Biennial Report to Congress on the Progress and Findings of Studies of Atlantic Striped Bass Populations

2021

Cover: Atlantic striped bass being reeled in during 2021 State-Federal Cooperative Winter Tagging Program off of Virginia Beach, VA. Photo credit: Eric Packard, Volunteer Angler.

Introduction

The 1997 reauthorization of the Atlantic Striped Bass Conservation Act 16 U.S.C. 5151 *et seq.* (Striped Bass Act) mandates the Secretaries of the Department of Commerce and the Department of the Interior to submit biennial reports to Congress and to the Atlantic States Marine Fisheries Commission on the progress and findings of studies of migratory and estuarine Atlantic striped bass (*Morone saxatilis*) populations. This document includes catch and landings data available through 2020 with an emphasis on calendar years 2019 to 2020, and the most recent information available on stock status through 2017.

Status of the Stocks

The coastwide Atlantic striped bass population includes four major stock components: the Hudson River, Delaware River/Bay, Chesapeake Bay, and Albemarle Sound-Roanoke River stocks. The Atlantic coastal migratory stock includes primarily Hudson River, Delaware River/Bay, and Chesapeake Bay–origin fish, and is managed at the coastwide level by the Commission. The predominantly resident Albemarle Sound-Roanoke River stock is currently managed by the State of North Carolina with Commission oversight. However, striped bass stocks that occupy coastal rivers from the Tar-Pamlico River in North Carolina south are not discussed herein because those stocks do not undertake extensive Atlantic Ocean migrations and are considered primarily endemic and riverine.

Fenwick Wood holding a nice striped bass caught off Cape Cod in Massachusetts. Photo credit: Anthony Wood, NEFSC

Atlantic Stock (Commission Managed)

The 2018 Benchmark Stock Assessment for Atlantic Striped Bass uses catch and survey data through 2017, and represents the best scientific information available

on the status of the coastal migratory stock for use in fisheries management.[1,2] The assessment was peer-reviewed by an independent panel of scientific experts at the 66th Northeast Regional Stock Assessment Workshop/Stock Assessment Review Committee, and approved by the Commission's Atlantic Striped Bass Management Board for management use in April 2019. Based on the 2018 benchmark assessment, the Atlantic striped bass stock is overfished and overfishing is occurring (see Figures 1 and 2).

Total fishing mortality in 2017 was estimated at 0.31, which is above both the target (0.20) and threshold (0.24) fishing mortality reference points (see Figure 1).[3]

Female spawning stock biomass was estimated at 151 million pounds (68,476 metric tons) in 2017, which is below the spawning stock biomass threshold of 202 million pounds (91,436 metric tons) and below the target of 252 million pounds (114,295 metric tons) (see Figure 2).

Spawning stock biomass has declined since a time-series high in 2003. The decrease in biomass is largely attributed to high fishing mortality coupled with a period of below average recruitment (age-1 fish) from 2006 to 2014 (see Figure 3), and is also reflected in a declining trend of coastwide catch from 2007 to 2020 (see Figure 4).

Definitions
Migratory – Individuals that leave the inshore rivers and estuaries and move into offshore habitats along the Atlantic Coast.
Resident – Individuals that remain in nearshore, river, and estuarine systems year-round and contribute minimally to the coastal migratory stock.
Spawning Stock Biomass (SSB) – The total weight of the fish in a stock that are large enough to spawn; the biomass of all fish beyond the age or size class in which 50 percent of the individuals are mature.
Fishing mortality (F) – The rate of removals from a population by fishing.
Recruitment – The number of 1-year-old fish entering the population.
Overfished – A stock is overfished or depleted if the stock has reached critically low biomass or abundance.
Overfishing – A stock is experiencing overfishing if fishing is negatively affecting the stock through reduced growth and/or recruitment.
Landings – The number or pounds of fish caught and kept by commercial and recreational anglers.
Release Mortality – The number or proportion of fish that die after being caught and released alive.
Total Removals – The total number of fish removed from the population, which includes both landings and release mortality.

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[1] Northeast Fisheries Science Center (NEFSC). 2018. 66th Northeast Regional Stock Assessment Workshop (66th SAW) Assessment Report. US Dept. Commer. Northeast Fish Sci Cent Ref Doc. 19-08; 719 p.

[2] NEFSC. 2018. 66th Northeast Regional Stock Assessment Workshop (66th SAW) Assessment Summary Report. US Dept. Commer. Northeast Fish Sci Cent Ref Doc. 19-01; 45 p.

[3] Overfishing is occurring when fishing mortality exceeds the fishing mortality threshold. The fishing mortality target provides a higher baseline for management purposes to ensure the fishing mortality threshold is not exceeded.
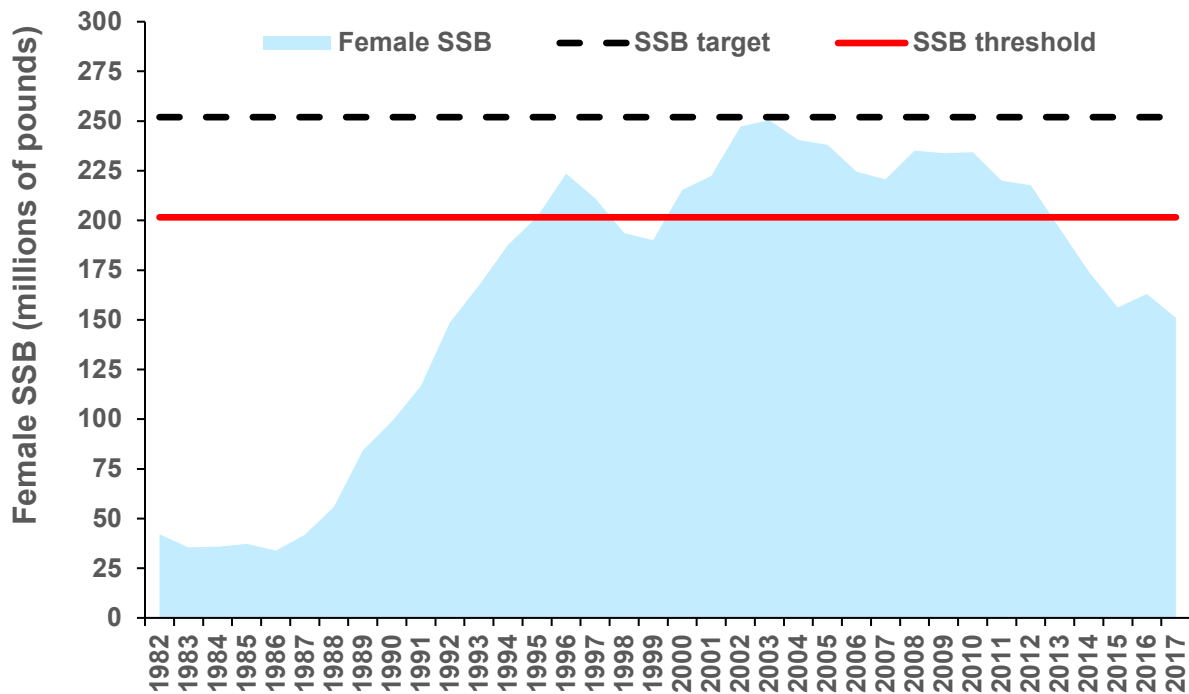
Figure 1. Coastal Migratory Atlantic Striped Bass Stock Fishing Mortality (F) Estimates and Biological Reference Points, 1982 to 2017.
Source: Atlantic Striped Bass Benchmark Stock Assessment, 2018
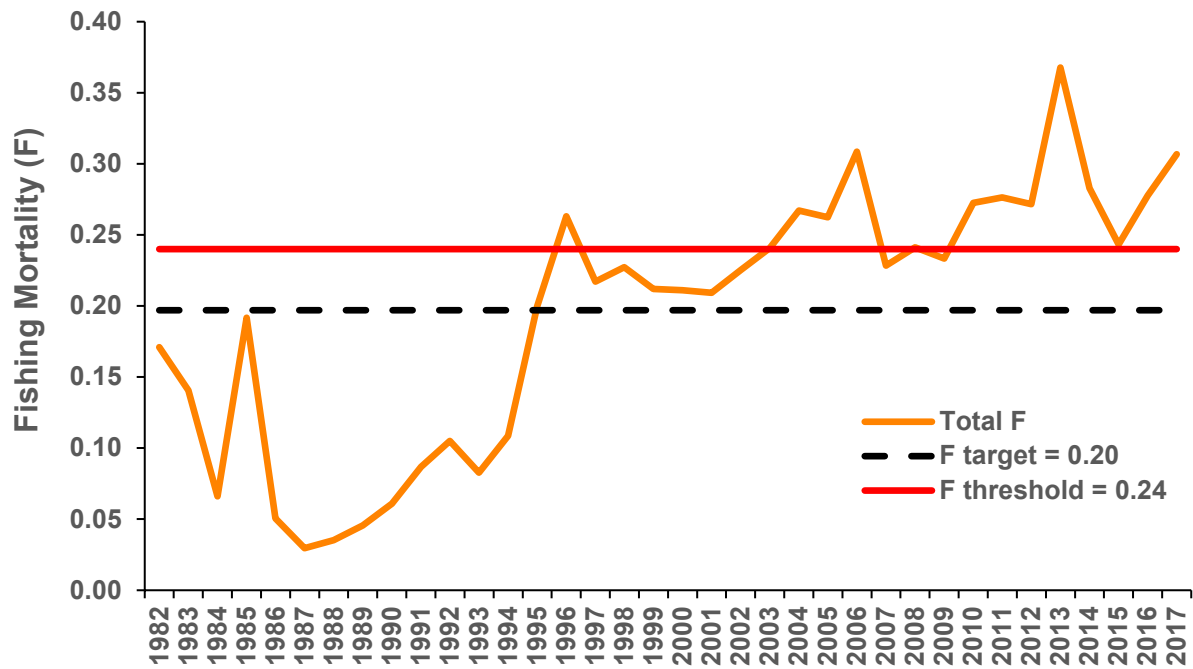

Figure 2. Coastal Migratory Atlantic Striped Bass Female Spawning Stock Biomass (SSB) Estimates and Biological Reference Points, 1982 to 2017.
Source: Atlantic Striped Bass Benchmark Stock Assessment, 2018

Figure 3. Coastal Migratory Atlantic Striped Bass Stock Recruitment (Abundance of Age-1 Fish) and Total Abundance Estimates, 1982 to 2017.
Source: Atlantic Striped Bass Benchmark Stock Assessment, 2018
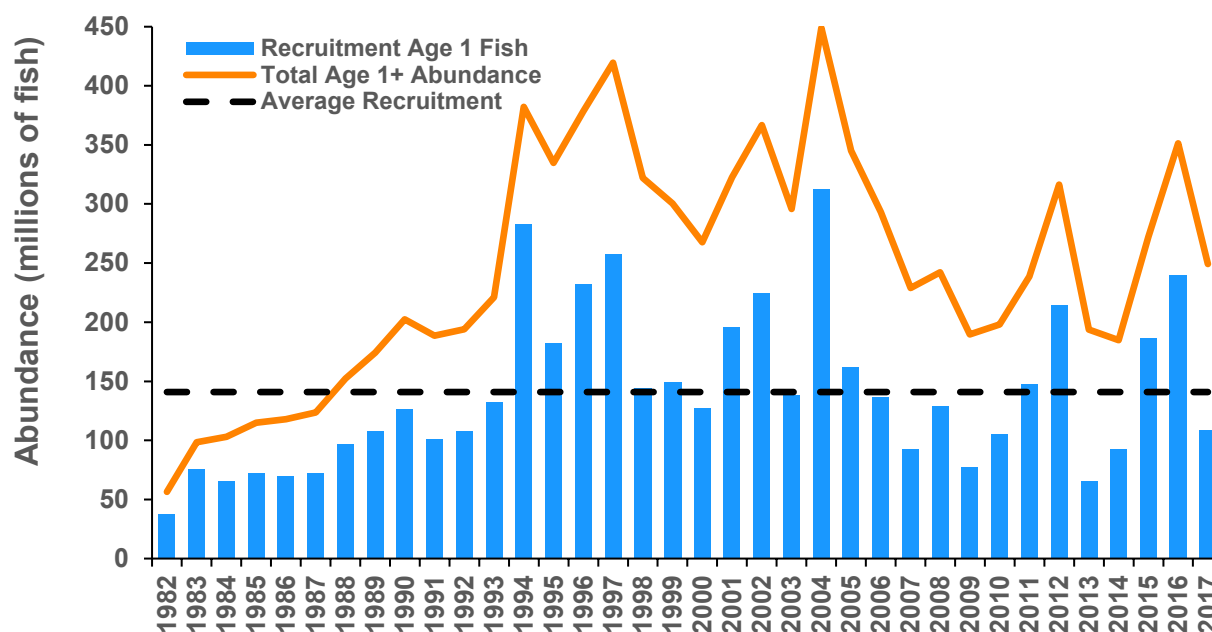
Albemarle Sound and Roanoke River Stock (North Carolina–Managed)

The 2020 North Carolina benchmark stock assessment for the Albemarle Sound-Roanoke River striped bass stock was completed in August 2020.[4] The assessment uses catch and survey data through 2017, and was peer-reviewed by an independent panel of experts and approved by the Management Board for management use in May 2021. Based on the 2020 benchmark assessment, the Albemarle Sound-Roanoke River Atlantic striped bass stock is overfished and overfishing is occurring.

In 2017, fishing mortality for the Albemarle Sound-Roanoke River stock was estimated at 0.27, which is above both the target (0.13) and threshold (0.18) fishing mortality reference points. These fishing mortality reference points are specific to the Albemarle Sound-Roanoke River stock (see Figure 5).
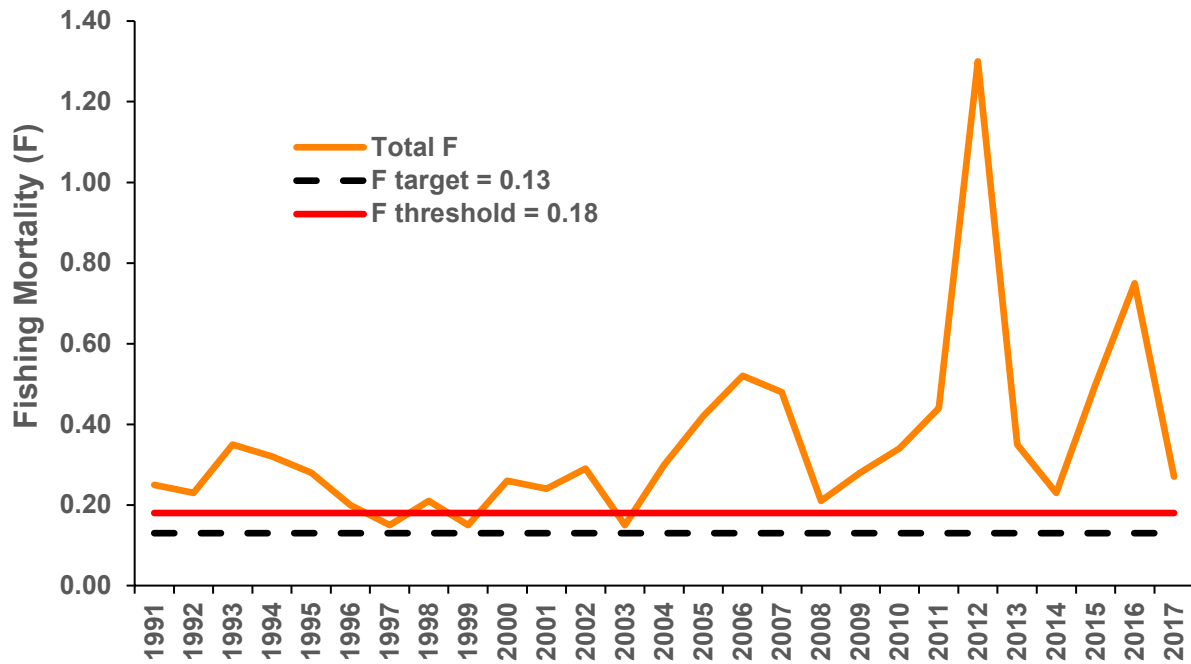
Female spawning stock biomass in 2017 was estimated at 78,576 pounds (36 metric tons), which is below the spawning stock biomass threshold of 267,390 pounds (121 metric tons) and below the target of 350,371 pounds (159 metric tons). These reference points are also specific to the Albemarle Sound-Roanoke River stock (see Figure 6).

The trends in the Albemarle Sound-Roanoke River stock are similar to the coastal migratory stock described above, with a decline in spawning stock biomass since 2004 and only a few strong recruitment (age-1 fish) events since 2001 (see Figure 6).

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[4] Lee, L.M., T.D. Teears, Y. Li, S. Darsee, and C. Godwin (editors). 2020. Assessment of the Albemarle Sound-Roanoke River striped bass (*Morone saxatilis*) in North Carolina, 1991-2017. North Carolina Division of Marine Fisheries, NCDMF SAP-SAR-2020-01, Morehead City, North Carolina. 171 p.
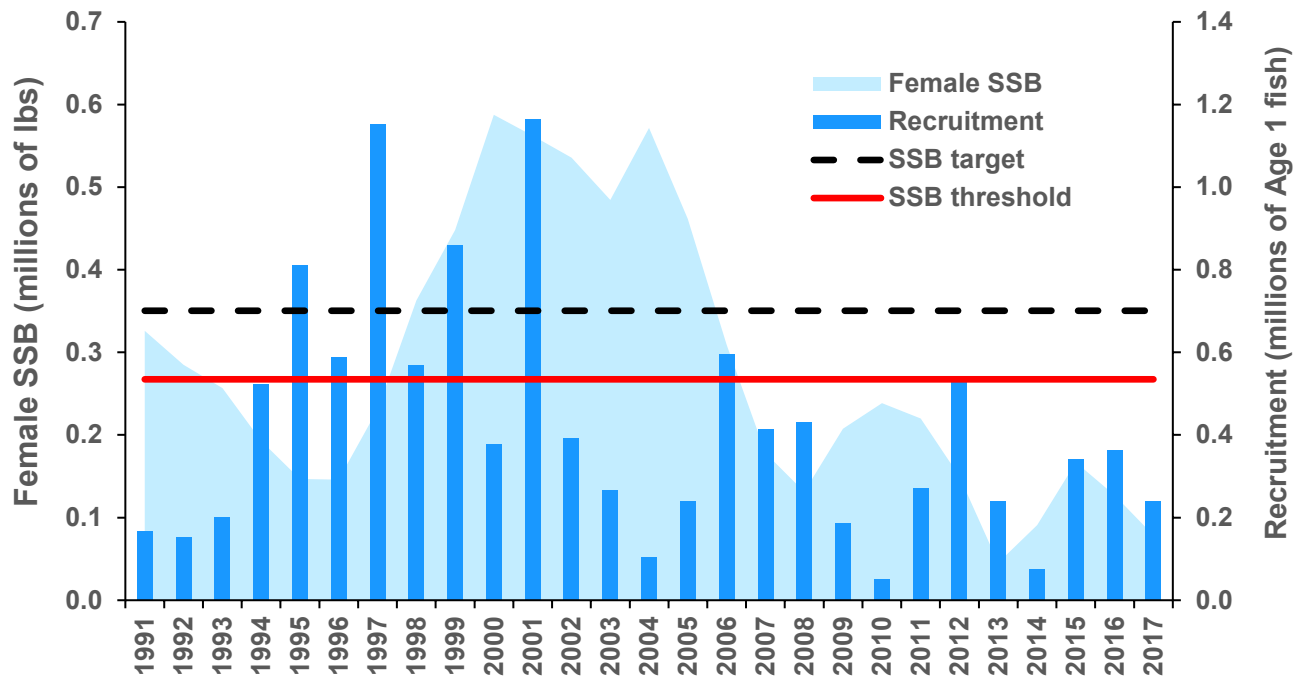
Figure 5. Albemarle Sound-Roanoke River Striped Bass Stock Fishing Mortality (F) Estimates and Biological Reference Points, 1991 to 2017.

Source: Albemarle Sound-Roanoke River Atlantic Striped Bass Benchmark Stock Assessment, 2020[5]

Figure 6. Albemarle Sound-Roanoke River Striped Bass Stock Female Spawning Stock Biomass (SSB), Recruitment (Abundance of Age-1 Fish) Estimates, and Biological Reference Points, 1991 to 2017.

Source: Albemarle Sound-Roanoke River Atlantic Striped Bass Benchmark Stock Assessment, 2020

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[5] The 2020 Albemarle Sound-Roanoke River benchmark stock assessment uses recreational catch data collected from the North Carolina creel survey, which started in 1991.

Status of the Fisheries

Atlantic Stock (Commission Managed)

Total Atlantic striped bass removals (commercial and recreational landings plus discards and release mortality) in 2019 and 2020 are estimated at 5.48 million fish and 5.11 million fish, respectively (see Figure 4).

Total commercial removals (landings plus discards) were 0.74 million fish in 2019 and 0.64 million fish in 2020 (see Figure 4).[6] The commercial landings for 2019 were 4.28 million pounds (1,944 metric tons) and 3.56 million pounds (1,615 metric tons) for 2020.

The commercial landings for 2019 had a landed value of $15.36 million, and a landed value of $10.46 million for 2020.[7] The coastwide striped bass commercial landings by state for 2019 and 2020 are listed in Figure 8.

Total recreational removals (landings plus release mortality) were 4.74 million fish in 2019 and 4.47 million fish in 2020 (see Figure 4). Note: these numbers are derived from the revised Marine Recreational Information Program estimates and should not be directly compared to versions of this report published prior to 2019.

For all recreationally targeted species on the Atlantic Coast, Atlantic striped bass were the largest landings by weight for 2019 at 23.56 million pounds (10,685 metric tons);[8] landings for 2020 were 14.86 million pounds (6,740 metric tons) due in part to the implementation of more restrictive measures through Addendum VI (refer to "Management Changes and Actions" for more information).

Albemarle Sound and Roanoke River Stock (North Carolina Managed)

In 2019, commercial landings in the Albemarle Sound Management Area were estimated at 136,820 pounds (31,371 fish) and the combined recreational landings in the Albemarle Sound and Roanoke River Management Areas were estimated at 89,730 pounds (27,305 fish) (see Figure 7).

In 2020, commercial landings in the Albemarle Sound Management Area were estimated at 124,385 pounds (27,323 fish) and the combined recreational landings in the Albemarle Sound and Roanoke River Management Areas were estimated at 42,776 pounds (12,961 fish) (see Figure 7).[9]

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[6] Commercial discard estimates are derived via a generalized additive model (GAM), and are therefore re-estimated for the entire time series when a new year of data is added.

[7] Based on the NOAA Fisheries One Stop Shop (FOSS) database (queried November 2, 2021). FOSS is an automated program anyone can use to get a quick summary of U.S. commercial fisheries landings.

[8] National Marine Fisheries Service (2021). Fisheries of the United States, 2019. U.S. Department of Commerce, NOAA Current Fishery Statistics No. 2019. Available at: https://www.fisheries.noaa.gov/national/sustainable-fisheries/fisheries-united-states

[9] The recreational creel surveys during spring 2020 were cut short due to COVID-19.

Figure 4. Commercial and Recreational Removals for the Coastal Migratory Atlantic Striped Bass Stock, 1982 to 2020.
Source: commercial discards and recreational release mortality estimates are from the Atlantic States Marine Fisheries Commission; landings data are from 2021 the Commission's state compliance reports and the Marine Recreational Information Program (queried July 8, 2021).
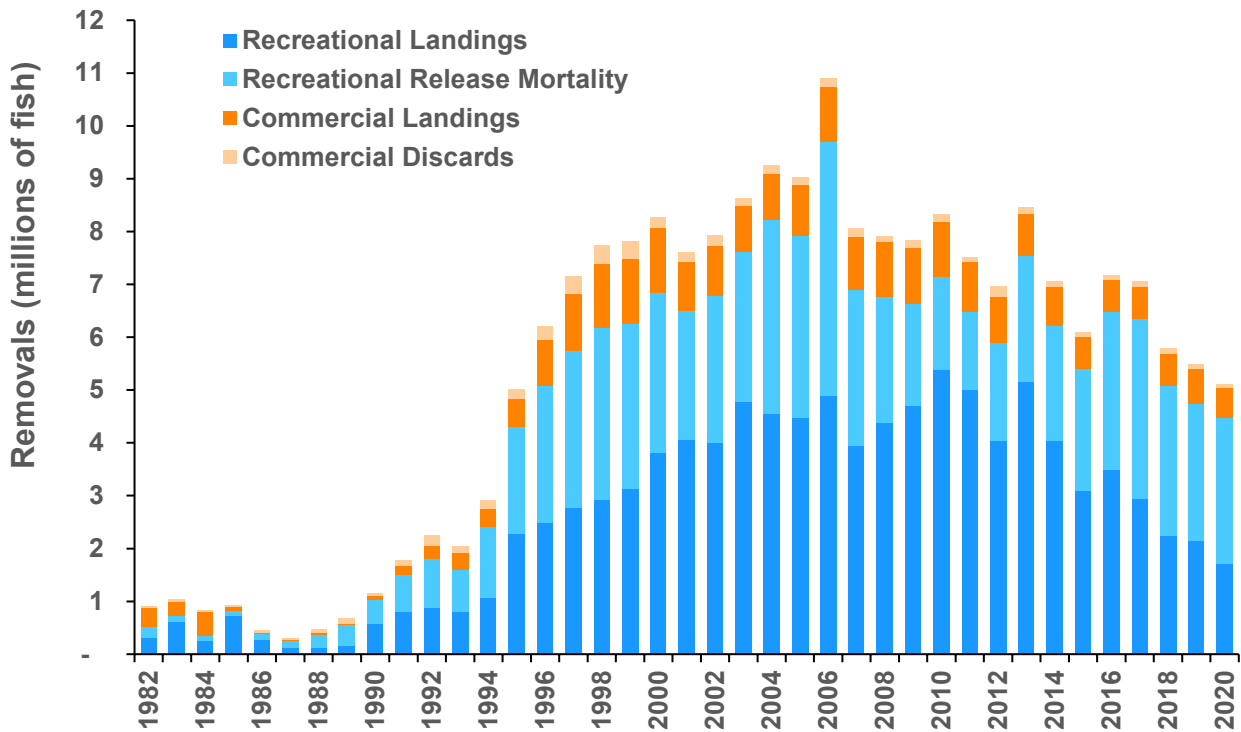
Figure 7. Commercial and Recreational Removals for the Albemarle Sound-Roanoke River Striped Bass Stock, 1991 to 2020.
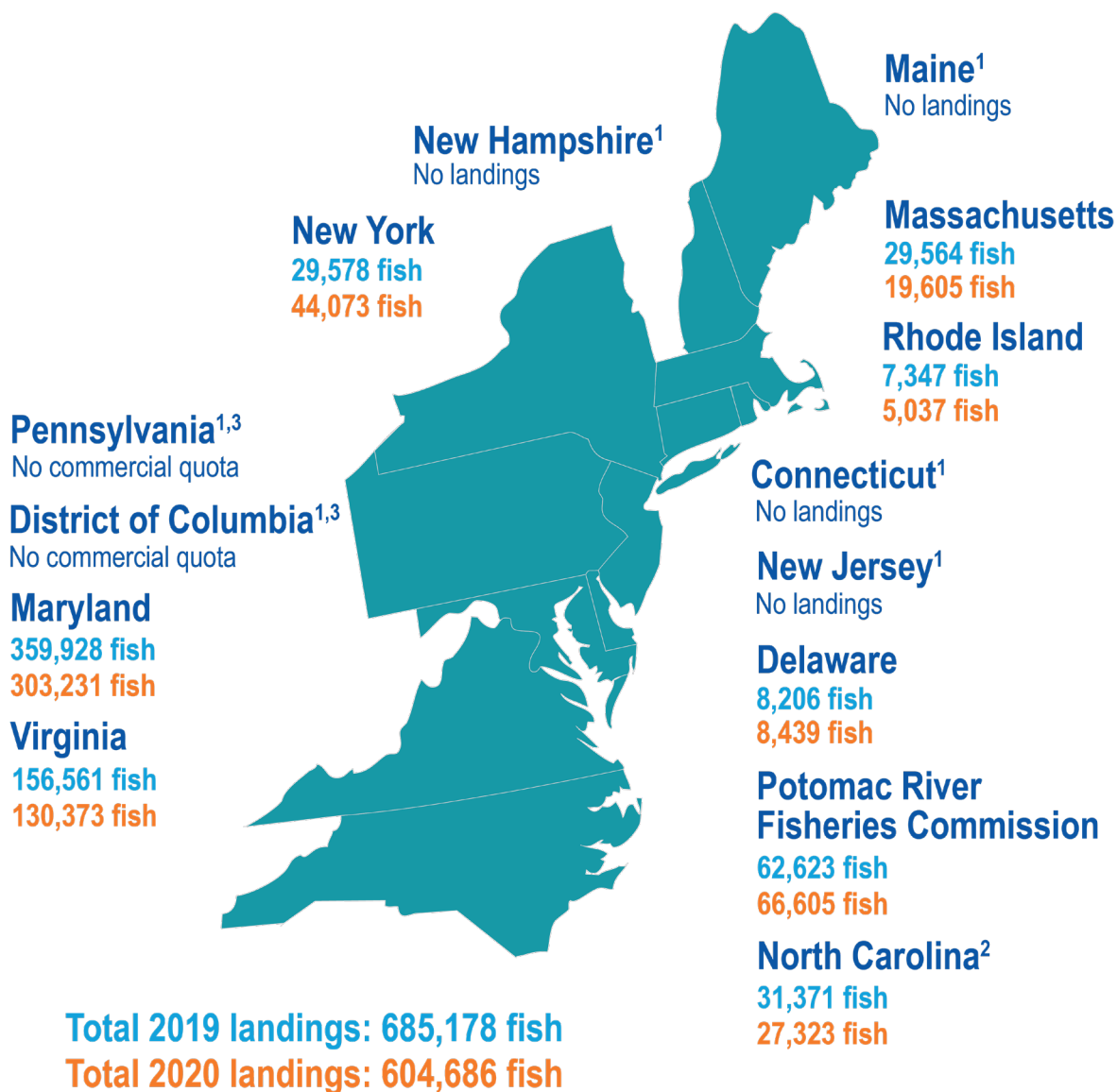Source: Albemarle Sound-Roanoke River Atlantic Striped Bass Benchmark Stock Assessment, 2020.
*The recreational creel surveys during spring 2020 were cut short due to COVID-19.
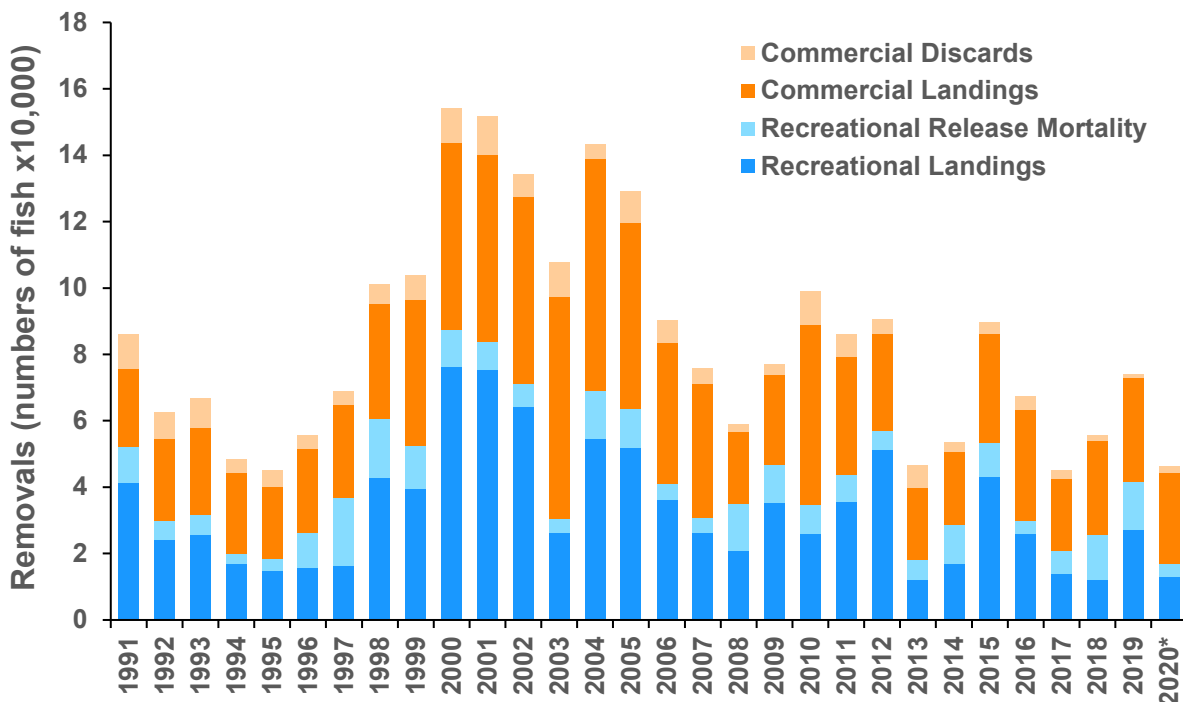
Figure 8. Coast-Wide Striped Bass Commercial Landings – 2019 (numbers in blue) and 2020 (numbers in orange) (Landings do not include discards).
Sources: 2021 State Compliance Reports for Atlantic Striped Bass (Atlantic States Marine Fisheries Commission).

Maine[1]
No landings

New Hampshire[1]
No landings

New York
29,578 fish
44,073 fish

Massachusetts
29,564 fish
19,605 fish

Rhode Island
7,347 fish
5,037 fish

Pennsylvania[1,3]
No commercial quota

District of Columbia[1,3]
No commercial quota

Connecticut[1]
No landings

New Jersey[1]
No landings

Maryland
359,928 fish
303,231 fish

Delaware
8,206 fish
8,439 fish

Virginia
156,561 fish
130,373 fish

Potomac River Fisheries Commission
62,623 fish
66,605 fish

North Carolina[2]
31,371 fish
27,323 fish

Total 2019 landings: 685,178 fish
Total 2020 landings: 604,686 fish

[1] Commercial fishing for striped bass within these jurisdictions is prohibited.
[2] Includes only landings from within Albemarle Sound/Roanoke River.
[3] Pennsylvania and the District of Columbia do not have a striped bass commercial quota.

Status of Monitoring

Implementation of fishery-dependent monitoring programs for striped bass continued for all jurisdictions with commercial fisheries or substantial recreational fisheries. These programs define the catch and effort composition of these fisheries.

All states and jurisdictions with a commercial fishery continued to implement commercial fish market tagging programs to limit illegal landings and sale of striped bass.

The Commission's Interstate Fishery Management Plan requires certain states to monitor the striped bass population independent of the fisheries.

Juvenile abundance indices are required from Maine (Kennebec River), New York (Hudson River), New Jersey (Delaware River), Maryland (Chesapeake Bay tributaries), Virginia (Chesapeake Bay tributaries), and North Carolina (Albemarle Sound).

The Commission's Striped Bass Technical Committee annually reviews the juvenile abundance indices for recruitment failure.

Josh Newhard (USFWS) preparing to release a tagged striped bass during the 2021 State-Federal Cooperative Winter Tagging Program. Photo credit: Eric Packard, volunteer angler.

Additional Resources

Atlantic States Marine Fisheries Commission – Atlantic Striped Bass webpage
www.asmfc.org/species/atlantic-striped-bass

Atlantic States Marine Fisheries Commission – Striped Bass compliance reports
Available at www.asmfc.org or upon request from Commission staff.

FishWatch – Atlantic Striped Bass profile
www.fishwatch.gov/profiles/atlantic-striped-bass

Marine Recreational Information Program (MRIP)
www.st.nmfs.noaa.gov/recreational-fisheries

NOAA Fisheries One Stop Shop (FOSS) – U.S. Commercial Fisheries Landings
https://www.fisheries.noaa.gov/foss/

Spawning stock sampling is mandatory for New York (Hudson River), Pennsylvania (Delaware River), Delaware (Delaware River), Maryland (Upper Chesapeake Bay and Potomac River), Virginia (Rappahannock River and James River), and North Carolina (Roanoke River and Albemarle Sound).

NOAA's National Marine Fisheries Service (NOAA Fisheries), the U.S. Fish and Wildlife Service, Massachusetts, New York, New Jersey, Maryland, Virginia, and North Carolina continued their fishery-independent tag and release programs, which provide data used to determine survivorship and migration patterns.

In 2020, many state and federal fishery monitoring efforts were

suspended, reduced, or modified due to COVID-19 restrictions, including fishery-independent surveys, sampling of commercial catches, and the Access Point Angler Intercept Survey, which is a component of NOAA Fisheries' Marine Recreational Information Program that collects catch information directly from saltwater anglers to inform recreational catch and landings estimates. NOAA Fisheries was able to fill gaps in 2020 recreational catch data with data collected from 2018 and 2019, which introduces some additional uncertainty to 2020 catch estimates. NOAA Fisheries intends to re-evaluate 2020 catch estimates in early 2022 by comparing 2020 estimates based on prior years (i.e., 2018 and 2019) with estimates based on shoulder years (i.e., 2019 and 2021).

Striped bass compliance reports are submitted annually and are reviewed by the Commission's Striped Bass Plan Review Team. Compliance reporting requirements are detailed in Amendment 6 and its Addenda I-VI. No compliance issues have been identified at this time.

A growing concern among anglers, and a factor that may contribute to increased natural mortality of striped bass in Chesapeake Bay, is the presence of mycobacteriosis, a disease caused by a group of bacteria that infects internal organs and causes skin ulcers. Although the contribution of the disease to declining catch or spawning stock biomass are unknown, the 2018 benchmark stock assessment recommended investigating impacts of the disease in future stock assessments.

Stock assessments are typically updated biennially by adding the most recent catch and survey information to the existing time series and running the statistical catch-at-age model. Benchmark stock assessments are conducted roughly every 5 years and explore new data sources and analytical advances to stock dynamics modeling. The next stock assessment update is tentatively scheduled for fall 2022 and a benchmark assessment, including external peer review, may be considered for 2024.

Management Changes and Actions

Atlantic Stock (Commission-Managed)

The 2018 benchmark stock assessment, which used updated recreational catch estimates and improvements to the statistical catch-at-age model, changed our understanding of striped bass stock status and fishery dynamics. The benchmark assessment found the stock to be overfished since 2013 and experiencing overfishing in 13 of the past 15 years. In response to the assessment findings, the Management Board initiated Addendum VI to Amendment 6 to end overfishing and initiate stock rebuilding.

Approved in October 2019, Addendum VI reduced all state commercial quotas by 18 percent, and implemented a 1-fish bag limit and a 28-inch to less than 35-inch recreational slot size limit for ocean fisheries and a 1-fish bag limit and an 18-inch minimum size limit for recreational fisheries in the Chesapeake Bay. Additionally, because catch and release practices contribute significantly to overall fishing mortality, Addendum VI requires recreational anglers to use circle hooks when fishing for striped bass with bait to reduce release mortality in the recreational fisheries. Angler outreach and education are a necessary element to garner support and compliance with this important conservation

measure. States implemented the new commercial quotas and recreational measures in April 2020, while circle hook regulations were implemented in January 2021 to provide time for program development and public scoping processes.

Following implementation of Addendum VI, the Management Board initiated development of Draft Amendment 7 in August 2020 to build upon Addendum VI's actions to end overfishing and initiate stock rebuilding. The Amendment also aims to address some of the longstanding concerns with striped bass fisheries management, including the use of conservation equivalency programs and the impacts of catch and release fishing practices on stock status. Final action on Amendment 7 is anticipated for 2022 with implementation prior to the 2023 fishing season. The Commission is actively discussing how to quickly react to the anticipated 2022 stock assessment update, should additional conservation be needed to achieve the stock rebuilding timeline.

Albemarle Sound and Roanoke River Stock (North Carolina Managed)

Following the results of the 2020 Albemarle Sound-Roanoke River benchmark stock assessment, North Carolina implemented a 2020 Revision to Amendment 1 of the North Carolina Estuarine Striped Bass Fishery Management Plan. The revision lowered the annual total allowable landings (TAL) for the Albemarle Sound and Roanoke River management areas for 2021 and 2022 in order to reduce fishing mortality to the target level. The new TAL is 51,216 pounds, which is a 57 percent reduction from 2017 landings.
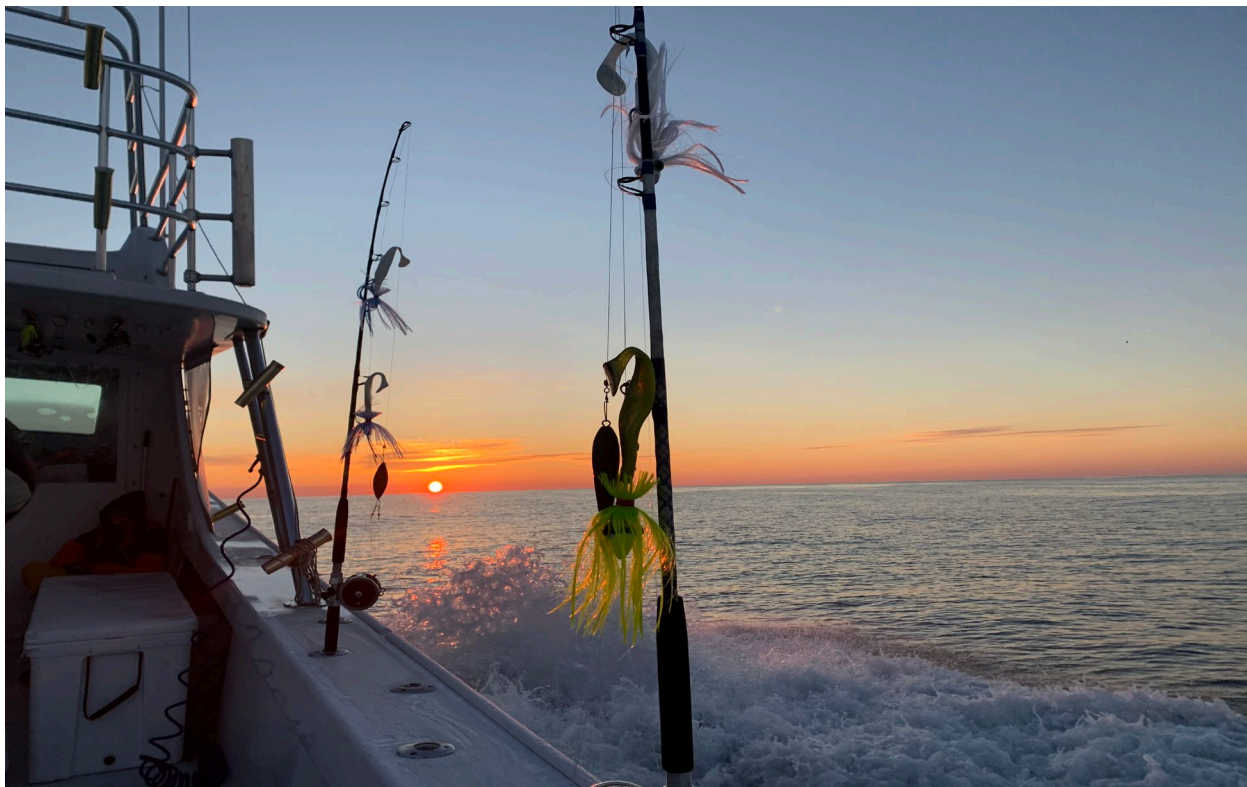
F/V *Midnight Sun* heading out onto the Atlantic Ocean in January for the 2021 State-Federal Cooperative Winter Tagging Program. Photo credit: Eric Packard, volunteer angler.

Status of Research

Literature was surveyed in the 2019–2020 period for relevant new information on Atlantic striped bass and citations for those studies are provided below, categorized by topic. Any papers published in 2018 that were not part of the previous report are included here for completeness.

Environmental Quality, Disease, Contaminants, and Physiology

Anweiler, K.V., K. Brenkert, T.L. Darden, E.J. McElroy and M.R. Denson. 2019. Effects of temperature and hypoxia on the metabolic performance of juvenile striped bass (*Morone saxatilis*). Fishery Bulletin 117(4): 337-347.

Béland, K., G. Séguin and S. Lair. 2020. Emamectin benzoate is a safe and effective anthelmintic against coelomic nematode *Philometra rubra* in striped bass *Morone saxatilis.* Diseases of Aquatic Organisms 142: 47-53.

Benson, C., B. Shea, C. de Silva, D. Donovan, P.E. Holder, S.J. Cooke and A.J. Gallagher. 2019. Physiological consequences of varying shark exposure on a large teleost species. Canadian Journal of Zoology cjz-2019-0173.R1

Breau, H.M. 2020. Toxicity of a brine effluent on early life-stage and juvenile striped bass (*Morone saxatilis*). MS thesis, Dalhousie University, Halifax, Nova Scotia. 89 pp.

Deemer, T.J. 2020. Olfactory chemoreceptory abilities of the larval and juvenile life history stages of striped bass (*Morone saxatilis*). MS thesis, University of Delaware. 24 pp.

Fazio, F., C. Saoca, G. Costa, A. Zumbo, G. Piccione and V. Parrinoc. 2019. Flow cytometry and automatic blood cell analysis in striped bass *Morone saxatilis* (Walbaum, 1792): A new hematological approach. Aquaculture 513.

Fazio, F., G. Lanteri, C. Saoca, C. Iaria, G. Piccione, T. Orefice, E. Calabrese and I. Vazzana. 2019. Individual variability of blood parameters in striped bass *Morone saxatilis*: possible differences related to weight and length. Aquaculture International 28: 1665–1673.

Fazio, F., C. Iaria, C. Saoca, A. Costa, G. Piccione, and N. Spanò. 2019. Effect of dietary vitamin C supplementation on the blood parameters of striped bass *Morone saxatilis* (Walbaum, 1752). Turk. J. Fish. & Aquat. Sci. 20(6), 491-497.

Gauthier, D.T., A.N. Haines, and W.K. Vogelbein. 2021. Elevated temperature inhibits Mycobacterium shottsii infection and Mycobacterium pseudoshottsii disease in striped bass Morone saxatilis. Diseases of Aquatic Organisms 144: 159-174.

Gervasi, C.L., S.K. Lowerre-Barbieri, W.K. Vogelbein, J. Gartland and R. Latour. 2019. The reproductive biology of Chesapeake Bay striped bass with consideration of the effects of mycobacteriosis. Bulletin of Marine Science 95(2): 117-137.

Guillette, T.C., J. McCorde, M. Guillette, M.E. Polera, K.T. Rachels, C. Morgeson, N. Kotlarz, D.R.U. Knappe, B.J. Reading, M. Strynar, and S.M. Belcher. 2020. Elevated levels of per- and polyfluoroalkyl substances in Cape Fear River Striped Bass (*Morone saxatilis*) are associated with biomarkers of altered immune and liver function. Environment International 136: 105358.

Jesse, J.A. 2020. Quantifying drivers of mycobacteriosis in Atlantic striped bass and consequences of increased natural mortality on biological reference points. MS thesis, University of Maryland, College Park. 100 pp.

Kraskura, K. and J.A. Nelson. 2020. Hypoxia tolerance is unrelated to swimming metabolism of wild, juvenile striped bass (*Morone saxatilis*). Journal of Experimental Biology 223.

Lleras, D.A. 2019. Thermal and Low Oxygen Tolerance of a Southern Population of Striped Bass (*Morone saxatilis*). MS thesis, Georgia Southern University. Electronic Theses and Dissertations.

Nelson, J.A., K. Kraskura and G.K. Lipkey. 2019. Repeatability of hypoxia tolerance of individual juvenile striped bass *Morone saxatilis* and effects of social status. Physiological and Biochemical Zoology 92(4): 396–407.

Genetics

Harris, S.C., W.R. Cope, I. Wirgin and E.M. Hallerman. 2020. Population Genetic Assessment of Anadromous and Resident Striped Bass (*Morone saxatilis*) in the Roanoke River System, Eastern United States. Fishes 5: 0024.

Kowalchyk, C.K. 2020. Influence of genetic and environmental adaptation on striped bass (*Morone saxatilis*) egg characteristics. MS thesis, Department of Applied Ecology, North Carolina State University, Raleigh. 59 pp.

LeBlanc, N.M., B.I. Gahagan, S.N. Andrews, T.S. Avery, G.N. Puncher, B.J. Reading, C.F. Buhariwalla, R. A. Curry, A.R. Whiteley and S.A. Pavey. 2020. Genomic population structure of Striped Bass (*Morone saxatilis*) from the Gulf of St. Lawrence to Cape Fear River. Evolutionary Applications 00: 1–19.

Wirgin, I., L. Maceda, M. Tozer, J. Stabile and J. Waldman. 2020. Atlantic coastwide population structure of striped bass *Morone saxatilis* using microsatellite DNA analysis. Fisheries Research 226.

Habitat Use and Distribution

Andrews, S.N. 2019. Restoration potential for reproduction by striped bass (*Morone saxatilis*) in the Saint John River, New Brunswick. PhD dissertation, University of New Brunswick. 217 pp.

Andrews, S.N., M.J. Dadswell, C.F. Buhariwalla, T. Linnansaari, and R.A. Curry. 2019. Looking for Striped Bass in Atlantic Canada: The Reconciliation of Local, Scientific, and Historical Knowledge. Northeastern Naturalist 26(1): 1–30.

Andrews, S. N., C. F. Buhariwalla, B. Fleet-Pardy, M. J. Dadswell, T. Linnansaari and R. A. Curry. 2019. Left out in the cold: the understudied overwintering ecology of striped bass in Canada. Environmental Biology of Fishes 102: 499–518.

Andrews, S.N, T. Linnansaari, R.A. Curry, N. M. Leblanc and S. A. Pave. 2020. Winter ecology of striped bass (*Morone saxatilis*) near its northern limit of distribution in the Saint John River, New Brunswick. Environ Biol Fish.

Andrews, S. N., T. Linnansaari, N. M. Leblanc, S. A. Pavey and R. A. Curry. 2020. Movements of juvenile and sub-adult striped bass *Morone saxatilis* in the Saint John River, New Brunswick, Canada. Endangered Species Research 43: 281–289.

Buchanan, J. R., T.D., Tuckey and M. Fabrizio. 2020. Estimation of juvenile striped bass relative abundance in the Virginia portion of Chesapeake Bay. Annual Progress Report: 2019 - 2020. Virginia Institute of Marine Science, William & Mary.

Gallagher, B.K., M.C. Fabrizio and T.D. Tuckey. 2018. Estimation of juvenile striped bass relative abundance in the Virginia portion of Chesapeake Bay. Annual Progress Report: 2017-2018. Virginia Institute of Marine Science, College of William and Mary.

Gallagher, B.K., M.C. Fabrizio and T.D. Tuckey. 2019. Estimation of juvenile striped bass relative abundance in the Virginia portion of Chesapeake Bay. Annual Progress Report: 2018-2019. Virginia Institute of Marine Science, College of William and Mary.

Itakura, H., M.H.P. O'Brien, and D. Secor. 2021. Tracking oxy-thermal habitat compression encountered by Chesapeake Bay striped bass through acoustic telemetry. ICES Journal of Marine Science.

Muhling, B.A., C.F. Gaitán, C.A. Stock, V.S. Saba, D. Tommasi, and K.W. Dixon. 2019. Potential Salinity and Temperature Futures for the Chesapeake Bay Using a Statistical Downscaling Spatial Disaggregation Framework. Estuaries and Coasts 41: 349–372.

Nack, C.C., D.P. Swaney and K.E. Limburg. 2019. Historical and Projected Changes in Spawning Phenologies of American Shad and Striped Bass in the Hudson River Estuary. Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science 11: 271–284.

Oleynik, H.A. 2020. Changes in a mid-Atlantic estuary: trends and drives of the fish and macroinvertebrate community in Delaware Bay. MS thesis, University of Delaware. 70 pp.

Phillips, O.M. 2020. Recruitment characteristics of juvenile striped bass (*Morone saxatilis*) across recovery periods, year classes, and subestuaries of the Chesapeake Bay. MS thesis, Virginia Institute of Marine Science, Gloucester, Virginia.

Rothermel, E.R. 2019. Seasonal migrations of Atlantic sturgeon and striped bass through the Maryland wind energy area. MS thesis, University of Maryland, College Park. 153 pp.

Rothermel E.R., M.T. Balazik, J.E. Best, M.W. Breece, D.A. Fox, B.I. Gahagan, D.E. Haulsee, A.L. Higgs, M.H. P. O'Brien, M.J. Oliver, I.A. Park and D.H. Secor . 2020. Comparative migration ecology of striped bass and Atlantic sturgeon in the US Southern mid-Atlantic bight flyway. PLoS ONE 15(6): e0234442.

Schloesser, R.W. and M.C. Fabrizio. 2019. Nursery Habitat Quality Assessed by the Condition of Juvenile Fishes: Not All Estuarine Areas Are Equal. Estuaries and Coasts 42, 548–566.

Secor, D.H., M.H.P. O'Brien, B.I. Gahagan, J.C. Watterson and D.A. Fox. 2020. Differential migration in Chesapeake Bay striped bass. PLoS ONE 15(5): e0233103.

Secor, D.H., M.H.P. O'Brien, B.I. Gahagan, D.A. Fox, A.L. Higgs and J.E. Best. 2020. Multiple spawning run contingents and population consequences in migratory striped bass Morone saxatilis. PLoS ONE 15(11): e0242797.

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Appendix

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This document should be cited as follows:
Appelman, M.H., Wood, A., Laney, R.W., Franke, E., Minkkinen, S., and Newhard, J. 2021. Biennial Report to Congress on the Progress and Findings of Studies of Striped Bass Populations – FY 2019 and 2020, 19 p. National Marine Fisheries Service, Silver Spring, MD.