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The Millennium Assessment of Grand Bank Yellowtail Flounder Stock in NAFO Divisions 3LNO

by

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Abstract

All available information on the biology, assessment, fishery and management of Grand Bank yellowtail flounder stock, Division 3LNO, are drawn together to assess the status of the stock. Recent surveys by Canada and Spain indicate that stock size has been increasing since the moratorium was declared in 1994. Catches rates in the 1998-1999 fisheries were comparable to the mid 1960s.

A surplus production model, incorporating current and historical survey and catch indices, was used to assess relative biomass, fishing mortality rates and short and medium term yield projections. Results are presented in a precautionary approach framework.

I. Fishery and Management

A. TAC regulation

The stock has been under TAC regulation since 1973, when a precautionary level of 50,000 t was established. In 1976, the TAC was lowered to 9000 t, following a series of high catches (Fig.1; Table 1) and a reduction in stock size. From 1977 to 1988, the TAC varied between 12,000 t and 23,000 t and was unchanged at 15,000 t for the last 4 years of that period. The TAC was set at 5000 t in 1989 and maintained at that level for 1990, following sharp declines in stock size after the large catches in 1985 and 1986. From 1991-1993, a TAC of 7000 t was set because there appeared to be a slight improvement in recruitment to the fishable stock. In 1994, the TAC of 7000 t was recommended by Scientific Council, but the NAFO Fisheries Commission decided that no directed fisheries would be permitted for this stock and the 2 other flatfish fisheries on the Grand Bank (American plaice and witch flounder). From 1995 to 1997, the TAC has been set at zero and a fishery moratorium was imposed. In 1997, a precautionary re-opening TAC of 4,000 t was advised for 1998. In addition other management measures were imposed which recommended that the re-opening be delayed to August to allow the majority of yellowtail flounder spawning to be completed and that the fishery be restricted to Divisions 3N and 3O. For the 1999 fishery, a TAC was set to 6000 t and again restricted to Divisions 3N and 3O, but there were no restrictions on the time period. For the 2000 fishery, a TAC of 10,000 t was recommended.

B. Catch trends

The nominal catch increased from negligible levels in the early 1960's to a peak of over 39,000 t in 1972 (Table 1; Fig. 1). With the exception of 1985 and 1986, when the catch was around 30,000 t, catches have been in the range of 10,000 to 18,000 t from 1976-93. Canada and the USSR were the major participants in the fishery up to 1975, with Canada taking virtually all the catch from 1976-81 (Table 1). Canadian catches were consistently around the TAC in the mid to late 1970's, but were under the TAC's in the early 1980's as much of the fishery for flounders was directed toward American plaice in Div. 3L. Canadian catches were stable around 6700 t from 1991-93, but declined to “ 0" t in 1994.

Catches by other nations began to increase in 1982 as freezer trawlers started to fish in the NAFO Regulatory Area on the Tail of the Bank, NAFO Divisions 3NO (Tables 1&2) (see also Walsh et al. 1995). In 1985 and 1986, as well as for the period of 1989-1994, catches for all other nations combined exceeded those of Canada. USA catches declined steadily from 3,800 t in 1985 to zero in 1991 and 1992 (Table 2) and increased to 700 t during the 1993-94 period. Catches by Spain and Portugal have also decreased to relatively low levels during the period of 1992-96. South Korea, which had been involved in this fishery since 1982, and caught between 3500 and 5900 t per year from 1989 to 1992, has had no vessels in this fishery since early 1993. It should be noted that the catches for S. Korea in many years included a substantial amount of yellowtail flounder determined from breakdowns of catches reported as unspecified flounder.

Before the moratorium in 1994

Overall, the catches from this stock exceeded the TAC in each year from 1985-93, often by a factor of two (Table 1; Fig.1). However, there is still considerable doubt about the precise catch levels from this stock in the recent years before the moratorium. Up to one-third of the catch in some years (almost two-thirds in 1994) was being determined from Canadian surveillance reports and estimates of the proportion of yellowtail flounder in catches of unspecified flounder by S. Korea (Table 2; see also Brodie et al. 1994).

During the moratorium 1994-1997

During the moratorium, the nominal catch of yellowtail flounder in 1995 was 67 t, of which EU-Spain took 65 t in the Regulatory Area. In 1996, the nominal catch was 287 tons of which EU-Spain took 232 t in the Regulatory Area, mainly Div 3N, (Tables 1 and 2). In 1996, Canada reported a catch of 55 t in a co-operative Department of Fisheries and Oceans (DFO) and fishing industry exploratory survey. In the 1996 Statlant 21A statistics, EU-Spain reported a catch of 27 t on the Flemish Cap, NAFO Div 3M. STACFIS noted that this catch was probably an error in reporting or identification since the yellowtail flounder distribution doesn’t extend to the Flemish Cap. In 1997, EU-Spain reported 657 t as a by-catch in the skate fishery and Canada reported a catch of 145 t in the co-operative Department of Fisheries and Oceans (DFO) and fishing industry exploratory survey and 1 t by-catch (Table 1 & 2).

After the moratorium 1998-1999

In 1998, a total catch of 4300 t was taken in 1) a directed commercial fishery by Canada (3700 t), 2) as bycatch (85 t) in the Portuguese Greenland halibut otter trawl fishery in the NAFO Regulatory Area of Div. 3N and 3) as bycatch (562 t) in the Spanish skate fishery in the NAFO Regulatory Area of Div. 3NO (Table 1 & 2).

In 1999 four countries reported landings and a total catch of 6,561 t was taken in 1) directed fishery by Canada (5,413t), 2) as bycatch (300 t) in the Portuguese Greenland halibut/redfish fishery, 3) as bycatch (752 t) in the Spanish skate fishery and 4) as bycatch (96 t) in the Russian Greenland halibut fishery. The latter three fisheries took place in the NAFO Regulatory Area of Divisions 3NO (Tables 1 and 2).

Noteworthy is that in the 1998 and 1999 fisheries the TAC have been exceeded by 9%.

Table 3 shows a breakdown of the catches from Canadian vessels by year, division and gear. With the exception of the 1991-1993 period when Canadian vessels pursued a mixed fishery for plaice and yellowtail flounder in Div 3O, the majority of catches have been taken in Div. 3N.

C. Commercial CPUE data

A multiplicative model was used to analyze the catch and effort data for this stock as in past assessments before the 1994-97 moratorium (Brodie et al. 1994). Because available data from NAFO Statistical Bulletins exists only from 1974 onward in a format that identifies main species- yellowtail data, it was decided to use Canadian (Newfoundland) trawler data from the 1965 to 1993 fisheries and the 1998-1999 fishery from files maintained at the

Northwest Atlantic Fisheries Center in St. John’s to analyze the catch and effort data. It should be noted that for some years, particularly the late 1970’s, the Canadian fleet provided the only source of CPUE data for this stock. The data used in the model were the same data used to calculate the CPUE series in previous assessments (Brodie et al, 1994). Values of catch and effort (hrs) less than 10 were eliminated. Plots of the residuals indicated data with higher levels of catch and effort tended to be less variable. Therefore a weighted regression was conducted. Table 4 show the results of the analysis and Figure 2 shows the standardized series from 1965 to 1999.

In the top panel of Figure 2 , the catch per unit of effort declined steadily from 1965 to 1976, then increased marginally to a relatively stable level from 1980-85. The index again declined sharply in 1986 and remained at this relatively low level through to 1990. In 1991 the CPUE declined by almost half to the lowest level observed but increased in 1992 and again in 1993 to about the 1990 level. The catch rate in 1998 , after four years of the stock under moratorium, increased sharply to a level comparable to the late 1960’s. Preliminary data for 1999 indicate a further increase. The revised 1998 data represents a downward revision from the 1999 assessment because there was a problem discovered with the compilation of that preliminary data. The previous assessment suggested it was the highest catch rate observed.

A substantial part of the effort labelled 'directed' for one species or the other in this Division was actually effort directed at a mixed fishery for American plaice and yellowtail flounder during 1991-1993 as seen in the by-catch totals in Table 3. Given this major shift in the fishery from the 1965-90 (generally in Div. 3N) and the 1991-93 periods (more effort in Div. 3O), some caution must be used in comparing the recent catch rates with those of earlier years. Nonetheless, it is difficult to interpret the 1991-1993 values for CPUE in any way other than to say that they indicate that the stock was at a relatively low level. In 1998 and 1999, the yellowtail fishery had by-catch restriction of 5% for both American plaice and cod which directly affected the fishing pattern of the Canadian fleet. The fleet spent additional time searching for good catches of yellowtail with low by-catches of both restricted species, which they found mainly in the central area of Div. 3N where yellowtail are aggregated (Simpson and Walsh 1999). Once again caution should be used in comparing the post moratorium catch rates with other fishery periods, however, such a comparatively high catch rate could indicate that the stock size is at a relatively high level in accordance with a similar perception from survey indices (Walsh et al. 1999; Simpson et al. 1999).

An analysis of the catch rate data separately by division suggest generally similar trends over the time period with the caveat that Div. 3O tended to have larger between year variability, primarily before 1985 (Fig. 2 lower panel). The preliminary data for 1999 suggests a 20% increase in Div. 3N and a 38% decrease in Div. 3O which is probably indicative of the changes in the fishing pattern in an effort to minimize the plaice bycatch problem in Div 3N.

D. The 1999 Canadian fishery description

The Canadian fleet averaged 0.89 tons per hour fishing mainly in shallow waters of Div. 3N using a codend mesh size ranging from 145 to 155 mm. The fishery is very localized because of the need to minimize the bycatch of plaice which is under moratorium. Plaice bycatch was about 4% of the total catch. Low bycatch of cod (1%) was attributed to the use of a sorting grid in the codend. Modal length of yellowtail in the catch was 37 cm (Fig. 3). Analysis of maturity data indicated the fishery took place on pre-spawning and post spawning fish. The fleet ceased fishing from June 15-July 31 which is regarded as the time of peak spawning for yellowtail flounder.

E. The 1999 Non-Canadian fisheries’ description (NAFO SCS Doc 00/9; SCS Doc 00/16;SCR Doc. 00/20)

Length frequency of the catches by Russia, Spain and Portugal in the Regulatory Area of Divisions 3NO are presented in Fig. 3. The length frequency of yellowtail flounder in the Portuguese fishery were sampled from the July to December in Div. 3N and August and September in Div. 30 catches and those of the Spanish fishery were sampled in catches taken in October and November in Div. 3N. The Russian length frequency was taken from catches in Div. 3N. The mode in the length frequencies of the Portuguese (36 cm) and Russian (34 cm) catches are shifted to the right of the Spanish (30 cm) catches (Fig. 3).

F. Codend mesh sizes in multi-country fisheries

The length frequencies of yellowtail flounder from fisheries in the Regulatory Area are compared to the length frequencies of yellowtail flounder catches in the Canadian directed fishery in Division 3NO. Each fleet used diamond mesh codends of different mesh sizes. The Canadian fleet used an average mesh size of 145 mm, the Portuguese and Russian fleet used the regulated mesh size of 130 mm and the Spanish fleet, because they were directing for skate used a mesh size of 220 mm**.**

The mode in the length frequencies of the Portuguese (36 cm) , Canadian (37cm) and Russian (34 cm) catches are shifted to the right of the Spanish (30 cm) catches (Fig. 3). There doesn't appear to be an accepted explanation of why the length selection by the 130 mm mesh codends used by Russia and Portugal and the 145-155 mm mesh size codends used by Canada have better selection than 220 mm mesh codends used in the Spanish skate fishery in which yellowtail as small as 16 cm were found.

II. Research Survey Data

A. Sampling gear studies (NAFO SCR Doc. 00/19, 46)

Preliminary analysis of comparative fishing trials carried out by Canada and Spain in the Regulatory Area of Div. 3N in May of 2000 were presented in the form of 14 pairs of side by side parallel trawling between the two fishing vessels. Trials consisted of a mixture of two tow durations, 15 minute and 30 minute tows, typical of that use by each country. Catches (wt) of yellowtail flounder by the Predreira trawl used by Spain exceeded that of the Campelen trawl used by Canada often by as much as 6 to 7 times. The huge differences in catchability are attributed to the difference in sweep lines (lower bridle + ground warp) used on both trawls (in excess of 200 m Spain: 46 m Canada) and the smaller footgear used by Spain. Clearly these long sweep lines have a huge herding effect thus increasing the numbers of fish arriving in the trawl mouth. This conclusion is strongly supported from data gathered by Spain during their 2000 survey where they carried out alternate hauls comparisons, aboard their own vessel, between the Prederira rigged in the normal manner and the Campelen rigged with 240 m sweep lines. Thirteen 30 minute tows were carried out in the Regulatory Area of Div. 3N in which the Prederira catches were only the 32% higher than the Campelen trawl (Fig. 4)

B. Canadian stratified-random surveys spring and fall surveys (NAFO SCR Doc. 00/35)

Abundance and biomass trends

Figures 5 and 6 and Table 5 compare the population abundance and biomass estimates of yellowtail flounder in the spring and fall surveys. Survey estimates of abundance show similar trends in both series although the fall estimates have generally been higher. The fall survey indicates that the upward trend in stock size started in 1993 while the spring survey showed the trend increasing in 1995. In addition, biomass estimates are consistently higher in Div. 3N during the fall surveys from 1992 onward and for Div. 3O, in general there doesn't appear to be an obvious trend between spring and fall estimates (Fig. 6). In Div. 3L, the fall biomass has generally been higher since 1995. In the 1999 spring survey, both the abundance and biomass sharply increased in size over the 1998 estimate and can be regarded as a "year' effect caused by a change in catchability. Similar results were seen in 3LNO plaice stock. In the 1999 fall survey abundance and biomass estimates were lower and in lined with expected values.

Figure 7 shows the result of a regression of the biomass estimates from the spring and fall time series. A linear relationship is evident with 66% of the variation being explained by the model. Two time regimes may be evident here but the significance of this occurrence is not clear. The 1999 estimate puts stock biomass at 366, 000 tons (81% higher than the 1998 estimate) in the spring and 249,000 tons (8% higher than the 1998 estimate) for the fall estimate (Table 5).

Size and age composition

Length

Figure 8 shows the length composition of survey catches from spring and fall surveys by year for Div. 3LNO combined. Size composition in most years shows a bimodal distribution. More smaller fish were present in the survey catches beginning in the fall of 1995 onward due to the increase in efficiency of the new survey gear over the old gear. In 1999, more small fish (<20cm) are evident in the fall survey.

Age (NAFO SCR Doc 00/32)

Preliminary analysis of age determination from whole and sectioned otoliths showed good agreement in aging yellowtail up to and including age 7. Noteworthy is that this analysis was based on a sample size of 204 pairs of otoliths. From age 8 onward sectioned otoliths gave higher readings than whole otolith readings. Maximum age of 13 years was estimated for males and 16 years for females in comparison for 10 and 11 from whole otoliths. Modal length frequency analysis using the Peterson method indicate good agreement for younger ages up to 5 years by whole otoliths and suggested that growth in the first three years was on average 5 cm per year. Further studies are planned.

Abundance at age

Given that there is still some uncertainty with the age reading the interpretation of Tables 6 and 7 and Figures 9 and 10 are to be treated with caution. Estimates of fish beyond age 7 put in a 'plus' category.

Because of the year effect evident in the 1999 spring survey, these indices will not be discussed in relation to other years. The fall indices in 1999 will be used to indicate the strength of the year-classes from 1995 to 1998 in comparison to the long-term average. Because of the switching in survey gears in 1995, long term average abundance of ages 1 to 3 were calculated from 1996-1999 while that of age 4 were calculated from the full series. The 1998 year-class at age 1 is well below average (mean=4.4), the year-classes of 1997 at age 2 (mean =31.5, the 1996 at age 3 (mean = 65.9) and the 1995 at age 4 (mean =75.3) are moderately above the long term average.

Tables 6 and 7 & Figures 9 and 10 show the abundance and biomass of ages 1-4 pre-recruits, fully mature fish (ages 5+) and fully recruited fish (age 7+) for the spring and fall time series. The biomass was estimated yearly from a length-weight regression analysis for the period 1990-98. Weights of individual fish have been collected at sea annually since 1990. For data prior to 1989 the biomass is proportioned using an length-weight regression analyses averaged over 6 years. Discounting the 1999 spring survey results and the uncertainty in the ageing the abundance and biomass of all three categories have generally shown an upward trend.

C. Cooperative DFO/fishing industry seasonal surveys (NAFO SCR Doc. 00/42).

Cooperative surveys in Divisions 3NO between DFO and the Canadian fishing industry were carried out using a commercial fishing gear without a codend liner. These surveys indicate drastic changes in catch rate and distribution of yellowtail flounder and other species in March of 1997, 1998 and 1999 compared with surveys at other times of the year. CPUE observed in the 7 other cooperative surveys was relatively high compared to historic CPUE data from the fishery. The similarity in CPUE estimates from the remaining grid surveys, and the low CPUE of other species in the March surveys, suggested that catchability in the grid area during March is lower than that found in other seasons. The amount of the stock in the grid has been decreasing since 1998 coincident with the extension of the spatial range of the stock farther northward with increasing stock size. With the exception of March surveys, CPUE in the 1999 grid surveys is lower when compared to previous surveys.

The length range of yellowtail flounder in these surveys ranged from 21-54 cm with only 11% of the catch in any one trip being less than 30 cm. These surveys also pointed to the difficulty of directing a fishery for yellowtail flounder without incurring varying levels of by-catch of American plaice and cod whose fisheries are under moratoria.

D. Spanish stratified-random spring surveys in the Regulatory Area of Div. 3NO (NAFO SCR Doc. 00/46)**.**

Beginning in 1995 EU-Spain has conducted stratified-random surveys for groundfish in the Regulatory Area of Div. 3NO. These surveys cover a depth range of approximately 45 to 1300 m. The biomass index increased between 1995 (27 704 tons) and 1996 (129 642 tons), decreased in 1997 (115 728 tons), increased in 1998 (425 375 tons) and again in 1999 to 589 200 tons. In 2000 the survey biomass decreased by 24% to 447,403 tons (Fig. 11A). Whether the decrease in stock size in 2000 is a natural decrease or whether the 1999 survey was an anomalous year as seen in the 1999 Canadian spring survey where a strong 'year' effect was evident is unknown.

Figure 11B shows the length composition of the 2000 survey catches of yellowtail flounder with a mode of 29 cm similar to the 1999 survey value.

E. Stock distribution (NAFO SCR Doc. 00/35).

Analysis of 1998 and 1999 spring and fall showed the stock was more widely distributed in all three divisions and continues to occupy depths less than 100 m. The majority of the stock is consistently concentrated in Div. 3N on and to the area west of the Southeast Shoal. In the 1998 and 1999 surveys, expansion of the range into Div. 3L was evident and yellowtail flounder are found on all traditional grounds similar to historic times.

F. Biological studies

Growth from tagging studies

Tagging returns from experiments carried out in the early 1990s with Peterson disks were explored for an estimate of growth rate. Only fish where the length at recapture was greater than or equal to the length at release were used. Four fish which had apparent growth rates of more than 30 cm per year were also eliminated from the analyses. (See Walsh and Morgan, MS 1999 for further details on the tagging). For this analysis, 125 fish had acceptable length information. The average growth for all fish combined was 1.61 $\pm$ 0.18 cm/year (mean $\pm$ std err). The fish were divided into 3 size categories (less than 25 cm, greater than or equal to 25 cm but less than 30 cm, and greater than or equal to 30 cm) to determine if growth rate differed with size. Data were ranked and analysed using a general linear model followed by Tukey's multiple comparisons. There was a significant effect of size at release on growth rate (F=9.64, df=2,124, p<0.001). The growth rates for fish in the less than 25 cm and the 25 to 30 cm categories were not significantly different but both were different from the 30 cm and greater size category (Fig. 12). Average growth rates were 1.9, 2.7 and 1.0 cm/ year for the three size categories respectively. Fish in the two smaller size categories had a higher growth rate than fish in the largest size category, indicating that growth declines at larger sizes.

This contrasts with earlier perceptions of larger growth rates for younger yellowtail flounder and the preliminary results of Peterson method of ageing fish by modal analysis of length frequencies reported in Section IIB. It hope that tag returns from the new 2000 to 2004 tagging experiments and resolution of age determination by otoliths may shed some light on these differences in growth.

Maturity

Maturity at age and size were estimated using Canadian spring research vessel data from 1984-99. For estimates of maturity at age observed proportions mature were produced using the method of Morgan and Hoenig (1997) to account for the length stratified sampling design. For both age and size, estimates were produced using a probit model with a logit link function and a binomial error structure (SAS, 1989). L_{50} has declined in males, by about 5 cm from around 30 cm to 25 cm, while female L_{50} has been fairly stable at about 34 cm (Fig 13). Similarly, for males there has been a decline in age at 50% maturity of about 1.5 years over the time period from about 5.5 to 4.0 years while for females, A_{50} has shown little trend, varying around 6.5 years (Fig. 14)..

III. Assessment Results

Length based female spawning stock biomass

Due to unreliably in the aging of older fish, Scientific Council recommended in 1999 that a length base SSB be explored (NAFO 1999).

Estimates of female proportion mature at length, population numbers at length, and annual length weight relationships were used to produce an index of female SSB from the spring survey. Annual length weight relationships were unavailable prior to 1990 so for those years a relationship was produced using data from 1990-1993. The specific length-weight relationships are given in Table 8. Female SSB declined from 1984 to 1992. Since 1995 it has increased substantially (Fig. 15). The average index over the 1996-1998 period was 66 000 t, similar to levels in the mid-1980's. There was a large increase in the index in 1999 consistent with the large increase in the overall survey index for that year and is interpreted to be an anomalous estimate.

Relative cohort strength

Relative cohort strength was estimated from a multiplicative model using ages 3 and 4 abundance from the 1984-1999 Canadian spring and 1990-1999 Canadian fall research vessel surveys. The model took the form:

$$\log(N_{ijk})=\tau + \alpha_i+\beta_j+\delta_k+\varepsilon$$

where: N_{ijkt} = number at age i from survey j belonging to cohort k

τ = intercept

α_i = age effect for i=3 and 4

β_j = survey effect for j=spring and fall

δ_k = cohort effect

ε = residuals from the fitted model

The model showed no obvious pattern in the residuals (Fig. 16) and there was a significant fit to the data. However there was no significant cohort effect, suggesting that there has been little contrast in cohort size over the time period.

R^2=0.51, n=51

Source	DF	Type III SS	Mean Square	F Value	Pr > F
AGE	1	18.37488273	18.37488273	15.79	0.0004
COHORT	16	20.26955625	1.26684727	1.09	0.4027
SURVEY	1	0.06940278	0.06940278	0.06	0.8086

Estimates of relative cohort strength from this model are plotted in Fig 17. Although there was no significant difference between cohorts the estimates for 1993 and 1994 are somewhat higher than the other cohorts in the time series.

Stock status

Estimation of Parameters

Several formulations of a surplus production analysis (ASPIC) were presented (SCR Doc. 00/44).

STACFIS agreed that the production model that provided the best fit to the data included the catch data (1965-2000), Russian spring surveys (1972-1991), Canadian spring surveys (1971-1982), Canadian spring (1984-1999) and fall (1990-1999) surveys and the Spanish spring (1995-2000) surveys. In the final run and for all projections the input data included the Spanish survey biomass estimate in the year 2000 and assumed that the 2000 fishery would catch the TAC plus an additional 10% overrun, i.e. 11 000 tons, similar to the 1998 and 1999 fisheries.

Because of differences in catchability among the various indices, relative indices of biomass and fishing mortality rate were used instead of absolute values. As this stock was assessed with a production model, fishing mortality refers to yield/biomass ratio.

Results

The production model suggests that a maximum sustainable yield (MSY) of 17 000 tons can be produced by total stock biomass of 83 000 tons (B_{msy}) at a fishing mortality rate of 0.21 (F_{msy}) (Table 9). The analysis showed that relative population size (B_t / B_{msy}) has been below the level at which MSY can be obtained from 1973 to 1994, when the moratorium was announced. Since the moratorium, the stock has been rebuilding so that B_t = B_{msy} in 2000, i.e. B_t / B_{msy} = 1.1 (Table 10; Fig. 18).

Relative fishing mortality rate (F_t / F_{msy}) was above F_{msy}, in particular from the mid-1980s to early-1990s when the catches exceeded or doubled the recommended TACs (Fig. 19; Table 1). In 2000, relative F is projected to be 61% F_{msy} if the TAC (+ 10% over-run) is taken (Table 10).

Since 1994, when the moratorium (1994-1997) was put in place the estimated yield has been below sustainable production levels (Table 10; Fig. 20).

The model was bootstrapped (Table 11) to derive estimates of yield projections for 2001 assuming a status quo F (F_{2000}=F_{2001}) (Table 12;Fig 21) and assuming F_{2001}=2/3 F_{msy} (Table 13; Fig 22) and additional analysis was conducted. By constraining the catch in 2000 to 11 000 tons, percentiles of fishing mortality, yield and biomass for a series of multipliers were estimated (Table 14). A status quo F results in a yield of 11 700 tons in 2001 and F_{2001}=2/3 F_{msy} results in a yield of 12 700 tons in 2001.

Medium term projections (10 years) were carried out by extending the ASPIC bootstrap projections forward to the year 2010 under an assumption of constant fishing mortality at 2/3 F_{msy} i.e. 0.139. The output shows that yield reaches a maximum at 15 000 tons in the year 2010 (Table 15; Fig. 23). The results depicted in Figure 24 show the percentiles of predicted absolute yield and biomass, yield relative to MSY and biomass relative to B_{msy}. The probability of biomass falling below B_{msy} is between 10 and 20% from 2003 onward. The projections are conditional on the estimated values of r and K.

Reference points

Stock-recruitment relationships

The estimates of relative cohort strength from the multiplicative model are plotted against the index of female SSB from the spring survey in Fig 25. There is no indication of a stock recruit relationship. This is not surprising given the lack of contrast in year class strength over the time period

Precautionary approach (NAFO SCR Doc 00/50)

The stock trajectory estimated in the surplus production analysis is depicted in Fig. 26 against proposed harvest control rule. Also illustrated is the trajectory of a projection based on a scenario of status quo fishing mortality, together with the confidence intervals of the relative fishing mortality and relative biomass at the end of 2001.

In this framework, the precautionary reference points were defined as follows. The limit fishing mortality, F_{lim}, was taken as F_{MSY}. The limit biomass reference point was taken as the estimate of the biomass when the fishery was closed, as concerns with the biomass level (estimated with 1993 data) were key considerations in the 1994 discussions leading to the moratorium. It is noted that at that level of biomass, the stock responded rapidly to the reduction of fishing pressure. The fishing mortality target was taken as 2/3 F_{MSY}, which represents the reference point typically requested by managers when production models are used. No target has been determined by managers for biomass and B_{MSY} is used here, as an interim value, as the biomass target. Rather than provide buffer reference points, it is proposed to use risk analyses to make annual evaluations of the risk of passing limit reference points.

The management measure in place in recent years, which included moratorium on directed fisheries (1995, 1996 and 1997) and TACs based on a fishing mortality much below the 2/3 F_{MSY} target, have led to a rapid increase of the stock so that the biomass is now estimated to be above B_{MSY}. The harvest control rule described here captures many of the strategies that have governed the management of yellowtail flounder in recent years. In hindsight, such strategies appear to have been instrumental in rebuilding this stock. The formal adoption of such a framework as a working model would help to cast future management strategies in the perspective of such a precautionary approach. Further work is expected.

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Table 1. Nominal catches by country and TACs (tons) of yellowtail in NAFO Divisions 3LNO.

Year	Canada	France	USSR/ Russia	South Korea	Other [b]	Total	TAC
1960	7	-	-	-	-	7	
1961	100	-	-	-	-	100	
1962	67	-	-	-	-	67	
1963	138	-	380	-	-	518	
1964	126	-	21	-	-	147	
1965	3,075	-	55	-	-	3,130	
l966	4,185	-	2,834	-	7	7,026	
l967	2,l22	-	6,736	-	20	8,878	
l968	4,l80	l4	9,l46	-	-	l3,340	
l969	l0,494	l	5,207	-	6	l5,708	
l970	22,8l4	l7	3,426	-	l69	26,426	
l97l	24,206	49	l3,087	-	-	37,342	
l972	26,939	358	ll,929	-	33	39,259	
l973	28,492	368	3,545	-	4l0	32,8l5	50,000
l974	l7,053	60	6,952	-	248	24,3l3	40,000
l975	l8,458	l5	4,076	-	345	22,894	35,000
l976	7,9l0	3l	57	-	59	8,057	9,000
1977	ll,295	245	97	-	l	ll,638	l2,000
l978	l5,09l	375	-	-	-	l5,466	l5,000
l979	l8,ll6	202	-	-	33	l8,35l	l8,000
l980	l2,0ll	366	-	-	-	l2,377	l8,000
l98l	l4,l22	558	-	-	-	l4,680	2l,000
l982	ll,479	ll0	-	1,073	657	13,319	23,000
l983	9,085	l65	-	1,223	-	10,473	l9,000
l984	l2,437	89	-	2,373	1,836 [b]	16,735	l7,000
l985	13,440	-	-	4,278	11,245 [b]	28,963	l5,000
1986	14,168	77	-	2,049	13,882 [b]	30,176	15,000
1987	13,420	51	-	125	2,718	16,314	15,000
1988	10,607	-	-	1,383	4,166b [b]	16,158	15,000
1989	5,009	139	-	3,508	1,551	10,207	5,000
1990	4,966	-	-	5,903	3,117	13,986	5,000
1991	6,589	-	-	4,156	5,458	16,203	7,000
1992	6,814	-	-	3,825	123	10,762	7,000
1993	6,697	-	-	-	6,868	13,565	7,000
1994 [c]	-	-	-	-	2069	2069	7,000 [d]
1995 [c]	2	-	-	-	65	67	0 [d]
1996 [c]	55	-	-	-	232	287	0 [d]
1997 [c]	146	-	-	-	657	803	0 [d]
1998 [c]	3,701	-	-	-	647	4,348	4,000
1999 [c]	5,413		96	-	1,052 [b]	6,561	6,000

[a] see text for explanation of South Korean catches
[b] includes catches estimated from Canadian survelliance reports
[c] provisional
[d] no directed fishery permitted

Table 2. Breakdown of 1984-99 catches from Table 1 listed as "other."

Year	Spain	Portugal	Panama	USA	Cavman Is	Misc.	Total
1984	25	-	1,800	-	-	11	1,836
1985	2,425	-	4,208	3,797	803	12	11,245
1986	366	5,521	4,044	2,221	1,728	2	13,882
1987	1,183	-	-	1,535	-	-	2,718
1988	3,205	-	-	863	-	100 [b]	4,163
1989	1,126	5	-	319	-	101 [b]	1,551
1990	119	11	-	6	-	2,981 [b]	3,117
1991	246	-	-	-	-	5,212b [b]	5,458
1992	122	1	-	-	-	-	123
1993	-	-	-	68	-	6,800 [a]	6,868
1994	719	-	-	700 [a]	-	650 [a]	2,069
1995	65	-	-	-	-	-	65
1996	232	-	-	-	-	-	232
1997	657	-	-	-	-	-	657
1998	562	85	-	-	-	-	647
1999	752	300 [a]	-	-			1,052

[a] Not reported to NAFO.Catches estimated from surveillance reports.
[b] Includes some estimated catches.

Table 3. Canadian catches of yellowtail flounder by division, from 1973-99. Data for 1990-93 and 1998-99 are from preliminary Canadian statistics, and are slightly different from STATLANT data. Catches given for 1994-97 are by-catch totals for all gears, from STATLANT 21A data.

	OTTER TRAWL				OTHER GEARS
Year	3L	3N	3Ø	3LNO	3LNO
1973	4188	21470	2827	28475	17
1974	1107	14757	1119	16983	70
1975	2315	13289	2852	18456	2
1976	448	4978	2478	7904	6
1977	2546	7166	1583	11295	0
1978	2537	10705	1793	15035	56
1979	2575	14359	1100	18034	82
1980	1892	9501	578	11971	40
1981	2345	11245	515	14105	17
1982	2305	7554	1607	11466	13
1983	2552	5737	770	9059	26
1984	5264	6847	318	12429	8
1985	3404	9098	829	13331	9
1986	2933	10196	1004	14133	35
1987	1584	10248	1529	13361	59
1988	1813	7146	1475	10434	173
1989	844	2407	1506	4757	252
1990	1263	2725	664	4652	317
1991	815	2980	2283	6078	564
1992	95	1266	4636	5997	812
1993	1	2030	3902	5933	764
1994					0
1995					2
1996					0
1997					1
1998	0	2940	726	3666	26
1999	0	5319	91	5410	3

Table 4. ANOVA results and regression coefficients from a multiplicative model utilized to derive a standardized catch rate series for Yellowtail flounder in NAFO Div. 3LNO (1998 & 1999 based on preliminary data).

REGRESSION OF MULTIPLICATIVE MODEL
MULTIPLE R............. 0.725
MULTIPLE R SQUARED..... 0.526

ANALYSIS OF VARIANCE

SOURCE OF VARIATION	DF	SUMS OF SQUARES	MEAN SQUARE	F-VALUE
INTERCEPT	1	4.76E1	4.76E1	
REGRESSION	45	6.41E0	1.42E-1	19.620
Cntry|Gear|TC	2	7.83E-1	3.92E-1	53.974
Division	2	8.11E-1	4.06E-1	55.897
Month	11	6.16E-1	5.60E-2	7.715
Year	30	3.63E0	1.21E-1	16.694
RESIDUALS	796	5.78E0	7.26E-3	
TOTAL	842	5.98E1		

REGRESSION COEFFICIENTS

CATEGORY	CODE	VAR #	REG. COEF	STD. ERR	NO. OBS
Cntry|Gear|TC	3125	INT	0.161	0.121	842
Division	34				
Month	10				
Year	65				
1	3114	1	-0.298	0.032	162
	3124	2	-0.217	0.033	146
2	32	3	-0.230	0.028	194
	35	4	-0.260	0.030	178
3	1	5	-0.225	0.084	19
	2	6	-0.307	0.082	21
	3	7	-0.221	0.065	35
	4	8	-0.201	0.053	59
	5	9	-0.243	0.046	112
	6	10	-0.330	0.046	111
	7	11	-0.307	0.046	113
	8	12	-0.219	0.047	107
	9	13	-0.077	0.047	91
	11	14	-0.124	0.054	56
	12	15	-0.132	0.064	40
4	66	16	-0.056	0.150	11
	67	17	-0.074	0.149	12
	68	18	-0.228	0.146	14
	69	19	-0.362	0.136	20
	70	20	-0.386	0.125	42
	71	21	-0.419	0.124	41
	72	22	-0.537	0.124	45
	73	23	-0.412	0.123	50
	74	24	-0.824	0.126	37
	75	25	-0.832	0.126	38
	76	26	-0.927	0.133	26
	77	27	-0.733	0.126	38
	78	28	-0.707	0.124	51
	79	29	-0.681	0.124	47
	80	30	-0.570	0.128	30
	81	31	-0.566	0.129	30
	82	32	-0.665	0.133	24
	83	33	-0.537	0.132	24
	84	34	-0.567	0.132	28
	85	35	-0.540	0.130	30
	86	36	-0.842	0.130	30
	87	37	-0.800	0.130	30
	88	38	-0.874	0.132	26
	89	39	-0.900	0.142	17
	90	40	-0.731	0.140	16
	91	41	-1.419	0.137	21
	92	42	-1.270	0.141	15
	93	43	-0.772	0.138	18
	98	44	-0.285	0.151	11
	99	45	-0.221	0.146	12

PREDICTED CATCH RATE

YEAR	LN TRANSFORM MEAN	LN TRANSFORM S.E.	RETRANSFORMED MEAN	RETRANSFORMED S.E.	CATCH	EFFORT
1965	0.1614	0.0146	1.171	0.141	3075	2626
1966	0.1053	0.0112	1.109	0.117	4185	3774
1967	0.0877	0.0116	1.089	0.117	2122	1948
1968	-0.0664	0.0091	0.935	0.089	4180	4471
1969	-0.2008	0.0066	0.818	0.066	10494	12824
1970	-0.2245	0.0036	0.800	0.048	22814	28504
1971	-0.2578	0.0034	0.774	0.045	24206	31265
1972	-0.3752	0.0032	0.689	0.039	26939	39125
1973	-0.2502	0.0031	0.780	0.043	28492	36514
1974	-0.6631	0.0038	0.516	0.032	17053	33038
1975	-0.6705	0.0035	0.512	0.030	18458	36020
1976	-0.7660	0.0053	0.465	0.034	7910	16999
1977	-0.5718	0.0041	0.565	0.036	11295	19978
1978	-0.5458	0.0033	0.581	0.034	15091	25995
1979	-0.5191	0.0034	0.596	0.035	18116	30385
1980	-0.4084	0.0047	0.666	0.046	12011	18046
1981	-0.4047	0.0045	0.668	0.045	14122	21139
1982	-0.5041	0.0055	0.605	0.045	11479	18986
1983	-0.3755	0.0050	0.688	0.048	9085	13210
1984	-0.4051	0.0052	0.668	0.048	12437	18630
1985	-0.3782	0.0043	0.686	0.045	13440	19589
1986	-0.6805	0.0045	0.507	0.034	14168	27941
1987	-0.6386	0.0044	0.529	0.035	13420	25378
1988	-0.7130	0.0050	0.491	0.035	10607	21614
1989	-0.7382	0.0074	0.478	0.041	5009	10481
1990	-0.5691	0.0069	0.566	0.047	4966	8772
1991	-1.2576	0.0064	0.284	0.023	6642	23348
1992	-1.1083	0.0071	0.330	0.028	6809	20625
1993	-0.6110	0.0064	0.543	0.044	6697	12333
1998	-0.1234	0.0098	0.883	0.087	3739	4236
1999	-0.0592	0.0084	0.942	0.086	5413	5746

AVERAGE C.V. FOR THE RETRANSFORMED MEAN: 0.075

LEGEND FOR AVOVA RESULTS:

CGT CODES: 3114 = Can(NFLD) TC 4 Side Trawler
3124 = " TC 4 Stern Trawler
3125 = " TC 5 "

DIVISION CODES: 32 = 3L, 34 = 3N, 35 = 3O

Table 5. A comparison of spring and fall abundance and biomass estimates derived from annual bottom trawl surveys in Div. 3LNO (SCR Doc. 00/35)

BIOMASS (000t)			Abundance (million)		
	SPRING	*FALL*		*SPRING*	*FALL*
1984	217.7	.	**1984**	544.2	
1985	146.8	.	**1985**	374.1	
1986	138.2	.	**1986**	326.5	
1987	124.6	.	**1987**	394.2	
1988	81	.	**1988**	203.1	
1989	103.8	.	**1989**	532.9	
1990	103.1	65.8	**1990**	367.4	192.5
1991	93.4	82.4	**1991**	320.3	297.1
1992	61.4	64.5	**1992**	217.4	215.9
1993	93.3	112.8	**1993**	246.3	371.9
1994	55.6	106.4	**1994**	148.4	287.9
1995	70.6	129.8	**1995**	187.4	592.2
1996	175.6	134.3	**1996**	639.4	579.1
1997	174.9	222.9	**1997**	695.5	781.5
1998	202.2	231.6	**1998**	733.6	828.2
1999	365.7	249.9	**1999**	1,289.9	937.1

Table 6A. Abundance (millions) at age (sexes combined) by year, Div 3LNO Yellowtail Flounder - Spring

Age	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.6	0.5	1.5	1.0
2	0.0	0.2	0.0	10.2	0.7	4.0	0.2	1.7	1.1	0.3	0.0	0.0	33.4	7.3	18.3	63.5
3	5.3	16.7	2.4	29.0	4.7	40.0	12.1	5.8	17.5	3.3	5.0	1.6	88.8	71.3	22.9	70.4
4	32.6	37.8	10.2	81.9	25.5	249.9	78.9	58.7	55.8	35.7	7.4	20.0	120.2	152.8	93.0	116.4
5	85.5	35.5	39.5	37.7	15.5	98.5	92.4	89.0	36.5	43.3	26.7	24.4	97.6	165.1	243.8	290.4
6	141.1	91.3	57.8	58.4	21.5	55.2	58.4	73.8	47.4	53.3	42.5	57.3	99.1	116.8	190.9	401.2
7	184.5	132.2	141.6	104.9	63.2	56.8	65.9	58.0	37.5	68.3	44.0	55.7	129.5	116.9	100.7	221.7
8+	93.8	60.1	74.6	71.9	71.9	28.6	59.3	32.9	21.7	42.2	21.8	28.4	66.0	63.4	62.1	124.3
Age 1+	**542.8**	**373.8**	**326.1**	**394.1**	**202.9**	**532.9**	**367.4**	**319.8**	**217.5**	**246.3**	**147.4**	**187.3**	**639.2**	**694.1**	**733.1**	**1288.9**
Age 1-4	**37.9**	**54.7**	**12.6**	**121.1**	**30.9**	**293.9**	**91.3**	**66.3**	**74.4**	**39.3**	**12.4**	**21.5**	**247.1**	**231.8**	**135.6**	**251.2**
Age 5+	**504.9**	**319.1**	**313.5**	**273.0**	**172.1**	**239.0**	**276.1**	**253.6**	**143.1**	**207.1**	**135.0**	**165.8**	**392.1**	**462.3**	**597.5**	**1037.6**
Age 7+	**278.3**	**192.3**	**216.1**	**176.8**	**135.1**	**85.4**	**125.2**	**90.8**	**59.2**	**110.5**	**65.8**	**84.1**	**195.5**	**180.3**	**162.8**	**346.0**

Table 6B. Abundance (millions) at age by year, Div 3LNO Yellowtail Flounder-Fall

Age	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1						8.8	0.9	2.7	6.7	2.8
2	1.3	1.6	1.2	0.9	2.3	83.9	17.8	7.9	12.6	35.2
3	11.3	37.2	18.6	6.6	5.9	122.4	63.6	44.4	26.3	72.6
4	28.9	64.5	53.5	74.4	38.5	89.7	132.6	125.7	75.0	70.3
5	44.3	46.9	34.0	104.5	48.4	70.6	145.1	204.9	243.8	213.4
6	38.5	61.2	33.7	77.5	70.9	87.7	97.9	178.9	256.5	323.3
7	45.0	52.4	45.6	67.3	69.8	84.4	82.7	142.5	143.7	148.2
8+	22.1	33.2	29.1	40.2	52.1	44.5	38.7	74.6	63.5	73.8
age1+	**191.4**	**297.0**	**215.9**	**371.5**	**288.0**	**592.1**	**579.2**	**781.5**	**828.0**	**939.6**
ages1-4	**41.5**	**103.3**	**73.4**	**82.0**	**46.7**	**304.8**	**214.9**	**180.6**	**120.5**	**180.9**
age 5+	**149.9**	**193.7**	**142.5**	**289.5**	**241.3**	**287.3**	**364.3**	**600.9**	**707.5**	**758.7**
age7+	**67.1**	**85.6**	**74.8**	**107.5**	**121.9**	**129.0**	**121.3**	**217.1**	**207.2**	**222.0**

Table 7A. Biomass estimates ('000t) at age (sexes combined) by year, Div. 3LNO Yellowtail Flounder - Spring

Age	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1													0.0	0.0	0.0	0.0
2		0.0		0.1	0.0	0.0	0.0	0.0	0.0	0.0			0.4	0.1	0.2	0.8
3	0.2	1.3	0.1	1.2	0.2	1.7	0.7	0.3	0.9	0.2	0.3	0.1	3.6	2.9	1.0	2.7
4	2.9	3.6	1.1	5.1	2.2	21.9	6.5	5.1	5.2	3.5	0.8	2.2	11.9	14.9	8.9	11.5
5	15.4	6.9	6.5	5.7	2.0	15.5	12.8	15.7	6.5	8.1	5.2	4.6	17.1	28.5	44.0	49.8
6	47.5	29.9	16.6	16.3	5.4	16.0	15.5	21.8	14.7	16.6	13.4	17.9	29.8	35.3	57.7	112.1
7	89.3	64.3	64.6	48.5	25.5	27.2	27.9	26.6	18.0	33.4	21.0	26.1	58.8	53.0	46.0	100.9
8+	62.8	41.6	50.2	48.4	46.2	20.6	40.1	23.3	16.1	32.5	16.1	20.2	47.2	44.6	42.8	85.4
Age 1+	**218.2**	**147.7**	**139.0**	**125.3**	**81.5**	**103.0**	**103.4**	**92.7**	**61.4**	**94.4**	**56.9**	**71.0**	**168.8**	**179.3**	**200.8**	**363.3**
Age 1-4	**3.2**	**4.9**	**1.2**	**6.3**	**2.4**	**23.7**	**7.2**	**5.4**	**6.1**	**3.8**	**1.1**	**2.3**	**15.9**	**17.9**	**10.2**	**15.1**
Age 5+	**215.0**	**142.8**	**137.8**	**119.0**	**79.2**	**79.3**	**96.2**	**87.4**	**55.3**	**90.7**	**55.7**	**68.7**	**152.9**	**161.4**	**190.6**	**348.2**
Age 7+	**152.1**	**105.9**	**114.8**	**96.9**	**71.7**	**47.8**	**68.0**	**49.9**	**34.1**	**65.9**	**37.1**	**46.3**	**106.0**	**97.6**	**88.8**	**186.3**

Table 7B. Biomass ('000t) at age by year, Div. 3LNO Yellowtail Flounder-Fall

Age	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1						0.0	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0	1.2	0.2	0.1	0.2	0.6
3	1.0	1.9	1.0	0.3	0.3	4.9	2.6	1.8	1.0	2.7
4	3.6	5.8	5.3	8.5	4.1	8.4	12.6	12.2	7.0	6.4
5	8.9	8.5	6.0	19.6	9.1	12.8	24.5	35.0	41.6	36.4
6	13.6	18.3	10.2	24.2	22.4	27.6	29.3	51.4	70.6	89.0
7	21.8	24.4	20.6	32.2	32.8	39.0	37.9	62.3	60.1	62.2
8+	15.4	23.1	20.6	29.2	37.3	31.6	27.6	50.2	42.1	51.0
age1+	**64.3**	**82.0**	**63.7**	**114.0**	**106.0**	**125.6**	**134.7**	**213.1**	**222.6**	**248.3**
ages1-4	**4.7**	**7.8**	**6.4**	**8.8**	**4.4**	**14.5**	**15.4**	**14.2**	**8.2**	**9.7**
age 5+	**59.6**	**74.3**	**57.4**	**105.2**	**101.6**	**111.0**	**119.2**	**199.0**	**214.4**	**238.6**
age7+	**37.1**	**47.4**	**41.2**	**61.4**	**70.1**	**70.7**	**65.4**	**112.6**	**102.3**	**113.2**

Table 8. Length weight relationships used to produce an index of female SSB from the spring survey. The relationships are of the form log(weight)=(a*log(length))+b)

Year	*a*	*b*
prior to 1990	3.10	-5.19
1990	3.19	-5.33
1991	3.05	-5.12
1992	3.02	-5.06
1993	3.11	-5.20
1994	3.09	-5.19
1995	3.10	-5.20
1996	3.09	-5.15
1997	3.09	-5.17
1998	3.05	-5.11
1999	3.15	-5.27

Table 9. Output from production model for 3LNO yellowtail flounder (biomass in kt) assuming a catch of 11, 000 tons in 2000 fishery and including the Spanish 2000 survey result, 1965-2000.

10 Jun 2000 at 20:05.29

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

Author: Michael H. Prager
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Tiburon, California 94920 USA

ASPIC User's Manual
is available gratis
from the author

CONTROL PARAMETERS USED (FROM INPUT FILE)

Number of years analyzed:	36	Number of bootstrap trials:	0
Number of data series:	5	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-06	Lower bound on r:	1.000E-01
Relative conv. criterion (restart):	3.000E-06	Upper bound on r:	5.000E+00
Relative conv. criterion (effort):	1.000E-02	Random number seed:	911
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	4	5
1 Canadian Campelen Survey	1.000				
	16				
2 Canadian Yankee Survey	0.000	1.000			
	0	12			
3 Canadian Fall Survey	0.839	0.000	1.000		
	10	0	10		
4 Russian Survey	0.933	0.198	1.000	1.000	
	8	11	2	19	
5 Spanish Survey	0.903	0.000	0.828	0.000	1.000
	5	0	5	0	6

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	1.035E-02	1	N/A	1.000E+00	N/A	
Loss(1) Canadian Campelen Survey	7.527E-01	16	5.377E-02	1.000E+00	1.265E+00	0.743
Loss(2) Canadian Yankee Survey	2.648E-01	12	2.648E-02	1.000E+00	2.568E+00	0.797
Loss(3) Canadian Fall Survey	7.944E-01	10	9.930E-02	1.000E+00	6.848E-01	0.832
Loss(4) Russian Survey	4.824E+00	19	2.838E-01	1.000E+00	2.397E-01	0.312
Loss(5) Spanish Survey	3.020E+00	6	7.550E-01	1.000E+00	9.007E-02	0.328
TOTAL OBJECTIVE FUNCTION:	9.66617383E+00					

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

Number of restarts required for convergence:	12	
Est. B-ratio coverage index (0 worst, 2 best):	1.7738	< These two measures are defined in Prager
Est. B-ratio nearness index (0 worst, 1 best):	1.0000	< et al. (1996), Trans. A.F.S. 125:729

MODEL PARAMETER ESTIMATES (NON-BOOTSTRAPPED)

Parameter		Estimate	Starting guess	Estimated	User guess
B1R	Starting biomass ratio, year 1965	2.214E+00	2.000E+00	1	1
MSY	Maximum sustainable yield	1.724E+01	1.300E+01	1	1
r	Intrinsic rate of increase	4.170E-01	5.000E-01	1	1
....	Catchability coefficients by fishery:				
q(1)	Canadian Campelen Survey	3.040E+00	3.000E+00	1	1
q(2)	Canadian Yankee Survey	7.825E-01	1.000E+00	1	1
q(3)	Canadian Fall Survey	3.320E+00	3.000E+00	1	1
q(4)	Russian Survey	1.592E+00	1.000E+00	1	1
q(5)	Spanish Survey	3.423E+00	3.000E+00	1	1

MANAGEMENT PARAMETER ESTIMATES (NON-BOOTSTRAPPED)

Parameter		Estimate	Formula	Related quantity
MSY	Maximum sustainable yield	1.724E+01	Kr/4	
K	Maximum stock biomass	1.654E+02		
Bmsy	Stock biomass at MSY	8.271E+01	K/2	
Fmsy	Fishing mortality at MSY	2.085E-01	r/2	
F(0.1)	Management benchmark	1.876E-01	0.9*Fmsy	
Y(0.1)	Equilibrium yield at F(0.1)	1.707E+01	0.99*MSY	
B-ratio	Ratio of B(2001) to Bmsy	1.089E+00		
F-ratio	Ratio of F(2000) to Fmsy	6.061E-01		
F01-mult	Ratio of F(0.1) to F(2000)	1.485E+00		
Y-ratio	Proportion of MSY avail in 2001	9.920E-01	2*Br-Br^2	Ye(2001) = 1.711E+01
....	Fishing effort at MSY in units of each fishery:			
fmsy(1)	Canadian Campelen Survey	6.859E-02	r/2q(1)	f(0.1) = 6.173E-02

Table 10. Estimates of relative biomass and fishing mortality rates for 3LNO yellowtail flounder (biomass in kt) from production model, 1965-2000.

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	1965	0.018	1.831E+02	1.783E+02	3.130E+00	3.130E+00	-5.805E+00	8.421E-02	2.214E+00
2	1966	0.041	1.742E+02	1.694E+02	7.026E+00	7.026E+00	-1.744E+00	1.989E-01	2.106E+00
3	1967	0.055	1.654E+02	1.615E+02	8.878E+00	8.878E+00	1.582E+00	2.637E-01	2.000E+00
4	1968	0.087	1.581E+02	1.534E+02	1.334E+01	1.334E+01	4.616E+00	4.170E-01	1.912E+00
5	1969	0.108	1.494E+02	1.450E+02	1.571E+01	1.571E+01	7.454E+00	5.197E-01	1.806E+00
6	1970	0.199	1.411E+02	1.328E+02	2.643E+01	2.643E+01	1.088E+01	9.545E-01	1.706E+00
7	1971	0.330	1.256E+02	1.133E+02	3.734E+01	3.734E+01	1.473E+01	1.581E+00	1.518E+00
8	1972	0.433	1.030E+02	9.075E+01	3.926E+01	3.926E+01	1.690E+01	2.075E+00	1.245E+00
9	1973	0.455	8.061E+01	7.208E+01	3.281E+01	3.281E+01	1.689E+01	2.183E+00	9.747E-01
10	1974	0.404	6.469E+01	6.019E+01	2.431E+01	2.431E+01	1.592E+01	1.937E+00	7.822E-01
11	1975	0.440	5.630E+01	5.207E+01	2.289E+01	2.289E+01	1.486E+01	2.109E+00	6.807E-01
12	1976	0.156	4.826E+01	5.160E+01	8.057E+00	8.057E+00	1.480E+01	7.489E-01	5.836E-01
13	1977	0.204	5.500E+01	5.699E+01	1.164E+01	1.164E+01	1.557E+01	9.795E-01	6.651E-01
14	1978	0.262	5.894E+01	5.911E+01	1.547E+01	1.547E+01	1.584E+01	1.255E+00	7.127E-01
15	1979	0.317	5.931E+01	5.790E+01	1.835E+01	1.835E+01	1.568E+01	1.520E+00	7.172E-01
16	1980	0.212	5.665E+01	5.835E+01	1.238E+01	1.238E+01	1.575E+01	1.017E+00	6.849E-01
17	1981	0.242	6.002E+01	6.069E+01	1.468E+01	1.468E+01	1.602E+01	1.160E+00	7.257E-01
18	1982	0.212	6.136E+01	6.284E+01	1.332E+01	1.332E+01	1.625E+01	1.017E+00	7.419E-01
19	1983	0.155	6.429E+01	6.743E+01	1.047E+01	1.047E+01	1.665E+01	7.450E-01	7.773E-01
20	1984	0.237	7.047E+01	7.053E+01	1.673E+01	1.673E+01	1.687E+01	1.138E+00	8.520E-01
21	1985	0.454	7.060E+01	6.377E+01	2.896E+01	2.896E+01	1.627E+01	2.178E+00	8.536E-01
22	1986	0.611	5.791E+01	4.936E+01	3.018E+01	3.018E+01	1.436E+01	2.932E+00	7.002E-01
23	1987	0.406	4.210E+01	4.018E+01	1.631E+01	1.631E+01	1.267E+01	1.948E+00	5.090E-01
24	1988	0.447	3.846E+01	3.612E+01	1.616E+01	1.616E+01	1.176E+01	2.146E+00	4.650E-01
25	1989	0.295	3.406E+01	3.466E+01	1.021E+01	1.021E+01	1.142E+01	1.413E+00	4.118E-01
26	1990	0.414	3.527E+01	3.381E+01	1.399E+01	1.399E+01	1.121E+01	1.984E+00	4.265E-01
27	1991	0.554	3.250E+01	2.923E+01	1.620E+01	1.620E+01	1.002E+01	2.658E+00	3.929E-01
28	1992	0.424	2.632E+01	2.537E+01	1.076E+01	1.076E+01	8.955E+00	2.034E+00	3.182E-01
29	1993	0.633	2.451E+01	2.143E+01	1.356E+01	1.356E+01	7.763E+00	3.036E+00	2.964E-01
30	1994	0.096	1.871E+01	2.146E+01	2.069E+00	2.069E+00	7.783E+00	4.625E-01	2.262E-01
31	1995	0.002	2.442E+01	2.917E+01	6.700E-02	6.700E-02	9.999E+00	1.102E-02	2.953E-01
32	1996	0.007	3.435E+01	4.034E+01	2.870E-01	2.870E-01	1.269E+01	3.412E-02	4.154E-01
33	1997	0.015	4.676E+01	5.375E+01	8.000E-01	8.000E-01	1.509E+01	7.139E-02	5.653E-01
34	1998	0.065	6.105E+01	6.715E+01	4.348E+00	4.348E+00	1.660E+01	3.106E-01	7.381E-01
35	1999	0.083	7.330E+01	7.865E+01	6.561E+00	6.561E+00	1.718E+01	4.001E-01	8.863E-01
36	2000	0.126	8.392E+01	8.704E+01	1.100E+01	1.100E+01	1.718E+01	6.061E-01	1.015E+00
37	2001		9.010E+01						1.089E+00

Table 11. Bootstrap estimates from production model of 3LNO yellowtail flounder (biomass in kt), 1965-2000

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	2.414E+00	2.214E+00	-8.28%	2.279E+00	2.315E+00	2.307E+00	2.315E+00	8.375E-03	0.003
K	1.637E+02	1.654E+02	1.04%	1.459E+02	1.946E+02	1.533E+02	1.771E+02	2.377E+01	0.145
r	4.163E-01	4.170E-01	0.16%	3.241E-01	5.077E-01	3.711E-01	4.606E-01	8.952E-02	0.215
q(1)	3.031E+00	3.040E+00	0.28%	2.315E+00	3.722E+00	2.687E+00	3.421E+00	7.335E-01	0.242
q(2)	7.707E-01	7.825E-01	1.53%	5.677E-01	9.654E-01	6.602E-01	8.658E-01	2.057E-01	0.267
q(3)	3.303E+00	3.320E+00	0.49%	2.397E+00	4.368E+00	2.826E+00	3.810E+00	9.838E-01	0.298
q(4)	1.586E+00	1.592E+00	0.36%	1.262E+00	2.001E+00	1.416E+00	1.776E+00	3.603E-01	0.227
q(5)	3.439E+00	3.423E+00	-0.48%	2.399E+00	4.596E+00	2.886E+00	4.111E+00	1.224E+00	0.356
MSY	1.698E+01	1.724E+01	1.54%	1.510E+01	1.797E+01	1.613E+01	1.744E+01	1.303E+00	0.077
Ye(2001)	1.724E+01	1.711E+01	-0.80%	1.584E+01	1.851E+01	1.658E+01	1.777E+01	1.189E+00	0.069
Bmsy	8.185E+01	8.271E+01	1.04%	7.294E+01	9.731E+01	7.665E+01	8.854E+01	1.188E+01	0.145
Fmsy	2.082E-01	2.085E-01	0.16%	1.620E-01	2.539E-01	1.856E-01	2.303E-01	4.476E-02	0.215
fmsy(1)	6.936E-02	6.859E-02	-1.11%	5.823E-02	8.461E-02	6.391E-02	7.782E-02	1.391E-02	0.201
fmsy(2)	2.711E-01	2.665E-01	-1.71%	2.303E-01	3.230E-01	2.467E-01	2.989E-01	5.221E-02	0.193
fmsy(3)	6.402E-02	6.281E-02	-1.90%	5.037E-02	8.360E-02	5.535E-02	7.510E-02	1.975E-02	0.308
fmsy(4)	1.334E-01	1.310E-01	-1.80%	1.176E-01	1.520E-01	1.252E-01	1.427E-01	1.751E-02	0.131
fmsy(5)	6.163E-02	6.092E-02	-1.15%	4.414E-02	8.912E-02	5.129E-02	7.405E-02	2.276E-02	0.369
F(0.1)	1.873E-01	1.876E-01	0.14%	1.458E-01	2.285E-01	1.670E-01	2.073E-01	4.028E-02	0.215
Y(0.1)	1.681E+01	1.707E+01	1.52%	1.495E+01	1.779E+01	1.597E+01	1.726E+01	1.290E+00	0.077
B-ratio	1.108E+00	1.089E+00	-1.70%	8.564E-01	1.366E+00	9.674E-01	1.238E+00	2.703E-01	0.244
F-ratio	6.029E-01	6.061E-01	0.53%	4.609E-01	8.301E-01	5.218E-01	6.995E-01	1.777E-01	0.295
Y-ratio	1.003E+00	9.920E-01	-1.07%	9.571E-01	1.000E+00	9.857E-01	9.995E-01	1.383E-02	0.014
f0.1(1)	6.242E-02	6.173E-02	-1.00%	* * * * *	0.201				
f0.1(2)	2.440E-01	2.398E-01	-1.54%	* * * * *	0.193				
f0.1(3)	5.762E-02	5.653E-02	-1.71%	* * * * *	0.308				
f0.1(4)	1.201E-01	1.179E-01	-1.62%	* * * * *	0.131				
f0.1(5)	5.546E-02	5.483E-02	-1.04%	* * * * *	0.369				
q2/q1	2.530E-01	2.574E-01	1.74%	1.965E-01	3.241E-01	2.196E-01	2.864E-01	6.676E-02	0.264
q3/q1	1.078E+00	1.092E+00	1.31%	8.574E-01	1.312E+00	9.542E-01	1.214E+00	2.601E-01	0.241
q4/q1	5.215E-01	5.236E-01	0.41%	4.204E-01	6.427E-01	4.638E-01	5.730E-01	1.092E-01	0.209
q5/q1	1.125E+00	1.126E+00	0.10%	8.140E-01	1.454E+00	9.691E-01	1.294E+00	3.248E-01	0.289

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:	16
Trials replaced for MSY out-of-bounds:	0
Trials replaced for r out-of-bounds:	0
Residual-adjustment factor:	1.0703

Table 12. Relative biomass and fishing mortality rates for the 2001 yield projections using status quo F, i.e. $F_{2000} = F_{2001}$

```
                                                     11 Jun 2000 at 18:34.36
3LNO yellowtail flounder (biomass in kt)
2001 F=.66

USER CONTROL INFORMATION (FROM INPUT FILE)
--------------------------------------------------
Name of biomass (BIO) file            aspic.bio
Name of output file (this file)       runnafo1.prj
Number of years of projections          1

Year          Input data          User data type
----          -----------         --------------
2001           1.000E+00           F/F(2000)
```

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
1965	2.413E+00	2.214E+00	-8.25%	2.279E+00	2.315E+00	2.307E+00	2.315E+00	8.397E-03	0.003
1966	2.233E+00	2.106E+00	-5.67%	2.148E+00	2.163E+00	2.166E+00	2.163E+00	0.000E+00	0.000
1967	2.084E+00	2.000E+00	-4.03%	2.032E+00	2.047E+00	2.039E+00	2.047E+00	0.000E+00	0.000
1968	1.970E+00	1.912E+00	-2.95%	1.928E+00	1.961E+00	1.940E+00	1.961E+00	7.177E-03	0.004
1969	1.849E+00	1.806E+00	-2.29%	1.816E+00	1.870E+00	1.833E+00	1.870E+00	3.890E-02	0.021
1970	1.738E+00	1.706E+00	-1.83%	1.713E+00	1.803E+00	1.723E+00	1.788E+00	5.754E-02	0.033
1971	1.547E+00	1.518E+00	-1.84%	1.513E+00	1.643E+00	1.532E+00	1.597E+00	6.369E-02	0.041
1972	1.272E+00	1.245E+00	-2.09%	1.231E+00	1.362E+00	1.252E+00	1.332E+00	7.919E-02	0.062
1973	9.966E-01	9.747E-01	-2.20%	9.440E-01	1.103E+00	9.698E-01	1.066E+00	9.209E-02	0.092
1974	8.030E-01	7.822E-01	-2.60%	7.440E-01	9.239E-01	7.719E-01	8.567E-01	8.478E-02	0.106
1975	7.001E-01	6.807E-01	-2.77%	6.375E-01	8.337E-01	6.691E-01	7.558E-01	8.663E-02	0.124
1976	6.022E-01	5.836E-01	-3.10%	5.305E-01	7.509E-01	5.703E-01	6.659E-01	9.562E-02	0.159
1977	6.853E-01	6.651E-01	-2.95%	6.172E-01	8.110E-01	6.525E-01	7.378E-01	8.533E-02	0.125
1978	7.330E-01	7.127E-01	-2.78%	6.700E-01	8.425E-01	7.016E-01	7.791E-01	7.753E-02	0.106
1979	7.370E-01	7.172E-01	-2.69%	6.784E-01	8.401E-01	7.079E-01	7.829E-01	7.500E-02	0.102
1980	7.043E-01	6.849E-01	-2.74%	6.458E-01	8.028E-01	6.763E-01	7.490E-01	7.262E-02	0.103
1981	7.448E-01	7.257E-01	-2.57%	6.956E-01	8.276E-01	7.188E-01	7.826E-01	6.377E-02	0.086
1982	7.599E-01	7.419E-01	-2.36%	7.170E-01	8.296E-01	7.378E-01	7.964E-01	5.860E-02	0.077
1983	7.952E-01	7.773E-01	-2.24%	7.621E-01	8.510E-01	7.773E-01	8.256E-01	4.830E-02	0.061
1984	8.662E-01	8.520E-01	-1.64%	8.427E-01	9.243E-01	8.548E-01	8.969E-01	3.904E-02	0.045
1985	8.634E-01	8.536E-01	-1.13%	8.456E-01	9.190E-01	8.548E-01	8.892E-01	2.908E-02	0.034
1986	7.099E-01	7.002E-01	-1.37%	6.899E-01	7.612E-01	7.003E-01	7.339E-01	3.133E-02	0.044
1987	5.193E-01	5.090E-01	-1.97%	4.966E-01	5.748E-01	5.073E-01	5.433E-01	3.608E-02	0.069
1988	4.744E-01	4.650E-01	-1.98%	4.517E-01	5.361E-01	4.631E-01	4.974E-01	3.431E-02	0.072
1989	4.206E-01	4.118E-01	-2.11%	3.948E-01	4.738E-01	4.073E-01	4.457E-01	3.834E-02	0.091
1990	4.363E-01	4.265E-01	-2.24%	4.116E-01	4.994E-01	4.222E-01	4.655E-01	4.329E-02	0.099
1991	4.014E-01	3.929E-01	-2.11%	3.745E-01	4.678E-01	3.864E-01	4.322E-01	4.583E-02	0.114
1992	3.266E-01	3.182E-01	-2.56%	2.921E-01	3.951E-01	3.074E-01	3.609E-01	5.352E-02	0.164
1993	3.051E-01	2.964E-01	-2.87%	2.491E-01	4.012E-01	2.730E-01	3.402E-01	6.270E-02	0.206
1994	2.342E-01	2.262E-01	-3.43%	1.730E-01	3.326E-01	1.986E-01	2.766E-01	7.795E-02	0.333
1995	3.053E-01	2.953E-01	-3.27%	2.256E-01	4.157E-01	2.567E-01	3.583E-01	1.016E-01	0.333
1996	4.324E-01	4.154E-01	-3.94%	3.249E-01	5.905E-01	3.699E-01	5.036E-01	1.337E-01	0.309
1997	5.850E-01	5.653E-01	-3.36%	4.487E-01	7.802E-01	5.028E-01	6.733E-01	1.705E-01	0.291
1998	7.632E-01	7.381E-01	-3.29%	5.893E-01	1.005E+00	6.649E-01	8.910E-01	2.261E-01	0.296
1999	9.135E-01	8.863E-01	-2.98%	7.126E-01	1.185E+00	7.997E-01	1.045E+00	2.454E-01	0.269
2000	1.036E+00	1.015E+00	-2.09%	8.108E-01	1.305E+00	9.135E-01	1.170E+00	2.569E-01	0.248
2001	1.108E+00	1.089E+00	-1.70%	8.564E-01	1.366E+00	9.674E-01	1.238E+00	2.703E-01	0.244
2002	1.171E+00	1.153E+00	-1.51%	8.849E-01	1.405E+00	1.022E+00	1.298E+00	2.758E-01	0.236

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

Table 12 (cont'd)

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Results from ASPICP.EXE, version 2.31                                  11 Jun 2000 at 18:34.36
3LNO yellowtail flounder (biomass in kt)
2001 F=.66
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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
1965	7.715E-02	8.421E-02	9.14%	7.243E-02	8.552E-02	7.243E-02	8.241E-02	9.985E-03	0.129
1966	1.875E-01	1.989E-01	6.08%	1.738E-01	2.044E-01	1.791E-01	1.970E-01	1.576E-02	0.084
1967	2.537E-01	2.637E-01	3.92%	2.384E-01	2.737E-01	2.467E-01	2.644E-01	1.774E-02	0.070
1968	4.060E-01	4.170E-01	2.73%	3.808E-01	4.374E-01	3.946E-01	4.208E-01	2.618E-02	0.064
1969	5.107E-01	5.197E-01	1.76%	4.820E-01	5.495E-01	4.936E-01	5.283E-01	3.471E-02	0.068
1970	9.422E-01	9.545E-01	1.31%	8.928E-01	1.013E+00	9.119E-01	9.730E-01	6.102E-02	0.065
1971	1.567E+00	1.581E+00	0.93%	1.498E+00	1.658E+00	1.525E+00	1.606E+00	8.091E-02	0.052
1972	2.062E+00	2.075E+00	0.64%	2.005E+00	2.129E+00	2.027E+00	2.091E+00	6.274E-02	0.030
1973	2.170E+00	2.183E+00	0.64%	2.086E+00	2.232E+00	2.124E+00	2.201E+00	3.901E-02	0.018
1974	1.915E+00	1.937E+00	1.18%	1.819E+00	1.977E+00	1.867E+00	1.944E+00	7.719E-02	0.040
1975	2.074E+00	2.109E+00	1.68%	1.903E+00	2.195E+00	2.002E+00	2.130E+00	1.284E-01	0.062
1976	7.362E-01	7.489E-01	1.74%	6.787E-01	7.811E-01	7.103E-01	7.565E-01	4.626E-02	0.063
1977	9.650E-01	9.795E-01	1.50%	9.189E-01	1.001E+00	9.427E-01	9.835E-01	4.078E-02	0.042
1978	1.237E+00	1.255E+00	1.45%	1.197E+00	1.273E+00	1.219E+00	1.256E+00	3.165E-02	0.026
1979	1.498E+00	1.520E+00	1.48%	1.441E+00	1.541E+00	1.479E+00	1.521E+00	3.188E-02	0.021
1980	1.003E+00	1.017E+00	1.46%	9.687E-01	1.023E+00	9.873E-01	1.015E+00	2.756E-02	0.027
1981	1.146E+00	1.160E+00	1.26%	1.114E+00	1.162E+00	1.126E+00	1.157E+00	2.561E-02	0.022
1982	1.009E+00	1.017E+00	0.76%	9.863E-01	1.043E+00	9.912E-01	1.023E+00	1.569E-02	0.016
1983	7.412E-01	7.450E-01	0.51%	7.126E-01	7.817E-01	7.254E-01	7.577E-01	2.973E-02	0.040
1984	1.134E+00	1.138E+00	0.33%	1.072E+00	1.232E+00	1.096E+00	1.176E+00	7.990E-02	0.070
1985	2.173E+00	2.178E+00	0.23%	2.038E+00	2.372E+00	2.096E+00	2.256E+00	1.598E-01	0.074
1986	2.928E+00	2.932E+00	0.13%	2.800E+00	3.121E+00	2.852E+00	3.014E+00	1.614E-01	0.055
1987	1.946E+00	1.948E+00	0.07%	1.878E+00	2.043E+00	1.911E+00	1.992E+00	8.048E-02	0.041
1988	2.144E+00	2.146E+00	0.07%	2.053E+00	2.250E+00	2.101E+00	2.195E+00	9.352E-02	0.044
1989	1.409E+00	1.413E+00	0.26%	1.329E+00	1.495E+00	1.371E+00	1.451E+00	7.998E-02	0.057
1990	1.981E+00	1.984E+00	0.17%	1.827E+00	2.131E+00	1.908E+00	2.056E+00	1.479E-01	0.075
1991	2.643E+00	2.658E+00	0.58%	2.372E+00	2.887E+00	2.511E+00	2.772E+00	2.617E-01	0.099
1992	2.014E+00	2.034E+00	1.01%	1.706E+00	2.330E+00	1.871E+00	2.163E+00	2.921E-01	0.145
1993	2.984E+00	3.036E+00	1.75%	2.311E+00	3.644E+00	2.635E+00	3.350E+00	7.155E-01	0.240
1994	4.530E-01	4.625E-01	2.09%	3.264E-01	5.966E-01	3.847E-01	5.281E-01	1.434E-01	0.317
1995	1.075E-02	1.102E-02	2.47%	7.775E-03	1.414E-02	9.191E-03	1.261E-02	3.418E-03	0.318
1996	3.331E-02	3.412E-02	2.45%	2.398E-02	4.345E-02	2.815E-02	3.849E-02	1.033E-02	0.310
1997	6.951E-02	7.139E-02	2.71%	5.136E-02	9.233E-02	5.980E-02	8.122E-02	2.142E-02	0.308
1998	3.073E-01	3.106E-01	1.05%	2.253E-01	4.065E-01	2.618E-01	3.529E-01	9.106E-02	0.296
1999	3.971E-01	4.001E-01	0.76%	2.984E-01	5.434E-01	3.416E-01	4.619E-01	1.203E-01	0.303
2000	6.029E-01	6.061E-01	0.53%	4.609E-01	8.301E-01	5.218E-01	6.995E-01	1.777E-01	0.295
2001	6.029E-01	6.061E-01	0.53%	4.609E-01	8.301E-01	5.218E-01	6.995E-01	1.777E-01	0.295

TABLE OF PROJECTED YIELDS

2001	1.175E+01	1.173E+01	-0.16%	1.153E+01	1.193E+01	1.164E+01	1.185E+01	2.166E-01	0.018

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

Table 13. Relative biomass and fishing mortality rates for the 2001 yield projections using F_{2001}= $2/3F_{msy}$

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Results from ASPICP.EXE, version 2.31                                                        11 Jun 2000 at 22:08.19
3LNO yellowtail flounder (biomass in kt)
2001 F=.66

USER CONTROL INFORMATION (FROM INPUT FILE)
--------------------------------------------------
Name of biomass (BIO) file            aspic.bio
Name of output file (this file)       runnafo3.prj
Number of years of projections          1

Year          Input data          User data type
----          -----------         --------------
2001           1.100E+00           F/F(2000)
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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
1965	2.413E+00	2.214E+00	-8.25%	2.279E+00	2.315E+00	2.307E+00	2.315E+00	8.397E-03	0.003
1966	2.233E+00	2.106E+00	-5.67%	2.148E+00	2.163E+00	2.166E+00	2.163E+00	0.000E+00	0.000
1967	2.084E+00	2.000E+00	-4.03%	2.032E+00	2.047E+00	2.039E+00	2.047E+00	0.000E+00	0.000
1968	1.970E+00	1.912E+00	-2.95%	1.928E+00	1.961E+00	1.940E+00	1.961E+00	7.177E-03	0.004
1969	1.849E+00	1.806E+00	-2.29%	1.816E+00	1.870E+00	1.833E+00	1.870E+00	3.890E-02	0.021
1970	1.738E+00	1.706E+00	-1.83%	1.713E+00	1.803E+00	1.723E+00	1.788E+00	5.754E-02	0.033
1971	1.547E+00	1.518E+00	-1.84%	1.513E+00	1.643E+00	1.532E+00	1.597E+00	6.369E-02	0.041
1972	1.272E+00	1.245E+00	-2.09%	1.231E+00	1.362E+00	1.252E+00	1.332E+00	7.919E-02	0.062
1973	9.966E-01	9.747E-01	-2.20%	9.440E-01	1.103E+00	9.698E-01	1.066E+00	9.209E-02	0.092
1974	8.030E-01	7.822E-01	-2.60%	7.440E-01	9.239E-01	7.719E-01	8.567E-01	8.478E-02	0.106
1975	7.001E-01	6.807E-01	-2.77%	6.375E-01	8.337E-01	6.691E-01	7.558E-01	8.663E-02	0.124
1976	6.022E-01	5.836E-01	-3.10%	5.305E-01	7.509E-01	5.703E-01	6.659E-01	9.562E-02	0.159
1977	6.853E-01	6.651E-01	-2.95%	6.172E-01	8.110E-01	6.525E-01	7.378E-01	8.533E-02	0.125
1978	7.330E-01	7.127E-01	-2.78%	6.700E-01	8.425E-01	7.016E-01	7.791E-01	7.753E-02	0.106
1979	7.370E-01	7.172E-01	-2.69%	6.784E-01	8.401E-01	7.079E-01	7.829E-01	7.500E-02	0.102
1980	7.043E-01	6.849E-01	-2.74%	6.458E-01	8.028E-01	6.763E-01	7.490E-01	7.262E-02	0.103
1981	7.448E-01	7.257E-01	-2.57%	6.956E-01	8.276E-01	7.188E-01	7.826E-01	6.377E-02	0.086
1982	7.599E-01	7.419E-01	-2.36%	7.170E-01	8.296E-01	7.378E-01	7.964E-01	5.860E-02	0.077
1983	7.952E-01	7.773E-01	-2.24%	7.621E-01	8.510E-01	7.773E-01	8.256E-01	4.830E-02	0.061
1984	8.662E-01	8.520E-01	-1.64%	8.427E-01	9.243E-01	8.548E-01	8.969E-01	3.904E-02	0.045
1985	8.634E-01	8.536E-01	-1.13%	8.456E-01	9.190E-01	8.548E-01	8.892E-01	2.908E-02	0.034
1986	7.099E-01	7.002E-01	-1.37%	6.899E-01	7.612E-01	7.003E-01	7.339E-01	3.133E-02	0.044
1987	5.193E-01	5.090E-01	-1.97%	4.966E-01	5.748E-01	5.073E-01	5.433E-01	3.608E-02	0.069
1988	4.744E-01	4.650E-01	-1.98%	4.517E-01	5.361E-01	4.631E-01	4.974E-01	3.431E-02	0.072
1989	4.206E-01	4.118E-01	-2.11%	3.948E-01	4.738E-01	4.073E-01	4.457E-01	3.834E-02	0.091
1990	4.363E-01	4.265E-01	-2.24%	4.116E-01	4.994E-01	4.222E-01	4.655E-01	4.329E-02	0.099
1991	4.014E-01	3.929E-01	-2.11%	3.745E-01	4.678E-01	3.864E-01	4.322E-01	4.583E-02	0.114
1992	3.266E-01	3.182E-01	-2.56%	2.921E-01	3.951E-01	3.074E-01	3.609E-01	5.352E-02	0.164
1993	3.051E-01	2.964E-01	-2.87%	2.491E-01	4.012E-01	2.730E-01	3.402E-01	6.270E-02	0.206
1994	2.342E-01	2.262E-01	-3.43%	1.730E-01	3.326E-01	1.986E-01	2.766E-01	7.795E-02	0.333
1995	3.053E-01	2.953E-01	-3.27%	2.256E-01	4.157E-01	2.567E-01	3.583E-01	1.016E-01	0.333
1996	4.324E-01	4.154E-01	-3.94%	3.249E-01	5.905E-01	3.699E-01	5.036E-01	1.337E-01	0.309
1997	5.850E-01	5.653E-01	-3.36%	4.487E-01	7.802E-01	5.028E-01	6.733E-01	1.705E-01	0.291
1998	7.632E-01	7.381E-01	-3.29%	5.893E-01	1.005E+00	6.649E-01	8.910E-01	2.261E-01	0.296
1999	9.135E-01	8.863E-01	-2.98%	7.126E-01	1.185E+00	7.997E-01	1.045E+00	2.454E-01	0.269
2000	1.036E+00	1.015E+00	-2.09%	8.108E-01	1.305E+00	9.135E-01	1.170E+00	2.569E-01	0.248
2001	1.108E+00	1.089E+00	-1.70%	8.564E-01	1.366E+00	9.674E-01	1.238E+00	2.703E-01	0.244
2002	1.158E+00	1.140E+00	-1.53%	8.706E-01	1.389E+00	1.009E+00	1.283E+00	2.734E-01	0.236

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

Table 13 (cont'd)

Results from ASPICP.EXE, version 2.31 11 Jun 2000 at 22:08.19
3LNO yellowtail flounder (biomass in kt)
2001 F=.66

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
1965	7.715E-02	8.421E-02	9.14%	7.243E-02	8.552E-02	7.243E-02	8.241E-02	9.985E-03	0.129
1966	1.875E-01	1.989E-01	6.08%	1.738E-01	2.044E-01	1.791E-01	1.970E-01	1.576E-02	0.084
1967	2.537E-01	2.637E-01	3.92%	2.384E-01	2.737E-01	2.467E-01	2.644E-01	1.774E-02	0.070
1968	4.060E-01	4.170E-01	2.73%	3.808E-01	4.374E-01	3.946E-01	4.208E-01	2.618E-02	0.064
1969	5.107E-01	5.197E-01	1.76%	4.820E-01	5.495E-01	4.936E-01	5.283E-01	3.471E-02	0.068
1970	9.422E-01	9.545E-01	1.31%	8.928E-01	1.013E+00	9.119E-01	9.730E-01	6.102E-02	0.065
1971	1.567E+00	1.581E+00	0.93%	1.498E+00	1.658E+00	1.525E+00	1.606E+00	8.091E-02	0.052
1972	2.062E+00	2.075E+00	0.64%	2.005E+00	2.129E+00	2.027E+00	2.091E+00	6.274E-02	0.030
1973	2.170E+00	2.183E+00	0.64%	2.086E+00	2.232E+00	2.124E+00	2.201E+00	3.901E-02	0.018
1974	1.915E+00	1.937E+00	1.18%	1.819E+00	1.977E+00	1.867E+00	1.944E+00	7.719E-02	0.040
1975	2.074E+00	2.109E+00	1.68%	1.903E+00	2.195E+00	2.002E+00	2.130E+00	1.284E-01	0.062
1976	7.362E-01	7.489E-01	1.74%	6.787E-01	7.811E-01	7.103E-01	7.565E-01	4.626E-02	0.063
1977	9.650E-01	9.795E-01	1.50%	9.189E-01	1.001E+00	9.427E-01	9.835E-01	4.078E-02	0.042
1978	1.237E+00	1.255E+00	1.45%	1.197E+00	1.273E+00	1.219E+00	1.256E+00	3.165E-02	0.026
1979	1.498E+00	1.520E+00	1.48%	1.441E+00	1.541E+00	1.479E+00	1.521E+00	3.188E-02	0.021
1980	1.003E+00	1.017E+00	1.46%	9.687E-01	1.023E+00	9.873E-01	1.015E+00	2.756E-02	0.027
1981	1.146E+00	1.160E+00	1.26%	1.114E+00	1.162E+00	1.126E+00	1.157E+00	2.561E-02	0.022
1982	1.009E+00	1.017E+00	0.76%	9.863E-01	1.043E+00	9.912E-01	1.023E+00	1.569E-02	0.016
1983	7.412E-01	7.450E-01	0.51%	7.126E-01	7.817E-01	7.254E-01	7.577E-01	2.973E-02	0.040
1984	1.134E+00	1.138E+00	0.33%	1.072E+00	1.232E+00	1.096E+00	1.176E+00	7.990E-02	0.070
1985	2.173E+00	2.178E+00	0.23%	2.038E+00	2.372E+00	2.096E+00	2.256E+00	1.598E-01	0.074
1986	2.928E+00	2.932E+00	0.13%	2.800E+00	3.121E+00	2.852E+00	3.014E+00	1.614E-01	0.055
1987	1.946E+00	1.948E+00	0.07%	1.878E+00	2.043E+00	1.911E+00	1.992E+00	8.048E-02	0.041
1988	2.144E+00	2.146E+00	0.07%	2.053E+00	2.250E+00	2.101E+00	2.195E+00	9.352E-02	0.044
1989	1.409E+00	1.413E+00	0.26%	1.329E+00	1.495E+00	1.371E+00	1.451E+00	7.998E-02	0.057
1990	1.981E+00	1.984E+00	0.17%	1.827E+00	2.131E+00	1.908E+00	2.056E+00	1.479E-01	0.075
1991	2.643E+00	2.658E+00	0.58%	2.372E+00	2.887E+00	2.511E+00	2.772E+00	2.617E-01	0.099
1992	2.014E+00	2.034E+00	1.01%	1.706E+00	2.330E+00	1.871E+00	2.163E+00	2.921E-01	0.145
1993	2.984E+00	3.036E+00	1.75%	2.311E+00	3.644E+00	2.635E+00	3.350E+00	7.155E-01	0.240
1994	4.530E-01	4.625E-01	2.09%	3.264E-01	5.966E-01	3.847E-01	5.281E-01	1.434E-01	0.317
1995	1.075E-02	1.102E-02	2.47%	7.775E-03	1.414E-02	9.191E-03	1.261E-02	3.418E-03	0.318
1996	3.331E-02	3.412E-02	2.45%	2.398E-02	4.345E-02	2.815E-02	3.849E-02	1.033E-02	0.310
1997	6.951E-02	7.139E-02	2.71%	5.136E-02	9.233E-02	5.980E-02	8.122E-02	2.142E-02	0.308
1998	3.073E-01	3.106E-01	1.05%	2.253E-01	4.065E-01	2.618E-01	3.529E-01	9.106E-02	0.296
1999	3.971E-01	4.001E-01	0.76%	2.984E-01	5.434E-01	3.416E-01	4.619E-01	1.203E-01	0.303
2000	6.029E-01	6.061E-01	0.53%	4.609E-01	8.301E-01	5.218E-01	6.995E-01	1.777E-01	0.295
2001	6.632E-01	6.668E-01	0.53%	5.070E-01	9.131E-01	5.740E-01	7.695E-01	1.955E-01	0.295

TABLE OF PROJECTED YIELDS

2001	1.285E+01	1.283E+01	-0.16%	1.262E+01	1.304E+01	1.274E+01	1.296E+01	2.256E-01	0.018

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

F multiplier	2001 F absolute 5	25	50	75	95
1.1	0.111	0.126	0.138	0.152	0.174
1.0	0.101	0.115	0.126	0.138	0.158
0.8	0.080	0.092	0.101	0.110	0.127
0.6	0.060	0.069	0.075	0.083	0.095
0.4	0.040	0.046	0.050	0.055	0.063
Fmsy	0.147	0.186	0.209	0.231	0.260
2/3 Fmsy	0.098	0.124	0.139	0.154	0.173

F multiplier	2001 Yield 5	25	50	75	95
1.1	12.38	12.56	12.68	12.78	12.91
1.0	11.40	11.60	11.71	11.82	11.95
0.8	9.37	9.56	9.68	9.79	9.93
0.6	7.21	7.37	7.50	7.60	7.75
0.4	4.92	5.06	5.16	5.25	5.38

F multiplier	2001 Yield ratio 5	25	50	75	95
1.1	0.84	0.94	0.98	1.00	1.00
1.0	0.84	0.94	0.98	1.00	1.00
0.8	0.82	0.93	0.98	1.00	1.00
0.6	0.81	0.93	0.97	0.99	1.00
0.4	0.78	0.92	0.97	0.99	1.00

F multiplier	2001 Biomass ratio 5	25	50	75	95
1.1	0.73	0.93	1.06	1.19	1.37
1.0	0.74	0.94	1.07	1.20	1.39
0.8	0.76	0.96	1.10	1.23	1.41
0.6	0.79	0.99	1.12	1.25	1.44
0.4	0.81	1.01	1.15	1.28	1.47

F multiplier	2002 Biomass ratio 5	25	50	75	95
1.1	0.77	0.98	1.11	1.24	1.42
1.0	0.79	1.00	1.14	1.26	1.44
0.8	0.83	1.05	1.18	1.31	1.49
0.6	0.87	1.10	1.23	1.36	1.53
0.4	0.91	1.15	1.28	1.41	1.58

Table 14. The percentiles of fishing mortality yield, yield / MSY, biomass / Bmsy for 2001 and biomass / Bmsy for 2002, for a series of F multipliers on absoulte F 2000. The results are derived from an ASPIC bootstrap run (500 iterations) with a catch constraint of 11,000 tonnes in 2000.

Table 15 Relative biomass and fishing mortality rates for medium term yield projections 2001-2010 using $F_{2001\ to\ 2010} = 2/3F_{msy}$

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Results from ASPICP.EXE, version 2.31                                      13 Jun 2000 at 12:46.16
3LNO yellowtail flounder (biomass in kt)
2001-2011 F projections


USER CONTROL INFORMATION (FROM INPUT FILE)
--------------------------------------------------
Name of biomass (BIO) file            aspic.bio
Name of output file (this file)       runnafo6.prj
Number of years of projections        10

Year          Input data          User data type
----          -----------         --------------
2001           1.100E+00           F/F(2000)
2002           1.100E+00           F/F(2000)
2003           1.100E+00           F/F(2000)
2004           1.100E+00           F/F(2000)
2005           1.100E+00           F/F(2000)
2006           1.100E+00           F/F(2000)
2007           1.100E+00           F/F(2000)
2008           1.100E+00           F/F(2000)
2009           1.100E+00           F/F(2000)
2010           1.100E+00           F/F(2000)
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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
1965	2.413E+00	2.214E+00	-8.25%	2.279E+00	2.315E+00	2.307E+00	2.315E+00	8.397E-03	0.003
1966	2.233E+00	2.106E+00	-5.67%	2.148E+00	2.163E+00	2.166E+00	2.163E+00	0.000E+00	0.000
1967	2.084E+00	2.000E+00	-4.03%	2.032E+00	2.047E+00	2.039E+00	2.047E+00	0.000E+00	0.000
1968	1.970E+00	1.912E+00	-2.95%	1.928E+00	1.961E+00	1.940E+00	1.961E+00	7.177E-03	0.004
1969	1.849E+00	1.806E+00	-2.29%	1.816E+00	1.870E+00	1.833E+00	1.870E+00	3.890E-02	0.021
1970	1.738E+00	1.706E+00	-1.83%	1.713E+00	1.803E+00	1.723E+00	1.788E+00	5.754E-02	0.033
1971	1.547E+00	1.518E+00	-1.84%	1.513E+00	1.643E+00	1.532E+00	1.597E+00	6.369E-02	0.041
1972	1.272E+00	1.245E+00	-2.09%	1.231E+00	1.362E+00	1.252E+00	1.332E+00	7.919E-02	0.062
1973	9.966E-01	9.747E-01	-2.20%	9.440E-01	1.103E+00	9.698E-01	1.066E+00	9.209E-02	0.092
1974	8.030E-01	7.822E-01	-2.60%	7.440E-01	9.239E-01	7.719E-01	8.567E-01	8.478E-02	0.106
1975	7.001E-01	6.807E-01	-2.77%	6.375E-01	8.337E-01	6.691E-01	7.558E-01	8.663E-02	0.124
1976	6.022E-01	5.836E-01	-3.10%	5.305E-01	7.509E-01	5.703E-01	6.659E-01	9.562E-02	0.159
1977	6.853E-01	6.651E-01	-2.95%	6.172E-01	8.110E-01	6.525E-01	7.378E-01	8.533E-02	0.125
1978	7.330E-01	7.127E-01	-2.78%	6.700E-01	8.425E-01	7.016E-01	7.791E-01	7.753E-02	0.106
1979	7.370E-01	7.172E-01	-2.69%	6.784E-01	8.401E-01	7.079E-01	7.829E-01	7.500E-02	0.102
1980	7.043E-01	6.849E-01	-2.74%	6.458E-01	8.028E-01	6.763E-01	7.490E-01	7.262E-02	0.103
1981	7.448E-01	7.257E-01	-2.57%	6.956E-01	8.276E-01	7.188E-01	7.826E-01	6.377E-02	0.086
1982	7.599E-01	7.419E-01	-2.36%	7.170E-01	8.296E-01	7.378E-01	7.964E-01	5.860E-02	0.077
1983	7.952E-01	7.773E-01	-2.24%	7.621E-01	8.510E-01	7.773E-01	8.256E-01	4.830E-02	0.061
1984	8.662E-01	8.520E-01	-1.64%	8.427E-01	9.243E-01	8.548E-01	8.969E-01	3.904E-02	0.045
1985	8.634E-01	8.536E-01	-1.13%	8.456E-01	9.190E-01	8.548E-01	8.892E-01	2.908E-02	0.034
1986	7.099E-01	7.002E-01	-1.37%	6.899E-01	7.612E-01	7.003E-01	7.339E-01	3.133E-02	0.044
1987	5.193E-01	5.090E-01	-1.97%	4.966E-01	5.748E-01	5.073E-01	5.433E-01	3.608E-02	0.069
1988	4.744E-01	4.650E-01	-1.98%	4.517E-01	5.361E-01	4.631E-01	4.974E-01	3.431E-02	0.072
1989	4.206E-01	4.118E-01	-2.11%	3.948E-01	4.738E-01	4.073E-01	4.457E-01	3.834E-02	0.091
1990	4.363E-01	4.265E-01	-2.24%	4.116E-01	4.994E-01	4.222E-01	4.655E-01	4.329E-02	0.099
1991	4.014E-01	3.929E-01	-2.11%	3.745E-01	4.678E-01	3.864E-01	4.322E-01	4.583E-02	0.114
1992	3.266E-01	3.182E-01	-2.56%	2.921E-01	3.951E-01	3.074E-01	3.609E-01	5.352E-02	0.164
1993	3.051E-01	2.964E-01	-2.87%	2.491E-01	4.012E-01	2.730E-01	3.402E-01	6.270E-02	0.206
1994	2.342E-01	2.262E-01	-3.43%	1.730E-01	3.326E-01	1.986E-01	2.766E-01	7.795E-02	0.333
1995	3.053E-01	2.953E-01	-3.27%	2.256E-01	4.157E-01	2.567E-01	3.583E-01	1.016E-01	0.333
1996	4.324E-01	4.154E-01	-3.94%	3.249E-01	5.905E-01	3.699E-01	5.036E-01	1.337E-01	0.309
1997	5.850E-01	5.653E-01	-3.36%	4.487E-01	7.802E-01	5.028E-01	6.733E-01	1.705E-01	0.291
1998	7.632E-01	7.381E-01	-3.29%	5.893E-01	1.005E+00	6.649E-01	8.910E-01	2.261E-01	0.296
1999	9.135E-01	8.863E-01	-2.98%	7.126E-01	1.185E+00	7.997E-01	1.045E+00	2.454E-01	0.269
2000	1.036E+00	1.015E+00	-2.09%	8.108E-01	1.305E+00	9.135E-01	1.170E+00	2.569E-01	0.248
2001	1.108E+00	1.089E+00	-1.70%	8.564E-01	1.366E+00	9.674E-01	1.238E+00	2.703E-01	0.244
2002	1.158E+00	1.140E+00	-1.53%	8.706E-01	1.389E+00	1.009E+00	1.283E+00	2.734E-01	0.236
2003	1.197E+00	1.182E+00	-1.28%	9.175E-01	1.427E+00	1.059E+00	1.328E+00	2.693E-01	0.225
2004	1.226E+00	1.215E+00	-0.91%	9.447E-01	1.447E+00	1.095E+00	1.358E+00	2.632E-01	0.215
2005	1.252E+00	1.242E+00	-0.79%	9.613E-01	1.459E+00	1.123E+00	1.376E+00	2.535E-01	0.202
2006	1.272E+00	1.263E+00	-0.72%	9.774E-01	1.468E+00	1.136E+00	1.387E+00	2.508E-01	0.197
2007	1.287E+00	1.279E+00	-0.58%	9.960E-01	1.474E+00	1.155E+00	1.400E+00	2.456E-01	0.191
2008	1.298E+00	1.292E+00	-0.49%	1.009E+00	1.479E+00	1.169E+00	1.405E+00	2.368E-01	0.182
2009	1.308E+00	1.302E+00	-0.45%	1.021E+00	1.484E+00	1.183E+00	1.411E+00	2.281E-01	0.174
2010	1.315E+00	1.309E+00	-0.42%	1.033E+00	1.486E+00	1.194E+00	1.416E+00	2.220E-01	0.169
2011	1.320E+00	1.315E+00	-0.37%	1.046E+00	1.488E+00	1.202E+00	1.419E+00	2.172E-01	0.165

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

Table 15 (cont'd)

Results from ASPICP.EXE, version 2.31 13 Jun 2000 at 12:46.16
3LNO yellowtail flounder (biomass in kt)
2001-2011 F projections

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
1965	7.715E-02	8.421E-02	9.14%	7.243E-02	8.552E-02	7.243E-02	8.241E-02	9.985E-03	0.129
1966	1.875E-01	1.989E-01	6.08%	1.738E-01	2.044E-01	1.791E-01	1.970E-01	1.576E-02	0.084
1967	2.537E-01	2.637E-01	3.92%	2.384E-01	2.737E-01	2.467E-01	2.644E-01	1.774E-02	0.070
1968	4.060E-01	4.170E-01	2.73%	3.808E-01	4.374E-01	3.946E-01	4.208E-01	2.618E-02	0.064
1969	5.107E-01	5.197E-01	1.76%	4.820E-01	5.495E-01	4.936E-01	5.283E-01	3.471E-02	0.068
1970	9.422E-01	9.545E-01	1.31%	8.928E-01	1.013E+00	9.119E-01	9.730E-01	6.102E-02	0.065
1971	1.567E+00	1.581E+00	0.93%	1.498E+00	1.658E+00	1.525E+00	1.606E+00	8.091E-02	0.052
1972	2.062E+00	2.075E+00	0.64%	2.005E+00	2.129E+00	2.027E+00	2.091E+00	6.274E-02	0.030
1973	2.170E+00	2.183E+00	0.64%	2.086E+00	2.232E+00	2.124E+00	2.201E+00	3.901E-02	0.018
1974	1.915E+00	1.937E+00	1.18%	1.819E+00	1.977E+00	1.867E+00	1.944E+00	7.719E-02	0.040
1975	2.074E+00	2.109E+00	1.68%	1.903E+00	2.195E+00	2.002E+00	2.130E+00	1.284E-01	0.062
1976	7.362E-01	7.489E-01	1.74%	6.787E-01	7.811E-01	7.103E-01	7.565E-01	4.626E-02	0.063
1977	9.650E-01	9.795E-01	1.50%	9.189E-01	1.001E+00	9.427E-01	9.835E-01	4.078E-02	0.042
1978	1.237E+00	1.255E+00	1.45%	1.197E+00	1.273E+00	1.219E+00	1.256E+00	3.165E-02	0.026
1979	1.498E+00	1.520E+00	1.48%	1.441E+00	1.541E+00	1.479E+00	1.521E+00	3.188E-02	0.021
1980	1.003E+00	1.017E+00	1.46%	9.687E-01	1.023E+00	9.873E-01	1.015E+00	2.756E-02	0.027
1981	1.146E+00	1.160E+00	1.26%	1.114E+00	1.162E+00	1.126E+00	1.157E+00	2.561E-02	0.022
1982	1.009E+00	1.017E+00	0.76%	9.863E-01	1.043E+00	9.912E-01	1.023E+00	1.569E-02	0.016
1983	7.412E-01	7.450E-01	0.51%	7.126E-01	7.817E-01	7.254E-01	7.577E-01	2.973E-02	0.040
1984	1.134E+00	1.138E+00	0.33%	1.072E+00	1.232E+00	1.096E+00	1.176E+00	7.990E-02	0.070
1985	2.173E+00	2.178E+00	0.23%	2.038E+00	2.372E+00	2.096E+00	2.256E+00	1.598E-01	0.074
1986	2.928E+00	2.932E+00	0.13%	2.800E+00	3.121E+00	2.852E+00	3.014E+00	1.614E-01	0.055
1987	1.946E+00	1.948E+00	0.07%	1.878E+00	2.043E+00	1.911E+00	1.992E+00	8.048E-02	0.041
1988	2.144E+00	2.146E+00	0.07%	2.053E+00	2.250E+00	2.101E+00	2.195E+00	9.352E-02	0.044
1989	1.409E+00	1.413E+00	0.26%	1.329E+00	1.495E+00	1.371E+00	1.451E+00	7.998E-02	0.057
1990	1.981E+00	1.984E+00	0.17%	1.827E+00	2.131E+00	1.908E+00	2.056E+00	1.479E-01	0.075
1991	2.643E+00	2.658E+00	0.58%	2.372E+00	2.887E+00	2.511E+00	2.772E+00	2.617E-01	0.099
1992	2.014E+00	2.034E+00	1.01%	1.706E+00	2.330E+00	1.871E+00	2.163E+00	2.921E-01	0.145
1993	2.984E+00	3.036E+00	1.75%	2.311E+00	3.644E+00	2.635E+00	3.350E+00	7.155E-01	0.240
1994	4.530E-01	4.625E-01	2.09%	3.264E-01	5.966E-01	3.847E-01	5.281E-01	1.434E-01	0.317
1995	1.075E-02	1.102E-02	2.47%	7.775E-03	1.414E-02	9.191E-03	1.261E-02	3.418E-03	0.318
1996	3.331E-02	3.412E-02	2.45%	2.398E-02	4.345E-02	2.815E-02	3.849E-02	1.033E-02	0.310
1997	6.951E-02	7.139E-02	2.71%	5.136E-02	9.233E-02	5.980E-02	8.122E-02	2.142E-02	0.308
1998	3.073E-01	3.106E-01	1.05%	2.253E-01	4.065E-01	2.618E-01	3.529E-01	9.106E-02	0.296
1999	3.971E-01	4.001E-01	0.76%	2.984E-01	5.434E-01	3.416E-01	4.619E-01	1.203E-01	0.303
2000	6.029E-01	6.061E-01	0.53%	4.609E-01	8.301E-01	5.218E-01	6.995E-01	1.777E-01	0.295
2001	6.632E-01	6.668E-01	0.53%	5.070E-01	9.131E-01	5.740E-01	7.695E-01	1.955E-01	0.295
2002	6.632E-01	6.668E-01	0.53%	5.070E-01	9.131E-01	5.740E-01	7.695E-01	1.955E-01	0.295
2003	6.632E-01	6.668E-01	0.53%	5.070E-01	9.131E-01	5.740E-01	7.695E-01	1.955E-01	0.295
2004	6.632E-01	6.668E-01	0.53%	5.070E-01	9.131E-01	5.740E-01	7.695E-01	1.955E-01	0.295
2005	6.632E-01	6.668E-01	0.53%	5.070E-01	9.131E-01	5.740E-01	7.695E-01	1.955E-01	0.295
2006	6.632E-01	6.668E-01	0.53%	5.070E-01	9.131E-01	5.740E-01	7.695E-01	1.955E-01	0.295
2007	6.632E-01	6.668E-01	0.53%	5.070E-01	9.131E-01	5.740E-01	7.695E-01	1.955E-01	0.295
2008	6.632E-01	6.668E-01	0.53%	5.070E-01	9.131E-01	5.740E-01	7.695E-01	1.955E-01	0.295
2009	6.632E-01	6.668E-01	0.53%	5.070E-01	9.131E-01	5.740E-01	7.695E-01	1.955E-01	0.295
2010	6.632E-01	6.668E-01	0.53%	5.070E-01	9.131E-01	5.740E-01	7.695E-01	1.955E-01	0.295

TABLE OF PROJECTED YIELDS

2001	1.285E+01	1.283E+01	-0.16%	1.262E+01	1.304E+01	1.274E+01	1.296E+01	2.256E-01	0.018
2002	1.339E+01	1.335E+01	-0.27%	1.295E+01	1.375E+01	1.317E+01	1.360E+01	4.375E-01	0.033
2003	1.383E+01	1.378E+01	-0.31%	1.322E+01	1.436E+01	1.353E+01	1.412E+01	5.937E-01	0.043
2004	1.415E+01	1.413E+01	-0.17%	1.339E+01	1.484E+01	1.383E+01	1.454E+01	7.125E-01	0.050
2005	1.444E+01	1.440E+01	-0.24%	1.352E+01	1.523E+01	1.402E+01	1.486E+01	8.375E-01	0.058
2006	1.463E+01	1.462E+01	-0.07%	1.358E+01	1.552E+01	1.411E+01	1.506E+01	9.482E-01	0.065
2007	1.479E+01	1.478E+01	-0.07%	1.367E+01	1.578E+01	1.426E+01	1.526E+01	9.968E-01	0.067
2008	1.492E+01	1.491E+01	-0.03%	1.370E+01	1.600E+01	1.435E+01	1.544E+01	1.088E+00	0.073
2009	1.498E+01	1.501E+01	0.22%	1.367E+01	1.612E+01	1.440E+01	1.556E+01	1.160E+00	0.077
2010	1.504E+01	1.509E+01	0.31%	1.366E+01	1.620E+01	1.437E+01	1.562E+01	1.246E+00	0.083

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

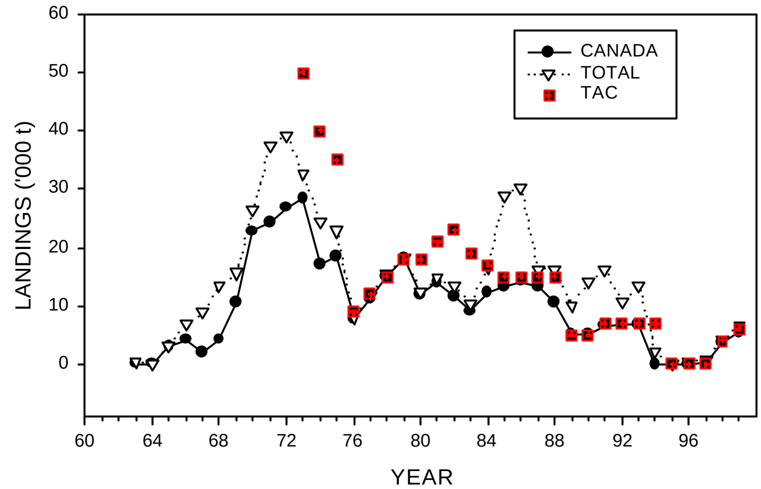
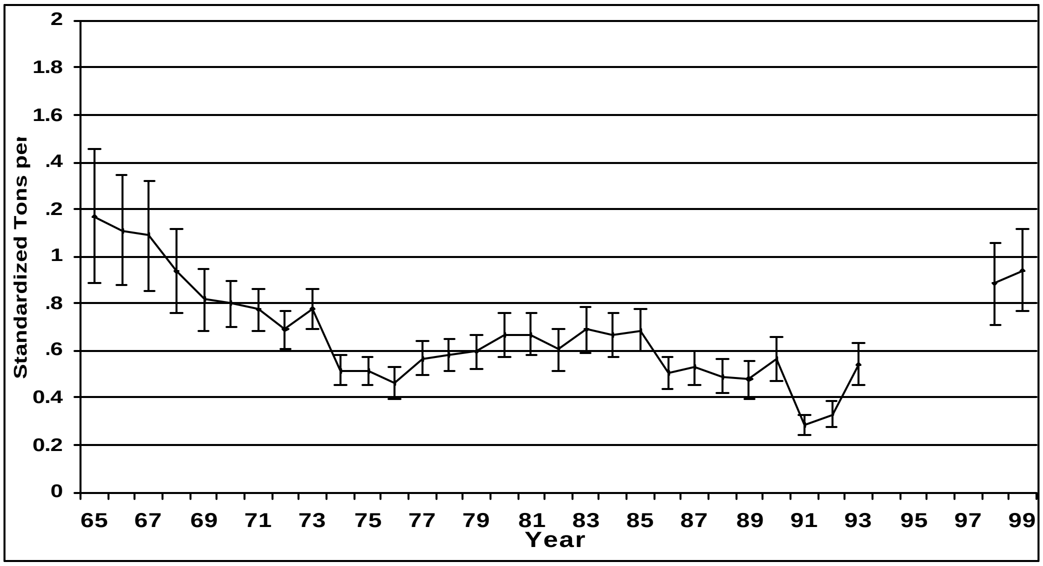


Fig. 1 Landings and TACs of yellowtail flounder in Division 3LNO

A) Div. 3LNO from 1965-1993,1998-1999



B) Div 3N and 3O separately from 1965-1993,1998-1999

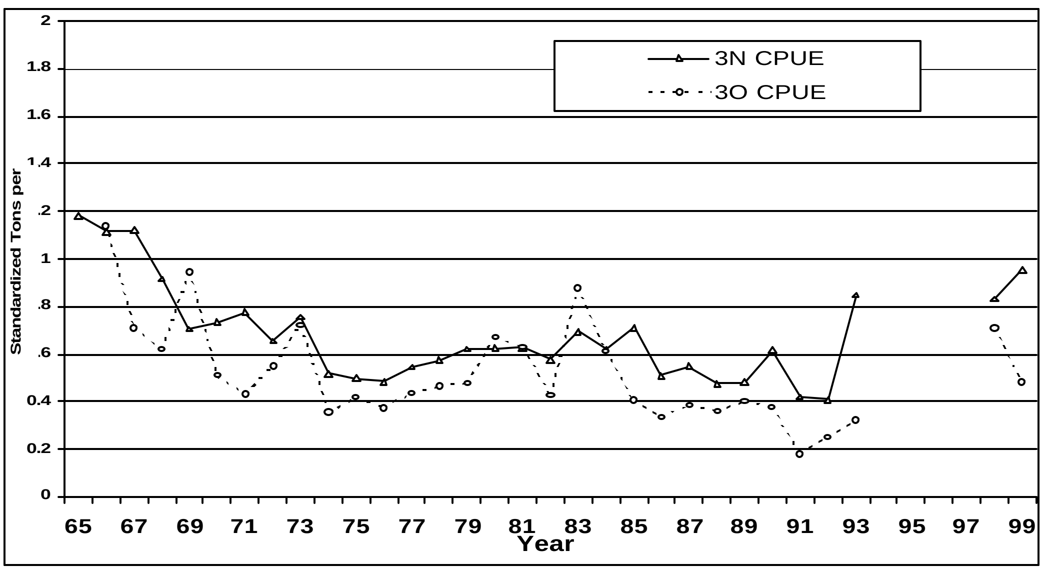


Figure 2. Standardized CPUE with approximate 95% confidence intervals for yellowtail flounder in Div. 3LNO form 1965-1993 and 1998-1999 (preliminary) under different treatments of the database. From 1991-1993 the fishery was a mixed fishery with American plaice. There was not directed fishery from 1994-1997.

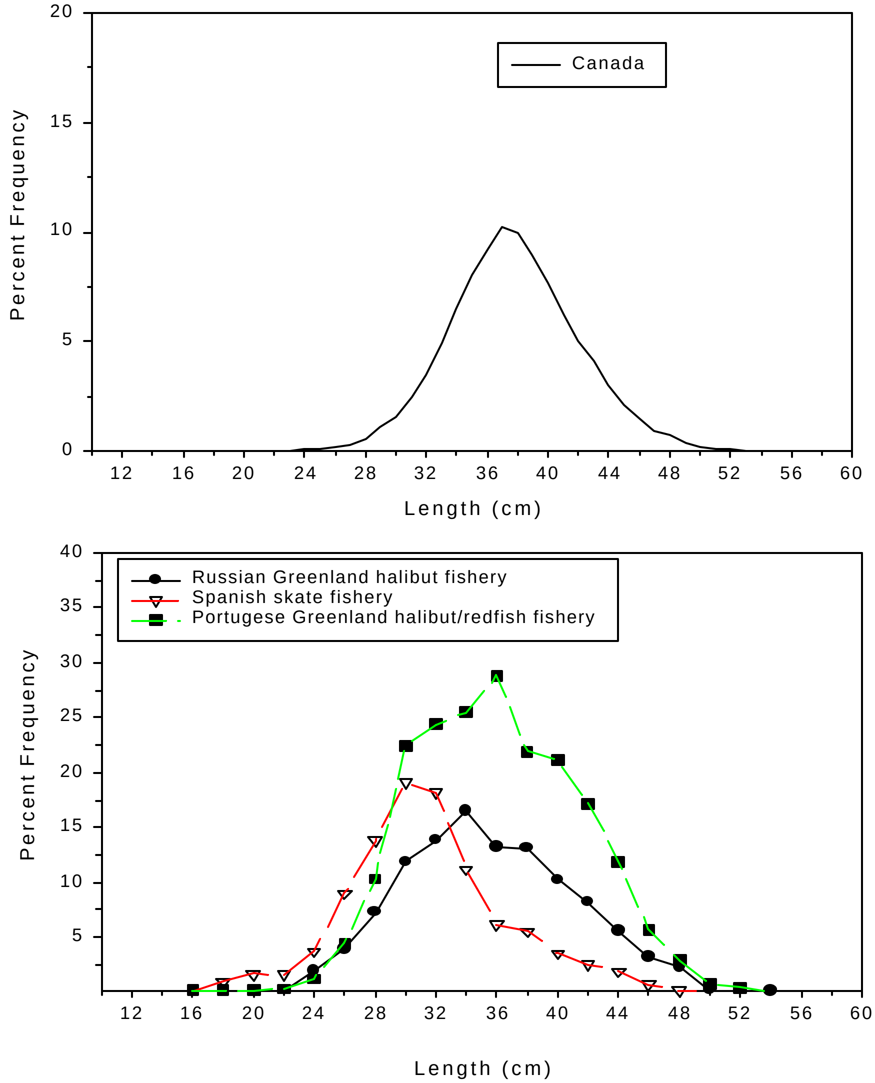


Fig. 3 (Top Panel) Length frequency of yellowtail flounder in the 1999 Canadian fishery. using 145-155 mm mesh codends.
(Bottom Panel) Comparison of length frequencies of yellowtail flounder in the bycatch fisheries of Russia (130 mm mesh codend), Portugal (130 mm mesh codend) and Spain (220 mm mesh codend).

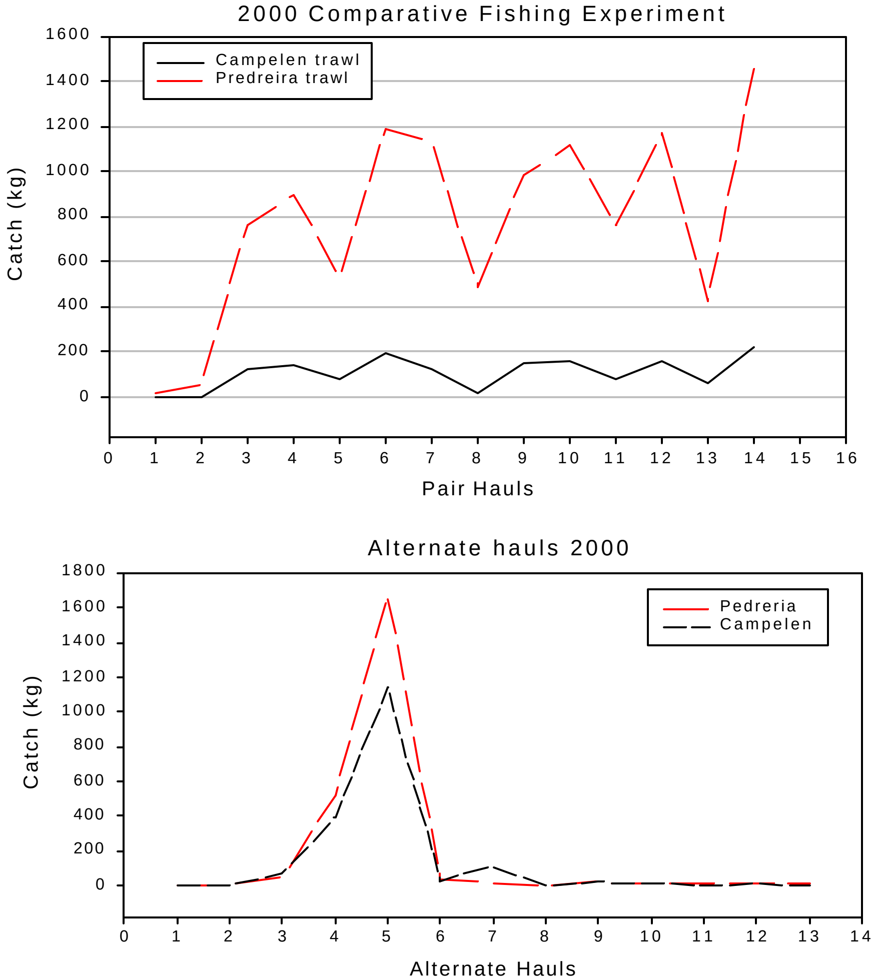


Fig. 4. (Top Panel) Results of comparative fishing between Canadian Campelen trawl and the Spanish Predreira trawl using parallel hauls and two vessels. (Bottom Panel) Results of comparative fishing between Predreira trawl and Campelen trawl both rigged with the same long ground warps and using the alternate haul method.

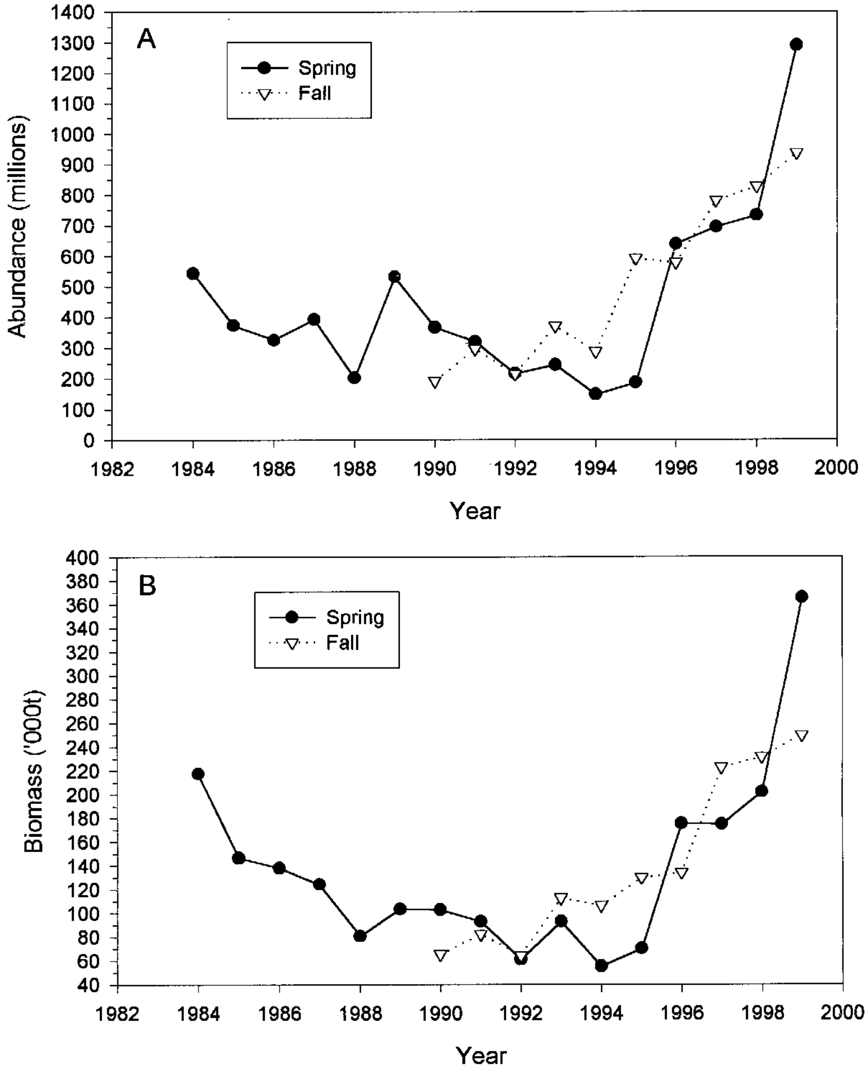


Fig. 5. **A**. The abundance and (**B**) biomass of yellowtail flounder estinated from annual bottom trawl surveys by Canada

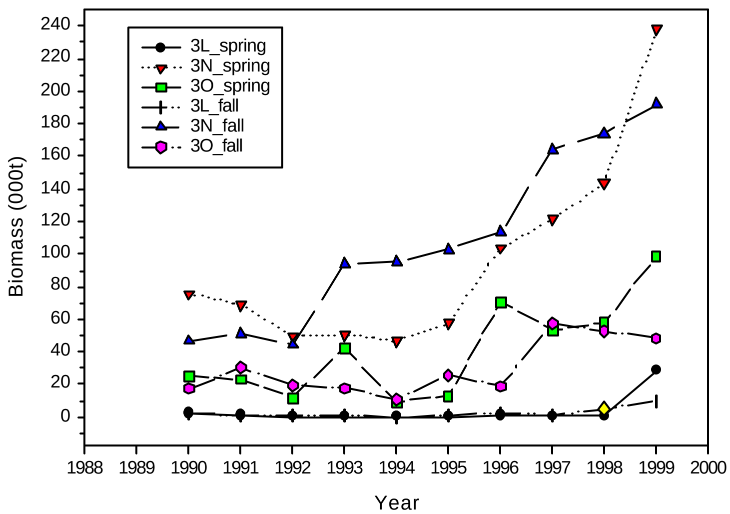


Fig. 6. Comparison of spring and fall biomass estimates of yellowtail flounder for 1990-99 surveys by division.

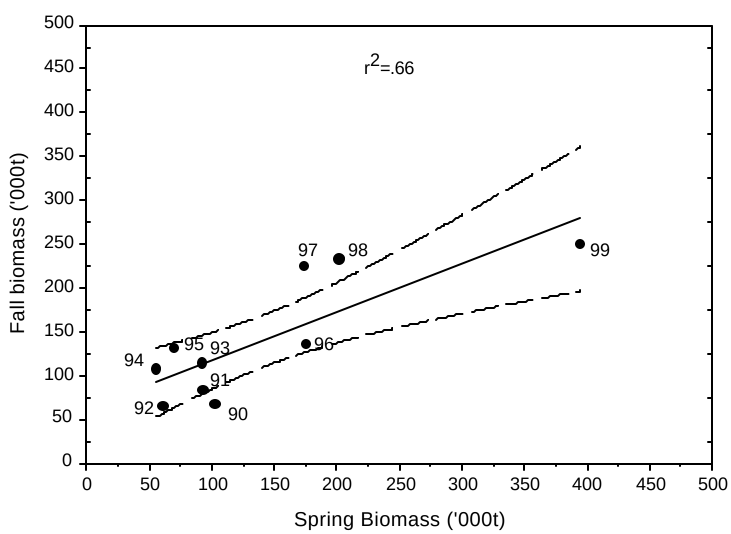


Fig. 7. Regression of fall and spring biomass estimates from annual bottom trawl surveys for yellowtail flounder on the Grand Bank, 1990-99.

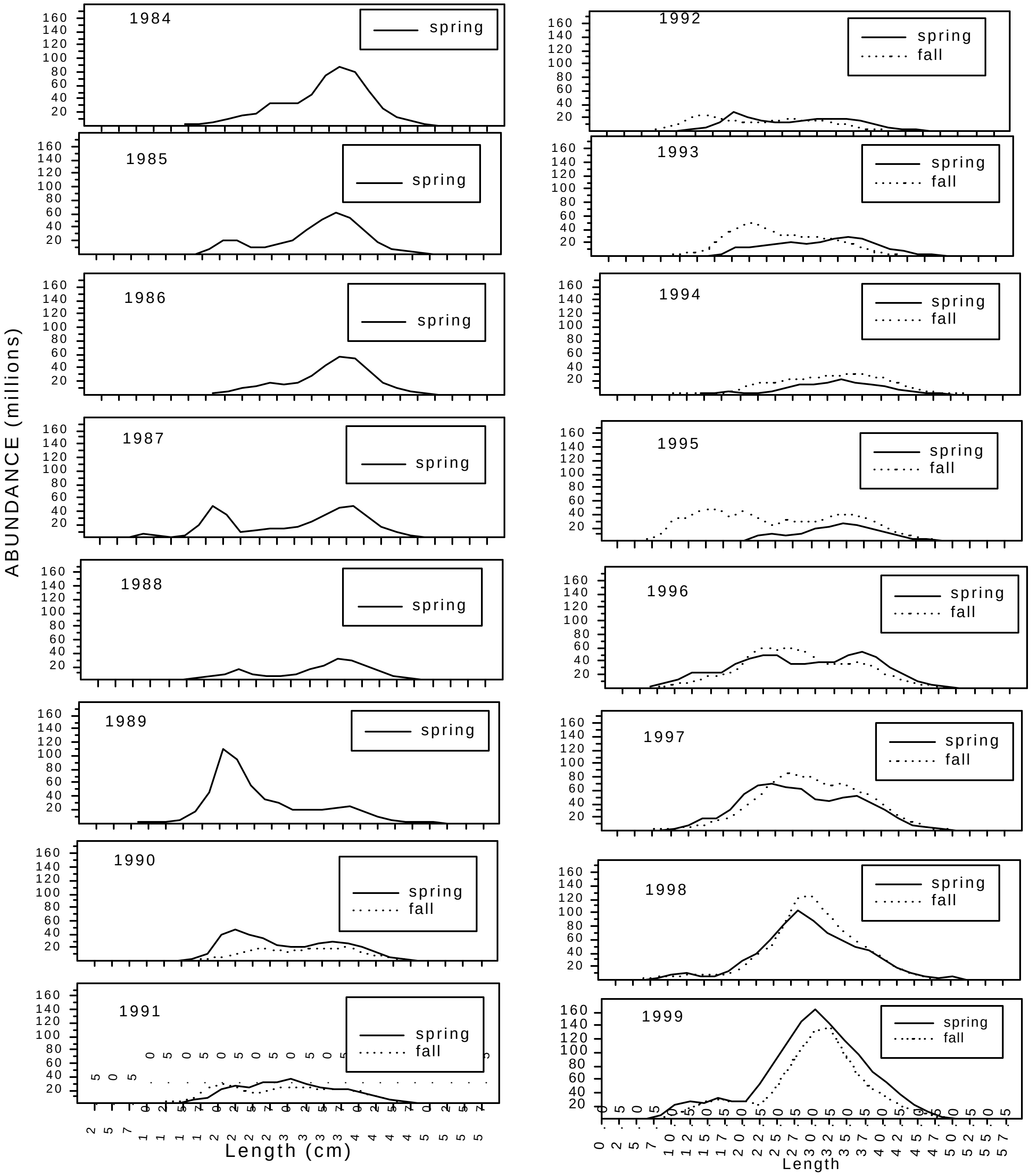


Fig. 8. Abundance at length for yellowtail from spring and fall surveys 1984-99

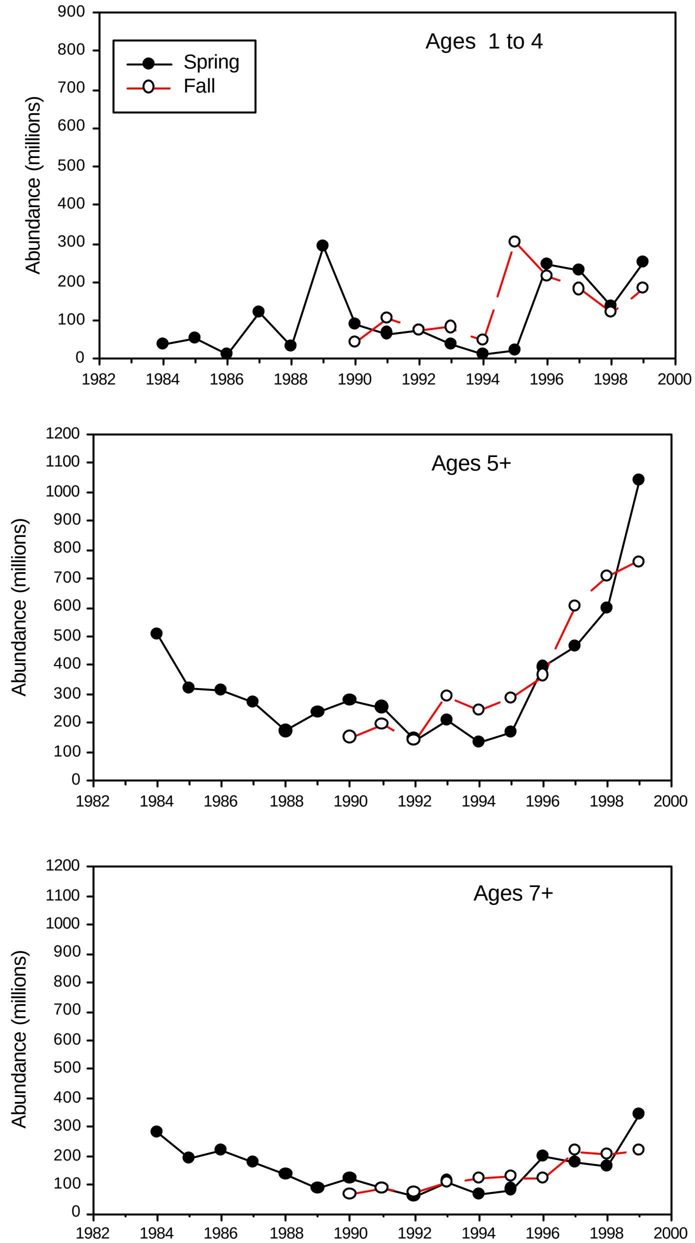


Fig.9 . Comparison of 1984-99 spring and fall survey estimates of pre-recruit, partially recruited and fully recruited ages of yellowtail flounder from Div. 3LNO.

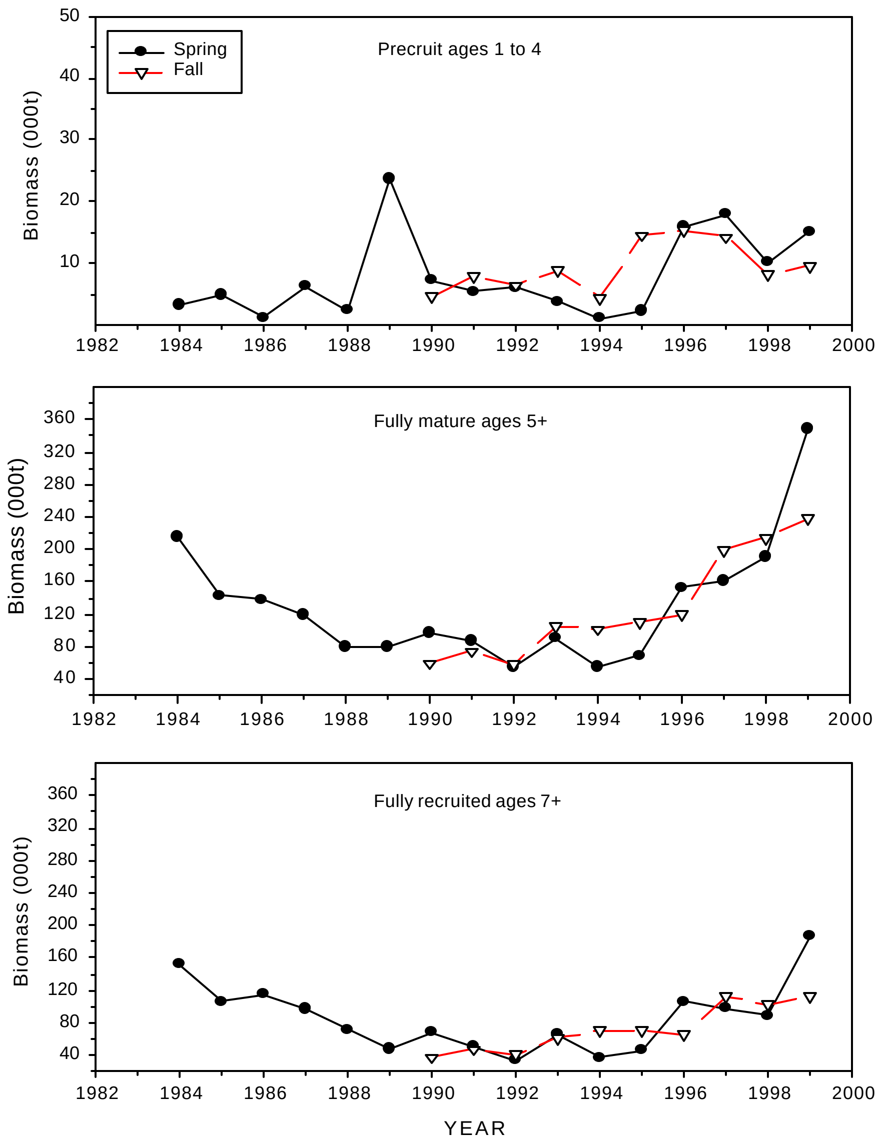
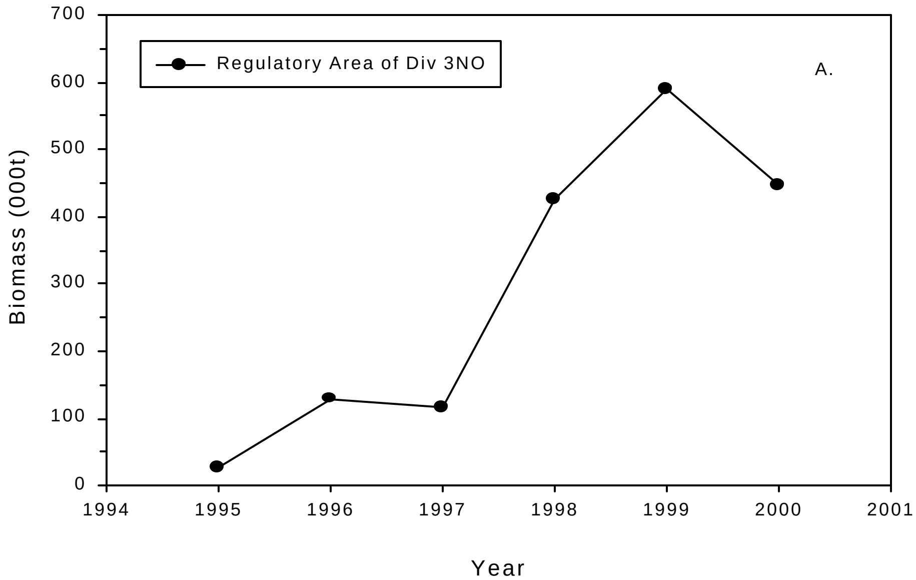


Fig. 10 Survey biomass of yellowtail from spring and fall surveys, 1984-99



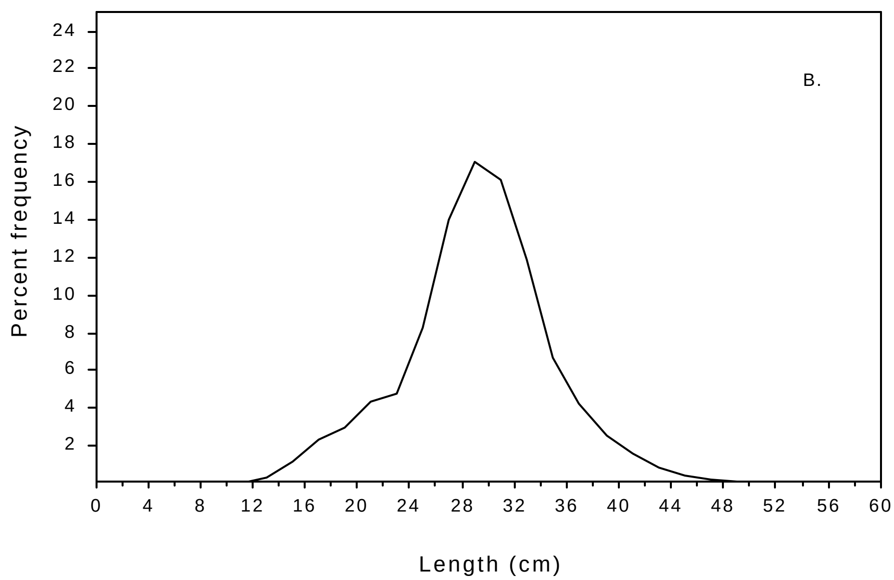


Fig. 11. A. Biomass of yellowtail flounder from the Spanish surveys in the Regulatory Area of Div.3NO.
B. Length frequency of yellowtail flounder in the 2000 Spanish survey in the
Regulatory Area of Div. 3LNO

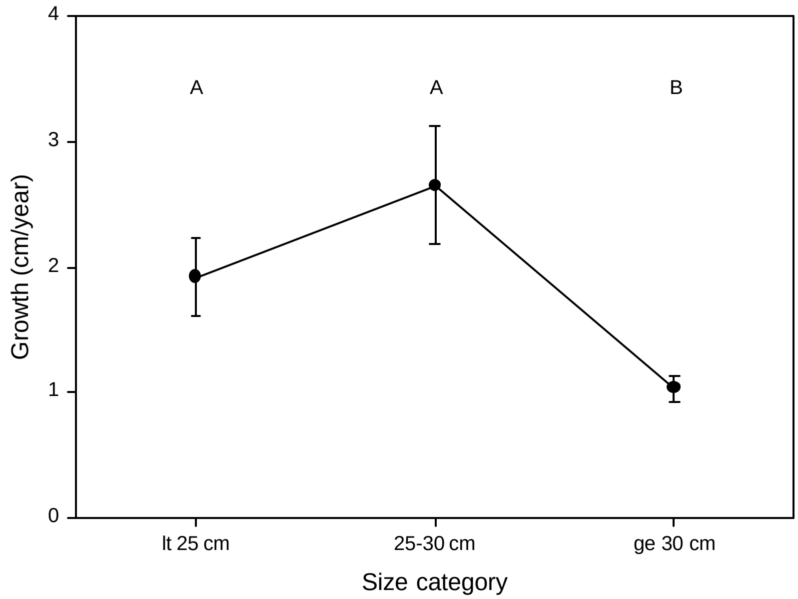


Fig. 12 Growth (cm/year) of yellowtail flounder for fish that were in three different size categories at the time of release. The size categories are less than 25 cm, greater than or equal to 25 cm but less than 30 cm, and greater than or equal to 30 cm. Size categories with the same letter are not significantly different according to Tukey's multiple comparisons.

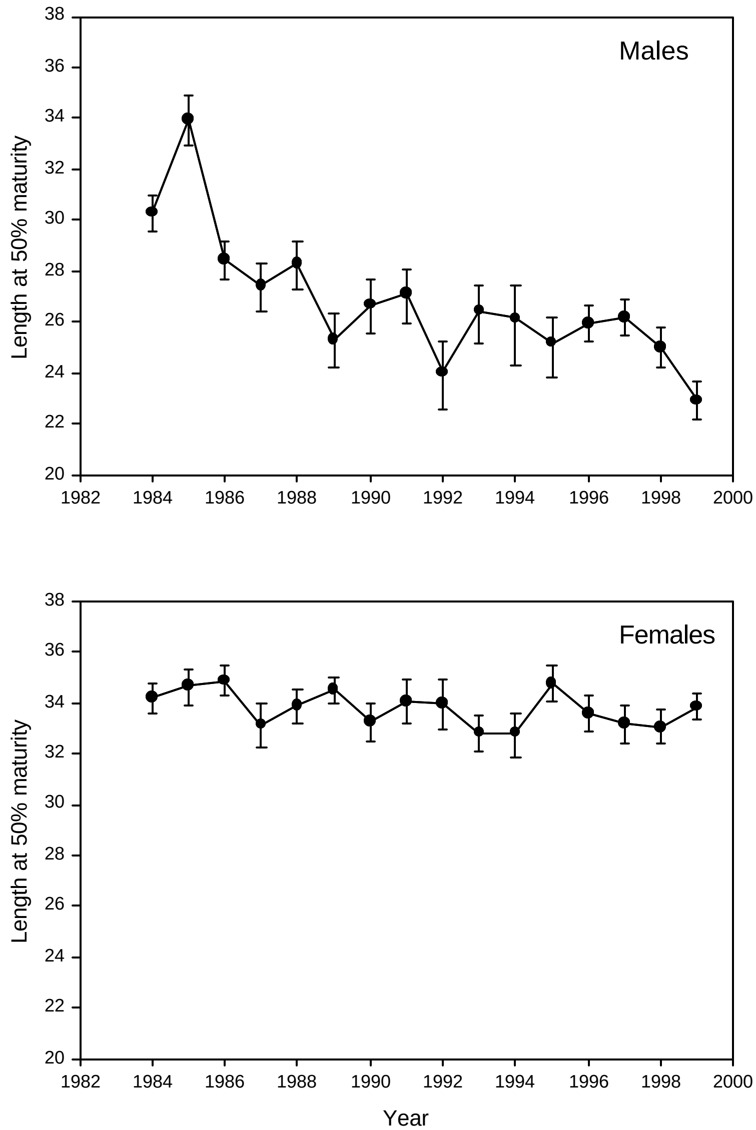


Fig. 13. Length at 50% maturity of male and female yellowtail flounder from annual spring surveys of Div. 3LNO from 1984-99.

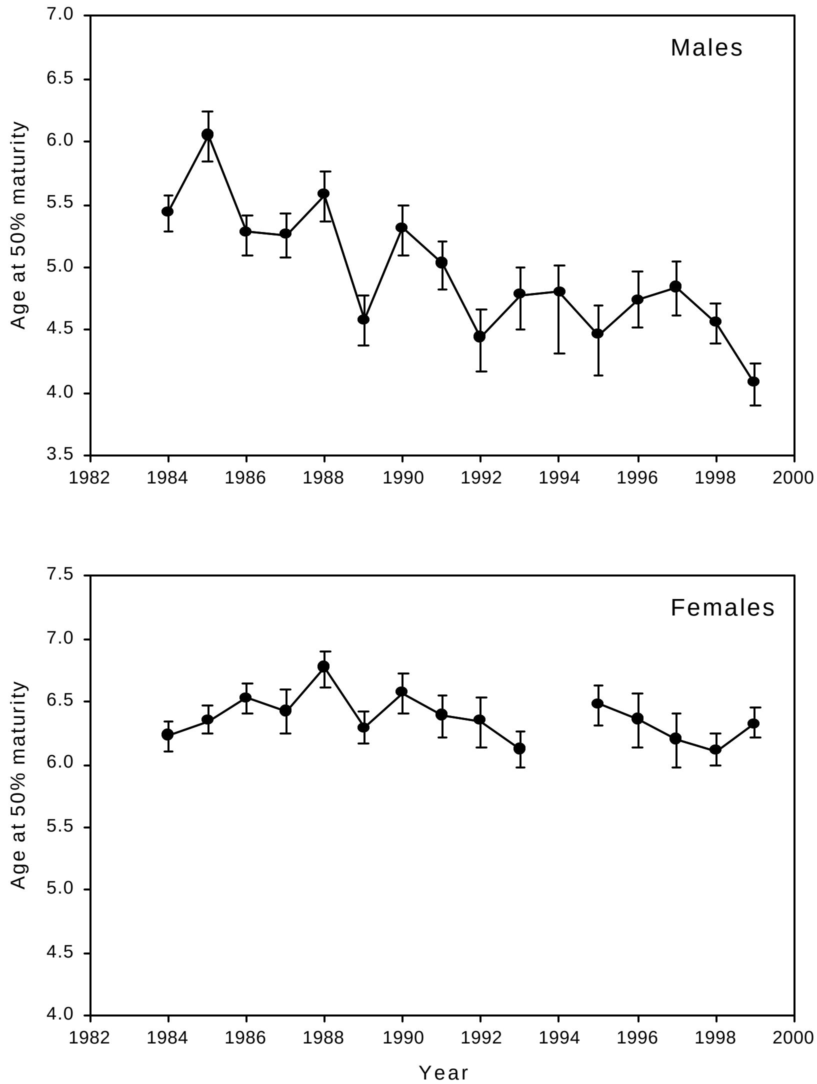


Fig 14. Age at 50% maturity of male and female yellowtail flounder from annual spring surveys of Div. 3LNO from 1984-99.

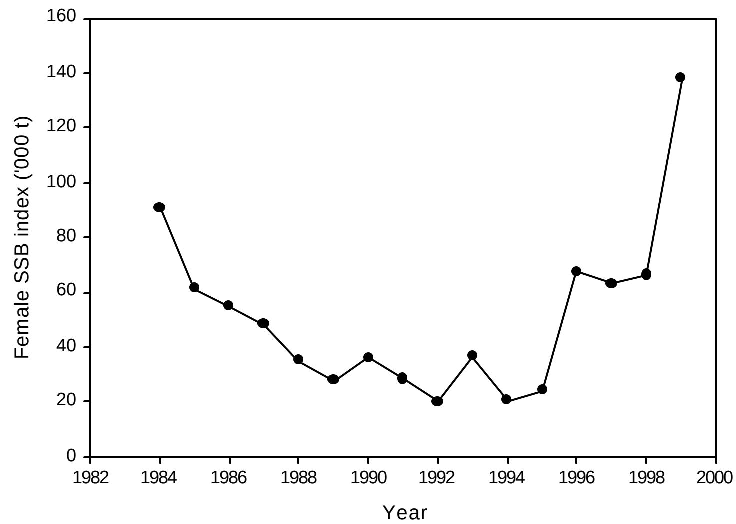


Fig. 15 Index of female spawning stock biomass ('000 t) as calculated from Canadian spring research vessel surveys.

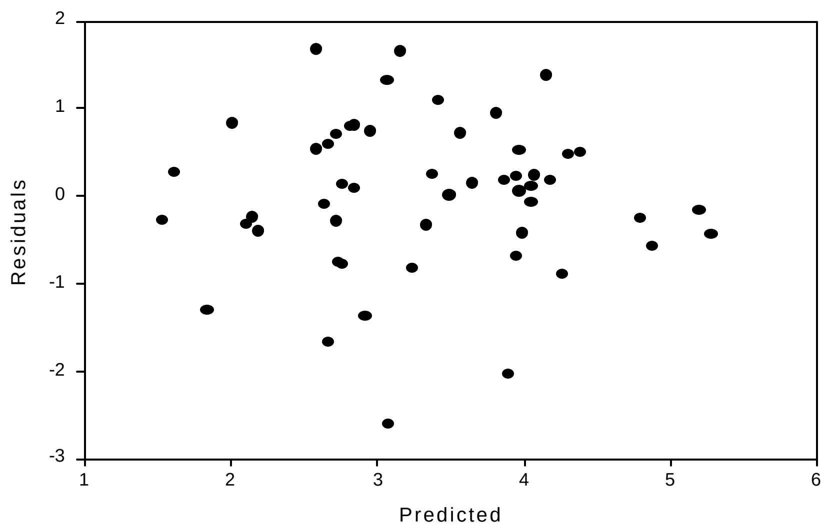


Fig.16 Residual plot from relative cohort strength model for yellowtail flounder.

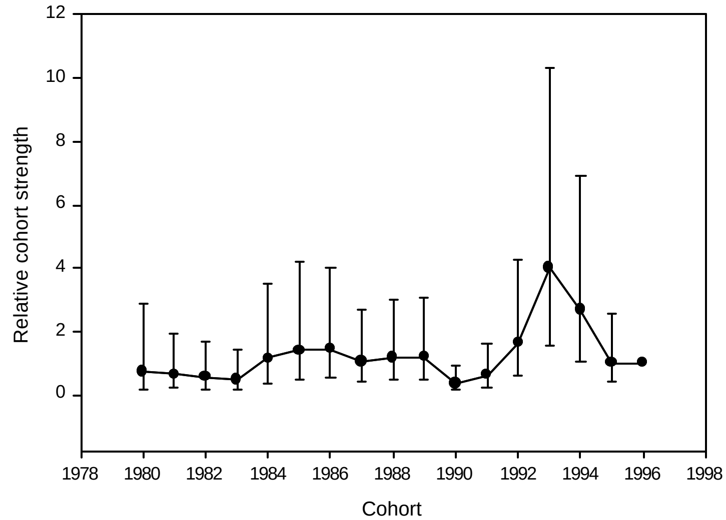


Fig. 17. Relative cohort strength of yellowtail flounder from 1980 to 1996 from multiplicative model.

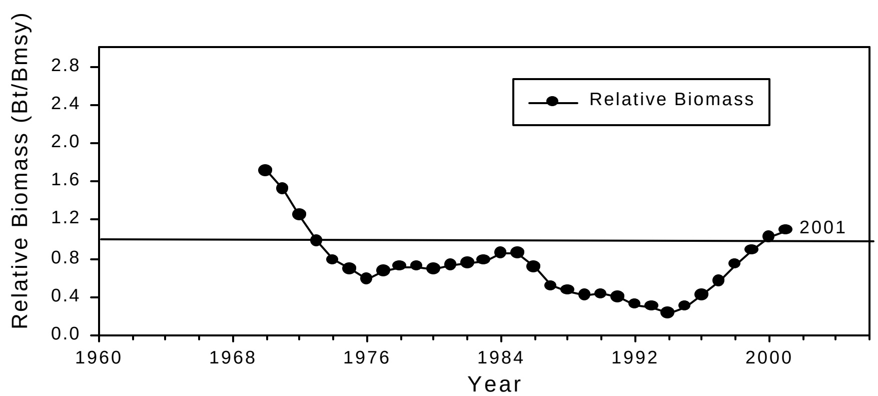


Fig. 18. Relative biomass indices from production analysis of Div. 3LNO yellowtail flounder using the 1965-2000 index.

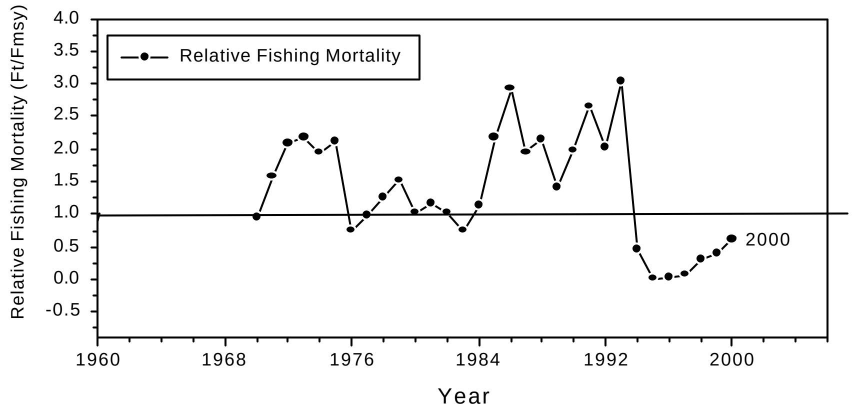


Fig. 19. Relative fishing mortailty rates from production analysis of Div. 3LNO yellowtail flounder using the 1965-2000 index.

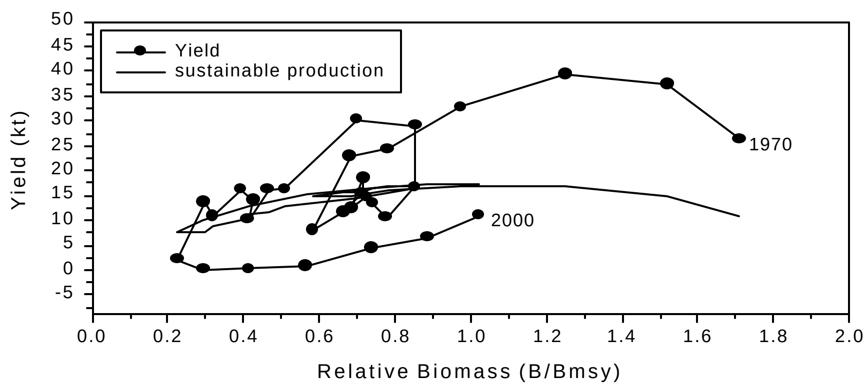


Fig. 20. Yield trajectory from production analysis of Div. 3LNO yellowtail flounder using the 1965-2000 index.

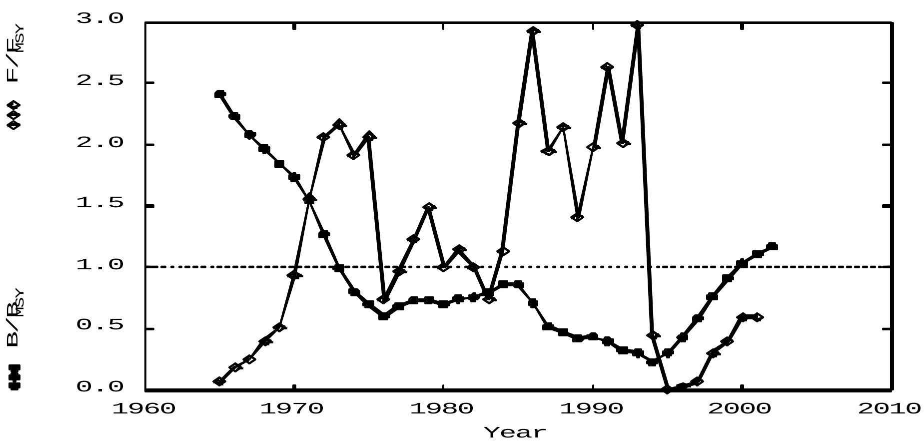


Fig. 21 Relative biomass and fishing mortality projections for 2001 assuming status quo F in 2001, i.e. $F_{2000} = F_{2001}$

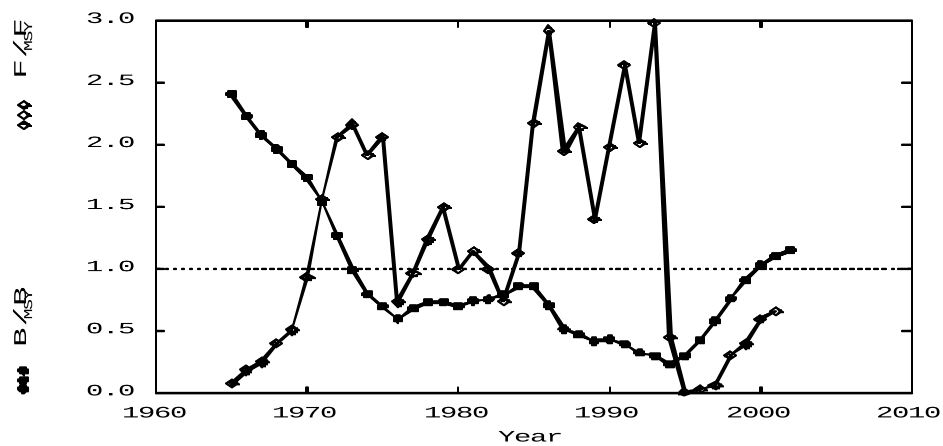


Fig. 22. Relative biomass and fishing mortality projections for 2001 assuming $F_{2001} = 2/3F_{msy}$

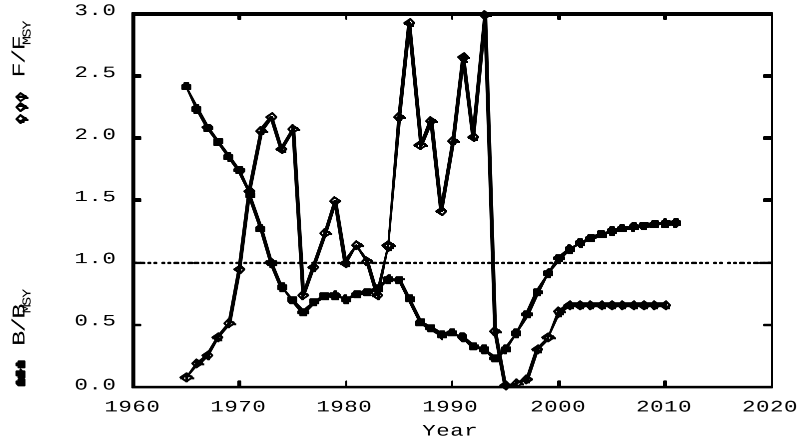


Fig. 23. Relative biomass and fishing mortality for medium term projections assuming $F_{2001 \text{ to } 2010} = 2/3F_{msy}$

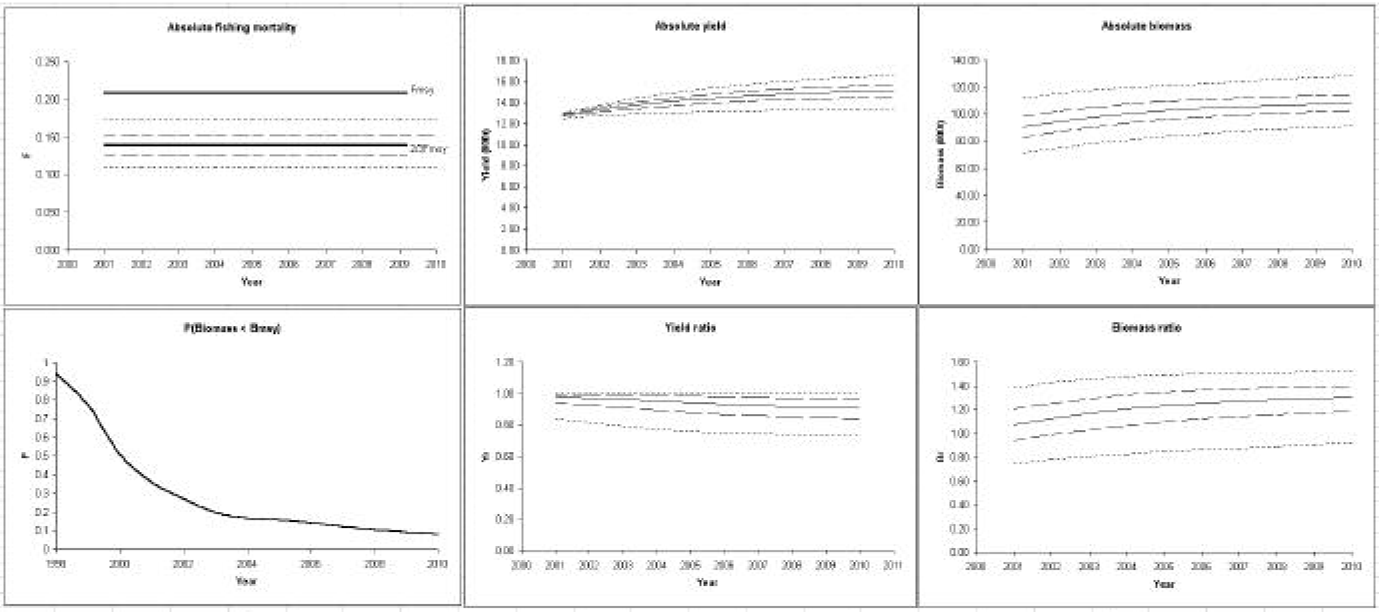
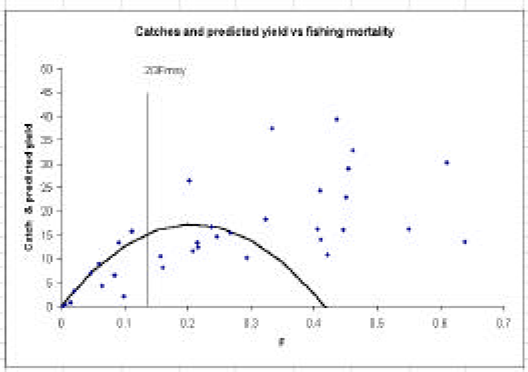


Figure 24. Medium term projections for Yellowtail flounder at a constant fishing mortality of 0.66 Fmsy.

The figures show the 5,25,50,75 & 95th percentiles of fishing mortality, yield, potential yield / MSY, biomass and biomass / Bmsy. The probability of biomass being less than Bmsy is also given

The results are derived from an ASPIC bootstrap run (500 iterations) with a catch constraint of 11,000 tonnes in 2000.



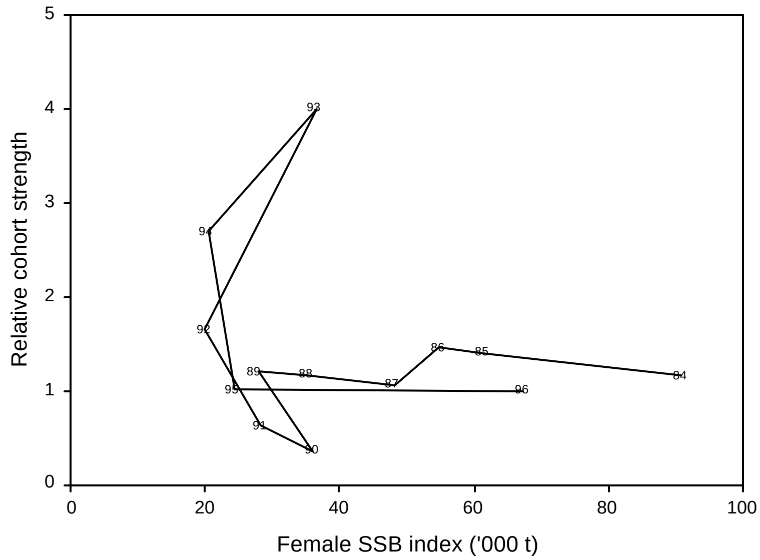


Fig. 25. Relative cohort strength vs. female spawning stock biomass ('000 t) index from Canadian spring research vessel surveys.

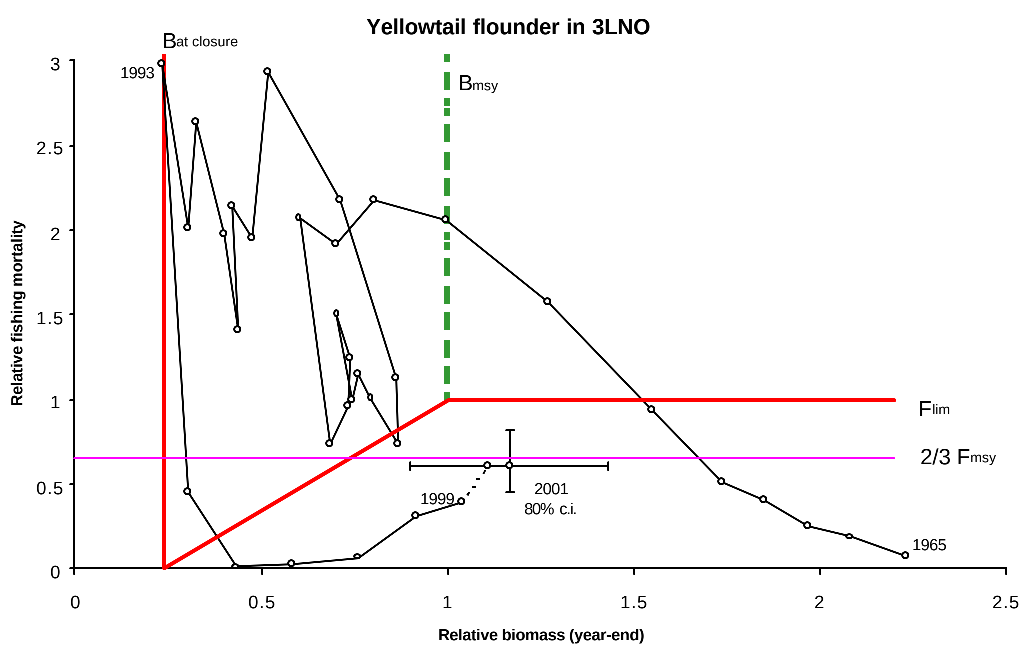


Fig. 26. Yellowtail flounder in Div. 3LNO: stock trajectory estimated in the production model analysis under the precautionary approach framework.