



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

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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 $F_{\text{THRESHOLD}}$.

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 ($B_{\text{THRESHOLD}}$) 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 $B_{\text{THRESHOLD}}$ and overfishing is occurring if current F is greater than $F_{\text{THRESHOLD}}$. 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	$F = F_{TARGET} \leq F_{MSY}$
	$F < F_{THRESHOLD}$	Overfished, overfishing is not occurring; adopt and follow rebuilding plan	Not overfished, overfishing is not occurring; rebuild stock	$F = F_{TARGET} \leq F_{MSY}$

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 ($1,000,000 \times 0.00548$), leaving 994,520 alive. On day 2, another 5,450 fish die ($994,520 \times 0.00548$) 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:

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

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%.

F_{MAX}. 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, F_{x%}, 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

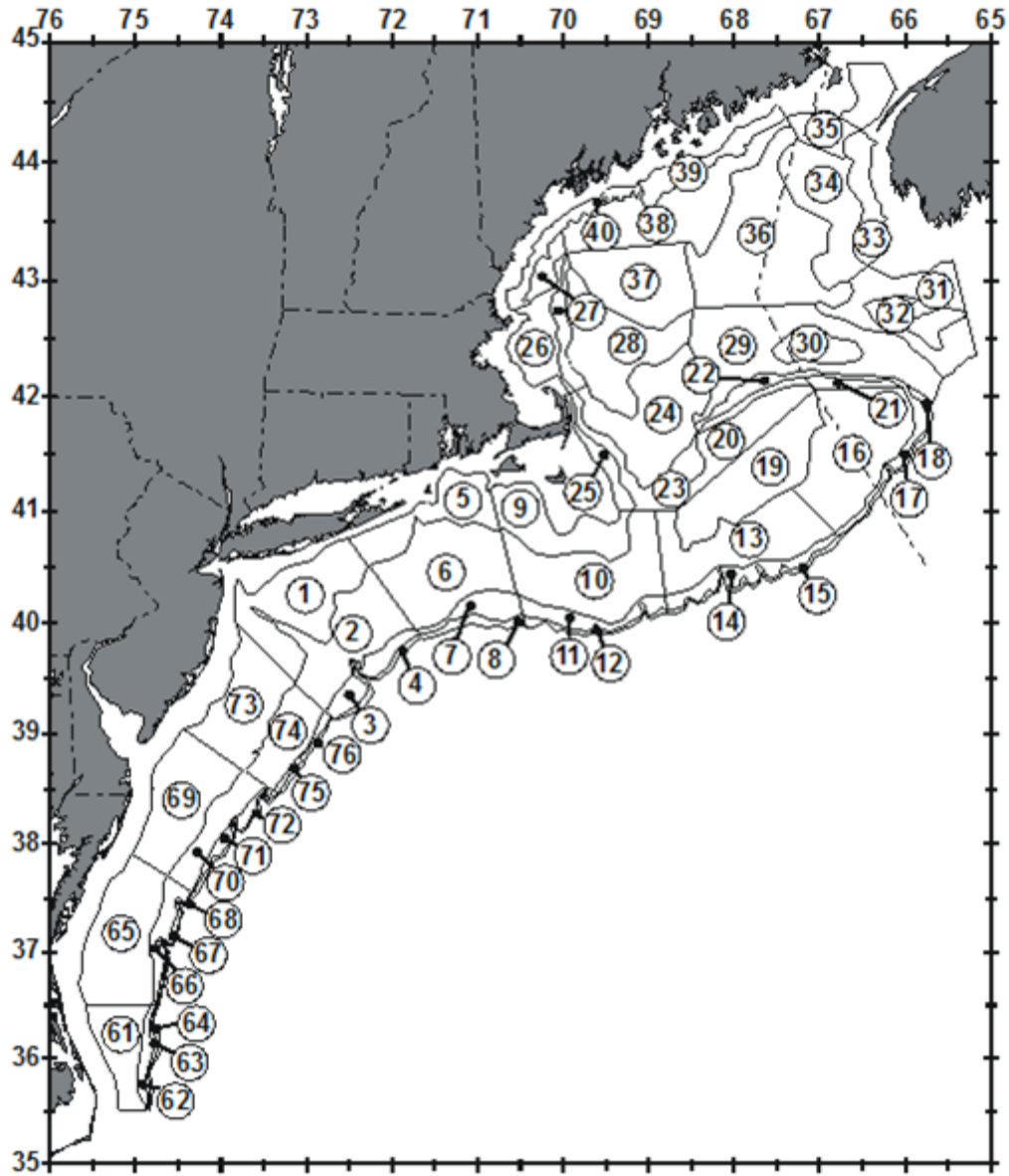


Figure 1. Offshore depth strata sampled during Northeast Fisheries Science Center bottom trawl research surveys. Some of these may not be sampled presently.

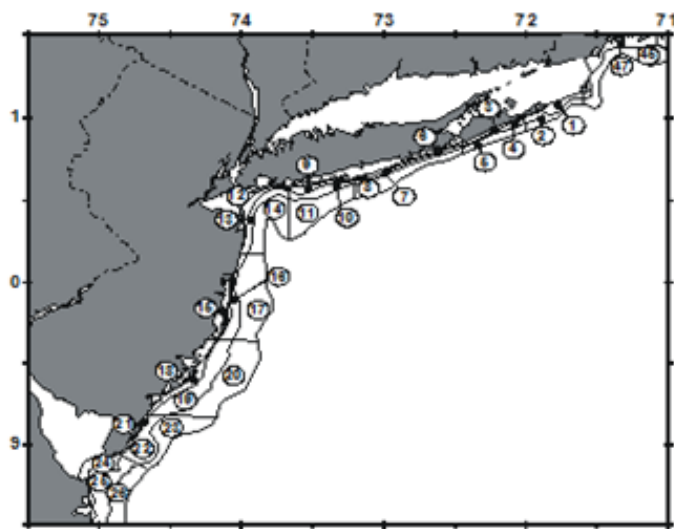
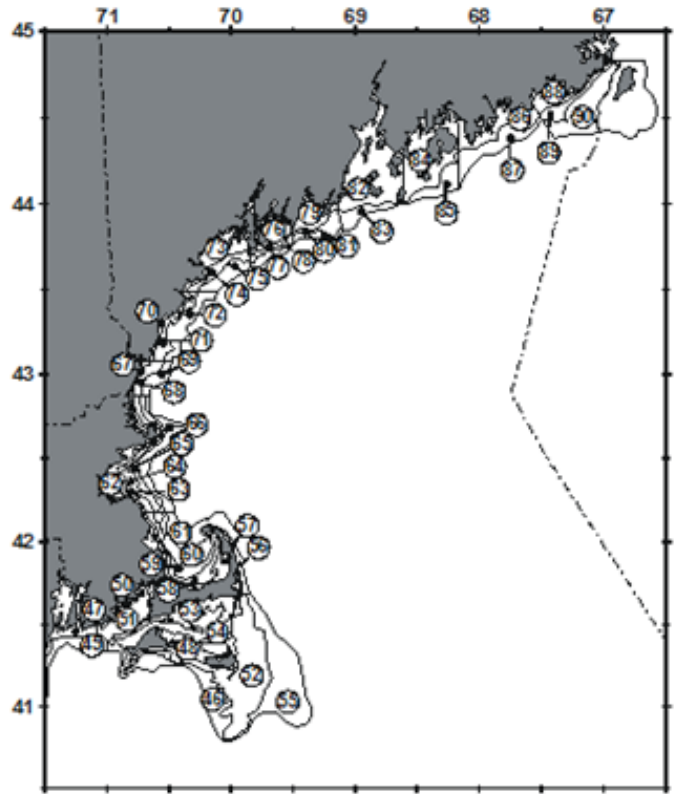
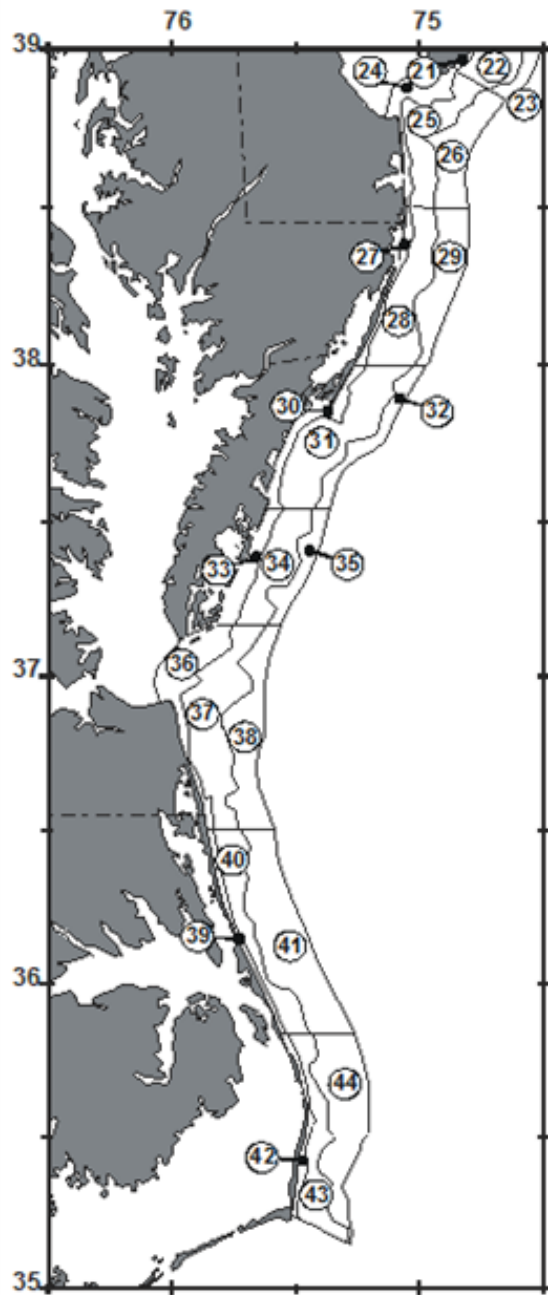


Figure 2. Inshore depth strata sampled during Northeast Fisheries Science Center bottom trawl research surveys. Some of these may not be sampled presently.

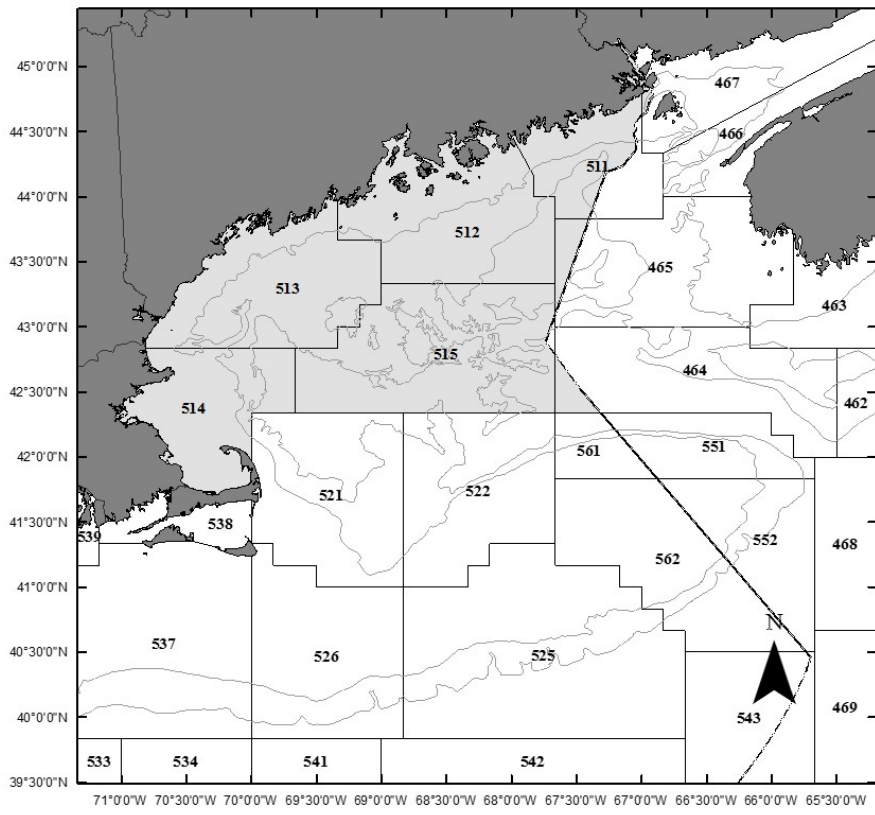
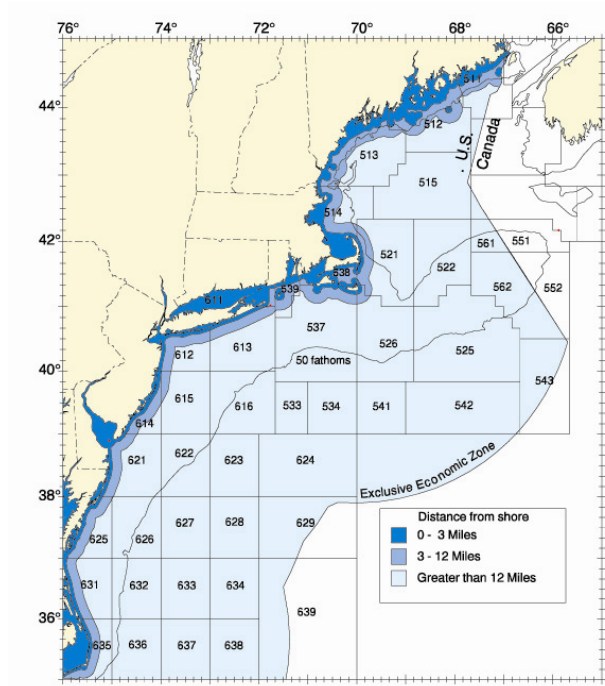


Figure 3. Statistical areas used for reporting commercial catches.

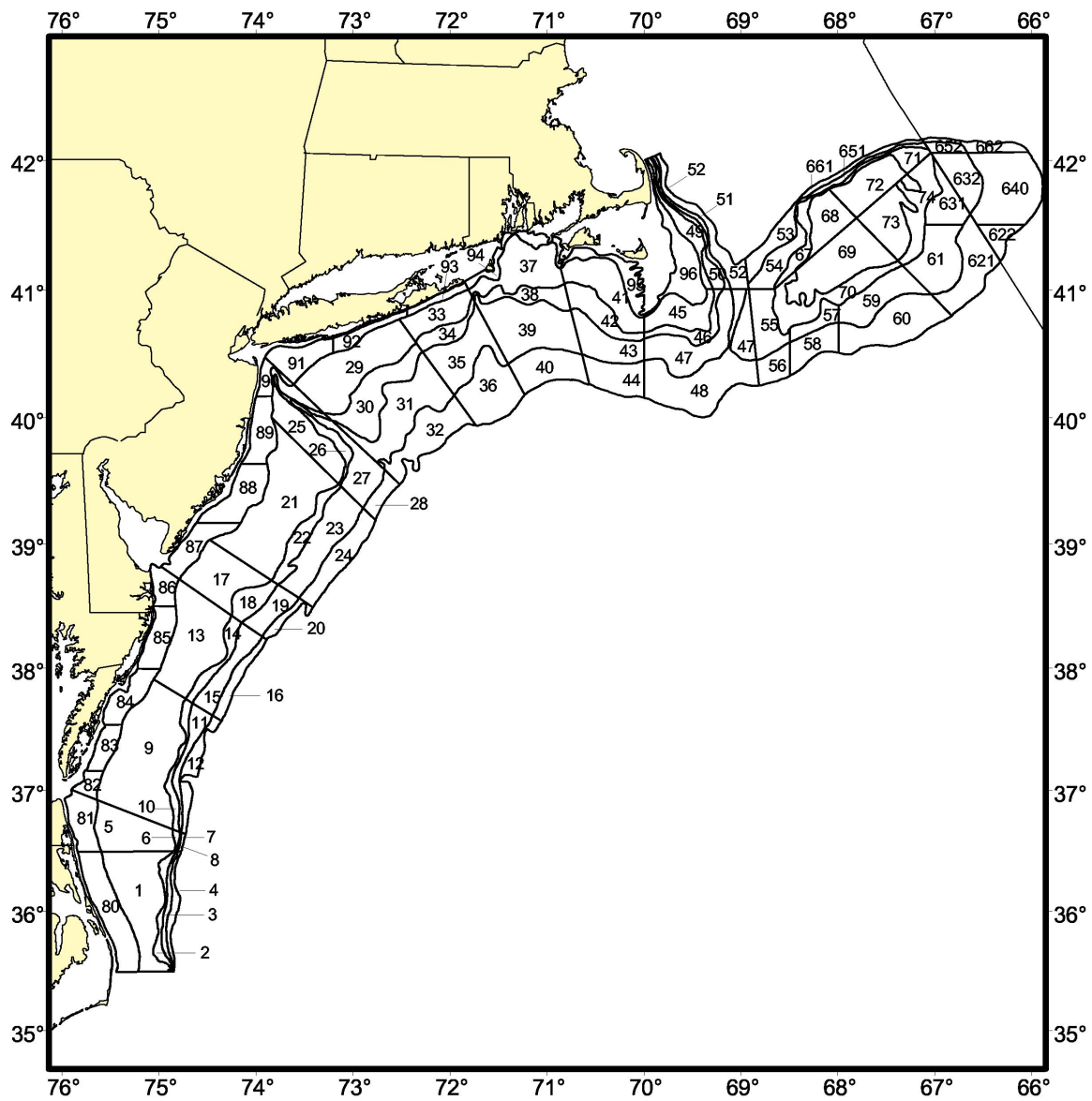


Figure 4. Northeast Fisheries Science Center shellfish resource survey strata, along the east coast of the US.

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 = $\frac{1}{2} SSB_{35\%}$ = 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 ChesMMAF, 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 $\frac{1}{2} SSB_{MSY}$ threshold proxy = $\frac{1}{2} SSB_{35\%}$ = 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.

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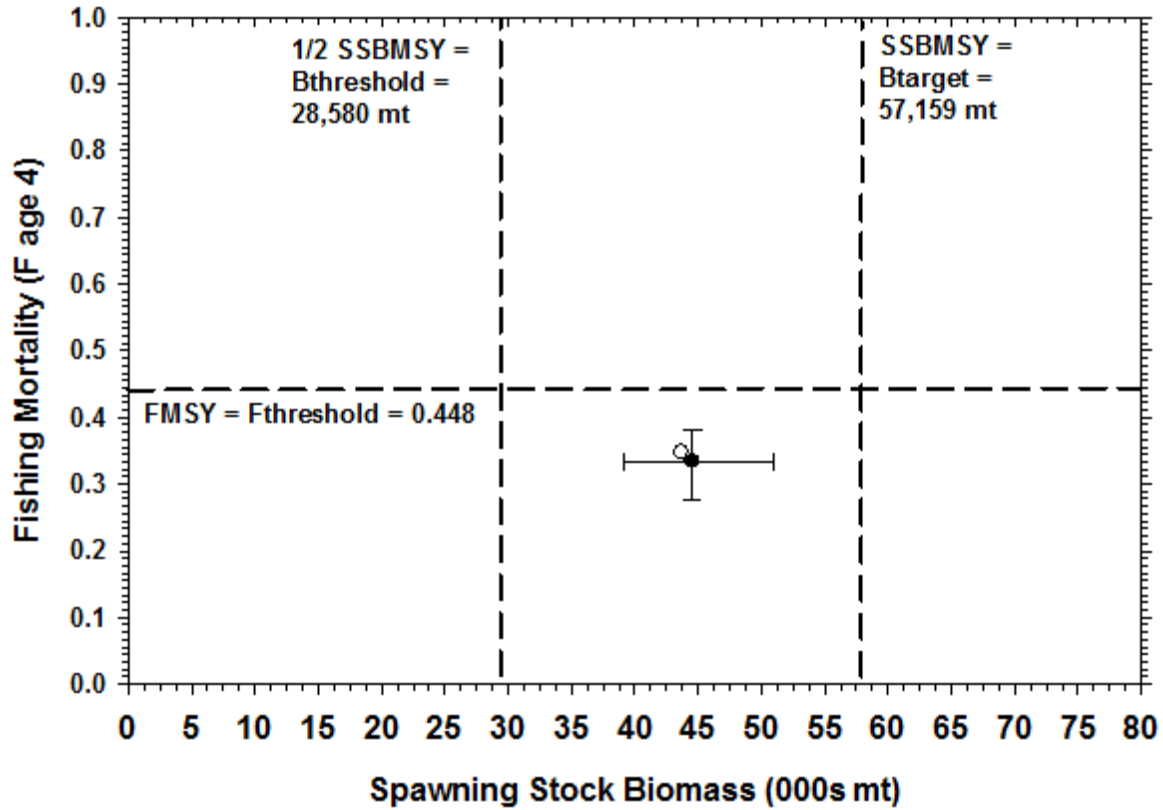


Figure A1. Estimates of summer flounder spawning stock biomass (SSB) and fully-recruited fishing mortality (F, peak at age 4) relative to the 2018 SAW-66 biological reference points. Filled circle with 90% confidence intervals shows the assessment point estimates. The open circle shows the retrospectively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

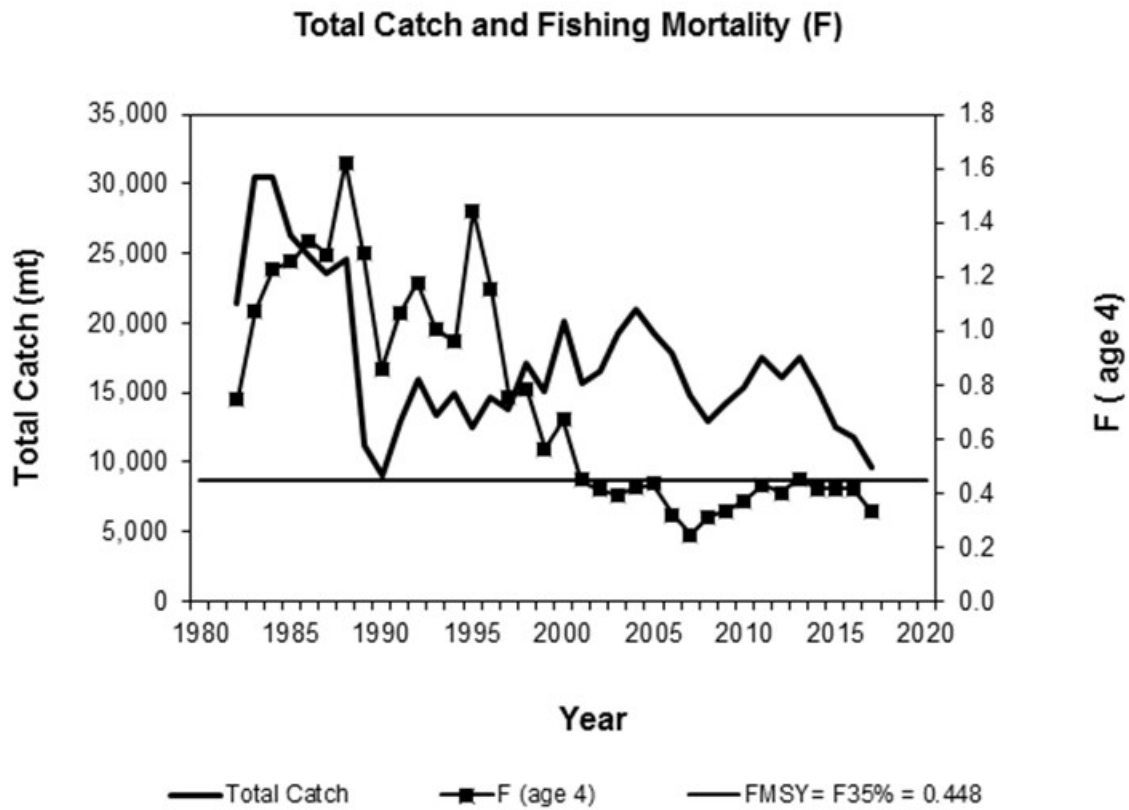


Figure A2. Total fishery catch (metric tons; mt; solid line) and fully-recruited fishing mortality (F, peak at age 4; squares) of summer flounder through 2017. The horizontal solid line is the 2018 SAW-66 threshold fishing mortality reference point proxy.

Spawning Stock Biomass (SSB) and Recruitment (R)

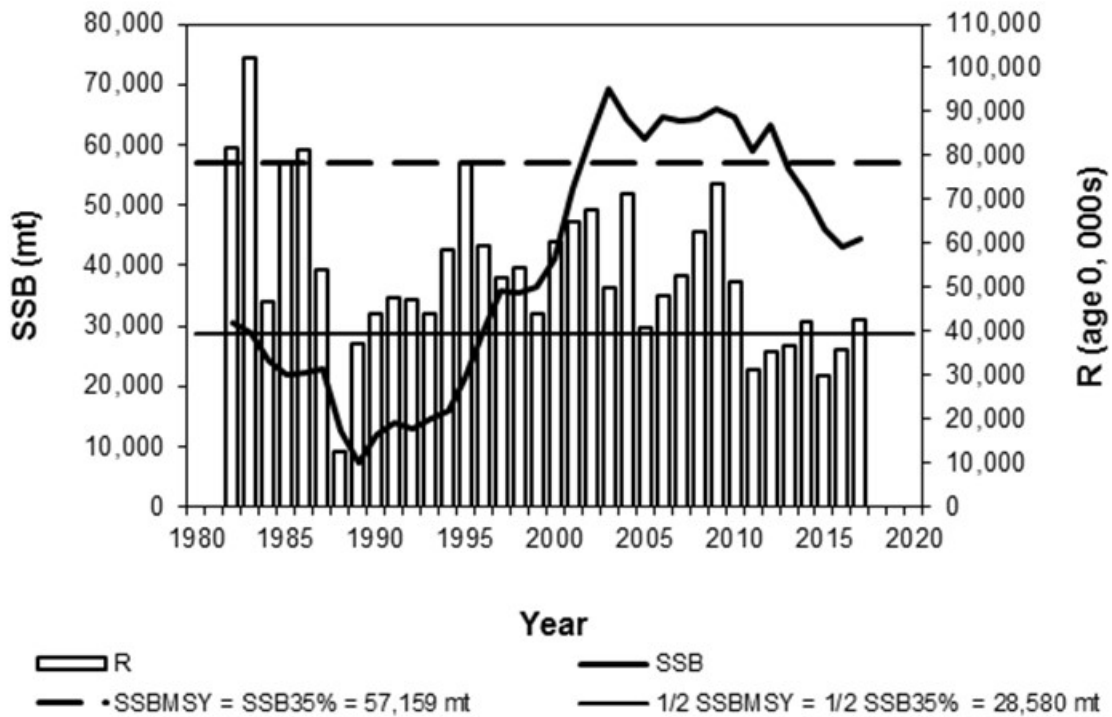


Figure A3. Summer flounder spawning stock biomass (SSB; solid line) and recruitment at age 0 (R; vertical bars) by calendar year through 2017. The horizontal dashed line is the 2018 SAW-66 target biomass reference point proxy. The horizontal solid line is the 2018 SAW-66 threshold biomass reference point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

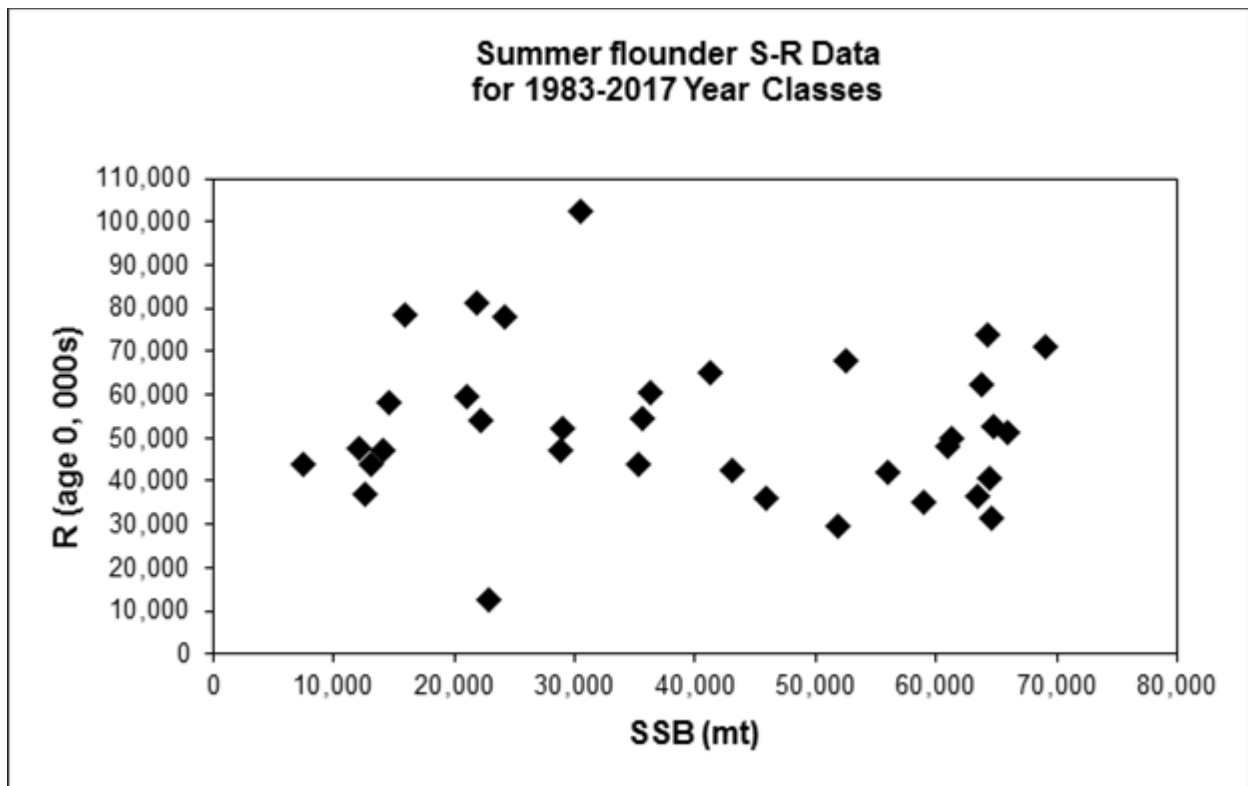


Figure A4. Stock-recruitment (SSB-R) scatter plot for the summer flounder 1983-2017 year classes. The largest recruitment (R) point is the 1983 year class (R = 102 million, SSB = 30,451 mt). The lowest recruitment point is for the 1988 year class (R = 12 million, SSB = 22,913 mt). The 2017 year class is at R = 42 million, SSB₂₀₁₆ = 43,000 mt.

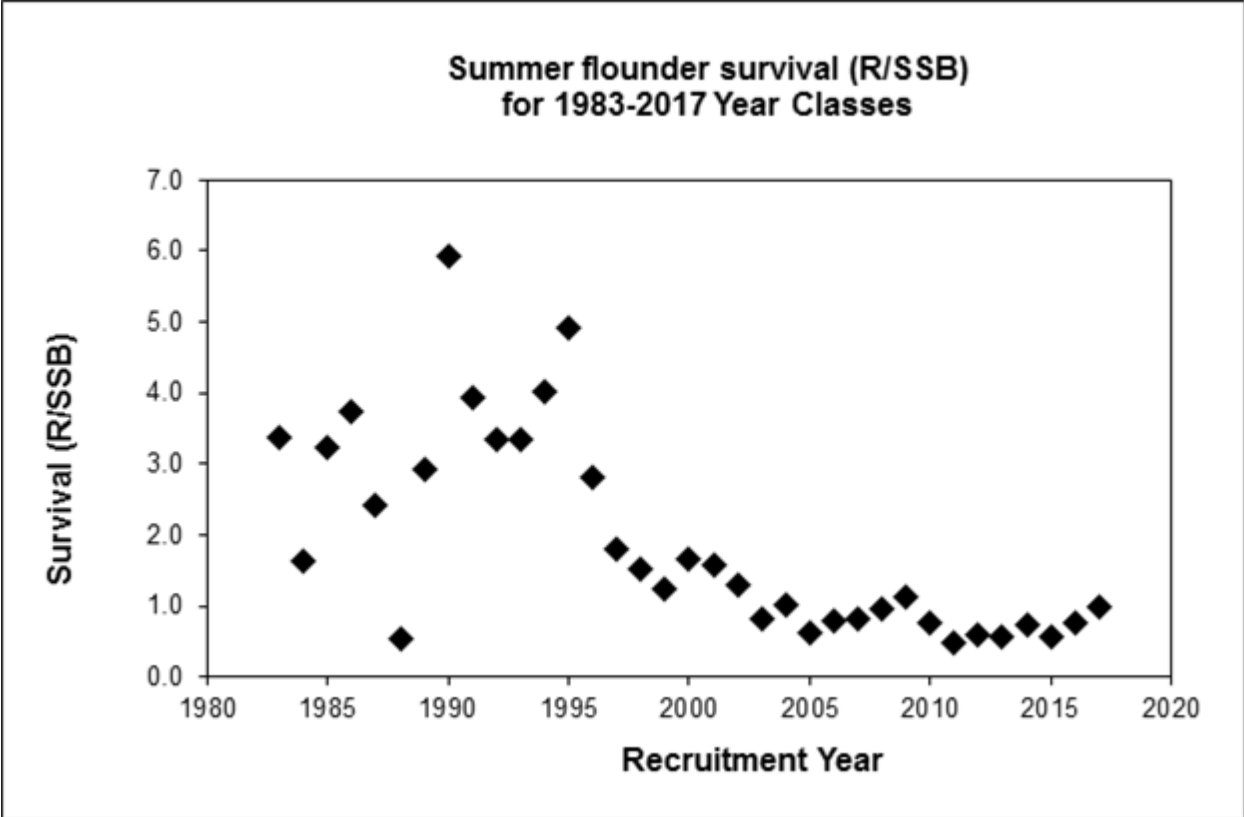


Figure A5. Recruits per Spawning Stock Biomass ratio (R/SSB) plot indicative of the relative survival of the summer flounder 1983-2017 year classes.

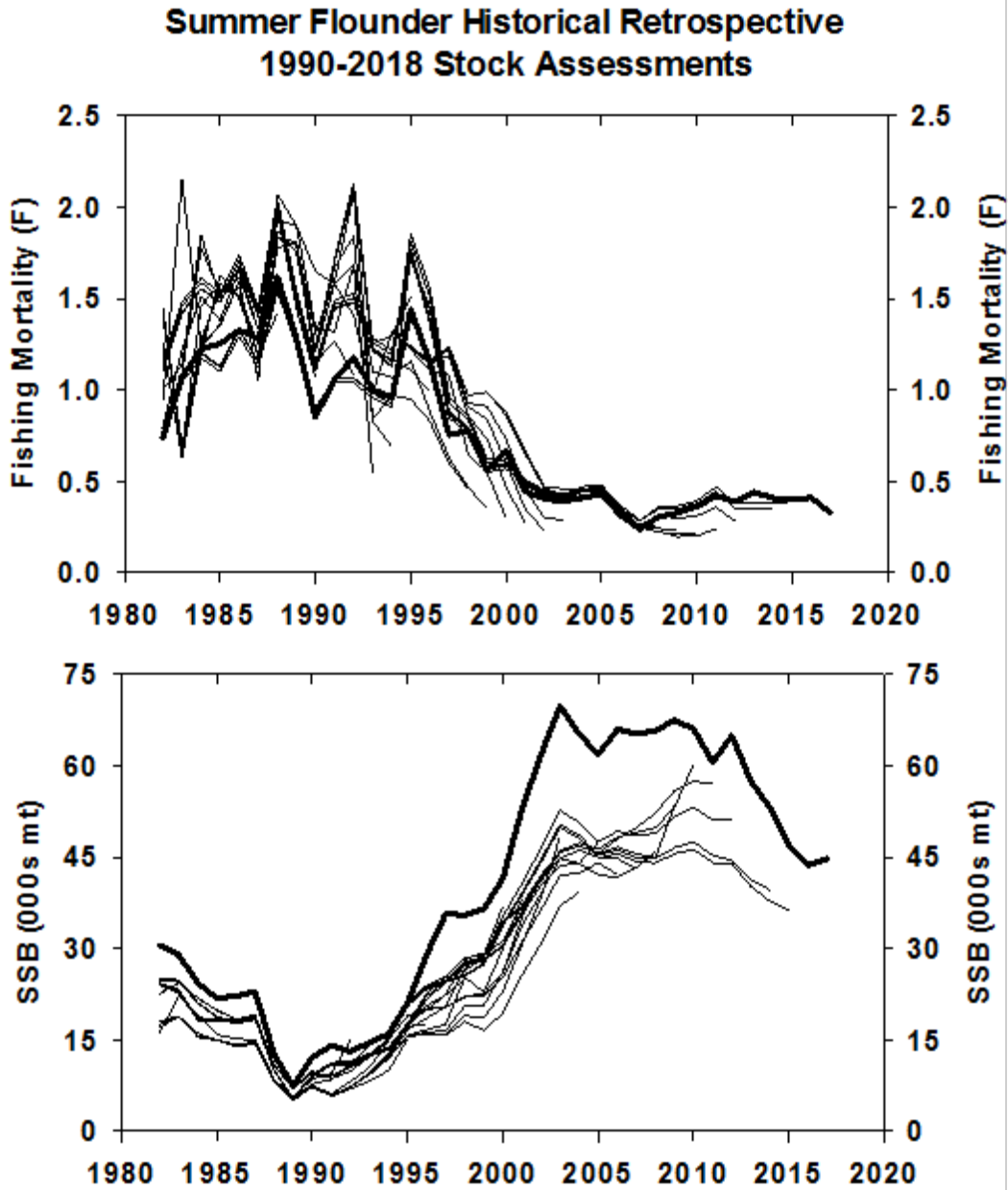


Figure A6. Historical retrospective of the 1990-2018 stock assessments of summer flounder. The heavy solid lines are the 2018 SAW-66 estimates.