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1997 Assessment of Georges Bank (5Zjmnh) Yellowtail Flounder (*Limanda ferruginea*)

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ABSTRACT

Yellowtail flounder (*Limanda ferruginea*) on Georges Bank is a transboundary resource which has supported a directed Canadian fishery since 1993. Removals of yellowtail flounder by the Canadian fishery peaked in 1994, when 2139 t were landed. Quota regulation commenced in 1995. Landings in 1996 were 483 t (including an estimated 11 t of regulatory discards from the scallop fishery) against a quota of 430 t. The fishery is prosecuted almost exclusively by vessels <65' fishing otter trawls.

Resource status was determined by virtual population and surplus production analyses. The latter approach, which does not require age structured input data, was included because of uncertainties in the catch at age information. Both methods indicated that biomass decreased to under 4000 t in the late 1980s' and has been recovering since then. In 1996, biomass was estimated as 10,365 and 13,495 t from the surplus production and VPA models, respectively. Exploitation rate was well above the target level of 20% during the 1983 to 1987 period, declined somewhat during the 1988 to 1994 period, and in 1995-1996 was at the lowest values observed in the series. The VPA indicates that the 1995 year-class is the weakest since 1986, but the observation is inconsistent with 1997 Canadian survey results. Status quo yield projections for 1997 range between 1053-2014 t for the VPA and surplus production models, respectively. Fishing at $F_{0.1}$ in 1997 implies a yield of 2470 and 4526 t for the VPA and surplus production models, respectively. All yields are for combined Canada and USA landings.

RÉSUMÉ

La limande à queue jaune (*Limanda ferruginea*) du banc Georges est une ressource transfrontalière qui alimente une pêche canadienne dirigée depuis 1993. Les prises canadiennes ont atteint un pic de 2 139 t en 1994. Après l'établissement d'un quota en 1995, les débarquements ont chuté à 483 t en 1996 (y inclus environ 11 t rejetées légalement à la mer dans le cadre de la pêche du pétoncle), le quota annuel ayant été fixé à 430 t. La pêche est effectuée presque exclusivement par des chalutiers de moins de 65 pi.

Des analyses des populations virtuelles et de production excédentaire ont servi à déterminer l'état de la ressource. Cette dernière analyse, qui ne requiert pas de données sur les prises selon l'âge, a été utilisée à cause d'incertitudes à ce titre. Les deux analyses ont indiqué que, après avoir chuté à moins de 4 000 t vers la fin des années 80, la biomasse est maintenant en voie de rétablissement et qu'elle devrait atteindre 10 365 t et 13 495 t, respectivement, en 1996. De 1983 à 1987, le taux d'exploitation se situait bien au-dessus du pourcentage cible de 20 %; il a par la suite quelque peu diminué de 1988 à 1994 pour atteindre en 1995-1996 le plus faible niveau observé. L'analyse des populations virtuelles indique que la classe d'âge de 1995 est la moins abondante depuis 1986, bien que cette observation ne corresponde pas aux résultats des relevés canadiens de 1997. D'après les modèles obtenus de l'analyse des populations virtuelles et de l'analyse de production excédentaire, le rendement de statu quo en 1997 varie de 1 053 t à 2 014 t, respectivement, tandis que la pêche à $F_{0,1}$ laisse supposer un rendement de 2 470 t et de 4 526 (débarquements canadiens et américains confondus) respectivement.

INTRODUCTION

Yellowtail flounder (*Limanda ferruginea*) range from Labrador to Chesapeake Bay and are considered relatively sedentary. Yellowtail flounder are typically caught at depths between 37 and 73 m, and a major concentration occurs on Georges Bank to the east of the Great South Channel. Based on tagging investigations (Royce *et al.* 1959; Lux 1963), the management unit is considered to include Georges Bank east of the Great South Channel encompassing statistical areas 5Zj, 5Zm, 5Zn and 5Zh (Fig. 1). Thus, the management unit is transboundary in nature. An earlier Canadian summary of stock status indicated that yellowtail flounder on the Canadian portion of Georges Bank could be the basis of a sustainable managed fishery (Anon. 1994a). This conclusion was based on several observations: yellowtail flounder are comparatively sedentary as adults more than one year-class was present in the Canadian landings and that spawning (which occurs in late spring) likely occurs in Canadian waters. However, the sources of recruitment and the degree of mixing across the international boundary are not clear.

A recent assessment conducted by the National Marine Fisheries Service (NMFS), USA concluded that the stock was at low biomass levels, overexploited and collapsed relative to historic abundance levels (Anon. 1994b). An updated analysis including both USA and Canadian landings confirmed the conclusions of the NMFS assessment, but also noted that based on updated landings and survey information, F had decreased in 1995 (Gavaris *et al.* 1996). The assessment presented here contains current information on landings and discards in 1996, and also revised estimates of USA landings and discards in 1994 and 1995.

The Fisheries

The USA yellowtail fishery is almost exclusively conducted by vessels using otter trawl gear. USA landings were negligible prior to the mid-1930s, but landings increased to average 6,500 t in 1948-1949 (Anon. 1994b). After declining to 1,600 t by 1955, landings recovered to a peak of 18,300 t in 1969. Between 1968 and 1974, landings averaged 15,600 t but more recently, landings have averaged 2,060 t between 1986 and 1996 (Table 1). The low landings since 1995 may be attributable, at least in part, to the recent expansion (both spatially and seasonally) of the haddock spawning closed area on eastern Georges Bank. Discarding of undersized yellowtail is considered a major contributor to overall mortality in the United States fishery.

Landings and discard estimates from the USA yellowtail fishery from 1994 to 1996 have been revised from those presented in Gavaris *et al.* (1996). Last year's estimates are compared with this year in the text table on the next page.

	Last Year's Estimate of USA landings (t)	Last Year's Estimate of USA discards (t)	Current Estimate of USA landings (t)	Current Estimate of USA discards (t)
1994	1500	2300	1589	153
1995	1000	700	292	29
1996			751	72

Thus, the estimates of total USA removals in 1994 and 1995 used in Gavaris *et al.* (1996) are considerably higher than the revised estimates. However, projections of fishing mortality and stock biomass assumed that 1996 removals by the USA fishery would be 385 t, the USA target TAC.

Prior to 1993, Canadian landings were small, typically less than 100 t (Table 1, Fig. 2). Peak landings of 1328 t of specified yellowtail occurred in 1994 in an unrestricted fishery, and after a TAC of 400 t was established, specified yellowtail landings dropped to 397 t in 1995. In 1996, landings of specified yellowtail flounder were 434 t against a quota of 430 t (Table 2).

Flatfish landed as "unspecified" flatfish in the Canadian fishery have been significant and generally consist of yellowtail on Georges Bank. To estimate the proportion of unspecified flatfish that were actually yellowtail, 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, from both otter trawls and scallop drags. For otter trawl landings, the ratio was relatively constant over the months of the fishery, and values of 0.61 and 1.00 were used for 5Zj and 5Zm, respectively. For scallop drags, however, the ratio varied on a seasonal basis, and monthly values were used. The unspecified flounder problem was less of a concern in 1995 and 1996 due to improved monitoring of the landings (Table 3). Table 4 shows the total Canadian yellowtail landings, which includes both the specified yellowtail flounder plus the assumed yellowtail flounder, calculated as described above.

Over the 1994-1995 period, there have also been some reports from industry of highgrading of landings by size to meet the 13 inch minimum size requirement for USA importation. Gavaris *et al.* (1996) compared the length-frequency composition of samples taken by observers at sea with those obtained by port samplers in 1994 and 1995, and no indication of discarding was detected. However, for 1996, there does appear to be an indication of discarding of smaller-sized fish (Fig. 3). This observation is inconsistent with industry reports, which indicated that discarding was insignificant in 1996.

The majority of Canadian landings of yellowtail flounder are made by otter trawl, from vessels less than 65 ft, tonnage classes 2 and 3 (Fig. 4). Peak months for fishing were August and September in 1994 and 1995. 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. 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 1995 and 1996 fishery, only 155 mm square mesh gear was used. The same rigging of the foot gear was used from 1994 to 1996.

There was also a trip limit of 17,000 lb. imposed by industry in 1995 to equitably share the reduced quota among eligible participants. In 1996, no trip limit was in place, and the quota of 430 t was allocated based on previous catch history.

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" (Figs. 5, 6).The distribution of fishing activity changed somewhat from 1994 to 1996, with the total area fished being more constricted in 1995 and 1996.

Prior to 1996, some yellowtail flounder were landed in the scallop fishery. In 1996, there were no reported landings of yellowtail by the scallop fleet, with all yellowtail flounder caught required by regulation to be discarded at sea. Based on at sea observer records, the amount of yellowtail flounder discarded was estimated as 11 t.

Age and Length Composition

We compiled the Canadian catch at age for 1993 to 1996. Samples for length and age composition were obtained by Canadian port technicians and at sea observers (Observer Program). Canada does not age yellowtail flounder at present, thus seasonal USA age-length keys were applied to the length composition of the Canadian catch. In the last assessment, we followed the USA convention of not providing a separate catch at age for males and females. However, since yellowtail flounder exhibit dimorphic growth typical of flatfish with females achieving a greater asymptotic length than males (Mosely 1988), we concluded that the approach of aggregating sexes might produce a bias. Thus, we elected to reconstruct the age and length composition of landings using a sex-disaggregated approach for the Canadian fishery from 1993 to 1996. The sampling data used to construct the Canadian catch at age are summarized below:

	Number of length measurements used from: A. Observer Program	B. Port Samples	Number of Age Determinations Available:
1993	1821	1114	103 (18)[1]
1994	6142	1644	175 (21)
1995	122	1831	240 (40)
1996	2444	1733	141 (6)

1. Numbers in parentheses refer to the number of ages which were assigned to lengths which did not have age at length information available. Such assignments were made from the inspection of age length keys.

The length-frequency samples from the OP were combined by trip, with samples from sets weighted according to weight caught in the set. The port samples and OP samples were then combined by month, gear type/tonnage class (OTB/TC1-3, OTB/TC4+ and scallop drag) weighted according to trip caught weight, before being further combined by half-year and year. USA length-weight relationships by quarter were used for these calculations. In the case of miscellaneous gear (which included longline, gillnet, etc.) combinations were done on a half year basis rather than monthly. USA age length keys (available from surveys conducted in the spring and fall) were then applied by quarter and/or half-year to get catch at age.

The Canadian catch at age using the sex-disaggregated approach is compared with the sex-combined catch at age from last year's assessment in Fig. 7. Similar age compositions were obtained in 1993,1994 and 1996, but more substantial differences were noted for 1995. Of more concern, however, is the indication that the age composition is relatively stable and comprised generally of ages 3 and 4 (Fig. 8), while the catch at length and reports from the fishery indicate that the length composition of the landings is increasing (Fig. 9).

The USA catch at age for recent years is shown on Fig. 10. Again, the age composition appears to be largely ages 3 and 4. Ages 2 and 5 are somewhat better represented in the USA catch at age than in the Canadian equivalent.

When trends in length at age are compared (Fig. 11), an increase in the mean length at age is noted for both the Canadian and USA data. These trends in the mean lengths at age are problematic, and are likely masking expected changes in age composition, given the increasing average length of the catch (Fig. 9).

While recognizing these difficulties with the catch at age, it was still considered desirable to include age structured catch information in a virtual population analysis. In the absence of sex-disaggregated USA landings, the sex-combined catch at age from Gavaris et al. (1996) was updated for the 1996 Canadian fishery and combined with the USA sex-combined catch at age. The resultant catch and weight at age data are shown in Table 5 and 6, 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 1993-96 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 considered. As well, only vessels with reported landings in two or more years in 1993-96 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. 6). 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. 12. 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. This is consistent with industry observations of increasing catch rates in the last two 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. 13).

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. In general, the use of age and sex-specific age length keys results in higher abundance at ages 3+ when compared to unsexed keys.

Results from the Canadian survey and trends over time are shown in Fig. 14 (also Tables 7-10 for all surveys). USA age sampling was not available at the time of writing to apply against the 1997 DFO results. In 1997, the Canadian survey index was at the highest value recorded in the series. However, when the numbers caught at length in 1997 were compared with 1996, it was noted that the increase in the index, while driven partially by new recruitment, might also be caused by interannual variation in survey catchability. The sex-combined index for all ages from Gavaris et al. (1996) was updated, along with the biomass index from Canadian surveys from 1987 to 1997 (Table 10 a and b, respectively).

The overall trend for the NMFS spring survey is shown in Fig. 15. Similar to the Canadian spring series, the series has followed an increasing trend since 1988. However, during the late 1960s and early 1970s the index was considerably higher. The NMFS fall series shows a similar trend to the NMFS spring index and has followed a generally declining trend since 1963. It has remained at low levels since 1989. (Fig. 16).

The spatial distribution of the 1997 Canadian spring survey catch compared with the average of the five preceding years is shown on Fig. 17. Over the past five years, the highest catch of yellowtail flounder was found in 5Zm, near the Yellowtail Hole, corresponding well with the distribution of the commercial fishery shown on Fig. 6. The 1997 results indicate that the population density has increased relative to the past five years.

Figures 18 and 19 are similar to Fig. 17, and contain comparisons of the USA spring and fall survey results contrasted to the five year average. In general, recent catches have not revealed the concentration of yellowtail seen in the Canadian survey, but sampling intensities in key yellowtail habitats have been low, particularly during the fall survey.

The resource distribution in 1997 is compared with the abundant years 1971-1973 as indicated in the NMFS spring survey (Fig. 20). The Canadian catches were downweighted by a factor of 2.4 to account for observed differences in catchability among the surveys. Differences in sampling intensity between the two surveys make comparisons difficult, but it appears as though the resource was more broadly distributed during the earlier period.

Most of the catch of yellowtail flounder seen during Canadian surveys occurs in the 5Zm area. In the past five years, the average proportion of biomass in Canadian waters has been 38, 67 and 59%, as indicated in the Canadian and USA spring and fall surveys, respectively (Table 11). There is, however, considerable interannual variation in the proportion of biomass in Canadian waters.

The length composition of yellowtail flounder caught in the past three Canadian spring surveys is shown on Fig. 21, disaggregated by sex. An increase in modal length from 1995 to 1997 is apparent for both males and females. Consistent with observations from the fishery, the average length of fish has increased, as has the overall size range. There are also above average numbers of smaller fish (mode of about 25 cm) found in the 1997 survey results.

ESTIMATION OF STOCK PARAMETERS

Concerns were noted with the catch at age data, including the observation that few age groups were present in the population making results more dependent on assumptions for the fishing mortality at the oldest age group, and also whether recent low levels of sampling has had deleterious effects. Surplus production models which employ aggregate biomass data and do not rely on age structure, could circumvent these concerns. It is recognized however, that where VPA can be applied satisfactorily, it provides better information for stock projections. Consequently, two methods of analysis were used, the traditional age-structured VPA and the aggregate biomass surplus production model.

The aggregate biomass method used was a non-equilibrium surplus production model, as implemented in the software ASPIC (A Stock-Production model Incorporating Covariates) (Prager 1995). The method requires total landings along with one or more abundance indices (including CPUE or RV indices) as input. In our case, the DFO spring survey (1987 to 1996) and the NMFS spring survey (1968 to 1996) were considered beginning of year biomass indices and the NMFS fall survey (1963 to 1996) 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

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

where

$Y_t =$ observed yield in year t

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

and

$I_{s,t} =$ bottom trawl survey biomass index

for $s =$ DFO spring survey, time $t = 1987$ to 1996
$s =$ NMFS spring survey, time $t = 1968$ to1996
$s =$ NMFS fall survey, time $t = 1963$ to 1996

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

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

or

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

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

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

or

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

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

$\kappa_{s,a}$ = 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

$$\Psi_{s,a,t}(\theta,\kappa) = \sum_{s,a,t}\left(\ln I_{s,a,t} - \kappa_{s,a} + \ln N_{a,t}(\theta)\right)^2$$

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 and 7 were calculated assuming that the fishing mortality for these was equal to the average fishing mortality on ages 4 and 5. The abundance at age 1 was set to 20 million. For all other times, 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 expessed 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 using a Newton-Raphson algorithm

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

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 population weighted arithmetic average for ages 4 to 5 during that time interval,

$$F_{6,t} = \sum_{a=4}^{5} N_{a,t} F_{a,t} \Big/ \sum_{a=4}^{5} N_{a,t}$$

The data used were annual catch at age ,

$C_{a,t}$ = catch

for ages $a = 1,\ 2 \ldots\ 7$ and for $t = 1973$ to 1996

and bottom trawl survey abundance indices

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

for $s =$ DFO spring survey, ages $a = 2,\ 3 \ldots 6$, time $t = 1987,\ 1988,\ \ldots 1996$

$s =$ NMFS spring survey, ages $a = 1,\ 2 \ldots 7$, time $t = 1973,\ 1974 \ldots\ 1996$

$s =$ NMFS fall survey, ages $a = 1,2 \ldots 7$, time $t = 1973.5,\ 1974.5\ \ldots\ 1996.5$

$s =$ NMFS spring scallop survey, ages $a =$ 1,2,3,5,6,7, time $t = 1971,\ 1972\ \ldots\ 1996$

All available data were used except when the indices were 0 (logarithm not defined).

Myers and Cadigan (1995) reported that correlated errors among ages within a survey can be sufficiently large to produce model mis-specification biases in estimates of population parameters from standard assessment methods. Their simulation however, showed that maximum likelihood estimators from models which ignored correlation performed similar to those from models which incorporated correlation when the correlated errors were small. An estimate of the correlation among ages within a survey was computed using the standard sample estimator for the coefficient of linear correlation where the pairs of observations were the residuals from each abundance index source: $\left(e_{i,t}, e_{j,t}\right)$ for all ages $i \neq j$ and all times t. For the three survey sources used in this assessment, the correlation was found to be small; DFO spring survey $\hat{\rho} = -0.12$, NMFS spring survey $\hat{\rho} = 0.06$, NMFS fall survey $\hat{\rho} = 0.27$, and NMFS scallop survey $\hat{\rho} = 0.32$. Accordingly, no correction was made for this type of model mis-specification.

The statistical properties of population estimates from the VPA are given in Table 12. The model formulation employed this year provided less biased and more precise estimates than those provided in the last Canadian assessment (Gavaris et al. 1996). Cadrin et al. (1997) completed a detailed examination of the statistical properties of a very closely related VPA model for this stock, and concluded that on average, bootstrap analyses indicated that results from the VPA calibration were insensitive to the effects of minor statistical problems, including trended residuals, correlated errors and outliers.

ASSESSMENT RESULTS

The initial surplus production model fit is shown in Appendix One. In general, the overall fit of the observations to the model appear good (r^2 of 0.692, 0.564 and 0.706 for NMFS fall, spring and DFO spring, respectively). There are some runs of either positive or negative residuals, but the overall magnitude of the residuals appears small. In plotting the results, we have elected not to show the first five years, as Prager (1974) notes that initial biomass values are poorly estimated for the first 3-5 years of the series.

Bootstrapped estimates of model parameters (based on 500 trials) are provided in Appendix Two.

Results from the VPA are summarized in Tables 13 through 16.

Population abundance estimates (total biomass) provided from both assessment models show good concurrence (Fig. 22). Both models indicate a steady decline in population biomass from the early 1970's, an increase in the early 1980's attributable to the strong 1980 year class, then a decrease to under 4000 t in 1988. Biomass has been recovering since then, and in 1996 was estimated as 10,365 and 13,495 t from the surplus production and VPA models, respectively. However, biomass remains low compared to the biomass at maximum sustainable yield, as indicated from the surplus production model (37,540 t).

The VPA and surplus production models produce similar patterns of exploitation rate over time (Fig. 23). Exploitation rate was well above the target level of 20% during the 1983 to 1987 period, declined somewhat during the 1988 to 1994 period, and in 1995-1996 was at the lowest of the values observed in the series.

Recruitment as indicated from the VPA is shown on Fig. 24. Recruitment during the 1980s was considerably poorer than that experienced during the 1970s. Recruitment in the 1990s has generally improved, but no exceptional year-classes were noted, such as those in 1974 and 1980. The strength of the 1995 year-class is uncertain at this point. The VPA indicates that the 1995 year-class is the weakest since the 1986 cohort. However, the 1997 Canadian survey indicated above average numbers of fish at a mode of 25 cm, which probably represents the 1995 year-class. The current VPA also indicates that the 1992 year-class is not as strong as previously estimated.

OUTLOOK

Since two assessment models were used, two projections are provided, with scenarios illustrating exploitation rates equivalent to the status quo F_{96} and for $F_{0.1}$. In the F_{96} option, the fishing mortality in 1997 is equal to that in 1996. The $F_{0.1}$ option implies an exploitation rate of 20% in 1997. The $F_{2/3MSY}$ is the exploitation rate corresponding to two-thirds of the exploitation rate observed at MSY from the surplus production model (see Appendix Three) and is comparable to the $F_{0.1}$ option from the VPA.

		Yield 1997	Biomass 1997	Biomass 1998
F_{96}	VPA	1053	12268	14013
	Production	2014	16856	25321
$F_{0.1}$	VPA	2470	12268	12533
$F_{2/3MSY}$	Production	4526	16856	22336

Status quo yield estimates for 1997 range between 1053-2014 t. Fishing at $F_{0.1}$ in 1997 implies a yield of 2470-4526 t.

Projection results differ because the production model assumes an average long-term population growth rate, while the age-based VPA model use estimated abundance at age and average 1994-1996 stock conditions (partial recruitment, mean weight, maturation).

The assessment of Georges Bank yellowtail flounder is complicated by low levels of sampling. The changing spatial patterns of fishing and low levels of sampling, particularly in 1994 and 1995, contribute to the uncertainty in estimates of recent age composition of both the USA and Canadian catch. In particular, the size of the 1995 year-class is a major source of concern.

Because of such uncertainties, two assessment approaches were employed, each with strengths and weaknesses. For example, the VPA should generate more precise projections, since age structure in the current year is known. However, as indicated earlier, there are significant uncertainties in the age composition of the landings in 1996 which will impact the reliability of the projections. The uncertainty in the size of the 1995 year-class is not a concern in the short-term, as that year-class will not be recruited to the 1997 fishery.

The projections of biomass and fishing mortality from the VPA relative to $F_{0.1}$ also have some uncertainty (Fig. 25). For example, compared with other groundfish resources, a large decrease in yield in 1997 is required to achieve a modest increase in the probability of not exceeding the target mortality or reducing population biomass in 1997. The uncertainty reflected in Fig. 25 does not include other sources such as recent age composition, catch information and variation in natural mortality.

The surplus production approach attempts to capture separate elements of stock dynamics such as growth and recruitment in a simplified model but may have limited ability to project stock status. The model indicator of stock growth is obtained from observations throughout the entire survey series, and may not reflect the most recent stock conditions. In particular, current relatively low biomass levels may be unlikely to produce adequate recruitment, and estimates of yield from the surplus production model may be optimistic. However, use of all available survey information in the surplus production model does allow a description of resource productivity during the entire period, which the VPA does not, due to problems in reconstructing the fishery catch at age prior to 1973.

ACKNOWLEDGMENTS

We thank Dr. Mike Prager for his assistance in the initial setup of the ASPIC model, and his helpfulness in resolving any difficulties we encountered. The VPA model described here is closely related to one developed by S.X. Cadrin and coworkers at the 24th Northeast Regional Stock Assessment Workshop, April, 1997. We thank Steve and our USA NMFS colleagues for their excellent collaboration throughout the assessment process. We also thank Peter Perley and Mike Strong for assistance in construction of the Canadian catch at age and development of the Canadian survey indices, respectively. Heath Stone provided a helpful review of an earlier draft of this document.

LITERATURE CITED

Anon. 1994. Report of the 1994 Fall Regional Assessment Process (RAP) Meeting, 31 October - 2 November, 1994. Biological Station, St. Andrews, New Brunswick.

Cadrin, S.X., Overholtz, W.J., Neilson, J.D., Gavaris, S., and S.E. Wigley. 1997. Stock Assessment of Georges Bank Yellowtail Flounder. Northeast Fisheries Science Center Reference Document 97-xx.

Gavaris, S. 1988. An adaptive framework for the estimation of population size. CAFSAC Res. Doc. 88/29.

Gavaris, S., J.J. Hunt, J.D. Neilson, and F. Page. 1996. Assessment of Georges Bank yellowtail flounder. DFO Atl. Fish. Res. Doc. 96/22.

Lux, F.M. 1963. Identification of New England yellowtail flounder groups. Fish. Bull. 63: 1-10.

Mosely, S.D. 1986. Age structure, growth, and intraspecific growth variations of yellowtail flounder, *Limanda ferruginea* (Storer), on four northeastern United States fishing grounds. Univ. Mass. MS thesis.

Prager, M.H. 1995. User's Manual for ASPIC: A Stock-Production Model Incorporating Covariates, Program Version 3.6x. Southeast Fisheries Science Center, Miami Laboratory. Miami Laboratory Document MIA-92/93-55, Fourth Edition.

Royce, W.F., R.J. Buller, and E.D. Premetz. 1959. Decline of the yellowtail flounder (*Limanda ferruginea*) off New England. Fish. Bull. 146: 169-267.

APPENDIX ONE -- INITIAL MODEL FIT

Georges Bank Yellowtail -- ASPIC 3.6x -- Three Indices Extended Series

16 Apr 1997 at 15:10

ASPIC -- A Surplus-Production Model Including Covariates (Ver. 3.64) FIT Mode

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CONTROL PARAMETERS USED (FROM INPUT FILE)

Number of years analyzed:	34	Number of bootstrap trials:	0
Number of data series:	3	Lower bound on MSY:	1.000E+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:	1.000E+01
Relative conv. criterion (effort):	1.000E-04	Random number seed:	1964285
Maximum F allowed in fitting:	5.000	Monte Carlo search trials:	50000

PROGRAM STATUS INFORMATION (NON-BOOTSTRAPPED ANALYSIS) code 0

Normal convergence.

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

	1	2	3
1 USA Fall Survey	1.000 34		
2 USA Spring Survey	0.755 29	1.000 29	
3 Canadian Survey	0.547 10	0.662 10	1.000 10

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

Loss component number and title	Weighted SSE	N	Weighted MSE	Current weight	Suggested weight	R-squared in CPUE

Loss(-1)	SSE in yield	0.000E+00					
Loss(0)	Penalty for B1R > 2	0.000E+00	1	N/A	1.000E+00	N/A	
Loss(1)	USA Fall Survey	7.842E+00	34	2.451E-01	1.000E+00	9.748E-01	0.692
Loss(2)	USA Spring Survey	7.646E+00	29	2.832E-01	1.000E+00	8.436E-01	0.564
Loss(3)	Canadian Survey	1.242E+00	10	1.552E-01	1.000E+00	1.539E+00	0.706

TOTAL OBJECTIVE FUNCTION: 1.67295690E+01

Number of restarts required for convergence:	86
Est. B-ratio coverage index (0 worst, 2 best):	1.2842
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	1.379E+00	1.548E+00	1	1
MSY	Maximum sustainable yield	1.275E+01	1.110E+01	1	1
r	Intrinsic rate of increase	6.791E-01	6.600E-01	1	1
....	Catchability coefficients by fishery:				
q(1)	USA Fall Survey	1.421E-01	1.229E-01	1	1
q(2)	USA Spring Survey	1.359E-01	1.274E-01	1	1
q(3)	Canadian Survey	3.274E-01	3.020E-01	1	1

MANAGEMENT PARAMETER ESTIMATES (NON-BOOTSTRAPPED)

Parameter		Estimate	Formula	
MSY	Maximum sustainable yield	1.275E+01	Kr/4	
K	Maximum stock biomass	7.511E+01		
Bmsy	Stock biomass at MSY	3.755E+01	K/2	
Fmsy	Fishing mortality at MSY	3.396E-01	r/2	
F(0.1)	Management benchmark	3.056E-01	0.9*Fmsy	
Y(0.1)	Equilibrium yield at F(0.1)	1.263E+01	0.99*MSY	
B-ratio	Ratio of B(1997) to Bmsy	4.541E-01		
F-ratio	Ratio of F(1996) to Fmsy	2.800E-01		
Y-ratio	Proportion of MSY avail in 1997	7.020E-01	2*Br-Br^2	Ye(1997) = 8.952E+00
....	Fishing effort at MSY in units of each fishery:			
fmsy(1)	USA Fall Survey	2.389E+00	r/2q(1)	f(0.1) = 2.150E+00

Georges Bank Yellowtail -- ASPIC 3.6x -- Three Indices Extended Series

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	0.215	5.178E+01	5.169E+01	1.110E+01	1.110E+01	1.095E+01	6.324E-01	1.379E+00
2	1964	0.300	5.162E+01	4.972E+01	1.490E+01	1.490E+01	1.140E+01	8.825E-01	1.375E+00
3	1965	0.322	4.813E+01	4.652E+01	1.500E+01	1.500E+01	1.202E+01	9.496E-01	1.281E+00
4	1966	0.255	4.515E+01	4.546E+01	1.160E+01	1.160E+01	1.219E+01	7.515E-01	1.202E+00
5	1967	0.209	4.573E+01	4.688E+01	9.800E+00	9.800E+00	1.196E+01	6.156E-01	1.218E+00
6	1968	0.314	4.790E+01	4.651E+01	1.460E+01	1.460E+01	1.202E+01	9.245E-01	1.275E+00
7	1969	0.434	4.532E+01	4.219E+01	1.830E+01	1.830E+01	1.253E+01	1.277E+00	1.207E+00
8	1970	0.417	3.955E+01	3.792E+01	1.580E+01	1.580E+01	1.274E+01	1.227E+00	1.053E+00
9	1971	0.338	3.650E+01	3.668E+01	1.240E+01	1.240E+01	1.275E+01	9.956E-01	9.718E-01
10	1972	0.471	3.684E+01	3.485E+01	1.640E+01	1.640E+01	1.268E+01	1.386E+00	9.810E-01
11	1973	0.525	3.312E+01	3.103E+01	1.628E+01	1.628E+01	1.236E+01	1.545E+00	8.819E-01
12	1974	0.576	2.920E+01	2.714E+01	1.562E+01	1.562E+01	1.176E+01	1.695E+00	7.774E-01
13	1975	0.713	2.534E+01	2.247E+01	1.601E+01	1.601E+01	1.067E+01	2.099E+00	6.747E-01
14	1976	0.845	2.000E+01	1.704E+01	1.440E+01	1.440E+01	8.925E+00	2.489E+00	5.325E-01
15	1977	0.760	1.452E+01	1.314E+01	9.985E+00	9.985E+00	7.356E+00	2.239E+00	3.866E-01
16	1978	0.514	1.189E+01	1.223E+01	6.284E+00	6.284E+00	6.952E+00	1.513E+00	3.166E-01
17	1979	0.476	1.256E+01	1.312E+01	6.241E+00	6.241E+00	7.352E+00	1.401E+00	3.344E-01
18	1980	0.488	1.367E+01	1.412E+01	6.896E+00	6.896E+00	7.787E+00	1.438E+00	3.640E-01
19	1981	0.403	1.456E+01	1.561E+01	6.299E+00	6.299E+00	8.395E+00	1.188E+00	3.877E-01
20	1982	0.831	1.666E+01	1.446E+01	1.203E+01	1.203E+01	7.919E+00	2.448E+00	4.436E-01
21	1983	1.229	1.255E+01	9.256E+00	1.138E+01	1.138E+01	5.486E+00	3.620E+00	3.342E-01
22	1984	1.097	6.660E+00	5.313E+00	5.830E+00	5.830E+00	3.349E+00	3.231E+00	1.773E-01
23	1985	0.596	4.179E+00	4.274E+00	2.546E+00	2.546E+00	2.738E+00	1.754E+00	1.113E-01
24	1986	0.718	4.370E+00	4.204E+00	3.020E+00	3.020E+00	2.695E+00	2.116E+00	1.164E-01
25	1987	0.776	4.045E+00	3.790E+00	2.940E+00	2.940E+00	2.444E+00	2.284E+00	1.077E-01
26	1988	0.593	3.549E+00	3.645E+00	2.163E+00	2.163E+00	2.355E+00	1.747E+00	9.450E-02
27	1989	0.258	3.741E+00	4.557E+00	1.176E+00	1.176E+00	2.905E+00	7.600E-01	9.962E-02
28	1990	0.662	5.470E+00	5.383E+00	3.565E+00	3.565E+00	3.394E+00	1.950E+00	1.457E-01
29	1991	0.343	5.299E+00	6.125E+00	2.101E+00	2.101E+00	3.818E+00	1.010E+00	1.411E-01
30	1992	0.712	7.016E+00	6.695E+00	4.768E+00	4.768E+00	4.141E+00	2.097E+00	1.868E-01
31	1993	0.625	6.389E+00	6.379E+00	3.985E+00	3.985E+00	3.964E+00	1.840E+00	1.701E-01
32	1994	0.604	6.369E+00	6.423E+00	3.881E+00	3.881E+00	3.989E+00	1.779E+00	1.696E-01
33	1995	0.094	6.477E+00	8.469E+00	7.990E-01	7.990E-01	5.089E+00	2.778E-01	1.725E-01
34	1996	0.095	1.077E+01	1.374E+01	1.306E+00	1.306E+00	7.593E+00	2.800E-01	2.867E-01
35	1997		1.705E+01						4.541E-01

Georges Bank Yellowtail -- ASPIC 3.6x -- Three Indices Extended Series

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	8.680E-01	1.511E+00	0.2147	1.110E+01	1.110E+01	-0.55428	0.000E+00
2	1964	1.094E+00	2.109E+00	0.2997	1.490E+01	1.490E+01	-0.65639	0.000E+00
3	1965	1.648E+00	2.269E+00	0.3225	1.500E+01	1.500E+01	-0.32001	0.000E+00
4	1966	2.909E+00	1.796E+00	0.2552	1.160E+01	1.160E+01	0.48242	0.000E+00
5	1967	1.294E+00	1.471E+00	0.2090	9.800E+00	9.800E+00	-0.12830	0.000E+00
6	1968	1.386E+00	2.209E+00	0.3139	1.460E+01	1.460E+01	-0.46632	0.000E+00
7	1969	1.972E+00	3.052E+00	0.4338	1.830E+01	1.830E+01	-0.43669	0.000E+00
8	1970	3.173E+00	2.932E+00	0.4167	1.580E+01	1.580E+01	0.07908	0.000E+00
9	1971	1.948E+00	2.379E+00	0.3381	1.240E+01	1.240E+01	-0.19970	0.000E+00
10	1972	2.592E+00	3.311E+00	0.4706	1.640E+01	1.640E+01	-0.24504	0.000E+00
11	1973	2.521E+00	3.692E+00	0.5247	1.628E+01	1.628E+01	-0.38145	0.000E+00
12	1974	4.271E+00	4.049E+00	0.5755	1.562E+01	1.562E+01	0.05336	0.000E+00
13	1975	6.912E+00	5.014E+00	0.7127	1.601E+01	1.601E+01	0.32088	0.000E+00
14	1976	9.589E+00	5.946E+00	0.8451	1.440E+01	1.440E+01	0.47779	0.000E+00
15	1977	3.603E+00	5.349E+00	0.7601	9.985E+00	9.985E+00	-0.39495	0.000E+00
16	1978	2.691E+00	3.616E+00	0.5139	6.284E+00	6.284E+00	-0.29537	0.000E+00
17	1979	4.191E+00	3.348E+00	0.4758	6.241E+00	6.241E+00	0.22476	0.000E+00
18	1980	1.047E+00	3.436E+00	0.4883	6.896E+00	6.896E+00	-1.18824	0.000E+00
19	1981	2.454E+00	2.839E+00	0.4035	6.299E+00	6.299E+00	-0.14588	0.000E+00
20	1982	5.297E+00	5.850E+00	0.8314	1.203E+01	1.203E+01	-0.09924	0.000E+00
21	1983	5.339E+00	8.649E+00	1.2292	1.138E+01	1.138E+01	-0.48238	0.000E+00
22	1984	9.831E+00	7.720E+00	1.0972	5.830E+00	5.830E+00	0.24168	0.000E+00
23	1985	3.592E+00	4.192E+00	0.5958	2.546E+00	2.546E+00	-0.15458	0.000E+00
24	1986	3.684E+00	5.055E+00	0.7184	3.020E+00	3.020E+00	-0.31653	0.000E+00
25	1987	5.776E+00	5.458E+00	0.7757	2.940E+00	2.940E+00	0.05657	0.000E+00
26	1988	1.265E+01	4.175E+00	0.5934	2.163E+00	2.163E+00	1.10829	0.000E+00
27	1989	1.204E+00	1.816E+00	0.2581	1.176E+00	1.176E+00	-0.41116	0.000E+00
28	1990	4.918E+00	4.660E+00	0.6623	3.565E+00	3.565E+00	0.05375	0.000E+00
29	1991	2.878E+00	2.414E+00	0.3430	2.101E+00	2.101E+00	0.17600	0.000E+00
30	1992	8.277E+00	5.011E+00	0.7122	4.768E+00	4.768E+00	0.50184	0.000E+00
31	1993	7.311E+00	4.395E+00	0.6247	3.985E+00	3.985E+00	0.50888	0.000E+00
32	1994	4.327E+00	4.251E+00	0.6042	3.881E+00	3.881E+00	0.01757	0.000E+00
33	1995	2.257E+00	6.639E-01	0.0943	7.990E-01	7.990E-01	1.22375	0.000E+00
34	1996	1.002E+00	6.690E-01	0.0951	1.306E+00	1.306E+00	0.40424	0.000E+00

Georges Bank Yellowtail -- ASPIC 3.6x -- Three Indices Extended Series

UNWEIGHTED LOG RESIDUAL PLOT FOR DATA SERIES # 1

```
                  -2       -1.5      -1        -0.5       0        0.5        1        1.5        2
                  |    .    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |
Year   Residual   ----------------------------------------------------------------------------------
1963   -0.5543                                 ===========|
1964   -0.6564                               =============|
1965   -0.3200                                      ======|
1966    0.4824                                            |==========
1967   -0.1283                                         ===|
1968   -0.4663                                   =========|
1969   -0.4367                                   =========|
1970    0.0791                                            |==
1971   -0.1997                                        ====|
1972   -0.2450                                       =====|
1973   -0.3815                                    ========|
1974    0.0534                                            |=
1975    0.3209                                            |======
1976    0.4778                                            |==========
1977   -0.3950                                    ========|
1978   -0.2954                                      ======|
1979    0.2248                                            |====
1980   -1.1882                  ========================|
1981   -0.1459                                         ===|
1982   -0.0992                                          ==|
1983   -0.4824                                  ==========|
1984    0.2417                                            |=====
1985   -0.1546                                         ===|
1986   -0.3165                                      ======|
1987    0.0566                                            |=
1988    1.1083                                            |======================
1989   -0.4112                                    ========|
1990    0.0538                                            |=
1991    0.1760                                            |====
1992    0.5018                                            |==========
1993    0.5089                                            |==========
1994    0.0176                                            |
1995    1.2238                                            |========================
1996    0.4042                                            |========
                  ----------------------------------------------------------------------------------
```

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

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	*	7.037E+00	0.00000	0.0
2	1964	0.000E+00	0.000E+00	0.0	*	7.016E+00	0.00000	0.0
3	1965	0.000E+00	0.000E+00	0.0	*	6.541E+00	0.00000	0.0
4	1966	0.000E+00	0.000E+00	0.0	*	6.136E+00	0.00000	0.0
5	1967	0.000E+00	0.000E+00	0.0	*	6.216E+00	0.00000	0.0
6	1968	1.000E+00	1.000E+00	0.0	2.813E+00	6.510E+00	-0.83905	-3.697E+00
7	1969	1.000E+00	1.000E+00	0.0	1.117E+01	6.160E+00	0.59523	5.010E+00
8	1970	1.000E+00	1.000E+00	0.0	5.312E+00	5.376E+00	-0.01195	-6.385E-02
9	1971	1.000E+00	1.000E+00	0.0	4.607E+00	4.961E+00	-0.07394	-3.535E-01
10	1972	1.000E+00	1.000E+00	0.0	6.450E+00	5.007E+00	0.25315	1.443E+00
11	1973	1.000E+00	1.000E+00	0.0	2.938E+00	4.501E+00	-0.42664	-1.563E+00
12	1974	1.000E+00	1.000E+00	0.0	2.719E+00	3.968E+00	-0.37806	-1.249E+00
13	1975	1.000E+00	1.000E+00	0.0	1.676E+00	3.444E+00	-0.72014	-1.768E+00
14	1976	1.000E+00	1.000E+00	0.0	2.273E+00	2.718E+00	-0.17875	-4.449E-01
15	1977	1.000E+00	1.000E+00	0.0	9.990E-01	1.973E+00	-0.68081	-9.745E-01
16	1978	1.000E+00	1.000E+00	0.0	7.420E-01	1.616E+00	-0.77844	-8.741E-01
17	1979	1.000E+00	1.000E+00	0.0	1.227E+00	1.707E+00	-0.33014	-4.800E-01
18	1980	1.000E+00	1.000E+00	0.0	4.456E+00	1.858E+00	0.87475	2.598E+00
19	1981	1.000E+00	1.000E+00	0.0	1.960E+00	1.979E+00	-0.00970	-1.910E-02
20	1982	1.000E+00	1.000E+00	0.0	2.500E+00	2.264E+00	0.09914	2.360E-01
21	1983	1.000E+00	1.000E+00	0.0	2.642E+00	1.706E+00	0.43743	9.361E-01
22	1984	1.000E+00	1.000E+00	0.0	1.646E+00	9.052E-01	0.59794	7.408E-01
23	1985	1.000E+00	1.000E+00	0.0	9.880E-01	5.680E-01	0.55364	4.200E-01
24	1986	1.000E+00	1.000E+00	0.0	8.470E-01	5.939E-01	0.35494	2.531E-01
25	1987	1.000E+00	1.000E+00	0.0	3.290E-01	5.498E-01	-0.51341	-2.208E-01
26	1988	1.000E+00	1.000E+00	0.0	5.660E-01	4.824E-01	0.15992	8.365E-02
27	1989	1.000E+00	1.000E+00	0.0	7.290E-01	5.085E-01	0.36021	2.205E-01
28	1990	1.000E+00	1.000E+00	0.0	6.990E-01	7.435E-01	-0.06168	-4.447E-02
29	1991	1.000E+00	1.000E+00	0.0	6.310E-01	7.202E-01	-0.13216	-8.915E-02
30	1992	1.000E+00	1.000E+00	0.0	1.566E+00	9.536E-01	0.49606	6.124E-01
31	1993	1.000E+00	1.000E+00	0.0	4.820E-01	8.684E-01	-0.58873	-3.864E-01
32	1994	1.000E+00	1.000E+00	0.0	6.600E-01	8.656E-01	-0.27123	-2.056E-01
33	1995	1.000E+00	1.000E+00	0.0	2.579E+00	8.804E-01	1.07482	1.699E+00
34	1996	1.000E+00	1.000E+00	0.0	2.853E+00	1.463E+00	0.66756	1.390E+00

* Asterisk indicates missing value(s).

Georges Bank Yellowtail -- ASPIC 3.6x -- Three Indices Extended Series

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    -0.8390                             =================|
1969     0.5952                                              |============
1970    -0.0119                                              |
1971    -0.0739                                             =|
1972     0.2531                                              |=====
1973    -0.4266                                     =========|
1974    -0.3781                                      ========|
1975    -0.7201                                ==============|
1976    -0.1788                                          ====|
1977    -0.6808                                ==============|
1978    -0.7784                              ================|
1979    -0.3301                                       =======|
1980     0.8748                                              |=================
1981    -0.0097                                              |
1982     0.0991                                              |==
1983     0.4374                                              |=========
1984     0.5979                                              |============
1985     0.5536                                              |===========
1986     0.3549                                              |=======
1987    -0.5134                                    ==========|
1988     0.1599                                              |===
1989     0.3602                                              |=======
1990    -0.0617                                             =|
1991    -0.1322                                           ===|
1992     0.4961                                              |==========
1993    -0.5887                                  ============|
1994    -0.2712                                         =====|
1995     1.0748                                              |=====================
1996     0.6676                                              |=============
                   -------------------------------------------------------------------------------------
```

Georges Bank Yellowtail -- ASPIC 3.6x -- Three Indices Extended Series

RESULTS FOR DATA SERIES # 3 (NON-BOOTSTRAPPED) Canadian Survey

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	*	1.695E+01	0.00000	0.0
2	1964	0.000E+00	0.000E+00	0.0	*	1.690E+01	0.00000	0.0
3	1965	0.000E+00	0.000E+00	0.0	*	1.575E+01	0.00000	0.0
4	1966	0.000E+00	0.000E+00	0.0	*	1.478E+01	0.00000	0.0
5	1967	0.000E+00	0.000E+00	0.0	*	1.497E+01	0.00000	0.0
6	1968	0.000E+00	0.000E+00	0.0	*	1.568E+01	0.00000	0.0
7	1969	0.000E+00	0.000E+00	0.0	*	1.484E+01	0.00000	0.0
8	1970	0.000E+00	0.000E+00	0.0	*	1.295E+01	0.00000	0.0
9	1971	0.000E+00	0.000E+00	0.0	*	1.195E+01	0.00000	0.0
10	1972	0.000E+00	0.000E+00	0.0	*	1.206E+01	0.00000	0.0
11	1973	0.000E+00	0.000E+00	0.0	*	1.084E+01	0.00000	0.0
12	1974	0.000E+00	0.000E+00	0.0	*	9.558E+00	0.00000	0.0
13	1975	0.000E+00	0.000E+00	0.0	*	8.294E+00	0.00000	0.0
14	1976	0.000E+00	0.000E+00	0.0	*	6.546E+00	0.00000	0.0
15	1977	0.000E+00	0.000E+00	0.0	*	4.753E+00	0.00000	0.0
16	1978	0.000E+00	0.000E+00	0.0	*	3.893E+00	0.00000	0.0
17	1979	0.000E+00	0.000E+00	0.0	*	4.111E+00	0.00000	0.0
18	1980	0.000E+00	0.000E+00	0.0	*	4.475E+00	0.00000	0.0
19	1981	0.000E+00	0.000E+00	0.0	*	4.767E+00	0.00000	0.0
20	1982	0.000E+00	0.000E+00	0.0	*	5.453E+00	0.00000	0.0
21	1983	0.000E+00	0.000E+00	0.0	*	4.109E+00	0.00000	0.0
22	1984	0.000E+00	0.000E+00	0.0	*	2.180E+00	0.00000	0.0
23	1985	0.000E+00	0.000E+00	0.0	*	1.368E+00	0.00000	0.0
24	1986	0.000E+00	0.000E+00	0.0	*	1.431E+00	0.00000	0.0
25	1987	1.000E+00	1.000E+00	0.0	1.264E+00	1.324E+00	-0.04646	-6.011E-02
26	1988	1.000E+00	1.000E+00	0.0	1.235E+00	1.162E+00	0.06112	7.322E-02
27	1989	1.000E+00	1.000E+00	0.0	4.710E-01	1.225E+00	-0.95564	-7.538E-01
28	1990	1.000E+00	1.000E+00	0.0	1.578E+00	1.791E+00	-0.12644	-2.127E-01
29	1991	1.000E+00	1.000E+00	0.0	1.759E+00	1.735E+00	0.01401	2.446E-02
30	1992	1.000E+00	1.000E+00	0.0	2.475E+00	2.297E+00	0.07474	1.782E-01
31	1993	1.000E+00	1.000E+00	0.0	2.642E+00	2.092E+00	0.23359	5.504E-01
32	1994	1.000E+00	1.000E+00	0.0	2.753E+00	2.085E+00	0.27795	6.681E-01
33	1995	1.000E+00	1.000E+00	0.0	2.027E+00	2.120E+00	-0.04506	-9.342E-02
34	1996	1.000E+00	1.000E+00	0.0	5.304E+00	3.525E+00	0.40862	1.779E+00

* Asterisk indicates missing value(s).

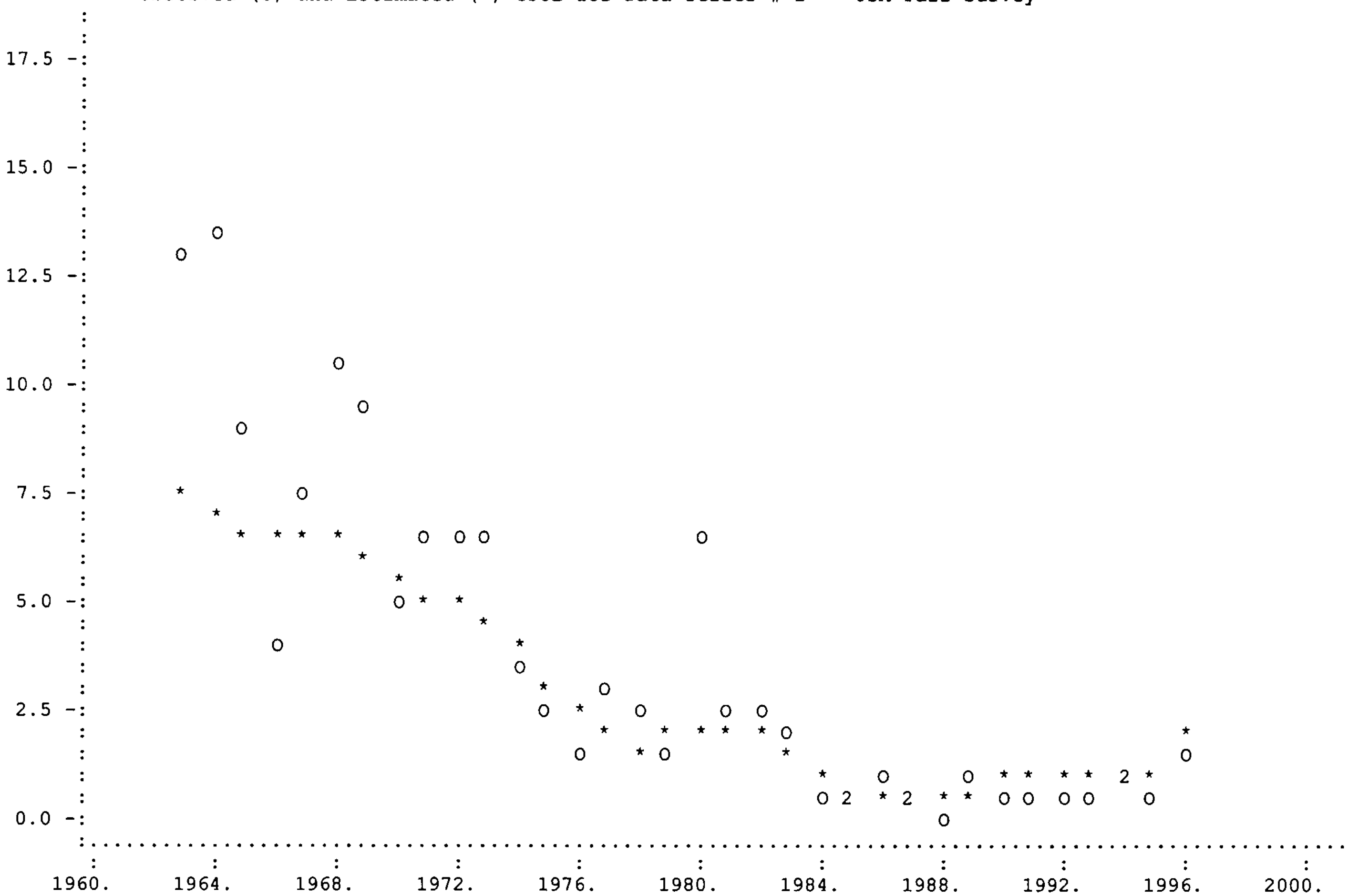
Georges Bank Yellowtail -- ASPIC 3.6x -- Three Indices Extended Series

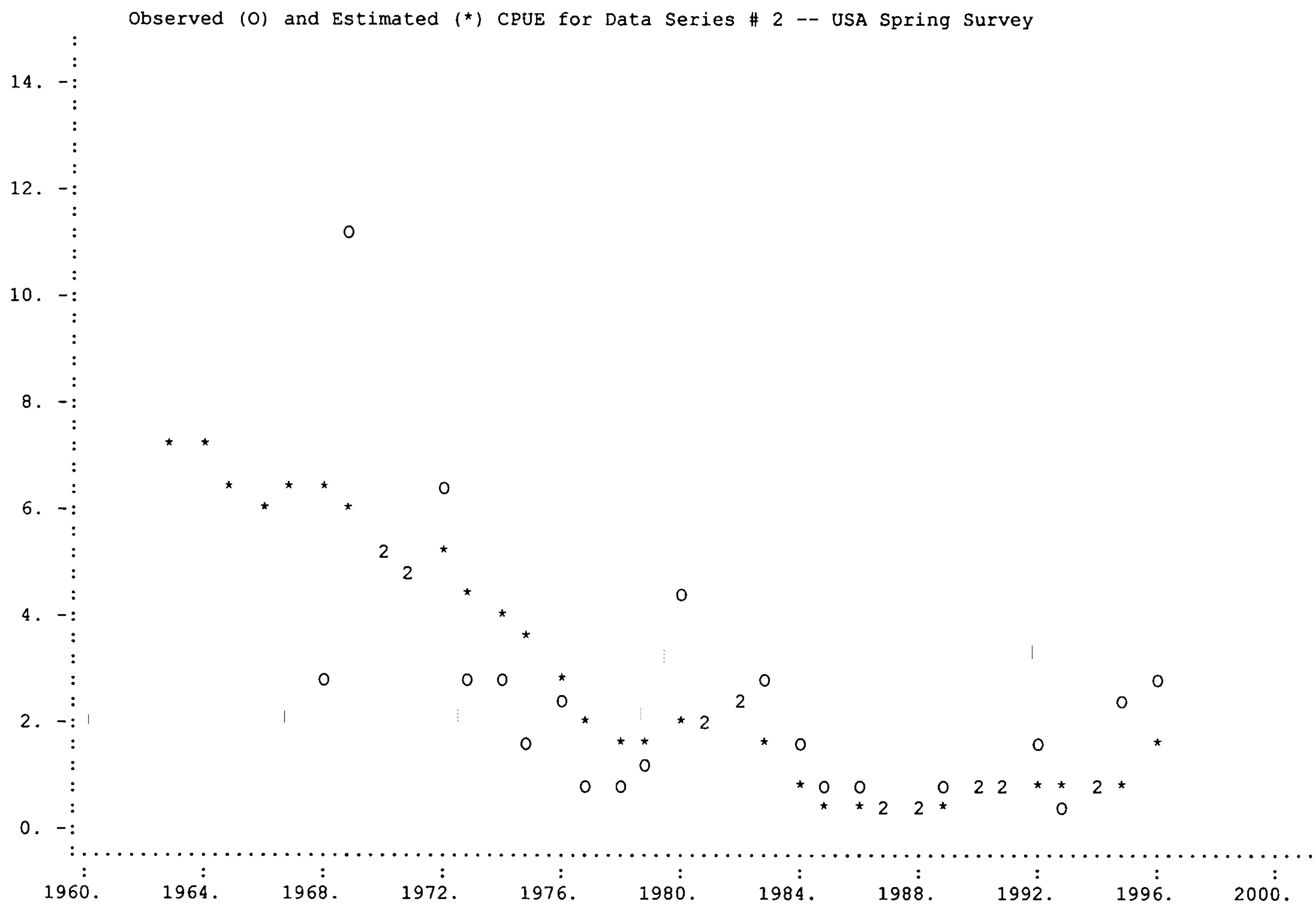
UNWEIGHTED LOG RESIDUAL PLOT FOR DATA SERIES # 3

```
                 -1       -0.75     -0.5      -0.25       0        0.25      0.5       0.75       1
                  |    .    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |
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     0.0000                                           |
1987    -0.0465                                         ==|
1988     0.0611                                           |==
1989    -0.9556     ======================================|
1990    -0.1264                                      =====|
1991     0.0140                                           |=
1992     0.0747                                           |===
1993     0.2336                                           |=========
1994     0.2779                                           |===========
1995    -0.0451                                         ==|
1996     0.4086                                           |================
                 ------------------------------------------------------------------------------------
```

Georges Bank Yellowtail -- ASPIC 3.6x -- Three Indices Extended Series

Observed (O) and Estimated (*) CPUE for Data Series # 1 -- USA Fall Survey

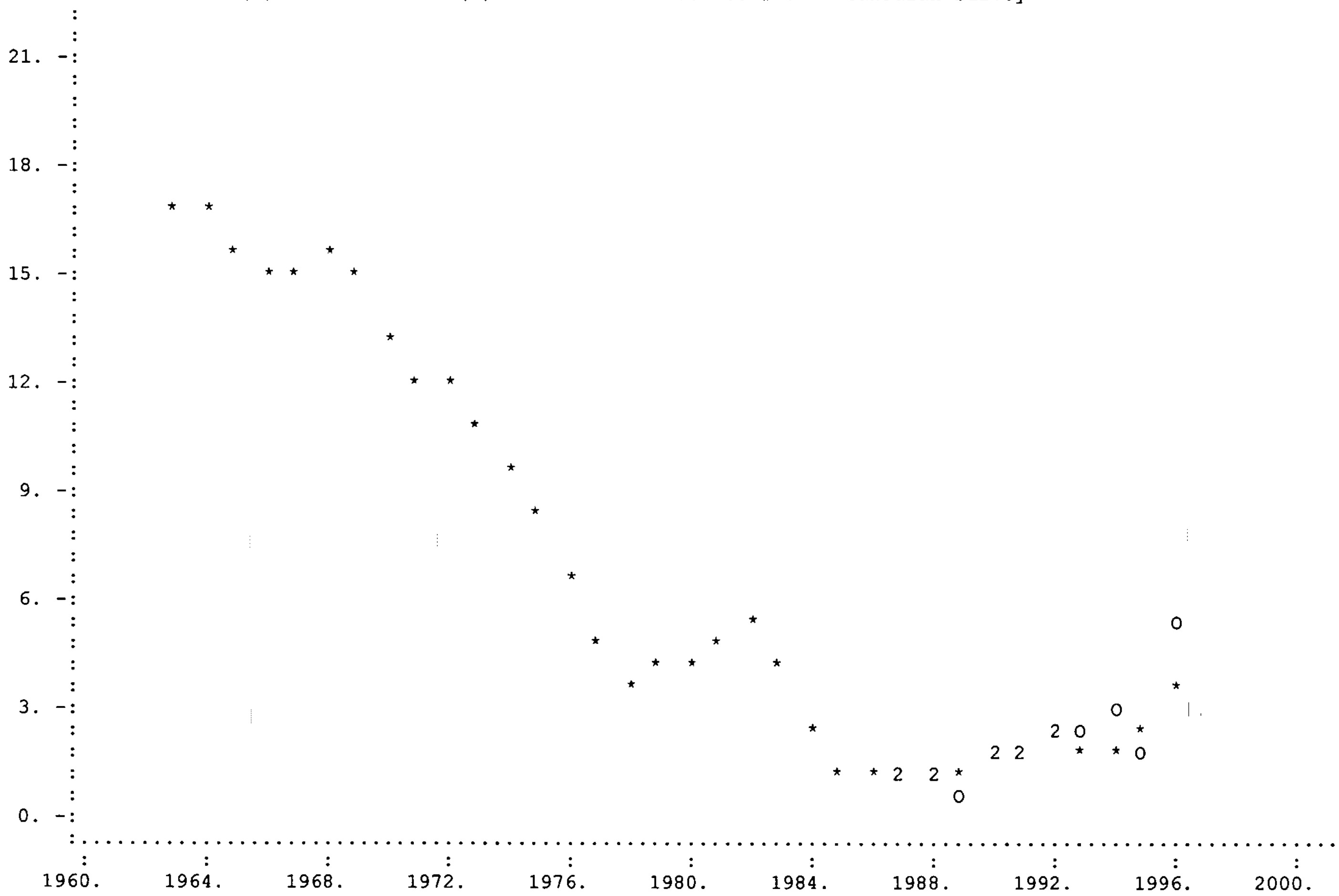




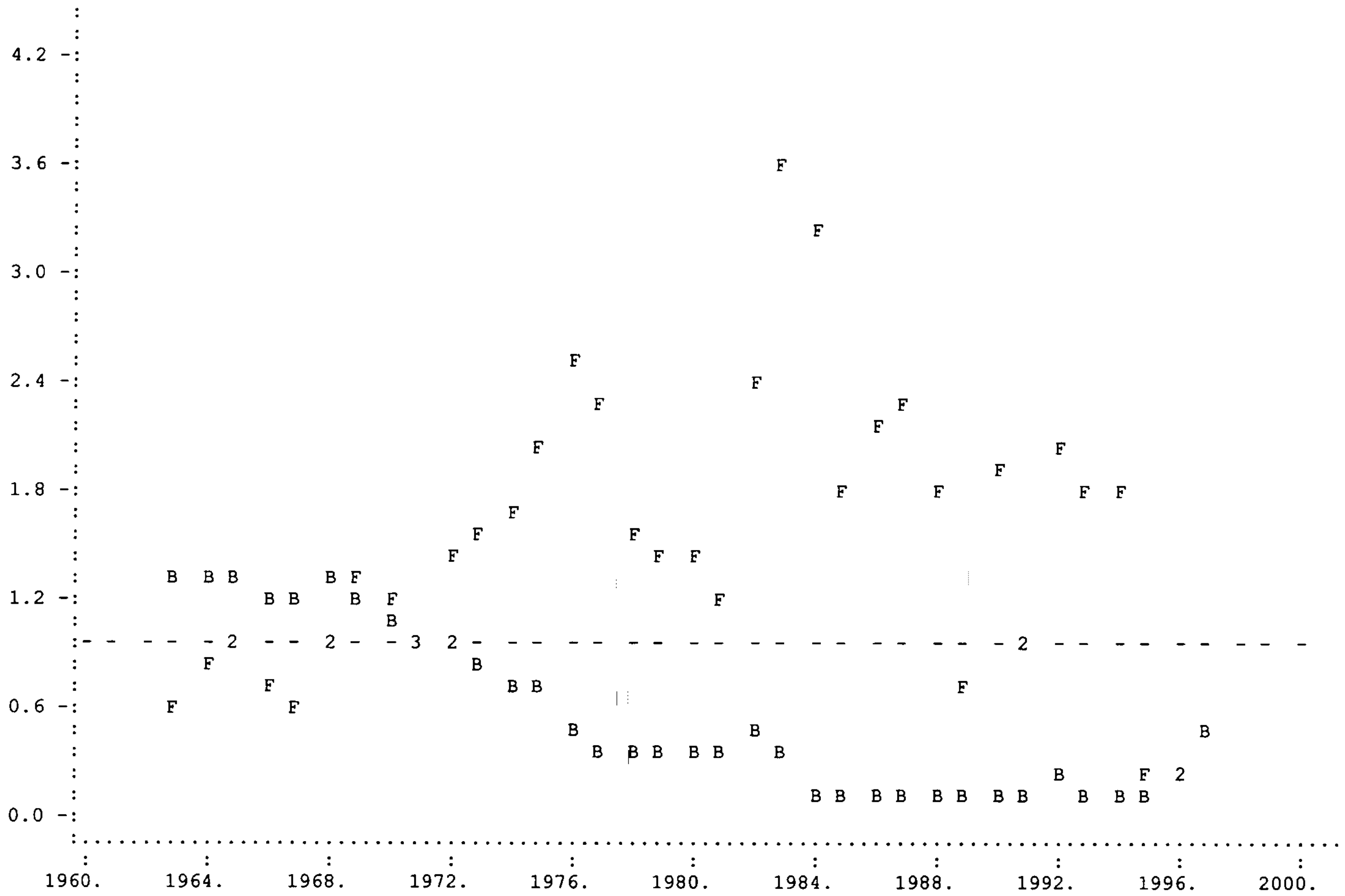
Observed (O) and Estimated (*) CPUE for Data Series # 2 -- USA Spring Survey
14.
12.
10.
8.
6.
4.
2.
0.
1960.
1964.
1968.
1972.
1976.
1980.
1984.
1988.
1992.
1996.
2000.

Georges Bank Yellowtail -- ASPIC 3.6x -- Three Indices Extended Series

Observed (O) and Estimated (*) CPUE for Data Series # 3 -- Canadian Survey



Time Plot of Estimated F-Ratio and B-Ratio



APPENDIX TWO -- BOOTSTRAPPED ESIIMATES OF MODEL PARAMETERS (500 TRIALS)

Georges Bank Yellowtail -- ASPIC 3.6x -- Three Indices Extended Series

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	1.366E+00	1.379E+00	0.94%	9.224E-01	1.460E+00	1.313E+00	1.395E+00	8.111E-02	0.059
K	7.508E+01	7.511E+01	0.03%	7.091E+01	8.822E+01	7.338E+01	7.812E+01	4.739E+00	0.063
r	6.798E-01	6.791E-01	-0.10%	5.456E-01	7.278E-01	6.428E-01	6.981E-01	5.529E-02	0.081
q(1)	1.445E-01	1.421E-01	-1.66%	1.322E-01	1.205E+00	1.407E-01	1.511E-01	1.042E-02	0.072
q(2)	1.409E-01	1.359E-01	-3.53%	1.249E-01	1.450E+00	1.336E-01	1.528E-01	1.923E-02	0.136
q(3)	3.367E-01	3.274E-01	-2.79%	2.678E-01	1.748E+00	3.137E-01	3.735E-01	5.971E-02	0.177
MSY	1.276E+01	1.275E+01	-0.04%	1.185E+01	1.291E+01	1.264E+01	1.282E+01	1.809E-01	0.014
Ye(1997)	8.988E+00	8.952E+00	-0.40%	6.815E+00	1.067E+01	7.925E+00	9.912E+00	1.987E+00	0.221
Bmsy	3.754E+01	3.755E+01	0.03%	3.545E+01	4.411E+01	3.669E+01	3.906E+01	2.369E+00	0.063
Fmsy	3.399E-01	3.396E-01	-0.10%	2.728E-01	3.639E-01	3.214E-01	3.491E-01	2.765E-02	0.081
fmsy(1)	2.347E+00	2.389E+00	1.79%	2.075E+00	2.508E+00	2.221E+00	2.414E+00	1.933E-01	0.082
fmsy(2)	2.441E+00	2.498E+00	2.36%	1.983E+00	2.679E+00	2.287E+00	2.555E+00	2.677E-01	0.110
fmsy(3)	1.009E+00	1.037E+00	2.82%	8.159E-01	1.184E+00	9.177E-01	1.080E+00	1.623E-01	0.161
F(0.1)	3.059E-01	3.056E-01	-0.09%	2.455E-01	3.275E-01	2.893E-01	3.141E-01	2.488E-02	0.081
Y(0.1)	1.263E+01	1.263E+01	-0.04%	1.174E+01	1.278E+01	1.252E+01	1.270E+01	1.791E-01	0.014
B-ratio	4.490E-01	4.541E-01	1.13%	3.221E-01	5.847E-01	3.857E-01	5.244E-01	1.387E-01	0.309
F-ratio	2.816E-01	2.800E-01	-0.56%	2.156E-01	3.925E-01	2.412E-01	3.311E-01	8.993E-02	0.319
Y-ratio	6.966E-01	7.020E-01	0.78%	5.405E-01	8.275E-01	6.226E-01	7.744E-01	1.518E-01	0.218
f0.1(1)	2.113E+00	2.150E+00	1.61%	1.867E+00	2.257E+00	1.999E+00	2.173E+00	1.740E-01	0.082
f0.1(2)	2.197E+00	2.249E+00	2.13%	1.784E+00	2.411E+00	2.058E+00	2.299E+00	2.409E-01	0.110
f0.1(3)	9.080E-01	9.336E-01	2.54%	7.343E-01	1.066E+00	8.259E-01	9.720E-01	1.461E-01	0.161
q2/q1	9.540E-01	9.563E-01	0.24%	8.424E-01	1.098E+00	8.882E-01	1.011E+00	1.232E-01	0.129
q3/q1	2.315E+00	2.303E+00	-0.49%	1.877E+00	2.757E+00	2.116E+00	2.521E+00	4.046E-01	0.175

NOTES ON BOOTSTRAPPED ESTIMATES:

- The bootstrapped results shown were computed from 500 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:          29
Trials replaced for MSY out-of-bounds:            15
Trials replaced for r out-of-bounds:              15
Residual-adjustment factor:                   1.0438
```

APPENDIX THREE -- PROJECTION AT 2/3 F_{msy}

Georges Bank Yellowtail -- ASPIC 3.6x -- Three Indices Extended Series Output from ASPIC-P.EXE Page 1
Bootstrap Run of Georges Bank Yellowtail (data: S.Gavaris) 23 Apr 1997 at 15:29

USER CONTROL INFORMATION (FROM INPUT FILE)

Name of biomass (BIO) file	aspic.bio
Name of output file (this file)	ytf23msy.prj
Number of years of projections	1

Year	Input data	User data type
1997	2.400E+00	F:F(1996)

TRAJECTORY OF RELATIVE 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	1.366E+00	1.379E+00	0.94%	9.224E-01	1.460E+00	1.313E+00	1.395E+00	8.111E-02	0.059
1964	1.365E+00	1.375E+00	0.73%	1.058E+00	1.439E+00	1.326E+00	1.387E+00	6.158E-02	0.045
1965	1.274E+00	1.281E+00	0.61%	1.054E+00	1.324E+00	1.243E+00	1.291E+00	4.780E-02	0.038
1966	1.195E+00	1.202E+00	0.58%	1.039E+00	1.233E+00	1.172E+00	1.209E+00	3.662E-02	0.031
1967	1.211E+00	1.218E+00	0.53%	1.102E+00	1.243E+00	1.188E+00	1.222E+00	3.448E-02	0.028
1968	1.269E+00	1.275E+00	0.48%	1.080E+00	1.292E+00	1.229E+00	1.278E+00	4.836E-02	0.038
1969	1.202E+00	1.207E+00	0.42%	1.040E+00	1.219E+00	1.167E+00	1.209E+00	4.140E-02	0.034
1970	1.051E+00	1.053E+00	0.21%	7.154E-01	1.066E+00	1.029E+00	1.056E+00	2.656E-02	0.025
1971	9.700E-01	9.718E-01	0.19%	4.809E-01	9.823E-01	9.509E-01	9.740E-01	2.308E-02	0.024
1972	9.786E-01	9.810E-01	0.25%	2.604E-01	9.917E-01	9.501E-01	9.834E-01	3.323E-02	0.034
1973	8.799E-01	8.819E-01	0.22%	2.117E-01	8.908E-01	8.501E-01	8.836E-01	3.349E-02	0.038
1974	7.760E-01	7.774E-01	0.19%	1.854E-01	7.847E-01	7.503E-01	7.788E-01	2.850E-02	0.037
1975	6.735E-01	6.747E-01	0.18%	1.697E-01	6.808E-01	6.516E-01	6.757E-01	2.415E-02	0.036
1976	5.316E-01	5.325E-01	0.16%	1.597E-01	5.500E-01	5.201E-01	5.332E-01	1.311E-02	0.025
1977	3.865E-01	3.866E-01	0.04%	2.474E-01	4.073E-01	3.807E-01	3.896E-01	3.364E-03	0.009
1978	3.165E-01	3.166E-01	0.05%	3.100E-01	3.478E-01	3.138E-01	3.206E-01	6.753E-03	0.021
1979	3.343E-01	3.344E-01	0.05%	3.285E-01	3.636E-01	3.318E-01	3.380E-01	6.191E-03	0.019
1980	3.639E-01	3.640E-01	0.03%	2.833E-01	3.872E-01	3.623E-01	3.664E-01	4.085E-03	0.011
1981	3.874E-01	3.877E-01	0.08%	2.225E-01	4.028E-01	3.819E-01	3.899E-01	3.111E-03	0.008
1982	4.429E-01	4.436E-01	0.14%	3.297E-01	4.498E-01	4.324E-01	4.456E-01	1.319E-02	0.030
1983	3.339E-01	3.342E-01	0.08%	2.779E-01	3.405E-01	3.267E-01	3.365E-01	6.985E-03	0.021
1984	1.770E-01	1.773E-01	0.17%	1.385E-01	1.850E-01	1.736E-01	1.784E-01	4.012E-03	0.023
1985	1.111E-01	1.113E-01	0.12%	9.858E-02	1.190E-01	1.098E-01	1.119E-01	1.470E-03	0.013
1986	1.162E-01	1.164E-01	0.13%	1.153E-01	1.231E-01	1.157E-01	1.169E-01	1.203E-03	0.010
1987	1.075E-01	1.077E-01	0.21%	1.056E-01	1.177E-01	1.067E-01	1.087E-01	1.471E-03	0.014
1988	9.409E-02	9.450E-02	0.44%	9.162E-02	1.063E-01	9.297E-02	9.576E-02	2.680E-03	0.028

1989	9.901E-02	9.962E-02	0.62%	9.521E-02	1.120E-01	9.721E-02	1.008E-01	3.599E-03	0.036
1990	1.449E-01	1.457E-01	0.55%	1.396E-01	1.613E-01	1.424E-01	1.483E-01	3.755E-03	0.026
1991	1.394E-01	1.411E-01	1.20%	1.232E-01	1.527E-01	1.372E-01	1.434E-01	6.202E-03	0.044
1992	1.843E-01	1.868E-01	1.35%	1.452E-01	1.973E-01	1.792E-01	1.920E-01	9.562E-03	0.052
1993	1.657E-01	1.701E-01	2.69%	1.429E-01	1.869E-01	1.580E-01	1.762E-01	1.565E-02	0.094
1994	1.623E-01	1.696E-01	4.49%	1.380E-01	1.925E-01	1.487E-01	1.779E-01	2.724E-02	0.168
1995	1.621E-01	1.725E-01	6.40%	1.236E-01	2.120E-01	1.414E-01	1.861E-01	4.464E-02	0.275
1996	2.761E-01	2.867E-01	3.84%	1.960E-01	3.671E-01	2.411E-01	3.222E-01	8.113E-02	0.294
1997	4.490E-01	4.541E-01	1.13%	3.221E-01	5.847E-01	3.857E-01	5.244E-01	1.387E-01	0.309
1998	5.950E-01	5.966E-01	0.27%	4.054E-01	7.786E-01	4.950E-01	6.920E-01	1.970E-01	0.331

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

TRAJECTORY OF RELATIVE 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	6.371E-01	6.324E-01	-0.74%	6.090E-01	8.223E-01	6.280E-01	6.758E-01	4.778E-02	0.075
1964	8.884E-01	8.825E-01	-0.67%	8.579E-01	1.047E+00	8.776E-01	9.346E-01	5.698E-02	0.064
1965	9.556E-01	9.496E-01	-0.63%	9.298E-01	1.140E+00	9.464E-01	9.989E-01	5.254E-02	0.055
1966	7.553E-01	7.515E-01	-0.51%	7.374E-01	8.759E-01	7.491E-01	7.899E-01	4.080E-02	0.054
1967	6.181E-01	6.156E-01	-0.40%	6.056E-01	7.210E-01	6.138E-01	6.518E-01	3.795E-02	0.061
1968	9.276E-01	9.245E-01	-0.33%	9.065E-01	1.045E+00	9.199E-01	9.617E-01	4.179E-02	0.045
1969	1.280E+00	1.277E+00	-0.20%	1.255E+00	1.414E+00	1.272E+00	1.310E+00	3.873E-02	0.030
1970	1.228E+00	1.227E+00	-0.09%	1.207E+00	1.359E+00	1.220E+00	1.251E+00	3.074E-02	0.025
1971	9.958E-01	9.956E-01	-0.02%	9.779E-01	1.086E+00	9.888E-01	1.012E+00	2.335E-02	0.023
1972	1.385E+00	1.386E+00	0.03%	1.360E+00	1.487E+00	1.374E+00	1.407E+00	3.242E-02	0.023
1973	1.544E+00	1.545E+00	0.07%	1.514E+00	1.657E+00	1.531E+00	1.566E+00	3.483E-02	0.023
1974	1.693E+00	1.695E+00	0.10%	1.661E+00	1.804E+00	1.678E+00	1.715E+00	3.649E-02	0.022
1975	2.098E+00	2.099E+00	0.02%	2.057E+00	2.219E+00	2.080E+00	2.124E+00	4.409E-02	0.021
1976	2.489E+00	2.489E+00	0.00%	2.452E+00	2.576E+00	2.477E+00	2.512E+00	3.424E-02	0.014
1977	2.239E+00	2.239E+00	-0.01%	2.207E+00	2.285E+00	2.230E+00	2.252E+00	3.110E-03	0.001
1978	1.513E+00	1.513E+00	0.00%	1.488E+00	1.523E+00	1.508E+00	1.517E+00	8.442E-03	0.006
1979	1.401E+00	1.401E+00	0.01%	1.385E+00	1.433E+00	1.397E+00	1.408E+00	2.273E-03	0.002
1980	1.438E+00	1.438E+00	0.03%	1.420E+00	1.497E+00	1.431E+00	1.447E+00	1.465E-02	0.010
1981	1.187E+00	1.188E+00	0.13%	1.165E+00	1.276E+00	1.177E+00	1.205E+00	2.500E-02	0.021
1982	2.448E+00	2.448E+00	0.03%	2.374E+00	2.697E+00	2.418E+00	2.506E+00	8.861E-02	0.036
1983	3.618E+00	3.620E+00	0.04%	3.523E+00	3.914E+00	3.579E+00	3.693E+00	1.139E-01	0.031
1984	3.231E+00	3.231E+00	0.01%	3.185E+00	3.465E+00	3.212E+00	3.266E+00	3.788E-02	0.012
1985	1.756E+00	1.754E+00	-0.08%	1.744E+00	1.867E+00	1.751E+00	1.763E+00	3.995E-03	0.002
1986	2.119E+00	2.116E+00	-0.16%	2.083E+00	2.196E+00	2.112E+00	2.125E+00	5.559E-03	0.003
1987	2.289E+00	2.284E+00	-0.22%	2.210E+00	2.327E+00	2.274E+00	2.304E+00	2.342E-02	0.010
1988	1.752E+00	1.747E+00	-0.27%	1.637E+00	1.807E+00	1.732E+00	1.774E+00	4.214E-02	0.024
1989	7.633E-01	7.600E-01	-0.43%	7.286E-01	7.907E-01	7.533E-01	7.718E-01	1.855E-02	0.024
1990	1.969E+00	1.950E+00	-0.92%	1.894E+00	2.780E+00	1.934E+00	1.998E+00	5.230E-02	0.027
1991	1.019E+00	1.010E+00	-0.89%	9.749E-01	1.823E+00	9.909E-01	1.039E+00	4.106E-02	0.040
1992	2.131E+00	2.097E+00	-1.60%	1.977E+00	3.086E+00	2.050E+00	2.205E+00	1.370E-01	0.064
1993	1.876E+00	1.840E+00	-1.96%	1.624E+00	2.079E+00	1.735E+00	1.985E+00	2.126E-01	0.113
1994	1.836E+00	1.779E+00	-3.11%	1.476E+00	2.306E+00	1.630E+00	2.026E+00	3.703E-01	0.202
1995	2.847E-01	2.778E-01	-2.41%	2.170E-01	3.995E-01	2.474E-01	3.291E-01	8.169E-02	0.287
1996	2.816E-01	2.800E-01	-0.56%	2.156E-01	3.925E-01	2.412E-01	3.311E-01	8.993E-02	0.319
1997	6.758E-01	6.720E-01	-0.56%	5.175E-01	9.420E-01	5.788E-01	7.947E-01	2.158E-01	0.319

TABLE OF PROJECTED YIELDS

1997	4.526E+00	4.493E+00	-0.74%	4.370E+00	4.625E+00	4.472E+00	4.566E+00	9.400E-02	0.021

Table 1. Landings of yellowtail flounder ('000s t) from Georges Bank by the United States and Canada, 1973 to 1996. The 1994-1996 landings for the United States are provided by S. Cadrin, NMFS, Woods Hole, earlier values are from Anon. (1994b).

	USA		Canada	
	Landings	Discards	Yellowtail	Unspecified flatfish
1973	15.9	0.4	0	<0.1
1974	14.6	1.0	0	<0.1
1975	13.2	2.8	0	<0.1
1976	11.3	3.1	0	<0.1
1977	9.4	0.6	0	<0.1
1978	4.5	1.8	0	<0.1
1979	5.5	0.7	0	<0.1
1980	6.5	0.4	0	<0.1
1981	6.2	0.1	0	<0.1
1982	10.6	1.4	0	<0.1
1983	11.3	0.1	0	<0.1
1984	5.8	0.0	0	<0.1
1985	2.5	0.0	0	<0.1
1986	3.0	0.0	0	<0.1
1987	2.7	0.2	0	<0.1
1988	1.9	0.3	0	<0.1
1989	1.1	0.1	<0.1	<0.1
1990	2.7	0.9	<0.1	<0.1
1991	1.8	0.3	<0.1	<0.1
1992	2.8	2.0	<0.1	<0.1
1993	2.1	1.2	0.2	0.6
1994	1.6	0.1	1.3	0.8
1995	0.3	<0.1	0.4	0.1
1996	0.8	0.1	0.4	<0.1

Table 2. Canadian landings (t) of known yellowtail flounder in 5Zjmhn, by gear type and month, 1993-1996

Year	Month	Otter Trawl	Scallop Drag	Total
1993	Jan	0	0	0
	Feb	0	0	0
	Mar	0	2	2
	Apr	0	3	3
	May	0	4	4
	Jun	6	1	7
	Jul	0	0	0
	Aug	4	1	5
	Sep	0	1	1
	Oct	66	3	69
	Nov	47	0	47
	Dec	13	0	13
Total		137	15	152
1994	Feb	0	1	1
	Mar	0	3	3
	Apr	0	3	3
	May	0	5	5
	Jun	67	2	68
	Jul	181	1	182
	Aug	359	2	360
	Sep	650	1	651
	Oct	52	2	54
	Nov	0	0	0
	Dec	0	0	0
Total		1308	20	1328
1995	Jan	0	0	0
	Feb	0	0	0
	Mar	0	1	1
	Apr	0	1	1
	May	0	2	2
	Jun	1	2	3
	Jul	0	4	4
	Aug	236	1	237
	Sep	148	1	149
	Oct	0	0	0
	Nov	0	0	0
	Dec	0	0	0
Total		386	12	397
1996	Jun	9	0	9
	Jul	3	0	3
	Aug	57	0	57
	Sep	232	0	232
	Oct	101	0	101
	Nov	22	0	22
	Dec	0	0	0
Total		423	11[1]	434

[1] Yellowtail landings from scallop drags were calculated as the ratio of yellowtail flounder to the landings of scallops in observed trips, raised by the total scallop landings in 1996.

Table 3. Canadian landings (t) of unspecified flounder considered to be yellowtail flounder in 5Zjmhn, by gear type and month, 1993-1996.

Year	Month	Otter Trawl	Scallop Drag	Total
1993	Jan	6	0	6
	Feb	10	0	10
	Mar	2	4	6
	Apr	5	6	11
	May	0	6	6
	Jun	38	1	39
	Jul	9	0	9
	Aug	4	1	5
	Sep	154	0	154
	Oct	124	0	124
	Nov	85	0	85
	Dec	67	0	67
Total		504	19	523
1994	Feb	0	0	0
	Mar	0	0	0
	Apr	0	0	0
	May	0	0	0
	Jun	238	0	238
	Jul	114	0	114
	Aug	269	0	269
	Sep	181	1	182
	Oct	3	1	4
	Nov	1	0	1
	Dec	2	0	2
Total		809	2	811
1995	Jan	0	0	0
	Feb	0	0	0
	Mar	0	0	0
	Apr	0	3	3
	May	0	3	3
	Jun	13	2	15
	Jul	3	3	6
	Aug	2	5	7
	Sep	11	0	11
	Oct	27	0	27
	Nov	0	0	0
	Dec	0	0	0
Total		56	18	74
1996	Jun	23	0	23
	Jul	2	0	2
	Aug	3	0	3
	Sep	15	0	15
	Oct	4	0	4
	Nov	1	0	1
	Dec	0	0	0
Total		49	0	49

Table 4. Canadian landings (t) of yellowtail flounder in 5Zjmhn, by gear type and month, 1993-1996[2]

Year	Month	Otter Trawl	Dredge	Total
1993	Jan	6	0	6
	Feb	11	1	12
	Mar	2	6	8
	Apr	6	9	15
	May	0	10	10
	Jun	45	2	47
	Jul	9	1	10
	Aug	8	2	10
	Sep	154	1	155
	Oct	189	3	192
	Nov	132	0	132
	Dec	80	0	80
Total		641	33	674
1994	Feb	0	1	1
	Mar	0	3	3
	Apr	0	3	3
	May	0	5	5
	Jun	305	2	305
	Jul	295	1	296
	Aug	628	2	630
	Sep	831	2	833
	Oct	55	2	57
	Nov	1	0	1
	Dec	2	0	2
Total		2118	21	2139
1995	Jan	0	0	0
	Feb	0	0	0
	Mar	0	1	1
	Apr	0	4	4
	May	0	5	5
	Jun	14	4	18
	Jul	3	7	10
	Aug	238	6	244
	Sep	159	1	160
	Oct	27	0	27
	Nov	0	0	0
	Dec	0	0	0
Total		442	29	472
1996	Jun	31	0	31
	Jul	5	0	5
	Aug	60	0	60
	Sep	248	0	248
	Oct	104	0	104
	Nov	23	0	23
	Dec	1	0	1
Total		472	11[2]	483

[2]Yellowtail landings included known yellowtail flounder, plus unspecified flounder. The proportion of unspecified flounder which was considered to be yellowtail was determined by the proportion of known yellowtail flounder in proportion to the landings of yellowtail, winter flounder and American plaice.

Table 5. Total catch at age (number in thousands) for Georges Bank yellowtail, 1973 to 1996.

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

Table 6. Total weight at age(kg) for Georges Bank (5Zjmnh) yellowtail flounder

	1	2	3	4	5	6	7	8
1973	0.010	0.375	0.464	0.527	0.603	0.689	1.067	1.136
1974	0.010	0.378	0.500	0.609	0.680	0.725	0.906	1.249
1975	0.010	0.340	0.492	0.554	0.618	0.687	0.688	0.649
1976	0.010	0.339	0.545	0.636	0.741	0.814	0.852	0.866
1977	0.010	0.364	0.527	0.634	0.782	0.865	1.036	1.013
1978	0.010	0.337	0.513	0.684	0.793	0.899	0.930	0.948
1979	0.010	0.356	0.462	0.649	0.728	0.835	1.003	0.882
1980	0.010	0.354	0.495	0.656	0.813	1.054	1.256	1.214
1981	0.010	0.389	0.493	0.603	0.707	0.798	0.832	1.044
1982	0.010	0.313	0.487	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	1.044
1986	0.010	0.343	0.540	0.664	0.823	0.864	0.956	1.140
1987	0.010	0.338	0.523	0.666	0.680	0.938	0.793	0.788
1988	0.010	0.351	0.557	0.688	0.855	1.054	0.873	1.385
1989	0.010	0.355	0.543	0.725	0.883	1.026	1.254	1.044
1990	0.010	0.337	0.419	0.588	0.699	0.807	1.230	1.044
1991	0.010	0.270	0.383	0.484	0.728	0.820	1.306	1.044
1992	0.010	0.341	0.381	0.528	0.648	1.203	1.125	1.044
1993	0.010	0.316	0.390	0.510	0.562	0.858	1.263	1.044
1994	0.010	0.277	0.352	0.472	0.629	0.787	0.896	1.166
1995	0.010	0.285	0.373	0.464	0.582	0.778	0.785	0.531
1996	0.010	0.304	0.410	0.568	0.725	0.926	1.031	1.209

Table 7. United States NEFSC spring survey mean number per tow at age for yellowtail flounder on Georges Bank, 1973 - 1996.

	2	3	4	5	6	7	8	Total
1973	3.266	2.368	1.063	0.410	0.173	0.023	0.020	9.254
1974	2.224	1.842	1.256	0.346	0.187	0.085	0.009	6.265
1975	2.939	0.860	0.298	0.208	0.068	0.000	0.013	4.806
1976	4.368	1.247	0.311	0.196	0.026	0.048	0.037	7.267
1977	0.671	1.125	0.384	0.074	0.013	0.000	0.000	2.267
1978	0.798	0.507	0.219	0.026	0.000	0.008	0.000	2.494
1979	1.933	0.385	0.328	0.059	0.046	0.041	0.000	3.071
1980	4.644	5.761	0.473	0.057	0.037	0.000	0.000	11.029
1981	1.027	1.779	0.721	0.205	0.061	0.000	0.026	3.831
1982	3.742	1.122	1.016	0.455	0.065	0.000	0.026	6.471
1983	1.865	2.728	0.531	0.123	0.092	0.061	0.092	5.492
1984	0.093	0.809	0.885	0.834	0.244	0.000	0.000	2.865
1985	2.199	0.262	0.282	0.148	0.000	0.000	0.000	3.001
1986	1.806	0.291	0.056	0.137	0.055	0.000	0.000	2.372
1987	0.128	0.112	0.133	0.053	0.055	0.000	0.000	0.481
1988	0.275	0.366	0.242	0.199	0.027	0.000	0.000	1.187
1989	0.424	0.740	0.290	0.061	0.022	0.022	0.000	1.606
1990	0.065	1.108	0.393	0.139	0.012	0.045	0.000	1.762
1991	0.000	0.254	0.675	0.274	0.020	0.000	0.000	1.658
1992	2.010	1.945	0.598	0.189	0.000	0.000	0.000	4.742
1993	0.290	0.500	0.317	0.027	0.000	0.000	0.000	1.180
1994	0.621	0.638	0.357	0.145	0.043	0.000	0.000	1.804
1995	1.180	4.810	1.490	0.640	0.010	0.000	0.000	8.170
1996	2.520	2.590	0.590	0.060	0.000	0.000	0.000	6.710

Table 8. United States NEFSC fall survey mean number per tow at age for yellowtail flounder on Georges Bank, 1973 - 1996.

	2	3	4	5	6	7	8	Total
1973.5	5.497	5.104	2.944	1.216	0.416	0.171	0.031	17.873
1974.5	2.854	1.524	1.060	0.460	0.249	0.131	0.000	10.901
1975.5	2.511	0.877	0.572	0.334	0.033	0.000	0.031	8.983
1976.5	1.929	0.475	0.117	0.122	0.033	0.000	0.067	3.079
1977.5	2.161	1.649	0.618	0.113	0.056	0.036	0.016	5.577
1978.5	1.272	0.773	0.406	0.139	0.011	0.000	0.024	7.354
1979.5	1.999	0.316	0.122	0.138	0.038	0.064	0.007	3.996
1980.5	5.086	6.050	0.678	0.217	0.162	0.006	0.033	12.993
1981.5	2.333	1.630	0.500	0.121	0.083	0.013	0.000	6.264
1982.5	2.185	1.590	0.423	0.089	0.000	0.000	0.000	6.711
1983.5	2.284	1.914	0.473	0.068	0.012	0.000	0.038	4.898
1984.5	0.400	0.306	2.428	0.090	0.029	0.000	0.018	3.932
1985.5	0.529	0.170	0.060	0.071	0.000	0.000	0.000	2.193
1986.5	1.107	0.341	0.081	0.000	0.000	0.000	0.000	1.810
1987.5	0.390	0.396	0.053	0.079	0.000	0.000	0.000	1.031
1988.5	0.213	0.102	0.031	0.000	0.000	0.000	0.000	0.365
1989.5	1.992	0.774	0.069	0.066	0.000	0.000	0.000	3.149
1990.5	0.326	1.517	0.280	0.014	0.000	0.000	0.000	2.137
1991.5	0.275	0.439	0.358	0.000	0.000	0.000	0.000	3.172
1992.5	0.396	0.712	0.162	0.144	0.027	0.000	0.000	1.592
1993.5	0.136	0.587	0.536	0.000	0.000	0.000	0.000	2.101
1994.5	0.22	0.98	0.71	0.26	0.03	0.03	0	3.350
1995.5	0.12	0.35	0.28	0.05	0.01	0	0	1.090
1996.5	0.310	1.450	0.410	0.060	0.000	0.000	0.000	2.370

Table 9. United States NEFSC scallop survey mean number per tow at age for yellowtail flounder on Georges Bank, 1973 - 1996

	1	2	3	4	5	6	7	8
1982	0.509	0.542	0.215	0.085	0.018	0.000	0.000	0.000
1983	0.276	0.549	0.464	0.095	0.041	0.010	0.010	0.000
1984	0.377	0.125	0.064	0.104	0.011	0.019	0.000	0.000
1985	0.662	0.079	0.003	0.015	0.000	0.000	0.000	0.000
1986	0.197	0.072	0.006	0.004	0.000	0.000	0.000	0.000
1987	0.104	0.151	0.136	0.010	0.014	0.008	0.000	0.000
1988	0.118	0.052	0.072	0.022	0.000	0.000	0.000	0.000
1989	0.194	0.458	0.233	0.065	0.000	0.000	0.000	0.000
1990	0.108	0.063	0.392	0.089	0.000	0.000	0.000	0.000
1991	2.434	0.030	0.147	0.146	0.000	0.000	0.000	0.000
1992	0.204	0.221	0.126	0.011	0.004	0.000	0.000	0.000
1993	1.295	0.100	0.333	0.300	0.027	0.011	0.000	0.000
1994	1.606	0.126	0.585	0.334	0.114	0.021	0.001	0.000
1995	0.697	0.333	1.008	0.554	0.019	0.046	0.013	0.000
1996	0.562	0.563	1.414	0.251	0.104	0.094	0.000	0.000

Table 10a. Canadian spring survey mean number per tow at age for yellowtail flounder on Georges Bank, 1987 - 1996. The 1997 total value is also shown.

	2	3	4	5	6	Total
1987	0.12	0.74	2.58	0.56	0.02	4.02
1988	0.67	1.81	0.80	0.67	0.01	3.96
1989	0.76	0.91	0.29	0.04	0.01	2.01
1990	1.92	4.04	1.07	0.4	0.01	7.44
1991	0.61	1.86	2.93	0.82	0	6.22
1992	10.06	4.59	1.14	0.29	0	16.08
1993	2.63	6.32	2.45	0.21	0.02	11.63
1994	6.38	3.46	2.63	0.86	0.19	13.52
1995	1.17	4.55	2.16	0.95	0.07	8.90
1996	5.62	8.23	7.16	1.36	0.17	22.54
1997						47.48

Table 10b. Canadian spring survey biomass index for yellowtail flounder on Georges Bank, 1987 - 1997.

Year	Index
1987	1264
1988	1235
1989	471
1990	1578
1991	1759
1992	2475
1993	2642
1994	2753
1995	2027
1996	5304
1997	13292

Table 11. Proportion (%) of yellowtail biomass occurring on the Canadian portion of Georges Bank from Canadian and US spring and fall surveys

Canadian Spring

Year	5Z1	5Z2	5Z3	5Z4	Proportion
1997	868.22	2464.21	2431.12	7528.86	25.07
1996	34.83	2798.56	1229.19	1240.95	53.42
1995	35.46	784.96	487.19	719.21	40.48
1994	90.80	500.50	745.30	1416.66	21.48
1993	58.95	1633.75	178.17	770.96	64.07
1992	118.74	431.52	326.59	1598.63	22.23
Average					37.79

US Spring

Year	US	Can	Proportion
1996	1291.36	3414.85	72.56
1995	804.50	1975.23	71.06
1994	425.94	510.09	54.50
1993	240.94	423.07	63.71
1992	674.12	1712.09	71.75
Average			66.72

US Fall

Year	Us	Can	Proportion
1996	1099.95	302.45	21.57
1995	215.15	221.44	50.72
1994	355.39	820.02	69.76
1993	106.33	488.75	82.13
1992	182.25	473.48	72.21
Average			59.28

Table 12. Statistical properties of VPA estimates for population abundance and survey calibration constants for Georges Bank yellowtail.

Age	Estimate	Standard Error	Relative Error	Bias	Relative Bias
		Population Abundance			
1	20000	0	0.00	0	0.00
2	5744	3156	0.55	864	0.15
3	10473	3872	0.37	699	0.07
4	10704	3619	0.34	549	0.05
5	5820	1444	0.25	142	0.02
6	1357	337	0.25	33	0.02
7	73	18	0.25	2	0.02
8	41	10	0.25	1	0.02
		Survey Calibration Constants			
NMFS Spring Survey					
1	0.006	0.001	0.226	0.000	0.025
2	0.065	0.012	0.193	0.001	0.018
3	0.118	0.022	0.188	0.002	0.017
4	0.162	0.030	0.188	0.003	0.018
5-7	0.224	0.042	0.188	0.004	0.017
NMFS Fall Survey					
1	0.041	0.008	0.194	0.001	0.019
2	0.084	0.016	0.189	0.001	0.018
3	0.171	0.032	0.188	0.003	0.018
4	0.211	0.040	0.188	0.004	0.018
5-7	0.293	0.061	0.207	0.006	0.021
NMFS Scallop Survey					
1	0.031	0.008	0.242	0.001	0.029
2	0.014	0.003	0.240	0.000	0.028
3	0.025	0.006	0.239	0.001	0.028
5-7	0.136	0.032	0.238	0.004	0.028
DFO Spring Survey					
2	0.144	0.043	0.295	0.006	0.043
3	0.475	0.139	0.293	0.020	0.042
4	0.842	0.247	0.293	0.036	0.043
5-6	1.098	0.321	0.293	0.047	0.042

Table 13.VPA results, population numbers (number in thousands) for Georges Bank yellowtail

	1	2	3	4	5	6	7	8	1+	2+	3+	Yearclass	Recruits
1973	28027	23064	28941	16783	5866	2237	465	0	05383	77356	54292	1972	28027
1974	49014	22633	14486	11867	5486	1485	712	134	05817	56803	34170	1973	49014
1975	66676	38195	10502	4824	3154	1352	458	182	25343	58667	20472	1974	66676
1976	22299	50645	8891	2355	954	738	508	99	86489	64190	13545	1975	22299
1977	15071	17702	13942	2705	731	308	218	161	50838	35767	18065	1976	15071
1978	49595	12041	6838	2663	689	247	57	64	72194	22599	10558	1977	49595
1979	22412	31915	7069	2014	708	158	111	14	64401	41989	10074	1978	22412
1980	21503	18139	17600	2714	547	96	7	21	60627	39124	20985	1979	21503
1981	59777	17326	11638	6544	958	163	5	2	96413	36636	19310	1980	59777
1982	21226	48892	13527	4749	1333	89	26	1	89843	68617	19725	1981	21226
1983	5738	15519	24359	4731	1019	185	18	4	51573	45835	30316	1982	5738
1984	8450	4070	5848	5762	1807	279	55	6	26277	17827	13757	1983	8450
1985	14265	6532	1621	1027	578	98	7	4	24132	9867	3335	1984	14265
1986	6606	11093	2366	600	263	111	27	2	21068	14462	3369	1985	6606
1987	6788	5266	3940	1063	183	73	44	8	17365	10577	5311	1986	6788
1988	18832	5432	1946	796	199	33	25	8	27271	8439	3007	1987	18832
1989	8441	14983	2331	536	104	18	14	3	26430	17989	3006	1988	8441
1990	11540	6744	10900	1309	205	25	5	4	30732	19192	12448	1989	11540
1991	21700	9250	3788	3477	362	73	5	2	38657	16957	7707	1990	21700
1992	18725	17394	7525	2006	701	40	10	1	46402	27677	10283	1991	18725
1993	22405	13178	6782	3895	517	124	15	2	46918	24513	11335	1992	22405
1994	21272	13674	9879	3068	1066	141	44	4	49148	27876	14202	1993	21272
1995	15112	17352	10419	2985	268	80	28	4	46248	31136	13784	1994	15112
1996	6015	12360	14065	7723	1801	97	54	13	42128	36113	23753	1995	6015
1997	18380	4879	9773	10155	5677	1324	71	40	50299	31919	27040	1996	18380

Table 14. Bias adjusted estimates of instantaneous fishing mortality rates for yellowtail flounder on Georges Bank. The total (population weighted) fishing mortality for ages 4 and older is also indicated.

Age	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
2	0.264	0.574	1.250	1.085	0.752	0.333	0.395	0.243	0.048	0.498	0.780	0.730
3	0.690	0.890	1.333	0.971	1.431	1.025	0.758	0.788	0.693	0.854	1.248	1.565
4	0.970	1.117	1.375	1.061	1.105	1.063	1.112	0.844	1.382	1.324	0.768	2.161
5	1.277	1.421	1.226	0.846	1.123	1.074	1.436	1.036	2.212	1.718	1.053	2.857
6	1.123	1.269	1.300	0.954	1.114	1.068	1.274	0.940	1.797	1.521	0.911	2.509
4+	1.047	1.232	1.344	1.036	1.171	1.091	1.214	0.891	1.469	1.403	0.820	2.304

Age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
2	0.815	0.834	0.796	0.650	0.119	0.388	0.006	0.623	0.161	0.312	0.234
3	0.816	0.600	1.392	1.092	0.381	0.948	0.455	0.412	0.455	1.252	0.449
4	1.237	1.057	1.471	1.791	0.766	1.113	1.426	1.276	0.845	1.153	1.097
5	1.699	1.333	1.972	2.123	1.113	0.852	2.315	1.643	1.295	1.518	0.184
6	1.468	1.195	1.722	1.957	0.940	0.982	1.871	1.459	1.067	1.166	0.410
4+	1.393	1.153	1.548	1.858	0.824	1.075	1.490	1.365	0.882	1.239	0.541

Table 15. Beginning of year weight at age (kg) for Georges Bank yellowtail

	Age Group							
	1	2	3	4	5	6	7	8
1973	0.002	0.061	0.417	0.494	0.564	0.645	0.857	1.101
1974	0.002	0.061	0.433	0.532	0.599	0.661	0.790	1.154
1975	0.002	0.058	0.431	0.526	0.613	0.683	0.706	0.767
1976	0.002	0.058	0.430	0.559	0.641	0.709	0.765	0.772
1977	0.002	0.060	0.423	0.588	0.705	0.801	0.918	0.929
1978	0.002	0.058	0.432	0.600	0.709	0.838	0.897	0.991
1979	0.002	0.060	0.395	0.577	0.706	0.814	0.950	0.906
1980	0.002	0.059	0.420	0.551	0.726	0.876	1.024	1.103
1981	0.002	0.062	0.418	0.546	0.681	0.805	0.936	1.145
1982	0.002	0.056	0.435	0.566	0.672	0.862	0.904	1.044
1983	0.002	0.054	0.371	0.542	0.692	0.844	1.035	1.005
1984	0.002	0.049	0.334	0.469	0.623	0.737	0.948	1.032
1985	0.002	0.060	0.345	0.495	0.605	0.725	0.735	0.993
1986	0.002	0.059	0.443	0.574	0.730	0.796	0.885	0.913
1987	0.002	0.058	0.424	0.600	0.672	0.879	0.828	0.868
1988	0.002	0.059	0.434	0.600	0.755	0.847	0.905	1.048
1989	0.002	0.060	0.437	0.635	0.779	0.937	1.150	0.955
1990	0.002	0.058	0.386	0.565	0.712	0.844	1.123	1.144
1991	0.002	0.052	0.359	0.450	0.654	0.757	1.027	1.133
1992	0.002	0.058	0.321	0.450	0.560	0.936	0.960	1.168
1993	0.002	0.056	0.365	0.441	0.545	0.746	1.233	1.084
1994	0.002	0.053	0.334	0.429	0.566	0.665	0.877	1.214
1995	0.002	0.053	0.321	0.404	0.524	0.700	0.786	0.690
1996	0.002	0.055	0.342	0.460	0.580	0.734	0.896	0.974
1997	0.002	0.054	0.332	0.431	0.557	0.700	0.853	0.959

Table 16. Beginning of year population biomass (t) for Georges Bank yellowtail

	Age Group											
	1	2	3	4	5	6	7	8	9	1+	2+	3+
1973	46	1412	12072	8299	3307	1442	399	0	0	26977	26931	25519
1974	84	1392	6273	6308	3284	982	563	155	0	19040	18956	17564
1975	115	2227	4529	2539	1935	924	323	140	0	12732	12617	10390
1976	37	2949	3827	1317	611	523	389	76	0	9730	9693	6744
1977	26	1068	5893	1590	516	247	200	150	0	9689	9663	8595
1978	83	699	2955	1599	489	207	51	63	0	6146	6063	5364
1979	38	1904	2789	1162	500	129	105	13	0	6640	6602	4698
1980	34	1079	7388	1494	397	84	7	23	0	10508	10473	9394
1981	107	1081	4862	3575	652	131	5	2	0	10415	10308	9228
1982	39	2735	5888	2688	895	77	24	1	0	12347	12308	9573
1983	12	844	9040	2566	705	156	19	4	0	13345	13334	12489
1984	14	199	1956	2703	1125	206	52	6	0	6261	6247	6048
1985	24	394	560	508	350	71	5	4	0	1916	1891	1498
1986	11	650	1048	345	192	88	24	2	0	2359	2348	1698
1987	11	306	1669	637	123	64	36	7	0	2854	2843	2537
1988	32	322	844	477	150	28	23	8	0	1884	1853	1531
1989	15	893	1018	341	81	17	16	3	0	2382	2368	1475
1990	22	392	4204	740	146	21	6	5	0	5534	5512	5121
1991	37	481	1361	1566	237	55	5	2	0	3744	3707	3226
1992	33	1016	2414	902	393	37	10	1	0	4805	4772	3756
1993	43	741	2473	1717	282	92	18	2	0	5368	5326	4585
1994	40	720	3295	1316	604	94	39	5	0	6112	6072	5352
1995	27	926	3349	1206	140	56	22	3	0	5730	5703	4777
1996	11	681	4808	3555	1045	71	48	13	0	10232	10221	9539
1997	34	262	3247	4378	3161	926	61	38	0	12108	12074	11812

Table 17. Projection results at $F_{0.1}$ for Georges Bank yellowtail.

Year	Age Group										
	1	2	3	4	5	6	7	8	1+	2+	3+
Population Numbers (000s)											
1997	18380	4879	9773	10155	5677	1324	71	40			
1998	18380	14969	3924	6887	6519	3620	844	46			
Fishing Mortality											
1997	0.005	0.018	0.150	0.243	0.250	0.250	0.250				
Weight at beginning of year for population (kg)											
1998	0.00	0.05	0.33	0.43	0.55	0.83	0.90	0.97			
Projected Population Biomass (t)											
1998	37	808	1303	2975	3598	3005	763	44	12533	12497	11688
Projected Catch Numbers (000s)											
1997	87	79	1237	1995	1143	267	14				
Average weight for catch (kg)											
1997	0.10	0.29	0.38	0.50	0.65	0.83	0.90				
Projected Yield (t)											
1996	9	23	468	1000	737	221	13		2470		

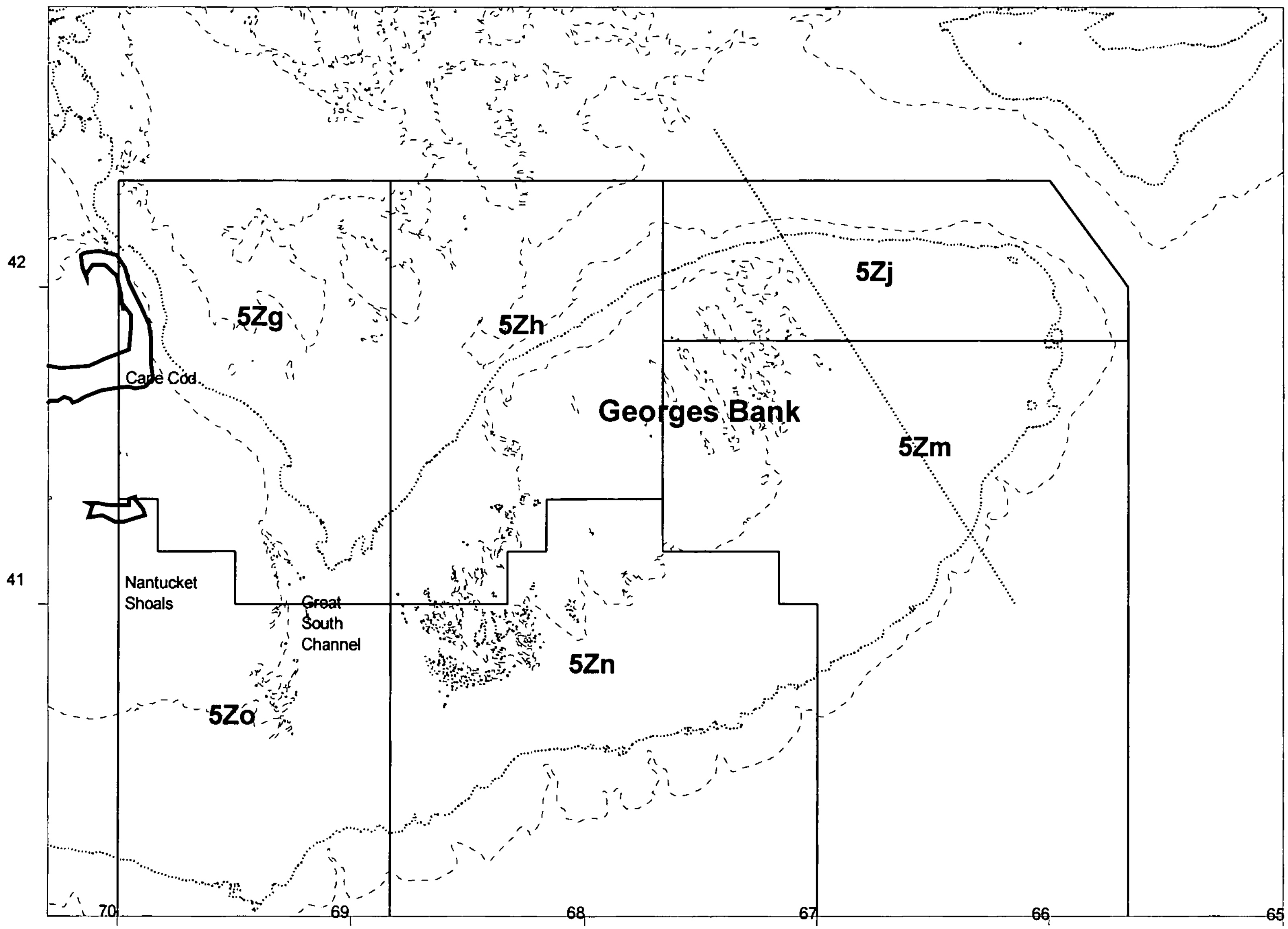


Fig. 1. Canadian fisheries statistical unit areas in NAFO Subdivision 5Ze.

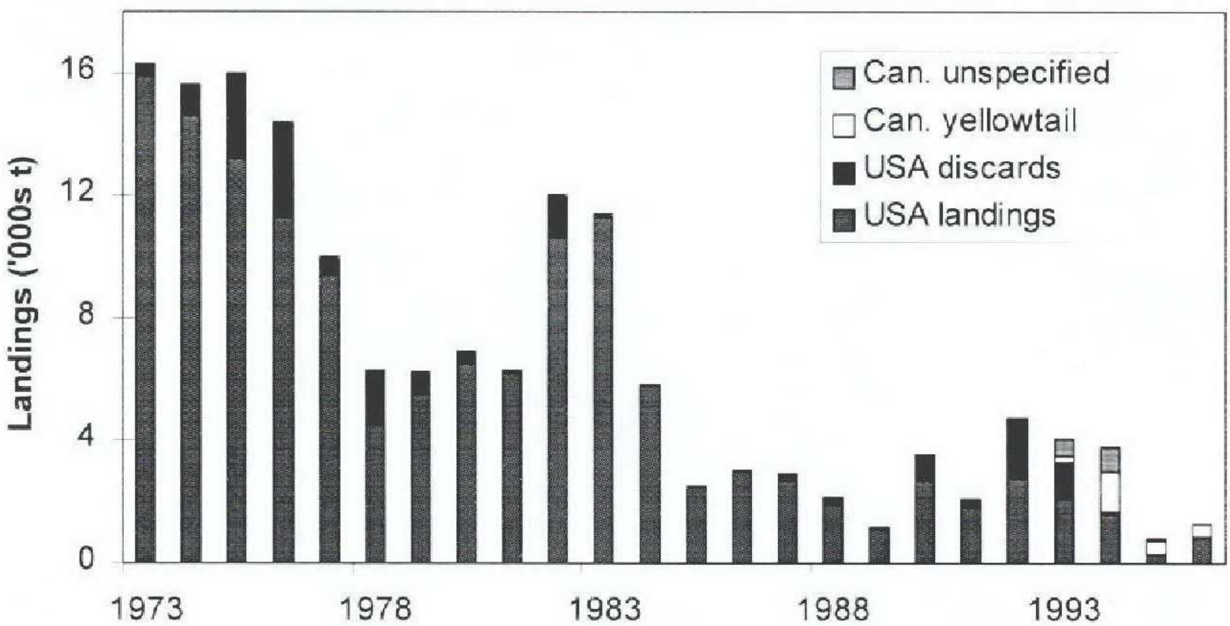
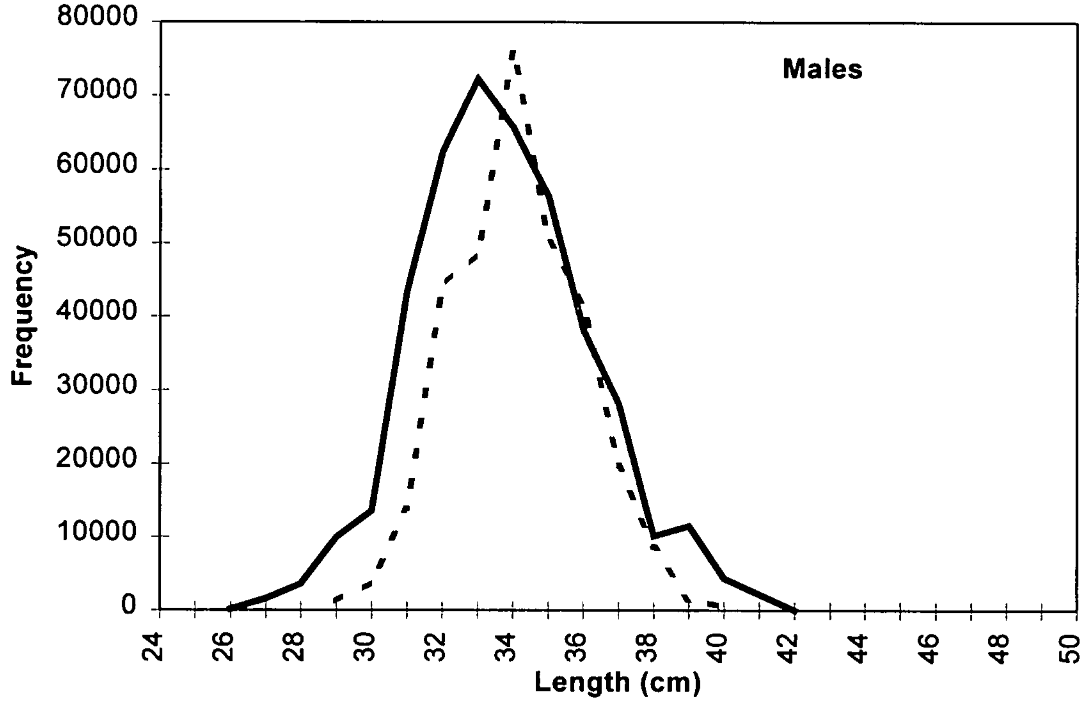


Fig. 2. Landings of Georges Bank yellowtail flounder by Canada and the United States, 1973 to 1996.



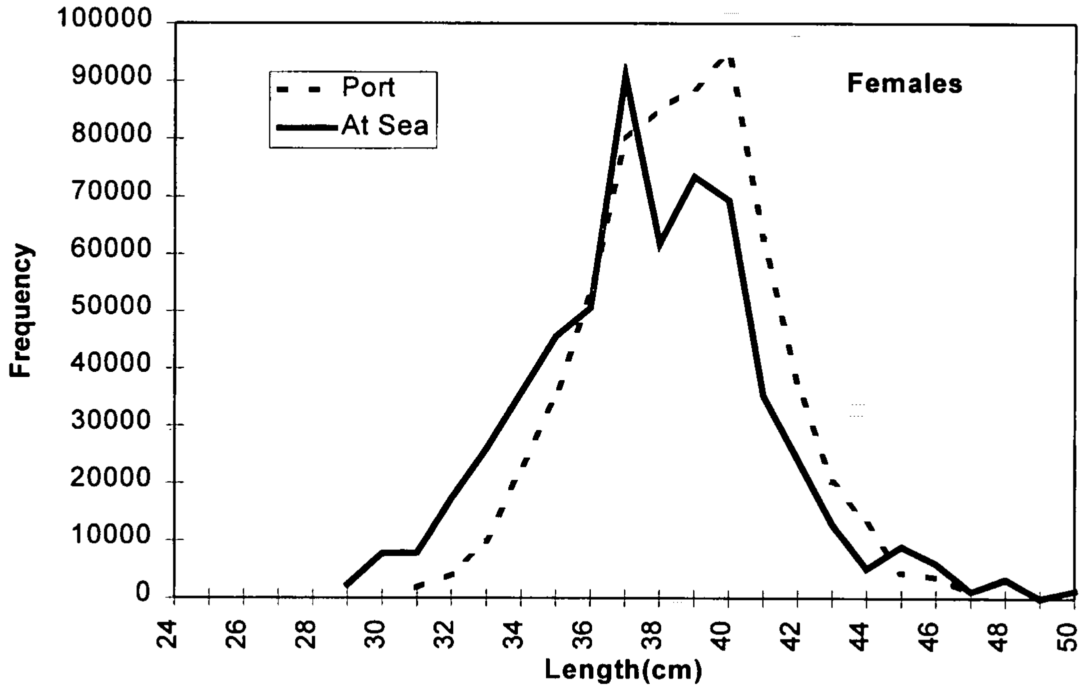


Fig. 3. Comparison of length frequency distributions of samples observed in 1996 by port technicians with those at sea samples collected with the Observer Program, 1996, Georges Bank.

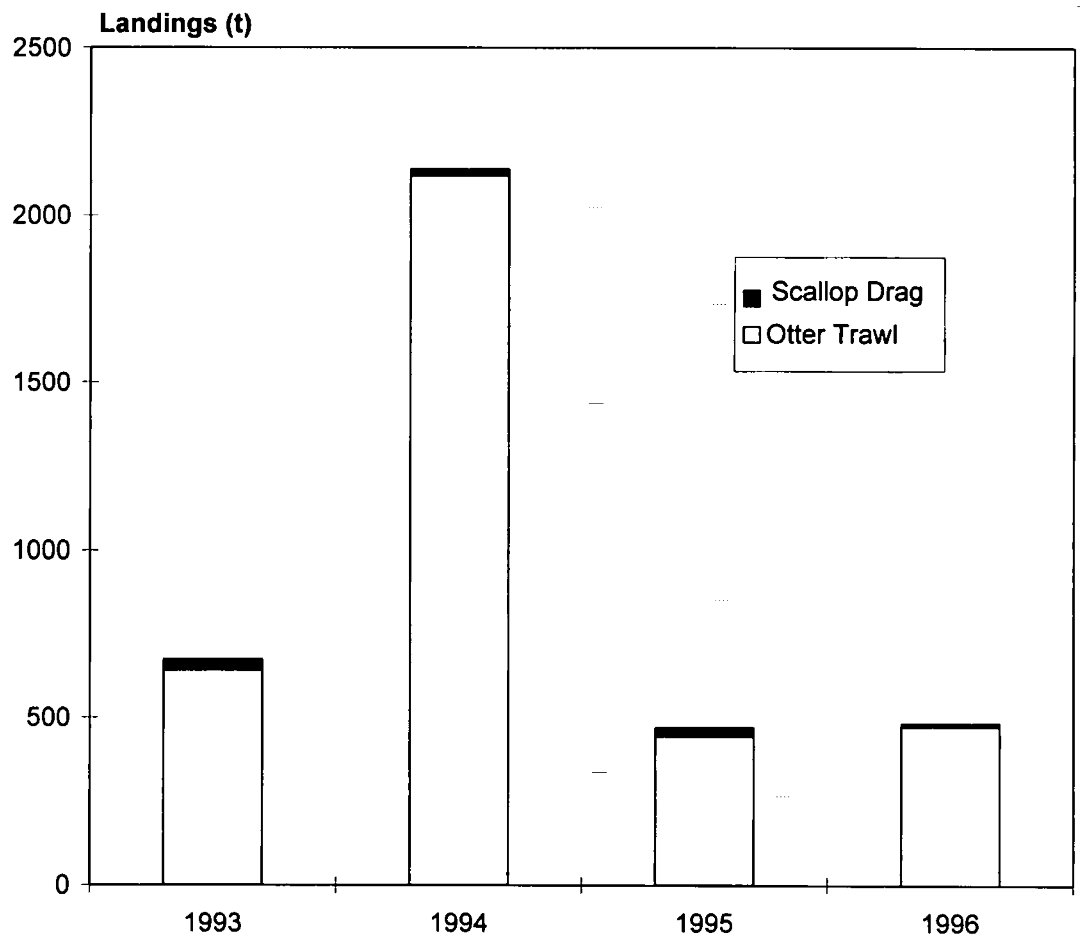


Fig. 4. Canadian landings by gear type, Georges Bank yellowtail flounder.

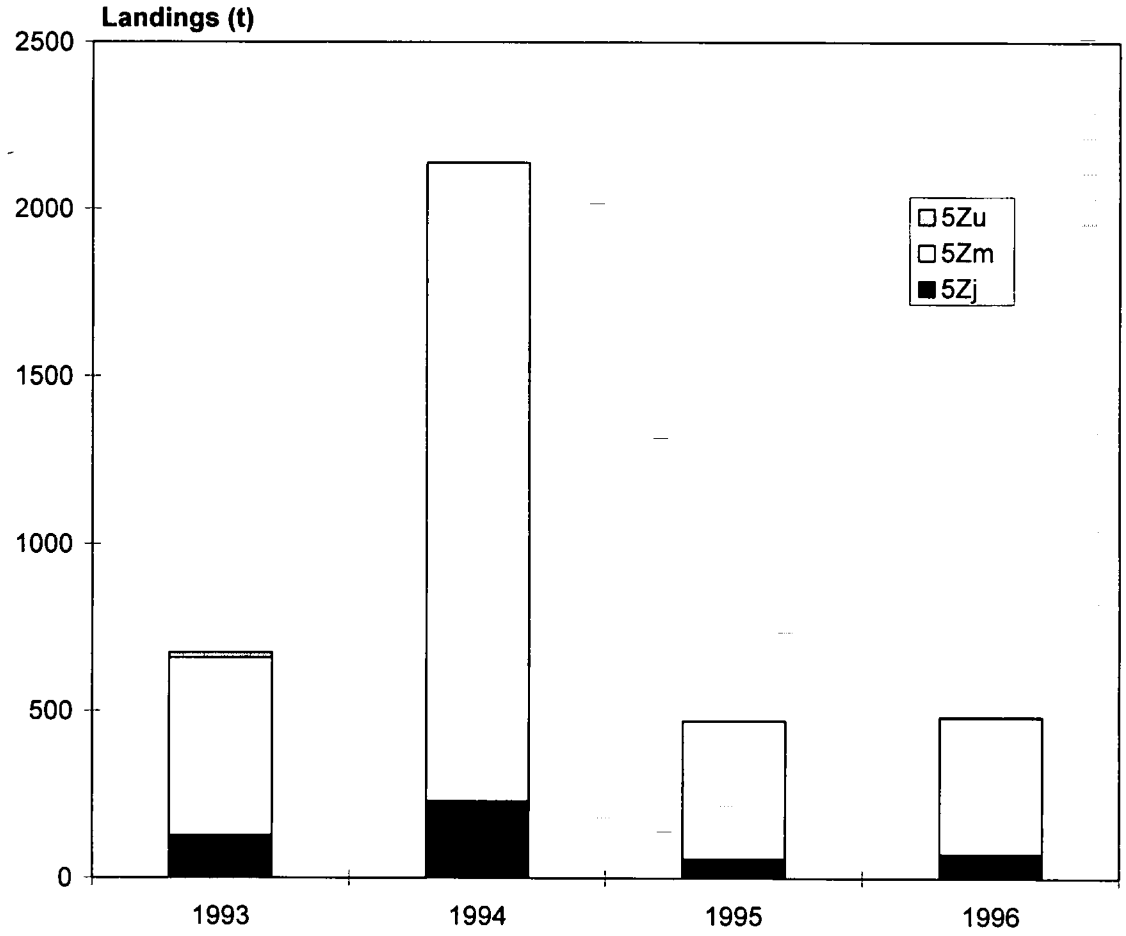


Fig. 5. Canadian landings by NAFO unit area, yellowtail flounder on Georges Bank.

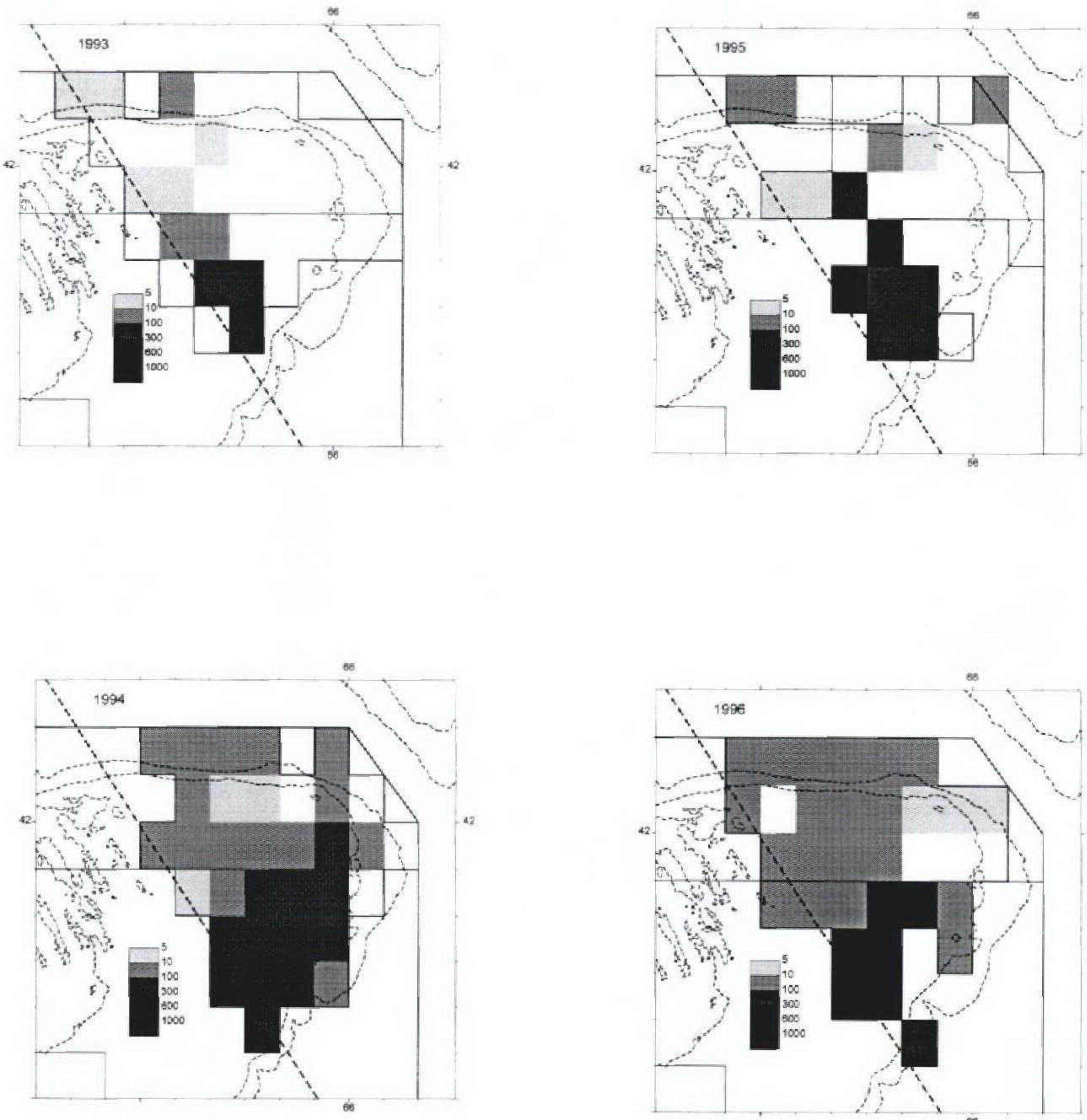


Fig 6. Distribution of Canadian mobile gear (TC 2 & 3) effort for 1993-96 where trip landings of yellowtail were > 500 lb, summarized by 10 min squares.

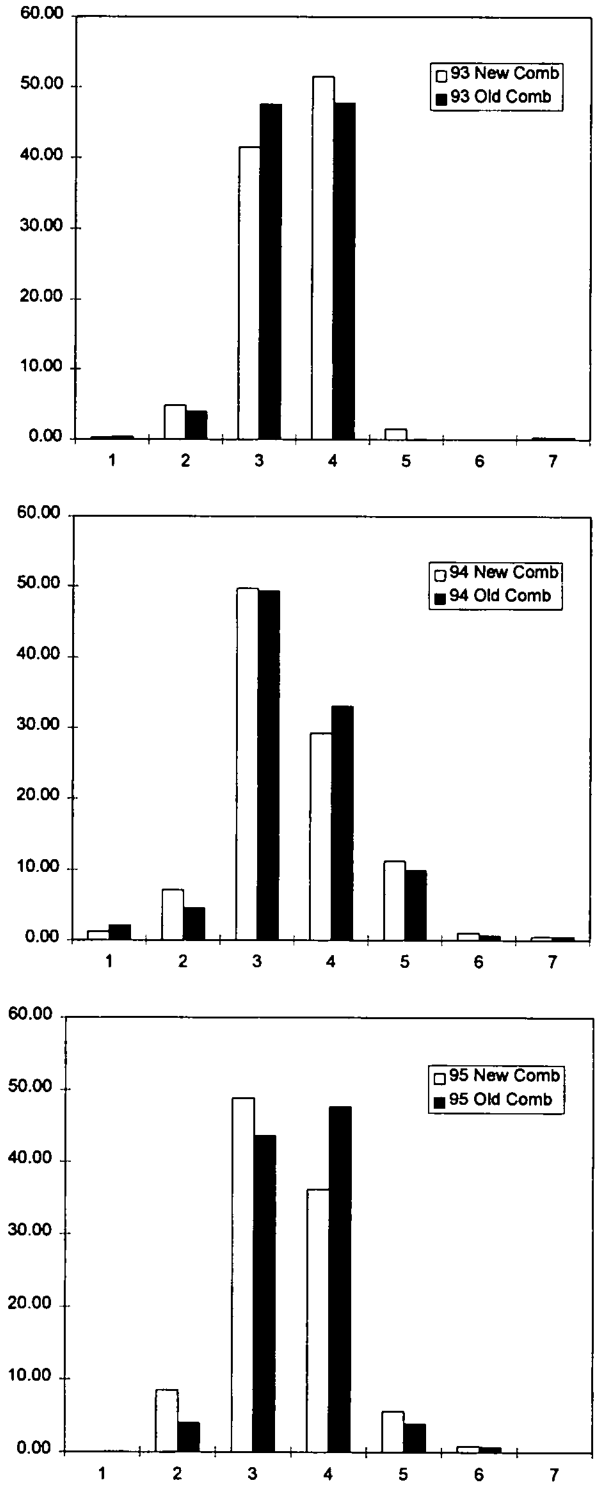


Fig. 7. Comparison of age composition obtained when using the sex aggregated method of reconstructing the Canadian catch at age (labelled "old") and that obtained using the sexes separate approach (labelled "new").

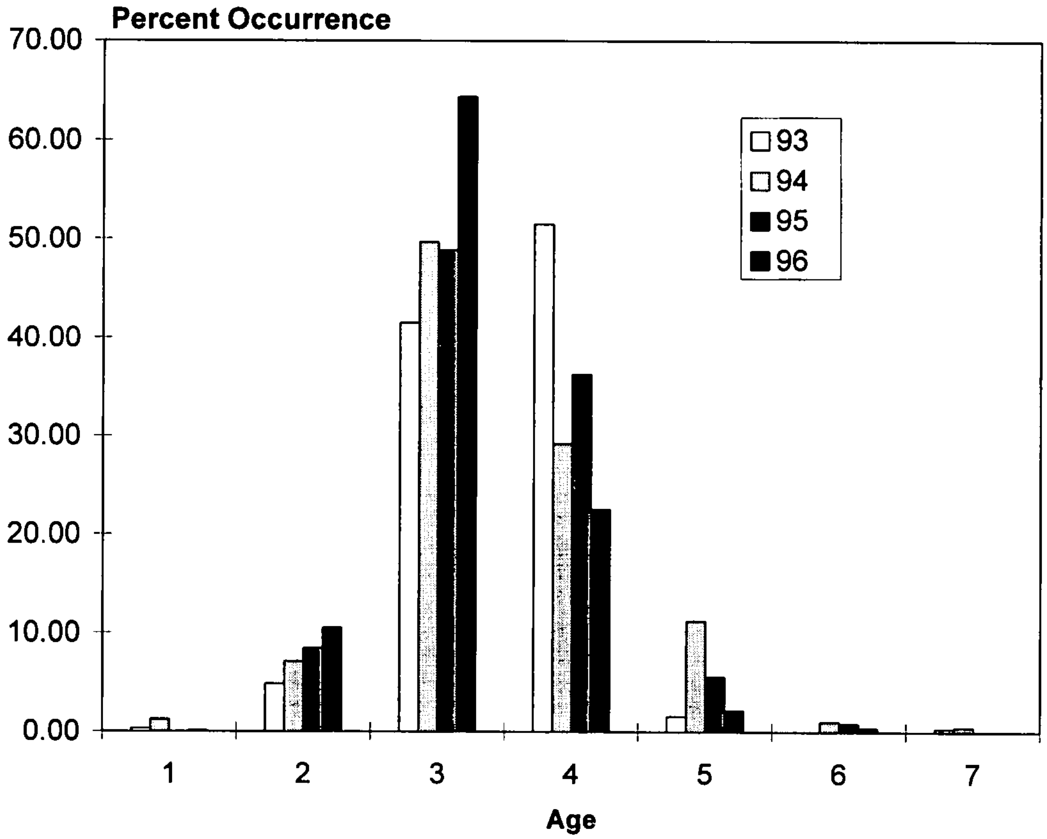


Fig. 8. Comparison of yellowtail flounder fishery age composition, 1993 to 1996, f or Canadian catches on Georges Bank.

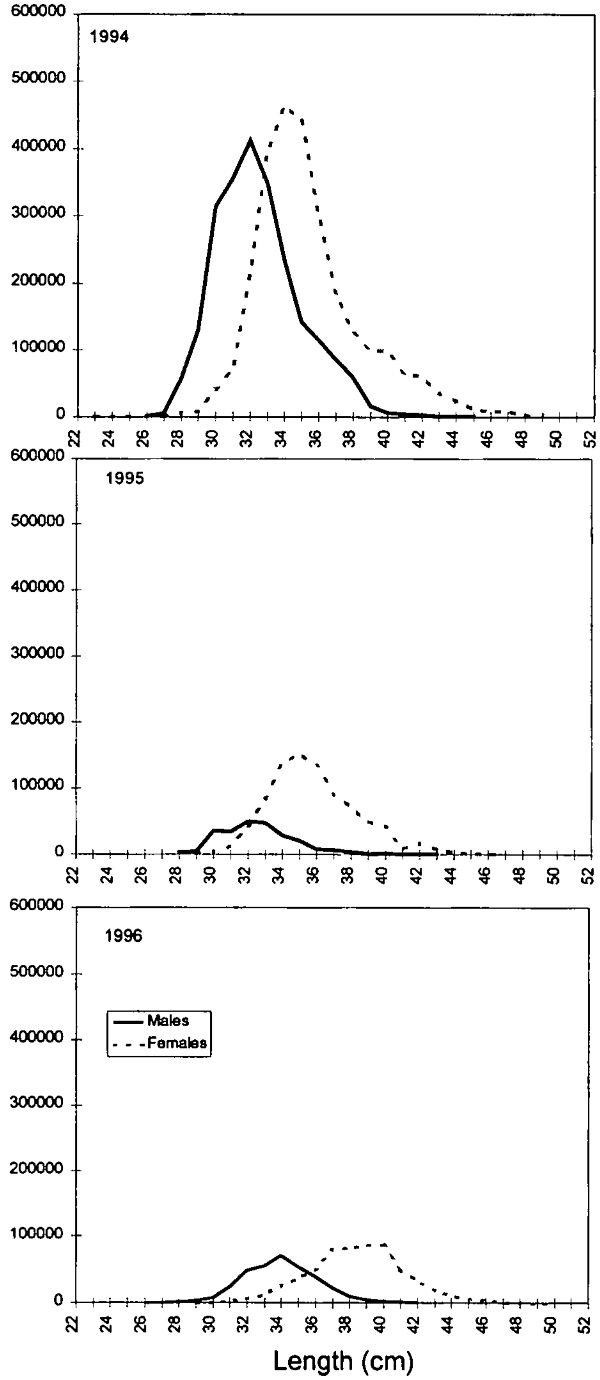


Fig. 9. Comparison of the yellowtail flouunder length frequency composition taken in the Canadian Georges Bank fishery from 1994 to 1996.

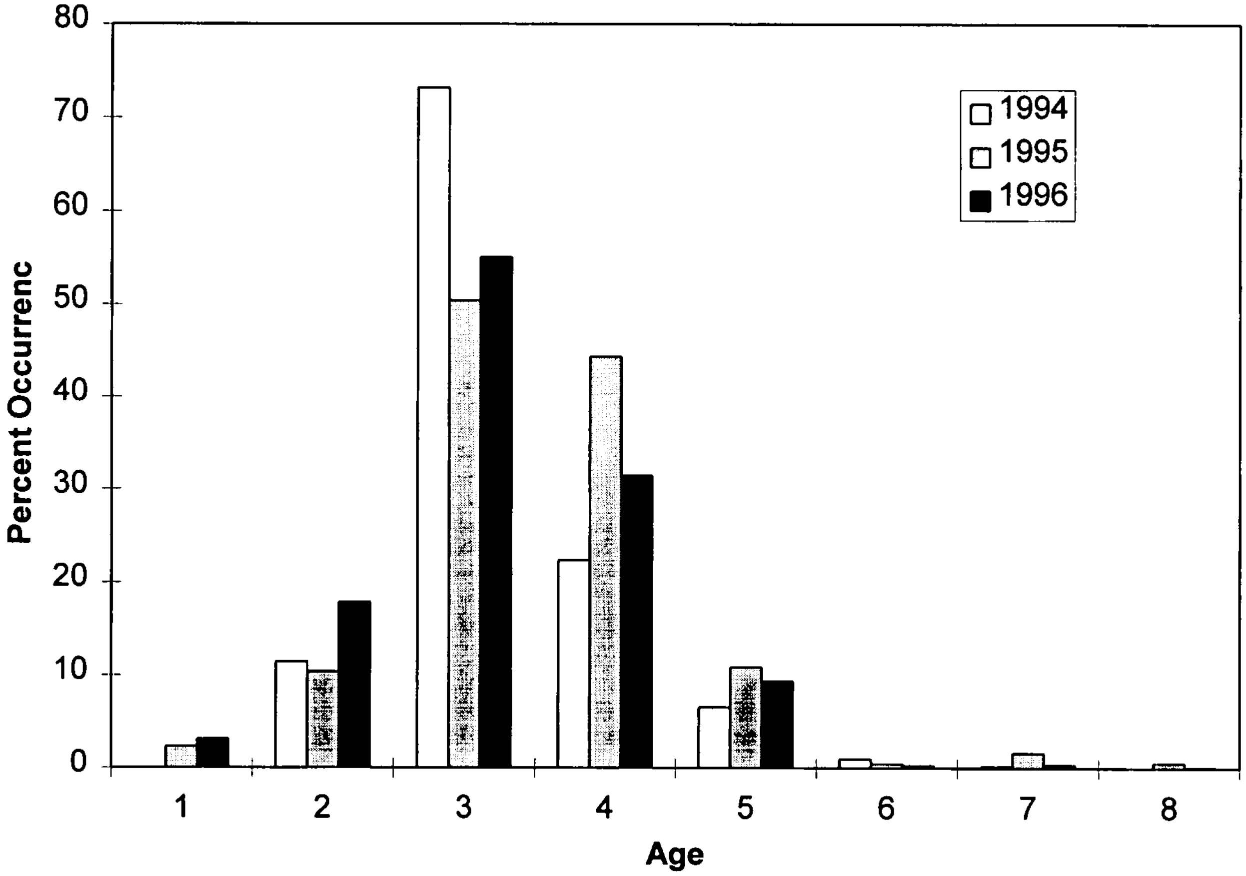


Fig. 10. USA yellowtail fishery age composition (including discards), 1993-1996, Georges Bank.

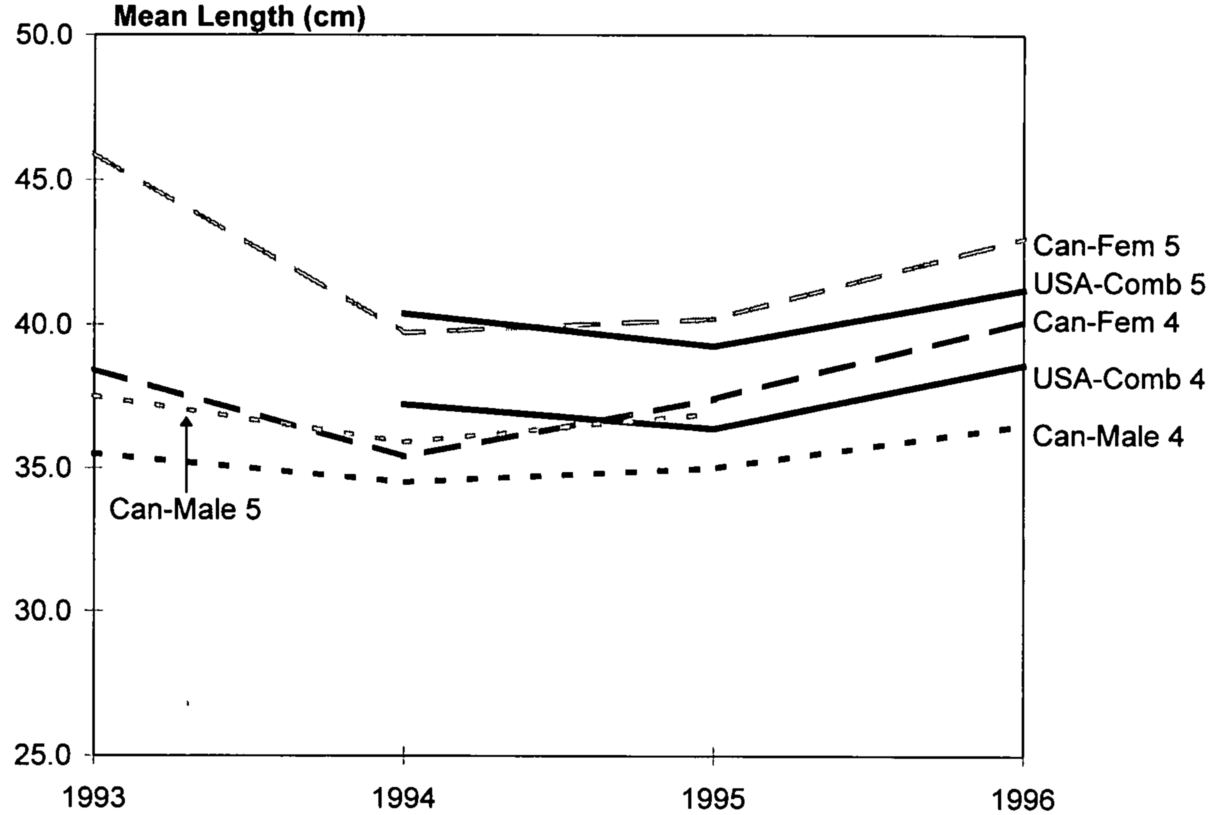


Fig. 11. Comparison of mean lengths at age of Georges Bank yellowtail flounder from the Canadian and USA catch at age matrices, 1993 to 1996.

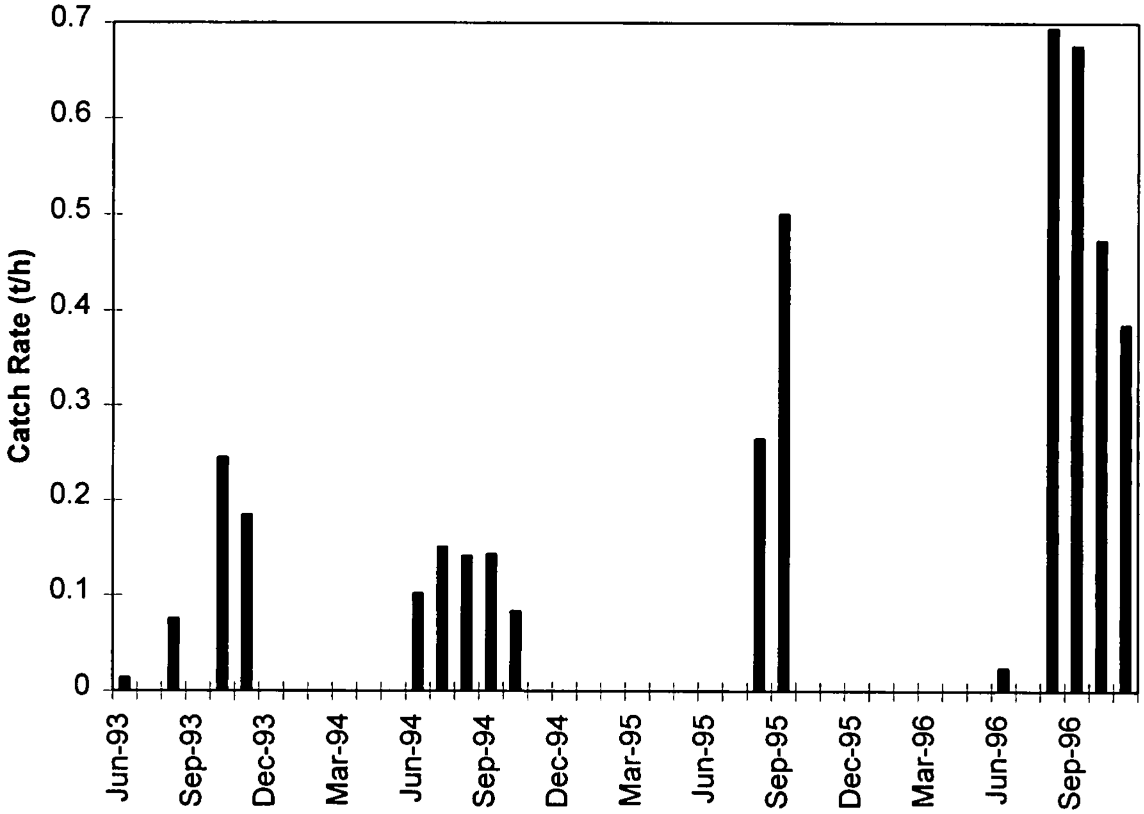
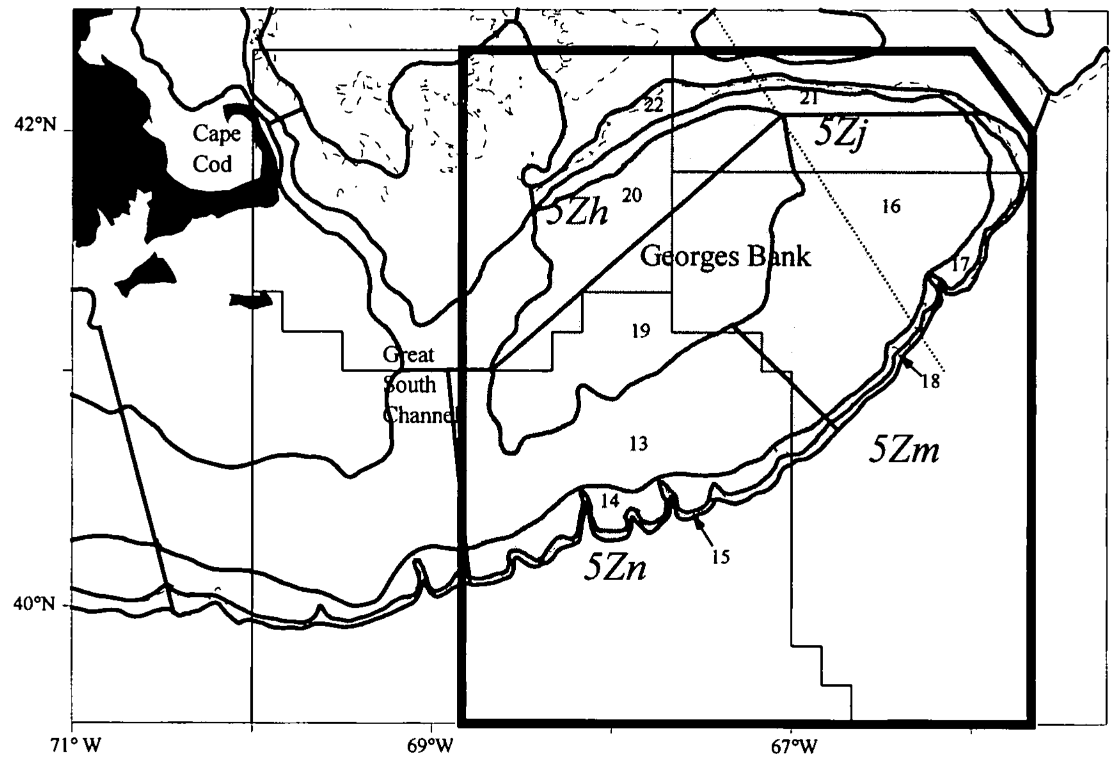


Fig. 12. Monthly catch rates of stern otter trawlers (TC 2-3), Georges Bank yellowtail flounder, 1993 to 1996.



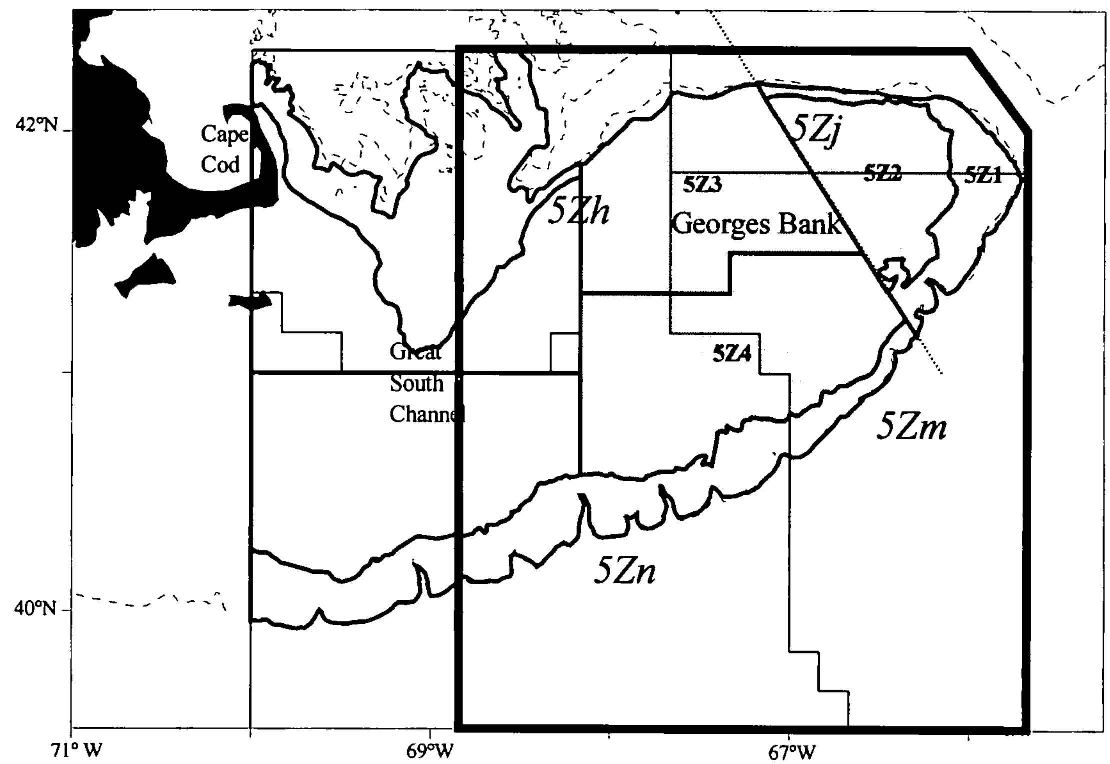


Fig. 13. USA (top) and Canadian (bottom) strata used to derive research survey abundance indices for Georges Bank groundfish surveys.

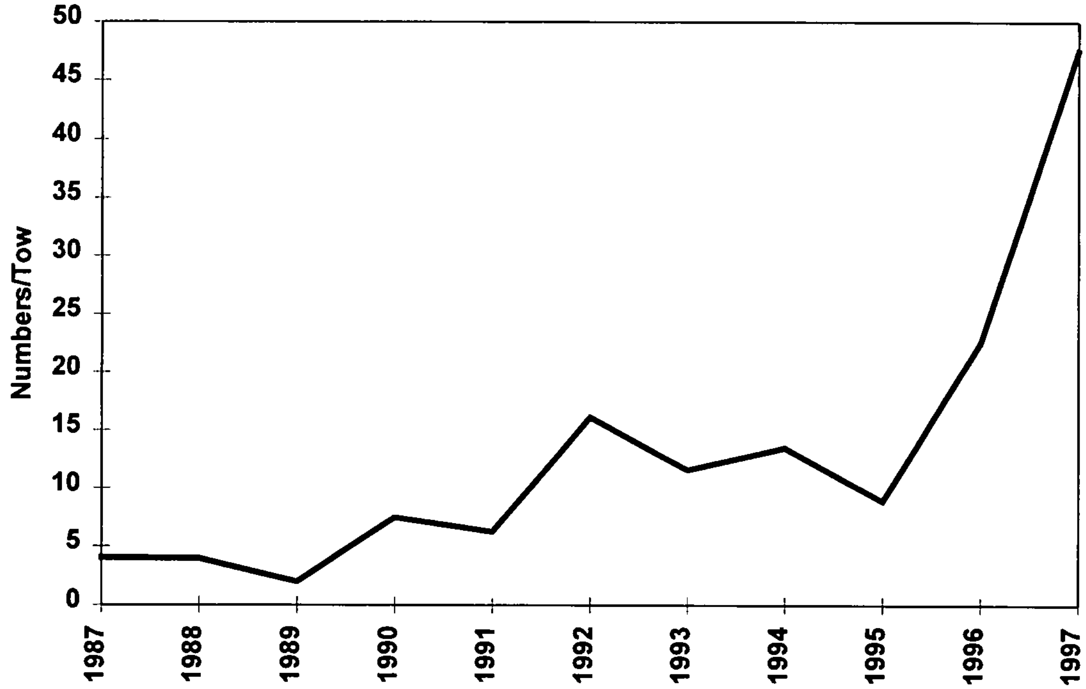


Fig. 14. Canadian spring survey results for yellowtail flounder (Strata 5Z1-4), 1987-1997.

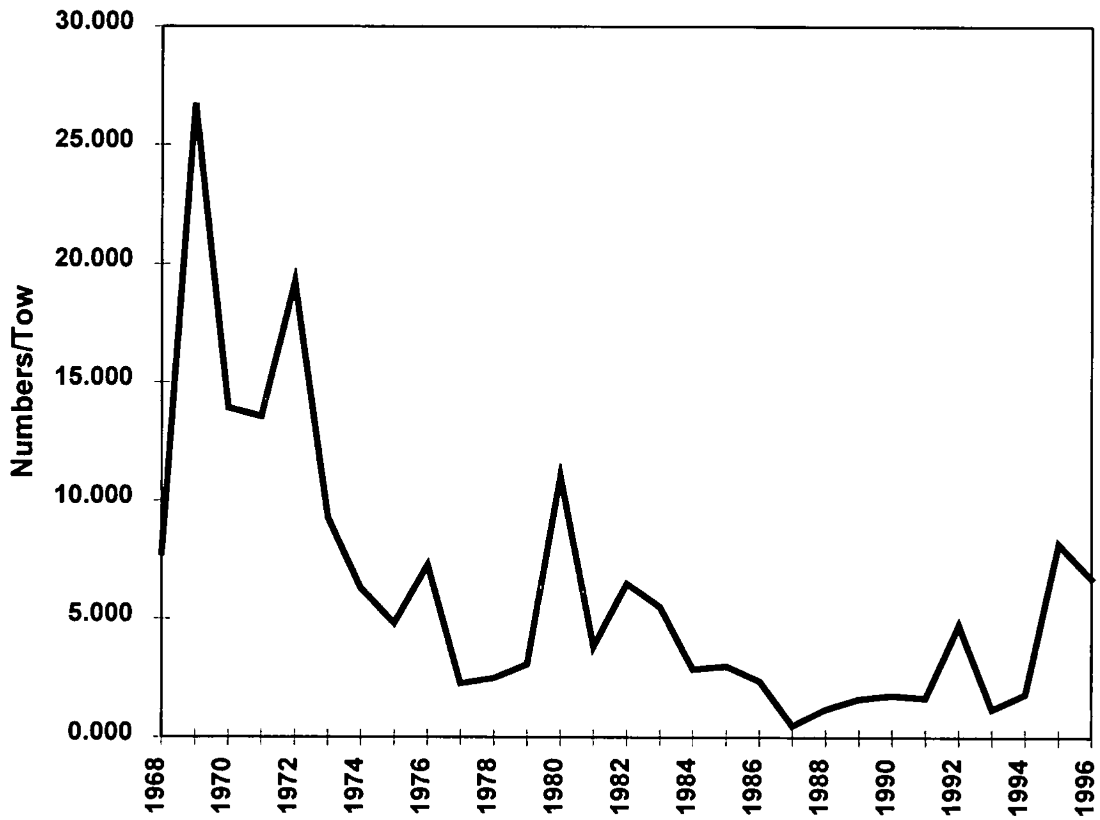


Fig. 15. USA spring survey results for yellowtail flounder on Georges Bank, 1968-1996.

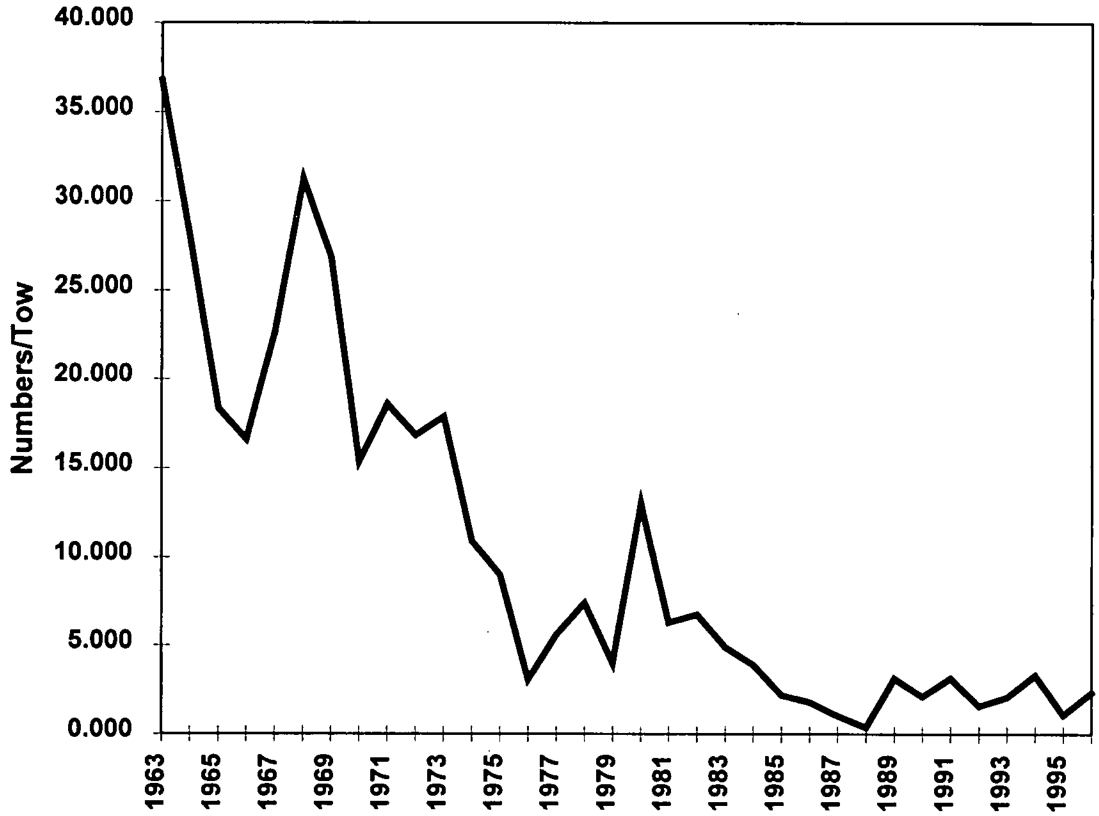


Fig. 16. USA fall survey results for yellowtail flounder on Georges Bank, 1963-1996.

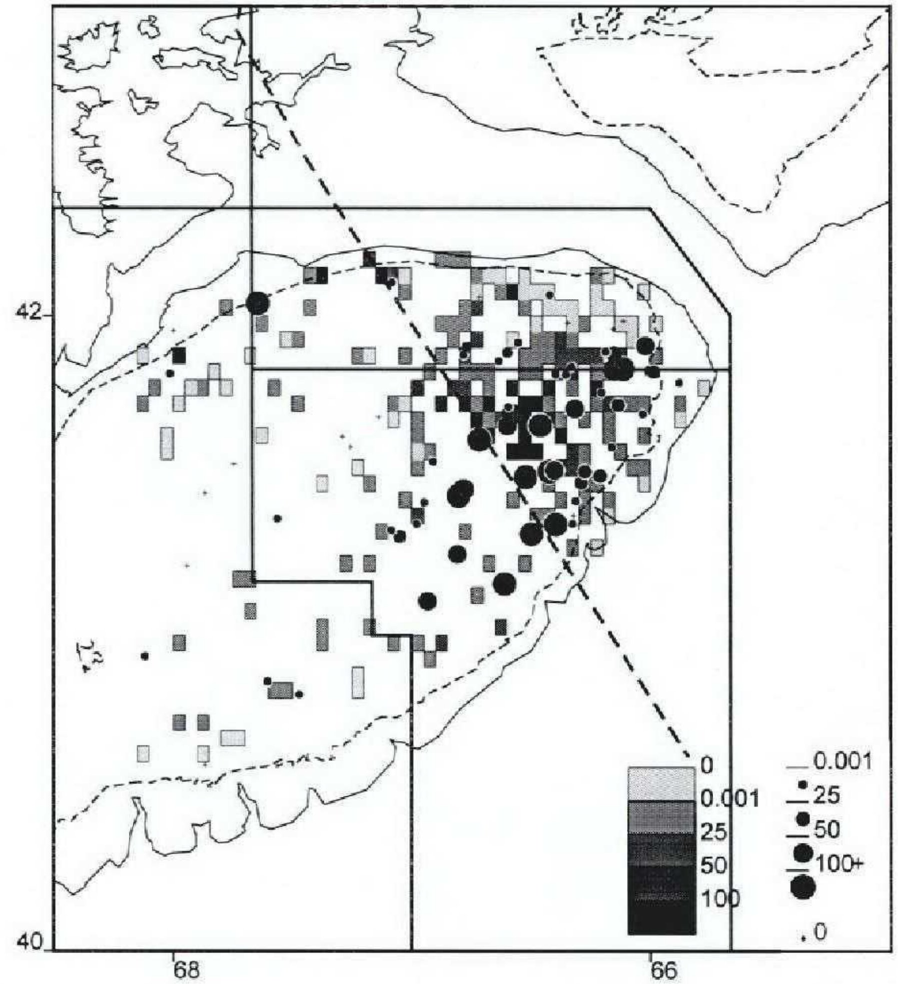


Fig. 17. The distribution of catches of yellowtail flounder (solid circles) in the Canadian Georges Bank spring survey in 1997, compared with the average distribution in the previous five years (shaded rectangles), averaged by 3' squares.

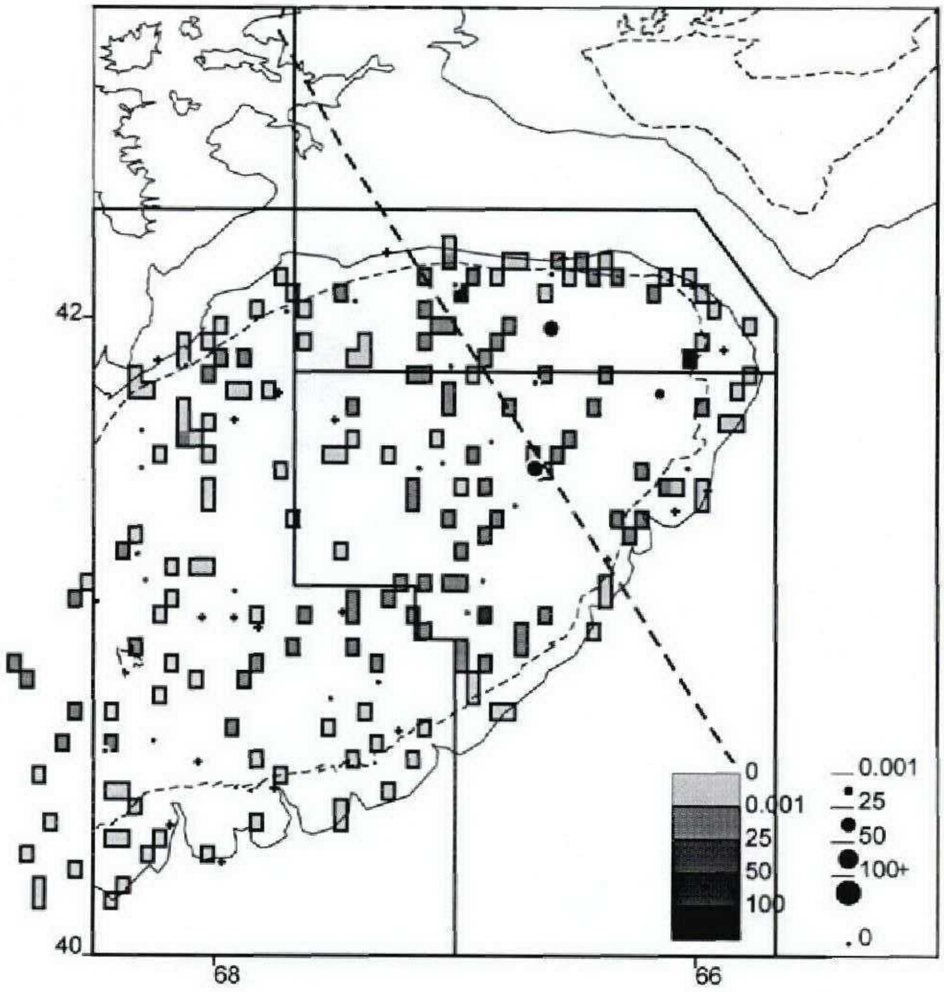


Fig. 18. The distribution of catches of yellowtail flounder in the USA Georges Bank spring survey in 1996 (solid circles), compared with the average distribution in the previous five years (shaded rectangles), averaged by 3' squares.

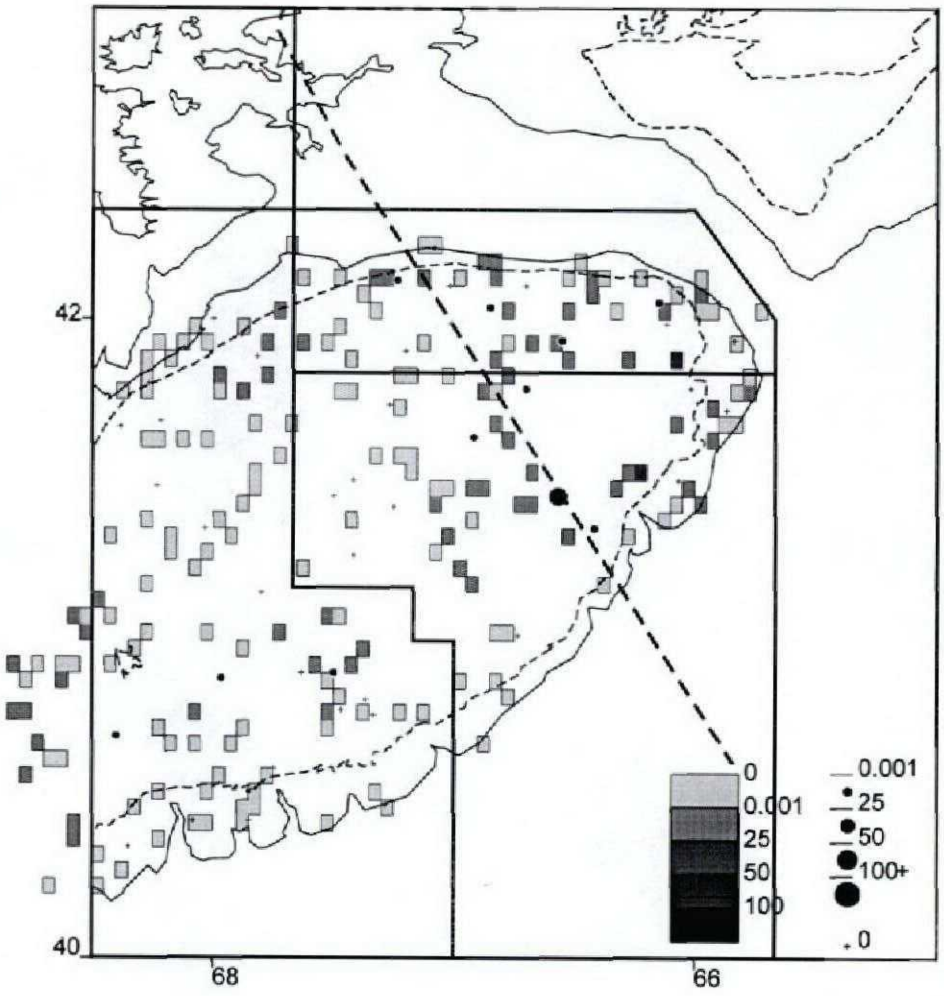


Fig. 19. The distribution of catches of yellowtail flounder in the USA Georges Bank fall survey in 1996 (solid circles), compared with the average distribution in the previous five years (shaded rectangles), averaged by 3' squares.

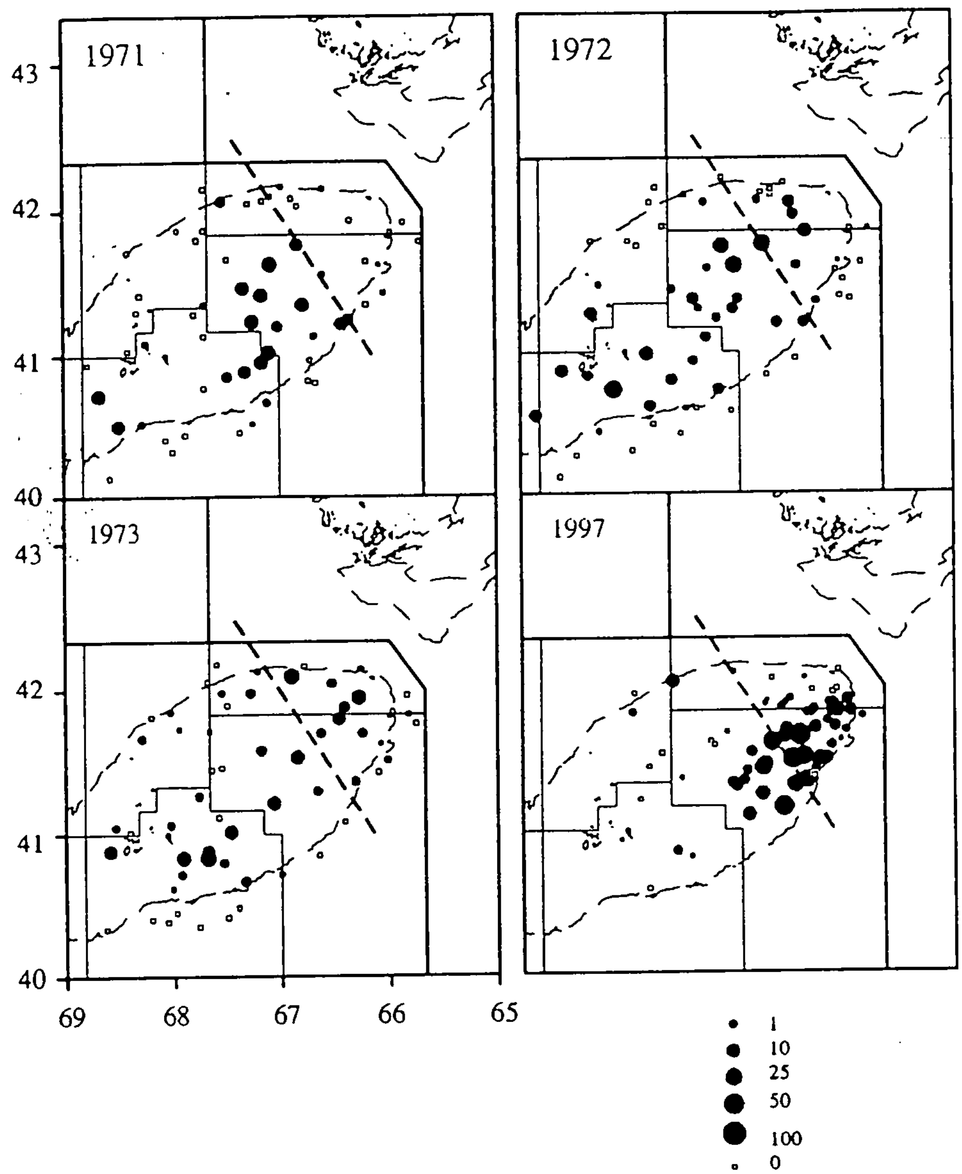


Fig. 20. Comparison of the distribution of yellowtail flounder as indicated in the Canadian 1997 spring survey compared with the abundant years 1971-1973 as indicated from the USA spring surveys.

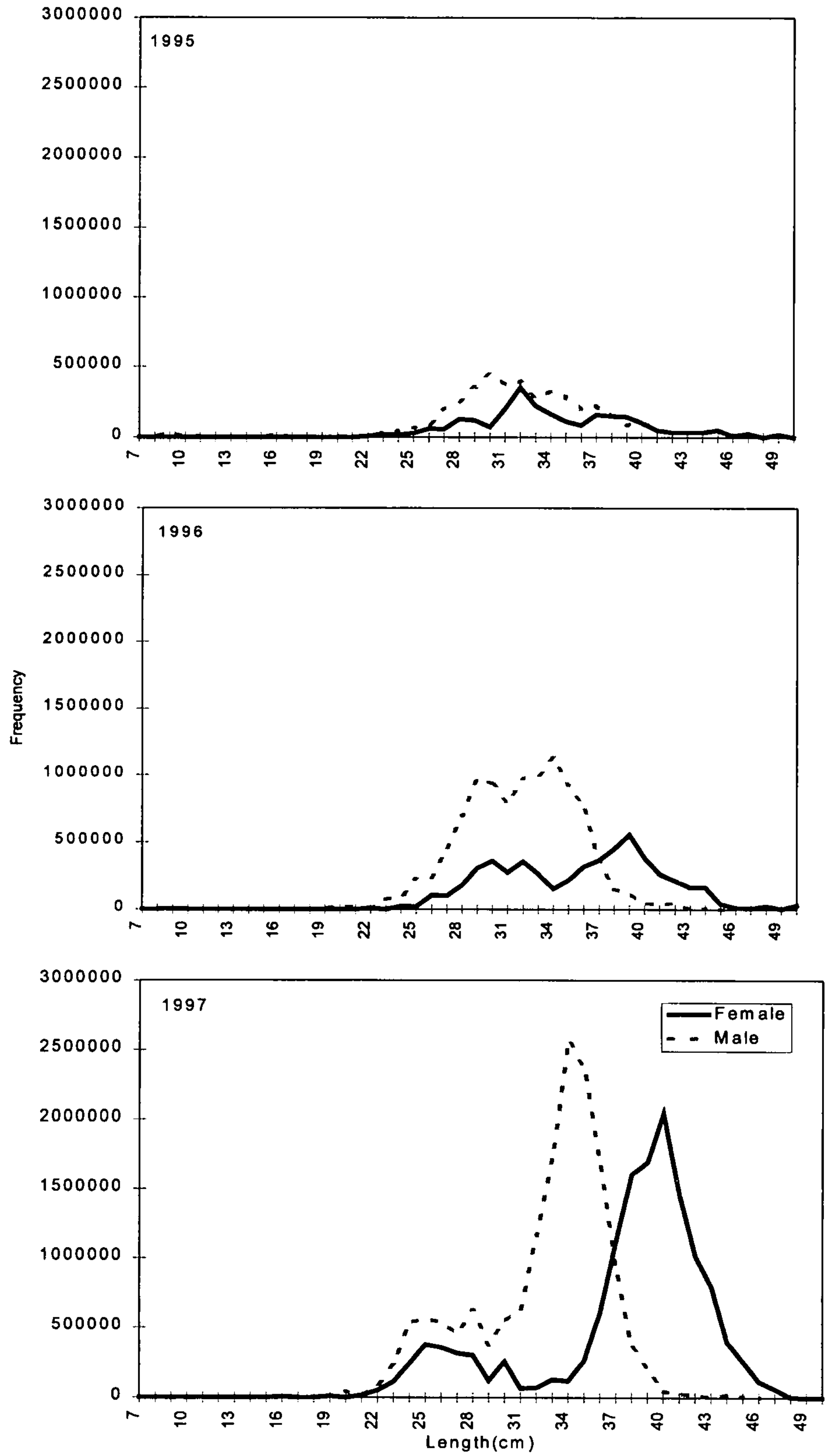


Fig. 21. Comparison of yellowtail flounder length composition in Canadian spring surveys, 1995 - 1997, Georges Bank.

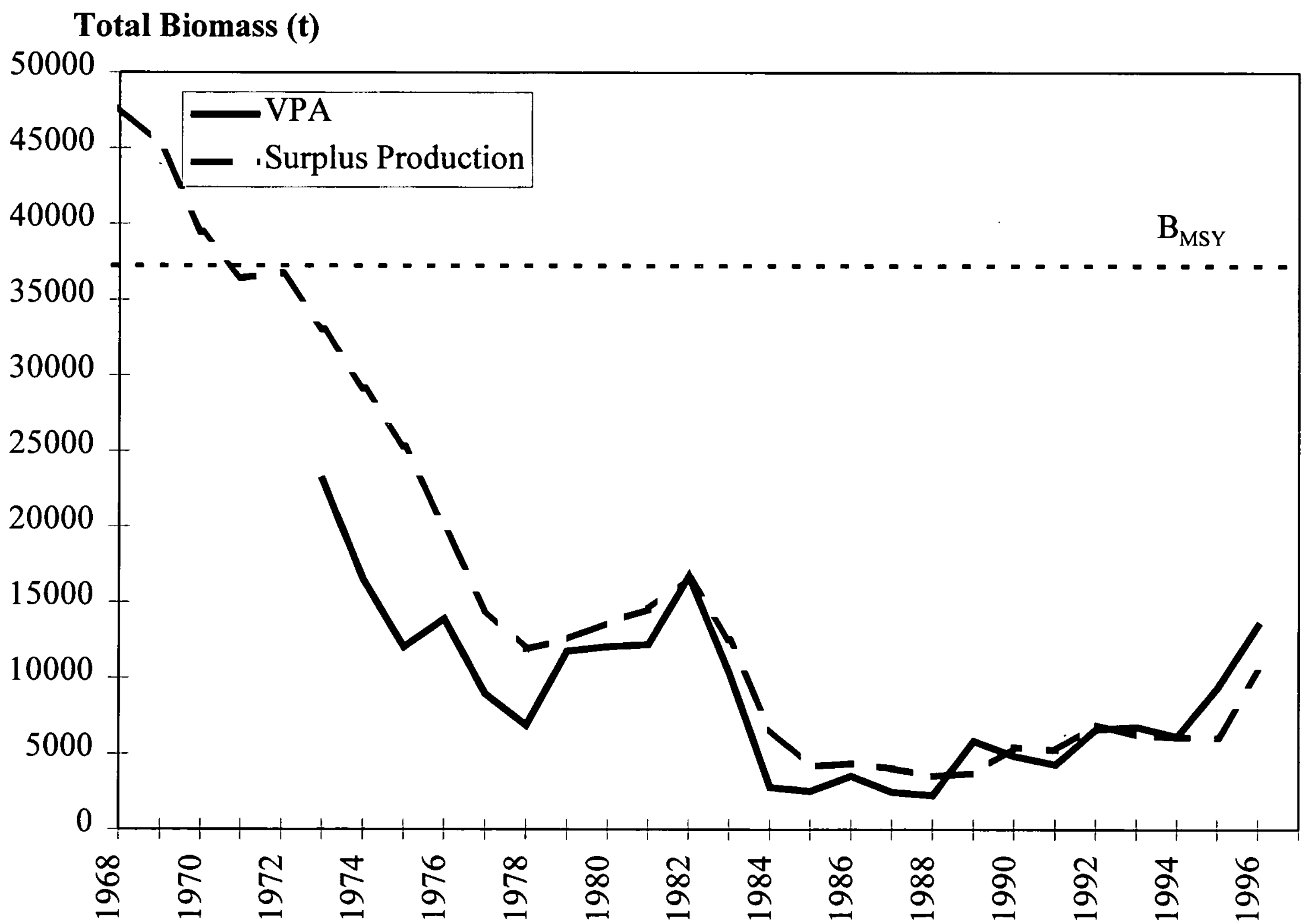


Fig. 22. Trends in biomass for Georges Bank Yellowtail Flounder as indicated from a virtual population analysis and a surplus production model.

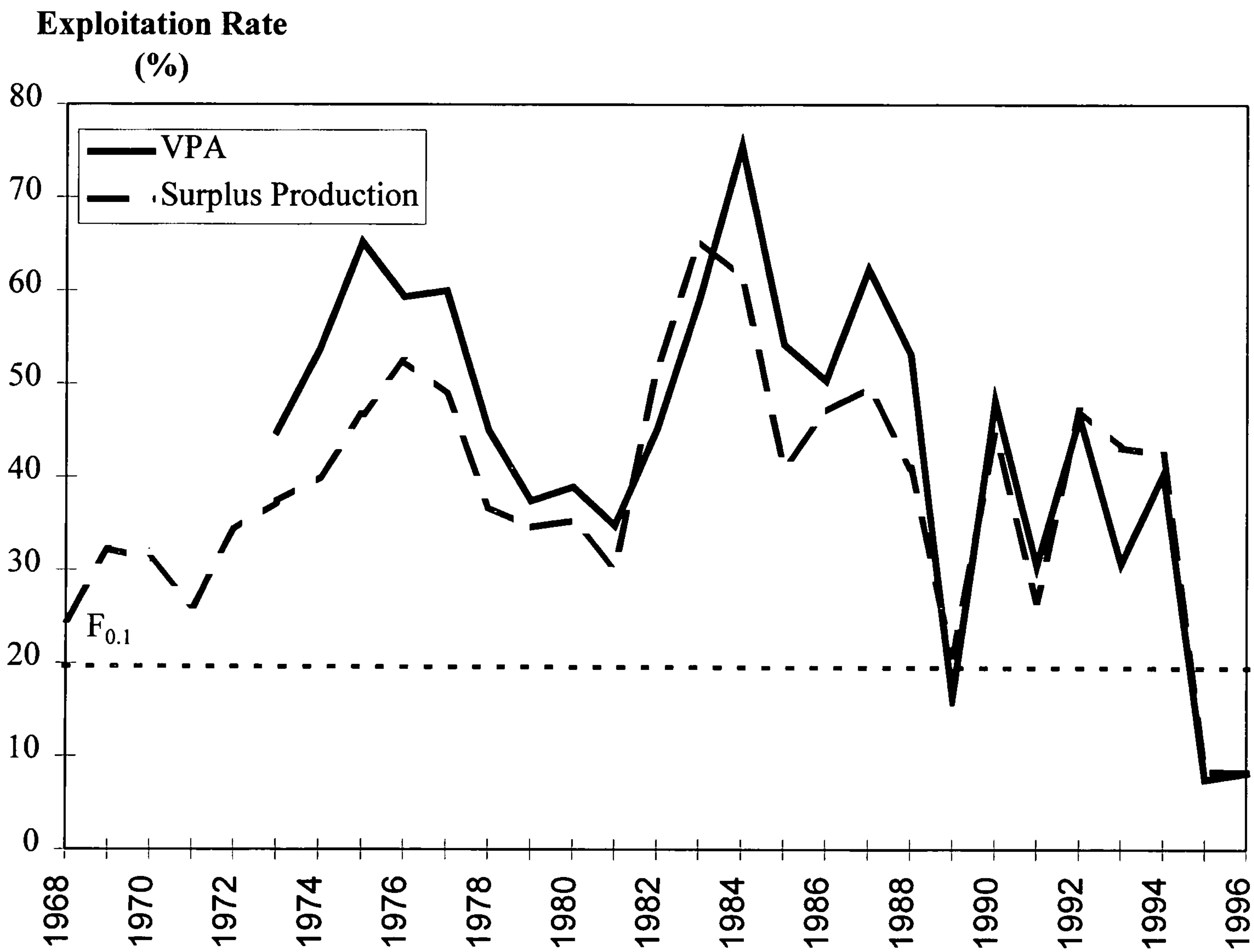


Fig. 23. Trends in exploitation rate for Georges Bank Yellowtail Flounder as indicated from a virtual population analysis and a surplus production model.

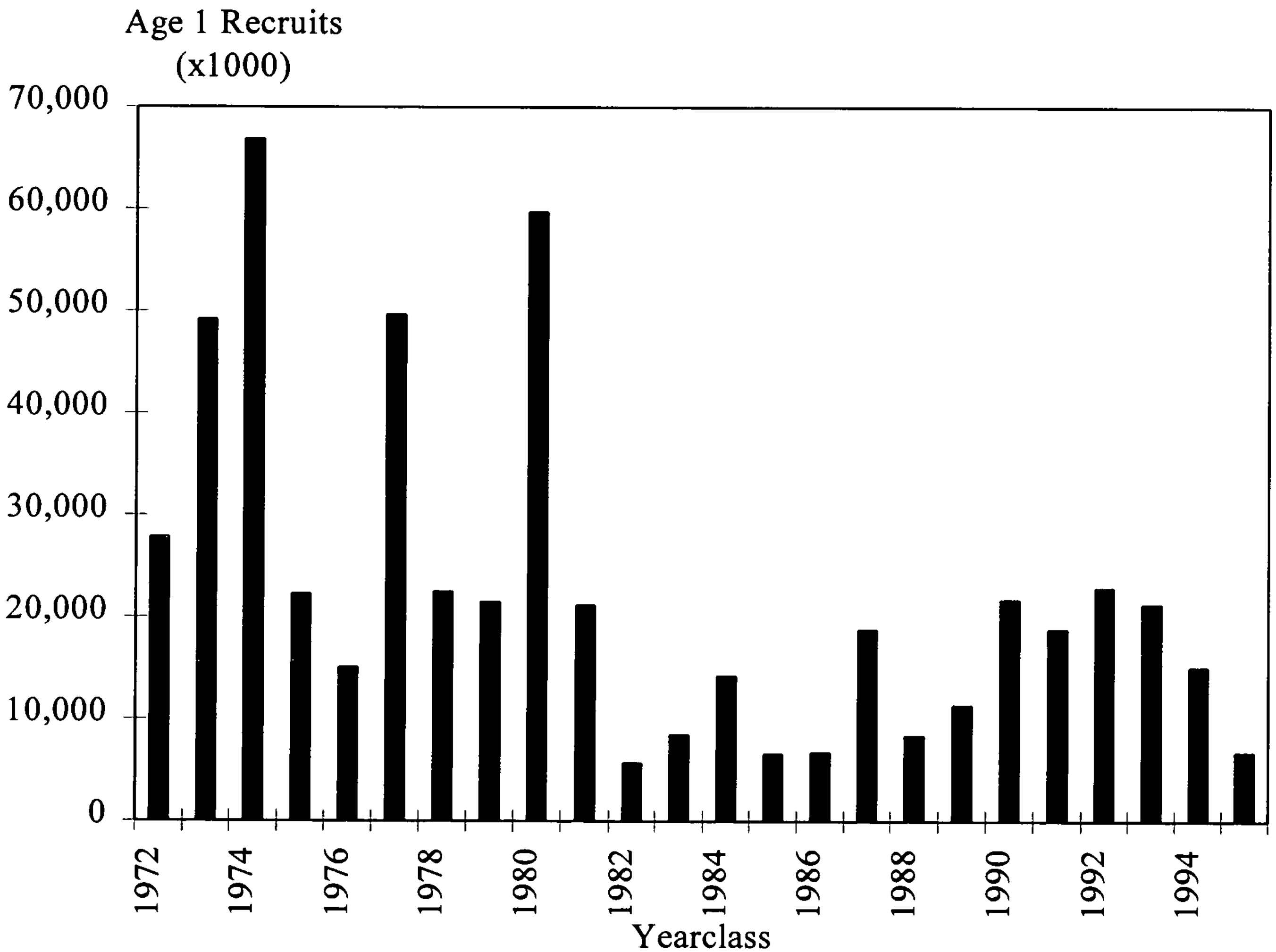


Fig. 24. Recruitment of Age 1 Georges Bank yellowtail flounder, as indicated from virtual population analysis.

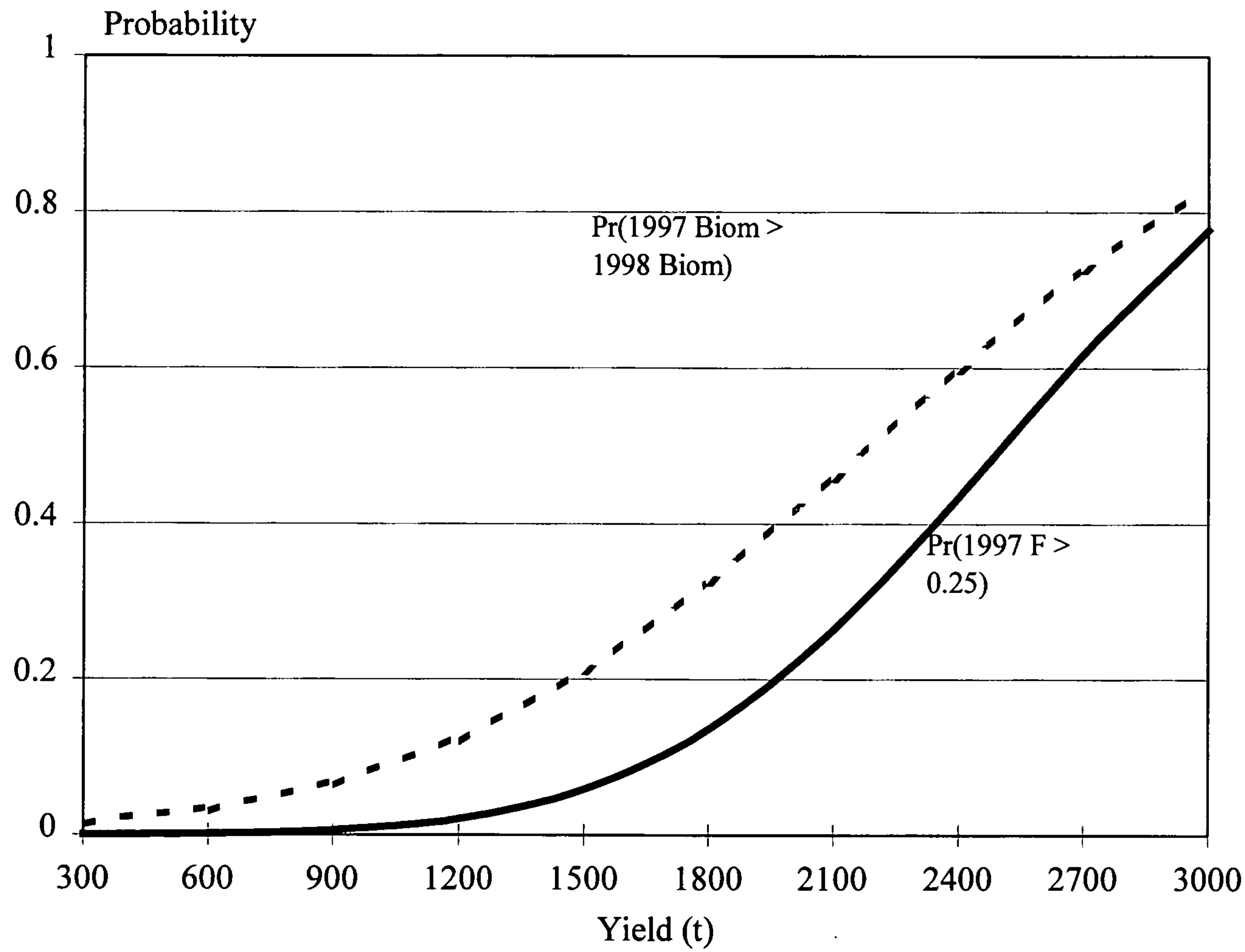


Fig. 25. Probability of exceeding $F_{0.1}$ in 1997 and of the 1998 biomass decreasing compared with 1997 for Georges Bank yellowtail flounder.