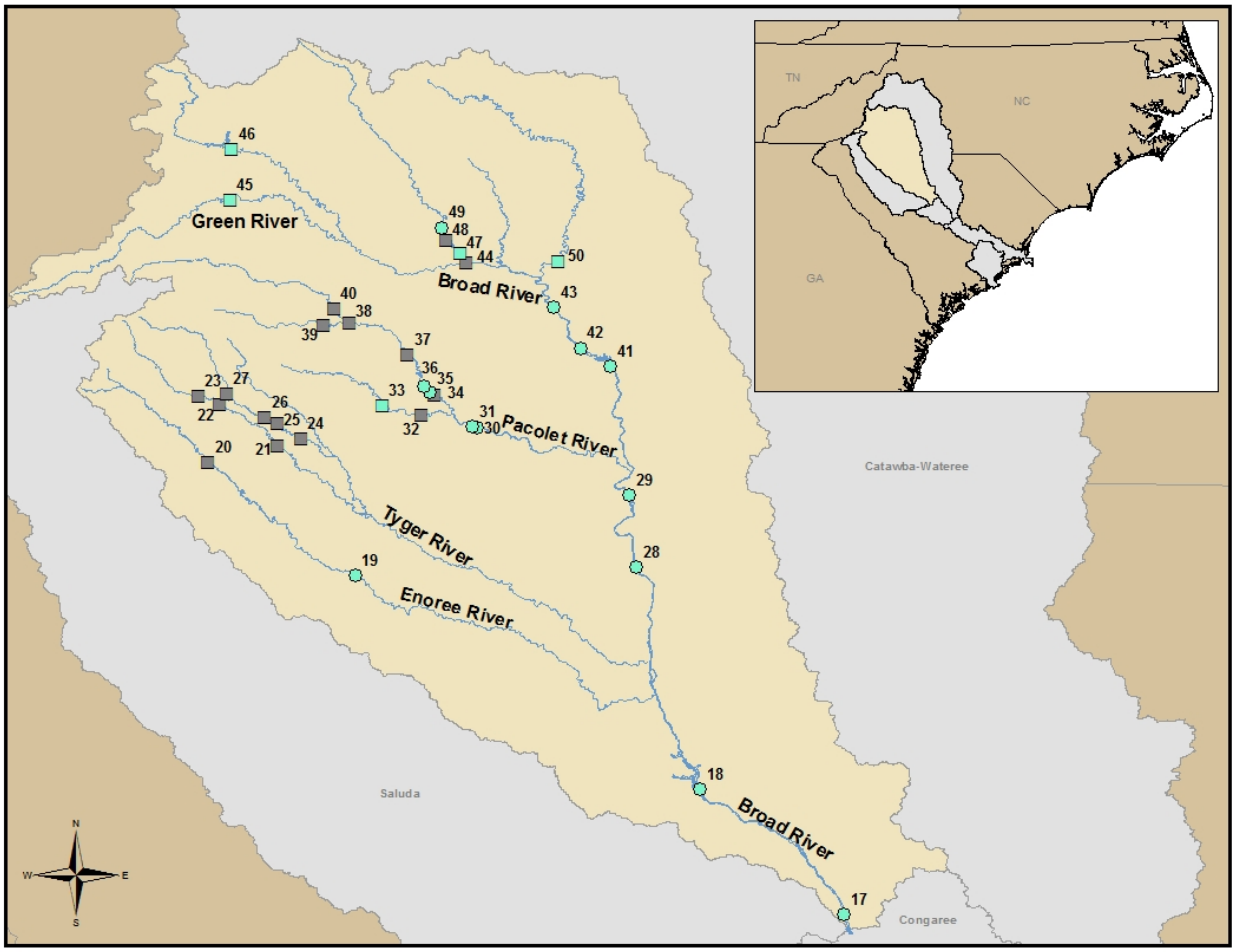

Figure 17. Existing dams in the Broad River sub-basin. Circles represent facilities that fall under FERC jurisdiction. Squares represent non-FERC facilities (e.g., U.S. Army Corps of Engineers, State, Other). Hydropower facilities are in teal. Numbers refer to dams listed in Table 3.

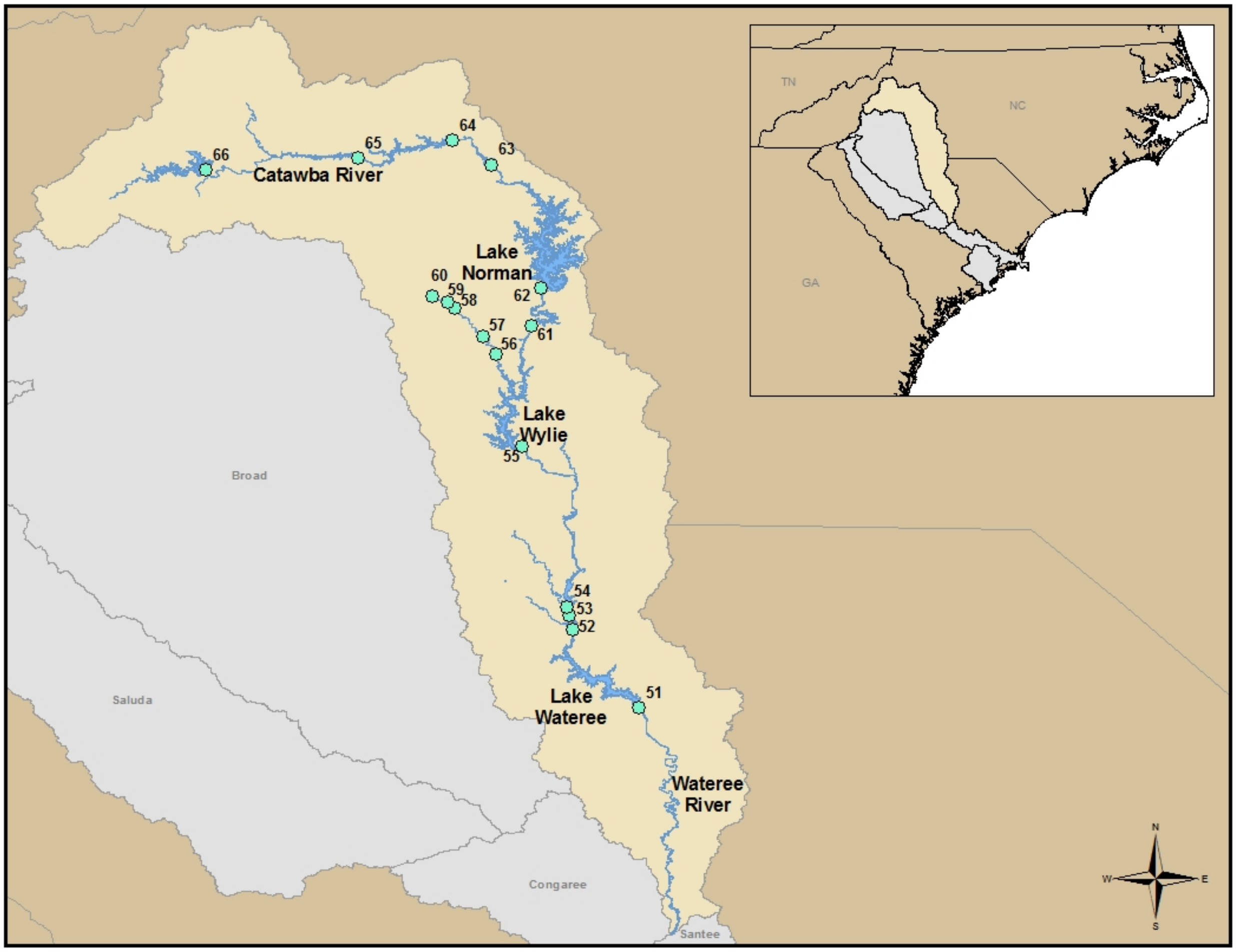

Figure 18. Existing dams in the Catawba-Wateree River sub-basin. All dams in this sub-basin are hydropower facilities that fall under FERC jurisdiction. Numbers refer to dams listed in Table 3.