Blueback Herring Sustainable Fishing Plan Update for South Carolina

Prepared by

Bill Post, Ellen Waldrop, and Chad Holbrook

March 16, 2020

Update approved August 4, 2020

South Carolina Dept. of Natural Resources

Wildlife and Freshwater Fisheries and Office of Fisheries Management

Updated-ASMFC River Herring Sustainable Fishing Plan for South Carolina

Introduction:

The purpose of this sustainable fisheries management plan is to allow existing river herring fisheries that are productive and cause no threat to future stock production and recruitment to remain in place and close all others. Some excerpts from the stock status review for SC's river herring were used in this document (ASMFC 2008). The review, which was prepared and submitted to the ASMFC shad and river herring board by SCDNR and the Stock Assessment Subcommittee (SASC), summarizes SC's fisheries for river herring.

Historically, river herring (blueback herring *Alosa aestivalis*) occurred in most of South Carolina's major rivers (Figure 1). Commercial fisheries for blueback herring in South Carolina occur to a limited extent in open rivers such as Winyah Bay tributaries (Lowther's lake area in the Pee Dee River), but the majority of river fishing activity occurs in hydro-electric tailraces of the Santee-Cooper River system (Figure 2). It remains the most important and the most closely monitored fishery in the state. A brief history of the Santee-Cooper Complex is detailed in Appendix 1. Recreational fisheries for blueback herring exist, but only as a bycatch to the American shad fishery.

Management of blueback herring in South Carolina is shared between the Marine Resources and Freshwater Divisions of the Department of Natural Resources (SCDNR). Management units are defined by stock and the complex of river(s) utilized. Management units include all rivers and tributaries within each area complex: Winyah Bay (Sampit, Lynches, Pee Dee, Bull Creek, Black, and Waccamaw Rivers) and the Santee-Cooper Rivers complex.

Current regulations:

The SCDNR manages commercial herring fisheries using a combination of seasons, gear restrictions, and catch limits. In 1964, commercial blueback herring fishing in Cooper River was restricted to daylight hours with a dip net not more than three feet in diameter and a limit of 100 lb (45.4 kg) per person per day. By 1969, regulations had been liberalized to allow nets with six foot diameters, fishing until ten o'clock p.m., and no limit on the harvest. Between 1966 and 1969, herring were abundant and the fishery expanded. Fishing success declined in the early 1970s and a limit of 600 kg of herring per person day was imposed in 1975. Today, the commercial fishery for blueback herring has a 10 bushel daily limit (227 kg) per boat in the Cooper and Santee Rivers and the Santee-Cooper Rediversion Canal. Seasons generally span the spawning season. All licensed fishermen have been required to report their daily catch and effort to the SCDNR since 1998. Current regulations are summarized in Appendix 2.

The recreational fishery has a 1 bushel (22.7 kg) fish aggregate daily creel for blueback herring in all rivers; however very few recreational anglers target blueback herring. Additionally, legislation to change the daily limit to a more reasonable limit has been developed and vetted through an internal working group and is awaiting introduction to the S.C. General Assembly.

Brief description - Current status of the stocks:

a. Landings:

Reported commercial landings data of river herring in South Carolina are available from the National Marine Fisheries Service and the state. Landings reported to the NMFS prior to 1979 were collected from major wholesale outlets located near the coast and probably did not account for inland landings which were generally not sold at these outlets. NMFS data collected since 1979 usually include inland landings. However, the wholesale dealer reporting system utilized by the NMFS may not include herring landings because herring sold as bait to licensed bait dealers may not be reported. In 1998, the state of South Carolina instituted mandatory reporting of commercial catch and effort.

In 1969, the South Carolina Department of Natural Resources instituted a commercial creel survey to estimate catch and effort in the fisheries in the Santee Cooper system. Surveys occur at landings used to off-load and transport catch. The majority of herring harvested from the Cooper River (1969-1989) were landed at two locations between the hours of six p.m. and ten p.m. daily. Creel clerks stationed at these locations interviewed individual fishermen as the catch was unloaded. The time, date, type of gear used, catch, and number of fishermen aboard were recorded as each boat landed. The survey was expanded to the major landing below the St. Stephen Dam on the Rediversion Canal starting in 1990 as water flow and fish abundance declined in the Cooper River and increased in the Santee River and the Rediversion Canal. During low flow years when flow is reduced in the Rediversion Canal, herring and the fishery moves to the Santee River below the Wilson Dam or to the Cooper River downstream of Pinopolis Dam. Surveys have been infrequent at those locations. Weight of harvest was estimated from the number of bushels of herring landed and a mean bushel weight of 25.4 kg (Cooke 1998). Numbers of adult blueback herring landed were estimated by dividing kg landed by the mean weight of an adult herring (0.14 kg). Although some landings are occasionally missed during the creel survey, the survey produces the most reliable estimates of catch and effort available for South Carolina waters. Landings were not estimated for reservoir fisheries with landings of mixed species and size composition.

SCDNR has conducted an annual recreational creel survey for American shad since 2001 to estimate exploitation and catch-per-unit-effort in the recreational fishery of the Santee Cooper system. These data consist of access point creel surveys (at end of a party's fishing day) for at least 2 h/d, 4 d/week along with effort estimates made by counting boats below the Pinopolis Dam, the Wilson Dam, or the Rediversion Canal at approximately 1400h each day of survey. Previous data demonstrated that a 1400h boat count measures maximum daily fishing pressure. Blueback herring are caught in this fishery; however, they are not targeted and are caught in minimal numbers.

SCDNR also conducted sportfishing creel surveys on the Cooper and Santee Rivers in 1981 - 1982 and 1991 - 1993 to evaluate the impact of the Rediversion Canal on these recreational

fisheries (Cook and Chappelear 1994). These surveys examined the total recreational fisheries on each river, but did not provide data on catch of blueback herring. Thus, the surveys could only be used to indicate change in the size of the fishery.

Recreational creel surveys were conducted on the Savannah River in the late 1990s by the Georgia Department of Natural Resources in 1997 and SCDNR in 1998 and 1999. Estimates of catch from these surveys varied from year to year largely due to dramatically different flow conditions. Catch estimates from each of these creel surveys were provided by Boltin (1999).

b. Fishery Independent Indices:

A variety of sample efforts have been conducted to assess the condition of blueback herring stocks in South Carolina. Annual passage counts at the St. Stephen Dam on the Santee-Cooper Rediversion Canal provide the longest times series of data (Table 1). Periodic electro-fishing and gill net sampling occurred in the Santee River below the Wilson Dam and population estimates were obtained for several years at that location. Population estimates (1980-1990) were orders of magnitude larger than passage for the same time frame (Table 2). In addition, annual electro-fishing sampling has been conducted in Winyah Bay and the Santee, Cooper, Edisto, and Combahee Rivers. Ichthyoplankton surveys were made for several years on the Santee and Cooper Rivers. More recently, annual gillnetting has occurred to assess CPUE for adult herring returning to the Santee River. As part of another program, electrofishing sampling now occurs in Lakes Marion and Moultrie (Santee-Cooper Lakes) to assess juvenile recruitment in rivers upstream of impoundments. However, the latter three surveys do not provide a long enough data series to provide sustainability.

c. Fishery Dependent Indices:

Over 1,000,000 kg of river herring were reported from South Carolina commercial fisheries in 1969. Landings declined precipitously soon after. They rebounded to a high of approximately 260,000 kg in the early 1980s and again in the 1990s. They have fluctuated at less than 70,000 kg since 2001. The bulk of the reported landings since 1989 have come from the Santee-Cooper system. Reported landings for the Pee Dee River of the Winyah Bay system have remained at less than 1,000 kg per year since mandatory reporting was initiated in 1998.

Annual variation in reported landings since the early 1970s was influenced by changes in allowable catch over the years. Landings in the Santee Cooper system were also affected by changes in discharge from the three dams and concurrent changes in fish migration and gear effectiveness.

Annual estimates of catch in kg, effort in person days, and kg catch/person day (CPUE) are available since 1969 from surveys of the Santee-Cooper fishery (Figure 3). Estimates of all three parameters have fluctuated widely over the time series. Highest estimates of landings and CPUE occurred early in the time series in the Cooper River prior to the diversion of water from the Cooper to the Santee system.

Many factors likely affected effort and landings. To evaluate potential causes of change, we separated data from the Cooper River into two times series (1969 - 1974 and 1975 – 2008) and subset data for the Santee River to those from 1975 – 2008. We then normalized the estimates by dividing annual values by the series mean. Sub setting the Cooper River data reduced the influence of the relatively large estimates obtained early in the time series on the rest of the data. Normalizing the time series placed all parameters on a comparable scale. Effort and landings were highly correlated in both the Cooper River fisheries (1969-1974, r^2=0.90; 1975-2008, r^2=0.85) and the Santee River fisheries (1990-2008, r^2=0.94) (Figure 4). Effort played an important role in dictating landings. However, CPUE was also related to effort. If we assume that CPUE was a measure of relative stock abundance, then we can speculate that changes in stock abundance and related fishing success led to changes in effort and then in landings.

CPUE in the Santee River fishery increased rapidly following increased flows from rediversion. CPUE leveled off in the mid to late 1990s and then declined abruptly following a severe drought that lasted from 1999 through mid 2002. Santee River CPUE has fluctuated without trend since that time. The initial CPUE increase in the Santee River fishery likely resulted from a combination of herring from the Cooper River stock that began to migrate into the Santee River as flow increased and improved production from improved spawning and nursery habitat. We do not know if reduced CPUE since the drought resulted from declining stock levels or from low fishing success caused by low water levels. Fishing did not occur, or was severely limited in 2002, and harvest estimates were not made.

4. Fisheries to be Closed:

a. Commercial: Winyah Bay (Sampit, Lynches, Bull Creek, Black, and Waccamaw Rivers). **Note: SC believes these fisheries are sustainable based on past and present anecdotal data, but since these data are not statistical in nature and under stipulations of Amendment 2, we must close these fisheries.**

5. Fisheries Requested to be Open:

a. Commercial: The Great Pee-Dee River and Santee-Cooper Rivers complex

b. Recreational: Little River
Winyah Bay System (Sampit, Lynches, Great Pee Dee, Little Pee Dee, Bull Creek, Black, and Waccamaw Rivers)
The Santee-Cooper Rivers complex
Ashepoo River
Combahee River
Edisto River
Savannah River

6. Sustainability

Systems with a sustainable fishery are defined as those that demonstrate their river herring stocks could support a commercial and / or recreational fishery that will not diminish potential future stock reproduction and recruitment. If fisheries exceed sustainability benchmarks, management action will be taken (Table 1). Additionally, if a river system is closely tied or included within the basin boundary to another river system where monitoring occurs, that river will then be managed under the sustainability metrics and management response of the monitored river (Fig 4). River basin boundaries included will be the Pee Dee, Santee, Edisto, Salkehatchie, and Savannah. Note: Pee Dee and Savannah River Basin boundaries include portions of NC and GA respectively.

Commercial

Little River

No commercial fishing for river herring is allowed.

Winyah Bay System (Sampit, Lynches, Bull Creek, Black, Little Pee Dee, and Waccamaw Rivers)**.**

No commercial fishing for river herring is allowed.

Great Pee-Dee River

The Pee Dee River is part of the Winyah Bay System which also includes the Sampit, Black, Waccamaw, and Little Pee Dee Rivers. It is a large free flowing river up to river kilometer (rkm) ~302 where the first barrier (Blewett Falls Dam) is located in NC (Figure 7). The Pee Dee River herring fishery takes place in a small oxbow lake area known as Lowthers Lake located at rkm 176 just north of I-95 and Darlington, SC. The herring fishery for the Pee-Dee River is so insignificant (<472 kg avg. for years 1998-2015; in some years <3 kg), it is believed fishing on this river is not having an overall negative impact on herring populations (Table 5, Figure 8). The number of licensed fishermen is declining with each passing year and those that remain in the fishery are subsistence fishermen who only use fish for personal consumption. As part of the requirements for the previous plan, SC collected fishery dependent biological data to assess the relative fitness of the Pee Dee River herring fishery. Scales for ageing, sex, and length information were collected from up to 100 fish during 2011, 2013, 2014, and 2015. Results show normal age distribution, some degree of repeat spawning, and no significant declines in overall length (Figures 9-10, Table 6). SC requests to maintain this fishery with a 1,000kg harvest cap for the season. During this time, length and age data from the spawning stock will continue to be collected and analyzed. Status of the fishery will continue to be measured by three year running averages of total landings. If at any time, landings exceed the proposed cap for three consecutive years, regulation changes would be considered for this fishery. Based on documented low landings (1,000 kg. is equivalent to < 4 days' allowable catch in the commercial fishery) and

results of biological data, SC believes this is a reasonable request for the small Pee Dee River herring fishery.

Santee-Cooper Rivers complex (Wateree, Congaree, Broad, Wando, Ashley, Cooper, Santee Rivers)

The term 'relative exploitation", as appears on Table 2, is calculated as estimated harvest in numbers divided by a minimum population estimate in numbers. The minimum population estimate is calculated as the harvest in numbers plus the passage in numbers at the St. Steven's lift on the Rediversion Canal. Since only a portion of fish in the Rediversion Canal and the Santee River actually move above the St. Steven's Dam, the minimum population estimate is an underestimate of the actual population. During years when both passage counts and population estimates were made (1986-1990), the minimum population estimates averaged 2.3 percent of the population estimate (Table 3). Consequently, estimates of relative exploitation in Table 2 are gross overestimates of the true exploitation rate for the Santee stock. To account for this, adjusted exploitation rates were developed using "scalar" values. These were created by dividing minimum population estimates by population estimates for years when population estimates occurred and calculating a mean for those years (0.023, Table 4). In an attempt to address variation and the possibility that the relationship between population size and fish passage has changed over time, an additional scaler was created in the same manner using the lower confidence limits from the population estimates (0.440, Table 4). When compared to other years in this range, the estimate for 1988 appeared to be an outlyer. As a result, a final scaler was created using the lower confidence limits, but excluding the estimates for 1988 (0.052,Table 4). All scalers (0.023, 0.440, 0.052) were then multiplied by the annual relative exploitation to produce adjusted and more realistic estimates of exploitation rates (Table 2). SC believes the estimate using the 0.052 scaler (lower bound without 1988 value) is the most appropriate and realistic to depict approximate exploitation from this fishery.

Adjusted exploitation rates using the 0.052 scaler were very low and no trend was apparent among years. By comparison, u_{msy} (target exploitation rates) for blueback herring of the Chowan River, North Carolina was $u_{msy} = 0.67$, while that for herring of the Connecticut River, Connecticut and St. John River, New Brunswick were $u_{msy} = 0.75$ (Crecco and Gibson 1990). Adjusted estimates of u imposed by the commercial fishery in the Rediversion Canal are well under all of these benchmarks. Continued harvest at these low rates should be sustainable and should allow for recruitment and future stock reproduction. In addition, numbers of blueback herring passed (438,746), at St. Stephen Dam in 2009, exceeded the past 5 years combined. During the years 1980-1990 concurrent population estimates of the Santee stock below the Rediversion Canal were orders of magnitude greater than fish passed at the dam. Also, recent declines in commercial landings correlate directly to a notable reduction in trips (Figure 5).

SC proposes that the "interim" sustainability benchmark of u = 0.050 continues to be used to manage the Santee-Cooper River herring fishery. Status of the fishery relative to this benchmark will continue to be measured by three year running averages of the scaled annual relative

exploitation rates. Annual exploitation rates will be estimated by multiplying annual estimates of relative exploitation by 0.052. Since the development of the original plan, three year running average scaled exploitation rates have not exceeded the sustainability benchmark of 0.050 (Figure 6).

ACE Basin (Ashepoo, Combahee, Edisto, and Salkehatchie

Rivers) No commercial fishing for river herring is allowed.

Savannah River (Coosawhatchie and Savannah)

No commercial fishing for river herring is allowed.

Recreational

Little River

No recreational monitoring occurs in this river system. However, since the Little River is included within the Pee Dee River Watershed boundary, sustainability metrics and management response for the commercial Great Pee Dee River will be applied for this river.

Winyah Bay System (Sampit, Lynches, Bull Creek, Black, Great Pee Dee, Little Pee Dee, and Waccamaw Rivers)**.**

No recreational monitoring occurs in this river system. However, since the Little River is included within the Pee Dee River Watershed boundary, sustainability metrics and management response for the commercial Great Pee Dee River will be applied for this river.

Santee-Cooper River Complex (Wateree, Congaree, Broad, Wando, Ashley, Cooper, Santee Rivers)

No recreational monitoring occurs in the Santee-Cooper River Complex. However, since the all rivers are included within the Santee River Watershed boundary, sustainability metrics and management response for the commercial Santee River will be applied for this river.

ACE Basin (Ashepoo, Combahee, Edisto, and Salkehatchie Rivers)

No recreational monitoring occurs in the Ace Basin Rivers. These rivers are included in SC's Alternative Management Plan for river herring.

Savannah River (Coosawhatchie and Savannah)

No recreational monitoring occurs in the Savannah River Complex. These rivers are included in SC's Alternative Management Plan for river herring.

7. Adaptive Management

SCDNR will continue to monitor both fish passage and the commercial fishery landings in the Santee-Cooper system. In addition, fishery independent sampling for spawning adults in the lower Santee River will continue annually.

If collected data indicates changes in exploitation or decreasing abundance in juveniles, action will be taken by SCDNR. These actions may include increasing days for escapement, limiting seasons, etc. In the event these actions are not successful in reversing negative trends, SCDNR would then be forced to close this fishery.

Several recommendations were included for SC as part of the stock status review for river herring. They are highlighted in the following:

"We recommend that age data be obtained from blueback herring of the Santee River, the Santee-Cooper Rediversion Canal, and the Cooper River and that the commercial creel survey of tailrace fisheries in the system be continued." Age and harvest data are important to understanding current stock dynamics and factors affecting recent river herring abundance. "We also recommend that a sample program be developed or existing programs be improved to track annual production of young."

SC has since implemented all suggested recommendations as part of ASMFC/ACFCMA funded work or by utilizing other SCDNR funding sources. With the dissolution of Anadromous Fish Conservation Act funds, SCDNR was forced to be creative in order to meet requirements of Amendment 2. To complete all mandated goals annually, personnel from other areas and funding sources have been used. Once these funds expire it is anticipated SCDNR will simply not have adequate personnel to complete the work. Furthermore, to date SCDNR has had ~48% cut from the state's appropriated operating budget and is expecting more cuts. If a reduction in force (RIF) is implemented and project personnel are affected, SCDNR will not be able to meet the requirements.

LITERATURE CITED

ASMFC. 2008. Amendment 2 to the Interstate fishery management plan for shad and river herring. Atlantic States Marine Fisheries Commission, Washington, D.C. USA.

ASMFC. 2008. River herring stock status report. Atlantic States Marine Fisheries Commission, Washington, D.C. USA.

Boltin, W.R., III. 1999. New Savannah Bluff Lock and Dam Creel Survey Report: February1, 1999-June 30, 1999. South Carolina Department of Natural Resources, Wildlife and Freshwater Fisheries Section. Abbeville, SC. August 1999.

Christie, R. W. and D. H. Barwick. 1984. Santee-Cooper blueback herring studies completion report. SCR 1-8. South Carolina Wildlife and Marine Resources Department. Columbia, SC. 73 pp.

Cooke, D.W. 1998. Santee-Cooper blueback herring studies. Rediversion Project. Annual Progress Report. SCR 1-21. South Carolina Department of Natural Resources. Columbia, SC. 54 pp.

Cooke, D.W. and S.J. Chappelear. 1994. Santee-Cooper Blueback Herring Studies. Annual Progress Report. SCR 1-16. South Carolina Department of Natural Resources. Columbia, SC. 144 pp

Crecco, V. A. and M. Gibson. 1990. Stock assessment of river herring from selected Atlantic coast rivers. Special Report No. 19 of the Atlantic States Marine Fisheries Commission.

Stevens, R. E. 1957. The striped bass of the Santee-Cooper reservoirs. Proceedings of the Annual Conference of Southeastern Association of Game and Fish Commissioners.

USACE (U.S. Army Corps of Engineers). 1975. Final Environmental Statement, Cooper River Rediversion Project, Charleston Harbor, South Carolina. U.S. Army Corps of Engineers. Charleston, SC. 201 pp.

Figure 1. South Carolina Rivers.

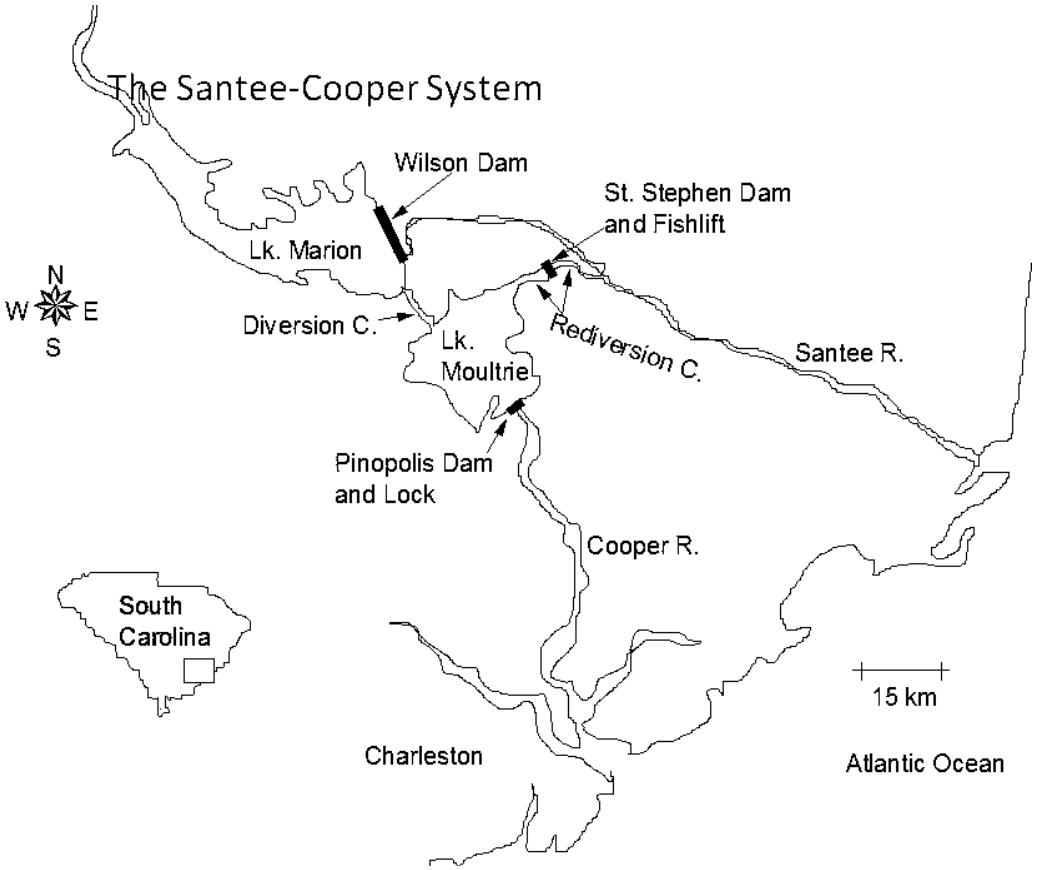


Figure 2. Santee-Cooper Rivers complex in South Carolina.

Table 1. Sustainability values and triggers.

Index	Benchmark Value	Years included in index	Management trigger
Santee-Cooper Rivers Complex	u = 0.050	1990-2015	3 consecutive years below benchmark
Pee Dee River	1000kg	1998-2015	3 consecutive years below benchmark

Table 2. Annual number of blueback herring passed at the St. Stevens Fish Lift, Santee-Cooper Rediversion Canal; harvested in the commercial fishery, minimum population size*, relative exploitation.

Year	Metric Tons	Harvest Data (Kg)	Number caught (Lbs/.3)	Passage	Minimum Population	Relative Exploitation	Scalar M-R	Scalar M-R LCI all years	3-yr running avg.	Scalar M-R LCI w/o 1988	3-yr running avg.
							0.023	0.440		0.052	
1990	1.28	1280	9,408	71,000	80,408	0.12	0.003	0.053		0.006	
1991	9.83	9830	72,251	400,000	472,251	0.15	0.003	0.066		0.008	
1992	91.77	91770	674,510	589,000	1,263,510	0.53	0.012	0.233	0.117	0.027	0.014
1993	180.92	180920	1,329,762	345,000	1,674,762	0.79	0.018	0.348	0.216	0.041	0.025
1994	128.91	128910	947,489	298,000	1,245,489	0.76	0.018	0.335	0.305	0.039	0.036
1995	206.89	206890	1,520,642	561,000	2,081,642	0.73	0.017	0.321	0.335	0.038	0.039
1996	265.06	265060	1,948,191	1,452,285	3,400,476	0.57	0.013	0.251	0.302	0.030	0.036
1997	142.24	142240	1,045,464	176,814	1,222,278	0.86	0.020	0.379	0.317	0.045	0.037
1998	179.61	179610	1,320,134	112,466	1,432,600	0.92	0.021	0.405	0.345	0.048	0.041
1999	**120.38**	**120380**	**884,793**	**182,798**	**1,067,591**	**0.83**	**0.019**	**0.365**	**0.383**	**0.043**	**0.045**
2000	**134.83**	**134830**	**991,001**	**695,586**	**1,686,587**	**0.59**	**0.014**	**0.260**	**0.343**	**0.031**	**0.040**
2001	**24.29**	**24290**	**178,532**	**1,862,015**	**2,040,547**	**0.09**	**0.002**	**0.040**	**0.222**	**0.005**	**0.026**
2002	**0**	**0**	**0**	**421,459**	**421,459**	**0**	**0**	**0**	**0.100**	**0**	**0.012**
2003	52.25	52250	384,038	86,909	470,947	0.82	0.019	0.361	0.134	0.043	0.016
2004	9	9000	66,150	35,545	101,695	0.65	0.015	0.286	0.216	0.034	0.025
2005	35.04	35040	257,544	175,184	432,728	0.6	0.014	0.264	0.304	0.031	0.036
2006	7.5	7500	55,125	105,129	160,254	0.34	0.008	0.150	0.233	0.018	0.027
2007	50.7	50700	372,645	49,343	421,988	0.88	0.021	0.387	0.267	0.046	0.031
2008	**0**	**0**	**0**	**8,503**	**8,503**	**0**	**0**	**0**	**0.179**	**0**	**0.021**
2009	71.6	71600	526,260	438,746	965,006	0.55	0.013	0.242	0.210	0.029	0.025
2010	69.6	69600	511,560	217,750	729,310	0.70	0.016	0.309	0.183	0.036	0.022
2011	37.6	37600	276,360	336,210	612,570	0.45	0.011	0.199	0.249	0.023	0.029
2012	**18.9**	**18900**	**138,915**	**37,117**	**176,032**	**0.79**	**0.018**	**0.348**	**0.285**	**0.041**	**0.034**
2013	**33.5**	**33500**	**246,225**	**113,860**	**360,085**	**0.68**	**0.016**	**0.301**	**0.282**	**0.036**	**0.033**
2014	**52.1**	**52120**	**383,082**	**171,200**	**554,282**	**0.69**	**0.016**	**0.304**	**0.318**	**0.036**	**0.037**
2015	**22.5**	**22500**	**165,375**	**244,631**	**410,006**	**0.40**	**0.009**	**0.178**	**0.261**	**0.021**	**0.031**

*number lifted + number harvested in fishery

Drought years or mechanical failures at the fish lock

Table 3. Mark recapture population estimates of blueback herring in the Santee River, South Carolina.

Year	N	CV	Confidence Interval Lower	Upper
1980	5,895,796	0.25	3,012,000	8,780,000
1981	4,054,521	0.23	2,236,000	5,873,000
1982	664,151	0.17	400,000	888,000
1983	2,352,005	0.45	297,000	4,407,000
1984	2,625,000	0.24	1,417,000	3,833,000
1985	6,205,353	0.71	0	14,822,650
1986	9,061,064	0.41	1,817,496	16,304,632
1987	3,805,457	0.29	1,657,618	5,953,296
1988	5,507,918	0.50	116,348	10,899,488
1989	5,501,964	0.22	3,153,678	7,850,250
1990	9,353,003	0.22	5,358,472	13,347,534

Table 4. Calculation of scalar for adjusting relative exploitation rate for the Santee River.

Year	Minimum Population	M-R Population	M-R Lower CI	M-RLower CI w/o 1988	min/M-R	min/M-R LCI	min/M-R LCI w/o 1988
1986	187,000	9,061,064	1,817,496	1,817,496	0.021	0.103	0.103
1987	74,000	3,805,457	1,657,618	1,657,618	0.019	0.045	0.045
1988	232,000	5,507,918	116,348		0.042	1.994	
1989	147,000	5,501,964	3,153,678	3,153,678	0.027	0.047	0.047
1990	71,162	9,353,003	5,358,472	5,358,472	0.008	0.013	0.013
				Scalar	0.023	0.440	0.052

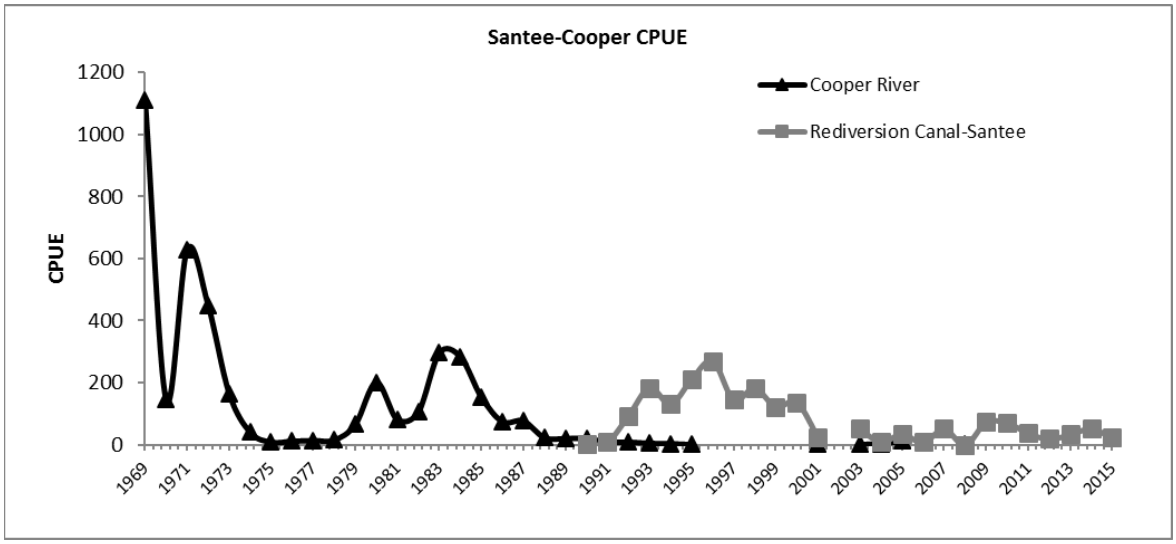
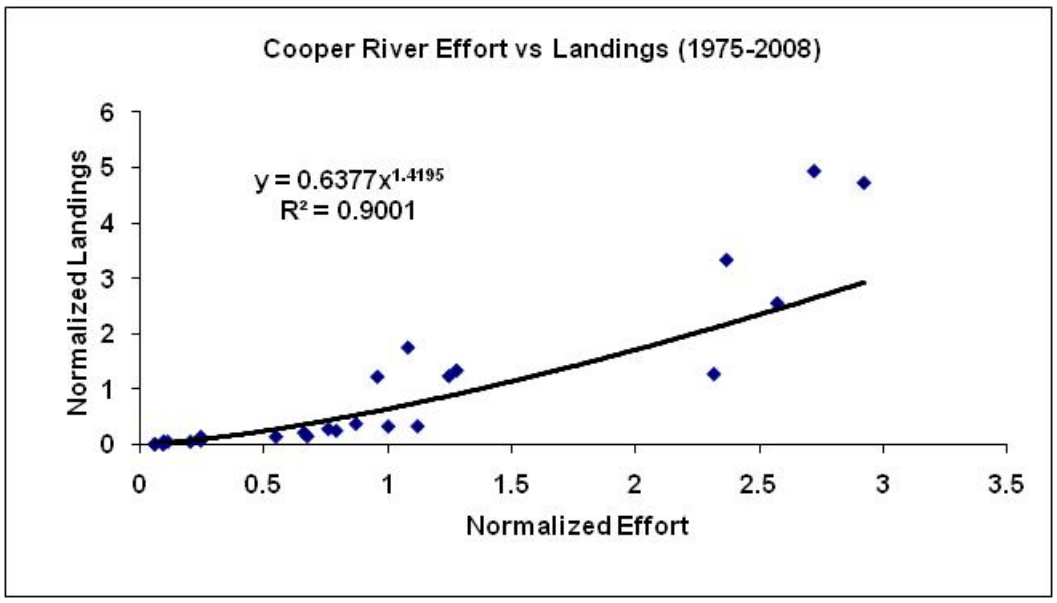


Figure 3. Estimated effort (CPUE) in the commercial fishery for blueback herring in the Cooper River and the Santee-Cooper Rediversion Canal, South Carolina.



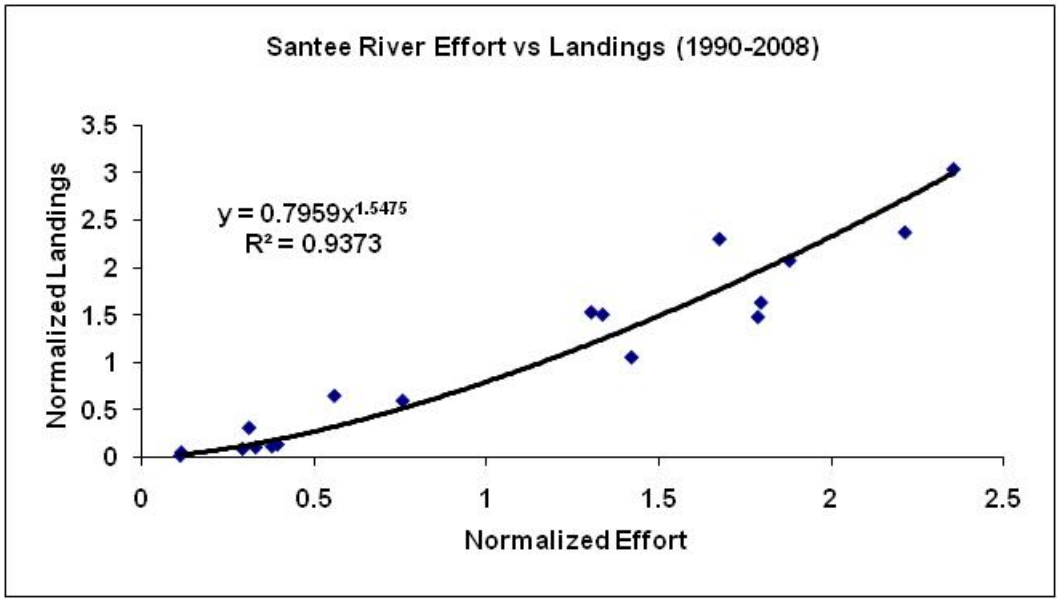


Figure 4. Normalized effort vs. normalized landings in the commercial fisheries of the Cooper and Santee Rivers, South Carolina.

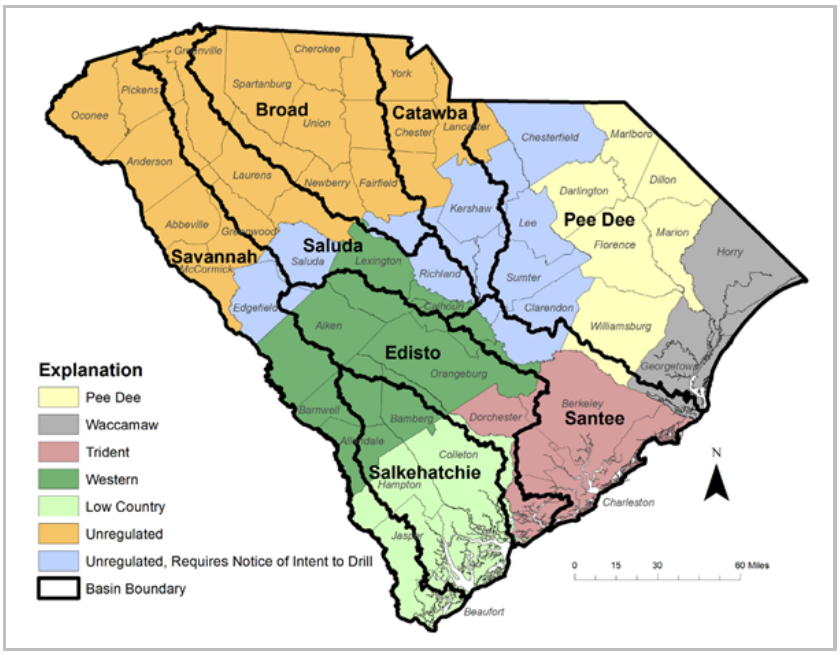


Figure 7. SC river systems defined by river basin boundaries

(https://www.clemson.edu/public/water-assessment/).

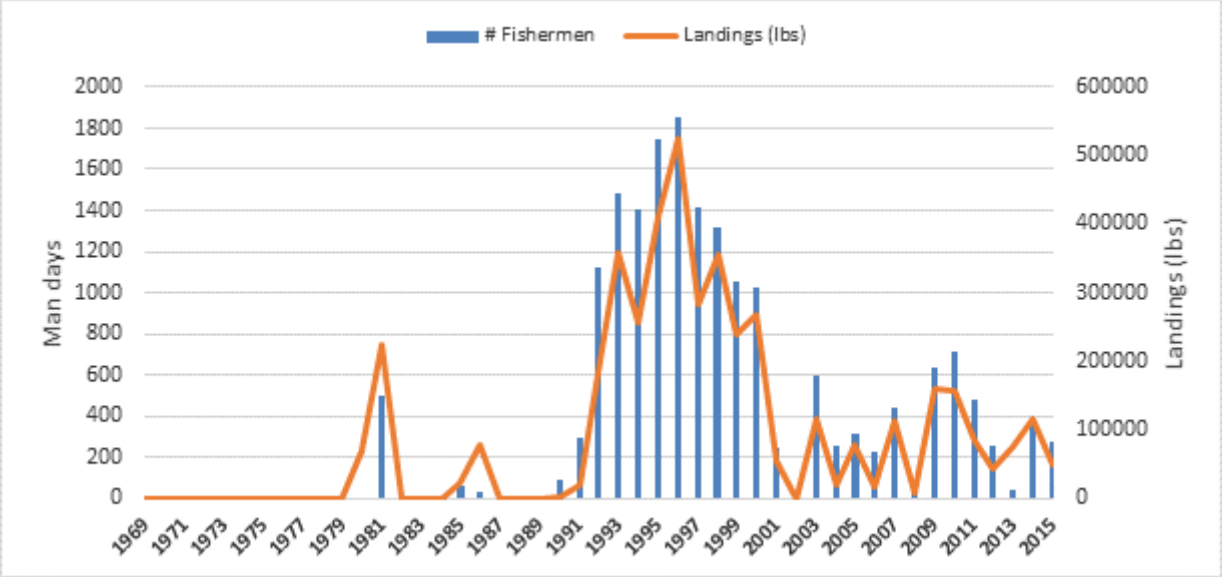


Figure 5. Number of Santee River fishermen versus pounds of herring harvested 1969-2015.

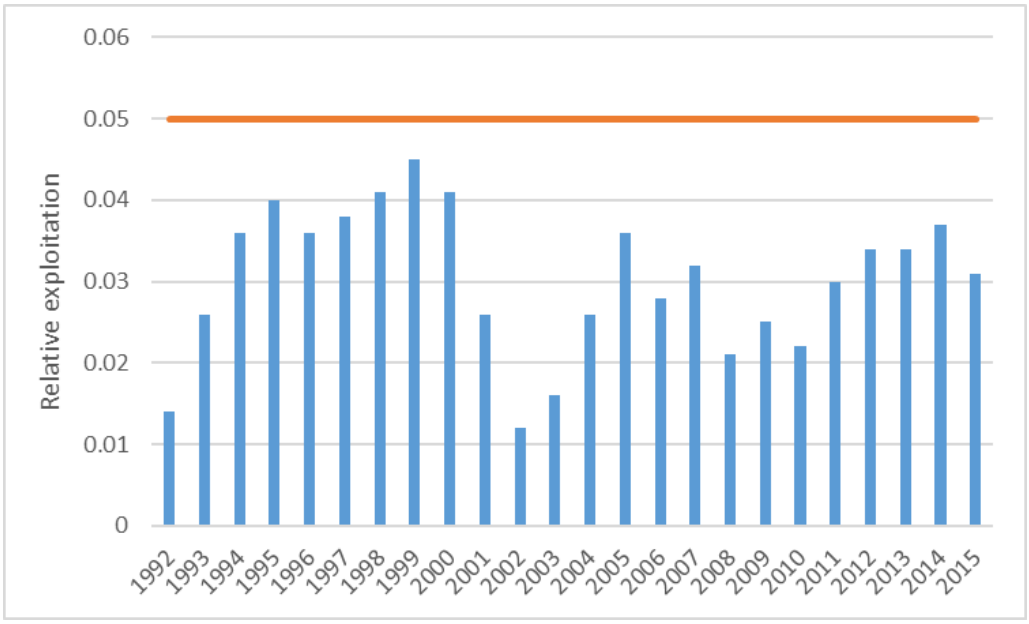


Figure 6. Relative exploitation for the Santee blueback herring fishery compared to .050 benchmark target (1992-2015).

Table 5. Landings of blueback herring from the Pee-Dee River (1998-2015).

Year	Kg.
1998	2
1999	15
2000	323
2001	817
2002	131
2003	350
2004	93
2005	162
2006	14
2007	259
2008	643
2009	660
2010	999
2011	894
2012	855
2013	758
2014	767
2015	919

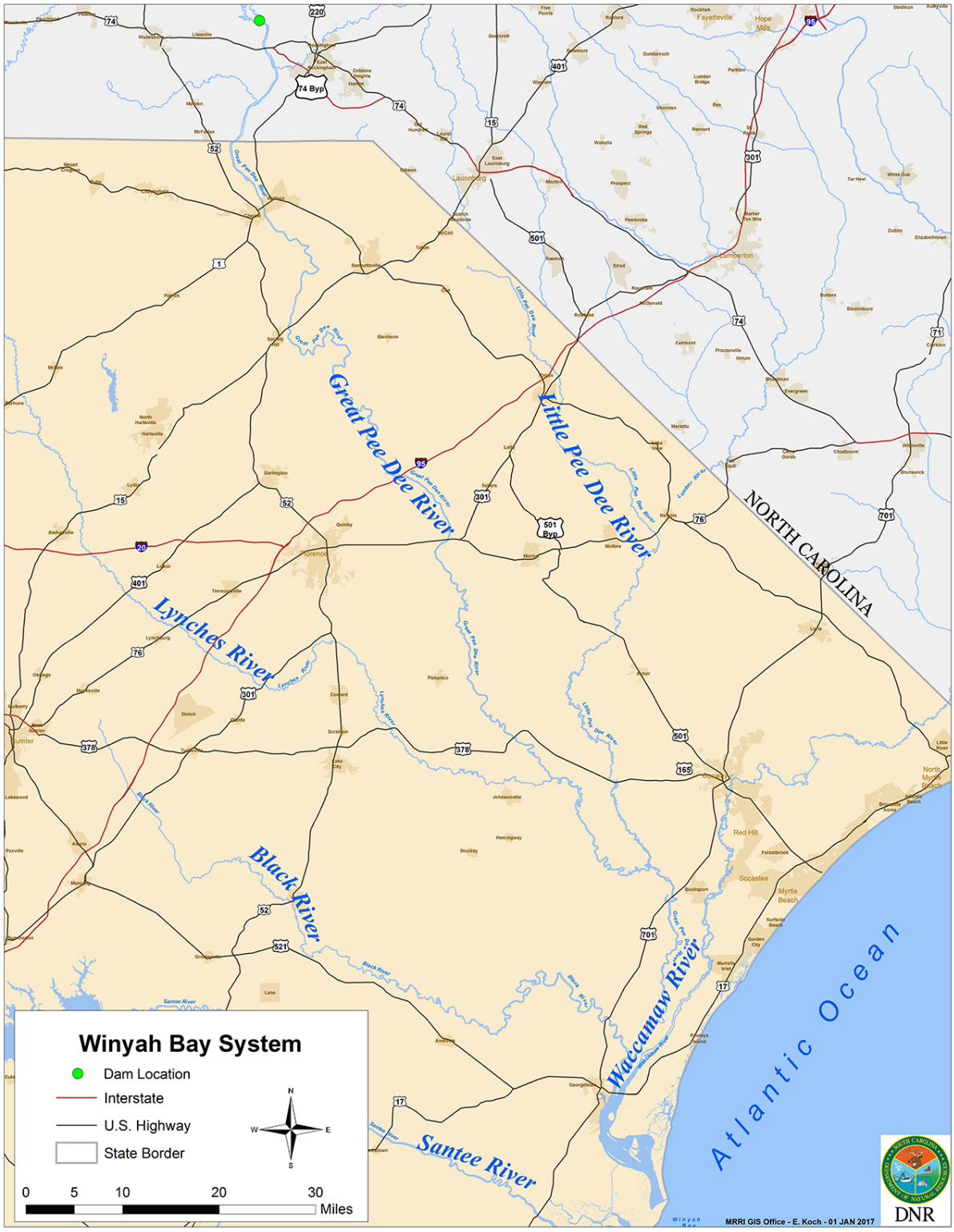


Figure 7. Winyah Bay System including the Pee Dee River.

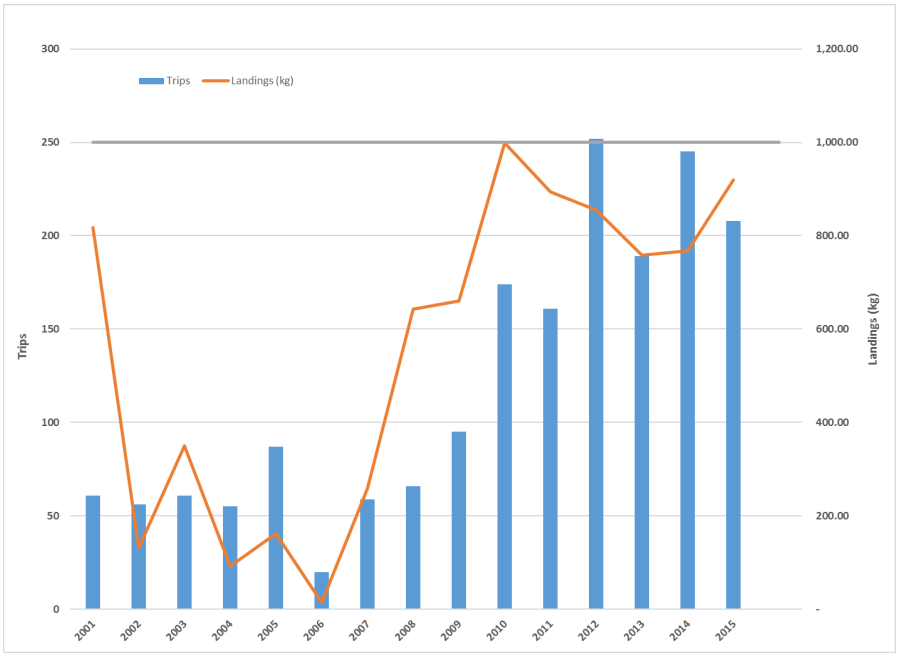


Figure 8. Pee-Dee River blueback herring landings compared to number of trips (2001-2015).

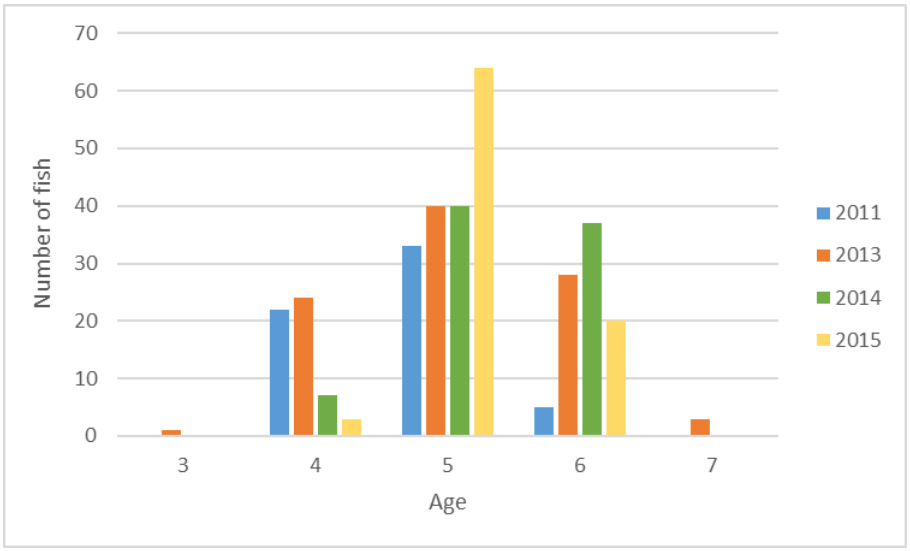


Figure 9. Pee-Dee River blueback herring age distribution (2011, 2013-2015).

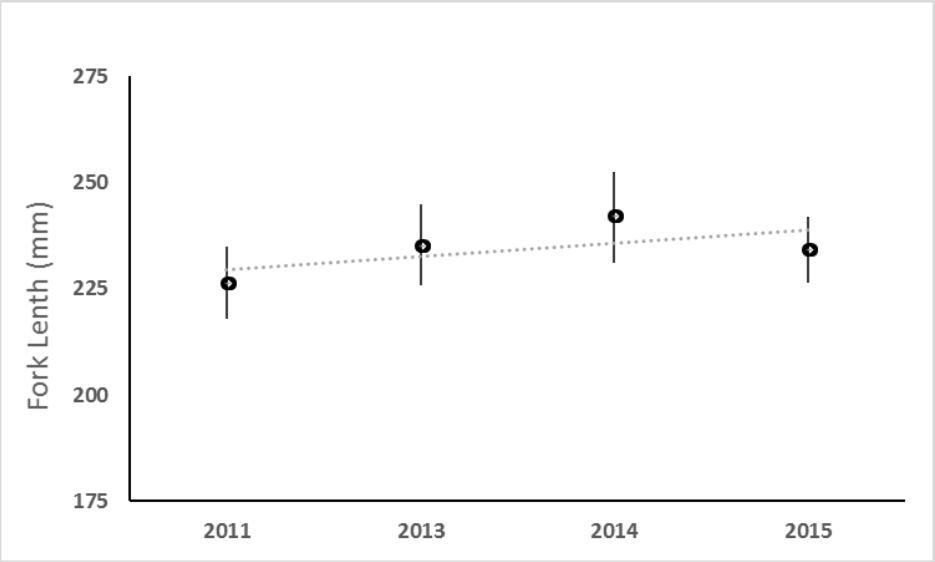


Figure 10. Pee-Dee River blueback herring mean fork length and standard deviations for 2011 and 2013-2015.

Table 6. Percent of repeat spawning Pee-Dee River blueback herring (2011, 2013-2015).

	2011	2013	2014	2015
% with one spawning mark	33	28	25	15
% with two spawning marks	5	11	1	2
% repeat spawners	38	41	26	17

Appendix 1. Brief description of the Santee-Cooper Complex

In 1938, the South Carolina Public Service Authority (SCPSA) initiated the Santee-Cooper Diversion Project. The project dammed Santee River at river km 143.201 and the headwaters of Cooper River creating two reservoirs joined by a canal (Figure 2). The canal allowed Santee River water to be diverted into Lake Moultrie and the Cooper River. Benefits provided were flood control, improved navigation, and hydroelectric power production. Wilson Dam, a flood control structure constructed on Santee River (river km 143) created Lake Marion. Pinopolis Dam (river km 77), a hydroelectric facility and navigation lock, impounded diverted water from Lake Marion along with the headwaters of Cooper River to form Lake Moultrie. In 1957, it was documented that blueback herring, passed into the lakes during boat lockings, provided as much as 25% of the diet of adult Santee-Cooper striped bass (Stevens 1957). Since then, the SCPSA has operated the lock three to six times daily during the spring spawning run, to allow blueback herring to enter the lake system. This action not only supplemented the system's forage base but also provided anadromous fish access to additional spawning areas. From 1975 to 1984, a hydroacoustic survey estimated 2.2 - 10.8 million blueback herring (mean = 5.7 million) were admitted into Lake Moultrie annually (Christie and Barwick 1984).

As a result of the Santee-Cooper Diversion Project, increased flows down the Cooper River from diverted Santee River water accelerated shoaling in Charleston Harbor (USACE 1975). The Cooper River Rediversion Project was proposed to reduce shoaling by reducing the flow to Charleston Harbor. In 1985, the U.S. Army Corps of Engineers (USACE) finished construction of a 9.5-mile canal to re-divert approximately 75% of the Cooper River flow back into Santee River. The project set a maximum weekly average discharge of 127 cms for Cooper River with the remainder being diverted to Santee River via the new Rediversion Canal. During periods of low water inflow (i.e. below 127 cms), virtually all water released from Lake Moultrie flows down Cooper River. This is because power generation at Pinopolis Dam is more efficient than at the new hydro-facility. Discharge is not regulated at the St. Stephen Dam on the Rediversion Canal. Wilson Dam still releases a continuous 14.6 cms from Lake Marion into Santee River. Concern that reduced discharge to Cooper River would attract fewer blueback herring, decreasing the number that annually migrated through Pinopolis Lock into the Santee-Cooper lakes arose. The USACE predicted that while fisheries resources may decline on Cooper River they would increase on Santee River (USACE 1975). To maintain the number of anadromous fish entering the lakes, the USACE constructed a fish lock on the Rediversion Canal to allow Santee River fish access to Lake Moultrie.

In 1985, water flowing from the Cooper River was re-diverted to the Santee River. A fish lock, constructed at the St. Stephen Dam on the Rediversion Canal, was designed to mitigate the decline of fish passage on the Cooper River. Despite this effort, total fish passage rapidly declined after Rediversion. High or intermittent discharges from the St. Stephen Dam hindered fish from entering the lock. In 1990, a flow agreement with the SCPSA was initiated allowing the lock to function more effectively and the numbers of fish passed to increase. Blueback herring passage through the two facilities has never equaled the pre-Rediversion levels that occurred at the navigation lock though. Modifications to the fish lock entrance channel to increase passage efficiency have been ongoing since construction. Phase I of the modifications was completed for the 1995 season. The modification provided a corridor for fish passage that was protected from

the turbulence of hydro-production, and is essentially a collection gallery that moved the entrances to the lock farther downstream. Phase IIA provided adjustable weir gates installed in the gallery prior to the 1997 season. Phase IIB became operational about halfway through the 2000 season and included a bypass siphon system that can deliver an additional attraction flow of 14 cms around the facility rather than through the fish lock grating. A juvenile separating device was also constructed to safely pass out-migrants downstream from this attraction flow.

Appendix 2. Summary of current regulations on take of blueback herring in South Carolina.

General

There is no run of the river commercial fishing activity for herring in any statewide waters except the Santee-Cooper Complex and the Pee Dee River.

Season

The open season is 15 February - 15 April in the Pee Dee River. The open season in the Santee River is 15 February - 1 May. The open commercial season for the Rediversion Canal of Santee River and the Tailrace Canal of Cooper River is 1 March – 30 April of each year.

Harvest Limits

The allowable daily take of herring for net fisheries is 10 US bushels per boat in the Tailrace Canal of the Cooper River and 10 US bushels per boat in the Rediversion Canal. There are no other caps or quotas in effect for commercial herring fisheries in South Carolina.

Gears

Approved commercial gears are anchored (set or stationary) and drift gill-nets in all open riverine waters seaward of dams, with the exceptions of open portions of the Santee and Cooper River where other gears are allowed. Circular drop-nets up to six feet in diameter, lift-nets and cast-nets are the only gears allowed in the upper Tailrace Canal of the Cooper River and in the open portions of the Rediversion Canal of the Santee River. Lift-nets, cast-nets, and hook & line may be used within the Santee-Cooper Lakes and cast-nets and/or hook & line are legal gear in other inland reservoirs. Legal minimum mesh size for gill-nets is 2 1/2" stretched mesh in all State waters open to such gear. The length of any gill-net may not exceed one half of the width of the waterway where it is fished. Gill-nets may not be fished within 200 yards of any previously

deployed net. Regulatory changes implemented in 2001 restricted net lengths to a maximum of 200 yards in freshwaters and 300 yards in inland marine waters.

Lift Periods

There is a weekly 84-hour lift period in effect for the Pee Dee River during the open gill-netting season. The use of nets in the Cooper River Tailrace Canal is allowed only from sunrise until 10:00. Fishing with nets in the Rediversion Canal is allowed from 7:00 PM - 12:00 midnight EST or 8:00 PM – 12:00 AM EDT, with no lift period. Portions of several rivers are closed to commercial gear.

Actual regulations can be found at: http://www.scstatehouse.gov/code/t50c005.php, under Article15.