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1998 Assessment of Georges Bank (5Zjmnh) Yellowtail Flounder

by

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Abstract

Combined Canada/USA landings of yellowtail flounder on Georges Bank have been increasing over the past three years, and population biomass has been increasing since 1995. Other measures of stock abundance such as fishery catch rates and survey size composition support the view that the resource is recovering. Results from surplus production analyses suggest that total population biomass is approaching half the level that can produce maximum sustainable yield. Exploitation rates have been low during the past three years. Recent recruitment is improved relative to the 1980s, but is poorer than in the 1960s. With combined Canada/USA catches of 1800 t in 1998 (equivalent to total catches in 1997), there is negligible risk of exceeding $F_{0.1}$, and a high probability that the population biomass will continue to increase. Recent management measures by both the USA and Canada have had the desired effect of rebuilding the population.

Résumé

Les débarquements totaux de limande à queue jaune du Canada et des États-Unis en provenance du banc Georges ont augmenté au cours des trois dernières années et la biomasse de cette population est à la hausse depuis 1995. Les autres indices de l'abondance du stock, comme les taux de capture et la composition des tailles appuient l'hypothèse selon laquelle il y a rétablissement de la ressource. Les analyses de la production excédentaire portent à croire que la biomasse de la population totale se rapproche de la moitié du niveau du rendement maximum soutenu. Les taux d'exploitation ont été faibles au cours des trois dernières années. Le recrutement des dernières années est supérieur à celui des années 1980, mais plus faible que celui des années 1960. Les prises totales du Canada et des États-Unis n'ayant atteint que 1 800 t en 1998 (ce qui équivaut au total de 1997), le risque de dépasser le niveau $F_{0,1}$ est pratiquement nul et il y a une forte probabilité que la biomasse de la population continue de s'accroître. Des mesures de gestion récemment prises par les deux pays ont eu l'effet escompté, qui était d'obtenir le rétablissement de la population.

Introduction

Yellowtail flounder (*Limanda ferruginea*) range from Labrador to Chesapeake Bay and are typically caught at depths between 37 and 73 m, and a major concentration occurs on Georges Bank from the NE peak to the east of the Great South Channel. Yellowtail flounder appear to be relatively sedentary, although seasonal movements have been reported (Royce et al. 1959). Spawning occurs during spring and summer, peaking in May. Larvae are pelagic for a month or more, then develop demersal form and settle to benthic habitats. Growth is sexually dimorphic, with females growing at a faster rate than males (Moseley 1986). Based on tagging investigations (Royce *et al.* 1959; Lux 1963), the management unit is considered to include Georges Bank encompassing statistical areas 5Zj, 5Zm, 5Zn and 5Zh (Fig. 1). Thus, the management unit is transboundary in nature. Both the USA and Canada employ the same convention for the management unit.

The Georges Bank yellowtail stock has been assessed for the last four decades using yield-per-recruit analyses and various models for estimating abundance and mortality from catch and survey data. Results 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 cohort abundance (Conser et al. 1991, Rago et al. 1994) confirmed that F greatly exceeded 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 1994a). An updated analysis of combined U.S. and Canadian catch and survey indices confirmed historical patterns of stock abundance and F, but indicated that F decreased in 1995 (Gavaris et al. 1996). Projections based on updated landings and survey information suggested that F decreased and SSB was increasing (NEFMC 1996). Recently, a VPA and biomass dynamics modelling based assessment confirmed that biomass was increasing and recent F levels were comparatively low (Neilson et al. 1997).

The most recent Canadian and USA perspectives on resource status are combined here in a single assessment document. This current assessment addresses the following terms of reference:

a. Update the status of Georges Bank yellowtail flounder through 1997 and characterize the variability of estimates of stock size and fishing mortality rates (of interest for both countries).

b. Provide projected estimates of catch for 1998-1999 and spawning stock biomass for 1999-2000 at various levels of F (Canadian management requires short-term forecasts only, whereas USA requires two year forecasts).

c. Review existing biological reference points and advise on new reference points for Georges Bank yellowtail flounder (a requirement for the United States Sustainable Fisheries Act (SFA)).

d. Provide projected estimates of F for 1998 and beginning of year adult biomass for 1999 at various levels of yield in 1998. Characterize the risk of exceeding $F_{0.1}$ and the risk of not achieving 0% , 10% and 20% adult biomass increase for the various levels of yield in 1998 (of interest for both countries).

e. Provide a historical perspective for current stock status and production (of interest for both countries).

The Fisheries

Reported landings of Georges Bank yellowtail flounder from 1935 to the present are shown in Fig.2. Landings, which have been predominantly taken by the U.S. fleet, gradually increased to 7,300 mt in 1949, decreased in the early 1950s 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. 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. In every year since 1985, landings have been 3,000 mt or less. U.S. landings fell to a low of 1,100 mt in 1989, averaged 2,200 from 1990 to 1994 and dropped to record lows of 200 mt in 1995, then increased to 1,000 mt in 1997.

The principle fishing gear used in the USA fishery to catch yellowtail flounder is the otter trawl, but scallop dredges and sink gillnets contribute some landings. In recent years, otter trawls caught greater than 95% of total landings from the Georges Bank stock, dredges caught 2-5% of annual totals, and gillnet landings were less than 0.1%. Current levels of recreational and foreign fishing are negligible. Discarding of small yellowtail is an important source of mortality due to intense fishing pressure, discrepancies between minimum size limits and gear selectivity, and recently imposed trip limits for the scallop dredge fishery. U.S. trawlers that land yellowtail flounder generally target multiple species on the 'Southwest Part' of the Bank, on the northern edge, and just east of the closed area adjacent to the international boundary. Methods of estimating U.S. discards described in NEFSC (1997) indicate that 1997 discards were approximately 100 mt.

Over the past 25 years, the USA fishery for yellowtail flounder has been managed using several strategies. From 1971 to 1976, national quotas were allocated by the International Commission for Northwest Atlantic Fisheries. 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 in). In 1986, the Council's Multispecies Fishery Management Plan increased the minimum legal size to 30 cm (12 in), increased minimum mesh size to 140 mm (5.5 in), and imposed seasonal closures. Amendment 4 to the Plan further increased the minimum legal size to 33 cm (13 in) in 1989. Amendments 5 and 7, in 1995 and 1996, limited days at sea, closed areas year-round, further increased minimum mesh size to 142 mm (6 in diamond or square) and imposed trip limits for groundfish bycatch in the sea scallop fishery.

The Canadian fishery for yellowtail flounder is directed and began in 1993. Prior to 1993, Canadian landings were small, typically less than 100 t (Table 1, Fig. 2). Peak landings of 1328 t of yellowtail occurred in 1994 when the fishery was unrestricted. After a TAC of 400 t was established, yellowtail landings dropped to 397 t in 1995. In 1997, landings of yellowtail flounder were 809 t against a quota of 800 t (Table 2).

Flatfish landed as "unspecified" in the Canadian fishery have been significant in previous years, and generally consist of yellowtail on Georges Bank. To estimate the proportion of unspecified flatfish that were actually yellowtail in 1997, we calculated the ratio of known yellowtail to the sum of known winter flounder, American plaice and yellowtail flounder caught by month and unit area. For otter trawl landings, the ratio was relatively constant over the months of the fishery, and the values of 0.31 and 0.92 were used for 5Zj and 5Zm, respectively. The unspecified flounder problem has been considerably reduced over time, due to improved monitoring of the landings. In 1997, only 32 t of unspecified flounder were landed. Table 1 shows the total Canadian yellowtail landings, which includes both the specified yellowtail flounder plus the assumed yellowtail flounder, calculated as described above.

The majority of Canadian landings of yellowtail flounder are made by otter trawl, from vessels less than 65 ft, tonnage classes 2 and 3. The fishery takes place from June to December, with peak months for fishing activity occurring from July to October in 1997. The number of vessels participating in the fishery was about 55 in 1994, and dropped to about 40 in 1995 because of a requirement for participants to have a catch history of greater than 5 t of yellowtail flounder. About 45 vessels participated in the fishery in 1996 and 1997. Industry representatives indicated that about half the fleet fished 140 mm square mesh gear in 1994, with one quarter fishing 130 mm square mesh and one quarter fishing 155 square mesh. By agreement among those participating in the Canadian fishery, only 155 mm square mesh gear was used from 1995 to 1997. The same rigging of the foot gear was used from 1994 to 1997.

A trip limit of 17,000 lb. was imposed by industry in 1995 to equitably share the reduced quota among eligible participants. In 1996 and 1997, no trip limit was in place, and the quota was allocated based on previous catch history.

The Canadian yellowtail directed fishing activity was concentrated in the southern half of the Canadian fishing zone, in the portion of 5Zm referred to as the "Yellowtail Hole" The distribution of fishing activity over the past four years is shown on Fig. 3. Comments from industry have indicated that the area where good rates are encountered expanded slightly from 1996 to 1997. Fig. 3 shows that the distribution of the fishery appears to have spread to the west relative to 1995 and 1996.

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.

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 t.

Age and Length Composition

Sampling information for 1997 is summarized in Table 2. In general, sampling of the fishery by both countries has been inadequate. For the United States, very few length measurements are available to characterize the fishery during the third and fourth quarters of 1997. Canada has more length measurements available through that period, but no age determinations have been made (Canada collects age determination material, but the age determination program is not yet operational). The low number of age determinations available has hampered the development of reliable age length keys. This problem has also been noted in the most recent assessment.

A problem with the Canadian sea samples was detected in 1997. When the length composition information from the sea samples was compared with those obtained from the port sampling program, discrepancies were apparent (Fig. 4). We attribute these differences to problems of flatfish species and sex identifications within the at sea observer program. Given such potential errors, we elected to characterize the Canadian landings using the length measurements obtained from the port sampling program.

The commercial fishery length composition for the USA is shown in Fig. 5. Comparable information for Canada is given in Fig. 6. As can be seen, the average size of the commercial landings has increased in the Canadian fishery from 1994 to 1997. However, such trends in average size are less apparent in the USA fishery. The Canadian fishery age composition in 1997 is contrasted to the previous year in Fig. 7. The modal age in 1997 was four, compared with three years in 1996. The USA age composition also demonstrated a trend of increasing age in the catch (Fig. 7)

The combined catch at age and weight at age information for both countries is shown in Tables 3 and 4, respectively.

Abundance Indices

Commercial Fishery Catch Rates

Catch (t) and effort (h) for less than 65 ft Canadian otter trawlers fishing for yellowtail flounder in 1993-97 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 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. Examination of the spatial distribution of effort showed highest concentrations in the area described by fishermen as the "Yellowtail Hole" located in the southeast part of the bank and adjacent to the Canada-USA boundary (Fig. 3). Therefore, only landings and effort from the Yellowtail Hole were included in the analysis.

Yellowtail landings and effort for trips were aggregated by month and year and monthly catch rates (t/h) are shown in Fig. 8. The catch rate decreased between 1993 and 1994 but increased by a factor of over two between 1994 and 1995 and increased further in 1996 and 1997. This is consistent with industry observations of increasing catch rates in the last three years. The increase from 1996 to 1997 appears to be smaller than in the preceding years.

Substantial gear changes occurred in the fishery between 1993 and 1994 with the introduction of 'flounder gear' which uses a small diameter footgear. Changes in mesh size also occurred, as described earlier. However, fishing practices have been relatively constant since 1994. While catch rates may prove to be useful as an index of abundance for this resource, the time series is too short to be included directly in the assessment at present.

Research Vessel Surveys

Bottom trawl surveys are conducted annually on Georges Bank by the Canadian Department of Fisheries and Oceans (DFO) in spring and by the NMFS in spring and fall. Both agencies use a stratified random design, though different strata boundaries are defined (Fig. 9). USA spring and autumn bottom trawl survey catches (strata 13-21), USA scallop survey catches (strata 54-74, Fig. 9), and Canadian bottom trawl survey catches (strata 5Z1-5Z4, Fig. 9) were used to estimate relative stock biomass and relative abundance at age for Georges Bank yellowtail. Standardization coefficients, which compensate for survey door, vessel, and net changes in USA groundfish surveys (1.22 for old doors, 0.85 for the Delaware II, and 1.76 for the 'Yankee 41' net; Rago et al. 1994) were applied to the catch of each tow.

Aging of DFO survey samples has not been done and therefore age sampling from the corresponding NMFS spring survey was used to obtain abundance indices by age. Males and females were treated separately and then combined for the index at age. However, the small number of fish aged in some years and the further partitioning of the age length key by sex resulted in low precision for the estimates.

Results from the Canadian and USA spring surveys are shown on Fig. 10 and Tables 5-6. The USA and Canadian survey series show good concurrence. The surveys indicated low abundance in the late 1980s, but have been following an increasing trend since then. USA age sampling was not available at the time of writing to apply against the 1998 DFO results. In 1997, the Canadian survey index was at the highest value recorded in the series. The 1998 survey index was down somewhat, but still follows an increasing trend since 1995.

The U.S. fall survey series is the longest available for this resource. In general, the series follows the same trends indicated by the spring series (Table 7, Fig. 11), but the indication of the start of resource rebuilding was not apparent until 1996.

The most recent geographic distribution of the survey catches is shown in relation to the previous 5-yr mean in Figs. 12 – 14 for the Canadian Spring, USA spring and USA fall surveys. The Canadian survey suggest that the resource has expanded beyond the area associated with the highest catch rates in the past, consistent with observations from the fishery (Fig. 12). The spring USA survey encountered the largest catches of yellowtail flounder in the Yellowtail Hole of 5Zm (Fig. 13.) The USA fall 1997 survey had a similar distribution of survey catches, but the set density in areas of key yellowtail flounder habitat was low.

Consistent with the indications from the commercial fishery, the average size of the fish in the research survey catches has been increasing (see Fig. 15 and 16 for Canada and USA spring survey results, respectively.

USA scallop survey indices of yellowtail abundance at age were also evaluated. The survey indices were delta transformed (Pennington 1986), because there is a high proportion of tows with no yellowtail catch. The age-1 index from the NEFSC scallop survey was revised to address concerns about catchability estimates. Previous assessments, which used age data from the fall survey to characterize catches from the scallop survey, had a problematic pattern to catchability estimates (NEFSC 1997). Inspection of catch at length from the scallop survey and the range of length at age-1 from the fall survey suggests that age-1 yellowtail grow substantially between the scallop and autumn surveys. Using the fall age data appears to classify many age-2 fish as age-1, inflating the age-1 index, and reducing the age-2 index. The age-1 index was revised to reflect the total catch of yellowtail in the smallest length mode, which was fairly well defined and stable (generally 9 to 23 cm). The revised scallop age-1 index has generally increased since the early 1990s (Table 8).

ESTIMATION OF STOCK PARAMETERS

Low levels of sampling and contradictions among sources of information on relative yearclass strength indicate that there is a great deal of uncertainty in estimates of catch at age in recent years. Therefore, two methods of analysis were updated from the previous assessment: the traditional age-structured virtual population analysis (VPA) and the surplus production model, as a confirmatory analysis that does not rely on age structure information.

Virtual Population Analysis

The adaptive framework, ADAPT (Gavaris 1988), was used to calibrate the VPA with the research survey abundance trend results. The model formulation employed assumed that the error in the catch at age was negligible. The error in the survey abundance indices was assumed to be independent and identically distributed after taking natural logarithms of the values. The annual natural mortality rate, M, was assumed constant and equal to 0.2. A model formulation using as parameters the ln population abundance at the beginning of the year following the terminal year for which catch at age is available was considered (Gavaris 1993). The following model parameters were defined:

$\theta_{a.1997}$ = ln population abundance

for ages a = 1 to 6 at the beginning of year 1997

$q_{s.a}$ = ln calibration constants

for each survey source s and relevant ages a

ADAPT was used to solve for the parameters by minimizing the sum of squared differences between the ln observed abundance indices and the ln population abundance adjusted for catchability by the calibration constants. The objective function for minimization was defined as

$$\underset{s.a.t}{\Psi}(\theta,q)=\sum_{s.a.t}\left(\ln I_{s.a.t}-q_{s.a}+\ln N_{a.t}(\theta)\right)^2$$

for time t

For convenience, the population abundance $N_{a.t}(\theta)$ is abbreviated by $N_{a.t}$. At the beginning of the year 1997, i.e. $t=1997$, the population abundance for ages 2-5 was obtained directly from the parameter estimates, $N_{a.1997}=e^{\theta_{a.1997}}$. The population abundance for ages 6+ were calculated assuming that the fishing mortality for these was equal to the average fishing mortality on ages 4 and 5. The population abundance was computed using the virtual population analysis algorithm which incorporates the exponential decay model

$$N_{a+\Delta t.t+\Delta t}=N_{a.t}e^{-(F_{a.t}+M_a)\Delta t}$$

Year was used as the unit of time, therefore ages were expressed as years and the fishing and natural mortality rates were annual instantaneous rates. The fishing mortality rate exerted during the time interval t to $t+\Delta t$, $F_{a.t}$, was obtained by solving the catch equation.

$$C_{a.t}=\frac{F_{a.t}\Delta t N_{a.t}\left(1-e^{-(F_{a.t}+M_a)\Delta t}\right)}{(F_{a.t}+M_a)\Delta t}$$

for $C_{a.t}$ = the catch at age a during the time interval t to $t+\Delta t$

The fishing mortality rate for age 6+ in the last time interval of each year was assumed equal to the fishing mortality at age 5.

The data used were annual catch at age ,

$C_{a.t}$ = catch

for ages a = 1, 2...6+ and for t=1973-1997 (before 1973, catches from distant water fleets and U.S. discards comprised a large portion of total catch and were not well sampled),

and bottom trawl survey abundance indices

$I_{s,a,t}$ = abundance index

for s= DFO spring survey, ages a=2, 3...6, time t=1987-1997
s= NMFS spring survey (yankee 41), ages a=1, 2...6+, time t=1973-1981
s= NMFS spring survey (yankee 36), ages a=1, 2, ...6+, time t=1982-1997
s= NMFS fall survey, ages a=1, 2...6+, time t=1973-1997
s= NMFS scallop survey, age a=1, time t=1982-1997

Choice of survey indices was based on correlations among indices and reliability of age data. Correlations were moderate to strong for ages 3-6, but the Canadian and NEFSC fall surveys were not positively correlated at ages 1 and 2 (Table 9). Fig. 17 shows correspondence among normalized indices. The Canadian age-1 index is based on many lengths that have no corresponding age sample from the NMFS spring survey, and is not considered to be a reliable index. Alternative ADAPT configurations were performed to assess the sensitivity of results to the choice of indices used.

Approximate coefficients of variation (CVs) for abundance estimates ranged 20-50%, and improved with age (Appendix A). Estimates of q for each index were well estimated (CV=17-26%). Although the model generally fit the data well, there were some slight trends in residuals (e.g., fall age-2 Fig. 18), and there were three statistical outliers (e.g., spring-36 age-1 1981; fall age-1 1988; and fall age-2 1995).

Variance and model bias of estimates were assessed using bootstrap analysis of the VPA calibration. One thousand bootstrap estimations were performed by randomly resampling survey residuals. Bootstrapped abundance estimates had only slightly greater CVs than the least squares approximations reported above. Bootstrapped Fs were estimated with similar precision to abundance estimates: CVs were high at age-2 (CV = 50%) but decreased with age (CV=18% for ages 4-6). Bootstrap analysis indicates that SSB in 1997 was well estimated (CV=15%). Bootstrap estimates of bias were relatively low for older ages (1-10% for age-3+ abundance estimates, 2% for F_{4+}, and 4% for SSB), but were substantial for the age-2 abundance estimate (15%). However, there are several difficulties in completely correcting for bias (NEFSC 1997). Therefore, bias correction was not incorporated into stochastic projections.

Consistency of VPA estimates was assessed using retrospective analysis (Sinclair et al. 1990). Unfortunately, the length of the Canadian survey limited the number of retrospective comparisons. Retrospective ADAPT runs were made by iteratively truncating the terminal year of catch and survey data back to a terminal year of 1991 (when the Canadian survey had five years of data).

Short-term projections of landings and SSB incorporated uncertainty in VPA estimates using the 1,000 bootstrap estimates of age 2-6+ 1998 abundance. Projections through 1999 were simulated for each of the 1,000 abundance estimates by randomly sampling point estimates of 1973-1997 age-1 abundance 100 times (totaling 100,000 simulated trajectories). Projections assumed geometric mean partial recruitment 1994-1997, mean discard ratios at age 1994-1997, mean weight of landings at age 1994-1997, and proportion mature at age from 1992-1997 survey observations.

Surplus Production Model

A non-equilibrium surplus production model, ASPIC (A Stock-Production model Incorporating Covariates) (Prager 1994, 1995) was also used to assess stock status and biological reference points. The method requires total catch along with one or more abundance indices (including CPUE or RV indices) as input. In our case, the DFO spring survey (1987 to 1998) was an index of biomass at the end of the previous year, the NMFS spring survey (1968 to 1997) were considered beginning of year biomass index and the NMFS fall survey (1963 to 1997) was treated as a midyear index. The error in the survey abundance indices was assumed to be independent and identically distributed after taking natural logarithms of the values. The following model parameters were defined:

$r =$ population intrinsic rate of increase

$K =$ maximum population size

$q_s =$ survey catchability

$B_1 =$ population biomass (t) at the start of the first year

ASPIC was used to solve for the parameters by minimizing the sum of squared differences between the ln observed survey catch rate and the ln predicted survey catch rate. The objective function for minimization was defined as

$$\Psi_{s,t}(r, K, q, B_1) = \sum_{s,t}\left(\ln I_{s,t} - \ln\left(Y_t/\hat{f}_t\right)\right)^2$$

where

$Y_t =$ observed yield in year t

(the analysis from the previous assessment, Neilson et al. 1997, was revised to include discard estimates, Table 1)

$\hat{f}_t =$ predicted effort in year t

and

$I_{s,t} =$ biomass index

for s= DFO spring survey, time t=1987-1998
s= NMFS spring survey (yankee 36) time t=1968-1972, 1982-1997
s= NMFS spring survey (yankee 41) time t=1973-1981

s= NMFS fall survey time t=1963-1997

A solution for $\hat{f}_t$ is obtained from

$$qf_t = \frac{(r/K)Y_t}{\ln\left[\frac{(r/K)B_t\left(e^{(r-qf_t)}-1\right)}{r-qf_t}+1\right]} \quad \text{when } r \neq qf_t$$

or

$$qf_t = \frac{(r/K)Y_t}{\ln\left[1+(r/K)B_t\right]} \quad \text{when } r = qf_t$$

using an iterative procedure. A solution for B_t is obtained from

$$B_{t+\Delta t} = \frac{(r-qf_t)B_t e^{(r-qf_t)\Delta t}}{(r-qf_t)+(r/K)B_t\left(e^{(r-qf_t)\Delta t}-1\right)} \quad \text{when } r \neq qf_t$$

or

$$B_{t+\Delta t} = \frac{B_t}{1+(r/K)B_t\Delta t} \quad \text{when } r = qf_t$$

Correlations among survey biomass indices were moderate to strong (r= 0.5 to 0.8) (Appendix B). Most of the variance in the NMFS spring 36, Canada, and NMFS fall surveys was explained by the model (R^2= 0.75, 0.58, and 0.56), but none of the variance in the NMFS spring 41 series was explained. Biomass estimates for the first two to five years of the analysis (1963 to 1964-66) are imprecise and are not considered reliable (Prager 1994, 1995).

Survey residuals were randomly resampled 1,000 times to estimate precision and model bias. Bootstrap estimates from ASPIC (see last page of Appendix B) suggest that there is 80% confidence that current biomass is 54-86% of B_{MSY} (44,000 mt). The 1997 F estimate from ASPIC was low (0.08), and bootstrap estimates of F_{97} indicate that there is negligible probability that F exceeded F_{MSY}. The bootstrap analyses indicates that the MSY, K, r, B_{msy} and F_{msy} were well estimated (Interquartile Ranges <19%), but q, and the ratios of current year B and F relative to B_{msy} and F_{msy} were generally more variable (IQR 14-28%). Also, biomass in 1963 was poorly estimated (IQR > 150%). As suggested by Prager (1994,1995), biomass estimates in the first several years are unreliable. Alternative configurations were explored to examine sensitivity of estimates to including discards and treating the NMFS spring survey as a single index.

Assessment Results

The VPA indicates that the stock continued to rebuild from the collapsed state of the early 1990s. Growth in stock biomass was the product of high survival and moderate recruitment. Fully-recruited F (F_{4-5}) remained low in 1997 (0.13, Fig. 19). Recruitment has been relatively stable for the last several years (age-1 abundance averaged 20 million from 1991 to 1996), but only the 1993 cohort exceeded the 1972-1996 average (Fig. 20). SSB increased to 15,700 mt in 1997 (Fig. 20).

Bootstrap distributions suggest that there is nearly 100% probability that SSB in 1997 exceeded the current rebuilding target of 10,000 mt (80% confidence interval of 13,500-19,200 mt) and nearly 100% probability that F in 1997 was less than $F_{0.1}$ (80% CI of 0.11-0.17) (Fig. 21). Estimates of bias were low for F_{4-5} (2%) and SSB (4%). Given the substantial uncertainty in estimates of catch at age, statistical bias was considered negligible for F_{4-5} and SSB, and abundance of older cohorts. Bias of the estimate of age-2 abundance (N_2) was greater (15%), and decreases the reliability of the estimate. However, bias of the N_2 estimate is low relative to the associated uncertainty (CV=75%), and 1998 projections will be minimally affected by the bias, because age-2 are only 10% recruited to the fishery.

Three alternative ADAPT configurations were explored which 1) included the Canadian age-1 index, 2) included preliminary 1998 indices from the Canadian survey (based on cohort slicing), and 3) excluded the scallop survey index. All three sensitivity runs estimated age-2 abundance in 1998 to be approximately 50% lower than reported in Appendix A. However, the Canadian age-1 index is composed of many lengths with no corresponding age sample from the NMFS spring survey, there is considerable subjectivity involved in cohort slicing samples from the 1998 Canadian survey, and there is no a priori evidence for excluding the NMFS scallop survey. A fourth sensitivity analysis that combined the NMFS spring survey into a single tuning index (using the conversion factor for the Yankee-41 net reported by Sissenwine and Bowman 1978) estimated very similar parameters to those reported in Appendix A, but had large negative residuals for the surveys that used the Yankee-41 net.

Although some retrospective differences were substantial, there were no patterns of positive or negative inconsistency. Initial estimates of abundance of the 1990 and 1993 cohorts were much greater than revised estimates, presumably resulting from imprecise discard estimates. Abundance estimates in penultimate years were relatively consistent. Fully-recruited F estimates were more consistent than retrospective recruitment estimates, and SSB estimates were very consistent (Fig. 22).

The magnitude and recent decrease in mortality indicated by the VPA was confirmed by a modified catch curve analysis which incorporates multiple surveys (A. Sinclair, Marine Fish Division, Gulf Fisheries Centre, pers. comm.) Results indicated that total mortality exceeded 1.0 in most years, but decreased to 0.4 in the last three years.

Patterns and magnitude of F and biomass estimates from the surplus production model generally confirm age-based estimates (Fig. 23). However, the 1997 mean biomass estimate from ASPIC (24,000 mt) was substantially greater than the biomass estimate from ADAPT (18,000, Fig. 23). The sensitivity analysis that excluded discards had lower estimates of MSY by 15% and B_{msy} by 5% but a similar estimate of F_{MSY}. Combining the NMFS spring 36 and 41 series had negligible effects on parameter estimates.

ASPIC results indicate that a maximum sustainable yield of 13,700 mt can be produced when stock biomass is approximately 44,000 mt (B_{MSY}, Fig. 24) and F is 0.31 (F_{MSY}). Assuming equilibrium age structures, current partial recruitment and mean weight at age, a biomass weighted F of 0.31 is equivalent to a fully-recruited F of 0.39. The MSY and B_{MSY} estimates are slightly greater, and *r* was slightly lower, than the estimates in the last assessment (Neilson et al. 1997), because discards were not included in the previous assessment. MSY reference points estimated from stock-recruit data are similar: MSY=13,200 mt, SSB_{MSY}=33,800 mt, and fully-recruited F_{MSY}=0.37 (Overholtz 1998).

Results from VPA indicate that all cohorts were less than 30 million in age-1 abundance, except four year classes that exceeded 50 million in age-1 abundance (1973, 1974, 1977, and 1981). The relationship of SSB and recruitment suggests that strong recruitment is more likely at high levels of SSB (Fig. 25). For example, three of the four dominant cohorts in the VPA time series (1973 to 1997) were produced when SSB exceeded 10,000 mt, and three of the six cohorts produced when SSB exceeded 10,000 mt were greater than 50 million in age-1 abundance. Extending the series of stock and recruitment using survey estimates of age-1 abundance (scaled with the ADAPT estimate of catchability) and total biomass estimates from the production model (1968-1997) supports the conclusion that much greater levels of recruitment can be produced at greater levels of stock biomass (Fig. 25).

Yield and spawning biomass per recruit reference points were revised by incorporating updated estimates of partial recruitment (1994-1997), mean weights (1994-1997), and maturity (1997). F_{max} is calculated as 0.82 but the maximum yield per recruit is not well defined, $F_{0.1}$ as 0.25, and $F_{20\%}$ as 0.53 (Table 10, Fig. 26). An alternative analysis with ages 1-14 (the oldest observed age in surveys) had similar estimates of F_{max} (0.83), slightly greater estimate of $F_{0.1}$ (0.28), and a substantially greater estimate of $F_{20\%}$ (0.62).

Outlook

We present projections in accordance with the management requirements for Canada and the USA. For Canada, projections of landings in 1998 and beginning of year biomass for 1998 and 1999 are required. For the USA, projections of landings in 1999 and spawning stock biomass during the spawning season in 1999 and 2000 are required, and assume *status quo* fishing mortality in 1998. Age-based projection inputs included average 1994-1997 partial recruitment, weights at age, and maturity at age (Tables 11a and 11b illustrate F_{97} and $F_{0.1}$ results respectively). Projections of ASPIC parameters were obtained assuming a *status quo* F (0.08, Appendix B) and a biomass-weighted approximation to $F_{0.1}$.

Canada

The 1998 projection results are documented below for two scenarios of fishing mortality:

		Yield 1998 (000s t)	Biomass 1998 (beg. year, total)	Biomass 1999
F_{97}	Age-based (VPA)	1.8	16.1	21.3
	Biomass-based (Surplus Production)	2.6	26.2	36.3
$F_{0.1}$	Age-based (VPA	3.2	16.1	19.7
	Biomass based (Surplus Production)	5.5	26.2	33.3

The risk of not achieving fishing targets for population growth and exploitation rate from 1998 to 1999 was explored using VPA projections at various levels of yield (Fig. 27). A fishery yield in 1998 equal to that of 1997 (1788 t) is associated with negligible risk of exceeding the $F_{0.1}$ fishing mortality target and has a low risk of not achieving growth in spawning stock biomass. A fishery yield associated with $F_{0.1}$ (3244 t), however, has a greater than 60% risk that a 20% growth in biomass will not occur.

USA

Age-based projections suggest that landings and SSB increase in 1999 and 2000 at $F_{status\ quo}$ or $F_{0.1}$. However, at greater levels of F there is substantial risk of decreasing SSB (Fig. 28).

Age-based (000s t)

1998 Landings	1998 SSB	$F_{1999\text{-}2000}$	1999 Landings	1999 SSB	2000 SSB	Consequences/Implications
1.8	17.8	0.13 ($F_{status\ quo}$)	2.2	21.5	24.1	SSB increases to about 70% SSB_{MSY} in 2000; landings in 1999 increase slightly.
		0.25 ($F_{0.1}$)	4.0	20.6	21.4	SSB increases to about 60% SSB_{MSY} in 2000; landings in 1999 increase to twice the 1997 level.

Biomass-based (000s t)

1998 Landings	1998 SSB	$F_{1999\text{-}2000}$	1999 Landings	1999 B	2000 B	Consequences/Implications
2.6	26.2	0.08 ($F_{status\ quo}$)	3.4	36.3	46.4	Biomass surpasses B_{MSY} in 2000; landings in 1999 increase to almost twice the 1997 level.
		0.17	7.3	36.3	42.5	Biomass increases to about 97%

($F_{0.1}$)	B_{MSY} in 2000; landings in 1999 increase to four times the 1997 level.

As indicated in the projections for both Canada and the USA, biomass-based estimates are more optimistic than those obtained using the age-based (VPA) approach. For the VPA approach, such differences may be attributed to poor sampling and the absence of age determinations from the Canadian fishery. The surplus production model attempts to describe long term average dynamics, which may not apply if recent recruitment has been weak.

Conclusions

Although there are some differences in results from the two analytical models, information on current stock status is relatively clear. We conclude that the stock is still rebuilding: SSB in 1997 (from ADAPT) was approximately half SSB_{msy} (from stock-recruit analysis), and total biomass in 1997 (from ASPIC) was also approximately half B_{msy} (from ASPIC). Fishing mortality in 1997 remained at levels which should allow continued rebuilding: fully-recruited F (from ADAPT) was well below $F_{0.1}$ and was approximately one-third the level of fully-recruited F_{msy} (from stock-recruit analysis), and F on total biomass (from ASPIC) was also approximately one-third of F_{msy} (from ASPIC).

Despite the congruence in results on stock status, forecasting yield, SSB, and risk is difficult. Age-based projections are generally more informative, but are currently hampered by poor sampling and the absence of age determinations from the Canadian fishery. Conversely, projections based on biomass dynamics imply high levels of recruitment at the current biomass level. While there are suggestions of good recruitment evident from examination of the spring survey length distributions in 1997, they were not confirmed in the age-based estimates of abundance. Given the uncertainties in both the VPA and the biomass dynamics model, we consider the more conservative age-based projections and risk analyses from the VPA to be more risk-averse.

Research Recommendations

- More complete sampling of spatial and temporal aspects of the U.S. fishery and dedicated age-length keys for the Canadian fishery are needed for more reliable age-based estimates.
- Stochastic age-based simulation of rebuilding scenarios is needed to confirm the expected growth rates from the production model.
- Consistent sampling of Georges Bank strata during NMFS winter surveys mat substantially improve the assessment.
- Extented VPA of historical catch and survey information would help to assess historical stock conditions and MSY reference points.
- Determination of quantity of yellowtail flounder discarded in Canadian scallop fishery.

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Table 1. Commercial catch (000s t) of Georges Bank yellowtail flounder.

	USA Landings	USA Discards	Canada Landings	Foreign Landings	Total
1963	10.990	6.368	0.000	0.100	17.458
1964	14.914	4.855	0.000	0.000	19.769
1965	14.248	4.266	0.000	0.800	19.314
1966	11.341	2.545	0.000	0.300	14.186
1967	8.407	4.389	0.000	1.400	14.196
1968	12.799	3.722	0.000	1.800	18.321
1969	15.944	3.105	0.000	2.400	21.449
1970	15.506	6.037	0.000	0.250	21.793
1971	11.878	2.824	0.000	0.503	15.205
1972	14.157	1.330	0.000	2.243	17.730
1973	15.899	0.364	0.000	0.260	16.523
1974	14.607	0.980	0.000	1.000	16.587
1975	13.205	2.715	0.000	0.091	16.011
1976	11.336	3.021	0.000	0.000	14.357
1977	9.444	0.567	0.000	0.000	10.011
1978	4.519	1.669	0.000	0.000	6.188
1979	5.475	0.720	0.000	0.000	6.195
1980	6.481	0.382	0.000	0.000	6.863
1981	6.182	0.095	0.000	0.000	6.277
1982	10.621	1.376	0.000	0.000	11.997
1983	11.350	0.072	0.000	0.000	11.422
1984	5.763	0.028	0.000	0.000	5.791
1985	2.477	0.043	0.000	0.000	2.520
1986	3.041	0.019	0.000	0.000	3.060
1987	2.742	0.233	0.000	0.000	2.975
1988	1.866	0.252	0.000	0.000	2.118
1989	1.134	0.073	0.000	0.000	1.207
1990	2.751	0.818	0.000	0.000	3.569
1991	1.784	0.246	0.000	0.000	2.030
1992	2.859	1.873	0.000	0.000	4.732
1993	2.089	1.089	0.696	0.000	3.874
1994	1.589	0.141	2.142	0.000	3.871
1995	0.292	0.024	0.495	0.000	0.811
1996	0.751	0.039	0.483	0.000	1.273
1997	0.966	0.058	0.810	0.000	1.834
average	7.697	1.610	0.132	0.318	9.758

Table 2. Sampling intensity for estimation of landings at age for Georges Bank yellowtail flounder.

US	Quarter	Size	Port Samples Trips	Port Samples Lengths	Port Samples Ages	Sea Samples Trips	Sea Samples Lengths	Sea Samples Ages	Landings (mt)
	1	small	6	366					81.11
		large	3	467					296.45
		all	6	833	236	3	149	109	377.56
	2	small	5	591					107.76
		large	3	259					168.55
		all	5	850	280	2	27	107	276.31
	3	small							51.09
		large							55.64
		all	1	103	63	2	7	59	106.73
	4	small							62.98
		large							142.39
		all	0	0	0	1	41	0	205.37
Canada	2	all	3	600	0				100.29
	3	all	6	1347	0	3	1452	0	524.00
	4	all	4	961	0	6	2010		185.44

Table 3. Total catch at age (number) of Georges Bank yellowtail flounder (thousands).

	Age								
Year	1	2	3	4	5	6	7	8+	Total
1973	347	4,890	13,243	9,276	3,743	1,259	278	81	33117
1974	2,143	8,971	7,904	7,398	3,544	852	452	173	31437
1975	4,372	25,284	7,057	3,392	2,084	671	313	164	43337
1976	615	31,012	5,146	1,347	532	434	287	147	39520
1977	330	8,580	9,917	1,721	394	221	129	124	21416
1978	9,659	3,105	4,034	1,660	459	102	37	35	19091
1979	233	9,505	3,445	1,242	550	141	79	52	15247
1980	309	3,572	8,821	1,419	321	85	4	10	14541
1981	55	729	5,351	4,556	796	122	4	-	11613
1982	2,063	17,491	7,122	3,246	1,031	62	19	3	31037
1983	696	7,689	16,016	2,316	625	109	10	8	27469
1984	428	1,917	4,266	4,734	1,592	257	47	17	13258
1985	650	3,345	816	652	410	60	5	-	5938
1986	158	5,771	978	347	161	52	16	8	7491
1987	140	2,653	2,751	761	132	39	32	41	6549
1988	483	2,367	1,191	624	165	15	20	3	4868
1989	185	1,516	668	262	68	11	8	-	2718
1990	219	1,931	6,123	800	107	17	3	-	9200
1991	412	54	1,222	2,430	293	56	4	-	4471
1992	2,389	8,359	2,527	1,269	510	20	7	-	15081
1993	5,194	1,009	2,777	2,392	318	65	9	1	11765
1994	71	861	5,742	2,571	910	99	37	1	10291
1995	14	157	895	715	137	13	11	4	1944
1996	50	383	1,509	716	167	9	5	1	2841
1997	16	595	1,258	1,502	341	26	45	19	3802
mean	1,249	6,070	4,831	2,294	776	192	74	36	15522

Table 4. Mean weight at age for the total catch of Georges Bank yellowtail flounder (kg).

	Age							
Year	1	2	3	4	5	6	7	8+
1973	0.010	0.347	0.462	0.527	0.603	0.689	1.067	1.136
1974	0.010	0.339	0.498	0.609	0.680	0.725	0.906	1.249
1975	0.010	0.309	0.489	0.554	0.618	0.687	0.688	0.649
1976	0.010	0.304	0.542	0.636	0.741	0.814	0.852	0.866
1977	0.010	0.337	0.524	0.634	0.782	0.865	1.036	1.013
1978	0.010	0.309	0.510	0.684	0.793	0.899	0.930	0.948
1979	0.010	0.325	0.460	0.649	0.728	0.835	1.003	0.882
1980	0.010	0.318	0.492	0.656	0.813	1.054	1.256	1.214
1981	0.010	0.340	0.490	0.603	0.707	0.798	0.832	1.042
1982	0.010	0.297	0.485	0.650	0.748	1.052	1.024	1.311
1983	0.010	0.296	0.440	0.604	0.736	0.952	1.018	0.987
1984	0.010	0.240	0.378	0.500	0.642	0.738	0.944	1.047
1985	0.010	0.363	0.497	0.647	0.733	0.819	0.732	1.042
1986	0.010	0.342	0.540	0.664	0.823	0.864	0.956	1.140
1987	0.010	0.309	0.521	0.666	0.680	0.938	0.793	0.788
1988	0.010	0.319	0.555	0.688	0.855	1.054	0.873	1.385
1989	0.010	0.342	0.542	0.725	0.883	1.026	1.254	1.042
1990	0.010	0.281	0.389	0.574	0.696	0.807	1.230	1.042
1991	0.010	0.258	0.359	0.479	0.725	0.820	1.306	1.042
1992	0.010	0.283	0.360	0.519	0.646	1.203	1.125	1.042
1993	0.010	0.275	0.367	0.503	0.561	0.858	1.263	1.044
1994	0.010	0.262	0.351	0.471	0.628	0.786	0.896	1.166
1995	0.010	0.260	0.367	0.463	0.582	0.777	0.785	0.540
1996	0.010	0.309	0.409	0.523	0.667	0.866	0.916	1.215
1997	0.010	0.309	0.458	0.592	0.712	0.874	0.989	1.042
mean	0.010	0.307	0.459	0.593	0.711	0.872	0.987	1.035

Table 5. Canadian DFO spring survey indices of Georges bank yellowtail flounder abundance at age (#/tow) and stratified total biomass.

	Age							
Year	1	2	3	4	5	6	Total	Wt (000s t)
1987	0.12	0.68	2.00	1.09	0.06	0.00	3.95	1.264
1988	0.00	0.66	1.89	0.80	0.59	0.01	3.96	1.235
1989	0.11	0.78	0.80	0.32	0.10	0.02	2.13	0.471
1990	0.00	1.27	4.62	1.12	0.43	0.01	7.45	1.578
1991	0.02	0.59	1.72	2.91	0.99	0.00	6.24	1.759
1992	0.22	10.04	4.52	1.21	0.16	0.00	16.14	2.475
1993	0.33	2.16	5.04	3.47	0.62	0.00	11.63	2.642
1994	0.00	6.03	3.33	3.08	0.75	0.33	13.51	2.753
1995	0.21	1.31	4.07	2.22	1.14	0.11	9.07	2.027
1996	0.45	5.54	8.44	7.49	1.37	0.16	23.45	5.304
1997	0.10	9.48	15.16	19.09	3.11	0.54	47.49	13.292
1998	0.89*	0.29*	3.31*				16.04	4.292
mean	0.20	3.50	4.69	3.89	0.85	0.11	13.19	3.258

*Preliminary: Based on cohort slicing (visual inspection)

Table 6. NEFSC spring survey indices of Georges bank yellowtail flounder abundance at age (#/tow) and total biomass (kg/tow).

	Age									biomass
Year	1	2	3	4	5	6	7	8+	Total	(kg)
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
mean	0.268	2.215	2.349	1.073	0.342	0.082	0.034	0.010	6.373	2.447

Table 7. NEFSC fall survey indices of Georges bank yellowtail flounder abundance at age (#/tow) and total biomass (kg/tow).

	Age										biomass
Year	0	1	2	3	4	5	6	7	8+	Total	(kg)
1963	0.000	14.722	7.896	11.226	1.858	0.495	0.281	0.034	0.233	36.746	12.788
1964	0.000	1.721	9.723	7.370	5.998	2.690	0.383	0.095	0.028	28.007	13.623
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	3.988
1967	0.106	9.137	9.313	2.699	1.007	0.309	0.076	0.061	0.000	22.708	7.575
1968	0.000	11.782	11.946	5.758	0.766	0.944	0.059	0.000	0.000	31.254	10.536
1969	0.135	8.106	10.381	5.855	1.662	0.553	0.149	0.182	0.000	27.023	9.279
1970	1.048	4.610	5.133	3.144	1.952	0.451	0.063	0.017	0.000	16.417	4.979
1971	0.025	3.627	6.949	4.904	2.248	0.551	0.234	0.024	0.024	18.586	6.365
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	17.996	6.602
1974	1.030	4.623	2.854	1.524	1.060	0.460	0.249	0.131	0.000	12.133	3.733
1975	0.361	4.625	2.511	0.877	0.572	0.334	0.033	0.000	0.031	9.420	2.365
1976	0.000	0.336	1.929	0.475	0.117	0.122	0.033	0.000	0.067	3.078	1.533
1977	0.000	0.928	2.161	1.649	0.618	0.113	0.056	0.036	0.016	5.614	2.829
1978	0.037	4.729	1.272	0.773	0.406	0.139	0.011	0.000	0.024	7.443	2.383
1979	0.018	1.312	1.999	0.316	0.122	0.138	0.038	0.064	0.007	4.041	1.520
1980	0.078	0.761	5.086	6.050	0.678	0.217	0.162	0.006	0.033	13.217	6.722
1981	0.000	1.584	2.333	1.630	0.500	0.121	0.083	0.013	0.000	6.345	2.621
1982	0.000	2.424	2.185	1.590	0.423	0.089	0.000	0.000	0.000	6.711	2.270
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
mean	0.148	2.821	3.296	2.492	1.079	0.386	0.086	0.033	0.017	10.375	3.770

Table 8. NEFSC scallop survey index of Georges bank yellowtail flounder age-1 abundance.

year	#/tow
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
mean	0.556

Table 9. Correlations among normalized indices of abundance at age for Georges Bank yellowtail flounder.

Age-1

	Spring	*Fall*	*Canada*	*Scallop*
Spring	1.00			
Fall	0.40	1.00		
Canada	0.18	-0.01	1.00	
Scallop	0.36	0.70	0.22	1.00

Age-2

	Spring	*Fall*	*Canada*
Spring	1.00		
Fall	0.60	1.00	
Canada	0.63	-0.06	1.00

Age-3

	Spring	*Fall*	*Canada*
Spring	1.00		
Fall	0.70	1.00	
Canada	0.76	0.61	1.00

Age-4

	Spring	*Fall*	*Canada*
Spring	1.00		
Fall	0.65	1.00	
Canada	0.70	0.75	1.00

Age-5

	Spring	*Fall*	*Canada*
Spring	1.00		
Fall	0.21	1.00	
Canada	0.74	0.46	1.00

Age-6

	Spring	*Fall*	*Canada*
Spring	1.00		
Fall	0.44	1.00	
Canada	0.64	1.00	1.00

Table 10. Yield and spawning stock per recruit analyses for Georges Bank yellowtail flounder.

```
The NEFC Yield and Stock Size per Recruit Program - PDBYPRC
 PC Ver.1.2 [Method of Thompson and Bell (1934)] 1-Jan-1992
            ----------------------------------------
            Run Date: 23- 4-1998;  Time: 08:58:08.50
GEORGES BANK YELLOWTAIL FLOUNDER - TRAC 1998

Proportion of F before spawning:  .4167
Proportion of M before spawning:  .4167
Natural Mortality is Constant at:  .200
Initial age is:  1; Last age is:  8
Last age is a PLUS group;
Original age-specific PRs, Mats, and Mean Wts from file:
==> gbyt8.dat
-----------------------------------------------------------
Age-specific Input data for Yield per Recruit Analysis
-----------------------------------------------------------
```

Age	Fish Mort Pattern	Nat Mort Pattern	Proportion Mature	Average Weights Catch	Average Weights Stock
1	.0000	1.0000	.0000	.100	.100
2	.0900	1.0000	.5200	.285	.285
3	.5400	1.0000	.8600	.396	.396
4	.9600	1.0000	.9800	.512	.512
5	1.0000	1.0000	1.0000	.647	.647
6	1.0000	1.0000	1.0000	.826	.826
7	1.0000	1.0000	1.0000	.897	.897
8+	1.0000	1.0000	1.0000	1.041	1.041

```
-----------------------------------------------------------
Summary of Yield per Recruit Analysis for:
GEORGES BANK YELLOWTAIL FLOUNDER - TRAC 1998

 Slope of the Yield/Recruit Curve at F=0.00: -->    2.4606
   F level at slope=1/10 of the above slope (F0.1): ----->     .248
     Yield/Recruit corresponding to F0.1: ----->     .2194
   F level to produce Maximum Yield/Recruit (Fmax): ----->     .821
     Yield/Recruit corresponding to Fmax: ----->     .2508
   F level at 20 % of Max Spawning Potential (F20): ----->     .686
     SSB/Recruit corresponding to F20: -------->     .5347
```

Table 11a. Age-based projection of the Georges Bank yellowtail flounder stock at status quo F.

PROJECTION RUN: Georges Bank yellowtail - status quo projection
INPUT FILE: gbytsq.in
OUTPUT FILE: gbytsq.out
RECRUITMENT MODEL: 3
NUMBER OF SIMULATIONS: 100

F-BASED PROJECTIONS
CONSTANT F:0.130

SPAWNING STOCK BIOMASS (THOUSAND MT)

YEAR	AVG SSB (000 MT)	STD
1998	18.044	2.854
1999	22.053	4.064
2000	24.947	5.283

PERCENTILES OF SPAWNING STOCK BIOMASS (000 MT)

YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
1998	11.743	13.621	14.537	16.131	17.799	19.761	21.786	22.976	25.820
1999	13.867	16.270	17.418	19.197	21.545	24.463	27.535	29.636	33.053
2000	15.379	17.668	18.873	21.068	24.162	28.006	32.541	34.937	38.926

ANNUAL PROBABILITY THAT SSB EXCEEDS THRESHOLD: 10.00000 THOUSAND MT

YEAR	Pr(SSB > Threshold Value)
1998	1.000
1999	1.000
2000	1.000

RECRUITMENT UNITS ARE: 1000.000 FISH

BIRTH YEAR	AVG RECRUITMENT	STD
1998	23123.139	16356.631
1999	23138.766	16356.953
2000	23072.730	16295.333

PERCENTILES OF RECRUITMENT UNITS ARE: 1000.000 FISH

BIRTH YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
1998	5822.000	6714.000	6892.000	13738.000	19303.000	22773.000	50272.000	60926.000	68014.000
1999	5822.000	6714.000	6892.000	13738.000	19303.000	22773.000	50272.000	60926.000	68014.000
2000	5822.000	6714.000	6892.000	13738.000	19303.000	22773.000	50272.000	60926.000	68014.000

LANDINGS FOR F-BASED PROJECTIONS

YEAR	AVG LANDINGS (000 MT)	STD
1998	1.816	0.272
1999	2.249	0.364
2000	2.621	0.524

PERCENTILES OF LANDINGS (000 MT)

YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
1998	1.208	1.397	1.484	1.634	1.788	1.977	2.172	2.310	2.528
1999	1.471	1.695	1.817	2.000	2.220	2.462	2.721	2.893	3.235
2000	1.621	1.886	2.032	2.240	2.555	2.922	3.315	3.617	4.097

DISCARDS FOR F-BASED PROJECTIONS

YEAR	AVG DISCARDS (000 MT)	STD
1998	0.030	0.010
1999	0.033	0.013
2000	0.034	0.015

PERCENTILES OF DISCARDS (000 MT)

YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
1998	0.014	0.017	0.019	0.023	0.028	0.035	0.042	0.047	0.062
1999	0.012	0.016	0.019	0.024	0.030	0.040	0.054	0.060	0.070
2000	0.012	0.016	0.019	0.024	0.030	0.045	0.056	0.061	0.079

Table 11b. Age-based projection of the Georges Bank yellowtail flounder stock at $F_{0.1}$.

PROJECTION RUN: Georges Bank yellowtail - reference point projection
INPUT FILE: gbytf01.in
OUTPUT FILE: gbytf01.out
RECRUITMENT MODEL: 3
NUMBER OF SIMULATIONS: 100

F-BASED PROJECTIONS
CONSTANT F:0.248

SPAWNING STOCK BIOMASS (THOUSAND MT)

YEAR	AVG SSB (000 MT)	STD
1998	17.372	2.768
1999	19.807	3.813
2000	21.263	4.829

PERCENTILES OF SPAWNING STOCK BIOMASS (000 MT)

YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
1998	11.318	13.092	13.966	15.523	17.146	19.041	21.004	22.177	25.067
1999	12.430	14.447	15.502	17.117	19.311	21.986	24.915	27.028	30.172
2000	12.788	14.723	15.773	17.701	20.487	24.033	28.190	30.429	34.264

ANNUAL PROBABILITY THAT SSB EXCEEDS THRESHOLD: 10.00000 THOUSAND MT

YEAR	Pr(SSB > Threshold Value)
1998	1.000
1999	1.000
2000	1.000

RECRUITMENT UNITS ARE: 1000.000 FISH

BIRTH YEAR	AVG RECRUITMENT	STD
1998	23123.139	16356.631
1999	23138.766	16356.953
2000	23072.730	16295.333

PERCENTILES OF RECRUITMENT UNITS ARE: 1000.000 FISH

BIRTH YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
1998	5822.000	6714.000	6892.000	13738.000	19303.000	22773.000	50272.000	60926.000	68014.000
1999	5822.000	6714.000	6892.000	13738.000	19303.000	22773.000	50272.000	60926.000	68014.000
2000	5822.000	6714.000	6892.000	13738.000	19303.000	22773.000	50272.000	60926.000	68014.000

LANDINGS FOR F-BASED PROJECTIONS

YEAR	AVG LANDINGS (000 MT)	STD
1998	3.294	0.493
1999	3.748	0.621
2000	4.109	0.873

PERCENTILES OF LANDINGS (000 MT)

YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
1998	2.190	2.536	2.692	2.965	3.244	3.585	3.942	4.191	4.587
1999	2.416	2.810	3.012	3.321	3.710	4.128	4.550	4.856	5.477
2000	2.499	2.921	3.123	3.466	3.983	4.611	5.276	5.821	6.561

DISCARDS FOR F-BASED PROJECTIONS

YEAR	AVG DISCARDS (000 MT)	STD
1998	0.055	0.018
1999	0.061	0.025
2000	0.063	0.027

PERCENTILES OF DISCARDS (000 MT)

YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
1998	0.025	0.031	0.035	0.042	0.052	0.065	0.078	0.089	0.116
1999	0.021	0.030	0.035	0.044	0.055	0.075	0.101	0.112	0.130
2000	0.023	0.030	0.035	0.043	0.055	0.083	0.103	0.113	0.146

Appendix A. ADAPT calibration of Georges Bank Yellowtail VPA.

```
Woods Hole Assessment Toolbox  GB yellowtail 1973-1997  Run Number  49   4/9/98   1:07:21
PM
GB yellowtail 1973-1997  1973 - 1998
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 ( 1997 ), 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 ]
          1973             1
          1997             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 not used

The Indices that will be used in this run are:
USspr 1
USspr 2
USspr 3
USspr 4
USspr 5
USspr 6
USfall 1
USfall 2
USfall 3
USfall 4
USfall 5
USfall 6
Canada 2
Canada 3
Canada 4
Canada 5
Canada 6
Scall 1
USs2 1
USs2 2
USs2 3
USs2 4
USs2 5
USs2 6
```

RESULTS

Approximate Statistics Assuming Linearity Near Solution
Sum of Squares: 220.954625414183
Mean Square Residuals: 0.69483

	PAR. EST.	STD. ERR.	T-STATISTIC	C.V.
N 2	1.72E+04	8.66E+03	1.99E+00	0.50
N 3	9.35E+03	3.50E+03	2.67E+00	0.37
N 4	1.01E+04	3.28E+03	3.07E+00	0.33
N 5	9.53E+03	1.91E+03	4.98E+00	0.20

Catchability Estimates in Original Units

	Estimate	Std.Err.	C.V.
q USspr 1	3.49E-06	9.57E-07	0.27
q USspr 2	5.64E-05	1.24E-05	0.22
q USspr 3	1.32E-04	2.79E-05	0.21
q USspr 4	2.17E-04	4.58E-05	0.21
q USspr 5	3.34E-04	7.05E-05	0.21
q USspr 6	4.73E-04	1.11E-04	0.23
q USfall 1	3.96E-05	6.89E-06	0.17
q USfall 2	7.91E-05	1.34E-05	0.17
q USfall 3	1.65E-04	2.79E-05	0.17
q USfall 4	1.90E-04	3.21E-05	0.17
q USfall 5	2.46E-04	4.53E-05	0.18
q USfall 6	3.40E-04	7.40E-05	0.22
q Canada 2	1.86E-04	4.80E-05	0.26
q Canada 3	5.52E-04	1.41E-04	0.26
q Canada 4	9.28E-04	2.37E-04	0.26
q Canada 5	1.07E-03	2.74E-04	0.26
q Canada 6	7.27E-04	2.35E-04	0.32
q Scall 1	2.65E-05	5.71E-06	0.22
q USs2 1	7.77E-06	2.30E-06	0.30
q USs2 2	8.12E-05	2.15E-05	0.26
q USs2 3	1.02E-04	2.69E-05	0.26
q USs2 4	1.10E-04	2.91E-05	0.26
q USs2 5	9.42E-05	2.50E-05	0.26
q USs2 6	1.07E-04	2.83E-05	0.26

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

	1973	1974	1975	1976	1977	1978	1979
USspr 1	0.000	0.000	0.000	0.000	0.000	0.000	0.000
USspr 2	0.000	0.000	0.000	0.000	0.000	0.000	0.000
USspr 3	0.000	0.000	0.000	0.000	0.000	0.000	0.000
USspr 4	0.000	0.000	0.000	0.000	0.000	0.000	0.000
USspr 5	0.000	0.000	0.000	0.000	0.000	0.000	0.000
USspr 6	0.000	0.000	0.000	0.000	0.000	0.000	0.000
USfall 1	1.087	1.158	0.801	-1.055	0.609	1.278	0.544
USfall 2	1.580	0.980	0.512	-0.229	1.005	0.590	0.019
USfall 3	0.580	0.050	-0.024	-0.771	0.368	0.130	-1.138
USfall 4	0.505	-0.147	0.310	-0.898	0.819	0.213	-0.838
USfall 5	0.257	-0.526	0.011	-0.002	0.281	0.194	0.013
USfall 6	0.082	-0.069	-1.613	-1.195	-0.362	-0.666	0.207
Canada 2	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Canada 3	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Canada 4	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Canada 5	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Canada 6	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Scall 1	0.000	0.000	0.000	0.000	0.000	0.000	0.000
USs2 1	2.608	-0.253	-0.284	2.111	0.000	1.036	0.516
USs2 2	0.656	0.217	-0.096	0.037	-0.948	-0.299	-0.387
USs2 3	-0.259	0.258	-0.268	0.343	-0.333	-0.430	-0.820
USs2 4	-0.673	-0.028	-0.692	0.258	0.225	-0.491	0.367
USs2 5	-0.523	-0.483	-0.325	1.025	0.224	-1.302	-0.509
USs2 6	-0.416	0.193	-0.859	-0.361	-2.211	-1.681	0.673
Col Avg	0.457	0.113	-0.211	-0.061	-0.029	-0.119	-0.113

	1980	1981	1982	1983	1984	1985	1986
USspr 1	0.000	0.000	-0.619	0.000	0.000	0.925	0.181
USspr 2	0.000	0.000	0.342	0.884	-1.102	2.119	1.244
USspr 3	0.000	0.000	-0.593	-0.232	0.022	0.221	-0.120
USspr 4	0.000	0.000	-0.126	-0.847	-0.470	0.242	-1.037
USspr 5	0.000	0.000	-0.206	-1.531	0.289	-0.467	0.461
USspr 6	0.000	0.000	0.493	0.807	0.362	0.000	-0.128
USfall 1	-0.039	-0.388	1.431	-0.698	0.945	1.166	0.206
USfall 2	1.718	0.750	-0.321	1.255	0.751	0.626	0.816
USfall 3	1.361	0.217	0.123	-0.172	-0.519	-0.094	0.274
USfall 4	0.710	-0.402	-0.288	-0.313	1.996	-1.228	0.031
USfall 5	0.841	-0.267	-1.044	-1.354	-0.824	-0.104	0.000
USfall 6	1.787	1.305	0.000	-0.184	-0.029	0.000	0.000
Canada 2	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Canada 3	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Canada 4	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Canada 5	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Canada 6	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Scall 1	0.000	0.000	-0.545	0.082	0.173	0.566	-0.514
USs2 1	-1.322	-4.411	0.000	0.000	0.000	0.000	0.000
USs2 2	1.327	-0.411	-0.097	0.000	0.000	0.000	0.000
USs2 3	1.357	0.428	-0.277	0.000	0.000	0.000	0.000
USs2 4	0.421	-0.079	0.691	0.000	0.000	0.000	0.000
USs2 5	-0.134	0.715	1.312	0.000	0.000	0.000	0.000
USs2 6	0.624	1.762	2.277	0.000	0.000	0.000	0.000
Col Avg	0.721	-0.065	0.150	-0.192	0.133	0.361	0.129

	1987	1988	1989	1990	1991	1992	1993
USspr 1	0.000	0.173	0.546	0.000	2.062	0.000	-0.271
USspr 2	-1.019	-0.170	-0.860	-2.134	0.000	0.825	-1.010
USspr 3	-1.885	0.424	0.986	-0.352	-0.832	0.775	-0.758
USspr 4	-0.711	0.324	1.141	0.298	-0.198	0.358	-1.219
USspr 5	-0.201	1.202	0.390	0.969	0.768	-0.423	-2.247
USspr 6	-0.346	0.186	1.129	1.516	-0.858	0.000	0.000
USfall 1	-0.949	-4.301	-0.241	0.000	1.167	-1.595	0.659
USfall 2	0.463	-0.422	0.773	-0.279	-1.083	-1.019	-2.150
USfall 3	0.181	-0.669	1.089	0.366	-0.085	-0.331	-0.406
USfall 4	-0.811	-1.032	0.140	0.692	-0.003	-0.326	0.251
USfall 5	1.526	0.000	1.424	-0.762	0.000	0.363	0.000
USfall 6	0.000	0.000	0.000	0.000	0.000	1.516	0.000
Canada 2	-0.447	-0.552	-1.561	0.000	-1.314	1.322	-0.033
Canada 3	-0.143	0.677	-0.637	-0.355	-0.254	0.070	0.298
Canada 4	0.069	0.016	-0.484	-0.189	-0.189	-0.540	-0.091
Canada 5	-1.449	1.108	-0.415	0.926	0.912	-2.021	0.115
Canada 6	0.000	-1.522	-0.333	-1.088	0.000	0.000	0.000
Scall 1	-1.522	-1.651	-0.050	-1.242	1.656	-0.995	1.490
USs2 1	0.000	0.000	0.000	0.000	0.000	0.000	0.000
USs2 2	0.000	0.000	0.000	0.000	0.000	0.000	0.000
USs2 3	0.000	0.000	0.000	0.000	0.000	0.000	0.000
USs2 4	0.000	0.000	0.000	0.000	0.000	0.000	0.000
USs2 5	0.000	0.000	0.000	0.000	0.000	0.000	0.000
USs2 6	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Col Avg	-0.483	-0.388	0.179	-0.109	0.125	-0.135	-0.384

	1994	1995	1996	1997	1998
USspr 1	0.000	-0.722	-0.651	-1.623	0.000
USspr 2	0.264	-0.062	0.030	0.649	0.000
USspr 3	-0.728	2.075	0.127	0.871	0.000
USspr 4	-0.842	1.444	1.226	0.416	0.000
USspr 5	-1.156	1.907	0.676	-0.433	0.000
USspr 6	-0.713	-1.560	0.344	-1.231	0.000
USfall 1	0.259	-1.183	-1.596	0.734	0.000
USfall 2	-1.204	-3.088	-1.491	-0.549	0.000
USfall 3	0.289	-1.125	-0.377	0.684	0.000
USfall 4	1.205	-0.015	-0.536	-0.033	0.000
USfall 5	1.058	-0.394	-1.324	0.634	0.000
USfall 6	1.228	-0.775	0.000	-1.231	0.000
Canada 2	1.559	-1.368	0.665	1.729	0.000
Canada 3	-0.462	0.158	-0.190	0.836	0.000
Canada 4	0.000	0.179	0.706	0.523	0.000
Canada 5	-0.582	1.202	0.249	-0.046	0.000
Canada 6	1.216	0.800	1.004	-0.076	0.000
Scall 1	1.008	0.229	0.429	0.888	0.000
USs2 1	0.000	0.000	0.000	0.000	0.000
USs2 2	0.000	0.000	0.000	0.000	0.000
USs2 3	0.000	0.000	0.000	0.000	0.000
USs2 4	0.000	0.000	0.000	0.000	0.000
USs2 5	0.000	0.000	0.000	0.000	0.000
USs2 6	0.000	0.000	0.000	0.000	0.000
Col Avg	0.141	-0.128	-0.042	0.152	0.000

STOCK NUMBERS (Jan 1) in thousands - C:\SXC\gbyt.49

	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

	1987	1988	1989	1990	1991	1992	1993
1	7025	19361	8552	11831	22365	17223	16539
2	5310	5625	15414	6834	9488	17938	11939
3	4080	1947	2463	11248	3848	7719	7123
4	1108	851	516	1412	3669	2045	4033
5	188	219	132	186	432	805	526
6	155	49	36	34	86	42	122
1+	17865	28051	27114	31545	39889	45772	40282

	1994	1995	1996	1997	1998
1	27010	20934	14801	21069	00
2	8842	22050	17127	12072	17235
3	8862	6460	17911	13676	9346
4	3319	2060	4479	13299	10059
5	1138	391	1040	3019	9529
6	165	78	95	791	2730
1+	49335	51972	55452	63926	48898

FISHING MORTALITY - C:\SXC\gbyt.49

	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	0.17	0.43
2	0.80	0.63	0.12	0.37	0.01	0.72	0.10
3	1.37	1.13	0.36	0.92	0.43	0.45	0.56
4	1.42	1.66	0.82	0.98	1.32	1.16	1.07
5	1.50	1.79	0.84	1.01	1.38	1.20	1.10
6	1.50	1.79	0.84	1.01	1.38	1.20	1.10

	1994	1995	1996	1997
1	0.00	0.00	0.00	0.00
2	0.11	0.01	0.03	0.06
3	1.26	0.17	0.10	0.11
4	1.94	0.48	0.19	0.13
5	2.15	0.49	0.20	0.13
6	2.15	0.49	0.20	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	1.18	1.08

	1994	1995	1996	1997
4,5	2.05	0.49	0.19	0.13

BACKCALCULATED PARTIAL RECRUITMENT

	1973	1974	1975	1976	1977	1978	1979
1	0.01	0.04	0.05	0.03	0.02	0.24	0.01
2	0.28	0.46	0.78	0.98	0.53	0.32	0.38
3	0.74	0.73	0.84	0.88	1.00	1.00	0.70
4	0.97	0.96	0.94	0.97	0.77	0.96	0.97
5	1.00	1.00	1.00	1.00	0.80	0.99	1.00
6	1.00	1.00	1.00	1.00	0.80	0.99	1.00

	1980	1981	1982	1983	1984	1985	1986
1	0.02	0.00	0.09	0.12	0.02	0.04	0.03
2	0.31	0.03	0.40	0.63	0.32	0.69	0.81
3	1.00	0.50	0.68	1.00	0.68	0.67	0.58
4	0.96	0.96	0.96	0.59	0.89	0.96	0.97
5	0.98	1.00	1.00	0.61	1.00	1.00	1.00
6	0.98	1.00	1.00	0.61	1.00	1.00	1.00

	1987	1988	1989	1990	1991	1992	1993
1	0.01	0.02	0.03	0.02	0.01	0.14	0.39
2	0.53	0.35	0.14	0.37	0.00	0.60	0.09
3	0.91	0.63	0.42	0.91	0.31	0.37	0.51
4	0.95	0.93	0.98	0.97	0.95	0.96	0.97
5	1.00	1.00	1.00	1.00	1.00	1.00	1.00
6	1.00	1.00	1.00	1.00	1.00	1.00	1.00

	1994	1995	1996	1997
1	0.00	0.00	0.02	0.01
2	0.05	0.02	0.13	0.42
3	0.58	0.34	0.50	0.80
4	0.90	0.99	0.99	1.00
5	1.00	1.00	1.00	1.00
6	1.00	1.00	1.00	1.00

MEAN BIOMASS

	1973	1974	1975	1976	1977	1978	1979
1	255	445	600	205	141	412	211
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	1316	996	492	664	408	164	241
1+	24599	17062	12264	14000	9708	7361	12053

	1980	1981	1982	1983	1984	1985	1986
1	199	553	186	49	76	129	60
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	144	76	73	164	111	45	68
1+	12668	12684	17673	11677	3593	2859	3841

	1987	1988	1989	1990	1991	1992	1993
1	63	173	77	106	201	144	123
2	1036	1221	4522	1461	2212	3314	2839
3	1073	598	1024	2632	1024	2044	1828
4	365	265	234	475	905	581	1151
5	61	81	72	75	157	280	165
6	63	21	25	17	37	27	62
1+	2661	2360	5955	4766	4536	6389	6168

	1994	1995	1996	1997	
1	245	190	134	191	
2	1988	5176	4739	3291	
3	1636	1985	6336	5393	
4	645	691	1936	6695	
5	275	164	573	1828	
6	52	42	72	650	
1+	4840	8248	13789	18049	00

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

	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	1372	1031	502	691	424	171	251
1+	21103	14085	8331	9160	7557	5441	7632

	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	150	78	75	171	107	46	71
1+	10050	9660	12455	10427	3485	2732	3763

	1987	1988	1989	1990	1991	1992	1993
1	00	00	00	00	00	00	00
2	1004	1183	4299	1406	2089	1796	1508
3	1106	621	1059	2744	1062	2120	1635
4	375	269	244	495	934	603	1197
5	63	82	75	78	162	290	172
6	64	21	26	18	38	28	64
1+	2613	2176	5705	4740	4285	4837	4576

	1994	1995	1996	1997
1	00	00	00	00
2	1057	2734	2506	1744
3	1456	1750	5565	4739
4	628	703	1948	6715
5	268	171	588	1871
6	51	44	74	666
1+	3460	5401	10680	15734

The number of bootstraps: 1000
Bootstrap Output Variable: N hat

	NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP StdError	C.V. FOR NLLS SOLN
N 2	17235	19819	10978	0.64
N 3	9346	10258	4183	0.45
N 4	10059	10754	3216	0.32
N 5	9529	9630	1758	0.18

	BIAS ESTIMATE	BIAS STD ERROR	PERCENT BIAS	NLLS EST CORRECTED FOR BIAS	C.V. FOR CORRECTED ESTIMATE
N 2	2584	347	14.99	14651	0.749320
N 3	913	132	9.77	8433	0.496071
N 4	695	102	6.91	9363	0.343462
N 5	101	56	1.06	9428	0.186503

Bootstrap Output Variable: Q_unscaled

	NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP StdError	C.V. FOR NLLS SOLN
q USspr1	0.0000035	0.0000036	0.0000010	0.30
q USspr2	0.0000564	0.0000579	0.0000135	0.24
q USspr3	0.0001321	0.0001341	0.0000260	0.20
q USspr4	0.0002170	0.0002190	0.0000371	0.17
q USspr5	0.0003340	0.0003401	0.0000740	0.22
q USspr6	0.0004729	0.0004839	0.0000995	0.21
q USfall1	0.0000396	0.0000403	0.0000088	0.22
q USfall2	0.0000791	0.0000810	0.0000157	0.20
q USfall3	0.0001653	0.0001654	0.0000161	0.10
q USfall4	0.0001900	0.0001919	0.0000242	0.13
q USfall5	0.0002459	0.0002488	0.0000354	0.14
q USfall6	0.0003403	0.0003493	0.0000770	0.23
q Canada2	0.0001859	0.0001960	0.0000598	0.32
q Canada3	0.0005521	0.0005533	0.0000661	0.12
q Canada4	0.0009282	0.0009302	0.0000906	0.10
q Canada5	0.0010706	0.0010975	0.0002656	0.25
q Canada6	0.0007273	0.0007680	0.0002535	0.35
q Scall1	0.0000265	0.0000270	0.0000059	0.22
q USs21	0.0000078	0.0000093	0.0000056	0.72
q USs22	0.0000812	0.0000822	0.0000129	0.16
q USs23	0.0001015	0.0001027	0.0000157	0.16
q USs24	0.0001098	0.0001109	0.0000134	0.12
q USs25	0.0000942	0.0000965	0.0000201	0.21
q USs26	0.0001069	0.0001129	0.0000406	0.38

	BIAS ESTIMATE	BIAS STD ERROR	PERCENT BIAS	NLLS EST CORRECTED FOR BIAS	C.V. FOR CORRECTED ESTIMATE
q USspr1	0.00000007	0.000000033	1.999	0.000003418	0.30
q USspr2	0.00000155	0.000000428	2.752	0.000054802	0.25
q USspr3	0.00000206	0.000000823	1.562	0.000130020	0.20
q USspr4	0.00000197	0.000001175	0.907	0.000215058	0.17
q USspr5	0.00000610	0.000002340	1.825	0.000327862	0.23
q USspr6	0.00001102	0.000003146	2.331	0.000461863	0.22
q USfall1	0.00000074	0.000000278	1.871	0.000038820	0.23
q USfall2	0.00000193	0.000000496	2.445	0.000077162	0.20
q USfall3	0.00000015	0.000000510	0.092	0.000165123	0.10
q USfall4	0.00000192	0.000000766	1.009	0.000188104	0.13
q USfall5	0.00000298	0.000001119	1.213	0.000242883	0.15
q USfall6	0.00000900	0.000002434	2.645	0.000331269	0.23
q Canada2	0.00001007	0.000001892	5.417	0.000175819	0.34
q Canada3	0.00000113	0.000002091	0.204	0.000551016	0.12
q Canada4	0.00000197	0.000002863	0.212	0.000926241	0.10
q Canada5	0.00002691	0.000008400	2.514	0.001043720	0.25
q Canada6	0.00004074	0.000008015	5.601	0.000686551	0.37
q Scall1	0.00000050	0.000000186	1.900	0.000026030	0.23
q USs21	0.00000153	0.000000176	19.747	0.000006232	0.89
q USs22	0.00000098	0.000000408	1.210	0.000080221	0.16
q USs23	0.00000113	0.000000498	1.112	0.000100393	0.16
q USs24	0.00000103	0.000000423	0.941	0.000108787	0.12
q USs25	0.00000228	0.000000636	2.421	0.000091967	0.22
q USs26	0.00000600	0.000001285	5.615	0.000100856	0.40

Bootstrap Output Variable: N t1

	NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP StdError	C.V. FOR NLLS SOLN
Age 1	18990.7	19027.1	596.6	0.0314
Age 2	17235.1	19819.4	10978.1	0.6370
Age 3	9345.7	10258.3	4183.4	0.4476
Age 4	10058.6	10753.7	3216.0	0.3197
Age 5	9529.0	9629.6	1758.4	0.1845
Age 6	2730.1	2759.0	504.0	0.1846

	BIAS ESTIMATE	BIAS STD ERROR	PERCENT BIAS	NLLS EST CORRECTED FOR BIAS	C.V. FOR CORRECTED ESTIMATE
Age 1	36.47	18.87	0.192	18954.20	0.03
Age 2	2584.38	347.16	14.995	14650.69	0.75
Age 3	912.62	132.29	9.765	8433.10	0.50
Age 4	695.14	101.70	6.911	9363.42	0.34
Age 5	100.65	55.61	1.056	9428.33	0.19
Age 6	28.85	15.94	1.057	2701.27	0.19

Bootstrap Output Variable: F t

	NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP StdError	C.V. FOR NLLS SOLN
Age 1	0.0008	0.0010	0.0007	0.82
Age 2	0.0560	0.0600	0.0261	0.47
Age 3	0.1072	0.1094	0.0341	0.32
Age 4	0.1333	0.1359	0.0235	0.18
Age 5	0.1333	0.1359	0.0235	0.18
Age 6	0.1333	0.1359	0.0235	0.18

	BIAS ESTIMATE	BIAS STD ERROR	PERCENT BIAS	NLLS EST CORRECTED FOR BIAS	C.V. FOR CORRECTED ESTIMATE
Age 1	0.0001542	0.0000217	18.364	0.0006855	1.00
Age 2	0.0039944	0.0008248	7.132	0.0520144	0.50
Age 3	0.0021982	0.0010774	2.050	0.1050097	0.32
Age 4	0.0026058	0.0007432	1.954	0.1307220	0.18
Age 5	0.0026058	0.0007432	1.954	0.1307220	0.18
Age 6	0.0026058	0.0007432	1.954	0.1307220	0.18

Bootstrap Output Variable: F full t

NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP StdError	C.V. FOR NLLS SOLN
0.1333	0.1359	0.0235	0.18

BIAS ESTIMATE	BIAS STD ERROR	PERCENT BIAS	NLLS EST CORRECTED FOR BIAS	C.V. FOR CORRECTED ESTIMATE
0.00261	0.00074	1.95	0.13072	0.18

Bootstrap Output Variable: B mean

NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP StdError	C.V. FOR NLLS SOLN	
18048.5266	18831.7230	2749.7476	0.15	
BIAS ESTIMATE	**BIAS STD ERROR**	**PERCENT BIAS**	**NLLS EST CORRECTED FOR BIAS**	**C.V. FOR CORRECTED ESTIMATE**
783.1963	86.9547	4.34	17265.3303	0.16

Bootstrap Output Variable: SSB f mean

NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP StdError	C.V. FOR NLLS SOLN	
7694.4980	7971.5622	1136.2280	0.15	
BIAS ESTIMATE	**BIAS STD ERROR**	**PERCENT BIAS**	**NLLS EST CORRECTED FOR BIAS**	**C.V. FOR CORRECTED ESTIMATE**
277.064	35.931	3.60	7417.434	0.15

Bootstrap Output Variable: SSB spawn t

NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP StdError	C.V. FOR NLLS SOLN	
15734.3045	16296.6180	2307.9784	0.15	
BIAS ESTIMATE	**BIAS STD ERROR**	**PERCENT BIAS**	**NLLS EST CORRECTED FOR BIAS**	**C.V. FOR CORRECTED ESTIMATE**
562.31	72.98	3.57	15171.99	0.15

Appendix B. ASPIC analysis of Georges Bank yellowtail flounder.

```
Georges Bank Yellowtail -- ASPIC 3.6x -- Including Discards
                                                                                      09 Apr 1998 at 14:46

ASPIC -- A Surplus-Production Model Including Covariates (Ver. 3.65)                              FIT Mode

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CONTROL PARAMETERS USED (FROM INPUT FILE)
---------------------------------------------------------------------------------------------------------
Number of years analyzed:                    35          Number of bootstrap trials:                   0
Number of data series:                        4          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-08          Lower bound on r:                     1.000E-01
Relative conv. criterion (restart):   3.000E-08          Upper bound on r:                     5.000E+00
Relative conv. criterion (effort):    1.000E-04          Random number seed:                     1964287
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  USA Fall Survey                    |    1.000
                                       |       35
                                       |
 2  USA Spring Survey 36               |    0.777    1.000
                                       |       21       21
                                       |
 3  USA Spring Survey 41               |    0.796    0.000    1.000
                                       |        9        0        9
                                       |
 4  Canadian Survey - lagged           |    0.269    0.627    0.000    1.000
                                       |       12       12        0       12
                                       ------------------------------------------
                                                1        2        3        4
```

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	6.521E-01	1	N/A	1.000E+00	N/A	
Loss(1)	USA Fall Survey	8.085E+00	35	2.450E-01	1.000E+00	1.020E+00	0.768
Loss(2)	USA Spring Survey 36	4.787E+00	21	2.520E-01	1.000E+00	9.919E-01	0.571
Loss(3)	USA Spring Survey 41	2.040E+00	9	2.915E-01	1.000E+00	8.574E-01	-0.037
Loss(4)	Canadian Survey - lagged	2.352E+00	12	2.352E-01	1.000E+00	1.062E+00	0.400

TOTAL OBJECTIVE FUNCTION: 1.79171009E+01

NOTE: B1-ratio constraint term contributing to loss. Sensitivity analysis advised.

Number of restarts required for convergence:	65
Est. B-ratio coverage index (0 worst, 2 best):	1.9105
Est. B-ratio nearness index (0 worst, 1 best):	1.0000

MODEL PARAMETER ESTIMATES (NON-BOOTSTRAPPED)

Parameter		Estimate	Starting guess	Estimated	User guess
B1R	Starting biomass ratio, year 1963	4.485E+00	2.000E+00	1	1
MSY	Maximum sustainable yield	1.366E+01	1.400E+01	1	1
r	Intrinsic rate of increase	6.207E-01	6.000E-01	1	1
....	Catchability coefficients by fishery:				
q(1)	USA Fall Survey	1.209E-01	1.000E-01	1	1
q(2)	USA Spring Survey 36	1.396E-01	1.000E-01	1	1
q(3)	USA Spring Survey 41	9.693E-02	1.000E-01	1	1
q(4)	Canadian Survey - lagged	2.870E-01	3.000E-01	1	1

MANAGEMENT PARAMETER ESTIMATES (NON-BOOTSTRAPPED)

Parameter		Estimate	Formula	
MSY	Maximum sustainable yield	1.366E+01	Kr/4	
K	Maximum stock biomass	8.805E+01		
Bmsy	Stock biomass at MSY	4.402E+01	K/2	
Fmsy	Fishing mortality at MSY	3.103E-01	r/2	
F(0.1)	Management benchmark	2.793E-01	0.9*Fmsy	
Y(0.1)	Equilibrium yield at F(0.1)	1.353E+01	0.99*MSY	
B-ratio	Ratio of B(1998) to Bmsy	6.523E-01		
F-ratio	Ratio of F(1997) to Fmsy	2.455E-01		
Y-ratio	Proportion of MSY avail in 1998	8.791E-01	2*Br-Br^2	Ye(1998) = 1.201E+01
....	Fishing effort at MSY in units of each fishery:			
fmsy(1)	USA Fall Survey	2.568E+00	r/2q(1)	f(0.1) = 2.311E+00

Georges Bank Yellowtail -- ASPIC 3.6x -- Including Discards

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	0.119	1.974E+02	1.464E+02	1.746E+01	1.746E+01	-6.385E+01	3.842E-01	4.485E+00
2	1964	0.198	1.161E+02	9.964E+01	1.977E+01	1.977E+01	-8.601E+00	6.393E-01	2.638E+00
3	1965	0.243	8.776E+01	7.953E+01	1.931E+01	1.931E+01	4.655E+00	7.826E-01	1.993E+00
4	1966	0.202	7.310E+01	7.017E+01	1.419E+01	1.419E+01	8.829E+00	6.515E-01	1.660E+00
5	1967	0.216	6.774E+01	6.565E+01	1.420E+01	1.420E+01	1.036E+01	6.967E-01	1.539E+00
6	1968	0.304	6.390E+01	6.033E+01	1.832E+01	1.832E+01	1.176E+01	9.785E-01	1.451E+00
7	1969	0.406	5.734E+01	5.279E+01	2.145E+01	2.145E+01	1.308E+01	1.309E+00	1.303E+00
8	1970	0.489	4.897E+01	4.455E+01	2.179E+01	2.179E+01	1.362E+01	1.576E+00	1.112E+00
9	1971	0.381	4.080E+01	3.993E+01	1.520E+01	1.520E+01	1.354E+01	1.227E+00	9.268E-01
10	1972	0.482	3.914E+01	3.678E+01	1.773E+01	1.773E+01	1.328E+01	1.553E+00	8.891E-01
11	1973	0.505	3.469E+01	3.270E+01	1.652E+01	1.652E+01	1.275E+01	1.628E+00	7.880E-01
12	1974	0.583	3.092E+01	2.846E+01	1.659E+01	1.659E+01	1.194E+01	1.878E+00	7.023E-01
13	1975	0.684	2.627E+01	2.342E+01	1.601E+01	1.601E+01	1.065E+01	2.203E+00	5.968E-01
14	1976	0.799	2.091E+01	1.797E+01	1.436E+01	1.436E+01	8.858E+00	2.575E+00	4.751E-01
15	1977	0.715	1.542E+01	1.399E+01	1.001E+01	1.001E+01	7.301E+00	2.305E+00	3.502E-01
16	1978	0.474	1.271E+01	1.307E+01	6.188E+00	6.188E+00	6.907E+00	1.526E+00	2.886E-01
17	1979	0.443	1.342E+01	1.398E+01	6.195E+00	6.195E+00	7.298E+00	1.428E+00	3.049E-01
18	1980	0.459	1.453E+01	1.495E+01	6.863E+00	6.863E+00	7.704E+00	1.479E+00	3.300E-01
19	1981	0.384	1.537E+01	1.636E+01	6.277E+00	6.277E+00	8.266E+00	1.236E+00	3.491E-01
20	1982	0.795	1.736E+01	1.510E+01	1.200E+01	1.200E+01	7.754E+00	2.560E+00	3.943E-01
21	1983	1.174	1.311E+01	9.733E+00	1.142E+01	1.142E+01	5.352E+00	3.781E+00	2.979E-01
22	1984	1.015	7.044E+00	5.705E+00	5.791E+00	5.791E+00	3.308E+00	3.271E+00	1.600E-01
23	1985	0.539	4.561E+00	4.675E+00	2.520E+00	2.520E+00	2.747E+00	1.737E+00	1.036E-01
24	1986	0.664	4.789E+00	4.612E+00	3.060E+00	3.060E+00	2.712E+00	2.138E+00	1.088E-01
25	1987	0.711	4.441E+00	4.184E+00	2.975E+00	2.975E+00	2.473E+00	2.291E+00	1.009E-01
26	1988	0.518	3.939E+00	4.089E+00	2.118E+00	2.118E+00	2.420E+00	1.669E+00	8.948E-02
27	1989	0.238	4.241E+00	5.076E+00	1.207E+00	1.207E+00	2.967E+00	7.663E-01	9.634E-02
28	1990	0.602	6.001E+00	5.933E+00	3.569E+00	3.569E+00	3.434E+00	1.938E+00	1.363E-01
29	1991	0.301	5.867E+00	6.751E+00	2.030E+00	2.030E+00	3.867E+00	9.690E-01	1.333E-01
30	1992	0.635	7.704E+00	7.448E+00	4.732E+00	4.732E+00	4.232E+00	2.047E+00	1.750E-01
31	1993	0.526	7.204E+00	7.360E+00	3.874E+00	3.874E+00	4.186E+00	1.696E+00	1.636E-01
32	1994	0.498	7.516E+00	7.781E+00	3.871E+00	3.871E+00	4.402E+00	1.603E+00	1.707E-01
33	1995	0.079	8.047E+00	1.030E+01	8.110E-01	8.110E-01	5.631E+00	2.538E-01	1.828E-01
34	1996	0.079	1.287E+01	1.612E+01	1.273E+00	1.273E+00	8.148E+00	2.544E-01	2.923E-01
35	1997	0.076	1.974E+01	2.408E+01	1.834E+00	1.834E+00	1.081E+01	2.455E-01	4.484E-01
36	1998		2.872E+01						6.523E-01

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

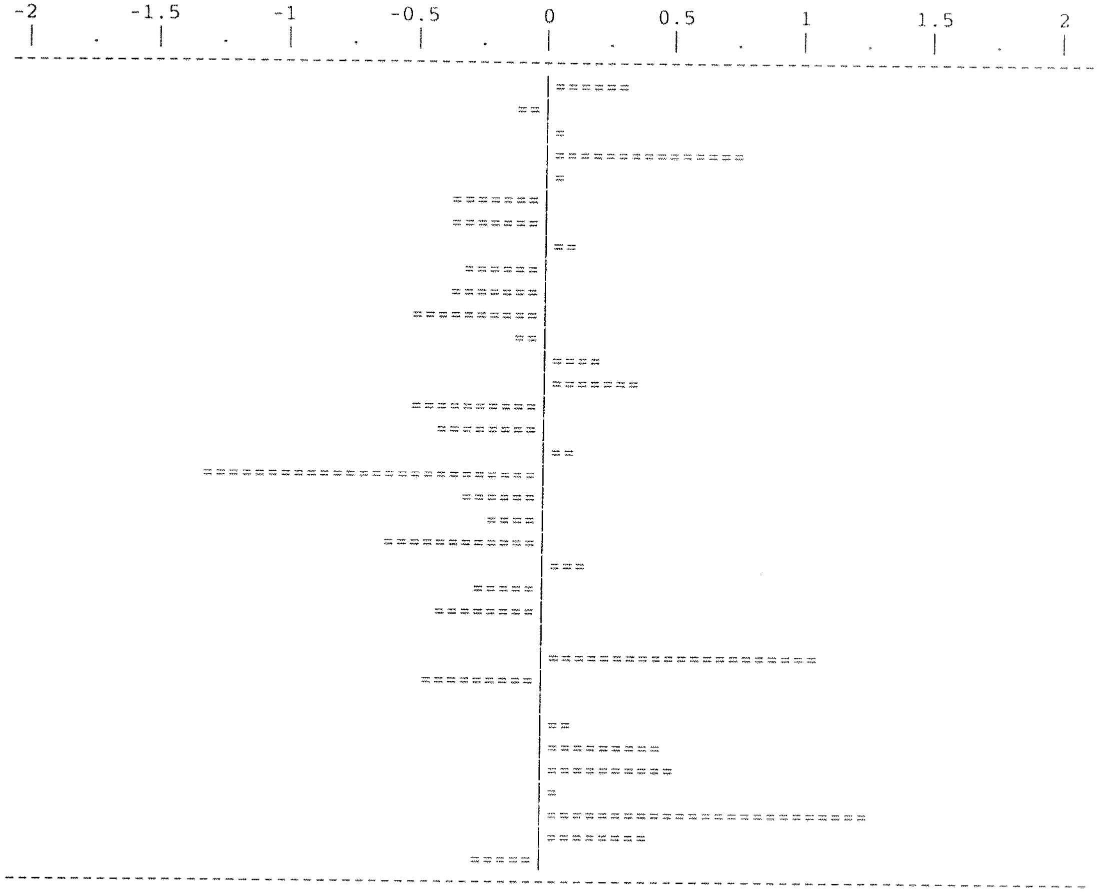
Data type CC: CPUE-catch series Series weight: 1.000

Obs	Year	Observed effort	Estimated effort	Estim F	Observed yield	Model yield	Resid in log effort	Resid in yield
1	1963	1.365E+00	9.866E-01	0.1192	1.746E+01	1.746E+01	0.32479	0.000E+00
2	1964	1.451E+00	1.642E+00	0.1984	1.977E+01	1.977E+01	-0.12338	0.000E+00
3	1965	2.121E+00	2.010E+00	0.2429	1.931E+01	1.931E+01	0.05416	0.000E+00
4	1966	3.557E+00	1.673E+00	0.2022	1.419E+01	1.419E+01	0.75436	0.000E+00
5	1967	1.874E+00	1.789E+00	0.2162	1.420E+01	1.420E+01	0.04635	0.000E+00
6	1968	1.739E+00	2.513E+00	0.3037	1.832E+01	1.832E+01	-0.36816	0.000E+00
7	1969	2.312E+00	3.362E+00	0.4063	2.145E+01	2.145E+01	-0.37463	0.000E+00
8	1970	4.377E+00	4.048E+00	0.4892	2.179E+01	2.179E+01	0.07820	0.000E+00
9	1971	2.389E+00	3.151E+00	0.3808	1.520E+01	1.520E+01	-0.27696	0.000E+00
10	1972	2.802E+00	3.989E+00	0.4821	1.773E+01	1.773E+01	-0.35335	0.000E+00
11	1973	2.503E+00	4.182E+00	0.5053	1.652E+01	1.652E+01	-0.51331	0.000E+00
12	1974	4.443E+00	4.823E+00	0.5829	1.659E+01	1.659E+01	-0.08207	0.000E+00
13	1975	6.770E+00	5.658E+00	0.6837	1.601E+01	1.601E+01	0.17951	0.000E+00
14	1976	9.365E+00	6.612E+00	0.7991	1.436E+01	1.436E+01	0.34809	0.000E+00
15	1977	3.539E+00	5.919E+00	0.7153	1.001E+01	1.001E+01	-0.51444	0.000E+00
16	1978	2.597E+00	3.918E+00	0.4735	6.188E+00	6.188E+00	-0.41144	0.000E+00
17	1979	4.076E+00	3.667E+00	0.4432	6.195E+00	6.195E+00	0.10555	0.000E+00
18	1980	1.021E+00	3.798E+00	0.4590	6.863E+00	6.863E+00	-1.31379	0.000E+00
19	1981	2.395E+00	3.175E+00	0.3836	6.277E+00	6.277E+00	-0.28182	0.000E+00
20	1982	5.285E+00	6.574E+00	0.7945	1.200E+01	1.200E+01	-0.21831	0.000E+00
21	1983	5.360E+00	9.711E+00	1.1735	1.142E+01	1.142E+01	-0.59428	0.000E+00
22	1984	9.766E+00	8.400E+00	1.0151	5.791E+00	5.791E+00	0.15066	0.000E+00
23	1985	3.554E+00	4.461E+00	0.5391	2.520E+00	2.520E+00	-0.22714	0.000E+00
24	1986	3.732E+00	5.491E+00	0.6635	3.060E+00	3.060E+00	-0.38618	0.000E+00
25	1987	5.845E+00	5.884E+00	0.7111	2.975E+00	2.975E+00	-0.00668	0.000E+00
26	1988	1.239E+01	4.286E+00	0.5180	2.118E+00	2.118E+00	1.06121	0.000E+00
27	1989	1.235E+00	1.968E+00	0.2378	1.207E+00	1.207E+00	-0.46547	0.000E+00
28	1990	4.923E+00	4.977E+00	0.6015	3.569E+00	3.569E+00	-0.01105	0.000E+00
29	1991	2.781E+00	2.488E+00	0.3007	2.030E+00	2.030E+00	0.11116	0.000E+00
30	1992	8.215E+00	5.257E+00	0.6353	4.732E+00	4.732E+00	0.44645	0.000E+00
31	1993	7.108E+00	4.356E+00	0.5264	3.874E+00	3.874E+00	0.48978	0.000E+00
32	1994	4.315E+00	4.117E+00	0.4975	3.871E+00	3.871E+00	0.04714	0.000E+00
33	1995	2.291E+00	6.517E-01	0.0788	8.110E-01	8.110E-01	1.25722	0.000E+00
34	1996	9.770E-01	6.533E-01	0.0789	1.273E+00	1.273E+00	0.40246	0.000E+00
35	1997	4.851E-01	6.303E-01	0.0762	1.834E+00	1.834E+00	-0.26196	0.000E+00

Georges Bank Yellowtail -- ASPIC 3.6x -- Including Discards

UNWEIGHTED LOG RESIDUAL PLOT FOR DATA SERIES # 1

Year	Residual
1963	0.3248
1964	-0.1234
1965	0.0542
1966	0.7544
1967	0.0464
1968	-0.3682
1969	-0.3746
1970	0.0782
1971	-0.2770
1972	-0.3533
1973	-0.5133
1974	-0.0821
1975	0.1795
1976	0.3481
1977	-0.5144
1978	-0.4114
1979	0.1056
1980	-1.3138
1981	-0.2818
1982	-0.2183
1983	-0.5943
1984	0.1507
1985	-0.2271
1986	-0.3862
1987	-0.0067
1988	1.0612
1989	-0.4655
1990	-0.0111
1991	0.1112
1992	0.4464
1993	0.4898
1994	0.0471
1995	1.2572
1996	0.4025
1997	-0.2620



RESULTS FOR DATA SERIES # 2 (NON-BOOTSTRAPPED) USA Spring Survey 36

Data type I0: Start-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	*	2.756E+01	0.00000	0.0
2	1964	0.000E+00	0.000E+00	0.0	*	1.621E+01	0.00000	0.0
3	1965	0.000E+00	0.000E+00	0.0	*	1.225E+01	0.00000	0.0
4	1966	0.000E+00	0.000E+00	0.0	*	1.020E+01	0.00000	0.0
5	1967	0.000E+00	0.000E+00	0.0	*	9.456E+00	0.00000	0.0
6	1968	1.000E+00	1.000E+00	0.0	2.813E+00	8.920E+00	-1.15409	-6.107E+00
7	1969	1.000E+00	1.000E+00	0.0	1.117E+01	8.005E+00	0.33318	3.165E+00
8	1970	1.000E+00	1.000E+00	0.0	5.312E+00	6.837E+00	-0.25233	-1.525E+00
9	1971	1.000E+00	1.000E+00	0.0	4.607E+00	5.696E+00	-0.21218	-1.089E+00
10	1972	1.000E+00	1.000E+00	0.0	6.450E+00	5.464E+00	0.16591	9.861E-01
11	1973	0.000E+00	0.000E+00	0.0	*	4.843E+00	0.00000	0.0
12	1974	0.000E+00	0.000E+00	0.0	*	4.316E+00	0.00000	0.0
13	1975	0.000E+00	0.000E+00	0.0	*	3.668E+00	0.00000	0.0
14	1976	0.000E+00	0.000E+00	0.0	*	2.920E+00	0.00000	0.0
15	1977	0.000E+00	0.000E+00	0.0	*	2.152E+00	0.00000	0.0
16	1978	0.000E+00	0.000E+00	0.0	*	1.774E+00	0.00000	0.0
17	1979	0.000E+00	0.000E+00	0.0	*	1.874E+00	0.00000	0.0
18	1980	0.000E+00	0.000E+00	0.0	*	2.028E+00	0.00000	0.0
19	1981	0.000E+00	0.000E+00	0.0	*	2.145E+00	0.00000	0.0
20	1982	1.000E+00	1.000E+00	0.0	2.500E+00	2.423E+00	0.03129	7.702E-02
21	1983	1.000E+00	1.000E+00	0.0	2.642E+00	1.831E+00	0.36682	8.113E-01
22	1984	1.000E+00	1.000E+00	0.0	1.646E+00	9.834E-01	0.51510	6.626E-01
23	1985	1.000E+00	1.000E+00	0.0	9.880E-01	6.367E-01	0.43933	3.513E-01
24	1986	1.000E+00	1.000E+00	0.0	8.470E-01	6.685E-01	0.23669	1.785E-01
25	1987	1.000E+00	1.000E+00	0.0	3.290E-01	6.199E-01	-0.63358	-2.909E-01
26	1988	1.000E+00	1.000E+00	0.0	5.660E-01	5.499E-01	0.02885	1.609E-02
27	1989	1.000E+00	1.000E+00	0.0	7.290E-01	5.921E-01	0.20803	1.369E-01
28	1990	1.000E+00	1.000E+00	0.0	6.990E-01	8.378E-01	-0.18109	-1.388E-01
29	1991	1.000E+00	1.000E+00	0.0	6.310E-01	8.190E-01	-0.26076	-1.880E-01
30	1992	1.000E+00	1.000E+00	0.0	1.566E+00	1.075E+00	0.37582	4.906E-01
31	1993	1.000E+00	1.000E+00	0.0	4.820E-01	1.006E+00	-0.73539	-5.236E-01
32	1994	1.000E+00	1.000E+00	0.0	6.600E-01	1.049E+00	-0.46351	-3.892E-01
33	1995	1.000E+00	1.000E+00	0.0	2.579E+00	1.123E+00	0.83109	1.456E+00
34	1996	1.000E+00	1.000E+00	0.0	2.853E+00	1.796E+00	0.46272	1.057E+00
35	1997	1.000E+00	1.000E+00	0.0	4.359E+00	2.756E+00	0.45852	1.603E+00

* Asterisk indicates missing value(s).

Georges Bank Yellowtail -- ASPIC 3.6x -- Including Discards

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UNWEIGHTED LOG RESIDUAL PLOT FOR DATA SERIES # 2
                   -2       -1.5       -1       -0.5        0        0.5        1        1.5        2
                    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |
Year      Residual  -------------------------------------------------------------------------------------
1963      0.0000                                            |
1964      0.0000                                            |
1965      0.0000                                            |
1966      0.0000                                            |
1967      0.0000                                            |
1968     -1.1541                     =======================|
1969      0.3332                                            |=======
1970     -0.2523                                       =====|
1971     -0.2122                                        ====|
1972      0.1659                                            |===
1973      0.0000                                            |
1974      0.0000                                            |
1975      0.0000                                            |
1976      0.0000                                            |
1977      0.0000                                            |
1978      0.0000                                            |
1979      0.0000                                            |
1980      0.0000                                            |
1981      0.0000                                            |
1982      0.0313                                            |=
1983      0.3668                                            |=======
1984      0.5151                                            |==========
1985      0.4393                                            |=========
1986      0.2367                                            |=====
1987     -0.6336                               =============|
1988      0.0288                                            |=
1989      0.2080                                            |====
1990     -0.1811                                        ====|
1991     -0.2608                                       =====|
1992      0.3758                                            |========
1993     -0.7354                             ===============|
1994     -0.4635                                   =========|
1995      0.8311                                            |=================
1996      0.4627                                            |=========
1997      0.4585                                            |=========
                    -------------------------------------------------------------------------------------
```

RESULTS FOR DATA SERIES # 3 (NON-BOOTSTRAPPED) USA Spring Survey 41

Data type I0: Start-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	*	1.914E+01	0.00000	0.0
2	1964	0.000E+00	0.000E+00	0.0	*	1.126E+01	0.00000	0.0
3	1965	0.000E+00	0.000E+00	0.0	*	8.506E+00	0.00000	0.0
4	1966	0.000E+00	0.000E+00	0.0	*	7.085E+00	0.00000	0.0
5	1967	0.000E+00	0.000E+00	0.0	*	6.566E+00	0.00000	0.0
6	1968	0.000E+00	0.000E+00	0.0	*	6.194E+00	0.00000	0.0
7	1969	0.000E+00	0.000E+00	0.0	*	5.558E+00	0.00000	0.0
8	1970	0.000E+00	0.000E+00	0.0	*	4.747E+00	0.00000	0.0
9	1971	0.000E+00	0.000E+00	0.0	*	3.955E+00	0.00000	0.0
10	1972	0.000E+00	0.000E+00	0.0	*	3.794E+00	0.00000	0.0
11	1973	1.000E+00	1.000E+00	0.0	2.938E+00	3.362E+00	-0.13495	-4.245E-01
12	1974	1.000E+00	1.000E+00	0.0	2.719E+00	2.997E+00	-0.09727	-2.778E-01
13	1975	1.000E+00	1.000E+00	0.0	1.676E+00	2.546E+00	-0.41831	-8.705E-01
14	1976	1.000E+00	1.000E+00	0.0	2.273E+00	2.027E+00	0.11449	2.459E-01
15	1977	1.000E+00	1.000E+00	0.0	9.990E-01	1.494E+00	-0.40254	-4.951E-01
16	1978	1.000E+00	1.000E+00	0.0	7.420E-01	1.232E+00	-0.50664	-4.895E-01
17	1979	1.000E+00	1.000E+00	0.0	1.227E+00	1.301E+00	-0.05869	-7.417E-02
18	1980	1.000E+00	1.000E+00	0.0	4.456E+00	1.408E+00	1.15205	3.048E+00
19	1981	1.000E+00	1.000E+00	0.0	1.960E+00	1.490E+00	0.27447	4.705E-01
20	1982	0.000E+00	0.000E+00	0.0	*	1.682E+00	0.00000	0.0
21	1983	0.000E+00	0.000E+00	0.0	*	1.271E+00	0.00000	0.0
22	1984	0.000E+00	0.000E+00	0.0	*	6.828E-01	0.00000	0.0
23	1985	0.000E+00	0.000E+00	0.0	*	4.421E-01	0.00000	0.0
24	1986	0.000E+00	0.000E+00	0.0	*	4.641E-01	0.00000	0.0
25	1987	0.000E+00	0.000E+00	0.0	*	4.304E-01	0.00000	0.0
26	1988	0.000E+00	0.000E+00	0.0	*	3.818E-01	0.00000	0.0
27	1989	0.000E+00	0.000E+00	0.0	*	4.111E-01	0.00000	0.0
28	1990	0.000E+00	0.000E+00	0.0	*	5.817E-01	0.00000	0.0
29	1991	0.000E+00	0.000E+00	0.0	*	5.686E-01	0.00000	0.0
30	1992	0.000E+00	0.000E+00	0.0	*	7.467E-01	0.00000	0.0
31	1993	0.000E+00	0.000E+00	0.0	*	6.982E-01	0.00000	0.0
32	1994	0.000E+00	0.000E+00	0.0	*	7.285E-01	0.00000	0.0
33	1995	0.000E+00	0.000E+00	0.0	*	7.800E-01	0.00000	0.0
34	1996	0.000E+00	0.000E+00	0.0	*	1.247E+00	0.00000	0.0
35	1997	0.000E+00	0.000E+00	0.0	*	1.913E+00	0.00000	0.0

* Asterisk indicates missing value(s).

Georges Bank Yellowtail -- ASPIC 3.6x -- Including Discards

UNWEIGHTED LOG RESIDUAL PLOT FOR DATA SERIES # 3

```
                    -2      -1.5       -1      -0.5        0       0.5        1       1.5        2
                     |    .    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |
Year   Residual    ---------------------------------------------------------------------------------
1963     0.0000                                             |
1964     0.0000                                             |
1965     0.0000                                             |
1966     0.0000                                             |
1967     0.0000                                             |
1968     0.0000                                             |
1969     0.0000                                             |
1970     0.0000                                             |
1971     0.0000                                             |
1972     0.0000                                             |
1973    -0.1349                                          ===|
1974    -0.0973                                           ==|
1975    -0.4183                                     ========|
1976     0.1145                                             |==
1977    -0.4025                                     ========|
1978    -0.5066                                   ==========|
1979    -0.0587                                            =|
1980     1.1520                                             |=======================
1981     0.2745                                             |=====
1982     0.0000                                             |
1983     0.0000                                             |
1984     0.0000                                             |
1985     0.0000                                             |
1986     0.0000                                             |
1987     0.0000                                             |
1988     0.0000                                             |
1989     0.0000                                             |
1990     0.0000                                             |
1991     0.0000                                             |
1992     0.0000                                             |
1993     0.0000                                             |
1994     0.0000                                             |
1995     0.0000                                             |
1996     0.0000                                             |
1997     0.0000                                             |
                   ---------------------------------------------------------------------------------
```

RESULTS FOR DATA SERIES # 4 (NON-BOOTSTRAPPED) Canadian Survey - lagged

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

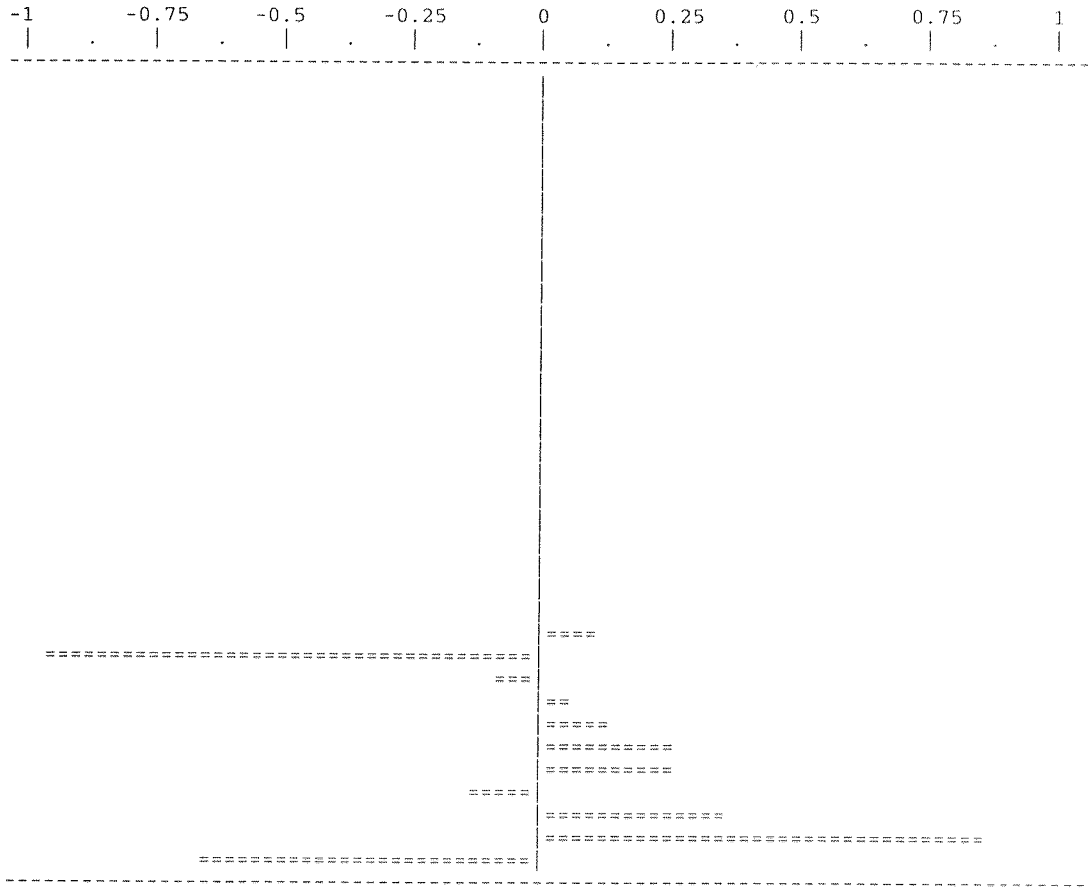
Obs	Year	Observed effort	Estimated effort	Estim F	Observed index	Model index	Resid in log index	Resid in index
1	1963	0.000E+00	0.000E+00	0.0	*	3.333E+01	0.00000	0.0
2	1964	0.000E+00	0.000E+00	0.0	*	2.518E+01	0.00000	0.0
3	1965	0.000E+00	0.000E+00	0.0	*	2.098E+01	0.00000	0.0
4	1966	0.000E+00	0.000E+00	0.0	*	1.944E+01	0.00000	0.0
5	1967	0.000E+00	0.000E+00	0.0	*	1.834E+01	0.00000	0.0
6	1968	0.000E+00	0.000E+00	0.0	*	1.646E+01	0.00000	0.0
7	1969	0.000E+00	0.000E+00	0.0	*	1.405E+01	0.00000	0.0
8	1970	0.000E+00	0.000E+00	0.0	*	1.171E+01	0.00000	0.0
9	1971	0.000E+00	0.000E+00	0.0	*	1.123E+01	0.00000	0.0
10	1972	0.000E+00	0.000E+00	0.0	*	9.956E+00	0.00000	0.0
11	1973	0.000E+00	0.000E+00	0.0	*	8.873E+00	0.00000	0.0
12	1974	0.000E+00	0.000E+00	0.0	*	7.540E+00	0.00000	0.0
13	1975	0.000E+00	0.000E+00	0.0	*	6.002E+00	0.00000	0.0
14	1976	0.000E+00	0.000E+00	0.0	*	4.424E+00	0.00000	0.0
15	1977	0.000E+00	0.000E+00	0.0	*	3.646E+00	0.00000	0.0
16	1978	0.000E+00	0.000E+00	0.0	*	3.852E+00	0.00000	0.0
17	1979	0.000E+00	0.000E+00	0.0	*	4.169E+00	0.00000	0.0
18	1980	0.000E+00	0.000E+00	0.0	*	4.410E+00	0.00000	0.0
19	1981	0.000E+00	0.000E+00	0.0	*	4.981E+00	0.00000	0.0
20	1982	0.000E+00	0.000E+00	0.0	*	3.763E+00	0.00000	0.0
21	1983	0.000E+00	0.000E+00	0.0	*	2.022E+00	0.00000	0.0
22	1984	0.000E+00	0.000E+00	0.0	*	1.309E+00	0.00000	0.0
23	1985	0.000E+00	0.000E+00	0.0	*	1.374E+00	0.00000	0.0
24	1986	1.000E+00	1.000E+00	0.0	1.264E+00	1.274E+00	-0.00823	-1.044E-02
25	1987	1.000E+00	1.000E+00	0.0	1.235E+00	1.130E+00	0.08845	1.045E-01
26	1988	1.000E+00	1.000E+00	0.0	4.710E-01	1.217E+00	-0.94941	-7.462E-01
27	1989	1.000E+00	1.000E+00	0.0	1.578E+00	1.722E+00	-0.08746	-1.442E-01
28	1990	1.000E+00	1.000E+00	0.0	1.759E+00	1.684E+00	0.04380	7.539E-02
29	1991	1.000E+00	1.000E+00	0.0	2.475E+00	2.211E+00	0.11291	2.643E-01
30	1992	1.000E+00	1.000E+00	0.0	2.642E+00	2.067E+00	0.24533	5.748E-01
31	1993	1.000E+00	1.000E+00	0.0	2.753E+00	2.157E+00	0.24407	5.962E-01
32	1994	1.000E+00	1.000E+00	0.0	2.027E+00	2.309E+00	-0.13038	-2.823E-01
33	1995	1.000E+00	1.000E+00	0.0	5.304E+00	3.692E+00	0.36218	1.612E+00
34	1996	1.000E+00	1.000E+00	0.0	1.329E+01	5.665E+00	0.85282	7.627E+00
35	1997	1.000E+00	1.000E+00	0.0	4.292E+00	8.241E+00	-0.65238	-3.949E+00

* Asterisk indicates missing value(s).

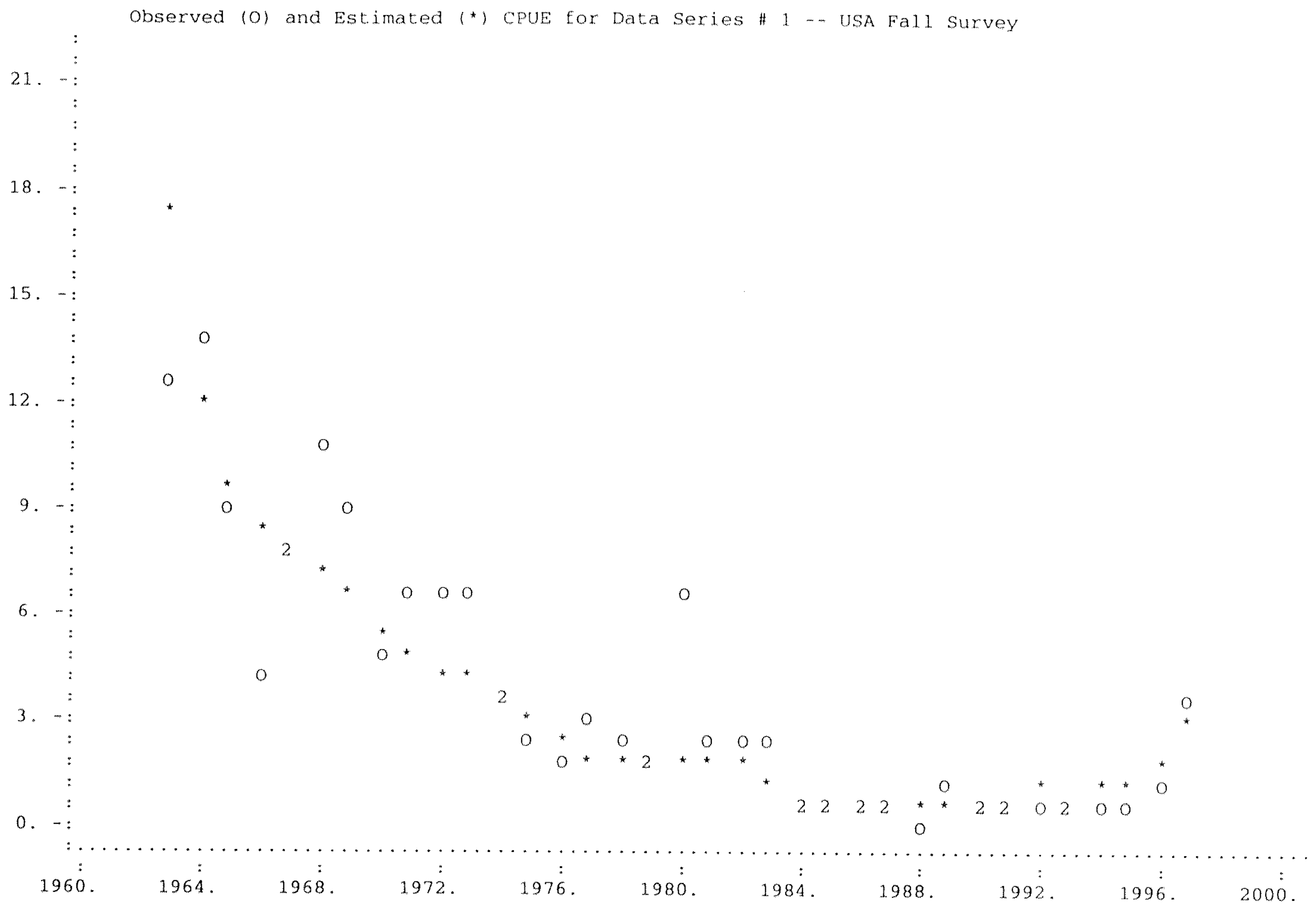
Georges Bank Yellowtail -- ASPIC 3.6x -- Including Discards

UNWEIGHTED LOG RESIDUAL PLOT FOR DATA SERIES # 4

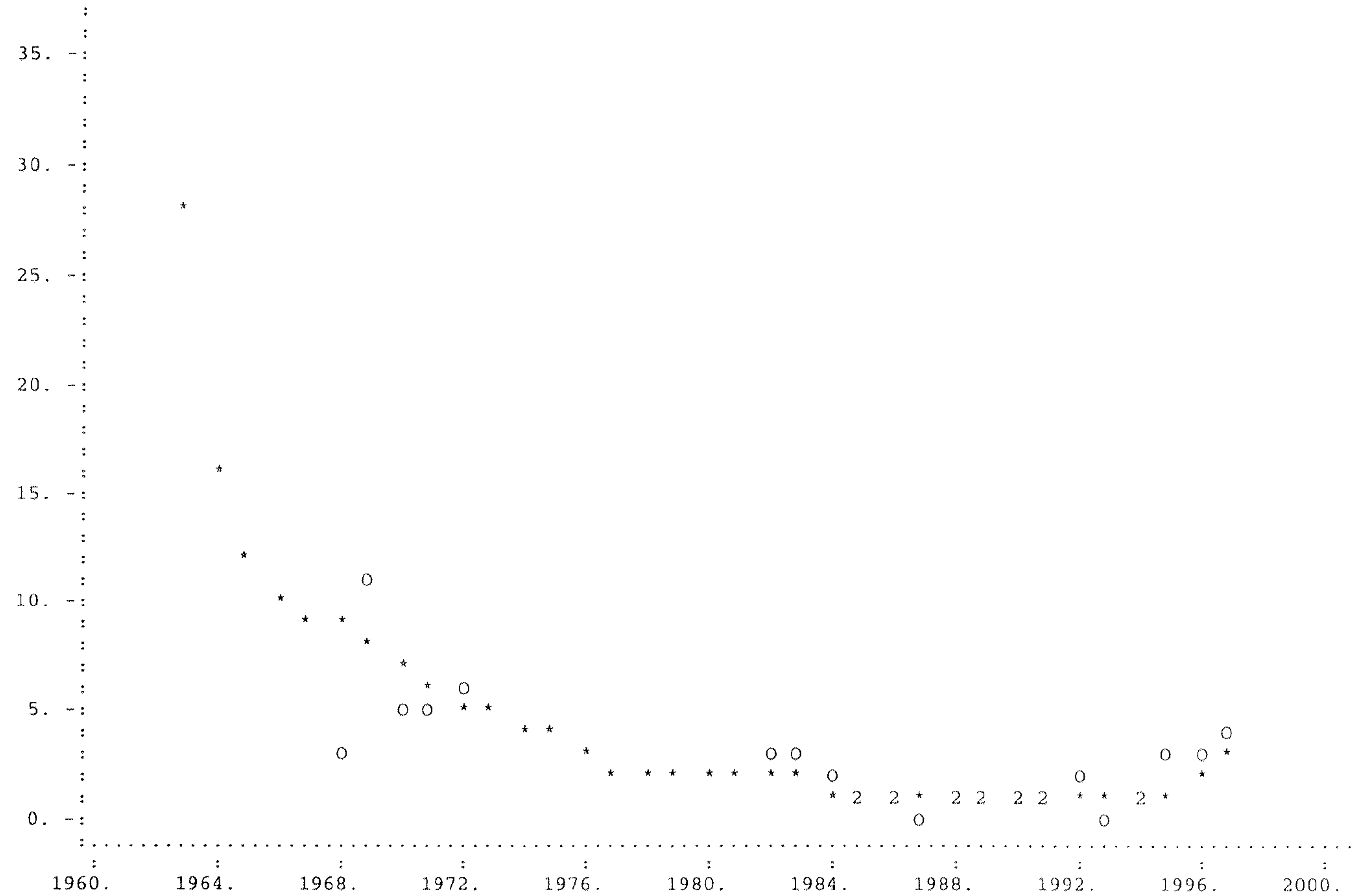
Year	Residual
1963	0.0000
1964	0.0000
1965	0.0000
1966	0.0000
1967	0.0000
1968	0.0000
1969	0.0000
1970	0.0000
1971	0.0000
1972	0.0000
1973	0.0000
1974	0.0000
1975	0.0000
1976	0.0000
1977	0.0000
1978	0.0000
1979	0.0000
1980	0.0000
1981	0.0000
1982	0.0000
1983	0.0000
1984	0.0000
1985	0.0000
1986	-0.0082
1987	0.0885
1988	-0.9494
1989	-0.0875
1990	0.0438
1991	0.1129
1992	0.2453
1993	0.2441
1994	-0.1304
1995	0.3622
1996	0.8528
1997	-0.6524



Georges Bank Yellowtail -- ASPIC 3.6x -- Including Discards

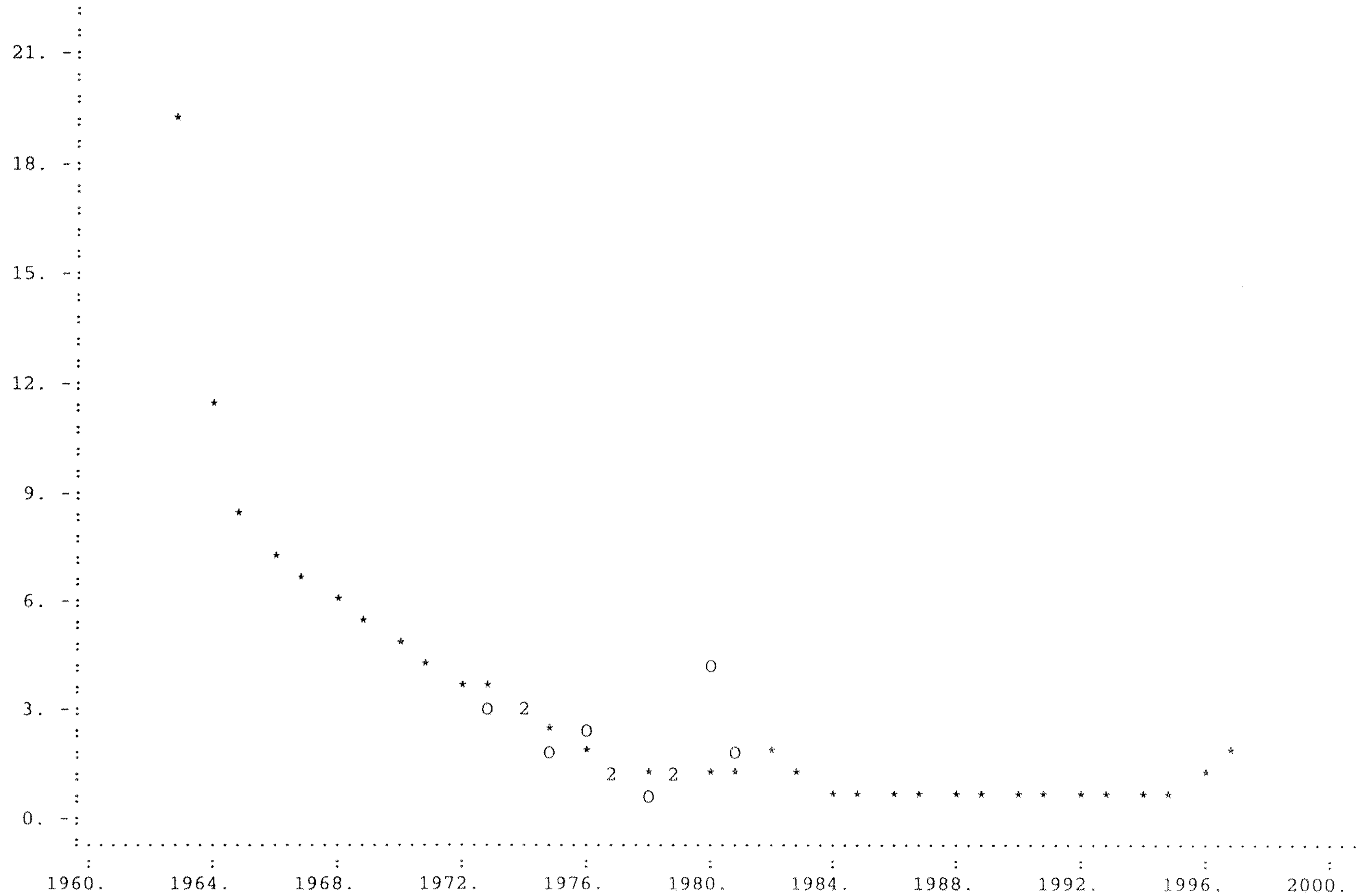


Observed (O) and Estimated (*) CPUE for Data Series # 2 -- USA Spring Survey 36

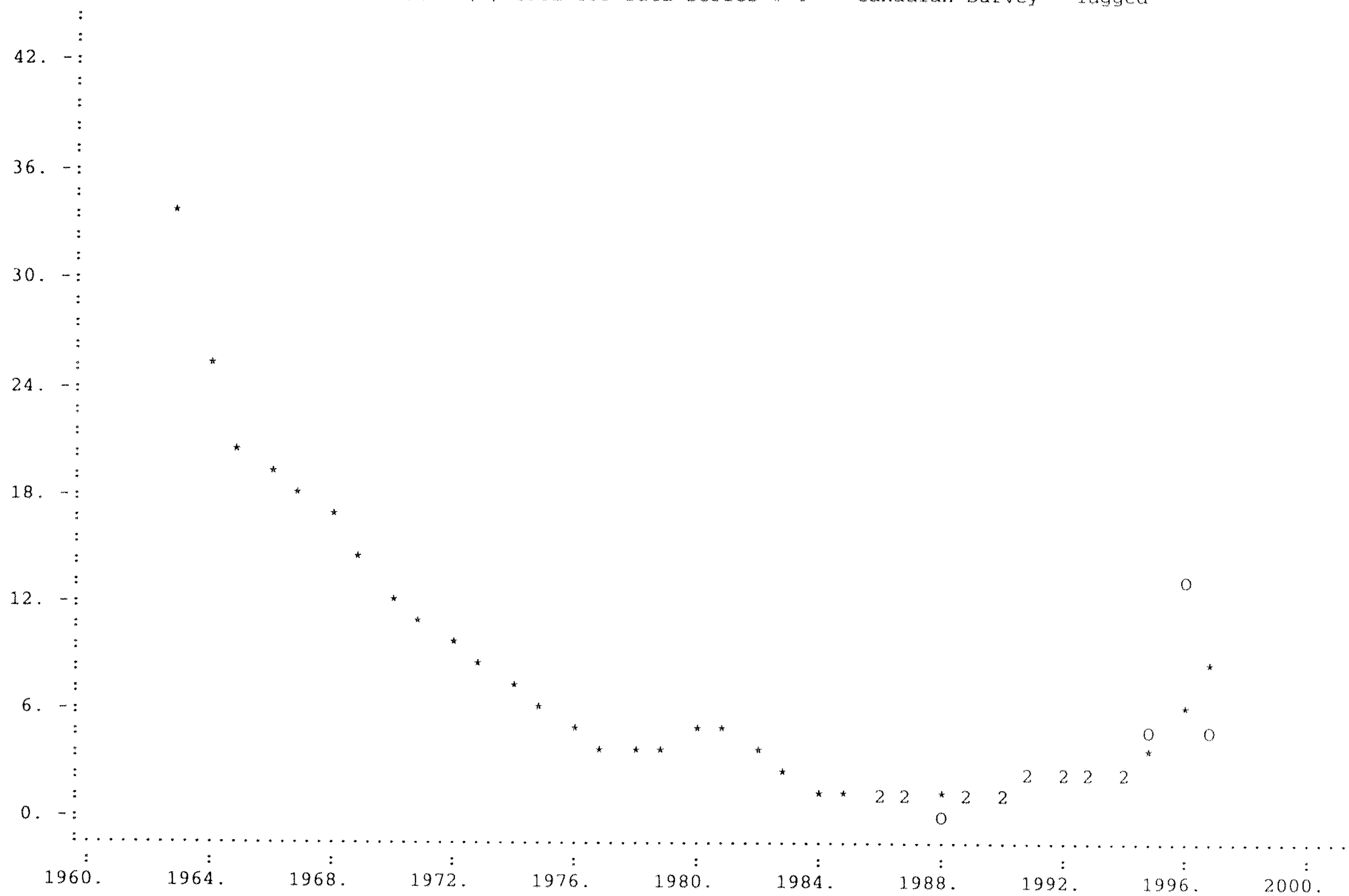


Georges Bank Yellowtail -- ASPIC 3.6x -- Including Discards

Observed (O) and Estimated (*) CPUE for Data Series # 3 -- USA Spring Survey 41

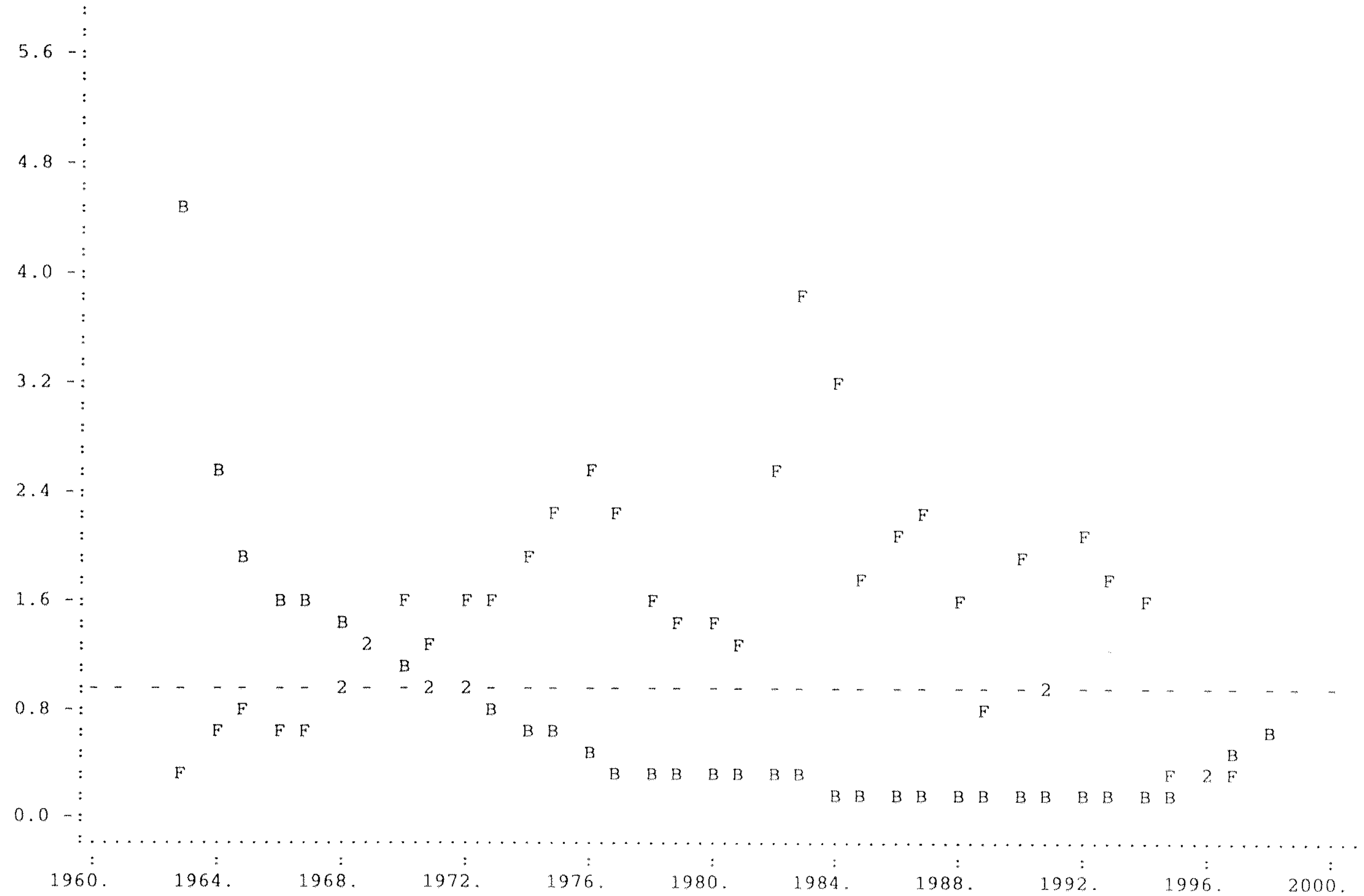


Observed (O) and Estimated (*) CPUE for Data Series # 4 -- Canadian Survey - lagged



Georges Bank Yellowtail -- ASPIC 3.6x -- Including Discards

Time Plot of Estimated F-Ratio and B-Ratio



Bootstrapped Estimates of ASPIC Model Parameters.

```
Georges Bank Yellowtail -- ASPIC 3.6x -- Including Discards
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
B1ratio	5.323E+00	4.485E+00	-15.75%	4.236E+00	3.201E+01	4.669E+00	1.391E+01	9.237E+00	1.735
K	8.192E+01	8.805E+01	7.49%	3.223E+01	9.038E+01	7.033E+01	8.729E+01	1.696E+01	0.207
r	6.726E-01	6.207E-01	-7.72%	5.939E-01	4.739E+00	6.271E-01	7.533E-01	1.262E-01	0.188
q(1)	1.317E-01	1.209E-01	-8.23%	1.130E-01	1.580E-01	1.215E-01	1.394E-01	1.792E-02	0.136
q(2)	1.544E-01	1.396E-01	-9.58%	1.309E-01	2.146E-01	1.419E-01	1.708E-01	2.892E-02	0.187
q(3)	1.051E-01	9.693E-02	-7.77%	8.451E-02	1.568E-01	9.445E-02	1.237E-01	2.921E-02	0.278
q(4)	3.197E-01	2.870E-01	-10.22%	2.498E-01	4.202E-01	2.812E-01	3.652E-01	8.396E-02	0.263
MSY	1.388E+01	1.366E+01	-1.59%	1.321E+01	1.526E+01	1.358E+01	1.426E+01	6.807E-01	0.049
Ye(1998)	1.251E+01	1.201E+01	-4.01%	1.092E+01	1.367E+01	1.165E+01	1.324E+01	1.595E+00	0.127
Bmsy	4.096E+01	4.402E+01	7.49%	1.611E+01	4.519E+01	3.516E+01	4.364E+01	8.481E+00	0.207
Fmsy	3.363E-01	3.103E-01	-7.72%	2.970E-01	2.370E+00	3.136E-01	3.767E-01	6.310E-02	0.188
fmsy(1)	2.565E+00	2.568E+00	0.13%	2.296E+00	2.925E+00	2.423E+00	2.731E+00	3.079E-01	0.120
fmsy(2)	2.169E+00	2.223E+00	2.49%	1.861E+00	2.553E+00	2.015E+00	2.348E+00	3.330E-01	0.154
fmsy(3)	3.217E+00	3.202E+00	-0.46%	2.605E+00	3.975E+00	2.875E+00	3.583E+00	7.078E-01	0.220
fmsy(4)	1.059E+00	1.081E+00	2.14%	8.441E-01	1.331E+00	9.491E-01	1.190E+00	2.405E-01	0.227
F(0.1)	3.027E-01	2.793E-01	-6.95%	2.673E-01	2.133E+00	2.822E-01	3.390E-01	5.679E-02	0.188
Y(0.1)	1.375E+01	1.353E+01	-1.58%	1.308E+01	1.511E+01	1.344E+01	1.412E+01	6.739E-01	0.049
B-ratio	6.770E-01	6.523E-01	-3.64%	5.418E-01	8.856E-01	6.058E-01	7.864E-01	1.806E-01	0.267
F-ratio	2.338E-01	2.455E-01	5.00%	1.734E-01	2.976E-01	2.018E-01	2.649E-01	6.315E-02	0.270
Y-ratio	8.981E-01	8.791E-01	-2.12%	7.932E-01	9.787E-01	8.468E-01	9.541E-01	1.073E-01	0.119
f0.1(1)	2.308E+00	2.311E+00	0.11%	2.066E+00	2.632E+00	2.180E+00	2.458E+00	2.771E-01	0.120
f0.1(2)	1.952E+00	2.001E+00	2.24%	1.675E+00	2.298E+00	1.814E+00	2.113E+00	2.997E-01	0.154
f0.1(3)	2.895E+00	2.882E+00	-0.42%	2.344E+00	3.577E+00	2.588E+00	3.225E+00	6.370E-01	0.220
f0.1(4)	9.529E-01	9.733E-01	1.93%	7.597E-01	1.198E+00	8.541E-01	1.071E+00	2.165E-01	0.227
q2/q1	1.176E+00	1.155E+00	-1.78%	9.879E-01	1.428E+00	1.073E+00	1.280E+00	2.073E-01	0.176
q3/q1	7.975E-01	8.020E-01	0.57%	6.328E-01	1.039E+00	7.092E-01	9.025E-01	1.932E-01	0.242
q4/q1	2.415E+00	2.375E+00	-1.68%	1.931E+00	3.081E+00	2.146E+00	2.740E+00	5.932E-01	0.246

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:        105
Trials replaced for MSY out-of-bounds:            1
Trials replaced for r out-of-bounds:             46
Residual-adjustment factor:                  1.0488
```

USER CONTROL INFORMATION (FROM INPUT FILE)

Name of biomass (BIO) file	GBYTnet.bio
Name of output file (this file)	GBYTnet.prj
Number of years of projections	3

Year	Input data	User data type
1998	1.000E+00	F:F(1997)
1999	1.000E+00	F:F(1997)
2000	1.000E+00	F:F(1997)

TABLE OF PROJECTED YIELDS

1998	2.592E+00	2.546E+00	-1.76%	2.506E+00	2.679E+00	2.547E+00	2.608E+00	6.039E-02	0.023
1999	3.435E+00	3.321E+00	-3.32%	3.218E+00	3.616E+00	3.324E+00	3.502E+00	1.775E-01	0.052
2000	4.256E+00	4.065E+00	-4.50%	3.873E+00	4.526E+00	4.056E+00	4.434E+00	3.779E-01	0.089

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	2.022E+02	1.876E+02	-7.20%	1.739E+02	5.738E+02	1.874E+02	4.136E+02	2.262E+02	1.119
1964	1.204E+02	1.178E+02	-2.19%	1.093E+02	2.425E+02	1.136E+02	1.879E+02	2.352E+01	0.195
1965	9.082E+01	9.053E+01	-0.32%	8.108E+01	1.134E+02	8.716E+01	1.001E+02	1.040E+01	0.115
1966	7.576E+01	7.586E+01	0.14%	6.751E+01	8.700E+01	7.219E+01	7.946E+01	7.270E+00	0.096
1967	6.984E+01	7.033E+01	0.70%	6.342E+01	7.731E+01	6.692E+01	7.262E+01	5.697E+00	0.082
1968	6.565E+01	6.631E+01	1.01%	6.057E+01	7.243E+01	6.357E+01	6.793E+01	4.365E+00	0.067
1969	5.884E+01	5.955E+01	1.20%	5.452E+01	6.454E+01	5.721E+01	6.079E+01	3.578E+00	0.061
1970	5.026E+01	5.096E+01	1.38%	4.646E+01	5.479E+01	4.884E+01	5.184E+01	2.999E+00	0.060
1971	4.188E+01	4.257E+01	1.66%	3.776E+01	4.546E+01	4.055E+01	4.326E+01	2.712E+00	0.065
1972	4.006E+01	4.071E+01	1.61%	3.629E+01	4.315E+01	3.888E+01	4.132E+01	2.441E+00	0.061
1973	3.545E+01	3.606E+01	1.72%	3.239E+01	3.830E+01	3.449E+01	3.660E+01	2.113E+00	0.060
1974	3.153E+01	3.210E+01	1.78%	2.945E+01	3.402E+01	3.075E+01	3.257E+01	1.811E+00	0.057
1975	2.675E+01	2.727E+01	1.94%	2.465E+01	2.891E+01	2.612E+01	2.765E+01	1.528E+00	0.057
1976	2.131E+01	2.176E+01	2.15%	1.956E+01	2.315E+01	2.079E+01	2.207E+01	1.278E+00	0.060
1977	1.577E+01	1.618E+01	2.62%	1.422E+01	1.744E+01	1.531E+01	1.645E+01	1.145E+00	0.073
1978	1.305E+01	1.345E+01	3.09%	1.153E+01	1.468E+01	1.260E+01	1.372E+01	1.120E+00	0.086
1979	1.377E+01	1.418E+01	2.93%	1.222E+01	1.540E+01	1.332E+01	1.444E+01	1.126E+00	0.082
1980	1.487E+01	1.526E+01	2.62%	1.335E+01	1.643E+01	1.442E+01	1.551E+01	1.090E+00	0.073
1981	1.568E+01	1.603E+01	2.26%	1.428E+01	1.709E+01	1.527E+01	1.627E+01	9.934E-01	0.063
1982	1.761E+01	1.789E+01	1.63%	1.645E+01	1.873E+01	1.728E+01	1.807E+01	7.867E-01	0.045
1983	1.329E+01	1.349E+01	1.50%	1.250E+01	1.408E+01	1.306E+01	1.361E+01	5.453E-01	0.041
1984	7.171E+00	7.321E+00	2.09%	6.608E+00	7.764E+00	7.008E+00	7.408E+00	3.999E-01	0.056
1985	4.671E+00	4.816E+00	3.09%	4.171E+00	5.234E+00	4.528E+00	4.899E+00	3.705E-01	0.079
1986	4.894E+00	5.043E+00	3.05%	4.360E+00	5.451E+00	4.747E+00	5.124E+00	3.771E-01	0.077
1987	4.545E+00	4.699E+00	3.39%	4.013E+00	5.112E+00	4.384E+00	4.777E+00	3.927E-01	0.086
1988	4.049E+00	4.221E+00	4.23%	3.481E+00	4.672E+00	3.880E+00	4.311E+00	4.310E-01	0.106
1989	4.343E+00	4.566E+00	5.14%	3.665E+00	4.978E+00	4.113E+00	4.619E+00	5.057E-01	0.116
1990	6.074E+00	6.361E+00	4.73%	5.265E+00	6.734E+00	5.777E+00	6.389E+00	6.115E-01	0.101
1991	5.888E+00	6.251E+00	6.17%	5.139E+00	6.724E+00	5.681E+00	6.306E+00	6.256E-01	0.106
1992	7.638E+00	8.099E+00	6.03%	6.753E+00	8.637E+00	7.405E+00	8.152E+00	7.466E-01	0.098

1993	6.997E+00	7.590E+00	8.48%	6.212E+00	8.234E+00	6.624E+00	7.653E+00	9.055E-01	0.129
1994	7.059E+00	7.891E+00	11.79%	6.146E+00	8.678E+00	6.523E+00	7.906E+00	1.383E+00	0.196
1995	7.119E+00	8.388E+00	17.83%	5.776E+00	9.808E+00	6.302E+00	8.507E+00	2.205E+00	0.310
1996	1.142E+01	1.308E+01	14.57%	9.174E+00	1.518E+01	9.851E+00	1.341E+01	3.562E+00	0.312
1997	1.787E+01	1.963E+01	9.88%	1.356E+01	2.246E+01	1.522E+01	2.034E+01	5.115E+00	0.286
1998	2.622E+01	2.811E+01	7.19%	2.011E+01	3.220E+01	2.306E+01	2.933E+01	6.267E+00	0.239
1999	3.627E+01	3.792E+01	4.55%	2.908E+01	4.345E+01	3.240E+01	3.990E+01	7.497E+00	0.207
2000	4.637E+01	4.795E+01	3.40%	3.795E+01	5.422E+01	4.215E+01	5.065E+01	8.501E+00	0.183
2001	5.546E+01	5.697E+01	2.73%	4.597E+01	6.280E+01	5.100E+01	5.958E+01	8.575E+00	0.155

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

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	1.156E-01	1.206E-01	4.34%	6.362E-02	1.301E-01	8.320E-02	1.219E-01	3.871E-02	0.335
1964	1.918E-01	1.937E-01	0.98%	1.352E-01	2.137E-01	1.601E-01	2.000E-01	2.605E-02	0.136
1965	2.346E-01	2.346E-01	0.00%	2.016E-01	2.631E-01	2.184E-01	2.452E-01	2.242E-02	0.096
1966	1.957E-01	1.947E-01	-0.48%	1.743E-01	2.167E-01	1.869E-01	2.046E-01	1.773E-02	0.091
1967	2.101E-01	2.083E-01	-0.85%	1.900E-01	2.286E-01	2.027E-01	2.183E-01	1.565E-02	0.074
1968	2.955E-01	2.925E-01	-1.02%	2.692E-01	3.199E-01	2.857E-01	3.039E-01	1.821E-02	0.062
1969	3.957E-01	3.908E-01	-1.24%	3.637E-01	4.274E-01	3.842E-01	4.083E-01	2.412E-02	0.061
1970	4.766E-01	4.694E-01	-1.52%	4.386E-01	5.173E-01	4.619E-01	4.919E-01	2.992E-02	0.063
1971	3.713E-01	3.656E-01	-1.54%	3.439E-01	4.105E-01	3.601E-01	3.833E-01	2.318E-02	0.062
1972	4.713E-01	4.636E-01	-1.62%	4.367E-01	5.116E-01	4.567E-01	4.851E-01	2.843E-02	0.060
1973	4.947E-01	4.864E-01	-1.68%	4.584E-01	5.311E-01	4.793E-01	5.081E-01	2.882E-02	0.058
1974	5.718E-01	5.615E-01	-1.80%	5.301E-01	6.118E-01	5.538E-01	5.865E-01	3.264E-02	0.057
1975	6.708E-01	6.577E-01	-1.95%	6.197E-01	7.183E-01	6.486E-01	6.877E-01	3.915E-02	0.058
1976	7.820E-01	7.646E-01	-2.23%	7.143E-01	8.603E-01	7.535E-01	8.042E-01	5.072E-02	0.065
1977	6.968E-01	6.785E-01	-2.63%	6.262E-01	7.820E-01	6.669E-01	7.208E-01	5.387E-02	0.077
1978	4.605E-01	4.478E-01	-2.76%	4.118E-01	5.210E-01	4.398E-01	4.774E-01	3.763E-02	0.082
1979	4.320E-01	4.209E-01	-2.56%	3.896E-01	4.844E-01	4.139E-01	4.466E-01	3.265E-02	0.076
1980	4.488E-01	4.386E-01	-2.27%	4.097E-01	4.966E-01	4.322E-01	4.621E-01	2.995E-02	0.067
1981	3.769E-01	3.700E-01	-1.82%	3.506E-01	4.082E-01	3.658E-01	3.857E-01	1.983E-02	0.053
1982	7.833E-01	7.715E-01	-1.50%	7.377E-01	8.347E-01	7.643E-01	7.977E-01	3.341E-02	0.043
1983	1.155E+00	1.135E+00	-1.68%	1.079E+00	1.239E+00	1.123E+00	1.178E+00	5.497E-02	0.048
1984	9.929E-01	9.696E-01	-2.35%	9.040E-01	1.095E+00	9.558E-01	1.021E+00	6.545E-02	0.066
1985	5.261E-01	5.112E-01	-2.82%	4.714E-01	5.874E-01	5.028E-01	5.435E-01	4.077E-02	0.078
1986	6.476E-01	6.286E-01	-2.93%	5.812E-01	7.316E-01	6.190E-01	6.708E-01	5.175E-02	0.080
1987	6.918E-01	6.679E-01	-3.45%	6.085E-01	7.853E-01	6.555E-01	7.188E-01	6.332E-02	0.092
1988	5.021E-01	4.823E-01	-3.94%	4.416E-01	5.909E-01	4.769E-01	5.338E-01	5.692E-02	0.113
1989	2.325E-01	2.227E-01	-4.20%	2.062E-01	2.684E-01	2.204E-01	2.430E-01	2.256E-02	0.097
1990	5.930E-01	5.660E-01	-4.56%	5.319E-01	6.756E-01	5.621E-01	6.219E-01	5.975E-02	0.101
1991	2.997E-01	2.842E-01	-5.16%	2.666E-01	3.334E-01	2.831E-01	3.143E-01	3.113E-02	0.104
1992	6.421E-01	6.036E-01	-6.00%	5.575E-01	7.135E-01	5.972E-01	6.795E-01	7.062E-02	0.110
1993	5.420E-01	5.005E-01	-7.65%	4.596E-01	6.309E-01	4.997E-01	5.927E-01	7.907E-02	0.146
1994	5.294E-01	4.756E-01	-10.16%	4.220E-01	6.340E-01	4.746E-01	6.074E-01	1.328E-01	0.251
1995	8.610E-02	7.660E-02	-11.04%	6.607E-02	1.105E-01	7.574E-02	1.018E-01	2.609E-02	0.303
1996	8.637E-02	7.861E-02	-8.98%	6.850E-02	1.128E-01	7.636E-02	1.032E-01	2.681E-02	0.310
1997	8.314E-02	7.730E-02	-7.02%	6.766E-02	1.090E-01	7.427E-02	9.545E-02	2.118E-02	0.255
1998	8.314E-02	7.730E-02	-7.02%	6.766E-02	1.090E-01	7.427E-02	9.545E-02	2.118E-02	0.255
1999	8.314E-02	7.730E-02	-7.02%	6.766E-02	1.090E-01	7.427E-02	9.545E-02	2.118E-02	0.255
2000	8.314E-02	7.730E-02	-7.02%	6.766E-02	1.090E-01	7.427E-02	9.545E-02	2.118E-02	0.255

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

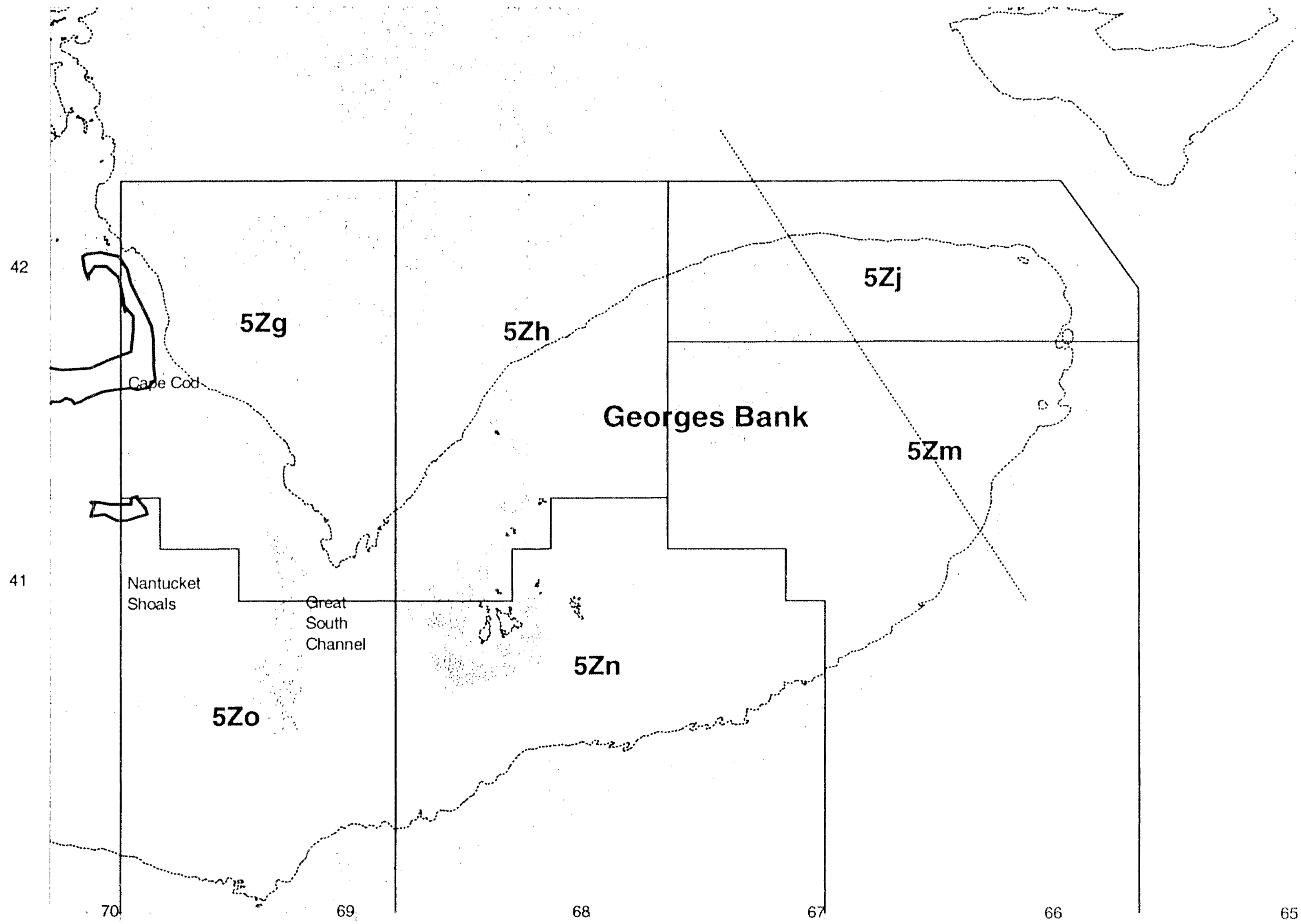


Fig. 1. Canadian fisheries statistical unit areas in NAFO Subdivision 5Ze.

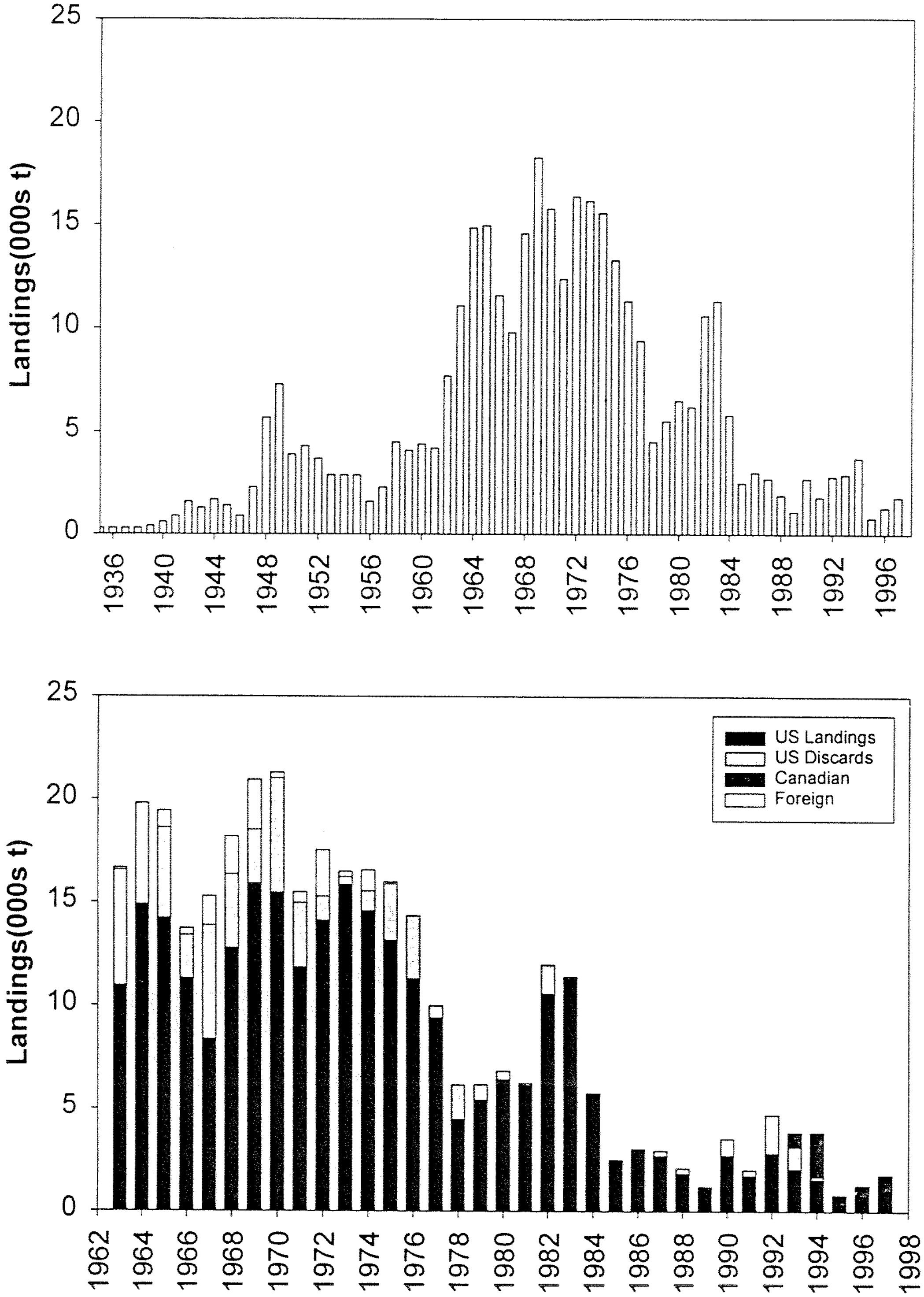


Fig. 2 . Landings of Georges Bank yellowtail flounder by Canada and the United States. The top panel shows landings from 1935 – 1997, and the bottom panel shows the national composition of landings from 1963 – 1997.

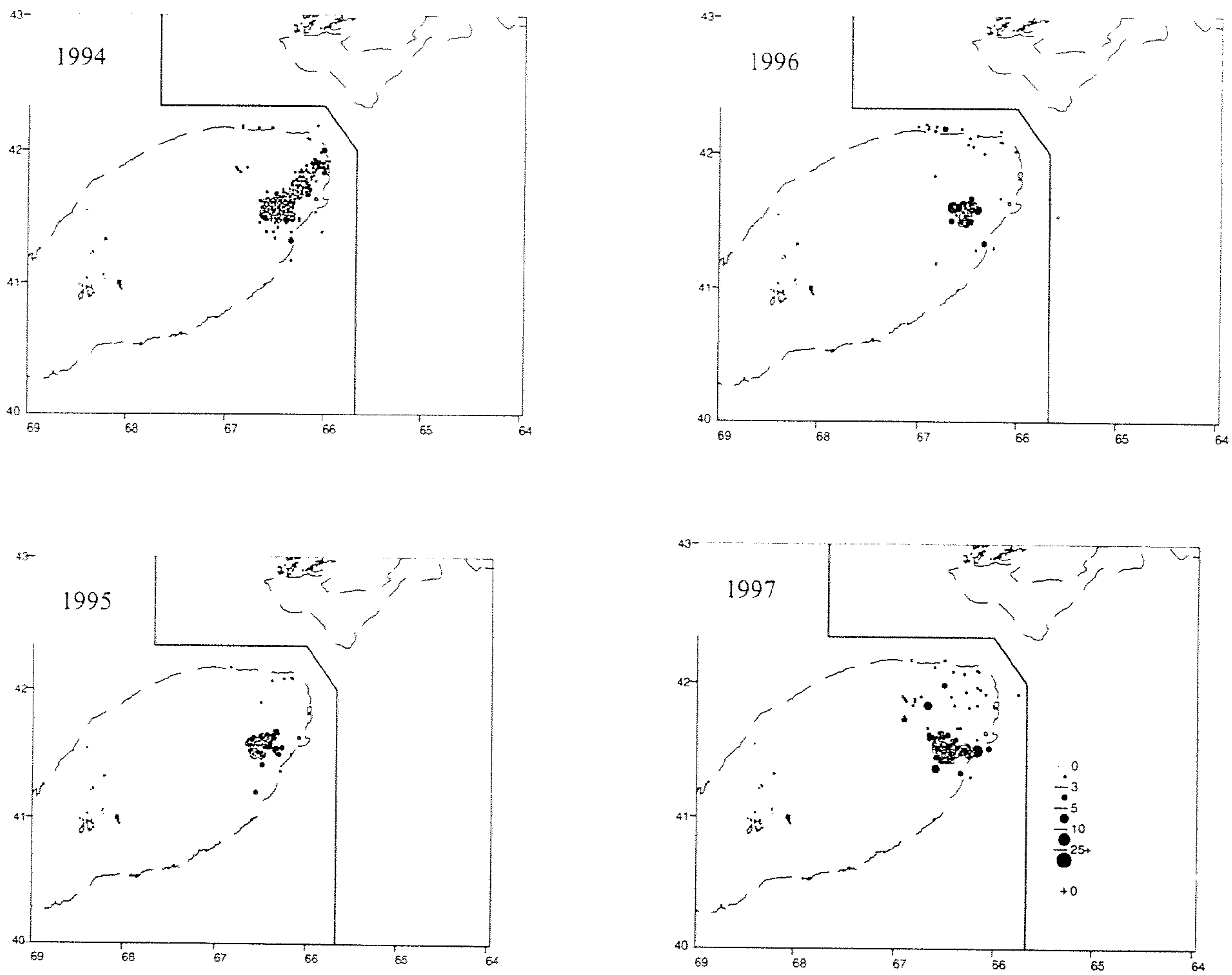


Fig 3. Distribution of Canadian mobile gear (TC 2 & 3) effort for 1994-97 where trip landings of yellowtail were > 0.5t, expanding symbols represent metric tonnes.

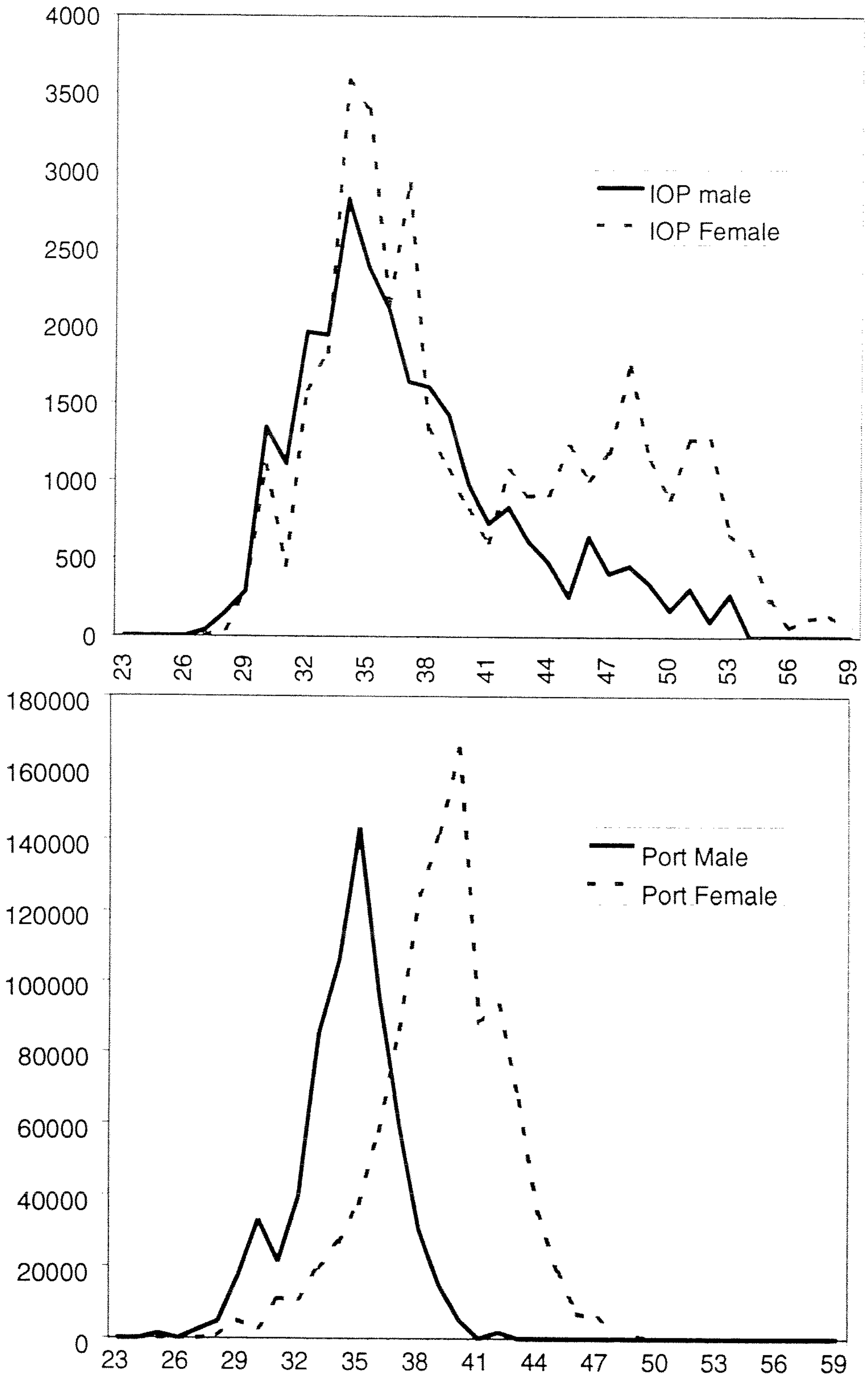


Fig. 4. Comparison of length frequency distributions of samples observed in 1997 by port technicians with those at sea sample collected with the Observer Program, 1997, Georges Bank

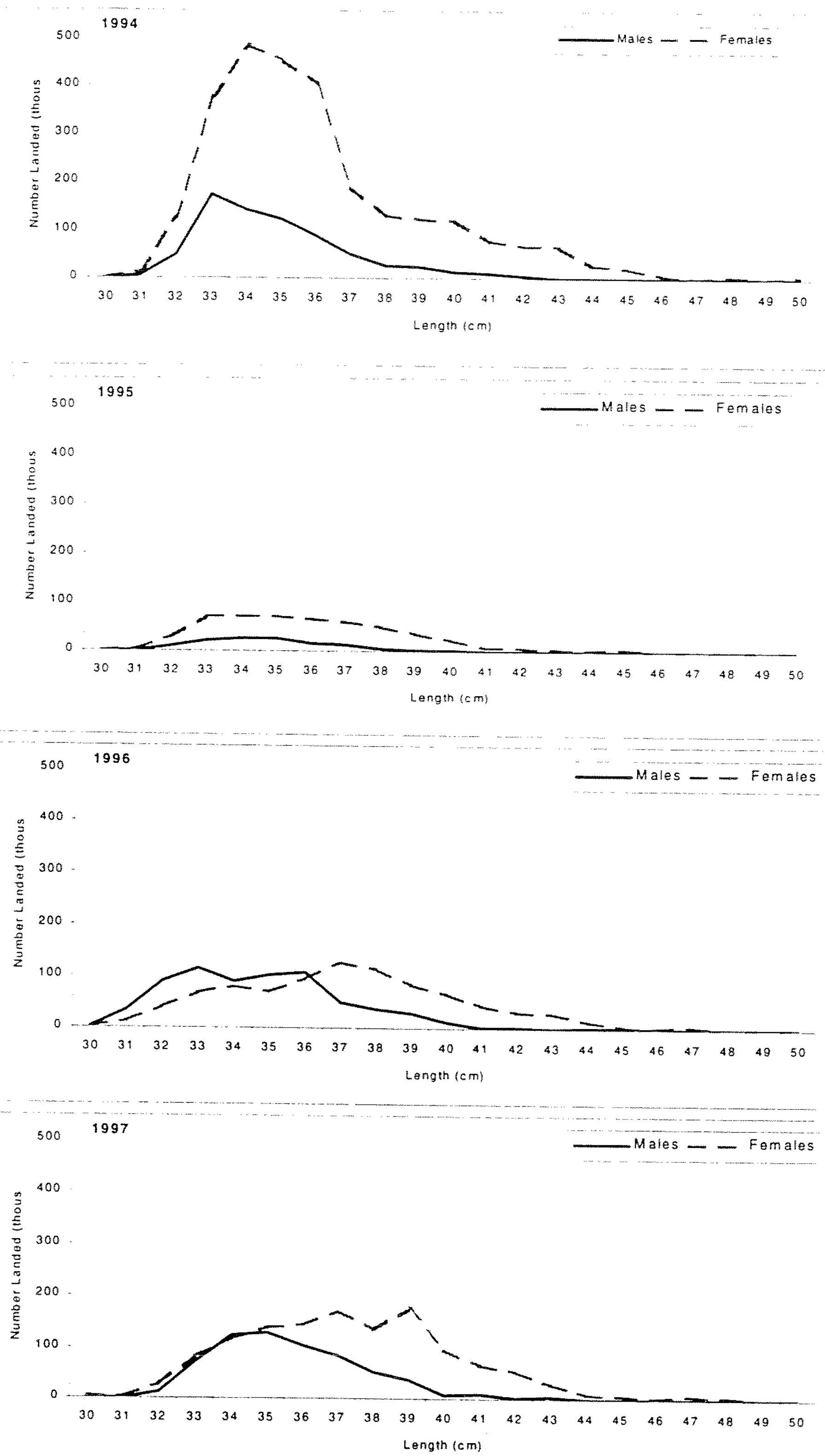


Fig. 5. Comparison of USA yellowtail flounder fishery length compositions , 1994-1997.

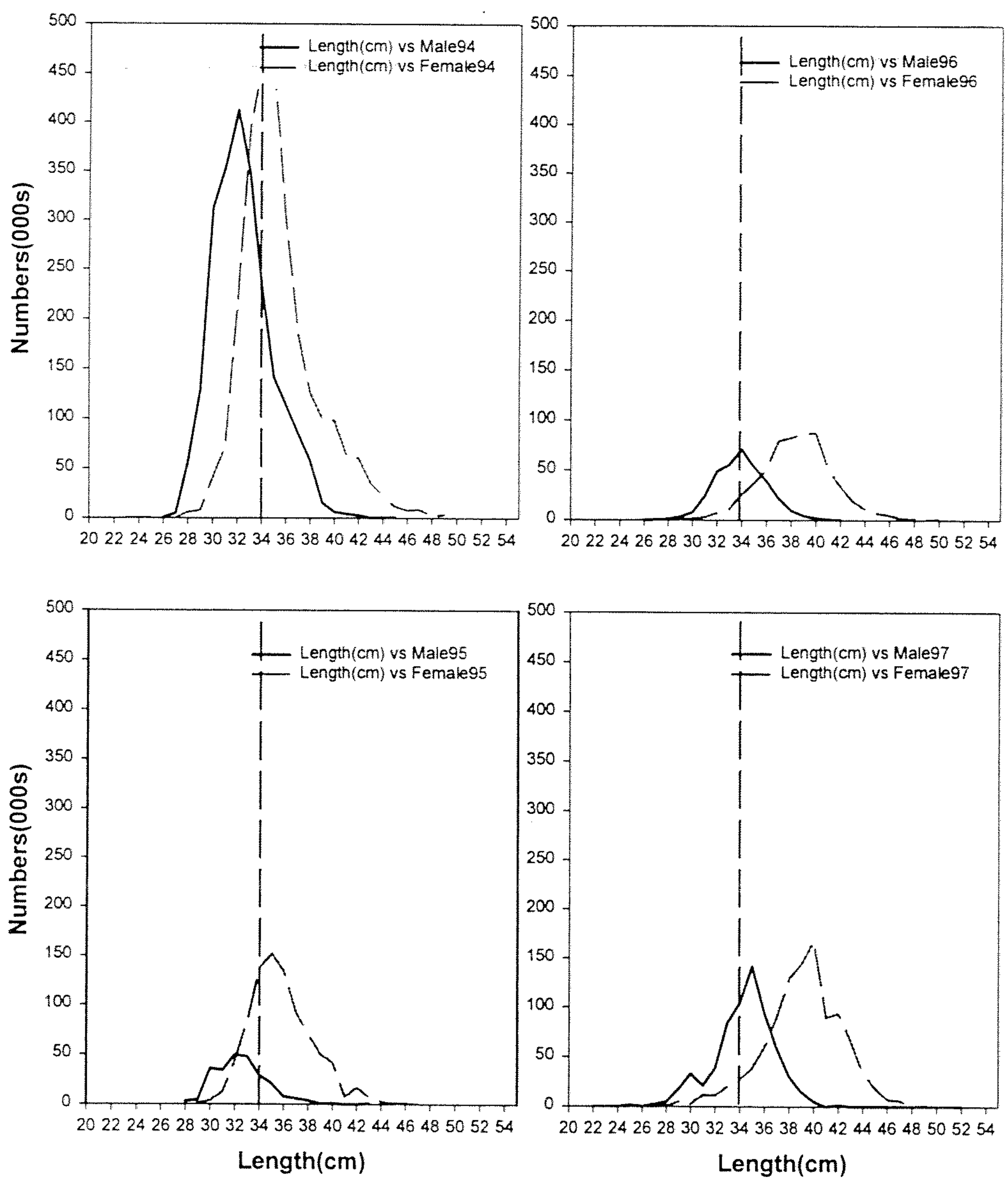


Fig. 6. Comparison of the yellowtail flounder length frequency composition taken in the Canadian Georges Bank fishery from 1994 to 1997. The dashed vertical line represents the modal length of females in 1994.

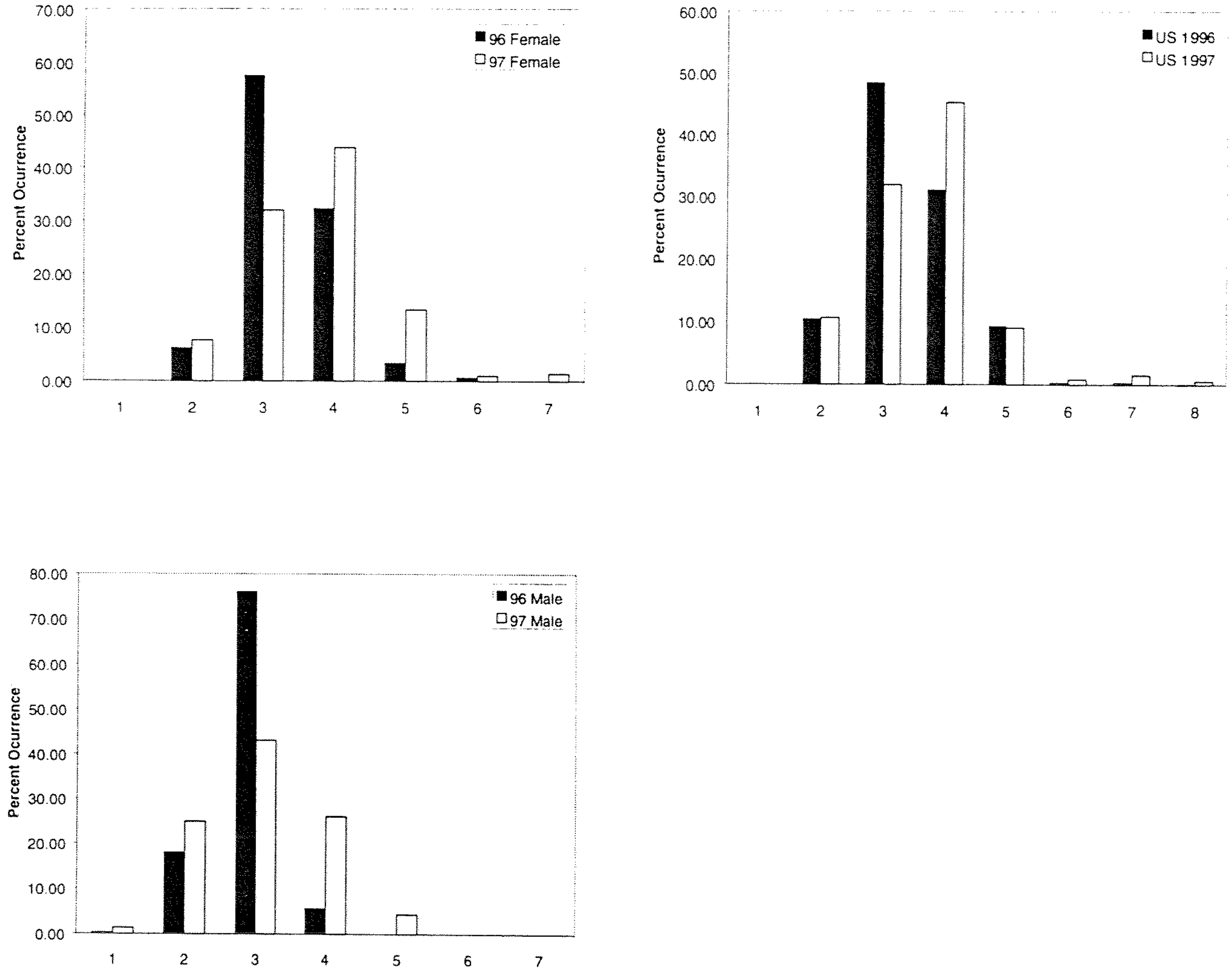


Fig. 7. Comparison of yellowtail flounder fishery age composition, 1996 and 1997, for Canadian (left panels, males and females) and USA(right panel, sexes aggregated) catches on Georges Bank.

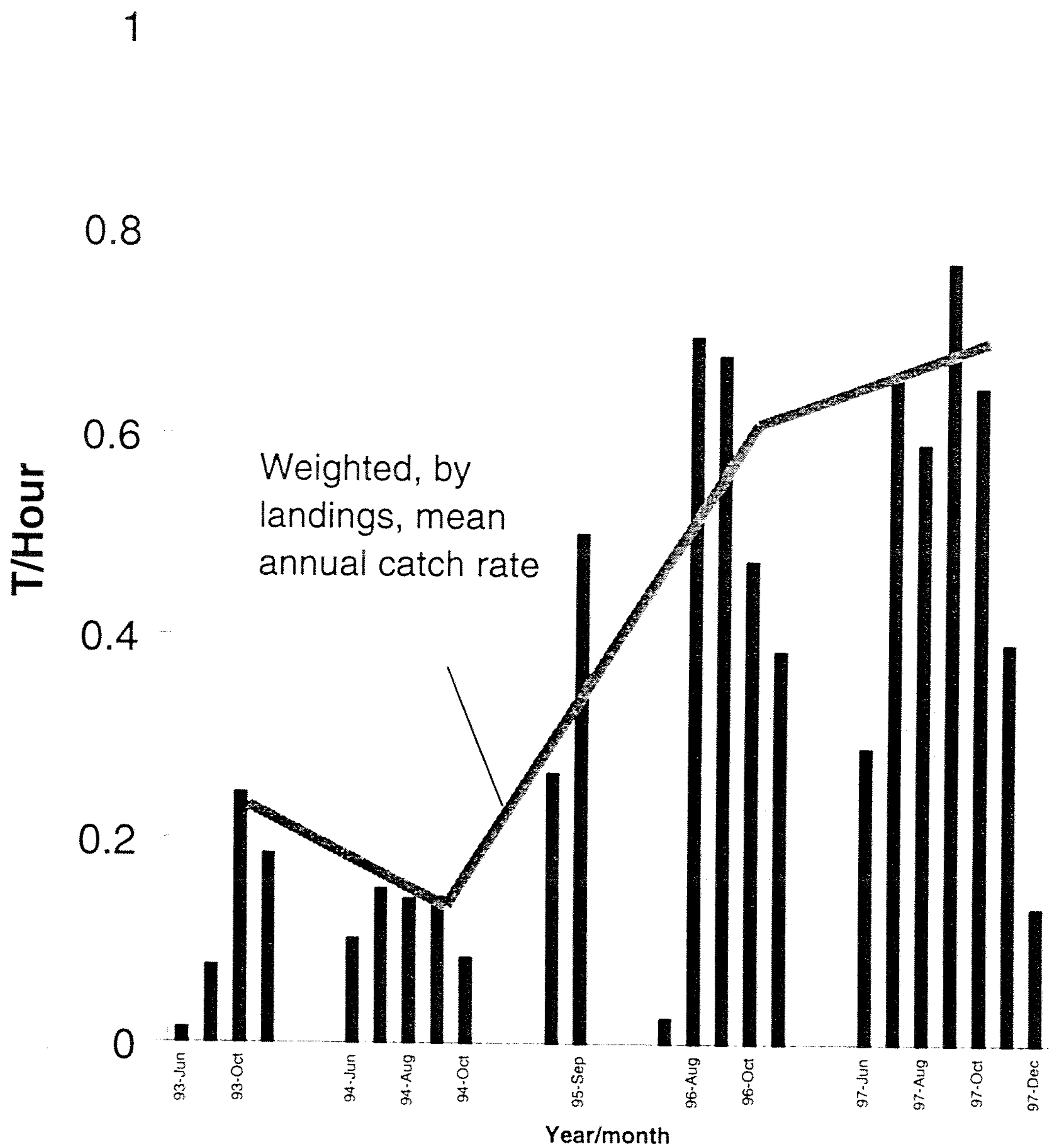


Fig. 8. Monthly catch rates of stern trawlers (TC 2-3) in the Canadian fishery, Georges Bank Yellowtail flounder, 1993 to 1997.

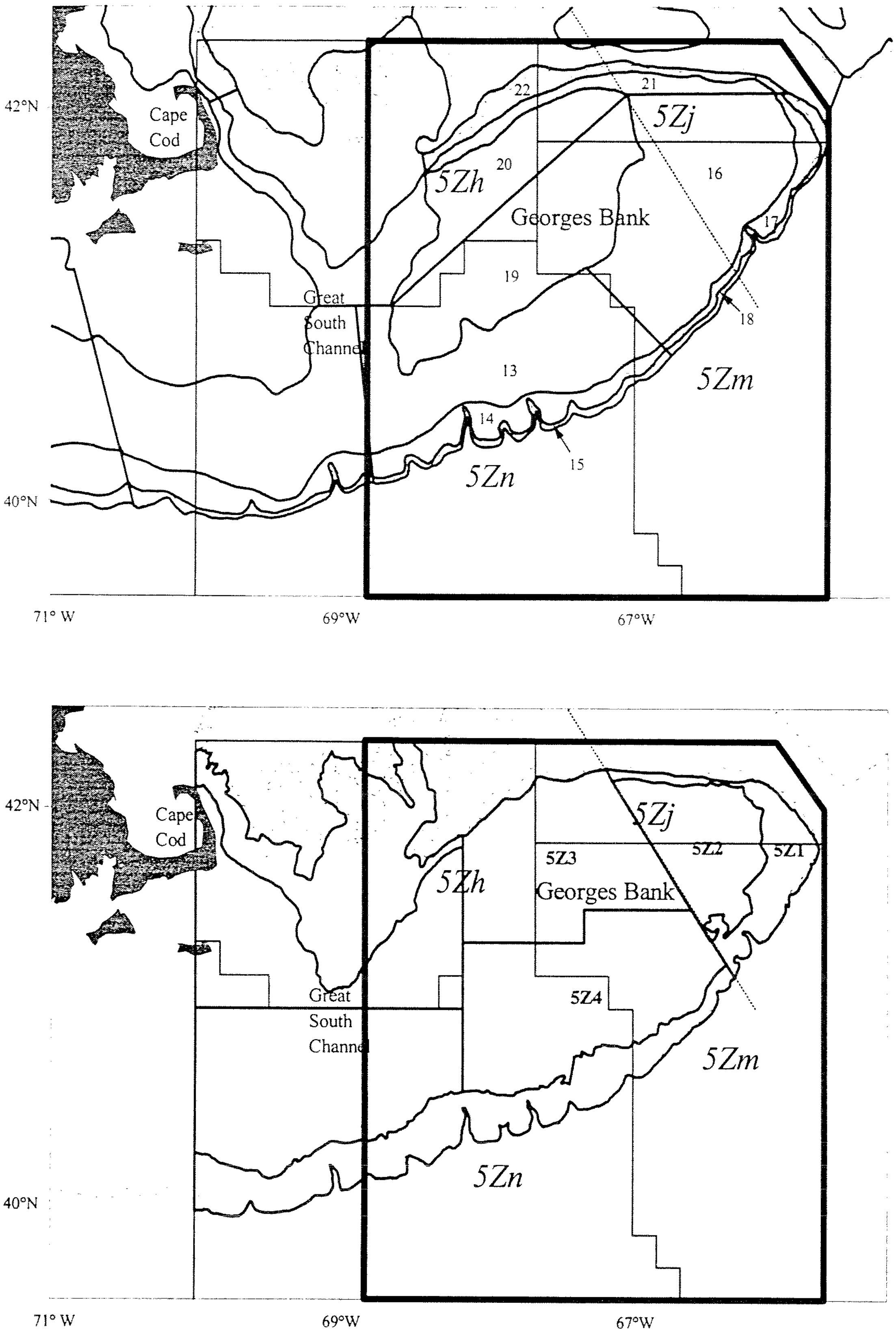


Fig. 9. USA (top) and Canadian (bottom) strata used to derive research survey abundance indices for Georges Bank groundfish surveys.

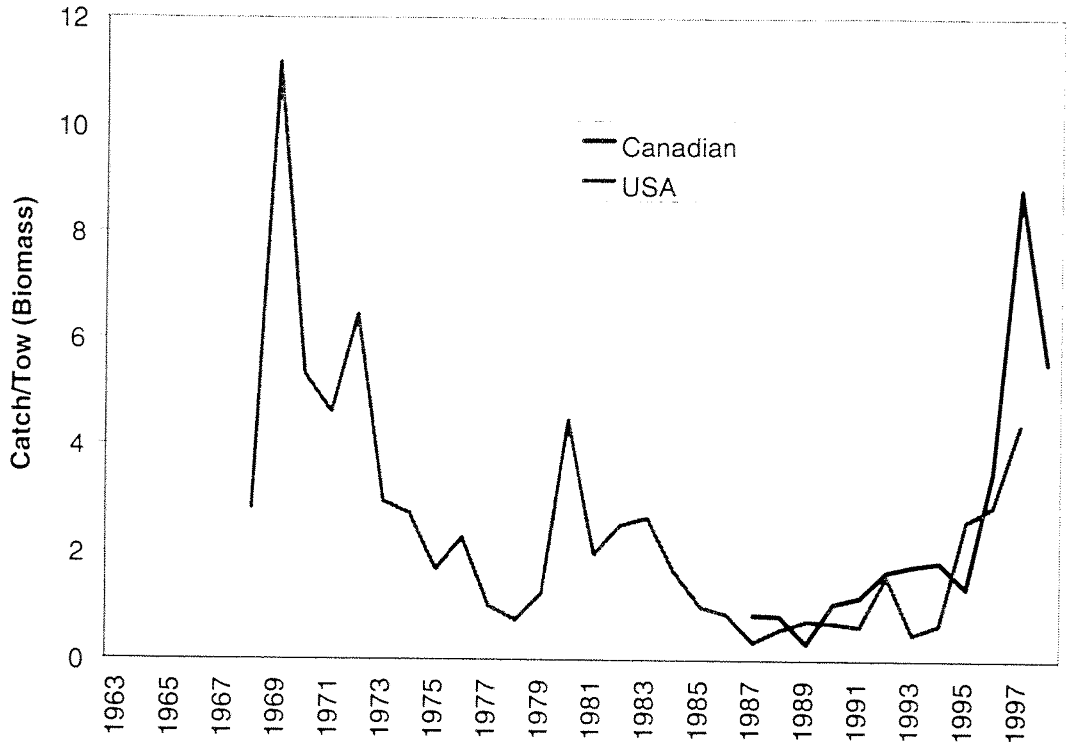


Fig. 10. USA and Canadian spring survey results for yellowtail flounder (Strata 5Z1-4), 1987-1997 (the series includes 1998 for the Canadian survey).

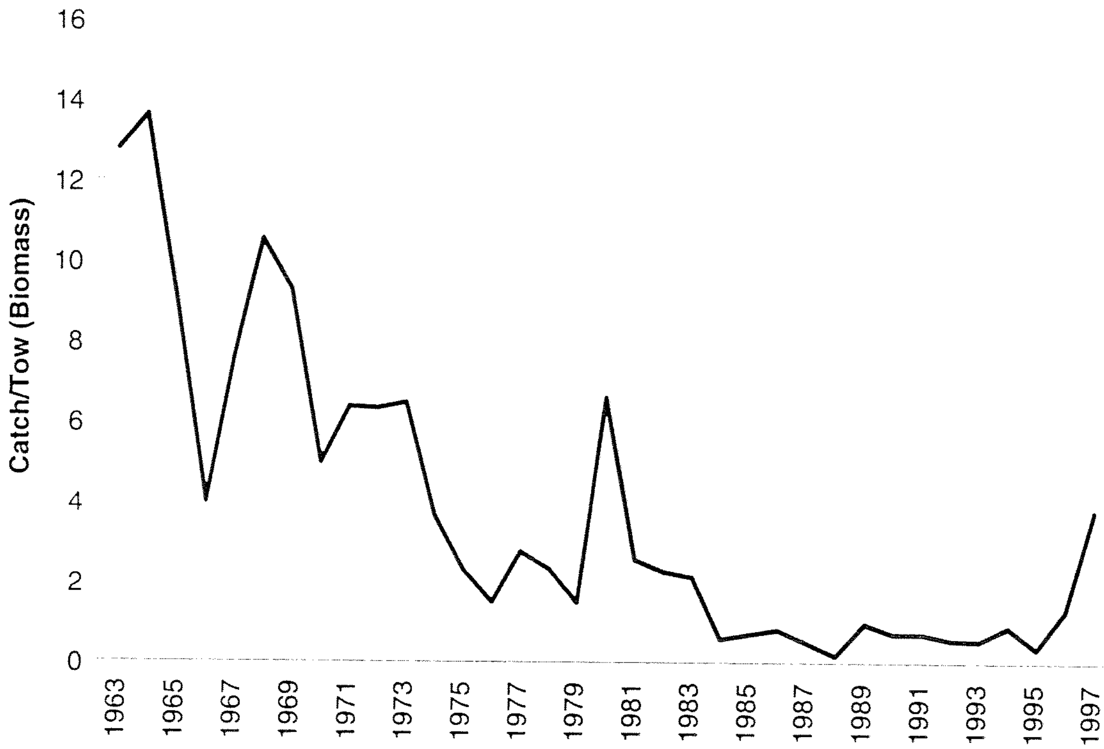


Fig. 11. USA fall survey results for yellowtail flounder on Georges Bank, 1963-1997.

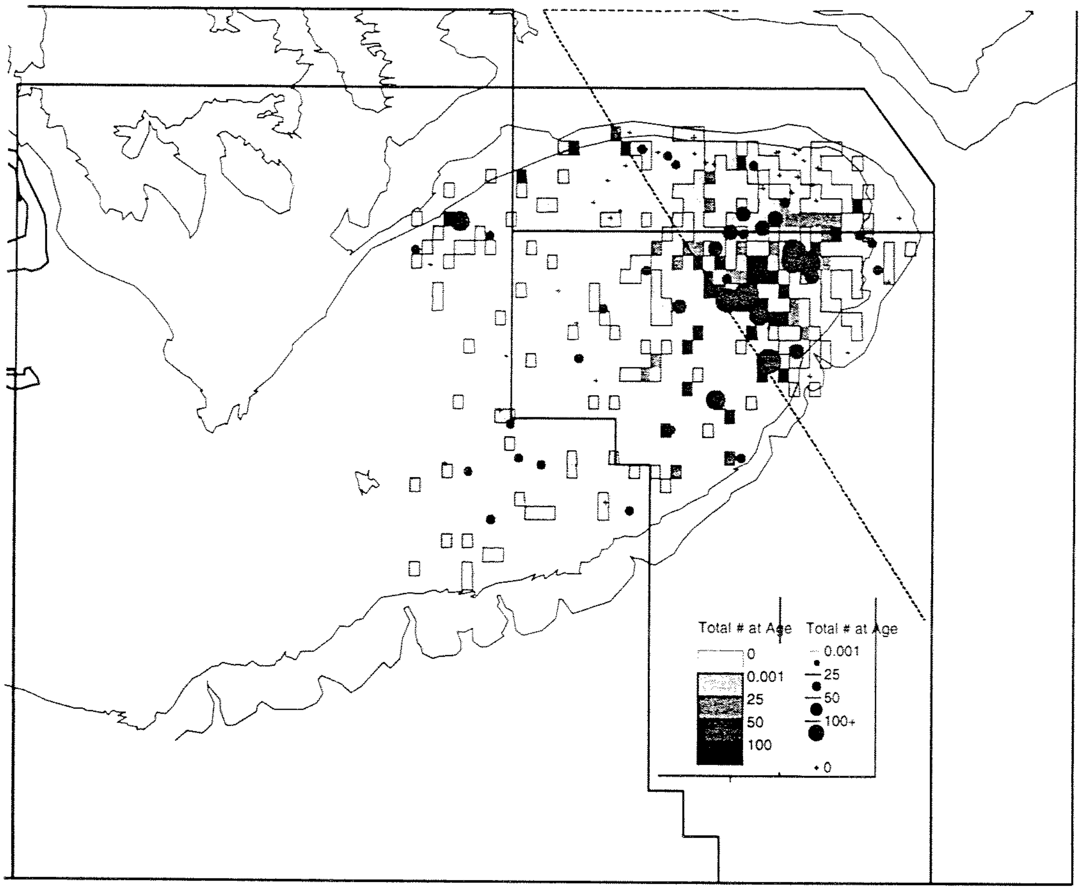


Fig. 12. The distribution of catches of yellowtail flounder (solid circles) in the Canadian Georges Bank spring survey in 1998 compared with the average distribution in the previous five years (shaded rectangles), averaged by 3' squares.

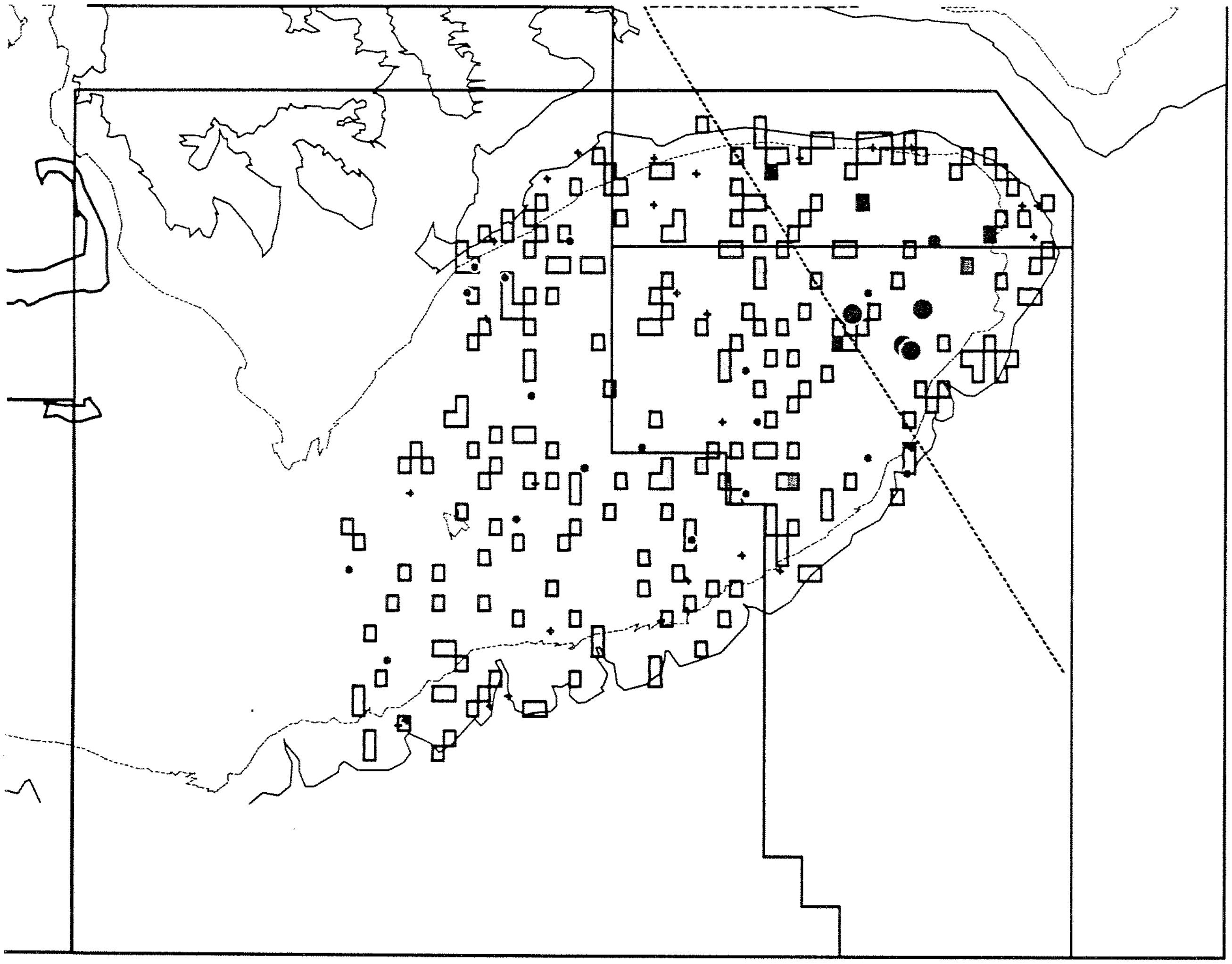


Fig. 13. The distribution of catches of yellowtail flounder in the USA Georges Bank spring survey in 1997 (solid circles), compared with the average distribution in the previous five years (shaded rectangles), averaged by 3' squares.

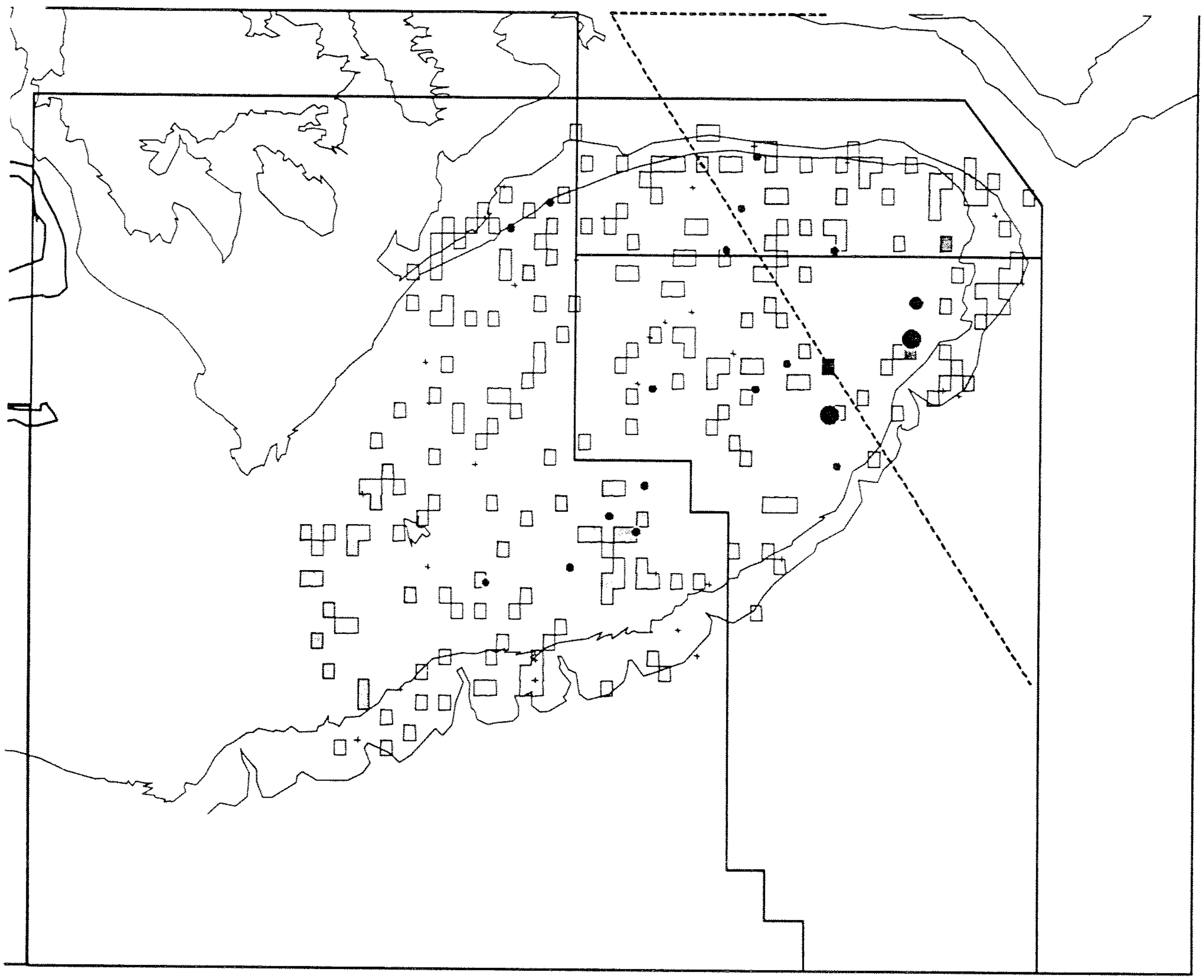


Fig. 14. The distribution of catches of yellowtail flounder in the USA Georges Bank fall survey in 1997 (solid circles), compared with the average distribution in the previous five years (shaded rectangles), averaged by 3' squares.

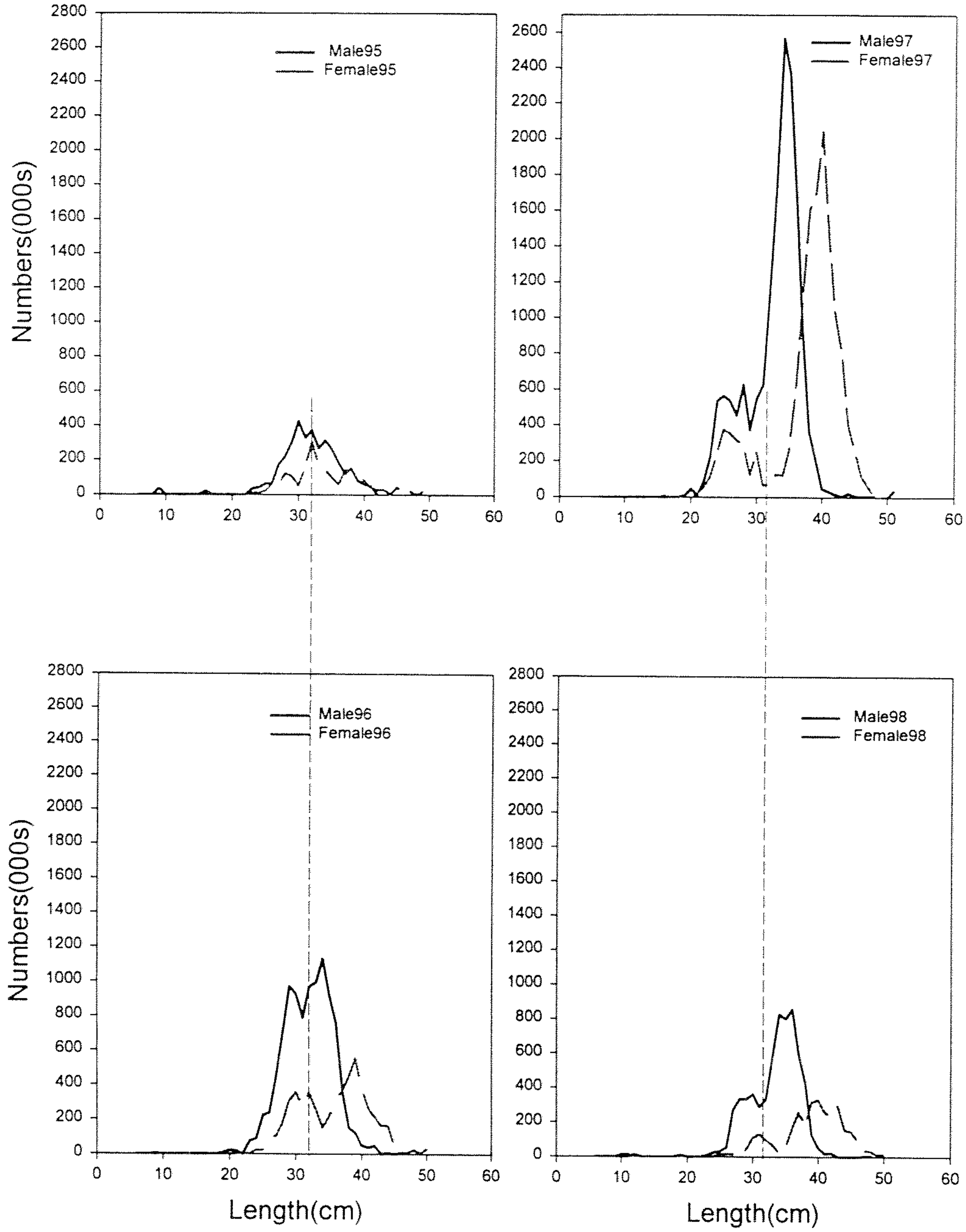


Fig. 15. Comparison of yellowtail flounder length composition in Canadian spring surveys, 1995 - 1998, Georges Bank. The dashed line represents modal length of female yellowtail flounder in 1995.

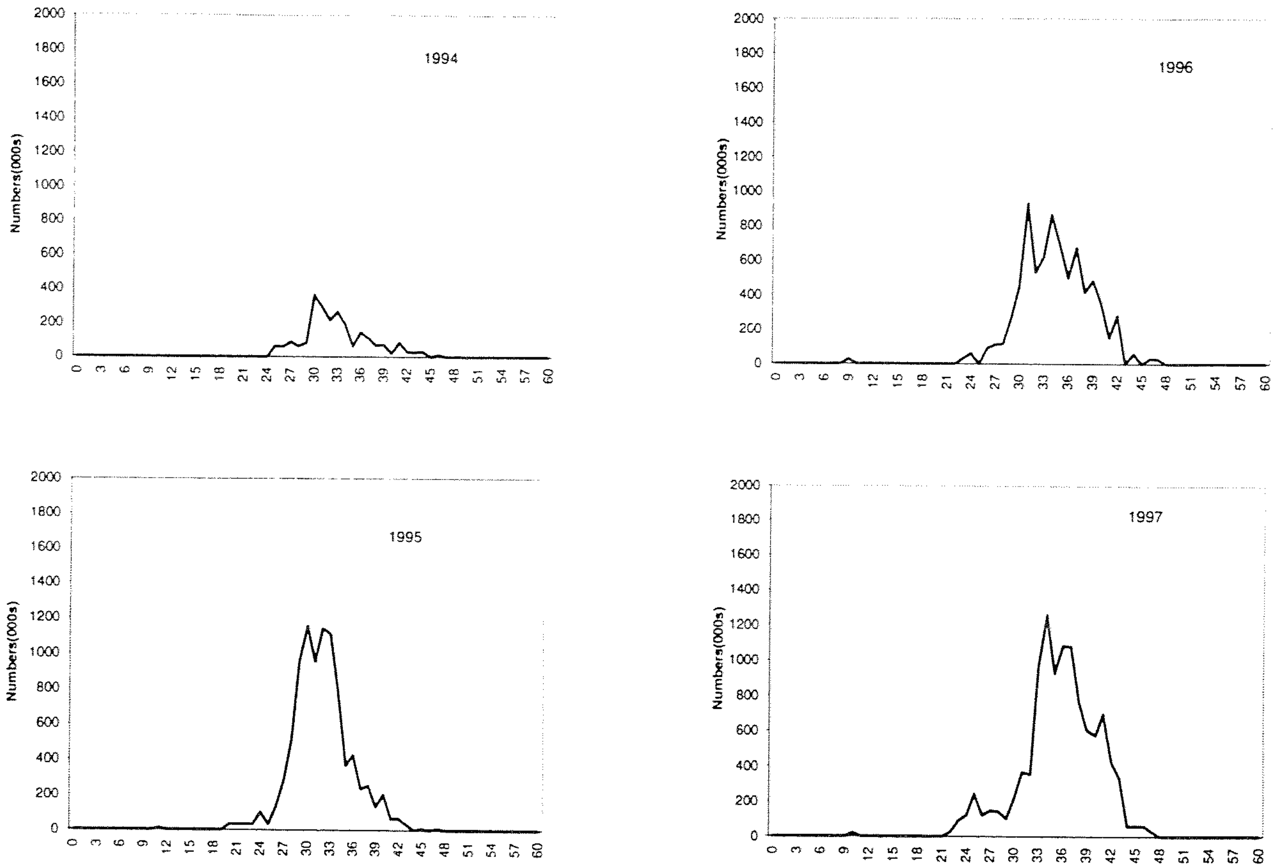


Fig. 16. Comparison of length composition of yellowtail flounder caught in USA spring research vessel surveys, 1994-1997.

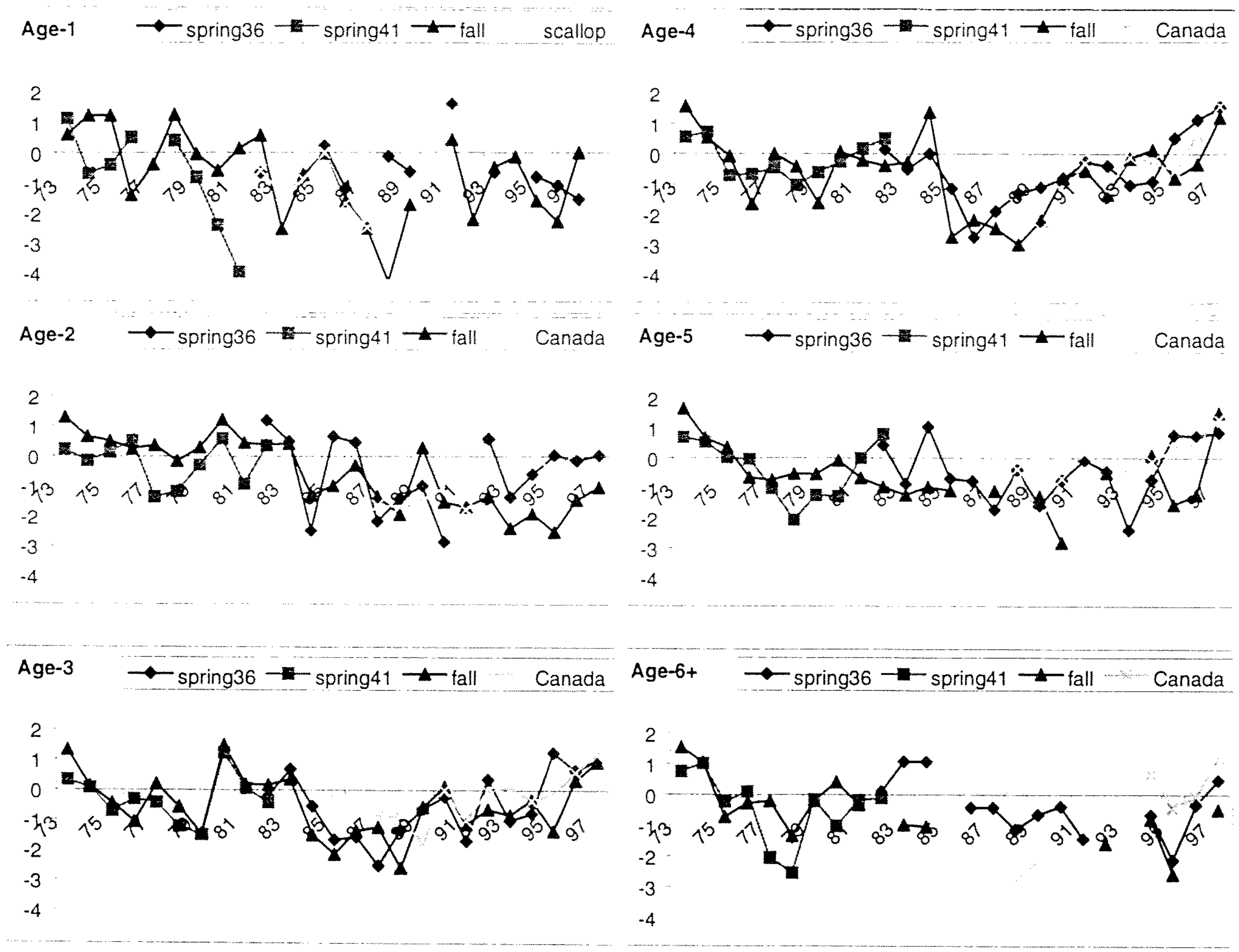


Figure 17. Normalized indices of abundance at age [Ln(x/mean)] for Georges Bank yellowtail flounder.

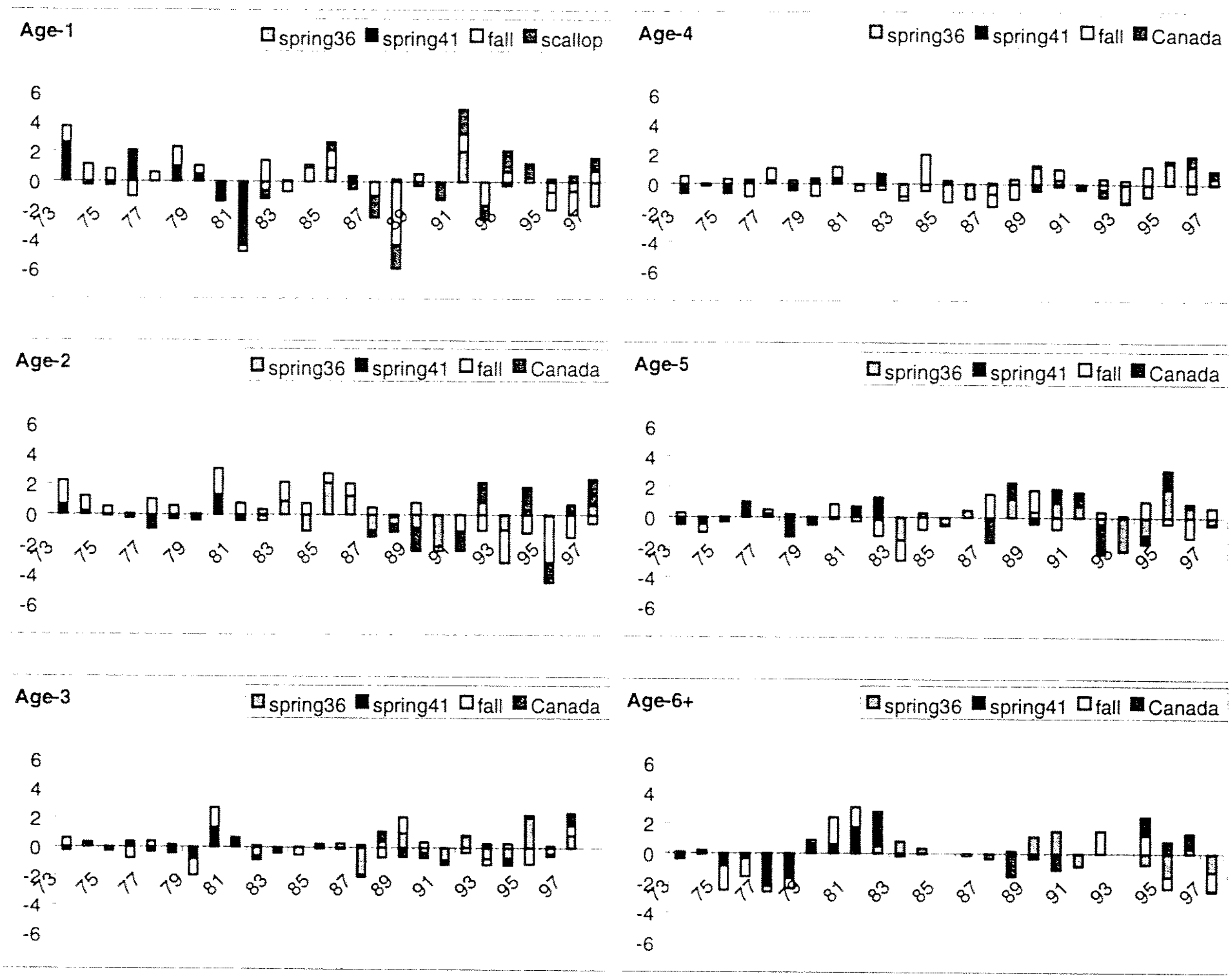


Figure 18. Standardized residuals from ADAPT calibration of the Georges Bank yellowtail flounder VPA.

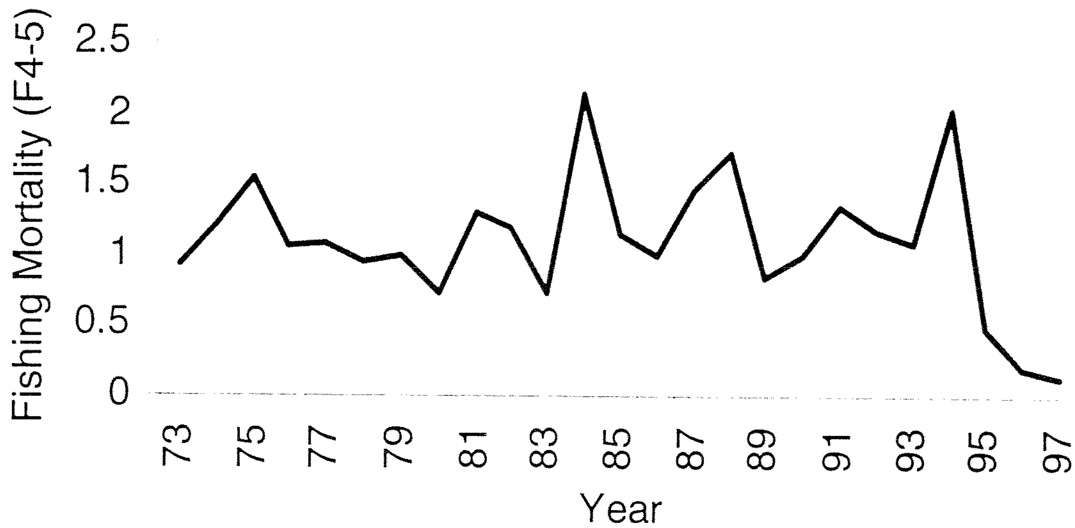


Figure 19. Instantaneous rate of fishing mortality (F 4-5) of Georges Bank yellowtail flounder.

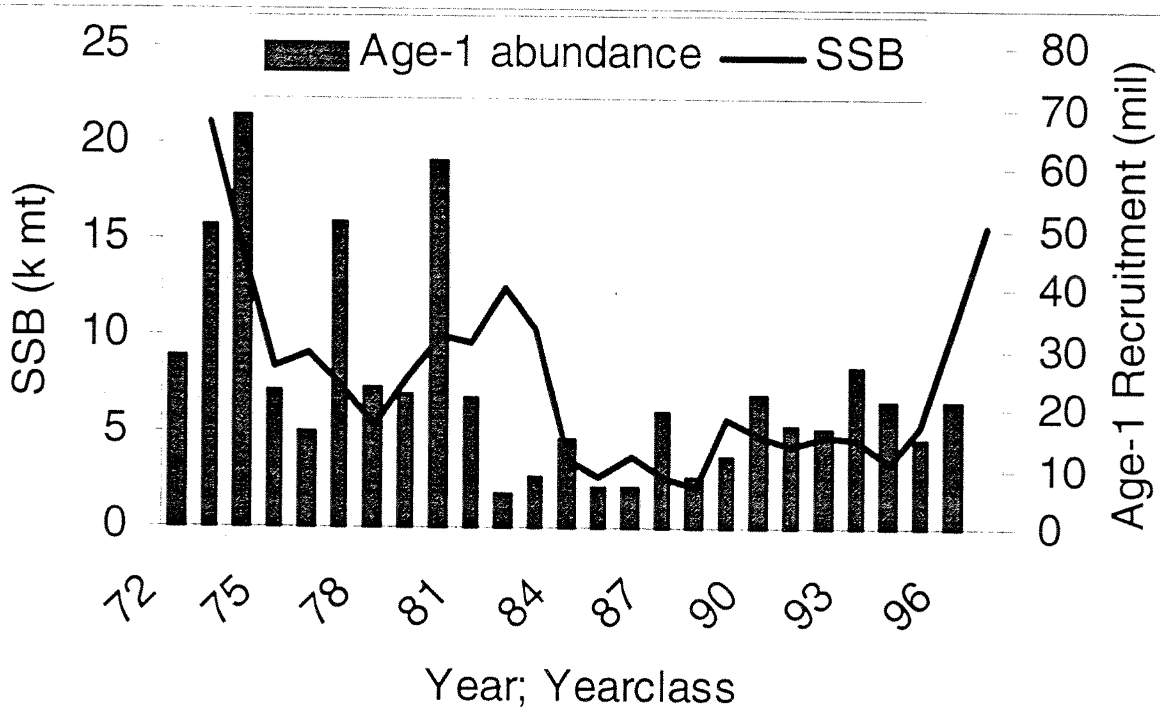


Figure 20. Spawning stock biomass and age-1 recruitment of Georges Bank yellowtail flounder.

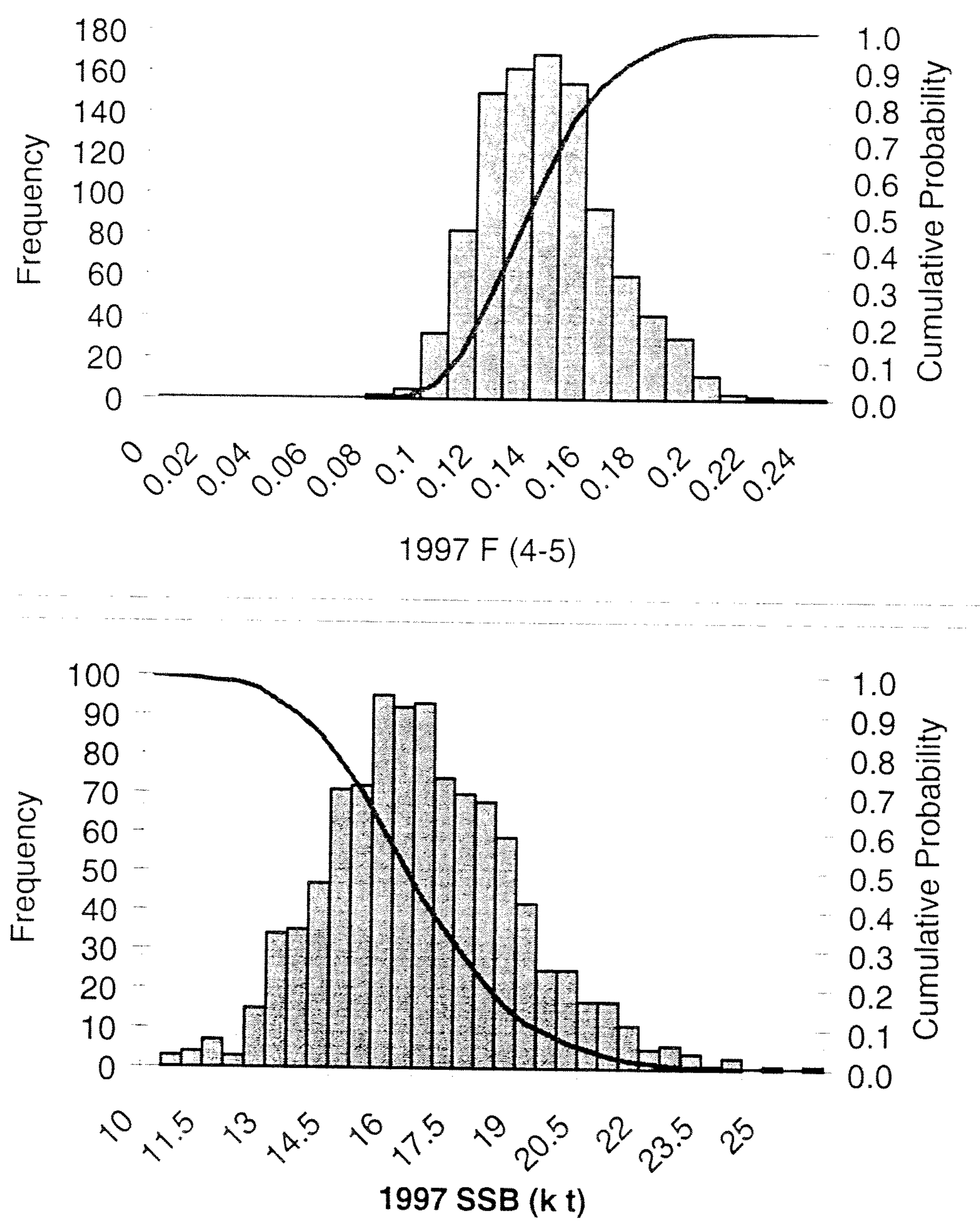


Figure 21. Bootstrap distributions of fully-recruited fishing mortality (above) and spawning stock biomass (below) of Georges Bank yellowtail flounder in 1997.

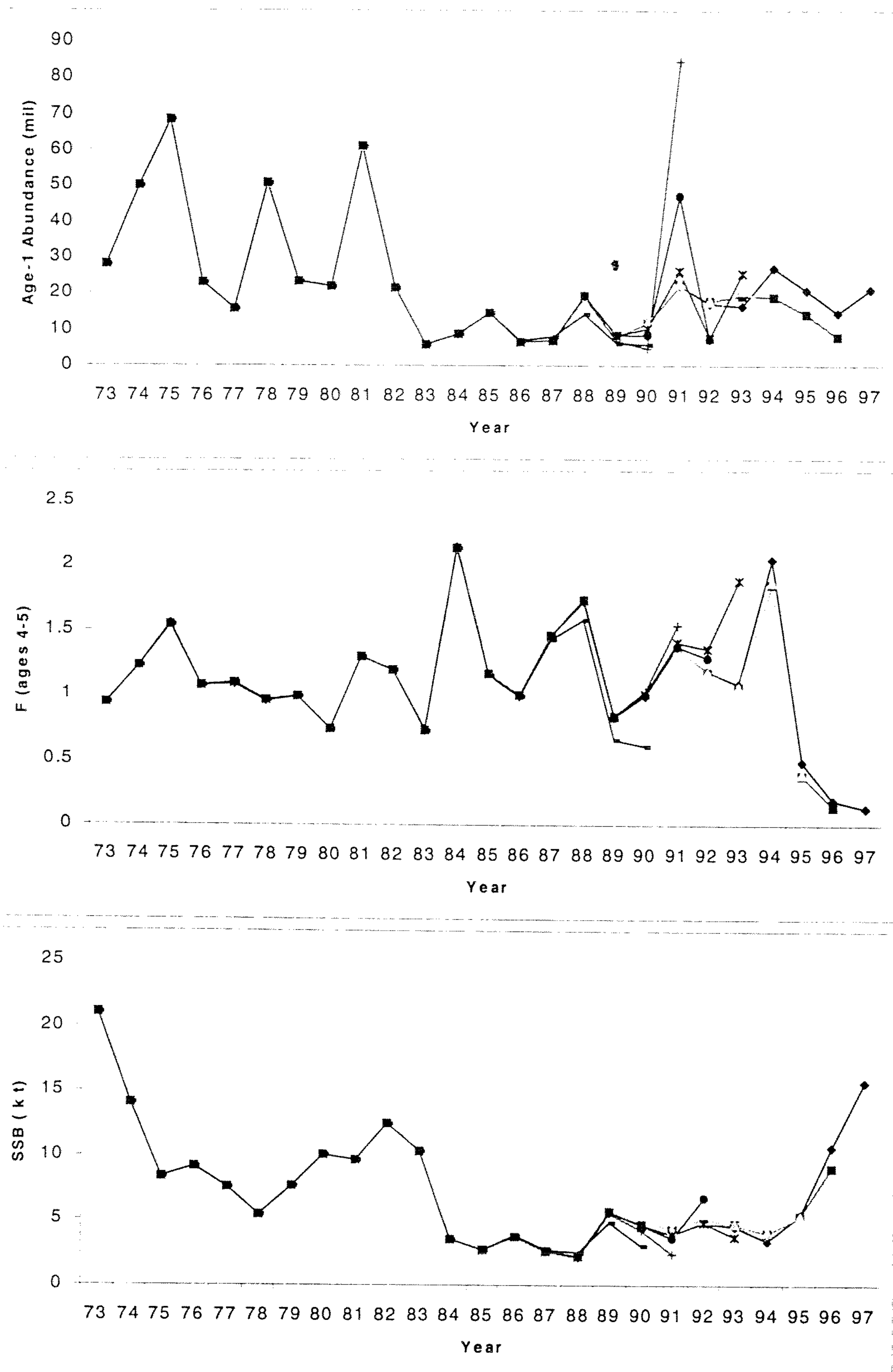
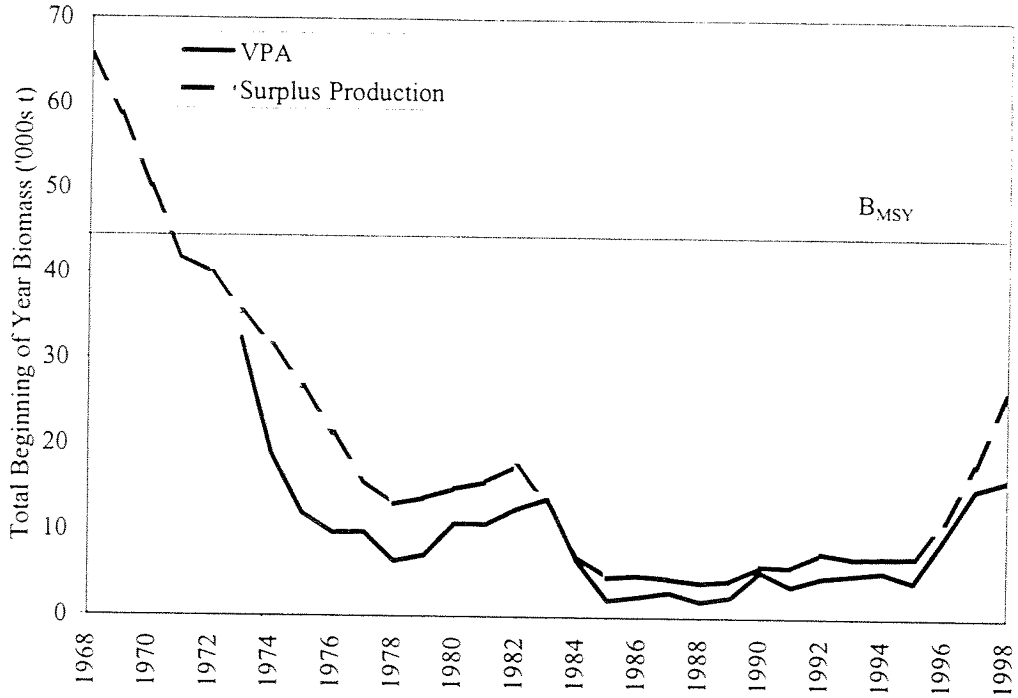


Fig. 22. Retrospective analyses of Georges Bank yellowtail flounder, showing the impacts of additional year's of data on estimates of spawning stock biomass (bottom panel), fishing mortality (middle panel) and recruitment (top panel).



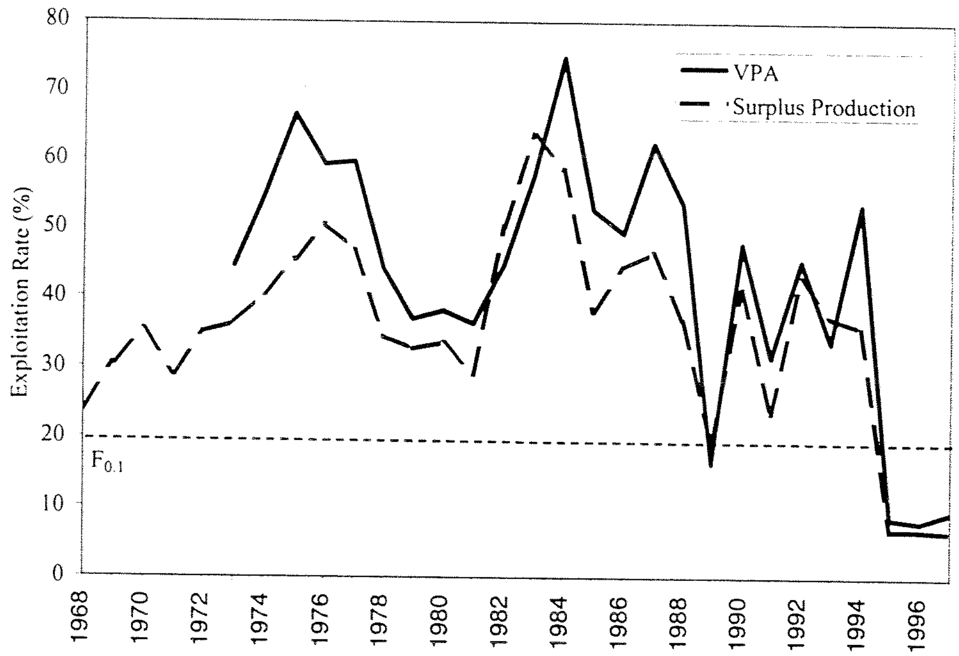


Figure 23. Comparison of results from VPA and surplus production modeling of Georges Bank yellowtail flounder.

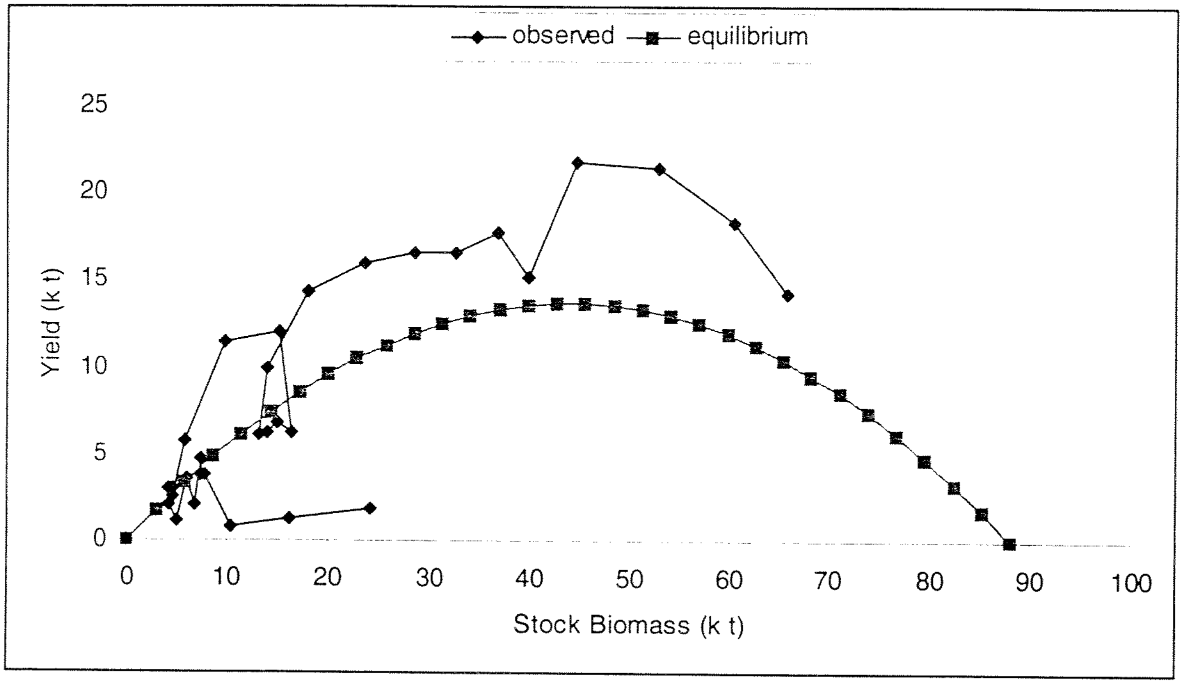


Figure 24. Observed yield and fitted biomass of Georges Bank yellowtail flounder from ASPIC results.

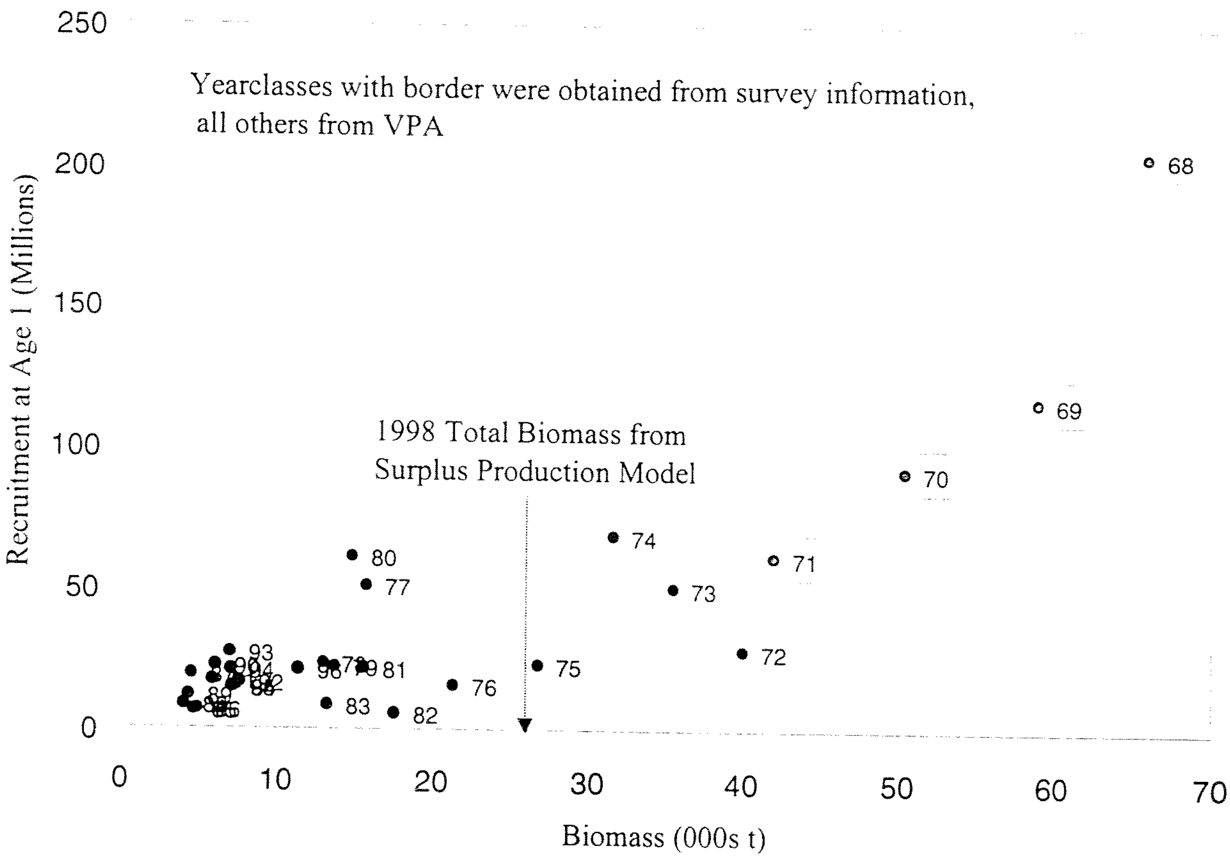


Figure 25. Relationship between total stock biomass from surplus production modelling and age –1 recruitment from the VPA (1972 to 1996 year-classes) or recruitment from the USA fall surveys (1969 to 1971 year-classes), Georges Bank yellowtail flounder.

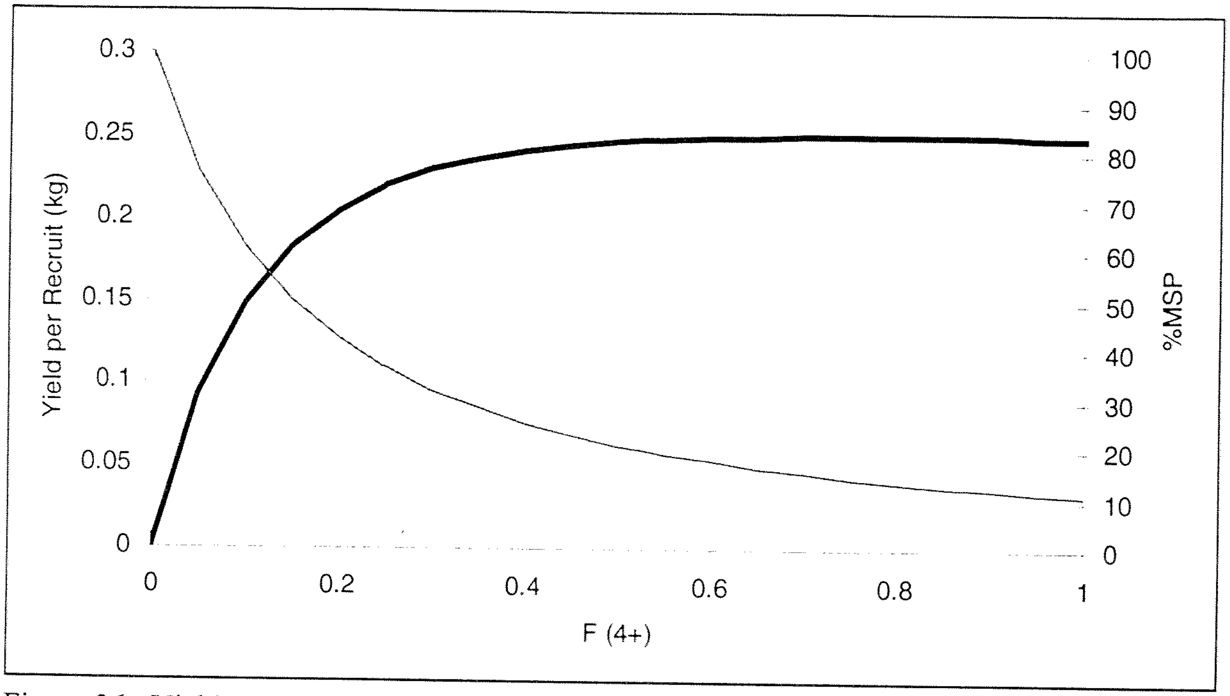


Figure 26. Yield per recruit and percent maximum spawning potential (SSB/R) of Georges Bank yellowtail flounder.

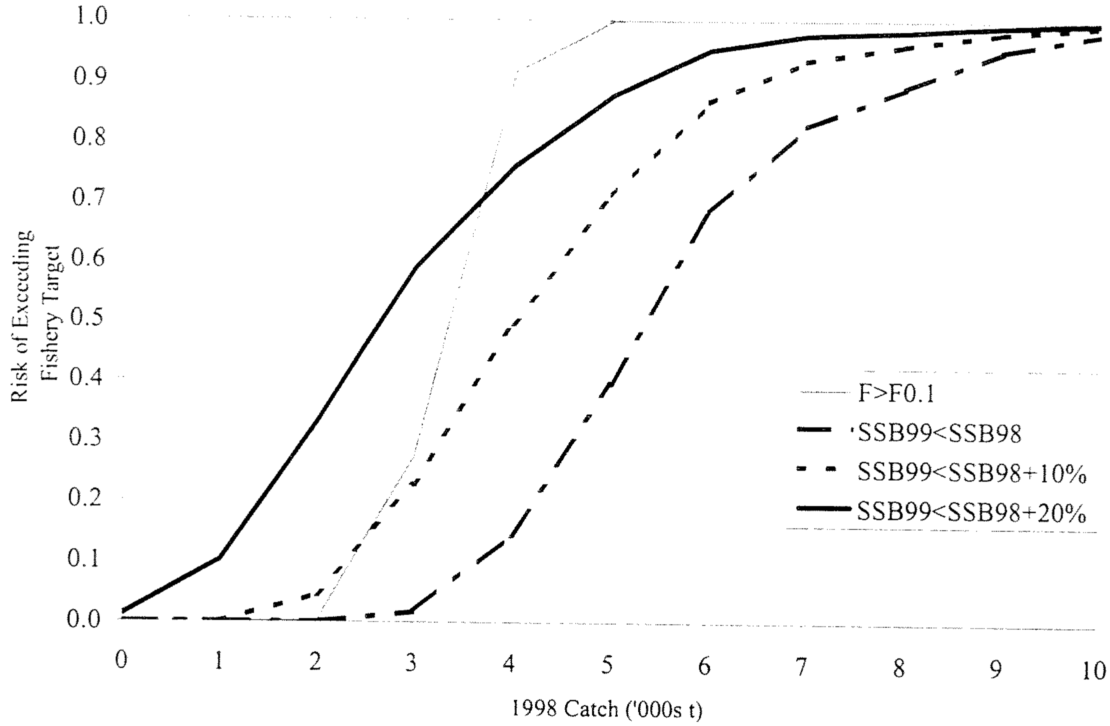


Fig. 27. Risk of exceeding various fishery targets ($F_{0.1}$, spawning stock biomass in 1999 being less than 1998, or not having a 10 or 20% increase in biomass in 1999) .

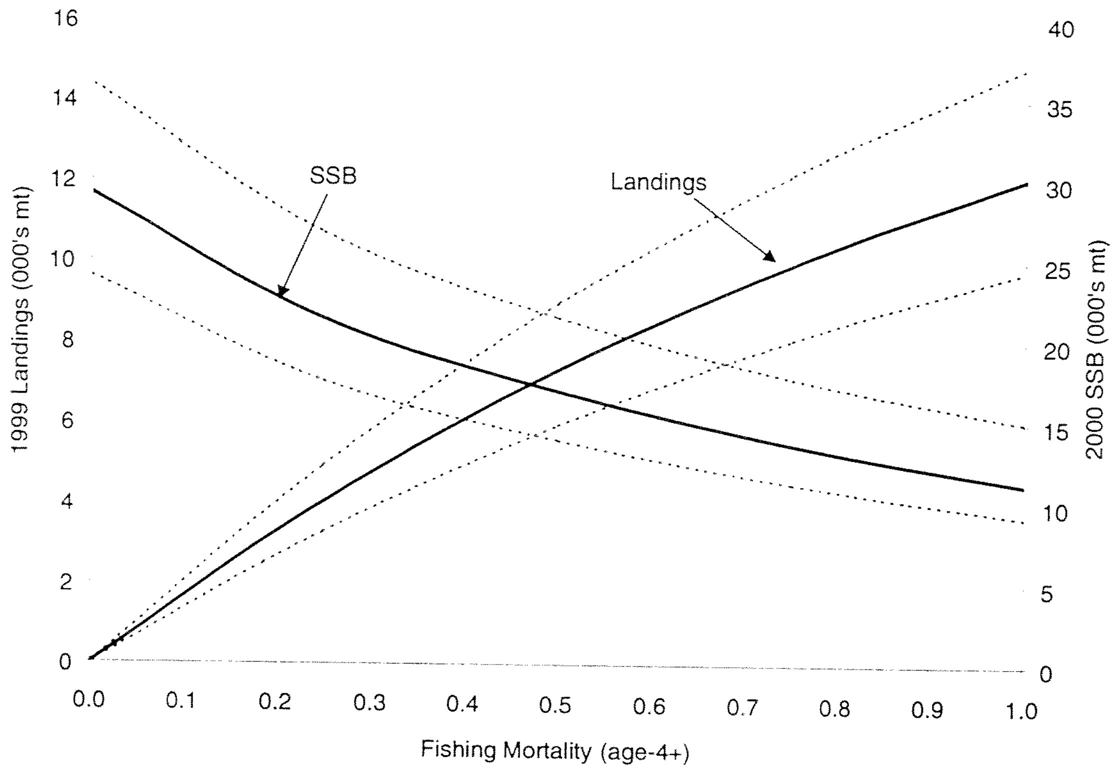


Figure 28. ASPIC projections (median and interquartile range) of Georges Bank yellowtail flounder catch (above) and total stock biomass (below) at status quo F.