Northeast Fisheries Science Center Reference Document 00-08

TRAC Advisory Report on Stock Status

A Report of the Third Meeting of the
Transboundary Resources Assessment Committee (TRAC),
Woods Hole, Massachusetts,
April 26-28, 2000

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Northeast Region
Northeast Fisheries Science Center
Woods Hole, Massachusetts

July 2000

Northeast Fisheries Science Center Reference Documents

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This report's publication history is as follows: manuscript submitted for review--June 19, 2000; manuscript accepted through technical review--July 6, 2000; manuscript accepted through policy review--July 11, 2000; and camera-ready copy submitted for publication--July 14, 2000. This report may be cited as:

Transboundary Resources Assessment Committee. 2000. TRAC advisory report on stock status: a report of the third meeting of the Transboundary Resources Assessment Committee (TRAC), Woods Hole, Massachusetts, April 26-28, 2000. *Northeast Fish. Sci. Cent. Ref. Doc.* 00-08; 20 p. Available from: National Marine Fisheries Service, 166 Water St., Woods Hole, MA 02543.

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INTRODUCTION

This *Advisory Report on Stock Status* provides results of the third meeting of the Transboundary Resources Assessment Committee (TRAC), held in Woods Hole, MA April 26-28, 2000. The meeting was attended by 32 Canadian and USA scientists, managers and industry representatives. The purpose of the meeting was to review assessments of Georges Bank cod, haddock and yellowtail flounder management units and to prepare documentation required for management of these resources.

The TRAC process was initiated in 1998 as a forum for joint peer review of assessments for Northwest Atlantic transboundary stocks of mutual interest to Canada and the United States. The process includes two working bodies, these being the Transboundary Assessment Working Group, or TAWG, consisting of Canadian and USA scientists and industry members, and the TRAC itself. The TAWG produces the assessments and addresses research recommendations and other needs as requested by the TRAC. The TRAC, consisting of Canadian and USA scientists, managers and industry members, reviews these assessments and other products and generates final documentation on stock status. For Canada, this takes the form of Stock Status Reports (available from DFO Canada) for use in preparing management advice for the current fishing year (Canada typically opens its Georges Bank fisheries June 1). For the USA, the primary products are advisory reports in Stock Assessment Workshop (SAW) format, available from NEFSC Woods Hole, MA for use in preparing management advice for the subsequent fishing year (here, the 2001 Fishing Year). These advisory reports consider stock status only, since projections of fishing mortality and stock size for the 2001 fishing year will require additional commercial landings information for 2000 and policy guidance on fishing mortality rates which will not be available until autumn.

The first meeting of the TRAC, held in St. Andrews, N.B. Canada in 1998, involved "benchmark" assessments in which the models and approaches used were subject to rigorous evaluation. Subsequent TRAC meetings have provided peer-reviewed assessment "updates" in which these models and approaches have been employed using the latest available data. It is anticipated that normally, benchmark assessments will be prepared every third year, at which time additional provision will be made for review of assessment models and databases; but it has not been deemed necessary to conduct such expanded reviews annually. Also, the TRAC has met annually since 1998 and has considered only Georges Bank cod, haddock and yellowtail flounder. However, the TRAC is a logical venue for other transboundary stock assessments and could meet more often if required to do so.

The TAWG met in St. Andrews, New Brunswick, Canada April 3 - 5, 2000 and completed assessments for Georges Bank and South (5Z and 6) cod, Georges Bank (5Z) haddock, and Georges Bank (5Z) yellowtail flounder, together with assessments for Eastern Georges Bank (5Zj,m) cod and haddock (the Canadian and USA management units for Georges Bank yellowtail

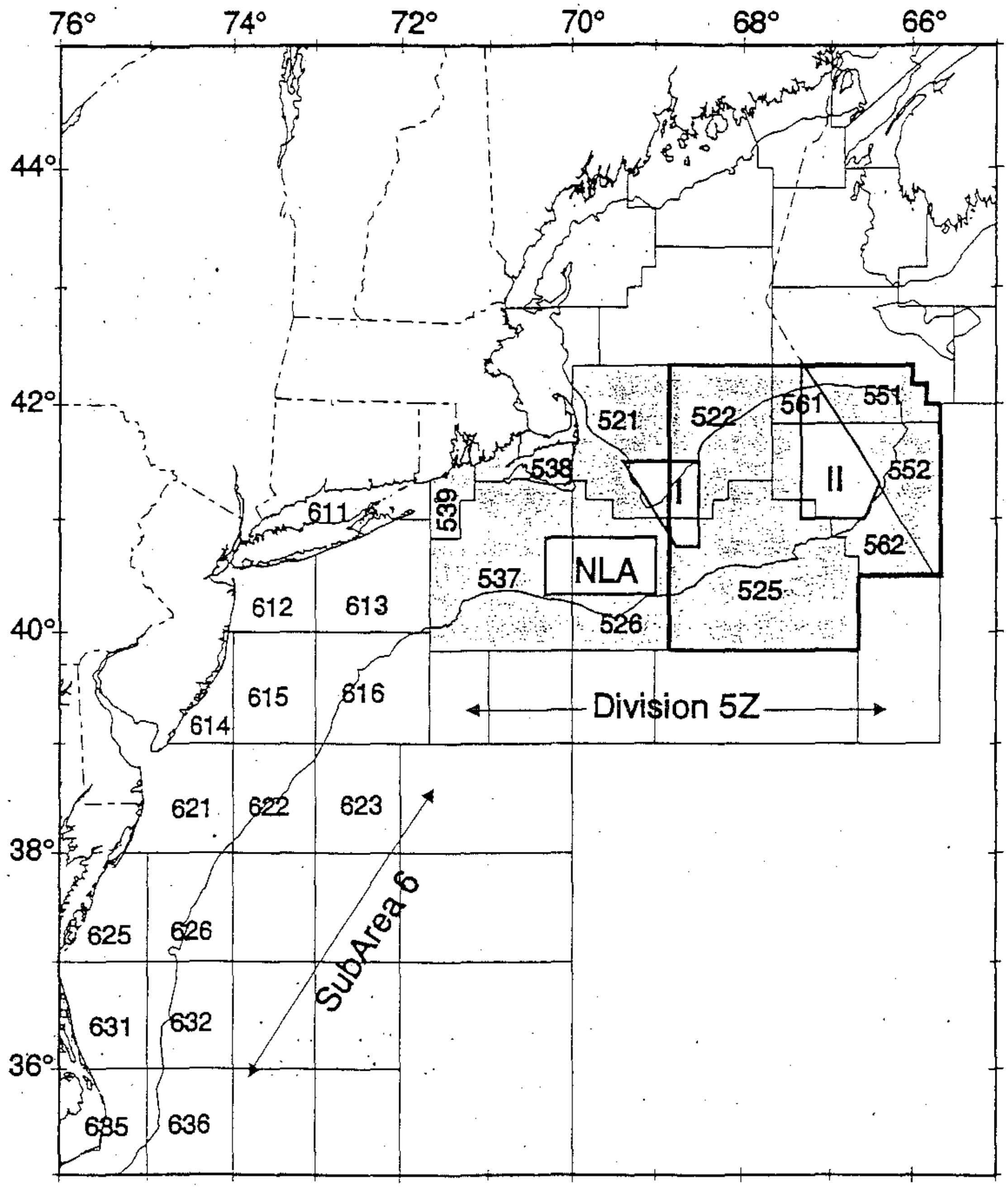


Figure 1. Northeast statistical reporting areas included in Georges Bank cod, haddock and yellowtail assessments. Stock areas are as follows: cod, statistical areas 521 and higher (Northwest Atlantic Fisheries Organization or NAFO Division 5Z and Subarea 6); haddock, statistical areas 521-539 (shaded); and yellowtail, statistical areas 522, 525, 551-52, and 561-62 (dark border).

are the same). Statistical areas and stock boundaries for the USA assessments are given in Figure 1. The Canadian 5Zj and 5Zm areas coincide with USA statistical reporting areas 551-61 and 552-62, respectively. The present meeting of the TRAC peer-reviewed these 5 assessments and completed advisory and stock status reports (advisory reports for the USA management units are given below). Complete assessment documents for the USA assessments will be published in the Northeast Fisheries Science Center reference document series. A Proceedings providing a summary of TRAC deliberations and other supporting documentation will be published separately.

The determinations of resource status presented below include evaluations of whether *overfishing is occurring* and whether the stock is *overfished.* This is mandated by the Sustainable Fisheries Act or SFA (PL 104-297) of 1996, now part of the Magnuson-Stevens Fisheries Conservation and Management Act or MSFCMA. National Standard Guidelines published in 1998 require use of "status determination criteria" in the form of threshold levels for such evaluations. Overfishing is said to be occurring if instantaneous fishing mortality (F) exceeds the Maximum Fishing Mortality Threshold (MFMT, or $F_{THRESHOLD}$); and a stock is considered to be overfished if it falls below the Minimum Stock Size Threshold (MSST, or $B_{THRESHOLD}$, usually ½ B_{MSY} or ½ the stock biomass level which will produce maximum sustainable yield). Because overfished stocks must be rebuilt, $F_{THRESHOLD}$ will vary according to resource status. It will normally be equivalent to F which produces maximum sustainable yield or MSY (F_{MSY}) for a stock with moderate to high biomass, decreasing monotonically to zero as the stock becomes progressively more depleted. Values for $F_{THRESHOLD}$ at biomass levels below B_{MSY} are projected to result in stock rebuilding to B_{MSY} within specified time frames, e.g. 10 years for a stock for which B is between ½ B_{MSY} and B_{MSY}.). Note that $F_{THRESHOLD}$ is a limit reference point indicating the point at which harvests should be constrained substantially and the probability for exceeding this value should be low. "Target" levels of fishing mortality are used to increase this probability, i.e., F_{TARGET} is set sufficiently below $F_{THRESHOLD}$ to ensure that fishing mortality exceeds the threshold only rarely.

These relationships are determined by "control rules" which govern fishing activities with respect to stock status and target and limit reference points. Control rules specify how F should vary with biomass, and provide threshold and target levels determined by stock biomass levels relative to B_{MSY}. Control rules for Georges Bank and South cod, Georges Bank haddock, and Georges Bank yellowtail flounder, and evaluations of stock status for 1999, are given in the following advisory reports.

These stocks are managed under the New England Fishery Management Council's Multispecies Fishery Management Plan (FMP) by both indirect and direct effort controls including a moratorium on permits and days-at-sea restrictions. Canadian management measures include total allowable catches (TACs) based on an $F_{0.1}$ management strategy (further information including projections of harvests in year 2000 and stock size in 2001 is given in the DFO Stock Status Reports for 2000 referenced below). Measures for both countries are designed to keep F at levels which will promote stock rebuilding.

For further information

Applegate, A., S. Cadrin, J. Hoenig, C. Moore, S. Murawski and E. Pikitch. 1998. Evaluation of existing overfishing definitions and recommendations for new overfishing definitions to comply with the Sustainable Fisheries Act. Final Report of the Overfishing Definition Review Panel to the New England Fishery Management Council, 179 p.

DFO 2000. Eastern Georges Bank cod. DFO Sci. Stock Status Report A3-04 (2000).

DFO 2000. Eastern Georges Bank haddock. DFO Sci. Stock Status Report A3-08 (2000).

DFO 2000. Yellowtail flounder on Georges Bank. DFO Sci. Stock Status Report A3-15 (2000).

Restrepo, V.R., P.M. Mace and F. Serchuk. 1999. The precautionary approach: a new paradigm or business as usual? p 61-70 *In*: NMFS. 1999. Our living oceans. Report on the status of U.S. living marine resources, 1999. U.S. Dep. Commer., NOAA Tech Memo. NMFS-F/SPO-41, 301 p.

DEFINITIONS OF TECHNICAL TERMS

ADAPT: A computer program used to optimally fit a virtual population analysis (VPA, see below) to abundance data.

Biological Reference Points: Specific values for variables that describe the state of a fishery, used to evaluate its status. These may include "target" reference points, corresponding to a desired goal (e.g., fishing mortality that produces MSY), and "limit" reference points, or "thresholds" carrying an unacceptability high risk to the stock if exceeded. Examples are $F_{0.1}$, F_{MSY}, $F_{THRESHOLD}$, and F_{max}.

Biomass-weighted F: An estimate of fishing mortality in which F estimates for each age group are weighted by corresponding stock biomass at age. This calculation is needed to make average F estimates from age structured assessments comparable to those obtained from surplus-production (e.g. ASPIC) modeling of all components in the stock.

B_{MSY}: The long-term average stock biomass level required to achieve Maximum Sustainable Yield or MSY, when the stock is fished at F_{MSY}.

$B_{THRESHOLD}$ (Minimum Stock Size Threshold or MSST): One of two Status Determination Criteria, specified in the National Standard Guidelines as the greater of (a) ½ B_{MSY}, or (b) the minimum stock size at which rebuilding to B_{MSY} will occur within 10 years when fishing at the Maximum Fishing Mortality Threshold or MFMT. At stock sizes below $B_{THRESHOLD}$, the stock is considered to be overfished.

Control Rule: A protocol for specifying harvest rates in relation to stock status and limit and target reference points. Technically, a harvest strategy which, if implemented, would be expected to result in a long-term average catch approximating MSY. In the National Standard Guidelines, the "MSY Control Rule" is used to determine the limit fishing mortality, or Maximum Fishing Mortality Threshold (MFMT). Control rules are also known as "decision rules" or "harvest control laws" in some of the scientific literature.

Exploitation Pattern: The distribution of fishing mortality over the age composition of the fish population, determined by the type of fishing gear, areal and seasonal distribution of fishing, and the growth and migration of the fish. The pattern is expressed as a series of values ranging from 0.0 to 1.0.

Exploitation Rate: The proportion of a population at the beginning of the year that is caught during the year. For example, if 720,000 fish were caught during the year from a population of 1 million fish alive at the beginning of the year, the annual exploitation rate would be 0.72 or 72%. Note that this rate cannot exceed unity; obviously, more fish cannot die than were originally present.

Fishing Mortality Rate (F): That part of the total mortality rate applying to a fish population that is caused by fishing. Fishing mortality is usually expressed as an *instantaneous* rate, and can range to values exceeding unity, such as 2.0 or higher.

F_{max}: The fishing mortality rate that results in the maximum level of yield per recruit. This is the point beyond which growth overfishing begins.

F_{MSY}: The fishing mortality rate that produces MSY by taking a constant fraction of a stock that is fluctuating around B_{MSY}.

$F_{0.1}$: The fishing mortality rate at which the increase in yield per recruit in weight for an increase in a unit of effort is 10 percent of the yield per recruit produced by the first unit of effort on the unexploited stock (i.e., the slope of the yield-per-recruit curve for the $F_{0.1}$ rate is one-tenth the slope of the curve at its origin).

F_{TARGET}: The fishing mortality rate which (with some specified probability level) will prevent $F_{THRESHOLD}$ from being exceeded.

$F_{THRESHOLD}$ (Maximum Fishing Mortality Threshold or MFMT): One of two Status Determination Criteria, specified in the National Standard Guidelines as the fishing mortality rate associated with the MSY Control Rule. Usually, $F_{THRESHOLD}$ is F_{MSY} if stock biomass is moderate to high, and a lower value if it is low. Exceeding $F_{THRESHOLD}$ for one year or more constitutes overfishing.

Fully-recruited F: An estimate of fishing mortality for all age groups fully vulnerable to fishing.

Maximum Sustainable Yield (MSY): The largest long-term average catch or yield that can be taken from a stock or stock complex under prevailing ecological and environmental conditions.

Maximum Spawning Potential Reference Points: Reference points based on some fraction of maximum spawning potential (MSP) as determined from spawning stock biomass per recruit models, used to define overfishing. MSP is the spawning stock biomass per recruit in the absence of fishing; it is then reduced to a percentage of the maximum as F increases.

Mean Biomass: The product of mean abundance (numbers) and the average weight of individual fish. Mean abundance is calculated from abundance at the beginning of the year and the annual mortality rate, while average weights are derived from population size and weight at age data.

Mortality Rates: The rates at which fish die from fishing and/or natural causes. Biologists tend to work with *instantaneous* rates, in which time intervals are sufficiently short so as to allow separation of the primary components as instantaneous fishing mortality (F) and instantaneous natural mortality (M). Together the two equal instantaneous total mortality (Z); i.e. $Z = F+M$.

Natural Mortality Rate (M): That part of total mortality applying to a fish population that is caused by factors other than fishing. It is common practice to consider all sources together since they usually account for much less than fishing mortality. It is usually expressed as an instantaneous rate as noted above.

Nominal Catch: The sum of the catches that are landed (expressed as live weight or equivalents). Nominal catches do not include unreported discards.

Overfishing/overfished: According to the National Standard Guidelines, "overfishing occurs whenever a stock or stock complex is subjected to a rate or level of fishing mortality that jeopardizes the capacity of a stock or stock complex to produce MSY on a continuing basis." Overfishing is occurring if $F_{THRESHOLD}$ is exceeded for a year or more. An "overfished" stock has been reduced below $B_{THRESHOLD}$ requiring management actions to rebuild to the MSY level within an acceptable time frame.

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

Recruitment: The number of fish that survive (from birth) to a specific age or grow to a specific size. The specific age or size at which recruitment is measured may correspond to when the young fish become vulnerable to capture or when numbers in a year class can be reliably estimated.

Recruitment Overfishing: The rate of fishing above which recruitment to the spawning stock becomes significantly reduced. This is characterized by a greatly reduced spawning stock, a decreasing proportion of older fish in the catch, and generally very low recruitment year after year.

Spawning Stock Biomass (SSB): The total weight of all sexually mature fish in the population.

Spawning Stock Biomass Per Recruit (SSB/R): The expected lifetime contribution to the spawning stock biomass for a recruit. For a given exploitation pattern, rate of growth, and rate of natural mortality, an expected equilibrium value of SSB/R can be calculated for each level of F and compared to the maximum level of SSB/R that would be realized if there were no fishing.

Status Determination Criteria: Objective and measurable criteria used to determine if overfishing is occurring or the stock is in an overfished state according to National Standard Guidelines.

TAC: Total allowable catch is the total regulated catch from a stock in a given time period, usually a year.

Virtual Population Analysis or VPA: A retrospective analysis of the catches from a given year class which provides estimates of fishing mortality and stock size at each age. A VPA takes natural mortality into account as well as removals from fishing. The method requires accurate statistics of catch by year, information on natural mortality, and a reasonably accurate estimate of F in the terminal year of the time series. Even when an approximate fishing mortality rate is used in the last year, a precise estimate of abundance can usually be determined for the stock in years prior to the most recent one or two. This technique is used extensively in fishery assessments, since the conditions for its use are so common; many fisheries are heavily exploited, the annual catches for a year class can generally be determined, and the natural mortality rate is known within a fairly small range and is low compared with the fishing mortality rate.

Year class (or cohort): Fish in a stock born in the same year. For example, the 1987 year class of cod includes all cod born in 1987, which would be age 1 in 1988, age 2 in 1989, etc.

Yield per recruit (Y/R or YPR): The average expected yield in weight from a single recruit. Y/R is calculated assuming that F is constant over the life span of a year class. The calculated vallue is also dependent on the exploitation pattern, rate of growth, and natural mortality rate.

A. GEORGES BANK COD ADVISORY REPORT

State of Stock: Although at a low biomass the stock is not overfished and overfishing is not occurring according to the SFA harvest control rule. Fishing mortality declined from a record high of 1.42 (70% exploitation) in 1994 to 0.22 (18% exploitation) in 1999 (Figure A1). Fishing mortality on biomass in 1999 was about twice the target F. Spawning stock biomass has increased from the time series low in 1994 to 35,000 mt in 1999 (50% of the Amendment 7 rebuilding target) (Figure A2). Although mean biomass has increased from the record low in 1995 it is still only about 40% of B_{MSY} (108,000 mt; Amendment 9) in 1999 (Figures A2 and A4). Since the 1990 year class, the sizes of recruiting year classes have all been well below average. The 1997 year class is estimated to be the weakest in the time series (Figure A2).

Catch and Status Table (weights in '000 mt, recruitment in millions): Georges Bank Cod

Year	1992	1993	1994	1995	1996	1997	1998	1999	Max[1]	Min[1]	Mean[1]
Total commercial landings[2]	28.6	23.1	15.2	7.9	8.9	10.4	8.8	9.9	57.2	7.9	30.4
US commercial landings[2]	16.9	14.6	9.9	6.8	7.0	7.5	6.9	8.1	40.1	6.8	22.1
Canada commercial landings	11.7	8.5	5.3	1.1	1.9	2.9	1.9	1.8	17.8	1.1	8.3
Discards	Discards occur but reliable estimates not presently available										
US recreational landings[3]	0.4	1.9	1.0	1.3	0.6	0.8	0.5	0.4	8.7	0.3	2.0
Catch used in assessment	28.6	23.1	15.2	7.9	8.9	10.4	8.8	9.9	57.2	7.9	30.4
Mean Biomass	51.0	36.7	30.7	30.1	35.7	40.9	40.0	43.0	135.2	30.1	78.4
Spawning stock biomass[4]	39.5	29.8	20.0	20.1	24.1	28.1	31.8	34.8	92.6	20.1	57.3
Recruitment (age 1)	6.9	9.2	7.7	4.7	8.8	10.4	2.8	6.8	42.8	2.8	16.3
F (ages 4-8)	0.80	1.14	1.42	0.57	0.38	0.65	0.39	0.22	1.42	0.22	0.63
Exploitation rate	51%	63%	70%	40%	29%	44%	30%	18%	70%	18%	43%
F (age 1+, wb)	0.57	0.64	0.50	0.26	0.25	0.26	0.22	0.23	0.64	0.22	0.39

[1]Over period 1978-1999. [2] US landings for 1994-1999 are provisional. [3]Not used in assessment. [4]At beginning of the spawning season (i.e., March 1).

Stock Identification and Distribution: The Georges Bank cod stock is distributed primarily from the Northeast Peak of Georges Bank to Nantucket Shoals, with minor occurrence in the Southern New England and Mid-Atlantic regions. The distribution on the Northeast Peak spans the US-Canada boundary.

Catches: Commercial landings increased in the late 1970s and early 1980s, peaking at a record high 57,200 mt in 1982. During 1983-1986, landings declined, but subsequently increased through 1990 (Figure A1). Total commercial landings declined to a record low of 7,900 mt in 1995 and have since remained relatively stable. Landings were 9,900 mt in 1999(Figure A1). Recreational landings have ranged from 300 mt to 8,700 mt accounting for 1-19% of the total cod catch.

Data and Assessment: An analytical assessment (VPA) of 1978-1999 commercial landings-at-age data was conducted assuming M=0.2. The VPA was tuned using the ADAPT method. Information on recruitment and abundance was taken from NEFSC spring and autumn and Canadian spring survey catch-per-tow-at-age data. Discards and recreational catches were not included in the VPA. Precision associated with the estimates of fishing mortality , spawning stock biomass , and mean biomass in 1999 were evaluated (Figures A5 and A6 and A7).

SFA Control Rule: F_{MSY} (weighted by stock biomass at age) is estimated to be 0.32 and the MSY is estimated to be 35,000 mt from a B_{MSY} of 108,000 mt. Mean biomass in 1999 was 43,000 mt and F weighted by biomass was 0.23 (Figure A4). When stock biomass is greater than B_{MSY} fishing mortality is not to exceed $F_{THRESHOLD}$=F_{MSY} ; when biomass is between ½ B_{MSY} and 1/4 B_{MSY} F will be defined by a five year rebuilding time period and when biomass is between B_{MSY} and 1/2 B_{MSY} F will be defined by a 10 year rebuilding time period. F weighted by biomass is the metric for the SFA control rule.

Biological Reference Points: Yield and SSB per recruit analyses , with an assumed M of 0.20, indicate that $F_{0.1}$ = 0.18 (15% exploitation), and the corresponding SSB per recruit is 40% of the maximum (Figure A3).

Fishing Mortality: Fishing mortality (4-8,unweighted) doubled between 1979 and 1985 from 0.35 (27% exploitation) to 0.74 (48% exploitation), declined to 0.48 (35% exploitation) in 1986-1987, then increased to a record high of 1.42 (70% exploitation) in 1994. F has since declined to 0.22 (18% exploitation) in 1999 (Figure A1). There is an 80% probability that the F in 1999 was between 0.19-0.26 (Figure A5). Biomass weighted F has remained relatively stable since 1995 while fully recruited F has declined since 1997, indicating that younger cod are being exploited more heavily, particularly the 1995 and 1996 year classes (Figure A1).

Recruitment: Strong year classes were produced in 1980, 1983, and 1985. The 1990 year class was slightly above average, and all subsequent year classes have been well below average. The 1997 year class is the weakest year class since 1978 (Figure A2).

Stock Biomass: Spawning stock biomass declined by about 40% between 1980 and 1985/1986 (92,600 mt to 56,000 mt), increased in 1988 (74,000 mt), and then declined to a record low in 1994 (20,000 mt). SSB has since gradually increased to 35,000 mt in 1999 as a result of growth and survival of recent year classes rather than improved recruitment (Figure A2). There is an 80% probability that the SSB in 1999 was between 32,000 mt and 38,000 mt (Figure A6). Mean biomass trends were similar to the SSB trends. There is an 80% probability that the mean biomass in 1999 was between 39,000 mt and 49,000 mt (Figure A7)

Special Comments:

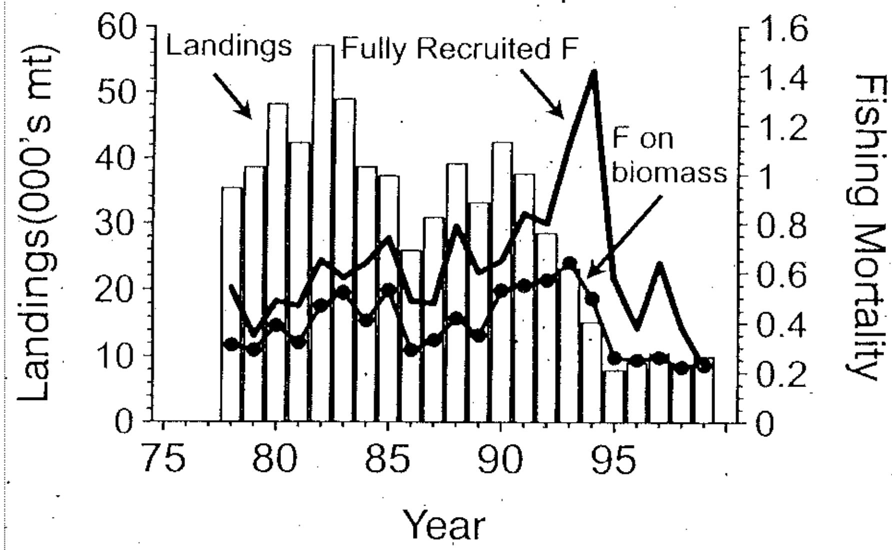
Retrospective analysis indicates a pattern of inconsistencies in which estimates of F in the last year of the VPA are less than revised estimates of F.

Low levels of sampling of U.S. landings and discards contribute to the uncertainty in estimates of the size and age composition of U.S. catch . U.S port sampling for cod has been chronically low, threatening to undermine the integrity of the stock assessment. VTR and at sea observations by the Sea Sampling program are inadequate to reliably estimate the quantity of discard or characterize the size and age compositions.

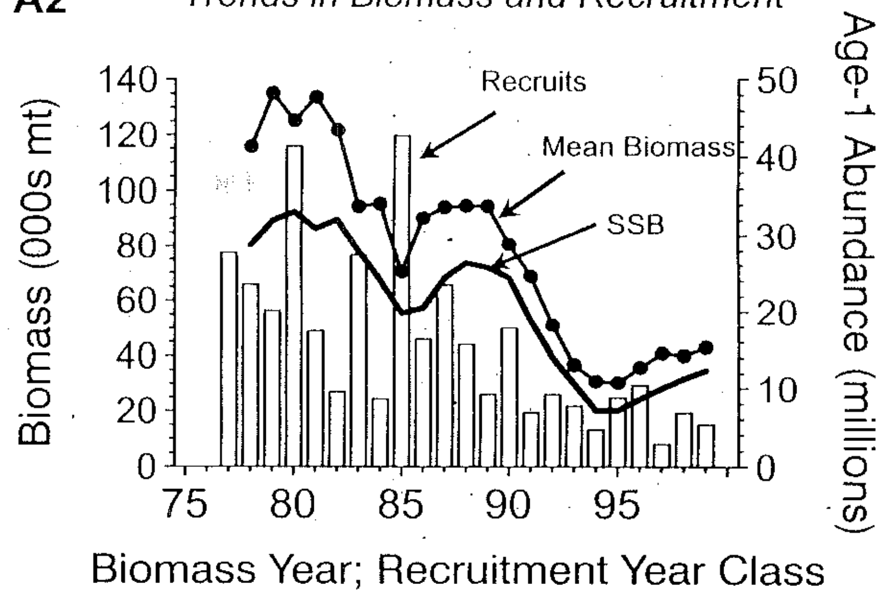
Source of Information: O'Brien L. and S.X. Cadrin. 1999. Assessment of the Georges Bank Atlantic cod stock for 1998, NEFSC Lab. Ref. 99-03. Overfishing Definition Review Panel. 1998. Evaluation of existing overfishing definitions and recommendations for new over fishing definitions to comply with the SFA. O'Brien, L. 2000. Assessment of the Georges Bank Atlantic cod stock for 1999, NEFSC Ref. Doc. 2000-xx.

Georges Bank Atlantic Cod

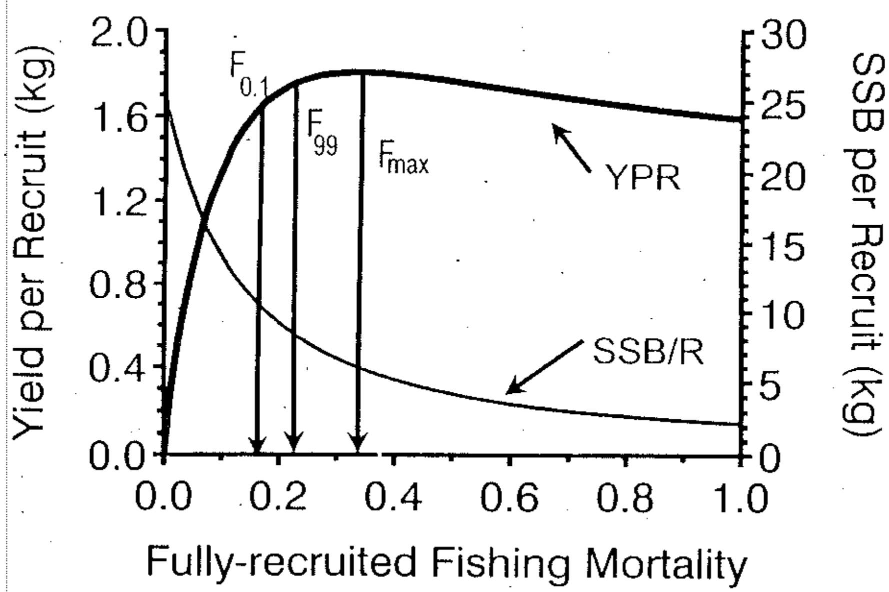
A1 *Trends in Total Commercial Landings and Fishing Mortality*



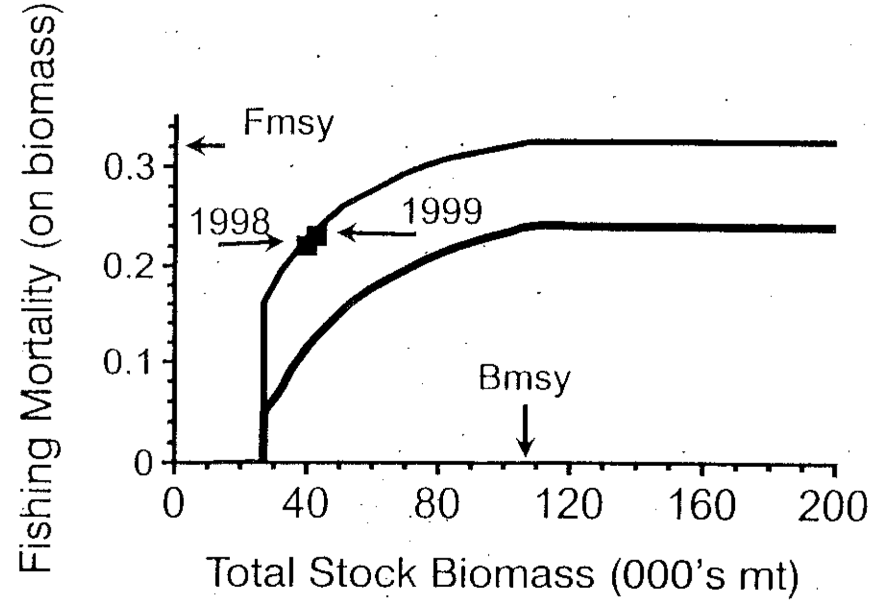
A2 *Trends in Biomass and Recruitment*



A3 *Yield and Spawning Biomass per Recruit*

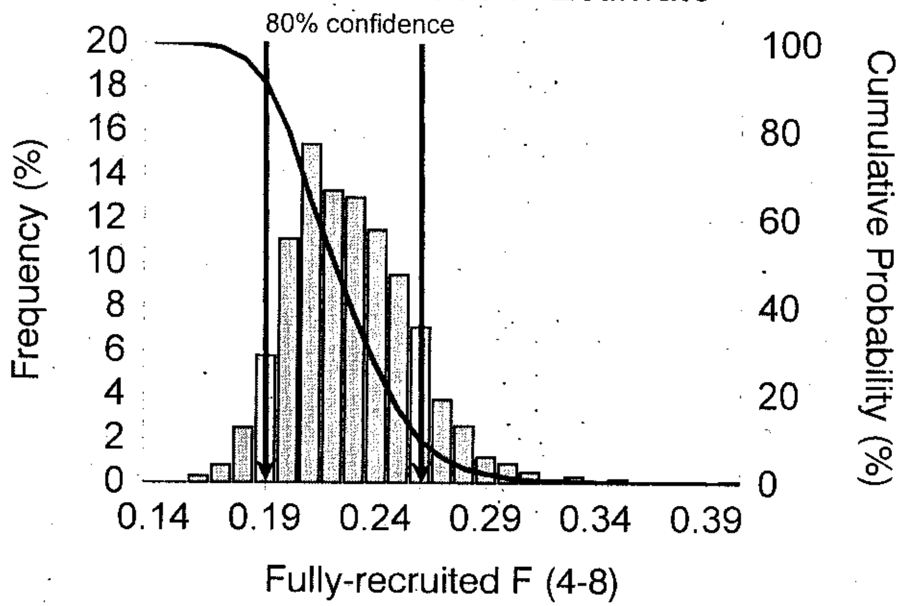


A4 *Harvest Control Rule and Recent Stock Status*

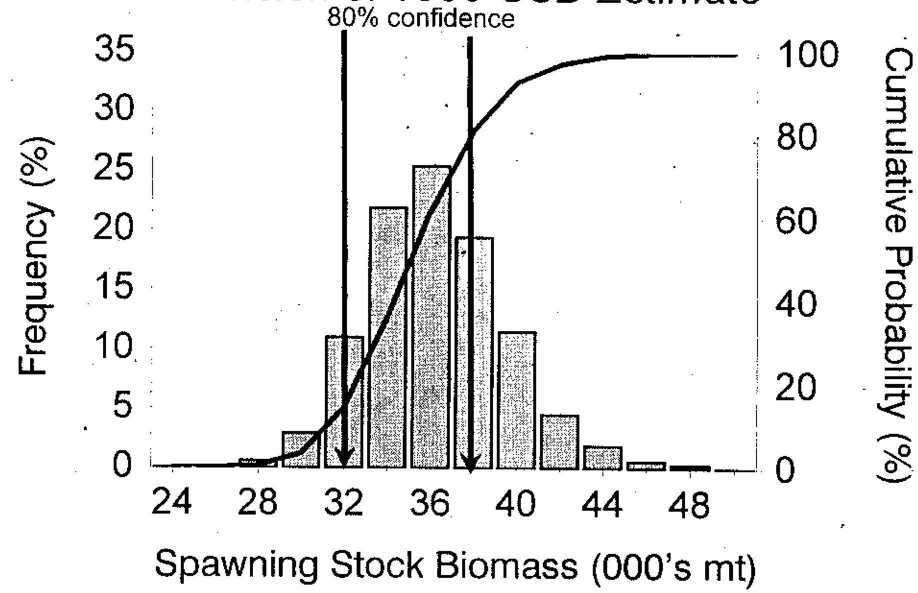


Georges Bank Atlantic Cod

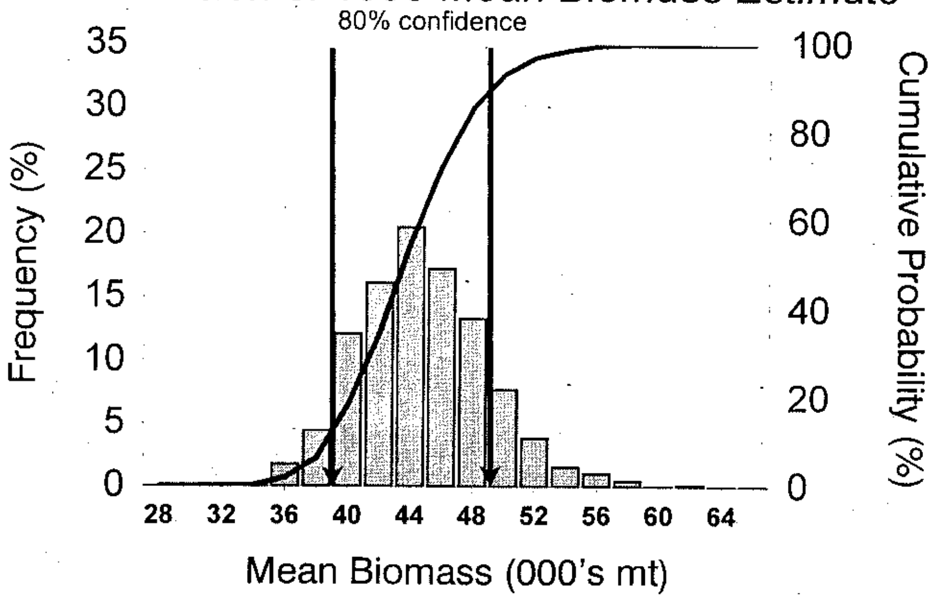
A5 *Precision of 1999 F Estimate*



A6 *Precision of 1999 SSB Estimate*



A7 *Precision of 1999 Mean Biomass Estimate*



B. GEORGES BANK HADDOCK ADVISORY REPORT

State of Stock: This stock is overfished and overfishing is occurring according to the SFA harvest control rule. Fishing mortality has been reduced from pre-1994 levels; however, fishing mortality in 1999 (0.16, 13% exploitation) remains above the rebuilding target. Spawning stock biomass has increased more than 4-fold from the 1993 record low levels, due to high survivorship and improved recruitment since 1994. However, the 1999 estimate (48,500 mt) is less than 50% of the spawning stock biomass estimated to produce maximum sustainable yield (105,000 mt). The age structure of the population is continuing to expand and age 4+ biomass is at its highest level since 1982. The 1996 year class, estimated at 19.5 million fish at age 1, was partially recruited to the fishery in 1999 and the majority of this year class will be mature in 2000. The 1998 and 1999 year classes are currently estimated at 48.8 and 35.2 million fish at age 1, respectively. These year classes are the largest observed since 1978; however, they are below the long term average observed when the stock was in a healthy condition (1931-1960). Nevertheless, these year classes provide a significant opportunity for continued rebuilding of spawning stock biomass.

Catch and Status Table (weights in '000 mt, recruitment in millions): Georges Bank Haddock

Year	1992	1993	1994	1995	1996	1997	1998	1999	Max[1]	Min[1]	Mean[1]
Landings											
US commercial[2]	2.0	0.7	0.2	0.2	0.3	0.9	1.8	2.8	52.9	0.2	12.2
Canada landings	4.1	3.7	2.4	2.1	3.6	2.7	3.4	3.7	18.3	0.5	5.1
Other commercial	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	82.6[3]	0.0[3]	10.7[3]
Total landings	6.1	4.4	2.6	2.3	4.0	3.6	5.2	6.5	150.4	2.3	21.0
Discards											
US commercial discards	N/A	N/A	0.5	0.1	0.3	0.6	0.1	N/A	N/A	N/A	N/A
Catch used in assessment	6.1	4.4	3.1	2.4	4.3	4.3	5.3	6.5	150.4	2.4	21.8
Spawning stock biomass[4]	13.6	11.0	14.4	24.3	29.8	36.7	41.3	48.5	180.5	11.0	48.2
Recruitment (age 1)	9.3	15.3	12.4	10.4	9.9	19.5	11.3	48.8	471.9	0.4	9.2[5]
F (ages 4-7, unweighted)	0.44	0.43	0.36	0.14	0.18	0.12	0.14	0.16	0.61	0.11	0.34
Exploitation rate	32%	32%	28%	12%	15%	10%	12%	13%	42%	9%	26%

[1] Over period 1963-1999. [2] Data 1994 through 1999 are provisional. [3] Over period 1962-1976. [4]At beginning of the spawning season. [5] Geometric mean.

Stock Identification and Distribution: Georges Bank haddock are distributed from the Northeast Peak to Nantucket Shoals, with minor occurrence in the Southern New England and Mid-Atlantic regions. Highest concentrations are currently found along the Northern Edge and Northeast Peak of Georges Bank. Historically, haddock were also abundant in the Great South Channel area of Georges Bank, and recent commercial landings and research vessel surveys suggest that abundance in this area has increased significantly.

Catches: Total commercial landings increased sharply in 1965 and 1966 as a result of strong recruitment and increased exploitation by distant water fleets commencing in the early 1960s. Landings declined to less than 6,000 mt between 1972 and 1976, but increased in the late 1970s to 27,500 mt in 1980. Total landings have since declined to an estimated 2,300 mt in 1995, and increased to 6,500 mt in 1999 (Figure B1). Discards have been periodically estimated and added to the catch when levels were significant. Estimates of regulatory discarding occurring from 1994-1998 in response to U.S. trip limits are included in the current assessment. Landings by US vessels are almost exclusively by otter trawl while Canadian landings are taken by otter trawl and long line gear. Recreational landings from this stock have been negligible.

Data and Assessment: An analytical assessment (VPA) was conducted incorporating 1931-1999 commercial catch-at-age data, assuming natural mortality (M) = 0.2. The VPA was tuned with the ADAPT method using Canadian DFO spring and NEFSC spring and autumn survey numbers at age. The precision and uncertainty associated with the estimates of fishing mortality and spawning stock biomass in 1999 were quantitatively evaluated (Figures B4 and B5).

Biological Reference Points: Yield and spawning stock biomass per recruit analyses performed with an assumed M of 0.20 indicate that $F_{0.1} = 0.26$ (21% exploitation) and the corresponding SSB per recruit is 40.9% of maximum (Figure B3).

SFA Control Rule: The SFA harvest control rule established SSB as a proxy for B_{MSY}, $F_{0.1}$ as a proxy for F_{MSY}, and fully recruited F (ages 4-7, unweighted) as the metric for fishing mortality (Figure B7). When SSB is greater than 105,000 mt (SSB_{MSY}), the threshold fishing mortality rate is $F_{0.1}$ (0.26, 21% exploitation) and the target fishing mortality rate is 75% of F_{MSY} proxy (0.20, 16% exploitation). As SSB declines below SSB_{MSY}, the threshold fishing mortality rate declines linearly from 0.26 to 0.00 at 1/2 SSB_{MSY} (52,500 mt), and the target fishing mortality rate declines linearly from 0.20 to 0.00 at 68,000 mt. Based on 1999 estimates of SSB and fishing mortality, the stock was overfished and overfishing was occurring (Figure B7).

Fishing Mortality: Fishing mortality remained between 0.28 and 0.46 (22% - 34% exploitation) during most of the 1980s and early 1990s before declining to 0.14 (12% exploitation) in 1995 (Figure B1). Fishing mortality has remained constant at approximately 0.15 (13% exploitation) since 1995. There is an 80% probability that fishing mortality in 1999 lies between 0.14 (12% exploitation) and 0.18 (15% exploitation) (Figure B4).

Recruitment: While recruitment has improved in the 1990s, recruitment since 1979 has been far below the historical average recruitment estimated for 1931 to 1960 when healthy stock conditions were observed. The 1998 (48.8 million) and 1999 (35.2 million) year classes are currently estimated to be the strongest since 1978; however, these year classes are considerably below 1931-1960 levels.

Spawning Stock Biomass: SSB declined by 84% between 1978 and 1993 (69,000 mt to 11,000 mt). SSB began to increase in 1994 with higher survivorship and improved recruitment, and reached 48,500 mt by 1999 (Figure B2). There is an 80% probability that SSB was between 43,800 mt and 54,500 mt (Figure B5). SSB during the 1931-1960 period when landings were sustained between 40,000 and 60,000 mt was estimated to average 105,000 mt, more than 2-fold higher than current SSB levels. The probability of strong recruitment is significantly greater when SSB exceeds 80,000 mt (Figure D6).

Special Comments:

1. Inadequate sampling of U.S. landings and discards contribute to uncertainty in estimates of the size and age composition of the U.S. catch. U.S. port sampling for haddock and other groundfish species has been chronically low, threatening to undermine the integrity of stock assessments. Vessel trip reports (logbooks) and at-sea observations are inadequate to reliably estimate the quantity of haddock discards or to characterize their size and age composition.

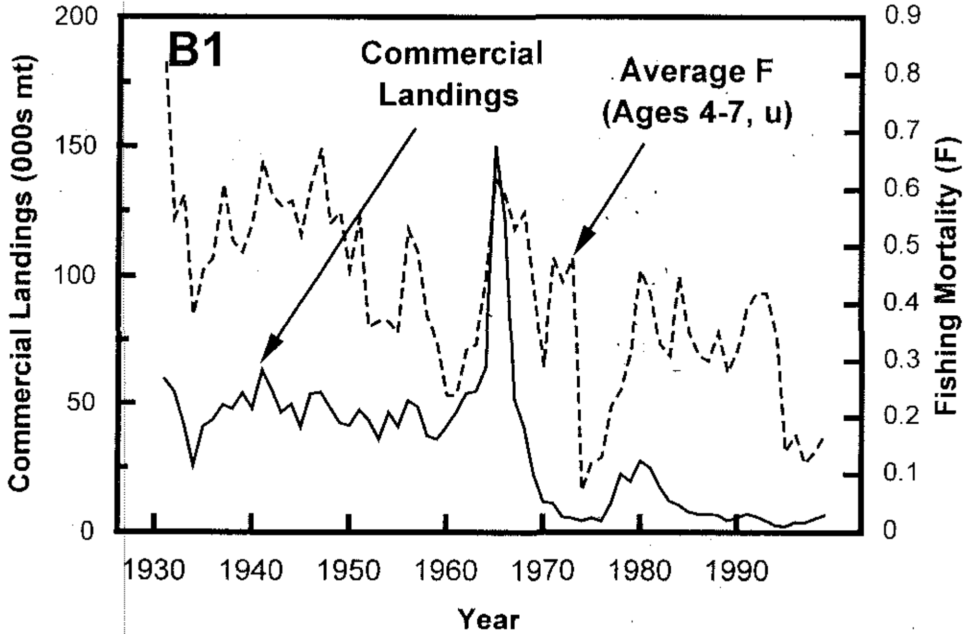
2. The existence of Closed Area II and days-at-sea limitations have largely displaced the U.S. fleet to the western part of Georges Bank. Comprehensive stock rebuilding will require the accumulation of haddock biomass and the realization of haddock recruitment in the western part of the stock area.

3. Estimates of the 1998 and 1999 year classes were sensitive to a few large tows in research vessel surveys.

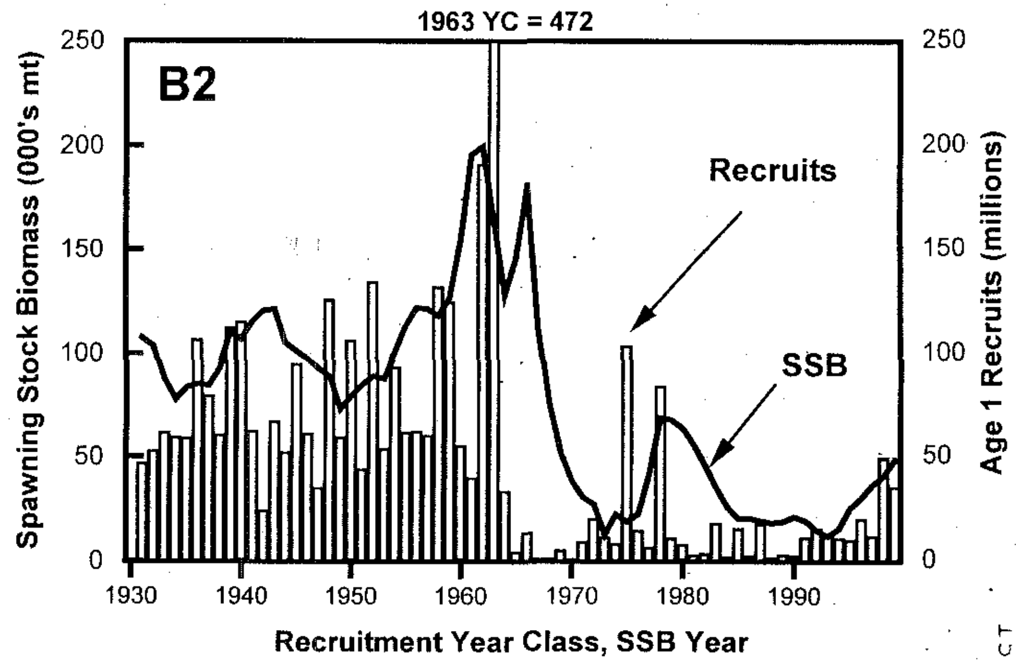
Source of Information: Brown, R.W. 2000. Assessment of the 5Z Georges Bank haddock stock, 1931-1999. NEFSC Ref. Doc. 2000-xx.

Georges Bank Haddock

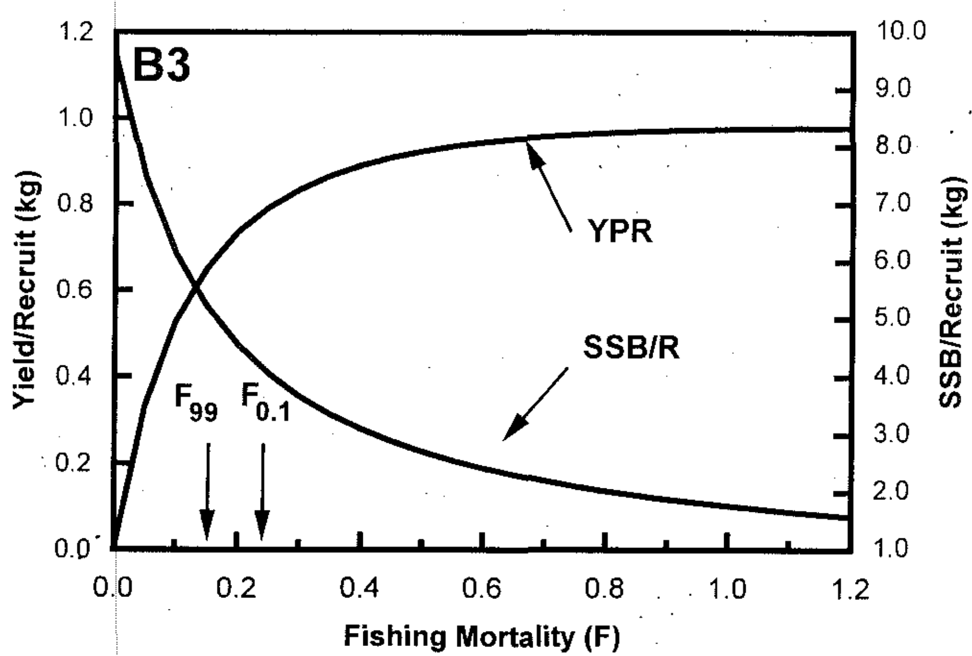
Trends in Commercial Landings and Fishing Mortality



Trends in Spawning Stock Biomass and Recruitment

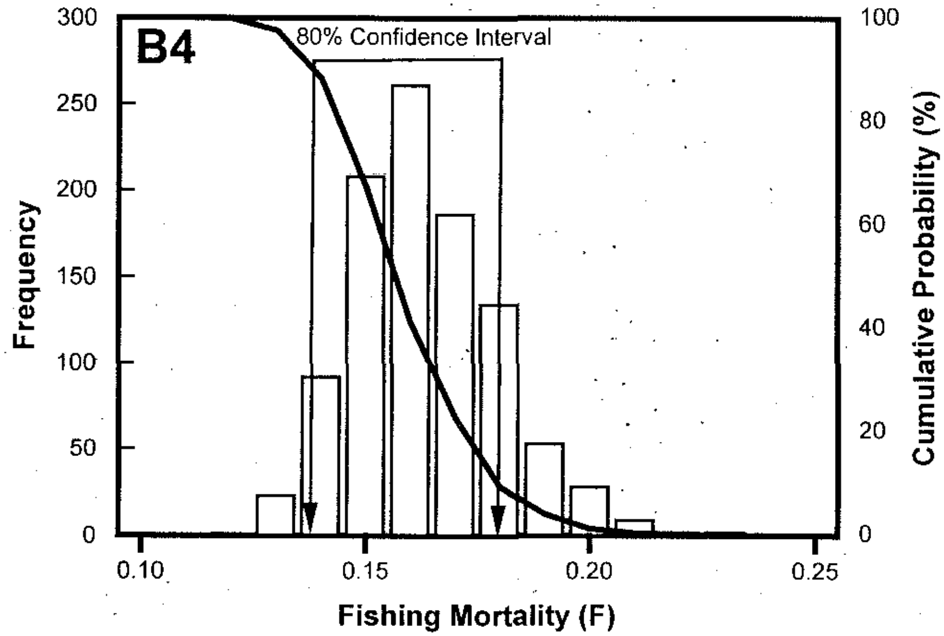


Yield and Spawning Stock Biomass per Recruit

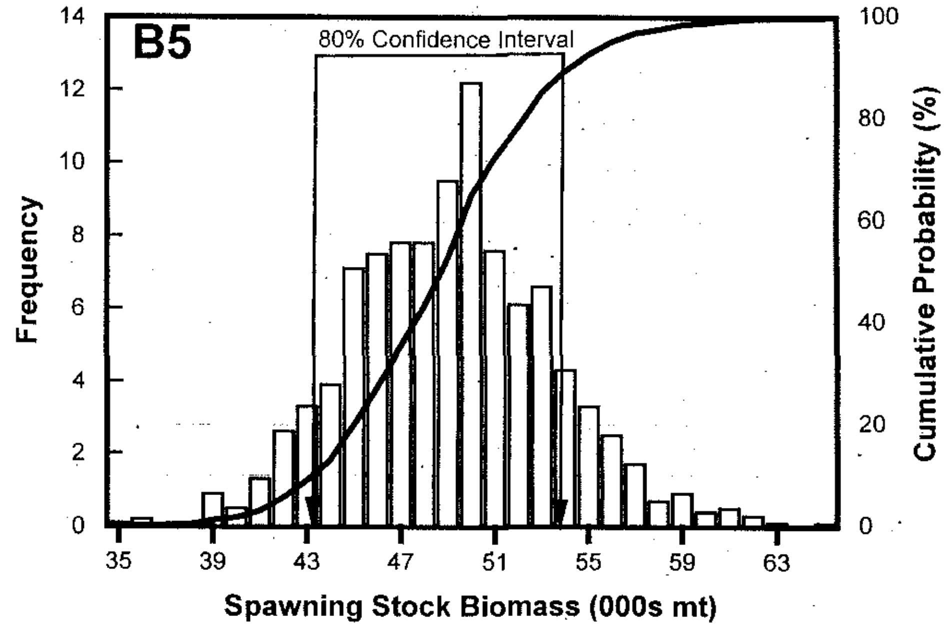


Georges Bank Haddock

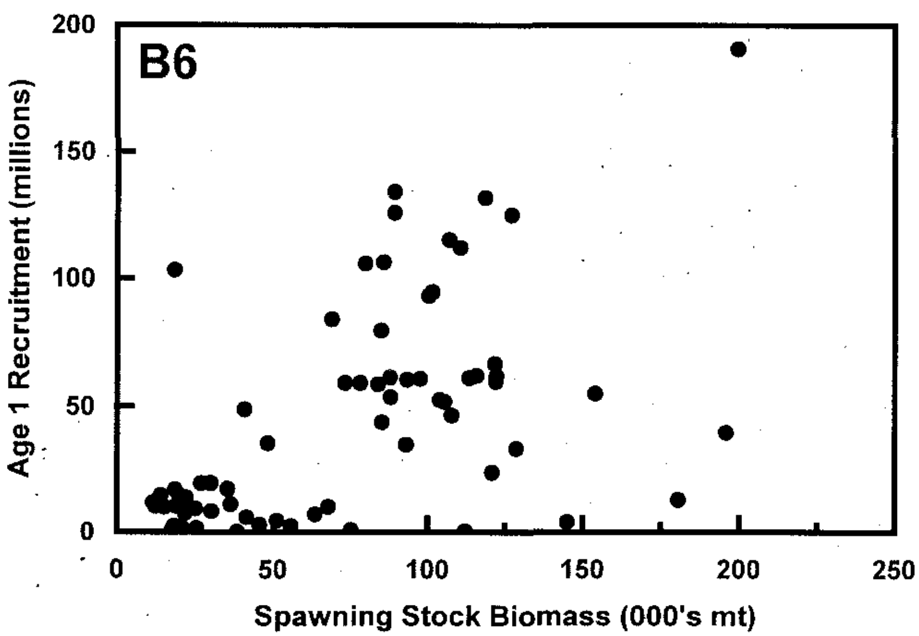
Precision of 1999 F Estimate



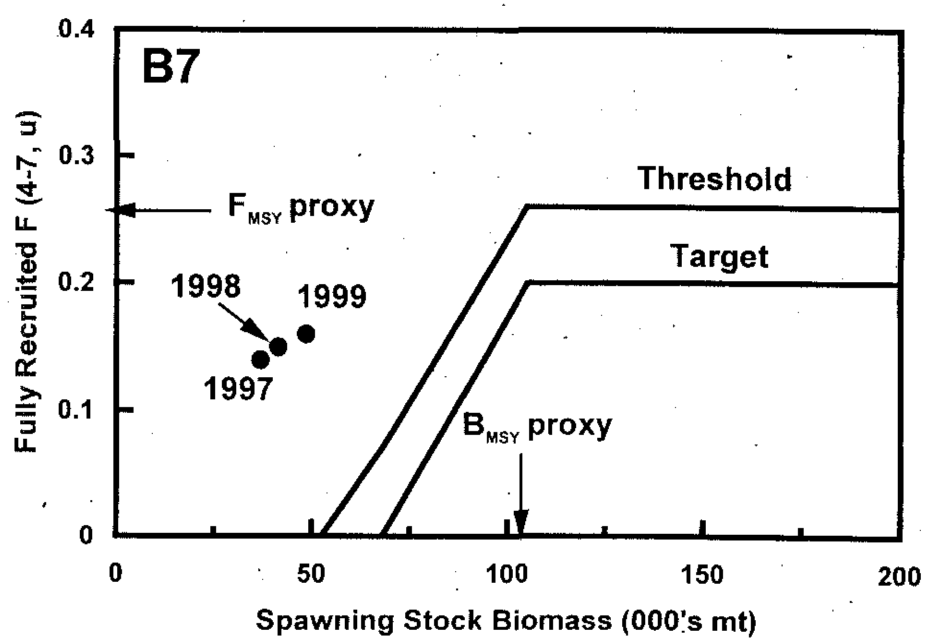
Precision of 1999 SSB Estimate



Spawning Stock and Recruitment



SFA Harvest Control Rule



C. GEORGES BANK YELLOWTAIL FLOUNDER ADVISORY REPORT

State of Stock: The stock is not overfished, and overfishing is not occurring according to the SFA harvest control rule. In 1999, mean biomass was 49,600 mt (92% of B_{MSY}), and fishing mortality was low (fully recruited F = 0.13, F on biomass = 0.09, 30% of F_{MSY}, Figure C1). Recruitment is strong, with an outstanding 1997 year class and above average 1996 and 1998 cohorts (Figure C2). Spawning stock biomass continues to increase as these year classes mature (33,500 mt in 1999, Figure C2).

Catch and Status Table (weights in '000 mt, recruitment in millions): Georges Bank Yellowtail Flounder

Year		1992	1993	1994	1995	1996	1997	1998	1999	Max[1]	Min[1]	Mean[1]
US												
	Landings[2]	2.9	2.1	1.6	0.3	0.8	1.0	1.8	2.0	15.9	0.3	7.4
	Discards	1.9	1.1	0.1	0.0	0.0	0.1	0.1	0.5	5.6	0.0	1.5
Canada												
	Landings	<0.1	0.7	2.1	0.5	0.5	0.8	1.2	2.0	2.1	0.0	0.1
	Discards[3]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total catch		4.7	3.9	3.9	0.8	1.3	1.8	3.1	4.4	21.3	0.8	9.4
Mean Biomass[4]		7.5	6.6	4.5	5.8	11.0	18.3	28.2	49.6	52.0	4.0	22.6
SSB[4]		4.8	4.4	2.6	2.8	6.0	11.3	15.8	33.5	33.5	2.2	8.4
Recruitment (age 1)[4]		16.1	12.5	12.7	19.2	29.8	37.0	89.6	43.1	89.6	5.8	27.0
F (age 4+,u)[4]		1.19	1.12	2.45	0.81	0.43	0.37	0.25	0.13	2.45	0.13	1.08
Exploitation rate[4]		64%	62%	86%	51%	32%	28%	20%	11%	86%	11%	61%
F (age 1+,wb)[4]		0.61	0.50	0.94	0.14	0.11	0.11	0.10	0.09	1.38	0.09	0.57

[1]Over period 1963-1999, except as otherwise noted.
[2]U.S. landings for 1994-1999 are provisional.
[3]Canadian discards previous to 1996 are unknown, but considered to be small.
[4]From VPA, 1973-1999, except for maximum and mean biomass which are from production model estimates 1963-1999.

Stock Distribution and Identification: Yellowtail flounder inhabit relatively shallow waters (20-100 m) of the northwest Atlantic from Labrador to Chesapeake Bay. Tagging observations, larval distribution, and geographic patterns of landings and survey data indicate that yellowtail flounder on Georges Bank comprise a relatively discrete stock. The Georges Bank yellowtail stock is defined as the entire Bank, east of the Great South Channel (U.S. statistical reporting areas 522, 525, 551, 552, 561, and 562).

Catches: Landings, which were predominantly taken by the U.S. fleet, averaged 16,300 mt during 1962-1976, with some taken by distant water fleets (Figure C1). No foreign landings of yellowtail have occurred since 1975. U.S. landings declined to approximately 6,000 mt between 1978 and 1981. Landings rose to over 10,500 mt in 1982 and 1983 with strong recruitment and intense fishing effort. Landings fell to a low of 1,100 mt in 1989, averaged 2,200 mt from 1990 to 1994 and dropped to record lows of 300 and 800 mt in 1995 and 1996. For the first time on record, the majority of yield was landed by Canadian fishermen in 1995. In the late 1990s, total landings steadily increased to 4,400 mt in 1999.

Discarding of small yellowtail has been an important source of mortality in the Georges Bank yellowtail population. The magnitude of discarded catch has generally been related to the size of recruiting cohorts, except in recent years, when increased mesh sizes appear to have reduced trawl discards. In 1999, yellowtail bycatch in the U.S. scallop fishery increased substantially, primarily as a result of fishing in Closed Area II under an exemption program. A TAC of 387 mt was allocated to the scallop fishery in Closed Area II. Estimated bycatch from the exemption program was approximately 20% of total U.S. catch, nearly all of which was discarded.

Data and Assessment: A virtual population analyses (VPA) of 1973-1999 commercial landings and discards at age was performed using the ADAPT method (assuming natural mortality, M = 0.2). Information on recruitment and stock abundance was obtained from Canadian spring surveys, NEFSC spring and autumn bottom trawl surveys, and NEFSC scallop surveys. Precision and uncertainty associated with estimates of F, SSB, and mean biomass in 1999 were evaluated with bootstrap analysis (Figures C5-C7).

A non-equilibrium surplus production model was also used to assess the stock due to uncertainties in the age composition in recent years (see special comments). Input data included commercial landings and discards and three of the surveys used in the VPA. Unlike the VPA, no information on age structure is required.

Biological Reference Points: $F_{0.1}$ was estimated to be 0.25 (20% exploitation, Figure C3). Spawning biomass per recruit is estimated to be 40% of maximum spawning potential at $F_{0.1}$. The surplus production model estimated MSY to be 16,600 mt at a total stock biomass of 54,000 mt (B_{MSY}), and F_{MSY} is 0.31 (which is F on biomass, F1+,wb).

SFA Control Rule: The SFA control rule specifies a biomass threshold of 25% B_{MSY} (13,500 mt), a maximum F threshold of F_{MSY}, and F on biomass (1+,wb) as the metric for fishing mortality. When biomass is between B_{MSY} and 1/2 B_{MSY} (27,000 mt), threshold F is the maximum F that allows rebuilding to B_{MSY} in 10 years at the estimated intrinsic rate of increase. When biomass is between 1/2 B_{MSY} and 1/4 B_{MSY}, threshold F is the maximum F that allows rebuilding to B_{MSY} in 5 years. When biomass is below 1/4 B_{MSY}, threshold F = 0. When biomass exceeds B_{MSY}, target F is the tenth percentile of the F_{MSY} estimate. When biomass is less than B_{MSY}, target F is based on rebuilding to B_{MSY} at the tenth percentile of the intrinsic rate of increase estimate (Figure C4). Current biomass is approaching B_{MSY} and current F is well below the control rule target (Figure C4).

Fishing Mortality: The VPA and the surplus production model produce similar trends in exploitation rates. Fully-recruited F (ages 4-5, unweighted) was very high (averaged 1.2, 65% exploitation) during the 1973-1994 period, but declined in the late 1990s to 0.13 (11% exploitation) in 1999 (Figure C1). There is an 80% probability that fully-recruited F in 1999 was between 0.11 and 0.16 (9% to 13% exploitation, Figure C5). F on biomass (1+,wb) generally exceeded F_{MSY} from the 1960s to 1994 and sharply decreased to approximately 0.1 from 1996 to 1999.

Recruitment: Age 1 recruitment estimates from VPA indicate that four dominant year classes of approximately 50 million were produced during 1973-1980. All other cohorts produced from 1975 to 1995 were less than 25 million at age 1. Recruitment increased in the late 1990s. The 1997 yearclass appears to be the strongest in the VPA time series at 90 million fish at age 1, and the 1996 and 1998 year classes are also above average (Figure C2).

Stock Biomass: Spawning biomass was 21,000 mt in 1973, declined to less than 4,000 mt from 1984-1988, fluctuated below 6,000 mt from 1989 to 1995, and steadily increased to 33,000 mt in 1999. There is an 80% probability that SSB in 1999 was between 27,700 mt and 38,800 mt (Figure C6). Trends in mean biomass (ages 1+) are similar to those for SSB. There is an 80% probability that mean biomass in 1999 was between 41,800 mt and 60,500 mt (Figure C7).

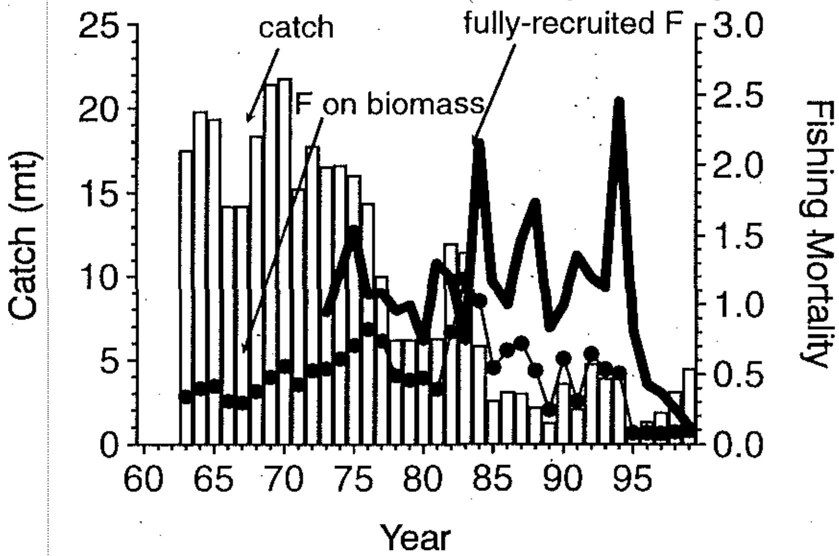
Special Comments: Inadequate sampling of U.S. landings and discards and absence of age determinations from the Canadian fishery contribute to uncertainty in estimates of size and age of catch. Retrospective analysis indicates a pattern of inconsistencies in which estimates of F in the last year of the VPA are less than revised estimates of F.

Statistical problems were encountered in finding a stable solution to the production model. There was considerable uncertainty in estimates of MSY reference points. Consequently, the production model was not used for projections. A more comprehensive examination of MSY reference points requires a benchmark assessment.

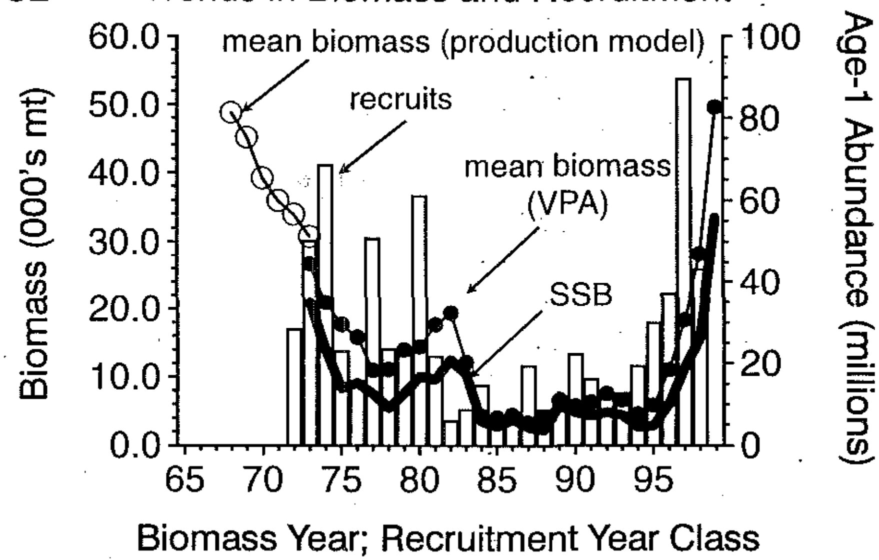
Source of Information: S.X. Cadrin, J.D. Neilson, S. Gavaris, and P. Perley. 2000. Assessment of the Georges Bank yellowtail flounder stock for 2000. NEFSC Ref. Doc. 2000-xx.

Georges Bank Yellowtail Flounder

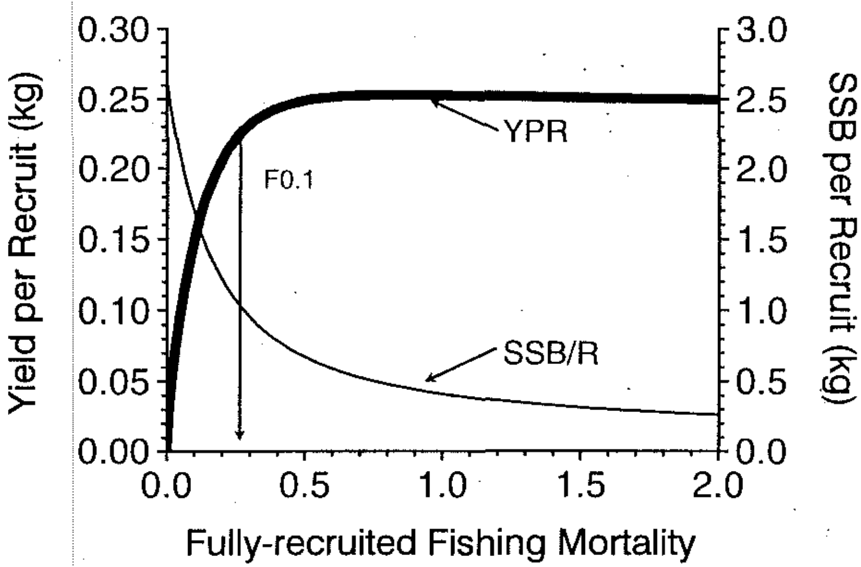
C1 *Trends in Catch and Fishing Mortality*



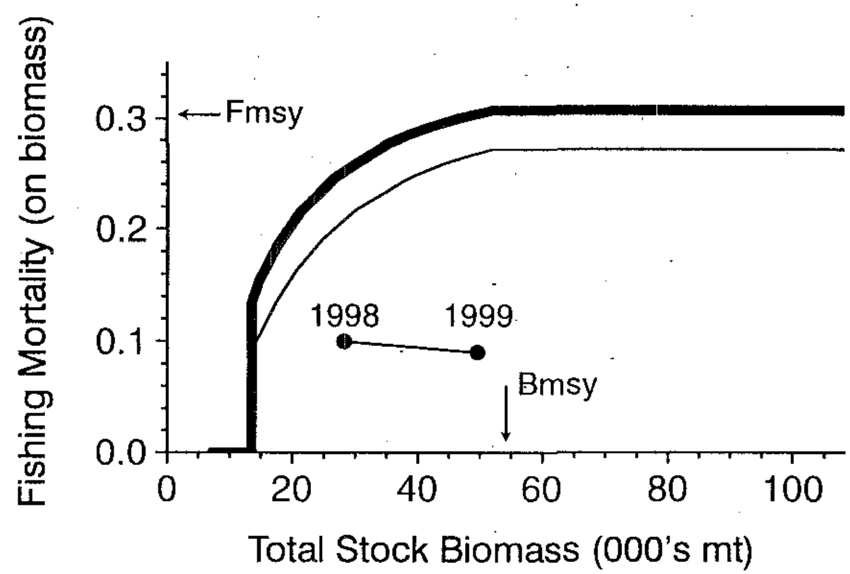
C2 *Trends in Biomass and Recruitment*



C3 *Yield and Spawning Biomass per Recruit*

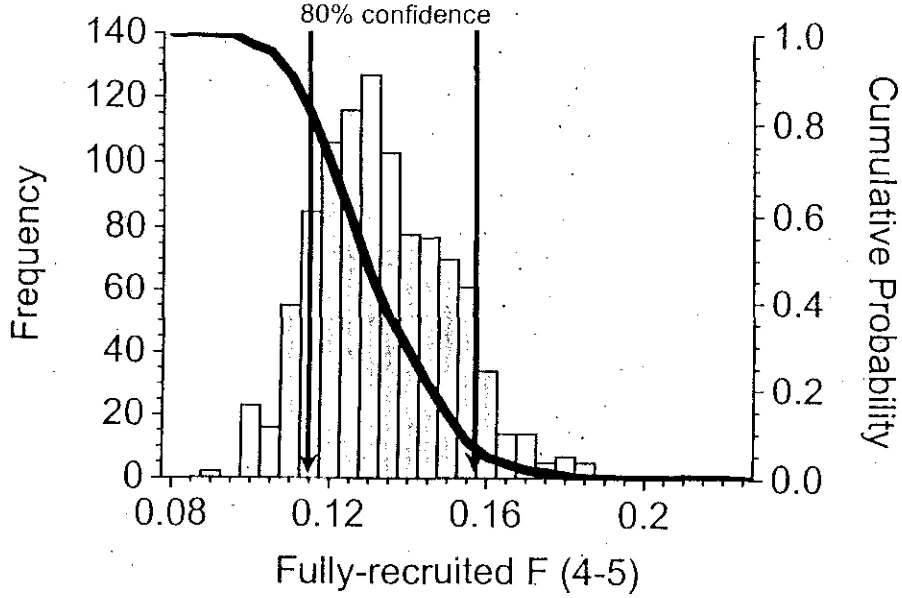


C4 *Harvest Control Rule and Recent Stock Status*

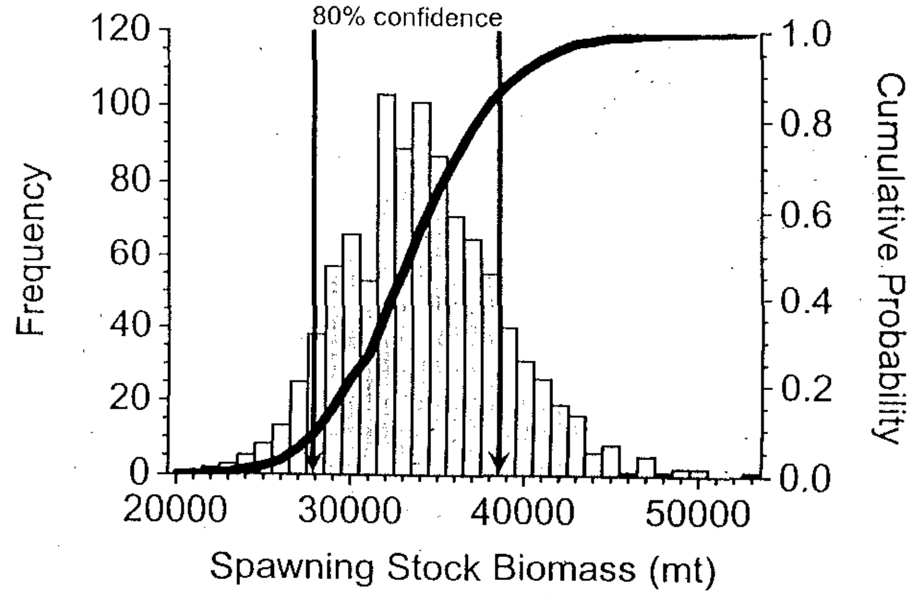


Georges Bank Yellowtail Flounder

C5 *Precision of 1999 F Estimate*



C6 *Precision of 1999 SSB Estimate*



C7 *Precision of 1999 Mean Biomass Estimate*