Northeast Fisheries Science Center Reference Document 13-04

56th Northeast Regional Stock Assessment Workshop (56th SAW)

Assessment Summary Report

by the Northeast Fisheries Science Center

April 2013

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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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SAW-56 ASSESSMENT SUMMARY REPORT

Introduction

The 56th SAW Assessment Summary Report contains summary and detailed technical information on two stock assessments reviewed during February 19-22, 2013 at the Stock Assessment Workshop (SAW) by the 56th Stock Assessment Review Committee (SARC-56): Atlantic surfclam (*Spisula solidissima*) and white hake (*Urophycis tenuis*). The SARC-56 consisted of 3 external, independent reviewers appointed by the Center for Independent Experts [CIE], and an external SARC chairman from the MAFMC SSC. The SARC evaluated whether each Term of Reference (listed in the Appendix) was completed successfully based on whether the work provided a scientifically credible basis for developing fishery management advice. The reviewers' reports for SAW/SARC-56 are available at website: http://www.nefsc.noaa.gov/nefsc/saw/ under the heading "SARC 56 Panelist Reports".

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

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

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

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

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

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

Outcome of Stock Assessment Review Meeting

Text in this section is based on SARC-56 Review Panel reports (available at http://www.nefsc.noaa.gov/nefsc/saw/ under the heading "SARC-56 Panelist Reports").

The **Atlantic surfclam** stock is neither overfished nor experiencing overfishing in 2011. The GBK component is nearly in an unfished condition. The surfclam fishery has been concentrated in relatively small areas for economic reasons. Much of the stock area has not been heavily fished. This explains the low overall *F* estimates, and is consistent with previous assessment results. Commercial LPUE trends show striking similarity to the declining surfclam stock trends estimated in the analytical assessment. Therefore, the SARC recommended that a more formal investigation of commercial LPUE for use in the assessment model be undertaken for future assessments. The assumed natural mortality rate (M = 0.15) is uncertain and may overstate stock productivity. Further work on M is recommended to better understand stock vulnerability. A statistical catch-at-age and length model (SS3) replaced the biomass dynamic model (KLAMZ) used previously. Stock assessment results from the northern and southern areas were combined to evaluate the status of the stock for the entire EEZ. The SARC could not decide whether to recommend changing from the current single stock definition. The SARC noted that this should not prevent conducting stock assessments by subareas, nor should it preclude area-based management, if appropriate. Although absolute biomass is uncertain, trends in biomass are relatively certain. The ratio B_{2011}/ B_{1999}, where B_{1999} is a B_{MSY} proxy, is relatively stable because estimates of B_{2011} and B_{1999} generally vary together. Fishing mortality estimates are less robust because they compare the catch estimate against the less certain scale of biomass. This uncertainty is not considered to be a serious problem in relation to stock status because overall F is estimated to be well below $F_{THRESHOLD}$ = M = 0.15.

The **white hake** stock is not overfished and overfishing is not occurring. This favorable determination of stock status is a change from the previous stock assessment in which white hake was judged to be overfished and subject to overfishing in 2007. Fishing mortality has varied over a wide range since the 1970s but presently is well below the $F_{MSY\ proxy}$. The improving condition of the stock is indicated by the more than three-fold increase in spawning stock biomass from a time series low in 1997. The estimated increase in spawning stock biomass from 2007 to 2011 was during a period when F was low and recruitment was near the long-term average. The 2013 SAW/SARC-56 white hake assessment model was a statistical catch-at-age model (ASAP) incorporating formulations that differed from the 2008 Statistical Catch-at-Age (SCAA) model. Results from the previous SCAA and new ASAP model formulations using revised data were similar in trend and magnitude. The improved stock status is not the result of changing assessment models. Recent recruitment was sampled when carrying out short term projections, while biological reference points (BRPs) were based on recruitment estimates from the entire time series. The SARC-56 Panel did not find a clear reason to derive BRPs based on the shorter, recent time series of recruitment. The SARC-56 Panel recommended that the $F_{MSY\ proxy}$ of F40% currently in place should remain. This decision was based on consideration of the risks of depleting the stock associated with F40% and F35% as well as on the sensitivity of these risks to the assumed stock-recruitment steepness parameter.

SARC-56 concluded the **Atlantic surfclam** and **white hake** assessments were effective in delineating stock status, determining BRPs and proxies, and in projecting probable short-term trends in stock biomass, fishing mortality, and catches.

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.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Stock Synthesis (SS). A stock assessment model that can be fit to many different types of data including catches, discards, survey trends, and age and size composition data from fisheries or surveys. Multiple subareas with different population dynamics can be modeled simultaneously. The structure of SS allows for building of simple to complex models depending upon the data available. Stock Synthesis is a forward projecting model like ASAP but substantially more flexible.

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.

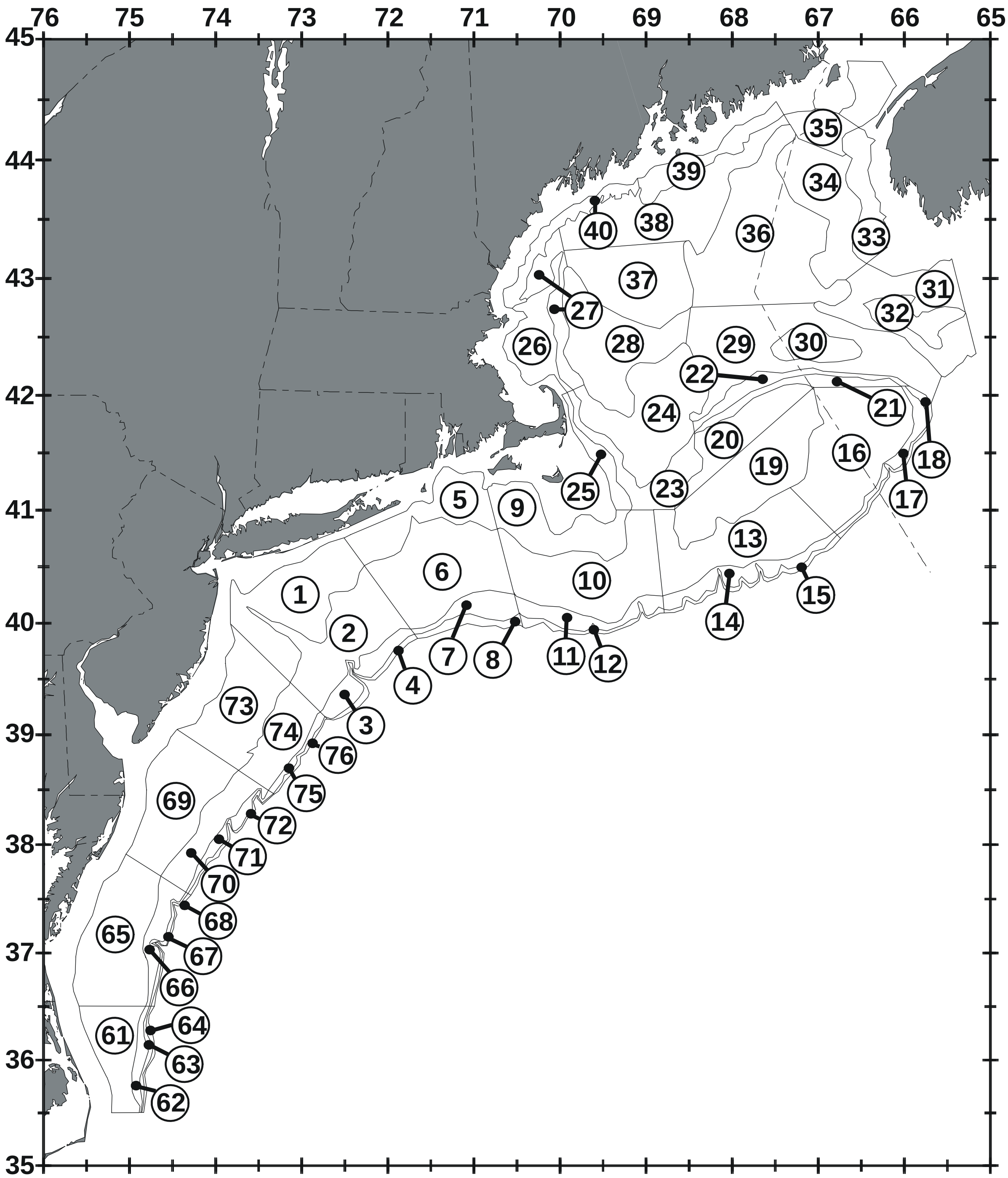


Figure 1. Offshore depth strata sampled during Northeast Fisheries Science Center bottom trawl research surveys. Some of these may not be sampled presently.

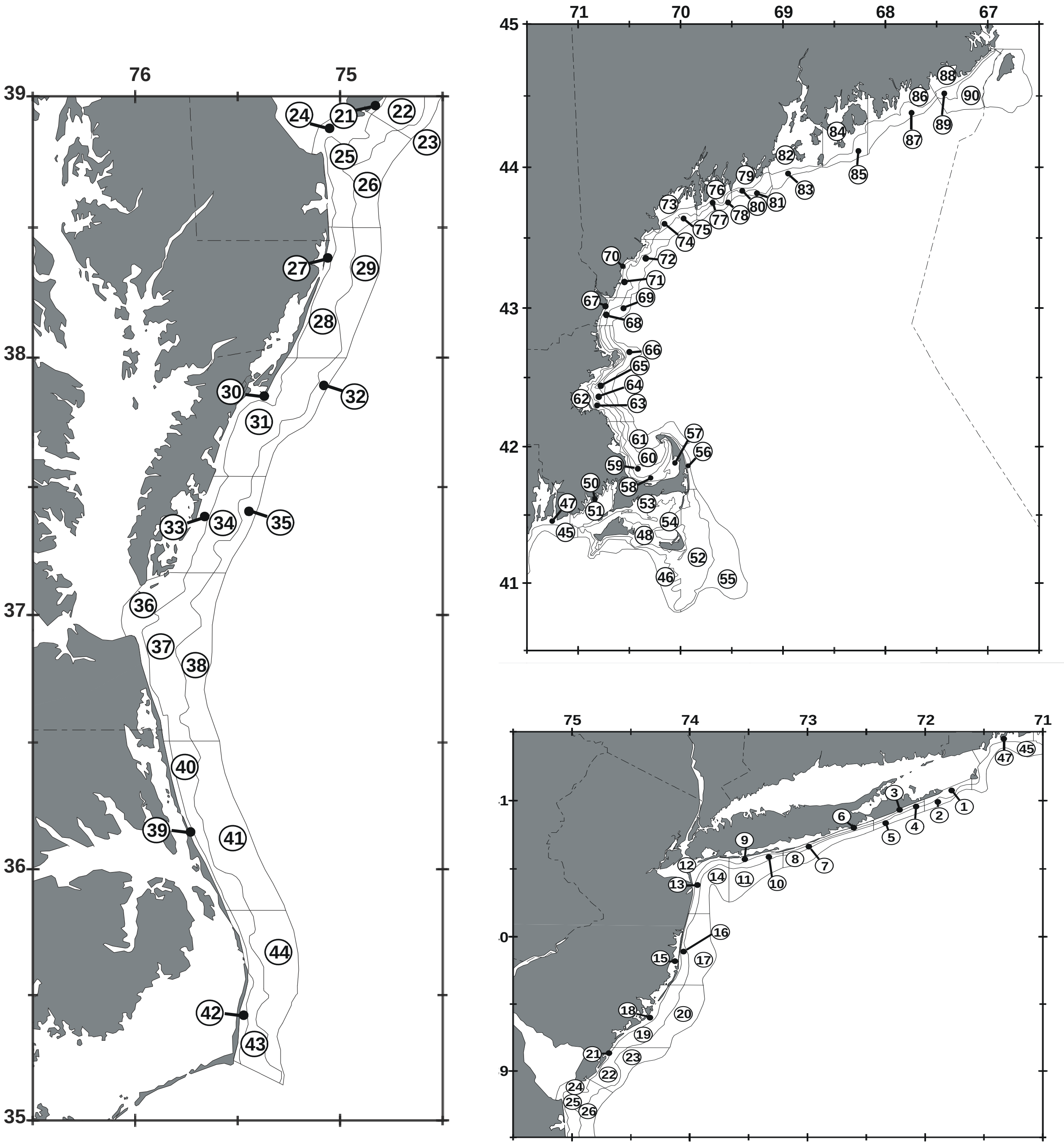
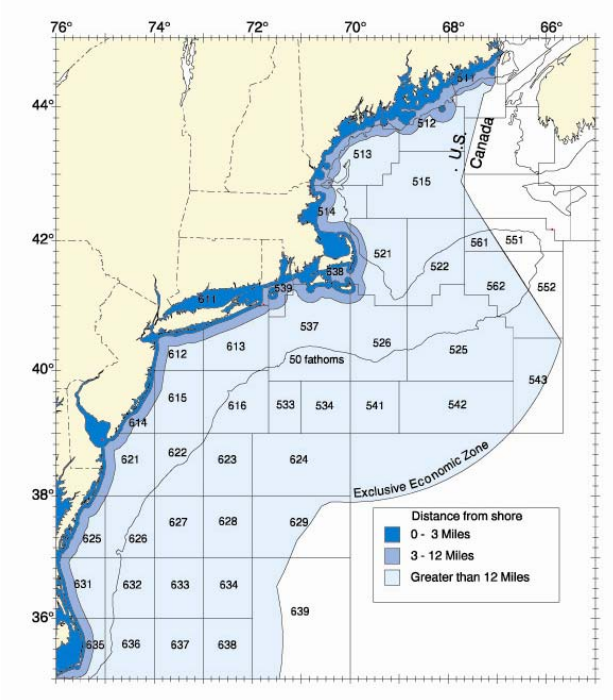


Figure 2. Inshore depth strata sampled during Northeast Fisheries Science Center bottom trawl research surveys. Some of these may not be sampled presently.



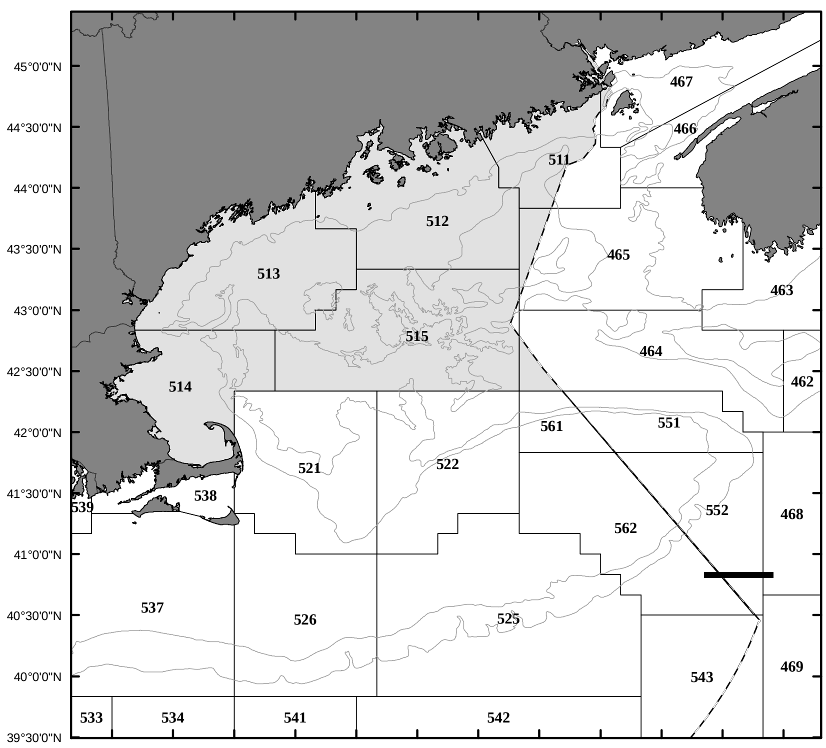


Figure 3. Statistical areas used for reporting commercial catches.

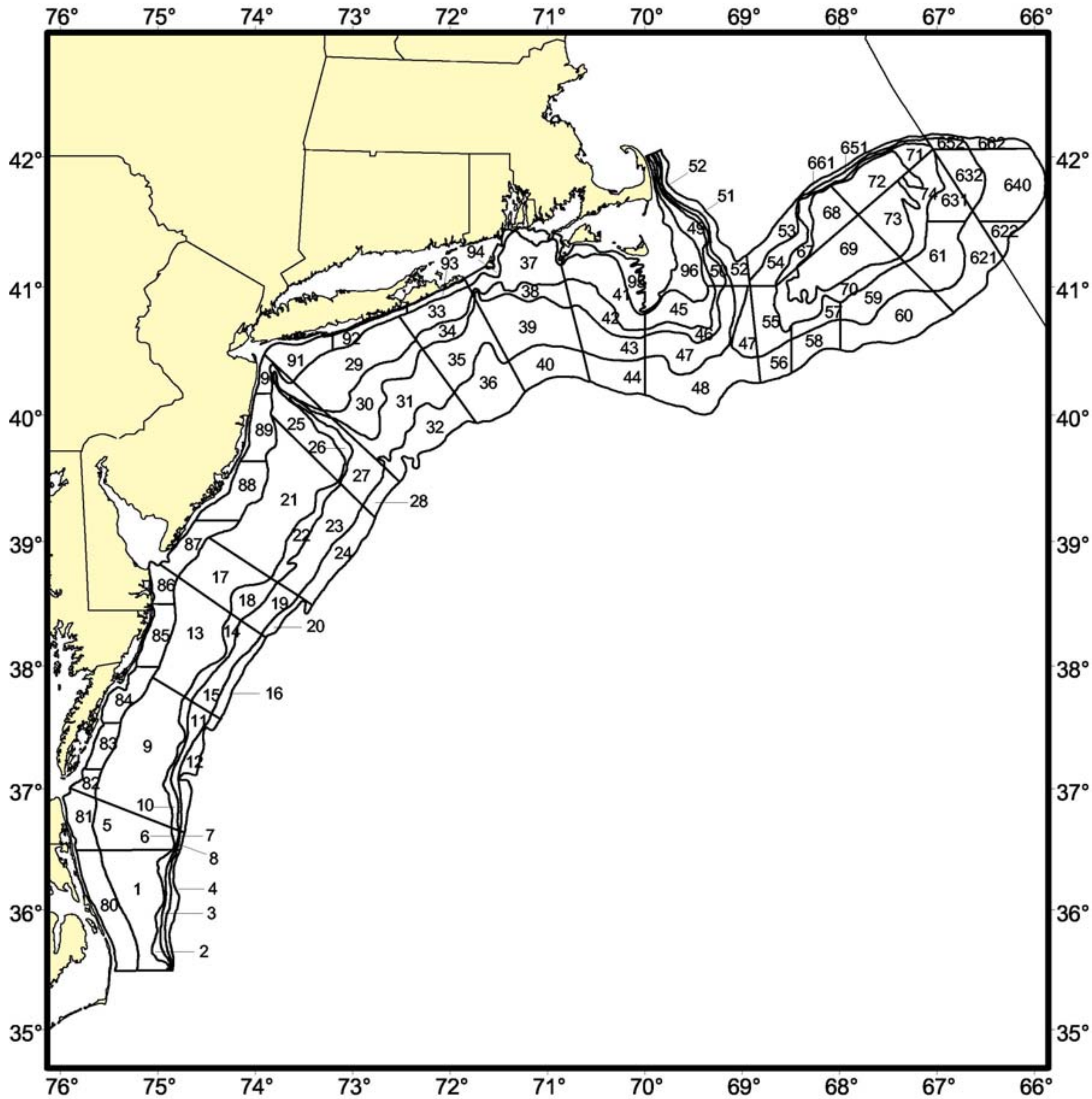


Figure 4. Northeast Fisheries Science Center clam resource survey strata, along the east coast of the US.

A. ATLANTIC SURFCLAM ASSESSMENT SUMMARY FOR 2013

State of Stock: The Atlantic surfclam resource in the US EEZ is not overfished and overfishing is not occurring in 2011.

The surfclam EEZ resource is summarized by six regions and two stock assessment areas. From north to south, the regions are: Georges Bank (GBK), Southern New England (SNE), Long Island (LI), New Jersey (NJ), Delmarva (DMV) and southern Virginia (SVA) (Figure A1) and the two stock assessment areas are northern (GBK) and southern (remaining regions). Surfclams and fisheries in state waters are not included in this assessment. Stock assessment results from the two areas were combined to evaluate the status of the stock for the entire EEZ resource. The resource is defined as a single stock.

Estimated biomass of the entire resource during 2011 (approximate 120+ mm shell length, SL) was 1,060 thousand mt (2,337 million lbs), with a 95% confidence interval of 802 – 1401 thousand mt meats. The 95% confidence interval overlaps the B_{Target} = ½ B_{1999} = 972 thousand mt meats (2142 million lbs) but is entirely above $B_{Threshold}$ = ½ B_{Target} = 486 thousand mt meats (1071 million lbs; Figure A2). Estimated annual fishing mortality during 2011 for the entire resource was F= 0.027 (95% confidence interval 0.016 – 0.045), which is entirely below the overfishing threshold F_{MSY} *proxy* = M = 0.15 (Figure A3).

Estimated biomass on Georges Bank during 2011 (ages 7+, approximately 120+ mm shell length, SL) was 357 thousand mt of meats (787 million lbs) with a 95% confidence interval 252 - 506 mt. Surfclams on Georges Bank were not fished from 1990 to 2008 due to the risk of paralytic shellfish poisoning (PSP). There was light fishing in years 2009-2011 under an exempted fishing permit. Fishing mortality on Georges Bank was close to zero (F_{2011} = 0.009; 95% confidence interval 0.006 – 0.013) during 2011.

Estimated biomass of the southern area during 2011 (ages 6+, approximately 120+ mm shell length, SL) was 703 thousand mt (1,549 million lbs), with a 95% confidence interval of 481 – 1028 thousand mt meats (Figure A4). Estimated fishing mortality during 2011 for the southern area was F= 0.037 (95% confidence interval 0.025 – 0.056) (Figure A5).

Projections for 2012 - 2016: Catch during 2012-2013 for all projections was assumed equal to mean catch during 2007 – 2011 (23,357 mt). However, in the status quo catch and quota scenarios 8,635 mt of catch was deducted from the south and taken in the north. Catches were landings plus a 12% allowance for incidental mortality. Discards were assumed to be zero since 1990 when the size limit was discontinued. Projections used three plausible assumptions about catches during 2013-2016 (see table below). The status quo catch is probably the most realistic. The F_{MSY} proxy (OFL) is the most aggressive in terms of total harvest, but fishing at the F_{MSY} proxy level is not allowed under the FMP. The quota is the maximum level of landings allowed under the FMP.

Projection Table

Year	Southern area			GBK area			Southern + GBK		
	F=0.15 (M)	Status-quo catch	Quota	F=0.15 (M)	Status-quo catch	Quota	F=0.15 (M)	Status-quo catch	Quota
Biomass (mt)									
2011	704,366	704,366	704,366	370,217	370,217	370,217	1,074,583	1,074,583	1,074,583
2012	699,480	699,480	699,480	338,866	338,866	338,866	1,038,346	1,038,346	1,038,346
2013	690,839	690,839	690,839	308,580	308,580	308,580	999,419	999,419	999,419
2014	633,310	677,921	672,888	252,941	271,536	271,536	886,251	949,457	944,424
2015	604,667	686,541	676,966	208,410	238,833	238,833	813,077	925,374	915,799
2016	617,034	731,098	717,356	175,171	212,330	212,330	792,205	943,428	929,686
Biomass / Bthreshold (Bthreshold=B1999/4)									
1999	1,513,100			506,882			2,019,982		
Bthreshold	378,275			126,721			504,996		
2011	1.86	1.86	1.86	2.92	2.92	2.92	2.13	2.13	2.13
2012	1.85	1.85	1.85	2.67	2.67	2.67	2.06	2.06	2.06
2013	1.83	1.83	1.83	2.44	2.44	2.44	1.98	1.98	1.98
2014	1.67	1.79	1.78	2.00	2.14	2.14	1.75	1.88	1.87
2015	1.60	1.81	1.79	1.64	1.88	1.88	1.61	1.83	1.81
2016	1.63	1.93	1.90	1.38	1.68	1.68	1.57	1.87	1.84

Year	Southern area			GBK area			Southern + GBK		
	F=0.15 (M)	Status-quo catch	Quota	F=0.15 (M)	Status-quo catch	Quota	F=0.15 (M)	Status-quo catch	Quota
	Landings (mt, catch - 12% incidental mortality)								
2011	16,089	16,089	16,089	2,127	2,127	2,127	18,216	18,216	18,216
2012	18,728	18,728	18,728	2,127	2,127	2,127	20,854	20,854	20,854
2013	60,767	13,145	18,504	28,352	7,710	7,710	89,119	20,854	26,213
2014	57,705	13,145	18,504	23,444	7,710	7,710	81,150	20,854	26,213
2015	55,609	13,145	18,504	19,570	7,710	7,710	75,178	20,854	26,213
2016	54,683	13,145	18,504	16,829	7,710	7,710	71,512	20,854	26,213
Landings (bu, catch - 12% incidental mortality)									
2011	2,086,796	2,086,796	2,086,796	275,848	275,848	275,848	2,362,644	2,362,644	2,362,644
2012	2,429,011	2,429,011	2,429,011	275,848	275,848	275,848	2,704,859	2,704,859	2,704,859
2013	7,881,636	1,704,882	2,399,944	3,677,240	999,977	999,977	11,558,875	2,704,859	3,399,921
2014	7,484,494	1,704,882	2,399,944	3,040,787	999,977	999,977	10,525,280	2,704,859	3,399,921

2015	7,212,525	1,704,882	2,399,944	2,538,250	999,977	999,977	9,750,776	2,704,859	3,399,921
2016	7,092,540	1,704,882	2,399,944	2,182,694	999,977	999,977	9,275,234	2,704,859	3,399,921

Year	Southern area			GBK area			Southern + GBK		
	F=0.15 (M)	Status-quo catch	Quota	F=0.15 (M)	Status-quo catch	Quota	F=0.15 (M)	Status-quo catch	Quota
	Fully recruited fishing mortality								
2011	0.037	0.037	0.037	0.009	0.009	0.009	0.028	0.028	0.028
2012	0.044	0.044	0.044	0.010	0.010	0.010	0.033	0.033	0.033
2013	0.150	0.031	0.044	0.150	0.039	0.039	0.150	0.034	0.042
2014	0.150	0.031	0.044	0.150	0.044	0.044	0.150	0.035	0.043
2015	0.150	0.031	0.044	0.150	0.050	0.050	0.150	0.035	0.044
2016	0.150	0.030	0.043	0.150	0.055	0.055	0.150	0.035	0.044
Exploitation rate (catch/biomass)									
2011	0.026	0.026	0.026	0.006	0.006	0.006	0.019	0.019	0.019
2012	0.030	0.030	0.030	0.007	0.007	0.007	0.022	0.022	0.022
2013	0.099	0.021	0.030	0.103	0.028	0.028	0.100	0.023	0.029
2014	0.102	0.022	0.031	0.104	0.032	0.032	0.103	0.025	0.031
2015	0.103	0.021	0.031	0.105	0.036	0.036	0.104	0.025	0.032
2016	0.099	0.020	0.029	0.108	0.041	0.041	0.101	0.025	0.032

Catch and Status Table

Whole stock

Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Min[1]	Max[1]	Mean[1]
Landings[3]	22016	25017	24197	21163	23573	24915	22519	20149	18102	18587	13186	25017	20851
Catch[3]	24658	28019	27100	23702	26401	27904	25221	22567	20274	20818	14768	28019	23353
Quota[3]	25061	25061	26218	26218	26218	26218	26218	26218	26218	26218	13880	26218	21850
Estimated biomass[4]	1823	1744	1714	1687	1591	1438	1308	1187	1100	1060	1060	2499	1902
Recruitment[5]	1163	1085	1757	2596	2407	2206	1750	2286	3257	2089	906	6717	3481
F[6]	0.022	0.024	0.024	0.022	0.025	0.029	0.028	0.026	0.025	0.027	0.015	0.029	0.020

Southern area

Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Min[2]	Max[2]	Mean[2]
Landings[3]	22016	25017	24197	21163	23573	24915	22519	20138	16800	16191	13186	25017	20241
Catch[3]	24658	28019	27100	23702	26401	27904	25221	22555	18817	18134	14768	28019	22670
Quota[3]	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
Estimated biomass[4]	1207	1128	1104	1079	1013	912	827	750	706	703	703	1974	1391
Recruitment[5]	849	851	1438	2240	2027	1906	1594	2115	3017	1704	552	4698	2454
F[6]	0.032	0.036	0.036	0.034	0.040	0.046	0.045	0.043	0.038	0.037	0.019	0.046	0.028

Northern area

Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Min[1]	Max[1]	Mean[1]
Landings[3]	0	0	0	0	0	0	0	11	1302	2397	0	2766	375
Catch[3]	0	0	0	0	0	0	0	12	1458	2684	0	3097	420
Quota[3]	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
Estimated biomass[4]	616	616	610	608	578	526	481	437	394	357	357	616	511
Recruitment[5]	314	234	319	356	380	300	156	171	240	385	156	3597	1027
F[6]	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.009	0.000	0.009	0.001

1 - Min, max and mean are calculated based on the years 1982 - 2011

2 - Min, max and mean are calculated based on the years 1979 - 2011

3 - Landing, catch and quota units are metric tons of meats

4 - Biomass units are thousands of metric tons of meat

5 - Recruitment units are millions of age zero clams

6 – Note that F depends on commercial selectivity and the selectivity used in this assessment covers a smaller subset of the available clams than the selectivity used in previous assessments. Thus, the F estimates given here are not directly comparable to the F estimates from previous assessments.

Stock Distribution and Identification: Atlantic surfclams are distributed along the coast from Maine through North Carolina at depths ranging from the sub-tidal zone in state waters to about 50 m in the EEZ. All Atlantic surfclams in the EEZ are currently assessed and managed as a single unit stock, although there are differences between regions in biological characteristics and fishing activity.

Landings: Annual landings from the EEZ have been stable since the mid 1980s (Figure A6), ranging between 19 and 25 thousand mt. Landings in 2011 were 19 thousand mt (41 million lbs). The EEZ landings have been at or below the quota due to the ITQ tag system. Landings were less than the quota during 2004-2011 due to market limitations.

Areas of highest landings have shifted from DMV north to NJ over time (Figure A7). Since 1979, 85-100% of landings have been taken from the Mid-Atlantic Bight (SVA, DMV and NJ). About 15% of landings were taken from SNE and LI in 2011. Fishing on GBK has recently begun after 20 years of closure due to paralytic shellfish poisoning (PSP). Landings on GBK accounted for about 5% of the total in 2011.

The regional distribution of fishing effort (Figure A8) is similar to that of landings. Fishing effort in NJ and SNE has increased in recent years, while landings have declined in NJ and increased in SNE. LPUE trends since the early 2000's are generally downward for the southern area (Figure A9). LPUE in the GBK experimental fishery was about five times higher than elsewhere. There has been a doubling of effort over the previous ten years while catches have remained stable; effort has shifted into LI and SNE from NJ (Figure A8). LPUE values by region in the most recent years were at or among the lowest since the ITQ began in 1990 except on GBK (Figure A9).

Data and Assessment: The updated assessment includes a number of improvements relative to the SAW-49 assessment (NEFSC 2010) including: updated survey gear efficiency estimates based on new cooperative depletion experiments, a new estimate of survey gear size selectivity, new growth curves, new shell length-meat weight relationships, and a new approach to assessing the stock where the northern and southern areas are assessed separately, with parameters in the north borrowed from the south due to data limitations in GBK.

A statistical catch at age and length model called Stock Synthesis (SS3) (Methot and Wetzel. *In press*) replaced the biomass dynamic model used previously (KLAMZ). The new model incorporates age and length structure. Age composition data from the 1982 to 2011 NEFSC clam surveys, and commercial length composition from port samples (when available) were utilized in this assessment for the first time. Evaluation of cooperative research data indicates that survey capture efficiency is more uncertain than portrayed in previous assessments. Uncertainty about capture efficiency increased uncertainty about biomass levels substantially. However, conclusions about stock status are robust to this uncertainty.

Biological Reference Points: By definition, overfishing occurs whenever the annual fishing mortality rate on the entire stock is higher than F_{MSY} or the F_{MSY} proxy. The stock is defined as overfished if biomass (ages 6+ in the south and ages 7+ in the north) falls below $B_{Threshold}$ (estimated as ½ B_{MSY} proxy).

The current proxy for F_{MSY} is $F = M$ where M is assumed to be 0.15 y^{-1}. The proxy for B_{MSY} is one-half of the estimated biomass (ages 6+ in the south and ages 7+ in the north) during 1999 (Figure A2). The 1999 biomass and related biomass biological reference points, as well as MSY, were re-estimated in this assessment. The previous and revised reference point values are shown in the table below.

Previous and revised reference points[1]

Reference Point	Last assessment	Revised
F_{MSY}	M=0.15 y^{-1}	Same
B_{1999}	1086 thousand mt meats	1944 thousand mt meats
$B_{MSY\ proxy}$ =½B_{1999} (target)	543 thousand mt meats	972 thousand mt meats
$B_{Threshold}$ = ½ $B_{MSY\ proxy}$	272 thousand mt meats	486 thousand mt meats
MSY	NA	98 thousand mt meats

1 – Biomass based reference points from the previous assessment are for animals > 120 mm SL, while those from the current assessment are for animals aged 6+ in the south and 7+ in the north. The two different measures are comparable because the ages were chosen to match the lengths used last assessment.

Fishing Mortality: Fishing mortality for surfclams during 2011 was F = 0.027 over the whole stock (90% confidence interval 0.016-0.045). It has remained low during the entire time series and never approached the threshold (Figure A3). The F for the southern area during 2011 was 0.037 (0.025-0.056), while the F for GBK during 2011 was 0.009 (0.006-0.013).

Recruitment: Recruitment (age 0) has been below average for the whole stock since 1999 (Figure A10).

Stock Biomass: Biomass increased from 1330 thousand mt meats (2932 million lbs) and peaked at 2500 thousand mt meats (5512 million lbs) between 1982 and 1988 (Figure A2). During 1989-2011, biomass declined at a rate of about 3.5% per year. Stock biomass during 2011 was 1060 thousand mt meats (2337 million lbs) with a 95% confidence interval 802-1401 thousand mt, which was slightly less than the previous low of 1100 thousand mt (2425 million lbs) during 2010.

Biomass in the south during 2011 was 703 thousand mt (481-1028 thousand mt). Biomass in GBK during 2011 was 357 thousand mt (252-506 thousand mt).

Special Comments:

Fishing mortality rates for surfclams in the southern region during 2011 were estimated to be low in this assessment despite decades of steady fishing and declines in LPUE. Low model estimates of fishing mortality are supported by the presence of old surfclams (30+ y) and because survey age and size composition data resemble the expected age and size composition in an unexploited population. The catches are low relative to minimum swept area biomass estimates. The explanation for the low estimated F is that the fishery is concentrated in small areas for economic reasons. Most of the stock is not impacted by the fishery. Low F estimates agree with previous assessment results.

Estimates of biomass in both the northern and southern areas were uncertain in terms of absolute biomass (scale) but estimated trends in biomass were relatively certain. This is important in considering reference points for surfclams. For example, point estimates of B_{MSY} proxy and B_{2011} are uncertain for surfclams due to difficulties in estimating both scale and B_{MSY} in a stock where fishing mortality has always been light. However, the ratio B_{2011}/B_{1999}, where B_{1999} is a B_{MSY} proxy, is stable because estimates of B_{2011} and B_{1999} are correlated (correlation coefficient = 0.90). Fishing mortality estimates for surfclams, in contrast, are not robust because they compare the scale of catch against the absolute but uncertain scale of biomass. Despite scale uncertainty, the overfishing status determination is relatively certain because the overall fishing mortality rate is low and almost certainly less than $F_{Threshold} = M = 0.15$ based on sensitivity testing, survey size and age data and various other model calculations. Similarly, quota catch projections indicate the probability of overfishing or overfished conditions are <1% even at the extremes of a large range of biomasses.

The size-selectivity of the fishery is an important factor in this assessment and tends to buffer the resource from the effects of fishing to some degree. The fishery does not begin to select clams until they reach relatively large sizes. Surfclams are reproductive at very small sizes and thus are sexually mature for several years before becoming available to the fishery (Cargnelli et al. 1999).

A term of reference for this assessment was to address stock structure. The SAW Working Group (WG) considered the alternative of splitting GBK from the southern area, but failed to reach a consensus. The WG provided a summary of its arguments in the report for the SARC panel to consider. The SARC Panel concluded the material presented did not contain sufficient information to allow it to reach a decision on stock definition. The Panel notes this decision does not prevent the stock assessment from being conducted by subareas, nor does it preclude area-based management.

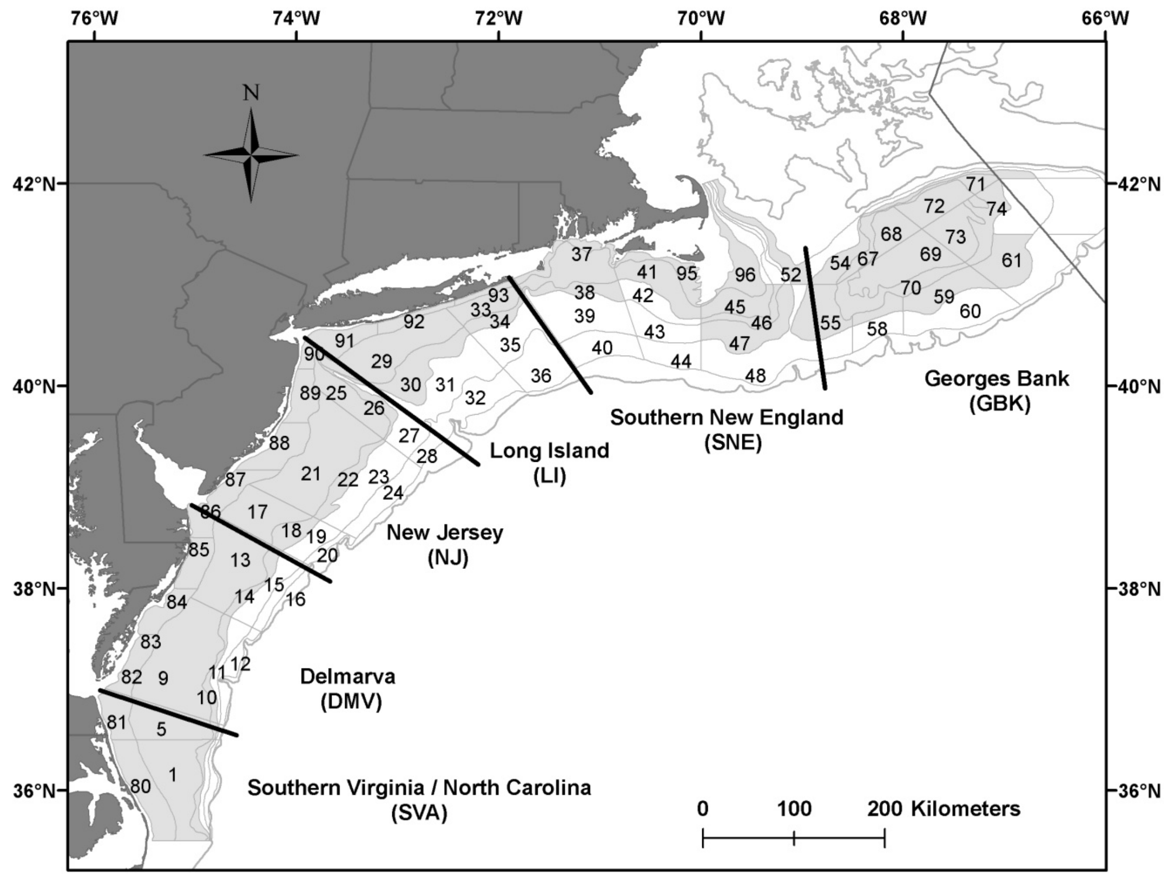
References

Cargnelli LM, Griesbach SJ, Packer DB, Weissberger W. 1999. Essential fish habitat source document: Atlantic surfclam, *Spisula solidissima*, life history and habitat characteristics. NOAA Tech. Mem. NMFS-NE-142.

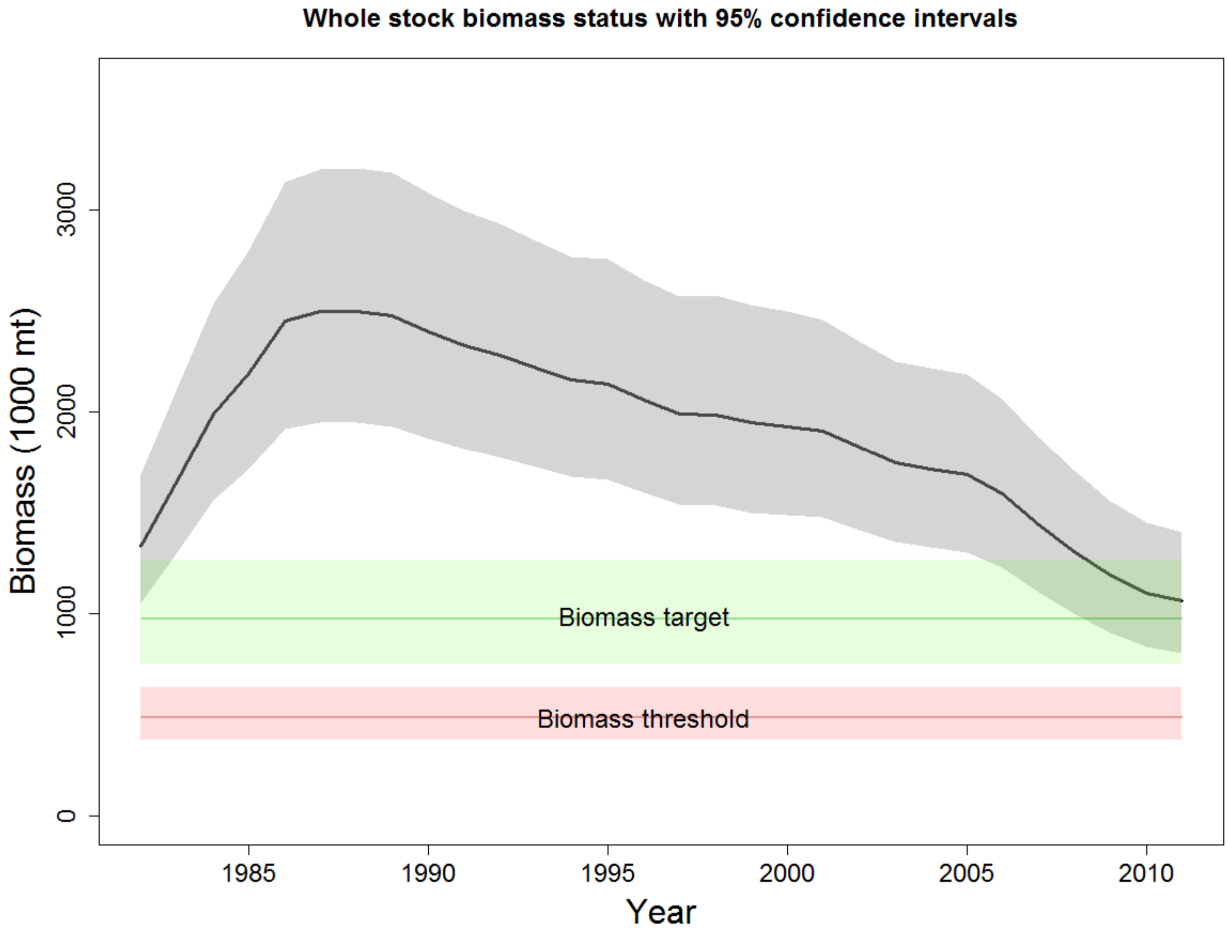
Methot RD, Wetzel CR. In Press. Stock synthesis: A biological and statistical framework for fish stock assessment and fishery management. Fisheries Research. In Press.

NEFSC. 2010. Atlantic surfclam stock assessment. In: 49th Northeast Regional Stock Assessment Workshop (49th SAW) Assessment Report. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 10-03; 383 p.

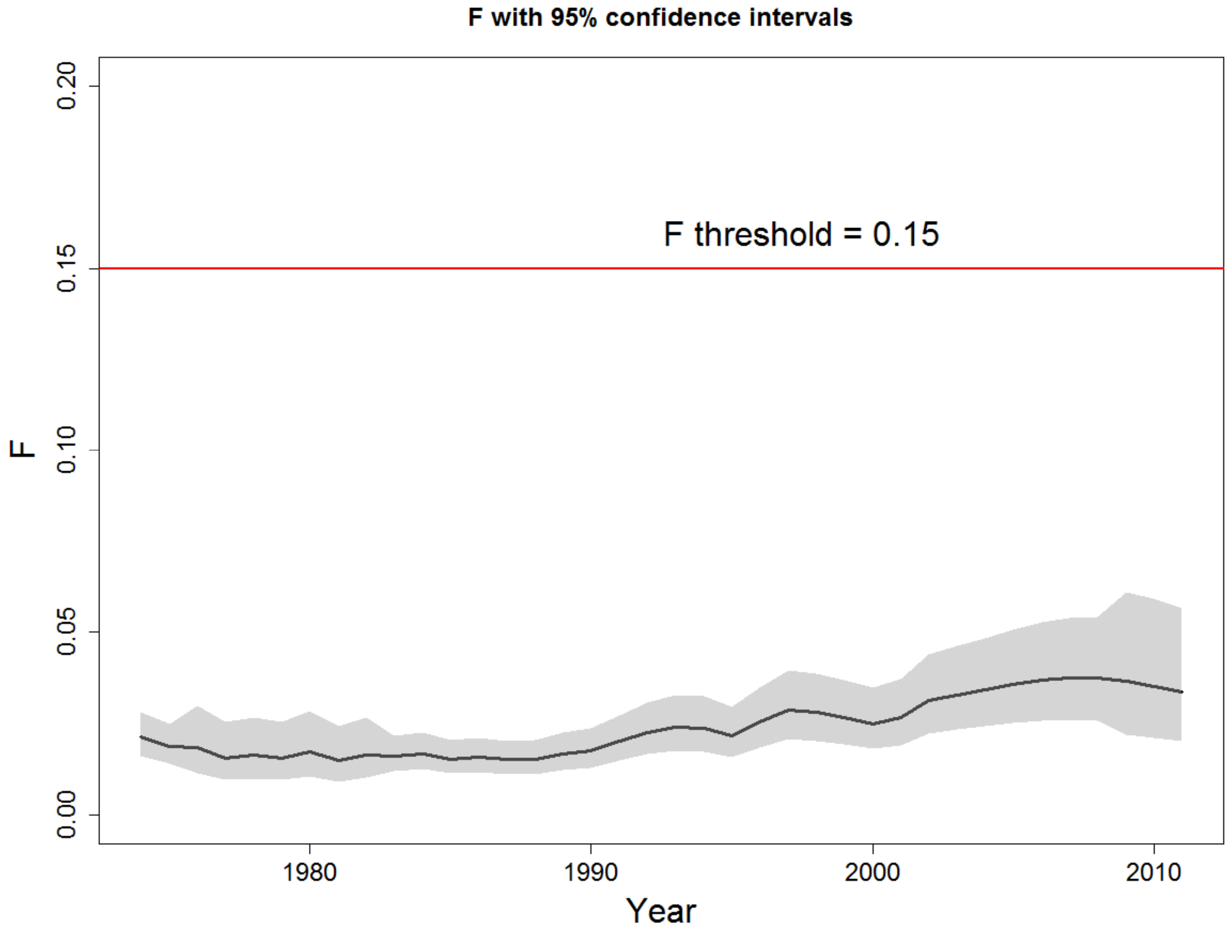
Atlantic Surfclam - Figures



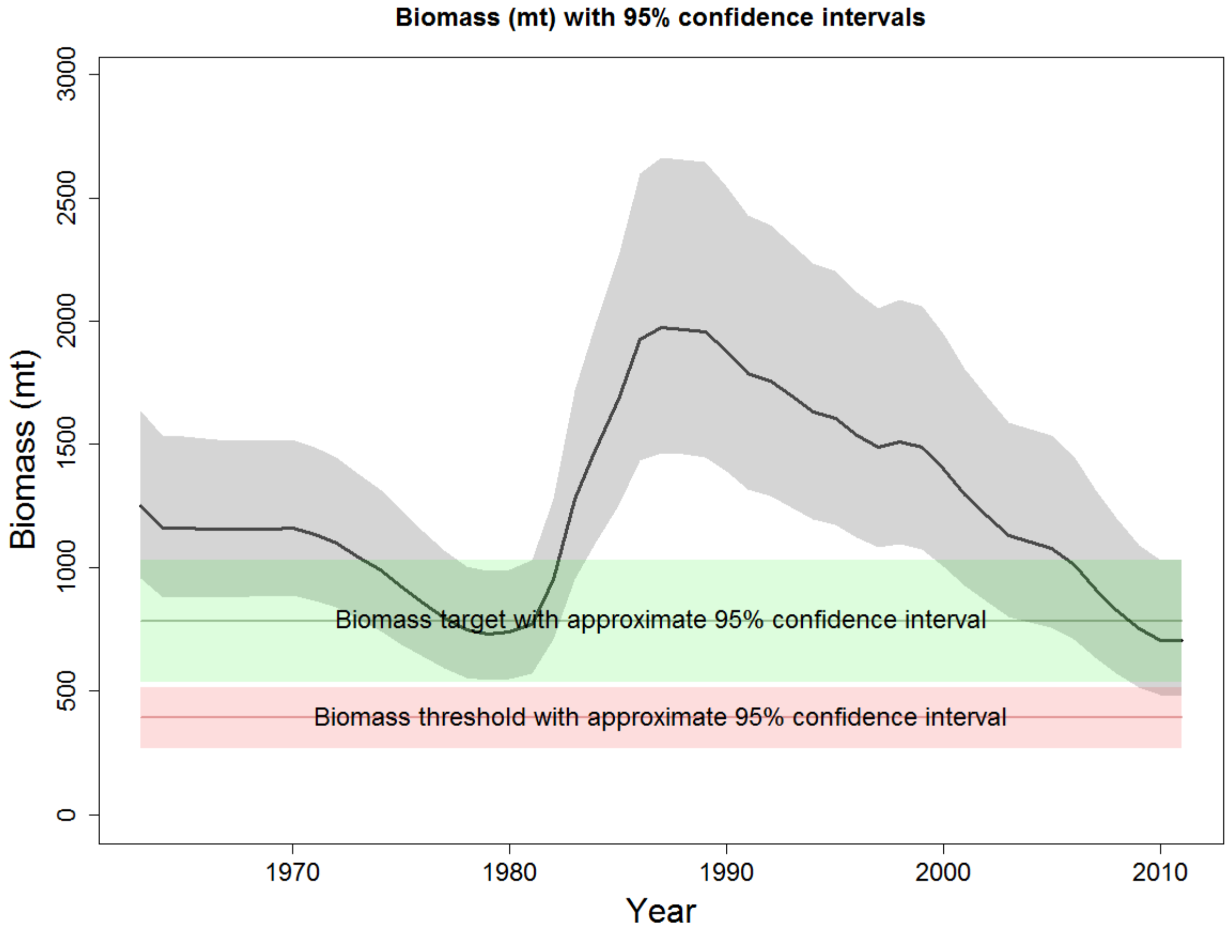
A1. Assessment regions for the Atlantic surfclam stock in the US Exclusive Economic Zone (EEZ). NEFSC shellfish strata with potential surfclam habitat are shown in grey and identified by stratum ID numbers.



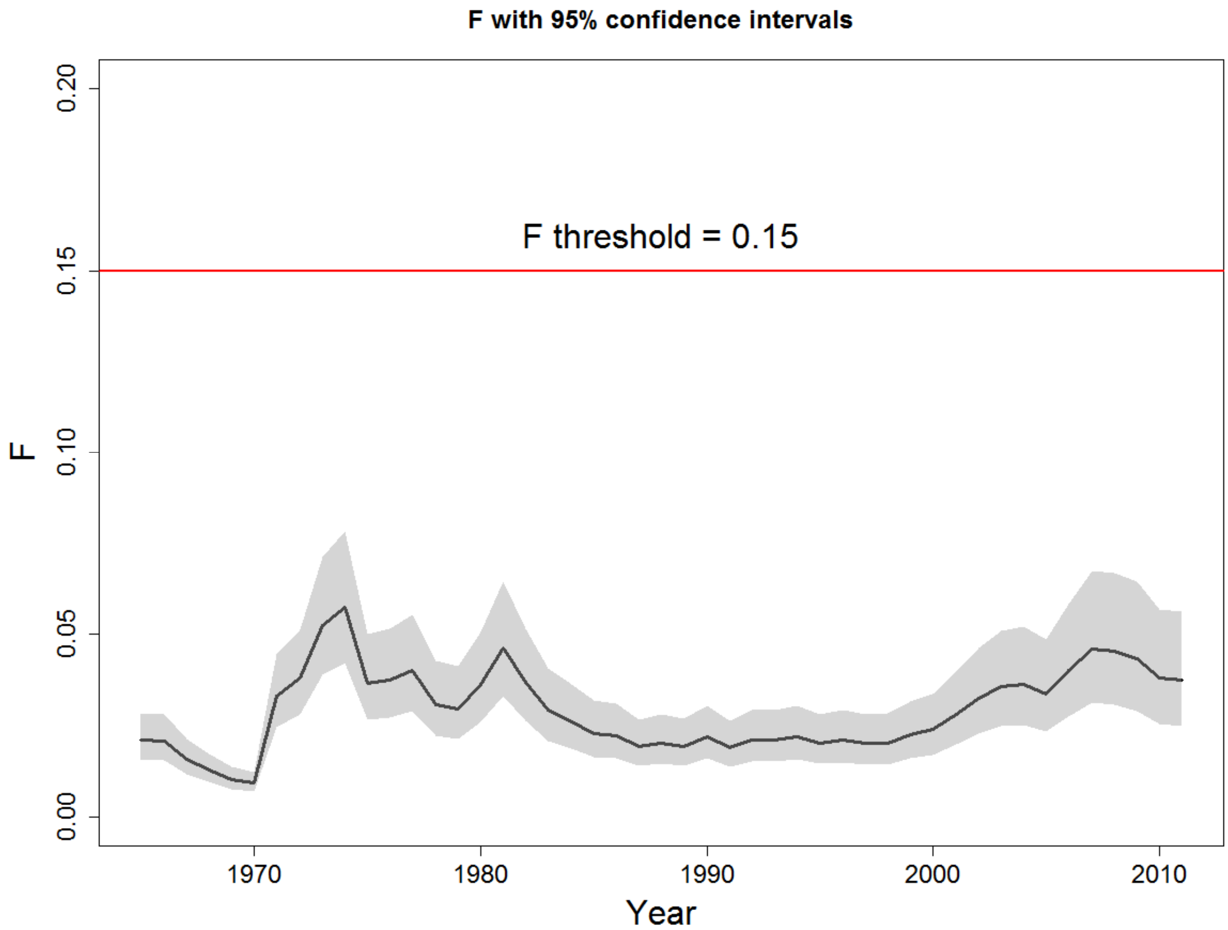
A2. Atlantic surfclam. Whole stock biomass status estimates with approximate 95% confidence intervals on the estimates and reference points.



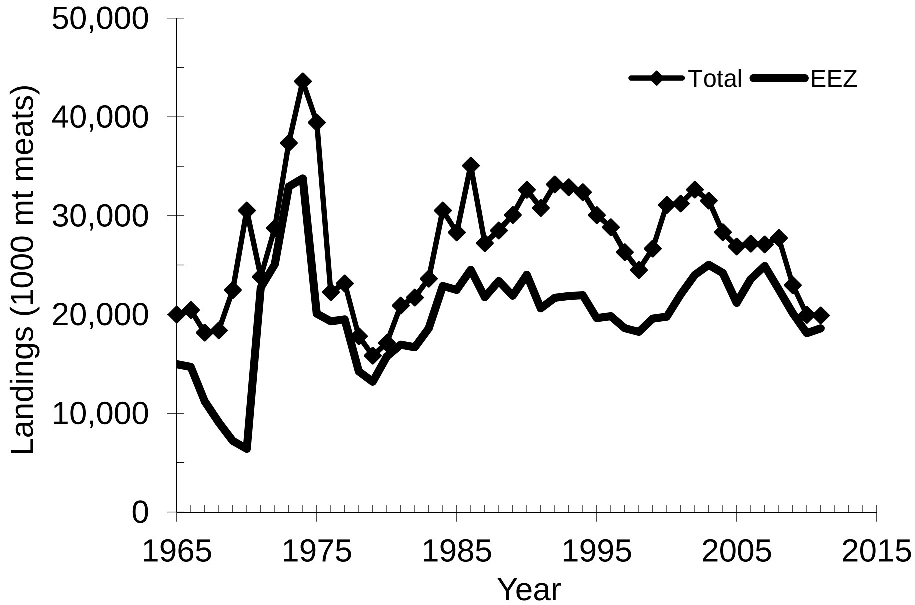
A3. Atlantic surfclam. Whole stock fishing mortality estimates with approximate 95% confidence intervals, and the overfishing threshold.



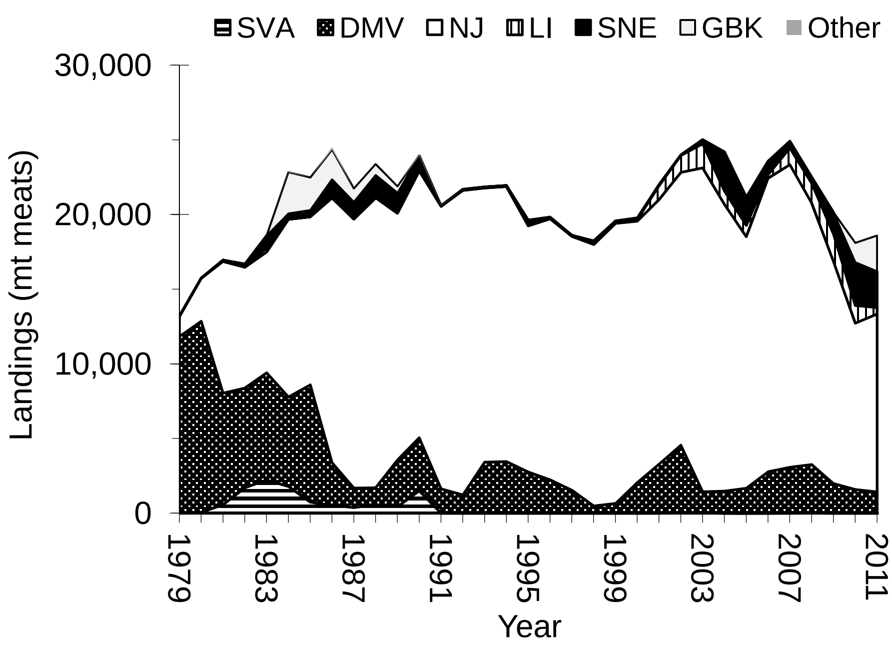
A4. Atlantic surfclam. Southern area biomass estimates, and biomass reference points with approximate 95% confidence intervals.



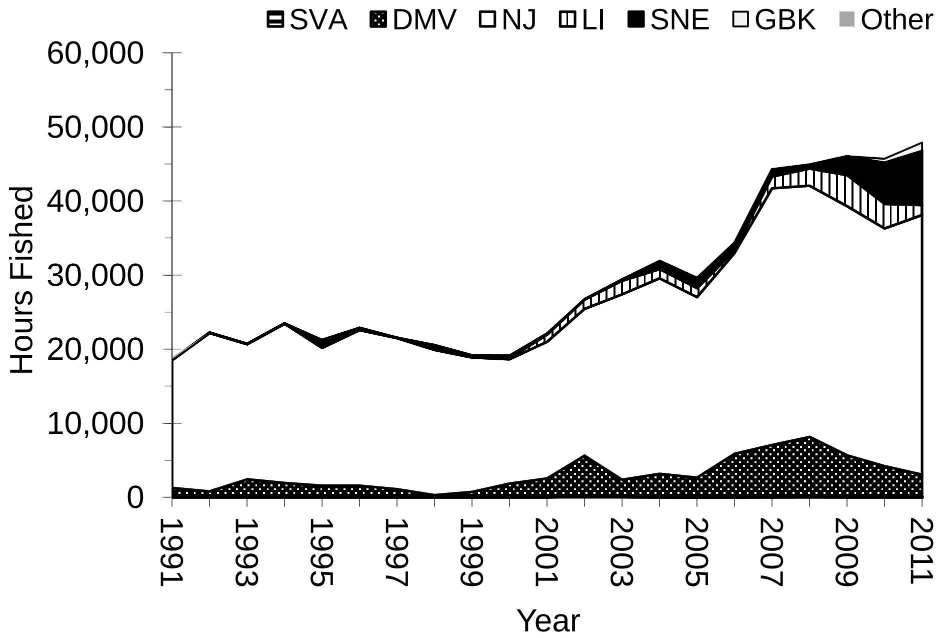
A5. Atlantic surfclam. Southern area fishing mortality estimates with approximate 95% confidence intervals, and the overfishing threshold.



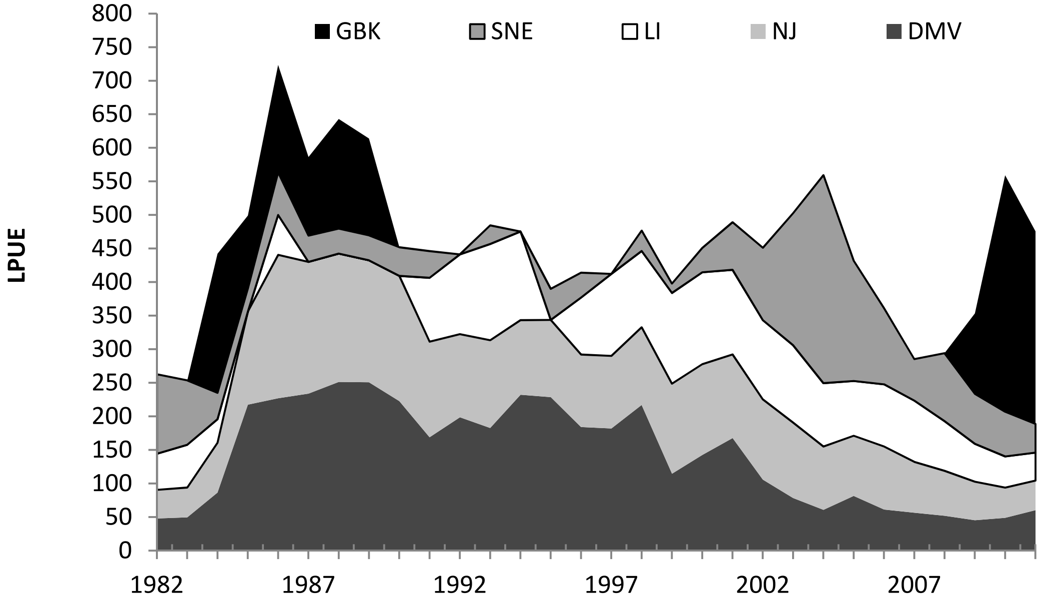
A6. Surfclam landings (total and EEZ) during 1965-2011.



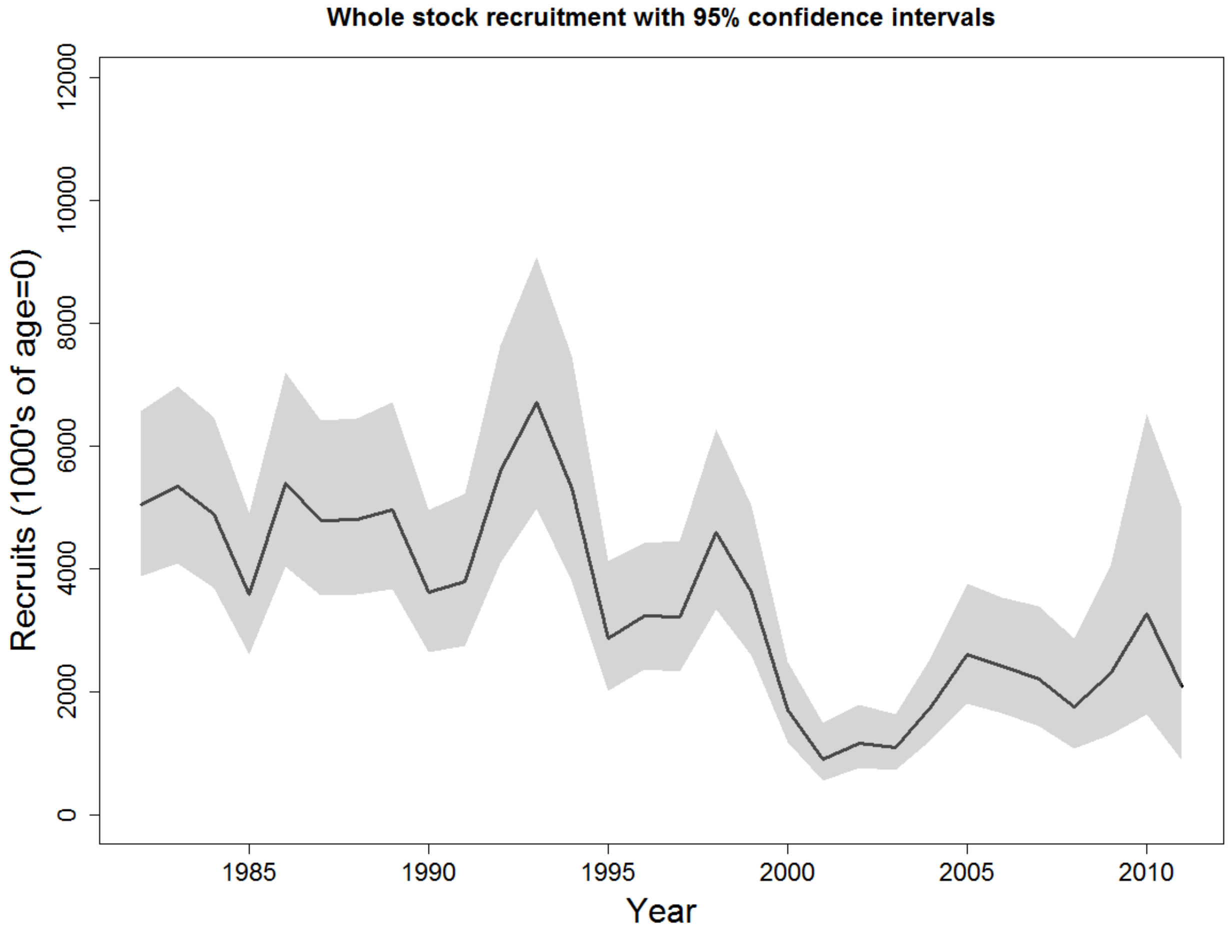
A7. Surfclam landings from the US EEZ during 1979-2011, by stock assessment region.



A8. Surfclam hours fished from the US EEZ during 1991-2011, by stock assessment region.



A9. Nominal landings per unit effort (LPUE, bushels landed per hour fished) for surfclam, by region



A10. Atlantic surfclam. Whole stock recruitment estimates with approximate 95% confidence intervals.

B. GULF OF MAINE-GEORGES BANK WHITE HAKE ASSESSMENT SUMMARY FOR 2012/13

State of Stock: White hake is not overfished and overfishing is not occurring, both with high certainty (Figure B1). Spawning stock biomass (SSB) in 2011 is estimated to be 26,877 mt which is 83% of the revised SSBMSY proxy (32,400 mt) (Figure B2). The 2011 fully selected fishing mortality is estimated to be 0.13 which is below (66% of) the revised FMSY proxy (0.20) (Figure B3). This stock status is a change from the previous stock assessment (see Special Comments).

Projections: Projection models were run sampling estimated age-1recruitment from a cumulative density function derived from agreed assessment model (ASAP) under two recruitment assumptions: the complete recruitment series between 1963 and 2009, and recent recruitment between 1995 and 2009, a period of lower recruitment. Recruitment estimates for 2010 and 2011 were not included in the re-sampling due to their greater variance. The catch scenarios were defined by the revised F_{MSY} and 75%F_{MSY} proxies. The projections at 75%F_{MSY} using the 1963-2009 time series of recruitment show SSB increasing from 28,886 mt in 2012 to 34,473 mt in 2015 and 35,371 mt in 2016, with the catches also increasing during this period (Table B1). Short term projections (2012-2016) were not greatly impacted by the recruitment assumption because these recruits do not fully enter the spawning stock or fishery by 2015. However, projected SSB increases to a lower level, peaking in 2015 and declining slightly in 2016 under the recent recruitment scenario. The SARC panel favored the recent recruitment scenario for short term projections (through 2016).

Catches: United States commercial landings of white hake averaged around 16,400 mt through the mid 1910s, then began declining to a low of 1,131 mt in 1967 (Figure B4). Landings then increased to a peak in 1985 of 7,351 mt followed by a secondary peak of 8,509 mt in 1992. United States landings have since declined both due to lower abundance and management measures implemented to reduce effort. Foreign landings have generally been low for this stock, ranging from no landings to 1,683 mt with an average of 362 mt. Discards averaged 1,256 mt in the 1960s, declined to about 900 mt in the 1970s, increased to 1,200 mt in the 1980s, and have declined to less than 200 mt since. Catch data are a source of uncertainty for this stock assessment, because of potentially mixed reported landings with red hake and uncertain identification to species by observers. Recreational catches averaged less than 12 mt and were imprecisely estimated, so are not included in the assessment.

Catch and Status Table (weights in mt): White Hake

Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011		Max	Min	Mean
Landings														
US [1]	3,268	4,435	3,523	2,671	1,703	1,530	1,341	1,712	1,820	2,899		21,669	1,131	7,613
Foreign[2,3]	158	129	86	85	89	56	39	79	104	86		1,683	0	362
Total[2]	3,426	4,564	3,609	2,756	1,792	1,586	1,380	1,791	1,924	2,985		9,647	1,147	4,207
Discards[2]	123	324	113	93	62	36	171	83	91	54		1,896	36	768
Catch Used in Assessment[4]	3,547	4,879	3,720	2,828	1,853	1,621	1,545	1,872	2,014	3,039		10,666	1,545	4,958
Recreational[5]	10.70	9.50	11.30	6.20	7.90	1.60	11.00	3.90	6.10	12.70		106.40	0.00	11.33
SSB[6]	12,556	13,322	12,999	11,577	11,134	14,205	15,888	16,017	21,106	26,877		34,399	7,847	18,425
January 1 Biomass[6]	15,275	16,098	15,423	14,897	13,579	16,744	19,225	19,148	24,626	31,225		39,023	9,873	22,408
F[6]	0.35	0.46	0.35	0.31	0.19	0.13	0.12	0.14	0.11	0.13		1.07	0.11	0.35
Recruitment (000s of fish) [6]	2,506	2,458	2,296	3,841	4,946	4,047	5,053	5,672	5,898	4,006		13,072	2,296	5,439

[1]US Landings max, min, and mean based on 1893-2011.
[2]Foreign and total landings and discards max, min, and mean based on 1964-2011.
[3] Foreign landings are for NAFO Areas 5 and 6.
[4]Catch used in assessment is does not include recreational catch or catch of age-0 fish
[5] Recreational catch max, min, and mean based on 1981-2011.
[6] Assessment model results max, min, and mean based on 1963-2011.

Stock Distribution and Identification: White hake, *Urophycis tenuis*, is a demersal gadoid species distributed from the Newfoundland to North Carolina, and is most abundant in the Gulf of Maine (Bigelow and Schroeder 1953, Collette and Klein-McPhee 2002). White hake is managed as a single stock in United States waters. Based on a genetic study in Canadian waters, there is evidence for both population structure within and mixing among stock units (Roy *et al.* 2012). No such studies exist for white hake in US waters.

Data and Assessment: The 2013 assessment considered a wide range of data up to 2012, including state and federal surveys and commercial LPUE. The 2013 assessment model uses data from NEFSC surveys, vessel trip reports, dealer landings records and on-board fishery observers through 2011.

The previous assessment (GARM III, 2008) of Gulf of Maine-Georges Bank white hake was conducted using a statistical catch-at-age model (SCAA, also referred to as an age-structured production model, ASPM) that incorporated commercial landings and discards. In this 2013 SAW/SARC56 assessment, the model put forward by the white hake working group was a statistical catch-at-age model (ASAP) incorporating some formulations that differed from the GARM III SCAA model.

The 2013 assessment includes revised and updated catch estimates and minor changes to the strata used to compute the Northeast Fisheries Science Center (NEFSC) spring and autumn survey indices. The catch data in the previous assessment were derived using survey species proportions at length to split the combined red and white hake catch data into separate red and white hake catches. At the SAW/SARC 51 red hake assessment (NEFSC 2011), reported red hake landings and estimated discards were used, so to be consistent, the same approach is used for white hake. The revised catch had a larger impact on the assessment than revisions to the survey indices. The fishery age composition data from 1963-1981 were derived from a pooled age-length key derived from the 1982-2004 (without 2003 for the fall) and 2011-2012 survey age data. Results from the SCAA and ASAP model formulations using the revised data were similar in trend and magnitude.

The 2013 model assumes two fishery selectivity time blocks instead of a single block as used in the previous assessment model based on model fits. The 2013 model assumes asymptotic selectivity at age for the catch whereas the previous model (NEFSC 2008) allowed domed selectivity at age for the catch and the NEFSC surveys, in each case based on the best fit to the data available at the time. All catch sources were combined into a single fleet. Estimates of abundance in numbers/tow from the NEFSC spring and autumn surveys (1963-2011) were used in the ASAP model along with associated estimates of variance and annual age composition. All changes in model configuration were informed by model diagnostics.

Biological Reference Points: There are a number of changes in the assessment model and data from the previous assessment, as shown below.

	GARM III (2008)	SARC 56
F_{MSY} proxy (F40%)	0.125 (on age 6)	0.20 (on age 6)
SSB/R	5.94	6.19
Mean Recruitment	8.0 million	5.5 million
SSB_{MSY} proxy	56,300 mt	32,400 mt
F pattern	Domed	Asymptotic at age 6
MSY	5,800 mt	5,630 mt

Based on the demographic and selectivity parameters of the white hake stock, the SPR based F reference point of F40% corresponds to fully selected F =0.20. The SARC panel recommended that F40% (i.e. fully selected F=0.20) remain as the proxy for F_{MSY}.
When the F_{MSY} value of 0.20 is used in long-term projections, including the full 1963-2009 recruitment time series, the estimate of SSB_{MSY} is 32,400 mt. The estimate of SSB in 2011 is 26,877 mt and fishing mortality in 2011 is 0.13.

Fishing Mortality: The estimates of fishing mortality were above F_{MSY} proxy at the start of the time series, declined to below F_{MSY} proxy during the 1970s, increased to more than 5 times the F_{MSY} proxy in the 1990s, but have been below the threshold since 2006 (Figure B3). The 2011 Ffull is estimated at 0.13 (90% posterior probability interval 0.11 – 0.16), well below the FMSY proxy =0.20 (Figure B3).

Biomass: The estimates of spawning stock biomass (SSB) have generally increased from a time series low of 7,850 in 1997 (Figure B2). SSB in 2011 is estimated to be 26,877 mt (90% posterior probability interval 23,127 – 30,729 mt). The spawning stock biomass is at 83% of the SSBMSY proxy=32,400 mt.

Recruitment: The time series mean recruitment (age 1) was 5.4 million. Strong year classes were produced in 1984, 1988 and 1989 (Figure B5). Mean recruitment between 1995 and 2009 was 3.8 million. Recent recruitments were near the time series average.

Special Comments:

- Estimated spawning stock biomass has increased from 14,205 mt in 2007 to 26,877 mt in 2011 in a period when F was low and recruitment has been near the long term average following a low period. This result is not due to a change in the model but reflects signals in the data. Landings have increased during this period as well.
- The SARC Panel notes that although recent recruitment has been sampled for reasons of short term projections, biological reference points were based on recruitments from the entire time series. There is no clear reason at this time to base reference points on a reduced time series of recruitment.
- The SAW Working Group (WG) recommended an F_{MSY} proxy of F35% based on simulations under fishing mortalities associated with F35% and F40%, indicating a central tendency for risk that SSB would be reduced below 20% of virgin biomass of less than 5%. The WG chose F35% on the basis that there was little difference in risk for F35% and F40% and F35% offered higher yield opportunities. Upon further review of the risk, the SARC Panel identified a greater difference in risk levels between the reference points than originally indicated by the WG. Risk increased steeply as F was increased from F40% to F35% and as stock-recruitment steepness was decreased from h=0.8 to h=0.7. Consequently, the SARC Panel recommended that in the absence of more detailed investigation of stock-recruitment dynamics and associated risk levels, the F_{MSY} proxy of F40% currently in place should remain.

References:

Bigelow, H.B. and W.C. Schroeder. 1953. Fishes of the Gulf of Maine. U.S. Fish and Wildl. Serv., Fish. Bull. 74: 223-230 p.

Collette BB, Klein-MacPhee G. 2002. Bigelow and Schroeder's fishes of the Gulf of Maine, 3rd ed. Smithsonian Institution Press. Washington D.C.

NEFSC (Northeast Fisheries Science Center). 2008. Assessment of 19 Northeast Groundfish Stocks through 2007: Report of the 3rd Groundfish Assessment Review Meeting (GARM III), Northeast Fisheries Science Center, Woods Hole, Massachusetts, August 4-8, 2008. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 08-15: 884 p + xvii.

NEFSC (Northeast Fisheries Science Center). 2011. 51st Northeast Regional Stock Assessment Workshop (51st SAW) Assessment Report. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 11-02: 856 p.

Roy D, Hurlbut TR. 2012. Biocomplexity in a demersal exploited fish, white hake (*Urophycis tenuis*): depth-related structure and inadequacy of current management approaches. Can. J. Fish. Aquat. Sci. 69(3): 415-429.

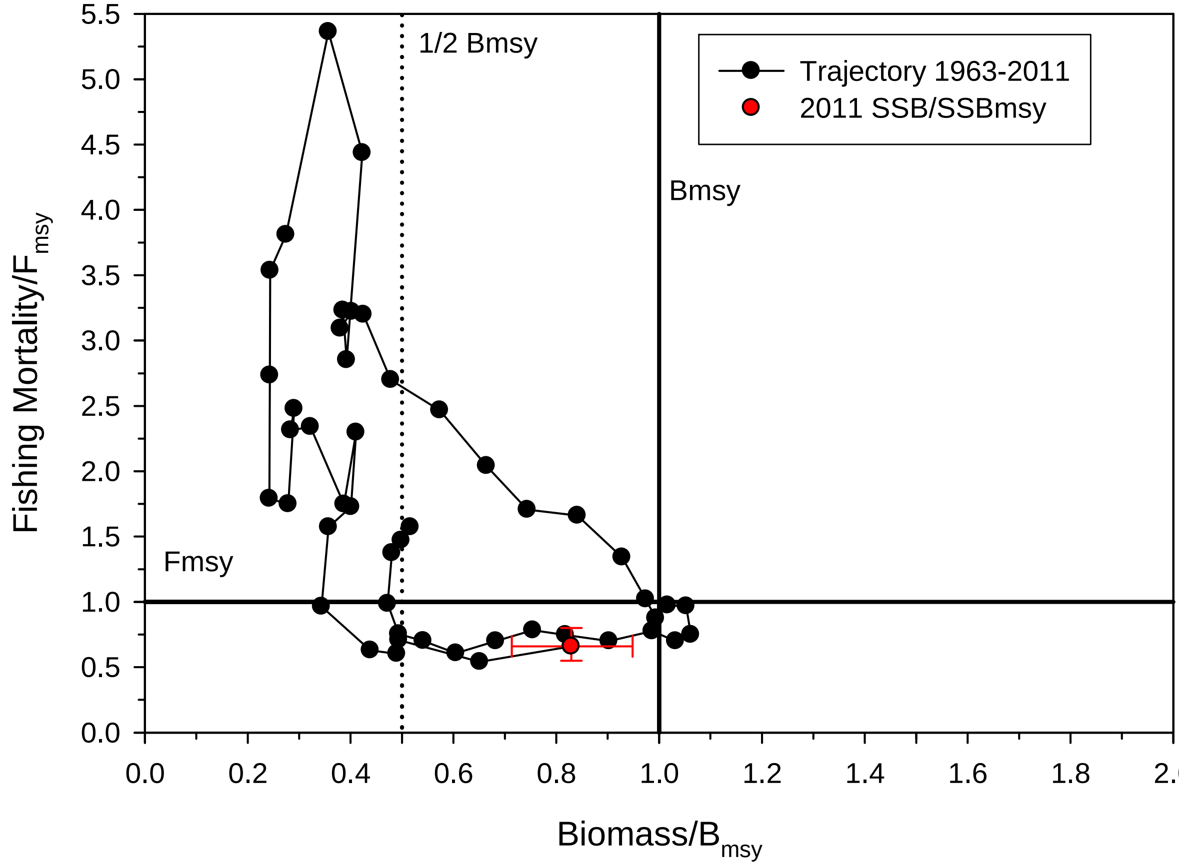
Table B1. Short term projections of total fishery yield and spawning stock biomass for Gulf of Maine-Georges Bank white hake based on a harvest scenario of fishing at 75% FMSY between 2013 and 2015. Catch in 2012 has been estimated at 2,900 mt

Long Time Series of Recruitment (1963-2009)

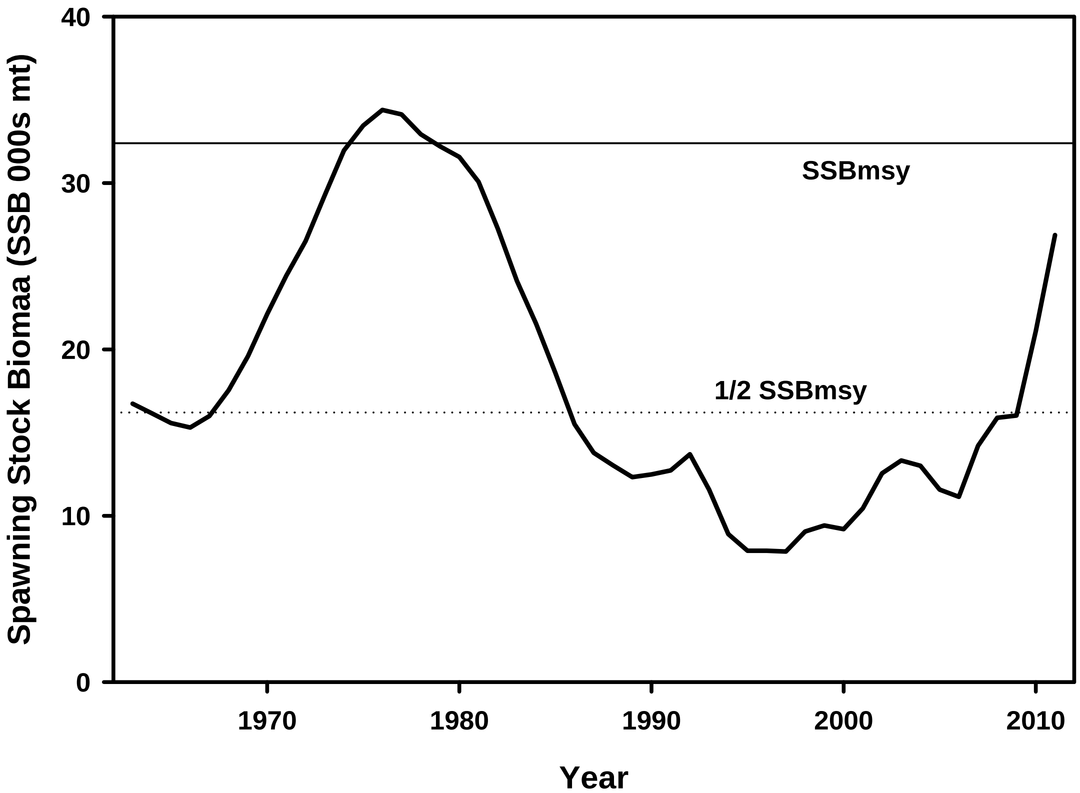
Year	Catch	5%	95%	SSB	5%	95%	F
2012	2,900	-	-	28,886	24,659	33,166	0.12
2013	4,181	3,313	5,205	31,999	27,297	37,095	0.15
2014	4,450	3,566	5,567	33,656	28,911	39,175	0.15
2015	4,595	3,704	5,742	34,473	29,952	39,951	0.15
2016	4,668	3,803	5,830	35,371	30,641	41,248	0.15

Short Time Series of Recruitment (1995-2009)

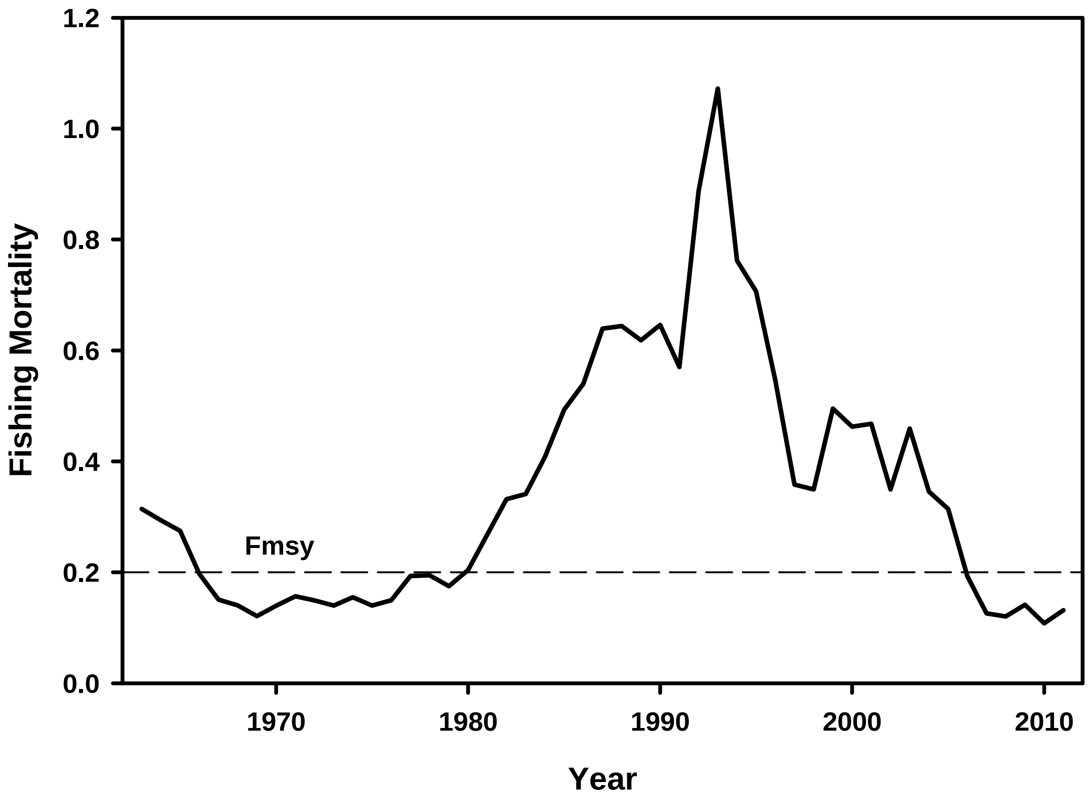
Year	Catch	5%	95%	SSB	5%	95%	F
2012	2,900	-	-	28,886	24,659	33,166	0.12
2013	4,177	3,552	4,823	31,986	27,255	37,085	0.15
2014	4,435	3,796	5,137	33,559	28,765	39,087	0.15
2015	4,532	3,929	5,266	33,893	29,505	39,269	0.15
2016	4,490	3,919	5,193	33,683	29,521	38,663	0.15



B1. Stock status of Gulf of Maine-Georges Bank white hake for 2011 relative to F40% proxy MSY reference points for spawning stock biomass (SSB) and fishing mortality (FFull); 2011 estimate is the colored dot, error bars represent 90% posterior probability intervals. Dotted line is the 1963-2010 time series ratio of SSB to SSB_{MSY} based on 2012 MSY reference points.

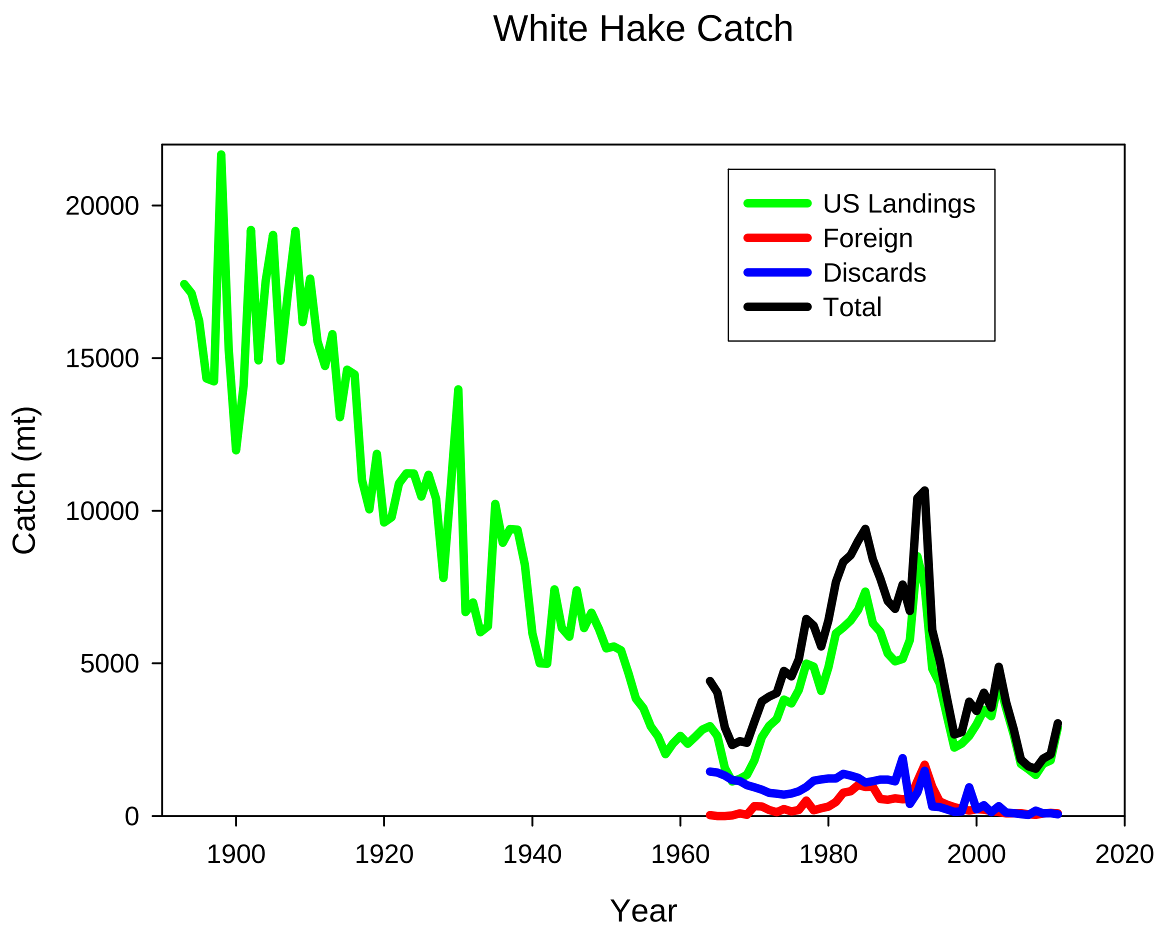


B2. Estimated trends in the spawning stock biomass of Gulf of Maine-Georges Bank white hake between 1963 and 2011 and the corresponding SSB_{target} (SSBMSY) and SSBthreshold (1/2 SSBMSY) based on the 2013 assessment using F40%.

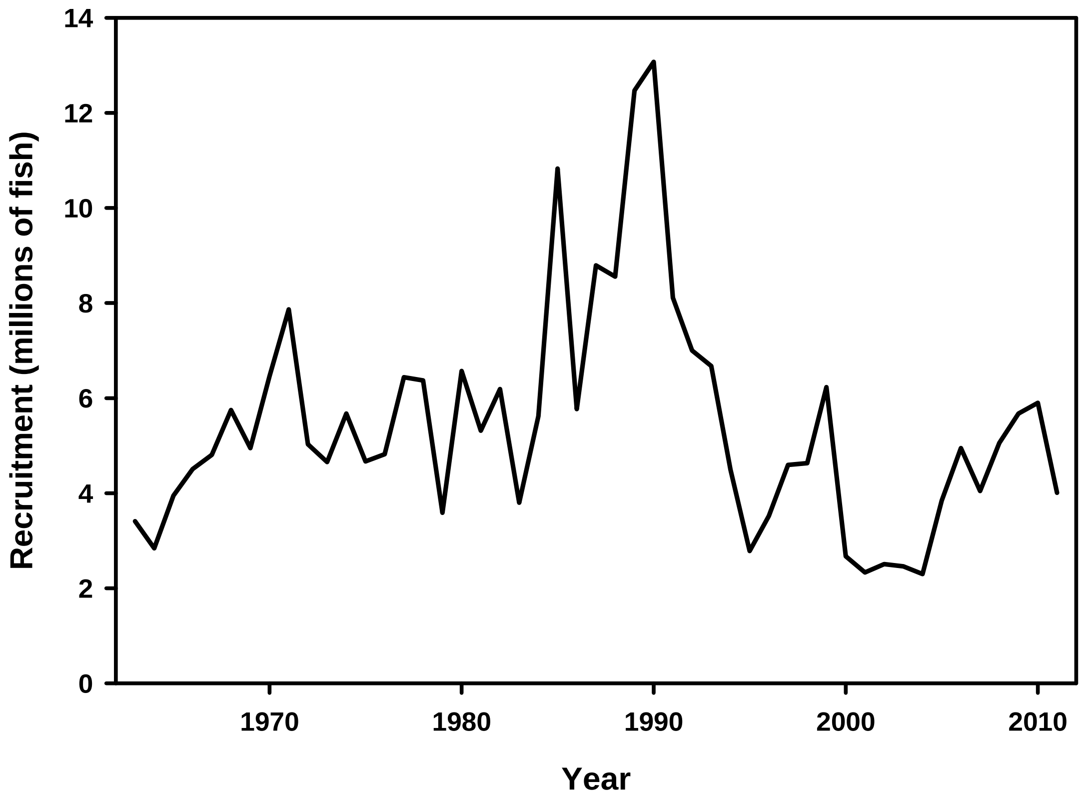


B3. Estimated trends in the fully selected fishing mortality (Ffull) of Gulf of Maine-George Bank white hake between 1963 and 2011, and the corresponding FMSY (F40%) based on the 2013 assessment.

**Note that the time series includes two selectivity blocks (1963-1997, 1998-2011) and the Ffull values are not comparable between blocks.*



B4. Catches of Gulf of Maine-Georges Bank white hake from 1893-2011. The green line is United States landings back to 1893. The blue line is United States discards and the red line is foreign landings. The black line (on top) is the total catch from 1964-2011.



B5. The time series of mean Gulf of Maine-Georges Bank white hake recruitment at age 1.

Appendix: Stock Assessment Terms of Reference for SAW/SARC56, February 19-22, 2013
(To be carried out by SAW Working Groups) (v. 8/22/2012)

A. Atlantic surfclam

1. Estimate catch from all sources including landings and discards. Describe the spatial and temporal patterns in landings, discards, fishing effort and LPUE. Characterize the uncertainty in these sources of data.

2. Present the survey data being used in the assessment (e.g., regional indices of abundance, recruitment, state surveys, age-length data, relevant cooperative research, etc.). Investigate the utility of commercial LPUE as a measure of relative abundance. Characterize the uncertainty and any bias in these sources of data.

3. Evaluate the current **stock** definition in terms of spatial patterns in biological characteristics, population dynamics, fishery patterns, the new cooperative survey, utility of biological reference points, etc. If appropriate, recommend one or more alternative stock definitions, based on technical grounds. Integrate these results into TOR-4.

4. Estimate annual fishing mortality, recruitment and stock biomass (both total and spawning stock) for the time series (integrating results from TOR-3), and estimate their uncertainty. Include a historical retrospective analysis to allow a comparison with previous assessment results. Review the performance of historical projections with respect to stock size, recruitment, catch and fishing mortality.

5. State the existing **stock status** definitions for "overfished" and "overfishing". Then update or redefine biological reference points (BRPs; point estimates or proxies for B_{MSY}, $B_{THRESHOLD}$, F_{MSY} and MSY) and provide estimates of their uncertainty. This should be carried out using the existing stock definition and, if possible, for the recommended "alternative" stock definitions from TOR-3. If analytic model-based estimates are unavailable, consider recommending alternative measurable proxies for BRPs. Comment on the appropriateness of existing BRPs and the "new" (i.e., updated, redefined, or alternative) BRPs.

6. Evaluate stock status with respect to the existing assessment model and with respect to any new assessment model. Determine stock status based on the existing stock definition and, if appropriate and if time permits, for "alternative" stock definitions from TOR-3.
   a. When working with the existing model, update it with new data and evaluate stock status (overfished and overfishing) with respect to the existing BRP estimates.
   b. Then use the newly proposed model and evaluate stock status with respect to "new" BRPs and their estimates (from TOR-5).

7. Develop approaches and apply them to conduct stock projections and to compute the statistical distribution (e.g., probability density function) of the OFL (overfishing level) and candidate ABCs (Acceptable Biological Catch; see Appendix to the SAW TORs).
   a. Provide numerical annual projections (3-5 years). Each projection should estimate and report annual probabilities of exceeding threshold BRPs for F, and

probabilities of falling below threshold BRPs for biomass. Use a sensitivity analysis approach in which a range of assumptions about the most important uncertainties in the assessment are considered (e.g., terminal year abundance, variability in recruitment).

b. Comment on which projections seem most realistic. Consider the major uncertainties in the assessment as well as sensitivity of the projections to various assumptions.
c. Describe this stock's vulnerability (see "Appendix to the SAW TORs") to becoming overfished, and how this could affect the choice of ABC.

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

B. White hake

1. Estimate catch from all sources including landings and discards. Describe the spatial and temporal distribution of fishing effort. Characterize the uncertainty in these sources of data. Analyze and correct for any species mis-identification in these data. Comment on the consistency of the approach to identify the catch of white hake with respect to that used in the red hake assessment.

2. Present the survey data being used in the assessment (e.g., regional indices of abundance, recruitment, state surveys, age-length data, etc.). Investigate the utility of commercial or recreational LPUE as a measure of relative abundance. Characterize the uncertainty and any bias in these sources of data.

3. Evaluate the utility of pooled age-length keys for development of a stock assessment model.

4. Estimate annual fishing mortality, recruitment and stock biomass (both total and spawning stock) for the time series, and estimate their uncertainty. Include a historical retrospective analysis to allow a comparison with previous assessment results. Review the performance of historical projections with respect to stock size, recruitment, catch and fishing mortality.

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

6. Evaluate stock status with respect to the existing model (from previous peer reviewed accepted assessment) and with respect to a new model developed for this peer review. In both cases, evaluate whether the stock is rebuilt.
    a. If possible update the ASPM with new data and evaluate stock status (overfished and overfishing) with respect to the relevant BRP estimates.
    b. Then use the newly proposed model and evaluate stock status with respect to "new" BRPs and their estimates (from TOR-5).

7. Develop approaches and apply them to conduct stock projections and to compute the statistical distribution (e.g., the probability density function) of the OFL (overfishing level) and candidate ABCs (Acceptable Biological Catch; see Appendix to the SAW TORs).
    a. Provide numerical annual projections (3-5 years). Each projection should estimate and report annual probabilities of exceeding threshold BRPs for F, and probabilities of falling below threshold BRPs for biomass. Use a sensitivity analysis approach in which a range of assumptions about the most important uncertainties in the assessment are considered (e.g., terminal year abundance, variability in recruitment).

b. Comment on which projections seem most realistic. Consider the major uncertainties in the assessment as well as sensitivity of the projections to various assumptions.
c. Describe this stock's vulnerability (see "Appendix to the SAW TORs") to becoming overfished, and how this could affect the choice of ABC.

8. Evaluate the validity of the current **stock** definition, taking into account what is known about migration among stock areas. Make a recommendation about whether there is a need to modify the current stock definition for future stock assessments.

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

Appendix to the SAW Assessment TORs:

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

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

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

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

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

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

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

"Vulnerability. A stock's vulnerability is a combination of its productivity, which depends upon its life history characteristics, and its susceptibility to the fishery. Productivity refers to the capacity of the stock to produce 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)

Rules of Engagement among members of a SAW Assessment Working Group:

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

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