Northeast Fisheries Science Center Reference Document 08-11

A Report of the 47th Northeast Regional Stock Assessment Workshop

47th Northeast Regional Stock Assessment Workshop (47th SAW) Assessment Summary Report

July 2008

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

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SAW-47 ASSESSMENT SUMMARY REPORT

Introduction

The 47h SAW Assessment Summary Report contains summary and detailed technical information on one assessment reviewed in June 2008 at the Stock Assessment Workshop (SAW) by the 47th Stock Assessment Review Committee (SARC-47): summer flounder (*Paralichthys dentatus*). The SARC-47 consisted of three external, independent reviewers appointed by the Center for Independent Experts (CIE) and an external SARC chairman from the South Atlantic Fishery Management Council staff. 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-47 are available at website: http://www.nefsc.noaa.gov/nefsc/saw/ under the heading "SARC 47 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 FTHRESHOLD.

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 (BTHRESHOLD) the stock is in an overfished condition. The Sustainable Fisheries Act mandates that a stock rebuilding plan be developed should this situation arise.

Since 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 should be managed on the basis of maximum sustainable yield (MSY). The biomass that produces this yield is called BMSY and the fishing mortality rate that produces MSY is called FMSY.

Given this, stocks under review are classified with respect to current overfishing definitions. A stock is overfished if its current biomass is below BTHRESHOLD and overfishing is occurring if current F is greater than FTHRESHOLD. The table below depicts status criteria.

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

Based on the Review Panel reports (available at http://www.nefsc.noaa.gov/nefsc/saw/ under the heading "SARC 47 Panelist Reports"), the SARC review committee concluded that the assessment successfully met all of its terms of reference. The SARC felt that the extensive data for the assessment were correctly compiled, and the assessment was conducted in accord with good scientific practice. The review committee agreed that the 'ASAP' catch-age model best estimated stock status parameters, and that F35% and F40% were reasonable new proxies for the overfishing threshold and the target fishing mortality, respectively. The new assessment used a revised natural mortality rate value (changed from M = 0.20 to M = 0.25), which took account of differential longevity between the sexes. The SARC accepted this revision, but noted that model results are sensitive to M, and that estimation of M could be revisited in the future.

The SARC felt that: (1) combining separate surveys is a significant research question beyond the scope of this assessment; (2) treating zero catches from the survey as missing values was acceptable; (3) alternative models were examined and adequately presented; (4) the final assessment model provides a credible basis for developing management advice; (5) the number of catch-at-age matrices and fleets that can be modeled separately is constrained by data availability; (6) spatial and temporal patterns in age compositions of both the commercial landings and trawl surveys were adequately explored; (7) sex ratios, and differences in growth and maturity between males and female summer flounder were explored, but only limited analyses could be undertaken as sex-specific data from the commercial and recreational fisheries (as well as from State surveys) are not available; and (8) the inclusion of certain environmental factors in the current model configurations did not improve model performance.

The SARC understood that a minimal number of projections were provided, and that additional projections would subsequently be prepared in consultation with fishery managers.

The SARC felt that comparison of the new assessment results with the "existing biological reference points" (developed in 2006) is not advisable - due to the changes this year in the assessment model and the yield per recruit inputs.

The SARC noted that the description of the commercial and recreational fisheries provided in the reports was incomplete. Furthermore, the Panel recommends that future reports contain a more synoptic and transparent description of the model specification and model building/ selection procedures, including estimates of uncertainty in F/Fmsy and SSB/SSBmsy.

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:

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

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, 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 rebuilding 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 2 (SS2). This application provides a statistical framework for calibration of a population dynamics model using a diversity of fishery and survey data. SS2 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 searched for 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 SS2 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), see above.

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 5 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.

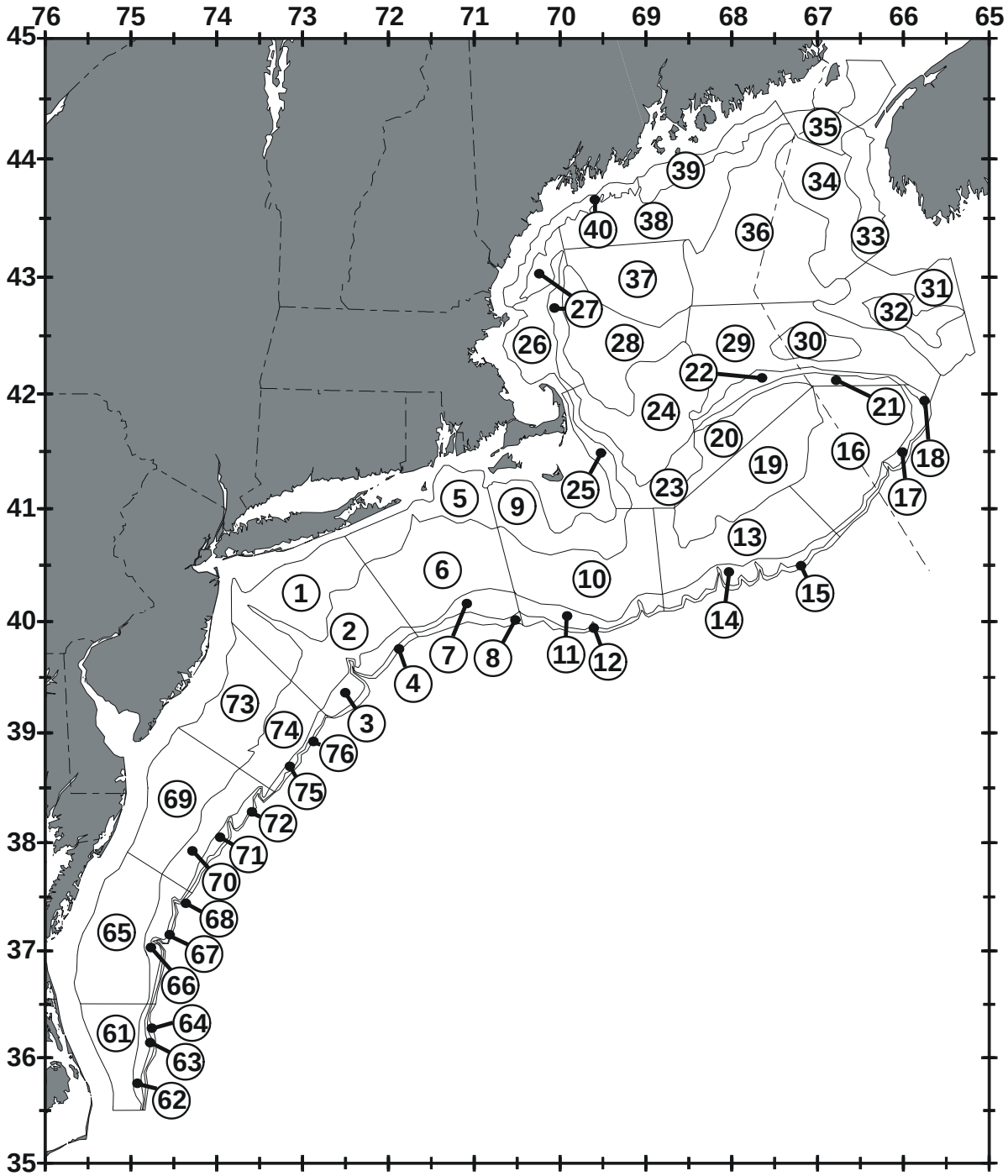

Figure 1. Offshore depth strata sampled during Northeast Fisheries Science Center bottom trawl research surveys.

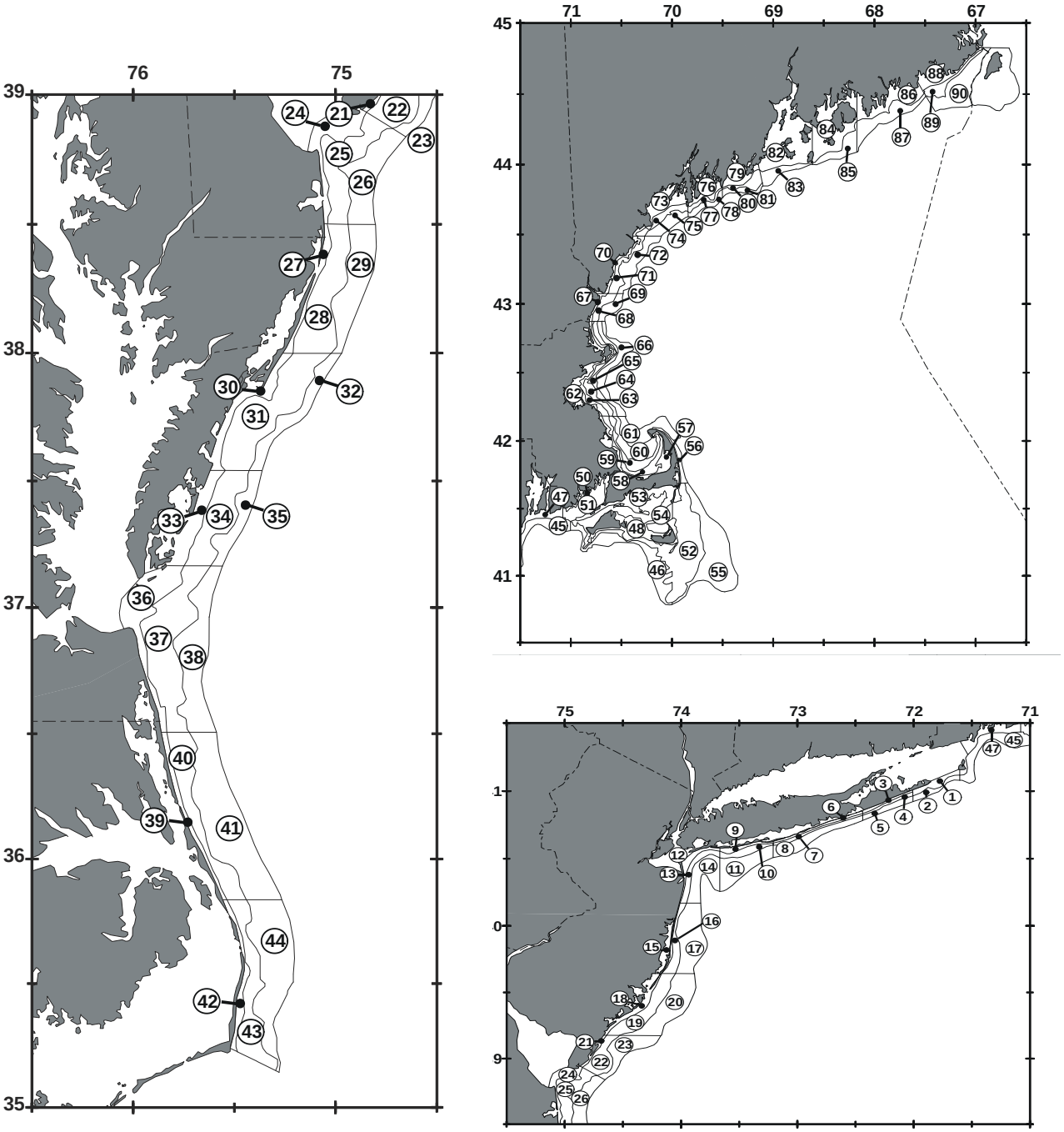

Figure 2. Inshore depth strata sampled during Northeast Fisheries Science Center bottom trawl research surveys.

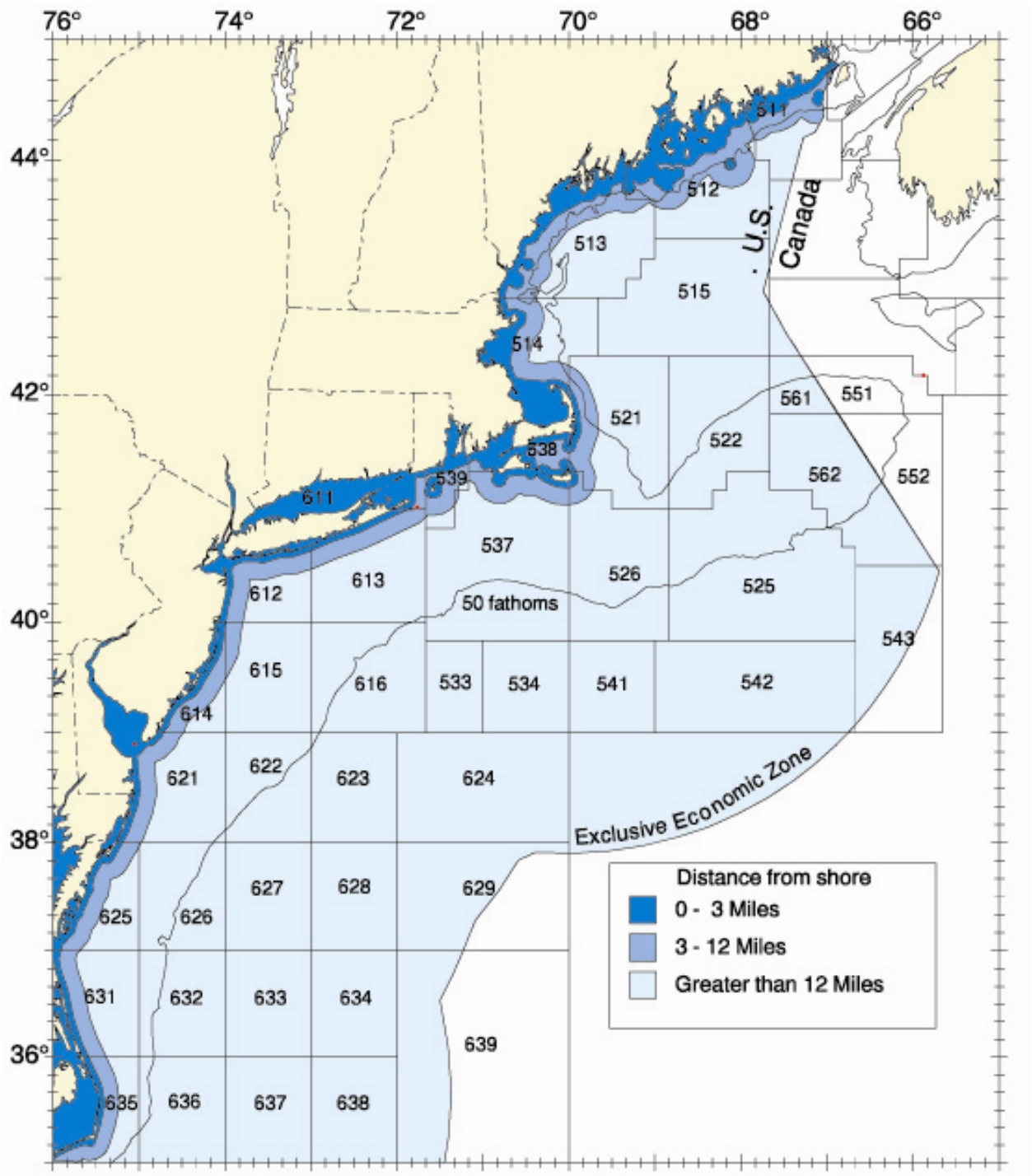

Figure 3. Statistical areas used for reporting commercial catches.

A. SUMMER FLOUNDER ASSESSMENT SUMMARY FOR 2008

State of Stock: The summer flounder stock is not overfished and overfishing is not occurring relative to the proposed 2008 assessment biological reference points. The stock is currently under a rebuilding program with a deadline of January 1, 2013 [corresponds to November 1, 2012 estimate of SSB]. Fishing mortality calculated from the average of the current fully recruited ages (3-7+) ranged between 1.143 and 2.042 during 1982-1996. The fishing mortality rate has declined to below 1.000 since 1996 and was estimated to be 0.288 in 2007, below the proposed fishing mortality threshold reference point = F35% (= FMSY proxy) = 0.310 (Figure A1). There is an 80% probability that the fishing mortality rate in 2007 was between 0.253 and 0.325. Spawning stock biomass (SSB) declined from 24,674 mt in 1982 to 7,017 in 1989, then increased to 43,932 mt by 2004. SSB was estimated to be 43,363 in 2007, about 72% of the proposed SSB35% (= SSBMSY target proxy reference point) = 60,074 mt (Figures A2 & A3). There is an 80% chance that SSB in 2007 was between 39,325 and 48,122 mt. The arithmetic average recruitment from 1982 to 2007 is 41.6 million fish at age 0. The 1982 and 1983 year classes are the largest in the assessment time series, at 73.5 and 81.6 million fish; the 1988 year class is the smallest at 12.8 million fish. The 2007 year class is currently estimated to be about 40.0 million fish (Figure A2).

The assessment has exhibited a retrospective pattern of underestimation of F and overestimation of SSB; the causes of this pattern have not been determined (Figures A4 & A5). No retrospective pattern in recruitment is evident (Figure A6). Over the last 3 years, the annual retrospective change in fishing mortality has ranged from +30 [2004] to -5% [2006]; over the last 3 years, the annual retrospective change in SSB has ranged from -29 [2004] to +6% [2006].

Forecasts for 2008-2009: Stochastic forecasts (see Forecast Table on the following page) do not explicitly account for the recent retrospective pattern in the assessment, as per the 2006 S&T Peer Review (Terceiro 2006) recommendation. If landings in 2008 are 7,153 mt (15.8 million lbs; the 2008 TAL), and discards are 885 mt (2.0 million lbs), the forecast estimates a median (50% probability) F in 2008 = 0.238 and a median SSB on November 1, 2008 of 46,992 mt, which is above the proposed biomass threshold of one-half SSBMSY = 30,037 mt (Figure A3). Fishing at Frebuild = 0.274 in 2009 results in forecast median (50%ile) landings of 9,211 mt (20.3 million lbs); the corresponding 25%ile of landings is 8,653 mt (19.1 million lbs). Continued fishing at Frebuild = 0.274 during 2010-2012 is forecast to rebuild the stock to SSBMSY = 60,074 in 2012. Fishing at F35% = 0.310 during 2009-2012 is forecast to result in SSB = 56,471 mt in 2012, which is below the proposed SSBMSY. Fishing at F40% = 0.255 during 2009-2012 is forecast to result in SSB = 62,181 mt in 2012, which is above the proposed SSBMSY.

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 northeast to the US-Canada border. 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 recent summer flounder genetics study, which revealed no population subdivision at Cape Hatteras (Jones and Quattro 1999), is consistent with the definition of the current management unit. A recent consideration of summer flounder stock structure incorporating tagging data concluded that evidence 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 off Virginia-North Carolina (Kraus and Musick, 2003). The conclusions of Kraus and Musick (2003) are consistent with the current stock assessment unit.

Forecast Table

2008 Landings = 7,153 mt; F2008 = 0.238

2008-2009 recruitment drawn from distribution of 1982-2007 ASAP estimates

Forecast probabilities are 25% and 50% intervals of landings* for F

Landings, Discards, and Spawning Stock Biomass (SSB) in mt

	2008			2009		
Frebuild = 0.274	Land	Disc	SSB	Land	Disc	SSB
25%ile	7153	885	46992	8653	1132	54253
50%ile	7153	885	46992	9211	1208	51663

	2008			2009		
FMSY = F35%=0.310	Land	Disc	SSB	Land	Disc	SSB
25%ile	7153	885	46992	9627	1265	53171
50%ile	7153	885	46992	10249	1350	50632

	2008			2009		
Ftarget = F40%=0.255	Land	Disc	SSB	Land	Disc	SSB
25%ile	7153	885	46992	8104	1057	54861
50%ile	7153	885	46992	8626	1129	52246

* based on previous TAL specification percentiles

Catch and Status Table (weights in 000s mt, recruitment in millions, arithmetic means)

Year	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	Max[1]	Min[1]	Mean[1]
Commercial landings	5.1	4.8	5.1	5.0	6.6	6.5	8.2	7.8	6.3	4.5	17.1	4.0	8.2
Commercial discards	0.4	1.5	0.7	0.5	0.5	0.5	0.2	0.2	0.3	0.3	1.5	0.2	0.6
Recreational landings	5.7	3.8	7.5	5.3	3.6	5.3	4.8	4.7	5.0	4.4	12.7	1.4	5.3
Recreational discards	0.7	0.7	1.0	1.3	0.8	0.9	1.0	1.0	0.8	1.1	1.3	0.1	0.6
Catch used in assessment	11.9	10.9	14.2	12.0	11.4	13.1	14.3	13.8	12.3	10.4	26.5	8.0	14.6
Commercial quota	5.0	5.0	5.0	4.9	6.6	6.3	7.6	8.1	6.4	4.7	8.1	4.7	7.5
Recreational harvest limit	3.4	3.4	3.4	3.2	4.4	4.2	5.1	5.5	4.3	3.1	5.5	3.1	5.0
Spawning stock biomass[2]	27.7	28.1	30.3	35.7	40.4	43.7	43.9	42.1	41.7	43.4	43.9	7.0	24.8
Recruitment (age 0)	40.6	32.1	39.4	37.1	42.1	31.7	49.0	24.0	28.8	40.0	81.6	12.8	41.6
F (ages 3-7+)	0.80	0.57	0.68	0.50	0.44	0.42	0.46	0.47	0.37	0.29	2.04	0.29	1.09

1: Over the period 1982-2007

2: On November 1 annually

Catch: Total landings peaked in 1983 at 26,100 mt. During the late 1980s and into 1990, landings declined markedly, reaching 4,200 mt in the commercial fishery in 1990 and 1,400 mt in the recreational fishery in 1989. Total landings were only 6,500 mt in 1990. Reported 2007 landings in the commercial fishery were 4,489 mt, about 5% under the commercial quota. Commercial discards are estimated from fishery observer data and have recently accounted for 5%-10% of the total commercial removals, assuming a discard mortality rate of 80%. Estimated 2007 landings in the recreational fishery were 4,445 mt, about 36% above the recreational harvest limit. Recreational discard losses have recently accounted for 10%-15% of the total recreational removals, assuming a discard mortality rate of 10%. Total commercial and recreational landings in 2007 were 8,934 mt, and total catch was estimated at 10,368 mt (Figure A1).

Data and Assessment: The age-structured assessment model for summer flounder has changed from an ADAPT VPA model to a forward projecting ASAP model (NFT 2008a). With the same inputs and underlying assumptions, these two models produce similar results. A new value for natural mortality (M) has been adopted, changing from a constant value of M = 0.20 to an age-specific schedule of M with mean = 0.25. Biological reference points have been revised to reflect changes in the input data and the assessment model. The fishery catch is now modeled as two fleets; totals landings and total discards. Data from multiple trawl surveys were used in the ASAP calibration, including indices of recruitment and stock abundance from the following surveys: NEFSC winter, spring, and autumn, Massachusetts spring and autumn, Rhode Island, Connecticut spring and autumn, Delaware and New Jersey. Recruitment indices from surveys conducted by the states of North Carolina, Virginia, and Maryland were also used in the calibration.

Biological Reference Points (BRP): The FMP Amendment 12 (MAFMC 1999) Biological Reference Points were estimated as yield at Fmax, used as a proxy for MSY, at 21,444 mt (47.3 million lbs), and the corresponding total stock biomass (TSB) as 97,430 mt (214.8 million lbs). The 2006 NMFS S&T Peer Review recommended that spawning stock biomass (SSB) be used as the biomass reference point. The 2006 S&T assessment reference points, which are the existing BRPs, are Fmax = FMSY = 0.280 and SSBMSY = 89,411 mt = 197.1 million lbs (Terceiro 2006).

The proposed biological reference points for summer flounder are based on yield and SSB per recruit and projection models in the NOAA NFT framework (NFT 2006, 2008b; Thompson and Bell 1934). The recommended proxy for FMSY changed from Fmax to F35%, and F40% is recommended as an Ftarget (see Special Comments). The proposed fishing mortality threshold reference point is F35% = 0.310, a proxy for FMSY. The proposed SSB target reference point is estimated as the projection of Jan 1, 2008 stock sizes at F35% = 0.310 and recruitment generated by random sampling from a cumulative density function (mean=41.6 million fish per year; 1982-2007). The proposed SSBMSY target is estimated to be 60,074 mt (132.4 million lbs), and the biomass threshold, one-half SSBMSY, is estimated to be 30,037 mt (66.2 million lbs). F40% = 0.255 is proposed as an Ftarget.

Fishing Mortality: Fishing mortality calculated from the average of the currently fully recruited ages (3-7+) ranged between 1.143 and 2.042 during 1982-1996. The fishing mortality rate has declined to below 1.000 since 1996 and was estimated to be 0.288 in 2007, below the proposed fishing mortality threshold reference point = F35% = 0.310 (Figure A1). There is an 80% probability that the fishing mortality rate in 2007 was between 0.253 and 0.325.

Recruitment: The arithmetic average recruitment from 1982 to 2007 is 41.6 million fish at age 0. The 1982 and 1983 year classes are the largest in the time series, at 73.5 and 81.6 million fish. Recruitment declined from 1983 to 1988, with the 1988 year class the smallest at only 12.8 million fish. The 2007 year class is currently estimated to be about 40.0 million fish (Figure A2).

Spawning Stock Biomass: Spawning stock biomass (SSB) declined from 24,674 mt in 1982 to 7,017 in 1989, then increased to 43,932 mt by 2004. SSB was estimated to be 43,363 in 2007, about

72% of the proposed SSB35% = SSBMSY target reference point = 60,074 mt (Figures A2 & A3). There is an 80% chance that SSB in 2007 was between 39,325 and 48,122 mt.

Special Comment: The previously accepted, peer-reviewed 2006 NMFS S&T ADAPT VPA assessment model (Terceiro 2006) was updated through 2007. Using that ADAPT VPA model with a constant M = 0.20, the stock would be considered overfished and overfishing would be occurring based on the existing BRPs (i.e., those defined in 2006). Although this specific comparison was requested, comparison of current assessment results with those biological reference points is not advised due to the changes in assessment model and yield per recruit inputs this year.

It is recommended that the basis for the biological reference points be changed from a threshold and target at Fmax to a threshold at F35% and a target at F40%. This is because Fmax is not currently well estimated for summer flounder and, when compared to the use of F35%, provides only a marginal increase in yield (<5%) while requiring a much higher fishing mortality (80%) and resulting in 37% lower SSB per recruit.

The change in assessment model used is not the reason for the perceived change in stock status. An important assumption that affects stock status perception is the value of natural mortality (M) used in the assessment and reference point calculations. The expert opinion of the SDWG, supported by the SARC, is that M=0.25 is more appropriate for the summer flounder stock. The change in stock status is also due to the addition of two new years of data to the new assessment, indicating a continuing decline in fishing mortality which is now estimated to be between the proposed Fthreshold and Ftarget. SSB is estimated to have stabilized, but is projected to reach the biomass target by the end of 2012 at the Frebuild level.

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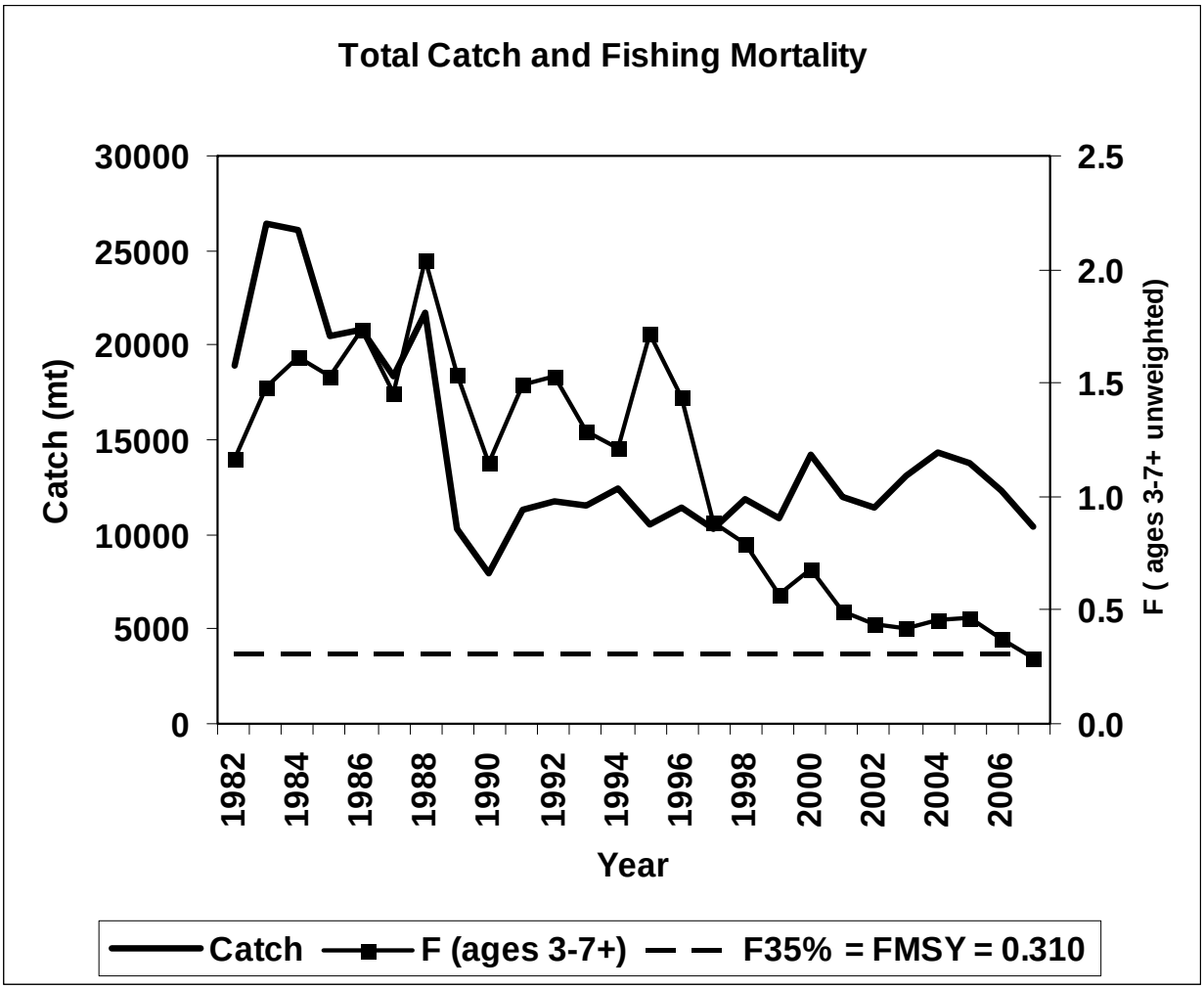

Figure A1. Total catch (landings and discards, metric tons) and fishing mortality rate (F, ages 3-7+ unweighted) for summer flounder. The proposed overfishing threshold (F35%) is shown.

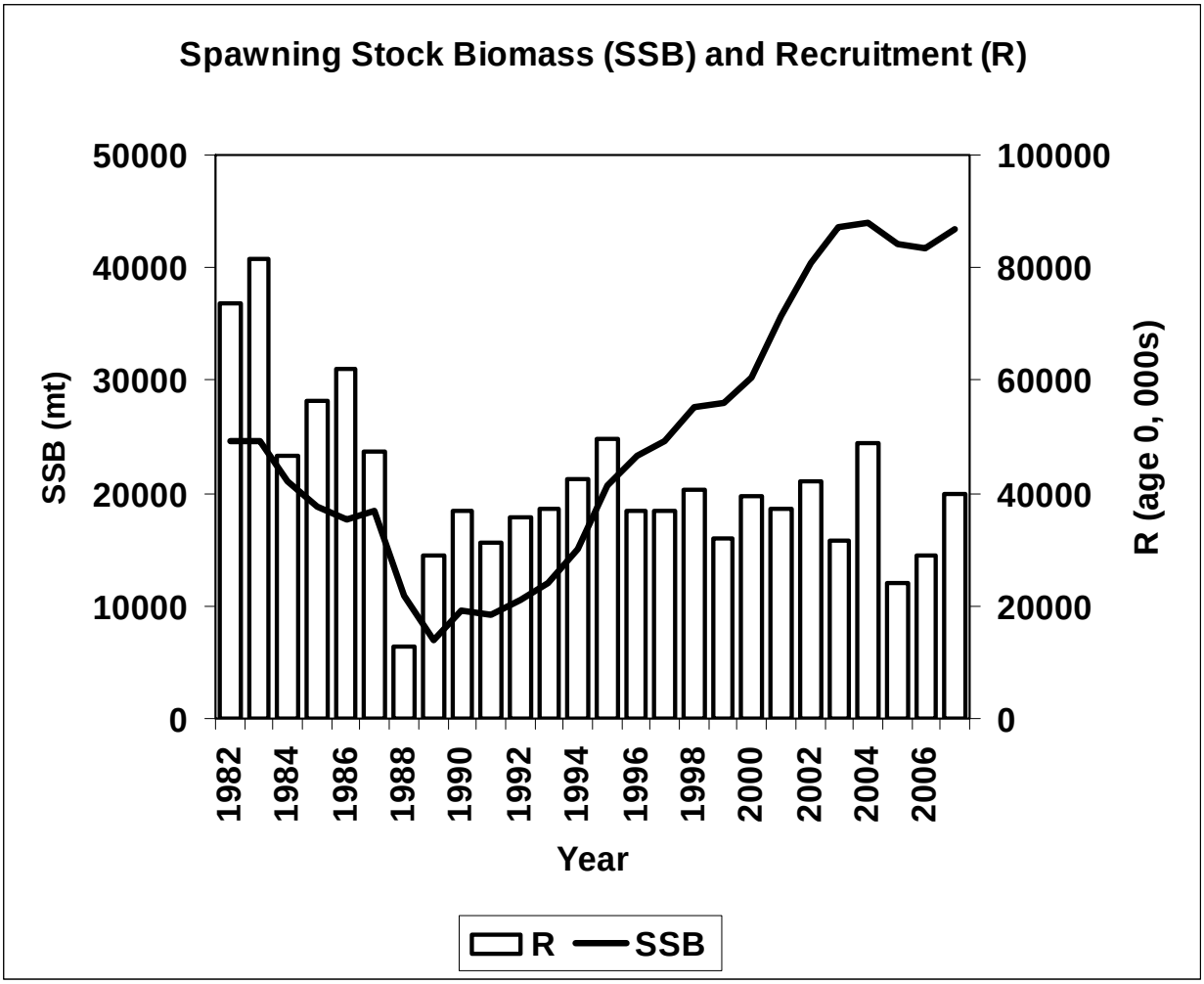

Figure A2. Spawning stock biomass (SSB) and recruitment (age 0) for summer flounder.

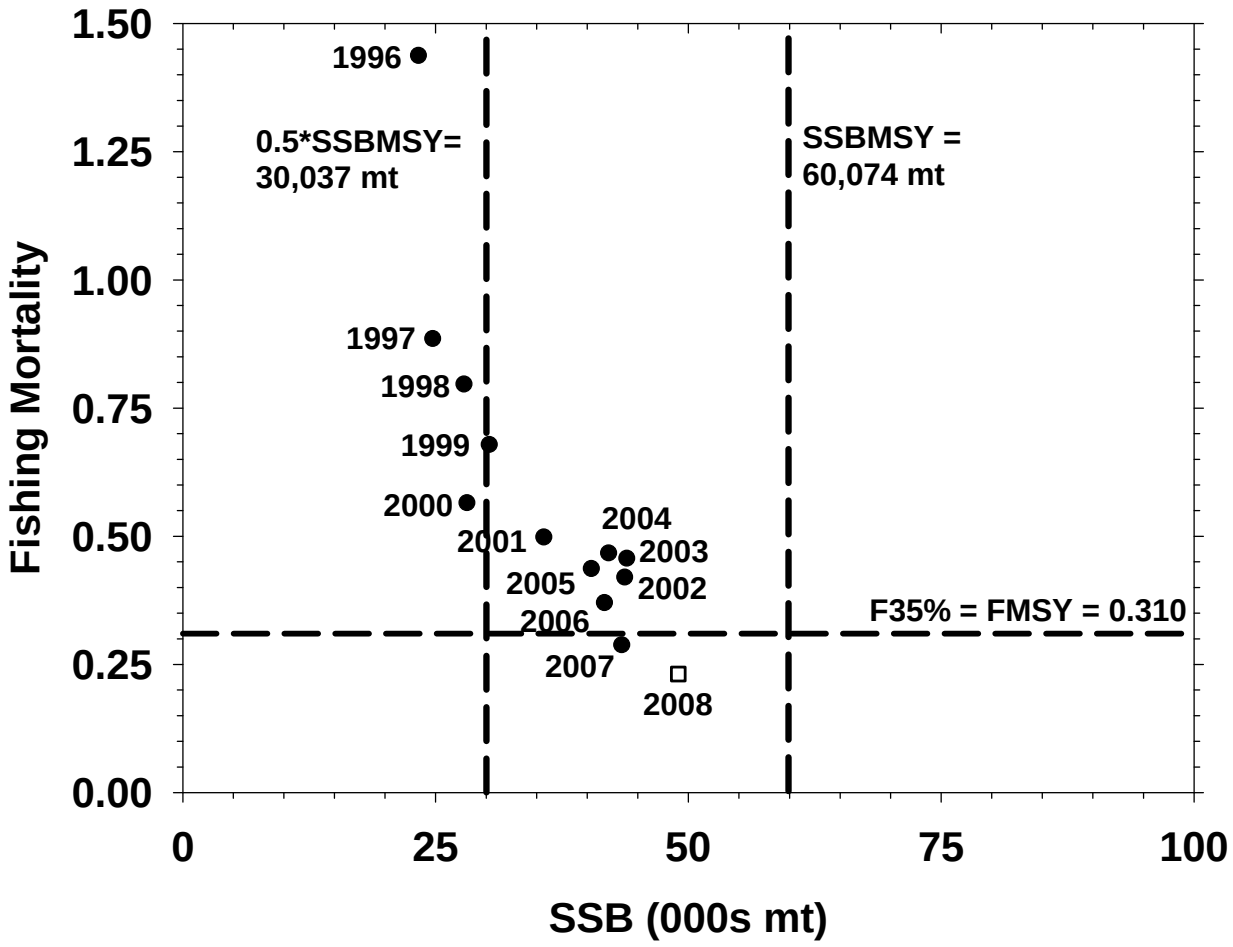

Figure A3. Spawning stock biomass (000s metric tons), fishing mortality, and proposed biological reference points for summer flounder.

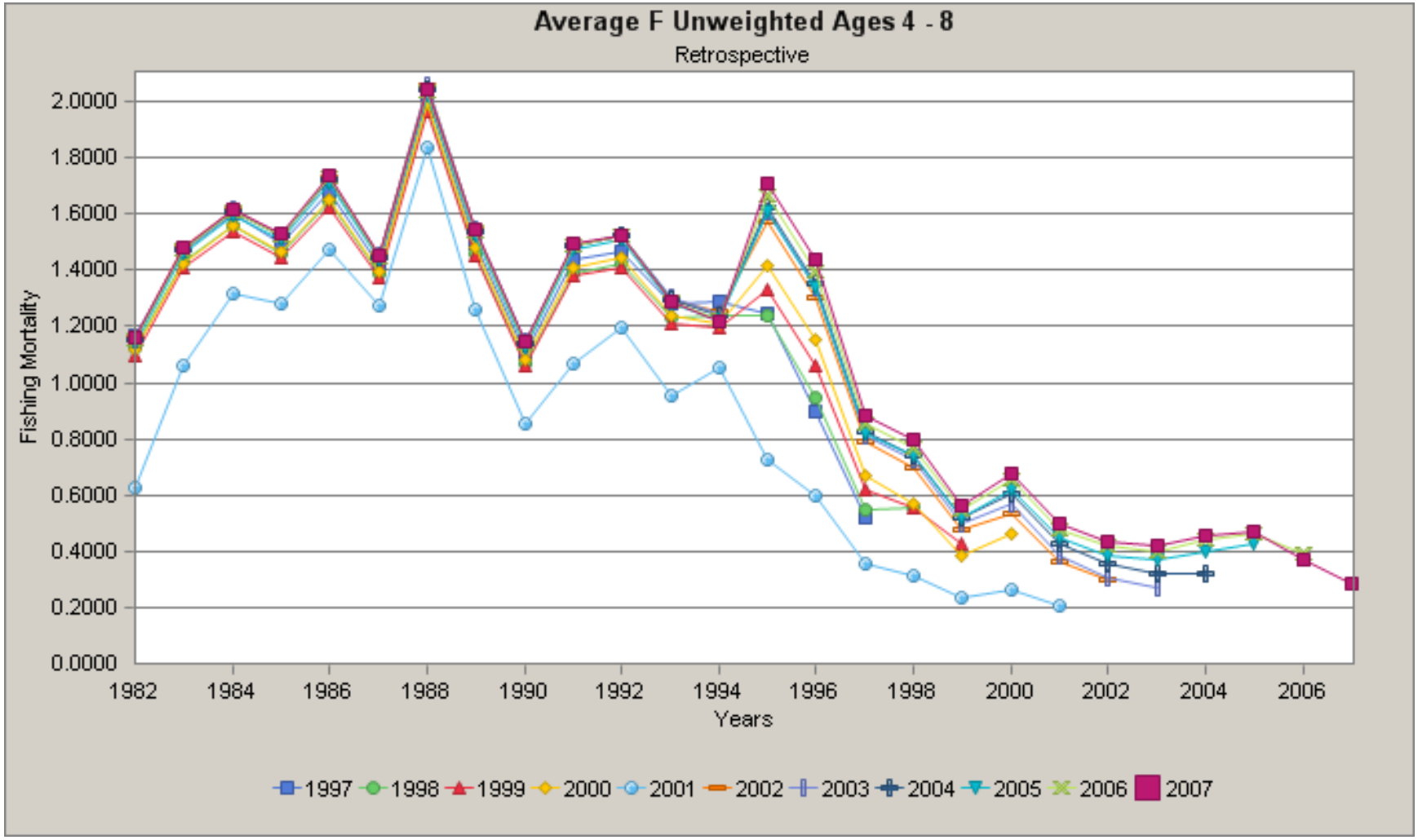

Figure A4. Retrospective analysis of fishing mortality for summer flounder. Note that model ages 4-8 (see Figure title) are true ages 3-7+.

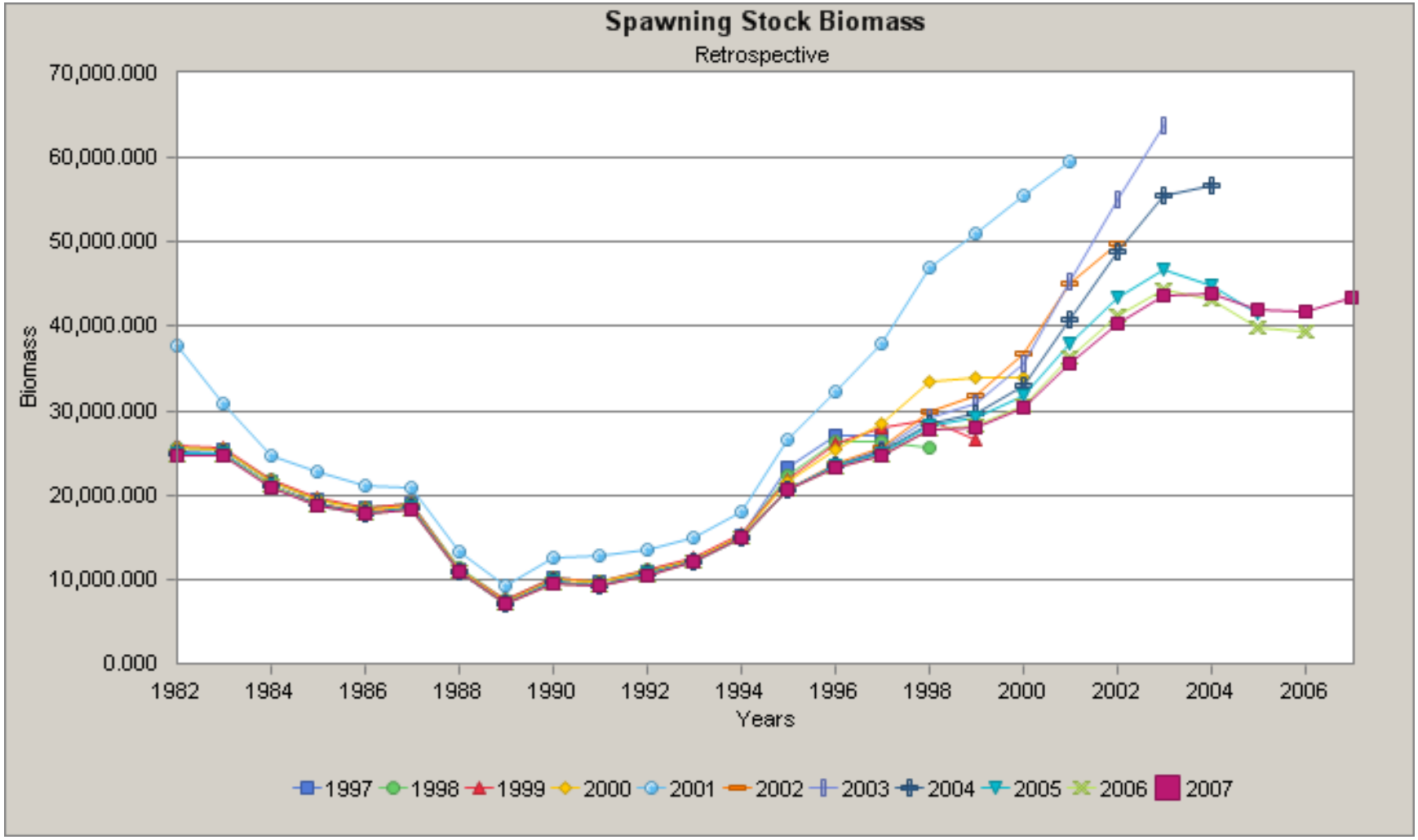

Figure A5. Retrospective analysis of spawning stock biomass (metric tons) for summer flounder.

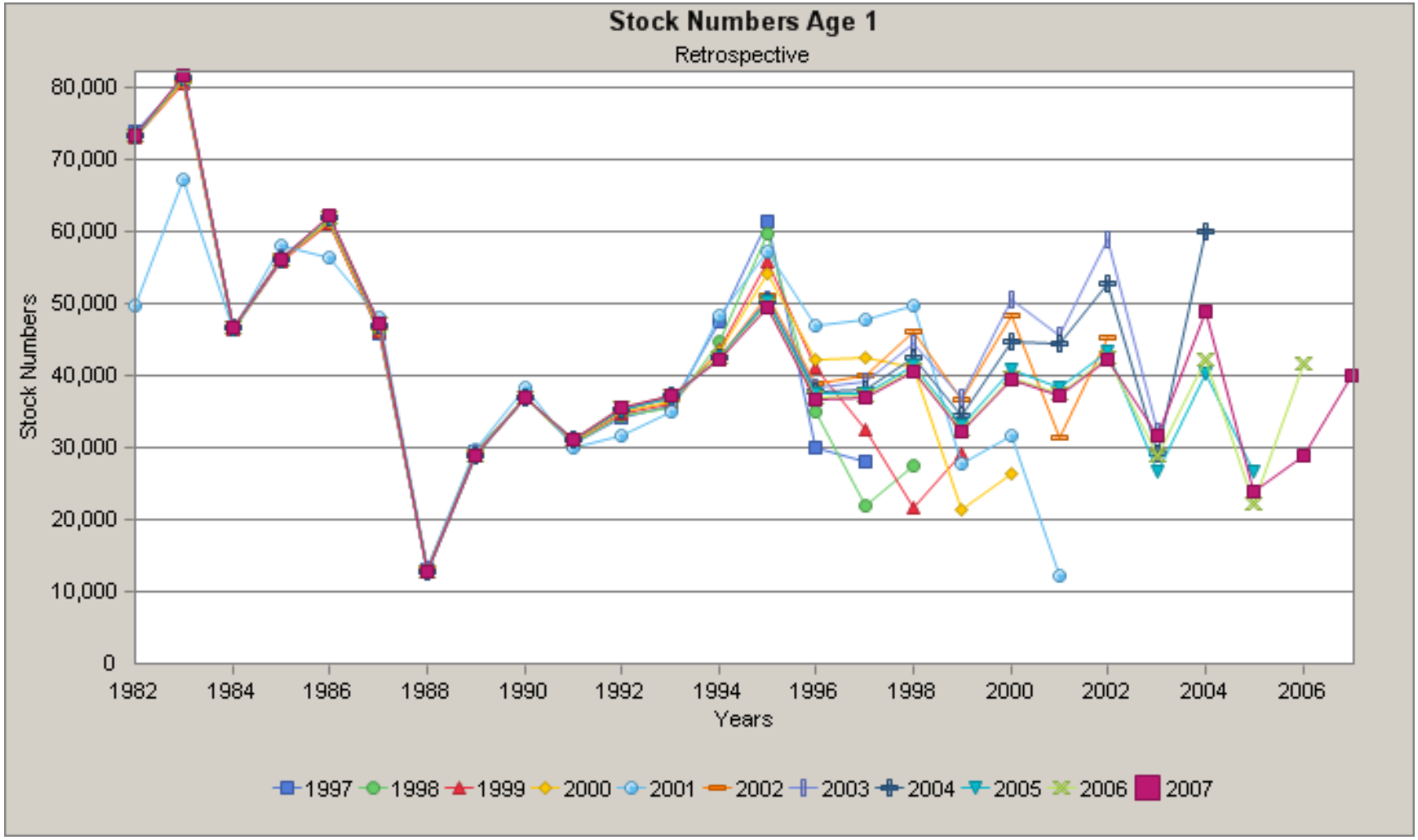

Figure A6. Retrospective analysis of recruitment (000s of fish at age 0) for summer flounder. Note that model age 1 (see Figure title) is true age 0.

Appendix: Terms of Reference

TORs for SAW/SARC-47, Spring 2008 Assessment

A. Summer flounder

1. Characterize the commercial and recreational catch, effort and CPUE, including descriptions of landings, discards and discard mortality.

2. Review methods for using fishery-independent surveys as abundance indices in assessment models.

   a. Evaluate whether to combine several of the surveys into a composite survey index. If appropriate, implement this approach.

   b. Develop and implement an appropriate statistical method to account for the probability of observing zeros in NEFSC survey tows.

3. Evaluate the feasibility of implementing alternative approaches to assess status of summer flounder stock and comment on any potential effects on estimates of F, SSB, and BRPs. Alternative approaches could consider:

   a. Separate Catch at age matrices for commercial and recreational fisheries, and resulting partial recruitment vectors for each fishery.

   b. Regional differences (north, south) in catch at age matrices.

   c. Potential gender differences in life span, growth rate, and natural mortality and implications of these factors for observed age- and length-specific sex ratios.

   d. Strength of evidence for natural mortality rate used in the assessment; Update the estimate if appropriate.

4. Compare results from alternative modeling approaches with those from the VPA model, to evaluate the robustness of VPA model results. Perform retrospective analyses of F, SSB, and recruitment for the models, and describe potential effects of retrospective patterns on assessment and rebuilding.

5. Based on the "best" model or models, estimate fishing mortality rate, recruitment, spawning stock biomass, and total stock biomass for the current year and characterize the uncertainty of those estimates. If possible, also include estimates for earlier years with uncertainty estimates.

6. Examine and evaluate the role of the environment on past and present summer flounder recruitment success.

7. Biological Reference Points

   a. Update or redefine biological reference points (BRPs; proxies for B_{MSY} and F_{MSY}), taking into account conclusions from earlier assessments and findings from TOR 6 (i.e., recruitment and the environment). Estimate uncertainty in BRPs. Comment on the scientific adequacy of existing and redefined BRPs.

   b. Evaluate current stock status with respect to the existing BRPs, as well as with respect to updated or redefined BRPs (from TOR 7a).

8. Stock Projections

   a. Recommend what modeling approaches and data should be used for conducting single and multi-year stock projections, computing TACs or TALs, and measures of uncertainty.

   b. If possible,

      i. Provide numerical examples of short term projections (2-3 years) of biomass and fishing mortality rate, and characterize their uncertainty, under various TAC/F strategies and

      ii. Compare projected stock status to existing rebuilding or recovery schedules, as appropriate.

9. Review, evaluate and report on the status of the Research Recommendations offered in recent SARC reviewed assessments and in the 2006 “Methot” Review.

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