Northeast Fisheries Science Center Reference Document 10-01

A Report of the 49th Northeast Regional Stock Assessment Workshop

49th Northeast Regional Stock Assessment Workshop (49th SAW) Assessment Summary Report

by Northeast Fisheries Science Center

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NOAA's National Marine Fisheries Serv., 166 Water St., Woods Hole MA 02543

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
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Table of Contents

SAW-49 ASSESSMENT SUMMARY REPORT

Introduction

The 49th SAW Assessment Summary Report contains summary and detailed technical information on two stock assessments reviewed in November-December 2009 at the Stock Assessment Workshop (SAW) by the 49th Stock Assessment Review Committee (SARC-49): Atlantic surfclam (*Spisula solidissima*), and butterfish (*Peprilus triacanthus*). The SARC-49 consisted of three external, independent reviewers appointed by the Center for Independent Experts (CIE) and an external SARC chairman from the Mid-Atlantic Fishery Management Council Science and Statistics Committee (MAFMC SSC). The SARC evaluated whether each Term of Reference (listed in the Appendix) was completed successfully based on whether the work provided a scientifically credible basis for developing fishery management advice. The reviewers' reports for SAW/SARC-49 are available at website: http://www.nefsc.noaa.gov/nefsc/saw/ under the heading "SARC 49 Panelist Reports".

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

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

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

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

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

Fisheries management may take into account 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 49 Panelist Reports"), the SARC review committee concluded that the Terms of Reference (ToRs) for the Atlantic surfclam assessment were met. Commercial landings and effort data were well characterized. Two semi-independent analytical approaches were used to assess the stock, namely, efficiency corrected swept-area biomass and the KLAMZ model. The KLAMZ model was used as the primary tool for stock status determination. Estimates of whole stock biomass from 1981-2008 were fairly stable with a gradual decreasing trend in abundance since the late 1990s. Whole stock estimates of fishing mortality (F) were low and fairly stable, while estimates of growth and recruitment showed a consistent decline over the time period of the analysis. Despite these downward trends, there was consensus that the Atlantic surfclam stock is not overfished and overfishing is not occurring. Concerns were raised about the validity of the whole stock assumption, particularly given the sedentary nature of surfclams and the potential for metapopulation dynamics.

The review panel concluded that the ToRs for the butterfish assessment were met in that the information specified by each ToR was provided; however, the review panel felt that not all of the assessment results could be used to support management. This conclusion was not a result of poor analytical procedures or any fault of the Coastal/Pelagic Working Group. It was due to the significant uncertainty associated with the input data and KLAMZ assessment model output. Commercial catch estimates were not precisely known due to a lack of precision of the discard estimates. Of the available survey data, only the NEFSC fall index appeared to be a reliable indicator of butterfish relative abundance. Estimates of biomass and F were fairly imprecise, and the KLAMZ model struggled to capture the scale of butterfish biomass. The review panel felt that the biomass and F estimates reflect appropriate trends, but recommended that the point biomass and F estimates be interpreted with caution. The review panel did not accept the adequacy of the redefined BRPs or the BRPs used for stock status determination in the 2004 butterfish assessment. The review panel questioned the application of MSY theory to a short-lived recruitment-dominated population, particularly the use of equilibrium methods when trends in the data suggest the stock is declining even with low fishing mortality. It was agreed that overfishing was not likely occurring. The review panel concluded that the decline in the butterfish stock appears to be driven by environmental processes and low recruitment. Determination of an overfished versus not overfished condition was not resolved at the meeting, which left the overfished status of butterfish unknown.

Glossary

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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.

F**ishery 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 (SS). This application provides a statistical framework for calibration of a population dynamics model using a diversity of fishery and survey data. SS is designed to accommodate both age and size structure and with multiple stock sub-areas. Selectivity can be cast as age specific only, size-specific in the observations only, or size-specific with the ability to capture the major effect of size-specific survivorship. The overall model contains subcomponents which simulate the population dynamics of the stock and fisheries, derive the expected values for the various observed data, and quantify the magnitude of difference between observed and expected data. Parameters are 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 SS allows for building of simple to complex models depending upon the data available.

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

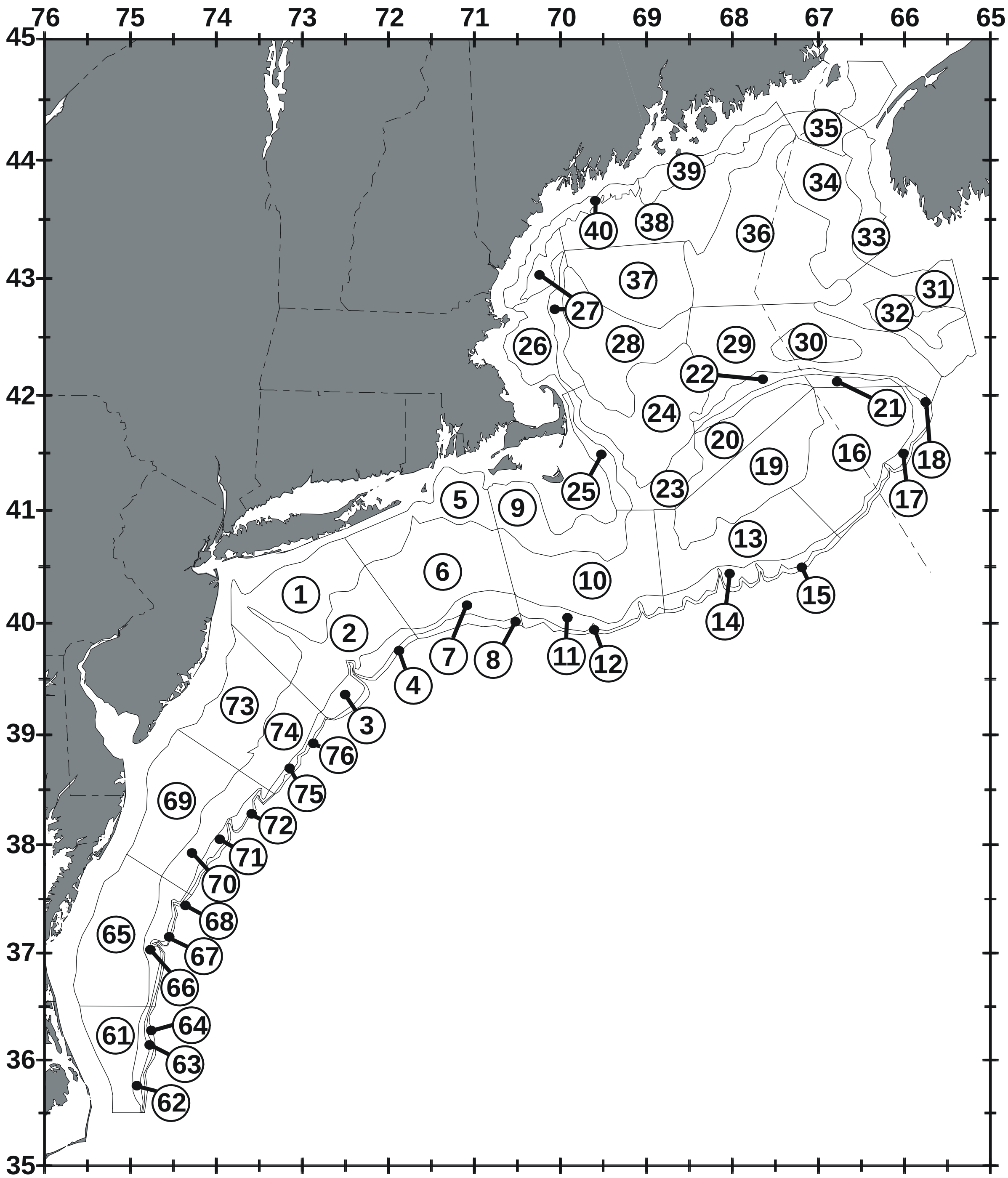

Figure 1. Offshore depth strata sampled during Northeast Fisheries Science Center bottom trawl research surveys.

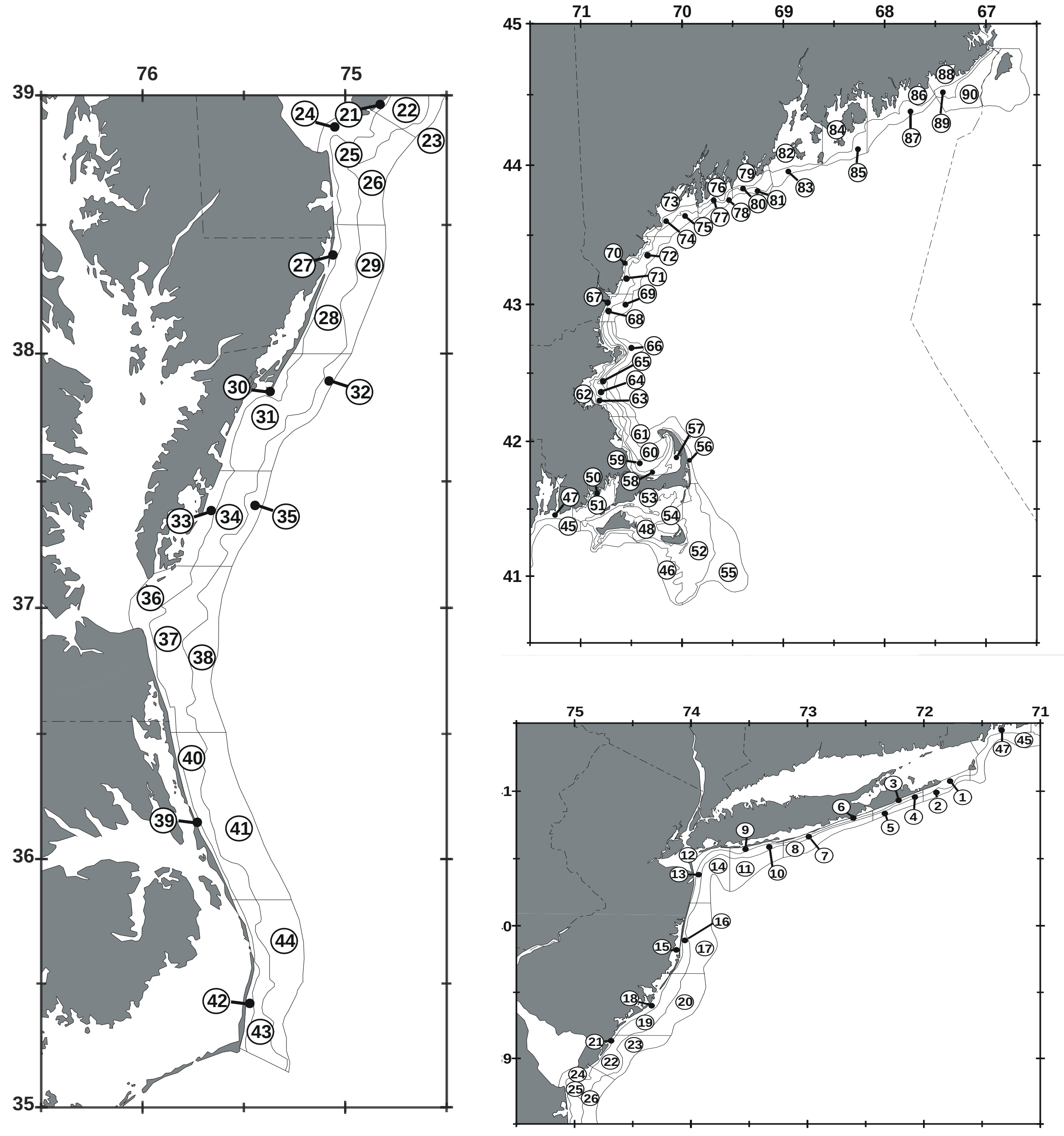

Figure 2. Inshore depth strata sampled during Northeast Fisheries Science Center bottom trawl research surveys.

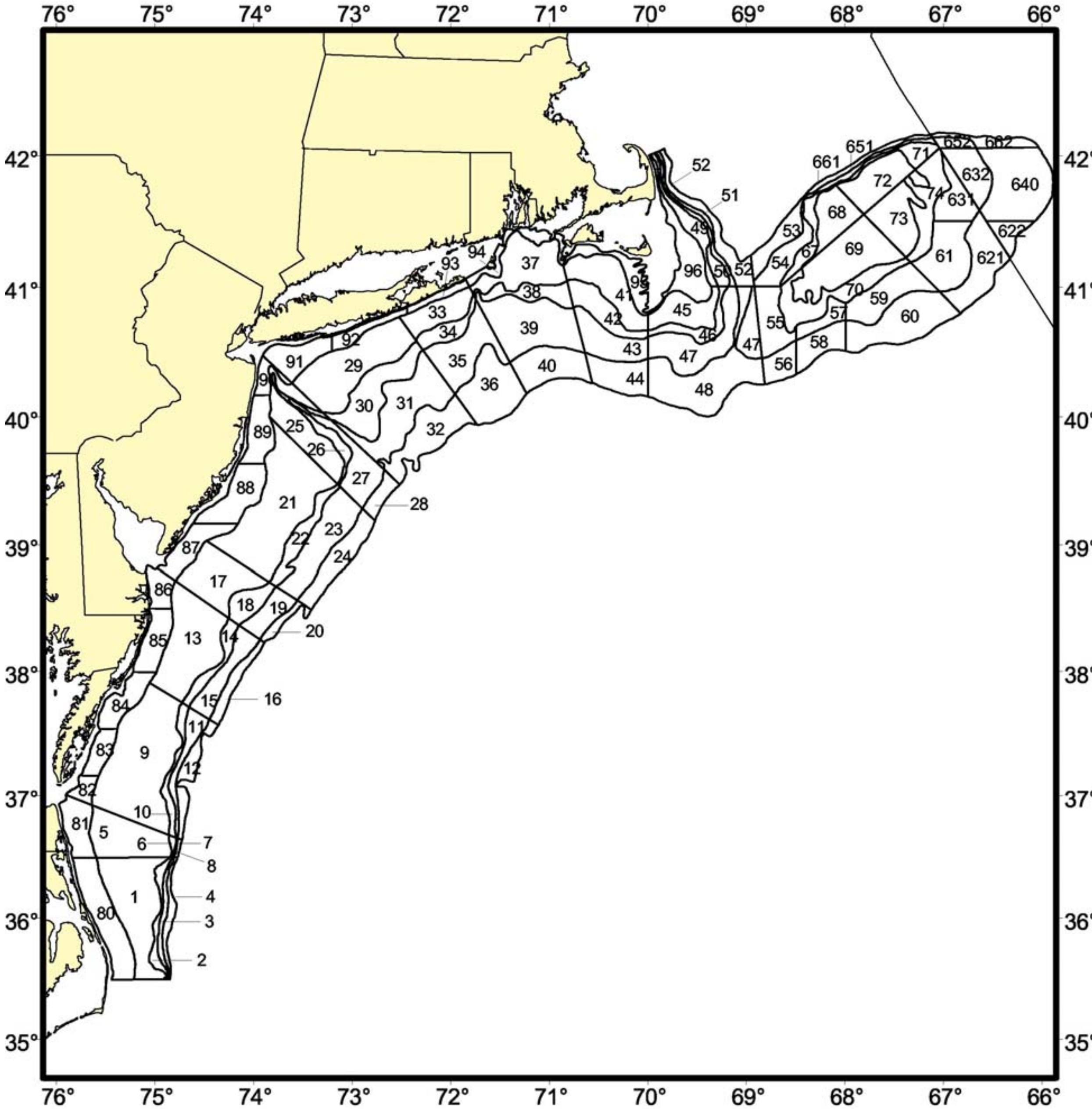

Figure 3. Northeast Fisheries Science Center clam resource survey strata, along the east coast of the US.

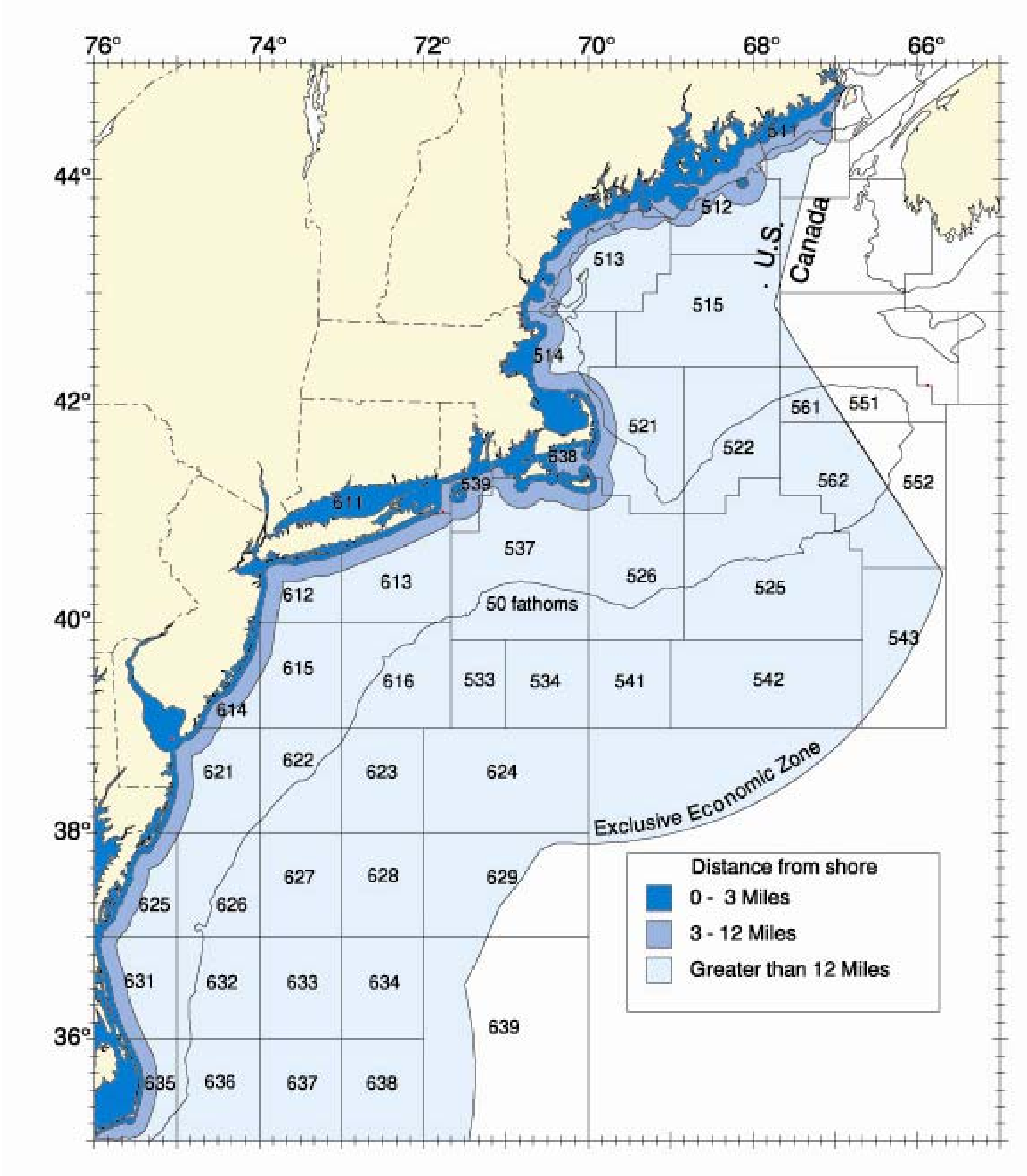

Figure 4. Statistical areas used for reporting commercial catches.

A. ATLANTIC SURFCLAM ASSESSMENT SUMMARY FOR 2009

State of Stock

The Atlantic surfclam stock in the US EEZ (Exclusive Economic Zone, 3 to 200 nm from shore, Figure A1), is not overfished and overfishing is not occurring. Surfclam biomass varies with latitude. Relative to historic conditions, in the southern regions (DMV and NJ) recruitment, growth rate, and biomass have declined. In contrast, surfclam biomass and recruitment have increased on Georges Bank and the Long Island region. Estimated stock biomass during 2008 (120+ mm shell length, SL) was 878 thousand mt meats, which is above the biomass target (B_{Target} = ½ 1999 biomass = 543 thousand mt meats) and above the biomass threshold ($B_{Threshold}$ = ½ B_{Target} = 272 thousand mt meats) (Figure A2). Estimated fishing mortality during 2008 was F= 0.027 y^{-1}, which is below the overfishing threshold ($F_{Threshold} = M = 0.15\ y^{-1}$) (Figure A3). These estimates are for the EEZ stock only, exclude state waters, and include the portion of the EEZ stock on Georges Bank where no fishing occurred between 1990 and 2008.

Landings and Status Table: Atlantic surfclam (EEZ only, 1000 mt) [4]

Year:	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	Min[1]	Max[1]	Mean[1]
Quota	19.8	19.8	22	24.2	25.1	26.2	26.2	26.2	26.2	26.2	13.8	26.2	21.4
Landings:[2,3,4]	19.6	19.7	22	24	25	24.2	21.2	23.6	24.9	22.5	6.4	33.8	20.1
Biomass:[4,5]	1086	1074	1059	1037	1012	984	955	931	905	878	831	1092	995
Fishing mortality:[3,4]	0.019	0.019	0.022	0.025	0.026	0.026	0.023	0.027	0.029	0.027	0.018	0.031	0.024
Recruitment:	98	95	94	89	87	84	82	82	81	80	80	112	99

[1] Min, max and mean for 1965-2008 (landings), 1978-2008 (quota), 1981-2008 (biomass and fishing mortality), or 1982-2008 (recruitment).
[2] Landings not adjusted for incidental mortality, which is assumed to be ≤12% of landings. Discards have been very low since 1992.
[3] Fishing mortality is an annual rate assuming that incidental mortality was 12% of landings.
[4] See assessment for regional estimates.
[5] For shell lengths 120mm+.

Projections

Projections were used for two purposes: 1) to forecast future stock conditions and 2) for decision table analyses in which the relative performance of a range of realistic management policies (harvest levels) was evaluated. Projections of both types were for 2009-2015. For projections, landings in 2009 were estimated in October of 2009 based on available data. Catches in simulation analyses included a 12% allowance for incidental mortality.

Projections of both types examined four plausible harvest strategies during 2010-2015 (see table below). The "FMP minimum" management strategy assumed that landings during 2010-2015 would be at the minimum quota level specified in the Fishery Management Plan (FMP). The "Industry estimated" strategy assumed landings anticipated by industry representatives who participated on the Working Group. The "FMP maximum" strategy assumed landings at the maximum quota level specified in the FMP. The "F_{MSY} proxy" policy assumed catches at the fishing mortality rate threshold (F=M=0.15 y^{-1}). Additional details are given in the SARC49 assessment report.

Management strategies used in projection analyses, expressed in terms of total catch.

Year	FMP minimum	Industry estimate	FMP maximum	F_{MSY} proxy
Assumed catch in 1000 mt (landings + 12% incidental mortality allowance)				
2008	25.2	25.2	25.2	25.2
2009	20.7	20.7	20.7	20.7
2010	16.0	21.6	29.4	129.3
2011	16.0	23.3	29.4	114.0
2012	16.0	25.0	29.4	102.3
2013	16.0	25.9	29.4	93.4
2014	16.0	25.9	29.4	86.8
2015	16.0	25.9	29.4	73.5

Forecast projections

Forecast results (Figure A4) indicate that surfclam biomass will continue to decline slowly through 2015. In all cases, this occurs because surplus production has been negative and is likely to remain negative due to poor recruitment and slow growth in the more southern regions.

Decision table analysis

Projections for decision table analysis (Table A1) included three values for natural mortality (low, medium and high levels of natural mortality with M=0.1, 0.15 and 0.2 per year) and three survey dredge catchabilities as “states of nature”. The states of nature were considered in combination and assigned subjective probabilities. The probability of overfishing and overfished status for this stock appears low under all of the states of nature considered. Overfishing and overfished status are more likely if target fishing mortality rates rise to the threshold level F_{MSY} proxy = 0.15. Additional details are given in the SARC49 assessment report.

Stock Distribution and Identification

The US Atlantic surfclam stock is distributed from Maine to North Carolina at depths ranging from the sub-tidal zone in state waters to about 50 m in the EEZ. Atlantic surfclams in the EEZ are assessed and managed as a single unit stock, although there are differences between regions in biological characteristics, fishing activity and population dynamics. From north to south, regions of interest are: Georges Bank (GBK), Southern New England (SNE), Long Island (LI), New Jersey (NJ), Delmarva (DMV) and southern Virginia (SVA) (Figure A1).

Catches

Catch is assumed to be 12% larger than landings in stock assessment calculations to adjust for incidental mortality during fishing. The 12% incidental mortality estimate is considered to be an upper bound. Incidental mortality may occur when surfclams contact fishing equipment (i.e. dredge and sorting equipment) but are not landed.

Discarding reached substantial levels (33% by weight of the total catch in the NJ region) in the late 1970s because of minimum size limits, declined through the mid- to late-1980s, and has been near zero since 1992 following the suspension of minimum size limits in 1990.

Annual landings from the EEZ were variable prior to 1979 (Figure A5). In particular, landings decreased from 15 thousand mt meats during 1965 to a record low of 6 thousand mt during 1970. Landings increased to a record high of 34 thousand mt during 1974. Landings stabilized by 1983 due to quota management and varied between 19 and 25 thousand mt per year in later years. Landings in 2008 were 22 thousand mt. The EEZ quota and landings are generally similar, although landings have been less than the quota during 2004-2008 due to market demand.

Since 1979, 85-100% of landings have been taken from the Mid-Atlantic Bight (SVA, DMV and NJ). Areas of highest landings have shifted north from DMV to NJ over time (Figure A6). After 1983, the importance of DMV declined and NJ has supplied the bulk of landings since 1985. About 8% of landings were taken from SNE and LI since 2005.

The regional distribution of fishing effort (Figure A7) is similar to that of landings (Figure A6) although fishing effort in DMV has increased in recent years. Declining LPUE trends (Figures A8) reflect stock conditions for regions where clam fishing occurred (excluding Georges Bank) but overstate declines in biomass for the stock as a whole (including GBK, Figure A10).

Data and Assessment

The updated assessment is similar to the previous SAW-44 assessment. Improvements include updated estimates of survey gear efficiency, survey gear size selectivity, growth curves and shell length-meat weight relationships based on fresh (unfrozen) samples. Age composition data from the 1982 to 2008 NEFSC clam surveys were utilized more fully than in previous assessments. An updated KLAMZ model was used to assess fishable biomass and fishing mortality during 1981-2008 for the entire stock and for the DMV and NJ regions. Also, efficiency corrected swept area biomass was calculated for all regions based on survey data for 1997-2008. New discard estimates for 1976-1981 were incorporated.

Biological Reference Points

The current proxy for F_{MSY} is $F = M = 0.15$ y^{-1} (Figure A3). The proxy for B_{MSY} is one-half of the estimated fishable biomass during 1999 (Figure A2). The 1999 biomass and related biological reference points were re-estimated in this assessment. The original and revised reference point values are shown in the table below.

By definition, overfishing occurs whenever the fishing mortality rate on the entire stock is larger than F_{MSY} proxy. The stock would be considered overfished if total biomass fell below $B_{Threshold}$ (estimated as ½ B_{MSY} proxy). When stock biomass is less than the biomass threshold, the fishing mortality rate threshold is reduced from F_{MSY} to zero in a linear manner.

Reference Point	Last assessment	Revised
F_{MSY}	M=0.15 y^{-1}	Same
B_{1999}	1,460 thousand mt meats	1086 thousand mt meats
B_{MSY} =½B_{1999} **(target)**	730 thousand mt meats	543 thousand mt meats
$B_{Threshold}$ = ½ B_{MSY}	365 thousand mt meats	272 thousand mt meats

Revised biomass reference points are lower than previous values primarily because of new information about the shell length and meat weight relationships, and about the efficiency and size selectivity of the dredge used in NEFSC clam surveys.

Fishing Mortality

Based on the KLAMZ model for the entire stock, fishing mortality for surfclams during 2008 was $F = 0.027$ (CV = 0.16, Figure A9). Fishing mortality rates are near zero in the north and at the highest levels estimated in the assessment for 1982-2008 in the south ($F = 0.07$ [CV = 0.16] in DMV, and approximately $F = 0.1$ [CV = 0.16] in NJ during 2008). Fishing mortality for the whole stock began increasing in 1997 to current levels that are close to the peak levels estimated for the mid-1980s. Landings have been relatively constant during recent years (Figure A6) and the increase in fishing mortality since 1997 can be explained by the decline in biomass (Figure A10) and increase in fishing effort (Figure A7).

Recruitment

Recruitment has been below average since 1999 (Figure A11). The last strong year classes on GBK, NJ and DMV occurred in 1999, 1992 and 1993, respectively. The assessment report describes factors that may have reduced recent surfclam recruitments in the DMV and NJ regions.

Stock Biomass

Biomass of the total Atlantic surfclam stock (120+ mm shell length [SL]) is declining from high levels during the late 1990s to current levels which are similar to the levels during 1981-1992 (Figure A10). High stock biomass (120+ mm SL) during the late 1990s was due to good recruitment (Figure A11) and relatively faster growth rates in southern regions in the past. Total biomass increased to peak levels during the late 1990's (Figure A10) and then declined at about 3% per year afterwards. Stock biomass during 2008 was 878 (CV = 0.16) thousand mt.

The decline in surfclam biomass since the late 1990s (Figure A10) can be explained by negative surplus production caused by lower recruitment and slower growth rates in the NJ and DMV regions (Figures A11, A12 and A13).

The distribution of surfclam biomass has shifted to the north during 1982-2008 (Figures A14 and A15). NJ held the largest fraction of surfclam biomass during 1994-2002. During 2008, the largest fraction of surfclam biomass was in GBK (Figure A15) due to declining biomass in DMV and NJ, and increasing biomass on GBK.

Special Comments

Although the total surfclam stock is above the biomass threshold, biomass varies from north to south with the southern DMV resource in relatively poor condition, the NJ region (where the fishery is concentrated) in fair condition, and the SNE, LI and GBK regions in nearly virginal condition. DMV and NJ are experiencing poor recruitment and reduced growth rates.

An alternative stock structure should be considered in the next surfclam assessment because of biological and fishery differences among regions.

Commercial LPUE data were not used in the assessment model because LPUE does not necessarily represent total stock biomass. Nevertheless, declining trends in LPUE for DMV, NJ, and LI correspond with declining surfclam trends in the NEFSC survey data for these regions (Figure A8).

The Georges Bank (GBK) region currently contains approximately 48% of the stock biomass. GBK has been closed to fishing for many years due to the threat of Paralytic Shellfish Poisoning (PSP). The FDA recently reopened GBK to fishing for surfclams contingent on continued testing for and absence of PSP.

Agency, academic and industry personnel have made progress in estimating the efficiency of NEFSC and commercial clam survey dredges. Collaborative studies to measure dredge efficiency should continue.

The “dome-shaped” size-selectivity of the NEFSC survey dredge was characterized based on cooperative field work in 2008. As this information had a substantial effect on the current stock assessment, it would be advisable to repeat the field experiment.

Given past issues with the *Delaware II* NEFSC clam survey dredge gear, including low and variable capture efficiency as well as “dome-shaped” size selectivity, these aspects of the surfclam survey could be improved by using a commercial clam dredge, preferably with a liner and other modifications to increases catches of small surfclams.

A constant M (0.15 y^{-1}) was assumed in the assessment, but that value is uncertain and should be re-evaluated in the next assessment. Reductions in biomass in inshore southern regions are due partly to changes in environmental conditions and likely increasing natural mortality in those areas.

The current biomass reference points were based on the observation that the stock was at a high biomass level in 1999. Biomass reference points might be reviewed, given potential climate related shifts in distribution and the *ad-hoc* basis of the reference points.

The current proxy for F_{MSY} is $M = 0.15$. This reference point should be reviewed in the next assessment. The productivity of the stock appears low for a species with $M = 0.15$, and geographic variation in natural mortality rate is likely.

Growth curves fit to survey age data, and used in stock assessment modeling, indicate that growth rates have declined in the southern regions (DMV and NJ). These changes should have a substantial effect on potential fishery yield in some regions. The proportion of the stock in the south has declined. The northern region now contains most of the stock biomass, and the growth rate there is unchanged. For the entire stock, growth rate of has been relatively stable.

The bulk of fishing effort takes place in the southern DMV and NJ regions where regional fishing mortality rates were 7% and 10% per year during 2008. The long term performance of the fishery at these mortality rates is uncertain because these levels of regional fishing mortality are relatively high from a historical perspective.

Model results indicate that surplus production for the stock as a whole and particularly in the southern regions (NJ, DMV) has been negative indicating that biomass would have declined even in the absence of fishing.

Under current FMP specifications, the surfclam resource is not “vulnerable” to becoming overfished or likely to experience overfishing by 2015. Total stock biomass is relatively high, total fishing mortality rates are low (3% per year according to KLAMZ models), and the FMP restricts harvest to levels far below the F_{MSY} proxy harvest level. The relatively low biomass, slow growth and poor recruitment of stock in the south (DMV and NJ) are offset by better conditions in the north.

Although the current KLAMZ stock assessment model is performing well, it assumes a smooth trend in recruitment from year to year that is not supported by survey age composition data.

A preliminary stock synthesis assessment model (SS3) for the entire surfclam stock was developed for review and potential use as the main model in the next assessment. It is not intended for use by managers in this assessment cycle because of a variety of issues that were not fully resolved.

In the early 1970s surfclams were landed off Chesapeake Bay, but were fished down rapidly. The fishery then returned to traditional grounds off DMV and NJ. NEFSC surveys in the 1970s and 1980s extended to Cape Hatteras. With low survey catches and no commercial fishery south of DMV, this area has been surveyed less intensively since the late 1990s.

References

MAFMC. 2003. Amendment 13 to the Atlantic surfclam and ocean quahog fishery management plan. Mid-Atlantic Fishery Management Council. Dover, DE.

MAFMC. 2006. Overview of the surfclam and ocean quahog fisheries and quota considerations for 2007. Mid-Atlantic Fishery Management Council. Dover, DE.

NEFSC. 2007. Assessment of Atlantic surfclams, p. 14-284. *In:* 44th Northeast Regional Stock Assessment Workshop (44th SAW): 44th SAW assessment report. U.S. Dept Comm, NEFSC Ref Doc 07-10. 1

NEFSC. 2007. 44th Northeast Regional Stock Assessment Workshop (44th SAW). 2007. 44th SAW assessment summary report. U.S. Dept Comm. NEFSC Ref Doc. 07-03. 2

NEFSC. 2008. Resource survey report, surfclam/ocean quahog. Northeast Fisheries Science Center, Woods Hole, MA. 3

Weinberg JR, Dahlgren TG, Halanych KM. 2002. Influence of rising sea temperature on commercial bivalve species of the U.S. Atlantic coast. Amer Fish Soc Symp. 32: 131-140.

Weinberg JR. 2005. Bathymetric shift in the distribution of Atlantic surfclams: response to warmer ocean temperature. ICES J Mar Sci. 62: 1444-1453.

1 Available at: http://www.nefsc.noaa.gov/nefsc/publications/crd/crd0710/.
2 Available at http://www.nefsc.noaa.gov/nefsc/publications/crd/crd0703/
3 Available at: http http://www.nefsc.noaa.gov/femad/ecosurvey/mainpage/

Tables

Table A1. Decision table showing probabilities of a simulated surfclam stock with total biomass (120+ mm) at or lower than the target level (B_{Target}=B_{1999}/2), at or lower than the threshold level ($B_{Threshold}$=B_{Target}/2), and with fishing mortality rates at or higher than the threshold level ($F_{Threshold}$=M) during 2015. The analysis examines nine states of nature and four possible management approaches. Probabilities for states of nature are described as Low, Medium or High. The column "Pattern ID for dredge efficiency" is to help readers make comparisons among rows.

States of nature			Management actions				
Natural mortality	Survey dredge efficiency	Probability for state of nature	FMP minimum	Industry estimate	FMP maximum	F_{MSY} proxy	Pattern ID for dredge efficiency
Probability of stock biomass below B_{MSY} proxy target level in 2015							
Low	Low	Low	0	0	0	0.612	
Low	Medium	Medium	0	0	0	0.982	
Low	High	Low	0	0	0.004	1	
Medium	Low	Medium	0	0	0	0.91	
Medium	Medium	High	0	0	0.002	0.952	
Medium	High	Medium	0.006	0.012	0.014	0.998	
High	Low	Low	0	0	0	0.618	
High	Medium	Medium	0	0.002	0.002	0.924	
High	High	Low	0	0.002	0.018	0.984	
Probability of stock biomass below $B_{Threshold}$ level in 2015							
Low	Low	Low	0	0	0	0	
Low	Medium	Medium	0	0	0	0	
Low	High	Low	0	0	0	0.894	
Medium	Low	Medium	0	0	0	0	
Medium	Medium	High	0	0	0	0.002	
Medium	High	Medium	0	0	0	0.268	
High	Low	Low	0	0	0	0	
High	Medium	Medium	0	0	0	0	
High	High	Low	0	0	0	0.294	
Probability of overfishing in 2015							
Low	Low	Low	0	0	0	0.908	
Low	Medium	Medium	0	0	0	1	
Low	High	Low	0	0	0	1	
Medium	Low	Medium	0	0	0	0.312	
Medium	Medium	High	0	0	0	0.948	
Medium	High	Medium	0	0	0	1	
High	Low	Low	0	0	0	0.002	
High	Medium	Medium	0	0	0	0.196	
High	High	Low	0	0	0	0.996	

Figures

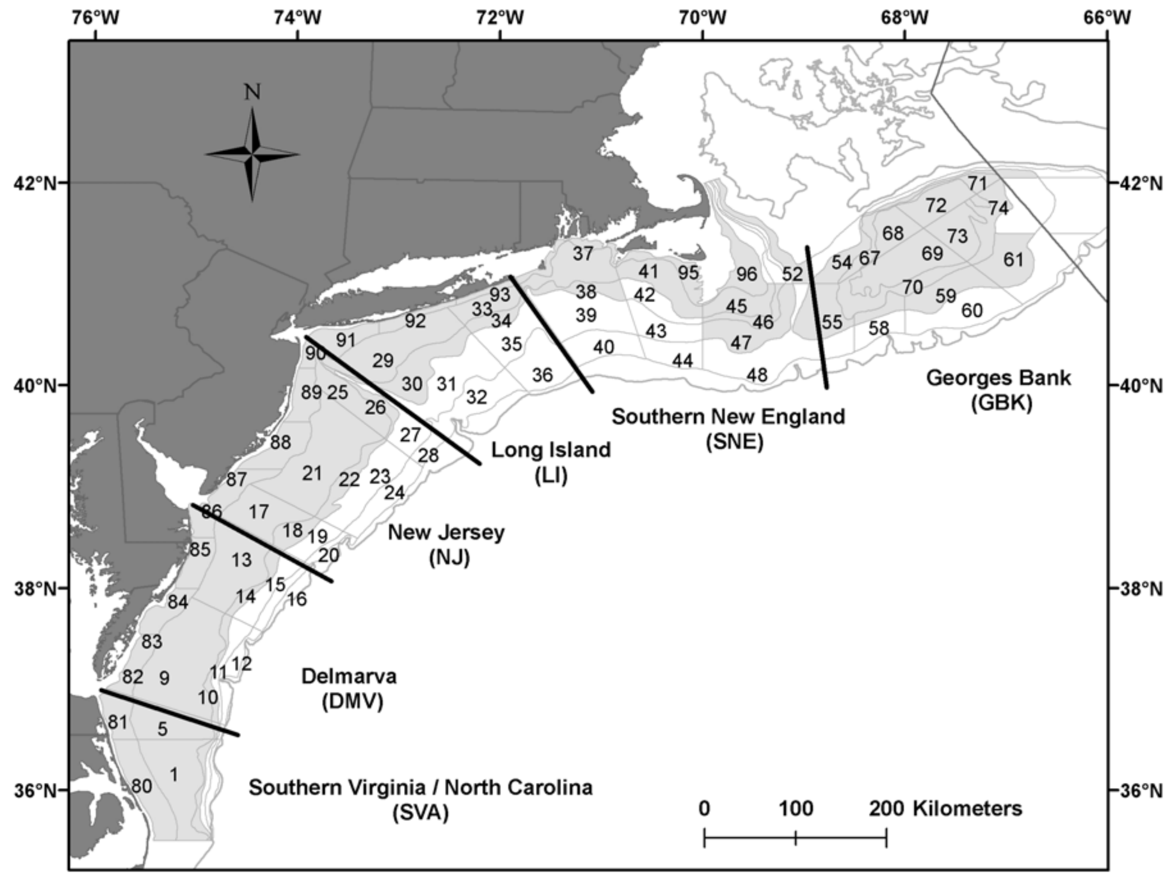

Figure A1. Assessment regions for the Atlantic surfclam stock in the US Exclusive Economic Zone (EEZ). NEFSC shellfish strata with potential surfclam habitat are shown in grey and identified by stratum ID numbers.

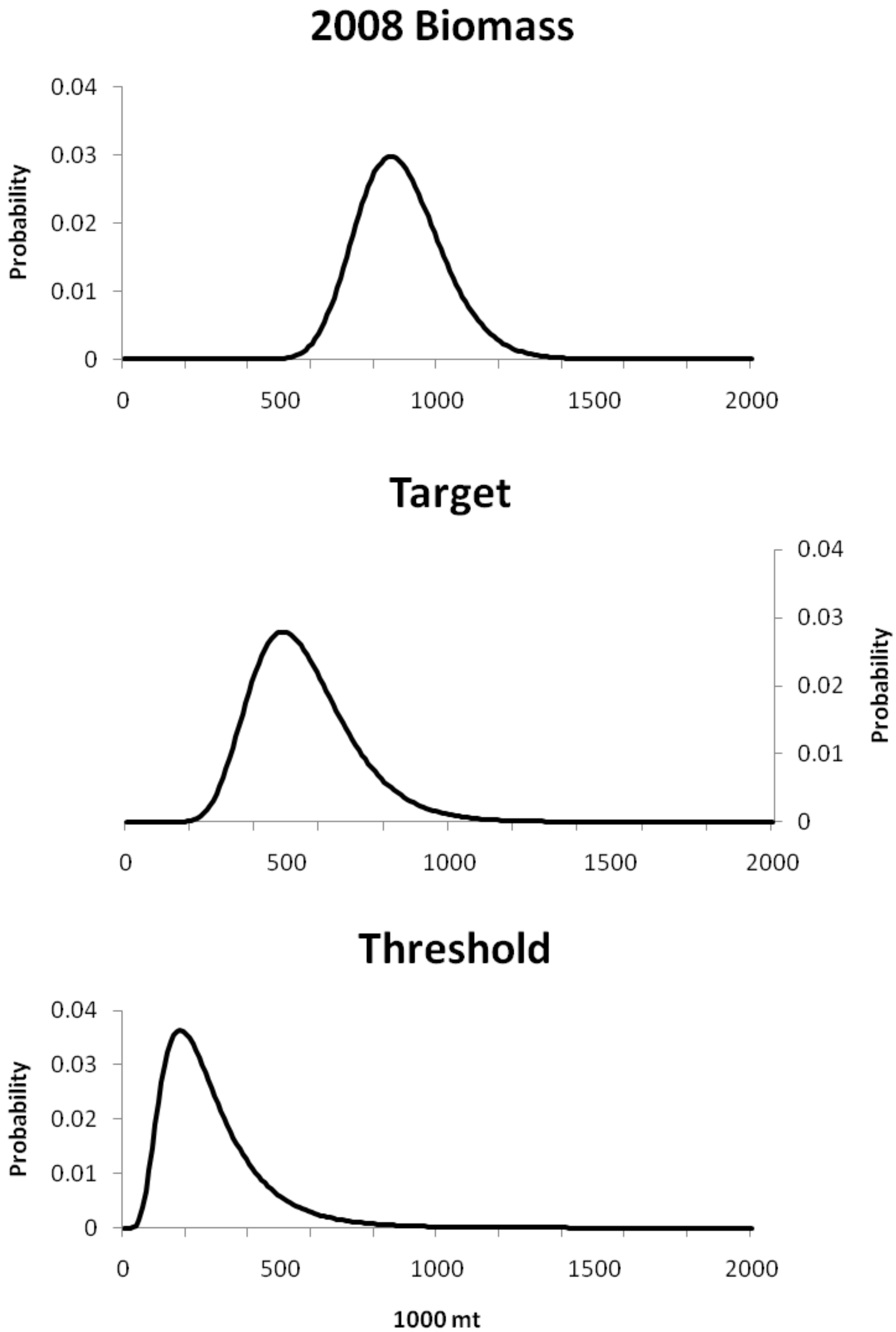

Figure A2. Probability density functions for estimated stock biomass (120+ mm SL) of surfclams during 2008, the estimated biomass target and the estimated biomass threshold.

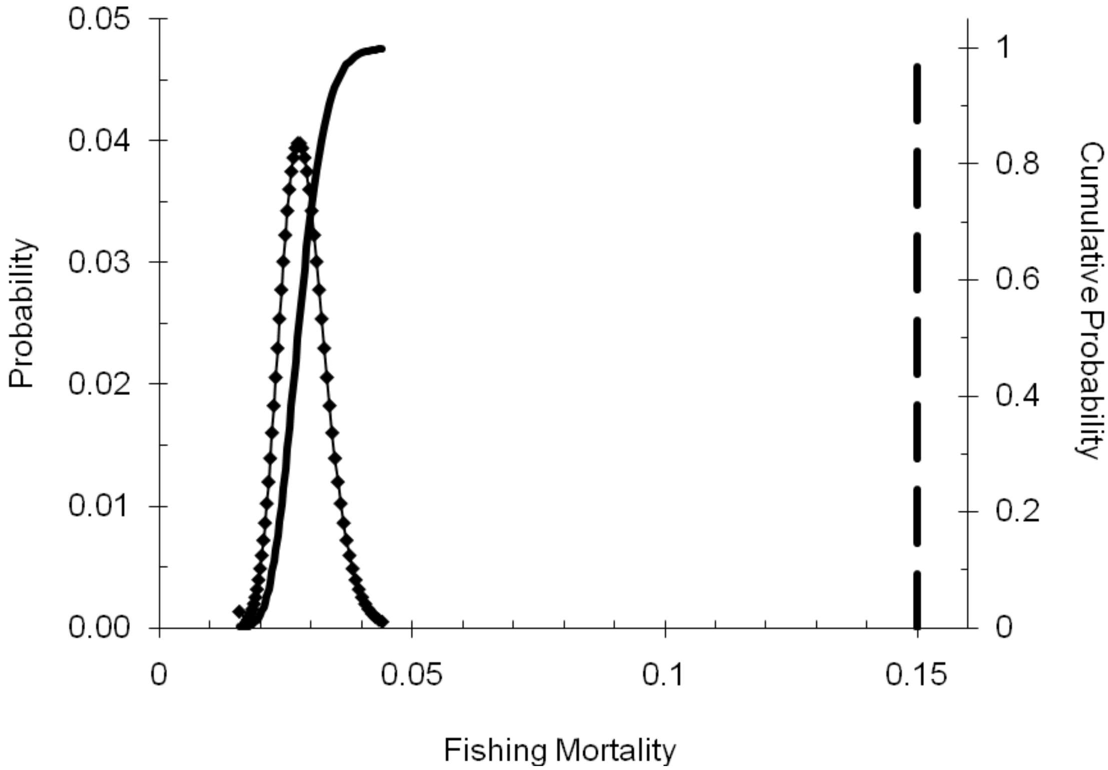

Figure A3. Estimated surfclam fishing mortality rate and confidence interval for 2008. The vertical line shows the fishing mortality threshold ($F_{Threshold}$ = M = 0.15) for comparison.

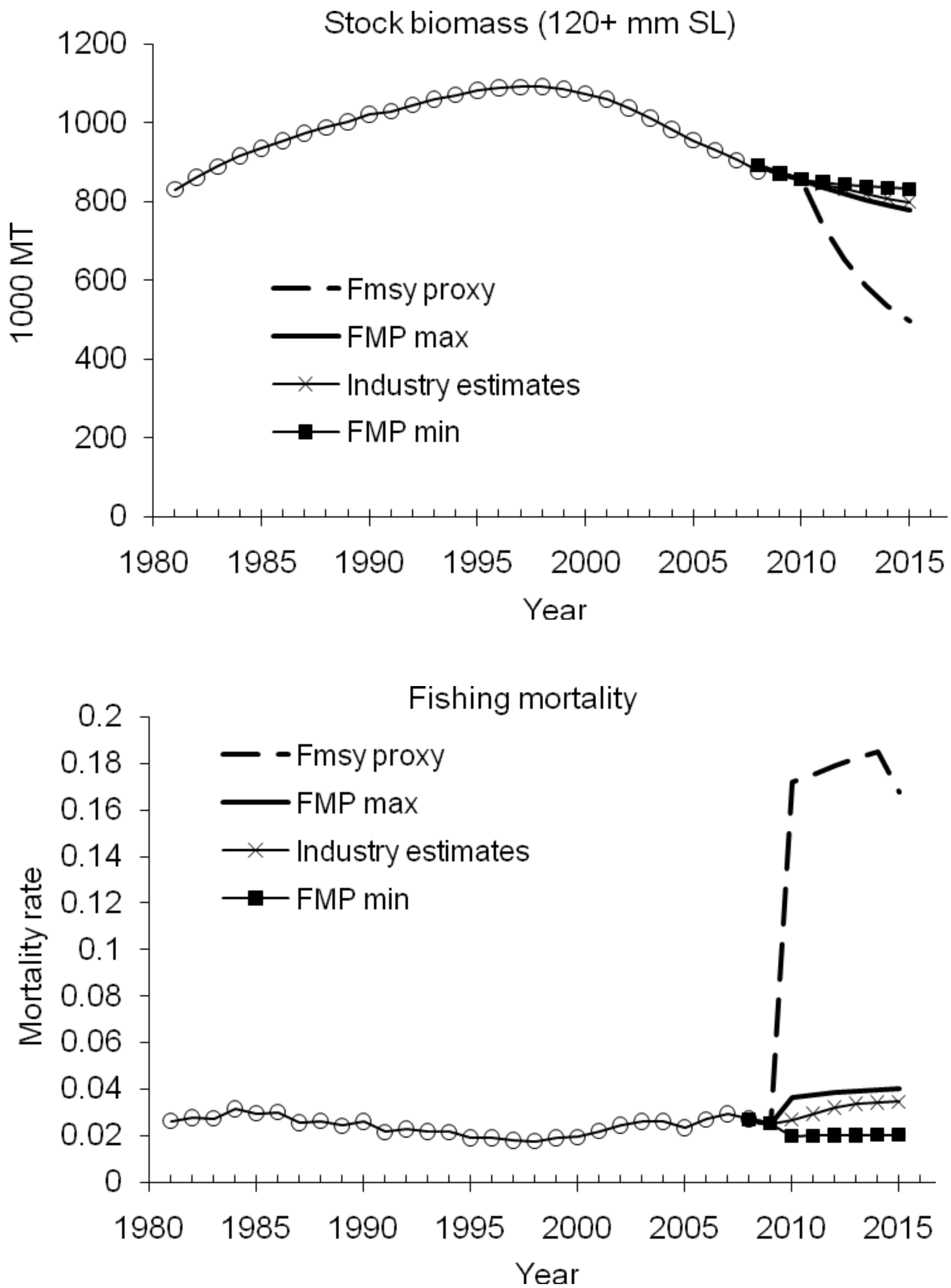

Figure A4. Basecase biomass and fishing mortality estimates for 1982-2008 from the KLAMZ model for the entire stock of surfclams, with projections for 2009-2015 assuming four harvest policies.

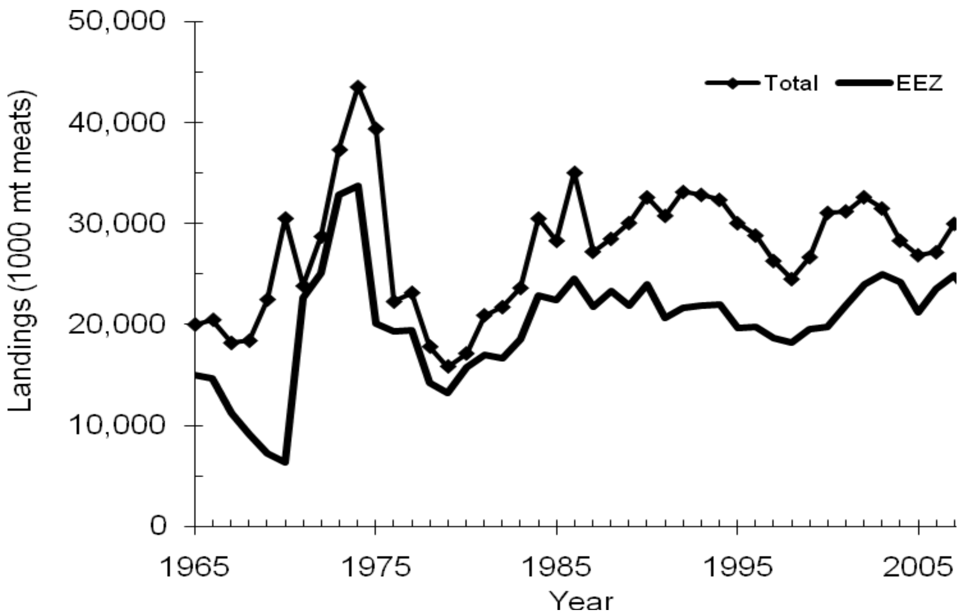

Figure A5. Surfclam landings (total and EEZ) during 1965-2008.

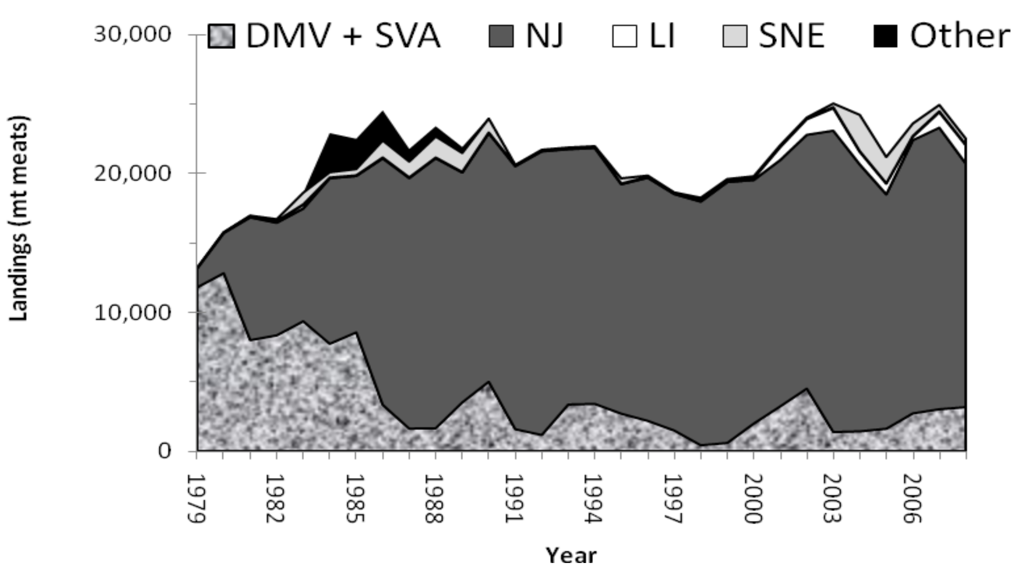

Figure A6. Surfclam landings from during 1979-2008 by stock assessment region.

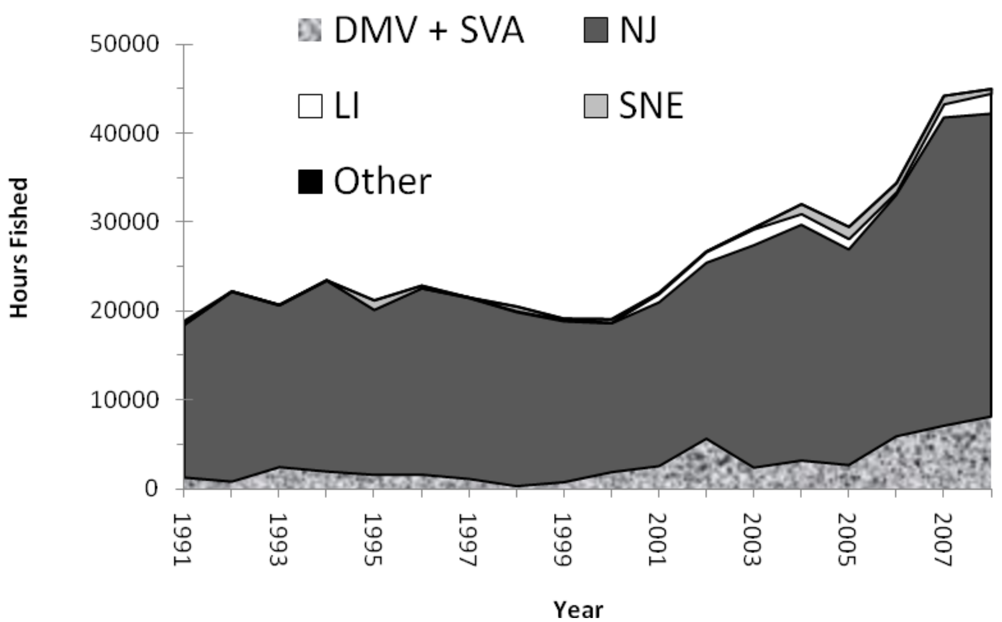

Figure A7. Total fishing effort (hours fished during all trips by all vessels) for surfclam during 1991-2008 in the US EEZ, by stock assessment region.

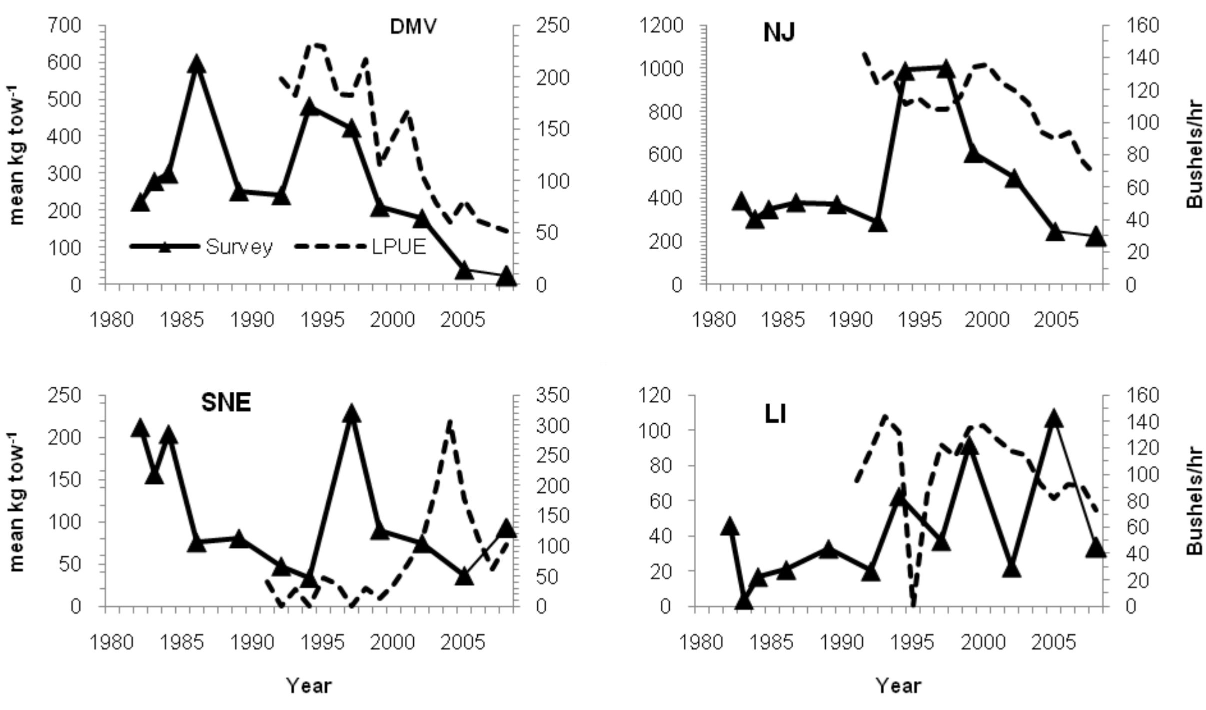

Figure A8. Trends in stock biomass for surfclams (120+ mm SL) based on the NEFSC clam survey and commercial LPUE from logbooks.

Figure A9. Fishing mortality estimates for surfclam with approximate 80% confidence intervals with projections through 2015 based on industry estimates for landings.

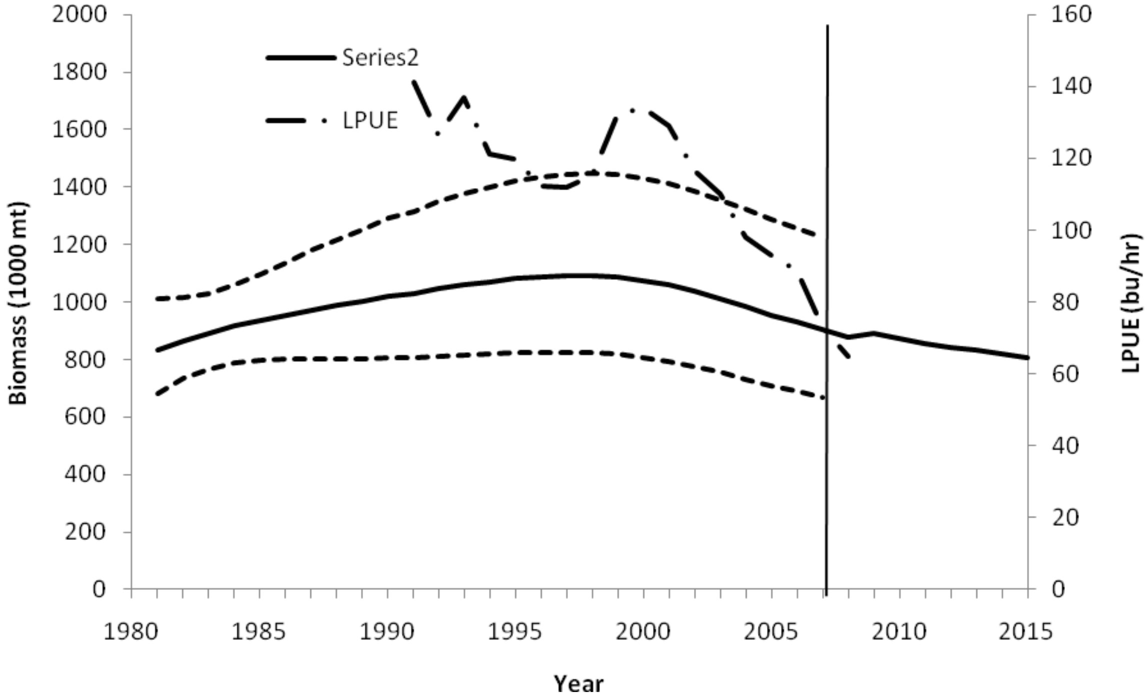

Figure A10. Surfclam biomass estimates (labeled "Series2") with approximate 80% confidence intervals. Nominal commercial LPUE from logbooks (total reported landings / total reported hours fished, all vessels and all trips) for the entire fishery (not including GBK where fishing did not occur) are shown for comparison. LPUE data were not used in estimating biomass. Projections to 2015, based on industry estimates of landings, are also shown.

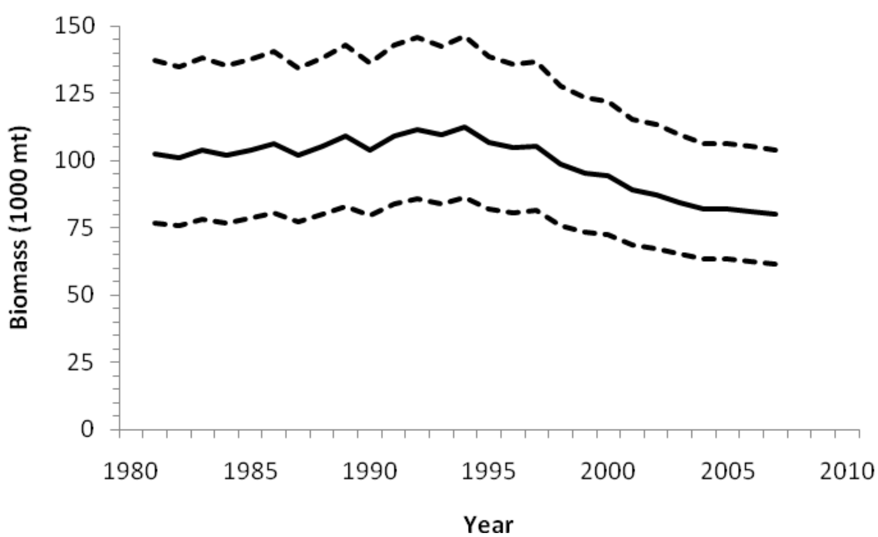

Figure A11. Surfclam recruit biomass estimates with approximate 80% confidence intervals.

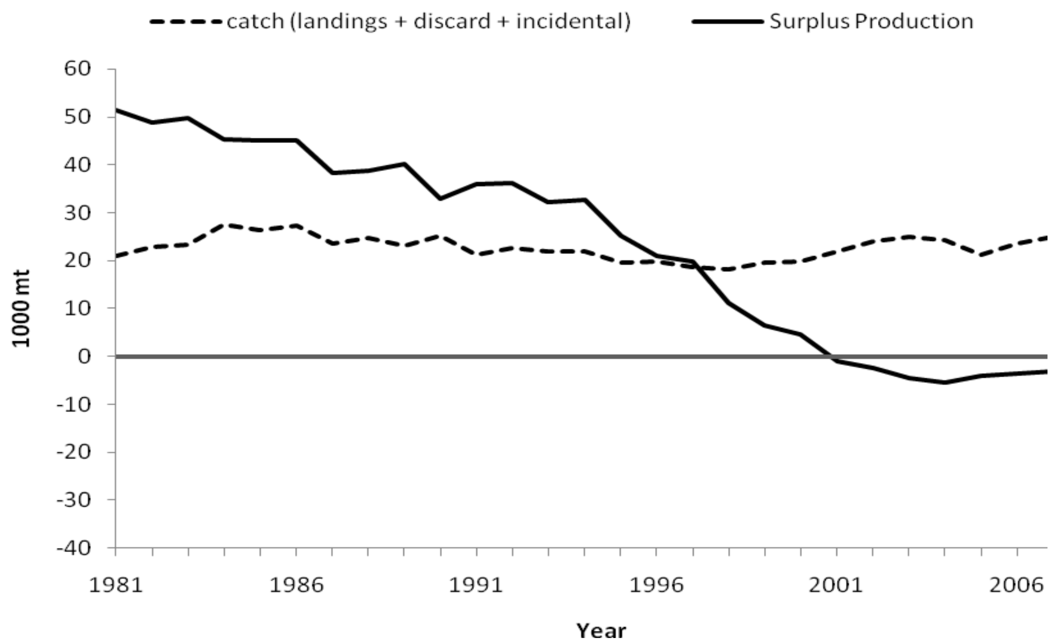

Figure A12. Estimated surfclam catch and surplus production by year.

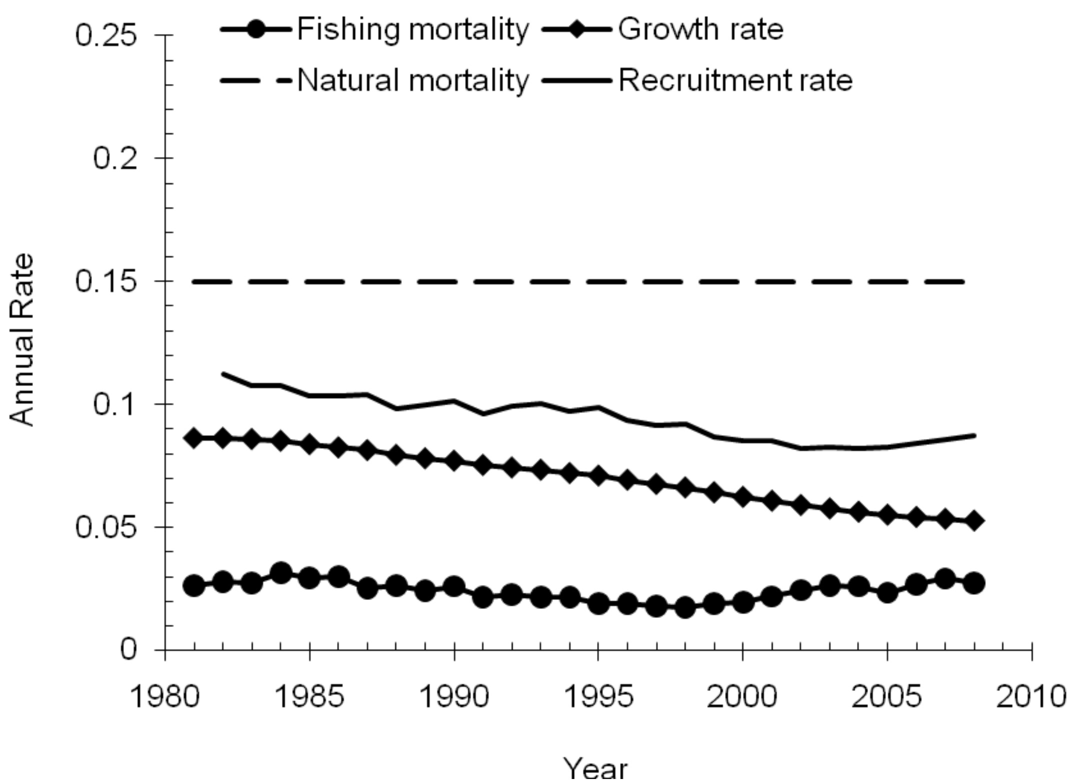

Figure A13. Estimated annual rates (e.g. the recruitment rate is based on the ratio of recruitment and stock biomass) of gain and loss for surfclam during 1982-2008.

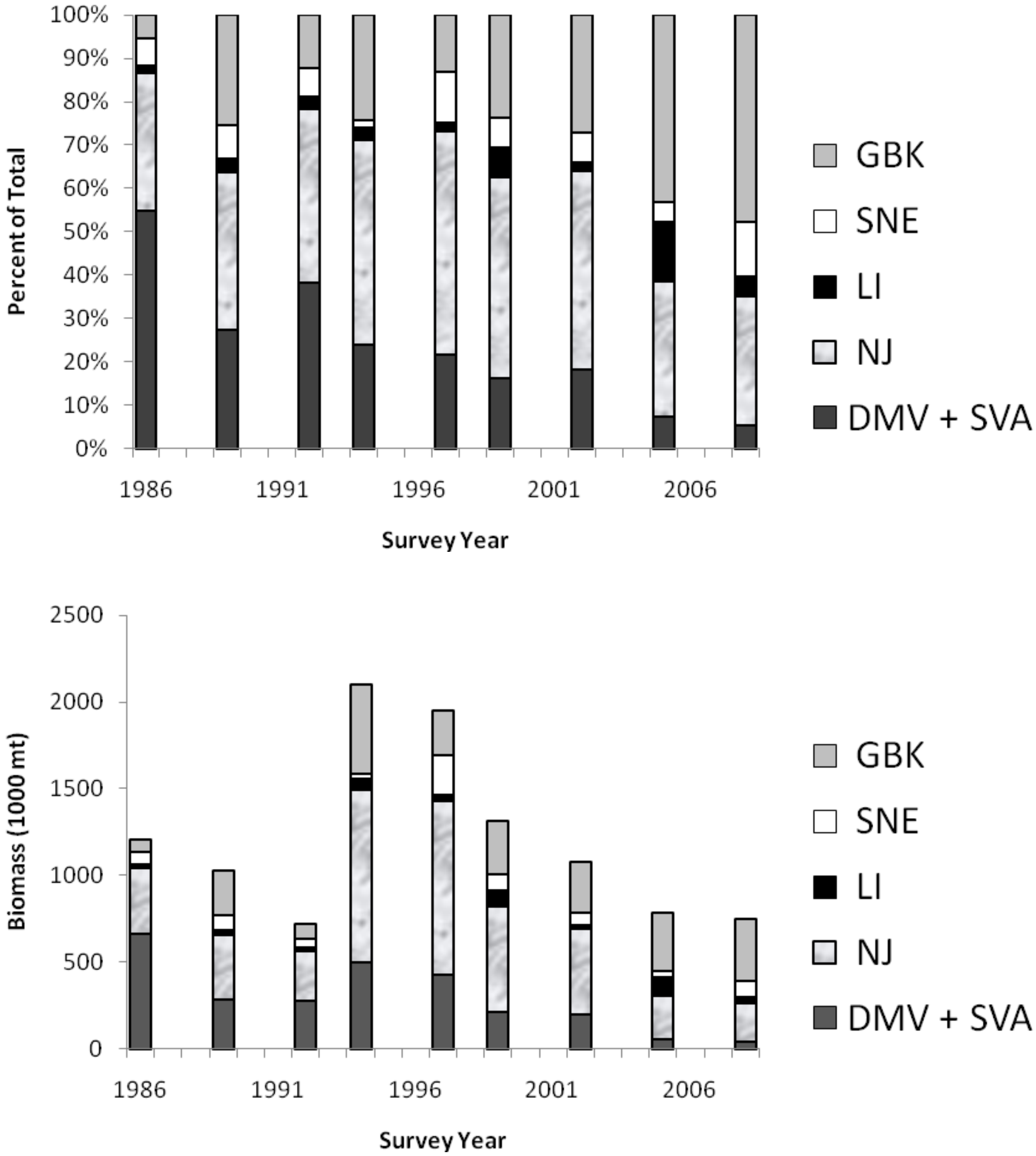

Figure A14. Efficiency corrected swept area biomass estimates for surfclams (120+ mm SL), by region, during years with NEFSC clam surveys.

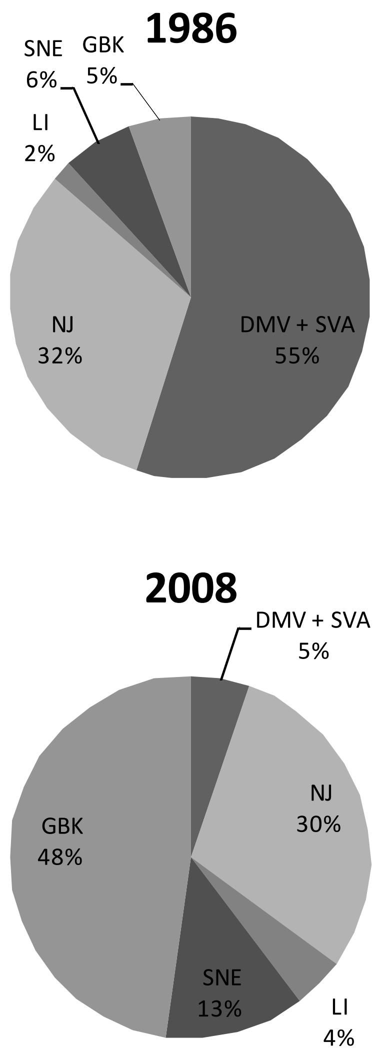

Figure A15. Percentage of efficiency corrected swept area biomass, by region, for surfclams (120+ mm SL) during 1986 and 2008.

B. ATLANTIC BUTTERFISH ASSESSMENT SUMMARY FOR 2009

State of Stock

Estimated fishing mortality and spawning biomass in 2008 are 0.02 and 45,000 mt, respectively. Estimates of fishing mortality and total biomass are highly uncertain (CV(F_{2008}) = 0.63, CV(B_{2008})= 0.60). The population has been declining over time, but fishing mortality does not appear to be a major cause. Although $F_{0.1}$ (= 1.04) is proposed as an F_{MSY} proxy, this proxy may not be appropriate because the assumed natural mortality rate (M=0.8) on which it is based may be too low, considering inconsistencies among multiple estimation methods. Butterfish are relatively short-lived and have a high natural mortality rate which results in the spawning biomass being strongly dependent on recruitment. The current fishing mortality rate (F_{2008} = 0.02) is well below all candidate overfishing threshold reference points ($F_{30\%}$=0.72, $F_{40\%}$=0.52, and $F_{0.1}$=1.04 in the current assessment).

Neither B_{MSY} nor a proxy for B_{MSY} could be determined in the current assessment, given the assessment uncertainties. Therefore overfished status is unknown based on the current assessment. Although predation is likely an important component of butterfish total mortality, estimates of consumption by the top six finfish predators of butterfish within the NEFSC food habits database appear to be very low and similar in magnitude to historic fishing mortality. Without identification of an underlying cause(s) for the population decline it is inappropriate to apply biomass reference points which assume that the population biomass can reach an equilibrium state at a fixed value of F.

It would be inappropriate to compare the previous status determination criteria from SARC 38 in 2004 (F_{MSY} =0.38, B_{MSY}=22,800 mt) with the current assessment estimates of SSB and F. Measures of population abundance in the current assessment are scaled much higher than those in the previous assessment. These new estimates are more consistent with swept area biomass computations and results of calibration experiments between the *R/V Albatross* and *FSV Bigelow*. Furthermore, the previous biological reference points which were based on an analysis of surplus production do not seem applicable now given the non-equilibrium population dynamics described above.

Forecasts

Methods for forecasting recruitment were not developed in this assessment. Under the assumptions that future recruitment is equal to the average of recruitments over the last 10 years, M is constant at 0.8, and current fishing mortality rate will continue (F=0.02), and based on the KLAMZ model the population is expected to increase. Quantitative projections of population size are very uncertain because of uncertainty regarding KLAMZ model output, the assumed value of M, and future recruitment levels.

Catch and Status Table: Butterfish

Year	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	Min[2]	Max[2]	Mean[2]
US Landings[1]	2.1	1.4	4.4	0.9	0.5	0.5	0.4	0.6	0.7	0.5	0.4	11.7	3.0
Foreign Landings[1]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	31.7	2.4
US Discard Estimates[1]	8.9	7.0	4.5	2.3	2.1	1.2	0.6	0.8	0.2	1.2	0.2	10.2	5.4
Total Catch[1]	11.0	8.5	8.9	3.2	2.6	1.8	1.1	1.4	0.9	1.6	0.9	39.3	10.8

Year	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	Min[3]	Max[3]	Mean[3]
Spawning Biomass[1]	82.5	108.2	98.2	63.6	53.3	74.6	58.4	43.7	63.0	45.0	43.7	199.6	100.5
Recruitment Biomass[1]	92.8	56.6	20.6	28.2	62.4	22.8	16.4	53.0	13.1	38.8	13.1	184.8	65.2
Fishing Mortality	0.08	0.07	0.10	0.05	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.17	0.07

[1] 1000 mt [2] 1973-2008 [3] 1974-2008

Stock Distribution and Identification

Butterfish (*Peprilus triacanthus*) are distributed from the Florida to Nova Scotia, occasionally straying as far north as the Gulf of St Lawrence, but are primarily found from Cape Hatteras to the Gulf of Maine where the population is considered to be a unit stock. It is a fast growing species that schools by size and makes seasonal inshore and offshore movements in response to changes in water temperature. Butterfish move northward and inshore to feed and spawn in the summer and move southward and offshore in the winter to avoid cool waters.

Catches

Total catches of butterfish increased from 14,500 mt in 1965 to a peak of 39,300 mt in 1973 and were dominated by catches from the offshore foreign fleets (Figure B1). Total catches then declined to 11,200 mt in 1977, as effort in the foreign fisheries was reduced. Catches increased to 21,600 mt in 1984, with the development of a domestic trawl fishery for butterfish, but then declined to 2,800 mt in 1990. During 1991-2001, catches ranged between 3,800 mt and 12,200 mt. Catches declined during 2002-2008 due to the lack of a directed fishery and ranged between 900 mt and 3,200 mt. Discards comprise a majority of the total butterfish catch, averaging 59% during 1987-2001 and 63% during 2002-2008. Total catch estimates were highly variable and imprecise (CVs ranged from 0.6 – 1.2 for most years) due to the uncertain discard estimates.

Data and Assessment

Atlantic butterfish were last assessed in 2004 during SARC 38 (NEFSC 2004). The current assessment relies on biomass indices (kg/tow) from the NEFSC spring, fall and winter surveys, US landings, revised US discard estimates and earlier estimates of foreign catches from previous assessment documents. The NEFSC fall bottom trawl survey (Figure B2) is considered the most reliable biomass index because most of the population is thought to be within the survey domain and CVs were generally acceptable (0.2 – 0.4). Catch and biomass indices from 1973-2008 are used in the assessment. As in the previous assessment, the delay-difference model (KLAMZ) was used in the current assessment. Compared to SARC 38 the current assessment changes included updated data through 2008, use of different survey strata, and most notably, prior information on survey catchability (See Special Comments).

Fishing Mortality

The peak in fishing mortality rate on total biomass (F = 0.21) matched the peak in total catch in 1973. F then dropped to 0.08 by the end of the 1970s (Figure B3). Fishing mortality ranged between 0.05 and 0.12 during the 1980s and stayed below 0.1 during the 1990s. A small spike in landings in 2001 caused $F_{2001} = 0.10$, but F has been ≤ 0.05 from 2002 - 2008 (F_{2008}=0.02).

Recruitment

Recruit biomass (< Age 1), estimated from the assessment model, has been highly variable throughout the time series, but has declined over time (Figure B3). Recruit biomass throughout the time series averaged 65,200 mt, and during 2000-2008 it was 34,600 mt. Recruit biomass in 2008 was 38,800 mt.

Spawning Biomass

Like recruitment, spawning stock biomass (Age 1+) has been variable and has declined over time (Figure B3). Since 1974 spawning biomass averaged 165,600 mt, and during 2000-2008 averaged 67,500 mt. Spawning biomass is strongly dependent on recruitment because butterfish are relatively short-lived, mature early (A_{50} = 1 year), and have a high natural mortality rate (assumed at M=0.8). Spawning stock biomass in 2008 was 45,000 mt.

Biological Reference Points

The population has been declining over time, but fishing mortality does not appear to be a major cause. Although $F_{0.1}$ (= 1.04) is proposed as an F_{MSY} proxy, this proxy may not be appropriate because the natural mortality rate on which it is based (M=0.8) is likely underestimated. Nevertheless, the current fishing mortality rate is well below all candidates for an overfishing threshold (candidate reference points considered were $F_{30\%}$=0.72, $F_{40\%}$=0.52, and $F_{0.1}$=1.04 in the current assessment, Figure B4).

Neither B_{MSY} nor a proxy for B_{MSY} could be determined in the current assessment. The decline in biomass and recruitment since 1975 appears to be unrelated to either fishing mortality or consumption by the top six finfish predators in the NEFSC database. Without identification of an underlying cause(s) for the decline, it is inappropriate to apply biomass reference points which assume that the population biomass can reach an equilibrium state at a fixed value of F.

Trends in recruitment and SSB and their implications for biological reference points are depicted in Figure B5. Results suggest that even an F=0 would be insufficient to achieve replacement of the stock through recruitment.

Special Comments

The large difference in the scale of biomass estimates between the current and previous assessment is due primarily to the inclusion of prior information about the catchability of age 1+ fish in the NEFSC fall survey. Survey catch efficiency estimates of the *FSV Bigelow* relative to the *R/V Albatross IV* obtained from a recent study as well as assumptions on the range of possible values for the ratio of the survey to stock area and the efficiency of the *FSV Bigelow* were included in the current assessment model as prior information on catchability.

Spawning stock biomass and recruitment have declined in recent years, even in the absence of substantial fishing pressure. The cause of poor recruitment is unknown, but could be due to predation that has not been accounted for or to changes in abiotic factors. High natural mortality rates imply short life spans for incoming recruits and few older fish in the population, even if fishing mortality is low.

Validity of KLAMZ model estimates of biomass and fishing mortality was supported by the application of a simple "envelope" analysis method that established a feasible range for biomass (Figure B6). Model based estimates of stock biomass and fishing mortality rates were consistent with simple empirical interpretations of the data. The method was based on a feasible range of assumed fishing mortality rates applied to the observed catch series, and a feasible range of catchabilities applied to the NEFSC fall trawl survey catch weights per tow. Additional details are provided in Appendix B of the butterfish Assessment Report.

Estimation of total mortality rates (Z) from the catch at age analysis in the fall and spring surveys showed consistently higher values (Z = 1.5 to 2.9) than those estimated from the KLAMZ model (Figure B7). Mortality related to spawning could possibly explain this, as described for Norway pout (Sparholt et al. 2002a, Sparholt et al 2002b, Lambert et al. 2009), but there is currently no biological evidence to support this hypothesis for butterfish. If total mortality is in fact this high, then the current assumed value of M (= 0.8) is too low. The estimate of natural mortality used in the current assessment is based on a study by Murawski and Waring (1979).

Additional sources of uncertainty include low precision in the discard estimates in some years due to low levels of observer coverage, low catchability for this pelagic fish, and conflicting trends among research bottom trawl surveys, most notably between the NEFSC spring and fall surveys. In the spring, seasonal migrations result in a high concentration of butterfish in deeper offshore strata, and possibly outside the survey area at that time.

Based on analyses presented in Amendment 10 to the Atlantic Mackerel, Squid and Butterfish Fishery Management Plan (MAFMC 2009), the largest source of butterfish discards is the small-mesh (48-52 mm diamond mesh liner, inside stretched measurement) *Loligo pealeii* fishery, primarily due to year-round co-occurrence of the two species. Since 2000, the *Loligo* fishery has been managed based on either quarterly or trimester-based landings quotas and has been closed at least once per year. During this same time period, *Loligo* relative abundance indices from NEFSC fall surveys have been above average during most years. Measures of effective effort in the *Loligo* fishery have not been computed.

The six species that prey on butterfish that were considered in estimation of butterfish consumption were smooth dogfish (*Mustelus canis*)*,* spiny dogfish (*Squalus acanthias*), silver hake (*Merluccius bilinearis*), summer flounder (*Paralichthys dentatus*), bluefish (*Pomatomus saltatrix),* and goosefish (*Lophius americanus*)*.*

References

Lambert G, Nielsen JR, Larsen LI, Sparholt H. 2009. Maturity and growth population dynamics of Norway pout (*Trisopterus esmarkii*) in the North Sea, Skagerrak, and Kattegat. ICES J Mar Sci. 66: 1899-1914.

Mid-Atlantic Fishery Management Council. [MAFMC]. 2009. Amendment 10 to the Atlantic mackerel, squid and butterfish fishery management plan. 560 p.

Murawski SA,Waring GT. 1979. A population assessment of butterfish, *Peprilus triacanthus,* in the Northwestern Atlantic ocean. Trans Am Fish Soc. 108:427-439.

NEFSC. 2004. 38th Northeast regional stock assessment workshop advisory report. March 2004.

Sparholt H, Larsen LI, Nielsen JR. 2002a. Verification of multispecies interactions in the North Sea by trawl survey data on Norway pout (*Trisopterus esmarkii*). ICES J Mar Sci. 59: 1270-1275.

Sparholt H, Larsen LI, Nielsen JR. 2002b. Non-predation natural mortality of Norway pout (*Trisopterus esmarkii*) in the North Sea. ICES J Mar Sci. 59: 1276-1284.

Figures

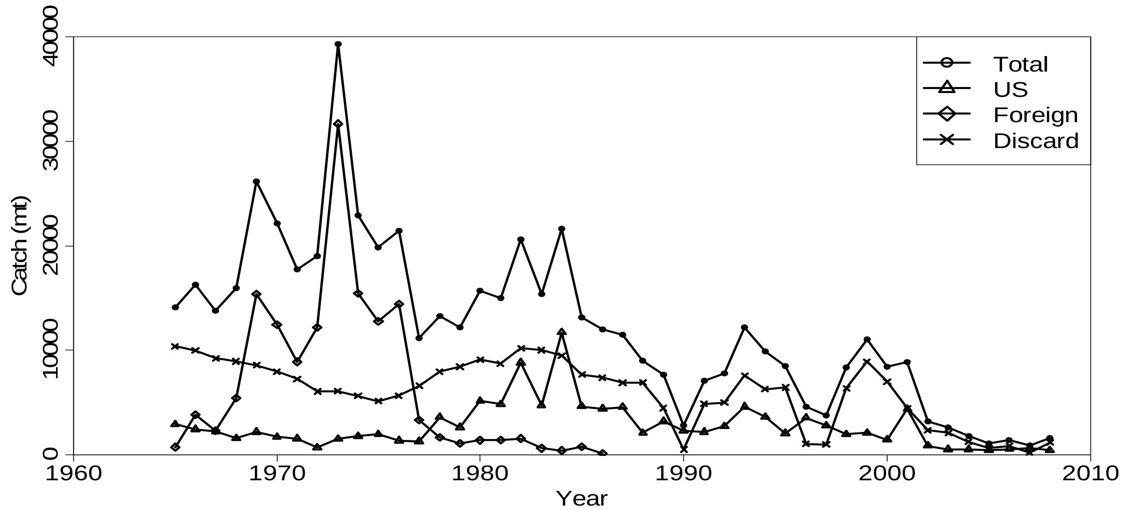

Figure B1. Total butterfish catch, US and foreign landings, and estimated discards between 1965 and 2008.

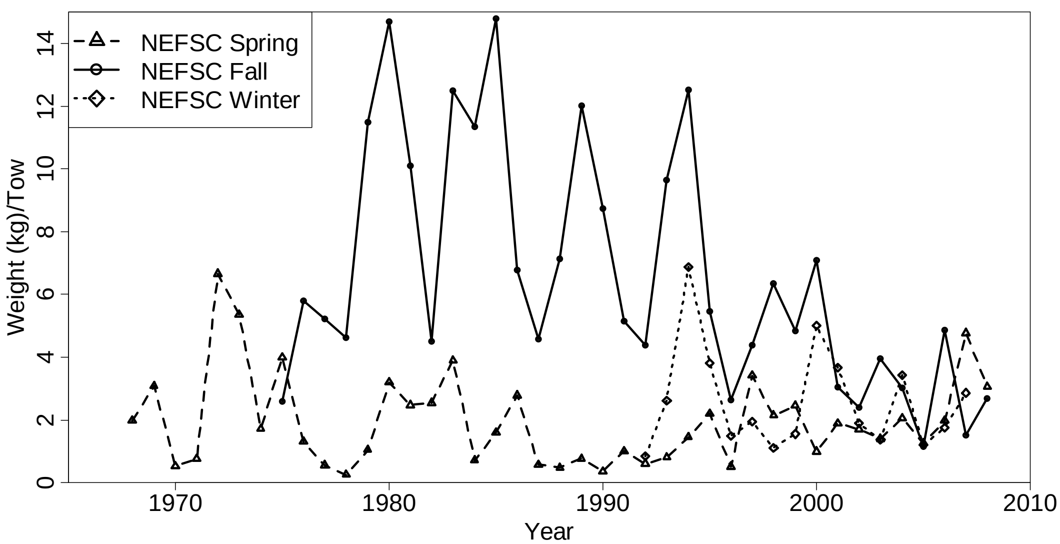

Figure B2. NEFSC spring (triangle), autumn (circle) and winter (diamond) bottom trawl survey stratified mean butterfish weight per tow.

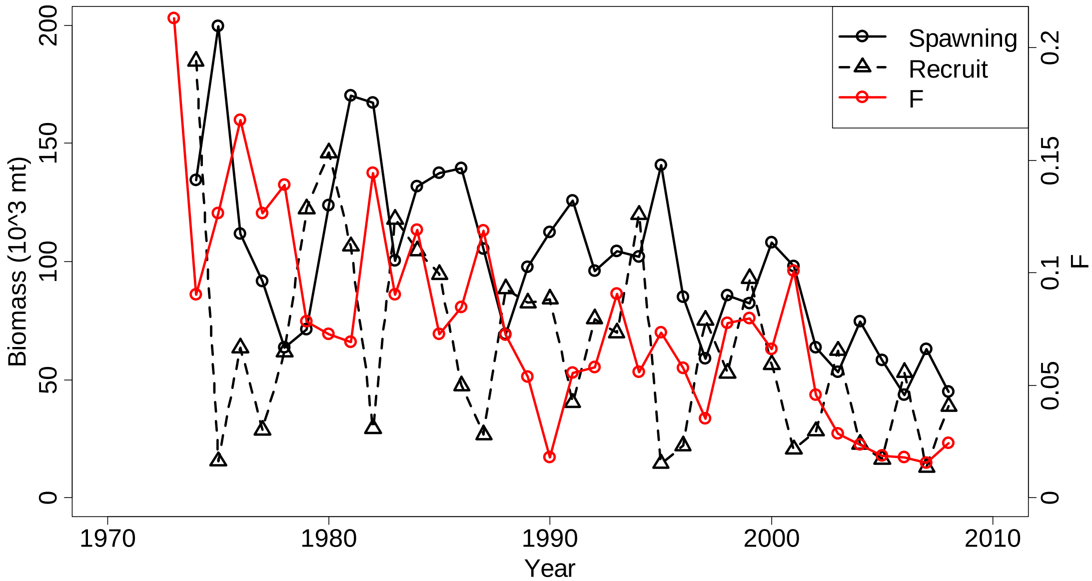

Figure B3. Butterfish spawning biomass, recruit biomass and fishing mortality estimates (KLAMZ model).

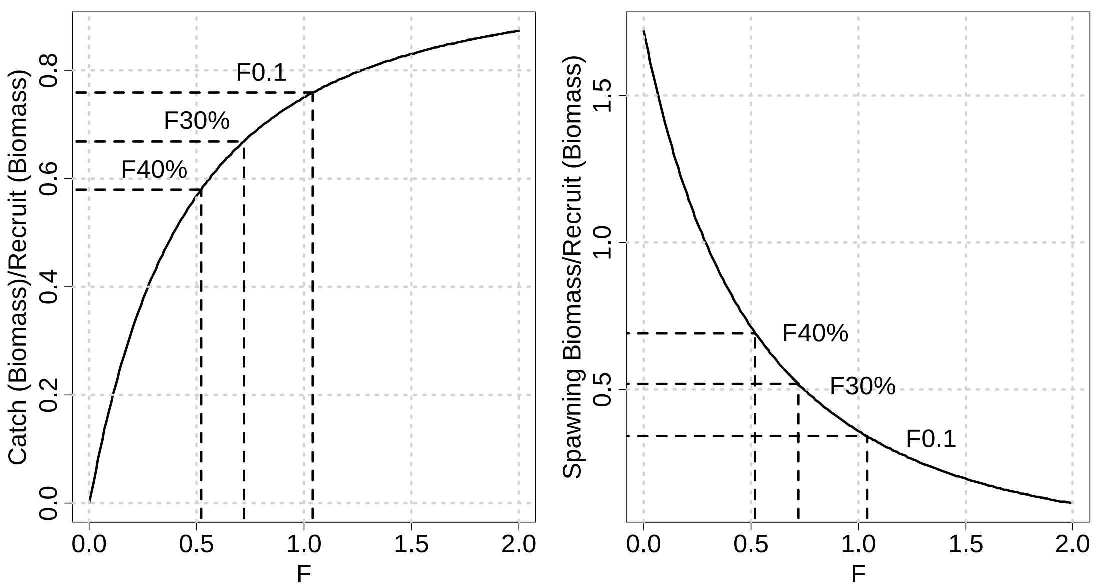

Figure B4. Equilibrium ratio of catch and spawning biomass to recruit biomass given constant fishing mortality on butterfish.

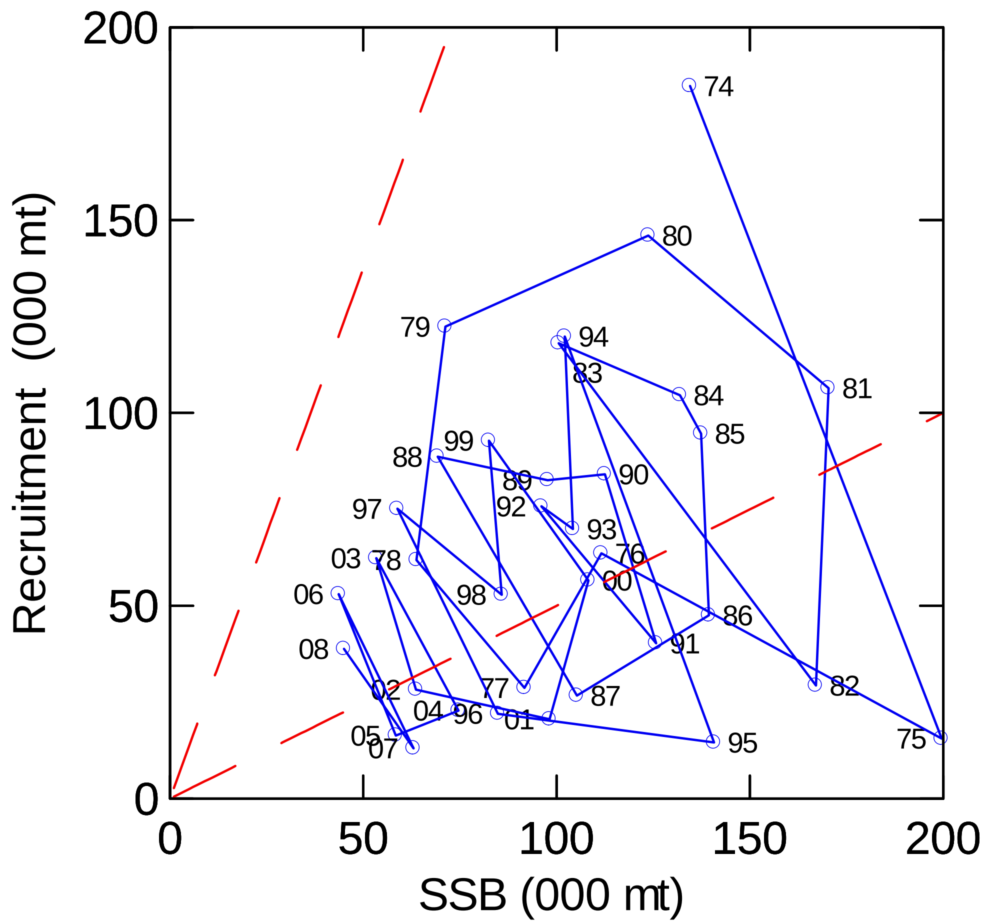

Figure B5. Butterfish spawning biomass (mt) and recruitment (mt) from 1974 -2008. The dashed diagonal lines represent theoretical population replacement lines assuming $F_{0.1}$=1.04 (steeper slope) and F=0 (shallow slope).

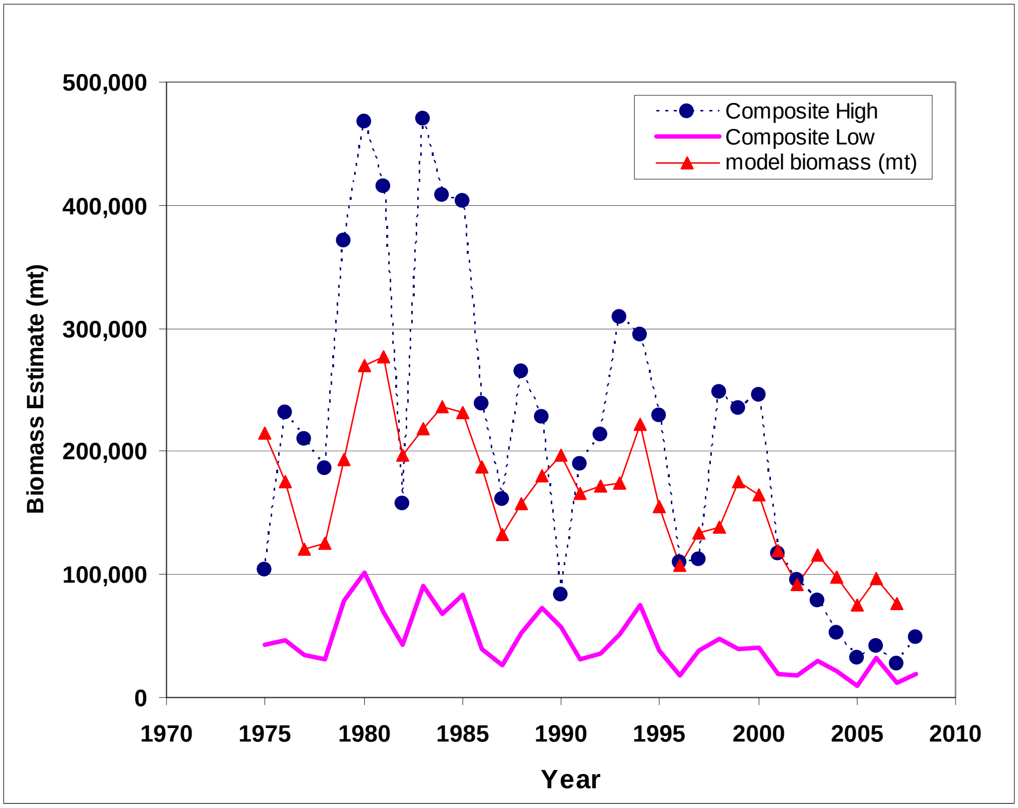

Figure B6. Comparison of the “envelope” measure of butterfish stock biomass (termed “Composite”) with KLAMZ model-based estimates (triangles).

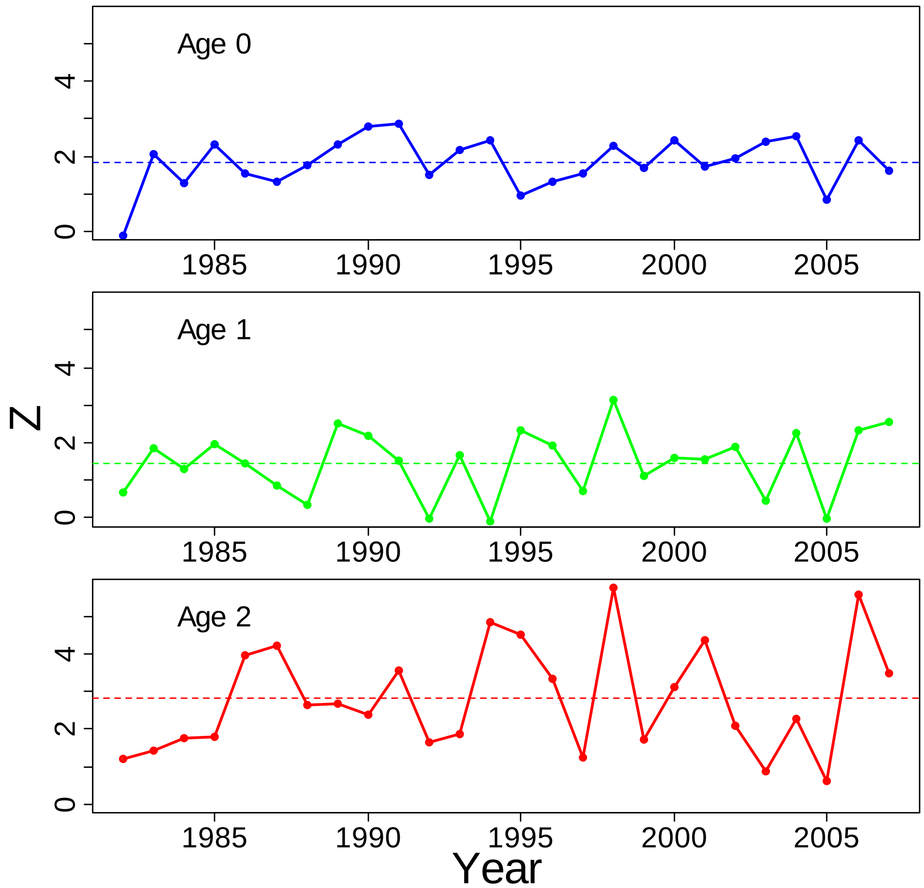

Figure B7. Annual estimates of total instantaneous butterfish mortality (Z) by year and age from fall NEFSC survey age composition.

Appendix: Terms of Reference

Assessment Terms of Reference for SAW/SARC49 (Nov-Dec 2009)

(file vers.: 8/12/09)

A. Atlantic surfclam

1. Characterize the commercial catch including landings, effort, LPUE and discards. Describe the uncertainty in these sources of data.

2. Characterize the survey data that are being used in the assessment (e.g., regional indices of abundance, recruitment, state surveys, age-length data, etc.). Describe the uncertainty in these sources of data.

3. Estimate annual fishing mortality, recruitment and stock biomass (both total and spawning stock) for the time series, and characterize the uncertainty of those estimates.

4. Update or redefine biological reference points (BRPs; estimates or proxies for B_{MSY}, $B_{THRESHOLD}$, and $F_{MSY;}$ and estimates of their uncertainty). Comment on the scientific adequacy of existing and redefined BRPs.

5. Evaluate stock status with respect to the existing BRPs, as well as with respect to updated or redefined BRPs (from TOR 4).

6. Identify potential environmental, ecological, and fishing-related factors that could be responsible for low recruitment.

7. Develop and apply analytical approaches and data that can be used for conducting single and multi-year stock projections and for computing candidate ABCs (Acceptable Biological Catch; see Appendix to the TORs).
    a. Provide numerical short-term projections (1-5 years; through 2015). Each projection should estimate and report annual probabilities of exceeding threshold BRPs for F, and probabilities of falling below threshold BRPs for biomass. In carrying out projections, consider a range of assumptions about the most important uncertainties in the assessment.
    b. Comment on which projections seem most realistic, taking into consideration uncertainties in the assessment.
    c. Describe this stock's vulnerability to becoming overfished, and how this could affect the choice of ABC.

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

Assessment TORs -- SAW/SARC49 (Nov-Dec 2009)

(file vers.: 8/12/09)

B. Butterfish

1. Characterize the commercial catch including landings, effort and discards by fishery (i.e., *Loligo* fishery vs other fisheries). Characterize recreational landings. Describe the uncertainty in these sources of data. Evaluate the precision of the bycatch data with respect to achieving temporal management objectives throughout the year.

2. Characterize the survey data that are being used in the assessment (e.g., indices of abundance including RV Bigelow data, NEAMAP and state surveys, age-length data, etc.). Describe the uncertainty in these sources of data.

3. Estimate annual fishing mortality, recruitment and stock biomass (both total and spawning stock) for the time series, and characterize the uncertainty of those estimates.

4. Update or redefine biological reference points (BRPs; estimates or proxies for B_{MSY}, $B_{THRESHOLD}$, and $F_{MSY;}$ and estimates of their uncertainty). Comment on the scientific adequacy of existing and redefined BRPs.

5. Evaluate stock status with respect to the existing BRPs, as well as with respect to updated or redefined BRPs (from TOR 4).

6. Evaluate the magnitude, trends and uncertainty of predator consumptive removals on butterfish and associated predation mortality estimates and, if feasible, incorporate said mortality predation estimates into models of population dynamics.

7. Develop and apply analytical approaches and data that can be used for conducting single and multi-year stock projections and for computing candidate ABCs (Acceptable Biological Catch; see Appendix to the TORs).
    a. Provide numerical short-term projections (1-5years). Each projection should estimate and report annual probabilities of exceeding threshold BRPs for F, and probabilities of falling below threshold BRPs for biomass. In carrying out projections, consider a range of assumptions about the most important uncertainties in the assessment.
    b. Comment on which projections seem most realistic, taking into consideration uncertainties in the assessment.
    c. For a range of candidate ABC scenarios, compute the probabilities of rebuilding the stock by January 1, 2015.
    d. Describe this stock's vulnerability to having overfished status (consider mean generation time), and how this could affect the choice of ABC.

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

Appendix to the SAW TORs:

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

(The text below is from DOC National Standard Guidelines, Federal Register, vol. 74, no. 11, January 16, 2009)

On "Acceptable Biological Catch":

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

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

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

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

On "Vulnerability":

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

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