Neuse River Striped Bass Monitoring Program, 2020

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Abstract. In spring 2020, 205 Striped Bass *Morone saxatilis* were collected from the Neuse River spawning grounds via boat electrofishing. Mean CPUE was 34.8 fish/h. Growth was rapid, as mean total length was 535 mm for age-3 males and 547 mm for age-3 females. In 2020, seven year-classes were present for males (age 2-8) and seven year-classes were present (age 3-7, 9, and 11) for females. The most abundant year class was 2018 for males and 2016 for females. The most notable fish collected was a 1105 mm female that was 14 kg. This post spawn female was the second largest fish collected on the spawning grounds since sampling began. Of the 197 samples for PBT analysis, 178 (90.4%) exhibited a genotype indicative of hatchery parentage. All fish less than 500 mm were hatchery origin. This suggests no or very limited natural recruitment since 2015 when evidence of low-level natural recruitment occurred. No significant populations gains were evident in this sample, and more time will be needed for recent management actions to have observable effects. Cooperation with NC Division of Marine Fisheries will be required to improve the stock, as the population is spatially extant in joint and coastal waters for most of the year.

The North Carolina Wildlife Resources Commission (NCWRC) is responsible for annual spawning stock assessments of migratory Striped Bass *Morone saxatilis* populations utilizing inland waters within the Central Southern Management Area (CSMA). The CSMA is defined as all internal coastal, joint, and contiguous inland waters of North Carolina south of a line from Roanoke Marshes Point across to Eagle Nest Bay in Dare County, to the South Carolina state line (NCDENR 2013). The goal of CSMA Striped Bass assessments is to monitor Striped Bass populations migrating to the spawning grounds within the Tar, Neuse, and Cape Fear rivers.

Striped Bass in the CSMA are considered a stock of concern by the North Carolina Division of Marine Fisheries (NCDMF). The need for conservative management efforts is supported by "truncated size and age distributions, low overall abundance, and an absence of older fish in spawning ground surveys" (NCDENR 2013). In addition, little evidence of natural recruitment has been observed. Rachels and Ricks (2015) outlined that cryptic mortality (undocumented fishing mortality) was a major concern for managers attempting to reduce the high mortality experienced by Striped Bass in the Neuse River. Additionally, Rachels and Ricks (2016) observed that gillnet effort (number of nets set annually) in the lower Neuse River commercial fishery was a good predictor of Striped Bass mortality the following year. Striped Bass mortality in the Neuse River is similar to the total annual mortality that led to the collapse of the Chesapeake Bay Striped Bass stock in the 1970s (Richards and Rago 1999). The collapse of the Chesapeake Bay stock is well documented as having experienced recruitment overfishing that reduced the spawning stock biomass to levels that could not produce dominant year-classes (Richards and Deuel 1987; Richards and Rago 1999). Prior to October 2018, recreational harvest in inland and joint waters was managed with a 457 mm minimum length limit with a protective slot from 559 mm to 686 mm. In October 2018, NCWRC established a 660 mm minimum length limit in inland waters. In March 2019, NCDMF suspended recreational and commercial harvest of Striped Bass in coastal waters and also suspended the use of gill nets in the Neuse River upstream of the Minnesott Beach Ferry line to reduce Striped Bass mortality and bycatch in commercial gear. To simplify regulations across jurisdictions, NCWRC and NCDMF suspended Striped Bass harvest in joint waters of the Neuse River and NCWRC also suspended harvest in all inland waters of the Neuse River and its tributaries below Falls Dam. These management actions were intended to reduce chronically high mortality of Striped Bass across the entire Neuse River, and they have yet to be evaluated.

Spawning stock data collected in inland waters by NCWRC should be combined with NCDMF data collected in joint and coastal waters to develop a comprehensive stock assessment model for Striped Bass within the CSMA. Estimates of fishing mortality rates coupled with analyses of basic population trends are critical for determining the appropriate harvest of Striped Bass from the CSMA Striped Bass fisheries while still allowing for stock preservation and growth. Development and execution of comprehensive inter-agency fisheries management plans are necessary to support the enhancement of Striped Bass populations within coastal North Carolina for the benefit of recreational and commercial anglers (NCDENR 2013).

In the Neuse River, Striped Bass have been surveyed by NCWRC staff using boat-mounted electrofishing each spring since 1994 to assess spawning stock characteristics. This time series encompasses the removal of Quaker Neck dam in 1998 and Milburnie Dam in 2017. Due to the removal of these dams, Striped Bass can utilize previously unavailable upper basin spawning habitat to the base of Falls Dam. Analyses of catch data suggest Striped Bass spatial distribution during spawning varies among years since the removal of these dams and is likely driven by rainfall and water level in the Neuse River.

Due to low spawning stock abundance and limited Striped Bass recruitment, an annual stocking program has occurred on the Neuse River since 1993. However, since stocking began there has been little improvement in Striped Bass age-structure or survival (Dycus et al. 2014). From 1993 to 2011, the Roanoke River was the broodfish source. In 2012, the stocking program began using Neuse River broodfish to determine if stocking endemic Striped Bass results in an increase in spawning stock abundance (e.g., Bulak et al. 2004). Stocked Striped Bass in the Neuse River were marked using genetic tags from 2010 to present. To date, hatchery contribution has been high (72%–90%) and evidence of wild recruitment has been low or undetectable (Ricks et al. 2020). Understanding contribution of hatchery fish to the Neuse River spawning stock will assist management decisions and assessment of Fishery Management Plan (FMP) objectives.

This report documents the annual NCWRC Striped Bass spawning stock survey conducted in the Neuse River in 2020. The objective of this spawning stock survey was to quantify Striped Bass spawning stock characteristics by estimating relative abundance, size-structure, age-structure, mortality, and contribution of hatchery fish to the spawning stock. These efforts were adjusted from the normal annual sampling design due to logistical limitations associated with the COVID-19 outbreak.

Methods

Spawning Stock Assessment. NCWRC staff collected Striped Bass in the Neuse River from April 19, 2020, through May 9, 2020. Due to COVID-19 logistical limitations, sampling was altered from typical annual sampling. Striped Bass sampling efforts were only conducted in Goldsboro, NC, from river kilometer 240 to river kilometer 211, and continued until 200 individuals were collected (Figure 1). In previous years, sampling was more widespread throughout the Neuse River. Striped Bass were collected using a boat-mounted electrofishing unit (Smith-Root 7.5 GPP). To minimize size selection during sampling, fish were netted as they were encountered, and electrofishing time (seconds) was recorded for each sample site. Mean daily water temperature (°C) was recorded at each sample site. Mean daily discharge (ft^3/s) was recorded from the U.S. Geological Survey gaging station (02087500) near Clayton, NC.

Striped Bass were measured for total length (TL; mm) and weight (g). Sex was determined by applying directional pressure to the abdomen toward the vent and observing the presence of milt (male) or eggs (female). To estimate contribution of hatchery fish to the spawning stock using Parental Based Tagging (PBT) analysis, a partial pelvic fin clip was removed from Striped Bass until 200 fin clips were collected and archived. Scale samples were also taken from all fish where fin clips were taken. Ages were assigned for fish identified as hatchery origin by PBT analysis, and scale ages were applied for non-hatchery fish. For Striped Bass without ages, ages were assigned using a sex specific age-length-key using 2020 PBT and scale ages.

All field data were recorded using a Trimble Yuma field computer and archived in the NCWRC BIODE database. Relative abundance of Striped Bass for each sample was indexed by catch per unit effort (CPUE; fish/h). Mean CPUE was calculated for all sampling sites during a calendar week. Site-specific CPUE was analyzed to elucidate spatial differences in spawning ground utilization. Daily mean CPUE and peak daily CPUE were calculated to analyze annual trends in abundance. Length-frequency distributions by sex were used to evaluate size structure. Mean lengths at age were calculated for the entire sample following methods described by Bettoli and Miranda (2001).

Broodfish collections and stocking. Broodfish collections were conducted via boat-mounted electrofishing. Collections were in conjunction with spawning stock survey with additional sites added to acquire sufficient number of broodfish. Broodfish were transported to Watha State Fish Hatchery. Fry were transported to Edenton National Fish Hatchery for rearing of juveniles, with the goal of producing 100,000 phase II (125–200 mm) fingerlings. Fin clips for genotyping were collected from all broodfish for future PBT assessments.

Hatchery contribution. Genotyping for parentage analysis was conducted on fin clip samples by the South Carolina Department of Natural Resources (SCDNR) Hollings Marine Lab. Parentage-based tagging analysis was available for year-classes stocked in the Neuse River since 2010. Because a portion of the Neuse River Striped Bass stock may be in age-classes older than 2010, hatchery contribution presented herein should be considered preliminary and finalized data will be addressed completely in a future report.

Results

Spawning Stock Assessment. In 2020, 205 Striped Bass were collected (Table 1). Overall mean (SE) CPUE was 34.8 (12.0) fish/h (Table 2) including fish collected during broodfish collections, male Striped Bass ranged 380–685 mm, with the peak occurring in the 525–550 mm size-class (Figure 2). Females ranged 538–1105 mm TL, with the peak occurring in the 600–625 mm size-class (Figure 2). A total of 178 Striped Bass were assigned ages using PBT, 20 were aged with scales, and 7 Striped Bass were assigned ages using a sex specific age-length key. Using a sex specific age-length-key, seven Striped Bass were assigned ages (Tables 2, 3). Male Striped Bass were represented by seven year-classes (ages 2–8) with the 2018 year-class (age 2) comprising 21% of the total sample. Age-4 males were second most abundant and contributed 18.3% to the total sample. Age-6+ males accounted for 10.5% of the total sample. Female Striped Bass were represented by seven year-classes (ages 3–7, 9, and 11), with the 2016 year-class (age 4) comprising 10% of the total sample. Females age-6+ accounted for 10.2% of the total sample. The peak size-class corresponded with age-2 males, which had a mean length of 420 mm (Tables 3, 4). The peak size-class corresponded with age-4 females, which had a mean length of 589mm (Tables 3, 5). The most notable fish collected was a 1105 mm female that was 14 kg. This post spawn female was determined by scale ageing to be age 11 and was the second largest fish collected on the spawning grounds since sampling began in 1994.

Broodfish collections and stocking. Broodfish collections consisted of 11 females and 23 males that were collected via electrofishing and transported to Watha State Fish Hatchery for spawning. Broodfish were euthanized after spawning was complete. Fin clip samples were provided to the SCDNR Hollings Marine Laboratory to determine hatchery or wild origin for future sampling collections containing the 2020 year-class. Hatchery-reared progeny were transported to Edenton National Fish Hatchery for grow-out to phase II size. Phase II stockings consisted of stocking 96,933 fish at the Bridgeton BAA in Bridgeton, NC, between November 3, 2020, and December 1, 2020 (Table 6).

Hatchery contribution. Genetic analysis of 197 fin clip samples collected in 2020 was completed by hatchery parentage (90.4%). The 2016 hatchery-reared year-class was 25.4% (n = 50) of the total sample. There were 19 samples (9.5%) that could not be assigned hatchery parentage and were designated as unknown origin; however, hatchery parentage assignment is not available for pre-2010 year-classes. The 19 individuals classified as unknown were either hatched in the wild or stocked before 2010 (Figure 3; SCDNR 2020). The peak of the non-hatchery Striped Bass at 575 mm suggests that a wild year class was produced in 2015.

Discussion

Overall, results of the 2020 Striped Bass spawning stock survey were similar to previous years. However, because sampling plans were altered significantly due to Covid-19, caution should be taken when comparing these results to other years. The notable observation of the age-11 1105 mm female collected during this abbreviated sample demonstrates the potential for growth and survival of Striped Bass in the Neuse River. If conservation and recovery goals are met, observations like this should be more common.

Striped Bass in the Neuse River continued to exhibit fast growth that has been observed in previous years (Ricks and Buckley 2018). Mean length for male and female Striped Bass at age 3 was 535 mm and 547 mm, respectively. These values are higher than what was observed for the Roanoke River Striped Bass population in 2018 (Male = 414 mm, Female = 420 mm; Smith and Potoka 2019). Mechanisms for fast growth in the Neuse River are poorly understood but could likely be attributed to low density and large forage base in the system.

Ricks et al. (2020) indicated that high mortality rates for Striped Bass were a major factor limiting the attainment of recovery goals. While mortality rates could not be calculated for 2020 due to variable fishing mortality across cohorts, no significant changes in the age structure have occurred, which suggests mortality is still consistent with previous years. Not enough time has passed to determine if harvest closures have been effective in reducing mortality, however the collection of an age-11 fish suggests that these measures could be beneficial.

The high contribution of hatchery-reared fish in 2020 suggests stocked fish contribute prodigiously. As age-classes begin to completely overlap in size, fish of unknown origin belonging to pre-2010 year-classes may be sampled more frequently in genetics analyses. The true contribution of hatchery-reared Striped Bass to the Neuse River population will be unknown until the age-structure is comprised exclusively of fish hatched since spring 2010. Given the current truncated age structure, this will likely occur by 2021. In 2020, all fish under 500 mm were of hatchery origin. This suggests no or very limited natural recruitment since 2015 when evidence of low-level natural recruitment occurred (Ricks and Buckley 2018). Evidence of poor wild recruitment has been documented in previous research (Hawkins 1980, Nelson and Little 1991, Barwick and Homan 2008). The Neuse River Striped Bass population is maintained by stocking and is not capable of supporting sustainable harvest, which is not the current management goal (NCDENR 2013). It is likely that recruitment overfishing has occurred given the high mortality rates present in the Neuse River since at least 1994 (Rachels and Ricks 2016). Recruitment overfishing has been implicated as a principal factor for Striped Bass recruitment failure in other fisheries (Goodyear et al. 1985; Richards and Deuel 1987; Richards and Rago 1999). Increasing egg deposition on the spawning grounds by increasing the spawning stock biomass and advancing the female age-structure to older individuals may lead to improved wild recruitment (Goodyear 1984).

Management Recommendations

1. Maintain current harvest suspension and gear restrictions in inland and joint waters. Once harvest is allowed, maintain the 26-in minimum length limit and 2 fish/day daily creel limit in inland and joint waters of the Neuse River for recreational fisheries.
2. Maintain support for the gill net suspension above the Minnesott Beach Ferry. The increased MLL in conjunction with reduced exploitation will increase female spawning stock biomass and potentially improve wild recruitment.
3. Continue stocking 100,000 phase II fingerlings utilizing Neuse River broodfish.
4. Elucidate mechanisms affecting natural recruitment. Streamflow, trophic interactions, juvenile nursery habitat, and stock-recruit relationships should be investigated to isolate likely determinants of recruitment bottlenecks.
5. Develop NCWRC Boating Access Areas on the Neuse River upstream of Smithfield, NC. Current access is limited for boat angling and NCWRC field sampling despite the availability of fish habitat during average to above-average spring streamflow. NCWRC should support and facilitate access at sites near Buffalo Rd and Anderson Point Park in Wake County.
6. The age-6+ metric was calculated to compare to previous surveys, but the utility of this metric should be evaluated in future analysis. The use of an age-9+ group should also be evaluated since it is typically used in other Striped Bass assessments on the Atlantic slope.
7. Foster an effective partnership with NCDMF and work cooperatively with the goal to conserve and enhance of Striped Bass populations in coastal North Carolina.

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TABLE 1. Weekly mean CPUE (average CPUE across all sample sites with standard error) of Striped Bass collected by electrofishing on the Neuse River spawning grounds during spring 2020. Pooled CPUE (total catch/total effort) is also provided.

Sample Week	N	Effort (h)	Catch	Mean CPUE (SE)	Pooled CPUE	Discharge (ft3/s)	Water temp (°C)
4/19/2020 - 4/25/2020	3	2.07	84	52.1 (31.2)	40.6	1297	17.0
5/3/2020 - 5/9/2020	7	3.32	121	27.3 (11.8)	36.4	1923	20.2
Totals and Mean CPUE	10	5.4	205	34.8 (12)	38.5	1610	

TABLE 2. Striped Bass age distributions (percent composition) collected by electrofishing in the Neuse River, spring 2020.

		Percent Composition		
Year Class	Age	Male	Female	Overall
2018	2	21.0		21.0
2017	3	14.3	1.6	15.9
2016	4	18.3	10.1	28.4
2015	5	7.4	6.8	14.2
2014	6	7.3	5.0	12.3
2013	7	2.4	3.3	5.8
2012	8	0.5	0.0	0.5
2011	9		1.5	1.5
2010	10		0.0	0.0
2009	11		0.5	0.5
Totals		71.2	28.8	100.0

TABLE 3. Age composition and mean total length (mm) at age of Striped Bass collected from the Neuse River by electrofishing, 2020.

Year Class	Age	N Aged	N Total	N Estimated	% Composition	Total Length (mm) Mean	SE	Min	Max
					2020 Males				
2018	2	42	43	1	29.45	420	3	380	452
2017	3	29	29	0	20.10	535	7	476	626
2016	4	37	38	1	25.70	545	4	500	618
2015	5	15	15	0	10.37	572	9	528	654
2014	6	15	15	0	10.27	625	7	592	670
2013	7	5	5	0	3.42	652	15	603	685
2012	8	1	1	0	0.68	687			
Totals		144	146	2	99.99				
					2020 Females				
2018	2								
2017	3	2	3	1	5.6	547	12	546	570
2016	4	19	21	2	35.0	589	7	552	706
2015	5	14	14	0	23.7	630	6	602	668
2014	6	9	10	1	17.3	675	10	614	730
2013	7	6	7	1	11.5	727	33	662	912
2012	8								
2011	9	3	3	0	5.1	737	14	701	750
2010	10								
2009	11	1	1	0	1.7	1105			
Totals		54	59	5	100				

TABLE 4. Mean total length (mm) at age for male Neuse River Striped Bass year-classes collected 1994–2020. Only those year-classes with four or more individuals aged are included.

	Age							
Year Class	1	2	3	4	5	6	7	8
1992		422	502	543	596	659	721	
1993		423	462	537	591	655		
1994		425	499	532	603			
1995		424	483	539	590			
1996		405	494	547	604	664	664	
1997		424	508	565	632	656		
1998		431	526	596	584		718	
1999		443	529	534	596			
2000		451	519	577	612			
2001		481	506	584				
2002		430	517					
2003		465	503	552				
2004		418	491	532	609		622	
2005			441	569	621	631		
2006	237		501	569	579	640	678	
2007		435	531	560	621	656	698	
2008			529	578	583	674		
2009		425	504	539	617			
2010			505	562	629	625	686	692
2011		437	539	577	632	660	697	735
2012			524	563	601	624	663	
2013		443	533	560	609	627	652	
2014			509	568	602	625		
2015		421	485	530	572			
2016		415	489	545				
2017			535					
2018		420						
Mean	237	432	506	557	604	646	680	714
Min		405	441	530	572	624	622	692
Max		481	539	596	632	674	721	735

TABLE 5. Mean total length (mm) at age for female Neuse River Striped Bass year-classes collected 1994–2020. Only those year-classes with four or more individuals aged are included.

Year Class	Age 1	2	3	4	5	6	7	8
1992			521	572	631	657		
1993						697	761	
1994			535	582		681		
1995			519	540	621			
1996		425	561	585	634	684	728	
1997		512	551	600		689		
1998					588			
1999				544	614			
2000			540	590	667		857	
2001			571					
2002								
2003				597				
2004			519	565	619	671		
2005			431	578	618	668		736
2006			530	585	637		710	
2007				591		691	733	
2008			521		600	703		752
2009				568	652		742	
2010			518	606	654	721	742	764
2011			556	611		722	744	
2012				609	634	693		
2013				580	640	679	727	
2014			510	607	624	675		
2015		428	502	561	630			
2016			517	589				
Mean		455	525	583	629	688	749	751
Min		425	431	540	588	657	710	736
Max		512	571	611	667	722	857	764

TABLE 6. Summary of Neuse River Striped Bass spawning stock characteristics, 1994–2020. Due to reporting inconsistencies, data were reanalyzed and may differ slightly from annual NCWRC final reports.

Year	Effort (h)	N	Males	Females	M : F Ratio	Mortality (Z)	CPUE (fish/h)					Total Length (mm)			Stocking			Hatchery Contribution
							Age 3	Age 6+	Peak Daily	Mean Daily (SE)	Pooled	Male Mean	Female Mean	Max	Phase I	Phase II	Fry	
1994	7.3	120	91	28	3.3:1	1.08	0.5	3.1	29.7	18.6 (4.7)	16.2	559	650	805	103,057	79,933	0	
1995	11.0	215	183	32	5.7:1	0.73	14.4	1.1	33.2	18.4 (6.2)	19.6	519	613	780	99,176	0	0	
1996	19.3	226	168	58	2.9:1	0.85	2.5	1.2	28.0	11.1 (3.3)	11.7	515	603	818	100,000	100,760	0	
1997	21.3	143	114	29	3.9:1	0.61	2.2	0.8	16.0	6.4 (1.6)	6.7	515	639	840	100,000	0	0	
1998	17.0	221	175	43	4.1:1	0.45	3.1	2.0	39.9	13.9 (4.7)	12.8	501	629	940	207,730	83,195	0	
1999	13.8	292	242	50	4.8:1	0.75	12.4	2.0	46.9	19.0 (3.9)	21.2	523	592	840	100,000	0	0	
2000	20.2	353	242	111	2.2:1	0.45	3.9	1.4	60.0	16.7 (4.2)	17.4	502	612	940	121,993	108,000	0	
2001	17.5	154	131	23	5.7:1	0.52	3.8	0.2	28.0	8.4 (2.5)	8.8	550	622	726	103,000	0	0	
2002	20.0	102	84	18	4.7:1	0.36	0.3	1.3	12.0	4.3 (1.0)	5.1	538	696	814	0	147,654	0	
2003	31.7	402	304	98	3.1:1	0.65	6.5	2.2	61.9	11.3 (3.2)	12.7	539	606	918	100,000	0	0	
2004	11.3	73	54	19	2.8:1	0.78	0.7	1.4	12.6	6.4 (1.1)	6.4	581	656	925	100,000	168,011	0	
2005	23.2	127	107	18	5.9:1	0.44	1.3	1.1	11.6	5.2 (1.4)	5.4	543	714	1140	114,000	0	0	
2006	12.0	58	53	5	10.6:1	0.53	0.6	0.5	8.6	3.8 (1.5)	4.8	448	739	874	146,340	99,595	0	
2007	19.3	172	140	32	4.4:1	0.63	7.5	0.5	28.0	7.7 (2.6)	8.9	498	609	894	172,882	69,953	0	
2008	25.2	141	110	31	3.5:1	0.98	1.2	0.1	16.6	4.8 (1.4)	5.6	514	560	831	313,798	0	0	
2009	18.2	362	330	31	10.6:1	0.84	16.6	0.2	57.3	18.0 (7.0)	19.8	501	604	882	100,228	104,061	0	
2010	14.5	141	122	19	6.4:1	0.94	4.8	0.8	22.9	9.5 (2.8)	9.7	556	618	762	0	107,142	0	
2011	15.0	176	115	60	1.9:1	0.84	2.2	1.4	20.3	11.8 (2.1)	11.6	516	614	823	0	102,089	0	
2012	17.6	144	117	27	4.3:1	0.62	4.1	1.3	33.1	5.9 (2.4)	8.2	549	596	767	50,180	90,178	0	
2013	19.9	322	265	56	4.7:1	0.74	5.3	2.9	29.5	13.2 (2.8)	16.2	545	622	931	181,327	113,834	0	
2014	26.9	316	224	87	2.6:1	0.86	2.8	4.1	56.0	10.1 (3.1)	11.6	583	650	850	79,864	78,866	0	82.6
2015	13.2	228	200	28	7.1:1	0.94	6.4	0.0	134.0	19.8 (10.6)	17.3	582	656	830	0	109,107	799,700	74.3
2016	14.6	104	79	25	3.2:1	0.53	2.3	2.1	15.5	6.6 (1.7)	7.1	579	607	829	80,910	134,559	1,173,000	72.0
2017	22.7	200	155	45	3.4:1	0.68	4.3	2.4	29.7	10.3 (2.6)	8.8	563	688	842	0	14,203	0	85.0
2018	20.9	279	236	43	5.5:1	0.60	5.1	3.4	44.1	11.4 (2.3)	13.0	536	620	827	96,900	86,556	670,464	77.6
2019	19.2	299	233	66	3.5:1	0.69	6.7	1.3	136.7	15.1 (5.1)	15.5	528	561	803	0	85,693	1,755,000	89.8
2020*	5.4	10	146	59	2.5:1		5.9	7.4	52.2	34.8 (12.0)	38.5	522	643	1105	0	96,933	0	90.4
Avg.	17.7	199.3	163.7	42.3	3.9:1		4.6	1.5	39.4		12.6	534	630	864				

* Sampling in 2020 was shortened due to COVID-19. Mortality could not be calculated due to a change in fishing mortality across cohorts.

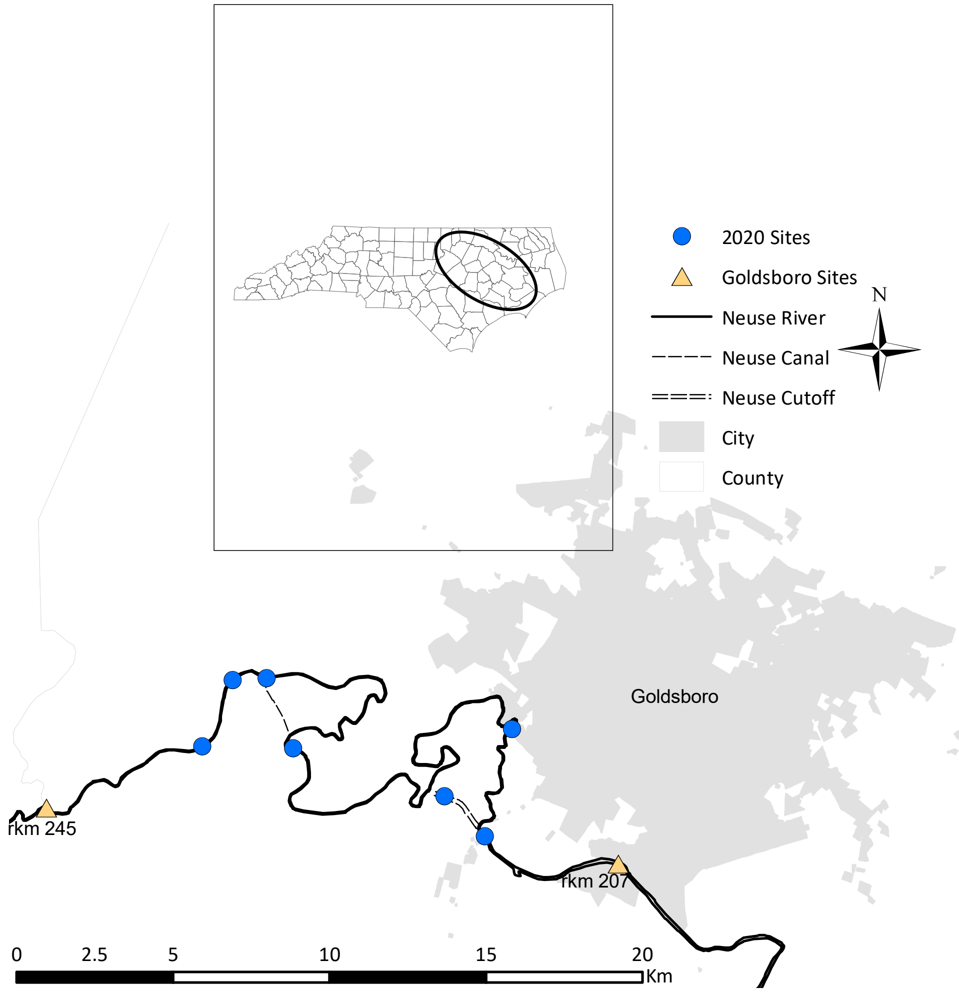

FIGURE 1. Sampling sites for the Neuse River Striped Bass monitoring program, spring 2020.

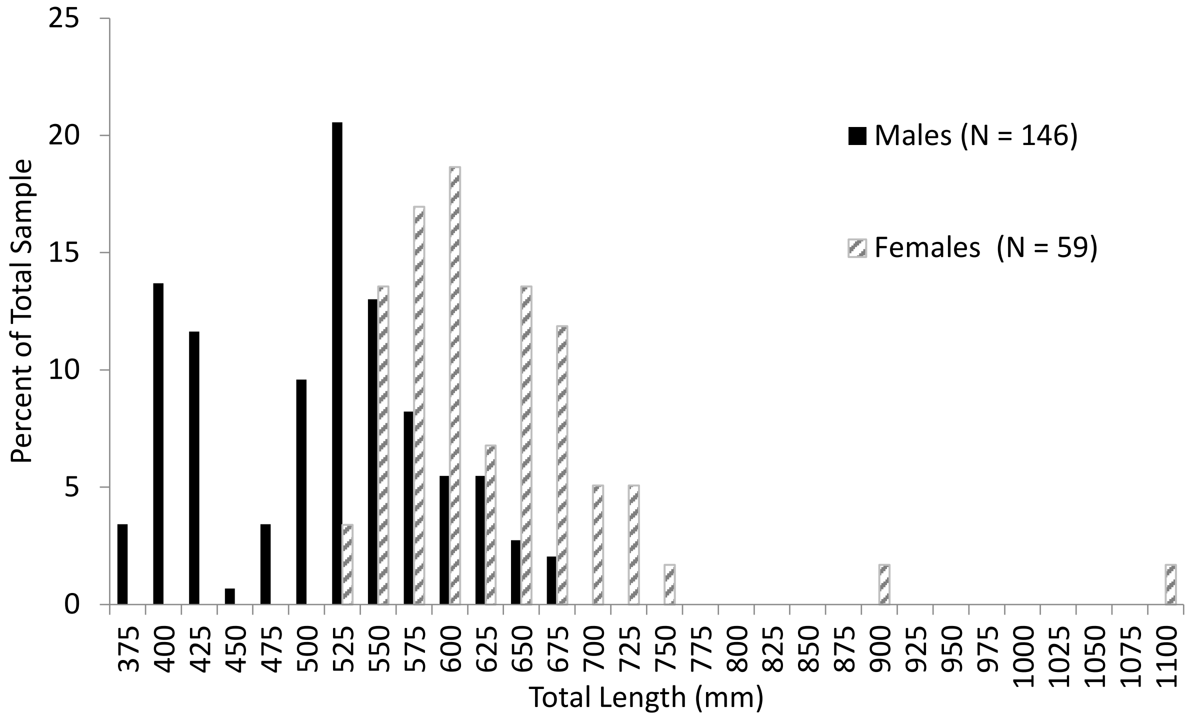

FIGURE 2. Length-frequency distributions for Striped Bass collected from the Neuse River, spring 2020. Male and female plots sum separately to 100%.

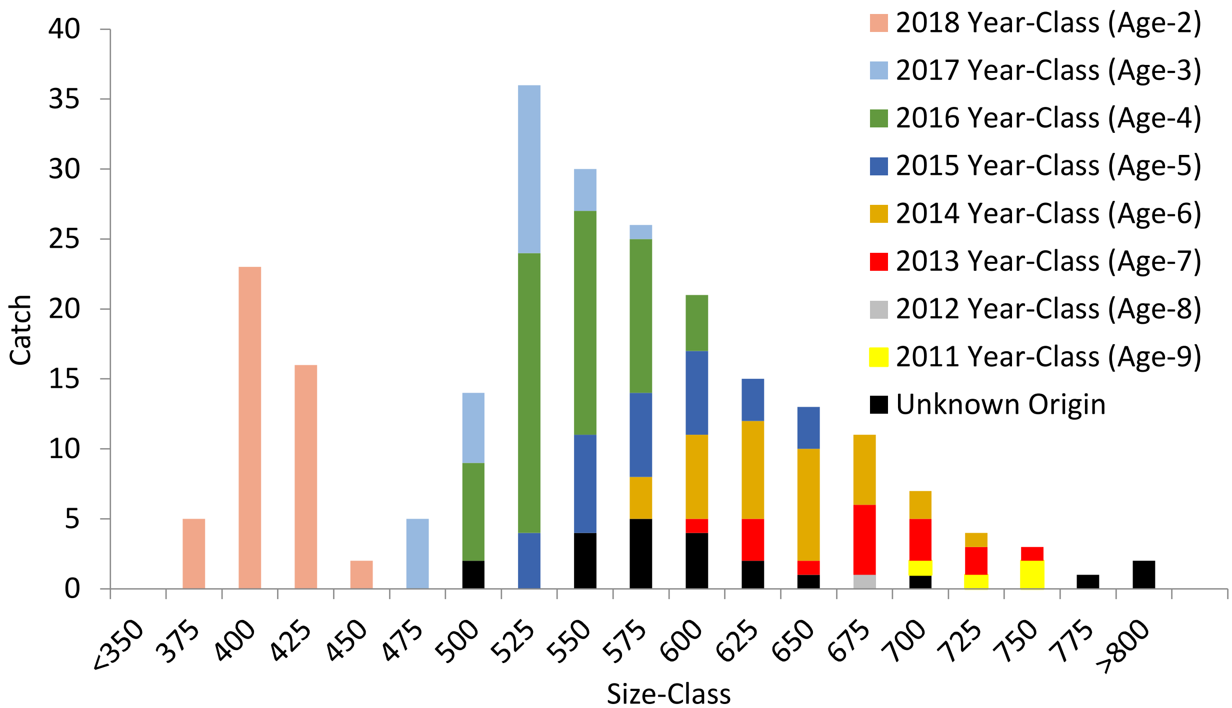

FIGURE 3. Composition of hatchery and unknown origin fish by size-class from genetic samples collected during the spring 2020 spawning stock survey and broodfish collections.