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Report of the Thirteenth Northeast Regional Stock Assessment Workshop (13th SAW)

NOAA/National Marine Fisheries Service
Northeast Fisheries Science Center
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SUMMARY

The Thirteenth Northeast Regional Stock Assessment Workshop (Fall 1991) was held in Woods Hole Massachusetts in two sessions. The Stock Assessment Review Committee (SARC) session took place 2 - 6 December 1991 and the Plenary, 13 and 14 January 1992. A total of 118 individuals attended all or parts of the sessions (Table 1). Organizations represented, included the States of Maine, Massachusetts, Rhode Island, Connecticut, New York, Maryland, and North Carolina; Manomet Bird Observatory; University of New Hampshire; International Wildlife Coalition; IMR Bergen Norway; Canadian Department of Fisheries and Oceans; Atlantic States Marine Fisheries Commission; New England, Mid-Atlantic, and South Atlantic Fishery Management Councils; and, Office of Research and Environmental Information, Office of Protected Resources, Fisheries Statistics Division, Northeast Regional Office, and Alaska and Northeast Fisheries Science Centers of the National Marine Fisheries Service.

The objective of the SARC was to provide a thorough technical review of presented analyses for harbor porpoise, black sea bass, summer flounder, Atlantic herring, haddock, Georges Bank cod, Atlantic sea scallops, and winter flounder. In the **Consensus Summary of Assessments**, the SARC discusses major sources of uncertainties in each assessment and how uncertainties may affect determination of stock status, discusses problems with presented analyses, and makes recommendations.

A major objective of the Plenary was to prepare the **Advisory Report on Stock Status** based on the SARC report. The Advisory Report is intended to serve as scientific advice for fishery managers. It contains summaries of the status of each reviewed species/stock and the recommendations of the Plenary.

As a result of discussions relative to the Advisory Report, formation of three Working Groups was recommended for the consideration of the SAW Steering Committee:

- o Working Group on Marine Mammal By-Catch (#33) to develop a long term strategy to improve data for use in expanding marine mammal by-catch rates to estimate total amount of by-catch, especially for the Gulf of Maine gillnet fleets.
- o Atlantic Herring Working Group (#34) to examine Gulf of Maine (including Georges Bank and south) Atlantic herring science and assessment issues. Group membership should include US state and federal, and Canadian scientists.
- o Winter Flounder Working Group (#35) to perform an age structure analytical assessment for at least some stock components or regions, including Georges Bank. This Working Group would be similar to the one on summer flounder, with membership from the states and NEFSC.

Special topics at the Plenary included presentations on "Consideration of Biological Reference Points as Targets for Fishery Management" and two Working Group Reports: "Adequacy of Biological Sampling," including summary of past analyses, review of changes in sampling protocol during surveys, random vs length stratified age sampling on NEFSC surveys, and suggested terms of reference; and, "Recreational Fisheries Statistics," with presentations on the Marine Recreational Fisheries Sampling Survey (MRFSS) and its use.

The Plenary recommended, for SAW Steering Committee consideration, seven species/stocks to review at the next SARC session and to hold the SAW-14 SARC in June and the Plenary, four weeks later, in July.

Table 1.

List of Participants

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Ronald Smolowitz

THE PLENARY

INTRODUCTION

The Plenary of the Thirteenth Northeast Regional Stock Assessment Workshop (Thirteenth SAW) was held in Woods Hole, Massachusetts, 13 - 14 January 1992. More than 80 individuals (from the Northeast, Mid-Atlantic, and Southeast regions) attended the session. The Plenary agenda is presented in Table P1 and working papers which accompanied some presentations are listed in Table P2.

The major objective of the Plenary was the preparation of the **Advisory Report on Stock Status** based on the report of the Stock Assessments Review Committee. Formation of three SAW Working Groups was recommended as a result of discussions relative to the Advisory Report:

o Working Group on Marine Mammal By-Catch (#33) to develop a long term strategy to improve data on levels of fishing activity for use in expanding marine mammal by-catch rates to estimate total amount of by-catch, especially for the Gulf of Maine gillnet fleets. Proposed Terms of Reference are:

1. Develop a short term approach toward estimating the amount of fishing effort and landings that are missed in the weighout data system.

2. Develop a longer term approach for improving the correspondence between the several sets of data relating to fishing effort and catch, including the MMEP logbooks and registration system, and the state and federal permit systems, and to evaluate other approaches to collecting such data as survey questionnaires and the vessel lists used to allocate observers to vessels.

3. Develop recommendations for collecting fishing activity data at a greater level of resolution as might be needed to account for changes in fishing practices, including those which can be anticipated as gear changes are made to reduce the frequency of marine mammal by-catch.

o Atlantic Herring Working Group (#34) to examine Gulf of Maine (including Georges Bank and south) Atlantic herring science and assessment issues. Group membership should include U. S. state and federal, and Canadian scientists. Proposed terms of reference are:

1. Compare methods to assess Atlantic herring stocks.

2. Compare research programs to evaluate the abundance and distribution of individual herring stocks.

3. Compare research programs to delineate stocks or stock complexes of herring in the western North Atlantic.

4. Compare research programs to determine the spawning, recruitment, and population dynamics of the Georges Bank stock in relation to neighboring stocks of herring.

5. Compare habitat use in relation to other stocks of fish and marine mammals.

o Winter Flounder Working Group (#35) to perform an age structure analytical assessment for at least some stock components or regions, including Georges Bank. This Working Group would be similar to the one on summer flounder, with membership from the states and NEFSC.

Nine presentations were made relative to the three special topics on the agenda; two on the topic of Consideration of Biological Reference Points as Targets for Fishery Management; four relative to the Report of the Adequacy of Biological Sampling Working Group; and, three on the Report of the Recreational Fisheries Statistics Working Group.

The Plenary recommended, for SAW Steering Committee consideration, six species/stocks to review at the next SARC session and three special topics to address at the next Plenary session (leaving the option to add other topics of current importance); and that the SARC be held in mid-June and the Plenary in mid-July.

Table P1

13th NORTHEAST REGIONAL STOCK ASSESSMENT WORKSHOP

PLENARY

Carriage House, Quissett Campus
Woods Hole, Massachusetts

January 13 and 14, 1992

AGENDA

Monday, January 13

10:00	Opening Remarks	R. Roe
10:15	Chairman's Remarks	A. Rosenberg
10:30	SARC Report	A. Rosenberg
11:00	Advisory Report on Stock Status Discussion and Preparation	
12:00	Lunch	
1:00	Continue Preparation of Advisory Report	
5:00	Adjourn	

Tuesday, January 14

9:00	Review and Complete Advisory Report	A. Rosenberg
9:30	Consideration of Biological Reference Points as Targets for Fishery Management	S. Murawski W. Gabriel
10:15	Coffee	

Table P1 (Continued)

10:30	Report of the Adequacy of Biological Sampling Working Group	
	Summary of past analyses - age sampling requirements of NEFSC Bottom Trawl Surveys - variability in commercial catch at age data	F. Almeida
	Review of changes in sampling protocol during surveys	J. Burnett
	Random vs length stratified age sampling on NEFSC surveys	J. Forrester
12:00	Lunch	
1:00	Terms of Reference and Working Group membership	F. Almeida
1:30	Report of the Recreational Fisheries Statistics Working Group	
	Introduction	P. Perra
	Overview of Marine Recreational Fisheries Sampling Survey (MRFSS)	D. Van Voorhees
	Use of the MRFSS data for cod	M. Terceiro
3:00	Coffee	
3:15	SAW-14 Terms of Reference and Timing	
3:45	Other Business	
4:15	Closing Remarks	A. Rosenberg

Table P2.

SAW-13 Plenary Papers

SAW/13/P/1	Consensus Summary of Assessments	SARC
SAW/13/P/2	MRFSS Catch Statistics for Atlantic Cod	Rec.Fish. Work. Gr.
SAW/13/P/3	Marine Recreational Fishery Statistics Survey, General Information and Abstract	J. Witzig

CONSIDERATION OF BIOLOGICAL REFERENCE POINTS AS TARGETS FOR FISHERY MANAGEMENT

The plenary discussed a generalized definition and some of the problems related to the use of biological reference points (BRP). The most general definition presented was that a biological reference point is "a particular position attained within a biological coordinate system". F_{max} is an example of a particular position on the axes of yield per recruit and fishing mortality rate. In this case, growth (reflected in weight at age) and mortality (M) are considered constants, but most likely change with stock size, temperature, predator and prey abundance, and other factors. Thus, F_{max} should be estimated as a function of stock size in addition to yield and F, to allow growth and M to change as a function of the size of the stock.

Ideally, a biologically based management objective should have a corresponding set of biological reference points. Many problems arise from the need for a point-estimate of a BRP to act as a target to achieve a management objective. (Table PA1). If the management objective is to maintain the status quo, then model constants such as growth and mortality estimated from current conditions are appropriate to generate associated biological reference points. However, if a management objective entails achieving a different fishing mortality rate and/or different stock size, for example, and model constants change as a function of stock size then the initial reference point based on status quo conditions may no longer be valid.

In some cases, management objectives have been supported by relatively ad hoc, arbitrary reference points. For example, $F_{0.1}$ is often adopted as a reference point when the objective is to maintain yield per recruit while reducing the possibility of recruitment failure. Although $F_{0.1}$ leads to several desirable stock conditions compared to F_{max}, e.g. more year classes, implying less chance of recruitment failure and large fluctuations in yield, there are no parameters directly related to recruitment or its variability. Moreover, it is quite unlikely that the catch and effort obtained under an $F_{0.1}$ level corresponds to any optimum catch and effort from an economic perspective, which may also be a component of the management objectives.

When the management objective is to prevent stock collapse, F_{med}, F_{rep} and F-M relationships can be used as conservative reference points: stock collapse is prevented by maintaining rates or stock sizes above or below specified levels. These reference points do little to allow prediction of the actual point of collapse without prior knowledge of such a collapse, however.

Because F_{med} and F_{rep} assume no density dependent mechanisms within the stock and recruitment (S-R) relationship (i.e. that the S-R relationship is a straight line), the reference points are conservative (in preventing stock collapse) if S-R values are observed over a wide range of stock sizes. If S-R values are observed only for stock sizes on the left hand, ascending limb of the S-R curve, however, the reference points may not be as conservative. Moreover, the same F_{med} value could be obtained from substantially different S-R patterns, which indicates the need for additional alternative reference points.

Some SSB/R based reference points also do not distinguish among different possible age structures within the stock: the same SSB/R level (e.g. 20% of maximum spawning potential) can be obtained from a potentially infinite number of combinations of partial recruitment and fully recruited F, leading in turn to different age structures. This has implications not only for stability of yield, etc. mentioned earlier but also egg production: the number of eggs per kg of smaller fish is lower than for larger older fish, given the non-linear relationship between fecundity and length. The SSB/R reference points thus are only coarsely approximated, especially when observed SSB/R values are combined from periods of different age structures.

Several improvements to BRP's and their use were also discussed. These included the application of bootstrap analyses of the confidence intervals around the reference point (e.g., F_{med}) which results in a range of values with associated probabilities. This allows the incorporation of information about stochastic patterns in recruitment, for example. This information can be presented in a framework of risk analysis, giving a concise summary of potential outcomes and their likelihood.

Additionally, the probability distribution of current F could be overlain by the probability distribution of target F (e.g. F_{med})to yield the probability that the target F is currently being achieved, or the probability of being a particular distance from the target F.

Additional modifications suggested were to investigate multispecies reference points for those species that are influenced by others through biological or technological interactions. Spatial effects, such as split jurisdictions or the effects of over-fishing a local stock while under exploiting the aggregate population also need to be addressed. New models for reference points and extensions of existing ones are needed in order to avoid inappropriate ad hoc use of existing reference points currently available as guides for managers.

"Long-term" reference points may be estimated based on periods of stable stock dynamics, including relatively constant biological (e.g. growth, maturity) and environmental (e.g. influences on pre-recruit survival) factors. However, these features may vary through time, and co-vary with each other. As well, choice of target levels of stock size or mortality rate may be tempered in various cases by starting conditions, knowledge of incoming year class strength, uncertainty about rates of rebuilding and economic considerations, for example.

Table PA1. Correspondence between potential management objectives and biological reference points. Parentheses denote previous ad hoc usage of reference point with respect to objective (e.g. use of yield-based model for recruitment-based objectives) or application of status quo parameter estimates outside range of status quo conditions (e.g. growth rates observed at low stock size assumed equivalent to growth rates at higher stock size). These management objective are examples based primarily on single-species biological considerations, and are obviously only a subset of possible management objectives.

Management Objective	**Biological Reference Point**
Investigate stock production potential without irreversible effects (adaptive management of unexploited stock)	None
Maintain maximum fish production	F_{msy} , F_{max}
Develop maximum fish production	F_{msy} , (F_{max})
Maintain (conserve) existing stock biomass	F_{med} , F_{rep} , ($F_{0.1}$)
Rebuild depleted stocks	F_{low} , (F_{med}) , (F_{rep})
Prevent stock collapse (predictive)	S/R-based points (salmon) (% virgin SSB) (F-M relationship)
Present stock extinction	None

REPORT OF THE ADEQUACY OF BIOLOGICAL SAMPLING WORKING GROUP

The presentation from this working group focused on four areas: (1) an introduction and summary of past analyses, (2) a review of changes in the sampling protocol during NEFSC bottom trawl surveys with preliminary results of the effects of those changes on sampling intensity and age/length key structure, (3) a discussion of the statistical effects of using random versus length stratified sampling during the surveys, and (4) terms of reference.

Introduction and Review of Past Studies

Frank Almeida, chairman of the Adequacy of Biological Sampling Working Group, provided an overview of the uses in stock assessment research and sources of biological samples collected by the NEFSC. The three major sources of samples are from the NEFSC Port Sampling Program, the sea sampling program, and numerous resource surveys. The fishery dependent sources (port and sea samples) primarily provide information concerning the length and age composition of removals from populations. Samples from the port sampling program are allocated annually based on projected monthly landings by statistical area, port, and market category; sample collections are constrained primarily by logistical considerations such as the availability and accessibility of the landings. Both length and age samples from this program require consideration from the working group.

Resource surveys provide fishery independent information on the composition of populations. The sample design of the surveys (both station selection and biological sampling) are completely controlled by the scientific staff. All individual fish captured are identified, weighed and measured (or at least sub-sampled and numbers expanded to the total catch by simple ratios) during each tow. The sampling component of interest to the working group is the number of age samples only.

Past Studies

There have been three studies conducted at the NEFSC since 1987 examining the variance of catch at age estimates from commercial and survey data. A study conducted by Moseley and Mayo in 1988, reported at the Eighth SAW, examined variability in commercial catch at age with the specific objective of determining optimal age sampling requirements in the ports. Variances of catch at age were estimated for 10 species/stocks using the method developed by Gavaris and Gavaris (1983) and sampling data from 1981-1985. During the discussion of this method in the Eighth SAW, it was pointed out that the method utilized random sampling theory and underestimated variances of cluster samples such as those in the commercial fishery. Optimal sample sizes were estimated for each species stock and allocated to market category based on the historical percentages of each category in the landings.

An analysis of the variation in catch at age of herring stocks was conducted by Almeida and Fogarty in 1988 with the objective of determining the CV of stock biomass at age from VPA and presented at the Ninth SAW. This analysis used a stratified cluster sample design with basic units being gear/area/month combinations of the samples. Variances of catch at age, mean weight at age, and proportion mature at age were calculated as inputs to VPA. Results indicated that for the predominant age groups, CV's were generally less that 20% during 1967-1988. During an exhaustive review of the method conducted by a professor in the Department of Resource Economics of the University of Massachusetts, Amherst, it was determined that co-variance terms assumed to be negligible in the analysis may, in fact, be negative and as a result variances in this study may have been slightly overestimated. While no sampling recommendations were made as a result of the analysis, the statistical method utilized may be very useful to the Working Group in examining commercial sample levels.

An analysis of age sampling requirements on NEFSC surveys was also conducted during 1988 and presented at the Eighth SAW. The objective of this study was to define shipboard sampling plans that minimized variance of proportion at age for given costs (in terms of the time required to collect and age samples). Sampling plans were developed for several species on a stock-area basis under the assumption that existing species-specific length sampling groups would not change under the new plans. However, since the completion of this study, the biological sampling protocol onboard NEFSC research vessels has changed substantially.

Changes in the NEFSC Survey Sampling Protocol

A review of changes in the NEFSC survey biological sampling protocol and preliminary results from the 1991 Autumn Bottom Trawl Survey was presented by Jay Burnett. The first change was in sampling frequency for age and reproductive biology samples from a per-watch to a per-station basis, made to ensure that the spatial distribution of samples is adequate to meet the statistical requirements of stratified random sampling. This protocol now matches that used for feeding ecology collections. While it was shown that for most species the spatial coverage of age samples was adequate during past surveys, the improvement in coverage of some species was presented in a series of distributional maps for catch and age sample collections for the autumn 1990 and autumn 1991 surveys (see example for butterfish, Figure PB1). The second major change was a revision of the length groups (strata) used in sampling for age and reproductive studies. Formerly, large strata (5-10 cm) were used in sampling, however, to ensure that sampling is done in accordance with the analytical methods used to analyze the data, length strata were revised to 1-, 2- or 3-cm groups, depending on the species sampled. Results of this change indicated a more uniform distribution of age samples across lengths and a decrease in the variance of numbers at age for butterfish and American plaice (the only species for which age data were available for preliminary evaluation). The other changes in the sampling protocol were the collection of individual fish weights which will improve estimates of seasonal changes in weight at length for all species sampled, and the assignment of individual fish identification numbers to facilitate relating all biological parameters, including food habits data, for individual fish.

Compared to the 1990 Autumn Bottom Trawl Survey, the 1991 survey resulted in the collection of about 10% fewer total age samples and an average of about 11% fewer samples/station. The percentage of the total catch sampled for ages increased for three species, remained about the same for 7 species, and decreased for 10 (Table PB1). For some species that were encountered very frequently during the survey (i.e. butterfish and silver hake), the new protocol may have resulted in over-sampling for ages and other biological parameters. Of some concern was the reduced number of age samples for some species for which analytical assessments (VPA's) are performed, associated with reduced catches of those species (primarily haddock and cod), and the potential for under-sampling species collected infrequently on the surveys. It was felt however, that adequate information was obtained during the 1991 autumn survey to make necessary adjustments in the new sampling protocol to ensure adequate sampling in subsequent surveys.

Random vs. Stratified Age Sampling During Surveys

A comparison of the variances of proportion at age, $\mathrm{Var}(\hat{p}_i)$, resulting from three common methods of sampling for age determination was then presented by Janice Forrester. Assuming a large initial sample of fish, the first method consists of a simple random sample (RS) from the large initial sample, wherein all the specimens in the simple random sample are aged. In the second method, all of the specimens in the large initial sample are measured for length, stratified by length, and a sub-sample of fixed size selected from each length group or stratum for ageing (fixed allocation, FA, currently utilized on NEFSC surveys). The third is also a stratified method, except that the size of the age sub-sample from a given length group is proportional to the number of specimens occurring in that length group (proportional allocation, PA).

The equations for $\mathrm{Var}(\hat{p}_i)$ were presented and compared and factors influencing the magnitude of $\mathrm{Var}(\hat{p}_i)$ were discussed. For the two stratified methods, stratum weights (proportion at length l, p_l) are unknown and must be estimated from the length sample. The effect of errors in estimation is to increase the component of the within length stratum variability, and to introduce a component of variance due to variation between length strata. The within length group component of variation is also altered when allocation changes from fixed to proportional, since extra information (p_l) is used within each length group to determine the proportional allocation. The between group component remains unchanged.

It was shown that $\text{Var}(\hat{p}_i)_{PA}$ is always less than or equal to $\text{Var}(\hat{p}_i)_{RS}$; the variances are equal when the size of the length sample equals the size of the age sample. This is to be expected, since a truly simple random sample will give proportional allocation. Comparisons of the magnitude of $\text{Var}(\hat{p}_i)_{FA}$ and $\text{Var}(\hat{p}_i)_{RS}$ are more difficult to make, but examination of the variance equations indicates that the fixed allocation will tend to have a smaller variance for those species with many length groups.

A measure of the total variability of the age-length key was also discussed. This measure, Vartot (Kimura, 1977), is simply the sum of the $\text{Var}(p_i)$ over all ages in the key. In the derivation of his measure, Kimura used data from the commercial fishery for Pacific ocean perch and Pacific cod and calculated Vartot while varying the size of the age and the length samples. It was found that $\text{Vartot}_{PA} \backslash \text{Vartot}_{FA}$ for each combination of age and length sample size for both species, although Kimura acknowledged that this could change for a population with a different age structure. He also found that $\text{Vartot}_{RS} \backslash \text{Vartot}_{FA}$ for ocean perch for all combinations of age and length sample size. However, for constant age sample size, Vartot_{FA} became less than Vartot_{RS} as the size of the length sample (N) increased for Pacific cod, possibly due to the greater number of length groups for cod (25) as compared to ocean perch (12).

For the two species examined, increasing the size of the age sample (n_s) reduced Vartot more than increasing the size of the length sample (N). This was the result of the between length group component of variability having N in the denominator, while the within length group component had n_s in its denominator. The length sample was large (minimum of 100) and the size of the age sample was always less than N, making the between length component a smaller percentage of the total variability. Therefore, an increase in N resulted in a proportionately smaller decrease in variability than an increase in n_s.

The issue of the relative value of increasing N vs increasing n_s is relevant to NEFSC commercial sampling since the size of both N and n_s can be changed during sampling. However only the size of the age sample is of concern during the bottom trawl surveys, since all individuals are measured and the size of the catch cannot be controlled.

The logistics of implementation of random or proportional allocation sampling plans for commercial and survey data were also discussed. It was recognized that selecting a truly random sample of fish would be prohibitively difficult to obtain in the ports given the constraints described. It was also pointed out that while selecting a proportionally allocated sample aboard research vessels is technically possible given advances in the computer capabilities onboard ship, it would take a prohibitive amount of time to sample each station.

Terms of Reference

The following terms of reference were presented and discussed during the SAW:

1. Determine appropriate algorithms for calculation of proportion at age and length and possible modification to existing software. The advantages and disadvantages of utilizing bootstrapping techniques or analytical approximations must be fully examined. This determination is critical to any further studies examining variation in catch at age from both commercial fishery and survey samples.

2. Conduct simulation experiments to examine the effects of changes in the number of length and age samples on variance estimates around estimated catch at age from the commercial fishery.

   The goal of these simulations will be to estimates variance around stock biomass estimates from population models such as VPA, and the contribution to overall variance made by variability in the estimation of catch at age. Discussion was centered on the potential sources of variability seen in stock assessment models and the impact of decreasing the variability around catch at age given its apparent small contribution to overall variance of stock biomass estimates. Cost (time) savings from minimizing age sample collections may be the most important result of the simulations rather than substantially decreasing variance around biomass estimates.

3. Conduct simulation experiments to examine age sample collection designs (simple random vs. length stratified with fixed allocations vs. length stratified with proportional allocations of age samples) on the variance of mean catch per tow at age from bottom trawl surveys.

4. Analyze the effects of changes in the age sampling protocol during bottom trawl survey on variance of catch per tow at age.

5. Evaluate the substitutability of samples among the various sources [i.e. ports, surveys (NEFSC and states), and sea sampling programs] to determine potential tradeoffs between sources. This term of reference would most likely be accomplished as a joint project between the Adequacy of Biological Sampling and Sea Sampling Working Groups.

References

Gavaris, S. and Gavaris C.A. 1983. Estimates of catch at age and its variance for ground fish stocks in the New Foundland region. W. G. Doubleday and D. Rivard, eds. Sampling Commercial Catches of Marine Fish and Invertebrates. Can. Spec. Publ. Fish. Aquat. Sci. 66, pp 178-182.

Kimura D.K. 1977. Statistical assessment of age-length key. J. Fish. Res. Board, Can. 31:317-324.

Table PB1. Comparison of age samples by species in terms of total number of samples and sampling ratios (% of the total catch sampled for ages) between autumn bottom trawl surveys during 1991 and 1990 (NS = not sampled; 1991 catch figures preliminary).

	1991			1990		
Species	Samples	Catch	Ratio	Samples	Catch	Ratio
American plaice	424	1634	26.0	775	2876	27.0
Atlantic cod	253	332	76.2	713	1184	60.2
Black sea bass	101	637	15.9	129	343	37.6
Bluefish	160	1386	11.5	282	796	35.4
Butterfish	855	65399	1.3	607	77480	0.8
Cusk	12	19	63.2	1	14	7.1
Goosefish	159	194	82.0	NS	107	-
Haddock	239	1402	17.1	448	650	68.9
Halibut	12	14	85.7	15	17	88.2
Ocean pout	84	206	40.8	78	211	37.0
Pollock	91	155	58.7	164	210	78.1
Red hake	662	4966	13.3	639	3138	20.4
Redfish	321	1282	25.0	640	2633	24.3
Scup	343	69369	0.5	401	29721	1.4
Silver hake	1527	19595	7.8	1208	15727	7.7
Summer fldr	235	371	63.3	156	181	86.2
Weakfish	125	4968	2.5	119	8237	1.4
White hake	943	2006	47.0	700	1524	45.9
Windowpane	253	803	31.5	359	1366	26.3
Winter fldr	356	1164	30.6	322	593	54.3
Witch fldr	114	225	50.7	124	169	73.4
Wolffish	6	17	35.3	NS	22	-
Yellowtail	277	580	47.8	476	994	47.9
Total	7552	176724	4.3	8356	147935	5.7

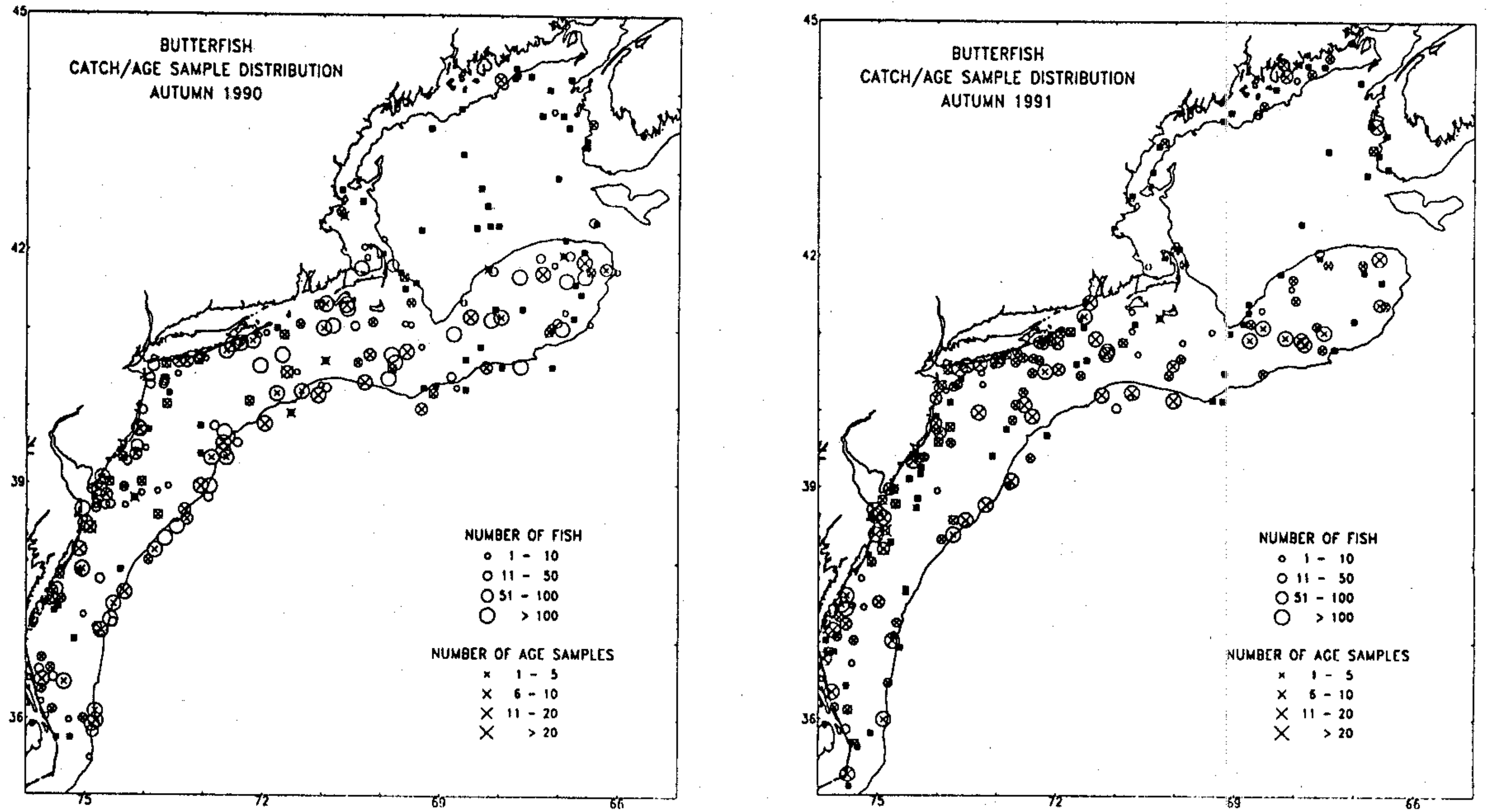

Figure PB1. Distribution of butterfish catches and age samples from the 1990 and 1991 NEFSC bottom trawl surveys. Circles indicate stations where butterfish were caught during the surveys, X's indicate those stations where age samples were collected.

RECREATIONAL FISHERIES STATISTICS WORKING GROUP REPORT

Members: P. Perra, Chair (ASMFC); C. Moore (MAFMC), J. Witzig (NMFS, WO); M. Terceiro and T. Morrissey (NEFSC).

Introduction

Paul Perra, Chairman of the Recreational Fisheries Statistics Working Group, provided introductory comments on the collection and availability of recreational fisheries data for use in stock assessments. Data and information on the marine recreational fisheries (MRF) are collected by the NMFS' Marine Recreational Fisheries Statistics Survey (MRFSS) and by the general survey of hunting and fishing conducted by the Fish & Wildlife Service. In addition, a number of the coastal states conduct special surveys which include collection of MRF data. Presently, the states of Maine, New Hampshire, Connecticut, Maryland and Virginia conduct such surveys. As there is no common depository for MRF data, it is difficult to locate and access available information for use in stock assessments. In addition, information collected in special surveys sometimes is not apparent from the title of the survey. The Virginia Black Drum Survey, for example, includes the collection of data on the recreational fisheries for bluefish, striped bass, and weakfish.

Information on individual state and federal agency programs and the issues in MRF catch and effort surveys along the Atlantic coast is contained in a handbook of recreational fisheries statistics programs compiled by the Atlantic States Marine Fisheries Commission (ASMFC) in 1989.

MRFSS Program Overview

David Van Voorhees, NMFS Fisheries Statistics Division, presented an overview of the MRFSS (SAW/13/PL/3). The survey is divided into 7 subregions: North Atlantic, Mid-Atlantic, South Atlantic, Gulf of Mexico, Pacific Northwest, Northern California, and Southern California. Data for the North Atlantic (Maine through Connecticut) and Mid-Atlantic (New York through Virginia) subregions have been collected continuously since the survey was initiated in January, 1979.

The MRFSS consists of two independent but complementary surveys: a telephone survey to collect data on fishing effort, and an intercept survey to collect data on the catch. Data from the two surveys are combined to provide an estimate of the total number of fishing trips and the total catch in number and weight for each species.

The telephone survey is designed as a stratified random sample with the primary sampling unit being a coastal county household. The definition of coastal county varies by subregion, but generally includes all counties within 25 or 50 miles of the coast. A strata corresponds to a state/subregion during a 2-month sampling period or wave. A proportional sample allocation based on historical fishing effort is used to determine the telephone interview quota in each wave. The survey is carried out in 2-week periods of interviewing conducted near the end of each wave. Data obtained from the telephone survey includes number of fishermen per household, number of fishing trips in the last 2-month period, the location of each trip, the mode of each trip (shore, party or charter boat, and private or rental boat), and the location of the household.

The intercept survey consists of on-site interviews of marine anglers. The survey is designed as a stratified random sample with the primary sampling unit being a fishing trip. A strata corresponds to a fishing mode during a two month sampling period. In the North Atlantic and Mid-Atlantic subregions, sampling is conducted in five 2-month sampling periods from March through December. Selection of specific interview sites is based on historical information on the fishing activity at all sites within the subregion. Fishermen are interviewed at the completion of their fishing trip. Data collected includes information only regarding the fishing trip just completed, selected demographic information, and information on the respondents catch. Length and weight data are recorded for a sample of each species in the catch.

The allocation of interviews under the intercept survey is based on empirical data and estimates from previous MRFSS results. Complete coast-wide site lists are created and site assignments are selected based on historical information on site-specific fishing activity. Sampling is scheduled to cover all weekdays, weekends and holidays.

Three types of records are established for the telephone survey:

1. the household

2. the individual angler, and

3. the individual angler by trip.

The telephone survey records are linked by an identification code assigned to the household. Six types of records are established for the intercept survey:

1. site and angler

2. catch types B1 and B2 (catch not available for

   identification: B1 fish killed, B2 released alive)

3. catch type A (catch available for identification)

4. individual angler contribution to a mixed group catch

5. economic data (1987 only), and

6. identification of fishing party membership.

The total number of marine recreational fishing trips taken by residents of coastal counties is estimated by multiplying the mean number of fishing trips reported in the telephone survey by projections of the number of full time occupied housing units in the survey dialing area. Ratio estimators are used to account for the proportion of households without telephones and non-coastal resident and out of state resident fishing trips. Estimates of total number of fish caught are calculated from the estimated total number of fishing trips by mode and the average number of fish caught per trip obtained from the intercept survey.

Since 1987 the results from the telephone survey have been compared with the statistical distribution of reported fishing effort for the previous 4-year period plus the current year to produce a historical data base for every 2-month sampling period by state and mode. To adjust extreme or "outlying" reported number of fishing trips which tend to have a disproportionate effect on the estimate of average fishing effort, any household which reported more fishing trips than the 95th percentile for the 5-year distribution was reduced to the value of the 95th percentile.

There is a relatively low incidence of reported fishing activity in the party/charter boat mode by households contacted in the telephone survey. Typically, households either reported a large number of fishing trips or no fishing trips in the mode. To reduce the effect of small sample sizes on the effort estimates for the charter boat fishery, telephone survey data for the previous 4 years plus the current year are combined at the state and wave level and estimates are produced using a prevalence rate from the combined data base.

The data for trips and catch are calculated for each sampling strata (subregion/mode/wave). Annual estimates are calculated by summing the estimates for the sampling waves on a calendar year basis. All data are maintained in their unaggregated form in the MRFSS data base. The data are stored on magnetic tape for mainframe and minicomputer usage and on high density floppy diskettes and removable hard diskette cartridges for use on micro-computers. Data are stored in ASCII, EBCDIC and SAS data library formats.

Use Of MRFSS Data For Atlantic Cod

Mark Terceiro reported on the results of an examination of the adequacy of MRFSS catch statistics and biological sample data for Atlantic cod for use in stock assessments (SAW/13/PL/2).

Since MRFSS catch statistics for cod are routinely estimated by subregion (North Atlantic, Mid-Atlantic) and state of landing, there is no direct information available from the MRFSS sampling program that is comparable to the commercial fishery statistical area designation used to allocate commercial catch of cod to different stocks (NAFO area 5Y for the Gulf of Maine stock, areas 5Z and 6 for the Georges Bank and South stock). To allocate the catch statistics to the different stocks, it was necessary to assume that recreational catches of cod recorded by the intercept survey were removed from the ocean in the fisheries Statistical Areas adjacent to the state and county of landing. For recreational catches landed in Massachusetts, which borders both stock areas, information from the intercept survey on the landing site was used to allocate catches for the state to the appropriate stock. Catches recorded at landing sites bordering Massachusetts and Cape Cod Bays were allocated to the Gulf of Maine stock: catches recorded at landing sites in other areas of the state were allocated to the Georges Bank and South stock. Using this allocation procedure, about 56% of the total recreational catch in weight of cod along the Atlantic coast during the period 1979-1990 was removed from the Gulf of Maine stock and 44% from the Georges Bank stock; however, the relative proportions were quite variable over time.

Length frequency sampling intensity was highly variable over the period, ranging from 100 fish measured per 298 MT of catch in 1983 to 100 fish per 3312 MT of catch in 1986 for the Gulf of Maine stock and ranging from 100 fish per 307 MT of catch in 1980 to 100 fish per 3009 MT of catch in 1982. An examination of the distribution of length frequency samples by state and fishing mode revealed potential for bias in the characterization of the estimated catch because the samples are not stratified in proportion to the catch. The distribution of the samples reflects the opportunistic nature of sampling for length frequencies in the MRFSS intercept survey.

A number of problems were identified relative to the use of MRFSS data to estimate the catch of Atlantic cod by stock:

1. due to the absence of sampling for January and February in the New England and Mid-Atlantic subregions, no estimates are available when some party boats may continue to land cod;

2. the current allocation scheme cannot properly categorize the catches of long range trips;

3. catch estimates for the Georges Bank and South stock have a relatively large CV; and

4. length frequency sample sizes may be too small to accurately characterize the catch, and are not distributed in proportion to the catch.

Discussion

In addition to the problems identified above, the discussion related to the need to weight trip specific data on catch from the survey before pooling catch frequency and length frequency data for higher analyses. There also was considerable discussion of the pooling and averaging of charter boat trips under the survey to reduce the effect of small sample sizes on the effort estimates for the charter boat fishery (there is a very low incidence of reported fishing activity in the party/charter modes by households contacted in the telephone survey). It was noted that averaging is a real problem for the party/charter mode. A comment was made that it should be possible to verify the estimates for this mode given the relatively limited number and accessibility of the participants.

Plenary Conclusion

The MRFSS needs to better identify where the fish are caught and to report the catch in a manner compatible with the fishery statistical reporting areas.

Intercept sampling of the party/charter mode should give emphasis to deployment of interviewers on board the vessels.

The availability of state data and other possible sources of data to augment MRFSS catch length frequencies should be determined.

NMFS permit files and other possible sources of information on the party/charter boat fleets should be examined to determine the availability of information for use in development of reliable estimates of the party/charter boat catch and effort.

Reference

Atlantic States Marine Fisheries Commission. 1989. Handbook for Recreational Fisheries Statistics Programs of the Atlantic Coast. ASMFC Special Report No. 16, June 1989.

FOURTEENTH SAW TERMS OF REFERENCE AND TIMING

A list of possible species/stocks to review and special topics to address next was developed for the consideration of the SAW Steering Committee.

Suggested Species/Stocks to Review

The following species were identified for review at the next Stock Assessment Review Committee session:

Squid	Lobster
Mackerel	Pollack
Butterfish	Herring
Scallops	(if there is additional information on stock structure)

Special Topics

- Sea Sampling Analysis Working Group (WG #28)
  The Terms of Reference for this working group were develop at SAW-12. The group should address Term of Reference #1 -- "Determination of sample sizes with particular attention paid to precision, selection of more species and fisheries, and further analysis of the 1990 data base."

- Overview of the National Stock Assessment Workshop
  Dr. Andrew Rosenberg was requested to make this presentation.

- Standardization of SAW Documentation
  The goal is to determine what information is most useful to managers and how to present this information in the most simple and easiest to understand form. Dr. Fred Serchuk will take a look at SAW documentation (presentation of data in tables and graphs) and discuss how advice is presented in other organizations, i.e., ICES and CAFSAC.

Discussion

Although additional presentations on biological reference points and the possible need for a working group on the topic was discussed, it was concluded that, for the time being, it is sufficient to have addressed the topic at this SAW. The primary goal of the next SAW should be the species review and with the Plenary agenda remaining "under-topiced", leaving room for important items that would come up in the next few months.

The need for holding a regional workshop on common assessment procedures such as ADAPT or Laurec-Shepherd tuning was brought up and the possibility of NEFSC hosting such a workshop was discussed. It was, however, noted that a variety of analytical methods are already performed at the SARC meetings which scientists should be encouraged to attend as a form of education and training. NAFO, it was reported, also holds training sessions on assessment methodology and thought has been given to training on the National level for people from NMFS and the states.

Discussion of standardization of SAW documentation lead to the conclusion that this may be an ongoing dialogue for some time.

Timing

Barring conflicts with meetings already planned, it was recommended to hold the next SARC session in mid-June and the Plenary in mid-July.

OTHER BUSINESS

The Plenary recognized Dr. Andrew Rosenberg for his excellent leadership and significant contribution to the SAW process. Dr. Rosenberg chaired three SAWs, beginning with SAW-11 when the current structure was introduced. Recently, Dr. Rosenberg was re-assigned within NMFS from the Northeast Fisheries Science Center to the Office of Research and Environmental Information. His new duties include organizing and convening the National Stock Assessment Workshop and developing and editing the National Status of Fisheries Resources report.

STOCK ASSESSMENT REVIEW COMMITTEE CONSENSUS SUMMARY OF ASSESSMENTS

INTRODUCTION

The Stock Assessment Review Committee (SARC) of the 13th Regional Stock Assessment Workshop (SAW) met at the Northeast Fisheries Science Center, Woods Hole, Massachusetts during December 2-6, 1991. The twelve SARC members represented a number of fisheries organizations in the USA and one in Canada (Table S1). In addition to the SARC, more than sixty individuals attended the meeting, many of whom made significant contributions to the review.

The agenda for this session included review of eight species/stocks of animals distributed in inshore and offshore waters from the Gulf of Maine through the Mid-Atlantic (Table S2). Nineteen papers (Table S3) were presented by scientists involved in the work on the species/stocks under review. Presentations included full and revised assessments, preliminary work for estimating harbor porpoise by-catch, an analysis of yield and spawning stock biomass per recruit, and a computer program for calculating yield and spawning biomass per recruit.

The SARC technically evaluated all information presented and determined: the best current assessment of the resource, the major sources of uncertainty in the assessment, and how these uncertainties might affect the picture of stock status. In response to technical questions that were raised, the Committee considered it necessary to perform analyses in addition to those presented. These analyses were intended either to implement specific recommendations for improving the existing analyses or to explore sources and effects of uncertainties.

Table S1

SAW-13 STOCK ASSESSMENT REVIEW COMMITTEE

Andrew Applegate	New England Fishery Management Council
Peter Colosi	Northeast Regional Office, NMFS
Ray Conser	Northeast Fisheries Science Center, NMFS
Wendy Gabriel	Northeast Fisheries Science Center
Stratis Gavaris	Dept. of Fisheries and Oceans, Canada
Tom Hoff	Mid Atlantic Fishery Management Council
Anne Hollowed	Alaska Fisheries Science Center, NMFS
Anne Lange	Maryland Dept. of Natural Resources/ASMFC
Andrew Rosenberg (Chair)	Office of Research and Environmental Information, NMFS
David Stevenson	Maine Dept. of Marine Resources/ASMFC
Mark Terceiro	Northeast Fisheries Science Center, NMFS
Gordon Waring	Northeast Fisheries Science Center, NMFS

Table S2.

13th NORTHEAST REGIONAL STOCK ASSESSMENT WORKSHOP

STOCK ASSESSMENT REVIEW COMMITTEE SESSION

NEFC Aquarium Conference Room
Woods Hole, MA

December 2 (9:00 AM) - December 7, 1991

AGENDA

Monday, December 2

OPENING	Chairman	A. Rosenberg
SPECIES/STOCK	SOURCE/PRESENTER(S)	SUGGESTED RAPPORTEUR(S)
Porpoise By-Catch	NEFC/T.Smith,K.Bisack	W.Gabriel/ A.Hollowed
Black Sea Bass	NEFC/G. Shepherd	A. Applegate/ A. Rosenberg

DISCUSSION, CLARIFICATION

Tuesday, December 3

Summer Flounder	NEFC/W. Gabriel	A. Lange/ A. Rosenberg
Sea Herring	ME DMR/D. Stevenson NEFC/K. Friedland	T. Hoff/ R. Conser
Haddock	NEFC/D. Hayes	S. Gavaris/ P. Colosi

REPORTS - DISCUSSION, CLARIFICATION

Wednesday, December 4

Cod - Georges Bank	NEFC/F.Serchuk, R. Mayo, S. Wigley	M. Terceiro/ A. Applegate
Sea Scallops -	NEFC/S. Wigley	D. Stevenson/ A. Rosenberg

REPORTS - DISCUSSION, CLARIFICATION

Table S2 (Continued).

Thursday, December 5

Winter Flounder	Working Group/ P. Howell, M. Gibson, S. Correia	P. Colosi/ R. Conser

REPORTS - DISCUSSION, CLARIFICATION

Friday, December 6

ADDITIONAL SARC ANALYSES

FINALIZE REPORTS

REVIEW REPORTS AND FINALIZE CONSENSUS SUMMARY OF ASSESSMENTS

Saturday, December 7

IF NECESSARY, COMPLETE CONSENSUS SUMMARY OF ASSESSMENTS

Table S3.

SAW-13 SARC PAPERS

SAW/13/SARC 1	Application of a Length Based Yield and Spawning Biomass per Recruit Model for Black Sea Bass, a Protogynous Hermaphrodite	G. Shepherd J. Idoine
SAW/13/SARC/2	Stock Assessment of Inshore Winter Flounder	P. Howell M. Gibson D. Witherell
SAW/13/SARC/3	Report of the Stock Assessment Workshop (SAW) Summer Flounder Working Group (WG #21)	Working Group
SAW/13/SARC/4	Overview of the Assessment of Harbor Porpoise Status	T. Smith
SAW/13/SARC/5	Overview of Information Sources for Estimation for Harbor Porpoise By-catch in the Gulf of Maine Sink Gill Net Fishery	T. Smith
SAW/13/SARC/6	Harbor Porpoise Historical Survey	R. Barnaby
SAW/13/SARC/7	Estimating Total Effort in the Gulf of Maine Sink Gillnet Fishery	K. Bisack G. DiNardo
SAW/13/SARC/8	Utilization of Observer Program Information to Characterize Gulf of Maine Sink Gillnet Effort	S. Drew
SAW/13/SARC/9	Interim Exemption for Commercial Fisheries	H. Kaufman G. DiNardo
SAW/13/SARC/10	Withdrawn	
SAW/13/SARC/11	Observer Coverage and Entanglements of Marine Mammals in the Gulf of Maine/George's Bank Sink Gillnet Fishery	G. Power S. Drew
SAW/13/SARC/12	Some Problems with Using Federal and State Permit Systems for Vessel Identification	J. Walden
SAW/13/SARC/13	Assessment of the Georges Bank Haddock Stock 1991	D. Hayes N. Buxton

Table S3 (Continued).

SAW/13/SARC/14	BIOREF - A model to estimate the effects of discard mortality on biological reference points	S. Correia
SAW/13/SARC/15	Tuning Index for Atlantic Herring	K. Friedland D. Stevenson
SAW/13/SARC/16	Assessment of the Coastal Atlantic Herring Stock	D. Stevenson M. Lazzari
SAW/13/SARC/17	Current Resource Conditions in USA Georges Bank and Mid-Atlantic Sea Scallop Populations: Results of the 1991 NEFSC Sea Scallop Research Vessel Survey	S. Wigley F. Serchuk N. Buxton
SAW/13/SARC/18	Revised Assessment of the Georges Bank Cod Stock - 1991	F. Serchuk R. Mayo S. Wigley L. O'Brien N. Buxton
SAW/13/SARC/19	Stock Assessment of Winter Flounder in Rhode Island 1991: A Report to the RI Marine Fisheries Council	M. Gibson

HARBOR PORPOISE

Preliminary analyses for the estimation of by-catch of harbor porpoise in the Gulf of Maine sink gillnet fishery were presented to the SARC for evaluation, comments, and recommendations (SAW/13/SARC/4 through 12). The primary work to date has been estimating fishing effort to combine with rate kills per unit of effort estimates to obtain total kill by the fishery. Several shortcomings of the effort data were discussed. The SARC recommended some alternative approaches to the estimation problem and recommended some sampling experiments to be conducted to calibrate the database.

Background

Harbor porpoise (Phocoena phocoena) occur in several areas in the northwestern Atlantic, and are killed as by-catch in several fisheries in the U.S. and in Canada. The sink gillnet fishery in the Gulf of Maine is the principal fishery causing by-catch of harbor porpoise. An assessment of the potential magnitude of by-catch of harbor porpoise by fisheries was required as part of planned NMFS "status review" under the Marine Mammal Protection Act (MMPA) and the Endangered Species Act (ESA). Furthermore, under the 1988 amendments in the MMPA, the Gulf of Maine sink gillnet fishery was designated as a category I fishery. This classification requires sufficient mandatory observer coverage to estimate by-catch.

An initial indication of the potential impact of fisheries by-catch on harbor porpoise was evaluated from the ratio of total by-catch to total population. The by-catch mortality was compared with estimates of replacement from reproduction to provide an indication of current resource conditions. New, but preliminary, estimates of total by-catch are higher than previously thought, but new estimates of abundance are also substantially higher then previously available (NEFSC 1991). These estimates, however, were not reviewed by the SARC.

Biological Reference Points

Marine mammal populations are classified under the MMPA based on whether or not the population size is within range of the optimal sustained population size (OSP). OSP is based on the ratio of the current population to "pre-exploitation" population size. If, based on the ratio of the current population to historic population size, the population is below OSP, then it is classified as depleted. The ESA provides a more general classification of the status of the species. Two classifications have been defined under ESA: threatened, and endangered. There are no precise criteria for listing a species as threatened or endangered under the ESA.

Estimates of harbor porpoise OSP have been based on information from: a) historical levels of porpoise by-catch, b) reproductive rates, and c) total population size (Smith 1983). For harbor porpoise, this approach is currently less feasible because estimates of historical levels of by-catch, reproductive rates, and natural mortality may not be reliable. It is not clear that back-calculation of historical by-catch can be conducted due to the lack of historical by-catch rates and probable changes in fishing practices and technology.

To complete the MMPA status review, the simple ratio of total by-catch to total population size has been used to provide an initial indication of the likely biological significance of the by-catch. This approach provides a static picture of current conditions, and does not provide any indication of likely trends in abundance or potentially depleted conditions due to historical by-catches. Consequently, this approach has not generally been considered adequate under the requirements of the MMPA. It may, however, be the only analysis that can be supported by currently available data sources. (Long-term programs to monitor abundance and obtain other supporting life history information have been implemented to provide a firmer basis for determining population status in the future.)

Methods of Estimation of Ratio of By-Catch to Population Size

Population size is assumed to be estimable from sighting survey data with a CV of approximately 30%. By-catch can be estimated as a function of kill rate within the fishery. Kill rate (as kills per trip) has been estimated with a CV of approximately 24%, from a sea sampling program established in the second half of 1989. As the program coverage is expanded from 1% of fleet in 1989-90 to 10% of the fleet in 1991, the CV is expected to decline. Porpoise kills are also reported in the Marine Mammal Exemption Program (MMEP) logbooks, although this information is used to estimate kill rates at present.

The SARC noted that kill rate could be evaluated in several different units for expansion to an estimate of total kill by the fishery. Two principal bases for expansion were noted: effort and catch. This report summarizes the adequacy of the currently available data and possible estimation methods in assessing by-catch mortality. Several recommendations concerning improving data and analysis are made.

Estimation of total effort

Effort can be measured using several different metrics: 1.) number of vessels participating in the fishery, 2.) number of trips, 3.) number of vessel days absent, 4.) number of vessel days fished, and 5.) number of gear (string) hours fished.

The analysis to date has only been conducted for vessels greater than 5 GRT. Four data sets were examined with respect to precision and accuracy with which each metric was estimated: 1.) Federal fishery permit; 2.) Marine Mammal Exemption registry/logbook; 3.) NEFSC weighout report and 4.) NEFSC sea sampling (Table SA1). A Federal permit is required in order to fish for regulated species, but does not necessarily indicate participation in the fishery. A marine mammal exemption certificate and completed logbook is required in order to participate in the sink gillnet fishery. The NEFSC weighout report is a voluntary report of landings and fishing activity obtained from records of fish buyers or face-to-face interviews with fishery participants. The NEFSC Sea Sampling Investigation coordinates a mandatory Gulf of Maine sink gillnet fishery under the MMEP. Voluntary compliance has been good and no enforcement actions have been necessary.

The number of vessels participating in the fishery is poorly defined by any of the data sets examined. Although it would be expected that not all Federal permit holders would actually participate in the fishery, it would be expected that most sink gill net fishery participants would have both MMEP logbooks and federal permits, and that a subset of those participants would be detected by the weighout program. In 1990, about 25% of the participants indicating activity through MMEP logbooks were not detected under the weighout program (Figure SA1). However, in 1990, 40% of vessels appearing in the weighout data base as participants in sink gill net fisheries in the Gulf of Maine had neither federal permits nor MMEP logbook submissions. This may occur when fishermen are not targeting on regulated groundfish species, for example. The sea sampling program is not designed to achieve 100% coverage of the fishery. In 1990, the NEFSC weighout program detected the largest number of known active participants in the sink gillnet fishery in the Gulf of Maine.

Estimates of total number of trips by the entire fishery are presently only available from NEFSC weighout data. This system tracks most landings; however, trips with very small or no landings of saleable fish are not recorded. Reporting by fish buyers is voluntary, although the level of participation is high. Trip information is not recorded under the federal permit program. Under the present computerized MMEP data entry system, there were cases where information from consecutive trips without mammal takes was combined into a single record. As well, although data were originally requested on a per trip basis, some respondents aggregated information on a monthly basis. Those data were entered as a single month-long "trip". Numbers of NEFSC sea-sampled trips are available, but reflect only sampling intensity rather than total fleet activity.

Estimates of number of days absent by the entire fishery are not comparable among data bases; and for this fishery, do not reflect time gear was actually in the water. Federal permit data do not include any estimates of effort, either as days absent, days fished or even actual participation. Under the MMEP data entry system, days absent were not directly reported and were estimated with levels of resolution from day to month, depending on how information was aggregated. Data collection under the NEFSC weighout system emphasizes direct observation of species composition, tonnage and price of landings rather than associated effort, which, for non-interviewed trips, may be estimated only indirectly by port agents, based on their experience and ancillary interview data. In the NEFSC sea sampling data base, days absent (per trip) reflect only the time the vessel was away from the dock, rather than the time gear was fishing; e.g., a vessel could be absent one half day to set gear and a second half day to haul gear; but gear could be fishing any amount of time between being set and hauled.

Under the MMEP data system, fishermen are asked to report the number of hours gear was in the water. In the NEFSC weighout data base, as with days absent, days fished may be estimated indirectly by the port agent for trips when direct interview data are unavailable. Under that system, days fished correspond to decimal fractions of a 24 hour period of gear operation. In the NEFSC sea sampling system, the observer reports the skipper's estimate of hours of gear operation (which can be converted to decimal fractions of a 24 hour day) as well as the amount of gear operated. This is the finest scale estimation of effort, as hours fished per string of gear.

To evaluate the feasibility of calibrating weighout effort estimates of decimal fractions of days fished (estimated over the entire fishery with potentially less reliability) to hours fished using sea sampling data (estimated over a subset of the fishery with high accuracy), the SARC compared respective effort estimates for trips for which both sea sampling and weighout data were available. The relationship between the two estimates was poor. The relatively coarse scale of resolution within the weighout data base was insufficient to estimate soak time in hours (as estimated by the sea sampling program). Variance in soak times is removed in the weighout reporting system; weighout effort estimates appear biased toward 24 hour periods. (If it is critical to measure effort as hours of soak time, a coarser alternative method would be to estimate average soak time per trip from sea sampling data and then re-scale the number of trips estimated from the weighout data base accordingly.)

The SARC concluded that at this point, number of trips as estimated from the weighout data base appears to be most the most accurate metric of total effort in the sink gillnet fishery. That program provides the highest estimate of known active participants; and although resolution of effort at the level of number of trips is coarse, estimates are available for all tonnage classes in the fishery and are more likely to be based on direct observation than estimates of days fished.

Estimation of total landings

The SARC believes that at present, total landings in the sink gill net fishery are more completely and accurately monitored than total effort. Consequently, an alternative and probably preferable method of estimating total kill would be based on some form of kill rate per ton of fish landed (e.g., based on the NEFSC sea sampling data set); and subsequent calculation of total kills as a function of total tons of fish landed by the Gulf of Maine sink gill net fishery. Appropriate stratification by sub-fisheries and seasons, in terms of kill rates, species targets and/or species composition of landings, should be investigated.

Estimation of kill rates

The current estimation procedure utilizes a simple estimate of the total kills per tons landed (or per unit effort), based on sea samples. The sea sampling data base contains a large number of zero observations (no kills). Alternative models for evaluating the data should be explored under assumptions of different distributions of the probability of encounter.

The underlying distribution of kill rate in 1990 is difficult to evaluate from the small number of non-zero observations currently available (17). Likewise, any definitive evaluation of behavior and tradeoffs between alternative estimators of kill rates cannot presently be made because of the small (non-zero) data set. Meanwhile, potential alternative distributions and estimators should be identified (e.g., average kill rates as summed kills over summed landings, delta distribution estimators, etc.) if data from increased coverage during 1991 are adequate to begin to address these questions.

Similarly, current data are insufficient to identify more homogeneous segments within the fishery to serve as bases for stratification, e.g., time, area, target species. Stratification schemes should be developed ~~simultaneously for both kill rate and expansion metrics (effort or catch). It may be necessary to expand further~~ the sampling effort in a single year to define appropriate strata, distributions and/or estimators.

At present, there is no sensitivity analysis of effects of error in kill rate estimates on overall estimates of kill. The precision of kill rate and the precision of catch or effort metric(s) will both influence the precision of the estimate of total kills. The SARC noted that the cited 24% sampling CV applied to the estimate of kill rate was not a direct estimate of measurement error: a low CV did not seem consistent with the paucity of non-zero observations with respect to kill rate. The SARC was also consequently uncertain about the accuracy of the expected decrease in CV anticipated under increased sea sampling coverage. The degree of precision will be related to the types of estimators used. The nature of the estimator(s) is still undefined however.

Problems and Recommendations

1. For estimates of total catch or effort, current census and sampling programs do not include all catch and effort. Weighout data are known to be incomplete (e.g., in 1990, 48 of 140 sea-sampled trips were not present in the weighout data base), but the extent of the deficiency (beyond catch reported as general canvas data) is unknown.

Recommendations:

- o Estimate how much catch and effort is being missed by the weighout data collection system, including extent of under-tonnage effects.
- o Improve correspondence between estimates from other data sets (e.g., MMEP).
- o Use additional sources of information, e.g., New Hampshire gillnet questionnaire program (census); NEFSC sea sampling vessel lists and contact program; supplemental telephone surveys; port visits.

2. For estimates of kill rates, low coverage rate and small sample size (non-zero observations) in 1990 sea sampling data (Table SA2) precludes identification of appropriate distributions, estimators and stratification schemes; and may not reflect activity and behavior of entire fleet.

Recommendations:

- o Examine 1991 sea sampling data for adequacy of coverage with respect to estimation problems above.
- o Implement more intensive sampling (single year or more) if necessary.
- o Identify appropriate underlying distributions, estimators.
- o Describe behavior of alternative estimators, and tradeoffs between different estimators.
- o Examine stratification schemes, e.g., area, season, target species, etc.

3. For estimates of total kill, total expected CV is unclear, and may be underestimated given the observed distribution of kill rate.

Recommendations:

- o Undertake sensitivity analysis of effects of error in component estimates on overall estimates of total kill, including alternate estimators.
- o Compare estimates of total kill based on kills per catch weight vs. kills per trip.
- o Compare actual CVs in kill rates observed under 1% vs. 10% sea sampling coverage.
- o Evaluate if additional sea sampling coverage is necessary (beyond 10%) to achieve target CV levels.

Other Models for Investigation

- o GLMs may be used to estimate the catchability coefficient (q) for harbor porpoise, incorporating season, area or other effects.

- o Production model approaches may be possible (although rates of decline must be large for application of Schaefer's work).

Literature Cited

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NEFSC. 1991. Preliminary Estimates of Harbor Porpoise Abundance and By-Catch. Northeast Fisheries Science Center Reference Document 91-04.

Table SA1. Comparison of characteristics of alternative sources of effort data for the Gulf of Maine sink gillnet fishery.

Attribute	Federal Permit Program	Marine Mammal Exemption Program	NEFSC Weighout System	NEFSC Sea Sampling Program
Number of vessels	Any vessel that may potentially harvest groundfish regulated under the NEFC Multispecies FMP	Any vessel that may potentially harvest groundfish and submits a logbook of activity in a sink gillnet fishery	Any vessel recorded in buyer's reports or port agent interviews (not available for under-tonnage vessel)	Any vessel participating in the sea sampling program
Number of trips	Not recorded	Data base info may be collapsed over several trips (raw data available for expansion)	Trips without fish caught or sold not observed; system designed to track landings; voluntary	Only a subset of trips are sampled
Days absent	Not recorded	Data base info may be collapsed or extrapolated over several trips; level of resolution varies from month to day	Estimated from port agent's best estimate or interview to nearest day; may vary agent by agent; not available for under-tonnage vessels	Observed directly, per trip; days in which gear is set (but not hauled) not observed
Days fished	Not recorded	Hours gear in water/24 (per trip) (ideally), estimated by fisherman; combined over trips in data base	Hours gear in water/24 (per trip); port agent's best estimate or direct interview; not available for under-tonnage vessels	Hours gear in water/24 (per trip); direct interview; number of strings of gear also recorded (finest scale effort information)

Table SA2. Incidental takes of marine mammals recorded by the NEFSC Sea Sampling Investigation

STATISTICAL AREA		511			512			513			514			OFFSHORE			521/538			TOTALS		
		HP	HS	O-MM	HP	HS	O-MM	HP	HS	O-MM	HP	HS	O-MM	HP	HS	O-MM	HP	HS	O-MM	HP	HS	O-MM
1989	JUN																					
	JUL																					
	AUG																					
	SEP																					
	OCT							1	2		2									3	2	
	NOV							1			1									2		
	DEC							2												2		
1990	JAN							2												2		
	FEB										1									1		
	MAR										2									2		
	APR							3			1									4		
	MAY																					
	JUN								1												1	
	JUL								3												3	
	AUG																					
	SEP				1															1		
	OCT							1			3									4		
	NOV							1			1									2		
	DEC										1									1		
1991	JAN							1			1									2		
	FEB										1									1		
	MAR							1												1		
	APR							2						1						3		
	MAY							3												3		
	JUN	2							2					2					1	4	2	1
	JUL	2	1		1	1	1		7	1										3	9	2
	AUG								4	1		3									7	1

OFFSHORE AREAS = 465, 464, 515, 522, 561, 562

HP = HARBOR PORPOISE
HS = HARBOR SEAL
O-MM = OTHER MARINE MAMMAL:

SPECIES	#	DATE TAKEN	AREA
WHITESIDED DOLPHIN	1	JUN 91	521
	1	JUL 91	513
	1	AUG 91	513
MINKE WHALE	1	JUL 91	512

VENN DIAGRAM SHOWING RELATIONSHIP BETWEEN THE 1990 FEDERAL PERMIT, WEIGHOUT, AND MMEP LOGBOOK DATA FROM THE GULF OF MAINE SINK GILLNET FISHERY

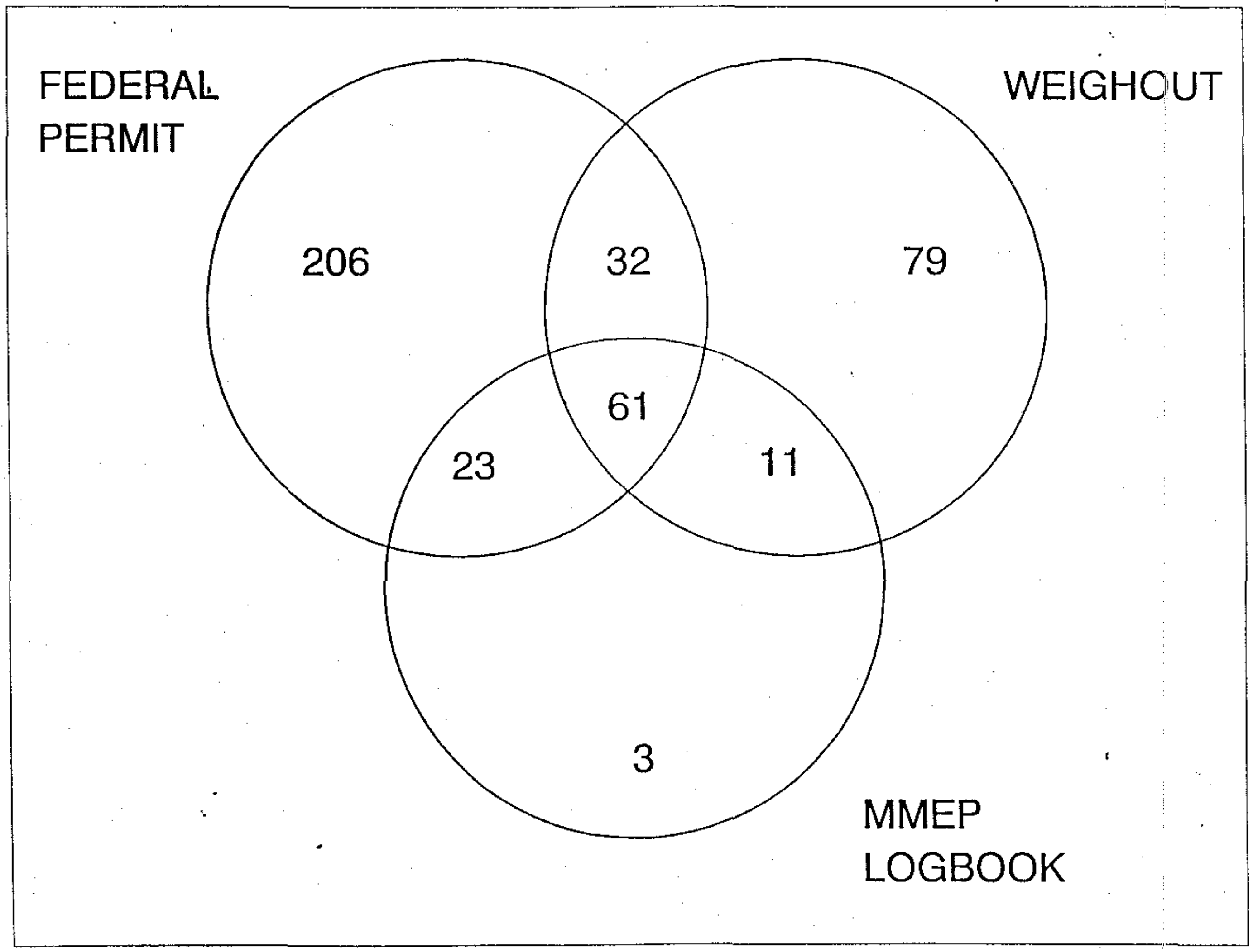

Figure SA1. Comparison of the number of individual vessels greater than 5GRT recorded in three data sources.

BLACK SEA BASS

An analysis of yield and spawning stock biomass per recruit based on a distributed delay model was presented to the SARC (SAW/13/SARC/1). This analysis has important implications for the development of biological reference points for hermaphroditic species.

Background

Black sea bass (Centropristis striata) occur over most of the east coast of the United States. Although some mixing possibly occurs, two stocks separated near Cape Hatteras, N.C. are believed to exist (NEFC 1990). In the Mid-Atlantic/New England stock, black sea bass are found in areas of hard bottom along the inner continental shelf. They commonly aggregate near bottom wreckage, e.g. sunken vessels and artificial reef material, and rock outcroppings.

A substantial portion of fishing mortality results from recreational hook and line fishing. Much of this fishing effort occurs aboard party boats that carry passengers for hire. Although most commercial landings consist of trawl caught fish, the directed commercial fishing is primarily conducted by setting traps near hard bottom areas.

Black sea bass are protogynous hermaphrodites with many individuals transforming to males after a brief transition period. Sex ratios among the smallest mature fish (approximately 12 cm) favor females (Mercer 1978, Wenner 1986). Because of differential growth rates between sexes, the sex ratio favors females at intermediate sizes but skews toward a male-dominated ratio as the fish undergo transition. A small component of the stock remains female throughout its life but reaches a lower maximum size (Table SB1).

Data Sources

The primary data needed for the distributed delay model prescribed in SAW/13/SARC/1 are growth rates (days per cm) and variances by 1 cm length category, probabilities of transition at length, a maturity ogive (at length) for females, a partial recruitment vector, and a natural mortality rate. Growth rates were derived from back-calculated lengths at age determined from samples taken in coastal Long Island during 1979-1980 (Alexander 1981) and calculated from inter-annuli distances with linear growth rates within annuli assumed. The delay (time in days to grow through a 1 cm interval) and variance estimates were extrapolated for size categories between the largest length in the data set and the maximum potential length.

Sex transition probabilities were estimated from a composite of the frequency of transitional stage fish recorded in field observations from the Mid and South Atlantic (Mercer 1978, Low 1981, Wenner 1986). Maturity at length data were estimated from samples of NEFSC bottom trawl surveys between 1982 and 1990 (O'Brien et al 1991).

Natural mortality (M) was assumed to be 0.3 at lengths less than 11 cm, and 0.2 at lengths of 11 cm to the maximum length because of sex change.

Methodology

A distributed delay model was used to simulate the flow of a cohort through successive stages defined by length. The amount of time individual fish remain within a length and sex category was determined from the delay within each length stage, mortality rates (fishing and natural), and probability of transforming from female to male through a brief (1 cm) transitional stage. Yield and total spawning biomass were calculated by aggregating the results for each individual in a cohort throughout all stages of the model, rather than an "average" representation.

The delay model differs from the traditional yield per recruit analysis (Thompson and Bell 1934) in that growth is a function of time in a fixed length interval rather than an average weight at a fixed time interval (i.e. age). This approach allows considerably more flexibility in parameterization of the model by length and sex to account for different growth, maturity and mortality rates.

Results

Estimates of F_{max} from the delay model were very similar to estimates using the traditional Thompson-Bell model (Table SB2). Moreover, yield per recruit was insensitive to the influence of transition (Figure SB1), in part due to similar growth rates between males and females at intermediate size. Spawning stock biomass per recruit estimates were highly sensitive to transition, especially at low to intermediate levels of F (Figure SB2). Varying the size at recruitment resulted in considerable changes in SSB/R. In general, transition affected the estimates of SSB/R by removing females from the spawning stock over and above removals from mortality. Therefore SSB/R at F=0 was much lower and SSB/R was nearly constant over a wide range of higher fishing mortality rates. When expressed as a percent of maximum spawning potential (%MSP), the spawning stock size per recruit at high F ranged from 25 to 70% rather than 10 to 45% estimated to occur without transition.

SARC Analyses

The initial 1:1 sex ratio starting conditions used in the model seemed to be inconsistent with the life history of a protogynous species. Due to the uncertainty, the SARC made additional runs of the delay models using a different sex ratio to determine the sensitivity to the initial sex ratio. There was little affect on yield per recruit using a 3:1 (F:M) ratio except that the percentage of females in the yield increased. Likewise, the influence on SSB/R was minimal.

Major Sources of Uncertainty

The SARC identified two additional sources of uncertainty in the parameters used for the model. A knife edge recruitment vector was used at 16, 25, and 32 cm. Length frequency data and the diversity of fisheries exploiting the black sea bass stocks suggested a sloped partial recruitment curve may be more appropriate.

Other protogynous fish primarily in tropical reef habitats exhibit transition rates which are dependent on the presence of dominant males within a restricted area. Since black sea bass are known to inhabit restricted hard bottom habitats and transform to large, dominant males at older ages, the probabilities of transition may shift with respect to size in response to the total population and available habitat. The estimates of SSB/R may be influenced by potential density dependent changes in the transition probabilities.

Recommendations

Standard analyses overestimate SSB/R and underestimate %MSP for any given level of F. The model results illustrate that for species with this type of complex life history, the control of spawning stock biomass is very sensitive to regulation by minimum size. Size restrictions falling between female maturation (12 cm) and the reduction in transition frequencies (38 cm) tend to be more effective in maximizing SSB/R than reductions in overall fishing mortality.

The protogynous life history of black sea bass suggests a selective advantage to limiting spawning stock biomass in favor of some other aspect. Within the current range of F, spawning stock biomass may not be a limiting ecological factor. If this is the case, a measure of spawning potential derived from SSB may not give a good measure of an overfishing target.

Improved length frequency data would provide an estimate of partial recruitment and improve the model's results. Because of the complex life history and the questionable importance of spawning stock biomass in contributing to spawning potential, the impact of male abundance on female maturation, growth, and transition rates may be important.

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Table SB1. Mean length at age from distributed delay model and mean back-calculated lengths at age (Mercer 1978).

Age	Distributed Delay Male	Distributed Delay Female	Backcalculated Male	Backcalculated Female
1	9.5	9.5	8.7	9.0
2	17.5	16.0	16.5	16.3
3	21.5	21.0	21.1	20.4
4	25.6	24.5	24.4	23.6
5	29.3	28.3	27.6	26.1
6	32.3	32.0	31.4	27.9
7	35.6	35.3	34.6	33.6
8	39.0	39.0	36.5	
9	42.0	42.2	38.4	
10	44.6	45.7		
11	47.6	48.7		
12	49.2			
13	51.7			
14	53.7			
15	55.8			
16	58.0			
17	60.0			

Table SB2. Estimates of F_{max} from distributed delay model with and without transitional phase and using Thompson-Bell model.

Size (age) at entry	Distributed Delay w/transition	Distributed Delay w/o transition	Thompson-Bell
16 (2)	0.16	0.17	0.17
21 (3)	0.20	0.21	0.21
25 (4)	0.25	0.27	0.26
28 (5)	0.31	0.33	0.33
32 (6)	0.45	0.47	0.45
35 (7)	0.63	0.64	0.63

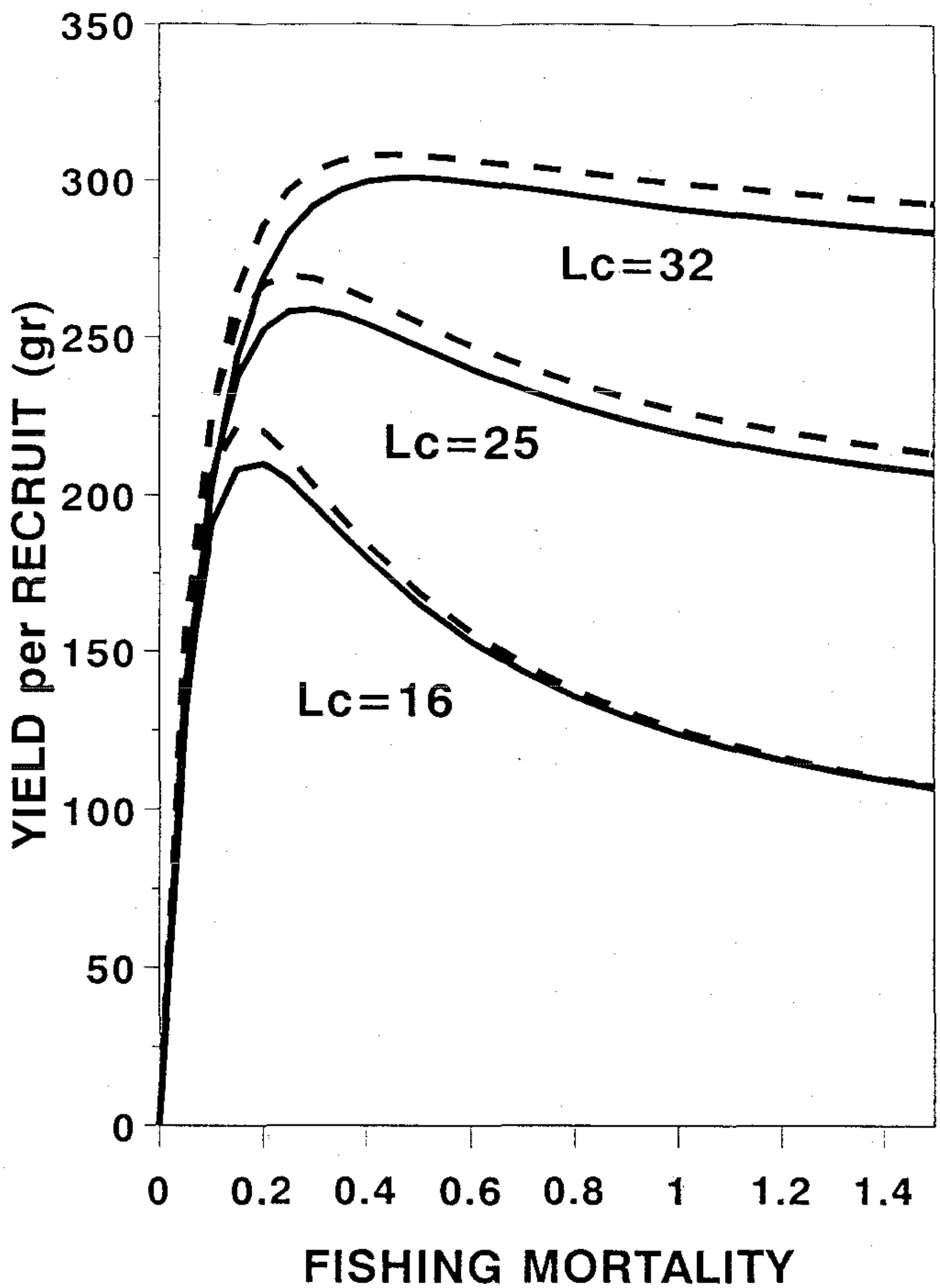

Figure SB1. Yield per recruit for black sea bass calculated by the distributed delay model without transitions (solid) and with a transitional phase (dotted). M=0.3(1-10cm) and 0.2(11-max length). Lc gives the respective length at first capture for each pair of lines.

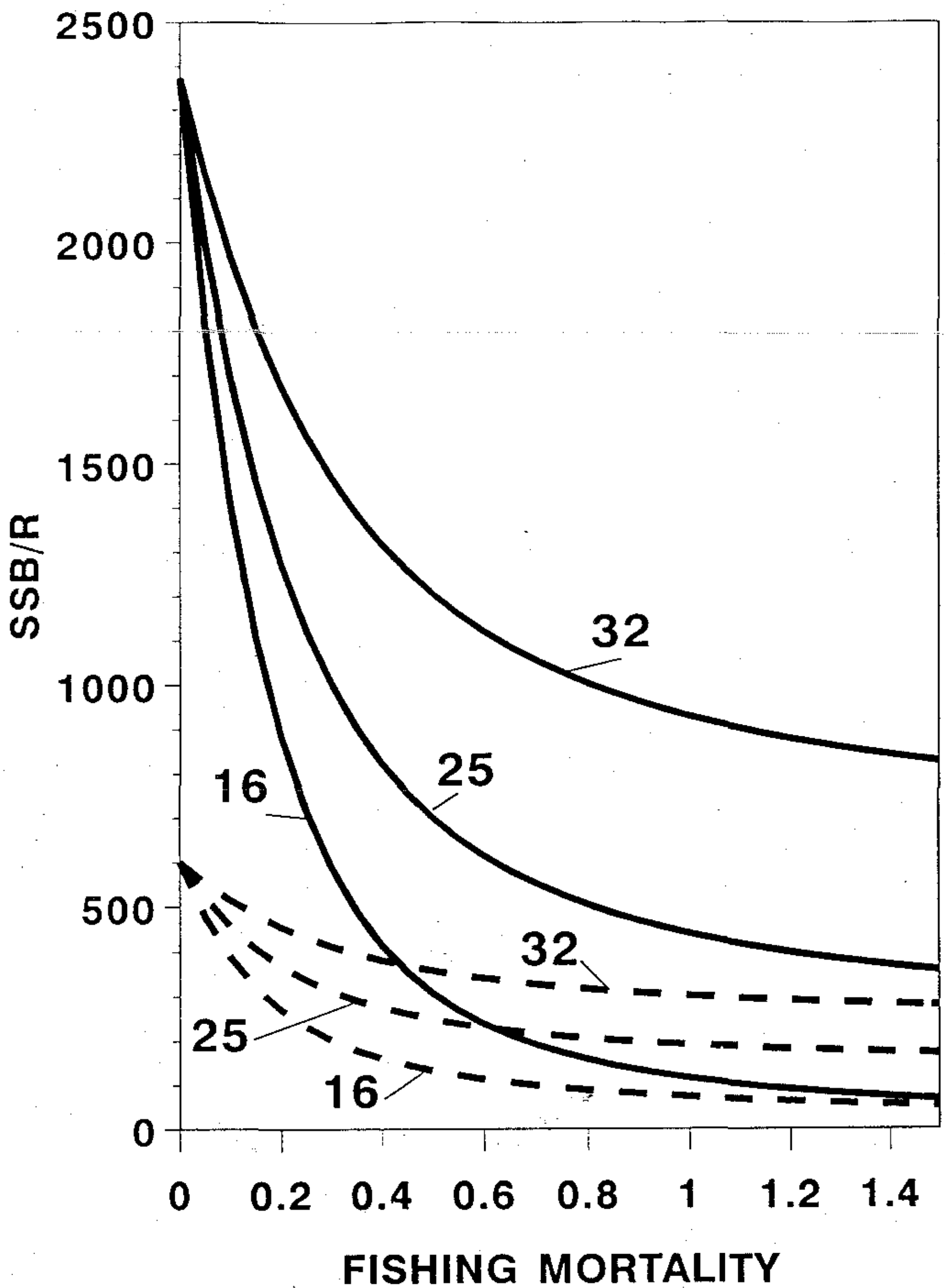

Figure SB2. Spawning stock biomass per recruit for black sea bass calculated by the distributed delay model without transition (solid) and with a transitional phase (dotted). M=0.3(1-10cm) and 0.2 (11cm-max length). The length at first capture for each line is indicated.

SUMMER FLOUNDER

An analytical assessment of the stock of summer flounder was presented to the SARC (SAW/13/SARC/3). The assessment was prepared by the Summer Flounder Working Group which includes state representatives from Maine to North Carolina, the New England and Mid-Atlantic Fishery Management Councils, and the Northeast Fisheries Science Center. Updated information from the commercial and recreational fisheries, and research vessel surveys from the NEFSC and five states were incorporated into ADAPT VPA tuning to provide age-specific fishing mortality rates and stock size estimates. Yield and stock size projections were made for 1991, 1992, and 1993.

Fishing mortality rates on fully recruited ages (2+) have generally exceeded 1.0 between 1982-1990 with the 1990 average at 1.1. Spawning stock biomass is low and the age composition is very truncated with few fish over age 3. The fishery is largely dependent on recent recruitment which has declined over the past decade.

Background

For assessment purposes, the previous definition of Wilk et al. (1980) of a unit stock of summer flounder extending from Cape Hatteras north to New England has been accepted. This species is fished from Maine to North Carolina. The majority of commercial landings are taken by otter trawl, but the recreational fishery accounts for about 40%, on average, of total landings.

The resource is managed, under the Mid-Atlantic Fishery Management Council's Fishery Management Plan for Summer Flounder, as a single stock unit from the southern border of North Carolina, northeast to the U.S.-Canadian border. Recent commercial landings have declined from a mean (1980-90) of 11,900 mt to 4,200 mt, in 1990. Recreational landings of 2,400 mt in 1990 were also well below the recent mean (8,100 mt).

Data Sources

Northeast Region (ME-VA) commercial landings for 1980-1990, were derived from the NEFSC commercial landings files. North Carolina commercial landings were provided by the NC Division of Marine Fisheries (NCDMF). Total commercial landings ranged from 10,000 to 17,000 mt during 1980-1988, but have dropped to 8,100 and 4,200 mt in 1989 and 1990. Recreational landings (A+B1 fish type, National Marine Fisheries Service, Marine Recreational Fishery Statistics Surveys (MRFSS)) which ranged from 6,000 to 16,100 MT during the 1980-1988 period, also showed a dramatic decline to 1,500 and 2,400 mt in 1989 and 1990 (Table SC1).

Discards from the commercial fishery during 1989-1990 were estimated using observed discards and days fished from sea sampling trips to calculate a fishery discard rate. This rate was applied to the total days fished in the fishery to provide an estimate of total fishery discard. Tests of accuracy of the procedure were made by comparing landings estimated from sea sampling trips with landings from the weighout data. Results indicate that sea sampling of summer flounder has been adequate to provide reliable estimates of discard during 1989 and 1990, and that total discards in mt were about 10% and 30% of the reported NER landings level. However, since estimates for discards are not available for 1982-1987, these recent estimates were not included in total catch for the assessment. Since excluding discards from the total catch probably results in underestimation of fishing mortality, continuation of sea sampling on summer flounder trips is recommended, so these estimates may be included in future assessments.

Age samples were available to construct the catch-at-age matrix for the NER (ME-VA) commercial landings for the period 1982-1990. (Table SC2a). A landings-at-age matrix for 1982-1990 was also developed for the North Carolina winter trawl fishery, which accounts for 99% of summer flounder commercial landings in North Carolina (Table SC2b), using NCDMF and NEFSC age-length data. The recreational catch-at-age matrix was developed from MRFSS sample length frequency, NEFSC commercial age-length and NEFSC survey age-length data (Table SC2c). The Working Group report gives full details of the calculations leading to the catch-at-age-matrices.

Northeast Region total commercial, North Carolina winter trawl, and recreational catch at age totals were summed to provide a total fishery catch-at-age matrix (Table SC2d). The numbers and proportions at age of fish age 4 and older are low and quite variable, reflecting the limited numbers of fish available to be sampled. For assessment purposes, ages 0-4 and an ages 5+ grouping were used in further analyses. Overall mean lengths and weights at age for the total catch were calculated as weighted means (by number in the catch at age) of the respective mean values at age from the NER (ME-VA) commercial, NC commercial winter trawl, and recreational (ME-NC) fisheries (Tables SC3a and SC3b).

Age-specific mean catch rates, in numbers, from the NEFSC spring offshore survey (Table SC4a; 1976-1991), the Massachusetts DMF spring and autumn inshore surveys (Table SC4b; 1978-1991), and the Connecticut DEP spring to fall trawl survey (Table SC4c; 1984-1991), were available as indices of abundance. Young-of-year survey indices were also available from two Virginia IMS surveys, (1980-1991 and 1986-1991), two North Carolina age 0 surveys (1981-1991 and 1987-1991), a Massachusetts beach seine survey (1982-91) and a Delaware DFW trawl survey (1981-1991). Survey results for each available time series were used to qualitatively detect recent trends in recruitment (Table SC5). Most surveys agreed that the 1980, 1983, and 1985 year classes were the largest of the past decade, with the 1988 year class the poorest since 1980.

A General Linear Model (GLM) of the MRFSS estimates of catch rate (mean catch number per angler per trip) was used to produce a standardized index of abundance based on year category regression coefficients for the Mid-Atlantic, private/rental boat fishery (Table SC6a). A standardized index of abundance for summer flounder was developed based on the NEFSC commercial weighout data base for the Northeast region (ME-VA), 1982-1990. Tonnage class 4 vessels fishing in areas South of Delaware Bay in 1990 were set as the standard cell. A GLM incorporating year, tonnage class, and fishing area main effects explained 26% of the variance in the observed catch per unit effort (CPUE), and indicated a recent pattern of decreasing stock size (Table SC6b).

Mean catch per trip was calculated for summer flounder harvested from the North Carolina winter trawl fishery. Vessels in this fishery are tonnage classes 2 and 3. Recent index estimates are lower relative to peak levels observed in 1983 and 1984 (Table SC6c).

Methodology

ADAPT tuning for the VPA was used. All survey, recreational, and commercial fisheries CPUE indices were included in the tuning procedure, weighted by the inverse of their residual variances. Natural mortality was assumed to be 0.2. Fishing mortality rates and abundances of ages 0-4 were estimated for 1990 in the tuning. The mortality rate on age 5+ fish was set equal to the rate for age 4.

Assessment Results

For the final VPA analysis, the fully recruited fishing mortality rate (ages 2+) in 1990 was estimated to be 1.1, decreasing from 1988 and 1989. Stock size in numbers has declined over the decade along with stock biomass (Table SC7). The abundance of the 1991 year-class at age 0 was estimated using the catchability coefficients estimated for each age 0 index by ADAPT. This year-class was about the same size as the 1990 year class. The coefficients of variation on the abundance at age estimates in the last year were around 30%.

Spawning biomass (males and females; mt), at the beginning (November 1) of the spawning season, over the time series was estimated as:

Year	1982	1983	1984	1985	1986	1987	1988	1989	1990
SSB	16334	22325	19433	16174	15436	15423	8297	7173	11351

The relationship between stock and recruitment is given in Figure SC1.

SARC Analyses

The SARC re-estimated the size of the 1991 recruitment at age 0 using ADAPT parameters. It was felt that the age 0 fish in the terminal year + 1 should be calculated in the same manner as for the other years, rather than by the RCRTINX procedure, as in the previous assessment. All input was the same as for the other years and the resulting estimate was 46.7 million fish(CV 27%), on January 1. The SARC tested the impact of including age 5 fish in the ADAPT tuning procedure since significant numbers of 5 year olds were seen in the catch-at-age matrix. However, the resulting CV for the age 5 group was so high (0.73) that nothing was gained by adding this year-class.

The SARC also incorporated the recreational CPUE (GLM) indices, by age, which provided 5 additional indices in the ADAPT tuning for the VPA. The recreational catch is a major portion of the total fishery removals. Addition of these indices resulted in slightly lower estimates of terminal F. The consensus of the SARC was to include these revised estimates in the final projections.

Projections

Catch and stock projections were made for 1991-1993 using the NEFSC projection program (Table SC8). One recruitment level, as estimated by ADAPT, was used for 1991. Recruitment in 1992-1993 was the geometric mean of level in 1986-1990. Partial recruitment was taken as the geometric mean of 1989-1990. Spawning biomass was projected to the peak of the spawning season. Two levels of fishing mortality rate were used, the status quo F in 1990 (1.07) and reference level F_{max}(0.23).

Major Sources of Uncertainty

Major sources of uncertainty identified by the SARC were:

- Although survey indices are weighted in the ADAPT run, this may not fully take account of very short series which appear to perform well in recent years. This may particularly be a problem in the estimation of recruitment and needs further investigation.

- The inability to include discards in the analysis.

Recommendations

- Continue sea sampling for summer flounder discards and continue to produce discard estimates.

- Consider development of a set of recommendations for criteria to be used for inclusion of specific indices in tuning methods for the VPA.

- Where possible, ADAPT should be used, rather than RCRTINX, to estimate recruitment in terminal year +1, to be consistent with the estimation of recruitment in the other years. ADAPT also takes into account, to some degree, the length of the time series.

- More maturity data.

- Since there is uncertainty in the inclusion of all indices and the status of the stock is changing (with only 2- year-classes in the fishery), the next assessment, for 1992, should be complete, rather than merely an update.

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Tabe SC1. Commercial and recreational landings (metric tons, A+ B1) of summer flounder, Maine to North Carolina (NAFO Statistical Areas 5, 6), 1980-1990, as reported by NMFS Fisheries Statistics Division (U.S.) and NEFC (foreign).

	U.S.				U.S.	
Year	Comm	Rec	Foreign*	Total	% Comm	%Rec
1980	14,159	11,722	75	25,956	55	45
1981	9,551	5,124	59	14,734	65	35
1982	10,400	8,573	35	18,973	55	45
1983	13,403	16,171	**	29,574	45	55
1984	17,130	13,099	**	30,229	57	43
1985	14,675	7,750	2	22,427	65	35
1986	12,186	7,971	2	20,159	60	40
1987	12,271	5,956	1	18,237	67	33
1988	14,686	8,356	**	23,042	64	36
1989	8,125	1,459	NA	9,584	85	15
1990	4,212	2,435	NA	6,647	63	37
Ave	11,891	8,056	16	19,963	60	40

NA = not available

* foreign catch includes both directed foreign fisheries and joint venture fishing.

** less than 0.5 metric ton

Table SC2a. Commercial landings at age of summer flounder (000s), ME-VA, 1982-90. Does not include discards, assumes catch not sampled by NEFC weighout has same biological characteristics as weighout catch.

	AGE										
YEAR	0	1	2	3	4	5	6	7	8	9	Total
~~1982~~	~~1,441~~	~~6,879~~	~~5,630~~	~~232~~	~~61~~	~~97~~	~~57~~	~~22~~	~~2~~	~~0~~	~~14,421~~
1983	1,956	12,119	4,352	554	30	62	13	17	4	2	19,109
1984	1,403	10,706	6,734	1,618	575	72	3	5	1	4	21,121
1985	840	6,441	10,068	956	263	169	25	4	2	1	18,769
1986	407	7,041	6,374	2,215	158	93	29	7	2	0	16,326
1987	332	8,908	7,456	935	337	23	24	27	11	0	18,053
1988	305	11,116	8,992	1,280	327	79	18	9	5	0	22,131
1989	196	3,284	4,775	578	61	5	1	1	1	0	8,902
1990	0	3,591	1,158	618	109	25	8	1	1	0	5,511

Table SC2b. Number (000s) of summer flounder harvested at age by the North Carolina winter trawl fishery, 1982-90. The 1982-1987 NCDMF length samples were aged using NEFC age-lengths keys for comparable times and areas (i.e, same quarter and statistical areas). The 1988-1990 NCDMF length samples were aged using NCDMF age-lengths keys.

	AGE								
Year	0	1	2	3	4	5	6	7	8	Total
1982	981	3,463	1,022	142	52	19	6	4	2	5,692
1983	492	3,778	1,581	287	135	41	3	3	<1	6,321
1984	907	5,658	3,889	550	107	18	<1	0	0	11,130
1985	198	2,974	3,529	338	85	24	5	<1	0	7,154
1986	216	2,478	1,897	479	29	32	1	1	<1	5,134
1987	233	2,420	1,299	265	28	1	0	0	0	4,243
1988	0	2,917	2,225	471	228	39	1	6	<1	5,878
1989	2	49	1,437	716	185	37	1	2	0	2,429
1990	2	142	730	418	117	12	1	<1	0	1,424

Table SC2c. Estimated recreational catch at age of summer flounder (000s), MRFSS 1979-90 (catch type A+B1+B2). Catch type B2 is allocated to age groups 0 and 1, with 25% hooking mortality.

	AGE									
YEAR	0	1	2	3	4	5	6	7	8	Total
1979	1,486	13,401	4,874	1,437	250	5	3	75	0	21,812
1980	5,595	8,143	5,509	1,733	1,044	400	1,022	200	133	24,406
1981	2,146	3,755	2,315	1,166	755	261	9	9	2	10,461
1982	2,802	8,728	5,678	440	167	<1	5	0	0	17,820
1983	9,541	17,374	2,857	231	2	<1	0	0	0	30,005
1984	9,746	15,250	3,619	1,233	393	157	106	0	0	30,504
1985	1,391	7,518	3,913	1,511	1,315	120	105	0	0	15,873
1986	3,788	6,651	2,394	1,472	108	371	120	12	0	14,999
1987	2,091	8,511	1,882	500	258	10	11	382	0	13,645
1988	3,167	7,156	3,167	708	288	44	44	10	0	14,584
1989	150	688	747	427	19	12	4	0	6	2,053
1990	250	4,469	566	118	4	6	1	0	0	5,414

Table SC2d. Total catch at age of summer flounder (000s), ME-NC, 1982-90.

	AGE										
YEAR	0	1	2	3	4	5	6	7	8	9	Total
1982	5,224	19,070	12,329	814	280	116	68	26	4	0	37,931
1983	11,989	33,271	8,790	1,072	167	103	16	20	5	4	55,437
1984	12,056	31,614	14,242	3,401	1,075	247	110	5	1	4	62,755
1985	2,427	16,933	17,510	2,805	1,663	313	135	5	2	1	41,794
1986	4,411	16,170	10,665	4,166	295	496	150	20	86	0	36,459
1987	2,656	19,839	10,637	1,700	620	34	35	409	11	0	35,941
1988	3,472	21,189	14,384	2,459	842	162	63	25	6	0	42,602
1989	348	4,021	6,959	1,721	265	54	6	3	7	0	13,384
1990	252	8,203	2,454	1,154	230	43	10	2	1	0	12,349

Table SC3a. Mean length (cm) at age of all landed summer flounder, ME-NC, 1982-90.

	AGE										
YEAR	0	1	2	3	4	5	6	7	8	9	MEAN LENGTH ALL AGES
1982	29.1	34.8	39.3	52.5	56.8	61.0	60.3	68.0	70.6		36.2
1983	28.0	35.1	41.9	48.9	50.3	53.6	60.6	65.1	69.4	72.0	35.0
1984	28.8	33.8	39.1	46.0	51.9	58.3	70.8	68.4	74.0	70.7	35.2
1985	30.3	34.6	38.7	46.5	54.5	58.9	68.1	74.5	73.3	75.0	38.0
1986	29.8	35.4	39.6	47.6	54.3	59.3	65.2	72.4	77.8		38.0
1987	29.2	35.3	39.6	46.5	55.6	63.1	66.5	70.6	73.5		37.5
1988	31.3	35.8	39.1	46.2	54.3	60.0	72.7	68.7	72.8		37.7
1989	32.0	38.0	40.7	45.7	49.3	58.5	56.6	63.1	59.0		40.6
1990	31.7	36.7	42.2	47.4	51.8	59.0	64.5	71.4	75.2		39.1

Table SC3b. Mean weight (kg) at age of all landed summer flounder, ME-NC, 1982-90.

	AGE										
YEAR	0	1	2	3	4	5	6	7	8	9	MEAN WEIGHT ALL AGES
1982	0.254	0.435	0.654	1.687	2.135	2.795	2.621	3.762	4.284		0.534
1983	0.218	0.447	0.786	1.297	1.466	1.706	2.567	3.169	3.875	4.370	0.475
1984	0.228	0.399	0.640	1.055	1.592	2.245	3.476	3.620	4.640	4.030	0.485
1985	0.282	0.426	0.612	1.092	1.782	2.343	2.670	4.682	4.780	4.800	0.611
1986	0.256	0.454	0.659	1.173	1.790	2.503	3.267	2.994	4.415		0.624
1987	0.237	0.445	0.651	1.121	1.933	2.852	3.080	3.020	4.140		0.557
1988	0.287	0.459	0.618	1.103	1.790	2.508	3.903	3.832	4.438		0.574
1989	0.318	0.550	0.707	1.038	1.391	2.451	2.257	3.105	2.251		0.715
1990	0.308	0.496	0.815	1.203	1.595	2.459	3.068	4.426	5.029		0.652

Table SC4a. Summer flounder spring offshore mean # per tow (fitted delta values), NEFC survey offshore strata 1-12, 61-76.

	AGE										
YEAR	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**TOTAL**
1976	0.03	1.50	0.60	0.25	0.06	0.01	0.01				2.46
1977	0.54	1.17	0.62	0.09	0.08	0.01		0.01			2.51
1978	0.52	0.71	0.49	0.14	0.03	0.02	0.02			0.01	1.92
1979	0.11	0.32	0.15	0.07	0.06			0.02			0.73
1980	0.01	0.64	0.28	0.13	0.02	0.05	0.03	0.01		0.01	1.18
1981	0.58	0.52	0.17	0.08	0.05	0.03	0.02	0.01			1.46
1982	0.53	1.09	0.09	0.02							1.72
1983	0.36	0.44	0.21	0.05	0.01				0.01		1.08
1984	0.24	0.46	0.13	0.07		0.01	0.01				0.93
1985	0.42	1.18	0.16	0.03	0.02						1.80
1986	1.23	0.36	0.17	0.02	0.01						1.78
1987	0.55	0.51	0.02	0.02							1.11
1988	0.43	0.58	0.05	0.02							1.07
1989	0.09	0.35	0.03	0.01							0.48
1990	0.62	0.03	0.06								0.71
1991	0.71	0.25		0.02							0.98

Table SC4b. MADMF Spring and Fall survey cruises, 1978 - 1991: stratified mean number per tow at age.

SPR					Age					
	0	1	2	3	4	5	6	7	8+	Total
1978		0.097	0.520	0.274	0.221		0.042			1.15
1979			0.084	0.087	0.147	0.048	0.011			0.37
1980		0.055	0.061	0.052	0.075	0.053	0.055	0.011		0.36
1981	0.010	0.395	0.558	0.074	0.031	0.043	0.060		0.031	1.17
1982		0.376	1.424	0.118	0.084	0.020				2.02
1983		0.241	1.304	0.544	0.021	0.009	0.003			2.12
1984		0.042	0.073	0.063	0.111	0.010				0.30
1985		0.142	1.191	0.034	0.042					1.41
1986		0.966	0.528	0.140	0.008					1.64
1987		0.615	0.583	0.012						1.21
1988		0.153	0.966	0.109	0.012					1.24
1989			0.338	0.079		0.010				0.43
1990		0.247	0.021	0.079	0.012					0.36
1991		0.029	0.048	0.010						0.09

FALL					Age					
	0	1	2	3	4	5	6	7	8+	Total
1978		0.011	0.124	0.024		0.007				0.17
1979			0.047	0.101		0.019				0.17
1980		0.114	0.326	0.020	0.020	0.010				0.49
1981	0.009	0.362	0.367	0.011						0.75
1982		0.255	1.741	0.016						2.01
1983		0.026	0.583	0.140	0.004					0.75
1984	0.033	0.453	0.249	0.120	0.008					0.86
1985	0.051	0.108	1.662	0.033						1.85
1986	0.128	2.149	0.488	0.128						2.89
1987		1.159	0.598	0.010	0.004					1.77
1988		0.441	0.414	0.018						0.87
1989			0.286	0.024						0.31
1990		0.108		0.012						0.12
1991	0.021	0.493	0.262	0.010						0.79

Table SC4c. CTDEP spring to fall (April - September) trawl survey, 1984-1991: delta mean number per tow at age.

Year	Age								
	1	2	3	4	5	6	7	8	Total
1984	0.609	0.201	0.042	0.027	0.014	0.005			0.98
1985	0.496	0.344	0.061	0.024	0.016	0.012			0.95
1986	1.775	0.278	0.107	0.020			0.004	0.004	2.19
1987	1.347	0.205	0.031	0.021	0.003	0.007			1.61
1988	0.680	0.382	0.064	0.034	0.006				1.17
1989	0.021	0.082	0.023	0.009	0.003	0.003			0.15
1990	0.524	0.205	0.037	0.013	0.007				0.78
1991	0.780	0.324	0.118	0.009	0.003	0.006			1.24

Table SC5. Summary of recruitment indices from state, federal and university research surveys, Cape Hatteras to Massachusetts.

	YEAR CLASS											
Survey	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
NEFC[1] (age 1)	0.58	0.53	0.36	0.24	0.42	1.23	0.55	0.43	0.09	0.62	0.71	
NEFC[1] (age 2)	1.09	0.44	0.46	1.18	0.36	0.51	0.58	0.35	0.03	0.25		
MASS[2] (age 1)	0.40	0.38	0.24	0.04	0.14	0.97	0.62	0.15	0.00	0.25	0.03	
MASS[2] (age 2)	1.42	1.30	0.07	1.19	0.53	0.58	0.97	0.34	0.02	0.05		
CT[3] (age 1)					0.50	1.78	1.35	0.68	0.02	0.52	0.78	
VIMS[4] (age 0)	1.94	1.45	1.12	0.92	0.37	0.35	0.44	0.19	0.17	0.26	0.66	0.54
MASS[5] (age 0)			3	3	1	19	5	5	2	3	11	4
VIMS[6] (age 0)							4.01	2.64	0.15	1.30	1.95	1.38
NC[7] (age 0)								13.25	1.70	4.77	4.56	5.92
NC[8] (age 0)		0.81	0.12	0.95	0.55	0.01	0.08	0.13	0.20	0.09	0.31	0.09
DE[9] (age 0)		0.18	0.06	0.19	0.04	0.07	--	0.14	0.18	0.01	0.21	0.41

1 Number per tow (fitted delta stratified mean number per tow), NEFC spring offshore trawl survey
2 Number per tow (stratified mean number per tow), MADMF spring trawl survey
3 Number per tow (delta mean number per tow), CTDEP trawl survey
4 Number per tow (stratified mean number per tow), VIMS historical trawl survey
5 Total number, MADMF beach seine survey (fixed stations)
6 Number per tow, VIMS young fish survey (fixed stations)
7 Number per tow (stratified mean number per tow), NCDMF Pamlico Sound trawl survey
8 Number per tow (delta mean number per tow), NCDMF Estuarine trawl survey
9 Number per tow, DEDFW 16 foot headrope trawl survey

Table SC6a. Indices of abundance (mean total catch number per angler per trip with upper and lower 95% confidence intervals) for summer flounder calculated from MRFSS 1979-88 intercept data (catch types A + B1 + B2). Indices calculated for the Mid-Atlantic private/rental boat strata, and for all subregion/mode strata coastwide. Coastwide indices are the product of retransformed year category regression coefficients estimated by a weighted least-squares regression model of log transformed mean total catch number per angler per trip (year, subregion, and fishing mode main effects) and the catch rate for the standard (1990, Mid-Atlantic, private/rental boat strata).

YEAR	MID-ATLANTIC (NY-VA) PRIVATE/RENTAL BOAT			COASTWIDE GLM INDEX		
	MEAN	L95	U95	MEAN	L95	U95
1979	4.755	4.387	5.123	3.885	2.908	5.093
1980	4.210	3.973	4.447	4.189	2.822	5.041
1981	4.241	3.996	4.486	4.519	3.308	6.026
1982	4.421	4.137	4.705	5.615	4.130	7.467
1983	5.243	4.929	5.557	5.634	3.989	7.734
1984	5.307	4.931	5.683	3.737	3.022	5.130
1985	3.324	3.106	3.542	3.571	2.622	4.756
1986	4.503	4.250	4.756	5.541	4.041	7.419
1987	5.965	5.632	6.298	4.874	3.493	6.619
1988	4.756	4.495	5.017	4.819	3.337	6.734
1989	2.145	1.992	2.229	3.189	2.411	4.141
1990	3.704	3.499	3.909	3.704	-----	-----

Table SC6b. General Linear Model (GLM) of commercial weighout landings and effort (10% trips) data to develop standardized index of abundance. Variation in CPUE is modeled as a result of year (YR), vessel tonnage class (TC), and fishing area (AREA; North and South of Delaware Bay) main effects, with no interactions. The corrected, transformed YR parameter estimates are used as indices of stock biomass (mt per day fished).

Dependent variable: LN CPUE

SOURCE	DF	SS	MSE	F	PR > F	R-SQUARE
Model	11	7774.6	706.8	1007.9	0.0	0.26
Error	31435	22042.4	0.7			
Total	31446	29817.0				

MODEL SS

VARIABLE	DF	TYPE I SS	F	PR > F
YR	8	3362.1	599.4	0.0
TC	2	3044.3	2170.7	0.0
AREA	1	1368.2	1951.2	0.0

Corrected, transformed YR parameter estimates

	Estimate	Lower 95% CI	Upper 95% CI
1982	3.757	3.675	3.859
1983	3.525	3.438	3.614
1984	3.210	3.133	3.288
1985	2.527	2.468	2.587
1986	2.259	2.206	2.313
1987	2.094	2.045	2.145
1988	2.000	1.953	2.048
1989	1.318	1.275	1.352
1990	1.000		

Table SC6c. Catch per unit effort (kg/trip) for summer flounder from the North Carolina winter trawl fishery, 1982-1990.

Year	Number of trips	Mean kg per trip	Standard deviation	Standard error	C.V.	Relative to 1990
1982	24	3,875	3,402	694	88	1.619
1983	30	5,489	5,998	1,095	109	2.293
1984	62	5,575	6,805	864	122	2.329
1985	60	3,185	3,219	416	101	1.330
1986	72	2,306	2,576	304	112	0.963
1987	91	2,435	3,091	324	127	1.017
1988	71	3,217	3,215	382	100	1.344
1989	76	2,772	2,679	307	97	1.158
1990	93	2,394	1,925	200	80	1.000
Mean		3,472				1.450

Table SC7. Estimates of instantaneous fishing mortality (F), beginning year stock sizes (000s of fish), and mean stock biomass (MT) for Summer Flounder as estimated from virtual population analysis (VPA), calibrated using the ADAPT procedure, 1982 - 1990.

(a) Fishing Mortality

■	1982	1983	1984	1985	1986	1987	1988	1989	1990
0 ■	0.0742	0.1498	0.2532	0.0577	0.0852	0.0642	0.3016	0.0138	0.0060
1 ■	0.6756	0.9140	0.7350	0.6819	0.6601	0.6704	1.0382	0.6890	0.5120
2 ■	1.5165	0.7839	1.5200	1.3252	1.3949	1.3913	1.8692	1.3157	1.3444
3 ■	1.1308	0.4743	0.8263	1.9617	1.6242	0.8935	1.9156	1.6161	0.8038
4 ■	1.5754	0.7461	1.3600	1.4585	1.5372	1.3493	2.0668	1.4367	1.0741
5 ■	1.5754	0.7461	1.3600	1.4585	1.5372	1.3493	2.0668	1.4367	1.0741
Mean F (unweighted) summed through age 5									
2 ■	1.4495	0.6876	1.2666	1.5510	1.5234	1.2458	1.9796	1.4513	1.0741
Mean F (weighted by N) summed through age 5									
2 ■	1.4923	0.7379	1.3482	1.4071	1.4614	1.3106	1.8872	1.3734	1.1310

(b) Stock Numbers (Jan 1) in thousands

■	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
0 ■	80738.5	95241.9	59559.3	47853.8	59694.9	47217.9	14737.6	28018.0	46512.1	46741.0
1 ■	42912.0	61376.2	67129.4	37854.3	36983.3	44882.8	36255.5	8924.6	22624.3	37852.9
2 ■	17457.0	17878.1	20145.8	26355.4	15670.8	15648.2	18795.8	10510.9	3668.5	11100.8
3 ■	1328.3	3136.9	6683.9	3607.3	5734.2	3180.1	3186.9	2373.5	2308.8	783.0
4 ■	390.2	351.0	1598.3	2394.9	415.3	925.2	1065.4	384.2	386.1	846.1
5 ■	290.4	306.8	533.0	640.5	1031.4	712.9	313.2	99.0	92.2	133.8
0+■	143116.5	178291.0	155649.5	118706.1	119529.9	112567.1	74354.5	50310.2	75591.9	97457.6
Sum of Stock Numbers through age 5										
2 ■	19466.	21673.	28961.	32998.	22852.	20466.	23361.	13368.	6456.	12864.

(c) Mean Biomass (MT)

■	1982	1983	1984	1985	1986	1987	1988	1989	1990
0 ■	17936.34	17520.19	10918.87	11896.28	13295.94	9834.46	3326.08	8021.59	12946.45
1 ■	12437.26	16543.58	17400.75	10715.15	11261.49	13336.90	9543.66	3251.67	8027.54
2 ■	5456.05	8942.83	6153.70	8274.32	5161.12	5097.86	4904.66	3825.91	1522.70
3 ■	1238.88	2959.46	4408.69	1612.45	3092.37	2167.79	1461.19	1135.94	1752.89
4 ■	389.73	332.74	1288.32	2083.26	352.60	909.22	754.14	262.97	348.13
5 ■	457.23	622.27	972.02	1205.27	1611.88	1186.20	454.58	122.58	195.30
0+■	37915.49	46921.06	41142.34	35786.73	34775.39	32532.43	20444.31	16620.66	24793.02
Sum of Mean Biomass through age 5									
2 ■	7541.89	12857.30	12822.72	13175.30	10217.96	9361.07	7574.57	5347.40	3819.03

Table SC8. Input parameters and projection results for summer flounder: landings and spawning stock biomass (mt). Starting stock sizes on 1 January 1991 are as estimated by VPA. Partial recruitment vector is the geometric mean of F at age, 1989-90. Recruitment levels in 1992-93 are estimated as the geometric mean of numbers at age 0 (000s) during 1986-90. F_{SQ} is F in 1990 (1.07) estimated for ages 2-5+ by VPA; F_{max} = 0.23, as estimated in the 1990 assessment reviewed by SAW 11; M = 0.20 for all ages (USDC 1990).

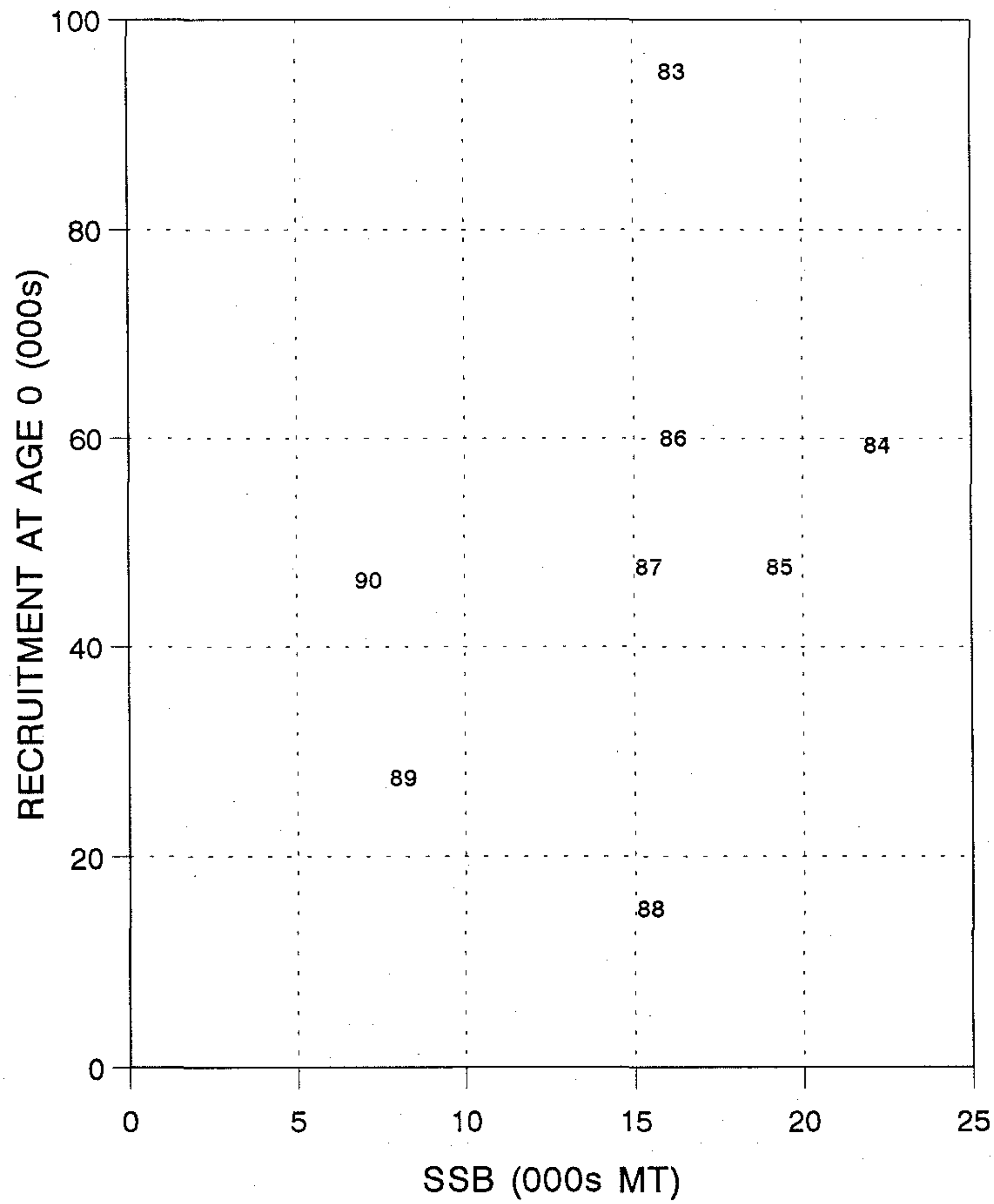
(a)

Age	Stock size in 1991	Fishing Mortality Pattern	Proportion Mature	Average Weights Stock and Catch
0	46741	0.03	0.38	0.237
1	37853	0.47	0.72	0.432
2	11101	1.00	0.90	0.642
3	783	1.00	1.00	1.164
4	846	1.00	1.00	1.811
5+	134	1.00	1.00	3.384

(b)

Recruitment in 1992-93	1991 (F_{SQ} = F1990) F	Land.	SSB	1992 F	Land.	SSB	1993 SSB
Low = 21345	1.07	12330	13265	F_{SQ} =1.07	16236	13475	11016
	1.07	12330	13265	F_{max}=0.23	4726	21539	29962
Mid = 35213	1.07	12330	13265	F_{SQ} =1.07	16331	14505	13951
	1.07	12330	13265	F_{max}=0.23	4747	22591	33727
High= 58090	1.07	12330	13265	F_{SQ} =1.07	16487	16205	18793
	1.07	12330	13265	F_{max}=0.23	4781	24326	39939

SUMMER FLOUNDER



FigureSC1: Stock and recruitment data for Summer Flounder. The datapoint labels indicate the year class of each cohort.

ATLANTIC HERRING

An analytical assessment of the aggregated stock complex of Atlantic herring from New Brunswick to Cape Hatteras was performed during the meeting and reviewed by the SARC. This assessment differed from previous analyses as an aggregated stock complex over the area was considered because the SARC concluded that the available catch data and survey indices were representative of mixtures of the herring spawning groups in the region.

The current fully recruited fishing mortality rate was estimated to be 0.13 for the stock complex. Recent recruitment has been strong, particularly the very large 1988 year-class. The assessment indicates that the abundance of the stock complex has increased rapidly in recent years. However, the SARC cautioned that, while overall abundance is high and harvest rate low, individual, local, stock units could easily be over-exploited.

Background

Important commercial fisheries for juvenile herring (primarily ages 2 to 3) have existed since the last century along the coast of Maine and New Brunswick. Development of large scale fisheries for adult herring is comparatively recent, primarily occurring in the western Gulf of Maine, on Georges Bank and on the Scotian Shelf. Extensive foreign fishing activity occurred on Georges Bank in the late 1960s where total landings from the stock complex peaked in 1967 at 373,600 mt. Recent domestic landings in coastal waters have been around 50,000 mt.

Traditionally, Atlantic herring (Clupea harengus) of the northeast U.S. coast have been assessed as two separate stocks - Gulf of Maine and Georges Bank. The species is widely distributed in continental shelf waters from Labrador to Cape Hatteras. Gulf of Maine herring migrate from feeding grounds along the Maine coast to Massachusetts Bay during autumn to the southern New England-Mid Atlantic region during winter, with larger individuals tending to migrate further distances (USDC 1991). Fish from the Gulf of Maine mix with fish from Nantucket Shoals and Georges Bank south of Cape Cod in winter.

Working Paper SAW/13/SARC/16 attempted an analytical assessment similar to the previous assessment of the "coastal" stock which included all herring found in NAFO areas 6, 5Y, and 5ZW, but not areas 5Ze or 4 (i.e., in coastal U. S. waters over the entire range of the species, but not in offshore waters on Georges Bank or in Canadian waters [USDC 1990 and Fogarty, et al. 1989]). After extensive review and discussion, the SARC consensus was that both the catch at age matrix and the spring survey indices of abundance reflect not only the "coastal" stock but also intermixing of fish from New Brunswick weir catches and Georges Bank stocks. The SARC, therefore, decided that the assessment should be based on an aggregate (4Xb) stock complex, including coastal, Georges Bank and New Brunswick weir caught fish.

Data Sources

Landings data for primary fishing areas are presented in Table SD1. Catch at age data were developed as in the previous assessment (NEFC 1990) and combined with catch data for New Brunswick weirs and Georges Bank (Table SD2). Weight and maturity at age data for the Gulf of Maine (Table SD3) were assumed to be representative of the entire stock complex.

Total reported domestic landings in 1990 were 54,410 mt with 22,400 mt landed in Maine, 31,310 mt in Massachusetts, and 700 mt in Rhode Island. An additional 11,475 mt were landed aboard foreign processing ships during winter Internal Waters Processing operations, 9,475 in Massachusetts and 2,000 mt in Rhode Island. The total catch was 65,880 mt, an increase of 12,425 mt over 1989. Maine domestic landings increased by 6,770 mt (43%) from 1989. Most of the growth in the Maine herring industry in recent years has been in bait landings: reported bait landings in Maine have increased from <500 mt a year during the 1970s to 15,587 mt in 1990 (SAW/13/SARC/16). Massachusetts domestic landings also increased dramatically (28%) between 1989 and

1990. Mobile gear (purse seines) continued to account for the great majority of the catch. Less than 1000 mt were landed by fixed gear (weirs and stop seines) fishermen in Maine in 1990 (Simard and Chenoweth 1991). The recreational fishery is insignificant.

Age at 50% maturity is 3 years and occurs when fish are approximately 26 cm (Table SD3b). The rate of natural mortality was assumed to be equal to 0.2.

Standardized bottom trawl surveys have been conducted in the spring by the Northeast Fisheries Science Center in offshore waters from Cape Hatteras to Nova Scotia since 1968. Autumn survey results, available since 1963, are not considered in this assessment since herring are highly aggregated at this time of year, in preparation for spawning; and the tuning of aggregation and spawning appears to have shifted, relative to tuning of the survey.

The Eleventh SAW SARC (NEFC 1990) expressed two principal concerns over the survey index which were addressed by working paper SAW/13/SARC/15. First, was the issue of which strata sets should be used to quantify the Gulf of Maine stock. Second, the SARC had recommended age disaggregated indices be investigated. In addition, SAW/13/SARC/15 investigated the relative fishing power of the research vessels **Albatross** and **Delaware** for herring.

The survey catch per tow was transformed for the difference in fishing power between the Albatross and Delaware by a factor of 0.54 (applied to Delaware catch). This factor was applied to individual tows since both vessels have been used on the same survey in some years. Survey indices were then computed as delta transformed kg/tow. The indices were smoothed with the integrated moving average model fit with a theta of 0.4.

The spring herring survey adjusted indices (Table SD4) are most appropriate for use in VPA tuning. The adjusted time series shows high catch rates in 1968 and 1969 followed by a long period of low catch rates and then increased abundance since 1986. An additional index of spawning biomass was obtained from the larval survey data collected during MARMAP cruises (NEFC 1990). These data are average number of larvae less than 10 mm over the survey area.

Survey strata were examined individually to determine if there were patterns in abundance by strata over time which might suggest a strategy for selecting a strata set to represent Gulf of Maine stock (SAW/13/SARC/15). The SARC concluded that there appears to be no objective criteria to separate non-stock herring from the tuning index for the Gulf of Maine stock by selection of survey strata. Because of intermixing, catch at age and survey data on herring represent samples from a stock complex over the range from New Brunswick to Cape Hatteras. The assessment using these data gives results for the aggregate stock complex.

Methodology

Separable VPA (Pope and Shepherd 1982) was used to determine the partial recruitment pattern in the terminal year. Estimates of abundance in 1990 for ages 4 to 6 were made in ADAPT. Herring were estimated to be fully recruited at age 2 and the exploration pattern was assumed to be flat-topped. Fishing mortality rates on ages 2 and 6 through 11 in 1990 were set equal to the average of ages 3, 4, and 5. (NEFSC spring survey indices on ages 2 to 6 and the larval abundance index were used for calibration in the ADAPT method [Gavaris 1988, Conser and Powers 1990] to estimate fishing mortality rates and abundance at age.)

Assessment Results

Fishing mortality rates for fully recruited herring (ages 2+) in the aggregate stock complex are estimated to have been 0.13 in 1990 and at similar levels in the previous 6 years (Table SD5a). Stock size estimates for 1990 at ages 4 through 6 had coefficients of variation around 60%. Recent good recruitment, particularly the

1988 year-class, has rebuild this stock complex substantially in numbers (Table SD5b) and biomass (Table SD5c).

Estimated spawning biomass (000s mt) projected to the beginning of the spawning season (October 1) is:

Year	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
SSB	847	642	502	489	338	135	215	281	139	78	47	33

Year	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
SSB	38	34	33	31	59	108	229	320	406	470	545	582

Figure SD1 gives the stock and recruitment data. Biological reference points have not been recalculated from the previous assessment ($F_{0.1}$=0.24).

Major Sources of Uncertainty

The need to perform an assessment on the aggregate stock complex because of the nature of the data was extensively discussed. While estimated fishing mortality rates are low on the aggregate, they are likely to be high on some localized components and managers must be alerted to this possibility. Localized overfishing could be occurring within the stock complex in spite of the overall good condition of the resource.

There is some uncertainty associated with lack of discard data for herring. Some discard from the mackerel fishery is known to occur but has not been estimated for this assessment.

The trawl survey was primarily designed for demersal fish and may give an imprecise (highly variable) index of pelagic fish abundance. However, because of the long time series of data and historical performance of the index, the problem is not as severe as with many other pelagic species.

The SARC was concerned about potential problems arising from the use of aggregate age-length keys from the surveys. An iterated age-length key approach should be explored in future work.

The weights at age used in the analysis did not include New Brunswick weir caught fish, which may have a different growth pattern.

Recommendations

- The SARC recommends that a SAW Working Group, which includes ASMFC, USA Federal and Canadian scientists, be formed to a) re-evaluate possibilities for assessing stocks on a finer scale than the aggregate complex and b) develop assessment data and methodology to improve the estimates of resource status.

- Alternative fishery independent indices should be examined for herring. More integration of the data from larval surveys and the Fisheries Ecology program into the assessment is desirable, particularly with respect to the evaluation of the Georges Bank stock.

- Data from internal waters processing needs to be collated and provided on a regular basis for incorporation into the NEFSC data base for assessment purposes.

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Table SD1: Catches of Atlantic herring (metric tons) from major fishing areas in the Gulf of Maine region, 1960-1990

YEAR	GULF OF MAINE/1	GEORGES BANK/2	NEW BRUNSWICK/3	NOVA SCOTIA/4
1960	60500	0	n.a.	n.a.
1961	27300	67700	n.a.	n.a.
1962	71900	152200	n.a.	n.a.
~~1963~~	~~70100~~	~~98000~~	~~29400~~	~~30300~~
1964	35100	131400	29400	57400
1965	34700	42900	3300	86400
1966	30500	142700	35800	150200
1967	36300	218700	30000	156700
1968	62100	373600	33100	196400
1969	56300	310800	26500	150500
1970	55800	247300	15800	190400
1971	51000	267300	12700	129100
1972	62400	174200	32700	153400
1973	32300	202300	19900	122700
1974	37200	149500	20600	149700
1975	36300	146100	30800	143900
1976	50300	43500	29200	115200
1977	50200	2200	23500	117200
1978	48400	2100	38800	95900
1979	63600	1300	37800	59000
1980	82100	1700	13500	79600
1981	63600	1700	19100	87700
1982	33000	700	26000	84700
1983	22700	1000	11400	84400
1984	31800	1600	8700	78100
1985	26000	200	27900	112400
1986	32600	200	27900	73700
1987	39600	--	27300	101200
1988	40200	--	33400	124700
1989	52100	--	44100	84500
1990	64700	--	48600	101900

Includes IWP catches & area 6 catches after 1986
2/Includes areas 5Z & area 6
3/Fixed gear only
4/Subject to separate assessment

Table SD2. Catch at age in millions of fish for the Atlantic Herring stock complex including New Brunswick wein catches and U.S. catch from Maine to Cape Hatteras, 1967 - 1990.

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
1	136.26	18.48	71.67	5.99	153.35	8.30	36.13	33.69	43.74	74.59	594.11	269.52
2	416.89	1373.80	578.06	489.16	232.10	996.74	344.91	424.27	637.71	522.85	569.29	1216.01
3	228.54	284.79	398.41	189.63	410.14	65.48	1304.07	146.70	119.66	250.48	83.73	141.40
4	209.71	180.91	234.42	493.96	327.59	165.62	294.16	751.72	112.53	47.70	71.30	26.57
5	130.68	397.19	300.77	296.38	333.70	261.95	76.94	78.79	610.98	49.62	21.28	42.29
6	270.46	266.92	309.62	151.93	222.06	209.44	47.39	18.52	46.41	209.53	18.73	6.17
7	389.40	464.73	216.87	128.14	135.93	126.30	36.23	9.15	17.44	10.44	50.46	8.22
8	50.20	356.11	215.26	79.23	69.38	55.57	19.64	5.62	9.41	3.36	2.66	32.14
9	11.55	25.11	130.01	69.75	26.39	32.22	4.87	3.08	5.59	2.57	0.71	1.09
10	10.39	9.10	29.33	32.41	30.41	23.71	5.56	0.47	0.71	0.68	0.39	0.64
11	0.17	0.65	1.03	2.88	3.53	1.65	0.35	0.39	0.45	0.21	0.34	0.23
1+	1854.25	3377.79	2485.45	1939.46	1944.58	1946.98	2170.25	1472.40	1604.63	1172.03	1413.00	1744.28

	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	7.04	340.13	61.66	52.76	31.42	18.88	29.95	40.73	50.32	79.87	27.39	12.68
2	1155.56	223.97	1147.28	662.38	265.13	177.77	560.76	245.49	222.44	504.37	473.84	551.42
3	425.95	359.34	36.47	112.20	59.32	131.96	85.29	225.39	134.98	109.61	149.44	197.92
4	59.50	185.83	67.45	6.82	29.37	40.35	51.52	48.40	178.85	61.64	70.23	98.38
5	15.97	22.51	48.44	30.26	1.28	29.80	26.53	38.57	45.19	121.49	67.42	35.21
6	17.09	6.25	5.73	19.37	6.71	2.28	13.56	16.08	20.25	36.95	130.29	39.73
7	6.52	8.77	1.67	2.31	7.36	4.78	1.20	7.62	6.11	10.16	32.99	79.94
8	4.51	1.35	1.49	0.45	0.35	1.97	2.45	0.46	2.57	2.49	9.07	32.14
9	6.98	0.75	0.13	0.90	0.18	0.61	0.76	0.49	0.29	0.51	2.66	18.18
10	0.35	4.64	0.16	0.13	0.14	0.18	0.10	0.19	0.33	0.20	0.26	5.69
11	0.10	0.11	1.04	0.18	0.10	0.14	0.17	0.34	0.10	0.17	0.35	1.95
1+	1699.57	1153.65	1371.52	887.76	401.36	408.72	772.29	623.76	661.43	927.46	963.94	1073.24

Table SD3(a). Weight at age in kg (Jan 1) for Atlantic Herring from the Gulf of Maine, 1967 - 1991.

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
1	0.002	0.003	0.004	0.014	0.012	0.028	0.009	0.010	0.017	0.012	0.010	0.008	0.004	0.009
2	0.020	0.011	0.017	0.025	0.032	0.031	0.043	0.029	0.029	0.031	0.027	0.025	0.020	0.018
3	0.058	0.041	0.044	0.064	0.085	0.077	0.074	0.076	0.071	0.076	0.066	0.071	0.060	0.057
4	0.092	0.105	0.055	0.115	0.138	0.147	0.143	0.135	0.135	0.131	0.135	0.138	0.154	0.123
5	0.141	0.151	0.189	0.103	0.198	0.205	0.209	0.186	0.180	0.187	0.184	0.191	0.218	0.230
6	0.263	0.187	0.229	0.246	0.262	0.253	0.245	0.232	0.217	0.201	0.212	0.220	0.252	0.285
7	0.283	0.251	0.262	0.286	0.266	0.320	0.283	0.252	0.252	0.245	0.219	0.245	0.216	0.311
8	0.383	0.267	0.269	0.314	0.297	0.324	0.319	0.282	0.260	0.278	0.260	0.255	0.298	0.209
9	0.286	0.306	0.266	0.303	0.319	0.282	0.347	0.305	0.287	0.296	0.293	0.287	0.308	0.315
10	0.290	0.290	0.282	0.282	0.321	0.310	0.268	0.315	0.289	0.318	0.306	0.326	0.315	0.360
11	0.313	0.313	0.313	0.313	0.313	0.313	0.324	0.305	0.314	0.399	0.281	0.345	0.313	0.372

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1	0.006	0.012	0.014	0.012	0.006	0.015	0.013	0.005	0.004	0.001	0.008
2	0.026	0.024	0.033	0.033	0.031	0.026	0.030	0.025	0.017	0.021	0.021
3	0.068	0.076	0.082	0.086	0.084	0.075	0.070	0.063	0.055	0.057	0.118
4	0.140	0.149	0.168	0.158	0.155	0.152	0.128	0.110	0.108	0.116	0.161
5	0.198	0.218	0.208	0.221	0.192	0.197	0.172	0.152	0.145	0.154	0.192
6	0.280	0.249	0.278	0.241	0.228	0.216	0.216	0.182	0.175	0.184	0.222
7	0.317	0.296	0.305	0.307	0.270	0.240	0.231	0.223	0.206	0.201	0.231
8	0.343	0.319	0.332	0.345	0.289	0.270	0.239	0.235	0.233	0.224	0.231
9	0.337	0.342	0.354	0.340	0.315	0.286	0.255	0.240	0.246	0.225	0.218
10	0.305	0.446	0.368	0.396	0.303	0.290	0.281	0.271	0.272	0.263	0.200
11	0.373	0.313	0.313	0.528	0.313	0.313	0.320	0.247	0.247	0.294	0.294

Table SD3(b). Percent mature (females) for Atlantic Herring in the Gulf of Maine, 1967 - 1990.

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	2	7	35	47	42	31	49	63	66	65	36	17	39	13	28
4	69	88	98	99	99	98	99	99	99	99	98	95	98	93	97
5	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
6	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
7	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
8	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
9	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
10	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
11	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0
3	59	58	51	68	34	15	40	36	12
4	99	99	99	99	98	94	100	99	89
5	100	100	100	100	100	100	100	100	100
6	100	100	100	100	100	100	100	100	100
7	100	100	100	100	100	100	100	100	100
8	100	100	100	100	100	100	100	100	100
9	100	100	100	100	100	100	100	100	100
10	100	100	100	100	100	100	100	100	100
11	100	100	100	100	100	100	100	100	100

Table SD4. Spring NEFSC bottom trawl survey indices corrected for vessel by age and year, and NEFSC larval survey index by year for Atlantic Herring.

(a) Spring NEFSC bottom trawl survey indices by age and year

	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
2	7.9400	0.2100	4.4200	0.3200	0.9100	0.3300	0.1300	0.0800	0.9000	0.1900
3	8.8300	1.5900	1.3700	0.6400	0.7300	3.9200	1.4600	0.3200	0.2800	0.3500
4	4.2800	1.5100	1.1700	0.4100	0.8100	2.7100	3.7100	0.7900	0.3100	0.4300
5	2.3400	3.4800	0.4300	0.1800	0.2900	0.4900	0.0800	0.5200	0.2600	0.0900
6	0.0000	1.7500	0.2700	0.1500	0.0300	0.5100	0.0400	0.0100	0.0900	0.0300

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
2	0.3400	2.5600	0.2300	0.0300	0.4000	0.2000	1.9200	2.3000	7.4900	1.2500
3	2.0900	0.9500	2.5900	0.1000	0.0900	0.0600	0.5700	0.9100	19.9500	2.0900
4	0.3100	1.7200	2.9800	1.5000	0.0700	0.1400	0.1500	0.5900	1.4000	2.5700
5	0.1900	0.2700	0.1500	0.4500	0.0500	0.0000	0.0300	0.0500	2.3400	1.5600
6	0.0200	0.0300	0.0100	0.0300	0.0000	0.0400	0.0000	0.0100	0.0100	0.1400

	1988	1989	1990	1991
2	3.0100	1.7300	2.8200	1.7265
3	3.6900	1.6000	2.4100	2.4604
4	3.5100	2.7000	2.5400	1.5787
5	3.3000	2.0100	1.0600	0.8918
6	0.2200	1.3100	0.1600	0.2430

(b) NEFSC larval survey index by year

	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
	--	--	--	89.7000	81.4000	355.2000	304.5000	55.9000	2.2000	19.2000

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
	2.4000	6.0000	1.9000	29.7000	18.2000	3.7000	2.3000	95.4000	60.4000	31.4000

	1988	1989	1990	1991
	184.9000	454.3000	394.1000	109.6400

Table SD5. Estimates Sof instantaneous fishing mortality (F), beginning year stock sizes (000,000s of fish), and mean stock biomass (000s of MT), for Atlantic Herring as estimated from virtual population analysis (VPA), calibrated using the ADAPT procedure, 1967 - 1990.

(a) Fishing Mortality

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
1	0.029	0.008	0.039	0.005	0.022	0.008	0.040	0.023	0.049	0.066	0.201	0.115
2	0.177	0.446	0.351	0.399	0.252	0.196	0.508	0.894	0.758	1.307	1.007	0.814
3	0.149	0.176	0.222	0.185	0.698	0.104	0.425	0.421	0.688	0.785	0.749	0.748
4	0.135	0.169	0.215	0.473	0.558	0.690	0.918	0.466	0.675	0.657	0.536	0.566
5	0.131	0.407	0.469	0.461	0.690	1.311	0.829	0.678	0.891	0.733	0.707	0.721
6	0.213	0.429	0.650	0.460	0.769	1.436	0.914	0.478	1.197	0.922	0.691	0.452
7	0.408	0.688	0.758	0.621	1.017	1.632	1.130	0.434	1.219	1.007	0.590	0.763
8	0.345	0.827	0.820	0.705	0.841	2.133	1.520	0.506	1.149	0.824	0.779	0.981
9	0.363	0.290	0.853	0.699	0.539	1.380	1.589	1.154	1.612	1.271	0.401	0.891
10	0.252	0.547	0.655	0.528	0.775	1.532	0.986	0.616	0.944	0.908	0.645	0.783
11	0.252	0.547	0.655	0.528	0.775	1.532	0.986	0.616	0.944	0.908	0.645	0.783

	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	0.019	0.175	0.043	0.033	0.017	0.004	0.018	0.014	0.019	0.040	0.005	0.009
2	1.016	1.333	1.554	0.855	0.228	0.125	0.177	0.197	0.099	0.268	0.347	0.126
3	0.772	1.105	0.811	0.590	0.160	0.169	0.081	0.100	0.158	0.065	0.118	0.237
4	0.848	0.968	0.622	0.336	0.297	0.155	0.092	0.061	0.108	0.101	0.054	0.106
5	0.818	0.961	0.733	0.640	0.096	0.560	0.145	0.092	0.074	0.099	0.152	0.034
6	0.736	0.928	0.696	0.750	0.278	0.248	0.540	0.123	0.064	0.080	0.147	0.126
7	1.338	1.145	0.692	0.685	0.732	0.327	0.199	0.675	0.063	0.041	0.095	0.126
8	1.454	1.243	0.588	0.398	0.201	0.435	0.277	0.109	0.506	0.033	0.047	0.126
9	0.584	1.098	0.342	0.892	0.273	0.641	0.296	0.081	0.093	0.174	0.044	0.126
10	0.830	1.032	0.736	0.690	0.319	0.483	0.198	0.111	0.072	0.085	0.126	0.126
11	0.830	1.032	0.736	0.690	0.319	0.483	0.198	0.111	0.072	0.085	0.126	0.126

Mean F (unweighted)

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
2+	0.242	0.453	0.565	0.506	0.691	1.195	0.981	0.626	1.008	0.932	0.675	0.750
5+	0.281	0.534	0.694	0.572	0.772	1.565	1.136	0.640	1.137	0.939	0.637	0.768

	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
2+	0.923	1.084	0.751	0.653	0.290	0.363	0.221	0.166	0.131	0.103	0.126	0.126
5+	0.942	1.063	0.646	0.678	0.317	0.454	0.265	0.186	0.135	0.085	0.105	0.113

Mean F (weighted by N)

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
2+	0.197	0.407	0.396	0.415	0.586	0.367	0.514	0.562	0.813	1.020	0.869	0.800
5+	0.256	0.554	0.654	0.526	0.766	1.469	0.979	0.613	0.923	0.888	0.636	0.779

	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
2+	0.935	1.123	1.397	0.791	0.221	0.156	0.150	0.121	0.106	0.140	0.165	0.125
5+	0.839	1.007	0.722	0.680	0.342	0.485	0.205	0.114	0.073	0.085	0.126	0.088

(b) Stock Numbers (Jan 1) in millions

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
1	5302.9	2655.0	2084.9	1413.8	7726.6	1178.1	1009.3	1657.2	1016.0	1293.5	3603.9	2743.4	418.3
2	2846.3	4218.4	2157.0	1642.1	1152.1	6187.2	957.0	793.6	1326.3	792.2	991.6	2413.1	2002.3
3	1822.3	1953.2	2210.6	1243.0	901.9	733.3	4163.8	471.5	265.9	508.9	175.5	296.7	875.4
4	1836.4	1285.2	1341.4	1449.4	846.1	367.3	541.1	2229.1	253.3	109.4	190.0	68.0	115.0
5	1177.6	1313.8	888.6	886.1	739.7	396.3	150.8	176.8	1144.8	105.5	46.4	91.0	31.6
6	1560.3	845.9	716.2	455.3	457.3	303.7	87.4	53.9	73.5	384.5	41.5	18.7	36.3
7	1284.5	1032.8	451.1	306.3	235.3	173.5	59.1	28.7	27.4	18.2	125.2	17.0	9.8
8	190.1	699.3	425.0	173.1	134.8	69.7	27.8	15.6	15.2	6.6	5.4	56.8	6.5
9	41.9	110.2	250.3	153.2	70.0	47.6	6.8	5.0	7.7	3.9	2.4	2.0	17.4
10	51.6	23.9	67.5	87.3	62.3	33.4	9.8	1.1	1.3	1.3	0.9	1.3	0.7
11	0.8	1.7	2.3	7.7	7.1	2.3	0.6	0.9	0.8	0.4	0.8	0.5	0.2

Table SD5 (Continued)

1+	16114.8	14139.2	10595.0	7817.3	12333.3	9492.3	7013.5	5433.4	4132.1	3224.4	5183.6	5708.6	3513.4
2+	10812.	11484.	8510.	6404.	4607.	8314.	6004.	3776.	3116.	1931.	1580.	2965.	102.
5+	4307.	4027.	2801.	2069.	1707.	1026.	342.	282.	1271.	520.	223.	187.	3095.

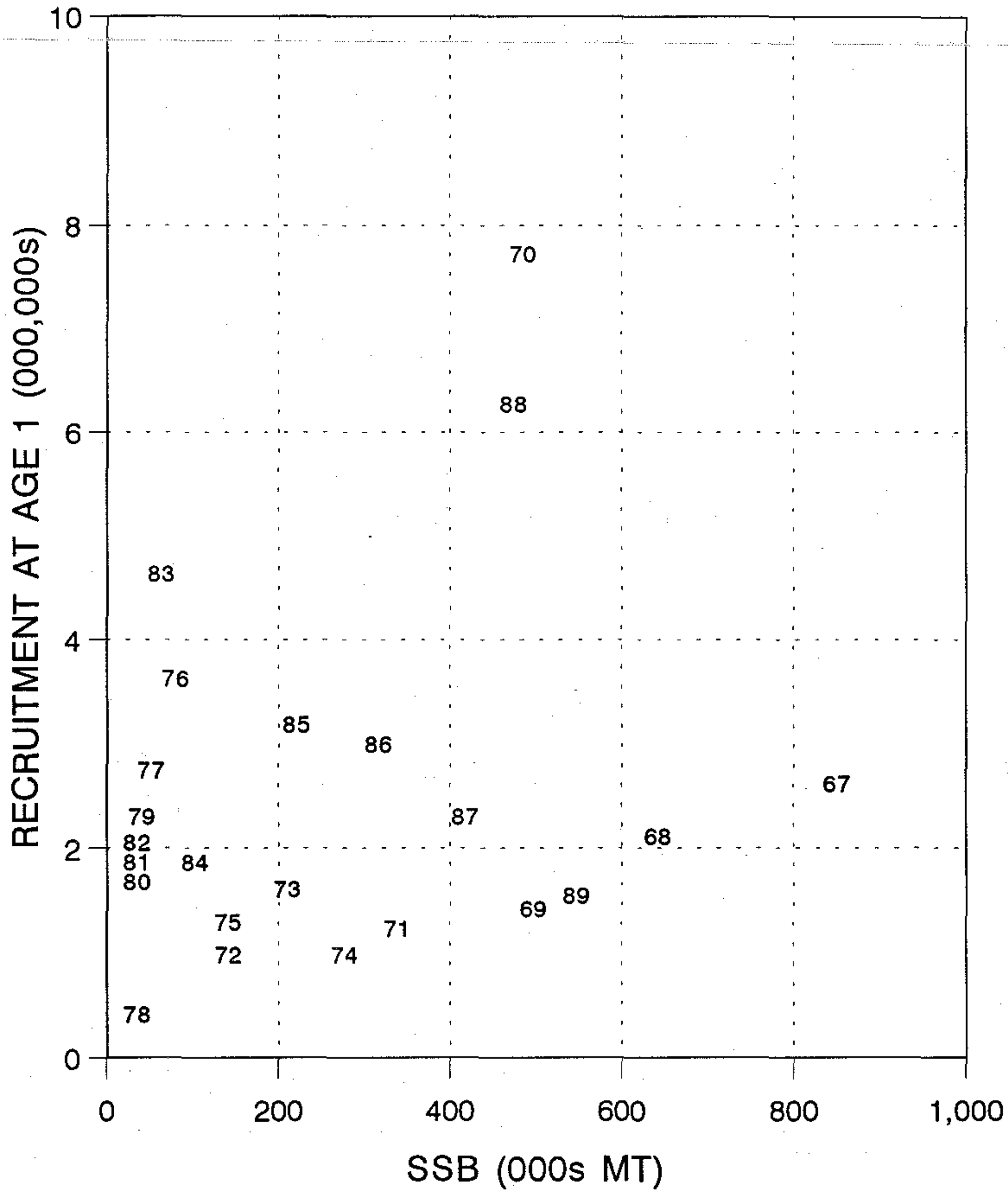
	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1	2339.7	1624.3	1811.6	2072.5	4677.1	1885.0	3231.2	2948.0	2271.8	6316.7	1509.7	0.0
2	336.1	1607.8	1274.1	1435.5	1668.4	3812.2	1516.2	2608.6	2368.1	1787.7	5146.9	1224.6
3	593.7	72.6	278.3	443.8	935.4	1205.1	2613.8	1019.2	1934.5	1482.4	1034.9	3715.0
4	331.3	160.9	26.4	126.3	309.7	646.4	909.5	1936.0	712.4	1484.7	1078.5	668.2
5	40.3	103.1	70.7	15.4	76.8	217.0	482.6	700.8	1423.3	527.5	1152.0	794.0
6	11.4	12.6	40.6	30.5	11.5	35.9	153.7	360.2	532.9	1055.3	370.8	911.3
7	14.2	3.7	5.2	15.7	18.9	7.3	17.2	111.3	276.6	402.9	746.2	267.7
8	2.1	3.7	1.5	2.1	6.2	11.2	4.9	7.1	85.6	217.3	300.0	538.6
9	1.2	0.5	1.7	0.8	1.4	3.3	6.9	3.6	3.5	67.8	169.7	216.5
10	8.0	0.3	0.3	0.6	0.5	0.6	2.0	5.2	2.7	2.4	53.1	122.5
11	0.2	2.2	0.4	0.4	0.4	1.0	3.6	1.6	2.3	3.3	18.1	51.4
1+	3678.2	3591.7	3510.7	4143.7	7706.3	7825.2	8941.6	9701.8	9613.6	13348.0	11579.9	8509.8
2+	77.	126.	120.	66.	116.	276.	5710.	6754.	7342.	7031.	10070.	8510.
5+	1339.	1967.	1699.	2071.	3029.	5940.	671.	1190.	2327.	2276.	2810.	2902.

(c) Mean Biomass (000s MT)

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
1	23.7	16.8	18.5	26.8	131.6	37.2	14.4	25.3	20.7	20.4	47.5	30.6	3.0
2	68.8	77.7	64.7	77.8	45.4	260.6	37.0	25.6	43.5	17.2	24.2	60.7	37.1
3	120.0	96.1	142.5	109.4	68.4	75.9	334.4	37.9	16.9	36.9	11.7	23.0	49.8
4	184.1	152.6	56.0	176.2	106.7	45.5	55.4	275.0	28.5	13.2	21.7	8.8	14.1
5	162.4	191.1	163.3	136.1	114.6	47.8	21.9	24.0	133.8	14.1	5.8	13.4	5.1
6	328.6	135.0	130.3	80.0	95.8	40.8	13.6	9.1	9.1	48.8	6.0	3.5	6.6
7	264.7	167.7	92.9	63.5	40.0	25.0	9.6	5.3	4.0	2.7	19.7	3.0	0.9
8	50.1	113.6	78.9	35.2	24.4	9.6	4.3	3.1	2.3	1.2	0.9	9.5	1.0
9	9.2	23.8	42.2	31.4	16.3	6.5	1.1	0.8	1.1	0.7	0.5	0.4	4.0
10	12.1	4.9	13.2	18.1	13.2	4.6	1.5	0.2	0.2	0.3	0.2	0.3	0.1
11	0.2	0.4	0.5	1.7	1.4	0.3	0.1	0.2	0.1	0.1	0.1	0.1	0.0
1+	1223.9	979.6	803.0	756.3	657.9	553.9	493.2	406.3	260.3	155.5	138.3	153.3	121.8
2+	1200.2	962.8	784.4	729.5	526.2	516.7	478.9	381.1	239.6	135.0	90.8	122.7	118.8
5+	827.3	636.5	521.3	366.1	305.6	134.7	52.1	42.6	150.6	67.8	33.3	30.2	17.8

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	29.3	17.3	32.3	41.0	80.4	22.0	61.1	47.7	18.2	51.4	6.8
2	7.0	34.1	38.6	64.2	72.6	155.6	66.3	99.2	64.3	46.8	219.6
3	34.1	5.2	25.0	51.4	104.0	146.0	261.9	79.7	153.0	114.3	80.5
4	33.0	20.8	4.0	21.5	47.4	101.5	132.9	235.0	79.4	169.2	138.4
5	6.4	15.5	12.0	3.0	12.2	37.3	90.0	109.1	201.7	72.9	190.0
6	2.2	2.4	7.0	7.5	2.4	5.8	30.2	69.0	86.9	166.8	65.2
7	2.7	0.8	1.0	3.5	4.5	1.7	2.9	22.8	56.0	79.6	136.9
8	0.3	0.9	0.4	0.6	1.6	2.4	1.1	1.2	18.2	45.8	56.6
9	0.2	0.2	0.4	0.3	0.3	0.7	1.8	0.8	0.7	15.3	30.7
10	1.8	0.1	0.1	0.2	0.2	0.1	0.5	1.2	0.7	0.6	12.4
11	0.0	0.5	0.1	0.1	0.2	0.3	1.0	0.4	0.5	0.7	4.5
1+	117.1	97.9	120.7	193.4	325.7	473.4	649.6	666.1	679.6	763.3	941.6
2+	87.8	80.6	88.4	152.4	245.4	451.4	588.6	618.4	661.4	711.9	934.8
5+	13.6	20.4	20.9	15.2	21.3	48.4	127.4	204.5	364.8	381.6	496.3

ATLANTIC HERRING



Figure$_{SD1}$: Stock and recruitment data for Atlantic Herring. The datapoint labels indicate the year class of each cohort.

HADDOCK

An analytical assessment of Georges Bank haddock was reviewed by the SARC (SAW/13/SARC/13). Age specific population abundance and fishing mortality rates were estimated using ADAPT.

The population biomass between 1987 and 1991 has remained relatively stable at just over 20,000 mt,the lowest level recorded. Recruitment since 1988 has been poor and the moderate 1983, 1985, and 1987 year-classes have sustained the fishery. Fishing mortality rate on age 4 and older for the past decade has been variable between 0.3 and 0.5 with no persistent trend. Productivity of this resource is well below historical levels.

A summary of haddock landings from the Gulf of Maine was presented along with abundance trends and fishing mortality rates estimated from bottom trawl survey data. Landings from this stock have declined to record low levels. It was not possible to perform an analytical assessment of this stock, however the indications are clear that it is in a depleted state.

Background

The haddock (Melanogrammus aeglefinus) within USA waters are considered to comprise two management units, Georges Bank (Division 5Z/Subarea 6) and Gulf of Maine (Division 5Y). These definitions are based on tagging studies, meristic data, age composition and growth. The principal spawning site within the Georges Bank unit is thought to be on the Northeast peak. There is, however, evidence of the existence of separate spawning groups in other areas as well.

The New England haddock fishery developed in the early 1900s with the introduction of bottom trawls. During the early 1960s the foreign distant water fleets and a developing Canadian bottom trawl fleet entered the fishery. Following the Magnuson Act extended jurisdiction to 200 mi in 1977, only USA and Canada continued to exploit haddock. The International Court of Justice established a maritime boundary between USA and Canada in late 1984 which partitioned the Georges Bank management unit. Since then, fishing activity by each country has been restricted to their respective territories and management strategies and practices have diverged.

Data Sources

Georges Bank

Between 1935 and 1960 landings from the Georges Bank stock averaged about 46,000 mt, ranging between 26,000 and 63,000 mt. During 1965 and 1966, total landings were about 150,000 and 120,000 mt respectively, due in large part to increased exploitation by the USSR fleet (Table SE1a). Subsequently, landings declined rapidly to a low of just over 4,000 mt in 1974 and have never recovered to pre 1960 levels. Landings in 1990 increased from the 1989 low to about 5,000 mt, with the US accounting for 40% of the total. Otter trawling accounts for over 99% of USA landings. While otter trawling is also predominant in the Canadian fishery, line trawls accounted for 26% of landings.

Discarding of haddock is currently considered negligible but there was significant discarding of small haddock during 1974, 1977, 1978 and 1980. Estimates of tonnage discarded were derived based on interviews and/or bottom trawl survey results (Overholtz, et al 1983) and were assumed to be comprised of 2 year olds in 1974, 1977, and 1980 representing the 1972, 1975 and 1978 year-classes; and of 3 year olds, the 1975 year-class, in 1978. These discard estimates were included in the catch at age.

The age composition of the commercial catch was updated for 1982-1990. Because of low sampling intensity, samples were pooled into two spatial strata, eastern and western Georges Bank and into three temporal strata, first half, third quarter and fourth quarter of the year. Further collapsing of strata was not considered suitable as this might introduce bias due to differences in age-length characteristics, although the SARC expressed some concern about the very small sample sizes available with this stratification. The USA catch at age was combined with that for the Canadian commercial fishery.

The catch at age in the last decade has been dominated by the 1978, 1983, 1985 and 1987 year classes (Table SE2). Though sampling intensity was low and there were gaps in coverage, the precision of mean catch at age for these dominant year-classes was good, with relative error being roughly 5%. Mean weight at age of landed haddock is given in Table SE3a. Mean weights at age at the beginning of the year were computed using Rivard's (1980) procedure (Table SE3b). Maturity at age has shifted substantially over time (SE3c) which has important implications for SSB/R analysis as described below.

Trends in USA commercial CPUE were examined using a General Linear Model which included only those trips where total catch was at least 50% cod, haddock, and winter flounder. Effects included in the model were statistical area quarter, vessel ton-class and year. CPUE was apparently high in the mid 1960s, declined sharply to a low in the early/mid 1970s, increased in the late 1970s, and declined again after 1980 (Table SE4). The commercial CPUE was not used in the analytical assessment however, as it was not considered to be representative of stock abundance in recent years due to changes in fishing patterns after the introduction of the maritime boundary between USA and Canada.

NEFC bottom trawl surveys have been conducted by two vessels over the time series and have had a change in trawl doors. With information from paired comparison experiments, a ratio estimator was used to determine size specific vessel and trawl door effects. These were all found to be significant and suggested that haddock less than 20 cm were affected differently by the changes compared to larger haddock. Further examination of the size specific comparisons revealed that the available observations for haddock less than 20 cm were insufficient to draw firm conclusions that there was a differential size effect. The SARC concluded that the same conversion factors should be applied to all size groups but recognized that size specific behavior could result in differences. However, confirmation of size specific differences would require additional information. The conversion ratios were applied to the age specific stratified means to adjust the bottom trawl survey results. Using Albatross IV with polyvalent trawl doors as the standard, the correction for surveys with BMV doors was 1.63 and for surveys by the Delaware II 0.85. The resultant survey data and the Canadian indices are given in Table SE5. There was also a change in nets during the spring survey, however, there were no paired comparison experiments to evaluate its effect. An intervention analysis was conducted which suggested that the effect was negligible, therefore, no adjustment was attempted for the change in nets.

The NMFS surveys during both spring and fall identified the strong 1962, 1963, 1975 and 1978 year-classes. In recent years, both of these surveys and the Canadian survey suggest that recruitment has been very poor and the moderately sized 1983, 1985 and 1987 year-classes have been prominent against this background. Overall abundance continues to be low in comparison to historical levels.

Gulf of Maine

Landings from the Gulf of Maine were presented along with abundance trends and fishing mortality rates estimated from bottom trawl survey information. Landings in this area have declined to their lowest level since 1956 (Table SEb).

Survey indices for the Gulf of Maine (Table SE6) show a large decline since the early part of the series to record low levels. There have not been any good year-classes since the early 1980s.

Methodology

The ADAPT framework (Gavaris 1988, Conser and Powers 1990) was used for calibration of the virtual population analysis with the survey abundance indices. The spring surveys were compared to the beginning of year population numbers while the fall surveys were compared to the population numbers one age older for the respective year-class at the beginning of the subsequent year. This was considered appropriate given the seasonal pattern of landings. The tuning indices were weighted equally in the final assessment.

Abundance and fishing mortality rates for ages 1 to 8 were estimated. The instantaneous rate of natural mortality was assumed to be 0.2. The fishing mortality rate on age 9+ was assumed equal to the rate on age 8. Stock numbers at age for 1991 and calibration coefficients for the available survey indices were estimated using ADAPT.

Results

The estimated fishing mortality rate, unweighted by abundance, on fully recruited ages (4-9) in 1990 was 0.52, the highest since 1968 (Table SE7a), and has varied between 0.34 and 0.5 over the past decade. Stock abundance has remained relatively stable over the past decade at about 10% of the level of the early 1960s (Table SE7b). The coefficients of variation on the 1990 estimates of stock abundance are between 47% for age 1 and 28% for age 4.

The analysis confirmed that the 1983, 1985, and 1987 year-classes, while only about one sixth as big as the 1975 and 1978 year-classes, were considerably better than the intervening year-classes. The 1989 and 1990 year-classes were estimated to be weaker than the 1983. 1985, and 1987 year-classes. Population biomass has remained stable in recent years at around 20,000 mt, the lowest recorded level (Table SE7c). Productivity of this resource is well below historical levels.

The spawning biomass (in mt) at the start of the season was:

Year	SSB	Year	SSB	Year	SSB
1963	164252	1973	12255	1983	32601
1964	128555	1974	21779	1984	24238
1965	145017	1975	18355	1985	19769
1966	180505	1976	22021	1986	19270
1967	112084	1977	57541	1987	17874
1968	75072	1978	78250	1988	16231
1969	51156	1979	65697	1989	16985
1970	38486	1980	66891	1990	18737
1971	30200	1981	59205		
1972	26881	1982	43991		

Figure SE1 plots the stock and recruitment results.

SARC Analyses

Examination of the size specific conversion factors for USA survey changes led to adoption of a single conversion factor for all sizes and survey results were adjusted accordingly. The ADAPT formulation was modified to include the Canadian spring surveys as well as including the most recent year of each of the USA surveys and estimating all ages in the terminal year. Uncertainty regarding robustness of reference points to observed changes in growth and maturity over declining stock sizes led the SARC to recommend that three alternative sets of reference points be computed corresponding to the three available maturity and size at age schedules (Table SE8 and Figure SE2). The current fishery exploitation pattern at is expected to persist in the near term and was used in the projections. The analyses of proportion mature at age were not reviewed by SARC. Estimates of yield based reference points ($F_{0.1}$ F_{max}) are relatively robust to changing input parameters, while the SSB based reference point ($F_{30\%}$) is more sensitive to recent declines in age at maturity. Choice between the points then becomes a management decision with respect to goals for the resource (e.g., maintain existing status, rebuild, etc.).

Catch Projections

Short term projections were calculated using the ADAPT 1991 population size estimates for ages 1 to 9+ ~~and assuming recruitment (geometric mean of 1986-1989) for year-classes 1992-1993 plus or minus one standard~~ error. Projections were made at status quo F, $F_{0.1}$ and $F_{30\%}$ (Table SE9).

Major Sources of Uncertainty

- Survey index conversion factors due to gear changes may be size specific, but the current data are insufficient to define size effects.
- Maturity schedules have changed for this stock due to its reduced abundance. If the stock recovers, growth and maturation could shift again, affecting the interpretation of reference points.
- Small sample sizes for age length keys may result in imprecisions in determining catch at age.
- The partial recruitment pattern has been variable in recent years in response to changing year-class size and may affect the projections.

Recommendations

- Consider the use of sea sampling to augment port sampling information on length frequency and ages.
- Monitor and review proportion mature at age.
- Investigate methods for extending the analyses to include biological catch data and population trends beginning in 1960.

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Table SE1a. Commercial landings (metric tons, live) of haddock from Georges Bank and South (NAFO Division 5Z and Statistical Area 6).[1]

Year	USA	Canada	USSR	Spain	Other	Total
1960	40800	77	0	0	0	40877
1961	46384	266	0	0	0	46650
1962	49409	3461	1134	0	0	54004
1963	44150	8379	2317	0	0	54846
1964	46512	11625	5483	2	464	64086
1965	52823	14889	81882	10	758	150362
1966	52918	18292	48409	1111	544	121274
1967	34728	13040	2316	1355	30	51469
1968	25469	9323	1397	3014	1720	40923
1969	16456	3990	65	1201	540	22252
1970	8415	1978	103	782	22	11300
1971	7306	1630	374	1310	242	10862
1972	3869	609	137	1098	20	5733
1973	2777	1563	602	386	3	5331
1974	2396	462	109	764	559	4290
1975	3989	1358	8	61	4	5420
1976	2904	1361	4	46	9	4324
1977	7934	2909	0	0	0	10843
1978	12160	10179	0	0	0	22339
1979	14279	5182	0	0	0	19461
1980	17470	10017	0	0	0	27487
1981	19176	5658	0	0	0	24834
1982	12625	4872	0	0	0	17497
1983	8682	3208	0	0	0	11890
1984	8807	1463	0	0	0	10270
1985	4273	3484	0	0	0	7757
1986	3339	3415	0	0	0	6754
1987	2156	4703[2]	0	0	0	6859
1988	2492	4046[2]	0	0	0	6538
1989	1430	3059	0	0	0	4489
1990	2001	3283	0	0	0	5284

1 All landings 1960-1979 are from Clark et al. (1982); USA landings 1980-1981 are from Overholtz et al. (1983); USA landings 1982-1991 are from NMFS, NEFC Detailed Weighout Files and Canvass data; Canadian landings 1980-1990 from Gavaris and Van Eeckhaute (1991).

2 1895 tons were excluded because of suspected misreporting (Gavaris and Van Eeckhaute 1991).

Table SE1b. Landings (mt live weight) of haddock from the Gulf of Maine (Division 5Y).

Year	USA	Canada	Other	Total
1956	7278	29	0	7307
1957	6141	25	0	6166
1958	7082	285	0	7367
1959	4497	163	0	4660
1960	4541	383	0	4924
1961	5297	112	0	5409
1962	5003	107	0	5110
1963	4742	3	44	4789
1964	5383	70	0	5453
1965	4204	159	0	4363
1966	4579	1125	0	5704
1967	4907	589	0	5496
1968	3437	120	0	3557
1969	2423	59	231	2713
1970	1457	38	67	1562
1971	1194	85	27	1306
1972	909	23	4	936
1973	509	49	0	558
1974	622	198	9	829
1975	1180	79	4	1263
1976	1865	91	0	1956
1977	3296	26	0	3322
1978	4538	641	0	5179
1979	4622	257	0	4879
1980	7270	203	0	7473
1981	5987	513	0	6500
1982	5694	1278	0	6972
1983	5593	2003	0	7596
1984	2792	1245	0	4037
1985	2234	791	0	3025
1986	1589	225	0	1814
1987	828	90	0	918
1988	414	0	0	414
1989	263	0	0	263
1990	433	0	0	433

Note: Landings 1956-1979 from Clark et al (1982). Landings 1980-1990 from NAFO and NEFSC data files

Table SE2. Total commercial catch (numbers 000's) at age of haddock from Georges Bank and South (NAFO Division 5Z and Statistical Area 6), 1963-1990.[1]

	Age Group									
Year	1	2	3	4	5	6	7	8	9+	TOTAL
1963	2910	4047	7418	11152	8198	2205	1405	721	1096	39152
1964	10101	15935	4554	4776	8722	5794	2082	1028	1332	54324
1965	9601	125818	44496	5356	4391	6690	3772	1094	1366	202584
1966	114	6843	100810	19167	2768	2591	2332	1268	867	136760
1967	1150	168	2891	20667	10338	1209	993	917	698	39031
1968	8	2994	709	1921	14519	3499	667	453	842	25612
1969	2	11	1698	448	654	5954	1574	225	570	11136
1970	46	158	16	570	186	214	2308	746	464	4708
1971	1	1375	223	40	289	246	285	1469	928	4856
1972	156	2	450	81	32	120	78	66	1236	2221
1973	2560	2075	3	386	53	30	77	15	447	5646
1974	46	4320[2]	657	2	70	2	2	53	249	5401
1975	192	1034	1864	375	4	42	4	4	88	3607
1976	144	473	550	880	216	0	23	4	112	2402
1977	1	19585[3]	187	680	515	357	4	39	111	21479
1978	1	761	14395[4]	305	567	517	139	14	67	16766
1979	1	26	1726	7169	525	410	315	96	46	10314
1980	8	31000[5]	347	975	6054	594	546	153	81	39758
1981	1	1743	10998	831	937	2572	331	158	94	17665
1982	1	1165	1633	3733	391	569	1119	106	110	8827
1983	0	214	813	690	2239	272	186	800	76	5290
1984	0	93	297	727	397	1482	234	267	543	4041
1985	0	2406	550	194	461	228	526	78	152	4596
1986	6	54	2810	223	146	173	150	266	60	3888
1987	0	1995	129	1613	122	73	89	106	135	4262
1988	4	52	2384	134	931	149	55	64	106	3879
1989	0	1263	86	877	143	358	46	28	45	2847
1990	2	12	1437	160	872	97	175	40	43	2839

1 Data 1963-1979 from Clark et al. (1982); Data 1980-1981 from Overholtz et al. (1983); Data 1982-1990 current assessment and Gavaris and Van Eekhaute (1991)

2 Of this total, approximately 1000000 fish were added to the catch at age to account for high discards that occurred during 1974 (W. Overholtz, personal communication).

3 Of this total, approximately 12800000 fish were added to the catch at age to account for high discards that occurred during 1977 (W. Overholtz, personal communication).

4 Of this total, approximately 5000000 fish were added to the catch at age to account for high discards that occurred during 1978 (W. Overholtz, personal communication).

5 Of this total, approximately 20000000 fish were added to the catch at age to account for high discards that occurred during 1980 (W. Overholtz, personal communication).

Table SE3a. Mean weight (kg round weight) at age of haddock landed from Georges Bank and South (NAFO Division 5Z and Statistical Area 6).[1] Values enclosed in parentheses are averages from surrounding years.

	Age								
Year	1	2	3	4	5	6	7	8	9+
1963	0.57	0.87	1.18	1.47	1.68	2.15	2.35	3.04	3.10
1964	0.50	0.83	1.12	1.43	1.64	2.01	2.40	2.64	2.97
1965	0.58	0.69	1.03	1.35	1.67	1.99	2.26	2.66	3.11
1966	0.58	0.73	0.89	1.26	1.70	2.07	2.28	2.87	3.18
1967	0.66	0.70	0.95	1.18	1.42	2.05	2.31	2.66	3.10
1968	0.59	0.81	1.05	1.32	1.57	2.10	2.32	2.62	2.86
1969	0.52	0.78	1.10	1.69	1.75	1.99	2.52	2.99	3.63
1970	0.71	1.27	1.22	1.93	2.19	2.39	2.58	3.23	3.75
1971	(0.67)	1.03	1.31	1.74	2.39	2.81	2.92	3.10	3.72
1972	0.62	1.03	1.74	2.04	2.42	2.92	3.06	3.44	3.66
1973	0.60	1.03	1.58	2.13	2.41	3.29	3.42	3.86	3.94
1974	0.72	1.06	1.82	2.32	2.83	3.76	4.05	3.92	4.26
1975	0.62	0.98	1.63	2.21	2.20	2.94	4.00	4.05	4.33
1976	0.50	0.99	1.39	1.99	2.66	(3.08)	3.69	4.67	4.94
1977	(0.53)	1.07	1.44	2.17	2.73	3.21	4.15	4.00	4.99
1978	(0.53)	0.94	1.50	2.04	2.79	3.19	3.37	3.61	5.11
1979	(0.53)	1.00	1.28	2.02	2.51	3.14	3.78	3.79	4.87
1980	0.55	0.94	1.21	1.73	2.17	2.82	3.60	3.56	3.87
1981	0.39	0.87	1.24	1.83	2.30	2.72	3.71	4.04	4.44
1982	0.22	0.97	1.45	1.88	2.37	2.76	3.24	3.96	4.09
1983	(0.33)	1.02	1.37	1.83	2.21	2.65	3.25	3.36	4.27
1984	(0.33)	0.92	1.32	1.83	2.20	2.67	2.96	3.41	3.72
1985	(0.33)	0.99	1.39	1.98	2.46	2.72	3.06	3.72	3.80
1986	0.45	0.94	1.36	1.83	2.56	2.83	2.96	3.46	3.78
1987	(0.43)	0.83	1.43	2.00	2.25	2.63	3.02	3.77	4.29
1988	0.42	0.98	1.34	1.68	2.06	2.45	2.97	3.49	3.96
1989	(0.53)	0.89	1.48	1.79	2.21	2.57	3.24	3.56	3.82
1990	0.64	0.97	1.46	1.80	2.11	2.58	2.82	3.17	4.16

1 Data 1963-1979 from Clark et al. (1982); data 1980-present current assessment and Gavaris and Van Eeckhaute (1991).

Table SE3b. Mean weight at age at spawning for Georges Bank haddock. Mean weight at spawning was calculated from mean weight at capture in the commercial catch using the procedures described by Rivard (1980).

	Age								
Year	1	2	3	4	5	6	7	8	9+
1963	0.472	0.767	1.072	1.392	1.536	2.035	2.217	2.673	3.100
1964	0.426	0.688	0.987	1.299	1.553	1.838	2.272	2.491	2.970
1965	0.517	0.587	0.925	1.230	1.545	1.807	2.131	2.527	3.110
1966	0.528	0.651	0.784	1.139	1.515	1.859	2.130	2.547	3.180
1967	0.596	0.637	0.833	1.025	1.338	1.867	2.187	2.463	3.100
1968	0.513	0.731	0.857	1.120	1.361	1.727	2.181	2.460	2.860
1969	0.333	0.678	0.944	1.332	1.520	1.768	2.300	2.634	3.630
1970	0.589	0.813	0.975	1.457	1.924	2.045	2.266	2.853	3.750
1971	0.540	0.855	1.290	1.457	2.148	2.481	2.642	2.828	3.720
1972	0.481	0.831	1.339	1.635	2.052	2.642	2.932	3.169	3.660
1973	0.451	0.799	1.276	1.925	2.217	2.822	3.160	3.437	3.940
1974	0.617	0.797	1.369	1.915	2.455	3.010	3.650	3.661	4.260
1975	0.491	0.840	1.314	2.006	2.259	2.884	3.878	4.050	4.330
1976	0.342	0.783	1.167	1.801	2.425	2.603	3.294	4.322	4.940
1977	0.398	0.731	1.194	1.737	2.331	2.922	3.575	3.842	4.990
1978	0.386	0.706	1.267	1.714	2.461	2.951	3.289	3.871	5.110
1979	0.398	0.728	1.097	1.741	2.263	2.960	3.472	3.574	4.870
1980	0.437	0.706	1.100	1.488	2.094	2.660	3.362	3.668	3.870
1981	0.247	0.692	1.080	1.488	1.995	2.429	3.235	3.814	4.440
1982	0.102	0.615	1.123	1.527	2.083	2.520	2.969	3.833	4.090
1983	0.198	0.474	1.153	1.629	2.038	2.506	2.995	3.299	4.270
1984	0.191	0.551	1.160	1.583	2.006	2.429	2.801	3.329	3.720
1985	0.196	0.572	1.131	1.617	2.122	2.446	2.858	3.318	3.800
1986	0.331	0.557	1.160	1.595	2.251	2.639	2.837	3.254	3.780
1987	0.285	0.611	1.159	1.649	2.029	2.595	2.923	3.341	4.290
1988	0.289	0.649	1.055	1.550	2.030	2.348	2.795	3.247	3.960
1989	0.392	0.611	1.204	1.549	1.927	2.301	2.817	3.252	3.820
1990	0.571	0.717	1.140	1.632	1.943	2.388	2.692	3.205	4.160

Table SE3c. Percentage mature of female Georges Bank haddock.

Year	Age 1	2	3	4+	Source
1963	0	0	78	100	Clark (1959)
1964	0	0	78	100	Clark (1959)
1965	0	0	78	100	Clark (1959)
~~1966~~	~~0~~	~~0~~	~~78~~	~~100~~	~~Clark (1959)~~
1967	0	0	78	100	Clark (1959)
1968	0	28	76	100	Clark et al. (1982)
1969	0	28	76	100	Clark et al. (1982)
1970	0	28	76	100	Clark et al. (1982)
1971	0	28	76	100	Clark et al. (1982)
1972	0	28	76	100	Clark et al. (1982)
1973	0	34	92	100	Clark et al. (1982)
1974	0	34	92	100	Clark et al. (1982)
1975	0	34	92	100	Clark et al. (1982)
1976	0	34	92	100	Clark et al. (1982)
1977	0	61	100	100	Overholtz (1987)
1978	0	26	99	100	Overholtz (1987)
1979	0	8	71	100	Overholtz (1987)
1980	0	41	100	100	Overholtz (1987)
1981	0	52	94	100	Overholtz (1987)
1982	0	31	67	100	Overholtz (1987)
1983	0	11	39	100	Overholtz (1987)
1984	12	33	94	100	O'Brien (pers. comm.)
1985	26	77	97	100	O'Brien et al. (1991)
1986	26	77	97	100	O'Brien et al. (1991)
1987	26	77	97	100	O'Brien et al. (1991)
1988	26	77	97	100	O'Brien et al. (1991)
1989	26	77	97	100	O'Brien et al. (1991)
1990	26	77	97	100	O'Brien et al. (1991)

Table SE4. Commercial CPUE indices derived from GLM analysis for Georges Bank haddock 1964-1990.

Year	No interaction model		All interactions except those involving year	
	$\log_e$	transformed	$\log_e$	transformed
1964	1.765	5.84	1.771	5.88
1965	1.500	4.48	1.520	4.57
1966	3.712	40.93	3.752	42.61
1967	2.653	14.20	2.681	14.60
1968	2.282	9.79	2.268	9.66
1969	0.517	1.68	0.527	1.69
1970	0.708	2.03	0.740	2.10
1971	0.102	1.11	0.115	1.12
1972	0.347	1.41	0.385	1.47
1973	-0.894	0.41	-0.871	0.42
1974	-2.852	0.06	-2.831	0.06
1975	-1.008	0.36	-0.997	0.37
1976	0.217	1.24	0.258	1.29
1977	2.547	12.77	2.604	13.51
1978	0.777	2.17	0.828	2.29
1979	1.007	2.74	1.056	2.87
1980	0.775	2.17	0.825	2.28
1981	2.572	13.09	2.651	14.17
1982	1.711	5.53	1.755	5.78
1983	1.384	3.99	1.439	4.21
1984	1.243	3.47	1.285	3.61
1985	0.715	2.04	0.750	2.12
1986	0.571	1.77	0.589	1.80
1987	0.076	1.08	0.087	1.09
1988	-0.030	0.97	-0.009	0.99
1989	-0.327	0.72	-0.314	0.73
1990	0.000	1.00	0.000	1.00

Table SE5a. Stratified mean catch per tow (numbers) for haddock in NEFC offshore spring research vessel bottom trawl surveys on Georges Bank (Strata 13-25, 29-30), 1968-1990.

Unadjusted for changes in gear usage

Year	Age group 0	1	2	3	4	5	6	7	8	9+	Total	Total 1+
1968	0.00	0.27	1.90	0.31	0.47	4.51	1.13	0.17	0.30	0.23	9.29	9.29
1969	0.00	0.00	0.05	0.39	0.17	0.28	2.84	0.69	0.19	0.31	4.92	4.92
1970	0.00	0.45	0.17	0.00	0.22	0.31	0.31	1.34	0.66	0.57	4.03	4.03
1971	0.00	0.00	0.78	0.17	0.00	0.08	0.08	0.06	0.55	0.15	1.87	1.87
1972	0.00	2.70	0.06	0.41	0.08	0.02	0.03	0.09	0.02	0.87	4.28	4.28
1973	0.00	20.59	3.25	0.00	0.36	0.06	0.00	0.12	0.01	0.86	25.25	25.25
1974	0.00	1.43	8.92	1.92	0.00	0.16	0.00	0.01	0.07	0.25	12.76	12.76
1975	0.00	0.63	0.65	2.23	0.42	0.00	0.09	0.06	0.01	0.10	4.19	4.19
1976	0.00	54.22	0.20	0.40	0.62	0.29	0.00	0.03	0.00	0.07	55.83	55.83
1977	0.00	0.41	22.42	0.28	0.82	0.40	0.30	0.00	0.03	0.08	24.74	24.74
1978	0.00	0.05	0.65	10.69	0.24	0.63	0.55	0.11	0.04	0.07	13.03	13.03
1979	0.00	24.24	1.06	0.76	3.83	0.22	0.11	0.25	0.04	0.03	30.54	30.54
1980	0.00	3.49	31.34	0.34	0.70	3.27	0.45	0.25	0.31	0.16	40.31	40.31
1981	0.00	2.70	2.69	15.95	1.79	0.62	1.46	0.20	0.09	0.04	25.54	25.54
1982	0.00	0.62	1.25	0.77	3.33	0.34	0.23	0.50	0.00	0.00	7.04	7.04
1983	0.00	0.29	0.37	0.39	0.15	1.62	0.01	0.03	0.78	0.12	3.76	3.76
1984	0.00	1.40	0.79	0.43	0.42	0.39	0.48	0.05	0.03	0.20	4.19	4.19
1985	0.00	0.00	4.96	0.76	0.40	0.87	0.34	1.17	0.10	0.25	8.85	8.85
1986	0.00	2.49	0.18	2.06	0.24	0.11	0.21	0.12	0.33	0.11	5.85	5.85
1987	0.00	0.00	3.62	0.06	0.81	0.08	0.10	0.05	0.22	0.01	4.95	4.95
1988	0.00	1.55	0.04	0.99	0.13	0.32	0.12	0.11	0.12	0.00	3.38	3.38
1989	0.00	0.03	4.26	0.55	0.87	0.17	0.50	0.07	0.06	0.01	6.52	6.52
1990	0.00	1.05	0.00	6.97	0.40	0.71	0.07	0.16	0.00	0.01	9.37	9.37
1991	0.00	0.66	1.30	0.29	2.26	0.11	0.12	0.03	0.05	0.02	4.84	4.84

Adjusted for changes in gear usage

Year	0	1	2	3	4	5	6	7	8	9+	Total	Total 1+
1968	0.00	0.44	3.10	0.51	0.77	7.36	1.85	0.28	0.49	0.38	15.17	15.17
1969	0.00	0.00	0.08	0.64	0.28	0.46	4.64	1.13	0.31	0.51	8.03	8.03
1970	0.00	0.73	0.28	0.00	0.36	0.51	0.51	2.19	1.08	0.93	6.58	6.58
1971	0.00	0.00	1.27	0.28	0.00	0.13	0.13	0.10	0.90	0.24	3.05	3.05
1972	0.00	4.41	0.10	0.67	0.13	0.03	0.05	0.15	0.03	1.42	6.99	6.99
1973	0.00	33.62	5.31	0.00	0.59	0.10	0.00	0.20	0.02	1.40	41.23	41.23
1974	0.00	2.34	14.57	3.14	0.00	0.26	0.00	0.02	0.11	0.41	20.84	20.84
1975	0.00	1.03	1.06	3.64	0.69	0.00	0.15	0.10	0.02	0.16	6.84	6.84
1976	0.00	88.54	0.33	0.65	1.01	0.47	0.00	0.05	0.00	0.11	91.17	91.17
1977	0.00	0.67	36.61	0.46	1.34	0.65	0.49	0.00	0.05	0.13	40.40	40.40
1978	0.00	0.08	1.06	17.46	0.39	1.03	0.90	0.18	0.07	0.11	21.28	21.28
1979	0.00	39.58	1.73	1.24	6.25	0.36	0.18	0.41	0.07	0.05	49.87	49.87
1980	0.00	5.70	51.18	0.56	1.14	5.34	0.73	0.41	0.51	0.26	65.83	65.83
1981	0.00	3.76	3.74	22.19	2.49	0.86	2.03	0.28	0.13	0.06	35.53	35.53
1982	0.00	0.86	1.74	1.07	4.63	0.47	0.32	0.70	0.00	0.00	9.79	9.79
1983	0.00	0.47	0.60	0.64	0.24	2.65	0.02	0.05	1.27	0.20	6.14	6.14
1984	0.00	2.29	1.29	0.70	0.69	0.64	0.78	0.08	0.05	0.33	6.84	6.84
1985	0.00	0.00	4.96	0.76	0.40	0.87	0.34	1.17	0.10	0.25	8.85	8.85
1986	0.00	2.49	0.18	2.06	0.24	0.11	0.21	0.12	0.33	0.11	5.85	5.85
1987	0.00	0.00	3.62	0.06	0.81	0.08	0.10	0.05	0.22	0.01	4.95	4.95
1988	0.00	1.55	0.04	0.99	0.13	0.32	0.12	0.11	0.12	0.00	3.38	3.38
1989	0.00	0.03	3.63	0.47	0.74	0.14	0.43	0.06	0.05	0.01	5.56	5.56
1990	0.00	0.89	0.00	5.94	0.34	0.60	0.06	0.14	0.00	0.01	7.98	7.98
1991	0.00	0.56	1.11	0.25	1.93	0.09	0.10	0.03	0.04	0.02	4.13	4.13

Table SE5b. Stratified mean catch per tow (numbers) for haddock in NEFC offshore autumn research vessel bottom trawl surveys on Georges Bank (Strata 13-25, 29-30), 1963-1990.

Unadjusted for changes in gear usage

Year	Age group 0	1	2	3	4	5	6	7	8	9+	Total	Total 1+
1963	56.33	17.04	6.19	4.57	5.60	3.99	1.37	1.13	0.79	0.31	97.32	40.99
1964	1.59	75.75	42.78	3.91	1.20	2.56	1.05	0.46	0.17	0.22	129.69	128.10
1965	0.22	6.82	51.94	6.51	0.72	0.54	0.61	0.54	0.17	0.18	68.25	68.03
1966	4.12	0.64	1.94	12.34	2.25	0.35	0.33	0.22	0.08	0.05	22.32	18.20
1967	0.02	4.51	0.24	0.67	4.54	1.09	0.33	0.14	0.22	0.12	11.88	11.86
1968	0.06	0.04	0.64	0.09	0.22	2.59	0.85	0.18	0.11	0.26	5.04	4.98
1969	0.26	0.02	0.00	0.19	0.09	0.11	1.02	0.34	0.06	0.18	2.27	2.01
1970	0.03	2.77	0.14	0.01	0.19	0.18	0.34	0.92	0.32	0.27	5.17	5.14
1971	1.63	0.00	0.21	0.05	0.01	0.15	0.02	0.06	0.50	0.19	2.82	1.19
1972	4.53	1.69	0.00	0.35	0.06	0.00	0.06	0.04	0.02	0.87	7.62	3.09
1973	2.17	6.04	1.08	0.00	0.13	0.03	0.00	0.05	0.01	0.48	9.99	7.82
1974	0.50	1.19	0.66	0.21	0.00	0.01	0.00	0.00	0.00	0.15	2.72	2.22
1975	15.76	0.42	0.48	3.26	0.62	0.00	0.02	0.00	0.01	0.20	20.77	5.01
1976	2.90	43.07	0.35	0.36	0.55	0.20	0.00	0.03	0.07	0.17	47.70	44.80
1977	0.11	1.75	15.33	0.46	0.47	0.52	0.28	0.03	0.01	0.07	19.03	18.92
1978	10.82	0.69	0.85	7.59	0.15	0.21	0.37	0.01	0.00	0.01	20.70	9.88
1979	1.08	37.29	0.03	0.74	3.12	0.21	0.23	0.04	0.01	0.00	42.75	41.67
1980	9.56	2.22	10.41	0.37	0.15	1.39	0.39	0.38	0.07	0.05	24.99	15.43
1981	0.31	5.02	1.70	3.03	0.17	0.34	0.43	0.00	0.00	0.01	11.01	10.70
1982	0.91	0.00	0.89	0.23	0.94	0.09	0.05	0.14	0.01	0.07	3.33	2.42
1983	3.89	0.16	0.14	0.18	0.20	0.63	0.08	0.00	0.07	0.01	5.36	1.47
1984	0.02	2.23	0.59	0.16	0.19	0.04	0.30	0.00	0.00	0.08	3.61	3.59
1985	11.35	0.65	1.53	0.22	0.05	0.10	0.07	0.17	0.00	0.05	14.19	2.84
1986	0.00	5.11	0.09	1.21	0.06	0.13	0.13	0.02	0.03	0.03	6.81	6.81
1987	1.80	0.00	0.79	0.10	0.77	0.06	0.06	0.02	0.02	0.00	3.62	1.82
1988	0.07	3.02	0.18	1.30	0.12	0.40	0.12	0.11	0.00	0.03	5.35	5.28
1989	0.57	0.06	3.30	0.24	0.81	0.11	0.16	0.02	0.02	0.00	5.29	4.72
1990	0.94	0.82	0.03	1.45	0.06	0.21	0.05	0.00	0.00	0.00	3.56	2.62

Adjusted for changes in gear usage

Year	0	1	2	3	4	5	6	7	8	9+	Total	Total 1+
1963	91.98	27.83	10.11	7.46	9.14	6.52	2.24	1.85	1.29	0.51	158.92	66.94
1964	2.60	123.70	69.86	6.39	1.96	4.18	1.71	0.75	0.28	0.36	211.78	209.19
1965	0.36	11.14	84.82	10.63	1.18	0.88	1.00	0.88	0.28	0.29	111.45	111.09
1966	6.73	1.05	3.17	20.15	3.67	0.57	0.54	0.36	0.13	0.08	36.45	29.72
1967	0.03	7.36	0.39	1.09	7.41	1.78	0.54	0.23	0.36	0.20	19.40	19.37
1968	0.10	0.07	1.05	0.15	0.36	4.23	1.39	0.29	0.18	0.42	8.23	8.13
1969	0.42	0.03	0.00	0.31	0.15	0.18	1.67	0.56	0.10	0.29	3.71	3.28
1970	0.05	4.52	0.23	0.02	0.31	0.29	0.56	1.50	0.52	0.44	8.44	8.39
1971	2.66	0.00	0.34	0.08	0.02	0.24	0.03	0.10	0.82	0.31	4.61	1.94
1972	7.40	2.76	0.00	0.57	0.10	0.00	0.10	0.07	0.03	1.42	12.44	5.05
1973	3.54	9.86	1.76	0.00	0.21	0.05	0.00	0.08	0.02	0.78	16.31	12.77
1974	0.82	1.94	1.08	0.34	0.00	0.02	0.00	0.00	0.00	0.24	4.44	3.63
1975	25.74	0.69	0.78	5.32	1.01	0.00	0.03	0.00	0.02	0.33	33.92	8.18
1976	4.74	70.33	0.57	0.59	0.90	0.33	0.00	0.05	0.11	0.28	77.89	73.16
1977	0.15	2.43	21.32	0.64	0.65	0.72	0.39	0.04	0.01	0.10	26.47	26.32
1978	15.05	0.96	1.18	10.56	0.21	0.29	0.51	0.01	0.00	0.01	28.79	13.74
1979	1.50	51.87	0.04	1.03	4.34	0.29	0.32	0.06	0.01	0.00	59.47	57.96
1980	13.30	3.09	14.48	0.51	0.21	1.93	0.54	0.53	0.10	0.07	34.76	21.46
1981	0.43	6.98	2.36	4.21	0.24	0.47	0.60	0.00	0.00	0.01	15.31	14.88
1982	1.49	0.00	1.45	0.38	1.54	0.15	0.08	0.23	0.02	0.11	5.44	3.95
1983	6.35	0.26	0.23	0.29	0.33	1.03	0.13	0.00	0.11	0.02	8.75	2.40
1984	0.03	3.64	0.96	0.26	0.31	0.07	0.49	0.00	0.00	0.13	5.90	5.86
1985	11.35	0.65	1.53	0.22	0.05	0.10	0.07	0.17	0.00	0.05	14.19	2.84
1986	0.00	5.11	0.09	1.21	0.06	0.13	0.13	0.02	0.03	0.03	6.81	6.81
1987	1.08	0.00	0.79	0.10	0.77	0.06	0.06	0.02	0.02	0.00	3.62	1.82
1988	0.07	3.02	0.18	1.30	0.12	0.40	0.12	0.11	0.00	0.03	5.35	5.28
1989	0.49	0.05	2.81	0.20	0.69	0.09	0.14	0.02	0.02	0.00	4.51	4.02
1990	0.80	0.70	0.03	1.24	0.05	0.18	0.04	0.00	0.00	0.00	3.03	2.23

Table SE5c. Stratified mean catch per tow (numbers) for haddock in Canadian offshore research vessel bottom trawl surveys on Georges Bank, 1986-1990.

					Age group						
Year	0	1	2	3	4	5	6	7	8	9+	Total	Total 1+
1986	0.00	4.06	0.22	6.05	1.07	0.19	0.29	0.34	0.37	0.42	13.01	13.01
~~1987~~	~~0.00~~	~~0.03~~	~~3.04~~	~~0.69~~	~~2.51~~	~~0.67~~	~~0.08~~	~~0.30~~	~~0.10~~	~~0.86~~	~~8.28~~	~~8.28~~
1988	0.00	1.47	0.05	8.50	0.17	2.88	0.18	0.17	0.11	0.50	14.03	14.03
1989	0.00	0.03	5.20	0.07	2.05	0.18	0.42	0.03	0.03	0.23	8.24	8.24
1990	0.00	0.93	0.11	9.86	0.13	3.36	0.23	1.09	0.13	0.34	16.18	16.18
1990	0.00	0.76	1.68	0.14	8.92	0.11	1.58	0.09	0.44	0.19	13.91	13.91

Table SE6a. Stratified mean catch per tow in numbers for haddock in NEFC offshore spring research vessel bottom trawl surveys in the Gulf of Maine (Strata 26-28, 36-40), 1968-1990.

Unadjusted for changes in gear usage

Year	Age group 0	1	2	3	4	5	6	7	8	9+	Total	Total 1+
1968	0.00	0.00	0.00	0.00	0.31	2.97	0.64	0.05	0.00	0.13	4.10	4.10
1969	0.00	0.00	0.00	0.05	0.01	0.13	1.82	0.47	0.00	0.05	2.53	2.53
1970	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.41	0.06	0.04	0.61	0.61
1971	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.43	0.12	0.59	0.59
1972	0.00	0.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.18	0.57	0.57
1973	0.00	0.09	0.53	0.00	0.04	0.00	0.00	0.00	0.00	0.23	0.89	0.89
1974	0.00	0.59	0.06	0.22	0.00	0.00	0.00	0.00	0.00	0.09	0.96	0.96
1975	0.00	0.03	1.31	0.10	0.25	0.00	0.01	0.00	0.00	0.16	1.86	1.86
1976	0.00	3.46	0.07	1.21	0.12	0.61	0.00	0.02	0.00	0.10	5.59	5.59
1977	0.00	0.60	2.39	0.02	0.90	0.27	0.39	0.00	0.00	0.00	4.57	4.57
1978	0.00	0.06	0.47	0.22	0.05	0.09	0.03	0.00	0.00	0.00	0.92	0.92
1979	0.00	0.25	0.00	1.10	0.78	0.06	0.11	0.04	0.00	0.00	2.34	2.34
1980	0.00	0.86	0.12	0.14	0.36	0.28	0.05	0.00	0.00	0.00	1.81	1.81
1981	0.00	0.88	0.98	0.50	0.00	0.18	0.22	0.00	0.00	0.18	2.94	2.94
1982	0.00	0.04	0.35	0.75	0.35	0.13	0.04	0.01	0.00	0.00	1.67	1.67
1983	0.00	1.00	0.06	0.86	0.21	0.21	0.00	0.08	0.00	0.06	2.48	2.48
1984	0.00	0.01	0.35	0.08	0.19	0.08	0.00	0.00	0.03	0.00	0.74	0.74
1985	0.00	0.01	0.31	1.09	0.06	0.17	0.06	0.05	0.02	0.00	1.77	1.77
1986	0.00	0.05	0.00	0.14	0.39	0.00	0.04	0.07	0.02	0.00	0.71	0.71
1987	0.00	0.04	0.03	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.10	0.10
1988	0.00	0.04	0.00	0.00	0.01	0.12	0.01	0.00	0.00	0.00	0.18	0.18
1989	0.00	0.00	0.04	0.04	0.00	0.01	0.01	0.01	0.00	0.00	0.11	0.11
1990	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.03

Adjusted for changes in gear usage

Year	Age group 0	1	2	3	4	5	6	7	8	9+	Total	Total 1+
1968	0.00	0.00	0.00	0.00	0.51	4.85	1.05	0.08	0.00	0.21	6.70	6.70
1969	0.00	0.00	0.00	0.08	0.02	0.21	2.97	0.77	0.00	0.08	4.13	4.13
1970	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.67	0.10	0.07	1.00	1.00
1971	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.03	0.70	0.20	0.96	0.96
1972	0.00	0.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.29	0.93	0.93
1973	0.00	0.15	0.87	0.00	0.07	0.00	0.00	0.00	0.00	0.38	1.45	1.45
1974	0.00	0.96	0.10	0.36	0.00	0.00	0.00	0.00	0.00	0.15	1.57	1.57
1975	0.00	0.05	2.14	0.16	0.41	0.00	0.02	0.00	0.00	0.26	3.04	3.04
1976	0.00	5.65	0.11	1.98	0.20	1.00	0.00	0.03	0.00	0.16	9.13	9.13
1977	0.00	0.98	3.90	0.03	1.47	0.44	0.64	0.00	0.00	0.00	7.46	7.46
1978	0.00	0.10	0.77	0.36	0.08	0.15	0.05	0.00	0.00	0.00	1.50	1.50
1979	0.00	0.35	0.00	1.53	1.08	0.08	0.15	0.06	0.00	0.00	3.25	3.25
1980	0.00	1.20	0.17	0.19	0.50	0.39	0.07	0.00	0.00	0.00	2.52	2.52
1981	0.00	1.22	1.36	0.70	0.00	0.25	0.31	0.00	0.00	0.25	4.09	4.09
1982	0.00	0.06	0.49	1.04	0.49	0.18	0.06	0.01	0.00	0.00	2.32	2.32
1983	0.00	1.63	0.10	1.40	0.34	0.34	0.00	0.13	0.00	0.10	4.05	4.05
1984	0.00	0.02	0.57	0.13	0.31	0.13	0.00	0.00	0.05	0.00	1.21	1.21
1985	0.00	0.01	0.31	1.09	0.06	0.17	0.06	0.05	0.02	0.00	1.77	1.77
1986	0.00	0.05	0.00	0.14	0.39	0.00	0.04	0.07	0.02	0.00	0.71	0.71
1987	0.00	0.03	0.03	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.09	0.09
1988	0.00	0.04	0.00	0.00	0.01	0.12	0.01	0.00	0.00	0.00	0.18	0.18
1989	0.00	0.00	0.03	0.03	0.00	0.01	0.01	0.01	0.00	0.00	0.09	0.09
1990	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.03

Table SE6b. Stratified mean catch per tow in numbers for haddock in NEFC offshore autumn research vessel bottom trawl surveys in the Gulf of Maine (Strata 26-28, 36-40), 1963-1990.

Unadjusted for changes in gear usage

Year	Age group 0	1	2	3	4	5	6	7	8	9+	Total	Total 1+
1963	23.89	8.18	1.14	2.02	4.66	3.31	1.12	0.88	0.70	0.78	46.68	22.79
1964	0.02	3.34	1.52	0.48	0.82	1.62	0.96	0.32	0.22	0.21	9.51	9.49
1965	0.00	0.29	5.39	3.40	0.17	0.98	0.77	0.44	0.21	0.05	11.70	11.70
1966	0.00	0.01	0.38	4.88	1.60	0.17	0.42	0.28	0.05	0.02	7.81	7.81
1967	0.00	0.00	0.00	0.88	5.52	1.21	0.33	0.09	0.11	0.03	8.17	8.17
1968	0.00	0.00	0.00	0.00	0.13	4.19	0.95	0.17	0.20	0.09	5.73	5.73
1969	0.00	0.00	0.00	0.02	0.02	0.02	2.78	0.57	0.09	0.15	3.65	3.65
1970	0.00	0.03	0.00	0.00	0.00	0.03	0.06	1.38	0.41	0.06	1.97	1.97
1971	0.18	0.00	0.04	0.00	0.03	0.00	0.07	0.12	1.31	0.19	1.94	1.76
1972	0.00	0.80	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.52	1.34	1.34
1973	0.74	0.02	0.64	0.00	0.22	0.02	0.02	0.03	0.01	1.09	2.79	2.05
1974	0.01	1.13	0.12	0.30	0.00	0.00	0.00	0.00	0.02	0.21	1.79	1.78
1975	0.59	0.14	1.29	0.37	0.93	0.00	0.03	0.03	0.00	0.31	3.69	3.10
1976	1.10	1.20	0.05	0.86	0.11	0.55	0.00	0.13	0.00	0.06	4.06	2.96
1977	0.03	2.74	2.65	0.10	0.85	0.13	0.21	0.00	0.00	0.07	6.78	6.75
1978	0.13	0.01	1.65	3.78	0.38	0.93	0.78	0.12	0.01	0.19	7.98	7.85
1979	0.59	0.30	0.01	0.79	1.97	0.41	0.30	0.09	0.05	0.02	4.53	3.94
1980	3.24	0.42	0.26	0.00	0.24	0.88	0.55	0.11	0.08	0.08	5.86	2.62
1981	0.02	0.28	0.40	0.60	0.28	0.55	0.72	0.00	0.13	0.05	3.03	3.01
1982	0.25	0.03	0.42	0.51	0.34	0.02	0.03	0.15	0.00	0.00	1.75	1.50
1983	0.00	0.37	0.04	0.41	0.35	0.26	0.11	0.05	0.12	0.04	1.75	1.75
1984	0.00	0.14	0.35	0.01	0.17	0.00	0.34	0.00	0.00	0.14	1.15	1.15
1985	0.00	0.09	0.47	2.73	0.02	0.18	0.15	0.39	0.00	0.05	4.08	4.08
1986	0.00	0.01	0.00	0.07	0.30	0.14	0.02	0.03	0.06	0.00	0.63	0.63
1987	0.02	0.00	0.13	0.13	0.17	0.06	0.25	0.16	0.00	0.10	1.02	1.00
1988	0.00	0.00	0.00	0.04	0.02	0.08	0.00	0.04	0.14	0.00	0.32	0.32
1989	0.00	0.07	0.07	0.02	0.01	0.04	0.06	0.06	0.00	0.00	0.33	0.33
1990	0.01	0.03	0.00	0.09	0.00	0.00	0.00	0.02	0.02	0.00	0.17	0.16

Adjusted for changes in gear usage

Year	Age group 0	1	2	3	4	5	6	7	8	9+	Total	Total 1+
1963	30.01	13.36	1.86	3.30	7.61	5.41	1.83	1.44	1.14	1.27	67.23	37.22
1964	0.03	5.45	2.48	0.78	1.34	2.65	1.57	0.52	0.36	0.34	15.53	15.50
1965	0.00	0.47	8.80	5.55	0.28	1.60	1.26	0.72	0.34	0.08	19.11	19.11
1966	0.00	0.02	0.62	7.97	2.61	0.28	0.69	0.46	0.08	0.03	12.75	12.75
1967	0.00	0.00	0.00	1.44	9.01	1.98	0.54	0.15	0.18	0.05	13.34	13.34
1968	0.00	0.00	0.00	0.00	0.21	6.84	1.55	0.28	0.33	0.15	9.36	9.36
1969	0.00	0.00	0.00	0.03	0.03	0.03	4.54	0.93	0.15	0.24	5.96	5.96
1970	0.00	0.05	0.00	0.00	0.00	0.05	0.10	2.25	0.67	0.10	3.22	3.22
1971	0.29	0.00	0.07	0.00	0.05	0.00	0.11	0.20	2.14	0.31	3.16	2.87
1972	0.00	1.31	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.85	2.19	2.19
1973	1.21	0.03	1.05	0.00	0.36	0.03	0.03	0.05	0.02	1.78	4.56	3.35
1974	0.02	1.85	0.20	0.49	0.00	0.00	0.00	0.00	0.03	0.34	2.93	2.91
1975	0.96	0.23	2.11	0.60	1.52	0.00	0.05	0.05	0.00	0.51	6.02	5.06
1976	1.80	1.96	0.08	1.40	0.18	0.90	0.00	0.21	0.00	0.10	6.63	4.83
1977	0.04	3.81	3.69	0.14	1.18	0.18	0.29	0.00	0.00	0.10	9.43	9.39
1978	0.18	0.01	2.30	5.26	0.53	1.29	1.08	0.17	0.01	0.26	11.10	10.92
1979	0.96	0.49	0.02	1.29	3.22	0.67	0.49	0.15	0.08	0.03	7.39	6.43
1980	4.51	0.58	0.36	0.00	0.33	1.22	0.77	0.15	0.11	0.11	8.15	3.64
1981	0.03	0.46	0.65	0.98	0.46	0.90	1.18	0.00	0.21	0.08	4.95	4.92
1982	0.41	0.05	0.69	0.83	0.56	0.03	0.05	0.24	0.00	0.00	2.86	2.45
1983	0.00	0.60	0.07	0.67	0.57	0.42	0.18	0.08	0.20	0.07	2.86	2.86
1984	0.00	0.23	0.57	0.02	0.28	0.00	0.56	0.00	0.00	0.23	1.88	1.88
1985	0.00	0.09	0.47	2.73	0.02	0.18	0.15	0.39	0.00	0.05	4.08	4.08
1986	0.00	0.01	0.00	0.07	0.30	0.14	0.02	0.03	0.06	0.00	0.63	0.63
1987	0.02	0.00	0.13	0.13	0.17	0.06	0.25	0.16	0.00	0.10	1.02	1.00
1988	0.00	0.00	0.00	0.04	0.02	0.08	0.00	0.04	0.14	0.00	0.32	0.32
1989	0.00	0.06	0.06	0.02	0.01	0.03	0.05	0.05	0.00	0.00	0.28	0.28
1990	0.00	0.03	0.00	0.08	0.00	0.00	0.00	0.02	0.02	0.00	0.14	0.14

Table SE7. Estimates of instantaneous fishing mortality (F), beginning year stock sizes (000s of fish), and mean stock biomass (MT) for Georges Bank haddock as estimated from virtual population analysis (VPA), calibrated using the ADAPT procedure, 1963-1990.

(a) Fishing Mortality

AGE	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
1	0.0170	0.0239	0.3858	0.0309	0.1033	0.0212	0.0022	0.0110	0.0030	0.0205	0.1576	0.0048	0.0282	0.0015	0.0001	0.0002	0.0000
2	0.1492	0.1219	0.4599	0.5273	0.0582	0.4248	0.0366	0.2438	0.5156	0.0074	0.4095	0.4336	0.1431	0.0900	0.2971	0.0779	0.0059
3	0.2882	0.2500	0.5834	0.8473	0.4436	0.3695	0.4567	0.0686	0.6463	0.3143	0.0137	0.2178	0.3370	0.1053	0.0465	0.3718	0.2542
4	0.3133	0.3047	0.5242	0.5392	0.4063	0.6035	0.4232	0.2709	0.2443	0.5159	0.4892	0.0113	0.1859	0.2628	0.1835	0.0997	0.3202
5	0.3741	0.4331	0.5109	0.5709	0.6364	0.5622	0.4223	0.3108	0.2141	0.3153	0.7757	0.1505	0.0281	0.1552	0.2418	0.2296	0.2489
6	0.3083	0.4970	0.7089	0.6550	0.5288	0.4585	0.4747	0.2358	0.8888	0.1291	0.5523	0.0555	0.1268	0.0000	0.4137	0.4086	0.2587
7	0.3251	0.5385	0.7172	0.5785	0.5675	0.6341	0.3850	0.3392	0.5665	0.8090	0.1142	0.0619	0.1503	0.0947	0.0434	0.2793	0.4710
8	0.3357	0.4206	0.6123	0.5632	0.4720	0.5545	0.4538	0.3173	0.3768	0.2428	0.3461	0.1073	0.1696	0.2207	0.2305	0.2105	0.3172
9	0.3357	0.4206	0.6123	0.5632	0.4720	0.5545	0.4538	0.3173	0.3768	0.2428	0.3461	0.1073	0.1696	0.2207	0.2305	0.2105	0.3172

AGE	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	0.0009	0.0002	0.0005	0.0000	0.0000	0.0000	0.0005	0.0000	0.0003	0.0000	0.0005
2	0.6943	0.2682	0.2500	0.1270	0.0451	0.2182	0.0491	0.2095	0.0751	0.1047	0.0519
3	0.1005	0.5697	0.4338	0.2771	0.2608	0.4048	0.4273	0.1589	0.4158	0.1715	0.1665
4	0.2228	0.3701	0.3831	0.3289	0.4289	0.2715	0.2839	0.4681	0.2465	0.2636	0.5537
5	0.4930	0.3467	0.2976	0.4185	0.3198	0.5358	0.3379	0.2476	0.5462	0.4531	0.4560
6	0.4951	0.4015	0.3672	0.3489	0.5450	0.3069	0.3929	0.2817	0.5433	0.4175	0.6442
7	0.6543	0.5728	0.3045	0.1950	0.5774	0.3771	0.3406	0.3601	0.3558	0.3177	0.3701
8	0.4414	0.3953	0.3602	0.3722	0.4739	0.3829	0.3325	0.4313	0.4792	0.3088	0.5060
9	0.4414	0.3953	0.3602	0.3722	0.4739	0.3829	0.3325	0.4313	0.4792	0.3088	0.5060

Mean F (unweighted)

AGE	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
2+	0.3037	0.3733	0.5911	0.6056	0.4481	0.5202	0.3883	0.2630	0.4787	0.3221	0.3809	0.1432	0.1638	0.1437	0.2109	0.2360	0.2741
3+	0.3258	0.4092	0.6099	0.6167	0.5038	0.5338	0.4385	0.2657	0.4734	0.3670	0.3768	0.1017	0.1667	0.1513	0.1986	0.2586	0.3125
4+	0.3320	0.4357	0.6143	0.5783	0.5138	0.5612	0.4355	0.2986	0.4446	0.3758	0.4373	0.0823	0.1384	0.1590	0.2239	0.2397	0.3222
5+	0.3358	0.4620	0.6323	0.5861	0.5353	0.5527	0.4379	0.3041	0.4846	0.3478	0.4269	0.0965	0.1289	0.1383	0.2320	0.2677	0.3226
6+	0.3262	0.4692	0.6627	0.5900	0.5101	0.5504	0.4418	0.3024	0.5522	0.3559	0.3397	0.0830	0.1541	0.1340	0.2295	0.2772	0.3410

AGE	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
2+	0.4429	0.4149	0.3446	0.3050	0.3906	0.3600	0.3121	0.3236	0.3927	0.2932	0.4068
3+	0.4069	0.4359	0.3581	0.3304	0.4400	0.3803	0.3497	0.3398	0.4380	0.3201	0.4575
4+	0.458	0.4136	0.3455	0.3393	0.4698	0.3762	0.3367	0.3700	0.4417	0.3449	0.5060
5+	0.5051	0.4223	0.3379	0.3414	0.4780	0.3971	0.3473	0.3504	0.4808	0.3612	0.4965
6+	0.5081	0.4412	0.348	0.3221	0.5176	0.3625	0.3497	0.3761	0.4644	0.3382	0.5066

Mean F (weighted by N)

AGE	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
2+	0.2875	0.2238	0.5002	0.7510	0.4573	0.5246	0.4466	0.3095	0.4238	0.2519	0.3819	0.3337	0.2199	0.1425	0.2793	0.3054	0.2731
3+	0.3220	0.3808	0.5915	0.7663	0.4690	0.5406	0.4507	0.3124	0.3950	0.2592	0.3354	0.1599	0.2804	0.1671	0.1706	0.3475	0.3033
4+	0.3334	0.4195	0.6078	0.5562	0.4712	0.5481	0.4496	0.3159	0.3836	0.2468	0.3560	0.1076	0.1696	0.2214	0.2319	0.2153	0.3153
5+	0.3515	0.4601	0.6376	0.5916	0.5989	0.5432	0.4510	0.3235	0.3861	0.2394	0.3018	0.1125	0.1372	0.1572	0.2779	0.2855	0.2921
6+	0.3214	0.4852	0.6913	0.6000	0.5126	0.4971	0.4534	0.3242	0.4158	0.2381	0.2820	0.1062	0.1534	0.1604	0.3241	0.3464	0.3247

AGE	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
2+	0.6036	0.4669	0.3505	0.3316	0.3831	0.2792	0.3670	0.2840	0.4160	0.1678	0.2483
3+	0.3984	0.5033	0.3720	0.3530	0.4479	0.3888	0.3976	0.3960	0.4387	0.2969	0.2519
4+	0.4439	0.3926	0.3577	0.3714	0.4727	0.3836	0.3312	0.4299	0.4807	0.3090	0.4659
5+	0.5011	0.3975	0.3219	0.3806	0.4847	0.4046	0.3469	0.3398	0.5256	0.4002	0.4561
6+	0.5392	0.4149	0.3273	0.3289	0.5233	0.3598	0.3490	0.3800	0.4793	0.3862	0.4563

Table SE7 (Continued)

(b) Stock Numbers (Jan 1) in thousands

AGE	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
1	190696.20	471862.13	33152.21	4136.35	12948.14	421.70	987.84	4658.06	367.84	8508.40
2	32265.31	153495.77	377188.27	18455.39	3283.40	9560.47	338.02	806.96	3772.08	300.26
3	32742.07	22754.72	111253.12	194970.81	8918.19	2536.21	5118.37	266.80	517.72	1844.16
4	45819.43	20094.85	14509.36	50824.71	68411.93	4685.71	1434.94	2654.15	203.96	222.09
5	29030.14	27423.03	12130.77	7032.95	24268.73	37310.68	2098.14	769.47	1657.28	130.79
6	9186.25	16350.01	14560.09	5958.69	3253.50	10515.35	17410.07	1126.05	461.69	1095.37
7	5594.50	5525.90	8143.63	5867.43	2534.13	1569.79	5443.21	8866.76	728.30	155.41
8	2794.45	3309.10	2640.35	3254.39	2693.76	1176.27	681.71	3032.31	5171.12	338.40
9	4217.24	4250.79	3258.24	2200.93	2031.09	2162.80	1711.22	1873.02	3240.96	6301.30
1+	352345.58	725066.30	576836.04	292701.64	128342.88	69938.99	35223.53	24053.57	16120.93	18896.18
2+	161649.38	253204.17	543683.83	288565.29	115394.74	69517.29	34235.69	19395.51	15753.09	10387.78
3+	129384.07	99708.40	166495.56	270109.90	112111.34	59956.82	33897.67	18588.55	11981.02	10087.52
4+	96642.01	76953.68	55242.44	75139.10	103193.15	57420.61	28779.30	18321.75	11463.30	8243.36
5+	50822.58	56858.83	40733.08	24314.39	34781.21	52734.89	27344.36	15667.60	11259.34	8021.27
6+	21792.44	29435.80	28602.31	17281.44	10512.48	15424.21	25246.21	14898.13	9602.06	7890.47

AGE	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
1	19402.98	10521.11	7634.20	103024.63	13704.31	6018.02	83599.85	10011.44	7111.59	2422.82
2	6824.94	13569.44	8572.34	6076.63	84219.14	11219.24	4926.23	68444.86	8189.43	5821.57
3	244.02	3710.25	7200.82	6082.83	4547.13	51231.56	8496.95	4009.73	27987.96	5127.81
4	1102.70	197.07	2443.22	4208.91	4482.54	3553.67	28919.72	5394.97	2968.91	12963.20
5	108.54	553.54	159.54	1661.02	2649.71	3054.71	2633.53	17190.68	3534.81	1678.82
6	78.13	40.91	389.87	127.00	1164.48	1703.41	1987.94	1681.11	8596.65	2046.22
7	788.23	36.82	31.69	281.19	103.98	630.37	926.83	1256.60	838.90	4711.10
8	56.66	575.68	28.34	22.32	209.41	81.51	390.33	473.80	534.78	387.33
9	1675.95	2695.27	620.62	621.72	592.74	388.08	185.74	248.59	315.56	398.89
1+	30282.15	31900.09	27080.62	122106.25	111673.44	77880.56	132067.12	108711.79	60078.59	35557.77
2+	10879.17	21378.98	19446.42	19081.63	97969.13	71862.54	48467.27	98700.35	52967.00	33134.95
3+	4054.23	7809.54	10874.08	13005.00	13750.00	60643.30	43541.04	30255.49	44777.57	27313.38
4+	3810.21	4099.30	3673.26	6922.16	9202.86	9411.74	35044.09	26245.76	16789.61	22185.57
5+	2707.52	3902.23	1230.05	2713.25	4720.32	5858.07	6124.37	20850.79	13820.70	9222.37
6+	2598.97	3348.68	1070.51	1052.23	2070.61	2803.36	3490.85	3660.11	10285.89	7543.55

AGE	1983	1984	1985	1986	1987	1988	1989	1990	1991
1	2849.31	16569.94	1520.74	14252.81	969.74	17153.33	320.01	4573.35	4149.24
2	1982.73	2332.82	13566.32	1245.08	11663.79	793.96	14040.34	262.00	3742.53
3	3712.16	1429.69	1825.80	8930.13	970.52	7744.35	602.98	10352.45	203.65
4	2720.70	2303.63	901.79	997.18	4768.78	677.87	4183.41	415.87	7175.62
5	7235.61	1603.18	1228.24	562.79	614.64	2444.84	433.75	2631.54	195.71
6	1020.71	3898.09	953.35	588.46	328.67	392.84	1159.26	225.73	1365.51
7	1160.45	589.57	1850.51	574.24	325.26	203.04	186.81	625.19	97.04
8	2844.61	781.80	270.97	1039.13	334.42	185.77	116.47	111.32	353.52
9	268.13	1574.90	523.83	232.71	422.17	304.74	185.91	118.48	113.43
1+	23794.41	31083.61	22641.55	28422.52	20397.98	29900.72	21228.93	19315.92	17396.24
2+	20945.10	14513.67	21120.81	14169.71	19428.24	12747.39	20908.92	14742.57	13247.00
3+	18962.37	12180.85	7554.49	12924.63	7764.45	11953.44	6868.58	14480.57	9504.47
4+	15250.21	10751.17	5728.69	3994.50	6793.93	4209.09	6265.59	4128.12	9300.82
5+	12529.51	8447.54	4826.89	2997.33	2025.16	3531.21	2082.19	3712.26	2125.20
6+	5293.90	6844.36	3598.66	2434.54	1410.52	1086.37	1648.44	1080.72	1929.49

Table SE7 (Continued)

(c) Mean Biomass (MT)

AGE	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
1	97711.55	211379.94	14552.48	2142.22	7371.41	223.21	465.06	2981.65	223.05	4734.17
2	23693.41	108931.99	190530.50	9573.09	2025.62	5758.80	234.79	827.63	2774.94	279.30
3	30569.04	20522.76	79447.60	107550.01	6247.68	2030.27	4127.60	285.45	457.59	2508.72
4	52681.45	22564.34	13937.21	45266.24	60533.46	4251.08	1804.70	4085.30	286.53	323.55
5	37105.72	33320.57	14499.16	8334.77	23351.15	40990.15	2733.51	1319.54	3243.20	247.35
6	15483.66	23665.72	19032.90	8291.04	4736.09	16176.20	25196.67	2181.53	790.42	2725.51
7	10227.78	9377.11	12046.79	9295.01	4086.84	2470.17	10384.63	17682.48	1485.36	299.47
8	6577.01	6508.84	4808.66	6533.09	5217.57	2163.86	1496.30	7646.75	12181.40	940.56
9	10121.59	9406.25	6937.83	4895.52	4584.77	4343.16	4559.93	5483.70	9161.51	18634.04
1+	284171.207	445677.515	355793.121	201880.987	118154.591	78406.888	51003.174	42494.023	30604.010	30692.659
2+	186459.654	234297.572	341240.646	199738.771	110783.177	78183.678	50538.110	39512.376	30380.965	25958.485
3+	162766.247	125365.583	150710.147	190165.686	108757.554	72424.880	50303.326	38684.745	27606.021	25679.185
4+	132197.211	104842.823	71262.547	82615.679	102509.870	70394.611	46175.724	38399.300	27148.435	23170.466
5+	79515.763	82278.487	57325.341	37349.436	41976.410	66143.536	44371.030	34313.997	26861.902	22846.919
6+	42410.042	48957.916	42826.178	29014.663	18625.257	25153.388	41637.520	32994.455	23618.698	22599.573

AGE	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
1	9787.64	6849.71	4232.01	46653.12	6582.79	2890.58	40158.06	4988.48	2513.58	482.99
2	5263.68	10654.14	7111.42	5222.23	71010.04	9207.42	4452.27	42526.49	5689.46	4547.40
3	347.14	5519.60	9081.74	7286.44	5803.22	58527.25	8741.04	4190.59	24206.41	5507.05
4	1697.24	412.14	4479.73	6705.10	8079.14	6264.14	45549.11	7611.21	4141.12	18466.59
5	167.05	1321.42	313.83	3718.91	5847.20	6928.27	5325.75	26910.81	6262.99	3134.53
6	180.65	135.75	977.77	354.52	2793.60	4070.36	5006.46	3416.74	17572.00	4310.28
7	2313.28	131.20	106.93	898.66	383.00	1687.70	2552.15	3041.70	2167.84	11987.09
8	168.52	1942.86	95.94	85.10	680.66	241.34	1155.04	1245.04	1628.10	1174.37
9	5088.02	9885.29	2246.60	2507.07	2403.49	1626.46	706.26	710.13	1055.81	1249.11
1+	25013.22	36852.10	28645.97	73431.15	103583.13	91443.51	113646.14	94641.16	65237.30	50859.40
2+	15225.58	30002.39	24413.96	26778.03	97000.34	88552.93	73488.08	89652.69	62723.72	50376.41
3+	9961.90	19348.25	17302.54	21555.80	25990.30	79345.51	69035.81	47126.20	57034.26	45829.01
4+	9614.76	13828.65	8220.80	14269.37	20187.08	20818.26	60294.77	42935.61	32827.85	40321.97
5+	7917.52	13416.51	3741.07	7564.27	12107.95	14554.12	14745.65	35324.41	28686.73	21855.37
6+	7750.47	12095.09	3427.24	3845.35	6260.75	7625.85	9419.91	8413.60	22423.75	18720.84

AGE	1983	1984	1985	1986	1987	1988	1989	1990
1	852.21	4955.97	454.85	5811.79	377.94	6528.87	153.72	2652.21
2	1724.99	1903.45	10976.26	1035.98	7943.67	680.22	10771.58	224.65
3	4044.38	1512.11	1904.27	9021.31	1166.11	7748.25	745.40	12654.13
4	3866.63	3129.19	1423.66	1446.69	6956.75	918.55	5992.45	525.76
5	11924.95	2750.54	2138.89	1114.32	1114.86	3549.05	703.88	4071.88
6	2081.63	7338.06	2034.14	1256.32	685.98	679.08	2222.84	393.29
7	3115.76	1213.11	4302.41	1312.98	752.08	462.61	472.46	1343.78
8	7277.99	1939.54	763.86	2787.56	934.86	470.56	324.96	253.11
9	871.80	4262.32	1508.42	682.01	1342.96	875.87	556.60	353.50
1+	35760.34	29004.29	25506.76	24468.96	21275.19	21913.05	21943.88	22472.30
2+	34908.13	24048.31	25051.91	18657.17	20897.25	15384.19	21790.16	19820.10
3+	33183.14	22144.87	14075.65	17621.19	12953.58	14703.97	11018.59	19595.45
4+	29138.76	20632.76	12171.38	8599.89	11787.47	6955.72	10273.19	6941.31
5+	25272.13	17503.57	10747.72	7153.19	4830.73	6037.17	4280.74	6415.56
6+	13347.18	14753.03	8608.83	6038.87	3715.87	2488.12	3576.86	2343.68

Table SE8. Fishing Mortality Reference Points from Yield per Recruits using three sets of maturity and growth data for Georges Bank haddock.

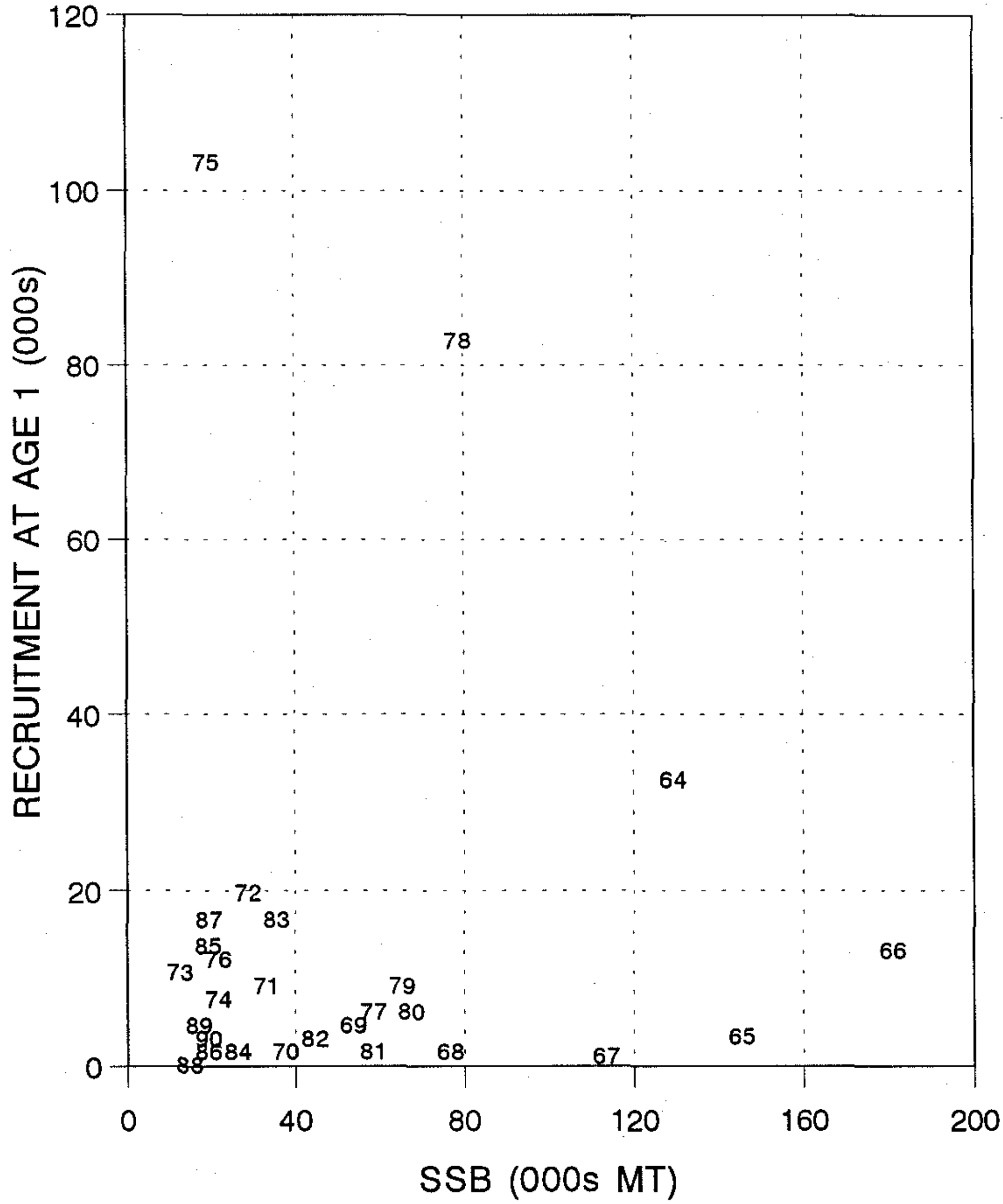
	1963-1967	1968-1983	1985-1990
$F_{0.1}$	0.23	0.24	0.24
$F_{30\%}$	0.32	0.34	0.40
F_{max}	0.82	0.72	0.82

Table SE9. Input parameters and projection results for Georges Bank haddock: landings and spawning stock biomass (mt). Partial recruitment vector is the geometric mean of F at age, 1989-1990. Recruitment levels in 1992-1993 are estimated as the geometric mean of numbers at age 1 (000s) during 1986-1990.

Age	Stock Size in 1991	Fishing Mortality Pattern	Proportion Mature	Average Weights Stock	and Catch
1	4149	0.0005	0.26	0.344	0.467
2	3743	0.1758	0.77	0.620	0.933
3	204	0.4031	0.97	1.142	1.410
4	7177	1.0000	1.00	1.599	1.847
5	196	1.0000	1.00	2.050	2.275
6	1366	1.0000	1.00	2.453	2.630
7	97	1.0000	1.00	2.820	3.012
8	354	1.0000	1.00	3.270	3.528
9	113	1.0000	1.00	3.968	3.968

Recruitment in 1992-93	1991 (F_{SQ} = F1990) F	Land.	SSB	1992 F	Land.	SSB	1993 SSB
LOW = 1489	0.51	7363	16545	F_{SQ} = 0.51	5163	13355	10860
	0.51	7363	16545	$F_{0.1}$ = 0.24	2708	14073	13612
	0.51	7363	16545	$F_{20\%}$ = 0.40	4229	13643	11886
MID = 3222	0.51	7363	16545	F_{SQ} = 0.51	5163	13503	11637
	0.51	7363	16545	$F_{0.1}$ = 0.24	2708	14221	14397
	0.51	7363	16545	$F_{20\%}$ = 0.40	4230	13790	12666
HIGH = 6968	0.51	7363	16545	F_{SQ} = 0.51	5163	13821	13317
	0.51	7363	16545	$F_{0.1}$ = 0.24	2709	14539	16094
	0.51	7363	16545	$F_{20\%}$ = 0.40	4230	14109	14353

GEORGES BANK HADDOCK



FigureSE1: Stock and recruitment data for Georges Bank Haddock. The datapoint labels indicate the year class of each cohort.

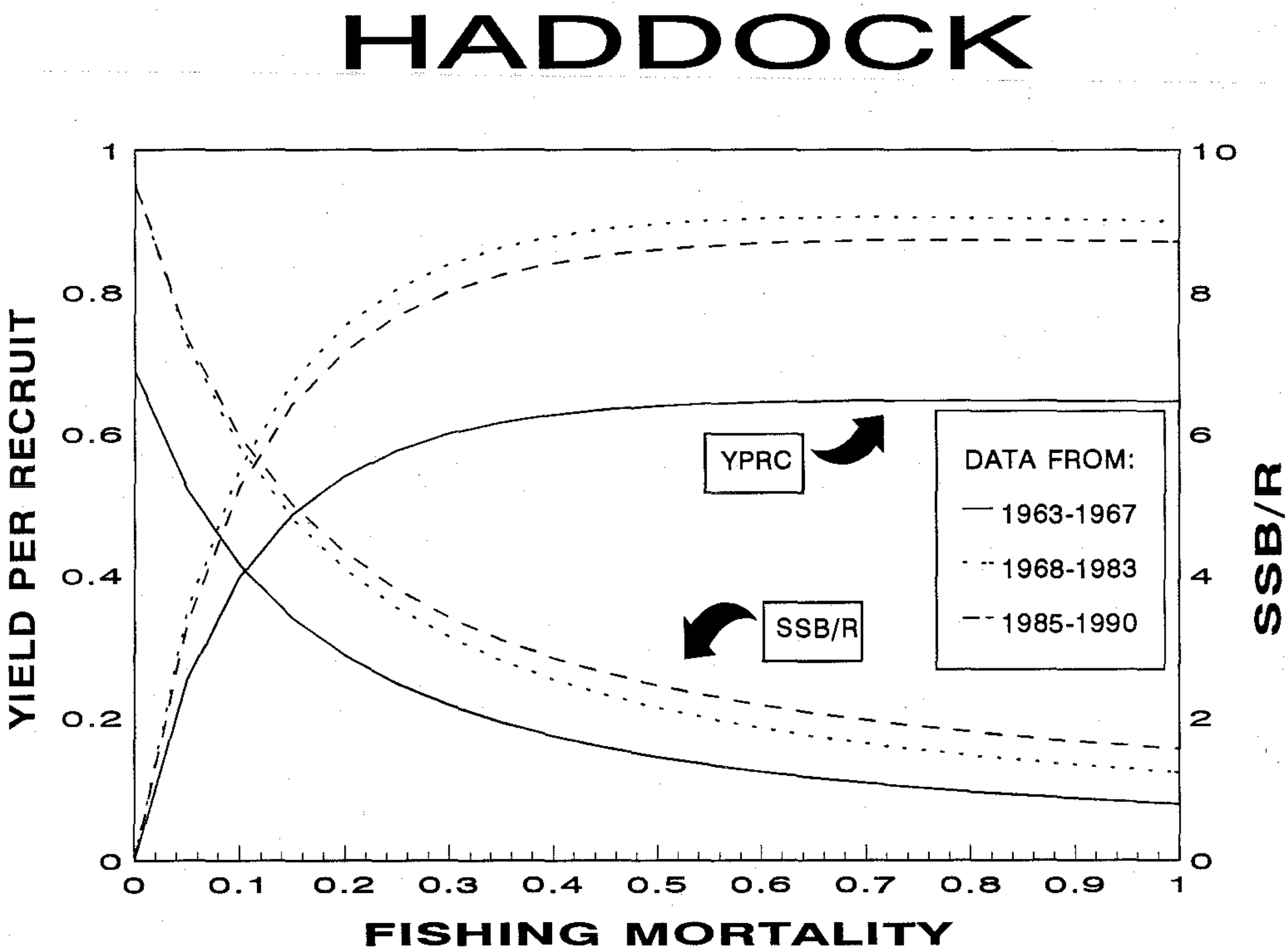


Figure SE2: Yield and spawning biomass per recruit using three sets of maturation data for Georges Bank haddock.

GEORGES BANK COD

An updated analytical assessment of the Georges Bank cod stock for 1978-1990 was presented to the SARC (SAW/13/SARC/18). The assessment included estimates of abundance and fishing mortality rates from Virtual Population Analysis (VPA) tuned with the ADAPT method. Fully recruited instantaneous fishing mortality rates (ages 4 and older) have varied between 0.5 and 0.7 during the past decade. Since 1980, stock abundance has been bolstered by good recruitment from the 1985, 1988, and 1990 year-classes, while total stock size has remained relatively stable since 1986. Spawning stock biomass has increased as a result of good recruitment and biomass has increased and is at its highest level since 1983.

Data Sources

Table SF1 shows the commercial landings for this stock (NAFO Divisions 5Z and 6) from 1960 through 1990. The USA and Canada are the sole contributors to these landings since 1978. Total landings in 1990 were about 42,500 mt, up from 33,100 mt in 1989, and the highest since 1983 (48,900 mt). Otter trawls are the principal gear (84% by weight in the USA fishery in 1990) followed by sink gill nets (9% in 1990), line trawls (5% in 1990), and other gears (2% in 1990).

The USA catch at age matrix was constructed as in previous assessments. In this update, Canadian catch at age, mean lengths at age, and mean weights at age are incorporated directly from the Canadian assessment, so those data differ from previous assessments, when certain characteristics of the Canadian catch at age were derived from USA data. There were some differences in the age compositions of USA and Canadian landings in 1990. In USA landings, age 2 (25%), age 3 (26%), age 4 (15%), and age 5 (25%) cod dominated by weight; in Canadian landings, age 2 fish accounted for only 4% by weight, with age 3, age 4, and age 5 fish accounting for 35%, 16%, and 29% by weight, respectively. The low proportion of age 2 fish in Canadian landings reflects the impact of regulations increasing the legal minimum mesh size in 1990. Total commercial landings at age, mean weights at age, and mean lengths at age for the stock are presented in Table SF2. The review of the previous cod assessment recommended including commercial fishery discard estimates and recreational fishery catch estimates in the updated assessment (NEFC 1990). These data are still problematic and SAW Working Groups have been formed to address some of the problems. Neither discards nor recreational catches are included in the catch at age data presented here. However, the magnitude of recreational catch has been tabulated (Table SF3). Recreational catches in recent years (from both Gulf of Maine and Georges Bank stocks) are estimated to have been between 5000 - 7000 mt.

Fishery independent abundance indices are available from the NEFSC groundfish survey. Spring indices suggest stable stock levels in recent years (1988-1991), while autumn surveys suggest an increase from 1987 to 1990 (Table SF4). In the autumn survey index at age matrix, the 1988 year-class appears as the largest of recent cohorts (Table SF5). Preliminary analysis of the autumn 1991 index noted a steep decline from 1990. Since there is no other evidence to suggest a decline of this magnitude is real, the SARC considers the 1991 autumn survey to be anomalous, possibly reflecting reduced availability of cod to the survey in autumn 1991.

Results of analyses to determine the effects of changes in vessel and gear configurations were presented at SAW 12 (NEFSC 1991). Vessel fishing power studies were necessary due to the use of the DELAWARE II when the ALBATROSS IV was unavailable and the joint use of the vessels in some years. An evaluation of the changes in trawl efficiency was necessary because the NEFC survey trawl doors were changed in 1985. In this assessment, the door effect conversion coefficient (1.56) and vessel conversion coefficient (0.79) for Atlantic cod were applied when necessary to adjust the spring and autumn survey indices used in tuning the VPA. The adjusted survey indices suggest larger stock sizes in the early part of the time series (1978-1984) than did the unadjusted indices Table SF5b).

USA commercial fishery abundance indices for Georges Bank cod were derived based on all cod trips taken in areas from Georges Bank west to New Jersey during 1978-1990 (Table SF6a). The trend of the aggregate index shows declining stock size from 1983 to 1987, and relatively stable stock levels since 1988. A GLM model incorporating year, month, tonnage class, statistical area and depth effects explained 31% of the variation in catch per day fished (Table SF6b). Age disaggregated CPUE indices (Table SF5c) based on this GLM CPUE analysis were used in the ADAPT tuning.

The rate of natural mortality was assumed to be 0.2 for all ages. Updated information on the maturity ogive for Georges Bank cod (O'Brien MS 1991) was incorporated in the VPA, catch and spawning biomass per recruit analysis, and stock projections.

Methodology

The ADAPT method (Gavaris 1988, Conser and Powers 1990) was used to obtain terminal year fishing mortality rates for VPA estimation of stock size and fishing mortality rates for ages 1 to 5. The fishing mortality rates for ages 6 through 10 in 1990 were set equal to the average of ages 4 and 5. The tuning indices, spring and autumn survey numbers per tow ages and commercial CPUE for ages 2 to 6, were weighted equally in the final analysis. Stock size and fishing mortality rates were estimated for ages 1-10+ from 1978-1990.

The partial recruitment vector for this stock was judged to be flat topped from the ADAPT analysis, with full recruitment at age 4, and was calculated from the geometric mean of F over the years 1985-1989 for input to the projection analyses.

Assessment Results

The analysis indicated increasing fishing mortality rates (unweighted) on ages 4 to 8 since 1978, peaking in 1988 at about F = 0.8. The SARC noted that the fishing mortality rate for ages 4 to 8 in 1989, F = 0.61, was very close to that estimated in the previous assessment reviewed at SAW 11 (NEFC 1990). F on ages 4 to 8 in 1990 was estimated to be 0.71 (Table SF7a).

Stock numbers at age estimates from the VPA (Table SF7b) indicated an increase in abundance from 1978 to a peak in 1981 at about 85 million fish (due to the recruitment of the strong 1980 year-class) declining to about 45 million fish in 1985, an increase in stock size to about 68 million fish in 1986 due to recruitment of the strong 1985 year-class, and stable stock sizes in the 60-65 million fish range during 1987 to 1990. The large 1980 and 1985 year-classes are estimated at 41 and 43 million fish at age 1, respectively, while the poorest recent year-classes were spawned in 1982, 1984, 1986 and 1989, with only 10, 8, 14, and 11 million fish at age 1, respectively. The geometric mean recruitment for 1978 to 1987 was about 20 million fish at age 1. The 1990 year-class is estimated at about 28 million fish at age 1 in 1991.

Stock biomass has been relatively stable since 1986 (Table SF7c) after a decrease from the 1978 - 1982 level. Spawning biomass projected to the peak of the spawning season (both sexes) over the period was:

1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
80612	89501	92748	86483	89656	78409	67257	55479	55783	66941	72147	70775	74914

Figures SF1 plots stock and recruitment data.

Biological reference points were recalculated using the calculated partial recruitment pattern and maturity ogive (Table SF8a) as $F_{0.1}$(0.16), $F_{20\%}$(0.36), F_{max}(0.30).

SARC Analyses

Landings and spawning stock biomass projections for Georges Bank cod were made during the SARC meeting. Projections were carried out under three F scenarios for the 1991-1993 period: 1) status quo F_{SQ} (0.71), 2) $F_{0.1}$ (0.16), and 3) $F_{20\%}$ (0.36), which is about the same as F_{max}.The status quo F was assumed in 1991 for all projections. The partial recruitment vector for projections assumed full recruitment at age 4 and was estimated as the geometric mean of F at age for 1985-1989. The recruitment in 1991 was estimated in ADAPT. The 1992-1993 recruitment for projections was estimated as the geometric mean of numbers at age 1 during 1978-87, plus or minus one standard error. Input parameters and the results are in Table SF8.

Major Sources of Uncertainty

The SARC noted that progress has been made in assessment work for Georges Bank cod by including NEFSC survey indices adjusted for gear and vessel changes, and by the development of a GLM standardized commercial CPUE index. Some of the same sources of uncertainty identified in the last assessment remain, however (NEFC 1990). The omission of commercial fishery discards and recreational catch estimates from the catch at age matrix continue to introduce uncertainty into the results. Commercial fishery discard mortality may be a significant component of total mortality in certain years, but estimates were not available for this assessment. Estimated recreational catches may contribute up to approximately 10-15% of the total landings (Table SF3). Because many of the procedures to include recreational catches of cod in the catch at age matrix remain to be determined (i.e., it is difficult to divide the estimated recreational catch by stock), they continue to be omitted from the analytic assessment. Omission of commercial discards and recreational catch results in an underestimation of the total fishery removals from the stock.

Recommendations

Future assessments should include, if possible, reliable estimates of commercial fishery discard and recreational catches in the catch at age matrix.

Literature Cited

O'Brien, L., J. Burnett, and R.K. Mayo. MS 1991. Maturation of nineteen species of finfish off the northeast coast of the United States, 1985-1990.

NEFC. 1990. Report of the Eleventh NEFC Stock Assessment Workshop, Fall 1990. NEFC Reference Document 90-09.

NEFSC. 1991. Report of the Twelfth Northeast Regional Stock Assessment Workshop (12th SAW) Spring 1991. NEFSC Reference Document 91-03.

Table SF1. Commercial landings (metric tons, live) of Atlantic cod from Georges Bank and South (Division 5Z and Subarea 6), 1960 - 1990.

Year	Country						Total
	USA	Canada	USSR	Spain	Poland	Other	
1960	10834	19	-	-	-	-	10853
1961	14453	223	55	-	-	-	14731
1962	15637	2404	5302	-	143	-	23486
1963	14139	7832	5217	-	-	1	27189
1964	12325	7108	5428	18	48	238	25165
1965	11410	10598	14415	59	1851	-	38333
1966	11990	15601	16830	8375	269	69	53134
1967	13157	8232	511	14730	-	122	36752
1968	15279	9127	1459	14622	2611	38	43136
1969	16782	5997	646	13597	798	119	37939
1970	14899	2583	364	6874	784	148	25652
1971	16178	2979	1270	7460	256	36	28179
1972	13406	2545	1878	6704	271	255	25059
1973	16202	3220	2977	5980	430	114	28923
1974	18377	1374	476	6370	566	168	27331
1975	16017	1847	2403	4044	481	216	25008
1976	14906	2328	933	1633	90	36	19926
1977	21138	6173	54	2	-	-	27367
1978	26579	8778	-	-	-	-	35357
1979	32645	5978	-	-	-	-	38623
1980	40053	8063	-	-	-	-	48116
1981	33849	8499	-	-	-	-	42348
1982	39333	17824	-	-	-	-	57157
1983	36756	12130	-	-	-	-	48886
1984	32915	5763	-	-	-	-	38678
1985	26828	10443	-	-	-	-	37271
1986	17490	8411	-	-	-	-	25901
1987	19035	11845	-	-	-	-	30880
1988	26310	12932	-	-	-	-	39242
1989	25097	8001	-	-	-	-	33098
1990*	28193	14310	-	-	-	-	42503

* Provisional

Table SF2. Catch at age (thousands of fish; metric tons) and mean weight (kg) and mean length (cm) at age of total commercial landings of Atlantic cod from the Georges Bank and South cod stock (NAFO Division 5Z and Statistical Area 6), 1978 - 1990.

Year	Age 1	2	3	4	5	6	7	8	9	10+	Total
					Total Commercial Catch in Numbers (000's) at Age						
1978	2	393	7748	2303	830	131	345	47	40	15	11854
1979	34	1989	900	4870	1212	458	77	253	4	48	9845
1980	89	3777	5828	500	2308	1076	445	87	167	10	14287
1981	27	3205	4221	2464	235	1406	417	123	130	62	12290
1982	331	9138	3824	2787	2000	281	673	213	71	83	19401
1983	108	4286	8063	2456	1055	776	95	235	100	65	17239
1984	81	1307	3423	3336	840	516	458	44	171	121	10297
1985	134	6426	2443	1368	1885	412	218	203	21	97	13207
1986	156	1326	4573	797	480	627	87	72	47	29	8194
1987	26	7473	1406	2121	279	252	270	63	38	24	11952
1988	10	1577	8022	1012	1497	244	161	197	50	47	12817
1989	-	2088	2922	4155	331	541	82	43	50	18	10230
1990	7	4942	5042	1882	2264	229	245	36	17	38	14702
					Total Commercial Catch in Weight (Tons) at Age						[a]
1978	1	515	19072	7990	3597	759	2546	396	469	188	35357
1979	30	2971	1936	20504	5923	3285	710	2612	47	606	38623
1980	75	5516	14383	1833	13036	7184	3732	790	1404	157	48116
1981	24	4789	9954	8416	1223	10156	3574	1213	1848	1114	42348
1982	253	12813	10188	10682	10705	1829	6300	2114	890	1329	57157
1983	104	6387	19168	8125	4891	4963	759	2420	1122	951	48886
1984	85	2137	8388	12073	4270	3398	4078	448	1934	1854	38678
1985	121	9111	5095	5318	9589	2641	1765	2076	242	1309	37271
1986	145	1955	11189	2917	2692	4507	778	717	596	400	25901
1987	19	11071	3509	8883	1620	1945	2419	635	431	344	30880
1988	8	2398	18923	3553	8083	1619	1412	1964	560	696	39242
1989	-	3375	6633	15673	1784	3624	670	456	589	276	33098
1990	6	7708	12412	6628	11074	1449	2068	387	218	543	42503
					Total Commercial Catch Mean Weight (kg) at Age						
1978	0.707	1.311	2.462	3.469	4.334	5.791	7.379	8.421	11.729	12.522	2.983
1979	0.882	1.494	2.151	4.210	4.887	7.173	9.215	10.323	11.699	12.629	3.923
1980	0.838	1.460	2.468	3.667	5.648	6.676	8.386	9.086	8.408	15.721	3.368
1981	0.877	1.494	2.358	3.416	5.204	7.223	8.570	9.863	14.214	17.966	3.446
1982	0.764	1.402	2.664	3.833	5.353	6.510	9.361	9.923	12.535	16.017	2.946
1983	0.967	1.490	2.377	3.308	4.636	6.396	7.994	10.299	11.217	14.628	2.836
1984	1.049	1.635	2.450	3.619	5.084	6.586	8.903	10.178	11.307	15.322	3.756
1985	0.901	1.418	2.086	3.888	5.087	6.411	8.097	10.228	11.547	13.494	2.822
1986	0.928	1.475	2.447	3.661	5.608	7.189	8.940	9.953	12.689	13.804	3.161
1987	0.741	1.481	2.495	4.188	5.808	7.717	8.958	10.074	11.354	14.319	2.584
1988	0.786	1.521	2.359	3.511	5.400	6.635	8.772	9.968	11.208	14.806	3.062
1989	-	1.616	2.270	3.772	5.391	6.698	8.174	10.614	11.783	15.356	3.235
1990	0.831	1.560	2.462	3.522	4.891	6.329	8.442	10.745	12.831	14.280	2.891
					Total Commercial Catch Mean Length (cm) at Age						
1978	39.5	50.0	60.8	67.9	72.7	80.4	88.2	93.1	103.4	106.5	64.0
1979	44.7	52.2	57.7	73.2	76.8	87.5	95.3	99.5	103.4	106.4	69.6
1980	43.8	51.8	61.2	69.7	80.9	86.0	92.4	93.8	92.4	114.6	65.5
1981	44.4	52.2	60.2	68.4	78.2	88.0	93.5	97.5	110.3	119.5	65.6
1982	42.2	51.2	64.4	70.5	79.1	84.3	96.0	97.4	105.8	115.0	61.9
1983	45.5	52.3	60.4	67.0	75.3	84.4	90.7	99.1	101.9	111.4	62.3
1984	47.2	54.0	61.5	69.8	77.8	85.5	94.4	98.6	102.3	112.8	68.6
1985	44.9	51.1	57.5	71.4	78.0	84.3	91.3	98.8	102.3	108.2	61.1
1986	45.0	51.9	61.1	69.2	80.7	87.7	94.4	98.0	105.9	108.4	64.4
1987	40.7	51.8	61.2	73.0	81.8	90.1	94.5	98.2	102.5	111.2	59.7
1988	40.8	52.8	60.4	68.5	79.5	85.3	93.6	97.7	101.5	111.2	64.1
1989	-	53.8	60.0	70.4	79.2	85.2	91.7	100.3	103.2	113.3	65.6
1990	41.7	53.5	61.0	68.7	76.6	83.2	92.1	100.2	106.0	110.8	63.0

[a] Totals differ slightly from sum of weights at age.

Table SF3. Estimated number (000's) and weight (metric tons, live) of Atlantic cod caught by marine recreational fishermen, by region, in 1960, 1965, 1970, 1974, and 1979 - 1990.

	North Atlantic [1,2]		Mid-Atlantic [2]		All Regions	
Year	No. of Cod (000's)	Wt. of Cod (mt)	No. of Cod (000's)	Wt. of Cod (mt)	No. of Cod (000's)	Wt. of Cod (mt)
1960	3998	11426	793	2590	4791	14016
1965	4970	13144	62	421	5032	13565
1970	3690	16188	154	104	3844	16292
1974	2155	8566	746	3802	2901	12368
1979	3083	3762	8	55	3091	3817
1980	2403	6376	36	9	2439	6385
1981	4440	7281	482	1367	4922	8648
1982	2663	4378	586	3633	3249	8011
1983	3511	7432	244	852	3755	8284
1984	2463	5061	102	330	2565	5391
1985	3611	8644	62	338	3673	8982
1986	1493	3261	56	187	1549	3448
1987	1890	3287	173	519	2063	3806
1988	2035	4740	837	2823	2872	7563
1989	3097	5561	350	1279	3447	6840
1990	2484	4753	228	717	2712	5470

1 During 1960, 1965, and 1970 marine recreational fishery statistics surveys, 'North Atlantic' included Maine to New York; in subsequent surveys, 'North Atlantic' included only Maine to Connecticut (ie., excluding New York).

2 For surveys conducted in 1979 and afterward, total weight caught was derived by multiplying the number of cod caught in each region by the mean weight of cod landed in whole form in each region (Type A catch) obtained from intercept (creel) survey sampling.

Table SF4a. Stratified mean catch per tow in numbers and weight (kg) for Atlantic cod in NEFC offshore spring and autumn research vessel bottom trawl surveys on Georges Bank (Strata 13-25), 1963 - 1991. [a,b]

	Spring		Autumn	
Year	No/Tow	Wt/Tow	No/Tow	Wt/Tow
1963	-	-	2.80	11.0
1964	-	-	1.91	7.1
1965	-	-	2.72	7.2
1966	-	-	3.08	5.0
1967	-	-	6.66	8.4
1968	3.03	7.8	2.11	5.3
1969	2.98	11.0	1.41	5.0
1970	2.78	9.7	3.25	7.7
1971	2.17	8.8	2.04	6.1
1972	5.75	11.7	8.39	14.2
1973	11.98 [c]	24.5 [c]	7.87	19.0
1974	9.45	22.5	2.24	5.1
1975	4.42	16.1	4.11	8.7
1976	4.52	11.5	6.69	10.9
1977	4.04	9.5	4.42	11.5
1978	7.89	19.3	6.97	21.5
1979	3.31	10.5	4.83	15.2
1980	4.97	15.3	2.36	6.2
1981	8.47	24.0	7.34	17.5
1982	6.65 [d]	14.2 [d]	2.38	4.3
1983	4.94	14.8	2.33	4.0
1984	2.62	9.5	3.04	6.3
1985	6.94	21.5	2.43	3.5
1986	5.04	16.7	3.12	4.7
1987	3.26	10.3	2.33	4.4
1988	5.86	13.4	3.11	5.8
1989	6.07	16.1	6.05	6.9
1990	5.99	17.3	6.05 [4.58*]	17.2 [10.5*]
1991	5.32	13.4	1.09	1.7

[a] Spring surveys during 1973-1981 were accomplished with a '41 Yankee' trawl; in all other years, spring surveys were accomplished with a '36 Yankee' trawl. No adjustments have been made to the catch per tow data for these gear differences.

[b] During 1963-1984, BMV oval doors were used in spring and autumn surveys; since 1985, Portuguese polyvalent doors have been used in both surveys. No adjustments have been made to the catch per tow data for these gear differences.

[c] Excludes unusually high catch of 1894 cod (2558 kg) at Station 230 (Strata tow 20-4).

[d] Excludes unusually high catch of 1032 cod (4096 kg) at Station 323 (Strata tow 16-7).

[*] Excluding unusually high catch of 111 cod (504 kg) at Station 205 (Strata tow 23-4).

Table SF4b. Standardized stratified mean catch per tow in numbers and weight (kg) for Atlantic cod in NEFC offshore spring and autumn research vessel bottom trawl surveys on Georges Bank (Strata 13-25), 1963 - 1990. [a,b,c]

	Spring		Autumn	
Year	No/Tow	Wt/Tow	No/Tow	Wt/Tow
1963	-	-	4.37	17.8
1964	-	-	2.98	11.6
1965	-	-	4.25	11.7
1966	-	-	4.81	8.1
1967	-	-	10.38	13.6
1968	4.72	12.6	3.30	8.6
1969	4.64	17.8	2.20	8.0
1970	4.34	15.6	5.07	12.5
1971	3.39	14.2	3.19	9.9
1972	8.97	19.0	13.09	23.0
1973	18.68 [d]	39.7 [d]	12.28	30.8
1974	14.75	36.4	3.49	8.2
1975	6.89	26.0	6.41	14.1
1976	7.06	18.6	10.44	17.7
1977	6.30	15.4	5.45	12.5
1978	12.31	31.2	8.59	23.3
1979	5.16	16.9	5.95	16.5
1980	7.75	24.9	2.91	6.7
1981	10.44	26.1	9.04	19.0
1982	8.20 [e]	15.4 [e]	3.71	6.9
1983	7.70	24.0	3.64	6.5
1984	4.08	15.4	4.75	10.3
1985	6.94	34.9	2.43	3.5
1986	5.04	27.0	3.12	4.7
1987	3.26	16.6	2.33	4.4
1988	5.86	21.8	3.11	5.8
1989	4.80	10.8	4.78	4.6
1990	4.74	11.6	3.62 [f]	7.1 [f]
1991	4.20	9.0		

[a] During 1963-1984, BMV oval doors were used in spring and autumn surveys; since 1985, Portuguese polyvalent doors have been used in both surveys. Adjustments have been made to the 1963-1984 catch per tow data to standardize these data to polyvalent door equivalents. Conversion coefficients of 1.56 (numbers) and 1.62 (weight) were used in this standardization (NEFC 1991).

[b] Spring surveys during 1981-1982 and 1989-1991 and autumn surveys during 1977-1981 and 1989-1991 were accomplished with the R/V Delaware II; in all other years, the surveys were accomplished using the R/V Albatross IV. Adjustments have been made to the R/V Delaware II catch per tow data to standardize these to R/V Albatross IV equivalents. Conversion coefficients of 0.79 (numbers) and 0.67 (weight) were used in this standardization (NEFC 1991).

[c] Spring surveys during 1973-1981 were accomplished with a '41 Yankee' trawl; in all other years, spring surveys were accomplished with a '36 Yankee' trawl. No adjustments have been made to the catch per tow data for these gear differences.

[d] Excludes unusually high catch of 1894 cod (2558 kg) at Station 230 (Strata tow 20-4).

[e] Excludes unusually high catch of 1032 cod (4096 kg) at Station 323 (Strata tow 16-7).

[f] Excludes unusually high catch of 111 cod (504 kg) at Station 205 (Strata tow 23-4).

Table SF5(a). Stratified mean catch per tow at age (numbers) of Atlantic Cod in NEFC offshore spring and autumn bottom trawl surveys on Georges Bank, 1963 - 1991. Unadjusted for changes in gear and vessel usage. [a,b,c,d,e,f]

	Age Group											Totals	
Year	0	1	2	3	4	5	6	7	8	9	10+	0+	1+
Spring													
1968	0.329	0.087	1.035	0.529	0.426	0.247	0.158	0.090	0.053	0.036	0.037	3.027	2.698
1969	0.000	0.079	0.350	1.141	0.569	0.289	0.209	0.138	0.082	0.046	0.072	2.975	2.975
1970	0.000	0.244	0.522	0.308	0.830	0.104	0.420	0.176	0.039	0.087	0.053	2.783	2.783
1971	0.000	0.133	0.525	0.322	0.143	0.375	0.091	0.225	0.195	0.051	0.122	2.172	2.172
1972	0.036	1.860	1.175	1.693	0.327	0.076	0.208	0.078	0.141	0.074	0.080	5.748	5.712
1973 [g]	0.036	0.334	7.464	1.403	1.628	0.273	0.201	0.227	0.032	0.130	0.249	11.977	11.941
1974	0.000	0.286	2.921	3.828	0.488	1.284	0.282	0.065	0.165	0.022	0.112	9.453	9.453
1975	0.000	0.041	0.242	1.309	1.982	0.167	0.440	0.083	0.060	0.069	0.025	4.418	4.418
1976	0.071	0.834	1.232	0.605	0.443	1.008	0.105	0.168	0.023	0.000	0.035	4.524	4.453
1977	0.000	0.018	2.261	0.692	0.335	0.179	0.466	0.033	0.042	0.000	0.013	4.039	4.039
1978	2.123	0.241	0.120	3.545	0.621	0.499	0.092	0.457	0.033	0.091	0.070	7.892	5.769
1979	0.070	0.279	0.871	0.191	1.226	0.347	0.150	0.056	0.093	0.008	0.014	3.305	3.235
1980	0.067	0.025	1.452	1.723	0.134	0.950	0.383	0.123	0.020	0.019	0.071	4.967	4.900
1981	0.244	1.869	1.555	2.255	1.353	0.081	0.706	0.218	0.117	0.000	0.069	8.467	8.223
1982 [h]	0.120	0.396	2.755	1.141	1.051	0.843	0.013	0.242	0.052	0.013	0.028	6.654	6.534
1983	0.052	0.211	1.261	1.954	0.491	0.447	0.276	0.035	0.123	0.000	0.087	4.937	4.885
1984	0.000	0.258	0.296	0.511	0.744	0.286	0.272	0.143	0.000	0.100	0.005	2.615	2.615
1985	0.244	0.098	2.633	0.757	1.058	1.328	0.270	0.203	0.172	0.025	0.150	6.938	6.694
1986	0.092	0.871	0.423	1.824	0.360	0.545	0.633	0.063	0.119	0.095	0.015	5.040	4.948
1987	0.000	0.034	1.612	0.403	0.752	0.060	0.179	0.147	0.016	0.027	0.025	3.255	3.255
1988	0.180	0.700	0.684	3.115	0.413	0.645	0.045	0.020	0.052	0.000	0.007	5.861	5.681
1989	0.000	0.481	1.689	0.940	1.939	0.288	0.436	0.064	0.050	0.102	0.085	6.074	6.074
1990	0.052	0.246	1.172	2.161	0.826	1.134	0.158	0.176	0.016	0.020	0.034	5.995	5.943
1991	0.130	1.314	0.632	1.012	1.095	0.571	0.411	0.049	0.051	0.000	0.057	5.322	5.192
Autumn													
1963	0.012	0.461	0.499	0.590	0.575	0.227	0.209	0.112	0.066	0.009	0.044	2.804	2.792
1964	0.006	0.410	0.448	0.377	0.345	0.093	0.087	0.040	0.032	0.019	0.053	1.910	1.904
1965	0.111	0.833	0.640	0.453	0.310	0.107	0.115	0.072	0.052	0.015	0.015	2.723	2.612
1966	0.657	1.085	0.641	0.330	0.169	0.064	0.061	0.040	0.025	0.001	0.011	3.084	2.427
1967	0.046	4.869	0.855	0.335	0.260	0.085	0.085	0.035	0.033	0.008	0.045	6.656	6.610
1968	0.045	0.201	1.033	0.502	0.174	0.047	0.043	0.017	0.015	0.005	0.031	2.113	2.068
1969	0.000	0.220	0.399	0.401	0.212	0.060	0.039	0.012	0.015	0.014	0.038	1.410	1.410
1970	0.265	1.082	0.867	0.336	0.445	0.098	0.000	0.021	0.035	0.035	0.063	3.247	2.982
1971	0.256	0.386	0.405	0.250	0.193	0.305	0.117	0.027	0.057	0.000	0.048	2.044	1.788
1972	0.607	4.771	0.830	1.135	0.256	0.156	0.366	0.070	0.131	0.014	0.053	8.389	7.782
1973	0.130	1.121	3.891	0.758	1.290	0.135	0.145	0.112	0.040	0.089	0.161	7.872	7.742
1974	0.296	0.262	0.419	0.975	0.105	0.073	0.066	0.000	0.044	0.000	0.000	2.240	1.944
1975	1.524	0.637	0.270	0.400	1.080	0.072	0.100	0.000	0.000	0.000	0.024	4.107	2.583
1976	0.000	3.941	1.328	0.489	0.178	0.474	0.035	0.173	0.025	0.034	0.013	6.690	6.690
1977	0.123	0.192	2.778	0.570	0.204	0.141	0.321	0.006	0.022	0.000	0.063	4.420	4.297
1978	0.321	1.505	0.207	3.392	0.782	0.272	0.134	0.279	0.041	0.024	0.011	6.968	6.647
1979	0.096	1.314	1.393	0.182	1.309	0.240	0.146	0.029	0.093	0.006	0.018	4.826	4.730
1980	0.227	0.644	0.458	0.628	0.062	0.204	0.043	0.054	0.020	0.000	0.000	2.360	2.133
1981	0.212	2.860	1.826	1.265	0.478	0.044	0.470	0.046	0.052	0.015	0.067	7.335	7.123
1982	0.205	0.561	1.342	0.141	0.044	0.062	0.000	0.010	0.000	0.000	0.014	2.379	2.174
1983	0.661	0.415	0.655	0.510	0.035	0.030	0.002	0.000	0.008	0.000	0.015	2.331	1.670
1984	0.119	1.600	0.065	0.568	0.558	0.011	0.040	0.025	0.004	0.025	0.028	3.043	2.924
1985	1.084	0.220	0.803	0.103	0.115	0.101	0.000	0.000	0.004	0.000	0.000	2.430	1.346
1986	0.096	2.280	0.153	0.382	0.010	0.061	0.090	0.016	0.000	0.008	0.028	3.124	3.028
1987	0.204	0.414	1.353	0.112	0.195	0.028	0.012	0.000	0.000	0.007	0.000	2.325	2.121
1988	0.549	0.903	0.433	0.909	0.091	0.178	0.000	0.011	0.039	0.000	0.000	3.113	2.564
1989	0.332	3.466	1.304	0.232	0.632	0.070	0.010	0.005	0.000	0.000	0.000	6.051	5.719
1990 [i]	0.198	0.458	1.942	1.473	0.264	0.184	0.015	0.016	0.000	0.000	0.028	4.578	4.380
1991													

[See footnote following SF5(b).]

Table SF5(b). Standardized stratified mean catch per tow at age (numbers) of Atlantic cod in NEFC offshore spring and autumn bottom trawl on Georges Bank, 1963 - 1991. [a,b,c]

	Age Group											Totals					
Year	0	1	2	3	4	5	6	7	8	9	10+	0+	1+	2+	3+	4+	5+
Spring																	
1968	0.513	0.136	1.615	0.825	0.665	0.385	0.246	0.140	0.083	0.056	0.058	4.722	4.209	4.073	2.459	1.633	0.969
1969	0.000	0.123	0.546	1.780	0.888	0.451	0.326	0.215	0.128	0.072	0.112	4.641	4.641	4.518	3.972	2.192	1.304
1970	0.000	0.381	0.814	0.480	1.295	0.162	0.655	0.275	0.061	0.136	0.083	4.341	4.341	3.961	3.147	2.666	1.371
1971	0.000	0.207	0.819	0.502	0.223	0.585	0.142	0.351	0.304	0.080	0.175	3.388	3.388	3.181	2.362	1.860	1.636
1972	0.056	2.902	1.833	2.641	0.510	0.119	0.324	0.122	0.220	0.115	0.125	8.967	8.911	6.009	4.176	1.535	1.025
1973 [d]	0.056	0.521	11.644	2.189	2.540	0.426	0.314	0.354	0.050	0.203	0.388	18.684	18.628	18.107	6.463	4.274	1.735
1974	0.000	0.446	4.557	5.972	0.761	2.003	0.440	0.101	0.257	0.034	0.175	14.747	14.747	14.301	9.744	3.772	3.011
1975	0.000	0.064	0.378	2.042	3.092	0.261	0.686	0.129	0.094	0.108	0.039	6.892	6.892	6.828	6.451	4.409	1.317
1976	0.111	1.301	1.922	0.944	0.691	1.572	0.164	0.262	0.036	0.000	0.055	7.057	6.947	5.646	3.724	2.780	2.089
1977	0.000	0.028	3.527	1.080	0.523	0.279	0.727	0.051	0.066	0.000	0.020	6.301	6.301	6.273	2.746	1.666	1.143
1978	3.312	0.376	0.187	5.530	0.969	0.778	0.144	0.713	0.051	0.142	0.109	12.312	9.000	8.624	8.436	2.906	1.938
1979	0.109	0.435	1.359	0.298	1.913	0.541	0.234	0.087	0.145	0.012	0.022	5.156	5.047	4.611	3.253	2.955	1.042
1980	0.105	0.039	2.265	2.688	0.209	1.482	0.597	0.192	0.031	0.030	0.111	7.749	7.644	7.605	5.340	2.652	2.443
1981	0.301	2.303	1.916	2.779	1.667	0.100	0.870	0.269	0.144	0.000	0.085	10.435	10.134	7.831	5.914	3.135	1.468
1982 [e]	0.148	0.488	3.395	1.406	1.295	1.039	0.016	0.298	0.064	0.016	0.035	8.200	8.053	7.564	4.169	2.763	1.468
1983	0.081	0.329	1.967	3.048	0.766	0.697	0.431	0.055	0.192	0.000	0.136	7.702	7.621	7.291	5.324	2.276	1.510
1984	0.000	0.402	0.462	0.797	1.161	0.446	0.424	0.223	0.000	0.156	0.008	4.079	4.079	3.677	3.215	2.418	1.257
1985	0.244	0.098	2.633	0.757	1.058	1.328	0.270	0.203	0.172	0.025	0.150	6.938	6.694	6.596	3.963	3.206	2.148
1986	0.092	0.871	0.423	1.824	0.360	0.545	0.633	0.063	0.119	0.095	0.015	5.040	4.948	4.077	3.654	1.830	1.470
1987	0.000	0.034	1.612	0.403	0.752	0.060	0.179	0.147	0.016	0.027	0.025	3.255	3.255	3.221	1.609	1.206	0.454
1988	0.180	0.700	0.684	3.115	0.413	0.645	0.045	0.020	0.052	0.000	0.007	5.861	5.681	4.981	4.297	1.182	0.769
1989	0.000	0.380	1.334	0.743	1.532	0.228	0.344	0.051	0.040	0.081	0.067	4.798	4.798	4.418	3.084	2.342	0.810
1990	0.041	0.194	0.926	1.707	0.653	0.896	0.125	0.139	0.013	0.016	0.027	4.736	4.695	4.501	3.575	1.868	1.215
1991	0.103	1.038	0.499	0.799	0.865	0.451	0.325	0.039	0.040	0.000	0.045	4.204	4.102	3.064	2.564	1.765	0.900
Autumn																	
1963	0.019	0.719	0.778	0.920	0.897	0.354	0.326	0.175	0.103	0.014	0.069	4.374	4.356	3.636	2.858	1.938	1.041
1964	0.009	0.640	0.699	0.588	0.538	0.145	0.136	0.062	0.050	0.030	0.083	2.980	2.970	2.331	1.632	1.044	0.505
1965	0.173	1.299	0.998	0.707	0.484	0.167	0.179	0.112	0.081	0.023	0.023	4.248	4.075	2.775	1.777	1.070	0.587
1966	1.025	1.693	1.000	0.515	0.264	0.100	0.095	0.062	0.039	0.002	0.017	4.811	3.786	2.094	1.094	0.579	0.315
1967	0.072	7.596	1.334	0.523	0.406	0.133	0.133	0.055	0.051	0.012	0.070	10.383	10.312	2.716	1.382	0.860	0.454
1968	0.070	0.314	1.611	0.783	0.271	0.073	0.067	0.027	0.023	0.008	0.048	3.296	3.226	2.913	1.301	0.518	0.246
1969	0.000	0.343	0.622	0.626	0.331	0.094	0.061	0.019	0.023	0.022	0.059	2.200	2.200	1.856	1.234	0.608	0.278
1970	0.413	1.688	1.353	0.524	0.694	0.153	0.000	0.033	0.055	0.055	0.098	5.065	4.652	2.964	1.611	1.087	0.393
1971	0.399	0.602	0.632	0.390	0.301	0.476	0.183	0.042	0.089	0.000	0.075	3.189	2.789	2.187	1.555	1.165	0.864
1972	0.947	7.443	1.295	1.771	0.399	0.243	0.571	0.109	0.204	0.022	0.083	13.087	12.140	4.697	3.402	1.632	1.232
1973	0.203	1.749	6.070	1.182	2.012	0.211	0.226	0.175	0.062	0.139	0.251	12.280	12.078	10.329	4.259	3.076	1.064
1974	0.462	0.409	0.654	1.521	0.164	0.114	0.103	0.000	0.069	0.000	0.000	3.494	3.033	2.624	1.970	0.449	0.285
1975	2.377	0.994	0.421	0.624	1.685	0.112	0.156	0.000	0.000	0.000	0.037	6.407	4.029	3.036	2.615	1.991	0.306
1976	0.000	6.148	2.072	0.763	0.278	0.739	0.055	0.270	0.039	0.053	0.020	10.436	10.436	4.288	2.217	1.454	1.176
1977	0.152	0.237	3.424	0.702	0.251	0.174	0.396	0.007	0.027	0.000	0.078	5.447	5.296	5.059	1.635	0.933	0.682
1978	0.396	1.855	0.255	4.180	0.964	0.335	0.165	0.344	0.051	0.030	0.014	8.587	8.192	6.337	6.082	1.902	0.938
1979	0.118	1.619	1.717	0.224	1.613	0.296	0.180	0.036	0.115	0.007	0.022	5.948	5.829	4.210	2.493	2.269	0.656
1980	0.280	0.818	0.564	0.774	0.076	0.251	0.053	0.067	0.025	0.000	0.000	2.908	2.629	1.810	1.246	0.472	0.396
1981	0.261	3.525	2.250	1.559	0.589	0.054	0.579	0.057	0.064	0.018	0.083	9.040	8.778	5.254	3.003	1.444	0.855
1982	0.320	0.875	2.094	0.220	0.069	0.097	0.000	0.016	0.000	0.000	0.022	3.711	3.391	2.516	0.423	0.203	0.134
1983	1.031	0.647	1.022	0.796	0.055	0.047	0.003	0.000	0.012	0.000	0.023	3.636	2.605	1.958	0.936	0.140	0.086
1984	0.186	2.496	0.101	0.886	0.870	0.017	0.062	0.039	0.006	0.039	0.044	4.747	4.561	2.065	1.964	1.078	0.207
1985	1.084	0.220	0.803	0.103	0.115	0.101	0.000	0.000	0.004	0.000	0.000	2.430	1.346	1.126	0.323	0.220	0.105
1986	0.096	2.280	0.153	0.382	0.010	0.061	0.090	0.016	0.000	0.008	0.028	3.124	3.028	0.748	0.595	0.213	0.203
1987	0.204	0.414	1.353	0.112	0.195	0.028	0.012	0.000	0.000	0.007	0.000	2.325	2.121	1.707	0.354	0.242	0.047
1988	0.549	0.903	0.433	0.909	0.091	0.178	0.000	0.011	0.039	0.000	0.000	3.113	2.564	1.661	1.228	0.319	0.228
1989	0.262	2.738	1.030	0.183	0.499	0.055	0.008	0.004	0.000	0.000	0.000	4.780	4.518	1.780	0.750	0.566	0.067
1990 [f]	0.156	0.362	1.534	1.164	0.209	0.145	0.012	0.013	0.000	0.000	0.022	3.617	3.460	3.098	1.564	0.401	0.192

[a] During 1963-1984, BMV oval doors were used in spring and autumn surveys; since 1985, Portuguese polyvalent doors have been used in both surveys. Adjustments have been made to the 1963-1984 catch per tow data to standardize these data to polyvalent door equivalents. Conversion coefficients of 1.56 (numbers) and 1.62 (weight) were used in this standardization (NEFC 1991). [b] Spring surveys during 1981-1982 and 1989-1991 and autumn surveys during 1977-1981 and 1989-1991 were accomplished with the R/V Delaware II; in all other years, the surveys were accomplished using the R/V Albatross IV. Adjustments have been made to the R/V Delaware II catch per tow data to standardize these to R/V Albatross IV equivalents. Conversion coefficients of 0.79 (numbers) and 0.67 (weight) were used in this standardization (NEFC 1991). [c] Spring surveys during 1973-1981 were accomplished with a '41 Yankee' trawl; in all other years, spring surveys were accomplished with a '36 Yankee' trawl. No adjustments have been made to the catch per tow data for these gear differences. [d] Excludes unusually high catch of 1894 cod (2558 kg) at Station 230 (Strata tow 20-4). [e] Excludes unusually high catch of 1032 cod (4096 kg) at Station 323 (Strata tow 16-7). [f] Excludes unusually high catch of 111 cod (504 kg) at Station 205 (Strata tow 23-4).

Table SF6 Standardized effort for Georges Bank cod

a) USA CPUE and derived effort for Georges Bank cod 1965-1990

Year	Total Landings (mt)	USA Landings (mt)	USA CPUE Index (All Cod Trips)	Total Standard Days Fished	USA Standard Days Fished
1965	38333	11410	0.745	51483	15324
1966	53134	11990	0.730	72811	16430
1967	36752	13157	0.862	42616	15256
1968	43136	15279	1.053	40954	14506
1969	37939	16782	1.262	30054	13294
1970	25652	14899	1.178	21781	12650
1971	28179	16178	1.224	23018	13215
1972	25059	13406	1.065	23527	12586
1973	28923	16202	1.452	19924	11161
1974	27331	18377	1.487	18380	12358
1975	25008	16017	1.326	18857	12077
1976	19926	14906	1.553	12827	9596
1977	27367	21138	1.782	15357	11862
1978	35357	26579	1.937	18252	13720
1979	38623	32645	2.102	18375	15531
1980	48116	40053	2.158	22298	18562
1981	42348	33849	1.891	22393	17899
1982	57157	39333	2.176	26270	18078
1983	48886	36756	2.005	24388	18337
1984	38678	32915	1.424	27152	23106
1985	37271	26828	1.149	32359	23355
1986	25901	17490	0.956	27096	18386
1987	30880	19035	0.836	36947	22775
1988	39242	26310	1.051	37344	25037
1989	33098	25097	1.058	31294	23729
1990	42503	28193	1.273	33375	22138

b) GLM of CPUE is modeled as a function of year, month, vessel tonnage class, depth and fishing area effects with no interactions

Source	DF	SS	FSF	F	PR>F	R-Square
Model	45	47262	1050	527.13	0.0	0.31
Error	51969	103545	1.99			
Total	52014	150807				

<u>Model SS</u>

Variable	DF	Type I SS	F	PR>F
Year	12	4585	191.8	0.0
Month	11	729	33.3	0.0
Ton Class	9	18195	1014.7	0.0
Area	9	19541	1089.7	0.0
Depth	4	4202	528.3	0.0

Table SF7. Estimates of instantaneous fishing mortality (F), beginning year stock sizes (millions of fish), and mean stock biomass (metric tons) for Georges Bank cod estimated from vitual population analysis (VPA) calibrated using the ADAPT procedure, 1978 - 1990.

(a) Fishing Mortality

■	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1 ■	0.0001	0.0016	0.0049	0.0007	0.0212	0.0126	0.0032	0.0177	0.0040	0.0020	0.0005	0.0000	0.0007
2 ■	0.1073	0.1019	0.2448	0.2437	0.3540	0.4134	0.2070	0.3780	0.2425	0.2665	0.1638	0.1290	0.2761
3 ■	0.4086	0.3811	0.4845	0.4757	0.5144	0.6120	0.6918	0.7448	0.5096	0.4392	0.5114	0.5155	0.5210
4 ■	0.3861	0.4902	0.3780	0.3885	0.6758	0.7500	0.5562	0.6671	0.5810	0.4724	0.6633	0.5488	0.7564
5 ■	0.3838	0.3608	0.4561	0.3061	0.6361	0.5913	0.6286	0.7205	0.5218	0.4108	0.7352	0.4716	0.6668
6 ■	0.1379	0.3789	0.6370	0.5621	0.7405	0.5471	0.6572	0.7427	0.5600	0.5786	0.7823	0.6526	0.7116
7 ■	0.3091	0.1122	0.7911	0.5476	0.5816	0.6032	0.7443	0.6532	0.3342	0.5022	0.9452	0.6676	0.7116
8 ■	1.4849	0.3921	0.1789	0.5227	0.6067	0.4102	0.6319	0.9119	0.4649	0.4324	0.8707	0.7200	0.7116
9 ■	0.3605	0.4384	0.4895	0.4425	0.6617	0.6510	0.5990	0.7209	0.5466	0.4805	0.7430	0.5630	0.7116
10 ■	0.3605	0.4384	0.4895	0.4425	0.6617	0.6510	0.5990	0.7209	0.5466	0.4805	0.7430	0.5630	0.7116

Mean F (unweighted) summed through age 8

■	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
2 ■	0.4597	0.3167	0.4529	0.4352	0.5870	0.5610	0.5882	0.6883	0.4592	0.4432	0.6674	0.5293	0.6221
3 ■	0.5184	0.3526	0.4876	0.4671	0.6258	0.5857	0.6517	0.7400	0.4953	0.4726	0.7514	0.5960	0.6798
4 ■	0.5404	0.3468	0.4882	0.4654	0.6481	0.5804	0.6437	0.7391	0.4924	0.4793	0.7993	0.6121	0.7116
5 ■	0.5789	0.3110	0.5158	0.4846	0.6412	0.5380	0.6655	0.7571	0.4702	0.4810	0.8334	0.6279	0.7004
6 ■	0.6440	0.2944	0.5357	0.5441	0.6429	0.5202	0.6778	0.7693	0.4530	0.5044	0.8661	0.6800	0.7116

Mean F (weighted by N) summed through age 8

■	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
2 ■	0.3644	0.2732	0.3919	0.3762	0.4533	0.5575	0.5130	0.5099	0.4436	0.3197	0.4481	0.3466	0.4423
3 ■	0.3926	0.4303	0.4878	0.4571	0.5918	0.6241	0.6285	0.7217	0.5190	0.4633	0.5620	0.5407	0.5998
4 ■	0.3621	0.4375	0.4921	0.4413	0.6509	0.6459	0.5913	0.7083	0.5409	0.4753	0.7306	0.5557	0.7062
5 ■	0.3275	0.3422	0.5103	0.5154	0.6301	0.5511	0.6630	0.7303	0.5178	0.4826	0.7663	0.5857	0.6748
6 ■	0.2658	0.3169	0.6045	0.5563	0.6200	0.5166	0.6934	0.7533	0.5154	0.5240	0.8516	0.6585	0.7116

(b) Stock Numbers (Jan 1) in millions

■	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
1 ■	27709.458	23520.385	20102.494	41405.724	17453.596	9553.430	27647.452	8459.370	43295.317	14117.329	23300.206
2 ■	4268.010	22684.776	19226.098	16377.999	33875.709	13990.295	7723.964	22562.527	6804.698	35306.053	11534.766
3 ■	25526.833	3138.750	16773.002	12323.427	10509.168	19466.681	7576.151	5141.225	12658.150	4371.401	22144.301
4 ■	7946.731	13888.923	1755.438	8459.180	6270.250	5144.081	8642.266	3105.570	1998.761	6225.795	2306.799
5 ■	2877.694	4422.392	6964.730	984.812	4696.271	2611.864	1989.336	4057.151	1304.808	915.292	3178.090
6 ■	1124.260	1605.041	2524.086	3613.874	593.659	2035.307	1183.810	868.667	1616.096	633.964	496.928
7 ■	1434.115	801.933	899.681	1092.941	1686.588	231.788	964.215	502.326	338.412	755.814	291.027
8 ■	67.155	861.985	586.895	333.944	517.508	771.906	103.812	375.017	214.015	198.347	374.502
9 ■	146.042	12.454	476.810	401.788	162.115	230.969	419.347	45.181	123.356	110.072	105.388
10 ■	54.348	148.122	28.274	189.906	187.147	148.280	293.322	205.890	75.303	68.854	97.699
1+■	71154.646	71084.762	69337.506	85183.595	75952.012	54184.599	56543.675	45322.924	68428.914	62702.922	63829.706

■	1989	1990	1991
1 ■	27652.329	10914.778	27721.261
2 ■	19067.547	22639.812	8929.931
3 ■	8016.939	13721.887	14064.203
4 ■	10871.614	3919.780	6672.340
5 ■	972.952	5141.326	1506.340
6 ■	1247.458	497.085	2160.809
7 ■	186.070	531.815	199.771
8 ■	92.594	78.144	213.728
9 ■	128.364	36.901	31.405
10 ■	45.707	81.389	47.539
1+■	68281.574	57562.916	61547.328

Sum of Stock Numbers through Age 8

■	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
2 ■	43244.798	47403.800	48729.929	43186.177	58149.153	44251.921	28183.555	36612.482	24934.939	48406.666	40326.413
3 ■	38976.788	24719.025	29503.831	26808.178	24273.444	30261.626	20459.590	14049.955	18130.241	13100.614	28791.647
4 ■	13449.955	21580.275	12730.829	14484.751	13764.276	10794.946	12883.439	8908.730	5472.091	8729.212	6647.346
5 ■	5503.224	7691.352	10975.392	6025.572	7494.026	5650.865	4241.173	5803.161	3473.330	2503.417	4340.547
6 ■	2625.530	3268.959	4010.661	5040.760	2797.755	3039.001	2251.837	1746.010	2168.523	1588.126	1162.457

■	1989	1990	1991
2 ■	40455.174	46529.847	33747.123
3 ■	21387.627	23890.036	24817.192
4 ■	13370.688	10168.149	10752.989
5 ■	2499.074	6248.370	4080.649
6 ■	1526.122	1107.044	2574.308

Table SF 7 (Continued)

(c) Mean Biomass (MT)

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
1	17755.170	18787.611	15232.069	32900.522	11962.836	8322.305	26244.853	6849.442	36345.090	9471.904
2	4817.276	29253.076	22658.852	19761.581	36465.128	15581.545	10374.450	24298.737	8110.446	41786.989
3	47076.437	5120.413	29975.110	21124.300	20006.391	31685.200	12281.705	6938.431	22181.468	8058.510
4	20860.521	42233.365	4888.881	21842.751	16012.059	10984.624	21943.781	8074.071	5078.589	18981.847
5	9447.244	16542.427	28846.601	4021.688	17035.957	8366.284	6876.065	13490.586	5211.962	3978.168
6	5524.839	8740.474	11414.872	18267.007	2504.863	9169.878	5235.677	3606.109	8137.876	3399.083
7	8293.136	6347.555	4787.034	6596.367	10954.887	1273.639	5554.789	2736.104	2343.828	4864.433
8	273.382	6715.131	4438.602	2345.132	3524.457	5950.865	717.328	2314.948	1555.915	1480.891
9	1311.261	107.692	2896.543	4213.443	1362.037	1744.451	3265.148	340.957	1102.820	906.573
10	520.969	1382.629	321.151	2517.175	2009.119	1460.479	3094.867	1815.717	732.378	715.182
1+	115880.233	135230.373	125459.716	133589.967	121837.732	94539.271	95588.663	70465.103	90800.373	93643.580

	1988	1989	1990
1	16594.985	20275.631	8217.907
2	14707.212	26257.450	28100.381
3	37378.879	12998.289	24071.382
4	5424.810	28864.012	8888.076
5	11148.117	3819.980	16817.297
6	2099.658	5622.286	2064.195
7	1519.967	1016.849	2945.720
8	2291.436	642.541	550.921
9	764.746	1058.046	310.663
10	936.536	490.983	762.574
1+	92866.345	101046.066	92729.116

Sum of Mean Biomass through age 8

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
2	96292.834	114952.441	107009.953	93958.826	106503.741	83012.036	62983.795	61458.987	52620.084	82549.922
3	91475.558	85699.365	84351.100	74197.245	70038.613	67430.491	52609.344	37160.250	44509.638	40762.932
4	44399.121	80578.952	54375.990	53072.945	50032.223	35745.291	40327.639	30221.819	22328.170	32704.423
5	23538.600	38345.587	49487.109	31230.194	34020.164	24760.667	18383.859	22147.747	17249.581	13722.575
6	14091.357	21803.160	20640.508	27208.506	16984.207	16394.382	11507.793	8657.162	12037.619	9744.408

	1988	1989	1990
2	74570.079	79221.407	83437.971
3	59862.867	52963.956	55337.590
4	22483.988	39965.668	31266.208
5	17059.178	11101.656	22378.132
6	5911.061	7281.676	5560.835

(d) Spawning Stock Biomass (MT) at the Start of the Spawning Season

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
1	912.420	1091.374	853.501	1944.251	1196.361	891.444	3134.797	746.818	7070.416	1623.739	2841.103
2	1411.039	7537.722	6887.809	5786.490	16097.285	6333.726	4265.226	11745.374	4663.473	24508.085	7376.050
3	33870.299	3731.664	22412.808	15935.176	15633.981	26071.778	10479.485	6813.401	19063.116	6859.866	33453.373
4	20221.560	38260.811	4298.186	21376.010	15801.422	12642.967	21675.189	8046.015	4752.248	17460.635	5794.122
5	8795.476	16583.656	30443.505	3953.976	17469.404	9649.442	7105.685	14931.635	5402.020	3811.999	12931.914
6	4878.540	8125.931	12539.689	20328.601	2953.984	10514.676	5670.257	4238.096	8610.188	3662.912	2618.845
7	8219.068	5561.112	5915.158	7298.293	12174.290	1462.550	6216.251	3181.919	2343.686	5395.330	1978.329
8	362.296	6816.068	5041.519	2692.383	4171.797	6846.193	815.144	2973.144	1719.673	1694.003	2960.374
9	1321.928	111.135	3959.820	4102.278	1561.374	2114.470	3960.919	420.103	1240.842	1044.629	956.938
10	619.840	1681.777	396.231	3065.301	2596.458	1882.154	3933.790	2382.911	917.837	880.184	1236.102
1+	80612.465	89501.249	92748.226	86482.758	89656.355	78409.399	67256.744	55479.414	55783.497	66941.382	72147.151

	1989	1990
1	3583.774	1492.373
2	13019.326	15035.672
3	12031.672	22086.160
4	28051.490	9261.011
5	3784.614	19111.912
6	6508.370	2494.228
7	1185.781	3435.261
8	766.422	629.103
9	1225.004	369.928
10	618.049	998.390
1+	70774.503	74914.037

The above SSBs by age (a) and year (y) are calculated following the algorithm used in the NEFSC projection program, i.e.

$$SSB(a,y) = W(a,y) \times P(a,y) \times N(a,y)\exp[-Z(a,y)]$$

where $Z(a,y) = 0.1667 \times M(a,y) + 0.1667 \times F(a,y)$
$N(a,y)$ - Jan 1 stock size estimates (males & females)
$P(a,y)$ - proportion mature (generally females)
$W(a,y)$ - weight at age at the beginning of the spawning season

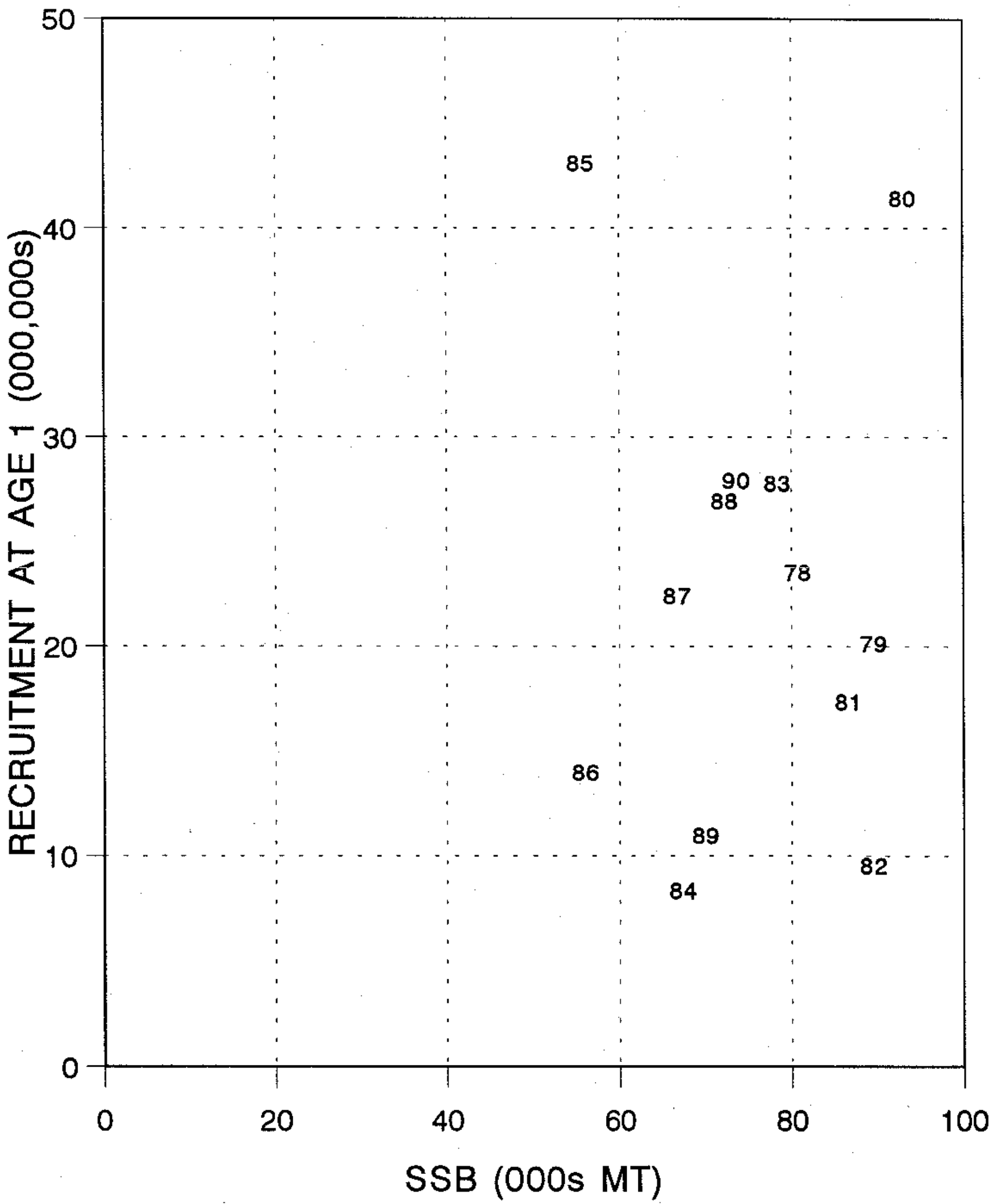
The $W(a,y)$ are assumed to be the same as the Jan1 weight at age estimates (see "WT AT AGE" table in input section).
Jan1 weights at age are calculated as geometric means in ADAPT from the mid-year weight at age estimates (from the catch) of the cohort in successive years

Table SF8. Input parameters and projection results for Georges Bank cod.

Age	Stock Size in 1991	Fishing Mortality Pattern	Proportion Mature	Average Weights Stock	Average Weights Catch
1	27721	0.0025	0.23	0.600	0.822
2	8930	0.3631	0.64	1.128	1.531
3	14064	0.8830	0.91	1.901	2.407
4	6672	1.0000	0.98	2.947	3.731
5	1506	1.0000	1.00	4.536	5.420
6	2161	1.0000	1.00	6.138	6.914
7	200	1.0000	1.00	7.741	8.657
8	214	1.0000	1.00	9.387	10.271
9	31	1.0000	1.00	11.031	11.973
10+	48	1.0000	1.00	14.700	14.700

Recruitment in 1992-93	1991 (F_{SQ} = F1990) F	1991 Land.	1991 SSB	1992 F	1992 Land.	1992 SSB	1993 SSB
LOW = 17171	0.71	42012	68649	F_{SQ} = 0.71	37031	62543	60119
	0.71	42012	68649	$F_{0.1}$ = 0.16	10336	67287	90871
	0.71	42012	68649	$F_{20\%}$ = 0.36	21457	65516	77719
MID = 20474	0.71	42012	68649	F_{SQ} = 0.71	37035	62984	62366
	0.71	42012	68649	$F_{0.1}$ = 0.16	10337	67728	93181
	0.71	42012	68649	$F_{20\%}$ = 0.36	21459	65957	80005
HIGH = 24411	0.71	42012	68649	F_{SQ} = 0.71	37040	63509	65043
	0.71	42012	68649	$F_{0.1}$ = 0.16	10338	68254	95934
	0.71	42012	68649	$F_{20\%}$ = 0.36	21462	66482	82731

GEORGES BANK COD



FigureSF1: Stock and recruitment data for Georges Bank Cod. The datapoint labels indicate the year class of each cohort.

ATLANTIC SEA SCALLOPS

The results of the 1991 NEFSC sea scallop research vessel survey and an evaluation of current resource conditions, recruitment prospects, and abundance levels in the USA Georges Bank and Mid-Atlantic sea scallop populations (SAW/13/SARC/17) was presented to update existing scientific information. Because the analyses and methodology are well established, results were not reviewed extensively.

Background

Atlantic sea scallops (Placopecten magellanicus) occur in waters from Newfoundland and Nova Scotia to North Carolina and are one of the most valuable living marine resources of the Northeast region. The primary fishing gear is the scallop dredge (usually accounting for more than 95% of the landings), with relatively small amounts taken by the otter trawl. The fishery is conducted year round. USA and Canadian sea scallop landings for 1887 - 1990 are presented in Table SG1.

Sea scallop research vessel surveys have been conducted by the Northeast Fisheries Science Center in 1975 and annually since 1977 to monitor and assess trends in abundance, size composition, and recruitment patterns of USA offshore sea scallop resources.

The 1991 NEFSC sea scallop survey was conducted from 29 July to 23 August using the R/V OREGON II. Areas sampled included Georges Bank and Mid-Atlantic regions in depths between 28-110 meters.

Methodology

Sampling was performed using a 2.44 m wide commercial sea scallop dredge equipped with a 5.1 cm ring bag and a 3.8 cm polypropylene mesh liner to retain small scallops. Detailed specification of this gear are provided in Serchuk and Smolowitz (1980). Individual station (tow), catch, and location data are provided in the 1991 Sea Scallop Fishermen's Report (NEFSC 1991). At each station, the survey dredge was towed for 15 minutes at 3.5 knots with a 3:1 wire scope.

Revised strata sets developed in 1989 (Serchuk and Wigley 1989a) for assessing and summarizing resource conditions were used in analyzing the 1975-1991 survey results.

Survey Results

Results were based upon 189 tows on the USA portion of Georges Bank and 228 tows in the Mid-Atlantic region. Survey indices of relative abundance were calculated for each sampling stratum and strata set included in the Mid-Atlantic and USA Georges Bank regions (Tables SG2 and SG3).

Survey results indicate that resource abundance in the Mid-Atlantic region has declined from the record-high levels of the late 1980s. Survey indices of harvestable size and total scallops declined for all areas (NY Bight, Delmarva, Virginia-NC) while the abundance of pre-recruit scallops increased significantly only in Delmarva. Harvestable biomass has also declined over the past several years in the Mid-Atlantic (Table SG4).

On the USA portion of Georges Bank, the 1991 survey and abundance indices were among the highest in the time series (Table SG3). The 1988 year-class appears to be very strong and is expected to support landings during 1992 and 1993. Total and harvestable biomass, high in 1990 and 1991 (Table SG5) is likely to remain so during 1992.

Literature Cited

NEFSC (Northeast Fisheries Science Center). 1991. Sea Scallop Survey Fishermen's Report. July 29 - August 23, 1991 Virginia Capes - Georges Bank, 15pp.

Serchuk, F.M., and R. J. Smolowitz. 1980. Size selection of sea scallops by an offshore scallop survey dredge. ICES C.M. 1980/K:26, 22pp.

Serchuk, F.M., and S.E. Wigley. 1989a. Current resource conditions in USA Georges Bank and Mid-Atlantic sea scallop populations: Results of the 1989 NMFS sea scallop research vessel survey. Ninth NEFC SAW, Working Paper No. 9, 52pp.

Table SG1 United States and Canadian sea scallop landings (metric tons, meats) from the Northwest Atlantic (NAFO Subarea 5 and Statistical Area 6), 1887 - 1990.

Year	USA[1]	Year	USA	CANADA[2]	Total
1887	112	1947	6,647		6,647
1888 *	91	1948	7,546		7,546
1889	141	1949	8,299		8,299
1892	53	1950	9,063		9,063
1897	435	1951	8,503	91	8,594
1898	156	1952	8,451	91	8,542
1899 *	24	1953	10,713	136	10,849
1900 *	79	1954	7,997	91	8,088
1901	286	1955	10,036	136	10,172
1902	61	1956	9,102	317	9,419
1903 *	62	1957	9,523	771	10,294
1904	216	1958	8,608	1,179	9,787
1905	200	1959	11,178	2,378	13,556
1906 *	255	1960	12,065	3,470	15,535
1907 *	236	1961	12,456	4,565	17,021
1908	834	1962	11,174	5,715	16,889
1909 *	843	1963	9,038	5,898	14,936
1910 *	919	1964	7,704	5,922	13,626
1911 *	663	1965	9,105	7,052	16,157
1912 *	842	1966	7,237	7,669	14,906
1913 *	353	1967	4,646	5,025	9,671
1914 *	386	1968	5,473	5,243	10,716
1916 *	266	1969	3,363	4,320	7,683
1919	89	1970	2,613	4,097	6,710
1921	38	1971	2,593	3,908	6,501
1924	154	1972	2,655	4,177	6,832
1926	506	1973	2,401	4,223	6,624
1928	216	1974	2,722	6,137	8,859
1929	1,130	1975	4,422	7,414	11,836
1930	1,111	1976	8,721	9,780	18,501
1931	1,058	1977	11,103	13,091	24,194
1932	1,517	1978	14,482	12,189	26,671
1933	2,009	1979	14,256	9,207	23,463
1935	1,955	1980	12,566	5,239	17,805
1937	3,989	1981	11,742	8,018	19,760
1938	4,041	1982	9,044	4,330	13,374
1939	4,440	1983	8,707	2,895	11,602
1940	3,467	1984	7,739	2,042	9,781
1941 #	3,622	1985	6,742	3,851	10,593
1942	3,258	1986	8,661	4,705	13,366
1943	2,508	1987	13,227	6,810	20,037
1944	2,209	1988	13,198	4,405	17,603
1945	2,590	1989	14,776	4,676	19,452
1946	5,326	1990	17,174	5,130	22,304

[1] USA landings: 1887-1960 from Lyles (1969); 1961-1975 from Fishery Statistics of the United States; 1963-1982 from ICNAF and NAFO Statistical Bulletins; 1964-1990 from Detailed Weighout Data, Northeast Fisheries Center, Woods Hole, Mass.

[2] Canadian landings: 1951-1958 from ICNAF Statistical Bulletins and Caddy (1975); 1953-1988 from Mohn et al. (1989) for Georges Bank and from ICNAF/NAFO Bulletins for Gulf of Maine and Mid-Atlantic; 1989 from NAFO SCS Doc. 90/21; 1990 from DFO, Statistics Branch, Halifax.

* Maine landings only - from Baird (1956).

USA landings for 1941 from O'Brien (1961).

Table SG2. USA sea scallop research survey relative abundance indices (standardized stratified mean number and mean weight per tow), [meats only, kg], mean shell height (mm), mean meat weight (g) per scallop, and average meat count (number of scallop meats per pound) of sea scallops from NEFSC surveys in the Mid-Atlantic, 1975, 1977-1991. Data are presented by principal scallop regions in the Mid-Atlantic[1]. Survey indices are presented for pre-recruit (<70 mm shell height), recruit (≥70 mm shell height), and total scallops per tow.

Area	Year	No. of Tows	Standardized Stratified Mean Number Per Tow			Standardized Stratified Mean Weight (kg) Per Tow[2]			Mean Shell Height	Average Meat Count
			Pre-recruit	Recruit	Total	Pre-recruit	Recruit	Total		
New York Bight	1975	28	39.4	34.7	74.1	0.10	0.62	0.72	75.3	46.9
	1977	101	1.4	56.7	58.1	<0.01	1.03	1.03	98.6	25.6
	1978	116	3.3	52.7	56.0	0.01	1.15	1.16	102.8	21.9
	1979	120	5.3	17.6	22.9	0.01	0.43	0.44	93.6	23.7
	1980	121	15.4	15.2	30.6	0.02	0.36	0.38	75.5	35.7
	1981	117	18.8	19.0	37.8	0.03	0.29	0.32	67.7	53.5
	1982	134	10.9	20.9	31.8	0.02	0.33	0.35	78.4	41.2
	1983	136	11.5	14.0	25.5	0.03	0.29	0.32	80.3	36.6
	1984	142	17.4	18.4	35.8	0.03	0.29	0.32	69.2	51.0
	1985	137	47.4	30.9	78.3	0.10	0.43	0.53	65.6	67.1
	1986	152	53.2	49.3	102.5	0.13	0.65	0.78	69.6	59.9
	1987	154	94.5	46.0	140.5	0.18	0.58	0.76	61.7	83.7
	1988	154	75.9	100.5	176.4	0.11	1.25	1.36	68.6	58.9
	1989	157	168.6	81.8	250.4	0.25	0.90	1.15	56.4	99.1
	1990	148	121.1	92.8	213.9	0.35	0.88	1.23	67.2	78.7
	1991	157	22.2	53.7	75.9	0.06	0.67	0.73	78.3	47.3
Delmarva	1975	15	36.2	24.0	60.2	0.11	0.44	0.55	75.2	49.3
	1977	10	10.7	47.5	58.2	0.03	0.91	0.94	92.2	28.1
	1978	45	27.3	75.8	103.2	0.09	1.58	1.67	91.6	28.0
	1979	43	25.4	64.6	90.0	0.04	0.95	0.99	78.8	41.2
	1980	43	81.1	35.9	117.0	0.13	0.68	0.81	63.3	65.7
	1981	41	4.7	14.3	19.0	0.01	0.32	0.33	90.3	26.2
	1982	44	10.0	18.6	28.6	0.04	0.43	0.47	89.8	27.8
	1983	49	25.7	16.5	42.2	0.09	0.37	0.46	77.0	41.7
	1984	52	19.8	19.3	39.1	0.03	0.38	0.41	69.8	43.7
	1985	54	70.4	35.8	106.2	0.15	0.43	0.58	58.9	82.5
	1986	62	123.5	83.5	207.0	0.37	0.93	1.30	68.5	72.3
	1987	61	52.9	59.5	112.4	0.16	0.74	0.90	74.1	56.7
	1988	62	75.9	39.1	115.0	0.15	0.62	0.77	64.6	67.9
	1989	62	113.1	97.2	210.3	0.24	1.09	1.33	67.5	71.6
	1990	62	27.7	80.9	108.6	0.06	0.87	0.93	76.9	53.0
	1991	61	53.5	29.3	82.8	0.16	0.47	0.63	71.3	59.4
Virginia-No. Carolina	1975	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
	1977	1	0.0	10.0	10.0	0.00	0.23	0.23	108.0	20.0
	1978	3	15.3	50.3	65.6	0.06	1.10	1.16	91.8	25.7
	1979	3	23.7	22.7	46.4	0.04	0.37	0.41	71.7	51.3
	1980	3	6.6	39.0	45.6	0.02	0.59	0.61	87.6	34.1
	1981	3	0.9	7.6	8.5	<0.01	0.20	0.20	107.7	18.8
	1982	7	0.4	3.7	4.1	<0.01	0.12	0.12	111.5	15.8
	1983	8	25.8	11.7	37.5	0.10	0.36	0.46	78.1	37.2
	1984	9	0.2	14.6	14.8	<0.01	0.27	0.27	98.7	25.3
	1985	10	1.7	7.3	9.0	<0.01	0.23	0.23	104.8	17.8
	1986	10	5.6	1.8	7.4	<0.02	0.04	0.06	69.1	55.9
	1987	10	0.1	2.1	2.2	<0.01	0.04	0.04	93.4	28.3
	1988	10	3.1	11.0	14.1	0.01	0.21	0.22	89.8	28.9
	1989	10	35.7	5.9	41.6	0.07	0.13	0.20	57.9	92.9
	1990	6	36.5	93.1	129.6	0.07	0.88	0.95	73.2	61.7
	1991	10	37.2	32.0	69.2	0.10	0.45	0.55	71.6	57.5
Mid-Atlantic (All Areas)	1975	43	38.8	32.6	71.4	0.10	0.59	0.69	75.3	47.2
	1977	112	2.8	55.1	57.9	0.01	1.00	1.01	97.7	25.9
	1978	164	7.8	56.8	64.6	0.02	1.23	1.25	99.4	23.4
	1979	166	9.1	26.2	35.3	0.02	0.52	0.54	86.5	29.8
	1980	167	27.1	19.2	46.3	0.04	0.42	0.46	70.1	45.8
	1981	161	16.1	18.0	34.1	0.02	0.30	0.32	70.1	48.2
	1982	185	10.6	20.3	30.9	0.03	0.34	0.37	80.4	38.1
	1983	193	14.3	14.4	28.7	0.04	0.30	0.34	79.4	37.8
	1984	203	17.6	18.5	36.1	0.02	0.31	0.33	69.5	49.2
	1985	201	51.0	31.5	82.5	0.11	0.43	0.54	64.1	69.8
	1986	224	65.2	54.8	120.0	0.17	0.69	0.86	69.3	63.3
	1987	225	85.7	47.9	133.6	0.17	0.61	0.78	63.6	78.0
	1988	226	74.9	88.3	163.2	0.12	1.12	1.24	68.1	59.9
	1989	229	156.9	83.6	240.5	0.24	0.93	1.17	58.1	93.5
	1990	216	103.2	90.6	193.8	0.29	0.88	1.17	68.2	74.9
	1991	228	28.0	49.0	77.0	0.08	0.63	0.71	76.8	49.4

[1] New York Bight: Strata 22-31, 33-35; Delmarva: Strata 10-11, 14-15, 18-19; VA-NC: Strata 6-7.

[2] Mean meat weight derived by applying the 1977-1982 USA Mid-Atlantic research survey sea scallop shell height meat weight equation, ln Meat Weight (g) = -12.1628 + 3.2539 ln Shell Height (mm) (n = 11943, r = 0.98) to the to the survey shell height frequency distributions.

Table SG3. USA sea scallop research survey relative abundance indices (standardized stratified mean number and mean weight per tow), [meats only, kg], mean shell height (mm), mean meat weight (g) per scallop, and average meat count (number of scallop meats per pound) of sea scallops from NEFSC surveys on Georges Bank, 1975, 1977-1991. Data are presented by principal scallop regions for the USA sector of Georges Bank[1]. Survey indices are presented for pre-recruit (<70 mm shell height), recruit (≥70 mm shell height), and total scallops per tow.

Area	Year	No. of Tows	Standardized Stratified Mean Number Per Tow: Pre-recruit	Recruit	Total	Standardized Stratified Mean Weight (kg) Per Tow[2]: Pre-recruit	Recruit	Total	Mean Shell Height	Average Meat Count
South Channel	1975	58	45.1	29.9	75.0	0.11	0.81	0.92	76.4	37.0
	1977	30	6.3	89.1	95.4	0.02	1.94	1.96	101.3	22.1
	1978	46	7.7	49.7	57.4	0.02	1.15	1.17	101.2	22.2
	1979	47	6.8	88.2	95.0	0.01	1.53	1.54	93.2	28.0
	1980	40	79.7	30.2	109.9	0.12	0.55	0.67	58.2	74.6
	1981	56	15.5	36.5	52.0	0.03	0.65	0.68	80.5	34.8
	1982	61	213.8	53.0	266.8	0.49	0.67	1.16	58.6	103.9
	1983	69	19.0	55.8	74.8	0.06	0.77	0.83	81.4	41.0
	1984	69	13.6	17.7	31.3	0.03	0.36	0.39	77.3	36.7
	1985	77	40.3	47.3	87.6	0.11	0.76	0.87	75.0	45.7
	1986	68	115.3	37.0	152.3	0.24	0.58	0.82	59.5	84.2
	1987	86	84.6	56.1	140.7	0.17	0.72	0.89	63.6	71.6
	1988	91	32.5	36.0	68.5	0.08	0.46	0.54	70.6	57.7
	1989	88	21.7	15.1	36.8	0.06	0.27	0.33	72.0	50.5
	1990	76	258.8	49.9	308.7	0.54	0.60	1.14	55.9	122.5
	1991	86	432.1	64.2	496.3	0.80	0.71	1.51	52.8	149.5
Southeast Part	1975	21	1.8	38.4	40.2	<0.01	1.02	1.02	110.3	17.8
	1977	21	3.2	27.2	30.4	0.01	0.68	0.69	103.6	20.0
	1978	18	2.2	27.1	29.3	<0.01	0.93	0.93	117.2	14.2
	1979	20	7.7	21.2	28.9	0.01	0.71	0.72	99.4	18.2
	1980	20	21.5	41.7	63.2	0.03	0.71	0.74	78.2	38.8
	1981	19	1.4	19.4	20.8	<0.01	0.46	0.46	102.5	20.5
	1982	22	0.8	9.8	10.6	<0.01	0.32	0.32	113.5	15.2
	1983	20	11.3	9.2	20.5	0.02	0.25	0.27	78.1	34.0
	1984	20	4.6	12.9	17.5	0.01	0.23	0.24	85.7	33.0
	1985	28	9.1	11.8	20.9	0.02	0.22	0.24	75.3	39.9
	1986	32	28.9	20.6	49.5	0.05	0.41	0.46	66.2	48.5
	1987	32	23.1	39.6	62.7	0.06	0.60	0.66	79.0	42.8
	1988	32	1.4	16.1	17.5	<0.01	0.32	0.32	96.9	24.6
	1989	31	23.6	11.8	35.4	0.07	0.23	0.30	70.2	54.4
	1990	32	1.6	8.4	10.0	<0.01	0.15	0.15	88.7	30.3
	1991	32	18.5	14.1	32.6	0.04	0.21	0.25	65.2	60.2
USA Northern Edge and Peak	1985	67	21.8	26.6	48.4	0.06	0.39	0.45	72.2	48.9
	1986	70	45.6	28.6	74.2	0.13	0.48	0.61	70.4	55.2
	1987	71	62.0	54.6	116.6	0.12	0.73	0.85	67.1	62.1
	1988	71	65.8	60.9	126.7	0.15	0.77	0.92	66.4	62.6
	1989	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
	1990[4]	65	66.9	196.8	263.7	0.22	1.83	2.05	75.8	58.3
	1991	71	118.7	66.9	185.6	0.31	0.85	1.16	66.1	72.4
USA Georges Bank	1985	172	26.5	31.8	58.3	0.07	0.50	0.57	74.2	46.4
	1986	170	61.3	28.9	90.2	0.14	0.49	0.63	64.4	64.9
	1987	189	62.6	51.9	114.5	0.12	0.70	0.82	66.8	63.0
	1988	194	38.0	40.8	78.8	0.09	0.54	0.63	69.4	56.6
	1989[3]	119	22.4	14.0	36.4	0.06	0.26	0.32	71.4	52.3
	1990[4]	173	135.2	87.8	223.0	0.31	0.89	1.20	63.9	84.1
	1991	189	224.1	51.4	278.2	0.45	0.65	1.10	56.4	114.8

1 South Channel: Strata 46-47, 49-55; Southeast Part: Strata 58-60; USA No. Edge & Peak: Strata 61, 621, 631, 651, 662, 71, 72, and 74.

2 Mean meat weight derived by applying the 1978-1982 USA Georges Bank research survey sea scallop shell height meat weight equation, ln Meat Weight (g) = -11.7656 + 3.1693 ln Shell Height (mm) (n = 5863, r = 0.98) to the to the survey shell height frequency distributions.

3 Combined South Channel and Southeast Part regions only.

4 Stratum 72 not sampled, excluded from analyses.

Table SG3. (continued).

Area	Year	No. of Tows	Standardized Stratified Mean Number Per Tow Pre-recruit	Recruit	Total	Standardized Stratified Mean Weight (kg) Per Tow[2] Pre-recruit	Recruit	Total	Mean Shell Height	Average Meat Count
Canada Northern Edge and Peak	1985	41	186.0	460.3	646.3	0.58	4.20	4.78	74.1	61.3
	1986	146	379.6	466.0	845.6	0.80	6.01	6.81	72.3	56.3
	1987	47	293.0	231.7	524.7	0.59	3.04	3.63	66.9	65.6
	1988	48	153.7	227.1	380.8	0.36	2.77	3.13	72.8	55.3
	1989	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
	1990	41	431.7	287.9	719.6	0.68	3.80	4.48	61.9	72.9
	1991	14	206.4	98.3	304.7	0.53	1.62	2.15	66.7	64.3
Total Northern Edge and Peak	1975	51	83.8	135.9	219.7	0.21	2.02	2.23	78.1	44.7
	1977	71	66.1	384.8	450.9	0.23	5.06	5.30	85.3	38.6
	1978	76	177.7	372.9	550.6	0.31	7.60	7.91	85.1	31.6
	1979	153	72.0	257.9	329.9	0.21	4.46	4.67	87.2	32.1
	1980	311	665.7	143.7	809.4	0.91	2.05	2.96	52.4	123.9
	1981	101	277.4	405.7	683.1	0.63	3.79	4.42	68.9	70.1
	1982	80	40.9	65.3	106.2	0.12	0.95	1.07	78.1	45.1
	1983	82	48.2	37.1	85.3	0.08	0.67	0.75	68.2	51.9
	1984	82	293.8	54.0	347.8	0.29	0.84	1.13	46.7	139.3
	1985	108	84.5	192.2	276.7	0.25	1.85	2.10	73.9	59.6
	1986	216	173.0	195.6	368.6	0.39	2.59	2.98	72.0	56.2
	1987	118	150.2	122.2	272.4	0.30	1.61	1.91	66.9	64.6
	1988	119	99.3	124.4	223.7	0.23	1.53	1.76	70.5	57.6
	1989	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
	1990[4]	106	223.8	236.0	459.8	0.42	2.68	3.10	66.4	67.4
	1991	85	152.2	78.9	231.1	0.40	1.14	1.54	66.4	68.1
Total Georges Bank (All Areas)	1975	130	51.7	74.6	126.3	0.13	1.34	1.47	79.9	39.0
	1977	122	34.3	218.3	252.6	0.12	3.18	3.30	87.6	34.7
	1978	140	79.7	184.0	263.7	0.14	3.88	4.02	87.1	29.8
	1979	220	36.6	152.3	188.9	0.10	2.70	2.80	88.6	30.6
	1980	371	377.4	92.3	469.7	0.52	1.37	1.89	53.4	112.6
	1981	176	97.2	152.4	249.6	0.22	1.62	1.84	70.6	61.5
	1982	163	91.0	51.2	142.2	0.22	0.74	0.96	66.5	66.9
	1983	171	31.9	38.2	70.1	0.06	0.63	0.69	73.4	46.3
	1984	171	148.7	34.6	183.3	0.15	0.57	0.72	49.1	114.9
	1985	213	56.3	111.6	167.9	0.17	1.19	1.36	74.1	56.2
	1986	316	129.9	123.0	252.9	0.28	1.68	1.96	70.1	58.5
	1987	236	105.5	85.4	190.9	0.21	1.14	1.35	66.9	64.3
	1988	242	59.5	75.6	135.1	0.14	0.96	1.10	71.2	55.9
	1989[3]	119	22.4	14.0	36.4	0.06	0.26	0.32	71.4	52.3
	1990[4]	214	193.6	127.3	320.9	0.38	1.47	1.85	63.0	78.7
	1991	203	220.8	62.3	283.1	0.46	0.83	1.29	58.5	99.2

[1] South Channel: Strata 46-47, 49-55; Southeast Part: Strata 58-60; No. Edge & Peak: Strata 61-662, 71-72, and 74.

[2] Mean meat weight derived by applying the 1978-1982 USA Georges Bank research survey sea scallop shell height meat weight equation, ln Meat Weight (g) = -11.7656 + 3.1693 ln Shell Height (mm) (n = 5863, r = 0.98) to the to the survey shell height frequency distributions.

[3] Combined South Channel and Southeast Part regions only.

[4] Stratum 72 not sampled, excluded from analyses.

Table SG4. Distribution of standardized stratified mean weight (g, meat) per tow among various meat count intervals for sea scallops from NEFSC sea scallop research vessel surveys in the Mid- Atlantic, 1975, 1977-1991.

				Meat Weight (g, meat) Per Tow [1]				
		Total Biomass	Harvestable[2] Biomass	Meat Count Interval[3]				
Area	Year	Per Tow(g)	Per Tow (g)	80 - 40	40 - 35	35 - 30	30 - 25	<25
New York Bight	1975	717	622	94	53	63	65	347
	1977	1029	1025	165	68	95	142	555
	1978	1158	1151	58	45	92	142	814
	1979	439	430	28	7	15	22	358
	1980	378	356	33	12	16	15	280
	1981	321	292	86	16	14	13	163
	1982	350	327	93	24	22	24	164
	1983	317	289	34	18	20	24	193
	1984	318	294	89	30	18	13	144
	1985	530	427	140	40	40	41	166
	1986	776	651	268	60	51	43	229
	1987	761	582	239	85	59	46	153
	1988	1357	1249	568	137	89	84	371
	1989	1146	901	452	100	76	58	215
	1990	1232	882	553	80	55	36	158
	1991	727	671	300	63	47	44	217
Delmarva	1975	555	444	48	42	51	63	240
	1977	941	911	162	72	63	69	545
	1978	1672	1584	186	74	78	108	1138
	1979	991	951	327	62	50	53	459
	1980	808	678	104	17	33	73	451
	1981	329	320	47	8	6	10	249
	1982	467	431	38	12	19	25	337
	1983	459	371	42	18	14	11	286
	1984	406	374	61	38	42	28	205
	1985	584	430	176	19	18	27	190
	1986	1299	925	416	115	110	91	193
	1987	899	739	244	148	139	91	117
	1988	768	621	109	77	86	88	261
	1989	1332	1090	582	138	93	69	208
	1990	930	867	493	116	75	66	117
	1991	633	470	80	50	59	59	222
Virginia-North Carolina	1975	N/S	N/S	N/S	N/S	N/S	N/S	N/S
	1977	227	227	11	13	15	18	170
	1978	1159	1097	177	7	15	18	880
	1979	411	372	111	49	46	26	140
	1980	608	592	174	35	24	55	304
	1981	204	201	4	4	9	15	169
	1982	119	118	1	4	4	3	106
	1983	458	361	26	7	3	4	321
	1984	265	265	35	49	48	28	105
	1985	231	228	1	-	5	18	204
	1986	60	44	4	-	1	3	36
	1987	35	35	10	2	3	3	17
	1988	222	215	16	12	26	30	131
	1989	203	134	10	11	7	10	96
	1990	952	880	591	123	82	23	61
	1991	546	452	149	42	26	28	207
Mid-Atlantic (All Areas)	1975	686	588	85	51	61	64	327
	1977	1012	1005	163	69	91	131	551
	1978	1251	1228	82	50	89	134	873
	1979	538	523	83	18	22	27	373
	1980	458	417	48	13	19	26	311
	1981	321	296	78	14	12	13	179
	1982	368	343	82	21	21	24	195
	1983	344	305	36	18	19	21	211
	1984	333	308	83	31	23	16	155
	1985	536	425	144	36	36	38	171
	1986	861	693	291	70	61	51	220
	1987	777	604	236	96	73	54	145
	1988	1237	1123	478	125	88	84	348
	1989	1167	925	470	105	79	59	212
	1990	1174	880	543	87	59	41	150
	1991	708	632	258	60	49	47	218

[1] Meat weight values derived from shell height values using 1977-1982 USA research survey equation,
$\ln$ Meat Weight (g) = -12.1628 + 3.2539 $\ln$ Shell Height (mm) (n = 11943, r = 0.98).
[2] Stratified mean weight (g, meat) per tow for sea scallops $\geq$70 mm; $\leq$80 count.
[3] Meat count is expressed as number of meats per pound.

Table SG5. Distribution of standardized stratified mean weight (g, meat) per tow among various meat count intervals for sea scallops from NEFSC sea scallop research vessel surveys in the USA sector of Georges Bank, 1975, 1977-1991.

				Meat Weight (g, meat) Per Tow [1]				
		Total Biomass	Harvestable[2] Biomass	Meat Count Interval[3]				
Area	Year	Per Tow (g)	Per Tow (g)	80 - 40	40 - 35	35 - 30	30 - 25	<25
South Channel	1975	918	812	39	26	34	43	670
	1977	1957	1938	156	102	218	220	1242
	1978	1173	1149	51	45	74	118	861
	1979	1541	1529	475	141	45	38	830
	1980	668	552	127	15	13	21	376
	1981	677	652	165	39	32	27	389
	1982	1165	671	296	34	22	21	298
	1983	827	773	313	67	55	53	285
	1984	387	360	59	20	22	26	233
	1985	869	763	174	56	100	117	316
	1986	820	577	153	42	41	38	303
	1987	891	724	281	77	69	59	238
	1988	539	459	188	37	36	34	164
	1989	331	271	57	14	17	17	166
	1990	1143	603	259	68	65	53	158
	1991	1505	707	376	49	34	29	219
Southeast Part	1975	1023	1018	16	20	36	67	879
	1977	687	679	57	30	29	24	539
	1978	934	928	19	10	15	14	870
	1979	720	710	34	6	14	13	643
	1980	739	707	245	52	25	12	373
	1981	461	458	55	30	25	16	332
	1982	316	315	9	9	11	7	279
	1983	273	248	14	4	12	19	199
	1984	240	228	63	28	12	10	115
	1985	238	219	46	15	14	19	125
	1986	463	407	78	19	18	13	279
	1987	664	604	153	116	73	35	227
	1988	323	319	46	22	28	36	187
	1989	296	233	25	17	19	26	146
	1990	150	146	41	9	11	5	80
	1991	245	210	65	9	8	5	123
USA Northern Edge and Peak	1985	450	393	125	30	26	17	195
	1986	610	481	103	38	43	33	264
	1987	852	735	286	59	62	62	266
	1988	918	772	302	104	74	65	227
	1989	N/S	N/S	N/S	N/S	N/S	N/S	N/S
	1990[4]	2052	1832	1457	159	58	40	118
	1991	1163	848	344	92	71	76	265
USA Georges Bank (All Areas)	1985	574	505	127	37	54	58	229
	1986	632	489	111	34	36	29	279
	1987	826	701	254	79	67	55	246
	1988	632	544	199	59	48	46	192
	1989	Not calculated since Northern Edge & Peak was not sampled in 1989 USA sea scallop survey.						
	1990[4]	1202	894	597	84	50	37	126
	1991	1099	649	295	56	42	41	215

[1] Meat weight values derived from shell height values using 1978-1982 USA research survey equation, ln Meat Weight (g) = -11.7656 + 3.1693 ln Shell Height (mm) (n = 5863, r = 0.98).

[2] Stratified mean weight (g, meat) per tow for sea scallops $\geq$70 mm, $\leq$80 count.

[3] Meat count is expressed as number of meats per pound.

[4] Stratum 72 not sampled.

Table SG5. (continued).

Area	Year	Total Biomass Per Tow (g)	Harvestable[2] Biomass Per Tow (g)	Meat Weight (g, meat) Per Tow[1] Meat Count Interval[3] 80 - 40	40 - 35	35 - 30	30 - 25	<25
Total Northern Edge and Peak	1975	2228	2015	538	285	207	162	823
	1977	5299	5064	1826	522	621	531	1564
	1978	7910	7604	632	468	746	818	4940
	1979	4666	4461	1009	261	233	256	2702
	1980	2963	2052	623	236	227	164	802
	1981	4417	3788	2565	244	221	157	601
	1982	1068	950	294	94	98	104	360
	1983	746	669	128	56	66	65	354
	1984	1133	837	227	74	65	65	406
	1985	2104	1846	1287	130	104	92	233
	1986	2676	2592	754	510	498	351	479
	1987	1913	1613	549	168	178	181	537
	1988	1760	1533	635	176	164	141	417
	1989	N/S	N/S	N/S	N/S	N/S	N/S	N/S
	1990[4]	3097	2679	1382	278	204	201	614
	1991	1539	1143	353	103	93	102	492
Total Georges Bank (All Areas)	1975	1471	1343	236	130	105	96	776
	1977	3298	3178	938	289	372	329	1250
	1978	4020	3879	295	220	351	398	2615
	1979	2801	2702	633	169	124	132	1644
	1980	1892	1373	412	139	128	94	600
	1981	1841	1625	919	103	92	66	445
	1982	964	743	243	59	57	59	325
	1983	688	627	168	51	53	52	303
	1984	725	569	142	48	41	42	296
	1985	1358	1193	694	85	86	87	241
	1986	1961	1678	477	301	294	209	397
	1987	1348	1136	388	129	123	114	382
	1988	1096	958	381	102	97	86	292
	1989	Not calculated since Northern Edge & Peak was not sampled in 1989 USA sea scallop survey.						
	1990[4]	1848	1467	732	153	118	112	352
	1991	1294	830	308	68	59	60	335

1 Meat weight values derived from shell height values using 1978-1982 USA research survey equation, ln Meat Weight (g) = -11.7656 + 3.1693 ln Shell Height (mm) (n = 5863, r = 0.98).
2 Stratified mean weight (g, meat) per tow for sea scallops $\geq$70 mm, $\leq$80 count.
3 Meat count is expressed as number of meats per pound.
4 Stratum 72 not sampled.

INSHORE WINTER FLOUNDER

The Atlantic States Marine Fisheries Commission Winter Flounder S&S Committee presented three papers to the SARC: 1) a stock assessment of the inshore winter flounder resource which included estimates of abundance and mortality rates for stock units representing the range of the resource (SAW/13/SARC/2); 2) a computer program, BIOREF, (SAW/13/SARC/14) for calculating yield and spawning biomass per recruit for a range of fishing rates based on inputs of minimum fish size, mesh size and percent discard mortality; and, 3) a study of winter flounder in Rhode Island (SAW/13/SARC/19) to provide details of the population analysis procedure used by the Committee in SAW/13/SARC/2. As part of the study, a preliminary VPA was presented for SARC comment and guidance on methodology.

The SARC review focused on noting areas of concern and alternative procedures to improve the analysis. Comments were offered regarding the calculation of mortalities, procedures for conducting age structured analyses, reference points, and stock units.

Background

Stock definition and structure

The winter flounder (Pseudopleuronectes americanus) is a common estuarine flatfish found in shoal water habitats along the northwest Atlantic coast. Genetically identifiable flounder stocks are numerous, with individual estuaries providing winter/spring spawning grounds. Stock groups inhabit adjacent estuarine units. Fish of these units migrate seasonally offshore and intermix in summer then move back to natal inshore nursery areas in winter where they spawn. At least one offshore stock has been identified on Georges Bank. These populations vary in growth rate, longevity and maturation. Therefore, the S&S Committee grouped the inshore population into three management units based on similar growth, seasonal movement and maturity patterns. These units are described below.

The Gulf of Maine unit includes stocks from coastal Maine, New Hampshire, and Massachusetts north of Cape Cod (excluding Georges Bank). The fish show relatively moderate growth rates with 50% of the females maturing between age three and four (about 30 cm in length) and exhibit limited seasonal movements inshore.

The Southern New England unit comprises stocks from coastal Massachusetts east and south of Cape Cod including Nantucket Sound, Vineyard Sound, Buzzards Bay, Narragansett Bay, Block Island Sound, Rhode Island Sound, Rhode Island Coastal Ponds and eastern long Island Sound to the Connecticut River including Fishers Island Sound. Flounder here show relatively fast growth rates, with 50% of females maturing at age three (27-30 cm) and may undertake extensive seasonal migrations.

The Mid-Atlantic unit includes stocks from Long Island Sound west of the Connecticut River to Montauk Point including Gardiners and Peconic Bays, coastal Long Island, NY, coastal New Jersey and Delaware. Flounder here are at the southern extent of the range and exhibit relatively slower growth rates. Here, 50% of the females mature between age two and three (25 cm). Seasonal movements are generally less than for the northern populations and may extend offshore in a northeast direction.

By comparison, the Georges Bank stock exhibits extremely fast growth. At 50% maturity females are two and one half years old (32 cm).

History of the Fishery

Since 1939, commercial landings (as recorded in Fisheries of the U.S.) ranged from 6 to 17 thousand mt. Coastwide, 69% of flounder landed in the last decade were taken by commercial gear, almost exclusively (95%) otter trawls. Landings increased steadily between 1939 and 1950, then dropped to a historic low in 1955 (6 thousand mt). Landings rose in the late 1950s, declined through the mid-1970s and increased in the 1980s to a peak of 17 thousand mt. Landings have since declined to the 7 thousand mt level in 1989. In the last decade, 58% of commercial catches were taken in the Southern New England stock unit, 15% in the Gulf of Maine, 7% in the Mid-Atlantic and 19% on Georges Bank.

Data on recreational catches of winter flounder have been collected from the NMFS Marine Recreational Fisheries Statistics Survey (MRFSS), beginning in 1979. Coastwide landings have ranged from 1.4 to 8 thousand mt and comprise about one third of the total. From 1979 through 1983, landings were fairly stable at around 6 thousand mt annually. In 1984, landings peaked at 8 thousand mt and have since declined to a low of 1.5 thousand mt in 1989. In the last decade, 62% of the recreational catch was taken from the Mid-Atlantic stock, 24% from the Gulf of Maine, and 14% from Southern New England.

Data Sources

Commercial and recreational landings by stock units for the years 1979 through 1989 are given in Table SH1. Commercial catches from the two northern stocks have shown a declining trend over the last decade, while the Mid-Atlantic shows no apparent trend. These patterns are reflected in the recreational catches, as well.

Fishery independent indices of abundance are available for the three management units from the Massachusetts DMF, Rhode Island DFW, Connecticut DEP, and the NEFSC bottom trawl surveys (Figure SH1). These indices indicate that in the Gulf of Maine management unit abundance declined in 1982-1983 in inshore waters and has remained low to the present. In the Southern New England unit, abundance declined from relatively high pre-1980 levels to the lowest survey point in 1990. The Mid-Atlantic management unit has shown a similar declining trend over the decade, while the NEFSC survey shows fluctuations with no definitive trend.

The Massachusetts DMF and the Connecticut DEP trawl surveys were used to develop pooled age-length keys from aging of winter flounder for the areas north of Cape Cod, east and south of Cape Cod, eastern Long Island Sound, western Long Island Sound and Little Egg Inlet/Barnegat Bay, New Jersey. Length-weight equations derived from the surveys were employed to calculate mean weights at age (Table SH2).

Tag and return data from past and ongoing studies were used to complement mortality estimates that are possible from the age-based calculations. A total of thirty-three studies, spanning 1931 to the present, were considered to cover the range of the resource.

Commercial catch based abundance indices for the Gulf of Maine and Southern New England units (Figure SH2) generally parallel trends in the surveys, showing declines in CPUE over the last decade. The Mid-Atlantic unit shows no clear trend. Recreational catch per effort, measured by the number of successful trips over total trips, indicates a declining trend for the two northern units with no trend seen in the Mid-Atlantic (Table SH3).

Methodology

Instantaneous total mortalities were calculated for six populations representing the three management units by two methods: catch curve based on aging studies and from tagging studies using methods of Robson and Chapman (1961) and Brownie et al. (1985). Relative exploitation rates (Hoenig and Heisey 1987) were estimated for the Southern New England unit. Natural mortalities were computed using the inverse relationship between life span and mortality (Hoenig, 1983):

$$\ln(M) = 1.46 - 1.10 \ln(t_{max})$$

where: M = instantaneous rate of natural mortality, and

t = theoretical maximum age, estimated as the oldest fish from the historical data.

A computer program, BIOREF, was developed by the Massachusetts DMF which employed a Thompson and Bell model, for computing yield and spawning biomass per recruit, incorporating the effects of discards. The program allows an exploratory analysis of the importance of commercial and recreational fishery discarding rates for the calculation of biological reference points. In addition, a preliminary age structured analytical assessment was presented by Rhode Island DFW for comment and recommendations. This analysis developed a catch at age matrix for the Narragansett Bay stock using an iterated age-length key approach (Hoening and Heisey 1987) and aging data from research surveys. Conventional VPA analysis (Gulland 1965) and CAGEAN (Deriso 1987) integrated analysis were then applied to try to estimate abundance and fishing mortality rates at age.

Assessment Results

Total instantaneous mortality rates for winter flounder estimated from thirty three tagging studies (Table SH4), are greater than 1.0 in recent years. In some cases, mortality rates have been high for many years. Similar results were obtained from catch curve analyses, although the SARC concluded that these results should be viewed with caution because of potential problems in the application of pooled age length keys across years (Table SH5). Estimates of natural mortality rate of around 0.3 give a fishing mortality rate of near 1.0.

The estimates of biological reference points by the BIOREF program (Table SH6) indicated that, in most cases, recent fishing mortality rates are above the reference level of 25% MSP. The SARC recommended against using F_{msy}because of uncertainties in the stock and recruitment relationship.

SARC Analyses

Most of the discussion centered on the development of age disaggregated indices and catch at age for input into methods for estimating total or fishing mortality rates and stock size. For all methods, re-analysis of the data using more appropriate procedures for application of age-length keys is needed.

The grouping of winter flounder into six stock units resulted in the ASFMC Committee's pooling the age data from several areas. Upon reviewing the Committee's procedures, the SARC noted that iterated age-length key methods (Kimura and Chikuni 1987, Hoening and Heisey 1987) applied to age/length keys must be done prior to pooling data over years. Pooling prior to inversion analysis may result in smoothing of recruitment and growth indices among data sets. Also, decisions about pooling should take account of stocks that have the most similar biological parameters since the outcome has bearing on such things as biological reference points. In this regard, pooling into six stock units versus the three management units is probably reasonable, but the Committee should re-evaluate these groupings.

Development of catch at age matrices from landings data, length frequency data, and the age-length keys would be best accomplished using some procedure similar to NEFSC's BIOSTAT program, which pro rates length samples according to the market category sampling scheme.

The SARC noted potential problems in the correct correspondence in terms of stock composition among the commercial fishery catch, the NEFSC abundance indices, and age composition which underlie the mortality estimates for the Southern New England management unit. Adjustments and recalculation are advised.

BIOREF is a potentially useful tool for calculating various harvesting strategies with respect to biological reference points. The SARC was, however, concerned about the Committee's use of F_{msy} as a reference point because of the uncertainty about the stock/recruitment parameter estimates which are sensitive to survey catchability variability. The reference points $F_{0.1}$ and F_{max} are probably more reliable, especially for coastwide application.

The SARC commented on the preliminary VPA calculations presented for the Rhode Island assessment. It advised that if VPAs are going to be chosen as the Committee's assessment method, standard tuning procedures, such as ADAPT (Gavaris 1988, Conser and Powers 1990) or Laurec Shepherd (1983) tuning (in the Lowestoft VPA package) should be used.

Major Sources of Uncertainty

- o Correct age/length keys and mortality estimates as affected by the pooling procedures used.

- o The use of a varying M for different stock units and ages.

Recommendations

- o The S&S should employ an age structured assessment in the future. This would probably be best accomplished in a Working Group framework with the participation of the NEFSC, as in the case of the Summer Flounder Working Group.

- o Review and revise age/length keys according to standard procedures for pooling catch-at-age matrices.

- o Commercial fishery data for Statistical area 539 and NEFSC survey data need to be re-analyzed. Commercial length frequency data should be weighted by market category landings. The NEFSC strata set used to calibrate recruitment and abundance indices needs to be reduced (i.e., exclude Mid-Atlantic strata and some southern New England strata) and some inshore strata might be included.

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Table SH1a. Winter flounder commercial landings (thousands of pounds) by year and stock unit. (Data source: NMFS weighout data).

YR	------State Waters------				----Exclusive Economic Zone---				
	Gulf ME	S.New Engl.	Mid-Atl.	Total	Gulf ME	S.New Engl.	Mid-Atl.	Geo. Bank	Total
1979	951	4052	842	5846	2992	9776	891	5231	18690
1980	841	4504	1104	6451	4849	17023	700	7016	29588
1981	1095	4752	1397	7244	4985	17706	1122	7145	30958
1982	802	4293	1013	6108	5010	15160	1099	5299	26568
1983	719	3832	991	5542	4307	14242	813	7788	17150
1984	524	3835	1081	5440	3679	13719	497	7842	25737
1985	400	3295	746	4441	1797	10990	1040	4159	18986
1986	257	2440	808	3505	2209	7373	515	3495	13592
1987	269	2065	886	3220	2118	8105	591	5281	16095
1988	229	1872	1275	3376	3075	8706	547	2438	14766
1989	175	1097	595	1867	2670	8000	809	1756	13235
MEAN:	569	3276	985	4822	3517	11891	784	4924	21397
%TOTAL:				18%					82%
1979-88 10-YR TREND	Neg. ***	Neg. ***	Neg.		Neg. **	Neg. **	Neg. *	Neg. *	

TREND - Slope of regression: landings versus years
* = 0.05<P<0.10; ** = 0.01<P<0.05; *** = P<0.01

--------PERCENTAGE OF COMMERCIAL LANDINGS--------

GULF OF MAINE: 16%
S. NEW ENGLAND: 58%
MID-ATLANTIC: 7%
GEORGES BANK: 19%

Table SH1b. **Winter flounder recreational catch (thousands of fish) by year, state and stock unit.**
(Data source: MRFSS positive intercept catch rates)

CATCH by STOCK UNIT

Year	Gulf of Maine Thousands Fish	Gulf of Maine Thousands Pounds	Southern New England Thousands Fish	Southern New England Thousands Pounds	Mid-Atlantic Thousands Fish	Mid-Atlantic Thousands Pounds	Total Catch Thousands Pounds
1979	3112	3112	2597	2597	7975	7018	12727
1980	5674	5220	3019	2777	7941	6670	14680
1981	3633	3960	1566	1707	4293	3778	9445
1982	4286	4072	2455	2332	6572	6572	12976
1983	3425	3117	1591	1448	9376	9282	13847
1984	1946	2218	1231	1403	15910	14955	18577
1985	3041	3467	1726	1968	11117	9561	14995
1986	2346	2557	1540	1679	8006	7366	11601
1987	1698	2360	1086	1510	4185	4059	7929
1988	1684	2235	773	850	3767	3531	6233
1989	1113	1225	538	592	1768	1537	3354
Mean	2905		1647		7355		12455
(SE)	(403)		(233)		(1194)		(1072)
% Total	24%		14%		62%		
11 Year Trend	Negative**		Negative**		No trend		

** slope of regression: landings versus years P<=0.01

Table SH2. Mean weight-at-age from lenght-weight equations from respective surveys. (kg)

Age	N. Cape Cod		S. and E.		Rhode Island		
	>12"	Spa.[1]	>12"	Spa.	>11"	>12"	Spa.
~~1~~	~~0.00~~	~~0.10~~	~~0.00~~	~~0.00~~	~~0.0~~	~~0.0~~	~~0.0~~
2	0.00	0.15	0.00	0.14	0.0	0.0	0.14
3	0.395	0.33	0.413	0.33	0.347	0.413	0.33
4	0.461	0.45	0.533	0.533	0.508	0.533	0.533
5	0.609	0.609	0.854	0.854	0.854	0.854	0.854
6	0.859	0.859	1.105	1.105	1.105	1.105	1.105
7	0.962	0.962	1.269	1.269	1.269	1.269	1.269
8	1.038	1.038	1.396	1.396	1.396	1.396	1.396
9	1.092	1.092	1.492	1.492	1.492	1.492	1.492
10	1.130	1.130	1.562	1.562	1.562	1.562	1.562
11	1.158	1.158	1.614	1.614	1.614	1.614	1.614
12	1.177	1.177	1.652	1.652	1.652	1.652	1.652
13	1.190	1.190	1.679	1.679			

Age	E. Long Island Sound			W. Long Island			New Jersey		
	>10"	>12"	Spa.	>9"	>10"	Spa.	>8"	>10"	Spa.
1	0.00	0.00	0.0	0.00	0.00	0.05	0.00	0.00	0.00
2	0.211	0.00	0.17	0.198	0.250	0.14	0.172	0.265	0.19
3	0.314	0.440	0.35	0.231	0.266	0.21	0.236	0.303	0.26
4	0.468	0.527	0.50	0.329	0.361	0.33	0.323	0.346	0.346
5	0.551	0.582	0.57	0.429	0.454	0.454	0.432	0.432	0.432
6	0.631	0.631	0.631	0.528	0.528	0.528	0.479	0.490	0.490
7	0.704	0.704	0.704	0.606	0.606	0.606	0.521	0.521	0.521
8	0.756	0.756	0.756	0.663	0.663	0.663	0.553	0.553	0.553
9	0.793	0.793	0.793	0.711	0.711	0.711	0.575	0.575	0.575
10	0.819	0.819	0.819						
11	0.837	0.837	0.837						
12	0.849	0.849	0.849						

Spawners (Spa.[1])

Table SH3 **Estimated recreational trips (in thousands) catching one or more winter flounder by stock unit.** Data from MRFSS, 1979-1988.

Year	Gulf of Maine	Southern New England	Mid-Atlantic
1979	461	385	935
1980	915	487	1197
1981	492	212	580
1982	636	361	846
1983	706	328	1523
1984	402	254	2288
1985	572	325	1796
1986	408	268	1673
1987	292	187	806
1988	455	209	902
1989	564	272	1567
Mean	537	299	1283
SE	52	27	158

*mid-Atlantic region includes western CT, NY, NJ, and DE

Regional mean catch for intercepts catching one or more winter flounder as a percentage of total intercepts.

Region: Year	Mean catch per angler North (ME-CT)	Mid (NY-DE)	% Total intercepts North (ME-CT)	Mid (NY-DE)
1979	6.75	7.32	14.9	7.2
1980	6.20	5.51	21.1	7.8
1981	7.39	6.41	11.9	6.3
1982	6.80	6.49	15.0	8.2
1983	4.85	5.79	12.2	11.0
1984	4.84	6.71	11.6	16.6
1985	5.31	5.84	11.7	13.7
1986	5.75	4.43	9.3	12.8
1987	5.82	5.20	9.0	7.5
1988	3.67	5.46	10.0	5.2
1989	4.01	3.88	8.8	4.7
Mean	5.58	5.73	12.3	9.2
SE	0.36	0.30	1.1	1.7

Table SH4. **Instantaneous total mortality estimates (Z) for winter flounder derived from tagging data.** Standard errors (SE) of the estimates and probability (P) of a greater chi-square are also given. The data are arranged by date within stock unit (Gibson 1990, 1991b).

Tagging Area	Year	Z	SE	P>X2
~~Gulf of Maine~~				
St. Johns Bay, ME	1940-1942	1.54	0.82	0.33
Mary's Bay, NS	1949-1950	1.00	0.70	0.69
Boston Harbor, MA	1960-1963	1.19	0.19	0.21
Merr. R. Ipswich Bay,MA	1964-1969	0.75	0.07	0.34
Beverly-Salem, MA	1964-1969	1.00	0.08	0.90
Quincy Bay	1964-1969	0.87	0.06	0.10
Plymouth Outer Harbor	1965-1969	0.94	0.16	0.20
Billingsgate Shoals	1964-1969	0.77	0.07	0.07
Southern New England				
Waquoit Bay, MA	1931-1936	0.90	0.05	0.11
Narragansett Bay,RI	1937-1942	0.89	0.23	0.27
Mystic River, CT	1938-1942	1.19	0.15	0.71
Pt. Judith Pd., RI	1937-1942	0.89	0.09	0.11
RI Sound, RI	1940-1942	0.45	0.11	0.92
Watch Hill, RI	1940-1942	1.15	0.18	0.26
Green Hill Pd.,RI	1956-1958	0.97	0.15	0.22
Narragansett Bay,RI	1958-1959	1.11	0.15	0.15
Hedgeface Shoal, MA	1964-1969	0.76	0.06	0.17
Tarpaulin Cove, MA	1964-1969	0.73	0.06	0.69
Tuckernuck Shoal, MA	1967-1969	1.01	0.13	0.55
Great Point,	1964-1969	0.60	0.04	0.17
Rodgers Shoal	1964-1969	0.62	0.04	0.37
Pendelton Wreck	1964-1969	0.69	0.11	0.09
Highland Light	1964-1969	0.80	0.08	0.40
Nantucket, MA	1964-1968	0.73	0.04	0.26
Provincetown	1964-1968	1.03	0.10	0.32
Waquoit Bay, MA	1970-1971	0.66	0.03	0.29
Niantic, CT	1983-1989	0.80	0.03	0.18
Narragansett Bay, RI	1986-1989	1.48	0.14	0.06
Mid-Atlantic				
Great South Bay, NY	1937-1941	1.46	0.12	0.62
Great Peconic Bay, LIS, NY	1938-1942	1.02	0.11	0.79
Gardiners Bay, LIS, NY	1938-1942	1.16	0.23	0.29
Port Jefferson, NY	1938-1942	1.21	0.14	0.74
Great South Bay, NY	1964-1968	1.29	0.08	0.13
Barnegat Bay, NJ	1978-1979	1.80	0.11	0.19

Table SH4. (Continued)

Oyster Bay, LIS, NY	1981-1983	1.36	0.27	0.20
Huntington Bay, LIS, NY	1981-1983	1.14	0.41	0.57
Shark River, NJ	1982-1985	1.95	0.48	0.10
Manasquan River, NJ	1982-1985	1.95	0.29	0.20
Barnegat Bay, NJ	1986-1987	1.86	0.46	0.07
Sandy Hook Bay, NJ	1986-1989	1.23	0.17	0.13
Offshore				
E.NE. Nantucket	1965-1969	0.69	0.13	0.09
W. Nantucket Shoals	1964-1969	0.61	0.07	0.24
Nantucket Shoals	1965-1969	0.78	0.06	0.07
Georges Bank	1967-1973	0.57	0.04	0.46

Table SH5. **Estimates of instantaneous mortality rates (Z) on winter flounder calculated from catch curve data by state and year.**

Area	Years	Z	SE(SD)	Data Source
GULF OF MAINE				
MA	1978-1983 Ages 4-7	1.28	0.15 (SD)	Witherell et al. 1990
	1984-1990 Ages 4-7	1.42	0.15 (SD)	Witherell et al. 1990
Georges Bank	1963-1966 Ages 7-12	0.70	0.09	Gibson (pers. comm.), from Lux 1973
SOUTHERN NEW ENGLAND				
MA	1978-1983 Ages 4-7	1.03	0.25 (SD)	Witherell et al. 1990
MA	1984-1990 Ages 4-7	1.42	0.13 (SD)	Witherell et al. 1990
RI				
RIDFW Spring	1986-1990	1.20	0.27	Gibson 1989b; 1990
RIDFW Winter	1986-1990 Ages 3-8	1.17	0.83	
URIGSO Winter	1986-1990 Ages 3-8	1.10	0.73	Gibson 1989b; 1990
MRC Winter	1986-1990 Ages 3-8	1.18	0.10	Gibson 1989b; 1990
E. Long Island Sound	1978-1983 Ages 3-9	0.72		NUSCo 1987
	1985-1990 Ages 3-8	1.01	0.03	CTDEP 1990
MID-ATLANTIC				
Great South Bay	1961-1963 Ages 3-6	1.13	0.16	Castaneda (pers. comm.) from Poole 1966
Long Island Sound				
central	1985-1990 Ages 3-8	1.07	0.05	CTDEP 1990
western	1988-1989 Ages 4-7	1.20	0.06	Castaneda (pers. comm.) NY DEC

Table SH6a. **Assumptions for the Thompson-Bell Yield-per-Recruit model of six winter flounder populations.**

Stock Unit:	Gulf of Maine	Southern New England			Mid-Atlantic	
Geographic location of data base used:	N. Cape Cod	S. Cape Cod	Narragansett Bay	East LIS	West LIS	NJ
Data source:	MA(1)	MA(1)	RI(2)	CT(3)	CT(3)	NJ(4)
Natural mortality (M)	0.28	0.28	0.35	0.35	0.42	0.42
Terminal age of model	13	13	12	12	10	10
Commercial/recreational exploitation ratio	52:48	95:5	60:40	60:40	40:60	10:90

All runs by Witherell of BIOREF model with input data provided by:

(1) Witherell *et al.* (1990)
(2) Gibson (1989a,1989b, and 1989c)
(3) CTDEP (1990)
(4) Danila (1978)

Table SH6b Input parameters for winter flounder RHODE ISLAND

Stock-Recruitment parameters =	Alpha= 8.73, B= 1.8, K= 15.92 (age 1 recruits/kg)
Natural Mortality (M) =	0.35 (all a (all ages)
Hooking Mortality =	0.15 (ages (ages 2 and up)
Commercial:Recreational ratio =	60:40
Legal size =	11" (with 3" mesh)
	12" (with 5" mesh)

							11" Fish, 3.0" Mesh		12" Fish, 5.0" Mesh	
AGE	PERCENT FEMALES MATURE	PERCENT > 11"	WEIGHT (kg) OF FISH > 11"	PERCENT > 12"	WEIGHT (kg) OF FISH > 12"	WEIGHT (kg) OF SPAWNERS	PERCENT SUBLEGALS RETAINED	PERCENT LEGALS RETAINED	PERCENT SUBLEGALS RETAINED	PERCENT LEGALS RETAINED
1	0.0	0.0	0.000	0.0	0.000	0.00	3.16	-	0.11	-
2	2.7	0.0	0.000	0.0	0.000	0.14	72.46	-	4.15	-
3	41.7	50.1	0.347	17.7	0.413	0.33	99.65	99.99	38.41	81.28
4	86.5	99.6	0.508	87.7	0.533	0.52	99.94	100.00	61.98	91.24
5	96.5	100.0	0.854	98.0	0.854	0.85	100.00	100.00	68.78	97.23
6	98.3	100.0	1.105	100.0	1.105	1.11	100.00	100.00	100.00	98.25
7	99.6	100.0	1.269	100.0	1.269	1.27	100.00	100.00	100.00	99.48
8	100.0	100.0	1.396	100.0	1.396	1.40	100.00	100.00	100.00	99.85
9	100.0	100.0	1.492	100.0	1.492	1.49	100.00	100.00	100.00	99.86
10	100.0	100.0	1.562	100.0	1.562	1.56	100.00	100.00	100.00	100.00
11	100.0	100.0	1.614	100.0	1.614	1.61	100.00	100.00	100.00	100.00
12	100.0	100.0	1.652	100.0	1.652	1.65	100.00	100.00	100.00	100.00

Natural mortality was calculated by Hoenig's method. Hooking mortality was estimated by Durso and Iwanowicz (1983). The commercial:recreational ratio was based on MRFSS positive intercepts, and on NMFS weighout data. The maturity schedule was based on Massachusetts DMF length based observations (1985-1989) applied to a pooled (1983-1989) age-length key for winter flounder south and east of Cape Cod. Weights were calculated from MDMF length-weight equations south and east of Cape Cod; the equation used to calculate legal and spawner weights included both sexes. The proportion of legals and sublegals retained was calculated by applying mesh selectivity curves (Simpson 1989) to the age-length key. Stock-recruitment parameter Alpha was calculated using the method of Boudreau and Dickie (1989), which was corroborated by observed stock-recruit data from Rhode Island.

Table SH6c. Fishery reference points, and corresponding percent maximum spawning biomass for winter flounder stocks analyzed at a 50% discard mortaliity from the commercial fishery.

						Reference point		
Stock	M	mesh	fish	max age	Alpha	Fmsy	%MSP	F25
NJ	0.42	3	8	9	12.00	0.50	34.5	0.73
	0.42	3	10	9	12.00	0.80	36.6	1.48
WLIS	0.42	3	9	9	12.79	0.60	38.6	1.17
	0.42	3	10	9	12.79	0.69	38.7	1.39
ELIS	0.35	3	10	12	8.73	0.50	31.1	0.67
	0.35	5	12	12	8.73	1.00	32.3	1.61
RI	0.35	3	11	12	8.73	0.57	24.7	0.58
	0.35	5	12	12	8.73	0.87	26.5	0.97
S.CAPE	0.28	4	12	13	7.60	0.50	27.6	0.58
	0.28	5	12	13	7.60	0.71	26.6	0.80
N.CAPE	0.28	4.5	12	13	7.28	0.50	31.1	0.69
	0.28	5	12	13	7.28	0.60	29.6	0.79

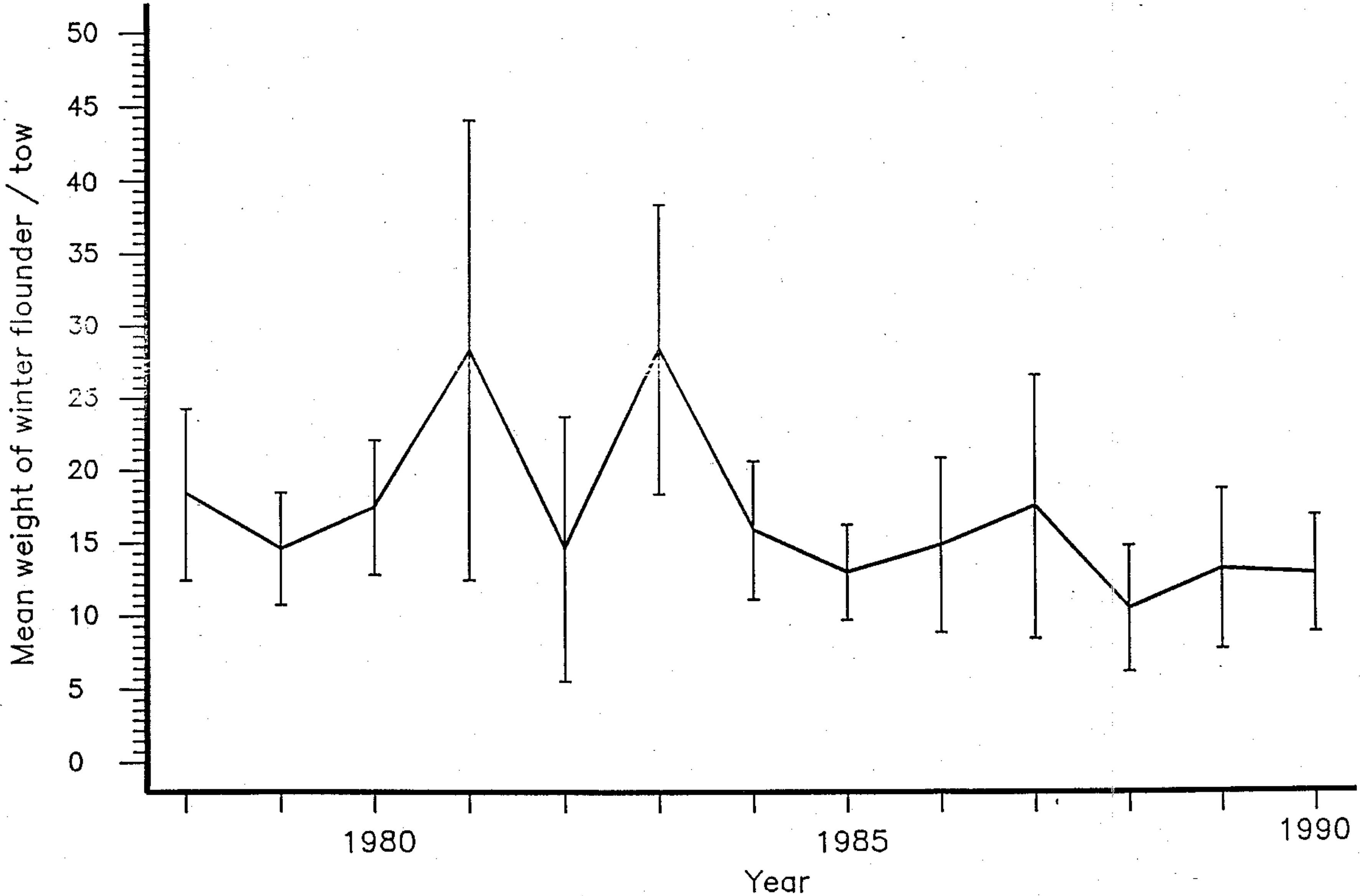


Figure SH1a. Relative abundance (Mean +/− 95% Confidence Interval) of winter flounder in Massachusetts, north of Cape Cod, for 1978 to 1990 (Witherell et al. 1990)

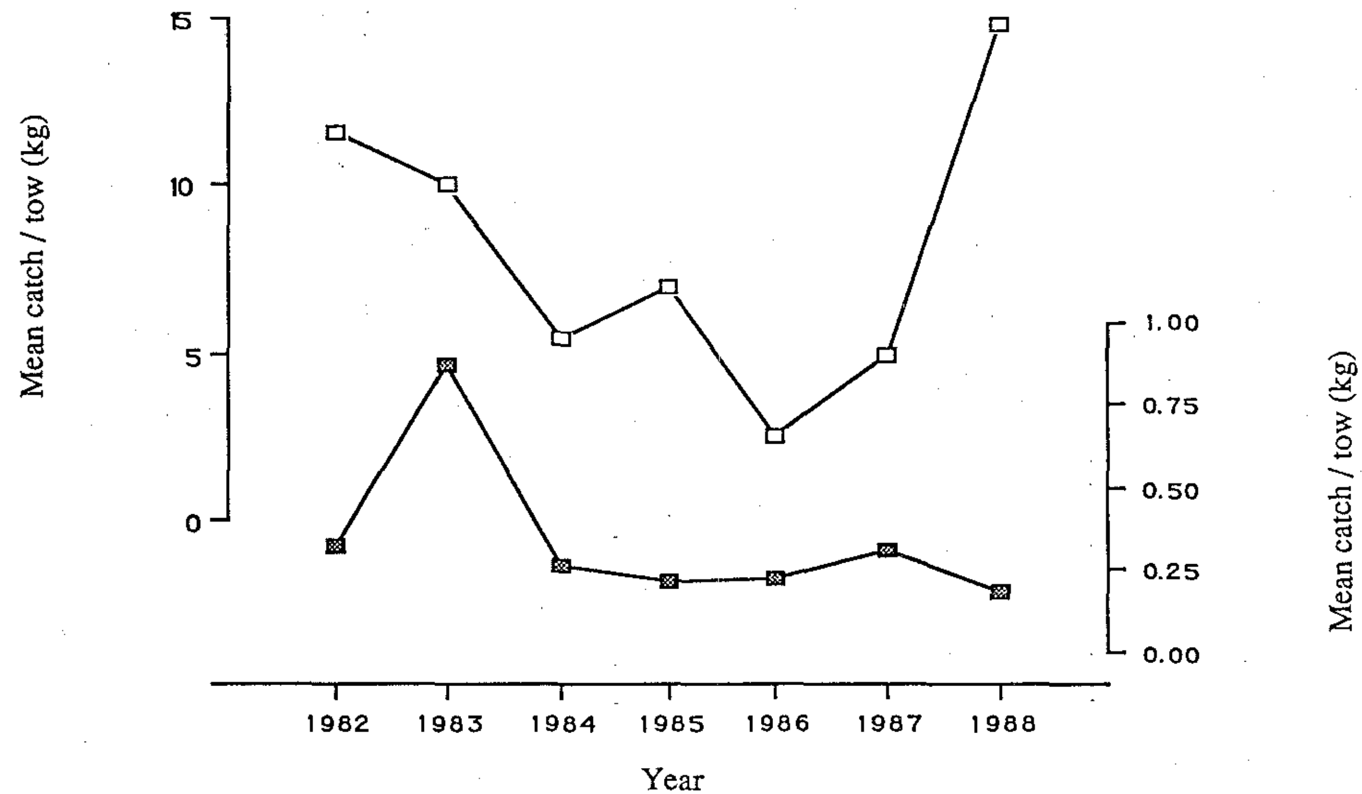


Figure SH1b . Stratified mean catch per tow in weight (kg) of winter flounder in NEFC/NMFS inshore (open symbols) and offshore (solid symbols) spring bottom trawl surveys in the Gulf of Maine area, 1982-1988.

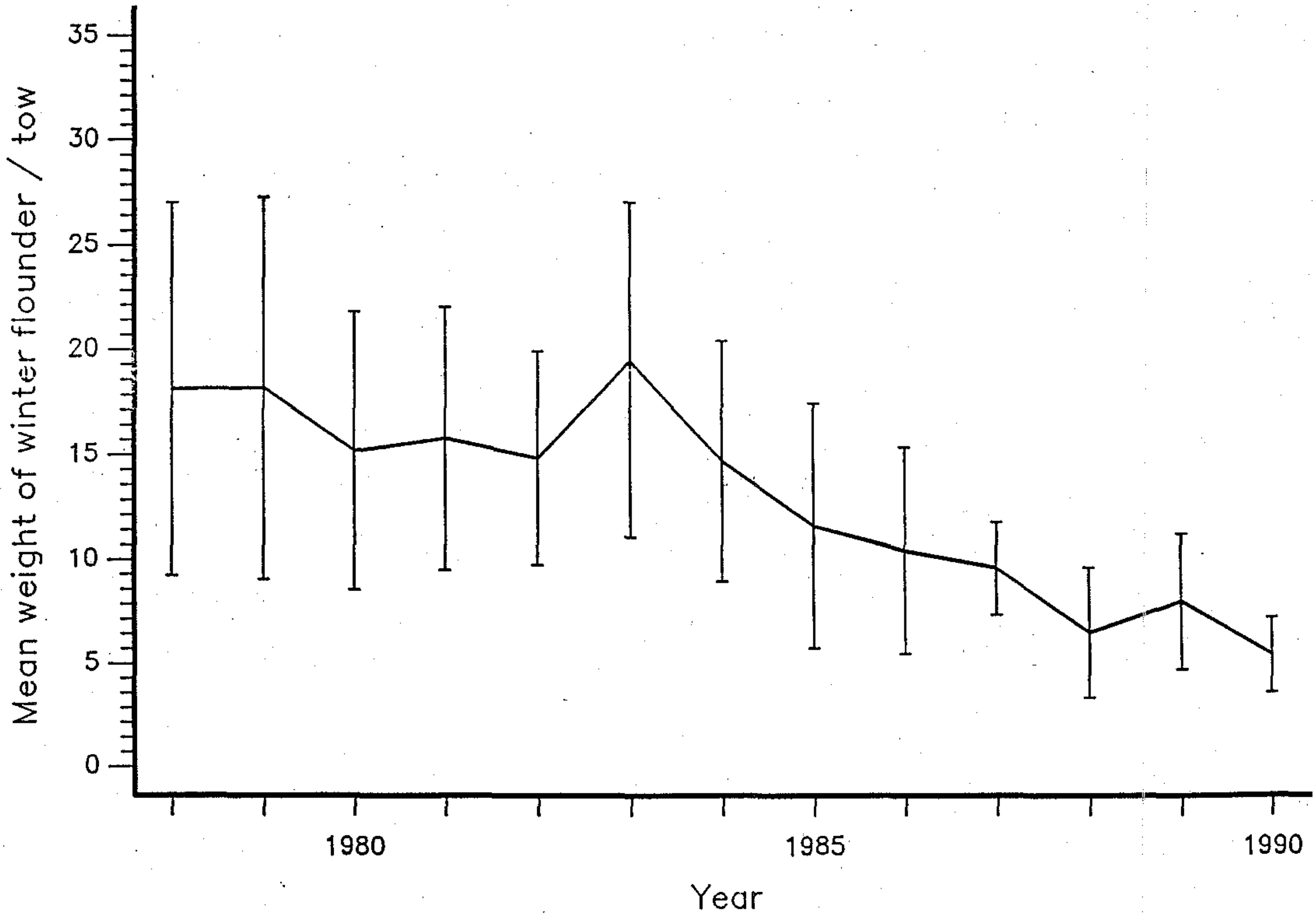


Figure SH1c Relative abundance (Mean +/− 95% Confidence Interval) of winter flounder in Massachusetts, south and east of Cape Cod, for 1978 to 1990 (Witherell et al. 1990)

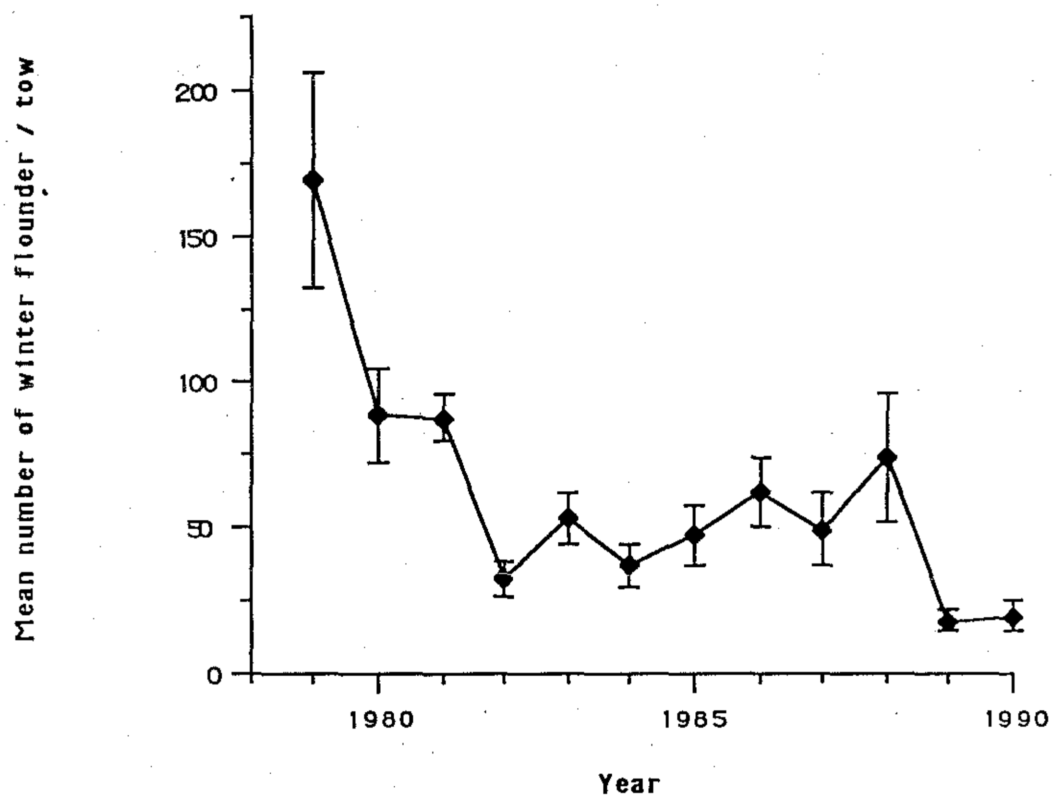


Figure SH1d Relative abundance (MEAN $\pm$ SE) of winter flounder in Rhode Island for 1979 to 1990 (modified from Gibson 1987).

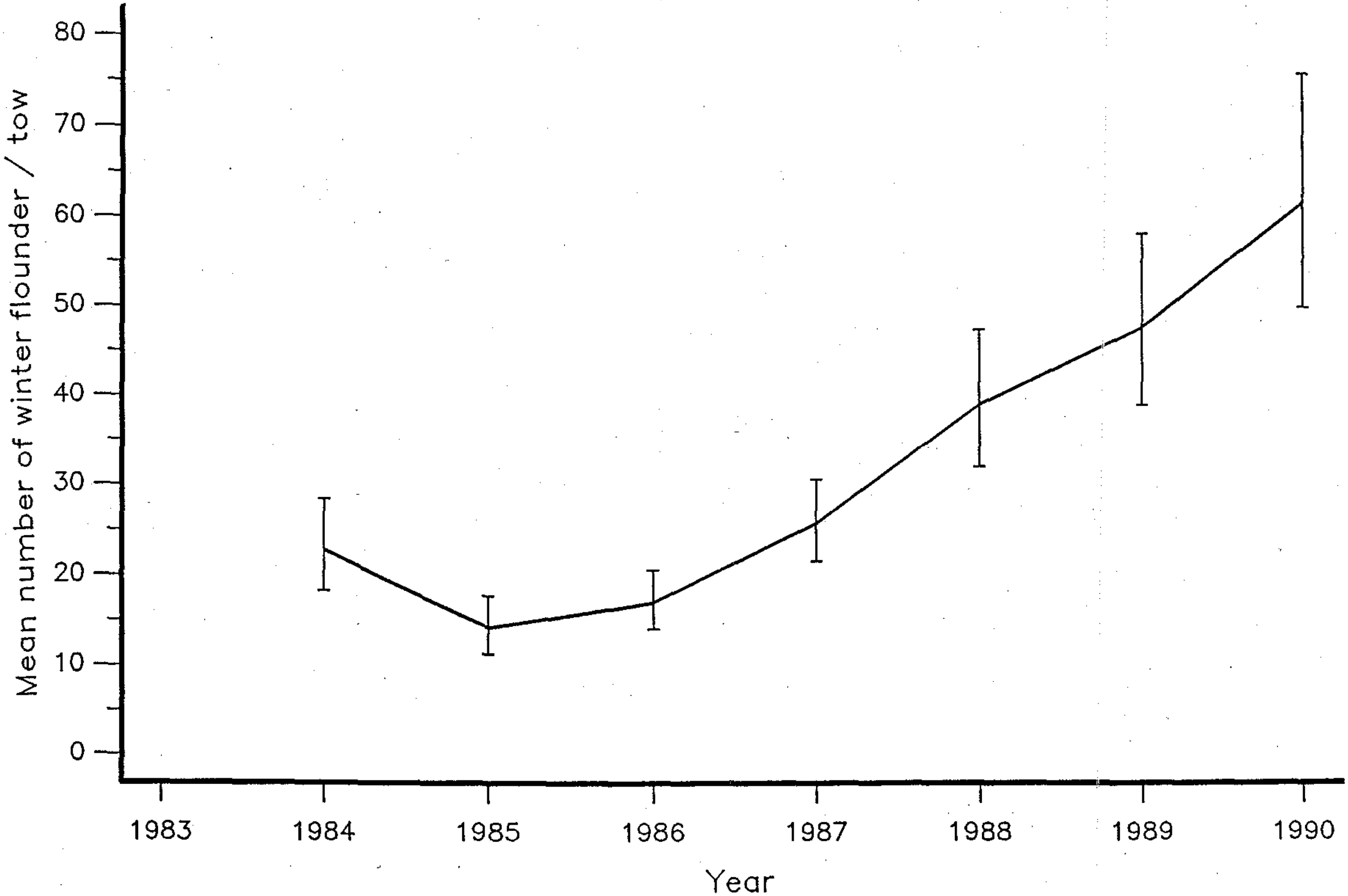


Figure SH1e Relative abundance (Mean +/− 95% Confidence Interval) of winter flounder in Connecticut, Long Island Sound, from 1984 to 1990 (from CT D.E.P. 1990)

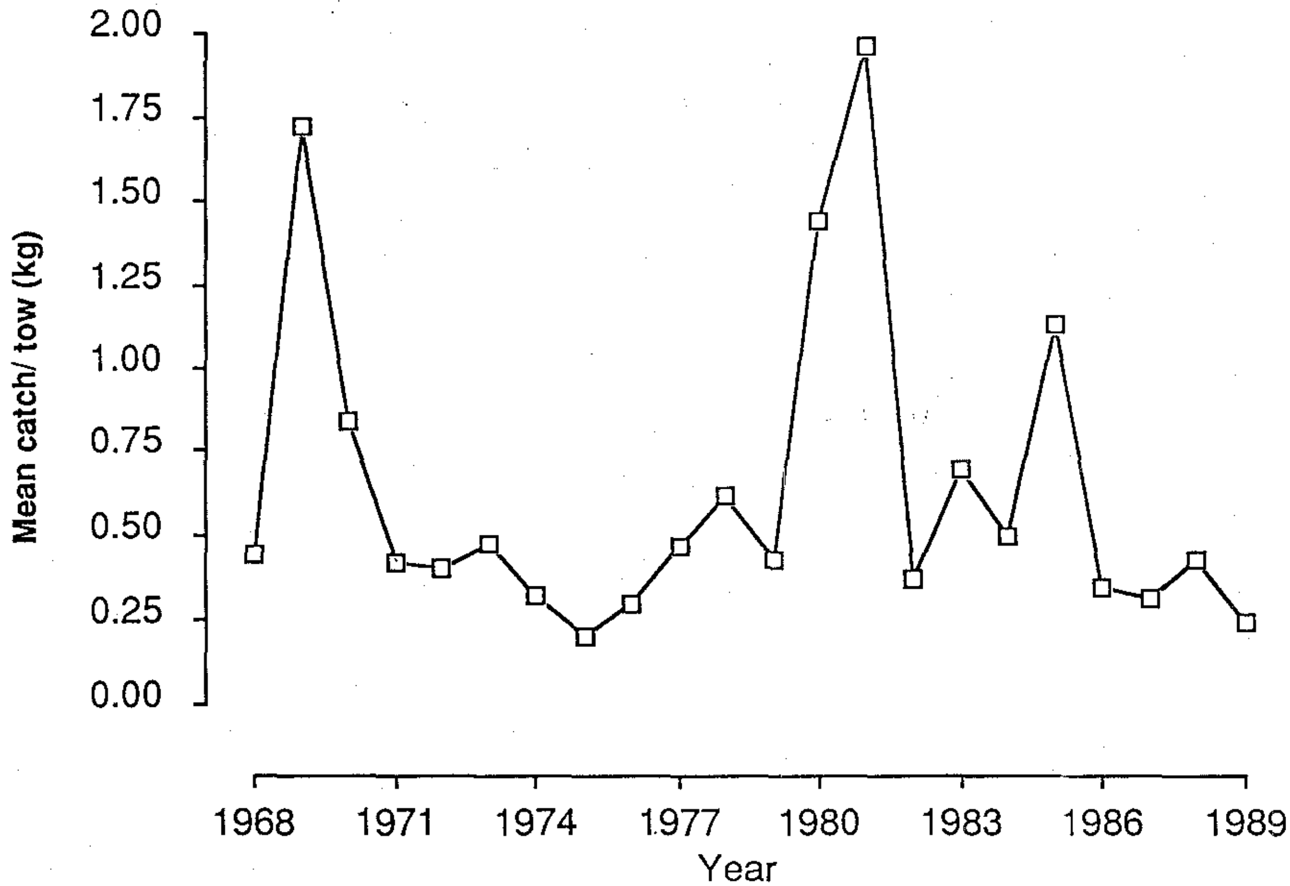


Figure SH1f Stratified mean catch per tow in weight (kg) of winter flounder in NEFC/NMFS spring bottom trawl surveys New England-Middle Atlantic waters (strata 1-12, 25, 61-76), 1968-1989.

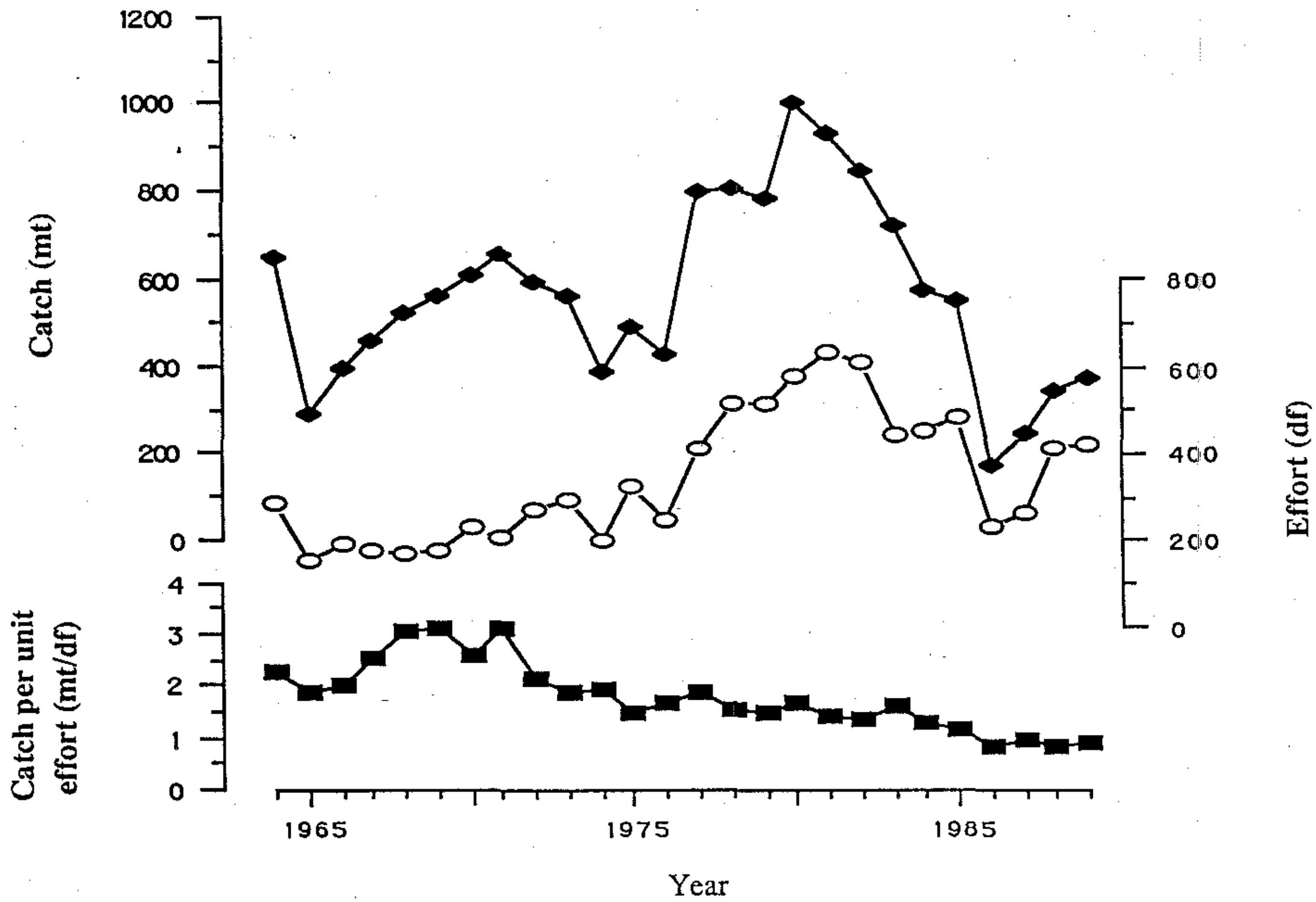


Figure SH2a. Catch (◆metric tons, mt), effort (○days fished, df), and catch per unit effort (■CPUEm mt/df) from the Gulf of Maine area in which landings consisted of greater than or equal to 50% winter flounder.

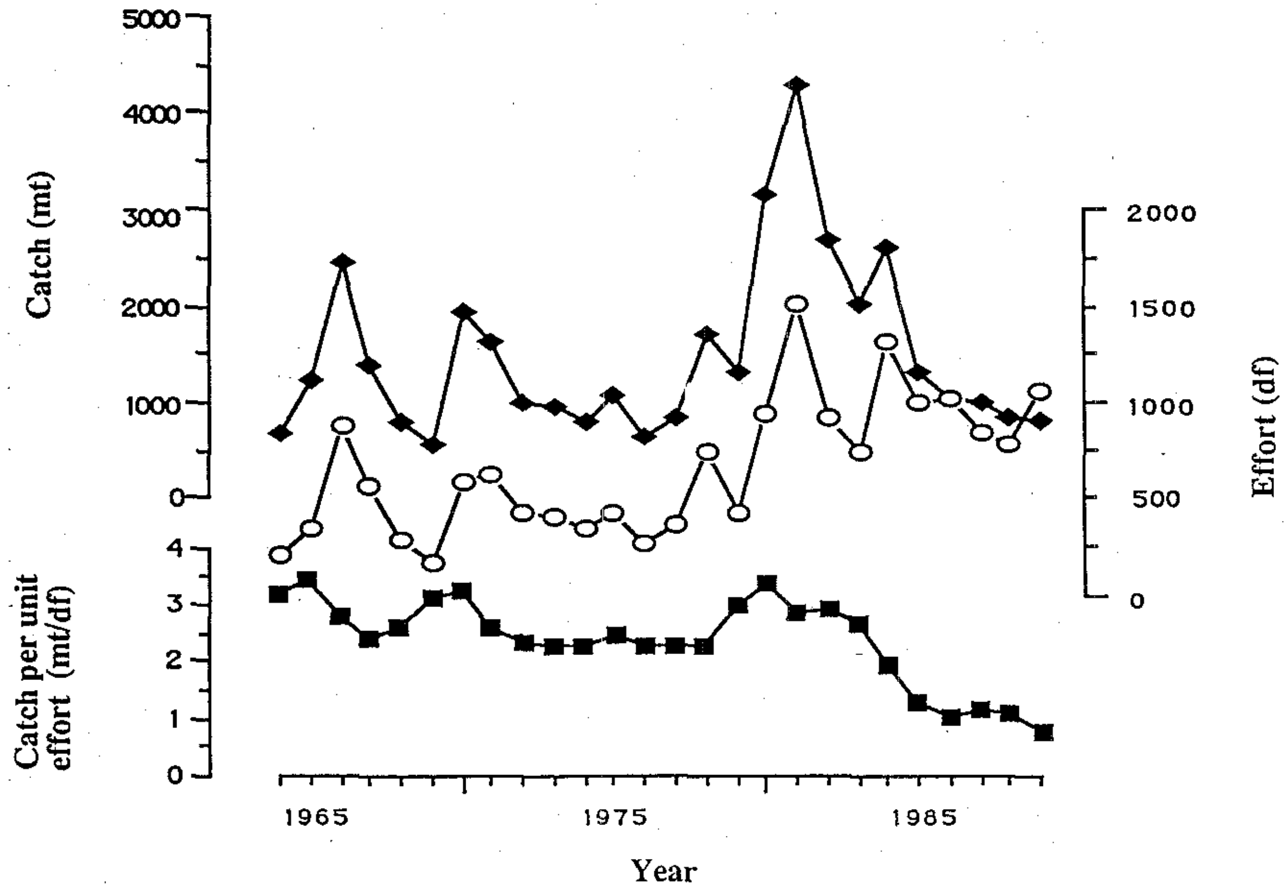


Figure SH2b: Catch (◆metric tons, mt), effort (○days fished, df), and catch per unit effort (■ CPUE, mt/df) from the southern New England area in which landings consisted of greater than or equal to 50% winter flounder.

ADVISORY REPORT ON STOCK STATUS

INTRODUCTION

The **Advisory Report on Stock Status** is a major product of the Northeast Regional Stock Assessment Workshop. It summarizes the technical information contained in the **Stock Assessment Review Committee (SARC), Consensus Summary of Assessments** and is intended to serve as scientific advice for fishery managers on resource status.

An important aspect of scientific advice on fishery resources is the determination of whether a stock is currently over-, fully-, or under-exploited. As these categories specifically refer to the act of fishing, they are best thought of in terms of exploitation rates relative to some reference value such as the replacement rate of fishing mortality, F_{rep}, or the rate of fishing mortality which should give the maximum yield per recruit in the long-term, F_{max}. Another important factor for classifying the status of a resource is the current stock level, e.g., spawning biomass (SSB). It is possible that a stock that is not currently overfished in terms of exploitation rates, is still at a low biomass level due to heavy exploitation in the past such that future recruitment to the stock is jeopardized. Conversely, a stock currently at a high level may be exploited at a rate greater than the overfishing definition level until such time as it is fished down to a stock size judged appropriate for maximum productivity or desirable from an ecological standpoint. Therefore, the SAW Plenary, where possible, classified stocks as high, medium, or low biomass compared to historic levels.

When definitions of overfishing are developed by the Fishery Management Councils they may relate to exploitation rate (e.g., threshold percentage of the maximum spawning potential of the stock, %MSP) or biomass level (e.g., threshold spawning biomass) or a combination of the two. The SAW used the council reference points wherever possible in classifying stocks. The figure below describes the contingencies identified by SAW for this classification.

STOCK LEVEL

EXPLOITATION RATE	LOW	MEDIUM	HIGH
OVER EXPLOITED	REDUCE EXPLOITATION REBUILD STOCK BIO MASS	REDUCE EXPLOITATION REBUILD AGE STRUCTURE	REDUCE EXPLOITATION INCREASE YIELD PER RECRUIT
FULLY EXPLOITED	REDUCE EXPLOITATION REBUILD STOCK BIOMASS	MAINTAIN EXPLOITATION RATE AND YIELD	MAINTAIN EXPLOITATION RATE AND YIELD
UNDER EXPLOITED	MAINTAIN LOW EXPLOITATION WHILE STOCK REBUILDS	INCREASE EXPLOITATION SLOWLY TO REFERENCE LEVEL	INCREASE EXPLOITATION TO REFERENCE LEVEL

Summary graphs of the assessment results for each stock have been prepared to encapsulate the status of resources. These graphs include the basic information on historical patterns in the fisheries and current status. Each graph includes, where possible, the definition of overfishing reference level from the relevant fishery management plan. For those stocks where catch and stock size projections were made in an analytical assessment, values of landings and spawning biomass are included, assuming that the fully recruited fishing mortality rate remains constant from the final assessed year until 1993. For these projections, recruitment was assumed to be at an average level from previous year's estimates. Full details of the projections under different assumptions on fishing mortality rate and recruitment are given in the Stock Assessment Review Committee report. The reader should note that these projections are indicative only. They may be pessimistic if recruitment is average, and there has been a substantial reduction in fishing mortality on an overfished stock. However, they may be very optimistic if recruitment is poorer than average, as might be expected for stocks at a low level.

For stocks where analytical assessments were performed, the SARC evaluated the associated measurement error and provided advice that recognizes this error. Assessment analyses provide imperfect measures of stock status. Nonetheless, measurement error does not necessarily translate directly into uncertainty in the assessment advice. In many cases, scientific advice is made with confidence even with the measurement variability in the assessment.

To evaluate the precision of assessments, this report contains graphs of the distribution of estimates of the 1990 fishing mortality rate and spawning stock biomass that account for random variation in the calibration data (survey and CPUE). The graphs express 1) the distribution of these estimates and 2) the cumulative distribution of outcomes for 200 runs. The former indicates uncertainty in the estimates and visually depicts the variability. The latter can be used to evaluate the risk of making a decision based on the estimated value. It expresses the probability (chance) that the fishing mortality rate was greater than a given level when measurement errors are considered. Regarding spawning stock biomass, the cumulative plot indicates the probability that was less than a given level. Readers who are interested in the methods used to estimate the measurement error should consult Efron (1982) and Conser (1992). Comments to guide managers in interpreting these graphs are included in each section.

The SAW Plenary session then noted specific points concerning stock status and, where possible, makes scientific recommendations. These points were agreed by consensus during the meeting. To clarify the report, the current level of fishing is reported as both fishing mortality rates (F) (instantaneous rates which are proportional to fishing effort) and annual exploitation rates (E) (the proportion of the vulnerable fish in the stock removed by the fishery each year). Many of the biological reference points used in definitions of overfishing are expressed in fishing mortality rates (F) because of the simple relationship to fishing effort. Exploitation rates are clearer for some readers because they are in terms of proportions (or percentages) of the available fish in the stock. The reader is referred to the introduction of the annual NEFSC **Status of the Fishery Resources Off the Northeastern United States** for more details concerning these parameters.

HARBOR PORPOISE

Preliminary analyses for the estimation of harbor porpoise by-catch were conducted as a first step in the evaluation of the impact of fisheries on the porpoise population in the Northeast region. To date, most of the work focused on the basic data analysis needed to estimate the number of porpoises killed by the Gulf of Maine sink gillnet fishery. This involved the estimation of fishing effort so that kill rate estimates from at-sea observer sampling can be expanded to estimate total kill.

Summary of Findings

- There are discrepancies between the number of tonnage vessels (greater than 5 GRT) recorded as participating in the sink gillnet fishery in the Federal fishery permit file, the MMEP registry, and the NEFSC weighout database.

- The NEFSC weighout database contains the largest number of active fishery participants, but does not contain a complete census. Some active vessels contained in other databases are not recorded in the weighout data.

- The most accurate measure of effort, given the currently available data, is the number of trips recorded in the weighout database. Finer resolution data (e.g. hours fishing) does not exist for most of the vessels in the fishery in any database.

- Landings can be estimated more accurately than the number of trips for the entire sink gillnet fishery.

- The weighout data represent an incomplete census of catch and effort in the fishery. Preliminary estimates of fishing effort must be considered highly uncertain. Quantitative estimates of the accuracy and precision of catch and effort statistics in the weighout database will be needed to make more reliable assessments of by-catch mortality.

- Although, the estimates of the kill rate of harbor porpoise by the fishery, obtained from the Sea Sampling Investigation, have a relatively low sampling variability, this may not be a good estimate of measurement error. Recent increased sampling intensity will clarify this issue.

Recommendations

- Estimate how much catch and effort is being missed by the weighout data collection system, including the activity of the under-tonnage fleet, via on-going calibration experiments.

- Conduct an evaluation of the impact of vessel operations (e.g. gear deployment and configuration) on projections of likely by-catch. This study is necessary to advise future mitigation strategies for managers to consider.

- Coordinate various surveys and sources of information to improve their utility and applicability to the problem of estimating porpoise kill. This could be done through a SAW Working Group. This Working Group should develop short- and long-term approaches to improving correspondence among several databases, relating to activities in the Gulf of Maine gillnet fishery. The Group should focus on the scientific assessment issues involved, rather than policy or management issues, in the context of the Stock Assessment Workshop.

- A comprehensive review of the estimates of stock size, total kill, biological rates, and reference points is needed once by-catch estimates are made. To meet the legislative time frame, this review should take place in April or May. It is likely that a full week will be needed to review these analyses.

BLACK SEA BASS

A new analysis of yield and spawning stock biomass per recruit for sea bass using a model which takes into account the life history characteristics of this species (sex change from female to male as animals grow) was developed. The work was intended to illustrate potential problems with standard biological reference point calculations for species with complex life patterns. No definitive determination of reference points were proposed for sea bass in the analysis, pending better information on some of the biological parameters.

Summary of Findings and Recommendations

- o Estimates of yield based reference points such as F_{max} were only marginally affected by the incorporation of the new model structure.

- o Estimates of spawning biomass based reference points are very sensitive to the inclusion of hermaphrodism in the model structure. Reference points based on spawning stock biomass per recruit become difficult to interpret for this type of life history and may not be a good measure of an overfishing target.

- o Yield and spawning biomass per recruit of sea bass are very sensitive to the minimum harvestable size of fish when life history characteristics are included in the analysis. This type of measure may be effective in managing fisheries for species which change sex as they grow.

SUMMER FLOUNDER

An analytical assessment was conducted to estimate fishing mortality rates and stock sizes at age for the stock of summer flounder from Maine to North Carolina. Landings in 1990 from the recreational fishery were estimated to be 2,400 MT and from the commercial fishery, 4,200 MT.

Summary of Stock Status

- The stock is over-exploited with respect to the definition of overfishing and the stock level is low.

- Recruitment has declined steeply over the past decade. The estimated size of the 1991 year class is below the decadal average and less than half of the peak year class size (1983) in the series.

- If the fishing mortality rate remains at the 1990 level and recruitment is the average of the last five years, landings in 1991 and 1992 are expected to increase over the low in 1990, but still be lower than any year before 1989. This picture may be optimistic because the current low stock size may make poor recruitment more likely. More detailed projections are given in the report of the Stock Assessment Review Committee (Table SC8).

- Stock biomass has declined steeply over the decade, particularly due to the very poor 1988 year class. It follows the recruitment pattern closely due to the compressed age structure and early maturity. There are very few extant age groups in the stock so each year's fishery is dominated by newly recruiting fish. Consideration of the measurement error in the assessment shows that there is about a 50% chance that the spawning biomass in 1990 was less than 11,000 MT and nearly 100% chance the stock was less than 16,000 MT.

- The 1990 fishing mortality rate on fully recruited fluke was estimated to be 1.1 (annual exploitation rate of 61%). This is five times greater than the reference level (F_{max}= 0.23 (annual exploitation rate 19%). Considering the uncertainty in the estimate shows that there is about a 60% chance that the fishing mortality rate is greater than 1.0 and a 100% chance it is greater than 0.7.

- There is some indication that stock biomass may be increasing in the last two years and that the fishing mortality rate has declined slightly.

Recommendations

- **Fishing mortality rates need to be reduced to rebuild the spawning stock biomass and age structure.**

- **Continue sea sampling on fluke trips to improve the database on discarding.**

SUMMER FLOUNDER

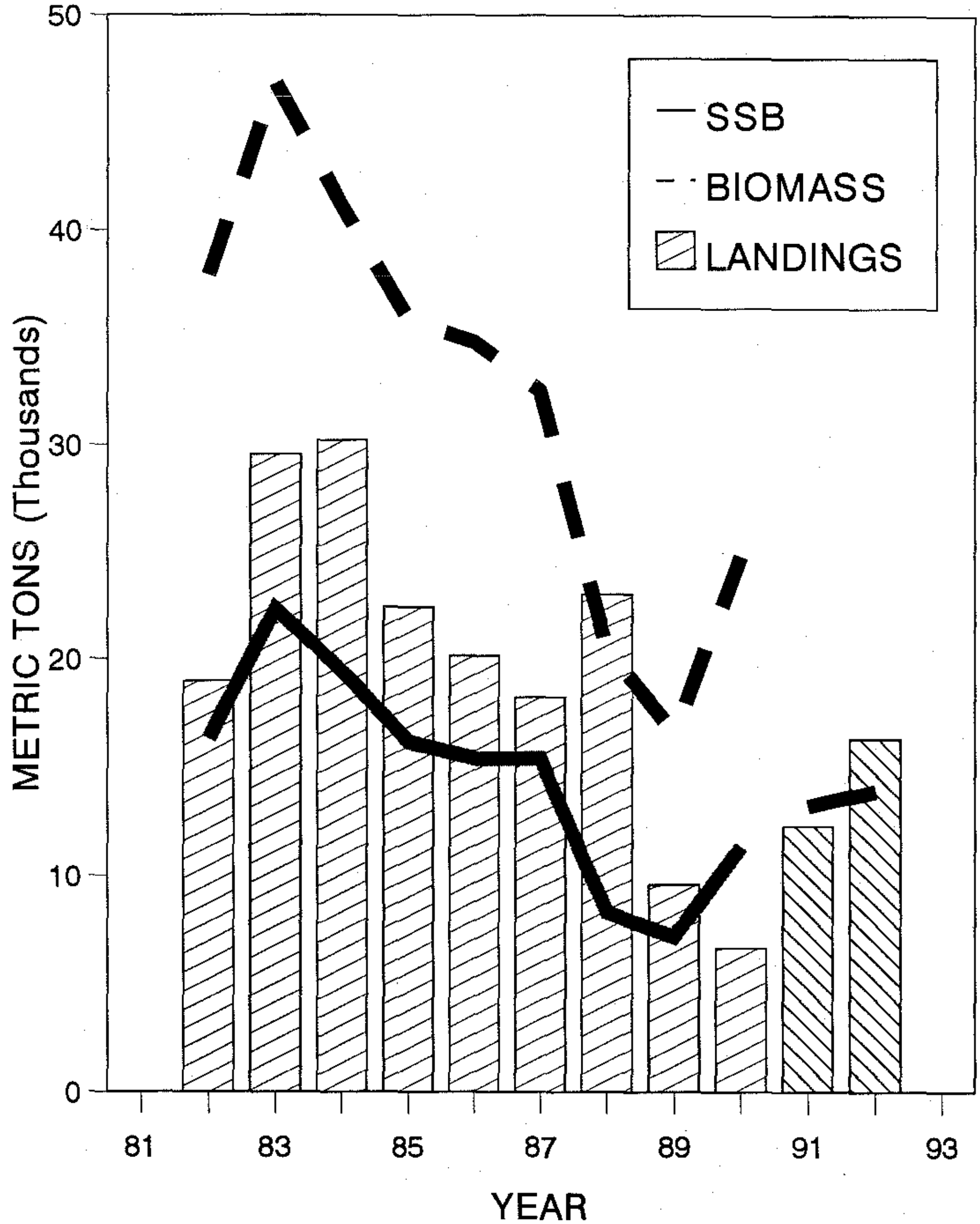


Figure AC1. Biomass, spawning stock biomass, and landings of Summer Flounder. Projected landings and spawning stock biomass (1991-1992) under status quo F.

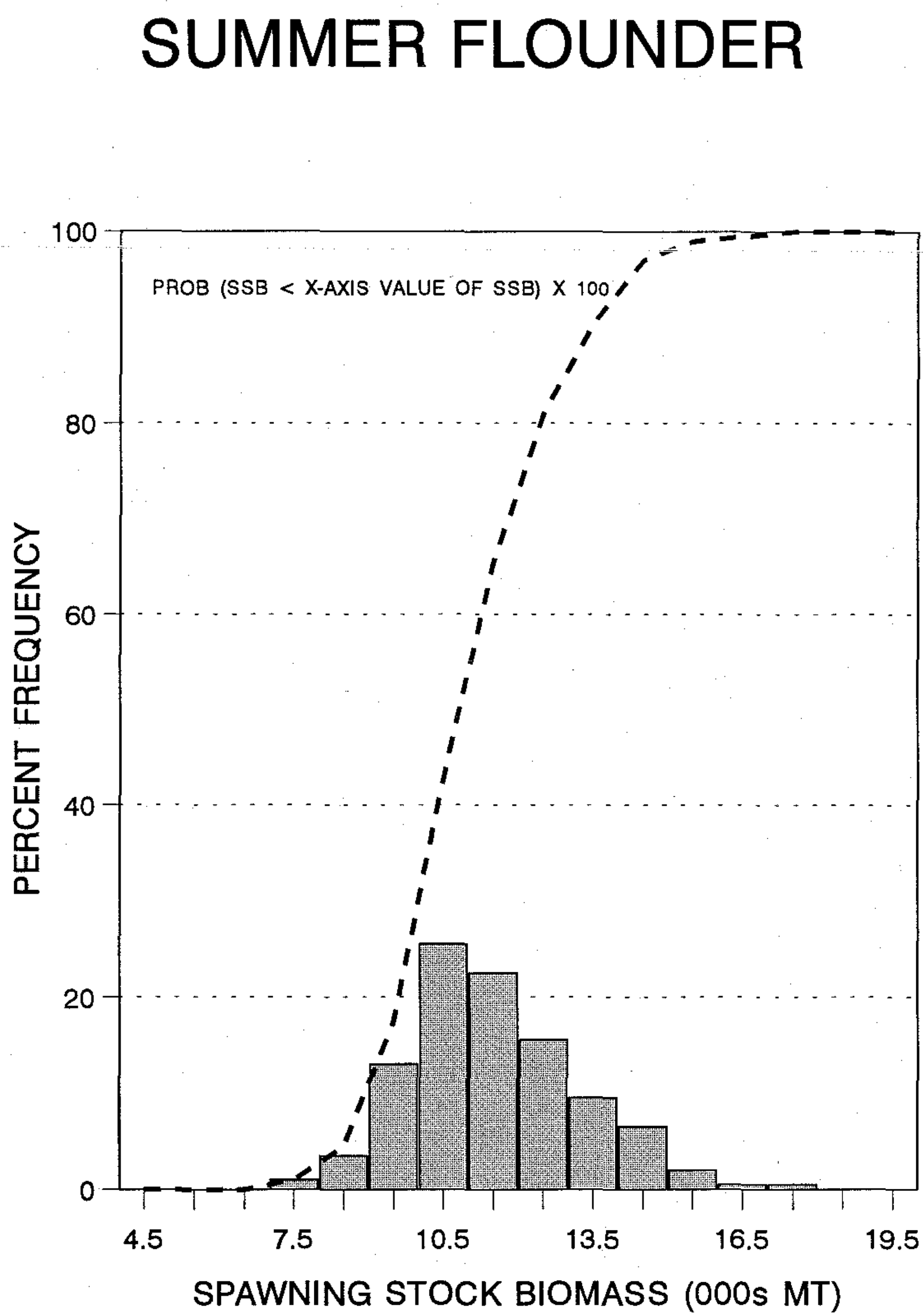


Figure AC2. Spawning stock biomass at the beginning of 1990 spawning season, percent frequency, and probability of SSB less than x-axis value of SSB (x100) as estimated from 200 Bootstrap replications.

SUMMER FLOUNDER

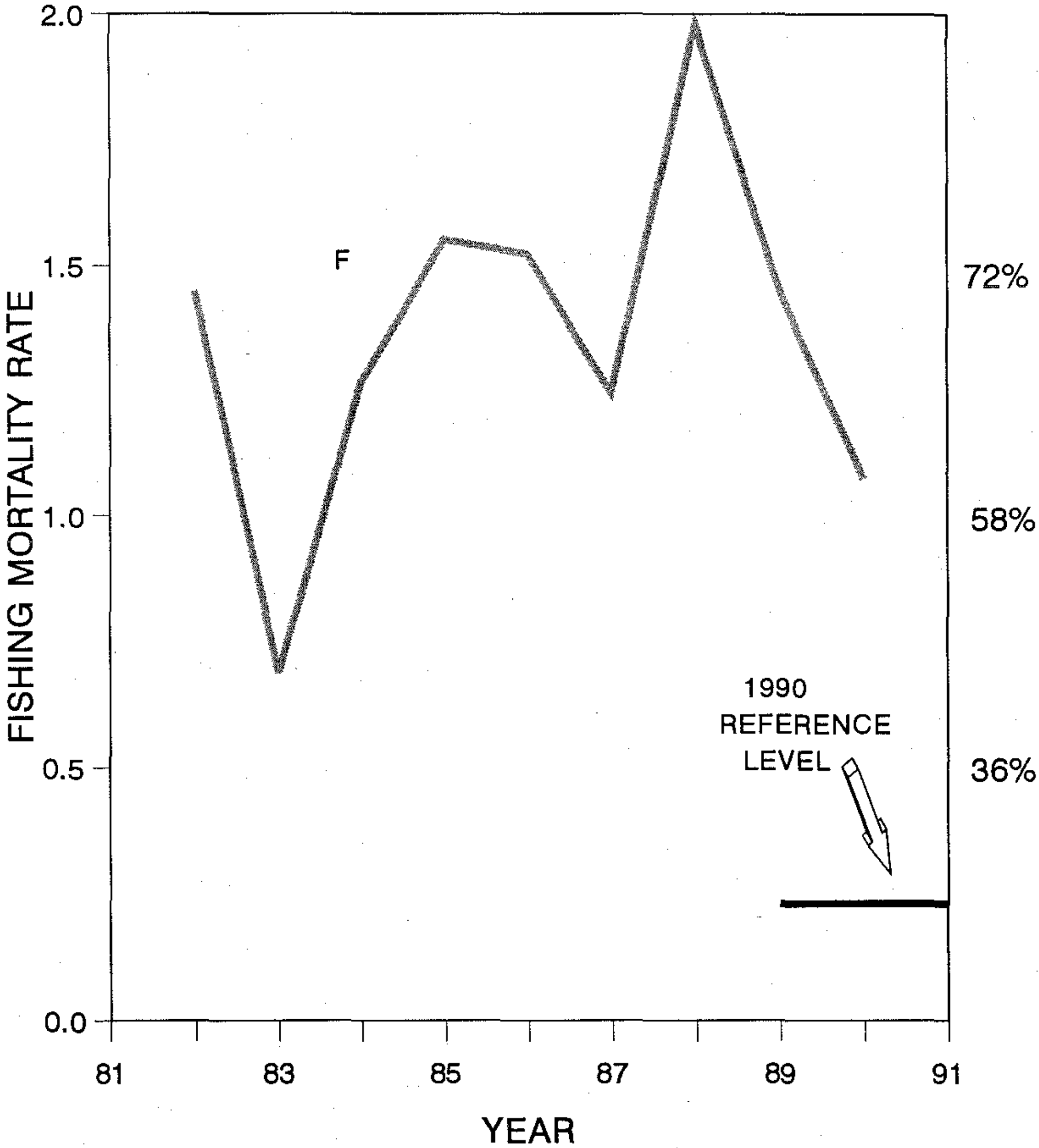


Figure AC3. Fishing mortality rate (left hand scale) and annual exploitation rate (right hand scale) for Summer Flounder. The 1990 reference level corresponds to the MAFMC definition of overfishing.

SUMMER FLOUNDER

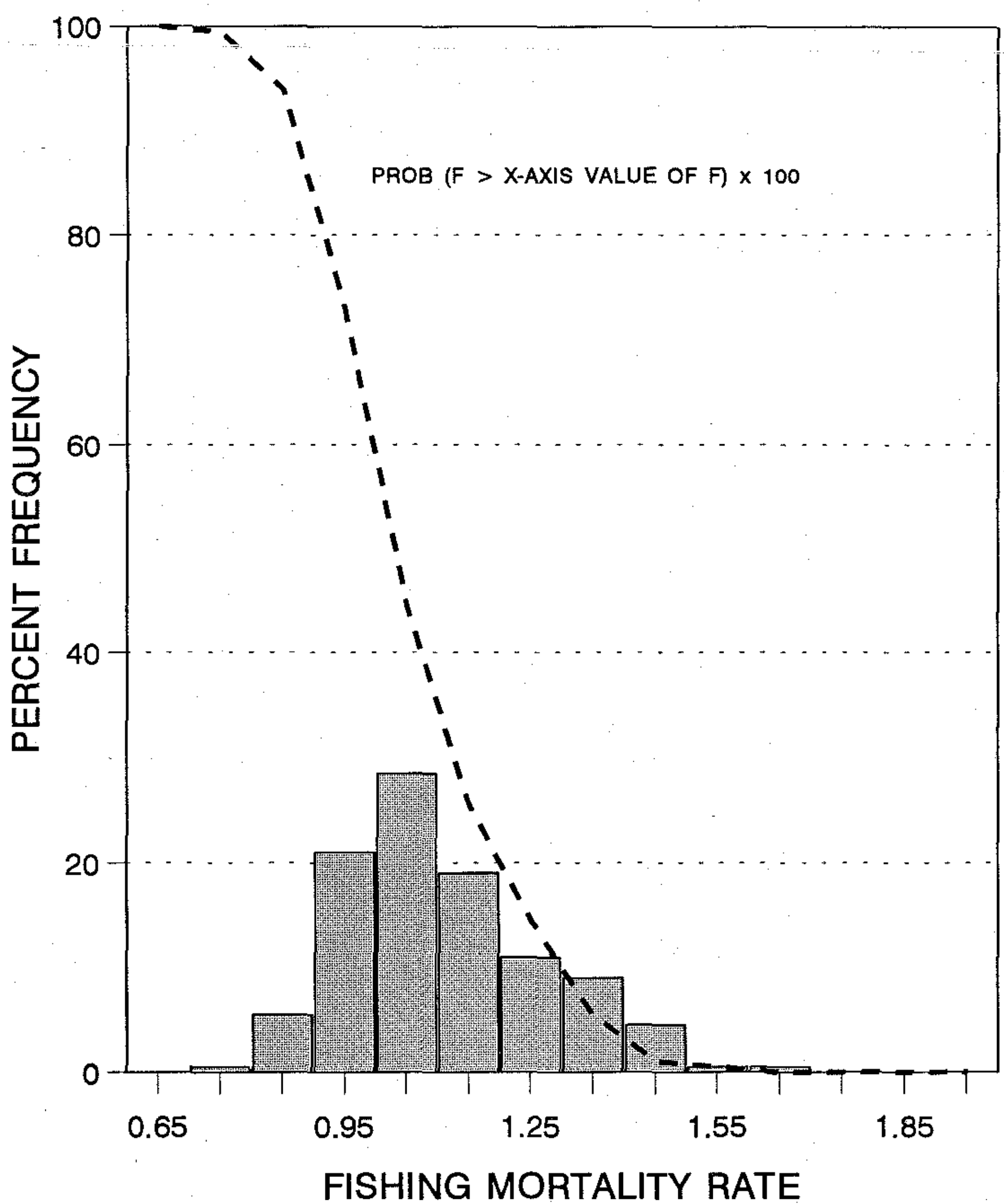


Figure AC4. Fishing mortality rate on fully recruited ages in 1990, percent frequency, and probability of F greater than x-axis value of F (x 100) as estimated from 200 Bootstrap replications.

SUMMER FLOUNDER

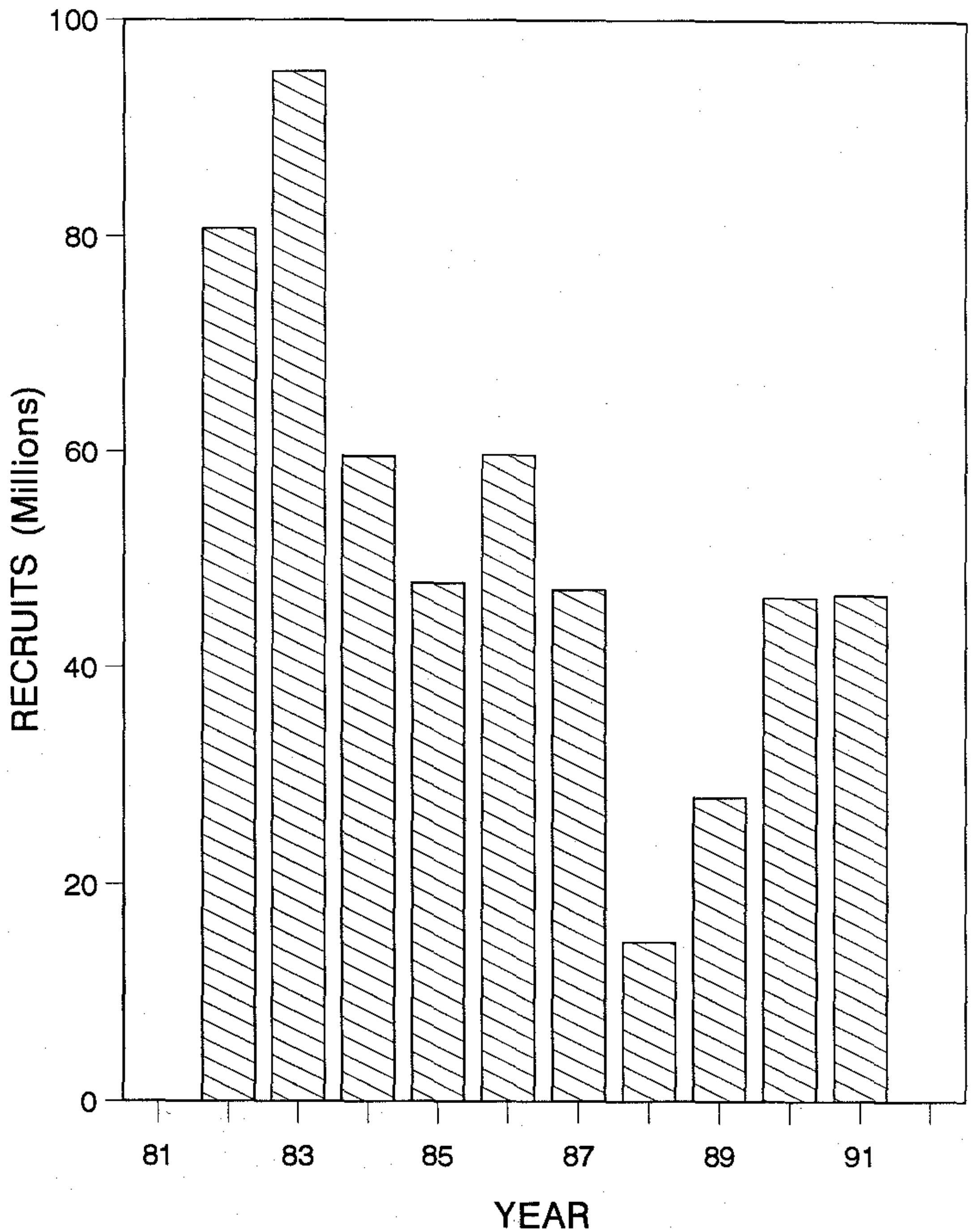


Figure AC5. Recruitment of Summer Flounder at age 0.

ATLANTIC HERRING

An analytical assessment was performed to estimate fishing mortality rates and stock abundance at age for an aggregate stock complex of herring including those from coastal waters, Nantucket Shoals, Georges Bank and those fish caught in New Brunswick weirs. These results can not be directly compared with other assessments which were on parts of this stock complex. Insufficient information exists to separate spawning stock components for this assessment. Domestic landings in 1990 were more than 54,000 MT, mostly from Maine and Massachusetts.

Summary of Status

- This stock is under-exploited and at a high level.

- There is no overfishing definition for herring at present but the stock complex appears to be under exploited. The abundance for the whole complex is high. However, there is the potential that individual components of the complex may be over exploited even though the aggregate is not.

- Several strong year-classes, in particular the 1988, have rebuilt the stock complex to higher levels. This followed a steep reduction in fishing mortality from the late 1970s. Taking account of the uncertainty in the assessment, there is a 50% chance the spawning stock is larger than 600,000 MT but it is unlikely to be as large as 1,000,000 MT.

- The fishing mortality rate on fully recruited age groups is about 0.13 (annual exploitation rate 11%) which is below the $F_{0.1}$ reference point (0.24; annual exploitation rate 19%). Even given the measurement error in the assessment there is only a small chance that the fishing mortality rate is greater than 0.2.

Recommendations

- Form a Working Group to improve stock discrimination in the data and develop new data sources. Include state, federal and Canadian scientists. This Working Group could perform the assessment in future.

- Improve data co-ordination so that IWP catches and biological sampling data are incorporated into the NEFSC data base routinely.

- If exploitation of herring is increased, extensive analysis of localized stocks is needed to monitor and ensure that overfishing does not occur.

ATLANTIC HERRING

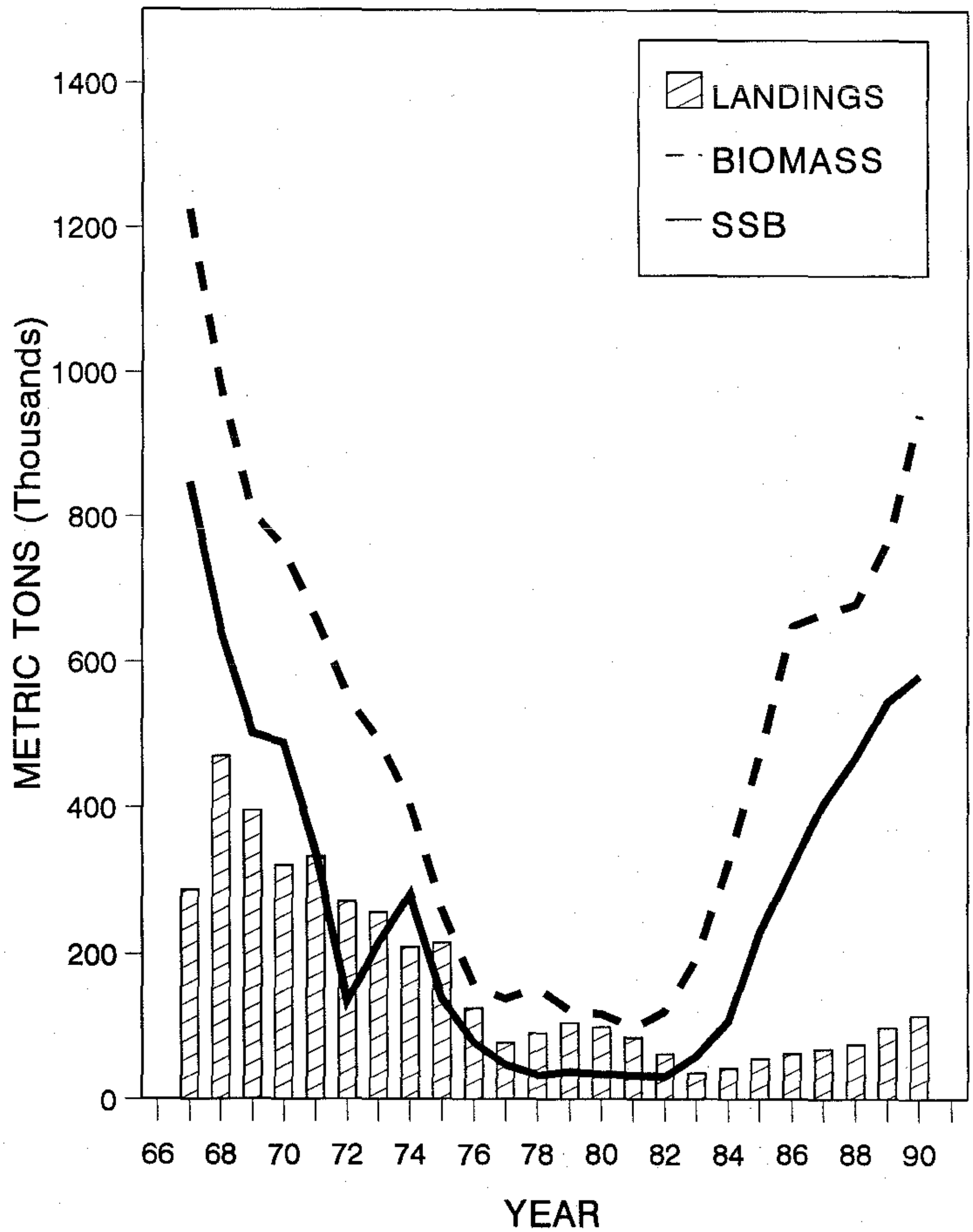


Figure AD1. Biomass, spawning stock biomass, and landings of Atlantic Herring.

ATLANTIC HERRING

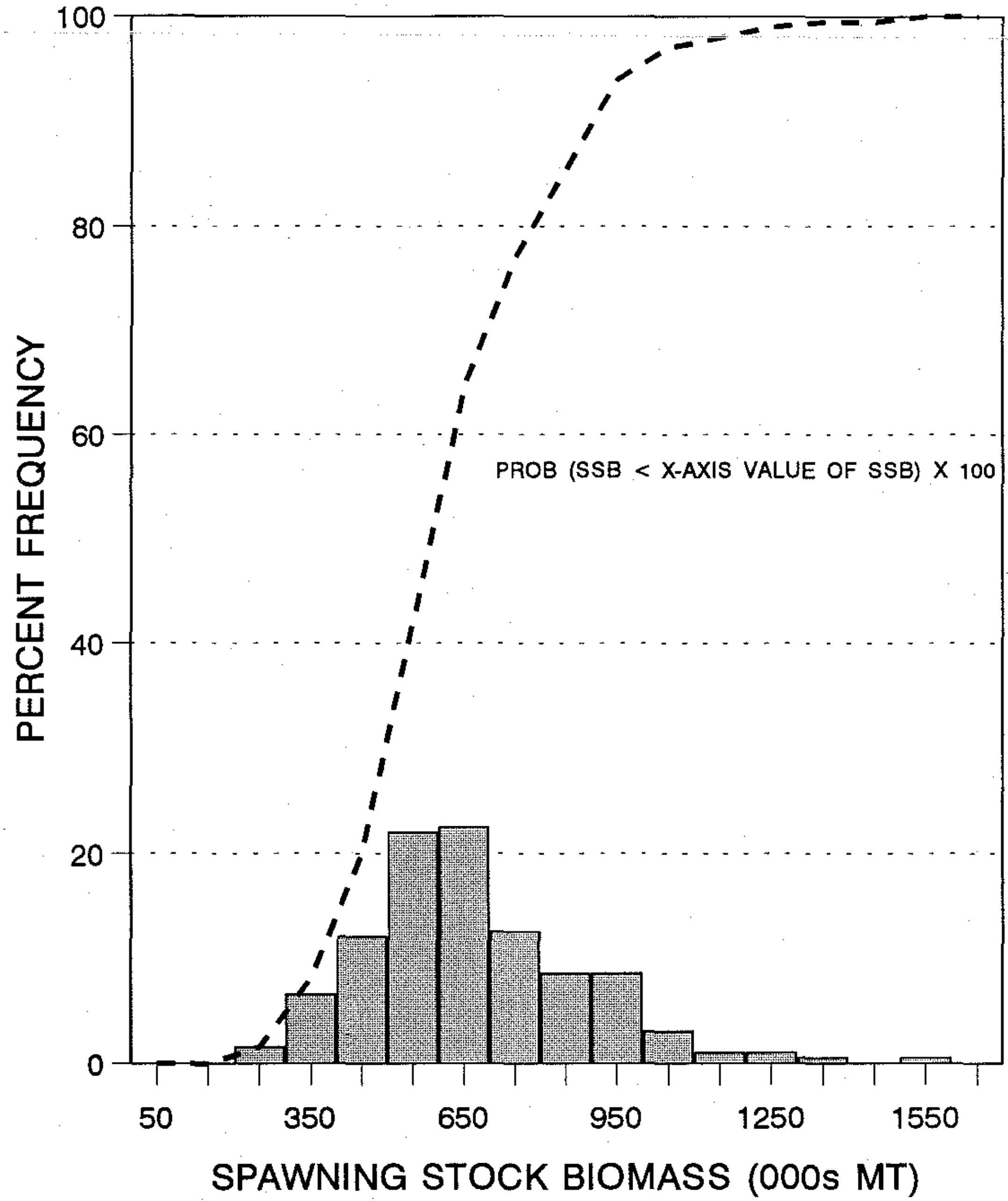


Figure AD2. Spawning stock biomass at the beginning of 1990 spawning season, percent frequency, and probability of SSB less than x-axis value of SSB (x100) as estimated from 200 Bootstrap replications.

ATLANTIC HERRING

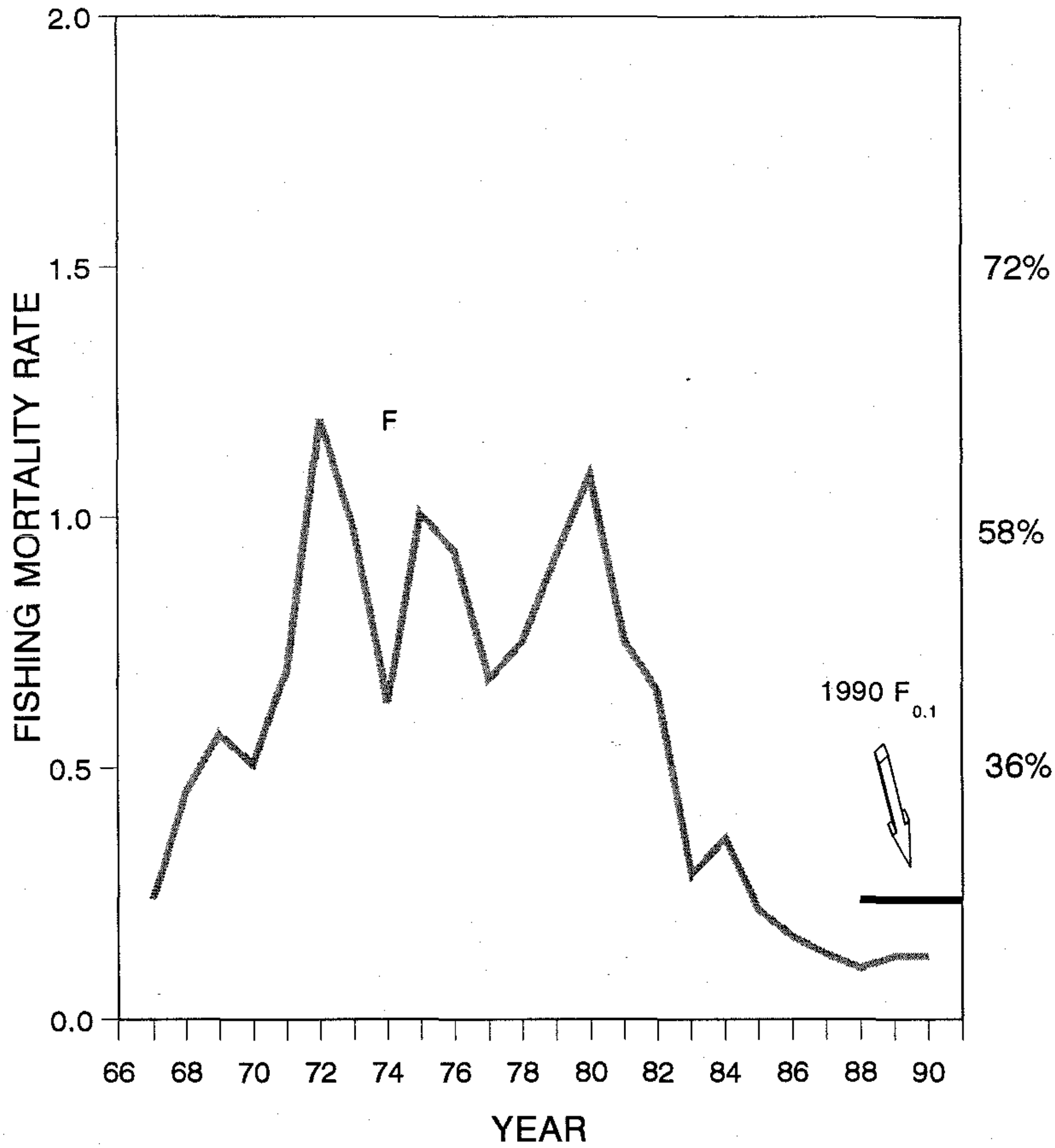


Figure AD3. Fishing mortality rate (left hand scale) and exploitation rate (right hand scale) for Atlantic Herring. The reference line corresponds to 1990 F0.1 value.

ATLANTIC HERRING

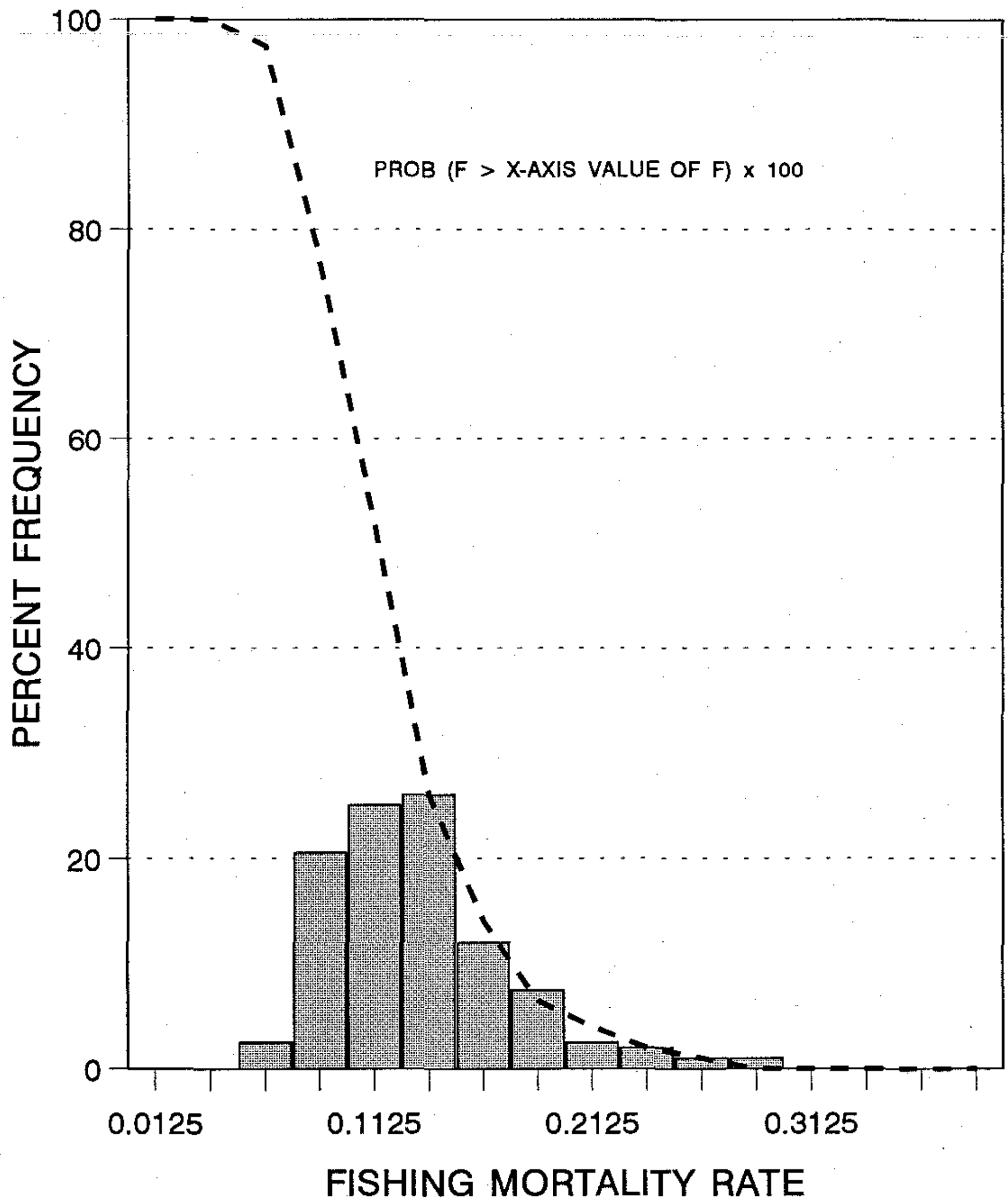


Figure AD4. Fishing mortality rate on fully recruited ages in 1990, percent frequency, and probability of F greater than x-axis value of F (x 100) as estimated from 200 Bootstrap replications.

ATLANTIC HERRING

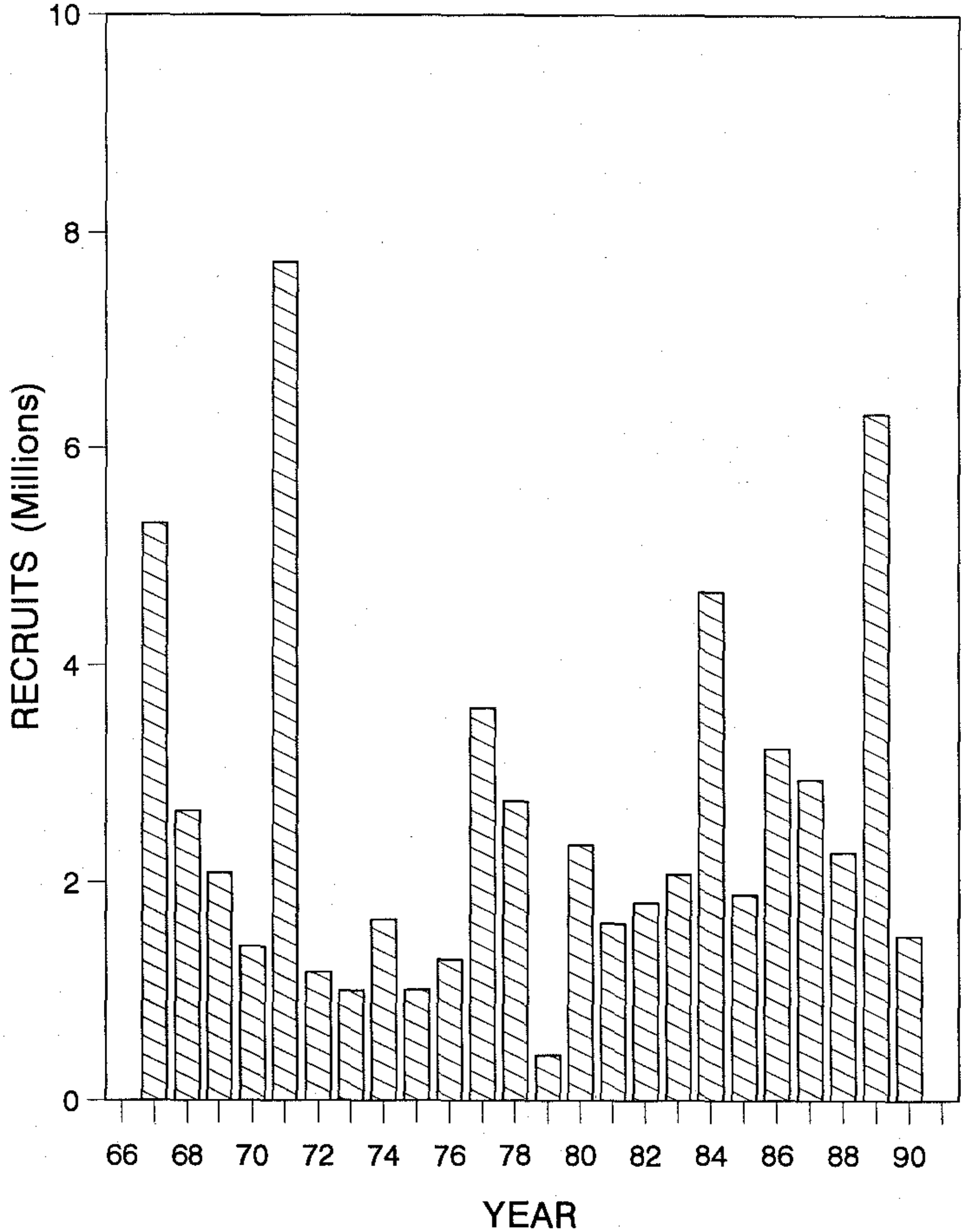


Figure AD5. Recruitment of Atlantic Herring at age 1.

HADDOCK

An analytical assessment was performed for Georges Bank haddock to estimate fishing mortality rates and abundance at age. This assessment differs from recent Canadian analyses of this stock because the present work includes all of Georges Bank, rather than just statistical reporting areas 551, 552, 561, and 562. Also, this new assessment includes adjustments for changes in survey methodology and uses Canadian as well as U.S. survey indices of abundance for calibration.

Landings and survey indices were tabulated for the Gulf of Maine stock. Current landings from Georges Bank are about 5,000 MT, while only about 400 MT are landed from the Gulf of Maine.

Summary of Status

- Both stocks of haddock are at very low levels. Georges Bank haddock are over-exploited compared to the definition of overfishing level. There is no estimate of exploitation rate for haddock in the Gulf of Maine.

- Recent year classes have generally been very poor compared to the very high recruitment levels in the early 1960s. The 1983, 1985 and 1987 year classes have been the best in recent years, but were only one sixth as big as 1975 and 1978 recruitment.

- Considering the measurement error in the assessment, there is about a 50% chance the spawning stock is less than 20,000 MT and nearly a 100% chance it is less than 25,000 MT.

- Fully recruited fishing mortality rates have varied around the $F_{30\%}$ level (0.40; annual exploitation rate 30%) reference level over the past decade. The current estimate of fully recruited fishing mortality rate (0.52; annual exploitation rate 37%) indicates exploitation is above this maintenance level now. Taking assessment uncertainty into account suggests that there is about a 50% chance the fishing mortality rate is greater than 0.5 and about a 90% chance it is greater than the reference level.

- The maturity schedule for Georges Bank haddock has shifted so that fish mature at a younger age and smaller size than in the past when the stock was more abundant. Thus, the $F_{30\%}$ reference point that is computed using the current growth and maturity schedule is higher (0.4) than that using data from the 1960s (0.32). Since %MSP reference points are sensitive to changes in the maturation schedule, consideration must be given not only to the target fishing mortality rate, but also to the desired stock abundance and associated growth and maturation schedules.

Recommendation

- Fishing mortality rates need to be reduced well below the overfishing definition level to enable the stocks to rebuild. This will be necessary for preserving any incoming recruitment for stock rebuilding. Note that the overfishing definition level is intended to be a harvest rate which would maintain the stock at its present level in the long term. Since the abundance of both Georges Bank and Gulf of Maine haddock are very low, reducing exploitation levels below a maintenance level may be necessary until significant rebuilding is observed.

GEORGES BANK HADDOCK

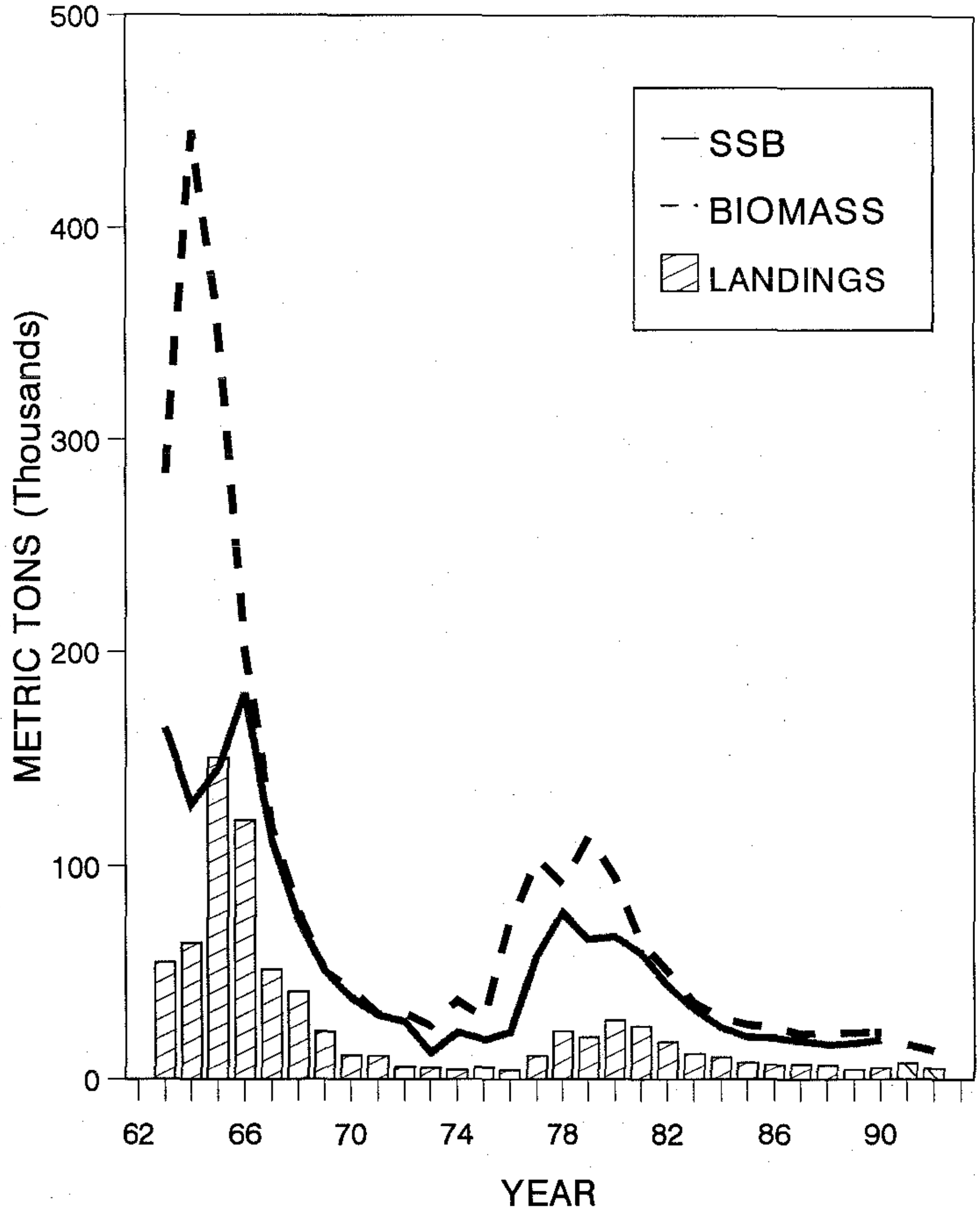


Figure AE1. Biomass and landings of Georges Bank Haddock. Projected landings and spawning stock biomass (1991-1992) under status quo F.

GEORGES BANK HADDOCK

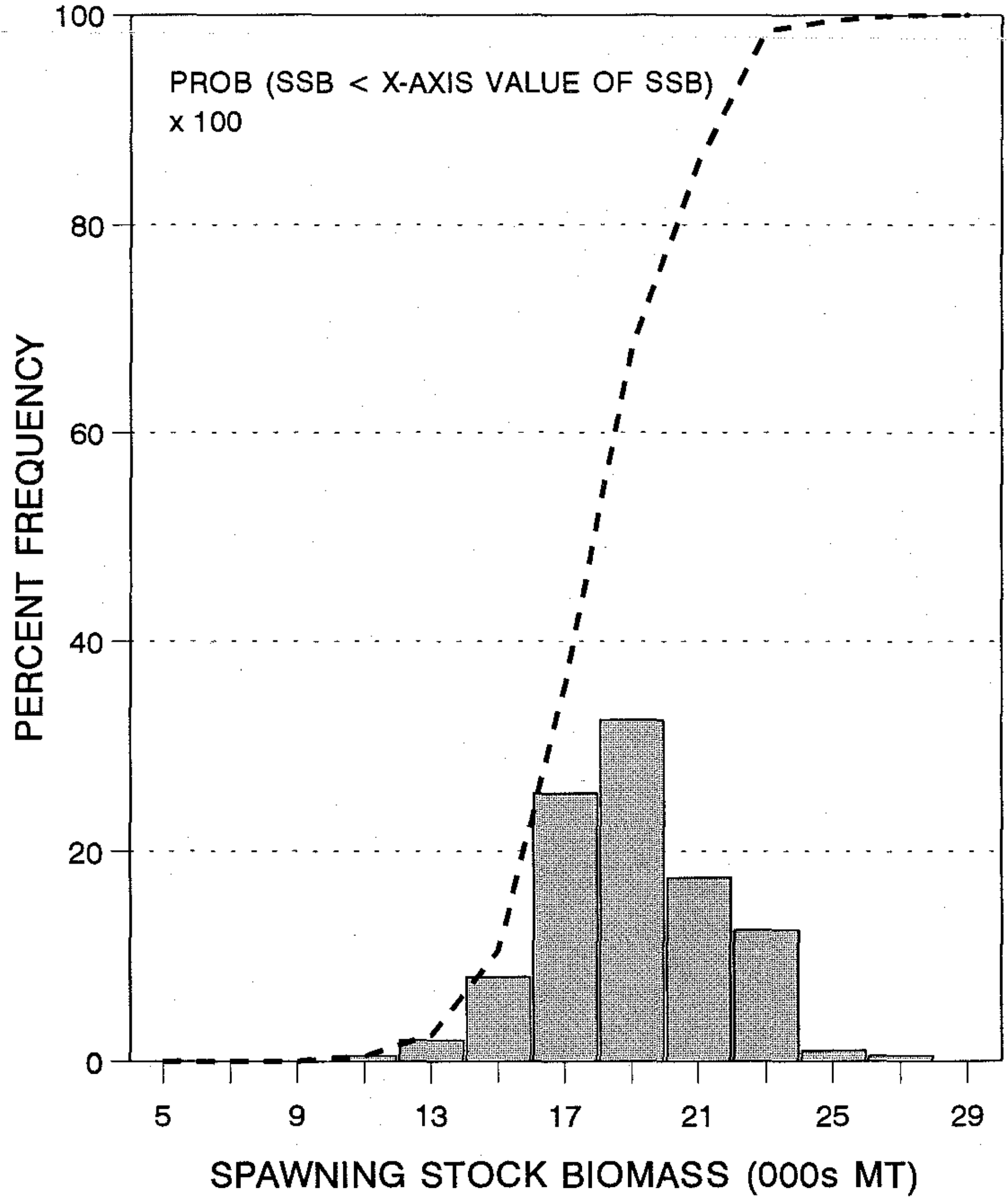


Figure AE2. Spawning stock biomass at the beginning of 1990 spawning season, percent frequency, and probability of SSB less than x-axis value of SSB (x100) as estimated from 200 Bootstrap replications.

GEORGES BANK HADDOCK

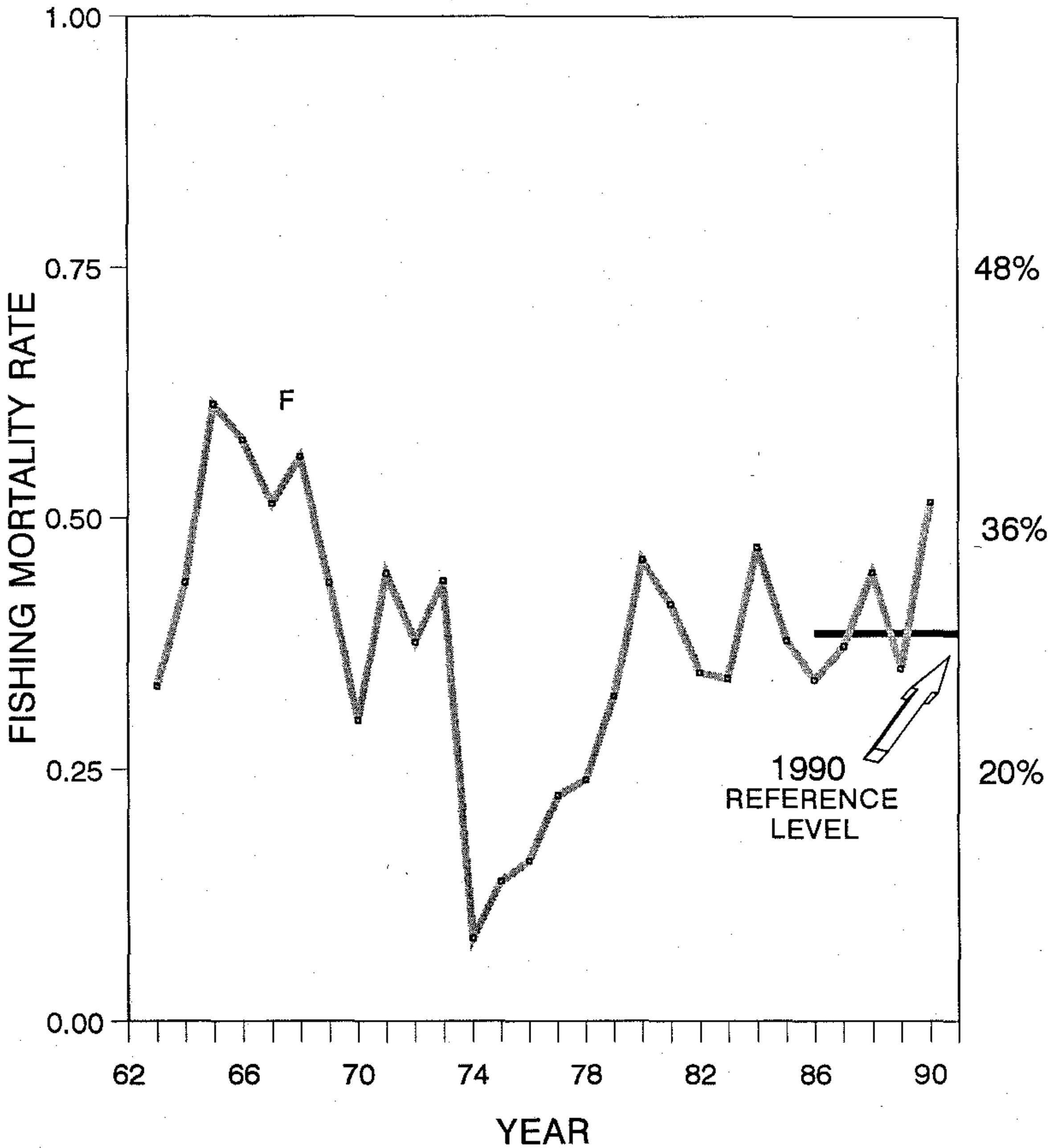


Figure AE3. Fishing mortality rate (left hand scale) and annual exploitation rate (right hand scale) for Georges Bank Haddock. The 1990 reference level corresponds to the NEFMC definition of overfishing.

GEORGES BANK HADDOCK

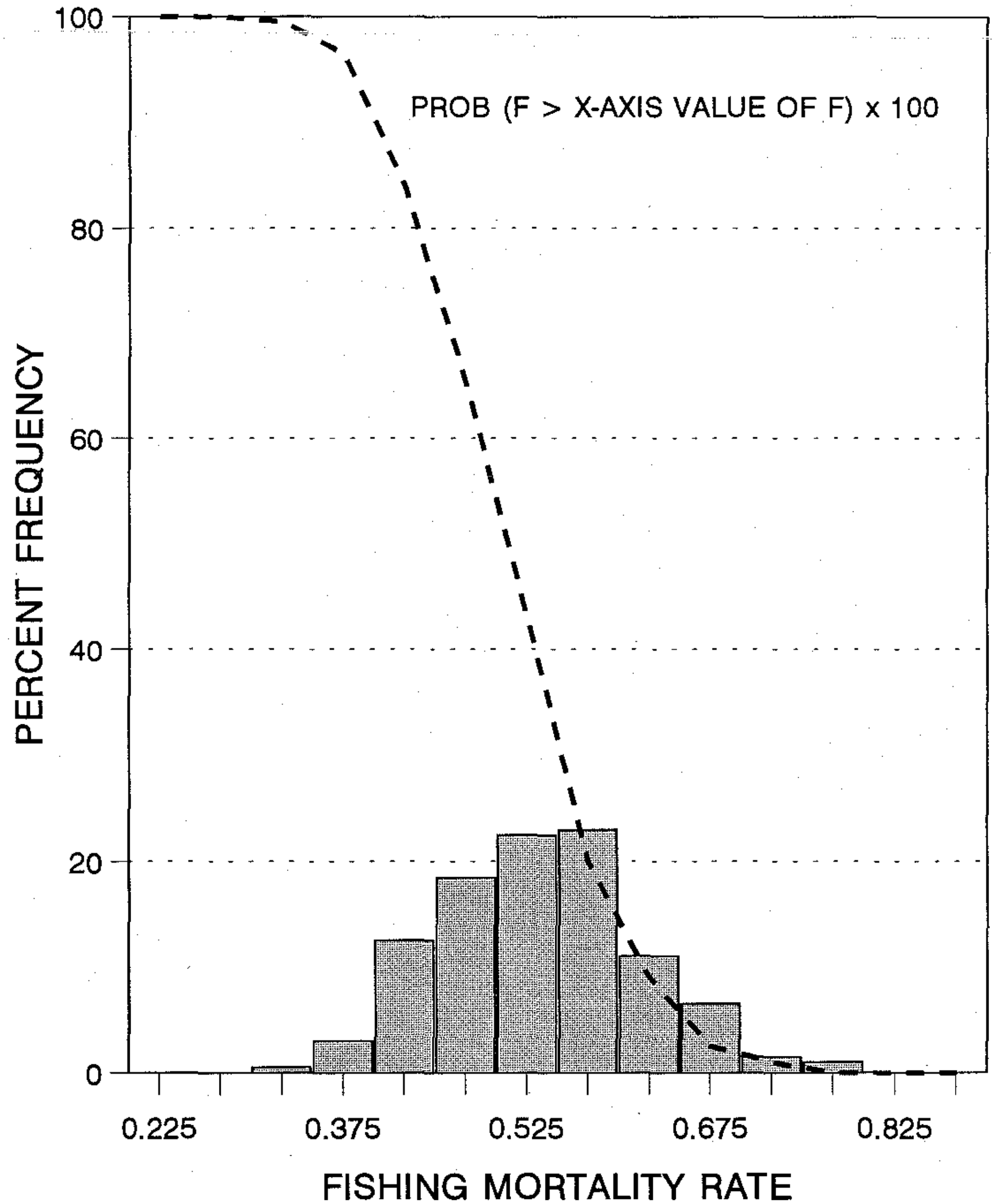


Figure AE4. Fishing mortality rate on fully recruited ages in 1990, percent frequency, and probability of F greater than x-axis value of F (x100) as estimated from 200 Bootstrap replications.

GEORGES BANK HADDOCK

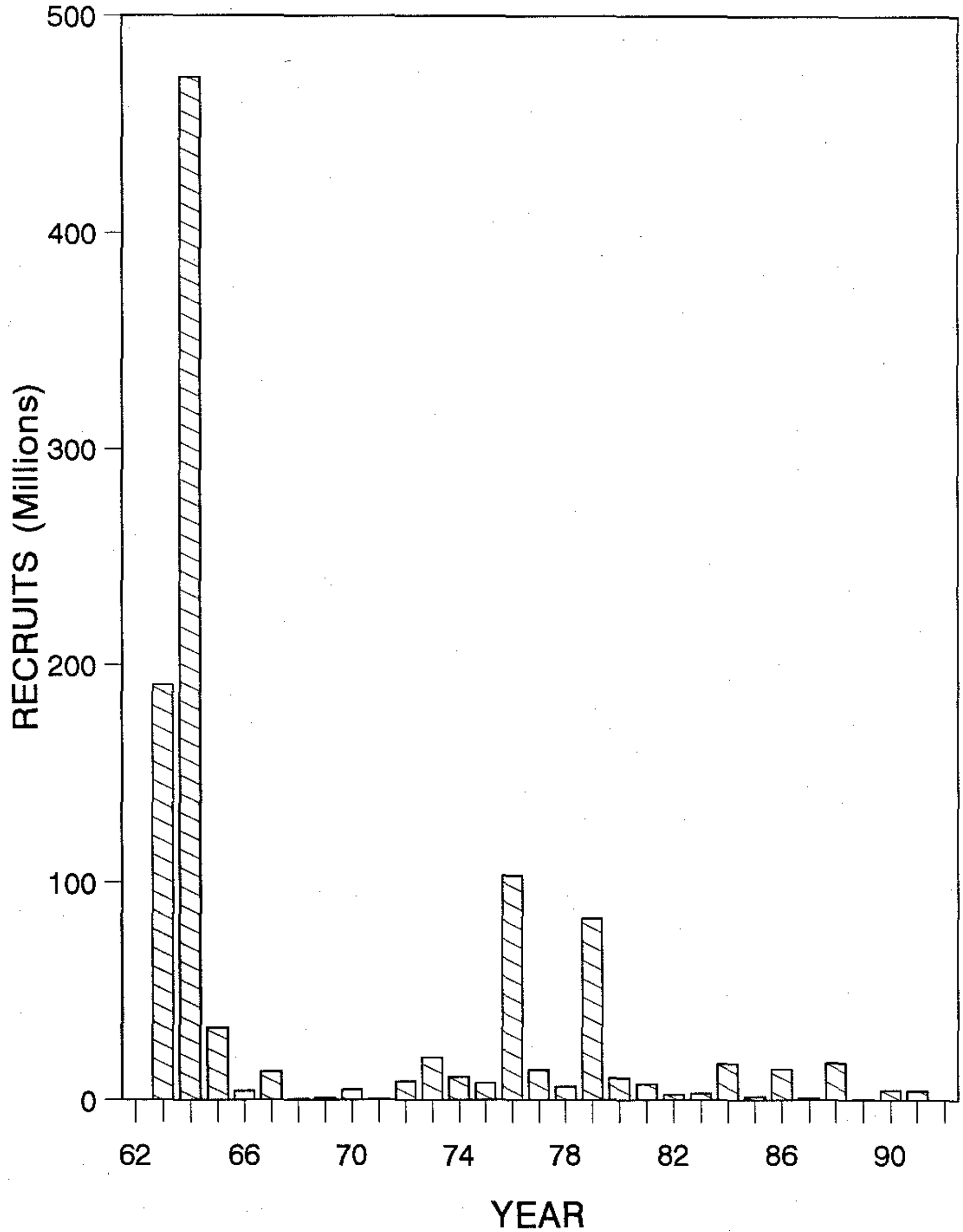


Figure AE5. Recruitment of Georges Bank Haddock at age 1.

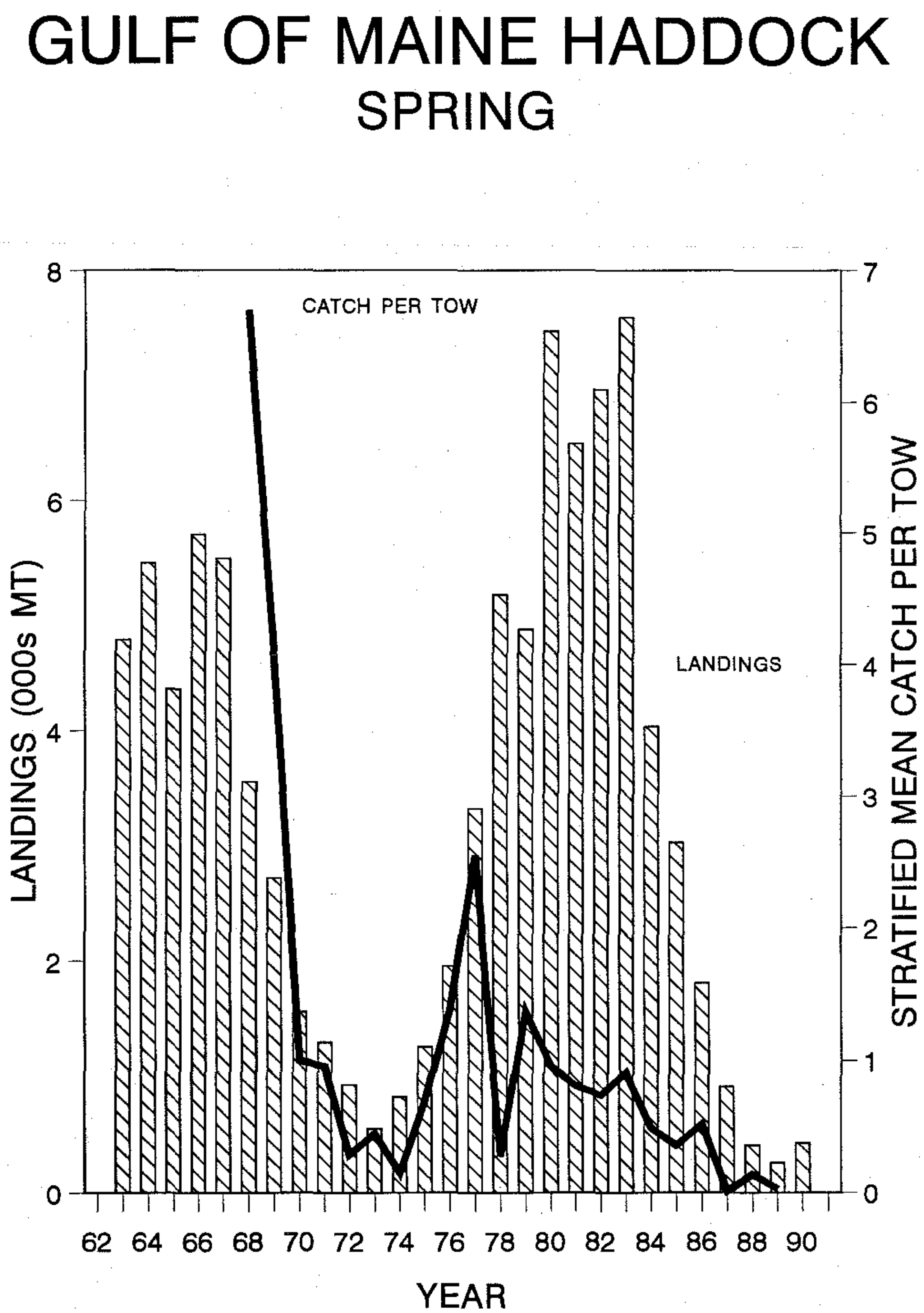


Figure AE6. Landings (left hand scale) and stratified mean catch per tow based on NEFSC spring bottom trawl surveys (right hand scale) for Haddock in the Gulf of Maine.

GULF OF MAINE HADDOCK
AUTUMN

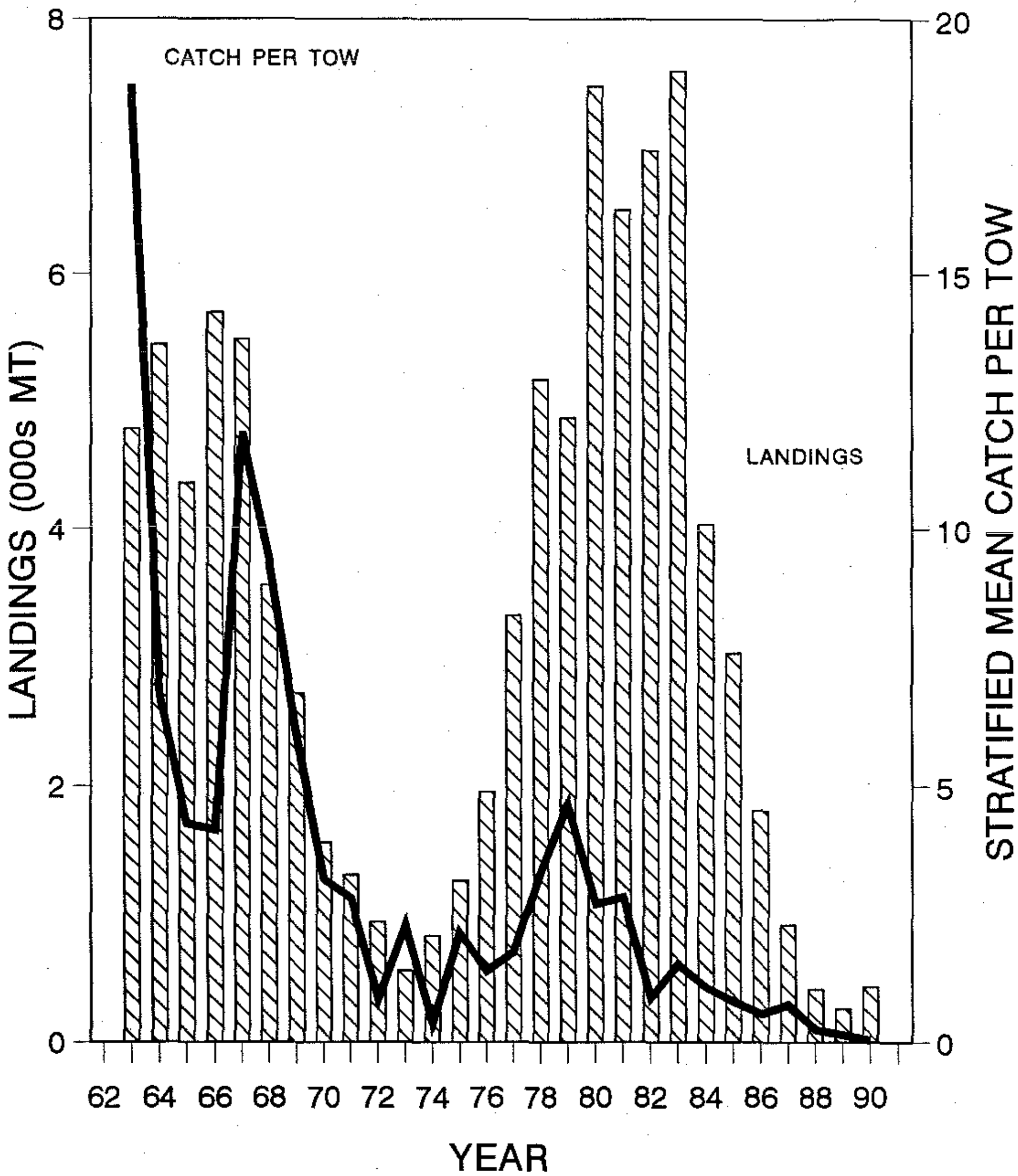


Figure AE7. Landings (left hand scale) and stratified mean catch per tow based on NEFSC autumn bottom trawl surveys (right hand scale) for Haddock in the Gulf of Maine.

GEORGES BANK COD

An analytical assessment was performed on this stock to estimate fishing mortality rates and stock abundance at age. Current commercial landings were 42,500 MT, the highest since 1983. Recreational landings have not been estimated for this stock alone, but from the Georges Bank and Gulf of Maine stocks combined, recreational fishermen are estimated to have landed 5,000 - 7,000 MT.

Summary of Status

- This stock is over-exploited with respect to the definition of overfishing and at a medium stock level. Biomass has declined from 1976 to 1982 levels.
- Several good year-classes (1985, 1988, 1990) have recently entered the fishery and are supporting the good landings, which are projected to be at similar levels in 1991 and 1992 if recruitment continues at the recent average and fishing mortality remains at the 1990 level.
- The 1990 fully recruited fishing mortality rate is estimated at 0.72 (annual exploitation rate 47%). This is two times the reference level, $F_{20\%}$(0.36; annual exploitation rate 26%).
- Accounting for uncertainty in the assessment, spawning biomass has a 50% chance of being greater than 75,000 MT and is almost certainly greater than 60,000 MT. The fishing mortality rate has a 50% chance of being greater than 0.7 and is certainly greater than the reference level (0.36).

Recommendations

- The fishing mortality rate needs to be reduced to increase yield per recruit and at least maintain the stock at its present level.
- Reducing F to the overfishing definition level would increase yield per recruit by 10% and spawning biomass per recruit by 90%. This would also increase catch rates (catch per unit of fishing effort) sharply.
- If the 1990 year-class is as strong as presently estimated, it may be vulnerable to the fishing gear in 1992 and result in high rates of discards of small fish. Management action may be warranted to forestall excessive discards in 1992.

GEORGES BANK COD

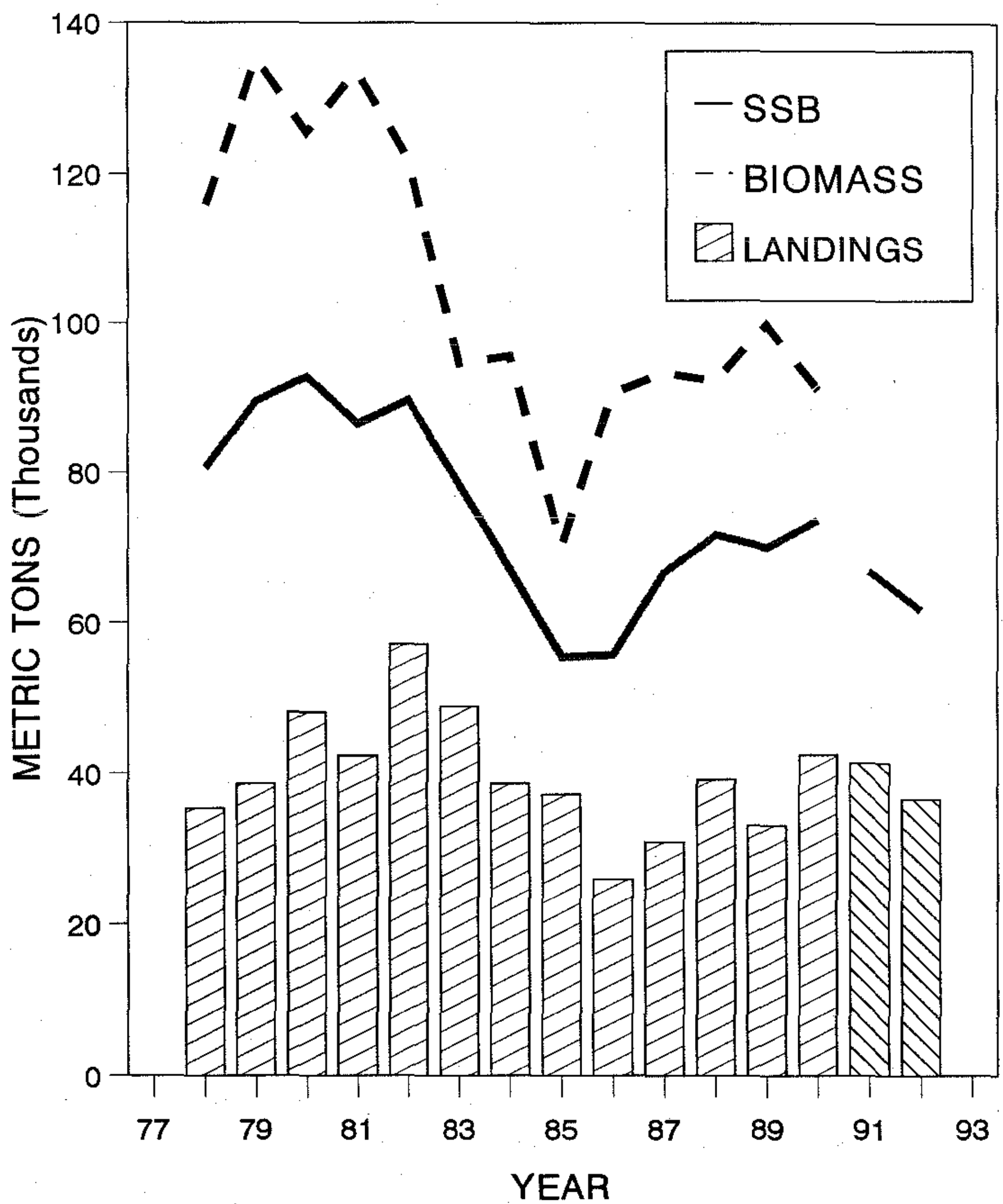


Figure AF1. Biomass, spawning stock biomass, and landings of Georges Bank Cod. Projected landings and spawning stock biomass (1991-1992) under status quo F.

GEORGES BANK COD

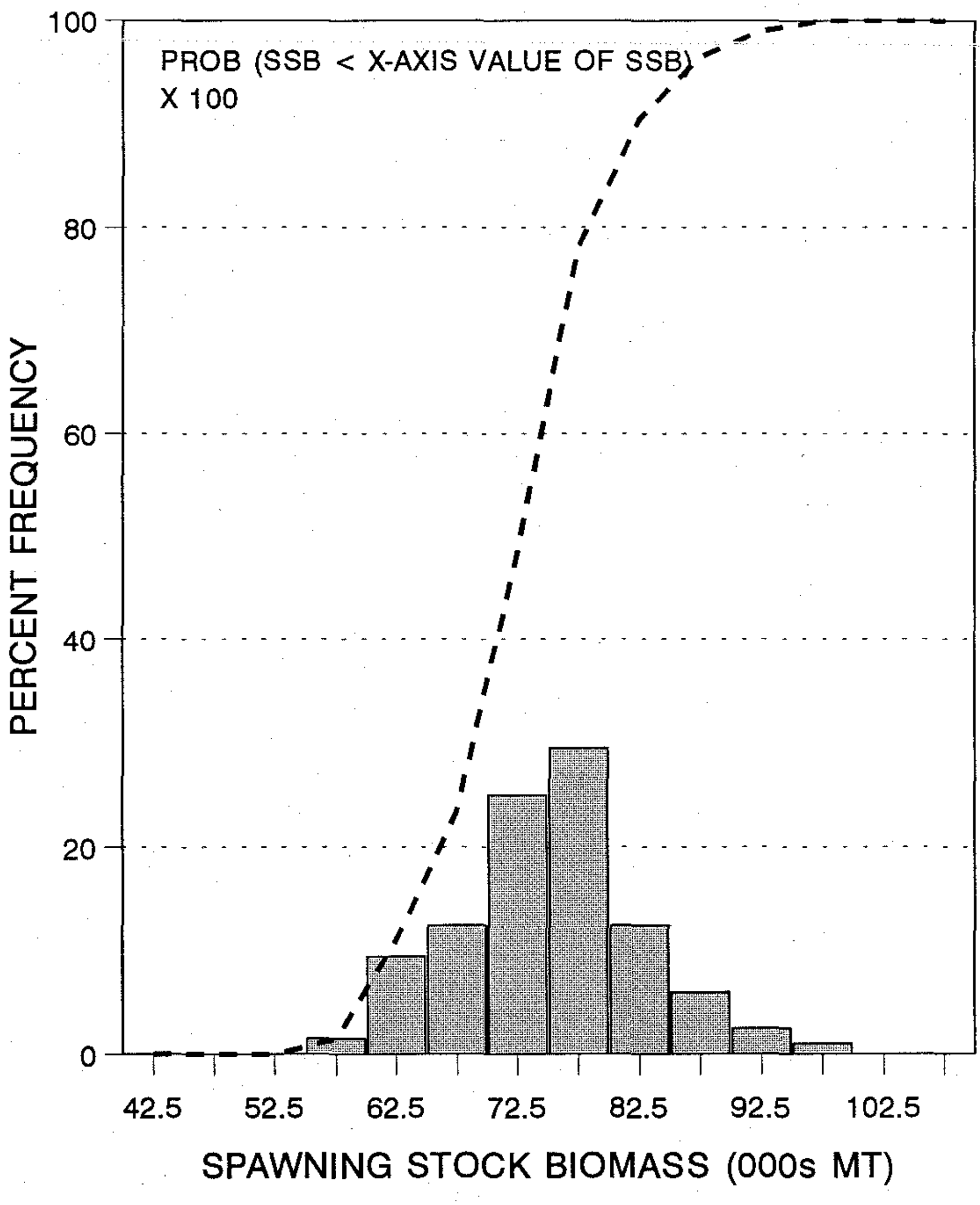


Figure AF2. Spawning stock biomass at the beginning of the 1990 spawning season, percent frequency, and probability of SSB less than x-axis value SSB (x 100) as estimated from 200 Bootstrap replications.

GEORGES BANK COD

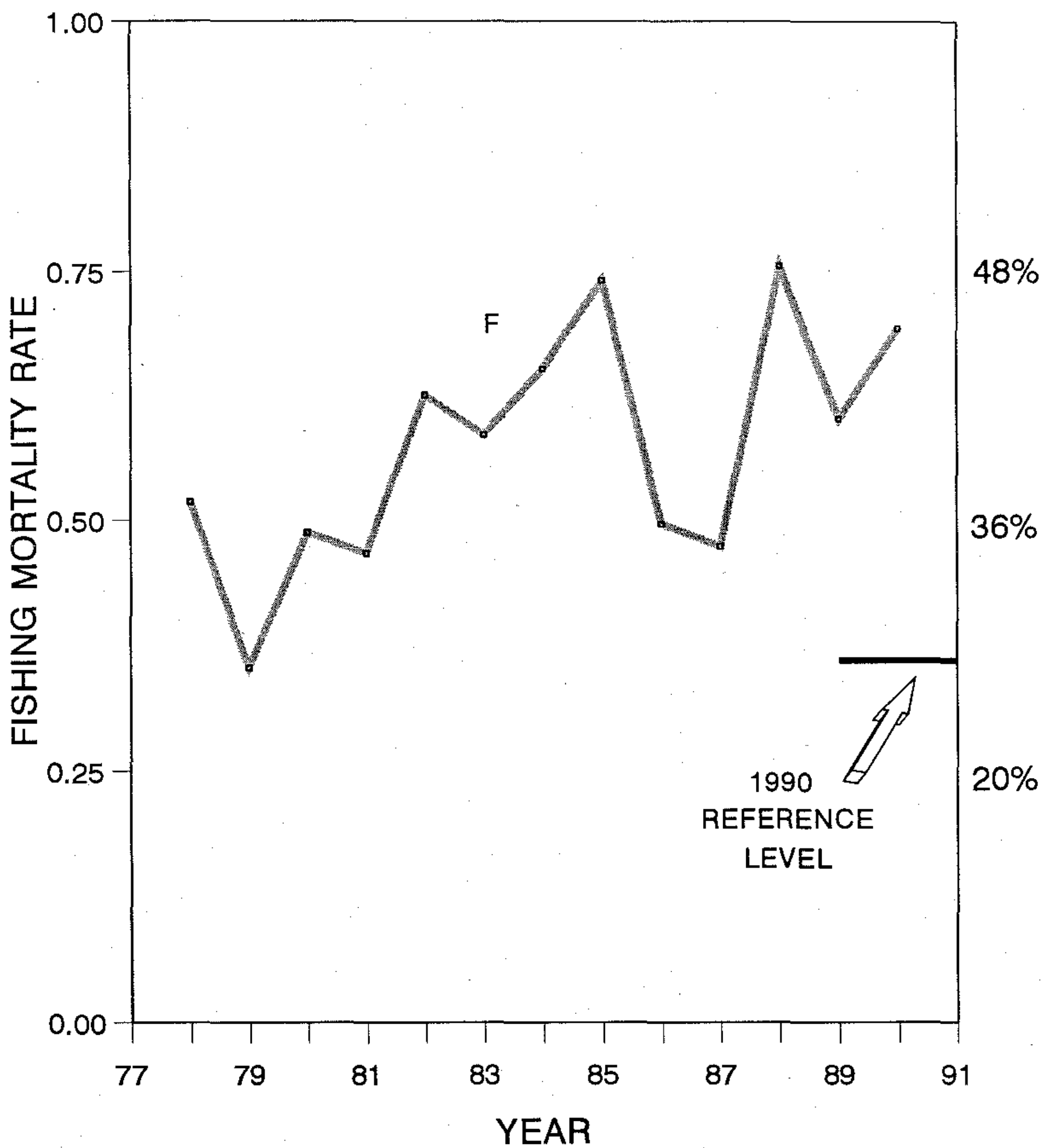


Figure AF3. Fishing mortality rate (left hand scale) and annual exploitation rate (right hand scale) for Georges Bank Cod. The 1990 reference level corresponds to the NEFMC definition of overfishing.

GEORGES BANK COD

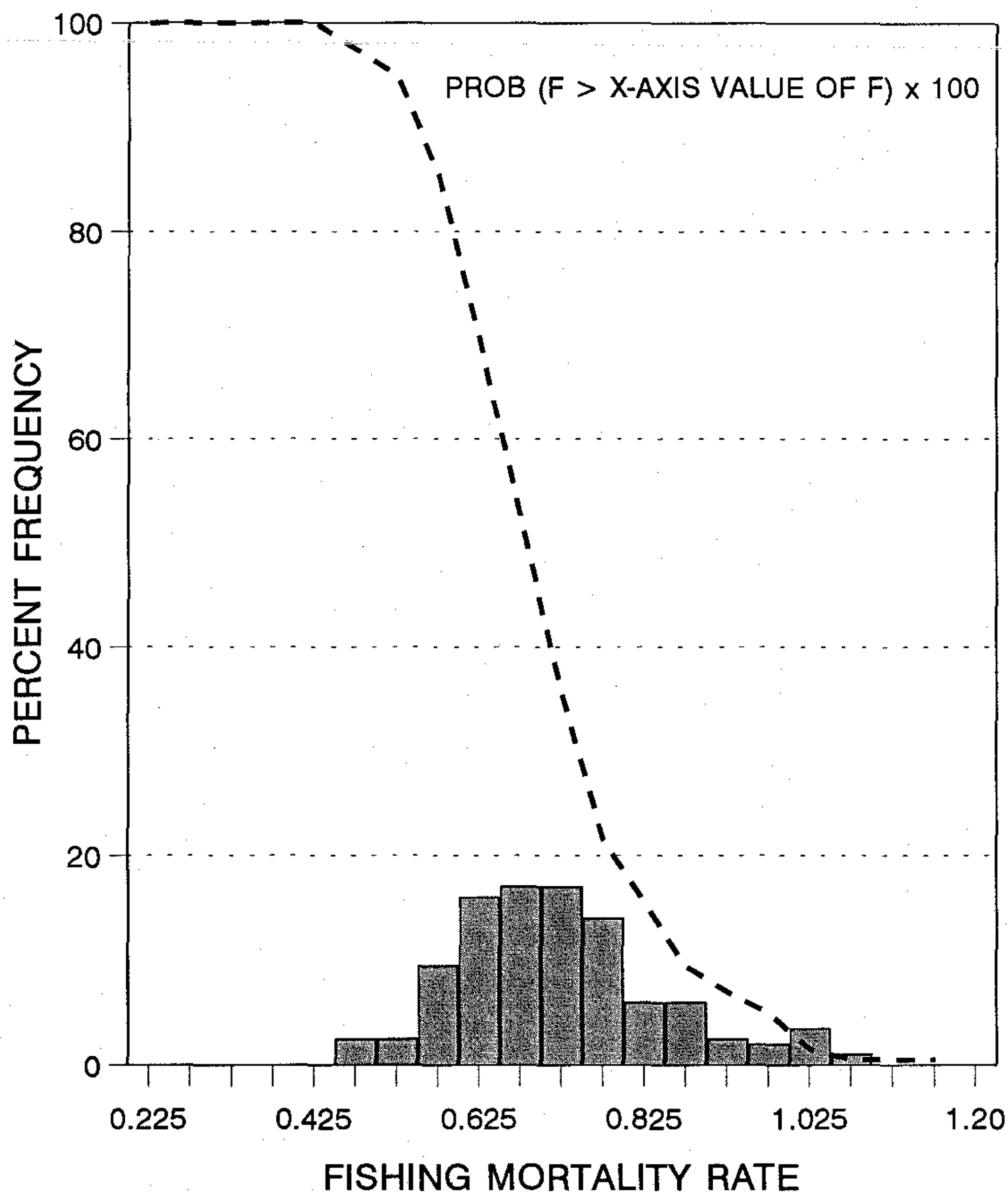


Figure AF4. Fishing mortality rate on fully recruited ages in 1990, percent frequency, and probability of F greater than x-axis value of F (x 100) as estimated from 200 Bootstrap replications.

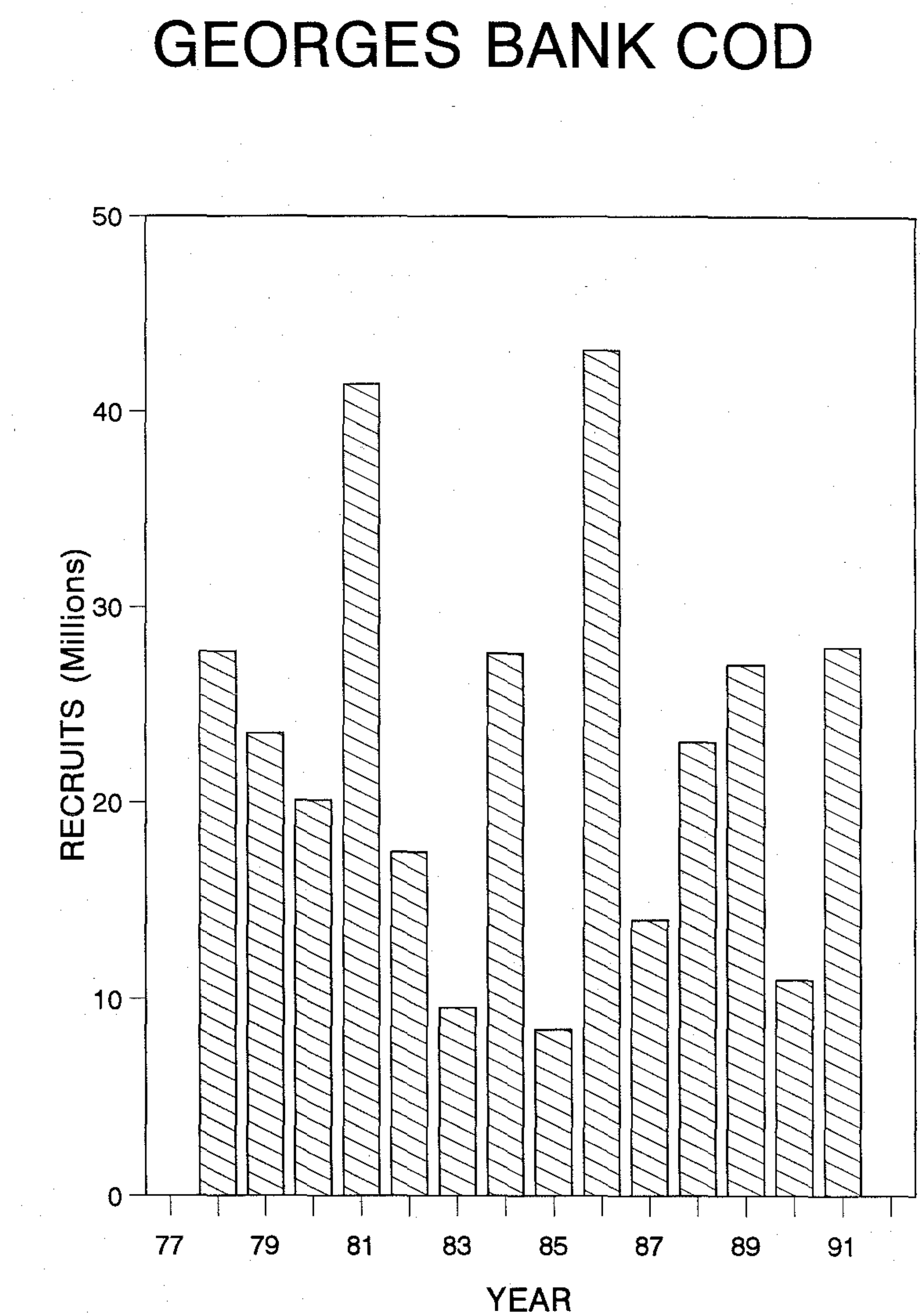


Figure AF5. Recruitment of Georges Bank Cod at age 1.

ATLANTIC SEA SCALLOPS

Sea scallop survey results were analyzed to provide an updated index of stock abundance and size composition. The 1990 domestic landings of scallops were around 17,000 MT.

Summary of Status

- Abundance of harvestable size scallops in the Mid-Atlantic region has declined in all areas. Pre-recruit abundance has increased in Delmarva to near the average for the time series.

- On the U.S. portion of Georges Bank, the 1991 pre-recruit survey abundance indices were among the highest in the time series. The 1988 year-class was very strong and is expected to support landings through 1993. Recruited abundance and biomass was slightly above average for the U.S. portion over the last decade.

Recommendations

- Although this was not a full assessment of sea scallop stocks, results of this survey, with respect to abundance and size composition, are consistent with the assessment presented in May 1991 (NEFSC 1991) that concluded sea scallops were currently overfished and at a medium stock level. Accordingly, fishing mortality needs to be reduced to rebuild the age structure of the population, to prevent rapid depletion of incoming year-classes and to improve yield per recruit.

USA SEA SCALLOP RELATIVE ABUNDANCE INDICES

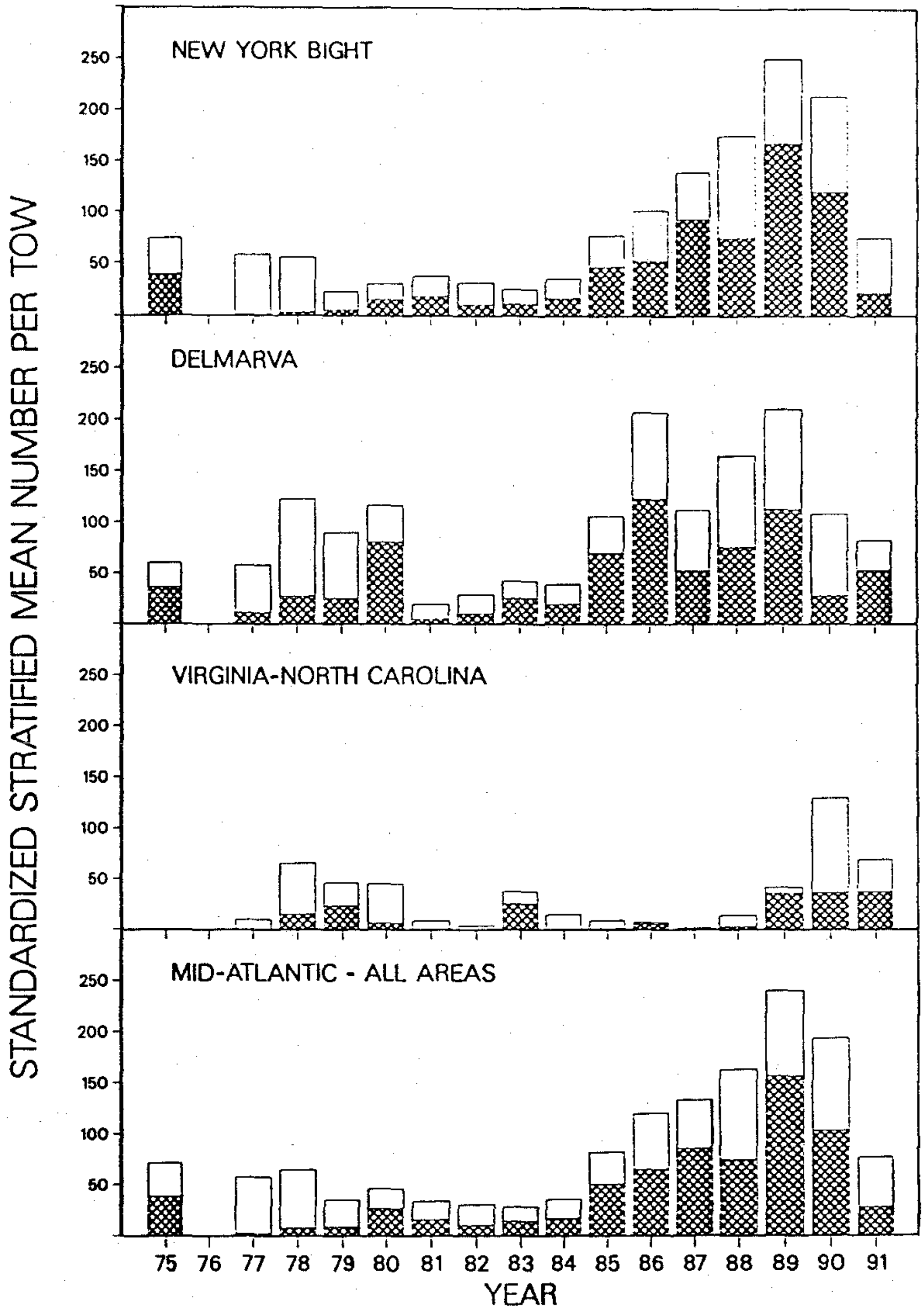


Figure AG1. Relative abundance indices of sea scallops, by principal scallop region in the Mid-Atlantic, from USA sea scallop research vessel surveys conducted during 1975 and 1977-1991. The shaded portion of each bar represents the relative abundance of pre-recruit scallops (<70 mm shell height); the upper, non-shaded portion of each bar represents the relative abundance of recruited or harvestable-size scallops (≥70 mm shell height).

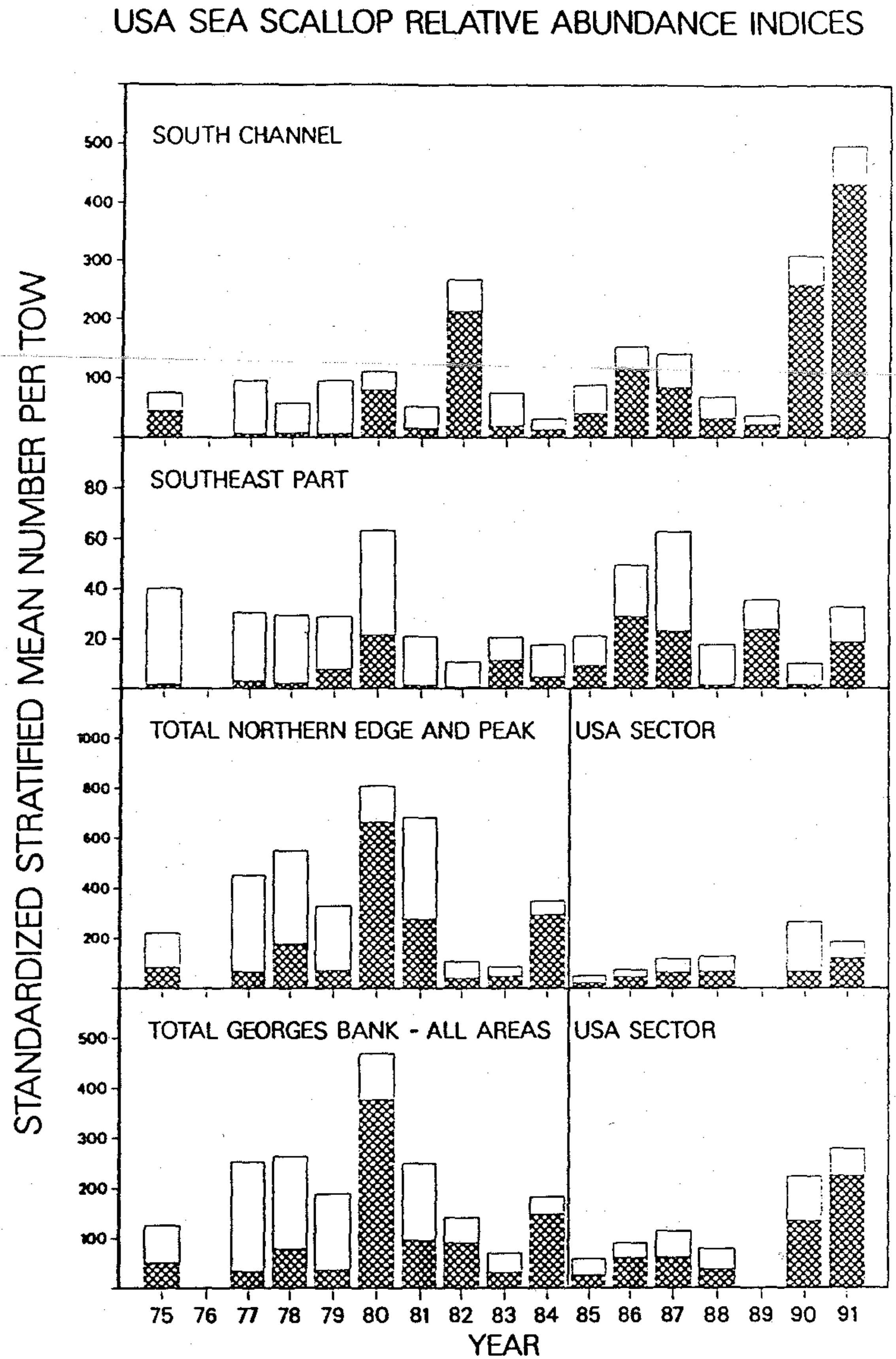


Figure AG2. Relative abundance indices of sea scallops, by principal scallop region on Georges Bank, from USA sea scallop research vessel surveys conducted during 1975 and 1977-1991. The shaded portion of each bar represents the relative abundance of pre-recruit scallops (<70 mm shell height); the upper, non-shaded portion of each bar represents the relative abundance of recruited or harvestable-size scallops (≥70 mm shell height).

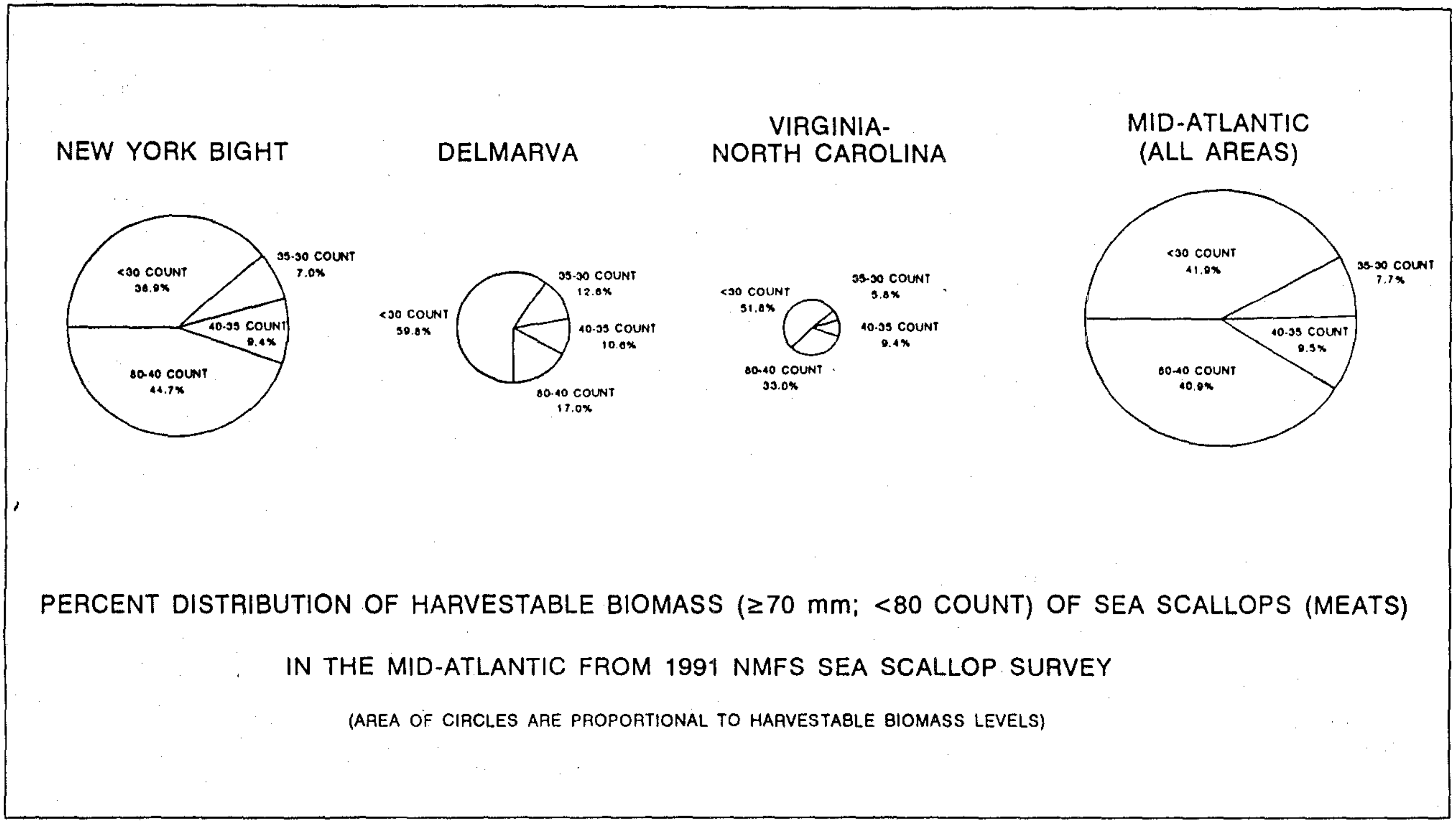
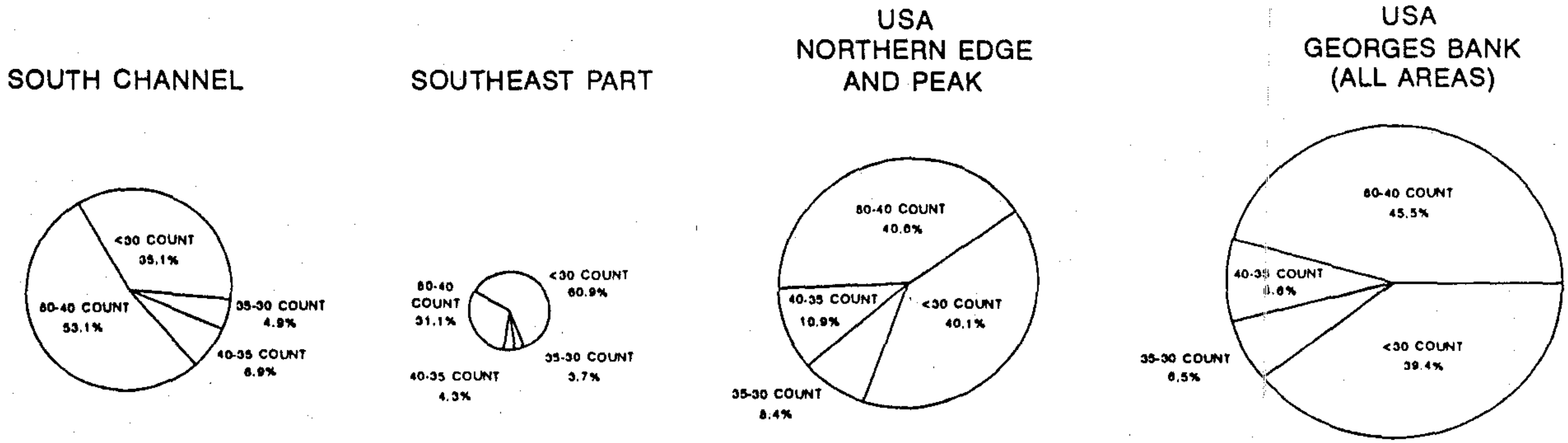


Figure AG3. Percentage distribution of harvestable biomass [meat weight] of sea scallops, within various meat count intervals [number of meats per pound], from the 1991 USA sea scallop research vessel survey in the Mid-Atlantic region. Harvestable biomass is defined as all sea scallops ≥70 mm shell height. Data derived from the 1991 survey distributions of standard stratified mean meat weight per tow.



PERCENT DISTRIBUTION OF HARVESTABLE BIOMASS (≥70 mm; <80 COUNT) OF SEA SCALLOPS (MEATS)

IN USA SECTOR OF GEORGES BANK FROM 1991 NMFS SEA SCALLOP SURVEY

(AREA OF CIRCLES ARE PROPORTIONAL TO HARVESTABLE BIOMASS LEVELS)

Figure AG4. Percentage distribution of harvestable biomass [meat weight] of sea scallops, within various meat count intervals [number of meats per pound], from the 1991 USA sea scallop research vessel survey in the USA portion of the Georges Bank region. Harvestable biomass is defined as all sea scallops ≥70 mm shell height. Data derived from the 1991 survey distributions of standard stratified mean meat weight per tow.

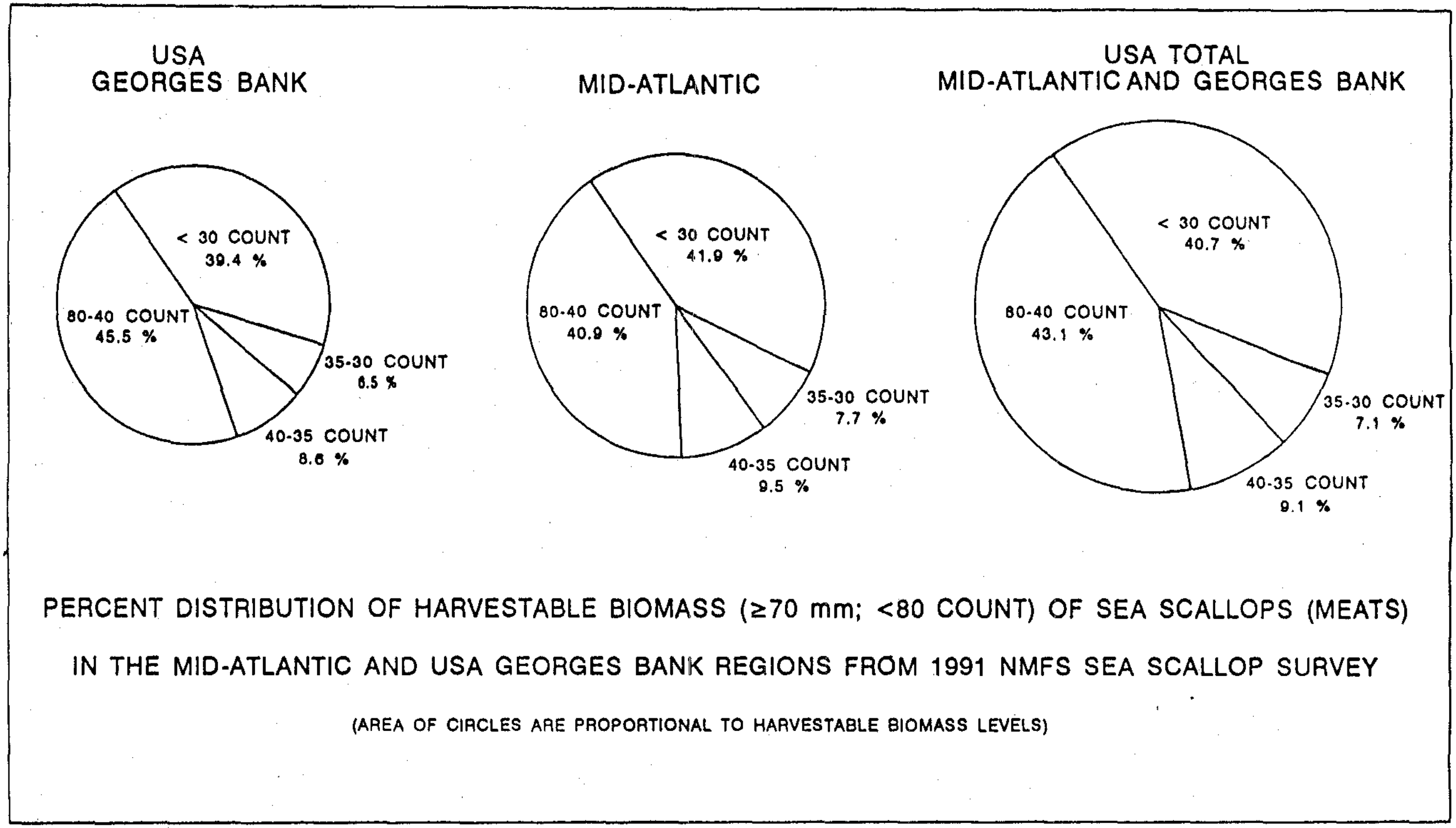


Figure AG5. Percentage distribution of harvestable biomass [meat weight] of sea scallops, within various meat count intervals [number of meats per pound], from the 1991 USA sea scallop research vessel survey in the USA portion of the Georges Bank and the Mid-Atlantic region. Harvestable biomass is defined as all sea scallops ≥70 mm shell height. Data derived from the 1991 survey distributions of standard stratified mean meat weight per tow.

INSHORE WINTER FLOUNDER

A stock assessment of inshore winter flounder stocks was conducted to estimate total mortality rate and biological reference points. Commercial landings in 1988 were about 18,000 MT and recreational landings were estimated to be 1,500 MT for that year.

Summary of Status

- The many sub-stocks of winter flounder are generally overexploited at present with stock levels in either the medium or low categories.

- Current fishing mortality rates, assuming natural mortality is in the range 0.3-0.4, are probably greater than 1.0 (annual exploitation rate 56%) in the Gulf of Maine, Southern New England, and the Mid-Atlantic.

- Overfishing definition fishing mortality rates ($F_{25\%}$) range between 0.5 and 1.5 for various assumptions concerning the discard mortality and the exploitation at age pattern. In general, current estimated fishing mortality rates were substantially higher than the reference levels. One exception is in Long Island Sound where the stock may be fully exploited at present.

Recommendations

- Reduce the fishing mortality rate in all areas to rebuild the stock biomass and increase yields.

- An age structured analytical assessment should be possible for at least some of the stock components or regions. This is probably best accomplished in a working group setting such as exists for summer flounder and include both coastal and Georges Bank stocks. Participation is recommended to include state biologists and NEFSC scientists.

- F_{MSY} is poorly defined for these stocks in general. Yield and spawning biomass per recruit reference points are more well determined for this species, although variable from stock to stock.

REFERENCES

Conser, R. 1992. The variance-bias tradeoff when using catch-age models to calibrate indices of abundance: which entails more risk? Canadian J. Fish. Aquat. Sci. Suppl. 1.

Efron, B. 1982. The jacknife, the bootstrap and other resampling plans. Philadelphia Society for Industrial and Applied Math 38:92p.

NEFSC. 1991. Report of the Twelfth Northeast Regional Stock Assessment Workshop. Northeast Fisheries Science Center Ref. Doc. 91-03.

SAW13 RESEARCH DOCUMENTS

(Appendix to CRD-92-02)

SAW13/1	Assessment of the Georges Bank Haddock Stock 1991	D. Hayes N. Buxton
SAW13/2	BIOREF - A Model to Estimate the Effects of Discard Mortality on Biological Reference Points	S. Correia
SAW13/3	Estimating Total Effort in the Gulf of Maine Sink Gillnet Fishery	K. Bisack G. DiNardo
SAW13/4	Report of the Stock Assessment Workshop (SAW) Summer Flounder Working Group (WG#21)	Working Group