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An Assessment of Greenland Halibut in Subarea 2 + Divisions 3KLMNO, with Projections under the Fisheries Commission Rebuilding Plan

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Abstract

Using Extended Survivors Analysis (XSA), estimates of stock status of Greenland Halibut in Subarea 2 and Divisions 3KLMNO are updated using the most recent catches and survey information. Results indicate that exploitable (ages 5+) biomass is estimated to be the lowest in the time series, and that the current estimate of average fishing mortality is the highest in the time series. Sensitivity analyses were conducted to examine the robustness of the assessment to the XSA shrinkage parameters. Inclusion of the Div. 3NO Spanish survey data to the calibration dataset was evaluated, but this index was not included in the final run due to the residual patterns over time. Estimates of stock status were also produced using ADAPT software, and were found to be generally consistent with the results from the XSA analyses.

Projections conducted using the TACs specified by the Fisheries Commission rebuilding plan indicated that prospects for stock rebuilding are currently poor. Projection results indicate that by 2008, the 5+ biomass will not have recovered to the level estimated for 2003, the year in which the rebuilding plan was established.

Introduction

Recent assessments of Greenland Halibut in Subarea 2 and Div. 3KLMNO have been based on the application of the Extended Survivors Analysis model (XSA; Shepherd, 1999) fitted within the Lowestoft assessment suite (Darby and Flatman, 1994). Results of the 2004 NAFO Scientific Council assessment of the state of the stock indicated that the exploitable biomass was at the lowest level in the time series and that fishing mortality had increased substantially in recent years (NAFO 2004, Darby *et al*., 2004). The 2004 assessment also included analyses of stock status using the ADAPTive framework (ADAPT, Gavaris 1988) and also estimates from a production model, ASPIC (Prager, 1994). The XSA model accepted by the Scientific Council was used as a basis for projections and provision of advice. We re-evaluate the status of the stock using the most recent stock surveys and catches. The results from the 2004 XSA model are compared with estimates derived from a variety of alternative XSA and ADAPT formulations. In all analysis, the 2004 catch is set at 25 486 tons, the 2004 STACFIS estimate of removals (NAFO, 2004).

Deterministic and stochastic projections are utilized to evaluate the recovery prospects for this stock under the Fisheries Commission rebuilding plan (NAFO, 2003).

Input Data

Catches

Catches increased from low levels in the early 1960s when the fishery began to over 36 000 tons in 1969, ranged from 18 000 tons to 39 000 tons until 1990 (Fig. 1), when an extensive fishery developed in the deep water of the NAFO Regulatory Area (Bowering and Brodie, 1995). The total catch estimated by STACFIS for 1990-94 was in the range of 47 000 to 63 000 tons annually, although estimates in some years were as high as 75 000 tons. Beginning in 1995, TACs for the resource were established for the whole stock areal distribution by the Fisheries Commission, and the catch declined to just over 15 000 tons in 1995, a reduction of about 75% compared to the average annual catch of the previous 5 years. The catch from 1996-98 was around 20 000 tons per year. Catches have been increasing since then and by 2001 had reached 38 000 tons before declining to 34 000 tons in 2002. For the 9 years preceding the Fisheries Commission rebuilding plan, the catch has achieved the TAC in only one year. In 2003, the total catch was estimated to be within the range 32 000 tons to 38 500 tons. The STACFIS estimate of catch for 2004 was 25 486 tons.

Fisheries Commission established a fifteen year re-building plan for this stock, in which TACs were set at 20, 19, 18.5, 16 ('000 tons), respectively, for the years 2004-07 (Fig. 1). Subsequent TAC levels “shall not be set at levels beyond 15% less or greater than the TAC of the preceding year” (NAFO, 2003). The estimated catch for 2004 represents a 27% over-run of the 2004 TAC.

Catch at age

The 2004 length sampling provided by EU-Portugal (Vargas *et al*., 2005), EU-Spain (González *et al*., 2005), and Russia (Vaskov *et al*., 2005) are quite similar, all indicating a modal catch length of about 40-44 cm. However, available age-length keys highlight the difference between Spanish and Canadian age interpretations (Alpoim *et al*., 2002; Darby *et al*., 2003). At a given age, the Spanish data have greater mean lengths than Canadian data. Until the differences can be resolved, Canadian age-length keys were applied in place of the Spanish age-length keys. Recent research suggests that despite these inconsistencies, the Canadian, EU and Russian age determination methods may be substantially underestimating ages (Treble *et al*., 2005).

Computation of Canadian catch-at-age is described by Brodie and Power (2005). Samples from the Canadian fishery were used to derive catch-at-age independently for each gear (see Table 5 of Brodie and Power, 2005). The 1997 year-class (age 7 in 2004) dominated the Canadian catch.

Russian aging was similar to Spanish aging, indicating a modal catch at age 6 for 2003. Therefore, the Russian catch was also derived by age using Canadian sampling data. The Portuguese length samples are also converted to catch-at-age using Canadian aging data as no aging data from EU-Portugal from 2004 catches are available.

No sampling data are available for the 2004 catches by EU-Latvia, EU-Estonia, Japan, and the Faroe Islands (EU-Denmark) (2 437 tons combined catch), operating in the NRA. A catch at age was developed for these fleets under the assumption that the age-composition was similar to that of the combined Spanish, Portuguese and Russian catches.

The catch numbers-at-age for 1975-2004 are given in Table 1. As in the recent past, in 2004 the modal catch was at age 7, corresponding to the 1997 year-class. Catch weights at age (Table 2) are computed as weighted means of the values from national sampling, and indicate no trends over time.

Survey Indices

Five survey series were available as age disaggregated catch per unit effort (Table 3):

a) EU 3M - a European Union summer survey in Div. 3M from 1991–2004, ages 1 – 12 (Casas and González Troncoso, 2005).

b) Can 2J+3K autumn survey, Engel series converted to Campelen data from 1978 to 1994, ages 1 to 16 (Dwyer and Healey, 2005).
c) Can 2J+3K autumn survey, true Campelen data from 1995 to 2003, ages 1 to 14 (Dwyer and Healey, 2005).

d) Can 3LNO spring survey, true Campelen data from 1996 to 2002, ages 1 to 8 (Dwyer and Healey, 2005).

e) EU-Spain 3NO – Spanish summer survey in Divisions 3NO from 1997-2004, ages 1-13 (González Troncoso *et al.*, 2005)

The EU 3M series was revised in 2005 (González Troncoso and Casas, 2005) to account for a vessel change during the time series.

Darby *et al.* (2003) examined the consistency within and between the EU and Canadian age disaggregated survey series covering different portions of the stock area. González-Castos and González Troncoso (2005) discuss this in detail and also examine the correlation of the index data against estimates of population numbers at age. The results indicated good agreement between and within surveys in the most recent time period, although there are certain survey-ages that are of concern.

A Russian survey series in Div. 3M contains information on Greenland halibut (Vaskov and Igashov, 2003), but is not suitable for input to the assessment model. This survey series was last updated in 2003. The series cannot be used to evaluate trends in stock abundance because the data for the years 2001 and 2002 are not comparable with those collected from 1987-1996 due to vessel changes and substantial changes to the area and depth coverage.

Results and Discussion

<u>Canadian Autumn Survey Index</u>

Due to the problems experienced with the Canadian multi-species survey in the autumn of 2004 (see Brodie, (2005) for detailed discussion), particularly in Div. 3LNO, Healey and Dwyer (2005) argue that the survey results for Greenland Halibut in 2004 are not comparable to those in prior years. It is thus necessary to remove the Canadian 2J+3KL series from the calibration dataset, and replace it with the Canadian 2J+3K data. To gauge the effect of this change on the current assessment of stock status, we have recomputed estimates of stock size using the 2004 assessment dataset and XSA settings (see Darby et al., 2004), but replacing the Canadian autumn 2J+3KL with the Canadian autumn 2J+3K index.

Figure 2 contains comparison plots of Recruitment (age1), 5+ and 10+ biomass, and average fishing mortality (5-10) are presented.

Results indicate virtually no change in perceptions of stock status, with the exception of the 10+ biomass – there is some change to age composition at oldest ages. It is noteworthy that recruitment and 5+ biomass are stable, thus projections conducted in last assessment and the resulting advice would be consistent with projections from a 2004 assessment which includes the 2J+3K index.

<u>XSA estimates using updated catch, survey data</u>

Following this exercise, we conduct an XSA assessment having the same settings as the agreed 2004 run, with an additional year of survey data (2J+3K autumn, 3LNO Spring, and EU 3M) and the 2004 catch at age. Note that this run implicitly combines the effect of replacing the 2J+3KL series with the 2J+3K, and also the effect of using the revised EU 3M data, which have been converted to account for vessel changes (González Troncoso and Casas, 2005). Estimated recruitment, 5+ biomass, 10+ biomass and average fishing mortality are presented in Fig. 3a-d. Note that the marked increase in average fishing mortality estimated in the previous assessment for the fishing year 2003 has been sustained into 2004; consequently, the exploitable biomass has decreased. In addition to these summary figures, we also present the XSA estimated age composition , estimated catchabilities (Q), the standard error of Log(Q), and also the scaled weights used to compute the estimates of survivors at each age (Figures 3e-h, respectively) of the estimated population. Darby and Flatman (1994) suggest that Log(Q) standard errors in excess of 0.5 are indicative of poor fit. In this analysis, the Log(Q) standard errors are quite high for several index-ages, and exceeds 1 for age 8 in the spring Div. 3LNO series, age 12 for the EU 3M data, and age 13 in the autumn Div. 2J+3K series.

Residual graphics are also presented for the 2005 run[1]. Bubble plots for each series, and plots of annual trends are in Fig. 4. In these plots, we see evidence of poor model fit: trends in the residuals along the cohorts, plus possible year-effects in some of the surveys. However, we note that these patterns are consistent with those that have been observed in the results from recent VPA analyses for this stock. Note that each of the Canadian Div. 2J+3K index at age 12, the Canadian Div. 3LNO index at age 8, and the EU 3M index at age 12 have a mean squared residual in excess of one.

Evaluation of EU-Spain 3NO data as potential calibration index

Next, we consider the addition of the Spanish Div. 3NO data series (González Troncoso *et al*., 2005) to the calibration indices. We note that the Spanish survey covers just a small portion of the overall stock area; however, this index has generally been consistent with other survey series throughout the stock area. In the following analyses, we include ages 1-13 from the Spanish Div. 3NO index.

We first consider a screening analysis to examine the Spanish Div. 3NO index. In this screening analysis, an XSA analysis including only the Spanish Div. 3NO series and the catch data was produced. Shrinkage is not used. We present only the residuals (Fig. 5) from this fit as a method to diagnose problems with the index prior to including it in an XSA run with the other indices. As seen in Figure 5, there are problems at the oldest ages. Further, most residuals are positive in the early years of this index, and conversely, most residuals are negative in the later years. The mean annual residual exhibits a declining trend over time. We note that the Spanish survey in Div. 3NO has been converted to account for a 2001 vessel change (González Troncoso *et al*., 2005), which may explain at least part of this trend.

Following this exploratory analysis, we consider an XSA run using the three data series as in the previous run, and also include the Spanish Div. 3NO survey series. The shrinkage settings from the previous analysis are unchanged (i.e. shrinkage parameters fixed at 0.5). The assessment settings and output (diagnostics and summary) are presented in Table 4. The trends in the assessment remain unaffected given the inclusion of the Spanish index (Fig. 6). Addition of the Spanish Div. 3NO series increases the estimates of recent recruitment, but estimates of the exploitable biomass, 10+ biomass, and average fishing mortality are quite similar. In both analyses, fishing mortality has increased substantially the past two years, and estimated biomass is estimated as the lowest in the time series. Notice that the XSA results with the Spanish data included indicate slightly higher estimates of recent fishing mortality.

Figures 6e-6h present the age composition of the population, the XSA catchability estimates and associated standard errors, and also the scaled weights used to produce survivor estimates. For estimates of scaled weights (used to compute log(survivors) at each age), we note that with the addition of another tuning index, the impact of shrinkage is reduced. In the previous XSA run, the F-shrinkage estimates of survivors (Fig. 3h) receive between 35-45% of the overall weight. In this run, the F-shrinkage contribution for the older ages (Fig. 6h) is now reduced to 25-35%. The reduced impact of the F-shrinkage leads to the increased estimate of average fishing mortality in 2004 observed in Fig. 6d.

Residual graphics for this run are given in Fig. 7. The residual trends noted in the previous run remain for those three input series; for the Spanish Div. 3NO series, there are consistently large residuals at the oldest two ages; also the mean squared residual for this index is high for ages 2, 12, and 13. In addition, most of the residuals from 1997-99 are positive, whereas the majority of residuals in the most recent period are negative.

Sensitivity Analysis

Next, we consider the effect of varying the shrinkage options in the XSA to examine the robustness of the results to varied shrinkage options. Exploratory XSA analyses for this stock in previous assessments have concluded that

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[1] R script (R software freely available at: www.r-project.org) for plotting XSA residuals available from the lead author upon request.

some degree of shrinkage is advisable. In addition to setting the shrinkage parameters at 0.5, we explore the effect of setting the shrinkage parameter (for both shrinkage towards the mean F in previous years and also shrinkage of the oldest age towards the mean F of previous ages) at 0.8; i.e. weaker shrinkage. Given the recent increasing trend in average fishing mortality, it is possible that the assessment is sensitive to the amount of shrinkage incorporated into the XSA. This comparison was investigated for two tuning datasets: one including the Spanish Div. 3NO index (see "+SP" series in Fig. 8) and another without the Spanish data. We present the sensitivity analysis results in Fig. 8 for exploitable biomass, recruitment at age 1, and average fishing mortality, and compare these to the result from the previous analysis.

Estimates of biomass are highly consistent for all runs; with one small difference. Although the trend in estimated biomass is identical, the analysis with decreased shrinkage (0.8) including the Spanish data suggests an increased exploitable biomass over 1995-2001. Note that all runs conducted in the current assessment suggest a peak biomass one year later than the peak estimated in the 2004 assessment (1991 and 1990, respectively). This is consistent with the result observed in the initial analysis using the revised EU Div. 3M index and the Canadian Div. 2J+3K index (see Fig. 3b).

The estimated recruitment for both analyses including the Spanish data are consistent with the estimates from the 2004 assessment. The current year runs excluding the Spanish data estimate lower recruitment in 2003 and 2004. It is noteworthy that the 1993-95 year-classes are consistent in this sensitivity analysis – such marked increases in recruitment have typically been problematic with respect to retrospective analyses in past assessments. Inclusion of the Spanish time series does not alter the estimates of these year-classes.

The average fishing mortality is also broadly consistent across the runs examined. However, we note two differences: the low shrinkage run including the Spanish data estimates slightly lower average *F* from 1993 to 1999. Secondly, as expected, the estimated fishing mortality in 2004 is higher in the low shrinkage runs (0.8).

<u>ADAPT</u>

In addition to the XSA analyses, several ADAPT (Gavaris, 1988) formulations were explored. Results of all explorations were consistent with the XSA results: average *F* has increased substantially in recent years, and the current exploitable biomass is estimated to be at an all time low.

All indices are equally weighted in the ADAPT results presented below (unlike the XSA which uses inverse-variance weighting). An ADAPT analysis (not shown) which included self-weighting of the indices indicated no discernable difference in results.

In the XSA software, catch data in the plus group is not used in the tuning algorithm. Population numbers in the plus group are derived by assuming that the plus group fishing mortality equals the fishing mortality on last true age, deriving the numbers from the catch equation:

$$C_t = \frac{F_t}{N_t}(1 - e^{-Z_t}).$$

Within the ADAPT software, there are two methods used to handle analyses which include a plus group. The "FIRST" and "FRATIO" methods are the two methods used to construct the fishing mortality constraints to determine the cohorts for which survivors are not estimated. Below, we fully describe these constraints for this application.

<u>Plus group method "FIRST"</u>

When using the FIRST plus-group method of ADAPT, the fishing mortality (or population abundance) of the plus group (ages 14 and older) is specified in the first year only (i.e. 1975). For all subsequent cohorts, an *F*-constraint on the oldest true age (age 13) is applied. From this, the plus group abundance for this cohort can be computed. The following equations formalize this concept; note that $Z_{a,t} = F_{a,t} + M_{a,t}$, where a and t represent subscripts for age and year, respectively.

$$N_{14+,1976} = N_{13,1975} \cdot e^{-Z_{13,1975}} + N_{14+,1975} \cdot e^{-Z_{14+,1975}} \text{, where}$$

$$N_{13,1976} = N_{12,1975} \cdot e^{-Z_{12,1975}} .$$

Plus group method "FRATIO"

Using the FRATIO method, all cohorts in the terminal time period (year 2005) must be specified, including the plus group. *F* for the plus-group is derived as a ratio of the last true age *F* that can be assigned or estimated. In this method, the catch data in the last true age and in the plus group is used in the estimation of the last true age *F*. More formally, we have:

$$F_{13,2004} = F_{13+,2004} \frac{\left[C_{14+,2004} + \alpha \cdot C_{13,2004}\right]}{\alpha \cdot C_{13+,2004}} \text{, and subsequently,}$$

$$N_{13,2004} = C_{13,2004} \cdot \frac{\left[F_{13,2004} + M_{13,2004}\right]}{F_{13,2004}\left(1 - e^{-\left(F_{13,2004} + M_{13,2004}\right)}\right)} .$$

Additional details can be found in Gavaris (MS, 1988) or from the on-line help of the ADAPT software.

We present comparative plots of three ADAPT analyses: (a) an analysis including the EU Div. 3M index, and the Canadian spring (Div. 3LNO) and autumn (Div. 2J+3K) indices using the FIRST plus group method, (b) an analysis using the same data but applying the FRATIO plus group method, and (c) an analysis identical to run (b), but we add the Spanish index (ages 1-13) to the calibration dataset. The ADAPT results are also compared to the previously presented XSA analysis which includes the 3NO Spanish series, with shrinkage parameters fixed at 0.5. Note that fundamental differences exist between the two methods in the treatment of the available data. The exploitable biomass, age 1 recruitment and average fishing mortality results are presented in Fig. 9. In the figures, the series labeled "$F_{13} = F_{bar}$(10-12)" uses the FIRST plus-group method, with fishing mortality on age 13 assumed to be equal to the average of that ages 10-12 from 1975-2004. For both FRATIO runs, the fishing mortality on the plus group is assumed equal to the fishing mortality on the last true age, for all years. Parameter estimates for the FRATIO run (with Spanish Div. 3NO index included) are presented in Table 5.

Trends in exploitable biomass, recruitment and average fishing mortality are consistent across methods. For the exploitable biomass, the two FRATIO analyses have almost identical estimates of 5+ biomass throughout the time series. However, the ADAPT FIRST run and XSA estimates of biomass are in close agreement at levels that are somewhat higher than the FRATIO results. The ADAPT FIRST and XSA results are similar as both methods do not use catch data from the plus group and in this analysis, for most ages, fleets estimates of survivors are given similar weights, close to the equal weighting used in ADAPT. The FRATIO ADAPT method uses additional information (catch in the plus group) which affects estimates of survivors.

Estimates of recruitment are quite consistent over time. In the recent period, 1999-2004, the XSA recruitment is estimated to be larger than the ADAPT estimates, which is consistent with the previous assessment (Darby *et al.*, 2004). Shelton (2005) provides additional discussion on this point and the impact on stock projections. Further, the ADAPT analysis which includes the Spanish data (and the XSA including Spanish series) suggests much larger recruitment than the two runs which exclude the Spanish data.

Fishing mortality estimates are different over time, yet have very similar patterns. We note the ADAPT estimates are higher than those of the XSA, with discrepancies more pronounced in 2004, due to the effect of the F-shrinkage in XSA (no shrinkage in ADAPT).

To illustrate residual patterns from the ADAPT analyses, Fig. 10 presents the residuals for the "Fratio+Spain" ADAPT run. Trends are very similar to those in the XSA analysis (e.g. Fig. 7b). As in the XSA run, the Div. 2J+3K age 13, Div. 3LNO age 8, and Spain Div. 3NO age 13 residuals indicate poor fit. The fit of the Spanish age 12 data is much improved, driven largely by the lower residual for the 2000 summer survey.

Final Run

Based upon the analyses previously presented, and the investigations of González-Costas and González (2005), an additional XSA analysis was considered. All XSA settings used in the previous analysis (see "XSA estimates using updated catch, survey data") were unchanged.

In this analysis, the Spanish 3NO index was excluded due to the general decreasing trend in the residuals over time (see Fig. 5). However, this index will be considered in future assessments to evaluate the feasibility of including the data to the calibration dataset. In addition, given that the coverage of the 1995 Canadian autumn was poor (Brodie (2005) documents the coverage intensity) and the model fit to this survey-year is poor (Fig. 4a, 4b), it was decided to exclude the 1995 Canadian autumn survey data from the final analysis.

A listing of settings and diagnostics of this final run are given in Table 6, as are estimates of survivors, fishing mortality at age, numbers at age, and the XSA stock summary table.

Figures 11a-d presents the estimates of recruitment, 5+ biomass, 10+ biomass and average fishing mortality. Results are quite similar to those presented in the previous analysis, which included the 1995 Canadian autumn data, but did not include the Spanish Div. 3NO data (see Fig. 3a-d). The XSA estimated age composition, estimated catchabilities (Q), the standard error of Log(Q), and also the scaled weights used to compute the estimates of survivors at each age of the estimated population are presented in Figures 11e-h. We note that by excluding the 1995 data from the Canadian autumn dataset, the SE(Log(q)) for this index is much reduced at the older ages. Consequently, the weights used to compute survivor estimates (Fig. 11h) have a higher contribution from this index for the older ages.

Residual graphics are presented for the final XSA run in Fig. 12. Again, the trends and patterns here are similar to those described in Fig. 4: trends in the residuals along the cohorts, plus possible year-effects in some of the surveys. Nonetheless, the Log(Q) standard errors are still relatively large, but in this run, only the SE(Log(Q)) for age 8 in the spring Div. 3LNO series exceeds 1.

Retrospective Analysis

A retrospective analysis was conducted for the final XSA formulation (Spanish survey series excluded and with both shrinkage parameters fixed at 0.5). Figure 13 presents the results of three years of retrospective XSA results. Estimates of 5+ biomass have been quite consistent; however, with the exclusion of three years of survey and catch data, a substantial change in 5+ biomass is observed. Retrospective patterns in estimates of recruitment have been problematic in previous assessments of this stock. In general, the recruitment estimates have been revised upwards as additional data is included in the model. Trends are evident in the retrospective estimates of fishing mortality, with revisions to the estimates for the early 1990s, and to the most recent estimates as additional data is included.

Projections

Using the XSA "final run" estimates, deterministic and stochastic projections of stock size were conducted.

As noted previously, the Fisheries Commission has implemented a 15-year rebuilding plan for this resource by instituting an exploitable biomass target (ages 5+) of 140 000 tons (NAFO, 2003). As an initial step, the Fisheries Commission established TACs of 20 000, 19 000, 18 500, and 16 000 tons for 2004-2007, respectively. In order to evaluate the population trends under the established TACs, deterministic and stochastic projections were conducted assuming current exploitation pattern and weights-at-age (2001 to 2003 average), and with natural mortality fixed at 0.2.

Attention is to be drawn on the fact that, as discussed by Patterson *et al.* (2000), current bootstrapping and stochastic projection methods generally underestimate uncertainty. The percentiles are therefore presented as relative measures of the risks associated with the current harvesting practices. They should not be taken as representing the actual probabilities of eventual outcomes.

The projection inputs are summarized in Table 7a with the variability in the projection parameters for the stochastic projections described by the coefficients of variation (column CV in the table). Numbers at age 2 and older at 1st of January 2005 and corresponding CVs are computed from the XSA output. Recruitment was bootstrapped from the 1975-2001 age 1 numbers from the XSA. Scaled selection pattern and corresponding CVs are derived from the 2002 to 2004 average from the XSA. Weights at age in the stock and in the catch and corresponding CVs are computed from the 2002-2004 average input data. Natural mortality was assumed to be 0.2 with a CV of 0.15 and a CV of 0.05 was assumed for the implementation of the management plan. The stochastic distributions were generated using @Risk software. The distribution was assumed lognormal for the numbers at age and normal for the other input data.

Deterministic projections were conducted assuming a future recruitment value of the 1996-2001 geometric mean from XSA estimates. Results indicate that although there is improvement in the 5+ biomass from the 2005 estimate (Fig. 14a), the projected biomass for 2008 remains below the level of 2003, when the FC rebuilding plan was implemented. Projected average fishing mortality (Fig. 14b) indicates a reduction in average F under the rebuilding plan TACs from 2005 to 2007.

The results of the stochastic projection (average fishing mortality, 5+ biomass and 10+ biomass) are plotted in Fig. 15, and projection results are in Table 7b. The trend in ages 10+ biomass is presented to illustrate the short term development of older portion of the population and should not be considered to represent SSB which is not precisely known.

Under the current management plan, the population 5+ biomass is expected to slowly increase until 2008. The deterministic projections suggest that the projected 2008 biomass (68 000 tons) will have not recovered to the level estimated in 2003 (approximately 80 000 tons). Further, the stochastic projections indicate that there is a low probability (less than 15%) of the 5+reaching the 2003 level by 2008. The exploitable 10+ biomass is expected to decrease by 45% (Table 7b).

Reference Points

Precautionary approach reference points have not previously been defined for this stock. Several of the standard approaches typically available for age-disaggregated assessments are not applicable for this stock given the difficulties in determining the spawner biomass (or appropriate proxy). Limit reference points could not be determined for this stock at this time.

Based on average weights and partial recruitment for the past 3 years, F_{Max} = 0.24 and $F_{0.1}$ = 0.14. The estimate of average fishing mortality (ages 5-10) for 2004 from the final run is on the order of 0.7, almost three times the F_{Max} level.

Conclusion

For all XSA and ADAPT analyses considered, results lead to the same conclusions of stock status: current estimates of exploitable biomass are at an all-time low, and fishing mortality has increased substantially in recent years, and is currently the highest estimate in the time series. Recent estimates of recruitment are below average, but suggest an improving trend from 1998-2003. The most recent estimate of recruitment is poor.

Deterministic and stochastic projections indicate that under the Fisheries Commission rebuilding plan, prospects for stock rebuilding are currently poor. Projection results indicate that by 2008, the 5+ biomass will not have recovered to the level estimated for 2003, the year in which the rebuilding plan was established.

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Table 1. Catch at age (000s).

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1975	0	0	0	0	334	2819	5750	4956	3961	1688	702	135	279	288
1976	0	0	0	0	17	610	3231	5413	3769	2205	829	260	101	53
1977	0	0	0	0	534	5012	10798	7346	2933	1013	220	130	116	84
1978	0	0	0	0	2982	8415	8970	7576	2865	1438	723	367	222	258
1979	0	0	0	0	2386	8727	12824	6136	1169	481	287	149	143	284
1980	0	0	0	0	209	2086	9150	9679	5398	3828	1013	128	53	27
1981	0	0	0	0	863	4517	9806	11451	4307	890	256	142	43	69
1982	0	0	0	0	269	2299	6319	5763	3542	1684	596	256	163	191
1983	0	0	0	0	701	3557	9800	7514	2295	692	209	76	106	175
1984	0	0	0	0	902	2324	5844	7682	4087	1259	407	143	106	183
1985	0	0	0	0	1983	5309	5913	3500	1380	512	159	99	87	86
1986	0	0	0	0	280	2240	6411	5091	1469	471	244	140	70	117
1987	0	0	0	0	137	1902	11004	8935	2835	853	384	281	225	349
1988	0	0	0	0	296	3186	8136	4380	1288	465	201	105	107	129
1989	0	0	0	0	181	1988	7480	4273	1482	767	438	267	145	71
1990	0	0	0	95	1102	6758	12632	7557	4072	2692	1204	885	434	318
1991	0	0	0	220	2862	7756	13152	10796	7145	3721	1865	1216	558	422
1992	0	0	0	1064	4180	10922	20639	12205	4332	1762	1012	738	395	335
1993	0	0	0	1010	9570	15928	17716	11918	4642	1836	1055	964	401	182
1994	0	0	0	5395	16500	15815	11142	6739	3081	1103	811	422	320	215
1995	0	0	0	323	1352	2342	3201	2130	1183	540	345	273	251	201
1996	0	0	0	190	1659	5197	6387	1914	956	504	436	233	143	89
1997	0	0	0	335	1903	4169	7544	3215	1139	606	420	246	137	89
1998	0	0	0	552	3575	5407	5787	3653	1435	541	377	161	92	51
1999	0	0	0	297	2149	5625	8611	3793	1659	623	343	306	145	151
2000	0	0	0	271	2029	12583	21175	3299	973	528	368	203	129	104
2001	0	0	0	448	2239	12163	22122	5154	1010	495	439	203	156	75
2002	0	0	0	479	1662	7239	17581	6607	1244	659	360	224	126	81
2003	0	0	0	1279	4491	10723	16764	6385	1614	516	290	144	76	85
2004	0	0	0	947	4196	8367	10480	4069	1301	532	289	184	88	76

Table 2. Catch Weight at age (kg).

Cw	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1975	0	0	0.126	0.244	0.609	0.76	0.955	1.19	1.58	2.21	2.7	3.37	3.88	5.764
1976	0	0	0.126	0.244	0.609	0.76	0.955	1.19	1.58	2.21	2.7	3.37	3.88	5.144
1977	0	0	0.126	0.244	0.609	0.76	0.955	1.19	1.58	2.21	2.7	3.37	3.88	5.992
1978	0	0	0.126	0.244	0.609	0.76	0.955	1.19	1.58	2.21	2.7	3.37	3.88	5.894
1979	0	0	0.126	0.244	0.609	0.76	0.955	1.19	1.58	2.21	2.7	3.37	3.88	6.077
1980	0	0	0.126	0.244	0.514	0.659	0.869	1.05	1.15	1.26	1.57	2.71	3.12	5.053
1981	0	0	0.126	0.244	0.392	0.598	0.789	0.985	1.24	1.7	2.46	3.51	4.79	7.426
1982	0	0	0.126	0.244	0.525	0.684	0.891	1.13	1.4	1.79	2.38	3.47	4.51	7.359
1983	0	0	0.126	0.244	0.412	0.629	0.861	1.18	1.65	2.23	3.01	3.96	5.06	7.061
1984	0	0	0.126	0.244	0.377	0.583	0.826	1.1	1.46	1.94	2.63	3.49	4.49	7.016
1985	0	0	0.126	0.244	0.568	0.749	0.941	1.24	1.69	2.24	2.95	3.71	4.85	7.01
1986	0	0	0.126	0.244	0.35	0.584	0.811	1.1	1.58	2.12	2.89	3.89	4.95	7.345
1987	0	0	0.126	0.244	0.364	0.589	0.836	1.16	1.59	2.13	2.82	3.6	4.63	6.454
1988	0	0	0.126	0.244	0.363	0.569	0.805	1.163	1.661	2.216	3.007	3.925	5.091	7.164
1989	0	0	0.126	0.244	0.4	0.561	0.767	1.082	1.657	2.237	2.997	3.862	4.919	6.37
1990	0	0	0.09	0.181	0.338	0.546	0.766	1.119	1.608	2.173	2.854	3.731	4.691	6.391
1991	0	0	0.126	0.244	0.383	0.592	0.831	1.228	1.811	2.461	3.309	4.142	5.333	7.081
1992	0	0	0.175	0.289	0.43	0.577	0.793	1.234	1.816	2.462	3.122	3.972	5.099	6.648
1993	0	0	0.134	0.232	0.368	0.547	0.809	1.207	1.728	2.309	2.999	3.965	4.816	6.489
1994	0	0	0.08	0.196	0.33	0.514	0.788	1.179	1.701	2.268	2.99	3.766	4.882	6.348
1995	0	0	0.08	0.288	0.363	0.531	0.808	1.202	1.759	2.446	3.122	3.813	4.893	6.79
1996	0	0	0.161	0.242	0.36	0.541	0.832	1.272	1.801	2.478	3.148	3.856	4.953	6.312
1997	0	0	0.12	0.206	0.336	0.489	0.771	1.159	1.727	2.355	3.053	3.953	5.108	6.317
1998	0	0	0.119	0.228	0.373	0.543	0.81	1.203	1.754	2.351	3.095	4.01	5.132	6.124
1999	0	0	0.176	0.253	0.358	0.533	0.825	1.253	1.675	2.287	2.888	3.509	4.456	5.789
2000	0	0	0	0.254	0.346	0.524	0.787	1.192	1.774	2.279	2.895	3.645	4.486	5.531
2001	0	0	0	0.249	0.376	0.57	0.83	1.168	1.794	2.367	2.95	3.715	4.585	5.458
2002	0	0	0.217	0.251	0.369	0.557	0.841	1.193	1.76	2.277	2.896	3.579	4.407	5.477
2003	0	0	0.188	0.247	0.389	0.564	0.822	1.199	1.651	2.166	2.7	3.404	4.377	5.409
2004	0	0	0.18	0.249	0.375	0.534	0.806	1.196	1.63	2.146	2.731	3.54	4.379	5.699

Table 3. Index data used to calibrate the assessment

2J3K Fal	1	2	3	4	5	6	7	8	9	10	11	12	13
1995.9	49.93	51.1	15.13	6.031	6.629	1.993	0.387	0.116	0.018	0.01	0.004	0.002	0.001
1996.9	98.68	47.82	32.01	9.539	6.283	2.466	0.836	0.191	0.179	0.039	0.024	0.012	0.017
1997.9	28.05	58.62	43.61	21.13	10.37	5.007	1.998	0.641	0.203	0.055	0.032	0.022	0.009
1998.9	23.35	25.07	31.19	21.87	10.86	4.452	2.066	0.565	0.132	0.059	0.028	0.021	0.013
1999.9	15.99	34.42	24.07	28.28	20.04	10.53	3.811	0.703	0.139	0.072	0.021	0.006	0.025
2000.9	38.57	21.94	16.43	13.2	13.76	7.207	2.161	0.502	0.063	0.03	0.015	0.004	0
2001.9	43.9	22.72	17	14.07	9.765	7.591	3.403	0.692	0.112	0.023	0.014	0.004	0.011
2002.9	40.67	24.08	12.5	9.679	6.027	1.974	0.719	0.19	0.039	0.013	0.004	0	0.003
2003.9	45.7	26.67	11.69	9.49	6.389	2.271	0.893	0.268	0.04	0.017	0.01	0.006	0.002
2004.9	32.49	32.93	13.89	12.31	9.209	2.684	1.198	0.358	0.083	0.032	0.006	0.004	0.008

3LNO Sp	1	2	3	4	5	6	7	8
1996.4	1.621	4.241	4.599	2.183	0.827	0.284	0.057	0.001
1997.4	1.162	3.924	5.16	3.227	1.461	0.507	0.099	0.013
1998.4	0.22	0.814	3.847	6.186	4.955	1.238	0.326	0.072
1999.4	0.292	0.552	1.149	1.982	3.388	1.09	0.242	0.05
2000.4	0.793	1.069	1.068	1.506	1.954	2.037	0.556	0.031
2001.4	0.565	0.714	0.739	0.676	0.796	0.716	0.279	0.023
2002.4	0.642	0.572	0.603	0.581	0.608	0.208	0.049	0.006
2003.4	0.926	2.137	1.663	1.569	1.055	0.206	0.051	0.008
2004.4	0.662	0.572	1.181	1.184	1.161	0.259	0.041	0.02

EU_3M	1	2	3	4	5	6	7	8	9	10	11	12
1991.6	1.619	0.257	0.433	1.311	2.869	1.605	2.751	0.664	0.575	0.437	0.176	0.015
1992.6	2.085	1.566	0.556	1.272	2.303	2.797	2.421	1.311	0.581	0.339	0.171	0.083
1993.6	1.769	1.548	0.966	0.861	1.269	1.921	2.024	1.574	0.965	0.264	0.129	0.048
1994.6	1.777	1.238	1.697	1.785	1.921	2.966	2.659	1.467	0.785	0.273	0.112	0.059
1995.6	12.407	2.543	2.23	1.909	2.656	5.098	3.766	2.122	1.308	0.26	0.066	0.022
1996.6	5.843	7.969	2.415	3.036	4.203	5.82	2.488	1.616	0.424	0.086	0.026	0.038
1997.6	3.325	3.775	5.996	6.497	7.105	8.455	4.992	2.152	0.657	0.22	0.028	0.021
1998.6	2.735	2.134	7.685	10.996	12.334	11.297	7.84	2.621	0.746	0.195	0.034	0.007
1999.6	1.059	0.7	3.008	10.468	13.413	12.583	5.554	1.823	0.348	0.102	0.008	0.003
2000.6	3.748	0.292	0.595	2.165	7.092	14.096	5.404	2.32	0.449	0.114	0.054	0
2001.6	8.031	1.433	1.811	0.993	2.788	7.787	6.625	3.213	0.183	0.045	0.006	0
2002.6	4.081	2.939	2.795	1.668	3.786	5.593	5.732	1.275	0.129	0.06	0.019	0.007
2003.6	2.198	1	0.608	1.514	2.476	2.937	1.93	0.466	0.131	0.099	0.019	0.005
2004.6	2.192	3.288	4.373	1.971	6.965	7.797	2.537	0.644	0.29	0.134	0.079	0.047

3NO Spi	1	2	3	4	5	6	7	8	9	10	11	12	13
1997.5	4.958	3.379	1.835	1.432	0.928	1.013	0.783	0.501	0.135	0.292	0.238	0.152	0.07
1998.5	1.149	4.556	6.932	5.536	3.285	1.855	0.802	0.556	0.23	0.188	0.146	0.233	0.188
1999.5	1.689	2.945	4.367	5.402	3.657	1.763	0.51	0.385	0.214	0.098	0.135	0.317	0.306
2000.5	0.955	0.245	0.417	0.545	1.507	1.82	1.151	0.403	0.192	0.081	0.1	0.162	0.287
2001.5	4.337	3.516	0.725	0.5	1.316	1.955	0.849	0.146	0.048	0.035	0.094	0.263	0.28
2002.5	2.839	0.736	1.262	0.765	1.158	0.906	0.427	0.217	0.016	0.013	0.019	0.019	0.006
2003.5	4.084	3.378	2.252	2.362	1.66	0.829	0.657	0.218	0.049	0.035	0.014	0.049	0.007
2004.5	1.22	7.829	2.397	2.326	1.31	0.817	0.456	0.183	0.039	0.02	0.01	0.018	0.018

Table 4a. Model structure for XSA (shrinkage=0.5, include 3NO Spain data).

Extended Survivors Analysis

G. halibut SA2+3KLMNO Index file: (Combined sexes with plus group).

CPUE data from file GhalTUN2005_Spain_2.txt

Catch data for 30 years. 1975 to 2004. Ages 1 to 14.

Fleet	First year	Last year	First age	Last age	Alpha	Beta
EU Survey	1995	2004	1	12	0.5	0.6
CAN 2J3K	1995	2004	1	13	0.8	1
CAN 3LNO	1996	2004	1	8	0.3	0.45
Spain 3NO	1997	2004	1	13	0.4	0.5

Time series weights :

Tapered time weighting not applied

Catchability analysis :

Catchability independent of stock size for all ages

Catchability independent of age for ages >= 11

Terminal population estimation :

Terminal year survivor estimates shrunk towards the mean F of the final 5 years.
S.E. of the mean to which the estimates are shrunk = .500

Oldest age survivor estimates for the years 1975 to 2004
shrunk towards1.000 * the mean F of ages 10 - 12

S.E. of the mean to which the estimates are shrunk = .500

Minimum standard error for population estimates from each cohort age = .500

Individual fleet weighting not applied

Table 4b. XSA Diagnostic Results (Shrinkage=0.5, Spanish data included.)

Fleet : EU Survey(MNPT)

Age	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
1	0.73	0.12	-0.18	-0.09	-0.85	0.17	0.84	0.1	-0.64	-0.19
2	0.08	1.03	0.42	0.12	-0.71	-1.39	-0.05	0.57	-0.57	0.51
3	0.18	-0.26	0.45	0.84	0.17	-1.16	0.14	0.32	-1.3	0.62
4	-0.05	0.24	0.48	0.81	0.9	-0.41	-0.9	-0.19	-0.53	-0.36
5	-0.51	0.13	0.47	0.51	0.38	-0.12	-0.78	-0.17	-0.34	0.43
6	-0.12	-0.13	0.43	0.55	0.09	0.05	-0.38	-0.47	-0.67	0.65
7	0.15	-0.51	0.12	0.72	0.32	-0.1	-0.06	-0.07	-0.79	0.22
8	0.2	-0.02	0.19	0.38	0.22	0.43	0.69	-0.42	-1.28	-0.39
9	1.04	-0.09	0.44	0.63	-0.06	0.38	-0.6	-0.83	-0.93	0.04
10	0.52	-0.59	0.34	0.35	-0.14	0.08	-0.71	-0.47	0.2	0.41
11	0.74	-0.31	-0.25	-0.06	-1.38	0.8	-1.22	0.06	-0.01	1.61
12	0.13	0.68	-0.03	-1.21	-1.98	99.99	99.99	-0.32	-0.65	1.5
13	No data for this fleet at this age									

Mean log catchability and standard error of ages with catchability
independent of year class strength and constant w.r.t. time

Age	1	2	3	4	5	6	7	8	9	10
Mean Log	-10.1709	-10.7125	-10.2211	-9.7697	-8.9214	-8.1861	-7.9852	-8.1288	-8.9482	-9.5771
S.E(Log q)	0.5253	0.7152	0.7133	0.5934	0.4539	0.4432	0.4227	0.5666	0.6451	0.4491

Age	11	12
Mean Log	-10.5804	-10.5804
S.E(Log q)	0.9016	1.1119

Regression statistics :

Ages with q independent of year class strength and constant w.r.t. time.

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Q
1	0.52	1.588	10.84	0.58	10	0.25	-10.17
2	0.32	3.931	11.21	0.81	10	0.14	-10.71
3	0.54	1.02	10.67	0.38	10	0.38	-10.22
4	0.44	2.608	10.44	0.73	10	0.2	-9.77
5	0.76	0.642	9.35	0.48	10	0.36	-8.92
6	1.88	-1.175	6.19	0.18	10	0.82	-8.19
7	1.76	-1.229	6.46	0.25	10	0.72	-7.99
8	57.83	-0.943	-46.21	0	10	32.97	-8.13
9	0.33	1.492	8.5	0.38	10	0.2	-8.95
10	0.71	0.57	9.03	0.32	10	0.33	-9.58
11	-3.77	-1.188	-5.43	0.01	10	3.32	-10.58
12	-7.64	-0.961	-24.41	0	8	8.32	-10.81
1							

Fleet : CAN 2J3K Fall(MNPT)

Age	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
1	-0.21	0.62	-0.38	-0.27	-0.46	0.17	0.21	0.07	0.07	0.18
2	0.21	-0.05	0.3	-0.29	0.32	0.06	-0.16	-0.19	-0.15	-0.06
3	-0.02	0.21	0.32	0.13	0.13	0.04	0.27	-0.29	-0.45	-0.34
4	-0.4	-0.12	0.15	-0.01	0.39	-0.11	0.25	0.07	-0.19	-0.03
5	-0.17	-0.03	0.29	-0.18	0.21	-0.02	-0.09	-0.27	0.08	0.17
6	-0.47	-0.36	0.54	0.26	0.52	0.02	0.25	-0.88	-0.2	0.32
7	-1.17	-0.6	0.23	0.39	1.01	0.19	0.45	-1	-0.31	0.81
8	-1.34	-0.8	0.4	0.28	0.76	0.36	0.69	-0.76	-0.24	0.65
9	-1.78	0.49	0.73	0.4	0.56	-0.09	0.39	-0.5	-0.55	0.34
10	-1.4	-0.05	0.3	0.5	0.9	0.12	0	-0.59	-0.16	0.38
11	-1.37	0.31	0.58	0.43	0.28	0.24	0.41	-0.73	0.08	-0.22
12	-1.55	0.22	0.71	0.54	-0.58	-0.93	-0.52	99.99	0.25	-0.22
13	-2.1	1.1	0.42	0.56	1.14	99.99	0.59	-0.21	-0.18	1.14

Mean log catchability and standard error of ages with catchability
independent of year class strength and constant w.r.t. time

Age	1	2	3	4	5	6	7	8	9	10	Age	11	12	13
Mean Log	-7.774	-7.7758	-8.038	-8.1921	-8.2702	-8.6713	-8.7482	-9.2997	-10.2311	-10.7621	Mean Log	-11.1039	-11.1039	-11.1039
S.E(Log q	0.3269	0.2138	0.2707	0.2279	0.1857	0.465	0.7436	0.7396	0.7643	0.6356	S.E(Log q)	0.6136	0.7779	1.0695

Regression statistics :

Ages with q independent of year class strength and constant w.r.t. time.

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Q
1	0.75	0.846	8.72	0.59	10	0.25	-7.77
2	0.92	0.298	8.05	0.66	10	0.21	-7.78
3	0.76	0.994	8.8	0.68	10	0.21	-8.04
4	0.74	1.529	8.9	0.82	10	0.16	-8.19
5	0.99	0.075	8.31	0.76	10	0.19	-8.27
6	0.97	0.071	8.73	0.39	10	0.48	-8.67
7	0.95	0.075	8.81	0.23	10	0.75	-8.75
8	3.31	-0.494	9.8	0.01	10	2.56	-9.3
9	1.98	-0.267	12.14	0.01	10	1.6	-10.23
10	1.6	-0.359	12.59	0.04	10	1.07	-10.76
11	0.61	0.845	9.59	0.37	10	0.38	-11.1
12	1.24	-0.212	12.43	0.1	9	0.98	-11.33
13	2.19	-0.608	16.23	0.04	9	2.35	-10.83
1							

Fleet : CAN 3LNO Spr(MNPT)

Age	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
1	99.99	0.5	0.43	-0.94	-0.47	0.28	-0.15	-0.08	0.16	0.28
2	99.99	0.83	0.89	-0.41	-0.51	0.34	-0.32	-0.63	0.63	-0.81
3	99.99	0.77	0.69	0.54	-0.41	-0.19	-0.37	-0.82	0.1	-0.3
4	99.99	0.52	0.39	0.85	-0.15	-0.16	-0.67	-0.63	0.12	-0.26
5	99.99	-0.16	0.23	0.93	0.34	-0.07	-0.69	-0.67	0.12	-0.04
6	99.99	-0.46	0.3	1.02	0.35	0.79	-0.1	-1.08	-0.69	-0.13
7	99.99	-0.65	-0.18	1.18	0.79	1.16	0.33	-1.27	-0.91	-0.44
8	99.99	-2.66	-0.21	1.48	1.3	0.81	0.4	-1.14	-0.72	0.74
9	No data for this fleet at this age									
10	No data for this fleet at this age									
11	No data for this fleet at this age									
12	No data for this fleet at this age									
13	No data for this fleet at this age									

Mean log catchability and standard error of ages with catchability
independent of year class strength and constant w.r.t. time

Age	1	2	3	4	5	6	7	8
Mean Log	-11.8715	-11.1805	-10.6437	-10.4173	-10.3019	-10.9433	-11.7427	-12.9646
S.E(Log q)	0.4685	0.6697	0.5557	0.5143	0.5005	0.687	0.9044	1.3324

Regression statistics :

Ages with q independent of year class strength and constant w.r.t. time.

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Q
1	0.47	1.784	11.69	0.62	9	0.2	-11.87
2	0.49	1.273	11.3	0.47	9	0.31	-11.18
3	0.39	3.476	11	0.82	9	0.14	-10.64
4	0.5	1.927	10.71	0.68	9	0.22	-10.42
5	0.66	0.998	10.46	0.54	9	0.33	-10.3
6	0.77	0.435	10.84	0.33	9	0.55	-10.94
7	1.08	-0.075	11.87	0.12	9	1.04	-11.74
8	-4.56	-0.466	-8.54	0	9	6.4	-12.96

Fleet : Spain 3NO(MNPT)

Age	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
1	99.99	99.99	0.61	-0.56	0.01	-0.81	0.61	0.13	0.38	-0.38
2	99.99	99.99	0.01	0.57	0.43	-1.87	0.54	-1.11	0.35	1.07
3	99.99	99.99	-0.46	1.01	0.81	-1.24	-0.5	-0.2	0.29	0.29
4	99.99	99.99	-0.37	0.79	0.9	-1.13	-0.92	-0.31	0.58	0.47
5	99.99	99.99	-0.33	0.41	0.31	-0.43	-0.3	-0.13	0.48	-0.02
6	99.99	99.99	0.12	0.56	-0.05	-0.19	0.04	-0.48	-0.15	0.17
7	99.99	99.99	0.19	0.38	-0.15	0.23	-0.22	-0.77	0	0.34
8	99.99	99.99	0.43	0.52	0.35	0.37	-0.74	-0.53	-0.39	-0.01
9	99.99	99.99	0.3	0.88	0.87	0.97	-0.5	-1.49	-0.49	-0.55
10	99.99	99.99	1.23	0.92	0.42	0.34	-0.36	-1.41	-0.25	-0.89
11	99.99	99.99	1.03	0.54	0.59	0.54	0.65	-0.82	-1.18	-1.34
12	99.99	99.99	1.09	1.44	1.81	1.23	2.07	-0.21	0.76	-0.33
13	99.99	99.99	0.92	1.73	2.11	2.21	2.26	-1.13	-0.53	0.34

Mean log catchability and standard error of ages with catchability
independent of year class strength and constant w.r.t. time

Age	1	2	3	4	5	6	7	8	9	10	11	12	13
Mean Log	-10.586	-10.4324	-10.5145	-10.4515	-10.1771	-10.0378	-9.9909	-9.8996	-10.4481	-10.2317	-9.7656	-9.7656	-9.7656
S.E(Log q)	0.5375	0.9868	0.747	0.7869	0.3582	0.3044	0.3818	0.492	0.8946	0.8983	0.9462	1.3676	1.6874

Regression statistics :

Ages with q independent of year class strength and constant w.r.t. time.

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Q
1	0.37	1.788	11.14	0.58	8	0.17	-10.59
2	0.3	1.508	11.07	0.44	8	0.28	-10.43
3	0.47	1.201	10.88	0.46	8	0.34	-10.51
4	0.49	1.11	10.75	0.44	8	0.38	-10.45
5	0.98	0.035	10.19	0.46	8	0.38	-10.18
6	1.58	-1.277	9.76	0.44	8	0.46	-10.04
7	2.49	-1.742	9.84	0.19	8	0.84	-9.99
8	-2.24	-1.651	7.37	0.04	8	0.99	-9.9
9	0.23	1.37	8.75	0.35	8	0.19	-10.45
10	0.22	3.036	8.21	0.72	8	0.13	-10.23
11	0.26	4.119	7.83	0.84	8	0.13	-9.77
12	0.37	2.143	7.48	0.66	8	0.27	-8.78
13	0.28	3.296	6.95	0.78	8	0.24	-8.78

Table 4c. Stock summary for XSA analysis with shrinkage parameters fixed at 0.5, including the Spanish 3NO survey.

Table 16 Summary (without SOP correction)

Terminal Fs derived using XSA with final year & oldest age shrinkage.

	RE(Age 1	TOTALE	TOTSPE	LANDIN(	YIELD/S!	FBAR 5-10
1975	112226	132737	21900	28814	1.3157	0.3652
1976	116593	134503	17669	24611	1.3929	0.422
1977	107441	156946	14816	32048	2.163	0.4237
1978	82280	167750	15903	39070	2.4568	0.4652
1979	98906	162519	15614	34104	2.1842	0.249
1980	129793	130892	12397	32867	2.6512	0.5384
1981	131562	115244	14011	30754	2.1949	0.4353
1982	130992	121240	19847	26278	1.324	0.379
1983	144909	122653	24102	27861	1.156	0.3158
1984	153327	115089	24216	26711	1.103	0.3872
1985	168315	147893	28905	20347	0.7039	0.2168
1986	189186	137876	33427	17976	0.5378	0.19
1987	158742	164145	42137	32442	0.7699	0.2881
1988	131811	168515	44097	19215	0.4357	0.1496
1989	115279	181850	43585	20034	0.4597	0.1291
1990	109209	206023	55526	47454	0.8546	0.2796
1991	95237	225054	62914	65008	1.0333	0.4365
1992	71716	193525	47763	63193	1.3231	0.4628
1993	85238	150333	36746	62455	1.6996	0.648
1994	143972	105771	28257	51029	1.8059	0.674
1995	174580	80109	25163	15272	0.6069	0.2312
1996	151534	82222	21862	18840	0.8618	0.2645
1997	116373	80396	22428	19858	0.8854	0.3204
1998	87063	94270	22062	19946	0.9041	0.3444
1999	72055	109780	22119	24226	1.0952	0.4123
2000	92656	117172	18092	34177	1.8891	0.4527
2001	101596	115760	15142	38232	2.5249	0.486
2002	107754	97951	12897	34062	2.6412	0.5092
2003	121446	82088	10897	35151	3.2259	0.6483
2004	77491	63416	10999	25486	2.3172	0.706
Arith. Mean	119309	132124	26183	32251	1.4839	0.3944
0 Units	(Thousar	(Tonnes	(Tonnes	(Tonnes)		

Table 5. ADAPT estimates of parameters. Analysis uses FRATIO plus group method, and includes the 3NO Spanish index.

APPROXIMATE STATISTICS ASSUMING LINEARITY NEAR SOLUTIC

ORTHOGONALITY OFFSET......... 0.006424
MEAN SQUARE RESIDUALS 0.471085

Parameter	Est.	Std. Err.	Rel. Err.	Bias	Rel. Bias
---------	---------	---------	---------	---------	---------
N[2005 2]	5.76E+04	2.13E+04	0.37	4.26E+03	0.074
N[2005 3]	8.33E+04	2.20E+04	0.264	3.36E+03	0.04
N[2005 4]	5.91E+04	1.28E+04	0.217	1.70E+03	0.029
N[2005 5]	3.84E+04	7.34E+03	0.191	8.85E+02	0.023
N[2005 6]	2.64E+04	5.08E+03	0.192	5.71E+02	0.022
N[2005 7]	7.55E+03	2.26E+03	0.299	2.72E+02	0.036
N[2005 8]	2.14E+03	1.04E+03	0.483	2.23E+02	0.104
N[2005 9]	1.41E+03	6.63E+02	0.47	1.43E+02	0.101
N[2005 10]	7.80E+02	3.68E+02	0.472	7.84E+01	0.101
N[2005 11]	4.41E+02	1.96E+02	0.446	3.89E+01	0.088
N[2005 12]	2.27E+02	9.95E+01	0.439	1.91E+01	0.084
N[2005 13]	9.92E+01	4.73E+01	0.476	9.82E+00	0.099
N[2005 14]	5.55E+01	3.45E+01	0.621	9.14E+00	0.165
2J3K_F_1	4.48E-04	1.02E-04	0.228	9.28E-06	0.021
2J3K_F_2	4.44E-04	9.94E-05	0.224	8.94E-06	0.02
2J3K_F_3	3.44E-04	7.61E-05	0.221	6.86E-06	0.02
2J3K_F_4	2.96E-04	6.50E-05	0.22	5.93E-06	0.02
2J3K_F_5	2.72E-04	5.94E-05	0.219	5.54E-06	0.02
2J3K_F_6	1.85E-04	4.05E-05	0.219	3.94E-06	0.021
2J3K_F_7	1.76E-04	3.90E-05	0.222	3.72E-06	0.021
2J3K_F_8	1.09E-04	2.43E-05	0.223	2.15E-06	0.02
2J3K_F_9	4.84E-05	1.08E-05	0.223	9.75E-07	0.02
2J3K_F_10	3.10E-05	6.91E-06	0.223	6.32E-07	0.02
2J3K_F_11	2.53E-05	5.63E-06	0.223	5.11E-07	0.02
2J3K_F_12	2.66E-05	6.27E-06	0.236	6.42E-07	0.024
2J3K_F_13	6.66E-05	1.65E-05	0.248	1.80E-06	0.027
3LNO_Spr_1	7.50E-06	1.82E-06	0.242	1.76E-07	0.024
3LNO_Spr_2	1.49E-05	3.52E-06	0.237	3.37E-07	0.023
3LNO_Spr_3	2.56E-05	5.98E-06	0.234	5.74E-07	0.022
3LNO_Spr_4	3.22E-05	7.47E-06	0.232	7.23E-07	0.022
3LNO_Spr_5	3.59E-05	8.27E-06	0.231	8.12E-07	0.023
3LNO_Spr_6	1.91E-05	4.40E-06	0.23	4.44E-07	0.023
3LNO_Spr_7	8.76E-06	2.02E-06	0.231	1.99E-07	0.023
3LNO_Spr_8	2.71E-06	6.28E-07	0.231	5.78E-08	0.021
EU_3M_1	4.12E-05	9.41E-06	0.228	8.54E-07	0.021
EU_3M_2	2.38E-05	5.32E-06	0.224	4.78E-07	0.02
EU_3M_3	3.92E-05	8.66E-06	0.221	7.81E-07	0.02
EU_3M_4	6.17E-05	1.35E-05	0.22	1.24E-06	0.02
EU_3M_5	1.43E-04	3.13E-05	0.219	2.92E-06	0.02
EU_3M_6	3.05E-04	6.67E-05	0.219	6.41E-06	0.021
EU_3M_7	3.90E-04	8.57E-05	0.22	8.05E-06	0.021
EU_3M_8	3.58E-04	7.89E-05	0.221	6.91E-06	0.019
EU_3M_9	1.74E-04	3.85E-05	0.221	3.35E-06	0.019
EU_3M_10	9.90E-05	2.19E-05	0.221	1.94E-06	0.02
EU_3M_11	4.55E-05	1.00E-05	0.221	8.90E-07	0.02
EU_3M_12	6.75E-05	1.94E-05	0.287	2.62E-06	0.039
3NO_Spain_1	2.74E-05	7.07E-06	0.259	7.47E-07	0.027
3NO_Spain_2	3.18E-05	8.01E-06	0.252	8.26E-07	0.026
3NO_Spain_3	2.94E-05	7.32E-06	0.248	7.52E-07	0.026
3NO_Spain_4	3.15E-05	7.76E-06	0.246	8.03E-07	0.025
3NO_Spain_5	4.11E-05	1.01E-05	0.245	1.06E-06	0.026
3NO_Spain_6	4.82E-05	1.18E-05	0.245	1.27E-06	0.026
3NO_Spain_7	5.25E-05	1.29E-05	0.246	1.36E-06	0.026
3NO_Spain_8	6.02E-05	1.49E-05	0.247	1.47E-06	0.024
3NO_Spain_9	3.93E-05	9.74E-06	0.248	9.45E-07	0.024
3NO_Spain_1	5.09E-05	1.26E-05	0.248	1.24E-06	0.024
3NO_Spain_1	8.93E-05	2.21E-05	0.248	2.19E-06	0.024
3NO_Spain_1	3.13E-04	7.78E-05	0.248	7.60E-06	0.024
3NO_Spain_1	5.03E-04	1.28E-04	0.255	1.33E-05	0.026

Table 6a. XSA Settings for Final Run

Catch data for 30 years. 1975 to 2004. Ages 1 to 14.

Fleet	First year	Last year	First age	Last age	Alpha	Beta
EU 3M July	1995	2004	1	12	0.5	0.6
CAN 2J3K Fall	1996	2004	1	13	0.8	1
CAN 3LNO Spr	1996	2004	1	8	0.3	0.45

Time series weights :

Tapered time weighting not applied

Catchability analysis :

Catchability independent of stock size for all ages

Catchability independent of age for ages >= 11

Terminal population estimation :

Terminal year survivor estimates shrunk towards the mean F of the final 5 years.
S.E. of the mean to which the estimates are shrunk = .500

Oldest age survivor estimates for the years 1975 to 2004
shrunk towards1.000 * the mean F of ages 10 - 12

S.E. of the mean to which the estimates are shrunk = .500

Minimum standard error for population estimates from each cohort age = .500

Individual fleet weighting not applied

Table 6b. XSA Diagnostic Results, Final Run.

Fleet : EU Survey(MNPT)

Age	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
1	0.71	0.1	-0.2	-0.11	-0.86	0.14	0.89	0.14	-0.52	-0.29
2	0.05	1	0.39	0.09	-0.74	-1.41	-0.09	0.62	-0.53	0.62
3	0.17	-0.28	0.44	0.83	0.15	-1.18	0.14	0.3	-1.24	0.66
4	-0.05	0.24	0.47	0.8	0.89	-0.42	-0.91	-0.18	-0.54	-0.3
5	-0.51	0.13	0.48	0.51	0.38	-0.12	-0.78	-0.18	-0.33	0.42
6	-0.11	-0.13	0.43	0.56	0.09	0.05	-0.39	-0.48	-0.68	0.66
7	0.19	-0.5	0.12	0.72	0.32	-0.1	-0.06	-0.09	-0.8	0.19
8	0.26	0.02	0.2	0.36	0.21	0.43	0.68	-0.43	-1.32	-0.41
9	1.05	-0.02	0.49	0.64	-0.08	0.36	-0.61	-0.85	-0.95	-0.03
10	0.47	-0.59	0.43	0.41	-0.12	0.05	-0.74	-0.47	0.18	0.38
11	0.62	-0.37	-0.25	0.05	-1.29	0.84	-1.24	0.03	0	1.61
12	-0.17	0.55	-0.08	-1.18	-1.78	99.99	99.99	-0.28	-0.65	1.57
13	No data for this fleet at this age									

Mean log catchability and standard error of ages with catchability
independent of year class strength and constant w.r.t. time

Age	1	2	3	4	5	6	7	8	9	10
Mean Log	-10.1511	-10.6848	-10.207	-9.7611	-8.9194	-8.1807	-7.9753	-8.1	-8.8999	-9.5023
S.E(Log q)	0.5244	0.7278	0.7055	0.5907	0.4529	0.4484	0.4235	0.5801	0.6561	0.4581

Age	11	12
Mean Log	-10.4829	-10.4829
S.E(Log q)	0.8862	1.0606

Regression statistics :

Ages with q independent of year class strength and constant w.r.t. time.

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Q
1	0.49	1.762	10.86	0.6	10	0.23	-10.15
2	0.34	3.038	11.16	0.73	10	0.18	-10.68
3	0.53	1.085	10.66	0.4	10	0.37	-10.21
4	0.44	2.608	10.43	0.73	10	0.2	-9.76
5	0.77	0.636	9.34	0.48	10	0.36	-8.92
6	1.94	-1.22	6.06	0.17	10	0.85	-8.18
7	1.78	-1.276	6.41	0.25	10	0.73	-7.98
8	-12.34	-1.097	20.95	0	10	7.08	-8.1
9	0.28	1.632	8.42	0.39	10	0.17	-8.9
10	0.67	0.615	8.89	0.3	10	0.32	-9.5
11	-7.7	-1.047	-18.57	0	10	6.79	-10.48
12	3.41	-0.674	20.51	0.01	8	3.64	-10.74

Fleet : CAN 2J3K Fall(MNPT)

Age	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
1	99.99	0.57	-0.42	-0.32	-0.49	0.12	0.23	0.09	0.17	0.06
2	99.99	-0.05	0.29	-0.29	0.31	0.06	-0.17	-0.13	-0.1	0.08
3	99.99	0.19	0.31	0.11	0.12	0.02	0.26	-0.32	-0.4	-0.3
4	99.99	-0.17	0.1	-0.06	0.33	-0.16	0.19	0.03	-0.25	-0.01
5	99.99	-0.04	0.28	-0.2	0.19	-0.04	-0.11	-0.3	0.08	0.14
6	99.99	-0.41	0.49	0.21	0.46	-0.03	0.19	-0.94	-0.26	0.29
7	99.99	-0.71	0.1	0.27	0.89	0.07	0.32	-1.15	-0.45	0.65
8	99.99	-0.89	0.27	0.12	0.61	0.21	0.54	-0.92	-0.43	0.49
9	99.99	0.37	0.59	0.22	0.35	-0.31	0.19	-0.7	-0.77	0.06
10	99.99	-0.21	0.23	0.41	0.76	-0.07	-0.2	-0.75	-0.34	0.18
11	99.99	0.07	0.41	0.38	0.2	0.12	0.22	-0.93	-0.08	-0.39
12	99.99	-0.09	0.48	0.4	-0.51	-0.94	-0.56	99.99	0.09	-0.3
13	99.99	0.53	0.09	0.34	1.03	99.99	0.7	-0.12	-0.22	1.05

Mean log catchability and standard error of ages with catchability
independent of year class strength and constant w.r.t. time

Age	1	2	3	4	5	6	7	8	9	10
Mean Log	-7.7293	-7.7689	-8.0211	-8.1381	-8.2501	-8.6149	-8.6116	-9.124	-9.9796	-10.5168
S.E(Log q)	0.3455	0.2042	0.2676	0.1872	0.1885	0.4645	0.6543	0.5973	0.4856	0.4455

Age	11	12	13
Mean Log	-10.8264	-10.8264	-10.8264
S.E(Log q)	0.4252	0.5288	0.6671

Regression statistics :

Ages with q independent of year class strength and constant w.r.t. time.

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Q
1	0.5	2.04	9.59	0.71	9	0.15	-7.73
2	0.99	0.038	7.81	0.65	9	0.22	-7.77
3	0.73	1.17	8.88	0.73	9	0.19	-8.02
4	0.85	0.776	8.56	0.8	9	0.16	-8.14
5	1.03	-0.143	8.17	0.75	9	0.21	-8.25
6	1.17	-0.309	8.29	0.31	9	0.58	-8.61
7	2.6	-0.957	6.3	0.05	9	1.71	-8.61
8	-9.39	-1.044	8.67	0	9	5.57	-9.12
9	0.31	1.636	8.77	0.45	9	0.14	-9.98
10	0.53	0.992	9.16	0.39	9	0.24	-10.52
11	0.48	2.468	8.91	0.77	9	0.16	-10.83
12	0.72	0.654	9.78	0.47	8	0.37	-11.01
13	0.77	0.713	9.44	0.63	8	0.39	-10.4

Fleet : CAN 3LNO Spr(MNPT)

Age	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
1	99.99	0.48	0.41	-0.97	-0.48	0.25	-0.1	-0.05	0.28	0.18
2	99.99	0.8	0.86	-0.44	-0.55	0.32	-0.36	-0.59	0.66	-0.7
3	99.99	0.76	0.68	0.52	-0.42	-0.21	-0.37	-0.85	0.16	-0.26
4	99.99	0.52	0.38	0.84	-0.16	-0.17	-0.68	-0.63	0.1	-0.2
5	99.99	-0.16	0.23	0.93	0.35	-0.07	-0.69	-0.67	0.13	-0.05
6	99.99	-0.46	0.31	1.03	0.34	0.79	-0.1	-1.08	-0.7	-0.12
7	99.99	-0.64	-0.17	1.18	0.8	1.16	0.33	-1.28	-0.91	-0.46
8	99.99	-2.62	-0.19	1.48	1.3	0.82	0.39	-1.15	-0.75	0.73
9	No data for this fleet at this age									
10	No data for this fleet at this age									
11	No data for this fleet at this age									
12	No data for this fleet at this age									
13	No data for this fleet at this age									

Mean log catchability and standard error of ages with catchability
independent of year class strength and constant w.r.t. time

Age	1	2	3	4	5	6	7	8
Mean Log	-11.8496	-11.1501	-10.6289	-10.4082	-10.3003	-10.9393	-11.7376	-12.9442
S.E(Log q)	0.4679	0.6497	0.5556	0.5108	0.5027	0.6892	0.9077	1.3216

Regression statistics :

Ages with q independent of year class strength and constant w.r.t. time.

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Q
1	0.41	2.273	11.64	0.68	9	0.16	-11.85
2	0.45	1.582	11.28	0.54	9	0.27	-11.15
3	0.41	3.189	10.98	0.8	9	0.15	-10.63
4	0.5	1.924	10.7	0.68	9	0.22	-10.41
5	0.66	0.958	10.45	0.54	9	0.34	-10.3
6	0.78	0.402	10.84	0.32	9	0.57	-10.94
7	1.09	-0.09	11.9	0.12	9	1.06	-11.74
8	5.59	-0.328	30.67	0	9	7.83	-12.94

Table 6c. XSA Estimates of survivors at age, Final Run.

Age 1 Catchability constant w.r.t. time and dependent on age

Year class = 2003

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU Survey	51321	0.55	0	0	1	0.292	0
CAN 2J3K	72411	0.5	0	0	1	0.354	0
CAN 3LN(	81806	0.5	0	0	1	0.354	0
F shrinka	0	0.5				0	0

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
68365	0.3	0.14	3	0.455	0

1

Age 2 Catchability constant w.r.t. time and dependent on age

Year class = 2002

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU Survey	62131	0.446	0.539	1.21	2	0.262	0
CAN 2J3K	79799	0.354	0.044	0.12	2	0.418	0
CAN 3LN(	66604	0.404	0.467	1.16	2	0.32	0
F shrinka	0	0.5				0	0

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
70529	0.23	0.18	6	0.779	0

Age 3 Catchability constant w.r.t. time and dependent on age

Year class = 2001

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU Survey	62246	0.382	0.305	0.8	3	0.246	0
CAN 2J3K	50334	0.289	0.11	0.38	3	0.43	0
CAN 3LN(	58632	0.332	0.246	0.74	3	0.324	0
F shrinka	0	0.5				0	0

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
55719	0.19	0.11	9	0.602	0

1

Age 4 Catchability constant w.r.t. time and dependent on age

Year class = 2000

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU Survey	46073	0.325	0.467	1.44	4	0.225	0.018
CAN 2J3K	38623	0.25	0.131	0.52	4	0.381	0.022
CAN 3LN(	35761	0.283	0.137	0.48	4	0.297	0.024
F shrinka	70162	0.5				0.097	0.012

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
41621	0.15	0.14	13	0.886	0.02

Age 5 Catchability constant w.r.t. time and dependent on age

Year class = 1999

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU Survey	32262	0.273	0.174	0.64	5	0.249	0.111
CAN 2J3K	26931	0.224	0.095	0.43	5	0.369	0.132
CAN 3LN(	26066	0.25	0.192	0.77	5	0.297	0.136
F shrinka	55053	0.5				0.085	0.067

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
29650	0.14	0.09	16	0.689	0.12

1

Age 6 Catchability constant w.r.t. time and dependent on age

Year class = 1998

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU Survey	8423	0.24	0.291	1.21	6	0.262	0.641
CAN 2J3K	10759	0.205	0.115	0.56	6	0.356	0.533
CAN 3LN(	8140	0.236	0.147	0.62	6	0.263	0.658
F shrinka	23417	0.5				0.119	0.28

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
10289	0.13	0.13	19	0.968	0.551

Age 7 Catchability constant w.r.t. time and dependent on age

Year class = 1997

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU Survey	2058	0.222	0.186	0.84	7	0.241	1.724
CAN 2J3K	2992	0.199	0.136	0.68	7	0.273	1.428
CAN 3LN(	1535	0.232	0.094	0.41	7	0.195	1.971
F shrinka	5719	0.5				0.291	0.978

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
2896	0.17	0.14	22	0.821	1.453

1

Age 8 Catchability constant w.r.t. time and dependent on age

Year class = 1996

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU Survey	1128	0.25	0.101	0.4	8	0.235	1.45
CAN 2J3K	1614	0.229	0.171	0.75	8	0.257	1.188
CAN 3LN(	1372	0.251	0.211	0.84	8	0.147	1.304
F shrinka	2782	0.5				0.361	0.843

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
1764	0.2	0.11	25	0.567	1.127

Age 9 Catchability constant w.r.t. time and dependent on age

Year class = 1995

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU Survey	1274	0.296	0.209	0.71	9	0.248	0.654
CAN 2J3K	1581	0.276	0.118	0.43	9	0.339	0.557
CAN 3LN(	1635	0.24	0.214	0.89	8	0.102	0.542
F shrinka	1773	0.5				0.31	0.509

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
1558	0.2	0.08	27	0.418	0.563

1

Age 10 Catchability constant w.r.t. time and dependent on age

Year class = 1994

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU Survey	1022	0.31	0.178	0.57	10	0.32	0.386
CAN 2J3K	795	0.289	0.162	0.56	9	0.36	0.473
CAN 3LN(	1449	0.274	0.238	0.87	7	0.047	0.287
F shrinka	937	0.5				0.274	0.415

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
927	0.2	0.09	27	0.444	0.418

Age 11 Catchability constant w.r.t. time and dependent on age

Year class = 1993

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU Survey	594	0.311	0.248	0.8	10	0.26	0.365
CAN 2J3K	296	0.273	0.099	0.36	9	0.415	0.633
CAN 3LN(	794	0.299	0.127	0.42	6	0.029	0.285
F shrinka	458	0.5				0.295	0.452

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
415	0.2	0.11	26	0.518	0.488

1

Age 12 Catchability constant w.r.t. time and age (fixed at the value for age) 11

Year class = 1992

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU Survey	289	0.291	0.241	0.83	10	0.233	0.455
CAN 2J3K	208	0.252	0.117	0.46	9	0.438	0.588
CAN 3LN(	456	0.324	0.144	0.45	5	0.029	0.311
F shrinka	288	0.5				0.3	0.457

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
253	0.2	0.09	25	0.472	0.505

Age 13 Catchability constant w.r.t. time and age (fixed at the value for age) 11

Year class = 1991

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU Survey	107	0.292	0.181	0.62	9	0.183	0.556
CAN 2J3K	143	0.261	0.241	0.92	9	0.447	0.443
CAN 3LN(	196	0.389	0.344	0.89	4	0.018	0.342
F shrinka	131	0.5				0.352	0.474

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
132	0.22	0.11	23	0.513	0.471

Table 6d. XSA Estimate of fishing mortality at age, Final Run.

F @ AGE(XSA)	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1975	0.000	0.000	0.000	0.000	0.007	0.103	0.322	0.481	0.635	0.643	0.576	0.446	0.560	0.560
1976	0.000	0.000	0.000	0.000	0.000	0.016	0.164	0.574	0.854	0.924	0.780	0.434	0.720	0.720
1977	0.000	0.000	0.000	0.000	0.008	0.132	0.413	0.685	0.719	0.585	0.205	0.257	0.351	0.351
1978	0.000	0.000	0.000	0.000	0.049	0.169	0.369	0.576	0.632	0.995	1.179	0.622	0.942	0.942
1979	0.000	0.000	0.000	0.000	0.054	0.197	0.418	0.467	0.159	0.200	0.537	0.837	0.529	0.529
1980	0.000	0.000	0.000	0.000	0.004	0.061	0.326	0.650	1.018	1.166	0.839	0.489	0.840	0.840
1981	0.000	0.000	0.000	0.000	0.020	0.124	0.445	0.889	0.689	0.440	0.199	0.255	0.300	0.300
1982	0.000	0.000	0.000	0.000	0.008	0.068	0.256	0.514	0.779	0.642	0.602	0.313	0.523	0.523
1983	0.000	0.000	0.000	0.000	0.018	0.140	0.454	0.551	0.396	0.330	0.147	0.138	0.206	0.206
1984	0.000	0.000	0.000	0.000	0.017	0.074	0.358	0.797	0.669	0.393	0.330	0.142	0.290	0.290
1985	0.000	0.000	0.000	0.000	0.038	0.133	0.274	0.379	0.311	0.158	0.077	0.124	0.120	0.120
1986	0.000	0.000	0.000	0.000	0.005	0.054	0.235	0.402	0.269	0.165	0.105	0.090	0.121	0.121
1987	0.000	0.000	0.000	0.000	0.002	0.045	0.407	0.599	0.411	0.247	0.197	0.169	0.205	0.205
1988	0.000	0.000	0.000	0.000	0.005	0.067	0.271	0.280	0.156	0.107	0.084	0.076	0.089	0.089
1989	0.000	0.000	0.000	0.000	0.003	0.040	0.222	0.223	0.143	0.131	0.140	0.154	0.142	0.142
1990	0.000	0.000	0.000	0.001	0.015	0.129	0.375	0.365	0.344	0.418	0.312	0.462	0.400	0.400
1991	0.000	0.000	0.000	0.003	0.046	0.134	0.395	0.644	0.712	0.613	0.578	0.601	0.603	0.603
1992	0.000	0.000	0.000	0.019	0.083	0.246	0.626	0.797	0.585	0.375	0.330	0.475	0.396	0.396
1993	0.000	0.000	0.000	0.019	0.237	0.515	0.805	0.950	0.835	0.530	0.404	0.606	0.518	0.518
1994	0.000	0.000	0.000	0.122	0.482	0.778	0.857	0.853	0.695	0.476	0.473	0.279	0.412	0.412
1995	0.000	0.000	0.000	0.009	0.040	0.114	0.344	0.381	0.341	0.242	0.265	0.286	0.266	0.266
1996	0.000	0.000	0.000	0.005	0.059	0.215	0.511	0.356	0.293	0.238	0.315	0.288	0.238	0.238
1997	0.000	0.000	0.000	0.005	0.057	0.208	0.555	0.528	0.372	0.306	0.319	0.294	0.274	0.274
1998	0.000	0.000	0.000	0.006	0.064	0.228	0.498	0.578	0.477	0.304	0.317	0.193	0.170	0.170
1999	0.000	0.000	0.000	0.004	0.031	0.135	0.691	0.728	0.569	0.392	0.321	0.462	0.267	0.267
2000	0.000	0.000	0.000	0.005	0.034	0.255	1.088	0.628	0.409	0.353	0.424	0.320	0.360	0.360
2001	0.000	0.000	0.000	0.010	0.049	0.288	0.979	0.880	0.395	0.377	0.563	0.440	0.436	0.436
2002	0.000	0.000	0.000	0.014	0.048	0.220	0.887	0.932	0.538	0.488	0.522	0.637	0.544	0.544
2003	0.000	0.000	0.000	0.028	0.171	0.496	1.188	1.004	0.615	0.448	0.413	0.408	0.460	0.460
2004	0.000	0.000	0.000	0.020	0.121	0.552	1.453	1.127	0.563	0.418	0.488	0.505	0.471	0.471

Table 6e. XSA Estimate of population numbers at age, Final Run.

N@A (XSA)	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1975	112392	126318	110187	66827	53833	31898	23092	14338	9313	3931	1773	415	720	735
1976	116795	92019	103421	90213	54714	43772	23565	13704	7254	4040	1691	816	218	113
1977	107650	95624	75339	84674	73860	44780	35286	16370	6322	2529	1313	635	433	311
1978	82557	88136	78290	61682	69325	59988	32128	19119	6756	2522	1154	876	402	459
1979	99270	67592	72160	64099	50501	54060	41500	18188	8798	2939	764	291	385	757
1980	130592	81275	55340	59080	52479	39188	36364	22374	9339	6146	1971	366	103	52
1981	132408	106920	66542	45308	48370	42777	30197	21493	9560	2762	1568	697	183	292
1982	131994	108407	87539	54480	37095	38821	30936	15850	7236	3930	1456	1052	442	513
1983	148037	108068	88756	71671	44605	30128	29704	19611	7762	2719	1694	653	630	1034
1984	154985	121202	88478	72667	58679	35885	21448	15452	9257	4279	1600	1198	466	798
1985	168588	126891	99232	72440	59495	47226	27277	12272	5700	3881	2364	942	851	838
1986	188816	138028	103890	81244	59309	46916	33862	16982	6881	3418	2714	1792	682	1135
1987	157663	154589	113008	85058	66517	48305	36385	21923	9298	4304	2372	2001	1340	2068
1988	129621	129084	126567	92523	69639	54336	37827	19832	9864	5047	2752	1595	1384	1664
1989	113567	106124	105685	103624	75752	56748	41603	23609	12274	6911	3711	2071	1211	591
1990	108208	92981	86887	86527	84840	61856	44662	27294	15463	8708	4964	2642	1454	1057
1991	94795	88593	76127	71137	70757	68464	44529	25137	15508	8975	4694	2975	1363	1019
1992	71353	77611	72534	62327	58043	55341	49036	24557	10812	6232	3982	2156	1335	1123
1993	84619	58419	63543	59386	50066	43740	35427	21472	9062	4932	3508	2344	1097	493
1994	143529	69280	47829	52025	47707	32332	21399	12975	6796	3219	2377	1918	1047	697
1995	174222	117512	56722	39159	37712	24129	12161	7438	4525	2776	1637	1212	1188	946
1996	151801	142641	96210	46440	31769	29653	17636	7060	4162	2635	1785	1028	745	461
1997	116283	124284	116785	78770	37850	24509	19575	8660	4048	2543	1701	1067	631	407
1998	87403	95204	101755	95615	64189	29267	16294	9201	4181	2284	1534	1013	651	359
1999	71308	71560	77947	83310	77784	49318	19069	8104	4228	2125	1380	915	683	707
2000	93493	58382	58588	63817	67940	61739	35289	7821	3203	1960	1176	820	472	378
2001	94537	76546	47799	47968	52004	53788	39162	9732	3418	1742	1127	630	488	232
2002	101527	77400	62670	39135	38868	40551	33033	12047	3304	1885	978	526	332	211
2003	105217	83123	63370	51310	31607	30318	26650	11137	3885	1580	947	475	228	252
2004	83501	86144	68056	51883	40852	21814	15120	6651	3341	1720	827	513	259	221
2005		68365	70529	55719	41621	29650	10289	2896	1764	1558	927	415	253	245

Table 6f. Stock summary for Final XSA analysis.

Table 16 Summary (without SOP correction)

Terminal Fs derived using XSA with final year & oldest age shrinkag

	RE Age 1	TOTALE	TOTSPE	LANDIN	YIELD/S:	FBAR 5-:
1975	112392	132757	21901	28814	1.3156	0.3652
1976	116795	134533	17671	24611	1.3927	0.422
1977	107650	157000	14819	32048	2.1626	0.4236
1978	82557	167826	15908	39070	2.456	0.4649
1979	99270	162646	15628	34104	2.1823	0.2488
1980	130592	131043	12411	32867	2.6482	0.5376
1981	132408	115442	14049	30754	2.1891	0.4344
1982	131994	121553	19919	26278	1.3193	0.3776
1983	148037	123090	24238	27861	1.1495	0.3146
1984	154985	115653	24382	26711	1.0955	0.3849
1985	168588	148852	29167	20347	0.6976	0.2153
1986	188816	138942	33771	17976	0.5323	0.1885
1987	157663	165911	42616	32442	0.7613	0.2851
1988	129621	170782	44686	19215	0.43	0.1477
1989	113567	184229	44299	20034	0.4522	0.1268
1990	108208	208592	56525	47454	0.8395	0.2742
1991	94795	228008	64420	65008	1.0091	0.4238
1992	71353	196322	50610	63193	1.2486	0.4519
1993	84619	152271	39685	62455	1.5738	0.6454
1994	143529	107248	31167	51029	1.6373	0.6901
1995	174222	81988	28760	15272	0.531	0.2435
1996	151801	81344	22714	18840	0.8294	0.2787
1997	116283	78019	21195	19858	0.9369	0.3378
1998	87403	91149	19714	19946	1.0117	0.3581
1999	71308	106296	19195	24226	1.2621	0.4242
2000	93493	113701	15065	34177	2.2686	0.4612
2001	94537	113509	13292	38232	2.8764	0.4946
2002	101527	96523	11626	34062	2.9299	0.5189
2003	105217	81025	9957	35151	3.5304	0.6535
2004	83501	62714	10159	25486	2.5087	0.7055

Table 7a. Input data for deterministic and stochastic projections.

Name	Value	Uncertainty (CV)	Name	Value	Uncertainty (CV)
Population at age in 2005			Selection pattern		(2002-2004)
N1	Bootstrap (1975-2001)		sH1	0.000	0.00
N2	68365	0.30	sH2	0.000	0.00
N3	70529	0.23	sH3	0.000	0.00
N4	55719	0.19	sH4	0.033	0.27
N5	41621	0.15	sH5	0.175	0.48
N6	29650	0.14	sH6	0.655	0.31
N7	10289	0.13	sH7	1.862	0.10
N8	2896	0.17	sH8	1.643	0.08
N9	1764	0.20	sH9	0.925	0.13
N10	1558	0.20	sH10	0.740	0.24
N11	927	0.20	sH11	0.777	0.26
N12	415	0.20	sH12	0.856	0.38
N13	253	0.20	sH13	0.807	0.26
N14	245	0.22	sH14	0.807	0.260
Weight in the catch (2002-2004)			Weight in the stock		(2002-2004)
WH1	0.000	0.00	WS1	0.000	0.00
WH2	0.000	0.00	WS2	0.000	0.00
WH3	0.195	0.10	WS3	0.000	0.00
WH4	0.249	0.01	WS4	0.000	0.00
WH5	0.378	0.03	WS5	0.378	0.03
WH6	0.552	0.03	WS6	0.552	0.03
WH7	0.823	0.02	WS7	0.823	0.02
WH8	1.196	0.00	WS8	1.196	0.00
WH9	1.680	0.04	WS9	1.680	0.04
WH10	2.196	0.03	WS10	2.196	0.03
WH11	2.776	0.04	WS11	2.776	0.04
WH12	3.508	0.03	WS12	3.508	0.03
WH13	4.388	0.00	WS13	4.388	0.00
WH14	6	0.03	WS14	5.528	0.027
TAC					
2005	19000	0.05			
2006	18500	0.05			
2007	16000	0.05			

Table 7b. Deterministic and stochastic projection results, assuming the catches over 2005-2007 follow the rebuilding plan TACs.

Deterministic	2005	2006	2007	2008
Catch (t)	19000	18500	16000	
5+B (t)	56900	59000	63000	67600
F (5-10)	0.64	0.55	0.40	

Stochastic (median values)	2005	2006	2007	2008
F (5-10)	0.64	0.54	0.38	
5+B (t)	56800	59400	63600	68900
10+B (t)	9900	7900	6100	5500

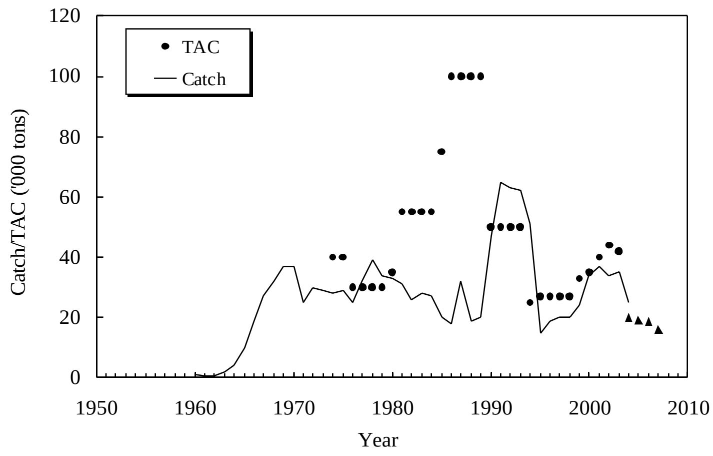


Fig. 1. Catches and TAC for Greenland Halibut in Sub-area 2 and Div. 3KLMNO. The triangles represent TACs established by the Fisheries Commission re-building plan.

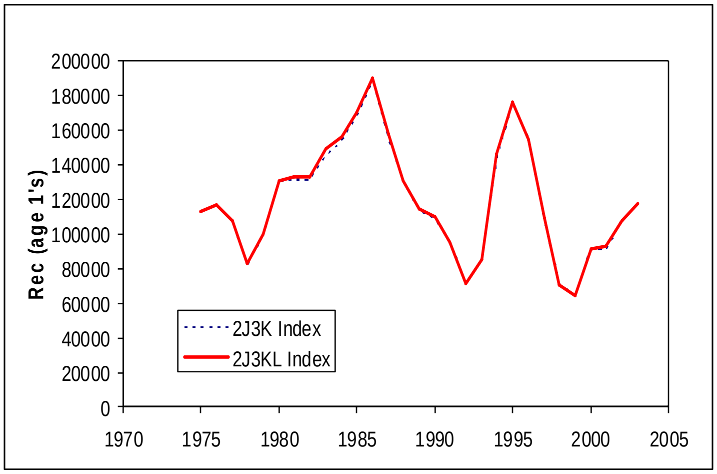


Fig. 2a. Recruitment from 2004 assessment (solid line), and run replacing 2J3KL MNPT index with 2J3K MNPT index.

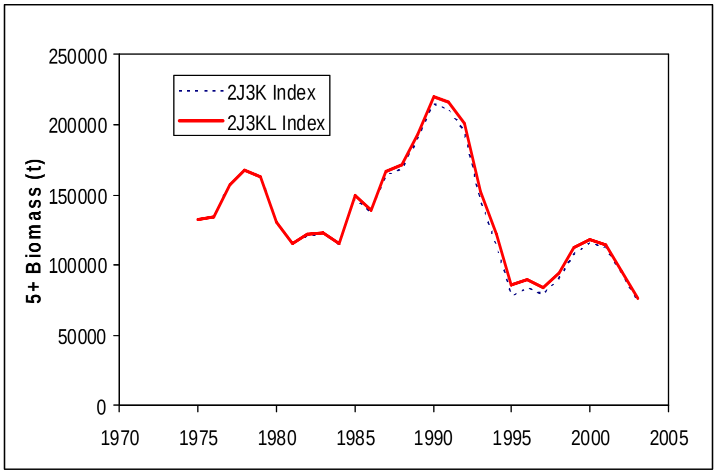


Fig. 2b. 5+ Biomass (t) from 2004 assessment (solid line), and run replacing 2J3KL MNPT index with 2J3K MNPT index.

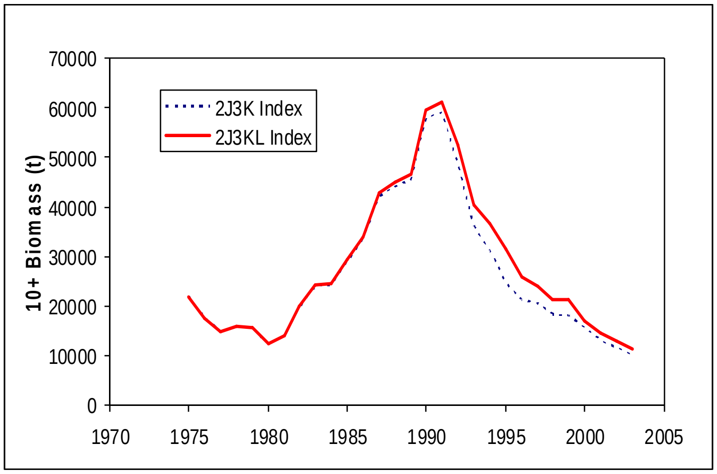


Fig. 2c. 10+ Biomass (t) from 2004 assessment (solid line), and run replacing 2J3KL MNPT index with 2J3K MNPT index.

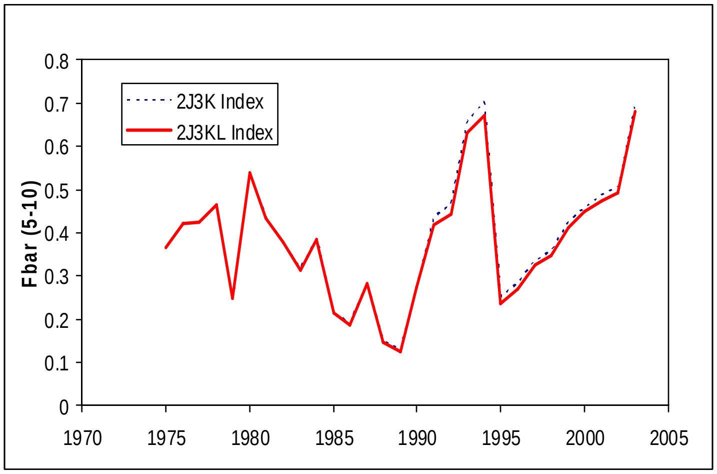


Fig. 2d. Average fishing mortality (5-10) from 2004 assessment (solid line), and run replacing 2J3KL MNPT index with 2J3K MNPT index.

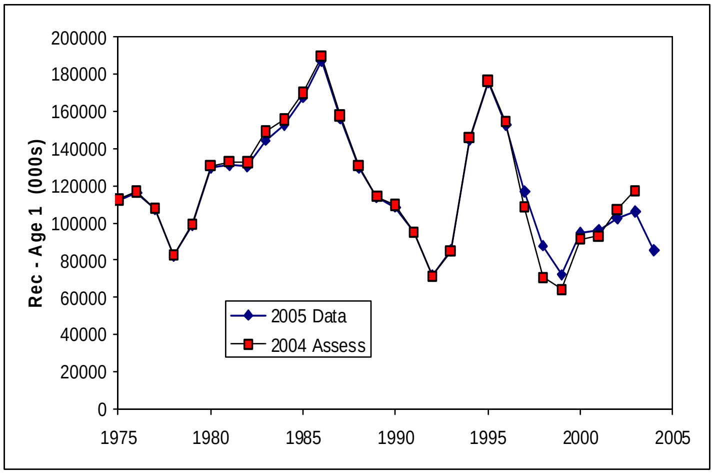


Fig. 3a. XSA estimate of Recruitment using most recent data.

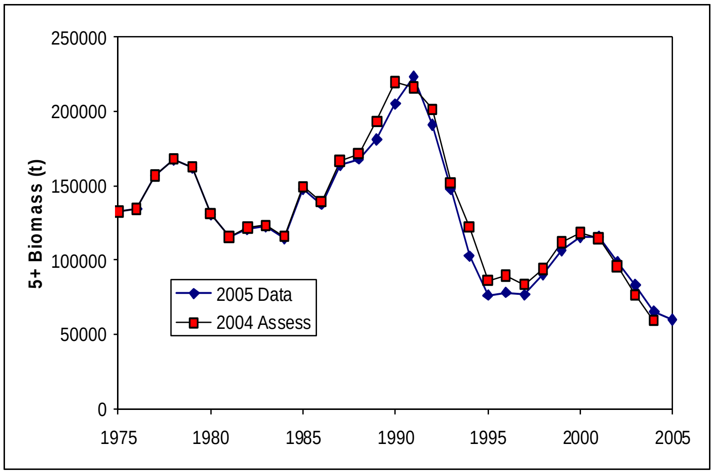


Fig. 3b. Estimated 5+ Biomass (t) using most recent data.

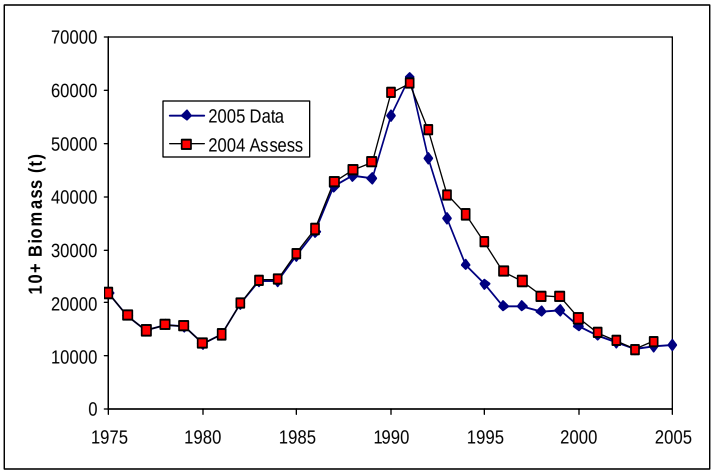


Fig. 3c. Estimated 10+ Biomass (t) using most recent data.

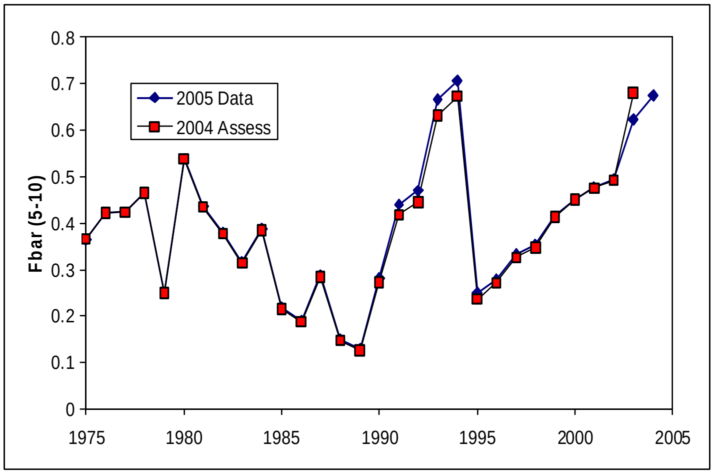


Fig. 3d. Estimated average fishing mortality, ages 5-10, using most recent data.

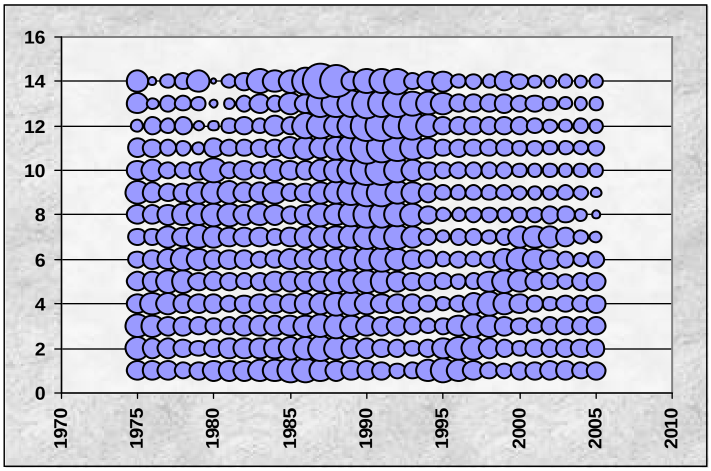


Fig. 3e. Population age composition. Bubbles are scaled to mean of each age class.

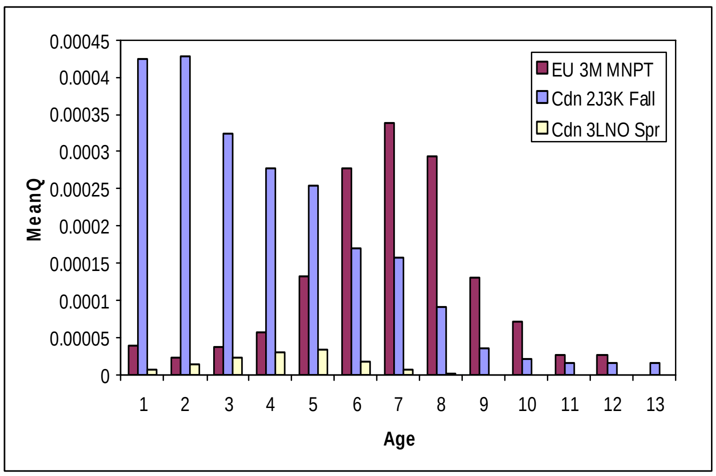


Fig. 3f. Mean catchability from XSA.

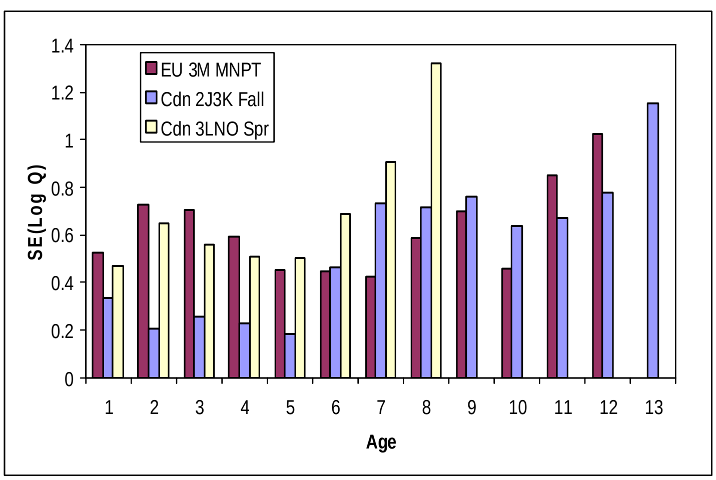


Fig. 3g. Standard Error estimates of Log(Q) from XSA.

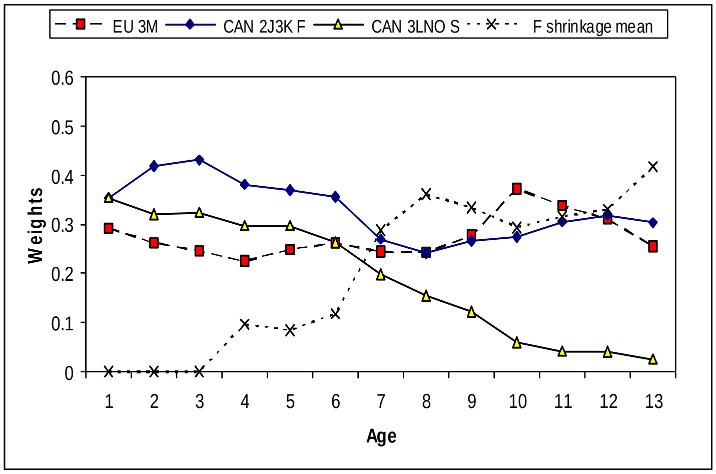


Fig. 3h. XSA scaled weights for computing estimates of survivors.

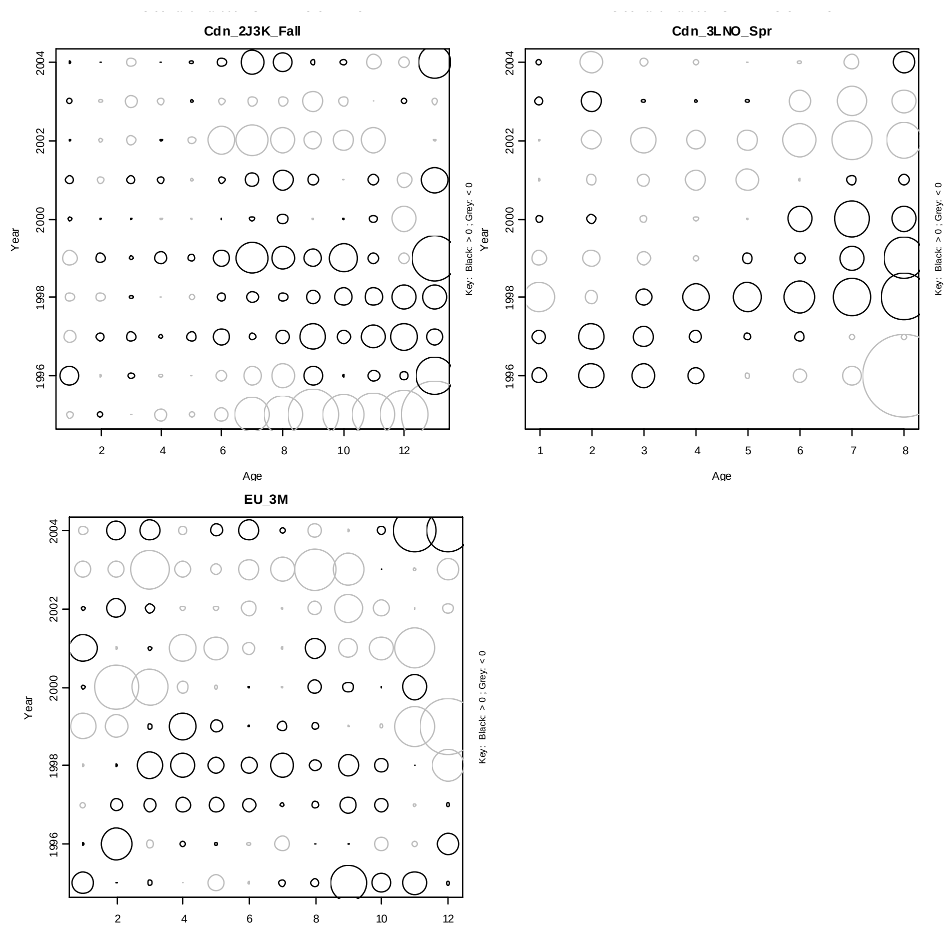


Fig. 4a. Residual bubble plots (by survey) for 2005 XSA run using the same settings as the 2004 agreed assessment.

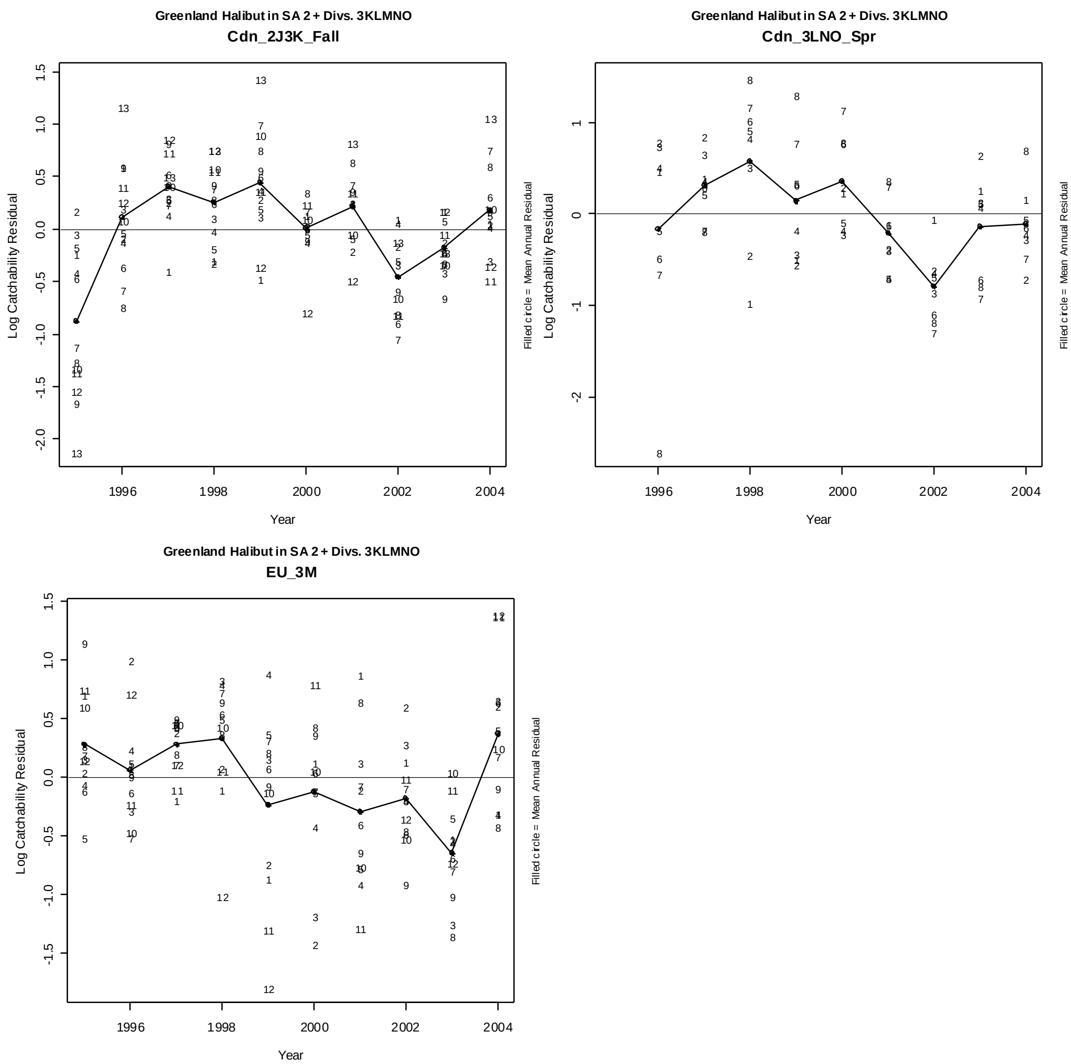


Fig. 4b. Annual residual (by survey) for 2005 XSA run using the same settings as the 2004 agreed assessment. Line connects the annual means; symbol = age.

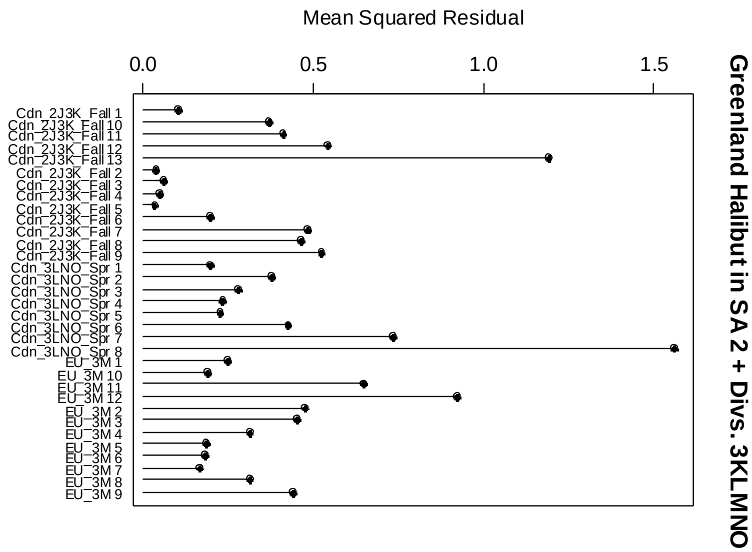


Fig. 4c. Mean Squared Residual) for 2005 XSA run using the same settings as the 2004 agreed assessment.

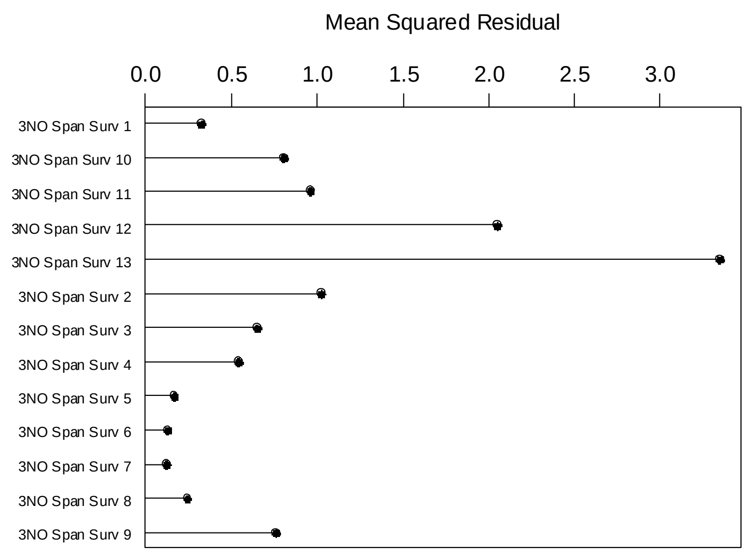


Fig. 5a. Mean Squared Residual from XSA diagnostic analysis with Spain 3NO index only.

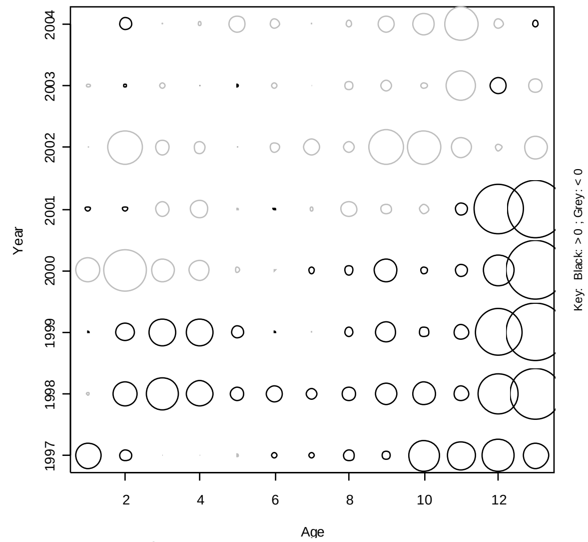


Fig. 5b. Residual bubble plot from XSA diagnostic analysis with Spain 3NO index only.

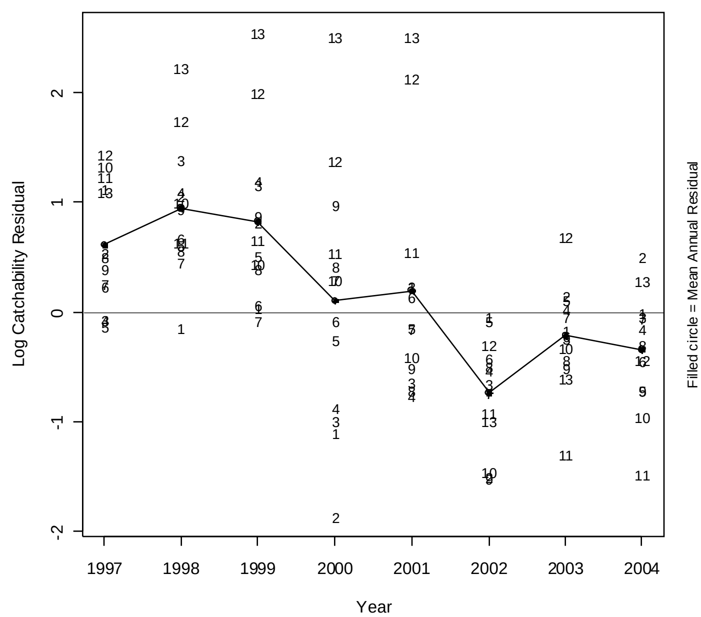


Fig. 5c. Annual residuals from XSA diagnostic analysis with Spain 3NO index only. The solid line indicates the mean annual residual.

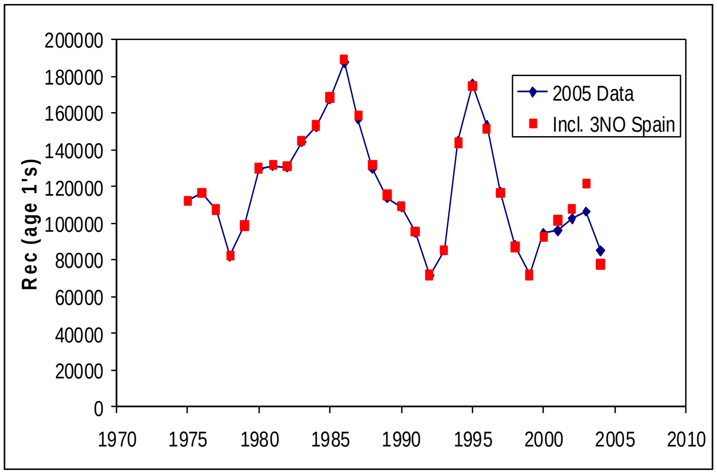


Fig. 6a. Estimated recruitment, Age 1. XSA analysis includes the Spanish 3NO index.

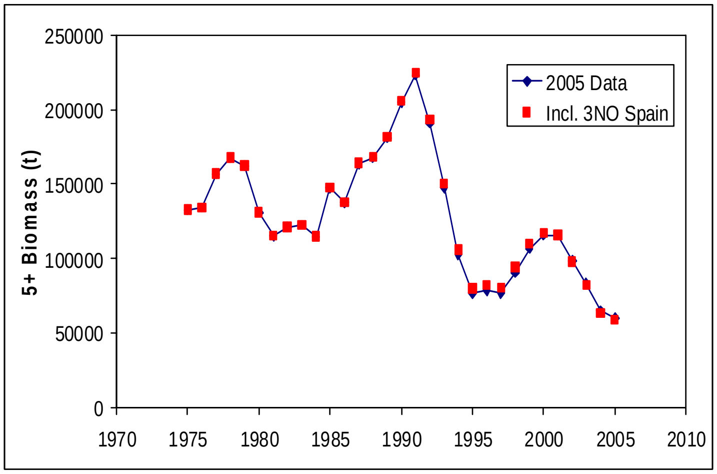


Fig. 6b. Estimated 5+ Biomass (t). XSA analysis includes the Spanish 3NO index.

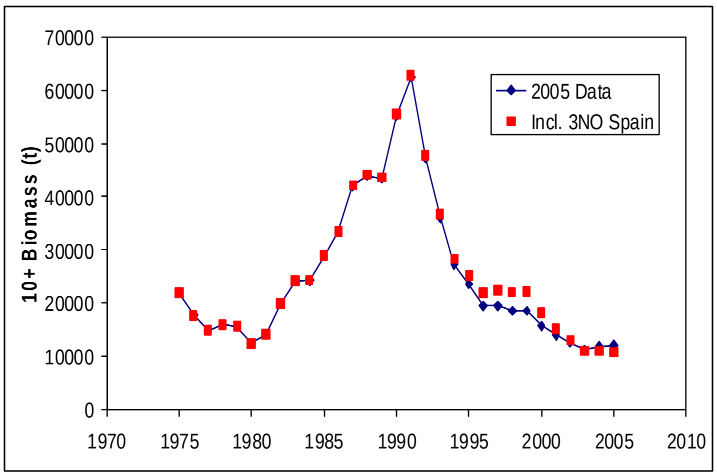


Fig. 6c. Estimated 10+ Biomass (t). XSA analysis includes the Spanish 3NO index.

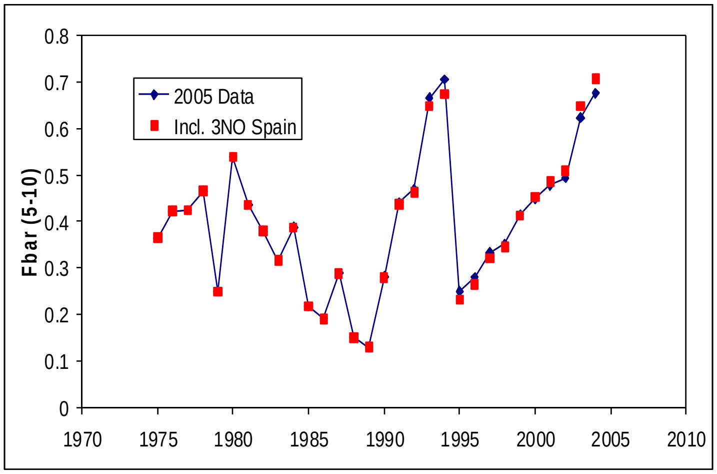


Fig. 6d. Estimated average fishing mortality, ages 5-10. XSA analysis includes the Spanish 3NO index.

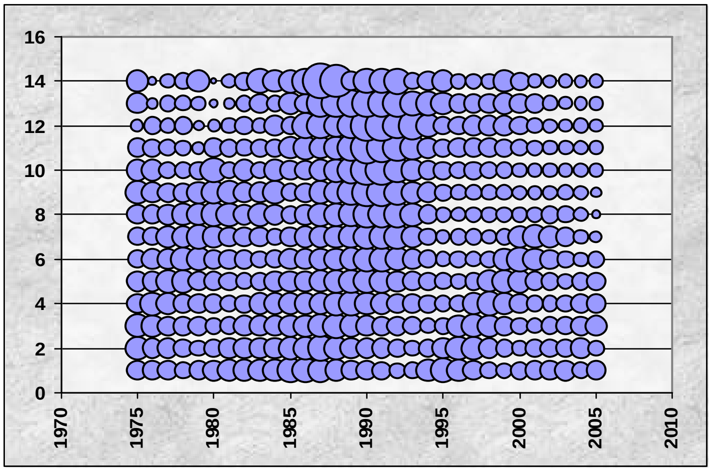


Fig. 6e. Population age composition. Bubbles are scaled to mean of each age class.

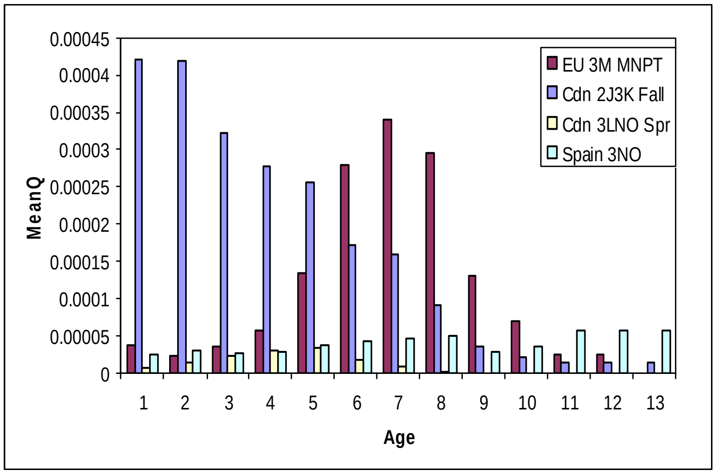


Fig. 6f. Mean catchability from XSA.

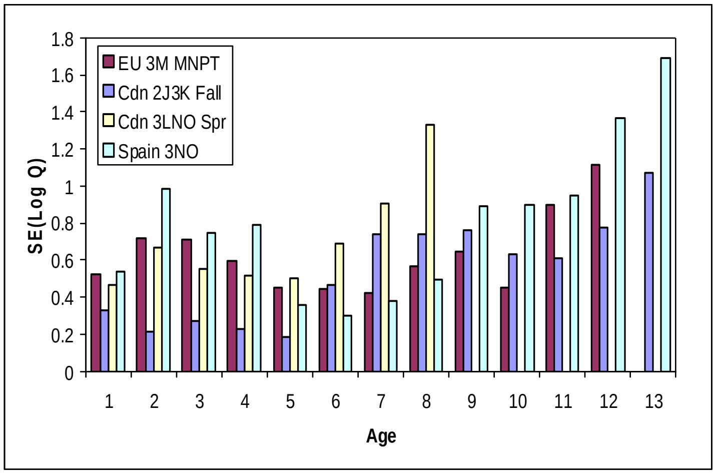


Fig. 6g. Standard Error estimates of Log(Q) from XSA.

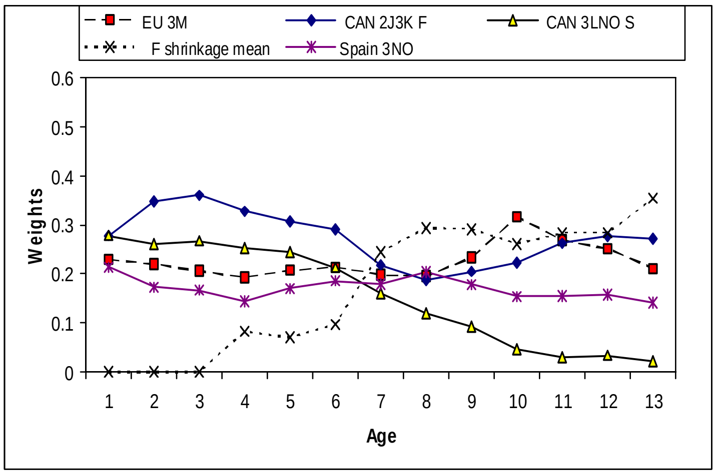


Fig. 6h. XSA scaled weights for computing estimates of survivors.

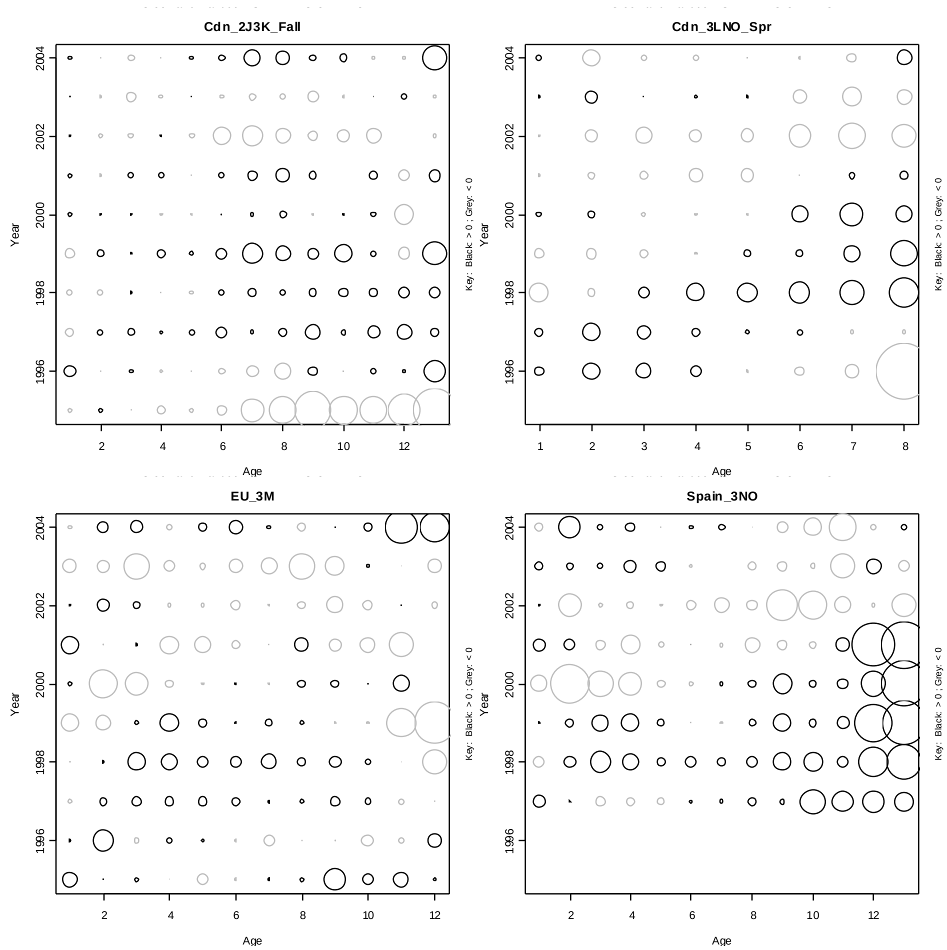


Fig. 7a. Residual bubble plots (by survey) for 2005 XSA run using the same settings as the 2004 agreed assessment, adding the Spanish 3NO data.

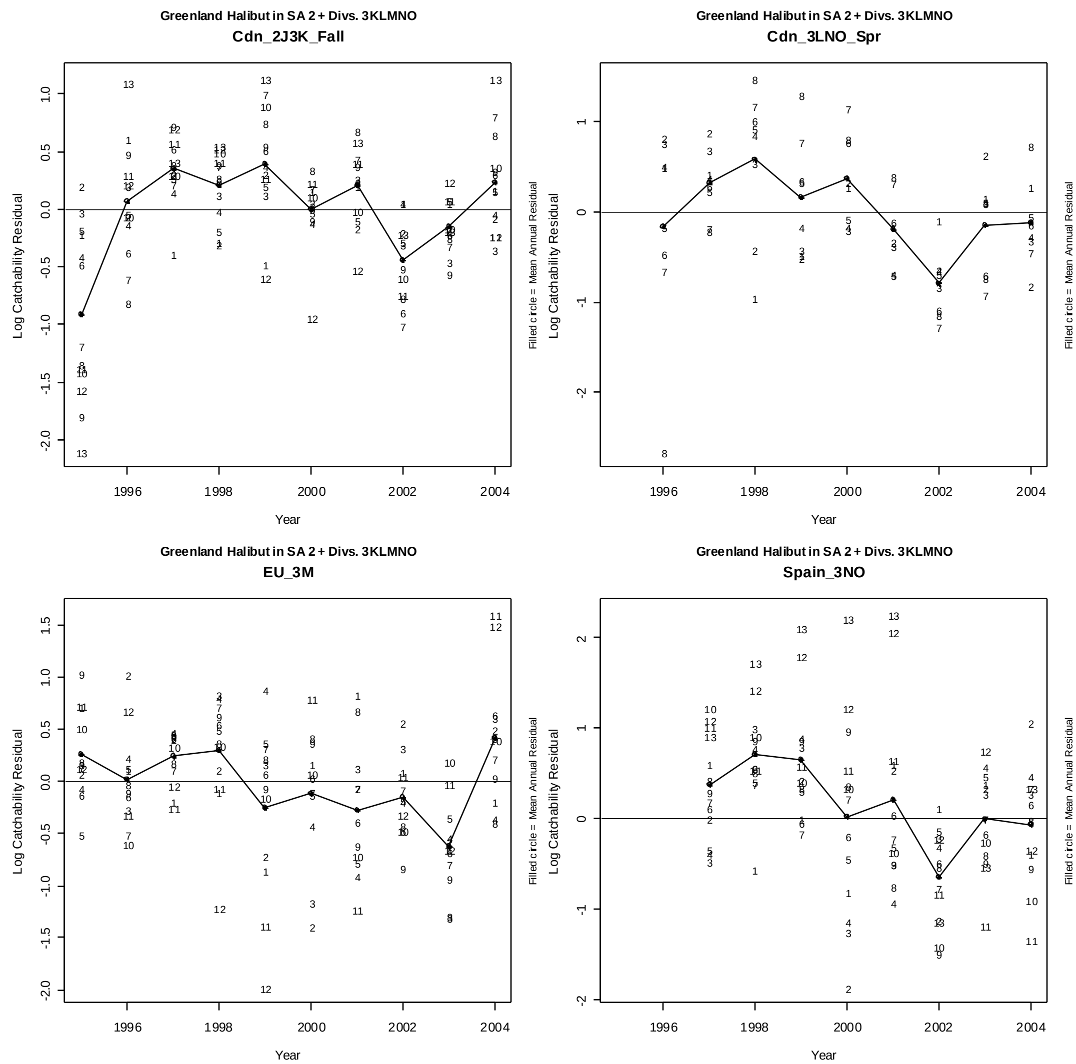


Fig. 7b. Annual residual (by survey) for 2005 XSA run using the same settings as the 2004 agreed assessment, adding the Spanish 3NO data. Line connects the annual means; symbol=age.

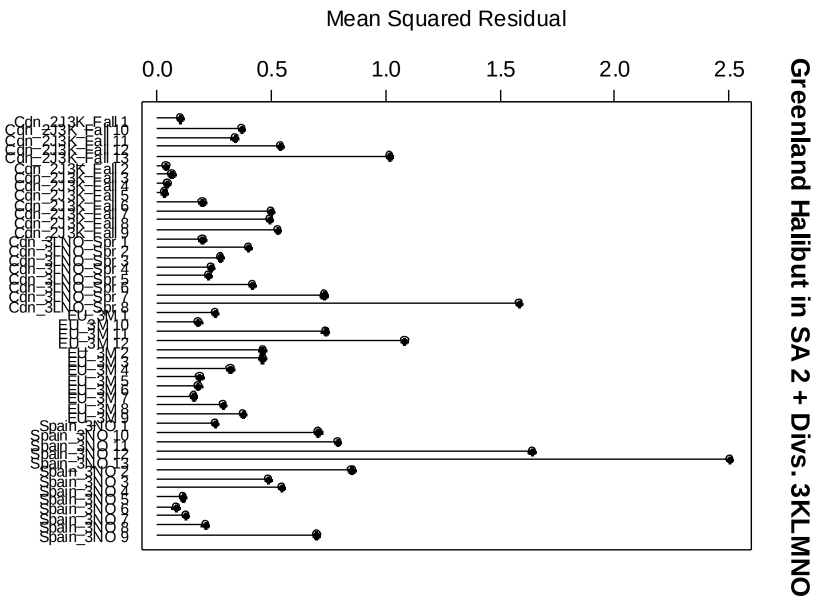


Fig. 7c. Mean Squared Residual for 2005 XSA run using the same settings as the 2004 agreed assessment, adding the Spanish 3NO data.

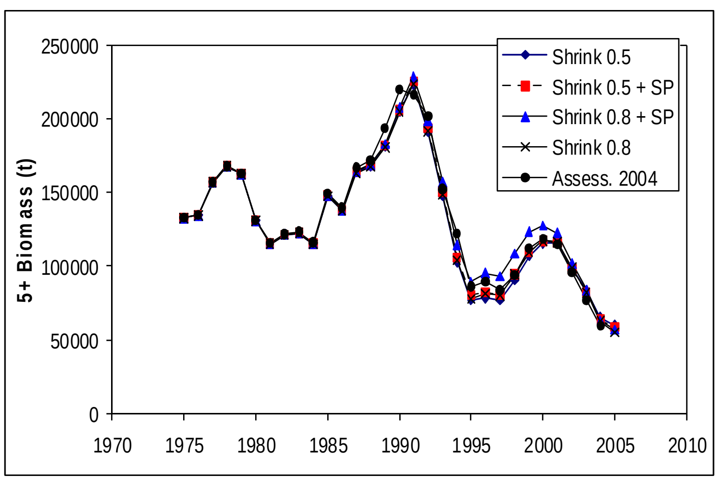


Fig. 8a. Sensitivity analysis on shrinkage parameter and inclusion of Spanish data. Exploitable biomass (5+; t).

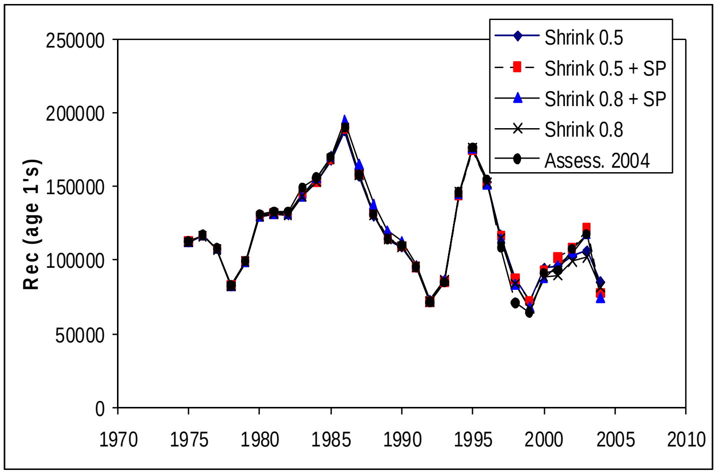


Fig. 8b. Sensitivity analysis on shrinkage parameter and inclusion of Spanish data. Recruitment (000s; age 1).

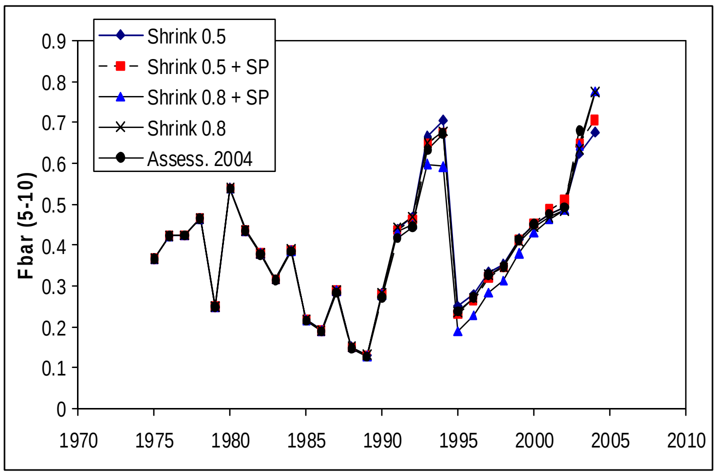


Fig. 8c. Sensitivity analysis on shrinkage parameter and inclusion of Spanish data. Average F (5-10).

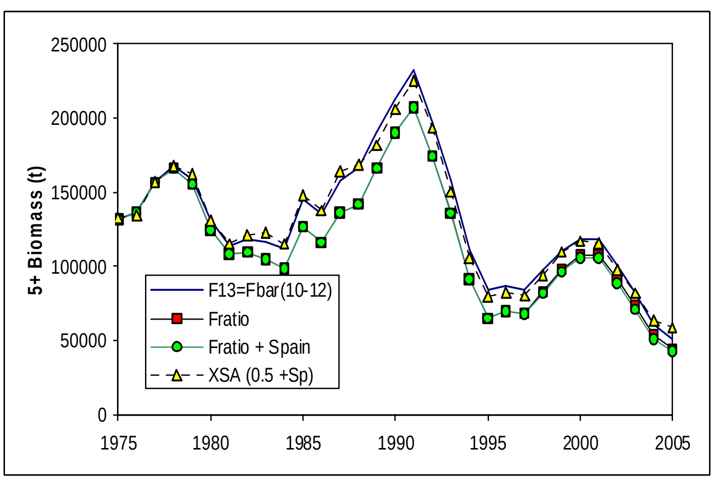


Fig. 9a. Estimates of exploitable biomass (ages 5+; tons) from ADAPT analyses.

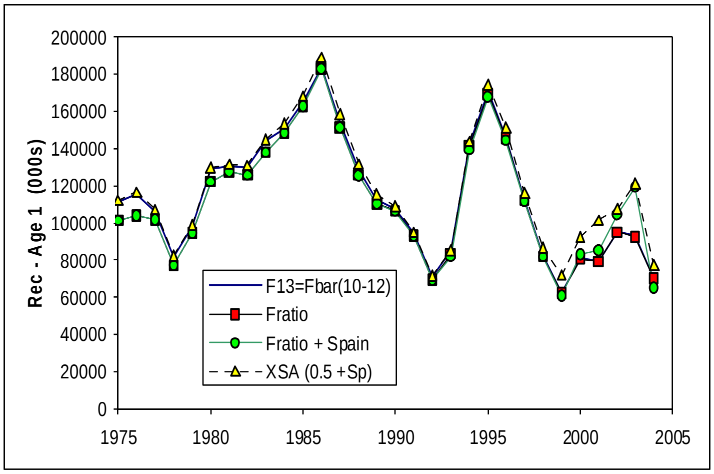


Fig. 9b. Estimates of recruitment (ages 1) from ADAPT analyses.

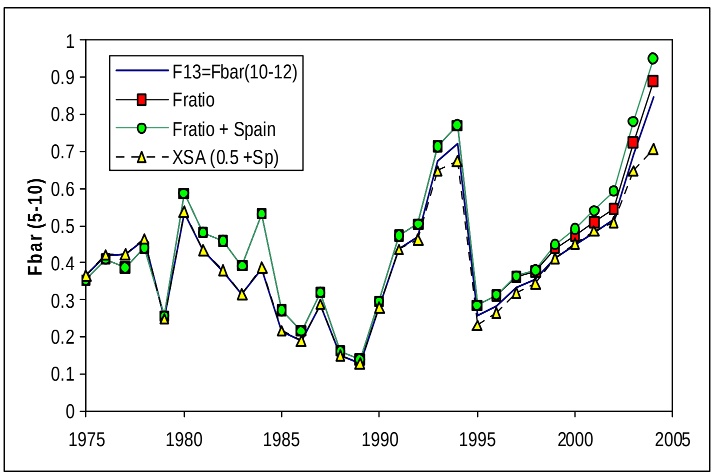


Fig. 9c. Estimates of average fishing mortality (ages 5-10) from ADAPT analyses.

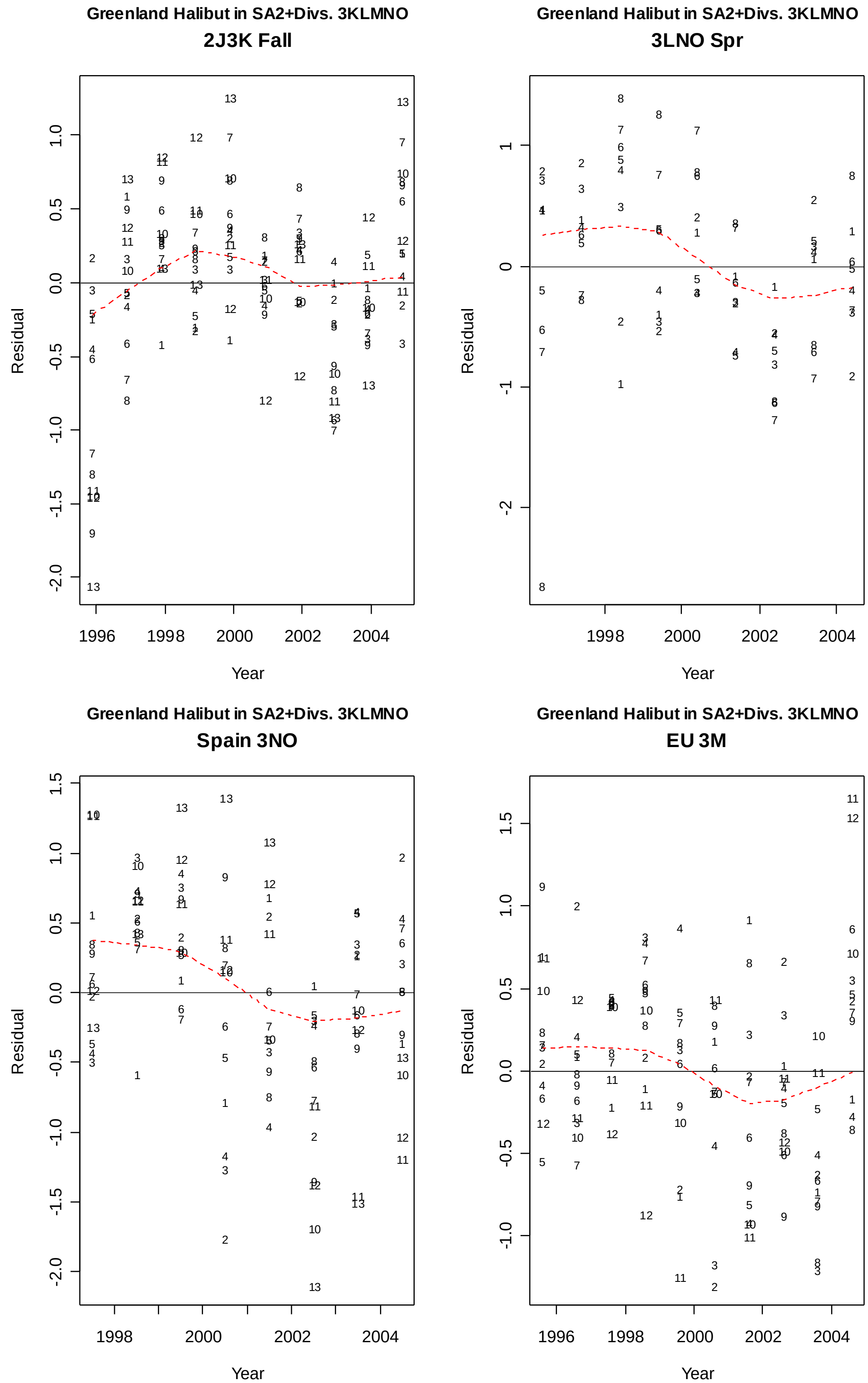


Fig. 10a. Residuals, by survey, from ADAPT "Fratio+Spain" analysis. In each panel, symbol=age, and the line is a loess smoother.

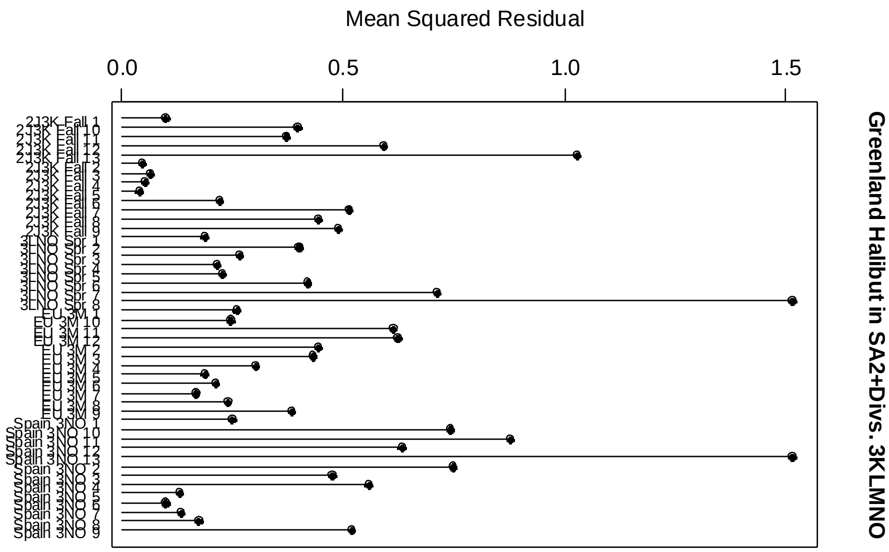


Fig. 10b. Mean Squared Residual for each survey-age from ADAPT "Fratio+Spain" analysis.

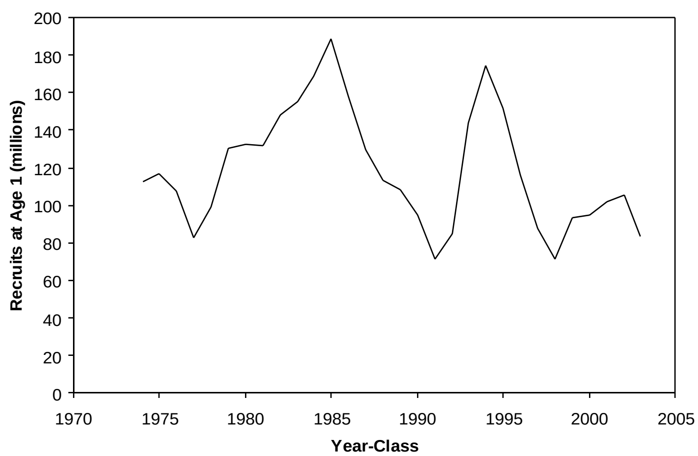


Fig. 11a. Estimated recruitment (age 1) from final run.

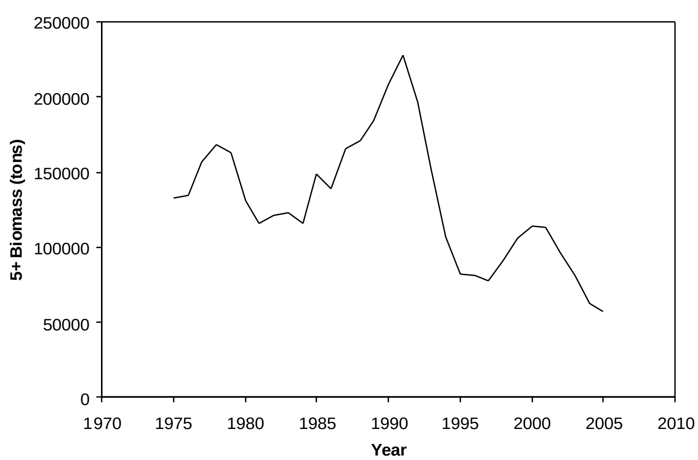


Fig. 11b. Estimated 5+ biomass (t) from final run.

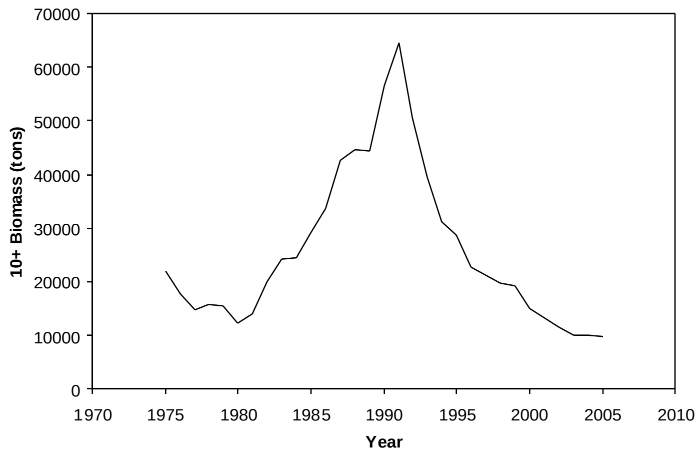


Fig. 11c. Estimated 10+ biomass (t) from final run.

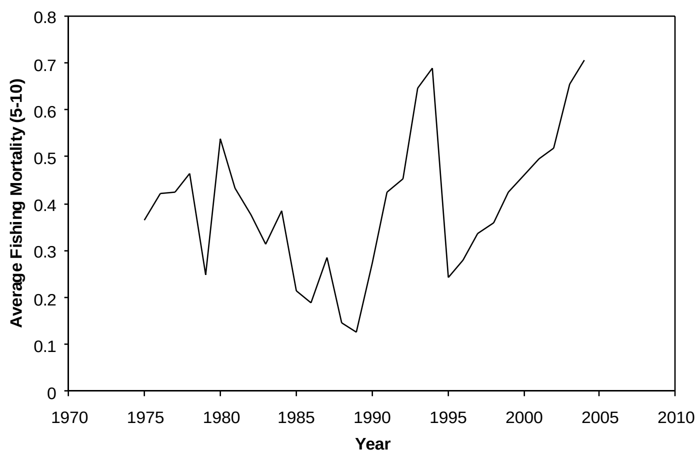


Fig. 11d. Estimated average fishing mortality (ages 5-10) from final run.

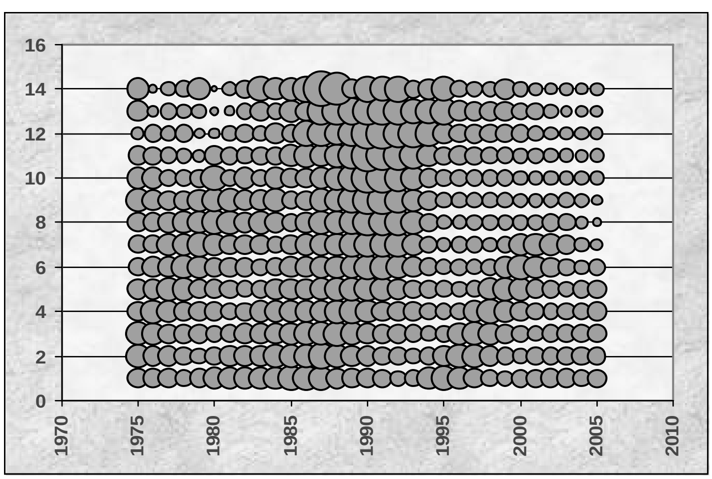


Fig. 11e. Population age composition. Bubbles are scaled to mean of each age class.

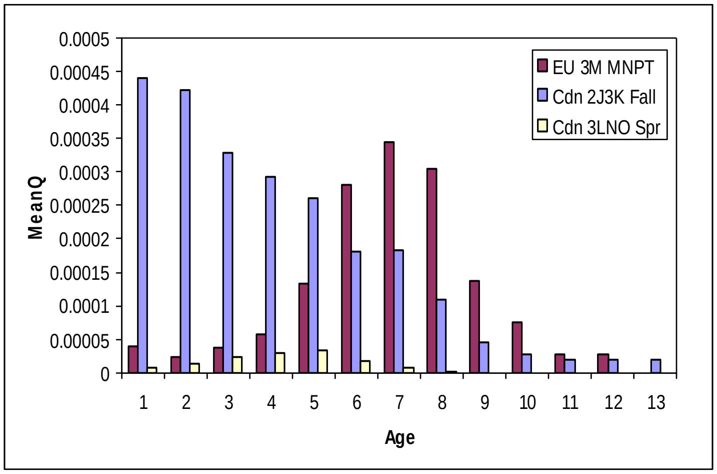


Fig. 11f. Mean catchability from XSA.

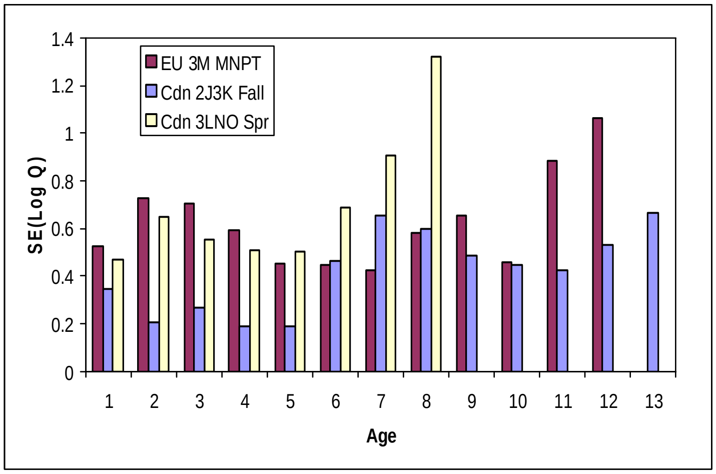


Fig. 11g. Standard Error estimates of Log(Q) from XSA.

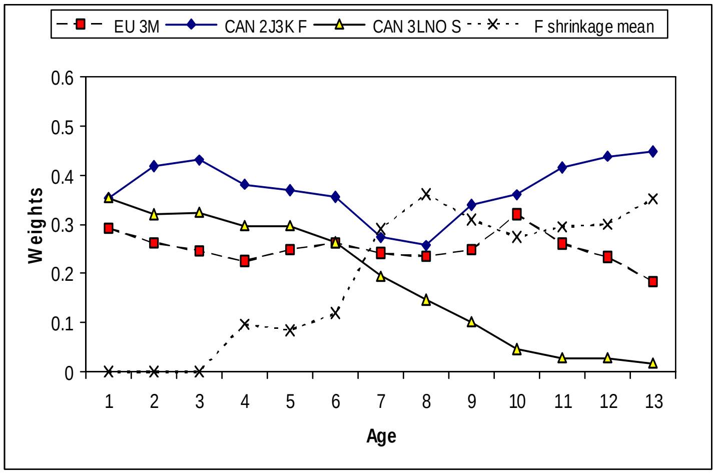


Fig. 11h. XSA scaled weights for computing estimates of survivors.

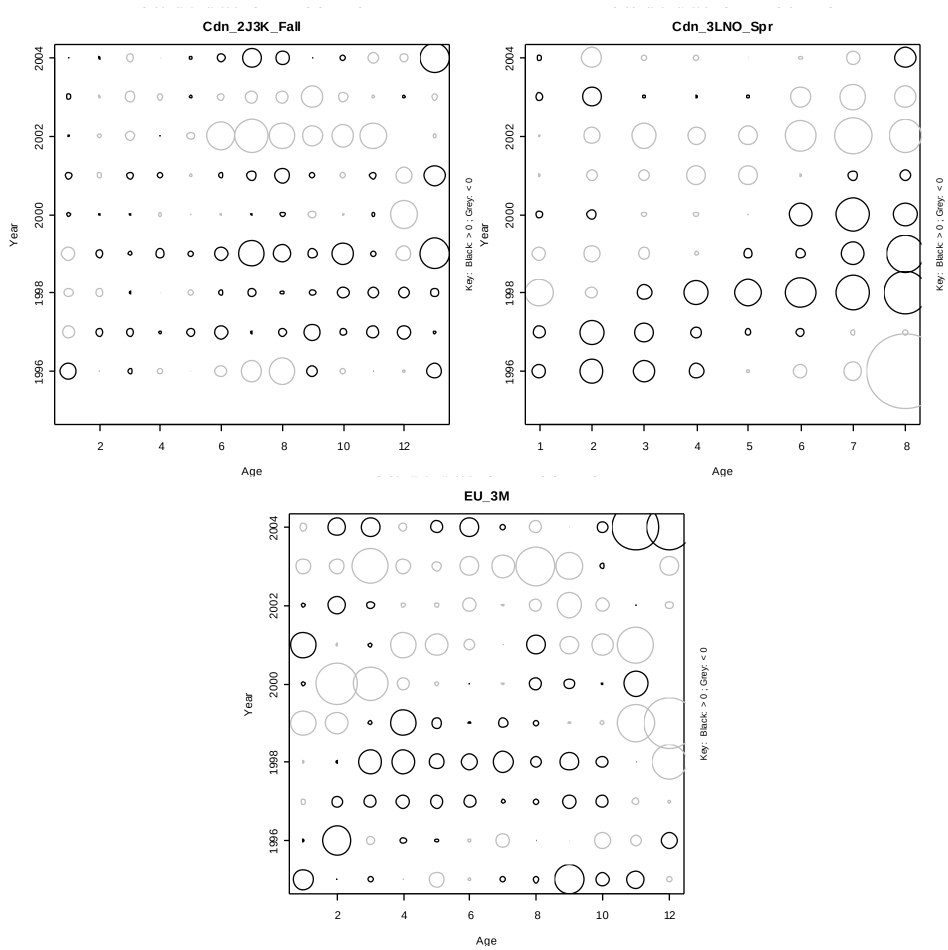


Fig. 12a. Residual bubble plots (by survey) for final XSA run.

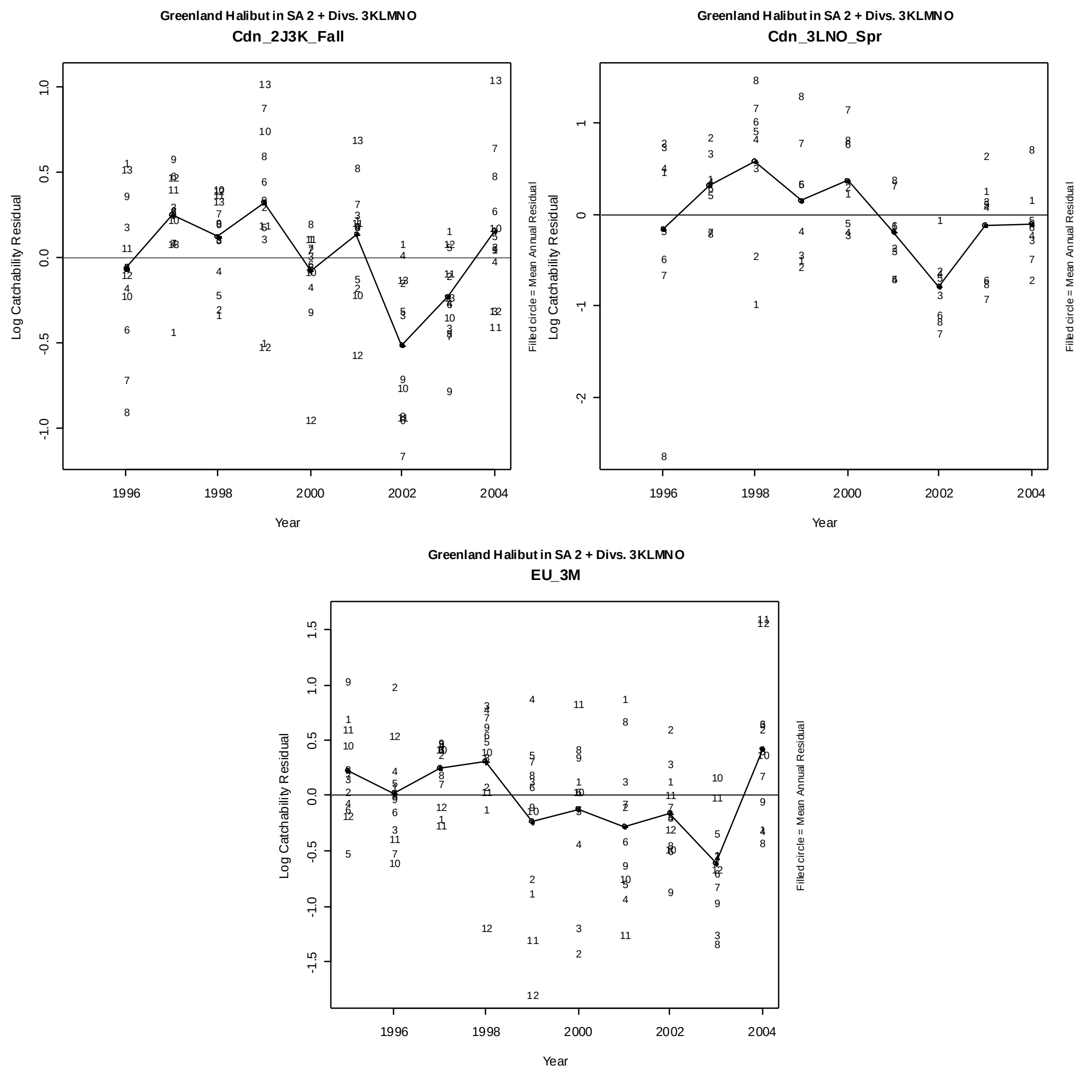
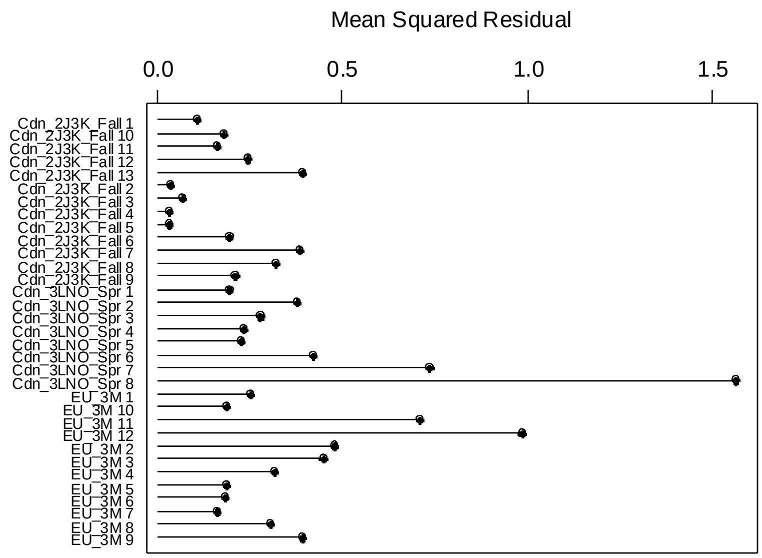


Fig. 12b. Annual residual (by survey) for final XSA run. Line connects the annual means; symbol=age.



Greenland Halibut in SA 2 + Divs. 3KLMNO

Fig. 12c. Mean Squared Residual for final XSA run.

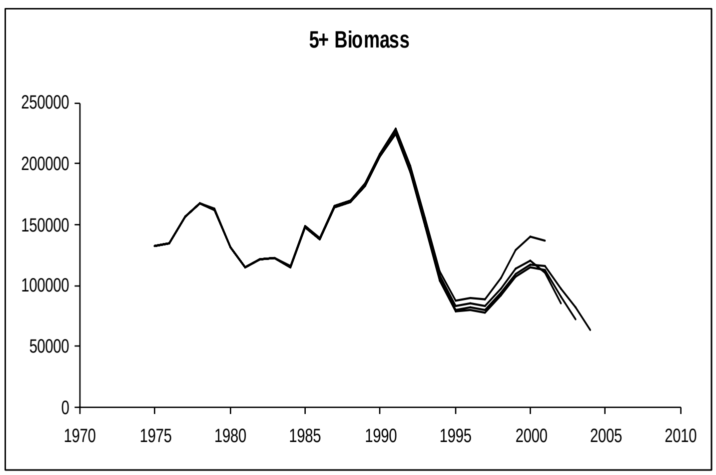


Fig. 13a. Retrospective estimates of exploitable biomass (t) from XSA.

Fig. 13b. Retrospective estimates of recruitment (age 1, 000s) from XSA.

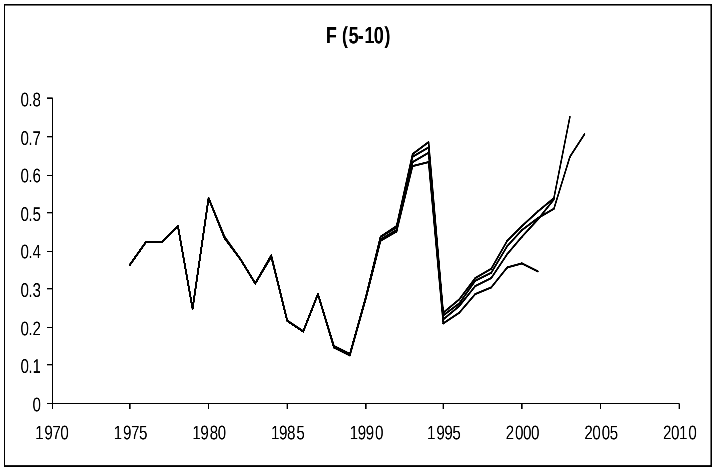


Fig. 13c. Retrospective estimates of average fishing mortality (average 5-10) from XSA.

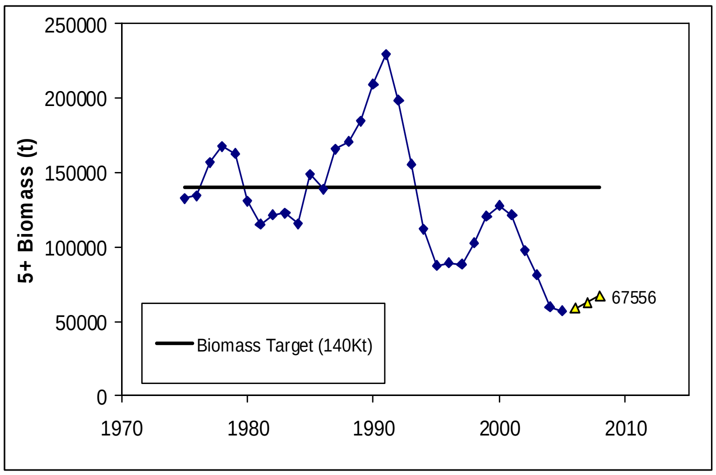


Fig. 14a. Greenland halibut in Subarea 2 + Div. 3KLMNO. Deterministic projection of 5+ biomass to 2008 (triangles) under FC rebuilding plan.

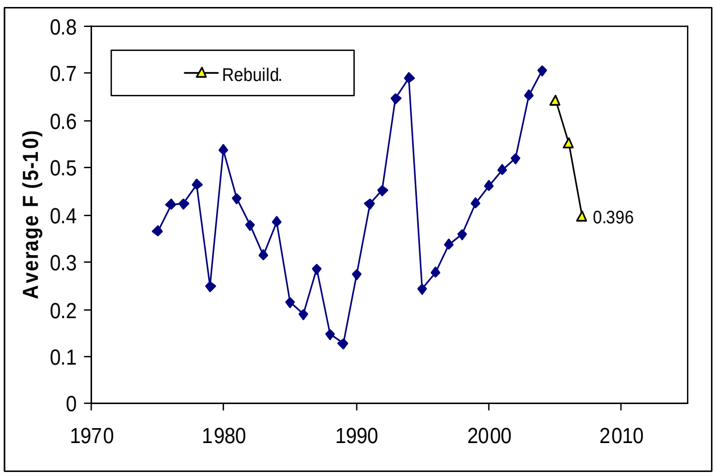


Fig. 14b. Greenland halibut in Subarea 2 + Div. 3KLMNO. Deterministic projection of average fishing mortality to 2007 (triangles) under FC rebuilding plan.

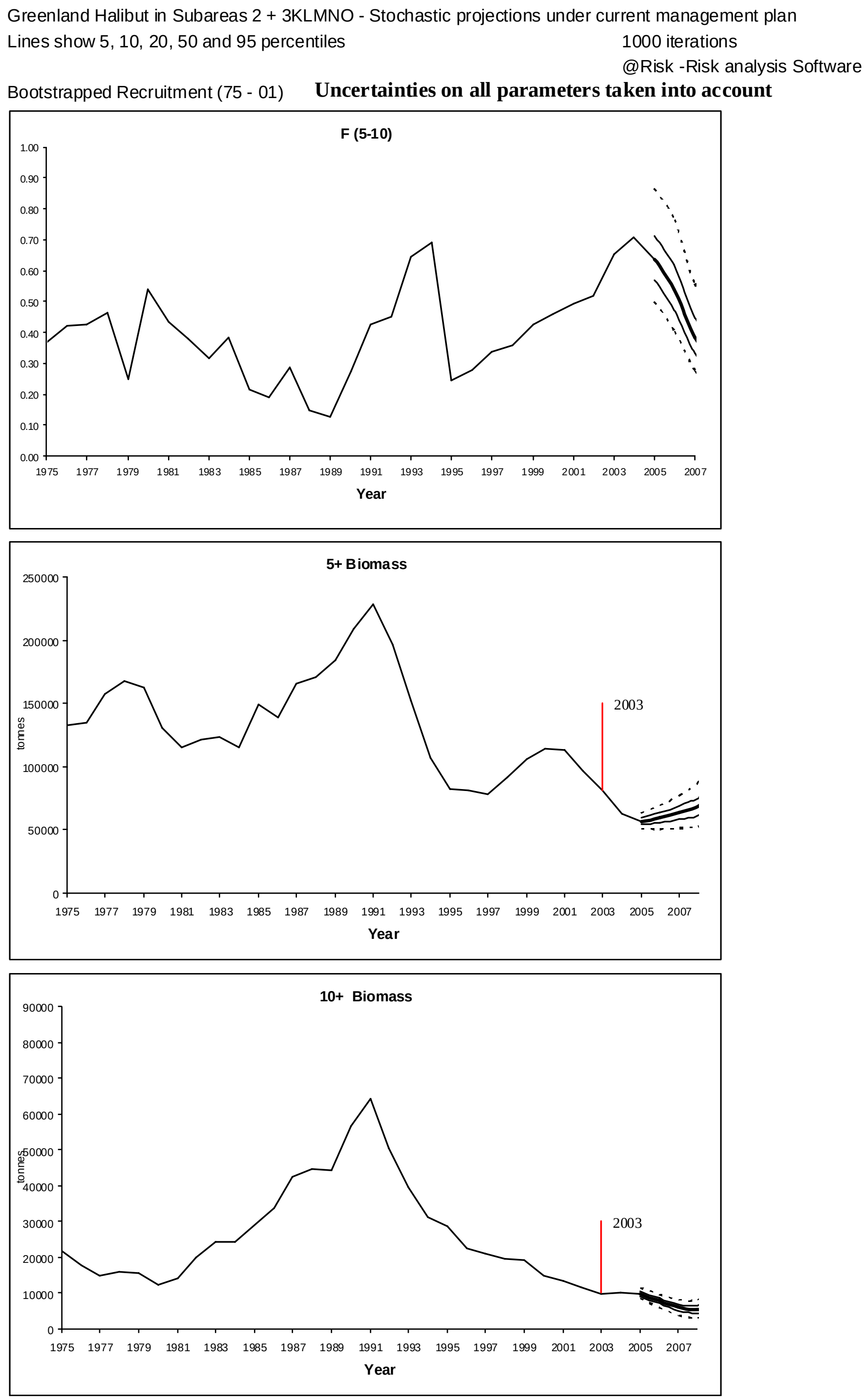


Fig. 15. Greenland halibut in Subarea 2 + Div. 3KLMNO: Projection estimates of average fishing mortality, 5+ biomass, and 10+ biomass over 2005-2007 under Fisheries Commission rebuilding plan. The biomass levels of 2003 (year in which rebuilding plan developed) are highlighted. The 5th, 25th, 50th (thick line), 75th, and 95th percentiles are shown.