Neuse River Striped Bass Monitoring Programs, 2018–2019

Federal Aid in Sport Fish Restoration
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Abstract. In spring 2018 and 2019, 279 and 299 Striped Bass *Morone saxatilis* were collected from the Neuse River spawning grounds via boat electrofishing. Mean daily CPUE was 12.6 fish/h in 2018 and 15.1 fish/h in 2019. Abundance of age-6 and older fish was 3.4 fish/hour in 2018 and 1.3 fish/h in 2019. Growth continued to be rapid, as age-3 mean total length was 485 mm for males and 502 mm for females in 2018, and 489 mm for males and 517 mm for females in 2019. In 2018, eight year-classes were present for males (age 2–9) and seven year-classes were present (age 3–9) for females. The 2014 and 2015 year-classes were the most abundant year-classes in 2018, representing 61.5% of the sample. In 2019, seven year-classes were present for males and females (age 3–9). The 2016 year-class was the most abundant in 2019 for both males and females. Annual mortality continued to remain high at 45% in 2018 and 50% in 2019. Hatchery contribution was 77.6% in 2018 and 89.8% in 2019. In 2018, the length-frequency peak of non-hatchery Striped Bass at 475 mm suggests recruitment of a natural year-class in 2015. This wild 2015 cohort was evident in the size structure data from 2019, with a peak at 525 mm. Overall, the low abundance and truncated age-distribution support catch-curve estimates indicating high spawning stock mortality, while results of parentage-based tagging suggest a high proportion of the spawning stock is hatchery-reared. 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) conducts annual spawning stock assessments of migratory Striped Bass *Morone saxatilis* populations utilizing inland waters within the Central Southern Management Area (CSMA). The CSMA management unit 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, and to recommend and evaluate management actions for stock improvement.

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). 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.

Spawning stock data collected in inland waters by NCWRC will 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 total allowable 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 1998 removal of Quaker Neck Dam on the main-stem Neuse River at river kilometer (rkm) 225 that blocked access to Striped Bass spawning habitat upstream of Goldsboro, NC (Burdick and Hightower 2006). Furthermore, in 2017 Milburnie Dam was removed, providing access to spawning habitats upstream to Falls Dam (rkm 376) when flows allow. Analyses of catch data suggest Striped Bass spatial distribution during spawning varies among years since the removal of Quaker Neck Dam.

Due to low spawning stock abundance and limited Striped Bass recruitment, an annual stocking program has occurred on the Neuse River since 1993. From 1994 to 2011, the Roanoke River was the broodfish source. However, since stocking began there has been little improvement in Striped Bass age-structure or mortality (Dycus et al. 2014). In 2012, the stocking program transitioned to Neuse River broodfish to determine if stocking river-specific Striped Bass would result in an increase in spawning stock abundance (e.g., Bulak et al. 2004). Parentage-based tagging techniques also began in 2012, providing the use of discrete genetic markers to evaluate the proportion of hatchery fish in the population. Preliminary assessments in 2012–2015 indicated very little natural reproduction occurred (NCWRC unpublished data), which was also observed by Barwick and Homan (2008). Understanding the contribution of hatchery fish to the Neuse River spawning stock will assist management decisions and assessment of Fishery Management Plan (FMP) objectives.

Prior to October 2018, inland waters in the Neuse River were managed with a 457 mm minimum length limit with a protective slot from 559 mm to 686 mm. In October 2018, a 660 mm minimum length limit was established by rule in inland waters. However, prior to implementation, a proclamation was signed in March 2019 by the NCWRC Executive Director to suspend the existing rules and establish a moratorium on recreational harvest in the Neuse River and all its tributaries below Falls Dam. This decision was made to support a moratorium established by the NCDMF in joint and coastal jurisdictions.

This report documents the annual NCWRC Striped Bass spawning stock survey conducted in the Neuse River in 2018 and 2019. 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.

Methods

Spawning Stock Assessment. During concurrent sampling for American Shad, NCWRC staff collected Striped Bass in the Neuse River from April 8, 2018 to 19 May 19, 2018 and from April 7, 2019 to May 18, 2019. Directed Striped Bass sampling began in Goldsboro and continued weekly during optimum spawning temperatures (18–22°C). Additional sites in Goldsboro, Raleigh, and Smithfield were sampled weekly as Striped Bass catches increased (Figure 1). Sampling at all sites was contingent upon adequate streamflow to allow boat access (Table 1). Sampling ceased when Striped Bass spawning appeared complete. 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.

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 parentage-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. Age assignment was done using a combination of data collected during PBT analyses, with scales read for age determination if the fish was not identified during PBT analyses as a known-aged hatchery fish. For fish without either a scale or a fin clip sample, ages were assigned based on a sex specific age-length key.

Before release, Striped Bass were tagged with an individually numbered internal anchor tag as a cooperative effort with the ongoing NCDMF Striped Bass tagging program (Winslow 2010). Recaptured, tagged Striped Bass were identified by tag number. Recaptures from the current sample year were recorded in the site of capture unless the recapture occurred on the same day as tagging.

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

grounds 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). The Chapman-Robson estimator was used to elucidate total instantaneous mortality (*Z*) following the recommendations of Smith et al. (2012).

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

Hatchery contribution. Genotyping for PBT 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. Since 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

2018 spawning stock assessment. Field staff collected 279 Striped Bass in 2018. Weekly mean (SE) CPUE was 13.0 (1.6) fish/h (Table 2). The peak in weekly mean CPUE was 18.2 (2.4) fish/h, occurring the week of April 29, 2018 with water temperatures measuring 18.3°C (Table 2). Due to low water levels limiting access to the Raleigh area of the Neuse River, sampling occurred less frequently (2.06 h of effort) than the Goldsboro area (10.3 h of effort) or Smithfield/Clayton area (8.9 h of effort). Despite comparable effort in Goldsboro (10.3 h) and the Smithfield/Raleigh area (10.9 h), 60% of the total sample was collected in Smithfield/Raleigh sites with the majority of those fish (88%) coming from the Smithfield/Clayton area. Total CPUE upstream of the Goldsboro sampling sites was 15.0 fish/h, compared to 10.5 fish/h observed in the Goldsboro sites.

Age assignment for 272 Striped Bass was conducted using PBT data. Using a sex specific age-length-key, 87 Striped Bass were assigned ages (Tables 3 and 4). Male Striped Bass were represented by eight year-classes (ages 2–9) with the 2015 year-class (age 3) dominating the electrofishing catch by comprising 39% of the total sample. Age-4 males were the second most abundant cohort and contributed 27% to the total sample (Tables 3 and 4). Males age-6+ accounted for 13.7% of the total sample (Table 3) and 16.4% of the male sample (Table 4). Female Striped Bass were represented by seven year-classes (ages 3–9) with the 2013 and 2015 year-class (age 3 and age 5) comprising 41.4% of the female sample (Table 4). Females age-6+ accounted for 6.4% of the total sample (Table 3) and 39.6% of the female sample (Table 4).

Male Striped Bass in Spring 2018 ranged from 259–768 mm, with the peak occurring in the 475–500 mm size-class. The male size distribution was slightly left skewed (Figure 2). The peak size-class corresponded with age-3 males, which had a mean length of 485 mm and was the most abundant age-class (Tables 4 and 5). Females ranged 475–858 mm TL. The peak size-class

was at 725 mm, however age 3 and age 5 were the most abundant age-classes, suggesting the peak at 725 mm consisted of several overlapping year classes (Tables 4 and 6).

The Chapman-Robson biased corrected method estimated mortality Z = 0.60 (SE = 0.07), which corresponds to a 45% annual mortality rate (*A;* Table 7).

2019 spawning stock assessment. In 2019, 299 Striped Bass were collected via electrofishing (Table 2). Weekly mean (SE) CPUE was 16.1 (3.2) fish/h (Table 2). The peak in weekly mean CPUE was 29.0 (8.7) fish/h, occurring the week of April 21, 2019 with water temperatures measuring 18.1°C (Table 2). Peak Striped Bass catch occurred April 25, 2019 with 29 fish (CPUE = 136.7 fish/h) collected near Raleigh. The 2019 sampling season effort was variable across sampling areas throughout the sampling period. Total sampling effort was similar downstream from Goldsboro (9.27 fish/h) and upstream from Goldsboro (9.95 fish/h). However, 91.6% of the total sample was collected from the sites above Goldsboro. Total CPUE in upper sampling sites was 27.5 fish/h, compared to 2.7 fish/h in lower sites.

A total of 353 Striped Bass were assigned ages using PBT data, and 23 fish were aged with scales. Using a sex specific age-length-key, 78 Striped Bass were assigned ages (Tables 3 and 4). Male Striped Bass were represented by seven year-classes (ages 3–9) with the 2016 year-class (age 3) dominating the electrofishing catch by comprising 55.7% of the total sample (Table 4). Age-4 males were the second most abundant cohort and contributed 23.6% to the total sample (Table 3). Males age-6+ accounted for 8.3% of the total sample (Table 3) and 11.4% of the male sample (Table 4). Female Striped Bass were represented by seven year-classes (ages 3–9), with the 2016 year-class (age 3) comprising 46.2% of the female sample and 11.6% of the total sample (Tables 3 and 4). Females age-6+ accounted for 2.8% of the total sample (Table 3) and 11.8% of the female sample (Table 4).

Male Striped Bass in Spring 2019 ranged from 448–803 mm, with the peak occurring in the 450–525 mm size-class. The male size distribution was left skewed (Figure 2). The peak size-class corresponded with age-3 males, which had a mean length of 489 mm and was the most abundant age-class (Tables 4 and 5). Females ranged 488–795 mm TL, with the peak occurring in the 500–575 mm size-class (Figure 2). The peak size-class corresponded with age-3 females, which had a mean length of 517 mm (Tables 4 and 6) and were the most abundant age-class.

The Chapman-Robson biased corrected method estimated mortality Z = 0.70 (SE = 0.06), which corresponds to a 50% annual mortality rate (*A;* Table 7).

2018 broodfish collections and stocking. Broodfish collections consisted of seven females and 20 males that were collected via electrofishing and transported to the Edenton National Fish Hatchery. 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 2018 year-class. Hatchery-reared progeny were moved to ponds for grow-out to phase-II sizes. Due to projected surplus in phase-II fingerlings, phase-I fish (25–50 mm TL) were stocked in Upper Broad Creek, a tributary of the Neuse River at Blackbeard's Marina (n = 96,900 fish) on June 8 (Table 8). Phase-I stockings were not genetically distinct from Bridgeton phase-II stockings; therefore, future genetic sampling will not be able to differentiate between these phase-I and phase-II stocking events. Phase-II stockings consisted of two distinct batches, an upriver batch stocked between November 1 and December 7 at Cox's Ferry BAA near Princeton (n = 42,881 fish) and a stocking at the Bridgeton BAA in Bridgeton between November 14 and December 13 (n = 43,675 fish; Table 5). On May 4,

670,464 fry were stocked into the Neuse River at Kinston (n = 521,472 fish) and at Bridgeton (n = 148,992 fish). The fry stockings at Kinston and Bridgeton were genetically distinct.

2019 broodfish collections and stocking. Broodfish collections consisted of 24 females and 39 males that were collected via electrofishing and transported to Edenton National Fish Hatchery. 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 2019 year-class. Hatchery-reared progeny were moved to ponds for grow-out to phase-II sizes. Phase-II stockings consisted of two distinct batches, an upriver batch stocked between October 29 and November 6 at the Goldsboro BAA in Goldsboro (n = 37,154 fish) and a stocking at the Bridgeton BAA in Bridgeton between November 11, 2019 and December 05, 2019 (n = 48,540 fish; Table 8). A total of 1,755,000 fry were also stocked in Kinston at the Kinston BAA (n = 863,000 fish) and in Bridgeton at the Bridgeton BAA (n = 892,200 fish).

2018 hatchery contribution. Genetic analysis of 322 fin clip samples collected in 2018 was completed by the SCDNR Hollings Marine Laboratory. Of the 322 samples, 250 exhibited a genotype indicative of hatchery parentage (78%). The 2015 hatchery-reared year-class was dominant, providing 23% (n = 75) of the total sample. Hatchery fish by remaining cohort were as follows: 2016 (7%; n = 22), 2014 (20%; n = 64), 2013 (11%; n = 35), 2012 (7%; n = 23), 2011 (5%; n = 17), and 2010 (4%; n = 14). The remaining 72 samples (22%) could not be assigned hatchery parentage and were designated as unknown origin; however, hatchery parentage assignment is not available for pre-2010 year-classes (age 8 and older in 2018). The 72 individuals classified as unknown were either naturally produced or were stocked before 2010 (Figure 3; SCDNR 2019). The peak in the size distribution of non-hatchery Striped Bass at 475 mm suggests that a wild year class was produced in 2015 (Figure 3).

2019 hatchery contribution. Genetic analysis of 226 fin clip samples collected in 2019 was completed by the SCDNR Hollings Marine Laboratory. Of the 266 samples, 203 exhibited a genotype indicative of hatchery parentage (89.8%). The 2016 hatchery-reared year-class was dominant, contributing 57% (n = 129) of the total sample. Hatchery fish by remaining cohort were represented as follows: 2015 (16%; n = 36), 2014 (6%; n = 14), 2013 (4%; n = 8), 2012 (2%; n = 5), 2011 (4%; n = 8), and 2010 (1%; n = 3). The remaining 23 samples (10%) could not be assigned hatchery parentage and were designated as unknown origin; however, hatchery parentage assignment was not available for pre-2010 year-classes (age 9 and older in 2019). The 29 individuals classified as unknown either hatched in the wild or were stocked before 2010 (Figure 3; SCDNR 2020). The peak in the size distribution of non-hatchery Striped Bass at 525 mm suggests that a wild year class was produced in 2015. (Figure 3).

Discussion

Results of the 2018 and 2019 Striped Bass spawning stock survey were similar to previous years. The pooled CPUE of Striped Bass in 2018 (13 fish/h) and in 2019 (15.5 fish/h) was slightly higher than the mean CPUE over time 1994–2019 (11.6 fish/h). No trends in mean daily CPUE were apparent since 1994, despite the removal of Quaker Neck Dam in 1998 and implementation of conservative harvest limits in 2008. The impact of regulation changes in 2018 and 2019 has yet to be formally evaluated. Peak Daily CPUE was higher in 2018 (44.1

fish/h) than the average for the time series (38.9 fish/h), and the 2019 values (136.7 fish/h; Table 8) were the highest observed since sampling began. Catch rates from sampling stations in the upper-spawning grounds between Smithfield and Milburnie dam are consistently the highest in the time series. However, because weekly sampling in this area is limited due to logistics, it is likely that portions of the spawning aggregations were missed during years where the peak daily catch rates were lower. For this reason, it should be noted that the increased observed peak daily catch rate in 2019 does not necessarily reflect an increase in relative abundance. Age 6 and older CPUE was 3.4 fish/h in 2018 and the second highest ever recorded; however, in 2019 age-6 CPUE was 1.3 fish/h. 2018 was one of five years in the time series where age-6 CPUE was 2.2 fish/h or higher. The maximum Striped Bass age observed in 2018 and 2019 was 9 years old. The management objective for the Neuse River is to have an expanded age structure that includes individuals older than age 9; the truncated age-structure is a result of high mortality rates.

Striped Bass in the Neuse River continue 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 485 mm and 502 mm in 2018. These Neuse River values are higher than what was observed for the Roanoke River Striped Bass population (Male = 414 mm, Female = 420 mm; Smith and Potoka 2019). Male mean total length in 2018 (536 mm) and 2019 (528 mm) was similar to the mean since sampling began in 1994 (534 mm). Female mean total length in 2018 (620 mm) and 2019 (561 mm) was slightly less than the mean since sampling began (630 mm; Table 7). Mechanisms for fast growth in the Neuse River are poorly understood but could likely be attributed to low Striped Bass density and a large forage base in the system.

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). Additionally, Rachels and Ricks (2016) documented that gillnet effort in the lower Neuse River was a good predictor of Striped Bass mortality rates the following year. In March 2019, NCDMF suspended harvest of Striped Bass and the use of gill nets in the Neuse River upstream of the Minnesott Beach Ferry line. The intent of this management action was to reduce Striped Bass mortality and bycatch in commercial gear. This management action has yet to be evaluated.

The high contribution of hatchery-reared fish in 2018 and 2019 suggests stocked fish continue to contribute prodigiously to the Neuse River population. 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 after the spring of 2010 (the first year PBT techniques were used). Given the current truncated age structure, this will likely occur by 2021. In 2018, 32% of fish less than 550 mm were non-hatchery. As documented in Ricks and Buckley (2018), this could be the first documented occurrence of wild recruitment since PBT analysis began in 2010. This observation is further supported from angler-caught juvenile Striped Bass fin clip samples from 2016 which revealed 79% were non-hatchery. Origins of these wild fish were unknown; possibilities include a natural spawning event in either the Neuse or the Tar rivers, or less likely, from the Roanoke River. Nonetheless, PBT analysis indicated 77% hatchery contribution in the Neuse River spawning grounds electrofishing sample in 2018 (SCDNR 2019).

In 2019, 91% of the non-hatchery fish that could be aged with scales were 4 years old and were produced in 2015. Hatchery contribution (89.9%) was high overall in 2019 (SCDNR 2020). While the possibility of 2015 natural recruitment is an encouraging step in terms of population recovery, the Neuse River Striped Bass population is still best described as a hatchery-supported fishery. Current management objectives focus on shifting population recruitment mechanisms toward a self-sustaining population. Evidence of poor natural recruitment has been documented in previous research (Hawkins 1980, Nelson and Little 1991, Barwick and Homan 2008). The determinant of poor wild recruitment has not been identified but includes variables such as egg density and fry transport to nursery areas. Trophic interactions, juvenile nursery habitat, and stock-recruit relationships should be investigated to isolate likely determinants of mortality bottlenecks. However, it is likely that recruitment overfishing is occurring given the high mortality rates present in the Neuse River since at least 1994. Recruitment overfishing has been implicated as a principle factor for Striped Bass recruitment failure (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 natural recruitment (Goodyear 1984). Protecting the female spawning stock through harvest restrictions in conjunction with reduced exploitation will increase SPR to the target (SPR = 0.45) used to create the *F* biological reference point in the FMP, potentially improving wild recruitment.

Management Recommendations

1. Continue to evaluate the current harvest moratorium on abundance and hatchery contribution of Striped Bass on the Neuse River spawning grounds.
2. Continue stocking 100,000 phase-II fingerlings utilizing broodfish collected from the Neuse River. Culture two unique genetic batches of phase-II fingerlings to evaluate stocking success at inland stocking locations. Inland stocking locations should be chosen based on potential carrying capacity of phase-II fish and potential trophic interactions with resident species.
3. Elucidate mechanisms affecting natural recruitment. Research stockings of Striped Bass fry should continue to determine if a recruitment bottleneck occurs during the egg development stage.
4. Develop NCWRC Boating Access Areas on the Neuse River upstream of Smithfield. Current access is limited for boat angling and NCWRC field sampling, despite the availability of fish habitat during average to above-average spring streamflow. Two sites have been considered: one near Buffalo Road and one at Anderson Point Park.
5. Replace field data loggers. An upgrade in technology is needed to avoid data loss and improve efficiency of data entry and storage.
6. Develop an age-9+ metric for future data comparisons between sample years.

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TABLE 1. Neuse River discharge requirements for boating access during spring electrofishing surveys.

Sample Area	Access Area	USGS Gage Station	Min Discharge (Ft3/s)	Min Gage (ft)	Site Status
Falls Dam	Buffalo Road	2087183	700	2.1	High Flows
Milburnie Dam	Anderson Point Park	2087183	500	2.0	Weekly Flows Allowing
Fire Dept Rd	Smithfield	2087500	900	2.8	Weekly Flows Allowing
Cox's Ferry	Cox's Ferry BAA	2089000	650	3.5	Weekly
Steven's Mill	Steven's Mill BAA	2089000	650	3.5	Optional/Brood
Kinston	Kinston BAA				Extreme Low Flows

TABLE 2. 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 2018 and 2019. Pooled CPUE (total catch/total effort) is also provided.

Year	Sample Week	N	Effort (h)	Catch	Mean CPUE (SE)		Pooled CPUE	Discharge (ft3/s)	Water temp (°C)
2018	April 8 – April 14	2	0.68	3	4.5	(1.76)	4.4	1137	13.8
2018	April 15 – April 21	8	2.85	7	2.2	(1.52)	2.5	3264	17.2
2018	April 22 – April 28	10	3.94	49	11.1	(2.36)	12.4	2148	16.6
2018	April 29 – May 5	23	9.06	165	18.2	(2.40)	18.2	1578	18.3
2018	May 6 – May 12	7	3.02	54	17.3	(5.07)	17.9	603	21.5
2018	May 13 – May 19	4	1.38	1	0.8	(0.80)	0.7	636	25.1
2018	Totals and Mean CPUE	54	20.9	279	11.6	(2.36)	13.3		
2019	April 7 – April 13	6	1.75	7	4.02	(1.59)	3.99	3126	18.3
2019	April 14 – April 20	9	2.27	9	3.72	(2.29)	3.96	4342	18.7
2019	April 21 – April 27	19	5.18	143	29	(8.66)	27.6	4647	18.1
2019	April 28 – May 4	16	5.17	118	22.3	(4.94)	22.8	2235	20.2
2019	May 5 – May 11	10	3.52	20	6.05	(1.99)	5.69	887	22.2
2019	May 12 – May 18	4	1.34	2	1.53	(0.88)	1.49	620	22.8
2019	Totals and Mean CPUE	64	19.2	299	16.1	(3.2)	15.6		

TABLE 3. Striped Bass age distributions (percent composition) collected by electrofishing in the Neuse River, spring 2018 and 2019.

			Percent Composition		
Sample Year	Year Class	Age	Male	Female	Overall
2018	2016	2	7.1	0.0	7.1
2018	2015	3	32.6	3.3	35.9
2018	2014	4	22.6	3.1	25.6
2018	2013	5	7.8	3.3	11.1
2018	2012	6	5.3	2.2	7.5
2018	2011	7	4.2	1.9	6.1
2018	2010	8	3.6	1.7	5.3
2018	2009	9	0.6	0.6	1.1
Totals			83.7	16.2	100.0
2019	2016	3	42.1	11.6	53.7
2019	2015	4	17.9	8.3	26.2
2019	2014	5	6.9	2.2	9.1
2019	2013	6	4.7	1.1	5.8
2019	2012	7	1.1	0.8	1.9
2019	2011	8	1.9	0.6	2.5
2019	2010	9	0.6	0.3	0.8
Totals			75.2	24.8	100

TABLE 4. Age composition and mean total length (mm) at age of Striped Bass collected from the Neuse River by electrofishing, 2018 and 2019.

Year Class	Age	N Aged	N Total	N Estimated	% Composition	Total Length (mm) Mean	SE	Min	Max
2018 Males									
2016	2	22	26	4	8.5	415	4	381	452
2015	3	77	117	40	38.9	485	2	425	541
2014	4	63	81	18	27.0	568	3	506	665
2013	5	25	28	3	9.2	609	10	469	700
2012	6	17	19	2	6.2	624	7	584	683
2011	7	14	15	1	5.1	697	12	620	756
2010	8	12	13	1	4.4	692	11	645	763
2009	9	2	2	0	0.7	737	25	704	768
Totals		232	301	69	100				
2018 Females									
2015	3	5	12	7	20.7	502	4	480	518
2014	4	7	11	4	19.0	607	17	549	695
2013	5	10	12	2	20.7	640	26	385	742
2012	6	7	8	1	13.8	693	15	641	731
2011	7	6	7	1	12.1	744	21	653	827
2010	8	4	6	2	10.3	764	23	695	802
2009	9	1	2	1	3.4	862	0	858	858
Totals		40	58	18	100				
2019 Males									
2016	3	122	153	31	55.7	489	3	448	774
2015	4	45	65	20	23.6	530	3	466	576
2014	5	16	25	9	9.0	602	5	552	638
2013	6	10	17	7	6.2	627	13	462	676
2012	7	4	4	0	1.6	663	26	618	731
2011	8	7	7	0	2.7	735	16	681	803
2010	9	2	2	0	0.9	708	28	690	733
Totals		206	273	67	100				
2019 Females									
2016	3	37	42	5	46.2	517	3	488	563
2015	4	25	30	5	33.0	561	5	515	610
2014	5	7	8	1	9.0	624	17	550	707
2013	6	4	4	0	4.7	679	21	639	737
2012	7	3	3	0	3.5	674	32	605	707
2011	8	2	2	0	2.5	715	56	667	794
2010	9	1	1	0	1.1	787	0	795	795
Totals		79	90	11	100				

TABLE 5. Mean total length (mm) at age for male Neuse River Striped Bass year-classes collected 1994–2019. 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		
2014			509	568	602			
2015		421	485	530				
2016		415	489					
Mean	237	433	505	557	606	648	683	714
Min		405	441	530	579	624	622	692
Max		481	539	596	632	674	721	735

TABLE 6. Mean total length (mm) at age for female Neuse River Striped Bass year-classes collected 1994–2019. Only those year-classes with four or more individuals aged are included.

	Age						
Year Class	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		
2014			510	607	624			
2015		428	502	561				
2016			517					
Mean		455	525	583	629	689	752	751
Min		425	431	540	588	657	710	736
Max		512	571	611	667	722	857	764

TABLE 7. Summary of Neuse River Striped Bass spawning stock characteristics and mean discharge, 1994–2019. 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	12.6 (1.6)	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
Avg.	18.2	206.5	164.4	41.6	3.9:1		4.6	1.5	38.9		11.6	534	630	855				

TABLE 8. Neuse River Striped Bass stockings 1982–2019.

Year	Spawning Hatchery	Growout Hatchery	Fry	Phase I	Phase II
1982				-	47,648
1983				-	-
1984				-	-
1985				-	-
1986				-	39,769
1987				-	-
1988				-	71,092
1989				-	-
1990				-	61,877
1991				-	-
1992				-	116,820
1993				48,000	-
1994				103,057	79,933
1995	Watha	Watha		99,176	-
1996	Watha			100,000	100,760
1997	Watha			100,000	-
1998	Watha			207,730	83,195
1999	Watha			100,000	-
2000	Watha			121,993	108,000
2001	Watha			103,000	-
2002	Watha	Edenton		-	147,654
2003	Watha			100,000	-
2004[a]	Watha	Edenton		100,000	168,011
2005	Watha			114,000	-
2006	Watha	Edenton		146,340	99,595
2007	Watha	Edenton		172,882	69,953
2008	Watha			313,798	-
2009	Watha	Edenton		100,228	104,061
2010[b]	Watha	Edenton		-	107,142
2011[b]	Watha	Edenton		-	102,089
2012[b,c]	Watha	Edenton		50,180	90,178
2013[b,c]	Watha	Edenton		181,327	113,834
2014[b,c]	Edenton	Edenton		79,864	78,866
2015[b,c]	Edenton	Edenton	799,700	-	109,107
2016[b,c]	Edenton	Edenton	1,173,000	80,910	134,559
2017[b,c]	Edenton	Edenton			14,203
2018[b,c]	Edenton	Edenton	670,464	96,900	86,556
2019[b,c]	Edenton	Edenton	1,755,000	-	85,693

[a] Hatchery staff observed phase II die-off post-stocking; stocking failed.

[b] Broodstock genotypes available.

[c] Neuse River broodstock utilized; Roanoke-source broodstock used 1994-2011.

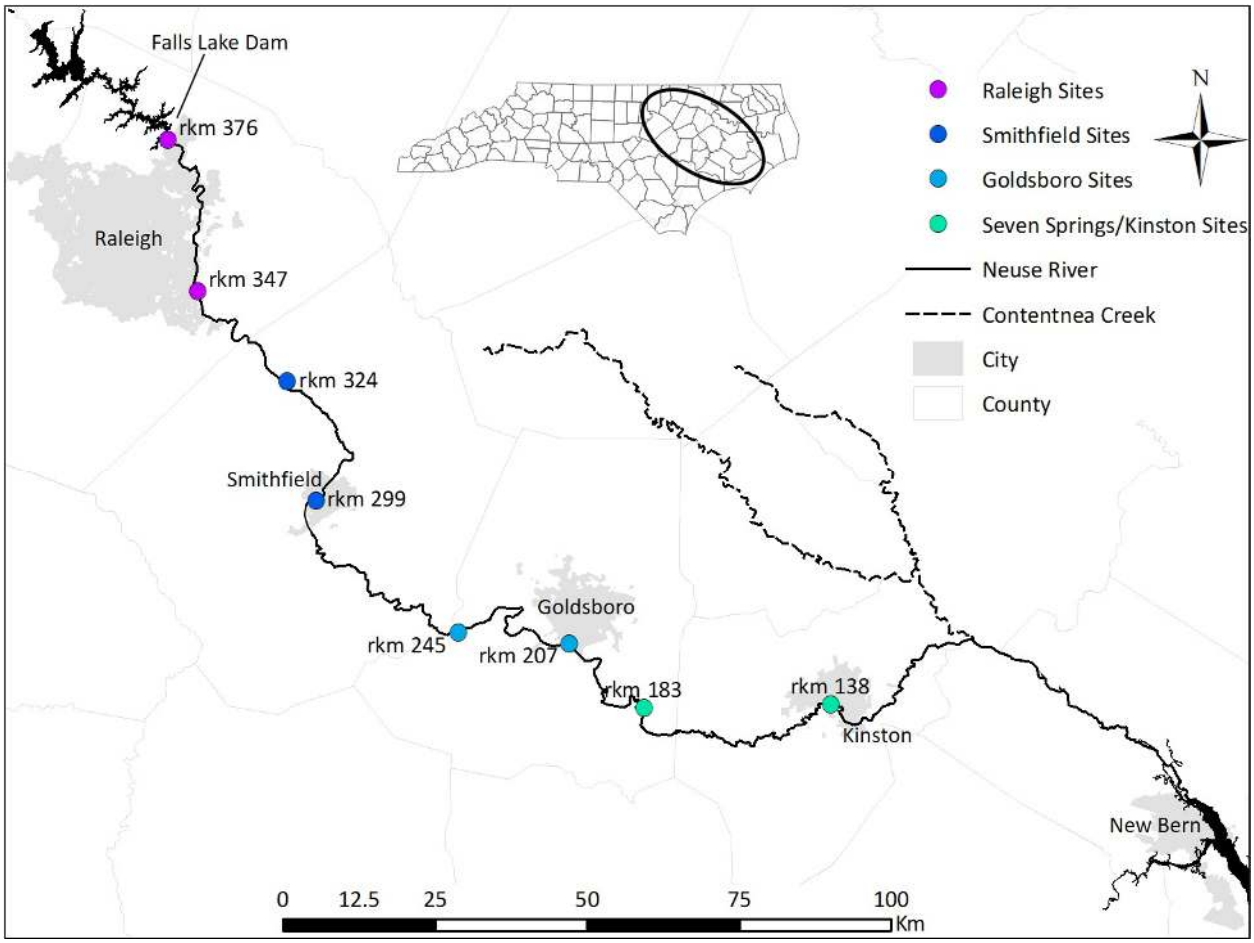
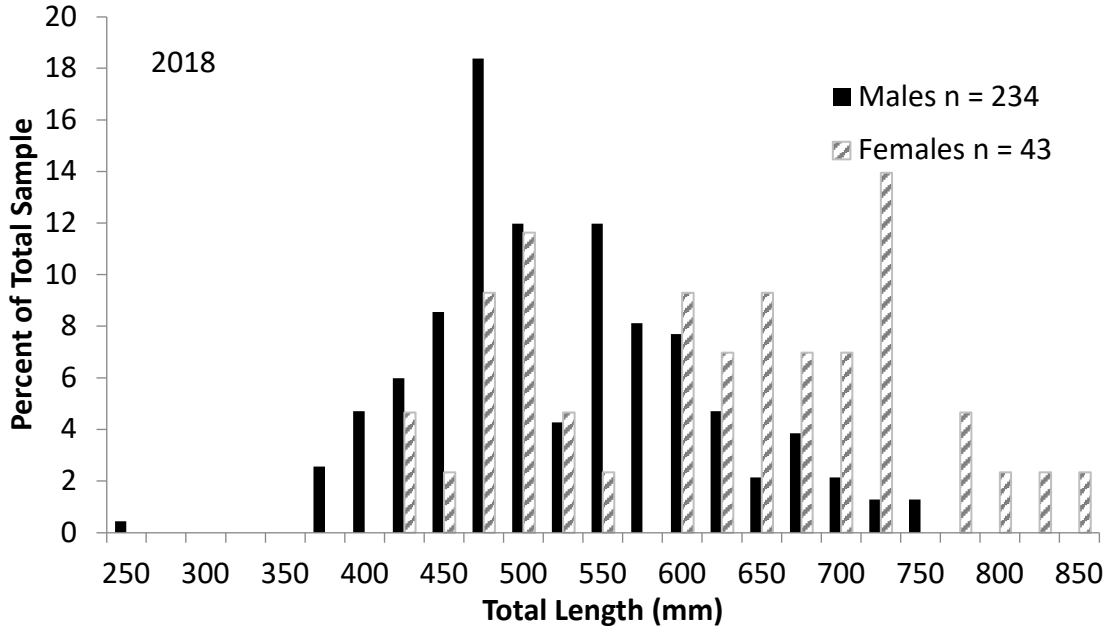


FIGURE 1. Sampling sites on the Neuse River spawning ground survey. Seven Springs and Kinston sites were not sampled in 2018 and 2019 as these sites are only sampled during extreme low water levels.



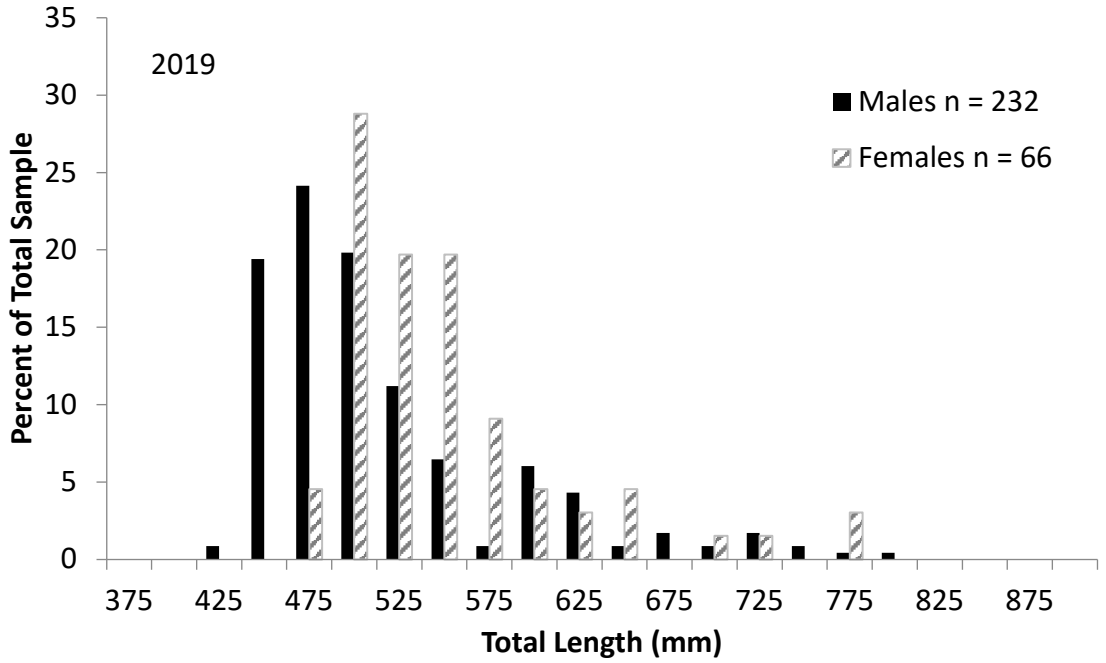


FIGURE 2. Length-frequency distributions for Striped Bass collected from the Neuse River, spring 2018 and 2019. Male and female plots sum separately to 100%. Note scale change on y-axis.

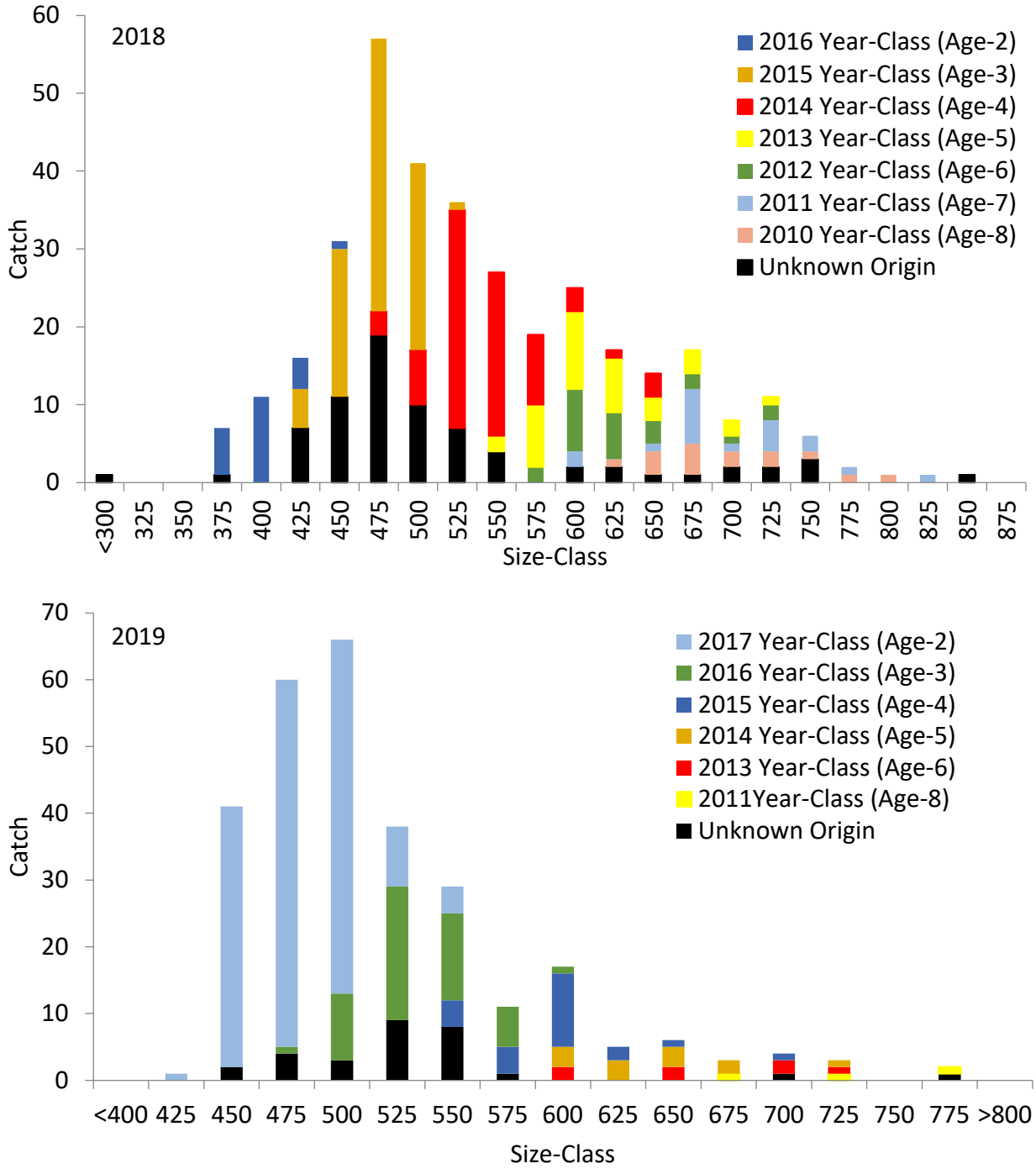


FIGURE 3. Composition of hatchery and unknown origin fish by size-class from genetic samples collected during the spring 2018 and 2019 spawning stock survey and broodfish collections. Note scale change on y-axis.