Northeast Fisheries Science Center Reference Document 01-19

33rd Northeast Regional Stock Assessment Workshop (33rd SAW)

Public Review Workshop

December 2001

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A Report of the 33rd Northeast Regional Stock Assessment Workshop

33rd Northeast Regional Stock Assessment Workshop (33rd SAW)

Public Review Workshop

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Northeast Region
Northeast Fisheries Science Center
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Northeast Fisheries Science Center Reference Documents

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The 33rd Northeast Regional Stock Assessment Workshop

Introduction

The Northeast Stock Assessment Workshop (SAW) is a process for preparing, peer reviewing and presenting stock assessment information in the Northeast region. A SAW cycle is six months, thus, twice a year, a number of fishery stock assessments are prepared and presented to a panel of assessment experts. The panel, the Stock Assessment Review Committee (SARC), prepares two reports. The first is the *SAW Advisory Report*; a brief summary of the stock status, management advice, short term stock forecasts and other relevant assessment information for each stock assessed and reviewed. The second report, the *SARC Consensus Summary of Assessments*, is more detailed, containing specific assessment data, results and SARC discussion and research recommendations.

The Advisory Report is presented to the public via a series of Public Review Workshops, described below. Subsequent to the Workshops, the draft Advisory Report is finalized and folded into a larger document known as the Public Review Workshop Report. The Report also includes a summary of any meetings of the Northeast Coordinating Council (consisting of the Region's executives and responsible for establishing SAW policy and scheduling assessments for review) that may have occurred during the SAW cycle.

This is the Public Review Workshop Report for SAW 33 and the 33rd SARC and includes the final version of the Advisory Report and a report from an August 20, 2001 meeting of the Northeast Coordinating Council.

SAW 33 reviewed assessments for Gulf of Maine cod, white hake and redfish. Assessments for the three stocks were peer reviewed by the 33rd Stock Assessment Review Committee (SARC) at its June 25 -29, 2001 meeting in Woods Hole, MA. The SARC also reviewed the work of the SAW Methods Working Group on production modeling. The Public Review Workshop of the 33rd Northeast Regional Stock Assessment Workshop (SAW 33) was held in two sessions. The first was at a meeting of the New England Fishery Management Council on July 25. The second was at a meeting of the Mid-Atlantic Fishery Management Council on August 9.

Copies of the SAW 33rd draft *Advisory Report on Stock Status* had been distributed to members of each Council prior to the Workshops.

The SAW Chairman, Dr. Terry Smith of the Northeast Fisheries Science Center (NEFSC), NMFS, conducted both Council Workshops.

ADVISORY REPORT ON STOCK STATUS

INTRODUCTION

The *Advisory Report on Stock Status* is one of two reports produced by the Northeast Regional Stock Assessment Workshop process. The *Advisory Report* summarizes the technical information contained in the *Stock Assessment Review Committee (SARC) Consensus Summary of Assessments* and is intended to serve as scientific advice for fishery managers on resource status.

An important aspect of scientific advice on fishery resources 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 simply 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 a stock's biomass falls below the threshold ($B_{THRESHOLD}$) the stock is in an overfished condition. The Sustainable Fisheries Act mandates plans for rebuilding the stock should this situation arise.

Since there are two dimensions to the status of the stock– 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 is increased 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. This philosophy is embodied in the Sustainable Fisheries Act — stocks should be 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, 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 $F_{THRESHOLD.}$

Overfishing guidelines are based on the precautionary approach to fisheries management and encourage the inclusion of a control rule in the overfishing definition. Control rules, when they exist, are discussed in the Advisory Report chapter for the stock under consideration. 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. The schematic noted below depicts a generic control rule of this nature.

		BIOMASS		
		B $<B_{THRESHOLD}$	$B_{THRESHOLD} <$ **B** $< B_{MSY}$	**B** $> B_{MSY}$
EXPLOITATION	$F_{THRESHOLD}$	$F_{THRESHOLD}$ = 0 or F min (The minimal achievable mortality rate.)	$F_{THRESHOLD}$ < FMSY (The maximum mortality rate that defines overfishing at various levels of biomass.)	$F_{THRESHOLD} = F_{MSY}$
RATE	F_{TARGET}	F_{TARGET} = 0 or F min (The minimal achievable mortality rate.)	$F_{TARGET} < F_{THRESHOLD}$ (Where F_{TARGET} is chosen to minimize the risk of exceeding $F_{THRESHOLD)}$	$F_{TARGET} <F_{MSY}$

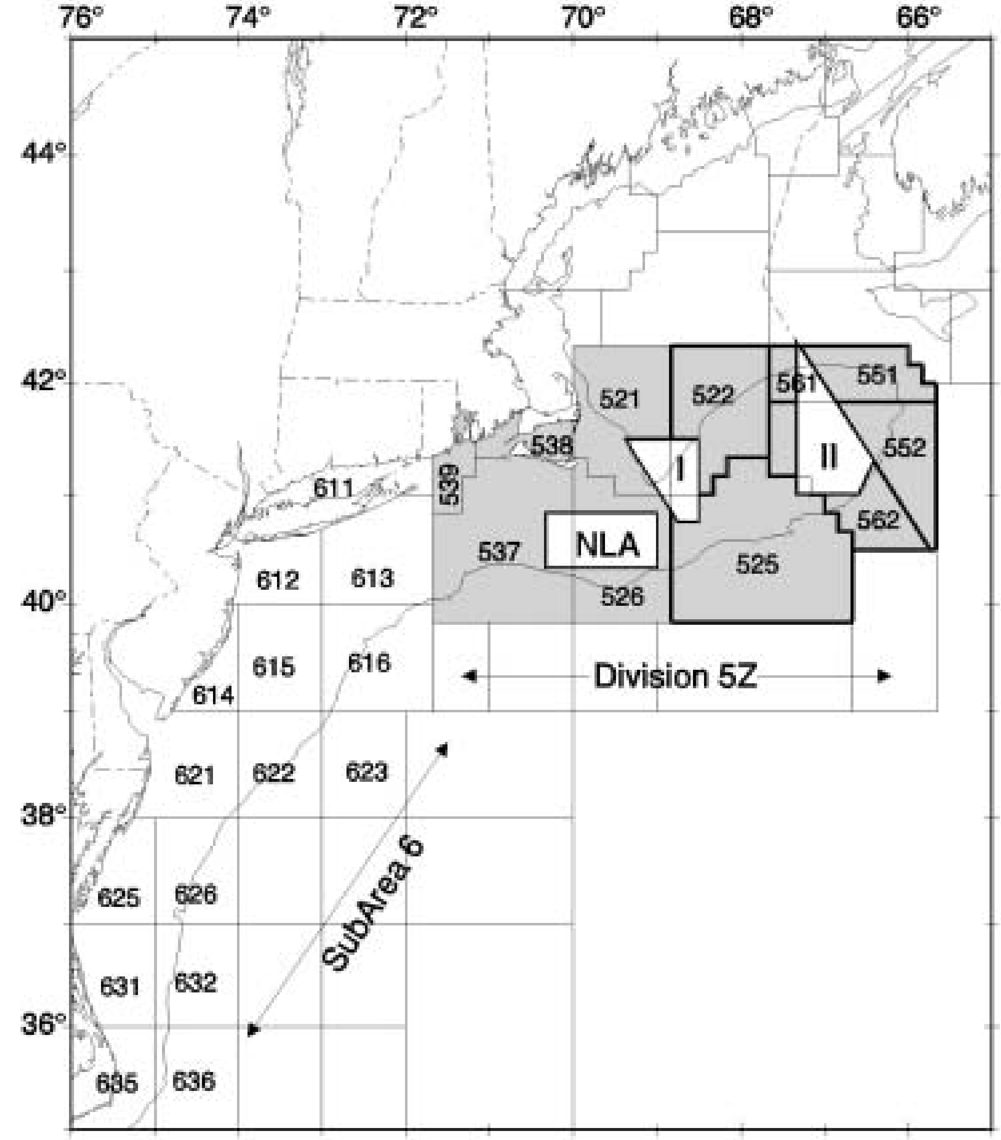


Figure 1. Statistical areas used for catch monitoring in offshore fisheries in the Northeast United States.

GLOSSARY OF TERMS

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

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 biomass rather than numbers. Biomass dynamic models employ assumptions about growth (in weight) 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” in some of the scientific literature.

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 the 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 the loss in fish weight due to mortality exceeds the gain in fish weight due to growth.

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, $\mathbf{F_{threshold}}$). 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 $\mathbf{F_{threshold}}$ overfishing is occurring.

Minimum Stock Size Threshold (MSST, $\mathbf{B_{threshold}}$). 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 $\mathbf{B_{threshold}}$, 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 reaches a level that causes a significant reduction in recruitment to the spawning stock. This is caused by a greatly reduced spawning stock and is characterized by a decreasing proportion of older fish in the catch and generally very low recruitment year after year.

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. The total weight of all sexually mature fish in a stock.

Spawning stock biomass per recruit (SSB/R). 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.

Survival Ratios. Ratios of recruits to spawners (or spawning biomass) in a stock-recruitment analysis.

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 also assumed to be constant.

A. GULF OF MAINE COD ADVISORY REPORT

State of Stock: The Gulf of Maine cod stock is not overfished but overfishing is occurring, relative to re-estimated reference points for B_{MSY} (B=90,300 mt) and F_{MSY} (F=0.23). Current total stock biomass, 24,400 mt in 2001, is just above 25% of B_{MSY} and current fully-recruited fishing mortality (F=0.73) is very high, more than 3 times F_{MSY} and 5 times $F_{0.1}$. Spawning stock biomass (SSB) has increased from 10,000 mt in 1998 to 18,000 mt in 2001 based, in part, on the partial maturation of the above-average 1998 year class. This year class is approximately twice as large as adjacent year classes and larger than any since 1992.

Management Advice: Fishing mortality has remained high despite recent trip limit and area closure management actions to reduce fishing mortality on Gulf of Maine cod. To meet the Amendment 7 fishing mortality target (F_{max} = 0.27), fully recruited F must be markedly reduced. The above average 1998 year class, which will become fully recruited in 2002, should be protected to enhance the spawning potential and rate of recovery of the stock.

Forecast for 2002: Short- and long-term projections were performed (short-term, Figure A4; long-term Figures A9-A10). The forecasts assume that fishing mortality in 2001 was the same as in 2000 (i.e., F *status quo* = 0.73 or 48% exploitation for fully recruited fish). This fishing mortality rate implies that total catches in 2001 will be about 7,500 mt.

Short-term Forecast Table: F_{2001} = 0.73; Basis: 2000 F point estimate from tuned VPA. Recruitment (age 1) of the 2001 and 2002 year classes derived from a Beverton-Holt stock recruitment function fit to VPA estimates of the 1981-1999 year classes. SSB was estimated to be 13,100 mt in 2000. Catches represent commercial and recreational landings and commercial discards. (weights in '000 mt).

$F_{2002-2003}$	2001		2002		2003	Consequences/Implications
	Catch	SSB	Catch	SSB	SSB	
0.15=$F_{0.1}$	7.5	18.2	2.6	21.3	29.8	SSB in 2003 increases well above 2001 level; catch in 2002 declines to 1/2 the 2000 level.
0.23= F_{msy}	7.5	18.2	3.9	21.1	28.2	SSB in 2003 increases well above 2001 level; catch in 2002 declines below the 2000 level.
0.27=F_{max}	7.5	18.2	4.5	21.1	27.4	SSB in 2003 increases well above 2001 level; catch in 2002 declines to less than the 2000 level..
0.73=F_{2000}	7.5	18.2	10.1	19.9	20.4	SSB in 2003 does not increase appreciably above 2001level; catch in 2002 increases by 75% above 2000 level

Long-term forecasts: Twenty five year projections (2001-2025) for catch, total biomass and spawning stock biomass (SSB) are shown in Figures A9-A10. The same constant F scenarios as above ($F_{0.1}$, F_{msy}, F_{max} and F_{2000}) were used based on a January 1, 2001 SSB of 18,200 mt and an age-based stock-recruitment relationship (Figures A11).

Catch and Status Table (weights in '000 mt, recruitment in millions of fish): Gulf of Maine Cod

Year	1993	1994	1995	1996	1997	1998	1999	2000	Max[1]	Min[1]	Mean[1]
USA commercial landings	8.3	7.9	6.8	7.2	5.4	4.2	1.6	3.7	17.8	1.6	9.1
Otter trawl	4.9	4.2	3.5	4.0	2.8	2.3	0.8	2.0	13.0	0.8	5.8
Sink gillnet	3.1	3.3	3.1	2.8	2.2	1.4	0.5	1.4	4.4	0.5	3.0
Handline/line trawl	0.3	0.3	0.3	0.3	0.4	0.4	0.3	0.3	0.5	<0.1	0.2
Other gear	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.3	<0.1	0.1
Canada commercial landings	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other commercial landings	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total commercial landings	8.3	7.9	6.8	7.2	5.4	4.2	1.6	3.7	17.8	1.6	9.1
Discards[2]	0.3	0.2	0.4	0.2	0.2	0.2	2.5	1.0	[3]3.6	[3]0.2	[3]1.0
US recreational landings	1.2	0.9	0.8	0.9	0.3	0.8	0.8	1.1	2.9	0.3	1.4
Catch used in assessment	9.5	8.8	7.6	8.1	5.7	5.0	4.9	5.8	20.9	4.8	11.1
Total Stock Biomass(Jan 1)	27.1	22.7	20.0	17.2	15.0	14.8	16.2	20.4	41.9	14.8	25.2
Spawning stock biomass[4]	11.4	13.1	14.6	12.9	10.3	9.9	11.1	13.1	24.2	9.9	15.8
Recruitment (age 1)	9.3	3.3	3.4	3.0	4.7	4.5	9.5	5.7	25.2	3.0	[5]6.6
F (ages 4-5, u)	0.94	2.04	1.12	1.01	0.88	0.70	0.77	0.73	2.04	0.64	1.01
Exploitation rate	56%	81%	62%	59%	54%	46%	49%	48%	81%	43%	59%

[1]Over period 1982-2000. [2] Used in assessment in 1999 and 2000 only. [3]Over period 1989-2000. [4]At beginning of the spawning season.
[5]Geometric mean.

Stock Distribution and Identification: Gulf of Maine cod are distributed from Massachusetts Bay north along the coast of Maine to the Bay of Fundy and eastward across the Gulf of Maine. Cod are found in most depths in the Gulf of Maine throughout the year, but appear to form coastal concentrations in summer months. Gulf of Maine cod are distinguished from those on Georges Bank by a slower rate of growth and later age at full sexual maturation. In recent years, the stock has become more concentrated in the inner western regions of the Gulf of Maine.

Catches: Commercial landings increased in the mid 1970s and early 1980s, reaching 14,000 mt in 1983. Landings declined during 1974-1986, increased to record highs in 1990 and 1991, but have since declined sharply (Figure A1). Total commercial landings in 1999 and 2000 were 1,636 mt and 3,730 mt, respectively. Discards in the commercial fishery have ranged from an estimated 200 mt to over 3,600 mt per year since 1989. Commercial discards in 1999 and 2000 were assumed to be in the range of 2,500 mt and 1,000 mt, respectively, or approximately 51% and 17% of the total catch in these years. Landings of cod from the recreational sector have ranged between 300-1,200 mt per year since 1993.

Data and Assessment: An analytical assessment (VPA) of 1982-2000 commercial and recreational landings-at-age data was tuned with the ADAPT method using standardized NEFSC and Massachusetts DMF spring and autumn survey catch-per-tow-at-age data. Commercial landings at age in 1999 and 2000 were raised to account for high discards in these two years. Standardized US commercial LPUE indices were used only through 1993 due to a change in the effort data collection from 1994 onward. An age structured production analysis that incorporated a Beverton-Holt stock recruitment relationship was used to derive estimates of B_{MSY} and F_{MSY}.

Biological Reference Points: The age-based production model estimated B_{MSY} as 90,300 mt and F_{MSY} as 0.23 (19% exploitation, fully-recruited, ages 4+) (Figure A11). Yield per recruit analyses performed with an assumed M of 0.20 indicate that $F_{0.1}$ =0.15 (13% exploitation), and F_{max} =0.27 (22% exploitation). (Figure A3).

A biomass target reference point less sensitive to variations in year class strength is the SSB corresponding to MSY (SSB_{MSY}) estimated as 78,000 mt (ages 1+) (Figure A11).

Fishing Mortality: Fully recruited fishing mortality (ages 4-5, u) remained very high (at or above 0.9 or 55% exploitation) between 1983 and 1997 (Figure A1), declined slightly in 1998 to 0.70 (46% exploitation), but increased to 0.73 (48% exploitation) in 2000. Current F continues to be far in excess of F_{MAX}, the Amendment 7 fishing mortality objective, and 3 times the revised estimate of Fmsy (0.23, 19% exploitation). The precision of the 2000 estimate of fishing mortality was evaluated with respect to the VPA formulation which included 1999 and 2000 discard estimates. There is an 80% probability that F in 2000 was between 0.58 and 0.96 (Figure A5). The uncertainty in discard estimates is not reflected in these precision estimates, however.

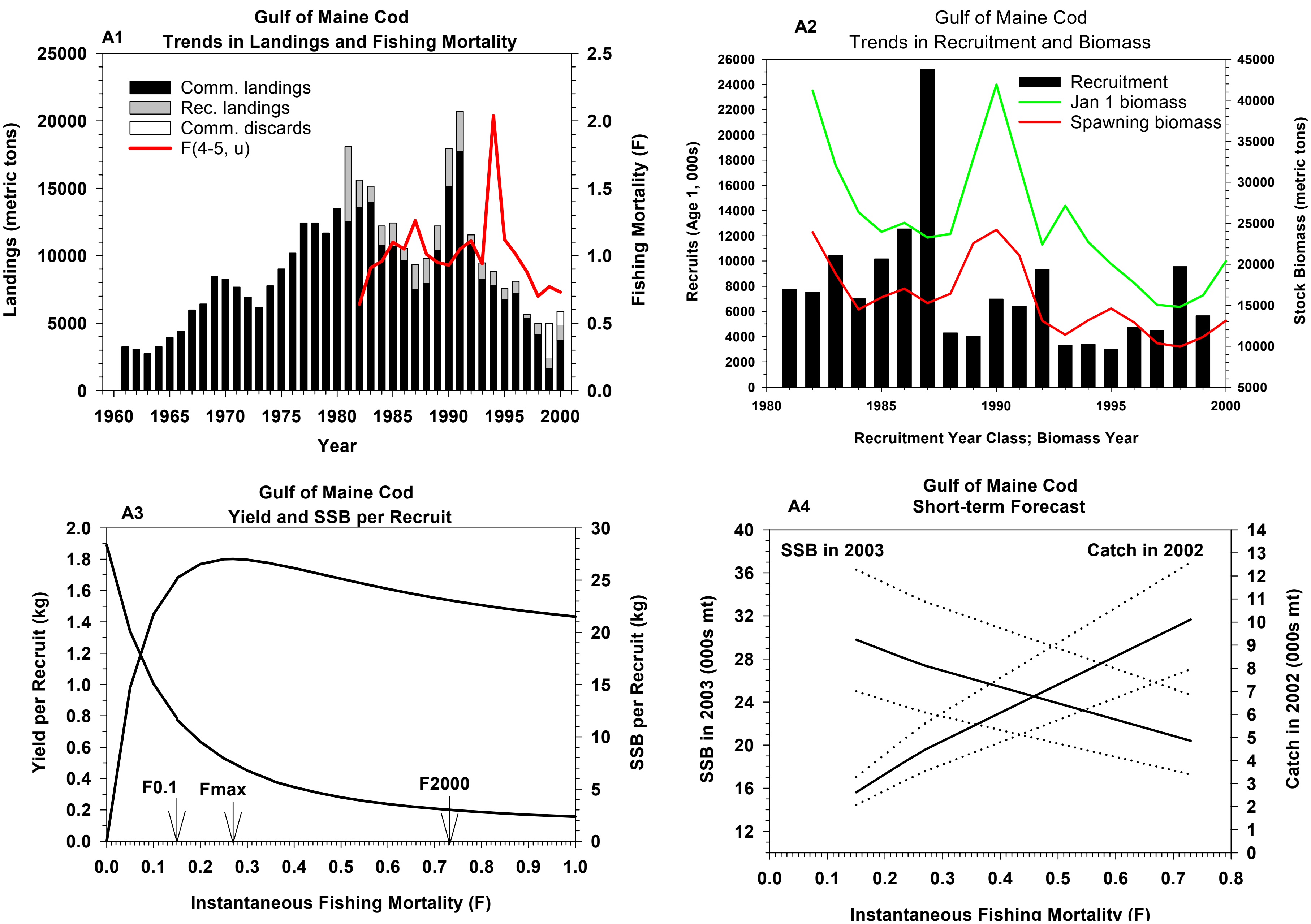
Recruitment: The 1987 year class was the strongest during the assessment period, although the survey data suggests that even stronger year classes occurred in the 1970s. Year classes subsequent to 1987, except for 1992 and 1998, have generally been below average. The 1993, 1994 and 1995 year classes are among the poorest in the VPA time series, averaging less than ½ the long term mean (Figure A2). Survival ratios (R/SSB) had been declining but now appear to be increasing.

Spawning Stock Biomass: SSB declined by 36% between 1982 and 1987 (23,900 mt to 15,300 mt), but increased to a peak of 24,200 mt in 1990 due to recruitment of the strong 1987 year class. SSB declined to 11,400 mt in 1993, increased slightly through 1995, but fell to a record-low 9,900 mt in 1998. Subsequently, SSB increased to 13,100 mt in 2000 (Figure A2) and to 18,200 mt in 2001. The precision of the 2000 estimate of SSB was evaluated with respect to the VPA formulation which included 1999 and 2000 discard estimates; there is an 80% probability that SSB in 2000 was between 11,200 and 15,600 mt (Figure A6).

Special Comments: Sampling of the commercial landings in the ports in recent years has not been proportional to the landings distribution by market category and has been particularly poor in sampling large cod. Poor sampling has contributed to a considerable degree of uncertainty in the assessment results. Sampling of discards and recreational catches is insufficient. Irrespective of the sampling issues, the estimation of discards remains problematic given that the sources of discard per trip information (sea sampling, VTR) may be either not representative or biased.

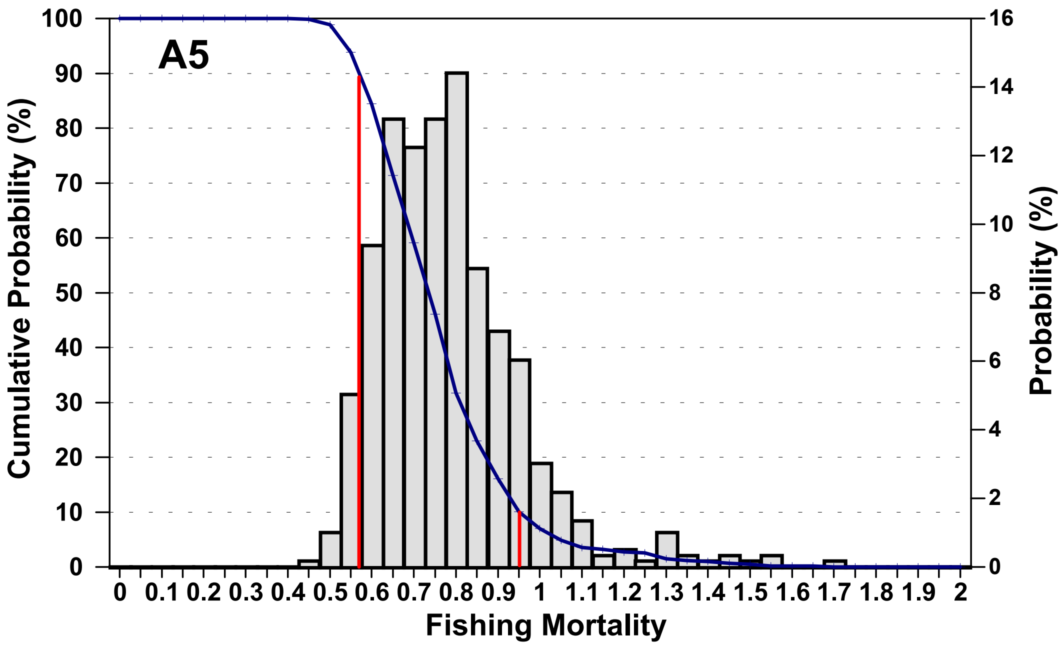
The revised B_{MSY} and SSB_{MSY} estimates are well above biomass levels noted during the period of the VPA (1982-2000), but are within the range of calculated biomass corresponding to observed survey biomass indices during the 1960s (Figures A7 and A8).

Source of Information: Report of the 33rd Northeast Regional Stock Assessment Workshop (33rd SAW), Stock Assessment Review Committee (SARC) Consensus Summary of Assessments, NEFSC Ref. Doc. 01-18; R.K. Mayo *et al.* 2001, The 2001 Assessment of the Gulf of Maine cod stock, in review.



A1
Gulf of Maine Cod
Trends in Landings and Fishing Mortality
Comm. landings
Rec. landings
Comm. discards
F(4-5, u)
Landings (metric tons)
Fishing Mortality (F)
Year
A2
Gulf of Maine Cod
Trends in Recruitment and Biomass
Recruitment
Jan 1 biomass
Spawning biomass
Recruits (Age 1, 000s)
Stock Biomass (metric tons)
Recruitment Year Class; Biomass Year
A3
Gulf of Maine Cod
Yield and SSB per Recruit
F0.1
Fmax
F2000
Yield per Recruit (kg)
SSB per Recruit (kg)
Instantaneous Fishing Mortality (F)
A4
Gulf of Maine Cod
Short-term Forecast
SSB in 2003
Catch in 2002
SSB in 2003 (000s mt)
Catch in 2002 (000s mt)
Instantaneous Fishing Mortality (F)

Gulf of Maine Cod
Precision of 2000 F Estimate



Precision of 2000 SSB Estimate

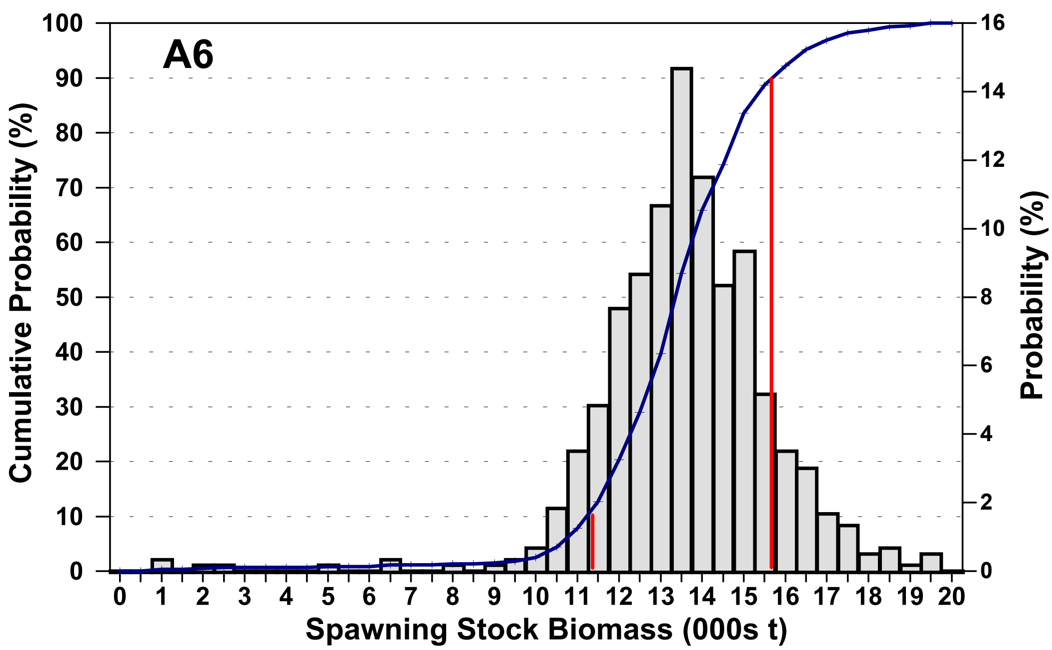


Figure A7. Trends in Total Biomass

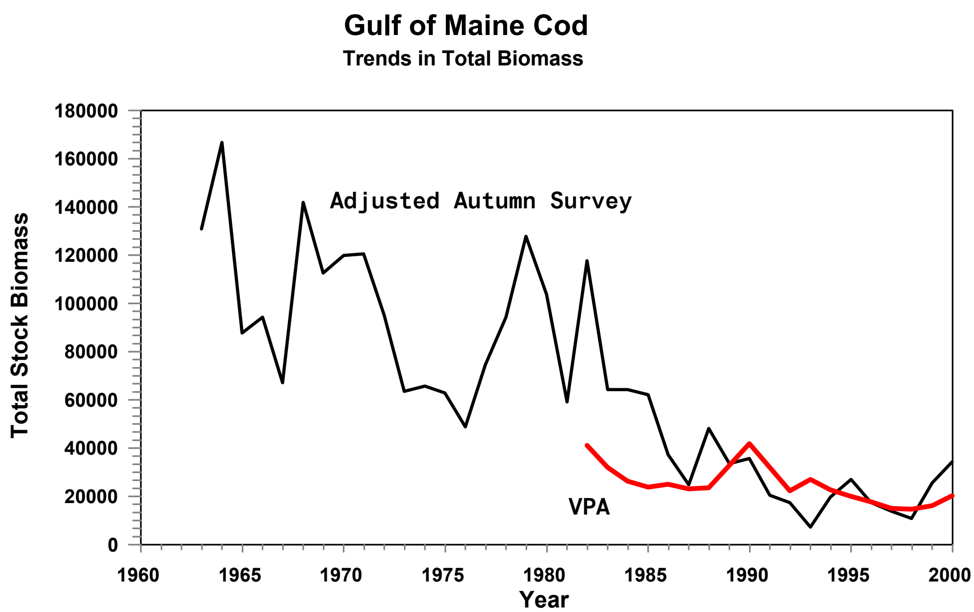
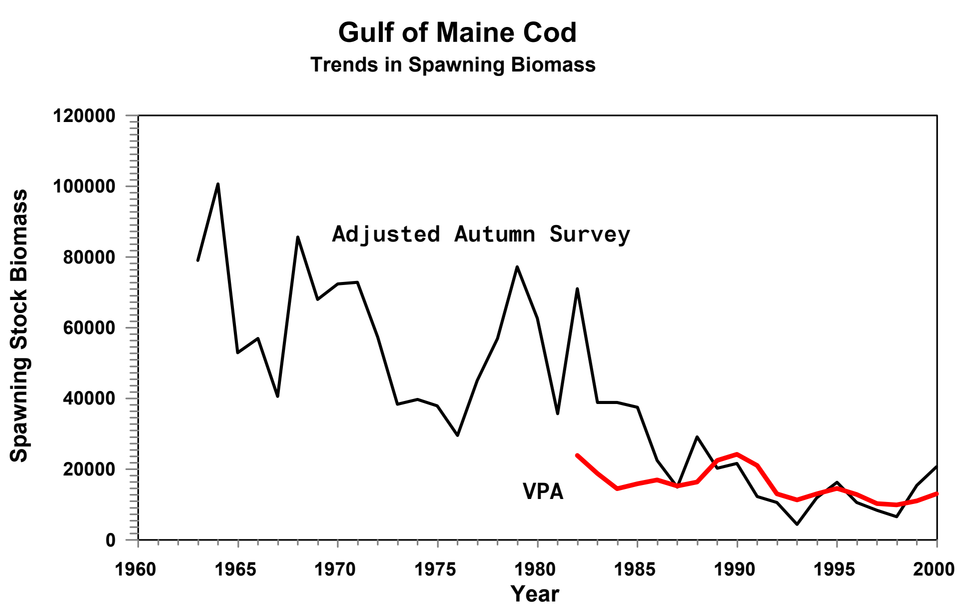


Figure A8. Trends in Spawning Stock Biomass



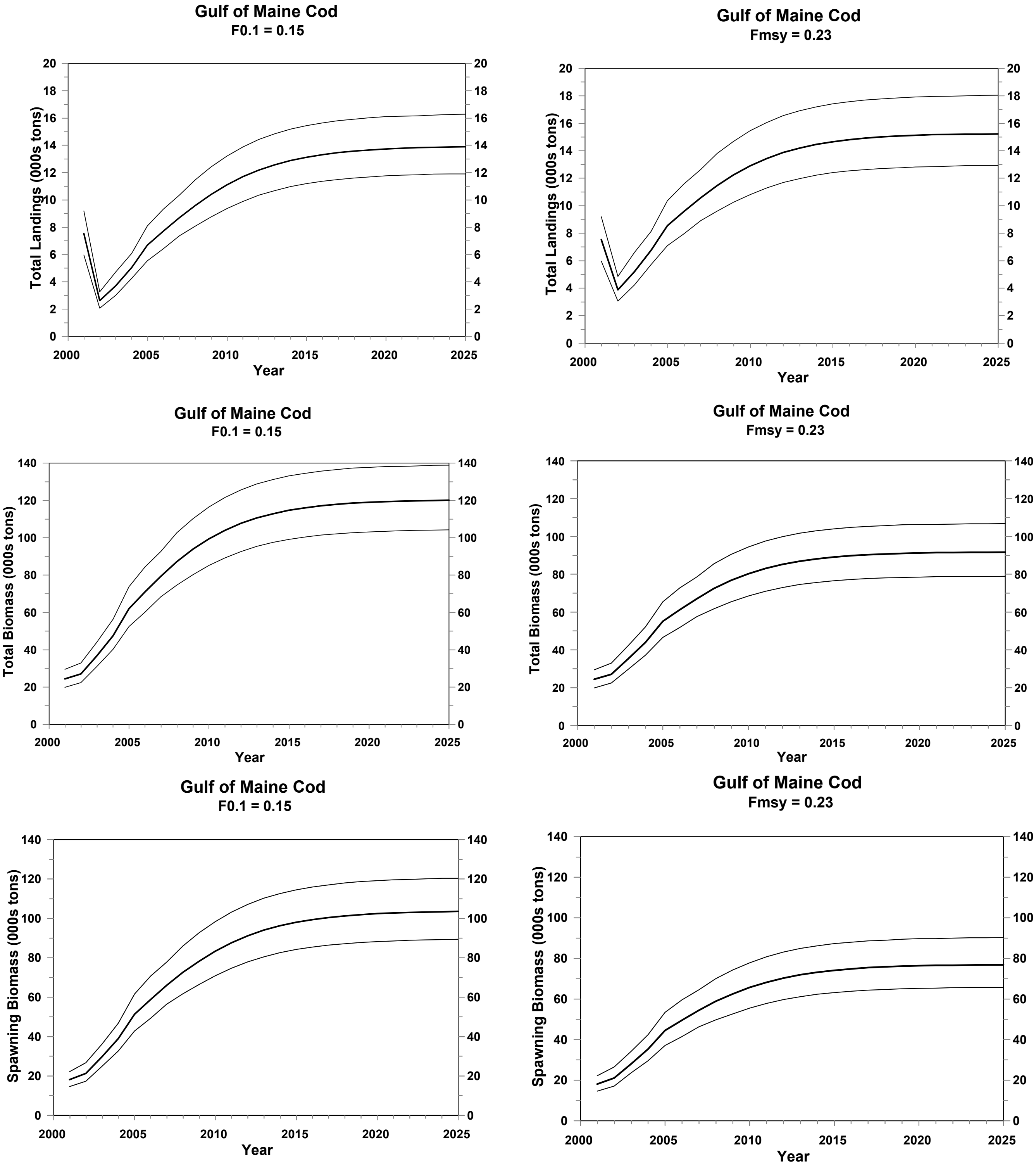


Figure A9. Long-term projections of total landings, total biomass and spawning biomass for Gulf of Maine cod under constant F of either F0.1 (left side panels) or Fmsy (right side panels.)

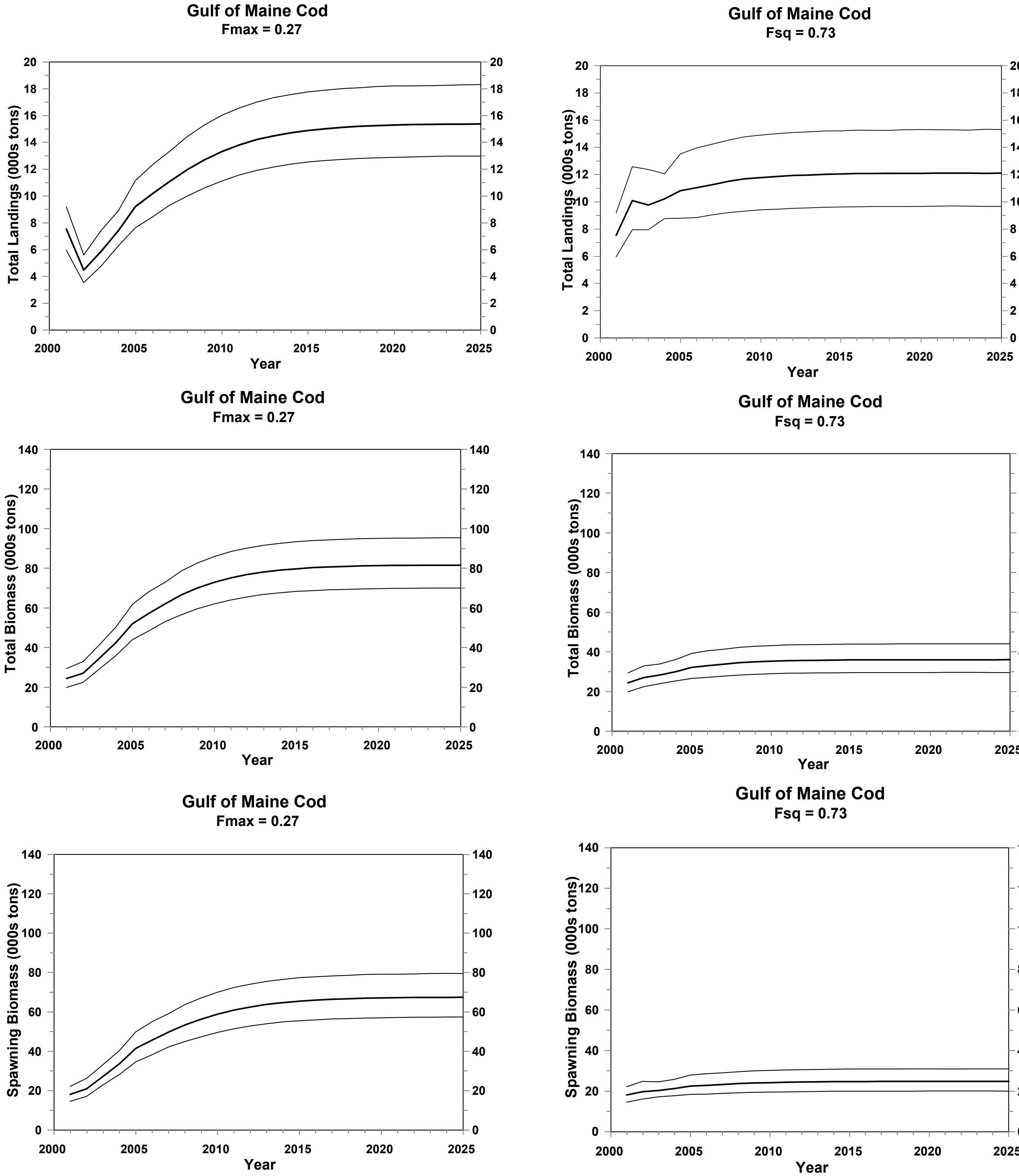


Figure A10. Long-term projections of total landings, total biomass and spawning biomass for Gulf of Maine cod under constant F of either Fmax (left side panels) or F_{SQ}(right side panels.)

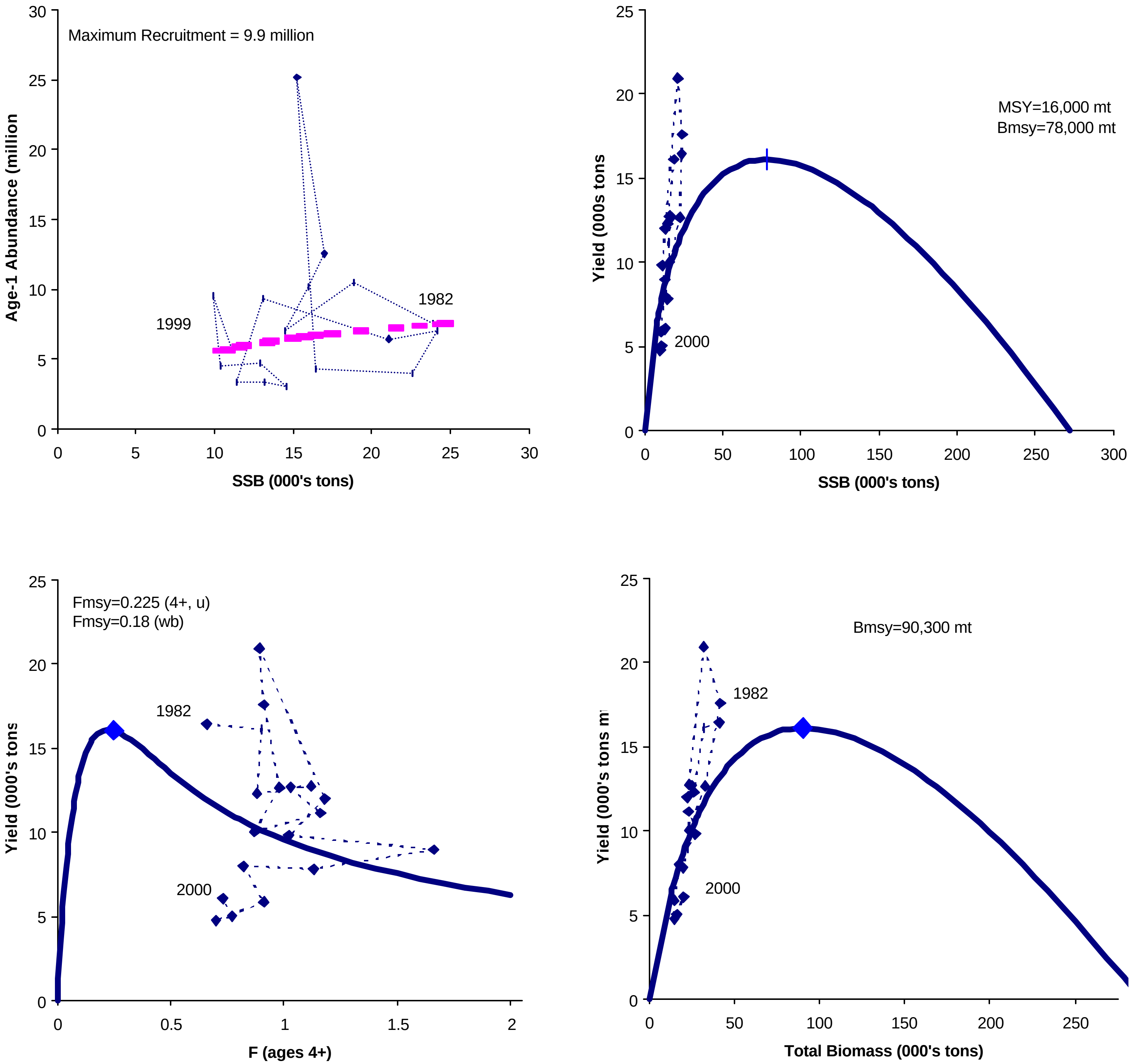


Figure A11. Biological Reference Points (age-structured S-R model and production model)

B. GULF OF MAINE-GEORGES BANK WHITE HAKE ADVISORY REPORT

State of Stock: The white hake stock is overfished and overfishing is occurring. Total stock biomass, as indicated by the NEFSC autumn survey, is low compared to the earlier decades (Figure B2). For fish less than 60 cm (ages 1-3) species mis-identification and poor discard data hamper estimation of the magnitude of the commercial catch. Trends in exploitation and biomass are best discerned for animals greater than 60 cm for which species identification is considered reliable. Survey biomass indices of 60+ cm fish have generally declined since 1984 and reached a record low in 1999. Exploitation on the 60+ cm component (ages 4+) has generally increased during this same time period (Figure B3). Survey indices of recruitment (age 2 fish) indicate strong year classes in 1984, 1988, and 1989; below average 1994-1997 year classes and moderate year classes in 1993 and 1998 (Figure B4).

Management Advice: Exploitation should be reduced immediately. As stock biomass for fish > 60 cm is currently below the corresponding $B_{threshold}$ (Figure B5) the Amendment 9 control rule requires that fishing mortality be as close to zero as practicable. This will protect the 1998 year class and allow for some stock rebuilding.

Forecast for 2002-2003: No forecasts were performed.

Catch and StatusTable (weights in '000 mt, recruitment in millions): Gulf of Maine-Georges Bank White Hake

Year	1993	1994	1995	1996	1997	1998	1999	2000	Max[1]	Min	Mean[1]
USA commercial landings[2]	7.5	4.7	4.3	3.3	2.2	2.4	2.6	3.0	8.4	1.1	4.2
Otter trawl	4.7	2.5	2.4	2.0	1.3	1.4	1.5	1.8	5.5	0.7	2.6
Sink gillnet	1.6	1.1	1.1	0.9	0.5	0.7	0.9	1.0	2.4	0.1	1.1
Handline/line trawl	1.2	1.2	0.8	0.3	0.4	0.3	0.1	0.1	1.5	<0.1	0.4
Other gear	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.2	<0.1	<0.1
Canada commercial landings	1.7	1.0	0.5	0.4	0.3	0.2	0.2	0.2	1.7	<0.1	0.4
Total commercial landings	9.1	5.7	4.8	3.7	2.5	2.6	2.8	3.2	9.6	1.1	4.6
Total Discards[2]	0.7	0.3	0.2	0.6	0.3	0.3	2.1	0.3	4.4	0.2	1.1
Otter Trawl Discards[3]	0.6	0.2	0.1	0.5	0.2	0.2	2.1	0.3	4.3	0.1	1.0
Sink Gill Net Discards[4]	0.1	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	<0.1	<0.1
US recreational landings[4]	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total Catch	9.8	5.9	4.9	4.2	2.7	2.8	4.9	3.5	10.5	1.4	5.6
Catch > 60 cm	5.6	4.0	2.2	2.9	2.3	2.5	3.1	3.0	6.4	0.9	3.4
Catch <= 60 cm	4.2	1.9	2.8	1.3	0.4	0.3	1.8	0.5	6.6	0.3	2.2
Total Exploitation index	0.8	0.8	0.6	0.7	0.6	0.7	1.4	0.5	1.4	0.1	0.6
Exploitation Index (> 60cm)	1.2	1.6	0.7	0.9	0.9	1.7	2.6	1.0	2.5	0.2	0.8
Exploitation Index (<= 60 cm)	0.7	0.4	0.5	0.4	0.2	0.1	0.9	0.1	1.6	0.1	0.5
Recruitment (Age 2)[5,6]	2.7	2.8	3.9	1.0	1.2	1.8	1.2	3.5	6.7	0.5	2.8
Total Biomass (kg/tow)[6]	11.7	7.0	8.2	6.3	4.5	4.3	3.4	6.7	16.7	3.4	9.5
Biomass > 60 cm (kg/tow)[6]	4.9	2.5	3.0	3.3	2.6	1.5	1.3	2.9	11.6	1.3	5.2
Biomass <= 60 cm (kg/tow)[6]	6.8	4.6	5.2	3.0	1.9	2.6	2.2	3.8	7.4	0.9	4.2

[1]1964-2000. [2]Due to species mis-identification some red hake landings may be reported as white hake landings. [3] Only otter trawl discards were used in the assessment. [4]Not used in assessment; over period 1989-2000. [5]1982-2000. [6]From autumn survey excluding the 1982 data point.

Stock Distribution and Identification: All white hake landed in US waters were treated as a unit stock for the purposes of this assessment. Two spawning groups of white hake are found in the Scotian Shelf-Gulf of Maine to Georges Bank region. One group arises from a winter-spring spawn in deep waters from the Scotian Shelf through Southern New England. Growth patterns suggest that winter-spring spawning fish accounts for the majority of the white hake taken in NEFSC bottom trawl surveys. A summer spawn in shallow areas on the Scotian Shelf accounts for the second, minor spawning group of white hake. These two groups mix extensively in certain areas of the Gulf of Maine and are not readily distinguished in commercial landings.

Catches: Commercial catches increased in the mid 1970s and early 1980s, exceeding 10,000 mt in 1985 (Figure B1). Catches declined during the late 1980s, increased again in the early 1990s and declined sharply through 1998 (Figure B1). Total catches increased to 4,900 mt in 1999 but declined to 3,500 mt in 2000. Estimates of commercial discards have ranged between 200 and 2,100 mt per year since 1993.

Data and Assessment: Trends in survey indices and exploitation ratios based on fish greater than 60 cm were used to derive trends in biomass and exploitation rates. A provisional analysis using a non-equilibrium surplus production model incorporating covariates (ASPIC) confirmed survey trends in exploitation rates and biomass for > 60cm white hake. A VPA analysis using ADAPT was performed but was not accepted

Biological Reference Points: New biological reference points for the portion of the stock > 60 cm were derived. A provisional biomass dynamics analysis of >60 cm fish indicates that biomass at the beginning of 2001 was about 20% of B_{MSY} (Bmsy = 14,700 mt) and fishing mortality in 2000 was more than twice F_{MSY} (F_{MSY} = 0.29) (Figures B5 and B6).

Fishing Mortality: Exploitation ratios for fish larger than 60 cm were low in the 1960s and 1970s, increased in the late 1970s and have been at a high level since the 1980s (Figure B3).

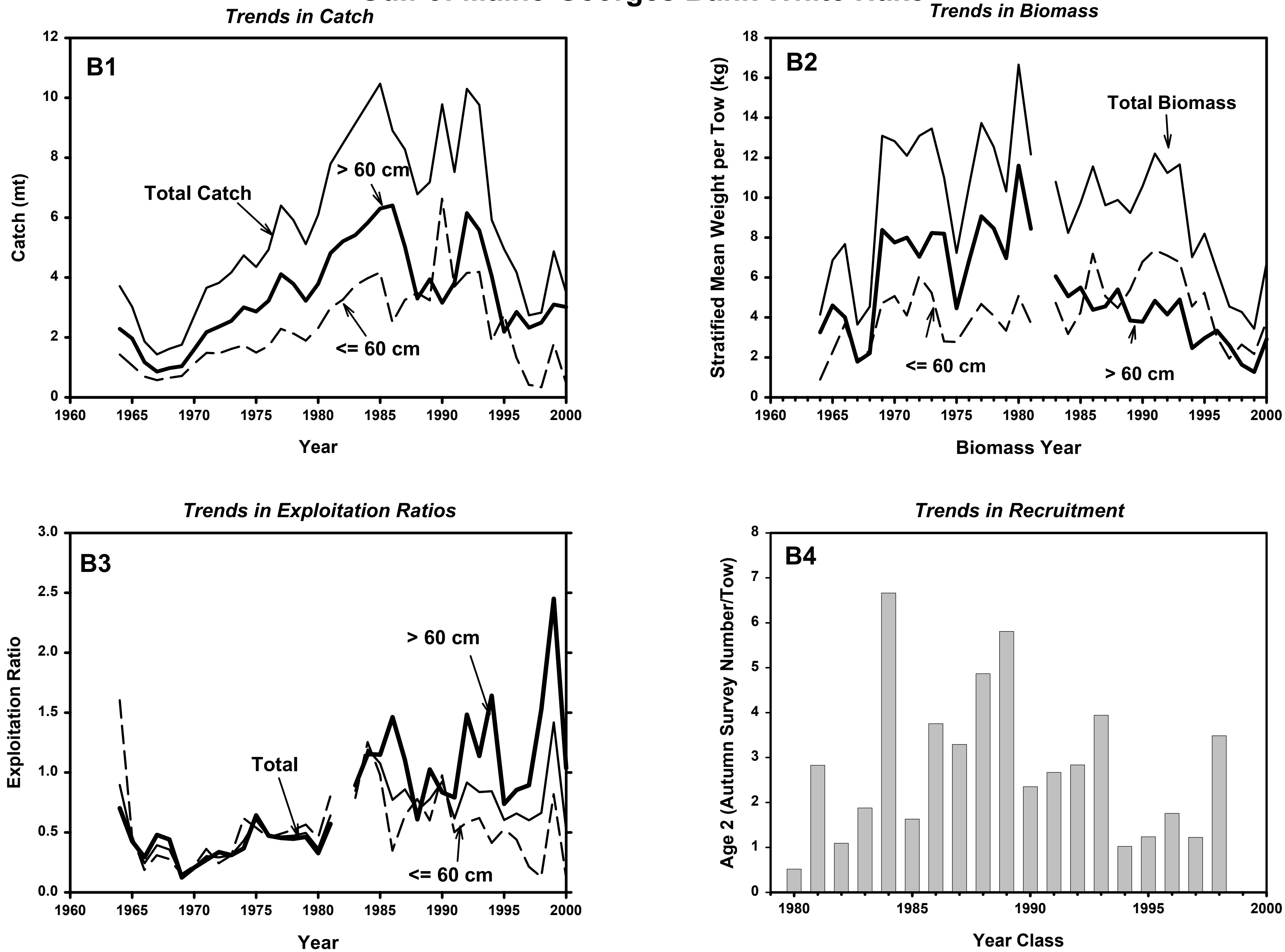
Recruitment: Strong year classes were produced in 1984, 1988 and 1989 followed by moderate year classes in the early 1990s (Figure B4). In recent years only the 1993 and 1998 year classes have been above average.

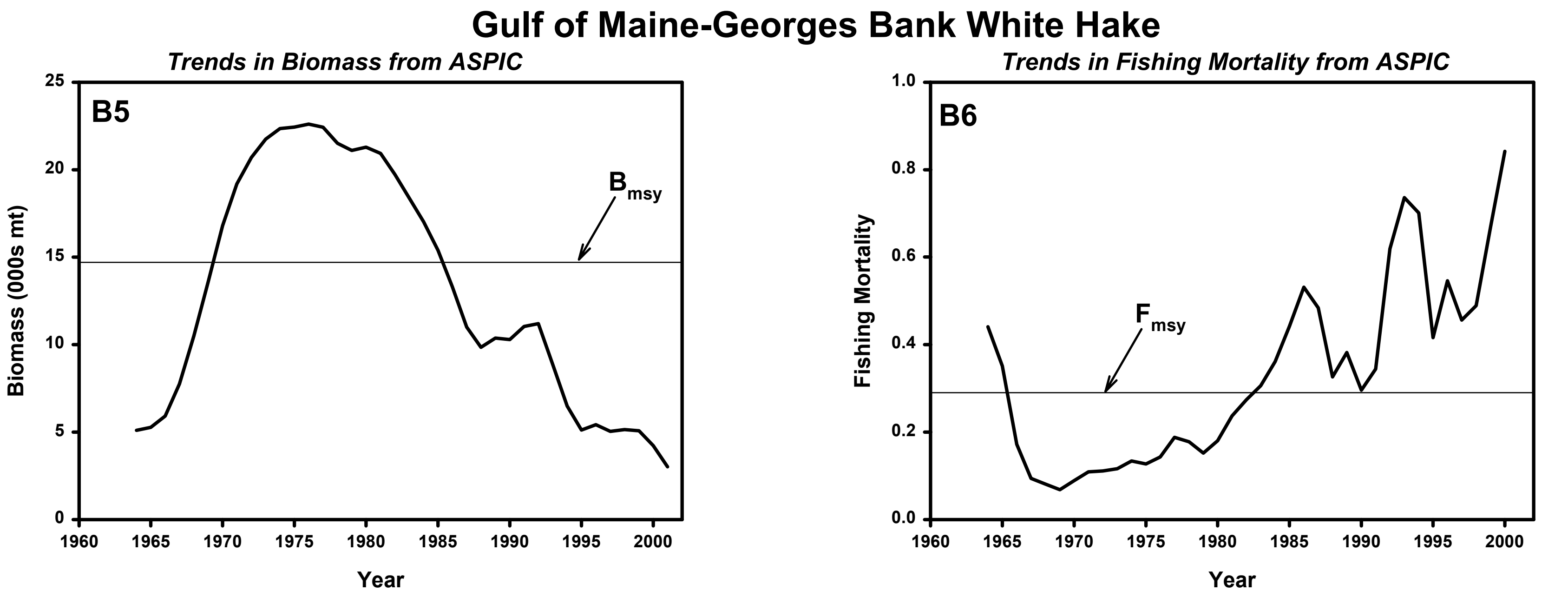
Stock Biomass: Biomass of fish > 60 cm was high in the 1970s and early 1980s (Figure B2), but declined to very low levels in 1999. Biomass of fish < 60 cm has been more stable through the time series.

Special Comments: There is considerable uncertainty in the total catches from this stock due to species mis-identification between red and white hake, poor estimates of discards, poor sampling of commercial landings, and possible mis-identification between US and Canadian stock components. Because of this there is little reliable information about the status of that portion of the biomass less than 60 cm. Biological reference points have been revised for the portion of the stock > 60 cm.

Source of Information: Report of the 33rd Northeast Regional Stock Assessment Workshop (33rd SAW), Stock Assessment Review Committee (SARC) Consensus Summary of Assessments, NEFSC Ref. Doc. 01-18; Prager, M. 1995. User's manual for ASPIC: A stock-production model incorporating covariates, program version 3.6x. SEFSC MIA-2/93-55, 4th edition-; Prager, M. 1994. A suite of extensions to a non-equilibrium surplus production model. Fish. Bull. 92: 374-389.

Gulf of Maine-Georges Bank White Hake




Gulf of Maine-Georges Bank White Hake
Trends in Biomass from ASPIC
B5
B_{msy}
Biomass (000s mt)
Year
Trends in Fishing Mortality from ASPIC
B6
F_{msy}
Fishing Mortality
Year

C. GULF OF MAINE-GEORGES BANK ACADIAN REDFISH ADVISORY REPORT

State of stock: The redfish stock is overfished but overfishing is not occurring. The current exploitation rate is low (Figure C2) and stock biomass has increased substantially since the 1980s (Figure C3). Recruitment appears to have improved considerably in recent years, and the age structure is beginning to broaden. However, compared to the 1950s and 1960s the population is, at present, dominated by young fish that have recruited over the past decade, many of which are immature. The ratio of current stock biomass to B_{MSY} is less than ½, and current F is well below the existing F_{MSY} proxy ($F_{20\%}$).

Management Advice: Given the longevity and slow growth rate of redfish, exploitation rates should remain very low to continue rebuilding of this stock, building on favorable 1992 and adjacent year classes. As the stock grows additional effort and discarding could increase, hampering recovery. Many of the fish from these year classes are reaching or exceeding the minimum landing size of 23 cm (9 in.), and retention of these year classes will increase in regulated mesh fisheries. Increases in fishing effort in deeper water portions of the Gulf of Maine could be detrimental to the recovery of this stock.

The SARC recommends $F_{50\%}$ as a more suitable proxy for F_{MSY} than the existing $F_{20\%}$ (see Biological Reference Points).

Forecast: Long-term projections indicate that the stock can rebuild to B_{MSY} in 2010 in the absence of fishing only under the assumption of continued strong recruitment (Figure C7).

Landings and Status Table, (weights in '000 mt, recruitment in millions):

Year	1993	1994	1995	1996	1997	1998	1999	2000	Max	Min	Mean
									(1934 - 2000)		
Total Comm Landings	0.8	0.4	0.4	0.3	0.3	0.3	0.4	0.3	55.9	0.3	17.4
USA	0.8	0.4	0.4	0.3	0.3	0.3	0.3	0.3	55.9	0.3	17.0
CAN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.1
Discards	Discards occur, but estimates not presently available										
USA Recr. Landings	Recreational catches considered negligible										
									(1969 - 2000)		
									Max	Min	Mean
Tot. stock biomass	44.3	51.6	66.1	81.6	99.2	111.2	120.5	134.6	153.7	29.2	77.6
Sp. stock biomass	32.5	35.9	40.3	47.7	62.7	81.9	100.5	119.6	131.0	23.7	71.6
Recruitment (Age 1)	327.5	73.3	35.0	22.4	24.9	32.2	34.5	29.2	327.5	1.6	36.5
Mean F (Ages 9+)	0.03	0.01	0.01	0.01	<0.01	<0.01	<0.01	<0.01	0.29	<0.01	0.1
NEFSC Autumn kg/tow	11.2	5.9	4.7	30.6	18.9	31.7	22.9	26.2	54.6[1]	3.4[1]	18.2[1]

[1]1963-2000

Stock Distribution and Identification: There are 3 species of redfish that inhabit the Northwest Atlantic. Acadian redfish, *Sebastes fasciatus* Storer, are distributed from the Gulf of St. Lawrence to the Gulf of Maine. Acadian redfish are found in more shallow water than their close congener, the deepwater redfish, *Sebastes mentella*. Both species are distinguished from the deeper bodied golden redfish, *Sebastes marinus,* by the presence of a small protuberance on the tip of the mandible, but Acadian redfish are virtually indistinguishable from deepwater redfish based on external morphology. Taken together, *Sebastes fasciatus* and *Sebastes mentella* are often referred to as beaked redfish.

Only the Acadian redfish is thought to occur in the Gulf of Maine-Georges Bank region (NAFO Subarea 5). Most are found in the deeper water along the coast of Maine, in the central Gulf of Maine, and in the Great South Channel. Recently, substantial numbers have been observed in the vicinity of Massachusetts Bay.

Catches: The fishery began in the 1930s. After reaching a peak of 56,000 mt in 1942, total landings declined to less than 10,000 mt during the mid-1960s. Landings subsequently increased to 20,000 mt in 1971, but have since declined steadily to less than 1000 mt since 1989 (Figure C1, Subarea 5). Landings in 2000 were 319 mt.

Data and Assessment: Abundance indices (mean number and weight per tow and length composition) from NEFSC Spring (since 1968) and autumn (since 1963) bottom trawl surveys are available through 2000. Abundance indices by age are available from NEFSC autumn surveys from 1975-2000. Standardized Commercial LPUE (50% redfish trips) and estimated total effort are available from 1942-1989. Commercial catch at age estimates are available from 1969-1985. Stock biomass and fishing mortality estimates from an analytical assessment (VPA) conducted in 1986 are available for 1969-1985.

An index of exploitation (catch/survey biomass index) was calculated from NEFSC autumn surveys from 1963-2000. An age structured dynamics model (ASDM) was applied to the above datasets from 1934-2000 to derive estimates of population biomass and fishing mortality and to estimate surplus production. A non age-structured biomass dynamics model (ASPIC) was employed to provide additional estimates of surplus production and to derive MSY-based reference points.

Biological Reference Points: Analyses of *Sebastes* spp. stock dynamics (Ralston et al. 1998, Dorn 2001) indicate that $F_{50\%}$ (0.04 for Acadian redfish) is a more appropriate proxy for F_{MSY} than the existing $F_{20\%}$ (0.12 for Acadian redfish) which was derived as a F_{MSY} proxy for groundfish stocks in general. A Thompson-Bell yield per recruit model applied to the Gulf of Maine-Georges Bank Acadian redfish stock (using an assumed M of 0.05) indicated that $F_{0.1} = 0.06$ (6% exploitation) and $F_{max} = 0.13$ (12% exploitation) (Figure C4). Current F is about 5% of $F_{50\%}$ (the more appropriate F_{MSY} proxy) and current biomass is about 33% of B_{MSY} (Figure C5).

The SARC concluded that estimates of recent biomass cannot be compared to the existing Bmsy target reference point in Amendment 9 due to methodological differences; as well, the existing fishing mortality rate threshold reference point is too high (by a factor of 2). The SARC recommends $F_{50\%}$ as a more suitable Fthreshold than the existing $F_{20\%}$

Fishing Mortality: Fully recruited fishing mortality (ages 9+) increased four-fold between 1968 and 1982, from F=0.07 to F=0.28, and sharply declined afterward (Figure C2). F has been well below $F_{50\%}$ (F=0.04) since the late 1980s, and in 2000, F was estimated to be 5% of $F_{50\%}$ (Figure C6).

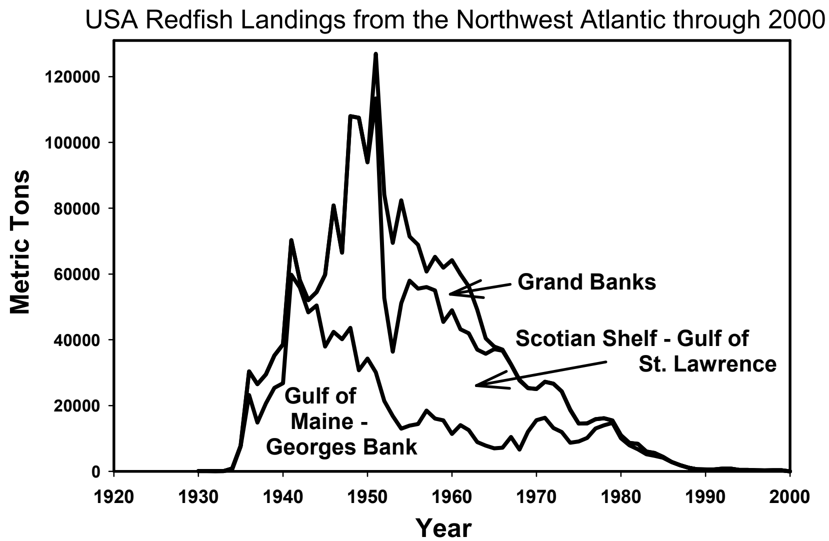
Recruitment: Subsequent to the appearance of several moderate year classes from the 1950's and early 1960s, the relatively strong 1971 and moderate 1978 year classes remained the most prominent until the 1992 year class appeared (Figure C3). Subsequent year classes have also been of moderate strength compared to most that appeared during the 1970s and 1980s. There are early indications that the 1999 year class may also be strong. The source of recent large year classes is not as certain as previous large year classes, and the possibility exists that these year classes immigrated into the Gulf of Maine region.

Stock Biomass: Total stock biomass was estimated to be extremely high during the initial phase of the fishery in the 1930s. Biomass began to decline precipitously following the onset of fishing and continued to decline sharply through the 1940s. A more gradual decline in biomass occurred during the 1950s, followed by a slight increase during the late 1960s. Total population biomass then declined sharply during the 1970s, remained low throughout the 1980s and increased steadily during the 1990s and is now at about 33% of B_{MSY} (Figure C5). Spawning stock biomass declined by 75% between 1969 and 1984, remained extremely low throughout the 1980s, and has since increased fourfold since the early 1990s (Figure C3).

Special Comments: The strong 1971 and 1978 year classes are no longer observable in the present population. SSB is now very dependent upon incoming recruitment from the 1992 and adjacent year classes.

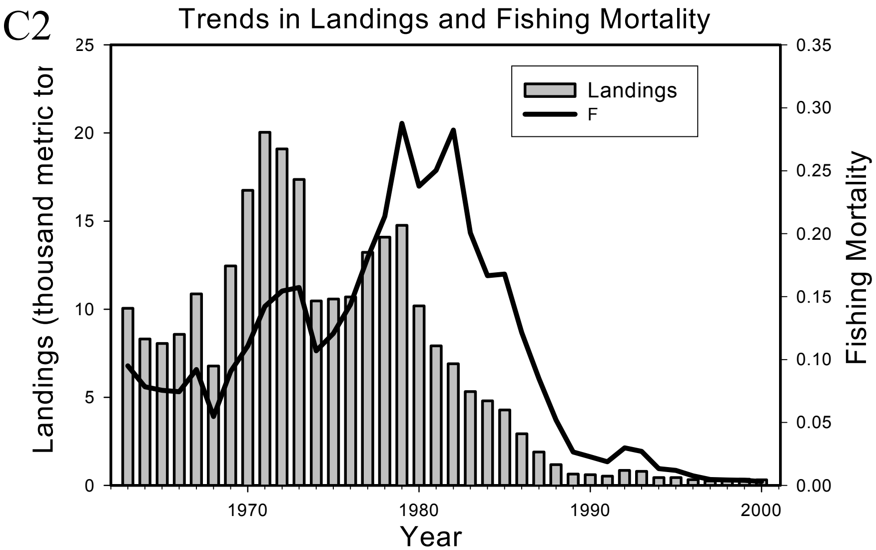
Source of Information: Report of the 33rd Northeast Regional Stock Assessment Workshop (33rd SAW), Stock Assessment Review Committee (SARC) Consensus Summary of Assessments, NEFSC Ref. Doc. 01-xx; Report of the 15th Northeast Regional Stock Assessment Workshop (15th SAW) Stock Assessment Review Committee (SARC) Consensus Summary of Assessments, NEFSC REF. DOC 93-06, Feb 1993; Report of the 2nd Stock Assessment Workshop (May 1986); R.K. Mayo *et al.* 2001, Biological Characteristics, Population Dynamics, and Current Status of Redfish, *Sebastes fasciatus* Storer, in the Gulf of Maine-Georges Bank Region, NEFSC Ref. Doc. 01-xx. Dorn, M. 2001. in press. Advice on west coast rockfish harvest rate from Bayesian meta-analysis of stock-recruit relationships. N. Am. J. Fish. Management. Ralston, R.; J.R. Bence; W.G. Clark; R.J. Conser; T. Jagielo and T.J. Quinn II. 2000. Panel Report: West Coast Groundfish Harvest Rate Policy Workshop. Sponsored by Scientific and Statistical Committee, PFMC. Alaska Fisheries Science Center, Seattle, WA: March 20-23, 2000.

C1



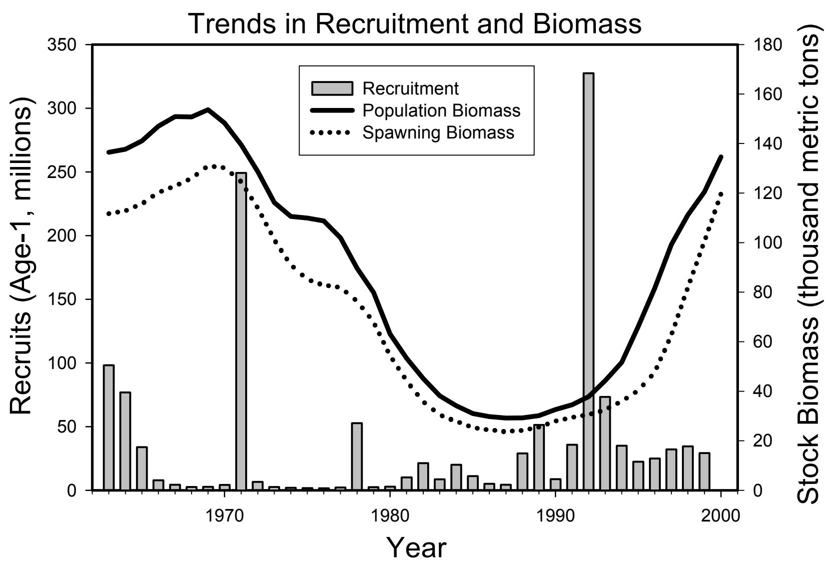
USA Redfish Landings from the Northwest Atlantic through 2000
Metric Tons
Year
Grand Banks
Scotian Shelf - Gulf of St. Lawrence
Gulf of Maine - Georges Bank

C2



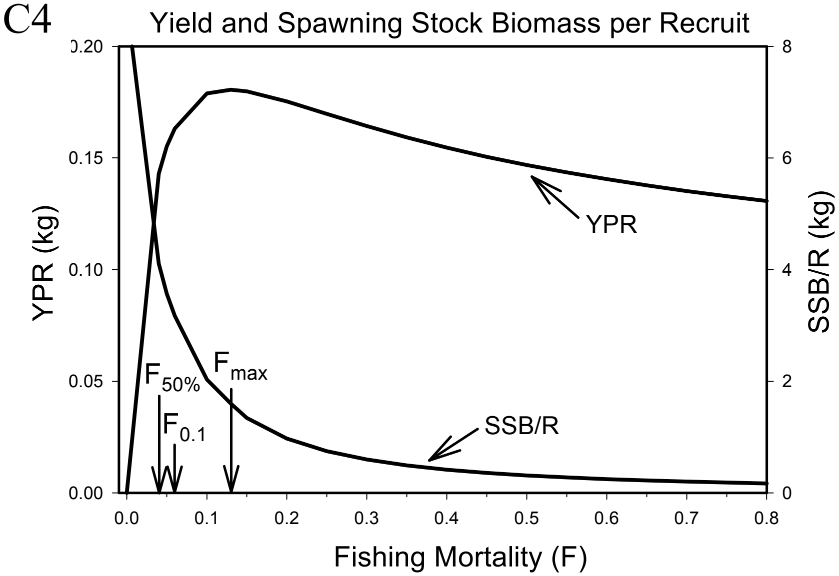
Trends in Landings and Fishing Mortality
Landings
F
Landings (thousand metric tor
Fishing Mortality
Year

C3



Trends in Recruitment and Biomass
Recruitment
Population Biomass
Spawning Biomass
Recruits (Age-1, millions)
Stock Biomass (thousand metric tons)
Year

C4



Yield and Spawning Stock Biomass per Recruit
YPR
SSB/R
YPR (kg)
SSB/R (kg)
F50%
F0.1
Fmax
Fishing Mortality (F)

Figure C5. Relative Biomass and 80% Confidence Limits from ASPIC

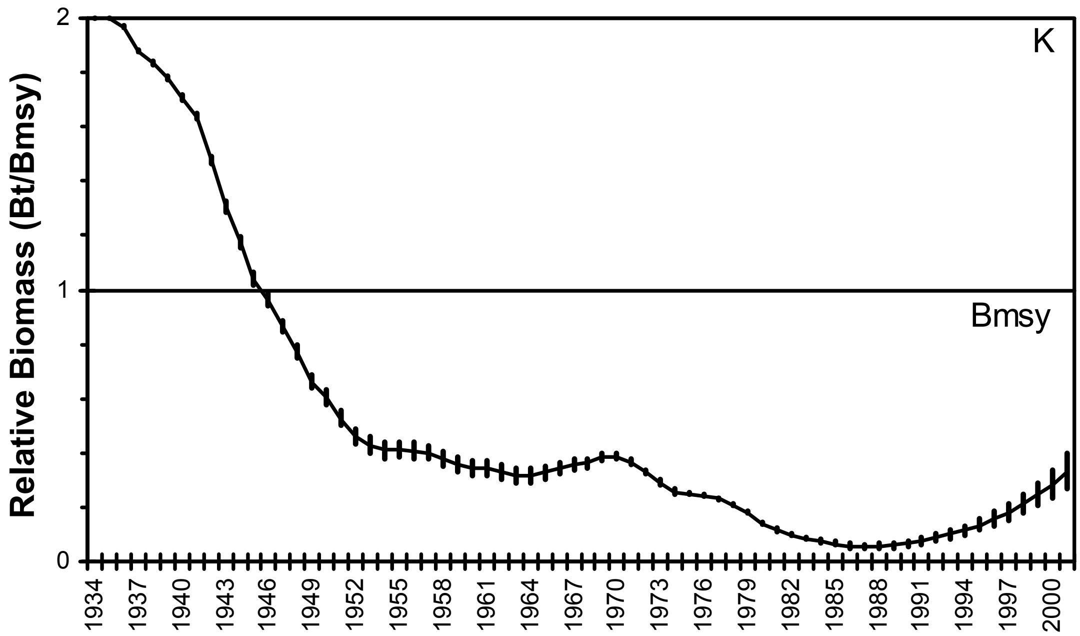


Figure C6. Relative Fishing Mortality and 80% Confidence Limits from ASPIC

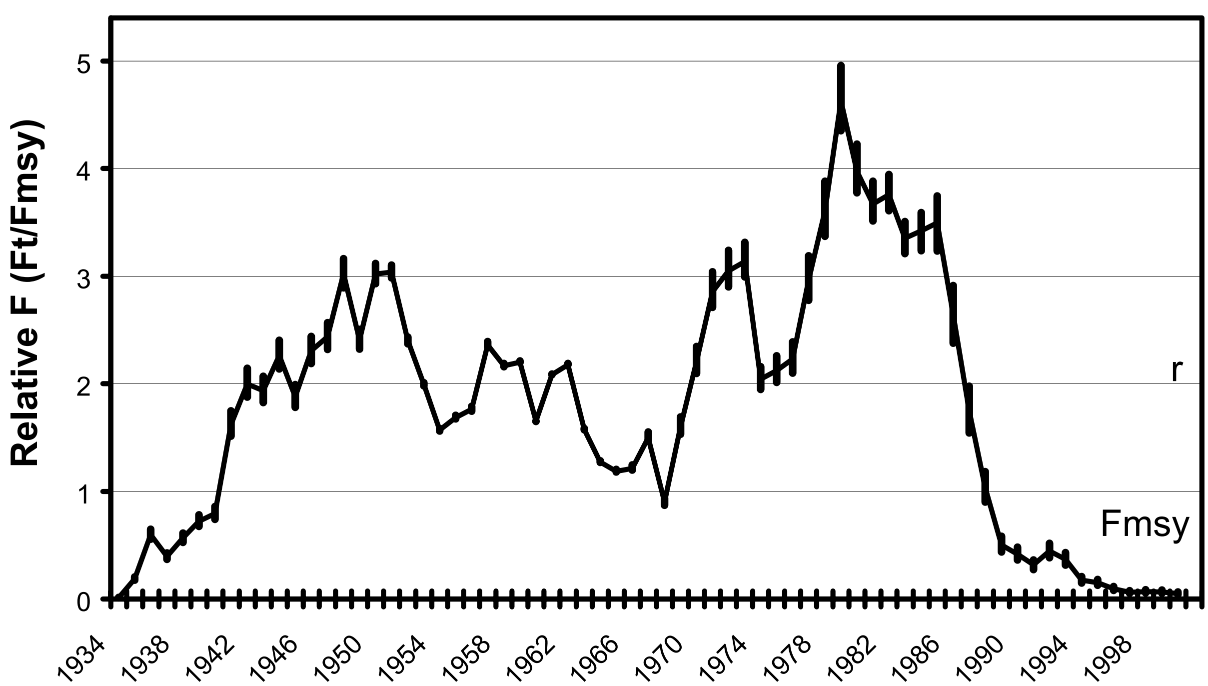
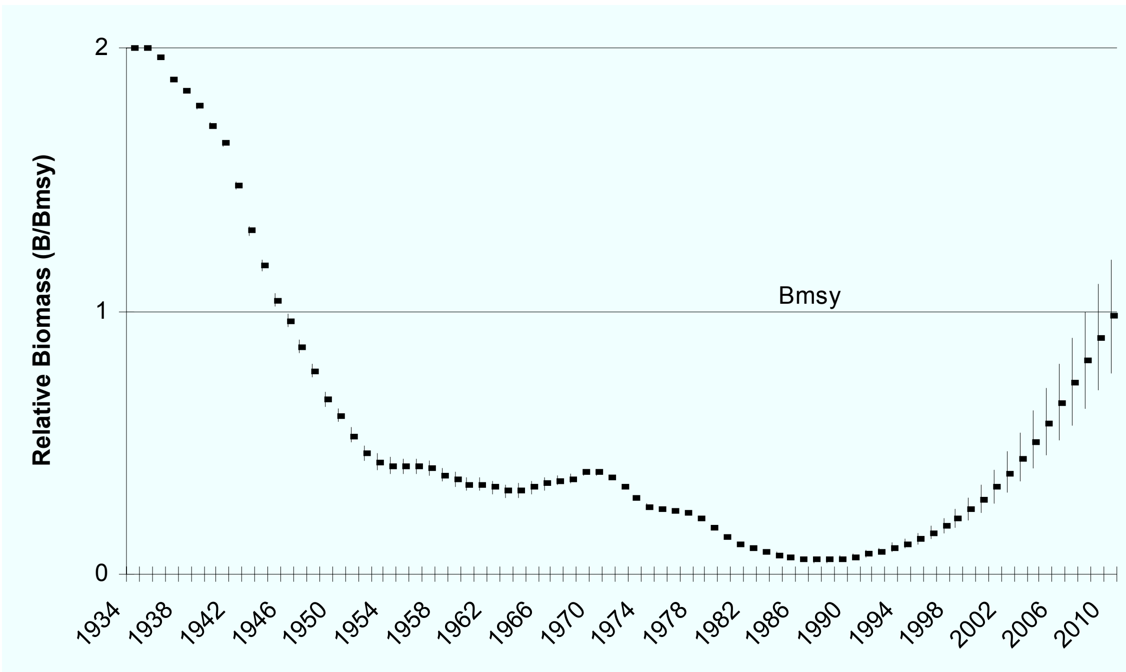


Figure C7. Projection at F=0 with 80% Confidence Limits Assuming Continued Strong Recruitment



D. SAW METHODS GROUP ADVISORY REPORT

The SARC reviewed working documents and presentations covering several aspects of production modeling. Production models are of special importance in resource assessment because of their role in the development of biological reference points such as those used by the Council.

Many of the biological reference points now in use, however, were developed from age-aggregated production models that pool information across age groups, whereas many of the managed stocks are fully assessed using age-disaggregated models (e.g. age-structured, cohort-analysis or VPA models). As pointed out in the November 2000 Report of the Groundfish Overfishing Definition Committee, many of the biological reference points developed using production modeling now need to be updated using more comprehensive approaches, which may include production modeling as one component.

SARCs have not formally reviewed such fundamental methodological issues in recent years. And although the current SARC had sufficient expertise to evaluate the production modeling approaches presented at this session, time constraints and the priority given to current stock assessment evaluations limited the discussion on production models and on the specification of biological references points in general.

In addition, although the presentations and discussions provided by Center scientists on these topics were enlightening and useful, the standard Advisory Report format for reporting scientific stock status and stock specific management advice to the Council is not well suited to reviews of technical issues that are more methodological in nature. Therefore we provide only a brief summary of our findings and indicate areas requiring further consideration, perhaps in a workshop setting supported by considerable analysis.

Terms of Reference

1) Evaluate the use of production models in providing estimates of biomass and yield targets and thresholds consistent with the provisions of SFA.

2) Provide guidance on the use and limitations of production model results for establishing management goals.

3) Evaluate various types of production models (age/stage structured, non-equilibrium, etc.) and provide guidance on the use of model types in differing circumstances of data availability, exploitation history and length of time series.

4) Compare estimates of MSY, Fmsy and Bmsy from production models with those based on catch at age model results as a basis for understanding biases, stability and precision of such estimated parameters.

Production Modeling in the Context of Other Approaches to Fisheries Management

Production modeling is a valuable tool in the stock assessment toolbox. It provides a reasonable method of synthesizing information, especially in those situations where very little information is available. (It relies simply upon recorded total catch and an index of abundance or fishing effort.) And, as demonstrated in the presentations discussed, there exist a variety of means of determining the quality of the information available from these methods and for presenting the information they contain.

And yet, there are many instances where there is more information available to the scientist and manager than that provided by total catch or a survey index alone, where the stock may be far from equilibrium, or where the more immediate consequences of the biological response to management actions may be as important as the longer-term consequences of these actions. In these instances, a more comprehensive approach may be required, and scientists and managers should not feel constrained to fitting the results from these more encompassing approaches into the statistics provided from a simple production model analysis.

Unfortunately, many of the biological reference points currently used as management proxies may fit into this category. Stock management will benefit from making use of this broader information base, but scientists will have to respond to that need by providing updated measures that characterize populations more broadly and indicate where additional information is needed and how the population, as defined, should be interpreted.

The utility of production and age-structured modeling is often improved if their interpretation is linked with simpler analyses, that may include simple exploratory data analyses, as well as to more complex analyses, such as age-structured or multispecies models.

All models benefit from longer data series that demonstrate a higher contrast in biomass levels in response to harvest rates. And it goes without saying that if the data in general is poor then no model will suffice. At the other extreme, good information may be poorly utilized, and consideration should be given to which summary statistics are the most informative and robust to uncertainties in the data.

One recommendation is the use of ratios with regard to biological reference points. For example, in representing current F contrasted with Fmsy it may be more reliable to consider the ratio of one to the other than considering either estimate in absolute terms. In many instances the absolute levels will change, while their relationship to one another remains stable. Possibilities for deriving more informative and robust measures should be explored.

The SARC notes there has been progress made on a number of fronts on production modeling and data analysis in general. Additional work is needed on utilizing information from production models, age-structured models and more generalized approaches in order to facilitate means for managers and stakeholders to interpret this information in the context of management decisions. This may indicate that we will need to step beyond a few simple biological reference points to viewing alternative means (alternative pathways) towards achieving our goal of sustainable fisheries. This also indicates that vehicles for development, review and implementation of these methods are needed and should be established.

Evaluation of Production Models and Modeling Approaches in General

- Model exploration illustrates the consequences of model choice and provides guidance on uncertainty.
- Model exploration demonstrates the limitation of both models and data.
- Multiple models may provide a needed perspective on uncertainty.
- Exploration of alternative methods demonstrates the limitations and consequences of lack of information.
- Graphical methods, diagnostic approaches, and model comparisons provide a good way of understanding the behavior of models to different pieces of information.
- A single number or statistic may give false sense of security (certainty) about the question being addressed.
- Both real data and simulated data are useful in understanding and characterizing model performance.

Recommendations

- Complex systems may require alternative perspectives and approaches.
- The SAW Methods Working Group should consider a decision theoretic framework under certain management conditions.
- Evolving methods and expanding an information base available for fishery management implies that managers will perceive “moving goal posts.” This does not mean the rules are changing, but rather that new information has been brought

to bear on the problem. This suggests that input controls, such as effort control, may be more a more effective and stable management tool than output controls, such as catch limits. Consideration should be given to such approaches.

- Scientists and managers should be encouraged to use modeling exercises to explore the effectiveness of control rules in achieving production and standing stock objectives and to explore the consequences and risks of alternate management actions.

- Adaptive approaches are encouraged in order to find limits of productivity.

- As information changes it will continue to be important to list chronological changes in the fishery, the stock, and the catch so that information from new scientific and management approaches can be linked to what has happened in the past.

Biological Reference Points

An evaluation of how biological reference points such as MSY, F_{MSY} and B_{MSY} compare between models is a useful exercise, but it is better done on a stock-by-stock basis where the units of comparison and models of choice are clearly defined.

In many instances, it may be difficult to compare B_{MSY}, for example, from one model to another in absolute terms, as the definition of biomass implicit in the model may vary from one model to the next. In one instance biomass may be best defined as the exploitable stock biomass, in another instance it may be best defined as the reproductive stock biomass, or even stock numbers.

This is all very difficult, of course, when the biological and legal settings have been framed in terms of these numbers. This suggests some alternative methods for using this information. First, how stock biomass has been defined should be made explicit for analysis, goal setting, and deliberations. Second, comparisons should be viewed in a relative rather than an absolute sense. For example, one might ask instead what is the ratio of current biomass to B_{MSY}, what is the current fishing mortality rate is relative to F_{MSY}, or what the current yield is relative to MSY. These comparisons are less likely to change as models and model estimates are updated than are the absolute values themselves. Finally, recognize that if two or more analytical approaches exist, one can always ask for short-term and long-term predictions under, for example, a status quo scenario or an F_{MSY} scenario for each approach to see what consequences, if any, exist under each perspective.

One major difference between production models and age-structured models is in how new biomass enters the standing stock. In production models the influx of new biomass comes in, usually instantaneously, as a proportion of the current biomass. In age-structured models new biomass comes in through recruitment, usually with a time lag and many times based upon a stock-recruitment relationship. Both representations are subject to assumptions and simplifications. It is the robustness of inferences to these assumptions that should form the basis of debate.

These suggestions will not solve all problems encountered in reference point comparisons, but consideration of these issues should move the process towards uses of these measures that have greater stability under uncertainty.

Northeast Coordinating Council

Stock Assessment Workshop (SAW) Issues

August 20, 2001
via teleconference

Participants:
ASMFC - L. Kline
NEFMC - C. Kellogg
NERO - G. Darcy, D. Morris
MAFMC - D. Furlong, T. Hoff
NEFSC - F. Almeida, S. Murawski, F. Serchuk, M. Sissenwine, P. Smith, T. Smith

SAW 33 The Council discussed the SAW 33 Public Review Workshops and the changes to the draft Advisory Report. Terry Smith will provide the NEFMC with a memo that documents the errors discovered after the NEFMC's PRW, and the changes to the document that resulted from correcting those errors. The revised document will be transmitted with the memo.

The rest of the meeting was devoted to a discussion of stocks to be scheduled for assessment review at upcoming SARCs. The Council discussion is summarized as an annotated schedule file. The final revised schedule is included as an attachment.

Assessment Schedule

SAW 34 (SARC, November-December 2001)

Monkfish - **confirmed**
Long-finned squid (loligo) - **confirmed**
Pollock - should be a joint US-Canada assessment - not yet ready, **postponed**

Addition: *Georges Bank winter flounder* - advanced from SAW 35.

TRAC (April 2002) *Sea herring* - TRAC scheduling for next year is uncertain. A review of an hydroacoustic based assessment of herring is still scheduled for this spring.

SAW 35 (SARC, June 2002)

Gulf of Maine winter flounder (ASMFC) - scheduling **dependent on results from ageing workshop** scheduled this week. **Leave on the agenda**.
Georges Bank winter flounder - **move** to SAW 34
Southern New England/Mid-Atlantic winter flounder (ASFMC) - scheduling **dependent on results from ageing workshop** scheduled this week. **Leave on the agenda**.
Southern New England/Mid-Atlantic yellowtail flounder - key issue is stock identification/stock combination. Research in progress but probably not complete to produce an assessment for the spring 2002 SARC. **Delay to SAW 36.**

Striped bass (ASMFC, from M&S Comm.) - Overall assessment cycle will be examined by M&S Committee at October ASMFC meeting. **May affirm or suggest rescheduling.**
Northern shrimp (ASMFC, from M&S Comm.) - Overall assessment cycle will be examined by M&S Committee at October ASMFC meeting. **May affirm or suggest rescheduling.**

Additions:

Summer flounder - benchmark with possible application and/or review of new reference points.
Black sea bass - Simple update. If fishery independent information can be collected and processed (such as tagging data) it is possible that the assessment could be a benchmark. If not the benchmark assessment would occur at a later date and be reviewed at a subsequent SARC (BSB currently listed at SAW 36).
Scup - Augmented working group will look at scup assessment issues this fall. A new assessment may result and this assessment would be reviewed at SAW 35.

SAW 36 (SARC, December 2002)
Tilefish - delay to 2004
Red crab - The New England Consortium has funded a three year study which would assess this stock. Research is not yet underway. It is not clear what information, if any, would be available for a fall 2002 SARC. **Leave on the agenda**.
Silver hake - Evaluation of FMP scheduled soon (year 4 default measures). Coordinate with NEFMC on timing of this action relative to the SARC. *Confirmed*.
Surfclam - A benchmark assessment will occur **if the** surfclam/ocean quahog **survey takes place** in 2002.

Additions:
Black sea bass - see notes for SAW 35.
Southern New England-MidAtlantic yellowtail flounder - moved from SAW 35.

SAW 37 (SARC, June 2003)
Scup - moved forward to SAW 35.
Black sea bass (ASMFC) - removed (see notes for SAW 35, SAW 36).

Ocean quahog - An assessment update will occur **if the** surfclam/ocean quahog **survey takes place** in 2002.

Bluefish (ASMFC, from M&S Comm.) - an update would be useful but there should be some discussions by the NECC in October about channeling some of the earmarked bluefish funds towards research that is directly assessment related.

Other business

Chris Kellog and Chris Moore should finalize the generic terms of reference originally drafted this spring and circulate them to Steve Murawski. Terms of reference for the SAW 34 species should be drafted in the next two weeks using the generic TOR as a template.

Revised Assessment Schedule (8/20/2001)

SAW 34 (SARC, November-December 2001)

Monkfish
loligo
Georges Bank winter flounder

SAW 35 (SARC, June 2002)

Gulf of Maine winter flounder
Southern New England/Mid-Atlantic winter flounder
Summer flounder
Black sea bass - update
Scup
Striped bass - tentative
Northern shrimp - tentative

SAW 36 (SARC, November-December 2002)

Red crab - tentative
Silver hake
Surfclam
Black sea bass - benchmark
Southern New England-MidAtlantic yellowtail flounder

SAW 37 (SARC, June 2003)

Ocean quahog
Bluefish

SAW 38 (SARC, November-December 2003)

Tilefish

SAW/SARC Assessment Reviews by Species

YEAR	85	1986		1987		1988		1989		1990		1991		1992		1993		1994		1995		1996		1997			1998		1999		2000		2001		2002		YEAR
SAW #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	SAW #
BLACK SEA BASS	X				+	+			X		X		X							X					X		X								X		BLACK SEA BASS
BLUEFISH	X		X	X	X	X					X						X	X					X														BLUEFISH
BUTTERFISH	X	X		X		X		X		X		X					X																				BUTTERFISH
COD, GB	X		X				X				X		X		X			X			+			X			X										COD, GB
COD, GOM	X		X				X					X			X				X		+			X			X						X				COD, GOM
CUSK	X																				+																CUSK
FLDR, AM. PLAICE	X	X		X							X			X							+							X				X					FLDR, AM. PLAICE
FLDR, SUMMER	X		X			X	+	+	X		X		X			X		X		X		X			X						X				X		FLDR, SUMMER
FLDR, WINTER, Offshore	X		X																																		FLDR, WINTER, Offshore
FLDR, WINTER, Inshore	X		X		+	+	+						X																								FLDR, WINTER, Inshore
FLDR, WINTER, SNE																					X							X							X		FLDR, WINTER, SNE
FLDR, WINTER, GOM																					X														X		FLDR, WINTER, GOM
FLDR, WINTER, GB																												X						X			FLDR, WINTER, GB
FLDR, WITCH	X	X																X			+								X								FLDR, WITCH
FLDR, YELLOWTAIL, SNE	X	X					X					X					X				+			X			X									X	FLDR, YELLOWTAIL, SNE
FLDR, YELLOWTAIL, GB																		X			+			X			X										FLDR, YELLOWTAIL, GB
FLDR, YELLOWTAIL, CC																												X									FLDR, YELLOWTAIL, CC
GOOSEFISH														X							+		X								X			X			GOOSEFISH
HADDOCK-GB	X	X		X									X							X	+			X			X										HADDOCK-GB
HADDOCK-GOM	X	X																			+											X					HADDOCK-GOM
HERRING, Atlantic					X				X		X		X			X					X						X										HERRING, Atlantic
LOBSTER, American	X		X							X		X		X		X					X	X															LOBSTER, American
MACKEREL, Atlantic	X	X		X		X		X		X		X								X										X							MACKEREL, Atlantic
OCEAN POUT	X										X										+																OCEAN POUT
OCEAN QUAHOG	X		X							X					X				X			+					X				X						OCEAN QUAHOG
POLLOCK	X		X						X	X						X					+																POLLOCK
RED HAKE	X	X									X										+																RED HAKE
REDFISH	X	X													X						+												X				REDFISH
RIV. HERRING/SHAD	X					X																															RIV. HERRING/SHAD
SALMON, Atlantic	X																																				SALMON, Atlantic
SCALLOPS	X	X				X			X	X	X	X	X	X						X			X						X			X					SCALLOPS
SCUP	X			X			X		X		X								X						X		X				X				X		SCUP
SHRIMP, NORTHERN	X		X		X																+				X										X		SHRIMP, NORTHERN
SILVER HAKE	X	X		X						X	X						X															X				X	SILVER HAKE
SKATES	X																													X		X					SKATES
SPINY DOGFISH	X										X							X								X											SPINY DOGFISH
SQUID, ILLEX	X	X		X		X		X		X		X		X			X				X								X								SQUID, ILLEX
SQUID, LOLIGO	X	X		X		X		X		X		X		X			X				X								X					X			SQUID, LOLIGO
STRIPED BASS	X																									X									X		STRIPED BASS
SURFCLAM, Atlantic	X		X				X		X						X				X			X				X				X						X	SURFCLAM, Atlantic
TAUTOG																				X										X							TAUTOG
TILEFISH	X													X		X																					TILEFISH
WEAKFISH			+																							X				X							WEAKFISH
WHITE HAKE	X	X									X								X		+							X					X				WHITE HAKE
WOLFFISH	X																				+																WOLFFISH

+ = No formal assessment review; research needs, working group or special topic report. X - assessment review has been completed; X - assessment review is planned.

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National Marine Fisheries Service, NOAA
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STANDARD MAIL A

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