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Assessment of the Georges Bank Yellowtail Flounder Stock for 2000

by

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A Report of the 3rd Transboundary Resources Assessment Committee Meeting

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ABSTRACT

Calibrated virtual population analysis and surplus production analysis indicate that the stock of yellowtail flounder (*Limanda ferruginea*) on Georges Bank is recovering from an overfished state. In 1999, mean biomass was 49,600 mt, which is 92% of B_{MSY}. Fishing mortality (F) in 1999 was low: fully recruited F was 0.13, and F on biomass was 0.09, or 30% of F_{MSY}. Recruitment is strong, with an outstanding 1997 yearclass and above average 1996 and 1998 cohorts. Spawning stock biomass continues to increase as these year classes mature. As indicated by projections from both the VPA and ASPIC, the short-term outlook for the stock is positive. At the current exploitation rate the stock is expected to increase by greater than 10% during 2000.

INTRODUCTION

Yellowtail flounder, *Limanda ferruginea,* inhabit relatively shallow waters (20-100 m) of the continental shelf of the northwest Atlantic from Labrador to Chesapeake Bay (Bigelow and Schroeder (1953). Spawning occurs during spring and summer, peaking in May. Larvae drift for approximately two months, then change form and settle to the bottom. Growth is sexually dimorphic, in that females grow to larger maximum size than males (Moseley 1986). On Georges Bank, female yellowtail grow to 55 cm total length and a weight of 1.5 kg, but high rates of fishing mortality have greatly reduced the average size and age.

Tagging observations, larval distribution, and geographic patterns of landings and survey data indicate that yellowtail flounder on Georges Bank comprise a relatively discrete stock (Neilson et al. 1986). Tag returns suggest that stock mixing is rare (Royce et al. 1959, Lux 1963). Geographic distribution of larvae are generally not continuous with adjacent spawning areas, but larval mixing occurs among stocks in some years (Silverman 1983). Despite vertical movement of larvae, which limits horizontal drift (Smith et al. 1978), U.S. and Canadian portions of Georges Bank are considered a single larval retention area (Sinclair 1986). 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, Figure 1a; Canadian statistical areas 5Zj, 5Zm, 5Zn, and 5Zh, Figure 1b).

A U.S. fishery for yellowtail flounder developed in the 1930s, coincident with the increased use of otter trawls, a decline in winter flounder abundance, and demand for food products during World War II (Scott 1954; Figure 2). The Georges Bank fishery intensified in the late 1940s from displacement of effort from the declining fishery in southern New England (Royce et al. 1959). A small amount of yellowtail were caught by distant water fleets in the 1960s and early 1970s. In 1993, a directed Canadian fishery for yellowtail began on Georges Bank.

The principal fishing gear used to catch yellowtail flounder is the otter trawl, although bycatch in the scallop dredge fishery can be substantial. The U.S. fleet generally targets multiple groundfish species but targets yellowtail during periods of increased availability (including recent years) on the "Southwest Part" (statistical area 525 or 5Zn, Figure 1) and the "Northern Edge" (area 522 or 5Zh). The Canadian fishery generally targets yellowtail in the "Yellowtail Hole" (area 552 or 5Zm, Neilson et al. 1999).

Over the past 25 years, the fishery for yellowtail flounder has been managed under several regimes. From 1971 to 1976, national quotas were allocated by the International Commission for Northwest Atlantic Fisheries. From 1977 to the present this transboundary resource has been managed separately by the U.S. and Canada. Minimum mesh size, area closures, and trip limits were imposed through the New England Fishery Management Council's Atlantic Groundfish Fishery Management Plan from 1977 to 1982. In 1982, the Council adopted an Interim Groundfish Plan, which established a minimum size limit of 28 cm (11") and a minimum mesh size of 130 mm (5 1/8"; with exemptions). In 1983, the minimum mesh size was increased to 140 mm (5.5"; with exemptions) In 1986, the Council's Multispecies Fishery Management Plan

increased the minimum legal size to 30 cm (12") and imposed seasonal area closures. Amendment #2 to the Plan further increased the minimum legal size to 33 cm (13") in 1989. Amendments #5, #6, and #7 to the U.S. management plan (1994-1996) were developed with the goal of rebuilding principal groundfish stocks, including Georges Bank yellowtail, by limiting days at sea, closing areas year-round (Figure 1), further increasing minimum mesh size to 152 mm (6" diamond or square, with fewer exemptions) and imposing trip limits for groundfish bycatch in the sea scallop fishery. In May 1999, the Council increased minimum mesh size to 165 mm (6 1/2") square or 142 mm (6") diamond. Amendment #9 to the U.S. plan proposes to implement a new overfishing definition based on maximum sustainable yield reference points, including a fishing mortality limit of F_{MSY} and a rebuilding target of B_{MSY}.

The Canadian government began quota management of the Georges Bank yellowtail resource in 1994 with the objective of rebuilding the stock. Other management measures in place for the Canadian fishery include a seasonal closure typically extending from Jan. 1 to May 31 (this has been in place since 1994, previously the seasonal closure was from March 1 to May 31). The directed groundfish fishery has 10% observer coverage and all gear sectors are subject to 100% dockside monitoring. The mesh size employed in the 1999 Canadian fishery is 155 mm square.

The Georges Bank yellowtail stock has been assessed for the last four decades using various models for estimating abundance and mortality from catch and survey data. Results from early assessments have shown that the instantaneous rate of fishing mortality (F) has exceeded the level of maximum yield-per-recruit (F_{max}) since the late 1950s (Brown and Hennemuth 1971, Pentilla and Brown 1973, Sissenwine et al. 1978, Clark et al. 1981, Collie and Sissenwine 1983, McBride and Clark 1983, McBride 1989). Virtual population analysis (VPA) calibrated with survey indices of abundance (Conser et al. 1991, Rago et al. 1994) confirmed that F consistently and significantly exceeded all relevant overfishing reference points. The 1994 assessment showed that the stock had collapsed and F needed to be substantially reduced to rebuild spawning stock biomass (SSB) (NEFSC 1994). An updated analysis of combined U.S. and Canadian catch and survey indices confirmed historical patterns of stock abundance and F, and indicated that F decreased in 1995 (Gavaris et al. 1996). In the last several years, the Georges Bank yellowtail flounder stock has increased at low fishing mortality rates: 45% of B_{MSY} in 1997 (Neilson et al. 1997, Cadrin et al. 1998) and 65% of B_{MSY} in 1998 (Neilson and Cadrin 1998). The stock had grown to 75% of B_{MSY} in 1999 from strong recruitment and low F (fully recruited F was 0.21; Neilson et al. 1999, Cadrin 2000). This report updates catch, survey indices, and estimates of stock size and fishing mortality through spring 2000.

FISHERY AND RESOURCE DATA

The Georges Bank yellowtail stock has been exploited since the late 1930s (Table 1, Figure 2). Total catch gradually increased to 9,800 mt in 1949, decreased in the early 1950s to 1,600 mt in 1956, and increased again in the late 1950s. Catch averaged 14,000 mt during 1963-1976. Strong recruitment and intense fishing effort produced catches greater than 11,000 mt in 1982 and 1983. The catch fell to a low of 1,200 mt in 1989, averaged 3,600 mt from 1990 to 1994 and

dropped to record low of 800 mt in 1995. In the late 1990s, the annual catch steadily increased to 4,400 mt in 1999. The USA fishery was the largest contributor to the total catch in all years except in 1994 and 1995 when the Canadian fishery removals were greater. Apart from the USA and Canada, no other countries have prosecuted this fishery since 1975.

Commercial Landings

U.S. commercial landings of yellowtail flounder were derived from dealer weighout reports. Previous to 1994, landings were allocated to statistical area, month, and gear type according to interview data collected by port agents (Burns et al. 1983). From 1994 to 1999, U.S. dealer landings were allocated to stock area using fishing vessel logbook data, by fishing gear, port, and season (Wigley, et al. 1998).

A significant biomass of flatfish have been landed as "unspecified" flatfish in the Canadian fishery in previous years, and generally consist of yellowtail on Georges Bank. The unspecified flounder problem has been considerably reduced over time, due to improved monitoring of the landings. Unspecified flounders in 5Zm totaled 11 mt in 1999, and all were assumed to be yellowtail flounder.

In previous years, there have been some landings of yellowtail flounder in the Canadian scallop fishery on Georges Bank. Management measures established in 1996 prohibit the landing of yellowtail flounder by this fleet, and no records of discarded quantities are available for 1997-1999. This represents a source of mortality for this resource that is of unknown magnitude, and efforts are required to quantify discarded catches. In 1996, at sea observer records estimated the amount of discarded yellowtail flounder as 11 mt. However, with the growth of the yellowtail flounder resource, it is possible that discards are considerably greater at present.

The Georges Bank yellowtail stock has been exploited since the late 1930s (Figure 2). Landings, which were predominantly taken by the U.S. fleet, gradually increased to 7,300 mt in 1949, decreased to 1,600 mt in 1956, and increased again in the late 1950s. Annual landings averaged 16,300 mt during 1962-1976, with some taken by distant water fleets. No foreign landings of yellowtail have occurred since 1975 (Table 1). U.S. landings declined to approximately 6,000 mt between 1978 and 1981. Strong recruitment and intense fishing effort produced greater than 10,500 mt in 1982 and 1983. Landings fell to a low of 1,100 mt in 1989, averaged 2,200 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 Georges Bank yellowtail yield was landed by Canadian fishermen in 1995. In the late 1990s, total landings steadily increased to 4,400 mt in 1999.

Previous U.S. stock assessments of Georges Bank yellowtail used port samples of length and age distribution by market category, quarter and statistical area to estimate landings at age (Conser et al. 1991, Rago et al. 1994). For 1994-1999, U.S. landings by statistical area were not available, and the frequency of port sampling was not adequate for quarterly estimates. Sampling intensity of the U.S. fishery continues to be poor (Table 2). Landings at age for 1994-1996 were estimated by half-year for the entire U.S. portion of the stock area. As in previous U.S. assessments, sample length frequencies were expanded to total landings at size using the ratio of landings to

sample weight (predicted from length-weight relationships by sex and season; Lux 1969b), and apportioned to age using pooled-sex age-length keys. Commercial age-length keys were derived from pooled port samples, sea samples, and survey samples. Estimates of U.S. landings at age and mean weight at age of landed yellowtail are presented in Table 3.

Landings at length from the Canadian fishery was estimated by month for the entire Canadian portion of the stock area. Port-sample length frequencies were expanded to total landings by sex and portioned to age using separate-sex age-length keys. Length samples from Canadian sea sampling were excluded from the analyses because sex identification was suspect. Commercial age-length keys were derived from pooled 2nd half U.S. port samples, 2nd half U.S. sea samples, and U.S. fall survey samples (otoliths from the Canadian fishery have been sampled but have not been processed). Estimates of Canadian catch at age of yellowtail are presented in Table 4. As observed in 1998 (Neilson et al. 1999), the size distribution of Canadian landings was larger than U.S. landings in 1999.

Commercial Discards

Discarding of small yellowtail has been an important source of mortality in the Georges Bank yellowtail fishery. Previous assessments estimated age-specific discard rates using selection ogives fit to multiple data sources: discard ratios from trip interviews, sea sampling, and survey length distributions (Conser et al. 1991, Rago et al. 1994). Discards for 1994-1998 were estimated from logbook data which was confirmed by the few available sea sample observations (method described by Cadrin et al. 1998).

Discarded catch from the 1999 U.S. fishery was also estimated from logbook information on discard to kept ratios by half-year and gear, except for discards from the scallop exemption program, which was estimated from relatively intensive observer sampling (P. Rago, personal communication). Discard ratios from the trawl fishery were 4% and 6% for the first and second half, respectively. All trip logs that had a valid statistical area and reported discards of any species were included in the analysis. The three U.S. trawl trips on Georges Bank sampled by observers in 1999 had 1%, 2%, and 3% discard ratios of yellowtail. Total discarded catch from the trawl fishery was estimated to be 89 mt. Total discarded yellowtail catch from the scallop dredge fishery was 395 mt, which was predominantly from the exemption program. From June 15 to November 2, 1999, 187 scallop vessels were permitted to fish in Closed Area II (Figure 1) with a total yellowtail bycatch allowance of 387 mt. Of the 644 trips in the exemption program, 141 had observers. In total, U.S. discards increased by over 500% from 1998 to 1999. Discards at age were estimated from sea sampled lengths by gear and pooled commercial and survey age-length keys. Discards at age and recent mean weights at age are reported in Table 5.

Total catch at age of Georges Bank yellowtail flounder (including U.S. landings, U.S. discards, and Canadian catch) for 1973-1999 is reported in Table 6. As shown in Figure 3, catch of age-1 yellowtail has been effectively minimized by mesh size regulations. Although the stock's age structure appears to be expanding as it rebuilds, the proportion of old fish in the catch remains less than historical observations.

Stock Abundance and Biomass Indices

Commercial Catch Rates - Landings (mt) and effort (h) for less than 65 ft Canadian otter trawlers fishing for yellowtail flounder in 1993-1999 were summarized on a trip basis. Initial examination of the trip records showed a large proportion of trips with very small amounts of yellowtail in the total catch. These trips were not considered to be representative of yellowtail directed effort, and therefore only trips with reported landings in 5Zm of more than 500 kg (1100 lb.) were included in the CPUE estimates. As well, only vessels with reported landings in two or more years in 1993-97 were included in the analysis.

Canadian mobile gear catch rates were examined for the directed fishery in 5Zm. Catch rates have increased between 1994 and 1996, remained constant from 1996 to 1998, then increased in 1999 (Figure 4). During discussions with industry in 1999, it was concluded that the increases in catch rates up to 1996 in this relatively new fishery probably reflected increased biomass, but were influenced by the developing skill of fishermen as well as gear development. During industry consultations in March 2000, it was noted that the increase in catch rates from 1998 to 1999 may under-represent the increase in abundance, since a significant number of fishermen did not switch to flounder gear. Industry noted that flounder gear would have higher catch rates. Catch rate indices will require further investigation before they are used as an index of abundance for VPA calibration.

Research Surveys - Four time series of research vessel data are available for Georges Bank yellowtail flounder. Relative stock biomass and abundance at age (Table 7) were derived from NEFSC spring and autumn bottom trawl survey catches (strata 13-21, Figure 5), NEFSC scallop survey catches (strata 54, 55, 58-72, 74, Figure 6), and Canadian bottom trawl survey catches (strata 5Z1-5Z4, Figure 7). Standardization coefficients, which compensate for survey door, vessel, and net changes in NEFSC groundfish surveys (1.22 for old doors, 0.85 for the Delaware II, and 1.76 for the 'Yankee 41' net; references in Rago et al. 1994) were applied to the catch of each tow. However, the spring survey data was treated as two series for analyses: the Yankee 36 net (1968-1972, 1982-1999) and Yankee 41 net (1973-1981). Indices of abundance at age were derived using survey-specific age-length keys for spring and autumn NEFSC surveys. The age-1 scallop survey index was length based, and the Kimura and Chikuni (1987) method was used to derive catch at age from the Canadian 2000 survey.

Survey indices illustrate that stock biomass decreased by approximately 90% from the 1960s to the early 1990s, despite several large year classes that temporarily interrupted the overall rate of decline (Figure 8). However, all survey indices have substantially increased since 1994. Age structure of surveys shows strong recruitment and a relatively broad age structure in the 1960s and early 1970s, generally poor recruitment and truncated age structure from the late 1970s to the early 1990s, and recent strong recruitment (Figure 9).

ESTIMATES OF STOCK SIZE AND FISHING MORTALITY

Virtual Population Analysis

Stock abundance for ages 1-6+, 1973-2000, was derived from a calibrated VPA using ADAPT (Gavaris 1988), which estimated age 2-5 survivors in 2000 and survey catchability coefficients (q) using nonlinear least squares according to agreement of survey indices with abundance estimates. The instantaneous rate of natural mortality (M) was assumed to be 0.2 based on tag returns (Lux 1969a) and relationships of Z to effort (Brown and Hennemuth 1971). Observations of few 14-year-old yellowtail from historical NEFSC surveys suggest that M is approximately 0.2. Yellowtail older than 4 years were assumed to be fully-recruited to estimate F for ages 5 and 6+ for all years in the VPA. Twenty-four series of survey indices were used in the VPA calibration (Figure 10). Variance and bias were evaluated using a bootstrap procedure in which residuals were randomly sampled for 1,000 bootstrap solutions. Consistency of VPA estimates was assessed using retrospective analysis (Sinclair et al. 1990).

Percent of mature fish at age was based on observations from the NEFSC spring survey within periods of similar stock biomass [1973-1991 from Almeida and Burnett (1997); 1992-1996 from spring survey observations]: age-2 were 42%-49% mature in years of moderate to high stock biomass (1973-1983), increased to 93% at low stock biomass (1984-1991), and decreased to 52% during stock rebuilding (1992-1996). Observations from 1997-1999 spring surveys were not significantly different than those from 1992-1996.

Abundance of ages 2-5 in 2000 were estimated with moderate to high precision (bootstrap CVs were 14% to 34%) with little bias (<4%). There were no high correlations among parameter estimates ($|r|<0.25$). There were some patterns in survey residuals but no large residuals in the last several years (Figure 11).

The analysis indicated that stock abundance of Georges Bank yellowtail was greater than 100 million in the early 1970s when the population was supported by several strong year-classes (Figures 12 and 13, Appendix A). Mean stock biomass declined from 27,000 mt in 1973 to 3,000 mt in 1987 due to poor recruitment and extremely high F (average $F_{ages\ 4\text{-}5}$=1.2 for 1973-1994), remained low through the early 1990s, and steadily grew from 4,000 mt in 1995 to 50,000 mt in 1999 with strong recruitment and low F (average $F_{ages\ 4\text{-}5}$= 0.4 for 1995-1999, 0.13 in 1999); Figure 13). Bootstrap results indicate that there is an 80% probability that fully-recruited F in 1999 was between 0.11 and 0.16, SSB in 1999 was between 27,700 mt and 38,800 mt, and mean biomass in 1999 was between 41,000 mt and 59,000 mt (Figure 14).

The early time series of recruitment is dominated by four strong year classes of greater than 50 million at age-1 (1973, 1974, 1977, and 1980 year classes). All 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 series at 90 million age-1 abundance, and the 1996 and 1998 year classes are also above average (Figure 13).

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 (Figure 13). The relationship between SSB and recruitment is variable but indicates that the likelihood of strong recruitment increases as a function of SSB. Adult biomass of less than 7500 mt has been associated with relatively low recruitment. At higher biomass, there is an increased probability of good recruitment. Few data are available to measure the magnitude and variability of recruitment at current high biomass.

Gains in exploitable biomass may be partitioned into those associated with somatic growth of yellowtail which have previously recruited to the fishery and those associated with new recruitment to the fishery (Rivard 1980). We used age-2 as a convenient age of first recruitment to the fishery. On average, growth contributes about 60% of total production with little variation in the proportion since 1973 (Figure 15). Surplus production is defined as the gains in exploitable biomass which are in excess of the needs to offset losses from natural mortality. When the fishery yield is less than the surplus production, there is a net increase in the population biomass. Since 1995, there has been considerable production in excess of fishery removals.

Retrospective analysis indicates a strong tendency toward overestimating abundance of older ages since 1994 (Figure 16). As a result, fully-recruited fishing mortality has been underestimated by recent assessments.

Sensitivity analyses were performed to explore several aspects of the VPA calibration. Given the retrospective error at older ages, two exploratory analyses were conducted. All age-6+ indices were excluded from one analysis because of their high partial variance in the model, and all indices were reweighted according to their partial variance to reduce the influence of indices for the youngest and oldest ages in another sensitivity analysis. The Canadian age-1 index was excluded from previous assessments because it was poorly correlated with other indices (Neilson et al. 1997, Cadrin et al. 1998). However, the survey detected the strong 1997 cohort at age-1 and was included in an exploratory calibration to assess the sensitivity of adding the index. Finally, preliminary age-based indices from the 2000 Canadian survey were excluded to assess the impact of the preliminary data. Results from all sensitivity analyses were similar to the analysis reported in Appendix A, and all had the same strong retrospective pattern.

Slight differences can be found in the results presented in Appendix A and those given in the Canadian Stock Status Report. The discrepancies are attributable to unresolved differences in the analytic software employed by the USA and Canada, and to the application of bias correction for results in the Stock Status Report. The VPA results used for the Stock Status Report are given in Appendix B.

Biomass Dynamics Model

Age-based assessments of Georges Bank yellowtail flounder have been complicated by the poor characterization of catch at age. Accordingly, a nonequilibrium surplus production model incorporating covariates (ASPIC; Prager 1994, 1995) has been used in recent stock assessments

to provide an alternative perspective on stock status (Neilson et al. 1997, Cadrin et al. 1998). The model analyzes total catch (1963 to 1999) and survey indices of stock biomass. Estimates of initial biomass (B_1), maximum sustainable yield (MSY), intrinsic rate of increase (r), and catchability of each survey (q) were estimated using nonlinear least squares of survey residuals. The NEFSC fall and spring yankee 36 series as well as the Canadian spring surveys contributed as independent biomass indices. The NEFSC scallop survey does not measure weights and was not included as a biomass index.

Correlations among survey biomass indices were strong (r= 0.78, 0.82, and 0.94; Appendix C). Most of the variance in survey indices was explained by the model (R^2= 0.61, 0.66, and 0.77). There were no apparent residual problems, and biomass residuals in the last year were positive (*i.e.*, surveys indicate greater current biomass than the model). However, the nonlinear solution was sensitive to the starting conditions when default convergence criteria were used (Prager 1995). Therefore, convergence criteria were made more restrictive. Survey residuals were randomly resampled 1,000 times for bootstrap estimates of precision and model bias. A large portion of bootstrap trials did not meet the convergence criteria, indicating that bootstrap variance is probably underestimated. The bootstrap analysis indicated that B_1, MSY, and r were very well estimated (the relative interquartile ranges, IQR, were <7%), and survey q's were slightly more variable (relative IQRs=10%-18%). Bootstrap calculations of K, B_{MSY}, and F_{MSY} were stable (relative IQRs=7%), but ratios of current conditions to MSY conditions (F_{1999}/F_{MSY} and B_{2000}/B_{MSY}) were less precise (relative IQRs=19%).

Patterns of stock biomass and F from VPA and the surplus production model were similar (Figure 17; Appendix C). The biomass dynamics model indicated that a maximum sustainable yield of 16,600 mt can be produced by the Georges Bank yellowtail stock at a stock biomass of 54,000 mt (B_{MSY}) and F on total biomass ($F_{1+,wb}$) of 0.31 (F_{MSY}). Estimates of MSY and B_{MSY} are greater than previous estimates, and biomass estimates for the 1960s are substantially less than previous estimates (Neilson et al. 1999, Cadrin 2000). However, biomass estimates for the first two to five years of the analysis (1963 to 1964-66) are imprecise and are not generally considered reliable (Prager 1994, 1995). Stock biomass was greater than 45,000 mt in the late 1960s. However, after 1967, F exceeded F_{MSY}, and biomass began to decline. Fishing mortality continued to exceeded F_{MSY} until 1995. Biomass declined to approximately 4,000 mt in the late 1980s. In 1995, F sharply decreased, and biomass began to increase. The biomass estimate for January 2000 (53,400 mt) is 99% of B_{MSY}.

PROJECTIONS

The surplus production model attempts to describe long term population dynamics in a simple model which projects past stock productivity forward. However, it is not clear whether past stock productivity will always be a good predictor of stock dynamics. Statistical problems were also encountered in finding a stable solution for the production model. Thus, the projections in this section are from the VPA only, and use the VPA results presented in Appendix B as initial values. Projections were also based on the following inputs listed in Table 8. The mean weight

and partial recruitment values represent an average of observations from 1997 to 1999. This range of years was selected recognizing a trend of increasing weights at age but also substantial interannual variation making reliance on a single year questionable.

Projected total Canada/USA yield at $F_{0.1}$ = 0.25 in 2000 would be about 8,000 mt. If fished at $F_{0.1}$ in 2000, the age-3+ biomass is projected to increase from 37,000 mt in January 2000 to 41,000 mt by the beginning of 2001 (Table 8, Figure 18).

Uncertainty about year-class abundance generates uncertainty in forecast results. This uncertainty was expressed as risk of achieving reference targets. For example, with *status quo* Canada and USA catches of 4400 t, there is a very small probability of exceeding $F_{0.1}$, and a very high probability that total biomass will continue to increase (Figure 19). At the $F_{0.1}$ yield, there is about a 40% chance of not achieving a 10% increase in biomass from the beginning of the year 2000 to 2001.

The calculations do not include uncertainty due to variations in weights at age, partial recruitment to the fishery and natural mortality, or systematic errors in data reporting and model mismatch.

DISCUSSION

This assessment is hampered by considerable problems in estimating age structure of the catch. The result of poor sampling of the U.S. catch and unavailability of age samples from the Canadian fishery are that abundance of cohorts over time is not well monitored. Increased sampling intensity would allow consideration of sexually dimorphic growth for U.S. catch at age. Availability of Canadian age samples will eliminate the need to borrow samples from other sources which may represent different components of the stock.

Retrospective inconsistencies may reflect inadequate sampling and mis-allocation of catch at age. Retrospective patterns indicate that VPA estimates of biomass and F may be overly optimistic. Updated VPAs may indicate that 1999 biomass levels are lower, and 1999 F was greater than reported here.

Despite these problems, similarity of results from VPA and the production model are somewhat reassuring that conclusions about trends in stock size and fishing mortality are reliable. The stock has responded to low mortality rates in the last several years with substantial increases through growth and recruitment.

The exploitation history since the early 1960s provides little information on productivity of the stock at large biomass. Further evaluation of MSY reference points may require exploration of alternative models and incorporation of historical information. Such investigation is warranted because the biomass dynamics model indicates that the stock is rapidly approaching B_{MSY}, and a desire to shift management goals from rebuilding to optimization.

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Table 1. Catch of Georges Bank yellowtail flounder (thousand mt) from the U.S., Canada and distant water fleets.

Year	US landings	US discards	Canada	Foreign	Total Catch
1963	11.0	5.6	0.0	0.1	16.7
1964	14.9	4.9	0.0	0.0	19.8
1965	14.2	4.4	0.0	0.8	19.4
1966	11.3	2.1	0.0	0.3	13.7
1967	8.4	5.5	0.0	1.4	15.3
1968	12.8	3.6	0.0	1.8	18.2
1969	15.9	2.6	0.0	2.4	20.9
1970	15.5	5.5	0.0	0.3	21.3
1971	11.9	3.1	0.0	0.5	15.5
1972	14.2	1.2	0.0	2.2	17.6
1973	15.9	0.4	0.0	0.3	16.5
1974	14.6	1.0	0.0	1.0	16.6
1975	13.2	2.7	0.0	0.1	16.0
1976	11.3	3.0	0.0	0.0	14.4
1977	9.4	0.6	0.0	0.0	10.0
1978	4.5	1.7	0.0	0.0	6.2
1979	5.5	0.7	0.0	0.0	6.2
1980	6.5	0.4	0.0	0.0	6.9
1981	6.2	0.1	0.0	0.0	6.3
1982	10.6	1.4	0.0	0.0	12.0
1983	11.4	0.1	0.0	0.0	11.4
1984	5.8	0.0	0.0	0.0	5.8
1985	2.5	0.0	0.0	0.0	2.5
1986	3.0	0.0	0.0	0.0	3.1
1987	2.7	0.2	0.0	0.0	3.0
1988	1.9	0.3	0.0	0.0	2.1
1989	1.1	0.1	0.0	0.0	1.2
1990	2.8	0.8	0.0	0.0	3.6
1991	1.8	0.2	0.0	0.0	2.0
1992	2.9	1.9	0.0	0.0	4.7
1993	2.1	1.1	0.7	0.0	3.9
1994	1.6	0.1	2.1	0.0	3.9
1995	0.3	0.0	0.5	0.0	0.8
1996	0.8	0.0	0.5	0.0	1.3
1997	1.0	0.1	0.8	0.0	1.8
1998	1.8	0.1	1.2	0.0	3.1
1999	2.0	0.5	2.0	0.0	4.4
average	7.4	1.5	0.2	0.3	9.4

Table 2. Samples of the 1999 Georges Bank yellowtail flounder fishery.

U.S. Port Samples

quarter	large lengths	small lengths	total lengths	trips	ages
1	102	335	437	4	119
2	164	116	280	3	76
3	0	0	0	0	0
4	323	251	574	4	105
sum	589	702	1291	11	300

U.S. Sea Samples

quarter	kept lengths trawl trips	kept lengths dredge trips	discard lengths trawl trips	discard lengths dredge trips	total lengths	trips	ages
1	0	0	0	0	0	0	0
2	0	135	22	671	828	6	381
3	0	0	481	2148	2629	10	687
4	16	0	0	16	32	1	0
sum	16		503	2835	3489	17	1068

Canadian Port Samples

quarter	lengths	trips
3	2874	13
4	2070	9
sum	4944	22

Table 3.U.S. landings at age and mean weight at age of Georges Bank yellowtail flounder.

Landings at age (thousands)	Age								
Year	1	2	3	4	5	6	7	8+	Total
1973	0	3837	13076	9274	3743	1259	278	81	31548
1974	180	6297	7818	7397	3544	852	452	173	26713
1975	427	16851	6943	3391	2084	671	313	164	30844
1976	43	19320	5085	1347	532	434	287	147	27195
1977	31	6616	9805	1721	394	221	129	124	19041
1978	0	2140	3970	1660	459	102	37	35	8403
1979	17	6804	3396	1242	550	141	79	52	12281
1980	0	2371	8696	1419	321	85	4	10	12906
1981	6	479	5267	4555	796	122	4	0	11229
1982	217	13132	7061	3245	1031	62	19	3	24770
1983	239	7667	16016	2316	625	109	10	8	26990
1984	244	1913	4266	4734	1592	257	47	17	13070
1985	371	3335	816	652	410	60	5	0	5649
1986	90	5733	978	347	161	52	16	8	7385
1987	15	1819	2730	761	132	39	32	41	5569
1988	0	1650	1181	624	165	15	20	3	3658
1989	0	1337	664	262	68	11	8	0	2350
1990	0	735	4582	738	105	17	3	0	6180
1991	0	27	867	2256	289	56	4	0	3499
1992	0	3183	1891	1176	502	20	7	0	6779
1993	0	375	1538	1392	287	65	4	1	3662
1994	0	129	2614	853	253	40	8	1	3897
1995	0	12	272	281	70	3	11	3	651
1996	0	161	751	482	144	5	5	1	1550
1997	0	205	616	875	175	16	30	12	1929
1998	0	422	1625	1156	366	53	14	0	3636
1999	0	1217	1645	666	277	54	4	0	3864
mean	70	3991	4228	2030	707	179	68	33	11305

Landed weight at age (kg)	Age							
Year	1	2	3	4	5	6	7	8+
1973	0.198	0.375	0.464	0.527	0.603	0.689	1.067	1.136
1974	0.200	0.378	0.500	0.609	0.680	0.725	0.906	1.249
1975	0.211	0.340	0.492	0.554	0.618	0.687	0.688	0.649
1976	0.185	0.339	0.545	0.636	0.741	0.814	0.852	0.866
1977	0.197	0.364	0.527	0.634	0.782	0.865	1.036	1.013
1978	0.182	0.337	0.513	0.684	0.793	0.899	0.930	0.948
1979	0.139	0.356	0.462	0.649	0.728	0.835	1.003	0.882
1980	0.138	0.354	0.495	0.656	0.813	1.054	1.256	1.214
1981	0.091	0.389	0.493	0.603	0.707	0.798	0.832	1.044
1982	0.213	0.313	0.487	0.650	0.748	1.052	1.024	1.311
1983	0.215	0.296	0.440	0.604	0.736	0.952	1.018	0.987
1984	0.208	0.240	0.378	0.500	0.642	0.738	0.944	1.047
1985	0.236	0.363	0.497	0.647	0.733	0.819	0.732	1.044
1986	0.234	0.343	0.540	0.664	0.823	0.864	0.956	1.140
1987	0.212	0.338	0.523	0.666	0.680	0.938	0.793	0.788
1988		0.351	0.557	0.688	0.855	1.054	0.873	1.385
1989		0.355	0.543	0.725	0.883	1.026	1.254	1.044
1990		0.337	0.419	0.588	0.699	0.807	1.230	1.044
1991		0.270	0.383	0.484	0.728	0.820	1.306	1.044
1992		0.341	0.381	0.528	0.648	1.203	1.125	1.044
1993		0.316	0.390	0.510	0.562	0.858	1.263	1.044
1994		0.300	0.355	0.473	0.629	0.787	0.896	1.166
1995		0.309	0.379	0.465	0.583	0.778	0.785	0.531
1996		0.321	0.417	0.569	0.726	0.926	1.031	1.209
1997		0.353	0.416	0.525	0.668	0.867	0.920	1.217
1998		0.360	0.468	0.540	0.664	0.819	0.879	1.042
1999	0.271	0.401	0.503	0.636	0.717	0.836	0.850	1.104
mean	0.196	0.338	0.465	0.593	0.711	0.871	0.980	1.044

Table 4. Canadian catch at age (thousands) of Georges Bank yellowtail flounder.

	Age								
Year	1	2	3	4	5	6	7	8+	Total
1993	5	85	727	901	27	0	5	0	1750
1994	70	415	2890	1701	654	59	29	0	5818
1995	0	100	576	427	66	10	0	0	1179
1996	1	107	655	229	22	4	0	0	1018
1997	9	242	607	614	164	10	15	7	1668
1998	19	447	1086	642	254	29	6	0	2482
1999	12	1141	1295	776	349	76	19	0	3667
mean	17	190	1091	774	187	17	10	1	2287

Table 5. U.S. discards at age (above) and recent mean weights at age (below) of Georges Bank yellowtail flounder.

Discards at age (thousands)	Age								
Year	1	2	3	4	5	6	7	8+	Total
1973	347	1053	167	2	0	0	0	0	1569
1974	1963	2674	86	1	0	0	0	0	4724
1975	3945	8433	114	1	0	0	0	0	12493
1976	572	11692	61	0	0	0	0	0	12325
1977	299	1964	112	0	0	0	0	0	2375
1978	9659	965	64	0	0	0	0	0	10688
1979	216	2701	49	0	0	0	0	0	2966
1980	309	1201	125	0	0	0	0	0	1635
1981	49	250	84	1	0	0	0	0	384
1982	1846	4359	61	1	0	0	0	0	6267
1983	457	22	0	0	0	0	0	0	479
1984	184	4	0	0	0	0	0	0	188
1985	279	10	0	0	0	0	0	0	289
1986	68	38	0	0	0	0	0	0	106
1987	125	834	21	0	0	0	0	0	980
1988	483	717	10	0	0	0	0	0	1210
1989	185	179	4	0	0	0	0	0	368
1990	219	1196	1541	62	2	0	0	0	3020
1991	412	27	355	174	4	0	0	0	972
1992	2389	5176	636	93	8	0	0	0	8302
1993	5189	549	512	99	4	0	0	0	6353
1994	1	317	238	17	3	0	0	0	577
1995	14	45	47	7	0	0	0	0	114
1996	49	115	103	6	0	0	0	0	273
1997	7	148	35	13	1	0	0	0	205
1998	7	102	81	26	4	0	0	0	220
1999	9	930	270	56	25	6	2	0	1298
mean	1085	1693	177	21	2	0	0	0	3154

Discarded weight at age (kg)	Age							
Year	1	2	3	4	5	6	7	8+
1994	0.130	0.238	0.287	0.417	0.512	0.622	----	----
1995	0.155	0.233	0.283	0.357	0.496	0.593	----	0.531
1996	0.137	0.266	0.312	0.418	----	----	----	----
1997	0.162	0.250	0.315	0.442	0.544	0.671	0.792	0.895
1998	0.190	0.280	0.380	0.450	0.590	0.700	0.760	----
1999	0.227	0.332	0.414	0.606	0.759	0.889	0.910	1.104
mean	0.167	0.267	0.332	0.448	0.580	0.695	0.821	0.843

Table 6. Total catch at age (thousands) of Georges Bank yellowtail flounder.

	Age							
Year	1	2	3	4	5	6	7	8+
1973	347	4890	13243	9276	3743	1259	278	81
1974	2143	8971	7904	7398	3544	852	452	173
1975	4372	25284	7057	3392	2084	671	313	164
1976	615	31012	5146	1347	532	434	287	147
1977	330	8580	9917	1721	394	221	129	124
1978	9659	3105	4034	1660	459	102	37	35
1979	233	9505	3445	1242	550	141	79	52
1980	309	3572	8821	1419	321	85	4	10
1981	55	729	5351	4556	796	122	4	0
1982	2063	17491	7122	3246	1031	62	19	3
1983	696	7689	16016	2316	625	109	10	8
1984	428	1917	4266	4734	1592	257	47	17
1985	650	3345	816	652	410	60	5	0
1986	158	5771	978	347	161	52	16	8
1987	140	2653	2751	761	132	39	32	41
1988	483	2367	1191	624	165	15	20	3
1989	185	1516	668	262	68	11	8	0
1990	219	1931	6123	800	107	17	3	0
1991	412	54	1222	2430	293	56	4	0
1992	2389	8359	2527	1269	510	20	7	0
1993	5194	1009	2777	2392	318	65	9	1
1994	71	861	5742	2571	910	99	37	1
1995	14	157	895	715	137	13	11	4
1996	50	383	1509	716	167	9	5	1
1997	16	595	1258	1502	341	26	45	19
1998	26	971	2792	1824	624	82	20	0
1999	21	3287	3209	1498	651	137	25	0
mean	1249	6070	4831	2294	776	192	74	36

Table 7a. Survey indices of Georges Bank yellowtail abundance and biomass.

NEFSC Spring Survey	Age									
Year	1	2	3	4	5	6	7	8+	Total	kg/tow
1968	0.149	3.364	3.579	0.316	0.084	0.160	0.127	0.000	7.779	2.813
1969	1.015	9.406	11.119	3.096	1.423	0.454	0.188	0.057	26.758	11.170
1970	0.093	4.485	6.030	2.422	0.570	0.121	0.190	0.000	13.911	5.312
1971	0.791	3.335	4.620	3.754	0.759	0.227	0.050	0.029	13.564	4.607
1972	0.138	7.136	7.198	3.514	1.094	0.046	0.122	0.000	19.247	6.450
1973	1.931	3.266	2.368	1.063	0.410	0.173	0.023	0.020	9.254	2.938
1974	0.316	2.224	1.842	1.256	0.346	0.187	0.085	0.009	6.265	2.719
1975	0.420	2.939	0.860	0.298	0.208	0.068	0.000	0.013	4.806	1.676
1976	1.034	4.368	1.247	0.311	0.196	0.026	0.048	0.037	7.268	2.273
1977	0.000	0.671	1.125	0.384	0.074	0.013	0.000	0.000	2.267	0.999
1978	0.936	0.798	0.507	0.219	0.026	0.000	0.008	0.000	2.494	0.742
1979	0.279	1.933	0.385	0.328	0.059	0.046	0.041	0.000	3.072	1.227
1980	0.057	4.644	5.761	0.473	0.057	0.037	0.000	0.000	11.030	4.456
1981	0.012	1.027	1.779	0.721	0.205	0.061	0.000	0.026	3.830	1.960
1982	0.045	3.742	1.122	1.016	0.455	0.065	0.000	0.026	6.472	2.500
1983	0.000	1.865	2.728	0.531	0.123	0.092	0.061	0.092	5.492	2.642
1984	0.000	0.093	0.809	0.885	0.834	0.244	0.000	0.000	2.865	1.646
1985	0.110	2.198	0.262	0.282	0.148	0.000	0.000	0.000	3.000	0.988
1986	0.027	1.806	0.291	0.056	0.137	0.055	0.000	0.000	2.372	0.847
1987	0.000	0.128	0.112	0.133	0.053	0.055	0.000	0.000	0.480	0.329
1988	0.078	0.275	0.366	0.242	0.199	0.027	0.000	0.000	1.187	0.566
1989	0.047	0.424	0.740	0.290	0.061	0.022	0.022	0.000	1.605	0.729
1990	0.000	0.065	1.108	0.393	0.139	0.012	0.045	0.000	1.762	0.699
1991	0.435	0.000	0.254	0.675	0.274	0.020	0.000	0.000	1.659	0.631
1992	0.000	2.010	1.945	0.598	0.189	0.000	0.000	0.000	4.742	1.566
1993	0.046	0.290	0.500	0.317	0.027	0.000	0.000	0.000	1.180	0.482
1994	0.000	0.621	0.638	0.357	0.145	0.043	0.000	0.000	1.804	0.660
1995	0.040	1.180	4.810	1.490	0.640	0.010	0.000	0.000	8.170	2.579
1996	0.030	0.990	2.630	2.700	0.610	0.060	0.000	0.000	7.020	2.853
1997	0.019	1.169	3.733	4.081	0.703	0.134	0.000	0.000	9.837	4.359
1998	0.000	2.081	1.053	1.157	0.759	0.323	0.027	0.000	5.400	2.324
1999	0.050	4.746	10.820	2.720	1.623	0.426	0.329	0.024	20.738	9.307
mean	0.253	2.323	2.647	1.146	0.406	0.103	0.045	0.011	6.934	2.739

Table 7b. Survey indices of Georges Bank yellowtail abundance and biomass.

NEFSC Fall Survey

	Age										
Year	0	1	2	3	4	5	6	7	8+	Total	kg/tow
1963	0.000	14.722	7.896	11.226	1.858	0.495	0.281	0.034	0.233	36.746	12.791
1964	0.000	1.721	9.723	7.370	5.998	2.690	0.383	0.095	0.028	28.007	13.625
1965	0.014	1.138	5.579	5.466	3.860	1.803	0.162	0.284	0.038	18.345	9.104
1966	1.177	8.772	4.776	2.070	0.837	0.092	0.051	0.000	0.000	17.775	3.989
1967	0.106	9.137	9.313	2.699	1.007	0.309	0.076	0.061	0.000	22.708	7.577
1968	0.000	11.782	11.946	5.758	0.766	0.944	0.059	0.000	0.000	31.254	10.535
1969	0.135	8.106	10.381	5.855	1.662	0.553	0.149	0.182	0.000	27.023	9.278
1970	1.048	4.610	5.133	3.144	1.952	0.451	0.063	0.017	0.000	16.417	4.978
1971	0.025	3.627	6.949	4.904	2.248	0.551	0.234	0.024	0.024	18.586	6.362
1972	0.785	2.424	6.525	4.824	2.095	0.672	0.279	0.000	0.000	17.604	6.328
1973	0.094	2.494	5.497	5.104	2.944	1.216	0.416	0.171	0.031	17.967	6.600
1974	1.030	4.623	2.854	1.524	1.060	0.460	0.249	0.131	0.000	11.931	3.734
1975	0.361	4.625	2.511	0.877	0.572	0.334	0.033	0.000	0.031	9.344	2.365
1976	0.000	0.336	1.929	0.475	0.117	0.122	0.033	0.000	0.067	3.079	1.533
1977	0.000	0.928	2.161	1.649	0.618	0.113	0.056	0.036	0.016	5.577	2.828
1978	0.037	4.729	1.272	0.773	0.406	0.139	0.011	0.000	0.024	7.391	2.383
1979	0.018	1.312	1.999	0.316	0.122	0.138	0.038	0.064	0.007	4.014	1.520
1980	0.078	0.761	5.086	6.050	0.678	0.217	0.162	0.006	0.033	13.071	6.722
1981	0.000	1.584	2.333	1.630	0.500	0.121	0.083	0.013	0.000	6.264	2.621
1982	0.000	2.424	2.185	1.590	0.423	0.089	0.000	0.000	0.000	6.711	2.271
1983	0.000	0.109	2.284	1.914	0.473	0.068	0.012	0.000	0.038	4.898	2.131
1984	0.012	0.661	0.400	0.306	2.428	0.090	0.029	0.000	0.018	3.944	0.593
1985	0.010	1.350	0.560	0.160	0.040	0.080	0.000	0.000	0.000	2.200	0.709
1986	0.000	0.280	1.110	0.350	0.070	0.000	0.000	0.000	0.000	1.810	0.820
1987	0.000	0.113	0.390	0.396	0.053	0.079	0.000	0.000	0.000	1.031	0.509
1988	0.011	0.019	0.213	0.102	0.031	0.000	0.000	0.000	0.000	0.376	0.171
1989	0.027	0.248	1.992	0.774	0.069	0.066	0.000	0.000	0.000	3.176	0.977
1990	0.147	0.000	0.326	1.517	0.280	0.014	0.000	0.000	0.000	2.284	0.725
1991	0.000	2.100	0.275	0.439	0.358	0.000	0.000	0.000	0.000	3.172	0.730
1992	0.000	0.151	0.396	0.712	0.162	0.144	0.027	0.000	0.000	1.592	0.576
1993	0.000	0.842	0.136	0.587	0.536	0.000	0.000	0.000	0.000	2.101	0.545
1994	0.010	1.200	0.220	0.980	0.710	0.260	0.030	0.030	0.000	3.440	0.897
1995	0.070	0.280	0.120	0.350	0.280	0.050	0.010	0.000	0.000	1.160	0.354
1996	0.000	0.140	0.350	1.870	0.450	0.070	0.000	0.000	0.000	2.880	1.303
1997	0.000	1.392	0.533	3.442	2.090	1.071	0.082	0.000	0.000	8.611	3.781
1998	0.050	1.900	4.817	4.202	1.190	0.298	0.055	0.019	0.000	12.531	4.347
1999	0.025	3.090	8.423	5.727	1.432	1.436	0.260	0.000	0.000	20.394	7.973
mean	0.142	2.803	3.475	2.625	1.091	0.412	0.090	0.032	0.016	10.687	3.900

Table 7c. Survey indices of Georges Bank yellowtail abundance and biomass.

Canadian Survey

	Age							
Year	1	2	3	4	5	6+	Total	kg/tow
1987	0.12	0.68	2.00	1.09	0.06	0.00	3.95	1.26
1988	0.00	0.66	1.89	0.80	0.59	0.01	3.96	1.24
1989	0.11	0.78	0.80	0.32	0.10	0.02	2.13	0.47
1990	0.00	1.27	4.62	1.12	0.43	0.01	7.45	1.58
1991	0.02	0.59	1.72	2.91	0.99	0.00	6.24	1.76
1992	0.22	10.04	4.52	1.21	0.16	0.00	16.14	2.48
1993	0.33	2.16	5.04	3.47	0.62	0.00	11.63	2.64
1994	0.00	6.03	3.33	3.08	0.75	0.33	13.51	2.75
1995	0.21	1.31	4.07	2.22	1.14	0.11	9.07	2.03
1996	0.45	5.54	8.44	7.49	1.37	0.16	23.45	5.30
1997	0.10	9.48	15.16	19.09	3.11	0.54	47.49	13.29
1998	0.92	3.10	3.81	5.15	2.44	0.59	16.01	4.29
1999	0.22	13.05	24.78	9.07	6.85	3.10	57.07	17.67
2000	0.06	8.43	43.32	7.20	6.73	3.48	69.22	19.95
mean	0.20	4.41	8.12	4.97	2.25	0.58	20.52	4.29

Scallop Survey

Year	age-1
1982	0.313
1983	0.140
1984	0.233
1985	0.549
1986	0.103
1987	0.047
1988	0.116
1989	0.195
1990	0.100
1991	2.117
1992	0.167
1993	1.129
1994	1.503
1995	0.609
1996	0.508
1997	1.062
1998	1.872
1999	1.038
mean	0.656

Table 8. Deterministic projection input assumptions and results for Georges Bank yellowtail for 2000 at F0.1 using bias adjusted population abundance at the beginning of 2000.

Year	Age Group								
	1	2	3	4	5	6+	1+	2+	3+
Beginning of Year Population Numbers (000s)									
2001	40000	32749	24323	36373	9825	9231			
Partial Recruitment to the Fishery									
2000	0	0.2	0.67	1	1	1			
Fishing Mortality									
2000	0	0.05	0.168	0.25	0.25	0.25			
Weight at beginning of year for population (kg)									
2000	0.05	0.18	0.37	0.49	0.61	0.9			
2001	0.05	0.18	0.37	0.49	0.61	0.9			
Beginning of Year Population Biomass (t)									
2000	2000	5622	19435	7550	5725	4584	44915	42915	37293
2001	2160	5895	8951	17932	6023	8345	49305	47145	41250
Projected Catch Numbers (000s)									
2000	0	1382	7363	3102	1889	1025			
Average weight for catch (kg)									
2000	0.1	0.32	0.45	0.58	0.7	0.9			
Projected Yield (t)									
2000	0	448	3306	1796	1313	927	7789		

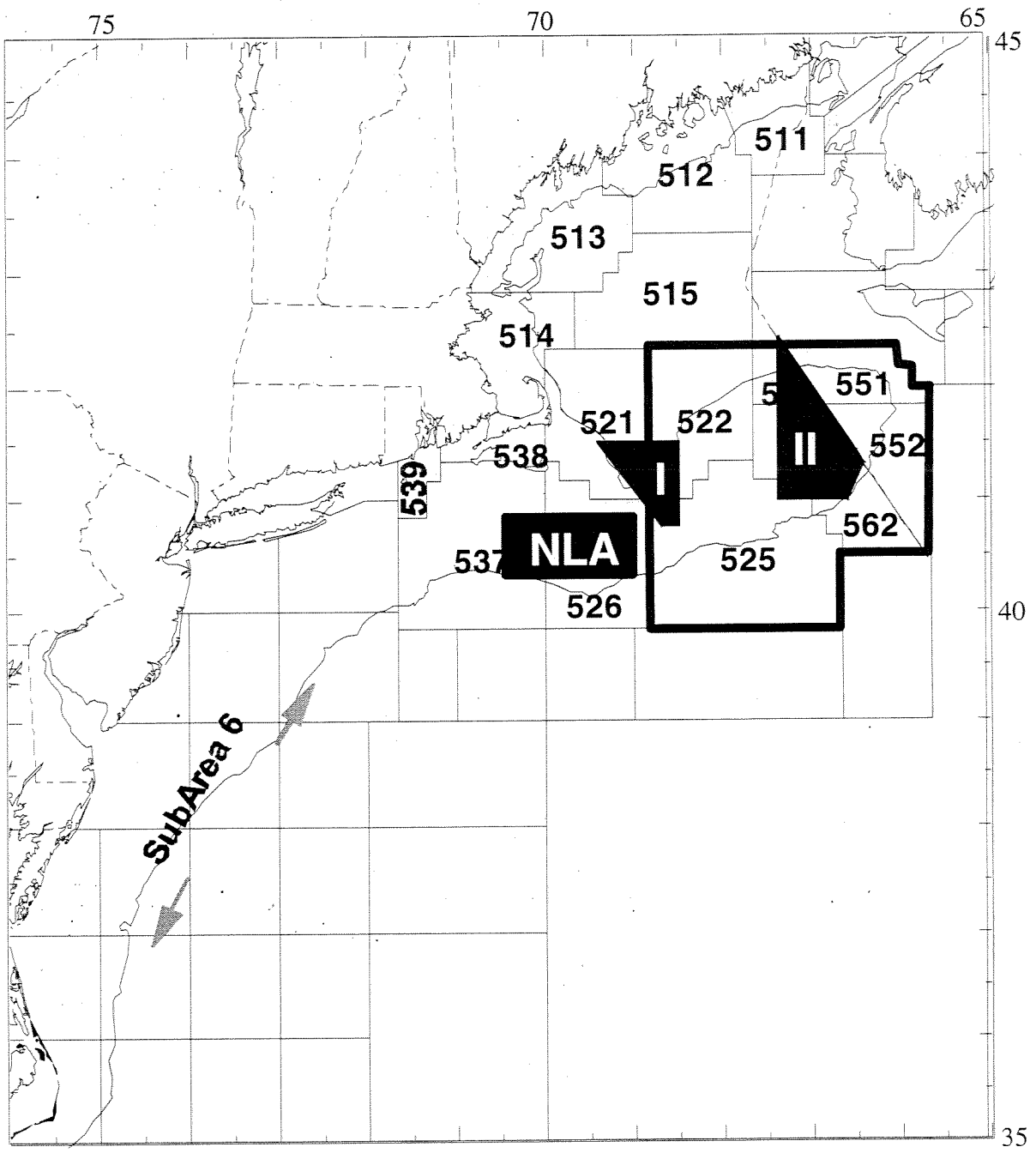


Figure 1a. Statistical areas used for monitoring northeast U.S. fisheries. Catches from areas 522, 525, 551, 552, 561, 562 (enclosed in bold line) are included in the Georges Bank yellowtail flounder assessment. Shaded areas have been closed to fishing year-round since 1994, with exceptions.

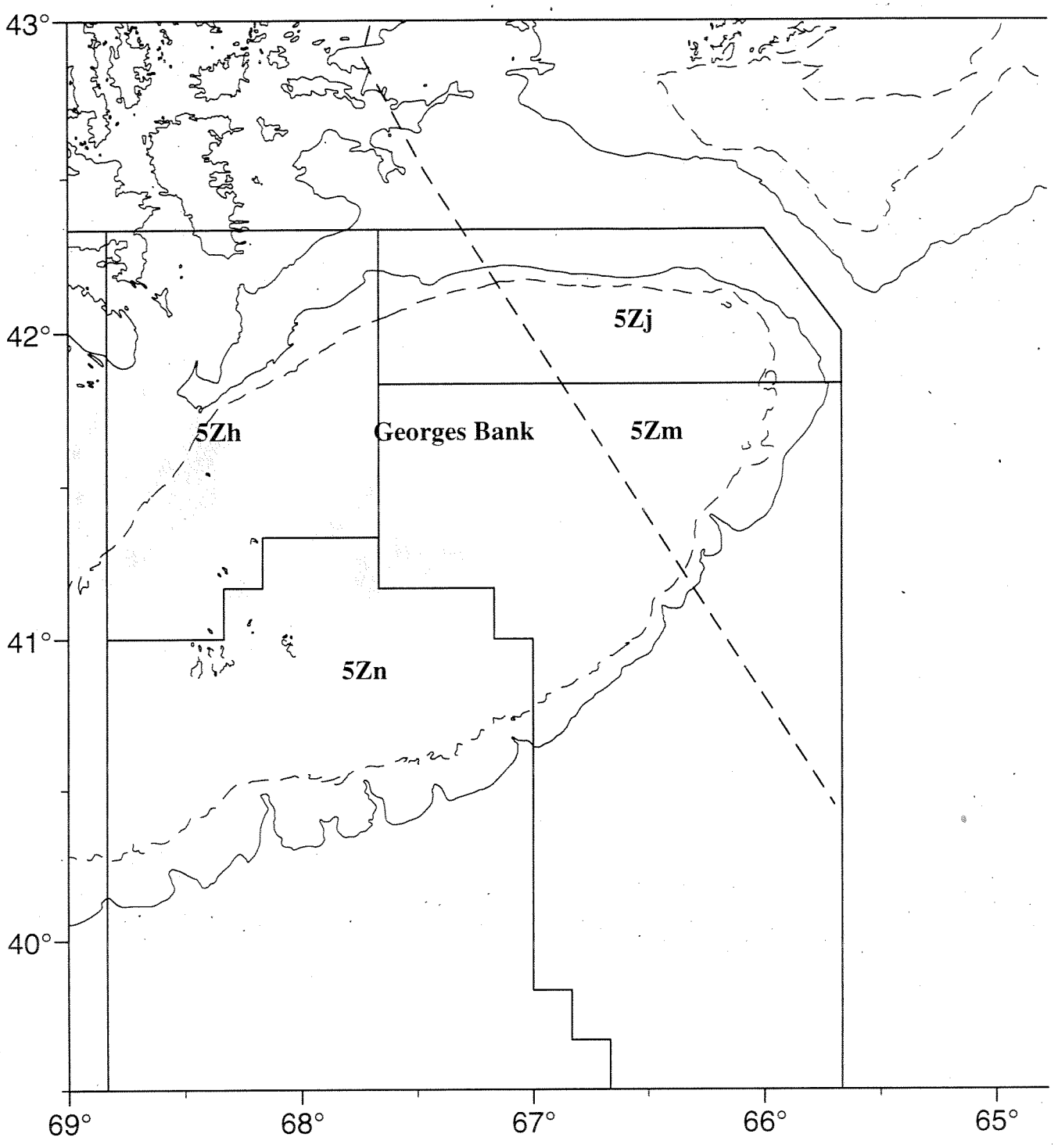


Figure 1b. Statistical areas used for monitoring Canadian fisheries. Catches from areas 5Zj, 5Zm, 5Zn, and 5Zh (enclosed in bold line) are included in the Georges Bank yellowtail flounder assessment.

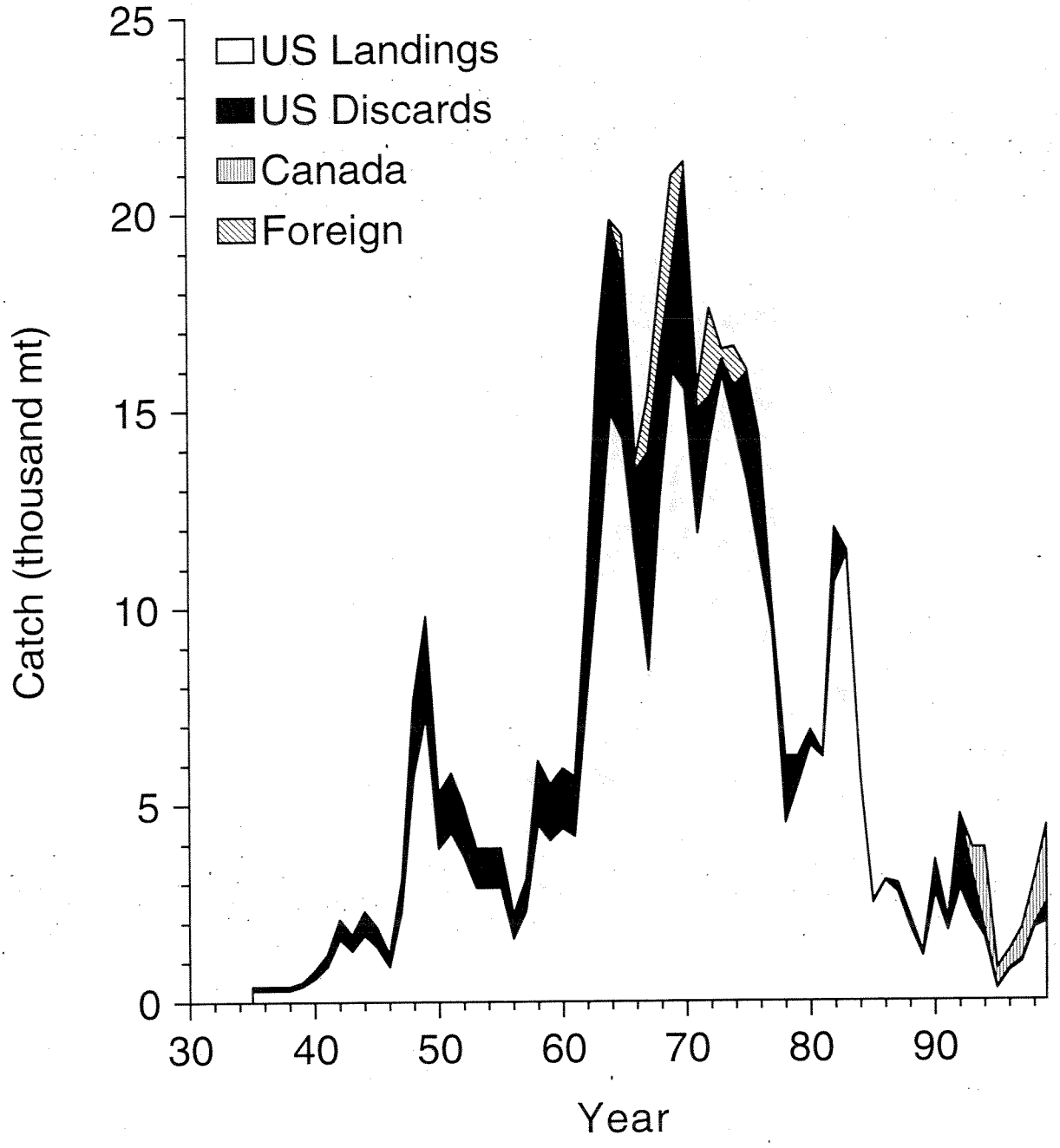


Figure 2. Total catch of Georges Bank yellowtail flounder.

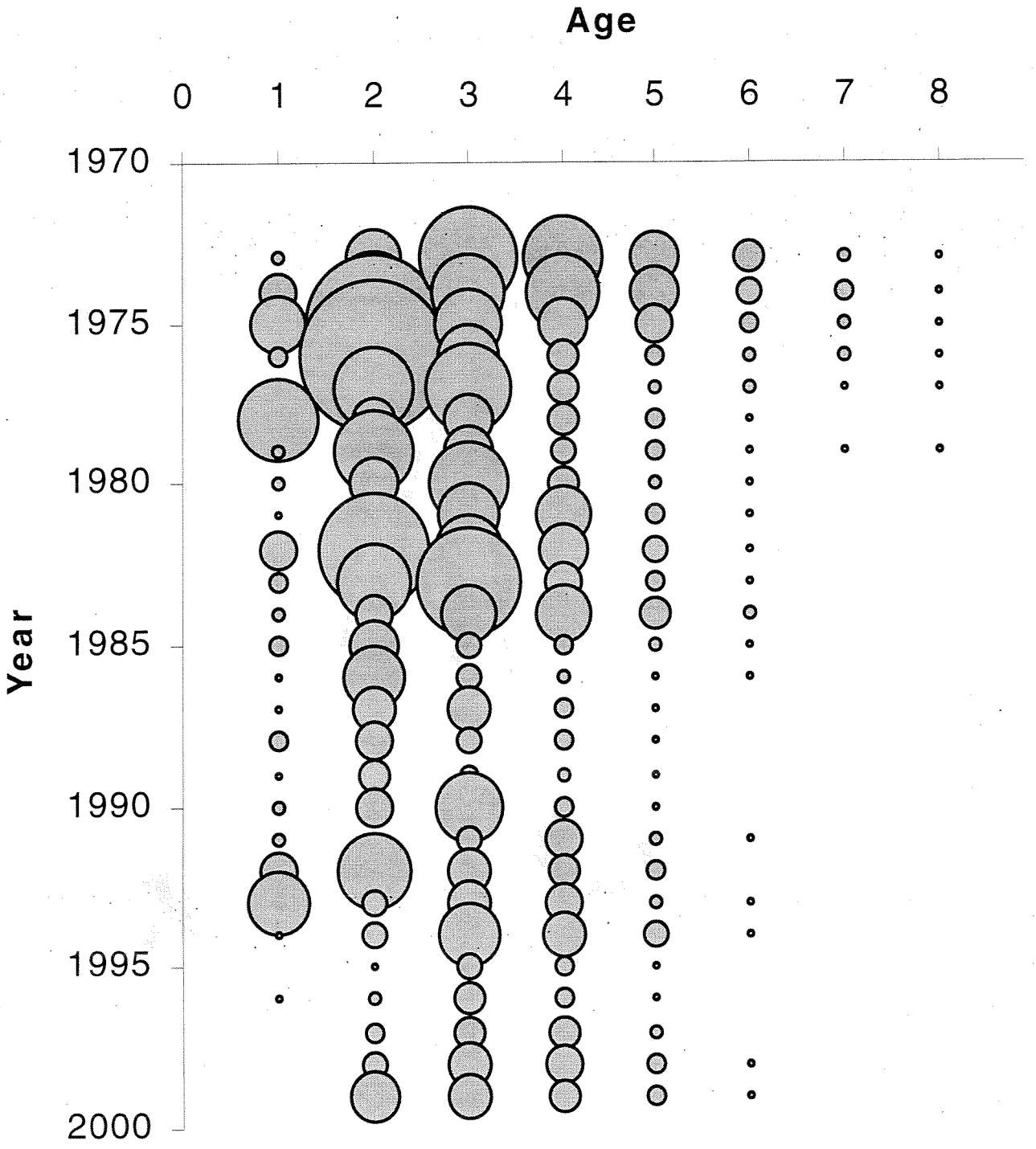


Figure 3. Georges Bank yellowtail flounder catch at age (circle size represents relative magnitude in the entire time series).

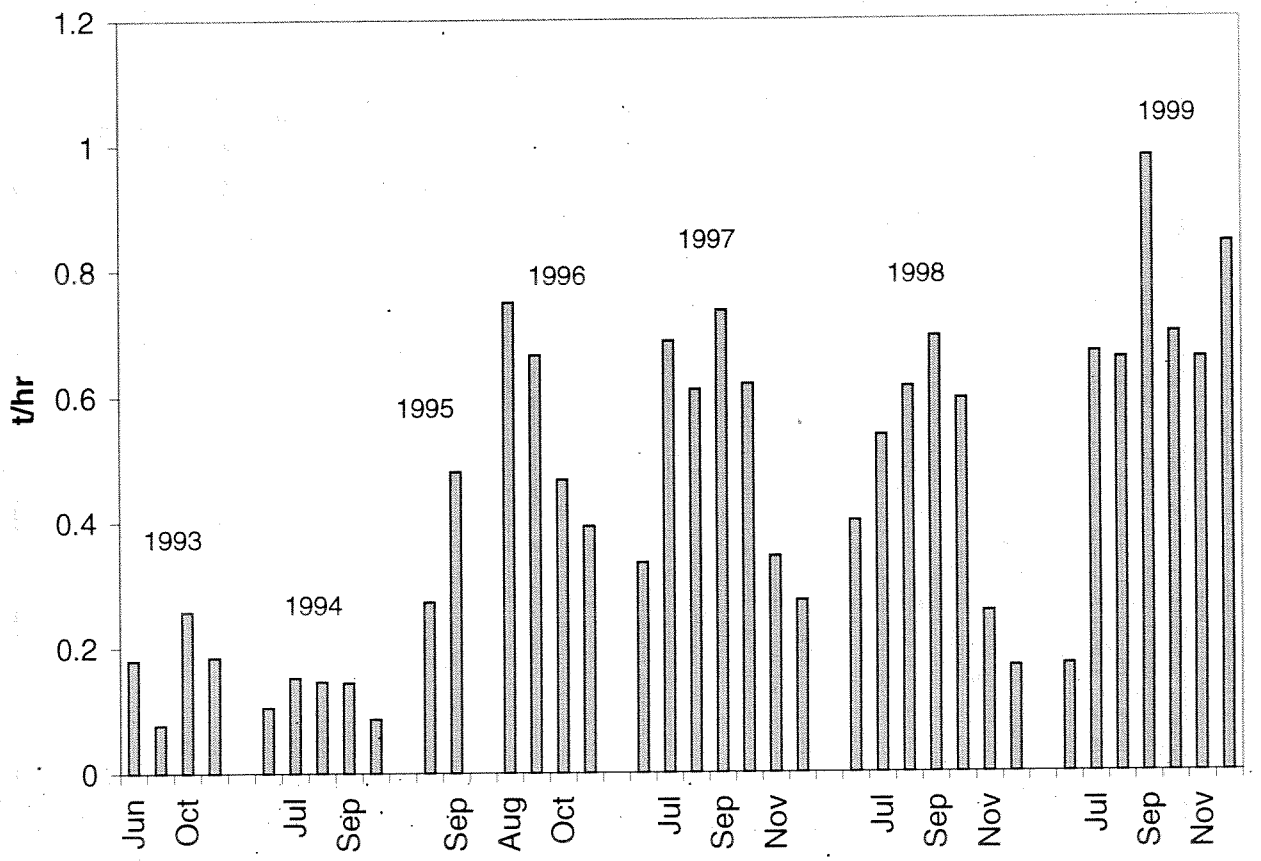


Figure 4. Monthly catch rates of Georges Bank yellowtail flounder by stern trawlers (TC 2-3) in 5Zm, 1993-1998.

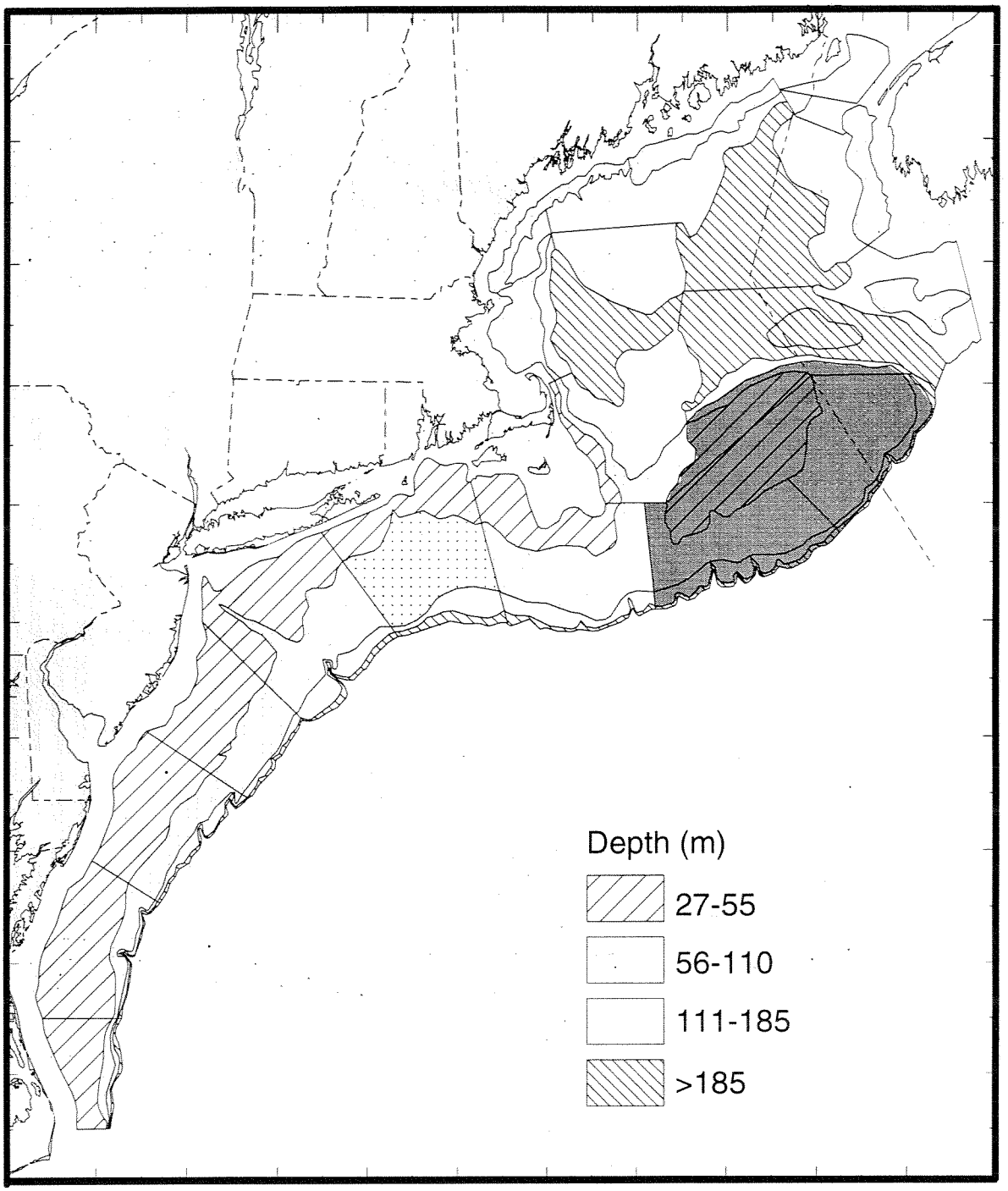


Figure 5. NEFSC groundfish survey strata. Strata 13-21 (shaded) are included in the Georges Bank yellowtail flounder assessment.

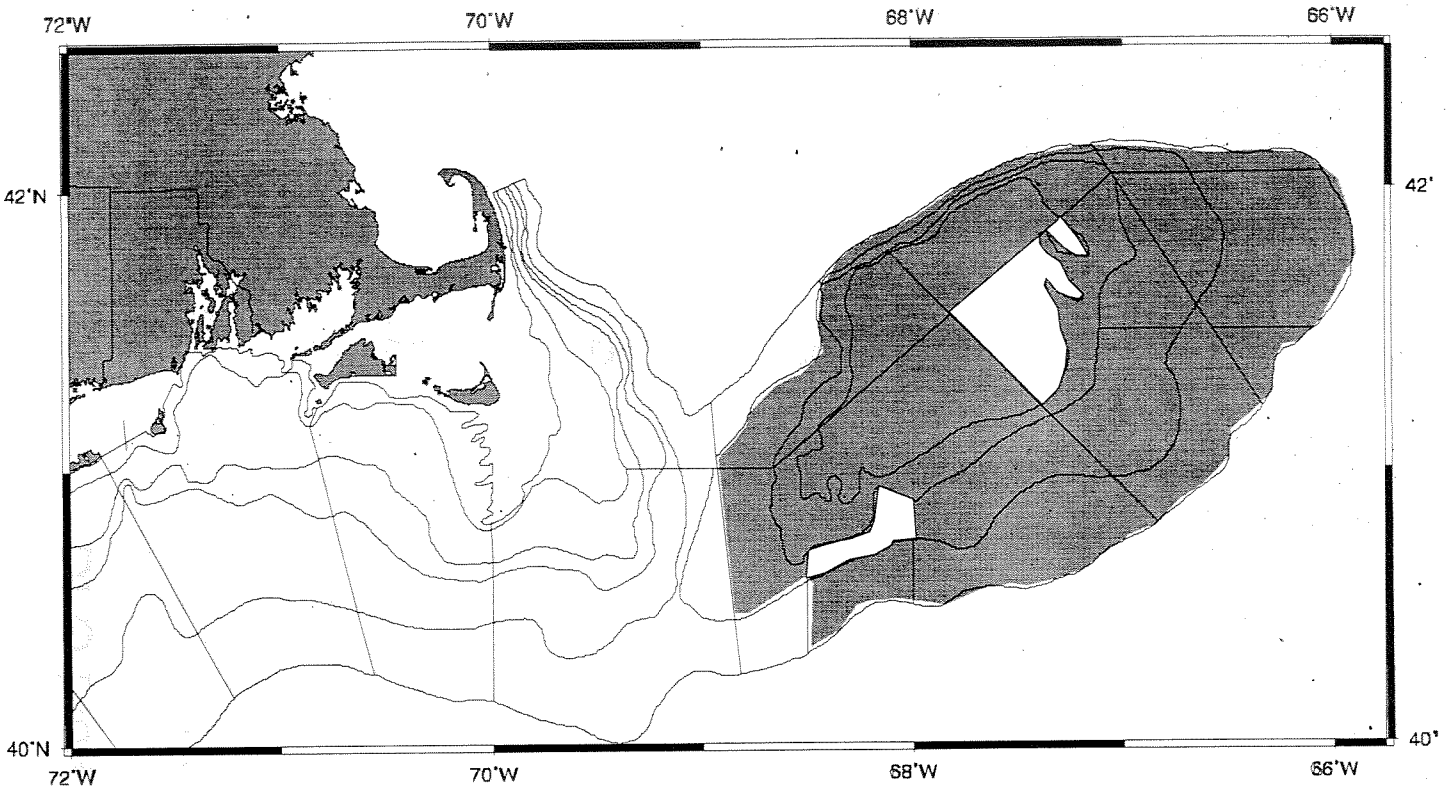


Figure 6. NEFSC scallop survey strata. Shaded strata (54, 55, 58-72, 74) are included in the Georges Bank yellowtail flounder assessment.

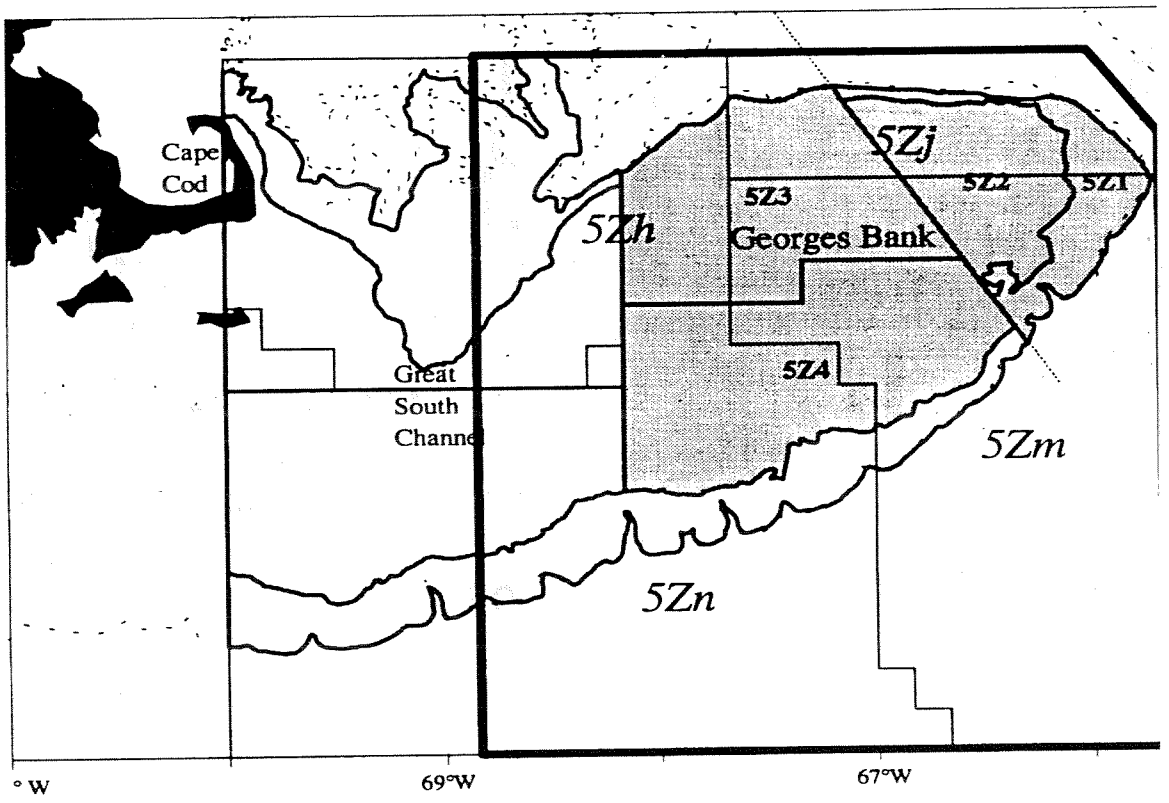


Figure 7. Canada DFO groundfish survey strata. Shaded strata are included in the Georges Bank yellowtail flounder assessment.

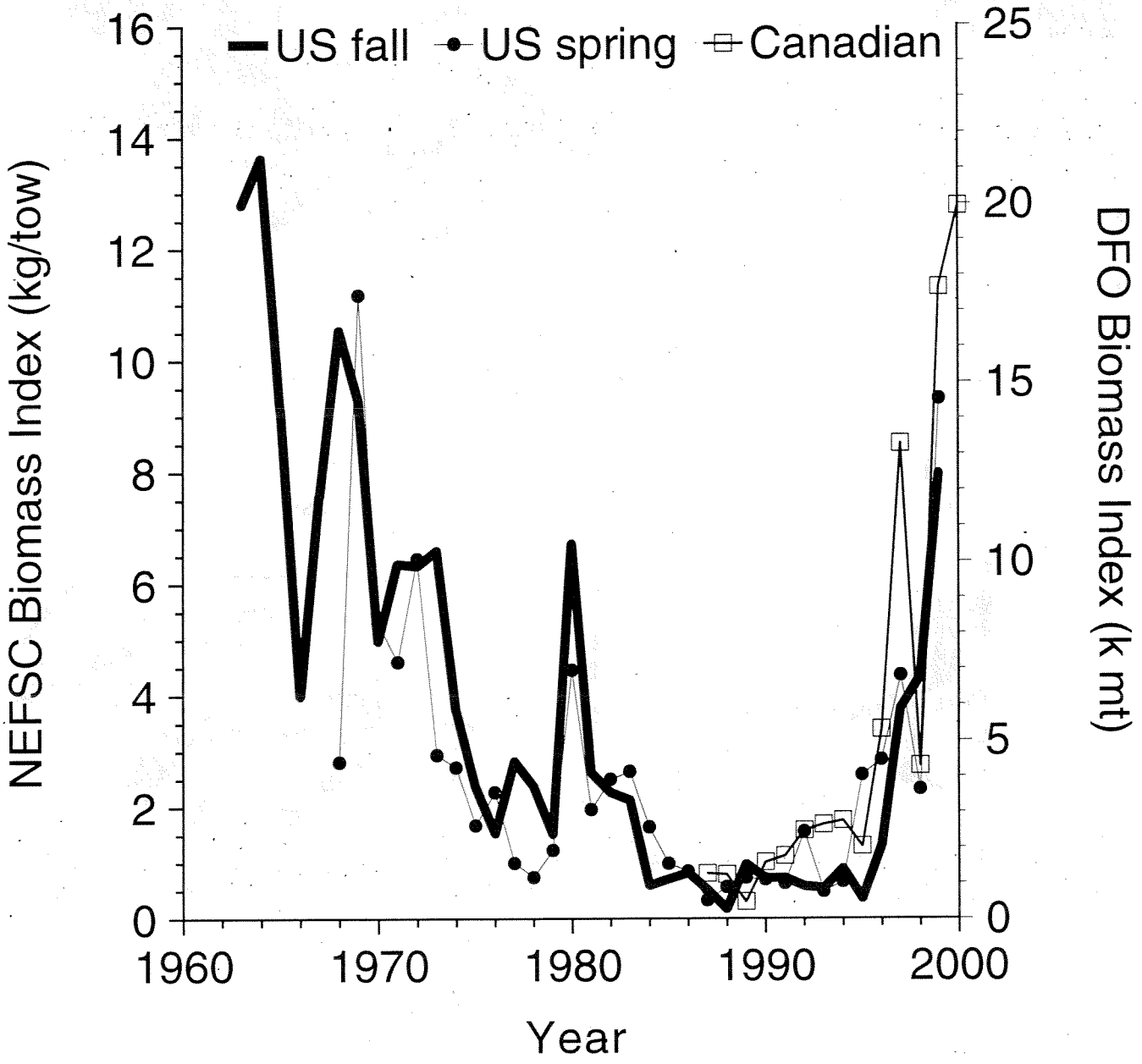


Figure 8. Survey indices of Georges Bank yellowtail flounder biomass.

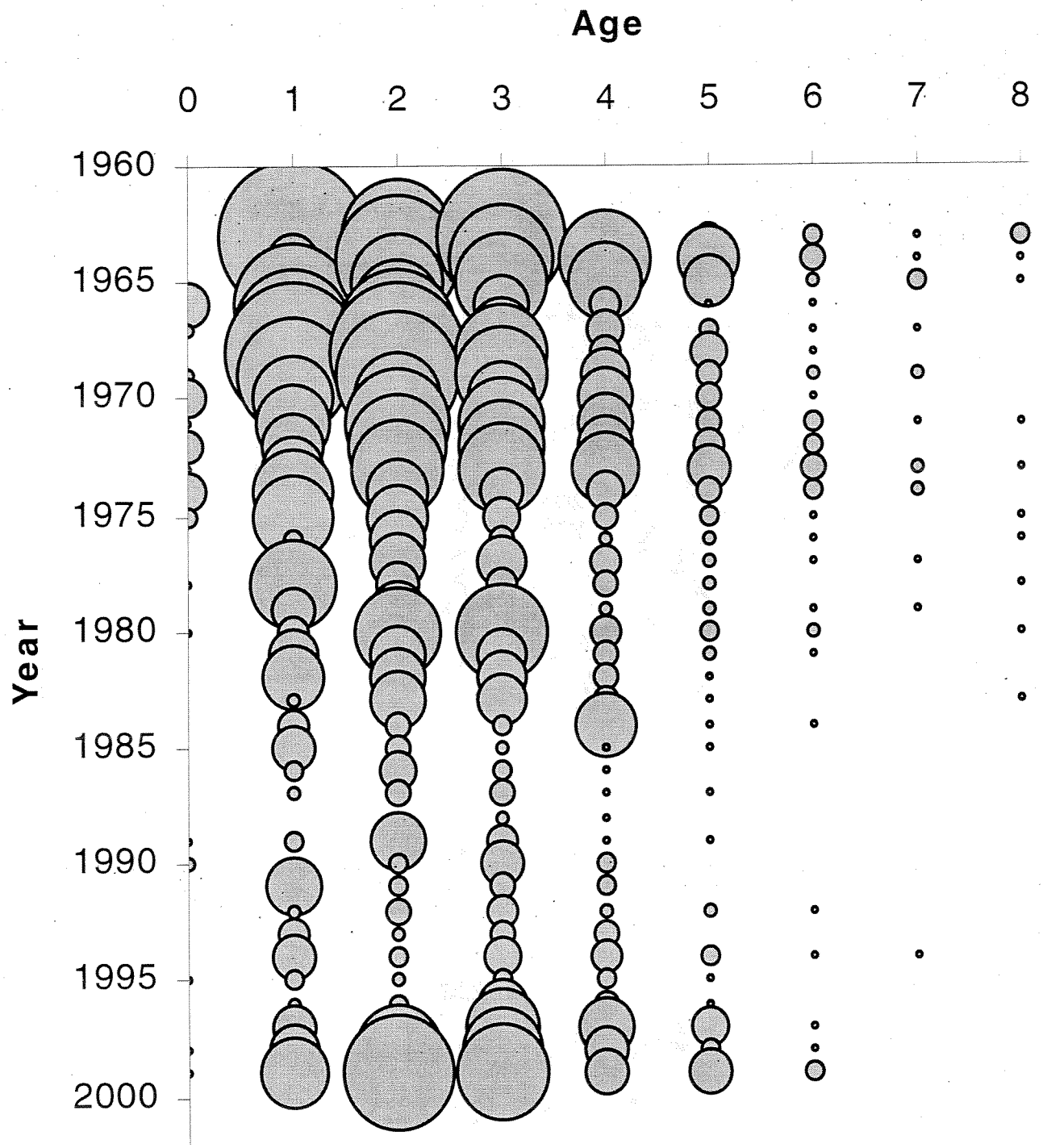


Figure 9. Indices of Georges Bank yellowtail flounder abundance at age (circle size represents relative magnitude in the entire time series).

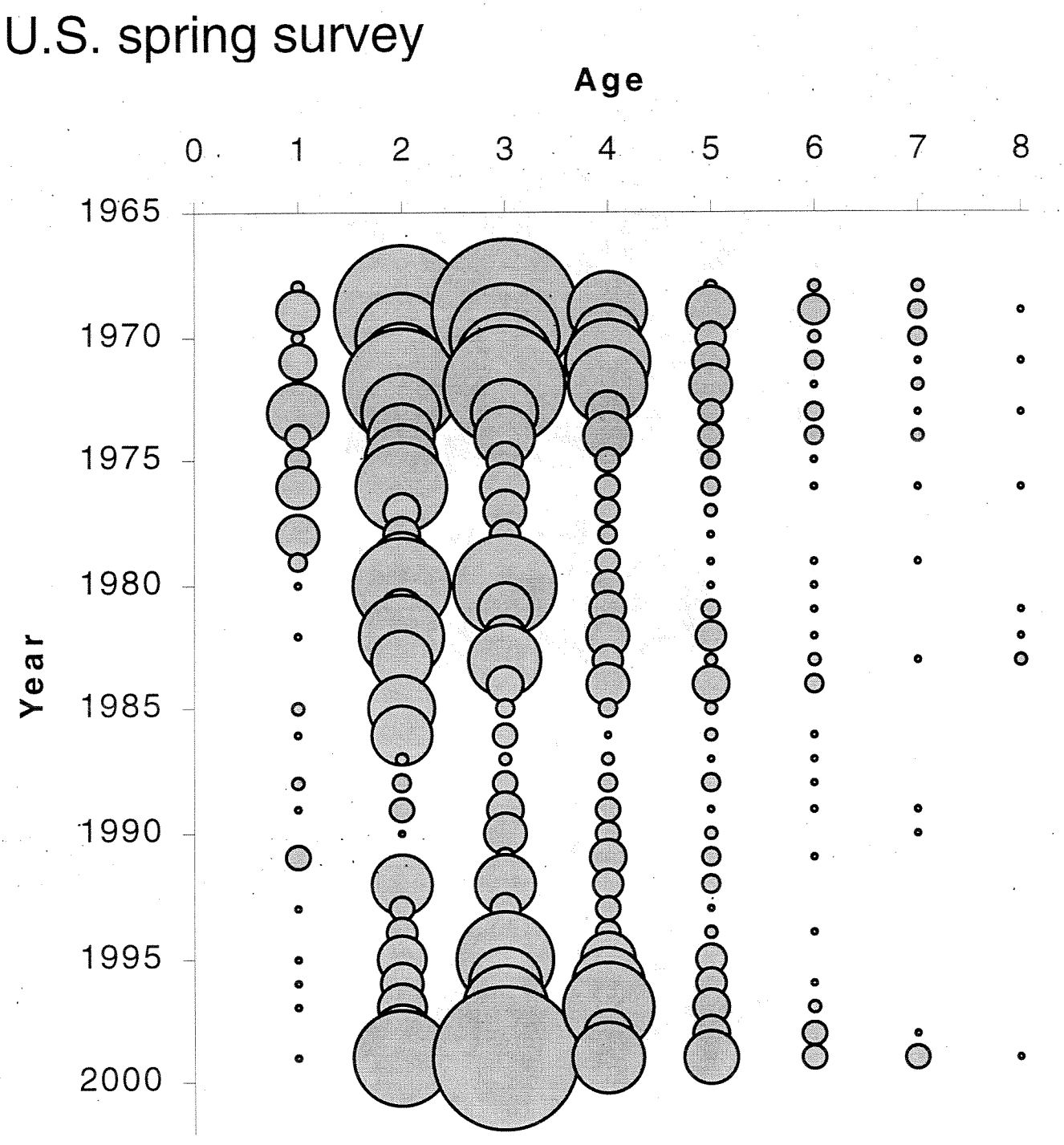


Figure 9 (cont.) Indices of Georges Bank yellowtail flounder abundance at age (circle size represents relative magnitude in the entire time series).

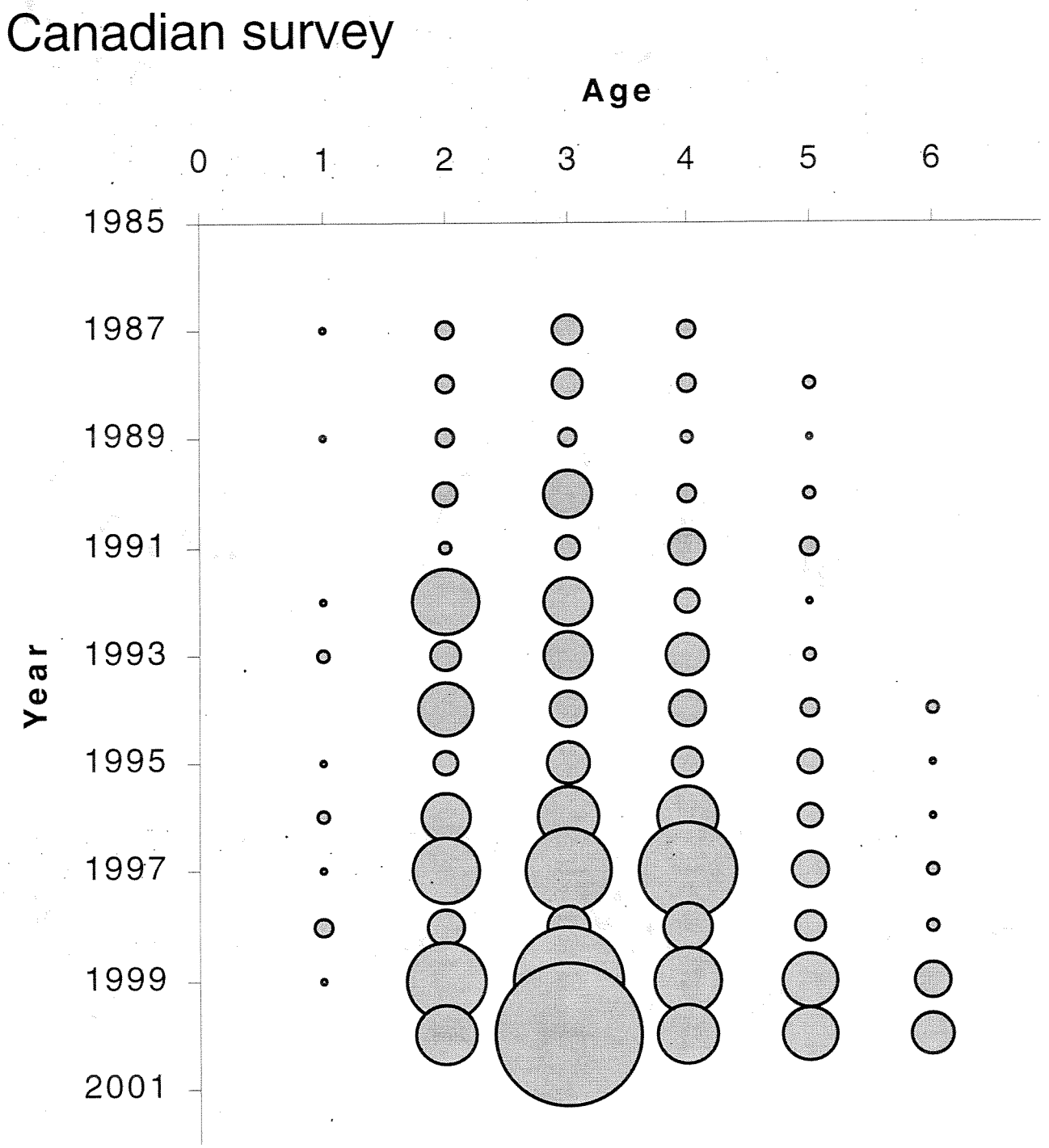


Figure 9 (cont.) Indices of Georges Bank yellowtail flounder abundance at age (circle size represents relative magnitude in the entire time series).

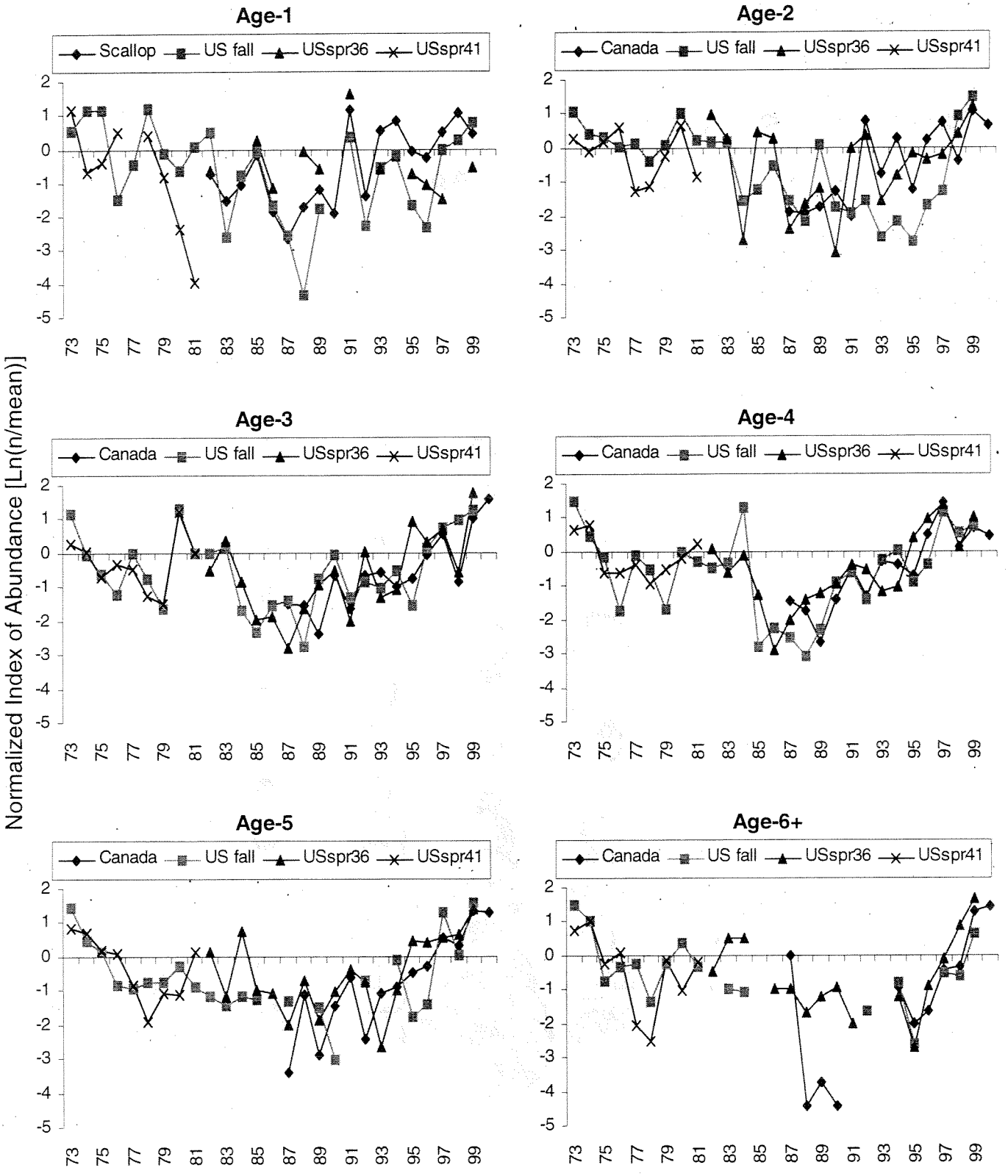


Figure 10. Survey indices of abundance for Georges Bank yellowtail flounder by age.

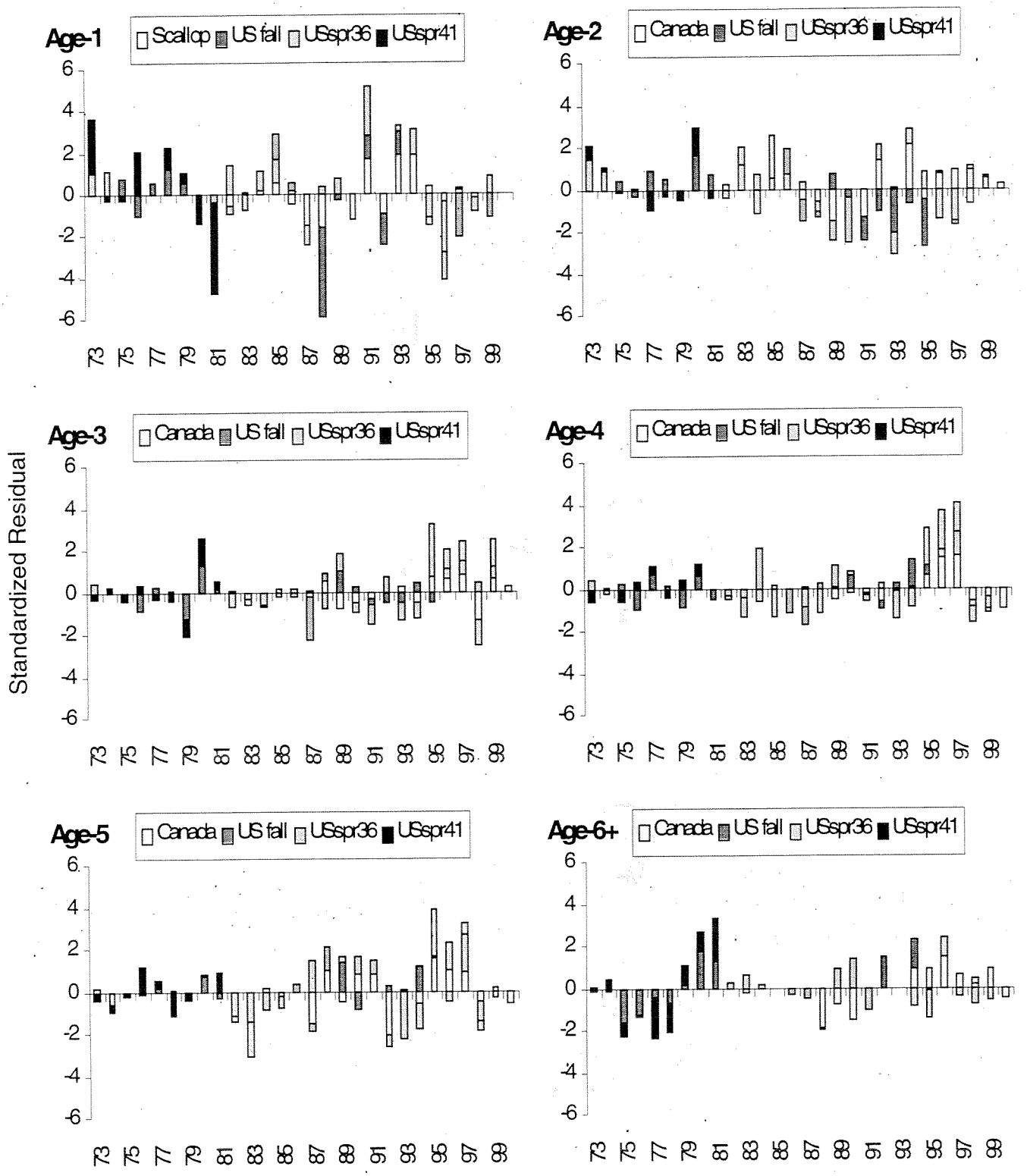


Figure 11. ADAPT residuals for VPA calibration of Georges Bank yellowtail flounder.

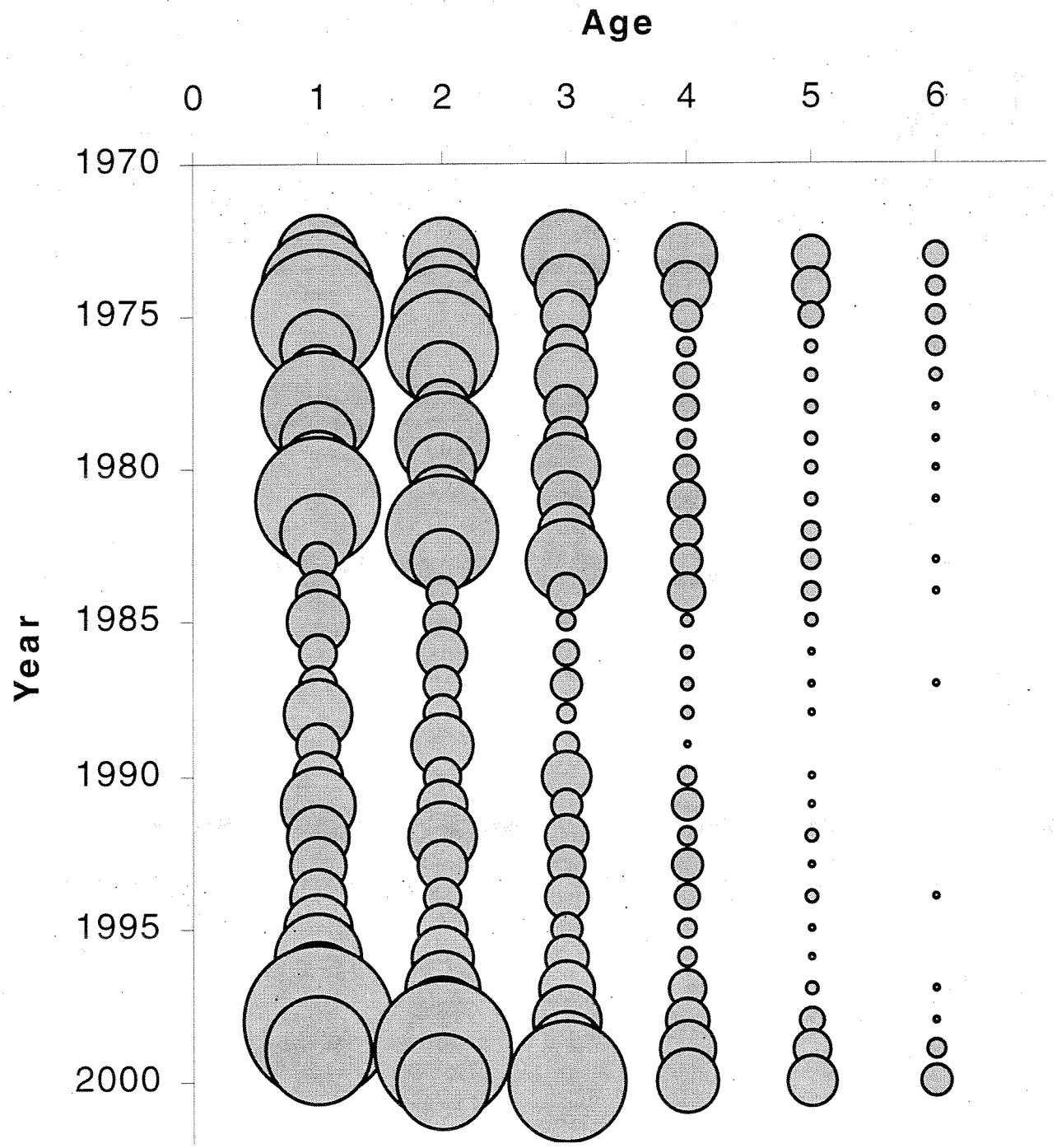


Figure 12. ADAPT VPA estimates of Georges Bank yellowtail flounder abundance at age (circle size represents relative magnitude in the entire time series).

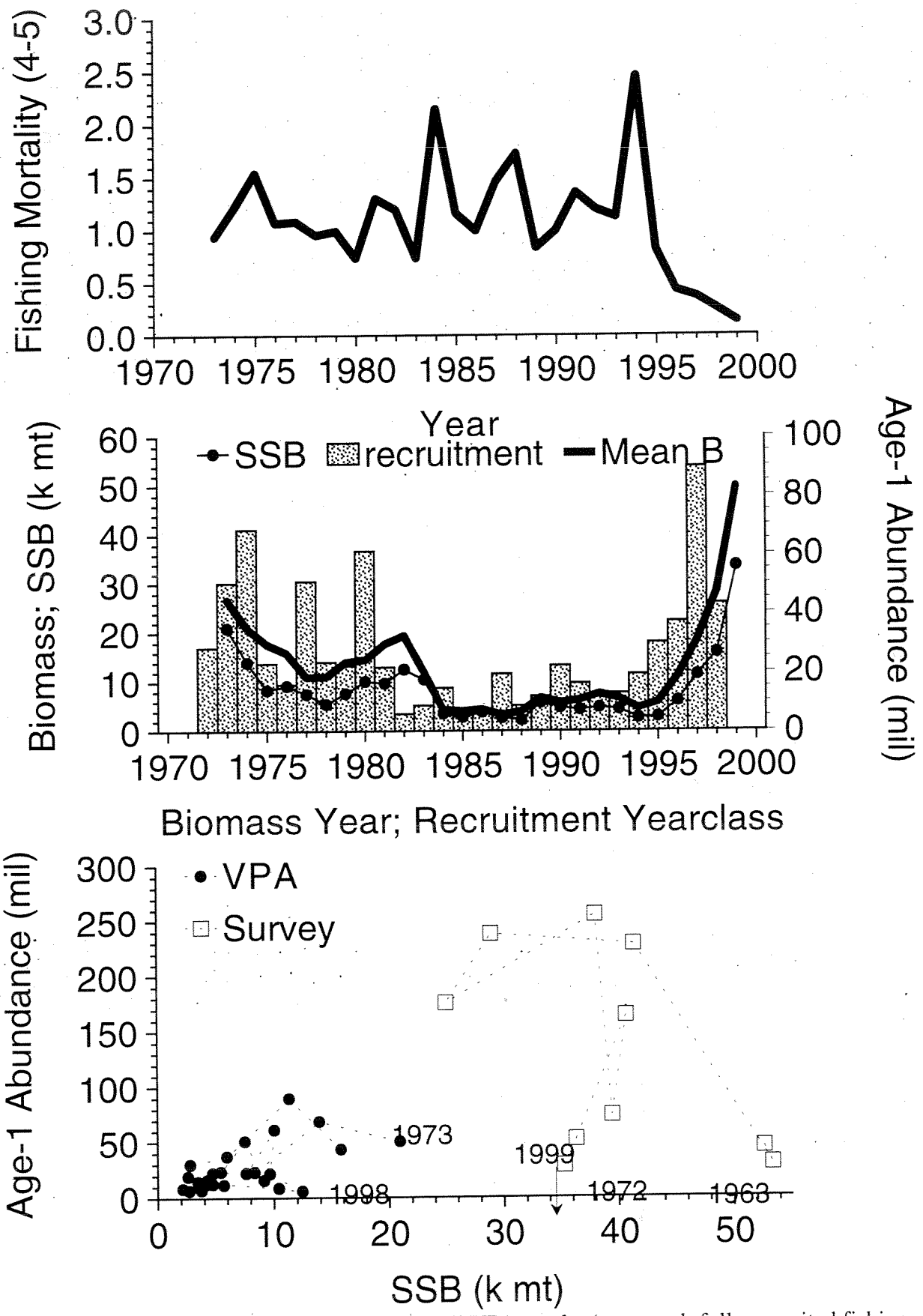


Figure 13. Summary of Georges Bank yellowtail VPA results (top panel: fully-recruited fishing mortality; middle panel: mature biomass and age-1 recruitment; bottom panel: stock and recruit estimates directly from VPA and hindcasted using survey indices and catchability estimates).

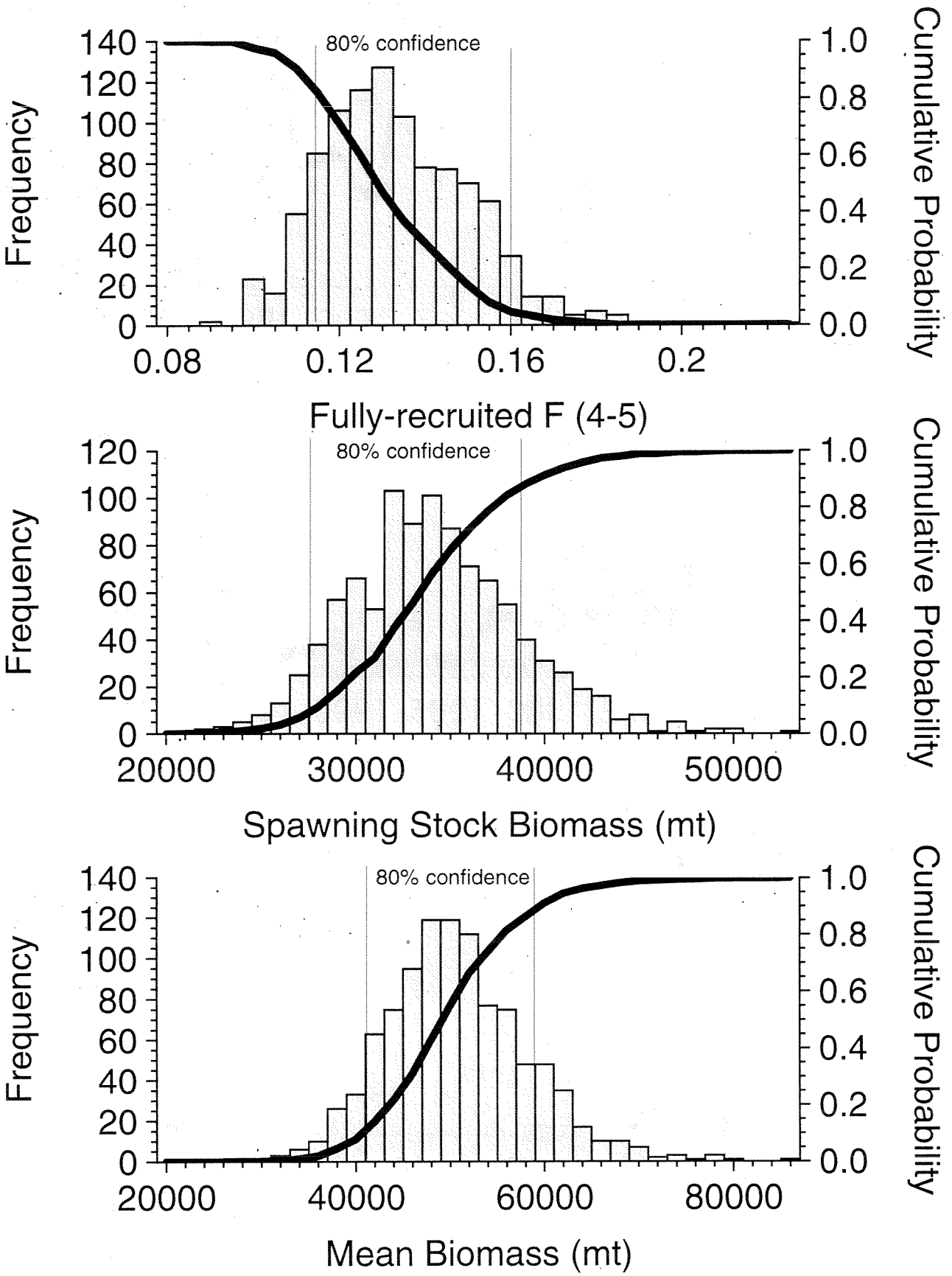
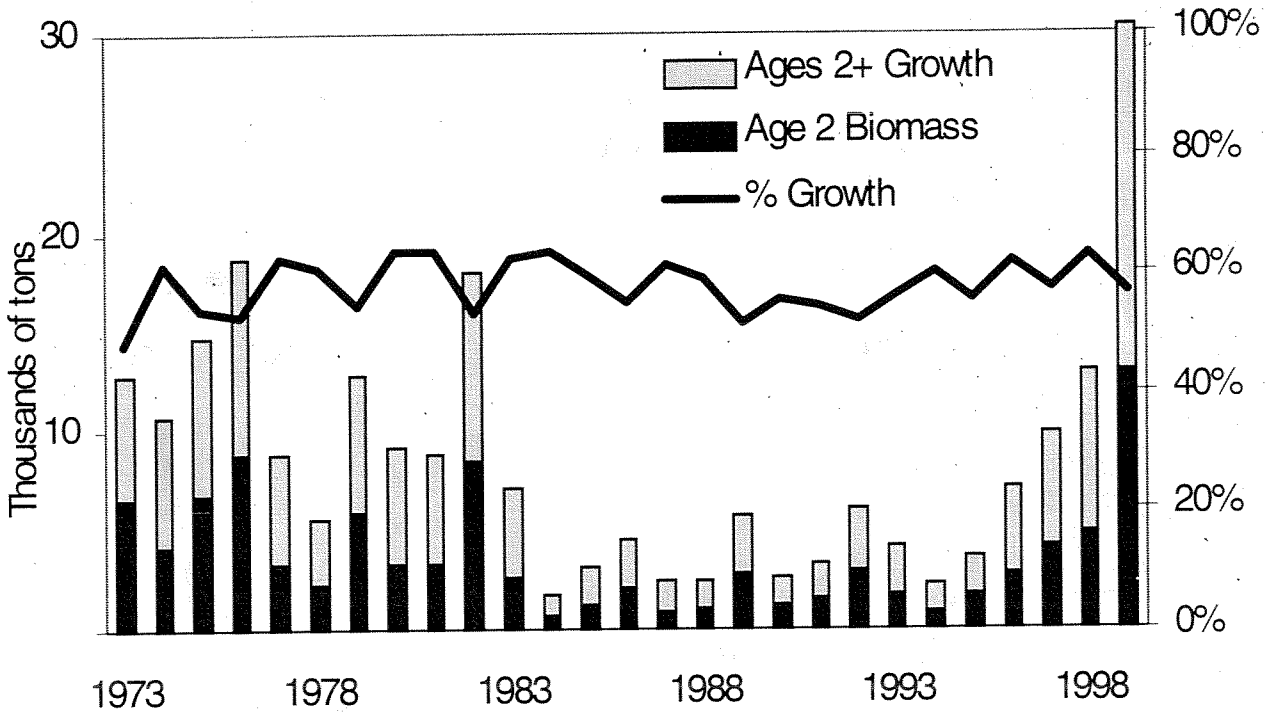


Figure 14. Bootstrap distributions of fully recruited fishing mortality, spawning stock biomass, and mean biomass of Georges Bank yellowtail in 1999.



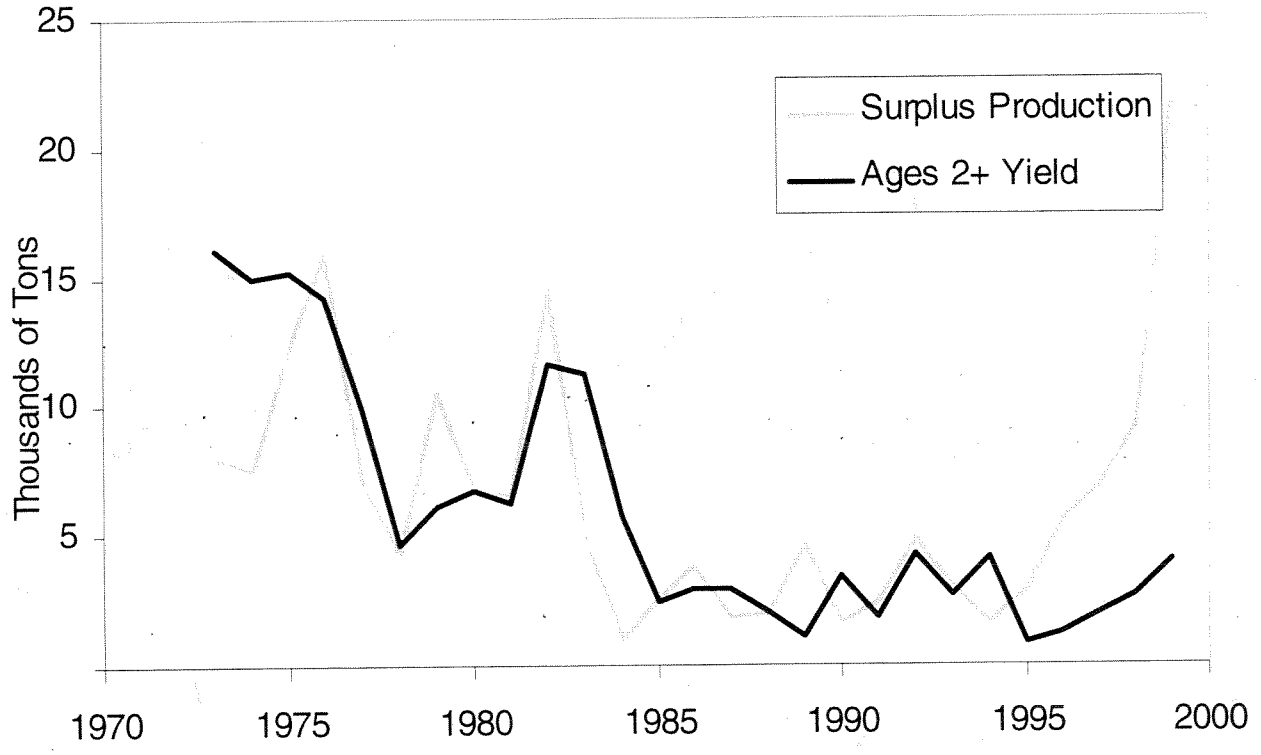


Figure 15. Production attributable to recruitment at age 2 (age 2 biomass) and growth of age 2+ yellowtail flounder (above; the line signifies the proportion of production attributable to growth). Surplus production (from the VPA) compared with fishery yield, Georges Bank yellowtail flounder (below)..

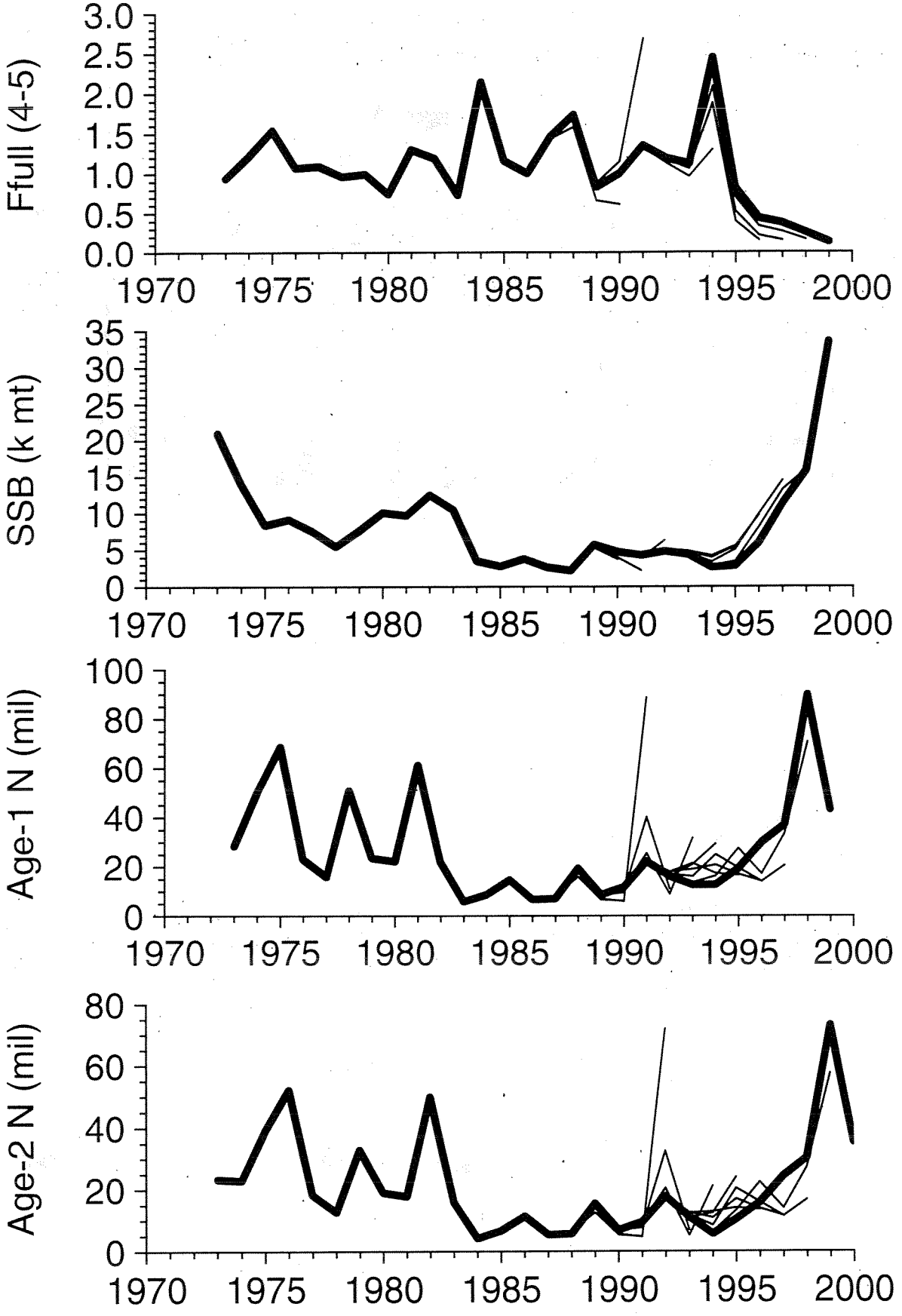


Figure 16. Retrospective analysis of Georges Bank yellowtail flounder VPA.

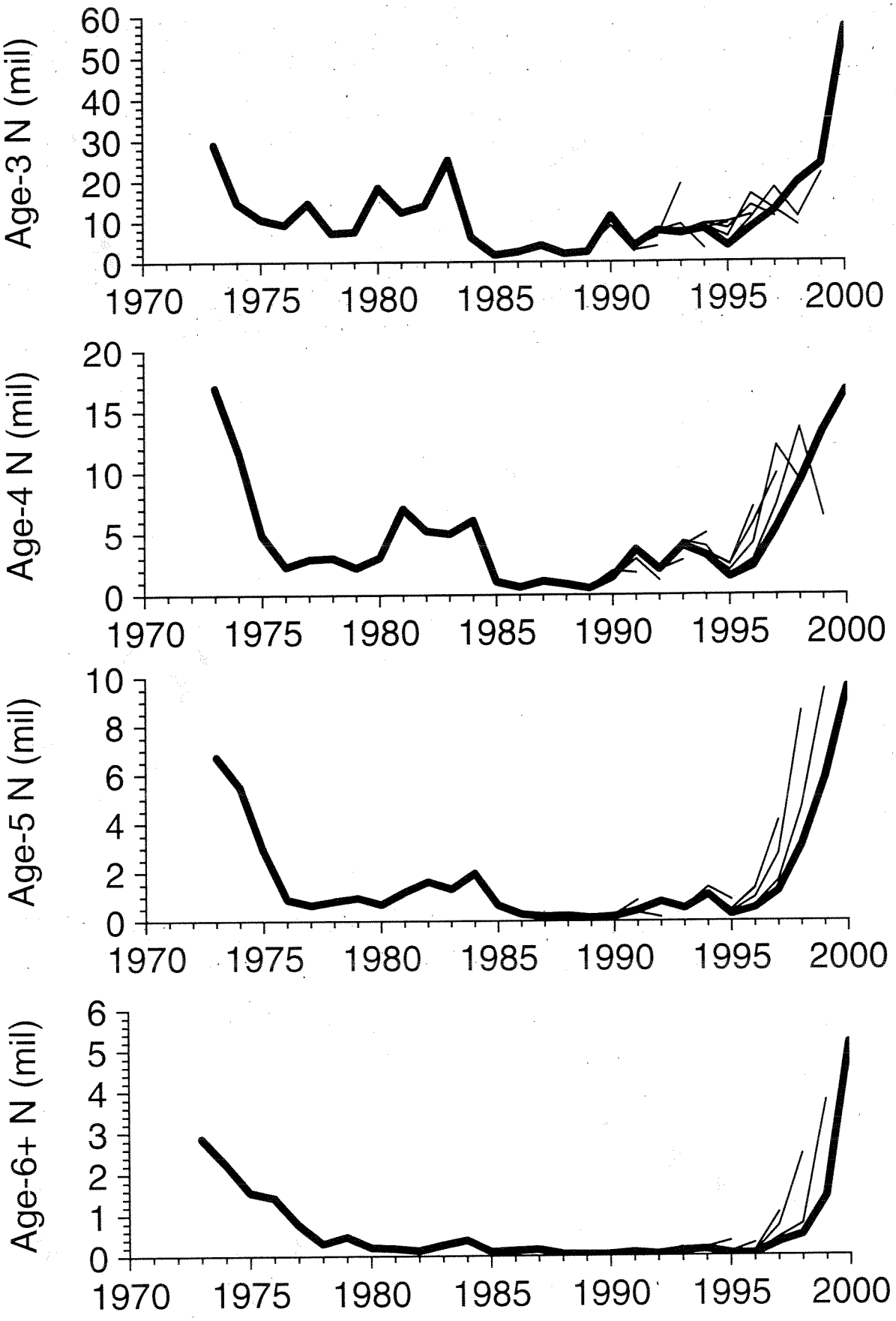


Figure 16 (cont.). Retrospective analysis of Georges Bank yellowtail flounder VPA calibration.

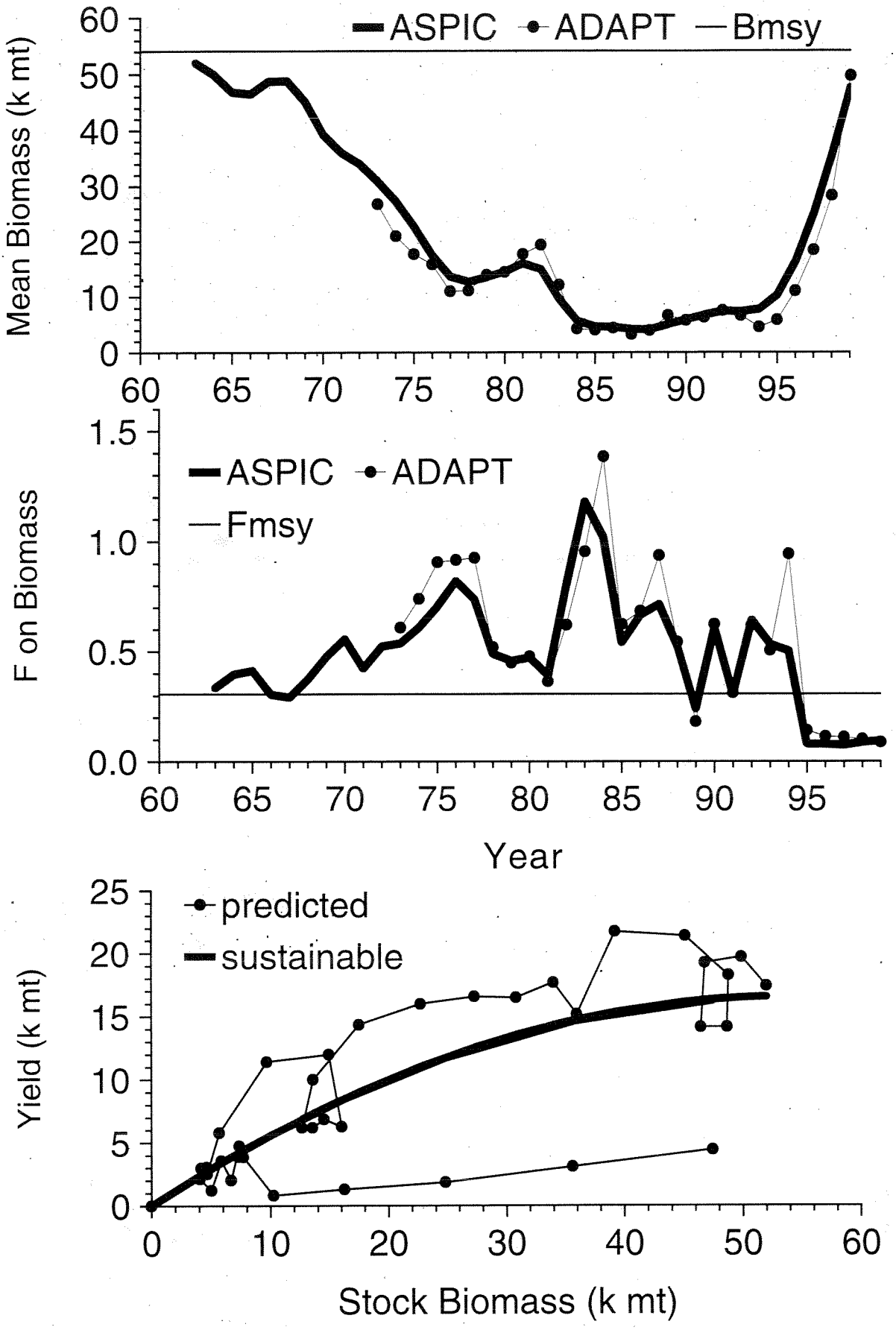


Figure 17. Surplus production analysis of Georges Bank yellowtail flounder.

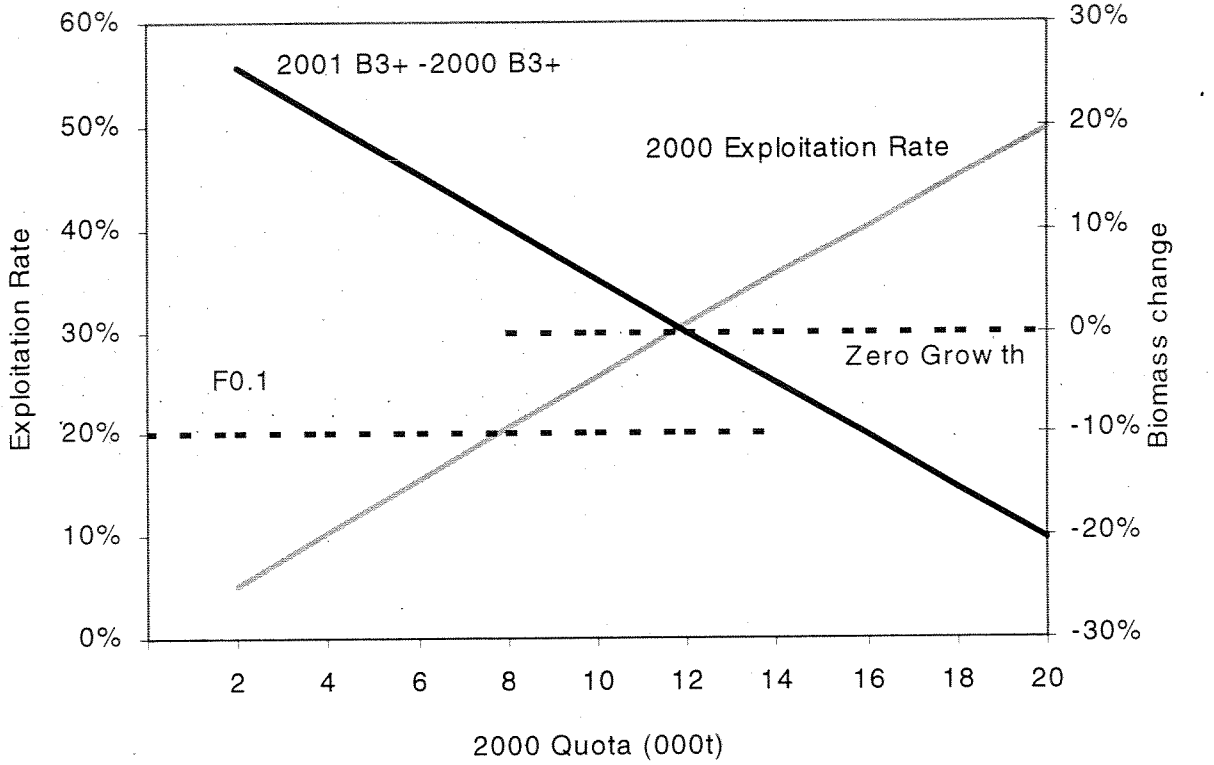


Figure 18. Implications of various 2000 quotas (combined Canada and USA) on exploitation rate and change in the 3+ population biomass of Georges Bank yellowtail flounder from 2000 to 2001.

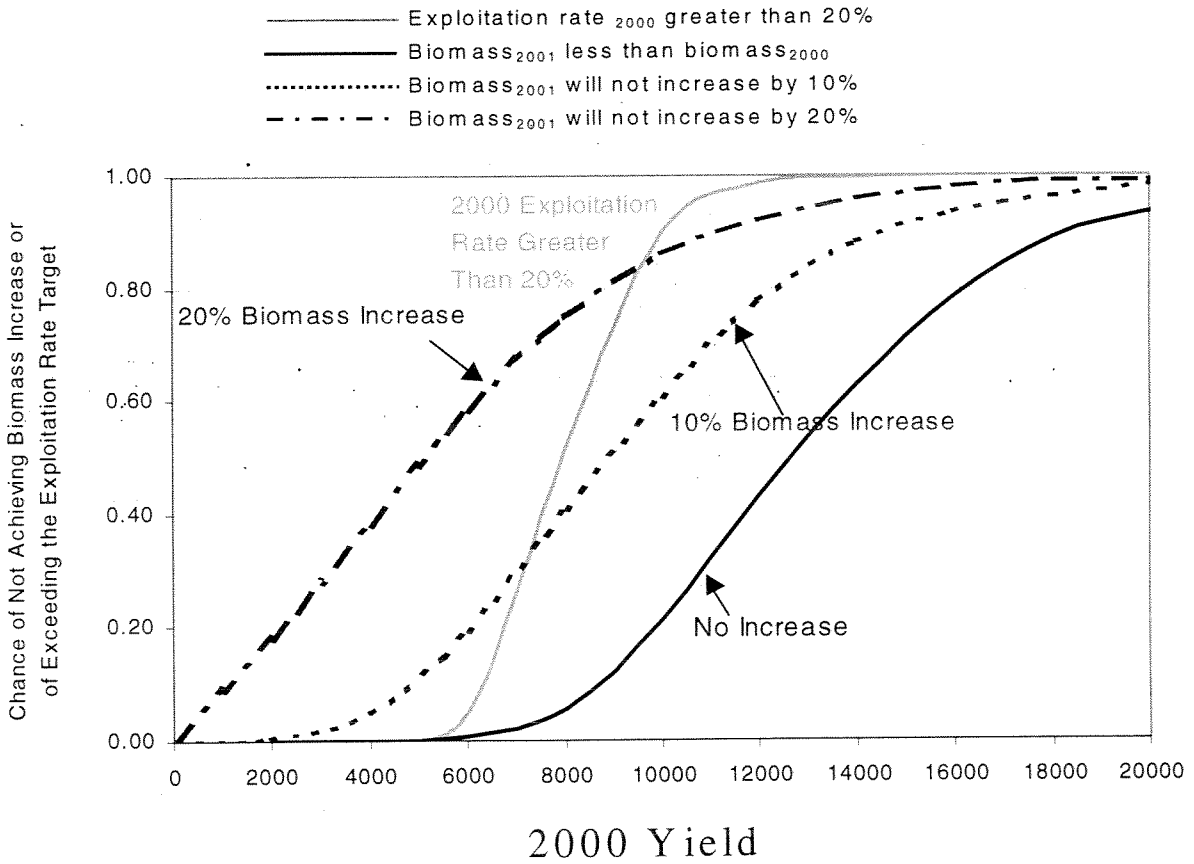


Figure 19. Risk of exceeding the F0.1 fishing mortality or not achieving increments of population biomass growth at various yields for the 2000 fishery, Georges Bank yellowtail flounder.

Appendix A. Georges Bank yellowtail flounder VPA calibration

```
Fisheries Assessment Toolbox  Georges Bank Yellowtail Flounder - TRAC 2000  Run Number  6   04/11/2000   3:11:48 PM
FACT Version 1.1.3
Georges Bank Yellowtail Flounder - TRAC 2000  1973 - 2000
Input Parameters and Options Selected
---------------------------------------
Natural mortality is 0.2
Oldest age (not in the plus group) is  5
For all years prior to the terminal year ( 27 ), backcalculated
stock sizes for the following ages used to estimate
total mortality (Z) for age  5 : 4 5
This method for estimating F on the oldest age is generally used when a
flat-topped partial recruitment curve is thought to be characteristic of the stock.
F for age  6 + is then calculated from the following
ratios of F[age 6 +] to F[age 5 ] : 1
Stock size of the  6 + group is then calculated using
the following method:  CATCH EQUATION
Objective function is Sum w*(LOG(OBS)-LOG(PRED))**2
 Indices normalized (by dividing by mean observed value)
before tuning to VPA stocksizes
Downweighting is None or Uniform
Biomass estimates (other than SSB) reflect mean stock sizes.
SSB calculated as in the NEFSC projection program
 The Indices that will be used in this run are:
 1            USs21
 2            USs22
 3            USs23
 4            USs24
 5            USs25
 6            USs26
 7            USspr1
 8            USspr2
 9            USspr3
 10           USspr4
 11           USspr5
 12           USspr6
 13           USfall1
 14           USfall2
 15           USfall3
 16           USfall4
 17           USfall5
 18           USfall6
 19           Canada2
 20           Canada3
 21           Canada4
 22           Canada5
 23           Canada6
 24           Scall1

Obs Indices (before transformation) by index and year; with Index means
```

	1973	1974	1975	1976	1977	1978	1979
USs21	1.93	0.32	0.42	1.03	0.00	0.94	0.28
USs22	3.27	2.22	2.94	4.37	0.67	0.80	1.93
USs23	2.37	1.84	0.86	1.25	1.13	0.51	0.39
USs24	1.06	1.26	0.30	0.31	0.38	0.22	0.33
USs25	0.41	0.35	0.21	0.20	0.07	0.03	0.06
USs26	0.22	0.28	0.08	0.11	0.01	0.01	0.09
USspr1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
USspr2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
USspr3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
USspr4	0.00	0.00	0.00	0.00	0.00	0.00	0.00
USspr5	0.00	0.00	0.00	0.00	0.00	0.00	0.00
USspr6	0.00	0.00	0.00	0.00	0.00	0.00	0.00
USfall1	2.49	4.62	4.63	0.34	0.93	4.73	1.31
USfall2	5.50	2.85	2.51	1.93	2.16	1.27	2.00
USfall3	5.10	1.52	0.88	0.48	1.65	0.77	0.32
USfall4	2.94	1.06	0.57	0.12	0.62	0.41	0.12
USfall5	1.22	0.46	0.33	0.12	0.11	0.14	0.14
USfall6	0.62	0.38	0.06	0.10	0.11	0.04	0.11
Canada2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Canada3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Canada4	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Canada5	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Canada6	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Scall1	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Appendix A. Georges Bank yellowtail flounder VPA calibration

	1980	1981	1982	1983	1984	1985	1986
USs21	0.06	0.01	0.00	0.00	0.00	0.00	0.00
USs22	4.64	1.03	0.00	0.00	0.00	0.00	0.00
USs23	5.76	1.78	0.00	0.00	0.00	0.00	0.00
USs24	0.47	0.72	0.00	0.00	0.00	0.00	0.00
USs25	0.06	0.21	0.00	0.00	0.00	0.00	0.00
USs26	0.04	0.09	0.00	0.00	0.00	0.00	0.00
USspr1	0.00	0.00	0.05	0.00	0.00	0.11	0.03
USspr2	0.00	0.00	3.74	1.87	0.09	2.20	1.81
USspr3	0.00	0.00	1.12	2.73	0.81	0.26	0.29
USspr4	0.00	0.00	1.11	0.53	0.89	0.28	0.06
USspr5	0.00	0.00	0.46	0.12	0.83	0.15	0.14
USspr6	0.00	0.00	0.09	0.25	0.24	0.00	0.06
USfall1	0.76	1.58	2.42	0.11	0.66	1.35	0.28
USfall2	5.09	2.33	2.19	2.28	0.40	0.56	1.11
USfall3	6.05	1.63	1.59	1.91	0.31	0.16	0.35
USfall4	0.68	0.50	0.42	0.47	2.43	0.04	0.07
USfall5	0.22	0.12	0.09	0.07	0.09	0.08	0.00
USfall6	0.20	0.10	0.00	0.05	0.05	0.00	0.00
Canada2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Canada3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Canada4	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Canada5	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Canada6	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Scall1	0.00	0.00	0.31	0.14	0.23	0.55	0.10

	1987	1988	1989	1990	1991	1992	1993
USs21	0.00	0.00	0.00	0.00	0.00	0.00	0.00
USs22	0.00	0.00	0.00	0.00	0.00	0.00	0.00
USs23	0.00	0.00	0.00	0.00	0.00	0.00	0.00
USs24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
USs25	0.00	0.00	0.00	0.00	0.00	0.00	0.00
USs26	0.00	0.00	0.00	0.00	0.00	0.00	0.00
USspr1	0.00	0.08	0.05	0.00	0.44	0.00	0.05
USspr2	0.13	0.28	0.42	0.07	0.00	2.01	0.29
USspr3	0.11	0.37	0.74	1.11	0.25	1.95	0.50
USspr4	0.13	0.24	0.29	0.39	0.68	0.60	0.32
USspr5	0.05	0.20	0.06	0.14	0.27	0.19	0.03
USspr6	0.06	0.03	0.04	0.06	0.02	0.00	0.00
USfall1	0.11	0.02	0.25	0.00	2.10	0.15	0.84
USfall2	0.39	0.21	1.99	0.33	0.28	0.40	0.14
USfall3	0.40	0.10	0.77	1.52	0.44	0.71	0.59
USfall4	0.05	0.03	0.07	0.28	0.36	0.16	0.54
USfall5	0.08	0.00	0.07	0.01	0.00	0.14	0.00
USfall6	0.00	0.00	0.00	0.00	0.00	0.03	0.00
Canada2	0.68	0.66	0.78	1.27	0.59	10.04	2.16
Canada3	2.00	1.89	0.80	4.62	1.72	4.52	5.04
Canada4	1.09	0.80	0.32	1.12	2.91	1.21	3.47
Canada5	0.06	0.59	0.10	0.43	0.99	0.16	0.62
Canada6	0.00	0.01	0.02	0.01	0.00	0.00	0.00
Scall1	0.05	0.12	0.20	0.10	2.12	0.17	1.13

	1994	1995	1996	1997	1998	1999	2000
USs21	0.00	0.00	0.00	0.00	0.00	0.00	0.00
USs22	0.00	0.00	0.00	0.00	0.00	0.00	0.00
USs23	0.00	0.00	0.00	0.00	0.00	0.00	0.00
USs24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
USs25	0.00	0.00	0.00	0.00	0.00	0.00	0.00
USs26	0.00	0.00	0.00	0.00	0.00	0.00	0.00
USspr1	0.00	0.04	0.03	0.02	0.00	0.05	0.00
USspr2	0.62	1.18	0.99	1.17	2.08	4.75	0.00
USspr3	0.64	4.81	2.63	3.73	1.05	10.82	0.00
USspr4	0.36	1.48	2.70	4.08	1.16	2.72	0.00
USspr5	0.15	0.64	0.61	0.70	0.76	1.62	0.00
USspr6	0.04	0.01	0.06	0.13	0.35	0.78	0.00
USfall1	1.20	0.28	0.14	1.39	1.90	3.09	0.00
USfall2	0.22	0.12	0.35	0.53	4.82	8.42	0.00
USfall3	0.98	0.35	1.87	3.44	4.20	5.73	0.00
USfall4	0.71	0.28	0.45	2.09	1.19	1.43	0.00
USfall5	0.26	0.05	0.07	1.07	0.30	1.44	0.00
USfall6	0.06	0.01	0.00	0.08	0.07	0.26	0.00
Canada2	6.03	1.31	5.54	9.48	3.10	13.05	8.43
Canada3	3.33	4.07	8.44	15.16	3.81	24.78	43.32
Canada4	3.08	2.22	7.49	19.09	5.15	9.07	7.20
Canada5	0.75	1.14	1.37	3.11	2.44	6.85	6.73
Canada6	0.33	0.11	0.16	0.54	0.59	3.10	3.48
Scall1	1.50	0.61	0.51	1.06	1.87	1.04	0.00

Catch at age (thousands) - D:\All_Work\YT\Trac2000\gbyt_2000.7

	1973	1974	1975	1976	1977	1978	1979
1	347	2143	4372	615	330	9659	233
2	4890	8971	25284	31012	8580	3105	9505
3	13243	7904	7057	5146	9917	4034	3445
4	9276	7398	3392	1347	1721	1660	1242
5	3743	3544	2084	532	394	459	550
6	1618	1477	1148	868	474	174	272
1+	33117	31437	43337	39520	21416	19091	15247

Appendix A. Georges Bank yellowtail flounder VPA calibration

	1980	1981	1982	1983	1984	1985	1986
1	309	55	2063	696	428	650	158
2	3572	729	17491	7689	1917	3345	5771
3	8821	5351	7122	16016	4266	816	978
4	1419	4556	3246	2316	4734	652	347
5	321	796	1031	625	1592	410	161
6	99	126	84	127	321	65	76
1+	14541	11613	31037	27469	13258	5938	7491

	1987	1988	1989	1990	1991	1992	1993
1	140	483	185	219	412	2389	5194
2	2653	2367	1516	1931	54	8359	1009
3	2751	1191	668	6123	1222	2527	2777
4	761	624	262	800	2430	1269	2392
5	132	165	68	107	293	510	318
6	112	38	19	20	60	27	75
1+	6549	4868	2718	9200	4471	15081	11765

	1994	1995	1996	1997	1998	1999
1	71	14	50	16	26	21
2	861	157	383	595	971	3287
3	5742	895	1509	1258	2792	3209
4	2571	715	716	1502	1824	1498
5	910	137	167	341	624	651
6	136	27	15	90	103	162
1+	10291	1945	2840	3802	6340	8828

Weight at age (mid year) in kg - D:\All_Work\YT\Trac2000\gbyt_2000.7

	1973	1974	1975	1976	1977	1978	1979
1	0.100	0.100	0.100	0.100	0.100	0.100	0.100
2	0.347	0.339	0.309	0.304	0.337	0.309	0.325
3	0.462	0.498	0.489	0.542	0.524	0.510	0.460
4	0.527	0.609	0.554	0.636	0.634	0.684	0.649
5	0.603	0.680	0.618	0.741	0.782	0.793	0.728
6	0.689	0.725	0.687	0.814	0.865	0.899	0.835

	1980	1981	1982	1983	1984	1985	1986
1	0.100	0.100	0.100	0.100	0.100	0.100	0.100
2	0.318	0.340	0.297	0.296	0.240	0.363	0.342
3	0.492	0.490	0.485	0.440	0.378	0.497	0.540
4	0.656	0.603	0.650	0.604	0.500	0.647	0.664
5	0.813	0.707	0.748	0.736	0.642	0.733	0.823
6	1.054	0.798	1.052	0.952	0.738	0.819	0.864

	1987	1988	1989	1990	1991	1992	1993
1	0.100	0.100	0.100	0.100	0.100	0.100	0.100
2	0.309	0.319	0.342	0.281	0.258	0.283	0.275
3	0.521	0.555	0.542	0.389	0.359	0.360	0.367
4	0.666	0.688	0.725	0.574	0.479	0.519	0.503
5	0.680	0.855	0.883	0.696	0.725	0.646	0.561
6	0.938	1.054	1.026	0.807	0.820	1.203	0.858

	1994	1995	1996	1997	1998	1999
1	0.100	0.100	0.100	0.100	0.100	0.100
2	0.262	0.260	0.309	0.309	0.290	0.371
3	0.351	0.367	0.409	0.458	0.398	0.490
4	0.471	0.463	0.523	0.592	0.512	0.634
5	0.628	0.582	0.667	0.712	0.653	0.721
6	0.786	0.777	0.866	0.874	0.996	0.841

Computed (Rivard)from midyear weights: Jan 1 Weights - D:\All_Work\YT\Trac2000\gbyt_2000.7

	1973	1974	1975	1976	1977	1978	1979
1	0.054	0.057	0.057	0.054	0.057	0.055	0.056
2	0.290	0.184	0.176	0.174	0.184	0.176	0.180
3	0.402	0.416	0.407	0.409	0.399	0.415	0.377
4	0.464	0.530	0.525	0.558	0.586	0.599	0.575
5	0.564	0.599	0.613	0.641	0.705	0.709	0.706
6	0.689	0.725	0.687	0.814	0.865	0.899	0.835

	1980	1981	1982	1983	1984	1985	1986
1	0.054	0.058	0.058	0.065	0.052	0.054	0.057
2	0.178	0.184	0.172	0.172	0.155	0.191	0.185
3	0.400	0.395	0.406	0.361	0.334	0.345	0.443
4	0.549	0.545	0.564	0.541	0.469	0.495	0.574
5	0.726	0.681	0.672	0.692	0.623	0.605	0.730
6	1.054	0.798	1.052	0.952	0.738	0.819	0.864

Appendix A. Georges Bank yellowtail flounder VPA calibration

	1987	1988	1989	1990	1991	1992	1993
1	0.056	0.054	0.060	0.062	0.059	0.060	0.062
2	0.176	0.179	0.185	0.168	0.161	0.168	0.166
3	0.422	0.414	0.416	0.365	0.318	0.305	0.322
4	0.600	0.599	0.634	0.558	0.432	0.432	0.426
5	0.672	0.755	0.779	0.710	0.645	0.556	0.540
6	0.938	1.054	1.026	0.807	0.820	1.203	0.858

	1994	1995	1996	1997	1998	1999	2000
1	0.062	0.057	0.057	0.059	0.052	0.052	0.057
2	0.162	0.161	0.176	0.176	0.170	0.193	0.193
3	0.311	0.310	0.326	0.376	0.351	0.377	0.715
4	0.416	0.403	0.438	0.492	0.484	0.502	0.637
5	0.562	0.524	0.556	0.610	0.622	0.608	0.800
6	0.786	0.777	0.866	0.874	0.996	0.841	0.841

Percent Mature (females)- D:\All_Work\YT\Trac2000\gbyt_2000.7

	1973	1974	1975	1976	1977	1978	1979
1	00	00	00	00	00	00	00
2	42	45	45	45	45	45	45
3	97	98	98	98	98	98	98
4	99	100	100	100	100	100	100
5	100	100	100	100	100	100	100
6	100	100	100	100	100	100	100

	1980	1981	1982	1983	1984	1985	1986
1	00	00	00	00	00	00	00
2	45	49	49	49	93	93	93
3	98	99	99	99	100	100	100
4	100	100	100	100	100	100	100
5	100	100	100	100	100	100	100
6	100	100	100	100	100	100	100

	1987	1988	1989	1990	1991	1992	1993
1	00	00	00	00	00	00	00
2	93	93	93	93	93	52	52
3	100	100	100	100	100	100	86
4	100	100	100	100	100	100	100
5	100	100	100	100	100	100	100
6	100	100	100	100	100	100	100

	1994	1995	1996	1997	1998	1999
1	00	00	00	00	00	00
2	52	52	52	52	52	52
3	86	86	86	86	86	86
4	100	100	100	100	100	100
5	100	100	100	100	100	100
6	100	100	100	100	100	100

```
pF is  0.4167
pM is  0.4167

Number  10
RSS              273.612705153635
Lambda          1.00E+01

Number  11
RSS              248.222644511329
Lambda          1.00E+00

Number  12
RSS              247.276752383281
Lambda          1.00E+02

Number  13
RSS              247.273606896648
Lambda          1.00E+01

Number  14
RSS              247.273616685068
Lambda          1.00E+00

Number  15
RSS              247.273607630377
Lambda          1.00E-01

Number  16
RSS              247.273606903715
Lambda          1.00E-02

Number  17
RSS              247.273606896655
Lambda          1.00E-03

Number  18
RSS              247.273606896648
Lambda          1.00E-04
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Appendix A. Georges Bank yellowtail flounder VPA calibration

RESULTS

Approximate Statistics Assuming Linearity Near Solution
Sum of Squares: 247.273606896648
Mean Square Residuals: 0.70049

	PAR. EST.	STD. ERR.	T-STATISTIC	C.V.
N 2	3.53E+04	1.54E+04	2.29E+00	0.44
N 3	5.71E+04	2.10E+04	2.71E+00	0.37
N 4	1.67E+04	5.35E+03	3.12E+00	0.32
N 5	9.58E+03	1.80E+03	5.34E+00	0.19
q USs21	1.25E-05	3.71E-06	3.36E+00	0.30
q USs22	3.37E-05	9.45E-06	3.57E+00	0.28
q USs23	5.91E-05	1.66E-05	3.57E+00	0.28
q USs24	1.83E-04	5.14E-05	3.57E+00	0.28
q USs25	4.75E-04	1.33E-04	3.57E+00	0.28
q USs26	8.46E-04	2.37E-04	3.57E+00	0.28
q USspr1	3.45E-05	8.96E-06	3.85E+00	0.26
q USspr2	4.30E-05	8.90E-06	4.83E+00	0.21
q USspr3	7.77E-05	1.56E-05	5.00E+00	0.20
q USspr4	2.35E-04	4.71E-05	5.00E+00	0.20
q USspr5	9.19E-04	1.84E-04	5.00E+00	0.20
q USspr6	3.80E-03	8.34E-04	4.56E+00	0.22
q USfall1	2.75E-05	4.61E-06	5.97E+00	0.17
q USfall2	4.58E-05	7.48E-06	6.12E+00	0.16
q USfall3	1.13E-04	1.84E-05	6.13E+00	0.16
q USfall4	3.04E-04	4.96E-05	6.13E+00	0.16
q USfall5	9.22E-04	1.63E-04	5.65E+00	0.18
q USfall6	2.59E-03	5.34E-04	4.85E+00	0.21
q Canada2	4.22E-05	9.76E-06	4.32E+00	0.23
q Canada3	6.93E-05	1.59E-05	4.36E+00	0.23
q Canada4	2.09E-04	4.77E-05	4.37E+00	0.23
q Canada5	6.53E-04	1.50E-04	4.35E+00	0.23
q Canada6	1.24E-03	3.40E-04	3.65E+00	0.27
q Scall1	4.02E-05	8.16E-06	4.93E+00	0.20

Catchability Estimates in Original Units

	Estimate	Std.Err.	C.V.
q USs21	7.77E-06	2.31E-06	0.30
q USs22	8.19E-05	2.30E-05	0.28
q USs23	1.04E-04	2.92E-05	0.28
q USs24	1.03E-04	2.89E-05	0.28
q USs25	8.35E-05	2.34E-05	0.28
q USs26	8.65E-05	2.43E-05	0.28
q USspr1	2.91E-06	7.55E-07	0.26
q USspr2	5.99E-05	1.24E-05	0.21
q USspr3	1.46E-04	2.93E-05	0.20
q USspr4	2.36E-04	4.71E-05	0.20
q USspr5	3.64E-04	7.27E-05	0.20
q USspr6	5.61E-04	1.23E-04	0.22
q USfall1	3.99E-05	6.68E-06	0.17
q USfall2	8.54E-05	1.40E-05	0.16
q USfall3	1.83E-04	2.99E-05	0.16
q USfall4	2.04E-04	3.33E-05	0.16
q USfall5	2.68E-04	4.74E-05	0.18
q USfall6	3.54E-04	7.28E-05	0.21
q Canada2	1.90E-04	4.40E-05	0.23
q Canada3	6.12E-04	1.40E-04	0.23
q Canada4	9.57E-04	2.19E-04	0.23
q Canada5	1.18E-03	2.72E-04	0.23
q Canada6	1.03E-03	2.84E-04	0.27
q Scall1	2.64E-05	5.35E-06	0.20

CORRELATION BETWEEN PARAMETERS ESTIMATED

1	0.04	0.05	0.06	0	0	0	0	0	0	-0.16	-0.01	-0.01	-0.01	-0.01	-0.01	-0.11	-0.01	-0.01	-0.01	-0.01	-0.01	-0.15	-0.02	-0.01	-0.01	-0.01	-0.13
0.04	1	0.05	0.07	0	0	0	0	0	0	-0.02	-0.11	-0.01	-0.01	-0.01	-0.01	-0.09	-0.09	-0.01	-0.01	-0.01	-0.01	-0.13	-0.13	-0.01	-0.01	-0.02	-0.11
0.05	0.05	1	0.09	0	0	0	0	0	0	-0.11	-0.09	-0.09	-0.01	-0.01	-0.01	-0.08	-0.07	-0.08	-0.01	-0.01	-0.01	-0.1	-0.1	-0.11	-0.02	-0.02	-0.09
0.06	0.07	0.09	1	0	0	0	0	0	0	-0.11	-0.11	-0.11	-0.13	-0.13	-0.14	-0.1	-0.09	-0.1	-0.13	-0.14	-0.14	-0.13	-0.13	-0.16	-0.21	-0.24	-0.11
0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-0.16	-0.02	-0.11	-0.11	0	0	0	0	0	0	1	0.02	0.02	0.01	0.01	0.02	0.03	0.02	0.02	0.01	0.02	0.02	0.04	0.02	0.03	0.02	0.03	0.04
-0.01	-0.11	-0.09	-0.11	0	0	0	0	0	0	0.02	1	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.02	0.02	0.03	0.03	0.03	0.02	0.03	0.03	0.03
-0.01	-0.01	-0.09	-0.11	0	0	0	0	0	0	0.02	0.02	1	0.01	0.01	0.02	0.02	0.02	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.02
-0.01	-0.01	-0.01	-0.13	0	0	0	0	0	0	0.01	0.02	0.01	1	0.02	0.02	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.02
-0.01	-0.01	-0.01	-0.13	0	0	0	0	0	0	0.01	0.02	0.01	0.02	1	0.02	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.02
-0.01	-0.01	-0.01	-0.14	0	0	0	0	0	0	0.02	0.02	0.02	0.02	0.02	1	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.04	0.02
-0.11	-0.09	-0.08	-0.1	0	0	0	0	0	0	0.03	0.02	0.02	0.01	0.01	0.02	1	0.02	0.01	0.01	0.01	0.01	0.03	0.03	0.02	0.02	0.02	0.02
-0.01	-0.09	-0.07	-0.09	0	0	0	0	0	0	0.02	0.02	0.02	0.01	0.01	0.02	0.02	1	0.01	0.01	0.01	0.01	0.03	0.03	0.02	0.02	0.02	0.02
-0.01	-0.01	-0.08	-0.1	0	0	0	0	0	0	0.02	0.02	0.02	0.01	0.01	0.02	0.01	0.01	1	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02
-0.01	-0.01	-0.01	-0.13	0	0	0	0	0	0	0.01	0.01	0.01	0.02	0.02	0.02	0.01	0.01	0.01	1	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.01
-0.01	-0.01	-0.01	-0.14	0	0	0	0	0	0	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.02	1	0.02	0.02	0.02	0.02	0.03	0.03	0.02
-0.01	-0.01	-0.01	-0.14	0	0	0	0	0	0	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.02	0.02	1	0.02	0.02	0.02	0.03	0.03	0.02
-0.15	-0.13	-0.1	-0.13	0	0	0	0	0	0	0.04	0.03	0.02	0.02	0.02	0.02	0.04	0.03	0.02	0.02	0.02	0.02	1	0.04	0.03	0.03	0.03	0.05
-0.02	-0.13	-0.1	-0.13	0	0	0	0	0	0	0.02	0.03	0.02	0.02	0.02	0.02	0.03	0.03	0.02	0.02	0.02	0.02	0.04	1	0.03	0.03	0.03	0.03
-0.01	-0.01	-0.11	-0.16	0	0	0	0	0	0	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	1	0.03	0.04	0.03
-0.01	-0.01	-0.02	-0.21	0	0	0	0	0	0	0.02	0.02	0.02	0.03	0.03	0.03	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	1	0.05	0.02
-0.01	-0.01	-0.02	-0.24	0	0	0	0	0	0	0.03	0.03	0.03	0.03	0.03	0.04	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.04	0.05	1	0.03
-0.13	-0.11	-0.09	-0.11	0	0	0	0	0	0	0.04	0.03	0.02	0.02	0.02	0.02	0.04	0.02	0.02	0.01	0.02	0.02	0.05	0.03	0.03	0.02	0.03	1

Appendix A. Georges Bank yellowtail flounder VPA calibration

```
CORRELATION BETWEEN PARAMETERS ESTIMATED (SYMBOLIC FORM)
N 2
N 3
N 4
N 5
USs2
USs2
USs2
USs2
USs2
USs2
USspr
USspr
USspr
USspr
USspr
USspr
USfall
USfall
USfall
USfall
USfall
USfall
Canada
Canada
Canada
Canada
Canada
Scall

SYMBOLS:  = LARGE NEGATIVE CORRELATION     whenever -1 <= R <  -L
          - MODERATE NEGATIVE CORRELATION whenever -L <= R <  -M
          . SMALL CORRELATION             whenever -M <= R <= +M
          + MODERATE POSITIVE CORRELATION whenever +M <  R <= +L
          * LARGE POSITIVE CORRELATION    whenever +L <  R <= +1

Where R is the estimated correlation, M is,  0.25  and L is  0.5

Partial variance (and proportion of total) by index

Index         Partial    Proportion
              Variance
USs2 1         3.451      0.192
USs2 2         0.315      0.018
USs2 3         0.293      0.016
USs2 4         0.138      0.008
USs2 5         0.355      0.02
USs2 6         1.079      0.06
USspr 1        1.062      0.059
USspr 2        0.767      0.043
USspr 3        0.825      0.046
USspr 4        0.677      0.038
USspr 5        0.847      0.047
USspr 6        0.409      0.023
USfall 1       1.27       0.071
USfall 2       0.791      0.044
USfall 3       0.228      0.013
USfall 4       0.409      0.023
USfall 5       0.501      0.028
USfall 6       0.657      0.037
Canada 2       0.708      0.039
Canada 3       0.293      0.016
Canada 4       0.386      0.022
Canada 5       0.792      0.044
Canada 6       0.907      0.051
Scall 1        0.775      0.043
```

Appendix A. Georges Bank yellowtail flounder VPA calibration

Standardized residuals by index and year; with row/column/grand means

	1973	1974	1975	1976	1977	1978	1979
USs21	2.597	-0.252	-0.283	2.102	0.000	1.032	0.514
USs22	0.643	0.206	-0.107	0.027	-0.955	-0.308	-0.396
USs23	-0.288	0.226	-0.297	0.311	-0.362	-0.458	-0.847
USs24	-0.594	0.048	-0.612	0.333	0.300	-0.413	0.442
USs25	-0.376	-0.336	-0.178	1.166	0.369	-1.151	-0.362
USs26	-0.162	0.444	-0.604	-0.108	-1.950	-1.423	0.922
USspr1	0.000	0.000	0.000	0.000	0.000	0.000	0.000
USspr2	0.000	0.000	0.000	0.000	0.000	0.000	0.000
USspr3	0.000	0.000	0.000	0.000	0.000	0.000	0.000
USspr4	0.000	0.000	0.000	0.000	0.000	0.000	0.000
USspr5	0.000	0.000	0.000	0.000	0.000	0.000	0.000
USspr6	0.000	0.000	0.000	0.000	0.000	0.000	0.000
USfall1	1.074	1.144	0.789	-1.060	0.597	1.264	0.533
USfall2	1.482	0.885	0.418	-0.319	0.909	0.496	-0.073
USfall3	0.456	-0.072	-0.146	-0.890	0.244	0.007	-1.255
USfall4	0.419	-0.230	0.225	-0.978	0.732	0.128	-0.919
USfall5	0.154	-0.625	-0.090	-0.104	0.178	0.092	-0.088
USfall6	0.036	-0.115	-1.653	-1.236	-0.406	-0.709	0.160
Canada2	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Canada3	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Canada4	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Canada5	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Canada6	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Scall1	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Col Avg	0.453	0.110	-0.212	-0.063	-0.031	-0.120	-0.114

	1980	1981	1982	1983	1984	1985	1986
USs21	-1.317	-4.393	0.000	0.000	0.000	0.000	0.000
USs22	1.311	-0.420	0.000	0.000	0.000	0.000	0.000
USs23	1.321	0.396	0.000	0.000	0.000	0.000	0.000
USs24	0.496	-0.002	0.000	0.000	0.000	0.000	0.000
USs25	0.011	0.858	0.000	0.000	0.000	0.000	0.000
USs26	0.874	2.006	0.000	0.000	0.000	0.000	0.000
USspr1	0.000	0.000	-0.401	0.000	0.000	1.137	0.396
USspr2	0.000	0.000	0.267	0.807	-1.170	2.037	1.166
USspr3	0.000	0.000	-0.714	-0.355	-0.101	0.096	-0.243
USspr4	0.000	0.000	-0.122	-0.942	-0.566	0.143	-1.131
USspr5	0.000	0.000	-0.307	-1.626	0.186	-0.567	0.358
USspr6	0.000	0.000	0.274	0.600	0.157	0.000	-0.331
USfall1	-0.048	-0.395	1.417	-0.704	0.932	1.153	0.197
USfall2	1.620	0.656	-0.410	1.159	0.657	0.532	0.721
USfall3	1.234	0.094	0.001	-0.293	-0.639	-0.216	0.151
USfall4	0.623	-0.484	-0.370	-0.396	1.904	-1.307	-0.054
USfall5	0.736	-0.367	-1.141	-1.450	-0.922	-0.205	0.000
USfall6	1.734	1.254	0.000	-0.229	-0.075	0.000	0.000
Canada2	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Canada3	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Canada4	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Canada5	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Canada6	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Scall1	0.000	0.000	-0.536	0.088	0.179	0.570	-0.505
Col Avg	0.716	-0.066	-0.170	-0.278	0.045	0.307	0.066

	1987	1988	1989	1990	1991	1992	1993
USs21	0.000	0.000	0.000	0.000	0.000	0.000	0.000
USs22	0.000	0.000	0.000	0.000	0.000	0.000	0.000
USs23	0.000	0.000	0.000	0.000	0.000	0.000	0.000
USs24	0.000	0.000	0.000	0.000	0.000	0.000	0.000
USs25	0.000	0.000	0.000	0.000	0.000	0.000	0.000
USs26	0.000	0.000	0.000	0.000	0.000	0.000	0.000
USspr1	0.000	0.389	0.762	0.000	2.284	0.000	0.275
USspr2	-1.087	-0.242	-0.929	-2.196	0.000	0.763	-0.982
USspr3	-2.001	0.298	0.859	-0.473	-0.948	0.661	-0.849
USspr4	-0.806	0.225	1.038	0.199	-0.294	0.264	-1.292
USspr5	-0.301	1.096	0.287	0.864	0.666	-0.516	-2.319
USspr6	-0.548	-0.018	0.921	1.307	-1.056	0.000	0.000
USfall1	-0.953	-4.291	-0.246	0.000	1.168	-1.508	1.075
USfall2	0.370	-0.511	0.679	-0.365	-1.157	-1.085	-2.131
USfall3	0.059	-0.788	0.963	0.244	-0.202	-0.436	-0.486
USfall4	-0.891	-1.112	0.056	0.606	-0.083	-0.397	0.201
USfall5	1.418	0.000	1.317	-0.859	0.000	0.273	0.000
USfall6	0.000	0.000	0.000	0.000	0.000	1.477	0.000
Canada2	-0.473	-0.577	-1.581	-0.025	-1.323	1.304	0.037
Canada3	-0.264	0.552	-0.756	-0.475	-0.371	-0.040	0.204
Canada4	0.033	-0.020	-0.518	-0.223	-0.222	-0.568	-0.107
Canada5	-1.562	0.986	-0.531	0.805	0.792	-2.124	0.017
Canada6	0.000	-1.937	-0.753	-1.504	0.000	0.000	0.000
Scall1	-1.509	-1.637	-0.040	-1.218	1.670	-0.895	1.918
Col Avg	-0.568	-0.474	0.090	-0.221	0.066	-0.188	-0.317

Appendix A. Georges Bank yellowtail flounder VPA calibration

	1994	1995	1996	1997	1998	1999	2000
USs21	0.000	0.000	0.000	0.000	0.000	0.000	0.000
USs22	0.000	0.000	0.000	0.000	0.000	0.000	0.000
USs23	0.000	0.000	0.000	0.000	0.000	0.000	0.000
USs24	0.000	0.000	0.000	0.000	0.000	0.000	0.000
USs25	0.000	0.000	0.000	0.000	0.000	0.000	0.000
USs26	0.000	0.000	0.000	0.000	0.000	0.000	0.000
USspr1	0.000	-0.400	-1.269	-2.073	0.000	-1.100	0.000
USspr2	0.741	0.771	0.061	-0.265	0.164	0.092	0.000
USspr3	-0.741	2.581	0.920	0.850	-1.186	1.347	0.000
USspr4	-0.883	1.771	1.924	1.383	-0.738	-0.174	0.000
USspr5	-1.194	2.235	1.379	0.544	-0.471	-0.314	0.000
USspr6	-0.844	-1.293	0.980	-0.353	0.246	-0.042	0.000
USfall1	1.153	-1.083	-2.436	0.048	-0.636	0.819	0.000
USfall2	-0.698	-2.256	-1.471	-1.493	0.882	0.501	0.000
USfall3	0.393	-0.528	0.490	0.671	0.417	0.530	0.000
USfall4	1.293	0.494	0.310	1.078	-0.272	-0.575	0.000
USfall5	1.188	0.111	-0.486	1.736	-0.963	0.099	0.000
USfall6	1.423	-0.186	0.000	-0.066	-0.800	-0.609	0.000
Canada2	2.077	-0.484	0.738	0.856	-0.741	-0.080	0.272
Canada3	-0.475	0.674	0.605	0.817	-1.358	0.629	0.258
Canada4	0.018	0.573	1.470	1.552	-0.628	-0.409	-0.951
Canada5	-0.639	1.516	0.937	0.912	-0.485	-0.002	-0.622
Canada6	0.859	0.840	1.420	0.580	0.138	0.876	-0.519
Scall1	1.915	0.338	-0.403	0.218	-0.161	0.008	0.000
Col Avg	0.329	0.315	0.304	0.389	-0.388	0.089	-0.312

Percent of total sum of squares by index and year; with row/column sums

	1973	1974	1975	1976	1977	1978	1979
USs21	1.911	0.018	0.023	1.252	0.000	0.302	0.075
USs22	0.117	0.012	0.003	0.000	0.258	0.027	0.044
USs23	0.024	0.014	0.025	0.027	0.037	0.060	0.203
USs24	0.100	0.001	0.106	0.031	0.026	0.048	0.055
USs25	0.040	0.032	0.009	0.385	0.039	0.375	0.037
USs26	0.007	0.056	0.103	0.003	1.077	0.573	0.241
USspr1	0.000	0.000	0.000	0.000	0.000	0.000	0.000
USspr2	0.000	0.000	0.000	0.000	0.000	0.000	0.000
USspr3	0.000	0.000	0.000	0.000	0.000	0.000	0.000
USspr4	0.000	0.000	0.000	0.000	0.000	0.000	0.000
USspr5	0.000	0.000	0.000	0.000	0.000	0.000	0.000
USspr6	0.000	0.000	0.000	0.000	0.000	0.000	0.000
USfall1	0.327	0.371	0.176	0.318	0.101	0.453	0.080
USfall2	0.622	0.222	0.050	0.029	0.234	0.070	0.001
USfall3	0.059	0.001	0.006	0.224	0.017	0.000	0.447
USfall4	0.050	0.015	0.014	0.271	0.152	0.005	0.239
USfall5	0.007	0.111	0.002	0.003	0.009	0.002	0.002
USfall6	0.000	0.004	0.774	0.433	0.047	0.142	0.007
Canada2	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Canada3	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Canada4	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Canada5	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Canada6	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Scall1	0.000	0.000	0.000	0.000	0.000	0.000	0.000
++	3.263	0.857	1.292	2.977	1.996	2.057	1.433

	1980	1981	1982	1983	1984	1985	1986
USs21	0.491	5.467	0.000	0.000	0.000	0.000	0.000
USs22	0.487	0.050	0.000	0.000	0.000	0.000	0.000
USs23	0.494	0.044	0.000	0.000	0.000	0.000	0.000
USs24	0.070	0.000	0.000	0.000	0.000	0.000	0.000
USs25	0.000	0.208	0.000	0.000	0.000	0.000	0.000
USs26	0.216	1.140	0.000	0.000	0.000	0.000	0.000
USspr1	0.000	0.000	0.046	0.000	0.000	0.366	0.044
USspr2	0.000	0.000	0.020	0.185	0.388	1.176	0.385
USspr3	0.000	0.000	0.144	0.036	0.003	0.003	0.017
USspr4	0.000	0.000	0.004	0.251	0.091	0.006	0.363
USspr5	0.000	0.000	0.027	0.749	0.010	0.091	0.036
USspr6	0.000	0.000	0.021	0.102	0.007	0.000	0.031
USfall1	0.001	0.044	0.569	0.140	0.246	0.376	0.011
USfall2	0.744	0.122	0.048	0.380	0.122	0.080	0.147
USfall3	0.431	0.002	0.000	0.024	0.116	0.013	0.006
USfall4	0.110	0.066	0.039	0.044	1.027	0.484	0.001
USfall5	0.153	0.038	0.369	0.595	0.241	0.012	0.000
USfall6	0.851	0.445	0.000	0.015	0.002	0.000	0.000
Canada2	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Canada3	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Canada4	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Canada5	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Canada6	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Scall1	0.000	0.000	0.081	0.002	0.009	0.092	0.072
++	4.048	7.628	1.368	2.525	2.261	2.699	1.114

Appendix A. Georges Bank yellowtail flounder VPA calibration

	1987	1988	1989	1990	1991	1992	1993
USs21	0.000	0.000	0.000	0.000	0.000	0.000	0.000
USs22	0.000	0.000	0.000	0.000	0.000	0.000	0.000
USs23	0.000	0.000	0.000	0.000	0.000	0.000	0.000
USs24	0.000	0.000	0.000	0.000	0.000	0.000	0.000
USs25	0.000	0.000	0.000	0.000	0.000	0.000	0.000
USs26	0.000	0.000	0.000	0.000	0.000	0.000	0.000
USspr1	0.000	0.043	0.165	0.000	1.477	0.000	0.021
USspr2	0.335	0.017	0.245	1.366	0.000	0.165	0.273
USspr3	1.134	0.025	0.209	0.063	0.255	0.124	0.204
USspr4	0.184	0.014	0.305	0.011	0.024	0.020	0.473
USspr5	0.026	0.340	0.023	0.212	0.126	0.076	1.523
USspr6	0.085	0.000	0.240	0.484	0.316	0.000	0.000
USfall1	0.258	5.217	0.017	0.000	0.386	0.644	0.327
USfall2	0.039	0.074	0.131	0.038	0.379	0.333	1.286
USfall3	0.001	0.176	0.263	0.017	0.012	0.054	0.067
USfall4	0.225	0.350	0.001	0.104	0.002	0.045	0.011
USfall5	0.570	0.000	0.491	0.209	0.000	0.021	0.000
USfall6	0.000	0.000	0.000	0.000	0.000	0.618	0.000
Canada2	0.063	0.094	0.709	0.000	0.496	0.482	0.000
Canada3	0.020	0.086	0.162	0.064	0.039	0.000	0.012
Canada4	0.000	0.000	0.076	0.014	0.014	0.091	0.003
Canada5	0.691	0.275	0.080	0.184	0.178	1.278	0.000
Canada6	0.000	1.063	0.160	0.641	0.000	0.000	0.000
Scall1	0.645	0.759	0.000	0.420	0.790	0.227	1.042
++	4.275	8.534	3.277	3.827	4.494	4.177	5.244

	1994	1995	1996	1997	1998	1999	2000	++
USs21	0.000	0.000	0.000	0.000	0.000	0.000	0.000	9.538
USs22	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.998
USs23	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.929
USs24	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.437
USs25	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.125
USs26	0.000	0.000	0.000	0.000	0.000	0.000	0.000	3.418
USspr1	0.000	0.045	0.456	1.218	0.000	0.343	0.000	4.224
USspr2	0.156	0.169	0.001	0.020	0.008	0.002	0.000	4.909
USspr3	0.156	1.888	0.240	0.205	0.399	0.514	0.000	5.617
USspr4	0.221	0.888	1.049	0.542	0.154	0.009	0.000	4.610
USspr5	0.404	1.415	0.538	0.084	0.063	0.028	0.000	5.769
USspr6	0.202	0.474	0.272	0.035	0.017	0.000	0.000	2.287
USfall1	0.377	0.332	1.681	0.001	0.115	0.190	0.000	12.758
USfall2	0.138	1.441	0.613	0.631	0.220	0.071	0.000	8.267
USfall3	0.044	0.079	0.068	0.128	0.049	0.079	0.000	2.384
USfall4	0.474	0.069	0.027	0.329	0.021	0.094	0.000	4.268
USfall5	0.400	0.003	0.067	0.854	0.262	0.003	0.000	4.426
USfall6	0.574	0.010	0.000	0.001	0.181	0.105	0.000	4.209
Canada2	1.222	0.066	0.154	0.207	0.155	0.002	0.021	3.673
Canada3	0.064	0.129	0.104	0.189	0.522	0.112	0.019	1.521
Canada4	0.000	0.093	0.612	0.683	0.112	0.047	0.256	2.002
Canada5	0.116	0.651	0.248	0.236	0.067	0.000	0.110	4.112
Canada6	0.209	0.200	0.571	0.095	0.005	0.218	0.076	3.239
Scall1	1.039	0.032	0.046	0.013	0.007	0.000	0.000	5.279
++	5.793	7.984	6.748	5.471	2.358	1.817	0.482	

STOCK NUMBERS (Jan 1) in thousands - D:\All_Work\YT\Trac2000\gbyt_2000.7

	1973	1974	1975	1976	1977	1978	1979
1	28290	50265	68516	22919	15760	50823	23375
2	23279	22848	39214	52140	18208	12605	32871
3	28937	14635	10589	9228	14628	7144	7510
4	16960	11709	4830	2284	2899	3003	2199
5	6729	5492	2893	885	651	816	957
6	2859	2240	1551	1417	768	304	465
1+	107055	107189	127593	88873	52914	74695	67376

	1980	1981	1982	1983	1984	1985	1986
1	22099	61066	21627	5818	8620	14594	6660
2	18927	17814	49947	15840	4134	6670	11361
3	18312	12264	13925	25067	6011	1650	2434
4	3032	7011	5199	4957	6031	1062	613
5	677	1198	1618	1319	1962	654	279
6	206	185	129	264	382	102	129
1+	63252	99538	92445	53266	27141	24732	21476

Appendix A. Georges Bank yellowtail flounder VPA calibration

	1987	1988	1989	1990	1991	1992	1993
1	7023	19351	8532	11709	22098	16087	12549
2	5310	5623	15406	6818	9388	17720	11009
3	4079	1947	2462	11242	3835	7638	6944
4	1108	851	516	1411	3664	2034	3967
5	188	219	132	185	432	801	517
6	155	49	36	34	86	42	120
1+	17863	28039	27085	31400	39503	44321	35106

	1994	1995	1996	1997	1998	1999	2000
1	12696	19199	29801	37016	89609	43121	00
2	5574	10330	15706	24354	30291	73342	35285
3	8101	3785	8316	12512	19401	23922	57073
4	3173	1437	2289	5443	9106	13358	16682
5	1083	271	529	1226	3097	5805	9581
6	155	53	47	321	508	1439	5196
1+	30782	35074	56688	80872	152012	160986	123817

FISHING MORTALITY - D:\All_Work\YT\Trac2000\gbyt_2000.7

	1973	1974	1975	1976	1977	1978	1979
1	0.01	0.05	0.07	0.03	0.02	0.24	0.01
2	0.26	0.57	1.25	1.07	0.74	0.32	0.39
3	0.70	0.91	1.33	0.96	1.38	0.98	0.71
4	0.93	1.20	1.50	1.05	1.07	0.94	0.98
5	0.95	1.25	1.59	1.09	1.10	0.97	1.01
6	0.95	1.25	1.59	1.09	1.10	0.97	1.01

	1980	1981	1982	1983	1984	1985	1986
1	0.02	0.00	0.11	0.14	0.06	0.05	0.03
2	0.23	0.05	0.49	0.77	0.72	0.81	0.82
3	0.76	0.66	0.83	1.22	1.53	0.79	0.59
4	0.73	1.27	1.17	0.73	2.02	1.14	0.98
5	0.74	1.33	1.22	0.74	2.27	1.18	1.01
6	0.74	1.33	1.22	0.74	2.27	1.18	1.01

	1987	1988	1989	1990	1991	1992	1993
1	0.02	0.03	0.02	0.02	0.02	0.18	0.61
2	0.80	0.63	0.12	0.38	0.01	0.74	0.11
3	1.37	1.13	0.36	0.92	0.43	0.46	0.58
4	1.42	1.66	0.82	0.98	1.32	1.17	1.10
5	1.50	1.79	0.84	1.01	1.39	1.22	1.14
6	1.50	1.79	0.84	1.01	1.39	1.22	1.14

	1994	1995	1996	1997	1998	1999
1	0.01	0.00	0.00	0.00	0.00	0.00
2	0.19	0.02	0.03	0.03	0.04	0.05
3	1.53	0.30	0.22	0.12	0.17	0.16
4	2.26	0.80	0.42	0.36	0.25	0.13
5	2.64	0.82	0.43	0.37	0.25	0.13
6	2.64	0.82	0.43	0.37	0.25	0.13

Average F for 4,5

	1973	1974	1975	1976	1977	1978	1979
4,5	0.94	1.22	1.54	1.07	1.09	0.96	0.99

	1980	1981	1982	1983	1984	1985	1986
4,5	0.74	1.30	1.19	0.73	2.14	1.16	1.00

	1987	1988	1989	1990	1991	1992	1993
4,5	1.46	1.73	0.83	1.00	1.35	1.19	1.12

	1994	1995	1996	1997	1998	1999
4,5	2.45	0.81	0.43	0.37	0.25	0.13

Biomass Weighted F

1973	1974	1975	1976	1977	1978	1979
0.61	0.74	0.91	0.92	0.93	0.52	0.44

1980	1981	1982	1983	1984	1985	1986
0.48	0.36	0.62	0.96	1.38	0.62	0.68

1987	1988	1989	1990	1991	1992	1993
0.94	0.54	0.18	0.62	0.31	0.61	0.50

Appendix A. Georges Bank yellowtail flounder VPA calibration

	1994	1995	1996	1997	1998	1999
	0.94	0.14	0.11	0.11	0.10	0.09

MEAN BIOMASS (using catch mean weights at age)

	1973	1974	1975	1976	1977	1978	1979
1	2547	4451	5996	2047	1412	4120	2107
2	6462	5404	6404	8972	3985	3040	8088
3	8797	4405	2648	2963	3847	2140	2271
4	5360	3840	1288	828	1042	1224	838
5	2408	1973	832	368	284	381	404
6	1169	858	496	648	371	161	225
1+	26743	20930	17663	15826	10943	11066	13934

	1980	1981	1982	1983	1984	1985	1986
1	1988	5532	1858	493	760	1291	596
2	4883	5368	10718	3003	649	1526	2431
3	5791	4034	4211	5879	1079	520	910
4	1296	2218	1839	1952	1210	379	239
5	356	435	646	629	467	260	133
6	140	76	73	163	104	45	65
1+	14454	17662	19346	12119	4271	4021	4374

	1987	1988	1989	1990	1991	1992	1993
1	630	1730	764	1051	1983	1339	860
2	1036	1221	4520	1457	2189	3255	2607
3	1073	598	1024	2629	1020	2017	1767
4	365	265	234	475	902	575	1117
5	61	81	72	75	157	277	160
6	70	22	23	16	36	27	57
1+	3235	3918	6637	5702	6285	7489	6568

	1994	1995	1996	1997	1998	1999	
1	1147	1739	2699	3354	8120	3907	
2	1211	2415	4341	6731	7825	24066	
3	1352	1092	2772	4909	6444	9842	
4	556	421	891	2463	3754	7205	
5	226	99	262	666	1627	3561	
6	41	26	30	214	407	1030	
1+	4532	5791	10995	18338	28178	49611	00

Jan 1 BIOMASS (using Jan 1 mean weights)

	1973	1974	1975	1976	1977	1978	1979
1	1528	2865	3905	1238	898	2795	1309
2	6751	4204	6902	9072	3350	2218	5917
3	11633	6088	4310	3774	5837	2965	2831
4	7869	6206	2536	1275	1699	1799	1264
5	3795	3290	1773	567	459	579	676
6	1970	1624	1066	1153	665	273	388
1+	33546	24277	20491	17079	12908	10630	12385

	1980	1981	1982	1983	1984	1985	1986
1	1193	3542	1254	378	448	788	380
2	3369	3278	8591	2725	641	1274	2102
3	7325	4844	5654	9049	2008	569	1079
4	1664	3821	2932	2682	2829	526	352
5	491	816	1087	913	1223	396	204
6	217	148	136	252	282	83	112
1+	14259	16449	19654	15998	7430	3636	4227

	1987	1988	1989	1990	1991	1992	1993
1	393	1045	512	726	1304	965	778
2	935	1007	2850	1145	1512	2977	1828
3	1722	806	1024	4103	1220	2329	2236
4	665	510	327	788	1583	879	1690
5	126	165	103	132	279	445	279
6	146	52	37	28	71	50	103
1+	3986	3584	4854	6921	5967	7646	6913

Appendix A. Georges Bank yellowtail flounder VPA calibration

	1994	1995	1996	1997	1998	1999
1	787	1094	1699	2184	4660	2242
2	903	1663	2764	4286	5150	14155
3	2519	1173	2711	4705	6810	9019
4	1320	579	1003	2678	4407	6706
5	609	142	294	748	1926	3529
6	122	41	41	281	506	1210
1+	6260	4693	8511	14881	23459	36861

SSB AT THE START OF THE SPAWNING SEASON -MALES AND FEMALES (MT) (using SSB mean weights)

	1973	1974	1975	1976	1977	1978	1979
1	00	00	00	00	00	00	00
2	2796	2530	2984	4200	1870	1413	3767
3	8895	4500	2678	3026	3883	2185	2320
4	5531	3982	1319	861	1084	1275	873
5	2509	2042	848	383	296	397	421
6	1218	888	505	673	386	168	234
1+	20949	13942	8334	9143	7519	5438	7616

	1980	1981	1982	1983	1984	1985	1986
1	00	00	00	00	00	00	00
2	2260	2678	5454	1534	629	1480	2358
3	5918	4161	4347	6031	1103	543	947
4	1351	2295	1908	2035	1195	394	248
5	371	449	670	656	450	270	139
6	146	78	75	170	101	47	67
1+	10047	9660	12455	10426	3479	2733	3760

	1987	1988	1989	1990	1991	1992	1993
1	00	00	00	00	00	00	00
2	1004	1183	4297	1402	2067	1765	1385
3	1106	621	1058	2741	1057	2093	1581
4	375	269	244	495	931	597	1162
5	63	82	75	78	162	287	166
6	72	22	24	17	37	28	59
1+	2620	2177	5699	4732	4253	4768	4353

	1994	1995	1996	1997	1998	1999
1	00	00	00	00	00	00
2	646	1276	2296	3559	4140	12745
3	1189	969	2451	4317	5684	8675
4	536	439	923	2547	3865	7374
5	208	103	272	689	1675	3644
6	37	27	31	222	419	1054
1+	2618	2814	5973	11335	15783	33491

Appendix A. Georges Bank yellowtail flounder VPA calibration

The number of bootstraps: 1000

Bootstrap Output Variable: N hat

	NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP StdError	C.V. FOR NLLS SOLN
N 2	35285	36465	11741	0.33
N 3	57073	58986	15866	0.28
N 4	16682	16912	3944	0.24
N 5	9581	9672	1307	0.14

	BIAS ESTIMATE	BIAS STD ERROR	PERCENT BIAS	NLLS EST CORRECTED FOR BIAS	C.V. FOR CORRECTED ESTIMATE	LOWER 80%CI	UPPER 80%CI
N 2	1180	371	3.34	34105	0.344260	25864	55679
N 3	1913	502	3.35	55160	0.287631	39003	77449
N 4	230	125	1.38	16452	0.239705	12447	22225
N 5	91	41	0.95	9490	0.137722	7944	11202

Bootstrap Output Variable: N t1

	NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP StdError	C.V. FOR NLLS SOLN
Age 1	20774.3	20767.7	420.2	0.0202
Age 2	35285.2	36465.1	11741.1	0.3327
Age 3	57073.1	58986.0	15865.8	0.2780
Age 4	16682.0	16912.3	3943.6	0.2364
Age 5	9580.8	9672.0	1306.9	0.1364
Age 6	5195.8	5245.2	709.1	0.1365

	BIAS ESTIMATE	BIAS STD ERROR	PERCENT BIAS	NLLS EST CORRECTED FOR BIAS	C.V. FOR CORRECTED ESTIMATE	LOWER 80%CI	UPPER 80%CI
Age 1	-6.55	13.29	-0.032	20780.83	0.02	20271.6	21361.7
Age 2	1179.89	371.29	3.344	34105.31	0.34	25863.9	55679.3
Age 3	1912.95	501.72	3.352	55160.15	0.29	39002.7	77449.2
Age 4	230.25	124.71	1.380	16451.74	0.24	12447.1	22225.1
Age 5	91.15	41.33	0.951	9489.70	0.14	7944.1	11201.6
Age 6	49.45	22.42	0.952	5146.30	0.14	4307.8	6075.0

Bootstrap Output Variable: F t

	NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP StdError	C.V. FOR NLLS SOLN
Age 1	0.0005	0.0006	0.0002	0.34
Age 2	0.0508	0.0528	0.0150	0.30
Age 3	0.1605	0.1660	0.0373	0.23
Age 4	0.1323	0.1333	0.0172	0.13
Age 5	0.1323	0.1333	0.0172	0.13
Age 6	0.1323	0.1333	0.0172	0.13

	BIAS ESTIMATE	BIAS STD ERROR	PERCENT BIAS	NLLS EST CORRECTED FOR BIAS	C.V. FOR CORRECTED ESTIMATE	LOWER 80%CI	UPPER 80%CI
Age 1	0.0000337	0.0000058	6.268	0.0005046	0.36	0.0003	0.0007
Age 2	0.0019774	0.0004739	3.893	0.0488223	0.31	0.0376	0.0733
Age 3	0.0055230	0.0011782	3.442	0.1549425	0.24	0.1225	0.2095
Age 4	0.0009787	0.0005445	0.740	0.1313423	0.13	0.1141	0.1575
Age 5	0.0009787	0.0005445	0.740	0.1313423	0.13	0.1141	0.1575
Age 6	0.0009787	0.0005445	0.740	0.1313423	0.13	0.1141	0.1575

Bootstrap Output Variable: F full t

NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP StdError	C.V. FOR NLLS SOLN
0.1323	0.1333	0.0172	0.13

BIAS ESTIMATE	BIAS STD ERROR	PERCENT BIAS	NLLS EST CORRECTED FOR BIAS	C.V. FOR CORRECTED ESTIMATE	LOWER 80%CI	UPPER 80%CI
0.00098	0.00054	0.74	0.13134	0.13	0.1141	0.1575

Bootstrap Output Variable: PR t

	NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP StdError	C.V. FOR NLLS SOLN
Age 1	0.0034	0.0035	0.0013	0.39
Age 2	0.3166	0.3214	0.1048	0.33
Age 3	1.0000	0.9777	0.0611	0.06
Age 4	0.8246	0.8100	0.1477	0.18
Age 5	0.8246	0.8100	0.1477	0.18
Age 6	0.8246	0.8100	0.1477	0.18

	BIAS ESTIMATE	BIAS STD ERROR	PERCENT BIAS	NLLS EST CORRECTED FOR BIAS	C.V. FOR CORRECTED ESTIMATE	LOWER 80%CI	UPPER 80%CI
Age 1	0.00014	0.000041	4.09	0.00321776	0.40	0.0022	0.0052
Age 2	0.00484	0.003313	1.53	0.31173765	0.34	0.2244	0.4848
Age 3	-0.02228	0.001932	-2.23	1.02228352	0.06	0.5124	1.0000
Age 4	-0.01460	0.004669	-1.77	0.83921078	0.18	0.6241	1.0000
Age 5	-0.01460	0.004669	-1.77	0.83921078	0.18	0.6241	1.0000
Age 6	-0.01460	0.004669	-1.77	0.83921078	0.18	0.6241	1.0000

Appendix A. Georges Bank yellowtail flounder VPA calibration

Bootstrap Output Variable: PR mean

	NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP StdError	C.V. FOR NLLS SOLN
Age 1	0.0018	0.0018	0.0003	0.15
Age 2	0.1501	0.1495	0.0142	0.09
Age 3	0.6042	0.5994	0.0131	0.02
Age 4	0.9328	0.9236	0.0585	0.06
Age 5	0.9377	0.9285	0.0590	0.06
Age 6	0.9377	0.9285	0.0590	0.06

	BIAS ESTIMATE	BIAS STD ERROR	PERCENT BIAS	NLLS EST CORRECTED FOR BIAS	C.V. FOR CORRECTED ESTIMATE	LOWER 80%CI	UPPER 80%CI
Age 1	0.00001	0.0000082	0.75	0.0017581	0.15	0.0014	0.0021
Age 2	-0.00052	0.0004496	-0.35	0.1505801	0.09	0.1355	0.1707
Age 3	-0.00481	0.0004148	-0.80	0.6090163	0.02	0.6019	0.6089
Age 4	-0.00922	0.0018504	-0.99	0.9420010	0.06	0.8500	0.9945
Age 5	-0.00925	0.0018652	-0.99	0.9469887	0.06	0.8546	1.0000
Age 6	-0.00925	0.0018652	-0.99	0.9469887	0.06	0.8546	1.0000

Bootstrap Output Variable: Mean Biomass

NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP StdError	C.V. FOR NLLS SOLN
49610.7113	50755.5776	7529.8448	0.15

BIAS ESTIMATE	BIAS STD ERROR	PERCENT BIAS	NLLS EST CORRECTED FOR BIAS	C.V. FOR CORRECTED ESTIMATE	LOWER 80%CI	UPPER 80%CI
1144.8663	238.1146	2.31	48465.8450	0.16	40536.7375	59069.5638

Bootstrap Output Variable: SSB f mean

NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP StdError	C.V. FOR NLLS SOLN
16387.0046	16696.9297	2236.6534	0.14

BIAS ESTIMATE	BIAS STD ERROR	PERCENT BIAS	NLLS EST CORRECTED FOR BIAS	C.V. FOR CORRECTED ESTIMATE	LOWER 80%CI	UPPER 80%CI
309.925	70.729	1.89	16077.079	0.14	13572.3780	19007.3689

Bootstrap Output Variable: SSB spawn t

NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP StdError	C.V. FOR NLLS SOLN
33491.2035	34120.0042	4542.6831	0.14

BIAS ESTIMATE	BIAS STD ERROR	PERCENT BIAS	NLLS EST CORRECTED FOR BIAS	C.V. FOR CORRECTED ESTIMATE	LOWER 80%CI	UPPER 80%CI
628.80	143.65	1.88	32862.40	0.14	27771.7907	38809.8356

Appendix B. VPA Results used for the Canadian Stock Status Report

Table B1. Statistical properties of estimates for population abundance at the beginning of 2000 and survey calibration constants (10^{-3}) for Georges Bank yellowtail.

		Bootstrap				Analytical Approximation			
Age	Estimate	Standard Error	Relative Error	Bias	Relative Bias	Standard Error	Relative Error	Bias	Relative Bias
				Population Abundance (000 s)					
2	34423	16248	0.472	3192	0.093	14952	0.434	3266	0.095
3	56028	20514	0.366	3500	0.062	20561	0.367	3663	0.065
4	16254	5324	0.328	845	0.052	5208	0.320	729	0.045
5	9526	1707	0.179	142	0.015	1778	0.187	124	0.013
				Survey Calibration Constants					
Scallop									
1	0.027	0.005	0.205	0.000	0.014	0.005	0.202	0.001	0.020
DFO Spring Survey									
2	0.193	0.043	0.223	0.003	0.016	0.044	0.230	0.005	0.026
3	0.620	0.135	0.218	0.005	0.009	0.141	0.228	0.016	0.026
4	0.967	0.221	0.229	0.019	0.020	0.220	0.228	0.025	0.026
5	1.175	0.261	0.222	0.036	0.031	0.269	0.229	0.031	0.026
6+	1.130	0.301	0.266	0.041	0.037	0.308	0.273	0.042	0.037
NMFS Spring Survey – Yankee 36 –1982-98									
1	0.003	0.001	0.257	0.000	0.021	0.001	0.258	0.000	0.033
2	0.061	0.012	0.200	0.002	0.025	0.013	0.206	0.001	0.021
3	0.148	0.027	0.184	0.002	0.015	0.030	0.199	0.003	0.019
4	0.238	0.048	0.201	0.003	0.012	0.047	0.199	0.005	0.020
5	0.362	0.070	0.194	0.008	0.022	0.072	0.199	0.007	0.020
6+	0.560	0.123	0.219	0.017	0.030	0.122	0.219	0.013	0.024
NMFS Spring Survey – Yankee 41 – 1973-81									
1	0.008	0.002	0.296	0.000	0.030	0.002	0.296	0.000	0.044
2	0.083	0.024	0.288	0.004	0.042	0.023	0.279	0.003	0.039
3	0.106	0.031	0.288	0.005	0.042	0.030	0.279	0.004	0.039
4	0.104	0.030	0.289	0.005	0.051	0.029	0.279	0.004	0.039
5	0.085	0.024	0.280	0.002	0.020	0.024	0.279	0.003	0.039
6+	0.084	0.025	0.297	0.003	0.040	0.023	0.279	0.003	0.039
NMFS Fall Survey									
1	0.041	0.006	0.157	0.001	0.016	0.007	0.167	0.001	0.014
2	0.089	0.014	0.154	0.001	0.013	0.014	0.163	0.001	0.013
3	0.194	0.030	0.156	0.001	0.006	0.032	0.162	0.003	0.013
4	0.219	0.034	0.156	0.003	0.013	0.036	0.163	0.003	0.013
5	0.273	0.047	0.172	0.004	0.014	0.048	0.176	0.004	0.015
6+	0.367	0.076	0.207	0.009	0.025	0.075	0.205	0.008	0.021

Appendix B. VPA Results used for the Canadian Stock Status Report

Table B2. Beginning of year population abundance numbers (000's) for Georges Bank yellowtail from a virtual population analysis using the bootstrap bias adjusted population abundance at the beginning of 2000.

Year	Age Group							
	1	2	3	4	5	6+	1+	3+
1973	27857	22950	28577	16854	6801	2940	105977	55171
1974	49338	22494	14392	11572	5543	2310	105649	33817
1975	67297	38460	10389	4748	2917	1607	125418	19662
1976	22618	51153	9102	2265	895	1460	87492	13721
1977	15642	17963	14350	2875	658	792	52280	18675
1978	50294	12509	7049	2986	826	313	73976	11173
1979	23135	32486	7451	2185	967	478	66703	11082
1980	21884	18731	18066	3024	684	211	62600	21986
1981	59983	17638	12121	6922	1209	191	98065	20444
1982	21271	49060	13782	5143	1633	133	91023	20692
1983	5753	15555	24496	4937	1332	271	52344	31036
1984	8501	4083	5878	5872	1975	398	26706	14123
1985	14338	6574	1631	1051	661	105	24360	3448
1986	6565	11152	2400	608	282	133	21140	3423
1987	6957	5232	3988	1090	189	160	17617	5428
1988	19083	5570	1918	834	220	51	27676	3024
1989	8452	15188	2444	514	133	37	26768	3129
1990	11591	6753	11068	1401	187	35	31035	12691
1991	21715	9292	3795	3613	436	89	38939	7933
1992	15814	17406	7559	2011	808	43	43641	10421
1993	12450	10795	6792	3923	522	123	34605	11359
1994	12591	5548	7929	3076	1089	164	30397	12258
1995	18931	10244	3767	1428	274	56	34700	5525
1996	29330	15487	8246	2280	532	48	55921	11105
1997	34669	23968	12334	5393	1224	323	77911	19274
1998	82816	28370	19086	8964	3067	329	142632	31446
1999	38169	67781	22351	13111	5698	1418	148528	42578
2000	40000	31231	52527	15408	9385	5093	153644	82413

Appendix C. Georges Bank yellowtail flounder production analysis

Georges Bank Yellowtail (yield and biomass in k mt)

06 Apr 2000 at 14:06.15

ASPIC -- A Surplus-Production Model Including Covariates (Ver. 3.74)

FIT Mode

Author: Michael H. Prager
National Marine Fisheries Service
Southwest Fisheries Science Center
3150 Paradise Drive
Tiburon, California 94920 USA

ASPIC User's Manual
is available gratis
from the author

CONTROL PARAMETERS USED (FROM INPUT FILE)

Number of years analyzed:	37	Number of bootstrap trials:	0
Number of data series:	3	Lower bound on MSY:	5.000E+00
Objective function computed:	in effort	Upper bound on MSY:	5.000E+01
Relative conv. criterion (simplex):	1.000E-09	Lower bound on r:	1.000E-01
Relative conv. criterion (restart):	3.000E-09	Upper bound on r:	5.000E+00
Relative conv. criterion (effort):	1.000E-05	Random number seed:	5844285
Maximum F allowed in fitting:	5.000	Monte Carlo search trials:	50000

PROGRAM STATUS INFORMATION (NON-BOOTSTRAPPED ANALYSIS) code 0

Normal convergence.

CORRELATION AMONG INPUT SERIES EXPRESSED AS CPUE (NUMBER OF PAIRWISE OBSERVATIONS BELOW)

	1	2	3
1 USA Fall	1.000 37		
2 USA Spring -lagged	0.781 23	1.000 23	
3 Canada - lagged	0.823 14	0.939 13	1.000 14

GOODNESS-OF-FIT AND WEIGHTING FOR NON-BOOTSTRAPPED ANALYSIS

Loss component number and title	Weighted SSE	N	Weighted MSE	Current weight	Suggested weight	R-squared in CPUE
Loss(-1) SSE in yield	0.000E+00					
Loss(0) Penalty for B1R > 2	0.000E+00	1	N/A	1.000E+00	N/A	
Loss(1) USA Fall	9.357E+00	37	2.673E-01	1.000E+00	9.140E-01	0.610
Loss(2) USA Spring -lagged	4.875E+00	23	2.321E-01	1.000E+00	1.053E+00	0.659
Loss(3) Canada - lagged	2.570E+00	14	2.142E-01	1.000E+00	1.141E+00	0.769
TOTAL OBJECTIVE FUNCTION:	1.68018243E+01					

Number of restarts required for convergence: 45
Est. B-ratio coverage index (0 worst, 2 best): 0.8970
Est. B-ratio nearness index (0 worst, 1 best): 0.9695

< These two measures are defined in Prager
< et al. (1996), Trans. A.F.S. 125:729

MODEL PARAMETER ESTIMATES (NON-BOOTSTRAPPED)

Parameter		Estimate	Starting guess	Estimated	User guess
B1R	Starting biomass ratio, year 1963	9.695E-01	2.000E+00	1	1
MSY	Maximum sustainable yield	1.664E+01	1.400E+01	1	1
r	Intrinsic rate of increase	6.154E-01	6.000E-01	1	1
.....	Catchability coefficients by fishery:				
q(1)	USA Fall	1.255E-01	1.000E-01	1	1
q(2)	USA Spring -lagged	1.436E-01	1.000E-01	1	1
q(3)	Canada - lagged	2.943E-01	3.000E-01	1	1

MANAGEMENT PARAMETER ESTIMATES (NON-BOOTSTRAPPED)

Parameter		Estimate	Formula	Related quantity
MSY	Maximum sustainable yield	1.664E+01	Kr/4	
K	Maximum stock biomass	1.081E+02		
Bmsy	Stock biomass at MSY	5.407E+01	K/2	
Fmsy	Fishing mortality at MSY	3.077E-01	r/2	
F(0.1)	Management benchmark	2.769E-01	0.9*Fmsy	
Y(0.1)	Equilibrium yield at F(0.1)	1.647E+01	0.99*MSY	
B-ratio	Ratio of B(2000) to Bmsy	9.874E-01		
F-ratio	Ratio of F(1999) to Fmsy	3.040E-01		
F01-mult	Ratio of F(0.1) to F(1999)	2.960E+00		
Y-ratio	Proportion of MSY avail in 2000	9.998E-01	2*Br-Br^2	Ye(2000) = 1.664E+01
.....	Fishing effort at MSY in units of each fishery:			
fmsy(1)	USA Fall	2.452E+00	r/2q(1)	f(0.1) = 2.207E+00

Appendix C. Georges Bank yellowtail flounder production analysis

ESTIMATED POPULATION TRAJECTORY (NON-BOOTSTRAPPED)

Obs	Year or ID	Estimated total F mort	Estimated starting biomass	Estimated average biomass	Observed total yield	Model total yield	Estimated surplus production	Ratio of F mort to Fmsy	Ratio of biomass to Bmsy
1	1963	0.336	5.242E+01	5.198E+01	1.746E+01	1.746E+01	1.661E+01	1.092E+00	9.695E-01
2	1964	0.396	5.158E+01	4.987E+01	1.977E+01	1.977E+01	1.653E+01	1.288E+00	9.539E-01
3	1965	0.413	4.834E+01	4.677E+01	1.931E+01	1.931E+01	1.633E+01	1.342E+00	8.940E-01
4	1966	0.305	4.536E+01	4.646E+01	1.419E+01	1.419E+01	1.631E+01	9.925E-01	8.388E-01
5	1967	0.292	4.748E+01	4.866E+01	1.420E+01	1.420E+01	1.647E+01	9.482E-01	8.780E-01
6	1968	0.376	4.975E+01	4.878E+01	1.832E+01	1.832E+01	1.648E+01	1.221E+00	9.200E-01
7	1969	0.476	4.790E+01	4.510E+01	2.145E+01	2.145E+01	1.617E+01	1.546E+00	8.859E-01
8	1970	0.556	4.262E+01	3.920E+01	2.179E+01	2.179E+01	1.536E+01	1.807E+00	7.882E-01
9	1971	0.423	3.619E+01	3.596E+01	1.521E+01	1.521E+01	1.477E+01	1.374E+00	6.692E-01
10	1972	0.522	3.575E+01	3.397E+01	1.773E+01	1.773E+01	1.433E+01	1.696E+00	6.612E-01
11	1973	0.536	3.236E+01	3.080E+01	1.652E+01	1.652E+01	1.355E+01	1.743E+00	5.984E-01
12	1974	0.608	2.939E+01	2.726E+01	1.659E+01	1.659E+01	1.254E+01	1.978E+00	5.435E-01
13	1975	0.705	2.534E+01	2.270E+01	1.601E+01	1.601E+01	1.103E+01	2.292E+00	4.686E-01
14	1976	0.820	2.035E+01	1.750E+01	1.436E+01	1.436E+01	9.014E+00	2.666E+00	3.764E-01
15	1977	0.736	1.501E+01	1.360E+01	1.001E+01	1.001E+01	7.313E+00	2.392E+00	2.776E-01
16	1978	0.489	1.231E+01	1.266E+01	6.188E+00	6.188E+00	6.878E+00	1.589E+00	2.277E-01
17	1979	0.457	1.300E+01	1.355E+01	6.195E+00	6.195E+00	7.293E+00	1.486E+00	2.405E-01
18	1980	0.472	1.410E+01	1.454E+01	6.863E+00	6.863E+00	7.746E+00	1.534E+00	2.608E-01
19	1981	0.391	1.498E+01	1.604E+01	6.277E+00	6.277E+00	8.404E+00	1.272E+00	2.771E-01
20	1982	0.802	1.711E+01	1.495E+01	1.200E+01	1.200E+01	7.921E+00	2.608E+00	3.164E-01
21	1983	1.178	1.303E+01	9.695E+00	1.142E+01	1.142E+01	5.415E+00	3.829E+00	2.410E-01
22	1984	1.017	7.027E+00	5.693E+00	5.791E+00	5.791E+00	3.316E+00	3.306E+00	1.299E-01
23	1985	0.540	4.552E+00	4.665E+00	2.520E+00	2.520E+00	2.747E+00	1.756E+00	8.418E-02
24	1986	0.665	4.778E+00	4.601E+00	3.060E+00	3.060E+00	2.711E+00	2.162E+00	8.837E-02
25	1987	0.714	4.429E+00	4.168E+00	2.975E+00	2.975E+00	2.466E+00	2.320E+00	8.191E-02
26	1988	0.521	3.920E+00	4.063E+00	2.118E+00	2.118E+00	2.406E+00	1.694E+00	7.250E-02
27	1989	0.240	4.209E+00	5.035E+00	1.207E+00	1.207E+00	2.953E+00	7.791E-01	7.783E-02
28	1990	0.607	5.954E+00	5.880E+00	3.569E+00	3.569E+00	3.422E+00	1.973E+00	1.101E-01
29	1991	0.304	5.807E+00	6.686E+00	2.030E+00	2.030E+00	3.858E+00	9.868E-01	1.074E-01
30	1992	0.641	7.635E+00	7.381E+00	4.732E+00	4.732E+00	4.232E+00	2.084E+00	1.412E-01
31	1993	0.531	7.135E+00	7.290E+00	3.874E+00	3.874E+00	4.184E+00	1.727E+00	1.320E-01
32	1994	0.502	7.445E+00	7.712E+00	3.871E+00	3.871E+00	4.407E+00	1.631E+00	1.377E-01
33	1995	0.079	7.982E+00	1.026E+01	8.110E-01	8.110E-01	5.702E+00	2.570E-01	1.476E-01
34	1996	0.078	1.287E+01	1.626E+01	1.273E+00	1.273E+00	8.479E+00	2.544E-01	2.381E-01
35	1997	0.074	2.008E+01	2.481E+01	1.834E+00	1.834E+00	1.172E+01	2.403E-01	3.713E-01
36	1998	0.087	2.996E+01	3.562E+01	3.087E+00	3.087E+00	1.464E+01	2.817E-01	5.541E-01
37	1999	0.094	4.151E+01	4.747E+01	4.441E+00	4.441E+00	1.632E+01	3.040E-01	7.677E-01
38	2000		5.339E+01						9.874E-01

Appendix C. Georges Bank yellowtail flounder production analysis

RESULTS FOR DATA SERIES # 1 (NON-BOOTSTRAPPED) USA Fall

Data type CC: CPUE-catch series. Series weight: 1.000

Obs	Year	Observed CPUE	Estimated CPUE	Estim F	Observed yield	Model yield	Resid in log scale	Resid in yield
1	1963	1.279E+01	6.522E+00	0.3359	1.746E+01	1.746E+01	-0.67335	0.000E+00
2	1964	1.362E+01	6.257E+00	0.3964	1.977E+01	1.977E+01	-0.77811	0.000E+00
3	1965	9.104E+00	5.868E+00	0.4130	1.931E+01	1.931E+01	-0.43921	0.000E+00
4	1966	3.988E+00	5.829E+00	0.3054	1.419E+01	1.419E+01	0.37952	0.000E+00
5	1967	7.575E+00	6.105E+00	0.2918	1.420E+01	1.420E+01	-0.21576	0.000E+00
6	1968	1.054E+01	6.120E+00	0.3756	1.832E+01	1.832E+01	-0.54320	0.000E+00
7	1969	9.279E+00	5.659E+00	0.4756	2.145E+01	2.145E+01	-0.49459	0.000E+00
8	1970	4.979E+00	4.918E+00	0.5560	2.179E+01	2.179E+01	-0.01231	0.000E+00
9	1971	6.365E+00	4.512E+00	0.4228	1.521E+01	1.521E+01	-0.34402	0.000E+00
10	1972	6.328E+00	4.263E+00	0.5219	1.773E+01	1.773E+01	-0.39512	0.000E+00
11	1973	6.602E+00	3.865E+00	0.5364	1.652E+01	1.652E+01	-0.53540	0.000E+00
12	1974	3.733E+00	3.420E+00	0.6085	1.659E+01	1.659E+01	-0.08746	0.000E+00
13	1975	2.365E+00	2.848E+00	0.7053	1.601E+01	1.601E+01	0.18596	0.000E+00
14	1976	1.533E+00	2.196E+00	0.8203	1.436E+01	1.436E+01	0.35941	0.000E+00
15	1977	2.829E+00	1.706E+00	0.7361	1.001E+01	1.001E+01	-0.50558	0.000E+00
16	1978	2.383E+00	1.588E+00	0.4889	6.188E+00	6.188E+00	-0.40575	0.000E+00
17	1979	1.520E+00	1.700E+00	0.4572	6.195E+00	6.195E+00	0.11204	0.000E+00
18	1980	6.722E+00	1.825E+00	0.4719	6.863E+00	6.863E+00	-1.30394	0.000E+00
19	1981	2.621E+00	2.012E+00	0.3914	6.277E+00	6.277E+00	-0.26420	0.000E+00
20	1982	2.270E+00	1.876E+00	0.8024	1.200E+01	1.200E+01	-0.19069	0.000E+00
21	1983	2.131E+00	1.216E+00	1.1781	1.142E+01	1.142E+01	-0.56061	0.000E+00
22	1984	5.930E-01	7.143E-01	1.0172	5.791E+00	5.791E+00	0.18614	0.000E+00
23	1985	7.090E-01	5.853E-01	0.5402	2.520E+00	2.520E+00	-0.19179	0.000E+00
24	1986	8.200E-01	5.772E-01	0.6651	3.060E+00	3.060E+00	-0.35103	0.000E+00
25	1987	5.090E-01	5.230E-01	0.7137	2.975E+00	2.975E+00	0.02715	0.000E+00
26	1988	1.710E-01	5.098E-01	0.5213	2.118E+00	2.118E+00	1.09238	0.000E+00
27	1989	9.770E-01	6.318E-01	0.2397	1.207E+00	1.207E+00	-0.43594	0.000E+00
28	1990	7.250E-01	7.378E-01	0.6070	3.569E+00	3.569E+00	0.01748	0.000E+00
29	1991	7.300E-01	8.388E-01	0.3036	2.030E+00	2.030E+00	0.13897	0.000E+00
30	1992	5.760E-01	9.261E-01	0.6411	4.732E+00	4.732E+00	0.47485	0.000E+00
31	1993	5.450E-01	9.147E-01	0.5314	3.874E+00	3.874E+00	0.51783	0.000E+00
32	1994	8.970E-01	9.677E-01	0.5019	3.871E+00	3.871E+00	0.07584	0.000E+00
33	1995	3.540E-01	1.287E+00	0.0791	8.110E-01	8.110E-01	1.29071	0.000E+00
34	1996	1.303E+00	2.041E+00	0.0783	1.273E+00	1.273E+00	0.44866	0.000E+00
35	1997	3.781E+00	3.113E+00	0.0739	1.834E+00	1.834E+00	-0.19451	0.000E+00
36	1998	4.347E+00	4.469E+00	0.0867	3.087E+00	3.087E+00	0.02771	0.000E+00
37	1999	7.973E+00	5.956E+00	0.0936	4.441E+00	4.441E+00	-0.29163	0.000E+00

UNWEIGHTED LOG RESIDUAL PLOT FOR DATA SERIES # 1

Year	Residual	-2 -1.5 -1 -0.5 0 0.5 1 1.5 2
1963	-0.6733	============|
1964	-0.7781	==============|
1965	-0.4392	=========|
1966	0.3795	|========
1967	-0.2158	====|
1968	-0.5432	===========|
1969	-0.4946	==========|
1970	-0.0123	|
1971	-0.3440	=======|
1972	-0.3951	========|
1973	-0.5354	===========|
1974	-0.0875	==|
1975	0.1860	|====
1976	0.3594	|=======
1977	-0.5056	==========|
1978	-0.4057	========|
1979	0.1120	|==
1980	-1.3039	==========================|
1981	-0.2642	=====|
1982	-0.1907	====|
1983	-0.5606	===========|
1984	0.1861	|====
1985	-0.1918	====|
1986	-0.3510	=======|
1987	0.0272	|=
1988	1.0924	|======================
1989	-0.4359	=========|
1990	0.0175	|
1991	0.1390	|===
1992	0.4749	|=========
1993	0.5178	|==========
1994	0.0758	|==
1995	1.2907	|==========================
1996	0.4487	|=========
1997	-0.1945	====|
1998	0.0277	|=
1999	-0.2916	======|

Appendix C. Georges Bank yellowtail flounder production analysis

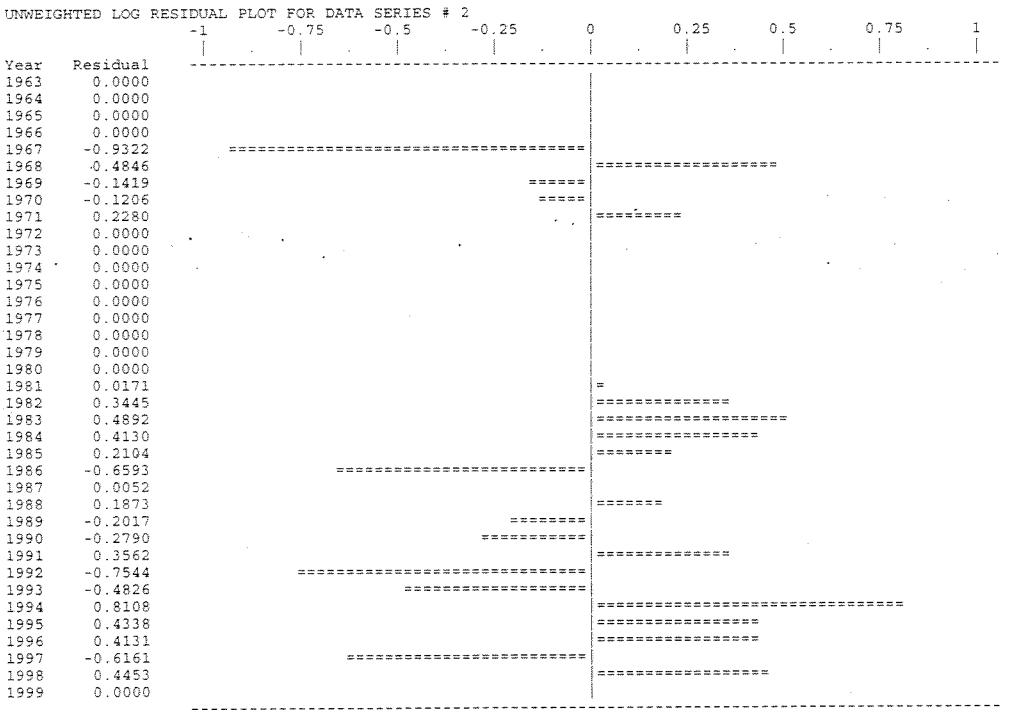
RESULTS FOR DATA SERIES # 2 (NON-BOOTSTRAPPED) USA Spring -lagged

Data type I2: End-of-year biomass index Series weight: 1.000

Obs	Year	Observed effort	Estimated effort	Estim F	Observed index	Model index	Resid in log index	Resid in index
1	1963	0.000E+00	0.000E+00	0.0	*	7.408E+00	0.00000	0.0
2	1964	0.000E+00	0.000E+00	0.0	*	6.943E+00	0.00000	0.0
3	1965	0.000E+00	0.000E+00	0.0	*	6.515E+00	0.00000	0.0
4	1966	0.000E+00	0.000E+00	0.0	*	6.819E+00	0.00000	0.0
5	1967	1.000E+00	1.000E+00	0.0	2.813E+00	7.145E+00	-0.93221	-4.332E+00
6	1968	1.000E+00	1.000E+00	0.0	1.117E+01	6.880E+00	0.48456	4.290E+00
7	1969	1.000E+00	1.000E+00	0.0	5.312E+00	6.122E+00	-0.14186	-8.096E-01
8	1970	1.000E+00	1.000E+00	0.0	4.607E+00	5.198E+00	-0.12061	-5.905E-01
9	1971	1.000E+00	1.000E+00	0.0	6.450E+00	5.135E+00	0.22796	1.315E+00
10	1972	0.000E+00	0.000E+00	0.0	*	4.647E+00	0.00000	0.0
11	1973	0.000E+00	0.000E+00	0.0	*	4.221E+00	0.00000	0.0
12	1974	0.000E+00	0.000E+00	0.0	*	3.639E+00	0.00000	0.0
13	1975	0.000E+00	0.000E+00	0.0	*	2.923E+00	0.00000	0.0
14	1976	0.000E+00	0.000E+00	0.0	*	2.156E+00	0.00000	0.0
15	1977	0.000E+00	0.000E+00	0.0	*	1.768E+00	0.00000	0.0
16	1978	0.000E+00	0.000E+00	0.0	*	1.867E+00	0.00000	0.0
17	1979	0.000E+00	0.000E+00	0.0	*	2.025E+00	0.00000	0.0
18	1980	0.000E+00	0.000E+00	0.0	*	2.152E+00	0.00000	0.0
19	1981	1.000E+00	1.000E+00	0.0	2.500E+00	2.458E+00	0.01714	4.249E-02
20	1982	1.000E+00	1.000E+00	0.0	2.642E+00	1.872E+00	0.34451	7.700E-01
21	1983	1.000E+00	1.000E+00	0.0	1.646E+00	1.009E+00	0.48918	6.368E-01
22	1984	1.000E+00	1.000E+00	0.0	9.880E-01	6.537E-01	0.41296	3.343E-01
23	1985	1.000E+00	1.000E+00	0.0	8.470E-01	6.863E-01	0.21038	1.607E-01
24	1986	1.000E+00	1.000E+00	0.0	3.290E-01	6.361E-01	-0.65934	-3.071E-01
25	1987	1.000E+00	1.000E+00	0.0	5.660E-01	5.630E-01	0.00524	2.957E-03
26	1988	1.000E+00	1.000E+00	0.0	7.290E-01	6.045E-01	0.18732	1.245E-01
27	1989	1.000E+00	1.000E+00	0.0	6.990E-01	8.552E-01	-0.20172	-1.562E-01
28	1990	1.000E+00	1.000E+00	0.0	6.310E-01	8.341E-01	-0.27903	-2.031E-01
29	1991	1.000E+00	1.000E+00	0.0	1.566E+00	1.097E+00	0.35624	4.693E-01
30	1992	1.000E+00	1.000E+00	0.0	4.820E-01	1.025E+00	-0.75436	-5.428E-01
31	1993	1.000E+00	1.000E+00	0.0	6.600E-01	1.069E+00	-0.48257	-4.094E-01
32	1994	1.000E+00	1.000E+00	0.0	2.579E+00	1.146E+00	0.81078	1.433E+00
33	1995	1.000E+00	1.000E+00	0.0	2.853E+00	1.849E+00	0.43380	1.004E+00
34	1996	1.000E+00	1.000E+00	0.0	4.359E+00	2.884E+00	0.41310	1.475E+00
35	1997	1.000E+00	1.000E+00	0.0	2.324E+00	4.303E+00	-0.61614	-1.979E+00
36	1998	1.000E+00	1.000E+00	0.0	9.307E+00	5.962E+00	0.44531	3.345E+00
37	1999	0.000E+00	0.000E+00	0.0	*	7.669E+00	0.00000	0.0

* Asterisk indicates missing value(s).

UNWEIGHTED LOG RESIDUAL PLOT FOR DATA SERIES # 2



Appendix C. Georges Bank yellowtail flounder production analysis

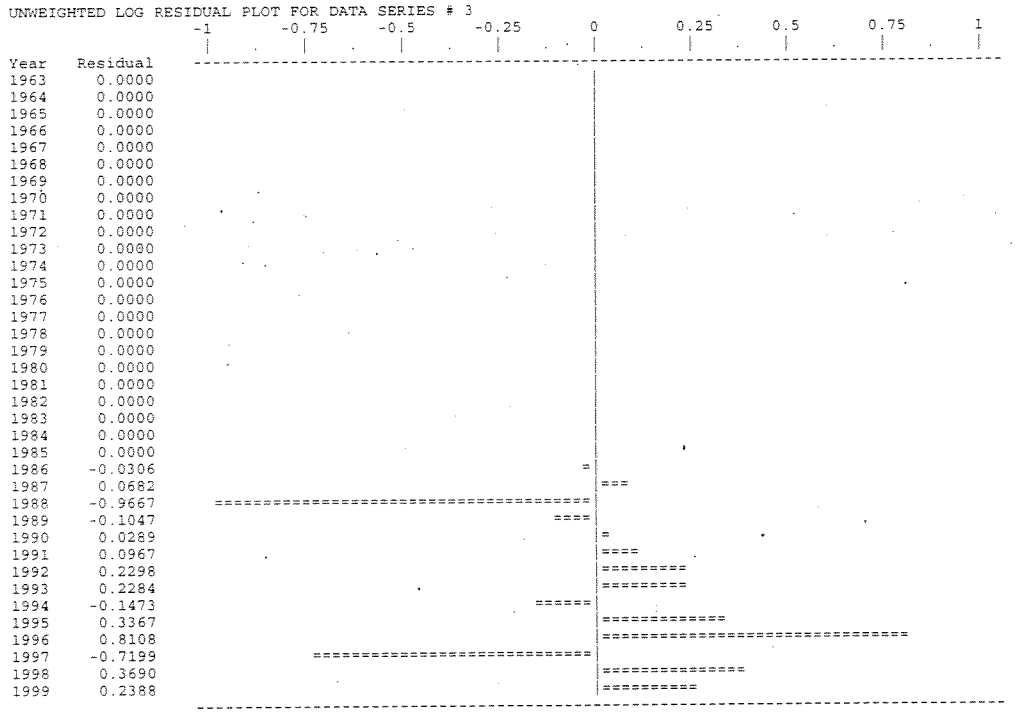
RESULTS FOR DATA SERIES # 3 (NON-BOOTSTRAPPED) Canada - lagged

Data type I2: End-of-year biomass index Series weight: 1.000

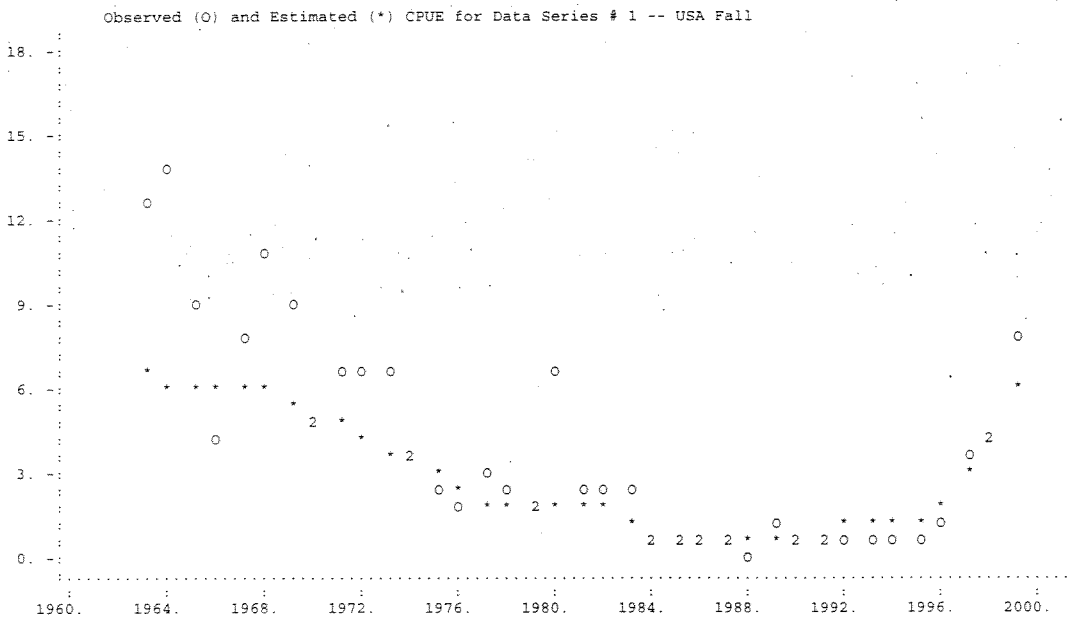
Obs	Year	Observed effort	Estimated effort	Estim F	Observed index	Model index	Resid in log index	Resid in index
1	1963	0.000E+00	0.000E+00	0.0	*	1.518E+01	0.00000	0.0
2	1964	0.000E+00	0.000E+00	0.0	*	1.422E+01	0.00000	0.0
3	1965	0.000E+00	0.000E+00	0.0	*	1.335E+01	0.00000	0.0
4	1966	0.000E+00	0.000E+00	0.0	*	1.397E+01	0.00000	0.0
5	1967	0.000E+00	0.000E+00	0.0	*	1.464E+01	0.00000	0.0
6	1968	0.000E+00	0.000E+00	0.0	*	1.410E+01	0.00000	0.0
7	1969	0.000E+00	0.000E+00	0.0	*	1.254E+01	0.00000	0.0
8	1970	0.000E+00	0.000E+00	0.0	*	1.065E+01	0.00000	0.0
9	1971	0.000E+00	0.000E+00	0.0	*	1.052E+01	0.00000	0.0
10	1972	0.000E+00	0.000E+00	0.0	*	9.521E+00	0.00000	0.0
11	1973	0.000E+00	0.000E+00	0.0	*	8.647E+00	0.00000	0.0
12	1974	0.000E+00	0.000E+00	0.0	*	7.456E+00	0.00000	0.0
13	1975	0.000E+00	0.000E+00	0.0	*	5.989E+00	0.00000	0.0
14	1976	0.000E+00	0.000E+00	0.0	*	4.417E+00	0.00000	0.0
15	1977	0.000E+00	0.000E+00	0.0	*	3.623E+00	0.00000	0.0
16	1978	0.000E+00	0.000E+00	0.0	*	3.826E+00	0.00000	0.0
17	1979	0.000E+00	0.000E+00	0.0	*	4.149E+00	0.00000	0.0
18	1980	0.000E+00	0.000E+00	0.0	*	4.409E+00	0.00000	0.0
19	1981	0.000E+00	0.000E+00	0.0	*	5.035E+00	0.00000	0.0
20	1982	0.000E+00	0.000E+00	0.0	*	3.835E+00	0.00000	0.0
21	1983	0.000E+00	0.000E+00	0.0	*	2.068E+00	0.00000	0.0
22	1984	0.000E+00	0.000E+00	0.0	*	1.339E+00	0.00000	0.0
23	1985	0.000E+00	0.000E+00	0.0	*	1.406E+00	0.00000	0.0
24	1986	1.000E+00	1.000E+00	0.0	1.264E+00	1.303E+00	-0.03060	-3.927E-02
25	1987	1.000E+00	1.000E+00	0.0	1.235E+00	1.154E+00	0.06824	8.146E-02
26	1988	1.000E+00	1.000E+00	0.0	4.710E-01	1.238E+00	-0.96673	-7.674E-01
27	1989	1.000E+00	1.000E+00	0.0	1.578E+00	1.752E+00	-0.10469	-1.742E-01
28	1990	1.000E+00	1.000E+00	0.0	1.759E+00	1.709E+00	0.02893	5.016E-02
29	1991	1.000E+00	1.000E+00	0.0	2.475E+00	2.247E+00	0.09673	2.282E-01
30	1992	1.000E+00	1.000E+00	0.0	2.642E+00	2.100E+00	0.22976	5.423E-01
31	1993	1.000E+00	1.000E+00	0.0	2.753E+00	2.191E+00	0.22841	5.622E-01
32	1994	1.000E+00	1.000E+00	0.0	2.027E+00	2.349E+00	-0.14730	-3.217E-01
33	1995	1.000E+00	1.000E+00	0.0	5.304E+00	3.788E+00	0.33665	1.516E+00
34	1996	1.000E+00	1.000E+00	0.0	1.329E+01	5.908E+00	0.81079	7.384E+00
35	1997	1.000E+00	1.000E+00	0.0	4.292E+00	8.817E+00	-0.71991	-4.525E+00
36	1998	1.000E+00	1.000E+00	0.0	1.767E+01	1.222E+01	0.36895	5.451E+00
37	1999	1.000E+00	1.000E+00	0.0	1.995E+01	1.571E+01	0.23883	4.238E+00

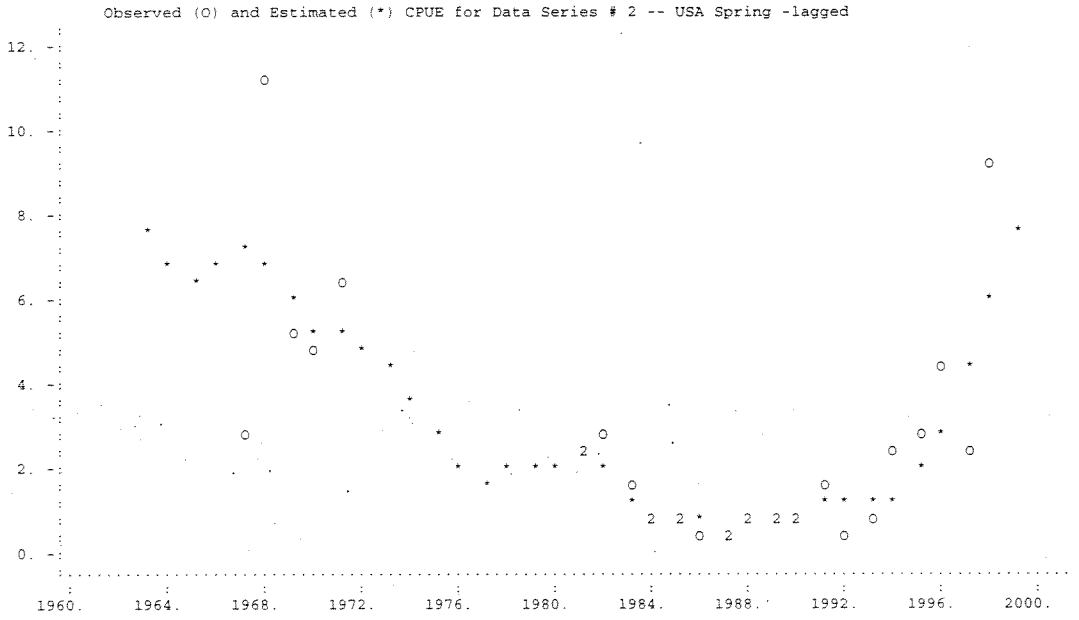
* Asterisk indicates missing value(s).

UNWEIGHTED LOG RESIDUAL PLOT FOR DATA SERIES # 3

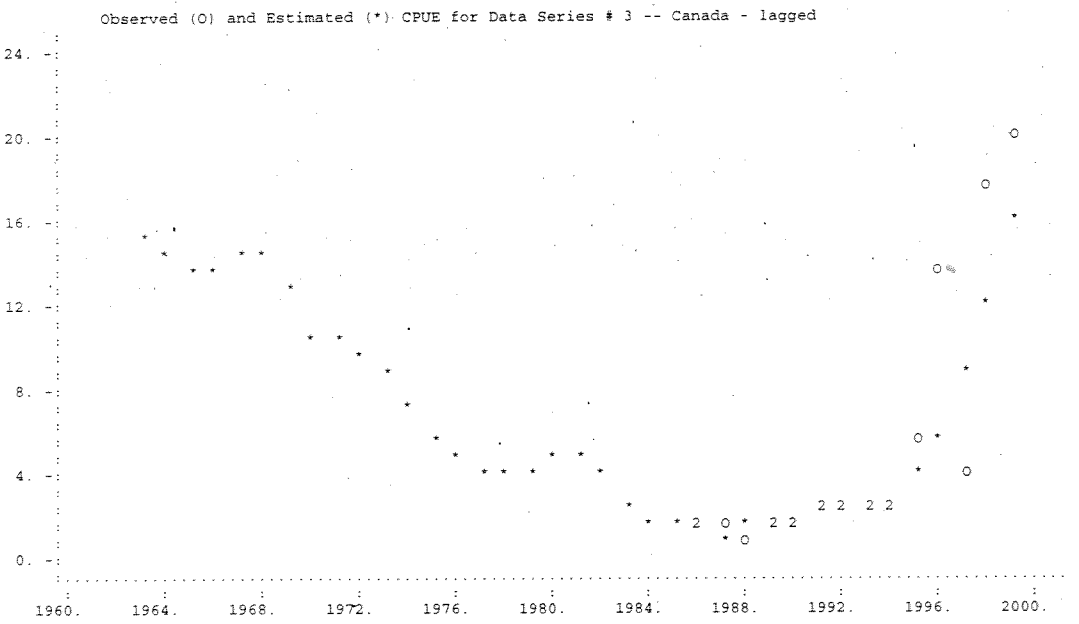


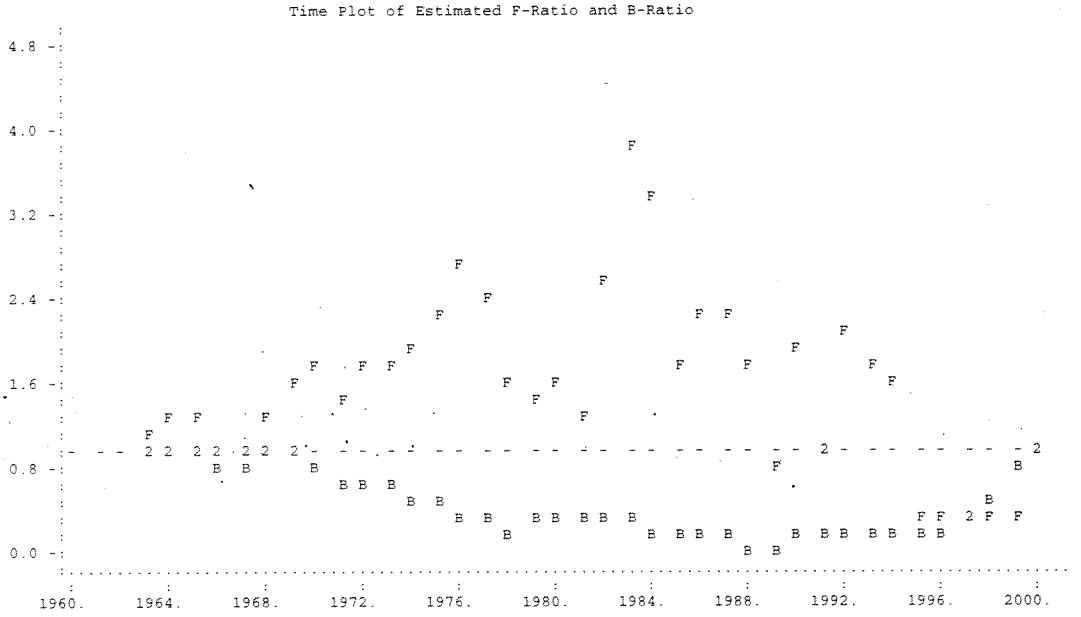
Appendix C. Georges Bank yellowtail flounder production analysis





Appendix C. Georges Bank yellowtail flounder production analysis





Appendix C. Georges Bank yellowtail flounder production analysis

RESULTS OF BOOTSTRAPPED ANALYSIS

Param name	Bias-corrected estimate	Ordinary estimate	Relative bias	Approx 80% lower CL	Approx 80% upper CL	Approx 50% lower CL	Approx 50% upper CL	Inter-quartile range	Relative IQ range
Blratio	9.578E-01	9.695E-01	1.22%	8.130E-01	9.992E-01	9.431E-01	9.728E-01	2.967E-02	0.031
K	1.099E+02	1.081E+02	-1.55%	1.029E+02	1.267E+02	1.072E+02	1.153E+02	8.076E+00	0.074
r	6.163E-01	6.154E-01	-0.14%	5.657E-01	6.607E-01	5.954E-01	6.374E-01	4.199E-02	0.068
q(1)	1.259E-01	1.255E-01	-0.33%	1.081E-01	1.361E-01	1.191E-01	1.310E-01	1.190E-02	0.095
q(2)	1.523E-01	1.436E-01	-5.71%	1.336E-01	1.711E-01	1.430E-01	1.608E-01	1.782E-02	0.117
q(3)	3.136E-01	2.943E-01	-6.16%	2.639E-01	3.864E-01	2.892E-01	3.443E-01	5.510E-02	0.176
MSY	1.670E+01	1.664E+01	-0.39%	1.591E+01	1.703E+01	1.660E+01	1.681E+01	2.093E-01	0.013
Ye(2000)	1.701E+01	1.664E+01	-2.23%	1.661E+01	1.897E+01	1.671E+01	1.867E+01	1.957E+00	0.115
Bmsy	5.493E+01	5.407E+01	-1.55%	5.147E+01	6.334E+01	5.359E+01	5.763E+01	4.038E+00	0.074
Fmsy	3.081E-01	3.077E-01	-0.14%	2.829E-01	3.303E-01	2.977E-01	3.187E-01	2.099E-02	0.068
fmsy(1)	2.447E+00	2.452E+00	0.22%	2.269E+00	2.785E+00	2.366E+00	2.587E+00	2.200E-01	0.090
fmsy(2)	2.010E+00	2.142E+00	6.61%	1.752E+00	2.280E+00	1.894E+00	2.147E+00	2.527E-01	0.126
fmsy(3)	9.766E-01	1.046E+00	7.07%	8.110E-01	1.177E+00	8.984E-01	1.072E+00	1.735E-01	0.178
F(0.1)	2.773E-01	2.769E-01	-0.13%	2.546E-01	2.973E-01	2.679E-01	2.868E-01	1.890E-02	0.068
Y(0.1)	1.654E+01	1.647E+01	-0.39%	1.575E+01	1.686E+01	1.643E+01	1.664E+01	2.072E-01	0.013
B-ratio	9.429E-01	9.874E-01	4.72%	7.750E-01	1.117E+00	8.573E-01	1.034E+00	1.764E-01	0.187
F-ratio	3.067E-01	3.040E-01	-0.88%	2.605E-01	3.714E-01	2.806E-01	3.376E-01	5.695E-02	0.186
Y-ratio	1.008E+00	9.998E-01	-0.83%	9.999E-01	1.000E+00	1.000E+00	1.000E+00	5.510E-06	0.000
f0.1(1)	2.202E+00	2.207E+00	0.20%	* * * * *	0.090				
f0.1(2)	1.809E+00	1.928E+00	5.94%	* * * * *	0.126				
f0.1(3)	8.790E-01	9.411E-01	6.36%	* * * * *	0.178				
q2/q1	1.189E+00	1.145E+00	-3.74%	1.047E+00	1.398E+00	1.123E+00	1.305E+00	1.815E-01	0.153
q3/q1	2.445E+00	2.345E+00	-4.10%	2.058E+00	3.075E+00	2.263E+00	2.759E+00	4.962E-01	0.203

NOTES ON BOOTSTRAPPED ESTIMATES:

- The bootstrapped results shown were computed from 1000 trials.
- These results are conditional on the constraints placed upon MSY and r in the input file (ASPIC.INP).
- All bootstrapped intervals are approximate. The statistical literature recommends using at least 1000 trials for accurate 95% intervals. The 80% intervals used by ASPIC should require fewer trials for equivalent accuracy. Using at least 500 trials is recommended.
- The bias corrections used here are based on medians. This is an accepted statistical procedure, but may estimate nonzero bias for unbiased, skewed estimators.

Trials replaced for lack of convergence: 201
Trials replaced for MSY out-of-bounds: 0
Trials replaced for r out-of-bounds: 3
Residual-adjustment factor: 1.0432

14 Apr 2000 at 10:09.22
Georges Bank Yellowtail (yield and biomass in k mt) Page 1
TRAC 2000; Ffull=0.25, Fon biomass=0.19 Output from ASPIC-P.EXE

USER CONTROL INFORMATION (FROM INPUT FILE)

Name of biomass (BIO) file: gbyt2000.bio
Name of output file (this file): gbyt2000.prj
Number of years of projections: 1

Year	Input data	User data type
2000	2.015E+00	F/F(1999)

TABLE OF PROJECTED YIELDS

Year	Bias-corrected estimate	Ordinary estimate	Relative bias	Approx 80% lower CL	Approx 80% upper CL	Approx 50% lower CL	Approx 50% upper CL	Inter-quartile range	Relative IQ range
2000	9.924E+00	1.015E+01	2.28%	9.196E+00	1.125E+01	9.417E+00	1.062E+01	1.204E+00	0.121

NOTE: Printed BC confidence intervals are always approximate.
At least 500 trials are recommended when estimating confidence intervals.

Appendix C. Georges Bank yellowtail flounder production analysis

Georges Bank Yellowtail (yield and biomass in k mt)
TRAC 2000; Ffull=0.25, Fon biomass=0.19
Output from ASPIC-P.EXE

TRAJECTORY OF ABSOLUTE BIOMASS (BOOTSTRAPPED)

Year	Bias-corrected estimate	Ordinary estimate	Relative bias	Approx 80% lower CL	Approx 80% upper CL	Approx 50% lower CL	Approx 50% upper CL	Inter-quartile range	Relative IQ range
1963	5.142E+01	5.242E+01	1.95%	4.813E+01	6.133E+01	4.978E+01	5.300E+01	3.221E+00	0.063
1964	5.064E+01	5.158E+01	1.85%	4.751E+01	6.085E+01	4.908E+01	5.216E+01	3.081E+00	0.061
1965	4.746E+01	4.834E+01	1.85%	4.448E+01	5.655E+01	4.599E+01	4.894E+01	2.954E+00	0.062
1966	4.454E+01	4.536E+01	1.84%	4.169E+01	5.287E+01	4.309E+01	4.596E+01	2.866E+00	0.064
1967	4.672E+01	4.748E+01	1.61%	4.399E+01	5.400E+01	4.535E+01	4.803E+01	2.678E+00	0.057
1968	4.907E+01	4.975E+01	1.38%	4.646E+01	5.517E+01	4.774E+01	5.030E+01	2.554E+00	0.052
1969	4.731E+01	4.790E+01	1.25%	4.496E+01	5.202E+01	4.602E+01	4.844E+01	2.426E+00	0.051
1970	4.212E+01	4.262E+01	1.19%	3.992E+01	4.586E+01	4.099E+01	4.318E+01	2.196E+00	0.052
1971	3.576E+01	3.619E+01	1.19%	3.376E+01	3.883E+01	3.477E+01	3.677E+01	1.999E+00	0.056
1972	3.543E+01	3.575E+01	0.91%	3.362E+01	3.803E+01	3.451E+01	3.631E+01	1.808E+00	0.051
1973	3.209E+01	3.236E+01	0.83%	3.049E+01	3.428E+01	3.131E+01	3.288E+01	1.573E+00	0.049
1974	2.922E+01	2.939E+01	0.57%	2.784E+01	3.114E+01	2.852E+01	2.986E+01	1.341E+00	0.046
1975	2.523E+01	2.534E+01	0.42%	2.409E+01	2.687E+01	2.468E+01	2.585E+01	1.170E+00	0.046
1976	2.028E+01	2.035E+01	0.34%	1.931E+01	2.165E+01	1.983E+01	2.081E+01	9.841E-01	0.049
1977	1.495E+01	1.501E+01	0.38%	1.407E+01	1.617E+01	1.453E+01	1.542E+01	8.881E-01	0.059
1978	1.226E+01	1.231E+01	0.43%	1.139E+01	1.345E+01	1.184E+01	1.271E+01	8.722E-01	0.071
1979	1.294E+01	1.300E+01	0.44%	1.206E+01	1.415E+01	1.253E+01	1.341E+01	8.849E-01	0.068
1980	1.404E+01	1.410E+01	0.40%	1.317E+01	1.523E+01	1.363E+01	1.450E+01	8.705E-01	0.062
1981	1.493E+01	1.498E+01	0.35%	1.411E+01	1.602E+01	1.455E+01	1.536E+01	8.090E-01	0.054
1982	1.708E+01	1.711E+01	0.19%	1.638E+01	1.793E+01	1.675E+01	1.741E+01	6.609E-01	0.039
1983	1.302E+01	1.303E+01	0.14%	1.254E+01	1.364E+01	1.279E+01	1.326E+01	4.766E-01	0.037
1984	7.015E+00	7.027E+00	0.16%	6.680E+00	7.483E+00	6.852E+00	7.202E+00	3.497E-01	0.050
1985	4.541E+00	4.552E+00	0.24%	4.236E+00	4.979E+00	4.393E+00	4.713E+00	3.199E-01	0.070
1986	4.768E+00	4.778E+00	0.21%	4.464E+00	5.211E+00	4.621E+00	4.943E+00	3.223E-01	0.068
1987	4.418E+00	4.429E+00	0.24%	4.108E+00	4.862E+00	4.268E+00	4.587E+00	3.188E-01	0.072
1988	3.906E+00	3.920E+00	0.36%	3.566E+00	4.399E+00	3.741E+00	4.088E+00	3.462E-01	0.089
1989	4.183E+00	4.209E+00	0.61%	3.795E+00	4.753E+00	4.005E+00	4.410E+00	4.048E-01	0.097
1990	5.920E+00	5.954E+00	0.59%	5.502E+00	6.611E+00	5.731E+00	6.184E+00	4.536E-01	0.077
1991	5.750E+00	5.807E+00	1.00%	5.296E+00	6.549E+00	5.530E+00	6.067E+00	5.372E-01	0.093
1992	7.550E+00	7.635E+00	1.13%	7.065E+00	8.496E+00	7.311E+00	7.948E+00	6.372E-01	0.084
1993	6.982E+00	7.135E+00	2.20%	6.398E+00	8.058E+00	6.692E+00	7.446E+00	7.547E-01	0.108
1994	7.173E+00	7.445E+00	3.80%	6.350E+00	8.659E+00	6.664E+00	7.851E+00	1.097E+00	0.153
1995	7.511E+00	7.982E+00	6.26%	6.129E+00	9.625E+00	6.758E+00	8.443E+00	1.685E+00	0.224
1996	1.210E+01	1.287E+01	6.42%	9.904E+00	1.517E+01	1.090E+01	1.357E+01	2.668E+00	0.221
1997	1.893E+01	2.008E+01	6.04%	1.567E+01	2.329E+01	1.715E+01	2.119E+01	4.039E+00	0.213
1998	2.857E+01	2.996E+01	4.89%	2.406E+01	3.453E+01	2.605E+01	3.174E+01	5.698E+00	0.199
1999	4.024E+01	4.151E+01	3.16%	3.391E+01	4.689E+01	3.661E+01	4.381E+01	7.201E+00	0.179
2000	5.284E+01	5.339E+01	1.05%	4.564E+01	5.946E+01	4.856E+01	5.634E+01	7.777E+00	0.147
2001	4.984E+01	5.428E+01	8.91%	3.877E+01	6.481E+01	4.475E+01	5.785E+01	1.311E+01	0.263

NOTE: Printed BC confidence intervals are always approximate.
At least 500 trials are recommended when estimating confidence intervals.

Appendix C. Georges Bank yellowtail flounder production analysis

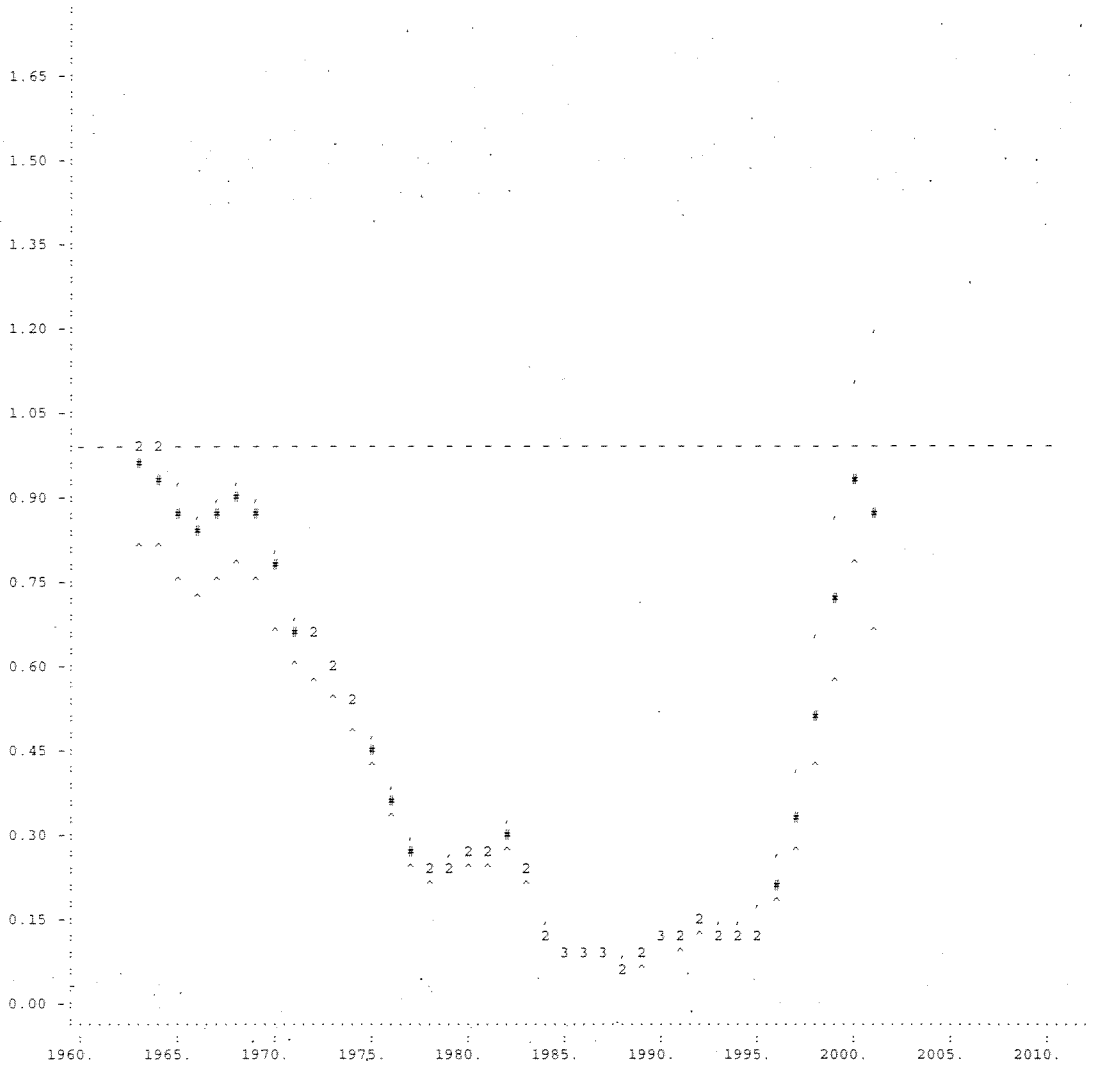
TRAJECTORY OF ABSOLUTE FISHING MORTALITY RATE (BOOTSTRAPPED)

Year	Bias-corrected estimate	Ordinary estimate	Relative bias	Approx 80% lower CL	Approx 80% upper CL	Approx 50% lower CL	Approx 50% upper CL	Inter-quartile range	Relative IQ range
1963	3.420E-01	3.359E-01	-1.79%	2.859E-01	3.651E-01	3.320E-01	3.532E-01	2.111E-02	0.062
1964	4.036E-01	3.964E-01	-1.77%	3.370E-01	4.305E-01	3.918E-01	4.164E-01	2.456E-02	0.061
1965	4.203E-01	4.130E-01	-1.74%	3.538E-01	4.490E-01	4.077E-01	4.344E-01	2.668E-02	0.063
1966	3.105E-01	3.054E-01	-1.65%	2.656E-01	3.308E-01	3.017E-01	3.205E-01	1.879E-02	0.061
1967	2.959E-01	2.918E-01	-1.39%	2.607E-01	3.135E-01	2.886E-01	3.046E-01	1.597E-02	0.054
1968	3.804E-01	3.756E-01	-1.25%	3.431E-01	4.007E-01	3.717E-01	3.914E-01	1.970E-02	0.052
1969	4.813E-01	4.756E-01	-1.19%	4.403E-01	5.074E-01	4.700E-01	4.951E-01	2.513E-02	0.052
1970	5.625E-01	5.560E-01	-1.15%	5.176E-01	5.947E-01	5.482E-01	5.782E-01	2.998E-02	0.053
1971	4.272E-01	4.228E-01	-1.03%	3.961E-01	4.517E-01	4.166E-01	4.392E-01	2.258E-02	0.053
1972	5.263E-01	5.219E-01	-0.84%	4.915E-01	5.541E-01	5.130E-01	5.395E-01	2.654E-02	0.050
1973	5.401E-01	5.364E-01	-0.69%	5.071E-01	5.685E-01	5.282E-01	5.540E-01	2.576E-02	0.048
1974	6.113E-01	6.085E-01	-0.46%	5.742E-01	6.414E-01	5.978E-01	6.262E-01	2.847E-02	0.047
1975	7.079E-01	7.053E-01	-0.38%	6.648E-01	7.431E-01	6.908E-01	7.245E-01	3.372E-02	0.048
1976	8.232E-01	8.203E-01	-0.35%	7.664E-01	8.699E-01	8.004E-01	8.446E-01	4.423E-02	0.054
1977	7.389E-01	7.361E-01	-0.38%	6.787E-01	7.907E-01	7.150E-01	7.629E-01	4.798E-02	0.065
1978	4.910E-01	4.889E-01	-0.44%	4.482E-01	5.279E-01	4.736E-01	5.078E-01	3.413E-02	0.069
1979	4.591E-01	4.572E-01	-0.42%	4.217E-01	4.912E-01	4.439E-01	4.736E-01	2.976E-02	0.065
1980	4.737E-01	4.719E-01	-0.37%	4.392E-01	5.031E-01	4.597E-01	4.870E-01	2.737E-02	0.058
1981	3.924E-01	3.914E-01	-0.28%	3.699E-01	4.118E-01	3.834E-01	4.013E-01	1.796E-02	0.046
1982	8.037E-01	8.024E-01	-0.16%	7.656E-01	8.364E-01	7.887E-01	8.189E-01	3.025E-02	0.038
1983	1.180E+00	1.178E+00	-0.14%	1.116E+00	1.231E+00	1.154E+00	1.204E+00	5.059E-02	0.043
1984	1.019E+00	1.017E+00	-0.20%	9.429E-01	1.081E+00	9.877E-01	1.048E+00	6.060E-02	0.059
1985	5.415E-01	5.402E-01	-0.23%	4.950E-01	5.794E-01	5.221E-01	5.594E-01	3.730E-02	0.069
1986	6.666E-01	6.651E-01	-0.22%	6.077E-01	7.143E-01	6.428E-01	6.891E-01	4.622E-02	0.069
1987	7.160E-01	7.137E-01	-0.32%	6.445E-01	7.769E-01	6.880E-01	7.457E-01	5.768E-02	0.081
1988	5.237E-01	5.213E-01	-0.46%	4.636E-01	5.755E-01	4.988E-01	5.472E-01	4.836E-02	0.092
1989	2.411E-01	2.397E-01	-0.57%	2.142E-01	2.625E-01	2.300E-01	2.503E-01	2.027E-02	0.084
1990	6.111E-01	6.070E-01	-0.68%	5.420E-01	6.608E-01	5.827E-01	6.335E-01	5.078E-02	0.083
1991	3.070E-01	3.036E-01	-1.10%	2.711E-01	3.300E-01	2.914E-01	3.185E-01	2.703E-02	0.088
1992	6.510E-01	6.411E-01	-1.52%	5.740E-01	7.017E-01	6.151E-01	6.765E-01	6.139E-02	0.094
1993	5.471E-01	5.314E-01	-2.86%	4.657E-01	6.071E-01	5.087E-01	5.764E-01	6.776E-02	0.124
1994	5.257E-01	5.019E-01	-4.51%	4.236E-01	6.161E-01	4.743E-01	5.725E-01	9.822E-02	0.187
1995	8.375E-02	7.907E-02	-5.59%	6.752E-02	1.036E-01	7.536E-02	9.384E-02	1.848E-02	0.221
1996	8.268E-02	7.827E-02	-5.34%	6.649E-02	1.005E-01	7.395E-02	9.196E-02	1.800E-02	0.218
1997	7.753E-02	7.393E-02	-4.65%	6.420E-02	9.302E-02	6.995E-02	8.590E-02	1.595E-02	0.206
1998	8.979E-02	8.667E-02	-3.48%	7.604E-02	1.071E-01	8.206E-02	9.907E-02	1.701E-02	0.189
1999	9.535E-02	9.355E-02	-1.88%	8.347E-02	1.114E-01	8.869E-02	1.044E-01	1.572E-02	0.165
2000	1.921E-01	1.885E-01	-1.88%	1.682E-01	2.244E-01	1.787E-01	2.104E-01	3.167E-02	0.165

NOTE: Printed BC confidence intervals are always approximate.
At least 500 trials are recommended when estimating confidence intervals.

Appendix C. Georges Bank yellowtail flounder production analysis

Bias-Corrected Time Plot of B-Ratio (#) with Approximate 80% Confidence Interval (^,)
(Dashed reference line is 1.0)



NOTE: Estimates beginning in 2001 depend on the user projection data listed on page 1.

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