Northeast Fisheries Science Center Reference Document 19-01

66th Northeast Regional Stock Assessment Workshop (66th SAW) Assessment Summary Report

by the Northeast Fisheries Science Center

February 2019

Northeast Fisheries Science Center Reference Document 19-01

66th Northeast Regional Stock Assessment Workshop (66th SAW) Assessment Summary Report

by Northeast Fisheries Science Center

NOAA Fisheries, Northeast Fisheries Science Center,
166 Water Street, Woods Hole, MA 02543

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Northeast Fisheries Science Center
Woods Hole, Massachusetts

February 2019

Northeast Fisheries Science Center Reference Documents

This series is a secondary scientific series designed to assure the long-term documentation and to enable the timely transmission of research results by Center and/or non-Center researchers, where such results bear upon the research mission of the Center (see the outside back cover for the mission statement). These documents receive internal scientific review, and most receive copy editing. The National Marine Fisheries Service does not endorse any proprietary material, process, or product mentioned in these documents.

Editorial Treatment: To distribute this report quickly, it has not undergone the normal technical and copy editing by the Northeast Fisheries Science Center's (NEFSC's) Editorial Office as have most other issues in the NOAA Center Reference Document NMFS-NE series. Other than the four covers and first two preliminary pages, all writing and editing have been performed by – and all credit for such writing and editing rightfully belongs to – those so listed on the title page.

If you do not have Internet access, you may obtain a paper copy of a document by contacting the senior Center author of the desired document. Refer to the title page of the document for the senior Center author's name and mailing address. If there is no Center author, or if there is corporate (*i.e.*, non-individualized) authorship, then contact the Center's Woods Hole Laboratory Library (166 Water St., Woods Hole, MA 02543-1026).

Information Quality Act Compliance: In accordance with section 515 of Public Law 106-554, the Northeast Fisheries Science Center completed both technical and policy reviews for this report. These predissemination reviews are on file at the NEFSC Editorial Office.

This document may be cited as:

> Northeast Fisheries Science Center (NEFSC). 2019. 66th Northeast Regional Stock Assessment Workshop (66th SAW) Assessment Summary Report. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 19-01; 40 p. Available from: http://www.nefsc.noaa.gov/publications/

Table of Contents

SAW-66 ASSESSMENT SUMMARY REPORT

Introduction

The 66th SAW Assessment Summary Report contains summary and detailed technical information on stock assessments reviewed during November 27-30, 2018 at the Stock Assessment Workshop (SAW) by the 66th Stock Assessment Review Committee (SARC-66): Summer flounder and Striped bass. The SARC-66 consisted of three external, independent reviewers appointed by the Center for Independent Experts [CIE], and an external SARC chairman from the MAFMC SSC. The SARC evaluated whether each Term of Reference (listed in the Appendix) was completed successfully based on whether the work provided a scientifically credible basis for developing fishery management advice. The reviewers' reports for SAW/SARC-66 are available on the Northeast Fisheries Science Center SAW website under the heading "SARC 66 Panelist Reports."

An important aspect of any assessment is the determination of current stock status. The status of the stock relates to both the rate of removal of fish from the population – the exploitation rate – and the current stock size. The exploitation rate is the proportion of the stock alive at the beginning of the year that is caught during the year. When that proportion exceeds the amount specified in an overfishing definition, overfishing is occurring. Fishery removal rates are usually expressed in terms of the instantaneous fishing mortality rate, F, and the maximum removal rate is denoted as $F_{THRESHOLD}$.

Another important factor for classifying the status of a resource is the current stock level, for example, spawning stock biomass (SSB) or total stock biomass (TSB). Overfishing definitions, therefore, characteristically include specification of a minimum biomass threshold as well as a maximum fishing threshold. If the biomass of a stock falls below the biomass threshold ($B_{THRESHOLD}$) the stock is in an overfished condition. The Sustainable Fisheries Act mandates that a stock rebuilding plan be developed should this situation arise.

As there are two dimensions to stock status – the rate of removal and the biomass level – it is possible that a stock not currently subject to overfishing in terms of exploitation rates is in an overfished condition; that is, has a biomass level less than the threshold level. This may be due to heavy exploitation in the past, or a result of other factors such as unfavorable environmental conditions. In this case, future recruitment to the stock is very important and the probability of improvement may increase greatly by increasing the stock size. Conversely, fishing down a stock that is at a high biomass level should generally increase the long-term sustainable yield. Stocks under federal jurisdiction are managed on the basis of maximum sustainable yield (MSY). The biomass that produces this yield is called B_{MSY} and the fishing mortality rate that produces MSY is called F_{MSY}.

Given this, federally managed stocks under review are classified with respect to current overfishing definitions. A stock is overfished if its current biomass is below $B_{THRESHOLD}$ and overfishing is occurring if current F is greater than $F_{THRESHOLD}$. The table below depicts status criteria.

		BIOMASS		
		$B < B_{THRESHOLD}$	$B_{THRESHOLD} < B < B_{MSY}$	$B > B_{MSY}$
EXPLOITATION RATE	$F > F_{THRESHOLD}$	Overfished, overfishing is occurring; reduce F, adopt and follow rebuilding plan	Not overfished, overfishing is occurring; reduce F, rebuild stock	$F = F_{TARGET} <= F_{MSY}$
	$F < F_{THRESHOLD}$	Overfished, overfishing is not occurring; adopt and follow rebuilding plan	Not overfished, overfishing is not occurring; rebuild stock	$F = F_{TARGET} <= F_{MSY}$

Fisheries management may take into account scientific and management uncertainty, and overfishing guidelines often include a control rule in the overfishing definition. Generically, the control rules suggest actions at various levels of stock biomass and incorporate an assessment of risk, in that F targets are set so as to avoid exceeding F thresholds.

Outcome of Stock Assessment Review Meeting

Text in this section is based on SARC-66 Review Panel reports (available on the Northeast Fisheries Science Center SAW website under the heading “SARC-66 Panelist Reports”).

SARC-66 concluded that the summer flounder stock is neither overfished nor did it experience overfishing in 2017. The Panel concluded that the SAW WG had reasonably and satisfactorily completed its tasks. Estimates of recreational catch came from newly calibrated MRIP time-series that reflected a revision of both the intercept and effort surveys. The Bigelow indices take account of trawl efficiency estimates at length from ‘sweep-study’ experiments. No factor was identified as strongly influencing the spatial shift in spawner biomass or the level of recruitment. The assessment shows that current mortality from all sources is greater than recent recruitment inputs to the stock, which has resulted in a declining stock trend.

SARC-66 concluded that the striped bass stock is overfished and experienced overfishing in 2017. The SARC Panel accepted the single stock, non-migration SCA model for management, and concluded that all ToRs were met for that model In addition, the Panel reviewed a new two stock model developed by the SAW WG. This model represents an innovative advance and the SARC panel recommends continued development and refinement for possible use in the future.

Glossary

ADAPT. A commonly used form of computer program used to optimally fit a Virtual Population Assessment (VPA) to abundance data.

ASAP. The Age Structured Assessment Program is an age-structured model that uses forward computations assuming separability of fishing mortality into year and age components to estimate population sizes given observed catches, catch-at-age, and indices of abundance. Discards can be treated explicitly. The separability assumption is relaxed by allowing for fleet-specific computations and by allowing the selectivity at age to change smoothly over time or in blocks of years. The software can also allow the catchability associated with each abundance index to vary smoothly with time. The problem's dimensions (number of ages, years, fleets and abundance indices) are defined at input and limited by hardware only. The input is arranged assuming data is available for most years, but missing years are allowed. The model currently does not allow use of length data nor indices of survival rates. Diagnostics include index fits, residuals in catch and catch-at-age, and effective sample size calculations. Weights are input for different components of the objective function and allow for relatively simple age-structured production model type models up to fully parameterized models.

ASPM. Age-structured production models, also known as statistical catch-at-age (SCAA) models, are a technique of stock assessment that integrate fishery catch and fishery-independent sampling information. The procedures are flexible, allowing for uncertainty in the absolute magnitudes of catches as part of the estimation. Unlike virtual population analysis (VPA) that tracks the cumulative catches of various year classes as they age, ASPM is a forward projection simulation of the exploited population. ASPM is similar to the NOAA Fishery Toolbox applications ASAP (Age Structured Assessment Program) and SS2 (Stock Synthesis 2).

Availability. Refers to the distribution of fish of different ages or sizes relative to that taken in the fishery.

Biological reference points. Specific values for the variables that describe the state of a fishery system which are used to evaluate its status. Reference points are most often specified in terms of fishing mortality rate and/or spawning stock biomass. The reference points may indicate 1) a desired state of the fishery, such as a fishing mortality rate that will achieve a high level of sustainable yield, or 2) a state of the fishery that should be avoided, such as a high fishing mortality rate which risks a stock collapse and long-term loss of potential yield. The former type of reference points are referred to as "target reference points" and the latter are referred to as "limit reference points" or "thresholds." Some common examples of reference points are $F_{0.1}$, F_{MAX}, and F_{MSY}, which are defined later in this glossary.

B_0. Virgin stock biomass, i.e., the long-term average biomass value expected in the absence of fishing mortality.

B_{MSY}. Long-term average biomass that would be achieved if fishing at a constant fishing mortality rate equal to F_{MSY}.

Biomass Dynamics Model. A simple stock assessment model that tracks changes in stock using assumptions about growth and can be tuned to abundance data such as commercial catch rates, research survey trends or biomass estimates.

Catchability. Proportion of the stock removed by one unit of effective fishing effort (typically age-specific due to differences in selectivity and availability by age).

Control Rule. Describes a plan for pre-agreed management actions as a function of variables related to the status of the stock. For example, a control rule can specify how F or yield should vary with biomass. In the National Standard Guidelines (NSG), the "MSY control rule" is used to determine the limit fishing mortality, or Maximum Fishing Mortality Threshold (MFMT). Control rules are also known as "decision rules" or "harvest control laws."

Catch per Unit of Effort (CPUE). Measures the relative success of fishing operations, but also can be used as a proxy for relative abundance based on the assumption that CPUE is linearly related to stock size. The use of CPUE that has not been properly standardized for temporal-spatial changes in catchability should be avoided.

Exploitation pattern. The fishing mortality on each age (or group of adjacent ages) of a stock relative to the highest mortality on any age. The exploitation pattern is expressed as a series of values ranging from 0.0 to 1.0. The pattern is referred to as "flat-topped" when the values for all the oldest ages are about 1.0, and "dome-shaped" when the values for some intermediate ages are about 1.0 and those for the oldest ages are significantly lower. This pattern often varies by type of fishing gear, area, and seasonal distribution of fishing, and the growth and migration of the fish. The pattern can be changed by modifications to fishing gear, for example, increasing mesh or hook size, or by changing the proportion of harvest by gear type.

Mortality rates. Populations of animals decline exponentially. This means that the number of animals that die in an "instant" is at all times proportional to the number present. The decline is defined by survival curves such as: $N_{t+1} = N_t e^{-z}$

where N_t is the number of animals in the population at time t and N_{t+1} is the number present in the next time period; Z is the total instantaneous mortality rate which can be separated into deaths due to fishing (fishing mortality or F) and deaths due to all other causes (natural mortality or M) and e is the base of the natural logarithm (2.71828). To better understand the concept of an instantaneous mortality rate, consider the following example. Suppose the instantaneous total mortality rate is 2 (i.e., Z = 2) and we want to know how many animals out of an initial population of 1 million fish will be alive at the end of one year. If the year is apportioned into 365 days (that is, the 'instant' of time is one day), then 2/365 or 0.548% of the population will die each day. On the first day of the year, 5,480 fish will die (1,000,000 x 0.00548), leaving 994,520 alive. On day 2, another 5,450 fish die (994,520 x 0.00548) leaving 989,070 alive. At the end of the year, 134,593 fish $[1,000,000 \times (1 - 0.00548)^{365}]$ remain alive. If we had instead selected a smaller 'instant' of time, say an hour, 0.0228% of the population would have died by the end of the first time interval (an hour), leaving 135,304 fish alive at the end of the year $[1,000,000 \times (1 - 0.00228)^{8760}]$. As the instant of time becomes shorter and shorter, the exact answer to the number of animals surviving is given by the survival curve mentioned above, or, in this example:

$N_{t+1} = 1,000,000e^{-2} = 135,335$ fish

Exploitation rate. The proportion of a population alive at the beginning of the year that is caught during the year. That is, if 1 million fish were alive on January 1 and 200,000 were caught during the year, the exploitation rate is 0.20 (200,000 / 1,000,000) or 20%.

FMAX. The rate of fishing mortality that produces the maximum level of yield per recruit. This is the point beyond which growth overfishing begins.

$F_{0.1}$. The fishing mortality rate where the increase in yield per recruit for an increase in a unit of effort is only 10% of the yield per recruit produced by the first unit of effort on the unexploited stock (i.e., the slope of the yield-per-recruit curve for the $F_{0.1}$ rate is only one-tenth the slope of the curve at its origin).

$F_{10\%}$. The fishing mortality rate which reduces the spawning stock biomass per recruit (SSB/R) to 10% of the amount present in the absence of fishing. More generally, Fx%, is the fishing mortality rate that reduces the SSB/R to x% of the level that would exist in the absence of fishing.

F_{MSY}. The fishing mortality rate that produces the maximum sustainable yield.

Fishery Management Plan (FMP). Plan containing conservation and management measures for fishery resources, and other provisions required by the MSFCMA, developed by Fishery Management Councils or the Secretary of Commerce.

Generation Time. In the context of the National Standard Guidelines, generation time is a measure of the time required for a female to produce a reproductively-active female offspring for use in setting maximum allowable rebuilding time periods.

Growth overfishing. The situation existing when the rate of fishing mortality is above F_{MAX} and when fish are harvested before they reach their growth potential.

Limit Reference Points. Benchmarks used to indicate when harvests should be constrained substantially so that the stock remains within safe biological limits. The probability of exceeding limits should be low. In the National Standard Guidelines, limits are referred to as thresholds. In much of the international literature (e.g., FAO documents), "thresholds" are used as buffer points that signal when a limit is being approached.

Landings per Unit of Effort (LPUE). Analogous to CPUE and measures the relative success of fishing operations, but is also sometimes used a proxy for relative abundance based on the assumption that CPUE is linearly related to stock size.

MSFCMA. Magnuson-Stevens Fishery Conservation and Management Act. U.S. Public Law 94-265, as amended through October 11, 1996. Available as NOAA Technical Memorandum NMFS-F/SPO-23, 1996.

Maximum Fishing Mortality Threshold (MFMT, $F_{THRESHOLD}$). One of the Status Determination Criteria (SDC) for determining if overfishing is occurring. It will usually be equivalent to the F corresponding to the MSY Control Rule. If current fishing mortality rates are above $F_{THRESHOLD,}$ overfishing is occurring.

Minimum Stock Size Threshold (MSST, $B_{THRESHOLD}$). Another of the Status Determination Criteria. The greater of (a) ½B_{MSY}, or (b) the minimum stock size at which rebuilding to B_{MSY} will occur within 10 years of fishing at the MFMT. MSST should be measured in terms of spawning biomass or other appropriate measures of productive capacity. If current stock size is below $B_{THRESHOLD}$, the stock is overfished.

Maximum Spawning Potential (MSP). This type of reference point is used in some fishery management plans to define overfishing. The MSP is the spawning stock biomass per recruit (SSB/R) when fishing mortality is zero. The degree to which fishing reduces the SSB/R is expressed as a percentage of the MSP (i.e., %MSP). A stock is considered overfished when the fishery reduces the %MSP below the level specified in the overfishing definition. The values of %MSP used to define overfishing can be derived from stock-recruitment data or chosen by analogy using available information on the level required to sustain the stock.

Maximum Sustainable Yield (MSY). The largest average catch that can be taken from a stock under existing environmental conditions.

Overfishing. According to the National Standard Guidelines, "overfishing occurs whenever a stock or stock complex is subjected to a rate or level of fishing mortality that jeopardizes the capacity of a stock or stock complex to produce MSY on a continuing basis." Overfishing is occurring if the MFMT is exceeded for 1 year or more.

Optimum Yield (OY). The amount of fish that will provide the greatest overall benefit to the Nation, particularly with respect to food production and recreational opportunities and taking into account the protection of marine ecosystems. MSY constitutes a "ceiling" for OY. OY may be lower than MSY, depending on relevant economic, social, or ecological factors. In the case of an overfished fishery, OY should provide for rebuilding to B_{MSY}.

Partial Recruitment. Patterns of relative vulnerability of fish of different sizes or ages due to the combined effects of selectivity and availability.

Rebuilding Plan. A plan that must be designed to recover stocks to the B_{MSY} level within 10 years when they are overfished (i.e. when B < MSST). Normally, the 10 years would refer to an expected time to rebuild in a probabilistic sense.

Recruitment. This is the number of young fish that survive (from birth) to a specific age or grow to a specific size. The specific age or size at which recruitment is measured may correspond to when the young fish become vulnerable to capture in a fishery or when the number of fish in a cohort can be reliably estimated by a stock assessment.

Recruitment overfishing. The situation existing when the fishing mortality rate is so high as to cause a reduction in spawning stock which causes recruitment to become impaired.

Recruitment per spawning stock biomass (R/SSB). The number of fishery recruits (usually age 1 or 2) produced from a given weight of spawners, usually expressed as numbers of recruits per kilogram of mature fish in the stock. This ratio can be computed for each year class and is often used as an index of pre-recruit survival, since a high R/SSB ratio in one year indicates above-average numbers resulting from a given spawning biomass for a particular year class, and vice versa.

Reference Points. Values of parameters (e.g. B_{MSY}, F_{MSY}, $F_{0.1}$) that are useful benchmarks for guiding management decisions. Biological reference points are typically limits that should not be exceeded with significant probability (e.g., MSST) or targets for management (e.g., OY).

Risk. The probability of an event times the cost associated with the event (loss function). Sometimes "risk" is simply used to denote the probability of an undesirable result (e.g. the risk of biomass falling below MSST).

Status Determination Criteria (SDC). Objective and measurable criteria used to determine if a stock is being overfished or is in an overfished state according to the National Standard Guidelines.

Selectivity. Measures the relative vulnerability of different age (size) classes to the fishing gears(s).

Spawning Stock Biomass (SSB). The total weight of all sexually mature fish in a stock.

Spawning stock biomass per recruit (SSB/R or SBR). The expected lifetime contribution to the spawning stock biomass for each recruit. SSB/R is calculated assuming that F is constant over the life span of a year class. The calculated value is also dependent on the exploitation pattern and rates of growth and natural mortality, all of which are also assumed to be constant.

Stock Synthesis (SS). This application provides a statistical framework for calibration of a population dynamics model using a diversity of fishery and survey data. SS is designed to accommodate both age and size structure and with multiple stock sub-areas. Selectivity can be cast as age specific only, size-specific in the observations only, or size-specific with the ability to capture the major effect of size-specific survivorship. The overall model contains subcomponents which simulate the population dynamics of the stock and fisheries, derive the expected values for the various observed data, and quantify the magnitude of difference between observed and expected data. Parameters are sought which will maximize the goodness-of-fit. A management layer is also included in the model allowing uncertainty in estimated parameters to be propagated to the management quantities, thus facilitating a description of the risk of various possible management scenarios. The structure of SS allows for building of simple to complex models depending upon the data available.

Survival Ratios. Ratios of recruits to spawners (or spawning biomass) in a stock-recruitment analysis. The same as the recruitment per spawning stock biomass (R/SSB).

TAC. Total allowable catch is the total regulated catch from a stock in a given time period, usually a year.

Target Reference Points. Benchmarks used to guide management objectives for achieving a desirable outcome (e.g., OY). Target reference points should not be exceeded on average.

Uncertainty. Uncertainty results from a lack of perfect knowledge of many factors that affect stock assessments, estimation of reference points, and management. Rosenberg and Restrepo (1994) identify five types: measurement error (in observed quantities), process error (or natural population variability), model error (mis-specification of assumed values or model structure), estimation error (in population parameters or reference points, due to any of the preceding types of errors), and implementation error (or the inability to achieve targets exactly for whatever reason)

Virtual Population Analysis (VPA) (or cohort analysis). A retrospective analysis of the catches from a given year class which provides estimates of fishing mortality and stock size at each age over its life in the fishery. This technique is used extensively in fishery assessments.

Year class (or cohort). Fish born in a given year. For example, the 1987 year class of cod includes all cod born in 1987. This year class would be age 1 in 1988, age 2 in 1989, and so on.

Yield per recruit (Y/R or YPR). The average expected yield in weight from a single recruit. Y/R is calculated assuming that F is constant over the life span of a year class. The calculated value is also dependent on the exploitation pattern, rate of growth, and natural mortality rate, all of which are assumed to be constant.

Figures

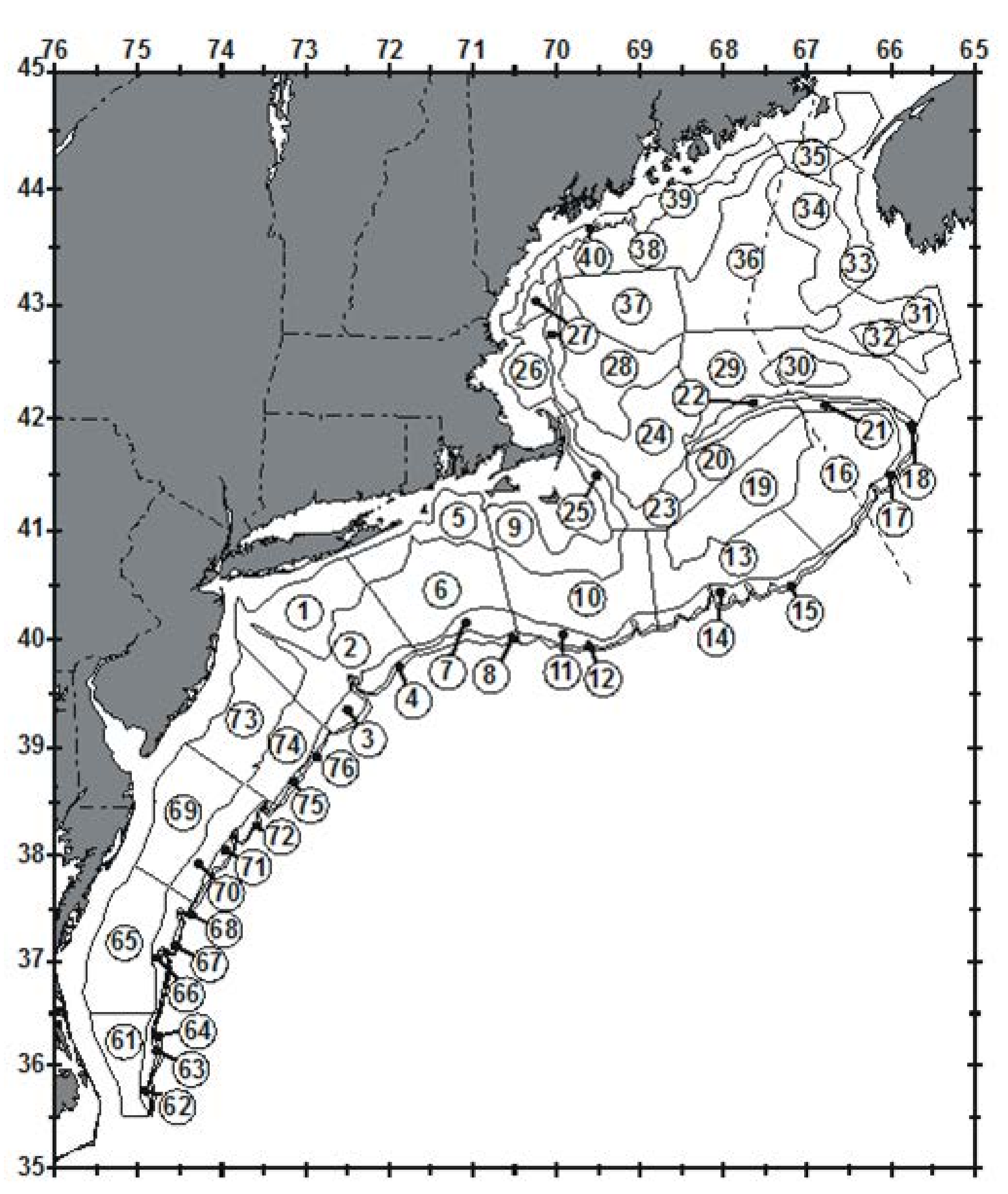


Figure 1. Offshore depth strata sampled during Northeast Fisheries Science Center bottom trawl research surveys. Some of these may not be sampled presently.

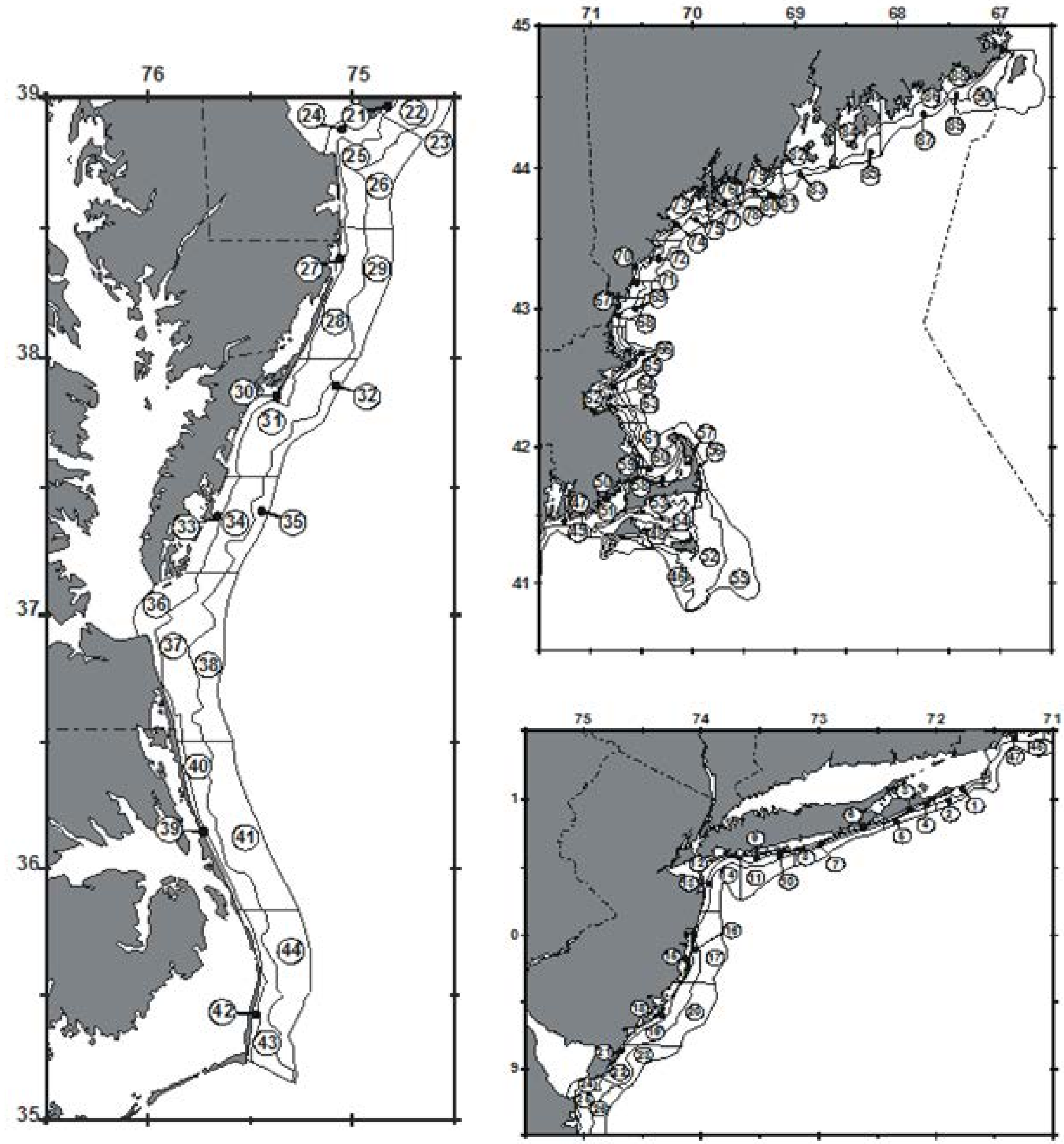
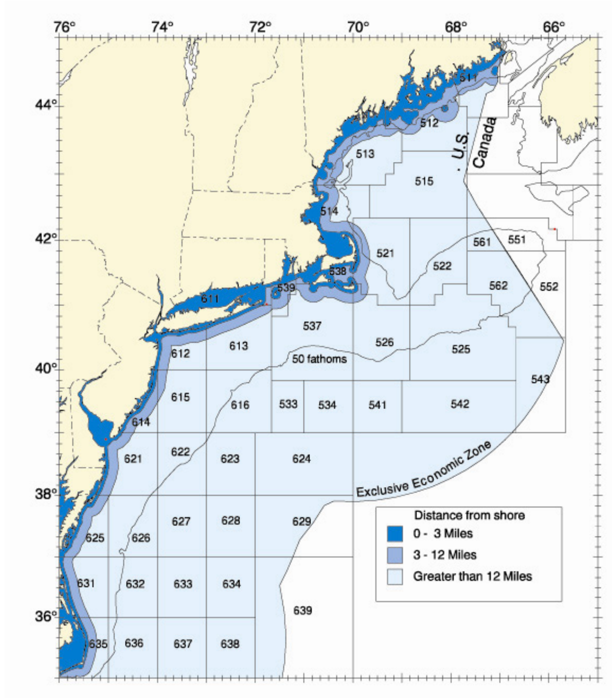


Figure 2. Inshore depth strata sampled during Northeast Fisheries Science Center bottom trawl research surveys. Some of these may not be sampled presently.



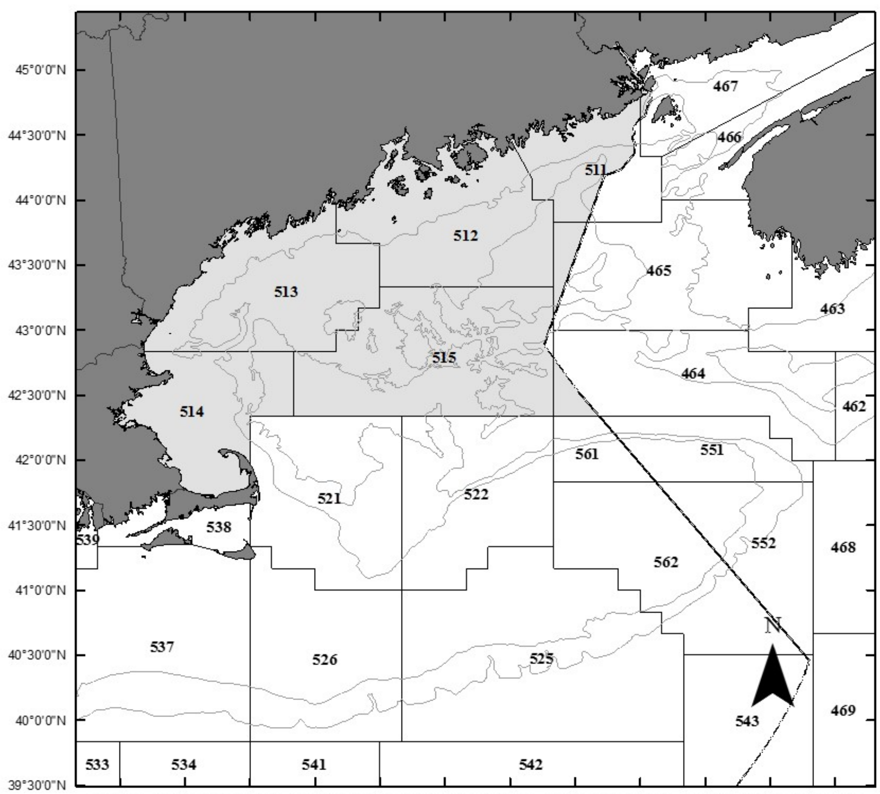


Figure 3. Statistical areas used for reporting commercial catches.

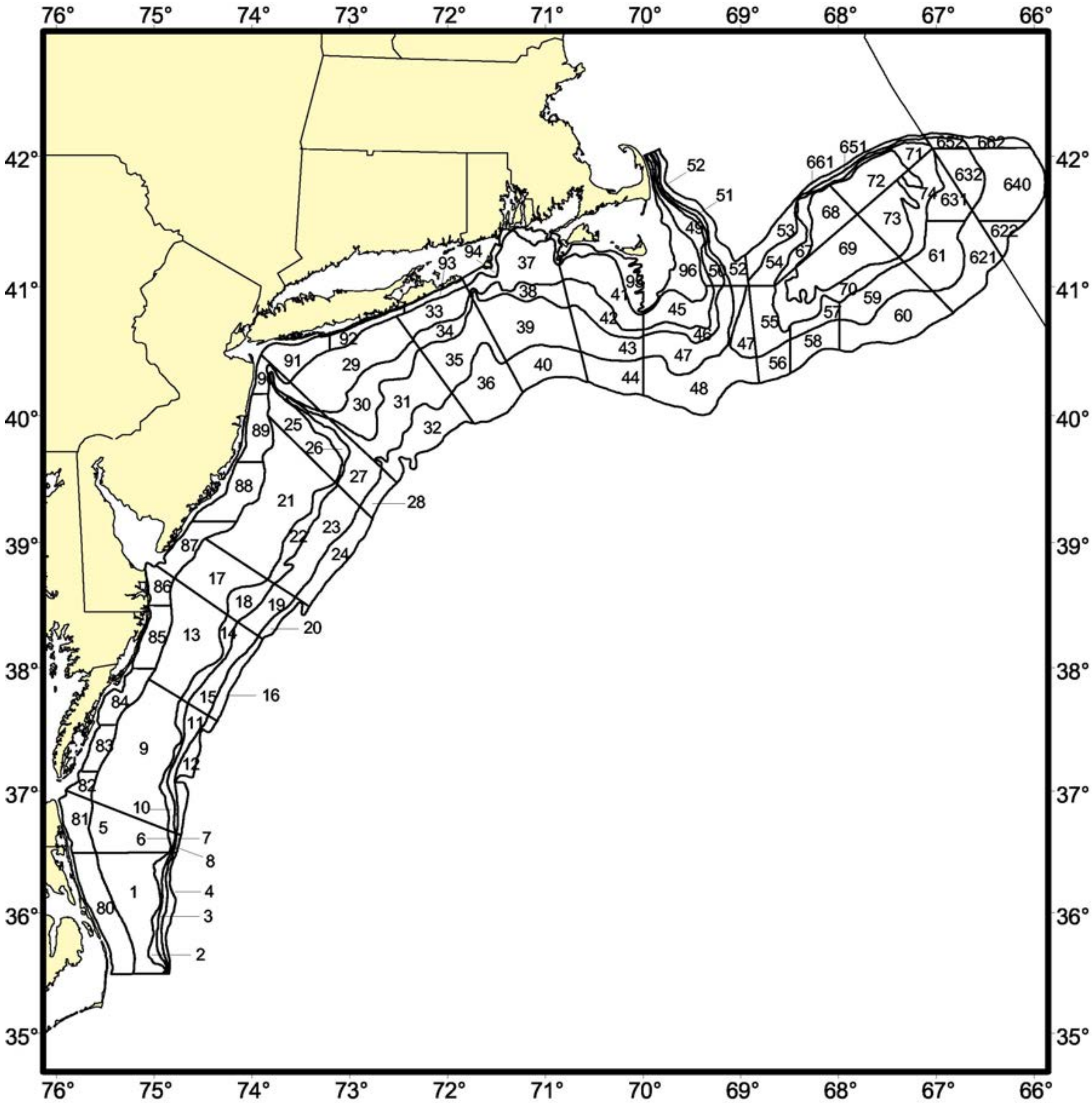


Figure 4. Northeast Fisheries Science Center shellfish resource survey strata, along the east coast of the US.

A. SUMMER FLOUNDER ASSESSMENT SUMMARY FOR 2018

State of Stock

The SAW/SARC-66 of 2018 concluded that summer flounder (*Paralichthys dentatus*) stock status was not overfished and overfishing was not occurring in 2017 relative to the new biological reference points from this assessment (Figures A1-A3). Fishing mortality on the fully selected age 4 fish ranged between 0.744 and 1.622 during 1982-1996 and then decreased to 0.245 in 2007. Since 2007 the fishing mortality rate has increased and was 0.334 in 2017, 75% of the 2018 SAW-66 F_{MSY} proxy = $F_{35\%}$ = 0.448 (Figures A1-A2). The 90% confidence interval for F in 2017 was 0.276 to 0.380. Spawning stock biomass (SSB) decreased from 30,451 mt in 1982 to 7,408 mt in 1989 and then increased to 69,153 mt in 2003. SSB in 2017 was estimated to be 44,552, 78% of the 2018 SAW-66 SSB_{MSY} target proxy = $SSB_{35\%}$ = 57,159 mt, and 56% above the 2018 SAW-66 SSB_{MSY} threshold proxy = ½ $SSB_{35\%}$ = 28,580 mt (Figures A1-A3). The 90% confidence interval for SSB in 2017 was 39,195 to 50,935 mt. The 1983 year class is the largest in the assessment time series at 102 million fish, while the 1988 year class is the smallest at only 12 million fish. The average recruitment from 1982 to 2017 is 53 million fish at age 0. Recruitment has been below average since 2011, ranging from 30 to 42 million and averaging 36 million fish (Figures A3-A4). The recruitment production per unit of spawning stock biomass was higher in the 1980s and early 1990s than in the years since 1996 (Figure A5).

Projections

This projection is provided as an example of consequences of fishing at the F_{MSY} proxy using the 2018 ABC (Note: assumed 2018 catch will need to be replaced with updated values according to the new MRIP estimates). This example projection uses the 2018 SAW-66 assessment model (data through 2017) to estimate the OFL catches for 2019-2023. The projections assume that 100% of the 2018 ABC (5,999 mt = 13.226 million lb) will be caught. The OFL projection uses F_{2019}-F_{2023} = F_{MSY} proxy = $F_{35\%}$ = 0.448. The OFL catches from 2019 onward are from projections which sample from the estimated annual recruitments from 1982-2017 (median = 51 million). The OFL catches are 14,208 mt in 2019 (CV = 12%), 14,040 mt in 2020 (CV = 11%), 14,411 mt in 2021 (CV = 11%), 14,912 in 2022 (CV=13%), and 15,335 in 2023 (CV=15%).

OFL Total Catch, Landings, Discards, Fishing Mortality (F)
and Spawning Stock Biomass (SSB) in 2018-2023
Catches and SSB in metric tons

Year	Total Catch	Landings	Discards	F	SSB
2018	5,999	4,628	1,371	0.194	49,827
2019	14,208	10,832	3,376	0.448	50,922
2020	14,040	10,567	3,473	0.448	52,323
2021	14,411	10,830	3,581	0.448	53,783
2022	14,912	11,261	3,651	0.448	54,877
2023	15,335	11,605	3,730	0.448	55,724

Catch and Status Table: Summer flounder

Catch weights and spawning stock biomass are in metric tons (mt); recruitment is in millions of age 0 fish; min, max and arithmetic mean values are for 1982-2017. Commercial catches are latest reported landings and estimated discards. Recreational catches in the table are MRIP 2018 calibrated landings and discard estimates.

Year	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Commercial landings	4,179	5,013	6,078	7,517	5,918	5,696	4,989	4,858	3,537	2,644
Commercial discards	1,162	1,522	1,478	1,143	754	863	830	703	772	906
Recreational landings	5,597	5,288	5,142	6,116	7,318	8,806	7,364	5,366	6,005	4,565
Recreational discards	1,970	2,484	2,710	2,711	2,172	2,119	2,092	1,572	1,482	1,496
Catch used in assessment	12,909	14,307	15,408	17,487	16,163	17,483	15,275	12,498	11,796	9,611
Spawning stock biomass	64,312	65,969	64,519	59,019	63,401	56,052	51,785	45,930	43,000	44,552
Recruitment (age 0)	62.5	73.7	51.3	31.3	35.2	36.7	42.3	29.8	35.9	42.4
Fully selected F (age 4)	0.314	0.336	0.372	0.431	0.401	0.452	0.418	0.416	0.417	0.334

Year	**Min**	**Max**	**Mean**
Commercial landings	2,644	17,130	7,216
Commercial discards	219	2,151	1,140
Recreational landings	2,566	16,655	7,875
Recreational discards	84	2,711	1,225
Catch used in assessment	9,028	30,470	17,216
Spawning stock biomass	7,408	69,153	39,845
Recruitment (age 0)	12.5	102.4	53.4
Fully selected F (age 4)	0.245	1.622	0.745

Stock Distribution and Identification

The Mid-Atlantic Fishery Management Council (MAFMC) and Atlantic States Marine Fisheries Commission (ASMFC) Fishery Management Plan for summer flounder defines the management unit as all summer flounder from the southern border of North Carolina and to the northeast to the US-Canada border. The current management unit is consistent with a summer flounder genetics study, which revealed no population subdivision at Cape Hatteras (Jones and Quattro 1999). For assessment purposes, the definition of Wilk et al. (1980) of a unit stock extending from Cape Hatteras north to New England has been accepted in this and previous assessments. A consideration of summer flounder stock structure incorporating tagging data supported the existence of stocks north and south of Cape Hatteras, with the stock north of Cape Hatteras possibly composed of two distinct spawning aggregations, off New Jersey and Virginia-North Carolina (Kraus and Musick 2003). The stock unit used in this assessment is consistent with the conclusions of Wilk et al. (1980) and Kraus and Musick (2003).

Catches

Reported 2017 landings in the commercial fishery were 2,644 mt = 5.829 million lb, about 103% of the commercial quota (2,567 mt = 5.659 million lb). Estimated 2017 landings in the recreational fishery were 1,447 mt = 3.190 million lb (Note: this value is not the revised MRIP estimate; see below), about 85% of the recreational harvest limit (1,711 mt = 3.772 million lb). Total commercial and recreational landings in 2017 were 4,091 mt = 9.019 million lb. Commercial discards in 2017 were estimated at 906 mt = 1.997 million lb. Recreational discards were estimated at 442 mt = 0.974 million lb. The estimated total catch in 2017 was 5,439 mt = 11.991 million lb, about 6% above the 2017 ABC of 5,125 mt = 11.299 million lb.

In July 2018, the Marine Recreational Information Program (MRIP) revised the previous estimates of recreational catch with a calibrated 1982-2017 time series that corresponds to new MRIP survey methods that were fully implemented in 2018. For comparison with the previous estimates, the revised estimate of 2017 recreational landings is 4,565 mt = 10.064 million lb, 3.2 times the previous estimate. The revised estimate of 2017 recreational discards is 1,496 mt = 3.298 million lb, 3.4 times the previous estimate.

The revised recreational catch estimates increased the 1982-2017 total annual catch by an average of 29% (from 13,308 mt = 29.339 million lb to 17,216 mt = 37.955 million lb), ranging from +11% in 1989 to +43% in 2017. The 2018 SAW-66 stock assessment model includes the revised estimates of recreational landings and discards.

Data and Assessment

The assessment approach implemented for summer flounder is a forward projecting age-structured model ASAP (Legault and Restrepo 1998, NFT 2013a). The catch in the model includes both commercial and recreational fishery landings and discards at age. The commercial and recreational fishery landings and discards are treated as four separate fleets in the model.

Indices of stock abundance, including age compositions from the NEFSC winter, spring, and fall, Massachusetts spring and fall, Rhode Island fall and monthly fixed, Connecticut spring and fall, Delaware, New York, New Jersey, VIMS ChesMMAP, and VIMS NEAMAP spring and fall trawl surveys, were used in the ASAP model calibration. Aggregate indices of stock abundance from the URI GSO trawl survey and NEFSC MARMAP and ECOMON larval surveys, and recruitment indices (age 0; Young-Of-the-Year, YOY) from surveys conducted by the states of Massachusetts, Delaware, Maryland, Virginia and North Carolina were also used in the model calibration. For the NEFSC indices, the years sampled by the FSV HB Bigelow (2009-2017) were treated as a separate series from the earlier years (1982-2008) that were sampled by the FSV Albatross IV. The Bigelow indices take into account trawl efficiency estimates at length from 'sweep-study' experiments.

The 2018 SAW-66 stock assessment model includes the revised MRIP estimates of recreational landings and discards. On average, the recreational catch increased about 1.5 times in the early 1980s and about 3.0 times in the most recent 5 years. The increase in estimated removals resulted in increased population size estimates from the assessment model compared to the previous assessment.

The summer flounder stock assessment has historically exhibited a retrospective pattern of underestimation of F and overestimation of SSB. This pattern has diminished in the current assessment, with minor internal model retrospective errors over the last 7 terminal years averaging -4% for F, +2% for SSB, and +2% for recruitment, likely due to changes in the catch data and model formulation. These retrospective errors are about one-tenth as large as their magnitude in the previous benchmark assessment 2013 SAW-57 (NEFSC 2013). The 2017 model estimates of F and SSB adjusted for this internal retrospective error are within the model estimate 90% confidence intervals, and so no adjustment of the terminal year estimates has been made for stock status determination or projections (Figure A1). The historical retrospective indicates that general trends of fishing mortality and stock biomass have been consistent among assessments going back to the 1990s (Figure A6).

Fishing Mortality

Fishing mortality on the fully selected age 4 fish ranged between 0.744 and 1.622 during 1982-1996 and then decreased to 0.245 in 2007. Since 2007 the fishing mortality rate has increased and was 0.334 in 2017, 75% of the 2018 SAW-66 F_{MSY} proxy = $F_{35\%}$ = 0.448 (Figures A1-A2). The 90% confidence interval for F in 2017 was 0.276 to 0.380.

Biomass

Spawning stock biomass (SSB) decreased from 30,451 mt in 1982 to 7,408 mt in 1989 and then increased to 69,153 mt in 2003. SSB has decreased since 2003 and was estimated to be 44,552 mt in 2017, 78% of the 2018 SAW-66 SSB_{MSY} target proxy = $SSB_{35\%}$ = 57,159 mt, and 56% above the 2018 SAW-66 ½ SSB_{MSY} threshold proxy = ½ $SSB_{35\%}$ = 28,580 mt. The 90% confidence interval for SSB in 2017 was 39,195 to 50,935 mt.

Recruitment

The 1983 year class is the largest in the assessment time series at 102 million fish, while the 1988 year class is the smallest at only 12 million fish. Average recruitment from 1982 to 2017 is 53 million fish at age 0. Recruitment has been below average since 2011, ranging from 30 to 42 million and averaging 36 million fish. The recruitment production per unit of spawning stock biomass was higher in the 1980s and early 1990s than in the years since 1996 (Figure A5).

Biological Reference Points

The SAW-57 (2013) biological reference points for summer flounder were based on stochastic yield and SSB per recruit and stochastic projection models in the NOAA NFT framework (NEFSC 2013; NFT 2013b, c; Thompson and Bell 1934) using values from the 2013 assessment. The associated threshold fishing mortality reference point was $F_{35\%}$ = 0.309 (CV = 15%) as a proxy for F_{MSY}. The biomass reference point proxy was estimated as the projection of Jan 1, 2013 stock sizes at $F_{35\%}$ = 0.309 and mean recruitment of 43 million fish per year (1982-2012). The SAW-57 target biomass SSB_{MSY} proxy was estimated to be 62,394 mt (137.6 million lb; CV = 13%), and the threshold biomass of one-half SSB_{MSY} was estimated to be 31,197 mt (68.8 million lb; CV = 13%). The MSY proxy was estimated to be 12,945 mt (28.539 million lb; CV = 13%; 10,455 mt = 23.049 million lb of landings plus 2,490 mt = 5.490 million lb of discards).

The new SAW-66 (2018) biological reference points for summer flounder are similarly based on those stochastic yield and SSB per recruit and stochastic projection models. The new threshold fishing mortality reference point estimate is $F_{35\%}$ = 0.448 (CV = 15%), and is a proxy for F_{MSY}. The biomass reference point proxy is estimated as the projection of Jan 1, 2018 stock sizes at $F_{35\%}$ = 0.448 and mean recruitment of 53 million fish per year (1982-2017). The target biomass SSB_{MSY} proxy is estimated to be 57,159 mt (126.0 million lb; CV = 15%), and the threshold biomass of one-half SSB_{MSY} is estimated to be 28,580 mt (63.0 million lb; CV = 15%). The MSY proxy is estimated to be 15,973 mt (35.214 million lb; CV = 15%). The increase in the F reference point (and MSY) but decrease in the biomass reference point is a result of changes in mean weights at age and selectivity.

Ecosystem Context

Aspects of the ecosystem seem to be changing in recent years. Fall ocean bottom and surface temperatures are increasing, and salinity is at or near the historical high. These physical data series may have shifted around 2012, the warmest year on record for this ecosystem. Spring chlorophyll concentrations, a measure of bottom-up ecosystem production in the summer flounder stock area, are variable, but the fall time series has been decreasing, especially during 2013-2017. Spring abundances for key zooplankton prey are variable and may be worth examining alongside recruitment patterns, an issue for future research. Both probability of occurrence and modeled habitat area show similar patterns of increases from the 1990s to the present, which suggests despite reduced abundance in the past five years, the distribution footprint of summer flounder has not contracted. Ecosystem Context indicators, and methods to develop them, can be found at:

Summer Flounder 2018 Ecosystem Context for Stock Assessments

Special Comments

The assessment shows that current mortality from all sources is greater than recent recruitment inputs to the stock, which has resulted in a declining stock trend. Although recruitment indices have been below average in the most recent years, the driver of this pattern has not been identified, nor is it clear if this pattern will persist in the future.

The projections provided in this report are based on the full time series of recruitment. If recent relatively low recruitment continues, these projections will overestimate future population size as well as catches associated with overfishing limits.

References

Jones WJ, Quattro JM. 1999. Genetic structure of summer flounder (*Paralichthys dentatus*) populations north and south of Cape Hatteras. Marine Biology 133: 129-135.

Kraus RT, Musick JA. 2003. A brief interpretation of summer flounder, *Paralichthys dentatus*, movements and stock structure with new tagging data on juveniles. Mar. Fish. Rev. 63(3): 1-6.

Legault CM, Restrepo VR. 1998. A flexible forward age-structured assessment program. ICCAT. Col. Vol. Sci. Pap. 49:246-253.

Northeast Fisheries Science Center (NEFSC) 2013. 57th Northeast Regional Stock Assessment Workshop (57th SAW) Assessment Report. US Dept Commerce, Northeast Fish Sci Cent Ref Doc. 13-16, 967 p.

NOAA Fisheries Toolbox (NFT) 2013a. Age Structured Assessment Program (ASAP) version 3.0.11. (Internet address: http://nft.nefsc.noaa.gov).

NOAA Fisheries Toolbox (NFT). 2013b. Yield per recruit (YPR) version 3.2.1. (Internet address: http://nft.nefsc.noaa.gov).

NOAA Fisheries Toolbox (NFT) 2013c. Age Structured Projection Model (AGEPRO) version 4.2. (Internet address: http://nft.nefsc.noaa.gov).

Thompson WF, Bell FH. 1934. Biological statistics of the Pacific halibut fishery. 2.Effect of changes in intensity upon total yield and yield per unit of gear. Rep. Int. Fish.(Pacific halibut) Comm. 8: 49 p.

Wilk SJ, Smith WG, Ralph DE, Sibunka J. 1980. The population structure of summer flounder between New York and Florida based on linear discriminant analysis. Trans. Am. Fish. Soc. 109:265-271.

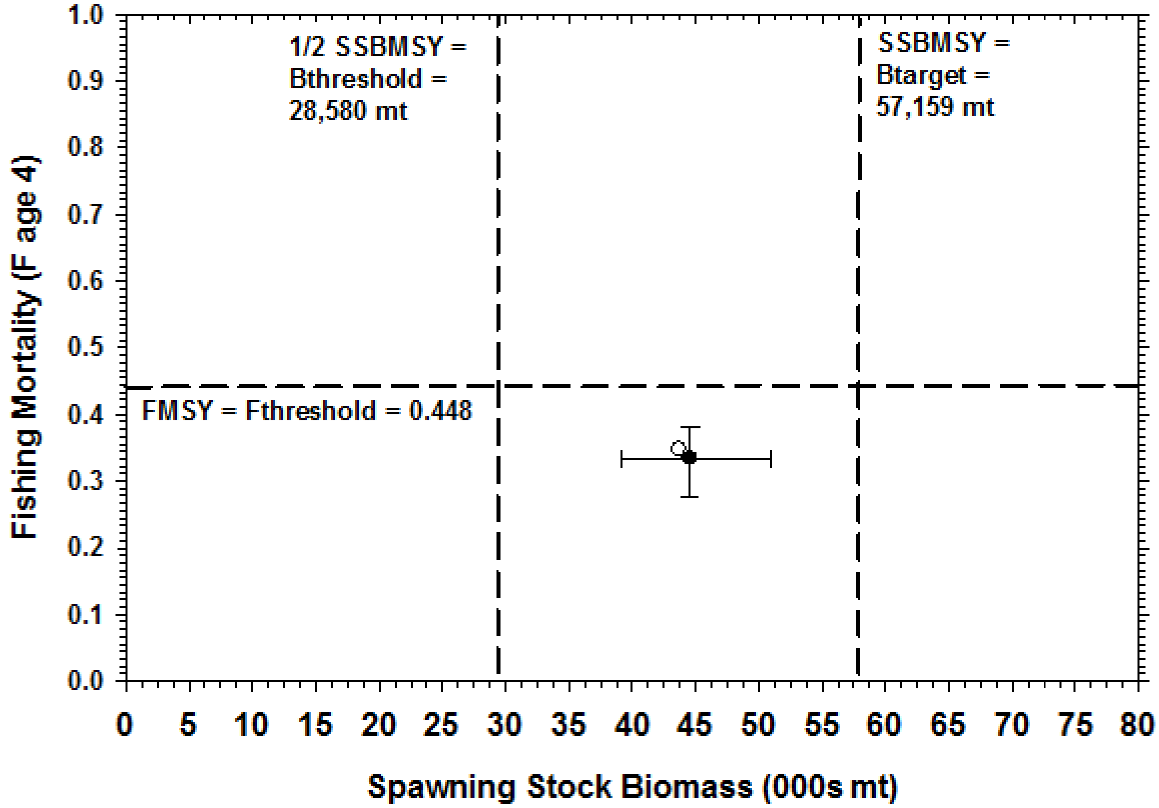


Figure A1. Estimates of summer flounder spawning stock biomass (SSB) and fully-recruited fishing mortality (F, peak at age 4) relative to the 2018 SAW-66 biological reference points. Filled circle with 90% confidence intervals shows the assessment point estimates. The open circle shows the retrospectively adjusted estimates.

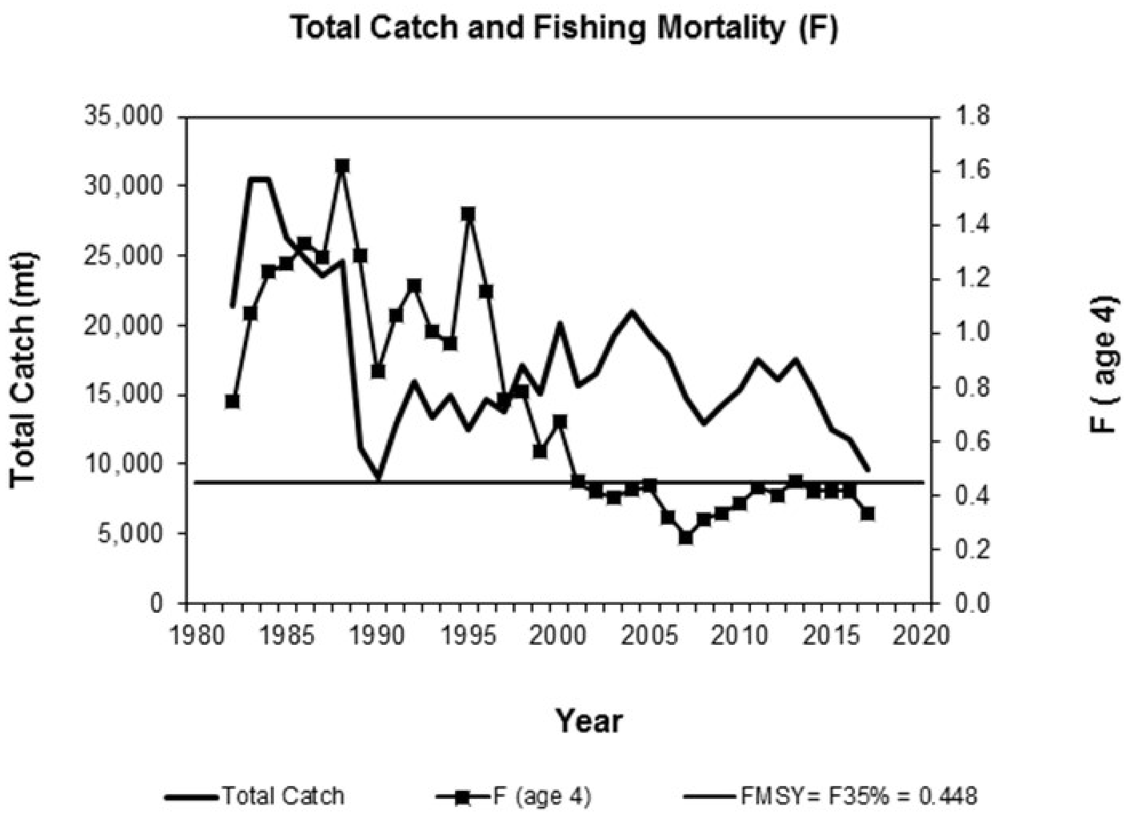


Figure A2. Total fishery catch (metric tons; mt; solid line) and fully-recruited fishing mortality (F, peak at age 4; squares) of summer flounder through 2017. The horizontal solid line is the 2018 SAW-66 threshold fishing mortality reference point proxy.

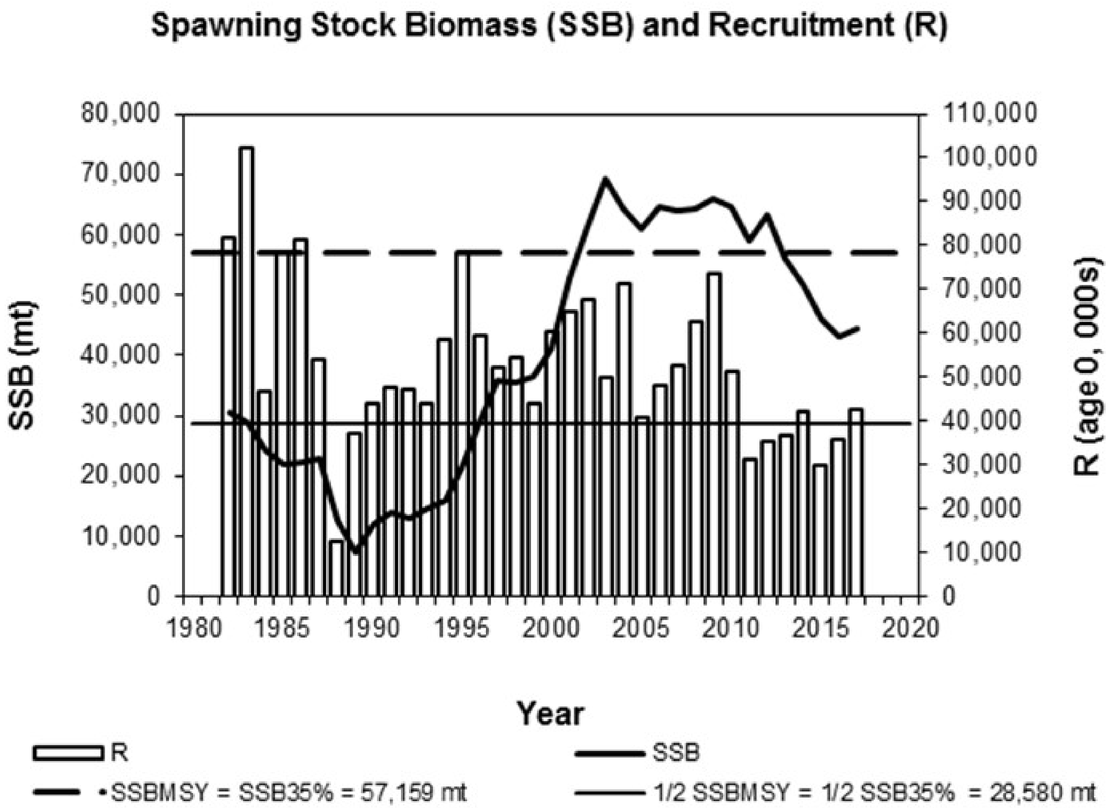


Figure A3. Summer flounder spawning stock biomass (SSB; solid line) and recruitment at age 0 (R; vertical bars) by calendar year through 2017. The horizontal dashed line is the 2018 SAW-66 target biomass reference point proxy. The horizontal solid line is the 2018 SAW-66 threshold biomass reference point proxy.

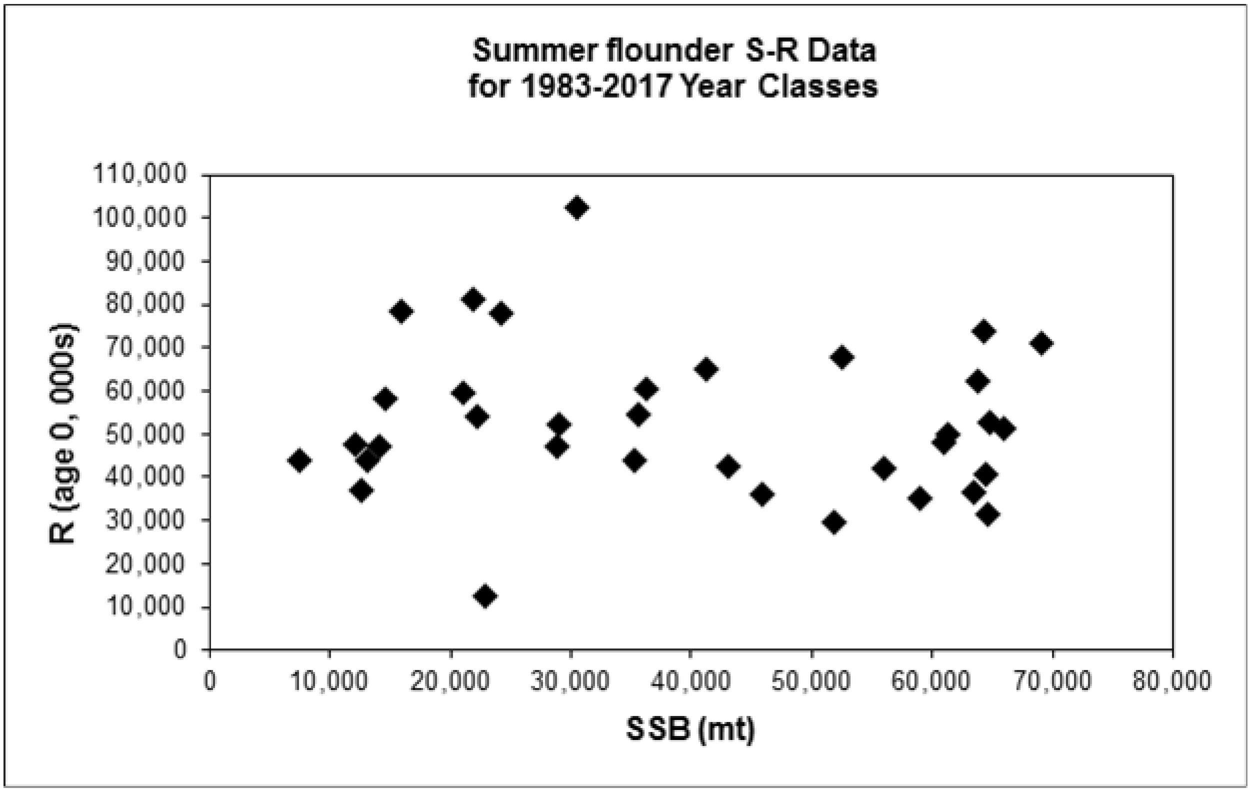


Figure A4. Stock-recruitment (SSB-R) scatter plot for the summer flounder 1983-2017 year classes. The largest recruitment (R) point is the 1983 year class (R = 102 million, SSB = 30,451 mt). The lowest recruitment point is for the 1988 year class (R = 12 million, SSB = 22,913 mt). The 2017 year class is at R = 42 million, SSB_{2016} = 43,000 mt.

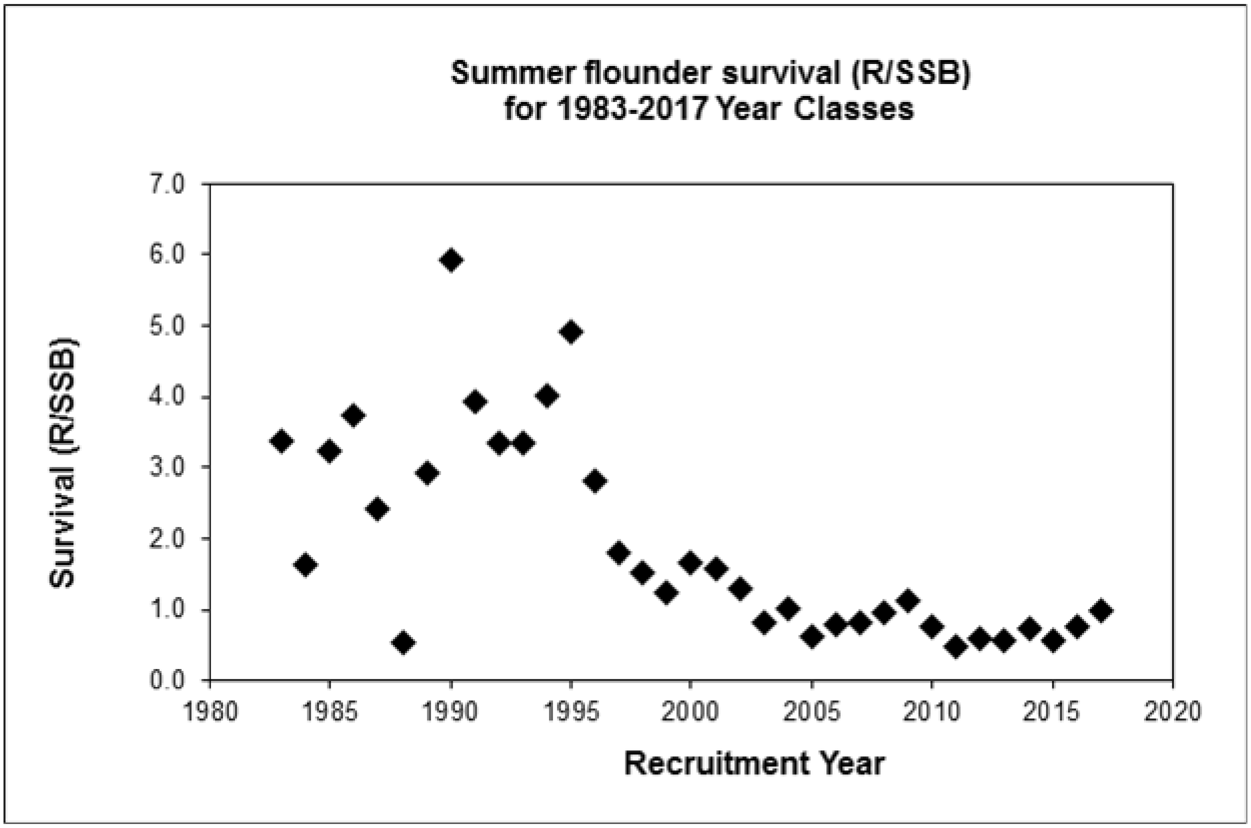


Figure A5. Recruits per Spawning Stock Biomass ratio (R/SSB) plot indicative of the relative survival of the summer flounder 1983-2017 year classes.

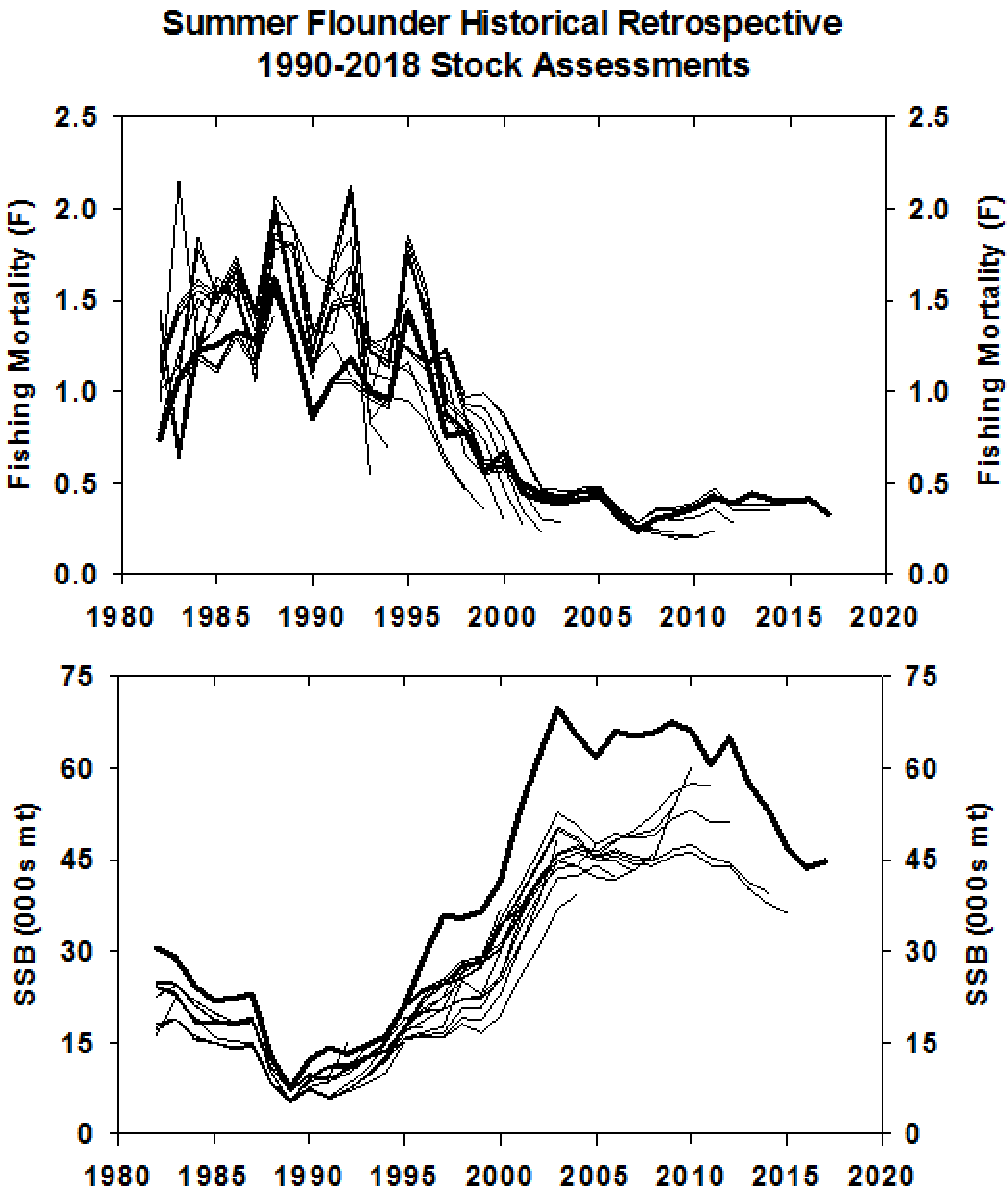


Figure A6. Historical retrospective of the 1990-2018 stock assessments of summer flounder. The heavy solid lines are the 2018 SAW-66 estimates.

B. ATLANTIC STRIPED BASS ASSESSMENT SUMMARY FOR 2018

State of Stock

The biomass threshold for Atlantic striped bass is the estimate of female spawning stock biomass (SSB) for year 1995. The F threshold is the F value that allows the stock to achieve the SSB threshold under long-term equilibrium conditions.

Female SSB for Atlantic striped bass in 2017 was 68,476 mt, which is less than the $SSB_{threshold}$ of 91,436 mt, indicating the stock is overfished (Figure B1). F_{2017} was 0.307, which is greater than the associated $F_{threshold}$ of 0.240, indicating the stock is experiencing overfishing (Figure B1).

Projections

Stock projections of female SSB were made by using the same population dynamics equations used in the assessment model. Four scenarios of constant catch or F are provided here.

The model projection began in year 2018 and ran for a total of 6 years. A composite selectivity pattern was calculated as the geometric mean of 2013-2017 of total F-at-age, scaled to the highest F. Residuals from the stock-recruitment fit from 1982-2017 were randomly re-sampled and added to the deterministic predictions of recruitment from the hockey-stick recruitment function to produce stochastic estimates of age-1 recruitment for each year of the projection. Projections were done using: constant 2017 catch; constant 2017 F; F equal to $F_{threshold}$; and F equal the F required to achieve the 1993 estimate of female SSB in the long term. Female SSB in 1993 was lower than the SSB threshold, but was still capable of producing a very strong year class, and so fishing mortality required to achieve the 1993 estimate of female SSB was explored as a sensitivity run to understand projected population dynamics under an F in between F in 2017 and the F threshold.

Under the projection with status quo F ($F=F_{2017}$), the population trajectory remained relatively flat from 2018-2023; reducing F to $F_{threshold}$ resulted in an increasing trend in SSB (Figure B2). However, under all four scenarios, the probability of female SSB being above $SSB_{threshold}$ in 2023 was very low (Figure B3). In addition, although the probability of F being above $F_{threshold}$ declined in the constant catch scenario, there was still a 60% chance of F being above $F_{threshold}$ in 2023 (Figure B4).

Catch and Status Table: Atlantic striped bass

Year	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Commercial landings (mt)	3,974	3,584	3,655	3,557	3,403	3,069	2,898	2,504	2,531	2,450
Commercial discards (mt)	432	488	418	367	640	409	530	468	492	504
Recreational catch† (mt)	32,949	31,692	32,944	29,190	28,127	34,403	23,982	22,063	24,962	21,797
Catch used in assessment (mt)	37,355	35,764	37,016	33,114	32,170	37,881	27,409	25,035	27,985	24,751
Female spawning stock biomass (mt)	106,656	106,094	106,261	99,768	98,798	88,864	78,999	70,858	73,924	68,476
Recruitment (Millions of age 1 fish)	129.2	77.5	104.9	147.9	214.4	65.4	92.6	186.9	239.6	108.8
Full F	0.241	0.233	0.273	0.276	0.272	0.368	0.283	0.243	0.278	0.307

†: MRIP 2018 calibrated landings plus 9% release mortality on fish released alive.

	Min	Max	Mean
Commercial landings (mt)	29	3,974	2,296
Commercial discards (mt)	24	1,458	470
Recreational catch† (mt)	1,031	34,403	18,256
Catch used in assessment (mt)	1,144	37,881	21,022
Female spawning stock biomass (mt)	15,369	113,602	74,920
Recruitment (Millions of age 1 fish)	37.9	312.2	140.9
Full F	0.030	0.368	0.195

Min, max, and mean values calculated for the assessment time series, 1982 - 2017

†: MRIP 2018 calibrated landings plus 9% release mortality on fish released alive.

	ASMFC 2014		Updated (SARC 66, 2018)	
Reference Point	Definition	Value	Definition	Value
SSB threshold	Estimate of 1995 female SSB	57,626 mt	Estimate of 1995 female SSB	91,436 mt
SSB target	125% SSB threshold	72,032 mt	125% SSB threshold	114,295 mt
F threshold	F projected to achieve SSB threshold	0.22	F projected to achieve SSB threshold	0.240
F target	F projected to achieve SSB target	0.18	F projected to achieve SSB target	0.197

Stock Distribution and Identification

The Atlantic coastal striped bass management unit includes the coastal and estuarine areas of all states and jurisdictions from Maine through North Carolina. The Albemarle-Roanoke stock is currently managed as a non- migratory stock by the state of North Carolina under the auspices of ASFMC. Coastal migratory striped bass are assessed and managed as a single stock, although the population is known to be comprised of multiple biologically distinct stocks, predominantly the Chesapeake Bay stock, the Delaware Bay stock, and the Hudson River stock.

Atlantic coastal migratory striped bass live along the eastern coast of North America from the St. Lawrence River in Canada to the Roanoke River and other tributaries of Albemarle Sound in North Carolina (ASMFC 1990). Atlantic striped bass are anadromous, meaning they return to their natal rivers to spawn.

Stocks which occupy coastal rivers from the Tar-Pamlico River in North Carolina south to the St. Johns River in Florida are believed to be primarily endemic and riverine, as historical tagging data suggest they do not presently undertake extensive Atlantic Ocean migrations, as the more northern stocks do. These areas are not considered part of the coastal striped bass management unit.

Catches

Annual commercial harvest of striped bass peaked at approximately 5,888 mt (13 million pounds) in 1973, but due to stock declines and subsequent management actions, landings decreased by 99 percent to 68 mt (151,000 pounds) in 1986 (Figure B5). Commercial landings gradually increased through the early 1990s as the stock recovered and management measures were liberalized. The quota system has kept the commercial landings relatively stable from 2004 – 2014, with average landings of 2,935 mt (6.5 million pounds). In response to the 2013 benchmark assessment, the commercial quota was reduced beginning in 2015 through Addendum IV. Landings averaged 2,133 mt (4.7 million pounds) from 2015 – 2017.

Commercial discards increased from the early 1980s to a peak of nearly 350,000 fish in 1998, and have been declining since then (Figure B5). Commercial discards averaged 105,000 fish from 2015 – 2017. Commercial landings have generally exceeded discards since the early 1990s; discards made up approximately 15% of total commercial removals coastwide from 2015 – 2017.

This assessment incorporated the newly calibrated MRIP estimates of recreational catch and length frequencies. The calibrated MRIP estimates of harvest were approximately 150% higher than uncalibrated estimates in recent years; calibrated estimates of live releases were approximately 200% higher than uncalibrated estimates (Figure B6). The calibration did not change the overall trend of the recreational catch.

Recreational harvest of striped bass increased from a low of 264,000 fish in 1984 to a high of 5.4 million fish in 2010. Harvest averaged 3.2 million fish for 2015 – 2017 (Figure B5).

The annual Atlantic coast harvest (in numbers) has been a small fraction of the total catch (harvest and releases, combined) since the 1980s because the live releases have accounted for 85 to 90% of the annual catch in most years; in 2015 – 2017, only 9% of the total catch was landed.

Recreational harvest and live releases showed different patterns after 2006, with releases declining faster initially and then increasing, and harvest staying relatively steady through 2013 before beginning to decline.

A recreational release mortality of 9% was applied to the total number of live releases to calculate the numbers of fish that died after being released alive. Recreational release mortalities increased from 79,660 fish in 1984 to a peak of 4.8 million fish in 2006 before declining through 2011 to 1.5 million fish (Figure B5). Live releases increased after that, with the number release mortalities averaging 2.9 million fish from 2015 – 2017.

Over the entire time series, about one third of the total removals (commercial landings, commercial discards, recreational landings, and recreational release mortalities combined) were taken in the Chesapeake Bay, with the rest coming from the ocean and other areas such as Delaware Bay and Long Island Sound (Figure B5). In 2017, the Chesapeake Bay accounted for 35% of total removals; from 2014-2016, it was closer to 50%.

Data and Assessment

The assessment used total catch (commercial landings, commercial discards, recreational landings, and recreational release mortalities) and catch-at-age from 1982-2017, split into two regions (Chesapeake Bay and the ocean/other areas). The assessment used seven fishery-independent indices of abundance for age-1+ striped bass, and one fishery-dependent index: the CT Long Island Sound trawl survey, the NJ ocean bottom trawl survey, the NY ocean haul seine survey, the MD spawning stock survey, ChesMMAP, the DE 30' trawl, the DE spawning stock electrofishing surveys, and an MRIP CPUE. Five recruitment indices for young-of-year (YOY) and age-1 fish were also used: a composite YOY index based on YOY surveys from MD and VA, a MD age-1 survey, a NY YOY survey, a NY Age-1 survey, and a NJ YOY survey. Two surveys used in the 2013 assessment were dropped due to either concerns about the design and long-term future of the survey (VA poundnet survey) or low catch rates of striped bass (NEFSC bottom trawl survey). The ChesMMAP survey was added to provide additional information on striped bass abundance in the Chesapeake Bay, and the DE 30' trawl survey was added to provide a longer time series of data on striped bass abundance in the Delaware Bay.

The SARC-66 accepted model for striped bass is a forward projecting statistical catch-at-age (SCA) model, specifically a single stock, non-migration SCA model. This SCA model estimates annual recruitment, annual full F by fleet, and selectivity parameters for indices and fleets in order to calculate abundance and female spawning stock biomass. Recruitment was estimated as deviations from mean recruitment. This model was approved for management use at SARC-57 in 2013, and several improvements to the input data were made for the 2018 assessment. In 2013, three fleets were used: a Chesapeake Bay fleet, an ocean fleet, and a commercial discard fleet. For the SARC-66 assessment in 2018, commercial discards were estimated by region, so the model used only two fleets: a Chesapeake Bay fleet and an ocean fleet. This allowed the model to better represent the regional dynamics of the fisheries and differences in selectivity patterns. In addition, proportions at age for the CT trawl survey and the MRIP CPUE were developed for the 2018 assessment based on length frequency information, so that neither of those indices had to be treated as age-aggregated indices as was done in the 2013 assessment; all age-1+ indices in the 2018 assessment had age-structure information for the model fitting.

As a complement to the SCA, Jiang et al.'s (2007) instantaneous rates tagging model (IRCR) was run on data from the USFWS coast-wide striped bass tagging program through the 2017 tagging year to estimate abundance, survival, fishing mortality, and natural mortality.

Fishing Mortality

Fishing mortality (F) in both Chesapeake Bay and the ocean has been increasing since 1990. The combined full F was 0.307 in 2017, above the current $F_{threshold}$ of 0.240. The combined full F has been at or above the threshold for 13 of the last 15 years (Figure B1).

Biomass

Total biomass was low at the beginning of the time series. Total biomass increased through the 1980s and 1990, peaking in 1999 before declining again. The total biomass of Atlantic coastal migratory stock striped bass was 173,663 mt (383 million pounds) in 2017. Total biomass peaked at 334,661 mt (738 million pounds) in 1999.

Female SSB showed a pattern similar to that of total biomass. Female SSB started out low and increased through the late-1980s and 1990s, peaking at 113,602 mt (250 million pounds) in 2003 before beginning to gradually decline; the decline became sharper in 2012 (Figure B1). Female SSB was estimated at 68,476 mt (151 million pounds) in 2017, which is below the SSB threshold of 91,436 mt (202 million pounds); female SSB has been below $SSB_{threshold}$ since 2013 (Figure B1).

Recruitment

The stock appears to have experienced low recruitment at the beginning of the time series. Mean recruitment through the early 1990s to the present has been higher.

The 2015 year class was strong, as was the 2011 year class. But the 2016 year class was below average (Figure B7). Recruitment in 2017 was estimated at 108.8 million age-1 fish, below the time series mean of 140.9 million fish.

Biological Reference Points

Biological reference points for Atlantic striped bass are based on the condition of the stock in 1995, the year the stock was declared recovered. The SSB threshold is the estimate of female SSB in 1995, and the SSB target is 125% of the estimate of 1995 female SSB. The F threshold and F target are the F rates that will maintain the stock at the SSB threshold and SSB target, respectively, under long term equilibrium recruitment conditions. The previous benchmark assessment (2013) estimated $SSB_{threshold}$ at 57,626 mt (127 million pounds) and the associated $F_{threshold}$ at 0.22. SSB_{target} was estimated at 72,032 mt (159 million pounds) and the associated F_{target} was 0.18. These reference points were for the total coastal migratory stock complex of Atlantic striped bass.

For the SARC-66 benchmark assessment in 2018, the definition of the targets and thresholds were kept the same as the previous assessment, but the values were re-estimated. $SSB_{threshold}$ was estimated at 91,436 mt (202 million pounds), with SSB_{target} equal to 114,295 mt (252 million pounds). $F_{threshold}$ was estimated at 0.240, and the associated F_{target} was 0.197.

Model-based estimates of MSY were not calculated for this assessment. An empirically-based proxy for MSY derived from the SSB target or threshold could be an area for future development, depending on management goals.

The new F reference points are similar to the values currently used in management, but the SSB reference points are significantly higher, primarily due to the inclusion of the new, calibrated MRIP values.

Special Comments

The new estimates of recreational catch resulted in higher estimates of recruitment and biomass compared to the 2016 assessment update that used uncalibrated estimates. However, it did not significantly change the overall population trend, which has been declining since about 2003.

An impressive amount of work went into developing the two stock model presented by the working group. This model represents an innovative advancement, and the SARC panel recommends continued development and refinement of that model.

References

ASMFC. 1990. Source document for the supplement to the Striped Bass FMP - Amendment #4. Washington (DC): ASMFC. Fisheries Management Report No. 16. 244 p.

ASMFC. 2014. Addendum IV to Amendment 6 to the Atlantic Striped Bass Interstate Fishery Management Plan. Arlington (VA): ASMFC. 20 p.

Jiang H, Pollock KH, Brownie C, Hoenig JM, Latour RJ, Wells BK, Hightower JE. 2007. Tag return models allowing for harvest and catch and release: evidence of environmental and management impacts on striped bass fishing and natural mortality rates. North American Journal of Fisheries Management 27:387-396.

Figures

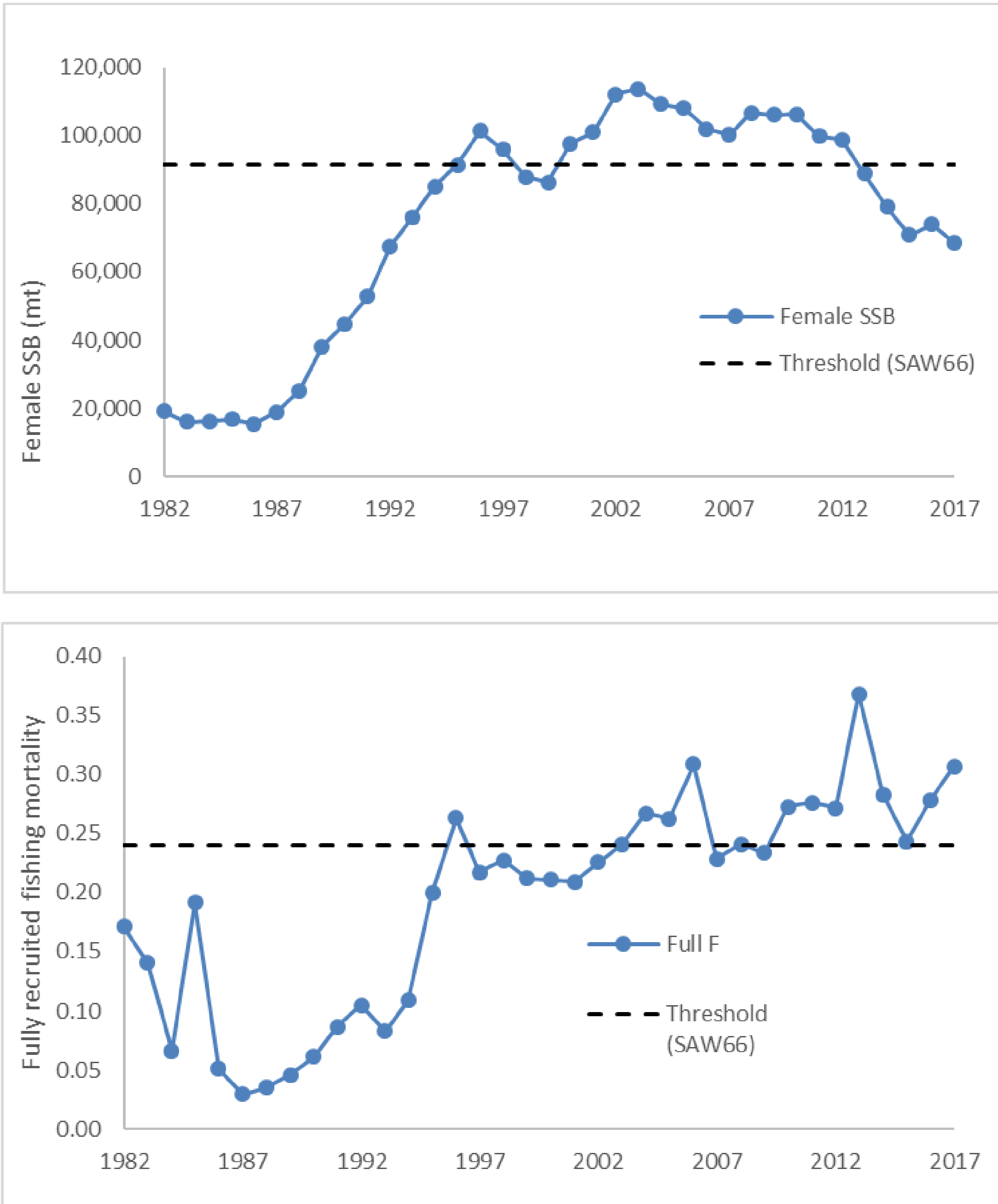


Figure B1. Female spawning stock biomass (SSB; top) and fishing mortality (F; bottom) for Atlantic striped bass through 2017, plotted with the respective SSB and F thresholds.

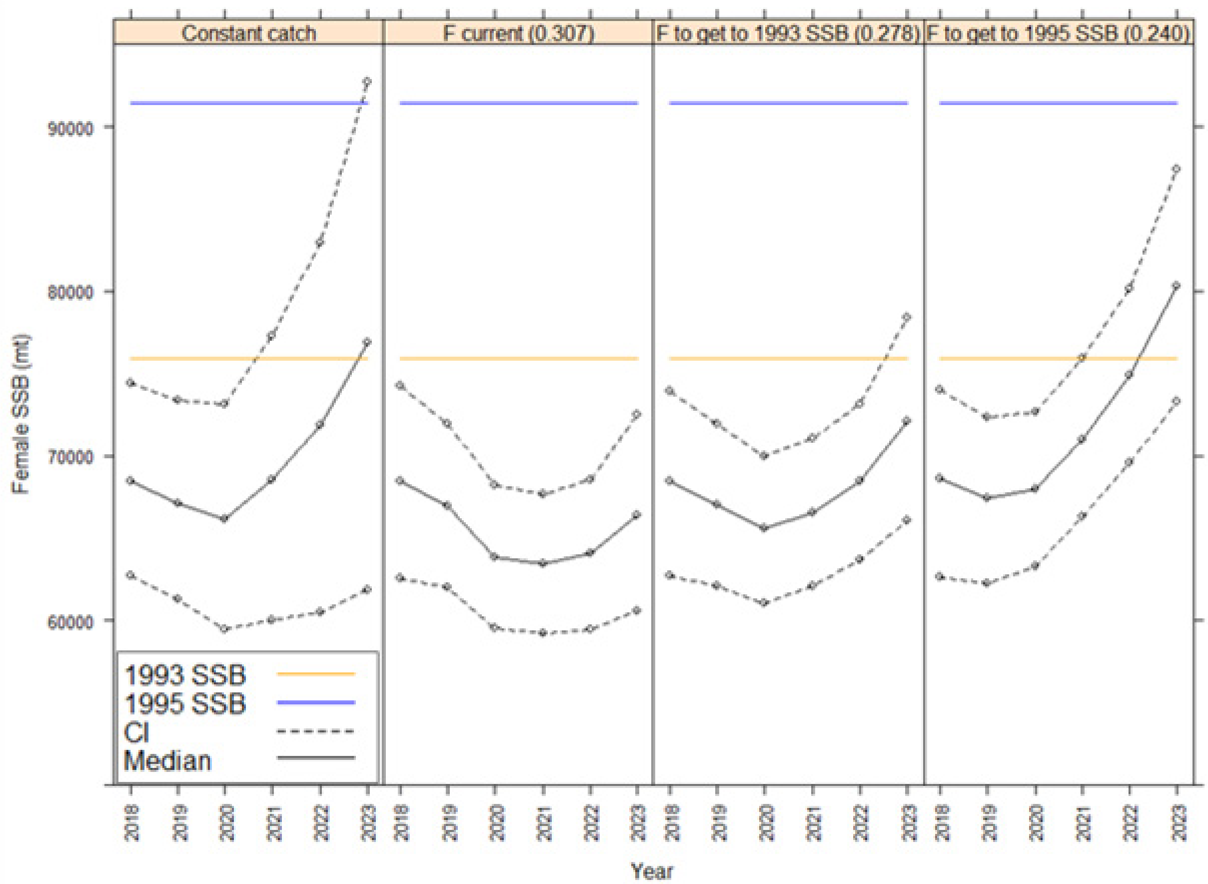


Figure B2. Trajectories of female Atlantic striped bass spawning stock biomass (SSB), with 95% confidence intervals, under different harvest scenarios. Projections were done using: constant 2017 catch; constant 2017 F; F equal the F required to achieve the 1993 estimate of female SSB in the long term; and F equal to $F_{threshold}$.

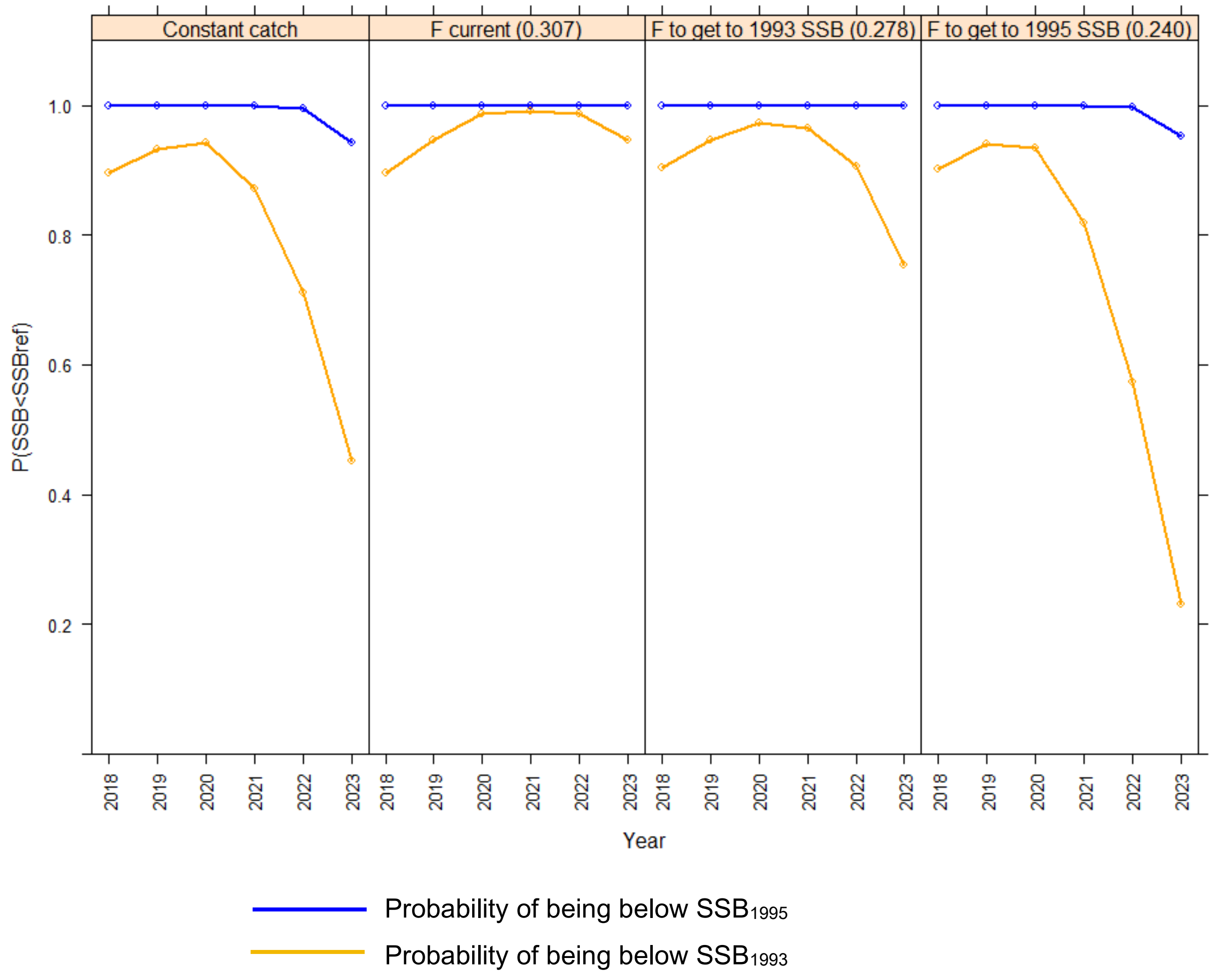


Figure B3. Probability of female Atlantic striped bass spawning stock biomass (SSB) being below the SSB threshold under different harvest scenarios. Projections were done using: constant 2017 catch; constant 2017 F; F equal the F required to achieve the 1993 estimate of female SSB in the long term; and F equal to $F_{threshold}$.

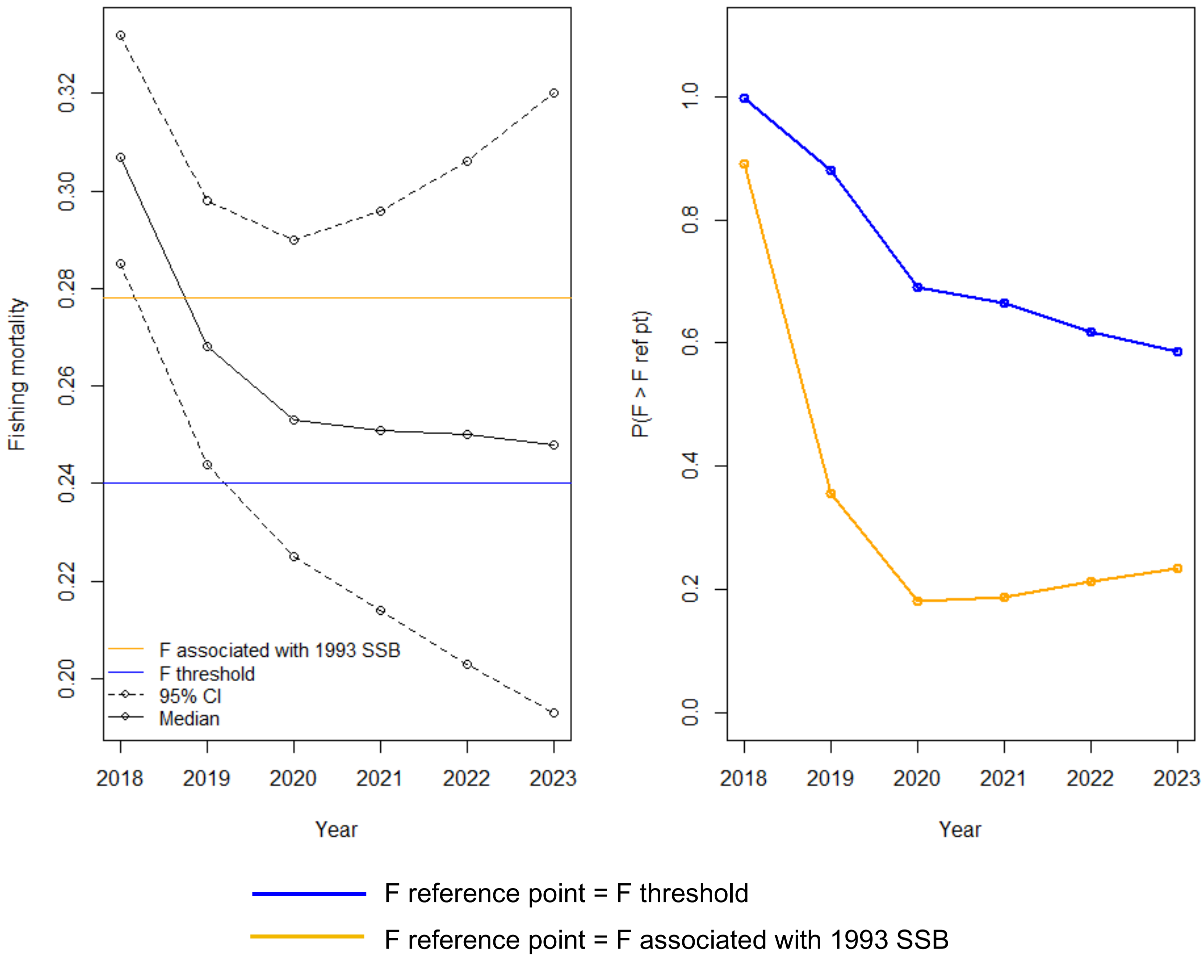


Figure B4. Atlantic striped bass. Trajectory of combined full fishing mortality (F) for the population (left) and the probability of F being above F threshold (right) under the constant 2017 catch scenario.

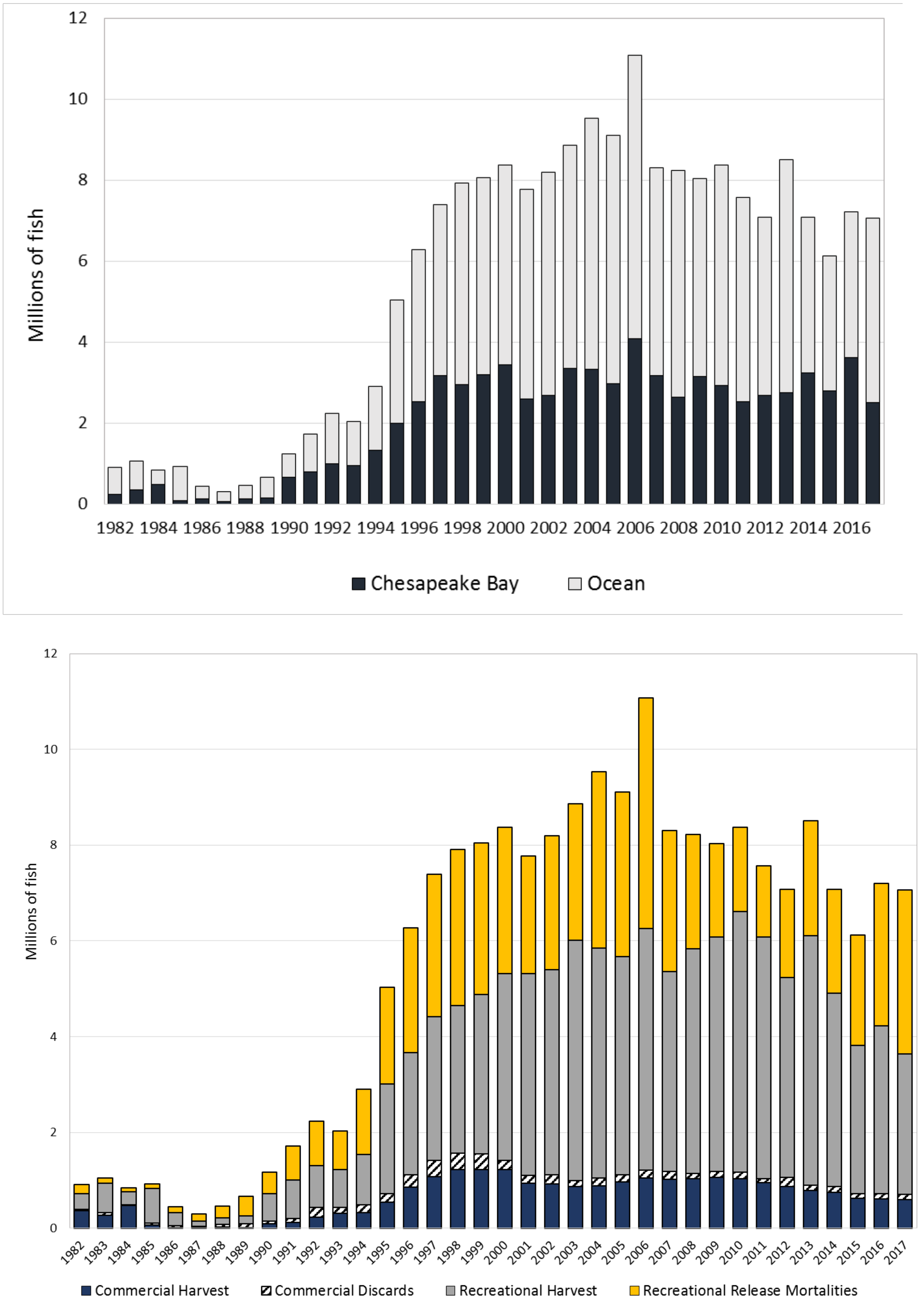


Figure B5. Total removals of Atlantic striped bass by region (top) and sector (bottom) through 2017.

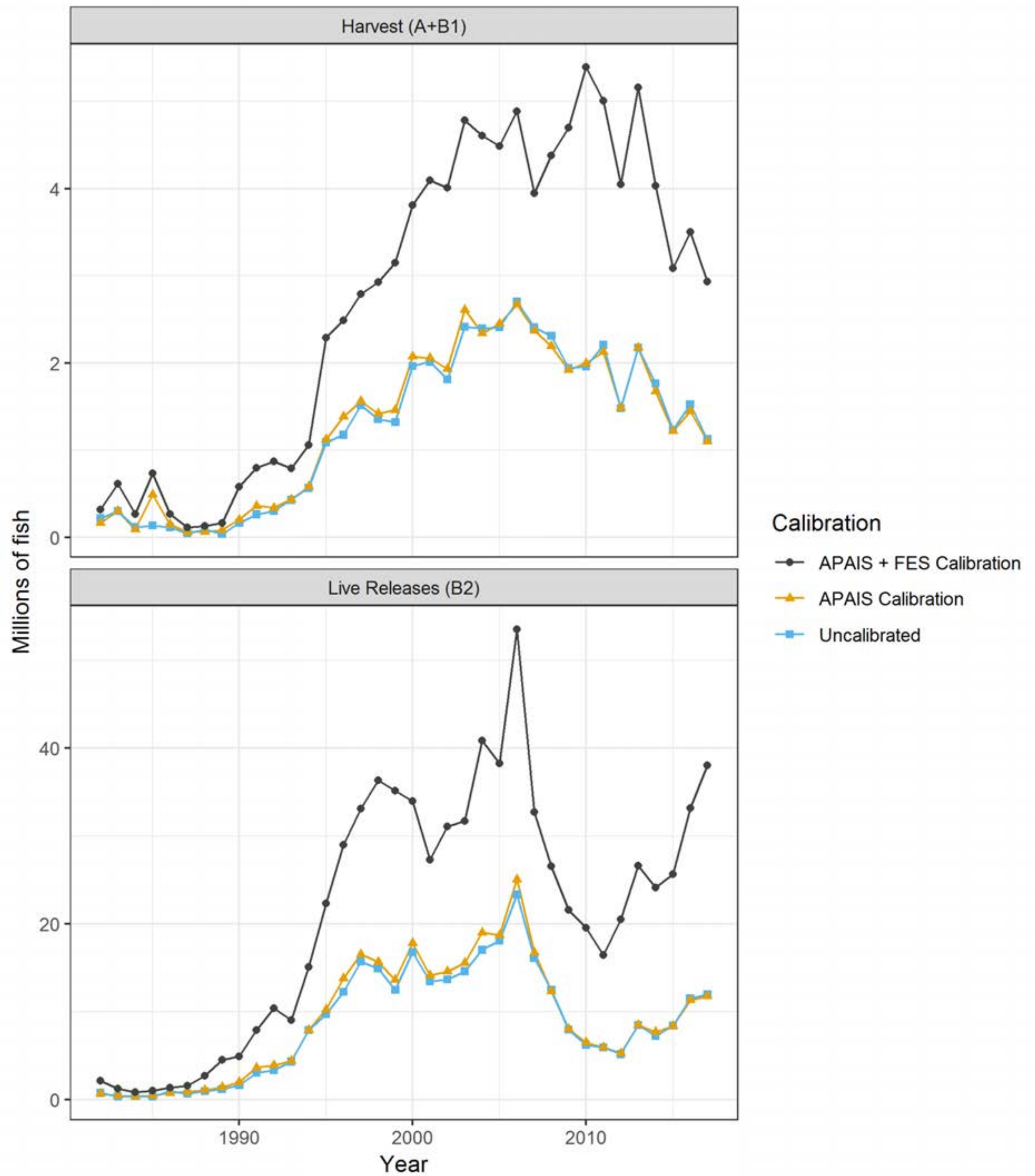


Figure B6. Comparison of calibrated and uncalibrated MRIP estimates of recreational harvest (top) and live releases (bottom) for Atlantic striped bass through 2017. Uncalibrated = original MRIP estimates; APAIS calibration = MRIP estimates after calibration to account for changes in the Access Point Angler Intercept Survey (APAIS). APAIS + FES calibration = MRIP estimates after calibration to account for APAIS changes and the change in effort estimation from the coastal household telephone survey to a mail-based fishing effort survey (FES).

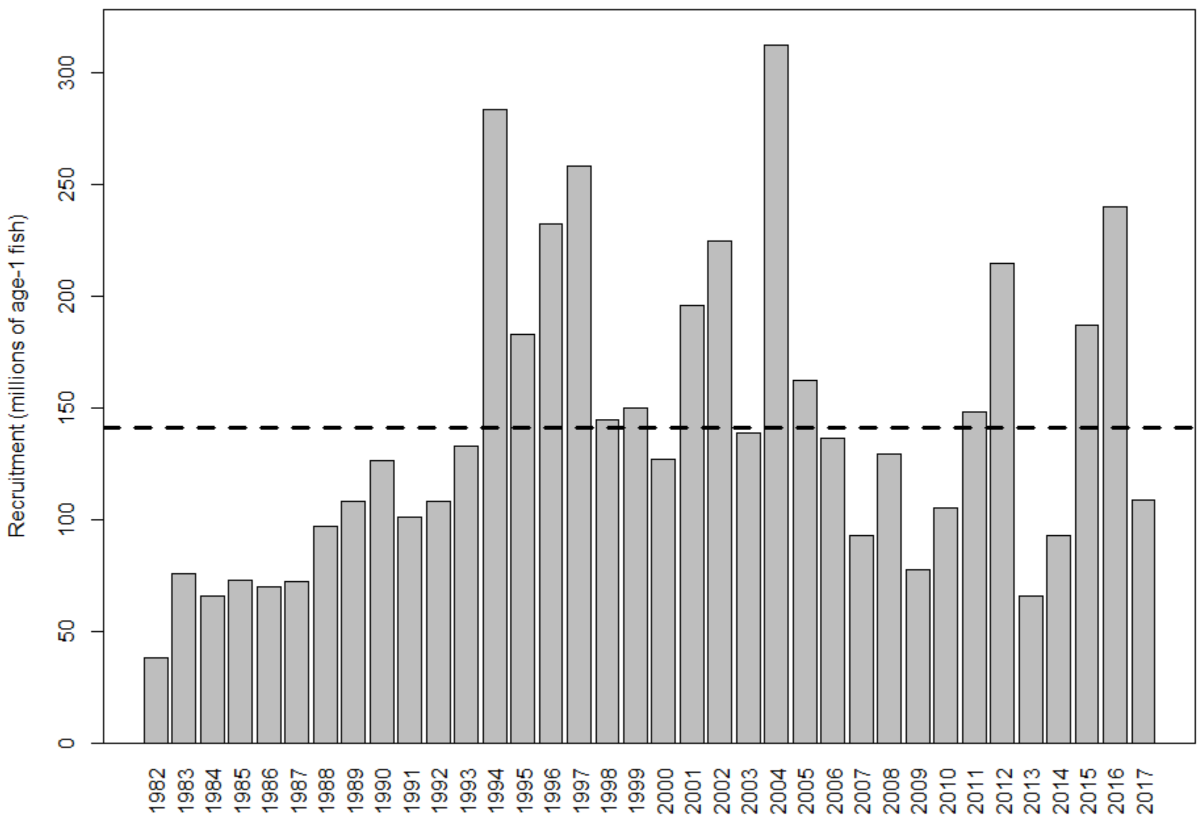


Figure B7. Annual estimates of recruitment for Atlantic striped bass through 2017. Dashed black line indicates time-series average for the stock.

Terms of Reference for SAW/SARC-66, Nov. 27-30, 2018

A. Summer flounder

1. Estimate catch from all sources, including landings and discards. Describe the spatial and temporal distribution of landings, discards, and fishing effort. Characterize the uncertainty in these sources of data. Compare previous recreational data to re-estimated Marine Recreational Information Program (MRIP) data (if available).

2. Present the survey data available, and describe the basis for inclusion or exclusion of those data in the assessment (e.g., indices of relative or absolute abundance, recruitment, state surveys, age-length data, etc.). Investigate the utility of commercial or recreational LPUE as a measure of relative abundance. Characterize the uncertainty and any bias in these sources of data.

3. Describe life history characteristics and the stock's spatial distribution (for both juveniles and adults), including any changes over time. Describe factors related to productivity of the stock and any ecosystem factors influencing recruitment. If possible, integrate the results into the stock assessment.

4. Estimate annual fishing mortality, recruitment and stock biomass (both total and spawning stock) for the time series, and estimate their uncertainty. Include retrospective analyses (both historical and within-model) to allow a comparison with previous assessment results and projections, and to examine model fit. Examine sensitivity of model results to changes in re-estimated recreational data.

5. State the existing stock status definitions for "overfished" and "overfishing". Then update or redefine biological reference points (BRPs; point estimates or proxies for B_{MSY}, $B_{THRESHOLD}$, F_{MSY} and MSY) and provide estimates of their uncertainty. If analytic model-based estimates are unavailable, consider recommending alternative measurable proxies for BRPs. Comment on the scientific adequacy of existing BRPs and the "new" (i.e., updated, redefined, or alternative) BRPs.

6. Make a recommendation[a] about what stock status appears to be, based on the existing model (i.e., model from previous peer reviewed accepted assessment) and with respect to a new modeling approach(-es) developed for this peer review.
   a. Update the existing model with new data and make a stock status recommendation (about overfished and overfishing) with respect to the existing BRP estimates.
   b. Then use the newly proposed modeling approach(-es) and make a stock status recommendation with respect to "new" BRPs and their estimates (from TOR-5).
   c. Include descriptions of stock status based on simple indicators/metrics (e.g., age- and size-structure, temporal trends in population size or recruitment indices, etc).

7. Develop approaches and apply them to conduct stock projections.
   a. Provide numerical annual projections (5 years) and the statistical distribution (i.e., probability density function) of the catch at F_{MSY} or an F_{MSY} proxy (i.e. the overfishing level, OFL) (see Appendix to the SAW TORs). Each projection should estimate and report annual probabilities of exceeding threshold BRPs for F, and probabilities of falling below threshold BRPs for biomass. Use a sensitivity analysis approach in which a range

of assumptions about the most important uncertainties in the assessment are considered (e.g., terminal year abundance, variability in recruitment).

   b. Comment on which projections seem most realistic. Consider the major uncertainties in the assessment as well as sensitivity of the projections to various assumptions. Identify reasonable projection parameters (recruitment, weight-at-age, retrospective adjustments, etc.) to use when setting specifications.
   c. Describe this stock's vulnerability (see "Appendix to the SAW TORs") to becoming overfished, and how this could affect the choice of ABC.

8. Review, evaluate and report on the status of the SARC and Working Group research recommendations listed in most recent SARC reviewed assessment and review panel reports and MAFMC SSC reports. Identify new research recommendations.

[a]NOAA Fisheries has final responsibility for making the stock status determination for this stock based on best available scientific information.

B. Striped bass

1. Investigate all fisheries independent and dependent data sets, including life history, indices of abundance, and tagging data. Discuss strengths and weaknesses of the data sources.

2. Estimate commercial and recreational landings and discards. Characterize the uncertainty in the data and spatial distribution of the fisheries. Review new MRIP estimates of catch, effort and the calibration method, if available.

3. Use an age-based model to estimate annual fishing mortality, recruitment, total abundance and stock biomass (total and spawning stock) for the time series and estimate their uncertainty. Provide retrospective analysis of the model results and historical retrospective. Provide estimates of exploitation by stock component and sex, where possible, and for total stock complex.

4. Use tagging data to estimate mortality and abundance, and provide suggestions for further development.

5. Update or redefine biological reference points (BRPs; point estimates or proxies for BMSY, SSBMSY, FMSY, MSY) for each stock component where possible and for the total stock complex. Make a stock status determination based on BRPs by stock component, where possible, and for the total stock complex.

6. Provide annual projections of catch and biomass under alternative harvest scenarios. Projections should estimate and report annual probabilities of exceeding threshold BRPs for F and probabilities of falling below threshold BRPs for biomass.

7. Review and evaluate the status of the Technical Committee research recommendations listed in the most recent SARC report. Identify new research recommendations. Recommend timing and frequency of future assessment updates and benchmark assessments.

Appendix to the SAW Assessment TORs:

Clarification of Terms used in the SAW/SARC Terms of Reference

On "Acceptable Biological Catch" (DOC Nat. Stand. Guidel. Fed. Reg., v. 74, no. 11, 1-16-2009):

Acceptable biological catch (ABC) is a level of a stock or stock complex's annual catch that accounts for the scientific uncertainty in the estimate of Overfishing Limit (OFL) and any other scientific uncertainty…" *(p. 3208) [In other words, OFL ≥ ABC.]*

ABC for overfished stocks. For overfished stocks and stock complexes, a rebuilding ABC must be set to reflect the annual catch that is consistent with the schedule of fishing mortality rates in the rebuilding plan. *(p. 3209)*

NMFS expects that in most cases ABC will be reduced from OFL to reduce the probability that overfishing might occur in a year. (p. 3180)

ABC refers to a level of ''catch'' that is ''acceptable'' given the ''biological'' characteristics of the stock or stock complex. As such, Optimal Yield (OY) does not equate with ABC. The specification of OY is required to consider a variety of factors, including social and economic factors, and the protection of marine ecosystems, which are not part of the ABC concept. (p. 3189)

On "Vulnerability" (DOC Natl. Stand. Guidelines. Fed. Reg., v. 74, no. 11, 1-16-2009):

"Vulnerability. A stock's vulnerability is a combination of its productivity, which depends upon its life history characteristics, and its susceptibility to the fishery. Productivity refers to the capacity of the stock to produce Maximum Sustainable Yield (MSY) and to recover if the population is depleted, and susceptibility is the potential for the stock to be impacted by the fishery, which includes direct captures, as well as indirect impacts to the fishery (e.g., loss of habitat quality)." (p. 3205)

Participation among members of a Stock Assessment Working Group:

Anyone participating in SAW meetings that will be running or presenting results from an assessment model is expected to supply the source code, a compiled executable, an input file with the proposed configuration, and a detailed model description in advance of the model meeting. Source code for NOAA Toolbox programs is available on request. These measures allow transparency and a fair evaluation of differences that emerge between models.

Guidance to SAW WG about "Number of Models to include in the Assessment Report":

In general, for any TOR in which one or more models are explored by the WG, give a detailed presentation of the "best" model, including inputs, outputs, diagnostics of model adequacy, and sensitivity analyses that evaluate robustness of model results to the assumptions. In less detail, describe other models that were evaluated by the WG and explain their strengths, weaknesses and results in relation to the "best" model. If selection of a "best" model is not possible, present alternative models in detail, and summarize the relative utility each model, including a comparison of results. It should be highlighted whether any models represent a minority opinion.

Procedures for Issuing Manuscripts in the *Northeast Fisheries Science Center Reference Document* (CRD) Series

Clearance

All manuscripts submitted for issuance as CRDs must have cleared the NEFSC's manuscript/abstract/webpage review process. If any author is not a federal employee, he/she will be required to sign an "NEFSC Release-of-Copyright Form." If your manuscript includes material from another work which has been copyrighted, then you will need to work with the NEFSC's Editorial Office to arrange for permission to use that material by securing release signatures on the "NEFSC Use-of-Copyrighted-Work Permission Form."

For more information, NEFSC authors should see the NEFSC's online publication policy manual, "Manuscript/abstract/webpage preparation, review, and dissemination: NEFSC author's guide to policy, process, and procedure," located in the Publications/Manuscript Review section of the NEFSC intranet page.

Organization

Manuscripts must have an abstract and table of contents, and (if applicable) lists of figures and tables. As much as possible, use traditional scientific manuscript organization for sections: "Introduction," "Study Area" and/or "Experimental Apparatus," "Methods," "Results," "Discussion," "Conclusions," "Acknowledgments," and "Literature/References Cited."

Style

The CRD series is obligated to conform with the style contained in the current edition of the United States Government Printing Office Style Manual. That style manual is silent on many aspects of scientific manuscripts. The CRD series relies more on the CSE Style Manual. Manuscripts should be prepared to conform with these style manuals.

The CRD series uses the American Fisheries Society's guides to names of fishes, mollusks, and decapod crustaceans, the Society for Marine Mammalogy's guide to names of marine mammals, the Biosciences Information Service's guide to serial title abbreviations, and the ISO's (International Standardization Organization) guide to statistical terms.

For in-text citation, use the name-date system. A special effort should be made to ensure that all necessary bibliographic information is included in the list of cited works. Personal communications must include date, full name, and full mailing address of the contact.

Preparation

Once your document has cleared the review process, the Editorial Office will contact you with publication needs – for example, revised text (if necessary) and separate digital figures and tables if they are embedded in the document. Materials may be submitted to the Editorial Office as email attachments or intranet downloads. Text files should be in Microsoft Word, tables may be in Word or Excel, and graphics files may be in a variety of formats (JPG, GIF, Excel, PowerPoint, etc.).

Production and Distribution

The Editorial Office will perform a copy-edit of the document and may request further revisions. The Editorial Office will develop the inside and outside front covers, the inside and outside back covers, and the title and bibliographic control pages of the document.

Once the CRD is ready, the Editorial Office will contact you to review it and submit corrections or changes before the document is posted online.

A number of organizations and individuals in the Northeast Region will be notified by e-mail of the availability of the document online.

Research Communications Branch
Northeast Fisheries Science Center
National Marine Fisheries Service, NOAA
166 Water St.
Woods Hole, MA 02543-1026

MEDIA
MAIL

Publications and Reports of the Northeast Fisheries Science Center

The mission of NOAA's National Marine Fisheries Service (NMFS) is "stewardship of living marine resources for the benefit of the nation through their science-based conservation and management and promotion of the health of their environment." As the research arm of the NMFS's Northeast Region, the Northeast Fisheries Science Center (NEFSC) supports the NMFS mission by "conducting ecosystem-based research and assessments of living marine resources, with a focus on the Northeast Shelf, to promote the recovery and long-term sustainability of these resources and to generate social and economic opportunities and benefits from their use." Results of NEFSC research are largely reported in primary scientific media (*e.g.*, anonymously-peer-reviewed scientific journals). However, to assist itself in providing data, information, and advice to its constituents, the NEFSC occasionally releases its results in its own media. Currently, there are three such media:

NOAA Technical Memorandum NMFS-NE -- This series is issued irregularly. The series typically includes: data reports of long-term field or lab studies of important species or habitats; synthesis reports for important species or habitats; annual reports of overall assessment or monitoring programs; manuals describing program-wide surveying or experimental techniques; literature surveys of important species or habitat topics; proceedings and collected papers of scientific meetings; and indexed and/or annotated bibliographies. All issues receive internal scientific review and most issues receive technical and copy editing.

Northeast Fisheries Science Center Reference Document -- This series is issued irregularly. The series typically includes: data reports on field and lab studies; progress reports on experiments, monitoring, and assessments; background papers for, collected abstracts of, and/or summary reports of scientific meetings; and simple bibliographies. Issues receive internal scientific review and most issues receive copy editing.

Resource Survey Report (formerly *Fishermen's Report*) -- This information report is a regularly-issued, quick-turnaround report on the distribution and relative abundance of selected living marine resources as derived from each of the NEFSC's periodic research vessel surveys of the Northeast's continental shelf. This report undergoes internal review, but receives no technical or copy editing.

TO OBTAIN A COPY of a *NOAA Technical Memorandum NMFS-NE* or a *Northeast Fisheries Science Center Reference Document*, either contact the NEFSC Editorial Office (166 Water St., Woods Hole, MA 02543-1026; 508-495-2350) or consult the NEFSC webpage on "Reports and Publications" (http://www.nefsc.noaa.gov/nefsc/publications/). To access *Resource Survey Report*, consult the Ecosystem Surveys Branch webpage (http://www.nefsc.noaa.gov/femad/ecosurvey/mainpage/).