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Assessment of NAFO Div. 3LNO Yellowtail Flounder

by

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Abstract

Canadian and Spanish surveys show the stock size increased since the moratorium on directed fishing was declared in 1994. Canadian spring and Spanish spring survey estimates remained high in 2013 and 2014, although they declined slightly each year from the high values observed in 2011. The 2013 Canadian fall estimates also remained high, similar to those in 2012. The 2014 fall survey was incomplete. The 2015 assessment uses ASPIC version 7.02 with updated catch and survey biomass indices for 2013 and 2014 to produce relative biomass and fishing mortality estimates. Relative biomass remains high in 2015 (1.8 times B_{msy}) and fishing mortality remains low (F_{2014}=0.06). Projections in the short and medium term are also updated and results are presented in a precautionary approach framework.

Fishery and management

A. TAC Regulation

The stock has been under TAC regulation since 1973, when an initial level of 50 000 t was established. In 1976, the TAC was lowered to 9 000 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 1990, following sharp declines in stock size after the large catches in 1985 and 1986, then increased to 7 000 tons in 1991-94. However, NAFO Fisheries Commission decided that no directed fisheries would be permitted for this stock and some other groundfish fisheries (cod, American plaice and witch flounder) on the Grand Bank during 1994. 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 as the basis for Scientific Council's recommended TAC of 10 000 t for the 2000 fishery. Since then, the stock production model has continued to be the basis of TAC advice, and TAC was set at 13 000 t in 2001, increased to 14 500 tons in 2003, to 15 000 tons in 2005, and to 15 500 tons in 2007. In 2008 and 2009, Scientific Council noted that this stock was well above B_{msy}, and recommended any TAC option up to 85% F_{msy} for 2009-2015. TAC has been set to 17 000 tons for 2009 to 2015.

B. Catch Trends

The nominal catch increased from negligible amounts in the early 1960s 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.

During the moratorium (1994-97), catches decreased from approximately 2 000 tons in 1994 to around 300 - 800 tons per year, as by-catch in other fisheries (Table 1). Since the fishery re-opened in 1998, catches have increased from 4 400 tons to a high of 14 100 tons in 2001. Overall, catches exceeded the TACs during 1985 to 1993 and again from 1998-2001, by about 10% in the latter period (Table 1; Fig. 1). Since 2002 the catches have been below the TAC. Corporate restructuring and labour disputes, in 2006, prevented the Canadian fleet from prosecuting the Yellowtail flounder fishery, and Canadian catch was only 177 tons. The nominal catch in that year was only 930 tons, well below the TAC of 15 500 tons. In 2007, the participation in the fishery increased by Canadian fleet, but was still low at 3 673 tons, and the nominal catch was 4 617 tons. Catch increased in 2008 to 11 400 tons. Catches since 2009 were lower than the TAC ranging from 3 100 to 10 700 tons taken of the 17 000 ton TACs. Reduction in the effort by the Canadian fleet in the recent years was the result of industry-related factors.

In some years, small catches of yellowtail have been reported from the Flemish Cap, NAFO Div. 3M. STACFIS previously noted that these catches were probably errors in reporting or identification, as the reported distribution of yellowtail flounder does not extend to the Flemish Cap.

Table 2 shows a breakdown of the Canadian catches by year, division and gear. Since the fishery reopened in 1998, Canadian catches have fluctuated from less than 200 t (2006) to over 13,000 t (2005). Low catches since 2006 were due to a variety of industry-related factors, such as corporate restructuring, labour disputes, and on-shore processing requirements. With the exception of 1991-1993, 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. The most important gear is otter trawl, and catches by other gears have been less than 10 t annually after 2002. The Canadian catch reported in 2012 was 1795 tons, which is the lowest value since 2006. In 2011 and 2012, most of the catch was taken in April to June (Table 3), whereas the fishery operated mostly year-round in other years from 2008-2014. In 2013 catch was higher at 7 900t and was slightly less at 6 800 t in 2014.

C. The 2009-2014 Fisheries by Non-Canadian Vessels (14/06, 10, 13, 14; SCS 15/ 05, 06, 07, 09)

Sampling of size composition from commercial catches of yellowtail flounder in 2013 and 2014 was available from the fisheries for Greenland halibut and skate in the NRA of Div. 3NO, and in the Canadian directed fishery for yellowtail, length frequencies were available for 2013. Available length frequencies from the Canadian, Spanish, and Portuguese catches for are plotted in Figures 2 and 3. The minimum codend mesh size in the Canadian fleet is 145 mm while Spain uses a minimum of 130 mm mesh size when fishing for Greenland halibut. In 2013, most of the Spanish catch ranged between 29-40 cm, and most of the by-catch (in 280mm skate fishery) was between 31-38 cm. Length distributions from Canadian yellowtail fisheries for 2000-2013 are given in Figure 2. The peak in distributions is very consistent, with modes around 36-37cm. In 2013 and 2014, sampling of the Portuguese fisheries in 3N showed modes from about 30-35cm.

II. Research Survey Data

A. Canadian Stratified-random Surveys Spring and Fall Surveys

Stratified-random research vessel surveys have been conducted in the spring in Divs. 3L, 3N and 3O since 1984 and in the fall since 1990. Up until 1994, the surveys were conducted using an *Engel* 145' high-rise groundfish trawl whereas the 1995-2014 surveys were carried out with a much more efficient *Campelen 1800* shrimp trawl. All data presented here are now in *Campelen 1800* trawl catch equivalents for 1984-94 with the actual data for 1995-2014.

Abundance and biomass trends
Figures 4 and 5 and Tables 4 and 5 compare the population abundance and biomass estimates of yellowtail flounder in the Canadian spring and autumn surveys. Detailed descriptions of trends in yellowtail flounder from both surveys are contained in Maddock Parsons (2015). Survey indices show similar trends in both series, although the fall estimates were generally higher from 1992 to 2002, with the exception of 1996 and 1999. Since then, there has been no trend in biomass estimates between the surveys. The fall survey indicates that the upward trend in stock size started in 1993 while the spring survey showed the trend starting in 1995.

Figure 5 shows the result of a regression of the biomass estimates from the spring and fall time series. A linear relationship is evident with 70% 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 more in agreement, and 1996-2012, when the stock was increasing and the estimates were more variable. Catchability estimates from the stock production model indicate *q's* from the Campelen surveys are around 3, and therefore swept-area stock-size is likely being overestimated in the spring and fall surveys.

Size composition and growth
Figure 7 shows the length composition of survey catches from spring and fall surveys by year for Div. 3LNO (combined sexes). Size composition in most recent years generally showed one main peak in the length frequencies in the spring surveys and multi-modal peaks in the fall surveys. 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 modes could be evidence of year classes moving through the time series.

In the spring surveys in 1996, 1997, 1999-2001 there were bimodal distributions seen in the data which can be tracked from year to year (Fig 6). For example following the first mode, in 1998 its peak is at 27.5 cm; by 1999, the peak has moved to 31.5 cm where it stays for 2000; and by 2001 it has moved to 32.5 cm. Over the next two years, the peak remained strong but doesn't appear to move because growth was probably reduced considerably (see Dwyer *et al*., 2003). At this point, it is probably made up of a number of different age classes. However since 2000 there were no bimodal peaks evident in the data. Smaller peaks of fish around 18cm are evident from about 2006 or 2007-2011 and then merge into the modal peak in following years.

In the fall surveys, multi-modal peaks are more common and unlike the spring surveys, were evident in surveys from 2001-2010 (Fig. 7). After 30-32 cm, growth slows and becomes almost negligible between years. This is consistent with the growth curves constructed using ages from thin-sectioned otoliths (Dwyer *et al*., 2003).

Figure 8 shows survey abundance less than 22 cm from Canada and Spain for the period 1995-2014 as a proxy for recruitment. The 2014 fall survey was incomplete and no recruitment proxy is shown for that survey year. At that size, yellowtail flounder are not recruited to any of the regulated fisheries. Population numbers at length for yellowtail flounder less than 22 cm (age 0-3 years) are plotted from the spring and fall Canadian surveys and total numbers caught from the spring Spanish surveys. The trends in spring and fall abundance < 22 cm are generally similar between series with the exception of the 2004 and 2005 Canadian fall surveys which had increased abundance of small fish compared to either the Canadian spring or Spanish spring surveys. From 2006 to 2012 Canadian survey estimates of small fish abundance have been near or slightly below the time series average. Estimates of abundance of small fish in the Canadian fall 2013 survey and the 2014 Canadian Spring survey were below average, however, and in the Spanish survey series, values have been lower than normal since 2007.

B. Spanish Stratified-random Spring Surveys in the Regulatory Area, Div. 3NO (*SCR Doc. 15/08*)
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 2003, after extensive comparative fishing between the vessel, C/V *Playa de Menduiňa* and Pedreira trawl with the replacement vessel, C/V *Vizconde de Eza*, using a Campelen 1800 shrimp trawl as the new survey trawl, all

data have been converted to Campelen units (Paz *et al*., 2003, 2004). In 2006, an error in the estimation method was corrected and all survey estimates were re-calculated (González-Troncoso *et al*., 2006).

The biomass of yellowtail in the Div. 3NO of the NRA increased sharply up to 1999, and since then has shown a similar annual fluctuation pattern seen in the Canadian spring surveys of Div. 3LNO (Fig. 4 and 9) and the 2014 estimate of biomass was lower than the previous survey estimates. Most (85%) of the biomass comes from strata 360 and 376 similar to other years. Length frequencies in the recent Spanish surveys showed modes around 32-34 cm (Fig. 10). As in the Canadian spring surveys (Fig. 4), this survey showed a similar progression of the peak in the length frequencies from 1998 to 2003. From 2007-2010, there was is some evidence of a recruitment pulse in recent years similar to the Canadian spring survey results.

C. Stock Distribution *(SCR Doc. 15/026)*

Distribution of yellowtail flounder in NAFO Divs. 3LNO are described for the Canadian spring (1984-2010) and autumn (1990-2010) survey series (Maddock Parsons, 2011b) and for 2011 to 2014 in Maddock Parsons (2015). The stock continues to occupy more northern areas, and while variable, the proportion of yellowtail north of 45 degree latitude has been stable around levels seen in the mid-80s (about 40%) (see Maddock Parsons 2015).

Correlation of spatial distribution in the surveys to temperature has not been updated for this assessment.

In a previous assessment, a steady increase in the abundance of yellowtail flounder was seen to coincide with a northward expansion of the stock from 1995 up to 2005 and also coincided with increasing bottom temperatures (Walsh and Brodie, 2006). Small amounts of yellowtail were sometimes found in deepwater.

D. Biological Studies

Maturity

Maturity at size by year was estimated using Canadian spring research vessel data from 1984-2014. Estimates were produced using a probit model with a logit link function and a binomial error structure (SAS, 1989). L50 has showed a general decline in males from the beginning of the time series to about 2000 after which it has been relatively stable. Current L50 for males is around 23 cm compared to 30 cm in the mid 1980's. Female L50 has been generally declining since the mid 1990's and current L50 is about 30 cm compared to 34 cm at the beginning of the time series (Fig. 11). There was significant inter-annual variation in the proportion mature at length for both males and females (generalized linear models: males $\chi2=491.32$, df=30, $p<0.0001$, females $\chi2=474.33$, df=30, $p<0.0001$). In general for both males and females, proportion mature at length in the last 10 years (2006-2014) was less than that of the first 10 years.

Weight at length

Log length – log weight regressions were fit for females for each year from the Canadian spring survey data from 1990-2014. The specific length weight relationships are given in Table 6. Annual length weight relationships were unavailable prior to 1990 so for those years a relationship produced using data from 1990-1993 is given. There seems to have been a slight down ward trend in weight at length since 1996. This can be best seen in the largest size range plotted, the 50.5 cm grouping. For this size group weight has declined by about 0.09 Kg since 1996 (average 1990-96 compared to average 2010-14 Fig. 12).

Female 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. Female SSB declined from 1984 to 1992 (Fig. 13). Since 1995 it has increased substantially. The average index over the 1996-1998 period was 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. Overall the SSB index increased from 1995 to 2008. The SSB index has been generally decreasing since 2010 but remains substantially higher than that of the mid-1980's.

E. Assessment Results

CPUE analysis

A multiplicative model (Gavaris, 1980) was used to analyze the catch and effort data for this stock as in assessments prior to the moratorium (Brodie et al. 1994), and in recent years (Maddock Parsons 2013). Logbook data from the Can (N) fleet identifying yellowtail as the directed species from 1965 to 1993, along with 1998-2005 and 2007-2014 data were utilized to derive a standardized catch rate series. This logbook data provides the longest series available because data from NAFO Statistical Bulletins exist only from 1974 onward in a format that identifies yellowtail as a main (directed fishery) species. The Can (N) fleet has taken the majority of the catch over the time period from this stock and provided the only source of CPUE data, particularly the late 1970's and also since 1998. The data from 2006 was not included in the standardization because only 177 tons were taken by the Can(N) fleet trawlers due to labour problems within the industry.

Ln (CPUE) was the dependent variable in the model. Independent variables (category types) were: (1) a combination country-gear-tonnage-class category type (CGT), (2) NAFO Division, (3) month and (4) Year. Consistent with previous catch rate standardizations (e.g. Maddock Parsons 2013), individual observations with catch less than 10 tons or effort less than 10 hours were eliminated prior to analysis. Subsequently, within each independent variable, categories with arbitrarily less than five observations were also eliminated, with the exception of the variable "year", which is the purpose of the standardization. The percentage of otter trawl catch with reported hours fished effort utilized in the analysis, after the selection criteria were applied, ranged from 33% in 1966 to 100% in 2005, and averaged 69% since 1965 and 93% since the fishery re-opened in 1998. The advantage of running the Gavaris model is that the derived index is retransformed into the original units of fishing effort and can be computed for any chosen combination of the main factors. 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 7 and 8 show the ANOVA and regression results of the CPUE analysis and the standardized series for Div. 3LNO from 1965-2014 (Fig. 14). ($r2$ = 66%)The catch per unit of effort declined steadily from 1965 to 1976 then increased marginally to a relatively stable level from 1980 to 1985. The index again declined to the lowest level in the series in 1991. The catch rate in 1998, after more than four and a half years of moratorium, was at a level comparable to the late 1960's then remained stable to 2002. The CPUE increased again for several consecutive years to 2008 then remained stable with some fluctuation to 2012. The highest rate in the series occurred in 2013 with a slight decreased in 2014. Monthly coefficients (Table 7) indicated that CPUE was highest during the fall period (September – October) and the best catch rates are in Div. 3N. Data from the Canadian fleet indicate that by-catch of American plaice has been problematic in this fishery since the moratorium but no attempt has been made to account for this factor in the CPUE analyses.

Standardizations of the data separately for Div. 3N and Div. 3O (Fig. 3B, from Maddock Parsons 2013) showed that, overall, the historical trends were the same, although the catch rate is generally lower in Div. 3O than in Div. 3N. Large fluctuations tend to occur more frequently in Div. 3O, primarily before 1985. In the period since the resumption of the directed fishery in 1998, catch rates showed opposite trends between most years within each division between 1998 and 2004 but trends were similar in recent years. Nevertheless, both series indicate recent catch rates are amongst the highest in the time series. Analysis of CPUE by Div. was not available for the 2014 catch information.

As noted previously, e.g. Brodie et al. (2004), the fluctuations in the combined index from 1990 to 1993 was due primarily to the switch in effort of the fleet to Div. 3O. A substantial part of the effort labeled '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. Given this major shift in the fishery from the 1965-90 to 1991-93, 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 another indication that the stock was low at that time. Since the resumption of the fishery in 1998, there was a 5% by-catch restriction of for both American plaice and cod which directly affected the fishing pattern of the Canadian fleet. The vessels spent additional time searching for good catches of yellowtail with low by-catches of both restricted species, which they found mainly in the central and northern areas of Div. 3N. Avoidance of yellowtail too small for filleting machines (less than about 35 cm) has also been a factor in the fishery in recent years. The by-catch limits were increased to 13% in 2009 and to 15% in 2010. Once again, caution should be used in comparing post-moratorium catch rates with other fishery periods. However, the overall CPUE has increased since 1998, under the constraint of 5% by-catch limitations for most years, and suggests that the stock size has increased to a relatively high level, in agreement with survey indices (Maddock Parsons 2015; Gonzalez-Troncoso et al. 2015).

Surplus production model (ASPIC)
A non-equilibrium surplus production model incorporating covariates (ASPIC; Prager, 1994, 1995, 2005, 2015) was applied to nominal catch and survey biomass indices, as was done in several previous assessments of this stock (Walsh *et al*., 2002; 2004;2006; Maddock Parsons *et al*., 2008; 2009; 2011; 2013). The Schaefer production model used assumes logistic population growth, in which the change in stock biomass over time (dB_t/dt) is a quadratic function of biomass (B):

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

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):

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

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

$$MSY = K\,r / 4; \quad B_{msy} = K / 2; \quad F_{msy} = r / 2$$

Initial biomass (expressed as the ratio: $B1/K$), K, MSY, and catchability coefficients for each biomass index (q_i) were estimated using non-linear least squares of survey residuals. Once a model formulation is accepted, a bootstrapped run can be made, in which survey residuals are randomly re-sampled 500 times to derive bias-corrected probability distributions for parameter estimates.

There was a major revision to the ASPIC program available for this assessment (version 7.02; Prager 2015). There were several changes to the leading parameters of the model; the user now provides starting guesses and bounds on MSY and FMSY instead of MSY and K. The input file now also requires bounds on catchability co-efficient (previously these bounds were computed heuristically by the program). As well, previous assessments of this stock, conducted in earlier versions of ASPIC, used relative convergence criteria chosen based on sensitivity analysis (Walsh and Brodie, 2013). Prager (2015) recommends the values for the 3 convergence criteria required for the program:

1. The convergence tolerance of the Nelder–Mead optimizer among its several trial parameter vectors (Simplex)= $1\text{x } 10^{-8}$
2. the convergence tolerance of randomized restarts, which are used by ASPIC to escape local minima (Restarts)= $3 \text{ x } 10^{-8}$
3. the convergence tolerance in computing fishing mortality when conditioning on yield (Effort)= $1 \text{ x } 10^{-4}$

Sensitivity of the assessment results to the new version of ASPIC (with new input parameters) was first explored by comparing the results of the last assessment to an ASPIC run in version 7.02 using the model formulation as close as possible to the last agreed formulation in 2013, including the convergence criteria used in the 2013 model. The results of this comparison run are given in Table 9 and Figure 15. Parameter estimates (including MSY, K and relative trajectories of biomass and fishing mortality) and model diagnostics were very similar using the new version of ASPIC and it was concluded that there should be no issues moving to the new version of the software in the current assessment of the stock.

Five model formulations with updated survey and catch data were then run in the new version of ASPIC in order to address questions about 1. the sensitivity of the model to the convergence criteria specified; 2. the effect of setting a penalty term on B1>K; 3. the effect of setting the catch in 2015 to a level less than the TAC (as the TAC hasn't been realized since before 2005; and finally 4. the effect of removing the Spain survey series (as residuals show a positive value in many years). These runs are described below:

Run 1: using the updated catch series and survey series and the catch in 2015 set to the TAC (17000t) with the model formulation comparable to the 2013 accepted assessment.
Run 2: as Run 1 but with the convergence criteria set to those recommended by Prager (2015).
Run 3: as Run 2 but with penalty on initial biomass (B1) greater than K set to 1
Run 4: as Run 3 but catch in 2015 set to the average catch from 2007-2014
Run 5: as Run 4 with Spanish survey out.

The parameter estimates from Runs 1 to 4 were very similar. Estimates of carrying capacity, K, MSY, and Fmsy were so close as to not cause concern over moving to the new model and using the updated information, with recommended convergence criteria, and the penalty on B1>K set to 1. Relative biomass and fishing mortality time series overlapped for most of the time series. The model run with the Spanish survey out (Run 5) did show differences in estimates of K (higher at 152.6 compared to 145), Bmsy (76.3 compared to 72.5 in Run 3) and other parameter estimates. A similar sensitivity study was conducted by Walsh and Brodie (2003) and they also concluded that the model was sensitive to excluding the Spanish series. STACFIS decided in 2004, however decided to keep the standard model formulation in order to preserve consistency with previous assessments. The same discussion and conclusion was taken at the current assessment, so the accepted model was decided as Run 4, with updated catch and survey series, recommended convergence criteria, penalty on B1/K set to 1, and, to be more in line with recent catch history (as TAC hasn't been taken since 2004 due to industry related factors), catch in 2015 was set to the average of the 2007-2014 catch (7400t). See Appendix 1 for the header data which outlines the input to the ASPIC model.

Because of differences in catchability among the various indices, relative (to *MSY* values) indices of biomass and fishing mortality rate were used instead of absolute values. Fishing mortality refers to yield (catch) /biomass ratio.
Input data/model formulation

The survey indices and catch series that were used in the production model are included in Table 8. The catch and indices (scaled to the mean of each series) are shown in Figure 16.

For the accepted model in 2015 (Run 4), then, correlations among biomass indices varied (see Appendix 2). Of the five pair-wise correlations among the biomass indices included in the production analysis, all were high (>0.7). This excludes a sixth possible comparison involving only 2 data points (Russian *vs*. Canadian fall).

The model fit the data relatively well (Table 9; Figs. 17 and 18). The majority of variance in survey indices was explained by the model, but fit varied among indices (r^2 ranged from 0.55 to 0.87). Residuals appeared to be randomly distributed for most of the survey indices (see Figure 18 and Appendix 2). The Spanish survey series, however, which covers only a portion of the stock area, showed negative residuals in the first 3 years followed by positive residuals in most years. This indicates that the series increased faster than the model estimates in the latter period. In recent years, residuals have been smaller, and in 2014, was negative.

ASPIC model estimates of relative biomass (B_t/B_{msy}) and fishing mortality rates (F_t/F_{msy}) are more precisely estimated than absolute values (Prager, 1995). Therefore the estimates of annual biomass (as of Jan 1) and fishing mortality rates were presented in relative terms.

The model results were very similar in trend to recent previous assessments, but parameter estimates were slightly higher. The model (Run 4) suggested that a maximum sustainable yield (*MSY*) of 18 730 (80% CL = 17 740, 19 420) tons can be produced when the total stock biomass (B_{msy}) is 72 500t (80% CL=65 510, 78 300) tons and the fishing mortality rate (F_{msy}) is 0.26 (80% CL = 0.23, 0.29) (Table 9; Appendix 2). Estimates of relative biomass and fishing mortality rates are given in Table 11 and shown in Fig. 19. 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. The analysis showed that relative biomass (B_t / B_{msy}) was below the level at which *MSY* can be produced from 1974 to 1998, and at its minimum in 1994 the ratio was about 0.20, which is below the suggested B_{lim} reference point of 30% B_{msy} proposed by the SC Study Group on Limit Reference Points (NAFO 2004, SCS Doc. 04/12). Since 1994, the stock increased rapidly to a point where B_t / B_{msy} >1.0, and at the beginning of 2016, the relative bias corrected biomass B_t / B_{msy} is estimated to be 1.77 (80% CL = 1.75, 1.78).

The relative fishing mortality rate (F_t / F_{msy}) was high during most of the historical fishery (Fig 19), 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 gradually increased to the advised level of $2/3F_{msy}$, but since 2006 the bias corrected *F*-ratios were considerably lower than $2/3F_{msy}$. If catches are similar to recent levels (7 400t) in 2016, the bias corrected *F*-ratio was calculated to be 0.22 (80% CL = 0.21, 0.24). Since the moratorium in 1994, the estimated yield from the stock had been below surplus production levels, until 2008 when the catch slightly exceeded the estimated surplus production. The stock is considered to be within the safe zone as defined in the Scientific Council Precautionary Approach Framework (NAFO, 2004).

Retrospective analysis
The surplus production model for the 2015 assessment was run with the same formulation, dropping out 5 years of data, one year at a time (2014-2010). The model parameter estimates and goodness of fit results are given in Table 12 and the relative biomass and fishing mortality estimates are plotted in Figure 20. There is virtually no retrospective pattern in the 2015 production model.

Projections
The accepted formulation for the 2015 assessment (Run 4) was used as the basis for projections in the short and medium term with 2015 catch=average catch from 2007-2014 (7400 t). A second 2015 catch scenario (with catch =TAC of 17000t (Run 3)) was also considered for projections. Model results for the ASPIC run used to project this scenario were nearly identical to the 2015 catch=average 2007-2014 run and are included in Table 9. Medium-term projections for both 2015 catch scenarios were carried out by extending the ASPIC bootstrap results forward to the year 2020 under assumptions of constant fishing mortality at 2/3 F_{msy}, 0.75 F_{msy}, 0.85 F_{msy}, and F_{msy}. Catch and biomass decrease slightly in the projections at 2/3 F_{msy}, 0.75 and 0.85 F_{msy} (Table 14). At all levels of F_{msy} considered, and for both catch scenarios examined, medium term projections indicated that the probability of the biomass in 2016 and 2017 being below B_{msy} is negligible (Table 15). Plots of projection results are shown in Figure 21.

Precautionary Approach Framework
The surplus production model outputs indicate that the stock is presently above B_{msy} and *F* is below F_{msy} (Fig. 20). 30% B_{msy} is considered a suitable limit reference point (B_{lim}) for stocks where a production model is used. At present, the risk of the stock being below B_{lim} = 30% B_{msy} is approximately zero. The stock is, therefore, in the safe zone as defined in the NAFO Precautionary Approach Framework.

Summary

Yellowtail flounder on the Grand Bank declined in the late 1980s and early 1990s to its lowest observed level in 1994 (about 20% B_{msy}) following several years of excessive catch. The stock was under a directed-fishery moratorium from January 1, 1994 until Aug 1, 1998. The stock increased rapidly during and following the closure, as strong year classes produced in the early to mid-1990s (albeit at low SSB levels), benefited from 4+ years of reduced fishing mortality. Catches increased from about 4 400 tons in 1998 to around 15 000 tons 2004 and 2005, but was very low in 2006 (due to corporate restructuring/labour dispute in the Canadian industry) and again well below the TAC in most years since then, although catches were nearer the 2000-2005 average in 2008 at 11 400 tons. Industry-related factors have been responsible for these low catches. Stock size estimates remain high, above B_{msy}. Fishing mortality is estimated to be below 2/3 F_{msy}, and well below the limit reference point ($F_{LIM} = F_{msy}$), and at levels of *F* between 2/3 F_{msy} and 85% F_{msy}, the stock is not projected to decrease below B_{LIM} in the medium term (to 2018).

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Table 1. Nominal catches by country and TACs (tons) of yellowtail in NAFO Divisions 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	3075	-	55	-	-	3130	
1966	4185	-	2,834	-	7	7026	
1967	2122	-	6,736	-	20	8878	
1968	4180	14	9146	-	-	13340	
1969	10494	1	5,207	-	6	15708	
1970	22814	17	3,426	-	169	26426	
1971	24206	49	13087	-	-	37342	
1972	26939	358	11929	-	33	39259	
1973	28492	368	3,545	-	410	32815	50000
1974	17053	60	6,952	-	248	24313	40000
1975	18458	15	4,076	-	345	22894	35000
1976	7910	31	57	-	59	8057	9000
1977	11295	245	97	-	1	11638	12000
1978	15091	375	-	-	-	15466	15000
1979	18116	202	-	-	33	18351	18000
1980	12011	366	-	-	-	12377	18000
1981	14122	558	-	-	-	14680	21000
1982	11479	110	-	1,073	657	13319	23000
1983	9085	165	-	1,223	-	10473	19000
1984	12437	89	-	2,373	1836 [b]	16735	17000
1985	13440	-	-	4,278	11245 [b]	28963	15000
1986	14168	77	-	2,049	13882 [b]	30176	15000
1987	13420	51	-	125	2718	16314	15000
1988	10607	-	-	1,383	4166 [b]	16158	15000
1989	5009	139	-	3,508	1551	10207	5000
1990	4966	-	-	5903	3117	13986	5000
1991	6589	-	-	4156	5458	16203	7000
1992	6814	-	-	3825	123	10762	7000
1993	6747	-	-	-	6868	13615	7000
1994	-	-	-	-	2069	2069	7000 [d]
1995	2	-	-	-	65	67	0 [d]
1996	-	-	-	-	232	232	0 [d]
1997	1	-	-	-	657	658	0 [d]
1998	3739	-	-	-	647	4386	4000
1999	5746	-	96	-	1052 [b]	6894	6000
2000 [c]	9463	-	212	-	1486	11161	10000
2001 [c]	12238	-	148	-	1759	14145	13000
2002 [c]	9959	-	103	-	636	10698	13000
2003 [c]	12708	-	184	-	914 [e]	13806	14500
2004	12575	-	158	-	621	13354	14500
2005	13140	299	8	-	486	13933	15000
2006	177	-	1	-	752	930	15000
2007	3673	-	76	-	874	4623	15500
2008	10217	384	143		659	11403	15500
2009	5416	87	3		662	6168	17000
2010	8070	580	101	-	628	9379	17000
2011	3947	338	82	-	863	5230	17000
2012	1796	321	84	-	1483	3684	17000
2013	7921		166	-	2597	10684	17000
2014	6802	6	85	-	1095	7988	17000
2015							17000

[a] South Korean catches ceased after 1992
[b] includes catches estimated from Canadian surveillance reports
[c] provisional
[d] no directed fishery permitted
[e] Includes catches averaged from a range of estimates

Table 2. Canadian catches (tons) of yellowtail flounder by division, from 1973 to 2014. Data from 2003-14 are from preliminary Canadian ZIF statistics and maybe slightly different from STATLANT data.

	OTTER TRAWL				
YEAR	3L	3N	30	3LNO	OTHER GEARS
1973	4188	21470	2827	28475	17
1974	1107	14757	1119	16983	70
1975	2315	13289	2852	18456	2
1976	448	4978	2478	7904	6
1977	2546	7166	1583	11295	0
1978	2537	10705	1793	15035	56
1979	2575	14359	1100	18034	82
1980	1892	9501	578	11971	40
1981	2345	11245	515	14105	17
1982	2305	7554	1607	11466	13
1983	2552	5737	770	9059	26
1984	5264	6847	318	12429	8
1985	3404	9098	829	13331	9
1986	2933	10196	1004	14133	35
1987	1584	10248	1529	13361	59
1988	1813	7146	1475	10434	173
1989	844	2407	1506	4757	252
1990	1263	2725	668	4656	310
1991	798	2943	2284	6025	564
1992	95	1266	4633	5994	820
1993	0	2062	3903	5965	782
1994	0	0	0	0	0
1995	0	0	0	0	2
1996	0	0	0	0	0
1997	0	1	0	1	0
1998	0	2968	742	3710	29
1999	0	5636	107	5743	3
2000	1409	7733	278	9420	43
2001	183	8709	3216	12108	130
2002	22	7707	2035	9764	195
2003	28	8186	4482	12696	1
2004	2760	7205	2609	12574	3
2005	284	10572	2283	13139	1
2006	-	176	-	176	1
2007	5	2053	1615	3672	1
2008	985	6976	2249	10210	6
2009	224	3228	1958	5410	3
2010	113	5584	2372	8069	2
2011	24	1887	2036	3947	1
2012	199	1171	424	1794	0
2013	82	6034	1804	7920	0
2014	2	5827	973	6802	0

Table 3. Monthly catch (t) of Yellowtail founder by Canadian vessels in NAFO Divisions 3LNO from 2009-2014.

	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sept	Oct	Nov	Dec
2009	542	313	287	304	723	711		316	604	526	676	410
2010	288	274	431	1345	1420	1147		66	486	993	766	855
2011	343		221	917	987	1191	286					
2012				398	382	506				49	390	70
2013	329	529	1316	478	829	830		278	1058	1074	849	351
2014	559	778	824	802	721	1002			168	418	1152	376

Table 4. Estimates of abundance (millions), biomass ('000 tons), mean number and weight (kg) per tow for Spring surveys in NAFO

	Abundance				Biomass				Mean number per tow				Mean weight (kg) per tow			
	3L	3N	3O	3LNO	3L	3N	3O	3LNO	3L	3N	3O	3LNO	3L	3N	3O	3LNO
1984	45.4	435.3	63.5	544.2	21.9	167.7	28.2	217.7	22.1	189.7	25.8	79.9	10.7	73.1	11.4	32.0
1985	49.9	240.1	84.1	374.1	21.1	88.2	37.5	146.8	9.4	104.6	34.2	37.1	4.0	38.4	15.2	14.6
1986	26.9	229.5	70.1	326.5	12.6	95.1	30.5	138.2	5.3	100.0	28.5	33.3	2.5	41.5	12.4	14.1
1987	12.3	291.0	90.9	394.2	5.8	77.5	41.2	124.6	2.4	128.1	36.9	40.2	1.1	34.1	16.7	12.7
1988	8.1	135.3	59.7	203.1	3.7	51.4	25.8	81.0	1.6	58.9	24.2	20.7	0.7	22.4	10.5	8.2
1989	7.9	478.3	46.7	532.9	4.0	78.3	21.5	103.8	1.6	208.4	18.9	54.3	0.8	34.1	8.7	10.6
1990	4.7	305.5	57.3	367.4	2.2	75.7	25.1	103.1	0.9	133.1	23.9	37.7	0.4	33.0	10.5	10.6
1991	2.2	268.1	50.0	320.3	1.1	69.1	23.3	93.4	0.4	111.7	19.7	32.5	0.2	28.8	9.2	9.5
1992	0.3	189.2	28.0	217.4	0.2	49.6	11.6	61.4	0.1	79.3	11.0	21.2	0.0	20.8	4.6	6.0
1993	0.2	145.0	101.1	246.3	0.1	50.8	42.4	93.3	0.0	60.4	39.8	24.0	0.0	21.1	16.7	9.1
1994	0.1	126.4	21.9	148.4	0.0	46.3	9.2	55.6	0.0	51.5	8.5	14.1	0.0	18.9	3.6	5.3
1995	0.0	158.8	28.5	187.4	0.0	57.9	12.7	70.6	0.0	66.1	11.2	18.2	0.0	24.1	5.0	6.9
1996	2.5	475.3	161.7	639.4	1.1	103.9	70.6	175.6	0.5	198.0	63.3	62.2	0.2	43.3	27.6	17.1
1997	1.2	554.9	139.4	695.5	0.5	121.3	53.2	174.9	0.2	233.2	54.6	67.7	0.1	51.0	20.8	17.0
1998	1.6	577.2	154.5	733.3	0.5	143.7	58.0	202.2	0.3	240.4	60.5	69.9	0.1	59.8	22.7	19.3
1999	55.4	965.4	269.1	1289.9	28.5	238.5	98.7	365.7	9.6	402.1	105.4	120.4	5.0	99.3	38.7	34.1
2000	40.7	695.3	186.5	922.5	17.5	197.3	72.1	287.0	7.6	289.6	73.1	89.6	3.3	82.2	28.3	27.9
2001	11.5	1119.9	197.2	1328.5	4.4	297.9	63.6	366.0	2.1	466.4	77.3	126.6	0.8	124.1	24.9	34.9
2002	1.6	528.3	161.0	690.9	0.6	147.3	51.6	199.5	0.3	220.0	63.1	66.5	0.1	61.4	20.2	19.2
2003	92.0	914.9	243.2	1250.1	34.7	280.2	72.0	386.9	16.9	381.0	95.3	120.2	6.4	116.7	28.2	37.2
2004	38.7	690.1	237.9	966.7	15.3	216.7	75.8	307.9	7.0	287.4	93.2	92.0	2.8	90.3	29.7	29.3
2005	115.6	822.0	227.1	1164.8	43.6	263.7	81.5	388.8	21.7	342.4	89.0	113.2	8.2	109.8	31.9	37.8
2006	251.5	1035.0	295.9	1582.4	85.7	319.1	99.1	503.8	47.1	660.7	169.8	183.0	16.0	203.7	56.9	58.3
2007	177.5	953.5	309.7	1440.7	60.9	292.8	89.3	443.0	33.3	397.1	121.4	140.0	11.4	121.9	35.0	43.0
2008	115.3	1114.6	250.6	1480.4	43.2	330.4	83.3	456.9	22.6	467.5	98.2	147.5	8.5	138.6	32.6	45.5
2009	47.0	751.6	117.9	916.4	13.2	213.5	44.4	271.2	8.8	313.0	46.2	89.0	2.5	88.9	17.4	26.3
2010	110.3	950.9	272.2	1333.3	28.6	276.9	89.2	394.7	21.0	396.0	106.7	130.8	5.5	115.3	35.0	38.7
2011	160.3	967.3	298.6	1426.1	55.8	266.9	100.2	422.9	29.7	402.9	117.7	137.9	10.3	111.1	39.5	40.9
2012	238.5	1184.6	269.1	1692.1	88.6	315.3	85.6	489.4	46.3	496.9	105.4	167.8	17.2	132.2	33.6	48.5
2013	210.6	955.5	196.5	1362.6	66.3	274.9	56.2	397.3	39.5	397.9	77.0	132.4	12.4	114.5	22.0	38.6
2014	101.0	773.6	204.7	1079.3	34.5	232.4	65.2	332.1	18.9	322.2	80.2	104.9	6.5	96.8	25.5	32.3

Table 5. Estimates of abundance (millions), biomass ('000 tons), mean number and weight (kg) per tow for Fall surveys in NAFO Divisions 3LNO from 1990-2014.

	Abundance				Biomass				Mean number per tow				Mean weight (kg) per tow			
	3L	3N	3O	3LNO	3L	3N	3O	3LNO	3L	3N	3O	3LNO	3L	3N	3O	3LNO
1990	4.4	148.5	39.5	192.5	2.1	46.5	17.3	65.8	0.8	65.9	16.1	19.3	0.4	20.6	7.0	6.6
1991	2.1	212.3	82.7	297.1	1.0	50.9	30.5	82.4	0.4	92.1	33.1	29.3	0.2	22.1	12.2	8.1
1992	2.0	158.0	55.8	215.9	0.9	44.1	19.4	64.5	0.4	86.4	22.7	22.4	0.2	24.1	7.9	6.7
1993	2.6	327.7	41.6	371.9	1.1	94.2	17.5	112.8	0.5	137.7	16.4	37.4	0.2	39.6	6.9	11.3
1994	0.1	259.3	28.5	287.9	0.0	95.5	10.9	106.4	0.0	108.0	11.2	28.0	0.0	39.8	4.3	10.4
1995	3.6	509.0	79.6	592.2	1.2	102.8	25.7	129.8	0.7	212.0	31.2	57.3	0.2	42.8	10.1	12.6
1996	6.7	516.3	56.2	579.1	2.2	113.2	18.9	134.3	1.1	215.0	22.7	51.6	0.4	47.1	7.6	12.0
1997	6.1	616.2	159.2	781.5	1.3	164.2	57.5	222.9	1.0	256.7	62.7	69.1	0.2	68.4	22.7	19.7
1998	13.1	632.1	183.0	828.2	5.2	173.6	52.8	231.6	2.1	241.2	69.0	71.1	0.8	66.3	19.9	19.9
1999	20.6	743.1	176.5	940.3	9.6	193.0	48.4	250.9	3.5	312.4	71.4	87.8	1.6	81.1	19.6	23.4
2000	37.9	860.3	254.1	1152.3	12.5	252.8	69.7	335.0	6.1	320.3	91.5	98.8	2.0	94.1	25.1	28.7
2001	74.5	1314.7	262.7	1651.9	25.5	368.9	81.4	475.8	11.7	489.5	95.3	139.8	4.0	137.3	29.5	40.3
2002	33.1	971.3	170.4	1174.8	13.6	272.7	53.5	339.7	5.2	361.7	61.4	99.3	2.1	101.5	19.3	28.7
2003	58.9	869.6	334.1	1262.6	18.6	252.0	97.7	368.3	9.2	364.8	127.1	110.9	2.9	105.7	37.2	32.3
2004	63.4	1158.6	209.1	1431.0	22.2	291.6	60.9	374.7	13.4	485.5	81.9	147.8	4.7	122.2	23.9	38.7
2005	38.8	1146.7	190.8	1376.3	14.1	261.5	67.1	342.7	6.6	446.1	68.7	122.7	2.4	101.7	24.2	30.6
2006	61.9	814.1	172.5	1048.5	21.2	232.3	52.0	305.5	10.2	339.1	68.1	95.4	3.5	96.7	20.5	27.8
2007	91.0	1414.2	252.0	1757.2	28.0	377.8	76.5	482.4	15.3	526.6	90.8	154.0	4.7	140.7	27.6	42.3
2008	81.9	787.1	300.2	1169.2	27.8	214.8	79.4	322.0	15.3	327.8	117.6	113.6	5.2	89.5	31.1	31.3
2009	45.1	709.9	145.0	900.0	16.5	180.7	40.7	237.8	7.6	282.7	52.6	80.2	2.8	72.0	14.7	21.2
2010	135.7	1335.9	184.7	1656.3	35.9	336.4	44.9	417.2	22.0	558.4	72.4	149.1	5.8	140.6	17.6	37.5
2011	103.0	759.2	176.5	1038.7	35.3	217.7	57.4	310.4	19.4	316.2	69.2	101.2	6.7	90.7	22.5	30.2
2012	93.4	827.5	342.1	1262.9	25.8	218.7	112.9	357.4	17.5	344.6	134.1	122.7	4.8	91.1	44.2	34.7
2013	103.2	901.9	180.2	1185.4	36.4	251.9	57.8	346.1	19.2	375.7	70.6	114.9	6.8	104.9	22.7	33.5
2014	57.9	0.0	0.0	57.9	19.8	0.0	0.0	19.8	9.7	0.0	0.0	9.7	3.3	0.0	0.0	3.3

Table 6. 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	3.1	-5.19
1990	3.19	-5.33
1991	3.05	-5.12
1992	3.02	-5.06
1993	3.11	-5.2
1994	3.09	-5.19
1995	3.1	-5.2
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	-5.2
2002	3.08	-5.2
2003	3.09	-5.22
2004	3.12	-5.24
2005	3.17	-5.32
2006	3.09	-5.21
2007	3.25	-5.46
2008	3.22	-5.42
2009	3.14	-5.3
2010	3.1	-5.23
2011	3.14	-5.3
2012	3.23	-5.43
2013	3.16	-5.34
2014	3.16	-5.32

Table 7. ANOVA results and regression coefficients from a multiplicative model utilized to derive a standardized CPUE index for Yellowtail flounder in NAFO Div. 3LNO. Analysis is based on HOURS FISHED from the Canadian ottertrawl fleet (2014 based on preliminary data).

REGRESSION OF MULTIPLICATIVE MODEL
MULTIPLE R............ 0.813
MULTIPLE R SQUARED..... 0.661

ANALYSIS OF VARIANCE

SOURCE OF VARIATION	DF	SUMS OF SQUARES	MEAN SQUARE	F-VALUE
INTERCEPT	1	3.70E1	3.701	
REGRESSION	60	1.69E1	2.82E-1	37.193
Cntry|Gear|TC(1)	3	8.52E-1	2.84E-1	37.452
Division(2)	2	9.58E-1	4.79E-1	63.227
Month(3)	11	4.78E-1	4.34E-2	5.730
Year(4)	44	1.13E1	2.57E-1	33.964
RESIDUALS	1146	8.69E0	7.58E-3	
TOTAL	1207	6.26E1		

REGRESSION COEFFICIENTS

CATEGORY	CODE	VAR #	REG. COEF	STD. ERR	NO. OBS
Cntry|Gear|TC	3125	INT	0.095	0.116	1207
Division	34				
Month	10				
Year	65				
(1)	3114	1	-0.302	0.033	162
	3124	2	-0.225	0.034	153
	3126	3	-0.077	0.034	144
(2)	32	4	-0.198	0.027	226
	35	5	-0.233	0.023	308
(3)	1	6	-0.174	0.064	34
	2	7	-0.265	0.059	39
	3	8	-0.157	0.054	49
	4	9	-0.190	0.045	83
	5	10	-0.124	0.039	157
	6	11	-0.143	0.039	170
	7	12	-0.199	0.041	140
	8	13	-0.108	0.042	129
	9	14	0.004	0.041	121
	11	15	-0.093	0.043	92
	12	16	-0.023	0.046	77
(4)	66	17	-0.051	0.147	11
	67	18	-0.100	0.155	12
	68	19	-0.256	0.145	14
	69	20	-0.430	0.136	20
	70	21	-0.413	0.122	42
	71	22	-0.450	0.120	41
	72	23	-0.554	0.121	45
	73	24	-0.426	0.120	50
	74	25	-0.852	0.123	37
	75	26	-0.864	0.122	38
	76	27	-0.916	0.132	26
	77	28	-0.786	0.124	38
	78	29	-0.740	0.121	51
(4)	79	30	-0.724	0.121	47
	80	31	-0.616	0.127	30
	81	32	-0.614	0.127	30
	82	33	-0.720	0.130	24
	83	34	-0.549	0.129	24
	84	35	-0.589	0.129	28
	85	36	-0.547	0.127	30
	86	37	-0.896	0.127	30
	87	38	-0.831	0.128	30
	88	39	-0.911	0.130	26
	89	40	-0.945	0.139	17
	90	41	-0.781	0.140	16
	91	42	-1.405	0.132	24
	92	43	-1.223	0.136	21
	93	44	-0.899	0.133	23
	98	45	-0.269	0.148	11
	99	46	-0.210	0.144	12
	100	47	-0.111	0.131	24
	101	48	-0.309	0.130	20
	102	49	-0.377	0.132	19
	103	50	-0.181	0.125	34
	104	51	-0.011	0.125	30
	105	52	0.086	0.125	32
	107	53	0.039	0.137	17
	108	54	0.154	0.125	35
	109	55	0.004	0.127	27
	110	56	0.030	0.128	27
	111	57	0.241	0.140	16
	112	58	0.044	0.152	12
	113	59	0.304	0.126	32
	114	60	0.257	0.128	26

LEGEND FOR AVOVA RESULTS:

CGT CODES:	3114 =	Can(NFLD)	TC 4 Side Trawler
	3124 =	"	TC 4 Stern Trawler
	3125 =	"	TC 5 "
	3126 =	"	TC 6 "

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

Table 8. Standardized CPUE for Yellowtail flounder in NAFO Div 3LNO based on a multiplicative model utilizing HOURS FISHED as a measure of effort. Results are from the CANADIAN OTTERTRAWL fleet (2014 based on preliminary data).

	PREDICTED CATCH RATE						
	LN TRANSFORM		RETRANSFORMED				% OF CATCH IN
YEAR	MEAN	S.E.	MEAN	S.E.	CATCH	EFFORT	THIS ANALYSIS
1965	0.0952	0.0135	1.097	0.127	3075	2804	39.5
1966	0.0439	0.0111	1.043	0.110	4185	4012	32.7
1967	-0.0043	0.0140	0.992	0.117	2122	2138	44.0
1968	-0.1611	0.0095	0.850	0.083	4180	4916	52.6
1969	-0.3350	0.0071	0.715	0.060	10494	14667	30.8
1970	-0.3176	0.0035	0.729	0.043	22814	31279	54.4
1971	-0.3543	0.0031	0.703	0.039	24206	34422	58.4
1972	-0.4585	0.0031	0.634	0.035	26939	42514	53.9
1973	-0.3306	0.0028	0.720	0.038	28492	39561	74.4
1974	-0.7573	0.0036	0.470	0.028	17053	36292	82.0
1975	-0.7692	0.0033	0.464	0.026	18458	39745	72.1
1976	-0.8205	0.0055	0.441	0.033	7910	17950	60.5
1977	-0.6910	0.0040	0.502	0.032	11295	22501	44.4
1978	-0.6444	0.0031	0.526	0.029	15091	28681	61.5
1979	-0.6292	0.0031	0.534	0.030	18116	33914	73.0
1980	-0.5205	0.0048	0.595	0.041	12011	20185	65.1
1981	-0.5191	0.0046	0.596	0.040	14122	23696	73.6
1982	-0.6247	0.0052	0.536	0.039	11479	21414	48.2
1983	-0.4541	0.0047	0.636	0.043	9085	14287	50.3
1984	-0.4933	0.0049	0.611	0.043	12437	20342	54.7
1985	-0.4521	0.0042	0.637	0.042	13440	21088	50.6
1986	-0.8007	0.0042	0.450	0.029	14168	31502	62.5
1987	-0.7356	0.0044	0.480	0.032	13420	27958	66.4
1988	-0.8160	0.0050	0.443	0.031	10607	23955	57.1
1989	-0.8496	0.0073	0.428	0.037	5009	11713	40.0
1990	-0.6860	0.0076	0.504	0.044	4969	9867	45.8
1991	-1.3103	0.0055	0.270	0.020	6589	24401	48.3
1992	-1.1281	0.0065	0.324	0.026	6814	21043	59.3
1993	-0.8035	0.0058	0.448	0.034	6747	15054	68.4
1998	-0.1739	0.0096	0.840	0.082	3739	4454	91.3
1999	-0.1146	0.0085	0.891	0.082	5746	6447	94.2
2000	-0.0156	0.0053	0.986	0.071	9463	9601	98.7
2001	-0.2141	0.0048	0.808	0.056	12238	15140	96.5
2002	-0.2815	0.0054	0.755	0.055	9959	13182	98.0
2003	-0.0862	0.0036	0.919	0.055	12708	13824	99.4
2004	0.0837	0.0037	1.089	0.067	12575	11543	99.4
2005	0.1812	0.0037	1.201	0.073	13140	10941	100.9
2007	0.1343	0.0066	1.144	0.093	3673	3210	99.9
2008	0.2495	0.0035	1.286	0.076	10217	7945	99.7
2009	0.0991	0.0040	1.106	0.070	5416	4896	99.6
2010	0.1255	0.0044	1.136	0.075	9366	8248	83.4
2011	0.3366	0.0075	1.400	0.121	5230	3735	74.9
2012	0.1391	0.0113	1.147	0.122	3131	2730	56.2
2013	0.3987	0.0038	1.493	0.092	7920	5306	91.7
2014	0.3519	0.0044	1.424	0.094	6801	4776	98.8

AVERAGE C.V. FOR THE RETRANSFORMED MEAN: 0.073

Table 9. Input indices used in the ASPIC production model for the 2015 assessment of Yellowtail flounder.

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	3.13					
1966	7.026					
1967	8.878					
1968	13.34					
1969	15.708					
1970	26.426					
1971	37.342	96.9				
1972	39.259	79.2				
1973	32.815	51.7				
1974	24.313	40.3				
1975	22.894	37.4				
1976	8.057	41.7				
1977	11.638	65.0				
1978	15.466	44.3				
1979	18.351	38.5				
1980	12.377	51.4				
1981	14.68	45.0				
1982	13.319	43.1				
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	65.8	
1991	16.203		27.5	93.4	82.4	
1992	10.762			61.4	64.5	
1993	13.615			93.3	112.8	
1994	2.069			55.6	106.4	
1995	0.067			70.6	129.8	9.3
1996	0.232			175.6	134.3	43.3
1997	0.658			174.9	222.9	38.7
1998	4.386			202.2	231.6	122.6
1999	6.894			365.7	249.9	197.0
2000	11.161			287.5	335.0	144.7
2001	14.145			366.0	475.8	182.7
2002	10.698			199.5	339.7	148.5
2003	13.806			386.5	368.3	136.8
2004	13.354			307.9	374.7	170.0
2005	13.933			388.8	342.7	156.48
2006	0.930			★	305.5	160.1
2007	4.623			443.0	482.4	160.7
2008	11.403			456.9	322.0	160.1
2009	6.168			271.2	237.8	183.4
2010	9.379			394.7	417.2	189.7
2011	5.23			422.9	310.4	203.8
2012	3.684			489.4	357.4	195.6
2013	10.684			397.3	346.1	188.0
2014	7.988			332.1	★	136.5
2015	7.400					

The average catch (2007-2014) is included as the 2015 catch in the input file.

★ Surveys in 2006 Spring and 2014 Fall were incomplete and results may not be comparable to other years

Table 10. Parameter estimates and model diagnostics comparing ASPIC versions 5.34 and 7.02 using the 2013 assessment formulation and ASPIC model runs (v7.02) for the 2015 assessment of Yellowtail founder in NAFO Divs. 3LNO.

	2013 Assess	2013 Assess ASPIC v5 vs v7 Run	2015 Run 1	2015 Run 2	2015 Run 3	2015 Run 4	2015 Run 5 Spain Out
	v 5.34 catch in 2013 TAC (17 000 t)	v 7.02 catch in 2013 TAC (17 000 t)	v7.02 catch in 2015 TAC (17 000t) prev cc	v7.02 catch in 2015 TAC (17 000t) recommended cc	v7.02 catch in 2015 TAC (17 000t) recommended cc penalty b1/k	v7.02 catch in 2015 (7400t avg07-14) recommended cc penalty b1/k	v7.02 catch in 2015 (7400t avg07-14) recommended cc penalty b1/k
starting guess B1/K*	1	1	1	1	1	1	1
penalty for B1>K*	0	0	0	0	1	1	1
B1/K	0.73	0.83	1.07	1.46	1.01	1.01	1.01
K	149.50	147.90	144.70	142.30	145.10	145.00	152.60
MSY	18.97	18.84	18.70	18.53	18.72	18.73	18.19
Bmsy	74.76	73.97	72.36	71.16	72.53	72.50	76.30
Fmsy	0.254	0.255	0.259	0.260	0.258	0.258	0.236
B/Bmsy	1.700	1.694	1.656	1.652	1.657	1.767	1.758
Y(Fmsy)	29.870	29.560	28.780	28.450	28.820	30.390	29.570
Ye	9.662	9.770	10.650	10.650	10.650	7.714	7.742
F/Fmsy	0.511	0.516	0.533	0.539	0.533		
phi					0.500	0.500	0.500
q (FC/Spring)	3.217	3.245	3.244	3.289	3.239	3.241	2.916
q (Yankee)	0.997	0.994	1.000	1.000	1.001	1.002	0.911
q (Can Fall)	3.190	3.220	3.230	3.286	3.227	3.228	2.892
q (Russian)	1.163	1.165	1.176	1.180	1.173	1.174	1.068
q (Spanish)	1.297	1.312	1.319	1.341	1.316	1.316	
R^2 FC/Spring	0.874	0.874	0.869	0.869	0.868	0.868	0.863
R^2 Yankee	0.804	0.804	0.804	0.805	0.804	0.804	0.805
R^2 Can Fall	0.722	0.724	0.731	0.731	0.730	0.730	0.763
R^2 Russian	0.548	0.551	0.555	0.558	0.553	0.553	0.519
R^2 Spanish	0.693	0.694	0.669	0.670	0.669	0.669	
Est contrast index (best=1.0)	0.802	0.798	0.891	0.892	0.891	0.891	0.856
Est nearness index (best=1.0)	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Tot Obj Function	6.997	6.994	7.137	7.133	7.137	7.137	3.694
MSE	0.086	0.086	0.083	0.083	0.083	0.083	0.055

* This is an input to the model.

Table 11. Bootstrap results (1000 iterations) from the accepted 2015 assessment (Run 4) of Yellowtail flounder (ASPIC version 7.02).

				Bias-corrected approximate confidence limits			
	Point Estimate	80% Lower	80% Upper	50% Lower	50% Upper	IQ range	Rel IQ range
B1/K	1.01	0.56	1.05	0.69	1.03	0.34	0.33
MSY	18.73	17.74	19.42	18.15	19.04	0.90	0.05
Fmsy	0.26	0.23	0.30	0.24	0.28	0.03	0.14
q (FC/Spring)	3.24	2.98	3.65	3.12	3.47	0.35	0.11
q (Yankee)	1.00	0.85	1.19	0.92	1.10	0.18	0.18
q (Can Fall)	3.23	2.90	3.58	3.07	3.42	0.35	0.11
q (Russian)	1.17	0.99	1.39	1.08	1.29	0.21	0.18
q (Spanish)	1.32	1.19	1.46	1.25	1.39	0.14	0.11
Ye(2016)	7.71	7.67	7.84	7.68	7.76	0.08	0.01
Bmsy	72.50	65.51	78.30	68.67	75.04	6.37	0.09
fmsy (FC/Spring)	0.08	0.07	0.09	0.07	0.08	0.01	0.11
fmsy (Yankee)	0.26	0.24	0.29	0.25	0.28	0.03	0.11
fmsy (Can Fall)	0.08	0.07	0.09	0.08	0.08	0.01	0.12
fmsy (Russian)	0.22	0.20	0.25	0.21	0.24	0.03	0.13
fmsy (Spanish)	0.20	0.17	0.22	0.18	0.21	0.03	0.13
B./Bmsy	1.77	1.75	1.78	1.76	1.77	0.02	0.01
F./Fmsy	0.22	0.21	0.24	0.22	0.23	0.01	0.06
Ye./MSY	0.41	0.39	0.44	0.40	0.43	0.03	0.06
q2/q1	0.31	0.26	0.36	0.28	0.33	0.05	0.16
q3/q1	1.00	0.89	1.09	0.94	1.04	0.10	0.10
q4/q1	0.36	0.31	0.42	0.33	0.39	0.06	0.16
q5/q1	0.41	0.36	0.45	0.38	0.43	0.05	0.11

Table 12. Estimates of relative F and B from the 2013 assessment (v5.34 and v7.02) and the 2015 assessment (ASPIC v7.02).

	F/F_{msy}			B/B_{msy}		
	2013v5	2013v7	2015v7	2013	2013v7	2015v7
1965	0.11	0.10	0.08	1.46	1.66	2.02
1966	0.23	0.21	0.19	1.60	1.74	1.98
1967	0.28	0.27	0.25	1.66	1.76	1.91
1968	0.42	0.41	0.40	1.68	1.75	1.85
1969	0.51	0.50	0.49	1.64	1.69	1.76
1970	0.93	0.92	0.90	1.59	1.63	1.67
1971	1.54	1.53	1.51	1.43	1.45	1.48
1972	2.05	2.04	2.02	1.16	1.18	1.19
1973	2.22	2.21	2.20	0.89	0.90	0.91
1974	2.04	2.03	2.02	0.69	0.70	0.70
1975	2.32	2.31	2.30	0.58	0.59	0.59
1976	0.83	0.83	0.82	0.47	0.47	0.48
1977	1.06	1.05	1.05	0.55	0.56	0.57
1978	1.33	1.33	1.32	0.61	0.61	0.62
1979	1.62	1.61	1.60	0.62	0.62	0.63
1980	1.08	1.07	1.06	0.58	0.59	0.60
1981	1.20	1.20	1.19	0.63	0.64	0.65
1982	1.03	1.03	1.02	0.66	0.66	0.67
1983	0.73	0.73	0.72	0.71	0.71	0.72
1984	1.08	1.08	1.07	0.80	0.81	0.82
1985	2.05	2.05	2.03	0.83	0.83	0.84
1986	2.82	2.81	2.79	0.67	0.68	0.69
1987	1.90	1.90	1.89	0.47	0.48	0.48
1988	2.10	2.10	2.09	0.43	0.44	0.44
1989	1.37	1.37	1.36	0.38	0.39	0.39
1990	1.89	1.89	1.88	0.41	0.41	0.41
1991	2.53	2.53	2.51	0.38	0.38	0.38
1992	1.93	1.93	1.92	0.30	0.31	0.31
1993	2.89	2.91	2.88	0.29	0.29	0.29
1994	0.43	0.43	0.43	0.22	0.21	0.22
1995	0.01	0.01	0.01	0.30	0.30	0.31
1996	0.02	0.02	0.02	0.45	0.45	0.46
1997	0.05	0.05	0.04	0.65	0.65	0.67
1998	0.24	0.24	0.23	0.88	0.88	0.90
1999	0.31	0.32	0.31	1.08	1.08	1.10
2000	0.46	0.46	0.46	1.23	1.23	1.26
2001	0.56	0.56	0.56	1.32	1.32	1.34
2002	0.41	0.41	0.41	1.35	1.35	1.37
2003	0.51	0.51	0.51	1.42	1.42	1.44
2004	0.48	0.49	0.49	1.45	1.44	1.45
2005	0.50	0.50	0.50	1.47	1.46	1.47
2006	0.03	0.03	0.03	1.48	1.48	1.48
2007	0.15	0.15	0.15	1.64	1.64	1.64
2008	0.35	0.36	0.36	1.71	1.71	1.72
2009	0.19	0.19	0.19	1.69	1.69	1.69
2010	0.29	0.29	0.29	1.73	1.73	1.73
2011	0.16	0.16	0.16	1.73	1.72	1.72
2012	0.09	0.11	0.11	1.77	1.77	1.77
2013	0.51	0.52	0.32	1.82	1.81	1.81
2014			0.24	1.70	1.69	1.76
2015			0.22			1.76
2016						1.77

Table 13. Model outputs (ASPIC version 7.02) for retrospective analysis.

Model	2015 Assessment Run 4 1965-2015	1965-2014	1965-2013	1965-2012	1965-2011	1965-2010
B1/K	1.011	1.008	1.004	1.001	1.008	1.002
K	145.000	145.000	145.700	145.700	145.000	145.400
MSY	18.730	18.730	18.690	18.680	18.730	18.700
Bmsy	72.500	72.510	72.830	72.870	72.510	72.720
Fmsy	0.258	0.258	0.257	0.256	0.258	0.257
B/Bmsy	1.767	1.761	1.762	1.810	1.761	1.722
Y(Fmsy)	30.390	30.320	30.280	30.950	30.320	29.740
Ye	7.714	7.868	7.822	6.412	7.868	8.943
q (FC/Spring)	3.241	3.240	3.269	3.283	3.240	3.275
q (Yankee)	1.002	1.002	0.995	0.994	1.002	0.997
q (Can Fall)	3.228	3.228	3.236	3.270	3.228	3.358
q (Russian)	1.174	1.174	1.169	1.169	1.174	1.173
q (Spanish)	1.316	1.316	1.334	1.331	1.316	1.310
R2 FC/Spring	0.868	0.868	0.879	0.874	0.868	0.852
R2 Yankee	0.804	0.804	0.805	0.805	0.804	0.804
R2 Can Fall	0.730	0.730	0.724	0.725	0.730	0.755
R2 Russian	0.553	0.553	0.553	0.554	0.553	0.555
R2 Spanish	0.669	0.669	0.705	0.694	0.669	0.661
Tot Obj Function	7.137	7.137	7.039	6.992	6.921	6.779
MSE	0.083	0.083	0.084	0.086	0.089	9.390

Table 14. Medium-term projections for yellowtail flounder. Estimates and 80% confidence limits of fishing mortality, biomass, yield and biomass /B_{msy} are shown, for projected F of 2/3 F_{msy}, 75% F_{msy} and 85% F_{msy}. The results are derived from an ASPIC bootstrap run (1000 iterations) with catch constraint in 2015 (avg catch 2007-14=7 400t).

	Projections with catch in 2015=avg 2007-2014 catch (7 400t)									
	Projected Catch ('000t)					Projected Relative Biomass (B_y/B_{msy})				
	2016	**2017**	**2018**	**2019**	**2020**	**2016**	**2017**	**2018**	**2019**	**2020**
2/3 F_{MSY}										
Approx 80% LCL	19.69	18.42	17.66	17.18	16.89	1.75	1.60	1.50	1.43	1.38
Estimated Yield	21.02	19.52	18.58	17.97	17.56	1.77	1.61	1.52	1.46	1.42
Approx 80%UCL	23.01	21.21	20.02	19.24	18.68	1.77	1.62	1.54	1.48	1.45
75% F_{MSY}										
Approx 80% LCL	21.95	20.25	19.24	18.61	18.20	1.75	1.57	1.45	1.37	1.32
Estimated Yield	23.43	21.44	20.21	19.40	18.85	1.77	1.58	1.47	1.40	1.35
Approx 80%UCL	25.64	23.27	21.72	20.70	19.95	1.77	1.60	1.49	1.43	1.39
85%F_{MSY}										
Approx 80% LCL	24.61	22.33	20.97	20.12	19.57	1.75	1.53	1.40	1.31	1.25
Estimated Yield	26.26	23.62	21.97	20.90	20.16	1.77	1.55	1.42	1.34	1.28
Approx 80%UCL	28.74	25.59	23.57	22.21	21.25	1.77	1.56	1.44	1.37	1.32
F_{MSY}										
Approx 80% LCL	28.49	25.20	23.25	22.03	21.21	1.75	1.49	1.32	1.21	1.14
Estimated Yield	30.39	26.60	24.27	22.74	21.68	1.77	1.50	1.35	1.25	1.18
Approx 80%UCL	33.24	28.78	25.98	24.03	22.70	1.77	1.52	1.37	1.28	1.22

	Projections with catch in 2015=TAC (17 000t)									
	Projected Catch ('000t)					Projected Relative Biomass (B_y/B_{msy})				
	2016	**2017**	**2018**	**2019**	**2020**	**2016**	**2017**	**2018**	**2019**	**2020**
2/3 F_{MSY}										
Approx 80% LCL	18.70	17.85	17.31	16.97	16.74	1.65	1.53	1.45	1.40	1.37
Estimated Yield	19.94	18.85	18.15	17.68	17.36	1.66	1.55	1.48	1.43	1.40
Approx 80%UCL	21.80	20.41	19.50	18.86	18.41	1.67	1.56	1.50	1.46	1.43
75% F_{MSY}										
Approx 80% LCL	20.85	19.62	18.85	18.35	18.03	1.65	1.51	1.41	1.35	1.30
Estimated Yield	22.22	20.70	19.72	19.07	18.63	1.66	1.52	1.43	1.38	1.34
Approx 80%UCL	24.29	22.40	21.15	20.27	19.67	1.67	1.53	1.46	1.41	1.37
85%F_{MSY}										
Approx 80% LCL	23.37	21.62	20.53	19.83	19.37	1.65	1.47	1.36	1.28	1.23
Estimated Yield	24.91	22.79	21.44	20.53	19.91	1.66	1.49	1.38	1.31	1.26
Approx 80%UCL	27.22	24.64	22.95	21.77	20.91	1.67	1.50	1.41	1.34	1.30
F_{MSY}										
Approx 80% LCL	27.05	24.38	22.73	21.67	20.97	1.65	1.43	1.28	1.19	1.12
Estimated Yield	28.82	25.66	23.66	22.32	21.38	1.66	1.44	1.31	1.22	1.16
Approx 80%UCL	31.49	27.69	25.24	23.54	22.35	1.67	1.46	1.33	1.25	1.20

Table 15. Yield (000 t), risk (%) of B_y<Bmsy and F_y>Fmsy for projected F values of 2/3 Fmsy, 75% Fmsy, 85% Fmsy and Fmsy. The results are derived from an ASPIC bootstrap run (1000 iterations) with catch constraint in 2015 of 7 400 tons (avg catch 2007-14).

			Catch2015=7 400t						
	Yield		$P(F_y>F_{msy})$			$P(B_y<B_{msy})$			
F level	2016	2017	2015	2016	2017	2015	2016	2017	$B_{2018}>B_{2014}$
2/3 Fmsy	21.02	19.52	<1%	<1%	<1%	<1%	<1%	<1%	<1%
75% Fmsy	23.43	21.44	<1%	<1%	<1%	<1%	<1%	<1%	<1%
85% Fmsy	26.26	23.62	5%	5%	5%	<1%	<1%	<1%	<1%
Fmsy	30.39	26.60	~50%	~50%	~50%	<1%	<1%	<1%	<1%

			Catch2015=17 000t (TAC)						
	Yield		$P(F_y>F_{msy})$			$P(B_y<B_{msy})$			
F level	2016	2017	2015	2016	2017	2015	2016	2017	$B_{2018}>B_{2014}$
2/3 Fmsy	19.94	18.85	<1%	<1%	<1%	<1%	<1%	<1%	<1%
75% Fmsy	22.22	20.7	<1%	<1%	<1%	<1%	<1%	<1%	<1%
85% Fmsy	24.91	22.79	5%	5%	5%	<1%	<1%	<1%	<1%
Fmsy	28.82	25.66	~50%	~50%	~50%	<1%	<1%	<1%	<1%

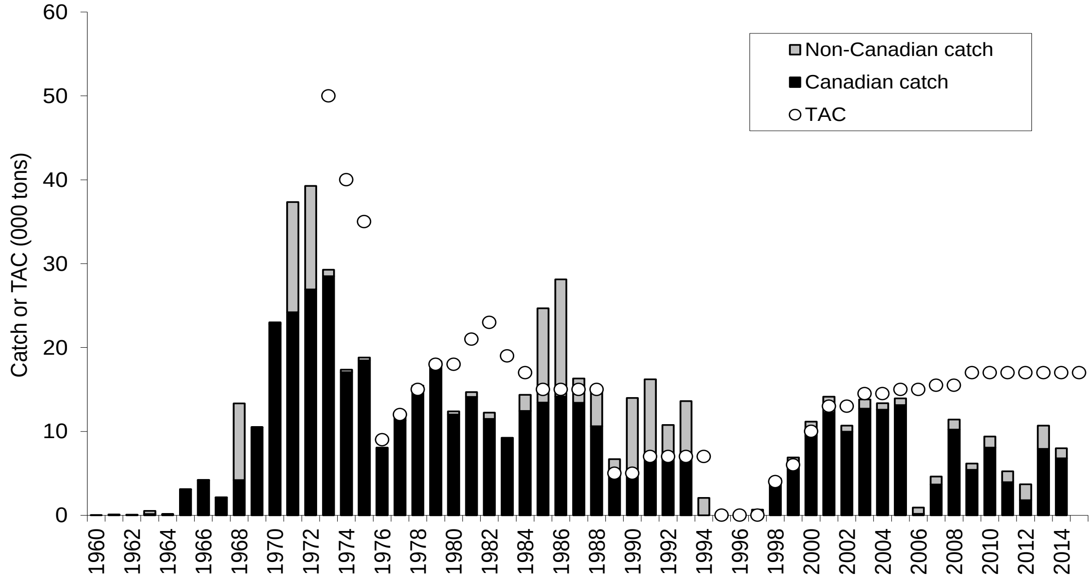

Figure 1. Catch (000 tons) and TAC of yellowtail flounder in NAFO Divisions 3LNO.

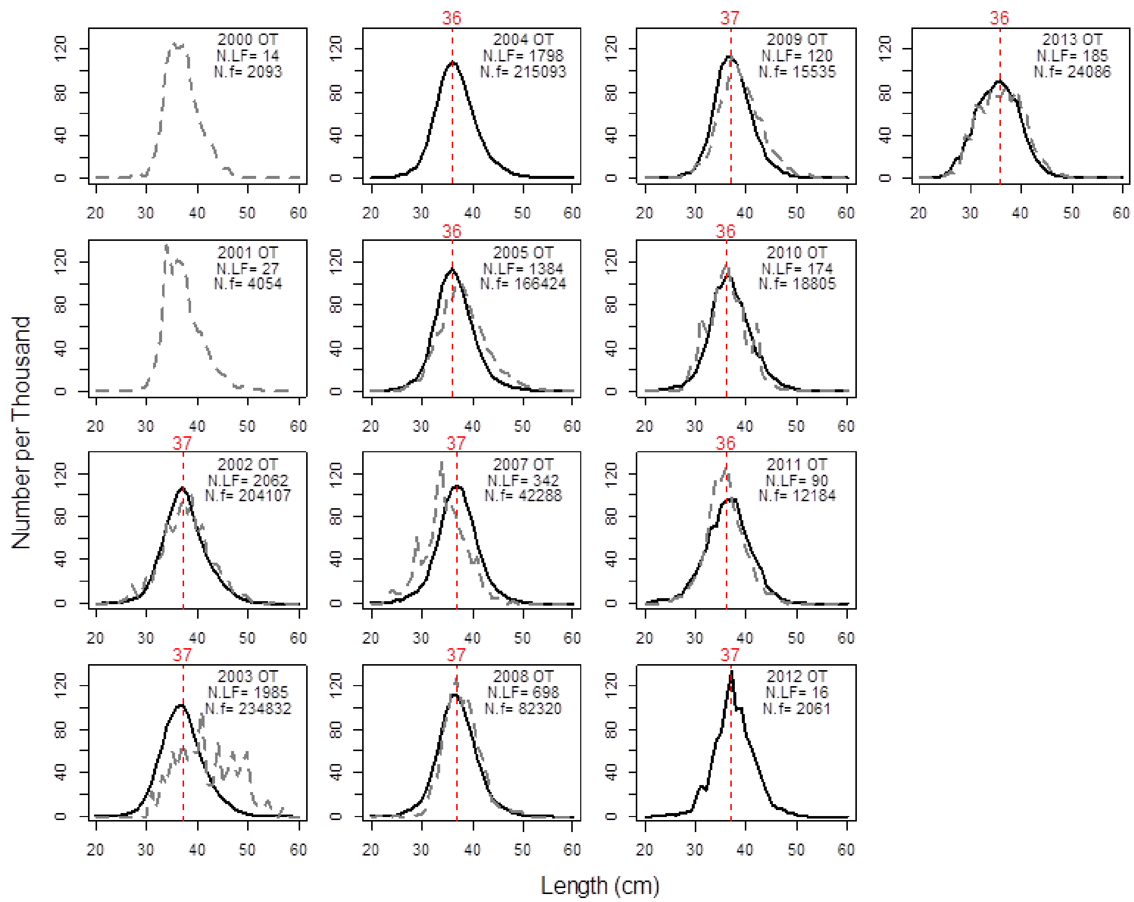

Figure 2. Length frequencies from the Canadian commercial ottertrawl fishery on Yellowtail Flounder in NAFO divs 3LNO from 2000-2013. Solid line indicates dockside sampling, hatched line shows at sea sampling.

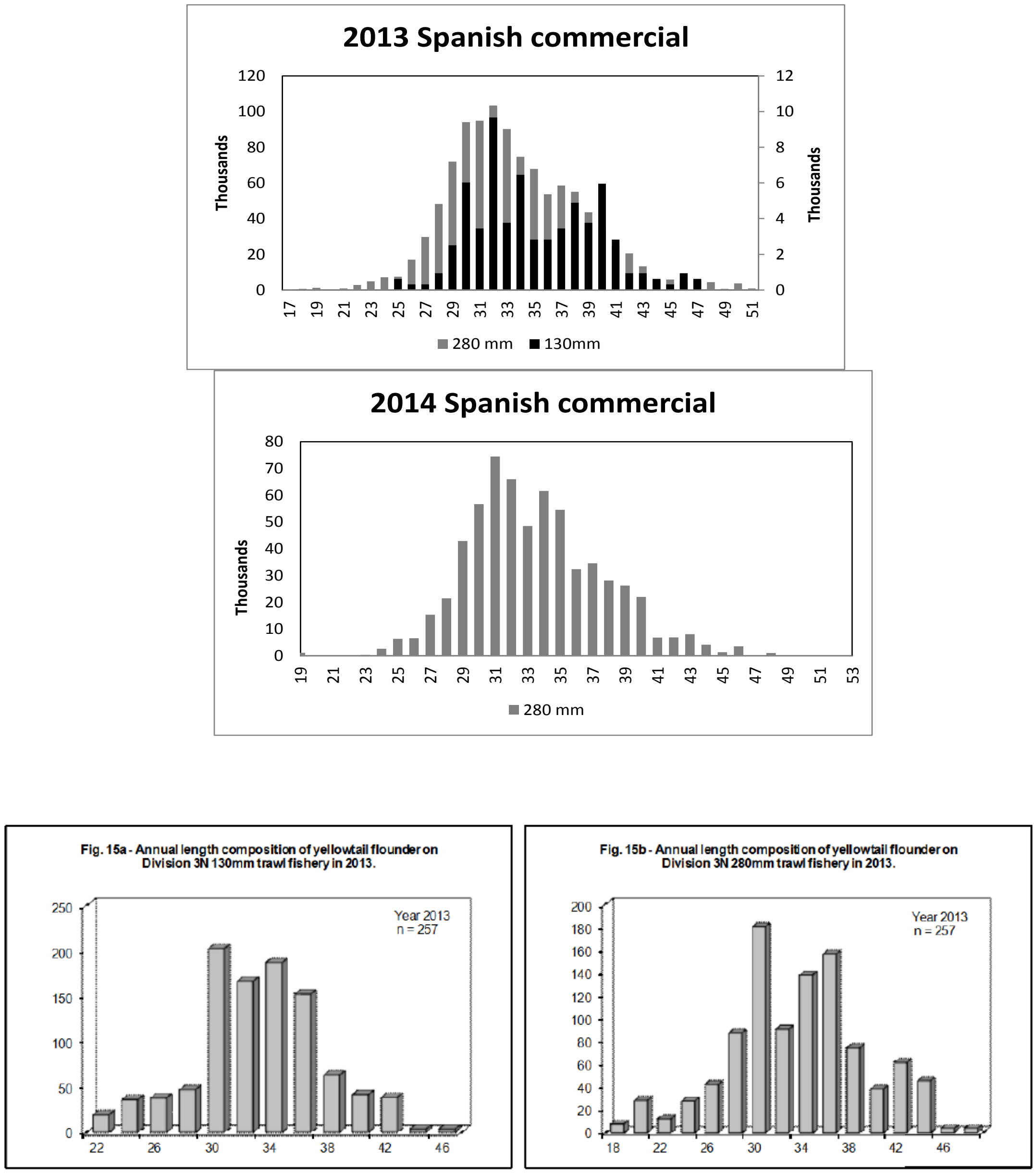

Figure 3. Length frequencies from commercial fisheries in the NRA of Divs 3NO conducted by Spain and Portugal in 2013 and 2014.

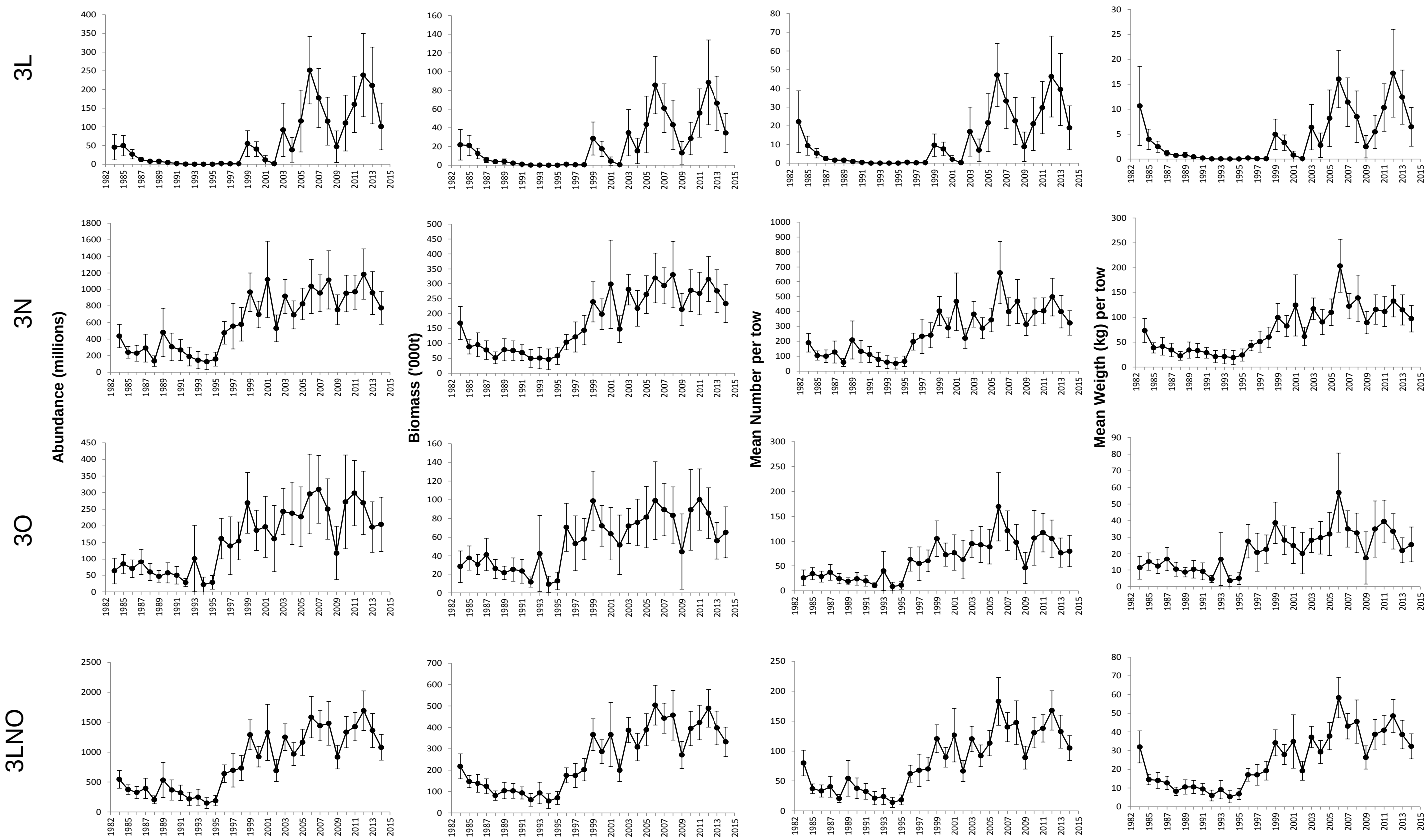

Figure 4. Abundance (millions), Biomass ('000 tons), Mean number and weight (kg) per tow for yellowtail flounder in spring surveys by NAFO division and for 3LNO combined from 1984-2014.
Error bars are 95% confidence limits.

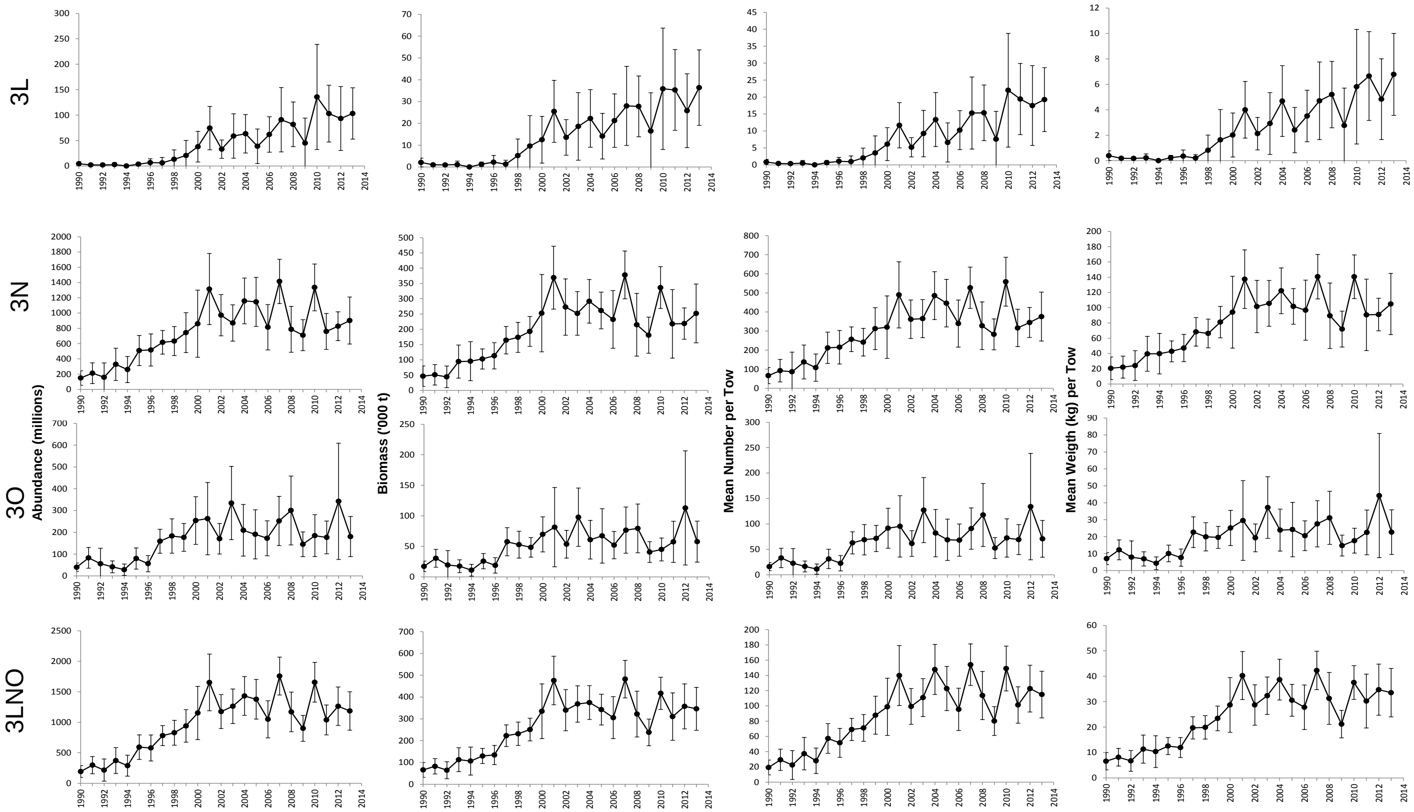

Figure 5. Abundance (millions), Biomass ('000 tons), Mean number and weight (kg) per tow for yellowtail flounder in autumn surveys by NAFO division and for 3LNO combined from 1990-2014. Error bars are 95% confidence limits.

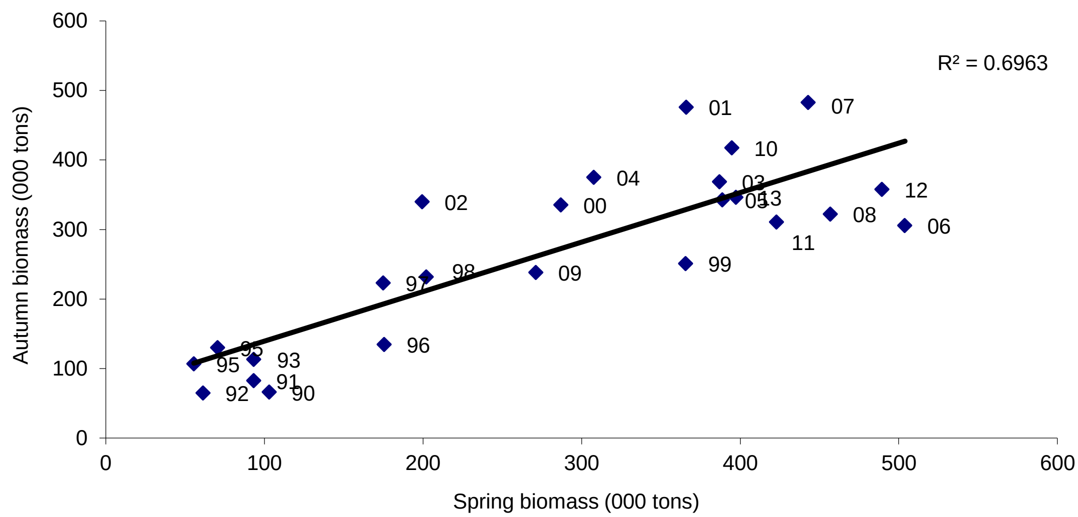

Fig. 6. Regression of Canadian spring and autumn estimates of yellowtail flounder biomass in Div. 3LNO, 1990-2013 (2014 autumn survey was incomplete).

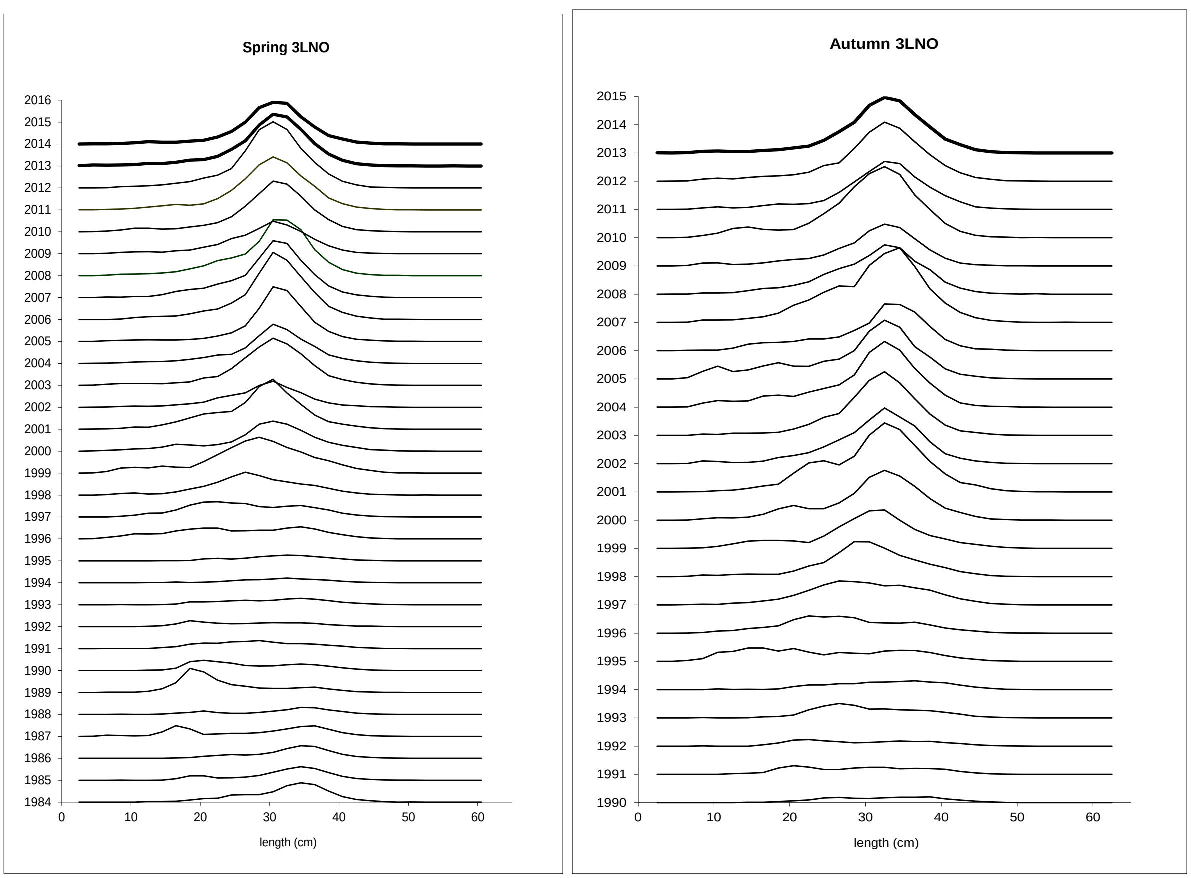

Figure 7. Abundance at length for 3LNO yellowtail flounder from Canadian spring (1984-2014) and autumn (1990-2013) surveys.

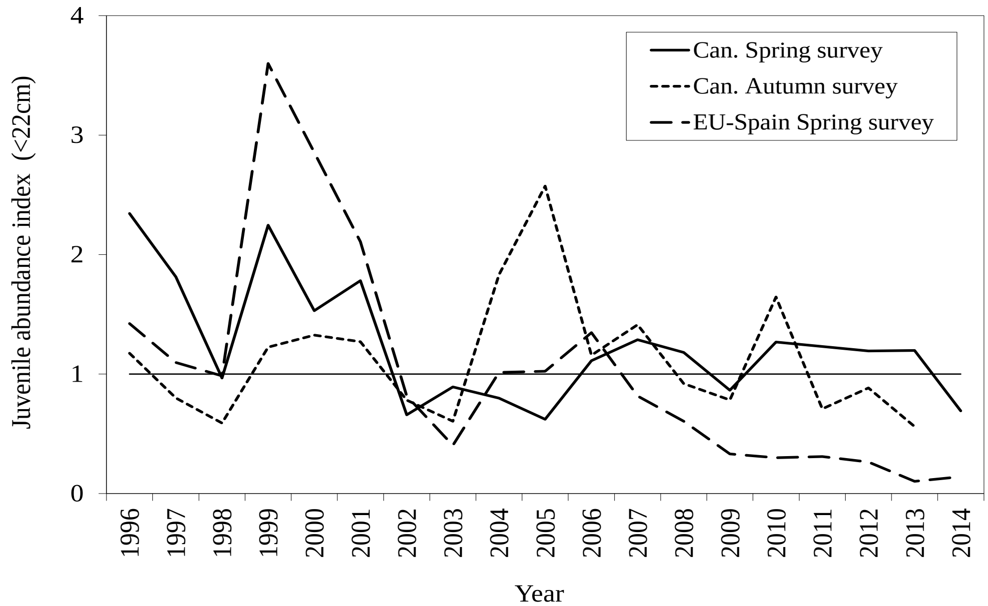

Figure 8. Population numbers (scaled to the mean of the series) of yellowtail flounder less than 22cm in the Canadian, and total numbers from Spanish survey, 1995-2014.

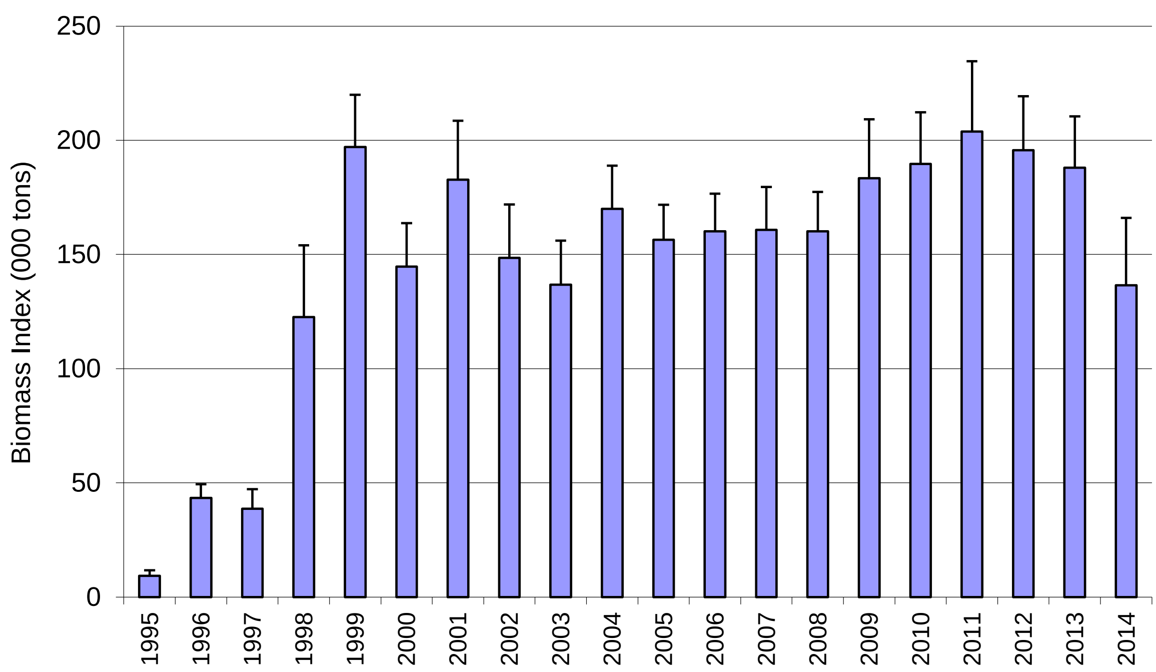

Figure 9. Converted biomass estimates from Spanish surveys in the NRA of Div. 3NO. Error bars are +1 SD.

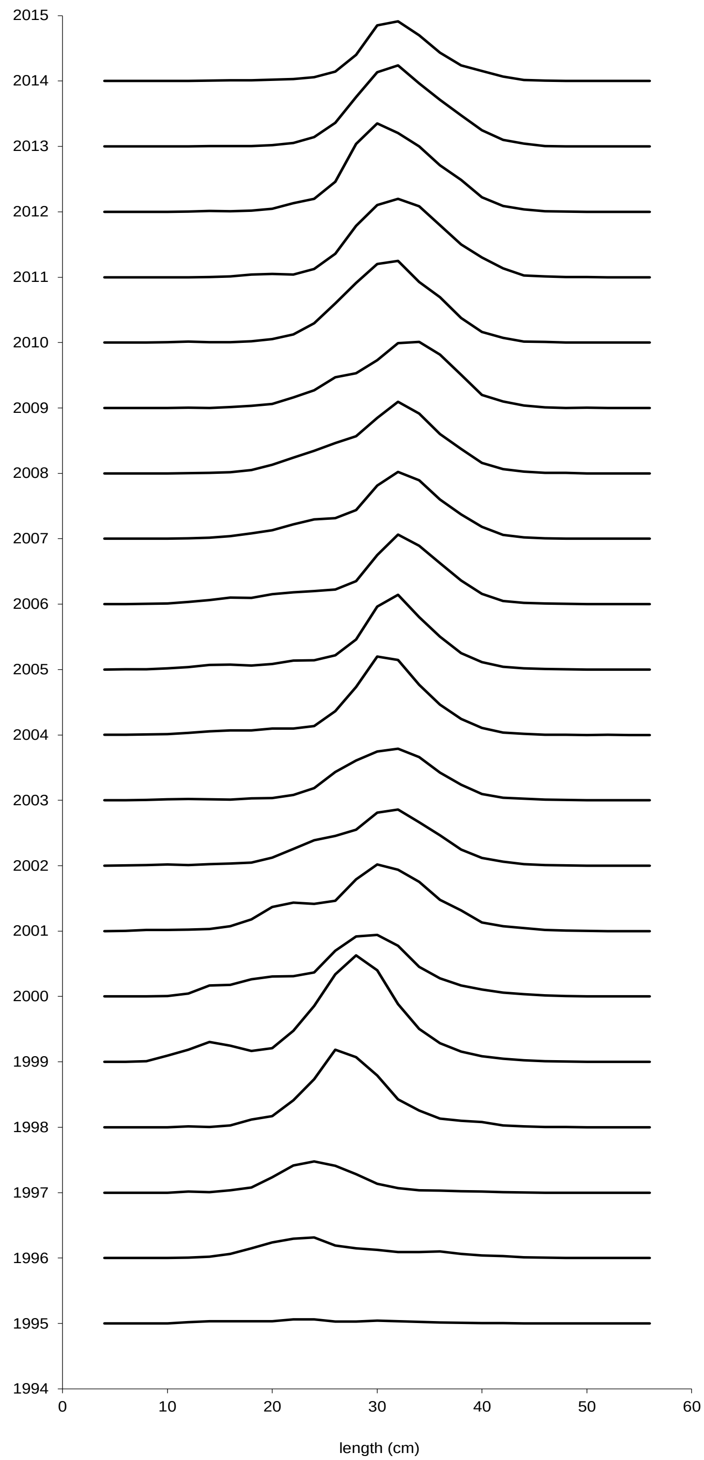

Figure 10. Length frequencies of yellowtail flounder in the Spanish spring survey in the NRA of Div. 3NO.

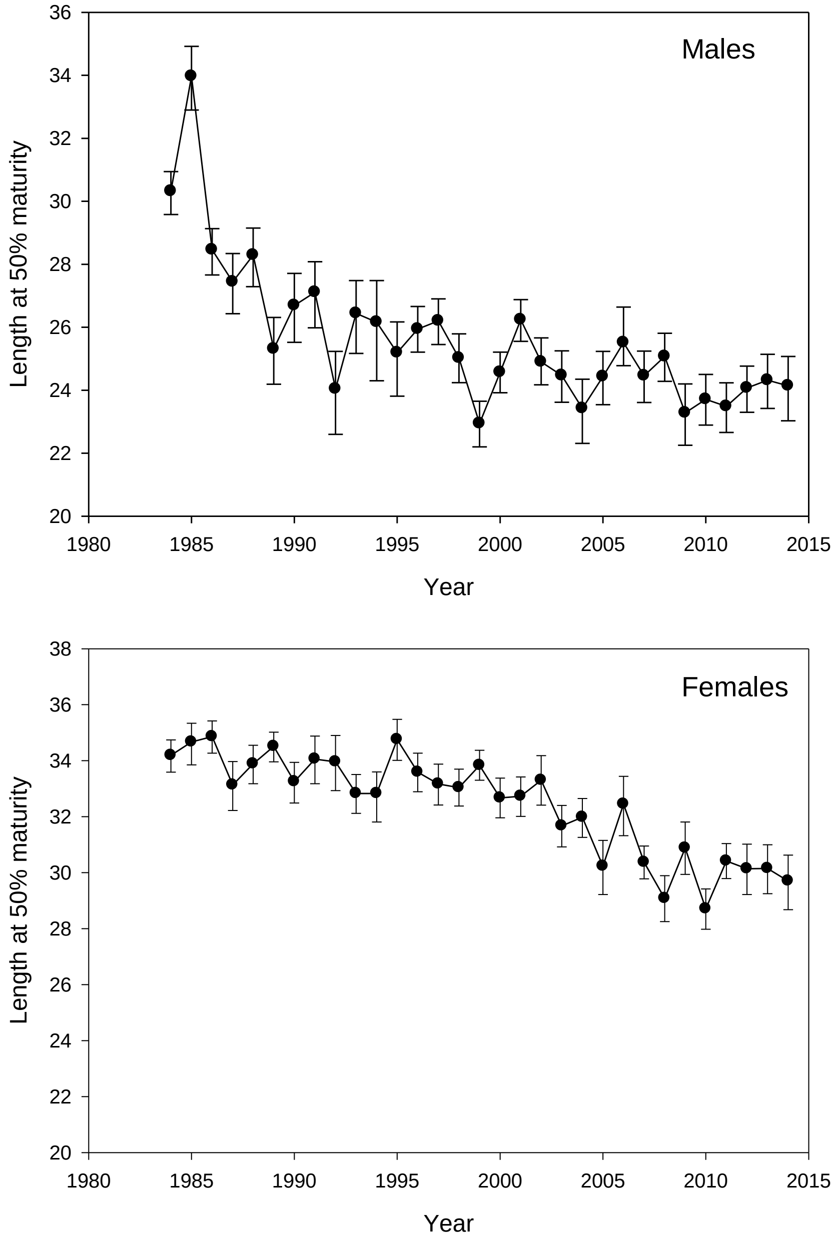

Figure 11. Length at 50% maturity of male and female yellowtail flounder from annual Canadian research vessel surveys of Div. 3LNO from 1984 to 2014.

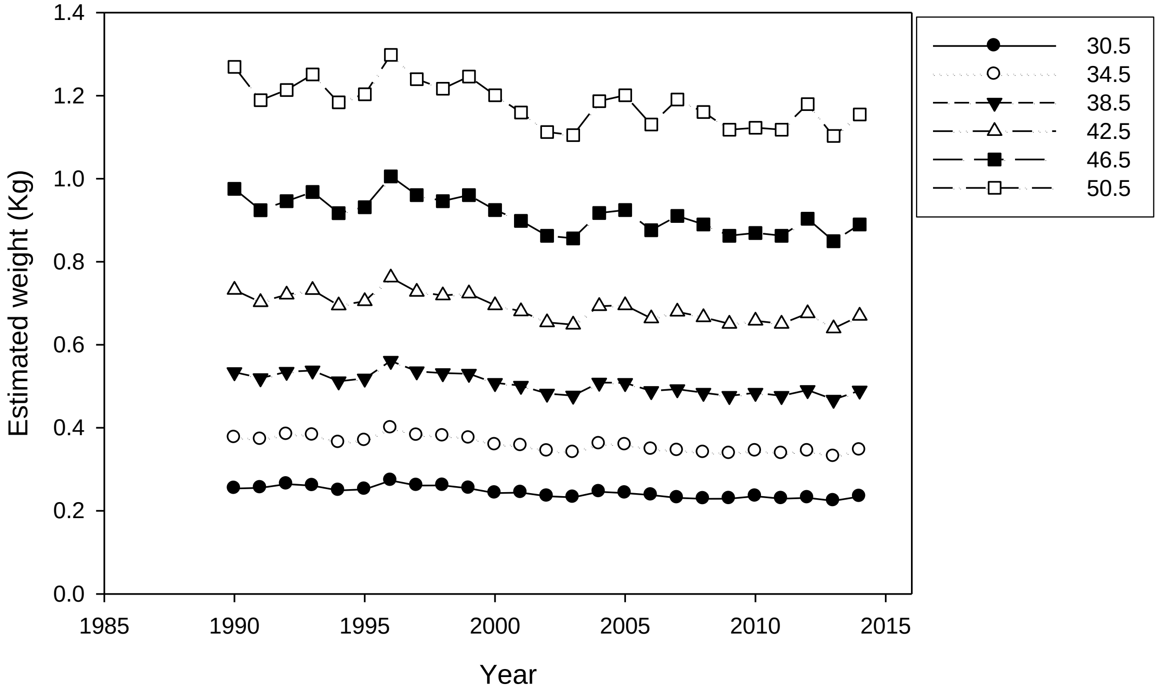

Figure 12. Estimated weight (Kg) at length (cm) for selected length groups for female yellowtail flounder in Div. 3LNO from Canadian spring surveys from 1990-2014.

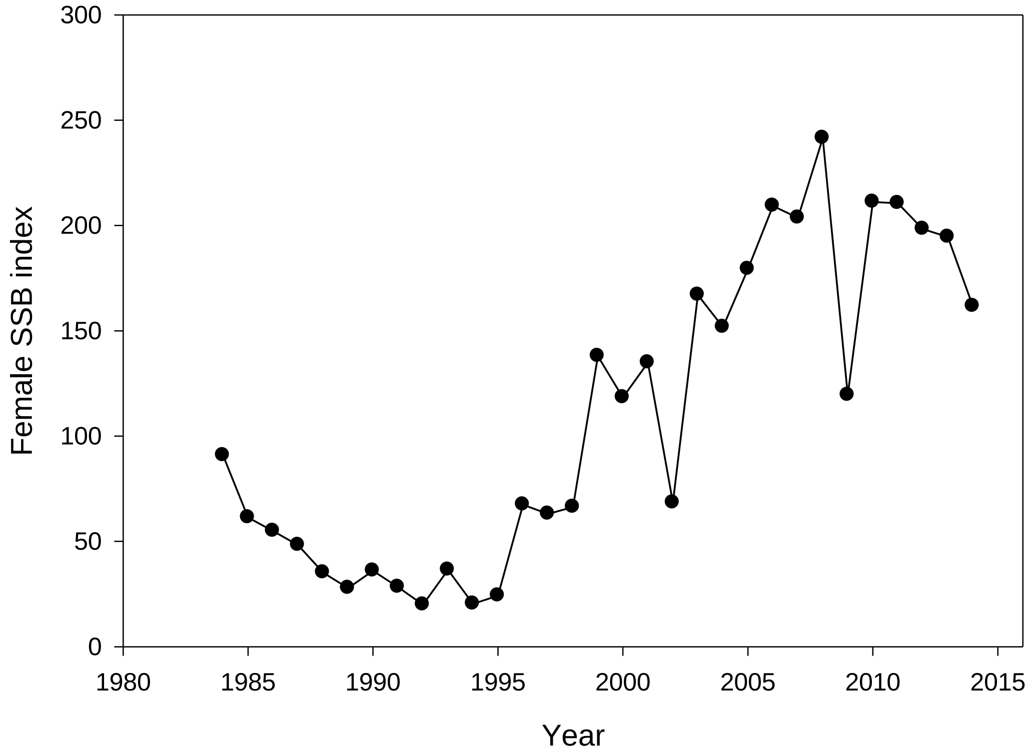

Figure 13. Index of female spawning stock biomass ('000t) for Div. 3LNO yellowtail flounder as calculated from Canadian spring research vessel surveys from 1984-2014 (the survey in 2006 was not considered representative).

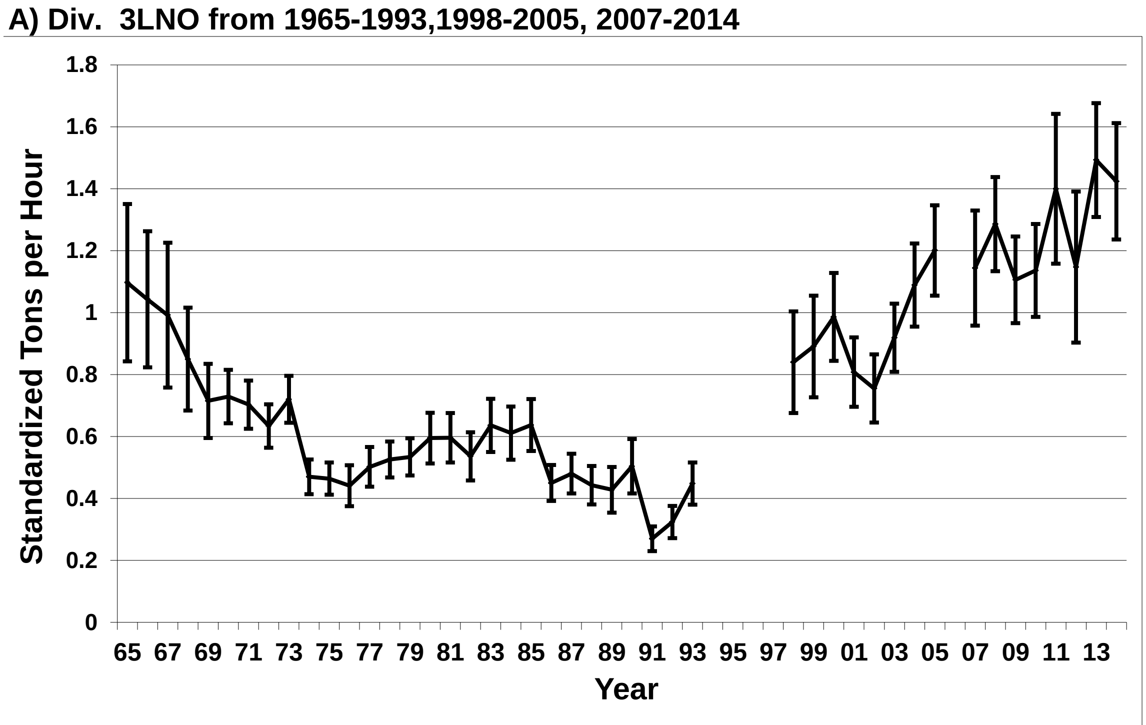

Figure 14. (A) Standardized CPUE ± 2 SE for Yellowtail in Div. 3LNO from 1965-1993, 1998-2005 and 2007-2014 (preliminary) under different treatments of the database. From 1991-1993 the fishery was a mixed fishery with American plaice. There was no directed fishery from 1994-1997.

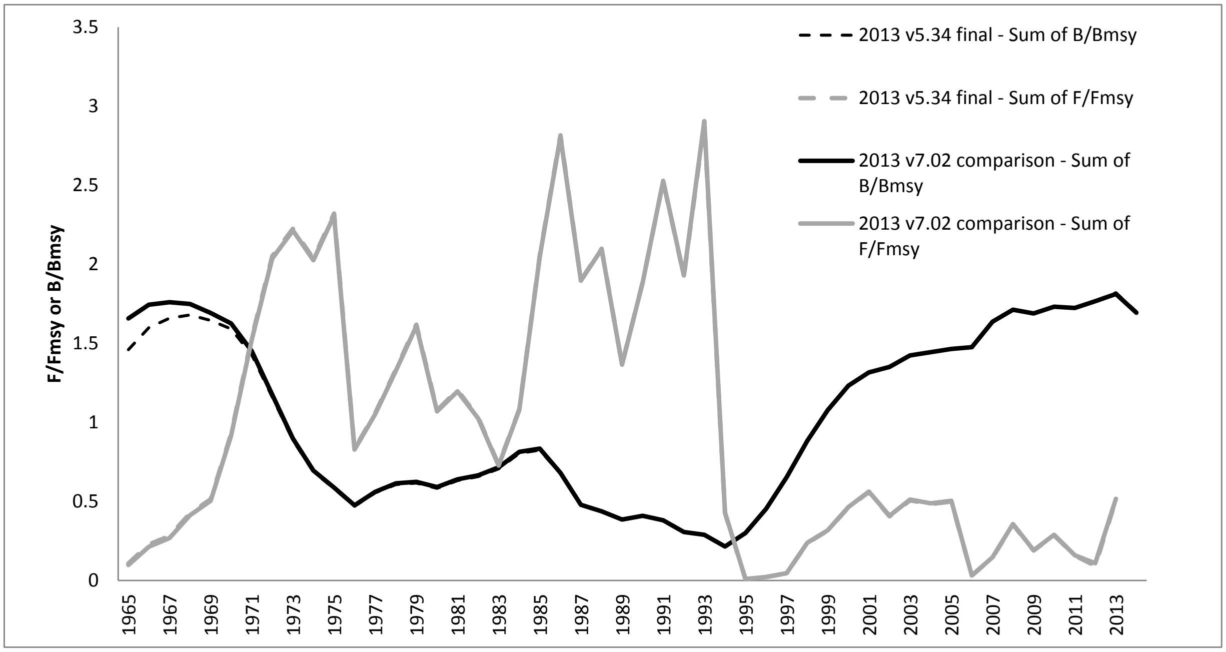

Figure 15. Comparison ASPIC runs for 2013 accepted assessment (version 5.34) with the same model formulation in ASPIC version 7.02

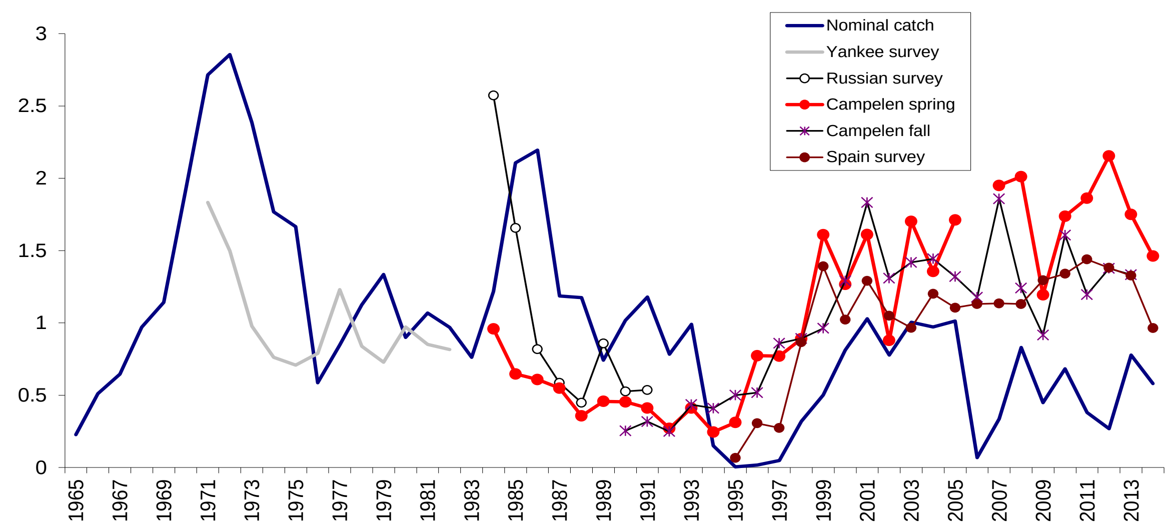

Figure 16. Nominal catch and survey series scaled to the mean in each series of the indices used in the 2015 assessment of yellowtail flounder.

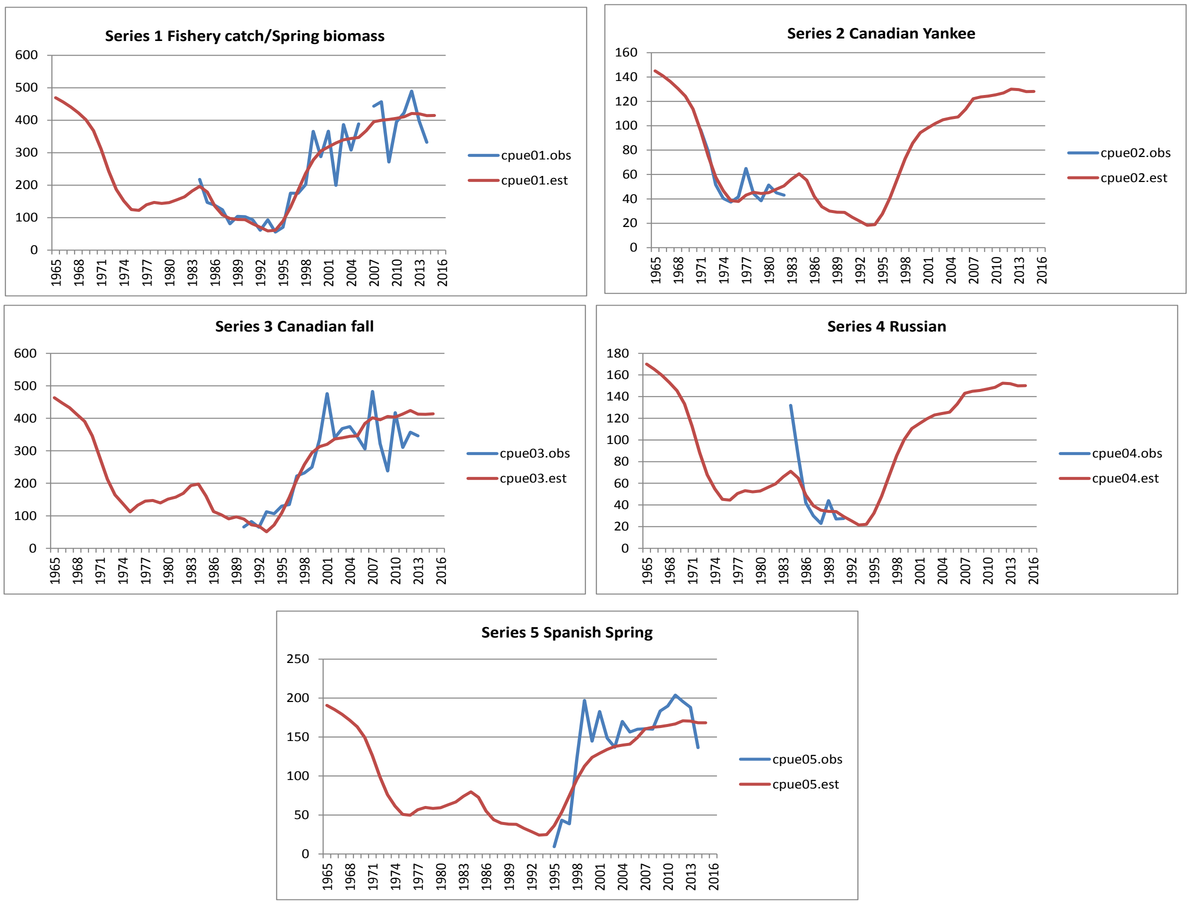

Figure 17. Observed and estimated CPUE for the data series used in the 2015 assessment of yellowtail flounder in NAFO Divs. 3LNO (ASPIC version7.02);

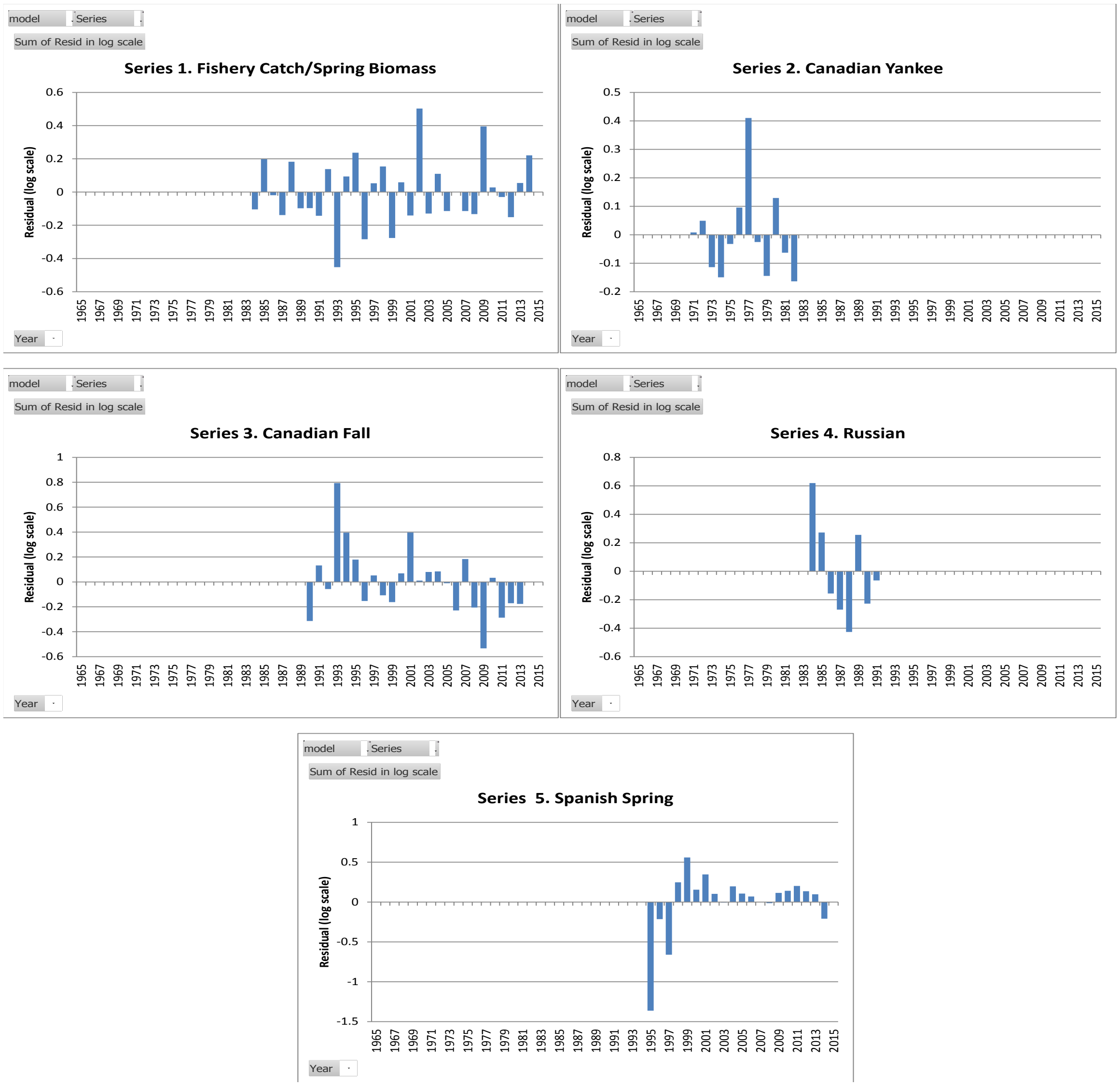

Figure 18. Residual plots for the catch and survey indices from the 2015 assessment of yellowtail flounder in NAFO Divs. 3LNO (ASPIC version 7.02).

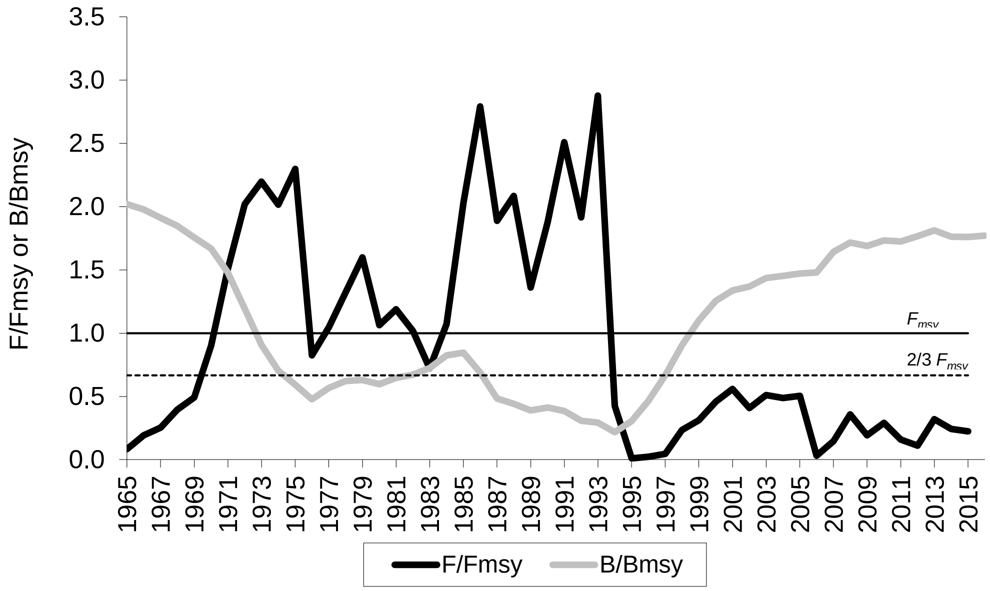

Figure 19. Yellowtail flounder in NAFO Divs. 3LNO: Relative fishing mortality (F/Fmsy) and relative biomass (B/Bmsy) estimates from the 2015 assessment (ASPIC version 7.02)

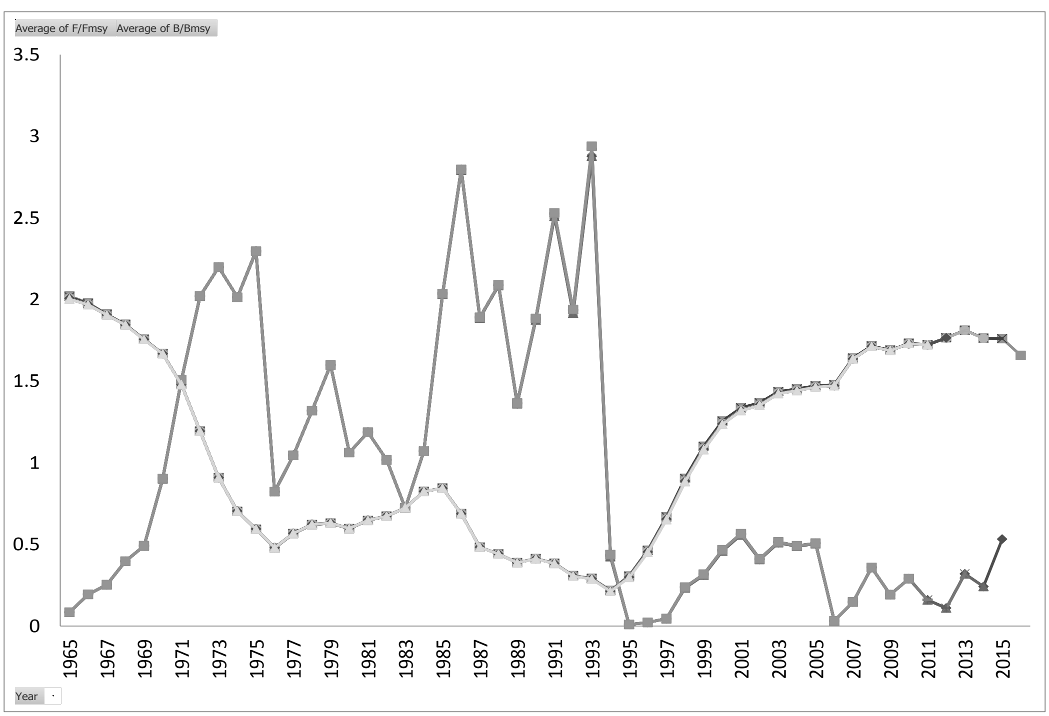

Figure 20. Retrospective view of the 2015 assessment of yellowtail flounder, dropping one year at a time 2015-2010.

Catch$_{2015}$= avg 2007-2014 (7 400

Catch$_{2015}$= TAC (17 000 t)

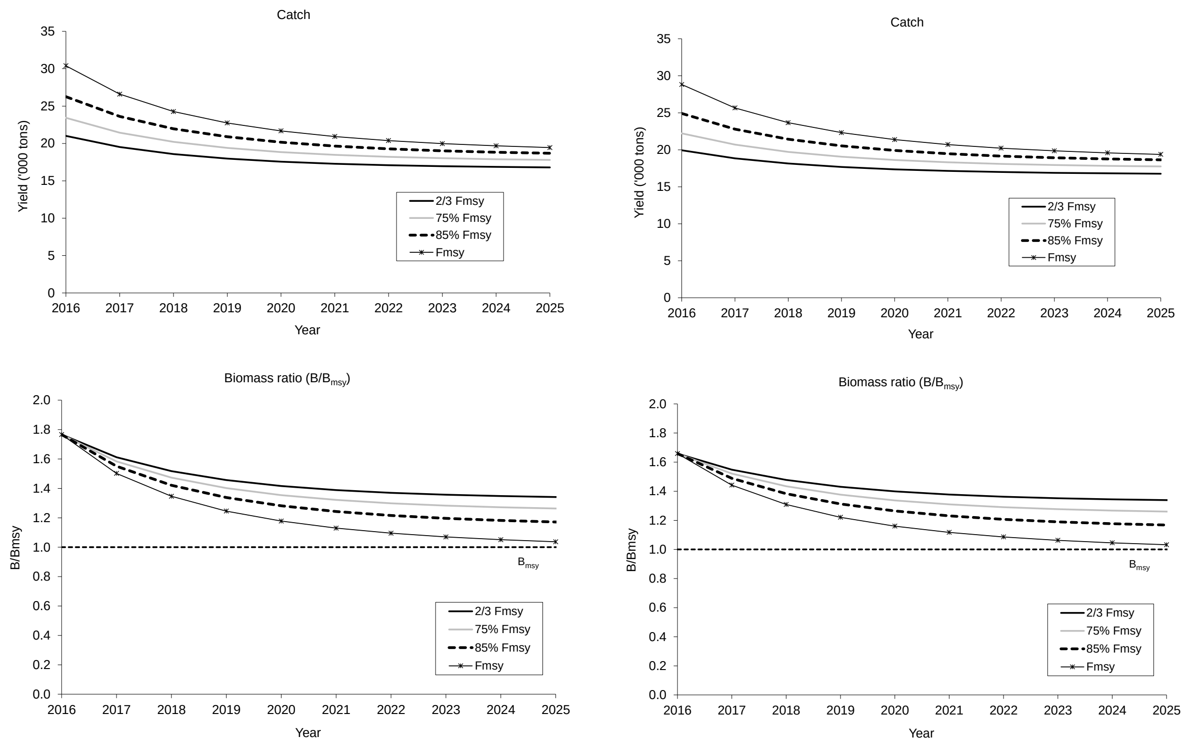

Figure 21. Yellowtail flounder in Div. 3LNO: stochastic projections for 2016-2018 for two 2015 catch scenarios (7 400t and 17 000t) at 3 levels of F (2/3 Fmsy, 75% and 85% Fmsy). Top panels show projected catch, and lower panels are projected relative biomass ratios (B/Bmsy). Results are derived from ASPIC bootstrap runs (1000 iterations).

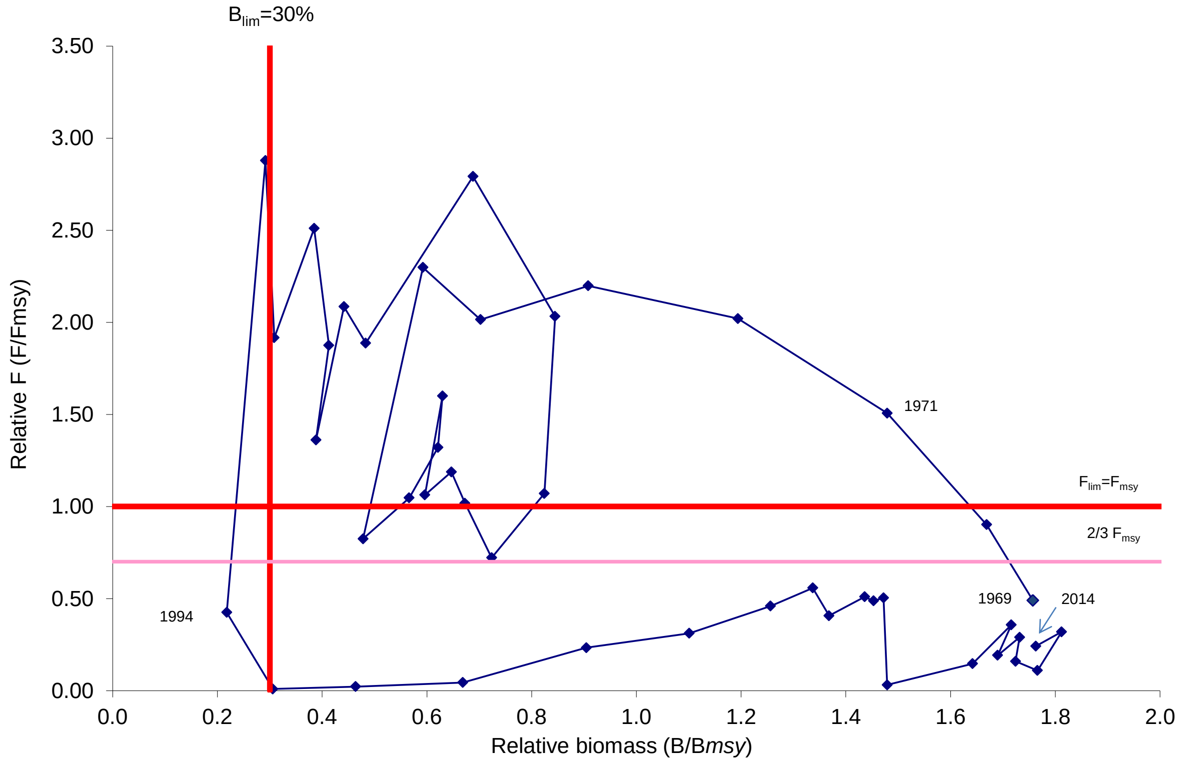

Figure 22. Yellowtail flounder in Div. 3LNO: stock trajectory estimated in the surplus production analysis, under a precautionary approach framework.

APPENDIX 1.

```
ASPIC-V7
"Yellowtail flounder 2015 NAFO"
# Program mode (FIT/BOT), verbosity, [if BOT] N bootstraps, [opt] user percentile:
FIT 112 1000
# Model shape, conditioning (YLD/EFT), obj. fn. (SSE/LAV/MLE/MAP):
LOGISTIC  YLD  SSE
# N years, N series:
51  5
# Monte Carlo mode (0/1/2), N trials:
0  50000
# Convergence criteria (3 values):
1d-8  3d-8  1.0d-4
# Maximum F, N restarts, [gen. model] N steps/yr:
5.0d0  8  24
# Random seed (large integer):
9114895
# Initial guesses and bounds follow:
# 'B1K', guess, estflag, min, max, ['penalty', penalty], or [priorname, prior params]
B1K    1  1  5.00E-01  3.00E+00  penalty  1
# 'MSY', guess, estflag, min, max, [if MAP] priorname, prior params
MSY    1.30E+01  1  1.00E+00  5.00E+01
# 'Fmsy', guess, estflag, min, max, [if MAP] priorname, prior params
Fmsy   2.00E-01  1  1.00E-02  1.00E+00
# q, guess, estflag, seriesweight, min, max, [if MAP] priorname, prior params
q      3.00E-00  1  1.00E+00  .2   5
q      1.00E-00  1  1.00E+00  .2   2.5
q      3.00E-00  1  1.00E+00  .2   5
q      1.00E-00  1  1.00E+00  .2   2.5
q      3.00E-00  1  1.00E+00  .2   5
(Series info follows in input file, but is omitted here)
```

```
Yellowtail flounder 2015 NAFO catch in 2015 avg 2006-2014                    Page 1
                                      Thursday, 04 Jun 2015 at 10:57:24
ASPIC -- A Surplus-Production Model Including Covariates (BETA Ver. 7.02)
                                            FIT program mode
Author:    Michael H. Prager                         LOGISTIC model mode
           Prager Consulting                         YLD conditioning
           http://www.mhprager.com                   SSE optimization

Reference:  Prager, M. H. 1994. A suite of extensions to a nonequilibrium       ASPIC program and user's guide
            surplus-production model.  Fishery Bulletin 92: 374-389.           available gratis at www.mhprager.com

CONTROL PARAMETERS (FROM INPUT FILE)    Input file: F:/...5/2015 assess/ytail_2015_v7_newcc_penaltyb1_k_avg07_14.a7inp
-----------------------------------------------------------------------------------------------------------------------
Operation of ASPIC:  Fit logistic (Schaefer) model by direct optimization.
Number of years analyzed:              51        Number of bootstrap trials:                 0
Number of data series:                  5        Objective function:                Least squares
Relative conv. criterion (simplex):    1.000E-08        Monte Carlo search mode, trials:     0      50000
Relative conv. criterion (restart):    3.000E-08        Random number seed:                  9114895
Relative conv. criterion (effort):     1.000E-04        Identical convergences required in fitting:     8
Maximum F allowed in fitting:          5.000


PROGRAM STATUS INFORMATION (NON-BOOTSTRAPPED ANALYSIS)                         error code   0
-----------------------------------------------------------------------------------------------------------------------
Normal convergence
Number of restarts required for convergence:    99


CORRELATION AMONG INPUT SERIES EXPRESSED AS CPUE (NUMBER OF PAIRWISE OBSERVATIONS BELOW)
-----------------------------------------------------------------------------------------------------------------------
                                  |
 1  Fishery-catch/Spring biomass  |  1.000
                                  |     30
                                  |
 2  Canadian Yankee Survey        |  0.000   1.000
                                  |      0      12
                                  |
 3  Canadian Fall Survey          |  0.861   0.000   1.000
                                  |     23       0      24
                                  |
 4  Russian Survey                |  0.933   0.000   1.000   1.000
                                  |      8       0       2       8
                                  |
 5  Spanish Survey Converted biomass...|  0.807   0.000   0.679   0.000   1.000
                                  |     19       0      19       0      20
                                  ---------------------------------------------
                                         1       2       3       4       5
```

GOODNESS-OF-FIT AND WEIGHTING (NON-BOOTSTRAPPED ANALYSIS)

Objective function component: label and source of variance	Weighted SSE	N	Weighted MSE	Current weight	Inv. var. weight	R-squared in CPUE
Loss(-1) Unmatched yield	0.000E+00					
Loss(0) Penalty on B1 > K	9.990E-05	1	N/A	1.000E+00	N/A	
Loss(1) Fishery-catch/Spring biomass	1.195E+00	30	4.267E-02	1.000E+00	1.375E+00	0.868
Loss(2) Canadian Yankee Survey	2.850E-01	12	2.850E-02	1.000E+00	2.058E+00	0.804
Loss(3) Canadian Fall Survey	1.733E+00	24	7.879E-02	1.000E+00	7.448E-01	0.730
Loss(4) Russian Survey	8.575E-01	8	1.429E-01	1.000E+00	4.106E-01	0.553
Loss(5) Spanish Survey Converted biomass_2006	3.067E+00	20	1.704E-01	1.000E+00	3.444E-01	0.669

TOTAL OBJECTIVE FUNCTION, MSE, RMSE: 7.13747364E+00 8.299E-02 2.881E-01

NOTE: Penalty on B1 > K is nonzero. Sensitivity analysis advised with several fixed B1/K.

Estimated contrast index (good=0.5, best=1.0): 0.8910 ..... Mean of B coverage proportions > and < Bmsy
Estimated nearness index (best=1.0): 1.0000 ..... Proportional closeness of any B to Bmsy

Yellowtail flounder 2015 NAFO catch in 2015 avg 2006-2014 Page 2

MODEL PARAMETER ESTIMATES (NON-BOOTSTRAPPED)

Parameter		Estimate	User guess	2nd guess	Min bound	Max bound	Estim?
B1/K	Starting relative biomass (in 1965)	1.010E+00	1.000E+00	2.555E+00	5.000E-01	3.000E+00	1
MSY	Maximum sustainable yield	1.873E+01	1.300E+01	1.112E+01	1.000E+00	5.000E+01	1
Fmsy	Fishing mortality rate at MSY	2.583E-01	2.000E-01	2.222E-01	1.000E-02	1.000E+00	1
phi	Shape of production curve (Bmsy/K)	0.5000	0.5000	-----	-----	-----	0
q(1)	Fishery-catch/Spring biomass	3.241E+00	3.000E+00	7.500E-01	2.000E-01	5.000E+00	1
q(2)	Canadian Yankee Survey	1.002E+00	1.000E+00	6.159E-01	2.000E-01	2.500E+00	1
q(3)	Canadian Fall Survey	3.228E+00	3.000E+00	1.631E+00	2.000E-01	5.000E+00	1
q(4)	Russian Survey	1.174E+00	1.000E+00	3.843E-01	2.000E-01	2.500E+00	1
q(5)	Spanish Survey Converted biomass_2006	1.316E+00	3.000E+00	1.471E+00	2.000E-01	5.000E+00	1

MANAGEMENT and DERIVED PARAMETER ESTIMATES (NON-BOOTSTRAPPED)

Parameter		Estimate	Logistic formula	General formula
MSY	Maximum sustainable yield	1.873E+01	----	----
Bmsy	Stock biomass giving MSY	7.250E+01	K/2	K*n**(1/(1-n))
K	Carrying capacity	1.450E+02	2*Bmsy	Bmsy/phi
n	Exponent in production function	2.0000	----	----

g	Fletcher's gamma	4.000E+00	----	[n**(n/(n-1))]/[n-1]
B./Bmsy	Ratio: B(2016)/Bmsy	1.767E+00	----	----
F./Fmsy	Ratio: F(2015)/Fmsy	2.238E-01	----	----
Fmsy/F.	Ratio: Fmsy/F(2015)	4.468E+00	----	----
Y.(Fmsy)	Approx. yield available at Fmsy in 2016	3.039E+01	MSY*B./Bmsy	MSY*B./Bmsy
	...as proportion of MSY	1.623E+00	----	----
Ye.	Equilibrium yield available in 2016	7.714E+00	4*MSY*(B/K-(B/K)**2)	g*MSY*(B/K-(B/K)**n)
	...as proportion of MSY	4.120E-01	----	----

--------- Fishing effort rate at MSY in units of each CE or CC series ---------

fmsy(1)	Fishery-catch/Spring biomass	7.970E-02	Fmsy/q(1)	Fmsy/q(1)

Yellowtail flounder 2015 NAFO catch in 2015 avg 2006-2014 Page 3

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	0.022	1.465E+02	1.448E+02	3.130E+00	3.130E+00	9.765E-02	8.369E-02	2.020E+00
2	1966	0.050	1.434E+02	1.408E+02	7.026E+00	7.026E+00	2.122E+00	1.933E-01	1.978E+00
3	1967	0.065	1.385E+02	1.361E+02	8.878E+00	8.878E+00	4.331E+00	2.527E-01	1.911E+00
4	1968	0.102	1.340E+02	1.304E+02	1.334E+01	1.334E+01	6.767E+00	3.961E-01	1.848E+00
5	1969	0.127	1.274E+02	1.239E+02	1.571E+01	1.571E+01	9.290E+00	4.907E-01	1.757E+00
6	1970	0.233	1.210E+02	1.135E+02	2.643E+01	2.643E+01	1.268E+01	9.014E-01	1.669E+00
7	1971	0.389	1.072E+02	9.594E+01	3.734E+01	3.734E+01	1.664E+01	1.507E+00	1.479E+00
8	1972	0.522	8.654E+01	7.527E+01	3.926E+01	3.926E+01	1.857E+01	2.020E+00	1.194E+00
9	1973	0.568	6.586E+01	5.782E+01	3.281E+01	3.281E+01	1.789E+01	2.198E+00	9.083E-01
10	1974	0.520	5.093E+01	4.672E+01	2.431E+01	2.431E+01	1.634E+01	2.015E+00	7.025E-01
11	1975	0.594	4.296E+01	3.857E+01	2.289E+01	2.289E+01	1.460E+01	2.298E+00	5.925E-01
12	1976	0.213	3.467E+01	3.784E+01	8.057E+00	8.057E+00	1.443E+01	8.245E-01	4.781E-01
13	1977	0.270	4.104E+01	4.306E+01	1.164E+01	1.164E+01	1.563E+01	1.047E+00	5.661E-01
14	1978	0.341	4.504E+01	4.536E+01	1.547E+01	1.547E+01	1.610E+01	1.320E+00	6.211E-01
15	1979	0.413	4.567E+01	4.441E+01	1.835E+01	1.835E+01	1.591E+01	1.600E+00	6.299E-01
16	1980	0.275	4.323E+01	4.509E+01	1.238E+01	1.238E+01	1.604E+01	1.063E+00	5.962E-01
17	1981	0.307	4.690E+01	4.786E+01	1.468E+01	1.468E+01	1.656E+01	1.188E+00	6.468E-01
18	1982	0.263	4.878E+01	5.066E+01	1.332E+01	1.332E+01	1.702E+01	1.018E+00	6.727E-01
19	1983	0.186	5.248E+01	5.616E+01	1.047E+01	1.047E+01	1.776E+01	7.220E-01	7.238E-01
20	1984	0.276	5.976E+01	6.053E+01	1.673E+01	1.673E+01	1.821E+01	1.071E+00	8.243E-01
21	1985	0.525	6.124E+01	5.519E+01	2.896E+01	2.896E+01	1.762E+01	2.032E+00	8.447E-01
22	1986	0.721	4.990E+01	4.185E+01	3.018E+01	3.018E+01	1.531E+01	2.792E+00	6.882E-01
23	1987	0.487	3.504E+01	3.347E+01	1.631E+01	1.631E+01	1.330E+01	1.887E+00	4.832E-01
24	1988	0.538	3.202E+01	3.001E+01	1.616E+01	1.616E+01	1.229E+01	2.085E+00	4.416E-01

25	1989	0.351	2.815E+01	2.905E+01	1.021E+01	1.021E+01	1.200E+01	1.361E+00	3.882E-01
26	1990	0.484	2.994E+01	2.889E+01	1.399E+01	1.399E+01	1.195E+01	1.875E+00	4.129E-01
27	1991	0.648	2.790E+01	2.499E+01	1.620E+01	1.620E+01	1.067E+01	2.510E+00	3.848E-01
28	1992	0.495	2.237E+01	2.175E+01	1.076E+01	1.076E+01	9.549E+00	1.916E+00	3.085E-01
29	1993	0.743	2.116E+01	1.832E+01	1.361E+01	1.361E+01	8.258E+00	2.878E+00	2.918E-01
30	1994	0.110	1.580E+01	1.885E+01	2.069E+00	2.069E+00	8.459E+00	4.250E-01	2.179E-01
31	1995	0.002	2.219E+01	2.761E+01	6.700E-02	6.700E-02	1.151E+01	9.397E-03	3.060E-01
32	1996	0.006	3.363E+01	4.078E+01	2.320E-01	2.320E-01	1.507E+01	2.203E-02	4.638E-01
33	1997	0.012	4.847E+01	5.688E+01	6.580E-01	6.580E-01	1.777E+01	4.479E-02	6.685E-01
34	1998	0.060	6.558E+01	7.279E+01	4.386E+00	4.386E+00	1.866E+01	2.333E-01	9.045E-01
35	1999	0.081	7.986E+01	8.561E+01	6.894E+00	6.894E+00	1.808E+01	3.118E-01	1.101E+00
36	2000	0.119	9.104E+01	9.412E+01	1.116E+01	1.116E+01	1.705E+01	4.592E-01	1.256E+00
37	2001	0.144	9.693E+01	9.811E+01	1.414E+01	1.414E+01	1.639E+01	5.582E-01	1.337E+00
38	2002	0.105	9.917E+01	1.018E+02	1.070E+01	1.070E+01	1.566E+01	4.070E-01	1.368E+00
39	2003	0.132	1.041E+02	1.048E+02	1.381E+01	1.381E+01	1.501E+01	5.102E-01	1.436E+00
40	2004	0.126	1.053E+02	1.061E+02	1.335E+01	1.335E+01	1.471E+01	4.875E-01	1.453E+00
41	2005	0.130	1.067E+02	1.070E+02	1.393E+01	1.393E+01	1.449E+01	5.042E-01	1.472E+00
42	2006	0.008	1.073E+02	1.134E+02	9.300E-01	9.300E-01	1.271E+01	3.174E-02	1.479E+00
43	2007	0.038	1.190E+02	1.219E+02	4.623E+00	4.623E+00	1.002E+01	1.468E-01	1.642E+00
44	2008	0.092	1.244E+02	1.234E+02	1.140E+01	1.140E+01	9.493E+00	3.578E-01	1.716E+00
45	2009	0.050	1.225E+02	1.242E+02	6.168E+00	6.168E+00	9.218E+00	1.924E-01	1.690E+00
46	2010	0.075	1.256E+02	1.253E+02	9.379E+00	9.379E+00	8.807E+00	2.899E-01	1.732E+00
47	2011	0.041	1.250E+02	1.266E+02	5.230E+00	5.230E+00	8.283E+00	1.599E-01	1.724E+00
48	2012	0.028	1.281E+02	1.298E+02	3.684E+00	3.684E+00	7.011E+00	1.099E-01	1.766E+00
49	2013	0.083	1.314E+02	1.295E+02	1.068E+01	1.068E+01	7.158E+00	3.195E-01	1.812E+00
50	2014	0.063	1.279E+02	1.278E+02	7.988E+00	7.988E+00	7.841E+00	2.421E-01	1.763E+00
51	2015	0.058	1.277E+02	1.279E+02	7.395E+00	7.395E+00	7.785E+00	2.238E-01	1.761E+00
52	2016		1.281E+02						1.767E+00

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

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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	Statist weight
1	1965	*	4.693E+02	0.0216	3.130E+00	3.130E+00	0.00000	1.000E+00
2	1966	*	4.561E+02	0.0499	7.026E+00	7.026E+00	0.00000	1.000E+00
3	1967	*	4.409E+02	0.0653	8.878E+00	8.878E+00	0.00000	1.000E+00
4	1968	*	4.226E+02	0.1023	1.334E+01	1.334E+01	0.00000	1.000E+00
5	1969	*	4.016E+02	0.1267	1.571E+01	1.571E+01	0.00000	1.000E+00
6	1970	*	3.679E+02	0.2328	2.643E+01	2.643E+01	0.00000	1.000E+00
7	1971	*	3.109E+02	0.3892	3.734E+01	3.734E+01	0.00000	1.000E+00
8	1972	*	2.439E+02	0.5216	3.926E+01	3.926E+01	0.00000	1.000E+00
9	1973	*	1.874E+02	0.5675	3.281E+01	3.281E+01	0.00000	1.000E+00

10	1974	*	1.514E+02	0.5204	2.431E+01	2.431E+01	0.00000	1.000E+00
11	1975	*	1.250E+02	0.5936	2.289E+01	2.289E+01	0.00000	1.000E+00
12	1976	*	1.226E+02	0.2129	8.057E+00	8.057E+00	0.00000	1.000E+00
13	1977	*	1.395E+02	0.2703	1.164E+01	1.164E+01	0.00000	1.000E+00
14	1978	*	1.470E+02	0.3410	1.547E+01	1.547E+01	0.00000	1.000E+00
15	1979	*	1.439E+02	0.4133	1.835E+01	1.835E+01	0.00000	1.000E+00
16	1980	*	1.461E+02	0.2745	1.238E+01	1.238E+01	0.00000	1.000E+00
17	1981	*	1.551E+02	0.3067	1.468E+01	1.468E+01	0.00000	1.000E+00
18	1982	*	1.642E+02	0.2629	1.332E+01	1.332E+01	0.00000	1.000E+00
19	1983	*	1.820E+02	0.1865	1.047E+01	1.047E+01	0.00000	1.000E+00
20	1984	2.177E+02	1.961E+02	0.2765	1.673E+01	1.673E+01	-0.10428	1.000E+00
21	1985	1.468E+02	1.789E+02	0.5248	2.896E+01	2.896E+01	0.19749	1.000E+00
22	1986	1.382E+02	1.356E+02	0.7211	3.018E+01	3.018E+01	-0.01897	1.000E+00
23	1987	1.246E+02	1.085E+02	0.4874	1.631E+01	1.631E+01	-0.13862	1.000E+00
24	1988	8.100E+01	9.723E+01	0.5385	1.616E+01	1.616E+01	0.18267	1.000E+00
25	1989	1.038E+02	9.413E+01	0.3514	1.021E+01	1.021E+01	-0.09779	1.000E+00
26	1990	1.031E+02	9.361E+01	0.4841	1.399E+01	1.399E+01	-0.09654	1.000E+00
27	1991	9.340E+01	8.098E+01	0.6484	1.620E+01	1.620E+01	-0.14264	1.000E+00
28	1992	6.140E+01	7.048E+01	0.4948	1.076E+01	1.076E+01	0.13791	1.000E+00
29	1993	9.330E+01	5.936E+01	0.7432	1.361E+01	1.361E+01	-0.45216	1.000E+00
30	1994	5.560E+01	6.108E+01	0.1098	2.069E+00	2.069E+00	0.09405	1.000E+00
31	1995	7.060E+01	8.946E+01	0.0024	6.700E-02	6.700E-02	0.23678	1.000E+00
32	1996	1.756E+02	1.321E+02	0.0057	2.320E-01	2.320E-01	-0.28434	1.000E+00
33	1997	1.749E+02	1.843E+02	0.0116	6.580E-01	6.580E-01	0.05254	1.000E+00
34	1998	2.022E+02	2.359E+02	0.0603	4.386E+00	4.386E+00	0.15412	1.000E+00
35	1999	3.657E+02	2.774E+02	0.0805	6.894E+00	6.894E+00	-0.27625	1.000E+00
36	2000	2.875E+02	3.050E+02	0.1186	1.116E+01	1.116E+01	0.05908	1.000E+00
37	2001	3.660E+02	3.179E+02	0.1442	1.414E+01	1.414E+01	-0.14077	1.000E+00
38	2002	1.995E+02	3.298E+02	0.1051	1.070E+01	1.070E+01	0.50280	1.000E+00
39	2003	3.865E+02	3.395E+02	0.1318	1.381E+01	1.381E+01	-0.12953	1.000E+00
40	2004	3.079E+02	3.437E+02	0.1259	1.335E+01	1.335E+01	0.11004	1.000E+00
41	2005	3.888E+02	3.467E+02	0.1302	1.393E+01	1.393E+01	-0.11450	1.000E+00
42	2006	*	3.676E+02	0.0082	9.300E-01	9.300E-01	0.00000	1.000E+00
43	2007	4.430E+02	3.951E+02	0.0379	4.623E+00	4.623E+00	-0.11450	1.000E+00
44	2008	4.569E+02	3.999E+02	0.0924	1.140E+01	1.140E+01	-0.13319	1.000E+00
45	2009	2.712E+02	4.023E+02	0.0497	6.168E+00	6.168E+00	0.39446	1.000E+00
46	2010	3.947E+02	4.059E+02	0.0749	9.379E+00	9.379E+00	0.02810	1.000E+00
47	2011	4.229E+02	4.104E+02	0.0413	5.230E+00	5.230E+00	-0.03003	1.000E+00
48	2012	4.894E+02	4.208E+02	0.0284	3.684E+00	3.684E+00	-0.15111	1.000E+00
49	2013	3.973E+02	4.196E+02	0.0825	1.068E+01	1.068E+01	0.05458	1.000E+00
50	2014	3.321E+02	4.141E+02	0.0625	7.988E+00	7.988E+00	0.22063	1.000E+00
51	2015	*	4.145E+02	0.0578	7.395E+00	7.395E+00	0.00000	1.000E+00

* Asterisk indicates missing value(s).

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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  -0.1043                      ====|
1985   0.1975                          |========
1986  -0.0190                         =|
1987  -0.1386                    ======|
1988   0.1827                          |=======
1989  -0.0978                      ====|
1990  -0.0965                      ====|
1991  -0.1426                    ======|
1992   0.1379                          |======
1993  -0.4522        ==================|
1994   0.0940                          |====
1995   0.2368                          |=========
1996  -0.2843               ===========|
1997   0.0525                          |==
1998   0.1541                          |======
1999  -0.2762               ===========|
2000   0.0591                          |==
2001  -0.1408                    ======|
2002   0.5028                          |====================
2003  -0.1295                     =====|
2004   0.1100                          |====
2005  -0.1145                     =====|
2006   0.0000                          |
2007  -0.1145                     =====|
2008  -0.1332                     =====|
2009   0.3945                          |================
2010   0.0281                          |=
2011  -0.0300                         =|
2012  -0.1511                    ======|
2013   0.0546                          |==
2014   0.2206                          |=========
2015   0.0000                          |
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Yellowtail flounder 2015 NAFO catch in 2015 avg 2006-2014 Page 6

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

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Data type I1: Abundance index (annual average) Series weight: 1.000

Obs	Year	Observed effort	Estimated effort	Estim F	Observed index	Model index	Resid in log index	Statist weight
1	1965	0.000E+00	0.000E+00	--	*	1.451E+02	0.00000	1.000E+00
2	1966	0.000E+00	0.000E+00	--	*	1.410E+02	0.00000	1.000E+00
3	1967	0.000E+00	0.000E+00	--	*	1.363E+02	0.00000	1.000E+00
4	1968	0.000E+00	0.000E+00	--	*	1.306E+02	0.00000	1.000E+00
5	1969	0.000E+00	0.000E+00	--	*	1.242E+02	0.00000	1.000E+00
6	1970	0.000E+00	0.000E+00	--	*	1.137E+02	0.00000	1.000E+00
7	1971	1.000E+00	1.000E+00	--	9.690E+01	9.610E+01	0.00828	1.000E+00
8	1972	1.000E+00	1.000E+00	--	7.920E+01	7.540E+01	0.04919	1.000E+00
9	1973	1.000E+00	1.000E+00	--	5.170E+01	5.792E+01	-0.11357	1.000E+00
10	1974	1.000E+00	1.000E+00	--	4.030E+01	4.680E+01	-0.14956	1.000E+00
11	1975	1.000E+00	1.000E+00	--	3.740E+01	3.864E+01	-0.03249	1.000E+00
12	1976	1.000E+00	1.000E+00	--	4.170E+01	3.790E+01	0.09553	1.000E+00
13	1977	1.000E+00	1.000E+00	--	6.500E+01	4.313E+01	0.41011	1.000E+00
14	1978	1.000E+00	1.000E+00	--	4.430E+01	4.544E+01	-0.02536	1.000E+00
15	1979	1.000E+00	1.000E+00	--	3.850E+01	4.448E+01	-0.14444	1.000E+00
16	1980	1.000E+00	1.000E+00	--	5.140E+01	4.516E+01	0.12932	1.000E+00
17	1981	1.000E+00	1.000E+00	--	4.500E+01	4.794E+01	-0.06327	1.000E+00
18	1982	1.000E+00	1.000E+00	--	4.310E+01	5.075E+01	-0.16335	1.000E+00
19	1983	0.000E+00	0.000E+00	--	*	5.626E+01	0.00000	1.000E+00
20	1984	0.000E+00	0.000E+00	--	*	6.063E+01	0.00000	1.000E+00
21	1985	0.000E+00	0.000E+00	--	*	5.529E+01	0.00000	1.000E+00
22	1986	0.000E+00	0.000E+00	--	*	4.192E+01	0.00000	1.000E+00
23	1987	0.000E+00	0.000E+00	--	*	3.353E+01	0.00000	1.000E+00
24	1988	0.000E+00	0.000E+00	--	*	3.006E+01	0.00000	1.000E+00
25	1989	0.000E+00	0.000E+00	--	*	2.910E+01	0.00000	1.000E+00
26	1990	0.000E+00	0.000E+00	--	*	2.894E+01	0.00000	1.000E+00
27	1991	0.000E+00	0.000E+00	--	*	2.503E+01	0.00000	1.000E+00
28	1992	0.000E+00	0.000E+00	--	*	2.179E+01	0.00000	1.000E+00
29	1993	0.000E+00	0.000E+00	--	*	1.835E+01	0.00000	1.000E+00
30	1994	0.000E+00	0.000E+00	--	*	1.888E+01	0.00000	1.000E+00
31	1995	0.000E+00	0.000E+00	--	*	2.765E+01	0.00000	1.000E+00
32	1996	0.000E+00	0.000E+00	--	*	4.085E+01	0.00000	1.000E+00
33	1997	0.000E+00	0.000E+00	--	*	5.698E+01	0.00000	1.000E+00
34	1998	0.000E+00	0.000E+00	--	*	7.292E+01	0.00000	1.000E+00
35	1999	0.000E+00	0.000E+00	--	*	8.576E+01	0.00000	1.000E+00
36	2000	0.000E+00	0.000E+00	--	*	9.428E+01	0.00000	1.000E+00
37	2001	0.000E+00	0.000E+00	--	*	9.828E+01	0.00000	1.000E+00
38	2002	0.000E+00	0.000E+00	--	*	1.020E+02	0.00000	1.000E+00

39	2003	0.000E+00	0.000E+00	--	*	1.050E+02	0.00000	1.000E+00
40	2004	0.000E+00	0.000E+00	--	*	1.062E+02	0.00000	1.000E+00
41	2005	0.000E+00	0.000E+00	--	*	1.072E+02	0.00000	1.000E+00
42	2006	0.000E+00	0.000E+00	--	*	1.136E+02	0.00000	1.000E+00
43	2007	0.000E+00	0.000E+00	--	*	1.221E+02	0.00000	1.000E+00
44	2008	0.000E+00	0.000E+00	--	*	1.236E+02	0.00000	1.000E+00
45	2009	0.000E+00	0.000E+00	--	*	1.244E+02	0.00000	1.000E+00
46	2010	0.000E+00	0.000E+00	--	*	1.255E+02	0.00000	1.000E+00
47	2011	0.000E+00	0.000E+00	--	*	1.269E+02	0.00000	1.000E+00
48	2012	0.000E+00	0.000E+00	--	*	1.301E+02	0.00000	1.000E+00
49	2013	0.000E+00	0.000E+00	--	*	1.297E+02	0.00000	1.000E+00
50	2014	0.000E+00	0.000E+00	--	*	1.280E+02	0.00000	1.000E+00
51	2015	0.000E+00	0.000E+00	--	*	1.281E+02	0.00000	1.000E+00

* Asterisk indicates missing value(s).

```
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   0.0083                          |
1972   0.0492                          |==
1973  -0.1136                     =====|
1974  -0.1496                    ======|
1975  -0.0325                         =|
1976   0.0955                          |====
1977   0.4101                          |================
1978  -0.0254                         =|
1979  -0.1444                    ======|
1980   0.1293                          |=====
1981  -0.0633                       ===|
1982  -0.1634                   =======|
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                          |
2003   0.0000                          |
2004   0.0000                          |
2005   0.0000                          |
2006   0.0000                          |
2007   0.0000                          |
2008   0.0000                          |
2009   0.0000                          |
2010   0.0000                          |
2011   0.0000                          |
2012   0.0000                          |
2013   0.0000                          |
2014   0.0000                          |
2015   0.0000                          |
           --------------------------------------------------------------------------------
```

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

----

Data type I2: Abundance index (end of year) Series weight: 1.000

Obs	Year	Observed effort	Estimated effort	Estim F	Observed index	Model index	Resid in log index	Statist weight
1	1965	0.000E+00	0.000E+00	--	*	4.630E+02	0.00000	1.000E+00
2	1966	0.000E+00	0.000E+00	--	*	4.472E+02	0.00000	1.000E+00
3	1967	0.000E+00	0.000E+00	--	*	4.325E+02	0.00000	1.000E+00
4	1968	0.000E+00	0.000E+00	--	*	4.113E+02	0.00000	1.000E+00
5	1969	0.000E+00	0.000E+00	--	*	3.906E+02	0.00000	1.000E+00
6	1970	0.000E+00	0.000E+00	--	*	3.462E+02	0.00000	1.000E+00
7	1971	0.000E+00	0.000E+00	--	*	2.794E+02	0.00000	1.000E+00
8	1972	0.000E+00	0.000E+00	--	*	2.126E+02	0.00000	1.000E+00
9	1973	0.000E+00	0.000E+00	--	*	1.644E+02	0.00000	1.000E+00
10	1974	0.000E+00	0.000E+00	--	*	1.387E+02	0.00000	1.000E+00
11	1975	0.000E+00	0.000E+00	--	*	1.119E+02	0.00000	1.000E+00
12	1976	0.000E+00	0.000E+00	--	*	1.325E+02	0.00000	1.000E+00
13	1977	0.000E+00	0.000E+00	--	*	1.454E+02	0.00000	1.000E+00
14	1978	0.000E+00	0.000E+00	--	*	1.474E+02	0.00000	1.000E+00
15	1979	0.000E+00	0.000E+00	--	*	1.396E+02	0.00000	1.000E+00
16	1980	0.000E+00	0.000E+00	--	*	1.514E+02	0.00000	1.000E+00
17	1981	0.000E+00	0.000E+00	--	*	1.575E+02	0.00000	1.000E+00
18	1982	0.000E+00	0.000E+00	--	*	1.694E+02	0.00000	1.000E+00
19	1983	0.000E+00	0.000E+00	--	*	1.929E+02	0.00000	1.000E+00
20	1984	0.000E+00	0.000E+00	--	*	1.977E+02	0.00000	1.000E+00
21	1985	0.000E+00	0.000E+00	--	*	1.611E+02	0.00000	1.000E+00
22	1986	0.000E+00	0.000E+00	--	*	1.131E+02	0.00000	1.000E+00
23	1987	0.000E+00	0.000E+00	--	*	1.034E+02	0.00000	1.000E+00
24	1988	0.000E+00	0.000E+00	--	*	9.086E+01	0.00000	1.000E+00
25	1989	0.000E+00	0.000E+00	--	*	9.664E+01	0.00000	1.000E+00
26	1990	1.000E+00	1.000E+00	--	6.580E+01	9.006E+01	-0.31389	1.000E+00
27	1991	1.000E+00	1.000E+00	--	8.240E+01	7.222E+01	0.13193	1.000E+00
28	1992	1.000E+00	1.000E+00	--	6.450E+01	6.830E+01	-0.05722	1.000E+00
29	1993	1.000E+00	1.000E+00	--	1.128E+02	5.101E+01	0.79369	1.000E+00
30	1994	1.000E+00	1.000E+00	--	1.064E+02	7.163E+01	0.39566	1.000E+00
31	1995	1.000E+00	1.000E+00	--	1.298E+02	1.086E+02	0.17868	1.000E+00
32	1996	1.000E+00	1.000E+00	--	1.343E+02	1.565E+02	-0.15282	1.000E+00
33	1997	1.000E+00	1.000E+00	--	2.229E+02	2.117E+02	0.05149	1.000E+00
34	1998	1.000E+00	1.000E+00	--	2.316E+02	2.578E+02	-0.10720	1.000E+00
35	1999	1.000E+00	1.000E+00	--	2.499E+02	2.939E+02	-0.16220	1.000E+00
36	2000	1.000E+00	1.000E+00	--	3.350E+02	3.129E+02	0.06819	1.000E+00
37	2001	1.000E+00	1.000E+00	--	4.758E+02	3.202E+02	0.39618	1.000E+00
38	2002	1.000E+00	1.000E+00	--	3.397E+02	3.362E+02	0.01039	1.000E+00

39	2003	1.000E+00	1.000E+00	--	3.683E+02	3.401E+02	0.07969	1.000E+00
40	2004	1.000E+00	1.000E+00	--	3.747E+02	3.445E+02	0.08411	1.000E+00
41	2005	1.000E+00	1.000E+00	--	3.427E+02	3.463E+02	-0.01034	1.000E+00
42	2006	1.000E+00	1.000E+00	--	3.055E+02	3.843E+02	-0.22948	1.000E+00
43	2007	1.000E+00	1.000E+00	--	4.824E+02	4.017E+02	0.18301	1.000E+00
44	2008	1.000E+00	1.000E+00	--	3.220E+02	3.956E+02	-0.20574	1.000E+00
45	2009	1.000E+00	1.000E+00	--	2.378E+02	4.054E+02	-0.53345	1.000E+00
46	2010	1.000E+00	1.000E+00	--	4.172E+02	4.036E+02	0.03325	1.000E+00
47	2011	1.000E+00	1.000E+00	--	3.104E+02	4.134E+02	-0.28658	1.000E+00
48	2012	1.000E+00	1.000E+00	--	3.574E+02	4.241E+02	-0.17123	1.000E+00
49	2013	1.000E+00	1.000E+00	--	3.461E+02	4.128E+02	-0.17616	1.000E+00
50	2014	0.000E+00	0.000E+00	--	*	4.123E+02	0.00000	1.000E+00
51	2015	0.000E+00	0.000E+00	--	*	4.136E+02	0.00000	1.000E+00

* Asterisk indicates missing value(s).

```
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  -0.3139                       =============|
1991   0.1319                                    |=====
1992  -0.0572                                  ==|
1993   0.7937                                    |================================
1994   0.3957                                    |================
1995   0.1787                                    |=======
1996  -0.1528                              ======|
1997   0.0515                                    |==
1998  -0.1072                                ====|
1999  -0.1622                              ======|
2000   0.0682                                    |===
2001   0.3962                                    |================
2002   0.0104                                    |
2003   0.0797                                    |===
2004   0.0841                                    |===
2005  -0.0103                                    |
2006  -0.2295                           =========|
2007   0.1830                                    |=======
2008  -0.2057                            ========|
2009  -0.5334                   =====================|
2010   0.0333                                    |=
2011  -0.2866                         ===========|
2012  -0.1712                             =======|
2013  -0.1762                             =======|
2014   0.0000                                    |
2015   0.0000                                    |
              --------------------------------------------------------------------------------
```

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

---

Data type I1: Abundance index (annual average) Series weight: 1.000

Obs	Year	Observed effort	Estimated effort	Estim F	Observed index	Model index	Resid in log index	Statist weight
1	1965	0.000E+00	0.000E+00	--	*	1.700E+02	0.00000	1.000E+00
2	1966	0.000E+00	0.000E+00	--	*	1.652E+02	0.00000	1.000E+00
3	1967	0.000E+00	0.000E+00	--	*	1.597E+02	0.00000	1.000E+00
4	1968	0.000E+00	0.000E+00	--	*	1.531E+02	0.00000	1.000E+00
5	1969	0.000E+00	0.000E+00	--	*	1.455E+02	0.00000	1.000E+00
6	1970	0.000E+00	0.000E+00	--	*	1.333E+02	0.00000	1.000E+00
7	1971	0.000E+00	0.000E+00	--	*	1.126E+02	0.00000	1.000E+00
8	1972	0.000E+00	0.000E+00	--	*	8.836E+01	0.00000	1.000E+00
9	1973	0.000E+00	0.000E+00	--	*	6.787E+01	0.00000	1.000E+00
10	1974	0.000E+00	0.000E+00	--	*	5.485E+01	0.00000	1.000E+00
11	1975	0.000E+00	0.000E+00	--	*	4.528E+01	0.00000	1.000E+00
12	1976	0.000E+00	0.000E+00	--	*	4.442E+01	0.00000	1.000E+00
13	1977	0.000E+00	0.000E+00	--	*	5.055E+01	0.00000	1.000E+00
14	1978	0.000E+00	0.000E+00	--	*	5.325E+01	0.00000	1.000E+00
15	1979	0.000E+00	0.000E+00	--	*	5.213E+01	0.00000	1.000E+00
16	1980	0.000E+00	0.000E+00	--	*	5.293E+01	0.00000	1.000E+00
17	1981	0.000E+00	0.000E+00	--	*	5.618E+01	0.00000	1.000E+00
18	1982	0.000E+00	0.000E+00	--	*	5.947E+01	0.00000	1.000E+00
19	1983	0.000E+00	0.000E+00	--	*	6.593E+01	0.00000	1.000E+00
20	1984	1.000E+00	1.000E+00	--	1.320E+02	7.105E+01	0.61937	1.000E+00
21	1985	1.000E+00	1.000E+00	--	8.500E+01	6.479E+01	0.27149	1.000E+00
22	1986	1.000E+00	1.000E+00	--	4.200E+01	4.912E+01	-0.15666	1.000E+00
23	1987	1.000E+00	1.000E+00	--	3.000E+01	3.929E+01	-0.26989	1.000E+00
24	1988	1.000E+00	1.000E+00	--	2.300E+01	3.522E+01	-0.42623	1.000E+00
25	1989	1.000E+00	1.000E+00	--	4.400E+01	3.410E+01	0.25492	1.000E+00
26	1990	1.000E+00	1.000E+00	--	2.700E+01	3.391E+01	-0.22792	1.000E+00
27	1991	1.000E+00	1.000E+00	--	2.750E+01	2.934E+01	-0.06466	1.000E+00
28	1992	0.000E+00	0.000E+00	--	*	2.553E+01	0.00000	1.000E+00
29	1993	0.000E+00	0.000E+00	--	*	2.150E+01	0.00000	1.000E+00
30	1994	0.000E+00	0.000E+00	--	*	2.213E+01	0.00000	1.000E+00
31	1995	0.000E+00	0.000E+00	--	*	3.241E+01	0.00000	1.000E+00
32	1996	0.000E+00	0.000E+00	--	*	4.787E+01	0.00000	1.000E+00
33	1997	0.000E+00	0.000E+00	--	*	6.678E+01	0.00000	1.000E+00
34	1998	0.000E+00	0.000E+00	--	*	8.545E+01	0.00000	1.000E+00
35	1999	0.000E+00	0.000E+00	--	*	1.005E+02	0.00000	1.000E+00
36	2000	0.000E+00	0.000E+00	--	*	1.105E+02	0.00000	1.000E+00
37	2001	0.000E+00	0.000E+00	--	*	1.152E+02	0.00000	1.000E+00
38	2002	0.000E+00	0.000E+00	--	*	1.195E+02	0.00000	1.000E+00

39	2003	0.000E+00	0.000E+00	--	*	1.230E+02	0.00000	1.000E+00
40	2004	0.000E+00	0.000E+00	--	*	1.245E+02	0.00000	1.000E+00
41	2005	0.000E+00	0.000E+00	--	*	1.256E+02	0.00000	1.000E+00
42	2006	0.000E+00	0.000E+00	--	*	1.332E+02	0.00000	1.000E+00
43	2007	0.000E+00	0.000E+00	--	*	1.431E+02	0.00000	1.000E+00
44	2008	0.000E+00	0.000E+00	--	*	1.449E+02	0.00000	1.000E+00
45	2009	0.000E+00	0.000E+00	--	*	1.458E+02	0.00000	1.000E+00
46	2010	0.000E+00	0.000E+00	--	*	1.471E+02	0.00000	1.000E+00
47	2011	0.000E+00	0.000E+00	--	*	1.487E+02	0.00000	1.000E+00
48	2012	0.000E+00	0.000E+00	--	*	1.524E+02	0.00000	1.000E+00
49	2013	0.000E+00	0.000E+00	--	*	1.520E+02	0.00000	1.000E+00
50	2014	0.000E+00	0.000E+00	--	*	1.500E+02	0.00000	1.000E+00
51	2015	0.000E+00	0.000E+00	--	*	1.502E+02	0.00000	1.000E+00

* Asterisk indicates missing value(s).

Yellowtail flounder 2015 NAFO catch in 2015 avg 2006-2014 Page11

```
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   0.0000                          |
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   0.6194                          |=========================
1985   0.2715                          |===========
1986  -0.1567                    ======|
1987  -0.2699               ===========|
1988  -0.4262         =================|
1989   0.2549                          |==========
1990  -0.2279                 =========|
1991  -0.0647                       ===|
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                          |
2003   0.0000                          |
2004   0.0000                          |
2005   0.0000                          |
2006   0.0000                          |
2007   0.0000                          |
2008   0.0000                          |
2009   0.0000                          |
2010   0.0000                          |
2011   0.0000                          |
2012   0.0000                          |
2013   0.0000                          |
2014   0.0000                          |
2015   0.0000                          |
              --------------------------------------------------------------------------------
```

RESULTS FOR DATA SERIES # 5 (NON-BOOTSTRAPPED) Spanish Survey Converted biomass_2006

Data type I1: Abundance index (annual average) Series weight: 1.000

Obs	Year	Observed effort	Estimated effort	Estim F	Observed index	Model index	Resid in log index	Statist weight
1	1965	0.000E+00	0.000E+00	--	*	1.906E+02	0.00000	1.000E+00
2	1966	0.000E+00	0.000E+00	--	*	1.853E+02	0.00000	1.000E+00
3	1967	0.000E+00	0.000E+00	--	*	1.791E+02	0.00000	1.000E+00
4	1968	0.000E+00	0.000E+00	--	*	1.717E+02	0.00000	1.000E+00
5	1969	0.000E+00	0.000E+00	--	*	1.632E+02	0.00000	1.000E+00
6	1970	0.000E+00	0.000E+00	--	*	1.494E+02	0.00000	1.000E+00
7	1971	0.000E+00	0.000E+00	--	*	1.263E+02	0.00000	1.000E+00
8	1972	0.000E+00	0.000E+00	--	*	9.909E+01	0.00000	1.000E+00
9	1973	0.000E+00	0.000E+00	--	*	7.612E+01	0.00000	1.000E+00
10	1974	0.000E+00	0.000E+00	--	*	6.151E+01	0.00000	1.000E+00
11	1975	0.000E+00	0.000E+00	--	*	5.077E+01	0.00000	1.000E+00
12	1976	0.000E+00	0.000E+00	--	*	4.981E+01	0.00000	1.000E+00
13	1977	0.000E+00	0.000E+00	--	*	5.669E+01	0.00000	1.000E+00
14	1978	0.000E+00	0.000E+00	--	*	5.972E+01	0.00000	1.000E+00
15	1979	0.000E+00	0.000E+00	--	*	5.846E+01	0.00000	1.000E+00
16	1980	0.000E+00	0.000E+00	--	*	5.936E+01	0.00000	1.000E+00
17	1981	0.000E+00	0.000E+00	--	*	6.300E+01	0.00000	1.000E+00
18	1982	0.000E+00	0.000E+00	--	*	6.669E+01	0.00000	1.000E+00
19	1983	0.000E+00	0.000E+00	--	*	7.394E+01	0.00000	1.000E+00
20	1984	0.000E+00	0.000E+00	--	*	7.968E+01	0.00000	1.000E+00
21	1985	0.000E+00	0.000E+00	--	*	7.266E+01	0.00000	1.000E+00
22	1986	0.000E+00	0.000E+00	--	*	5.509E+01	0.00000	1.000E+00
23	1987	0.000E+00	0.000E+00	--	*	4.407E+01	0.00000	1.000E+00
24	1988	0.000E+00	0.000E+00	--	*	3.950E+01	0.00000	1.000E+00
25	1989	0.000E+00	0.000E+00	--	*	3.824E+01	0.00000	1.000E+00
26	1990	0.000E+00	0.000E+00	--	*	3.803E+01	0.00000	1.000E+00
27	1991	0.000E+00	0.000E+00	--	*	3.290E+01	0.00000	1.000E+00
28	1992	0.000E+00	0.000E+00	--	*	2.863E+01	0.00000	1.000E+00
29	1993	0.000E+00	0.000E+00	--	*	2.412E+01	0.00000	1.000E+00
30	1994	0.000E+00	0.000E+00	--	*	2.481E+01	0.00000	1.000E+00
31	1995	1.000E+00	1.000E+00	--	9.300E+00	3.634E+01	-1.36301	1.000E+00
32	1996	1.000E+00	1.000E+00	--	4.330E+01	5.368E+01	-0.21493	1.000E+00
33	1997	1.000E+00	1.000E+00	--	3.870E+01	7.489E+01	-0.66013	1.000E+00
34	1998	1.000E+00	1.000E+00	--	1.226E+02	9.583E+01	0.24634	1.000E+00
35	1999	1.000E+00	1.000E+00	--	1.970E+02	1.127E+02	0.55842	1.000E+00
36	2000	1.000E+00	1.000E+00	--	1.447E+02	1.239E+02	0.15514	1.000E+00
37	2001	1.000E+00	1.000E+00	--	1.827E+02	1.292E+02	0.34677	1.000E+00
38	2002	1.000E+00	1.000E+00	--	1.485E+02	1.340E+02	0.10276	1.000E+00

39	2003	1.000E+00	1.000E+00	--	1.368E+02	1.379E+02	-0.00829	1.000E+00
40	2004	1.000E+00	1.000E+00	--	1.700E+02	1.396E+02	0.19677	1.000E+00
41	2005	1.000E+00	1.000E+00	--	1.565E+02	1.409E+02	0.10515	1.000E+00
42	2006	1.000E+00	1.000E+00	--	1.601E+02	1.493E+02	0.06953	1.000E+00
43	2007	1.000E+00	1.000E+00	--	1.607E+02	1.605E+02	0.00125	1.000E+00
44	2008	1.000E+00	1.000E+00	--	1.601E+02	1.625E+02	-0.01469	1.000E+00
45	2009	1.000E+00	1.000E+00	--	1.834E+02	1.635E+02	0.11514	1.000E+00
46	2010	1.000E+00	1.000E+00	--	1.897E+02	1.649E+02	0.14000	1.000E+00
47	2011	1.000E+00	1.000E+00	--	2.038E+02	1.667E+02	0.20082	1.000E+00
48	2012	1.000E+00	1.000E+00	--	1.956E+02	1.709E+02	0.13478	1.000E+00
49	2013	1.000E+00	1.000E+00	--	1.880E+02	1.705E+02	0.09779	1.000E+00
50	2014	1.000E+00	1.000E+00	--	1.365E+02	1.682E+02	-0.20907	1.000E+00
51	2015	0.000E+00	0.000E+00	--	*	1.684E+02	0.00000	1.000E+00

* Asterisk indicates missing value(s).

Yellowtail flounder 2015 NAFO catch in 2015 avg 2006-2014 Page13

```
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  -1.3630    ===========================|
1996  -0.2149                           ====|
1997  -0.6601                  =============|
1998   0.2463                               |=====
1999   0.5584                               |===========
2000   0.1551                               |===
2001   0.3468                               |=======
2002   0.1028                               |==
2003  -0.0083                               |
2004   0.1968                               |====
2005   0.1051                               |==
2006   0.0695                               |=
2007   0.0013                               |
2008  -0.0147                               |
2009   0.1151                               |==
2010   0.1400                               |===
2011   0.2008                               |====
2012   0.1348                               |===
2013   0.0978                               |==
2014  -0.2091                           ====|
2015   0.0000                               |
            --------------------------------------------------------------------------------
```

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

```
      :                                                      O
480. -:
      :      * *                                          O
      :         *                                        O
      :
      :          *                                          2* * **
400. -:              *                                     * ** 2   O
      :                                            O  O
      :            *                            O  O     *
      :                                              *
      :                                           ** *          O
320. -:                                              *
      :             *                           *    O
      :                                         O
      :                                        *         O
      :
240. -:                 *                          *
      :                          O
      :                                       O
      :               *          *            *     O
      :                        * *           OO
160. -:                         **
      :                *  * ** *    O O
      :                **          * O           *
      :                            *
      :                            * 2 2O   O  *
 80. -:                               O   *
      :                                 2 ** O
      :                                   O
      :
      :
  0. -:
      :..........................................................
      :     :     :     :     :     :     :     :     :     :     :
   1959.  1965.  1971.  1977.  1983.  1989.  1995.  2001.  2007.  2013.  2019.
```

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

```
      :
180. -:
      :
      :
      :
      :
```

```
150. -:
      :       * *
      :         *
      :          *                                          * *
      :           *                                       ** * *  **
120. -:                                                   *
      :            *                                  *
      :                                             * *
      :                                            **
      :             2                            * *
 90. -:
      :                                         *
      :              2
      :                                        *
      :                   0
 60. -:                *           *
      :               0       0   * *           *
      :                *   *  * 2*
      :                0  0 * 0*   0    *          *
      :                 2*   0        *
 30. -:                               * * *    *
      :                                * *
      :                                   **
      :
      :
  0. -:
      :............................................................
       :     :     :     :     :     :     :     :     :     :     :
    1959.  1965.  1971.  1977.  1983.  1989.  1995.  2001.  2007.  2013.  2019.
```

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

```
      :
480. -:                                            O      O
      :      *
      :       *
      :        *                                           *
      :         *                                         O * * **
400. -:                                                  * ** *
      :          *                                   *
      :                                           O O
      :           *                                 * *      O O
      :                                        O   2*  O
320. -:                                           * *       O
      :                                               O      O
      :                                       *
      :            *
      :                                      * O
240. -:                                                    O
      :                                     O O
      :             *                        *
      :                        * *
      :                      *
160. -:                  *       *   *           *
      :                *   * ** *
      :                  *                  O O
      :                *          *       OO *
      :                            ** * *
 80. -:                                  2
      :                                O  2 *
      :                                  *
      :
      :
  0. -:
      :..........................................................
       :     :     :     :     :     :     :     :     :     :     :
     1959. 1965. 1971. 1977. 1983. 1989. 1995. 2001. 2007. 2013. 2019.
```

```
      Observed (O) and Estimated (*) CPUE for Data Series # 4 -- Russian Survey
      :
240. -:
      :
      :
      :
      :
200. -:
      :
      :
      :
      :    * *
160. -:       *
      :      *                                        ** * **
      :       *                                     * ** *
      :       *           O                         *
      :                                           * *
120. -:                                            **
      :        *                                 * *
      :                                         *
      :
      :         *          O                    *
 80. -:
      :                    *
      :         *         * *                  *
      :          *    ** * **
      :           ** *       *   O            *
 40. -:                       O *
      :                       O* * **     *
      :                       O   OO * **
      :
      :
  0. -:
      :......................................................................................................
       :    :    :    :    :    :    :    :    :    :    :
   1959.  1965.  1971.  1977.  1983.  1989.  1995.  2001.  2007.  2013.  2019.
```

```
        Observed (O) and Estimated (*) CPUE for Data Series # 5 -- Spanish Survey Converted biomass_2006
          :
   240. -:
          :
          :
          :
          :
   200. -:                                                   O              O
          :        *                                                  O  O
          :         *                                        O        O     O
          :          *
          :           *                                         O       * ** * **
   160. -:                *                                          OO 2 2*
          :             *                                     O    *
          :                                                O      *
          :                                                  *2 *           O
          :               *                                 *
   120. -:                                                O  *
          :                                              *
          :
          :                *                            *
          :
    80. -:                   *             *
          :                            * *                *
          :                  *        **
          :                     * ** *       *           *
          :                   **             *
    40. -:                                    * * *     * OO
          :                                     * *
          :                                        **
          :
          :                                          O
     0. -:
          :.................................................................
           :      :      :      :      :      :      :      :      :      :      :
         1959.   1965.   1971.   1977.   1983.   1989.   1995.   2001.   2007.   2013.   2019.
```

```
                 Time Plot of Estimated F/Fmsy and B/Bmsy (dashed line = 1.0)
     :
3.0 -:
     :                             F
     :                       F
     :
     :
2.5 -:                             F
     :
     :              F
     :            F
     :                         F
2.0 -:       B B    F F          F
     :       B                 F  F F
     :        B B                                    B B BB B
     :          B                                B B B B
     :                 F                      B
1.5 -:            2                           B BB
     :                          F           BB
     :                 F                  B B
     :            B      F
     :                  F   F              B
1.0 -: -- - -- - -- -- - -- - -- 2 -- - -2 - -- -- -- - -- - -- - -- - -- - -- - -- - -- - -- - -- -- - -- - -
     :          F  B                      B
     :               F       BB
     :             B       B 2   B         B
     :              B  B BB B B                F
0.5 -:           F     B          B         B   F  F F F
     :        F                B B BB   F       F     F
     :       F                   B B  B    F          F   F
     :       F                    B    F         F   F   FF
     :      F                                F     F
0.0 -:                                F FF       F
     :..........................................................
      :      :      :      :      :      :      :      :      :      :      :
   1959.  1965.  1971.  1977.  1983.  1989.  1995.  2001.  2007.  2013.  2019.
```

Elapsed time: 0 hours, 0 minutes, 3.635 seconds.