Northeast Fisheries Science Center Reference Document 07-03

44th Northeast Regional
Stock Assessment Workshop (44th SAW)

44th SAW
Assessment Summary Report

January 2007

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

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The stock assessments which are the subject of this document were peer reviewed by a panel of assessment experts known as the Stock Assessment Review Committee (SARC). Panelists were provided by the Center for Independent Experts (CIE), University of Miami. Reports from the SARC panelists and a summary report from the SARC Chairman can be found at http://www.nefsc.noaa.gov/nefsc/saw.

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SAW-44 ASSESSMENT SUMMARY REPORT
INTRODUCTION

The 44th SAW Assessment Summary Report contains summary and detailed technical information on three assessments reviewed in November - December 2006 at the Stock Assessment Workshop (SAW) by the 44th Stock Assessment Review Committee (SARC-44): ocean quahogs (*Arctica islandica*), the northeast skate species complex (Barndoor skate, *Dipturus laevis*; Clearnose skate, *Raja eglanteria*; Little skate, *Leucoraja erinacea*; Rosette skate, *Leucoraja garmani*; Smooth skate, *Malacoraja senta*; Thorny skate, *Amblyraja radiata*; Winter skate, *Leucoraja ocellata*), and Atlantic surfclams (*Spisula solidissima*). The SARC-44 consisted of two external, independent reviewers and an external SARC chairman, all appointed by the Center for Independent Experts (CIE). 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' report for SAW/SARC-44 is available at website: http://www.nefsc.noaa.gov/nefsc/saw/ under the heading "Recent 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.

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

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

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

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

Outcome of Stock Assessment Review Meeting

The ocean quahog assessment was accepted by the SARC. Current biomass appears well above the B_{msy} proxy and current F appears well below the F_{msy} proxy. The SARC was concerned with the biomass estimates from the main assessment model (KLAMZ) because the model did not link long-term average recruitment to virgin biomass. The reviewers also expressed concern about the accuracy and precision of the dredge efficiency estimate, the approach used to fill missing survey data cells, the appropriateness of proxies for B_{msy} and F_{msy}, and management of the offshore stock as a single unit.

Assessment results for the seven skate species were only partially accepted. The SARC rejected the estimates of fishing mortality rate (F) as well as new Biological Reference Points (BRPs). The SARC felt that the absence of species-specific landings data made it extremely difficult to estimate F, and that estimates derived from a new model were too unreliable to accept at this time. The SARC felt that the existing BRPs were ad hoc and in need of improvement. The SARC felt that the proposed BRPs, derived from stock-recruit fits and length-based yield per recruit analysis, represented a positive step. However, they did not feel that sufficient work had been done on the new BRPs, to justify their use at this time. Accordingly, the assessment evaluated stock status with respect to the existing BRPs, and those results were accepted by the SARC. No absolute estimates of total biomass or spawning stock biomass were made in the assessment. Finally, the SARC accepted work which examined the NEFSC Food Habits Database to estimate skate diets and skate consumptive demand in the ecosystem.

The Atlantic surfclam assessment was accepted by the SARC, although the panel felt that the assessment could be improved by making better use of the available data on surfclam ages by developing a fully integrated age structured model. Some of the concerns raised earlier about the ocean quahog assessment were also raised about the surfclam assessment. In addition, the panel questioned whether the B_{msy} proxy (one half B_{1999}) was appropriate, and suggested that this topic could be reconsidered in a future assessment.

GLOSSARY

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

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.

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

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

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.

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.

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

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.

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."

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.

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%.

$F_{0.1}$. 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.

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.

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_{MSY}. The fishing mortality rate that produces the maximum sustainable yield.

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.

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.

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.

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.

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.

Minimum Stock Size Threshold (MSST, $B_{threshold}$). Another of the Status Determination Criteria. The greater of (a) $\frac{1}{2}B_{MSY}$, 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.

Mortality rates. Populations of animals decline exponentially. This means that the number of animals that die in an "instant" is at all times proportional to the number present. The decline is defined by survival curves such as:

$$N_{t+1} = N_t e^{-z}$$

where N_t is the number of animals in the population at time t and N_{t+1} is the number present in the next time period; Z is the total instantaneous mortality rate which can be separated into deaths due to fishing (fishing mortality or F) and deaths due to all other causes (natural mortality or M) and e is the base of the natural logarithm (2.71828).

To better understand the concept of an instantaneous mortality rate, consider the following example. Suppose the instantaneous total mortality rate is 2 (i.e., Z = 2) and we want to know how many animals out of an initial population of 1 million fish will be alive at the end of one year. If the year is apportioned into 365 days (that is, the 'instant' of time is one day), then 2/365 or 0.548% of the population will die each day. On the first day of the year, 5,480 fish will die (1,000,000 x 0.00548), leaving 994,520 alive. On day 2, another 5,450 fish die (994,520 x 0.00548) leaving 989,070 alive. At the end of the year, 134,593 fish [$1{,}000{,}000 \times (1 - 0.00548)^{365}$] remain alive. If, we had instead selected a smaller 'instant' of time, say an hour, 0.0228% of the population would have died by the end of the first time interval (an hour), leaving 135,304 fish alive at the end of the year [$1{,}000{,}000 \times (1 - 0.00228)^{8760}$]. As the instant of time becomes shorter and shorter, the exact answer to the number of animals surviving is given by the survival curve mentioned above, or, in this example:

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

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.

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}.

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.

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 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.

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.

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).

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.

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.

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.

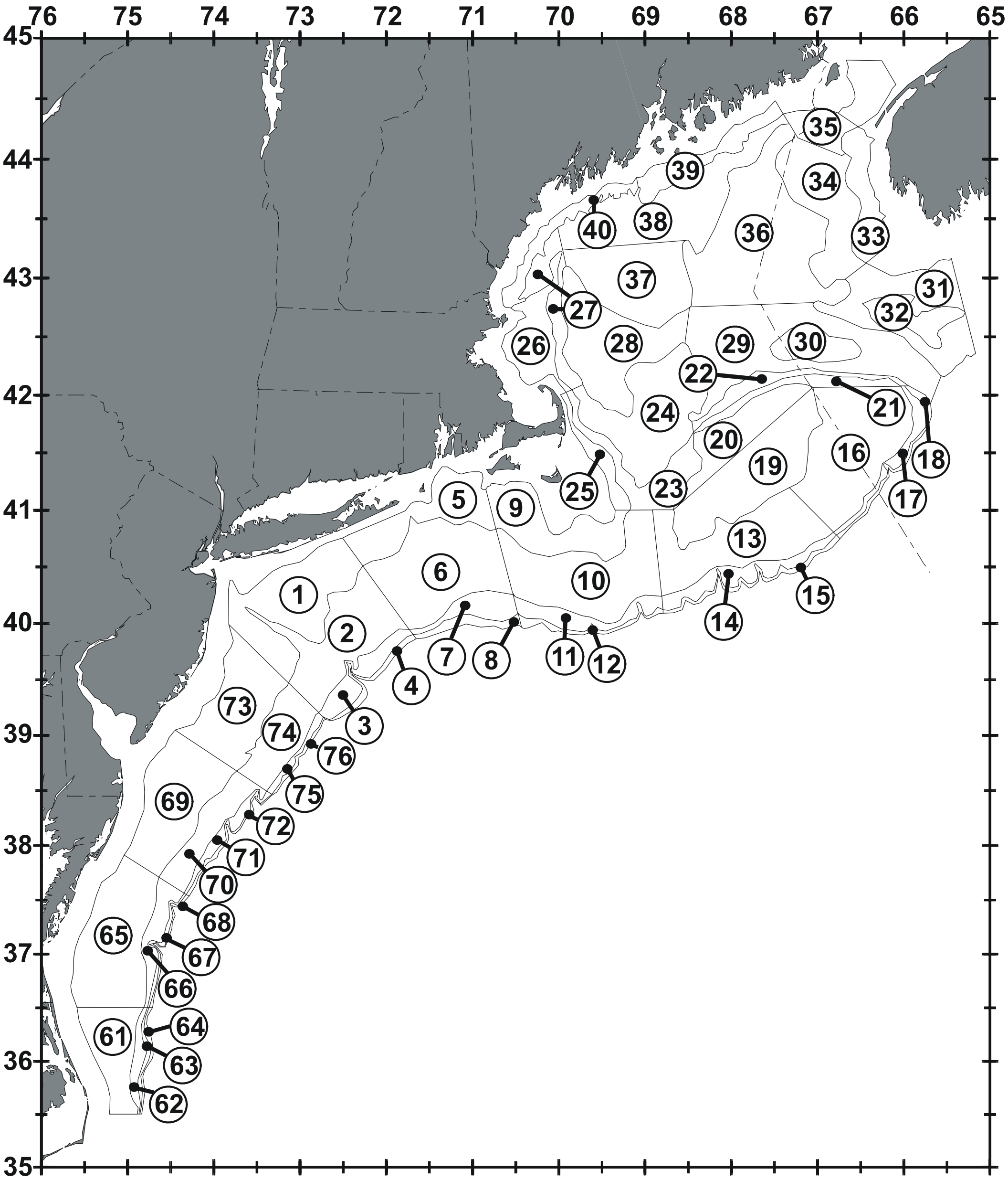

Figure 1. Offshore depth strata sampled during Northeast Fisheries Science Center bottom trawl research surveys.

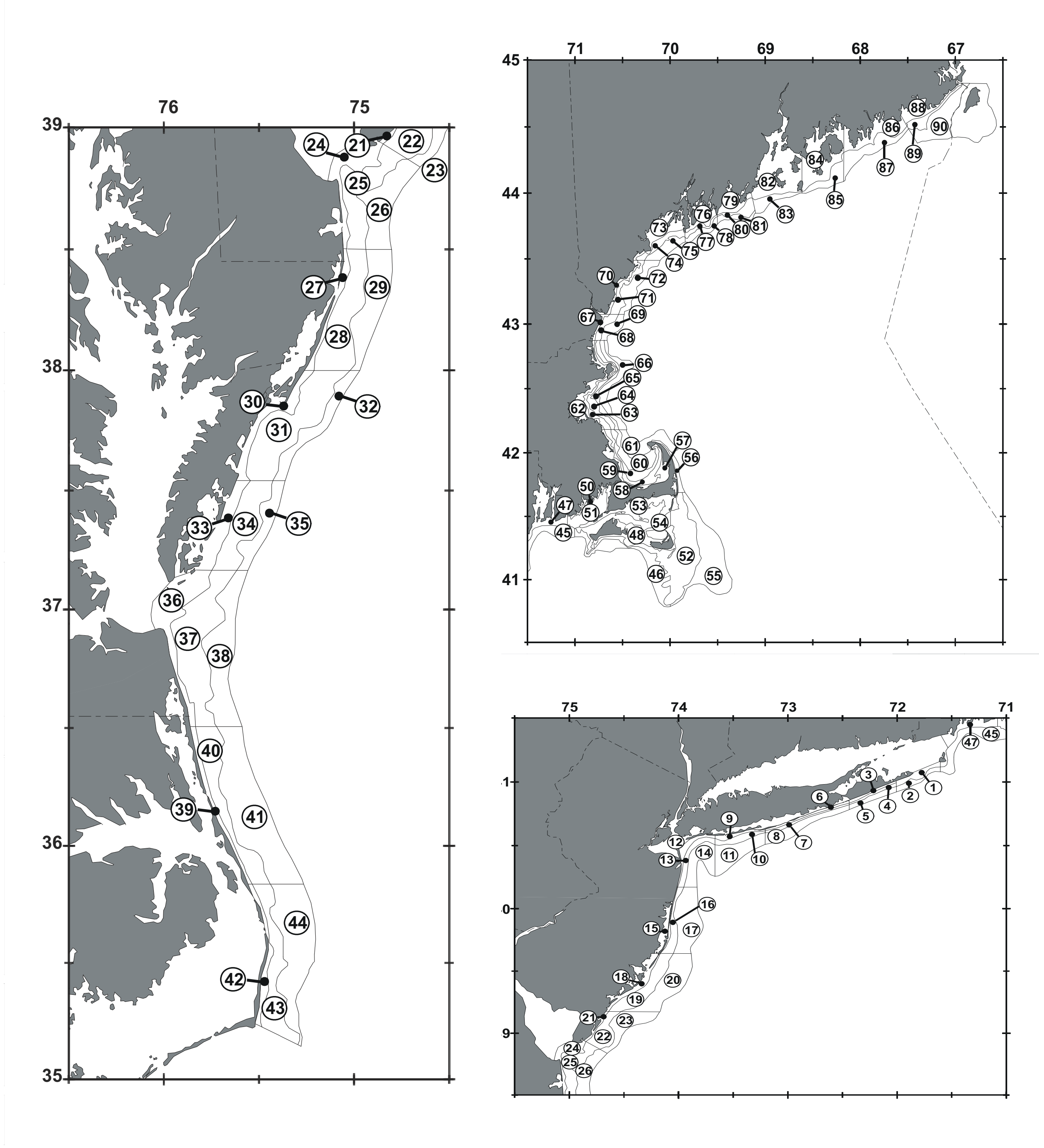

Figure 2. Inshore depth strata sampled during Northeast Fisheries Science Center bottom trawl research surveys.

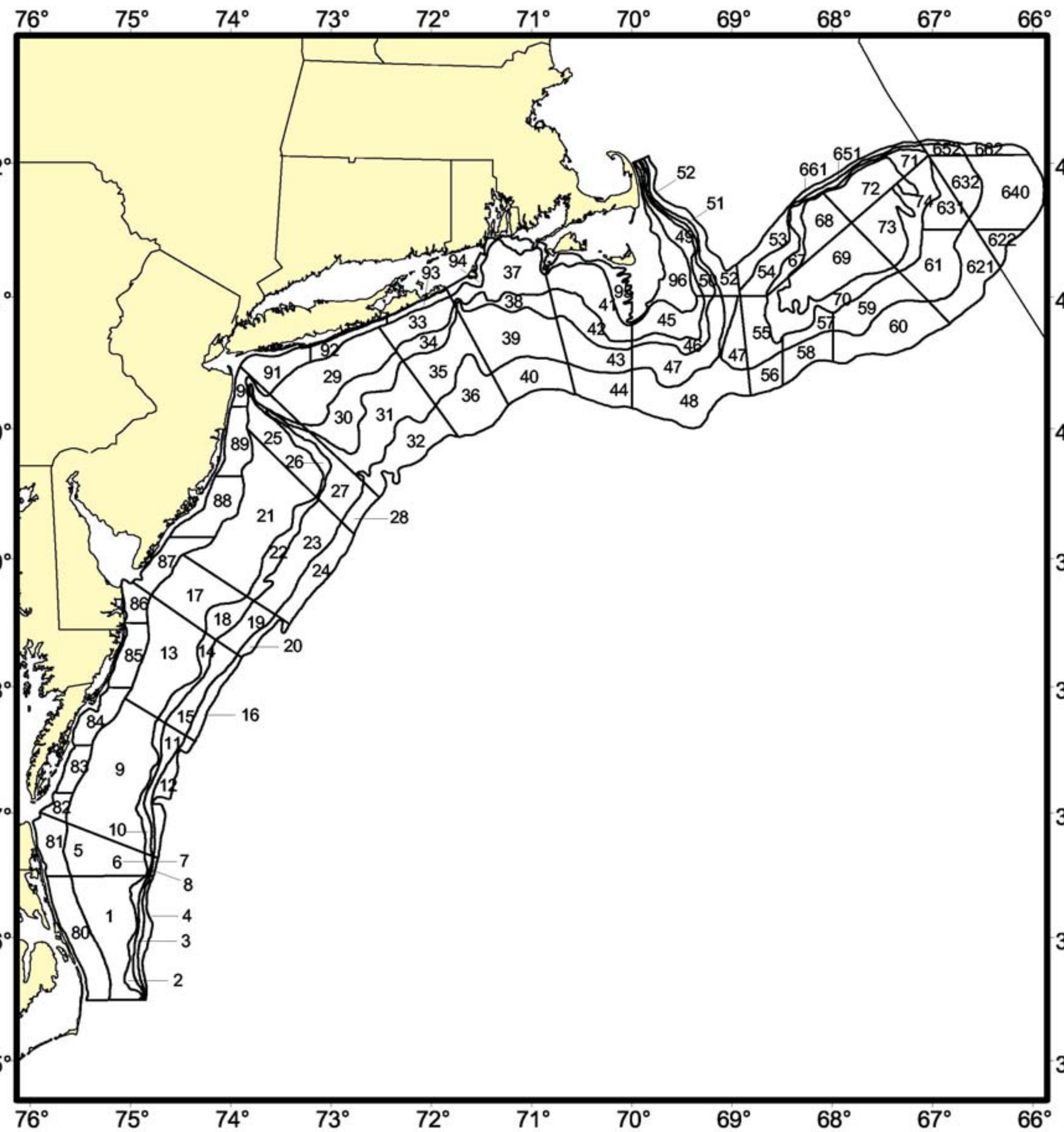

Figure 3. NEFSC clam survey strata.

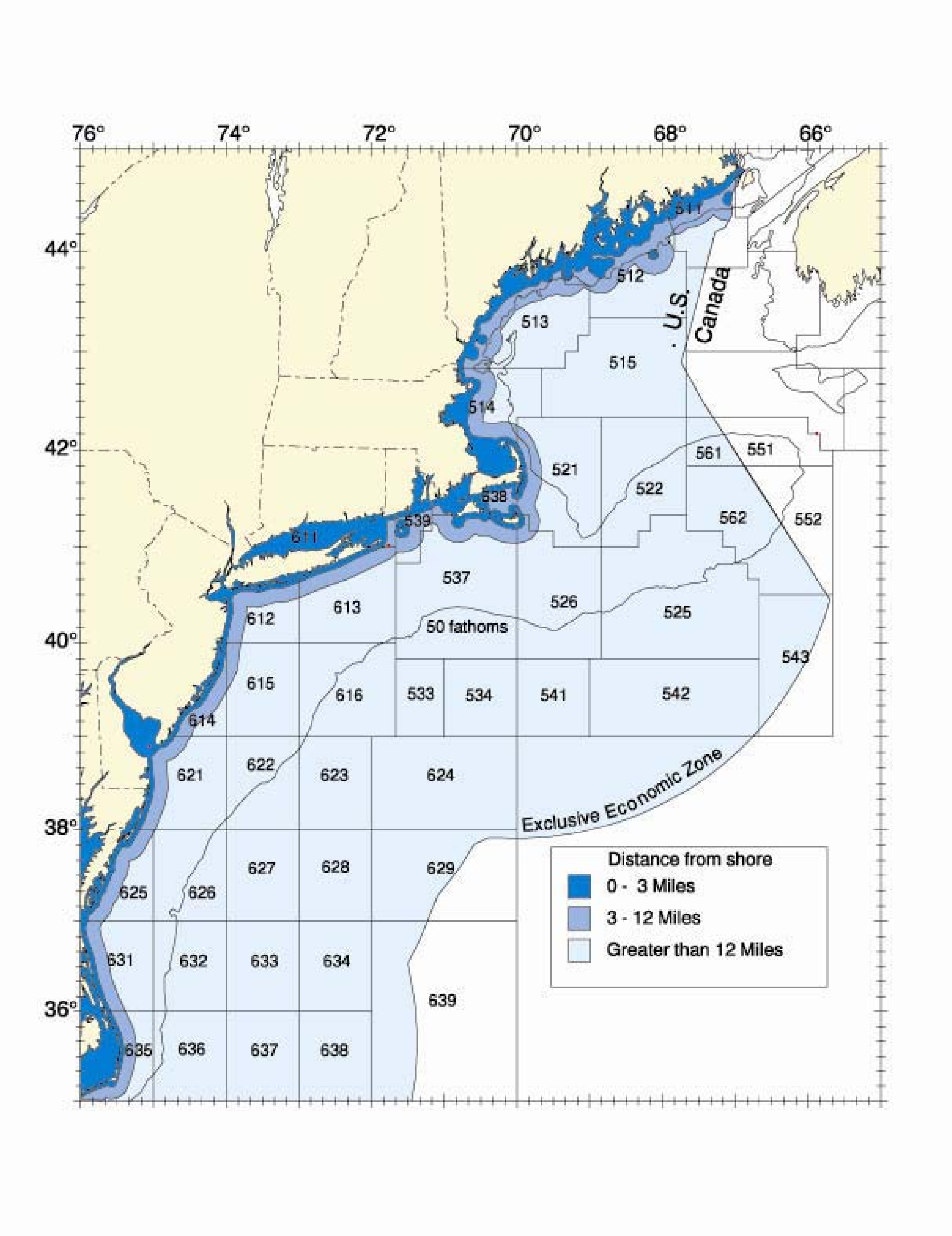

Figure 4. Statistical areas used for reporting commercial catches.

A. OCEAN QUAHOG ASSESSMENT SUMMARY FOR 2006

State of Stock: The ocean quahog stock (Figure A1) is not overfished and overfishing is not occurring. Estimated fishable stock biomass during 2005 was 3.039 million mt, which is above the management target of ½ virgin biomass = 1.987 million mt (Figures A2 and A3). Estimated fishing mortality during 2005 for the exploited region (all areas but Georges Bank, Figure A1) was F= 0.0077 y^{-1}, which is below the management target level $F_{0.1}$ = 0.0278 y^{-1} (Figures A4 and A5). These estimates for ocean quahog in the US Exclusive Economic Zone (EEZ) do not include Maine waters (Figure A1), which were assessed separately (see below). However, biomass and landings for Maine waters are minor and would have no appreciable effect on estimates for the whole stock.

Projections: Based on example calculations (below), biomass is projected to decline gradually through 2010. The scenario with landings equal to a 5.333 million bushel quota (24,189 mt meats) corresponds to current regulations, although recent landings have been less than the quota.

Example stock projections (biomass, landings and fishing mortality during 2006-2010) with three annual quota levels and with $F=F_{0.1}$. The current (2006) quota is 5.333 million bushels (24 thousand mt meats). Biomass and landings are thousand mt meats. Fishing mortality are annual rates. Mortality rates assume that incidental mortality at 5% of landings.

Year	Biomass All Regions (1000 mt)	Biomass less GBK (1000 mt)	Landings (1000 mt)	*F* All Regions (y^{-1})	*F* less GBK (y^{-1})
Quota = 4 million bushels (18,144 mt meats)					
2006	3,016	1,753	13	0.004	0.008
2007	2,995	1,731	18	0.006	0.011
2008	2,967	1,703	18	0.006	0.011
2009	2,940	1,676	18	0.007	0.011
2010	2,912	1,649	18	0.007	0.012
Quota = 5.333 million bushels (24,189 mt meats)					
2006	3,016	1,753	13	0.004	0.008
2007	2,995	1,731	24	0.009	0.015
2008	2,961	1,697	24	0.009	0.015
2009	2,927	1,663	24	0.009	0.015
2010	2,893	1,630	24	0.009	0.016
Quota = 6 million bushels (27,215 mt meats)					
2006	3,016	1,753	13	0.004	0.008
2007	2,995	1,731	27	0.010	0.017
2008	2,957	1,694	27	0.010	0.017
2009	2,921	1,657	27	0.010	0.017
2010	2,884	1,620	27	0.010	0.018
$F = F_{0.1}$=0.028 y^{-1} in exploited regions (F=0 for GBK)					
2006	3,016	1,753	13	0.004	0.028
2007	2,960	1,696	44	0.016	0.028
2008	2,905	1,642	42	0.015	0.028
2009	2,853	1,589	40	0.015	0.028
2010	2,802	1,538	39	0.015	0.028

Status Table: Ocean Quahog

Year:	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Min[1]	Max[1]	Mean[1]
Quotas:													
EEZ	20.2	19.6	18.1	20.4	20.4	20.4	20.4	20.4	22.7	24.2	13.6	27.2	21.5
Maine	--	--	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	< 0.1	0.3	0.3
Landings:[2,6]													
Maine	0.14	0.22	0.22	0.28	0.36	0.33	0.39	0.36	0.31	0.29	< 0.1	0.4	< 0.1
EEZ	19.9	19.4	17.7	17.1	14.4	16.7	17.6	18.5	17.3	13.3	10.4	22.4	18.0
Total	20.1	19.6	17.9	17.4	14.7	17.1	17.9	18.8	17.6	13.6	10.4	22.5	18.1
Biomass:[3,6]	3,296	3,263	3,231	3,202	3,173	3,148	3,121	3,093	3,065	3,039	3,039	3,973	3,478
Fishing mortality:[4,6]	0.0099	0.0099	0.0091	0.0090	0.0077	0.0091	0.0097	0.0103	0.0098	0.0077	0.0039	0.0104	0.0084
Recruitment:[5,6]	15.2 (all years)												

[1] Min, max and means for 1978-2005 (EEZ landings, EEZ quota, biomass and fishing mortality), 1990-2005 (Maine landings), or 1998-2005 (Maine quota).
[2] Landings (1000 mt) not adjusted for incidental mortality, which is assumed to be 5% of landings. Discards are very low.
[3] Biomass (1000 mt) for entire stock.
[4] Fishing mortality (annual rates) for whole stock less GBK.
[5] Recruitment (1000 mt per year) is an estimated average assuming zero recruitment in SVA, DMV and GBK.
[6] See assessment for regional estimates.

Stock Distribution and Identification: Ocean quahogs occur from Norway to Spain, intermittently across the North Atlantic, around Iceland, and down the North American coast to Cape Hatteras. Commercial concentrations occur in US waters on the continental shelf off the coast of Maine and between Georges Bank and the Delmarva Peninsula (Figure A1), to at least 90 m.

All ocean quahog in US waters are assessed and managed as a single stock (Figure A1). The EEZ portion of the ocean quahog stock includes federal waters (between 3 and 200 nm from shore) off southern Virginia, Delmarva, New Jersey, Long Island, Southern New England, and on Georges Bank (excluding Maine). The exploitable stock is the EEZ less Georges Bank because no fishing occurs on Georges Bank because of potential paralytic shellfish poisoning (PSP). Ocean quahog in Maine and the EEZ were assessed separately and results from both assessments are included in this summary.

The EEZ is used to characterize the condition of the ocean quahog stock during 1978-2005 as a whole because almost all of the stock (>99% of fishable biomass) is in EEZ waters. Biomass and fishing mortality estimates for Maine waters are available for 2005 only. However, biomass and landings for Maine waters are relatively minor and would not appreciably change biomass or fishing mortality estimates for the stock as a whole.

Catches: EEZ quotas have been set on an annual basis since 1979. EEZ landings (Figure A6) increased from 0 in 1975 to about 15,000 mt (meats) in 1979, peaked at 22,000 mt in 1992, and averaged about 17,000 mt after 2000. EEZ landings generally account for about 98-100% of total US landings. The EEZ quota has not been attained in recent years, partly due to low market demand. Ocean quahogs in EEZ landings range between 50 and 120 mm SL and are marketed primarily as meats in chowders and sauces.

Catches are assumed to be 5% greater than landings in stock assessment calculations for ocean quahog in EEZ and Maine waters to account for incidental mortality during fishing. Incidental mortality may occur when ocean quahogs contact fishing equipment (i.e. dredge and sorting equipment) without being landed.

Fishing effort from logbooks for ocean quahog in the EEZ shifted offshore and north over last two decades as traditional fishing grounds in the south were fished down, catch rates dropped, and as processing plants were relocated to the north (Figure A7). The fishery was concentrated off Delmarva and Southern New Jersey from the 1970s to mid-1980s. During the late 1980s and early 1990s, the fishery expanded northward into the Northern New Jersey and Long Island regions. In 1995, it expanded to the Southern New England region which accounted for the bulk of landings during 1997. After 1997, the fishery shifted back to the Long Island region, which accounted for about 60% of EEZ landings on average during 2002-2005. During 2001-2005, the fishery was concentrated in eleven 10' squares which were mostly off Long Island.

There are two principal fishing grounds for ocean quahogs in Maine waters, which cover about 60 nm^2 in total. Total annual landings in Maine waters ranged from 3 to 387 mt during 1990-2002 (Figure A8). After the 2002 peak, landings have declined and were 295 mt in 2005. Annual fishing effort in Maine waters peaked in 2002 at about 20,000 hours and then declined to about 17,000 hours in 2005 (Figure A9). Fishing effort in Maine waters (number of trips and hours fished from logbooks) in 2005 was greater than in any region of the EEZ. Ocean quahogs from Maine waters are relatively small, ranging 35-70 mm SL during 2005 and are marketed in the fresh and half-shell market at relatively high prices.

The most productive eastern fishing grounds were reopened by the State of Maine in late 2005 after three years of closure due to paralytic shellfish poison (PSP contamination). Effort and landings are therefore expected to increase in 2006.

Data and Assessment: Ocean quahogs were last assessed in 2003 (SAW-38). The 2003 assessment included complete data and estimates for the EEZ. Data from a preliminary survey in Maine waters during 2003 were also included, but fishing mortality and biomass during 2003 were not calculated for Maine waters because an efficiency estimate for the Maine survey dredge was not available. Information from the current ocean quahog assessments follows.

EEZ: NEFSC clam survey data for 1982-2005, fishery data for 1978-2005, new information about fishery selectivity, survey selectivity, and survey dredge efficiency from cooperative depletion studies were used to estimate fishable biomass during 1978-2005. Estimates for most regions (all but Southern Virginia and Georges Bank) were derived from a delay-difference model (KLAMZ). Biomass on Georges Bank (where no fishing occurs) was assumed to be stable at the level of the average efficiency corrected swept area biomass (ESB) during 1997-2005. For Southern Virginia a cumulative catch ("VPA") model was used instead of the KLAMZ model because survey data were insufficient. Discards were assumed to be zero and indirect mortality from commercial dredging was assumed to be 5% in both EEZ and Maine waters.

Maine: Biomass and fishing mortality of ocean quahogs in 2005 were calculated from landings data, together with a special survey carried out by the State of Maine in 2005 and survey dredge efficiency estimates. These estimates apply only to the area surveyed, which includes the primary fishing grounds. The assessment for Maine excludes waters outside of the survey area.

Biological Reference Points: Biomass reference points for ocean quahogs refer to the whole stock (as represented by the EEZ), while fishing mortality reference points refer to the exploited region only. The biomass target is one-half of the virgin biomass and the fishing mortality target is the $F_{0.1}$ fishing mortality in the exploited region (which excludes Georges Bank where no fishing occurs due to risk of PSP). The management thresholds are one quarter of the total virgin biomass (i.e., 1/2 B_{MSY}), and $F_{25\%}$ in the exploited region. Estimated biomass in 1978 is used as a proxy for virgin biomass and one-half of the biomass in 1978 is used as a proxy for $B_{MSY.}$ Biomass reference points were recalculated in this assessment based on estimates of fishable biomass in 1978 for each region (see below).

Fishing mortality reference points were recalculated for this assessment (assuming the same natural mortality as in the previous assessment, M=0.02 y^{-1}) using a length-based per recruit model and new information about maturity and fishery selectivity.

Reference Point	Last assessment	New
$F_{0.1}$ (target)	0.0275 y^{-1}	0.0278 y^{-1}
F_{MAX}	0.1810 y^{-1}	0.0760 y^{-1}
$F_{25\%}$ (threshold)	0.0800 y^{-1}	0.0517 y^{-1}
$F_{50\%}$	0.0200 y^{-1}	0.0180 y^{-1}
Virgin biomass	2.30 million mt meats	3.973 million mt meats
B_{MSY} =½virgin (target)	1.15 million mt meats	1.987 million mt meats
$B_{Threshold}$ = ½ B_{MSY}	0.575 million mt meats	0.993 million mt meats

The new estimate of $F_{25\%}$ (threshold) is substantially lower because of improved information about maturity and fishery selectivity. The biomass reference points are higher primarily because of new estimates of survey dredge efficiency. Other factors that affect the estimates are inclusion of biomass on GBK that is too deep to be sampled in the standard NEFSC survey (13% of total GBK stock biomass) and use of fishable biomass rather than 70+ mm biomass.

A length based per recruit model was used to calculate biological reference points for Maine waters, but only for purposes of comparison (i.e., they are not used to determine stock status). For ocean quahogs off Maine, F_{max} =0.0561, $F_{0.1}$=0.0247 and $F_{50\%}$ =0.013 y^{-1}. No biomass reference points were calculated for Maine waters.

Fishing Mortality: F= 0.0077 y^{-1} in 2005 for the exploitable portion of the EEZ (excluding GBK) (Figure A5). For the whole EEZ in 2005, F=0.0045 y^{-1} (Figure A4). For Maine waters, F=0.022 y^{-1} in 2005.

Recruitment: Mean annual recruitment to the whole stock was small (<1% per year during 2005). There is some evidence of recruitment and small ocean quahogs in most regions.

A pulse of recruitment in LI, first noticed in survey data in 1978, has recruited into the fishable stock, based on survey data collected in 2005. Very small ocean quahogs (< 5 mm) were detected in one of the Maine fishing grounds in the 2005 state survey.

The timing and potential contribution of new recruits to the fishable biomass is important but uncertain in the EEZ and in Maine waters. Growth is slow so that initial recruitment of year classes to the fishery is delayed for about two decades and full recruitment may require an additional twenty years, depending on the region. Successful reproductive events are regional and may be separated by decades.

Stock Biomass: Fishable stock biomass in 2005 was 3.039 million mt (Figure A3). Estimated virgin biomass in 1978 was 3.973 million mt (Figure A2). The ocean quahog population is a relatively unproductive stock that is being fished down from its virgin state towards its B_{MSY} reference point (½ virgin biomass, estimated as 50% of biomass during 1978). After several decades of relatively low fishing mortality, the stock is still above the B_{MSY} reference point.

Based on survey data, LPUE data and biomass estimates for 1977-2005, declines in stock biomass are most pronounced in southern regions. In particular, stock biomass is below the ½ virgin level in the Southern Virginia, Delmarva, and New Jersey regions.

An increasingly large fraction of the stock (84% during 2005 compared to 52% during 1978) now occurs in northern regions (LI, SNE and GBK). GBK is of particular importance because it contained 32% of total biomass in 1978 and 42% of total biomass in 2005.

Fishable biomass in Maine waters in 2005 was estimated to be 22,000 mt. Logbook data show that LPUE levels have declined since the peak in 2002, but remain relatively high overall (Figure A8). The Maine fishery is small, relative to the rest of the EEZ, and unique. In particular, the Maine fishery exploits relatively small ocean quahogs at a rate $F=0.022\ y^{-1}$ that is approximately three times higher than on the remainder of the exploitable stock.

Special Comments: Agency, academic and industry personnel have devoted considerable effort to estimating efficiency of the NEFSC clam survey dredge during the 1997-2005 surveys. Progress was made since the last assessment but survey dredge efficiency remains the chief source of uncertainty. Depletion experiments designed to measure dredge efficiency should continue to be part of each NEFSC clam survey.

Rate of indirect mortality due to fishing (currently assumed to be 5% of landings) is uncertain. Indirect mortality may be significant in Maine waters where fishing effort levels per unit area are highest.

The FMP currently uses the fishing mortality rate that generates 25% of the maximum spawning stock potential ($F_{25\%}$) as a threshold reference point. Threshold reference points for fishing mortality should be estimates or proxies for F_{MSY}. $F_{25\%}$ is probably not an appropriate proxy for F_{MSY} in a long-lived organism like ocean quahog. F_{MSY} proxies, targets and thresholds should be re-evaluated. Current quota levels keep fishing mortality rates substantially below $F_{25\%}$ and biomass is currently well above the target.

Questions about productivity of ocean quahog are becoming more important as the stock is fished down from high virgin levels to B_{MSY}. Additional studies focusing on recruitment, natural mortality, growth and stock response to reduced biomass levels are required.

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Murawski, S.A., J.W. Ropes and F.M. Serchuk. 1982. Growth of the ocean quahog, *Arctica islandica*, in the Middle Atlantic Bight. Fishery Bulletin 80: 21-34.

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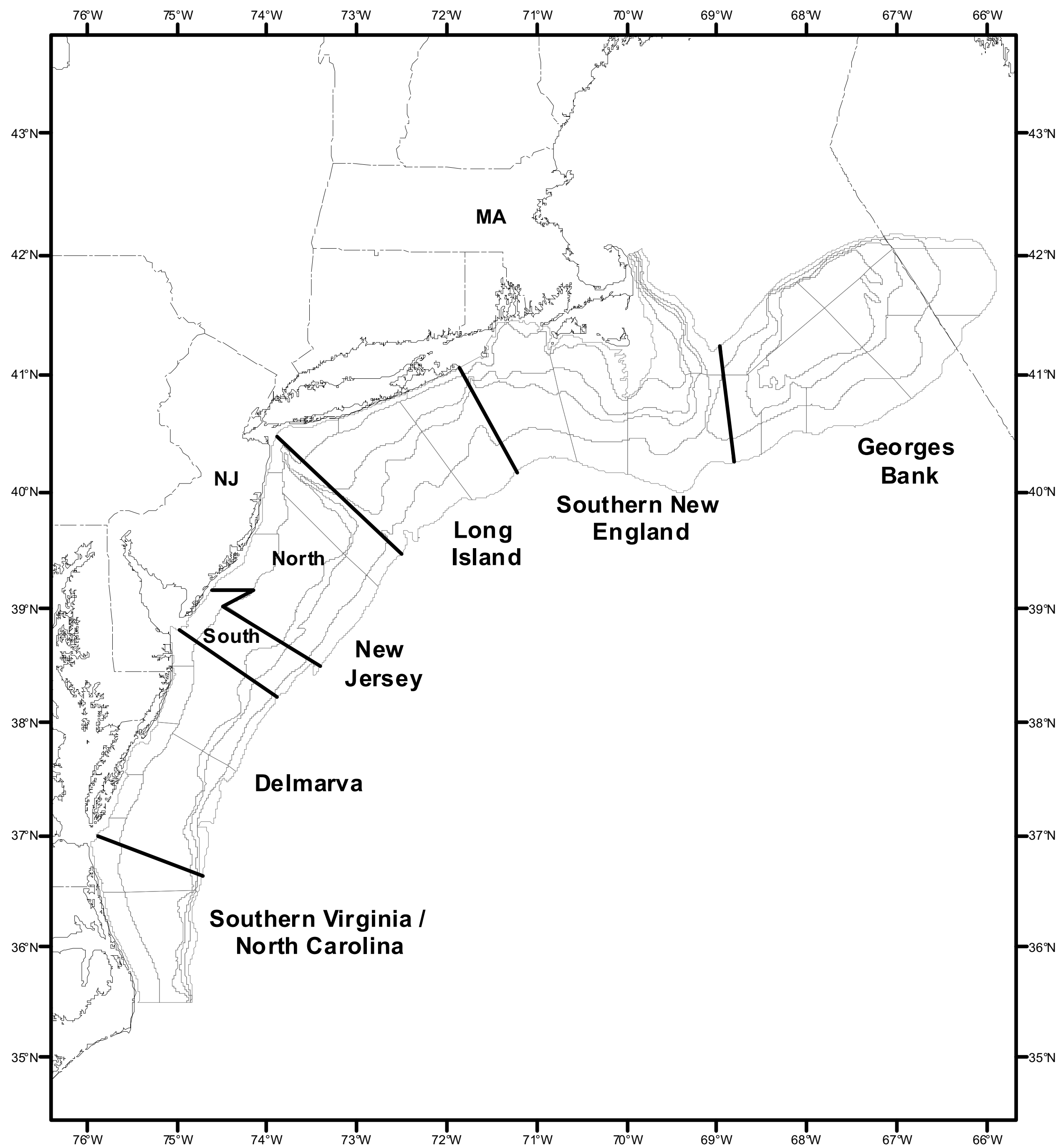
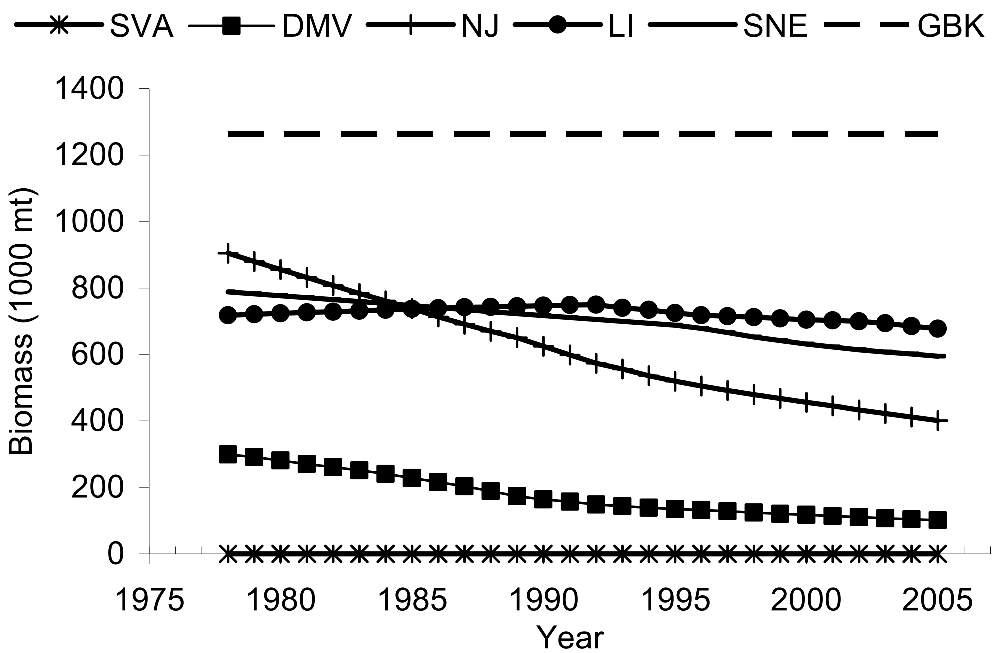
Northeast Fisheries Science Center (NEFSC). 2004. Ocean quahog. In: 38th Northeast Regional Stock Assessment Workshop (38th SAW) Advisory Report. NEFSC Ref. Doc. 04-04, 24 p.[2]

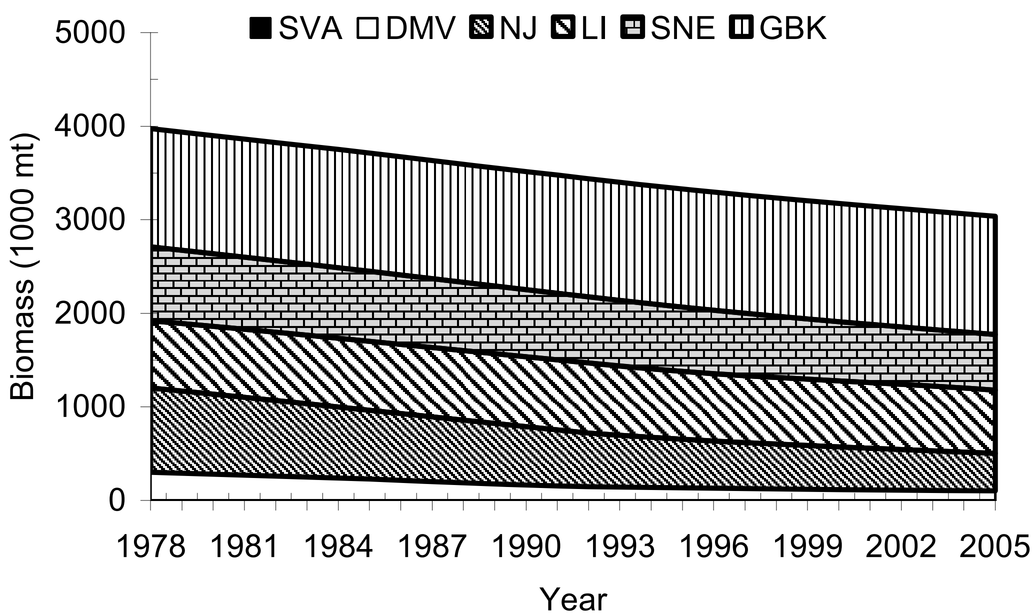
Powell, E. and R. Mann. 2005. Evidence of recent recruitment in the ocean quahog *Arctica islandica* in the Mid-Atlantic Bight. J. Shellfish Res. 24: 517-530.

[1] Available online at: http://www.nefsc.noaa.gov/nefsc/publications/crd/crd0316/
[2] Available online at: http://www.nefsc.noaa.gov/nefsc/publications/crd/crd0317/

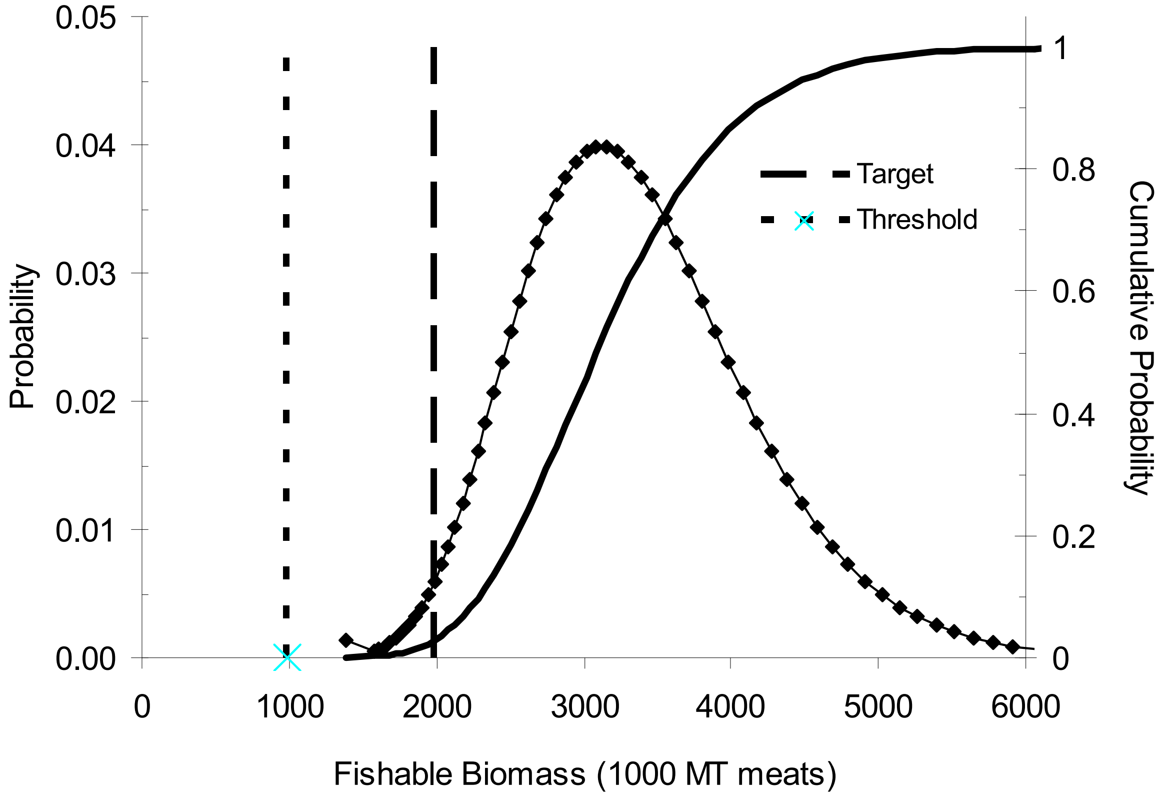


A1. Stock assessment regions for ocean quahog in the US EEZ, with survey strata and stock assessment regions. For ocean quahog, the southern and northern portions of the New Jersey region are combined. The Maine fishing area is along the Maine coast north of the 43^{o} 50' N.

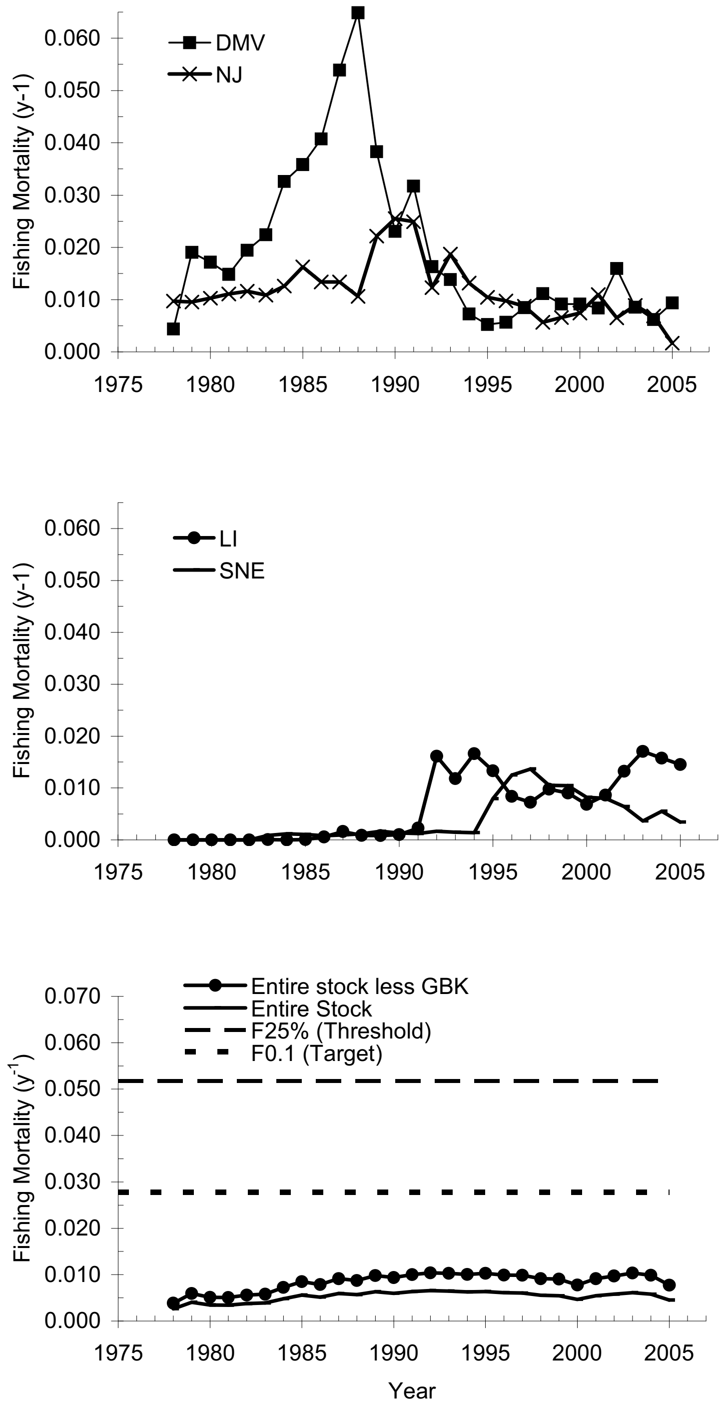




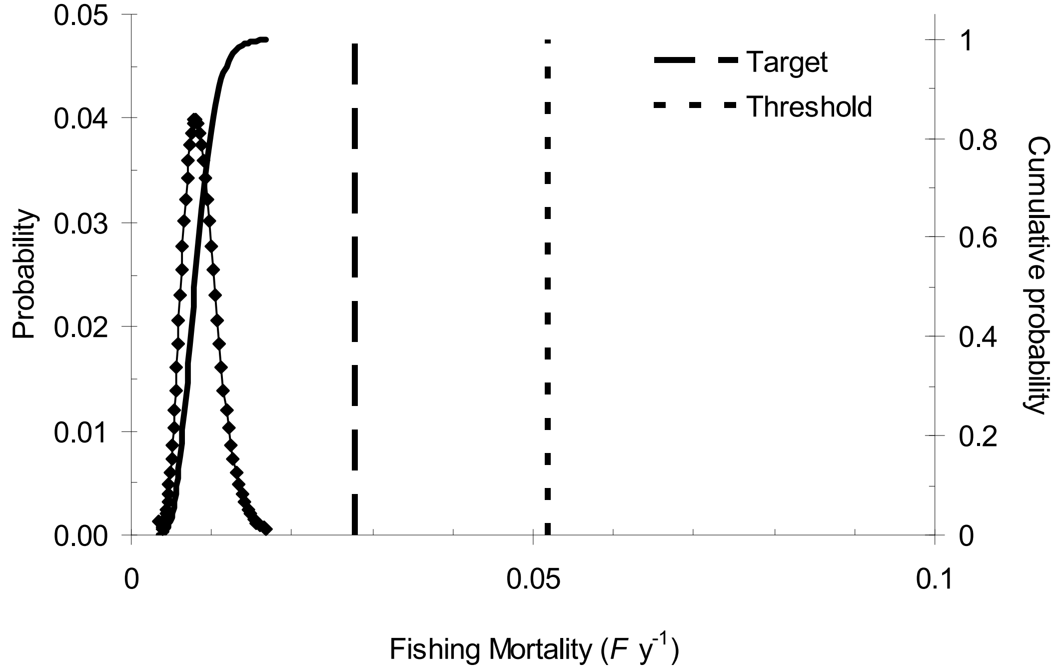
A2. Fishable biomass by region (*top*) and for the entire ocean quahog stock (*bottom*). Figures for SVA are near zero and do not show clearly in plots.



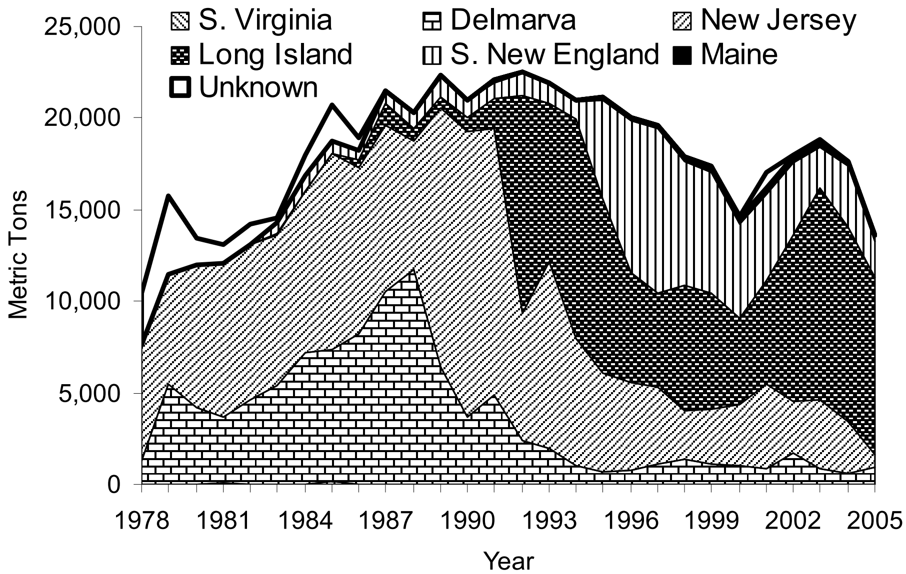
A3. Confidence interval for the 2005 fishable biomass of ocean quahog in the EEZ (all regions, including Georges Bank). The biomass target and threshold are shown for comparison.



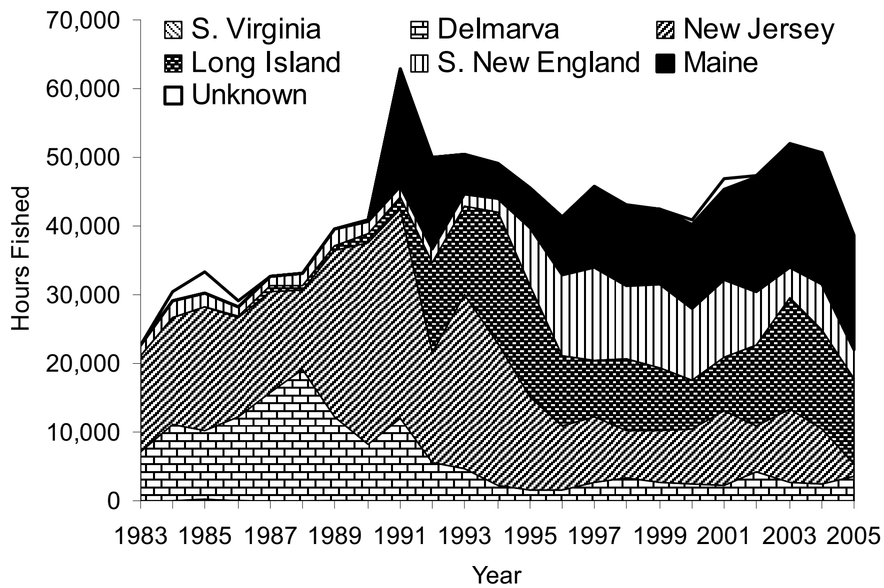
A4. Fishing mortality rates in southern regions (top), northern regions (middle) and for the exploitable portion (excluding Georges Bank) of the entire ocean quahog stock (bottom). Target and threshold reference points are shown for the exploitable portion of the stock in the bottom panel.



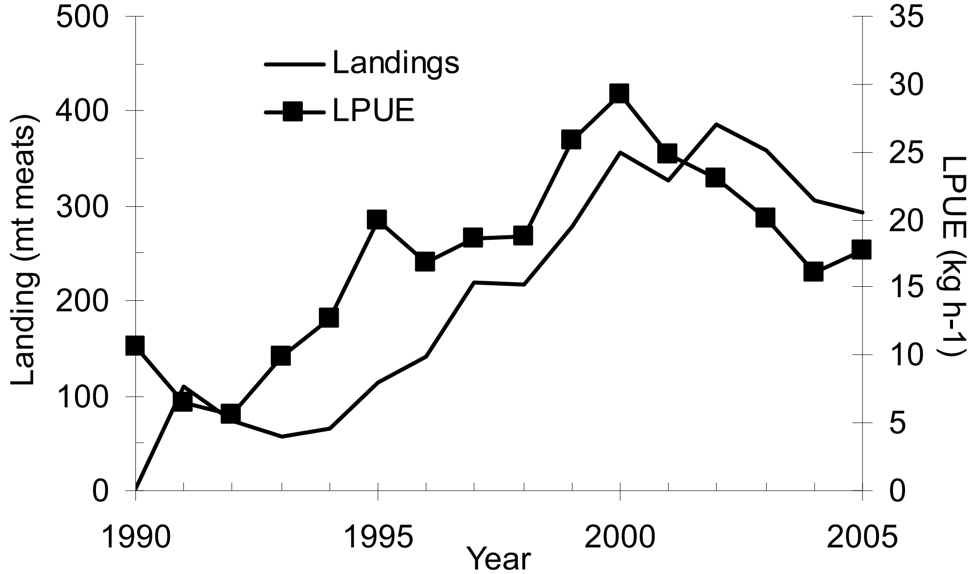
A5. Confidence interval for the 2005 fishing mortality estimate for ocean quahog in the exploitable region (EEZ less Georges Bank). The revised fishing mortality target and threshold are shown for comparison.



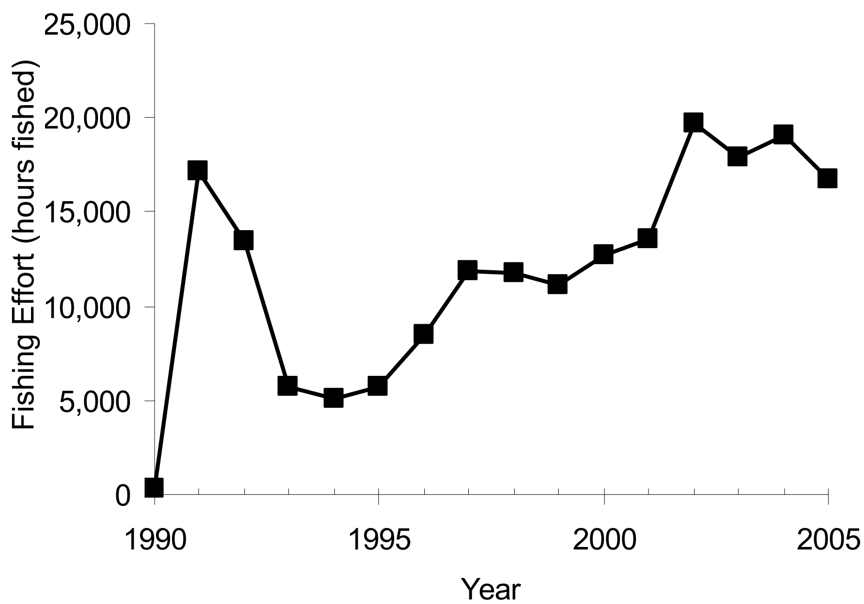
A6. Ocean quahogs landing (mt meats) in the EEZ by region during 1978-2005. Figures for SVA are near zero and do not show clearly in plots.



A7. Fishing effort (hours fished per year) for ocean quahog in the EEZ and Maine waters during 1983-2005 from mandatory logbooks. Figures for SVA are near zero and do not show clearly in plots.



A8. Ocean quahogs landing (mt meats) and LPUE (kg meats hr^{-1}) in Maine waters during 1990-2005.



A9. Fishing effort (hours fished per year) for ocean quahog in Maine waters during 1990-2005 from mandatory logbooks.

B. SKATE COMPLEX: ASSESSMENT SUMMARY F0R 2006

State of Stock: For the aggregate skate complex (comprising seven species), the NEFSC spring survey index of relative biomass was relatively stable during the 1970s, and then increased in the mid to late 1980s. The biomass index then declined until 1994, increased until 2000, and has since decreased (Figure B1-A). If the species in the complex are divided into large- (barndoor, winter, and thorny) and small-sized skates (little, clearnose, rosette, and smooth), it is evident that the increase in skate biomass in the mid to late 1980s was due to increases in winter and little skate (Figures B1-B and B1-C). The biomass of large-sized skates declined steadily from the mid-1980s to the mid-1990s and has since been stable (Figure B1-B). The increase in aggregate skate biomass from the mid-1990s to 2000 reflected an increase in little skate and the subsequent decline in biomass reflected decreases in little skate (Figure B1-C).

For winter skate, the 2003-2005 NEFSC autumn survey biomass index average of 3.34 kg/tow is below the biomass target of 6.46 kg/tow but above the threshold reference point of 3.23 kg/tow (Figure B2). Winter skate is thus not overfished. The 2003-2005 average of 3.34 kg/tow was more than 20% below the 2002-2004 average of 4.34 kg/tow; therefore, overfishing is occurring for winter skate (This uses the 2005 survey as the most recent data).

For little skate, the 2004-2006 NEFSC spring survey biomass index average of 4.59 kg/tow is below the biomass target of 6.54 kg/tow but above the threshold reference point of 3.27 kg/tow (Figure B2). Little skate is thus not overfished. The 2004-2006 average of 4.59 kg/tow was less than 20% below the 2003-2005 average of 5.65 kg/tow; therefore, overfishing is not occurring for little skate.

For barndoor skate, the 2003-2005 NEFSC autumn survey biomass index average of 0.96 kg/tow is below the biomass target of 1.62 kg/tow but above the threshold reference points of 0.81 kg/tow (Figure B2). Barndoor skate is thus not overfished. The 2003-2005 average of 0.96 kg/tow was above the 2002-2004 average of 0.88 kg/tow; therefore, overfishing is not occurring for barndoor skate.

For thorny skate, the 2003-2005 NEFSC autumn survey biomass index average of 0.56 kg/tow is below the biomass target and threshold reference points of 4.41 kg/tow and 2.20 kg/tow (Figure B2). Thorny skate is thus overfished. The 2003-2005 average of 0.56 kg/tow was less than 20% below the 2002-2004 average of 0.63 kg/tow; therefore, overfishing is not occurring for thorny skate.

For smooth skate, the 2003-2005 NEFSC autumn survey biomass index average of 0.18 kg/tow is below the biomass target of 0.31 kg/tow but above the threshold reference point of 0.16 kg/tow (Figure B2). Smooth skate is thus not overfished. The 2003-2005 average of 0.18 kg/tow was above the 2002-2004 average of 0.17 kg/tow; therefore, overfishing is not occurring for smooth skate.

For clearnose skate, the 2003-2005 NEFSC autumn survey biomass index average of 0.63 kg/tow is above the biomass target and threshold reference points of 0.56 kg/tow and 0.28 kg/tow (Figure B2). Clearnose skate is thus not overfished. The 2003-2005 average of 0.63 kg/tow was less than 30% below the 2002-2004 average of 0.75 kg/tow; therefore, overfishing is not occurring for clearnose skate.

For rosette skate, the 2003-2005 NEFSC autumn survey biomass index average of 0.049 kg/tow is above the biomass target and threshold reference points of 0.029 kg/tow and 0.015 kg/tow (Figure B2). Rosette skate is thus not overfished. The 2003-2005 average of 0.049 kg/tow was above the 2002-2004 average of 0.045 kg/tow; therefore, overfishing is not occurring for rosette skate.

Summary Status Table (Note: For all species except little skate, the most recent data used were from the 2005 NEFSC Autumn Survey):

Species	Series	Btarget	Bthresh	Current	Status	Critical Percent	Current Percent	Status
Winter	GOM-MA Off Autumn 67-98	6.46	3.23	3.34	Not Overfished	-20	-22.9	Overfishing
Little	GOM-MA All Spring 82-99	6.54	3.27	4.59	Not Overfished	-20	-15.9	No Overfishing
Barndoor	GOM-SNE Off Autumn 63-66	1.62	0.81	0.96	Not Overfished	-30	9.8	No Overfishing
Thorny	GOM-SNE Off Autumn 63-98	4.41	2.20	0.56	Overfished	-20	-11.2	No Overfishing
Smooth	GOM-SNE Off Autumn 63-98	0.31	0.16	0.18	Not Overfished	-30	3.7	No Overfishing
Clearnose	MA All Autumn 75-98	0.56	0.28	0.63	Not Overfished	-30	-16.2	No Overfishing
Rosette	MA Offshore Autumn 67-98	0.029	0.015	0.049	Not Overfished	-60	9.7	No Overfishing

Forecast for 2007-2008: No forecasts were made for any of the species in the skate complex.

Landings and Status Table (weights in '000 mt): Skate complex

Year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Max	Min	Mean
Skate Complex														
Commercial landings	14.2	10.9	13.8	11.7	13.4	13.1	13	15	16.1	13.9		16.1[1]	0.8[1]	7.3[1]
Commercial discards[2]	52.1	26.2	29.3	33.8	42.4	49.5	74.1	48.3	33.3	19.7		87.2[3]	19.7[3]	49.2[3]
Recreational landings	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1		<0.1	<0.1	<0.1
Recreational discards[4]	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1		<0.1	<0.1	<0.1
Total catch	14.3	10.9	13.8	11.7	13.4	13.1	13	15	16.1	13.9		16.1	6.7	12.1
Total biomass index[5]	11.3	5.6	7.0	12.1	11.0	10.5	9.9	10.0	7.9	6.3	8.1	25.3[6]	3.6[6]	10.9[6]
Winter skate														
Total Biomass index[5]	2.28	2.46	3.75	5.09	4.38	3.89	5.60	3.39	4.03	2.61		15.80[7]	1.08[7]	4.91[7]
SSB index[5]	0.79	0.66	1.58	1.33	1.75	1.40	3.15	1.91	2.22	1.00		12.28[7]	0.15[7]	2.75[7]
Recruitment index[8]	0.12	0.17	0.17	0.24	0.25	0.18	0.10	0.06	0.13	0.21		0.72[7]	0.01[7]	0.21[7]
Little skate														
Total Biomass index[5]	7.57	2.71	7.47	9.98	8.60	6.84	6.44	6.49	7.22	3.24	3.32	9.98[9]	2.71[9]	5.56[9]
SSB index[5]	4.55	1.60	3.63	5.08	4.42	4.78	4.86	4.40	4.34	2.45	2.47	5.08[9]	1.60[9]	3.25[9]
Recruitment index[8]	3.55	1.35	3.67	4.87	4.66	2.09	1.98	2.89	3.46	0.84	1.09	4.87[9]	0.83[9]	2.33[9]
Barndoor skate														
Total Biomass index[5]	0.04	0.10	0.09	0.30	0.29	0.54	0.78	0.55	1.29	1.04		2.63[10]	0.00[10]	0.31[10]
SSB index[5]	0.00	0.05	0.06	0.12	0.05	0.25	0.37	0.16	0.77	0.29		0.80[10]	0.00[10]	0.09[10]
Recruitment index[8]	0.00	0.00	0.01	0.02	0.01	0.03	0.07	0.04	0.03	0.09		0.25[10]	0.00[10]	0.03[10]
Thorny skate														
Total Biomass index[5]	0.81	0.85	0.65	0.48	0.83	0.33	0.44	0.74	0.71	0.22		7.97[10]	0.22[10]	2.60[10]
SSB index[5]	0.32	0.33	0.32	0.14	0.42	0.07	0.20	0.23	0.36	0.05		5.16[10]	0.05[10]	1.39[10]
Recruitment index[8]	0.07	0.05	0.02	0.03	0.05	0.04	0.05	0.10	0.05	0.04		0.29[10]	0.02[10]	0.14[10]
Smooth skate														
Total Biomass index[5]	0.18	0.23	0.03	0.07	0.15	0.29	0.11	0.19	0.21	0.13		0.50[10]	0.03[10]	0.20[10]
SSB index[5]	0.13	0.17	0.02	0.06	0.10	0.23	0.09	0.11	0.15	0.08		0.30[10]	0.02[10]	0.13[10]
Clearnose skate														
Total Biomass index[5]	0.43	0.61	1.12	1.05	1.03	1.61	0.89	0.66	0.71	0.52		1.61[11]	0.14[11]	0.55[11]
SSB index[5]	0.08	0.27	0.23	0.44	0.37	0.38	0.26	0.35	0.26	0.25		0.44[11]	0.00[11]	0.15[11]
Recruitment index[8]	0.04	0.08	0.14	0.09	0.06	0.08	0.17	0.14	0.10	0.05		0.17[11]	0.01[11]	0.08[11]
Rosette skate														
Total Biomass index[5]	0.043	0.013	0.05	0.067	0.033	0.121	0.052	0.033	0.048	0.065		0.121[7]	0.001[7]	0.029[7]
SSB index[5]	0.029	0.009	0.051	0.055	0.028	0.129	0.034	0.032	0.043	0.057		0.129[7]	0.001[7]	0.025[7]

[1]Over period 1964-2005; [2]Commercial fishery discard mortality rate unknown; [3]Over period 1989-2005; [4]Assuming 15% recreational fishery release mortality. [5]NEFSC survey kg/tow; [6]Over period 1968-2006; [7]Over period 1967-2005; [8]NEFSC survey number/tow; [9]Over period 1982-2006; [10]Over period 1963-2005; [11]Over period 1975-2005

Stock Distribution and Identification: The seven species in the northeast skate complex are distributed from near the tide line to depths exceeding 700 m (383 fathoms) (Figure B3). The species are: little skate (*Leucoraja erinacea*), winter skate (*L. ocellata*), barndoor skate (*Dipturus laevis*), thorny skate (*Amblyraja radiata*), smooth skate (*Malacoraja senta*), clearnose skate (*Raja eglanteria*), and rosette skate (*L. garmani*). Off the Northeast coast of the United States, the center of distribution for little and winter skates is Georges Bank and Southern New England. Barndoor skates are found in the Gulf of Maine, on Georges Bank, and in Southern New England. Thorny and smooth skates occur in the Gulf of Maine. Clearnose and rosette skates have a more southern distribution, and are found primarily in Southern New England and the Chesapeake Bight. Skates are not known to undertake large-scale migrations, but they do move seasonally in response to changes in water temperature, moving offshore in summer and early autumn and returning inshore during winter and spring. Information on stock structure for all skate species is lacking.

Catches: The principal commercial fishing method in the directed skate fishery is otter trawling. Skates are frequently taken as bycatch during groundfish trawling and scallop dredge operations, and are discarded. Recreational and foreign landings are currently insignificant. Skates have been reported in New England fishery landings since the late 1800s. Reported commercial fishery landings, primarily from off Rhode Island, however, did not exceed several hundred metric tons until the advent of distant-water fleets and the industrial fishery during the 1950s and 1960s. Skate landings reached 9,500 mt in 1969 primarily from the distant water fleet, but declined quickly during the 1970s, reaching 800 mt in 1981 (Figure B4). Landings have since increased, partly in response to demand for lobster bait, and more significantly, to the increased export market for skate wings. Landings are not reported by species, and over 99% of the landings are reported as “unclassified skates.” Wings were likely taken from large-bodied skates (winter, thorny and barndoor), with winter and thorny skate known to be used for human consumption. Bait landings are presumed to be primarily from little skate, based on areas fished and known species distribution patterns. Landings increased to 12,900 mt in 1993 and then declined somewhat to 7,200 mt in 1995. Landings increased again and the 2004 reported commercial landings of 16,073 mt were the highest on record. Estimates of discards suggest they may be 2-4 times larger than the average landings. Commercial fishery discard mortality rates by species are unknown.

Data and Assessment: The skate complex was last assessed at SARC 30 in 1999. In the current assessment, conclusions about the status of the seven species in the northeast US region skate complex are based mainly on standardized NEFSC research trawl survey data collected during 1963-2006 (i.e., spring survey of 2006 was used, but not the fall survey of 2006).

Biological Reference Points: Biomass reference points (Figure B2) are based entirely on survey data because commercial catches are not available by species. For all species except barndoor, the B_{msy} proxy (B_{target}) is estimated as the 75th percentile of the appropriate survey series for that species (see Summary Status Table). For barndoor skate, the B_{msy} proxy is the average of the autumn survey biomass indices from a short period, 1963-1966. This period is used for barndoor skates because the survey captured few barndoor skates for a protracted period after these years. The stocks are declared to be overfished when the three-year moving average of the NMFS trawl survey index (mean weight per tow) is less than one half of the 75th percentile of mean weight per tow of the reference survey series for that species ($B_{threshold}$).

The overfishing definition is based on changes in survey biomass indices. In any year, if the three-year moving average of the survey biomass index for a skate species declines by more than a critical percentage from the previous year’s moving average, then fishing mortality is assumed to be greater than F_{msy} and overfishing is assumed to be occurring for that skate species. The critical percentages for each species are given in the Summary Status Table.

Fishing Mortality: (Estimates made by the Working Group were not accepted by the SARC.)

Total Biomass: During the late 1960s and 1970s, indices of winter skate biomass from the NEFSC autumn surveys were stable, but below the time series mean (Figure B5). Winter skate indices increased to the time series mean by 1980, and then reached a peak during the mid 1980s. Winter skates indices began to decline in the late 1980s. Current NEFSC indices of winter skate biomass are below the time series mean (4.91 kg/tow) and are about 20% of the peak observed during the mid 1980s.

Little skate spring survey indices reached a peak in 1999, and declined thereafter (Figure B7).

Indices of barndoor skate biomass from the NEFSC autumn surveys were at the highest values during 1960s, and then declined to 0 fish per tow during the early 1980s (Figure B8). Since 1990, autumn survey indices have increased steadily.

NEFSC autumn survey biomass indices for thorny skate have declined continuously over the last 40 years (Figure B10), and the 2005 index was a record low.

Indices of smooth skate biomass from the NEFSC autumn survey were highest during the late 1970s (Figure B12). NEFSC survey indices declined during the 1980s, before stabilizing during the early 1990s at about 25% of the values of the 1970s.

NEFSC autumn survey biomass indices for clearnose skate increased from the mid-1980s through 2000 and have since declined to about the time series average (0.55 kg/tow) (Figure B13).

Indices of rosette skate biomass from the NEFSC autumn surveys peaked during 1980 and 1981 and then declined through 1986 (Figure B2). NEFSC biomass indices then increased and peaked again in 2001. Recent indices have been above the time series average (0.029 kg/tow).

Spawning Stock Biomass: Winter skate SSB generally follows the autumn total biomass index (Figure B5). Low values in the 1970s were followed by increases in the 1980s. SSB declined in the late 1980s and early 1990s, increased slightly until 2002, and has since declined again and is currently at a relatively low value.

Little skate SSB has been fairly stable through the time series with slightly higher values from 1999-2004 than in the 1980s and early 1990s (Figure B7).

The pattern in barndoor skate SSB indices is much the same as that of total biomass, with high values in the early 1960s, low to zero values in the 1970s and 1980s, and then a consistent increase in the 1990s and 2000s (Figure B8).

The decline in thorny skate SSB is similar but more pronounced than for total biomass (Figure B10).

Smooth skate SSB indices are very variable over the time series (Figure B12).

Clearnose skate SSB has generally increased over the survey time period (Figure B13).

Rosette skate SSB has been variable but has generally increased.

Recruitment: Winter skate recruitment indices (number/tow between 34 and 39 cm) were variable at a low level in the 1970s, increased to a higher level in the 1980s, but have since stabilized at a lower level (Figure B5).

Little skate recruitment indices (number/tow between 38 and 42 cm) peaked in 1999 and 2000, and have since been at a somewhat lower level. The 2005 and 2006 values are among the lowest in the time series (Figure B7).

Barndoor skate recruitment indices (number/tow between 55 and 69 cm) were high in the early 1960s, declined to low levels through the 1970s and the 1980s, but have since increased to about half the level in the 1960s (Figure B8).

Thorny skate recruitment indices (number/tow between 25 and 35 cm) were relatively high although variable from 1963 to 1990, but have since declined to very low levels (Figure B10).

Clearnose skate recruitment indices (number/tow between 42 and 50 cm) have been relatively stable through the time series with some high values in recent years (Figure B13).

For several skate species, time-lagged recruitment indices are positively related to spawning stock biomass indices (Figures B6, B9, B11 and B14).

Special Comments: Species composition and size structure of landings are unknown. Although discard rates are imprecisely known (and likely underestimated) and discard mortality rates are unknown, the absolute level of discards is probably high relative to the landings (1-3 times). A lack of information on the stock structure of the species in the skate complex has increased uncertainty about historical trends in abundance and recommendations of appropriate biological reference points.

Compared to other fishes, large species of skates have slow growth, late maturity and low fecundity, making them vulnerable to overfishing.

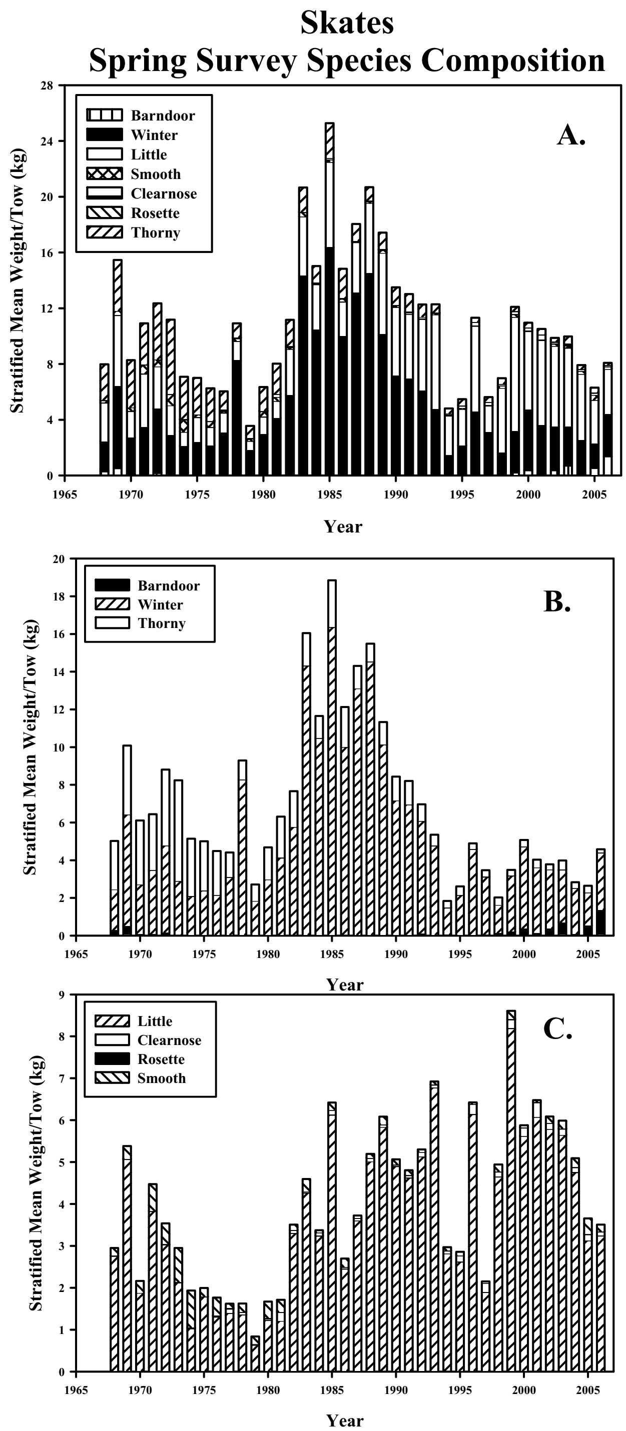
(The Working Group proposed new BRPs but they were not accepted by the SARC.)

Sources of Information:

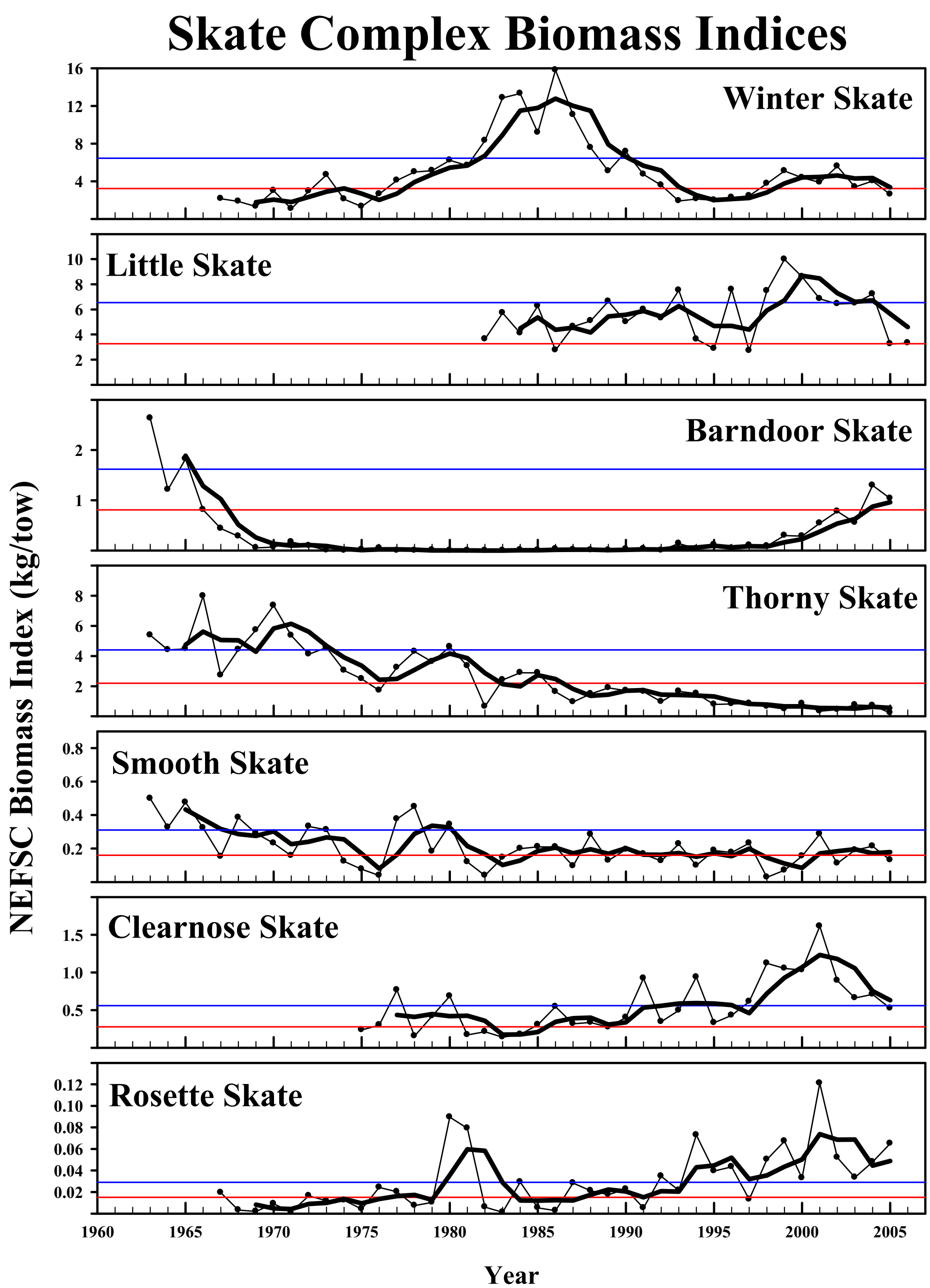
Bigelow, H.B., and W.C. Schroeder. 1953. Fishes of the Gulf of Maine. Fish. Bull., U.S. Fish. Wildl. Serv. 74(53), 577 p.

Northeast Fisheries Science Center (NEFSC). 2000. 30th Northeast Regional Stock Assessment Workshop (30th SAW), Stock Assessment Review Committee (SARC) Consensus Summary of Assessments. NEFSC Ref. Doc. 00-03, 477 p.

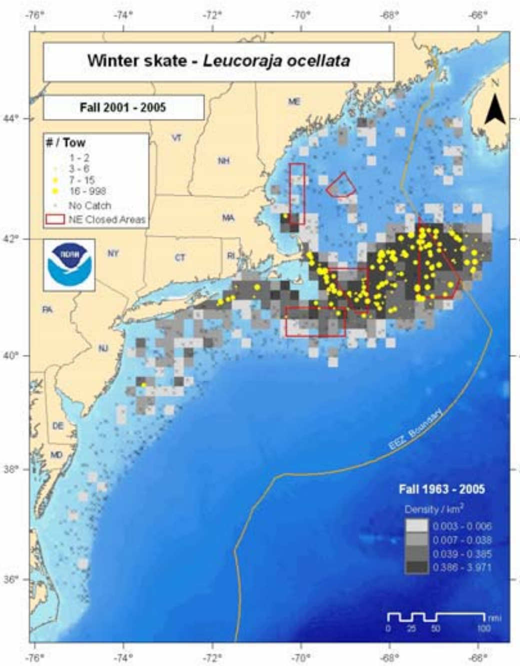
Northeast Fisheries Science Center (NEFSC). (in prep.) 44th Northeast Regional Stock Assessment Workshop (43rd SAW): 43rd SAW assessment report. NEFSC Ref. Doc.



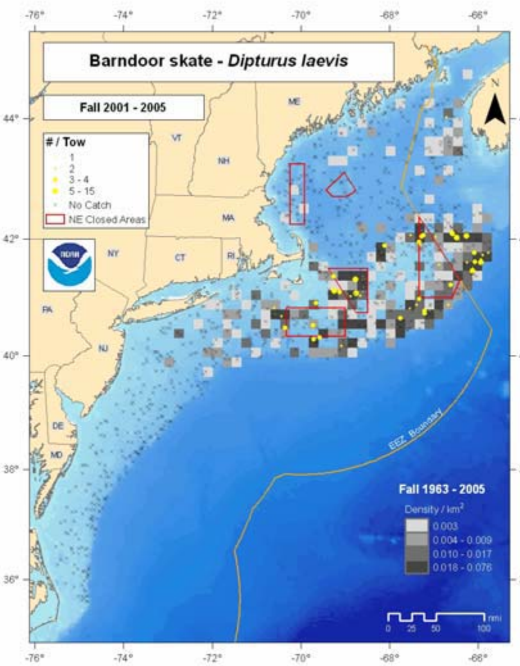
B1. Species composition of skates from the spring survey. Panel A shows the composition of all species, panel B shows the composition of large species (>100 cm maximum length), and panel C shows the composition of the small species (maximum length < 100cm).



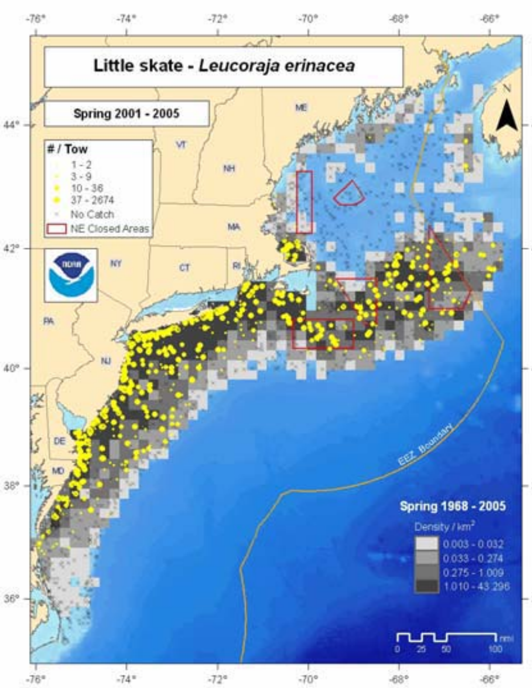
B2. NEFSC survey biomass indices (kg/tow). Thin lines with dots are annual indices. Thick lines are 3-year moving averages. Thin horizontal lines are the **current/existing** biomass targets and thresholds.



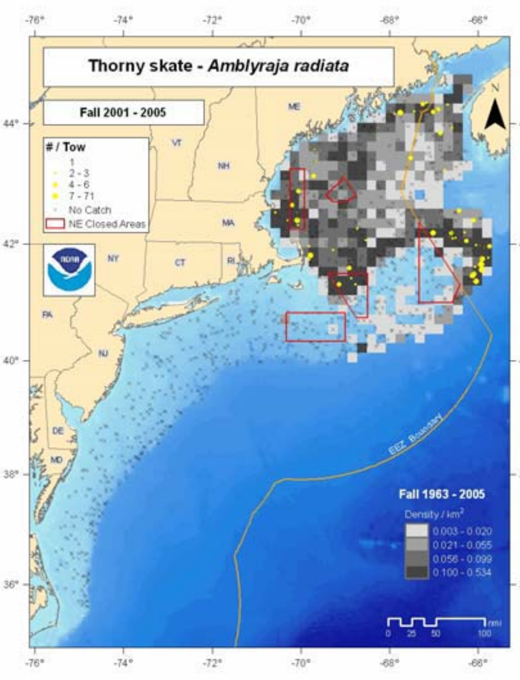
Relative species abundance and distribution from NEFSC bottom trawl survey by time block and relative species density for the full time series.



Relative species abundance and distribution from NEFSC bottom trawl survey by time block and relative species density for the full time series.

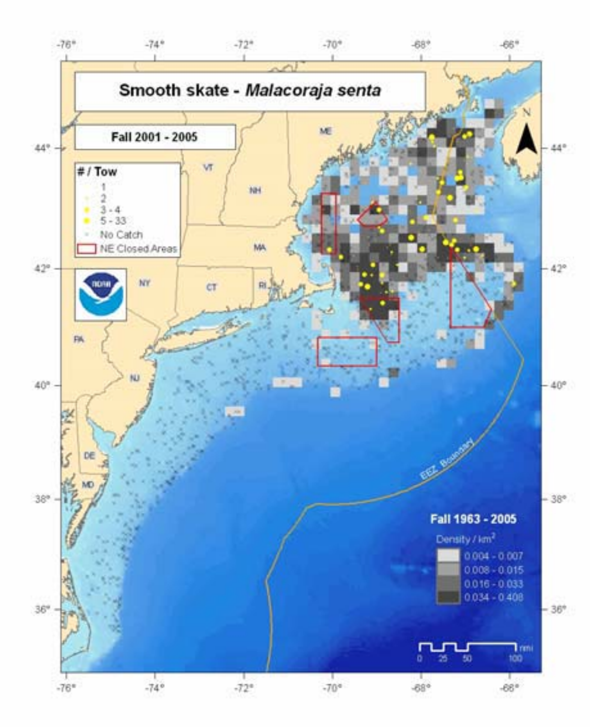


Relative species abundance and distribution from NEFSC bottom trawl survey by time block and relative species density for the full time series.

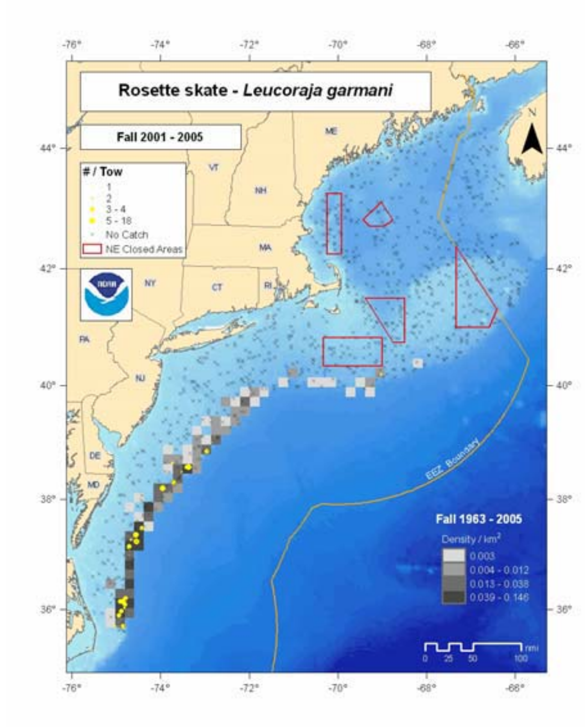


Relative species abundance and distribution from NEFSC bottom trawl survey by time block and relative species density for the full time series.

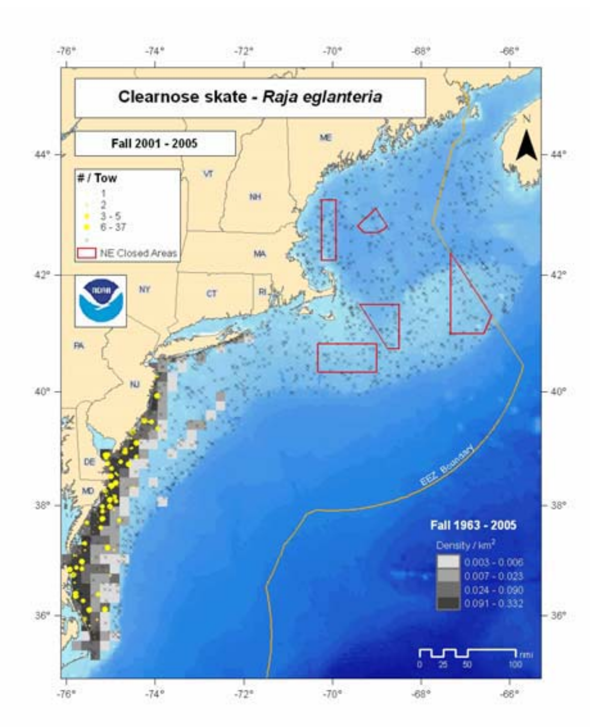
B3. Skate distributions, by species.



Relative species abundance and distribution from NEFSC bottom trawl survey by time block and relative species density for the full time series.

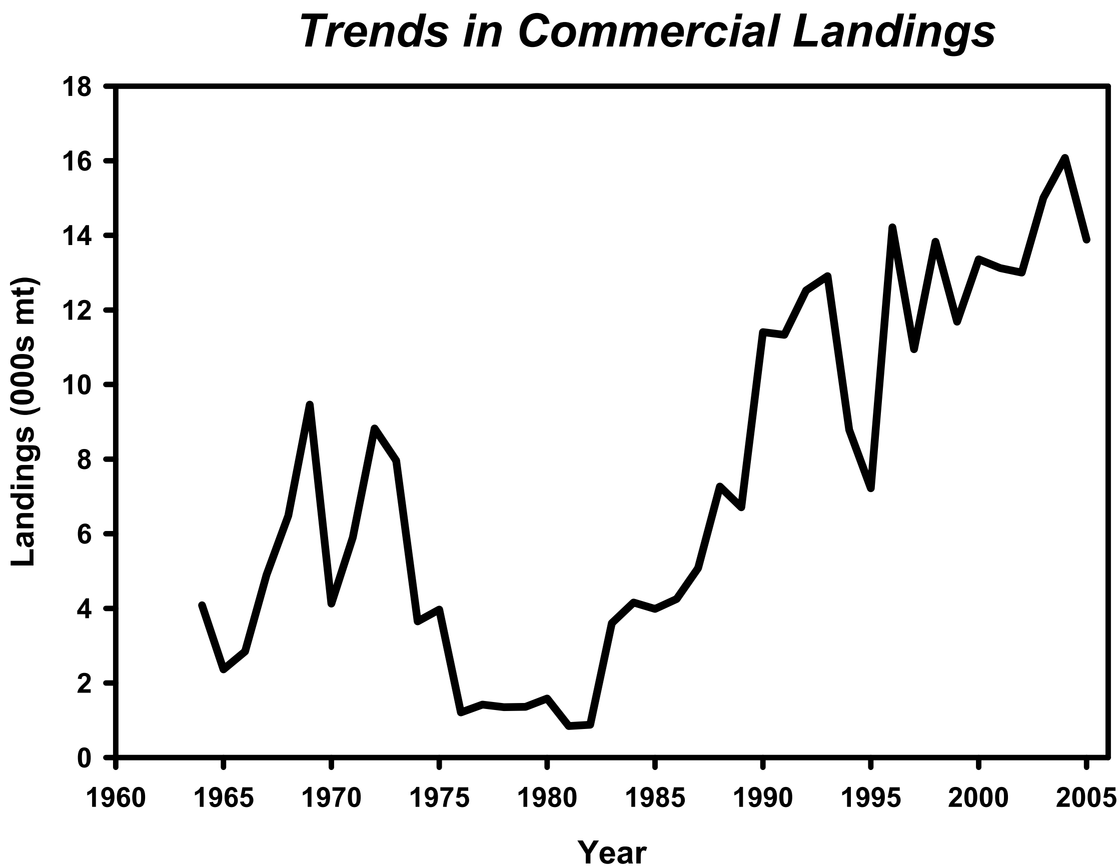


Relative species abundance and distribution from NEFSC bottom trawl survey by time block and relative species density for the full time series.

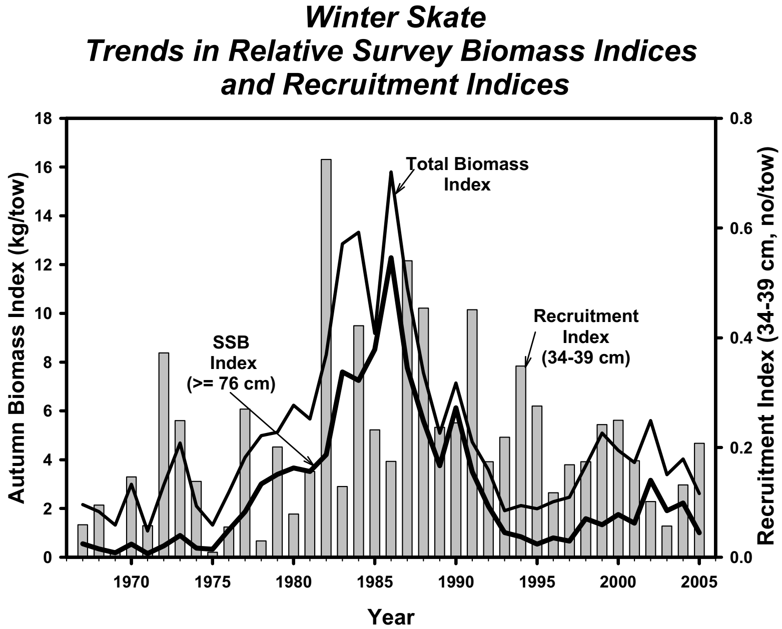


Relative species abundance and distribution from NEFSC bottom trawl survey by time block and relative species density for the full time series.

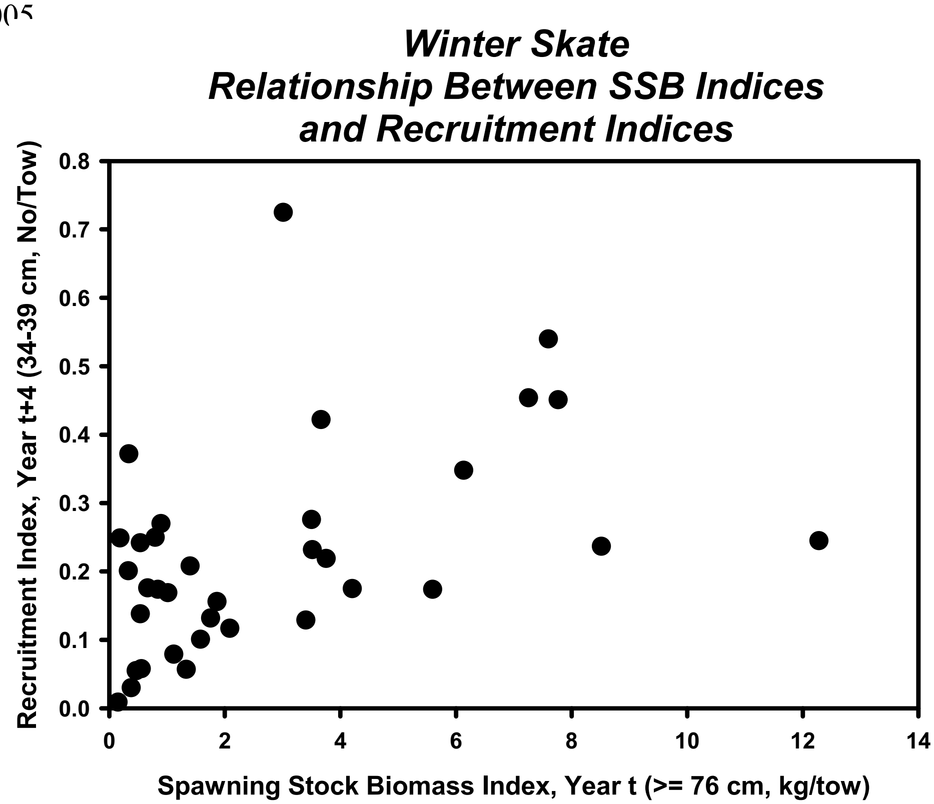
B3. (cont).



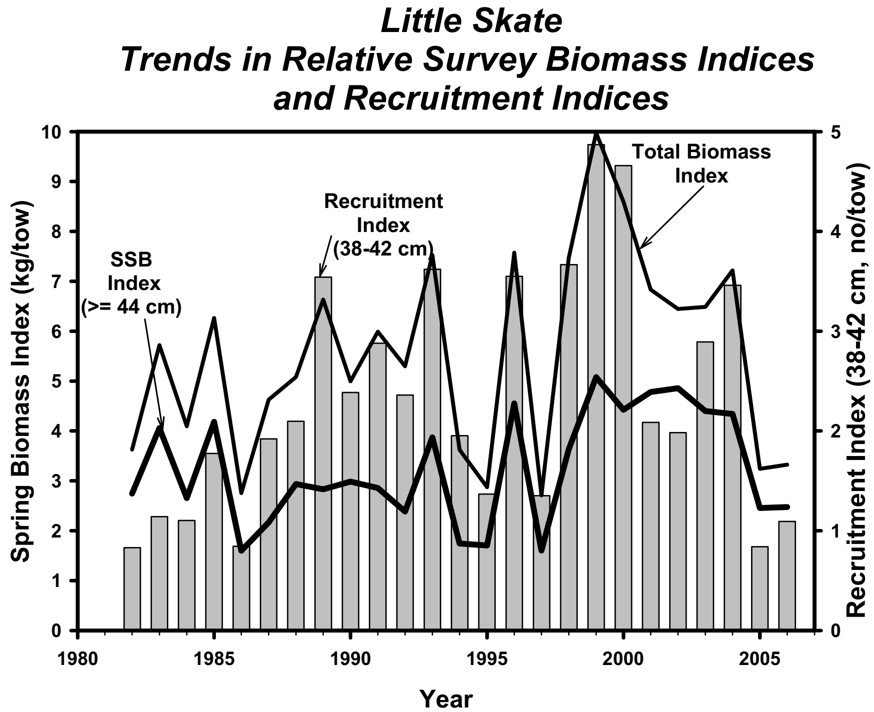
B4. Trends in commercial landings (000s mt) for all skate species combined, 1964-2005.



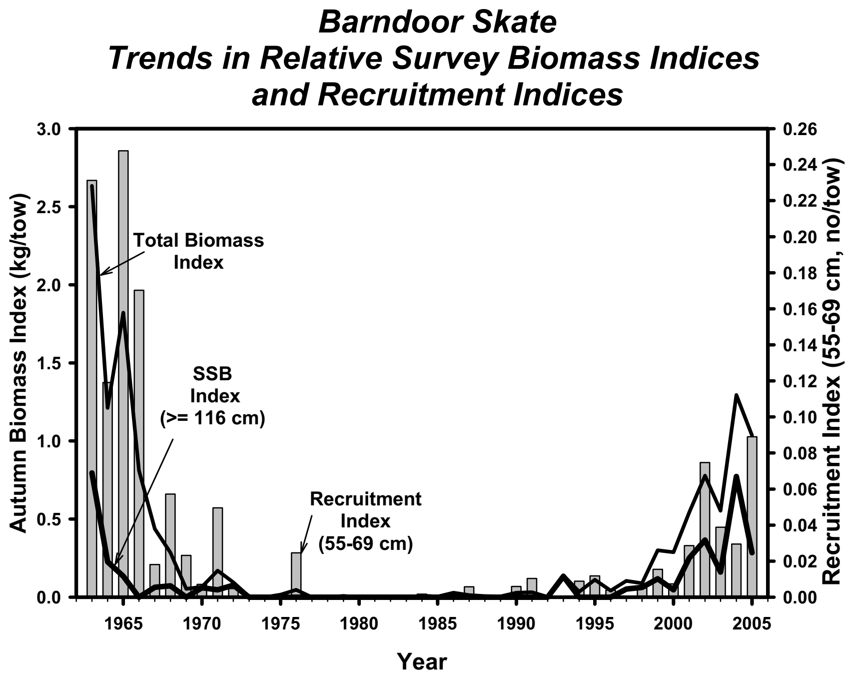
B5. Trends in autumn relative survey total biomass indices, spawning stock biomass indices (>= 76 cm) and recruitment indices (number/tow between 34 and 39 cm) for winter skate from 1967-2005.



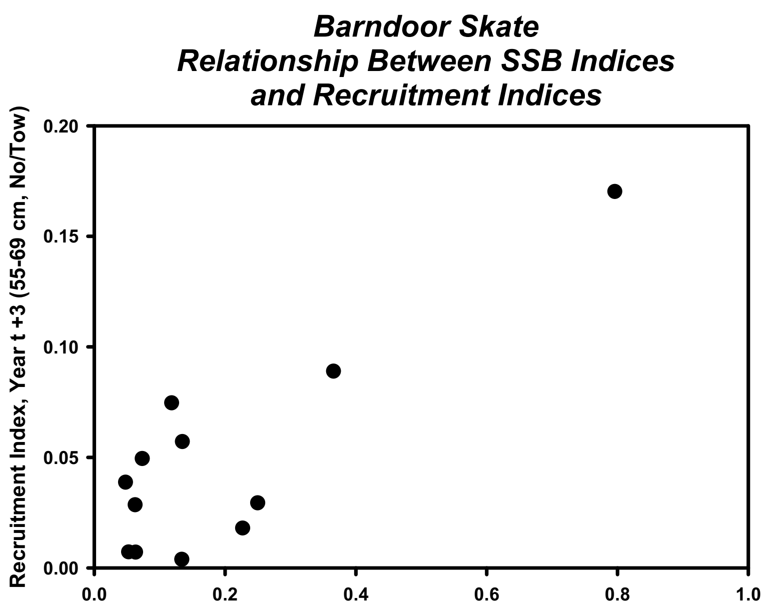
B6. Relationship between spawning stock biomass indices (>= 76 cm) and recruitment indices (number/tow, 34-39 cm) for winter skate. The time lag between SSB and recruitment accounts for the assumed age 3 at recruitment plus one year for hatching time.



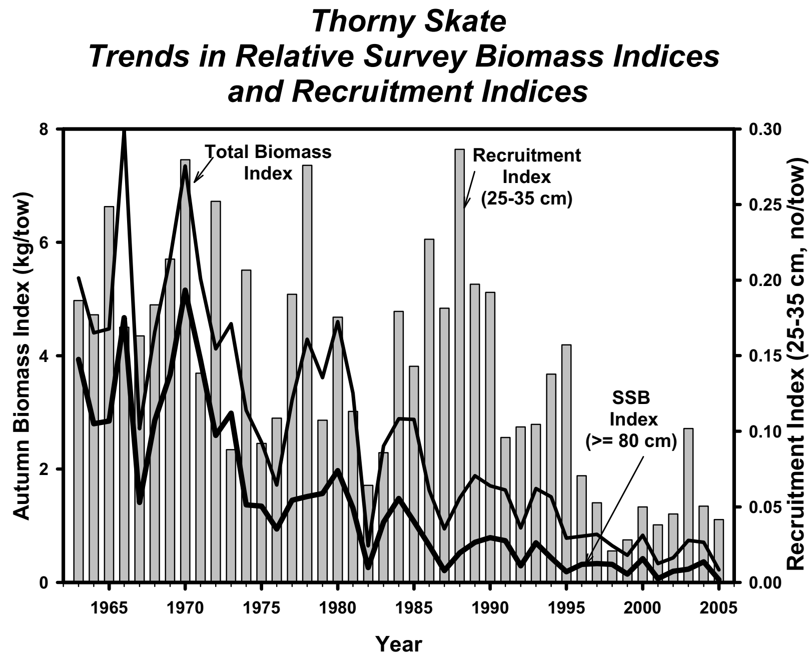
B7. Trends in spring relative survey total biomass indices, spawning stock biomass indices (>= 44 cm) and recruitment indices (number/tow between 38 and 42 cm) for little skate from 1982-2006.



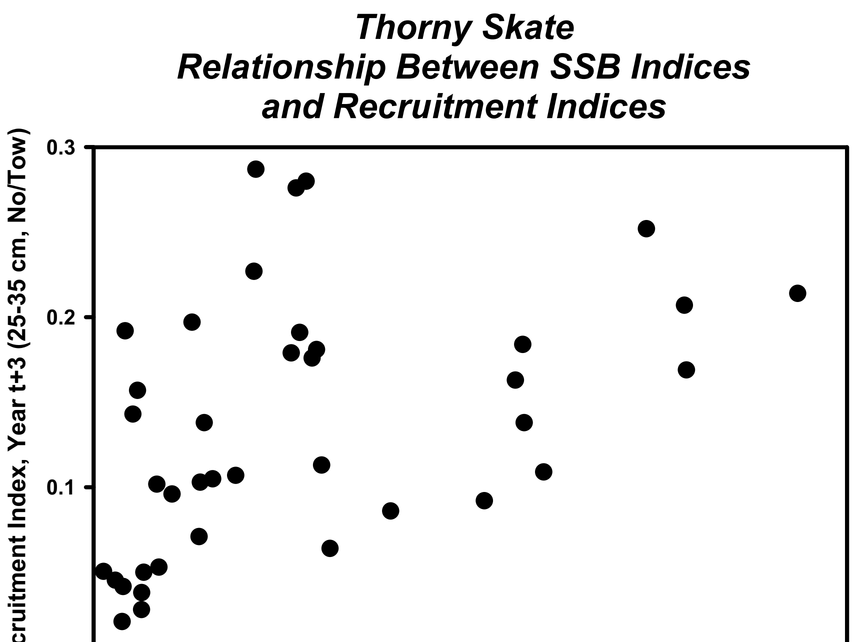
B8. Trends in autumn relative survey total biomass indices, spawning stock biomass indices (>= 116 cm) and recruitment indices (number/tow between 55 and 69 cm) for barndoor skate from 1963-2005.



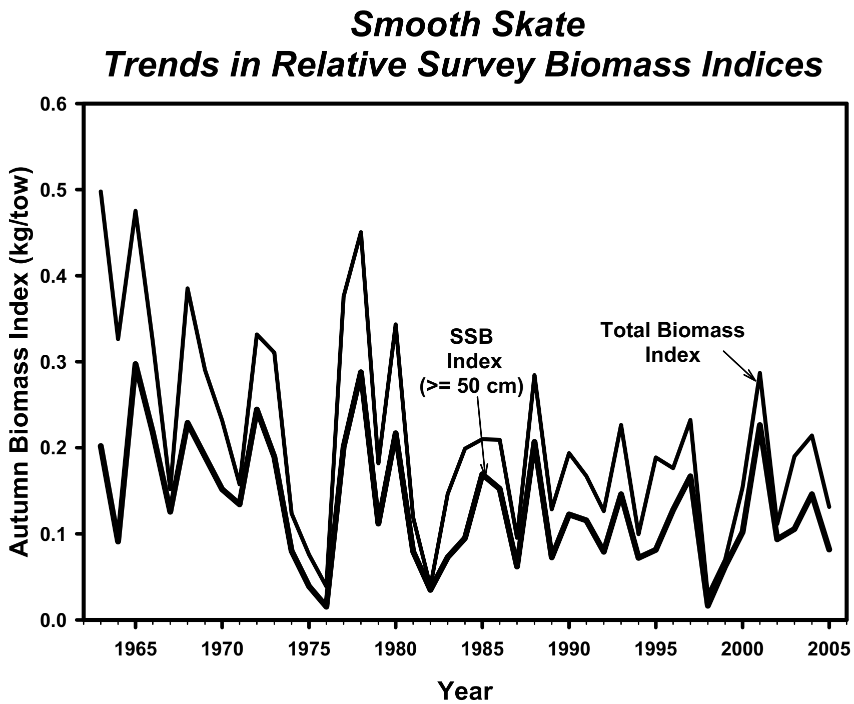
B9. Relationship between spawning stock biomass indices (>= 116 cm) and recruitment indices (number/tow, 55-69 cm) for barndoor skate. The time lag between SSB and recruitment accounts for the assumed age 2 at recruitment plus one year for hatching time.



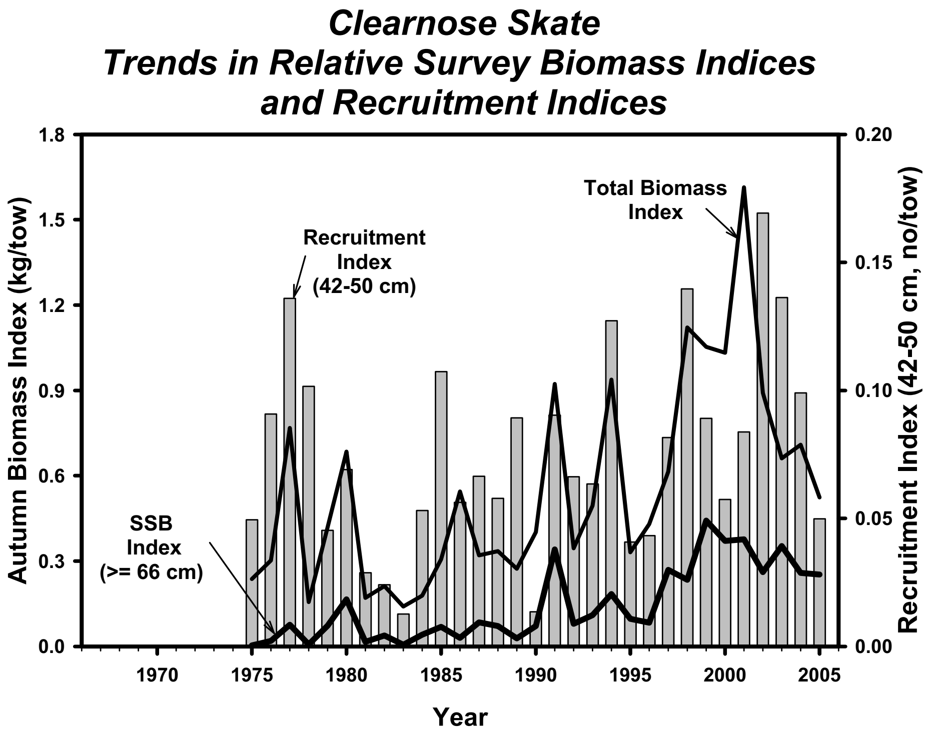
B10. Trends in autumn relative survey total biomass indices, spawning stock biomass indices (>= 80 cm) and recruitment indices (number/tow between 25 and 35 cm) for thorny skate from 1963-2005.



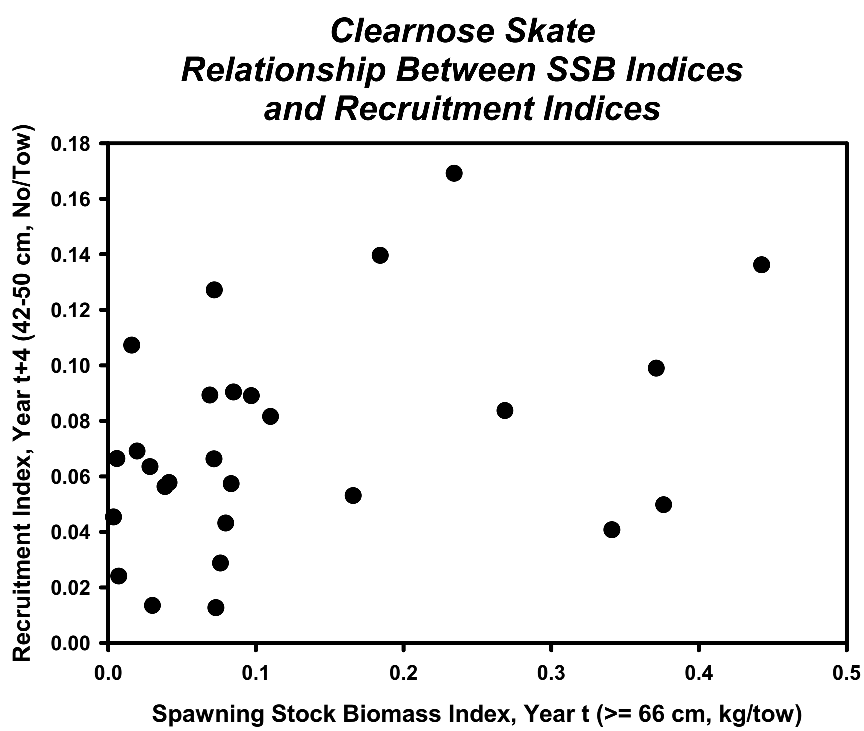
B11. Relationship between spawning stock biomass indices (>= 80 cm) and recruitment indices (number/tow, 25-35 cm) for thorny skate. The time lag between SSB and recruitment accounts for the assumed age 2 at recruitment plus one year for hatching time.



B12. Trends in autumn relative survey total biomass indices and spawning stock biomass indices (>= 50 cm) for smooth skate from 1963-2005.



B13. Trends in autumn relative survey total biomass indices, spawning stock biomass indices (>= 66 cm) and recruitment indices (number/tow between 42 and 50 cm) for clearnose skate from 1975-2005.



B14. Relationship between spawning stock biomass indices (>= 66 cm) and recruitment indices (number/tow, 42-50 cm) for clearnose skate. The time lag between SSB and recruitment accounts for the assumed age 3 at recruitment plus one year for hatching time.

C. ATLANTIC SURFCLAM ASSESSMENT SUMMARY FOR 2006

State of Stock: The Atlantic surfclam stock in the US EEZ (Exclusive Economic Zone, 3 to 200 nm from shore, Figure C1) is not overfished and overfishing is not occurring. Estimated fishable stock biomass in 2005 (120+ mm shell length, SL) was 1.17 million mt meats, which is above the management target of ½ 1999 biomass = 900 thousand mt meats (Figures C2-C5). Estimated fishing mortality in 2005 was F= 0.0192 y^{-1}, which is below the management threshold $F_{0.1}$ = 0.15 y^{-1} (Figures C6 and C7). These estimates are for the entire EEZ stock, including the portion of the EEZ stock on Georges Bank. Surfclam resources in state waters are not included.

All figures and information in this summary are for surfclams in the EEZ only, unless otherwise specified.

Projections: Based on example calculations (below), biomass is projected to decline gradually through 2010, although uncertainty about future conditions is high (CVs larger than 250% for all years); (The CV measures variability among 2000 stochastic projection runs; it does not measure precision of mean projected estimates.) Biomass is projected to decline because recent recruitment has been low and is likely to remain low over the next five years. For scenarios with landings equal to constant quotas, catch was calculated as landings plus an additional 12% to account for incidental mortality.

Year	Example 1: Landings = min quota = 1.85 million bu	Example 2: Status quo landings = mean 2003-2005 = 3.042 million bu	Example 3: Landings = max quota = 3.4 million bu	Example 4: $F = F_{MSY}$ = M = 0.15	CV
		Annual Catch in 1000s mt (= landings + 12%)			
All	16.0	26.3	29.4	variable	NA
		Biomass (1000 mt)			
2005	1,198	1,198	1,198	1,198	251%
2006	1,093	1,093	1,093	1,093	275%
2007	1,010	1,001	998	889	322%
2008	944	925	920	739	417%
2009	892	866	858	632	560%
2010	856	823	813	559	744%
		Fishing mortality (annual rate)			
2005	0.0188	0.0188	0.0188	0.0188	255%
2006	0.0156	0.0258	0.0288	0.1500	279%
2007	0.0169	0.0282	0.0317	0.1500	327%
2008	0.0181	0.0306	0.0345	0.1500	412%
2009	0.0193	0.0329	0.0372	0.1500	531%
2010	0.0202	0.0349	0.0396	0.1500	676%

Status Table: Atlantic surfclams (EEZ only, 1000 mt)

Year:	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Min[1]	Max[1]	Mean[1]
Quota:	19.8	19.8	19.8	19.8	19.8	22	24.2	25.1	26.2	26.2	13.9	26.2	20.9
Landings:[2,3,4]	19.8	18.6	18.2	19.6	19.7	22	24	25	24.2	21.2	6.4	33.8	19.8
Biomass:[4]	1,780	1,842	1,824	1,799	1,723	1,628	1,531	1,415	1,292	1,170	1,020	1,842	1,403
Fishing mortality:[3,4]	0.0115	0.0105	0.0104	0.0114	0.0120	0.0142	0.0166	0.0187	0.0199	0.0192	0.0104	0.0266	0.0175
Recruitment:[4]	185	189	116	121	76	62	63	43	32	27	27	289	121

[1] Min, max and mean for 1965-2005 (landings), 1978-2005 (quota), 1981-2005 (biomass and fishing mortality), or 1982-2005 (recruitment).
[2] Landings not adjusted for incidental mortality, assumed to be <= 12% of landings. Discards are very low.
[3] Fishing mortality is an annual rate assuming incidental mortality was 12% of landings.
[4] See assessment for regional estimates.

Stock Distribution and Identification: Atlantic surfclams are distributed along the US coast from Maine through North Carolina at depths ranging from the sub-tidal zone in state waters to about 50 m in the EEZ. The information in this report pertains only to the stock in the EEZ. All Atlantic surfclams in the EEZ are assessed and managed as a single unit stock (Figure C1). From north to south, the regions of particular interest are: Georges Bank (GBK), Southern New England (SNE), Long Island (LI), New Jersey (NJ), Delmarva (DMV) and southern Virginia (SVA). No fishing occurs currently on GBK because of potential paralytic shellfish poisoning (PSP).

Catches: Annual landings varied widely prior to 1979, but have since been relatively stable (Figure C9). Landings decreased from 15,000 mt (meats) during 1965 to the record low of 6,000 mt in 1970. Landings subsequently increased to the record high of 34,000 mt in 1974 and then declined to about 13,000 mt in 1979. Landings increased after 1979 and ranged between 19,000 to 25,000 mt from 1983 to 2005. The EEZ quota and landings are generally similar, although landings were less than the quota during 2004-2005 partly due to markets.

Since 1979, 85-100% of landings have been taken from the Mid-Atlantic Bight (SVA, DMV and NJ). Areas of highest landings shifted from DMV north to NJ over time (Figure C10). In particular, surfclam landings were primarily from DMV during 1979-1980 and almost evenly split between DMV and NJ during 1981-1983. After 1983, the importance of DMV declined and NJ has supplied the bulk of landings since 1985. Some landings were taken from SVA during the 1980s. Appreciable landings are sometimes taken from SNE and LI, and landings from SNE and LI increased during 2001-2005.

Discarding reached substantial levels (e.g., 33% by weight of the total catch in the NJ region) in the early 1980s because of minimum size limits, declined through the mid- to late-1980s, and has been low since 1990, a period when there were no minimum size limits.

The regional distribution of fishing effort (Figure C11) is similar to that of landings (Figure C10). LPUE trends for the entire fishery tend to mirror recent declining trends in stock biomass (Figure C2).

Catches are assumed to be 12% higher than landings in stock assessment calculations to account for incidental mortality during harvesting. 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

Data and Assessment: The updated assessment is similar to the SAW-37 2003 assessment, but with improvements to tabulate data, estimate survey gear efficiency, estimate biomass and make projections. New data from cooperative studies to estimate survey dredge efficiency and also from NEFSC clam surveys were important. NEFSC clam survey data from 1982-2005, data from a 2004 cooperative survey, fishery data from 1981-2005, and survey dredge efficiency estimates from cooperative studies during 1997-2005 were used in a KLAMZ delay-difference model to estimate fishable biomass and fishing mortality for surfclams in DMV, NJ and for the entire stock during 1981-2005. Fishable biomass in the updated assessment was considered to comprise clams 120+ mm SL in all regions (in contrast to 110+ or 120+ in the last assessment, depending on region). The assumed natural mortality rate was M=0.15 in all years, as in the last assessment. Catch was assumed equal to landings plus 12% of landings. Discards were assumed to be zero.

Efficiency corrected swept area biomass estimates were calculated for 1997, 1999, 2002, 2004 and 2005. Alternate estimates of fishing mortality were calculated as the ratio of catch and swept-area biomass. Results from these relatively simple alternate approaches were similar to KLAMZ model estimates.

Biomass for surfclam in individual regions, calculated for years with NEFSC clam surveys, was estimated by prorating the best estimate of total biomass using survey swept-area biomass data (Figures C3-C4). Survey and fishery age and length data were used to evaluate fishery and population age composition, but were not used in an analytical model.

The previous assessment used efficiency corrected swept area biomass estimates for status determination and did not include stochastic projections. The KLAMZ model was used only for DMV in the previous assessment.

Biological Reference Points: Overfishing occurs whenever the fishing mortality rate on the entire stock is higher than F_{MSY} (Figure C7). The stock is overfished if total biomass falls below $B_{Threshold}$ (estimated as ½ $B_{MSY,}$ Figure C5). When stock biomass is less than the biomass threshold, the fishing mortality rate threshold is reduced from F_{MSY} in a linear fashion to zero.

The current best proxy for F_{MSY} is $F = M = 0.15\ y^{-1}$ (Figure C7). The proxy for B_{MSY} is one-half of the estimated fishable biomass during 1999 (Figure C5). Original and revised reference point values are shown in the table below.

Reference Point	Previous assessment	Revised
F_{MSY}	M=0.15 y^{-1}	Same
B_{1999}	1,460 thousand mt meats	1,799 thousand mt meats
***B_{MSY} =½B_{1999}* (target)**	730 thousand mt meats	900 thousand mt meats
$B_{Threshold}$* = ½ *B_{MSY}	365 thousand mt meats	450 thousand mt meats

Biomass reference points were revised with new information about NEFSC clam dredge efficiency. Ratios of biomass estimates to biomass reference points are almost unaffected by the new information because the relative increase in biomass estimates and the B_{MSY} proxy are nearly identical. Fishing mortality estimates and the F_{MSY} proxy are more sensitive. Fortunately, conclusions about fishing mortality and reference points are robust because fishing mortality rates for the stock are relatively low. In particular, conclusions about stock status would not change unless either the mortality estimate or threshold was changed by 8-9 fold (Figure C7).

Fishing Mortality: Fishing mortality for surfclams in 2005 was F = 0.0192 (KLAMZ model for the entire stock, Figure C7). Annual estimates of fishing mortality are relatively low and precise (Figure C6). However, fishing mortality rates have increased since 1997 and are currently near the levels observed in the mid 1980s (Figure C6). As landings have been relatively constant during recent years (Figures C9 and C10), the recent increases in fishing mortality have been due to decreases in biomass (Figure C2).

Recruitment: The 1991 (age 14 during 2005) and 1998 (age 7 during 2005) year classes were relatively strong in the DMV and NNJ regions. Recruitment (Figure C8) has declined since the mid-1990s. In 2005, recruitment levels were at or near record lows in all regions but LI (GBK was not surveyed). No strong incoming year classes were evident in the 2005 survey data.

Recruitment to the commercial fishery occurs at about 120 mm SL, depending on region, markets, availability of large surfclams and other factors. Prior to 1993, surfclams in the DMV region reached 120 mm at about age 5. After 1993, surfclams in DMV reached 120 mm at about age 7. Surfclams in the NJ region reached 120 mm at about age 4 (prior to 1993) or age 5 (after 1993). Thus age at recruitment has changed, particularly in the southern DMV region, due to slower growth rates in recent years. Reductions in growth are important for the DMV region because a 2 y delay in recruitment means a reduction of about 26% in numbers of recruits from a cohort (assuming annual mortality rate M=0.15 y^{-1}). Slower growth also reduces potential fishery productivity after clams recruit.

Stock Biomass: The Atlantic surfclam stock is declining from record-high levels during the late 1990s toward lower levels similar to the early 1980's (Figure C2). High biomass during the late 1990s was due to relatively high recruitment (Figure C8) and relatively fast growth. Fishable biomass in 2005 was 1.17 million mt, which is less than the long term average (1.403 million mt) from 1981 to 2005.

The recent decline in surfclam biomass (Figure C2) is due to negative surplus production (Figure C13) caused by record low recruitment (Figure C8) and slower growth. The fishery appears to have been a secondary factor (Figure C13). When surplus production is negative, stock biomass will decline, even when no fishing occurs. When fishing occurs, stock biomass will decline whenever catch exceeds surplus production.

Regions with highest fishable biomass shifted from the south to the north during 1982-2005 (Figure C3). During 1982, DMV held the largest fraction of fishable surfclam biomass (Figure C4). The fraction of total biomass in DMV increased through the late-1980s and then declined to the current relatively low level (Figure C3). NJ held the largest share of surfclam biomass during 1994-2002. During 2005, the largest share of surfclam biomass was in GBK (Figure C4) due to declining biomass in NJ.

LPUE, biomass estimates, and survey biomass trends for surfclams in DMV and NJ declined in a consistent fashion after 1994 (Figure C12). LPUE generally increased during 1982-2005 in LI and varied without trend in SNE. LPUE appears to provide some independent confirmation about recent trends in surfclam biomass in the DMV and NJ regions, probably because the fisheries in DMV and NJ operate over most of the available surfclam habitat (NEFSC 2003).

Special Comments: Given the recent declining trends in stock biomass, a survey conducted in 2008 is critical.

Agency, academic and industry personnel have made progress in estimating efficiency of the NEFSC clam survey dredge during the 1997-2005 surveys. Survey dredge efficiency is the principal source of uncertainty. Collaborative depletion studies designed to measure dredge efficiency should continue to be part of the clam survey program.

The size-selectivity of the NEFSC survey dredge has not been sufficiently characterized, although survey selectivity information is essential to fully evaluate depletion experiments and to derive abundance and biomass estimates. Selectivity experiments should be part of the 2008 clam survey.

A constant M equal to 0.15 was assumed in the assessment. Reductions in biomass of surfclam in inshore southern regions are due partly to changes in environmental conditions. Assumptions about natural mortality should be re-evaluated in the next assessment.

The current biomass reference points were based on an assumption that the stock was at or near an equilibrium level in 1999. Recent evidence indicates that the 1999 biomass level was temporary due to strong recruitment. This assumption should be reviewed during the next assessment, and it may therefore be advisable to also review the current proxy reference points.

The 2008 clam survey should sample GBK, as GBK was not sampled during the 2005 survey. No fishing occurs on GBK but it accounts for the largest fraction of stock biomass and is becoming more important as biomass declines in southern regions.

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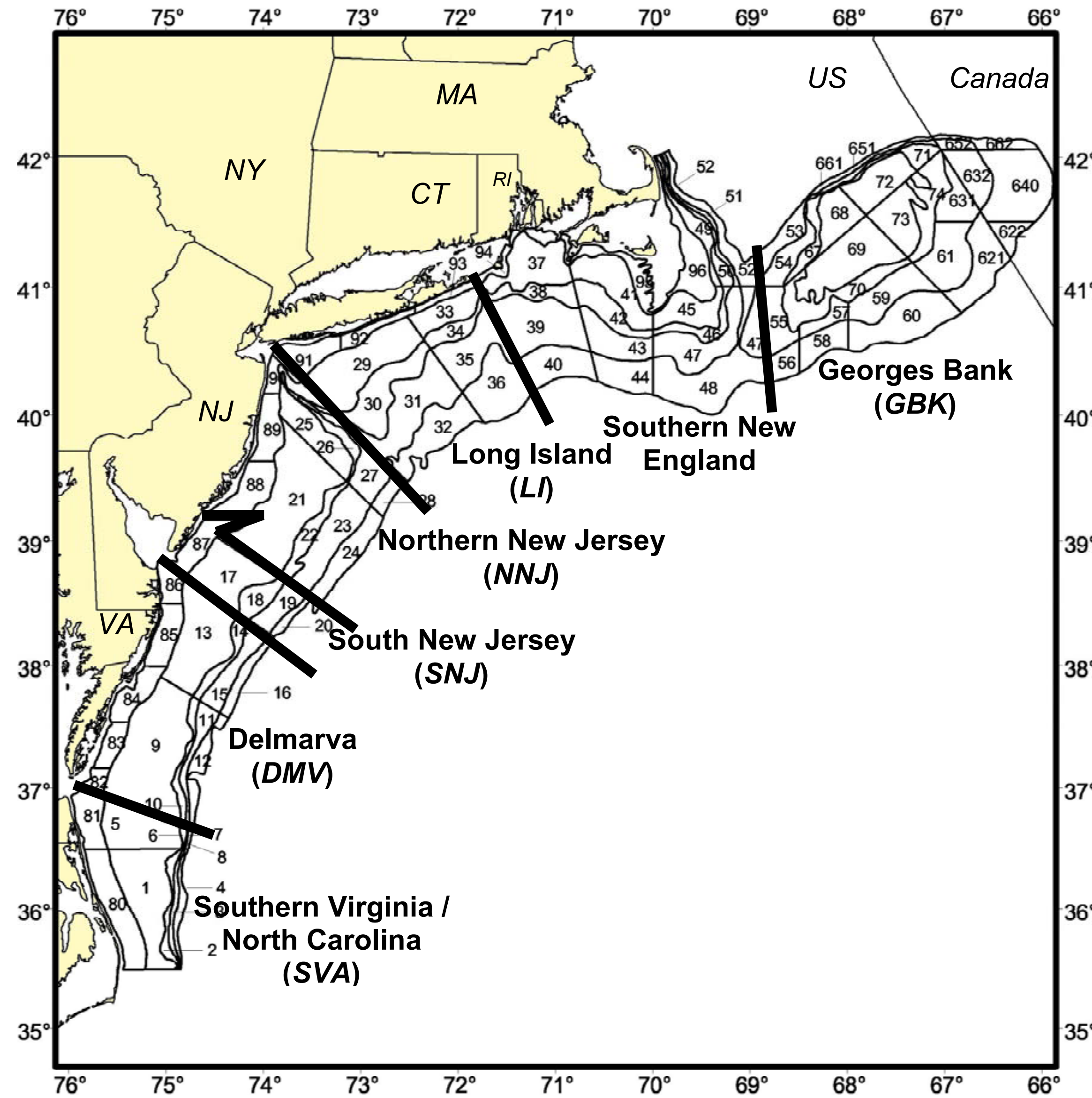
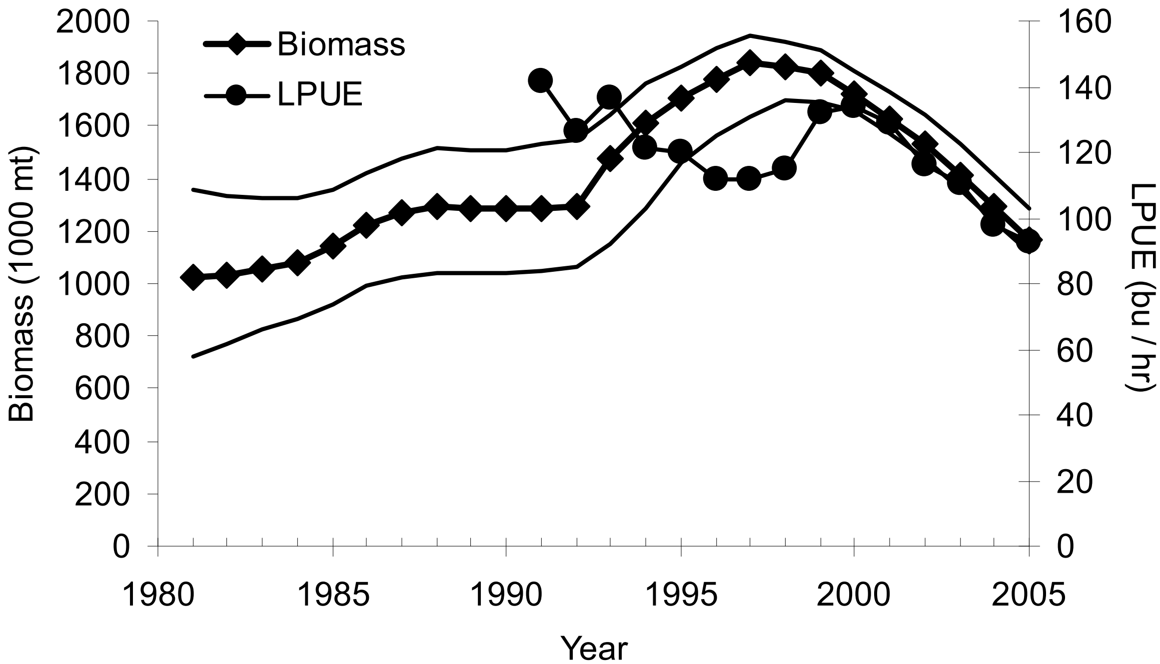
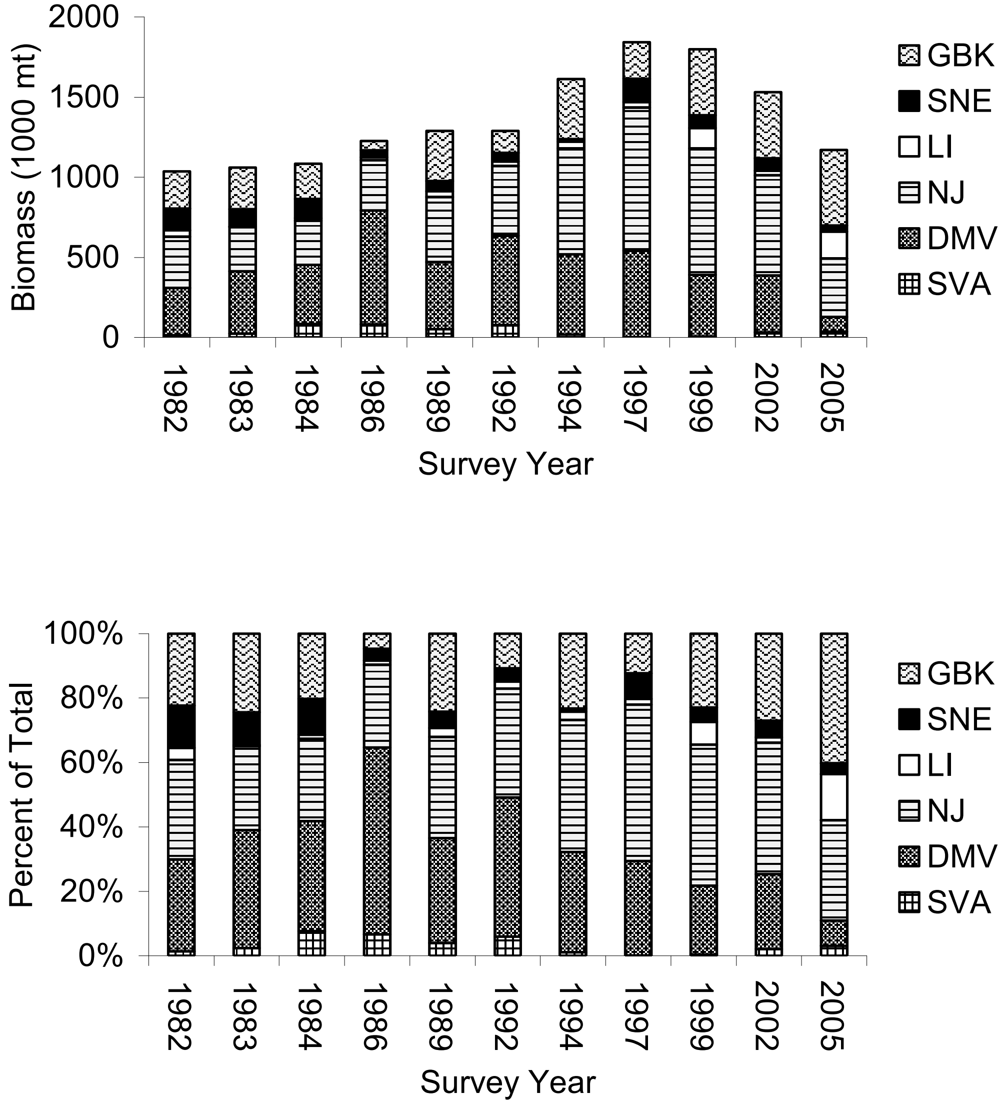
[4] Available at: http://www.nefsc.noaa.gov/nefsc/publications/crd/crd0317/atlsurfclam.pdf.
[5] Available at: http://www.nefsc.noaa.gov/esb/survey_reports/Clam%202005/all.pdf.
[6] Available at: http://www.nefsc.noaa.gov/nefsc/publications/crd/crd0501/.



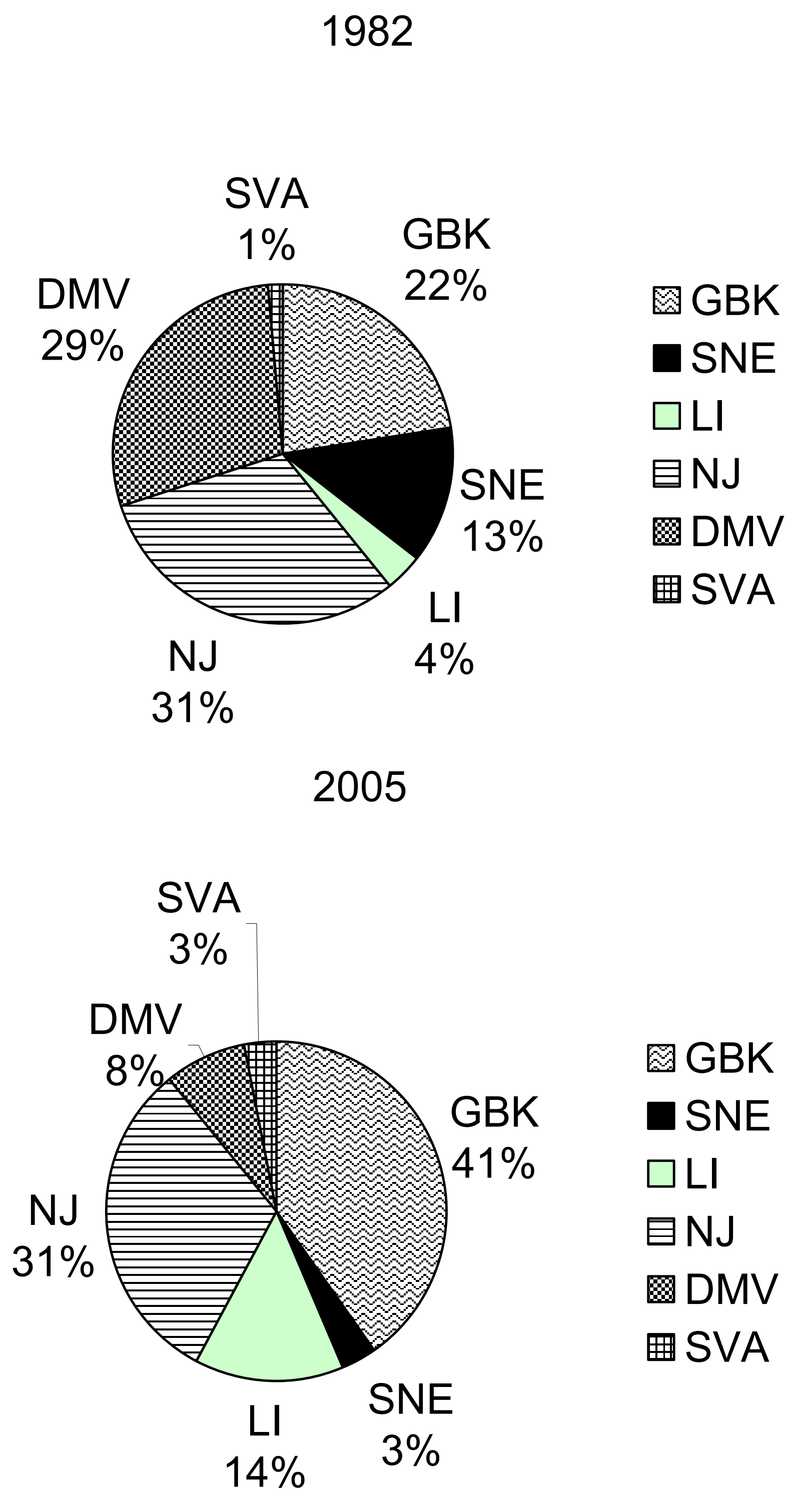
C1. Assessment regions for the Atlantic surfclam stock in the US EEZ with NEFSC shellfish survey strata and stratum numbers. In this assessment, the Southern New Jersey (SNJ) and Northern New Jersey (NNJ) regions were combined to form a single New Jersey (NJ) region.



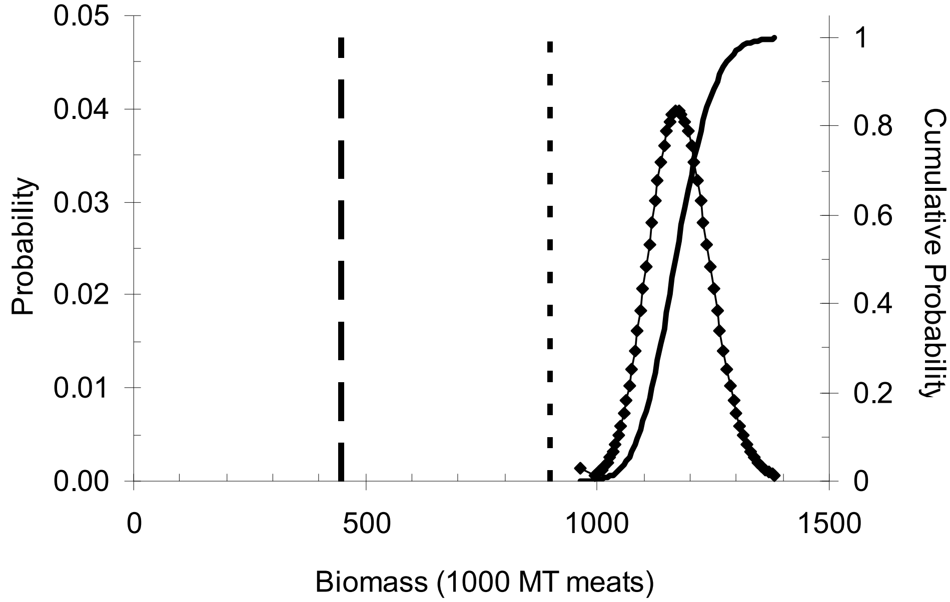
C2. Fishable surfclam biomass estimates with 80% empirical confidence intervals. Nominal LPUE from logbooks (total reported landings / total reported hours fished, all vessels and all trips) for the entire fishery are shown for comparison. LPUE data were not used in estimating biomass.



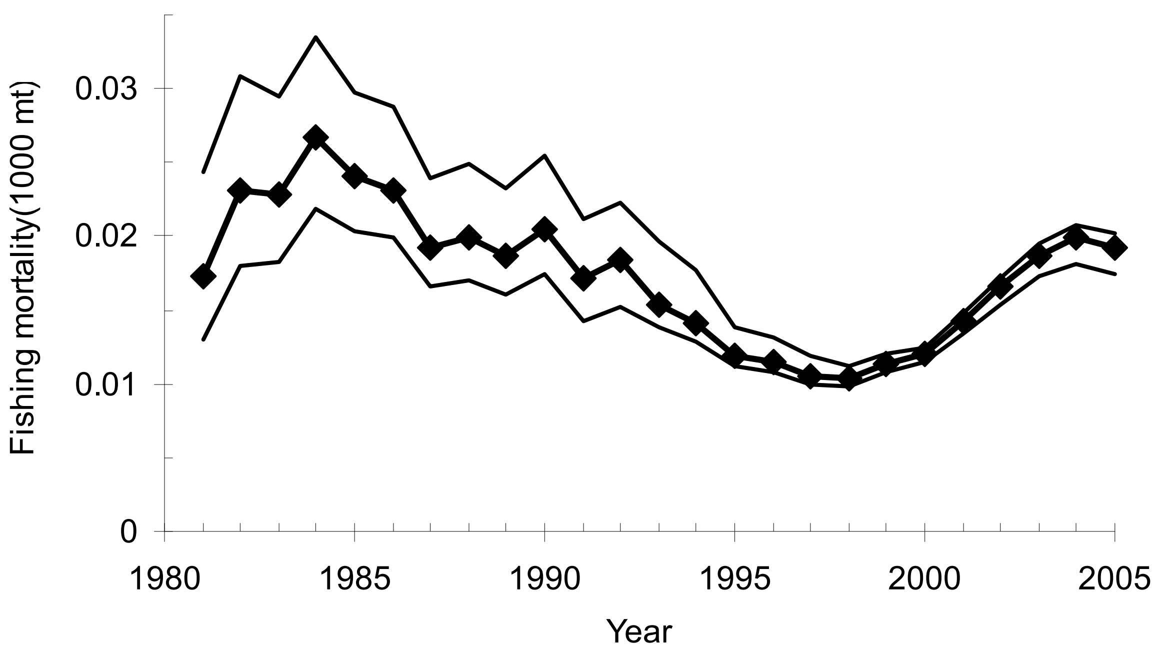
C3. Fishable surfclam biomass by region during years with NEFSC clam surveys.



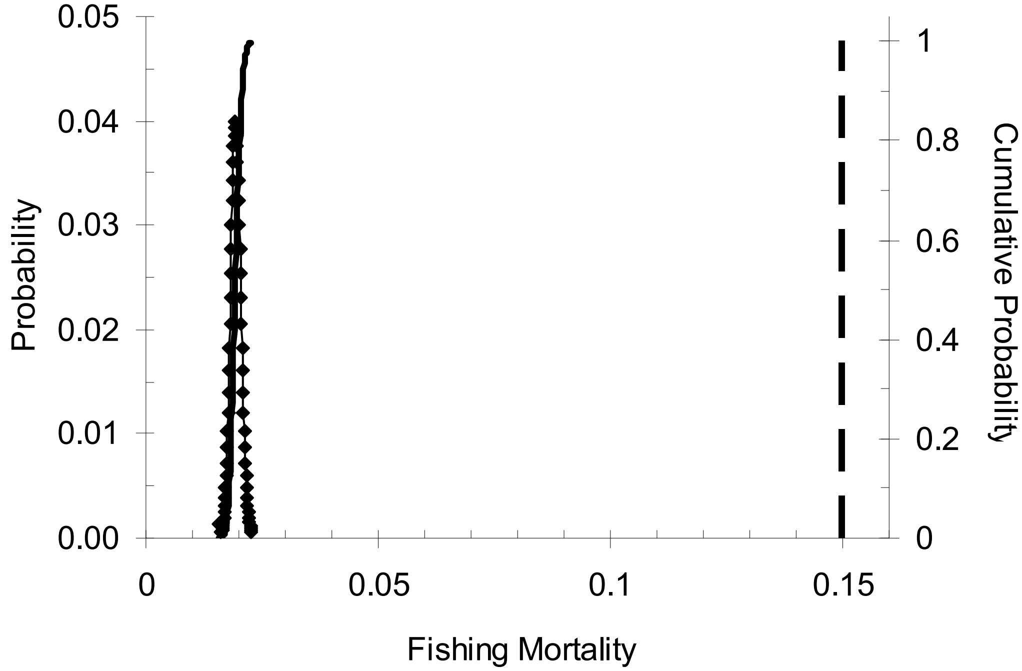
C4. Percentage of fishable surfclam biomass during 1982 and 2005, by region.



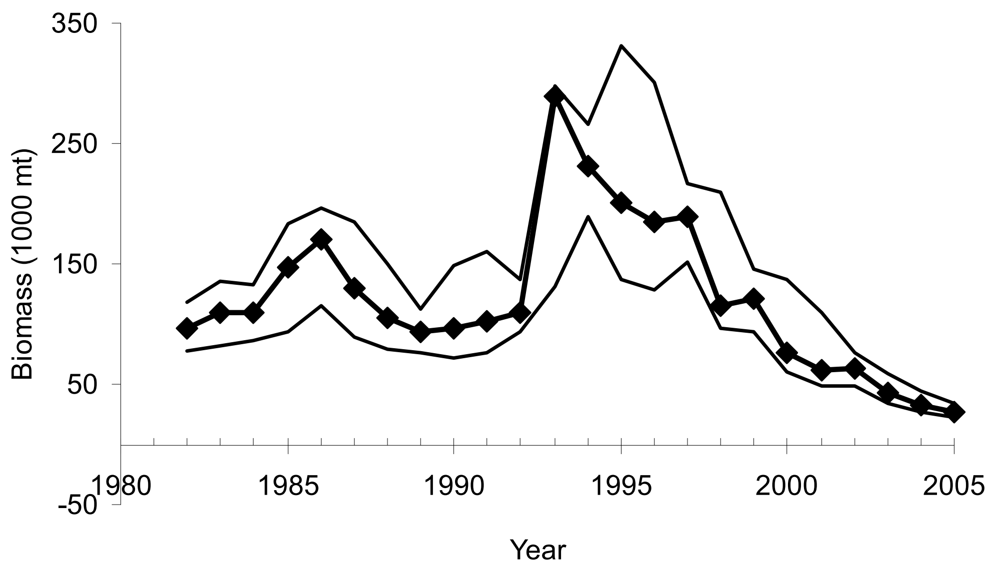
C5. The confidence interval describes uncertainty about estimated fishable biomass of surfclams in 2005. For comparison, the vertical lines are at the biomass threshold (long dash line left of center) and the biomass target (short dash line near center).



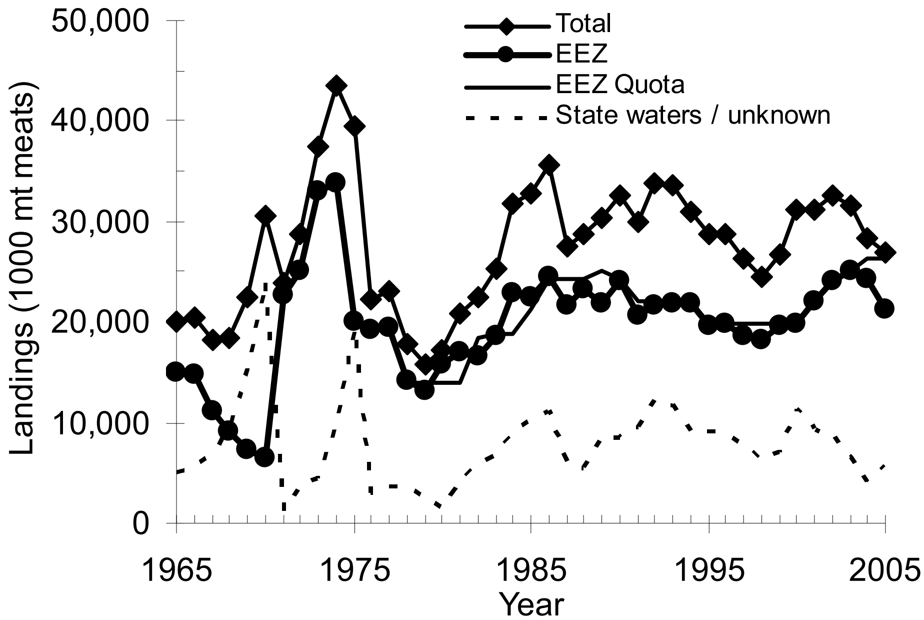
C6. Fishing mortality estimates for surfclams (with 80% confidence intervals).



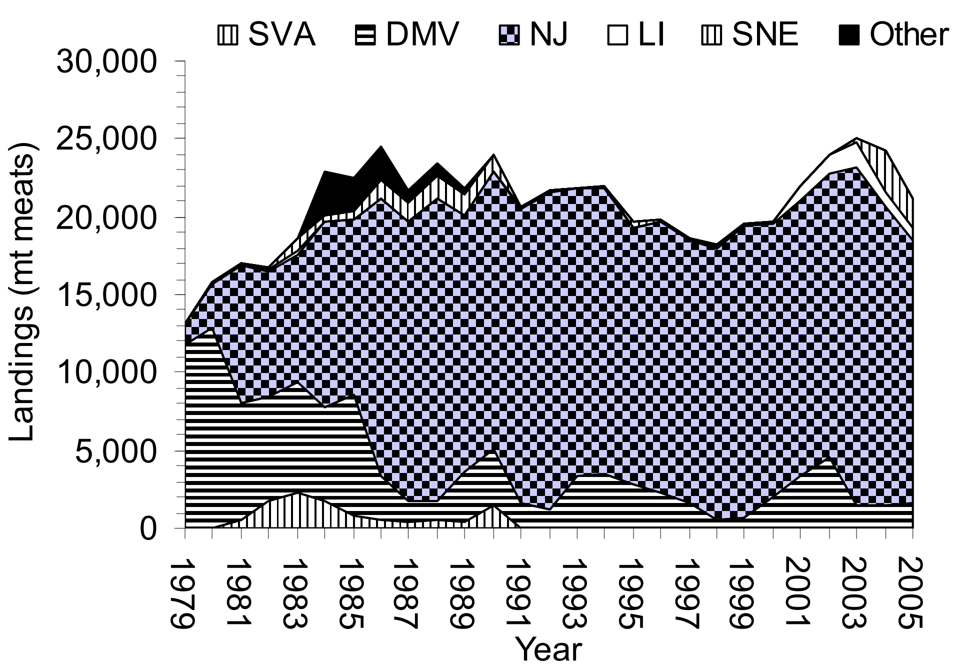
C7. The confidence interval describes uncertainty in estimated fishing mortality for surfclams in 2005. The dashed vertical line shows the fishing mortality threshold for comparison.



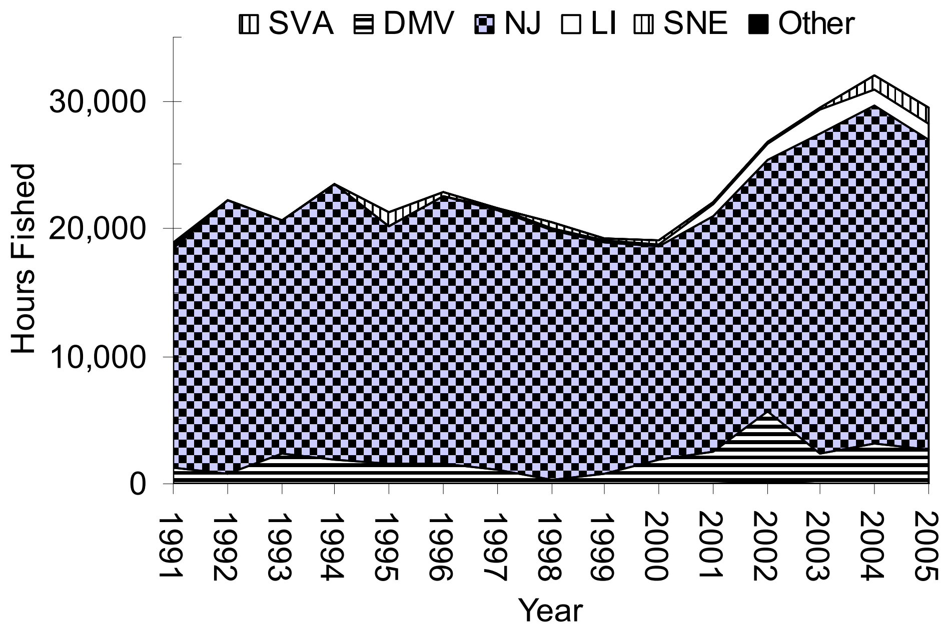
C8. Recruit biomass estimates for surfclams (with 80% empirical confidence intervals).



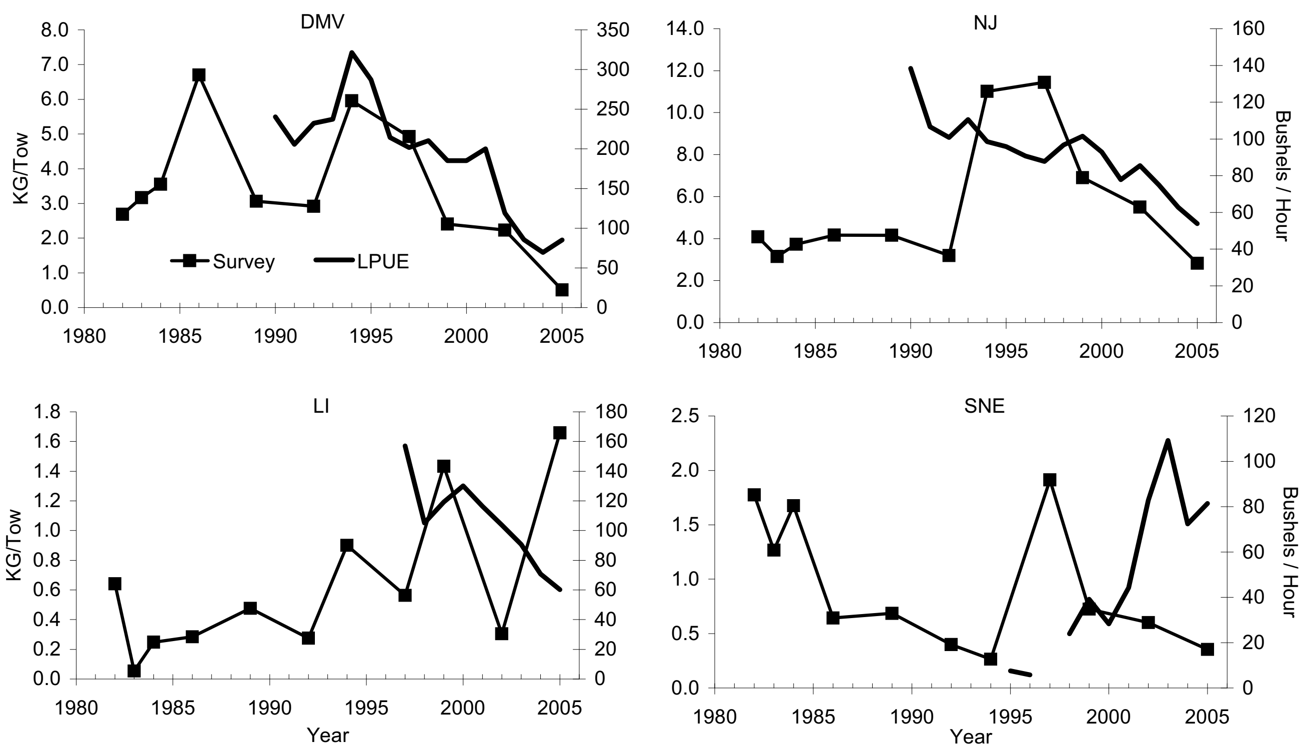
C9. Atlantic surfclam landings and EEZ surfclam quotas (in mt meats). Landings data for state waters are shown as well, but were not used in the assessment. The line for the EEZ quota is nearly the same as the line for EEZ landings and therefore difficult to see.



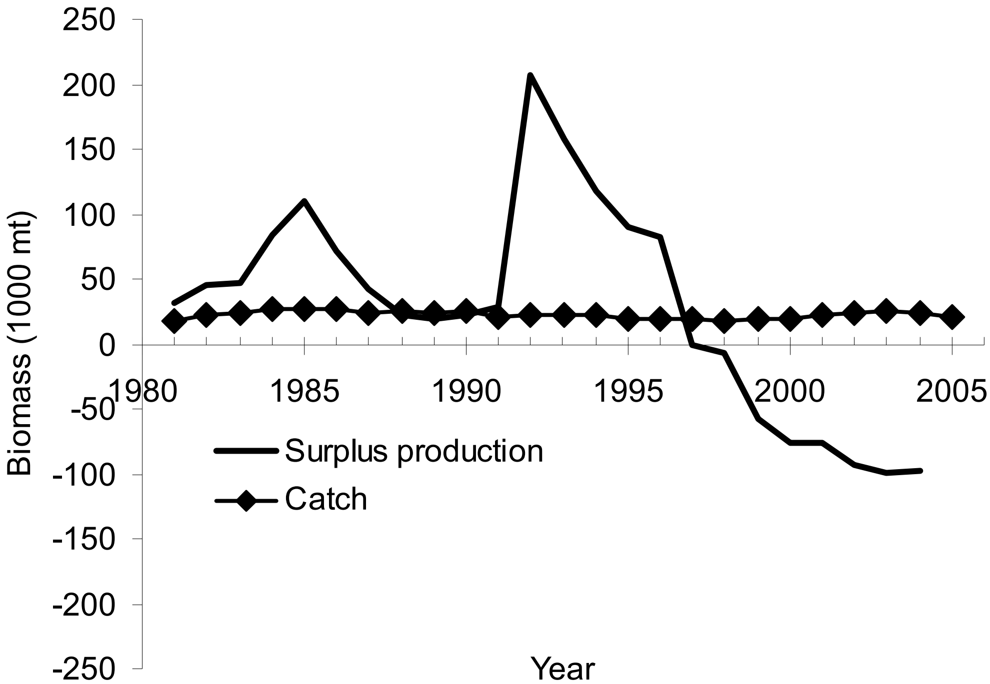
C10. Surfclam landings during 1979-2005 by stock assessment region.



C11. Total fishing effort (hours fished, all trips and all vessels) during 1991-2005 by stock assessment region.



C12. Trends in fishable biomass for surfclams 120+ mm SL based on the NEFSC clam survey and standardized LPUE from logbooks.



C13. Estimated surplus production for surfclams during 1982-2004, with catches for comparison.

APPENDIX. TERMS OF REFERENCE.

Terms of Reference for the 44th Northeast Regional Stock Assessment Workshop

(Last Revised Sept. 6, 2006)

Meeting Dates: November 28 – December 4, 2006

A. Ocean quahogs

1. Characterize the commercial catch including landings and discards.
2. Estimate fishing mortality, spawning stock biomass, and total stock biomass for the current year and characterize the uncertainty of those estimates. If possible, also include estimates for earlier years.
3. Either update or redefine biological reference points (BRPs; proxies for B_{MSY} and F_{MSY}), as appropriate. Comment on the scientific adequacy of existing and redefined BRPs.
4. Evaluate current stock status with respect to the existing BRPs, as well as with respect to updated or redefined BRPs (from TOR 3).
5. Recommend what modeling approaches and data should be used for conducting single and multi-year stock projections, and for computing TACs or TALs.
6. If possible,
    a. provide numerical examples of short term projections (2-3 years) of biomass and fishing mortality rate, and characterize their uncertainty, under various TAC/F strategies and
    b. compare projected stock status to existing rebuilding or recovery schedules, as appropriate.
7. Review, evaluate and report on the status of the SARC/Working Group Research Recommendations offered in recent SARC reviewed assessments.

B. Skate species complex

1. Characterize the commercial and recreational catch including landings and discards.

2. Estimate fishing mortality, spawning stock biomass, and total stock biomass for the current year and characterize the uncertainty of those estimates. If possible, also include estimates for earlier years.

3. Either update or redefine biological reference points (BRPs; proxies for B_{MSY} and F_{MSY}), as appropriate. Comment on the scientific adequacy of existing and redefined BRPs.

4. Evaluate current stock status with respect to the existing BRPs, as well as with respect to updated or redefined BRPs (from TOR 3).

5. Review, evaluate and report on the status of the SARC/Working Group Research Recommendations offered in recent SARC-reviewed assessments.

6. Examine the NEFSC Food Habits Database to estimate diet composition and annual consumptive demand for seven species of skates for as many years as feasible.

C. Atlantic surfclam

1. Characterize the commercial and recreational catch including landings and discards.

2. Estimate fishing mortality, spawning stock biomass, and total stock biomass for the current year and characterize the uncertainty of those estimates. If possible, also include estimates for earlier years.

3. Either update or redefine biological reference points (BRPs; proxies for B_{MSY} and F_{MSY}), as appropriate. Comment on the scientific adequacy of existing and redefined BRPs.

4. Evaluate current stock status with respect to the existing BRPs, as well as with respect to updated or redefined BRPs (from TOR 3).

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

6. If possible,

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

    b. compare projected stock status to existing rebuilding or recovery schedules, as appropriate.

b. Review, evaluate and report on the status of the SARC/Working Group Research Recommendations offered in recent SARC reviewed assessments.

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