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Stock Assessment and Management of the Grand Bank Yellowtail Flounder Stock

by

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Abstract

All available information on the biology, assessment, fishery and management of Grand Bank yellowtail flounder stock, Division 3LNO, is drawn together to assess the status of the stock in 2002. Recent surveys by Canada and Spain indicate that stock size has been increasing since a moratorium on directed fishing was declared in 1994. A surplus production model, incorporating current and historical survey and catch indices, was used to assess relative biomass, fishing mortality rates and to provide 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 5, 000 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 7, 000 t was set because there appeared to be a slight improvement in recruitment to the fishable stock. In 1994, a TAC of 7, 000 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 was set at zero and a fishery moratorium was imposed. Following an increase in survey biomass, Scientific Council in 1997 recommended a re-opening of the yellowtail flounder fishery with a precautionary TAC of 4,000 t for the 1998 fishery. With the cessation of the moratorium, other management measures were imposed, such as delaying the re-opening until August of 1998 to allow the majority of yellowtail flounder spawning in that year to be completed, and restricting the fishery to Div. 3N and 3O. For the 1999 fishery, a TAC was set at 6, 000 t and again restricted to Div. 3N and 3O, but there were no restrictions on the time period. A stock production model was used to estimate F_{buf} to arrive at an exploitation rate of 11% and recommended a TAC of 10,000 t for the 2000 fishery. For each of the 2001 and 2002 fisheries a stock production model was used to recommend a TAC of 13, 000 t

B. Catch Trends

The nominal catch increased from negligible amounts in the early 1960's to a peak of 39,000 t in 1972 (Table 1; Fig. 1). With the exception of 1985 and 1986, when the nominal catch was around 30,000 t, catches were in the range of 10,000 to 18,000 t from 1976 to 1993, the year before the moratorium. 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 TACs in the early 1980s as much of the Canadian fishery for flounders was directed toward American plaice in Div. 3L. Canadian catches were stable around 6,700 t from 1991-93, but declined to zero 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, Div. 3NO (Tables 1and 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) then increased to about 700 t during 1993-94. Catches by Spain and Portugal also decreased to relatively low levels during the period of 1992-96. South Korea, which fished this stock since 1982, and caught between 3, 500 and 5, 900 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

The nominal catch of yellowtail flounder in 1995 was 67 t, of which EU-Spain took 65 t in the Regulatory Area of Div. 3NO. 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 in other bottom trawl fisheries (Tables 1 and 2).

After the moratorium 1998-2001

In 1998, a total catch of 4 348 t was taken 1) in a directed commercial fishery by Canada (3,700 t), 2) as a by-catch (85 t) in the Portuguese Greenland halibut otter trawl fishery in the NAFO Regulatory Area of Div. 3N and 3) as a by-catch (562 t) in the Spanish skate fishery in the NAFO Regulatory Area of Div. 3NO (Table 1 and 2).

In 1999 four countries reported landings and a total catch of 6,561 t was taken 1) in directed fishery by Canada (5,413 t), 2) as a by-catch (300 t) in the Portuguese Greenland halibut/redfish fishery, 3) as a by-catch (752 t) in the Spanish skate fishery and 4) as by-catch (96 t) in the Russian Greenland halibut fishery. The latter three fisheries took place in the NAFO Regulatory Area of Div. 3NO (Tables 1 and 2). In the 2000 fishery, Spain, Portugal, Russia, and Estonia reported a total catch of 1,696 t in the NAFO Regulatory Area of Divisions 3NO and Canada reported a catch of 9, 423 from otter trawl fisheries inside the zone.

In 2001 the total catch was 14,147 tons, which is the highest level since 1991. Canadian vessels caught 12,240 tons, their highest total since 1987. Spain caught 1391 tons, with the remaining catch coming from Portugal, Russia, Estonia, and Lithuania (Tables 1 and 2). Catches by these five countries occurred in the NAFO Regulatory Area of Div. 3NO. As in previous years, some estimates of catch were used instead of officially reported statistics. In the 1998-2001 fisheries, catches have exceeded the TACs for this stock by about 10% per year.

Table 3 shows a breakdown of the Canadian catches 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 and by otter trawls. The Canadian otter trawl catch of yellowtail in Div. 3O in 2001 of 3206 t was the highest in this Division since 1993 and the third highest since the start of the time series in 1973.

C. Commercial CPUE Data

A multiplicative model was used to analyze the catch and effort data for this stock as in assessments prior to the moratorium (Brodie *et al*., 1994). Because available data from NAFO Statistical Bulletins exists only from 1974 onward in a format that identifies yellowtail as a main (directed fishery) species, it was decided to use Canada (Newfoundland) trawler data from 1965 to 1993, along with 1998-2001 data obtained from the commercial statistics branch of the Department of Fisheries and Oceans in St. John's to derive a standardized catch rate series. It should be noted that for some years, particularly the late-1970s, the Canadian fleet provided the only source of CPUE data for this stock. The historical data used in the model were the same data used to calculate the CPUE series in previous assessments (Brodie *et al*., 1994).

Factors included in each model were a combination country-gear-tonnage-class category type (CGT), month, NAFO Division and year. Consistent with previous catch rate standardizations individual observations of catch less than 10 tons or effort less than 10 hours fished were eliminated prior to analysis. Subsequently, any remaining categories with less than five data points in total were also eliminated. Plots of residuals from a preliminary run indicated data with higher levels of catch and effort tended to be less variable. Therefore a weighted regression was conducted. Tables 4A and 4B show the results of the analysis and Fig. 2 shows the standardized series from 1965 to 2001.

In the top panel of Fig. 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-1960s. Catch rates increased by a further 20% between 1998 and 2000 and was comparable to the highest on record, i.e. at the start of the directed fishery in 1965. In 2001 catch rate declined to the level estimated in 1998.

Standardizations of the data separately by division (Fig. 2, lower panel) showed that, overall, the historical trend was the same, although the catch rate is generally lower in Div. 3O than in Div. 3N, and, large fluctuations tend to occur more frequently in Div. 3O, primarily before 1985. In the period since the resumption of the directed fishery from 1998-2001, catch rates showed opposite trends within each Division between 1998 to 1999 (3N up, 3O down) and again between 2000 to 2001 (3N down, 3O up).

The decline in the combined 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. Given this major shift in the fishery from the 1965-90 and the 1991-93 periods, some caution must be used in comparison of catch rates between these periods. Nonetheless, it is reasonable to interpret the 1991-1993 values for CPUE as an indication that the stock was at a relatively low level. Since the resumption of the fishery in 1998, there has been a 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, 2000) where yellowtail are aggregated (Simpson and Walsh, 1999). Once again caution should be used in comparing post moratorium catch rates with other fishery periods, however, the increase in catch rates since 1998 under the constraint of 5% by-catch limitations suggests that the stock size is at a relatively high level, in accordance with a similar perception from survey indices (Walsh *et al*. 2001; Maddock-Parsons *et al*., 2001). Data from the Canadian fleet indicate that by-catch of American plaice has been particularly problematic in 2001 and that this has continued in 2002.

D. The 2001 Canadian Fishery (SCR Doc. 02/73)

The yellowtail fishery on the Grand Banks was prosecuted by Canada in 2001, for the fourth year following a 4-year moratorium on directed fishing. The fishery started in mid January 2001, ended in late December, and was prosecuted at locations similar to 2000, in addition to covering three new grounds. Over 26% of the Canadian catch in 2001 occurred in Div. 3O, compared to less than 3% in 1999 and 2000. Fishing occurred over a narrow depth range, mainly between 50 and 70 m. Effort was targeted for yellowtail flounder since 1998 in contrast to the past (pre-1994) practice of taking yellowtail in a mixed fishery over a much more extensive area of the Grand Bank. Yellowtail flounder was exploited as a single target species rather than part of a mixed fishery (per the historical fishery) by concentrating effort where it was most abundant and other species were minimal. Directed otter trawl catch of yellowtail in 2001 was 12,095 t up from 9,414 t in 2000, 6,609 t in 1999 and 3,795 t in 1998. Minimization of by-catch of some species was attempted by targeting spatial concentration of effort and the use of a sorting grate (aimed mainly at cod) with average spacing of 123 mm. Yellowtail dominated the catch in all areas and American plaice was the most common by-catch. By-catch levels of cod and plaice were higher in 2001 than in previous years (plaice as a percentage of yellowtail: 4.2% 1998, 4.4% in 1999, 6% in 2000, 10.4% in 2001; cod as a percentage of yellowtail: 2.3% in 1998, 1.2% in 2000, 3.1% in 2001). Size of yellowtail taken was similar to 1998 and 1999. Over all areas fished, using an average codend mesh size of 149 cm, average size of males and females in the catch was 36.4 and 39.3 cm respectively, very similar to 1998-2000. A total of 23 million individuals were estimated to have been removed by the fishery compared to 7.3, 12.9 and 17.9 million in 1998, 1999 and 2000. Age compositions were not calculated due to continued uncertainties with age determination (see below).

E. The 2001 Fishery by Non-Canadian Vessels (SCS Docs 02/4, 6, 7)

A comparison of the length frequencies of yellowtail flounder in various otter trawl fisheries by vessels from Spain, Portugal and Russia is presented in Fig. 3. The length frequencies in the Spanish and Russian fisheries were similar, with peaks in the mid-30 cm range. In the Portuguese 130 mm mesh codend the modal length is larger than that obtained in the catches in the Portuguese skate fishery where a codend mesh size of 300 mm is used. Interestingly, there appears to be smaller yellowtail flounder caught in the Portuguese skate fishery than in their regular fishery, the Spanish skate fishery, and the Canadian fishery.

II. Research survey data

A. Canadian Stratified-random Surveys Spring and Fall Surveys (SCR Doc. 02/43)

Abundance and biomass trends

Figures 4 and 5 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 since 1992, with the exception of 1996 and 1999. 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, where the majority of the biomass is located, during the fall surveys from 1992 onward. In Div. 3O, the upward trend in both indices began in 1995, but there doesn't appear to be an obvious overall trend between spring and fall estimates (Fig. 5). This may be due to the fact that most of the yellowtail biomass lies in two strata (351 and 352) on the border of Div. 3N and movement between Divisions is likely. In Div. 3L, there was very little biomass between 1990 and 1998, but since then the fall is showing an upward trend, although the trend is opposite in the spring surveys since 1999. In the 1999 spring survey, both abundance and biomass increased sharply over the 1998 estimate and STACFIS (2000) noted this as a survey with "year effects", probably caused by a change in catchability. Similar results were seen in Div. 3LNO A. plaice stock and the Spanish spring survey. Further evidence to support this unusual jump in the spring indices was that the 1999 fall survey abundance and biomass estimates were much lower. The 1999 survey estimates of stock biomass were 366,000 tons (81% higher than the 1998 estimate) in the spring and 249,000 tons (8% higher than the 1998 estimate) in the fall (Table 5). By 2000, the spring biomass was lower by 22% (288,000 t) while the fall estimate had increased by 34% (335, 000 t) when compared to the 1999 fall survey. In the 2000, fall survey, one large catch (~1,000 kg) in stratum 376 in Div. 3N contributed 60,000 t to the biomass total. In 2001 both biomass indices increased, and were 28% higher (367,000 t) in the spring and 42% higher (476,000 t) in the fall compared to 2000.

Figure 6 shows the result of a regression of the biomass estimates from the spring and fall time series. A linear relationship is evident with 78% of the variation being explained by the model. Two time regimes are present: 1990-1995, when the stock was at its lowest, and estimates were in agreement, and 1996-2001 when the stock was on the increase and the estimates were more variable. Coincidentally, the switch in survey gears took place in the fall of 1996 and probably what is being seen is a seasonal difference in catchability which would account for the widening confidence intervals. Catchability estimates from the stock production model indicate q is around 3 and therefore swept-area stock-size is being overestimated in the surveys (Walsh *et al*., 2001).

Size composition and growth

Figures 7 and 8 show the length composition of survey catches from spring and fall surveys by year for Div. 3LNO (combined sexes). Size composition in most years generally showed a bimodal distribution, usually with one dominant peak in the length frequencies. More small fish were present in the survey catches beginning in the fall of 1995 onward due to the increased efficiency of the new Campelen survey gear over the old gear. Annual shifts in modal peaks are evidence of year classes moving through the time series.

In the spring surveys in 1996, there was a strong mode at about 20.5 cm (approximately age 4), which can be seen moving progressively through time. In 1997, its peak is at 25.5 cm but by 1998, the peak has moved to 27.7 cm and the progression has slowed. Over the next three years, the peak remains strong, but growth is reduced considerably. At this point, it is made up of a number of different age classes. Another strong peak occurs in 1984 at about 36 cm, but because this peak probably represents fish from older age-classes, growth over the next several years is almost non-existent, and in fact, merges with age groups over the next few years.

Similarly, in the fall surveys, there is a peak at 15.5 cm (age 3) in 1995, which moves at an average rate of 5 cm/year in the earlier years, and begins to slow after 30.5 cm. This peak represents a number of age-classes as growth slows. Length modes, representing age classes, can be seen moving along the x-axis up until about 30 cm, after which growth slows and becomes almost negligible between years. This is consistent with the growth curves constructed using ages from thin-sections (Dwyer *et al*., 2003).

It is more difficult to comment on the growth of yellowtail in Spanish surveys as the Pedreira gear does not seem to pick up the fast-growing young fish, although there is a small peak at about 16 cm in 1999 (Fig. 9).

Age

Age validation studies undertaken for yellowtail flounder indicate that the thin-sectioned otolith technique is the best method for ageing this species (Dwyer *et al*., 2003). It was concluded that thin sections may possibly underestimate the ages of the oldest fish in the population but this method is the most accurate. Yellowtail flounder have been aged up to 25 years using this method. It is fairly certain that age estimation of yellowtail flounder using the traditional method of ageing the surface of whole otoliths is accurate up to the age of 5 years and potentially to the age of 7 years.

In order to increase the precision in the age determination using the new sectioning method, and to gain further insight into how and when the changes in growth and maturity with age affect accurate age readings, further studies are currently being undertaken. The main objectives of these studies are to pinpoint the exact age at which the two age methods (whole otoliths *vs* sectioned) deviate, and to determine the proportion of old fish in the population (clearer idea for the establishment of the 'plus' age-group). To facilitate these studies, production ageing using mass-sectioning of the otoliths will be used. Quality control of age reading will be addressed by setting up a reference collection, using image analysis and carrying out periodic tests of drift in age determination as recommended by Walsh and Burnett (2001). These results will be applied to the archived research and commercial otoliths with the goal of producing an age-structured assessment (SPA) by 2005.

Relative cohort strength

Relative cohort strength was estimated from a multiplicative model using abundance estimates at ages 3 and 4 from the 1984-2001 spring and 1990-2001 fall research vessel surveys by Canada. 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

Only ages 3 and 4 were included in the model as the inclusion of age 2 produced a pattern in the residuals. The model showed no obvious pattern in the residuals and a significant fit to the data. However there was no significant survey effect.

R^2=0.67, n=60

Source	**DF**	**Type III SS**	**Mean Square**	**F Value**	**Pr > F**
age	1	21.32716862	21.32716862	30.06	<.0001
cohort	18	31.57215517	1.75400862	2.47	0.0090
survey	1	1.85344436	1.85344436	2.61	0.1141

Since there was no significant survey effect the model was rerun using the same data but without estimating a survey effect. As in the previous model there was both a significant age and cohort effect.

R^2=0.65, n=60

Source	DF	Type III SS	Mean Square	F Value	Pr > F
age	1	21.66158809	21.66158809	29.35	<.0001
cohort	18	34.45684793	1.91426933	2.59	0.0061

Estimates of relative cohort strength from this model are plotted in Fig. 10. Cohort strength reached a minimum in 1990 but has increased since. The 1981 to 1983 and the 1990 and 1991 cohorts were significantly lower than the 1998 year-class. Cohorts since 1992 are not significantly different from the 1998 cohort and are the highest in the time series. These apparently good year classes should form the bulk of the fishery over the next few years.

Abundance at age

Given that there is still uncertainty with the age determination of older fish, estimates of fish beyond age 6 years were put in a 'plus' category (Tables 6 and 7 and Fig. 11 and 12). Because of the introduction of the new survey trawl in the fall of 1995, which is more efficient at catching fish of ages 1-2 years than the previous trawl, comparisons of year-classes in the 2001 spring and fall survey estimates will be restricted to cohorts of 1995-2001 only.

Pre-recruits: Since the fall of 1995 the estimates of pre-recruits, ages 1-4, have been much larger than the estimates from 1990-94 period, and this is evident in both the spring and fall surveys (Fig 11, top panel). Only the estimates from the fall 1995 and spring 1996 surveys (1992 and 1993 are strong year-classes) are close in magnitude as that of the estimate from the 1989 spring survey made up primarily by the strong 1985 year-class (Table 6A). In the 2001 surveys, the 1999 (age 2) and 2000 (age 1) estimates of year-class strength are above the long-term average in the spring but below the long-term average in the fall survey. The 1998 year class was moderately above the long term average, ranking 5th in the spring and 3rd in the fall time series. The 1997 year class at age 4 is well above the long term average and ranked the second highest in the spring time series (below the 1985 year-class) and the highest in the fall time series. It was also strong at earlier ages (Table 6A). Since 1995, the biomass of pre-recruits in both time series, although higher than those seen in earlier survey estimates, show no definite trend as expected only to note the spring and fall estimates track each other very well.

Recruits: In Figures 11-12, ages 5+ represent the mature population and ages 7+ represent the population that is fully recruited to the survey gear. The abundance and biomass of age 5+ has been steadily increasing since 1996 and in most years the fall estimate is higher than the spring estimate (Fig. 12, middle panel). The 1996 (age 5) and the 1995 (age 6) year-classes are also well above the long term averages in both series (Table 7) and in 2001 contribute 59% to the total biomass in the spring and 42% in the fall (Table 7). The abundance and biomass of age 7+ showed less definite a trend as the age 5+, however, since 1998 the trend has been mainly upward in both time series. In 2001, the biomass of the age 7+ component comprised 49% of the spring and 51% of the fall estimate of stock size (Table 7). It is suspected that the 1992-1994 year-classes, which were notably numerous at younger ages, constituted a significant proportion of the age 7+ biomass in 2001.

From the available indices for ages 5, 6 and 7+, it is seen that the biomass of ages 5+6 is consistently higher in the fall than in the spring, and that there is good correlation between them (Fig. 13). Similarly, age 7+ estimates are higher in the fall then in the spring, and these two series are also well correlated. A similar trend is evident in the pre-recruits.

B. Co-operative DFO/fishing Industry Seasonal Surveys (SCR Doc. 02/44)

Co-operative trawl surveys between Canadian Department of Fisheries and Oceans (DFO) and a Canadian fishing company in Div. 3NO have been carried out since 1996, using a commercial fishing gear without a codend liner. These surveys are done using a grid design, and cover an area of about 9,500 square n. miles. In July 2000, the grid was expanded to cover an additional 100 grid blocks, equal in size and adjacent to the original grid, including an area mainly to the north. Fourteen surveys of the original grid area were conducted, 1 in 1996, 4 each in 1997 and 1998, 3 in 1999, and 1 each in 2000 and 2001. A July survey has been carried out in each of the 6 years.

These surveys indicate very low catch rates of yellowtail flounder and other species in March of 1997, 1998 and 1999 compared with surveys at other times of the year, which may be due to changes in catchability. CPUE observed in the other co-operative surveys was relatively high compared to historic CPUE data from the fishery. The CPUE for the indexed grid blocks for July surveys from 1996-2001 has varied around a mean CPUE of about 760 kg/h, with the 2001 value being about 7% above the mean (Fig. 14). Most of the fish in the July surveys have spawned and are in the spent stage. On average, about 75% of the female yellowtail caught in these surveys were sexually mature.

Examination of catches of other species relative to yellowtail pointed out the limited area available for conducting a directed fishery for yellowtail flounder within the 5% American plaice by-catch restriction.

C. Spanish Stratified-random Spring Surveys in the Regulatory Area, Div. 3NO (SCR Doc. 02/3, 65)

Beginning in 1995, Spain has conducted stratified-random surveys for groundfish in the NAFO Regulatory Area (NRA) of Div. 3NO. These surveys cover a depth range of approximately 45 to 1,300 m. In 2001, extensive comparative fishing was done between the Pedreira trawl used in surveys up to 2001, and the Campelen trawl, used in 2001 and subsequent years.

Using the original Pedreira units, the biomass index increased 4-fold between 1995 and 1996-97, then increased sharply in 1998 and again in 1999, to a about 5 times the 1996-97 average. In 2000, the survey biomass showed a 24% decrease before rebounding to the 1999 level in the 2001 survey (Fig. 15a). This same pattern occurred in the Canadian spring survey from 1999-2001 (Walsh *et al*., 2002).

Figure 15B shows the bimodal length composition of the 2001 survey catches of yellowtail flounder with peaks at 24 cm and 32 cm. A higher proportion of females than males were found in the time series compared to the Canadian spring data.

Comparison of the Canadian survey results from just the NRA in Div. 3NO with the Spanish results showed general agreement in the trends from 1996-2001. This was true for comparisons with both the Spanish estimates (original Pedreira data and converted Campelen data, Fig. 15c and 15d).

D. Stock Distribution

Juveniles: An analysis of spatial distribution of juvenile yellowtail flounder from Canadian surveys showed that on average, 79% (S.D. 15.6) of all juveniles (ages 0 to 3 years) on the Grand Bank are found in the 4 strata on the Southeast Shoal and the area immediately west of the shoal (360, 361, 375 and 376 in Div. 3N, see Table 8). Typically, the majority of these juveniles are found in strata 360 and 376. Inter-annual variation in the spatial pattern is evident, which may be related to density and/or temperature.

Stock: (SCR Doc. 02/43). Analysis of the Canadian spring and fall surveys in 1999-2001 showed the stock was more widely distributed in all three Divisions, but that the stock continues to occupy depths less than 100 m. The majority of the stock is consistently concentrated in Div. 3N on and to the area immediately west of the Southeast Shoal. In these surveys, expansion of the range into Div. 3L was evident, in accordance with the population increase. Yellowtail flounder were found on all traditional grounds in Div. 3L, although there was poor survey coverage in the fall of 2000 in Div. 3L. There is a definite seasonal pattern in recent years in the proportion of biomass north of 45^0N. In the spring, the stock is more dispersed northward than in the fall. However, this metric does not track the changes in spatial location of the stock in Div. 3L, which showed higher catch rates and an increasing trend in the fall biomass, while the spring catch rates in Div. 3L were lower and the trend was declining. Recent tag returns from the 1998-2001 fishery, have also confirmed the northward extension of the stock in recent years.

E. Biological Studies

Maturity

Maturity at size was estimated using data from Canadian spring surveys from 1984-2001. Estimates were produced using a probit model with a logit link function and a binomial error structure. L_{50} declined in males, by about 7 cm from around 30 cm in the mid-1980s to 23 cm in 1999. The last 2 years have seen an increase with the L_{50} for males estimated to be 26 cm in 2001. Female L_{50} has been fairly stable, with at-most a 1 cm decline from 34 to 33 cm (Fig. 16). There was significant inter-annual variation in the proportion mature at length for both males and females (generalized linear models: males χ^2 = 317.9, df = 17, p <0.0001, females χ^2 = 78.0, df =17, p <0.0001).

Sex Ratios

Sex ratios in the 1984-2001 surveys generally show a dominance of male fish in the catches of both the spring and fall surveys (Fig. 17A). A closer examination of the sex ratios by length within the 2000 and 2001 spring and fall surveys is presented in Fig. 17B. The sex ratio shows two consistent bimodal peaks where males dominate the catches in the length range 12-18 cm and 24-34 cm. The reason for this is not known. Catches of the largest fish (greater than 34 cm) are dominated by females, which is common for many flatfishes exhibiting differences in growth rates by sex. There is no seasonal difference in this pattern. Beverton (1964) noted that the catches of small male North Sea plaice always exceeded females and that in older fish the sex ratio was reversed. Further examination of the data in detail is planned, since the opposite survey trend is seen in the Spanish spring survey data when compared with the Canadian survey data. Possible causes for this difference include differences in the total area surveyed, as well as the type of gear, used in the Spanish and Canadian surveys.

F. Assessment Results

Female Spawning Stock Biomass (SSB)

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 (Fig. 18). Annual length-weight relationships were unavailable prior to 1990 so for those years a relationship was produced using combined data from 1990-1993. The specific length-weight relationships are given in Table 9. Female SSB declined from 1984 to 1992, but since 1995 it has increased substantially. 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 abundance index for that year. Estimates for 1999-2001 have been fairly similar and much higher than previous values. The value of the index in 2001 is 135,000 t.

Stock-recruitment relationship

The estimates of relative cohort strength of ages 3 and 4 from the multiplicative model are plotted against the index of female SSB from the spring survey in Fig. 19. There is no indication of a stock recruit relationship, but there is perhaps some tendency for recruitment to increase with SSB, although a range of recruitment appears to be possible from any given SSB. This is not surprising given the lack of contrast in year-class strength over the time period

Surplus production model (ASPIC)

<u>Input data</u>

A non-equilibrium surplus production model incorporating covariates (ASPIC; Prager, 1994, 1995) was applied to nominal catch and survey biomass indices, as was done in the 2001 assessment of this stock (Walsh *et al*., 2001). The production model that provided the best fit to the data, as recommended by STACFIS in 2001 (NAFO, 2001) included: 1) the nominal catch data (1965-2001); 2) Russian spring surveys (1972-1991); 3) Canadian spring (Yankee) surveys (1971-1982); 4) Canadian Campelen spring (1984-2001); 5) Canadian Campelen fall surveys (1990-2001); and 6) the Spanish Pedreira spring (1995-2001) survey.

The input data for surplus production model are listed in Table 10. Estimated landings were used as nominal catch, but do not include discards or unreported landings. The Canadian spring surveys have used a variety of survey gears since this series began in 1971. A 'Yankee' otter trawl was used from 1971 to 1982, an 'Engel' otter trawl was used from 1984 to 1995 (spring), and since the fall of 1995 a 'Campelen' shrimp trawl has been used (McCallum and Walsh, 1997). Comparative tows of the Yankee and Engel trawls were used to derive a conversion factor of 1.4 for the Yankee catches by number but not by weight (biomass). The unconverted Yankee survey biomass was used here. Comparative tows of the Engel and Campelen trawls were used to derive a size-based conversion function (Warren *et al*., 1997; Walsh *et al*., 1998). Methods to link the 1971-1982 Yankee series to the 1984-2001 Campelen series have not been developed. Therefore the 1971-1982 and 1984-2001 series were considered to be separate indices of biomass.

Table 10 shows all the time series used in the model. The Canadian Yankee biomass index showed a downward trend from 1971 to 1982. The 1984-2001 Campelen spring biomass index (SCR Doc. 02/43) showed a downward trend from 1984 to 1995 before beginning to increase. By 1999, the biomass was double the previous highest point (1984) in the time series and the 2001 estimate is the largest in the time series. The biomass index from the Canadian fall surveys increased from low levels in the early-1990s to a high point in 2001. The biomass index from the 1986-94 Canadian fall juvenile groundfish surveys (Walsh *et al*., 1995) was not used because of a negative correlation with most indices (e.g. this index increased during the early-1990s when most other indices were decreasing (Walsh and Cadrin, 2000). Similarly, the average catch rate from the DFO/FPI grid surveys from July 1996-2001 also gave negative correlations with most indices and were excluded from the model. The biomass index from the 1972-1991 Russian bottom trawl survey sharply declined from relatively high levels in the 1970s and early-1980s to low levels in the late-1980s and early-1990s, in agreement with Canadian surveys (Brodie and Walsh, 1992). The 1995-2001 biomass index from the Spanish survey has generally shown a strong upward trend.

Surplus Production Model

The production model assumes logistic population growth, in which the change in stock biomass over time (dB_t/dt) is a quadratic function of biomass (B):

$$dB_t/dt = rB_t - (r/K)B^2_t \quad (1)$$

where r is the intrinsic rate of population growth, and K is carrying capacity. For a fished stock, the rate of change is also a function of catch biomass (C):

$$dB_t/dt = rB_t - (r/K)B_t^2 - C_t \quad (2)$$

Biological reference points can be calculated from the production model parameters:

$$MSY = K\,r / 4 \quad (3)$$
$$B_{msy} = K / 2 \quad (4)$$
$$F_{msy} = r / 2 \quad (5)$$

Initial biomass (expressed as a ratio to B_{msy}: $B1R$), r, MSY, and catchability coefficients for each biomass index (q_i) were estimated using non-linear least squares of survey residuals. Survey residuals were randomly re-sampled 500 times to derive bias-corrected probability distributions for parameter estimates.

Correlations among biomass indices varied (Table 11). Of the six pairwise correlations among the remaining five series of biomass indices included in the production analysis, five were strong ($r > 0.78$), and one was weak ($r = 0.2$)

In this run, and for all projections, the input data assumed that the 2002 fishery would take the TAC (13,000 t) plus an additional 10% overrun, i.e. 14,300 tons, which was similar to the 2001 assessment formulation.

Because of differences in catchability among the various indices, relative indices of biomass and fishing mortality rate were used instead of absolute values. Fishing mortality refers to yield/biomass ratio.

Results

The model fit the data relatively well (for detailed output, see Table 11). The majority of variance in survey indices was explained by the model, but fit varied among indices (r^2 ranged from 0.29 to 0.85; Table 11). Residuals appeared to be randomly distributed for most survey indices. However, the Russian series had a strong pattern of positive residuals during the 1970s and early-1980s and negative residuals for subsequent years (Table 11). The Russian spring survey index showed a more rapid decline in stock size than that detected by the Canadian spring survey index in the mid-1980s. The Spanish series, which is only 7 years in duration, showed negative residuals in the first 3 years followed by 4 positive residuals, indicating that this series increased faster than the model estimates in the latter period.

The ASPIC model suggests that a maximum sustainable yield (MSY) of 17,800 tons can be produced when the total stock biomass is 79,000 tons (B_{msy}) and the fishing mortality rate is 0.23 (F_{msy}) (Table 11). The MSY estimate is slightly above that estimated in last year's assessment (Walsh *et al*., 2001). Because of differences in selectivity of survey gears and the commercial gears (mainly otter trawl) used in the production model, estimates of absolute stock biomass and fishing mortality in a given year (t) are usually estimated less precisely than MSY and F_{msy}. To remove the effects of these differences in catchabilities, we use the ratios to MSY reference points (e.g. B_t/B_{msy} and F_t/F_{msy}) as relative indices. The relative levels of biomass B_t/B_{msy} describes whether a population is above or below the level at which MSY can be produced, and the relative level of fishing mortality rate F_t/F_{msy} suggests whether an increase or decrease in fishing effort might provide a higher sustainable yield (Prager, 1994). Estimates of relative biomass and fishing mortality rates are shown in Table 11. Biomass showed a continuous decline from the late-1960s to the mid-1970s, stabilized through the mid-1980s, before declining further until about 1994, when the moratorium was imposed (Fig. 20a). The analysis showed that relative biomass (B_t / B_{msy}) has been below the level at which MSY can be produced from 1973 to 1994-95. Since then, the stock increased to a point where B_t/B_{msy} reached the level which MSY can be obtained in the year 2000, i.e. $B_{2000} = B_{msy}. = B_t / B_{msy}$. For 2003, assuming a catch of 14,300 t in 2002, the relative biomass B_t / B_{msy} was 1.21, slightly above the above the level of 1.14 in last year's assessment (Walsh *et al*., 2001).

The relative fishing mortality rate (F_t/F_{msy}) was high during most of the history of the fishery (Fig. 20b), in particular during the mid to late-1980s to the early-1990s when landings were often double the TAC (Fig. 1). Since the fishery re-opened in 1998, the fishing mortality rate has been gradually increased to the target level of $2/3F_{msy}$, which was close to the F-ratio estimated in 2002 (67.5%) if the TAC + 10% over-run is taken (Table 11). Since the moratorium in 1994, the estimated yield from the stock has been below sustainable production levels (Fig. 21).

An ASPIC bootstrap run (500 iterations) with a catch constraint of 14,300 tons in 2002 was carried out. Table 12 shows the resulting management options for 2003-04 under a variety of fishing mortality values. Based on these, Scientific Council advised that catches in 2003 and 2004 should not exceed 14,500 tons, corresponding to approximately 2/3 F_{MSY}. Medium-term projections were carried out by extending the ASPIC bootstrap projections forward to the year 2012 under an assumption of constant fishing mortality at 2/3 F_{msy}. The output (Fig. 22) shows that yield gradually increases, reaching a maximum of 16,900 tons in 2012. The results also show the percentiles of predicted absolute yield and biomass, and biomass relative to B_{msy}. The probability of biomass falling below B_{msy} declines from about 15% in 2003 to less than 5% after 2010. The projections are conditional on the estimated values of r, the intrinsic rate of population growth and K, the carrying capacity.

Finally, the results of the ASPIC model, including the projected values for 2003, are shown in Fig. 23 in a precautionary framework (Rivard and Walsh, 2000). In this schematic diagram, F_{MSY} is taken to be F_{LIM}. No B_{LIM} is defined, although the lowest observed biomass occurred in 1994, which was the year that the moratorium was declared. The results indicate that the stock is presently above B_{MSY}, and that fishing mortality is below F_{MSY}.

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

Year	Canada	France	USSR/Rus	S.Korea[a]	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	4,166 [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	-	-	-	-	2,069	2,069	7,000 [d]
1995	2	-	-	-	65	67	0 [d]
1996	55	-	-	-	232	287	0 [d]
1997	146	-	-	-	657	803	0 [d]
1998	3,701	-	-	-	647	4,348	4,000
1999	5,413		96	-	1,052 [b]	6,561	6,000
2000 [c]	9,423		212		1,486	11,121	10,000
2001 [c]	12,240		148		1,759	14,147	13,000
2002							13,000

[a] see text for explanation of South Korean catches

[b] includes catches estimated from Canadian surveillance reports

[c] provisional

[d] no directed fishery permitted

Table 2. Breakdown of 1984-2001 "other" catches from Table 1.

Year	Spain	Portugal	Panama	USA	Cayman Is.	Estonia	Misc.	**Total**
1984	25	-	1,800	-	-	-	11	**1,836**
1985	2,425	-	4,208	3,797	803 [a]	-	12	**11,245**
1986	366	5,521	4,044	2,221	1,728 [a]	-	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	-	-	-	-	-	5,212 [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**
2000	1,114 [b]	247	-	-	-	53	-	**1,486**
2001	1,391 [b]	320 [b]	-	-	-	47	1	**1,759**

[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 to 2001. Data from 1990-93 and 1998-2001 are from preliminary Canadian ZIF statistics and are slightly different from STATLANT data. Catches given for 1994-97 are by-catch totals for all gears from STATLANT 21 data.

	OTTER TRAWL				
YEAR	**3L**	**3N**	**30**	**3LNO**	**OTHER GEARS**
1973	4,188	21,470	2,827	28,475	17
1974	1,107	14,757	1,119	16,983	70
1975	2,315	13,289	2,852	18,456	2
1976	448	4,978	2,478	7,904	6
1977	2,546	7,166	1,583	11,295	0
1978	2,537	10,705	1,793	15,035	56
1979	2,575	14,359	1,100	18,034	82
1980	1,892	9,501	578	11,971	40
1981	2,345	11,245	515	14,105	17
1982	2,305	7,554	1,607	11,466	13
1983	2,552	5,737	770	9,059	26
1984	5,264	6,847	318	12,429	8
1985	3,404	9,098	829	13,331	9
1986	2,933	10,196	1,004	14,133	35
1987	1,584	10,248	1,529	13,361	59
1988	1,813	7,146	1,475	10,434	173
1989	844	2,407	1,506	4,757	252
1990	1,263	2,725	664	4,652	317
1991	815	2,980	2,283	6,078	564
1992	95	1,266	4,636	5,997	812
1993	1	2,030	3,902	5,933	764
1994	0	0	0	0	0
1995	0	0	0	0	2
1996	0	0	0	0	0
1997	0	0	0	0	1
1998	0	2,940	726	3,666	26
1999	0	5,319	91	5,410	3
2000	1,407	7,724	278	9,409	5
2001	182	8,711	3,206	12,099	141

Table 4A. ANOVA results and regression coefficients from a multiplicative model utilized to derive a standardized catch rate series for Yellowtail flounder in NAFO Div. 3LNO (2000 based on preliminary data).

REGRESSION OF MULTIPLICATIVE MODEL

MULTIPLE R............. 0.736

MULTIPLE R SQUARED..... 0.542

ANALYSIS OF VARIANCE

SOURCE OF VARIATION	DF	SUMS OF SQUARES	MEAN SQUARE	F-VALUE
INTERCEPT	1	4.87E1	4.87E1	
REGRESSION	47	7.46E0	1.59E-1	21.083
Cntry|Gear|TC(1)	2	8.43E-1	4.22E-1	56.015
Division(2)	2	8.00E-1	4.00E-1	53.155
Month(3)	11	6.25E-1	5.68E-2	7.547
Year(4)	32	4.52E0	1.41E-1	18.757
RESIDUALS	838	6.31E0	7.53E-3	
TOTAL	886	6.25E1		

REGRESSION COEFFICIENTS

CATEGORY	CODE	VAR #	REG. COEF	STD. ERR	NO. OBS
Cntry|Gear|TC	3125	INT	0.151	0.118	886
Division	34				
Month	10				
Year	65				
(1)	3114	1	-0.303	0.032	162
	3124	2	-0.219	0.032	151
(2)	32	3	-0.214	0.028	203
	35	4	-0.252	0.029	188
(3)	1	5	-0.228	0.081	20
	2	6	-0.331	0.077	23
	3	7	-0.236	0.063	37
	4	8	-0.190	0.052	62
	5	9	-0.207	0.045	117
	6	10	-0.292	0.045	116
	7	11	-0.290	0.045	119
	8	12	-0.205	0.046	112
	9	13	-0.059	0.046	96
	11	14	-0.097	0.053	59
	12	15	-0.087	0.062	43
(4)	66	16	-0.068	0.146	11
	67	17	-0.074	0.146	12
	68	18	-0.242	0.145	14
	69	19	-0.406	0.134	20
	70	20	-0.395	0.122	42
	71	21	-0.428	0.122	41
	72	22	-0.547	0.121	45
	73	23	-0.435	0.121	50
	74	24	-0.847	0.124	37
	75	25	-0.848	0.123	38
	76	26	-0.936	0.130	26
	77	27	-0.762	0.124	38
	78	28	-0.731	0.121	51
	79	29	-0.696	0.121	47
	80	30	-0.590	0.126	30
	81	31	-0.585	0.127	30
	82	32	-0.687	0.131	24

CATEGORY	CODE	VAR #	REG. COEF	STD. ERR	NO. OBS
(4)	83	33	-0.546	0.131	24
	84	34	-0.580	0.130	28
	85	35	-0.557	0.127	30
	86	36	-0.860	0.128	30
	87	37	-0.817	0.128	30
	88	38	-0.895	0.130	26
	89	39	-0.894	0.141	17
	90	40	-0.750	0.137	16
	91	41	-1.408	0.136	21
	92	42	-1.262	0.140	15
	93	43	-0.770	0.135	18
	98	44	-0.271	0.149	11
	99	45	-0.179	0.145	12
	100	46	-0.085	0.131	24
	101	47	-0.319	0.131	20

LEGEND FOR AVOVA RESULTS:

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

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

Table 4B. Standardized catch rate index for Yellowtail flounder in NAFO Div. 3LNO from a multiplicative model utilizing HOURS FISHED as a measure of effort (2001 based on preliminary data).

PREDICTED CATCH RATE

	LN TRANSFORM		RETRANSFORMED			
YEAR	MEAN	S.E.	MEAN	S.E.	CATCH	EFFORT
1965	0.1511	0.0140	1.159	0.137	3075	2652
1966	0.0828	0.0106	1.085	0.112	4185	3858
1967	0.0769	0.0115	1.078	0.115	2122	1969
1968	-0.0911	0.0096	0.912	0.089	4180	4583
1969	-0.2553	0.0066	0.775	0.063	10494	13540
1970	-0.2438	0.0035	0.785	0.047	22814	29053
1971	-0.2768	0.0034	0.760	0.044	24206	31861
1972	-0.3963	0.0032	0.674	0.038	26939	39952
1973	-0.2835	0.0031	0.755	0.042	28492	37745
1974	-0.6961	0.0037	0.499	0.030	17053	34141
1975	-0.6964	0.0034	0.499	0.029	18458	36961
1976	-0.7852	0.0051	0.457	0.032	7910	17323
1977	-0.6105	0.0041	0.544	0.035	11295	20764
1978	-0.5800	0.0033	0.561	0.032	15091	26897
1979	-0.5447	0.0033	0.581	0.033	18116	31168
1980	-0.4391	0.0047	0.646	0.044	12011	18607
1981	-0.4340	0.0046	0.649	0.044	14122	21764
1982	-0.5359	0.0054	0.586	0.043	11479	19596
1983	-0.3953	0.0050	0.674	0.048	9085	13473
1984	-0.4287	0.0052	0.652	0.047	12437	19071
1985	-0.4062	0.0043	0.667	0.044	13440	20142
1986	-0.7089	0.0045	0.493	0.033	14168	28742
1987	-0.6657	0.0044	0.515	0.034	13420	26073
1988	-0.7435	0.0050	0.476	0.034	10607	22281
1989	-0.7424	0.0078	0.476	0.042	5009	10525
1990	-0.5986	0.0068	0.550	0.045	4966	9033
1991	-1.2565	0.0065	0.285	0.023	6642	23323
1992	-1.1108	0.0073	0.329	0.028	6809	20674
1993	-0.6192	0.0063	0.539	0.043	6697	12432
1998	-0.1197	0.0099	0.886	0.088	3739	4219
1999	-0.0283	0.0087	0.971	0.090	5413	5572
2000	0.0658	0.0053	1.069	0.078	9425	8815
2001	-0.1681	0.0052	0.846	0.061	12240	14464

AVERAGE C.V. FOR THE RETRANSFORMED MEAN: 0.075

Table 5. A comparison of spring and fall abundance and biomass estimates derived from annual bottom trawl surveys in Div. 3LNO (SCR Doc. 02/43)

	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	81.0	.	**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
2000	287.5	335.0	**2000**	922.5	1152.3
2001	366.0	475.8	**2001**	1328.5	1651.9

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
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
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
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
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
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
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
7+	279.7	192.6	216.6	176.9	135.2	85.4	125.3	91.2	59.2	110.5	66.8	84.1	195.7
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**
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**
Age 5+	**506.3**	**319.4**	**314.0**	**273.1**	**172.2**	**239.0**	**276.2**	**254.0**	**143.1**	**207.1**	**136.0**	**165.8**	**392.3**
Age 7+	**279.7**	**192.6**	**216.6**	**176.9**	**135.2**	**85.4**	**125.3**	**91.2**	**59.2**	**110.5**	**66.8**	**84.1**	**195.7**

Table 6A continued

Age	1997	1998	1999	2000	2001	*Average*
1	0.5	1.5	1.0	5.3	1.1	***0.8***
2	7.3	18.3	63.5	23.2	16.0	***10.0***
3	71.3	22.9	70.4	65.2	39.5	***27.8***
4	152.8	93.0	116.4	63.9	172.9	***78.5***
5	165.1	243.8	290.4	150.2	243.6	***100.8***
6	116.8	190.9	401.2	381.2	465.7	***134.0***
7+	181.7	163.0	346.0	233.6	389.8	***174.1***
Age 1+	695.5	733.3	1288.9	922.5	1328.6	***526.1***
Age 1-4	231.8	135.6	251.2	157.5	229.6	***117.2***
Age 5+	463.7	597.7	1037.7	765.0	1099.1	***409.0***
Age 7+	181.7	163.0	346.0	233.6	389.8	***174.1***

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

Age	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	*Average*
1						8.8	0.9	2.7	6.7	2.8	11.0	1.6	***4.9***
2	1.3	1.6	1.2	0.9	2.3	83.9	17.8	7.9	12.6	35.2	20.6	16.7	***27.8***
3	11.3	37.2	18.6	6.6	5.9	122.4	63.6	44.4	26.3	72.6	85.8	75.6	***47.5***
4	28.9	64.5	53.5	74.4	38.5	89.7	132.6	125.7	75.0	70.3	93.8	250.0	***91.4***
5	44.3	46.9	34.0	104.5	48.4	70.6	145.1	204.9	243.8	213.4	185.5	279.4	***135.1***
6	38.5	61.2	33.7	77.5	70.9	87.7	97.9	178.9	256.5	323.3	414.7	526.6	***180.6***
7+	68.2	85.6	75.9	108.0	121.9	129.1	122.0	217.4	207.4	222.6	341.2	502.0	***183.4***
age1+	192.5	297.1	217.0	372.0	287.9	592.2	579.9	781.8	828.3	940.2	1152.5	1651.9	***657.8***
ages1-4	41.5	103.3	73.4	82.0	46.7	304.8	214.9	180.6	120.5	180.9	211.1	343.9	***158.6***
age 5+	151.0	193.7	143.6	290.0	241.3	287.4	365.0	601.1	707.8	759.3	941.4	1308.0	***499.1***
age7+	68.2	85.6	75.9	108.0	121.9	129.1	122.0	217.4	207.4	222.6	341.2	502.0	***183.4***

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	2000	2001
1													0.0	0.0	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	0.3	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	2.7	3.0	1.6
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	5.7	14.9
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	49.8	26.9	41.2
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	113.6	128.2
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	120.4	121.4
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**	**270.0**	**307.5**
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**	**9.1**	**16.7**
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**	**260.9**	**290.8**
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**	**120.4**	**121.4**

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

Age	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1						0.0	0.0	0.0	0.0	0.0	0.1	0.0
2	0.0	0.0	0.0	0.0	0.0	1.2	0.2	0.1	0.2	0.6	0.4	0.3
3	1.0	1.9	1.0	0.3	0.3	4.9	2.6	1.8	1.0	2.7	4.5	3.9
4	3.6	5.8	5.3	8.5	4.1	8.4	12.6	12.2	7.0	6.4	8.6	24.7
5	8.9	8.5	6.0	19.6	9.1	12.8	24.5	35.0	41.6	36.4	32.1	52.0
6	13.6	18.3	10.2	24.2	22.4	27.6	29.3	51.4	70.6	89.0	115.9	149.3
7+	37.1	47.4	41.2	61.4	70.1	70.7	65.4	112.6	102.3	113.2	160.1	240.8
age1+	**64.3**	**82.0**	**63.7**	**114.0**	**106.0**	**125.6**	**134.7**	**213.1**	**222.6**	**248.3**	**321.6**	**471.0**
ages1-4	**4.7**	**7.8**	**6.4**	**8.8**	**4.4**	**14.5**	**15.4**	**14.2**	**8.2**	**9.7**	**13.6**	**28.9**
age 5+	**59.6**	**74.3**	**57.4**	**105.2**	**101.6**	**111.0**	**119.2**	**199.0**	**214.4**	**238.6**	**308.0**	**442.2**
age7+	**37.1**	**47.4**	**41.2**	**61.4**	**70.1**	**70.7**	**65.4**	**112.6**	**102.3**	**113.2**	**160.1**	**240.8**

Table 8. Percentage of juvenile yellowtail flounder (ages 0-3) found in the Southeast Shoal area in relation to the total numbers in Div. 3NO, 1988-1994 fall juvenile groundfish surveys and 1995-2001 fall Campelen surveys.

Stratum	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	Mean	SD
375	17.7	14.4	8.5	5.7	6.6	0.4	10.1	17.0	15.5	6.9	10.9	7.7	9.5	12.6	10.24	4.82
376	37.8	44.5	54.8	65.2	40.2	30.0	57.8	30.0	37.9	55.2	23.7	14.6	37.4	41.1	40.73	13.97
360	21.9	23.1	24.7	15.4	36.3	43.9	14.9	11.7	15.1	4.0	13.6	6.8	10.5	0.7	17.33	11.91
361	11.6	9.8	8.9	7.8	7.5	11.2	10.5	12.2	14.4	4.1	22.4	13.5	3.4	14.5	10.84	4.77
Total	**89.0**	**91.7**	**97.0**	**94.0**	**90.5**	**85.5**	**93.3**	**70.9**	**82.9**	**70.1**	**70.7**	**42.6**	**60.8**	**68.9**	79.13	15.63
Mean	22.2	22.9	24.2	23.5	22.6	21.4	23.3	17.7	20.7	17.5	17.7	10.7	15.2	17.2		
SD	11.2	15.4	21.7	28.1	18.1	19.4	23.1	8.5	11.5	25.1	6.3	4.0	15.1	17.0		

Table 9. 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
2000	3.17	-5.32
2001	3.09	-5.20

Table 10. Input data for ASPIC model.

Year	Nominal catch (000 t)	Yankee survey (000 t)	Russian survey (000 t)	Campelen spring (000 t)	Campelen fall (000 t)	Spain survey (000 t)
1965	3.130					
1966	7.026					
1967	8.878					
1968	13.340					
1969	15.708					
1970	26.426					
1971	37.342	96.9				
1972	39.259	79.2	106.0			
1973	32.815	51.7	217.0			
1974	24.313	40.3	129.0			
1975	22.894	37.4	126.0			
1976	8.057	41.7	131.0			
1977	11.638	65.0	188.0			
1978	15.466	44.3	110.0			
1979	18.351	38.5	98.0			
1980	12.377	51.4	164.0			
1981	14.680	45.0	158.0			
1982	13.319	43.1	125.0			
1983	10.473					
1984	16.735		132.0	217.7		
1985	28.963		85.0	146.8		
1986	30.176		42.0	138.2		
1987	16.314		30.0	124.6		
1988	16.158		23.0	81.0		
1989	10.207		44.0	103.8		
1990	13.986		27.0	103.1	66.4	
1991	16.203		27.5	93.4	82.8	
1992	10.762			61.4	64.2	
1993	13.565			63.3	114.8	
1994	2.069			55.6	106.8	
1995	0.067			70.6	126.8	27.7
1996	0.287			175.6	136.0	129.6
1997	0.800			174.9	215.0	115.7
1998	4.348			202.2	231.6	425.4
1999	6.561			365.7	246.9	589.2
2000	11.121			287.5	335.0	432.7
2001	14.147			366.0	475.8	597.2
2002	*14.300					

* assumes Catch in 2003 = TAC + 10% over-run

Table 11 . Results of ASPIC model, assuming catch in 2003 = TAC + 10%.

```
3LNO yellowtail flounder (biomass in kt) 10% overrun in 2002 fishery                                    Page 1
                                                                                         09 Jun 2002 at 19:06.10
ASPIC -- A Surplus-Production Model Including Covariates (Ver. 3.91)                                  FIT Mode

Author: Michael H. Prager; NOAA/NMFS/S.E. Fisheries Science Center                         ASPIC User's Manual
        101 Pivers Island Road; Beaufort, North Carolina  28516  USA                         is available gratis
                                                                                             from the author.
Ref:    Prager, M. H.  1994.  A suite of extensions to a nonequilibrium
        surplus-production model.  Fishery Bulletin 92: 374-389.

CONTROL PARAMETERS USED (FROM INPUT FILE)
--------------------------------------------------------------------------------------------------------------
Number of years analyzed:                      38           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-08           Lower bound on r:                        1.000E-01
Relative conv. criterion (restart):     3.000E-08           Upper bound on r:                        5.000E+00
Relative conv. criterion (effort):      1.000E-04           Random number seed:                        9114894
Maximum F allowed in fitting:               8.000           Monte Carlo search mode, trials:        2    50000

PROGRAM STATUS INFORMATION (NON-BOOTSTRAPPED ANALYSIS)                                                 code  0
--------------------------------------------------------------------------------------------------------------
Normal convergence.

CORRELATION AMONG INPUT SERIES EXPRESSED AS CPUE (NUMBER OF PAIRWISE OBSERVATIONS BELOW)
--------------------------------------------------------------------------------------------------------------
                                       |
 1  Fishery-catch/Spring biomass       |   1.000
                                       |      18
                                       |
 2  Canadian Yankee Survey             |   0.000   1.000
                                       |       0      12
                                       |
 3  Canadian Fall Survey               |   0.884   0.000   1.000
                                       |      12       0      12
                                       |
 4  Russian Survey                     |   0.933   0.198   1.000   1.000
                                       |       8      11       2      19
                                       |
 5  Spanish Survey                     |   0.935   0.000   0.785   0.000   1.000
                                       |       7       0       7       0       7
                                       ------------------------------------------------
                                               1       2       3       4       5

GOODNESS-OF-FIT AND WEIGHTING FOR NON-BOOTSTRAPPED ANALYSIS
--------------------------------------------------------------------------------------------------------------
                                                 Weighted            Weighted      Current    Suggested    R-squared
Loss component number and title                       SSE    N            MSE       weight       weight      in CPUE

Loss(-1)  SSE in yield                          0.000E+00
Loss( 0)  Penalty for B1R > 2                   4.715E-03    1            N/A    1.000E+00          N/A
Loss( 1)  Fishery-catch/Spring biomass          7.639E-01   18      4.774E-02    1.000E+00    1.403E+00        0.845
Loss( 2)  Canadian Yankee Survey                2.671E-01   12      2.671E-02    1.000E+00    2.508E+00        0.805
Loss( 3)  Canadian Fall Survey                  1.062E+00   12      1.062E-01    1.000E+00    6.307E-01        0.829
Loss( 4)  Russian Survey                        5.029E+00   19      2.958E-01    1.000E+00    2.265E-01        0.286
Loss( 5)  Spanish Survey                        3.055E+00    7      6.110E-01    1.000E+00    1.097E-01        0.425
TOTAL OBJECTIVE FUNCTION:                   1.01824135E+01

NOTE: B1/Bmsy constraint term contributing to loss. Sensitivity analysis advised.

Number of restarts required for convergence:             19
Est. B/Bmsy coverage index (0 worst, 2 best):        1.7960               < These two measures are defined in Prager
Est. B/Bmsy 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 B/Bmsy, year 1965            2.142E+00          2.000E+00            1            1
MSY       Maximum sustainable yield             1.779E+01          1.300E+01            1            1
r         Intrinsic rate of increase            4.529E-01          5.000E-01            1            1
........  Catchability coefficients by fishery:
q( 1)     Fishery-catch/Spring biomass          3.330E+00          3.000E+00            1            1
q( 2)     Canadian Yankee Survey                8.607E-01          1.000E+00            1            1
q( 3)     Canadian Fall Survey                  3.725E+00          3.000E+00            1            1
q( 4)     Russian Survey                        1.735E+00          1.000E+00            1            1
q( 5)     Spanish Survey                        3.919E+00          3.000E+00            1            1

MANAGEMENT PARAMETER ESTIMATES (NON-BOOTSTRAPPED)
--------------------------------------------------------------------------------------------------------------
Parameter                                        Estimate            Formula        Related quantity

MSY       Maximum sustainable yield             1.779E+01               Kr/4
K         Maximum stock biomass                 1.571E+02
Bmsy      Stock biomass at MSY                  7.856E+01                K/2
Fmsy      Fishing mortality at MSY              2.265E-01                r/2

F(0.1)    Management benchmark                  2.038E-01           0.9*Fmsy
Y(0.1)    Equilibrium yield at F(0.1)           1.761E+01           0.99*MSY

B./Bmsy   Ratio of B(2003) to Bmsy              1.209E+00
F./Fmsy   Ratio of F(2002) to Fmsy              6.746E-01
F01-mult  Ratio of F(0.1) to F(2002)            1.334E+00
Ye./MSY   Proportion of MSY avail in 2003       9.564E-01        2*Br-Br^2     Ye(2003) = 1.702E+01

........  Fishing effort at MSY in units of each fishery:
fmsy( 1)  Fishery-catch/Spring biomass          6.802E-02          r/2q( 1)       f(0.1) = 6.122E-023LNO yellowtail flounder
```

(biomass in kt) 10% overrun in 2002 fishery Page 2

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	0.019	1.683E+02	1.646E+02	3.130E+00	3.130E+00	-3.582E+00	8.394E-02	2.142E+00
2	1966	0.045	1.616E+02	1.576E+02	7.026E+00	7.026E+00	-2.474E-01	1.968E-01	2.057E+00
3	1967	0.059	1.543E+02	1.510E+02	8.878E+00	8.878E+00	2.674E+00	2.597E-01	1.964E+00
4	1968	0.093	1.481E+02	1.439E+02	1.334E+01	1.334E+01	5.483E+00	4.095E-01	1.885E+00
5	1969	0.115	1.402E+02	1.362E+02	1.571E+01	1.571E+01	8.198E+00	5.092E-01	1.785E+00
6	1970	0.212	1.327E+02	1.247E+02	2.643E+01	2.643E+01	1.159E+01	9.356E-01	1.690E+00
7	1971	0.352	1.179E+02	1.060E+02	3.734E+01	3.734E+01	1.550E+01	1.555E+00	1.501E+00
8	1972	0.466	9.605E+01	8.432E+01	3.926E+01	3.926E+01	1.758E+01	2.056E+00	1.223E+00
9	1973	0.497	7.438E+01	6.606E+01	3.281E+01	3.281E+01	1.728E+01	2.193E+00	9.468E-01
10	1974	0.446	5.885E+01	5.454E+01	2.431E+01	2.431E+01	1.611E+01	1.969E+00	7.491E-01
11	1975	0.494	5.064E+01	4.639E+01	2.289E+01	2.289E+01	1.479E+01	2.179E+00	6.447E-01
12	1976	0.176	4.254E+01	4.585E+01	8.057E+00	8.057E+00	1.470E+01	7.758E-01	5.415E-01
13	1977	0.227	4.918E+01	5.120E+01	1.164E+01	1.164E+01	1.563E+01	1.004E+00	6.261E-01
14	1978	0.289	5.317E+01	5.343E+01	1.547E+01	1.547E+01	1.597E+01	1.278E+00	6.769E-01
15	1979	0.350	5.368E+01	5.237E+01	1.835E+01	1.835E+01	1.581E+01	1.547E+00	6.833E-01
16	1980	0.234	5.114E+01	5.292E+01	1.238E+01	1.238E+01	1.589E+01	1.033E+00	6.510E-01
17	1981	0.265	5.466E+01	5.546E+01	1.468E+01	1.468E+01	1.625E+01	1.169E+00	6.958E-01
18	1982	0.230	5.623E+01	5.788E+01	1.332E+01	1.332E+01	1.656E+01	1.016E+00	7.158E-01
19	1983	0.167	5.947E+01	6.280E+01	1.047E+01	1.047E+01	1.707E+01	7.363E-01	7.570E-01
20	1984	0.252	6.606E+01	6.638E+01	1.673E+01	1.673E+01	1.736E+01	1.113E+00	8.409E-01
21	1985	0.481	6.669E+01	6.022E+01	2.896E+01	2.896E+01	1.679E+01	2.124E+00	8.489E-01
22	1986	0.653	5.451E+01	4.618E+01	3.018E+01	3.018E+01	1.471E+01	2.885E+00	6.939E-01
23	1987	0.438	3.905E+01	3.727E+01	1.631E+01	1.631E+01	1.287E+01	1.933E+00	4.970E-01
24	1988	0.484	3.561E+01	3.340E+01	1.616E+01	1.616E+01	1.191E+01	2.136E+00	4.532E-01
25	1989	0.319	3.136E+01	3.203E+01	1.021E+01	1.021E+01	1.155E+01	1.407E+00	3.991E-01
26	1990	0.446	3.270E+01	3.135E+01	1.399E+01	1.399E+01	1.136E+01	1.970E+00	4.162E-01
27	1991	0.603	3.008E+01	2.686E+01	1.620E+01	1.620E+01	1.008E+01	2.664E+00	3.829E-01
28	1992	0.468	2.395E+01	2.299E+01	1.076E+01	1.076E+01	8.889E+00	2.067E+00	3.049E-01
29	1993	0.719	2.208E+01	1.886E+01	1.356E+01	1.356E+01	7.509E+00	3.176E+00	2.810E-01
30	1994	0.111	1.602E+01	1.859E+01	2.069E+00	2.069E+00	7.418E+00	4.914E-01	2.040E-01
31	1995	0.003	2.137E+01	2.600E+01	6.700E-02	6.700E-02	9.804E+00	1.138E-02	2.720E-01
32	1996	0.008	3.111E+01	3.713E+01	2.870E-01	2.870E-01	1.280E+01	3.413E-02	3.960E-01
33	1997	0.016	4.363E+01	5.081E+01	8.000E-01	8.000E-01	1.552E+01	6.953E-02	5.553E-01
34	1998	0.067	5.834E+01	6.476E+01	4.348E+00	4.348E+00	1.720E+01	2.965E-01	7.427E-01
35	1999	0.085	7.120E+01	7.687E+01	6.561E+00	6.561E+00	1.775E+01	3.769E-01	9.063E-01
36	2000	0.130	8.239E+01	8.574E+01	1.112E+01	1.112E+01	1.763E+01	5.727E-01	1.049E+00
37	2001	0.156	8.890E+01	9.058E+01	1.415E+01	1.415E+01	1.737E+01	6.897E-01	1.132E+00
38	2002	0.153	9.213E+01	9.360E+01	1.430E+01	1.430E+01	1.714E+01	6.746E-01	1.173E+00
39	2003		9.496E+01						1.209E+00

3LNO yellowtail flounder (biomass in kt) 10% overrun in 2002 fishery Page 3

RESULTS FOR DATA SERIES # 1 (NON-BOOTSTRAPPED) Fishery-catch/Spring biomass

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

Obs	Year	Observed CPUE	Estimated CPUE	Estim F	Observed yield	Model yield	Resid in log scale	Resid in log yield
1	1965	*	5.482E+02	0.0190	3.130E+00	3.130E+00	0.00000	0.000E+00
2	1966	*	5.248E+02	0.0446	7.026E+00	7.026E+00	0.00000	0.000E+00
3	1967	*	5.026E+02	0.0588	8.878E+00	8.878E+00	0.00000	0.000E+00
4	1968	*	4.790E+02	0.0927	1.334E+01	1.334E+01	0.00000	0.000E+00
5	1969	*	4.535E+02	0.1153	1.571E+01	1.571E+01	0.00000	0.000E+00
6	1970	*	4.153E+02	0.2119	2.643E+01	2.643E+01	0.00000	0.000E+00
7	1971	*	3.531E+02	0.3521	3.734E+01	3.734E+01	0.00000	0.000E+00
8	1972	*	2.807E+02	0.4656	3.926E+01	3.926E+01	0.00000	0.000E+00
9	1973	*	2.200E+02	0.4967	3.281E+01	3.281E+01	0.00000	0.000E+00
10	1974	*	1.816E+02	0.4458	2.431E+01	2.431E+01	0.00000	0.000E+00
11	1975	*	1.544E+02	0.4936	2.289E+01	2.289E+01	0.00000	0.000E+00
12	1976	*	1.527E+02	0.1757	8.057E+00	8.057E+00	0.00000	0.000E+00
13	1977	*	1.705E+02	0.2273	1.164E+01	1.164E+01	0.00000	0.000E+00
14	1978	*	1.779E+02	0.2894	1.547E+01	1.547E+01	0.00000	0.000E+00
15	1979	*	1.744E+02	0.3504	1.835E+01	1.835E+01	0.00000	0.000E+00
16	1980	*	1.762E+02	0.2339	1.238E+01	1.238E+01	0.00000	0.000E+00
17	1981	*	1.847E+02	0.2647	1.468E+01	1.468E+01	0.00000	0.000E+00
18	1982	*	1.927E+02	0.2301	1.332E+01	1.332E+01	0.00000	0.000E+00
19	1983	*	2.091E+02	0.1668	1.047E+01	1.047E+01	0.00000	0.000E+00
20	1984	2.177E+02	2.210E+02	0.2521	1.673E+01	1.673E+01	0.01516	
21	1985	1.468E+02	2.005E+02	0.4810	2.896E+01	2.896E+01	0.31175	
22	1986	1.382E+02	1.538E+02	0.6535	3.018E+01	3.018E+01	0.10663	
23	1987	1.246E+02	1.241E+02	0.4377	1.631E+01	1.631E+01	-0.00414	
24	1988	8.100E+01	1.112E+02	0.4838	1.616E+01	1.616E+01	0.31698	
25	1989	1.038E+02	1.067E+02	0.3186	1.021E+01	1.021E+01	0.02713	
26	1990	1.031E+02	1.044E+02	0.4461	1.399E+01	1.399E+01	0.01235	
27	1991	9.340E+01	8.943E+01	0.6033	1.620E+01	1.620E+01	-0.04347	
28	1992	6.140E+01	7.655E+01	0.4681	1.076E+01	1.076E+01	0.22055	
29	1993	9.330E+01	6.280E+01	0.7192	1.356E+01	1.356E+01	-0.39588	
30	1994	5.560E+01	6.190E+01	0.1113	2.069E+00	2.069E+00	0.10739	
31	1995	7.060E+01	8.656E+01	0.0026	6.700E-02	6.700E-02	0.20375	
32	1996	1.756E+02	1.236E+02	0.0077	2.870E-01	2.870E-01	-0.35106	
33	1997	1.749E+02	1.692E+02	0.0157	8.000E-01	8.000E-01	-0.03332	
34	1998	2.022E+02	2.156E+02	0.0671	4.348E+00	4.348E+00	0.06424	
35	1999	3.657E+02	2.559E+02	0.0854	6.561E+00	6.561E+00	-0.35692	
36	2000	2.875E+02	2.855E+02	0.1297	1.112E+01	1.112E+01	-0.00708	
37	2001	3.660E+02	3.016E+02	0.1562	1.415E+01	1.415E+01	-0.19362	
38	2002	*	3.117E+02	0.1528	1.430E+01	1.430E+01	0.00000	0.000E+00

- Asterisk indicates missing value(s).

3LNO yellowtail flounder (biomass in kt) 10% overrun in 2002 fishery   Page 4

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UNWEIGHTED LOG RESIDUAL PLOT FOR DATA SERIES # 1
                   -1       -0.75     -0.5      -0.25       0        0.25      0.5       0.75        1
                    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |
Year   Residual    ------------------------------------------------------------------------------------
1965     0.0000                                             |
1966     0.0000                                             |
1967     0.0000                                             |
1968     0.0000                                             |
1969     0.0000                                             |
1970     0.0000                                             |
1971     0.0000                                             |
1972     0.0000                                             |
1973     0.0000                                             |
1974     0.0000                                             |
1975     0.0000                                             |
1976     0.0000                                             |
1977     0.0000                                             |
1978     0.0000                                             |
1979     0.0000                                             |
1980     0.0000                                             |
1981     0.0000                                             |
1982     0.0000                                             |
1983     0.0000                                             |
1984     0.0152                                             |=
1985     0.3118                                             |============
1986     0.1066                                             |====
1987    -0.0041                                             |
1988     0.3170                                             |=============
1989     0.0271                                             |=
1990     0.0123                                             |
1991    -0.0435                                           ==|
1992     0.2206                                             |=========
1993    -0.3959                             ================|
1994     0.1074                                             |====
1995     0.2038                                             |========
1996    -0.3511                               ==============|
1997    -0.0333                                            =|
1998     0.0642                                             |===
1999    -0.3569                               ==============|
2000    -0.0071                                             |
2001    -0.1936                                     ========|
2002     0.0000                                             |
                   ------------------------------------------------------------------------------------
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3LNO yellowtail flounder (biomass in kt) 10% overrun in 2002 fishery   Page 5

RESULTS FOR DATA SERIES # 2 (NON-BOOTSTRAPPED)   Canadian Yankee Survey

Data type I1: Year-average biomass index   Series weight: 1.000

Obs	Year	Observed effort	Estimated effort	Estim F	Observed index	Model index	Resid in log index	Resid in index
1	1965	0.000E+00	0.000E+00	0.0	*	1.417E+02	0.00000	0.0
2	1966	0.000E+00	0.000E+00	0.0	*	1.357E+02	0.00000	0.0
3	1967	0.000E+00	0.000E+00	0.0	*	1.299E+02	0.00000	0.0
4	1968	0.000E+00	0.000E+00	0.0	*	1.238E+02	0.00000	0.0
5	1969	0.000E+00	0.000E+00	0.0	*	1.172E+02	0.00000	0.0
6	1970	0.000E+00	0.000E+00	0.0	*	1.074E+02	0.00000	0.0
7	1971	1.000E+00	1.000E+00	0.0	9.690E+01	9.128E+01	0.05979	5.624E+00
8	1972	1.000E+00	1.000E+00	0.0	7.920E+01	7.257E+01	0.08739	6.628E+00
9	1973	1.000E+00	1.000E+00	0.0	5.170E+01	5.686E+01	-0.09516	-5.161E+00
10	1974	1.000E+00	1.000E+00	0.0	4.030E+01	4.694E+01	-0.15251	-6.639E+00
11	1975	1.000E+00	1.000E+00	0.0	3.740E+01	3.992E+01	-0.06532	-2.524E+00
12	1976	1.000E+00	1.000E+00	0.0	4.170E+01	3.947E+01	0.05501	2.232E+00
13	1977	1.000E+00	1.000E+00	0.0	6.500E+01	4.407E+01	0.38861	2.093E+01
14	1978	1.000E+00	1.000E+00	0.0	4.430E+01	4.599E+01	-0.03744	-1.690E+00
15	1979	1.000E+00	1.000E+00	0.0	3.850E+01	4.507E+01	-0.15764	-6.573E+00
16	1980	1.000E+00	1.000E+00	0.0	5.140E+01	4.555E+01	0.12077	5.848E+00
17	1981	1.000E+00	1.000E+00	0.0	4.500E+01	4.774E+01	-0.05902	-2.736E+00
18	1982	1.000E+00	1.000E+00	0.0	4.310E+01	4.982E+01	-0.14482	-6.717E+00
19	1983	0.000E+00	0.000E+00	0.0	*	5.406E+01	0.00000	0.0
20	1984	0.000E+00	0.000E+00	0.0	*	5.714E+01	0.00000	0.0
21	1985	0.000E+00	0.000E+00	0.0	*	5.183E+01	0.00000	0.0
22	1986	0.000E+00	0.000E+00	0.0	*	3.975E+01	0.00000	0.0
23	1987	0.000E+00	0.000E+00	0.0	*	3.208E+01	0.00000	0.0
24	1988	0.000E+00	0.000E+00	0.0	*	2.875E+01	0.00000	0.0
25	1989	0.000E+00	0.000E+00	0.0	*	2.757E+01	0.00000	0.0
26	1990	0.000E+00	0.000E+00	0.0	*	2.698E+01	0.00000	0.0
27	1991	0.000E+00	0.000E+00	0.0	*	2.312E+01	0.00000	0.0
28	1992	0.000E+00	0.000E+00	0.0	*	1.979E+01	0.00000	0.0
29	1993	0.000E+00	0.000E+00	0.0	*	1.623E+01	0.00000	0.0
30	1994	0.000E+00	0.000E+00	0.0	*	1.600E+01	0.00000	0.0
31	1995	0.000E+00	0.000E+00	0.0	*	2.238E+01	0.00000	0.0
32	1996	0.000E+00	0.000E+00	0.0	*	3.195E+01	0.00000	0.0
33	1997	0.000E+00	0.000E+00	0.0	*	4.373E+01	0.00000	0.0
34	1998	0.000E+00	0.000E+00	0.0	*	5.574E+01	0.00000	0.0
35	1999	0.000E+00	0.000E+00	0.0	*	6.616E+01	0.00000	0.0
36	2000	0.000E+00	0.000E+00	0.0	*	7.380E+01	0.00000	0.0
37	2001	0.000E+00	0.000E+00	0.0	*	7.796E+01	0.00000	0.0
38	2002	0.000E+00	0.000E+00	0.0	*	8.057E+01	0.00000	0.0

Asterisk indicates missing value(s).

3LNO yellowtail flounder (biomass in kt) 10% overrun in 2002 fishery Page 6

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UNWEIGHTED LOG RESIDUAL PLOT FOR DATA SERIES # 2
                   -1      -0.75     -0.5     -0.25      0       0.25     0.5      0.75      1
                    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |
Year  Residual   ---------------------------------------------------------------------------------
1965    0.0000                                           |
1966    0.0000                                           |
1967    0.0000                                           |
1968    0.0000                                           |
1969    0.0000                                           |
1970    0.0000                                           |
1971    0.0598                                           |==
1972    0.0874                                           |===
1973   -0.0952                                       ====|
1974   -0.1525                                     ======|
1975   -0.0653                                        ===|
1976    0.0550                                           |==
1977    0.3886                                           |================
1978   -0.0374                                          =|
1979   -0.1576                                     ======|
1980    0.1208                                           |=====
1981   -0.0590                                         ==|
1982   -0.1448                                     ======|
1983    0.0000                                           |
1984    0.0000                                           |
1985    0.0000                                           |
1986    0.0000                                           |
1987    0.0000                                           |
1988    0.0000                                           |
1989    0.0000                                           |
1990    0.0000                                           |
1991    0.0000                                           |
1992    0.0000                                           |
1993    0.0000                                           |
1994    0.0000                                           |
1995    0.0000                                           |
1996    0.0000                                           |
1997    0.0000                                           |
1998    0.0000                                           |
1999    0.0000                                           |
2000    0.0000                                           |
2001    0.0000                                           |
2002    0.0000                                           |
                 ---------------------------------------------------------------------------------
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3LNO yellowtail flounder (biomass in kt) 10% overrun in 2002 fishery Page 7

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

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

Obs	Year	Observed effort	Estimated effort	Estim F	Observed index	Model index	Resid in log index	Resid in index
1	1965	0.000E+00	0.000E+00	0.0	*	6.019E+02	0.00000	0.0
2	1966	0.000E+00	0.000E+00	0.0	*	5.748E+02	0.00000	0.0
3	1967	0.000E+00	0.000E+00	0.0	*	5.517E+02	0.00000	0.0
4	1968	0.000E+00	0.000E+00	0.0	*	5.224E+02	0.00000	0.0
5	1969	0.000E+00	0.000E+00	0.0	*	4.944E+02	0.00000	0.0
6	1970	0.000E+00	0.000E+00	0.0	*	4.392E+02	0.00000	0.0
7	1971	0.000E+00	0.000E+00	0.0	*	3.578E+02	0.00000	0.0
8	1972	0.000E+00	0.000E+00	0.0	*	2.771E+02	0.00000	0.0
9	1973	0.000E+00	0.000E+00	0.0	*	2.192E+02	0.00000	0.0
10	1974	0.000E+00	0.000E+00	0.0	*	1.887E+02	0.00000	0.0
11	1975	0.000E+00	0.000E+00	0.0	*	1.585E+02	0.00000	0.0
12	1976	0.000E+00	0.000E+00	0.0	*	1.832E+02	0.00000	0.0
13	1977	0.000E+00	0.000E+00	0.0	*	1.981E+02	0.00000	0.0
14	1978	0.000E+00	0.000E+00	0.0	*	2.000E+02	0.00000	0.0
15	1979	0.000E+00	0.000E+00	0.0	*	1.905E+02	0.00000	0.0
16	1980	0.000E+00	0.000E+00	0.0	*	2.036E+02	0.00000	0.0
17	1981	0.000E+00	0.000E+00	0.0	*	2.095E+02	0.00000	0.0
18	1982	0.000E+00	0.000E+00	0.0	*	2.215E+02	0.00000	0.0
19	1983	0.000E+00	0.000E+00	0.0	*	2.461E+02	0.00000	0.0
20	1984	0.000E+00	0.000E+00	0.0	*	2.484E+02	0.00000	0.0
21	1985	0.000E+00	0.000E+00	0.0	*	2.031E+02	0.00000	0.0
22	1986	0.000E+00	0.000E+00	0.0	*	1.455E+02	0.00000	0.0
23	1987	0.000E+00	0.000E+00	0.0	*	1.326E+02	0.00000	0.0
24	1988	0.000E+00	0.000E+00	0.0	*	1.168E+02	0.00000	0.0
25	1989	0.000E+00	0.000E+00	0.0	*	1.218E+02	0.00000	0.0
26	1990	1.000E+00	1.000E+00	0.0	6.640E+01	1.120E+02	-0.52320	-4.564E+01
27	1991	1.000E+00	1.000E+00	0.0	8.280E+01	8.922E+01	-0.07471	-6.423E+00
28	1992	1.000E+00	1.000E+00	0.0	6.420E+01	8.225E+01	-0.24771	-1.805E+01
29	1993	1.000E+00	1.000E+00	0.0	1.148E+02	5.968E+01	0.65411	5.512E+01
30	1994	1.000E+00	1.000E+00	0.0	1.068E+02	7.961E+01	0.29382	2.719E+01
31	1995	1.000E+00	1.000E+00	0.0	1.268E+02	1.159E+02	0.09005	1.092E+01
32	1996	1.000E+00	1.000E+00	0.0	1.360E+02	1.625E+02	-0.17809	-2.651E+01
33	1997	1.000E+00	1.000E+00	0.0	2.150E+02	2.173E+02	-0.01084	-2.342E+00
34	1998	1.000E+00	1.000E+00	0.0	2.316E+02	2.652E+02	-0.13557	-3.363E+01
35	1999	1.000E+00	1.000E+00	0.0	2.499E+02	3.069E+02	-0.20552	-5.702E+01
36	2000	1.000E+00	1.000E+00	0.0	3.350E+02	3.312E+02	0.01149	3.826E+00
37	2001	1.000E+00	1.000E+00	0.0	4.758E+02	3.432E+02	0.32672	1.326E+02
38	2002	0.000E+00	0.000E+00	0.0	*	3.538E+02	0.00000	0.0

- Asterisk indicates missing value(s).

3LNO yellowtail flounder (biomass in kt) 10% overrun in 2002 fishery   Page 8

```
UNWEIGHTED LOG RESIDUAL PLOT FOR DATA SERIES # 3
                   -1       -0.75     -0.5      -0.25      0        0.25      0.5       0.75      1
                    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |
Year  Residual     ----------------------------------------------------------------------------------
1965     0.0000                                             |
1966     0.0000                                             |
1967     0.0000                                             |
1968     0.0000                                             |
1969     0.0000                                             |
1970     0.0000                                             |
1971     0.0000                                             |
1972     0.0000                                             |
1973     0.0000                                             |
1974     0.0000                                             |
1975     0.0000                                             |
1976     0.0000                                             |
1977     0.0000                                             |
1978     0.0000                                             |
1979     0.0000                                             |
1980     0.0000                                             |
1981     0.0000                                             |
1982     0.0000                                             |
1983     0.0000                                             |
1984     0.0000                                             |
1985     0.0000                                             |
1986     0.0000                                             |
1987     0.0000                                             |
1988     0.0000                                             |
1989     0.0000                                             |
1990    -0.5232                        =====================|
1991    -0.0747                                          ===|
1992    -0.2477                                   ==========|
1993     0.6541                                             |==========================
1994     0.2938                                             |============
1995     0.0900                                             |====
1996    -0.1781                                      =======|
1997    -0.0108                                             |
1998    -0.1356                                        =====|
1999    -0.2055                                     ========|
2000     0.0115                                             |
2001     0.3267                                             |=============
2002     0.0000                                             |
                   ----------------------------------------------------------------------------------
```

3LNO yellowtail flounder (biomass in kt) 10% overrun in 2002 fishery   Page 9

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

Data type I1: Year-average biomass index   Series weight: 1.000

Obs	Year	Observed effort	Estimated effort	Estim F	Observed index	Model index	Resid in log index	Resid in index
1	1965	0.000E+00	0.000E+00	0.0	*	2.856E+02	0.00000	0.0
2	1966	0.000E+00	0.000E+00	0.0	*	2.734E+02	0.00000	0.0
3	1967	0.000E+00	0.000E+00	0.0	*	2.618E+02	0.00000	0.0
4	1968	0.000E+00	0.000E+00	0.0	*	2.495E+02	0.00000	0.0
5	1969	0.000E+00	0.000E+00	0.0	*	2.363E+02	0.00000	0.0
6	1970	0.000E+00	0.000E+00	0.0	*	2.163E+02	0.00000	0.0
7	1971	0.000E+00	0.000E+00	0.0	*	1.839E+02	0.00000	0.0
8	1972	1.000E+00	1.000E+00	0.0	1.060E+02	1.463E+02	-0.32188	-4.025E+01
9	1973	1.000E+00	1.000E+00	0.0	2.170E+02	1.146E+02	0.63855	1.024E+02
10	1974	1.000E+00	1.000E+00	0.0	1.290E+02	9.459E+01	0.31022	3.441E+01
11	1975	1.000E+00	1.000E+00	0.0	1.260E+02	8.046E+01	0.44856	4.554E+01
12	1976	1.000E+00	1.000E+00	0.0	1.310E+02	7.954E+01	0.49897	5.146E+01
13	1977	1.000E+00	1.000E+00	0.0	1.880E+02	8.881E+01	0.74993	9.919E+01
14	1978	1.000E+00	1.000E+00	0.0	1.100E+02	9.268E+01	0.17132	1.732E+01
15	1979	1.000E+00	1.000E+00	0.0	9.800E+01	9.083E+01	0.07594	7.166E+00
16	1980	1.000E+00	1.000E+00	0.0	1.640E+02	9.180E+01	0.58026	7.220E+01
17	1981	1.000E+00	1.000E+00	0.0	1.580E+02	9.620E+01	0.49618	6.180E+01
18	1982	1.000E+00	1.000E+00	0.0	1.250E+02	1.004E+02	0.21923	2.461E+01
19	1983	0.000E+00	0.000E+00	0.0	*	1.089E+02	0.00000	0.0
20	1984	1.000E+00	1.000E+00	0.0	1.320E+02	1.151E+02	0.13662	1.686E+01
21	1985	1.000E+00	1.000E+00	0.0	8.500E+01	1.045E+02	-0.20608	-1.945E+01
22	1986	1.000E+00	1.000E+00	0.0	4.200E+01	8.010E+01	-0.64557	-3.810E+01
23	1987	1.000E+00	1.000E+00	0.0	3.000E+01	6.464E+01	-0.76768	-3.464E+01
24	1988	1.000E+00	1.000E+00	0.0	2.300E+01	5.794E+01	-0.92384	-3.494E+01
25	1989	1.000E+00	1.000E+00	0.0	4.400E+01	5.556E+01	-0.23331	-1.156E+01
26	1990	1.000E+00	1.000E+00	0.0	2.700E+01	5.438E+01	-0.70012	-2.738E+01
27	1991	1.000E+00	1.000E+00	0.0	2.750E+01	4.659E+01	-0.52714	-1.909E+01
28	1992	0.000E+00	0.000E+00	0.0	*	3.988E+01	0.00000	0.0
29	1993	0.000E+00	0.000E+00	0.0	*	3.272E+01	0.00000	0.0
30	1994	0.000E+00	0.000E+00	0.0	*	3.225E+01	0.00000	0.0
31	1995	0.000E+00	0.000E+00	0.0	*	4.509E+01	0.00000	0.0
32	1996	0.000E+00	0.000E+00	0.0	*	6.440E+01	0.00000	0.0
33	1997	0.000E+00	0.000E+00	0.0	*	8.813E+01	0.00000	0.0
34	1998	0.000E+00	0.000E+00	0.0	*	1.123E+02	0.00000	0.0
35	1999	0.000E+00	0.000E+00	0.0	*	1.333E+02	0.00000	0.0
36	2000	0.000E+00	0.000E+00	0.0	*	1.487E+02	0.00000	0.0
37	2001	0.000E+00	0.000E+00	0.0	*	1.571E+02	0.00000	0.0
38	2002	0.000E+00	0.000E+00	0.0	*	1.624E+02	0.00000	0.0

- Asterisk indicates missing value(s).

3LNO yellowtail flounder (biomass in kt) 10% overrun in 2002 fishery Page10

UNWEIGHTED LOG RESIDUAL PLOT FOR DATA SERIES # 4

```
                   -1      -0.75     -0.5     -0.25       0       0.25      0.5      0.75      1
                    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |
Year  Residual   ------------------------------------------------------------------------------------
1965     0.0000                                             |
1966     0.0000                                             |
1967     0.0000                                             |
1968     0.0000                                             |
1969     0.0000                                             |
1970     0.0000                                             |
1971     0.0000                                             |
1972    -0.3219                                =============|
1973     0.6385                                             |==========================
1974     0.3102                                             |============
1975     0.4486                                             |==================
1976     0.4990                                             |====================
1977     0.7499                                             |==============================
1978     0.1713                                             |=======
1979     0.0759                                             |===
1980     0.5803                                             |=======================
1981     0.4962                                             |====================
1982     0.2192                                             |=========
1983     0.0000                                             |
1984     0.1366                                             |=====
1985    -0.2061                                     ========|
1986    -0.6456                   ==========================|
1987    -0.7677              ===============================|
1988    -0.9238        =====================================|
1989    -0.2333                                    =========|
1990    -0.7001                 ============================|
1991    -0.5271                        =====================|
1992     0.0000                                             |
1993     0.0000                                             |
1994     0.0000                                             |
1995     0.0000                                             |
1996     0.0000                                             |
1997     0.0000                                             |
1998     0.0000                                             |
1999     0.0000                                             |
2000     0.0000                                             |
2001     0.0000                                             |
2002     0.0000                                             |
                 ------------------------------------------------------------------------------------
```

3LNO yellowtail flounder (biomass in kt) 10% overrun in 2002 fishery Page11

RESULTS FOR DATA SERIES # 5 (NON-BOOTSTRAPPED) Spanish Survey

Data type I1: Year-average biomass index Series weight: 1.000

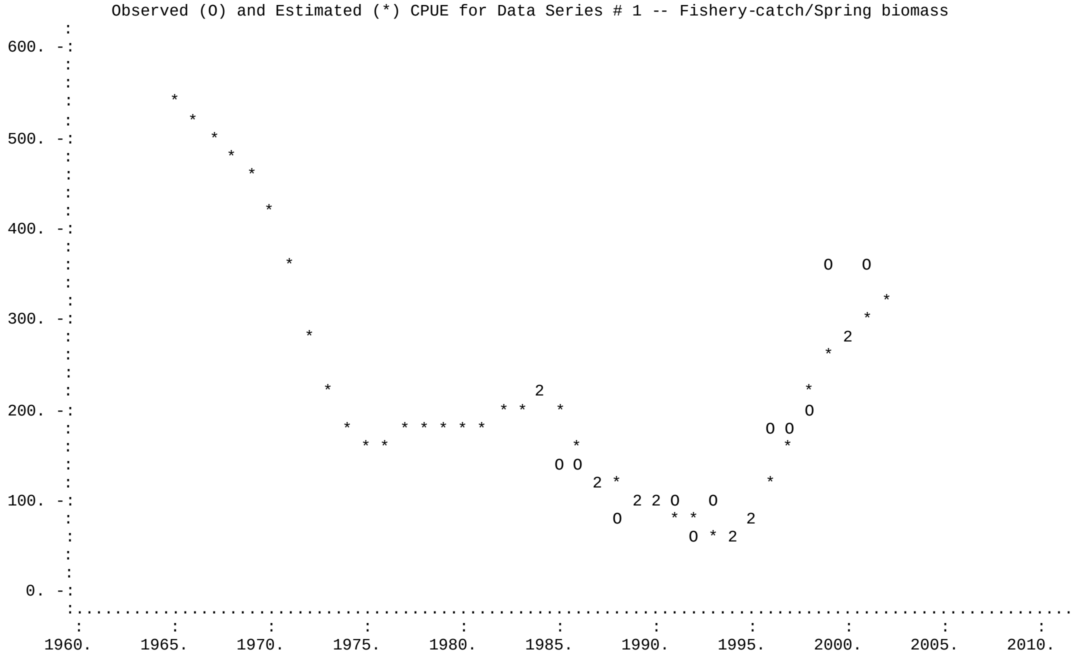
Obs	Year	Observed effort	Estimated effort	Estim F	Observed index	Model index	Resid in log index	Resid in index
1	1965	0.000E+00	0.000E+00	0.0	*	6.452E+02	0.00000	0.0
2	1966	0.000E+00	0.000E+00	0.0	*	6.178E+02	0.00000	0.0
3	1967	0.000E+00	0.000E+00	0.0	*	5.916E+02	0.00000	0.0
4	1968	0.000E+00	0.000E+00	0.0	*	5.638E+02	0.00000	0.0
5	1969	0.000E+00	0.000E+00	0.0	*	5.338E+02	0.00000	0.0
6	1970	0.000E+00	0.000E+00	0.0	*	4.888E+02	0.00000	0.0
7	1971	0.000E+00	0.000E+00	0.0	*	4.156E+02	0.00000	0.0
8	1972	0.000E+00	0.000E+00	0.0	*	3.304E+02	0.00000	0.0
9	1973	0.000E+00	0.000E+00	0.0	*	2.589E+02	0.00000	0.0
10	1974	0.000E+00	0.000E+00	0.0	*	2.137E+02	0.00000	0.0
11	1975	0.000E+00	0.000E+00	0.0	*	1.818E+02	0.00000	0.0
12	1976	0.000E+00	0.000E+00	0.0	*	1.797E+02	0.00000	0.0
13	1977	0.000E+00	0.000E+00	0.0	*	2.007E+02	0.00000	0.0
14	1978	0.000E+00	0.000E+00	0.0	*	2.094E+02	0.00000	0.0
15	1979	0.000E+00	0.000E+00	0.0	*	2.052E+02	0.00000	0.0
16	1980	0.000E+00	0.000E+00	0.0	*	2.074E+02	0.00000	0.0
17	1981	0.000E+00	0.000E+00	0.0	*	2.174E+02	0.00000	0.0
18	1982	0.000E+00	0.000E+00	0.0	*	2.268E+02	0.00000	0.0
19	1983	0.000E+00	0.000E+00	0.0	*	2.461E+02	0.00000	0.0
20	1984	0.000E+00	0.000E+00	0.0	*	2.602E+02	0.00000	0.0
21	1985	0.000E+00	0.000E+00	0.0	*	2.360E+02	0.00000	0.0
22	1986	0.000E+00	0.000E+00	0.0	*	1.810E+02	0.00000	0.0
23	1987	0.000E+00	0.000E+00	0.0	*	1.461E+02	0.00000	0.0
24	1988	0.000E+00	0.000E+00	0.0	*	1.309E+02	0.00000	0.0
25	1989	0.000E+00	0.000E+00	0.0	*	1.255E+02	0.00000	0.0
26	1990	0.000E+00	0.000E+00	0.0	*	1.229E+02	0.00000	0.0
27	1991	0.000E+00	0.000E+00	0.0	*	1.053E+02	0.00000	0.0
28	1992	0.000E+00	0.000E+00	0.0	*	9.010E+01	0.00000	0.0
29	1993	0.000E+00	0.000E+00	0.0	*	7.392E+01	0.00000	0.0
30	1994	0.000E+00	0.000E+00	0.0	*	7.286E+01	0.00000	0.0
31	1995	1.000E+00	1.000E+00	0.0	2.770E+01	1.019E+02	-1.30221	-7.418E+01
32	1996	1.000E+00	1.000E+00	0.0	1.296E+02	1.455E+02	-0.11538	-1.586E+01
33	1997	1.000E+00	1.000E+00	0.0	1.157E+02	1.991E+02	-0.54266	-8.339E+01
34	1998	1.000E+00	1.000E+00	0.0	4.254E+02	2.538E+02	0.51647	1.716E+02
35	1999	1.000E+00	1.000E+00	0.0	5.892E+02	3.012E+02	0.67087	2.880E+02
36	2000	1.000E+00	1.000E+00	0.0	4.327E+02	3.360E+02	0.25290	9.669E+01
37	2001	1.000E+00	1.000E+00	0.0	5.972E+02	3.550E+02	0.52023	2.422E+02
38	2002	0.000E+00	0.000E+00	0.0	*	3.668E+02	0.00000	0.0

- Asterisk indicates missing value(s).

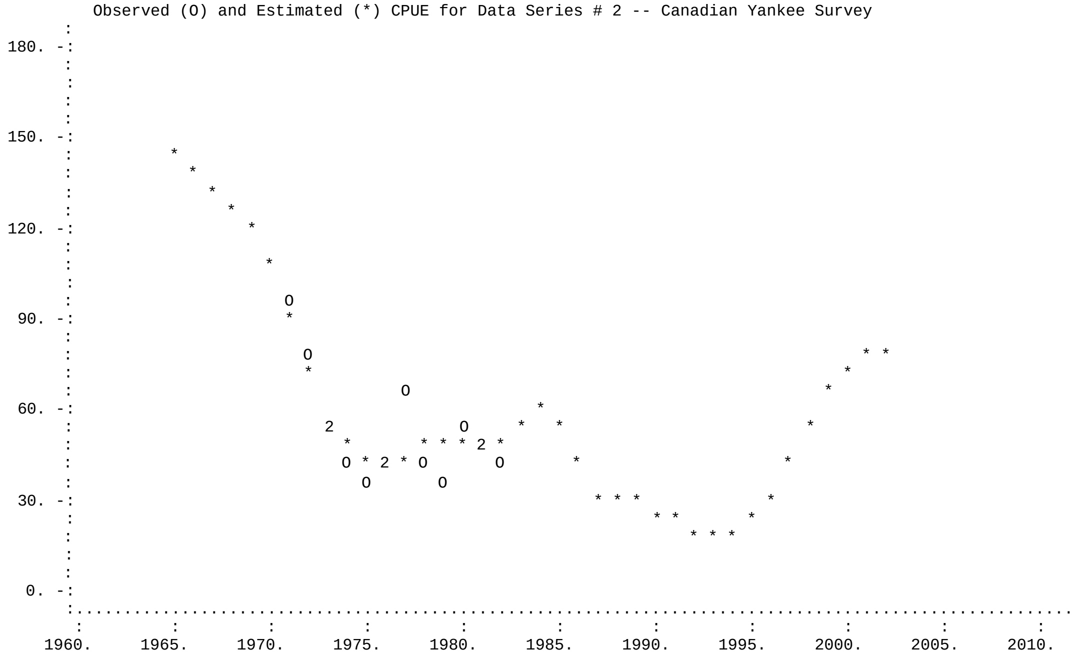
```
3LNO yellowtail flounder (biomass in kt) 10% overrun in 2002 fishery                                    Page12

UNWEIGHTED LOG RESIDUAL PLOT FOR DATA SERIES # 5
                   -2       -1.5       -1       -0.5        0        0.5        1       1.5        2
                    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |
Year   Residual    ------------------------------------------------------------------------------------
1965     0.0000                                             |
1966     0.0000                                             |
1967     0.0000                                             |
1968     0.0000                                             |
1969     0.0000                                             |
1970     0.0000                                             |
1971     0.0000                                             |
1972     0.0000                                             |
1973     0.0000                                             |
1974     0.0000                                             |
1975     0.0000                                             |
1976     0.0000                                             |
1977     0.0000                                             |
1978     0.0000                                             |
1979     0.0000                                             |
1980     0.0000                                             |
1981     0.0000                                             |
1982     0.0000                                             |
1983     0.0000                                             |
1984     0.0000                                             |
1985     0.0000                                             |
1986     0.0000                                             |
1987     0.0000                                             |
1988     0.0000                                             |
1989     0.0000                                             |
1990     0.0000                                             |
1991     0.0000                                             |
1992     0.0000                                             |
1993     0.0000                                             |
1994     0.0000                                             |
1995    -1.3022                   ==========================|
1996    -0.1154                                           ==|
1997    -0.5427                                  ===========|
1998     0.5165                                             |==========
1999     0.6709                                             |=============
2000     0.2529                                             |=====
2001     0.5202                                             |==========
2002     0.0000                                             |
                   ------------------------------------------------------------------------------------
```

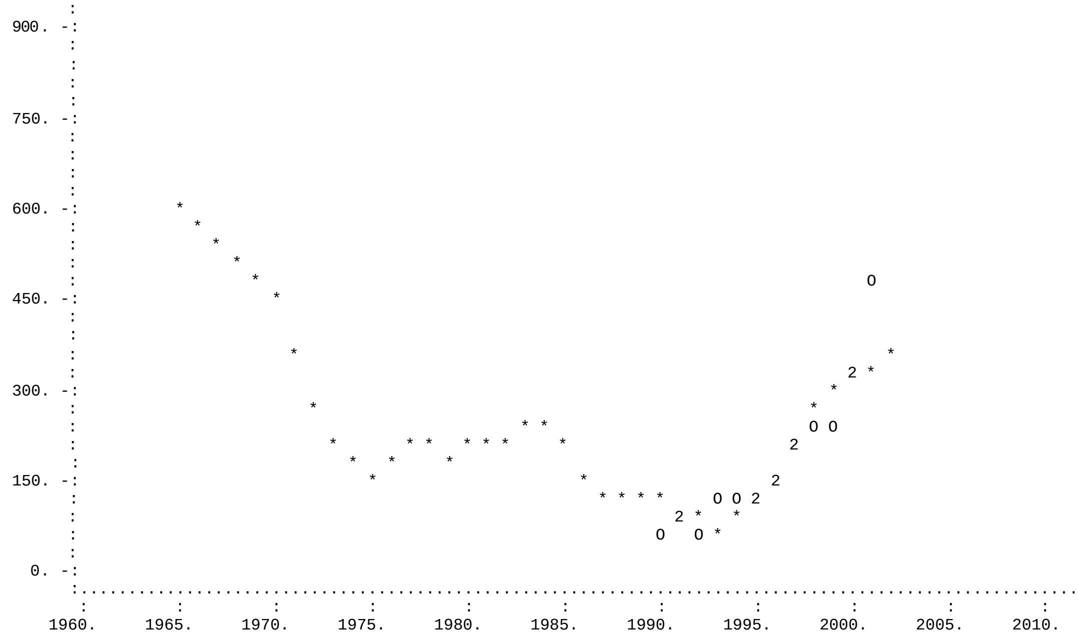
Observed (O) and Estimated (*) CPUE for Data Series # 1 -- Fishery-catch/Spring biomass



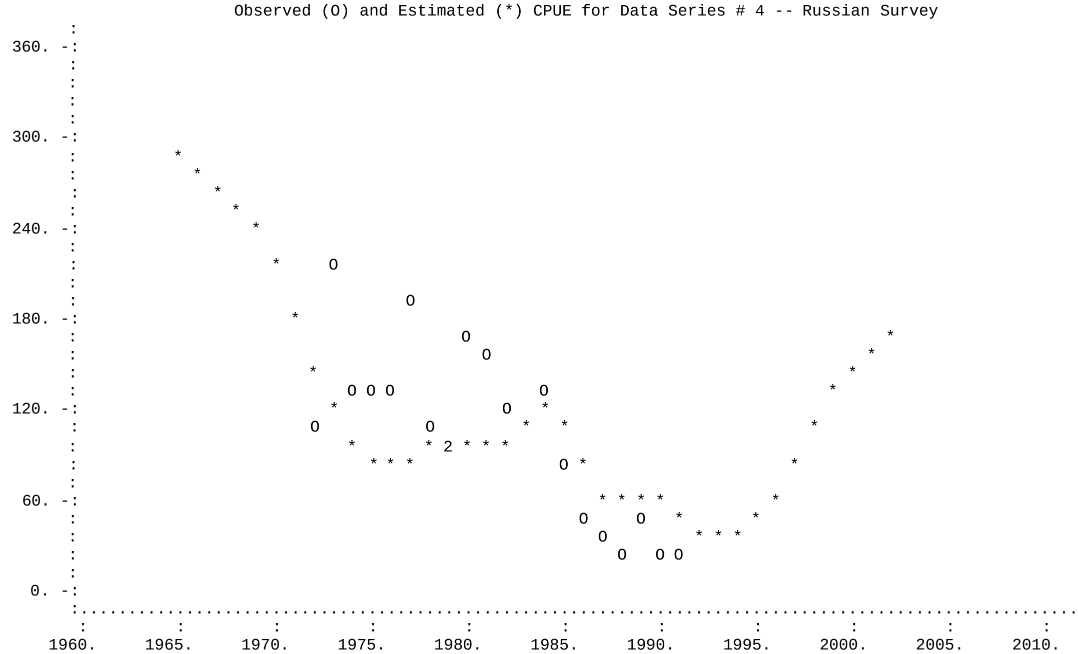
Observed (O) and Estimated (*) CPUE for Data Series # 2 -- Canadian Yankee Survey



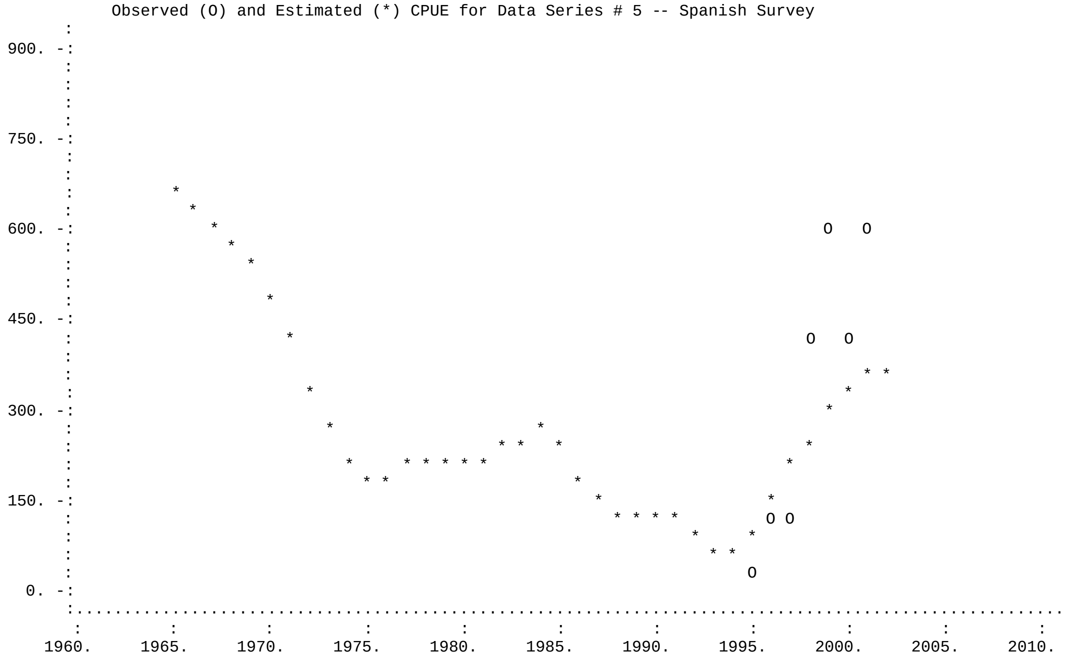
Observed (O) and Estimated (*) CPUE for Data Series # 3 -- Canadian Fall Survey



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



Observed (O) and Estimated (*) CPUE for Data Series # 5 -- Spanish Survey



Time Plot of Estimated F/Fmsy and B/Bmsy

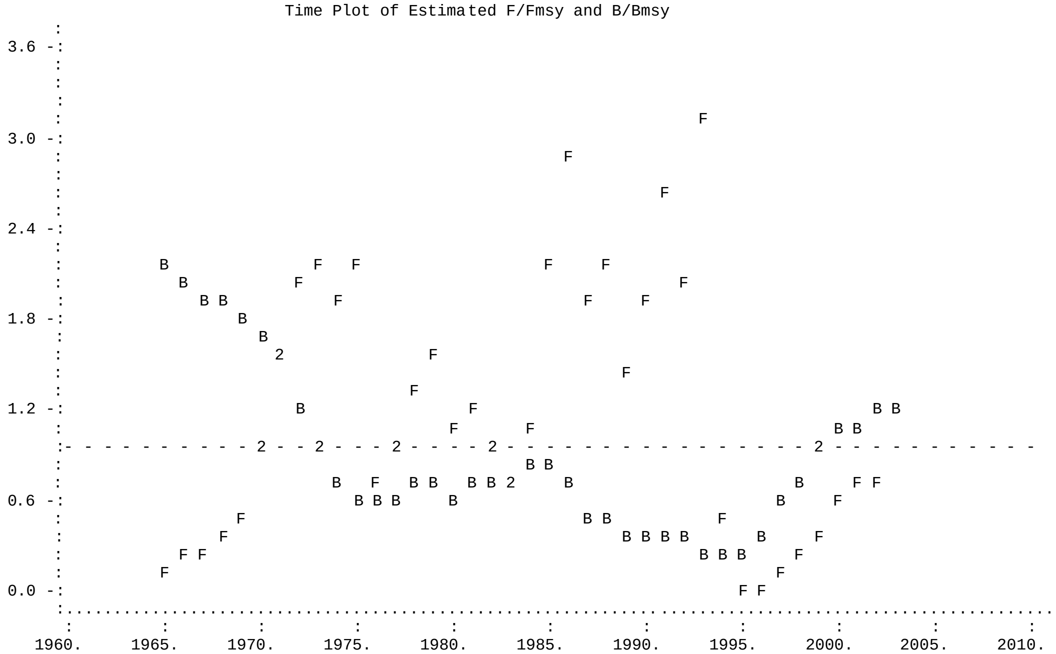


Table 12. Management options for yellowtail for 2003-2004. F multipliers are applied to F in 2002.

2003 F — **Percentiles**

F multiplier	**5**	**25**	**50**	**75**	**95**
1.0	0.134	0.145	0.155	0.168	0.193
0.9	0.120	0.130	0.139	0.151	0.174
0.8	0.107	0.116	0.124	0.134	0.154
0.6	0.080	0.087	0.093	0.101	0.116
0.4	0.054	0.058	0.062	0.067	0.077
2/3 Fmsy	0.132	0.143	0.153	0.166	0.191
Fmsy	0.198	0.215	0.229	0.248	0.286

2004 F — **Percentiles**

F multiplier	**5**	**25**	**50**	**75**	**95**
1.0	0.134	0.145	0.155	0.168	0.193
0.9	0.120	0.130	0.139	0.151	0.174
0.8	0.107	0.116	0.124	0.134	0.154
0.6	0.080	0.087	0.093	0.101	0.116
0.4	0.054	0.058	0.062	0.067	0.077
2/3 Fmsy	0.132	0.143	0.153	0.166	0.191
Fmsy	0.198	0.215	0.229	0.248	0.286

2003 Yield

F multiplier	**5**	**25**	**50**	**75**	**95**
1.0	14.443	14.614	14.712	14.809	14.936
0.9	13.079	13.243	13.339	13.430	13.555
0.8	11.702	11.853	11.946	12.032	12.148
0.6	8.889	9.007	9.089	9.169	9.269
0.4	6.000	6.085	6.150	6.210	6.285
2/3 Fmsy	14.266	14.436	14.534	14.631	14.758
Fmsy	20.741	20.927	21.028	21.132	21.288

2004 Yield

F multiplier	**5**	**25**	**50**	**75**	**95**
1.0	14.550	14.859	15.044	15.214	15.460
0.9	13.306	13.613	13.808	13.985	14.229
0.8	12.020	12.312	12.508	12.699	12.932
0.6	9.305	9.556	9.739	9.934	10.163
0.4	6.404	6.596	6.741	6.901	7.105
2/3 Fmsy	14.391	14.701	14.887	15.057	15.301
Fmsy	19.782	20.121	20.275	20.422	20.696

2004 B/ Bmsy

F multiplier	**5**	**25**	**50**	**75**	**95**
1.0	0.896	1.118	1.225	1.315	1.425
0.9	0.914	1.134	1.243	1.332	1.442
0.8	0.931	1.151	1.261	1.349	1.458
0.6	0.965	1.185	1.296	1.384	1.492
0.4	0.998	1.219	1.331	1.420	1.527
2/3 Fmsy	0.899	1.120	1.228	1.318	1.428
Fmsy	0.822	1.042	1.149	1.236	1.348

2005 B/ Bmsy

F multiplier	**5**	**25**	**50**	**75**	**95**
1.0	0.920	1.144	1.253	1.336	1.434
0.9	0.948	1.173	1.284	1.365	1.463
0.8	0.979	1.203	1.315	1.395	1.492
0.6	1.044	1.264	1.375	1.456	1.554
0.4	1.114	1.330	1.438	1.519	1.614
2/3 Fmsy	0.924	1.148	1.257	1.340	1.438
Fmsy	0.787	1.008	1.118	1.200	1.305

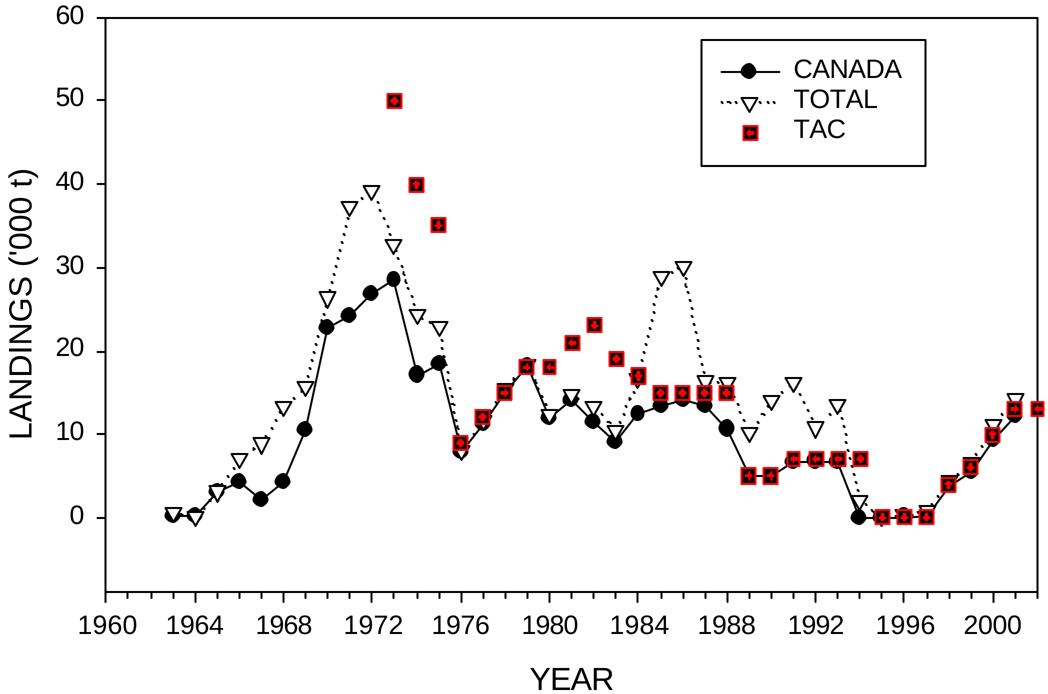
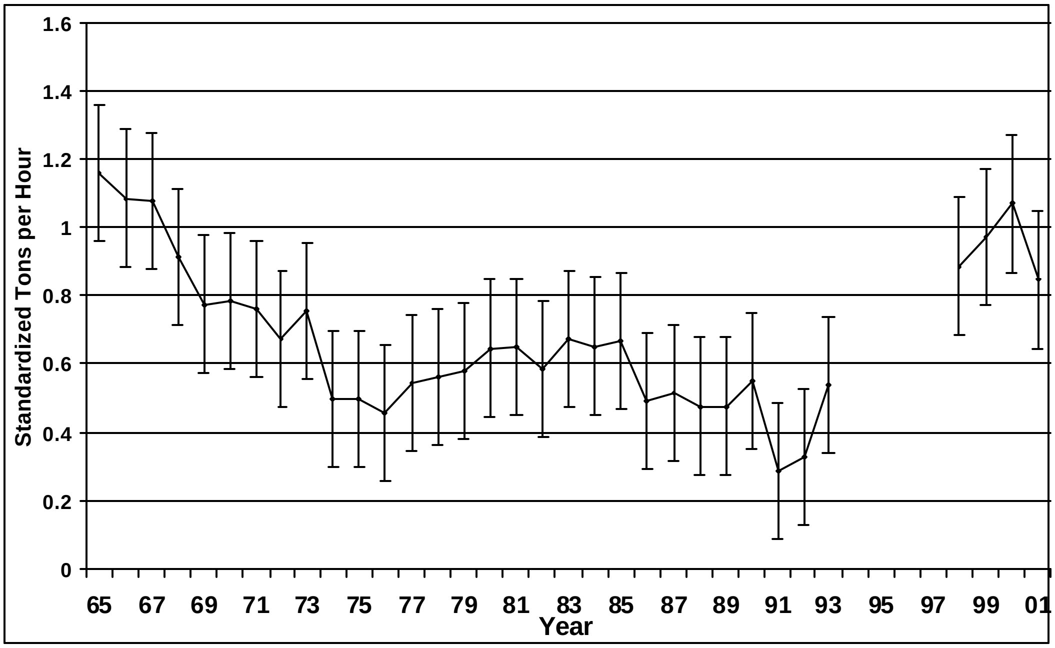


Fig. 1 Landings and TACs of yellowtail flounder in Division 3LNO

A) Div. 3LNO from 1965-1993,1998-2001



B) Div 3N and 3O separately from 1965-1993,1998-2001

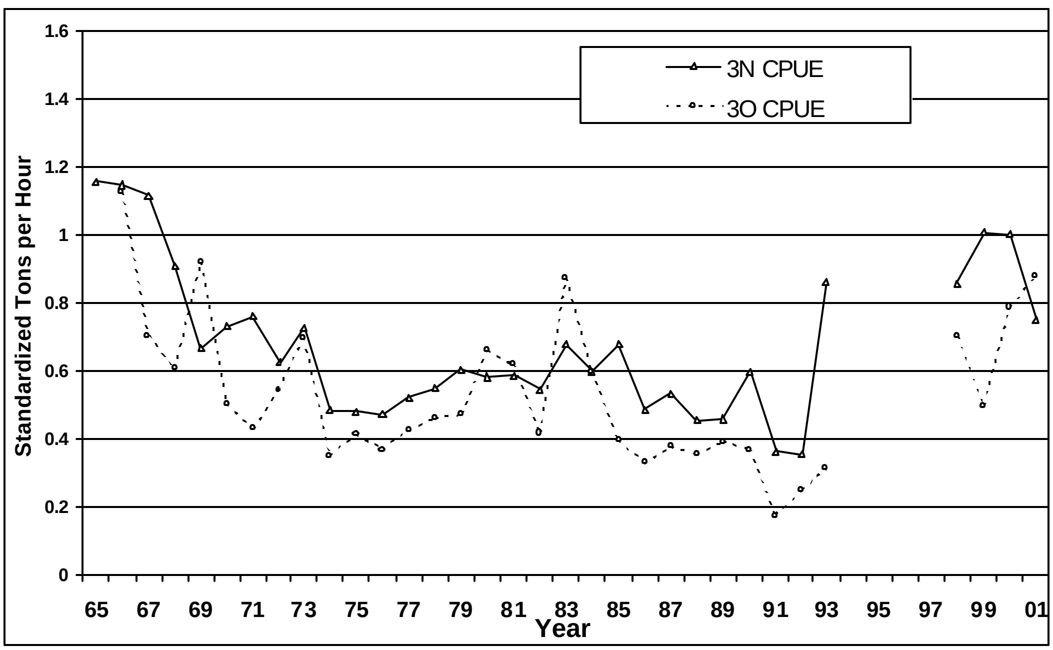


Fig. 2. Standardized CPUE ± 2 s.e. for Yellowtail in Div. 3LNO from 1965-1993 and 1998-2001 (preliminary) under different treatments of the database. From 1991-1993 the fishery was a mixed fishery with American plaice. There was no directed fishery from 1994-1997.

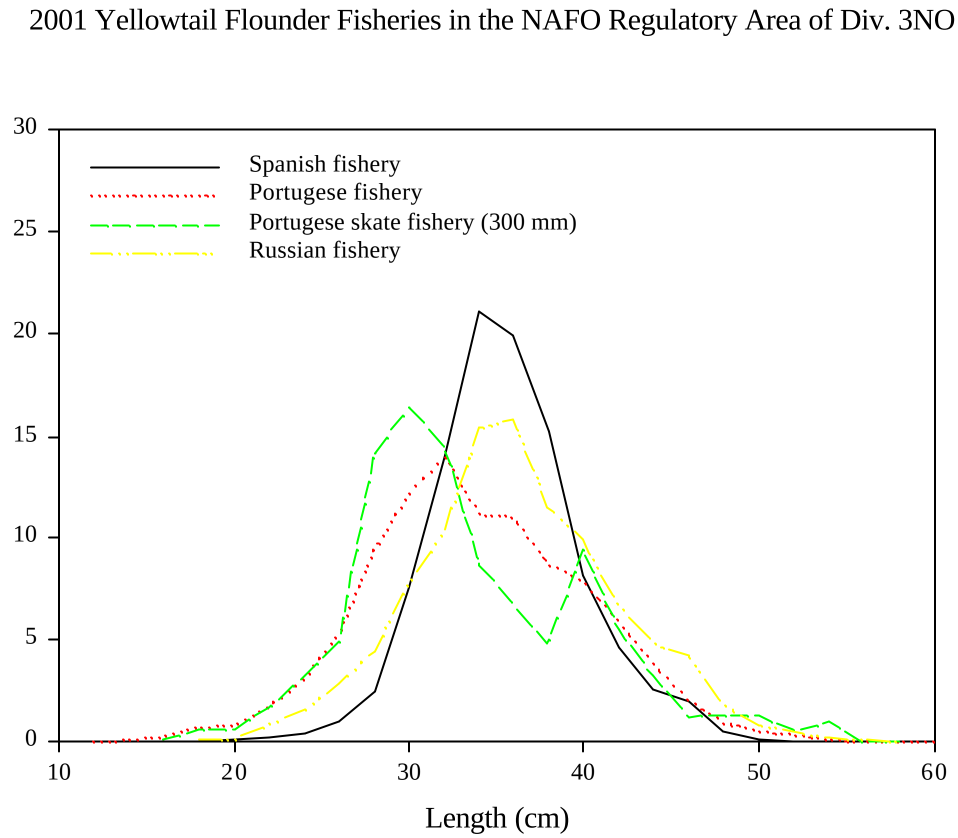


Fig. 3. Length frequencies of yellowtail flounder from fisheries in the NRA in Div. 3NO in 2001.

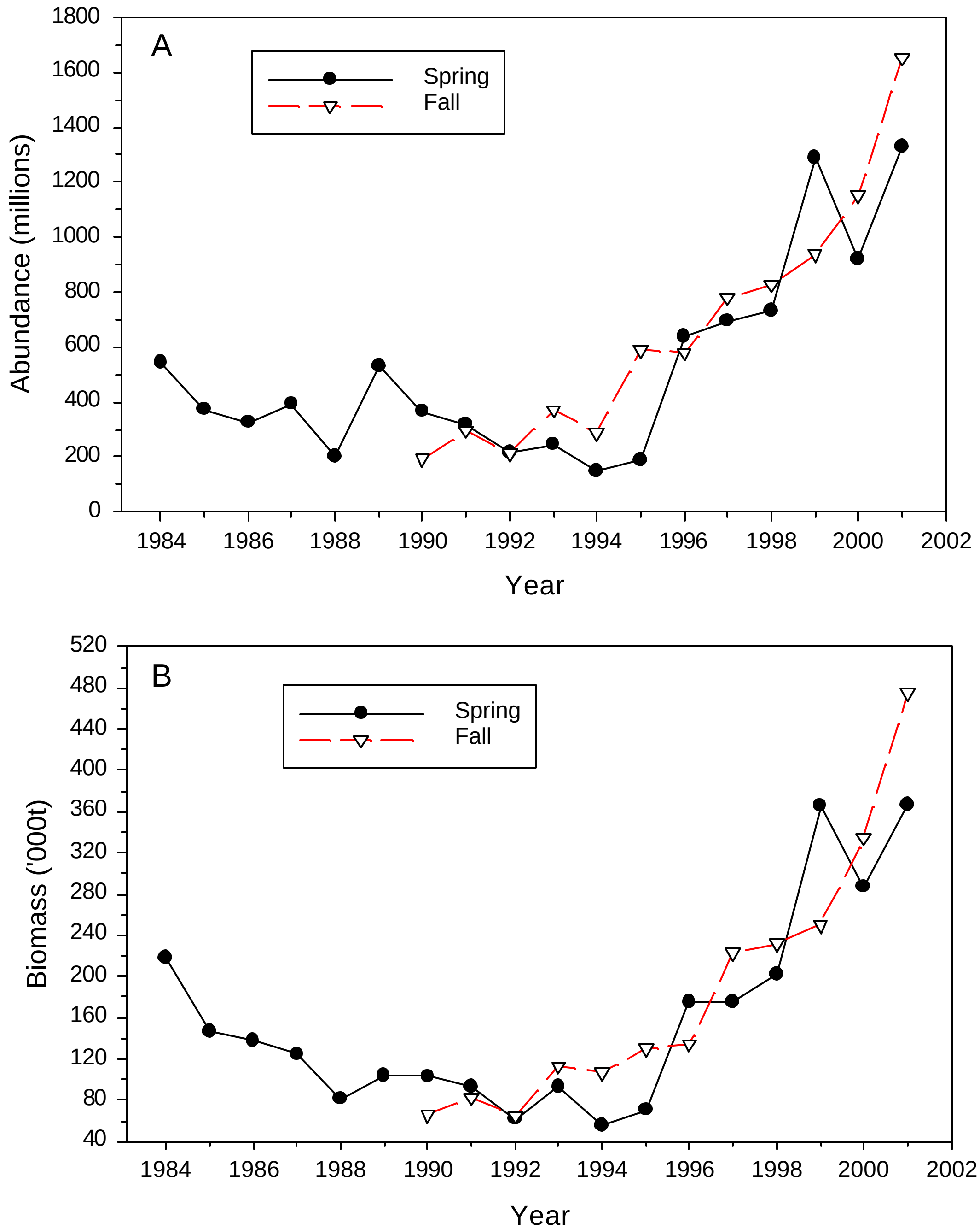


Fig.4 . **A**. The abundance and (**B**) biomass of yellowtail flounder estimated from annual bottom trawl surveys by Canada, 1984-2001

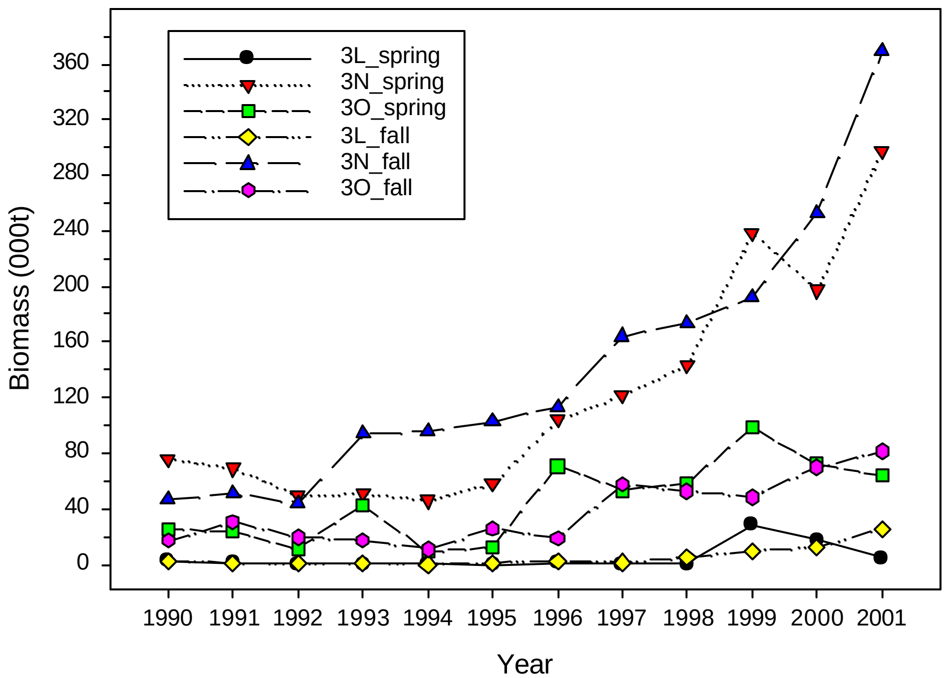


Fig.5 . Comparison of spring and fall biomass estimates of yellowtail flounder for 1990-2001 surveys by division.

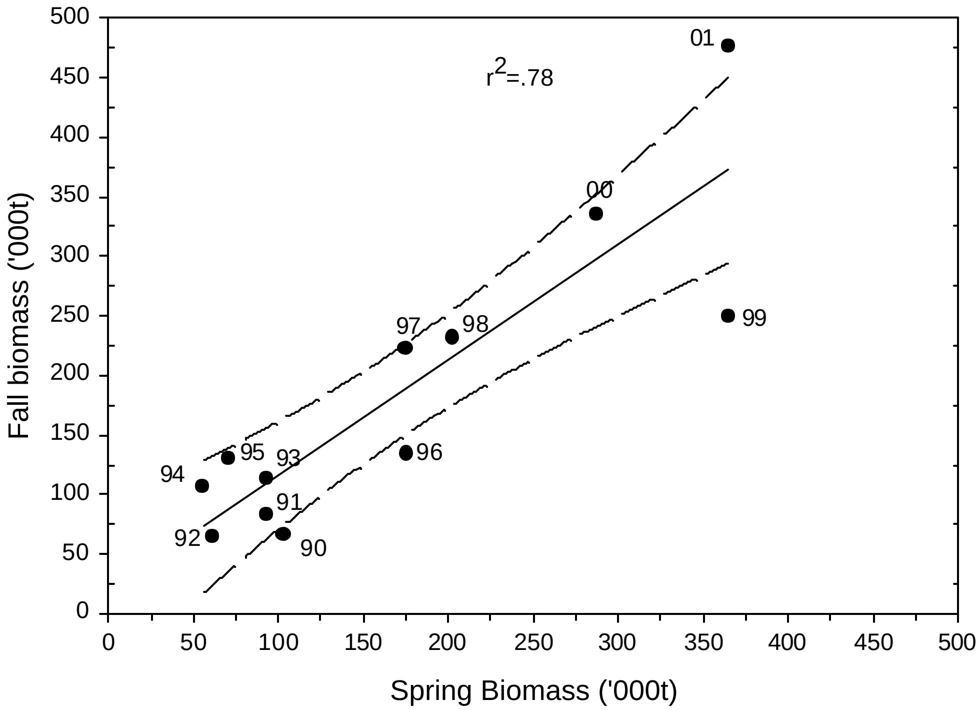


Fig. 6. Regression of fall and spring biomass estimates from annual bottom trawl surveys for yellowtail flounder on the Grand Bank, 1990-2001.

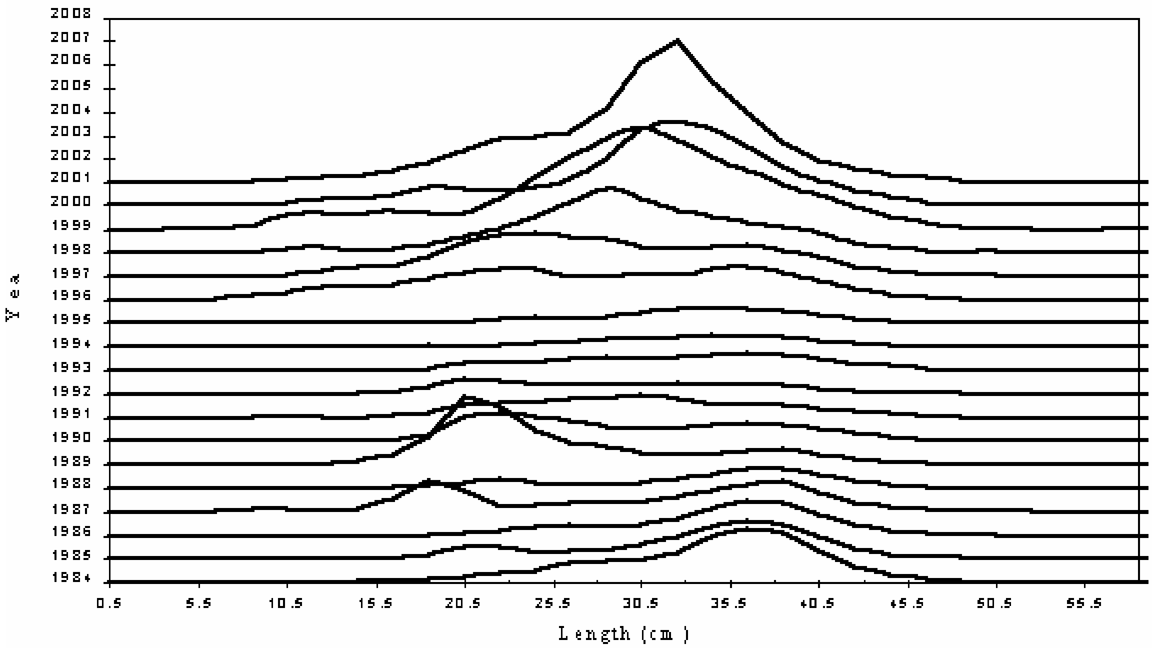


Fig. 7. Length frequency of yellowtail flounder in the spring surveys of Div. 3LNO, 1984-2001.

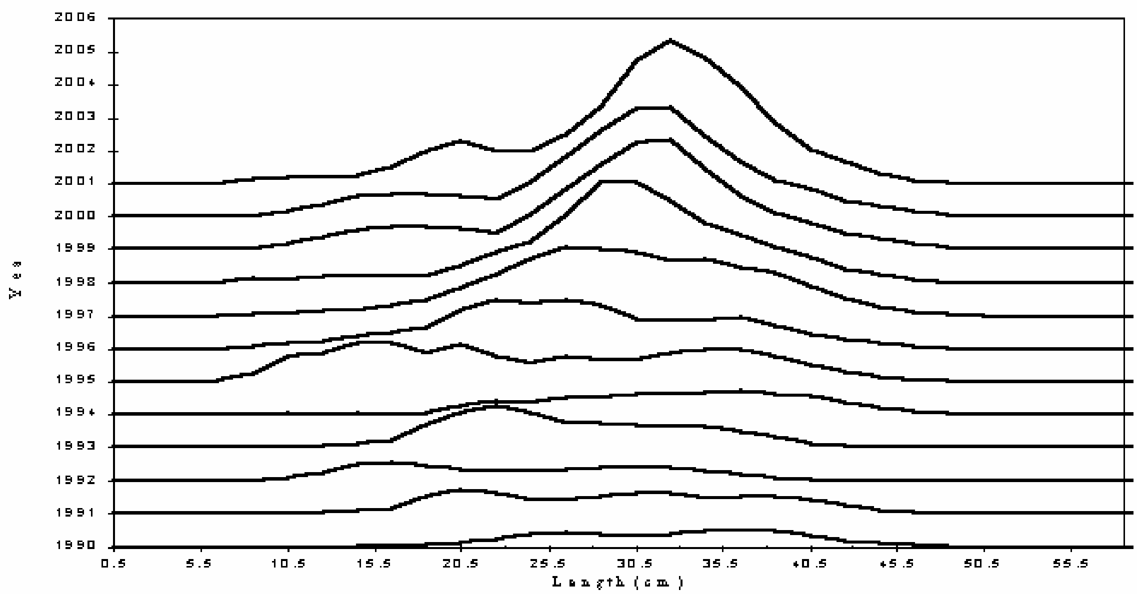


Fig. 8. Length frequency of yellowtail flounder in the fall surveys of Div 3LNO, 1990-2001

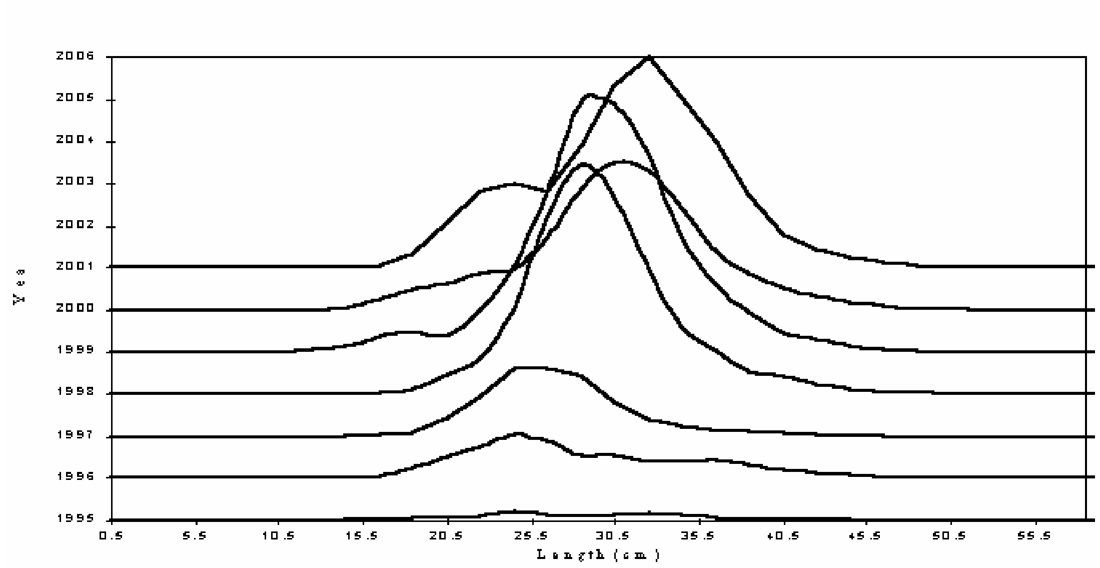


Fig. 9. Length frequency of yellowtail from the Spanish spring surveys in Div. 3NO from 1996-2001

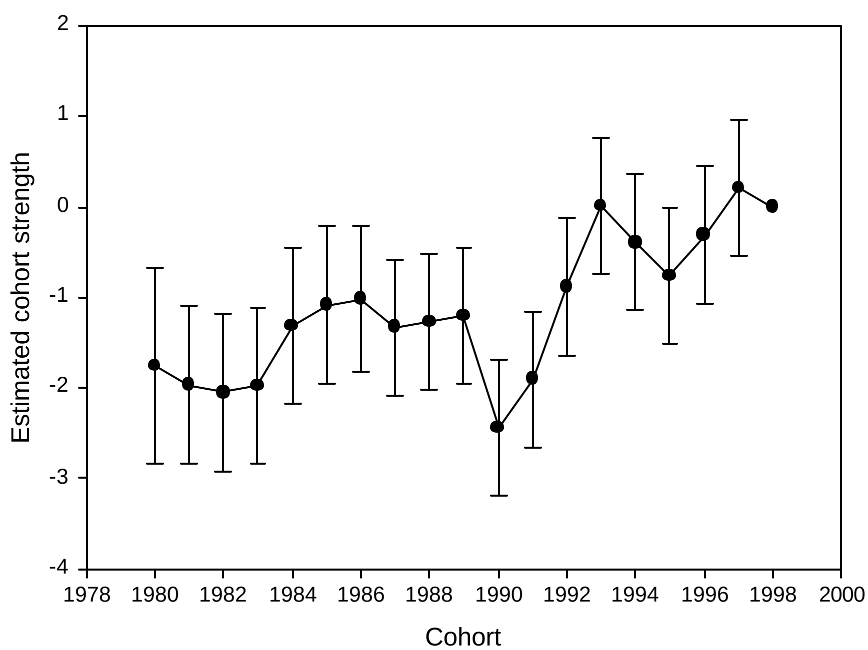


Fig. 10. Estimated relative cohort strength from the 1984-2001Canadian spring and the 1990-2001fall research vessel surveys for Div. 3LNO yellowtail flounder . Standard errors are also shown.

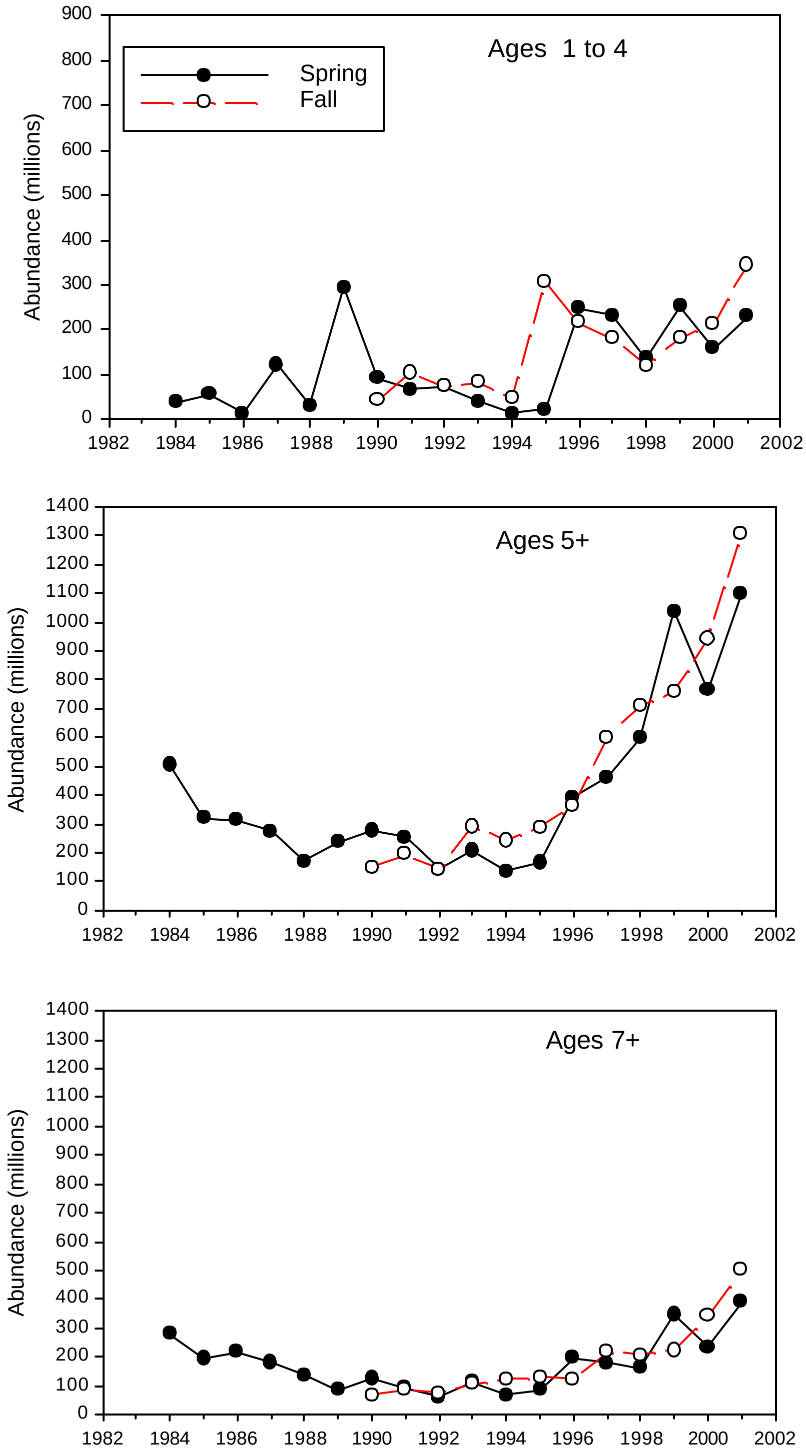


Fig.11 . Comparison of 1984-2001 spring and fall survey estimates of pre-recruit, partially recruited and fully recruited ages of yellowtail flounder from Div. 3LNO.

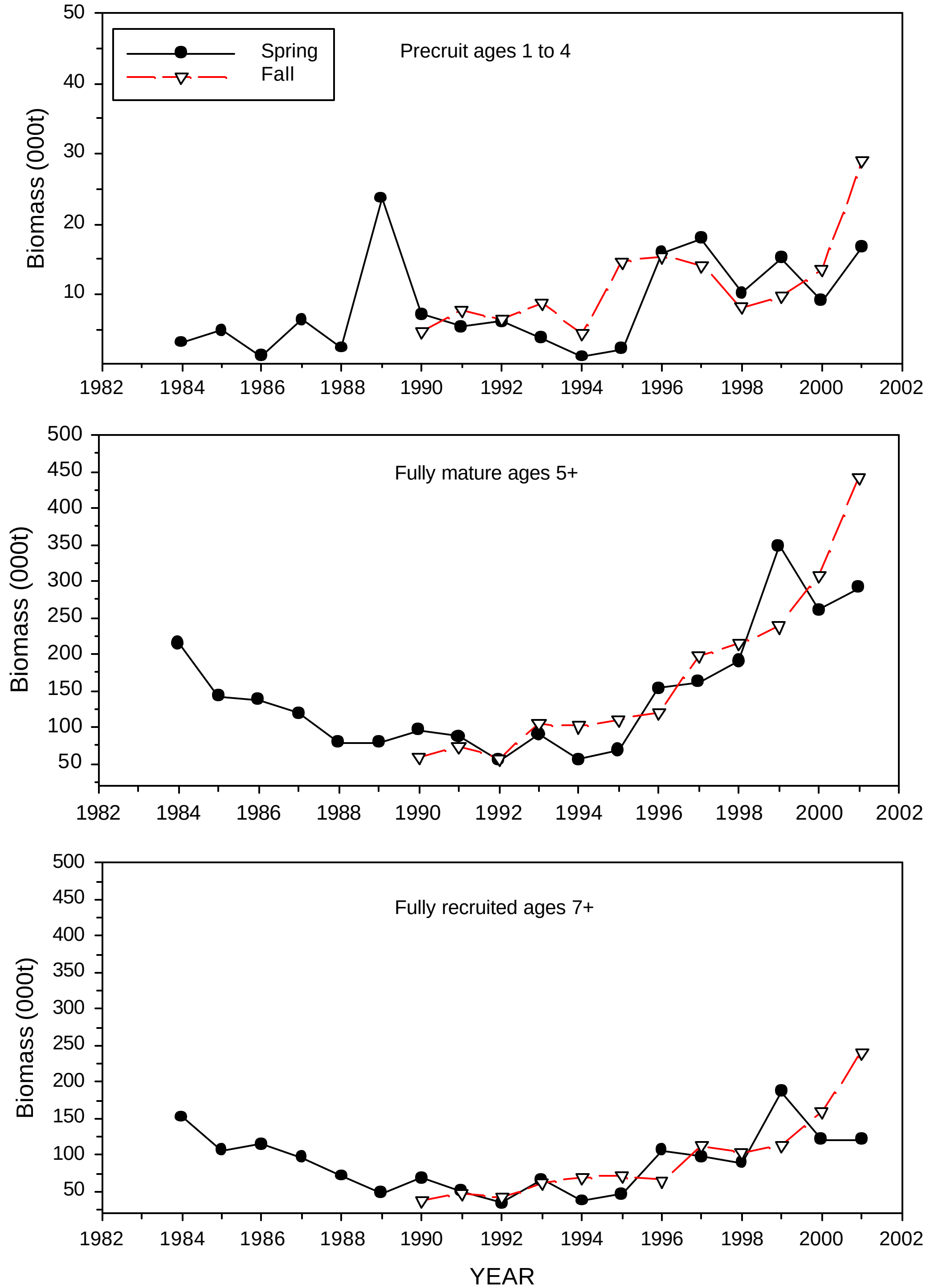


Fig.12. Survey biomass of yellowtail from spring and fall surveys, 1984-2001

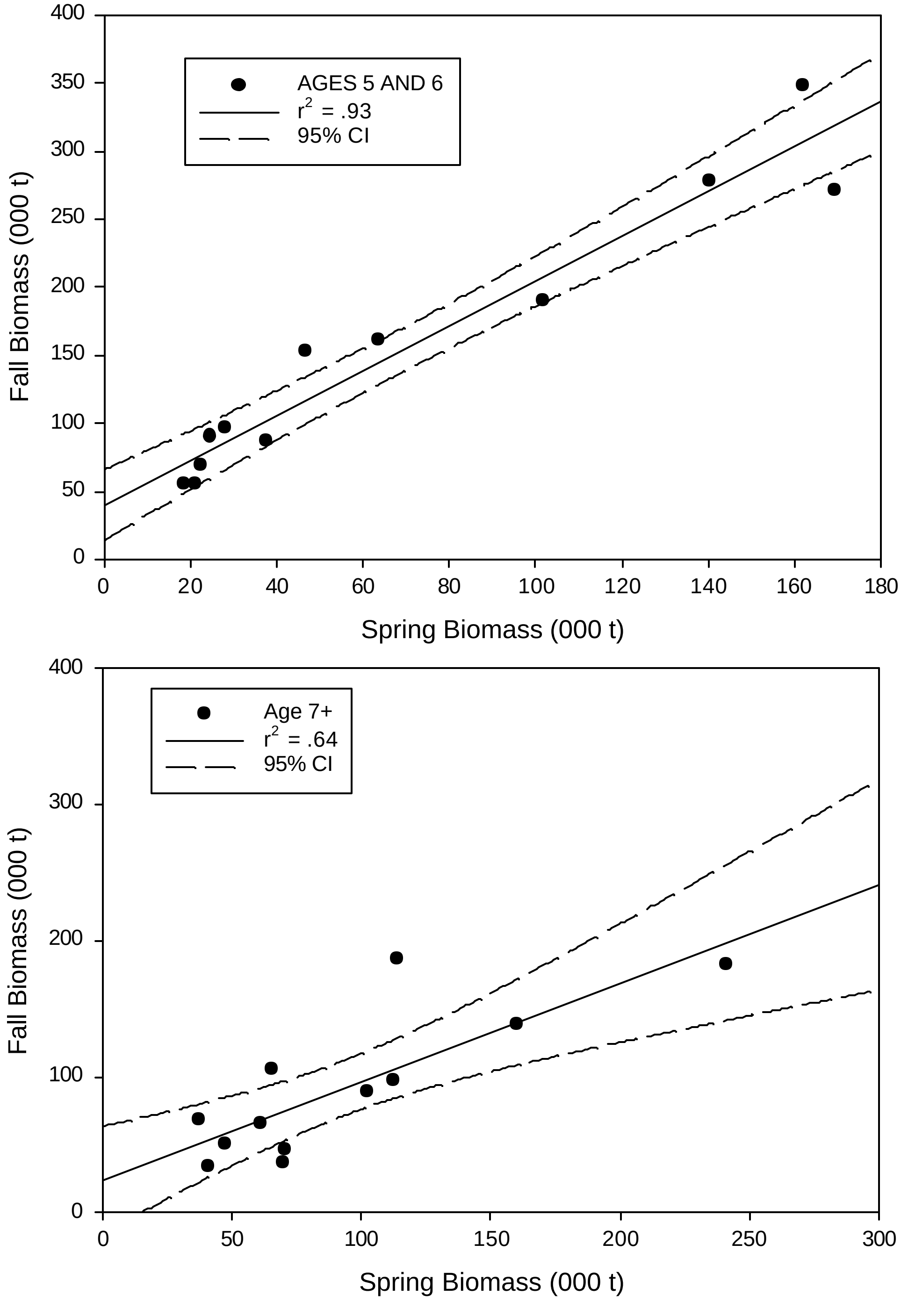


Fig.13. Regression of the biomass of ages 5& 6 from fall and spring surveys (Top panel)
Regression of the biomass of age 7+ from the fall and spring surveys (Bottom panel)

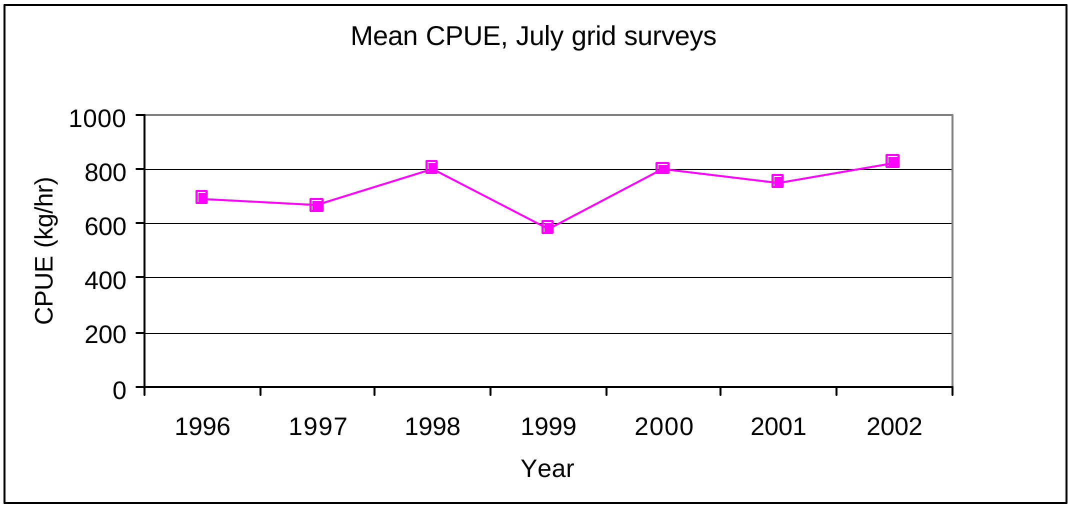


Fig 14. Mean CPUE of yellowtail from the DFO/FPI July grid surveys, 1996-2001.

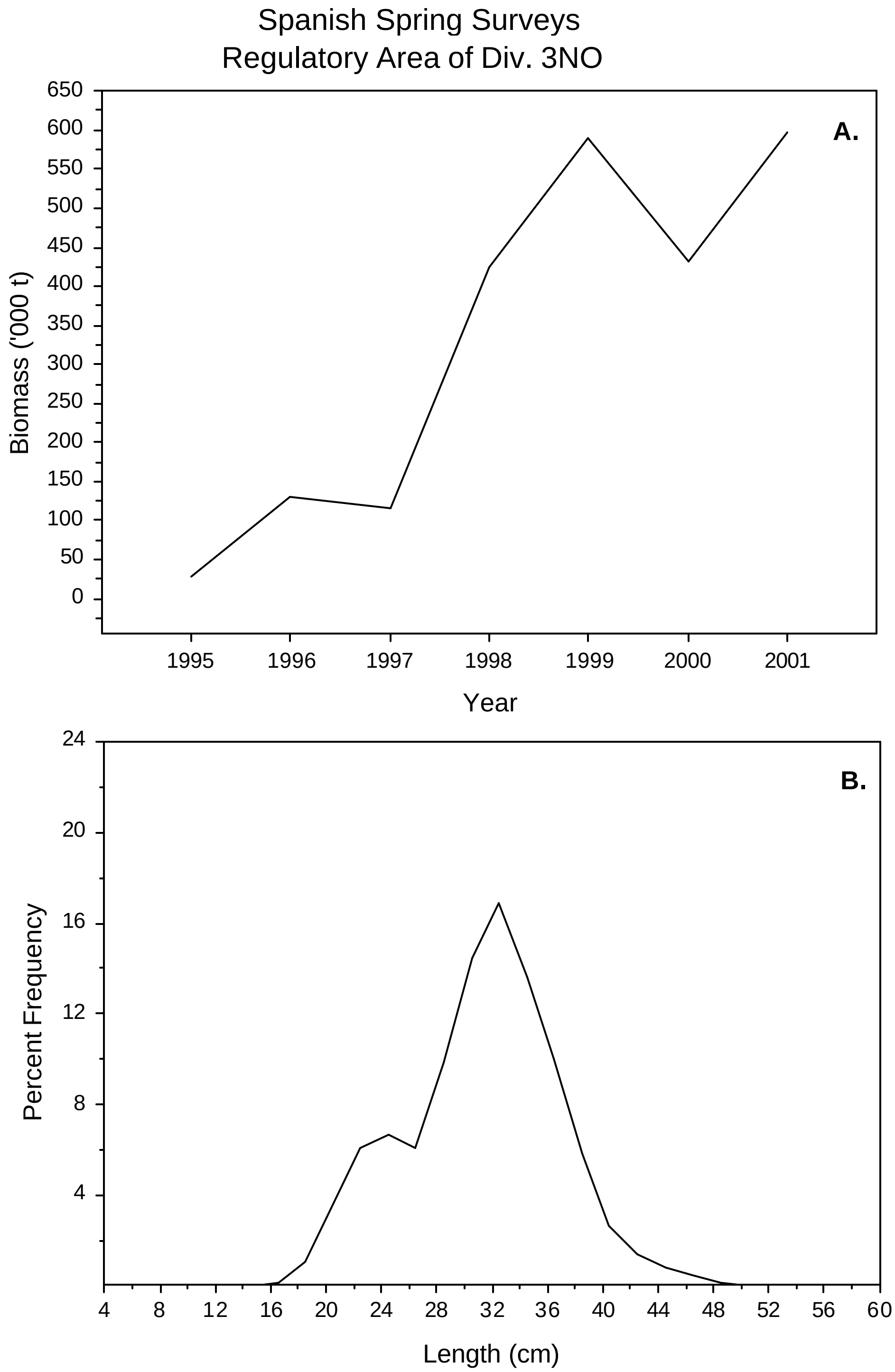
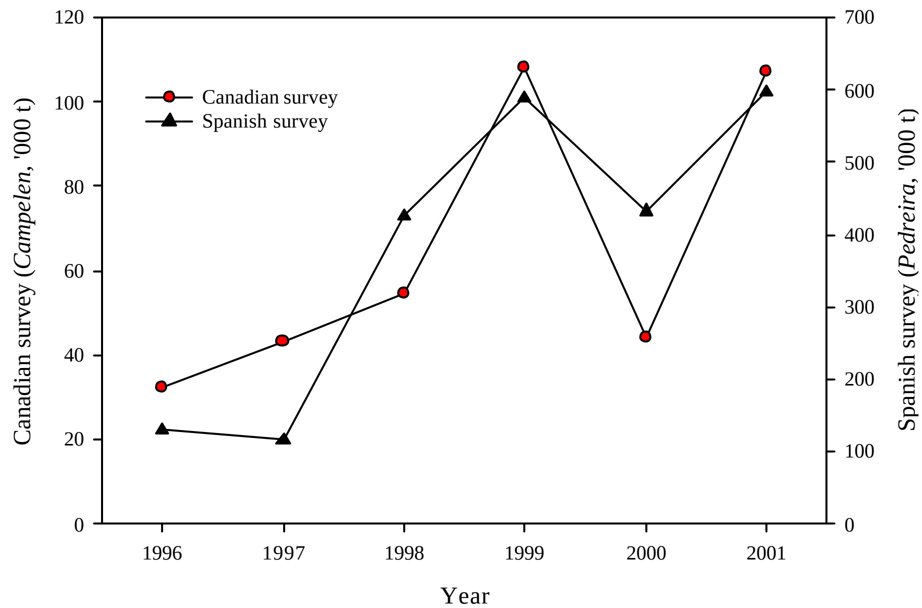


Fig. 15. **A.** Biomass of yellowtail flounder from the Spanish surveys in the Regulatory Area of Div. 3NO,
B. Length frequency of yellowtail flounder from the 2001 Spanish survey in the Regulatory Are



Fi. 15c. Comparison of Canadian Campelen survey biomass estimates (3NO outside 200 miles) of yellowtail flounder with Spanish survey biomass estimates (swept area method), in *Pedreira* units, 1996-2001 (from SCR 02/65).

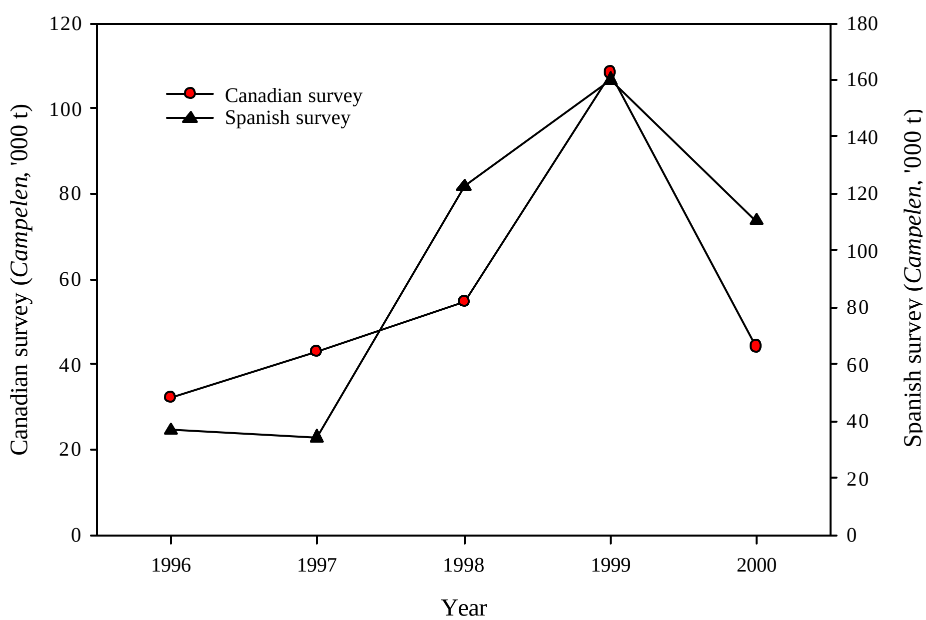
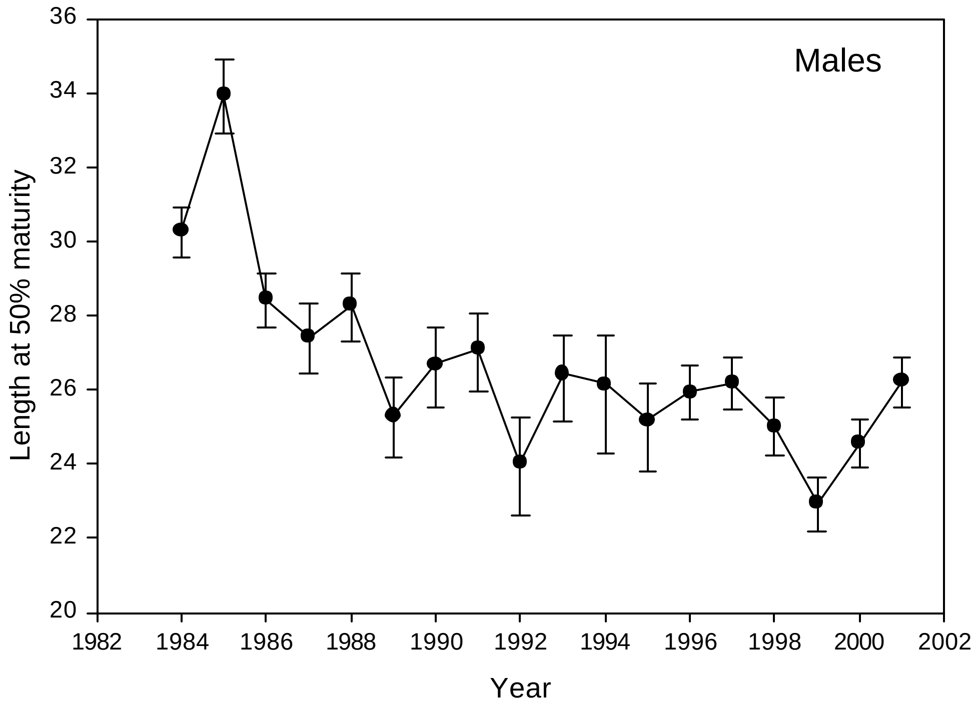


Fig. 15d. Comparison of Canadian Campelen survey biomass estimates (3NO outside 200 miles) of yellowtail flounder with Spanish survey biomass estimates (weight-length conversion), in *Pedreira*-transformed (*Campelen)* units, 1996-2000 (from 02/65).



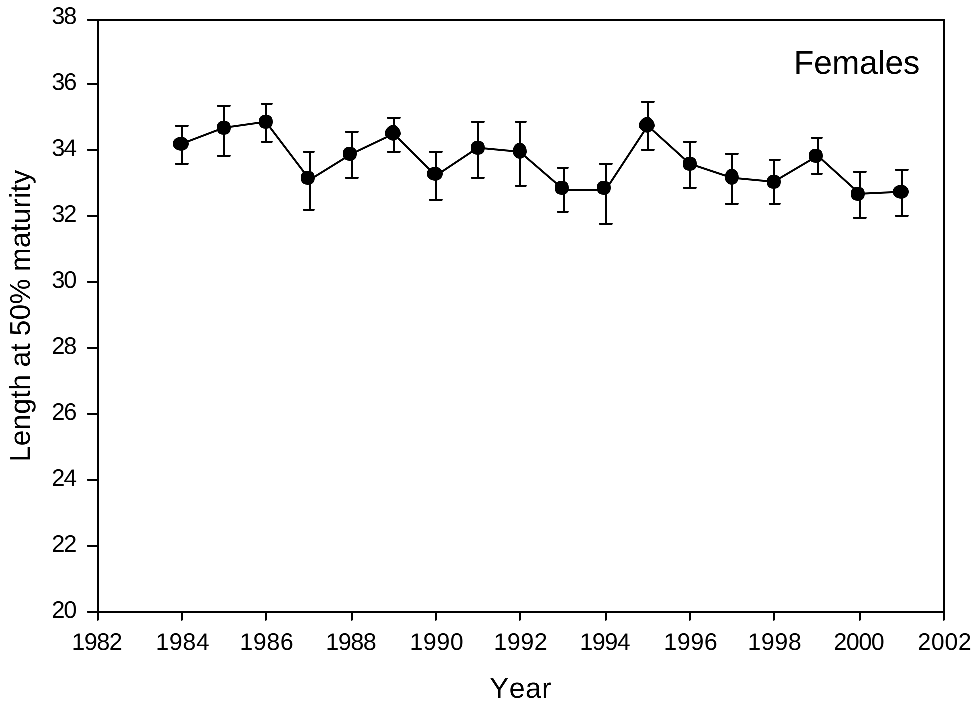


Fig 16. Length at 50% maturity of male and female yellowtail flounder from annual spring surveys of Div. 3LNO from 1984-2001.

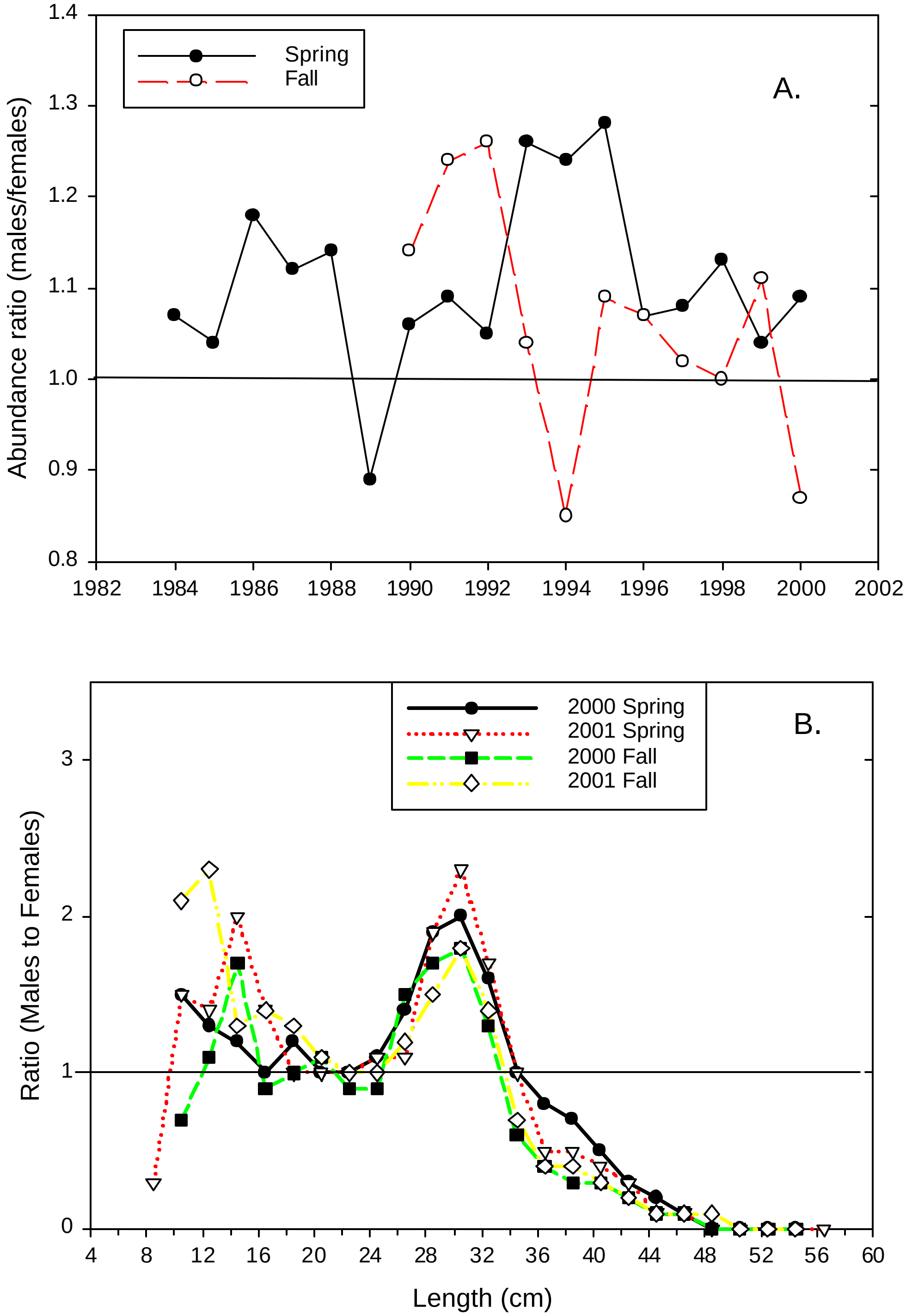


Fig 17. A Ratio of males to females in the spring and fall surveys of Div. 3LNO.
B. Sex ratio of yellowtail flounder from 2000 and 2001 spring and fall surveys

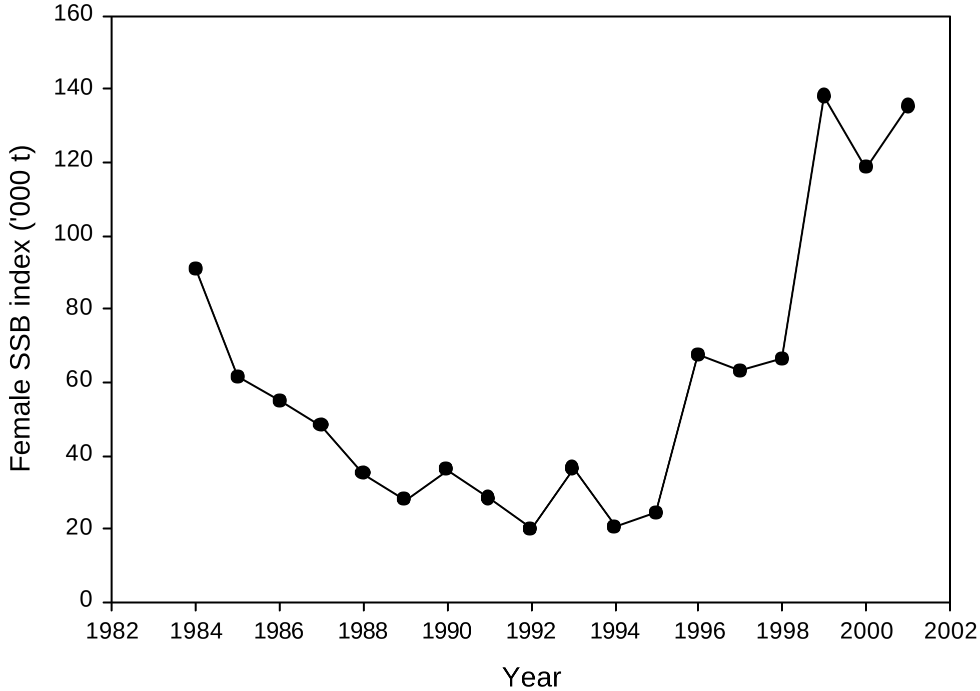


Fig. 18 . Index of female spawning stock biomass ('000 t) as calculated from Canadian spring research vessel surveys.

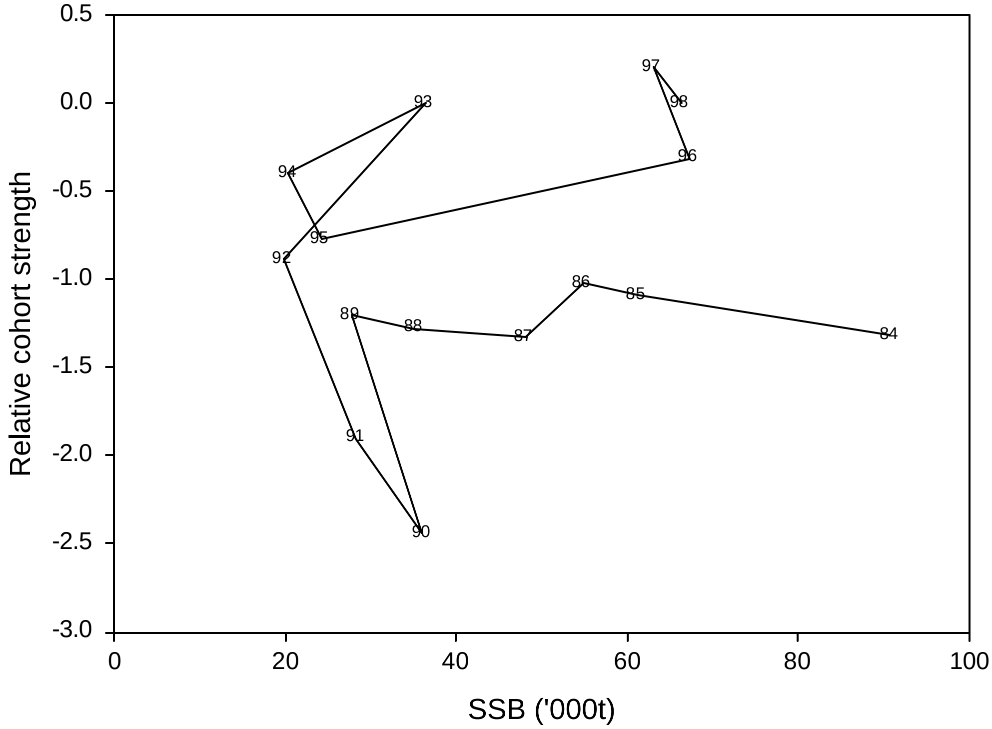


Fig. 19. Relative cohort strength as estimated from the multiplicative model vs index of female yellowtail flounder spawning stock biomass ('000t) from Canadian spring surveys of Div 3LNO. The label on each point indicates the year-class.

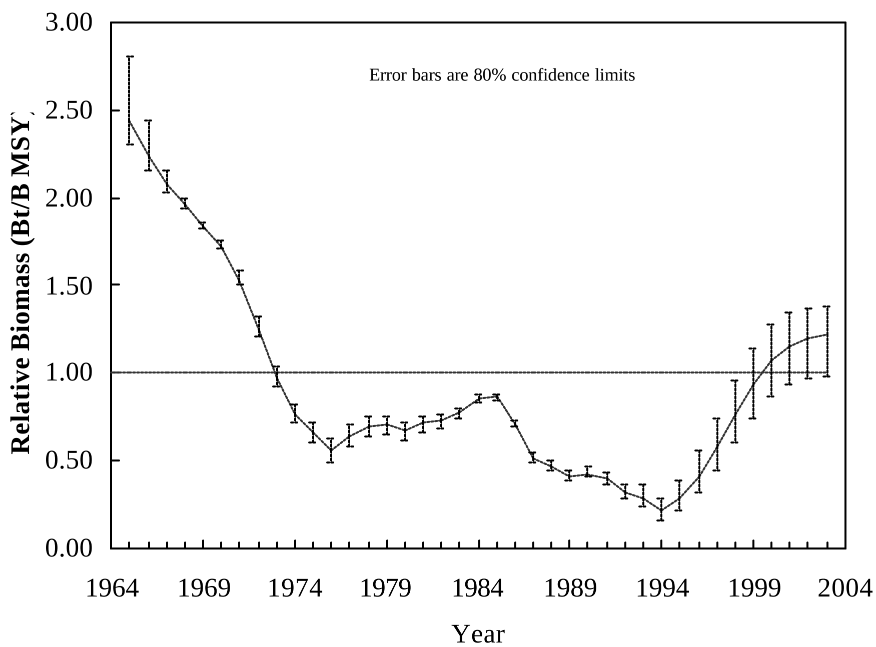


Fig 20a. Trends in relative biomass from ASPIC model, 3LNO yellowtail. Includes projected biomass to beginning of 2003.

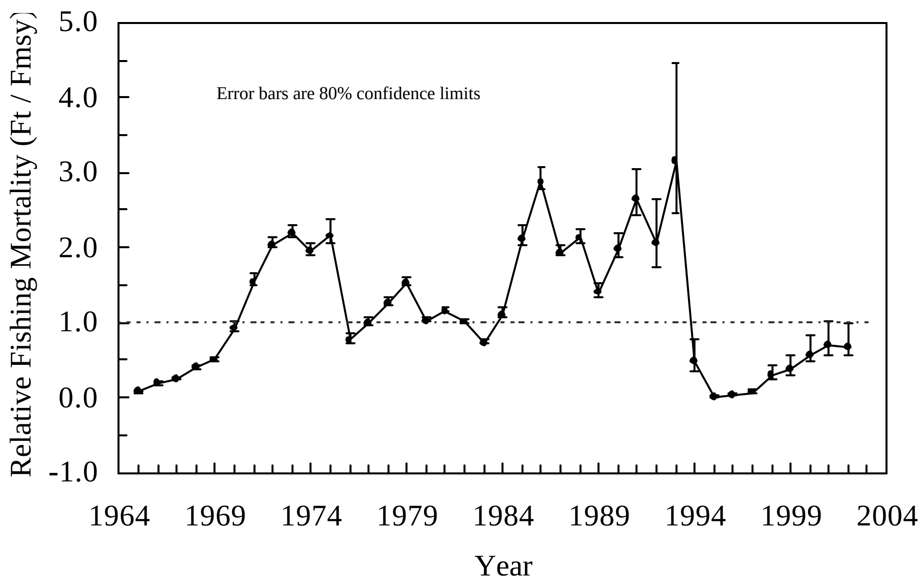


Fig 20b. Trends in relative fishing mortality from ASPIC model, 3LNO yellowtail.

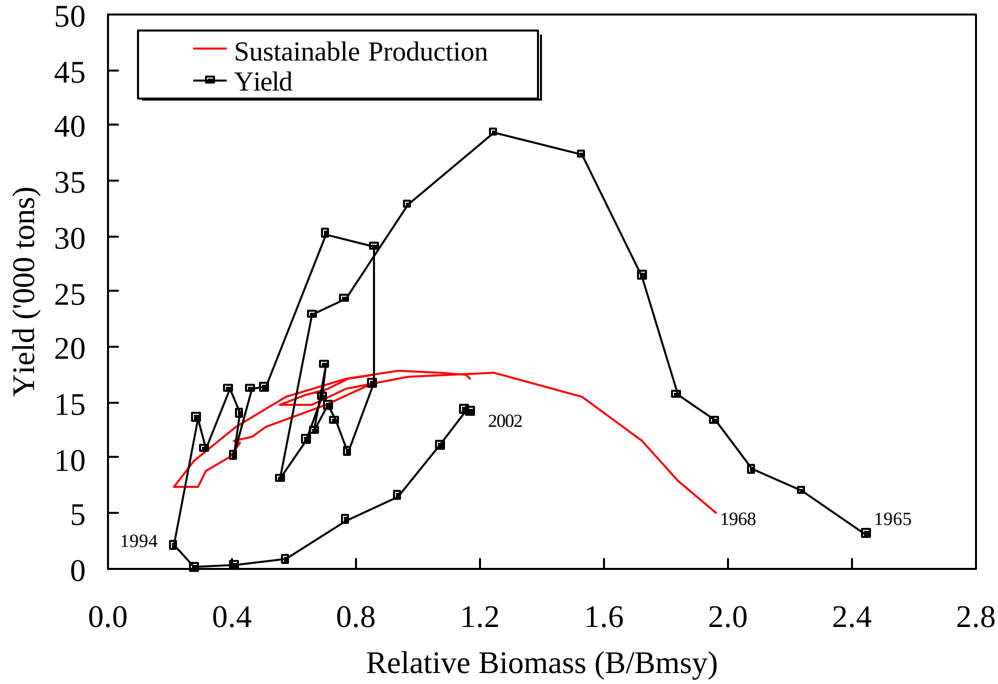


Fig. 21. Results of ASPIC model, 3LNO yellowtail, showing trajectories of yield and sustainable production plotted against relative biomass.

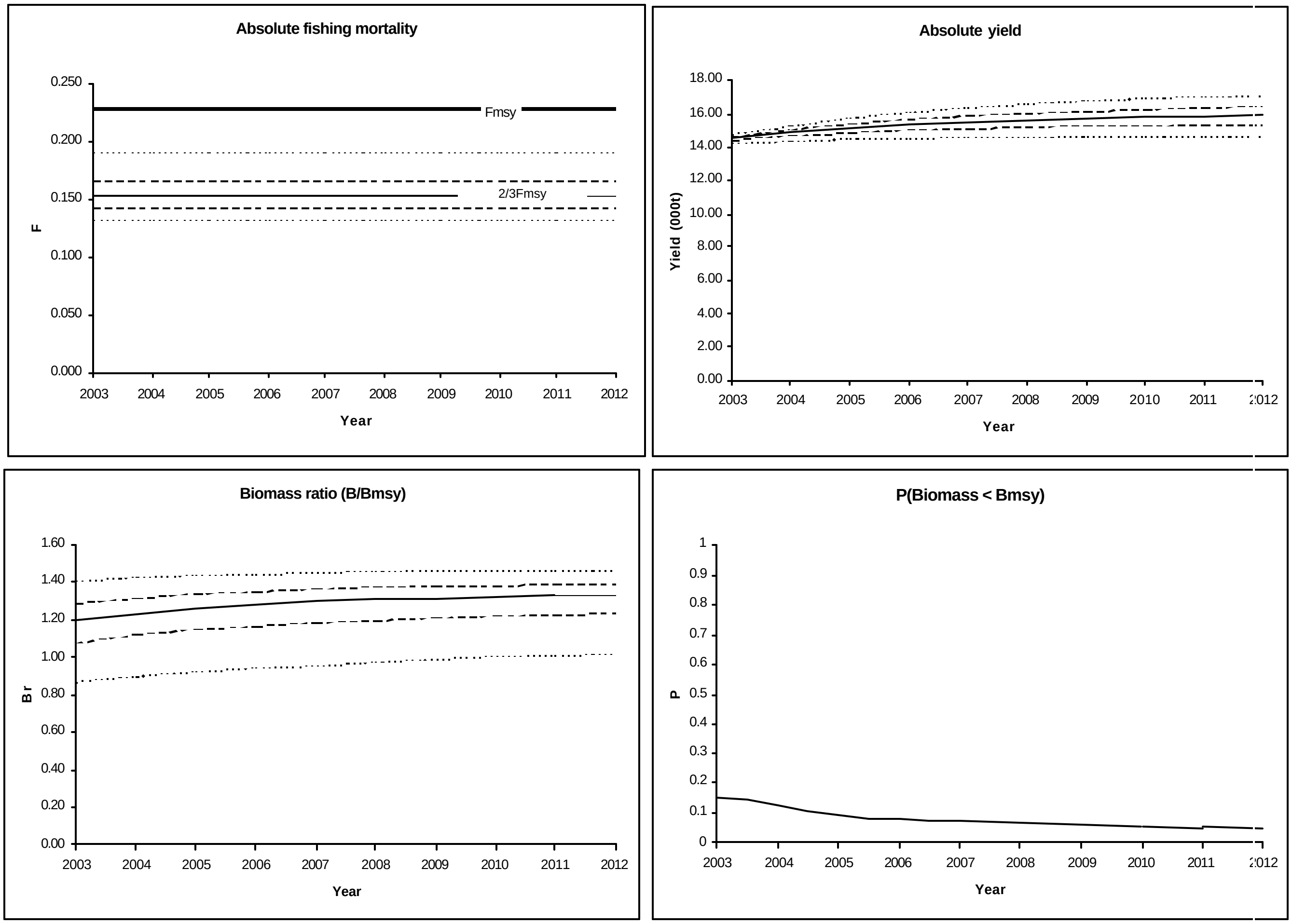


Fig 22. Results of ASPIC model, yellowtail flounder in Div. 3LNO - medium term projections at a constant fishing mortality of 2/3 F_{msy}. The figures show the 5^{th}, 25^{th}, 50^{th}, 75^{th} and 95^{th} percentiles of fishing mortality, yield, and biomass/B_{msy}. The probability of biomass being less than B_{msy} is also given, in the bottom right panel.

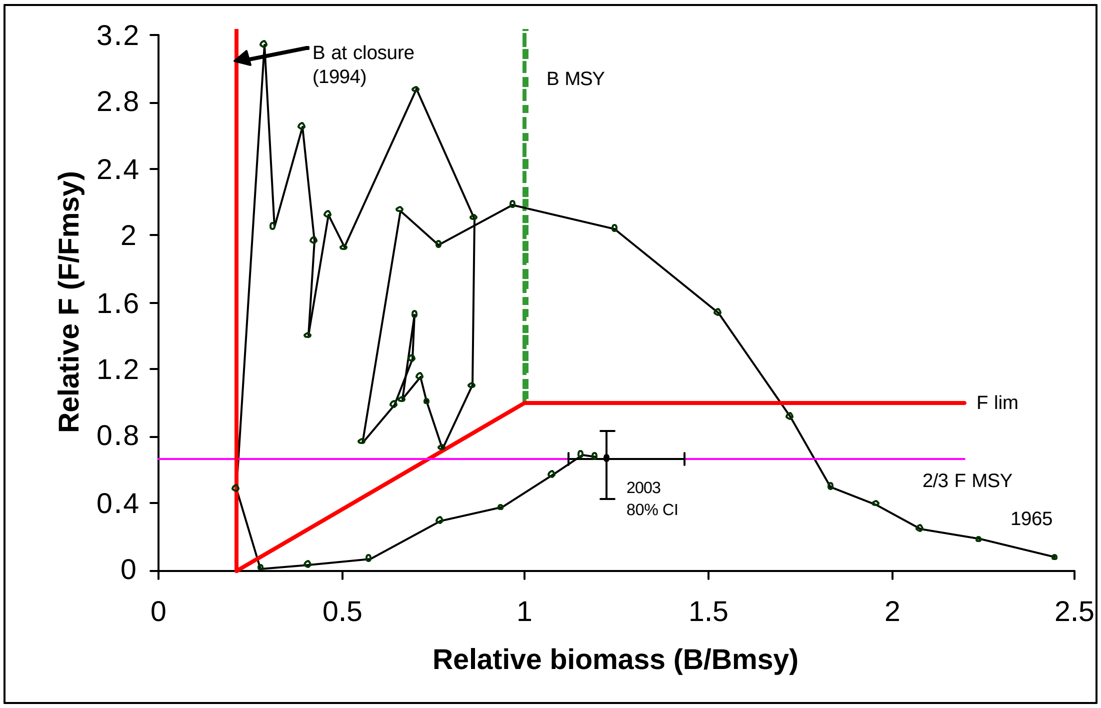


Fig. 23. Yellowtail in Div. 3LNO – stock trajectory from ASPIC model cast in a precautionary framework.