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The 1999 Assessment of Grand Bank Yellowtail Flounder Stock in NAFO Divisions 3LNO

by

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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 pre-cautionary 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.

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.

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) a bycatch (85 t) in the Portuguese Greenland halibut otter trawl fishery in the NAFO Regulatory Area of Div. 3N and 3) a bycatch (562 t) in the Spanish skate fishery in the NAFO Regulatory Area of Div. 3NO. In the 1998 Statland 21A statistics, Portugal reported a catch of 2 t in Div. 3M and STACFIS noted that this was an error in reporting or identification since the yellowtail flounder distribution doesn't extend to the Flemish Cap.

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.

<u>Commercial CPUE data</u>

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 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 Fig 2 gives the points in the series from 1965 to 1998

In the top panel of Figure 2, the catch per unit of effort declined fairly steadily from 1965 to 1976, then rose gradually 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 and has increased only slightly in the 2 subsequent years. The values in 1991-93 are the lowest value in the time series. The 1998 value is the highest in the time series.

Further examination of the data showed that the decline in 1991 was greatest in Div. 3O and that the CPUE in Div. 3N in 1991 and 1992, while lower than in 1990, was only slightly lower than the level observed in 1988 and 1989 (Fig. 2 lower panel). In 1993, the CPUE in Div 3O was the same as in 1992, while the CPUE in Div. 3N increased to a value just above that observed in 1990. Thus the decline in the overall index in 1991 and 1992 was due primarily to the switch in effort of the fleet to Div. 3O. 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 5. Figure 2 (middle panel) shows the CPUE for 3LNO with the 1991-93 mixed fishery data removed. Given this major shift in the fishery from the 1965-90 and the 1991-93 periods, 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, 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 (Kulka 1999) where yellowtail are aggregated (Simpson and Walsh 1999). Once again caution should be used in comparing this catch rate with other fishery periods, however , such a 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).

Table 6 provides information on the breakdown of the 1998 Canadian yellowtail flounder catches by month, division and fishing gear. Prior to August the catches reflect those taken in the DFO/FPI co-operative surveys from trips in May/June and July periods (see Simpson et al. 1999 for details). When the fishery began in August, the bulk of the catch was taken between August and October mainly by otter trawls. There were length, age samples and catch data from the 1998 Canadian fisheries, summarized in Table 7. Age data from the annual spring and fall surveys were used to convert the length data into age. The catch at age and mean weights at age from the fishery are shown in Table 8. Age 7 was dominant in both Divisons, with ages 6 and 8 comprising most of the remainder of the catch. This pattern is identical to that seen in the Canadian fishery prior to the moratorium (Table 9)

<u>Canadian fishery description (NAFO SCR Doc 99/61)</u>

The 3NO fishery started on August 1 and ended mid-November with nearly 100% observer coverage. Because of by-catch restrictions it occupied 6.6% of the total area of the Grand Bank where bottom depths are less than 91 m. By-catch levels of cod (2.3%) and plaice (4.2%) were kept to a minimum. Average size of males and females in the catch was 36.5 cm and 39.5 cm respectively and the catch was dominated by fish ages 6 to 8 years. The percentage of fish below the NAFO regulated minimum landing size of 27 cm was less than 1%.

<u>Non-Canadian fisheries (NAFO SCS Doc 99/16; SCS Doc 99/6)</u>

Length frequency of the catches by Spain and Portugal in the Regulatory Area of Div. 3N (NAFO SCS Doc. 99/6; Doc. 99/16) are presented in Fig. 3. The length frequency of yellowtail flounder in the Portuguese fishery were sampled from the September catches and those of the Spanish fishery were sampled in catches taken in August, September and October. Catches of the Portuguese and Spanish fleets range in size from 26 to 48 cm, with bimodal peaks at 34 and 38 cm, respectively. Age data from the 1998 Canadian fishery were used to convert these length frequencies into age data. Figure 4 shows the catch at age in both of these by-catch fisheries were dominated by ages 6 (1992 year-class) and 7 (1991 year-class).

Codend mesh sizes in mixed fisheries

The length frequencies of yellowtail from fisheries in the Regulatory Area are compared to the length frequencies of yellowtail flounder catches in the Canadian directed fishery of 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 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**.** Both the catches of Portugal and Spain showed similar length distributions and two bimodal peaks, one at 34 and the other at 38 cm, however, the Canadian catches had only one peak at 38 cm. There doesn’t appear to be a clear explanation of why the length selection by the 130 mm mesh codends used by Portugal and the 220 mm mesh codends used by Spain give almost identical length frequencies, i.e. both catch the same proportion of yellowtail from 24 to 30 cm.

Research survey data

A. Sampling gear studies (SCR Doc. 99/46,63, & 57).

Strict quality control fishing protocols are in place to minimize variability in gear deployment and trawl performance during the annual Canadian bottom trawl surveys. Geometry and performance of the Campelen 1800 shrimp trawl during the 1995–98 surveys were estimated from acoustic trawl instrumentation data. Statistical differences in geometry were estimated in comparisons between years and between the two vessels used in these surveys. The effect of these differences on change in catchabilities have not been estimated.

The design, performance and geometry of the survey bottom trawl, Engel 145 (96) high lift otter trawl, used in the Canadian cooperative DFO/Industry seasonal surveys of Div. 3NO yellowtail flounder were examined. The use of long trawl sweeps increases the effective trawl width in comparison to the Campelen survey trawl, however, and it is expected that the long sweeps will increase catches.

Spain conducted 17 comparative tows between their standard Pedreira otter trawl and the Campelen 1800 shrimp trawl using the alternative haul method during the 1999 annual survey in the Regulatory Area of Div. 3NO. Preliminary results showed the catches were higher in the Pedreria trawl than in the Campelen trawl. The use of long trawl sweeps and small trawl doors on such a large trawl as the Campelen may have adversely affected the geometry, performance and catchability of the trawl.

B. Canadian stratified-random surveys spring and fall surveys (SCR Doc. 99/44)

Abundance and biomass trends

Figures 6&7 and Table 10 compares 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 are generally higher. Both indicate a steady increase in stock size occurred between 1994 and 1995. A similar trend is seen in a comparison of biomass estimates for the same time period (Fig. 6). In addition, biomass estimates are consistently higher in Div. 3N during the fall surveys from 1992 onward and for Division 3O, in general there doesn't appear to be an obvious trend between spring and fall estimates (Fig. 7). In Div 3L, the fall biomass has generally been higher since 1995. Figure 8 shows the result of a regression of the biomass estimates from the spring and fall time series. A linear relationship is evident with 64% of the variation being explained by the model. Two density dependent time regimes may be evident here but the significance of this occurrence is not clear. The 1998 estimate puts stock biomass at 202, 000 tons in the spring and 231,000 tons for the fall estimate (Table 10).

Size and age composition

Length

Figure 9 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.

Abundance at age

Table 11 and Figures 10 & 11 provide information on the abundance at age of yellowtail from the spring and fall survey catches. Fish older than 9 years have not been aged from survey collections since 1991. However, due to increase efficiency of the new survey gear, an age 1 yellowtail flounder index has been started since the fall of 1995 (Fig. 10). In the spring series, the largest year classes (exceeding 150 million fish) were the 1977 year-class at age 7 in the 1984 survey, the 1985 year-class at age 4 in the 1989 survey and the 1992 and 1993 year-classes at ages 5 and 4 in the 1997 survey and at ages 6 and 7 in the 1998 surveys (Table 11A; Fig. 10). In the fall series, the largest year-classes were the 1992 year-class at age 5 and the 1991 year-class at age 6 in the 1997 survey and the 1993 year-class at age 5 and the 1992 year-class at age 6 in the 1998 survey (Table 11B;Fig 11). The 1994 to 1997 year-classes may be moderate to below average.

Table 12 and Figure 12 show the strength of ages 1-4 pre-recruits, fully mature fish (ages 5+) and fully recruited fish (age 7+) for the spring and fall time series. There is little difference in estimates of pre-recuits between spring and fall with the exception of the fall of 1995 when the new survey gear was introduces. After peaking in 1996 and 1997 with good contributions from the 1992 to 1994 year-classes, the 1998 estimate has shown a decrease indicating that incoming year-classes may be average to below average of the recent two years (Table 11). Fully mature fish (ages 5+) have been on the increase since 1994 and in general the fall estimates are somewhat larger than the spring estimates. The 1998 spring estimate of 191 million fish is still below the all time high in 1984 of 215 million fish (Table 12A). The estimates of fish fully recruited to the fishery (ages 7+) having been increasing modestly since 1994 in the spring series and since 1992 in the fall series. The estimates in recent years for the spring series are still well below the mid 1980s estimates. Although slightly higher in the fall there appears little differences in the spring and fall estimates of age 7+ fish.

Biomass at age

Table 12 shows the proportion of the biomass for individual cohorts from the spring and fall surveys. The biomass is 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. In both the spring and fall series, a large proportion of the biomass is contributed by ages 7 and 8 in most years, however, in 1998, ages 5-8 years contribute more extensively to the estimate of biomass (Table 12A&B).

The spring and fall estimates of pre-recruit biomass (ages 1 to 4) began increasing in 1994 to a high in 1996 and then began decreasing following a decrease in year-class strength (Fig. 11). The mature age 5+ spring biomass decreased from a high of 215 000 tons in 1984 to 56 000 tons in 1994 and then rose dramatically to a high of 190 000 tons in 1998 (Fig. 13; Table12A). The fall biomass which tends to be larger began its upward trend in 1992 reaching a high of 214 000 t in 1998 (Table 12B; Fig 13). The spring biomass of fully recruited age 7+ showed a similar decreasing trend from a 1984 high of 152 000 tons to 37 000 tons in 1994 and then began to increase to a high of 98 000 t in 1997. Similar to the fall series for mature biomass the upward trend began in 1992 and reach a high of 113 000 t. In general the fall estimates are higher than the spring series. In 1998, the spring survey biomass was 89 000t and the fall estimate was 102 000t, both down from their respective 1997 estimates.

Cooperative DFO/fishing industry seasonal surveys (SCR Doc. 99/42). 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 length range of yellowtail flounder in these surveys ranged from 23-52 cm and only 15% of the catch in any one trip was less than 30 cm; and exception was the July 1998 where the percentage was 39. Ages 6-8 dominated the catch. 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.

Spanish stratified-random spring surveys in the Regulatory Area of Div. 3NO (SCR Doc. 99/57)**.** 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 (Fig. 14).

The 1996 survey had a bi-modal distribution with one mode at 24 and the other mode at 36 cm, similar to the length composition in the Canadian surveys. Although the 1997 length composition showed only one modal peak at 24 cm in the Spanish survey there were two in the Canadian survey, 24 and 36 cm respectively. In 1998 the modal peak was 26 cm in the Spanish survey and 28 in the Canadian survey. In 1999 there was a modal peak of 28 cm in the Spanish survey, but there is no Canadian data available (Fig. 15). There is an apparent similarity in the length selection of the survey trawls used by Canada and Spain for yellowtail larger than 16cm, although more fish are caught in the Spanish trawl when comparing modal peaks probably due to the increase in swept area of the Spanish survey trawl when compared to the Canadian trawl. However, the Canadian trawl catches more fish in the 6 to 16 cm size range than the Spanish trawl (Fig. 15).

Using the mean-length-at age from the Canadian survey, the peak in the 1998 and the 1999 catches represents age 5, i.e. the 1993 and 1992 year-classes which has been identified strong year-classes in the Canadian spring and autumn surveys in 1996-98.

D. Stock distribution (SCR Doc. 99/44, 59, 60).

Analysis of 1985-97 fall surveys using geostatistics showed the stock was more widely distributed in all three divisions prior to the 1990's however, little or no catches have been found in Div. 3L. The majority of the stock is consistently concentrated in Div. 3N on and to the area west of the Southeast Shoal. While the stock is spatially localized, temperature and depth are significant factors affecting their distribution. In the 1998 surveys, some expansion of the range into Div. 3L was evident. The proportion of juveniles (ages 0 to 3) in the 1985-97 fall surveys on the Southeast Shoal is, on the average, 2 to 1, mostly in the southern section of the shoal, with the adjacent area immediately west of the shoal constituting the rest of the nursery area.

E. Biological studies

Growth

From 1990 onward, when yellowtail flounder were sampled for otoliths during the Canadian surveys individual weights of fish were also recorded. The mean length and weights at age from the spring and fall surveys in Div. 3LNO are present in Figures 16 & 17. There was a strong linear mean length at age relationship in both the spring and fall surveys. During 1990-1994 surveys a seasonal shift in growth is evident but absent in survey catches in 1995-1998 (Fig. 16). Average weight of age of males and females showed no obvious trends in both the 1990-98 Canadian spring and fall survey series (Fig. 17). Figure 18 compares the length-weight relationships in males and females and shows that that the weights of both sexes are equal up to about 38 cm and, afterwards, a higher weight is measured in females than in males at comparable sizes.

Tagging studies (SCR Doc 99/54)

Additional information on age and growth was derived from length and otolith information obtained from tag returns from tagging experiments conducted in the early 1990's. The analysis indicated there may be an ageing problem with older fish and that the growth rate according to tag returns was much lower than seen in Figure 16.

Maturity

Canadian results

Proportions mature at age were produced according to the method of Morgan and Hoenig (1997). From these data, proportions mature at age were estimated using a logistic model with a logit link function and a binomial error (SAS, 1989). The age at 50% maturity were also produced and are shown in Figure 19 for males and females. The model did not give a significant fit to the data in 1994. The estimated proportions mature at age for 1993 were used for 1994. There appears to be no consistent trend over the 1984-98 time period. Age at 50 % maturity indicated a small decrease in both sexes from 1997 to 1998.

Spanish results (SCR Doc. 99/16)

Length at 50% maturity (L_{50}) was calculated for males and females, separately, from samples collected during the 1995-99 Spanish surveys in the Regulatory Area. There has been a decreasing trend in 50% maturity at length in both sexes especially from 1997 to 1998. However, it is difficult to relate these results from samples taken in the Regulatory Area of Div. 3NO to the rest of the stock because samples did not contain many older fish and it is not clear if this decrease is representative of the entire population.

F. Assessment results

Female spawning stock biomass

For the period 1984 to 1998, female spawning stock biomass was calculated from data collected during Canadian spring stratified random surveys. For 1984 to 1995, data were converted from Engel to Campelen equivalents.

The age at 50% maturity was also produced and is shown in Figure 19. There appears to be no consistent trend over the 1984-98 time period (see maturity section above for details of calculations)

Mean weight at age was calculated for each year for the period 1990 to 1998, accounting for the length stratified sampling of the data (see Morgan 1999). Mean weight at age also showed little trend over the time period examined (Fig. 17). Very few data were available in 1995. Prior to 1990, individual fish weights were not available. For this period a length weight relationship for the period 1990-93 was used. This relationship was log weight=3.10*log length –5.19. This relationship was applied to mean lengths at age calculated for each year from 1984-1989, accounting for the length stratified sampling of the catch. Given the lack of weight data in 1995, a length weight relationship was applied to mean length at age to calculate mean weight at age for that year as well. In this case a length weight relationship combining data from 1994 and 1996 was used: log weight=3.08*log length –5.15.

To produce female spawning stock biomass, mean weight at age was multiplied by the estimated proportion mature at age and the abundance at age and then summed across all ages. The results are shown in Figure 20. From 1984 to 1995, SSB was highly variable but generally declined from 50,000 in 1984 to an average of 13 000 tons in 1988-89 and for the period 1990 to 1995 varied with out trend around an average value of 26 000 tons. From 1996-98 the biomass is stabled at around an average level of 64 000 t.

Year-class strength

Cohort strength, i.e. relative year-class strength, was estimated from a multiplicative model using ages 3 and 4 abundance from the 1984-98 Canadian spring and 1990-98 fall survey time (see Walsh et al 1997 for model formulation). Figure 21 shows the output of the model. To evaluate the fit of the model the residuals were plotted against the predicted values and the fit appears good (Fig. 22). Cohort strength was slightly stronger from 1984-1989 when compared with the period 1980-83. The 1990 cohort showed a slight decrease and from 1991 the succeeding cohorts increased in strength up to 1993 year class before declining again. The 1993 year class estimate was the highest in the time series and the most variable. Incoming year-classes are expected to be average.

Estimates of total mortality (Z-values).

Under the assumption that the spring survey index of age is proportional to the population abundance at age then the survey index can be used to calculate total mortality (Z) for those ages that are recruited to the survey. For those ages that are not fully recruited to the survey, the relative Z values could provide some indication of changes in Z although not reflective of the actual mortality . The calculated Z’s for ages 4 to 9 over the period 1984-98 are shown in Figure 23. Yellowtail are generally fully recruited to the survey gear at age 7. For ages 4 to 7 the trends in the data are similar with a marked decrease in total mortality during the moratorium, 1994-97, however the high Z’s for older fish even during the moratorium are unexplainable. The doubt about the accuracy of older ages maybe contributing to this unexplained pattern and limits the usefulness of this analysis.

Reference points

SSB/R relationship

Population abundance of age 4 cohorts were estimated from the cohort strength model output from and used with an estimation of female SSB. There is no apparent stock recruitment relationship. The large 1993 year-classes was produced when the SSB was close to the long-term average of 36 000 t. As data becomes available for cohort strength beyond 1995, there should be a shift in location to the right side of the graph given the average SSB for 1996-98 is 64 000 t.

Precautionary Approach Workshop in San Sebastien (NAFO SCR Doc. 99/3; SCS Doc. 99/4)

A non-equilibrium surplus production model (ASPIC) was applied to catch, effort, and survey biomass indices of Grand Bank yellowtail flounder (NAFO Div. 3LNO). The data generally fit the model well but results from the Div. 3L NO yellowtail flounder example application were sensitive to the choice of biomass indices. The Scientific Council concluded that parameter estimates were useful for deriving precautionary reference points. The model suggests that a maximum sustainable yield (MSY) of 16 000 tons can be produced by a total stock biomass of 91 000 tons (B_{msy}) at a fishing mortality rate on total biomass of 0.18 (F_{msy}), and estimated starting stock biomass was 70% of B_{msy} in 1998 (Fig. 25). Conditional non-parametric bootstrap estimates indicate that parameters were relatively well estimated.

Concerns were raised that ASPIC is limited to estimates of total biomass, but B_{lim} should be based on a threshold of SSB. Stock-recruit relationships, generated from survey data were examined. SSB was calculated as mature female biomass from annual maturity ogives, and recruitment estimates were taken from the same survey data. Scientific Council noted that there were a number of concerns with the survey data, and that the calculations had not yet been reviewed by STACFIS. Until these concerns are addressed and further analyses have been reviewed, Scientific Council emphasizes that the stock recruit relationship examined at this meeting must be treated as preliminary.

The ASPIC model results were used to provide reference points for illustrative purposes in the context of the NAFO PA framework (Fig. 25). F_{lim} was defined as the F_{msy} estimate (0.18) and F_{buf} was defined as the tenth percentile of the F_{msy} estimate (0.13). Noting the caveat expressed above, the low SSB values from the S/R curve for 1975, 1988 and 1989 were used to indicate a possible level of B_{lim}, and the ASPIC result (averaged for these 3 years) was 48 000 tons; B_{buf} was derived as the ninetieth percentile of the B_{lim} estimate (63 000 tons). B_{tr} was set at the B_{msy} level of 91 000 tons.

Summary

There is no analytical assessment for this stock. Spatial analysis has shown the stock is more widely distributed in Div. 3NO in the 1997-98 surveys than in the early-1990s but not as extensively as prior to the mid-1980s. It also shows that the stock may be spreading into historic grounds in Division 3L, although quantities are still low. The Canadian spring and autumn surveys and the Spanish surveys in the Regulatory Area show that stock abundance and biomass has been increasing in recent years. The increase in biomass is related to both an increase in growth and recruitment.

The age structure has remained stable in all of the surveys for which age data are available and many age classes are contributing to the biomass indices in 1996 -1998. The SSB is at a higher level in recent years relative to the mid-1980s and the relative cohort strength in 1995-98 surveys is above average, however, it may be declining because of average incoming year classes. The mean weights at age have also remained stable. Based on 8 additional surveys since the 1997 assessment, the current view is that the stock size has continuously increased since 1994.

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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	
1966	4,185	-	2,834	-	7	7,026	
1967	2,122	-	6,736	-	20	8,878	
1968	4,180	14	9,146	-	-	13,340	
1969	10,494	1	5,207	-	6	15,708	
1970	22,814	17	3,426	-	169	26,426	
1971	24,206	49	13,087	-	-	37,342	
1972	26,939	358	11,929	-	33	39,259	
1973	28,492	368	3,545	-	410	32,815	50,000
1974	17,053	60	6,952	-	248	24,313	40,000
1975	18,458	15	4,076	-	345	22,894	35,000
1976	7,910	31	57	-	59	8,057	9,000
1977	11,295	245	97	-	1	11,638	12,000
1978	15,091	375	-	-	-	15,466	15,000
1979	18,116	202	-	-	33	18,351	18,000
1980	12,011	366	-	-	-	12,377	18,000
1981	14,122	558	-	-	-	14,680	21,000
1982	11,479	110	-	1,073	657	13,319	23,000
1983	9,085	165	-	1,223	-	10,473	19,000
1984	12,437	89	-	2,373	1,836[b]	16,735	17,000
1985	13,440	-	-	4,278	11,245[b]	28,963	15,000
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	-	-	-	-	2069	2069	7,000[d]
1995	2	-	-	-	65	67	0
1996	[c] 55	-	-	-	232	287	0
1997	[c] 146	-	-	-	657	803	0
1998	[c] 3,701				647	4,348	4,000

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

Table 2. Breakdown of 1984-98 catches from Table 1 listed as "other."

Year	Spain	Portugal	Panama	USA	Cayman Islands	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	-	100b [b]	4,163
1989	1,126	5	-	319	-	101b [b]	1,551
1990	119	11	-	6	-	2,981b [b]	3,117
1991	246	-	-	-	-	5,212b [b]	5,458
1992	122	1	-	-	-	-	123
1993	-	-	-	68	-	6,800 [a]	6,868
1994	719	-	-	700a [a]	-	650 [a]	2,069
1995	65	-	-	-	-	-	65
1996	232	-	-	-	-	-	232
1997	657	-	-	-	-	-	657
1998	562	85	-	-	-	-	647

[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 1973-98.

	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
1998	0	2940	726	3675	26

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 based on preliminary data).

REGRESSION OF MULTIPLICATIVE MODEL
MULTIPLE R............. 0.758
MULTIPLE R SQUARED..... 0.575

ANALYSIS OF VARIANCE

SOURCE OF VARIATION	DF	SUMS OF SQUARES	MEAN SQUARE	F-VALUE
INTERCEPT	1	4.00E1	4.00E1	
REGRESSION	44	6.28E0	1.43E-1	24.043
Cntry|Gear|TC	2	6.70E-1	3.35E-1	56.396
Division	2	6.91E-1	3.46E-1	58.192
Month	11	6.28E-1	5.71E-2	9.613
Year	29	3.33E0	1.15E-1	19.361
RESIDUALS	783	4.65E0	5.94E-3	
TOTAL	828	5.09E1		

REGRESSION COEFFICIENTS

CATEGORY	CODE	VAR #	REG. COEF	STD. ERR	NO. OBS
Cntry|Gear|TC	3125	INT	0.166	0.119	828
Division	34				
Month	10				
Year	65				
1	3114	1	-0.295	0.032	162
	3124	2	-0.224	0.033	145
2	32	3	-0.229	0.028	194
	35	4	-0.260	0.030	173
3	1	5	-0.248	0.083	19
	2	6	-0.322	0.080	21
	3	7	-0.242	0.064	35
	4	8	-0.227	0.052	59
	5	9	-0.285	0.045	111
	6	10	-0.367	0.046	108
	7	11	-0.328	0.045	110
	8	12	-0.238	0.046	105
	9	13	-0.086	0.046	89
	11	14	-0.132	0.053	55
	12	15	-0.155	0.063	40
4	66	16	-0.029	0.149	11
	67	17	-0.053	0.148	12
	68	18	-0.220	0.144	14
	69	19	-0.346	0.134	20
	70	20	-0.366	0.123	42
	71	21	-0.402	0.122	41
	72	22	-0.520	0.122	45
	73	23	-0.392	0.122	50
	74	24	-0.795	0.124	37
	75	25	-0.816	0.124	38
	76	26	-0.908	0.132	26
	77	27	-0.706	0.125	38
	78	28	-0.685	0.122	51
	79	29	-0.658	0.122	47
4	80	30	-0.546	0.127	30
	81	31	-0.542	0.128	30
	82	32	-0.641	0.131	24
	83	33	-0.517	0.130	24
	84	34	-0.544	0.130	28
	85	35	-0.516	0.128	30
	86	36	-0.815	0.128	30
	87	37	-0.777	0.128	30
	88	38	-0.853	0.130	26
	89	39	-0.876	0.140	17
	90	40	-0.711	0.137	16
	91	41	-1.364	0.135	21
	92	42	-1.239	0.138	15
	93	43	-0.780	0.135	18
	98	44	0.292	0.150	9

PREDICTED CATCH RATE

YEAR	LN TRANSFORM MEAN	S.E.	RETRANSFORMED MEAN	S.E.	CATCH	EFFORT
1965	0.1659	0.0142	1.176	0.140	3075	2616
1966	0.1365	0.0111	1.143	0.120	4185	3661
1967	0.1125	0.0115	1.116	0.119	2122	1902
1968	-0.0541	0.0087	0.946	0.088	4180	4418
1969	-0.1803	0.0064	0.835	0.067	10494	12571
1970	-0.2000	0.0034	0.820	0.048	22814	27829
1971	-0.2366	0.0031	0.790	0.044	24206	30624
1972	-0.3541	0.0030	0.703	0.038	26939	38327
1973	-0.2258	0.0029	0.799	0.043	28492	35654
1974	-0.6289	0.0035	0.534	0.032	17053	31946
1975	-0.6501	0.0033	0.523	0.030	18458	35315
1976	-0.7421	0.0051	0.476	0.034	7910	16607
1977	-0.5402	0.0039	0.583	0.036	11295	19366
1978	-0.5190	0.0032	0.596	0.034	15091	25323
1979	-0.4916	0.0032	0.612	0.034	18116	29579
1980	-0.3805	0.0045	0.684	0.046	12011	17559
1981	-0.3762	0.0043	0.687	0.045	14122	20555
1982	-0.4755	0.0051	0.622	0.044	11479	18460
1983	-0.3515	0.0046	0.704	0.048	9085	12903
1984	-0.3781	0.0049	0.686	0.048	12437	18141
1985	-0.3501	0.0041	0.705	0.045	13440	19056
1986	-0.6489	0.0042	0.523	0.034	14168	27085
1987	-0.6113	0.0041	0.543	0.035	13420	24707
1988	-0.6875	0.0047	0.503	0.034	10607	21081
1989	-0.7101	0.0070	0.491	0.041	5009	10195
1990	-0.5453	0.0065	0.579	0.047	4966	8569
1991	-1.1983	0.0060	0.302	0.023	6642	22016
1992	-1.0727	0.0066	0.342	0.028	6809	19911
1993	-0.6143	0.0061	0.541	0.042	6697	12379
1998	0.4582	0.0098	1.578	0.156	3783	2397

AVERAGE C.V. FOR THE RETRANSFORMED MEAN: 0.073

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 = 30

Table 5. Catches and by-catches (t) of American plaice and yellowtail flounder, by division, from 1982-93 for Can(N) TC 5 stern trawlers. Figures in square brackets represent the percentage of directed catch taken by division each year, and the figures in parentheses represent the by-catch rates o f one species in the directed fishery for the other.

		Directed plaice fishery				Directed yellowtail fishery			
		Plaice		Yellowtail by-catch		Yellowtail		Plaice by-catch	
1982	3L	22452	[67]	1106	(5)	650	[12]	416	(39)
	3N	8631	[26]	2100	(20)	4568	[86]	1979	(30)
	3Ø	2423	[7]	560	(19)	71	[2]	50	(41)
1983	3L	11986	[60]	920	(7)	477	[10]	291	(38)
	3N	5733	[29]	1120	(16)	3909	[79]	1416	(27)
	3Ø	2330	[11]	256	(10)	535	[11]	355	(40)
1984	3L	10063	[55]	800	(7)	1787	[28]	781	(30)
	3N	6042	[33]	1162	(16)	4482	[70]	1813	(29)
	3Ø	2042	[12]	85	(4)	107	[2]	53	(33)
1985	3L	14617	[55]	995	(6)	793	[12]	328	(29)
	3N	9978	[38]	1764	(15)	5385	[84]	1439	(21)
	3Ø	1917	[7]	317	(14)	222	[4]	148	(40)
1986	3L	12410	[64]	890	(7)	619	[7]	319	(34)
	3N	4767	[25]	934	(16)	7632	[88]	1666	(18)
	3Ø	2128	[11]	375	(15)	450	[5]	241	(35)
1987	3L	14089	[80]	216	(2)	198	[2]	98	(33)
	3N	1774	[10]	357	(17)	7672	[91]	1492	(16)
	3Ø	1767	[10]	358	(17)	587	[7]	296	(34)
1988	3L	8262	[58]	165	(2)	220	[4]	95	(30)
	3N	3279	[23]	392	(11)	5096	[86]	912	(15)
	3Ø	2709	[19]	430	(14)	571	[10]	310	(35)
1989	3L	11049	[66]	149	(1)	64	[4]	41	(38)
	3N	3129	[19]	428	(12)	1321	[68]	514	(28)
	3Ø	2483	[15]	437	(15)	548	[28]	321	(37)
1990	3L	7388	[57]	176	(2)	194	[9]	92	(32)
	3N	2759	[21]	427	(13)	1753	[80]	626	(26)
	3Ø	2919	[22]	238	(8)	237	[11]	131	(36)
1991	3L	6107	[43]	328	(5)	93	[3]	56	(38)
	3N	2202	[15]	295	(12)	2212	[72]	440	(17)
	3Ø	6089	[42]	1067	(15)	758	[25]	411	(35)
1992	3L	550	[16]	31	(5)	62	[2]	34	(35)
	3N	182	[5]	35	(16)	977	[25]	145	(13)
	3Ø	2782	[79]	918	(25)	2898	[73]	1205	(29)
1993	3L	1	[-]	0	(0)	0	[0]	0	(0)
	3N	1302	[46]	63	(5)	1645	[42]	232	(12)
	3Ø	1538	[54]	436	(22)	2292	[58]	882	(28)

Table 6 . Catch of yellowtail flounder in Div. 3LNO in 1998 by vessels by month and gear.

Month	3N (OT*)	3N (Scot S*)	3O (OT)	3O (Scot S)	Total
Jan					
Feb					
Mar					
Apr					
May	10		6		16
Jun	25		2		27
Jul	41		19		60
Aug	909	4	145		1058
Sep	683	18	542	4	1247
Oct	1164		6		1170
Nov	116		6		122
Dec	1				1
Total	2949	22	726	4	3701

*
OT = otter trawl
Scot S = Scottish seine

Table 7. Data used in calculation of catch at age from the Canadian fishery for yellowtail in Div. 3NO in 1998.

Division	Len.Frequency	# meas.	Catch (t)	Description of catch (if different from LF)	Age-length key	# otoliths
3O	Aug, Can(N), OTB	524	172	Can, May-Aug		
	Sep, Can(M), OTB	853	64	Can(M), Sep-Dec		
	Sep, Can(N), OTB	8170	490	Can(N), Sep-Dec,OTB		
	Sep, Can(N), ScS	322	4			
			730		Can (N) 3O, Q3	242
3N	Aug, Can(N), OTB	13895	985	Can, May-Aug,OTB		
	Aug, Can(N), ScS	237	4			
	Sep, Can(N), OTB	13573	683			
	Sep, Can(N), ScS	775	18			
			1690		Can (N) 3N, Q3	669
3N	Oct, Can(N),OTB	14315	1164		Can (N) 3N, Q4	546
	Nov, Can(N),OTB	1048	117	Can(N),Nov-Dec,OTB		
			1281			
Totals		**53712**	**3701**			**1457**

Table 8 Catch at age and mean weight at a age of yellowtail flounder taken in the in the 1998 Canadian fishery.

	AVERAGE		Div. 30	CATCH		
AGE	WEIGHT	LENGTH		MEAN	STD. ERR.	C.V.
4	0.094	23.621		4	0.79	0.19
5	0.194	29. I15		68	7.83	0.12
6	0.321	33.703		397	30.75	0.08
7	0.471	37.692		735	36.77	0.05
8	0.687	42.038		278	22.78	0.08
9	0.750	42.841		15	10.44	0.71

	AVERAGE		Div. 3N	CATCH		
AGE	WEIGHT	LENGTH		MEAN	STD. ERR.	C.V.
3	0.052	19.764		1	0.32	0.45
4	0.098	23.837		34	3.14	0.09
5	0.206	29.542		374	24.73	0.07
6	0.337	34.118		1343	63.81	0.05
7	0.499	38.307		2313	83.86	0.04
8	0.758	43.186		1531	61.42	0.04
9	1.120	48.328		63	12.79	0.20

	AVERAGE		Div. 3NO	CATCH		
AGE	WEIGHT	LENGTH		MEAN	STD. ERR.	C.V.
3	0.052	19.764		1	0.32	0.45
4	0.098	23.814		38	3.24	0.09
5	0.204	29.477		442	25.94	0.06
6	0.333	34.024		1740	70.84	0.04
7	0.493	38.159		3047	91.57	0.03
8	0.747	43.009		1809	65.51	0.04
9	1.050	47.296		78	16.51	0.21

Table 9 Catch at age from the Canadian yellowtail fishery, 1977-98

AGE	1977	1978	1979	1980	1981	1982	1983	1984
4	1414	671	44	1229	3180	113	23	107
5	3723	3553	2003	4937	5193	1513	1748	1374
6	7918	10758	11116	7792	8173	4623	5587	11958
7	7116	10594	17838	7217	9513	7441	6744	11552
8	3503	3795	6315	2201	4098	6538	3456	662
9	933	259	605	275	330	2121	505	196
10	173	16	24	31	31	325	33	6

AGE	1985	1986	1987	1988	1989	1990	1991	1992
4	0	4	3	85	0	4	0	0
5	1162	813	471	546	131	259	203	176
6	8701	4210	5055	2877	986	1762	2700	3406
7	12201	13007	10935	7365	3878	4912	6644	6124
8	4172	8088	8437	7322	4150	2968	3081	3540
9	664	1650	1609	1226	541	330	334	361
10	26	186	107	66	16	2	0	0

AGE	1993	1994-97	1998
4	1	Moratoriun	38
5	134	Moratoriun	442
6	3017	Moratoriun	1740
7	6434	Moratoriun	3047
8	3752	Moratoriun	1809
9	418	Moratoriun	78
10	0	Moratoriun	0

Table 10 A comparison of spring and fall abundance and biomass estimates derived from annual bottom trawl surveys in Div. 3LNO (SCR Doc. 99/44)

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

Table 11A. 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
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
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
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
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
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
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
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
8	86.4	55.1	63.8	64.2	61.6	24.9	50.7	28.2	17.3	36.5	20.2	28.1	64.6	61.8	61.0
9	7.2	4.5	10.0	7.3	9.8	3.3	8.0	4.7	4.4	5.6	1.5	0.3	1.4	1.5	1.1
10	0.1	0.5	0.7	0.5	0.4	0.4	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unknown	1.4	0.3	0.5	0.1	0.1	0.0	0.1	0.4	0.0	0.0	1.0	0.0	0.2	1.4	0.2
Age 1+	**544.2**	**374.1**	**326.6**	**394.2**	**203.0**	**532.9**	**367.5**	**320.2**	**217.5**	**246.3**	**148.4**	**187.3**	**639.4**	**695.5**	**733.3**
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**
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**
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**

Table 11B. Abundance (millions) at age by year, Div 3LNO yellowtail Flounder-Fall

Age	1990	1991	1992	1993	1994	1995	1996	1997	1998
1						8.8	0.9	2.7	6.7
2	1.3	1.6	1.2	0.9	2.3	83.9	17.8	7.9	12.6
3	11.3	37.2	18.6	6.6	5.9	122.4	63.6	44.4	26.3
4	28.9	64.5	53.5	74.4	38.5	89.7	132.6	125.7	75.0
5	44.3	46.9	34.0	104.5	48.4	70.6	145.1	204.9	243.8
6	38.5	61.2	33.7	77.5	70.9	87.7	97.9	178.9	256.5
7	45.0	52.4	45.6	67.3	69.8	84.4	82.7	142.5	143.7
8	19.9	29.8	25.0	36.4	50.5	43.7	37.7	71.4	61.9
9	2.2	3.4	4.2	3.8	1.7	0.8	0.9	3.2	1.6
10									
Uknown	1.1	0.1	1.2	0.5	0.0	0.2	0.6	0.3	0.2
age1+	**192.5**	**297.1**	**217.1**	**372.0**	**288.0**	**592.3**	**579.8**	**781.8**	**828.2**
ages1-4	**41.5**	**103.3**	**73.4**	**82.0**	**46.7**	**304.8**	**214.9**	**180.6**	**120.5**
age 5+	**149.9**	**193.7**	**142.5**	**289.5**	**241.3**	**287.3**	**364.3**	**600.9**	**707.5**
age7+	**67.1**	**85.6**	**74.8**	**107.5**	**121.9**	**129.0**	**121.3**	**217.1**	**207.2**

Table 12A. 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
1													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
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
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
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
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
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
8	55.8	36.9	40.2	41.5	37.3	17.2	32.5	19.1	11.7	26.6	14.4	19.9	45.7	43.1	41.6
9	6.8	4.1	9.1	6.3	8.4	3.0	6.7	4.3	4.4	6.0	1.7	0.3	1.5	1.5	1.2
10	0.2	0.6	0.8	0.6	0.5	0.4	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
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**
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**
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**
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**

Table 12B. Biomass ('000t) at age by year, Div. 3LNO Yellowtail Flounder-Fall

Age	1990	1991	1992	1993	1994	1995	1996	1997	1998
1						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
3	1.0	1.9	1.0	0.3	0.3	4.9	2.6	1.8	1.0
4	3.6	5.8	5.3	8.5	4.1	8.4	12.6	12.2	7.0
5	8.9	8.5	6.0	19.6	9.1	12.8	24.5	35.0	41.6
6	13.6	18.3	10.2	24.2	22.4	27.6	29.3	51.4	70.6
7	21.8	24.4	20.6	32.2	32.8	39.0	37.9	62.3	60.1
8	13.3	19.9	16.8	25.4	35.5	30.7	26.6	47.3	40.6
9	2.0	3.2	3.9	3.8	1.8	0.9	1.0	3.0	1.6
10									
age1+	**64.3**	**82.0**	**63.7**	**114.0**	**106.0**	**125.6**	**134.7**	**213.1**	**222.6**
ages1-4	**4.7**	**7.8**	**6.4**	**8.8**	**4.4**	**14.5**	**15.4**	**14.2**	**8.2**
age 5+	**59.6**	**74.3**	**57.4**	**105.2**	**101.6**	**111.0**	**119.2**	**199.0**	**214.4**
age7+	**37.1**	**47.4**	**41.2**	**61.4**	**70.1**	**70.7**	**65.4**	**112.6**	**102.3**

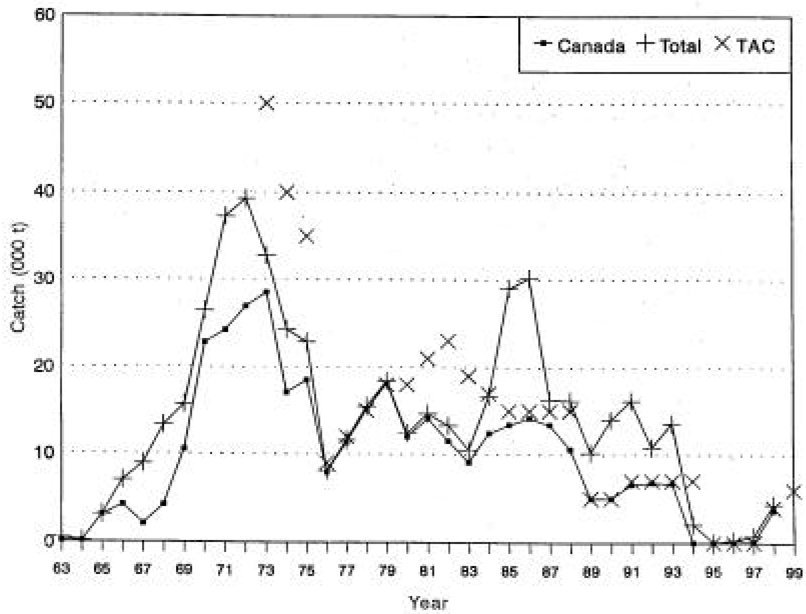
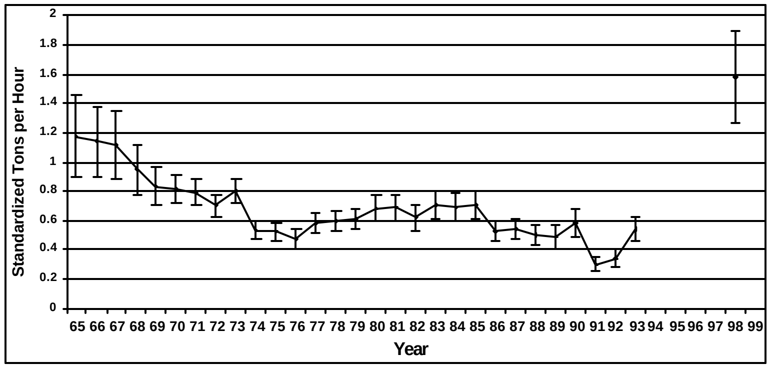
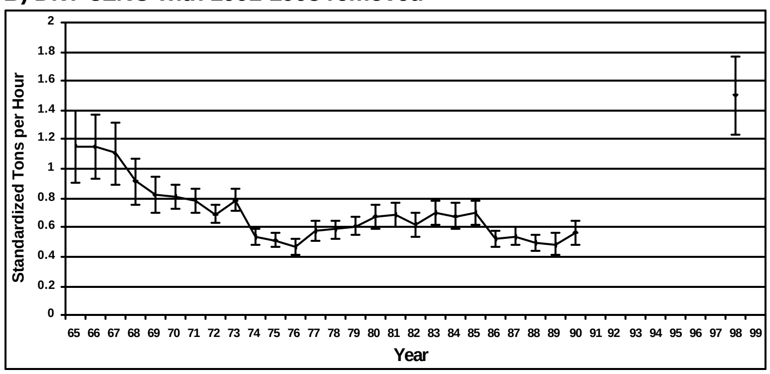


Fig. 1. Catches and TAC's of yellowtail in Div. 3LNO.

A) Div. 3LNO from 1965-1993 and 1998



B) Div. 3LNO with 1991-1993 removed



C) Div 3N and 3O separately from 1965-1993 and 1998

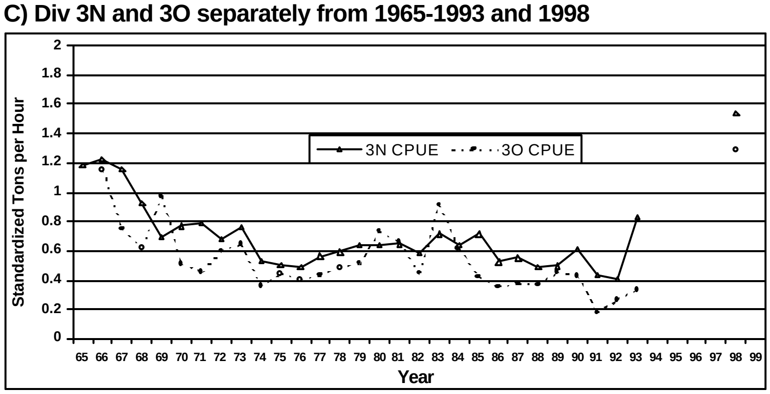


Fig. 2. Standardized CPUE with approximate 95% confidence intervals for Yellowtail in Div. 3LNO from 1965-1993 and 1998 (preliminary) under different treatments of the database. From 1991-1993 the fishery was a mixed fishery with American plaice. There was no directed fishery from 1994-1997.

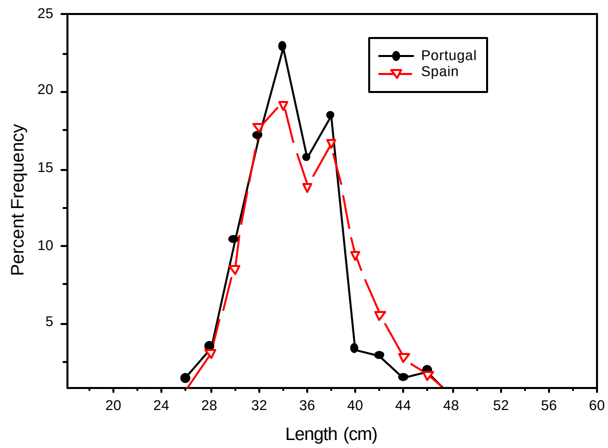


Fig. 3 Comparison of length frequencies of yellowtail flounder taken in the 1998 Spanish and Portugese bottom trawl fisheries.

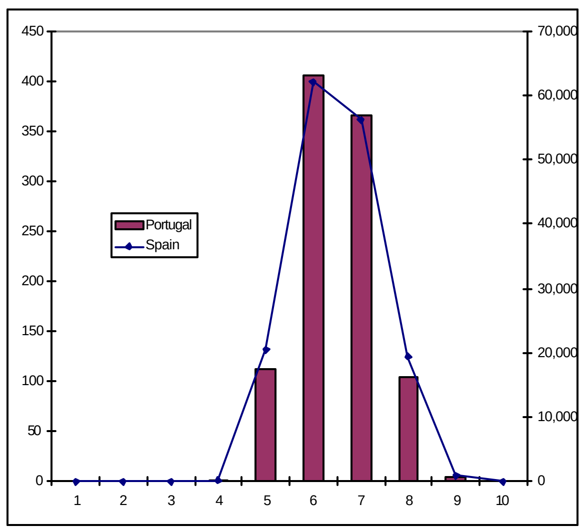


Fig. 4. Catch at age (numbers) of yellowtail flounder in the 1998 Portuguese and Spanish bottom trawl fisheries in the Regulatory Area of Div. 3NO.

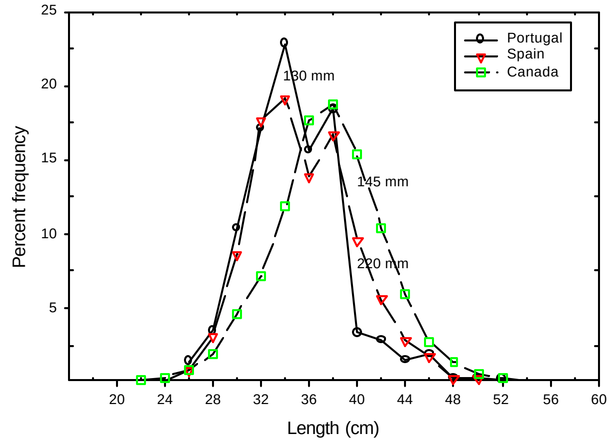


Fig. 5. Comparison of length frequencies of yellowtail founder according to the mesh size used in the codends of otter trawls fleets of Canada, Portugal and Spain.

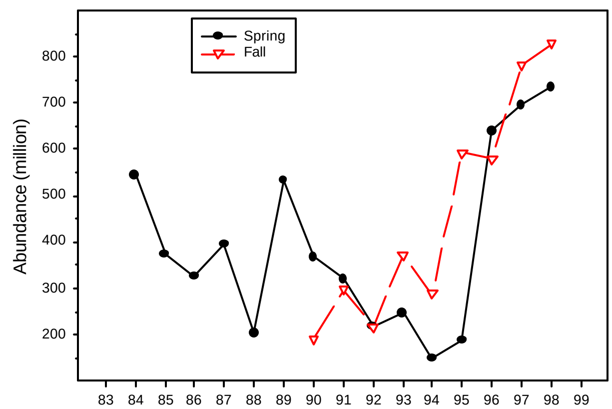


Fig. 6A. Comparison of population abundance indices derived from the spring (1984-98) and fall bottom trawl surveys (1990-98).

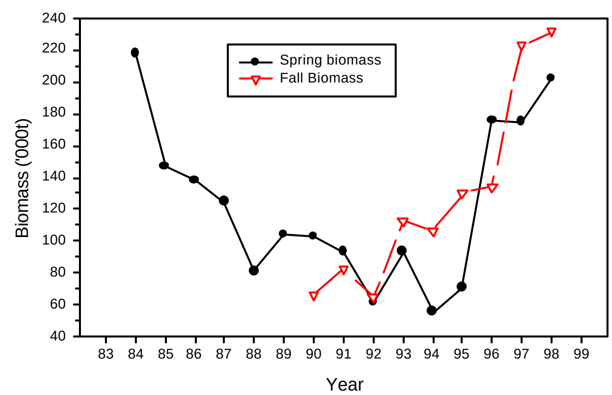


Fig. 6B. Biomass of yellowtail flounder from annual spring and fall bottom trawl surveys

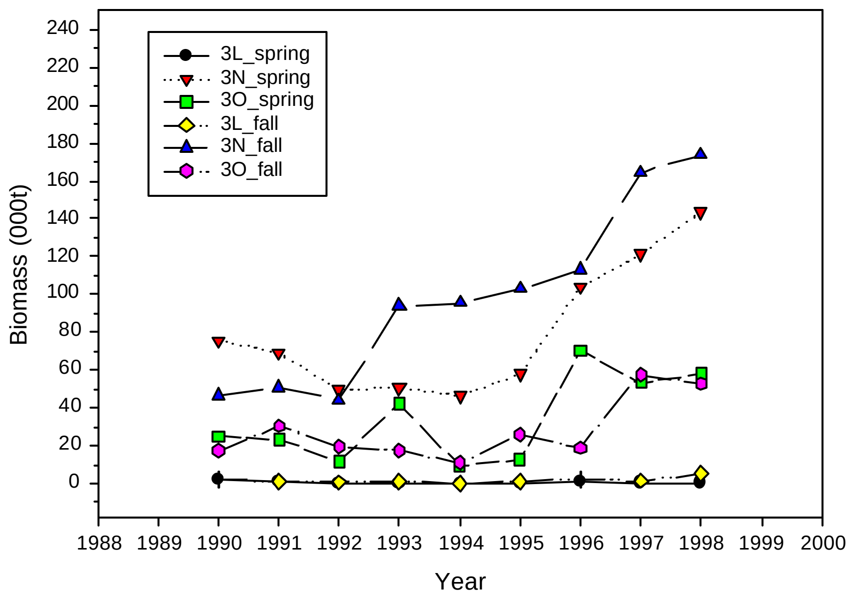


Fig. 7 Comparison of spring and fall biomass estimates of yellowtail flounder for 1990-98 surveys by division.

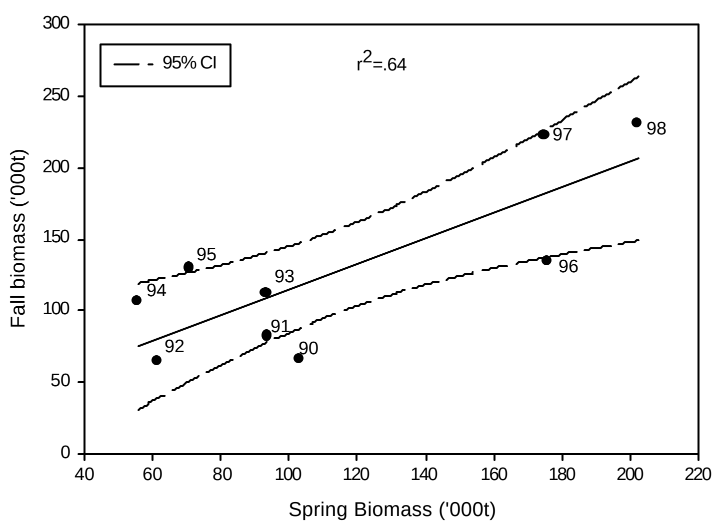


Fig. 8. Regression of fall and spring biomass estimates from annual bottom trawl surveys for yellowtail flounder on the Grand Bank, 1990-98.

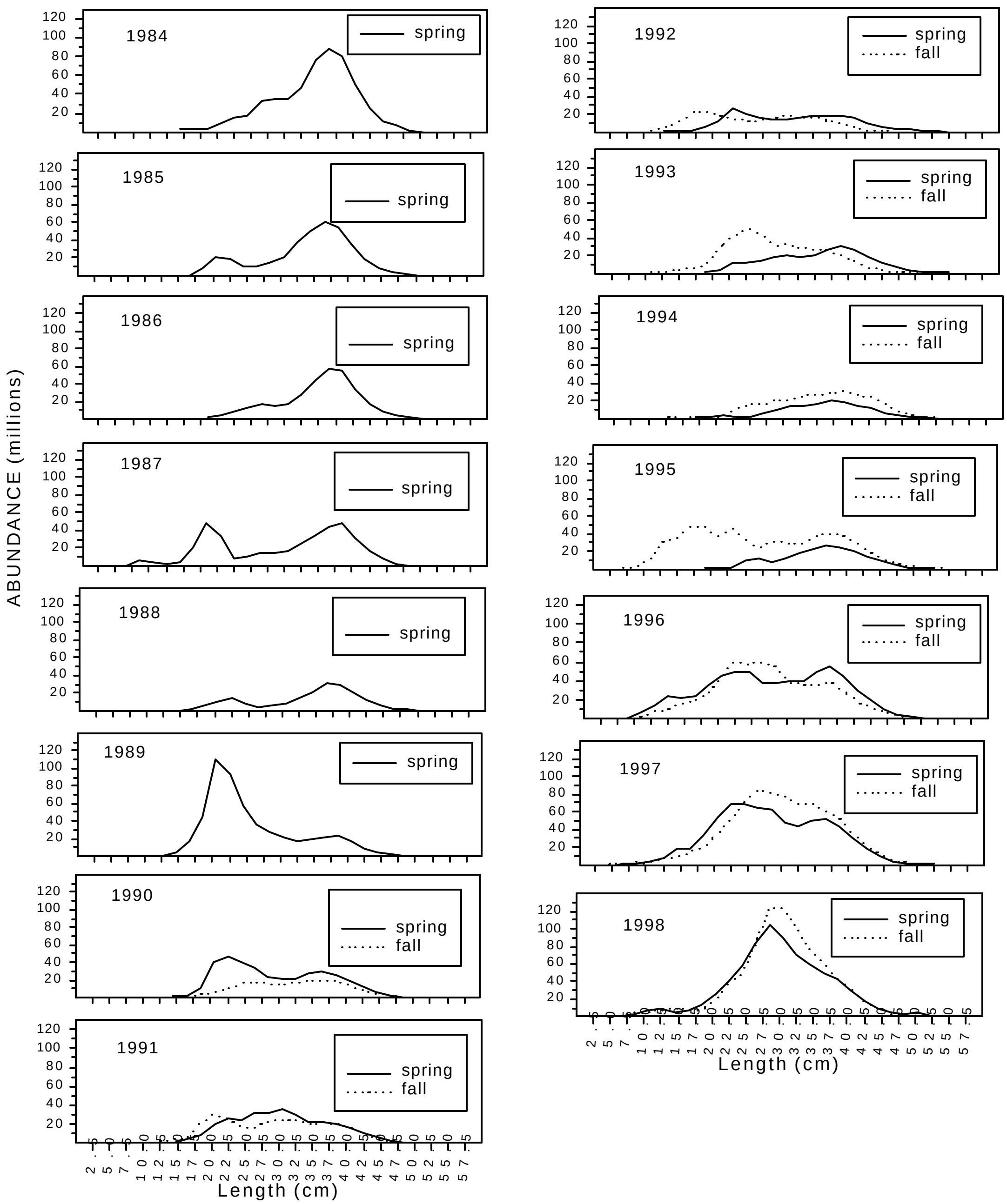


Fig. 9. Abundance at length for yellowtail from spring and fall surveys 1984-98

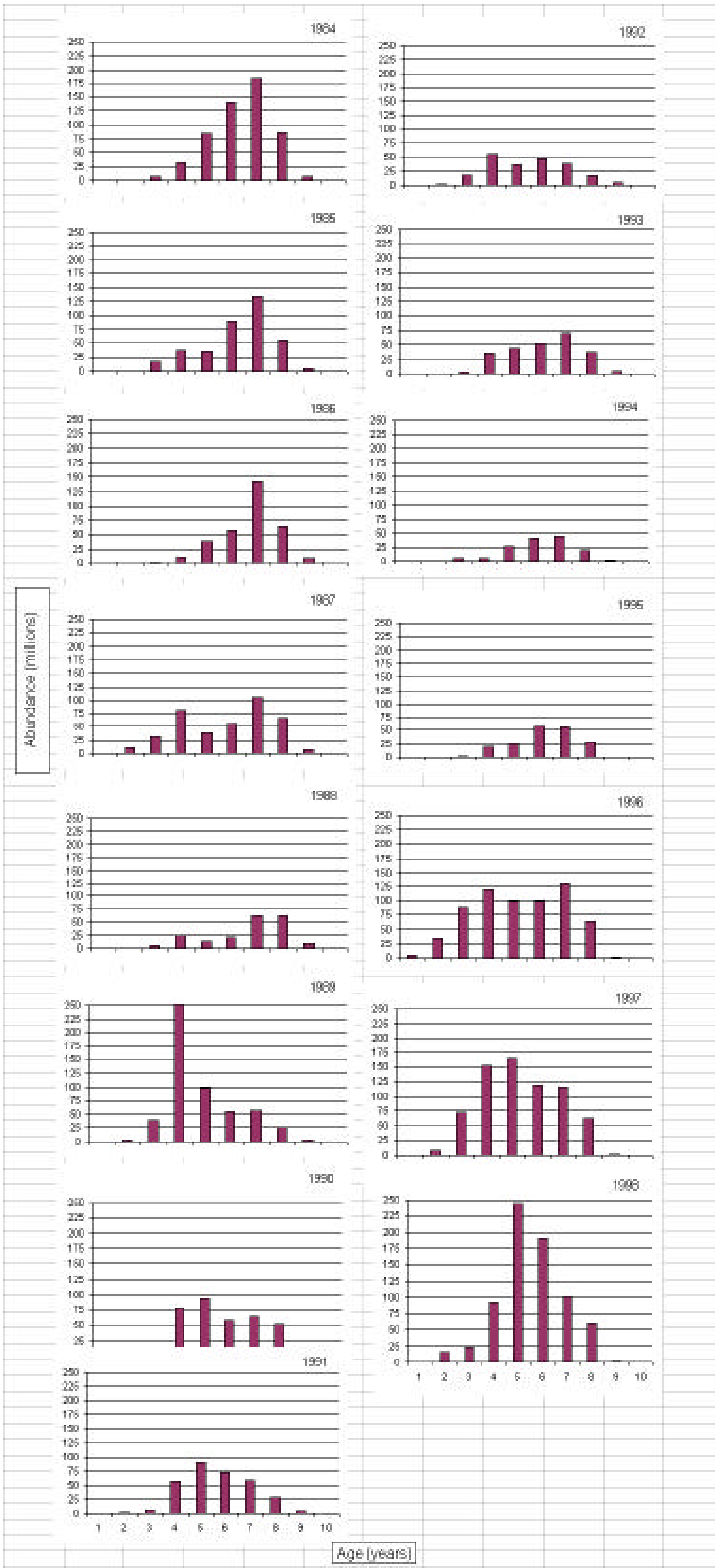


Fig. 10 Abundance-at-age of yellowtail flounder in the 1984-98 spring surveys of Div. 3LNO

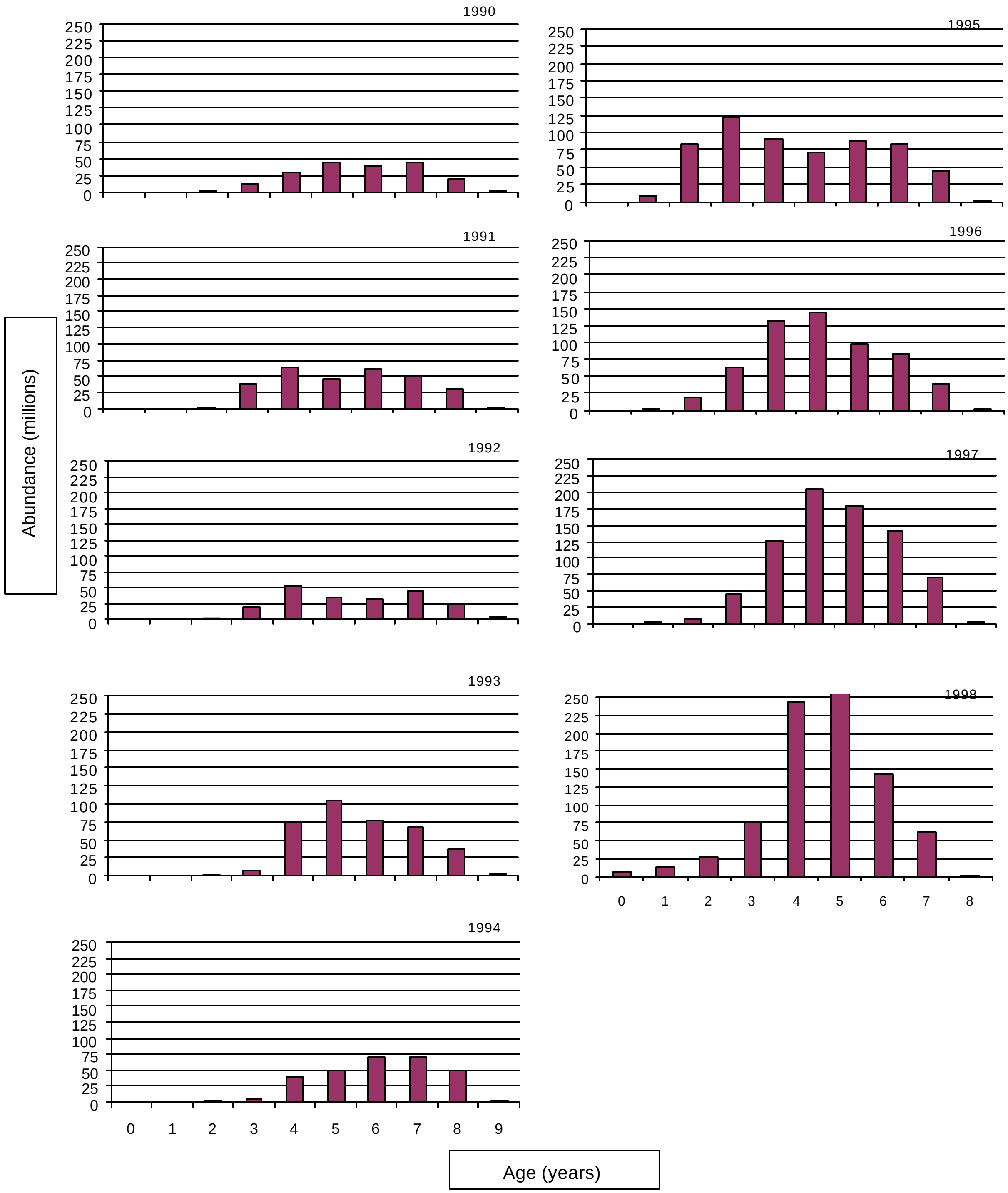


Fig. 11 Abundance-at-age of yellowtail flounder in the 1990-98 fall surveys of Div. 3LNO

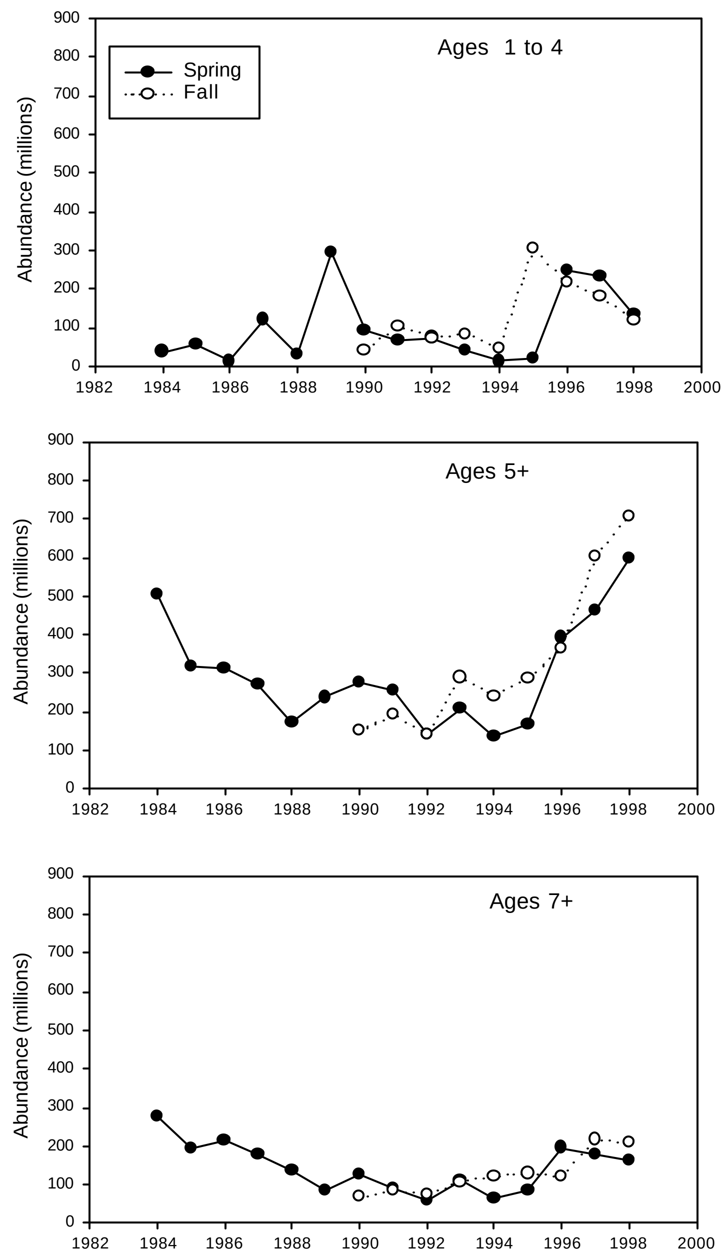


Fig. 12. Comparison of 1984-98 spring and fall survey estimates of pre-recruit, mature fish and fully recruited ages of yellowtail flounder from Div. 3LNO.

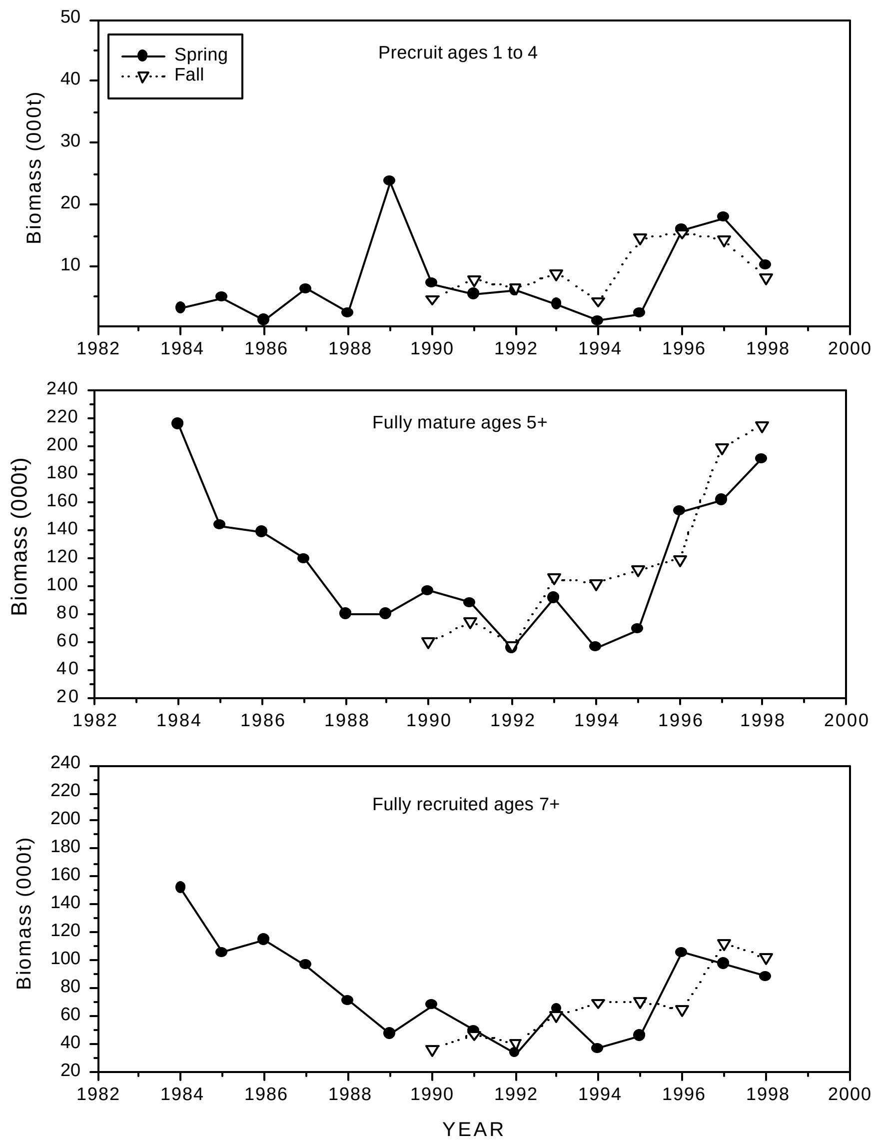
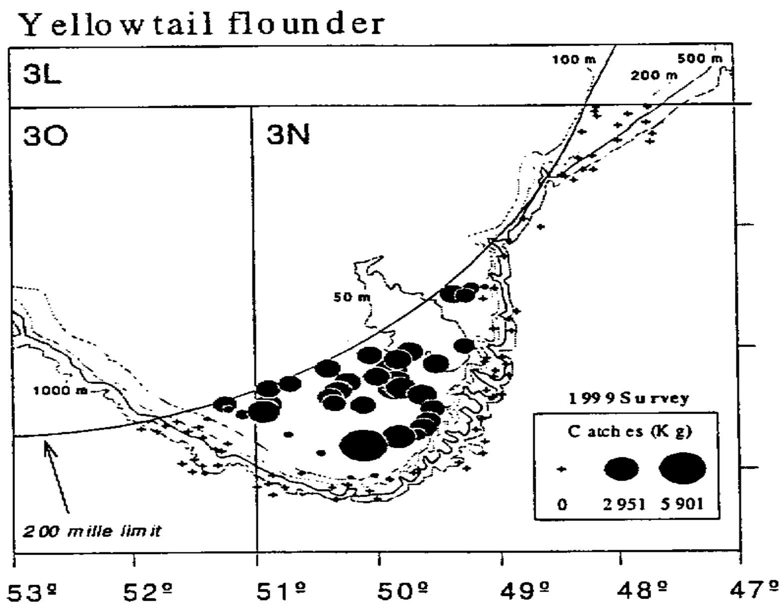


Fig. 13 Survey biomass of yellowtail from spring and fall surveys, 1984-98



Distribution of yellowtail catches in the 1999 Spanish survey in the Regulatory Area

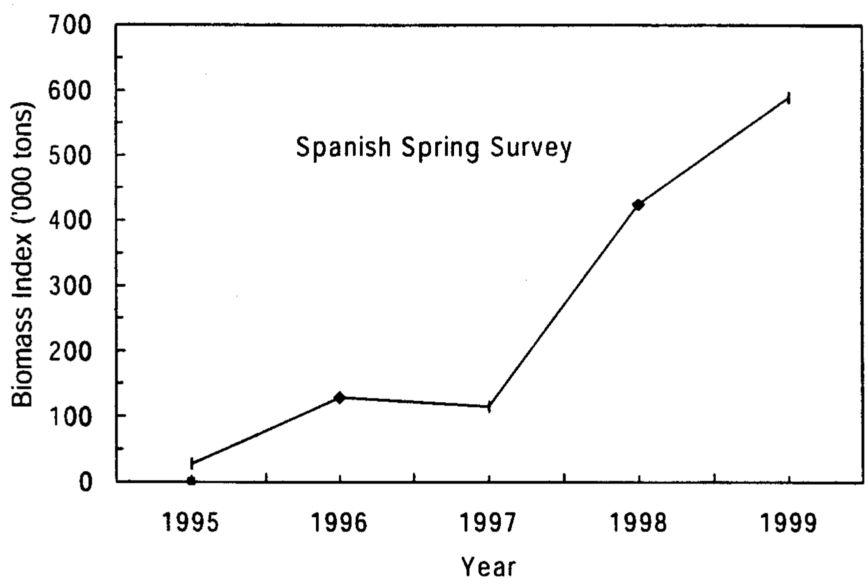


Fig 14. Biomass index for the Spanish surveys of yellowtail flounder in the regulatory Area, 1995-1999

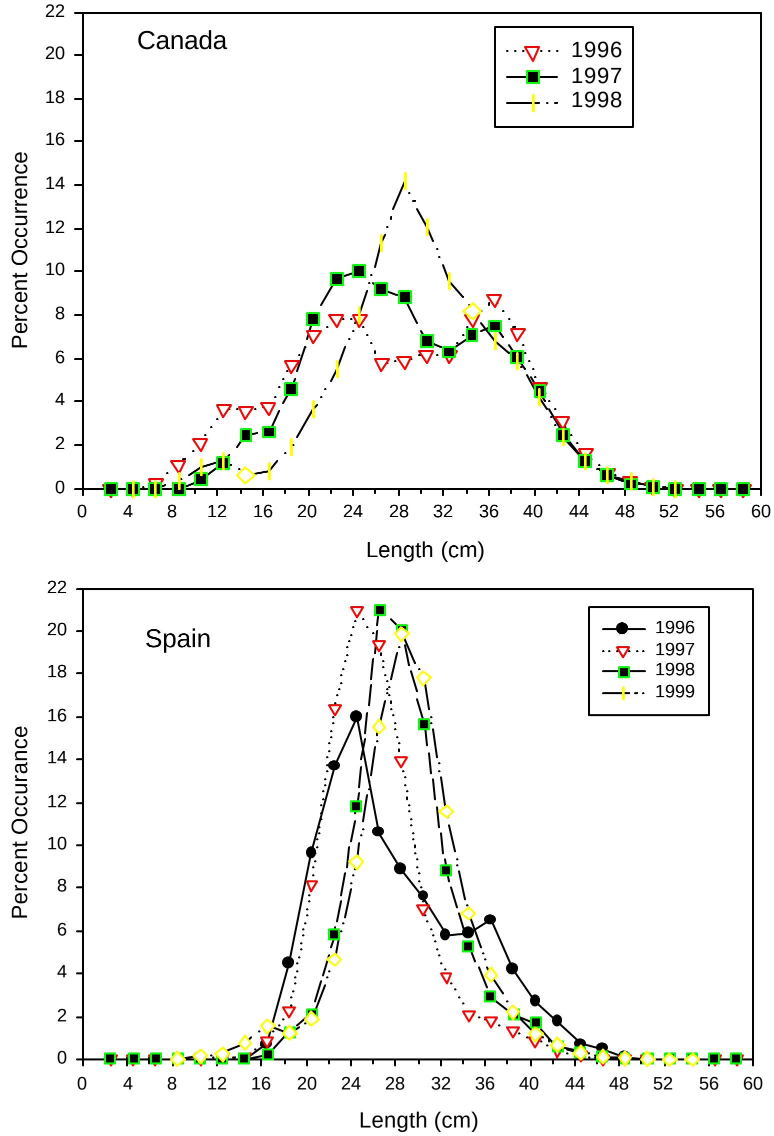


Fig. 15. Comparison of length frequencies of yellowtail flounder from the Canadian spring surveys of Div. 3LNO and the Spanish survey of the Regulatory Area of Div. 3NO, 1996-99.

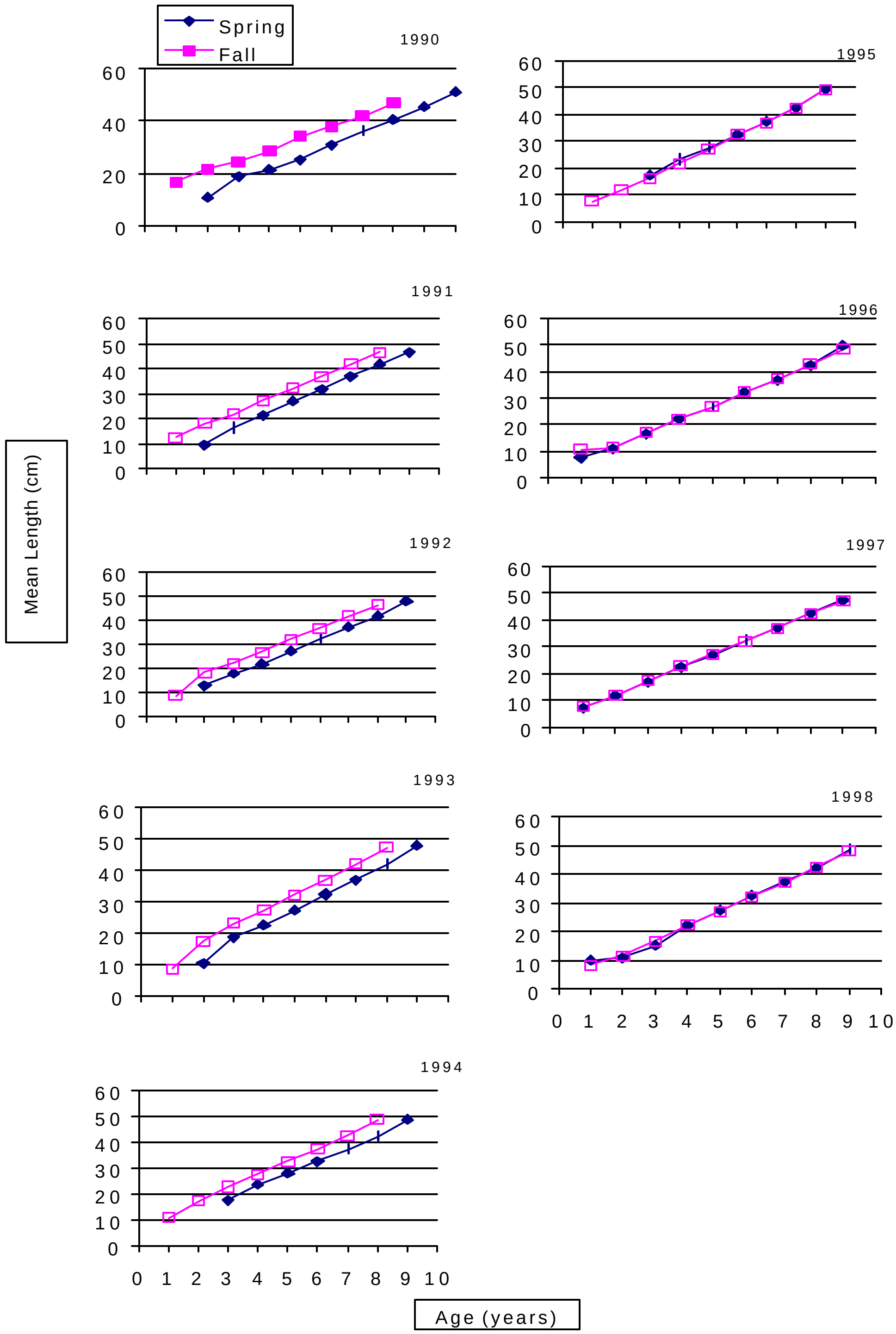


Fig. 16 Average length-at-age of yellowtail flounder from the spring and fall surveys in Div. 3LNO, 1990-98.

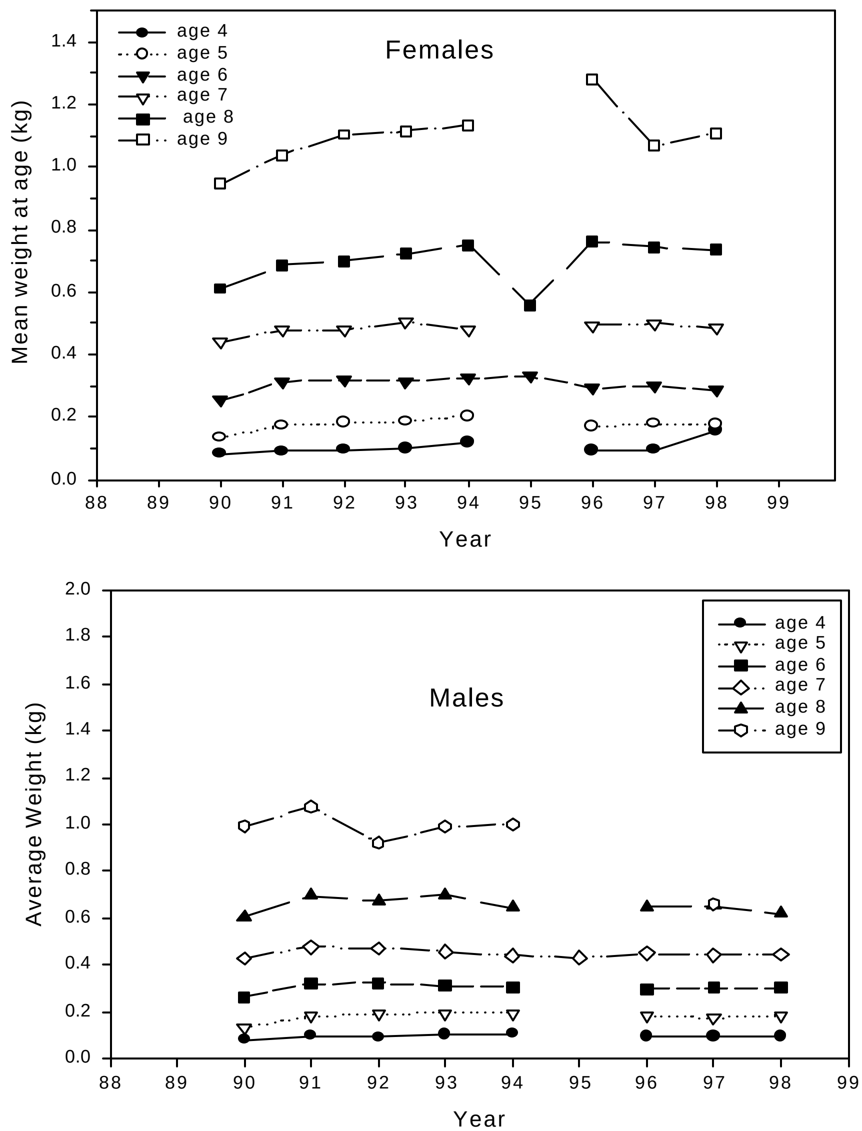


Fig 17 Average weight at age of female and male yellowtail flounder in Div. 3LNO

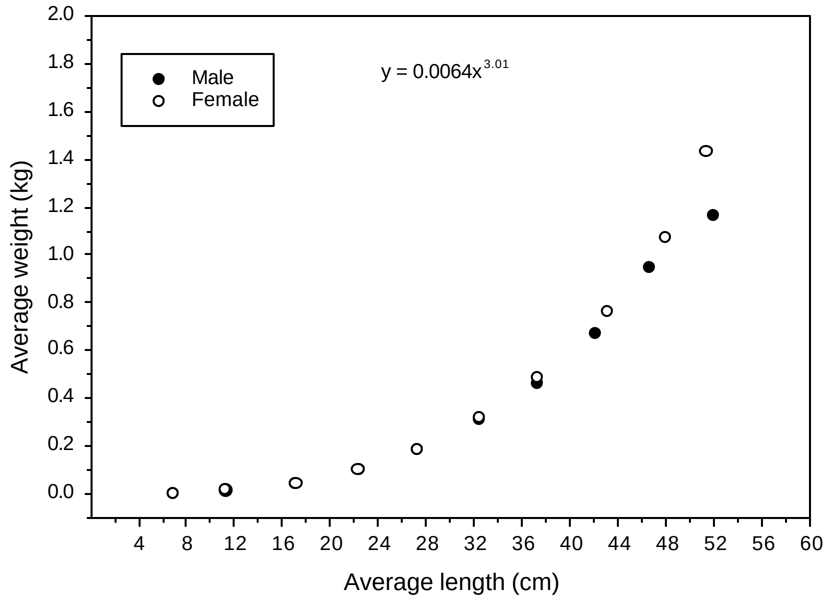


Fig. 18 Length-weight relationships for yellowtail flounder on the Grand Banks using data from spring, fall and juvenile bottom trawl surveys, 1990-98.

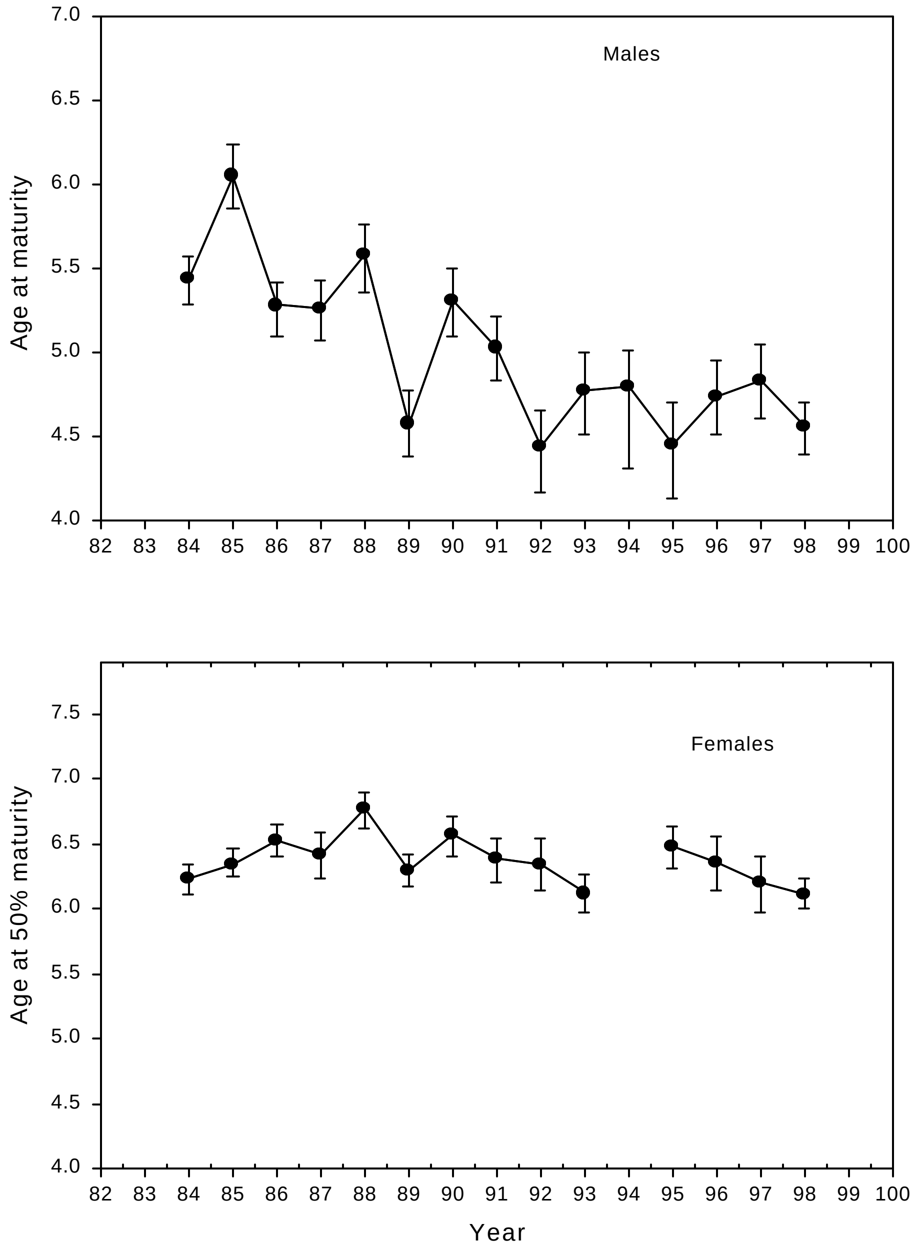


Fig. 19 Age at 50% maturity of male and female yellowtail flounder from annual spring surveys of Div 3LNO from 1984-98.

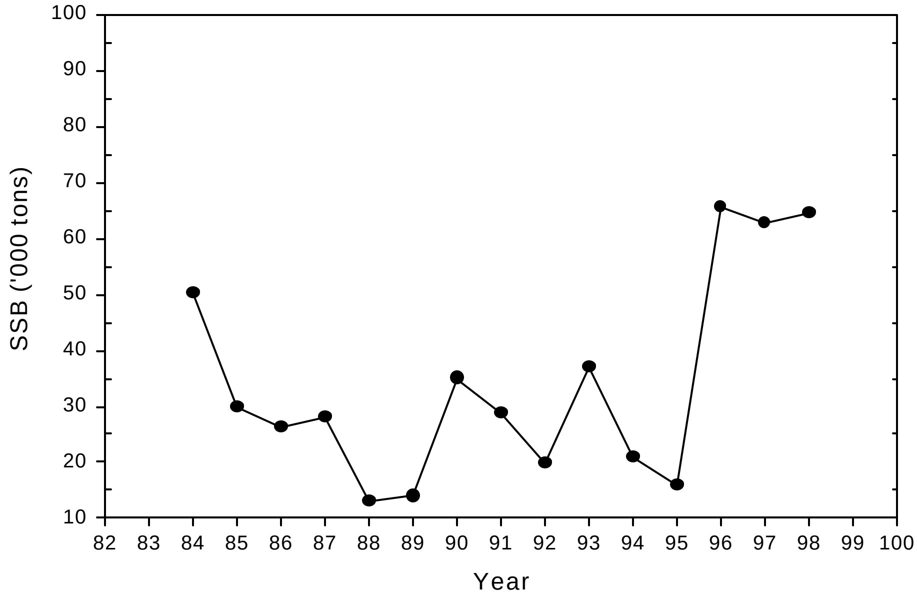


Fig.20 Female spawning stock biomass of yellowtail flounder estimated from annual spring surveys, 1984-98.

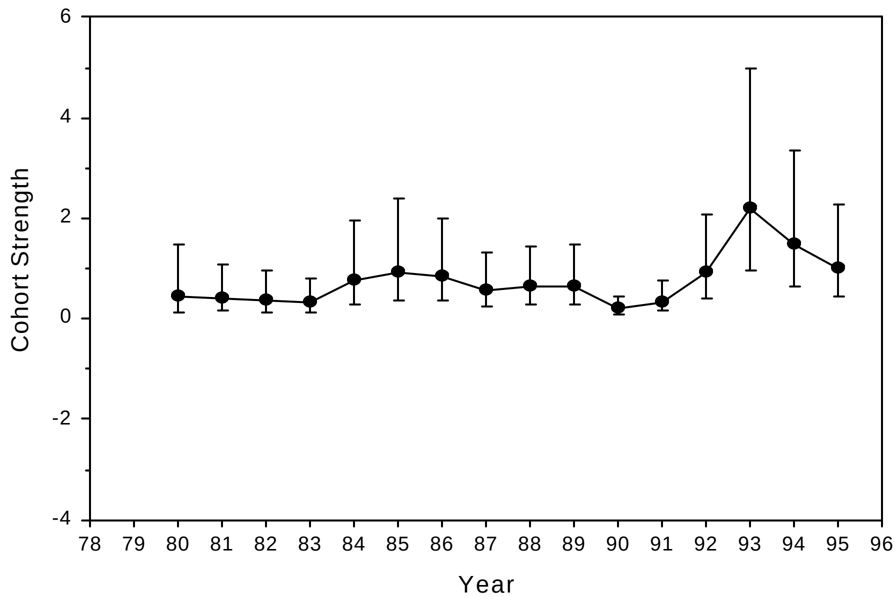


Fig. 21 Cohort strength as estimated from a multiplicative model of the data from annual spring and fall surveys of Div. 3LNO from 1984-98.

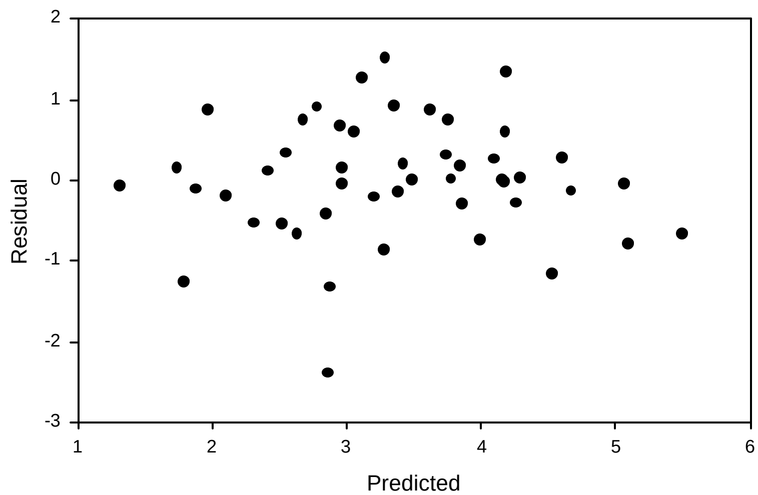


Fig. 22 Residual plot from cohort strength model usings ages 3 and 4 yellowtail flounder.

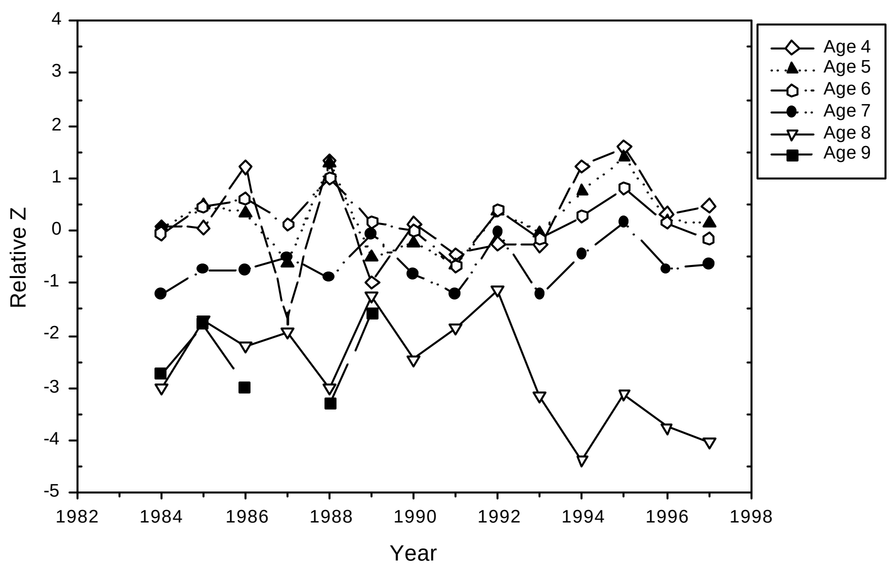
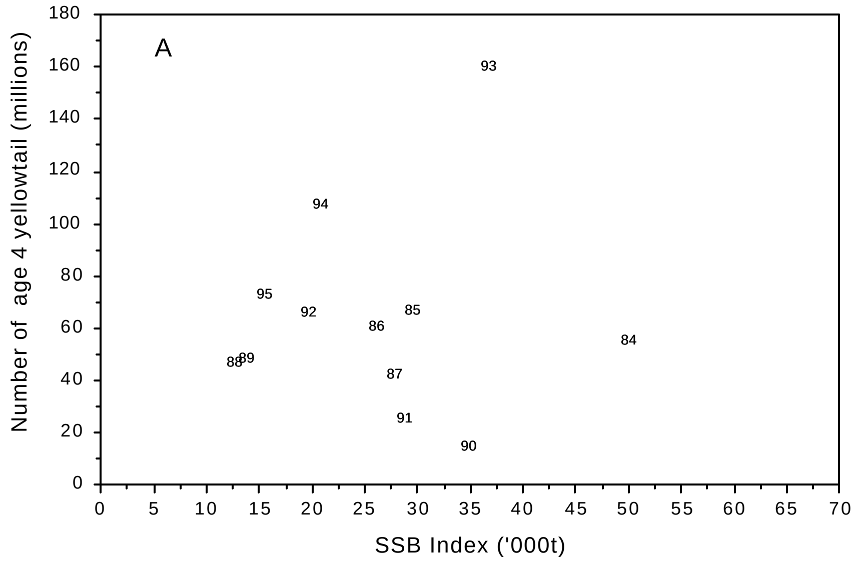


Fig. 23 Estimates of Z for yellowtail flounder calculated from trawl catches in annual surveys of Div. 3LNO, 1984-98.



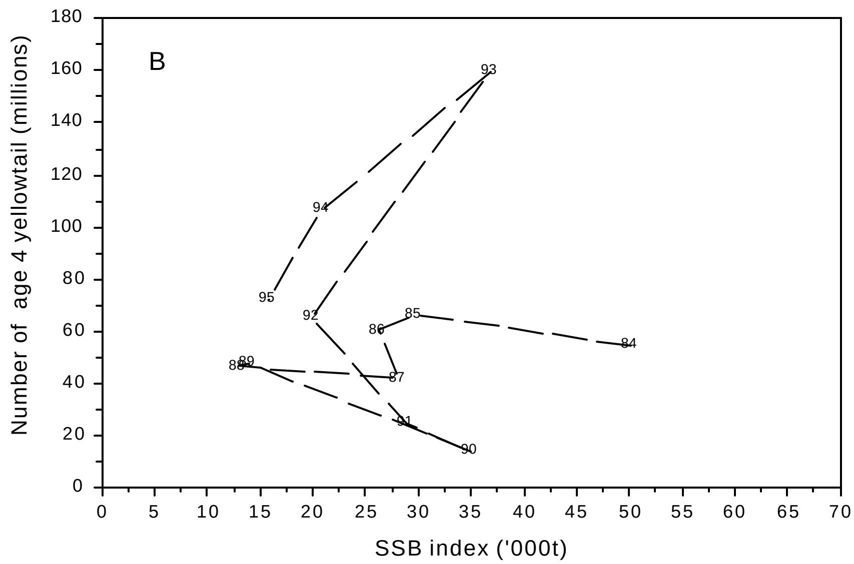


Fig. 24 Female spawning stock biomass index (0000 t) and recruitment at age 4 (millions) from the Canadian spring surveys from 1984 to 1998. Recruitment was predicted from a multiplicative model of cohort strength. **A.** point scatter and **B**. with trend line.

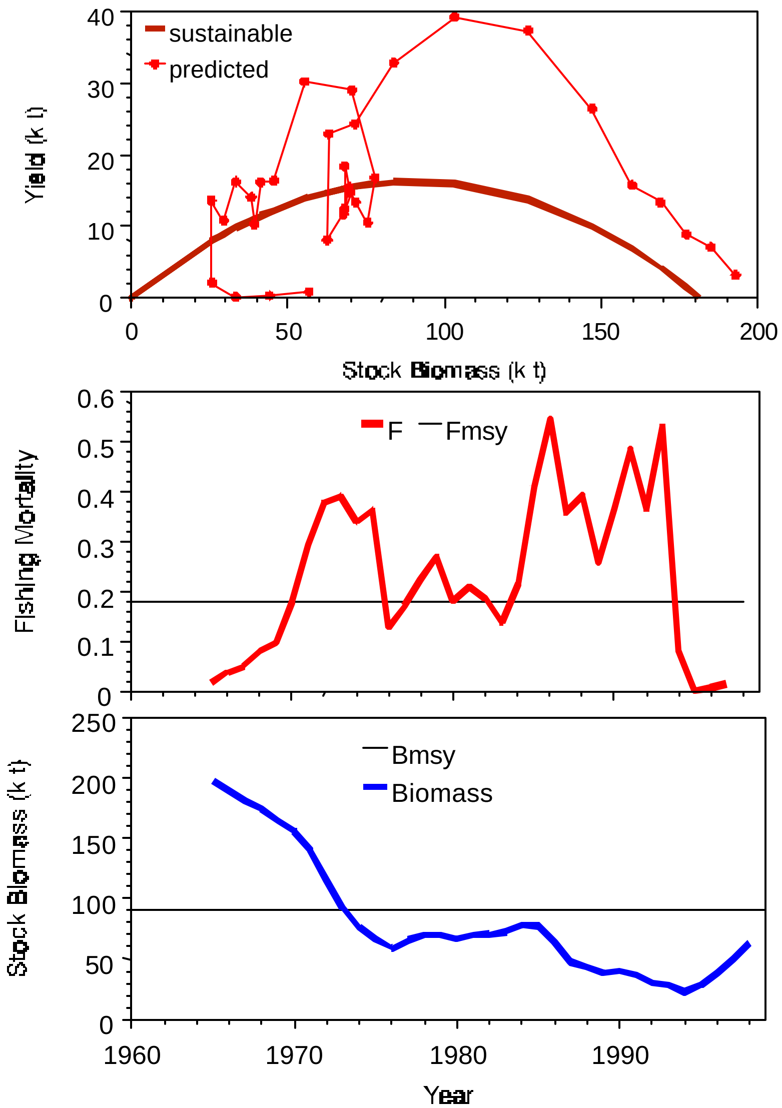


Fig. 25. Summary of results from surplus production analysis of Div. 3LNO yellowtail flounder.