NOT TO BE CITED WITHOUT PRIOR
REFERENCE TO THE AUTHOR(S)

Northwest Atlantic Fisheries Organization

Serial No. N5547 **NAFO SCR Doc. 08/45**

SCIENTIFIC COUNCIL MEETING – JUNE 2008

The 2008 Assessment of the Grand Bank Yellowtail Flounder Stock, NAFO Divisions 3LNO

by

Dawn Maddock Parsons, W. B. Brodie, M. J. Morgan and D. Power

Northwest Atlantic Fisheries Center, Science Branch, Department of Fisheries and Oceans, Canada.
80 East White Hills Road, St. John's, Newfoundland Canada, AlC 5Xl.
Email: dawn.parsons@dfo-mpo.gc.ca

Abstract

The last assessment of 3LNO yellowtail flounder in 2006 included biological, survey and catch information and also incorporated recent and historical survey and catch indices in a surplus production model (ASPIC). Information was provided on relative biomass and fishing mortality and projections were presented for short and medium term under a range of fishing mortalities. Canadian and Spanish surveys show the stock size has increased since the moratorium on directed fishing was declared in 1994. The 2006 and 2007 Canadian survey estimates of biomass are the highest in the series for the spring survey and in the fall survey, the 2007 biomass estimate is the highest in the series. Survey indices are updated, including estimates of biomass, abundance, mean numbers and mean weights per tow, length frequency data, and information on stock distribution. A more recent version of ASPIC (5.24) is compared to the accepted 2006 assessment (version 3.81) and no difference in model fit or output is evident. The 2008 assessment uses ASPIC version 5.24 with updated catch and survey biomass indices for 2006 and 2007 to produce relative biomass and fishing mortality estimate. 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, which was set at 13 000 t in 2001-2002, increasing to 14 500 tons for 2003 and 2004, 15 000 tons for 2005-

2006 and 15 500 tons for 2007 and 2008. Scientific Council again provided 2-year TAC advice in 2006, when the stock was last assessed, and confirmed the 2006 advice in 2007, following an interim monitoring update.

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. Both the 2004 and 2005 nominal catch estimates of 13 354 tons and 13 933 tons, respectively are below their respective TAC of 14 500 tons and 15 000 tons. In 2004, Canada caught 12 575 tons and in 2005 caught 13 137 tons. 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.

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. With the exception of the 1991-1993 period, when Canadian vessels pursued a mixed fishery for plaice and yellowtail flounder in Div. 3O, the majority of catches have been taken in Div. 3N. The most important gear is otter trawl. The Canadian otter trawl catch in Div. 3L of 2 760 t[1] in 2004 was the highest in this Division since 1986 but the catches declined by about 1 000 t in Div. 3N and 1 800 t in Div. 3O from 2003 to 2004. Although the Div. 3L and 3O catches were lower in 2005 when compared to 2004, Canada's highest catch of 10 572 t came from Div. 3N and represents the highest level from this division since 1981. In 2006, catch was negligible; with only 177 tons taken mainly in 3N (1 ton was taken in 3L). Canadian catch in 3L was only 5 tons in 2007, while in 3N and 3O catches increased from the previous year, to 2 053 t and 1 615 t respectively.

C. The 2006-2007 Fisheries by Non-Canadian Vessels (SCS Doc. 07/6, 8,9; SCS Doc. 08/5,6,8)

Sampling of size composition from commercial catches of yellowtail flounder in 2006 and 2007 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 2007 only. Available length frequencies from the Canadian and Spanish catches for 2006 and 2007 are plotted together in Figure 2. 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. No sampling of yellowtail flounder from the 2006 Spanish fishery for Greenland halibut was available. In 2007, the mode in the Spanish yellowtail by-catch was 32-34 cm, lower than that seen in years prior to 2006, or in fisheries by Canada and Portugal which had similar modes in the length frequencies of 36-38cm. In 2006 and 2007, skate fisheries of Portugal and Spain, where a minimum codend mesh size of 280 mm is used, the mode in the 2006 and 2007 catch by Portugal was 38-42 cm. The mode in the 2007 catch by Spain was lower, at 36 cm.

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

[1] Erroneously reported as 42 760 tons in Walsh *et al*., 2005

whereas the 1995-2007 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 1995-2007.

Abundance and biomass trends

Figures 3 and 4 and Tables 3 and 4 compare the population abundance and biomass estimates of yellowtail flounder in the Canadian spring and fall surveys. Detailed descriptions of survey trends in both series are contained in Maddock Parsons and Brodie (2008). 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. The spring survey showed more annual variation in stock size from 1999-2007, while the fall survey biomass estimates were relatively less variable, increasing steadily until 2002, when the biomass estimate decreased and remained stable until 2007 when the estimate increased again.

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 72% 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 1996-2007, 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 (see Appendix 1).

Size composition and growth

Figure 6 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 and 2000 there were bimodal distributions seen in the data which can be tracked from year to year. 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 (Fig. 6).

In the fall surveys, multi-modal peaks are more common and unlike the spring surveys, were evident in surveys from 2001-2007 (Fig. 6). 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 7 shows survey abundance less than 21 cm from Canada and Spain for the period 1995-2007 as a proxy for recruitment. 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 (Fig. 8). 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 much higher increases in abundance of small fish than either the Canadian spring or Spanish spring surveys. In 2006 and 2007, however, the number of small fish in the Canadian fall survey, although higher than either of the spring surveys, is more in line with trends in the other surveys.

With the exception of the spring and fall of 1995, (Canada switched to the Campelen trawl in the fall of 1995) the overall trend in the Canadian and the Spanish spring surveys is similar to the Canadian fall surveys from 1996-2003. In 2004 and 2005 surveys, the Canadian fall index is much higher (Fig. 7A). Walsh *et al.* (2006a) reported several large catches (numbers >1 000 fish) in the Southeast Shoal (nursery) area in the fall of 2004 and 2005 surveys, that were not evident in the spring surveys and these large catches also contained a large number of "juveniles".

Figure 7B shows that there was no linear relationship between 1996-2007 Canadian spring and fall estimates. However, if you remove the 2004 and 2005 estimates then a statistical significant relationship was evident (Fig. 7B and 7C).

Cohort strength model

Numbers at age are not available at this time, so the cohort strength model (Walsh *et al*., 2002) was not updated.

B. Spanish Stratified-random Spring Surveys in the Regulatory Area, Div. 3NO (*SCR Doc. 08/008*)

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. 3 and 8). Most (83%) of the biomass comes from strata 360 and 376 similar to other years. Length frequencies in the 2006 and 2007 Spanish survey showed a mode around 32-34 cm (Fig. 9). As in the Canadian spring surveys (Fig. 6), this survey showed a similar progression of the peak in the length frequencies from 1998 to 2005. There was no evidence of a recruitment pulse in recent years similar to the Canadian spring survey results.

C. Stock Distribution *(SCR Doc. 08/44)*

The 2006 and 2007 distribution of yellowtail flounder in NAFO Divs. 3LNO are described in the results of the Canadian spring and fall surveys (Maddock Parsons and Brodie, 2008). As in recent years, the stock continues to occupy more northern areas than in previous years with the increase in stock size.

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

In the 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 1984-2007. Estimates were produced using a probit model with a logit link function and a binomial error structure (SAS, 1989). L_{50} declined in males, by about 7 cm from around 30 cm in the mid-1980's to 23 cm in 1999. Although there have been short term fluctuations there has been little overall trend since 2000, with L_{50} averaging just under 25 cm. Female L_{50} has been fairly stable until the last 5 years which have all been estimated below the long term average of 33 cm (Fig. 10). There was significant inter-annual variation in the proportion mature at length for both males and females (generalized linear models: males χ^2=237.8, df=23, p<0.0001, females χ^2=339.5, df=23, p<0.0001). In general for males, years prior to 1992 were significantly different from 2007, and years prior to 1989 were significantly different from all years since 2000. After this there are also years that are significantly different from the final year but there is no pattern. For females, all years except 2005 are significantly different from 2007.

Weight at length

Log length – log weight regressions were fit for females for each year from the Canadian spring survey data from 1990-2007. The specific length weight relationships are given in Table 5. 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 0.1 Kg since 1996 (Fig. 11).

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. 12). Since 1995 it has increased substantially. The average index over the 1996-1998 period was 66 000 t, similar to levels in the mid-1980's. There was a large increase in the index in 1999 consistent with the large increase in the overall survey abundance index for that year. Estimates for 1999-2001 were fairly similar and much higher than any previous estimate. There was a large decline in the index in 2002, similar to the overall survey abundance and biomass indices. The SSB index increased again in 2003 and overall has been increasing since 1995. The 2002 to 2007 average is 163 000 t, substantially higher than that of the mid-1980's. In general the female SSB index mirrors the trend in the total survey biomass index.

E. ASPIC Model Comparisons

In the previous assessment of this stock, the version of the surplus production model (ASPIC; Prager 1994,1995) that was used (version 3.81) was not the most current version available. Comparisons with the newer version at the time gave results that were not comparable in some of the outputs, particularly in the outputs from bootstrapped estimates (see Walsh and Brodie, 2003). Since that time, a new suite of programs has become available (suite 5.0) and a comparison between the accepted assessment and the new version of ASPIC (version 5.24) is presented here.

Version 5.24 of ASPIC contains several changes from earlier versions, which are outlined in the documentation for the ASPIC suite (Prager, 2005). Changes most relevant to the yellowtail flounder assessment probably have to do with a change in the parameterization of the model, as well as a subtle change in the way the convergence criterion are handled.

Version 5.x of ASPIC can now fit the generalized production model, in addition to the logistic form of the production model that was fit in previous versions (including version 3.81). The generalized model requires parameterization in terms of MSY and carrying capacity K rather than MSY and intrinsic rate of increase r. This occurs because when the exponent n in the generalized model is in the region $n \leq 1$, then $r = \infty$. As a result, ASPIC 5.x requires a starting guess for K, not for r.

A parameter estimated by ASPIC is the biomass in the first year of the analysis. In previous versions, this was expressed (both in the input file and in ASPIC reports) as a ratio to the biomass providing MSY; i.e., as B1/BMSY. In version 5.x, it is expressed as a ratio to the carrying capacity, i.e., as B1/K. This change is required because in the generalized model, B_{MSY} is no longer a fixed proportion of K. The change reduces correlation between estimates of the starting biomass ratio and of B_{MSY}.

In the previous assessment (in 2006) the relative convergence criterion (simplex) was set to 1d-6 in order to facilitate running the bootstrap estimates (setting the convergence criterion to 1d-8, as recommended, took much longer to run). Version 5.x seems to have a change in the way the convergence criterion is handled, and in the model comparison, the convergence criterion is set to 1d-8 (the recommended value) in the run using version 5.24 of ASPIC.

For the comparison runs, the accepted 2006 assessment was run in ASPIC version 3.81. Walsh (2007) indicated that some errors in the survey series had been overlooked in the assessment in 2006. As well, the catch series used in that assessment was not the same as in the nominal catch table. The comparison run, here, corrects the noted errors, and uses the nominal catch table, so is not a direct replica of the 2006 assessment. The input file for the run using ASPIC version 5.24 is slightly different, due to the parameterization change, but was set up to reproduce the 2006 assessment as closely as possible. The input files for the comparison runs are given in Table 6, and the catch and biomass series used are given in Table 7.

Model outputs, parameter estimates and bootstrapped estimates from the two runs comparing ASPIC models are given in Tables 8 and 9. Results in the new version are very close to the results from the previously accepted version of ASPIC. The only difference in the model results seems to be the number of restarts for convergence, and that is probably the result of the change in convergence criterion to 1d-8 in version 5.24 of ASPIC.

Estimates of relative fishing mortality and relative biomass from the two comparison runs are given in Table 10 and Figure 13. The outputs are nearly identical and the plots overlay for the course of the entire series.

Since the results of ASPIC version 5.24 are nearly identical to the accepted version of ASPIC (3.81) used in the previous assessment, and older versions of ASPIC are no longer supported by the author, the 2008 assessment of yellowtail flounder will use ASPIC version 5.24.

F. Assessment Results

Stock-recruitment relationship

Since there were no available age data for 2002-2007, the recruitment index (cohort strength model, Walsh *et al*., 2002) was not updated.

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 (Brodie et al. 2006). Logbook data from the Can (N) fleet identifying yellowtail as the directed species from 1965 to 1993, along with 1998-2005 and preliminary 2007 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. Power, 2004), individual observations with catch less than 10 tons or effort less than 10 hours were eliminated prior to analysis. Subsequently, within each dependent 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 66% since 1965. 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 11 and 12 show the ANOVA and regression results of the CPUE analysis and Fig 14 shows the standardized series from 1965 to 2007. In Fig. 14A, 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 sharply in 1986 and remained at this relatively low level through to 1990. In 1991 the CPUE declined by almost half to the lowest level observed. 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. Catch rates initially increased slightly by 2000, declined marginally to 2002 then increased in succession by more than 50% to the highest in the series in 2005. There was a 10% reduction in the catch rate in 2007 but the index remains among the highest in the time series. Monthly coefficients (Table 12) indicated that CPUE was highest during the fall period (September – October) and the best catch rates are in 3N. Data from the Canadian fleet indicate that by-catch of American plaice has been problematic in this fishery, around 10%, since 2001, but no attempt has been made to account for this factor in the CPUE analyses.

Standardizations of the data separately by Division (Fig. 14B) showed that, overall, the historical trends were the same, although the catch rate is generally lower in Div. 3O than in Div. 3N, and that large fluctuations tend to occur more frequently in Div. 3O, primarily before 1985. In the period since the resumption of the directed fishery (1998-2005) catch rates showed opposite trends within each division between 1998 and 2001 and again in 2004 and 2007. CPUE increased sharply in Div. 3N from 2002 to 2004-05 but declined in 2007. In Div. 3O, CPUE has generally increased from 1999 to 2007.

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 has been a by-catch restriction of 5% for both American plaice and cod which directly affected the fishing pattern of the Canadian fleet. The 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. Once again, caution should be used in comparing post-moratorium catch rates with other fishery periods. However, the overall CPUE since 1998, under the constraint of 5% by-catch limitations, suggests that the stock size has increased to a relatively high level, in agreement with survey indices (Maddock Parsons 2008; Gonzalez-Troncoso *et al*. 2008; Maddock Parsons and Brodie 2005).

Surplus production model (ASPIC)

A non-equilibrium surplus production model incorporating covariates (ASPIC; Prager, 1994, 1995) was applied to nominal catch and survey biomass indices, as was done in the 2002, 2004 and 2006 assessments of this stock (Walsh *et al*., 2002; 2004;2006). 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 a ratio to B_{msy}: $B1R$), r, MSY, and catchability coefficients for each biomass index (q_i) were estimated using non-linear least squares of survey residuals. 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. This bootstrap analyses will be the basis for catch projections. In the model runs presented, and for all subsequent projections, it was assumed that the catch in 2008 would equal the TAC of 15 500 t, although catches in 2002-2005 and 2007 were estimated to be less than the TACs. In 2006, corporate restructuring and a labour dispute in the industry resulted in a near absence of yellowtail catch by the Canadian fleet.

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 production model formulation for the 2006 assessment included: 1) the nominal catch data (1965-2005); 2) Russian spring surveys (1972-1991); 3) Canadian Yankee spring surveys (1971-1982); 4) Canadian Campelen spring surveys (1984-2005); 5) Canadian Campelen fall surveys (1990-2005); and 6) the Spanish spring (1995-2005) survey (now in Campelen equivalents). These indices were the same (updated) indices accepted by STACFIS in the 2001, 2002 and 2004 assessments of this stock. In the 2008 assessment, these indices are first updated with catch (1965-2007), Canadian Campelen spring (1984-2007) and fall (1990-2007) surveys and Spanish surveys (1995-2007). The Russian survey (1972-1991) and Canadian Yankee survey (1971-1982) were included as in the previous assessment as well. The TAC in 2008 of 15 500 t is included in the catch series. Further analysis of the series incorporated into the final model formulation included various treatments of the Russian time series, and consideration of the removal of the 2006 Canadian spring survey estimate due to missing strata that have, in the recent past, contributed significantly to the annual spring biomass estimate.

The input data for surplus production model are listed in Table 7, and the ASPIC input file is shown in Table 6. Estimated landings were used as nominal catch, but do not include discards. The Canadian spring surveys have used a variety of survey gears since this series began in 1971. A 'Yankee' otter trawl was used from 1971 to 1982, an 'Engel' otter trawl was used from 1984 to 1995 (spring), and since the fall of 1995 a 'Campelen' shrimp trawl has been used (McCallum and Walsh, 1997). Comparative tows between the Yankee and Engel trawls were used to derive a conversion factor of 1.4 for the Yankee catches by number but not by weight (biomass). Therefore the unconverted Yankee survey biomass estimates were used here. Comparative tows between the Engel and Campelen trawls were used to derive a size-based conversion factor for the Engel survey results prior to fall 1995 (Warren *et al*., 1997; Walsh *et al*., 1998). Methods to link the 1971-1982 Yankee series to the 1984-2007 Campelen (or equivalent) series have not been developed; therefore, these two series were considered to be separate indices of biomass in the production model.

Other survey indices were examined in 2004 and again, in a 2007 sensitivity analysis (Walsh and Brodie, 2004; Walsh, 2007), and included the unconverted 1986-94 Canadian fall juvenile groundfish surveys (Walsh *et al*., 1995); the average catch rate from the DFO/FPI grid surveys from July 1996-2001 which both gave negative correlations with most indices and were excluded from the model. The Canadian trawler CPUE series was not used as an index in the model, due to previous results which showed a strong residual pattern (Walsh and Cadrin, 2000). As well, there are concerns that CPUE in various time periods may not be comparable, due to various restrictions which affected fleet behaviour and influenced CPUE, e.g. by-catch restrictions from 1998 onward. Formulations using these indices were not tested in this assessment.

Walsh and Brodie (2003) and Walsh (2007) looked at sensitivity of the ASPIC model to various indices of abundance for this stock, as well as to number of model assumptions. Some different model formulations in 2004 were explored to test the sensitivity of results to various indices and model assumptions. As in previous years, results with this version and formulation of ASPIC were not sensitive to starting estimates of various parameters (survey *q's*, random number seed, *B1/K*, etc.). As well, the sensitivity analysis by Walsh (2007) found better model fit by fixing the B1 Ratio to 2, due to the model assessing a penalty for B1>2, but in the new version of ASPIC, the penalty is assessed due to B1>K, so further investigation of this parameter will need to be conducted in future. The Juvenile/Fall series explored in the sensitivity analysis on Walsh (2007) was not considered for inclusion in the previous assessment, and will likely be considered in future stock production analysis of this stock.

Previous analyses have looked at the sensitivity of the model to the exclusion of the Russian series. In the sensitivity analysis presented by Walsh and Brodie (2003), the model formulation was very sensitive to excluding the Russian series: *MSY* increased to 21 000 t, K increased, and B_{MSY} increased from 80 000 t to 94 000 t. The model estimated B_1R to be 0.56 which would indicate that *B* at the start of the time series was far below B_{MSY}, increasing to about B_{MSY} by 1968-69. Although possible, this seems unlikely, given the trajectory of the only index available at that time (Canadian CPUE; see Brodie *et al*., 2006). That index showed a rapid decline in CPUE during the late 1960s, which would appear to be unlikely if biomass had doubled, as the ASPIC model indicated. Similar results were obtained when both the Russian and Spanish time series were excluded. As noted in Prager (1994), the starting biomass in the first year, even in relative terms, is usually quite imprecise, and he recommends against drawing inferences about the biomass in the first 2-4 years unless auxiliary information is available.

The sensitivity of the 2006 assessment model to various indices and model specifications was investigated and presented by Walsh (2007). The conclusion of that analysis was that with the addition of 4 more years of data, the model was robust enough to exclude the Russian series. Exclusion of the Russian series improved the fit of the model and made only marginal changes to output parameters.

The Russian survey series (1972-1991) included in previous assessments had been carried out using various methods (Bulatova *et al.*, 1997). In 1983, Russian bottom trawl surveys and stock assessment, were carried out according to Canadian methods. For the current assessment, the updated model formulation (2008 assessment) was also run with the Russian series excluded, with a truncated Russian survey series (1984-1991), and with the Russian series split into two times series (1972-1982 and 1984-1991) in order to investigate the effects on model output.

Following review by STACFIS in 2003, 2004 and again in 2006, there were no recommendations to change the standard formulation, which had been accepted in the assessments of this stock since 2000. To ensure comparability of results with the versions of ASPIC used in 2001, 2002 and 2004, the same version of the ASPIC software (v 3.81) was used in those assessments. Comparison of ASPIC versions 3.81 and 5.24 showed no difference in model results or fit, therefore the 2008 assessment of yellowtail used version 5.24 (version 3.81 is no longer supported).

2008 Assessment: The header information for the ASPIC input files for all of the runs completed for the 2008 assessment is given in Table 6. Five formulations of the model were explored, as follows:

Catch/Series included	Update of 2006 formulation	Russia Out	Russia Split- 2 Series	Russia (1984-1991)	2008 Accepted Formulation
Nominal catch data	1965-2007	1965-2007	1965-2007	1965-2007	1965-2007
Canadian Yankee spring	1971-1982	1971-1982	1971-1982	1971-1982	1971-1982
Canadian Campelen spring	1984-2007	1984-2007	1984-2007	1984-2007	1984-2007 (2006 OUT)
Canadian Campelen fall	1990-2007	1990-2007	1990-2007	1990-2007	1990-2007
Russian spring survey	1972-1991		1972-1982 1984-1991	1984-1991	1984-1991
Spanish spring survey	1995-2007	1995-2007	1995-2007	1995-2007	1995-2007

To investigate the effect of the Russian survey series on model fit and trends in the stock, the updated 2006 model formulation was run with the Russian series excluded, with a truncated Russian survey series (1984-1991; as data were collected using the same methods as the Canadian survey series followed) and with the Russian series split into two time periods, 1972-1982 and 1984-1991(used as two tuning indices in the model). Model output for these runs are included in Table 13 and can be compared to the updated assessment results with the same formulation as that accepted in 2006. Both the exclusion of the Russian series and using the shorter Russian series improved the fit of the model, while splitting the Russian series into two series improved some indicators of model fit (MSE, r^2 for the Catch/Canadian Spring series) but gave a negative r2 for the Russian survey (1972-1982). Using the latter part of the Russian survey series (1984-1991) seems to better improve the fit of the model, including lower MSE (0.09 compared to 0.14), improved r^2 for three of the indices, particularly the Russian survey (0.5 compared to 0.3), and fewer restarts (35 compared to 62). Using the Russian series (1984-1991) increased the *MSY* to 19 880 t, *K* increased to 162 600 t (compared to 158 300 t in the updated assessment) and B_{msy} increased to 81 300 t. Relative biomass and fishing mortality estimates from the 3 model formulations are shown in Figure 19. The model is sensitive, particularly in the early part of the time series, to the treatment of the Russian series. Figure 20 gives the survey series included in the model, standardized to the mean in each series, in order to visualize the trends in the various surveys compared to trends in the catch.

Further consideration of the Canadian spring survey resulted in removing the 2006 biomass estimate from the series used in the ASPIC formulation. In 2006, mechanical issues with the survey vessel resulted in reduced coverage of Div. 3N. Despite efforts to cover the majority of the yellowtail stock, a strata (373) that has contributed significantly to the biomass estimate in recent years, was not surveyed. As well, there were fewer sets in other important strata that may have impacted the biomass estimate in that year. It was decided to remove the 2006 estimate from the Canadian spring series for the ASPIC formulation accepted model in 2008.

For the accepted model in 2008 (see table above), then, correlations among biomass indices varied (see Appendix 1, pg 41). Of the five pair-wise correlations among the five 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 (Tables 13 and 14; Figs. 15-16). The majority of variance in survey indices was explained by the model, but fit varied among indices (r^2 ranged from 0.6 to 0.87). Residuals appeared to be randomly distributed for the most of the survey indices (see Figure 16 and Appendix 1). 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. This indicates that the series increased faster than the model estimates in the latter period. In recent years, residuals have been smaller, and in 2007, the residual 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 are very similar in trend to the 2002, 2004 and 2006 assessments, but estimate slightly higher parameters. The model suggests that a maximum sustainable yield (*MSY*) of 18 820 (80% CL = 17 770, 19 510) tons can be produced when the total stock biomass (B_{msy}) is 73 580 (80% CL=67 770, 85 010) tons and the fishing mortality rate (F_{msy}) is 0.26 (80% CL = 0.22, 0.29) (Table 13; Appendix 1). Estimates of relative biomass and fishing mortality rates are shown in Fig. 16. 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 1973 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 2009, assuming a catch of 15 500 t in 2008, the relative bias corrected biomass B_t /B_{msy} is estimated to be 1.71 (80% CL = 1.57, 1.67).

The relative fishing mortality rate (F_t /F_{msy}) was high during most of the historical fishery (Fig 17), 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 in 2006 and 2007 the bias corrected *F*-ratios were considerably lower than 2/3F_{msy} at 0.32 and 0.15 respectively, and the estimated F-ratio in 2008, if the TAC was taken, was 0.49 (80% CL =0.46. 0.55) (Appendix 1). Since the moratorium in 1994, the estimated yield from the stock has been below surplus production levels, allowing the stock to grow. The stock is considered to be within the safe zone as defined in the Scientific Council Precautionary Approach Framework (NAFO, 2004).

To further explore the effect of the low catch in the last two years, due to lower catch by the Canadian fleet, to the model output, a run with the accepted formulation was done with the catch in 2006 and 2007 adjusted to the mean catch in the previous 3 years (2003-2005). The results of that run are included in Table 13.

Retrospective analysis

The surplus production model (Update of the 2006 assessment with 2006 and 2007 data updated), was run with the same formulation, dropping out 5 years of data, one year at a time (2007-2003). The model parameter estimates and goodness of fit results are given in Table 15 and the relative biomass and fishing mortality estimates are plotted in Figure 18. Only one formulation affected the estimate of relative biomass (data from 1965-2005), and that difference is in the first part of the time series.

Projections

The accepted formulation for the 2008 assessment was used as the basis for projections in the short and medium term. Medium-term projections were carried out by extending the ASPIC bootstrap projections forward to the year 2018 under an assumption of constant fishing mortality at 2/3 F_{msy}, 0.75 F_{msy} and 0.85 F_{msy}. The projections are conditional on the estimated values of r, the intrinsic rate of population growth and K, the carrying capacity. All analyses assumed that the catch in 2008 would equal the TAC of 15 500 tons. However, the TACs have not been taken in recent years, and in particular, catches in the last two years were much lower than the TAC at 6% and 30%, respectively. At 2/3 F_{msy}, catch and stock size decrease slightly (Table 16). Catch and biomass decrease slightly in the projections at 2/3 F_{msy}, 0.75 and 0.85 F_{msy} (Tables 17 and 18). At all levels of F_{msy} considered for medium term projections (2/3 F_{msy}, 75% F_{msy} and 85%F_{msy}), the probability that the biomass in 2009 is below B_{msy} is negligible. Plots of projection results for 2.3 F_{msy} are shown in Figure 21.

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 2007. Stock size estimates remain high, above Bmsy, with a very low probability of being below B_{LIM} (=30% B_{msy}). Fishing mortality is estimated to be below $2/3F_{msy}$, 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).

References

BRODIE, W. B., S. J. WALSH, D. POWER, and M. J. MORGAN. 1994. An assessment of the yellowtail flounder stock in Divisions 3LNO. *NAFO SCR Doc*., No. 44, Ser. No. N2414, 40 p.

BRODIE, W. B., S. J. WALSH, and D. POWER. 2006. The Canadian fishery for yellowtail flounder in NAFO Divisions 3LNO in 2004 and 2005. *NAFO SCR Doc*., No. 40, Serial No. N5263, 12 p.

BRODIE, W. B., S. J. WALSH, M. J. MORGAN, and K. S. DWYER. 2004. An assessment of the Grand Bank yellowtail flounder stock, NAFO Divisions 3LNO in 2004. *NAFO SCR Doc*., No. 51, Serial No. N5004, 22 p.

BULATOVA, A.Y., A.A. VASKOV, V.M.KISELEVA and P.I. SAVVATIMSKY. 1997. Review of Russian bottom trawl surveys in the NAFO subareas 0,2,and 3 for 1954-95. *NAFO Sci. Coun. Studies*, **30**: 51-55.

CADRIN, S. X., and A. WESTWOOD. 2004. The use of electronic tags to stud fish movement: a case study with yellowtail flounder off New England. *ICES C.M. Doc*., No. 2004/K:813, 4 p.

COLBOURNE, E. B., and S. J. WALSH. 2006. The distribution and abundance of yellowtail flounder (*Limanda ferruginea*) in relation to bottom temperatures in NAFGO Divisions 3LNO based on multi-species surveys from 1990-2005. *NAFO SCR Doc*., No. **23**, Serial No. N5241, 16 p.

COLBOURNE, E. B., C. FITZPATRICK, D. SENCIAL, P. STEAD, W. BAILEY, J. CRAIG, and C. BROMLEY. 2004. An assessment of physical oceanographic conditions in NAFO Sub-areas 2 and 3 for 2003. *NAFO SCR Doc*., No. 15. Serial No. 4962, 26 p.

DWYER, K. S., S. J. WALSH, and S. E. CAMPANA. 2003. Age determination and validation of Grand Bank yellowtail flounder (*Limanda ferruginea*). *ICES J. Mar. Sci*., **60**: 1123-1138.

DWYER, K. S., M. KOEN-ALONSO, and S. J. WALSH. 2004. Finding the magical minimum sample size: a computer-intensive approach to minimize re-ageing effort to construct age-length keys for yellowtail flounder. *NAFO SCR Doc*., No. 49, Serial No. N5002, 11 p.

GONZÁLEZ-TRONCOSO, D., C. GONZÁLEZ, and X. PAZ. 2006. Atlantic cod and yellowtail flounder Indices from the Spanish survey conducted in Divisions 3NO of the NAFO Regulatory Area. *NAFO SCR Doc*., No. 13, Serial No. N5228, 26 p.

GONZÁLEZ-TRONCOSO, D., and X. PAZ. 2008. Atlantic cod and Yellowtail flounder indices from the Spanish Survey conducted in Divisions 3NO of the NAFO Regulatory Area. *NAFO SCR Doc*., No. 8, Serial No. N5499, 29 p.

KOEN-ALONSO, M, K. S. DWYER, and S. J. WALSH. 2006. An update on the Canadian re-aging effort for building age-length keys for yellowtail flounder on the Grand Bank. *NAFO SCR Doc*., No. 21, Serial No. N5238, 5 p.

MADDOCK PARSONS, D., and W. B. BRODIE. 2005. Cooperative surveys of yellowtail flounder in NAFO Divisions 3LNO, 1996-2004. . *NAFO SCR Doc*., No. 91, Serial No. N5087, 23 p.

MADDOCK PARSONS, D. and B. BRODIE. 2008. Distribution and Abundance of Yellowtail Flounder (*Limanda ferruginea*) on the Grand Bank, NAFO Divisions 3LNO, from Canadian Bottom Trawl Survey Estimates from 1984-2007. *NAFO SCR Doc*., No. XX, Serial No. NXXXX, XX p.

MCCALLUM, B. R., and S. J. WALSH. 1997. Groundfish survey trawls used at the Northwest Atlantic Fisheries Centre, 1971-present. *NAFO Sci. Coun. Studies*, **29**: 93-104.

NAFO. 2004. Report of the NAFO Study Group on Limit Reference Points. Lorient, France, 15-20 April, 2004. *NAFO SCS Doc*., No. 12, Serial No. N4980, 72 p.

PRAGER, M. H. 1994. A suite of extensions to a nonequilibrium surplus-production model. *Fish. Bull*., **92**: 374-389.

PRAGER, M. H. 1995. Users manual for ASPIC: a stock-production model incorporating covariates. *SEFSC Miami Lab Doc*., No. MIA-92/93-55

PRAGER, M. H. 2005. Users manual for ASPIC: a stock-production model incorporating covariates (ver. 5) and auxillary programs. *Beaufort Lab. Doc*., No. BL-2004-01.

PAZ X., D. GONZÁLEZ TRONCOSO, and E. ROMÁN. 2003. New time Series for yellowtail flounder from the Comparative experience between the C/V *Playa de Menduíña* and the R/V *Vizconde de Eza* in the NAFO Regulatory Area of Divisions 3NO, 1995-2002. *NAFO SCR Doc*., No. 6, Serial No. N4812, 15 p.

PAZ, X., D. GONZÁLEZ TRONCOSO, and E. ROMÁN. 2004. New time Series for yellowtail flounder from the comparative experiencebetween the C/V *Playa de Menduíña* and the R/V *Vizconde de Eza* in the NAFO Regulatory Area of Divisions 3NO, 1995-2003. *NAFO SCR Doc*., No. 10, Serial No. N4955.

SIMPSON, M. R., and S. J. WALSH. 2003. Changes in the spatial structure of Grand Banks yellowtail flounder: testing MacCall's basin hypothesis. *J. Sea Res*., **51**: 199-210.

VARGAS, J., R. ALPOIM, E. SANTOS, and A. M. AVILA DE MELO. 2004. Portuguese Research Report for 2003. *NAFO SCS Doc*., No. 5, Serial No. N4949, 50 p.

WALSH, S. J., W. B. BRODIE, D. B. ATKINSON, and D. POWER. 1995. An assessment of the yellowtail flounder stock in Divisions 3LNO. *NAFO SCR Doc*., No. 74, Serial No. N2591, 44 p.

WALSH, S. J., and S. X. CADRIN. 2000. Evaluating total allowable catch projections for yellowtail flounder (*Limanda ferruginea*) on the Grand Bank using multiple indices and surplus production analysis. *NAFO SCR Doc*., No. 44, Serial No. N4275, 40 p.

WALSH, S. J, M. J. MORGAN, W. B. BRODIE, K. S. DWYER, and L. MANSFIELD. 2001. A new tagging program for yellowtail flounder on the Grand Bank, NAFO Divisions. 3LNO. *NAFO SCR Doc*., No. 53, Serial No. N4431, 14 p.

WALSH, S. J., W. B. BRODIE, M. J. MORGAN, D. POWER, K. S. DWYER, and C. DARBY. 2002. Stock assessment and management of the Grand Bank yellowtail flounder stock. *NAFO SCR Doc*., No. 71, Serial No. N4684, 54 p.

WALSH, S. J, and W. B. BRODIE. 2003. Sensitivity analysis of survey biomass indices used to tuned ASPIC production model for Grand Bank yellowtail flounder. *NAFO SCR Doc*., No. 61, Serial No. N4880, 23 p.

WALSH, S. J., and M. J. MORGAN. 2004. Observations of natural behaviour of yellowtail flounder derived from data storage tags. *ICES J. Mar. Sci.*, **61**: 1151.

WALSH, S. J., M. F. VEITCH, W. B. BRODIE, and K. S. DWYER. 2004. Canadian bottom trawl survey estimates of the distribution and abundance of yellowtail flounder (*Limanda ferruginea*) on the Grand Bank, in NAFO Divisions 3LNO, from 1984-2003. *NAFO SCR Doc*., No. 36, Serial No. N4986, 50 p.

WALSH, S. J., M. F. VEITCH, K. S. DWYER, and W. B. BRODIE. 2005. Interim monitoring of yellowtail flounder stock status on the Grand Bank, NAFO Divisions 3LNO. *NAFO SCR Doc*., No. 55, Serial No. N5141, 16 p.

WALSH, S. J., and W. B. BRODIE. 2006. Exploring relationships between bottom temperatures and spatial and temporal patterns in the Canadian fishery for yellowtail flounder on the Grand Bank . *NAFO SCR Doc*., No. 26, Serial No. N5245, 15 p.

WALSH, S. J., M. F. Veitch, W. B. Brodie, AND E. COLBOURNE. 2006. DISTRIBUTION AND ABUNDANCE OF YELLOWTAIL flounder (*Limanda ferruginea*) on the Grand Bank, NAFO Divisions 3LNO, from Canadian bottom trawl survey estimates from 1984-2006. *NAFO SCR Doc*., No. 41, Serial No. N5264, 50 p.

WALSH, S. J., M. J. MORGAN, G. HAN, and J. CRAIG. 2006. Progress toward modeling tagging data to investigate spatial and temporal changes in habitat utilization of yellowtail flounder on the Grand Bank. *NAFO SCR Doc*., No. 29, Serial No. N5248, 30 p.

WALSH, S. J. 2007. Sensitivity Analysis and Alternate Model Formulation of Survey Biomass Indices used to Tuned ASPIC Surplus Production Model for Grand Bank Yellowtail Flounder. *NAFO SCR Doc*., No. 57, Serial No. N5409, 47 p.

WARREN, W., W. BRODIE, D. STANSBURY, S. WALSH, J. MORGAN, and D. ORR. 1997. Analysis of the 1996 comparative fishing trials between the *Alfred Needler* with the Engel 145 trawl and the *Wilfred Templeman* with the Campelen 1800 trawl. *NAFO SCR Doc.*, No. 68, Serial No. N2902, 12 p.

.

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							15500

[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 of yellowtail flounder by division, from 1973 to 2007. Data from 2003-07 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

Table 3. Estimates of abundance (millions), biomass ('000 tons), mean number and weight (kg) per tow for Spring surveys in NAFO Divisions 3LNO from 1984-2007.

	Spring Abundance (millions)				Spring Biomass ('000 tons)				Spring mean # per tow				Spring mean wt (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	62.1	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	34.3	280.2	72.0	386.5	16.9	381.0	95.3	120.2	6.3	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

Table 4. Estimates of abundance (millions), biomass ('000 tons), mean number and weight (kg) per tow for Fall surveys in NAFO Divisions 3LNO from 1990-2007.

	Fall Abundance (millions)				Fall Biomass ('000 tons)				Fall mean # per tow				Fall mean wt (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	10.3
1995	3.6	509.0	79.6	592.2	1.2	102.8	25.7	129.8	0.7	212.0	31.2	57.2	0.2	42.8	10.1	12.5
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

Table 5. Length weight relationships used to produce an index of female SSB from the spring survey. The relationships are of the form log(weight)=(a*log(length))+b)

Year	*a*	*b*
prior to 1990	3.10	-5.19
1990	3.19	-5.33
1991	3.05	-5.12
1992	3.02	-5.06
1993	3.11	-5.20
1994	3.09	-5.19
1995	3.10	-5.20
1996	3.09	-5.15
1997	3.09	-5.17
1998	3.05	-5.11
1999	3.15	-5.27
2000	3.17	-5.32
2001	3.09	-5.20
2002	3.08	-5.20
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

Table 6. Input files for model comparison runs and for the 2008 assessment of yellowtail flounder in NAFO Divs. 3LNO. Results for the current assessment are given in Appendix 1.

ASPIC version 3.81 with 1965-2005 data		ASPIC version 5.24		
		1965-2005 data	**1965-2007 data**	
'FIT'	## Mode (FIT, IRF, BOT) FALL ESTIMATES FOR 90-97 CORRECTED	FIT'	FIT	## Run type (FIT, BOT, or IRF)
'3LNO ytail (v3.81, 2002 formulation with 2005 data) 2006=TAC' FIT MODE		**'3LNO Yellowtail Corr**	**'3LNO Yellowtail Corr SM version 5.24 (2007)'**	
'EFF'	## Error type ('EFF' = condition on yield)	LOGISTIC YLD SSE	LOGISTIC YLD SSE	## See notes at end of this file
1	## Verbosity (0 to 4)	12	12	## Verbosity on screen (0-3); add 10 for SUM & PRN files
0	## Number of bootstrap trials, <= 1000	0	0	## Number of bootstrap trials, <= 1000
2 50000	## Monte Carlo search enable (0,1,2), N trials	2 50000	2 50000	## 0=no MC search, 1=search, 2=repeated srch; N trials
1d-6	## Convergence crit. for simplex set to same as 2001 and 2002	1d-8	1d-8	## Convergence crit. for simplex
3d-6	## Convergence crit. for restarts	3d-6 5	3d-6 5	## Convergence crit. for restarts, N restarts
1d-2	## Convergence crit. for estimating effort	1d-2 24	1d-2 24	## Conv. crit. for F; N steps/yr for gen. model
5	## Maximum F when estimating effort	5d0	5d0	## Maximum F when cond. on yield
1	## Statistical weight for B1 > K as residual	1	1	## Stat weight for B1>K as residual (usually 0 or 1)
5	## Number of data series (fisheries)	5	5	## Number of fisheries (data series)
1 1 1 1 1	## Statistical weights for fisheries	1 1 1 1 1	1 1 1 1 1	## Statistical weights for data series
2	## B1-ratio (starting guess)	2	2	## B1/K (starting guess, usually 0 to 1)
13	## MSY (starting guess)	13	13	## MSY (starting guess)
0.5	## r (starting guess)	400	400	## K (carrying capacity) (starting guess)
3 1 3 1 3	## q (starting guess)	3 1 3 1 3	3 1 3 1 3	## q (starting guesses -- 1 per data series)
1 1 1 1 1 1 1 1	## Flags to estimate parameters	1 1 1 1 1 1 1 1	1 1 1 1 1 1 1 1	## Estimate flags (0 or 1) (B1/K,MSY,K,q1...qn)
1 50	## Min and max allowable MSY	1 50	1 50	## Min and max constraints -- MSY
0.1 5	## Min and max allowable r	10 1000	10 1000	## Min and max constraints -- K
9114895	## Random number seed change by plus 1	9114895	9114895	## Random number seed (large integer)
42	## Number of years of data.	42	44	## Number of years of data in each series

notes: The model input file differs slightly in version 5.24 of ASPIC. The input files all contain the appropriate years of index data shown in Table 7
The shaded columns were the inputs for the model comparison runs (version 3.81 vs 5.24 with 1965-2005 data)

Table 7. Input indices used in the ASPIC production model. Indices for model comparison runs end in 2006 (2007 TAC only; 15 000 t). 2008 Assessment includes TAC of 15 500 t in 2008.

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	106.0			
1973	32.815	51.7	217.0			
1974	24.313	40.3	129.0			
1975	22.894	37.4	126.0			
1976	8.057	41.7	131.0			
1977	11.638	65.0	188.0			
1978	15.466	44.3	110.0			
1979	18.351	38.5	98.0			
1980	12.377	51.4	164.0			
1981	14.68	45.0	158.0			
1982	13.319	43.1	125.0			
1983	10.473					
1984	16.735		132.0	217.7		
1985	28.963		85.0	146.8		
1986	30.176		42.0	138.2		
1987	16.314		30.0	124.6		
1988	16.158		23.0	81		
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
2000	11.161			287.5	335	144.7
2001	14.145			366	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
2005	13.933			388.8	342.7	156.48
2006	0.930			503.8	305.5	160.1
2007	4.617			443	482.4	160.7
2008	15.500					

notes: The Campelen fall survey values are corrected from the 2006 assessment (see SCR 07/57). The catch series used in this assessment, which matches the nominal catch table, is slightly different from the previous assessment and does not affect the model results. The TAC in 2008 (15 500 t) is included in the catch series.

Table 8. Output of comparison runs of 2 versions of ASPIC using corrected data from the 2006 assessment (convergence criterion was set to 1d-6 and 1d-8 in version 5.24).

Model	Corr SM version 3.81 (2005)	Corr SM version 5.24 (2005) cc1d-8
B1/K		1.067
B1R	2.15	
MSY	17.69	17.70
r^2 (Catch/Canadian Spring)	0.827	0.828
r^2 (Yankee survey)	0.804	0.804
r^2 (Canadian fall)	0.875	0.875
r^2 (Russian)	0.294	0.293
r^2 (Spanish)	0.559	0.559
r	0.45	
K	158.90	158.80
Bmsy	79.43	79.42
Fmsy	0.22	0.22
Bratio	1.33	1.34
Fratio	0.64	0.64
Total Objective function	10.32	10.32
sum of N (GOF)	81	81
p (number of parameters B1R, MSY, r, qs)	8	9
MSE	0.14	0.14
restarts	33	100

Table 9. Comaprison of bootstrap results from 2 versions of ASPIC (3.81 and 5.24) using the 2006 assessment data.

	Point Estimate		Bias-corrected approximate confidence limits: 80% Lower		80% Upper		50% Lower		50% Upper		IQ range		Rel IQ range	
	v3.81	v5.24	v3.81	v5.24	v3.81	v5.24	v3.81	v5.24	v3.81	v5.24	v3.81	v5.24	v3.81	v5.24
B1ratio	2.29		2.15		2.63		2.22		2.63		0.41		0.18	
B1/K		1.07		1.06		1.22		1.10		1.19		0.09		0.08
K	158.20	158.80	146.60	144.80	177.30	189.80	151.40	149.00	166.60	167.30	15.21	18.29	0.10	0.12
r	0.44		0.38		0.50		0.41		0.47		0.06		0.14	
q(1)	3.25	3.28	2.76	2.79	3.81	3.95	2.97	3.03	3.54	3.62	0.57	0.58	0.18	0.18
q(2)	0.84	0.85	0.68	0.69	1.02	1.01	0.76	0.75	0.93	0.94	0.17	0.18	0.20	0.22
q(3)	3.65	3.68	2.94	3.03	4.42	4.55	3.28	3.34	4.04	4.14	0.75	0.80	0.21	0.22
q(4)	1.69	1.71	1.42	1.41	1.98	2.03	1.53	1.53	1.84	1.87	0.31	0.34	0.18	0.20
q(5)	1.37	1.36	1.13	1.09	1.67	1.69	1.24	1.23	1.51	1.51	0.27	0.29	0.20	0.21
MSY	17.43	17.70	16.52	16.32	18.30	18.38	17.00	17.00	17.89	17.92	0.89	0.92	0.05	0.05
Ye(2007)	15.62	15.72	14.58	14.50	16.85	17.06	15.03	14.96	16.35	16.26	1.31	1.30	0.08	0.08
Y.@Fmsy		23.63		18.41		26.52		20.72		25.04		4.32		0.18
Bmsy	79.11	79.42	73.32	72.42	88.63	94.90	75.70	74.50	83.31	83.64	7.61	9.14	0.10	0.12
Fmsy	0.22	0.22	0.19	0.18	0.25	0.26	0.21	0.20	0.24	0.24	0.03	0.04	0.14	0.17
fmsy(1)	0.07	0.07	0.06	0.06	0.08	0.08	0.06	0.06	0.07	0.07	0.01	0.01	0.18	0.17
fmsy(2)	0.27	0.26	0.23	0.24	0.31	0.33	0.25	0.25	0.29	0.30	0.04	0.04	0.15	0.16
fmsy(3)	0.06	0.06	0.05	0.05	0.07	0.07	0.05	0.05	0.07	0.07	0.01	0.01	0.23	0.23
fmsy(4)	0.13	0.13	0.12	0.12	0.15	0.16	0.12	0.13	0.14	0.15	0.02	0.02	0.13	0.14
fmsy(5)	0.16	0.16	0.13	0.13	0.20	0.22	0.14	0.15	0.18	0.19	0.04	0.04	0.24	0.25
F(0.1)	0.20		0.17		0.22		0.18		0.21		0.03		0.14	
Y(0.1)	17.26		16.36		18.12		16.83		17.71		0.88		0.05	
B-ratio	1.33	1.34	1.14	1.12	1.45	1.46	1.25	1.24	1.41	1.41	0.15	0.17	0.12	0.13
F-ratio	0.64	0.64	0.57	0.56	0.79	0.80	0.60	0.60	0.71	0.72	0.11	0.13	0.18	0.20
Y-ratio	0.89		0.80		0.98		0.84		0.94		0.10		0.11	
Ye./MSY		0.89		0.79		0.98		0.84		0.94		0.11		0.12
f0.1(1)	0.06		0.05		0.07		0.06		0.07		0.01		0.18	
f0.1(2)	0.24		0.21		0.28		0.22		0.26		0.03		0.15	
f0.1(3)	0.05		0.04		0.07		0.05		0.06		0.01		0.23	
f0.1(4)	0.12		0.10		0.13		0.11		0.13		0.01		0.13	
f0.1(5)	0.15		0.11		0.18		0.13		0.16		0.03		0.24	
q2/q1	0.25	0.26	0.20	0.20	0.31	0.31	0.22	0.23	0.28	0.28	0.06	0.06	0.25	0.22
q3/q1	1.12	1.12	0.94	0.96	1.31	1.31	1.02	1.03	1.21	1.22	0.20	0.19	0.18	0.17
q4/q1	0.52	0.52	0.42	0.43	0.63	0.63	0.47	0.47	0.58	0.57	0.10	0.10	0.20	0.19
q5/q1	0.42	0.42	0.34	0.33	0.50	0.49	0.37	0.37	0.46	0.45	0.08	0.08	0.20	0.19

Table 10. Comparison of the current version of ASPIC (version 5.24) with the older version (version 3.81) using the 2006 assessment data.

	F/Fmsy		B/Bmsy	
	v3.81	v5.24	v3.81	v5.24
1965	0.0841	0.08461	2.152	2.134
1966	0.1973	0.1981	2.064	2.052
1967	0.2606	0.2612	1.969	1.962
1968	0.411	0.4115	1.889	1.884
1969	0.5112	0.5117	1.789	1.785
1970	0.939	0.9394	1.692	1.69
1971	1.561	1.562	1.504	1.502
1972	2.059	2.06	1.227	1.225
1973	2.192	2.193	0.9523	0.9511
1974	1.961	1.963	0.7556	0.7545
1975	2.165	2.167	0.6519	0.6509
1976	0.7695	0.7703	0.55	0.549
1977	0.9979	0.9987	0.634	0.633
1978	1.273	1.274	0.6843	0.6832
1979	1.542	1.543	0.6904	0.6894
1980	1.029	1.029	0.6581	0.657
1981	1.166	1.167	0.7021	0.7011
1982	1.015	1.016	0.7214	0.7205
1983	0.7372	0.7373	0.7615	0.7606
1984	1.117	1.117	0.8436	0.8428
1985	2.137	2.136	0.8504	0.8497
1986	2.898	2.898	0.6952	0.6947
1987	1.939	1.939	0.4991	0.4987
1988	2.141	2.141	0.455	0.4546
1989	1.411	1.411	0.401	0.4006
1990	1.98	1.98	0.4173	0.417
1991	2.678	2.678	0.3835	0.3832
1992	2.08	2.079	0.3055	0.3053
1993	3.221	3.22	0.2811	0.281
1994	0.4982	0.498	0.2031	0.203
1995	0.0116	0.01159	0.2693	0.2692
1996	0.02823	0.0282	0.3899	0.3899
1997	0.05857	0.05849	0.5453	0.5456
1998	0.3067	0.3062	0.7294	0.7299
1999	0.4075	0.4069	0.8883	0.889
2000	0.5925	0.5914	1.023	1.024
2001	0.7104	0.7091	1.105	1.106
2002	0.5096	0.5086	1.146	1.147
2003	0.6274	0.6262	1.226	1.227
2004	0.5896	0.5885	1.261	1.263
2005	0.6006	0.5995	1.298	1.3
2006	0.638	0.6369	1.324	1.325
2007			1.334	1.335

Table 11 . ANOVA results and regression coefficients from a multiplicative model utilized to derive a standardized catch rate series for Yellowtail flounder in NAFO Div. 3LNO (2007 based on preliminary data).

REGRESSION OF MULTIPLICATIVE MODEL
MULTIPLE R............ 0.794
MULTIPLE R SQUARED..... 0.630

ANALYSIS OF VARIANCE

SOURCE OF VARIATION	DF	SUMS OF SQUARES	MEAN SQUARE	F-VALUE
INTERCEPT	1	3.96E1	3.96E1	
REGRESSION	53	1.06E1	2.01E-1	31.410
Cntry|Gear|TC(1)	3	7.09E-1	2.36E-1	37.011
Division(2)	2	8.30E-1	4.15E-1	64.955
Month(3)	11	4.16E-1	3.78E-2	5.915
Year(4)	37	6.53E0	1.76E-1	27.616
RESIDUALS	978	6.25E0	6.39E-3	
TOTAL	1032	5.65E1		

REGRESSION COEFFICIENTS

CATEGORY	CODE	VAR #	REG. COEF	STD. ERR	NO. OBS
Cntry|Gear|TC(1)	3125	INT	0.063	0.106	1032
Division(2)	34				
Month(3)	10				
Year(4)	65				
(1)	3114	1	-0.291	0.032	162
	3124	2	-0.221	0.033	153
	3126	3	-0.039	0.047	60
(2)	32	4	-0.213	0.027	211
	35	5	-0.251	0.025	247
(3)	1	6	-0.115	0.073	24
	2	7	-0.231	0.067	28
	3	8	-0.150	0.056	41
	4	9	-0.149	0.047	71
	5	10	-0.128	0.041	135
	6	11	-0.204	0.041	133
	7	12	-0.217	0.042	130
	8	13	-0.114	0.043	124
	9	14	0.007	0.043	110
	11	15	-0.085	0.046	76
	12	16	-0.025	0.051	59
(4)	66	17	-0.022	0.137	11
	67	18	-0.065	0.143	12
	68	19	-0.218	0.136	14
	69	20	-0.399	0.125	20
	70	21	-0.402	0.112	42
	71	22	-0.419	0.110	41
	72	23	-0.513	0.109	45
	73	24	-0.380	0.110	50
	74	25	-0.848	0.112	37
	75	26	-0.824	0.111	38
	76	27	-0.867	0.121	26
	77	28	-0.747	0.113	38
	78	29	-0.709	0.111	51
	79	30	-0.671	0.110	47

REGRESSION COEFFICIENTS

CATEGORY	CODE	VAR #	REG. COEF	STD. ERR	NO. OBS
(4)	80	31	-0.577	0.115	30
	81	32	-0.585	0.117	30
	82	33	-0.663	0.121	24
	83	34	-0.518	0.119	24
	84	35	-0.558	0.120	28
	85	36	-0.500	0.116	30
	86	37	-0.849	0.118	30
	87	38	-0.776	0.117	30
	88	39	-0.866	0.121	26
	89	40	-0.880	0.130	17
	90	41	-0.724	0.131	16
	91	42	-1.346	0.123	24
	92	43	-1.191	0.127	21
	93	44	-0.831	0.123	23
	98	45	-0.214	0.140	11
	99	46	-0.119	0.134	12
	100	47	-0.077	0.122	24
	101	48	-0.274	0.121	20
	102	49	-0.323	0.122	19
	103	50	-0.140	0.115	34
	104	51	0.027	0.116	30
	105	52	0.125	0.116	32
	107	53	0.031	0.125	17

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 12 . Standardized catch rate index for Yellowtail flounder in NAFO Div. 3LNO from a multiplicative model utilizing HOURS FISHED as a measure of effort. (2007 based on preliminary data).

PREDICTED CATCH RATE

Year	LN Transformed	S.E	Retransformed mean	S.E.	Catch	Effort	% of catch in analysis
1965	0.0633	0.0113	1.063	0.113	3075	2894	39.5
1966	0.0412	0.0105	1.040	0.107	4185	4024	32.7
1967	-0.0020	0.0128	0.995	0.112	2122	2133	44.0
1968	-0.1549	0.0094	0.855	0.083	4180	4888	52.6
1969	-0.3360	0.0068	0.714	0.059	10494	14688	30.8
1970	-0.3383	0.0035	0.714	0.042	22814	31950	54.4
1971	-0.3557	0.003	0.702	0.039	24206	34489	58.4
1972	-0.4502	0.0029	0.639	0.035	26939	42184	53.9
1973	-0.3167	0.0029	0.730	0.039	28492	39037	74.4
1974	-0.7850	0.0033	0.457	0.026	17053	37330	82.0
1975	-0.7608	0.0031	0.468	0.026	18458	39435	72.1
1976	-0.8035	0.0052	0.448	0.032	7910	17656	60.5
1977	-0.6832	0.0038	0.506	0.031	11295	22338	44.4
1978	-0.6461	0.0031	0.525	0.029	15091	28749	61.5
1979	-0.6075	0.003	0.546	0.03	18116	33202	73.0
1980	-0.5142	0.0043	0.599	0.039	12011	20064	65.1
1981	-0.5220	0.0045	0.594	0.04	14122	23778	73.6
1982	-0.6000	0.0053	0.549	0.04	11479	20904	48.2
1983	-0.4544	0.0045	0.635	0.042	9085	14298	50.3
1984	-0.4948	0.0049	0.610	0.043	12437	20384	54.7
1985	-0.4370	0.004	0.647	0.041	13440	20781	50.6
1986	-0.7857	0.0043	0.456	0.03	14168	31052	62.5
1987	-0.7130	0.0041	0.491	0.032	13420	27349	66.4
1988	-0.8024	0.0049	0.449	0.031	10607	23646	57.1
1989	-0.8171	0.0073	0.442	0.038	5009	11345	40.0
1990	-0.6609	0.0074	0.516	0.044	4969	9627	45.8
1991	-1.2827	0.0055	0.277	0.021	6589	23751	48.3
1992	-1.1276	0.0064	0.324	0.026	6814	21043	59.3
1993	-0.7673	0.0055	0.464	0.034	6747	14527	68.4
1998	-0.1510	0.0097	0.858	0.084	3739	4355	91.3
1999	-0.0556	0.008	0.945	0.085	5746	6079	94.2
2000	-0.0141	0.0053	0.987	0.071	9563	9693	97.7
2001	-0.2108	0.0049	0.810	0.057	12238	15099	96.5
2002	-0.2598	0.0054	0.772	0.056	9959	12907	98.0
2003	-0.0769	0.0035	0.927	0.055	12708	13705	99.4
2004	0.0901	0.0039	1.096	0.068	12756	11642	98.0
2005	0.1888	0.0037	1.209	0.074	13264	10968	100.0
2007	0.0945	0.0059	1.099	0.084	3673	3341	99.9

AVERAGE C.V. FOR THE RETRANSFORMED MEAN: 0.072

Table 13. Comparative outputs of ASPIC runs version 5.24 to run 2007 data (2008 TAC) with four model formulations.

Model	Update of 2006 formulation	Russia Out	Russia (1984-1991)	Russia Split-2 Series	2008 Accepted Formulation	2008 Assessment Accepted Formulation- catch in 2006 & 2007 avg 2003-2005
B1/K	1.051	0.335	0.419	0.636	0.868	0.490
B1R						
MSY	17.76	20.53	19.88	18.82	18.82	19.54
r^2 (Catch/Canadian Spring)	0.851	0.873	0.872	0.869	0.873	0.859
r^2 (Yankee survey)	0.804	0.799	0.801	0.798	0.804	0.802
r^2 (Canadian fall)	0.850	0.841	0.844	0.852	0.852	0.849
r^2 (Russian)	0.291					
r^2 (Russian 1972-1982)				-0.614		
r^2 (Russian 1984-1991)			0.537	0.546	0.558	0.546
r^2 (Spanish)	0.583	0.598	0.611	0.601	0.616	0.629
K	158.30	176.70	162.60	158.00	147.20	157.70
Bmsy	79.15	88.35	81.30	78.98	73.58	78.83
Fmsy	0.22	0.23	0.24	0.24	0.26	0.25
B (2009)/Bmsy	1.56	1.65	1.65	1.62	1.64	1.49
F (2008)/Fmsy	0.53	0.45	0.47	0.50	0.49	0.53
Total Objective function	10.55	5.22	6.13	7.15	6.10	6.08
sum of N (GOF)	87	68	76	87	75	75
p (number of parameters B1R, MSY, r, qs)	9	8	9	10	9	9
MSE	0.14	0.09	0.09	0.09	0.09	0.09
restarts	62	103	35	30	42	150

Note: The model formulations above include the catch and series as outlined in Table 7 for the appropriate years, with changes to the surveys as outlined in the model name

Table 14. Bootstrap results from the 2008 assessment of yellowtail flounder using ASPIC version 5.24.

				Bias-corrected approximate confidence limits					
	Point Estimate	Est. bias in pt est.	Est. rel. bias	80% Lower	80% Upper	50% Lower	50% Upper	IQ range	Rel IQ range
B1/K	1.06	-0.195	-18.44%	1.04	1.39	1.07	1.18	0.11	0.11
K	158.30	13.010	8.22%	140.80	178.00	145.80	163.80	18.03	0.11
q(1)	3.34	-0.031	-0.94%	2.87	3.99	3.12	3.74	0.62	0.19
q(2)	0.85	0.015	1.77%	0.69	1.02	0.76	0.92	0.16	0.19
q(3)	3.61	-0.037	-1.02%	2.90	4.37	3.25	4.00	0.74	0.21
q(4)	1.72	0.007	0.43%	1.47	2.10	1.59	1.92	0.33	0.19
q(5)	1.36	-0.005	-0.37%	1.09	1.65	1.22	1.51	0.29	0.21
MSY	17.75	0.695	3.91%	16.64	18.57	17.07	17.94	0.87	0.05
Ye(2007)	12.28	0.845	6.88%	10.92	14.09	11.25	12.88	1.63	0.13
Y.@Fmsy	27.61	0.542	1.96%	23.36	30.37	25.24	28.72	3.49	0.13
Bmsy	79.16	6.504	8.22%	70.40	88.98	72.90	81.92	9.02	0.11
Fmsy	0.22	-0.004	-1.97%	0.19	0.27	0.21	0.25	0.04	0.18
fmsy(1)	0.07	0.000	-0.12%	0.06	0.08	0.06	0.07	0.01	0.18
fmsy(2)	0.26	-0.007	-2.60%	0.24	0.33	0.25	0.30	0.04	0.17
fmsy(3)	0.06	0.000	0.77%	0.05	0.08	0.05	0.07	0.01	0.23
fmsy(4)	0.13	-0.002	-1.89%	0.12	0.15	0.13	0.14	0.02	0.13
fmsy(5)	0.16	0.001	0.70%	0.13	0.21	0.14	0.19	0.04	0.27
B-ratio	1.56	-0.028	-1.82%	1.41	1.64	1.50	1.61	0.11	0.07
F-ratio	0.55	-0.003	-0.59%	0.50	0.66	0.53	0.61	0.08	0.14
Ye./MSY	0.69	0.020	2.84%	0.59	0.83	0.63	0.75	0.13	0.18
q2/q1	0.26	0.010	3.91%	0.20	0.31	0.22	0.28	0.06	0.23
q3/q1	1.08	0.003	0.29%	0.92	1.25	0.99	1.16	0.16	0.15
q4/q1	0.52	0.013	2.44%	0.42	0.61	0.46	0.56	0.11	0.21
q5/q1	0.41	0.004	1.06%	0.34	0.47	0.37	0.44	0.07	0.18

Table 15. Model outputs (ASPIC version 5.24) for retrospective analysis.

Model	2006 Formulation (1965-2007)	2006 Formulation (1965-2006)	2006 Formulation (1965-2005)	2006 Formulation (1965-2004)	2006 Formulation (1965-2003)	2006 Formulation (1965-2002)
B1/K	1.051	1.114	1.057	1.078	0.7678	1.071
B1R						
MSY	17.76	17.54	17.71	17.68	17.96	17.59
r^2 (Catch/Canadian Spring)	0.851	0.822	0.828	0.804	0.790	0.751
r^2 (Yankee survey)	0.804	0.802	0.804	0.804	0.798	0.803
r^2 (Canadian fall)	0.850	0.823	0.875	0.876	0.865	0.841
r^2 (Russian)	0.291	0.292	0.293	0.295	0.289	0.297
r^2 (Spanish)	0.583	0.571	0.559	0.534	0.490	0.470
K	158.30	160.30	159.00	159.00	165.60	160.60
Bmsy	79.15	80.17	79.49	79.51	82.82	80.30
Fmsy	0.22	0.22	0.22	0.22	0.22	0.22
Bratio	1.56	1.48	1.33	1.30	1.25	1.22
Fratio	0.53	0.04	0.60	0.59	0.62	0.51
Total Objective function	10.55	10.55	10.32	10.28	10.28	10.18
sum of N (GOF)	87	84	81	78	75	72
p (number of parameters B1R, MSY	9	9	9	9	9	9
MSE	0.14	0.14	0.14	0.15	0.16	0.16
restarts	62	50	100	107	39	95

Table 16. Medium-term projections for yellowtail flounder. The 5, 50 and 95th percentiles of fishing mortality, biomass, yield and biomass /Bmsy, are shown, for projected F of 2/3 Fmsy. The results are derived from an ASPIC bootstrap run (500 iterations) with a catch constraint of 15 500 tons (TAC) in 2008.

F	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
5	0.135	0.135	0.135	0.135	0.135	0.135	0.135	0.135	0.135	0.135
50	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170
95	0.182	0.182	0.182	0.182	0.182	0.182	0.182	0.182	0.182	0.182
Fmsy	0.256	0.256	0.256	0.256	0.256	0.256	0.256	0.256	0.256	0.256
2/3 Fmsy	0.171	0.171	0.171	0.171	0.171	0.171	0.171	0.171	0.171	0.171

B	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
5	112.53	105.14	100.64	97.85	96.07	94.93	94.20	93.72	93.39	93.18
50	120.46	113.08	108.38	105.33	103.20	101.68	100.65	99.92	99.41	99.02
95	152.86	145.63	140.75	137.38	135.01	133.32	132.10	131.23	130.59	130.13

Y	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
5	19.68	18.63	17.98	17.58	17.32	17.13	17.00	16.89	16.82	16.76
50	19.85	18.84	18.18	17.74	17.44	17.23	17.09	16.99	16.93	16.88
95	20.28	19.54	19.03	18.64	18.37	18.16	18.01	17.92	17.85	17.81

Br	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
5	1.55	1.46	1.41	1.37	1.34	1.32	1.31	1.29	1.29	1.28
50	1.64	1.54	1.48	1.43	1.40	1.39	1.37	1.36	1.36	1.35
95	1.68	1.58	1.51	1.48	1.46	1.44	1.43	1.42	1.41	1.41

Table 17. Medium-term projections for yellowtail flounder. The 5, 50 and 95th percentiles of fishing mortality, biomass, yield and biomass /Bmsy, are shown, for projected F of 75% of Fmsy. The results are derived from an ASPIC bootstrap run (500 iterations) with a catch constraint of 15 500 tons (TAC) in 2008.

F	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
5	0.152	0.152	0.152	0.152	0.152	0.152	0.152	0.152	0.152	0.152
50	0.192	0.192	0.192	0.192	0.192	0.192	0.192	0.192	0.192	0.192
95	0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205
Fmsy	0.256	0.256	0.256	0.256	0.256	0.256	0.256	0.256	0.256	0.256
75% Fmsy	0.192	0.192	0.192	0.192	0.192	0.192	0.192	0.192	0.192	0.192

B	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
5	112.53	103.24	97.65	94.17	91.94	90.48	89.50	88.86	88.42	88.13
50	120.46	111.06	105.15	101.23	98.51	96.61	95.27	94.29	93.60	93.14
95	152.86	143.56	137.33	133.02	129.98	127.80	126.23	125.07	124.23	123.60

Y	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
5	21.95	20.46	19.56	19.00	18.61	18.32	18.10	17.93	17.79	17.69
50	22.14	20.70	19.77	19.15	18.71	18.42	18.21	18.07	17.97	17.90
95	22.66	21.56	20.77	20.23	19.84	19.57	19.34	19.21	19.13	19.07

Br	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
5	1.55	1.44	1.37	1.32	1.28	1.25	1.23	1.22	1.20	1.19
50	1.64	1.51	1.43	1.38	1.34	1.32	1.30	1.29	1.28	1.27
95	1.68	1.55	1.47	1.43	1.40	1.38	1.37	1.35	1.35	1.34

Table 18. Medium-term projections for yellowtail flounder. The 5, 50 and 95th percentiles of fishing mortality, biomass, yield and biomass /Bmsy, are shown, for projected F of 85% of Fmsy. The results are derived from an ASPIC bootstrap run (500 iterations) with a catch constraint of 15 500 tons (TAC) in 2008.

F	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
5	0.172	0.172	0.172	0.172	0.172	0.172	0.172	0.172	0.172	0.172
50	0.217	0.217	0.217	0.217	0.217	0.217	0.217	0.217	0.217	0.217
95	0.232	0.232	0.232	0.232	0.232	0.232	0.232	0.232	0.232	0.232
Fmsy	0.256	0.256	0.256	0.256	0.256	0.256	0.256	0.256	0.256	0.256
85% Fmsy	0.217	0.217	0.217	0.217	0.217	0.217	0.217	0.217	0.217	0.217

B	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
5	112.53	101.03	94.22	89.96	87.17	85.31	84.10	83.28	82.70	82.29
50	120.46	108.76	101.43	96.57	93.21	90.85	89.15	87.86	86.93	86.29
95	152.86	141.16	133.39	128.02	124.22	121.48	119.47	117.98	116.88	116.05

Y	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
5	24.56	22.49	21.25	20.46	19.89	19.45	19.09	18.81	18.61	18.44
50	24.78	22.77	21.47	20.59	19.98	19.57	19.28	19.06	18.90	18.79
95	25.41	23.79	22.70	21.93	21.37	21.02	20.74	20.50	20.32	20.18

Br	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
5	1.55	1.41	1.32	1.25	1.21	1.17	1.15	1.13	1.11	1.10
50	1.64	1.48	1.38	1.32	1.27	1.24	1.22	1.20	1.19	1.18
95	1.68	1.52	1.43	1.37	1.33	1.31	1.29	1.28	1.27	1.26

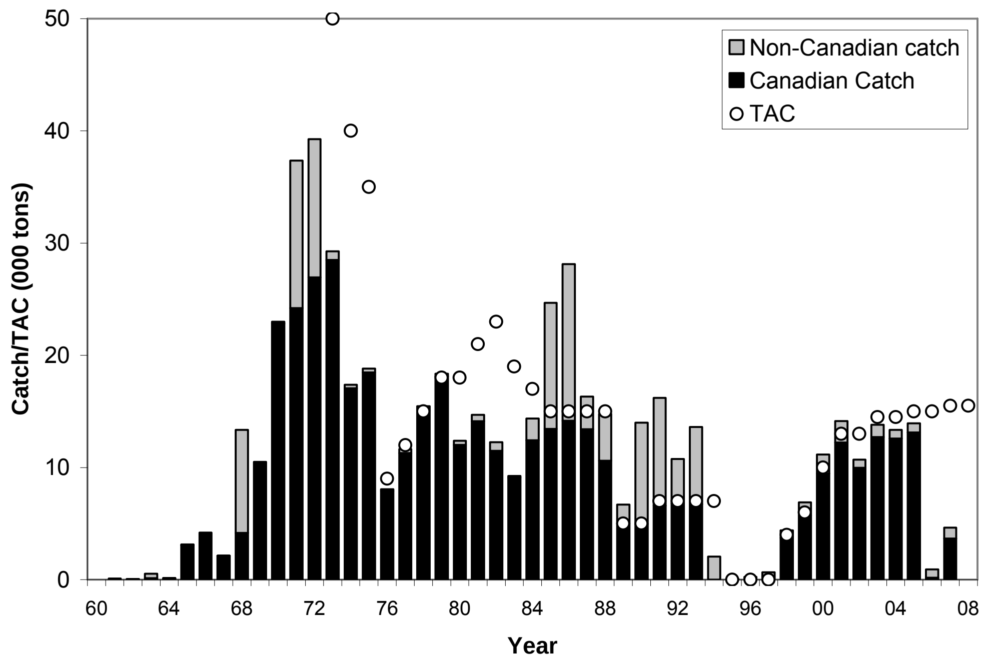


Figure 1. Catch (000 tons) and TAC of Yellowtail flounder in NAFO Divisions 3LNO.

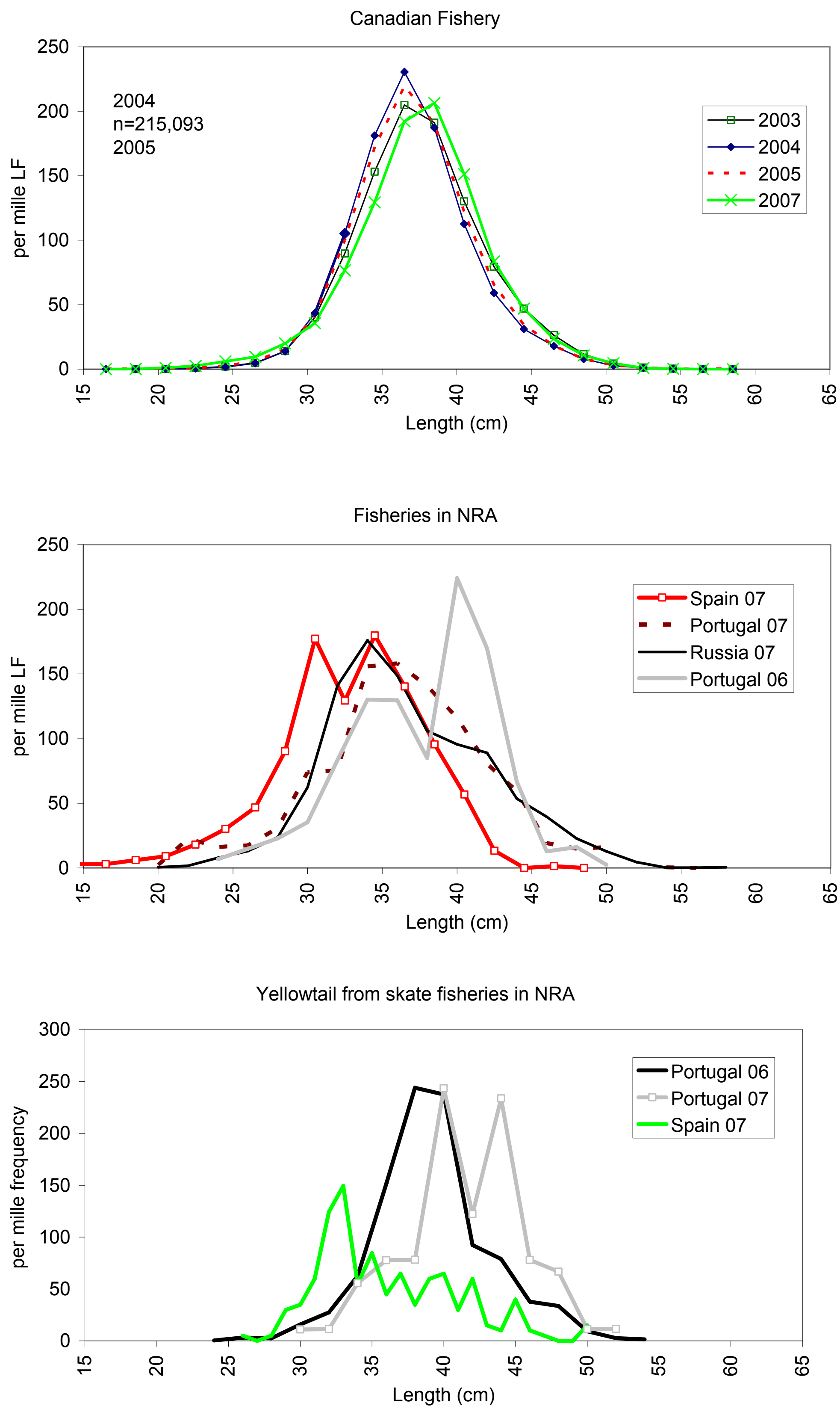


Figure 2. Length frequencies of yellowtail flounder in NAFO Divs. 3LNO from the Canadian fishery (upper panel), Portugese and Spanish fisheries (middle panel) and by-catch in skate fisheries (bottom panel).

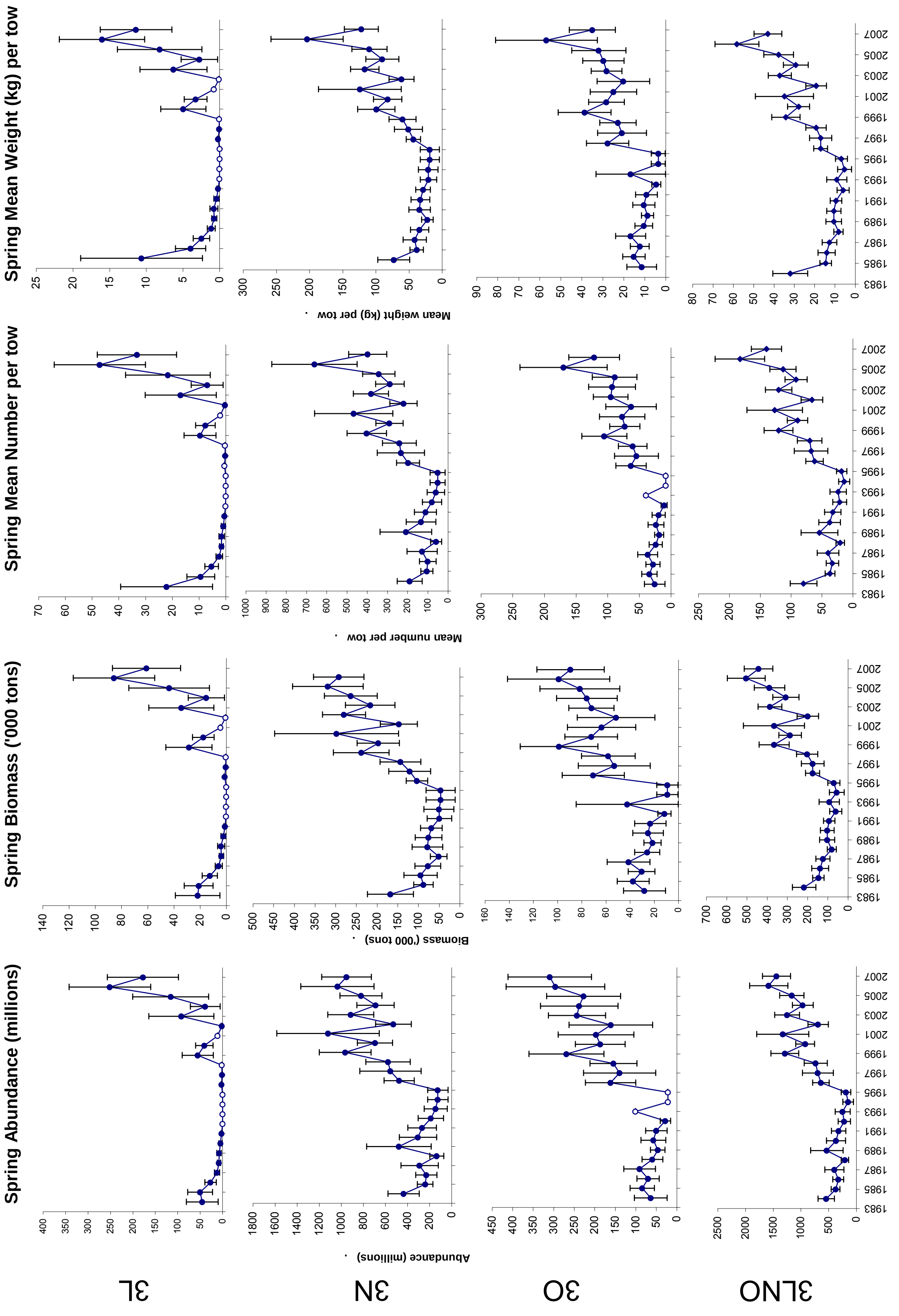


Figure 3. Abundance (millions), Biomass ('000 tons), Mean number and weight (kg) per tow for Yellowtail flounder in spring surveys by NAFO division and for 3LNO combined from 1984-2007.

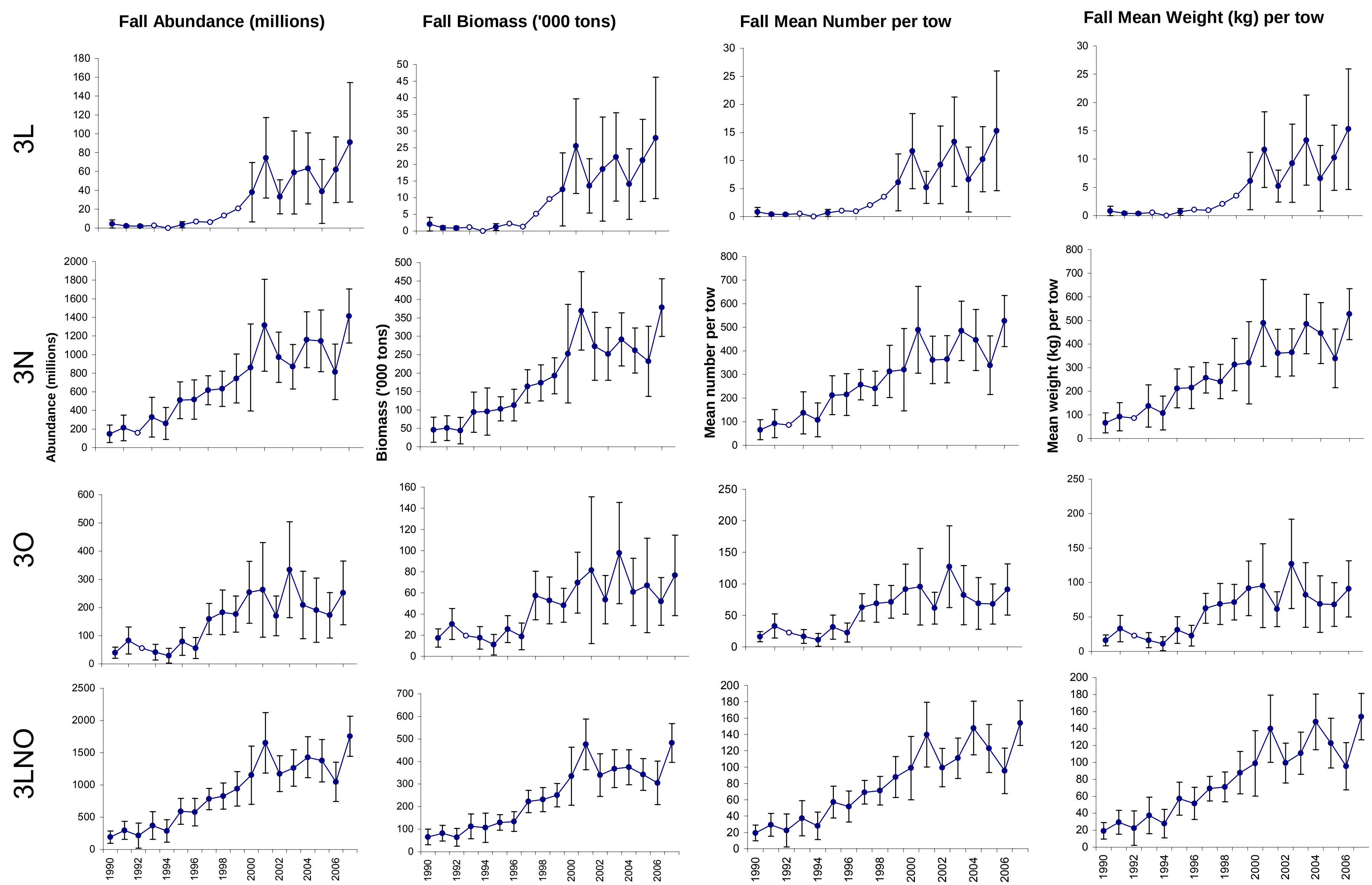


Figure 4. Abundance (millions), Biomass ('000 tons), Mean number and weight (kg) per tow for Yellowtail floudner in fall surveys in NAFO divisions 3LNO from 1990-2007.

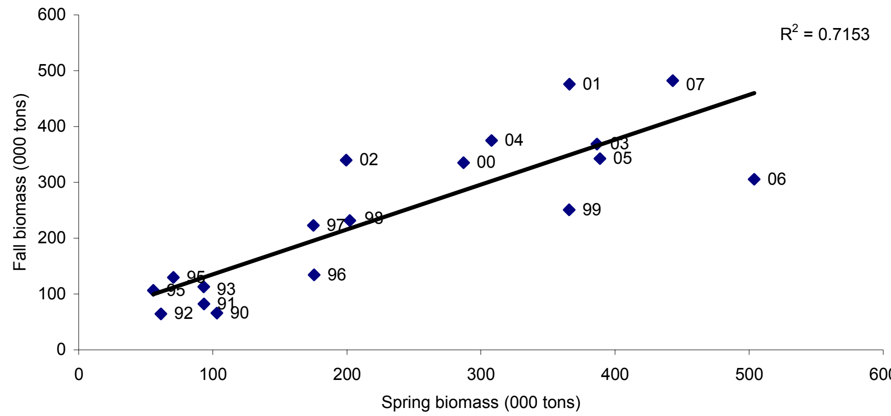


Fig. 5. Regression of Canadian spring and fall estimates of yellowtail flounder biomass in Div. 3LNO, 1990-2007.

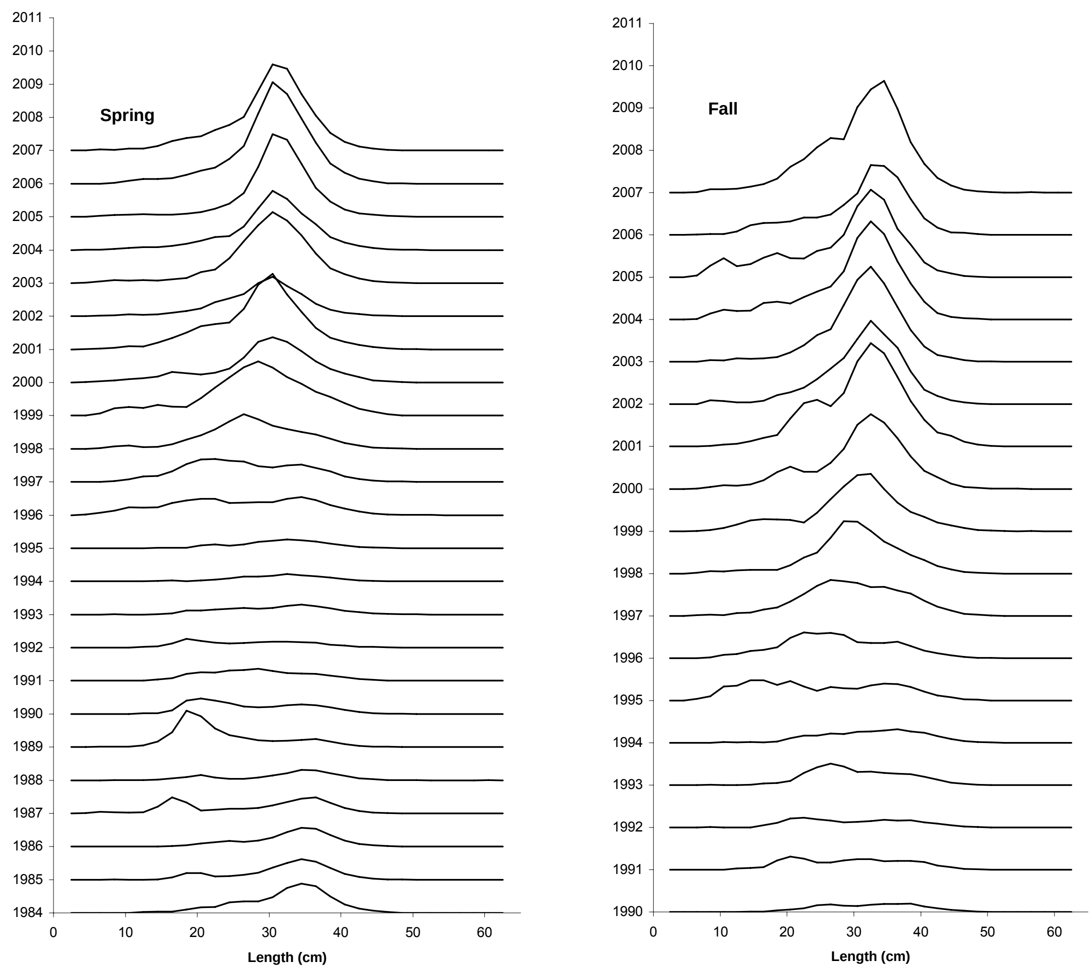


Figure 6. Abundance at length for 3LNO Yellowtail flounder from Canadian spring (1984-2007) and fall (1990-2007) surveys.

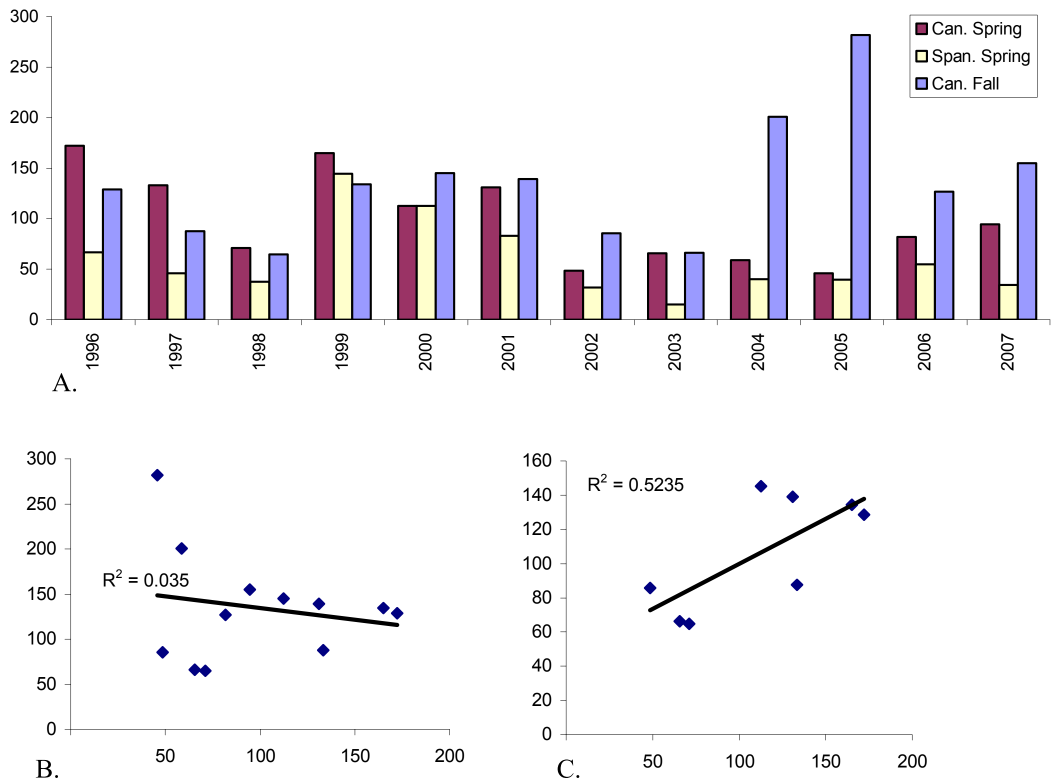


Figure 7. A. Population numbers of yellowtail flounder less than 22 cm in the Canadian and total numbers from Spanish surveys; B. regression of Canadian spring and fall estimates from 1996-2007; and C. regression of Canadian spring and fall estimates from 1996-2003.

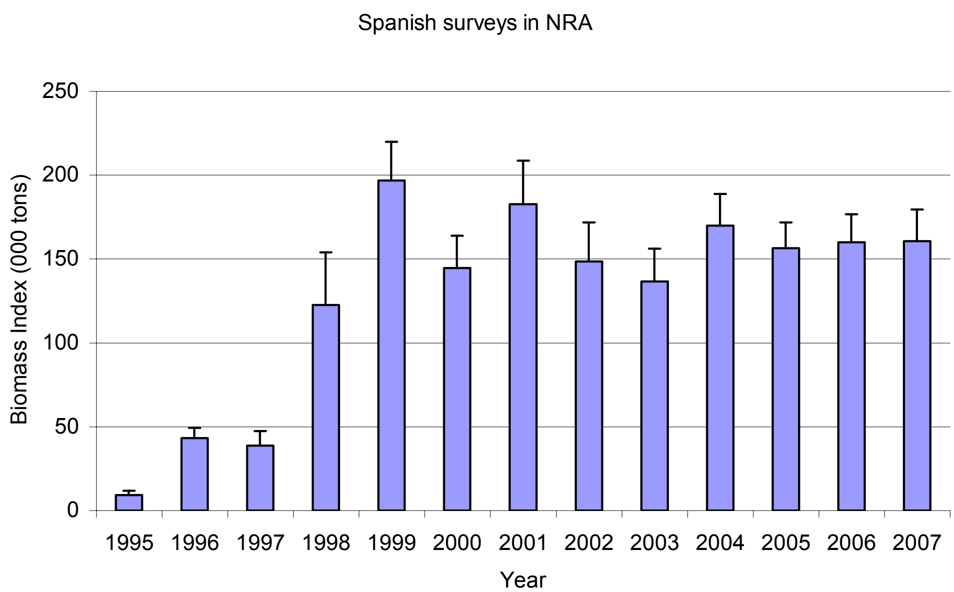


Figure 8. Converted biomass estimates from Spanish surveys in the NRA of Div. 3NO. Error bars are +1 SD.

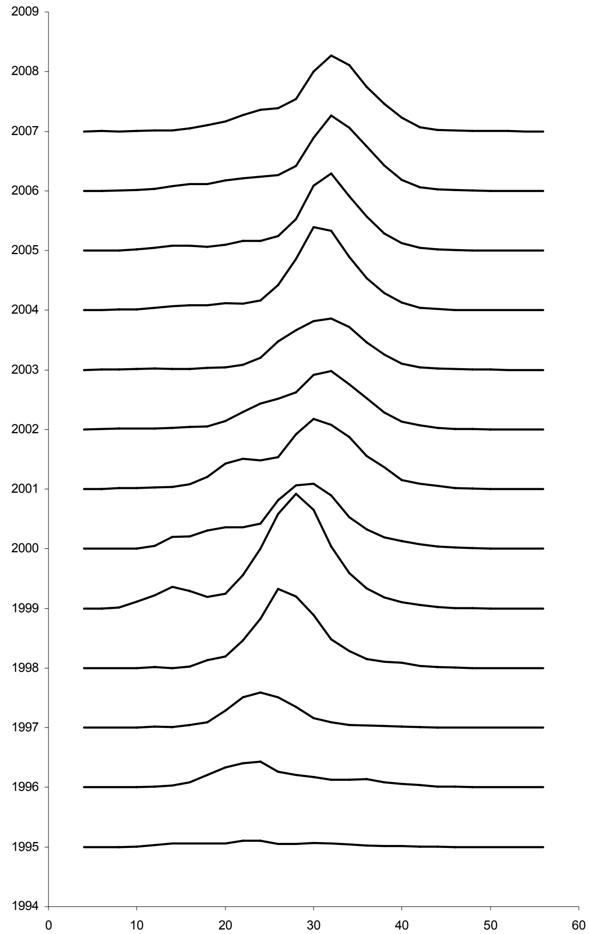


Figure 9. Length frequencies of yellowtail flounder in the Spanish spring surveys of NAFO Divs. 3LNO, 1995-2007 (sexes combined).

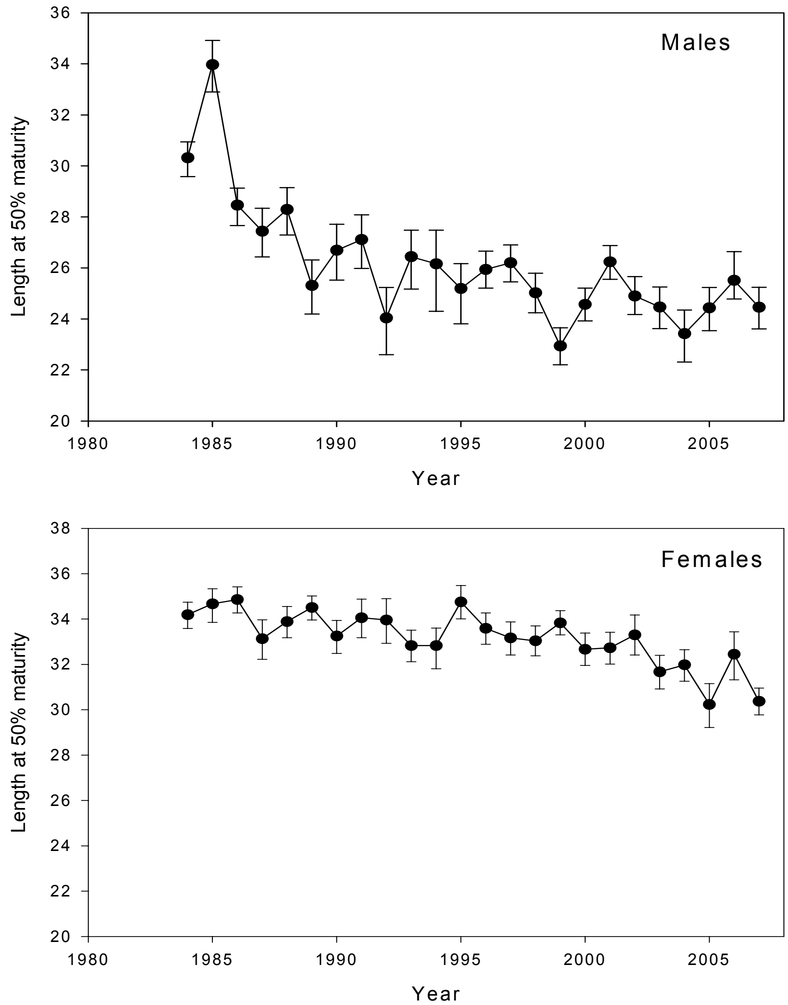


Figure 10. Length at 50% maturity of male and female yellowtail flounder from annual Canadian research vessel surveys of Div. 3LNO from 1984 to 2007.

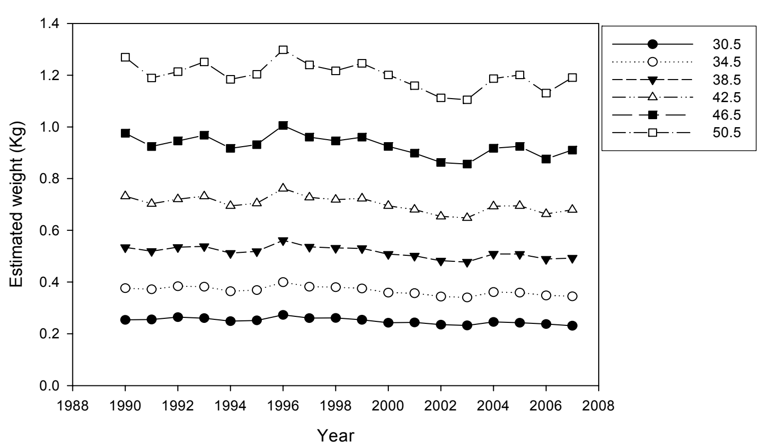


Figure11. Estimated weight (Kg) at length (cm) for selected length groups for female yellowtail flounder in Div. 3LNO from Canadian spring surveys from 1990-2007.

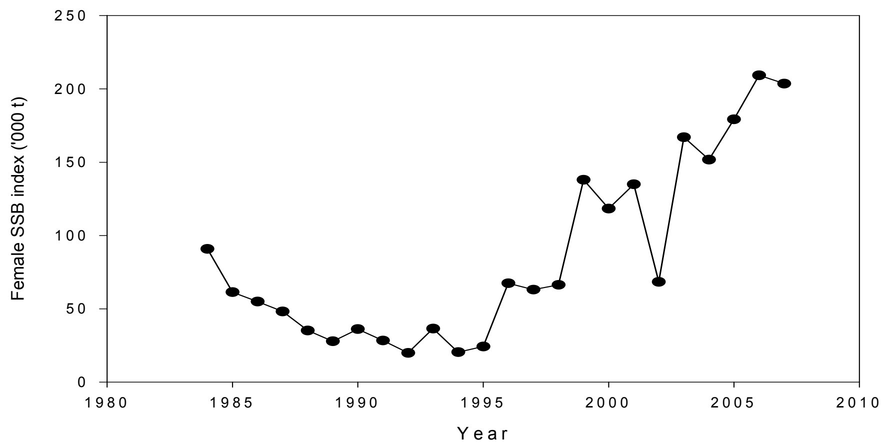


Figure 12. Index of female spawning stock biomass ('000t) for Div. 3LNO yellowtail flounder as calculated from Canadian spring research vessel surveys from 1984-2007.

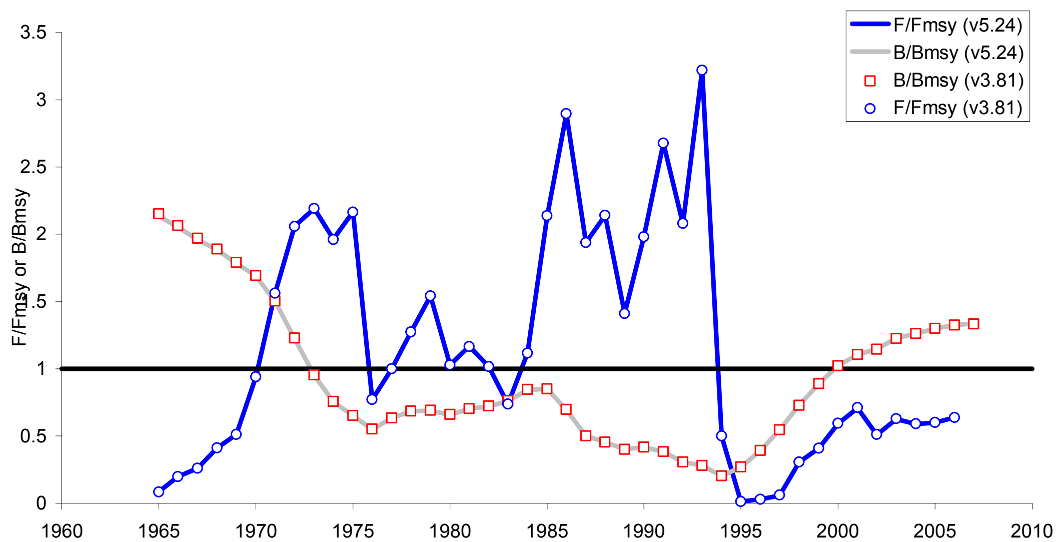
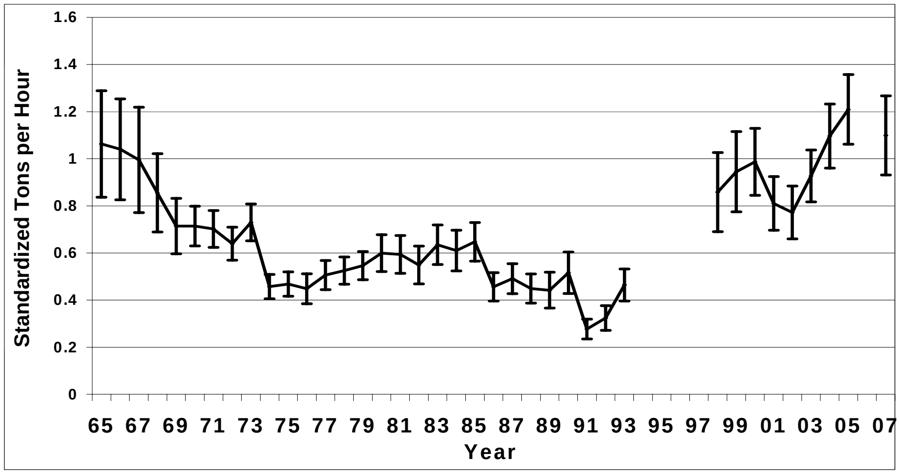


Figure 13. Relative fishing mortality (F/Fmsy) and relative biomass (B/Bmsy) estimates from 2 versions of ASPIC using the accepted 2006 assessment of yellowtail flounder in NAFO Divs. 3LNO.

A) Div. 3LNO from 1965-1993,1998-2005, 2007



B) Div 3N and 3O separately from 1965-1993,1998-2005, 2007

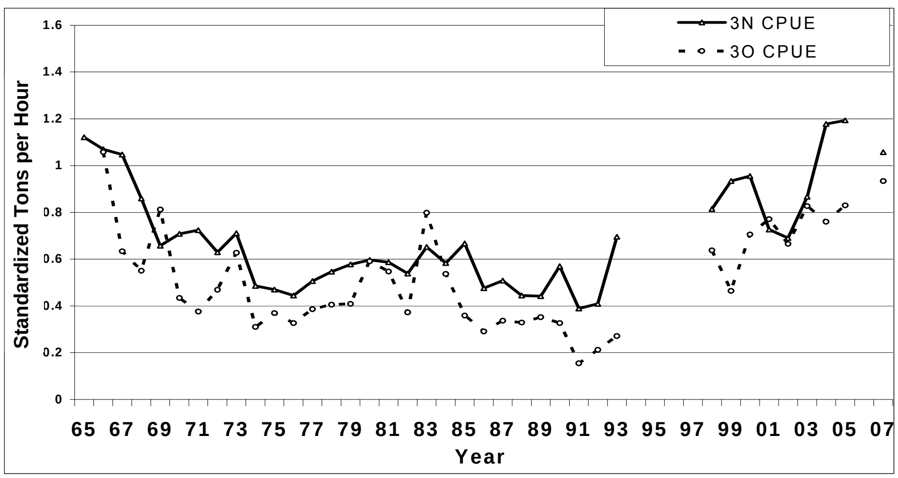


Fig. 14 Standardized CPUE ± 2 s.e. for Yellowtail in Div. 3LNO from 1965-1993 and 1998-2007 (preliminary for 2007) under different treatments of the database. From 1991-1993 the fishery was a mixed fishery with American plaice. There was no directed fishery from 1994-1997.

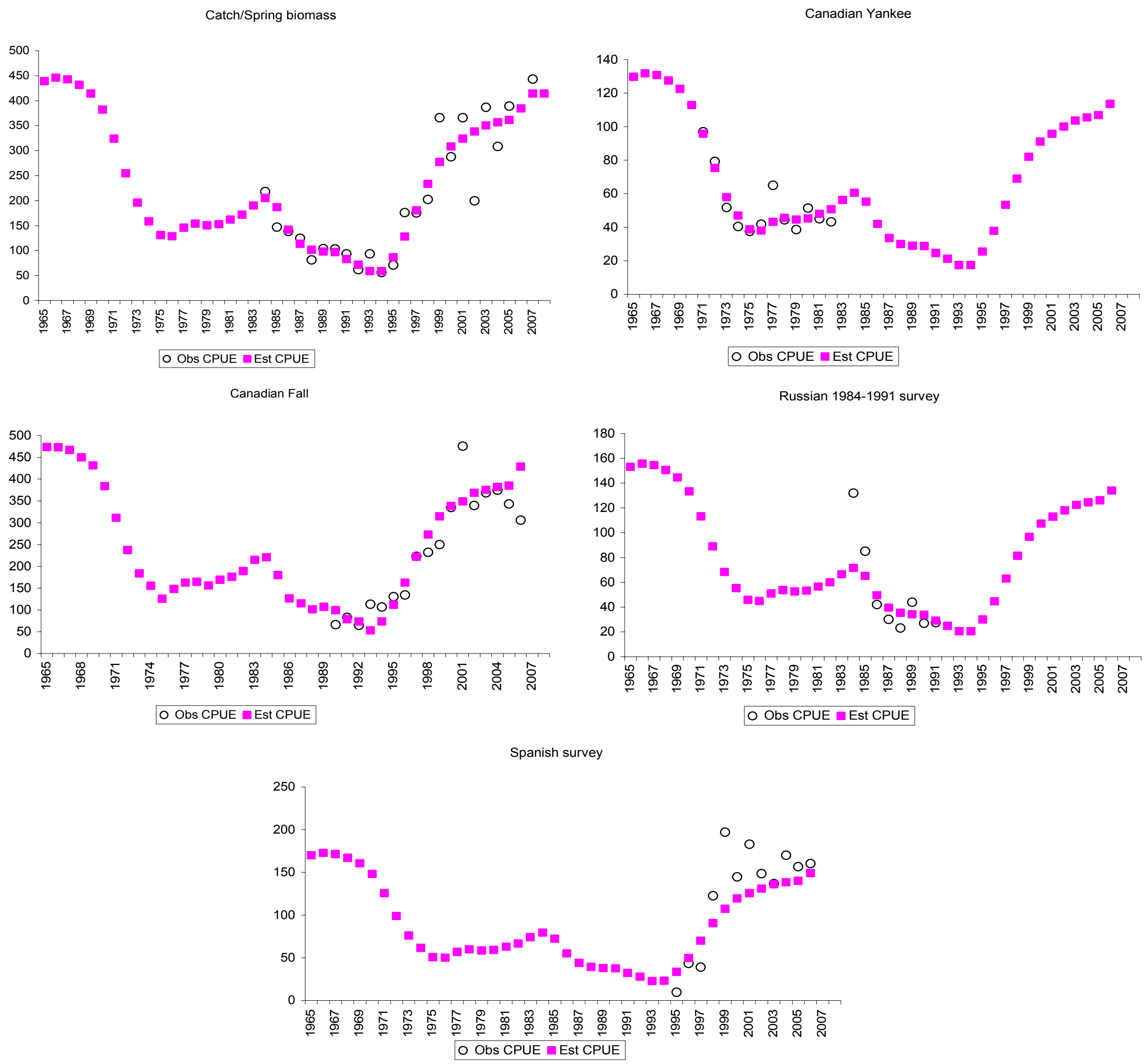


Figure 15. Observed (O) and estimated (□) CPUE for the data series used in the 2008 accepted assessment of yellowtail flounder in NAFO divs. 3LNO (ASPIC version 5.24);

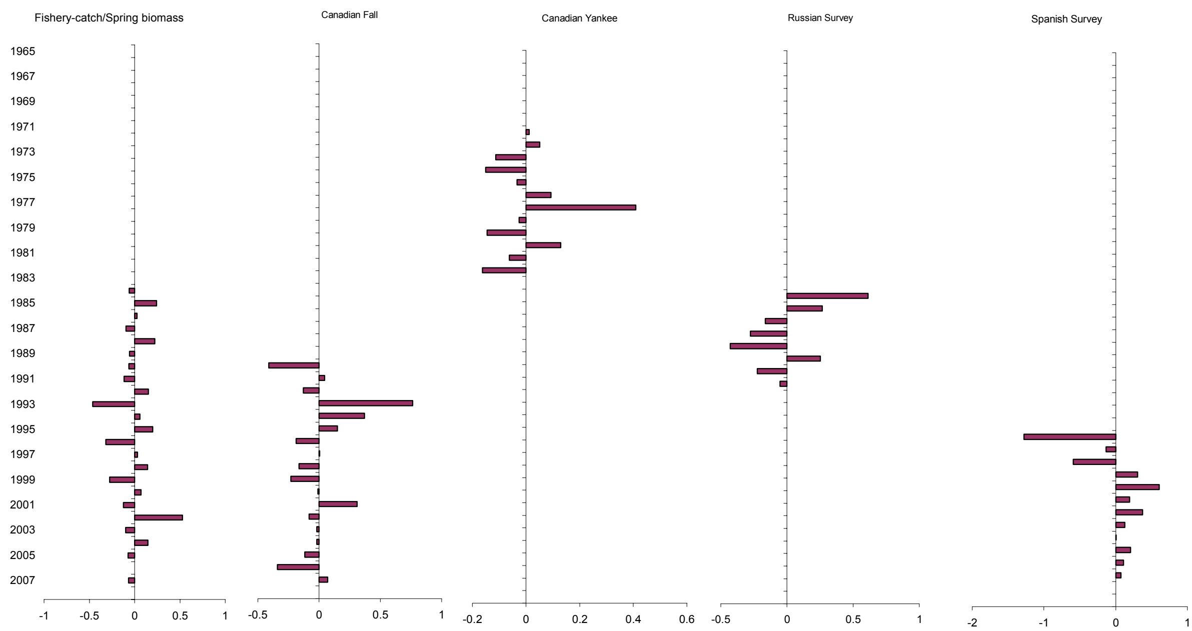


Figure 16. Residual plots for the catch and survey indices from the 2008 accepted assessment of yellowtail flounder in NAFO Divs. 3LNO (ASPIC version 5.24).

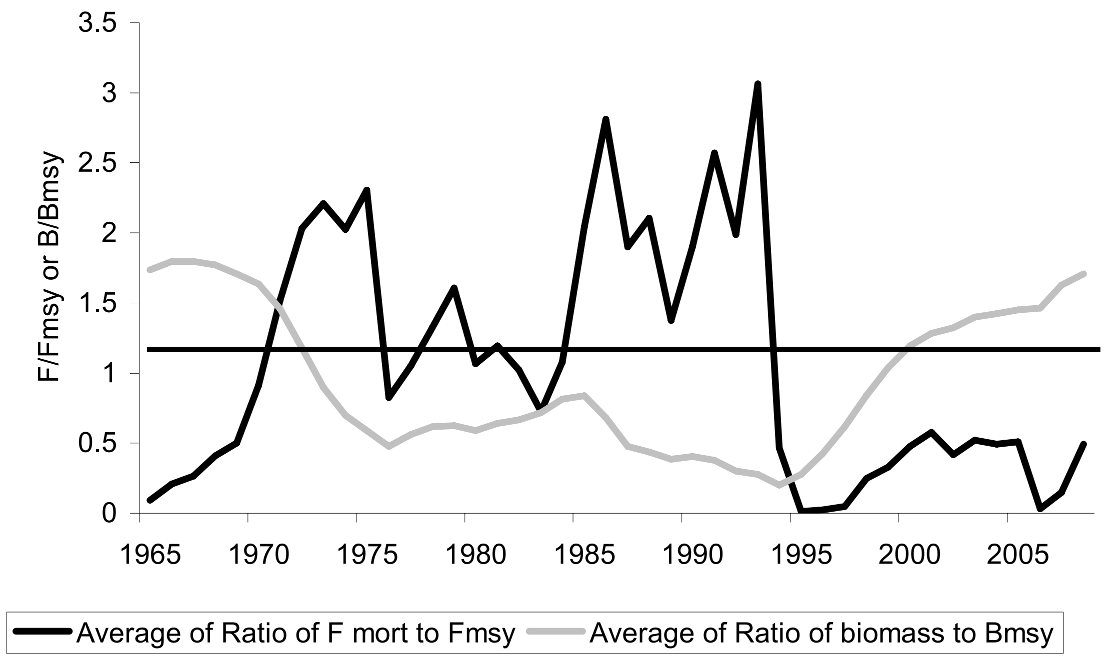


Figure 17. Yellowtail flounder in NAFO Divs. 3LNO: Relative fishing mortality (F/Fmsy) and relative biomass (B/Bmsy) estimates from the 2008 accepted model (ASPIC version 5.24)

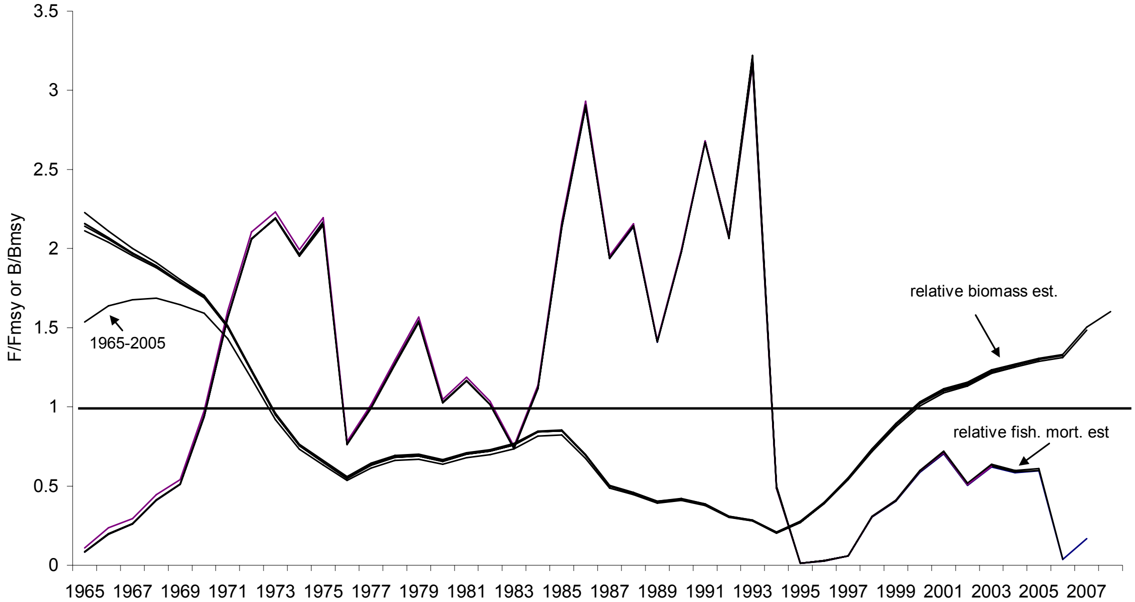


Figure 18. Retrospective view of the 2006 assessment formulation, updated with 2 years of catch and survey data, of yellowtail flounder, dropping one year at a time 2007-2003.

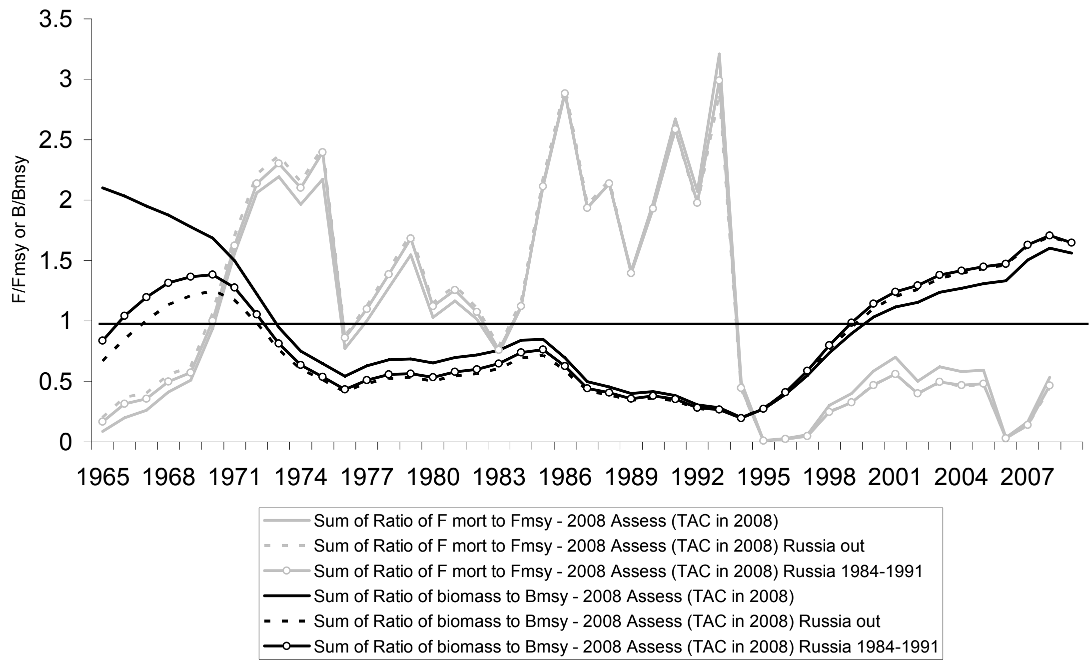


Figure 19. Relative fishing mortality estimates and relative biomass estimates for 3 model formulations of the 2008 assessment of yellowtail flounder in NAFO Divs. 3LNO.

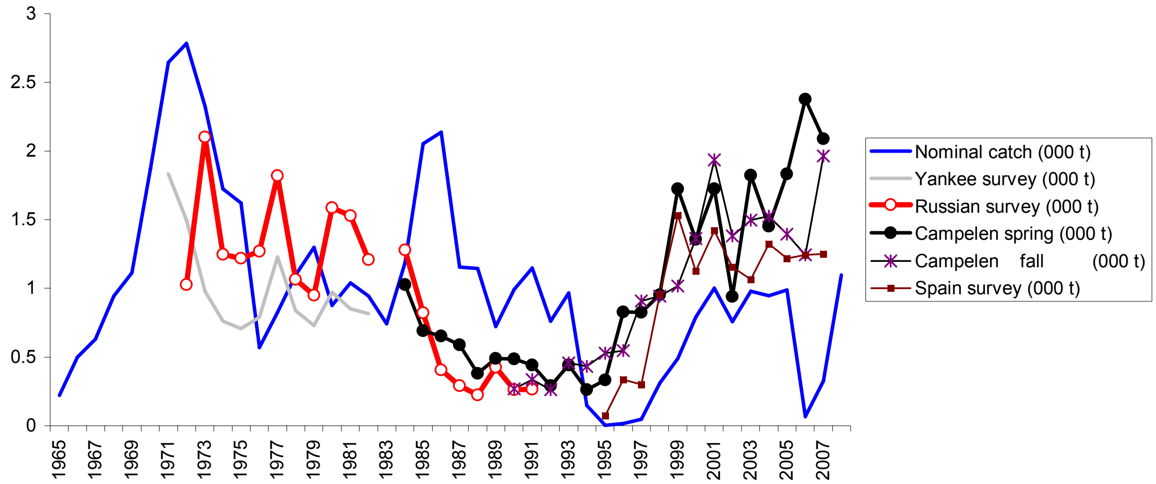


Figure 20. Nominal catch and survey series scaled to the mean in each series of the indices explored in the 2008 assessment of yellowtail flounder.

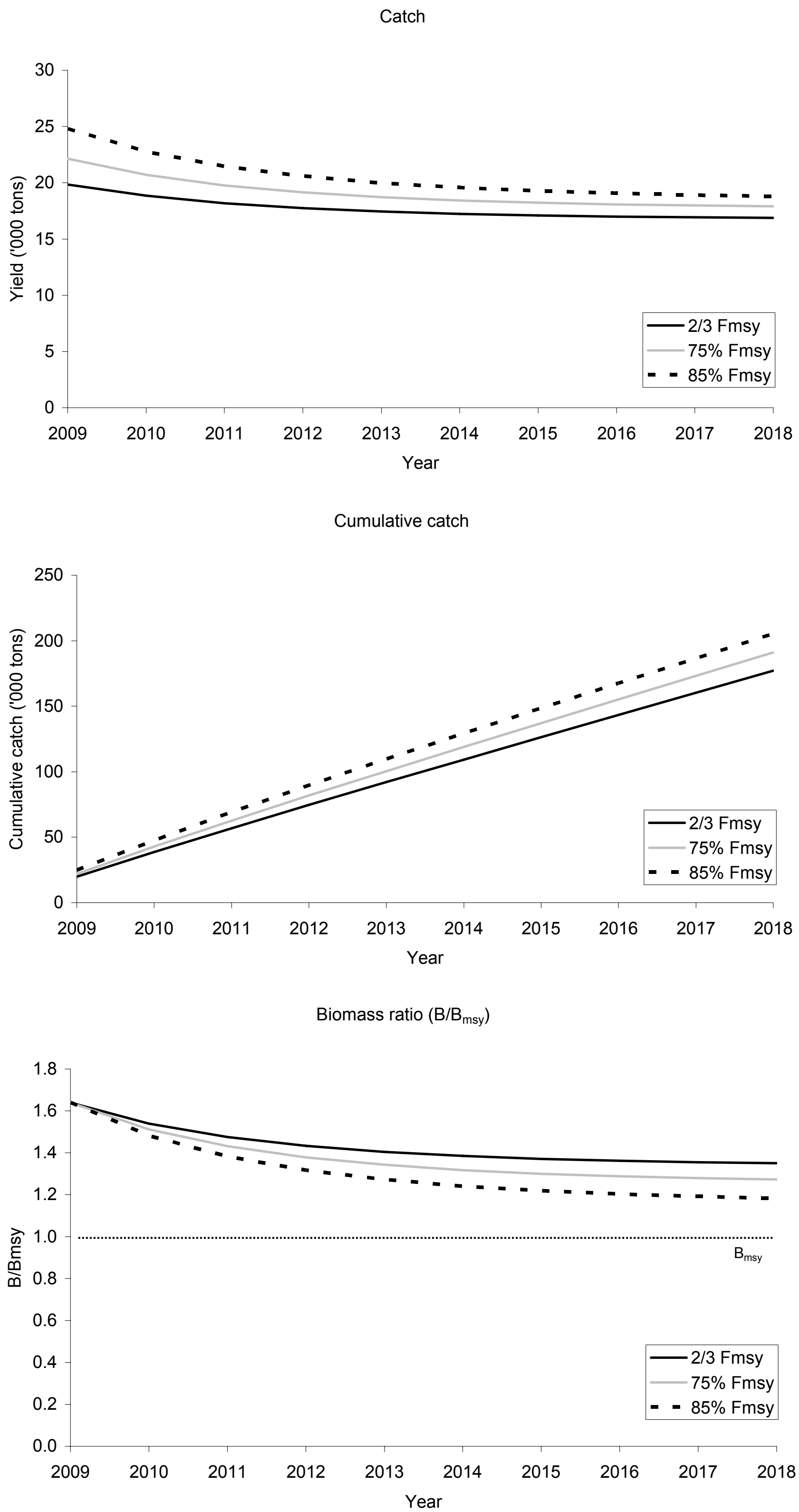


Figure 21. Yellowtail flounder in Div. 3LNO: medium term projections at 3 levels of F (2/3 F_{msy}, 75% and 85% F_{msy}). Top panel shows projected cumulative catch, middle panel gives projected catch, and lower panel is projected relative biomass ratios (B/B_{msy}). Results are derived from an ASPIC bootstrap run (500 iterations) with a catch of 15 500 tons assumed in 2008.

APPENDIX 1.

```
3LNO Yellowtail SM version 5.24 (2007) 2008=TAC RUSSIA 1984-1991; 2006 Spring OUT                     Page 1
                                                                          Saturday, 14 Jun 2008 at 10:54:22
ASPIC -- A Surplus-Production Model Including Covariates (Ver. 5.24)
                                                                                           BOT program mode
Author:      Michael H. Prager; NOAA Center for Coastal Fisheries and Habitat Research  LOGISTIC model mode
             101 Pivers Island Road; Beaufort, North Carolina  28516  USA                  YLD conditioning
             Mike.Prager@noaa.gov                                                          SSE optimization

Reference:   Prager, M. H. 1994. A suite of extensions to a nonequilibrium          ASPIC User's Manual is available
             surplus-production model.  Fishery Bulletin 92: 374-389.                     gratis from the author.

CONTROL PARAMETERS (FROM INPUT FILE)          Input file: i:\...assssessment\ytail_assessment_russiatrunc_08_06out.inp
------------------------------------------------------------------------------------------------------------------------
Operation of ASPIC:  Fit logistic (Schaefer) model by direct optimization with bootstrap.
Number of years analyzed:                          44          Number of bootstrap trials:                         500
Number of data series:                              5          Bounds on MSY (min, max):       1.000E+00     5.000E+01
Objective function:                     Least squares          Bounds on K (min, max):         1.000E+01     1.000E+03
Relative conv. criterion (simplex):         1.000E-08          Monte Carlo search mode, trials:        2         50000
Relative conv. criterion (restart):         3.000E-06          Random number seed:                             9114895
Relative conv. criterion (effort):          1.000E-02          Identical convergences required in fitting:           5
Maximum F allowed in fitting:                   5.000


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


CORRELATION AMONG INPUT SERIES EXPRESSED AS CPUE (NUMBER OF PAIRWISE OBSERVATIONS BELOW)
------------------------------------------------------------------------------------------------------------------------
                                       |
 1  Fishery-catch/Spring biomass       |   1.000
                                       |      23
                                       |
 2  Canadian Yankee Survey             |   0.000   1.000
                                       |       0      12
                                       |
 3  Canadian Fall Survey               |   0.900   0.000   1.000
                                       |      17       0      18
                                       |
 4  Russian Survey                     |   0.933   0.000   1.000   1.000
                                       |       8       0       2       8
                                       |
 5  Spanish Survey Converted biomass...|   0.819   0.000   0.758   0.000   1.000
                                       |      12       0      13       0      13
                                       --------------------------------------------------
                                               1       2       3       4       5


GOODNESS-OF-FIT AND WEIGHTING (NON-BOOTSTRAPPED ANALYSIS)
------------------------------------------------------------------------------------------------------------------------
                                                  Weighted              Weighted       Current    Inv. var.    R-squared
Loss component number and title                        SSE      N           MSE        weight       weight      in CPUE

Loss(-1)  SSE in yield                           0.000E+00
Loss(0)   Penalty for B1 > K                     0.000E+00      1           N/A     1.000E+00          N/A
Loss(1)   Fishery-catch/Spring biomass           9.610E-01     23     4.576E-02     1.000E+00    1.286E+00        0.873
Loss(2)   Canadian Yankee Survey                 2.844E-01     12     2.844E-02     1.000E+00    2.069E+00        0.804
Loss(3)   Canadian Fall Survey                   1.284E+00     18     8.026E-02     1.000E+00    7.330E-01        0.852
Loss(4)   Russian Survey                         8.512E-01      8     1.419E-01     1.000E+00    4.146E-01        0.558
Loss(5)   Spanish Survey Converted biomass_2006  2.716E+00     13     2.469E-01     1.000E+00    2.382E-01        0.616
..............................................................................................
TOTAL OBJECTIVE FUNCTION, MSE, RMSE:        6.09677878E+00          9.238E-02     3.039E-01
Estimated contrast index (ideal = 1.0):             0.7988          C* = (Bmax-Bmin)/K
Estimated nearness index (ideal = 1.0):             1.0000          N* = 1 - |min(B-Bmsy)|/K

3LNO Yellowtail SM version 5.24 (2007) 2008=TAC RUSSIA 1984-1991; 2006 Spring OUT                    Page 2


MODEL PARAMETER ESTIMATES (NON-BOOTSTRAPPED)
------------------------------------------------------------------------------------------------------------------------
Parameter                                         Estimate    User/pgm guess    2nd guess    Estimated    User guess

B1/K      Starting relative biomass (in 1965)    8.676E-01         2.000E+00    5.440E-01            1             1
MSY       Maximum sustainable yield              1.882E+01         1.300E+01    1.200E+01            1             1
K         Maximum population size                1.472E+02         4.000E+02    7.199E+01            1             1
phi       Shape of production curve (Bmsy/K)     0.5000            0.5000            ----            0             1

--------- Catchability Coefficients by Data Series ---------------
q(1)      Fishery-catch/Spring biomass           3.372E+00         3.000E+00    2.493E-01            1             1
q(2)      Canadian Yankee Survey                 9.965E-01         1.000E+00    6.807E-01            1             1
q(3)      Canadian Fall Survey                   3.581E+00         3.000E+00    1.464E-01            1             1
q(4)      Russian Survey                         1.176E+00         1.000E+00    7.015E-01            1             1
q(5)      Spanish Survey Converted biomass_2006  1.307E+00         3.000E+00    2.800E-01            1             1
```

MANAGEMENT and DERIVED PARAMETER ESTIMATES (NON-BOOTSTRAPPED)

Parameter		Estimate	Logistic formula	General formula
MSY	Maximum sustainable yield	1.882E+01	----	----
Bmsy	Stock biomass giving MSY	7.358E+01	K/2	K*n**(1/(1-n))
Fmsy	Fishing mortality rate at MSY	2.557E-01	MSY/Bmsy	MSY/Bmsy
n	Exponent in production function	2.0000	----	----
g	Fletcher's gamma	4.000E+00	----	[n**(n/(n-1))]/[n-1]
B./Bmsy	Ratio: B(2009)/Bmsy	1.637E+00	----	----
F./Fmsy	Ratio: F(2008)/Fmsy	4.936E-01	----	----
Fmsy/F.	Ratio: Fmsy/F(2008)	2.026E+00	----	----
Y.(Fmsy)	Approx. yield available at Fmsy in 2009	3.080E+01	MSY*B./Bmsy	MSY*B./Bmsy
	...as proportion of MSY	1.637E+00	----	----
Ye.	Equilibrium yield available in 2009	1.119E+01	4*MSY*(B/K-(B/K)**2)	g*MSY*(B/K-(B/K)**n)
	...as proportion of MSY	5.945E-01	----	----
---------	Fishing effort rate at MSY in units of each CE or CC series ---------			
fmsy(1)	Fishery-catch/Spring biomass	7.583E-02	Fmsy/q(1)	Fmsy/q(1)

3LNO Yellowtail SM version 5.24 (2007) 2008=TAC RUSSIA 1984-1991; 2006 Spring OUT 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	0.024	1.277E+02	1.301E+02	3.130E+00	3.130E+00	7.702E+00	9.407E-02	1.735E+00
2	1966	0.053	1.322E+02	1.322E+02	7.026E+00	7.026E+00	6.887E+00	2.079E-01	1.797E+00
3	1967	0.068	1.321E+02	1.312E+02	8.878E+00	8.878E+00	7.264E+00	2.645E-01	1.795E+00
4	1968	0.104	1.305E+02	1.279E+02	1.334E+01	1.334E+01	8.554E+00	4.078E-01	1.773E+00
5	1969	0.128	1.257E+02	1.228E+02	1.571E+01	1.571E+01	1.038E+01	5.001E-01	1.708E+00
6	1970	0.233	1.204E+02	1.133E+02	2.643E+01	2.643E+01	1.330E+01	9.122E-01	1.636E+00
7	1971	0.389	1.073E+02	9.608E+01	3.734E+01	3.734E+01	1.692E+01	1.520E+00	1.458E+00
8	1972	0.520	8.683E+01	7.553E+01	3.926E+01	3.926E+01	1.864E+01	2.033E+00	1.180E+00
9	1973	0.565	6.621E+01	5.809E+01	3.281E+01	3.281E+01	1.788E+01	2.209E+00	8.998E-01
10	1974	0.517	5.128E+01	4.700E+01	2.431E+01	2.431E+01	1.632E+01	2.023E+00	6.969E-01
11	1975	0.590	4.329E+01	3.881E+01	2.289E+01	2.289E+01	1.457E+01	2.307E+00	5.883E-01
12	1976	0.211	3.496E+01	3.811E+01	8.057E+00	8.057E+00	1.443E+01	8.267E-01	4.751E-01
13	1977	0.269	4.134E+01	4.331E+01	1.164E+01	1.164E+01	1.562E+01	1.051E+00	5.618E-01
14	1978	0.339	4.532E+01	4.563E+01	1.547E+01	1.547E+01	1.610E+01	1.325E+00	6.160E-01
15	1979	0.411	4.596E+01	4.466E+01	1.835E+01	1.835E+01	1.590E+01	1.607E+00	6.246E-01
16	1980	0.273	4.351E+01	4.531E+01	1.238E+01	1.238E+01	1.603E+01	1.068E+00	5.913E-01
17	1981	0.306	4.716E+01	4.805E+01	1.468E+01	1.468E+01	1.654E+01	1.195E+00	6.410E-01
18	1982	0.262	4.903E+01	5.086E+01	1.332E+01	1.332E+01	1.701E+01	1.024E+00	6.663E-01
19	1983	0.186	5.272E+01	5.642E+01	1.047E+01	1.047E+01	1.778E+01	7.258E-01	7.165E-01
20	1984	0.276	6.003E+01	6.072E+01	1.673E+01	1.673E+01	1.823E+01	1.078E+00	8.158E-01
21	1985	0.523	6.152E+01	5.535E+01	2.896E+01	2.896E+01	1.758E+01	2.046E+00	8.361E-01
22	1986	0.719	5.014E+01	4.199E+01	3.018E+01	3.018E+01	1.525E+01	2.810E+00	6.814E-01
23	1987	0.486	3.522E+01	3.358E+01	1.631E+01	1.631E+01	1.324E+01	1.900E+00	4.786E-01
24	1988	0.538	3.215E+01	3.002E+01	1.616E+01	1.616E+01	1.220E+01	2.105E+00	4.369E-01
25	1989	0.351	2.819E+01	2.904E+01	1.021E+01	1.021E+01	1.192E+01	1.374E+00	3.831E-01
26	1990	0.487	2.990E+01	2.872E+01	1.399E+01	1.399E+01	1.181E+01	1.904E+00	4.064E-01
27	1991	0.657	2.773E+01	2.465E+01	1.620E+01	1.620E+01	1.047E+01	2.571E+00	3.768E-01
28	1992	0.508	2.199E+01	2.118E+01	1.076E+01	1.076E+01	9.265E+00	1.987E+00	2.989E-01
29	1993	0.783	2.049E+01	1.738E+01	1.362E+01	1.362E+01	7.819E+00	3.063E+00	2.785E-01
30	1994	0.118	1.470E+01	1.746E+01	2.069E+00	2.069E+00	7.862E+00	4.633E-01	1.997E-01
31	1995	0.003	2.049E+01	2.554E+01	6.700E-02	6.700E-02	1.076E+01	1.026E-02	2.785E-01
32	1996	0.006	3.119E+01	3.796E+01	2.320E-01	2.320E-01	1.435E+01	2.390E-02	4.239E-01
33	1997	0.012	4.531E+01	5.346E+01	6.580E-01	6.580E-01	1.733E+01	4.813E-02	6.157E-01
34	1998	0.063	6.198E+01	6.916E+01	4.386E+00	4.386E+00	1.869E+01	2.480E-01	8.423E-01
35	1999	0.084	7.628E+01	8.221E+01	6.894E+00	6.894E+00	1.852E+01	3.279E-01	1.037E+00
36	2000	0.122	8.790E+01	9.131E+01	1.116E+01	1.116E+01	1.771E+01	4.780E-01	1.195E+00
37	2001	0.147	9.445E+01	9.598E+01	1.414E+01	1.414E+01	1.707E+01	5.763E-01	1.284E+00
38	2002	0.107	9.738E+01	1.003E+02	1.070E+01	1.070E+01	1.632E+01	4.172E-01	1.323E+00
39	2003	0.133	1.030E+02	1.039E+02	1.381E+01	1.381E+01	1.561E+01	5.194E-01	1.400E+00
40	2004	0.126	1.048E+02	1.058E+02	1.335E+01	1.335E+01	1.521E+01	4.937E-01	1.424E+00
41	2005	0.130	1.067E+02	1.072E+02	1.393E+01	1.393E+01	1.490E+01	5.084E-01	1.450E+00
42	2006	0.008	1.076E+02	1.140E+02	9.300E-01	9.300E-01	1.310E+01	3.190E-02	1.463E+00
43	2007	0.038	1.198E+02	1.228E+02	4.617E+00	4.617E+00	1.037E+01	1.470E-01	1.628E+00
44	2008	0.126	1.255E+02	1.228E+02	1.550E+01	1.550E+01	1.039E+01	4.936E-01	1.706E+00
45	2009		1.204E+02						1.637E+00

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

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

Obs	Year	Observed CPUE	Estimated CPUE	Estim F	Observed yield	Model yield	Resid in log scale	Statist weight
1	1965	*	4.388E+02	0.0241	3.130E+00	3.130E+00	0.00000	1.000E+00
2	1966	*	4.457E+02	0.0532	7.026E+00	7.026E+00	0.00000	1.000E+00
3	1967	*	4.426E+02	0.0676	8.878E+00	8.878E+00	0.00000	1.000E+00
4	1968	*	4.313E+02	0.1043	1.334E+01	1.334E+01	0.00000	1.000E+00
5	1969	*	4.142E+02	0.1279	1.571E+01	1.571E+01	0.00000	1.000E+00
6	1970	*	3.820E+02	0.2333	2.643E+01	2.643E+01	0.00000	1.000E+00
7	1971	*	3.240E+02	0.3886	3.734E+01	3.734E+01	0.00000	1.000E+00
8	1972	*	2.547E+02	0.5198	3.926E+01	3.926E+01	0.00000	1.000E+00
9	1973	*	1.959E+02	0.5649	3.281E+01	3.281E+01	0.00000	1.000E+00
10	1974	*	1.585E+02	0.5173	2.431E+01	2.431E+01	0.00000	1.000E+00
11	1975	*	1.309E+02	0.5899	2.289E+01	2.289E+01	0.00000	1.000E+00
12	1976	*	1.285E+02	0.2114	8.057E+00	8.057E+00	0.00000	1.000E+00
13	1977	*	1.460E+02	0.2687	1.164E+01	1.164E+01	0.00000	1.000E+00
14	1978	*	1.539E+02	0.3389	1.547E+01	1.547E+01	0.00000	1.000E+00
15	1979	*	1.506E+02	0.4109	1.835E+01	1.835E+01	0.00000	1.000E+00
16	1980	*	1.528E+02	0.2731	1.238E+01	1.238E+01	0.00000	1.000E+00
17	1981	*	1.620E+02	0.3055	1.468E+01	1.468E+01	0.00000	1.000E+00
18	1982	*	1.715E+02	0.2619	1.332E+01	1.332E+01	0.00000	1.000E+00
19	1983	*	1.903E+02	0.1856	1.047E+01	1.047E+01	0.00000	1.000E+00
20	1984	2.177E+02	2.048E+02	0.2756	1.673E+01	1.673E+01	-0.06126	1.000E+00
21	1985	1.468E+02	1.867E+02	0.5232	2.896E+01	2.896E+01	0.24022	1.000E+00
22	1986	1.382E+02	1.416E+02	0.7186	3.018E+01	3.018E+01	0.02438	1.000E+00
23	1987	1.246E+02	1.133E+02	0.4858	1.631E+01	1.631E+01	-0.09549	1.000E+00
24	1988	8.100E+01	1.012E+02	0.5382	1.616E+01	1.616E+01	0.22305	1.000E+00
25	1989	1.038E+02	9.793E+01	0.3515	1.021E+01	1.021E+01	-0.05821	1.000E+00
26	1990	1.031E+02	9.685E+01	0.4870	1.399E+01	1.399E+01	-0.06257	1.000E+00
27	1991	9.340E+01	8.311E+01	0.6574	1.620E+01	1.620E+01	-0.11671	1.000E+00
28	1992	6.140E+01	7.141E+01	0.5082	1.076E+01	1.076E+01	0.15108	1.000E+00
29	1993	9.330E+01	5.861E+01	0.7834	1.362E+01	1.362E+01	-0.46496	1.000E+00
30	1994	5.560E+01	5.889E+01	0.1185	2.069E+00	2.069E+00	0.05744	1.000E+00
31	1995	7.060E+01	8.614E+01	0.0026	6.700E-02	6.700E-02	0.19895	1.000E+00
32	1996	1.756E+02	1.280E+02	0.0061	2.320E-01	2.320E-01	-0.31604	1.000E+00
33	1997	1.749E+02	1.803E+02	0.0123	6.580E-01	6.580E-01	0.03035	1.000E+00
34	1998	2.022E+02	2.332E+02	0.0634	4.386E+00	4.386E+00	0.14270	1.000E+00
35	1999	3.657E+02	2.772E+02	0.0839	6.894E+00	6.894E+00	-0.27699	1.000E+00
36	2000	2.875E+02	3.079E+02	0.1222	1.116E+01	1.116E+01	0.06855	1.000E+00
37	2001	3.660E+02	3.237E+02	0.1474	1.414E+01	1.414E+01	-0.12294	1.000E+00
38	2002	1.995E+02	3.382E+02	0.1067	1.070E+01	1.070E+01	0.52771	1.000E+00
39	2003	3.865E+02	3.505E+02	0.1328	1.381E+01	1.381E+01	-0.09773	1.000E+00
40	2004	3.079E+02	3.567E+02	0.1262	1.335E+01	1.335E+01	0.14712	1.000E+00
41	2005	3.888E+02	3.614E+02	0.1300	1.393E+01	1.393E+01	-0.07317	1.000E+00
42	2006	*	3.844E+02	0.0082	9.300E-01	9.300E-01	0.00000	1.000E+00
43	2007	4.430E+02	4.142E+02	0.0376	4.617E+00	4.617E+00	-0.06711	1.000E+00
44	2008	*	4.141E+02	0.1262	1.550E+01	1.550E+01	0.00000	1.000E+00

* Asterisk indicates missing value(s).

RESULTS FOR DATA SERIES *# 2 (NON-BOOTSTRAPPED)* *Canadian Yankee 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	--	*	1.297E+02	0.00000	1.000E+00
2	1966	0.000E+00	0.000E+00	--	*	1.317E+02	0.00000	1.000E+00
3	1967	0.000E+00	0.000E+00	--	*	1.308E+02	0.00000	1.000E+00
4	1968	0.000E+00	0.000E+00	--	*	1.275E+02	0.00000	1.000E+00
5	1969	0.000E+00	0.000E+00	--	*	1.224E+02	0.00000	1.000E+00
6	1970	0.000E+00	0.000E+00	--	*	1.129E+02	0.00000	1.000E+00
7	1971	1.000E+00	1.000E+00	--	9.690E+01	9.575E+01	0.01193	1.000E+00
8	1972	1.000E+00	1.000E+00	--	7.920E+01	7.527E+01	0.05090	1.000E+00
9	1973	1.000E+00	1.000E+00	--	5.170E+01	5.789E+01	-0.11308	1.000E+00
10	1974	1.000E+00	1.000E+00	--	4.030E+01	4.684E+01	-0.15040	1.000E+00
11	1975	1.000E+00	1.000E+00	--	3.740E+01	3.867E+01	-0.03351	1.000E+00
12	1976	1.000E+00	1.000E+00	--	4.170E+01	3.798E+01	0.09348	1.000E+00
13	1977	1.000E+00	1.000E+00	--	6.500E+01	4.316E+01	0.40957	1.000E+00
14	1978	1.000E+00	1.000E+00	--	4.430E+01	4.548E+01	-0.02621	1.000E+00
15	1979	1.000E+00	1.000E+00	--	3.850E+01	4.451E+01	-0.14506	1.000E+00
16	1980	1.000E+00	1.000E+00	--	5.140E+01	4.516E+01	0.12952	1.000E+00
17	1981	1.000E+00	1.000E+00	--	4.500E+01	4.788E+01	-0.06206	1.000E+00
18	1982	1.000E+00	1.000E+00	--	4.310E+01	5.068E+01	-0.16204	1.000E+00
19	1983	0.000E+00	0.000E+00	--	*	5.623E+01	0.00000	1.000E+00
20	1984	0.000E+00	0.000E+00	--	*	6.051E+01	0.00000	1.000E+00
21	1985	0.000E+00	0.000E+00	--	*	5.516E+01	0.00000	1.000E+00
22	1986	0.000E+00	0.000E+00	--	*	4.185E+01	0.00000	1.000E+00
23	1987	0.000E+00	0.000E+00	--	*	3.347E+01	0.00000	1.000E+00
24	1988	0.000E+00	0.000E+00	--	*	2.992E+01	0.00000	1.000E+00
25	1989	0.000E+00	0.000E+00	--	*	2.894E+01	0.00000	1.000E+00
26	1990	0.000E+00	0.000E+00	--	*	2.862E+01	0.00000	1.000E+00
27	1991	0.000E+00	0.000E+00	--	*	2.456E+01	0.00000	1.000E+00
28	1992	0.000E+00	0.000E+00	--	*	2.110E+01	0.00000	1.000E+00
29	1993	0.000E+00	0.000E+00	--	*	1.732E+01	0.00000	1.000E+00
30	1994	0.000E+00	0.000E+00	--	*	1.740E+01	0.00000	1.000E+00
31	1995	0.000E+00	0.000E+00	--	*	2.546E+01	0.00000	1.000E+00
32	1996	0.000E+00	0.000E+00	--	*	3.783E+01	0.00000	1.000E+00
33	1997	0.000E+00	0.000E+00	--	*	5.328E+01	0.00000	1.000E+00
34	1998	0.000E+00	0.000E+00	--	*	6.892E+01	0.00000	1.000E+00
35	1999	0.000E+00	0.000E+00	--	*	8.193E+01	0.00000	1.000E+00
36	2000	0.000E+00	0.000E+00	--	*	9.099E+01	0.00000	1.000E+00
37	2001	0.000E+00	0.000E+00	--	*	9.565E+01	0.00000	1.000E+00
38	2002	0.000E+00	0.000E+00	--	*	9.993E+01	0.00000	1.000E+00
39	2003	0.000E+00	0.000E+00	--	*	1.036E+02	0.00000	1.000E+00
40	2004	0.000E+00	0.000E+00	--	*	1.054E+02	0.00000	1.000E+00
41	2005	0.000E+00	0.000E+00	--	*	1.068E+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	--	*	1.224E+02	0.00000	1.000E+00
44	2008	0.000E+00	0.000E+00	--	*	1.224E+02	0.00000	1.000E+00

* Asterisk indicates missing value(s).

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	--	*	4.735E+02	0.00000	1.000E+00
2	1966	0.000E+00	0.000E+00	--	*	4.730E+02	0.00000	1.000E+00
3	1967	0.000E+00	0.000E+00	--	*	4.672E+02	0.00000	1.000E+00
4	1968	0.000E+00	0.000E+00	--	*	4.501E+02	0.00000	1.000E+00
5	1969	0.000E+00	0.000E+00	--	*	4.310E+02	0.00000	1.000E+00
6	1970	0.000E+00	0.000E+00	--	*	3.840E+02	0.00000	1.000E+00
7	1971	0.000E+00	0.000E+00	--	*	3.109E+02	0.00000	1.000E+00
8	1972	0.000E+00	0.000E+00	--	*	2.371E+02	0.00000	1.000E+00
9	1973	0.000E+00	0.000E+00	--	*	1.836E+02	0.00000	1.000E+00
10	1974	0.000E+00	0.000E+00	--	*	1.550E+02	0.00000	1.000E+00
11	1975	0.000E+00	0.000E+00	--	*	1.252E+02	0.00000	1.000E+00
12	1976	0.000E+00	0.000E+00	--	*	1.480E+02	0.00000	1.000E+00
13	1977	0.000E+00	0.000E+00	--	*	1.623E+02	0.00000	1.000E+00
14	1978	0.000E+00	0.000E+00	--	*	1.646E+02	0.00000	1.000E+00
15	1979	0.000E+00	0.000E+00	--	*	1.558E+02	0.00000	1.000E+00
16	1980	0.000E+00	0.000E+00	--	*	1.689E+02	0.00000	1.000E+00
17	1981	0.000E+00	0.000E+00	--	*	1.755E+02	0.00000	1.000E+00
18	1982	0.000E+00	0.000E+00	--	*	1.888E+02	0.00000	1.000E+00
19	1983	0.000E+00	0.000E+00	--	*	2.149E+02	0.00000	1.000E+00
20	1984	0.000E+00	0.000E+00	--	*	2.203E+02	0.00000	1.000E+00
21	1985	0.000E+00	0.000E+00	--	*	1.795E+02	0.00000	1.000E+00
22	1986	0.000E+00	0.000E+00	--	*	1.261E+02	0.00000	1.000E+00
23	1987	0.000E+00	0.000E+00	--	*	1.151E+02	0.00000	1.000E+00
24	1988	0.000E+00	0.000E+00	--	*	1.009E+02	0.00000	1.000E+00
25	1989	0.000E+00	0.000E+00	--	*	1.071E+02	0.00000	1.000E+00
26	1990	1.000E+00	1.000E+00	--	6.580E+01	9.929E+01	-0.41138	1.000E+00
27	1991	1.000E+00	1.000E+00	--	8.240E+01	7.874E+01	0.04542	1.000E+00
28	1992	1.000E+00	1.000E+00	--	6.450E+01	7.338E+01	-0.12900	1.000E+00
29	1993	1.000E+00	1.000E+00	--	1.128E+02	5.263E+01	0.76237	1.000E+00
30	1994	1.000E+00	1.000E+00	--	1.064E+02	7.337E+01	0.37168	1.000E+00
31	1995	1.000E+00	1.000E+00	--	1.298E+02	1.117E+02	0.15042	1.000E+00
32	1996	1.000E+00	1.000E+00	--	1.343E+02	1.622E+02	-0.18890	1.000E+00
33	1997	1.000E+00	1.000E+00	--	2.229E+02	2.219E+02	0.00442	1.000E+00
34	1998	1.000E+00	1.000E+00	--	2.316E+02	2.731E+02	-0.16494	1.000E+00
35	1999	1.000E+00	1.000E+00	--	2.499E+02	3.147E+02	-0.23071	1.000E+00
36	2000	1.000E+00	1.000E+00	--	3.350E+02	3.382E+02	-0.00951	1.000E+00
37	2001	1.000E+00	1.000E+00	--	4.758E+02	3.487E+02	0.31088	1.000E+00
38	2002	1.000E+00	1.000E+00	--	3.397E+02	3.688E+02	-0.08217	1.000E+00
39	2003	1.000E+00	1.000E+00	--	3.683E+02	3.753E+02	-0.01870	1.000E+00
40	2004	1.000E+00	1.000E+00	--	3.747E+02	3.819E+02	-0.01904	1.000E+00
41	2005	1.000E+00	1.000E+00	--	3.427E+02	3.853E+02	-0.11729	1.000E+00
42	2006	1.000E+00	1.000E+00	--	3.055E+02	4.289E+02	-0.33931	1.000E+00
43	2007	1.000E+00	1.000E+00	--	4.824E+02	4.495E+02	0.07059	1.000E+00
44	2008	0.000E+00	0.000E+00	--	*	4.312E+02	0.00000	1.000E+00

* Asterisk indicates missing value(s).

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	--	*	1.531E+02	0.00000	1.000E+00
2	1966	0.000E+00	0.000E+00	--	*	1.555E+02	0.00000	1.000E+00
3	1967	0.000E+00	0.000E+00	--	*	1.544E+02	0.00000	1.000E+00
4	1968	0.000E+00	0.000E+00	--	*	1.505E+02	0.00000	1.000E+00
5	1969	0.000E+00	0.000E+00	--	*	1.445E+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	--	*	1.130E+02	0.00000	1.000E+00
8	1972	0.000E+00	0.000E+00	--	*	8.885E+01	0.00000	1.000E+00
9	1973	0.000E+00	0.000E+00	--	*	6.834E+01	0.00000	1.000E+00
10	1974	0.000E+00	0.000E+00	--	*	5.529E+01	0.00000	1.000E+00
11	1975	0.000E+00	0.000E+00	--	*	4.565E+01	0.00000	1.000E+00
12	1976	0.000E+00	0.000E+00	--	*	4.483E+01	0.00000	1.000E+00
13	1977	0.000E+00	0.000E+00	--	*	5.094E+01	0.00000	1.000E+00
14	1978	0.000E+00	0.000E+00	--	*	5.368E+01	0.00000	1.000E+00
15	1979	0.000E+00	0.000E+00	--	*	5.254E+01	0.00000	1.000E+00
16	1980	0.000E+00	0.000E+00	--	*	5.330E+01	0.00000	1.000E+00
17	1981	0.000E+00	0.000E+00	--	*	5.652E+01	0.00000	1.000E+00
18	1982	0.000E+00	0.000E+00	--	*	5.983E+01	0.00000	1.000E+00
19	1983	0.000E+00	0.000E+00	--	*	6.638E+01	0.00000	1.000E+00
20	1984	1.000E+00	1.000E+00	--	1.320E+02	7.143E+01	0.61407	1.000E+00
21	1985	1.000E+00	1.000E+00	--	8.500E+01	6.512E+01	0.26649	1.000E+00
22	1986	1.000E+00	1.000E+00	--	4.200E+01	4.940E+01	-0.16228	1.000E+00
23	1987	1.000E+00	1.000E+00	--	3.000E+01	3.951E+01	-0.27529	1.000E+00
24	1988	1.000E+00	1.000E+00	--	2.300E+01	3.532E+01	-0.42888	1.000E+00
25	1989	1.000E+00	1.000E+00	--	4.400E+01	3.416E+01	0.25306	1.000E+00
26	1990	1.000E+00	1.000E+00	--	2.700E+01	3.378E+01	-0.22417	1.000E+00
27	1991	1.000E+00	1.000E+00	--	2.750E+01	2.899E+01	-0.05287	1.000E+00
28	1992	0.000E+00	0.000E+00	--	*	2.491E+01	0.00000	1.000E+00
29	1993	0.000E+00	0.000E+00	--	*	2.044E+01	0.00000	1.000E+00
30	1994	0.000E+00	0.000E+00	--	*	2.054E+01	0.00000	1.000E+00
31	1995	0.000E+00	0.000E+00	--	*	3.005E+01	0.00000	1.000E+00
32	1996	0.000E+00	0.000E+00	--	*	4.466E+01	0.00000	1.000E+00
33	1997	0.000E+00	0.000E+00	--	*	6.289E+01	0.00000	1.000E+00
34	1998	0.000E+00	0.000E+00	--	*	8.136E+01	0.00000	1.000E+00
35	1999	0.000E+00	0.000E+00	--	*	9.671E+01	0.00000	1.000E+00
36	2000	0.000E+00	0.000E+00	--	*	1.074E+02	0.00000	1.000E+00
37	2001	0.000E+00	0.000E+00	--	*	1.129E+02	0.00000	1.000E+00
38	2002	0.000E+00	0.000E+00	--	*	1.180E+02	0.00000	1.000E+00
39	2003	0.000E+00	0.000E+00	--	*	1.223E+02	0.00000	1.000E+00
40	2004	0.000E+00	0.000E+00	--	*	1.244E+02	0.00000	1.000E+00
41	2005	0.000E+00	0.000E+00	--	*	1.261E+02	0.00000	1.000E+00
42	2006	0.000E+00	0.000E+00	--	*	1.341E+02	0.00000	1.000E+00
43	2007	0.000E+00	0.000E+00	--	*	1.445E+02	0.00000	1.000E+00
44	2008	0.000E+00	0.000E+00	--	*	1.445E+02	0.00000	1.000E+00

* Asterisk indicates missing value(s).

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	--	*	1.700E+02	0.00000	1.000E+00
2	1966	0.000E+00	0.000E+00	--	*	1.727E+02	0.00000	1.000E+00
3	1967	0.000E+00	0.000E+00	--	*	1.715E+02	0.00000	1.000E+00
4	1968	0.000E+00	0.000E+00	--	*	1.671E+02	0.00000	1.000E+00
5	1969	0.000E+00	0.000E+00	--	*	1.605E+02	0.00000	1.000E+00
6	1970	0.000E+00	0.000E+00	--	*	1.480E+02	0.00000	1.000E+00
7	1971	0.000E+00	0.000E+00	--	*	1.256E+02	0.00000	1.000E+00
8	1972	0.000E+00	0.000E+00	--	*	9.870E+01	0.00000	1.000E+00
9	1973	0.000E+00	0.000E+00	--	*	7.591E+01	0.00000	1.000E+00
10	1974	0.000E+00	0.000E+00	--	*	6.142E+01	0.00000	1.000E+00
11	1975	0.000E+00	0.000E+00	--	*	5.071E+01	0.00000	1.000E+00
12	1976	0.000E+00	0.000E+00	--	*	4.980E+01	0.00000	1.000E+00
13	1977	0.000E+00	0.000E+00	--	*	5.659E+01	0.00000	1.000E+00
14	1978	0.000E+00	0.000E+00	--	*	5.963E+01	0.00000	1.000E+00
15	1979	0.000E+00	0.000E+00	--	*	5.836E+01	0.00000	1.000E+00
16	1980	0.000E+00	0.000E+00	--	*	5.921E+01	0.00000	1.000E+00
17	1981	0.000E+00	0.000E+00	--	*	6.279E+01	0.00000	1.000E+00
18	1982	0.000E+00	0.000E+00	--	*	6.646E+01	0.00000	1.000E+00
19	1983	0.000E+00	0.000E+00	--	*	7.373E+01	0.00000	1.000E+00
20	1984	0.000E+00	0.000E+00	--	*	7.935E+01	0.00000	1.000E+00
21	1985	0.000E+00	0.000E+00	--	*	7.233E+01	0.00000	1.000E+00
22	1986	0.000E+00	0.000E+00	--	*	5.488E+01	0.00000	1.000E+00
23	1987	0.000E+00	0.000E+00	--	*	4.389E+01	0.00000	1.000E+00
24	1988	0.000E+00	0.000E+00	--	*	3.923E+01	0.00000	1.000E+00
25	1989	0.000E+00	0.000E+00	--	*	3.795E+01	0.00000	1.000E+00
26	1990	0.000E+00	0.000E+00	--	*	3.753E+01	0.00000	1.000E+00
27	1991	0.000E+00	0.000E+00	--	*	3.221E+01	0.00000	1.000E+00
28	1992	0.000E+00	0.000E+00	--	*	2.767E+01	0.00000	1.000E+00
29	1993	0.000E+00	0.000E+00	--	*	2.271E+01	0.00000	1.000E+00
30	1994	0.000E+00	0.000E+00	--	*	2.282E+01	0.00000	1.000E+00
31	1995	1.000E+00	1.000E+00	--	9.300E+00	3.338E+01	-1.27795	1.000E+00
32	1996	1.000E+00	1.000E+00	--	4.330E+01	4.961E+01	-0.13600	1.000E+00
33	1997	1.000E+00	1.000E+00	--	3.870E+01	6.986E+01	-0.59071	1.000E+00
34	1998	1.000E+00	1.000E+00	--	1.226E+02	9.037E+01	0.30498	1.000E+00
35	1999	1.000E+00	1.000E+00	--	1.970E+02	1.074E+02	0.60639	1.000E+00
36	2000	1.000E+00	1.000E+00	--	1.447E+02	1.193E+02	0.19290	1.000E+00
37	2001	1.000E+00	1.000E+00	--	1.827E+02	1.254E+02	0.37617	1.000E+00
38	2002	1.000E+00	1.000E+00	--	1.485E+02	1.310E+02	0.12507	1.000E+00
39	2003	1.000E+00	1.000E+00	--	1.368E+02	1.358E+02	0.00713	1.000E+00
40	2004	1.000E+00	1.000E+00	--	1.700E+02	1.382E+02	0.20692	1.000E+00
41	2005	1.000E+00	1.000E+00	--	1.565E+02	1.400E+02	0.11105	1.000E+00
42	2006	1.000E+00	1.000E+00	--	1.601E+02	1.490E+02	0.07211	1.000E+00
43	2007	1.000E+00	1.000E+00	--	1.607E+02	1.605E+02	0.00109	1.000E+00
44	2008	0.000E+00	0.000E+00	--	*	1.605E+02	0.00000	1.000E+00

* Asterisk indicates missing value(s).

ESTIMATES FROM BOOTSTRAPPED ANALYSIS

Param name	Point estimate	Estimated bias in pt estimate	Estimated relative bias	Bias-corrected approximate confidence limits 80% lower	80% upper	50% lower	50% upper	Inter-quartile range	Relative IQ range
B1/K	8.676E-01	-5.646E-02	-6.51%	3.922E-01	1.017E+00	7.572E-01	9.355E-01	1.783E-01	0.206
K	1.472E+02	5.438E+00	3.70%	1.355E+02	1.700E+02	1.411E+02	1.543E+02	1.320E+01	0.090
q(1)	3.372E+00	-1.031E-02	-0.31%	2.964E+00	3.791E+00	3.160E+00	3.583E+00	4.237E-01	0.126
q(2)	9.965E-01	2.915E-03	0.29%	8.203E-01	1.139E+00	8.958E-01	1.068E+00	1.726E-01	0.173
q(3)	3.581E+00	-2.392E-02	-0.67%	3.119E+00	4.053E+00	3.351E+00	3.841E+00	4.898E-01	0.137
q(4)	1.176E+00	-1.211E-02	-1.03%	9.956E-01	1.419E+00	1.096E+00	1.306E+00	2.101E-01	0.179
q(5)	1.307E+00	-6.097E-03	-0.47%	1.156E+00	1.525E+00	1.238E+00	1.423E+00	1.852E-01	0.142
MSY	1.882E+01	3.088E-01	1.64%	1.777E+01	1.951E+01	1.821E+01	1.904E+01	8.337E-01	0.044
Ye(2009)	1.119E+01	3.081E-01	2.75%	1.063E+01	1.226E+01	1.081E+01	1.158E+01	7.642E-01	0.068
Y.@Fmsy	3.080E+01	3.738E-01	1.21%	2.783E+01	3.288E+01	2.928E+01	3.168E+01	2.402E+00	0.078
Bmsy	7.358E+01	2.719E+00	3.70%	6.777E+01	8.501E+01	7.053E+01	7.713E+01	6.599E+00	0.090
Fmsy	2.557E-01	-2.452E-03	-0.96%	2.208E-01	2.891E-01	2.383E-01	2.722E-01	3.398E-02	0.133
fmsy(1)	7.583E-02	-1.825E-04	-0.24%	6.606E-02	8.327E-02	7.024E-02	7.964E-02	9.397E-03	0.124
fmsy(2)	2.566E-01	-1.308E-03	-0.51%	2.339E-01	2.958E-01	2.444E-01	2.802E-01	3.584E-02	0.140
fmsy(3)	7.142E-02	3.229E-04	0.45%	6.241E-02	8.399E-02	6.741E-02	7.703E-02	9.611E-03	0.135
fmsy(4)	2.174E-01	2.498E-03	1.15%	1.895E-01	2.508E-01	2.022E-01	2.351E-01	3.284E-02	0.151
fmsy(5)	1.957E-01	9.121E-04	0.47%	1.689E-01	2.329E-01	1.811E-01	2.155E-01	3.445E-02	0.176
B./Bmsy	1.637E+00	-7.976E-03	-0.49%	1.565E+00	1.673E+00	1.602E+00	1.657E+00	5.510E-02	0.034
F./Fmsy	4.936E-01	-2.812E-03	-0.57%	4.618E-01	5.478E-01	4.792E-01	5.210E-01	4.188E-02	0.085
Ye./MSY	5.945E-01	7.868E-03	1.32%	5.477E-01	6.804E-01	5.688E-01	6.377E-01	6.891E-02	0.116
q2/q1	2.955E-01	3.468E-03	1.17%	2.353E-01	3.368E-01	2.607E-01	3.121E-01	5.140E-02	0.174
q3/q1	1.062E+00	5.655E-04	0.05%	9.360E-01	1.209E+00	9.955E-01	1.139E+00	1.437E-01	0.135
q4/q1	3.488E-01	-6.084E-04	-0.17%	2.907E-01	4.138E-01	3.175E-01	3.816E-01	6.411E-02	0.184
q5/q1	3.875E-01	9.291E-04	0.24%	3.344E-01	4.344E-01	3.554E-01	4.113E-01	5.589E-02	0.144

INFORMATION FOR REPAST (Prager, Porch, Shertzer, & Caddy. 2003. NAJFM 23: 349-361)

Unitless limit reference point in F (Fmsy/F.):	2.026
CV of above (from bootstrap distribution):	0.7170E-01

NOTES ON BOOTSTRAPPED ESTIMATES:

- Bootstrap results were computed from 500 trials.
- Results are conditional on bounds set on MSY and K in the input file.
- All bootstrapped intervals are approximate. The statistical literature recommends using at least 1000 trials for accurate 95% intervals. The default 80% intervals used by ASPIC should require fewer trials for equivalent accuracy. Using at least 500 trials is recommended.
- Bias estimates are typically of high variance and therefore may be misleading.

Trials replaced for lack of convergence:	0	Trials replaced for MSY out of bounds:	0
Trials replaced for q out-of-bounds:	0		
Trials replaced for K out-of-bounds:	0	Residual-adjustment factor:	1.0589

Elapsed time: 1 hours, 0 minutes, 13 seconds.