Northeast Fisheries Center Reference Document 90-09

Report of the Eleventh NEFC Stock Assessment Workshop Fall 1990

NOAA/National Marine Fisheries Service
Northeast Fisheries Center
Woods Hole, MA 02543

December 1990

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Eleventh NEFC Stock Assessment Workshop
Fall 1990

Summary Report

SUMMARY

The 1990 Fall Stock Assessment Workshop (Eleventh SAW) was held in Woods Hole, Massachusetts in two sessions. The Stock Assessment Review Committee (SARC) met 15 - 19 October and the Plenary, 5-7 November 1990. The eighty-six participants included representatives of fisheries organizations in the states of Connecticut, Massachusetts, New York and the Atlantic States Marine Fisheries Commission; Mid-Atlantic and New England Fishery Management Councils; and NOAA's National Marine Fisheries Service, Northeast Fisheries Center (NEFC) and Northeast Regional Office (NERO).

The objective of the SARC was to provide a thorough technical review of submitted analyses on sea herring, summer flounder, scup, black sea bass, bluefish, silver hake, American plaice, cod, ocean pout, white and red hake, and small elasmobranchs (skates and dogfish). New analytical assessment estimates of fishing mortality rates and stock sizes at age for cod, herring, and summer flounder; and a new yield-per-recruit analysis for bluefish were reviewed. An analytical assessment of silver hake was performed at the meeting. Survey indices and trends in landings and catch per unit effort (CPUE) were examined for American plaice, scup, black sea bass, ocean pout, white hake, red hake, skates, and dogfish.

The SARC sought to determine:

- The best current assessment of the resource
- The major sources of uncertainties in the assessment
- How these uncertainties might affect the picture of stock status

The group also performed or recommended additional analyses to improve the presented work, and identified and discussed some generic issues to be considered by the Plenary and/or SAW Steering Committee. These issues include:

- Terms of reference for conducting species reviews
- SARC development of routine standard projections based on certain biological reference points
- Implementing a research document series
- Need for a joint U.S./Canada assessment of herring
- Survey gear modification analysis

The technical review and recommendations to improve analyses are presented in the SARC Consensus Summary of Assessments, Part II of this report.

A major objective of the Plenary was to review the report of the SARC and to prepare an Advisory Report on Stock Status of the Eleventh Stock Assessment Workshop, Part III of this report. The Advisory Report summarizes the technical information in the SARC report and notes the states of exploitation and depletion of the reviewed species. The Advisory Report is intended to serve as scientific advice for fishery managers on resource status.

Other objectives of the Plenary were:

- To agree to a set of guidelines for the presentation of assessment reports
- To review the Atlantic salmon assessment program, organization and work of the Marine Mammals Investigation, available information on the tilefish fishery, sea sampling progress, and modeling stock rebuilding strategies
- To present an overview and methodology of squid assessments

The Plenary confirmed that the SAW Steering Committee would be in place within several weeks to guide the next SAW process and to set priorities for species to review. Twenty species/stocks, as well as methodology used to estimate harbor porpoise by-catch, were identified to be in need of a technical review as soon as possible. The Plenary also identified the need to form a Sea Sampling Priorities Working Group with specific reference to studies that might be performed to provide a better basis for program design and definition, a working group on Modeling Rebuilding Strategies for the purpose of reviewing existing models and work to date, and a working group on Long Term Stock Trends to review evidence of physical and biological factors explaining historical abundance and distribution patterns; and to review the work of several existing working groups.

Recommended timing for SAW 12 includes a SARC meeting in the latter half of May, and a Plenary meeting in late June.

Eleventh NECF Stock Assessment Workshop
Fall 1990

The Plenary

INTRODUCTION

The Fall 1990 Northeast Fisheries Center (NEFC) Stock Assessment Workshop (Eleventh SAW) was held in two sessions according to the new structure recommended by the 10th SAW. The Stock Assessment Review Committee (SARC) met 15 - 19 October and the Plenary 5 - 7 November 1990. Both sessions were held at the Northeast Fisheries Center Aquarium Conference Room in Woods Hole, MA. Eighty-six individuals from marine fisheries management and scientific institutions and agencies attended all or part of the workshop.

This report presents an overview of the special topics (recommended during the 10th SAW) and reports presented at the Plenary: review of the Atlantic Salmon Assessment Program: overview and methodology of squid assessments; overviews of the NEFC Marine Mammals Investigation, and sea sampling progress; reviews of available information on the tilefish fishery, and modeling and stock rebuilding strategies; guidelines for the presentation of assessment reports; and the SARC report. In addition to this report, Eleventh SAW documentation includes a SARC Consensus Summary of Assessments, which provides a thorough technical review of the twelve species included in the SARC agenda, and a SAW Advisory Report that is based on the technical reviews. These reports serve as the most current source of information on the status of the reviewed fishery resources in the New England and Mid-Atlantic areas, and are designed for use by fishery scientists and managers.

Table 1 lists SAW participants. Table 2 shows the agenda. Table 3 is a list of working papers.

Table 1. SAW list of participants

National Marine Fisheries Service

Northeast Fisheries Center
Frank Almeida
Janet Anderson
Vaughn Anthony
Thomas Azarovitz
John Boreman
Ray Bowman
Jon Brodziak
Jay Burnett
Cherles Byrne
Darryl Christensen
Stephen Clark
Edward Cohen
Ray Conser
David Dow
Steven Edwards
Don Flescher
Michael Fogarty
Kevin Friedland
Wendy Gabriel
Patricia Gerrior
Richard Greenfield
Dennis Hansford
Daniel Hayes
Eugene Heyerdahl
Bruce Higgins
Joseph Idoine
Ambrose Jearld
Kathy Lang
Philip Logan
James Manning
Garry Mayer
Ralph Mayo
William Michaels
Nancy Munroe
Thomas Morrissey
Steven Murawski
Helen Mustafa
Arthur Neill
John Nicholas
Loretta O'Brien
William Overholtz
Joan Palmer
Linda Patanjo
John Pearce
Thomas Polacheck
Barbara Pollard
David Potter
Gregory Power
Anne Richards
Andrew Rosenberg
Ronnee Schultz
Frederic Serchuk
Gary Shepherd
Vaughn Silva
Michael Sissenwine
Tim Smith
Herb Stern
Mark Terceiro
Gordon Waring
Alan White
Susan Wigley
Mikolay Wojnowski
Patricia Yoos

Northeast Region
Doug Beach
Pat Kirkul
Robert Pawlowski
Keith Rodrigues
Linda Shaw

New York Department of Marine Resources/ Atlantic States Marine Fisheries Commissionon
John Mason

Maine Department of Marine Resources
David Stevenson

Massachusetts Division of Marine Fisheries
Steven Correia
Thomas Currier
Arnold Howe
Dan McKiernan
Paul Pierce
David Witherell

Connecticut Department of Environmental Protection
Penny Howell
David Simpson

Mid-Atlantic Fishery Management Council
Tom Hoff
Dave Keifer
Chris Moore

New England Fishery Management Council
Chris Kellogg
Pamela Mace

Monomet Bird Observatory
Friedrich von Krusenstiern

Marine Biological Laboratory
Edward Enos

US CGA
Jan McLeavey

Table 2. SAW SARC agenda

Eleventh Stock Assessment Workshop
STOCK ASSESSMENT REVIEW COMMITTEE
NEFC Aquarium Conference Room
Woods Hole, MA

AGENDA

Order of presentation for Species Reviews, expected Sources of analyses, and Suggested Rapporteurs: Days of reviews are subject to change.

Species	Source/Presenter	Rapporteur
	Monday, 15 October	
Sea herring[1]	Maine DMR - Stevenson	Hoff
Summer flounder[1]	NEFC - Gabriel	Mace
	Tuesday, 16 October	
Scup[2]	Conn. - Howell	Fogarty
Black sea bass[2]	NEFC - Shepherd	Fogarty
Bluefish[1]	NEFC - Gabriel	Mace
Silver hake[3]	NEFC - Mayo NEFMC - Russell	Polachek
	Wednesday, 17 October	
Sea scallops[1]	NEFMC - Russell	Conser
American plaice[2]	NEFC- Serchuk	Goodyear
Cod[1]	NEFC - Serchuk	Goodyear
	Thursday, 18 October	
Haddock[1]	NEFC - Mayo	Overholtz
Ocean pout[2]	NEFC - Wigley	Overholtz
White hake[2]	NEFC - Mayo	Stevenson
Red hake[2]	NEFC- Wigley	Stevenson
	Friday, 19 October	
Skates[2]	NEFC - Murawski	Mayo
Dogfish[2]	NEFC - Murawski	Mayo

Review of SARC Report

[1] Review new assessment or analysis
[2] New assessment or analysis
[3] Analysis and review

PLENARY
Northeast Fisheries Center
Aquarium Conference Room
Woods Hole, MA 02543

AGENDA

	Monday, 5 November	
9:30	Opening remarks A. Rosenberg, Moderator	A. Peterson, Jr.
9:45	Review Atlantic salmon assessment program	K. Friedland
10:45	Coffee	
11:00	Squid assessments: Overview and methodology	S. Murawski A.Rosenberg
12:00	Lunch	
1:30	Overview of Marine Mammals Investigation	T. Smith
2:00	Review of available information on the tilefish fishery	S. Murawski
3:00	Coffee	
3:15	Guidelines for presentation of assessment reports	A. Rosenberg
	Tuesday, 6 November	
9:30	Overview of sea sampling progress	D. Christensen
10:30	Coffee	
10:45	Modeling stock rebuilding strategies	A. Rosenberg P. Mace
12:00	Lunch	
1:30	Report of the Stock Assessment Committee	A. Rosenberg
	Wednesday, 7 November	
9:30	12th SAW terms of reference, timing	
10:00	Preparation of SAW Advisory Report	
12:00	Lunch	
1:30	Completion and approval of SAW Report	

Table 3. SAW-11 SARC and Plenary Papers

SAW 11 SARC Papers

		Presenter
SAW/11/SARC/1	Revised assessment of the Georges Bank cod stock 1990	F. Serchuk
SAW/11/SARC/2	Marine Finfish Survey Section 2.3 stock assessment of scup	P. Howell
SAW/11/SARC/3	Status of black sea bass north of Cape Hatteras, NC	G.S hepherd
SAW/11/SARC/4	The calculation of replacement fishing mortality rates, F_{rep}, for Gulf of Maine/Northern Georges Bank and the Southern Georges Bank/Mid-Atlantic stocks of whiting	H. Russell
SAW/11/SARC/5	Yield-per-recruit analysis for Atlantic coast bluefish-1990	W. Gabriel
SAW/11/SARC/6	Virtual population analysis of the Gulf of Maine Atlantic herring stock	D. Stevenson
SAW/11/SARC/7	Report of the Stock Assessment Workshop Summer Flounder Working Group (WG#21)	W. Gabriel
SAW/11/SARC/8	Updated assessment of American plaice in the Gulf of Maine-Georges Bank region: Data tables and figures, 1990	F. Serchuk
SAW/11/SARC/9	Overview of small elasmobranch stock status and population dynamics of the Northeast USA	S. Murawski
SAW/11/SARC/10	Ocean pout - Status of the fisheries resources off the Northeastern United States for 1990	S. Wigley
SAW/11/SARC/11	White hake - Status of the fisheries resources off the Northeastern United States for 1990	R. Mayo
SAW/11/SARC/12	Red hake - Status of the fisheries resources off the Northeastern United States for 1990	S. Wigley
SAW/11/SARC/13	Scup - Status of the fisheries resources off the Northeastern United States for 1990	W. Gabriel

SAW 11 Plenary Papers

SAW/11/PL/1	Report of the 11th NEFC Stock Assessment Workshop Stock Assessment Review Committee: Consensus summary of Assessments	A. Rosenberg SARC Chairman
SAW/11/PL/2	Guidelines for the presentation of assessment analyses	A. Rosenberg
SAW/11/PL/3	An overview of the Northeast Fisheries Center's Marine Mammals Investigation	T. Smith
SAW/11/PL/4	ICES guidance to Assessment Working Groups from ACFM and Secretariat	
SAW/11/PL/5	Overview of squid assessments and methodology: Northeast USA	S. Murawski
SAW/11/PL/6	Advisory report on stock status of the Eleventh Stock Assessment Workshop, National Marine Fisheries Service, Northeast Fisheries Center	A. Rosenberg
SAW/11/PL/7	Stock rebuilding strategies over different time scales	A. Rosenberg
SAW/11/PL/8	Overview of sea sampling progress	D. Christensen

REVIEW OF ATLANTIC SALMON ASSESSMENT PROGRAM

The Northeast Fisheries Center (NEFC) Atlantic salmon research program consists of assessment activities and basic research on assessment and stock identification techniques. Dr. Kevin Friedland of the Center described the program for the SAW. The NEFC involvement in salmon research increased in the mid-1980s after the United States joined the North Atlantic Salmon Conservation Organization (NASCO). The Center research program is organized into three areas of research: Carlin tagging, coded-wire tagging (CWT), and non-tag stock identification. Additionally, the Center performs routine assessment and advisory activities associated with all aspects of the research program.

The Carlin tag research program at the Northeast Fisheries Center is a cooperative program with state and other federal agencies. Carlin tags are affixed to smolts from the Penobscot River, Maine, thus continuing the time series of release-return data for Maine stocks begun in the early 1960s (Figure 1). Efforts have been made to tag other restored U.S. stocks, for example smolts from the Connecticut River, but the limited success of these tagging experiments has lead to a suspension of this part of the program.

The coded-wire tagging (CWT) program at the Center was begun in 1985 and is also a cooperative program between state and federal agencies (Figure 2). The CWT program is a fishery independent tagging system designed to ameliorate the suspected biases associated with Carlin tag return data. The CWT study necessitates a sampling program for the target fisheries since the tags cannot be detected by the fishermen. The Center coordinates U.S. participation in the Greenland and Canadian fisheries sampling programs.

Assessments based on Carlin tag returns from distant water fisheries have consisted of harvest estimation and modeling of restored salmon runs. Harvest estimates from Peterson type estimators that include parameters to account for the reporting rate of tags and non-catch fishing mortality. Harvest model sensitivity has been tested for parameters associated with distant-water recovery and run estimation. The model is most sensitive to values used for the distant-water fishery reporting rate (Figure 3). The harvest estimates have been summarized for the Greenland and Canadian fisheries by year, area, and week of recapture. Interceptions of U.S. salmon occur primarily along the north shore of Newfoundland during spring, simultane-

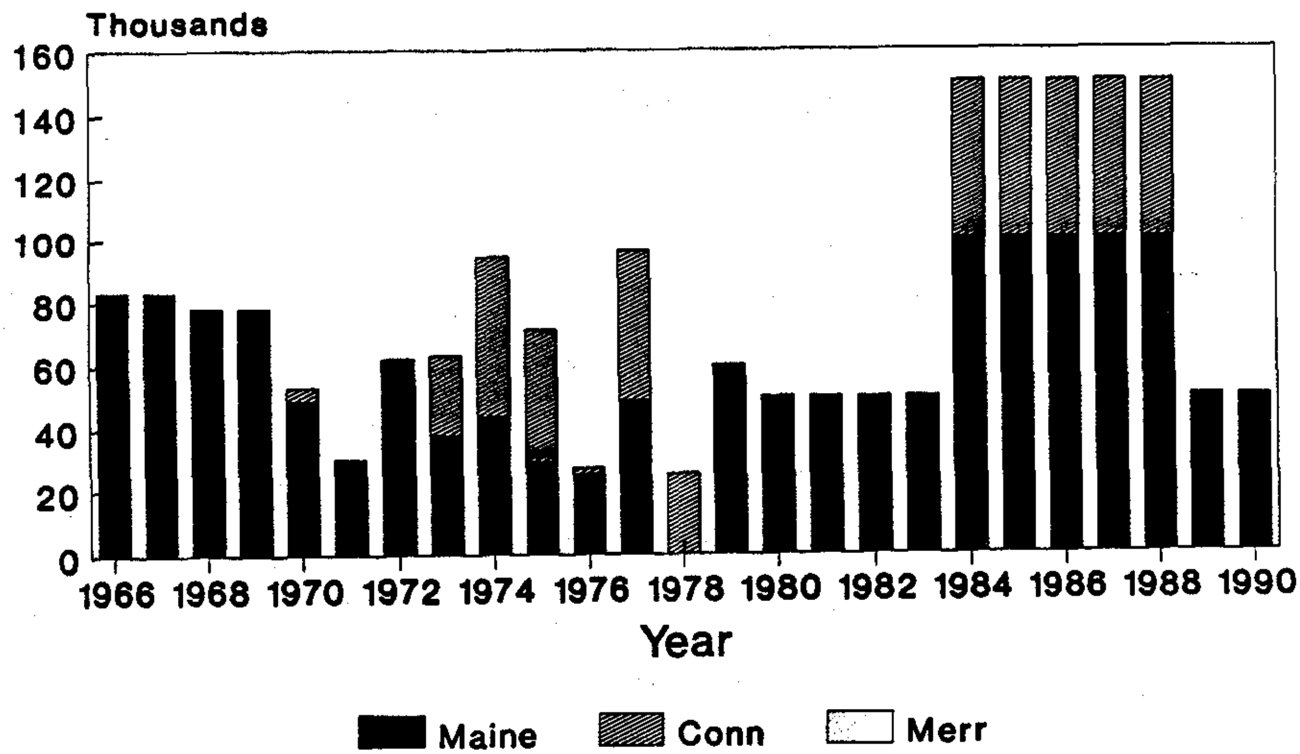


Figure 1. Carlin tagging of Atlantic salmon from the Penobscott, Connecticut, and Merrimack Rivers, 1966-1990.

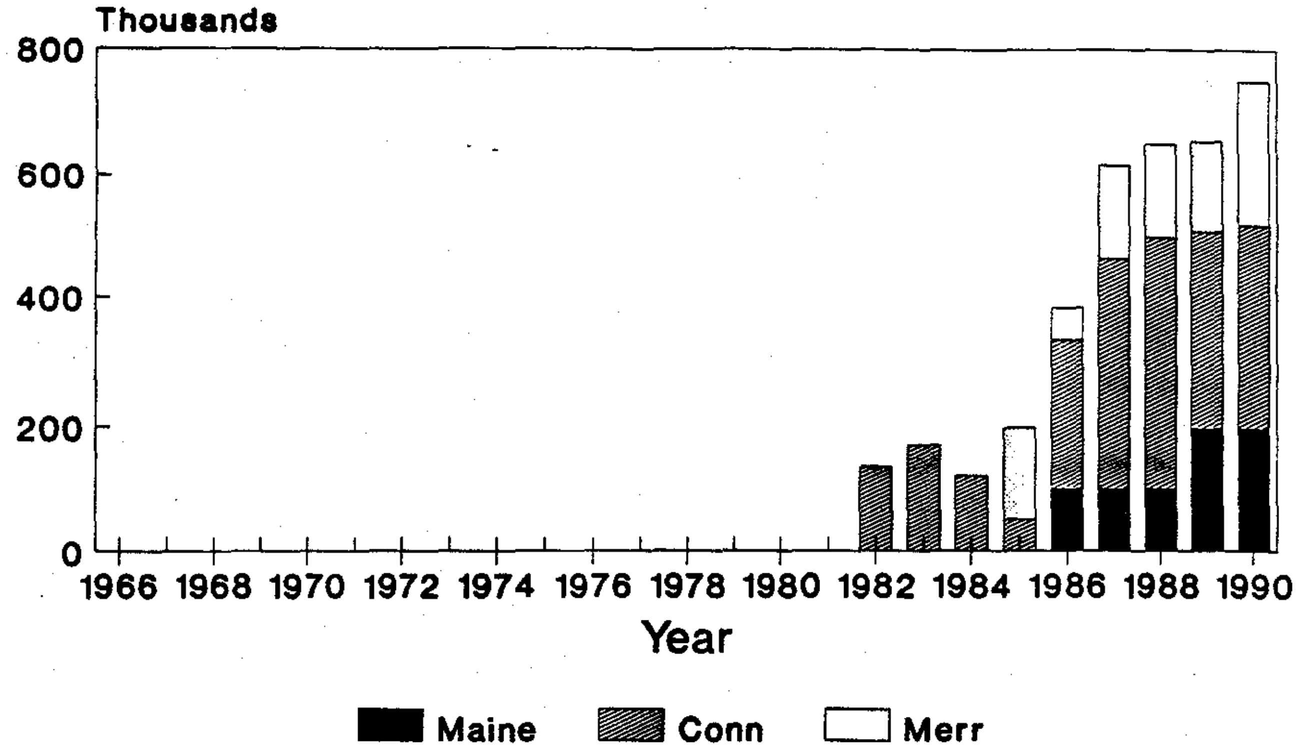


Figure 2. Coded-wire tagging of Atlantic salmon from the Penobscott, Connecticut, and Merrimack Rivers, 1989-1990

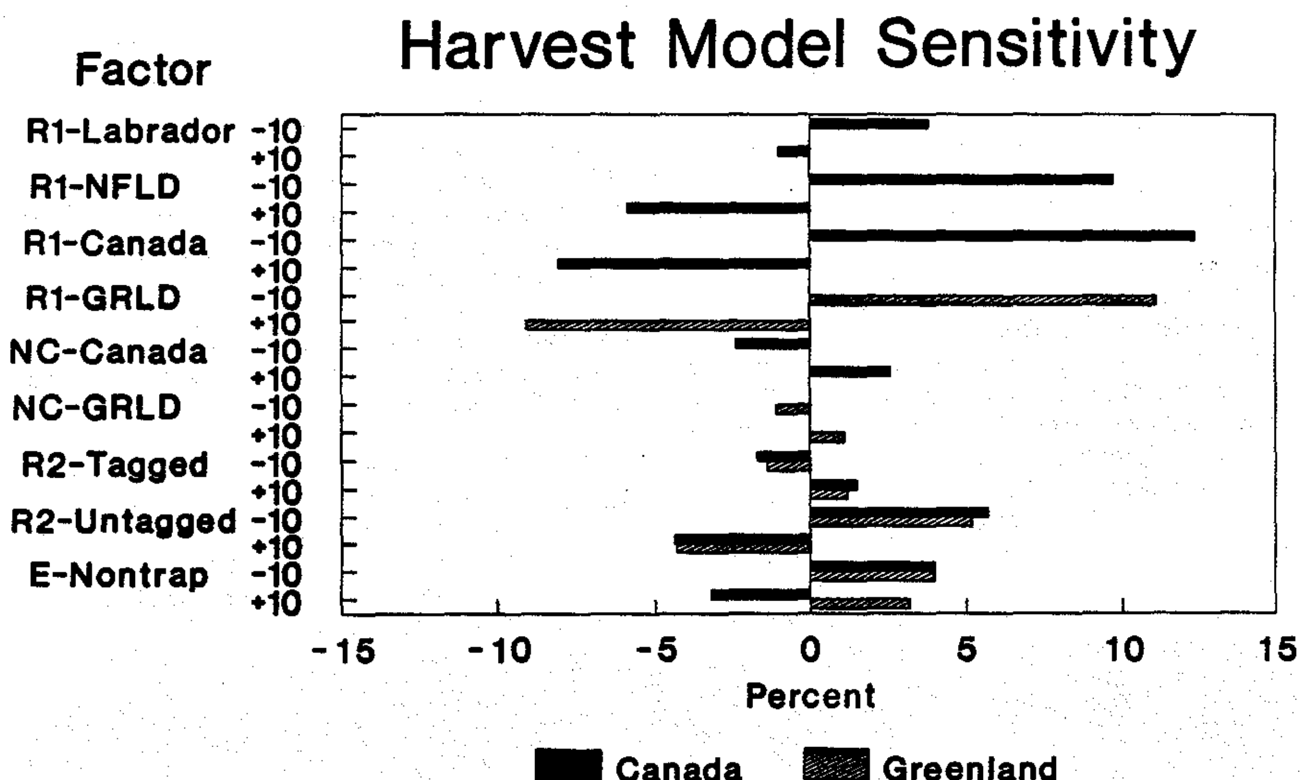


Figure 3. Harvest model for Greenland and Canadian Atlantic salmon fisheries.

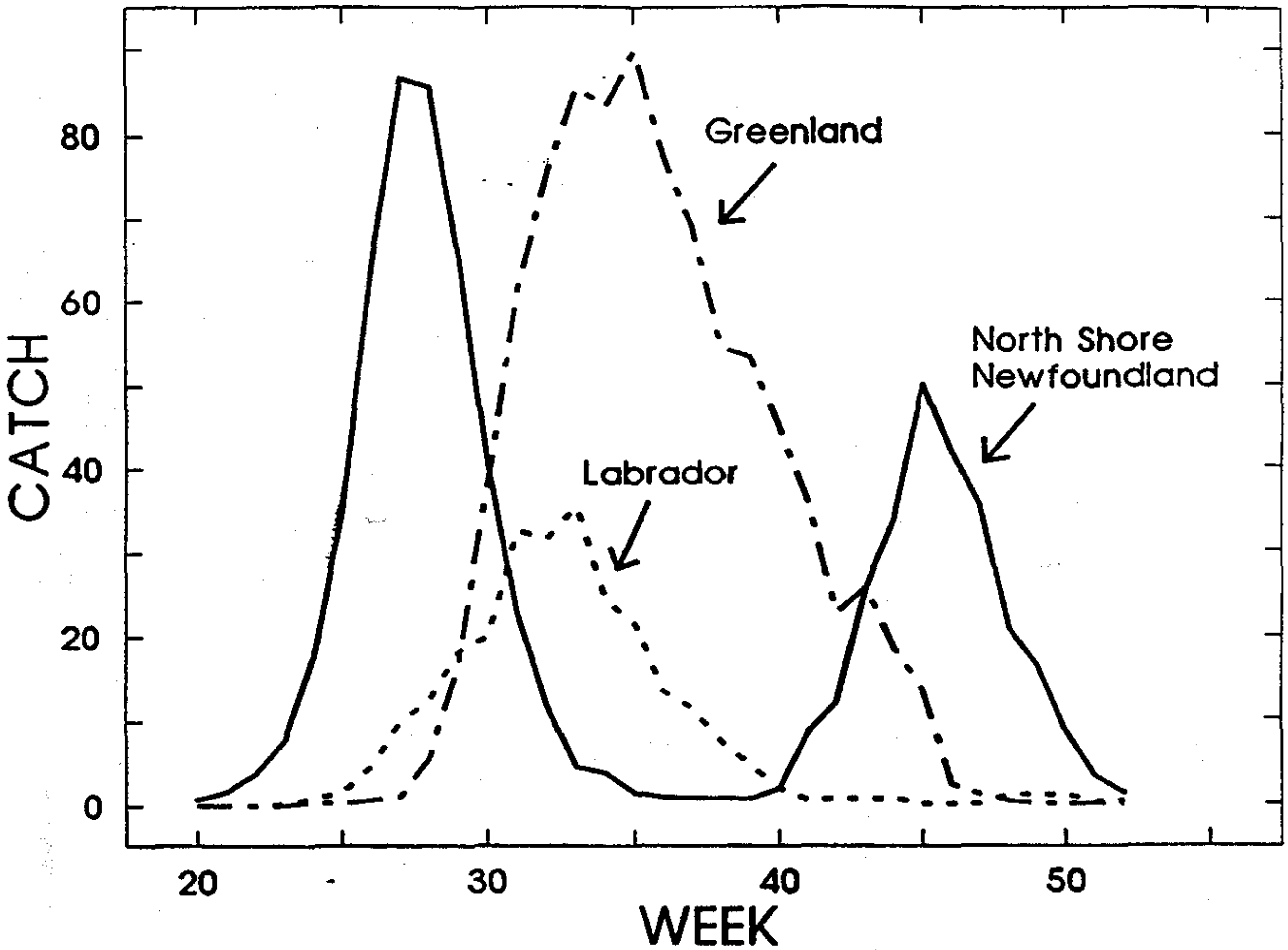


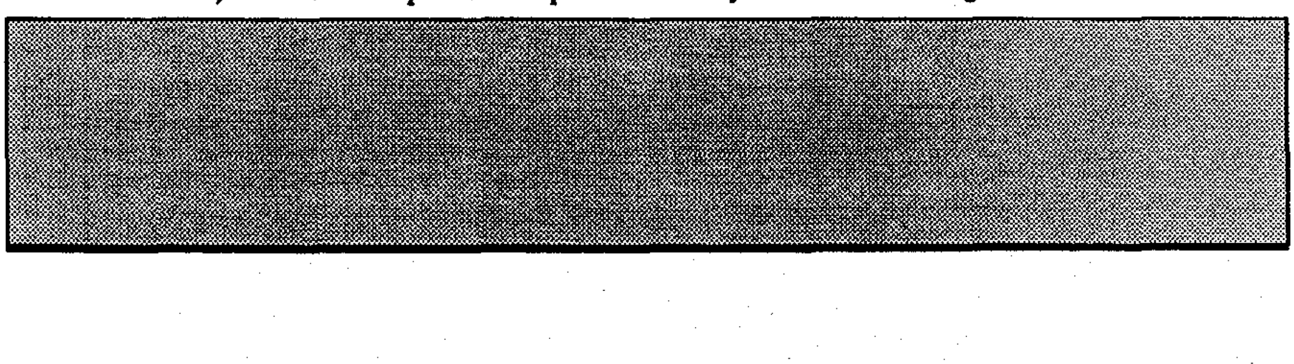
Figure 4. Summary of Greenland and Canadian Atlantic salmon fisheries.

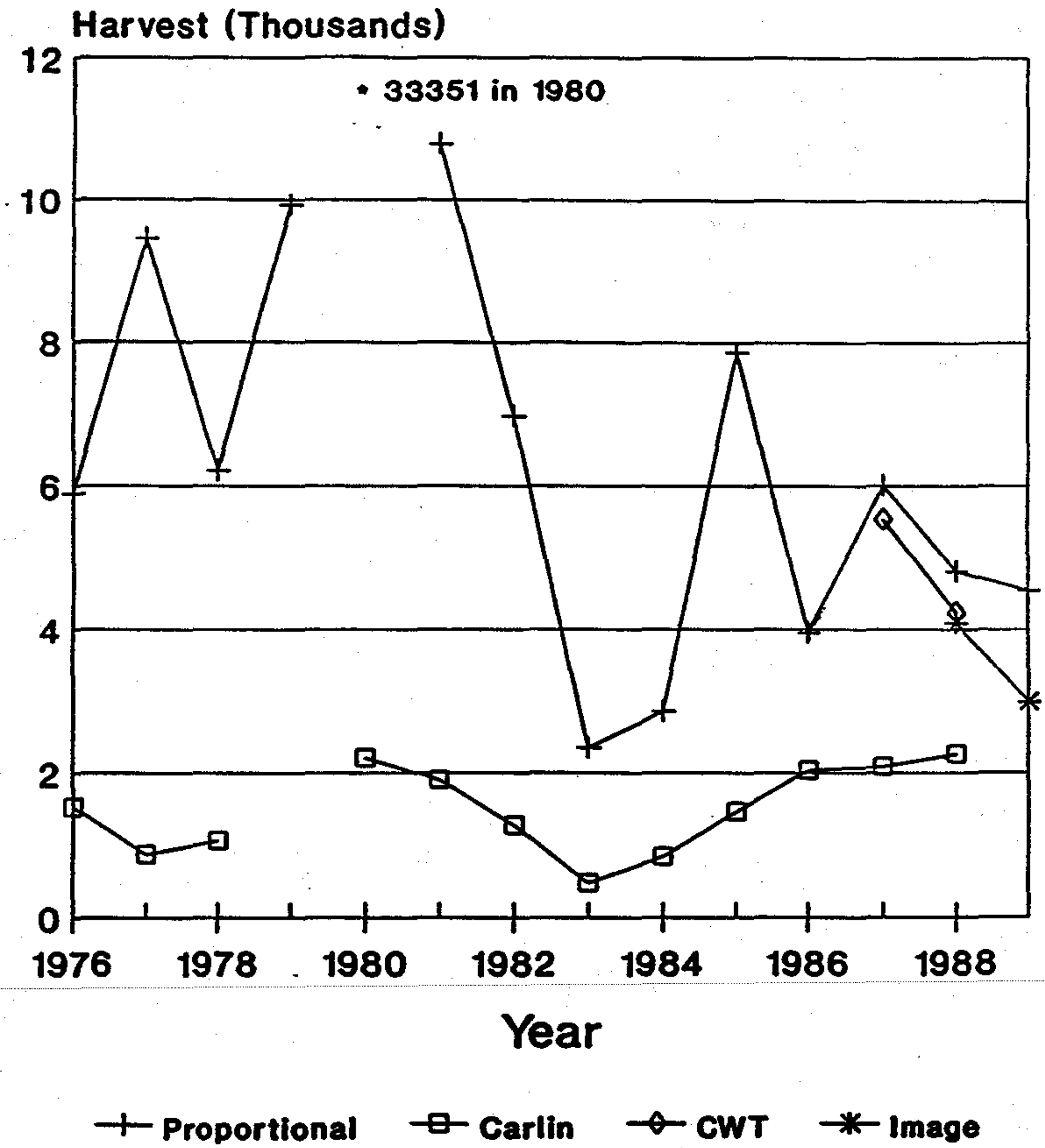
ously in Labrador and West Greenland during summer, and again along the north shore of Newfoundland during fall (Figure 4). These patterns have been modified in recent years by management changes affecting fishing dates in the respective fisheries.

Coded-wire tag based harvest estimates are only available for recent years. Because these estimates are not affected byreporting rate bias, they are considered more accurate than Carlin tag-based estimates. CWT-based estimates for Maine stock harvested at West Greenland are significantly higher than those based on Carlin tag data and suggest that there is a systematic downward bias in the estimates resulting from Carlin tagging (Figure 5).

Run reconstitution modeling of the U.S. stock complex has been performed for the extant stock (entire stock across all fisheries) and stock components in specific component is harvested at a mean level of 60 percent (Figure 6). Extant exploitation rate of the two sea-winter component (fish destined to be three sea-winter spawners) is at levels exceeding 80 percent (Figure 7). To estimate exploitation rate in specific fishing zones (i.e., Canada versus Greenland) it is necessary to assign or estimate a migration factor P (the fraction of the stocks returning from Canada). Estimation of P is a non-linear process and is the subject of ongoing research.

Stock identification research at the Center consists of ongoing image processing projects. Image processing, the collection of morphometric and meristic data on a computerized video system, is being applied to scales and otoliths to develop classification models for identification to county and continent of origin.





Note: No tags were released in 1978

Figure 5. Comparison of harvest estimates of Maine-origin salmon at West Greenland based on coded-wire and Carlin tag data.

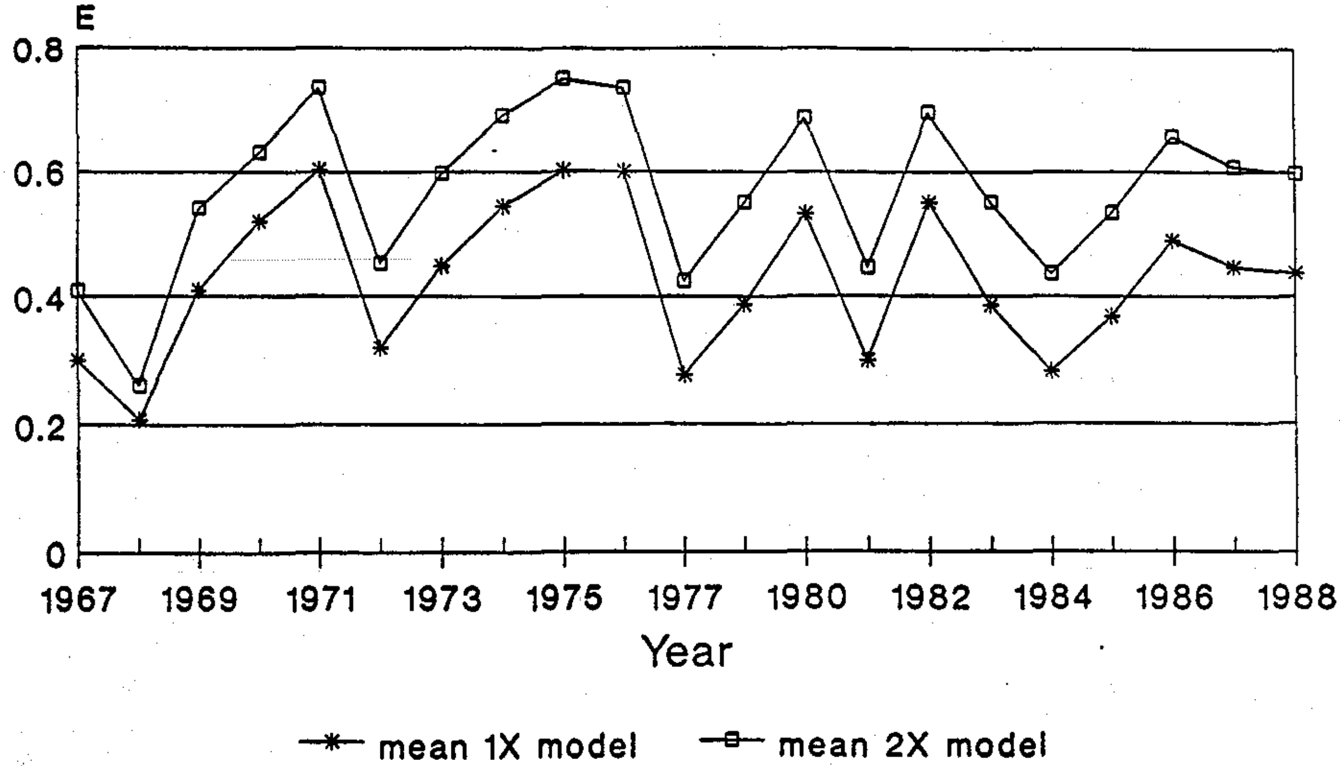


Figure 6. Exploitation rate for the extant one sea-winter stock.

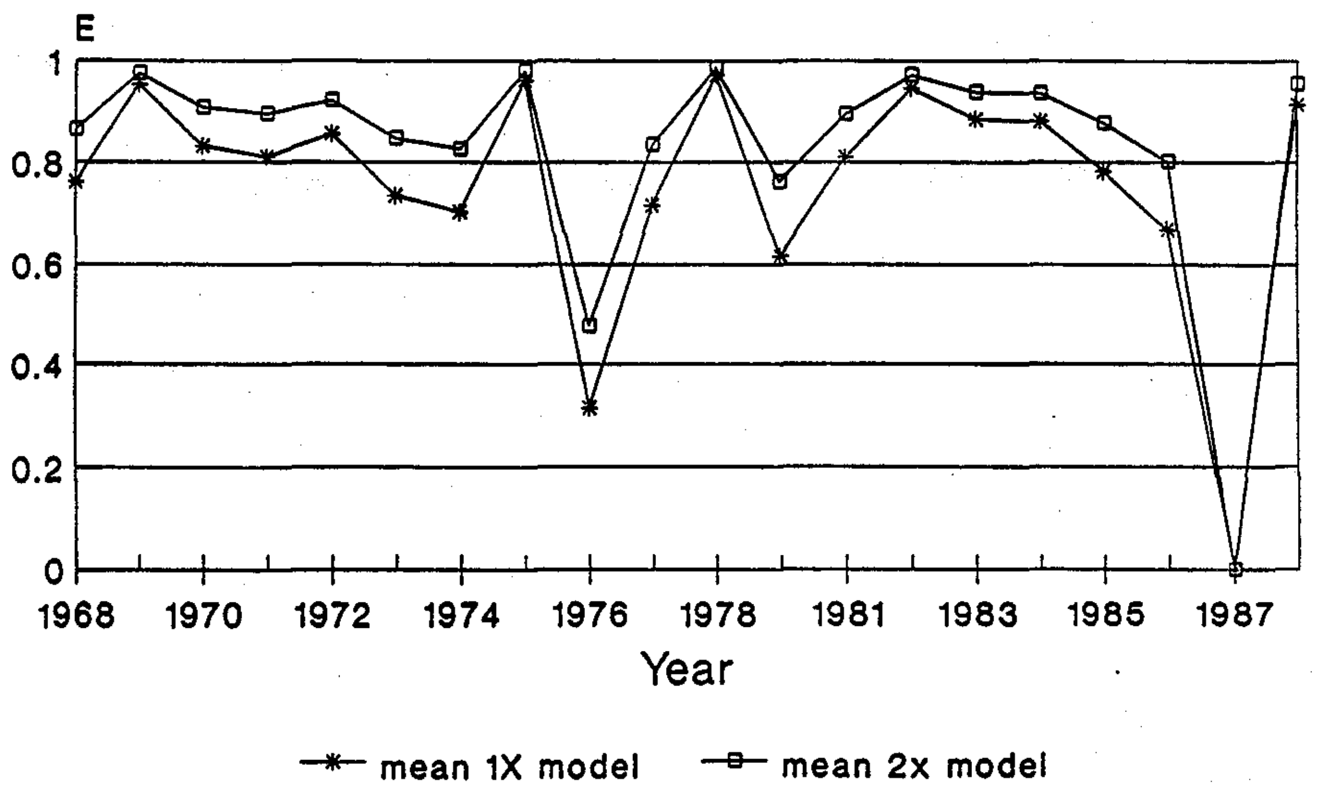


Figure 7. Exploitation rate for the extant two sea-winter stock.

SQUID ASSESSMENTS: OVERVIEW AND METHODOLOGY

The assessment of squid stocks in the Northeast region is the responsibility of the Mid-Atlantic Offshore Investigation at NEFC. Dr. Steve Murawski described some of the problems of assessing the resource and sought guidance on future directions in evaluating squid stocks.

The priority for improving the level of assessment for long-finned (*Loligo pealei*) and short-finned squid (*Illex illecebrosus*) populations has been relatively low in comparison to other species (yield-per-recruit and indexed assessments are currently used for *Loligo* and *Illex*, respectively). Both species produce two cohorts per year and exhibit a cross-over life cycle in which spring cohorts spawn in fall and fall cohorts spawn in spring. The cross-over of cohorts complicates the use of bottom trawl survey indices to monitor squid abundance because the survey data provide information on a mixture of cohorts.

Population abundance estimates based on survey indices need to account for the relative strength of cohorts. Length-based disaggregation of survey data was discussed as a way to assess cohort strength. Tracking relative cohort strength was also considered to be important for the determination of biological reference points for both species.

The spatial distribution of both species appears to be influenced by water temperature. In particular, abundance estimates for *Loligo* based on the area-swept model are probably dependent on the distribution of bottom temperature and suggest the development of a model to calibrate the survey indices to incorporate observed bottom temperature. The number of zero tows per cruise was mentioned as an alternative abundance indicator for *Loligo* in contrast to mean number- or mean weight-per-tow. Bottom temperature is also likely to have a significant effect on the distribution of *Illex* pre-recruits and recruits along with other environmental factors.

Further examination of catch and effort data, as well as by-catch data, may improve *Loligo* and *Illex* assessments. It was mentioned that the catchability of *Loligo* may vary within a fishery making the estimation of abundance using catch and effort data problematic. In addition, market prices for squid were cited as an important factor in determining fishing effort within a season. Uncertainty about the level of post-spawning and natural mortality was also discussed.

In summary, the discussion focussed on the direction of assessment research that should be pursued. Two, not necessarily dichotomous, possibilities were considered: continuing the status quo or increasing the technical level of assessment. It was argued that increasing the accuracy of technical assessments will be difficult due to data requirements and current uncertainties about the spatial and temporal distribution and life history parameters of both species. It was also argued that improving the current level of assessment is highly desirable given the magnitude of squid landings in comparison to other species.

There is currently a major fishery for squid in the Southwest Atlantic around the Falkland Islands. Dr. Andrew Rosenberg described the assessment and management system used there as background information for the discussion. Descriptions of assessment and management procedures for the Falkland fishery are discussed in Rosenberg *et al.* 1990 and Beddington *et al.* 1990.

REFERENCES

Rosenberg, A.A., G.P. Kirkwood, J.A. Crombie, and J.R. Beddington. 1990. The assessment of stocks of annual squid species. *Fish. Res.* 8:335-350.

Beddington, J.R., A.A. Rosenberg, J.A. Crombie, and G.P. Kirkwood. 1990. Stock assessment and the provision of management advice for the short-fin squid fishery in Falkland island waters. *Fish. Res.* 8:351-365.

OVERVIEW OF MARINE MAMMALS INVESTIGATION

BACKGROUND

Reauthorization of the Marine Mammal Protection Act (MMPA) in 1988 placed additional requirements on NMFS to monitor by-catch and determine optimum sustainable populations for marine mammal species. In 1990, the Center created a new research group, the Marine Mammal Investigation (MMI), to consolidate and expand its marine mammal research efforts. Dr. Tim Smith presented an overview of the work of the investigation. Research is organized into three projects: human interactions, optimum sustainable population size, and ecological roles and habitat requirements.

In the short term, MMI's highest priority is on the human interactions project. Objectives are to determine marine mammal by-catch rates, expand those rates to estimate total numbers killed in various commercial fisheries, and determine spatial/temporal differences in rates that may be useful for management. The focus will be on estimating the importance of the by-catch of marine mammals in the demersal gill net fishery in the Gulf of Maine and adjacent waters, and in the foreign and domestic Atlantic mackerel and squid trawl fisheries in the Mid-Atlantic Bight and Southern New England areas. Description of rates of by-catch and estimates of total kill are required for MMPA reauthorization in 1993.

In the medium term, the priority is on the optimum sustainable population size (OSP) project, where the focus is on estimating population sizes and vital rates for those species subject to by-catch in fisheries, and on monitoring humpback and right whale populations. Pilot whales and harbor porpoise are the main by-catch problem. Right and humpback whales are the subject of endangered species recovery plans.

Over the longer term, the priority will be on the ecological roles and habitat requirements project, which will focus on changes in predator-prey relationships, especially those involving interactions between pinnipeds and cetaceans and pelagic fishery resources in the Mid-Atlantic Bight and Southern New England. Studies are planned using geographic information system (GIS) technology to analyze co-distribution of marine mammals and fishery resources.

DISCUSSION

Research activities in FY91 will depend on funding and staffing levels. MMI will address all three research projects to some extent. Ecological studies on co-distribution of marine mammals and their prey were sidetracked when the R/V *Albatross IV* was decommissioned. Much of the research will be done under contract to others. A program review will be held in March/April 1991.

Concern was expressed over the effects of whale watching on right whales off Massachusetts. Airships could be used to observe the whales' behavior, but the priority for this work is not high now. Contract research is being done on right whale individual identification, habitat requirements, and population modeling.

NMFS is reviewing OSP methodology, which is based on the MMPA's rigid, single-species concept, and MMI is trying to organize a workshop with the Northwest Fisheries Center. Quality of the data is an important issue. Concern was voiced that the workshop would not supply information on alternatives to OSP in time to meet NMFS's January 1992 deadline for preparation of a draft environmental impact statement (EIS) for controlling incidental take. If NMFS does not have alternatives to OSP by then, it will have to proceed as is, with adverse consequences for fisheries.

Another unresolved issue is the by-catch of marine mammals in foreign fisheries. Harbor porpoise stock structure across the North Atlantic and in the North Sea is unclear. Beaked whales also could be affected if the swordfish driftnet fishery expands toward Iceland. MMI is exchanging tissue samples with other nations, and participates on several international scientific committees.

The needs of MMI will prompt a rethinking of resource survey boundaries: the shelf break 200 m contour is not sufficient to encompass marine mammal distributions offshore. There are some potential methodology interactions with other surveys, but marine mammal observers take up bunk space, and there are problems of shifting from one fishery to another. There are possible interactions with pelagic fisheries investigations, and MMI could use standard methodologies developed by others. But problems of covering under-tonnage vessels (important for marine mammals but not for demersal fishes) must be considered.

REVIEW OF AVAILABLE INFORMATION ON THE TILEFISH FISHERY

At the request of the Mid-Atlantic Fishery Management Council, Dr. Steve Murawski summarized the available information on tilefish.

Tilefish (*Lopholatilus chamaeleonticeps*) is found along the outer continental shelf from Nova Scotia to Surinam. In the Southern New England and Middle Atlantic Bight regions they concentrate in depths of 80 to 240 m, often occupying horizontal excavations in submarine canyon walls (*i.e.*, "pueblo villages"). The tilefish is a fairly long-lived species (maximum ages of 26 for males and 35 for females), and grow to 100 cm (females) and 112 cm (males) with weights up to 30+ kg. Growth rates are similar for both sexes for the first four years (about 10 cm per year), after which the rates diverge, with females growing slower. Sex ratios are skewed by age and size (females live longer, males grow larger).

The commercial exploitation of tilefish in the Southern New England-Middle Atlantic region began in 1915, and has followed a cyclic pattern since, ranging from 4,500 mt in 1916 to less than 1 mt during the 1940s and late 1960s (see Figure 1). Some of this fluctuation reflects changes in effort (e.g., no fishing during World War II, a developing longline fishery centered around New York and New Jersey in the late 1970s). The majority of landings (Figures 2 and 3) have come from statistical areas 616 and 526 (with the main landing ports in New York and New Jersey). There was an increase in effort from the mid 1970s to 1980 (Figure 4~~; a unit of effort measured as a 250-hook tub trawl~~ line), with a subsequent drop in 1981-82. CPUE analyses for this same period (Figure 5) show a consistent decline.

Yield-per-recruit (YPR) analyses give an F_{max} of 0.1 to 0.2, and estimates of mortality rates from 1987to 1982 suggested F = 0.4 to 0.6.

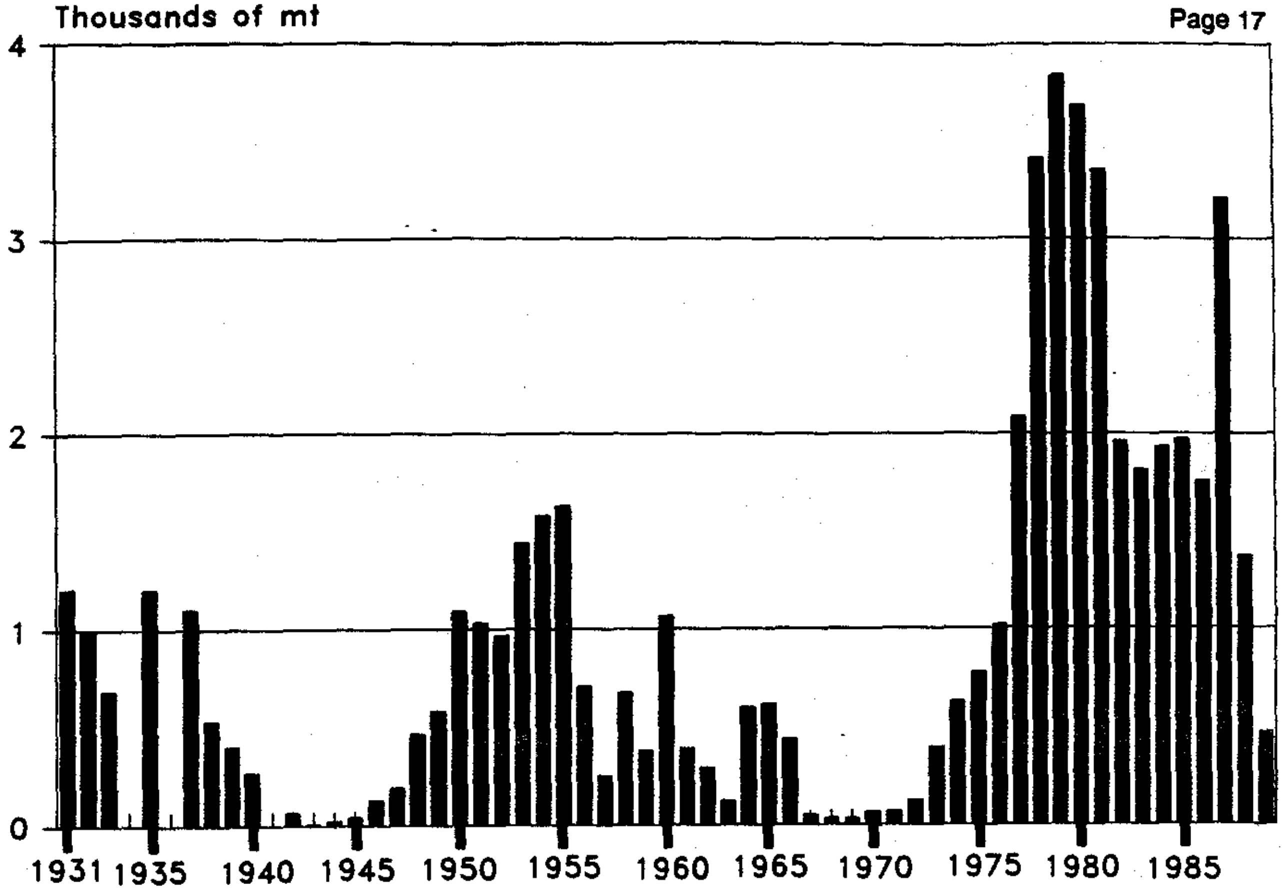


Figure 1. Tilefish landings in the southern New England-Middle Atlantic region, 1931-1989.

CONCERNS OF THE SAW

Several questions related to future work on this resource were raised during the discussion and are summarized below.

- Since the tilefish is similar to a reef fish (in terms of growth, and reproduction) the assumptions of conventional YPR methods do not hold. Work done on similar species (*e.g.*, black sea bass) and at the Southeast Center should be investigated and the sensitivity of the results of the analyses to violations of the underlying assumptions evaluated.

- Was the stock overfished and is it still being overfished? Is it depleted and in need of rebuilding?

- If we are data-limited, can the council (MAFMC) institute a 303 request for data necessary for an FMP, and institute a log book program? Should log books be mandatory or voluntary? The meeting generally concurred that a voluntary logbook system would be beneficial.

- Could sea sampling be used as a proxy for or supplement to log books?

- Should the VPA be updated with current CPUE data (old analysis was done in 1982, at the point landings began to decline again)? If so, do we need new age data, or can the old data be used along with the new CPUE and landings information? Whether this analyses is warranted depends on the need for management advice.

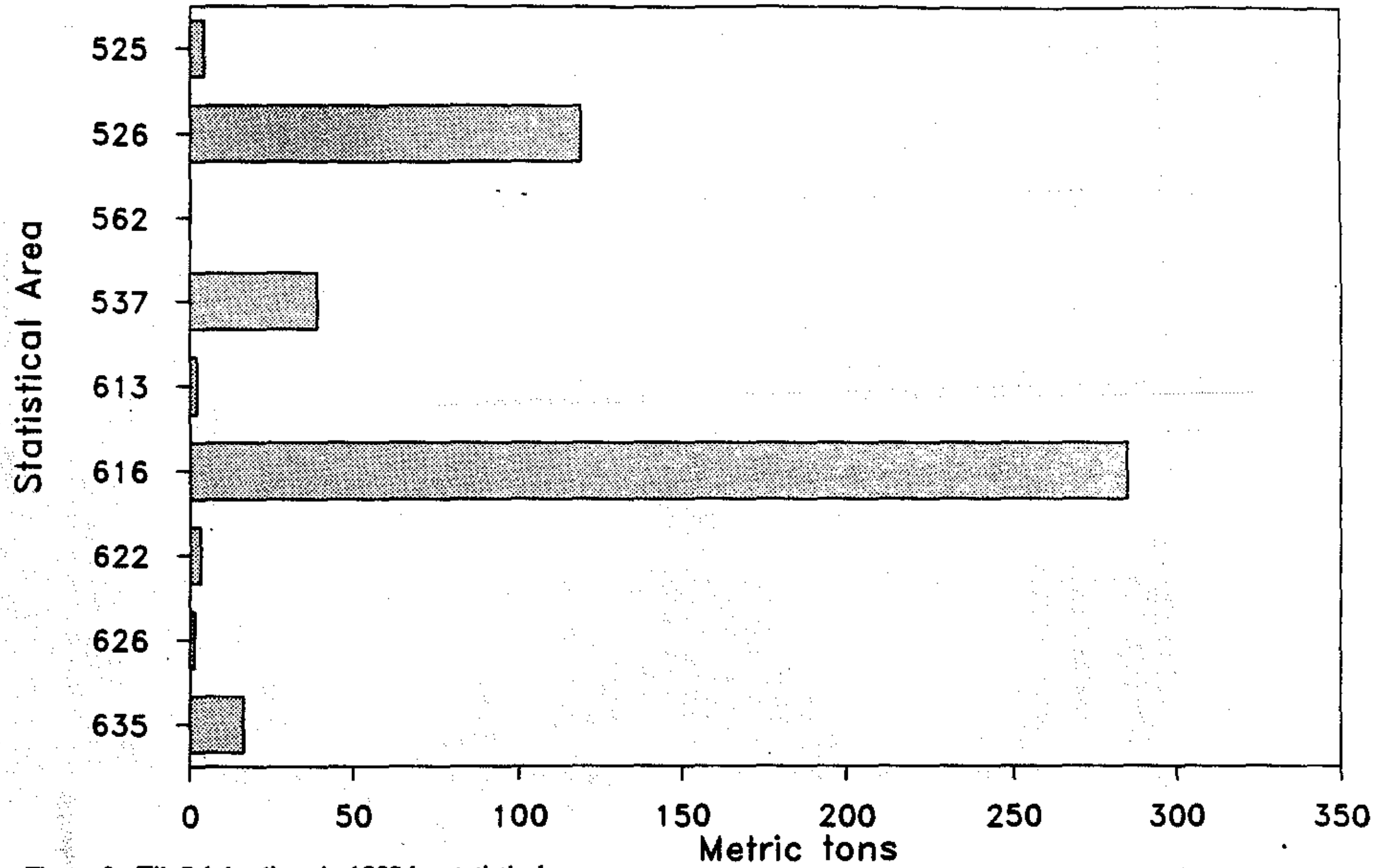


Figure 2. Tilefish landings in 1989 by statistical area.

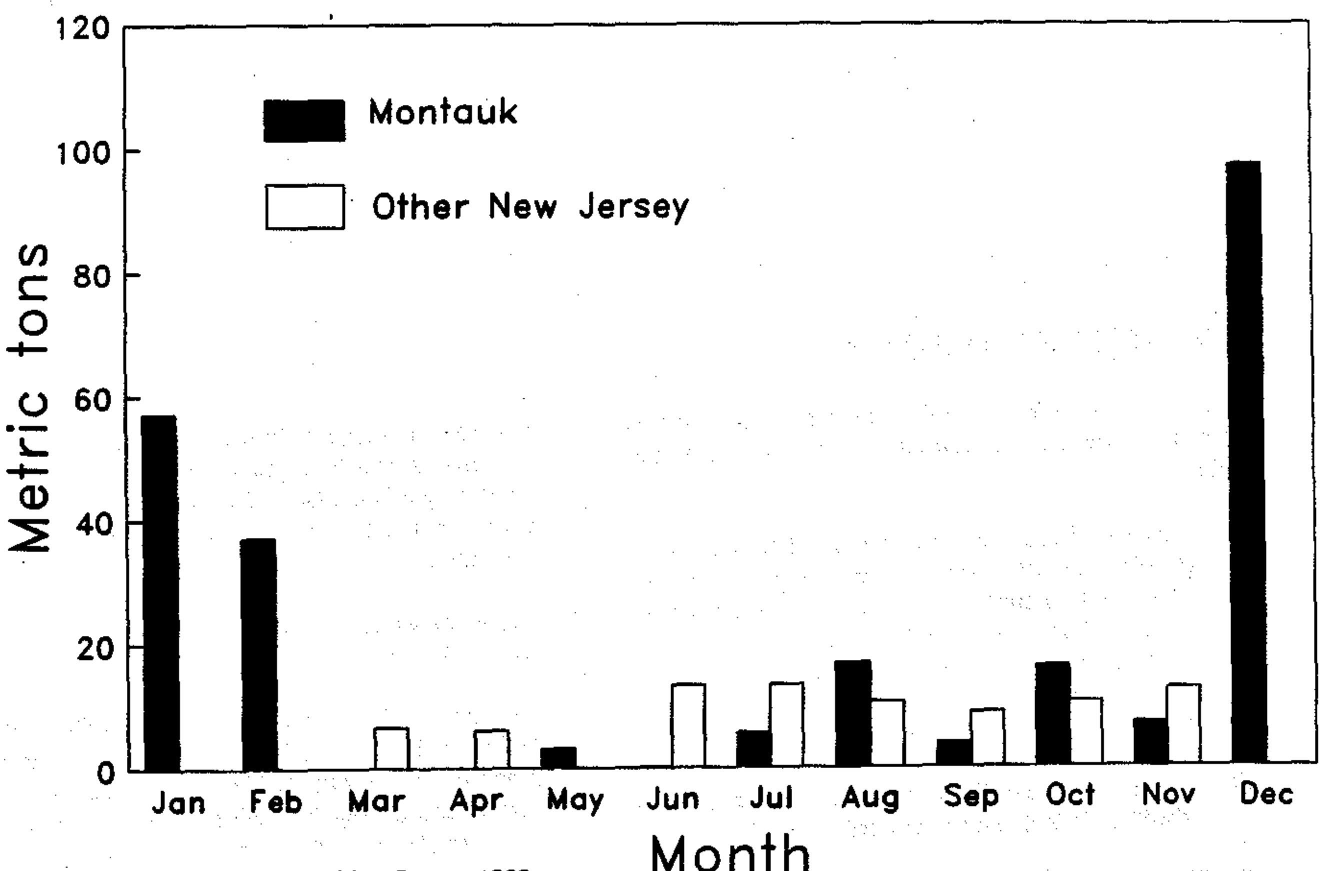


Figure 3. Tilefish landings in New Jersey, 1989.

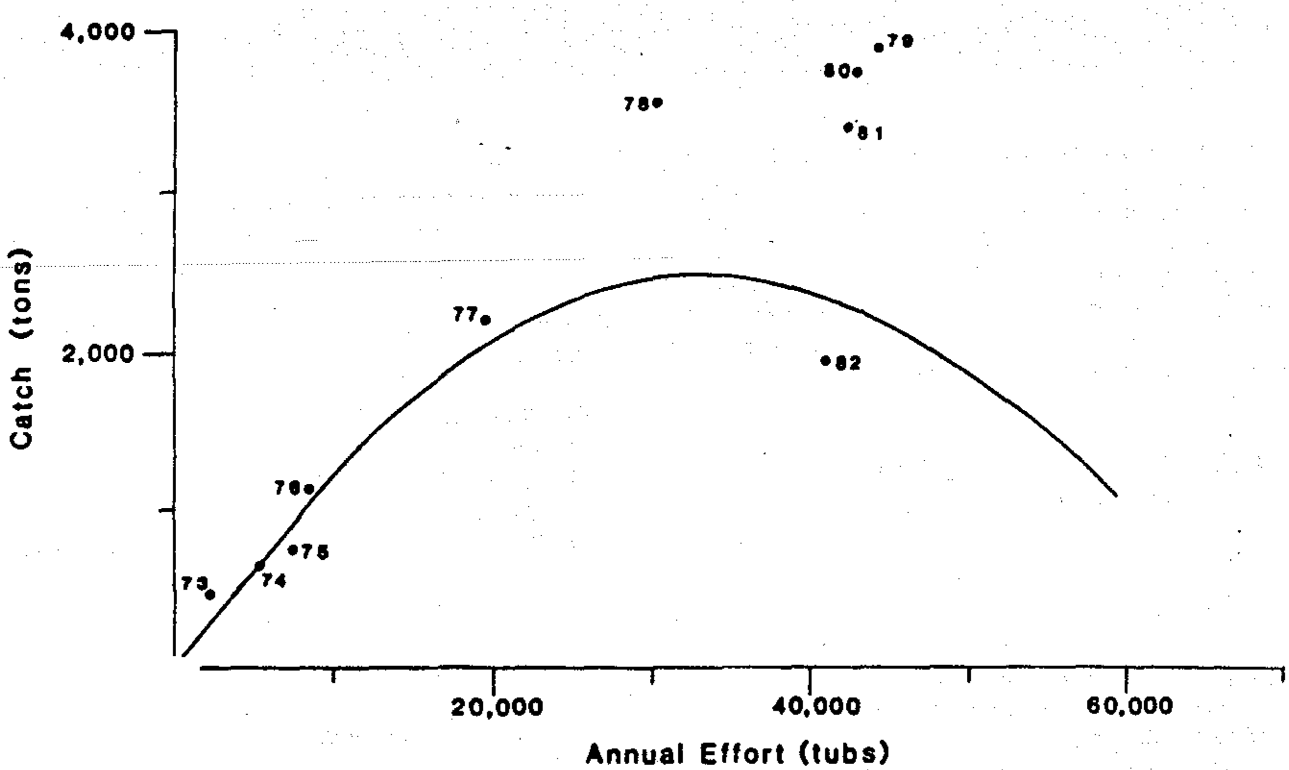


Figure 4. Tilefish, a unit-of-effort measured as a 250-hook tub trawl line.

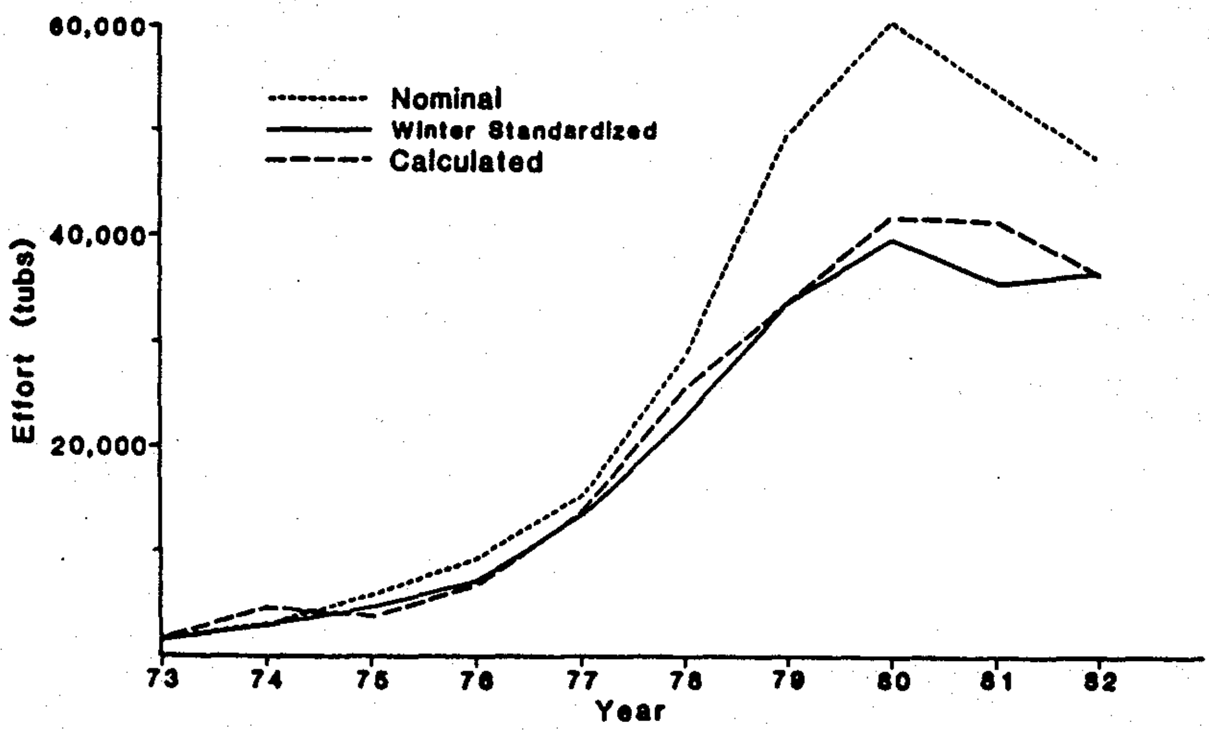


Figure 5. Catch-per-unit-effort analyses for tilefish, 1973-1982.

GUIDELINES FOR PRESENTATION OF ASSESSMENT REPORTS

Under the new structure of the SAW, technical reviews of assessment analyses are to be conducted on a regular basis. Standardizing the form in which assessment reports are presented would facilitate this process. Dr. Andrew Rosenberg presented a working draft of guidelines for assessment reports for discussion and revision by the Plenary. The recommended guidelines with additional comments by the session are given below.

RECOMMENDED GUIDELINES FOR PRESENTATION OF ASSESSMENT ANALYSES

These guidelines are intended to facilitate the reporting of assessment results to the SAW for review. Working groups and individual scientists should try to put their reports in this format wherever possible to help reviewers understand their work.

The section and subsections headings which should be included where possible are listed. If a section heading is not applicable to a report it should simply be omitted. However, if it is relevant but no data or analyses are available in the report, an explanatory note should be included. There are tables and figures associated with most sections. A brief description is needed for each table. Examples are given of table and figure formats.

Section Format

I. Title Page: At the top of the page please include in underline bold the statement:

This paper is not to be cited without permission of the senior author.

In the right hand corner please put an identification line in the format:

NEFC SAW/##/SARC/## for the Stock Assessment Review Committee
or

NEFC SAW/##/Pl/## for the Plenary Sessions

Numbers will be assigned by the Secretariat.

The title should identify the stock and the purpose of the paper. Please give authorship under the title and if he contact person for questions, revisions and data is n o t the first author please clarify in a footnote. if the paper is authored by a Working Group please designate a contact person and list the working group members in a page following the title page. The title page should be the first numbered page.

II. Introduction: Review briefly the context for the paper including:

- Stock definition
- History of the fishery
- Current fishing activity (scale, type of gear, where)
- Current management plan
- Reference to previous assessments if any (at least the most recent as appropriate)
- If paper is a response to a specific request

III. Data Sources

A. Commercial fishery data:

1. Landings in weight broken down by area, nation and gear type as appropriate with a totals column; include description of data sources (*e.g.* weigh-out;Table 1)

2. Length composition including sampling intensity for length and age (Table 2); include sampling intensity in numbers of fish sampled per 200 mt (not included in example)

3. Age composition of the landings

4. Discarding practices and analysis where available

5. Mean weights-at-age in the commercial catch (Table 3)

6. Commercial catch-at-age (Table 4)

7. Commercial CPUE and standardization analysis where available (Table 5)

B. Recreational fisheries data

1. Landings in weight by area with a totals column; include data source description (Table 6)

2. Length composition and sampling intensity for length and age. (Figure 1) In general, length frequency histograms should be plotted on the same scale for comparative purposes

3 Age composition

4. Released catch and hooking mortality

5. Mean weight at age in the recreational catch (as with Table 3)

6. Recreational catch at age (as with Table 4)

7. Recreational CPUE and standardization analysis where available

C. Research survey data:

1. Total abundance indices, catch per tow in weight and numbers, for each survey available including standard errors or coefficients of variation and sample sizes (Table 7) Eighty percent confidence intervals should be reported where possible

2 Abundance at age indices in numbers including recruitment and spawning stock biomass indices with standard errors (Table 8)

3. Length composition of the survey catch (as Figure 1)

4. Sampling intensity for age/length keys

5. Maturity at age

D. Other input data:

1. Life history parameters (*e.g.* natural mortality, growth)

2. Special studies (*e.g.* selectivity, tagging)

E. Totals

1. Include description of aggregation of the data to obtain, for example, the total catch at age matrix

2. Derived data such as stock weight at age at beginning of the year (Table 9)

IV. Analysis

A. Abundance and mortality

1. Relative abundance indices

a)Trends including interpretation, standard erors and tests of significance if possible

b)Mortality estimates from age and/or length composition

2 Absolute abundance estimates

a) Analytical assessment (*e.g.* VPA, DeLury): include method citation, description of input dataused from III above, interpretation and residual or other diagnostic analysis (Table 10 and 11)

b) Survey (*e.g.* acoustics) with precision and accuracy estimates if possible

3. Partial recruitment or selectivity: analytical assessment (*e.g.* SVPA) including diagnostics and residual analysis (Table 12)

B. Biological reference points

1. Yield-per-recruit/ spawning biomass per recruit

a) Input data; PR, weight-at-age, maturity at age, mortality rates

b) Table and graph of results with interpretation including reference points in fishing mortality and percent MSP (Table 13 and Figure 2)

2. Stock and recruitment analysis

a) Input data description

b) F_{rep} and other reference points (Figure 3)

c) Fitted relationship parameters if any and diagnostics.

3. Projections of catch and stock size

a) Input data description

b) Results with interpretation and assessment of uncertainty (Table 14)

V. Discussion

VI. Literature Cited

DISCUSSION

Several recommendations were discussed by the SAW Plenary under the commercial and recreational fishery data sections of the guidelines paper. It was decided that Table 2 was an appropriate addition to all assessment documents, but it should also include the number of age and length samples taken annually on a per ton basis. This would reflect the relative contribution of the samples. Although no table of discarding information was included in the guidelines, the participants felt that any information on discards that is available should be included whenever possible in assessment documents. Mean weight at age tables should be included in assessment documents and the methods used to obtain the data should be spelled out explicitly in the text and tables. The format for catch-at-age tables included in documents should have ages at the top and years along the side if a single table is produced. If a catch-at-age table is included with fishing mortality and stock size tables from a VPA, then the format should be years at the top and ages along the side.

Length frequency graphs should be included so that trends in cohorts and size distributions are easily followed. These figures should be bar graphs that contain the actual numbers of fish sampled. The same scale should be used on each axis of length frequency graphs.

Research survey results should include point estimates of catch per tow data with CVs and 80 percent CIs where possible. Fitted data from IMA models and other sources should be presented as figures with appropriate CIs. Age specific data was discussed, but it was agreed that age specific confidence intervals were not appropriate.

Standard VPA outputs should include F, stock size, and catch-at-age tables. Projections of catch and SSB should all reflect the assessment. A table of input values used in projections should be provided. It was agreed that the procedure used in the Lowestoft SVPA table with all diagnostics should also be included.

All Y/R figures should have SSB/R on the y axis instead of percent maximum SSB. Y/R tables should include a description of how the PR pattern used in the analysis was derived.

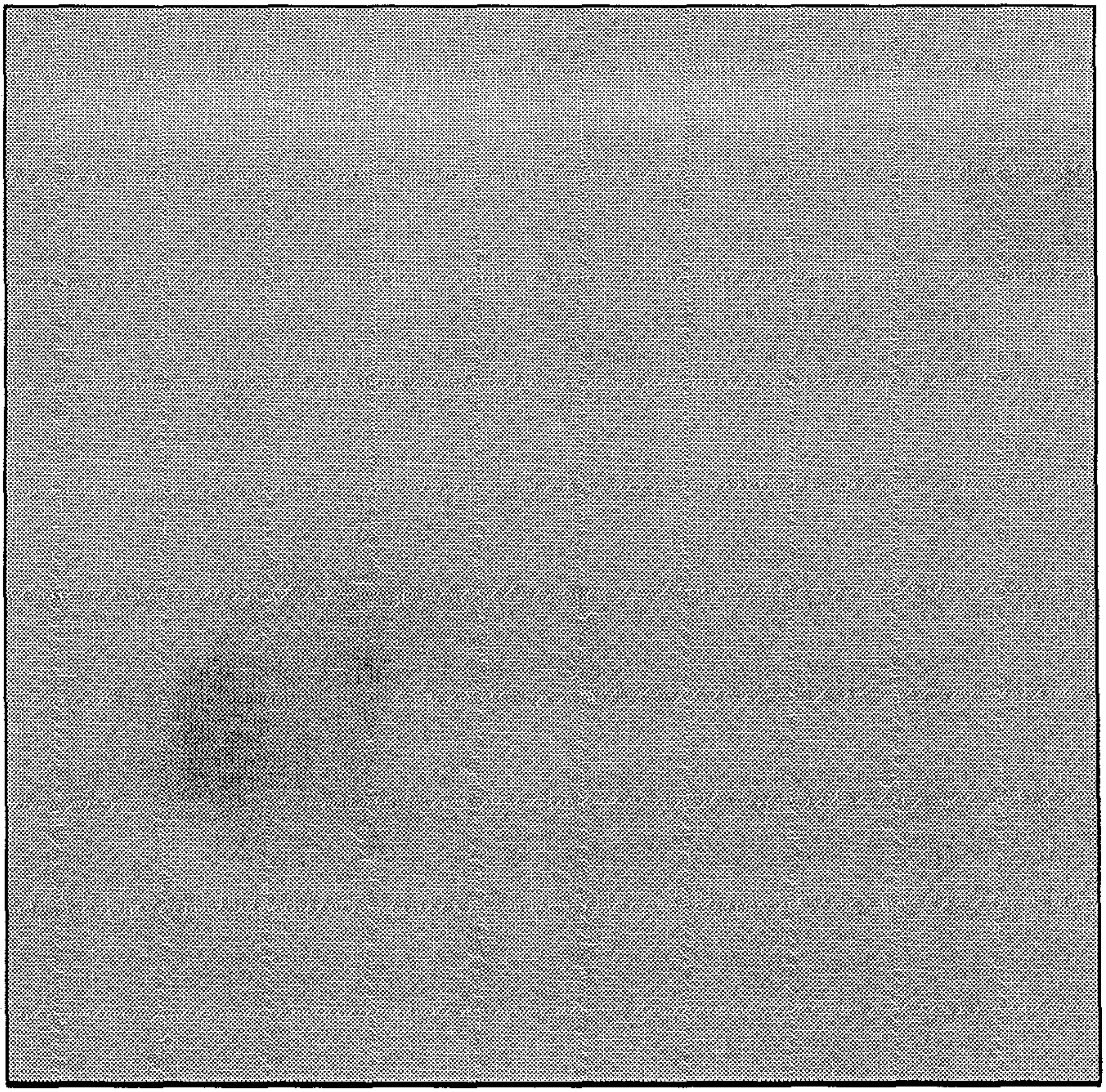


Table 1. Commercial landings (metric tons, live) of Atlantic cod from Georges Bank and South (NAFO Division 5Z and Statistical Area 6), and the Gulf of Maine (NAFO Division 5Y), 1960 - 1989.[1]

	Georges Bank and South					Gulf of Maine					Totals				
Year	USA	Canada	USSR	Other	Total	USA	Canada	USSR	Other	Total	USA	Canada	USSR	Other	Total
1960	10834	19	-	-	10853	3448	129	-	-	3577	14282	148	-	-	14430
1961	14453	223	55	-	14731	3216	18	-	-	3234	17669	241	55	0	17965
1962	15637	2404	5302	143	23486	2989	83	-	-	3072	18626	2487	5302	143	26558
1963	14139	7832	5217	1	27189	2595	3	133	-	2731	16734	7835	5350	1	29920
1964	12325	7108	5428	304	25165	3226	25	-	-	3251	15551	7133	5428	304	28416
1965	11410	10598	14415	1910	38333	3780	148	-	-	3928	15190	10746	14415	1910	42261
1966	11990	15601	16830	8713	53134	4008	384	-	-	4392	15998	15985	16830	8713	57526
1967	13157	8232	511	14852	36752	5676	297	-	-	5973	18833	8529	511	14852	42725
1968	15279	9127	1459	17271	43136	6360	61	-	-	6421	21639	9188	1459	17271	49557
1969	16782	5997	646	14514	37939	8157	59	-	268	8484	24939	6056	646	14782	46423
1970	14899	2583	364	7806	25652	7812	26	-	423	8261	22711	2609	364	8229	33913
1971	16178	2979	1270	7752	28179	7380	119	-	163	7662	23558	3098	1270	7915	35841
1972	13406	2545	1078	7230	25059	6776	53	11	77	6917	20182	2598	1089	7307	31976
1973	16202	3220	2977	6524	28923	6069	68	-	9	6146	22271	3288	2977	6533	35069
1974	18377	1374	476	7104	27331	7639	120	-	5	7764	26016	1494	476	7109	35095
1975	16017	1847	2403	4741	25008	8903	86	-	26	9015	24920	1933	2403	4767	34023
1976	14906	2328	933	1759	19926	10172	16	-	-	10188	25078	2344	933	1759	30114
1977	21138	6173	54	2	27367	12426	-	-	-	12426	33564	6173	54	2	39793
1978	26579	8904	-	-	35483	12426	-	-	-	12426	39005	8904	-	-	47909
1979	32645	6011	-	-	38656	11680	-	-	-	11680	44325	6011	-	-	50336
1980	40053	8094	-	-	48147	13528	-	-	-	13528	53581	8094	-	-	61675
1981	33849	8508	-	-	42357	12534	-	-	-	12534	46383	8508	-	-	54891
1982	39333	17862	-	-	57195	13582	-	-	-	13582	52915	17862	-	-	70777
1983	36756	12132	-	-	48888	13981	-	-	-	13981	50737	12132	-	-	62869
1984	32915	5761	-	-	38676	10806	-	-	-	10806	43721	5761	-	-	49482
1985	26828	10441	-	-	37269	10693	-	-	-	10693	37521	10441	-	-	47962
1986	17490	8508	-	-	25998	9664	-	-	-	9664	27154	8508	-	-	35662
1987	19035	11843	-	-	30878	7527	-	-	-	7527	26562	11843	-	-	38405
1988	26310	12725	-	-	39035	7958	-	-	-	7958	34268	12743	-	-	47011
1989	25097	7897	-	-	32994	10397	-	-	-	10397	35494	7897	-	-	43391

[1] USA landings from NMFS, NEFC Detailed Weighout Files and Canvass data; Canadian landings data for 1988 and 1989 from NAFO SCS Docs 88/18 and 89/21. Canadian landings data prior to 1988 from Hunt 1988, 1989 (CAFSAC Res Docs. 88/73; 89/47).

Table 2.

Table 4. USA and Canadian sampling of commercial Atlantic cod landings from the Georges Bank and South cod stock (NAFO Division 5Z and Statistical Area 6), 1978 - 1989.

	USA				Canada			
	Length Samples		Age Samples		Length Samples		Age Samples	
Year	No.	# Fish Measured	No.	# Fish Aged	No.	# Fish Measured	No.	# Fish Aged
1978	88	6841	76	1463	29	8027	29	1364
1979	80	6973	79	1647	13	3661	13	591
1980	69	4990	67	1119	10	2784	10	536
1981	59	4304	59	1231	17	4147	17	491
1982	151	11970	147	2579	17	4705	17	956
1983	146	12544	138	2945	15	3822	15	601
1984	100	8721	100	2431	7	1889	7	412
1985	100	8366	100	2321	29	7644	18	1064
1986	94	7515	94	2222	19	5759	19	888
1987	80	6395	79	1704	33	9130	33	1236
1988	76	6483	76	1576	40	10526	40	1927
1989	67	5648	67	1350	32		32	1561

Source: USA data: 1978-1985 from Serchuk and Wigley (Woods Hole Lab. Ref 86-12; USA data, 1986-1989, from NEFC files; Canadian data, 1978-1985, from Hunt and Gavaris 1986 (CAFSAC Res Doc 86/95); Canadian data, 1986-1989, from Hunt 1989 (CAFSAC Res Doc 89/47) and J. Hunt (pers. comm.).

Table 27. Mean weight (kg) at age of all landed summer flounder, ME-NC, 1982-88.

	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	0.491
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	0.290	0.474	0.648	1.158	1.985	2.699	3.968	3.913	4.500		0.584

Table 4.

Table 5. Catch at age (thousands of fish; metric tons) and mean weight (kg) and mean length (cm) at age of USA commercial landings of Atlantic cod from the Georges Bank and South cod stock (NAFO Division 5Z and Statistical Area 6), 1978 - 1989.

Year	Age 1	2	3	4	5	6	7	8	9	10	11+	Total
					USA Commercial Catch in Numbers (000's) at Age							
1978	-	331	5731	1636	625	53	288	35	28	8	-	8735
1979	34	1618	572	4107	910	403	59	244	-	31	14	7992
1980	88	3002	4707	286	1888	951	413	76	153	-	-	11564
1981	25	3060	3613	1960	101	1026	330	72	109	46	-	10342
1982	325	7855	2466	1682	1258	117	452	116	50	23	34	14378
1983	81	3542	3557	1244	854	722	85	218	88	26	36	12453
1984	81	1281	3305	2961	500	393	386	25	153	39	43	9167
1985	130	4280	1539	985	1388	273	173	165	12	68	18	9031
1986	137	1091	3290	432	337	412	58	53	38	4	22	5874
1987	12	4878	804	1380	188	173	153	41	23	14	4	7670
1988	-	1345	5662	688	1076	175	100	86	21	13	5	9171
1989	-	1770	2638	3237	207	362	51	20	13	-	-	8298
					USA Commercial Catch in Weight (Tons) at Age							
1978	-	438	14159	6041	2794	276	2168	274	356	81	-	26579
1979	30	2462	1411	17662	4525	2943	541	2507	-	417	147	32645
1980	74	4475	11663	1141	10937	6375	3504	657	1227	-	-	40053
1981	22	4592	8528	6644	524	7532	2773	716	1628	890	-	33849
1982	249	10960	7032	6465	6856	755	4281	1200	624	363	548	39333
1983	80	5303	13647	4271	4015	4628	679	2244	975	331	583	36756
1984	85	2099	8096	10650	2655	2655	3456	246	1739	508	726	32915
1985	118	6094	3320	3930	7219	1746	1397	1707	148	852	297	26828
1986	131	1586	7498	1475	1892	2964	528	537	507	56	316	17490
1987	10	6888	1953	5501	1063	1349	1306	392	242	185	66	19035
1988	-	2098	12981	2288	5677	1157	848	776	226	169	90	26310
1989	-	2958	5964	11861	1106	2403	439	209	157	-	-	25097
					USA Commercial Catch Mean Weight (kg) at Age							
1978	-	1.298	2.470	3.692	4.473	5.199	7.522	7.924	12.794	10.620	-	3.043
1979	0.889	1.522	2.464	4.301	4.974	7.309	9.127	10.264	-	13.435	10.620	4.085
1980	0.839	1.490	2.478	3.992	5.792	6.703	8.489	8.648	8.046	-	-	3.464
1981	0.885	1.501	2.360	3.389	5.209	7.339	8.397	9.988	14.884	19.527	-	3.274
1982	0.767	1.395	2.852	3.845	5.449	6.457	9.473	10.297	12.434	15.917	16.257	2.736
1983	0.993	1.497	2.436	3.434	4.703	6.407	7.955	10.280	11.091	12.970	16.213	2.952
1984	1.053	1.638	2.450	3.597	5.308	6.751	8.960	9.710	11.361	13.214	16.842	3.590
1985	0.914	1.424	2.157	3.989	5.201	6.398	8.075	10.355	12.107	12.431	16.877	2.971
1986	0.957	1.454	2.279	3.414	5.608	7.198	9.066	10.135	13.339	14.366	14.056	2.978
1987	0.801	1.412	2.429	4.043	5.657	7.811	8.520	9.466	10.621	13.124	18.177	2.482
1988	-	1.559	2.293	3.326	5.278	6.629	8.487	9.067	10.606	13.080	16.206	2.869
1989	-	1.672	2.260	3.664	5.351	6.632	8.686	10.673	11.622	-	-	3.025
					USA Commercial Catch Mean Length (cm) at Age							
1978	-	50.2	61.5	69.8	73.7	79.3	89.3	91.3	107.1	101.0	-	64.9
1979	44.7	52.9	61.0	73.9	77.5	88.2	95.3	99.4	-	108.4	101.0	70.9
1980	43.9	52.6	61.6	72.4	81.9	86.3	92.9	92.2	91.2	-	-	66.5
1981	44.6	52.3	60.4	68.5	78.4	88.7	93.1	98.2	112.8	123.2	-	64.6
1982	42.3	51.4	64.4	70.8	79.9	84.1	96.5	99.2	105.5	114.8	115.0	60.7
1983	46.3	52.7	61.5	68.1	75.9	84.5	90.7	99.1	101.5	107.4	114.8	63.3
1984	47.2	54.1	61.5	69.8	79.3	86.5	94.8	97.5	102.5	107.5	116.1	67.7
1985	45.1	51.8	58.6	72.4	79.0	84.5	91.4	99.4	104.7	105.5	117.0	62.5
1986	45.8	52.0	60.1	67.6	81.1	88.2	95.2	98.7	108.2	111.3	109.5	63.2
1987	43.3	51.7	61.3	72.7	81.6	90.9	93.2	96.6	100.1	107.3	120.0	59.4
1988	-	53.6	60.3	67.6	79.2	85.5	92.7	94.8	100.1	107.5	115.0	63.4
1989	-	54.7	60.1	70.0	79.3	85.3	94.2	100.4	103.6	-	-	64.8

Table 5.

Table 6. Indices of abundance (mean total catch number per angler-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 trip (year, subregion, and fishing mode main effects) and the catch rate for the standard (1988, Mid -Atlantic, private/rental boat strata).

YEAR	MID-ATLANTIC (NY-VA) PRIVATE/RENTAL BOAT MEAN TOTAL NUMBER/TRIP			COASTWIDE GLM INDEX		
	MEAN	L95	U95	MEAN	L95	U95
1979	4.755	4.387	5.123	2.550	1.980	3.327
1980	4.210	3.973	4.447	2.829	2.160	3.707
1981	4.241	3.996	4.486	3.132	2.379	4.125
1982	4.421	4.137	4.705	3.891	2.969	5.099
1983	5.243	4.929	5.557	3.874	2.876	5.217
1984	5.307	4.931	5.683	2.782	2.162	3.576
1985	3.324	3.106	3.542	2.490	1.911	3.248
1986	4.503	4.250	4.756	3.915	2.964	5.169
1987	5.965	5.632	6.298	3.372	2.531	4.494
1988	4.756	4.495	5.017	3.402	2.501	4.631
1989	2.145	1.992	2.229	2.145	-----	-----

Table 6.

Table 2. 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 - 1989.

Year	North Atlantic [1,2]		Mid-Atlantic [2]		All Regions	
	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

[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 7.

Table 3. Summer flounder spring offshore mean weight per tow delta values fitted to an ARIMA model with theta value = 0.240.

YEAR	DELTA MEAN	FITTED MEAN	FITTED UPPER 95% ci	FITTED LOWER 95% ci
1968	0.16	0.16		
1969	0.16	0.15		
1970	0.09	0.12		
1971	0.28	0.23	0.390	0.136
1972	0.21	0.26	0.447	0.156
1973	0.52	0.52	0.892	0.311
1974	1.27	1.08	1.833	0.639
1975	1.63	1.51	2.563	0.894
1976	1.94	1.77	2.999	1.045
1977	1.84	1.66	2.816	0.982
1978	1.50	1.22	2.071	0.722
1979	0.35	0.55	0.931	0.324
1980	0.79	0.73	1.241	0.432
1981	0.81	0.81	1.378	0.480
1982	1.15	0.91	1.546	0.539
1983	0.52	0.59	0.996	0.347
1984	0.38	0.51	0.863	0.301
1985	1.21	0.89	1.514	0.528
1986	0.85	0.76	1.281	0.446
1987	0.39	0.48	0.817	0.285
1988	0.66	0.51	0.864	0.311
1989	0.24	0.30	0.494	0.177
1990	0.27	0.28	0.490	0.157

Table 4. Summer flounder spring offshore mean # per tow (fitted delta values), NEFC survey offshore strata 1-12, 61-76.

	AGE											
YEAR	0	1	2	3	4	5	6	7	8	9	10	TOTAL
1976	0.00	0.03	1.50	0.60	0.25	0.06	0.01	0.01				2.46
1977	0.00	0.54	1.17	0.62	0.09	0.08	0.01		0.01			2.51
1978	0.00	0.52	0.71	0.49	0.14	0.03	0.02	0.02			0.01	1.92
1979	0.00	0.11	0.32	0.15	0.07	0.06			0.02			0.73
1980	0.00	0.01	0.64	0.28	0.13	0.02	0.05	0.03	0.01		0.01	1.18
1981	0.00	0.58	0.52	0.17	0.08	0.05	0.03	0.02	0.01			1.46
1982	0.00	0.53	1.09	0.09	0.02							1.72
1983	0.00	0.36	0.44	0.21	0.05	0.01				0.01		1.08
1984	0.00	0.24	0.46	0.13	0.07		0.01	0.01				0.93
1985	0.00	0.42	1.18	0.16	0.03	0.02						1.80
1986	0.00	1.23	0.36	0.17	0.02	0.01						1.78
1987	0.00	0.55	0.51	0.02	0.02							1.11
1988	0.00	0.41	0.57	0.05	0.02							1.05
1989	0.00	0.07	0.32	0.03	0.01							0.45
1990	0.00	0.56	0.03	0.05								0.64

Table 9.

Table 8. Mean weight at age (kg) at the beginning of the year (January 1) for Atlantic cod from the Georges Bank and South cod stock (NAFO Division 5Z and Statistical Area 6), 1978 - 1989. Values derived from catch mean weight-at-data (mid-year) using procedures described by Rivard (1980).

	Age										
Year	1	2	3	4	5	6	7	8	9	10	11+ [a]
1978	(0.663)	0.933	1.873	3.180	(3.852)	(4.477)	6.433	(7.620)	(10.164)	(12.829)	17.300
1979	0.674	1.157	1.782	3.260	4.286	5.716	6.893	8.789	(9.553)	13.079	17.300
1980	0.628	1.144	1.942	3.134	4.991	5.776	7.877	(9.040)	(10.774)	(12.578)	17.300
1981	0.688	1.122	1.875	2.898	4.557	6.520	7.506	9.195	11.361	(14.861)	17.300
1982	0.549	1.102	2.069	3.012	4.297	5.799	8.340	9.311	11.128	15.424	17.300
1983	0.766	1.072	1.851	3.130	4.253	5.907	7.157	9.874	10.692	12.702	17.300
1984	0.913	1.282	1.929	2.990	4.311	5.666	7.596	8.835	10.821	12.045	17.300
1985	0.725	1.206	1.887	3.172	4.384	5.981	7.478	9.750	11.283	12.034	17.300
1986	0.737	1.164	1.840	2.803	4.766	6.163	7.703	9.045	11.587	13.456	17.300
1987	0.501	1.173	1.906	3.197	4.610	6.576	8.027	9.452	10.599	13.092	17.300
1988	0.584	1.047	1.866	2.935	4.742	6.199	8.225	9.458	10.078	12.168	17.300
1989	(0.584)	1.130	1.846	2.950	4.293	5.937	7.407	9.659	10.826	12.166	17.300

[a] Mean weight-at-age values for 11+ set equal to mean (1978-1989) catch (mid-year) weight at age value for 11+.

( ) Values in parentheses are modified from calculated values.

Table 10.

Table 14. Summary statistics from Laurec-Shepherd tuning of VPA for Georges Bank cod (NAFO Division 5Z and Statistical Area 6), 1978 - 1989.

Disaggregated q's; Log transformation; No explanatory variate (mean used).
Fleet 1 (NEFC Spring Survey) has terminal q estimated as the mean.
Fleet 2 (NEFC Autumn Survey) has terminal q estimated as the mean.
Fleet 3 (USA Fleet) has terminal q estimated as the mean.
Fleets combined by ** variance **; terminal F's estimated using Laurec/Shepherd method.
Oldest age F = 1.0 * average of 5 younger ages. Fleets combined by variance of prediction.

Fishing mortalities

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	0.000	0.002	0.007	0.001	0.029	0.013	0.003	0.022	0.004	0.002	0.001	0.000
2	0.165	0.099	0.238	0.343	0.449	0.440	0.216	0.390	0.251	0.277	0.169	0.193
3	0.408	0.409	0.470	0.528	0.626	0.592	0.722	0.716	0.488	0.488	0.527	0.572
4	0.376	0.496	0.375	0.383	0.613	0.674	0.593	0.673	0.584	0.431	0.742	0.574
5	0.375	0.321	0.456	0.228	0.551	0.653	0.548	0.736	0.542	0.399	0.623	0.542
6	0.105	0.383	0.669	0.508	0.546	0.637	0.660	0.708	0.646	0.598	0.740	0.462
7	0.362	0.143	0.886	0.547	0.534	0.895	0.821	0.691	0.399	0.614	0.986	0.528
8	2.388	0.509	0.279	0.383	0.453	0.480	0.689	0.991	0.540	0.534	1.401	0.667
9	0.210	0.316	0.716	0.880	0.618	0.660	0.726	0.836	0.665	0.565	1.347	1.572
10	0.688	0.334	0.601	0.509	0.541	0.665	0.689	0.792	0.559	0.542	1.020	0.754

Log catchability estimates

Age 1

Fleet	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	-11.54	-11.22	-13.37	-9.93	-10.62	-10.59	-11.52	-11.22	-10.70	-12.81	-10.08	-11.22
2	-12.21	-11.08	-12.03	-12.04	-11.25	-10.62	-10.57	-11.03	-10.48	-11.77	-11.32	-11.08
3	-21.25	-16.06	-15.04	-17.13	-13.72	-14.46	-15.81	-14.09	-15.46	-16.98	-19.86	-20.56

SUMMARY STATISTICS

Fleet	Pred. q	SE(q)	Partial F	Raised F	SLOPE	SE Slope	INTRCPT	SE Intrcpt
1	-11.24	1.057	0.0000	0.0000	0.000E+00	0.000E+00	-11.235	0.293
2	-11.29	0.624	0.0000	0.0000	0.000E+00	0.000E+00	-11.290	0.173
3	-16.70	2.664	0.0013	0.0013	0.000E+00	0.000E+00	-16.701	0.739

Fbar	SIGMA(int.)	SIGMA(ext.)	SIGMA(overall)	Variance ratio
0.000	0.527	0.553	0.553	1.103

Age 2

Fleet	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	-10.01	-10.00	-9.25	-8.88	-9.13	-9.05	-9.94	-8.81	-9.43	-9.75	-9.53	-8.91
2	-9.54	-9.46	-9.35	-9.73	-9.89	-9.86	-9.60	-9.31	-10.08	-9.41	-10.03	-9.54
3	-11.62	-12.13	-11.45	-11.09	-10.98	-10.92	-11.62	-11.47	-11.39	-11.77	-12.07	-12.03

SUMMARY STATISTICS

Fleet	Pred. q	SE(q)	Partial F	Raised F	SLOPE	SE Slope	INTRCPT	SE Intrcpt
1	-9.39	0.471	0.0001	0.1193	0.000E+00	0.000E+00	-9.392	0.131
2	-9.58	0.309	0.0001	0.1842	0.000E+00	0.000E+00	-9.583	0.086
3	-11.54	0.429	0.2298	0.3135	0.000E+00	0.000E+00	-11.545	0.119

Fbar	SIGMA(int.)	SIGMA(ext.)	SIGMA(overall)	Variance ratio
0.193	0.221	0.240	0.240	1.172

Table 10. (con't.)

Table 14 (continued).

Age 3

Fleet	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	-8.57	-9.07	-8.85	-8.24	-8.52	-8.76	-9.19	-8.37	-8.54	-8.92	-8.50	-8.66
2	-8.82	-8.99	-9.06	-9.84	-8.05	-9.14	-8.94	-10.82	-9.36	-9.89	-9.34	-9.44
3	-10.71	-10.72	-10.77	-10.66	-10.64	-10.63	-10.46	-10.81	-10.86	-11.36	-11.13	-10.79

SUMMARY STATISTICS

Fleet	Pred. q	SE(q)	Partial F	Raised F	SLOPE	SE Slope	INTRCPT	SE Intrcpt
1	-8.68	0.294	0.0002	0.5590	0.000E+00	0.000E+00	-8.683	0.082
2	-9.31	0.707	0.0001	0.6506	0.000E+00	0.000E+00	-9.307	0.196
3	-10.79	0.248	0.4869	0.5725	0.000E+00	0.000E+00	-10.794	0.069

Fbar	SIGMA(int.)	SIGMA(ext.)	SIGMA(overall)	Variance ratio
0.572	0.183	0.257E-01	0.183	0.020

Age 4

Fleet	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	-9.15	-8.99	-8.83	-8.46	-8.24	-8.52	-8.94	-7.56	-8.25	-8.77	-8.10	-8.23
2	-9.23	-7.97	-8.52	-9.23	-8.06	-9.76	-9.31	-8.18	-9.50	-9.44	-9.40	-8.99
3	-10.80	-10.52	-10.99	-10.98	-10.67	-10.50	-10.70	-10.78	-10.98	-11.28	-10.81	-10.88

SUMMARY STATISTICS

Fleet	Pred. q	SE(q)	Partial F	Raised F	SLOPE	SE Slope	INTRCPT	SE Intrcpt
1	-8.50	0.474	0.0002	0.4376	0.000E+00	0.000E+00	-8.502	0.131
2	-8.97	0.646	0.0001	0.5863	0.000E+00	0.000E+00	-8.967	0.179
3	-10.82	0.230	0.4729	0.6104	0.000E+00	0.000E+00	-10.823	0.064

Fbar	SIGMA(int.)	SIGMA(ext.)	SIGMA(overall)	Variance ratio
0.574	0.197	0.881E-01	0.197	0.200

Age 5

Fleet	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	-8.40	-9.18	-8.56	-8.83	-8.28	-8.27	-8.24	-7.50	-7.40	-9.34	-8.20	-7.60
2	-9.30	-8.36	-8.24	-9.09	-8.85	-10.58	-10.34	-8.37	-8.96	-11.13	-9.40	-8.76
3	-10.80	-10.96	-10.80	-11.49	-10.77	-10.53	-10.82	-10.61	-10.80	-11.32	-10.91	-11.10

SUMMARY STATISTICS

Fleet	Pred. q	SE(q)	Partial F	Raised F	SLOPE	SE Slope	INTRCPT	SE Intrcpt
1	-8.32	0.638	0.0002	0.2656	0.000E+00	0.000E+00	-8.317	0.177
2	-9.28	0.972	0.0001	0.3202	0.000E+00	0.000E+00	-9.282	0.270
3	-10.91	0.289	0.4344	0.6568	0.000E+00	0.000E+00	-10.908	0.080

Fbar	SIGMA(int.)	SIGMA(ext.)	SIGMA(overall)	Variance ratio
0.542	0.254	0.253	0.254	0.992

Age 6

Fleet	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	-8.90	-9.02	-8.40	-8.18	-10.08	-8.61	-7.91	-7.48	-7.35	-7.75	-8.88	-7.84
2	-8.48	-8.43	-8.87	-9.42	-8.86	-10.10	-10.11	-10.68	-9.18	-8.83	-9.35	-8.74
3	-12.07	-10.78	-10.41	-10.69	-10.78	-10.55	-10.68	-10.62	-10.69	-10.91	-10.74	-11.20

SUMMARY STATISTICS

Fleet	Pred. q	SE(q)	Partial F	Raised F	SLOPE	SE Slope	INTRCPT	SE Intrcpt
1	-8.37	0.814	0.0002	0.2734	0.000E+00	0.000E+00	-8.367	0.226
2	-9.25	0.740	0.0001	0.2758	0.000E+00	0.000E+00	-9.254	0.205
3	-10.84	0.450	0.4633	0.6566	0.000E+00	0.000E+00	-10.844	0.125

Fbar	SIGMA(int.)	SIGMA(ext.)	SIGMA(overall)	Variance ratio
0.462	0.347	0.302	0.347	0.757

Table 10. (con't.)

Table 14 (continued).

Age 7

Fleet	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	-7.75	-9.08	-8.42	-8.15	-8.53	-8.20	-8.35	-7.33	-8.16	-7.97	-8.98	-7.68
2	-8.11	-8.20	-8.25	-9.77	-7.87	-11.75	-12.62	-8.95	-12.30	-8.46	-9.49	-11.84
3	-10.83	-11.77	-10.13	-10.62	-10.80	-10.22	-10.50	-10.64	-11.16	-11.06	-10.59	-11.07

SUMMARY STATISTICS

Fleet	Pred. q	SE(q)	Partial F	Raised F	SLOPE	SE Slope	INTRCPT	SE Intrcpt
1	-8.22	0.530	0.0003	0.3080	0.000E+00	0.000E+00	-8.217	0.147
2	-9.80	1.891	0.0001	4.0390	0.000E+00	0.000E+00	-9.802	0.525
3	-10.78	0.463	0.4926	0.7051	0.000E+00	0.000E+00	-10.783	0.128

Fbar	SIGMA(int.)	SIGMA(ext.)	SIGMA(overall)	Variance ratio
0.528	0.343	0.390	0.390	1.291

Age 8

Fleet	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	-6.37	-8.72	-9.70	-7.60	-8.88	-8.50	-10.75	-7.07	-7.03	-8.87	-7.88	-7.01
2	-8.07	-7.62	-9.33	-8.38	-9.00	-11.01	-12.36	-9.00	-11.81	-8.87	-11.83	-8.53
3	-8.93	-10.50	-11.29	-10.97	-10.97	-10.84	-10.67	-10.27	-10.75	-11.06	-10.60	-11.10

SUMMARY STATISTICS

Fleet	Pred. q	SE(q)	Partial F	Raised F	SLOPE	SE Slope	INTRCPT	SE Intrcpt
1	-8.20	1.326	0.0003	0.2034	0.000E+00	0.000E+00	-8.199	0.368
2	-9.65	1.709	0.0001	0.2165	0.000E+00	0.000E+00	-9.651	0.474
3	-10.66	0.640	0.5563	1.0291	0.000E+00	0.000E+00	-10.661	0.177

Fbar	SIGMA(int.)	SIGMA(ext.)	SIGMA(overall)	Variance ratio
0.667	0.546	0.503	0.546	0.848

Age 9

Fleet	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	-7.57	-5.98	-9.31	-13.56	-9.12	-12.08	-7.92	-6.58	-6.61	-7.77	-10.58	-5.54
2	-8.99	-4.35	-7.92	-8.96	-7.73	-12.88	-10.45	-8.41	-9.78	-11.06	-10.58	-6.51
3	-11.37	-10.80	-10.34	-10.13	-10.66	-10.52	-10.64	-10.46	-10.44	-11.05	-10.76	-10.77

SUMMARY STATISTICS

Fleet	Pred. q	SE(q)	Partial F	Raised F	SLOPE	SE Slope	INTRCPT	SE Intrcpt
1	-8.57	2.593	0.0002	0.0764	0.000E+00	0.000E+00	-8.568	0.719
2	-8.90	2.216	0.0001	0.1433	0.000E+00	0.000E+00	-8.901	0.615
3	-10.66	0.339	0.5532	1.7509	0.000E+00	0.000E+00	-10.663	0.094

Fbar	SIGMA(int.)	SIGMA(ext.)	SIGMA(overall)	Variance ratio
1.572	0.333	0.382	0.382	1.315

Table 11.

Table 15. Estimates of fishing mortality (F), stock size (thousands of fish) and stock biomass (metric tons) derived from Virtual Population Analysis (VPA) for Georges Bank and (NAFO Division 5Z and Statistical Area 6), 1978 - 1989.

AGE	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
						FISHING MORTALITY						
1	-	0.002	0.007	0.001	0.029	0.013	0.003	0.022	0.004	0.002	0.001	-
2	0.165	0.099	0.238	0.342	0.447	0.440	0.216	0.390	0.251	0.277	0.169	0.193
3	0.408	0.408	0.469	0.326	0.625	0.587	0.722	0.716	0.488	0.488	0.527	0.372
4	0.375	0.494	0.375	0.382	0.610	0.670	0.584	0.673	0.584	0.431	0.742	0.574
5	0.375	0.320	0.454	0.228	0.350	0.646	0.543	0.714	0.542	0.399	0.623	0.542
6	0.105	0.382	0.667	0.505	0.544	0.634	0.645	0.695	0.610	0.599	0.740	0.462
7	0.349	0.143	0.882	0.543	0.528	0.888	0.814	0.662	0.387	0.553	0.987	0.528
8	0.322	0.481	0.280	0.380	0.448	0.471	0.677	0.968	0.501	0.509	1.075	0.667
9	0.227	-	0.648	0.889	0.610	0.648	0.702	0.805	0.633	0.496	1.192	0.700
10	0.322	0.372	-	0.427	0.551	0.649	0.664	0.738	0.519	0.496	0.782	0.558
11+	-	0.372	-	-	0.551	0.649	0.664	0.738	0.519	0.496	0.782	0.558
F(3-8,U)	0.322	0.372	0.521	0.427	0.551	0.649	0.664	0.738	0.519	0.496	0.782	0.558
F(3-8,W)	0.389	0.437	0.490	0.468	0.591	0.606	0.650	0.709	0.511	0.462	0.569	0.564

AGE	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
						STOCK SIZE							
1	27245	22932	17823	42463	18220	9308	28587	8176	42713	13779	18527	(41000)'	(18300)
2	3195	22306	18738	14496	34738	14490	7523	23332	6550	34830	11255	15154	(33568)
3	25051	2218	16534	12094	8429	18199	7639	4964	12929	4172	21626	7781	10232
4	7663	13645	1208	8466	5852	3695	8288	3037	1986	6499	2098	10453	3595
5	2926	4312	6815	680	4729	2605	1548	3783	1268	907	3438	818	4819
6	782	1647	2563	3544	443	2234	1118	736	1516	604	498	1518	390
7	1434	577	920	1077	1751	211	970	480	301	675	272	195	783
8	183	828	409	312	512	846	71	352	203	167	318	83	94
9	200	-	419	253	175	268	432	30	109	101	82	89	35
10	40	131	-	180	85	78	115	175	11	48	50	20	36
11+	-	57	-	-	126	87	126	46	70	17	42	18	18
TOTNO	68719	68653	65429	83565	75060	52021	56417	45111	67656	61799	58226	77129	71870
SPWNO	33359	29756	30974	29057	31080	27543	20471	19565	18870	24249	26915	24608	29222

AGE	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
						STOCK BIOMASS AT AGE							
1	18064	15456	11193	29215	10003	7130	26100	5928	31479	6903	10020	(23944)	(9937)
2	2981	25808	21436	16265	38281	15534	9645	28139	7624	40855	11784	17124	(37495)
3	46920	3952	32118	22676	17440	33687	14736	9367	23789	7953	40355	14364	19165
4	24368	44483	3784	24533	17627	11565	24782	9634	5567	20778	6157	30835	10882
5	11273	18483	34011	3098	20321	11878	6471	16586	6044	4180	16399	3512	21917
6	3503	9416	14804	23187	2570	13195	6336	4403	9346	3972	3089	9012	2432
7	9224	3974	7251	8085	14687	1580	7367	3591	2317	5415	2236	1442	6175
8	1394	7279	3697	2869	4769	8349	627	3431	1835	1582	3085	801	695
9	2037	-	4515	2875	1944	2863	4679	333	1268	1047	830	962	368
10	511	1710	-	2660	1314	987	1381	2111	146	623	611	249	449
11+	-	978	-	-	2188	1503	2179	795	1216	290	729	310	311
TOTBIO	120275	131539	132801	135391	131064	107399	104503	84318	90631	93618	96015	102555	110337
SPWNBIO	84682	89926	92451	83642	83784	74769	61731	51788	46378	54345	62960	58762	66366

Spawning stock numbers and biomass are at spawning time (i.e., March 1).

Table 12.

Table 31. Results of separable virtual population analysis, 1985-1988, ages 0-4, summer flounder.

```
NATURAL MORTALITY =  0.200
       TERMINAL F =  1.500
       TERMINAL S =  1.000

       REFERENCE AGE (FOR UNIT SELECTION) IS  2

       NO. OF ITERATIONS CHOSEN IS   30
       MINIMUM DIFFERENCE BETWEEN ITERATIONS IS 10**-5

    ITERATION   SSQ
        1     43.7316
       21      0.6231

 APPROX. COEFF. VARIATION OF CATCH DATA =  22.8 %


YEAR   1985   1986   1987   1988
F(I) 1.5544 1.5321 1.2200 1.5000
S(J) 0.0428 0.4634 1.0000 1.0361 1.0000


LOG CATCH RATIO RESIDUALS 22
        85/86  86/87  87/88

 0/ 1  -0.087  0.156 -0.070        -0.001
 1/ 2  -0.022 -0.156  0.180         0.001
 2/ 3  -0.309  0.012  0.300         0.002
 3/ 4   0.420 -0.009 -0.409         0.002

        0.001  0.002  0.001         0.004
```

Table 13.

Table 32. Summary of input data and results, 1990 revised yield per recruit analysis for summer flounder, age 0-15 model.

Fraction F before spawning = 0.83
Fraction M before spawning = 0.83
First age = 0
Last age = 15

AGE	FPATTERN	MPATTERN	MATURITY	WEIGHT IN CATCH AND STOCK (KG)
0	0.050	0.200	0.380	0.237
1	0.500	0.200	0.720	0.432
2	1.000	0.200	0.900	0.642
3	1.000	0.200	0.970	1.164
4	1.000	0.200	0.990	1.811
5	1.000	0.200	1.000	2.449
6	1.000	0.200	1.000	3.074
7	1.000	0.200	1.000	3.434
8	1.000	0.200	1.000	4.380
9	1.000	0.200	1.000	4.841
10	1.000	0.200	1.000	5.336
11	1.000	0.200	1.000	5.767
12	1.000	0.200	1.000	6.135
13	1.000	0.200	1.000	6.445
14	1.000	0.200	1.000	6.704
15	1.000	0.200	1.000	6.917

SLOPE AT FFACTOR = 0: 10.090
$F_{0.01}$: 0.136
F_{max}: 0.232

FFACT	MFACT	CATCH WEIGHT	SPAWN WEIGHT	PERCENT MAX. SPAWN WEIGHT
0.00	1.00	0.0000	9.4975	1.0000
0.02	1.00	0.1711	8.0073	0.8431
0.10	1.00	0.4903	4.5022	0.4740
0.20	1.00	0.5756	2.5925	0.2730
0.30	1.00	0.5660	1.6880	0.1777
0.40	1.00	0.5433	1.1969	0.1260
0.60	1.00	0.4878	0.7146	0.0752
0.80	1.00	0.4457	0.4953	0.0522
1.00	1.00	0.4158	0.3772	0.0397
1.20	1.00	0.3943	0.3055	0.0322
1.40	1.00	0.3786	0.2582	0.0272
1.60	1.00	0.3669	0.2249	0.0237
1.80	1.00	0.3578	0.2001	0.0211
2.00	1.00	0.3506	0.1810	0.0191

Table 14.

Table I7a. COD STOCK PROJECTIONS

PROJECTION 1: STATUS QUO F

$F(1990) = F_{SQ} = 0.56$; thereafter $F = F_{SQ} = 0.56$

YEAR	1990	1991	1992
Jan 1 2+ Stock Size (000's)	53570	45715	40241
Mar 1 SSB (mt)	66208	72961	69529
Annual Catch (mt)	40015	43768	40538

PROJECTION 2: $F_{0.1}$

$F(1990) = F_{SQ} = 0.56$; thereafter $F = F_{0.1} = 0.149$

YEAR	1990	1991	1992
Jan 1 2+ Stock Size (000's)	53570	45715	49505
Mar 1 SSB (mt)	66208	77855	103783
Annual Catch (mt)	40015	13892	17765

PROJECTION 3: F_{max}

$F(1990) = F_{SQ} = 0.56$; thereafter $F = F_{max} = 0.274$

YEAR	1990	1991	1992
Jan 1 2+ Stock Size (000's)	53570	45715	46325
Mar 1 SSB (mt)	66208	76332	91686
Annual Catch (mt)	40015	24177	27951

PROJECTION 4: F_{rep}

$F(1990) = F_{SQ} = 0.56$; thereafter $F = F_{rep} = 0.47$

YEAR	1990	1991	1992
Jan 1 2+ Stock Size (000's)	53570	45715	41994
Mar 1 SSB (mt)	66208	74005	75769
Annual Catch (mt)	40015	38136	37820

Table 14. (con't.)

Table I7b. Detailed information on cod status quo projection
($F_{90} = F_{91} = F_{92} = 0.56$

Jan 1 Stock size ('000s) (number)

Age	1990	1991	1992
1	18300	20000	20000
2	33568	14929	16316
3	10232	21440	9535
4	3595	4785	10027
5	4819	1681	2238
6	390	2254	786
7	783	182	1054
8	94	366	85
9	35	44	171
10	36	16	21
11	18	16	8
Mar 1 SSB (mt)			
1	480.3	524.9	524.9
2	13570.4	6035.4	6596.0
3	14183.0	29719.1	13217.4
4	9299.8	12378.6	25938.2
5	19309.3	6736.7	8966.9
6	2143.0	12383.9	4320.5
7	5440.1	1267.2	7322.8
8	788.7	3072.3	715.6
9	323.8	406.7	1584.4
10	395.7	179.9	226.0
11	274.4	256.6	116.7
Annual catch (mt)			
1	45.6	49.8	49.8
2	10230.4	4549.9	4972.6
3	9451.7	19805.2	8808.2
4	5347.2	7117.4	14913.9
5	10367.9	3617.2	4814.7
6	1064.6	6151.7	2146.2
7	2664.3	620.6	3586.4
8	375.6	1463.2	340.8
9	151.9	190.8	743.1
10	193.6	88.0	110.6
11	122.1	114.2	51.9

Figure 1.

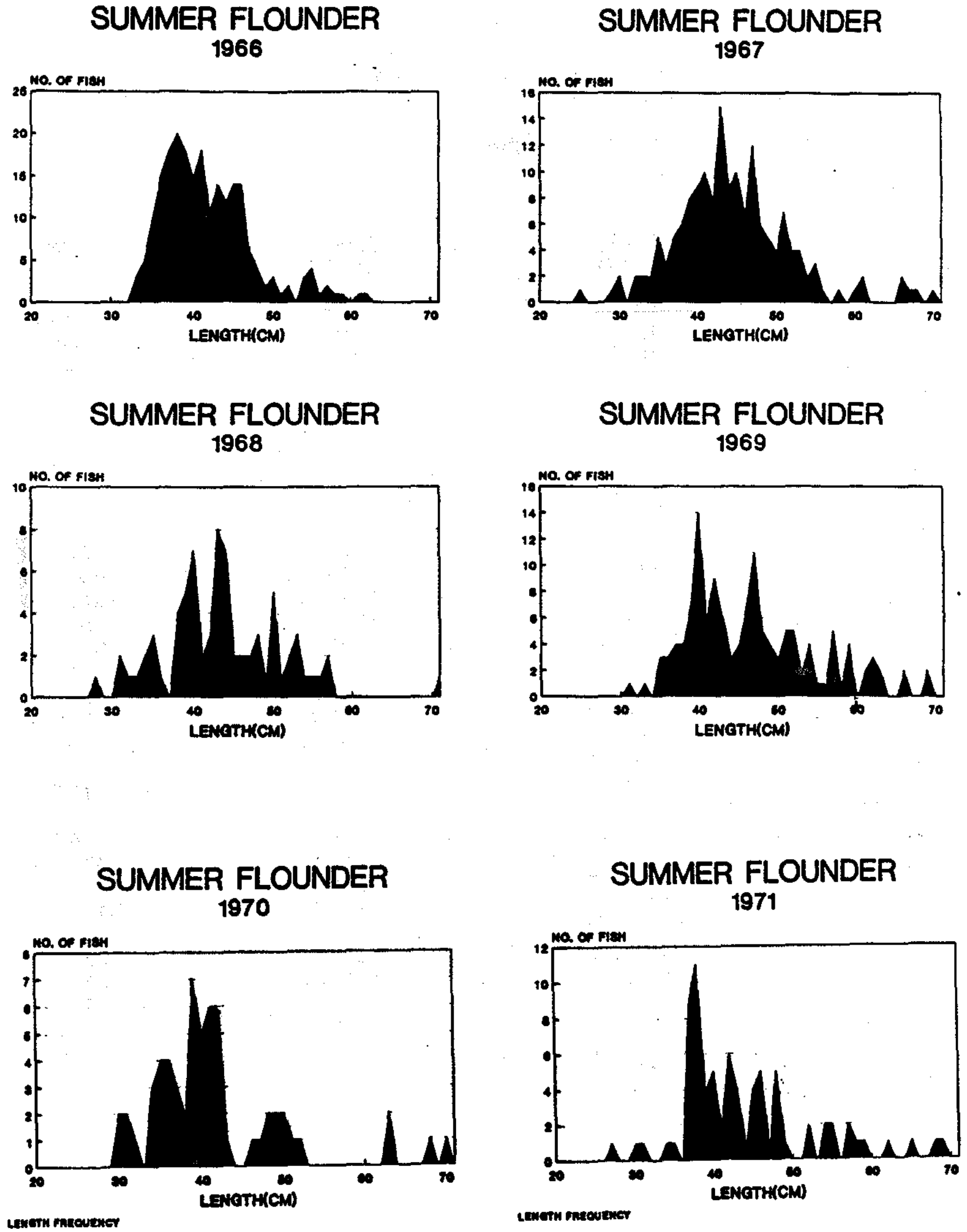
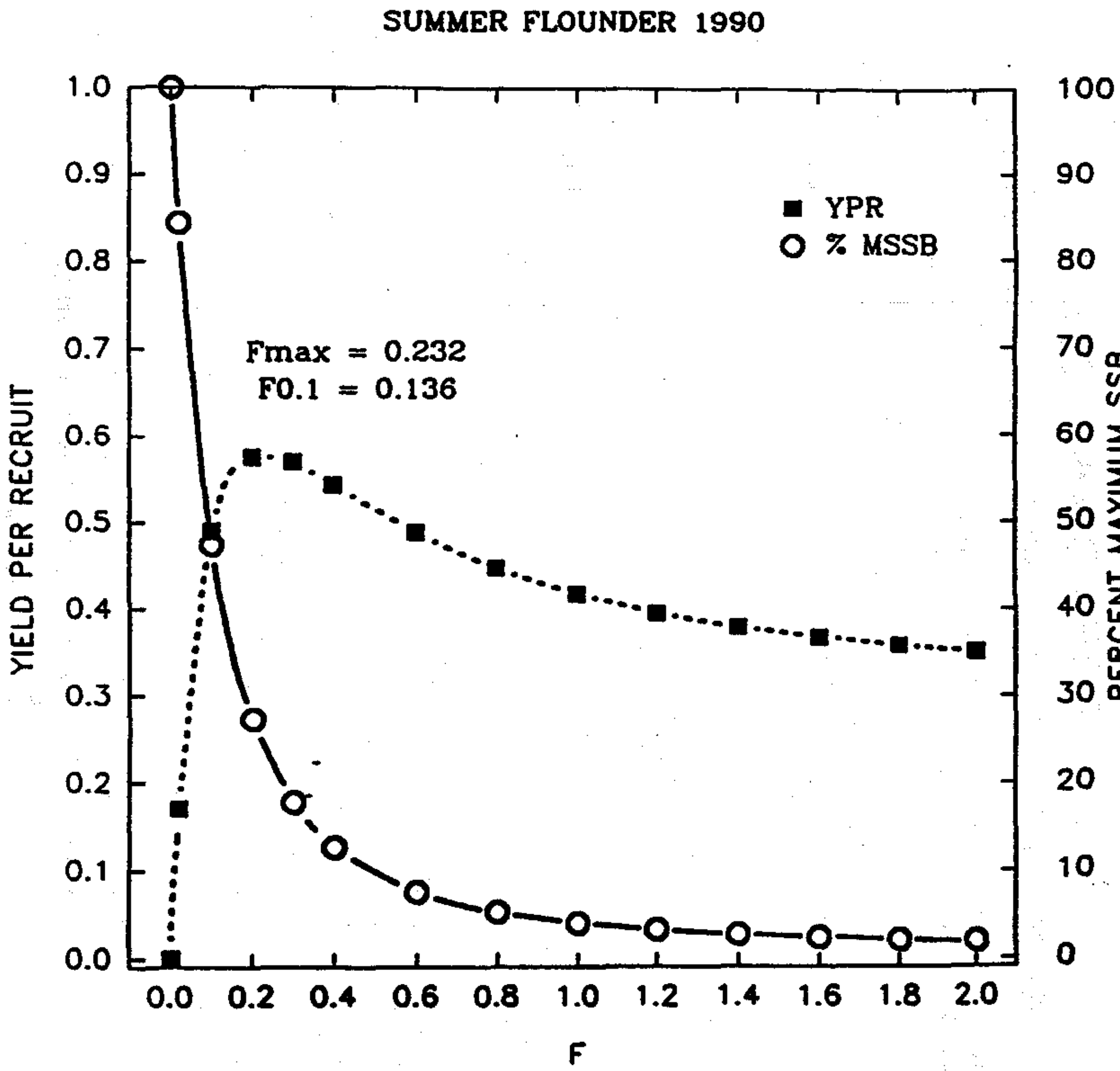


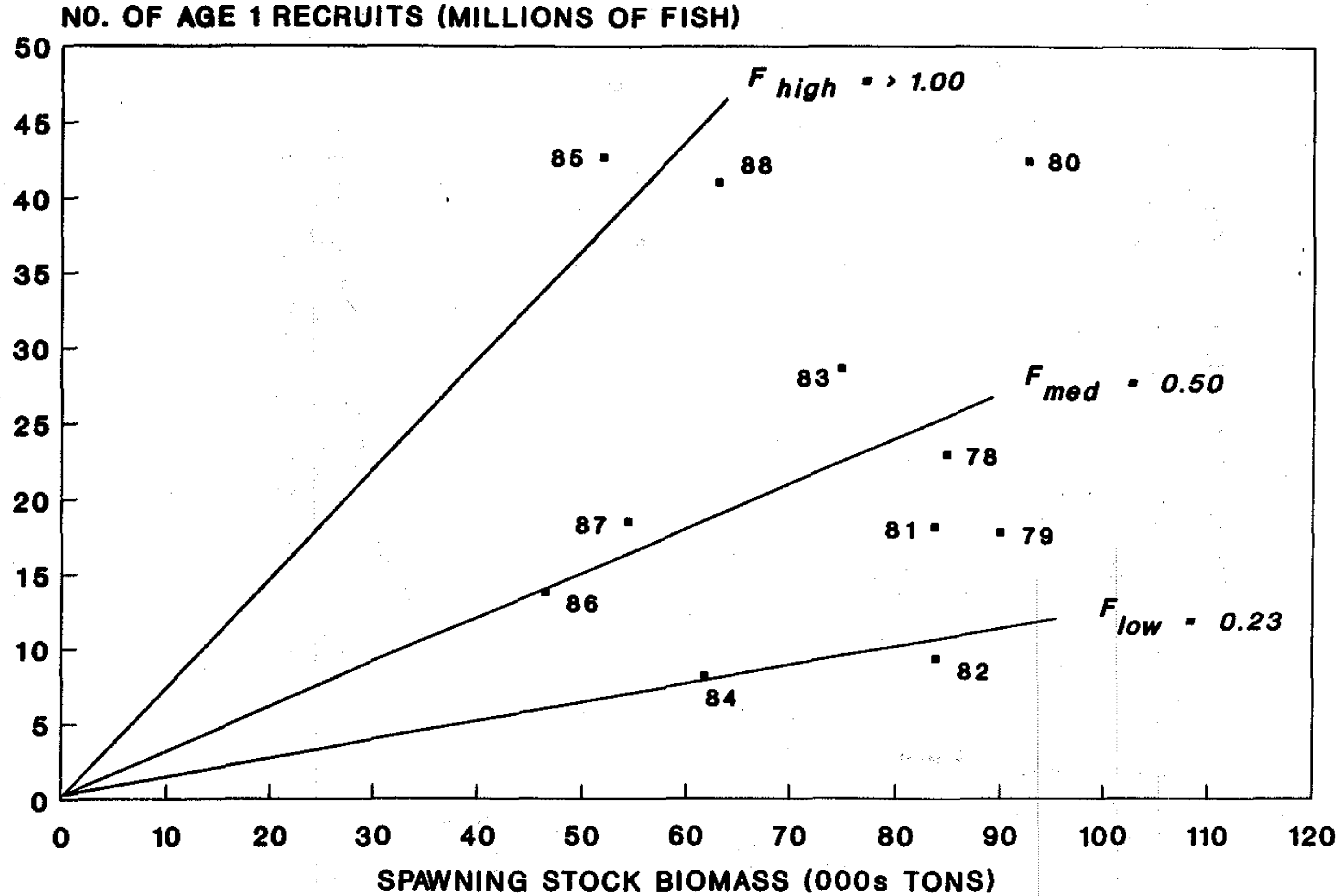
Figure 2. Length frequency distribution of summer flounder, Delaware Bay, Delaware Division of Fish and Wildlife trawl survey, 1966-71, 1979-84, 1990.

Figure 2.


SUMMER FLOUNDER 1990
YIELD PER RECRUIT
PERCENT MAXIMUM SSB
F
YPR
% MSSB
Fmax = 0.232
F0.1 = 0.136
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
100
90
80
70
60
50
40
30
20
10
0
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0

GEORGES BANK COD

STOCK AND RECRUITMENT SCATTERPLOT



OVERVIEW OF SEA SAMPLING PROGRESS

Darryl Christensen, Chief of the NEFC Fishery Statistics and Economics Branch, reviewed activities in the Sea Sampling Program since its initiation in 1988. Fieldwork and development of software modules for data processing are continuing under separate contracts to the Manomet Observatory and Technology Management Systems. To date modules have been developed for the trawl, gill net, and marine mammal databases. Data for these fisheries have been processed and are available through July of 1990. Length frequency data are available for 1989. Modules for length frequency data are being developed internally. Modules have not as yet been developed for pot, shellfish dredge, and longline fisheries. Currently, a new fieldwork contract is being advertised and should be awarded by the first of the year. The present contract is constrained by the number of trips initially specified; the new one will allow for additional trips with increased funding.

Less than 1 percent of all fishing trips in New England and Mid-Atlantic fisheries are now being covered in the program. Work to date has raised a number of challenging problems and issues such as the large number of variables and the volume of data being collected, trip definition in space and time, and the need to find acceptable proration procedures, particularly for effort data. Experience and information being gained in working with these data are providing valuable insights for dealing with similar problems in other data sets and analyses.

A summary of work completed to date is as follows:

Year	Number of Trips	Days Absent	Number of Tows
1989 (Jan-Dec)	357	896	3,601
1990(Jan-June)	174	355	1,607

Roughly one-third of the total number of trips were made in the groundfish sink gill net fishery, primarily due to the need for information on marine mammal kills. More detailed breakdowns of trips in each year are given in Table 1.

Several data sets for 1989 were reviewed. For the northern shrimp fishery, whiting, Atlantic herring, cod, red hake and dabs were the major discard components and for most of these species the amount discarded substantially exceeded the amount landed (Table 2). For American plaice, simple prorations based on ratio of shrimp landings to discard by weight and mean weight of discarded fish provided a 1989 discard estimate of 4.4 million dabs for this fishery. For the large mesh trawl fishery, most of the groundfish catch was kept with skates and dogfish being the major discard components (Table 3).

Examination of data for the Southern New England yellowtail flounder trawl fishery indicated that landings by weight for some other species (whiting, *Loligo* squid) were higher and that discard by weight of yellowtail in 1989 exceeded landings by more than four to one (Table 4). In the offshore winter fishery for summer flounder, landings were also higher for *Loligo* with sea robins, skates and spiny dogfish being the major discard components (Table 5). The species composition of the catch in this fishery differed in several respects from that observed for the spring 1989 groundfish survey, *e.g.*, 82 percent of the survey catch consisted of spiny dogfish with summer flounder being a relatively minor component. Several factors, *e.g.*, fishing patterns and gear configuration, could have contributed to the discrepancy; but the result was surprising in that earlier studies had indicated a much closer correspondence.

Table 1. Preliminary summary of domestic trips, January through December 1989, and January through June 1990

Fishery	Number of Trips	Days Absent	Number of Hauls
January Through December 1989			
Trawl			
Northern shrimp	48	57	161
Exempted fisheries	24	30	87
Large mesh Gulf of Maine & Georges Bank	68	308	1,507
Experimental whiting	10	35	130
Southern New England	50	112	545
Mid-Atlantic	28	93	400
Pots			
Black sea bass	9	9	115
Lobster	3	17	105
Gill net			
Groundfish, sink	102	131	472
Mackerel, drift	2	2	25
Swordfish, drift	13	102	54
Total	**357**	**896**	**3,601**
January Through June 1990			
Trawl			
Northern shrimp	31	33	83
Large mesh Gulf of Maine and Georges Bank	18	79	406
Southern New England	22	77	361
Mid-Atlantic	20	53	270
Experimental whiting	1	4	18
Pots			
Black sea bass	3	3	43
Lobster	2	11	52
Gill net			
Groundfish, sink	76	89	368
Swordfish, drift	1	6	6
Total	**174**	**355**	**1,607**

Table 2. Gulf of Maine northern shrimp trawl fishery, January through May 1989 and December 1989 through May 1990; all observed hauls using shrimp trawls

Species	Catch-Hail Weight in Pounds Kept	Discarded	Total
January through May 1989[1]			
Northern shrimp	36,805	24	36,829
Silver hake	2,263	8,592	10,855
Atlantic herring	965	5,562	6,527
Atlantic cod	2,919	3,150	6,069
Red hake	2,097	3,594	5,691
American plaice	1,041	3,846	4,887
Skates	128	1,228	1,356
Redfish	864	352	1,216
Lobster	66	1,133	1,199
Witch flounder	299	292	591
Sculpins	0	500	500
Pollock	235	182	417
Angler	250	83	333
White hake	35	193	228
Winter flounder	108	90	198
Ocean pout	0	176	176
Spiny dogfish	0	175	175
Yellowtail flounder	94	44	138
Lumpfish	0	92	92
Northern puffer	0	79	79
Smelt	0	72	72
Wolffishes	65	0	65
Atlantic halibut	50	5	55
Cusk	30	15	45
Blueback herring	0	25	25
December 1989 Through May 1990[2]			
Northern shrimp	44,209	30	44,239
Silver hake	3,651	6,368	10,019
Red hake	3,813	2,901	6,714
Atlantic cod	2,112	4,517	6,629
American plaice	683	5,731	6,414
Atlantic herring	1,345	2,923	4,268
Skates	212	2,186	2,398
Redfish	415	837	1,252
Sculpins	0	784	784
White hake	205	322	527
Lobster	18	507	525
Winter flounder	173	315	488
Angler	361	97	458
Witch flounder	132	275	407
Yellowtail flounder	89	184	273
Atlantic mackerel	235	35	270
Pollock	38	151	189
Ocean pout	0	177	177
Red & white hake mix	10	116	126
Lumpfish	0	91	91
Cusk	15	68	83
Windowpane flounder	0	79	79
Unclassified crab	0	44	44
Sea robins	0	43	43
Unclassified scallops	0	36	36

[1] 31 trips, 38 days absent, 94 hauls
[2] 36 trips, 38 days absent, 96 hauls

Table 3. Gulf of Maine and Georges Bank large mesh trawl fishery hauls, January through July, 1990 and January through December, 1989; all observed hauls where the cod end mesh was 5.5 inches or greater and no liner was used

Species	Catch - Hail Weight in Pounds Kept	Discarded	Total
January Through December, 1989[1]			
Skates	5,468	195,189	200,657
Atlantic cod	129,441	6,588	135,429
Spiny dogfish	591	60,189	60,780
Pollock	49,812	3,137	52,949
White hake	17,967	2,091	20,058
Haddock	17,808	1,558	19,366
American plaice	13,834	3,592	17,426
Winter flounder	16,067	182	16,249
Angler	10,242	860	11,102
Witch flounder	9,047	428	9,475
Ocean pout	54	8,486	8,540
Yellowtail flounder	6,073	1,485	7,558
Cusk	6,667	71	6,738
Rock crab	0	6,201	6,201
Sculpins	0	6,146	6,146
Northern puffer	0	5,893	5,893
Redfish	5,125	237	5,362
Windowpane flounder	4,346	635	4,981
Red hake	2,124	2,433	4,557
Unclassified crab	0	3,265	3,265
Squid (*Illex*)	78	3,157	3,235
Wolffishes	2,596	207	2,803
Lobster	897	647	1,544
Unclassified flounders	545	0	545
Mussels	0	537	537
January Through July, 1990[2]			
Skates	19,970	80,121	100,091
Atlantic cod	90,362	4,931	95,293
Silver hake	14,041	7,676	21,717
Haddock	17,801	613	18,414
Winter flounder	15,224	312	15,536
Spiny dogfish	0	9,853	9,853
Yellowtail flounder	7,112	2,725	9,837
Red hake	1,296	7,730	9,026
Pollock	7,075	382	7,457
Ocean pout	0	7,417	7,417
Windowpane flounder	4,042	1,507	5,549
Angler	5,129	397	5,526
American plaice	3,722	1,650	5,372
Fourspot flounder	0	4,104	4,164
Witch flounder	2,601	480	3,081
White hake	2,743	162	2,905
Sculpins	0	2,806	2,806
Lobster	884	1,246	2,130
Rock crab	0	1,920	1,920
Butterfish	1,050	508	1,558
Cusk	1,392	0	1,392
Redfish	1,178	145	1,323
Squid (*Illex*)	0	1,225	1,225
Mussels	0	1,194	1,194
Starfish	0	605	605

[1] 48 trips, 232 days absent, 675 hauls
[2] 21 trips, 111 days absent, 333 hauls

Table 4. Southern New England yellowtail flounder trawl fishery, January through December 1989; all observed hauls in statistical areas 526, 537, 538, 539 and 613 catching at least 100 pounds of yellowtail flounder

Species	Catch-Hail Weight in Pounds		
	Kept	Discarded	Total
Skates	945	146,358	147,303
Yellowtail flounder	13,815	64,829	78,644
Silver hake	30,635	13,419	44,054
Squid (*Loligo*)	36,274	4,564	40,838
Spiny dogfish	0	30,279	30,279
Ocean pout	970	25,420	26,390
Butterfish	4,765	11,999	16,764
Sculpins	0	15,617	15,617
Windowpane flounder	2,327	13,164	15,491
Atlantic cod	11,415	894	12,309
Red hake	375	11,245	11,620
Winter flounder	2,255	3,033	5,288
Fourspot flounder	0	5,250	5,250
Scup	2,641	1,615	4,256
Atlantic herring	25	3,081	3,106
Atlantic mackerel	960	854	1,814
Angler	1,563	236	1,799
Black sea bass	1,509	7	1,516
Unclassified crab	0	1,226	1,226
Lobster	470	227	697
Sea scallop	457	178	635
Unclassified flounders	0	608	608
Bluefish	403	38	441
Summer flounder	270	53	323
American shad	0	320	320

Table 5. Summer flounder offshore winter trawl fishery, November 1989 through May 1990; all hauls from all trips west of 70°W long. where at least one haul caught 100 pounds of summer flounder[1]

Species	Catch-Hail Weight in Pounds		
	Kept	Discarded	Total
Silver hake	57,306	10,731	68,037
Squid (*Loligo*)	54,562	3,110	57,672
Spiny dogfish	0	49,906	49,906
Summer flounder	19,715	9,171	28,886
Scup	9,701	16,895	26,596
Sea robins	97	14,629	14,726
Starfish	0	13,570	13,570
Fourspot flounder	2	12,437	12,439
Red hake	125	10,893	11,018
Skates	0	10,820	10,820
Butterfish	5,916	2,688	8,604
Angler	6,905	662	7,567
Black sea bass	6,259	519	6,778
Squid (*Illex*)	4,765	275	5,040
Atlantic mackerel	4,211	94	4,305
White hake	795	2,797	3,592
Sea scallop	2,918	576	3,494
Unclassified crab	113	761	874
Horseshoe crab	81	737	818
Blueback herring	0	795	795
Rock crab	169	606	775
Lobster	345	150	495
Witch flounder	220	193	413
Spotted weakfish	21	350	371
Weakfish	277	0	277

[1] 10 trips, 55 days absent, 182 hauls.

DISCUSSION

A number of issues were raised in this discussion, as follows:

- Definition of a fishery. What criteria should be used; and for practical purposes is it necessary?

- Methods for raising discard (should it be prorated based on catch of the "target species", effort data or some other means?

- Prioritization of work. Currently efforts are being made to meet everyone's needs, and it may prove necessary to prioritize requests on some scientific basis. Input from the Councils and other management agencies, SAW meetings, and the Steering Committee will also be useful.

- Validity of the results. It was suggested that vessel charters might provide a better representation of events in the fishery although the consensus appeared to be that such an approach could contribute to bias through modification of behavior. It was felt that "checks," if any, could be done within the confines of the current program. For example, species and size/age compositions and changes from year to year could be compared directly with survey results.

- Utility of these data for research programs and assessment analyses. Suggested priorities include: estimation of discard amounts and rates for key fisheries, *e.g.*, the northern shrimp fishery in the Gulf of Maine; a broader scale review of the problem for several fisheries for which discard is known to be significant; studies of "effective mesh size", and effects of tow length, liners *etc.* on selectivity; and use of sea sampling data to supplement bottom trawl surveys as a source of biological samples.

The session concluded with a review of objectives and potential recommendations. It was noted that the original impetus for the program was to improve assessments by providing estimates of discard and other information; and discard estimates would be the primary benefit although much other useful information could be derived as well. It was noted, however, that we have neither a clear statement of objectives nor a basis for evaluating the reliability of the information being developed. In other words, we need to determine what we want to estimate and how well we can estimate it.

The Sea Sampling Analysis Working Group was charged with reviewing this situation with specific reference to studies that might be performed to provide a better basis for program design and definition. In particular the group was asked to evaluate properties of estimates of discarded catches of all species from the northern shrimp fishery and attempt to estimate the discarded amount of Atlantic cod from all fisheries. Membership of the Group is as follows: Darryl Christensen, Chair; Ray Bowman, Jon Brodziak, Steve Clark, Tom Hoff, Chris Kellogg, Garry Mayer, Jan McLeavey, Joan Palmer, Greg Power, Andy Rosenberg, and Gordon Waring.

MODELING STOCK REBUILDING STRATEGIES

A presentation was made by Dr. Pamela Mace of the NEFMC staff on the principles underlying stock models of rebuilding strategies. This was followed by a presentation by Dr. Rosenberg of NEFC on appropriate diagnostics for examining the efficacy of a rebuilding program.

Guidelines for Fisheries Management Plans (FMPs) finalized in July, 1989 (50 CFR Part 602) require Regional Fisheries Management Councils to:

- Develop operational, measurable definitions of overfishing for each stock or stock complex managed under an FMP. The deadline for submission of the definitions for approval by the Secretary of Commerce is November 23, 1990. After February 25, 1991, all new and existing FMPs should contain approved definitions of overfishing.
- Determine whether overfishing is occurring according to the accepted definitions for each managed stock or stock complex.
- Develop and implement stock rebuilding strategies for those managed stocks or stock complexes that are overfished.

Both the New England and Mid-Atlantic Councils are in the process of completing the first two steps, and beginning to embark on the third step. The 602 Guidelines give little guidance on the development of rebuilding strategies. Section 602.11 (c)(6)(iii) states:

> "If data indicate that an overfished condition exists, a program must be established for rebuilding the stock over a period of time specified by the Council and acceptable to the Secretary."

The Guidelines also suggest that Stock Assessment and Fishery Evaluation (SAFE) Reports might provide information on the time necessary to allow a depleted stock to "rebuild to the MSY-producing level, threshold level, or other specified level under various harvest levels and prevailing environmental conditions".

The only variable that can be controlled directly by fisheries managers is the fishing mortality rate (F); managers do not have direct control over stock size. The problem, therefore, is one of defining an optimal or acceptable time-stream of Fs that will result in a high probability of a stock rebuilding to a prespecified level in a prespecified time period. It will probably be necessary to develop stochastic models to estimate likely stock responses to various time-streams of Fs.

Two possible reasons for implementing rebuilding strategies are:

- to reduce the probability of recruitment failure, or to avoid recruitment overfishing
- to reduce growth overfishing and/or to maximize yields.

Rebuilding strategies could be initiated immediately, or delayed to take advantage of the appearance of one or more above-average year classes in the fishery. The problem with the latter strategy is that the overfishing situation is likely to deteriorate in the interim. The time horizon for rebuilding should be related to the lifespan of the species: longer for long-lived species and shorter for short-lived, productive species.

Stock rebuilding strategies will be influenced by the tools available for management, practical constraints and species priorities. Management tools can be categorized into those that affect the age or size at entry (partial recruitment) and those that affect the overall F. The former category includes gear restrictions and minimum fish size restrictions; the latter includes indirect controls such as closed areas and closed seasons, and direct controls such as quotas and limited entry. There are practical constraints on both the implementation of each of these measures and their effectiveness. One of the major practical constraints on stock rebuilding strategies is that it will probably not be possible to implement policies requiring rapid changes in either effort or catch levels.

Species priorities will also influence stock rebuilding strategies, although rebuilding strategies targeted towards one particular stock or species will almost certainly affect other stocks or species (including those that belong to the same multispecies assemblage, and those that are captured in alternative fisheries). While they recognize the multispecies nature of most fisheries, NEFMC staff have developed a preliminary priority list for rebuilding depleted groundfish stocks. The order of priority is based on present and potential abundance and dollar value, as well as a subjective evaluation of the relative ease of rehabilitation:

1. Georges Bank cod
2. Gulf of Maine cod
3. Southern New England yellowtail flounder
4. Georges Bank haddock
5. Pollock
6. Winter flounder
7. American plaice
8. Georges Bank yellowtail flounder
9. Witch flounder
10. Gulf of Maine haddock
11 & 12. Northern and southern stocks of silver hake
13. Redfish

DISCUSSION

A question was raised concerning the level of importance of Georges Bank haddock on the NEFMC list of priorities, given the very low stock size and yet high potential yield in landings and dollars from the haddock stock. It was noted that the priority listing was based not only on the status of exploitation of the stocks, but also on the perceived likelihood of attaining some stock rebuilding in the near term. Therefore, scallops, Georges Bank cod, Gulf of Maine cod, and southern New England yellowtail were given higher priority than Georges Bank haddock.

Discussion followed concerning the single species yield/SSB simulation approach being considered for evaluation of rebuilding strategies. Several alternative modes of evaluation were suggested, including:

- A multispecies surplus production approach, which might be robust in terms of modeling long-term responses of the groundfish complex
- A yield/SSB simulation approach considering the multispecies harvest characteristics of the contemporary fleet
- Consideration of economic factors (*e.g.*, value of the landings, employment levels) as goals of rebuilding strategies.

It was noted that the current evaluations are intended to meet the 50 CFR Section 602 requirement for formulation of rebuilding strategies, relative to the biologically-based definitions of overfishing. It was recognized that the rebuilding goal for a given fishery, independent of the 602 guidelines, may ultimately include biological, economic, and social factors.

There was considerable discussion of the need to recognize the distinction, relative to the 602 regulations, between a stock in an "overfished condition" (*i.e.* a depleted stock) and therefore in need of rebuilding, and a stock experiencing a level of fishing exceeding some target F level over the short term, but not necessarily depleted. For stocks that are considered to be depleted, some common target F levels (*e.g.*, F_{rep}) may not necessarily constitute an adequate rebuilding strategy. It was noted that NEFC annually considers the status of exploitation for the stocks on the NEFMC priority list, and provided a working paper to SAW 10 as a starting point for determining which stocks are overfished. It was suggested that technical review by the SARC would be an appropriate mechanism to determine whether a given stock is overfished. However, this issue was discussed in detail by the Plenary in preparing the Advisory Report on stock status (see below).

Dr. Rosenberg presented an overview of a paper by Rosenberg and Brault (1990), prepared for a recent NAFO symposium. In their analysis of stock rebuilding over different time scales for cod and haddock on Georges Bank, several diagnostics were used for evaluating different strategies. Expected yield is clearly important but should be expressed in probabilistic terms, *i.e.*, the probability of attaining a given yield level. Similarly, the spawning stock biomass level is some measure of the viability of recruitment year-to-year and can be thought of as an indicator of the risk of recruitment failure; a lower stock implies higher risk. Again, probability of maintaining the spawning stock above a given level is more informative than average or deterministic levels of SSB. Finally, a rebuilt stock implies more than just an acceptable biomass level. It also should contain some rebuilt age structure. The measure of age structure suggested was the skewness of the age composition. Examples for cod and haddock were presented for discussion.

Discussion of Cod and Haddock Examples

There was concern that under the "no reduction" simulation for cod, average yields did not decrease over the ten-year simulation, even though current F is high. It was noted that this phenomenon was due in part to the distribution of recruitment employed, which was based on empirical data for recent years during which recruitment of cod has been consistently good. The maintenance of yields in spite of no reduction in F was an important reason to look at other characteristics of stock dynamics, such as average spawning stock biomass and the degree of truncation (skewness) of the age composition, in evaluating the different time frames for rebuilding.

The Plenary felt that evaluations such as those done here for cod and haddock, and in previous work by Overholtz, Sissenwine, and Clark (1986) for mackerel and haddock, was a good way to convey to managers the differing responses of stocks in terms of biomass and yield that could be expected given alternative time scales for rebuilding. It was noted that multispecies interactions may have a significant impact on expected responses of stocks, and that future work might consider these interactions. Finally, it was suggested that a priority list of species to be evaluated in this manner could be developed, and that formation of SAW working groups might be a good way to pursue future evaluations.

REFERENCES

Overholtz, W.J. M.P. Sissenwine, and S.H. Clark. 1986. Recruitment variabiity and its implications for managing and rebuilding the Georges Bank haddock stock. *Can. J. Fish. Aquat. Sci.* 43:748-753.

Rosenberg, A.A. and S. Brault. 1990. Stock rebuilding strategies over difference time scales. NAFO SCR Doc. 90/111:17p.

REPORT OF THE STOCK ASSESSMENT REVIEW COMMITTEE

The report of the SARC was presented to the Plenary by Dr. Rosenberg for comment. These notes summarize the discussion and suggestions made during the session. The Advisory Report (see below) then synthesizes the information on stock status.

GULF OF MAINE HERRING

The current assessment is for Gulf of Maine only. If assessments in the future are prepared jointly with Canadian scientists, the assessment should include North Atlantic herring stocks as a whole. This will alleviate some of the problems identified with the current assessment concerning possible mixture of the Gulf of Maine stock with other stocks during the time period that surveys and the fisheries are executed.

A question arose concerning the availability of variances around the elements of the catch-at-age matrix and the effects this variability will have on our uncertainty about the assessment results. It was pointed out that these variances may be less a source of uncertainty than the issue of mixture of stocks during the sampling periods.

A question was raised regarding the methods used to produce the mean weight-at-age table (Table A4, page 61.) Specifically, was the mean weight for the year unweighted by catch, or was the catch by month or quarter was used to weight the estimates. An examination of the total yield, mean weight-at-age and numbers-at-age tables suggests that the mean weighted by catch was used, thus producing a mean catch weight-at-age table.

SUMMER FLOUNDER

The Summer Flounder Working Group identified four major data needs at this point:

- Estimates of hooking mortality in the recreational fishery.
- Estimates of age frequency of recreational discards coastwide.
- Estimates of discard rates (including age composition) and discard mortality in the commercial fishery.
- Estimates of oldest observed ages (historical), as part of an evaluation of natural mortality rates for the species.

A suggestion was made to remove F_{rep} from Table B8 (page 70) since it was previously concluded by the SARC that the value calculated for F_{rep} was based on too short of a time series to be considered anything more than tentative. This suggestion was agreed to by the SAW chair and encountered no dissent.

At the SARC it was recommended that aging be kept up-to-date for this species due to the compressed age structure of the population, but this recommendation was not included in this report. Accordingly, it was suggested that this recommendation be forwarded to the Steering Committee.

SCUP

An error in the text of the SARC report was noted concerning the methods documented for age-at-length keys. Penny Howell indicated that annual keys (from Massachusetts) were used from 1982 to the present, and a pooled key was used for data prior to 1982. Since the assessment was performed focusing on Connecticut fisheries, there remains some uncertainty in the conversion from length to age in the assessment.

The use of length-based estimators of mortality was recommended by the SARC for future assessments of this species. The SAW agreed that these methods may be appropriate where data for other methods are unavailable, but strongly recommends that the sensitivity of estimates to the assumptions of the method (particularly stationarity of age composition) be closely examined.

BLACK SEA BASS

One of the SARC members thought that the statement about over-exploitation of this stock was stronger than it is currently stated in the consensus report. There was some disagreement about this since estimates of F_{max} are not definative, and the use of length-based estimates of F may be sensitive to estimates of the von Bertlanffy growth equation parameters. For black sea bass this is particularly a problem since the species undergoes sequential hermaphroditism and growth rates are affected by the sex change. As for scup, the SAW strongly recommends that the sensitivity of estimates to the assumptions of the method (particularly stationarity of age composition and fixed growth parameters) be closely examined.

BLUEFISH

It was pointed out that the yield-per-recruit analyses performed here include age 0 fish, which presumably includes eggs and larvae. Since mortality and growth rates change quickly for this species during the first year of its life, the use of a single mean weight and M for age 0 may have a large effect on the shape of the yield-per-recruit curve. It was suggested that future yield-per-recruit analyses for this species include quarterly or monthly values of M and mean weight for age 0 fish in order to determine the effects of the using a finer time resolution on the shape of the yield-per-recruit curve.

SILVER HAKE

This assessment contained many problems and uncertainties. Most of the discussion focused on the conclusions, particularly from the analysis of biological reference points. It was noted that the analysis uses four-year running averages of fishing mortality rates to evaluate current percent MSP versus the targets. This may cause problems when there is a trend in F as is the case here. Also, there is no reason to suppose the two silver hake stocks should have the same percent MSP. They should be evaluated and reported separately. The Plenary pointed out that the highly variable partial recruitment vector for silver hake meant that target F values in the future will be highly uncertain and will depend on the partial recruitment vector at some future time.

AMERICAN PLAICE

The SAW noted that it would be useful to have additional indices of recruit and pre-recruit abundance for this species. A possible source of information on the abundance of pre-recruits would be the discard rate (primarily from the shrimp fishery) obtained the sea sampling program.

The SARC consensus states that "The SARC checked that the length composition analysis, using the Beverton and Holt method for estimating Z/K, was not excessively affected by recent large incoming year-classes by examining data from the mid-1970s as well as recent length data." This statement was confusing to some members of the SAW. To clarify this point, the chair reviewed the discussion and analyses that took place during the SARC.

During the SARC, the committee felt that estimates of Z or Z/K would be useful in the assessment of this stock. As the data for this species are limited, the use of estimators based on the length frequency structure of the population were suggested. Initial estimates of Z for recent years using these methods were relatively high, however, some of the members of the committee were concerned that these estimates could have been biased due to the influx of relatively strong year classes. Further analyses were performed by extending the time series of estimates into the early 1970s when strong year classes were also evident. This is what was implied in the SARC consensus report when it was stated that the SARC checked the length composition analysis. The results of extending the time series of estimates into the 1970s suggested that the estimates of Z for recent years was not unduly affected by the incoming year class strength.

As with scup and black sea bass, the SAW encourages the continued testing of the applicability of length-based estimators of mortality where data for VPA or other analyses are lacking. As with the other species, the SAW strongly recommends that the sensitivity of estimates to the assumptions of the method be closely examined.

GEORGES BANK COD

During the discussion of the assessment for this stock, a concern was raised regarding the adequacy of the assessment for management purposes given that there was uncertainty present in many of the elements constituting the assessment. However, it was noted that many of these problems are common to most assessments. They should not preclude the use of the analysis but must be explicitly recognized and serve as strong cautionary notes for management. In particular, major sources of uncertainty include:

a) The adequacy of the recreational catch data,

b) The importance of discarding on Z and F,

c) The effects of NEFC gear changes during the trawl survey time series, and

d) The use of unstandardized commercial CPUE data in the VPA tuning.

At present, the cumulative effects of the sources of uncertainty are unknown. Suggestions were made that a more detailed analysis of the effects of the above sources of uncertainty be made in the next assessment of this stock. Particularly, points (c) and (d) above need to be addressed concerning the possible effects on estimates of F and percent MSP, as some participants in the SAW felt that the estimate of percent MSP was rather low. The point was also made that the sea sampling program should provide some estimate of discard rates, allowing the next assessment to include this source of mortality.

OCEAN POUT

The SAW noted that the SARC recommendation for updated age and growth studies were already underway through a cooperative study being conducted by the University of Massachusetts, the Commonwealth of Massachusetts and the NEFC.

As with Georges Bank cod, the importance of discards to the population dynamics of this species was emphasized. Thus, the SAW recommends that the results of the sea sampling program be examined in the next assessment of this species.

WHITE HAKE

As with ocean pout, the SARC recommended that age and growth studies of this species are needed, which the SAW indicated were already underway. For this species, discarding also appears to the an important source of mortality, again emphasizing the need to examine the database being provided by the sea sampling program.

RED HAKE

The SAW noted that the comments for this species are the same as for ocean pout and white hake regarding the need for growth and aging studies and examination of discard data.

SMALL ELASMOBRANCHS

This section of the consensus report generated little discussion.

TWELFTH SAW TERMS OF REFERENCE AND TIMING

A list of potential topics for review by the Stock Assessment Review Committee (SARC) and the SAW Plenary Session was developed by SAW participants for prioritization by the Steering Committee. Initial experience with the revised structure indicated that the SARC could adequately review about ten stock assessments (a mixture of analytic and non-analytic assessments) within a week. A more lengthy agenda would consequently require longer or more SARC meetings.

STOCK ASSESSMENT REVIEWS

For the Stock Assessment Review Committee portion of the 12th SAW, suggestions were made by both Councils as well as other participants for species or stock reviews. No suggested priority order was made.

- Center staff suggested the review of revised analytic assessments of:

    Atlantic mackerel
    Pollock

- MAFMC staff suggested the review of updated assessments of:

    Illex squid
    Loligo squid
    Butterfish
    Surf clams
    Ocean quahog
    Sea scallops

- NEFMC staff suggested the review of updated or revised (analytic or non-analytic) assessments of:

    Gulf of Maine cod
    Gulf of Maine haddock
    Georges Bank haddock
    Georges Bank yellowtail flounder
    Southern New England yellowtail flounder
    Georges Bank winter flounder

- General suggestions were made concerning the review of updated or revised assessments of:

    Gulf of Maine winter flounder
    Southern New England winter flounder
    Bluefish
    Weakfish
    Sea herring (Other than Gulf of Maine, Georges Bank stocks)
    Northern shrimp

- The Marine Mammal investigation requested that the SARC review methodology used to estimate harbor porpoise by-catch.

OTHER SPECIAL TOPICS AND WORKING GROUP REPORTS

The 12th SAW Plenary is recommended to consider the following issues (in no priority order):

- Discuss results of Sea Sampling Analysis Working Group (WG # 28), with D. Christensen as chair, was formed to evaluate properties of estimates of discard from current sea sampling data and estimates of sample size needed to achieve specified precision levels for discard estimates. Target examples may include the northern shrimp fishery and all Atlantic cod stocks.

- Review NEFC survey gear modifications and their effects on assessment analyses. Summarize how available information effects of gear modifications should be included in assessments.

- Discuss report of Methods Working Group (WG # 9) which addresses outstanding terms of reference, specifically terms 5 and 6 (9th SAW): Identify potential methods for evaluating stock status, relative to overfishing definitions; and consider the utility and reliability of those various methods.

- Discuss results of Lobster Assessment Working Group (WG #26) (to investigate feasibility of combined inshore/offshore lobster assessment, including evaluation of available information on migration patterns of lobster; and develop list of data requirements and collection techniques for lobster assessments).

- Discuss report of Working Group on Modeling Rebuilding Strategies (WG # 29), including review of existing models and work to date and review of specific rebuilding models. This Working Group was suggested with P. Mace as Chair to respond to Council needs in modeling rebuilding programs.

- Review evidence for physical and biological factors explaining historical (*i.e.*, beyond most recent decade) abundance and distribution patterns (WG # 30). This Working Group, with A. Rosenberg as Chair, was formed to review information on major long-term shifts in stock levels and/or distribution of fishery resources.

Recommendations are also sought from the Steering Committee on the following topics:

- Review the form and utility of the current multiple current products of NEFC, SARC and SAW and recommend preferred or revised formats for publication and distribution (including recommendations for a research review series);

- Evaluate the possibility of providing travel funding for Stock Assessment Review Committee members from universities or outside the region;

- Extend the format of the SAW to include a separate one-day "dialogue" meeting to report on an overview of assessment results to fishery managers (perhaps on a regional Council basis).

TIMING

Barring conflicts with Council and ICES meeting schedules, the SARC meeting will be held the week of 27 May, 1991; and the SAW Plenary meeting will be held the week of 24 June 1991. To enable participants time to develop analyses and working papers for distribution before the SARC meeting, a prioritized list of topics for agendas of the SARC and the SAW meetings would be needed from the Steering Committee by 1 January 1991.

Eleventh NEFC Stock Assessment Workshop
Fall 1990

Stock Assessment Review Committee
Consensus Summary of Assessments

INTRODUCTION

The Stock Assessment Review Committee (SARC) of the 11th Stock Assessment Workshop (SAW) met at Woods Hole, Massachusetts from October 15 to 19, 1990. The SARC originally was intended to have eleven members (Table 1), including two from outside the Northeast region. Unfortunately, both of the external SARC members had to withdraw shortly before the meeting.

On the agenda was the review of analyses on 14 species from the New England and Mid-Atlantic regions (Table 2). During the meeting, the SARC was informed that the report on sea scallops would not be complete in time for the session, so no review of scallops was undertaken although a short comment on the need to review this scallop analysis is included in this report. In addition, the review of Georges Bank haddock was dropped from the list because of time constraints. The assessment of haddock relied on analyses prepared by Canadian scientists, which were reviewed by CAFSAC prior to the SARC meeting. Because no one from Canada attended the SARC and the work had some review, it was agreed during the meetings that the time scheduled for haddock could be better spent on the other species.

For each stock, reports of analyses were presented to the SARC by one of the scientists involved in the work (Table 3). In some cases, working papers describing new analyses in detail were available. In other cases, summary descriptions, such as those given in the *Status of the Fishery Resources Off the Northeastern United States* (NEFC 1989), accompanied by tables and figures providing more detail were prepared for the meeting. For one of the species, silver hake, the only material available as a basis for an analytical assessment was from SAW 10. The SARC analyzed these data and results during the meeting.

The discussion on each species or stock focused on technically evaluating the information presented on stock status. We sought to determine:

- the best current assessment of the resource,
- the major sources of uncertainties in the assessment,
- how these uncertainties might affect the picture of stock status.

In some cases, the SARC performed analyses in addition to those already prepared for the meeting because of technical questions raised during the discussion. These analyses were intended either to implement specific recommendations for improving the analyses or to explore sources and effects of uncertainties.

The reports presented here are the consensus of the SARC on stock status for these species. Appropriate tables are attached to each report so that this document is self-contained.

Table 1. Members of the Stock Assessment Review Committee for SAW 11

Name	Affiliation
R. Conser	Northeast Fisheries Center, CUD
M. Fogarty	Northeast Fisheries Center, FED
P. Goodyear *(withdrew)*	Southeast Fisheries Center
T. Hoff	Mid-Atlantic Fishery Management Council
P. Mace	New England Fishery Management Council
R. Mayo	Northeast Fisheries Center, CUD
W. Overholtz	Northeast Fisheries Center, CUD
T. Polacheck	Northeast Fisheries Center, FED
A. Rosenberg ***(chairman)***	Northeast Fisheries Center, RPAC
D. Stevenson	Maine Department of Marine Resources and ASFMC Representative
R. Stevenson *(withdrew)*	Department of Fisheries and Oceans, Canada

Table 2. Agenda for fall 1990 SARC meeting

NEFC Aquarium Conference Room
Woods Hole, MA

9 AM, Monday, 15 October - 5 PM, Friday, 19 October

AGENDA

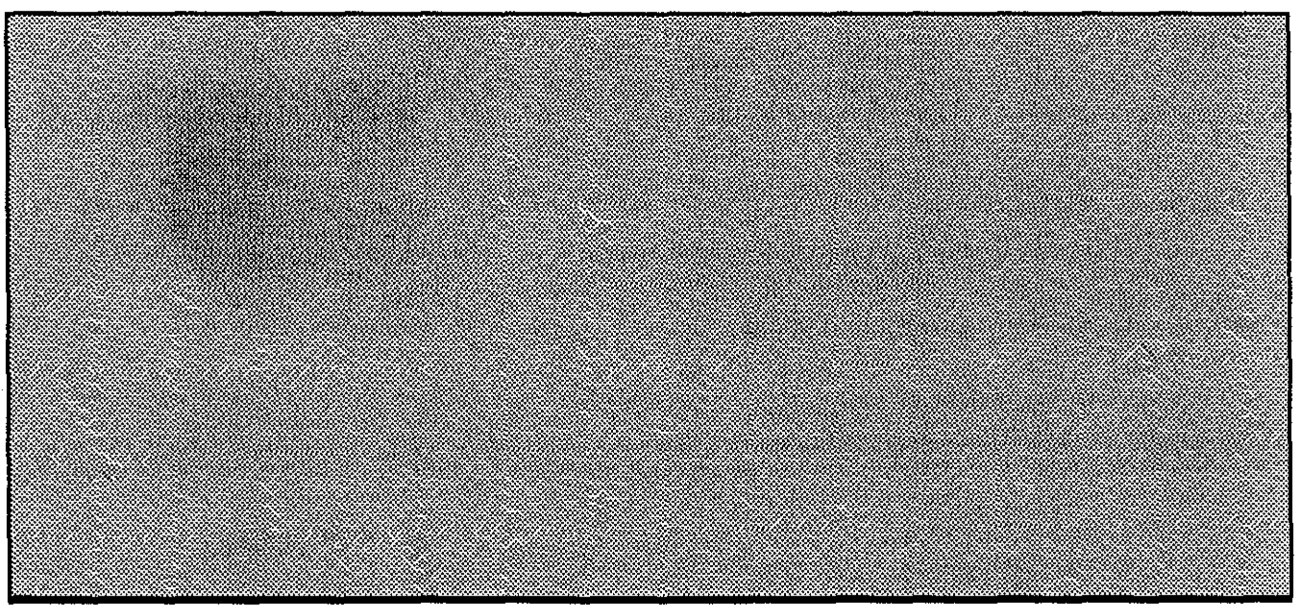
Order of presentation for species reviews, expected sources of analyses, and suggested rapporteurs: Days of reviews are subject to change.

Species	Source/Presenter	Rapporteur
Monday, 15 October		
Sea herring[1]	Maine DMR - Stevenson	Mace
Summer flounder[1]	NEFC - Gabriel	Hoff
Tuesday, 16 October		
Scup[2]	Connectivut - Howell	Fogarty
Black sea bass[2]	NEFC - Shepherd	Fogarty
Bluefish[1]	NEFC - Gabriel	Mace
Silver hake[3]	NEFC - Mayo NEFMC - Russell	Polachek
Wednesday, 17 October		
Sea scallops[1]	NEFMC - Russell	Conser
American plaice[2]	NEFC - Serchuk	Goodyear
Cod[1]	NEFC - Serchuk	Goodyear
Thursday, 18 October		
Haddock[1]	NEFC - Mayo	Overholtz
Ocean pout[2]	NEFC - Wigley	Overholtz
White hake[2]	NEFC - Mayo	Stevenson
Red hake[2]	NEFC- Wigley	Stevenson
Friday, 19 October		
Skates[2]	NEFC - Murawski	Mayo
Dogfish[2]	NEFC - Murawski	Mayo
Review of SARC Report		

[1] Review new assessment or analysis
[2] New assessment or analysis
[3] Analysis and review

Table 3. SAW 11 SARC documents

		Presenter
SAW/11/SARC/1	Revised assessment of Georges Bank cod stock, 1990	F. Serchuk
SAW/11/SARC/2	Marine Finfish Survey, section 2.3: Stock assessment of scup	P. Howell
SAW/11/SARC/3	Status of black sea bass north of Cape Hatteras, NC	G. Shepherd
SAW/11/SARC/4	The calculation of replacement fishing mortality rates, F_{rep}, for Gulf of Maine/Northern Georges Bank and the Southern Georges Bank/Mid-Atlantic stocks of whiting	H. Russell
SAW/11/SARC/5	Yield-per-recruit analysis for Atlantic coast bluefish, 1990	W. Gabriel
SAW/11/SARC/6	Virtual population analysis of the Gulf of Maine Atlantic herring stock	D. Stevenson
SAW/11/SARC/7	Report of the Stock Assessment Workshop Summer Flounder Working Group	W. Gabriel
SAW/11/SARC/8	Updated assessment of American plaice in the Gulf of Maine-Georges Bank region: Data tables and figures, 1990	F. Serchuk
SAW/11/SARC/9	Overview of small elasmobranch stock status and population dynamics of the Northeast U.S.A.	S. Murawski
SAW/11/SARC/10	Ocean pout: Status of the Fisheries Resources off the Northeastern United States for 1990	S. Wigley
SAW/11/SARC/11	White hake: Status of the fisheries resources off the Northeastern United States for 1990	R. Mayo
SAW/11/SARC/12	Red Hake: Status of the fisheries resources off the Northeastern United States for 1990	S. Wigley
SAW/11/SARC/13	Scup: Status of the fisheries resources off the Northeastern United States for 1990	W. Gabriel



GULF OF MAINE HERRING

An analytical assessment of Gulf of Maine Atlantic herring (*Clupea harengus harengus*) was conducted jointly by the Maine Department of Marine Resources and the NOAA/NMFS Northeast Fisheries Center (Paper SAW/11/SARC/6). Virtual population analysis estimates of stock size indicate an increase in abundance since 1982. The SARC identified several important sources of uncertainty which suggest that recent year-class sizes may have been overestimated.

STOCK DEFINITION

The Gulf of Maine stock was considered to include all fish found in NAFO areas 5Y and 5Zw (*i.e.*, excluding fish from area 6, which were assumed to belong to either the Georges Bank or Nantucket Shoals stocks; and excluding fish from Sub-area 4, which were assumed to belong to Atlantic Canadian stocks). However, an unknown amount of mixing occurs during winter/spring between Gulf of Maine, Georges Bank, and Nantucket Shoals stocks in the Mid-Atlantic and Southern New England areas. The SARC also noted that there is historical evidence that substantial numbers of juveniles originating from the Gulf of Maine are caught by New Brunswick weirs and shutoffs.

HISTORY OF THE FISHERY

Exploitation patterns in the Gulf of Maine herring fisheries have changed substantially over time. Historically, the predominant herring fishery was a juvenile fishery prosecuted with stop seines and weirs. Purse seine fisheries on larger fish gained increasing importance from the 1970s onward. Currently, purse seine fisheries for adults predominate (including increasing amounts sold over-the-side to foreign factory ships), while fixed gear catches represent only a small fraction of the total (9 percent in 1989). Larger fish were taken in the purse seine fishery by distant-water fleets beginning in the 1960s through 1976. Historically there have been changes in the relative importance of the fixed and mobile gear fisheries depending on availability of fish.

LANDINGS

Landings in 1989 were 53,455 mt, an increase of 13,222 mt (33 percent) over 1988. Total domestic landings were 40,387 mt, including 1,433 mt landed by fixed gears. An additional 13,068 mt were harvested for over-the-side sales. Total landings have been increasing continuously since 1985, but domestic landings have remained stable for the last three years (Table A1).

The total annual landings since 1983 are:

Landings (thousands of mt)						
1983	1984	1985	1986	1987	1988	1989
23.2	32.7	25.5	31.3	39.3	40.2	53.5

AGE COMPOSITION OF LANDINGS

Age 2 fish predominated in the catch (34 percent by number). The 1983 year class contributed 21 percent (by numbers) to the catch, the 1986 year class contributed 16 percent, and the other cohorts each contributed no more than 12 percent.

CATCH-AT-AGE

The catch-at-age matrix (Table A2) was compiled from landings and age-length keys derived by year, month, gear type, and area. No attempt was made to account for discards or misreporting, on which there is little information at present.

ABUNDANCE INDICES

Abundance indices that are potential VPA tuning candidates include the NEFC spring trawl survey, the Massachusetts brit survey and the Maine larval survey. Following trial runs made during the SARC, neither of the latter two indices were considered to be suitable for tuning in their present forms. Further exploration of survey indices would be valuable. The NEFC spring survey index indicates a general increasing trend in abundance since 1984 (Table A3).

ASSESSMENT PARAMETERS

Natural Mortality

A natural mortality rate of M = 0.2 was assumed.

Recruitment and partial recruitment:

The PR vector used was obtained from the previous herring assessment (NEFC 1989) analyses and was calculated as the geometric mean of F over the years 1982 to 1985.

Age	1	2	3	4	5+
PR	0.059	0.653	0.580	0.756	1.00

Table A1. Herring landings by state (mt), * = less than 1.0 mt

Year	ME	NH	MA	RI	CT	NY	NJ	DE	MD	VA
1940	17,249		2,676	61	*	16	857			*
1941	US Fishery statistics not collected									
1942	42,648		2,652	15		*	888			2
1943	25,948		1,329	11	2	66	992			
1944	37,254		599	14	2	18	647		1	31
1945	42,010		705	14	2	15	712	1	91	53
1946	36,346	*	930	64	47	286			18	14
1947	55,044		1,085	83	93	64	2,446	9	12	63
1948	82,786		2,315	559	1,498	10	752	9	40	95
1949	68,010		5,260	1,931	1,211	100	890		2	37
1950	84,157		3,663	375	351	63	498		20	45
1951	27,104		1,305	402	641	246	759		2	36
1952	65,636		1,598	1,185	1,234	25	716		2	8
1953	45,638		2,033	984	1,500	14	307	*	*	1
1954	56,080		1,304	477	768	145	294	1	1	2
1955	45,107		1,561	301	348	85	544		1	4
1956	63,735		2,058	284	373	190	430		*	35
1957	69,701		3,008	135	208	95	171		2	2
1958	77,576		3,183	160	41	134	124		*	*
1959	53,153		1,472	117	37	61	230		1	*
1960	69,114		889	113	59	89	147		2	3
1961	24,711		1,417	85	38	74	96		3	2
1962	71,098		604	76	26	29	93		5	
1963	69,109		841	142	14	39	69	*	4	5
1964	27,616		931	118	12	70	137	5	6	*
1965	31,842		2,016	172	5	126	113	3	4	88
1966	26,451		2,990	273	5	2,907	136	2	4	34
1967	29,310		1,615	180	*	67	24		2	498
1968	31,626		9,856	201		44	99		4	19
1969	24,598		4,484	2,044		60	168			25
1970	16,602		12,453	1,007	2	28	184		*	5
1971	12,964		19,671	1,310	1	7	39		*	1,112
1972	20,277		17,173	2,298	*	12	92		1	316
1973	16,892		4,881	4,239		10	52		7	174
1974	21,505		7,992	2,905	6	7	157	1	16	26
1975	17,354		14,590	4,063		56	100	*	14	3
1976	31,867		18,029	179	*	12	54		3	*
1977	33,144	25	17,188	293	*	8	33			*
1978	30,344		18,393	1,688	29	13	43		3	*
1979	40,541		23,038	1,281	2	58	30		1	*
1980	48,909	3,010	30,322	1,096	*	104	14		1	6
1981	51,979	48	12,300	688	12	49	16		*	
1982	23,207	581	7,123	1,363	13	18	11	7	2	*
1983	18,161	943	4,057	46	6	20	20		1	
1984	20,399	82	12,156	49		30	10			
1985	14,574	3	11,137	154		42	11			2
1986	23,812	1	11,550	583		49	20			
1987	19,392		18,503	312	11	53	23			64
1988	16,535		22,807	1,091		216	23			342
1989	15,629		24,504	214		9	31			

Table A2. Gulf of Maine herring catch-at-age matrix

Year	1	2	3	4	5	Age 6	7	8	9	10	Plus	Total
1967	0.0	7.4	13.0	5.1	1.7	4.0	2.5	0.2	0.1	0.1	0.1	34.3
1968	0.1	16.9	10.9	3.5	6.2	6.4	7.1	4.9	0.9	0.7	0.2	57.9
1969	0.1	8.9	18.2	1.0	3.6	6.6	7.1	6.8	5.5	1.7	0.3	59.7
1970	0.0	10.3	5.8	5.3	4.3	6.3	10.1	8.3	9.7	4.3	0.9	65.3
1971	1.4	2.7	5.1	8.1	10.6	14.5	8.6	5.2	4.0	2.8	1.1	63.9
1972	0.0	18.0	2.9	8.5	10.3	13.5	8.0	3.4	0.8	0.8	0.5	66.8
1973	0.2	7.4	10.7	1.3	2.8	3.5	3.9	2.4	0.6	0.1	0.1	33.1
1974	0.5	9.3	6.8	18.9	1.8	1.3	0.7	0.6	0.3	0.1	0.1	40.5
1975	0.6	8.8	4.9	4.4	17.6	2.2	1.0	0.6	0.3	0.1	0.1	40.8
1976	0.4	13.6	15.8	3.7	3.3	12.4	1.0	0.2	0.3	0.1	0.0	50.7
1977	1.3	18.7	7.5	7.0	2.4	2.4	10.0	0.6	0.2	0.1	0.1	50.3
1978	0.7	12.9	10.0	3.8	8.4	1.2	2.1	8.8	0.3	0.2	0.1	48.6
1979	0.0	23.4	15.4	8.9	3.8	4.5	1.1	1.1	2.3	0.1	0.0	60.6
1980	1.0	9.0	30.6	27.8	5.8	2.0	3.0	0.3	0.2	1.8	0.0	81.4
1981	0.1	38.4	2.0	10.9	10.0	1.6	0.5	0.5	0.0	0.0	0.4	64.4
1982	0.5	13.1	5.1	0.7	7.1	4.7	0.6	0.1	0.3	0.1	0.1	32.3
1983	0.6	7.1	5.2	4.7	0.2	2.0	2.5	0.1	0.1	0.1	0.0	22.6
1984	0.1	4.7	14.9	5.8	5.3	0.3	1.1	0.5	0.1	0.0	0.0	32.9
1985	0.1	8.6	5.3	5.8	3.5	2.0	0.1	0.4	0.2	0.0	0.0	26.0
1986	0.8	5.8	12.0	4.0	6.0	2.6	1.3	0.0	0.1	0.0	0.1	32.8
1987	0.3	4.0	7.9	17.3	3.7	2.8	0.8	0.4	0.0	0.1	0.0	37.4
1988	0.0	5.3	5.7	4.9	13.2	3.9	1.7	0.4	0.0	0.0	0.0	35.2
1989	0.0	6.6	6.9	6.9	7.5	16.8	4.9	1.5	0.4	0.0	0.0	51.7

Use of only a few recent years to estimate the current PR is justified because of the documented shift from fisheries that target juveniles to those that target adults.

Recruitment (numbers at age 1) in 1990 was calculated as the geometric mean of the numbers at age 1 for the years 1984 to 1988. This resulted in an estimated recruitment of 1,075.6 million fish.

Age-Specific Weights

Two sets of mean weights-at-age were derived from the commercial catch for each year. The first was the mean weights-at-age for the first four months only. These weights were used to compute biomass estimates for tuning the VPA. The second set of weights-at-age were mean weights in the catch during the entire fishing year (Table A4). These weights were used to report mean annual population biomass and annual catch biomass.

Proportion Mature At Age

Prior to 1977, maturity at age estimates were estimated from a predictive model based on a relationship between maturity, size at age and water temperature. Since then, maturity ogives have been derived from annual estimates of the proportions of mature fish collected in biological samples.

Fishing Mortality Of Oldest Ages

The fishing mortality for age 10 and the plus group was calculated as the mean of ages 2+, weighted by population numbers.

Terminal Fishing Mortality

The relationship between beginning-of-year 2+ biomass from the VPA and the NEFC spring survey index was used to determine the best estimate of the terminal fishing mortality (F_t). Use of the criteria of highest R^2 for recent years resulted in a best estimate of F_t of 0.275. Additional runs performed during the SARC indicated that:

- This result is sensitive to the values of the survey indices in the late 1960s (when the indices may have included an unknown contribution from the Georges Bank stock). The SARC also noted that a similar problem may occur with the latter half of the 1980s.

- The result is relatively insensitive to assumptions about the recent PR, linear *vs* multiplicative regressions or the use of alternative tuning procedures (ADAPT; Gavaris 1988) to estimate F_t.

- While there may be some dispute about the point estimate of $F_t = 0.275$, existing analyses support the conclusion that it is in the range of 0.2 to 0.3.

ASSESSMENT RESULTS

Trends In Fishing Mortality

Although mean fishing mortality has probably been increasing in recent years (from about 0.15 in 1985 to 0.21 in 1989), it is still substantially lower than the peak values observed during the late 1970s and early 1980s (a range of about 0.50 to 1.60) when the stock reached record low levels (Table A5).

Population Size

Both 2+ biomass and spawning stock biomass are estimated to have increased continuously since 1982 and are now approximately 4.9 and 6.5 times larger, respectively, than they were in that year (Table A5). The 1983 year class which reached peak biomass in 1986 still comprised 29 percent of the total 1989 biomass. The 1987 year class is good, though not as strong as 1983. These two

Table A3. NMFS bottom trawl survey spring Δ transformed index, fitted index, time series model $\theta = 0.4$

Year	Observed	Fitted
1968	4.004	2.577
1969	2.574	1.734
1970	0.734	0.817
1971	0.202	0.424
1972	0.237	0.429
1973	1.836	0.742
1974	0.686	0.566
1975	0.248	0.364
1976	0.280	0.331
1977	0.270	0.349
1978	0.470	0.462
1979	0.778	0.604
1980	1.180	0.629
1981	0.522	0.372
1982	0.081	0.162
1983	0.064	0.131
1984	0.144	0.202
1985	0.304	0.424
1986	3.010	1.198
1987	1.305	1.479
1988	2.472	2.042
1989	3.014	2.374
1990	2.072	2.226

Table A4. Gulf of Maine herring mean weights in the catch for the entire fishing year

Year	Age 1	2	3	4	5	6	7	8	9	10	Plus
1967	0.005	0.029	0.078	0.118	0.162	0.257	0.275	0.342	0.288	0.292	0.313
1968	0.007	0.025	0.059	0.142	0.194	0.215	0.245	0.260	0.273	0.292	0.313
1969	0.010	0.039	0.079	0.051	0.252	0.270	0.320	0.296	0.273	0.292	0.313
1970	0.021	0.063	0.106	0.167	0.210	0.240	0.304	0.309	0.311	0.292	0.313
1971	0.019	0.049	0.115	0.180	0.234	0.327	0.294	0.291	0.329	0.331	0.313
1972	0.035	0.051	0.120	0.187	0.234	0.273	0.314	0.357	0.273	0.292	0.313
1973	0.016	0.054	0.108	0.170	0.233	0.257	0.293	0.325	0.338	0.263	0.324
1974	0.017	0.053	0.108	0.169	0.204	0.232	0.247	0.272	0.286	0.293	0.305
1975	0.023	0.051	0.096	0.169	0.192	0.230	0.274	0.274	0.302	0.293	0.314
1976	0.018	0.042	0.114	0.179	0.206	0.211	0.260	0.282	0.319	0.334	0.399
1977	0.016	0.042	0.103	0.161	0.189	0.219	0.228	0.260	0.304	0.294	0.281
1978	0.013	0.040	0.120	0.186	0.226	0.256	0.273	0.285	0.317	0.349	0.345
1979	0.008	0.032	0.089	0.198	0.255	0.281	0.182	0.325	0.332	0.313	0.313
1980	0.015	0.041	0.103	0.169	0.268	0.319	0.344	0.241	0.306	0.391	0.372
1981	0.012	0.045	0.114	0.190	0.232	0.293	0.316	0.342	0.470	0.304	0.373
1982	0.020	0.049	0.130	0.194	0.250	0.267	0.300	.0322	0.342	0.423	0.313
1983	0.022	0.055	0.138	0.216	0.223	0.310	0.348	0.368	0.390	0.397	0.313
1984	0.019	0.051	0.133	0.182	0.227	0.260	.0305	0.343	0.314	0.402	0.528
1985	0.013	0.049	0.139	0.181	0.203	0.229	0.281	0.273	0.289	0.292	0.313
1986	0.021	0.053	0.116	0.166	0.215	0.230	0.251	0.260	0.299	0.292	0.313
1987	0.018	0.044	0.093	0.141	0.178	0.218	0.233	0.227	0.251	0.265	0.320
1988	0.009	0.034	0.090	0.129	0.164	0.187	0.228	0.238	0.254	0.292	0.247
1989	0.007	0.046	0.102	0.142	0.167	0.193	0.228	0.253	0.233	0.292	0.373

Table A5. Estimated fishing mortality at age, stock size, mean population biomass, and mean spawning stock biomass in Gulf of Maine Atlantic herring

Fishing Mortality Rate

Year	Age 1	2	3	4	5	6	7	8	9	10	Plus	Mean F	Rec
1967	0.004	0.417	0.604	0.208	0.064	0.087	0.069	0.026	0.064	0.329	0.329	0.329	2+
1968	0.027	0.782	0.611	0.163	0.231	0.250	0.229	0.201	0.162	0.579	0.579	0.579	2+
1969	0.024	0.615	0.681	0.112	0.136	0.277	0.300	0.285	0.336	0.474	0.474	0.474	2+
1970	0.010	0.649	0.291	0.181	0.171	0.388	0.746	0.712	0.782	0.442	0.442	0.442	2+
1971	0.048	0.417	0.358	0.408	0.422	0.667	1.019	1.292	0.855	0.511	0.511	0.511	2+
1972	0.002	0.343	0.336	0.778	0.915	1.181	1.076	1.210	0.747	0.455	0.455	0.455	2+
1973	0.025	0.510	0.152	0.169	0.476	0.852	1.309	1.200	0.802	0.307	0.307	0.307	2+
1974	0.045	0.778	0.471	0.255	0.299	0.428	0.445	0.748	0.444	0.458	0.458	0.458	2+
1975	0.044	0.384	0.542	0.363	0.343	0.608	0.592	0.735	1.251	0.397	0.397	0.397	2+
1976	0.028	1.070	0.607	0.447	0.398	0.385	0.507	0.197	0.748	0.756	0.756	0.756	2+
1977	0.068	1.073	0.759	0.390	0.546	0.527	0.556	0.695	0.263	0.872	0.872	0.872	2+
1978	0.036	0.430	0.589	0.498	0.681	0.386	0.871	1.009	0.849	0.495	0.495	0.495	2+
1979	0.015	0.861	0.437	0.750	0.825	0.709	1.352	1.381	0.639	0.746	0.746	0.746	2+
1980	0.051	2.018	1.122	0.988	1.049	1.044	1.151	1.354	1.342	1.306	1.306	1.306	2+
1981	0.015	1.794	1.061	0.674	0.780	0.844	0.907	0.597	0.184	1.596	1.596	1.596	2+
1982	0.037	0.850	0.338	0.645	0.874	0.901	0.992	0.613	0.831	0.751	0.751	0.751	2+
1983	0.046	0.303	0.266	0.321	0.299	0.479	1.261	0.426	0.605	0.313	0.000	0.313	2+
1984	0.003	0.201	0.465	0.380	0.676	0.850	0.556	1.132	1.804	0.333	0.333	0.333	2+
1985	0.013	0.130	0.120	0.233	0.360	0.602	0.494	0.506	1.943	0.149	0.000	0.149	2+
1986	0.054	0.198	0.106	0.104	0.326	0.430	0.903	0.030	0.212	0.153	0.153	0.153	2+
1987	0.017	0.178	0.234	0.176	0.125	0.244	0.230	1.057	0.076	0.188	0.188	0.188	2+
1988	0.004	0.244	0.182	0.156	0.167	0.176	0.224	0.179	0.156	0.275	0.000	0.197	2+
1989	0.017	0.180	0.160	0.208	0.275	0.275	0.275	0.275	0.275	0.275	0.207	0.207	2+

Estimated Stock Size, Numbers

Year	Age 1	2	3	4	5	6	7	8	9	10	+	Total	Spawn	2+
1967	1666.1	818.8	400.7	255.5	193.1	207.3	150.5	29.9	8.1	1.5	0.7	3732.0	775.4	2065.9
1968	678.2	1359.3	441.8	179.3	170.0	148.3	155.6	115.0	23.9	6.2	1.6	3279.1	808.9	2600.9
1969	468.4	540.6	509.3	196.3	124.8	110.4	94.6	101.4	77.0	16.6	3.0	2242.4	896.5	1774.0
1970	215.0	374.3	239.4	211.1	143.7	89.1	68.5	57.4	62.4	45.1	8.8	1514.9	797.0	1299.9
1971	1710.6	174.3	160.2	146.5	144.2	99.2	49.5	26.6	23.0	23.4	9.6	2567.2	587.4	856.6
1972	458.0	1335.1	94.1	91.7	79.8	77.4	41.7	14.6	6.0	8.0	4.9	2211.4	351.1	1753.4
1973	444.9	375.6	775.6	55.0	34.5	26.2	19.5	11.6	3.6	2.3	1.5	1750.2	536.1	1305.3
1974	760.9	355.2	184.6	545.4	38.0	17.5	9.1	4.3	2.9	1.3	1.0	1920.4	731.7	1159.4
1975	680.8	595.6	133.6	94.4	346.1	23.1	9.4	4.8	1.7	1.5	0.9	1891.8	569.6	1210.9
1976	920.7	533.3	332.0	63.6	53.8	201.1	10.3	4.2	1.9	0.4	0.2	2121.4	551.9	1200.7
1977	1318.5	733.2	149.8	148.1	33.3	29.6	112.0	5.1	2.8	0.7	0.6	2533.7	384.3	1215.2
1978	1745.8	1008.2	205.3	57.4	82.1	15.8	14.3	52.6	2.1	1.8	0.6	3186.1	259.0	1440.3
1979	334.3	1379.4	537.0	93.2	28.6	34.0	8.8	4.9	15.7	0.7	0.1	2436.7	395.0	2102.5
1980	1410.3	269.6	477.6	284.1	36.1	10.2	13.7	1.9	1.0	6.8	0.2	2511.4	396.3	1101.2
1981	628.5	1096.9	29.3	127.4	86.6	10.3	3.0	3.6	0.4	0.2	1.4	1987.6	237.9	1359.1
1982	690.6	507.1	149.3	8.3	53.1	32.5	3.6	1.0	1.6	0.3	0.4	1447.8	188.8	757.3
1983	704.1	545.1	177.4	87.2	3.6	18.2	10.8	1.1	0.4	0.6	0.0	1548.5	224.2	844.4
1984	1932.2	550.5	329.6	111.3	51.8	2.2	9.2	2.5	0.6	0.2	0.0	2990.1	344.2	1057.9
1985	828.0	1582.2	368.6	169.5	62.3	21.6	0.8	4.3	0.7	0.1	0.0	3038.0	507.3	2210.1
1986	787.8	669.5	1137.5	267.7	109.9	35.6	9.7	0.4	2.1	0.1	2.5	3022.7	803.0	2234.9
1987	979.5	611.2	449.9	837.8	197.4	65.0	19.0	3.2	0.3	1.4	0.1	3164.7	1145.5	2185.3
1988	1166.3	788.9	418.6	291.4	575.3	142.7	41.7	12.3	0.9	0.2	0.0	3438.5	1233.4	2272.2
1989	34.7	953.8	506.3	285.7	204.2	398.7	98.0	27.3	8.5	0.6	0.5	2518.2	1201.5	2483.5
1990	1000.0	27.9	652.3	353.2	190.0	127.0	247.9	61.0	17.0	5.3	0.7	2682.2	1231.6	1682.2

Table A5. (con't.)

Year	Age 1	2	3	4	5	6	7	8	9	10	Plus	2+ Total
						Mean Population Biomass						
1967	7.5	17.7	21.5	24.8	27.5	46.3	36.3	9.2	2.1	0.3	0.2	185.8
1968	4.2	21.6	17.9	21.4	26.8	25.7	31.0	24.6	5.5	1.3	0.3	176.0
1969	4.2	14.4	26.7	8.6	26.7	23.7	23.8	23.8	16.3	3.5	0.7	168.3
1970	4.1	15.9	20.1	29.3	25.2	16.2	13.5	11.6	12.4	9.7	2.0	155.9
1971	28.8	6.4	14.1	19.8	25.1	21.7	8.4	4.0	4.7	5.5	2.2	111.9
1972	14.5	52.5	8.7	10.9	11.3	11.5	7.4	2.8	1.1	1.7	1.1	109.0
1973	6.4	14.5	70.6	7.8	5.8	4.2	2.9	2.0	0.8	0.5	0.4	109.6
1974	11.5	12.0	14.5	74.1	6.1	3.0	1.7	0.8	0.6	0.3	0.2	113.2
1975	13.9	23.0	9.1	12.2	51.3	3.6	1.8	0.9	0.3	0.3	0.2	102.6
1976	14.8	12.7	26.0	8.4	8.3	32.1	1.9	1.0	0.4	0.1	0.1	90.9
1977	18.5	17.4	9.9	18.0	4.4	4.6	17.6	0.9	0.7	0.1	0.1	74.1
1978	20.2	29.9	17.0	7.7	12.3	3.1	2.4	8.7	0.4	0.5	0.1	82.1
1979	2.4	27.2	35.3	11.9	4.6	6.3	0.8	0.8	3.5	0.1	0.0	90.6
1980	18.7	4.4	27.3	28.1	5.5	1.9	2.6	0.2	0.2	1.4	0.0	71.6
1981	6.8	21.4	1.9	16.1	12.8	1.9	0.6	0.8	0.2	0.0	0.2	55.9
1982	12.3	15.4	15.0	1.1	8.1	5.3	0.6	0.2	0.3	0.1	0.1	46.2
1983	13.7	23.6	19.6	14.7	0.6	4.1	2.0	0.3	0.1	0.2	0.0	65.1
1984	33.2	23.1	32.0	15.4	7.8	0.4	2.0	0.5	0.1	0.1	0.0	81.3
1985	9.7	66.0	43.8	24.9	9.7	3.4	0.2	0.8	0.1	0.0	0.0	149.0
1986	14.6	29.3	113.7	38.3	18.4	6.1	1.5	0.1	0.5	0.0	0.7	208.5
1987	15.8	22.4	33.9	98.5	30.0	11.4	3.6	0.4	0.1	0.3	0.0	200.7
1988	9.5	21.7	31.3	31.6	79.0	22.2	7.7	2.4	0.2	0.0	0.0	196.2
1989	0.2	36.5	43.4	33.3	27.1	61.3	17.8	5.5	1.6	0.1	0.2	226.7
						Mean Spawning Stock Biomass						
1967	0.0	0.0	0.5	17.0	27.5	46.3	36.3	9.2	2.1	0.3	0.2	139.3
1968	0.0	0.0	1.3	18.7	26.8	25.7	31.0	24.6	5.5	1.3	0.3	135.2
1969	0.0	0.0	9.3	8.4	26.7	23.7	23.8	23.8	16.3	3.5	0.7	136.2
1970	0.0	0.0	9.5	29.0	25.2	16.2	13.5	11.6	12.4	9.7	2.0	129.1
1971	0.0	0.0	5.9	19.5	25.1	21.7	8.4	4.0	4.7	5.5	2.2	97.0
1972	0.0	0.0	2.7	10.7	11.3	11.5	7.4	2.8	1.1	1.7	1.1	50.2
1973	0.0	0.0	34.8	7.7	5.8	4.2	2.9	2.0	0.8	0.5	0.4	59.2
1974	0.0	0.0	9.1	73.6	6.1	3.0	1.7	0.8	0.6	0.3	0.2	95.3
1975	0.0	0.0	6.0	12.1	51.3	3.6	1.8	0.9	0.3	0.3	0.2	76.5
1976	0.0	0.0	17.0	8.3	8.3	32.1	1.9	1.0	0.4	0.1	0.1	69.2
1977	0.0	0.0	3.6	17.7	4.4	4.6	17.9	0.9	0.7	0.1	0.1	50.1
1978	0.0	0.0	2.9	7.3	12.3	3.1	2.4	8.7	0.4	0.5	0.1	37.7
1979	0.0	0.0	13.9	11.7	4.6	6.3	0.8	0.8	3.5	0.1	0.0	41.7
1980	0.0	0.0	3.5	26.2	5.5	1.9	2.6	0.2	0.2	1.4	0.0	41.5
1981	0.0	0.0	0.5	15.7	12.8	1.9	0.6	0.8	0.2	0.0	0.2	32.8
1982	0.0	0.0	8.9	1.1	8.1	5.3	0.6	0.2	0.3	0.1	0.1	24.7
1983	0.0	0.0	11.4	14.6	0.6	4.1	2.0	0.3	0.1	0.2	0.0	33.2
1984	0.0	0.0	16.3	15.2	7.8	0.4	2.0	0.5	0.1	0.1	0.0	42.3
1985	0.0	0.0	29.6	24.8	9.7	3.4	0.2	0.8	0.1	0.0	0.0	68.6
1986	0.0	0.0	38.0	37.5	18.4	6.1	1.5	0.1	0.5	0.0	0.7	102.8
1987	0.0	0.0	5.2	92.9	30.0	11.4	3.6	0.4	0.1	0.3	0.0	143.9
1988	0.0	0.0	12.6	31.6	79.0	22.2	7.7	2.4	0.2	0.0	0.0	155.9
1989	0.0	0.0	15.6	32.9	27.1	61.3	17.8	5.5	1.6	0.1	0.2	162.0

cohorts account for 47 percent of the estimated age 2+ biomass in 1990.

CATCH PROJECTIONS

Catch projections were performed by the SARC using the following input values:

Age	1990 Stock Size (millions)	Exploitation Pattern (kg)	Mean Wt. of of Catch (kg)	Mean Wt. of of Stock	Maturity (Ogive)
1	1075.6	0.059	0.014	0.014	0.0
2	27.9	0.653	0.045	0.045	0.0
3	652.3	0.580	0.108	0.108	0.386
4	353.2	0.756	0.152	0.152	0.980
5	190.0	1.0	0.185	0.185	1.0
6	127.0	1.0	0.211	0.211	1.0
7	247.9	1.0	0.244	0.244	1.0
8	61.0	1.0	0.248	0.248	1.0
9	17.0	1.0	0.265	0.265	1.0
10	5.3	1.0	0.265	0.265	1.0
11+	0.7	1.0	0.313	0.313	1.0

The exploitation pattern was the same as that used in the terminal year of the VPA. Mean weights-at-age and the maturity ogive were obtained by averaging over the years 1985 to 1989. In addition, natural mortality was fixed at 0.2 and recruitment (numbers at age 1) was fixed at 1075.6 million individuals. Catches were projected forward to 1992 assuming the status quo F (0.275) for 1990 and either $F_{0.1}$ (0.19), F_{rep} (0.5), or the F corresponding to 20 percent of the maximum spawning potential (0.37) (NEFC 1989). Projected stock size, SSB and catch are shown in Table A6.

MAJOR SOURCES OF UNCERTAINTY

The sources of uncertainty that were of greatest concern to the SARC were:

- Determination of which landings come from the Gulf of Maine stock. Exclusion of some of the New Brunswick fixed gear catches has probably resulted in underestimation of recruitment and fishing mortality rates on ages 1 and 2, and possibly age 3. On a relative scale, from year to year, this may be less of a problem. It is also likely to affect estimates of percent maximum spawning potential. Mixing with other herring stocks in the Mid-Atlantic and Southern New England regions may have resulted in overestimates of catches and survey indices at both ends of the time series (late 1960s to early 1970s and the most recent three to four years), since these are the periods when Georges Bank and Nantucket Shoals herring have been the most abundant. Substantial contributions by other stocks would most likely lead to overestimates of recent population levels for the Gulf of Maine stock.

- Determination of which survey strata to include in the survey index used for tuning. Inclusion of strata that may include fish from Georges Bank or Nantucket Shoals, particularly in the last five years, may result in overestimation of recent stock size, whereas exclusion of these strata may result in underestimates.

Table A6. Gulf of Maine herring, projected stock size, spawning stock biomass, and catch, 1990-1992

PROJECTION 1: STATUS QUO F

$F(1990) = F_{SQ} = 0.275$; thereafter $F = F_{SQ} = 0.275$

Year	1990	1991	1992
Jan 1 2+ stock size (millions)	1,682	1,979	2,170
Mean SSB (thousand mt)	180	168	142
Annual catch (thousand mt)	50	49	48

PROJECTION 2: $F_{0.1}$

$F(1990) = F_{SQ} = 0.275$; thereafter $F = F_{0.1} = 0.19$

Year	1990	1991	1992
Jan 1 2+ stock size (millions)	1,682	1,979	2,264
Mean SSB (thousand mt)	180	174	159
Annual catch (thousand mt)	50	35	37

PROJECTION 3: F_{rep}

$F(1990) = F_{SQ} = 0.275$; thereafter $F = F_{rep} = 0.5$

Year	1990	1991	1992
Jan 1 2+ stock size (millions)	1,682	1,979	1,949
Mean SSB (thousand mt)	180	153	107
Annual catch (thousand mt)	50	81	68

PROJECTION 4: F at 20% MSP

$F(1990) = F_{SQ} = 0.275$; thereafter $F = 0.37$

Year	1990	1991	1992
Jan 1 2+ stock size (millions)	1,682	1,979	2,072
Mean SSB (thousand mt)	180	161	126
Annual catch (thousand mt)	50	63	58

- Applicability of the aggregate 2+ biomass from the spring trawl survey as an index for tuning the VPA. The partial recruitment pattern for the survey may not reflect full recruitment at age 2, which should result in additional variability in the tuning estimates.

- Estimation of the partial recruitment vector. If the fishing mortality rate on the younger ages was higher than used in this assessment, recruitment may have been overestimated. Of course, the converse is also true and it is unclear at present which direction of bias is more likely. The SARC attempted to resolve the issue by running a separable VPA analysis but could not obtain acceptable results.

RECOMMENDATIONS

The SARC recommends that:

- A joint U.S./Canada assessment, incorporating relevant Canadian catches, should be conducted in the future.

- Alternative tuning methods should be further investigated. In particular, the potential for using other time series of abundance indices should be examined, consideration should be given to integrated methods that consider several time series concurrently, and, where possible, tuning indices should be disaggregated by age. Preliminary analyses along these lines that were made during the SARC meeting show promise and should be pursued.

LITERATURE CITED

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NEFC,1989. Report of the fall 1989 NEFC Stock Assessment Workshop (Ninth SAW). Woods Hole, MA: NOAA/ NMFS/ Northeast Fisheries Center. NEFC Reference Document 89-08. Available from: Northeast Fisheries Center, Water Street, Woods Hole, Mass., 02574.

SUMMER FLOUNDER

The SARC reviewed an analytical assessment performed by the Summer Flounder Working Group to estimate fishing mortality rates, stock size, and biological reference points for this species (SAW/11/SARC/7). Virtual population analysis estimates indicate that summer flounder are heavily over-exploited at present relative to estimates of F_{max}. There are still substantial uncertainties remaining in the analysis, however there was no clear indication of bias in the results.

STOCK STRUCTURE

Management of summer flounder is based on an assumed unit stock from the southern border of North Carolina, northeast to the U.S.-Canadian border.

LANDINGS

Reported commercial landings in 1989 of 9,700 mt (Table B1) were the lowest in the past 15 years and half the peak amount that was landed in 1979. Recreational landings declined even more precipitously in 1989 than commercial landings to 1,500 mt, 20 percent of the average for the past decade (Table B1). Traditionally, the commercial fishery lands about 60 percent of the total, with more than 70 percent of the commercial landings coming from the EEZ. The recreational fishery is mainly an inshore, private/rental boat fishery. There are no directed foreign or joint venture fisheries.

INDICES OF ABUNDANCE

Recent spring NEFC survey indices appear to be about one-fifth the level of indices from the mid- to late 1970s. Age composition data indicate a substantial reduction in the number of ages in the stock between 1976 and 1990 (Table B2), where by 1990 the maximum observed age was 3 years. The 1990 Age and Growth Workshop appears to have resolved previous aging inconsistencies. State surveys were used to qualitatively detect recent trends in recruitment, but there is little coherence among the survey index series (Table B3). Preliminary indices indicate that the 1989 and 1990 year classes appeared no better than average. The VIMS Young-of-the-Year survey is the only available predictor of recruitment for 1989 and 1990 that is coherent with past VPA estimates (see discussion that follows).

A Mid-Atlantic private/rental boat index for abundance, which suggested a declining trend in abundance since 1987, was developed using the intercept sample data from MRFSS. Mean catch-per-trip was calculated from the North Carolina winter trawl fishery, and the 1985 to 1989 CPUE values have remained lower than the average but have fluctuated without trends. Weigh-out landings from

Table B1. Commercial and recreational landings (mt, A+ B1) of summer flounder, Maine to North Carolina (NAFO Statistical Areas 5, 6), 1980-1989, as reported by NMFS Fisheries Statistics Division (U.S.) and NEFC (foreign)

Year	U.S. Commercial	U.S. Recreational	Foreign[1]	Total	U.S. %Commercial	U.S. %Recreational
1980	14,056	11,722	75	25,853	55	45
1981	9,904	5,124	59	15,087	66	34
1982	10,731	8,573	35	19,339	56	44
1983	13,942	16,171	**[2]	30,113	46	54
1984	16,992	13,099	**	30,091	56	44
1985	14,921	7,750	2	22,673	66	34
1986	12,955	7,971	2	20,928	62	38
1987	12,977	5,956	1	18,934	69	31
1988	16,272	8,356	**	24,628	66	34
1989	9,701	1,512	NA[3]	11,213	87	13
Average	13,245	8,623	19	21,886	63	37

[1] Foreign catch includes both directed foreign fisheries and joint venture fishing.
[2] ** = Less than 0.5 mt
[3] NA = Not available

Table B2. Summer flounder spring offshore mean number-per-tow (fitted Δ values), NEFC survey, offshore strata 1-12, 61-76

Year	Age 0	1	2	3	4	5	6	7	8	9	10	Total
1976	0.00	0.03	1.50	0.60	0.25	0.06	0.01	0.01				2.46
1977	0.00	0.54	1.17	0.62	0.09	0.08	0.01		0.01			2.51
1978	0.00	0.52	0.71	0.49	0.14	0.03	0.02	0.02			0.01	1.92
1979	0.00	0.11	0.32	0.15	0.07	0.06			0.02			0.73
1980	0.00	0.01	0.64	0.28	0.13	0.02	0.05	0.03	0.01		0.01	1.18
1981	0.00	0.58	0.52	0.17	0.08	0.05	0.03	0.02	0.01			1.46
1982	0.00	0.53	1.09	0.09	0.02							1.72
1983	0.00	0.36	0.44	0.21	0.05	0.01				0.01		1.08
1984	0.00	0.24	0.46	0.13	0.07		0.01	0.01				0.93
1985	0.00	0.42	1.18	0.16	0.03	0.02						1.80
1986	0.00	1.23	0.36	0.17	0.02	0.01						1.78
1987	0.00	0.55	0.51	0.02	0.02							1.11
1988	0.00	0.41	0.57	0.05	0.02							1.05
1989	0.00	0.07	0.32	0.03	0.01							0.45
1990	0.00	0.56	0.03	0.05								0.64

Virginia and north were subjected to ANOVA for vessel class, year, and area affects. The results explained 23 percent of the variance in the data where all parameter estimates were highly significant. A declining trend in CPUE since 1982 exists, but does not well reflect trends seen in the NEFC survey index except for the last three years, where both reflect record low abundance.

MORTALITY ESTIMATES

The rate of natural mortality was assumed to be 0.2. Total mortality estimates based on state and federal surveys increased steadily from 1976 to 1986. Pooled cohorts (survey data) showed a less clear pattern, but the mortality rate in recent years appears to be higher than in earlier years: total mortality averaged 2.3 between 1985 and 1989 compared to 1.2 between 1978 and 1984. Estimates of Z from the MRFSS ranged from 0.81 to 1.58. The SARC commented that these estimates of total mortality rate are not as reliable as estimates from virtual population analysis.

CATCH-AT-AGE

Catch-at-age matrices were developed from the MRFSS, North Carolina winter trawl fishery and the weigh-out landings, and were then summed to produce a total fishery

Table B3. Summary of summer flounder recruitment indices from state, federal, and university research surveys, Cape Hatteras to Massachusetts

Survey	Year Class										
	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
NEFC[1] (age 1)	0.58	0.53	0.36	0.24	0.42	1.23	0.55	0.41	0.07	0.56	
NEFC[1] (age 2)	1.09	0.44	0.46	1.18	0.36	0.51	0.58	0.32	0.03		
MASS[2] (age 1)	0.40	0.38	0.24	0.04	0.14	0.97	0.62	0.15	0.00	0.25	
MASS[2] (age 2)	1.42	1.30	0.07	1.19	0.53	0.58	0.97	0.34	0.02		
VIMS[3] (age 0)	1.36	1.25	1.65	0.73	0.50	0.53	0.45	0.19	0.14	0.28	0.38
MASS[4] (age 0)			3.00	3.00	1.00	19.00	5.00	5.00	2.00	3.00	11.00
VIMS[5] (age 0)							3.23	0.75	0.06	0.77	1.98
NC[6] (age 0)								19.86	2.61	6.86	4.20

[1] Number-per-tow (fitted Δ values), NEFC spring offshore trawl survey strata, 1-12, 61-76
[2] Number-per-tow (stratified mean), Massachusetts Division of Marine Fisheries spring trawl survey
[3] Number-per-tow (stratified mean), Virginia Institute of Marine Science historical trawl survey
[4] Total number, Massachusetts Division of Marine Fisheries beach seine survey (fixed stations)
[5] Number-per-tow, Virginia Institute of Marine Science young-of-the-year survey (fixed stations)
[6] Number-per-tow (stratified mean), North Carolina Division of Marine Fisheries

Table B4. Total catch-at-age of summer flounder (thousands), Maine to North Carolina, 1982 to 1988

Year	Age										Total Catch
	0	1	2	3	4	5	6	7	8	9	
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	55,473
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	36,549
1987	2,656	19,839	10,637	1,700	620	34	35	409	11	0	35,491
1988	3,541	21,995	14,069	2,143	643	131	63	20	5	0	42,610

catch-at-age matrix (Table B4). For the total catch at age during 1982-88, the average catch composition at age was: 0 = 13 percent, 1 = 49 percent, 2 = 30 percent and 3 = 6 percent. Summer flounder age 4 and older constituted an average of less than 3 percent. Mean weight-at-age varied little over the time series (Table B5).

VIRTUAL POPULATION ANALYSIS (VPA)

Ages 0 to 4 were included in analysis along with ages 5 and above which were combined as a plus group. Terminal F values in 1988 were estimated using the Laurec-Shepherd method, incorporating various survey and com-

Table B5. Mean weight-at-age (kg) of all landed summer flounder, Maine to North Carolina, 1982 to 1988

Year	Age 0	1	2	3	4	5	6	7	8	9	Mean Wt. 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	0.491
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	0.290	0.474	0.648	1.158	1.985	2.699	3.968	3.913	4.500		0.584

Table B6. Summer flounder VPA results

Fishing Mortality (F)-at-Age

Year / Age	1982	1983	1984	1985	1986	1987	1988	FBAR 82-85	FBAR 82-88
0	0.0755	0.1516	0.2574	0.0586	0.0834	0.0599	0.1234	0.1358	0.1157
1	0.6824	0.9200	0.7382	0.6932	0.6663	0.6413	0.9567	0.7585	0.7569
2	1.4778	0.7983	1.5229	1.3175	1.4297	1.3955	1.4643	1.2791	1.3437
3	1.0456	0.4543	0.8599	1.9470	1.5683	0.9755	1.3766	1.0767	1.1753
4	1.2617	0.6263	1.1914	1.6323	1.4990	1.1855	1.4196	1.1779	1.2594
+gp	1.2617	0.6263	1.1914	1.6323	1.4990	1.1855	1.4196		

Stock Number-At-Age (Start of Year)

Year / Age	1982	1983	1984	1985	1986	1987	1988	1989	GMST 82-85	AMST 82-85
0	79,185	93,820	58,362	46,986	60,741	50,311	33,588		67,183	69,588
1	42,066	60,118	66,011	36,938	36,279	45,751	38,795	24,307	49,832	51,283
2	17,213	17,407	19,615	25,832	15,120	15,255	19,725	12,202	19,739	20,016
3	1,362	3,215	6,414	3,502	5,664	2,963	3,094	3,735	3,149	3,623
4	422	392	1,671	2,222	409	966	915	639	885	1,177
+gp	323	347	571	609	1,043	762	312	243		
Total	**140,570**	**175,299**	**152,64**	**116,090**	**119,256**	**116,010**	**96,428**	**41,126**		

mercial CPUE indices. The tuning performed by the Working Group used six survey series. Lack of coherence of the surveys was cause for concern to the SARC. Therefore, during the review, an additional tuning run was made, utilizing the standard commercial CPUE disaggregated by age as a seventh tuning series. This commercial index has higher weight than the surveys in the results and improved the diagnostics for tuning. Thus, the SARC accepted this revised run and resultant VPA as the best current estimates for this stock. The fishing mortality rate on fully recruited ages was around 1.4 between 1982 and 1988 (Table B6). The analysis indicates that the fishing mortality rate has varied over the seven-year period, but the greater than 1.0 average suggests that the stock has been over-exploited for some years. The 1988 year class and the total estimated stock size in 1988 are the lowest in the series (Table B6). However, recruitment has remained fairly stable over this short time span.

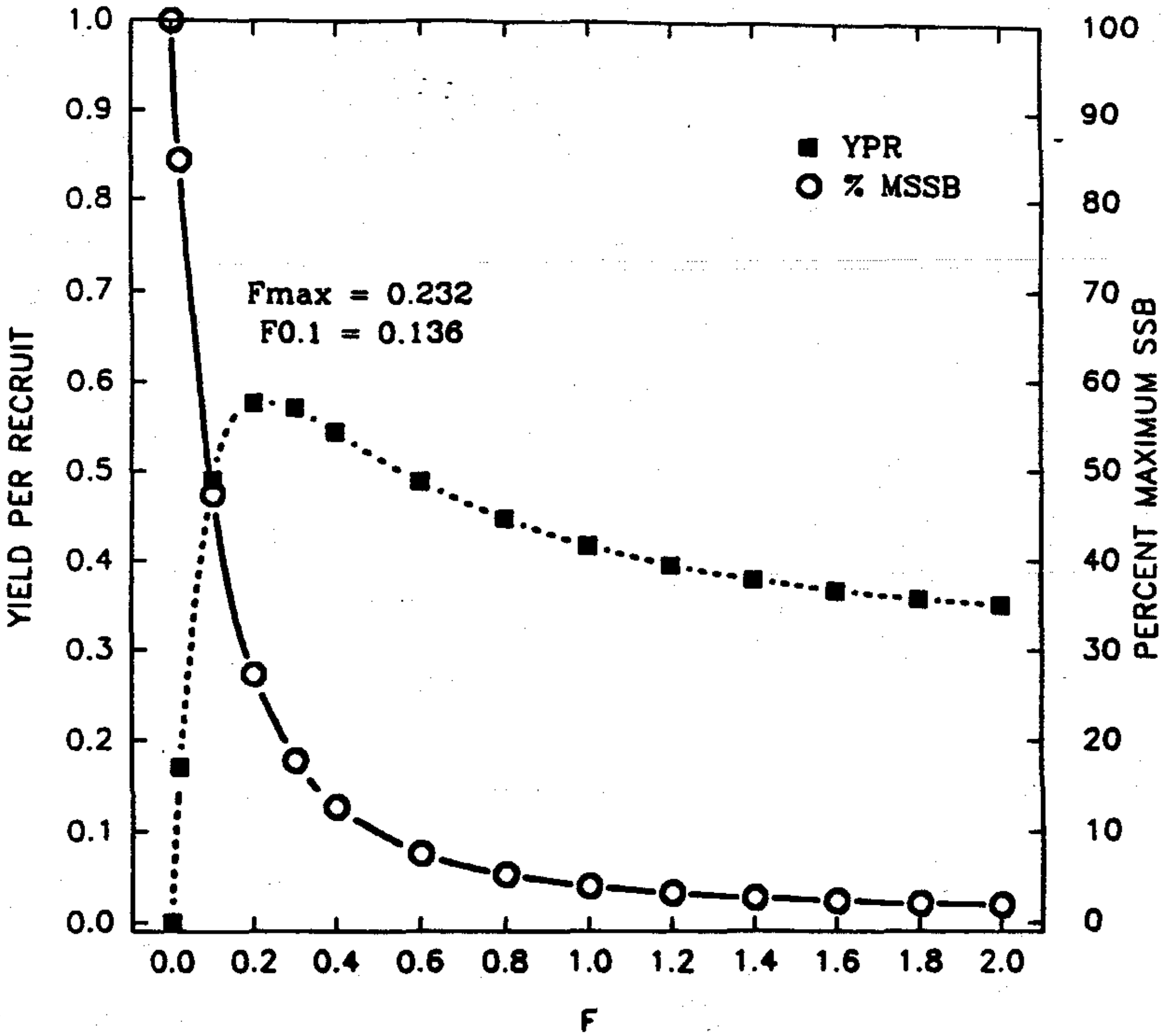

Figure B1. Results of revised yield-per-recruit analysis for summer flounder, 1990.

Yield-Per-Recruit (YPR) ANALYSIS

Biological reference points were calculated using Thompson and Bell Model. Maturity by age (females) was set at: 0 = 38 percent, 1 = 72 percent, 2 = 90 percent, 3 = 99 percent and 4+ = 100 percent. SPVA results have the following PR vector for age: 0 = 0.0428, 1 = 0.4634, 2 = 1.0000, 3 = 1.0361, 4 = 1.0000. The vector was simplified to be: 0 = 0.05, 1 = 0.50 and 2+ = 1.0. With the revised input parameters, $F_{0.1}$ = 0.14 and F_{max} = 0.23 were obtained as new estimates of the biological reference points (Table B7 and Figure B1). Significant sexual dimorphism exists among older age groups in this species and perhaps analyses should consider the sexes separately. It is unclear, however, what pragmatic impact this would have since all catch estimates and landing weights are pooled, and few older fish existent at present. The YPR model is driven by fishing mortality at age 1, and in fact, the very high Fs on age 1 fish are determining the status of this stock.

PROJECTIONS

Projections were made assuming low and high estimates of recruitment as well as an estimate based on VIMS survey data. The SARC conducted a calibration regression

Table B7. Summary of input data and results, 1990 revised yield-per-recruit analysis for summer flounder, age 0 to 15 model

Fraction F before spawning = 0.83
Fraction M before spawning = 0.83
First age = 0
Last age = 15

Age	FPATTERN	MPATTERN	Maturity	Weight in Catch and Stock (kg)
0	0.050	0.200	0.380	0.237
1	0.500	0.200	0.720	0.432
2	1.000	0.200	0.900	0.642
3	1.000	0.200	0.970	1.164
4	1.000	0.200	0.990	1.811
5	1.000	0.200	1.000	2.449
6	1.000	0.200	1.000	3.074
7	1.000	0.200	1.000	3.434
8	1.000	0.200	1.000	4.380
9	1.000	0.200	1.000	4.841
10	1.000	0.200	1.000	5.336
11	1.000	0.200	1.000	5.767
12	1.000	0.200	1.000	6.135
13	1.000	0.200	1.000	6.445
14	1.000	0.200	1.000	6.704
15	1.000	0.200	1.000	6.917

Slope at F factor = 0: 10.090
$F_{0.01}$: 0.136
F_{max}: 0.232

FFACT	MFACT	Catch Weight	Spawn Weight	Percent Maximum Spawn Weight
0.00	1.00	0.0000	9.4975	1.0000
0.02	1.00	0.1711	8.0073	0.8431
0.10	1.00	0.4903	4.5022	0.4740
0.20	1.00	0.5756	2.5925	0.2730
0.30	1.00	0.5660	1.6880	0.1777
0.40	1.00	0.5433	1.1969	0.1260
0.60	1.00	0.4878	0.7146	0.0752
0.80	1.00	0.4457	0.4953	0.0522
1.00	1.00	0.4158	0.3772	0.0397
1.20	1.00	0.3943	0.3055	0.0322
1.40	1.00	0.3786	0.2582	0.0272
1.60	1.00	0.3669	0.2249	0.0237
1.80	1.00	0.3578	0.2001	0.0211
2.00	1.00	0.3506	0.1810	0.0191

Table B8. Summer flounder projections

Long-term average yield and SSB at two levels of recruitment: 33.588 (lowest in the time series) and 93,820 (highest in the time series), and four reference fishing mortality levels: $F_{0.1}$ (0.136), F_{max} (0.232), F_{rep} (1.10) and F_{SQ} (1.42)

F	Yield (thousand mt)	SSB (thousand mt)
$F_{0.1}$	17.5 - 48.8	128.0 - 357.5
F_{max}	19.1 - 53.5	77.3 - 215.8
F_{rep}	13.8 - 38.5	11.4 - 31.9
F_{SQ}	12.8 - 35.7	8.7 - 24.4

Projected yield and mean annual SSB using the status quo F (1.42) and predicted recruitment estimates of 55,579 (±18,864) in 1989 and 57,058 (±18,864) in 1990 and thereafter

	1989 (mt)	1990 (mt)	1991 (mt)
Predicted Recruitment Estimates			
Mean SSB	18,838	21,902	21,228
Yield	9,701	22,429	21,616
Minus one s.e.			
Mean SSB	17,255	17,276	15,055
Yield	9,701	19,013	15,688
Plus one s.e.			
Mean SSB	20,419	26,528	27,402
Yield	9,701	25,845	27,545

Data Used in Summer Flounder Projections[1]

Age	1989 Stock Size (thousand)	Exploitation Pattern	Mean Wt. of Catch (kg)	Mean Wt. of Catch (kg)	Maturity (Ogive)
0	variable[2]	0.050	0.237	0.237	0.380
1	24,307	0.500	0.432	0.432	0.720
2	12,2021.0	0.642	0.642	0.900	
3	37,351.0	1.164	1.164	0.970	
4	6,391.0	1.811	1.811	0.990	
5+	2,431.0	2.449	2.449	1.000	

[1] M = 0.2, recruitment 1990 onward = 57,058 ± 18,864, 1989 landings = 9,701 mt
[2] 55,579 ± 18,864

of the VIMS survey versus the VPA estimates of numbers at age one. The resulting predictions of recruitment were a weighted average at the mean recruitment and the VIMS prediction using the RCRTINX2 program. VIMS data predict age 0 recruitment for 1987 to 1990 to be 65.7 million, 63.1 million, 55.6 million, and 57.1 million individuals, respectively. The standard errors for the last two estimates were both approximately 19 million. These estimates should be considered highly uncertain given the short time series of data and large standard errors. More work is needed on recruitment prediction and these estimates should only be used as a guideline.

Table B8 gives yield and spawning biomass projections for a) average yield under constant F and recruitment assumptions and b) projected yield for 1989 to 1991 using estimates of incoming recruitment. All of these projections are optimistic in assuming that recruitment will remain near the average level. Since the 1989 projection is well above the reported catch, and preliminary indications are that the 1990 catch will be even lower, these figures should be viewed with caution.

The relative yield and spawning biomass figures for different levels of F are useful for comparison rather than absolute levels. Under current F levels, incoming year classes may rebuild the stock biomass slightly. However, note that the case for one standard error below the estimated recruitment gives a scenario of declining stock, so any projection of stock rebuilding is uncertain and has a high risk. Longer term yield depends entirely on incoming recruitment and appears to be much greater for lower levels of fishing mortality rate, *i.e.*, near $F_{0.1}$ and F_{max}. Maintaining current F levels will continue to depress the stock and the yield on average.

SOURCES OF UNCERTAINTY

The principle sources of uncertainty in this assessment are:

- Only a very short time series of data is available for assessment. This means that new data may substantially influence the picture of the stock over time. There are insufficient data to estimate other reference points such as F_{rep} for this stock.

- The survey series are in poor agreement and make it more difficult to interpret the results of the assessment. More analyses of commercial CPUE seems one possible route to reducing uncertainty in stock status.

- Recruitment is poorly estimated but crucial because of the truncated age distribution. More analyses of other surveys and more work on the estimation of the errors in the estimates is required.

SCUP

The SARC reviewed analyses presented by the Connecticut Bureau of Fisheries on scup resources in Long Island Sound and adjacent waters (SAW/11/SARC/2). Estimates of mortality based on catch-curve calculations indicate that this resource is currently over-exploited, although these are highly uncertain estimates of current fishing mortality. Estimates of the biological reference point F_{rep} are not well founded at present, and further work will be necessary to determine this target level for stock maintenance.

STOCK STRUCTURE

For assessment purposes, scup within the Middle Atlantic Bight (Cape Cod to Cape Hatteras) are considered to be a unit stock.

LANDINGS

U.S. commercial landings ranged from 18,000 to 22,000 mt between 1953 and 1963. During 1975-81, landings fluctuated between 6,000 and 10,000 mt. Since 1981, domestic landings have declined sharply; the 1989 catch of 3,600 mt is the lowest since 1960. Reported landings by distant-water fleets peaked at nearly 6,000 mt in 1963, but declined to less than 100 mt by 1975. Total landings since 1967 are depicted in Table C1. Scup support important recreational fisheries with landings ranging from 1,600 to 6,000 mt during 1979-88.

ABUNDANCE INDICES

Catch-per-unit-effort of Southern New England from otter trawlers increased from 2.2 mt per day fished to 6.2 mt per day from 1977 to 1979. Recent levels decreased sharply from 5.8 mt per day during 1982-84, to 2.8 mt per day in 1989.

The NEFC autumn offshore survey index has fluctuated markedly, with high catch rates in 1975, 1981, and 1983 (Table C2), while the 1986 to 1988 levels were below the long-term mean. The 1989 survey index value increased relative to the 1986-88 levels in the Mid-Atlantic region. Surveys conducted in coastal waters of Connecticut and Massachusetts reveal generally similar patterns of relative year class strength compared to the NEFC surveys.

MORTALITY ESTIMATES

Catch curve analyses derived from the Connecticut survey indicate total mortality rates of Z = 0.7 to 1.1 for 1982 and 1985, and 1.48 for 1988. An earlier estimate,

Table C1. Total landings and catch-per-unit-effort of scup in Connecticut and coastwide, 1979 to 1988

Year	Commercial					Recreational	
	Coastwide[1] (1,000 mt)	Total (1,000 lb)	CT[2] (CPUE lb)	In-Sound (1,000 mt)	CT[2] (CPUE)	Coastwide[1] (1,000 mt)	In-Sound[3] (CT CPUE)
1979	8.0	626	130	478	88	3.7	NA
1980	7.9	219	56	193	50	3.9	NA
1981	9.8	228	63	141	642	.0	NA
1982	8.7	176	78	156	65	3.1	NA
1983	7.8	227	48	179	56	3.4	NA
1984	7.8	112	31	73	43	1.4	8.0
1985	6.7	109	29	80	49	3.3	13.2
1986	6.9	225	32	139	42	5.9	14.1
1987	6.1	144	31	87	38	3.2	8.8
1988	NA	215	60	17	29	NA	2.9

[1] Southern New England and Mid-Atlantic regional landings reported in NOAA Technical Memorandum NMFS-F/NEC-63, *Status of the Fishery Resources off the Northeastern United States for 1988.*
[2] Connecticut Department of Marine Fisheries Information System, unpublished statistics. Total= Areas 1-9; CPUE = arithmetic mean 1 lb+ catch-per-trawl hour. In-sound = Area 1-6; CPUE = geometric mean of 20 percent catch per trawl hour.
[3] Job 1 - Marine Angler Survey; CPUE = fish creeled per trip for positive catch trips.

Table C2. Continued stratified mean catch-per-tow (number and weight in kg) of scup in autumn NEFC bottom trawl surveys, 1982; Southern New England: strata 1, 2, 5, 6, 9; Massachusetts: strata 61, 65, 69, 73, 74

Year	<14cm	≥14cm	All Mean	Fish Lower 95% CI	Upper 95% CI	<14cm	≥14cm	All Mean	Fish Lower 95% CI	Upper 95% CI
1982	29.916	8.084	33.00	-3.773	69.773	39.547	1.499	41.046	-25.921	108.014
1983	0.826	8.171	8.997	1.620	16.375	4.041	0.250	4.291	-3.799	12.382
1984	3.547	7.792	11.339	0.921	21.756	42.563	15.784	58.347	-26.421	143.116
1985	35.129	25.223	60.352	-0.613	121.317	128.100	7.301	135.401	33.047	237.755
1986	23.920	5.885	29.805	-1.477	61.087	100.761	4.130	104.891	-54.108	263.890
1987	15.001	1.108	16.109	-10.455	42.674	0.407	0.082	0.489	-0.246	1.224
1988	16.188	0.407	16.595	-10.699	43.888	0	0	0		
1989	5.674	3.664	9.338	-1.894	20.570	235.779	29.924	265.703	-0.198	531.604

based on NEFC survey data during the latter 1970s, was approximately Z = 0.5 (Table C3). A length-based mortality estimator applied to the Connecticut survey data gave comparable results although the estimates were often lower. The SARC concluded that length-based estimates were probably more appropriate for scup, given the current state of the aging data. Similar trends in total mortality were obtained in analyses of Massachusetts survey data. Estimated total mortality rates increased from Z = 0.5 to 0.6 during the late 1970s, to more than Z = 0.9 in the late 1980s.

BIOLOGICAL REFERENCE POINTS

Estimates of $F_{0.1}$ and F_{rep} were provided based on demographic parameters derived from published work and ongoing biological investigations. The yield and spawning biomass-per-recruit model incorporated a constant natural mortality rate over all ages (M = 0.2) and age-specific discard mortality rates based on hooking mortality studies and assumed levels for commercial gear. Estimates of F_{rep} were derived with reference to survey estimates of recruitment (age 2) and spawning biomass for Connecticut, Massachusetts and NEFC surveys.

Estimates of $F_{0.1}$ ranged from F = 0.22 to 0.38 at minimum legal size limits of 15 to 25 cm (FL). The derived estimates of F_{rep} ranged from 0.34 to 0.48 under these size limit restrictions (discussed next.)

RECOMMENDATIONS

A single annual age-length key was applied to all length data for 1982 to 1986, and in 1983 Long Island

Sound key was used for Massachusetts data prior to 1982; it was not possible to specify year and area-specific age length keys. The SARC noted that it would be preferable to use annual area-specific age- length keys. Alternatively, length-based estimators that partition length composition data into component modal groups (*e.g.* MULTIFAN), or which use length projection methods could be used. The length-based estimator used in the current analysis assumes a constant growth rate and does not account for variability in growth. It would be desirable to base these analyses on samples derived from the commercial and recreational fisheries where possible, to provide an integrated measure of the size composition over the year. The current estimates rely on survey estimates which provide snapshots of the size composition.

It was noted that it would be preferable to estimate mortality rates for individual cohorts rather than assuming equilibrium conditions as in the current analysis.

The designation of age 2 as the recruitment age in the F_{rep} analysis should be modified because this species is harvested at age 1. Supplemental analyses were undertaken during the SARC in an attempt to address this difficulty. Age 0 indices and a spawning biomass index from the NEFC autumn survey were used in this analysis. The estimated levels of F_{rep} from this analysis appeared to be unreasonably low (F_{rep} = 0.07 to 0.12). It was the consensus of the SARC that the most probable explanation for this result was that the 0-group scup were not fully vulnerable to the survey gear. Therefore, it was concluded that F_{rep} could not be estimated from the current data without additional information on partial recruitment. The estimates made in this study are unreasonable.

It was noted that this species is subject to technological interactions in the multispecies fishery targeting summer flounder, scup, and black sea bass and that the development of management advice for these species should consider these interactions.

Table C3. Annual estimates of total mortality for Connecticut and Massachusetts spring survey data. Connecticut estimates are for May-November for catch curve and May-July for the length-based method.

	Catch Curve (Ages 2-7)		Length Based (L_r = 15 cm, L_{max} = 39 cm)	
Year	CT (se)	MA (se)	CT	MA
1978		0.92 (0.17)		0.29
1979		0.56 (0.11)		0.58
1980		0.47 (0.12)		0.84
1981		0.55 (0.08)		1.38
1982	1.12 (0.08)	1.19 (0.31)	0.88	1.17
1983	0.73 (0.08)	1.06 (0.13)	0.74	1.43
1984	0.98 (0.10)	0.39 (0.09)	0.88	0.39
1985	0.87 (0.11)	0.91 (0.12)	0.81	1.29
1986	1.46 (0.15)	1.36 (0.13)	0.76	0.91
1987	1.50 (0.16)	1.14 (0.22)	1.38	
1988	1.48 (0.16)		0.82	

BLACK SEA BASS

STOCK STRUCTURE

Black sea bass within the Middle Atlantic Bight are assumed to comprise a unit stock for assessment purposes.

LANDINGS

Total landings declined from a peak of 9,883 mt in 1952 to a low of 614 mt in 1971 (Table D1). Landings have fluctuated around 1,600 mt since 1971. Landings declined from 1,729 mt in 1988 to 1,240 mt in 1989. Black sea bass support important recreational fisheries in the Middle Atlantic Bight; estimated landings from this component are comparable to those from the commercial fishery. The estimated 1989 recreational landings were 2,098 mt. Some difficulties with the estimates of recreational catch in 1982 and 1986 were noted, and require further consideration.

ABUNDANCE INDICES

The NEFC spring survey index for black sea bass longer than 20 cm TL (post-recruits) declined from 6.09 per tow in 1977 to a low in 1982 of 0.20 per tow. The index averaged 0.53 per tow during 1988-89 (Table D2). Commercial catch-per-unit-effort was modeled using a general linear modelling method to standardize effort. Trends in the survey index are not generally reflected in trends in the

Table D1. Black sea bass commercial, recreational, and foreign landings (mt)

Year	Commercial	Recreational[1]	Foreign	Total
1950	5,736			
1951	8,361			
1952	9,883			
1953	6,521			
1954	5,141			
1955	5,131			
1956	5,251			
1957	4,320			
1958	5,242			
1959	3,655			
1960	3,102	2,699		5,801
1961	2,483			
1962	3,692			
1963	3,798			
1964	3,199			
1965	3,604	2,086		5,690
1966	1,652			
1967	1,302			
1968	1,201			
1969	1,199			
1970	1,100	1,662		2,762
1971	614			
1972	760			
1973	1,161			
1974	1,069			
1975	1,885			
1976	1,690			
1977	2,424			
1978	2,115		5	2,120
1979	1,875	616	41	2,532
1980	1,252	1,079	14	2,345
1981	1,129	1,124	39	2,292
1982	1,177	8,215	21	9,413
1983	1,576	2,737	20	4,333
1984	1,926	1,509	21	3,456
1985	1,541	2,472	35	4,048
1986	1,802	6,394	11	8,207
1987	1,890	1,597	4	3,491
1988	1,729	2,598	1	4,328
1989	1,240	2,098	-	3,338

[1] Recreational catch = A + B1 + .1*B2

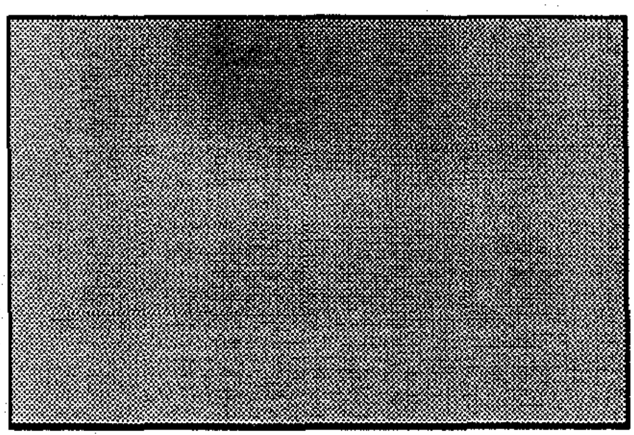

Table D2. NEFC survey indices (mean number-per-tow) for pre-recruits (<11 cm) from autumn inshore and recruits (>20) from spring offshore. Strata include 01-56 (inshore) and 01-12,61-76, and 25 (offshore)

Year	Pre-recruit Index	Recruit Index
1990		0.54
1989	2.13	0.52
1988	0.26	0.68
1987	0.34	1.17
1986	6.66	2.06
1985	2.90	0.39
1984	0.61	0.25
1983	1.42	0.67
1982	11.63	0.20
1981	0.10	0.89
1980	0.60	1.41
1979	0.91	5.21
1978	0.08	2.94
1977	15.87	6.09
1976	0.93	1.62
1975	3.95	2.02
1974	0.33	2.36
1973	0.45	0.87
1972	0.02	0.49

commercial fishery's catch-per-unit-effort, although it does appear possible to derive a recruitment index from the autumn survey time series. Standardized CPUE increased during 1980-84 to 3.5 mt per day fished but declined during 1985-86. CPUE declined from 2.49 mt per day in 1988 to 1.60 mt per day in 1989.

SUGGESTIONS

The SARC recommended that mortality estimates be made based on length composition data from the recreational and commercial fisheries. This work was completed during the SARC using the Hoenig method. These preliminary estimates suggest that fishing mortality rates are substantially in excess of F_{max} (0.3) for this species (Figure D1). This stock is currently categorized as fully exploited in the status of fisheries resources report (NEFC 1989), but this analysis suggests black sea bass may currently be overexploited. It was noted that the change in growth rates associated with the transition from female to male will complicate the estimation of mortality rates from sex-aggregated size composition estimates.

The adequacy of the traditional biological reference points for hermaphroditic species such as black sea bass was discussed. It was noted in particular that traditional spawning stock biomass-per-recruit analyses may not be meaningful for these species. Work in progress at NEFC using a distributed delay model to account for patterns of growth and the sex transition was described briefly.

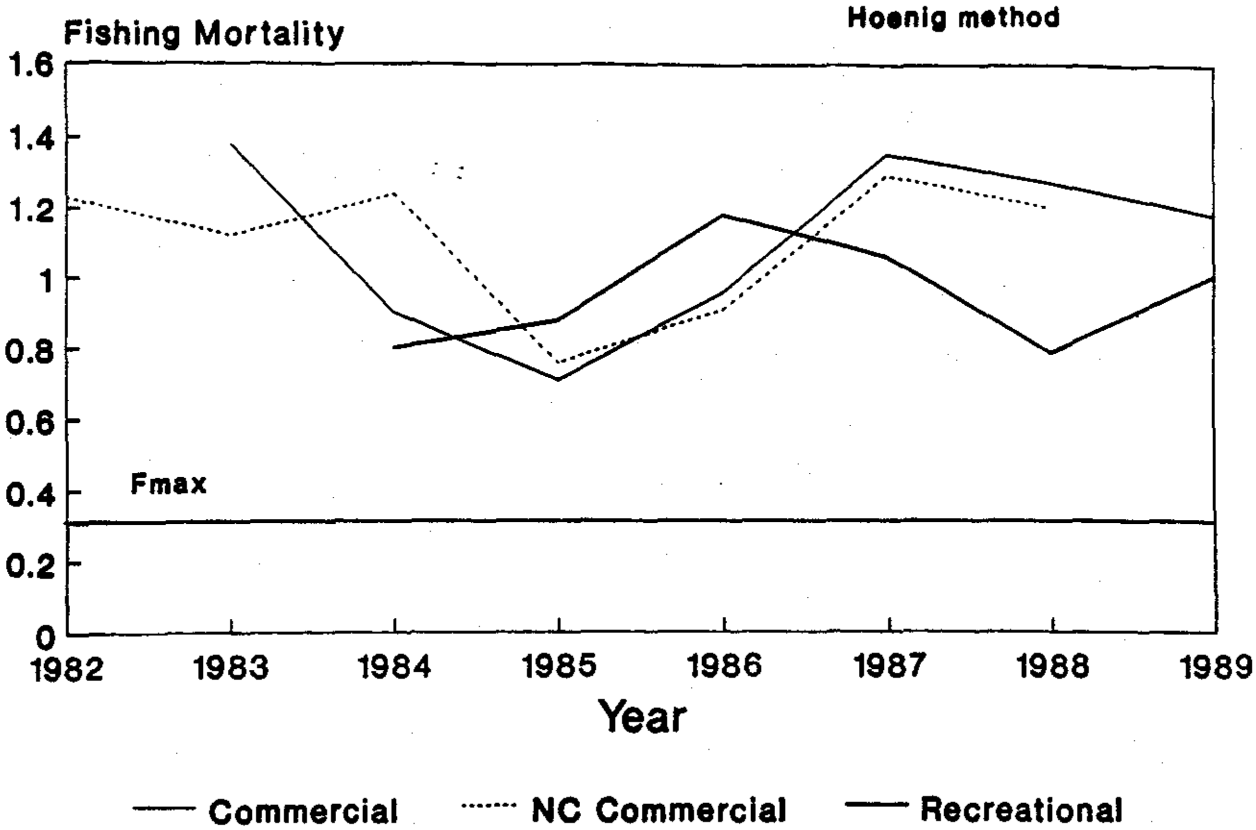

Figure D-1. Black sea bass mortality estimates using length-based methods.

BLUEFISH

A yield-per-recruit analysis for bluefish (*Pomatomus saltatrix*) was conducted by NEFC staff (SAW/11/SARC/5). The SARC concluded that additional investigation was needed to clarify the sensitivity of estimates to several sources of uncertainty but that the analysis represents the best current information on bluefish yield-per-recruit.

INPUT PARAMETERS

The yield-per-recruit analysis assumed nine age classes (ages 0 to 7 and a plus group). The natural mortality rate (M) on ages 1+ was fixed at 0.35. Three alternative estimates of M (0.5, 1.0, and 1.5) were used for age 0. Parameters of the von Bertalanffy growth equation were estimated to be L_{inf} = 94.6 cm, K = 0.242 and t_0 = -0.128. These estimates are similar to others derived in several previous studies of bluefish growth (Table E1). However, the analysis of yield-per-recruit used by ASMFC in the past assumed quite a different growth pattern for bluefish with L_{inf} = 90.7 $_{cm}$; K = 0.25 and t_0 = -1.12. This curve gives much

Table E1. Theoretical growth parameters (with correlation coefficients) of bluefish collected in several studies. Parameters were derived from back-calculated total lengths (in.).

L_{inf}	K	t_0	r^2
New Hampshire, 1986			
37.30	0.351	0.083	0.999
Connecticut, 1984-1985			
39.25	0.258-0.293	0.999	
North Carolina, 1982-1985			
36.77	0.373	-0.013	0.996
Atlantic (Wilk 1977)			
40.85	0.216	-0.152	0.998
New York (Richards 1976)			
35.34	0.322	-0.079	0.998

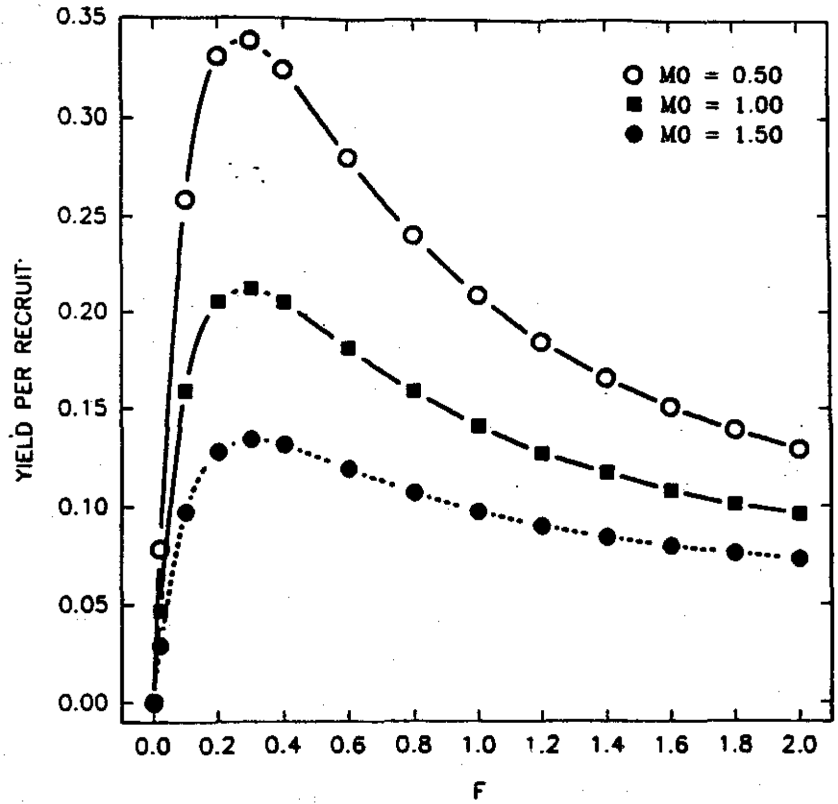

Figure E1. Results of revised yield-per-recruit analysis for Atlantic coast bluefish, ages 0 to 8+, 1990.

smaller sizes at the older ages and so a different pattern of yield-per-recruit. The new von Bertalanffy parameters were used to age sample length-frequencies by "cohort slicing," and to develop weights-at-age in the catch (based on the sample length frequencies) and the stock (from the unmodified parameter estimates). Partial recruitment (PR) vectors were derived from separable VPA runs. There were three alternative estimates of PR, corresponding to the three alternative estimates of M on age 0. Input parameters are summarized below:

Age	Exploitation Pattern	Natural Mortality	Maturity (Ogive)	Wt in Catch (kg)	Wt in Stock (kg)
.0	0.6,0.5,0.35	0.5,1.0,1.5	0.0	0.080	0.044
1	1.0	0.35	0.5	0.460	0.280
2	1.0	0.35	1.0	1.120	0.960
3	1.0	0.35	1.0	2.190	1.922
4	1.0	0.35	1.0	3.222	3.012
5	1.0	0.35	1.0	4.426	4.108
6	1.0	0.35	1.0	5.344	5.116
7	1.0	0.35	1.0	6.137	6.006
8+	1.0	0.35	1.0	7.876	7.658

RESULTS

The three alternative runs resulted in estimates of $F_{0.1}$ ranging from 0.177 to 0.192, and values of F_{max} from 0.269 to 0.305 (Figure E1). The SARC noted that the estimates of $F_{0.1}$ and F_{max} seemed to be relatively insensitive to the range of values of M at age 0 used in the analysis. However, estimates of yield-per-recruit were highly sensitive (Figure E1).

MAJOR SOURCES OF UNCERTAINTY

The SARC identified the following major sources of uncertainty:

- Estimates of M on young bluefish are arbitrary. High values of M may not be restricted to age 0.
- The cohort slicing approach may not be an adequate method for generating age-length keys and catch at age.
- Weights-at-age are still increasing at a rapid rate at the oldest ages used in the analysis. This is one of the reasons for the low (relative to M) estimates of the reference fishing mortality levels.

RECOMMENDATIONS

The SARC recommends that:

- Sensitivity analyses with higher estimates of M on age 1 fish (as well as age 0) should be attempted.

- A mixture of distributions method (*e.g.* MULTIFAN) should be used to generate age-length keys and the catch at age matrix.

- Weight-at-age information should be examined more thoroughly, particularly in the recreational fishery data, to confirm the growth pattern for this species.

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Wilk, S.J. 1977. Biological and fisheries data on bluefish, *Pomatomus saltatrix* (Linnaeus). Sandy Hook, NJ: NOAA/ NMFS Northeast Fisheries Center. Sandy Hook Technical Series Report No. 11. Available from: NMFS Northeast Fisheries Center, PO Box 428, Highlands, NJ, 07732.

SILVER HAKE

The SARC re-analyzed data on both the northern and southern stocks of silver hake to estimate stock size and fishing mortality rates. In addition the SARC reviewed an analysis of spawning stock biomass-per-recruit and the evaluation of the effect of an increase in mesh size prepared by the New England Fishery Management Council staff. Virtual population analyses of these two stocks were difficult and the results must be viewed with caution. While the SARC did agree that the VPA results are the best current information on stock status and improved on the last available assessments for both stocks, there were several problems identified in the analysis which make the results uncertain. No projections were done for this stock but a reanalysis of biological reference points was made in light of the new assessment.

STOCK STRUCTURE

Two stock components are identified for silver hake, divided at Georges Bank. The northern stock is located on northern Georges Bank and in the Gulf of Maine. The southern stock is on southern Georges Bank and extends down into the Mid-Atlantic Bight.

CATCH AT AGE

Both stocks were reviewed at the 10th SAW and a description of the fishery is presented in the report of that meeting (NEFC 1990). For the analyses conducted during the SARC the same catch-at-ge matrices were used as described at the 10th SAW. Table F1 give the catch at age for the stocks for 1955 to 1988. These data do not include estimates of discards. The SARC noted that there were very few fish landed for age groups above five, *i.e.*, that these age groups were poorly sampled by the fishery.

ABUNDANCE INDICES

NEFC autumn and spring survey indices for both stocks are available from 1973 until the present (Table F2). The early years, until 1981, used a different, more efficient net type (Yankee 41) than the later years of the surveys. For the spring survey the 1989 indices at age are also available. These numbers were not used in the analysis by the SARC, but were considered in interpreting the results of the various tuning runs.

NORTHERN STOCK

Assessment Parameters

The SARC reviewed the results that were presented at the 10th SAW, particularly the VPA tuning runs. Following some discussion, several additional tuning trials were made. Two methods were used; Laurec-Shepherd *ad hoc* tuning (Laurec and Shepherd 1982) and ADAPT Gavaris, 1988). For the northern stock the final set of calculations used as input were:

- The years 1976 to 1988, inclusive

- Equal weighting applied to all years

- F in the terminal year (1988) was estimated for ages 1 to 4 only (in ADAPT numbers in 1989 for ages 2 to 5 were also estimated)

- In Laurec-Shepherd, the F at age 5 was set equal to either that for age 3 or the mean of ages 3 and 4. In ADAPT, F at age 5 and 6 was set equal to the F on age 4

- The rate of natural mortality equal to 0.4

Table F1. Commercial catch-at-age (millions of fish) of silver hake from the Gulf of Maine - Northern Georges Bank stock and the Southern Georges Bank - Middle Atlantic stock

Commercial Catch-At-Age (Millions) of Silver Hake from the Gulf of Maine - Northern Georges Bank Stock

Year	Age 1	2	3	4	5	6	7	8	9+	Total
1955	17.0	19.9	50.2	69.2	30.4	13.7	6.5	3.3	1.5	211.8
1956	16.2	12.7	36.5	61.2	26.4	10.1	4.2	1.9	.9	170.2
1957	52.8	19.5	58.8	84.8	41.6	17.9	6.7	3.1	1.3	286.6
1958	20.9	20.2	40.1	57.6	28.4	17.2	5.7	2.8	1.2	194.2
1959	10.1	30.0	58.2	54.2	26.8	12.8	6.2	3.2	1.1	202.7
1960	4.4	37.7	76.2	53.2	20.8	8.8	4.7	2.3	.9	209.0
1961	1.1	23.2	59.7	51.5	18.9	8.0	4.1	1.9	.8	169.1
1962	2.6	33.5	127.2	122.8	47.4	12.5	5.9	2.2	1.0	355.1
1963	14.9	48.3	136.9	103.0	29.2	10.3	4.6	2.5	1.3	351.0
1964	1.4	46.6	133.1	123.4	50.2	20.6	11.7	5.6	2.1	94.9
1965	4.0	23.9	84.2	54.0	18.3	7.4	4.0	2.2	1.2	199.2
1966	5.3	20.3	82.6	70.9	19.8	6.5	3.3	1.9	1.1	211.7
1967	.7	5.3	32.5	54.9	20.3	5.3	2.4	1.1	.5	123.0
1968	1.3	4.0	25.8	49.5	36.5	13.7	5.0	1.9	.9	138.6
1969	3.1	10.6	16.8	21.3	16.2	9.1	5.0	1.9	1.0	85.0
1970	24.8	16.0	32.4	34.1	13.4	7.0	4.4	2.2	.8	135.2
1971	4.0	24.3	73.8	49.8	19.8	7.1	2.9	1.9	.8	184.4
1972	78.2	44.5	18.2	4.2	2.2	.7	.2	.1	.3	148.5
1973	33.4	91.5	24.2	4.5	1.8	.4	.1	.1	.2	156.1
1974	21.6	31.7	22.4	9.2	2.7	1.0	.4	.2	.2	89.4
1975	8.7	60.1	63.4	20.3	7.9	2.3	.5	.2	.4	164.0
1976	1.7	19.2	24.6	8.7	2.9	1.3	.2	.001	.001	58.7
1977	1.8	8.7	22.6	14.9	3.0	.5	.2	.001	.001	51.6
1978	2.7	8.3	7.1	10.8	13.5	2.4	.5	.3	.001	45.5
1979	.7	3.5	2.3	1.4	1.8	2.3	.4	.001	.001	12.4
1980	1.1	11.8	12.1	2.0	.5	.5	.8	.2	.001	29.0
1981	4.9	8.4	7.4	4.0	.6	.2	.2	.2	.001	25.9
1982	5.9	9.8	2.9	3.0	2.2	.1	.2	.1	.1	24.3
1983	2.6	14.1	4.0	1.8	1.7	.7	.2	.1	.001	25.2
1984	3.0	21.5	9.8	3.0	1.0	.7	.001	.001	.001	39.1
1985	10.4	6.8	13.9	3.9	.4	.7	.1	.001	.001	36.1
1986	3.1	14.0	8.1	3.8	1.1	.5	.2	.1	.001	30.9
1987	.5	13.2	11.1	1.6	.9	.1	.001	.001	.001	27.4
1988	.7	4.7	20.0	4.5	1.3	.2	.001	.001	.001	31.4

For the *ad hoc* tuning, the spring and autumn survey series were weighted by the inverse of the variance of the estimates of the mean catchability coefficients. The autumn survey was lagged by one year and one age. For ADAPT, F on the oldest age was set equal to Z on ages 3+ in year i divided by 4+ in year i+1 minus M. In addition, the catchability coefficients in ADAPT were estimated for ages 0 to 5+ for autumn surveys and ages 1 to 5+ for spring surveys versus mid-year stock size.

Weights-at-age are given in Table F3.

VPA Tuning

Considerable discussion took place comparing the results from the two tuning methods. There was better agreement between the two methods than achieved at the 10th SAW, but some differences remained which the SARC felt would not be resolved by further analyses on the data available. In particular, the ADAPT method gave a higher fishing mortality on age 3 in the terminal year than did the *ad hoc* tuning. This in turn implies that the 1985 year class was identified as large in ADAPT, while the Laurec-Shepherd estimates result in an average year class size for 1985. The SARC noted that both the spring and autumn 1989 and the spring 1990 NEFC bottom trawl survey all tend to confirm the large size of the 1985 year class.

Concerns were expressed about the implied partial recruitment vector in 1988 from the Laurec-Shepherd tuning results. The SARC agreed that the results from the ADAPT run appeared to be the most consistent with the recent survey results, which continue to show the strength

Table F1. (con't.)

Commercial Catch-At-Age (Millions) of Silver Hake from the Southern Georges Bank - Middle Atlantic Stock

	Age									
Year	1	2	3	4	5	6	7	8	9+	Total
1955	17.4	9.6	20.0	21.7	8.7	1.9	.7	.3	.1	80.3
1956	61.9	46.6	20.4	15.2	5.4	1.3	.7	.2	.1	151.7
1957	2.4	22.2	31.3	22.6	9.6	2.6	1.0	.3	.1	92.0
1958	20.6	27.8	24.8	15.5	5.4	1.4	.7	.2	.01	96.3
1959	11.8	11.4	36.6	24.7	8.7	2.0	.7	.2	.01	96.0
1960	12.0	17.0	12.7	10.6	4.9	1.6	.9	.4	.1	60.2
1961	.4	6.2	26.2	21.5	5.5	1.5	1.0	.3	.2	62.7
1962	.5	6.6	31.7	34.6	10.1	2.0	1.4	.6	.3	87.8
1963	6.5	33.8	171.7	196.2	53.5	8.2	2.5	1.2	.5	474.1
1964	18.4	65.3	286.8	271.5	85.1	19.5	9.5	4.6	1.9	762.6
1965	46.9	203.7	901.7	553.0	75.1	16.1	7.3	2.4	.8	1806.9
1966	18.7	359.8	507.6	289.7	77.8	25.1	10.9	5.0	1.2	1295.7
1967	15.7	121.5	216.3	154.9	30.8	7.3	3.0	1.5	.3	551.5
1968	9.7	24.5	143.4	90.8	29.0	11.1	4.4	1.4	.8	315.1
1969	1.8	20.0	111.0	100.6	40.7	11.4	10.3	4.2	2.6	302.6
1970	41.8	25.1	17.3	32.6	23.1	6.5	5.0	2.8	1.3	155.4
1971	8.0	41.3	92.3	79.0	44.4	18.7	12.3	11.1	8.0	315.1
1972	134.0	174.1	111.9	33.0	5.0	2.1	.5	.1	.1	460.8
1973	72.8	325.0	112.9	29.3	4.9	1.1	.5	.1	.01	546.4
1974	73.7	223.3	141.2	74.1	17.2	6.0	3.5	1.7	.5	541.2
1975	5.5	106.6	149.3	51.0	19.8	2.7	.2	.1	1.0	336.1
1976	7.6	86.6	142.8	95.2	10.4	1.3	.2	.01	.01	344.1
1977	2.6	34.0	132.6	68.8	11.2	3.1	2.2	.3	.01	254.8
1978	2.2	26.7	20.4	28.0	12.5	2.5	.8	.01	.01	93.1
1979	8.1	22.0	17.3	8.0	10.4	6.8	1.1	.2	.01	73.9
1980	3.6	17.4	19.4	9.5	4.4	2.5	2.8	.5	.3	60.6
1981	17.6	24.0	28.4	16.1	5.0	1.6	.8	.7	.4	94.7
1982	12.4	32.0	12.2	9.3	8.1	2.3	.9	.5	.5	78.0
1983	8.4	23.0	16.7	6.0	4.3	2.3	.9	.1	.2	61.8
1984	7.2	45.5	23.0	5.7	.9	.4	.3	.1	.01	83.1
1985	7.6	26.1	23.1	7.6	1.5	.2	.2	.01	.01	66.5
1986	11.3	28.2	18.3	5.3	1.0	.2	.1	.01	.01	64.4
1987	5.6	25.1	17.8	5.9	4.5	.2	.01	.01	.01	59.2
1988	3.4	23.5	20.1	5.8	.5	.01	.01	.01	.01	53.3

of the 1985 year class. Therefore, these ADAPT results were accepted as the best current information on the status of this stock. However, the SARC emphasized that there was a large amount of uncertainty associated with the results from this assessment and that the results should be used with caution. Some of this uncertainty, particularly with respect to the 1985 year class, may be resolved if the analyses were updated to include 1989 and 1990 data.

Fishing Mortality Rates

Trends in average fishing mortality rates (Table F4) are complicated by apparent fluctuation and changes in the partial recruitment vector over time. Fishing mortality rates on age 3 appeared to have increased sharply in 1984 and again in 1985 and have subsequently declined. The estimated rate for 1988 is the lowest in the time series. In contrast, the estimates of the fishing mortality rate for age 2 increased slightly in 1984 and then declined sharply in 1985, fell to its lowest level in the time series in 1987, and then increased by a factor of three in 1988.

Stock Sizes

Recent trends in recruitment and stock size (Table F4) are dominated by the 1985 cohort. This year class is estimated to be the largest since 1974 and three times larger than any other year class since 1975. However, as noted above in the discussion on tuning, estimates of the size of the 1985 year class were sensitive to the tuning procedure used. Estimates of total biomass increased in 1986 and declined in 1987 and 1988; while estimates of spawning

Table F2. Stratified mean number-per-tow (Δ)-at-age for silver hake from the Gulf of Maine - Northern Georges Bank stock (strata 20-30, 36-40), and (linear) Southern Georges Bank-Middle Atlantic stock (offshore strata 1-19,61-76, inshore strata 1-46, 52, 55) from NEFC bottom trawl surveys in the spring and autumn

Year	Age									Total		
	0	1	2	3	4	5	6	7	8	9+	0+	1+	2+
Stratified Mean-Number-Per-Tow (Δ)-At-Age for Gulf of Maine-Northern Georges Bank Silver Hake													
Spring													
1973	-	4.64	10.46	1.05	.13	.05	.01	-	-	-	16.34	16.34	11.70
1974	-	34.59	3.62	1.73	.39	.11	.05	.05	.01	.02	40.57	40.57	5.98
1975	-	56.51	57.52	7.29	1.23	.40	.05	-	-	-	123.00	123.00	66.49
1976	-	10.53	23.58	12.78	1.48	.51	.28	.04	.02	-	49.23	49.23	38.70
1977	-	5.00	4.88	4.25	1.71	.34	.13	.13	.02	.01	16.46	16.46	11.46
1978	-	3.57	1.55	.29	.16	.04	.01	.01	-	-	5.63	5.63	2.06
1979	-	7.06	10.80	.37	.07	.05	.04	.05	.03	-	18.46	18.46	11.40
1980	-	3.67	16.65	5.71	.40	.11	.10	.08	.02	.04	26.77	26.77	23.10
1981	-	9.92	5.70	3.69	1.17	.17	.06	-	.01	-	20.71	20.71	10.79
1982	-	11.32	5.77	1.64	.77	.54	.09	.01	-	.04	20.18	20.18	8.86
1983	-	10.85	8.40	.89	.28	.30	.11	.02	-	-	20.85	20.85	10.00
1984	-	3.80	5.28	.98	.11	.08	.08	.03	-	-	10.36	10.36	6.56
1985	-	39.49	4.13	2.36	.92	.20	.07	.11	-	-	47.29	47.29	7.80
1986	-	87.10	5.81	1.74	.57	.14	.06	-	-	-	95.42	95.42	8.32
1987	-	3.12	34.85	3.37	.47	.25	-	-	.04	-	42.10	42.10	38.98
1988	-	.93	1.76	4.92	.61	.12	.05	-	-	-	8.39	8.39	7.46
1989	-										120.86		
Autumn													
1973	5.87	7.20	8.51	3.24	.48	.32	.12	-	-	.06	25.80	19.93	12.73
1974	18.30	3.56	2.97	1.80	.25	.22	.11	-	-	-	27.20	8.90	5.34
1975	18.36	17.41	32.09	7.61	2.39	.87	.26	.08	.30	-	79.38	61.02	43.61
1976	6.48	3.26	14.61	20.36	8.60	1.40	1.08	.51	.01	.03	56.34	49.86	46.60
1977	2.66	3.03	6.05	13.05	8.21	1.34	.23	.05	-	-	34.61	31.95	28.93
1978	19.65	5.22	4.77	3.39	4.92	6.46	1.27	.12	.21	-	46.00	26.35	21.13
1979	1.16	28.44	17.35	2.06	.96	1.19	1.51	.25	.02	.02	52.96	51.80	23.36
1980	5.47	3.56	12.11	11.89	2.73	1.02	.83	1.52	.42	.08	39.61	34.14	30.58
1981	1.33	7.66	4.07	5.19	3.95	.75	.29	.28	.40	.07	23.99	22.66	14.99
1982	9.59	14.46	8.63	3.18	2.67	2.57	.24	.07	.07	.07	41.54	31.95	17.49
1983	1.45	43.04	29.76	1.22	.59	.63	.30	.06	.02	.01	77.09	75.64	32.60
1984	8.42	6.02	7.38	2.23	.50	.18	.10	-	-	.01	24.84	16.42	10.40
1985	37.59	43.00	3.97	6.61	1.41	.09	.01	.02	-	-	92.70	55.11	12.11
1986	14.52	87.78	6.34	11.58	2.45	.20	.04	.03	-	-	122.94	108.42	20.64
1987	1.88	3.40	43.32	10.15	1.03	.85	.06	.01	-	-	60.70	58.82	55.42
1988	39.59	4.06	6.30	18.26	1.40	.14	-	-	-	-	69.75	30.16	26.10
1989											105.60		

stock biomass increased in 1987 and remained constant in 1988. Both of these recent trends are dominated by the 1985 year class.

SOUTHERN STOCK

Assessment Parameters

After reviewing the analysis presented at the 10th SAW, the SARC decided that re-analysis similar to that performed on the northern stock was appropriate. The input parameters for the Laurec-Shepherd tuning procedure were the same as described for the northern stock. For ADAPT some changes were made. Estimates of F in the terminal year were only made for ages 1 to 3. The F at ages 4 to 6 in the terminal year was set equal to F at age 3. Other inputs were as for the northern stock.

VPA Tuning

The results from the initial runs, with input as described here for both tuning methods, continued to exhibit the strong temporal trends in estimates of catchability from

Table F2. (con't.)

Year	Age 0	1	2	3	4	5	6	7	8	9+	Total 0+	1+	2+
Stratified Mean Number-per-Tow (Lnear)- At -Age for Southern Georges Bank - Middle Atlantic Silver Hake													
Spring													
1973[1]	-	5.65	6.96	3.33	1.07	.11	.06	.04	-	.01	17.23	17.23	11.58
1974[1]	-	28.40	2.19	3.55	2.06	.69	.24	.07	-	.01	37.22	37.22	8.82
1975[1]	-	17.38	4.57	8.64	2.38	.66	.06	.01	-	-	33.70	33.70	16.32
1976[2]	-	12.08	5.15	3.40	1.70	.37	.10	.02	-	-	22.82	22.82	10.74
1977[2]	-	1.42	1.24	3.69	2.05	.42	.17	.12	.02	-	9.12	9.12	7.70
1978[2]	-	6.24	2.84	1.53	2.22	1.05	.32	.03	.01	-	14.24	14.24	8.00
1979[2]	-	5.18	1.44	1.00	.47	.72	.48	.05	-	-	9.33	9.33	4.15
1980[2]	-	3.60	3.07	2.10	.79	.25	.27	.21	.07	.02	10.38	10.38	6.78
1981[2]	-	3.69	1.84	2.01	1.37	.64	.25	.14	.09	.09	10.12	10.12	6.43
1982	-	1.31	3.11	1.02	1.03	.86	.30	.18	.06	.10	7.96	7.96	6.65
1983	-	4.12	3.83	1.08	.58	.24	.19	.11	.01	.02	10.18	10.18	6.06
1984	-	2.47	5.74	2.39	.59	.13	.11	.05	.02	.01	11.50	11.50	9.03
1985	-	8.91	3.98	3.99	1.41	.35	.08	.07	.03	.01	18.82	18.82	9.91
1986	-	3.35	9.57	2.19	1.74	.27	.04	-	-	-	17.20	17.20	13.81
1987	-	3.53	13.09	5.17	1.28	.64	.03	-	-	-	23.80	23.80	20.21
1988	-	4.58	2.42	5.57	.84	.06	-	-	-	-	13.47	13.47	8.89
1989											19.03		
Autumn													
1973[3]	10.51	2.89	3.09	1.32	.37	.19	.01	-	-	-	18.37	7.86	4.97
1974	121.59	4.19	1.58	.45	.10	.04	-	-	-	-	127.95	6.36	2.17
1975	40.81	3.78	2.16	1.32	.54	.18	.07	.02	.01	.01	48.91	8.10	4.32
1976	95.46	2.49	4.92	2.62	.91	.24	.13	.12	.01	-	106.91	11.45	8.96
1977	128.39	3.63	1.44	2.82	.96	.21	.03	.06	.05	-	137.60	9.21	5.58
1978	57.05	9.46	4.20	2.76	2.50	1.13	.16	.05	-	-	77.32	20.27	10.81
1979	18.72	2.01	1.75	1.27	.62	.45	.36	.07	.01	-	25.25	6.53	4.52
1980	42.85	3.74	1.39	3.34	1.04	.50	.20	.38	.03	.02	53.48	10.63	6.89
1981	49.19	2.42	.77	1.16	.83	.19	.04	-	.05	-	54.65	5.46	3.05
1982	60.74	2.85	2.28	.91	.39	.17	.07	-	.02	.01	67.45	6.71	3.86
1983	27.48	8.68	3.91	1.93	.38	.18	.07	.05	-	-	42.68	15.20	6.52
1984	22.23	4.79	2.29	.92	.24	.03	-	-	-	-	30.51	8.28	3.49
1985	89.94	16.30	3.53	3.13	.88	.07	.05	-	-	-	113.90	23.96	7.66
1986	19.96	4.95	2.21	.50	.16	.06	-	-	-	-	28.15	7.88	2.93
1987	.72	4.62	6.42	.49	.15	.05	-	-	-	-	12.44	11.73	7.11
1988	36.94	3.29	7.56	.82	.07	-	-	-	-	-	49.04	11.74	8.45
1989											28.17		

[1] Adjusted from offshore #41 trawl catches to equivalent inshore-offshore #36 trawl catches using a .320:1 ratio

[2] Adjusted from inshore-offshore #41 trawl catches to equivalent inshore-offshore #36 trawl catches using a .334:1 ratio.

[3] Adjusted from offshore #36 trawl catches to equivalent inshore-offshore #36 trawl catches using a .890:1 ratio.

the Laurec-Shepherd method and in the residuals for the ADAPT method. An extremely high estimate of the fishing mortality rate and q for age 1 in the terminal year was obtained because the 1987 autumn age 0 survey index appears to be an extreme outlier.

The SARC noted in the results from the ADAPT tuning that the temporal trend in the residuals appeared to be much stronger for the spring survey indices than for the autumn. Also, the 1988 age 4 index and the 1987 autumn index of age 0 accounted for 15 percent of the total sum of squares in the ADAPT analysis. Consequently, the SARC decided further runs would omit the spring survey series, the autumn age 0 index, and the 1988 age 4 index. The entire age 0 index was suspect because of the difficulty in sampling young hake.

Additional runs of the Laurec-Shepherd method were not thought to be useful due to the sensitivity of the method to error in the terminal year indices and the generally poor diagnostics from the initial runs.

Results from this additional analysis still suggested a possible time trend in the residuals with a tendency for the residuals to be negative prior to 1982 and positive thereaf-

Table F3. Mean weight (kg)-at-age of silver hake from the Gulf of Maine-Northern Georges Bank stock and the Southern Georges Bank - Middle Atlantic stock

Year	Age 1	2	3	4	5	6	7	8	9+
Gulf of Maine-Northern Georges Bank Stock									
1955	.046	.132	.200	.258	.331	.416	.530	.573	.654
1956	.055	.128	.204	.260	.326	.405	.499	.567	.699
1957	.064	.120	.193	.260	.322	.384	.453	.513	.644
1958	.045	.127	.210	.282	.341	.404	.494	.555	.628
1959	.051	.129	.190	.269	.348	.430	.521	.574	.656
1960	.064	.129	.171	.233	.320	.433	.512	.622	.696
1961	.065	.146	.186	.239	.303	.410	.516	.637	.685
1962	.069	.135	.172	.229	.303	.388	.503	.619	.752
1963	.080	.121	.176	.229	.308	.431	.573	.770	1.055
1964	.075	.123	.171	.228	.316	.456	.562	.702	.971
1965	.059	.147	.175	.233	.320	.448	.570	.744	.882
1966	.065	.144	.183	.229	.298	.427	.583	.772	.976
1967	.072	.155	.218	.266	.317	.385	.478	.744	.882
1968	.070	.161	.222	.278	.323	.387	.462	.589	.788
1969	.064	.154	.201	.291	.325	.375	.442	.506	.878
1970	.060	.118	.178	.232	.304	.392	.444	.509	.687
1971	.077	.122	.165	.211	.262	.344	.437	.524	.680
1972	.089	.195	.310	.437	.494	.588	.690	.794	.916
1973	.119	.173	.262	.414	.472	.544	.943	1.026	1.151
1974	.144	.217	.270	.314	.563	.407	.594	1.114	1.218
1975	.102	.167	.238	.361	.484	.604	.748	.867	1.285
1976	.102	.162	.237	.295	.422	.672	.645	.872	1.140
1977	.120	.172	.221	.277	.403	.536	.717	.899	.995
1978	.114	.196	.232	.277	.329	.446	.659	.762	.992
1979	.104	.139	.201	.258	.351	.349	.513	1.069	1.096
1980	.094	.134	.164	.206	.283	.355	.462	.662	1.200
1981	.115	.147	.188	.215	.238	.305	.410	.666	.811
1982	.117	.159	.197	.271	.289	.312	.418	.666	.811
1983	.129	.175	.249	.311	.310	.431	.425	.666	.811
1984	.126	.176	.242	.368	.404	.334	.500	.666	.811
1985	.142	.200	.256	.325	.412	.610	.574	.666	.811
1986	.145	.214	.270	.376	.538	.496	.621	.666	.811
1987	.092	.149	.251	.321	.578	.568	.579	.666	.811
1988	.101	.139	.181	.368	.526	.779	.537	.666	.811

ter. However, the trends did not appear to be as strong as in the results from previous runs. Time did not permit any statistical testing for whether the apparent remaining trends in the residuals were significant. The SARC felt that to the extent that a temporal trend in the residuals still remained, it would result in underestimates of the current (1988) Fs and overestimates of the current (Jan. 1, 1989) stock size.

The SARC agreed that the results from this analysis represented a considerable improvement in comparison with previously available assessments and represent the best current knowledge of the status of this stock. The need for caution in the application of the results was emphasized by:

- Possible temporal trends in the observed residuals,
- The sensitivity of the results to the choice of indices, and
- The contradictory role of the spring survey indices in the assessments of the northern and southern stocks.

Fishing Mortality Rates

Trends in fishing mortality rates (Table F5) for this stock are also complicated by fluctuations in the apparent partial recruitment vector as estimated by the VPA. The

Table F3. (con't.)

Year	Age 1	2	3	4	5	6	7	8	9+
Southern Georges Bank-Middle Atlantic Stock									
1955	.044	.101	.162	.222	.307	.422	.508	.662	.762
1956	.034	.074	.154	.223	.316	.438	.496	.664	.777
1957	.062	.085	.157	.224	.326	.465	.512	.683	.782
1958	.060	.088	.152	.215	.310	.409	.490	.682	.878
1959	.035	.105	.156	.227	.333	.439	.485	.629	.973
1960	.047	.074	.159	.216	.317	.445	.547	.702	.904
1961	.077	.105	.164	.217	.331	.498	.591	.832	.920
1962	.067	.106	.157	.215	.300	.441	.646	.778	1.007
1963	.076	.103	.161	.209	.286	.394	.468	.788	.906
1964	.057	.107	.154	.210	.301	.456	.545	.651	.929
1965	.063	.102	.153	.199	.300	.427	.512	.621	1.040
1966	.058	.089	.143	.207	.311	.453	.534	.654	.944
1967	.045	.092	.149	.204	.300	.451	.550	.701	.813
1968	.046	.096	.138	.194	.311	.454	.554	.767	.955
1969	.064	.111	.189	.243	.308	.399	.517	.698	1.135
1970	.049	.093	.163	.209	.270	.347	.445	.597	1.009
1971	.057	.096	.152	.204	.280	.343	.436	.580	.961
1972	.092	.201	.274	.370	.372	.451	.734	.752	1.151
1973	.096	.167	.251	.300	.393	.539	.485	.858	1.067
1974	.057	.178	.225	.302	.325	.415	.577	.680	.982
1975	.111	.141	.199	.332	.468	.585	.601	.775	1.062
1976	.064	.168	.195	.228	.453	.507	.927	1.132	.973
1977	.066	.168	.213	.257	.376	.573	.545	1.096	.973
1978	.081	.192	.286	.344	.333	.424	.606	.758	1.299
1979	.081	.183	.243	.287	.396	.358	.472	.638	1.625
1980	.103	.194	.212	.263	.315	.416	.509	.723	.731
1981	.060	.144	.220	.255	.265	.343	.431	.659	.973
1982	.106	.158	.210	.246	.298	.355	.435	.446	.673
1983	.113	.167	.207	.251	.285	.347	.512	.578	.522
1984	.044	.138	.183	.304	.324	.418	.512	.659	.720
1985	.089	.147	.214	.354	.520	.502	.512	.659	.973
1986	.078	.133	.193	.268	.385	.613	.512	.659	.973
1987	.119	.135	.187	.214	.466	.416	.706	.659	.973
1988	.061	.153	.176	.275	.367	.664	.512	.659	.973

estimates of age specific Fs suggest that age of full recruitment has generally been beyond age 3 and that there is considerable variability in the estimates of fishing mortality rates of age 3 fish relative to age 4. Estimates of the fishing mortality rates for age 2 show a slow, consistent decline since 1984, while estimates for age 3 only indicate a decline beginning after 1986. The SARC found that Almedia's (1987) assessment, which only included data through 1986, indicated a sharp decline in F beginning in 1984 that is not supported by the additional data included in this VPA. However, there is some indication that effort in this fishery may have declined in recent years, although detailed analyses of effort data were not available for review.

Stock Sizes

Recent trends in stock sizes are dominated by the uncertain estimates for the most recent years (Table F5). Recruitment for 1987 is estimated to be the highest since

Table F4. Fishing mortality rate estimates and numbers at age from ADAPT estimation procedure for the northern stock of silver hake

Age	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
							Stock Numbers (Jan. 1, millions) - Northern Stock										
1	357.8	398.3	172.1	50.8	38.1	90.1	76.9	48.1	57.3	84.0	104.6	60.2	104.7	327.9	38.9	16.9	0.0
2	227.1	212.5	249.3	108.3	32.6	24.0	58.2	51.0	31.4	34.4	51.5	68.0	37.9	61.7	217.3	25.6	10.8
3	85.3	77.3	116.5	117.9	56.8	14.8	9.3	36.1	24.5	14.2	15.0	23.0	28.0	19.8	29.9	134.8	13.3
4	19.4	37.4	33.5	26.2	58.9	19.6	4.1	4.4	14.3	10.4	7.1	6.8	7.4	7.4	6.7	10.9	74.0
5	7.5	9.3	17.5	5.8	10.4	27.3	4.3	1.6	1.3	6.3	4.5	3.3	2.1	1.8	1.8	3.2	3.7
6	1.4	3.5	4.0	5.3	1.5	4.5	7.2	1.4	0.7	0.4	2.4	1.6	1.4	1.1	0.3	0.5	1.1
7+	1.4	2.8	1.8	0.8	0.6	1.5	1.2	2.7	1.3	1.5	1.0	0.0	0.2	0.6	0.0	0.0	0.2
1+	700.0	741.2	594.8	315.0	199.0	181.8	161.3	145.4	130.7	151.1	186.2	162.9	181.7	420.3	294.8	192.0	103.0
							Summaries For Ages 2+, 3+, and 4+										
2+	342	343	423	264	161	92	84	97	73	67	82	103	77	92	256	175	103
3+	115	130	173	156	128	68	26	46	42	33	30	35	39	31	39	149	92
4+	30	53	57	38	71	53	17	10	18	19	15	12	11	11	9	15	79
							Fishing Mortality - Northern Stock										
1	0.1210	0.0685	0.0637	0.0418	0.0595	0.0373	0.0112	0.0283	0.1104	0.0896	0.0308	0.0628	0.1293	0.0116	0.0158	0.0518	
2	0.6777	0.2011	0.3487	0.2442	0.3939	0.5474	0.0763	0.3321	0.3961	0.4280	0.4070	0.4883	0.2473	0.3247	0.0771	0.2535	
3	0.4251	0.4370	1.0927	0.2941	0.6648	0.8860	0.3585	0.5260	0.4596	0.2881	0.3935	0.7358	0.9343	0.6902	0.6045	0.1999	
4	0.3333	0.3574	1.3504	0.5206	0.3695	1.1178	0.5436	0.8194	0.4175	0.4352	0.3698	0.7753	1.0369	0.9950	0.3467	0.6976	
5	0.3478	0.4371	0.7991	0.9399	0.4328	0.9271	0.7169	0.4857	0.8393	0.5536	0.6179	0.4633	0.2652	1.4523	0.9222	0.6976	
6	0.4135	0.4228	1.1931	0.3572	0.5128	1.0396	0.4913	0.5697	0.4671	0.3959	0.4324	0.7450	0.9557	0.8356	0.5868	0.6976	
7+	0.4135	0.4228	1.1931	0.3572	0.5128	1.0396	0.4913	0.5697	0.4671	0.3959	0.4324	0.7450	0.9557	0.8356	0.5868	0.6976	
									Average F								
2+	0.4352	0.3797	0.9962	0.4522	0.4811	0.9263	0.4463	0.5504	0.5078	0.4161	0.4422	0.6588	0.7325	0.8556	0.5207	0.5406	
3+	0.3867	0.4154	1.1257	0.4938	0.4986	1.0020	0.5203	0.5941	0.5301	0.4137	0.4492	0.6929	0.8296	0.9618	0.6094	0.5980	
4+	0.3770	0.4100	1.1339	0.5437	0.4570	1.0310	0.5608	0.6112	0.5478	0.4451	0.4631	0.6822	0.8034	1.0297	0.6106	0.6976	
								Average F (Weighted by N)									
2+	0.5857	0.2818	0.6635	0.3117	0.4847	0.8690	0.4140	0.5660	0.5878	0.4875	0.1523	0.2492	0.2044	0.4386	0.4311	0.4106	
3+	0.4044	0.4134	1.1162	0.3586	0.5079	0.9834	0.4891	0.5562	0.4573	0.3922	0.4260	0.7181	0.9186	0.8151	0.5749	0.2485	
4+	0.3447	0.3792	1.1642	0.5584	0.3830	1.0105	0.5615	0.6644	0.4540	0.4717	0.4583	0.6834	0.8790	1.0440	0.4740	0.6976	
								Average F (Weight by Catch)									
2+	0.6087	0.3155	0.8254	0.3465	0.5133	0.9033	0.3820	0.4666	0.4372	0.4213	0.4187	0.5839	0.7590	0.5821	0.3410	0.3054	
3+	0.4072	0.4160	1.1270	0.3985	0.5385	0.9886	0.5125	0.5652	0.4647	0.4136	0.4379	0.7256	0.9422	0.8433	0.5952	0.3148	
4+	0.3460	0.3817	1.1957	0.5946	0.3852	1.0151	0.5725	0.6840	0.4719	0.4775	0.4774	0.7044	0.9636	1.0609	0.5552	0.6976	

Table F4. (con't.)

Age	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
								Mean Biomass (thousand mt)									
1	33.19	45.80	14.05	4.19	3.66	8.32	6.56	3.68	5.16	7.77	10.96	6.07	11.55	38.98	2.92	1.38	
2	24.04	34.66	29.31	12.93	3.87	3.05	6.43	4.85	3.18	3.72	6.19	7.93	5.58	9.39	25.74	2.62	
3	15.23	14.14	14.40	20.15	7.73	1.93	1.31	3.86	3.09	2.02	2.58	3.32	3.95	3.26	4.73	18.35	
4	5.69	8.23	5.70	5.05	11.38	2.79	0.68	0.52	2.10	1.91	1.54	1.47	1.27	1.49	1.51	2.44	
5	2.49	3.55	4.94	1.35	2.85	4.97	0.91	0.30	0.18	1.18	0.88	0.89	0.63	0.43	0.59	1.01	
6	0.54	0.98	1.22	2.49	0.54	1.07	1.67	0.32	0.13	0.08	0.71	0.32	0.46	0.31	0.10	0.23	
7+	1.03	1.67	0.89	0.37	0.28	0.54	0.42	0.88	0.46	0.58	0.35	0.00	0.06	0.23	0.00	0.00	
1+	82.20	109.03	70.51	46.52	30.32	22.66	17.99	14.41	14.31	17.26	23.21	20.01	23.51	54.09	35.60	26.03	
2+	49.01	63.23	56.46	42.34	26.66	14.35	11.43	10.73	9.15	9.48	12.25	13.94	11.96	15.11	32.67	24.66	
3+	24.97	28.57	27.15	29.41	22.78	11.30	5.00	5.89	5.97	5.77	6.07	6.01	6.38	5.72	6.93	22.04	
4+	9.75	14.43	12.75	9.26	15.05	9.37	3.68	2.02	2.87	3.75	3.48	2.69	2.43	2.46	2.20	3.69	
								Mean SSB - Females (thousand mt)									
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	00.00	0.00	0.00	0.00	0.00	
2	7.09	10.22	8.65	3.81	1.14	0.90	1.90	1.43	0.94	1.10	1.8	22.34	1.65	2.77	7.59	0.77	
3	7.23	6.71	6.84	9.57	3.67	0.91	0.62	1.84	1.47	0.96	1.23	1.58	1.88	1.55	2.25	8.72	
4	2.84	4.12	2.85	2.52	5.69	1.40	0.34	0.26	1.05	0.95	0.77	0.74	0.64	0.75	0.75	1.22	
5	1.24	1.78	2.47	0.68	1.43	2.49	0.45	0.15	0.09	0.59	0.44	0.45	0.32	0.21	0.29	0.50	
6	0.27	0.49	0.61	1.25	0.27	0.54	0.84	0.16	0.07	0.04	0.36	0.16	0.23	0.15	0.05	0.12	
7+	0.52	0.83	0.44	0.18	0.14	0.27	0.21	0.44	0.23	0.29	0.18	0.00	0.03	0.11	0.00	0.00	
1+	19.20	24.16	21.86	18.02	12.34	6.50	4.36	4.28	3.84	3.93	4.79	5.26	4.74	5.55	10.94	11.33	

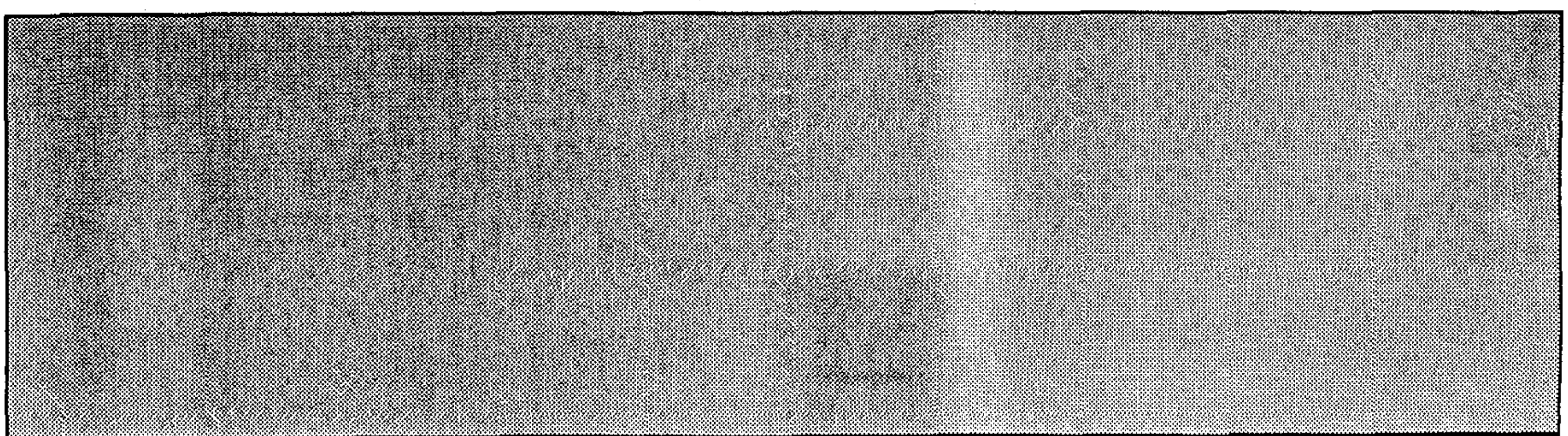

Table F5. Stock numbers, fishing mortality, mean biomass, and mean SSB for silver hake southern stock, 1973-1989

Age	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Stock Numbers (Jan. 1) in millions																	
1	1411.3	1195.7	773.5	214.4	204.7	241.6	188.2	113.9	160.5	159.9	204.9	138.9	178.3	220.4	318.8	147.2	0.0
2	866.9	886.4	741.1	514.0	137.5	135.1	160.1	119.5	73.4	93.2	97.0	130.5	87.2	113.3	138.5	209.1	95.9
3	336.6	315.0	411.4	409.5	273.6	64.3	68.7	89.3	65.9	29.6	36.3	46.2	50.2	37.1	52.9	72.3	120.9
4	81.3	133.2	95.5	153.5	157.6	74.9	26.4	31.9	44.0	20.9	9.8	10.6	12.2	14.8	9.9	20.9	32.0
5	23.8	30.5	28.6	22.3	25.0	49.3	27.3	11.2	13.6	16.3	6.4	1.7	2.5	1.9	5.5	1.8	9.2
6	3.2	11.9	6.4	3.0	6.4	7.6	22.8	9.8	3.9	5.0	4.3	0.8	0.4	0.4	0.5	0.0	0.8
7+	1.7	10.9	3.0	0.5	5.0	2.4	4.3	13.8	4.5	4.0	2.2	0.8	0.4	0.2	0.1	0.1	0.1
1+	2724.9	2583.7	2059.5	1317.2	809.9	575.2	497.8	389.3	365.7	328.9	360.9	329.5	331.2	388.1	526.1	451.4	258.9
Summaries for Ages 2+, 3+, and 4+																	
2+	1314	1388	1286	1103	605	334	310	275	205	169	156	191	153	168	207	304	259
3+	447	502	545	589	468	198	150	156	132	76	59	60	66	54	69	95	163
4+	110	187	134	179	194	134	81	67	66	46	23	14	15	17	16	23	42
Fishing Mortality - Southern Stock																	
1	0.0651	0.0783	0.0087	0.0443	0.0156	0.0112	0.0540	0.0394	0.1438	0.0995	0.0514	0.0654	0.0535	0.0647	0.0217	0.0286	
2	0.6123	0.3677	0.1932	0.2304	0.3596	0.2762	0.1837	0.1958	0.5095	0.5437	0.3418	0.5549	0.4548	0.3625	0.2503	0.1476	
3	0.5271	0.7929	0.5857	0.5549	0.8962	0.4899	0.3675	0.3082	0.7482	0.7011	0.8266	0.9360	0.8250	0.9224	0.5299	0.4151	
4	0.5799	1.1379	1.0554	1.4165	0.7619	0.6104	0.4618	0.4522	0.5923	0.7848	1.3679	1.0629	1.4436	0.5777	1.3048	0.4151	
5	0.2901	1.1656	1.8650	0.8435	0.7943	0.3705	0.6275	0.6571	0.5960	0.9329	1.7268	1.0642	1.3620	1.0084	4.6393	0.4151	
6	0.5389	0.9542	0.7278	0.7645	0.8891	0.5173	0.4524	0.3755	0.7012	0.8191	1.0588	1.0257	0.9927	0.8619	0.7330	0.4151	
7+	0.5389	0.9542	0.7278	0.7645	0.8891	0.5173	0.4524	0.3755	0.7012	0.8191	1.0588	1.0257	0.9927	0.8619	0.7330	0.4151	
Average F																	
2+	0.5145	0.8954	0.8591	0.7624	0.7650	0.4636	0.4242	0.3941	0.6414	0.7668	1.0634	0.9449	1.0118	0.7658	1.3651	0.3705	
3+	0.4950	1.0010	0.9923	0.8688	0.8461	0.5011	0.4723	0.4337	0.6678	0.8114	1.2078	1.0229	1.1232	0.8465	1.5880	0.4151	
4+	0.4869	1.0530	1.0940	0.9472	0.8336	0.5039	0.4986	0.4651	0.6477	0.8390	1.3031	1.0447	1.1978	0.8275	1.8525	0.4151	
Average F (Weighted by N)																	
2+	0.5824	0.5653	0.4239	0.5301	0.7350	0.4136	0.3108	0.2960	0.6174	0.6533	0.6056	0.6839	0.6725	0.5146	0.4906	0.2312	
3+	0.5242	0.9146	0.7377	0.7917	0.8453	0.5071	0.4470	0.3728	0.6775	0.7881	1.0399	0.9643	0.9617	0.8313	0.9742	0.4151	
4+	0.5155	1.1199	1.2059	1.3327	0.7735	0.5153	0.5146	0.4594	0.6069	0.8437	1.3810	1.0590	1.4072	0.6364	2.4438	0.4151	
Average F (Weight by Catch)																	
2+	0.5864	0.6622	0.6099	0.7250	0.7825	0.4489	0.3691	0.3321	0.6292	0.6725	0.7664	0.7196	0.7555	0.5920	0.8305	0.2892	
3+	0.5298	0.9316	0.8082	0.8964	0.8484	0.5206	0.4622	0.3923	0.6834	0.7943	1.0866	0.9660	0.9960	0.8517	1.3428	0.4151	
4+	0.5384	1.1216	1.2522	1.3517	0.7744	0.5349	0.5240	0.4739	0.6086	0.8470	1.4013	1.0590	1.4109	0.6565	2.7040	0.4151	

Table F5. (con't.)

Age	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
								Mean Biomass (thousand mt)									
1	108.35	54.17	70.48	11.08	11.06	16.04	12.25	9.50	7.43	13.34	18.64	4.89	12.76	13.75	30.95	7.30	
2	91.04	110.15	78.82	64.05	16.18	18.85	22.20	17.46	6.94	9.53	11.44	11.60	8.62	10.54	13.74	24.64	
3	55.07	41.39	52.06	51.44	32.66	12.18	11.66	13.57	8.62	3.76	4.33	4.67	6.20	3.97	6.43	8.70	
4	15.55	20.54	16.71	16.14	23.95	16.21	5.08	5.65	7.11	3.01	1.16	1.70	1.96	2.52	1.02	3.92	
5	6.75	5.01	5.30	5.78	5.48	11.45	6.74	2.17	2.28	2.6	0.75	0.29	0.60	0.40	0.51	0.45	
6	1.13	2.71	2.24	0.89	2.07	2.10	5.50	2.82	0.81	1.03	0.79	0.17	0.11	0.15	0.12	0.02	
7+	0.63	3.84	1.73	0.27	1.73	0.98	1.47	5.34	1.70	1.16	0.59	0.22	0.12	0.08	0.03	0.05	
1+	278.51	237.81	227.34	149.65	93.13	77.81	64.90	56.51	34.89	34.52	37.69	23.53	30.36	31.41	52.81	45.08	
									Mean Biomass								
2+	170.17	183.64	156.86	138.57	82.08	61.77	52.65	47.01	27.47	21.18	19.05	18.64	17.61	17.66	21.85	37.78	
3+	79.13	73.49	78.04	74.52	65.89	42.91	30.45	29.55	20.52	11.65	7.61	7.04	8.99	7.12	8.11	13.14	
4+	24.05	32.10	25.98	23.07	33.23	30.73	18.79	15.98	11.91	7.89	3.29	2.37	2.79	3.15	1.67	4.44	
								Mean SSB - Females (thousand mt)									
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
2	26.86	32.49	23.25	18.90	4.77	5.56	6.55	5.15	2.05	2.81	3.38	3.42	2.54	3.11	4.05	7.27	
3	26.16	19.66	24.73	24.44	15.52	5.79	5.54	6.45	4.09	1.79	2.05	2.22	2.94	1.89	3.06	4.13	
4	7.78	10.27	8.36	8.07	11.98	8.10	2.54	2.82	3.56	1.51	0.58	0.85	0.98	1.26	0.51	1.96	
5	3.37	2.51	2.65	2.89	2.74	5.72	3.37	1.08	1.14	1.34	0.3	80.14	0.30	0.20	0.25	0.23	
6	0.56	1.35	1.12	0.44	1.04	1.05	2.75	1.41	0.40	0.52	0.3	90.08	0.05	0.07	0.06	0.01	
7+	0.31	1.92	0.87	0.14	0.86	0.49	0.73	2.67	0.85	0.58	0.29	0.11	0.06	0.04	0.02	0.03	
1+	65.04	68.20	60.97	54.87	36.90	26.71	21.48	19.59	12.09	8.54	7.07	6.83	6.88	6.57	7.95	3.62	

1974, and is about 30 percent greater than that for any other year class during that time period. This estimate of the size of the 1986 year class is an overestimate to the extent that the 1988 estimate of F for age 2 is underestimated. Estimates of mean biomass increased sharply in 1987, as did estimates of spawning stock biomass in 1988. These increases are mainly a function of the low estimate of F for age 2 in 1988, and as such should be interpreted with caution.

MAJOR SOURCES OF UNCERTAINTY

The SARC identified four major sources of uncertainty that should be considered in interpreting and applying the results of the assessment:

- High amounts of discarding occur on these stocks. The amount and size range of discard for this species is largely driven by market considerations. The fraction of the catch discarded by age (size) is not likely to be constant over time. As such, the lack of information on what is believed to be large quantities of discards in the catch-at-age matrix, is a serious problem that could substantially affect the perception of the status of the stock based on the results from a VPA. The direction of the potential bias is not clear, because all sizes of silver hake may be discarded. However there will certainly be a reduction in the precision of the estimates due to this problem.

- Tuning indices for the spring survey for 1973 to 1981 have been adjusted to reflect the increased efficiency of the Yankee 41 trawl used in these surveys. The SARC recognized that there is reliable evidence indicating that the Yankee 41 trawl was substantially more efficient at catching silver hake than the standard Yankee 36 trawl used in other NEFC bottom trawl surveys. It is unclear whether the magnitude of the estimated efficiency factor was correct, especially since some of the time trends for the southern stock in comparing spring survey indices to VPA abundance estimates seem to be related to the change in the net after 1981. The SARC recommends that further analyses are needed to determine the most appropriate conversion factor between the two nets.

- The high value of the natural mortality rate (M = 0.40) needs further attention. One concern here is that substantial numbers of age 8 and 9+ fish were caught during the earlier history of the fishery. The SARC suggests that a more thorough look at the age and size distribution along with the growth curve for this species might help to resolve whether such a high natural mortality rate estimate is reasonable.

- The lack of older ages in the catch-at-age matrix and the need to truncate the age distributions makes it difficult to tune the VPA and means that projections of stock size and yield are highly dependent on the estimates of incoming recruitment. The fact that survey length-age keys are used to construct the catch-at-age matrix for the commercial catch is an additional source of uncertainty in the catch-at-age matrix. This is of particular concern for the older age classes, since the actual number of fish sampled and aged from the surveys is very small and since large overlaps exist in the size ranges among older aged fish.

SSB/R ANALYSIS

The SARC reviewed and revised an SSB/R analysis for silver hake submitted by the NEFMC (SAW/11/SARC/4). The basis for the revision was the new assessment results outlined above along with several suggestions made during the meeting. In particular, the re-analysis used observed weights-at-age rather than weights-at-age estimated from growth equations, and modified the method used to calculate a running average of percent MSP.

Input Parameters

Spawner-Recruit Plots

Population numbers at age on January 1 (Tables F4 and F5) for each of the years 1973 to 1986 were projected forward to the midpoint of the spawning season (August for the northern stock; June for the southern stock), using the fishing mortality matrix (Tables F4 and F5) and a constant M of 0.4. The projected numbers were then multiplied by the commercial weights-at-age (Table F3) and the maturities at age and summed to give annual estimates of SSB. These estimates of SSB were plotted against the VPA numbers at age 1, using a one-year lag (Figure F1). The replacement SSB/R was estimated as the inverse of the slope of the straight line passing through the origin and bissecting the data points (the median).

SSB/R Curves

The inputs to SSB/R (and YPR) analysis were:

Both stocks:	M	=	0.4
Age of recruitment		=	1
Oldest age		=	8 (3/M, no plus group)

Age	Partial Recruitment (northern)	Partial Recruitment (southern)	Wts at Age (northern)	Wts at Age (southern)	Proportion Mature (both)
1	.076	.069	.121	.078	0
2	.583	.468	.176	.141	.59
3	1	1	.240	.191	.95
4	1	1	.352	.283	1
5	1	1	.492	.412	1
6	1	1	.557	.523	1
7	1	1	.562	.551	1
8	1	1	.666	.659	1

Fraction of fishing mortality within year before spawning:
8/12 for northern stock (August)
6/12 for southern stock (June)

Fraction of natural mortality within year before spawning:
8/12 for northern stock (August)
6/12 for southern stock (June)

The partial recruitments (PRs) were estimated from the fishing mortality rates (Tables F4 and F5) for the years 1982 to 1986 inclusive, assuming a flat-topped PR with age 3 as the first age of full recruitment. PRs for ages 1 and 2 were calculated by dividing the fishing mortalities for ages 1 and 2 by the pooled fishing mortality for ages 3 to 6 (the fishing mortalities tabulated for ages 6 and 7+ in Tables F4 and F5), and then taking the geometric mean across years. Weights-at-age were calculated as unweighted averages across the years 1984 to 1988 inclusive (Table F3). The maturity ogive was taken from Morse (1979).

Results

The replacement SSB/R was estimated to be 0.13 kg for the northern stock and 0.16 kg for the southern stock. Corresponding values of percent MSP and F_{rep} are percent MSP = 31 percent and 42 percent respectively, and F_{rep} = 0.51 and 0.39 respectively (assuming the average PR vectors given in the text table). An average threshold percent MSP for both stocks (to the nearest 5 percent) is 35 percent. This corresponds to F_{rep} levels of 0.45 for the northern stock and 0.49 for the southern stock.

The four-year (1985-88) running average of pooled Fs for ages 3 to 6 (presented as the F estimates for ages 6 and 7+ in Tables F4 and F5; *i.e.*, the fully-recruited Fs) is 0.76 for the northern stock and 0.71 for the southern stock. If an average PR is calculated for the four most recent years of the VPA (1985-88) using the method outlined in the previous section, the corresponding percent MSP is estimated to be approximately 27 percent for both stocks.

Estimated Effects of an Increase in Mesh Size

The working paper submitted to the SARC contained an analysis of the affects of a change in mesh size from 2 inches to 2.5 inches. The partial recruitment vector was adjusted based on the results of the mesh selection experiments conducted during the 1960s (Jensen and Hennemuth 1966). The SARC agreed that the goal was an important one, but identified several problems in the analysis. A modification to the analysis was tried but gave unacceptable results. No guidance on the effectiveness of this mesh change can be given at present.

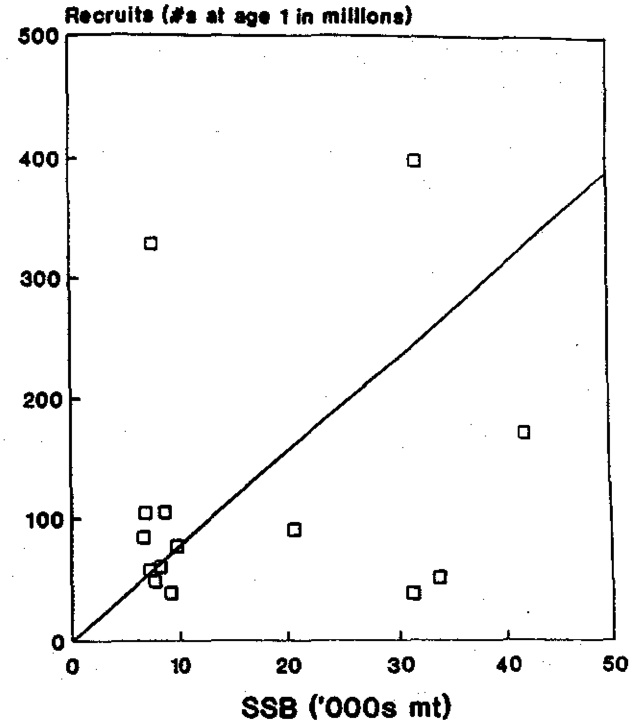

Figure 1a. Spawner-recruit data for the 1973-1986 year classes of the northern stock of silver hake. The solid line is the line that bisects the data.

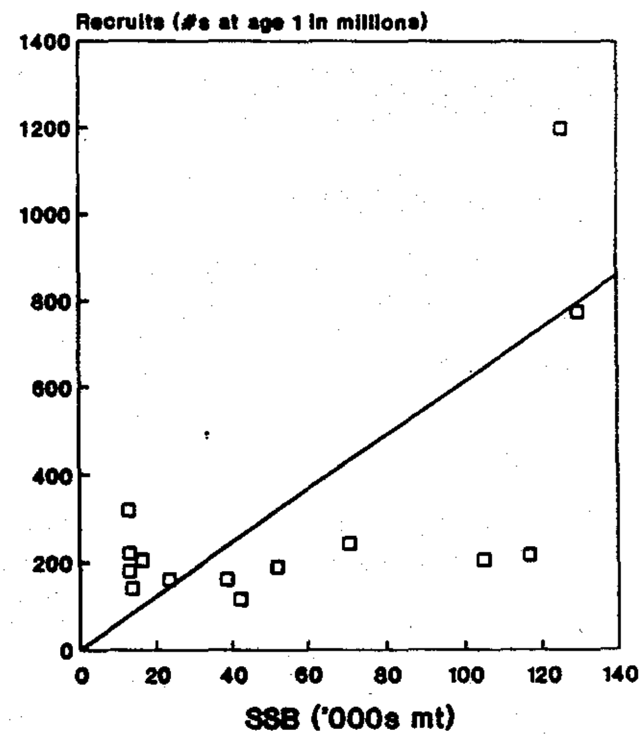

Figure 1b. Spawner-recruit data for the 1973-1986 year classes of the southern stock of silver hake. The solid line is the line that bisects the data.

Major Sources of Uncertainty

The SARC cautioned that the SSB/R results should be interpreted cautiously because of:

- The highly compressed age structure that is apparent throughout the entire time series used in the analysis,
- The need to project the assessment results two years in order to make the results current (this was not attempted by the SARC), and
- The high degree of uncertainty associated with the current VPA results.

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SEA SCALLOPS

The sea scallop analyses was not in a sufficiently complete form for the SARC to review. The Committee, however, feels that it is essential to review the New England Fishery Management Council staff analyses of this fishery prior to any application of the results. In light of the importance of this fishery and the timeliness of the analyses, when the results are ready for review, the Stock Assessment Workshop (SAW) Steering Committee should consider convening a special one-day session of the SARC to examine this work.

AMERICAN PLAICE

STOCK STRUCTURE

There is considerable uncertainty about the stock structure of plaice. In this and previous reviews, a single stock with a Gulf of Maine and a Georges Bank component, which also may be fished by different fleets, is assumed.

LANDINGS

Commercial landings have declined sequentially and dramatically from the 1982 peak (15,127 mt) to where 1989 landings were only 2,351 mt (Table H1). The U.S. commercial otter trawlers dominate the landings, while the recreational and foreign catches are insignificant. Plaice are managed as part of the NEFMC Multispieces FMP and are part of the overall demersal species complex. It is difficult to define directed effort. Fishermen are making slightly longer trips now than previously. If trips that take more than 50 percent plaice are defined as directed trips, the amount of catch taken in directed trip constituted 70 percent and 29 percent for Gulf of Maine and Georges Bank respectively in the early 1980s while by 1989 they accounted for only 6 percent and 3 percent of the catch. Total days fished by vessels that land plaice peaked in 1985 and appear to have declined continuously since then (Figure H1).

Commercial CPUE indices appear to be a barometer of harvestable stock, and were relatively stable during the 1960s, declined in the 1970s and sharply increased in 1977 when landings doubled. CPUE indices remained high through the early 1980s but then began a precipitous decline (Figure H1). The 1989 indices for both the Gulf of Maine and Georges Bank area were the lowest in the 1964-1989 time series.

Abundance and biomass indices from autumn NEFC research vessel surveys reached record-low values in 1987, similar to levels observed in the early 1970s, but have since increased slightly (Table H2). Survey size frequency data show that a small fraction of the stock is above the minimum legal size of 35.6 cm (Figure H2), but this corresponds with the relatively low mean weight of individuals noted in 1988 and 1989 and may indicate good recruitment.

Table H1. Commercial landings (mt, live) of American plaice from the Gulf of Maine, Georges Bank & Southern New England, and the Mid-Atlantic, 1960 - 1989

	Gulf of Maine			Georges Bank - So. New England					Mid-Atlantic			Totals		
Year	USA	CAN	Total	USA	CAN	USSR	Other	Total	USA	Other	Total	USA	Other	Total
1960	620	1	621	689	-	-	-	689	-	-	-	1309	1	1310
1961	692	-	692	830	-	-	-	830	-	-	-	1522	0	1522
1962	694	-	694	1233	44	-	-	1277	-	-	-	1927	44	1971
1963	693	-	693	1489	125	-	-	1614	-	-	-	2182	125	2307
1964	811	-	811	2800	177	-	11	2988	-	-	-	3611	188	3799
1965	967	-	967	2376	180	112	-	2668	-	-	-	3343	292	3635
1966	955	1	956	2388	243	279	1	2911	-	-	-	3343	524	3867
1967	1066	1	1067	2166	208	1018	10	3402	4	-	4	3236	1237	4473
1968	904	-	904	2332	178	338	7	2855	18	-	18	3254	523	3777
1969	1059	1	1060	2243	77	412	17	2749	-	-	-	3302	507	3809
1970	895	-	895	1691	92	945	698	3426	-	-	-	2586	1735	4321
1971	648	4	652	1522	39	340	502	2403	-	2	2	2170	887	3057
1972	569	-	569	1225	22	439	-	1686	1	2	3	1795	463	2258
1973	687	-	687	915	38	447	-	1400	1	-	1	1603	485	2088
1974	945	2	947	1311	27	20	2	1360	-	15	15	2256	66	2322
1975	1507	-	1507	916	25	148	-	1089	4	34	38	2427	207	2634
1976	2550	-	2550	958	24	3	-	985	1	-	1	3509	27	3536
1977	5647	-	5647	1414	35	128	-	1577	7	27	34	7068	190	7258
1978	7228	30	7258	2267	77	-	-	2344	8	1	9	9503	108	9611
1979	8835	-	8835	2516	23	6	1	2546	4	64	68	11355	94	11449
1980	11136	-	11136	2412	43	-	5	2460	1	-	1	13549	48	13597
1981	10324	1	10325	2511	15	-	-	2526	46	1	47	12881	17	12898
1982	11148	-	11148	3971	27	-	-	3998	8	-	8	15127	27	15154
1983	9137	7	9144	4018	30	-	-	4048	5	-	5	13160	37	13197
1984	6835	2	6837	3293	6	-	-	3299	7	-	7	10135	8	10143
1985	4757	1	4758	2259	38	-	-	2297	2	-	2	7018	39	7057
1986	2979	-	2979	1124	34	-	-	1158	2	-	2	4105	34	4139
1987	2758	-	2758	1042	48	-	-	1090	1	-	1	3801	48	3849
1988	2232	-	2232	1077	108	-	-	1185	1	-	1	3310	108	3418
1989	1645		1645	703	68	-	-	771	3	-	3	2351	68	2419

SUMMARY OF STOCK STATUS

The continuing decline in landings reflects a declining trend in harvestable biomass, as indicated in both catch-per-unit-effort and survey indices. The potentially strong 1986 and 1987 year classes offer the opportunity to halt and reverse this trend if fishing mortality and discarding are reduced. However, large numbers of fish from these year classes will be taken as by-catch and discarded in small-mesh fisheries.

SUGGESTIONS

The biological reference points of $F_{0.1}$ (0.17) and F_{max} (0.34) were developed previously and should be considered notional since no detailed catch-at-age or recent aging exists. Recent fishing mortality is unknown, but based on preliminary analysis of length composition data during the SARC meeting, it appears Fs have increased and are currently at, or exceed, F_{max}. The SARC checked that the length composition analysis, using the Beverton and Holt method for estimating Z/K, was not excessively affected by recent large incoming year classes by examining data from the mid-1970s as well as recent length data. The impression that the stock is currently over-exploited was supported by this analysis.

The population parameters need to be updated to effectively monitor this resource.

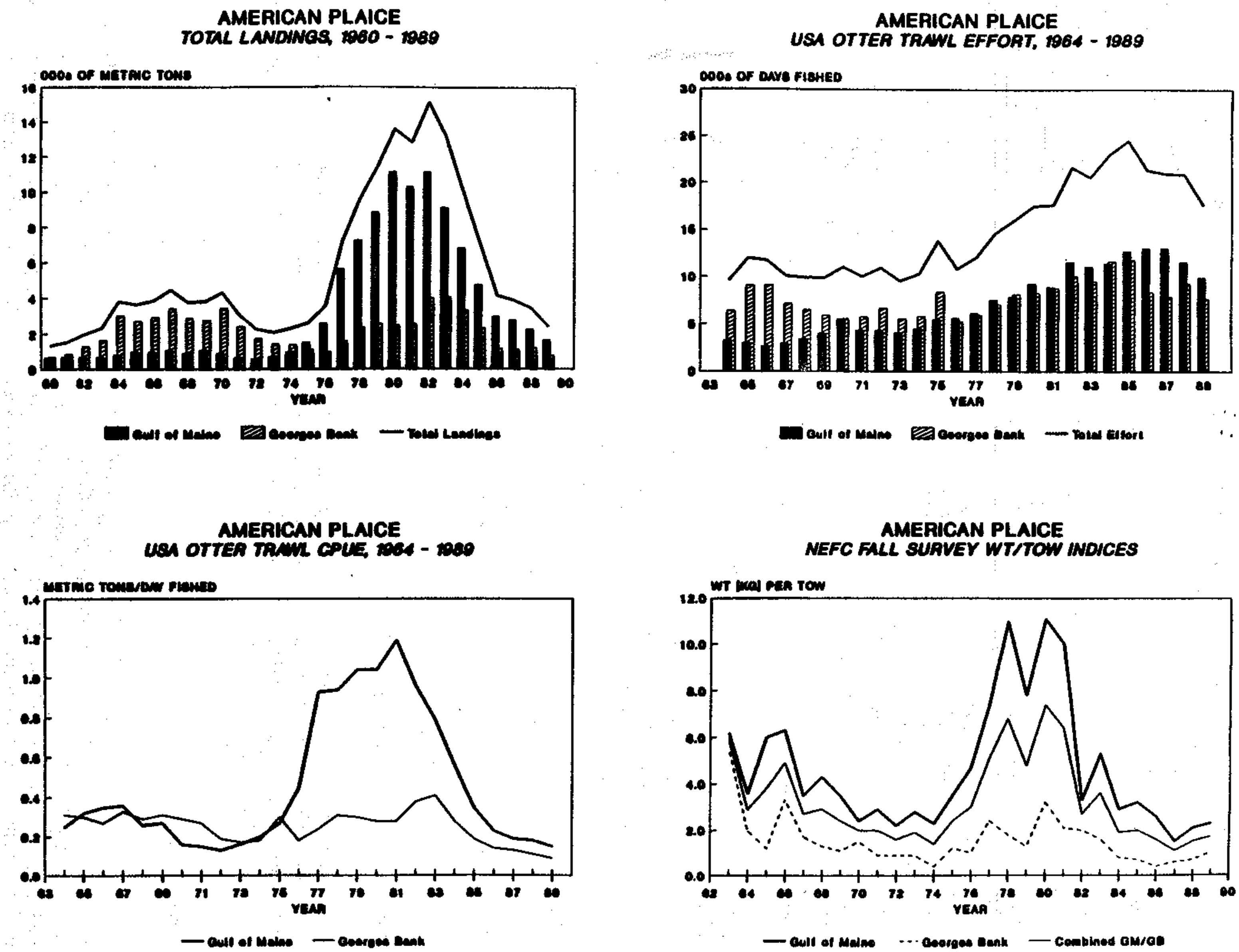

Figure H1. Stock assessment summary diagrams for American plaice in the Gulf of Maine-Georges Bank region.

Table H2. Stratified mean catch-per-tow in number and weight (kg) of American plaice from NEFC offshore spring and autumn bottom trawl surveys on Georges Bank (Strata 13-25), in the Gulf of Maine (Strata 26-30 and 36-40), and for the combined Gulf of Maine-Georges Bank area, 1963 to 1990[1,2]

	Georges Bank				Gulf of Maine				Combined			
	Spring		Autumn		Spring		Autumn		Spring		Autumn	
Year	(No.)	(Wt)	(No.)	(Wt)	(No.)	(Wt)	(No.)	(Wt)	(No.)	(Wt)	(No.)	(Wt)
1963	-	-	10.00	5.5	-	-	17.74	6.2	-	-	14.17	5.9
1964	-	-	5.55	2.0	-	-	10.53	3.6	-	-	8.23	2.9
1965	-	-	4.73	1.2	-	-	18.12	6.0	-	-	11.95	3.8
1966	-	-	11.15	3.3	-	-	23.44	6.3	-	-	17.77	4.9
1967	-	-	5.04	1.7	-	-	16.19	3.5	-	-	11.05	2.7
1968	5.91	1.6	6.03	1.3	16.14	5.0	10.82	4.3	11.42	3.4	8.61	2.9
1969	7.04	2.2	2.84	1.1	9.90	3.9	11.51	3.5	5.58	2.7	7.51	2.4
1970	4.01	1.4	4.93	1.5	6.65	2.1	7.77	2.4	5.43	1.8	6.46	2.0
1971	3.08	1.1	3.03	0.9	4.42	1.4	11.26	2.9	3.80	1.3	7.47	2.0
1972	3.24	1.2	3.28	0.9	5.17	1.4	11.00	2.2	4.28	1.3	7.44	1.6
1973	2.10	0.8	3.73	0.9	11.56	2.8	8.29	2.8	7.20	1.9	6.19	1.9
1974	4.89	1.3	1.37	0.4	11.28	2.5	11.62	2.3	8.33	1.9	6.90	1.4
1975	2.70	1.0	3.96	1.2	8.52	2.3	11.68	3.5	5.84	1.7	8.12	2.4
1976	3.26	1.0	2.80	1.0	19.20	5.4	16.13	4.7	11.85	3.4	9.99	3.0
1977	4.35	1.4	5.73	2.4	23.35	8.4	21.79	7.4	14.59	5.1	14.39	5.1
1978	5.32	1.6	5.72	1.8	15.14	5.7	29.33	11.0	10.61	3.8	18.45	6.8
1979	2.75	1.1	3.93	1.3	16.98	7.1	16.80	7.8	10.42	4.3	10.87	4.8
1980	9.71	1.4	8.87	3.2	32.75	11.4	24.63	11.1	22.13	6.8	17.37	7.4
1981	11.27	3.0	5.62	2.1	33.72	13.6	20.73	10.0	23.37	8.7	13.76	6.4
1982	11.46	4.0	6.56	2.0	16.45	6.8	6.27	3.3	14.15	5.5	6.41	2.7
1983	4.42	1.9	3.73	1.6	27.42	7.3	15.94	5.3	16.82	4.8	10.31	3.6
1984	1.72	0.7	1.88	0.8	5.84	2.1	11.55	2.9	3.94	1.4	7.09	1.9
1985	1.98	0.8	2.38	0.7	7.54	2.8	11.03	3.2	4.98	1.9	7.04	2.0
1986	1.59	0.5	1.30	0.4	4.36	1.3	9.43	2.6	3.09	0.9	5.68	1.6
1987	2.86	0.7	2.75	0.6	5.22	1.4	5.78	1.5	4.13	1.1	4.38	1.1
1988	1.20	0.4	4.25	0.7	5.62	1.2	14.34	2.1	3.58	0.8	9.69	1.5
1989	4.68	0.7	5.78	1.0	6.88	1.4	15.90	2.3	5.86	1.1	11.24	1.7
1990	3.03	0.6			8.90	1.5			6.21	1.1		

[1] Spring surveys during 1973-81 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 survey catch-per-tow data for these gear differences.

[2] During 1963-84, 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 survey catch-per-tow data for these gear differences.

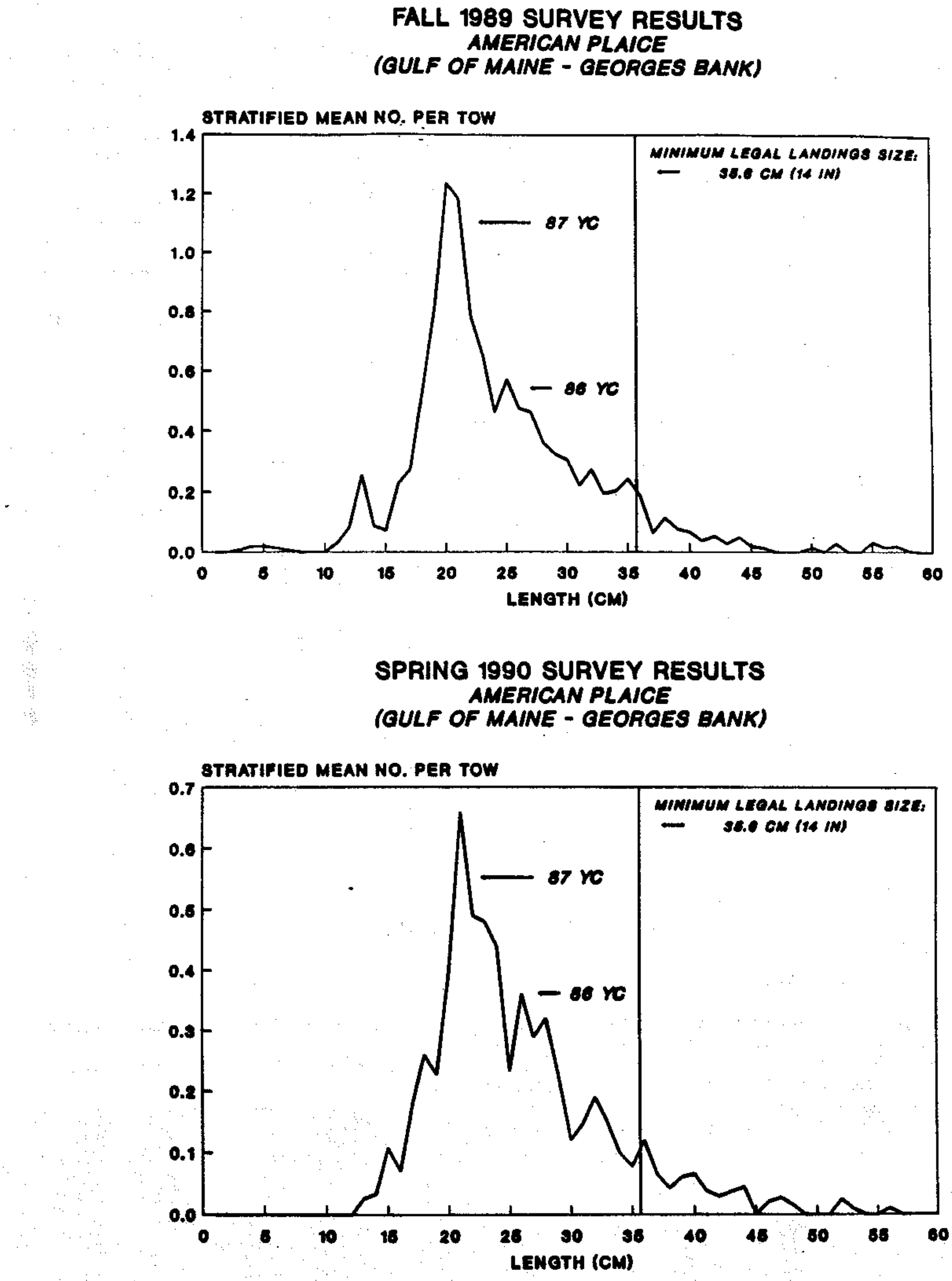

Figure H2. American plaice size frequency distributions from NEFC autumn and spring bottom-trawl surveys.

GEORGES BANK COD

An analytical assessment of this cod stock was presented to the SARC, including VPA estimates of abundance and fishing mortality as well as re-analysis of biological reference points for the stock. Two problems were identified in the assessment that are important sources of uncertainty in the estimates of current stock status and future prognoses. The SARC noted that failing accounting for gear modifications in the survey indices may have resulted in overestimation of recent year class sizes. In addition, survey information on the incoming 1988 year class is limited, and the estimate of year class strength is uncertain.

LANDINGS

Table I1 gives the landings from this stock for 1960 to 1989. Recent landings in the U.S. fishery are around 35,000 mt. Recreational fishing catches are not accounted for in these figures.

CATCH-AT-AGE

The landings in recent years were dominated by the strong 1985 year class, which accounts for 39 percent of the catch in numbers in 1989 (Table I2). Mean weights and lengths at age in the catch are also given in the Table.

ABUNDANCE INDICES

Abundance indices are available from U.S. commercial catch-per-unit-effort data (Table I3) and from NEFC surveys (Table I4). The commercial indices have not been analyzed to standardize across vessel categories and other sources of variability. For the survey indices, there were important modifications made to the survey gear in 1985, which is thought to have improved efficiency. This change in survey fishing power was not incorporated in the analysis, and was cause for concern to the SARC in relation to the use of these indices for tuning the VPA.

Natural Mortality

The rate of natural mortality for cod was assumed to be 0.2 over all ages.

Partial Recruitment and Terminal Fishing Mortality Rates

Laurec-Shepherd VPA tuning and separable VPA were used to obtain the exploitation pattern for this stock. The partial recruitment vector was judged to be flat-topped (Table I5). This vector was used in yield-per-recruit analysis and projections for the future.

The tuning analysis did not indicate any trends in catchability over time or major problems in the diagnostics. The commercial CPUE index was dominant for the older ages, while surveys were weighted more heavily on the younger ages.

ASSESSMENT RESULTS

Trends in Fishing Mortality

Fishing mortality rates (F) increased substantially from 1978 through 1985 (Table I6 and Fig. I1). F declined significantly after 1985 and remained at the lower level during 1986, 1987, and 1989. Estimates of the overall F during 1988 are uncertain due to highly variable F estimates on the older age groups. However, estimates of fishing effort have generally increased (with some fluctuations) throughout the 1978-89 period (Fig. I1). In particular, no decrease in effort (from the 1985 level) is apparent in recent years. The SARC recommends caution regarding the apparent reduction in F since 1985.

Population Numbers-at-Age

Trends in cod population numbers are heavily influenced by the recent recruiting year classes. The apparently strong 1988 year class has increased stock numbers appreciably in recent years (Table I6 and Fig. I1). The estimates of recruitment were obtained by calibrating the survey indices of age 1 to the VPA age 1 abundance in past years using the RCRTINX2 program. For 1989, however, only one index is available and the estimate of recruitment for the 1988 year class has a high standard error. In other words, the current estimate of 1988 year class strength is imprecise, and the SARC recommends caution in interpreting this trend.

Spawning Stock Biomass

Spawning stock biomass (SSB) declined precipitously from 1978 through 1986 (Table I6 and Fig. I1). SSB then increased appreciably over the 1986-90 period. The increase was due to the apparent reduction in F (after 1985) on the strong 1983, 1985, and 1988 year classes. Similar caveats, as noted above, apply to this apparent trend in SSB.

Table I1. Commercial landings (mt, live) of Atlantic cod from Georges Bank and South (NAFO Division 5Z and Statistical Area 6), and the Gulf of Maine (NAFO Division 5Y), 1960 to 1989[1]

	Georges Bank and South					**Gulf of Maine**					**Totals**				
Year	**USA**	**Canada**	**USSR**	**Other**	**Total**	**USA**	**Canada**	**USSR**	**Other**	**Total**	**USA**	**Canada**	**USSR**	**Other**	**Total**
1960	10834	19	-	-	10853	3448	129	-	-	3577	14282	148	-	-	14430
1961	14453	223	55	-	14731	3216	18	-	-	3234	17669	241	55	0	17965
1962	15637	2404	5302	143	23486	2989	83	-	-	3072	18626	2487	5302	143	26558
1963	14139	7832	5217	1	27189	2595	3	133	-	2731	16734	7835	5350	1	29920
1964	12325	7108	5428	304	25165	3226	25	-	-	3251	15551	7133	5428	304	28416
1965	11410	10598	14415	1910	38333	3780	148	-	-	3928	15190	10746	14415	1910	42261
1966	11990	15601	16830	8713	53134	4008	384	-	-	4392	15998	15985	16830	8713	57526
1967	13157	8232	511	14852	36752	5676	297	-	-	5973	18833	8529	511	14852	42725
1968	15279	9127	1459	17271	43136	6360	61	-	-	6421	21639	9188	1459	17271	49557
1969	16782	5997	646	14514	37939	8157	59	-	268	8484	24939	6056	646	14782	46423
1970	14899	2583	364	7806	25652	7812	26	-	423	8261	22711	2609	364	8229	33913
1971	16178	2979	1270	7752	28179	7380	119	-	163	7662	23558	3098	1270	7915	35841
1972	13406	2545	1878	7230	25059	6776	53	11	77	6917	20182	2598	1889	7307	31976
1973	16202	3220	2977	6524	28923	6069	68	-	9	6146	22271	3288	2977	6533	35069
1974	18377	1374	476	7104	27331	7639	120	-	5	7764	26016	1494	476	7109	35095
1975	16017	1847	2403	4741	25008	8903	86	-	26	9015	24920	1933	2403	4767	34023
1976	14906	2328	933	1759	19926	10172	16	-	-	10188	25078	2344	933	1759	30114
1977	21138	6173	54	2	27367	12426	-	-	-	12426	33564	6173	54	2	39793
1978	26579	8904	-	-	35483	12426	-	-	-	12426	39005	8904	-	-	47909
1979	32645	6011	-	-	38656	11680	-	-	-	11680	44325	6011	-	-	50336
1980	40053	8094	-	-	48147	13528	-	-	-	13528	53581	8094	-	-	61675
1981	33849	8508	-	-	42357	12534	-	-	-	12534	46383	8508	-	-	54891
1982	39333	17862	-	-	57195	13582	-	-	-	13582	52915	17862	-	-	70777
1983	36756	12132	-	-	48888	13981	-	-	-	13981	50737	12132	-	-	62869
1984	32915	5761	-	-	38676	10806	-	-	-	10806	43721	5761	-	-	49482
1985	26828	10441	-	-	37269	10693	-	-	-	10693	37521	10441	-	-	47962
1986	17490	8508	-	-	25998	9664	-	-	-	9664	27154	8508	-	-	35662
1987	19035	11843	-	-	30878	7527	-	-	-	7527	26562	11843	-	-	38405
1988	26310	12725	-	-	39035	7958	-	-	-	7958	34268	12743	-	-	47011
1989	25097	7897	-	-	32994	10397	-	-	-	10397	35494	7897	-	-	43391

[1] USA landings from NMFS Northeast Fisheries Center detailed weigh-out files and canvass data. Canadian landings data for 1988 and 1989 from NAFO SCS documents 88/18 and 89/21. Canadian laniings data prior to 1985 from Hunt (1988, 1989.)

Table I1. (con't.)

Estimated number (thousands) and weight (mt, live) of Atlantic cod caught by marine recreational fishermen, by region, in 1960, 1965, 1970, 1974, and 1979 to 1989

Year	North Atlantic[2,3]		Mid-Atlantic[3]		All Regions	
	Number (thousands)	Weight (mt)	Number (thousands)	Weight (mt)	Number (thousands)	Weight (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

[2] During 1960, 1965, and 1970 marine recreational surveys, "North Atlantic" included Maine to New York. In subsequent surveys, "North Atlantic" included only Maine to Connecticut, excluding New York.

[3] 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) data.

Table I2. Catch-at-age (thousands of fish; mt) and mean weight- (kg) and mean length-at-age (cm) of total commercial landings of Atlantic cod from the Georges Bank and South cod stock (NAFO Division 5Z and Statistical Area 6), 1978 to 1989

	Age											
Year	1	2	3	4	5	6	7	8	9	10	11+	Total
1978	-	442	7651	2185	834	71	385	46	37	10	-	11661
1979	41	1916	678	4863	1077	477	70	289	-	37	16	9464
1980	106	3609	5658	344	2270	1143	496	91	183	-	-	13900
1981	31	3829	4522	2453	126	1284	413	90	137	57	-	12942
1982	473	11422	3586	2445	1830	170	657	169	73	33	49	20907
1983	108	4711	7391	1654	1135	961	114	290	117	34	38	16553
1984	81	1328	3604	3356	593	487	496	32	200	51	56	10284
1985	160	6879	2328	1364	1771	338	213	201	15	84	22	13375
1986	156	1323	4560	804	485	634	88	73	47	4	26	8200
1987	29	7662	1471	2077	272	249	262	61	36	17	6	12142
1988	16	1592	8100	1008	1469	239	157	193	53	25	21	12873
1989	-	2415	3102	4178	313	513	73	37	41	8	7	10687
Total Commercial Catch in Weight-at-Age												
1978	-	570	18904	8066	3730	369	2895	365	475	109	-	35483
1979	36	2916	1670	20914	5359	3485	640	2969	-	493	174	38656
1980	89	5379	14020	1372	13146	7664	4212	790	1475	-	-	48147
1981	27	5746	10671	8314	656	9426	3470	896	2037	1114	-	42357
1982	363	15937	10226	9401	9969	1098	6225	1744	908	528	796	57195
1983	107	7053	18152	5681	5339	6156	904	2984	1296	441	775	48888
1984	85	2203	8961	12220	3209	3324	4468	315	2276	668	947	38676
1985	147	9528	4995	5519	9349	2234	1745	2121	194	1069	368	37269
1986	145	1951	11152	2944	2723	4562	790	729	598	56	348	25998
1987	21	11342	3624	8681	1579	1918	2346	607	405	229	126	30878
1988	13	2412	19049	3524	7902	1582	1379	1928	541	329	394	39053
1989	-	3798	6975	15465	1650	3362	605	393	481	116	149	32994
Total Commercial Catch Mean Weight (kg) at Age												
1978	-	1.290	2.471	3.692	4.472	5.197	7.519	7.935	12.838	10.900	-	3.043
1979	0.878	1.522	2.463	4.301	4.976	7.306	9.143	10.273	-	13.324	10.875	4.085
1980	0.840	1.490	2.478	3.988	5.791	6.705	8.492	8.681	8.060	-	-	3.464
1981	0.871	1.501	2.360	3.389	5.206	7.341	8.402	9.956	14.869	19.544	-	3.273
1982	0.767	1.395	2.852	3.845	5.448	6.459	9.475	10.320	12.438	16.000	16.245	2.736
1983	0.991	1.497	2.456	3.435	4.704	6.406	7.930	10.290	11.077	12.971	20.395	2.953
1984	1.049	1.659	2.486	3.641	5.411	6.825	9.008	9.844	11.380	13.098	16.911	3.761
1985	0.919	1.385	2.146	4.046	5.279	6.609	8.192	10.552	12.933	12.726	16.727	2.786
1986	0.929	1.475	2.446	3.662	5.614	7.196	8.977	9.986	12.723	14.000	13.385	3.170
1987	0.724	1.480	2.464	4.180	5.805	7.703	8.954	9.951	11.250	13.471	21.000	2.543
1988	0.813	1.515	2.352	3.496	5.379	6.619	8.783	9.990	10.208	13.160	18.762	3.034
1989	-	1.573	2.249	3.702	5.272	6.554	8.288	10.622	11.732	14.500	21.286	3.087
Total Commercial Catch Mean Length (cm) at Age												
1978	-	50.2	61.5	69.8	73.7	79.3	89.3	91.3	107.1	101.0	-	64.9
1979	44.7	52.9	61.0	73.9	77.5	88.2	95.3	99.4	-	108.4	101.0	70.9
1980	43.9	52.6	61.6	72.4	81.9	86.3	92.9	92.2	91.2	-	-	66.5
1981	44.6	52.3	60.4	68.5	78.4	88.7	93.1	98.2	112.8	123.2	-	64.6
1982	42.3	51.4	64.4	70.8	79.9	84.1	96.5	99.2	105.5	114.8	115.0	60.7
1983	46.3	52.7	61.5	68.1	75.9	84.5	90.7	99.1	101.5	107.4	114.8	63.3
1984	47.2	52.3	61.8	70.1	79.8	86.8	95.0	97.6	102.6	107.6	116.2	68.9
1985	45.3	51.4	58.4	72.7	79.3	85.4	91.9	100.1	105.6	106.1	117.6	61.2
1986	45.0	51.9	61.0	69.2	80.7	87.7	94.4	98.0	105.6	111.3	109.5	64.4
1987	40.5	51.8	60.8	73.0	81.9	90.1	94.4	97.8	102.2	108.1	122.1	59.4
1988	40.9	52.7	60.3	68.4	79.4	85.2	93.7	97.7	101.8	107.5	116.6	63.9
1989	-	53.0	59.8	70.0	78.5	84.5	92.3	100.4	103.1	111.2	115.4	64.6

Catch Projections

Projections were carried out under four F scenarios for the 1990-92 period: (1) status quo F (0.56); (2) $F_{0.1}$ (0.149); (3) F_{max} (0.274); and (4) F_{rep} (0.47). The status quo F was assumed for 1990 in all projections (Table I7). Stock size (number of fish, ages 2+) declines from the 1990 level for all projections. SSB increases from the 1990 level in all projections, including the status quo projection. The increase in SSB is particularly strong in the $F_{0.1}$ projection (57 percent increase from 1990 to 1992). In all projections other than the status quo projection, the projected catch declines. The projection results are heavily influenced by the apparent strong 1988 year class. Since the estimate of the size of this year class is imprecise, the SARC noted that these projections are likely to be overly optimistic because of potential biases identified above.

MAJOR SOURCES OF UNCERTAINTY

The major sources of uncertainty that were of greatest concern to the SARC were:

- **Age sampling:** The SARC noted that the estimates of the number of fish in the older age groups appears to be based on limited age sampling. In future assessments, consideration should be given to expanding the number of ages encompassed within the plus group (*e.g.*, ages 9+).

- **Recreational catch:** The recreational catch appears to be an important component of fishing mortality on cod (approximately 30 percent of the commercial landings by number and 20 percent by weight in 1989; Table I1). However, these catches are not included in the catch-at-age estimates used in the VPA. Difficulties in apportioning the recreational catch by area (and stock) and by age group have precluded their usage in the current assessment. Full utilization of the MRFSS intercept database may resolve some of these problems. The SARC strongly recommends that every attempt be made to fully incorporate the recreational catch into future assessments.

- **Discards:** As with most other groundfish on Georges Bank, discarding is generally thought to be a significant source of fishing mortality (F) on young cod. Discard estimates are not included in the catch at age matrix. Whether the F due to discarding is constant over years or highly variable is unknown. The age 1 recruitment estimates from VPA are affected in magnitude and perhaps in trend by the missing discards in the catch at age. These potential biases may have important ramifications on any percent MSP analysis which uses the VPA recruitment estimates as input parameters. The SARC strongly recommends that every attempt to made to estimate discards from the sea sampling data and to incorporate them into future assessments.

- **CPUE indices of abundance:** Catch-per-unit-effort (CPUE) indices of abundance play an important role in tuning the cod VPA. Although research survey indices are also used in the tuning, they are generally highly variable (but not biased). The CPUE indices, which tend to be less variable, are often weighted more heavily in the tuning process. Consequently, it is important to develop standardized CPUE indices that mimic population trends (i.e., unbiased indices). Such indices would not only be valuable for tuning the cod VPA (1978 to present), but would also provide a longer term perspective of stock abundance. The SARC strongly recommends that a general linear modeling (GLM) approach be used to standardize important fishing power factors (*e.g.*, vessel class, fishing area, month of the year, *etc.*), and that such indices be used in future assessments.

- Research survey indices: A gear change in the NEFC bottom trawl survey (*i.e.*, a trawl door change) oc-

Table I3. Total and USA commercial landings, USA catch-per-unit-effort indices (all cod trips), and derived effort indices for Georges Bank cod, 1967 to 1989

Year	Total Landings (mt)	USA Landings (mt)	USA[1] CPUE Index	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	35483	26579	1.937	18317	13720
1979	38656	32645	2.102	18391	15531
1980	48147	40053	2.158	22313	18562
1981	42357	33849	1.891	22398	17899
1982	57195	39333	2.176	26287	18078
1983	48888	36756	2.005	24389	18337
1984	38676	32915	1.424	27151	23106
1985	37269	26828	1.149	32445	23355
1986	25998	17490	0.956	27197	18386
1987	30878	19035	0.836	36945	22775
1988	39035	26310	1.051	37164	25037
1989	32994	25097	1.058	31195	23729

[1] All cod trips.

Table I4. Stratified mean catch per tow in numbers and weight (kg) for Atlantic cod from NEFC offshore spring and autumn research vessel bottom trawl surveys on Georges Bank (Strata 13-25) and in the Gulf of Maine (Strata 26-30 and 36-40), 1963 to 1990[1,2]

	Georges Bank				Gulf of Maine			
	Spring		Autumn		Spring		Autumn	
Year	no./tow	wt/tow	no./tow	wt/tow	no./tow	wt/tow	no./tow	wt/tow
1963	-	-	2.80	11.0	-	-	3.79	11.1
1964	-	-	1.91	7.1	-	-	2.57	14.1
1965	-	-	2.72	7.2	-	-	2.88	7.4
1966	-	-	3.08	5.0	-	-	2.43	8.0
1967	-	-	6.66	8.4	-	-	1.64	5.7
1968	3.03	7.8	2.11	5.3	3.49	11.1	2.81	12.0
1969	2.98	11.0	1.41	5.0	2.09	8.1	1.77	9.5
1970	2.78	9.7	3.25	7.7	1.41	6.8	3.14	10.1
1971	2.17	8.8	2.04	6.1	0.92	4.3	2.80	10.2
1972	5.75	11.7	8.39	14.2	1.32	5.0	5.97	8.0
1973	11.98[3]	24.5[3]	7.87	19.0	4.83	11.6	2.86	5.4
1974	9.45	22.5	2.24	5.1	1.86	4.6	2.78	5.5
1975	4.42	16.1	4.11	8.7	1.61	3.7	3.94	5.3
1976	4.52	11.5	6.69	10.9	1.78	4.7	1.38	4.2
1977	4.04	9.5	4.42	11.5	2.49	5.3	2.50	9.4
1978	7.89	19.3	6.97	21.5	1.32	4.8	4.67	11.9
1979	3.31	10.5	4.83	15.2	2.74	5.9	2.24	10.8
1980	4.97	15.3	2.36	6.2	1.74	5.7	5.71	13.1
1981	8.47	24.0	7.34	17.5	3.95	9.9	1.55	5.0
1982	6.65[4]	14.2[4]	2.38	4.3	3.04	7.9	4.98	9.9
1983	4.94	14.8	2.33	4.0	2.51	6.5	2.71	5.4
1984	2.62	9.5	3.04	6.3	2.18	3.6	1.55	5.4
1985	6.94	21.5	2.43	3.5	2.52	7.8	2.92	8.5
1986	5.04	16.7	3.12	4.7	1.96	3.6	1.95	5.1
1987	3.26	10.3	2.33	4.4	1.68	3.0	2.98	3.4
1988	5.86	13.4	3.11	5.8	3.13	3.3	5.90	6.6
1989	6.07	16.1	6.05	6.9	2.86	3.8	5.89	6.8
1990	5.99	17.3	2.99	4.6				

[1] Spring surveys during 1973-81 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.

[2] During 1963-84, 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.

[3] Excludes unusually high catch of 1,894 cod (2,558 kg) at Station 230 (strata tow 20-4).

[4] Excludes unusually high catch of 1,032 cod (4,096 kg) at Station 323 (strata tow 16-7).

curred in 1985. Preliminary studies indicate that the new gear is more effective on cod (Byrne and Forrester 1987). To the degree that the new gear is substantially more effective, current survey indices will overestimate cod abundance relative to the pre-1985 period; and fishing mortality rates may be underestimated when using these indices for VPA tuning.

The SARC conducted a simple sensitivity analysis of the effect of the gear change on the cod VPA. Significant increases were found for age 2 F in 1989, but only modest increases were found on the older ages. The strength of the 1988 year class was substantially reduced. Projected stock sizes would be affected as well since the 1988 year class is dominant during the projection period.

The SARC recommends that all available data on the potential change in effectiveness be thoroughly examined, and any adjustment that may prove to be necessary be incorporated into future assessments.

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O'Brien, L. 1990. Effects of fluctuations in stock abundance upon life history parameters of Atlantic cod, Gadus morhua L., for the 1970-1987 year classes from Georges Bank and the Gulf of Maine. Seattle: University of Washington. Master's thesis.

Table I5. Data used in yield-per-recruit analysis and in catch and spawning stock projections for Georges Bank cod. Natural mortality (M) = 0.2 for all age groups. Recruitment of age 1 cod in 1991 and 1992 assumed to be 20 million fish (*i.e.*, the geometric mean age 1 stock size during 1978-1988).

Age	1990 Stock Size (thousands)	Exploitation[1] Pattern	Mean Weight[2] of Catch (kg)	Mean Weight[2] of Stock (kg)	Maturity[3] Ogive
1	18300[4]	0.0064	0.768	0.543	0.05
2	33568	0.4434	1.523	1.117	0.39
3	10232	1.0000	2.355	1.873	0.84
4	3595	1.0000	3.792	3.027	0.97
5	4819	1.0000	5.485	4.548	1.00
6	390	1.0000	6.959	6.237	1.00
7	783	1.0000	8.675	7.886	1.00
8	94	1.0000	10.187	9.523	1.00
9	35	1.0000	11.063	10.501	1.00
10	36	1.0000	13.710	12.475	1.00
11+	18	1.0000	17.300[5]	17.300[5]	1.00

[1] Partial recruitment values derived from SVPA analysis (smoothed).
[2] Average of 1987-1989 values.
[3] Values derived from O'Brien (1990).
[4] Predicted value for age 1 stock size (1989 cohort) from RCRTINX2 analysis.
[5] Mean weight-at-age for 11+ set equal to the mean catch weight-at-age (mid-year) during 1978-89.

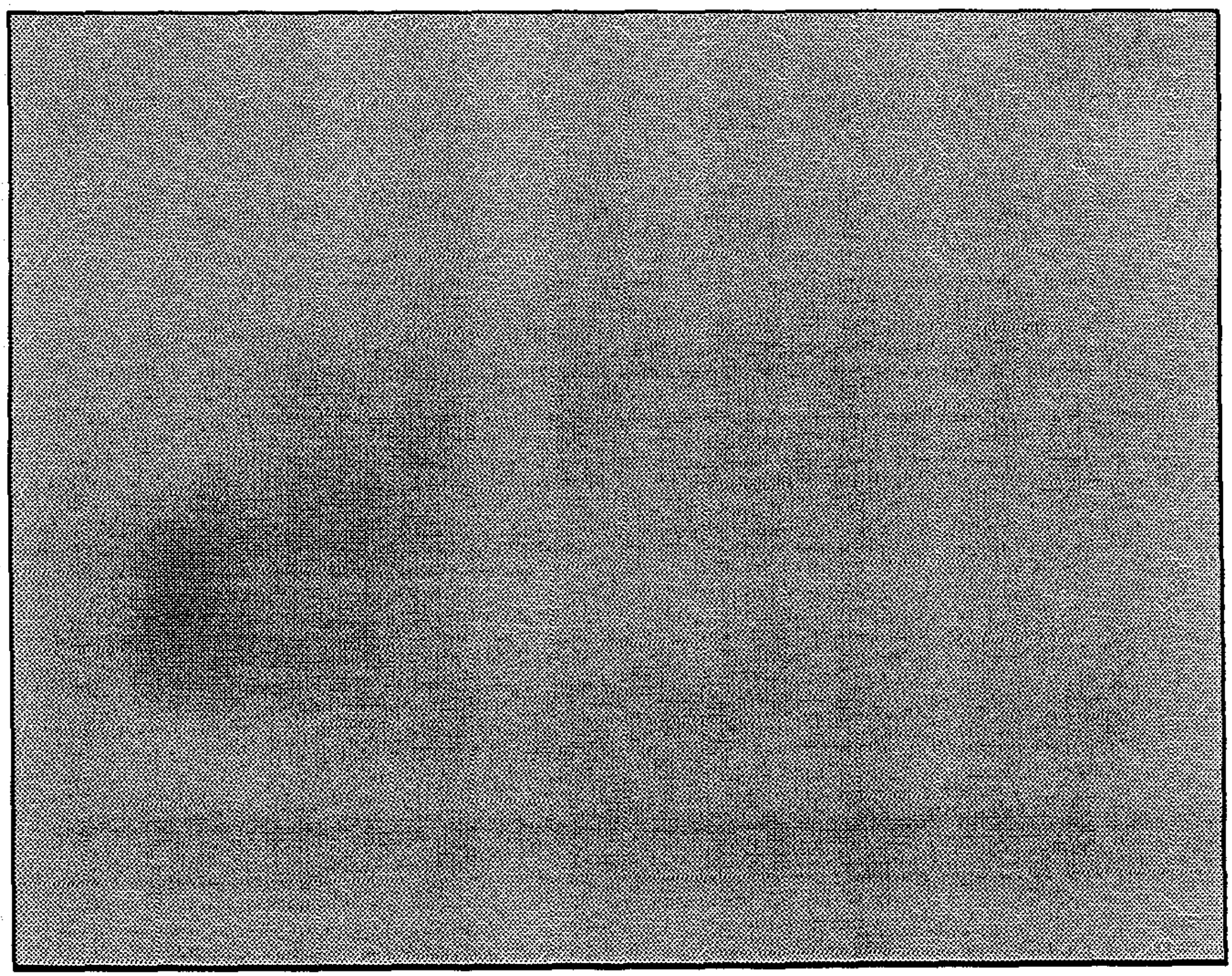


Table I6. Estimates of fishing mortality (F), stock size (thousands of fish) and stock biomass (mt) derived from Virtual Population Analysis [VPA] for Georges Bank cod (NAFO Division 5Z and Statistical Area 6), 1978 - 1989[1]

Year	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
							Fishing Mortality						
1	-0.002	0.007	0.001	0.029	0.013	0.003	0.022	0.004	0.002	0.001	-		
2	0.165	0.099	0.238	0.342	0.447	0.440	0.216	0.390	0.251	0.277	0.169	0.193	
3	0.408	0.408	0.469	0.526	0.625	0.587	0.722	0.716	0.488	0.488	0.527	0.572	
4	0.375	0.494	0.375	0.382	0.610	0.670	0.584	0.673	0.584	0.431	0.742	0.574	
5	0.375	0.320	0.454	0.228	0.550	0.646	0.543	0.714	0.542	0.399	0.623	0.542	
6	0.105	0.382	0.667	0.505	0.544	0.634	0.645	0.695	0.610	0.599	0.740	0.462	
7	0.349	0.143	0.882	0.543	0.528	0.888	0.814	0.662	0.387	0.553	0.987	0.528	
8	0.322	0.481	0.280	0.380	0.448	0.471	0.677	0.968	0.501	0.509	1.075	0.667	
9	0.227	-	0.648	0.889	0.610	0.648	0.702	0.805	0.633	0.496	1.192	0.700	
10	0.322	0.372	-	0.427	0.551	0.649	0.664	0.738	0.519	0.496	0.782	0.558	
11+	-	0.372	-	-	0.551	0.649	0.664	0.738	0.519	0.496	0.782	0.558	
F(3-8,U)	0.322	0.372	0.521	0.427	0.551	0.649	0.664	0.738	0.519	0.496	0.782	0.558	
F(3-8,W)	0.389	0.437	0.490	0.468	0.591	0.606	0.650	0.709	0.511	0.462	0.569	0.564	
							Stock Size						
1	27,245	22,932	17,823	42,463	18,220	9,308	28,587	8,176	42,713	13,779	18,527	[41,000]	[18,300]
2	3,195	22,306	18,738	14,496	34,738	14,490	7,523	23,332	6,550	34,830	11,255	15,154	[33,568]
3	25,051	2,218	16,534	12,094	8,429	18,199	7,639	4,964	12,929	4,172	21,626	7,781	10,232
4	7,663	13,645	1,208	8466	5,852	3,695	8,288	3,037	1,986	6,499	2,098	10,453	3,595
5	2,926	4,312	6,815	680	4,729	2,605	1,548	3,783	1,268	907	3,458	818	4,819
6	782	1,647	2,563	3,544	443	2,234	1,118	736	1,516	604	498	1,518	390
7	1,434	577	920	1,077	1751	211	970	480	301	675	272	195	783
8	183	828	409	312	512	846	71	352	203	167	318	83	94
9	200	-	419	253	175	268	432	30	109	101	82	89	35
10	40	131	-	180	85	78	115	175	11	48	50	20	36
11+	-	57	-	-	126	87	126	46	70	17	42	18	18
Total No.	68,719	68,653	65,429	83,565	75,060	52,021	56,417	45,111	67,656	61,799	58,226	77,129	71,870
Spawning No.	33,359	29,756	30,974	29,057	31,080	27,543	20,471	19,565	18,870	24,249	26,915	24,608	29,222
							Stock Biomass At Age						
1	18,064	15,456	11,193	29,215	10,003	7,130	26,100	5,928	31,479	6,903	10,820	[23,944]	[9,937]
2	2,981	25,808	21,436	16,265	38,281	15,534	9,645	28,139	7,624	40,855	11,784	17,124	[37,495]
3	46,920	3,952	32,110	22,676	17,440	33,687	14,736	9,367	23,789	7,953	40,355	14,364	19,165
4	24,368	44,483	3,784	24,533	17,627	11,565	24,782	9,634	5,567	20,778	6,157	30,835	10,882
5	11,273	18,483	34,011	3,098	20,321	11,078	6,671	16,586	6,044	4,180	16,399	3,512	21,917
6	3,503	9,416	14,804	23,107	2,570	13,195	6,336	4,403	9,346	3,972	3,089	9,012	2,432
7	9,224	3,974	7,251	8,085	1,4607	1,508	7,367	3,591	2,317	5,415	2,236	1,442	6,175
8	1,394	7,279	3,697	2,869	4,769	8,349	627	3,431	1,835	1,582	3,005	801	895
9	2,037	-	4,515	2,875	1,944	2,863	4,679	333	1,268	1,067	830	962	368
10	511	1,710	-	2668	1314	987	1,381	2,111	146	623	611	249	449
11+	-	978	-	-	2,188	1,503	2,179	795	1216	290	729	310	311
TOTBIO	120,275	131,539	1132,801	35,391	131,064	107,399	104,503	84,318	90,631	93,618	96,015	102,555	110,337
SPWNBIO	84,682	89,926	92,451	83,642	83,784	74,769	61,731	51,788	46,378	54,345	62,960	58,762	66,366

[1]Spawning stock numbers and biomass are at spawning time (*i.e.*, March 1).

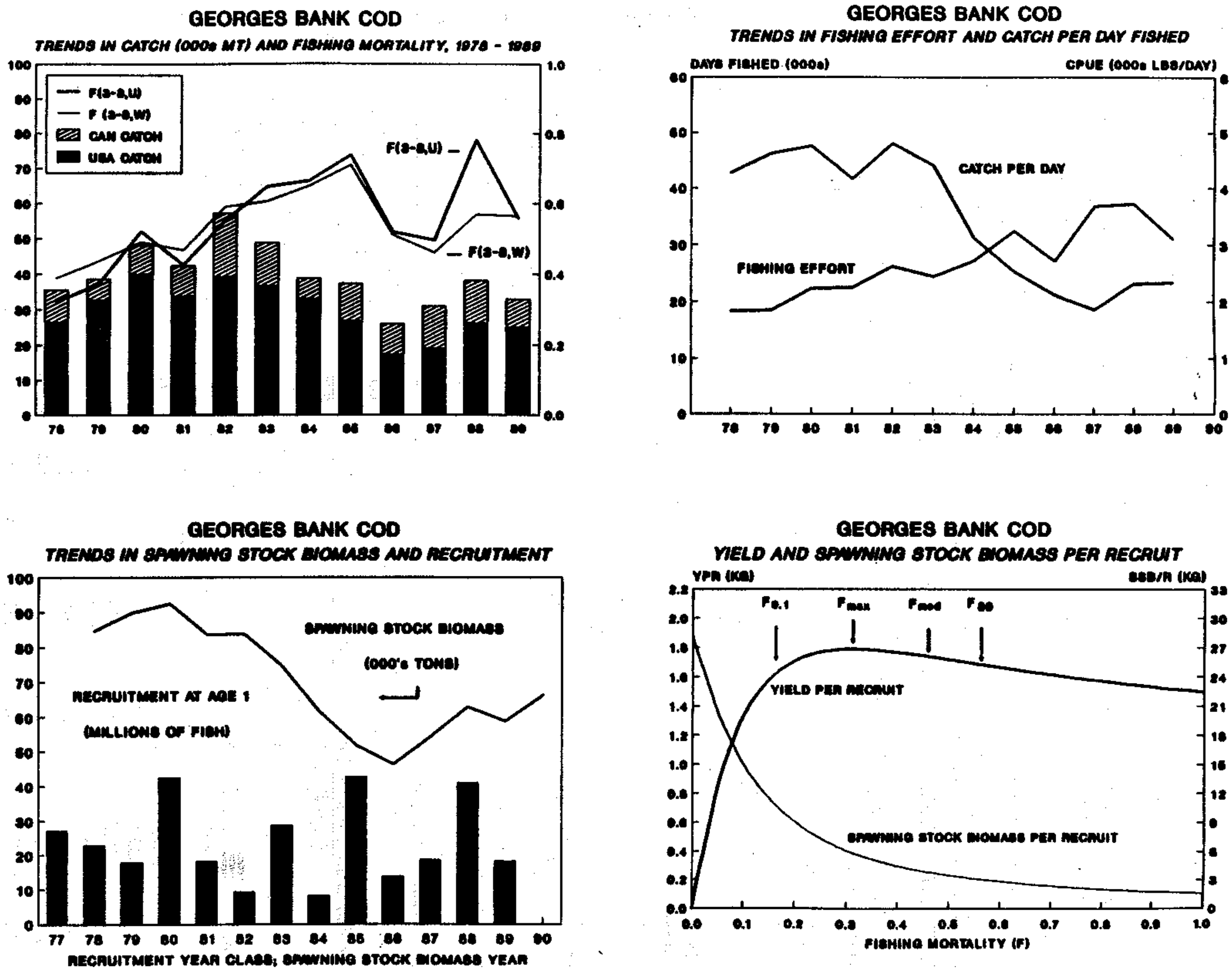


Figure I1. Stock assessment summary diagrams for Georges Bank cod.

Table I7. Cod stock projections, 1990-1992

PROJECTION 1: STATUS QUO F
$F(1990) = F_{SQ} = 0.56$; thereafter $F = F_{SQ} = 0.56$

	1990	1991	1992
Jan 1 2+ stock size (thousand)	53570	45715	40241
Mar 1 SSB (mt)	66208	72961	69529
Annual catch (mt)	40015	43768	40538

PROJECTION 2: $F_{0.1}$
$F(1990) = F_{SQ} = 0.56$; thereafter $F = F_{0.1} = 0.149$

	1990	1991	1992
Jan 1 2+ stock size (thousand)	53570	45715	49505
Mar 1 SSB (mt)	66208	77855	103783
Annual catch (mt)	40015	13892	17765

PROJECTION 3: F_{max}
$F(1990) = F_{SQ} = 0.56$; thereafter $F = F_{max} = 0.274$

	1990	1991	1992
Jan 1 2+ stock size) (thousand)	53570	45715	46325
Mar 1 SSB (mt)	66208	76332	91686
Annual Catch (mt)	40015	24177	27951

PROJECTION 4: F_{rep}
$F(1990) = F_{SQ} = 0.56$; thereafter $F = F_{rep} = 0.47$

	1990	1991	1992
Jan 1 2+ stock size (thousand)	53570	45715	41994
Mar 1 SSB (mt)	66208	74005	75769
Annual catch (mt)	40015	38136	37820

Detailed Information on Cod Status Quo Projection ($F_{90} = F_{91} = F_{92} = 0.56$)

January 1 Stock Size (thousand, number)

Age	Year 1990	1991	1992
1	18300	20000	20000
2	33568	14929	16316
3	10232	21440	9535
4	3595	4785	10027
5	4819	1681	2238
6	390	2254	786
7	783	182	1054
8	94	366	85
9	35	44	171
10	36	16	21
11	18	16	8

Mar 1 SSB (mt)

Age	Year 1990	1991	1992
1	480.3	524.9	524.9
2	13570.4	6035.4	6596.0
3	14183.0	29719.1	13217.4
4	9299.8	12378.6	25938.2
5	19309.3	6736.7	8966.9
6	2143.0	12383.9	4320.5
7	5440.1	1267.2	7322.8
8	788.7	3072.3	715.6
9	323.8	406.7	1584.4
10	395.7	179.9	226.0
11	274.4	256.6	116.7

Annual catch (mt)

Age	1990	1991	1992
1	45.6	49.8	49.8
2	10230.4	4549.9	4972.6
3	9451.7	19805.2	8808.2
4	5347.2	7117.4	14913.9
5	10367.9	3617.2	4814.7
6	1064.6	6151.7	2146.2
7	2664.3	620.6	3586.4
8	375.6	1463.2	340.8
9	151.9	190.8	743.1
10	193.6	88.0	110.6
11	122.1	114.2	51.9

Data Used in Cod Projections[1]

Age	1990 Stock Size (thousands)	Expoitation Pattern	Mean Wt. of Catch (kg)	Mean Wt. of Stock (kg)	Maturity (Ogive)
1	18300	0.0064	0.768	0.543	0.05
2	33568	0.4434	1.523	1.117	0.39
3	10232	1.0000	2.355	1.873	0.84
4	3595	1.0000	3.792	3.027	0.97
5	4819	1.0000	5.485	4.548	1.00
6	390	1.0000	6.959	6.237	1.00
7	783	1.0000	8.675	7.886	1.00
8	94	1.0000	10.187	9.523	1.00
9	35	1.0000	11.063	10.501	1.00
10	36	1.0000	13.710	12.475	1.00
11+	18	1.0000	17.300	17.300	1.00

M = 0.2

[1] Numbers at age 1 (thousands) for 1991 onward = geometric mean of numbers at age 1 from 1978-1988 = 20,000

OCEAN POUT

Ocean pout are primarily distributed in the Cape Cod Bay and Southern New England regions. The fishery is seasonal during December to May because the fish move to harder substrates to spawn. The assessment for this species consists of an annual update of landings and the NEFC spring survey index. Landings peaked at 27,000 mt in 1969 and declined continuously to 277 mt in 1975 (Table J1). The fishery averaged 600 mt from 1975 to 1983 and increased to 2,200 mt in 1987. Landings averaged 1,500 mt during 1988 and 1989 and will probably remain at this level in 1990. During 1982-86 catches occurred primarily in Cape Cod Bay, but more recently were concentrated in the Southern New England area (SA 537-539).

NEFC spring survey indices (weight per tow) for this species were relatively high in the late 1960s and early 1970s, declined somewhat in the mid-1970s, and increased in the early 1980s (Table J2). The survey index declined in the mid-1980s, remained stable during 1987-89, and increased in 1990. Ocean pout are currently categorized as fully exploited in the status of fisheries resources report (NEFC 1989), based on the landings and survey indices. The SARC found no basis for disagreeing with this conclusion. This species may be susceptible to overfishing because of low reproductive potential, due generally to very low fecundity. The SARC recommends that basic population dynamics information (*e.g.,* on age, growth, fecundity) be obtained for this species because of potential overfishing problems in the future.

REFERENCES

Northeast Fisheries Center. 1989. Status of the fishery resources off the Northeastern United States. Woods Hole, MA: NOAA/NMFS Northeast Fisheries Center. NOAA Technical Memorandum NMFS-F/NEC 72.

Table J1. Ocean pout landings (mt) in the Gulf of Maine, Georges Bank, Southern New England and Mid-Atlantic regions as reported to ICNAF-NAFO, 1960 - 1989

	USA				
Year	**5**	**6**	**Total**	**Other**	**Total**
1960	27	0	27	0	27
1961	1	0	1	0	1
1962	0	0	0	0	0
1963	20	0	20	0	20
1964	2123	0	2123	0	2123
1965	877	0	877	0	887
1966	7149	0	7149	6231	13380
1967	7090	0	7090	271	7361
1968	8373	364	8737	4324	13061
1969	5571	966	6537	20435	26972
1970	5851	426	6277	895	7172
1971	2678	1448	4126	1784	4910
1972	1927	358	2285	1066	3351
1973	2810	285	3095	2275	5370
1974	2790	459	3249	483	3732
1975	209	65	274	3	277
1976	341	337	678	0	678
1977	809	250	1059	0	1059
1978	715	320	1035	0	1035
1979	658	14	672	0	672
1980	339	11	350	0	350
1981	234	17	251	0	251
1982	317	4	321	0	321
1983	408	0	408	0	408
1984	1324	0	1324	0	1324
1985	1450	54	1504	0	1504
1986	789	13	802	0	802
1987	2111	74	2185	0	2185
1988	1770	41	1811	0	1811
1989	1300	6	1306	0	1306

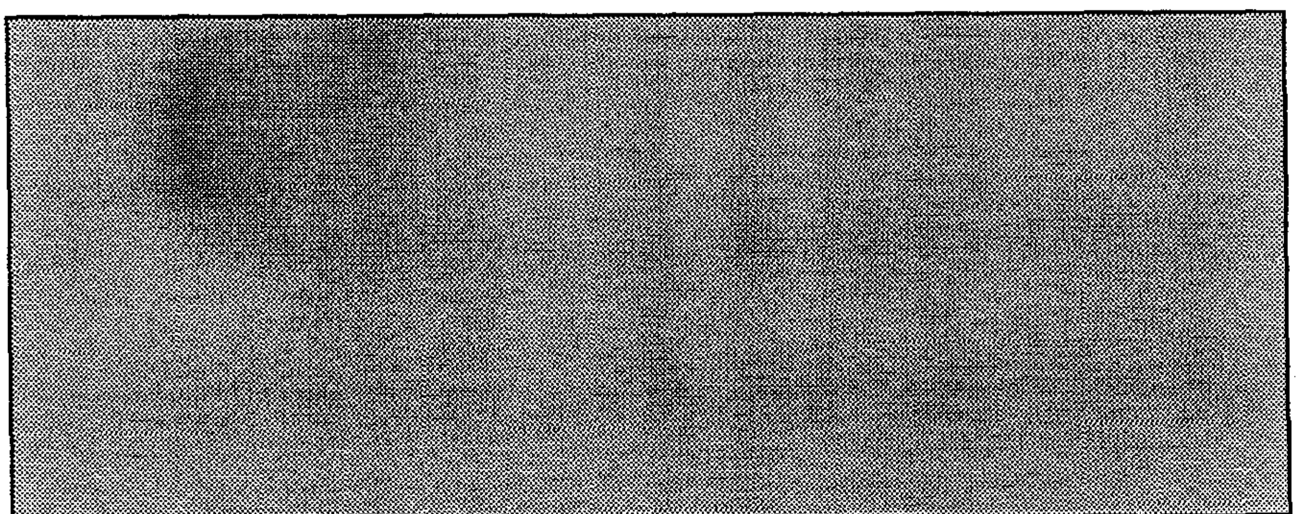


Table J2a. NEFC offshore spring bottom trawl survey indices for ocean pout

Year	Weight per Tow	SD	Average Weight	Mean Length
Combined SNE & Georges Bank (1-26,73-76)				
1968	5.366	0.1536	0.793	51.06
1969	6.154	0.9556	0.713	49.27
1970	5.180	0.1249	0.845	51.90
1971	2.183	0.5019	0.696	50.22
1972	4.453	0.1259	0.875	51.60
1973	3.373	0.5872	0.735	48.84
1974	1.479	0.3048	0.640	47.00
1975	1.344	0.3277	0.926	52.80
1976	1.400	0.3180	0.574	46.47
1977	3.566	0.1987	0.563	44.71
1978	3.371	0.5055	0.285	31.60
1979	1.493	0.3725	0.287	34.68
1980	5.729	0.1326	0.484	42.58
1981	7.605	0.1701	0.538	42.70
1982	4.743	0.1165	0.546	44.00
1983	4.236	0.6705	0.835	50.39
1984	5.540	0.1208	0.762	49.96
1985	6.494	0.1170	0.721	48.74
1986	6.345	0.1588	0.907	52.97
1987	2.705	0.9103	0.879	51.72
1988	3.244	0.5877	0.600	45.02
1989	2.792	0.4309	0.525	44.04
1990	5.074	0.1066	0.797	50.33
Southern New England - Mid-Atlantic (1-12,73-76)				
1978	4.895	0.7773	0.237	29.98
1979	2.218	0.6858	0.242	33.68
1980	9.023	0.2439	0.470	42.44
1981	2.549	0.3137	0.502	42.03
1982	5.649	0.1915	0.405	41.23
1983	4.126	0.8297	0.683	47.91
1984	8.559	0.2172	0.700	48.70
1985	9.305	0.2016	0.717	48.20
1986	10.265	0.2942	0.898	52.74
1987	4.021	0.1669	0.800	50.27
1988	3.277	0.9737	0.529	42.14
1989	2.907	0.6557	0.423	40.85
1990	5.506	0.1820	0.649	46.99
Georges Bank (13-26)				
1978	1.616	0.6179	0.968	54.69
1979	0.658	0.1373	1.017	50.97
1980	1.938	0.5099	0.575	43.55
1981	1.853	0.4686	1.224	55.63
1982	3.700	0.1191	1.399	60.81
1983	4.364	0.1080	1.100	54.75
1984	2.065	0.7065	1.319	61.31
1985	3.258	0.9750	0.733	50.53
1986	1.832	0.4270	0.973	54.62
1987	1.189	0.3785	1.436	61.90
1988	3.206	0.5847	0.714	49.58
1989	2.660	0.5381	0.753	51.19
1990	4.571	0.9134	1.168	58.76

WHITE HAKE

Stock boundaries for this species are uncertain and it is treated as a single stock. Like red hake, the only available resource monitoring data are landings in the commercial fishery and NEFC survey abundance indices. Landings increased steadily between 1968 and 1984 to 7,500 mt and have declined somewhat since then to 5,600 mt in 1989 (Table K1). The autumn survey tracked landings closely until the early 1980s. The extremely low 1982 autumn survey value was probably an anomaly. Spring survey values have been very low in recent years, but autumn survey values have remained fairly stable (Table K2).

The historical pattern of landings and survey abundance suggest that the long-term potential catch of this species is about 5,000 mt. At current exploitation levels, it is believed to be fully exploited and the SARC found no evidence contradicting this conclusion. Relative exploitation rates, as estimated by dividing landings by survey abundance values, have increased in recent years despite a decline in landings. Also, average weight has declined in both surveys in recent years. Reference F values for this species are unknown.

The SARC noted that the decline in the survey indices is cause for concern, and it is recommended that basic data on the population dynamics of this species be obtained in order to evaluate and monitor this trend.

References

Burnett, J., S. Clark, L. O'Brien. 1984. Preliminary assessment of white hake in the Gulf of Maine-Georges Bank area, 1984. Woods Hole, MA: NOAA/NMFS Northeast Fisheries Center. Laboratory Reference Document 84-31, 33p. Available from: Northeast Fisheries Center, Woods Hole, MA, 02574.

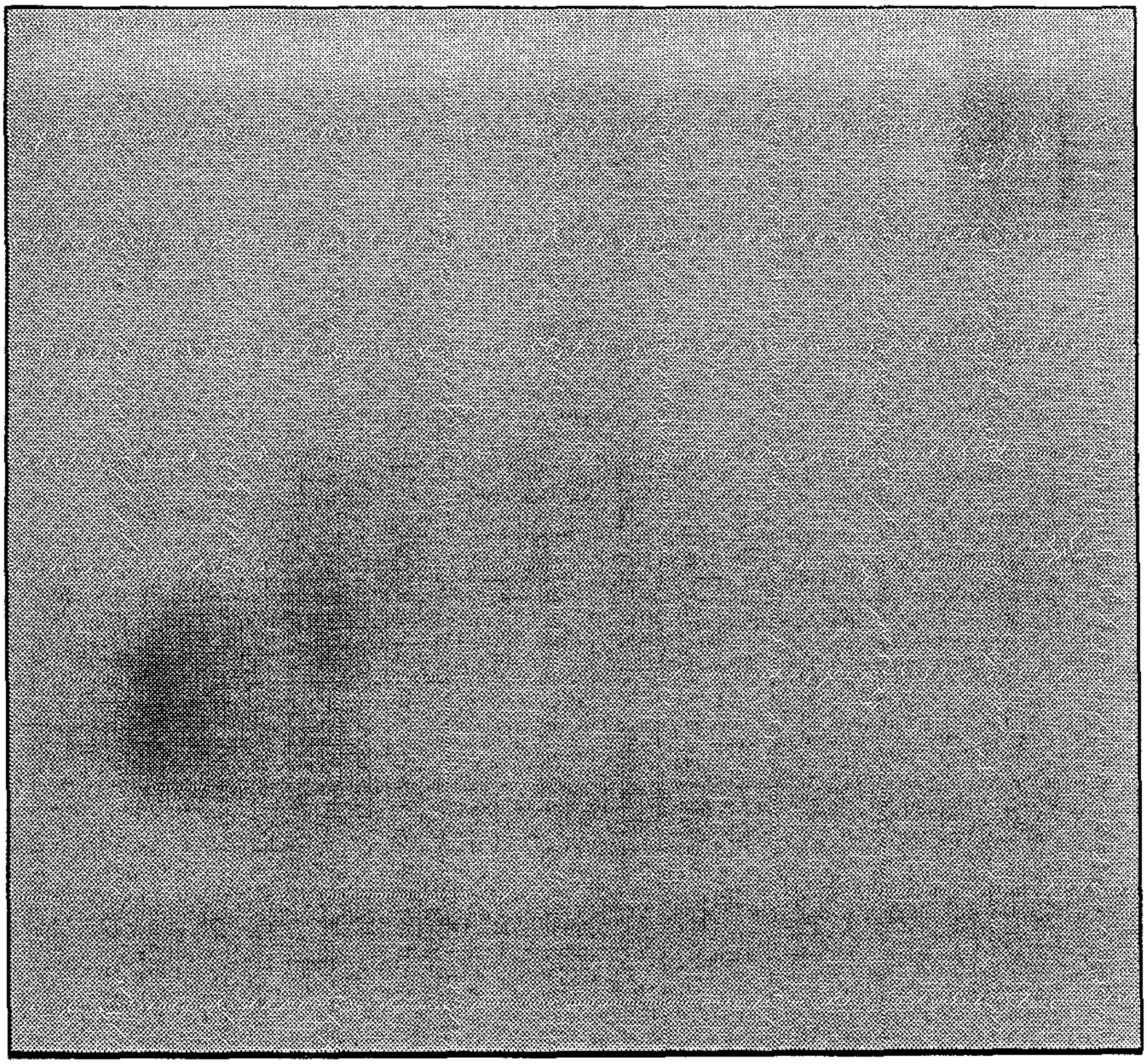


Table K1. Nominal catch of white hake (mt, live) by country from the Gulf of Maine to Cape Hatteras (NAFO subareas (5 and 6), 1960-1989

Year	5Y			5Z			SA6			Total			Total Subarea 5	Total
	Canada	USA	Other	Canada	USA	Other	Canada	USA	Other	Canada	USA	Other		
1960	-	2,421	-	-	906	-	-	-	-	-	3,327	-	3,327	3,327
1961	-	2,143	-	-	872	-	-	-	-	-	3,015	-	3,015	3,015
1962	1	2,596	-	8	551	-	-	-	-	9	3,147	-	3,156	3,156
1963	-	2,747	-	11	665	-	-	75	-	11	3,423	-	3,423	3,498
1964	3	2,888	-	26	1,327	-	-	36	-	29	4,251	-	4,244	4,280
1965	-	2,688	-	-	811	-	-	29	-	-	3,528	-	3,499	3,528
1966	-	926	-	-	334	-	-	43	-	-	1,303	-	1,260	1,303
1967	-	419	-	16	21	-	-	21	-	16	461	-	456	477
1968	5	334	-	80	24	-	-	24	-	85	382	-	443	467
1969	-	1,095	-	-	892	6	-	28	-	-	2,025	6	1,993	2,021
1970	12	1,564	-	34	909	222	-	20	58	46	2,493	280	2,741	2,819
1971	18	2,137	-	82	1,432	109	-	68	105	100	3,637	214	3,778	3,951
1972	8	2,839	-	32	1,026	159	-	54	-	40	3,919	159	4,064	4,118
1973	17	3,057	-	100	1,063	1	-	40	4	117	4,160	5	4,238	4,282
1974	36	3,839	-	196	1,001	-	-	60	-	232	4,900	-	5,072	5,132
1975	17	3,039	-	129	556	-	-	40	-	146	3,635	-	3,741	3,781
1976	-	3,542	-	195	548	-	-	25	-	195	4,115	-	4,285	4,310
1977	-	4,391	-	170	880	189	-	12	149	170	5,283	338	5,630	5,791
1978	20	4,151	-	135	923	1	-	15	28	155	5,089	29	5,230	5,273
1979	102	3,235	-	149	859	3	-	1	1	251	4,095	4	4,348	4,350
1980	14	3,835	-	291	980	1	-	4	1	305	4,819	2	5,121	5,126
1981	21	4,480	-	433	1,221	-	-	5	-	454	5,706	-	6,155	6,160
1982	352	4,906	-	412	1,074	1	-	4	1	764	5,984	2	6,745	6,750
1983	441	5,054	-	369	1,085	-	-	2	-	810	6,141	-	6,949	6,951
1984	479	4,998	-	534	1,480	-	-	12	-	1,013	6,490	-	7,491	7,503
1985	452	5,100	-	501	1,224	-	-	4	-	953	6,328	-	7,277	7,281
1986	308	3,972	-	648	785	-	-	6	-	956	4,763	-	5,713	5,719
1987	-	4,274	-	555	1,240	-	-	6	-	555	5,520	-	6,064	6,075
1988	-	3,755	-	534	1,600	-	-	42	-	534	5,397	-	5,889	5,931
1989	-	3,939	-	583	1,097	-	-	8	-	583	5,044	-	5,619	5,627

[1] 1960-1983 from Burnett *et al.* (1984)

Table K2. Stratified mean catch-per-tow in numbers and weight (kg) of white hake from NEFC offshore spring and autumn bottom trawl surveys in the Gulf of Maine and on Georges Bank, 1963-1990

Year	Spring			Autumn		
	Number/Tow	Weight/Tow	Average Weight	Number/Tow	Weight/tTw	Average Weight
1963[1]	-	-		5.00	6.31	1.26
1964	-	-		1.76	4.14	2.35
1965	-	-		4.39	6.85	1.56
1966	-	-		6.79	7.66	1.13
1967	-	-		3.90	3.64	0.93
1968	1.60	1.74	1.09	4.24	4.54	1.07
1969	3.76	5.09	1.35	9.24	13.10	1.42
1970	5.84	11.86	2.03	8.05	12.83	1.59
1971	3.31	5.13	1.55	10.38	12.10	1.17
1972	10.18	12.66	1.24	12.52	13.10	1.05
1973	9.24	12.21	1.32	9.05	13.46	1.49
1974	8.08	13.99	1.73	5.35	11.00	2.06
1975	9.31	11.22	1.21	5.28	7.23	1.37
1976	9.98	17.00	1.70	6.04	10.56	1.75
1977	6.12	11.01	1.80	9.78	13.74	1.40
1978	3.22	6.14	1.91	7.87	12.54	1.59
1979	5.26	4.97	0.94	5.62	10.31	1.83
1980	10.37	13.96	1.35	10.86	16.66	1.53
1981	17.09	19.92	1.17	8.70	12.16	1.40
1982	6.06	8.91	1.47	1.59	1.87	1.18
1983	3.21	3.12	0.97	7.96	10.60	1.33
1984	2.65	4.09	1.54	5.14	8.16	1.59
1985	4.33	5.38	1.24	9.36	9.74	1.04
1986	8.24	5.61	0.68	14.42	11.56	0.80
1987	7.14	6.44	0.90	7.59	9.62	1.27
1988	4.52	3.69	0.82	8.12	9.88	1.22
1989	3.65	3.22	0.88	11.76	9.23	0.78
1990[2]	11.11	11.65	1.65			

[1] 1963-1984 from Burnett *et al.* (1984)

[2] Includes 777 kg from a single tow in spring 1990.

RED HAKE

Two stocks tentatively have been identified, a Gulf of Maine-northern Georges Bank and a southern Georges Bank-Middle Atlantic stock.

NORTHERN STOCK

This stock was exploited by the foreign distant-water fleet in the mid-1970s, although to a lesser extent than the southern stock. Maximum landings reached 15,000 mt during this period, but have remained around 1,000 mt a year since 1977 (Table L1). Spring NEFC abundance indices generally increased following the end of foreign fishing (Table L1). Recruitment, as measured by survey abundance-at-age and -size data, was average or above average during the 1980s. This stock is categorized as under-exploited in the Status of Fisheries Resources Report (NEFC 1989), and the SARC could find no evidence to contradict this conclusion.

SOUTHERN STOCK

This stock was subject to a large foreign fishery during the 1960s and early 1970s. The largest catch, 108,000 mt, was taken in 1966. Catches declined rapidly beginning in 1973 and have remained less than 1,000 mt since 1985 (Table L2). The autumn survey index has been highly variable throughout the time series. Low values prevailed from 1984 to 1989. Age- and size-specific survey data indicate that the 1985 year class was strong, the 1986 and 1987 year classes were weak, and the 1988 year class was above average. This stock is also listed as under-exploited in the status of fisheries resources report (NEFC 1989), and there was no contradictory evidence presented.

GENERAL COMMENTS

Assessment of this species is limited to rather broad interpretations of landings and survey index values. Biological and population dynamics parameters (*e.g.*, stock structure, age and size at 50 percent maturity, M, $F_{0.1}$, F_{max}) that were derived years ago have not been evaluated for some time. This species is not subject to significant directed fishing effort and is probably discarded in fairly large numbers. To some extent, therefore, landings may be considerably underestimate catch. With the reduction in recorded landings in recent years, commercial length and age frequency data are not being compiled. Survey samples have not been aged since 1985.

Table L1. Red hake landings (mt) from the Gulf of Maine - northern Georges Bank stock (SAR 511-515, 521, 522, 561); and NEFC spring bottom trawl index (kg/tow) using strata 20-30, 36-40 (Δ distribution)

	Landings[1] (mt)			NEFC Spring SurveyIndex (kg/tow)
Year	USA	Other	Total	
1960	3792	0	3792	
1961	3276	0	3276	
1962	1911	0	1911	
1963	1225	2056	3281	
1964	197	1212	1409	
1965	152	2573	2725	
1966	885	4690	5575	
1967	577	1286	1863	
1968	597	2075	2672	0.869
1969	146	1875	2021	0.492
1970	261	771	1032	0.390
1971	377	4428	4805	0.569
1972	526	14488	15014	1.270
1973	355	14926	15281	2.041
1974	560	6332	7332	1.198
1975	450	8251	8701	2.108
1976	653	5684	6337	1.678
1977	889	2	891	1.383
1978	1223	0	1223	1.301
1979	1523	0	1523	1.187
1980	1029	0	1029	2.809
1981	1246	0	1246	4.350
1982	1210	0	1210	2.085
1983	894	0	894	3.080
1984	1059	0	1059	2.526
1985	991	0	991	3.961
1986	1457	0	1457	3.378
1987	1013	0	1013	3.587
1988	862	0	862	2.160
1989	774	0	774	2.111

[1] 1960-1985 landings values taken from SAW #2 Working paper #15. Landings values for 1986-1989 taken from NAFO Statistical Bulletin and weigh-out runs.

Table L2. Red hake landings (mt) from the southern Georges Bank -Middle Atlantic stock (SAR 525, 526, 562, 537-539, 6+); and NEFC autumn bottom trawl index using strata 1-19, 61-76 offshore, 1-46, 52, 55 inshore (Δ distribution)

	Landings[1] (mt)				NEFC Autumn Survey Index (kg/tow)
Year	USA	Rec.[2]	Other	Total	
1960	4286	317	0	4603	
1961	8105	612	0	8717	
1962	11865	892	0	12757	
1963	29712	770	2189	32671	7.588
1964	32622	848	10751	44221	3.016
1965	25246	634	67744	93624	3.887
1966	3985	94	103937	108016	2.077
1967	6764	165	52019	58984	1.078
1968	7001	575	11137	18713	2.432
1969	5539	489	47389	53417	2.364
1970	4679	410	6775	11864	1.681
1971	3227	287	31907	35421	1.734
1972	1995	177	59199	61371	3.051
1973	3603	317	47759	51679	1.875
1974	2183	191	24460	26834	0.571
1975	2065	52	17911	20028	3.763
1976	3905	645	18560	23110	2.326
1977	2522	750	4540	7812	2.304
1978	3327	971	2136	6434	1.594
1979	6624	245	968	7845	2.514
1980	3927	144	155	4226	2.989
1981	2124	79	196	2369	2.250
1982	2993	111	177	3281	2.048
1983	1334	49	107	1490	5.151
1984	1214	45	57	1316	0.662
1985	827	31	76	934	2.015
1986	634		50	684	0.929
1987	921		0	921	0.627
1988	871		0	871	0.645
1989	782	8	0	790	1.342

[1] Landing values for 1960-1985 taken from SAW 2 Working paper #15. Landings for 1986-1989 taken from from NAFO Statistical Bulletin and weigh-out runs.

[2] From marine angler survey; remaining years are estimated. 1986-88 have not been included.

SMALL ELASMOBRANCHS

DOGFISHES

Of the three species (spiny, smooth, and chain dogfishes) comprising this group, spiny dogfish clearly predominate in the commercial fishery. Only spiny dogfish is considered in this review. The population ranges from Newfoundland to Cape Hatteras and is considered as a single unit stock. Seasonal migrations are evident with movement northward in the spring and summer and southward in the winter. The fishery is directed primarily toward larger females.

Landings

Nominal catches of spiny dogfish remained below 1,000 t prior to the mid-1960s. Following the introduction of distant-water fleets, total nominal catches increased sharply to 8,400 t in 1966, and peaked at 21,600 t in 1972. The total catch subsequently declined to 7,000 t in 1977 and has remained below 5,000 t since 1983. The cumulative catch of spiny dogfish, however, equalled approximately 135,000 t between 1966 and 1977 (Table M1). The extent of discarding in both trawl and gillnet fisheries has not been quantified, but may be substantial, particularly during summer.

Population Dynamics

Published data suggest that spiny dogfish are relatively long-lived, slow-growing individuals. Ages up to 40 years have been noted in NEFC bottom trawl survey collections, although studies conducted elsewhere have indicated ages in excess of 100 years for this species. Consequently, both growth and natural mortality rates are relatively low. Age at first reproduction was estimated at 11 years for females, based on the occurrence of large embryos in the uterus. The production of large embryos increases with size (and age) from approximately 3.3 at 80 to 84 cm to 8 to 9 for females longer than 100 cm. A two-year gestation period was noted.

Yield-per-recruit analyses utilizing published growth information with an assumed M of 0.05, suggest $F_{0.1}$ and F_{max} values of 0.10 and 0.39, respectively. Given the relatively slow growth and late maturation rates, SSB/R declines rapidly with increases in F. Cumulative embryo production also declines rapidly with the replacement level of two pups per female occurring at F approximately equal to 0.45.

Fitted and observed NEFC spring bottom trawl survey indices suggest a substantial increase in the spiny dogfish population since the late 1960s (Table M2). While the observed indices were quite variable, smoothed indices

Table M1. Landings (mt) of spiny dogfish and skates from ICNAF/NAFO Areas 5 + 6 (Northeast USA), 1931-1989

Year	Spiny Dogfish	Skates (All Species)
1989	4,494	6,635
1988	3,172	5,873
1987	2,778	5,120
1986	2,838	4,328
1985	4,344	3,972
1984	4,514	4,140
1983	4,958	3,593
1982	6,964	592
1981	7,260	530
1980	4,394	954
1979	4,873	1,033
1978	1,418	1,353
1977	7,061	1,418
1976	14,374	1,212
1975	18,188	3,968
1974	17,584	3,651
1973	13,965	7,963
1972	21,595	8,823
1971	11,589	6,120
1970	5,060	4,128
1969	9,124	9,462
1968	4,107	6,483
1967	2,698	4,898
1966	8,390	2,844
1965	452	2,340
1964	713	4,070
1963	609	25
1962	528	44
1961	822	36
1960	877	61
1959	378	57
1958	428	41
1957	609	53
1956	248	38
1955	42	47
1954	29	54
1953	34	92
1952	24	95
1951	47	185
1950	67	73
1949	309	97
1948	26	312
1947	20	91
1946	73	66
1945	28	93
1944	27	227
1943	62	260
1942	58	391
1941	-	-
1940	248	169
1939	61	186
1938	67	228
1937	40	243
1936	-	-
1935	68	171
1934	-	-
1933	9	147
1932	16	467
1931	22	433

Table M2. Stratified mean number- and weight-per-tow indices for spiny dogfish from spring offshore bottom trawl data, 1968-1990. Computations used the Δ-distribution estimator, smoothed values were derived using an IMA model, with q=0.65 for weight-per-tow, and q=0.70 for numbers.

Year	Weight		Numbers	
	Observed	Fitted	Observed	Fitted
1968	56.069	32.768	33.964	24.872
1969	16.671	29.613	14.812	23.895
1970	14.718	29.823	13.353	24.413
1971	22.943	34.309	16.339	26.953
1972	44.523	42.580	48.883	31.736
1973	98.583	52.401	55.249	35.348
1974	93.503	57.248	51.850	37.175
1975	65.688	57.019	51.736	37.459
1976	57.395	55.297	38.790	36.210
1977	38.396	53.251	20.666	34.695
1978	55.507	54.542	32.890	35.533
1979	22.567	55.680	16.686	36.754
1980	82.360	67.388	44.626	42.080
1981	121.954	78.531	71.159	47.816
1982	198.958	84.233	80.361	51.625
1983	41.402	76.837	55.331	52.656
1984	48.956	78.753	24.119	53.366
1985	194.178	88.283	169.972	59.900
1986	54.829	85.305	26.391	58.796
1987	83.672	89.587	86.086	63.974
1988	92.536	95.303	65.947	67.000
1989	104.231	101.949	76.875	70.313
1990	151.901	108.603	97.118	72.949

Table M3. Total catch (thousands of mt) and minimum biomass (thousands of mt) estimated from trawl survey area-swept calculation, for skates off the Northeastern United States, 1965-1988

Year	Catch	Minimum Biomass
1965	2.4	
1966	2.8	
1967	2.8	
1968	2.5	148.0
1969	3.2	334.7
1970	1.7	162.0
1971	1.0	175.8
1972	2.5	145.0
1973	1.3	143.0
1974	2.3	72.8
1975	0.9	96.5
1976	2.0	80.0
1977	1.5	97.2
1978	1.5	89.9
1979	1.6	53.1
1980	2.0	102.7
1981	0.8	86.8
1982	1.0	70.2
1983	3.6	117.4
1984	4.1	81.1
1985	4.0	206.6
1986	4.3	102.0
1987	5.1	189.4
1988	5.9	167.4

suggested an approximate doubling of both biomass and abundance during the past 20 years. When the survey data were fitted to an exponential growth model, linear regression estimates of the intrinsic rate of growth were 0.06 and 0.09 for the logarithms of the smoothed and observed indices, respectively. Assuming that historic harvest levels have been minor compared to potential surplus production, these estimates suggest sustainable annual exploitation rates of approximately 10 percent.

Given the high degree of variability in the bottom trawl survey indices, it is not clear whether the stock has reached a maximum or is continuing to increase. The degree of discarding in commercial fishing operations may be quite high during certain seasons and the mortality of discarded dogfish, while presumed to be low, is unknown. The life history characteristics of this species (longevity, low growth and natural mortality rates, late maturation and low reproductive capacity) would suggest a high degree of vulnerability to exploitation. While the current stock biomass appears to be at a record high level, the committee is concerned that any attempt to increase the rate of exploitation should be done with caution.

Future Research

To better understand the dynamics of spiny dogfish and its response to exploitation, several issues should be investigated, including:

- Better evaluation of the NEFC survey indices as an indicator of stock abundance and biomass and means to estimate absolute population size
- Evaluating changes in population demographics over time, including size, age, and sex composition, and population fecundity
- Evaluation of stock recruitment relationships from survey data
- Better understanding of the trophic dynamics of spiny dogfish in the ecosystem
- Investigation of discard data to clarify the removals from the stock.

SKATES

Seven species of skates are found off the Northeast coast of the U.S. in significant quantities. Of these, the commercial fishery appears to be targeting little skates and winter skates. Only little skates are considered in this review.

Landings

Nominal catches of mixed skates remained less than 1,000 t prior to the mid-1960s. Following the introduction of distant-water fleets, total nominal catches increased sharply to 4,000 t in 1964 and peaked at 9,500 t in 1969. The total catch subsequently declined to less than 1,000 t between 1980 and 1982, but has since increased to 6,600 t in 1989 (Table M3). Recent increases in catches are attributed to increased landings of skate wings making species identification difficult.

Population Dynamics

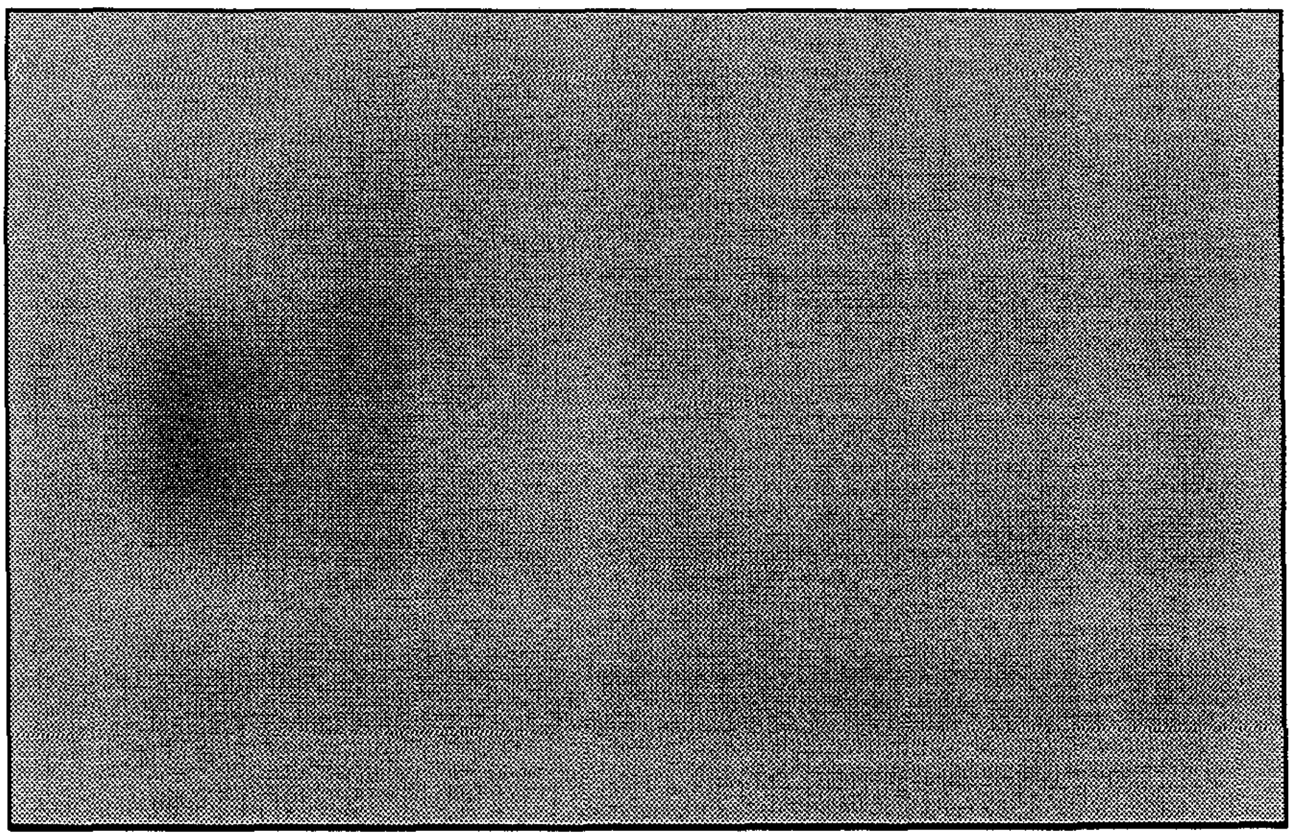
Little skates are relatively short-lived, fast growing individuals with maximum observed age of 8 years. Yield-per-recruit analyses utilizing published growth information with an assumed M of 0.4 to 0.5 suggest $F_{0.1}$ and F_{max} values of 0.49 to 0.60 and 1.0 to 2.0, respectively. The estimates of growth and longevity for little skates appear to contradict what has been reported for similar species in the Northeast Atlantic.

NEFC spring bottom trawl survey indices suggest a substantial increase in calculated biomass levels since the mid-1970s (Table M3). Given information on other stocks and the survey data, increasing catch must be cause for concern that these stocks may already be fully exploited.

Future Research

Given the lack of biological information on all skate species, several issues should be investigated, including:

- Better evaluation of the NEFC survey indices as an indicator of stock abundance and biomass and means to estimate absolute population size
- Evaluating changes in population demographics over time including age, growth, maturity, and mortality rates for winter, thorny, barndoor, and smooth skates
- Estimates of fecundity and a re-evaluation of growth rates and longevity for little skates
- Sampling of commercial landings to determine species composition
- An evaluation of the competitive interactions among skates and benthic foraging teleosts



Eleventh NEFC Stock Assessment Workshop
Fall 1990

Advisory Report on Stock Status

INTRODUCTION

The Advisory Report on Stock Status is intended to be a major product of the NEFC Stock Assessment Workshop. This report summarizes the technical information in the report of the Stock Assessment Review Committee (SARC) and is intended to serve as scientific advice for fishery managers on resource status.

An important aspect of scientific advice on fishery resources is a determination of whether a stock is currently over-, fully or under- exploited. The SAW Plenary agreed that these categories refer to the act of fishing and therefore 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}. However, the current stock level, *e.g.*, spawning biomass, is also an important factor for classifying the status of a resource. It is possible that a stock that is not currently over exploited was seriously depleted in the recent past such that future recruitment to the stock is jeopardized. Therefore, the SAW Plenary, where possible, classified stocks as depleted or not seriously depleted compared to historic levels.

The figure below describes the contingencies identified by the SAW for classifying stocks.

Stock Level

Exploitation Rates	Depleted	Not Depleted
Over exploited	Low stock High F	High stock High F
Fully expoited	Low stock Reference F	High stock Reference F
Under exploited	Low stock Low F	High stock Low F

GULF OF MAINE HERRING

An analytical assessment of Gulf of Maine herring was conducted by the ASMFC Atlantic Herring Technical Advisory Committee. Population size estimates indicate that the stock has been steadily increasing since the 1982 low point of 59,700 mt total stock size (28,300 mt of spawning stock). The current total stock size is estimated at 235,500 mt (185,900 mt of spawning stock). However, several sources of uncertainty in the analysis suggest that the current assessment may have overestimated stock size for the most recent years in particular.

Total landings in 1989 were 53,455 mt, which is an increase of 33 percent over the 1988 landings. The U.S. fishery is currently dominated by the purse seiners harvesting adult herring, with only 9 percent of the total catch taken by fixed gear. The 1987 year class was strong and in 1989, two-year-old fish made up 34 percent of the catch in numbers. However, a large fraction of the estimated current stock biomass, and the majority of the spawning stock is due to the 1983 year class. The current rate of fishing mortality of fully recruited herring was estimated to be 0.3.

Projections of stock size and catch under an assumption of constant recruitment at the average level for the most recent years indicate that if the fishing mortality rate is maintained at the current level, catches will remain approximately steady around 50,000 mt for the next three years, and the spawning stock biomass will gradually decline. Some increase in fishing mortality rate to F_{rep} (0.5) or F corresponding to the 20 percent maximum spawning potential level under the current estimates of the partial recruitment pattern (0.37), would increase the size of the catch to about 60,000 mt in 1991 and 1992, but will cause spawning stock biomass to decline significantly.

These catch projections may be biased upward (*e.g.* overestimates) because of the assumption that recruitment will continue to be high, and due to uncertainties in the assessment identified by the Stock Assessment Review Committee. The major reasons for concern were: 1) exclusion of landings from the New Brunswick fixed-gear fishery from the assessment, 2) mixing with stocks to the south may have affected landing figures and survey indices for the Gulf of Maine stock, 3) technical problems related to the use of a single survey index in conjunction with the catch data and 4) changes in the fishery which may have altered the selection pattern for different ages of herring. Additional analyses have been suggested to attempt to resolve some of these issues.

The SAW concluded that this stock is currently fully exploited with no indication of depletion.

SUMMER FLOUNDER

An analytical assessment was performed by the SAW Summer Flounder Working Group to estimate fishing mortality rates, stock size, and biological reference points. Commercial landings in 1989 were 9,700 mt, the lowest in the past 16 years and half of the amount landed in 1979. Recreational landings have also declined to 1,500 mt in 1989, less than 20 percent of the decadal average. The current fishing mortality rate on fully recruited summer flounder was estimated to be about 1.4 and has been generally greater than 1.0 since at least 1982. The 1988 year class was the smallest in the time series since 1982 and the stock size in 1988 was also the lowest in numbers of fish for the time series. There is some information indicating that the sizes of the 1989 and 1990 year classes are no better than average, but only a single survey was available for estimating of year class strength for these years and the confidence intervals around the estimates are wide. The age composition of the stock is extremely truncated with very few fish over the age of three years.

Revised estimates of $F_{0.1}$ (0.14) and F_{max} (0.23) were made using the partial recruitment pattern determined in the assessment. Projections based on these reference points indicate that long-term increases in both yield and spawning biomass will be achieved if the rate of fishing mortality is reduced substantially below recent levels. If the rate of fishing mortality is maintained at its current level, the recruitment expected from the 1989 and 1990 year classes will have no lasting effect on stock rebuilding.

Based on this assessment of stock sizes, fishing mortality rates, and biological reference points, the SAW concluded that this stock is over exploited and seriously depleted.

SCUP

Analysis of data on scup in Long Island Sound and in Massachusetts waters was prepared by the Marine Fisheries Unit of the Connecticut Department of Environmental Protection. The 1989 commercial landings of scup were 3,600 mt, the lowest level since 1960. Recreational catches were similar to the commercial landings in 1989, giving a total catch which is the lowest since 1981.

Total mortality estimates made from the Connecticut and Massachusetts survey data, combined with an assumed level of the natural mortality rate of 0.2, suggest that the fishing mortality rate for the last few years has been approximately 1.0. Calculated values of $F_{0.1}$ for minimum legal sizes between 15 and 25 cm were 0.22 to 0.38. F_{rep} can appear to be fully exploited compared to the reference levels. However, the large degree of uncertainty in the estimates of stock status suggest that the exploitation rates may have been underestimated. A cautious interpretation of the assessment results is recommended.

AMERICAN PLAICE

This species is evaluated on the basis of data and analysis provided by the NEFC Population Dynamics Branch staff on trends in landings, commercial catch-per-unit effort, survey indices, and preliminary analysis of length composition data from the surveys done during the SARC meeting. The 1989 landings were 2,351 mt, mostly by otter trawlers, following a steady decline through the past decade from a peak in 1982. Landings and survey indices in the late 1960s and early 1970s were similar to recent levels. Commercial catch-per-unit effort as an index of abundance shows that the stock is reduced to about one tenth of the peak level, while the survey indices suggest a six-fold decrease.

Preliminary analysis of length composition data from the surveys suggests that recent mortality rates have been greater than current estimates of F_{max} (0.34) or $F_{0.1}$ (0.17) indicating over exploitation of this stock. These estimates and the patterns in the indices indicate that this species is over exploited and depleted.

GEORGES BANK COD

An analytical assessment of this stock was carried out by NEFC Population Dynamics Branch staff and included estimation of fishing mortality rates, stock sizes and biological reference points. Recent commercial landings of Georges Bank cod have been around 35,000 mt. Total recreational landings, including the Gulf of Maine stock, are estimated to have been around 7,000 mt.

The assessment indicates that recent recruitment to the stock has been good with strong 1985 and 1988 year classes and at least average recruitment in intervening years. The fishing mortality rate on fully recruited cod in 1989 was estimated to be between 0.5 and 0.6, slightly below the 1988 level. Estimated spawning stock biomass declined from a 1980 peak by 50 percent in 1986 and has since apparently increased to 70 percent of the 1980 level. The following technical problems were identified in the analysis: 1) changes in survey methodology, 2) the omission of recreational catches and discards of sub legal fish from the catch data, 3) the need to standardize effort for commercial catch per unit indices of abundance. In general, these problems may have resulted in overestimation of the incoming recruitment and underestimation of recent fishing mortality rates.

The current estimate of the rate of fishing mortality is above the F_{max} reference point (0.27) and also slightly above F_{rep} (0.47). The most recent estimate of the median percent MSP from re-estimated stock and recruitment data is 12 percent. Projections of the catch and spawning stock size, which must be viewed in light of the possible underestimation of the fishing mortality rate and overestimate of recruitment noted above, indicate that catches are likely to be around 40,000 mt for the next three years if the rate of exploitation remains at the status quo or F_{rep} level. Spawning stock biomass is not projected to increase at these exploitation rates. If the rate of fishing mortality is reduced to the F_{max} level, the short-term projected catch decreases, but the spawning stock will increase assuming recruitment is maintained at the average level.

In comparison with the overfishing definition of the NEFMC and the current estimates of F_{rep}, this stock is over exploited but is not depleted compared to historical levels.

OCEAN POUT

This species is assessed on the basis of landings data and survey indices. The 1989 landings were 1,306 mt, mostly from southern New England. Pout landings have ranged between 200 and 2,000 mt over the past decade, although catches in the 1960s were nearly 30,000 mt.

The survey indices declined over the past decade until 1989 but have increased in 1990. The species is thought to be fully exploited, but there is insufficient information to definitively characterize the condition of this stock. However, ocean pout have very low fecundity and are therefore easily susceptible to over exploitation. Basic biological parameters for this species are needed for monitoring the resource and work is currently underway through a cooperative project by NEFC staff, the University of Massachusetts, and the Massachusetts Division of Marine Fisheries to estimate age and growth of pout.

WHITE HAKE

This species is assessed on the basis of landings data and survey indices. The 1989 landings were around 5,000 mt, which is about average for the past two decades. Average weight-per-tow in the surveys has declined in recent years, although mean numbers per tow in the autumn increased from 1988 to 1989. The resource is probably fully exploited but there is insufficient information for a definitive statement on stock status. Basic biological data are needed for future monitoring. Age and growth studies are currently underway at NEFC.

RED HAKE

This species is also assessed on the basis of landings and survey trends. There are two stocks tentatively identified.

not be determined given the current information on this stock. The stock appears to be over exploited and depleted based on these estimates of the mortality rate and the indications from the survey and landings data.

BLACK SEA BASS

This stock was evaluated on the basis of trends in landings and NEFC survey data as well as analysis of commercial catch per unit effort and length compositions of the survey catch provided by the NEFC Population Dynamics Branch staff. The 1989 commercial landings were 1,240 mt, substantially below peak landings in the 1950s of about 10,000 mt and a decrease over the previous three years. The recreational catch is large, 2,098 mt in 1989, but also decreased compared to 1988. The offshore spring survey index of recruited fish also has declined by 50 percent since 1987, but the time series has fluctuated widely since 1972.

Analysis of commercial catch rates indicates a decline in recent years probably reflecting lower abundance. Preliminary estimates of total mortality for black sea bass, based on commercial and recreational length composition data, suggest that black sea bass is exploited at a level well above the current estimate of F_{max} (0.3). The population dynamics parameter estimates for this species are being updated. An age validation study is also in progress which will improve monitoring capabilities.

The SAW concluded that this species is currently over exploited and depleted based on survey indices, current versus historical landings, and preliminary estimates of mortality rates.

BLUEFISH

Yield-per-recruit for bluefish has been re-estimated by the NEFC Population Dynamics Branch staff. Although the new analysis improves upon previous estimates, there remain concerns about the sensitivity of the analysis to some of the assumptions employed (*e.g.*, the natural mortality rate of age 0 and age 1 fish). The new estimates of biological reference points for bluefish range from $F_{0.1}$ equal to 0.18 to 0.19 and F_{max} equal to 0.27 to 0.31 depending on the choice of the rate of natural mortality assumed for age 0 fish. The yield-per-recruit curve is highly peaked so that fishing mortality rates higher than F_{max} would result in a substantial reduction in long-term yield.

SILVER HAKE

Analytical assessments of the northern and southern stocks of silver hake were carried out by the Stock Assessment Review Committee of the SAW. For the northern Georges Bank-Gulf of Maine stock, the 1989 landings were 4,600 mt, exclusively by the U.S. fishery. Over the past decade, landings have fluctuated between 4,000 and 9,000 mt. For the Southern Georges Bank-Mid-Atlantic Bight stock, 1989 landings were in the region of 13,000 mt, with fluctuations between 9,000 and 15,000 mt over the decade.

For both stocks there are currently few fish in the landings above age 5 and discarding of catch occurs for animals of all ages. This causes serious problems in the analysis and must be taken into account when interpreting the results. Several other technical problems were identified, namely:

- The effect of changing survey methodology
- The assumption of a high natural mortality rate used in the analysis
- The small number of ages in the analysis making projections highly dependent on recruitment estimates

These problems mean that the estimates for both of these stocks have a high level of uncertainty.

Fishing mortality rates estimated for the northern stock have varied substantially over the past decade. Mortality increased in 1984 and 1985 and was around 1.0 in 1985, but the estimates for 1986 to 1988 declined. This apparent decline is difficult to interpret because of problems in the assessment already noted. A very large 1985 year class recruiting to the northern stock has resulted in an increase in spawning biomass in recent years as these fish matured. The biological reference point, median percent MSP (31 percent) and a corresponding value of F_{rep} (0.51) for this stock have been revised using the new assessment information. Given the current assessment of the stock, the average fishing mortality rates at age for the last four years give a percentMSP level of about 27 percent. Although the 1988 fishing mortality rate is below the estimated F_{rep}, uncertainties in the assessment indicating this rate may have been underestimated suggest that this stock is probably at least fully exploited at present.

Fishing mortality rate estimates on the southern stock of silver hake have fluctuated widely in recent years and again must be considered highly uncertain. There is a drop in the estimates of the 1988 fishing mortality rate to around 0.4 on the fully recruited ages but rates a few years before were apparently much higher. Spawning stock biomass was also estimated to have increased in 1988 due to a large 1986 year class. The median percent MSP (42 percent) reference point and corresponding F_{rep} (0.39) have been recalculated for this stock. The average fishing mortality rates at age for the last four years give an estimate of the current percent MSP (27 percent).

Previous analyses and historical landings data suggest that there were much larger stock sizes of silver hake during the 1960s compared to current levels. Both of these stocks

Landings from the northern stock have been around 1,000 mt for the past decade and the survey index has remained fairly steady. There have been some indications of good recruitment and the stock is probably under exploited with no evidence of depletion

The southern stock has yielded less than 1,000 mt annually since 1985. The survey has been very variable over the last decade, but again there are some indications that recruitment was good in recent years and the stock is probably under exploited with no evidence of depletion.

SMALL ELASMOBRANCHS

There are three species of dogfish and seven species of skates in this grouping, dominated by spiny dogfish and little and winter skate. Dogfish landings have been less than 5,000 mt for most of the decade although there is known to be a large amount of discarding at sea. The survey indices for dogfish have increased steadily over the decade. Analysis of the increase in the index over time results in estimates of a sustainable annual exploitation rate for spiny dogfish of 10 percent.

The SAW concluded that spiny dogfish are under exploited and landings could be increased substantially without reaching a 10 percent exploitation rate based on analysis of the survey data. Nevertheless, given the limited reproductive capacity of dogfish populations, the precision of assessments should be increased substantially if the harvest increases.

Landings of skates of all species were 6,600 mt in 1989 reflecting a ten-fold increase over the last decade. There is little information available on most of the seven resident skate species. The survey indices have fluctuated widely but there is some suggestion that the population of little skates has increased in recent years. Current estimates of reference points give $F_{0.1} = 0.5$ to 0.6 and $F_{max} = 1.0$ to 2.0. However, these estimates are not in line with figures for skate stocks in other waters and must be viewed as preliminary.

Skates are probably under exploited but may be particularly vulnerable to recruitment overfishing given their low reproductive rates. However, insufficient information is currently available to definitively characterize the status of exploitation of these species. Several biological studies are underway.