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An Assessment of Greenland Halibut *(Reinhardtius hippoglossoides)* in NAFO Subarea 2 and Divisions 3KLMNO

by

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Abstract

Using catch history and fishery independent surveys to 2009, we assess the status of Greenland Halibut in Sub-Area 2 and Divisions 3KLMNO. An overview of catch sampling, survey data, estimates of maturation rates from Canadian autumn surveys are also provided. The consistency of the signals provided in the available survey data is also compared and discussed. Estimates of stock status of Greenland Halibut in Subarea 2 and Divisions 3KLMNO are produced using Extended Survivors Analysis (XSA, Shepherd, 1999). Variations in the F-shrinkage settings and the newly available deep-water time series from the EU Flemish Cap both make the current estimates of biomass more optimistic than from recent assessments. Despite these changes, estimated biomass (ages 5+) remains well below the long-term average, and all recent year-classes are estimated to be relatively weak. Estimated fishing mortality has decreased substantially under the Fisheries Commission Rebuilding Plan, and current estimates are low (0.25). Projections conducted under various catch and fishing mortality options indicate that the biomass targeted by the fishery (ages 5-9) will decline under all scenarios considered, including a case in which the current low levels of fishing mortality are maintained.

Introduction

Results of the 2008 NAFO Scientific Council assessment of this stock indicated that the exploitable (ages 5+) biomass in 2008 was one of the lowest in the estimated time series. Further, estimated average fishing mortality remained relatively high and the strength of recent year-classes was confirmed to be weak (Healey and Mahé, 2008).

A retrospective analysis indicated that in the recent past, fishing mortality tended to be over-estimated and biomass under-estimated as estimated magnitude of the 1996-2000 cohorts had been revised upwards with each successive assessment. Consequently, relatively strong shrinkage was applied to reduce the retrospective patterns. During the 2009 NAFO Scientific council assessment, survey coverage issues within the 2008 Canadian fall survey led to a decision that data from this survey were not comparable to those of previous years (see NAFO, 2009, also Healey and Brodie, 2009 for further detail). Hence, it was considered that updating the XSA assessment using the data available for 2008 would be inappropriate. However, the XSA model accepted by the Scientific Council in 2008 was used as a basis for projections and provision of advice. In this assessment, there are no coverage issues in the most recent surveys and we re-evaluate the status of the stock incorporating the most recent survey and catch data.

In 2003 Fisheries Commission established a fifteen year rebuilding plan for this stock (NAFO, 2003a), with the intent to: "*take effective measures to arrest the decline in the exploitable biomass and to ensure the rebuilding of this biomass to reach a level that allows a stable yield of the Greenland halibut fishery over the long term*". The plan states that "the objective of this programme shall be to attain a level of exploitable biomass 5+ of 140,000 tonnes on average", and in an attempt to improve the rebuilding prospects for this stock, TACs were set at 20, 19, 18.5, 16 ('000 tons), respectively, for the years 2004-07 (Figure 1). Subsequent TAC levels "*may be adjusted by the Scientific Council advice*" but "*shall not be set at levels beyond 15% less or greater than the TAC of the preceding year*".

During the 2009 assessment, the Scientific Council advised (NAFO, 2009, p. 11) that "*fishing mortality should be reduced to a level not higher than F0.1*" corresponding to a TAC of not higher than 8 800 tons. The 2010 TAC was subsequently set at 16 000 tons.

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 (Table 1, Figure 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 entire stock unit by the Fisheries Commission (previous TACs were set autonomously by Canada), and the catch declined to just over 15 000 tons in 1995. Catches increased through the late 1990's into the early part of the 2000's, but have decreased under the FC rebuilding plan. However, under this rebuilding plan, STACFIS estimated catches have exceeded the TAC considerably, ranging from 22% - 45%. The estimated total catch for 2009 is 23,160 tons.

Catch-at-age

Length sampling for otter trawl fisheries in the NAFO Regulatory Area (NRA) provided by EU-Portugal (Vargas et *al*., 2010), EU-Spain (González et *al*., 2010), and Russia (Skryabin et *al*., 2010) for 2009 otter trawl fisheries are quite similar (Figure 2), with modal catch length of about 46-48cm. Note that the length sampling from 2005-2009 generally indicates increases in the length of fish caught over this time frame. This is most strongly apparent in the Russian and Spanish sampling. (See Brodie et *al*., 2010, for Canadian sampling information.) Available age-length keys indicate a difference between Spanish and Canadian age interpretations (see 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, the length samples from these nations are converted to catch-at-age using Canadian age length keys. Recent research suggests that in addition to these inconsistencies, the Canadian, EU and Russian age determination methods may be underestimating ages (Treble et al., 2005). A workshop on age determination methods for Greenland Halibut was held in early 2006 (Treble and Dwyer, 2006), but consensus on age-readings for this species has not been attained; active research on this problem continues.

Computation of Canadian catch-at-age is described by Brodie et al (2010). Samples from the Canadian fishery were used to derive catch-at-age independently for each gear (see Table 5 of Brodie et al., 2010). The 2001 and 2002 year-classes (ages 8 and 7 in 2009) dominated the Canadian catch; with 80% of the catch (in numbers) from these two cohorts. Note that the proportion of older individuals has decreased considerably in the Canadian catch – age groups 9 and older accounted for over 20% of the numbers caught in 2004 and 2005 fisheries. However, in 2009, these age groups accounted for approximately 14% of the catch numbers, primarily attributable to reductions in the longline catches (only 3t for 2007) and changes to gillnet mesh size regulations within the Canadian EEZ (see Brodie et al., 2010).

No sampling data are available for 2009 catches taken by EU-Estonia, EU-Germany, St. Pierre and Miquelon (France) and the Faroe Islands (Denmark) (1088 t combined catch), all operating in the NAFO Regulatory Area (NRA). 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 fisheries operating within the NRA.

Total catch numbers-at-age for 1975-2009 are given in Table 2. As in the recent past, in 2009 the modal catch was at age 7 (2002 year-class). However, given the increasing length of fish caught, a larger proportion of the catch is now 8 years old (the 2001 year-class). Catch weights at age (Table 3) are computed as weighted means of the values from national sampling, and have generally been stable over time. However, at older ages (10+), there is evidence of a slight decrease in mean weights at age over the past decade. Ages 6-8 dominate the catch throughout the entire time period and the proportion of the catch from these age groups has been increasing. Age groups 10+ currently contribute about 9% to the total annual landings, less than half of the long-term average. To illustrate changes in the age composition of the catch over the past five years (particularly changes at ages 8+), the combined C@A from 2004-2009 is plotted in Figure 3. Within age groups 5-9, there has been an increasing proportion of older fish caught over this time period. These changes are important considering that individual weight increases about four-fold over these age groups (Table 3). For example, comparing catch-at-age in 2008 and 2009, the increased proportion of ages 8 and 9 in the catch results in only a minor increase in total catch numbers at age despite the 10% increase in total landings. The overall sum-of-products is 1.01 for the 2009 data, and is close to 1 for all six years.

Survey Data

Abundance Indices

At present, there is no synoptic survey which covers the entire distribution range of Greenland Halibut in Sub-Area 2 and Divisions 3KLMNO. Results of annual surveys by the EU on the Flemish Cap, and by Canada covering NAFO Divs. 3LNO during spring and NAFO Divs. 2J3KLMNO in autumn provide the best sources of information for this stock. Of importance for this assessment, in 2004 the EU survey was extended to cover depths down to 1400m (maximum depth covered prior to 2004 was 732m). Age-disaggregated abundance indices aggregated over depths of 0-700m, 700-1400m and 0-1400m depth over 2004-2009 are now available for potential inclusion in the analytical assessment (Vázquez, 2010 and D.González-Troncoso, pers. comm.). We note that the survey information available have variable temporal, and also spatial, coverage (depth and also NAFO Divisions). Refer to Vázquez (2010) and Healey (2010) for additional detail. Information on Greenland Halibut is also available from Spanish surveys of the NRA in Divs. 3NO, but this survey covers a very small portion of the stock area and is only partially considered here.

The following data series were considered as potential indices to calibrate the XSA-based assessment (Table 4):

a) EU 3M (0-700m) - European Union summer survey in Division 3M from 1995–2009, ages 1 – 12 (Vázquez, 2010).
b) EU 3M (700-1400m) - European Union summer survey in Division 3M from 2004–2009, ages 1 – 13 (D.González-Troncoso, pers. comm.).
c) EU 3M (0-1400m) - European Union summer survey in Division 3M from 2004–2009, ages 1 – 13 (D.González-Troncoso, pers. comm.).
d) Canadian 2J3K autumn survey, true Campelen data from 1996 - 2009, ages 1 to 13 (Healey, 2010).
e) Canadian 3LNO spring survey, true Campelen data from 1996 - 2009, ages 1 to 8 (Healey, 2010).

During the 2003 assessment, STACFIS agreed (NAFO, 2003b; Darby et *al.*, 2003) to exclude survey data from 1978-1994 from the calibration dataset as changes in survey catchability were apparent. Retrospective patterns in biomass, fishing mortality and recruitment were less severe when the 1978-1994 data were excluded. Darby et *al.* (2003) also reported improved within survey correlations for the shortened time series. The 1995 and 2008 Canadian fall survey results have also been excluded as the survey coverage in these years was incomplete; several of the deep water strata were not surveyed.

Estimates of Proportion Mature at Length and at Age

Trends in maturity at length and age are not necessarily the same and differences in them can give some hint to the cause of change. Therefore maturity at both length and age were examined. Proportion mature at age and length were estimated from fall Div. 2J3K RV data from 1978 to 2009. Observed proportion mature at age was calculated according to the method of Morgan and Hoenig (1997) to account for the length stratified method of sampling. Length data from 1978-1995 were converted to Campelen equivalents. Available sample sizes are given in Tables 5 and 6.

Estimates, along with age and length at 50% maturity, were produced by cohort. For males, A50 showed a general decline from the 1985 cohort from about 11 years to less than 9. The male A50 increased to almost 10 for the 1998 cohort (Figure 4). For females, estimates of A50 have generally been lower since the 1980 cohort. The average A50 for the 1966 to 1979 cohorts was 13.1 while it has been 12.2 since then. For both males ($\chi 2=79.05$, df=22, $p<0.0001$) and females ($\chi 2=58.3$, df=26, $p<0.0005$) there was a significant cohort affect. Table 7 provides the estimated proportions mature at age over 1975-2010.

Estimates of maturity at length were produced using the data described above and L50's are presented by cohort in Figure 5. L50 was fairly stable for females until about 1975 after which it became more variable and began to decline. Female L50 was about 80 cm prior to 1975. Most recent cohorts have an L50 of less than 75 cm. After an initial increase in L50 over the first 5 cohorts, male L50 has shown little trend. There was a significant cohort affect on proportion mature at length for both males ($\chi 2=342.5$, df=26, $p<0.0001$) and females ($\chi 2=60.1$, df=26, $p<0.0005$).

<u>Results and Discussion</u>

Exploratory Analysis of Survey Data

Prior to modeling the survey and catch data, some exploratory analyses were conducted to evaluate the internal consistency in each survey index series, the consistency of the contribution of each year-class to the total survey index, and the consistency of the age-specific information across the survey series.

Pair-wise plots of the each of the survey indices (by cohort on the log-scale) are presented in Figure 6. The data points in the panels below the numbered diagonal compare the logarithm of survey data at different ages for a common cohort. The solid line in each panel is the linear least squares regression line. Numeric values in the panels above the diagonal provide the correlation coefficient between the survey data at these ages. The p-values for testing whether or not the correlation is significantly different than 0 in each panel is indicated by the key shown on the right hand side. Regression and correlations are only computed if there are at least 5 points (i.e. cohorts) available for a given pair of ages. The scatter plots reveal that some of the low correlation values noted in previous assessments are partially due to one or two outlying points (e.g. ages 6 to 7 in Canadian fall Division 2J3K index) whereas other problems appear to be systematic.

A comparison of the correlation coefficients between successive ages in indices is presented in Figure 7. The relatively low correlation in some age-groups noted in previous assessments remains a cause for concern.

Estimated abundance by depth class in the EU survey has shown inconsistent trends. Over 2004-2009, the total abundance index for 0-700m depth has declined by almost 70%. At the same time, the abundance index in the deeper waters (>700m) has doubled. To assist with considerations on the potential incorporation of the deep-water information from the EU survey into the analytical assessment, age-by-age examinations of the correlation between the indices at various depth classes were produced (Figure 8). At the younger ages (<6 years), the correlation between the 0-700m and the 0-1400m indices is near 1, reflective of the fact that almost no young fish are captured in the deeper waters. The correlation coefficients between the 0-1400m and 700-1400m data show similar results for older (>6 years), as most of the older fish are observed in 700-1400m. The relatively low correlation between the 0-700m and 700-1400m series is reflecting the differing results by depth class noted previously. The divergent trend in these indices also suggests the information we have prior to 2004 is incomplete. This is an important consideration given that the analytical assessment of this stock is based upon survey data which do not cover the entire stock range.

A comparison of standardized indices illustrating the consistency of the dataset currently used to calibrate the analytical assessment is presented in Figure 9a and Figure 9b. In these figures each survey-age time-series is standardized to have mean 0 and variance 1 and are directly comparable. The survey data used to calibrate the XSA appears to be fairly consistent through time over a majority of age groups, though with less consistency in the recent period. The increases in the Canadian Div. 2J3K fall survey described in Healey (2010) are evident at ages 6-9. In addition, recent data from the Canadian Div. 3LNO survey at ages 6-8 are relatively large (discussed further below). The EU survey data from 0-700m does not generally reflect such increases.

Plots of the standardized proportions by age across years (SPAY) provide additional perspective on the cohort consistency within each of the survey indices (Figures 10a to 10c). In the SPAY plots, the annual index proportions were standardized at each age to have a mean of 0 and a variance of 1. (Cohorts are identified with text labels in the margin.) As noted in previous assessments, there are indications of continued difficulties in tracking cohorts in these surveys; particularly in the 2002-2007 data in the Canadian fall 2J3K survey index. Note that relatively poor indications of recruitment in the recent period is consistent across surveys.

Overall, these evaluations suggest that the patterns across surveys are reasonably consistent, but this is not to say that the tuning dataset is without problems, as demonstrated in the pair-wise scatter plots. Nonetheless, we rely on the assertion of Healey and Mahé (2006) that as XSA uses within cohort information to produce estimates of survivors, such analyses for this stock are still considered appropriate.

Assessment Results

Updated Run

Survey data over 1995-2009 and catch information from 1975-2009 were used to estimate numbers at age using the XSA formulation applied during the most recent analytical assessment (Healey and Mahé, 2008). The calibration data set includes the Canadian spring and fall survey data and also the EU survey (0-700m only). In the tables and figures, we refer to this analysis as the “update run”. Detail on the XSA settings, diagnostics and results can be found in Table 8. Estimated numbers at age and fishing mortality at age are presented in Tables 9 and 10, with a summary of the estimates presented in Table 11. Figure 11 illustrates the exploitable (ages 5+) biomass, average fishing mortality and the age 1 recruitment. (Estimates of 2010 survivors from the XSA are used to compute 2010 biomass assuming the 2010 stock weights at age are equal to the 2007-2009 average.)

The strong recruiting year-classes of the mid-1980’s, coupled with relatively low fishing mortalities contributed to a substantial increase in the exploitable biomass over 1985-1991. Subsequently, intense fishing pressure and poor recruitment contributed to significant stock declines (on the order of two-thirds reduction) in the early 1990’s. The large 1993-1995 year-classes lead to improvements in the exploitable biomass around the turn of the millennium. Estimates of exploitable biomass since the imposition of the Fisheries Commission rebuilding plan have declined and remain relatively low, averaging 83 000 t. The 2010 5+ biomass is estimated to be approximately 67 000 tons. This is the lowest value in the estimated time series.

From 1975-1990, average fishing mortality over ages 5-10 (Fbar(5-10)), although variable, was generally low, particularly so during the late 1980’s. Subsequent trends in Fbar closely mirror the trends in total landings (rapid increase from 1989-90; substantial decline in 1995; increasing into early 2000’s). Estimates of fishing mortality since the imposition of the rebuilding plan have decreased but remain relatively high as the corresponding population estimates of abundance are quite low. Although effort has been reduced under the rebuilding plan, the catches under the rebuilding plan have exceeded the TACs by considerable margins. Fbar(5-10) in 2009 is estimated to be 0.39.

Historical estimates of recruitment indicate two periods with relatively strong year-classes, one during the mid-1980’s and another during the mid-1990’s, each consisting of multiple year-classes. Over the past decade, age 1 recruitment is estimated to be about average over 1998-2002 (these fish are ages 7 to 11 in 2008), with more recent year-classes well below average. In fact, the estimated abundance of the 2003 - 2008 year-classes are the lowest values in the time series.

The XSA 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 Figure 12. 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 exceed 0.5 for 26 of the 33 index-ages, even exceeding 1 in some instances. The scaled weights indicate a dominance of the Canadian fall 2J3K survey over most ages, with increasing influence of shrinkage at older ages.

Selection patterns of the recent past are plotted in Figure 13, and with a strong peak at ages 7-9. Changes to gillnet fishing regulations within the Canadian EEZ have contributed to a dramatic decline of the relative F at the oldest ages (e.g. 2005 selection at ages 10+ compared to that of later years).

Residual graphics from the XSA analysis are presented in Figures 14 a-c. The trends and patterns are similar to those described in previous assessments of this stock: there are trends in the residuals along the cohorts, plus evidence of year-effects in some of the surveys. The mean squared residual (Figure 14a) is largest for ages 7 and 8 in the Canadian spring survey, and ages 11 and 12 in the EU summer survey. Negative residuals for ages 1-4 in the EU 0-700m index in each of the past three years has dramatically increased the MSE for these age groups compared to the last assessment. Trends in the mean annual over time in the various surveys are of concern (Figure 14b). Residual bubble plots (Figure 14c) further illustrate the problematic trends – evidence of cohort tracking and year effects, each of which indicate poor model fit.

Retrospective Analysis, Updated Run

A six-year retrospective analysis was conducted to examine the influence of removing successive years' data on the terminal estimates of biomass, fishing mortality and recruitment (Figure 15). Retrospective patterns in stock size and fishing mortality estimates have been problematic in earlier assessments of this stock (see Darby et *al*. 2003). The retrospective results indicate that the recent recruitment estimates have been revised upwards as additional data is included in the model. Trends are evident in the retrospective estimates of fishing mortality, particularly with the estimated fishing mortality in the terminal year. Earlier assessments (e.g. Healey and Mahé (2005)) demonstrated that the direction of the retrospective pattern has reversed over time.

Inclusion of EU Deep Water Survey Data

In the updated run presented above, only the EU 0-700m survey results were included over 1995-2009. Additional XSA analyses corresponding to two options for potential inclusion of the EU deep-water survey data were considered. First, the EU deep-water results over 2004 -2009 were added as a new series to the survey calibration dataset. The second option considered was to split the EU survey data into two independent time-series, specifically the 0-700m data over 1995-2003 and the 0-1400m data over 2004-2009. Figure 16 compares the estimates of 5+ biomass, Fbar(5-10) and Age 1 recruitment from these analyses, compared to the update run, and are labeled "Add EU DW" and "Split EU", respectively, in the figure panels. The XSA settings applied were identical to those in the update run.

A full comparison of model diagnostics from the "Add EU DW" and "Split EU" analyses (not shown) reveal only minor differences in model fit. Also, considering the conflicting signal between 0-700m and 700-1400m over 2004-2009, it was thought to be more appropriate to split the EU information into two periods (1995-2003 & 2004-2009) *a priori* and estimate separate catchabilities for this survey over each period. This was also considered most appropriate as it provides a more homogeneous time series of indices at age integrating data from an extended area of stock distribution. Full details on model specifications and the data included are given in Table 12. Estimated numbers at age and fishing mortality at age are provided in Tables 13 and 14, and a stock summary is provided in Table 15.

A series of figures of model estimates from the "Split EU" run are provided. The estimates of 5+ biomass, fishing mortality and recruitment (Figure 17) catchabilities, their standard errors and scaled weights used to estimate survivors (Figure 18) as well as the selection pattern in the most recent five years (Figure 19) show similar patterns to previous results. Full model settings and diagnostics, as well as the estimated numbers at age and fishing mortality at age matrices are provided in Table 12 - Table 15. The catchabilities for the EU 0-1400m series are much higher at older age groups than those for the EU 0-700m series in the updated run (Figure 12). Also, by splitting the EU data into two separate time-series, estimation of catchabilities over 2004-2009 for ages 1-12 partially "absorbs" the residual problem for young ages identified in the update run which in turn leads to increases in estimated strength of some recent cohorts. However, problems such as trends in residuals, multi-year effects (e.g. 2-3 years of positive residuals at most or all ages followed by 2-3 years of negative residuals) and cohort effects remain evident (Figure 20 a- c).

Note that as the EU 0-700m series now ends in 2003, it has little influence on the estimated survivors in 2010 (Figure 18). A comparison of the scaled weights between the Update Run and the Split EU run indicates a dramatic shift in the weightings to estimate survivors, particularly at ages 9+. There is less influence from the F-shrinkage estimate, and in the split EU run the EU 0-1400m index contributes the greatest weight to the estimation of survivors. The Canadian Fall Div. 2J3K index received 30%-50% of the weighting in the updated run, but this is reduced to < 30% for ages 9-13 in the split EU run.

The above results include survey data at ages 1-12 from the EU 0-1400m series. The correlation between the MNPT data at age 12 and age 13 (log-scale) in this survey is 0.94. Thus, an additional XSA analysis was conducted adding the age 13 information from the EU survey from 2004-2009 to the calibration data set. Differences between these results and the “split EU” are negligible. Note that the overall mean squared residual when using this dataset is 0.418.

Retrospective Analysis, Split EU Run

A three-year retrospective analysis of the “Split EU” run was conducted. Considering that the EU 0-1400m index time series spans 2004-2009, longer retrospective analyses would be ill-advised. The results are consistent with the retrospective patterns in the update run (see Figure 15) – biomass estimates are revised upwards and fishing mortality estimates revised downwards as additional data is added (Figure 21). Also recruitment estimates are unstable, with the estimated strength of the late 1990s and early 2000s year-classes being revised substantially as data are added. These patterns reflect the recent data from the Canadian Fall Div. 2J3K and EU 0-1400m indices, both of which indicate these year-classes are relatively strong. This is inconsistent with the data from these cohorts at the youngest ages.

Robustness

Sensitivity to each tuning index

To evaluate the consistency in estimated stock trends from each survey series, we compare the estimated 5+ biomass, age 1 recruitment and average fishing mortality (Figure 22) from a suite of XSA analyses calibrated using only one survey series. To avoid estimation problems using just the 2004-2009 EU 0-1400m series, we produce stock size estimates for the “EU only” run by using the 0-700m data over 1995-2003, and the 0-1400m data for 2004-2009. Observe that the estimated 5+ biomass from the analysis which includes only the Canadian fall index is almost identical to the results using all data series. This occurs as the ages which make up the majority of the 5+ biomass receive greatest weight from this survey in the “all data” run. There are major differences in the estimated recruitment in the most recent period. The exploitable biomass of the most recent five years is similar for analyses which use only the Canadian spring index or the EU data, because the estimated recruitments over 2000-2004 in these cases are consistent.
A comparison of 2010 5+ biomass and 2009 fishing mortality from these single-index runs is also provided (Figure 23) to highlight the differences at the end of the estimation period..

Sensitivity to shrinkage settings

The usage of F-shrinkage in XSA is typically employed to add stability to estimates of fishing mortality and biomass when subsequent analysis show that the estimates are biased or highly variable although effort and exploitation pattern are considered to have been relatively stable. However, the specifics of implementing F-shrinkage (number of years to shrink over, plus the degree of shrinkage) are subjective. F-shrinkage settings used in recent assessments and also to produce all results documented above take a 5 year mean with a log standard error of this mean set at 0.5 which would be considered relatively strong shrinkage (log standard error controls the degree of shrinkage; lower values imply more weight to the average F value and hence stronger shrinkage of the terminal year’s F to that mean value).

In this assessment, the fishing mortality results from the Split EU analysis indicates a substantial and consistent decline in average fishing mortality over 2003-2009. This warrants a re-evaluation of the impact of shrinking the terminal year fishing mortality to the average of the recent period, as population numbers could be under-estimated and fishing mortality over-estimated when using strong shrinkage. Previous assessments (see Healey and Mahé 2005, 2008) have also examined the sensitivity of the results to reducing the effect of F-shrinkage, but as retrospective and residual patterns were worse in these cases, no changes were accepted.

Consideration was given to both reducing the strength of the shrinkage and also shortening the time span over which to mean fishing mortality was computed. The following shrinkage settings were evaluated:

1) 5 years; log(SE)=0.5
2) 5 years; log(SE)=1.0
3) 5 years; log(SE)=10.0
4) 3 years; log(SE)=0.5
5) 3 years; log(SE)=1.0

The first case corresponds to the settings applied in recent assessments, and case 3 equates to a no shrinkage run; the effect of shrinkage is so low it basically does not impact the estimation of survivors.

Estimated 5+ biomass, age 1 recruitment and average fishing mortality for each set of shrinkage parameters are compared in Figure 24. Considering the consistent decline in estimated fishing mortality, it is unsurprising that terminal fishing mortality was highest for both cases with the highest degree of shrinkage (log(SE)=0.5 – cases 1 and 4 above). Also, under either log(SE)=0.5 or 1.0, the three year shrinkage means yield a lower terminal F than the five-year means. And as expected, the lowest estimate of terminal F comes from the analysis with minimal shrinkage (log(SE)=10.0). Again noting the steep decline in fishing mortality since 2003, unless the residual patterns and/or the retrospective patterns with reduced shrinkage are appreciably worse, it would seem advisable to reduce at least the time-frame over which to compute the mean F and possibly also the strength of the shrinkage. Full diagnostics for shrinkage over a shorter (3 year) timeframe were considered against the settings applied in recent assessments.

Reduced Shrinkage I: 3 years; log SE=0.5

Estimates of 5+ biomass, age 1 recruitment and age 5-10 average fishing mortality using shrinkage settings of 3 years, log(SE)=0.5 are plotted in Figure 25. The estimated catchabilities, their standard errors (Figure 26) and recent estimates of commercial selectivity (Figure 27) are generally similar to the Split EU run presented previously. In this analysis there are differences in the weightings used to estimate survivors (Figure 26; refer to Figure 18 for weightings from the Split EU run), with reduced influence of the F-shrinkage estimates for survivors ages 6+. Residual patterns (Figure 28) are also consistent with prior results, and the overall mean squared residual is 0.406.

A three-year retrospective analysis applying these shrinkage options in each analysis was conducted (see Figure 29). Although patterns are similar, the magnitude of retrospective revisions to biomass, recruitment and average fishing mortality are somewhat larger than those for the Split EU run (Figure 21), in which the shrinkage settings were 5 years, and log(SE)=0.5.

Reduced Shrinkage II: 3 years; log SE=1.0

Detailed XSA settings and output are provided in Table 16, with estimated numbers-at-age and fishing mortality-at-age in Tables 17 and 18. Table 19 contains a summary of the estimates; these are plotted in Figure 30. Estimated catchabilities, their standard errors and recent estimates of commercial selectivity (Figure 31, Figure 32) are generally similar to previous results. However while standard errors of catchabilities for the 2J3K survey and the Spring 3LNO are very similar between the reduced shrinkage I and II, they are smaller for the EU 0_1400 survey and larger for the EU 0_700 survey and overall, the mean standard errors across all surveys catchabilities is smaller. Applying these settings there is a substantial reduction in the influence of the F-shrinkage estimates. The residual patterns (Figure 33) are also consistent with prior results, with trends over time and multiple instances of difficulty tracking cohorts. We note that the residual patterns amongst the surveys are often in opposite direction over common time periods. The overall mean squared residual is 0.401.

A three-year retrospective analysis applying these shrinkage options in each analysis was conducted (see Figure 34). In this case, retrospective revisions are much smaller than in any of the previous cases. The difference in the estimates of 5+ biomass and average fishing mortality are minimal as the first two years, with a greater change as the third year of catch and survey data are excluded. A "retrospective matrix" was computed for estimates fishing mortality and population numbers (Table 20, Table 21). Entries in the matrix are the ratio of the N[y,a] (or F[y,a]) estimates in the "full-data" assessment to the one-year retrospective results, and indicate minimal change in the structure of these estimates.

Final Run

We suggest using the reduced shrinkage settings of 3 years and log(SE)=1.0 as the final run used to evaluate both current stock status and short-term management advice. First, the overall mean square residual is slightly improved compared to the 3-year and 5-year log(SE)=0.5 cases. In addition, a reduction in shrinkage now appears justified given the constant decrease in average fishing mortality over 2003-2009, which also appears consistent in the retrospective analysis.

In the final run, the fishable biomass (age 5+; Figure 30, upper panel) declined to low levels in 1995-97 due to very high catches and high fishing mortality. It increased during 1998-2000 due to greatly reduced catches, much lower fishing mortality and improved recruitment. Biomass increased over 2004-2008 with decreases in fishing mortality. However, it has shown decreases over 2008-2010, as weaker year-classes have recruited to the biomass. Estimates of 2010 survivors from the XSA are used to compute 2010 biomass assuming the 2010 stock weights are equal to the 2007-2009 average. The 2010 5+ biomass is estimated to be about 102 000 tons. The 10+ biomass peaked in 1991 and although it remains well below that peak, it has tripled over 2006-2010.

High catches in 1991-94 resulted in average fishing mortality over ages 5 to 10 (F5-10; Figure 30, center panel) exceeding 0.70. F5-10 increased over 1995-2003 with increasing catch, but declined after 2003 under the FC rebuilding plan. F5-10 in 2009 is estimated to be 0.25. Note that although F5-10 decreased from 2008 to 2009, the total fishing mortality over all age groups increased, due to a slight change in commercial selectivity.

The final run indicates that all recent year-classes are well below average strength (Figure 30, lower panel). These year-classes will recruit to the exploitable biomass in the next few years.

We note that estimates of exploitable biomass from the final run are higher from previously reported estimates over 2004-2008. This difference primarily arises as a result of the addition of the deep-water information from the EU survey to the analysis as well as a reduction in the amount of F-shrinkage applied.

As in recent assessments, the XSA diagnostics reveal serious problems in the model fit. The standard errors of the log-scale survey catchability parameters exceed 0.5 at most survey-ages. Darby and Flatman (1994) note that: "values greater than 0.5 indicate problems with that age for the fleet." Further, the survey-specific estimates of survivors indicate some inconsistencies. Residual patterns indicate severe model fit issues, including year and cohort effects, as well as evidence of the conflicting signals in some of the survey information. Retrospective patterns have been poor in recent assessments and although improved with the new data and model settings, the revisions to recruitment estimates from over a decade ago in the last year of the retrospective analysis are also cause for concern. Should these problems continue the reliability of this assessment must be reconsidered. Noting that the XSA provides a way to derive a signal from sometimes conflicting data, this assessment was considered acceptable noting that careful attention must continue to be paid to model diagnostics in future assessments.

Stochastic Projections

Projection results are contingent upon the accuracy of the estimated survivors. Reservations about the quality of the XSA estimates of survivors are expressed above and these reservations extend to projections of future population dynamics. Attention is also to be drawn to 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 a minimal measure of uncertainty associated with the evolution of the stock under the different harvesting option evaluated.

In order to evaluate the population trends under several potential management actions in the near term, stochastic projections from 2010 to 2014 were conducted assuming average exploitation pattern and weights-at-age from 2007 to 2009, and with natural mortality fixed at 0.2. Assuming the catch in 2010 remains at the 2009 level (23 150 t), the following projection scenarios were considered:

i) constant fishing mortality at F0.1 (0.21)
ii) constant fishing mortality at F2009 (0.26)
iii) constant landings at 16 000 tons, and
iv) constant landings at 23 150 tons.

An additional projection was undertaken assuming that the catches in 2010 will match the TAC of 16 000t and remain constant at this level in 2011-2013.

The projection inputs are summarized in Table 22 with the variability in the projection parameters described by the coefficients of variation (column CV in the table). Numbers at age 2 and older at 1st of January 2010 and corresponding CVs are computed from the XSA output. For the stochastic projections, recruitment was bootstrapped from the 1999-2008 age 1 numbers from the XSA. Scaled selection pattern and corresponding CVs are derived from the 2007 to 2009 average from the XSA. Weights at age in the stock and in the catch and corresponding CVs are also computed from the 2007-2009 average input data. Natural mortality was assumed to be 0.2 with a CV of 0.15. The stochastic distributions were generated using the @Risk software. The distribution was assumed lognormal for the numbers at age and normal for the other input data.

For each of the scenarios considered, projection results (Table 23 and Figures 36 - 40) of forecast yield up to 2013, exploitable (ages 5+) biomass, and ages 10+ biomass to 2014 are presented. Note that projected yield under F0.1 is close to 16 000 t over 2011-2013. Thus under both the F0.1 and 16Kt constant catch options, total biomass is projected to increase by approximately 10%. In the case for which the 2010 catches are assumed to be 16Kt in both 2010 and also in the projection period, total biomass is projected to increase by 20% by 2014.

Total biomass remains stable under yields corresponding to F2009 fishing mortality, but is projected to decrease by 15% if catches remain at 23 200t through 2013. Fishing at F2009 for the period 2011-2013 would correspond to a reduction in catch from 17.5 Kt in 2011 to about 16Kt in 2012 and 2013.

Table 24 provides growth rates of the exploitable (ages 5+), ages 10+ biomass, and ages 5-9 biomass relative to 2010, the terminal year of the current assessment. Note there are differences in the rates of increase in each of these columns reflecting changes in the age structure of the population, notably the improved status of the 10+ biomass in 2010 and subsequently through the projection period.

Table 25 presents the ratio of the exploitable (5 +) biomass at the end of the projection period to the target identified in the rebuilding plan. If catches are maintained at the current TAC level, total biomass is projected to be 80% of the 140,000 t, with five years remaining in the recovery plan. The potential of recovery to 140,000 t by 2014 is strongly dependent on future recruitment to the exploitable biomass, and recruitment has been very low in recent years.

In summary, all projections show declines of the age 5-9 exploitable biomass in forthcoming years despite relatively low projected fishing mortality levels. We focus upon ages 5-9 as they comprise 90% of recent commercial catch weight. The biomass declines occur as the below average year-classes reach age 5, and range from 6% to 21% in the scenarios evaluated.

Conclusion

Estimated stock biomass has shown decreases over 2008-2010, as weaker year-classes have recruited to the biomass. The level of recent biomass estimates is higher than that reported in previous assessments, as a result of including the new deep-water information from the EU survey, as well as a reduction in the amount of F-shrinkage required. The 10+ biomass peaked in 1991 and although it remains well below that peak, it has tripled over 2006-2010, becoming a larger fraction of the total 5+ biomass. Average fishing mortality (over ages 5-10) has been decreasing since 2003 under the Fisheries Commission Rebuilding Plan. As recent recruitment has been far below average, projections conducted under various catch and fishing mortality options indicate that the biomass targeted by the fishery (ages 5-9) will decline under all scenarios considered.

References

Alpoim, R., E. Roman, B. Greene, R. Burry and W.R. Bowering. 2002. Results of the Greenland Halibut (Reinhardtius hippoglossoides) Otolith Exchange between Spain, Canada and Portugal. NAFO SCR. Doc. 02/141. Ser. No. N4763.

Bowering, W.R., and W.B. Brodie. 1995. Greenland halibut (Reinhardtius hippoglossoides (Walbaum)). A Review of the Dynamics of its Distribution and Fisheries off Canada and West Greenland. In Deep-water fisheries of the North Atlantic Oceanic Slope. Edited by A.G. Hopper. NATO Advanced Science Institutes Series. Kluwer Academic Publishers, Boston. Pp. 113-160.

Brodie, W.B., D. Power, and B.P. Healey. 2010. The Canadian fishery for Greenland halibut in SA 2 + Divisions 3KLMNO, with emphasis on 2009. NAFO SCR Doc. 10/35, Ser. No. N5793.

Darby, C.D., and S. Flatman. 1994. Virtual Population Analysis: Version 3.1 (Windows/Dos) user guide. Info. Tech. Ser., MAFF Direct. Fish. Res., Lowestoft, (1): 85pp.

Darby, C.D., W.R. Bowering, and J.-C. Mahé 2003. An Assessment of Stock Status of the Greenland Halibut Resource in NAFO Subarea 2 and Divisions 3KLMNO Based on Extended Survivors Analysis with Short and Medium-term projections of Future Stock Development. NAFO SCR Doc. 03/64. Ser. No. N4883.

González-Costas F., González-Troncoso D., E. Román, M. Casas, G. Ramilo, C. Gonzalez, A. Vázquez, and A. Gago. 2010. Spanish Research Report for 2009. NAFO SCS Doc. 10/06, Ser. No. N5760.

Healey, B.P. and J.-C. Mahé. 2005. An Assessment of Greenland Halibut in Subarea 2 + Divisions 3KLMNO, with Projections under the Fisheries Commission Rebuilding Plan. NAFO SCR Doc. 05/63, Ser. No. N5149.

2006. An Assessment of Greenland Halibut (*Reinhardtius hippoglossoides*) in Subarea 2 + Divisions 3KLMNO. NAFO SCR Doc. 06/51, Ser. No. N5281.

2008. An Assessment of Greenland Halibut (*Reinhardtius hippoglossoides*) in Subarea 2 + Divisions 3KLMNO. NAFO SCR Doc. 08/48, Ser. No. N5550.

2009. An Assessment of Greenland Halibut (*Reinhardtius hippoglossoides*) in Subarea 2 + Divisions 3KLMNO. NAFO SCR Doc. 09/39, Ser. No. N5675.

Healey, B.P. and W.B. Brodie. 2009. Brief notes on the execution of Canadian multi-species surveys in 2007 and 2008. NAFO SCR Doc. 09/12, Ser. No. N5639.

Healey, B.P. 2008. Greenland halibut (Reinhardtius hippoglossoides) in NAFO Subarea 2 and Divisions 3LKMNO: stock trends based on annual Canadian research vessel survey results during 1978-2007. NAFO SCR Doc. 08/32, Ser. No. N5533.

Morgan, M.J. & J.M. Hoenig. 1997. Estimating age at maturity from length stratified sampling. J. Northw. Fish. Sci. 21:51-63.

NAFO. 2003a. NAFO Rebuilding Plan for the stock of Greenland Halibut in Subarea 2 and Divisions 3KLMNO. NAFO FC Doc 03/13, Ser. No. N4904.

NAFO. 2003b. Report of the Standing Committee on Fisheries Science (STACFIS), June 2003. NAFO Scientfic Council Reports, 2003.

NAFO. 2009. Report of the Scientific Council, June 2009. NAFO Scientfic Council Reports, 2009.

Patterson, K.R., R.M. Cook, C.D. Darby, S. Gavaris, B. Mesnil, A.E. Punt, V.R. Restrepo, D.W. Skagen, G. Stefansson, and M. Smith. 2000. Validating three methods for making probability statements in fisheries forecasts. ICES CM 2000 V:06

Shepherd, J.G. 1999. Extended survivors analysis: An improved method for the analysis of catch-at-age data and abundance indices ICES Journal of Marine Science Vol. 56, No. 5, October 1999, pp. 584-591.

I.A. Skyrabin, and M.V. Pochtar. 2010. Russian Research Report for 2009. NAFO SCS Doc. 10/05, Ser. No. N5755.

Treble, M.A., S.E. Campana, R.J. Wastle, C.M. Jones, and J. Boje. 2005. An assessment of age determination methods, with age validation of Greenland halibut from the Northwest Atlantic. NAFO SCR Doc. 05/43, Ser. No. N5129.

Treble, M.A and K.S. Dwyer. 2006. Report of the Greenland Halibut (*Reinhardtius hippoglossoides*) Age Determination Workshop. NAFO SCR Doc. 06/49, Ser. No. N5276.

Vargas, J., R. Alpoim, E. Santos, and A.M. Avila de Melo. 2010. Portuguese Research Report for 2009. NAFO SCS Doc. 10/07, Ser. No. N5761.

Vázquez A. 2010. Results from bottom trawl survey on Flemish Cap of June-July 2009. NAFO SCR Doc. 10/23, Ser. No. N5781.

Table 1. Landings and Total Allowable Catches (all in 000 tons) for Greenland Halibut in Sub-area 2 and Div. 3KLMNO. TACs were set autonomously by Canada until 1994. Since 1995, the TAC has been established by NAFO's Fisheries Commission. TAC values since 2004 (marked by *) have been set under the Fisheries Commission Rebuilding Plan.

Year	TAC - Canada (000 t)	TAC - FC (000 t)		Landings (t)
1975	40			28814
1976	30			24611
1977	30			32048
1978	30			39070
1979	30			34104
1980	35			32867
1981	55			30754
1982	55			26278
1983	55			27861
1984	55			26711
1985	75			20347
1986	100			17976
1987	100			32442
1988	100			19215
1989	100			20034
1990	50			47454
1991	50			65008
1992	50			63193
1993	50			62455
1994	25			51029
1995		27		15272
1996		27		18840
1997		27		19858
1998		27		19946
1999		33		24226
2000		35		34177
2001		40		38232
2002		44		34062
2003		42		35151
2004		20	*	25486
2005		19	*	23255
2006		18.5	*	23531
2007		16	*	22747
2008		16	*	21180
2009		16	*	23156
2010		16	*	

Table 2. Catch numbers at age matrix (in thousands) for Greenland Halibut in Sub-Area 2 and Divisions 3KLMNO.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14+	Total
1975	0	0	0	0	334	2819	5750	4956	3961	1688	702	135	279	288	20912
1976	0	0	0	0	17	610	3231	5413	3769	2205	829	260	101	53	16488
1977	0	0	0	0	534	5012	10798	7346	2933	1013	220	130	116	84	28186
1978	0	0	0	0	2982	8415	8970	7576	2865	1438	723	367	222	258	33816
1979	0	0	0	0	2386	8727	12824	6136	1169	481	287	149	143	284	32586
1980	0	0	0	0	209	2086	9150	9679	5398	3828	1013	128	53	27	31571
1981	0	0	0	0	863	4517	9806	11451	4307	890	256	142	43	69	32344
1982	0	0	0	0	269	2299	6319	5763	3542	1684	596	256	163	191	21082
1983	0	0	0	0	701	3557	9800	7514	2295	692	209	76	106	175	25125
1984	0	0	0	0	902	2324	5844	7682	4087	1259	407	143	106	183	22937
1985	0	0	0	0	1983	5309	5913	3500	1380	512	159	99	87	86	19028
1986	0	0	0	0	280	2240	6411	5091	1469	471	244	140	70	117	16533
1987	0	0	0	0	137	1902	11004	8935	2835	853	384	281	225	349	26905
1988	0	0	0	0	296	3186	8136	4380	1288	465	201	105	107	129	18293
1989	0	0	0	0	181	1988	7480	4273	1482	767	438	267	145	71	17092
1990	0	0	0	95	1102	6758	12632	7557	4072	2692	1204	885	434	318	37749
1991	0	0	0	220	2862	7756	13152	10796	7145	3721	1865	1216	558	422	49713
1992	0	0	0	1064	4180	10922	20639	12205	4332	1762	1012	738	395	335	57584
1993	0	0	0	1010	9570	15928	17716	11918	4642	1836	1055	964	401	182	65222
1994	0	0	0	5395	16500	15815	11142	6739	3081	1103	811	422	320	215	61543
1995	0	0	0	323	1352	2342	3201	2130	1183	540	345	273	251	201	12141
1996	0	0	0	190	1659	5197	6387	1914	956	504	436	233	143	89	17708
1997	0	0	0	335	1903	4169	7544	3215	1139	606	420	246	137	89	19803
1998	0	0	0	552	3575	5407	5787	3653	1435	541	377	161	92	51	21631
1999	0	0	0	297	2149	5625	8611	3793	1659	623	343	306	145	151	23702
2000	0	0	0	271	2029	12583	21175	3299	973	528	368	203	129	104	41662
2001	0	0	0	448	2239	12163	22122	5154	1010	495	439	203	156	75	44504
2002	0	0	0	479	1662	7239	17581	6607	1244	659	360	224	126	81	36262
2003	0	0	0	1279	4491	10723	16764	6385	1614	516	290	144	76	85	42367
2004	0	0	0	897	4062	8236	10542	4126	1307	529	289	184	87	75	30334
2005	0	0	0	534	1652	5999	10313	3996	1410	444	244	114	64	46	24816
2006	0	0	0	216	1869	6450	12144	4902	1089	372	136	47	32	40	27295
2007	0	0	0	88	570	3732	11912	5414	1230	472	163	80	41	29	23731
2008	0	0	0	29	448	3312	10697	5558	1453	393	115	46	26	15	22092
2009	0	0	0	61	476	3121	8801	7276	1949	508	206	67	31	34	22530

Table 3. Catch weights-at-age (kg) matrix for Greenland Halibut in Sub-Area 2 and Divisions 3KLMNO.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14+
1975	0.000	0.000	0.126	0.244	0.609	0.760	0.955	1.190	1.580	2.210	2.700	3.370	3.880	5.764
1976	0.000	0.000	0.126	0.244	0.609	0.760	0.955	1.190	1.580	2.210	2.700	3.370	3.880	5.144
1977	0.000	0.000	0.126	0.244	0.609	0.760	0.955	1.190	1.580	2.210	2.700	3.370	3.880	5.992
1978	0.000	0.000	0.126	0.244	0.609	0.760	0.955	1.190	1.580	2.210	2.700	3.370	3.880	5.894
1979	0.000	0.000	0.126	0.244	0.609	0.760	0.955	1.190	1.580	2.210	2.700	3.370	3.880	6.077
1980	0.000	0.000	0.126	0.244	0.514	0.659	0.869	1.050	1.150	1.260	1.570	2.710	3.120	5.053
1981	0.000	0.000	0.126	0.244	0.392	0.598	0.789	0.985	1.240	1.700	2.460	3.510	4.790	7.426
1982	0.000	0.000	0.126	0.244	0.525	0.684	0.891	1.130	1.400	1.790	2.380	3.470	4.510	7.359
1983	0.000	0.000	0.126	0.244	0.412	0.629	0.861	1.180	1.650	2.230	3.010	3.960	5.060	7.061
1984	0.000	0.000	0.126	0.244	0.377	0.583	0.826	1.100	1.460	1.940	2.630	3.490	4.490	7.016
1985	0.000	0.000	0.126	0.244	0.568	0.749	0.941	1.240	1.690	2.240	2.950	3.710	4.850	7.010
1986	0.000	0.000	0.126	0.244	0.350	0.584	0.811	1.100	1.580	2.120	2.890	3.890	4.950	7.345
1987	0.000	0.000	0.126	0.244	0.364	0.589	0.836	1.160	1.590	2.130	2.820	3.600	4.630	6.454
1988	0.000	0.000	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	0.000	0.000	0.126	0.244	0.400	0.561	0.767	1.082	1.657	2.237	2.997	3.862	4.919	6.370
1990	0.000	0.000	0.090	0.181	0.338	0.546	0.766	1.119	1.608	2.173	2.854	3.731	4.691	6.391
1991	0.000	0.000	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	0.000	0.000	0.175	0.289	0.430	0.577	0.793	1.234	1.816	2.462	3.122	3.972	5.099	6.648
1993	0.000	0.000	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	0.000	0.000	0.080	0.196	0.330	0.514	0.788	1.179	1.701	2.268	2.990	3.766	4.882	6.348
1995	0.000	0.000	0.080	0.288	0.363	0.531	0.808	1.202	1.759	2.446	3.122	3.813	4.893	6.790
1996	0.000	0.000	0.161	0.242	0.360	0.541	0.832	1.272	1.801	2.478	3.148	3.856	4.953	6.312
1997	0.000	0.000	0.120	0.206	0.336	0.489	0.771	1.159	1.727	2.355	3.053	3.953	5.108	6.317
1998	0.000	0.000	0.119	0.228	0.373	0.543	0.810	1.203	1.754	2.351	3.095	4.010	5.132	6.124
1999	0.000	0.000	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	0.000	0.000	0.000	0.254	0.346	0.524	0.787	1.192	1.774	2.279	2.895	3.645	4.486	5.531
2001	0.000	0.000	0.000	0.249	0.376	0.570	0.830	1.168	1.794	2.367	2.950	3.715	4.585	5.458
2002	0.000	0.000	0.217	0.251	0.369	0.557	0.841	1.193	1.760	2.277	2.896	3.579	4.407	5.477
2003	0.000	0.000	0.188	0.247	0.389	0.564	0.822	1.199	1.651	2.166	2.700	3.404	4.377	5.409
2004	0.000	0.000	0.180	0.249	0.376	0.535	0.808	1.196	1.629	2.146	2.732	3.538	4.381	5.698
2005	0.000	0.000	0.252	0.301	0.396	0.564	0.849	1.247	1.691	2.177	2.705	3.464	4.264	5.224
2006	0.000	0.000	0.129	0.267	0.405	0.605	0.815	1.092	1.495	1.874	2.396	3.139	3.747	4.701
2007	0.000	0.000	0.000	0.276	0.389	0.581	0.833	1.137	1.500	1.948	2.607	3.057	3.869	4.954
2008	0.000	0.000	0.000	0.278	0.404	0.617	0.891	1.195	1.605	2.038	2.804	3.247	4.232	4.721
2009	0.000	0.000	0.000	0.279	0.390	0.599	0.862	1.158	1.611	2.099	2.549	3.118	3.432	4.431

Table 4. Survey data (mean numbers per tow) used to calibrate various XSA analyses of Greenland Halibut in Sub-Area 2 and Divisions 3KLMNO.

2J3K Fall	1	2	3	4	5	6	7	8	9	10	11	12	13
1996	98.68	47.82	32.01	9.54	6.28	2.47	0.84	0.19	0.18	0.04	0.02	0.01	0.02
1997	28.05	58.62	43.61	21.13	10.37	5.01	2.00	0.64	0.20	0.06	0.03	0.02	0.01
1998	23.35	25.07	31.19	21.87	10.86	4.45	2.07	0.57	0.13	0.06	0.03	0.02	0.01
1999	15.99	34.42	24.07	28.28	20.04	10.53	3.81	0.70	0.14	0.07	0.02	0.01	0.03
2000	38.57	21.94	16.43	13.20	13.76	7.21	2.16	0.50	0.06	0.03	0.02	0.00	0.00
2001	43.90	22.72	17.00	14.07	9.77	7.59	3.40	0.69	0.11	0.02	0.01	0.00	0.01
2002	40.67	24.08	12.50	9.68	6.03	1.97	0.72	0.19	0.04	0.01	0.00	0.00	0.00
2003	45.70	26.67	11.69	9.49	6.39	2.27	0.89	0.27	0.04	0.02	0.01	0.01	0.00
2004	32.49	32.93	13.89	12.31	9.21	2.68	1.20	0.36	0.08	0.03	0.01	0.00	0.01
2005	16.06	16.15	8.56	13.84	10.98	6.85	3.96	0.66	0.12	0.03	0.03	0.01	0.01
2006	32.34	17.98	8.50	17.60	13.03	9.11	4.18	1.15	0.18	0.03	0.02	0.01	0.00
2007	32.61	14.51	12.81	18.77	9.57	10.35	6.17	2.14	0.34	0.08	0.04	0.02	0.01
2008						**Survey not completed**							
2009	50.62	19.15	11.40	8.42	9.89	5.40	3.59	1.39	0.25	0.08	0.02	0.01	0.01

EU 3M (0-700m)	1	2	3	4	5	6	7	8	9	10	11	12
1995	12.41	2.54	2.23	1.91	2.66	5.10	3.77	2.12	1.31	0.26	0.07	0.02
1996	5.84	7.97	2.42	3.04	4.20	5.82	2.49	1.62	0.42	0.09	0.03	0.04
1997	3.33	3.78	6.00	6.50	7.11	8.46	4.99	2.15	0.66	0.22	0.03	0.02
1998	2.74	2.13	7.69	11.00	12.33	11.30	7.84	2.62	0.75	0.20	0.03	0.01
1999	1.06	0.70	3.01	10.47	13.41	12.58	5.55	1.82	0.35	0.10	0.01	0.00
2000	3.75	0.29	0.60	2.17	7.09	14.10	5.40	2.32	0.45	0.11	0.05	0.00
2001	8.03	1.43	1.81	0.99	2.79	7.79	6.63	3.21	0.18	0.05	0.01	0.00
2002	4.08	2.94	2.80	1.67	3.79	5.59	5.73	1.28	0.13	0.06	0.02	0.01
2003	2.20	1.00	0.61	1.51	2.48	2.94	1.93	0.47	0.13	0.10	0.02	0.01
2004	2.19	3.29	4.37	1.97	6.97	7.80	2.54	0.64	0.29	0.13	0.08	0.05
2005	0.54	0.81	3.18	2.50	6.89	7.59	2.92	0.61	0.11	0.12	0.06	0.02
2006	0.68	0.40	0.65	1.17	5.98	7.46	3.31	0.77	0.22	0.18	0.13	0.06
2007	0.42	0.09	0.57	0.34	3.44	7.37	5.76	1.51	0.31	0.21	0.08	0.05
2008	0.20	0.10	0.15	0.19	1.50	5.70	6.16	1.13	0.35	0.26	0.12	0.05
2009	0.08	0.01	0.04	0.10	0.75	3.61	4.05	0.89	0.19	0.27	0.08	0.06

EU 3M (700-1400m)	1	2	3	4	5	6	7	8	9	10	11	12	13
2004	0.02	0.00	0.06	0.73	5.99	12.36	9.57	3.15	1.58	0.84	0.61	0.36	0.40
2005	0.00	0.00	0.02	0.26	2.22	5.26	4.37	1.70	0.54	0.96	0.57	0.35	0.18
2006	0.00	0.00	0.04	0.40	5.61	10.65	7.29	2.56	0.79	0.71	0.63	0.32	0.11
2007	0.03	0.00	0.05	0.20	4.60	12.39	13.93	5.50	1.51	1.31	0.72	0.40	0.17
2008	0.00	0.00	0.00	0.12	3.05	15.33	24.73	7.09	2.67	2.02	1.05	0.62	0.33
2009	0.00	0.00	0.02	0.05	1.83	12.90	25.56	8.64	2.33	2.48	0.88	0.69	0.64

EU 3M (0-1400m)	1	2	3	4	5	6	7	8	9	10	11	12	13
2004	1.40	2.19	2.92	1.54	6.80	9.16	4.95	1.46	0.73	0.37	0.26	0.16	0.15
2005	0.36	0.53	2.09	1.73	5.28	6.79	3.42	0.98	0.26	0.41	0.23	0.13	0.06
2006	0.45	0.26	0.44	0.91	5.85	8.56	4.68	1.39	0.42	0.36	0.30	0.15	0.05
2007	0.25	0.05	0.39	0.29	3.84	9.09	8.57	2.88	0.72	0.59	0.30	0.17	0.07
2008	0.13	0.07	0.10	0.16	2.03	9.00	12.53	3.18	1.14	0.87	0.44	0.25	0.13
2009	0.05	0.01	0.03	0.08	1.13	6.80	11.43	3.54	0.93	1.03	0.36	0.28	0.25

3LNO Spr	1	2	3	4	5	6	7	8
1996	1.62	4.24	4.60	2.18	0.83	0.28	0.06	0.00
1997	1.16	3.92	5.16	3.23	1.46	0.51	0.10	0.01
1998	0.22	0.81	3.85	6.19	4.96	1.24	0.33	0.07
1999	0.29	0.55	1.15	1.98	3.39	1.09	0.24	0.05
2000	0.79	1.07	1.07	1.51	1.95	2.04	0.56	0.03
2001	0.57	0.71	0.74	0.68	0.80	0.72	0.28	0.02
2002	0.64	0.57	0.60	0.58	0.61	0.21	0.05	0.01
2003	0.93	2.14	1.66	1.57	1.06	0.21	0.05	0.01
2004	0.66	0.57	1.18	1.18	1.16	0.26	0.04	0.02
2005	0.35	0.31	1.09	0.95	1.37	0.82	0.21	0.03
2006				**Survey not completed**				
2007	1.60	0.52	0.80	0.40	1.41	1.49	1.12	0.18
2008	0.44	0.77	0.96	0.71	1.25	0.75	0.64	0.28
2009	0.27	0.22	0.19	0.39	0.45	0.26	0.13	0.07

Table 5. Sample size for the estimation of proportion mature at age for males. Imm = immature and mat=mature.

age/cohort	1974		1975		1976		1977		1978		1979		1980		1981		1982		1983	
	imm	**mat**	**imm**	**mat**	**imm**	**mat**	**imm**	**mat**	**imm**	**mat**	**imm**	**mat**	**imm**	**mat**	**imm**	**mat**	**imm**	**mat**	**imm**	**mat**
0	.	.	.	.	.	.	.	.	4	0	.	.	.	.	.	.	.	.	.	.
1	.	.	.	.	.	.	6	0	50	0	37	0	56	0	35	0	7	0	26	0
2	.	.	.	.	84	0	96	0	79	0	124	0	71	0	30	0	75	0	112	0
3	.	.	142	1	156	1	145	0	154	0	136	0	89	0	97	0	98	0	90	0
4	159	3	120	1	140	0	158	0	135	0	136	0	138	0	120	0	134	0	115	0
5	148	19	168	3	189	1	166	0	149	0	185	0	187	0	124	0	121	0	125	0
6	174	9	164	8	142	0	136	1	117	0	153	0	136	0	144	0	134	1	57	1
7	164	11	129	0	160	1	114	2	132	2	135	3	154	3	143	6	71	1	72	2
8	179	6	153	10	123	15	113	9	101	6	141	12	90	12	63	5	47	6	18	1
9	90	27	73	23	83	14	48	18	60	24	22	10	18	3	8	5	4	2	.	.
10	12	8	36	18	9	10	14	7	4	5	1	0	1	3	.	.	.	.	.	.
11	6	3	2	3	.	.	1	2	.	.	.	.	.	.	.	.	.	.	.	.
12	0	1	0	1	0	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.

age/cohort	1984		1985		1986		1987		1988		1989		1990		1991		1992		1993	
	imm	**mat**	**imm**	**mat**	**imm**	**mat**	**imm**	**mat**	**imm**	**mat**	**imm**	**mat**	**imm**	**mat**	**imm**	**mat**	**imm**	**mat**	**imm**	**mat**
0	.	.	7	0	3	0	.	.	10	0	2	0	.	.	.	.	5	0	5	0
1	74	0	86	0	25	0	72	0	33	0	6	0	80	0	22	0	14	0	57	0
2	76	0	80	0	92	0	52	0	31	0	50	0	65	0	68	0	59	0	109	0
3	138	0	105	0	59	0	48	0	50	0	63	0	88	0	62	0	73	0	99	0
4	121	0	101	0	98	0	85	0	108	0	81	0	81	1	58	0	82	0	106	0
5	84	0	71	1	79	0	68	0	79	0	75	0	93	0	92	0	115	0	95	0
6	61	0	73	0	68	0	61	2	57	0	60	0	75	0	111	5	103	1	89	5
7	67	0	74	3	51	3	65	1	21	1	50	4	97	11	90	13	86	8	77	3
8	11	0	23	1	25	2	3	0	25	4	38	18	52	4	47	13	32	2	45	5
9	3	1	3	0	.	.	12	6	16	8	10	3	8	2	6	0	6	2	1	1
10	0	1	.	.	3	0	3	1	1	3	1	0	.	.	2	0	.	.	1	0
11	.	.	0	1	0	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
12	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Table 5 continued

age/cohort	1994		1995		1996		1997		1998		1999		2000		2001		2002		2003	
	imm	**mat**	**imm**	**mat**	**imm**	**mat**	**imm**	**mat**	**imm**	**mat**	**imm**	**mat**	**imm**	**mat**	**imm**	**mat**	**imm**	**mat**	**imm**	**mat**
0	48	0	42	0	3	0	14	0	.	.	13	0	8	0	10	0	37	0	10	0
1	72	0	128	0	87	0	110	0	61	0	90	0	132	0	155	0	107	0	92	0
2	136	0	118	0	118	0	126	0	92	0	94	0	149	0	107	0	97	0	112	0
3	100	0	127	0	57	0	63	0	88	0	98	0	60	0	54	0	58	0	57	0
4	119	0	111	0	77	0	94	0	149	0	86	0	80	5	102	5	104	0	84	0
5	114	0	104	0	107	0	164	2	94	0	89	11	116	7	135	0	101	1	.	.
6	93	1	123	3	106	1	82	1	67	17	101	6	125	3	97	4	.	.	.	.
7	108	6	50	4	58	5	61	27	73	20	109	4	87	6	.	.	.	.	.	.
8	12	3	20	3	23	18	23	14	49	9	64	12	.	.	.	.	.	.	.	.
9	2	2	6	1	2	2	5	5	11	3	.	.	.	.	.	.	.	.	.	.
10	1	0	0	2	1	0	1	0	.	.	.	.	.	.	.	.	.	.	.	.
11	1	0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
12	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

age/cohort	2004		2005		2006		2007	
	imm	**mat**	**imm**	**mat**	**imm**	**mat**	**imm**	**mat**
0	14	0	14	0	10	0	3	0
1	88	0	121	0	108	0	.	.
2	100	0	92	0	.	.	.	.
3	51	0	.	.	.	.	.	.
4	.	.	.	.	.	.	.	.
5	.	.	.	.	.	.	.	.
6	.	.	.	.	.	.	.	.
7	.	.	.	.	.	.	.	.
8	.	.	.	.	.	.	.	.
9	.	.	.	.	.	.	.	.
10	.	.	.	.	.	.	.	.
11	.	.	.	.	.	.	.	.
12	.	.	.	.	.	.	.	.

Table 6. Sample size for the estimation of proportion mature at age for females. Imm = immature and mat=mature.

age/cohort	1966		1967		1968		1969		1970		1971		1972		1973		1974		1975	
	imm	**mat**	**imm**	**mat**	**imm**	**mat**	**imm**	**mat**	**imm**	**mat**	**imm**	**mat**	**imm**	**mat**	**imm**	**mat**	**imm**	**mat**	**imm**	**mat**
0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	145	0
4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	154	0	129	0
5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	168	1	186	0	163	1
6	.	.	.	.	.	.	.	.	.	.	.	.	156	0	186	0	178	6	190	0
7	.	.	.	.	.	.	.	.	.	.	137	1	134	0	167	9	168	0	144	0
8	.	.	.	.	.	.	.	.	110	2	94	2	105	13	157	3	172	1	164	3
9	.	.	.	.	.	.	83	4	68	2	71	13	152	10	148	2	145	7	109	13
10	.	.	.	.	71	12	74	12	68	11	97	36	112	5	94	9	81	42	109	15
11	.	.	68	22	58	13	71	30	81	44	101	13	77	24	46	35	79	17	64	1
12	45	29	63	13	32	41	24	43	95	27	48	40	20	49	58	37	51	9	53	10
13	45	24	24	27	8	31	52	31	26	42	17	44	22	27	34	11	26	13	9	12
14	6	27	1	18	41	45	5	44	4	57	15	38	23	13	12	20	7	9	2	0
15	1	10	21	44	4	22	4	28	5	29	16	21	3	17	1	13	1	1	1	2
16	1	30	1	6	1	20	1	17	5	16	3	9	0	9	0	3	0	3	1	0
17	.	.	1	8	3	15	0	3	0	8	0	5	.	.	.	.	.	.	.	.
18	.	.	0	6	.	.	0	1	0	1	.	.	.	.	.	.	.	.	.	.
19	0	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
20	.	.	.	.	0	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Table 6 continued

age/cohort	1976		1977		1978		1979		1980		1981		1982		1983		1984		1985	
	imm	**mat**	**imm**	**mat**	**imm**	**mat**	**imm**	**mat**	**imm**	**mat**	**imm**	**mat**	**imm**	**mat**	**imm**	**mat**	**imm**	**mat**	**imm**	**mat**
0	.	.	.	.	1	0	.	.	.	.	.	.	.	.	.	.	.	.	1	0
1	.	.	10	0	48	0	58	0	64	0	35	0	12	0	28	0	61	0	81	0
2	73	0	121	0	104	0	153	0	71	0	48	0	66	0	110	0	89	0	86	0
3	121	0	148	0	151	0	149	0	122	0	114	0	112	0	112	0	149	0	131	0
4	134	0	160	0	169	0	134	0	124	0	119	0	137	0	116	0	114	0	96	0
5	166	0	157	0	148	0	186	0	178	0	124	0	108	0	115	0	82	0	72	0
6	127	0	137	0	121	0	154	0	146	0	142	0	115	0	54	0	62	0	86	0
7	157	1	138	0	134	0	126	0	157	0	171	0	73	0	72	1	54	0	74	0
8	128	4	124	0	117	0	142	0	120	0	74	1	62	1	52	0	22	0	33	0
9	94	5	83	3	126	3	70	1	52	0	47	2	20	0	5	2	6	0	10	0
10	61	0	63	5	31	4	26	0	23	5	9	4	2	1	1	0	3	0	1	0
11	47	8	19	6	22	0	24	5	2	3	1	0	.	.	2	0	0	1	6	1
12	14	2	4	1	13	4	5	0	.	.	2	3	1	0	.	.	2	5	5	4
13	1	0	5	7	2	1	.	.	0	1	1	0	.	.	1	7	0	5	6	1
14	5	5	1	0	0	1	0	1	.	.	.	.	1	2	0	2	0	1	0	1
15	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
16	.	.	.	.	.	.	.	.	.	.	.	.	0	1	.	.	.	.	.	.
17	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
18	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
19	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
20	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Table 6 continued

age/cohort	1986		1987		1988		1989		1990		1991		1992		1993		1994		1995	
	imm	mat	imm	mat	imm	mat	imm	mat	imm	mat	imm	mat	imm	mat	imm	mat	imm	mat	imm	mat
0	1	0	.	.	5	0	2	0	.	.	.	.	2	0	1	0	23	0	43	0
1	37	0	73	0	44	0	8	0	75	0	22	0	18	0	60	0	79	0	129	0
2	97	0	57	0	50	0	47	0	61	0	73	0	54	0	112	0	143	0	119	0
3	53	0	51	0	45	0	63	0	79	0	50	0	73	0	100	0	96	0	121	0
4	98	0	83	0	113	0	96	0	85	0	60	0	77	0	99	0	106	0	92	0
5	79	0	71	0	73	0	96	0	114	0	95	0	110	0	108	0	109	0	87	0
6	76	0	59	0	61	0	53	0	90	0	123	0	97	0	100	0	103	0	119	0
7	54	0	61	0	28	0	69	0	104	0	112	0	99	0	65	0	101	0	66	0
8	48	0	14	0	24	1	71	0	71	0	65	0	43	1	68	0	29	0	39	0
9	4	0	31	2	37	0	24	0	31	1	14	0	19	2	13	0	9	0	18	0
10	8	2	12	0	14	0	13	1	10	0	7	1	5	0	6	0	8	2	9	0
11	8	3	14	0	9	1	5	1	5	1	1	1	2	3	2	0	4	1	8	0
12	7	0	2	0	1	1	1	1	.	.	1	2	2	0	2	1	2	1	7	1
13	4	3	.	.	3	1	0	1	0	1	0	2	2	0	.	.	1	2	.	.
14	1	1	1	0	.	.	.	.	.	.	0	1	0	1	1	1	.	.	.	.
15	.	.	.	.	.	.	.	.	0	1	.	.	.	.	.	.	.	.	.	.
16	.	.	.	.	0	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
17	.	.	.	.	.	.	.	.	0	1	.	.	.	.	.	.	.	.	.	.
18	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
19	0	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
20	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Table 6 continued

age/cohort	**1996**		**1997**		**1998**		**1999**		**2000**		**2001**		**2002**		**2003**		**2004**		**2005**	
	imm	**mat**	**imm**	**mat**	**imm**	**mat**	**imm**	**mat**	**imm**	**mat**	**imm**	**mat**	**imm**	**mat**	**imm**	**mat**	**imm**	**mat**	**imm**	**mat**
0	1	0	7	0	.	.	12	0	9	0	1	0	45	0	7	0	6	0	7	0
1	96	0	104	0	64	0	76	0	133	0	156	0	108	0	93	0	88	0	121	0
2	131	0	120	0	86	0	121	0	144	0	104	0	105	0	109	0	89	0	94	0
3	76	0	71	0	71	0	106	0	55	0	56	0	62	0	53	0	59	0	.	.
4	81	0	104	0	138	0	76	0	82	0	91	0	109	0	82	0	.	.	.	.
5	102	0	170	0	105	0	106	0	137	0	117	0	101	0	.	.	.	.	.	.
6	101	0	76	0	81	0	104	0	122	0	103	0	.	.	.	.	.	.	.	.
7	66	0	80	0	123	0	122	1	89	0	.	.	.	.	.	.	.	.	.	.
8	54	1	53	3	86	0	103	2	.	.	.	.	.	.	.	.	.	.	.	.
9	28	0	35	1	46	5	.	.	.	.	.	.	.	.	.	.	.	.	.	.
10	8	0	16	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
11	8	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
12	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
13	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
14	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
15	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
16	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
17	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
18	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
19	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
20	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Table 7. Estimated proportions mature at age for Greenland Halibut in Sub-Area 2 and Divisions 3KLMNO from Canadian fall survey data in Divisions 2J and 3K. Plus group entries are computed using a catch-numbers weighted average of the proportion mature at ages 14 and older.

	Age													
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14+
1975	0	0	0	0.001	0.004	0.007	0.013	0.023	0.047	0.067	0.100	0.184	0.335	0.631
1976	0	0	0	0.001	0.007	0.003	0.010	0.036	0.037	0.027	0.119	0.205	0.335	0.571
1977	0	0	0	0.001	0.002	0.012	0.006	0.020	0.063	0.067	0.064	0.205	0.335	0.667
1978	0	0	0	0.002	0.002	0.004	0.022	0.013	0.041	0.107	0.117	0.143	0.335	0.656
1979	0	0	0	0.001	0.004	0.005	0.009	0.038	0.029	0.083	0.177	0.196	0.290	0.677
1980	0	0	0	0.001	0.002	0.007	0.009	0.018	0.064	0.060	0.158	0.277	0.310	0.584
1981	0	0	0	0.000	0.001	0.003	0.012	0.017	0.036	0.108	0.123	0.282	0.406	0.653
1982	0	0	0	0.000	0.000	0.002	0.006	0.021	0.034	0.070	0.177	0.232	0.451	0.693
1983	0	0	0	0.000	0.000	0.000	0.004	0.011	0.038	0.064	0.132	0.275	0.397	0.692
1984	0	0	0	0.000	0.000	0.000	0.001	0.008	0.021	0.067	0.119	0.236	0.401	0.721
1985	0	0	0	0.000	0.000	0.000	0.001	0.003	0.016	0.039	0.114	0.211	0.384	0.650
1986	0	0	0	0.000	0.000	0.000	0.000	0.002	0.008	0.029	0.071	0.190	0.345	0.634
1987	0	0	0	0.000	0.000	0.000	0.000	0.000	0.006	0.023	0.054	0.126	0.297	0.594
1988	0	0	0	0.000	0.000	0.000	0.001	0.000	0.002	0.015	0.060	0.099	0.215	0.493
1989	0	0	0	0.000	0.000	0.000	0.001	0.005	0.000	0.006	0.038	0.152	0.173	0.360
1990	0	0	0	0.000	0.000	0.000	0.001	0.002	0.015	0.001	0.023	0.092	0.332	0.545
1991	0	0	0	0.000	0.000	0.000	0.001	0.003	0.007	0.051	0.158	0.081	0.209	0.537
1992	0	0	0	0.000	0.000	0.000	0.000	0.002	0.010	0.017	0.154	0.971	0.249	0.609
1993	0	0	0	0.000	0.000	0.000	0.001	0.001	0.007	0.032	0.045	0.384	1.000	0.937
1994	0	0	0	0.000	0.000	0.000	0.001	0.003	0.003	0.021	0.097	0.111	0.680	0.907
1995	0	0	0	0.000	0.000	0.000	0.001	0.002	0.007	0.010	0.062	0.257	0.250	0.765
1996	0	0	0	0.000	0.000	0.000	0.000	0.002	0.006	0.017	0.028	0.168	0.526	0.782
1997	0	0	0	0.000	0.000	0.000	0.000	0.000	0.006	0.016	0.041	0.079	0.364	0.711
1998	0	0	0	0.000	0.000	0.001	0.000	0.000	0.000	0.014	0.039	0.097	0.203	0.570
1999	0	0	0	0.000	0.000	0.000	0.002	0.000	0.002	0.002	0.037	0.095	0.213	0.555
2000	0	0	0	0.000	0.000	0.000	0.001	0.004	0.001	0.009	0.017	0.092	0.212	0.509
2001	0	0	0	0.000	0.000	0.000	0.001	0.003	0.011	0.009	0.042	0.124	0.211	0.471
2002	0	0	0	0.000	0.000	0.000	0.000	0.002	0.009	0.028	0.069	0.181	0.533	0.829
2003	0	0	0	0.000	0.000	0.000	0.000	0.002	0.007	0.026	0.070	0.364	0.529	0.890
2004	0	0	0	0.000	0.000	0.000	0.000	0.001	0.006	0.024	0.072	0.166	0.817	0.972
2005	0	0	0	0.000	0.000	0.000	0.000	0.002	0.005	0.022	0.074	0.188	0.346	0.721
2006	0	0	0	0.000	0.000	0.000	0.000	0.002	0.006	0.020	0.076	0.209	0.406	0.733
2007	0	0	0	0.000	0.000	0.000	0.000	0.002	0.006	0.022	0.078	0.234	0.466	0.800
2008	0	0	0	0.000	0.000	0.000	0.000	0.002	0.006	0.022	0.076	0.259	0.529	0.809
2009	0	0	0	0.000	0.000	0.000	0.000	0.002	0.006	0.022	0.076	0.234	0.592	0.903
2010	0	0	0	0.000	0.000	0.000	0.000	0.002	0.006	0.022	0.076	0.234	0.529	0.838

Table 8a. XSA Settings, updated run. (Does not include the EU deep-water data from Div. 3M survey)
Lowestoft VPA Version 3.1

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Extended Survivors Analysis

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

CPUE data from file GhalTUN2010_XSA.txt

Catch data for 35 years. 1975 to 2009. Ages 1 to 14.

Fleet	First year	Last year	First age	Last age	Alpha	Beta
EU3M_0_	1995	2009	1	12	0.5	0.6
F2J3K	1996	2009	1	13	0.8	1
S3LNO	1996	2009	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 2009
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

Tuning converged after 68 iterations

Table 8b. XSA Diagnostics

Fleet : EU3M_0_700

Age	1995	1996	1997	1998	1999
1	1.32	0.7	0.34	0.28	-0.72
2	0.75	1.7	1.09	0.73	-0.26
3	0.67	0.22	0.94	1.32	0.59
4	0.5	0.79	1.02	1.36	1.44
5	-0.29	0.35	0.7	0.73	0.6
6	0.06	0.03	0.6	0.72	0.25
7	0.38	-0.33	0.28	0.89	0.49
8	0.56	0.32	0.48	0.64	0.49
9	1.24	0.15	0.64	0.78	0.05
10	0.28	-0.8	0.18	0.15	-0.39
11	0.16	-0.8	-0.71	-0.45	-1.82
12	-0.63	0.15	-0.42	-1.6	-2.22
13	No data for this fleet at this age				

Age	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1	0.48	1.27	0.59	0.23	0.62	-0.47	-0.09	-0.88	-1.21	-2.45
2	-1.18	0.34	1.09	0.01	1.46	0.45	0.04	-1.26	-1.51	-3.46
3	-0.9	0.16	0.53	-0.97	1.01	0.95	-0.25	-0.08	-1.25	-2.95
4	0.07	-0.58	-0.11	-0.26	0.03	0.26	-0.24	-1.08	-1.36	-1.84
5	0.1	-0.62	-0.19	-0.63	0.35	0.33	0.19	-0.12	-0.57	-0.95
6	0.21	-0.23	-0.39	-0.82	0.12	-0.02	-0.07	-0.13	-0.14	-0.19
7	0.07	0.11	0.08	-0.8	-0.37	-0.37	-0.4	0.11	0	-0.15
8	0.71	0.97	-0.13	-1.03	-0.57	-0.57	-0.52	-0.05	-0.42	-0.88
9	0.5	-0.47	-0.68	-0.75	0.14	-0.75	-0.09	0.04	-0.08	-0.72
10	-0.23	-1.03	-0.75	-0.04	0.21	0.12	0.62	0.69	0.63	0.37
11	0.31	-1.79	-0.52	-0.53	1.16	0.66	1.39	0.99	1.39	0.55
12	99.99	99.99	-0.76	-1.15	1.11	0.46	1.21	0.78	1.01	1.01
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	-10.7524	-11.3795	-10.7012	-10.3076	-9.136	-8.3364	-8.1329	-8.3584	-9.0033	-9.1693
S.E(Log q	1.0008	1.3662	1.1279	0.9553	0.5296	0.3732	0.4218	0.6383	0.6092	0.5381

Age	11	12
Mean Log	-9.8571	-9.8571
S.E(Log q	1.0514	1.1382

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	0.43	3.637	11.08	0.76	15	0.31	-10.75
2	0.34	3.884	11.26	0.73	15	0.33	-11.38
3	0.4	2.783	10.91	0.62	15	0.37	-10.7
4	0.36	4.962	10.67	0.82	15	0.21	-10.31
5	0.56	2.221	9.83	0.66	15	0.26	-9.14
6	1.39	-0.832	7.5	0.26	15	0.52	-8.34
7	1.93	-1.43	6.33	0.15	15	0.78	-8.13
8	-1.69	-2.422	10.49	0.06	15	0.93	-8.36
9	0.54	0.795	8.63	0.19	15	0.33	-9
10	2.59	-0.919	11.81	0.03	15	1.4	-9.17
11	-0.67	-3.238	4.97	0.22	15	0.54	-9.86
12	-1.38	-2.235	1.4	0.07	13	1.36	-9.94

Table 8b. XSA diagnostic results (cont.)

Fleet : F2J3K

Age	1995	1996	1997	1998	1999
1	99.99	0.46	-0.59	-0.65	-1.08
2	99.99	-0.04	0.3	-0.35	0.1
3	99.99	0.33	0.45	0.25	0.19
4	99.99	-0.19	0.08	-0.08	0.31
5	99.99	-0.04	0.29	-0.19	0.2
6	99.99	-0.47	0.42	0.15	0.4
7	99.99	-0.82	-0.02	0.15	0.78
8	99.99	-1.12	0.03	-0.12	0.36
9	99.99	0.11	0.33	-0.05	0.06
10	99.99	-0.35	0.06	0.21	0.56
11	99.99	-0.1	0.19	0.12	-0.09
12	99.99	-0.24	0.4	0.22	-0.69
13	99.99	0.37	0.05	0.33	0.93

Age	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1	-0.26	-0.1	-0.18	0.2	0.25	-0.16	0.71	0.41	99.99	0.99
2	-0.4	-0.43	-0.34	-0.24	0.23	-0.09	0.32	0.27	99.99	0.67
3	-0.06	-0.08	-0.45	-0.49	-0.32	-0.54	-0.16	0.56	99.99	0.3
4	-0.25	-0.05	-0.47	-0.54	-0.26	-0.15	0.35	0.8	99.99	0.46
5	-0.04	-0.17	-0.52	-0.46	-0.15	0	0.16	0.09	99.99	0.82
6	-0.09	0.12	-1.08	-0.66	-0.57	0.22	0.48	0.53	99.99	0.55
7	-0.04	0.21	-1.26	-0.79	-0.42	0.59	0.48	0.81	99.99	0.33
8	-0.02	0.32	-1.12	-0.65	-0.32	0.36	0.74	1.13	99.99	0.4
9	-0.6	-0.09	-0.95	-0.98	-0.19	0.25	0.61	1.03	99.99	0.48
10	-0.29	-0.42	-0.95	-0.48	0.09	0.15	0.04	1.01	99.99	0.37
11	-0.17	-0.09	-1.24	-0.37	-0.57	0.74	0.42	1.05	99.99	0.11
12	-1.18	-0.79	99.99	-0.16	-0.51	0.53	0.11	0.81	99.99	-0.28
13	99.99	0.55	-0.2	-0.32	0.88	0.68	99.99	0.37	99.99	0.12

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	-7.6153	-7.7754	-8.154	-8.1121	-8.2518	-8.5461	-8.4815	-8.8595	-9.654	-10.2471
S.E(Log q	0.5785	0.3444	0.3725	0.386	0.3415	0.5321	0.6522	0.6713	0.5863	0.5054

Age	11	12	13
Mean Log	-10.4283	-10.4283	-10.4283
S.E(Log q	0.5731	0.6083	0.5428

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	3.64	-2.437	-2.2	0.07	13	1.77	-7.62
2	1.7	-2.729	5.37	0.58	13	0.47	-7.78
3	1.13	-0.421	7.77	0.49	13	0.44	-8.15
4	2.1	-2.138	4.97	0.25	13	0.71	-8.11
5	2.18	-2.201	5.28	0.24	13	0.65	-8.25
6	1.46	-0.598	7.62	0.13	13	0.8	-8.55
7	1.32	-0.338	7.97	0.09	13	0.89	-8.48
8	0.61	0.709	8.97	0.23	13	0.42	-8.86
9	0.54	0.715	8.98	0.18	13	0.33	-9.65
10	1.16	-0.199	10.69	0.12	13	0.61	-10.25
11	1.48	-0.516	12.11	0.1	13	0.87	-10.43
12	1.87	-0.858	14.25	0.09	12	1.11	-10.58
13	0.83	0.642	9.35	0.61	11	0.35	-10.09

Table 8b. XSA diagnostic results (cont.)

Fleet : S3LNO

Age	1995	1996	1997	1998	1999
1	99.99	0.38	0.25	-1.28	-1.05
2	99.99	0.97	1.02	-0.35	-0.61
3	99.99	0.94	0.86	0.71	-0.3
4	99.99	0.77	0.63	1.09	0.08
5	99.99	-0.07	0.32	1.02	0.43
6	99.99	-0.48	0.29	1.02	0.33
7	99.99	-0.84	-0.38	0.97	0.59
8	99.99	-3.08	-0.66	1	0.82
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				

Age	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1	-0.11	-0.43	-0.3	0.33	0.38	0.06	99.99	1.42	0.57	-0.23
2	0.01	-0.46	-0.66	0.66	-0.39	-0.63	99.99	0.36	0.46	-0.37
3	-0.24	-0.66	-0.93	0.11	-0.23	-0.05	99.99	0.33	0.68	-1.23
4	0.01	-0.66	-0.86	0.08	-0.18	-0.41	99.99	-0.62	0.26	-0.19
5	0.02	-0.67	-0.81	-0.29	-0.25	-0.08	99.99	0.19	0.46	-0.26
6	0.78	-0.12	-1.17	-0.99	-0.78	0.27	99.99	0.8	0.36	-0.3
7	0.95	0.12	-1.49	-1.26	-1.28	0.21	99.99	1.71	1	-0.3
8	0.35	-0.07	-1.6	-1.22	-0.12	0.15	99.99	1.77	2.13	0.51
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	-11.7499	-11.3066	-10.8091	-10.6498	-10.3802	-10.9186	-11.5188	-12.4539
S.E(Log q	0.7018	0.6172	0.6917	0.5803	0.492	0.7058	1.023	1.4056

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	2.62	-1.591	12.45	0.08	13	1.73	-11.75
2	0.79	0.756	11.29	0.54	13	0.5	-11.31
3	0.81	0.533	10.86	0.42	13	0.58	-10.81
4	0.77	0.81	10.71	0.53	13	0.45	-10.65
5	0.88	0.364	10.42	0.44	13	0.45	-10.38
6	0.85	0.245	10.86	0.2	13	0.63	-10.92
7	0.83	0.189	11.28	0.1	13	0.88	-11.52
8	0.31	1.266	10.19	0.24	13	0.43	-12.45

Table 8b. XSA diagnostic results (cont.)

Terminal year survivor and F summaries :

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

Year class = 2008

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU3M_0_	3246	1.034	0	0	1	0.167	0
F2J3K	100665	0.6	0	0	1	0.496	0
S3LNO	29751	0.728	0	0	1	0.337	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
37588	0.42	0.87	3	2.051	0

1

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

Year class = 2007

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU3M_0_	3110	0.834	1.072	1.29	2	0.147	0
F2J3K	44695	0.5	0	0	1	0.41	0
S3LNO	23834	0.481	0.468	0.97	2	0.443	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
22844	0.32	0.51	5	1.591	0

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

Year class = 2006

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU3M_0_	5118	0.678	0.644	0.95	3	0.143	0
F2J3K	40682	0.384	0.055	0.14	2	0.445	0
S3LNO	35996	0.4	0.746	1.87	3	0.412	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
28760	0.26	0.39	8	1.531	0

Table 8b. XSA Diagnostic results (cont.)

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

Year class = 2005

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU3M_0_700	5771	0.559	0.401	0.72	4	0.127	0.01
F2J3K	27261	0.305	0.122	0.4	3	0.429	0.002
S3LNO	21884	0.374	0.255	0.68	3	0.284	0.003
F shrinkage ı	8194	0.5				0.16	0.007

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
17343	0.2	0.22	11	1.097	0.003

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

Year class = 2004

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU3M_0_700	7551	0.391	0.216	0.55	5	0.183	0.055
F2J3K	25077	0.26	0.195	0.75	4	0.412	0.017
S3LNO	17082	0.31	0.144	0.46	4	0.291	0.025
F shrinkage ı	10682	0.5				0.115	0.04

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
16336	0.17	0.15	14	0.92	0.026

Age 6 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
EU3M_0_700	11434	0.308	0.194	0.63	6	0.229	0.221
F2J3K	19964	0.235	0.191	0.81	5	0.39	0.132
S3LNO	13857	0.28	0.249	0.89	5	0.276	0.185
F shrinkage ı	14745	0.5				0.104	0.175

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
15390	0.15	0.12	17	0.785	0.168

Age 7 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
EU3M_0_700	11327	0.263	0.151	0.57	7	0.266	0.532
F2J3K	12635	0.219	0.14	0.64	6	0.371	0.489
S3LNO	12154	0.279	0.126	0.45	6	0.227	0.504
F shrinkage ı	8547	0.5				0.135	0.658

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
11538	0.14	0.08	20	0.534	0.525

Table 8b. XSA Diagnostic results (cont.)

Age 8 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
EU3M_0_700	5329	0.251	0.179	0.71	8	0.264	0.804
F2J3K	6119	0.209	0.126	0.6	7	0.349	0.73
S3LNO	7245	0.29	0.222	0.77	7	0.172	0.646
F shrinkage ı	5570	0.5				0.214	0.78

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
5952	0.15	0.08	23	0.546	0.745

Age 9 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
EU3M_0_700	1723	0.283	0.176	0.62	9	0.276	0.705
F2J3K	2584	0.249	0.156	0.63	8	0.313	0.52
S3LNO	2445	0.273	0.329	1.21	7	0.124	0.543
F shrinkage ı	2364	0.5				0.286	0.557

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
2237	0.18	0.1	25	0.533	0.581

Age 10 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
EU3M_0_700	1632	0.293	0.089	0.3	10	0.341	0.248
F2J3K	1758	0.285	0.158	0.55	9	0.33	0.232
S3LNO	1328	0.265	0.256	0.97	7	0.086	0.297
F shrinkage ı	908	0.5				0.243	0.409

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
1425	0.18	0.09	27	0.493	0.28

Table 8b. XSA Diagnostic results (cont.)

Age 11 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
EU3M_0_700	882	0.303	0.142	0.47	11	0.328	0.192
F2J3K	853	0.303	0.182	0.6	10	0.338	0.198
S3LNO	423	0.255	0.163	0.64	7	0.061	0.365
F shrinkage ı	454	0.5				0.273	0.344

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
695	0.2	0.1	29	0.523	0.237

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

Year class = 1997

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU3M_0_700	551	0.323	0.198	0.61	12	0.29	0.104
F2J3K	433	0.298	0.187	0.63	11	0.388	0.131
S3LNO	168	0.266	0.152	0.57	8	0.043	0.309
F shrinkage ı	170	0.5				0.279	0.305

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
344	0.2	0.14	32	0.674	0.163

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

Year class = 1996

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU3M_0_700	327	0.339	0.208	0.61	12	0.229	0.082
F2J3K	304	0.282	0.141	0.5	12	0.478	0.088
S3LNO	152	0.269	0.174	0.65	8	0.029	0.169
F shrinkage ı	110	0.5				0.263	0.228

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
232	0.2	0.13	33	0.618	0.114

Table 9. XSA estimated numbers at age (000s), updated run.

	Age													
N@A(XSA)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14+**
1975	112270	126272	110145	66813	53820	31894	23091	14337	9312	3931	1773	415	720	735
1976	116645	91919	103383	90179	54702	43762	23561	13703	7254	4040	1691	816	218	113
1977	107499	95500	75257	84643	73832	44771	35277	16367	6321	2529	1313	635	433	311
1978	82354	88012	78189	61615	69300	59966	32120	19112	6753	2521	1154	876	402	459
1979	98987	67426	72059	64016	50446	54040	41481	18181	8793	2937	763	290	385	756
1980	130053	81043	55203	58997	52412	39143	36347	22358	9334	6141	1969	365	103	52
1981	131781	106478	66353	45197	48302	42722	30160	21479	9548	2757	1564	696	183	292
1982	131006	107893	87177	54325	37004	38766	30891	15820	7225	3920	1452	1049	441	511
1983	146370	107258	88336	71374	44478	30053	29658	19573	7738	2710	1686	650	627	1030
1984	153573	119838	87816	72323	58436	35781	21387	15415	9226	4259	1593	1191	463	794
1985	166991	125735	98115	71897	59213	47028	27192	12222	5670	3856	2347	936	846	833
1986	186830	136721	102943	80330	58865	46685	33699	16913	6840	3393	2694	1778	677	1127
1987	156140	152963	111937	84282	65768	47941	36196	21790	9240	4271	2352	1985	1329	2051
1988	128552	127836	125236	91647	69005	53723	37530	19678	9755	5000	2725	1578	1371	1647
1989	112776	105249	104664	102534	75034	56228	41102	23365	12148	6821	3673	2049	1197	584
1990	107600	92333	86171	85691	83948	61269	44237	26883	15263	8605	4891	2611	1436	1043
1991	94369	88096	75596	70551	70072	67734	44048	24788	15172	8812	4609	2915	1337	999
1992	70964	77263	72127	61893	57563	54781	48438	24163	10526	5957	3848	2086	1286	1082
1993	84120	58100	63258	59052	49711	43346	34968	20983	8739	4699	3283	2235	1040	467
1994	142771	68872	47568	51791	47434	32040	21077	12599	6395	2955	2186	1733	957	637
1995	173040	116891	56388	38946	37521	23906	11923	7174	4218	2448	1421	1056	1037	825
1996	151095	141674	95702	46166	31594	29496	17453	6865	3947	2383	1516	851	617	382
1997	123295	123706	115993	78354	37626	24366	19447	8510	3889	2366	1495	847	486	313
1998	108305	100946	101282	94967	63848	29084	16177	9096	4059	2153	1389	844	470	259
1999	113882	88673	82647	82923	77253	49039	18919	8008	4142	2025	1273	796	545	563
2000	121292	93239	72599	67666	67623	61305	35060	7698	3124	1890	1094	732	375	299
2001	118063	99306	76338	59439	55155	53529	38806	9545	3318	1678	1070	563	416	198
2002	118225	96662	81305	62500	48259	43131	32820	11755	3151	1802	926	478	277	176
2003	90870	96794	79140	66567	50737	38007	28763	10963	3646	1454	879	432	189	209
2004	61753	74398	79248	64794	53343	37476	21415	8380	3198	1525	724	458	223	191
2005	45634	50559	60912	64883	52237	39998	23231	7995	3128	1436	770	331	208	148
2006	38720	37362	41394	49870	52639	41274	27319	9688	2930	1285	774	409	168	209
2007	52404	31701	30589	33891	40635	41406	27956	11379	3497	1413	715	511	293	206
2008	34079	42905	25955	25044	27668	32753	30523	12110	4417	1750	730	438	346	199
2009	45910	27901	35128	21250	20478	22247	23819	15311	4886	2302	1077	494	317	347
2010		37588	22844	28760	17343	16336	15390	11538	5952	2237	1425	695	344	485

Table 10. XSA estimated fishing mortality at age, updated run. (Average fishing mortality is computed over ages 5-10.)

	Age													
F@A(XSA)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14+**	**Fbar(5-10)**
1975	0	0	0	0.000	0.007	0.103	0.322	0.481	0.635	0.644	0.576	0.446	0.560	0.560	0.365
1976	0	0	0	0.000	0.000	0.016	0.164	0.574	0.854	0.924	0.780	0.434	0.720	0.720	0.422
1977	0	0	0	0.000	0.008	0.132	0.413	0.685	0.719	0.585	0.205	0.257	0.351	0.351	0.424
1978	0	0	0	0.000	0.049	0.169	0.369	0.576	0.633	0.995	1.180	0.622	0.943	0.943	0.465
1979	0	0	0	0.000	0.054	0.197	0.418	0.467	0.159	0.200	0.537	0.837	0.529	0.529	0.249
1980	0	0	0	0.000	0.004	0.061	0.326	0.651	1.019	1.168	0.841	0.490	0.842	0.842	0.538
1981	0	0	0	0.000	0.020	0.124	0.445	0.890	0.690	0.441	0.200	0.256	0.301	0.301	0.435
1982	0	0	0	0.000	0.008	0.068	0.256	0.515	0.781	0.644	0.604	0.314	0.525	0.525	0.379
1983	0	0	0	0.000	0.018	0.140	0.454	0.552	0.397	0.332	0.147	0.138	0.207	0.207	0.316
1984	0	0	0	0.000	0.017	0.075	0.360	0.800	0.673	0.396	0.332	0.142	0.292	0.292	0.387
1985	0	0	0	0.000	0.038	0.133	0.275	0.381	0.313	0.159	0.078	0.124	0.121	0.121	0.216
1986	0	0	0	0.000	0.005	0.055	0.236	0.405	0.271	0.167	0.106	0.091	0.121	0.121	0.190
1987	0	0	0	0.000	0.002	0.045	0.410	0.604	0.414	0.249	0.199	0.170	0.207	0.207	0.287
1988	0	0	0	0.000	0.005	0.068	0.274	0.282	0.158	0.109	0.085	0.076	0.090	0.090	0.149
1989	0	0	0	0.000	0.003	0.040	0.225	0.226	0.145	0.133	0.141	0.156	0.144	0.144	0.128
1990	0	0	0	0.001	0.015	0.130	0.379	0.372	0.349	0.424	0.318	0.469	0.407	0.407	0.278
1991	0	0	0	0.004	0.046	0.135	0.401	0.657	0.735	0.629	0.593	0.618	0.619	0.619	0.434
1992	0	0	0	0.019	0.084	0.249	0.637	0.817	0.607	0.396	0.343	0.496	0.415	0.415	0.465
1993	0	0	0	0.019	0.239	0.521	0.821	0.988	0.884	0.565	0.439	0.648	0.555	0.555	0.670
1994	0	0	0	0.122	0.485	0.789	0.878	0.894	0.760	0.532	0.528	0.314	0.461	0.461	0.723
1995	0	0	0	0.009	0.041	0.115	0.352	0.398	0.371	0.279	0.312	0.337	0.311	0.311	0.259
1996	0	0	0	0.005	0.060	0.217	0.518	0.368	0.312	0.266	0.383	0.360	0.296	0.296	0.290
1997	0	0	0	0.005	0.058	0.210	0.560	0.540	0.391	0.333	0.372	0.387	0.373	0.373	0.349
1998	0	0	0	0.006	0.064	0.230	0.503	0.587	0.496	0.325	0.357	0.237	0.244	0.244	0.367
1999	0	0	0	0.004	0.031	0.136	0.699	0.741	0.585	0.416	0.353	0.553	0.348	0.348	0.435
2000	0	0	0	0.004	0.034	0.257	1.101	0.642	0.422	0.369	0.465	0.366	0.479	0.479	0.471
2001	0	0	0	0.008	0.046	0.289	0.994	0.908	0.410	0.395	0.605	0.509	0.536	0.536	0.507
2002	0	0	0	0.009	0.039	0.205	0.897	0.971	0.573	0.518	0.562	0.729	0.699	0.699	0.534
2003	0	0	0	0.022	0.103	0.374	1.033	1.032	0.672	0.498	0.453	0.459	0.588	0.588	0.619
2004	0	0	0	0.015	0.088	0.278	0.785	0.786	0.601	0.484	0.582	0.588	0.563	0.563	0.504
2005	0	0	0	0.009	0.036	0.181	0.675	0.804	0.690	0.418	0.431	0.479	0.415	0.415	0.467
2006	0	0	0	0.005	0.040	0.190	0.676	0.819	0.529	0.386	0.216	0.136	0.236	0.236	0.440
2007	0	0	0	0.003	0.016	0.105	0.637	0.746	0.492	0.461	0.290	0.190	0.168	0.168	0.409
2008	0	0	0	0.001	0.018	0.119	0.490	0.708	0.452	0.285	0.191	0.123	0.087	0.087	0.345
2009	0	0	0	0.003	0.026	0.169	0.525	0.745	0.581	0.280	0.238	0.163	0.114	0.114	0.388

Table 11. Stock summary table from XSA analysis (no SOP correction; shrinkage parameters fixed at 0.5).
Terminal Fs derived using XSA with final year & oldest age shrinkage.

	RECRUITS Age 1	5+ BIO	10+ BIO	LANDINGS	YIELD/SSB	FBAR 5-10
1975	112270	132743	21900	28814	1.3157	0.3652
1976	116645	134511	17670	24611	1.3928	0.422
1977	107499	156960	14817	32048	2.1629	0.4237
1978	82354	167770	15904	39070	2.4566	0.4651
1979	98987	162553	15618	34104	2.1837	0.249
1980	130053	130932	12401	32867	2.6504	0.5382
1981	131781	115296	14021	30754	2.1934	0.4351
1982	131006	121323	19866	26278	1.3228	0.3786
1983	146370	122766	24138	27861	1.1542	0.3155
1984	153573	115243	24260	26711	1.101	0.3866
1985	166991	148155	28973	20347	0.7023	0.2164
1986	186830	138126	33519	17976	0.5363	0.1896
1987	156140	164669	42265	32442	0.7676	0.2873
1988	128552	169163	44246	19215	0.4343	0.1492
1989	112776	182280	43788	20034	0.4575	0.1284
1990	107600	206139	55801	47454	0.8504	0.2782
1991	94369	224671	63215	65008	1.0284	0.4337
1992	70964	192417	48713	63193	1.2973	0.4648
1993	84120	148314	37593	62455	1.6613	0.6698
1994	142771	102944	28481	51029	1.7917	0.723
1995	173040	77114	25124	15272	0.6079	0.2592
1996	151095	77117	19425	18840	0.9699	0.2901
1997	123295	74076	17946	19858	1.1066	0.3485
1998	108305	87519	16747	19946	1.191	0.3674
1999	113882	103166	16792	24226	1.4427	0.4346
2000	121292	111312	13480	34177	2.5354	0.4708
2001	118063	112761	12202	38232	3.1333	0.5071
2002	118225	99683	10680	34062	3.1895	0.5337
2003	90870	92934	8954	35151	3.9259	0.6185
2004	61753	81577	8934	25486	2.8528	0.5036
2005	45634	86244	8017	23225	2.8968	0.4672
2006	38720	90673	7159	23531	3.2871	0.4399
2007	52404	89666	8332	22747	2.7301	0.4094
2008	34079	89581	9437	21178	2.2442	0.3452
2009	45910	79187	11741	23156	1.9722	0.3875

Table 12a. XSA Settings, “split EU” run.

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Extended Survivors Analysis

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

CPUE data from file GhalTUN2010_run4.txt

Catch data for 35 years. 1975 to 2009. Ages 1 to 14.

Fleet	First year	Last year	First age	Last age	Alpha	Beta
EU3M_0_700	1995	2009	1	12	0.5	0.6
F2J3K	1996	2009	1	13	0.8	1
S3LNO	1996	2009	1	8	0.3	0.45
EU3M_0_1400	2004	2009	1	13	0.5	0.6

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 2009
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

Tuning converged after 54 iterations

Table 12b. XSA "split EU" diagnostics.

Log catchability residuals.
Fleet : EU3M_0_700

Age	1995	1996	1997	1998	1999
1	0.84	0.23	-0.14	-0.2	-1.19
2	0.28	1.24	0.63	0.26	-0.72
3	0.39	-0.07	0.66	1.04	0.3
4	0.02	0.32	0.55	0.89	0.97
5	-0.38	0.26	0.62	0.64	0.52
6	0	-0.02	0.54	0.67	0.2
7	0.24	-0.47	0.14	0.75	0.36
8	0.21	-0.03	0.13	0.29	0.14
9	1.08	-0.05	0.46	0.59	-0.14
10	0.55	-0.49	0.45	0.43	-0.12
11	0.79	-0.13	0.01	0.21	-1.13
12	0.05	0.76	0.25	-0.86	-1.55
13	No data for this fleet at this age				

Age	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1	0.01	0.76	0.04	-0.36	99.99	99.99	99.99	99.99	99.99	99.99
2	-1.64	-0.12	0.6	-0.53	99.99	99.99	99.99	99.99	99.99	99.99
3	-1.18	-0.11	0.25	-1.28	99.99	99.99	99.99	99.99	99.99	99.99
4	-0.4	-1.05	-0.57	-0.73	99.99	99.99	99.99	99.99	99.99	99.99
5	0.02	-0.71	-0.27	-0.7	99.99	99.99	99.99	99.99	99.99	99.99
6	0.17	-0.27	-0.44	-0.86	99.99	99.99	99.99	99.99	99.99	99.99
7	-0.06	-0.01	-0.03	-0.92	99.99	99.99	99.99	99.99	99.99	99.99
8	0.38	0.64	-0.43	-1.32	99.99	99.99	99.99	99.99	99.99	99.99
9	0.31	-0.62	-0.82	-0.82	99.99	99.99	99.99	99.99	99.99	99.99
10	0.04	-0.75	-0.41	0.31	99.99	99.99	99.99	99.99	99.99	99.99
11	0.97	-1.12	0.16	0.24	99.99	99.99	99.99	99.99	99.99	99.99
12	99.99	99.99	-0.08	-0.46	99.99	99.99	99.99	99.99	99.99	99.99
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	-10.2689	-10.9062	-10.4081	-9.8286	-9.0426	-8.2821	-7.9913	-8.002	-8.8105	-9.4351
S.E(Log q	0.6071	0.8609	0.7802	0.7285	0.5399	0.4764	0.4809	0.5732	0.6684	0.473

Age	11	12
Mean Log	-10.5174	-10.5174
S.E(Log q	0.7279	0.8184

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	0.29	2.296	11.3	0.6	9	0.14	-10.27
2	0.18	3.325	11.45	0.7	9	0.1	-10.91
3	0.43	0.991	10.93	0.3	9	0.34	-10.41
4	0.49	1.155	10.46	0.42	9	0.35	-9.83
5	0.83	0.293	9.34	0.31	9	0.48	-9.04
6	1.81	-0.909	6.47	0.15	9	0.87	-8.28
7	1.94	-1.178	6.08	0.18	9	0.91	-7.99
8	-1.45	-1.588	10.59	0.06	9	0.76	-8
9	0.23	2.209	8.34	0.54	9	0.13	-8.81
10	0.57	0.849	8.63	0.36	9	0.27	-9.44
11	0.95	0.043	10.34	0.09	9	0.74	-10.52
12	0.73	0.367	9.65	0.27	7	0.6	-10.79

Table 12b. XSA diagnostics, “split EU” run.

Fleet : F2J3K

Age	1995	1996	1997	1998	1999
1	99.99	0.58	-0.48	-0.53	-0.95
2	99.99	0.04	0.38	-0.27	0.18
3	99.99	0.39	0.51	0.32	0.26
4	99.99	-0.15	0.12	-0.03	0.36
5	99.99	-0.02	0.31	-0.17	0.23
6	99.99	-0.45	0.44	0.17	0.42
7	99.99	-0.82	-0.02	0.15	0.8
8	99.99	-1.14	0.01	-0.14	0.34
9	99.99	0.05	0.28	-0.11	0
10	99.99	-0.41	-0.05	0.13	0.46
11	99.99	-0.24	0.11	-0.03	-0.21
12	99.99	-0.43	0.26	0.16	-0.83
13	99.99	0.26	-0.17	0.2	0.91

Age	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1	-0.14	-0.01	-0.13	0.2	0.19	-0.18	0.63	0.18	99.99	0.63
2	-0.31	-0.34	-0.29	-0.23	0.19	-0.18	0.25	0.15	99.99	0.41
3	0.01	0	-0.38	-0.45	-0.32	-0.59	-0.26	0.48	99.99	0.02
4	-0.2	0	-0.42	-0.5	-0.25	-0.18	0.27	0.67	99.99	0.31
5	-0.01	-0.14	-0.49	-0.41	-0.12	0	0.12	0	99.99	0.7
6	-0.07	0.15	-1.06	-0.63	-0.53	0.25	0.47	0.47	99.99	0.38
7	-0.03	0.24	-1.23	-0.77	-0.39	0.65	0.51	0.77	99.99	0.13
8	-0.02	0.33	-1.08	-0.58	-0.29	0.41	0.84	1.17	99.99	0.16
9	-0.65	-0.11	-0.95	-0.89	-0.06	0.29	0.69	1.19	99.99	0.27
10	-0.39	-0.51	-0.97	-0.48	0.24	0.35	0.09	1.13	99.99	0.41
11	-0.31	-0.22	-1.37	-0.39	-0.53	1.02	0.67	1.11	99.99	0.38
12	-1.29	-0.93	99.99	-0.28	-0.42	0.71	0.49	1.17	99.99	-0.08
13	99.99	0.47	-0.33	-0.4	0.78	0.93	99.99	0.88	99.99	0.25

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	-7.7252	-7.8485	-8.2128	-8.1483	-8.2716	-8.5599	-8.4826	-8.8331	-9.5949	-10.1438
S.E(Log q	0.4752	0.2778	0.3737	0.3339	0.3071	0.5063	0.6409	0.6698	0.5971	0.5488

Age	11	12	13
Mean Log	-10.2813	-10.2813	-10.2813
S.E(Log q	0.6727	0.7312	0.615

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	1.88	-1.262	4.46	0.16	13	0.87	-7.73
2	1.35	-1.47	6.65	0.62	13	0.36	-7.85
3	0.91	0.294	8.48	0.49	13	0.35	-8.21
4	1.59	-1.358	6.46	0.32	13	0.51	-8.15
5	1.79	-1.71	6.29	0.3	13	0.51	-8.27
6	1.14	-0.229	8.27	0.19	13	0.6	-8.56
7	1.22	-0.263	8.12	0.11	13	0.82	-8.48
8	0.73	0.451	8.92	0.2	13	0.5	-8.83
9	0.98	0.02	9.57	0.1	13	0.61	-9.59
10	2.35	-0.945	13.81	0.04	13	1.29	-10.14
11	6.77	-1.666	30.23	0.01	13	4.25	-10.28
12	9.1	-2.135	44.24	0.01	12	5.69	-10.4
13	1.22	-0.537	10.86	0.4	11	0.63	-9.94

Table 12b. XSA 'split EU' run diagnostics.

Fleet : S3LNO

Age	1995	1996	1997	1998	1999
1	99.99	0.51	0.38	-1.15	-0.91
2	99.99	1.06	1.12	-0.25	-0.51
3	99.99	1.01	0.93	0.78	-0.23
4	99.99	0.81	0.67	1.13	0.13
5	99.99	-0.04	0.35	1.05	0.47
6	99.99	-0.45	0.31	1.04	0.36
7	99.99	-0.83	-0.37	0.98	0.61
8	99.99	-3.07	-0.67	1	0.82
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				

Age	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1	0.02	-0.32	-0.24	0.34	0.34	0.04	99.99	1.2	0.36	-0.58
2	0.11	-0.36	-0.59	0.69	-0.42	-0.71	99.99	0.26	0.2	-0.62
3	-0.17	-0.58	-0.86	0.16	-0.23	-0.1	99.99	0.26	0.56	-1.51
4	0.06	-0.61	-0.8	0.13	-0.16	-0.43	99.99	-0.75	0.16	-0.34
5	0.05	-0.64	-0.77	-0.24	-0.21	-0.07	99.99	0.1	0.32	-0.37
6	0.81	-0.09	-1.14	-0.96	-0.74	0.3	99.99	0.75	0.26	-0.45
7	0.97	0.15	-1.45	-1.24	-1.24	0.26	99.99	1.69	0.92	-0.45
8	0.36	-0.05	-1.56	-1.16	-0.1	0.2	99.99	1.81	2.06	0.35
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	-11.8713	-11.3957	-10.8699	-10.6875	-10.4075	-10.9394	-11.5297	-12.4483
S.E(Log q	0.6366	0.6342	0.73	0.6026	0.484	0.7006	1.0122	1.3894

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	1.62	-0.731	12.14	0.11	13	1.05	-11.87
2	0.59	1.631	11.36	0.59	13	0.35	-11.4
3	0.71	0.73	10.95	0.37	13	0.53	-10.87
4	0.67	1.136	10.77	0.52	13	0.4	-10.69
5	0.74	0.843	10.5	0.48	13	0.36	-10.41
6	0.74	0.454	10.84	0.22	13	0.54	-10.94
7	0.78	0.258	11.23	0.12	13	0.83	-11.53
8	0.35	1.216	10.3	0.24	13	0.47	-12.45

Table 12b. XSA 'split EU' run diagnostics

Fleet : EU3M_0_1400

Age	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1	99.99	99.99	99.99	99.99	1.46	0.43	0.77	-0.27	-0.49	-1.9
2	99.99	99.99	99.99	99.99	2.27	1.19	0.81	-0.75	-0.93	-2.59
3	99.99	99.99	99.99	99.99	1.49	1.37	0.15	0.36	-0.91	-2.46
4	99.99	99.99	99.99	99.99	0.81	0.88	0.44	-0.35	-0.61	-1.18
5	99.99	99.99	99.99	99.99	0.47	0.17	0.22	0	-0.3	-0.56
6	99.99	99.99	99.99	99.99	0.19	-0.24	-0.07	-0.11	0.07	0.15
7	99.99	99.99	99.99	99.99	0.01	-0.49	-0.35	0.14	0.3	0.39
8	99.99	99.99	99.99	99.99	-0.04	-0.35	-0.16	0.33	0.22	0.01
9	99.99	99.99	99.99	99.99	0.36	-0.67	-0.18	0.24	0.35	-0.1
10	99.99	99.99	99.99	99.99	-0.29	-0.12	-0.29	0.21	0.37	0.12
11	99.99	99.99	99.99	99.99	-0.07	-0.13	0.02	-0.04	0.34	-0.12
12	99.99	99.99	99.99	99.99	-0.04	0.09	0.02	-0.04	0.19	0.31
13	99.99	99.99	99.99	99.99	0.41	-0.2	-0.22	-0.33	0.1	0.58

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	-12.2078	-12.7045	-11.6514	-11.3601	-9.2619	-8.2196	-7.8116	-8.0355	-8.161	-7.4417
S.E(Log q	1.167	1.7516	1.4925	0.8377	0.3744	0.1652	0.3549	0.2469	0.3995	0.2772

Age	11	12	13
Mean Log	-7.2723	-7.2723	-7.2723
S.E(Log q	0.1748	0.1715	0.3765

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	-6.48	-0.456	3.16	0	6	8.24	-12.21
2	0.2	1.977	11.22	0.6	6	0.28	-12.7
3	0.32	1.282	11.08	0.47	6	0.45	-11.65
4	0.34	12.193	10.92	0.99	6	0.05	-11.36
5	0.5	5.794	9.96	0.97	6	0.07	-9.26
6	2.31	-1.64	5.21	0.28	6	0.33	-8.22
7	0.46	1.288	9.1	0.58	6	0.15	-7.81
8	0.69	1.277	8.41	0.81	6	0.16	-8.04
9	0.84	0.256	8.16	0.39	6	0.37	-8.16
10	0.67	0.816	7.37	0.61	6	0.19	-7.44
11	3.05	-1.049	8.98	0.06	6	0.53	-7.27
12	0.88	0.324	7.02	0.66	6	0.14	-7.18
13	0.46	2.891	6.13	0.88	6	0.11	-7.22

Table 13. XSA estimates of numbers at age (000s) from “Split EU” run.

N@A(XSA)	1	2	3	4	5	6	7	8	9	10	11	12	13	14+
1975	112270	126272	110145	66813	53820	31893	23091	14337	9312	3931	1773	415	720	735
1976	116644	91919	103383	90179	54702	43762	23561	13703	7254	4040	1691	816	218	113
1977	107498	95500	75257	84643	73832	44771	35277	16367	6321	2529	1313	635	433	311
1978	82352	88012	78189	61615	69300	59965	32120	19112	6753	2521	1154	876	402	459
1979	98987	67424	72058	64016	50446	54040	41481	18181	8793	2937	763	290	385	756
1980	130053	81044	55202	58996	52412	39143	36347	22358	9334	6141	1969	365	103	52
1981	131766	106478	66353	45196	48302	42722	30160	21479	9548	2757	1564	696	183	292
1982	131030	107881	87177	54325	37003	38766	30891	15820	7225	3920	1452	1049	441	511
1983	146382	107279	88326	71374	44478	30052	29658	19573	7738	2710	1686	650	627	1030
1984	153414	119847	87832	72315	58436	35781	21386	15415	9226	4259	1593	1191	463	794
1985	167270	125605	98123	71911	59206	47028	27192	12222	5670	3856	2347	936	846	833
1986	186759	136949	102837	80336	58876	46680	33699	16913	6839	3393	2694	1778	677	1127
1987	155607	152906	112124	84195	65774	47950	36191	21790	9240	4270	2352	1985	1329	2051
1988	128535	127400	125189	91800	68933	53727	37537	19674	9755	5000	2724	1578	1371	1647
1989	112594	105236	104306	102496	75159	56170	41105	23371	12145	6821	3673	2049	1197	584
1990	107584	92185	86160	85399	83916	61371	44189	26886	15268	8602	4891	2611	1436	1043
1991	94295	88082	75474	70542	69833	67708	44132	24749	15174	8816	4607	2915	1337	999
1992	70885	77202	72116	61793	57556	54584	48417	24232	10494	5959	3851	2084	1286	1082
1993	83612	58036	63208	59043	49629	43340	34807	20965	8796	4672	3284	2237	1039	466
1994	142229	68456	47516	51750	47427	31974	21072	12468	6381	3001	2164	1734	960	639
1995	171706	116448	56047	38902	37488	23900	11868	7170	4110	2437	1459	1038	1038	826
1996	149558	140581	95339	45887	31558	29469	17448	6820	3943	2295	1506	882	603	373
1997	122531	122448	115098	78057	37398	24337	19425	8506	3852	2364	1423	839	512	330
1998	107185	100320	100252	94234	63605	28897	16153	9078	4055	2123	1387	785	464	256
1999	111718	87755	82135	82079	76653	48840	18766	7989	4127	2022	1249	794	497	513
2000	119879	91467	71848	67246	66932	60814	34897	7573	3108	1878	1092	712	373	298
2001	120388	98149	74887	58824	54812	52964	38404	9412	3215	1665	1059	561	399	190
2002	125793	98566	80357	61312	47756	42850	32357	11426	3042	1718	915	470	275	175
2003	101735	102991	80699	65791	49765	37595	28532	10584	3377	1365	811	423	182	201
2004	72585	83294	84322	66071	52708	36680	21078	8192	2888	1304	651	401	216	184
2005	52227	59427	68195	69037	53282	39478	22579	7718	2973	1182	589	271	162	115
2006	46722	42760	48655	55833	56039	42129	26894	9155	2703	1159	566	262	119	148
2007	73830	38253	35009	39835	45517	44190	28656	11030	3060	1228	612	340	172	121
2008	47717	60447	31319	28663	32535	36751	32803	12683	4132	1392	578	354	206	118
2009	73122	39067	49490	25642	23441	26232	27092	17178	5355	2068	784	369	248	271
2010		59868	31986	40519	20938	18761	18653	14218	7480	2621	1234	456	242	366

Table 14. XSA estimates of fishing mortality at age (000s) from “Split EU” run.

F@A(XSA)	1	2	3	4	5	6	7	8	9	10	11	12	13	14+	Fbar(5-10)
1975	0	0	0	0.000	0.007	0.103	0.322	0.481	0.635	0.644	0.576	0.446	0.560	0.560	0.365
1976	0	0	0	0.000	0.000	0.016	0.164	0.574	0.854	0.924	0.780	0.434	0.720	0.720	0.422
1977	0	0	0	0.000	0.008	0.132	0.413	0.685	0.719	0.585	0.205	0.257	0.351	0.351	0.424
1978	0	0	0	0.000	0.049	0.169	0.369	0.576	0.633	0.995	1.180	0.622	0.943	0.943	0.465
1979	0	0	0	0.000	0.054	0.197	0.418	0.467	0.159	0.200	0.537	0.837	0.529	0.529	0.249
1980	0	0	0	0.000	0.004	0.061	0.326	0.651	1.019	1.168	0.841	0.490	0.842	0.842	0.538
1981	0	0	0	0.000	0.020	0.124	0.445	0.890	0.690	0.441	0.200	0.256	0.301	0.301	0.435
1982	0	0	0	0.000	0.008	0.068	0.256	0.515	0.781	0.644	0.604	0.314	0.525	0.525	0.379
1983	0	0	0	0.000	0.018	0.140	0.454	0.552	0.397	0.332	0.147	0.138	0.207	0.207	0.316
1984	0	0	0	0.000	0.017	0.075	0.360	0.800	0.673	0.396	0.332	0.142	0.292	0.292	0.387
1985	0	0	0	0.000	0.038	0.133	0.275	0.381	0.313	0.159	0.078	0.124	0.121	0.121	0.216
1986	0	0	0	0.000	0.005	0.055	0.236	0.405	0.271	0.167	0.106	0.091	0.121	0.121	0.190
1987	0	0	0	0.000	0.002	0.045	0.410	0.604	0.414	0.249	0.199	0.170	0.207	0.207	0.287
1988	0	0	0	0.000	0.005	0.068	0.274	0.282	0.158	0.108	0.085	0.076	0.090	0.090	0.149
1989	0	0	0	0.000	0.003	0.040	0.225	0.226	0.145	0.133	0.141	0.156	0.144	0.144	0.128
1990	0	0	0	0.001	0.015	0.130	0.380	0.372	0.349	0.424	0.318	0.469	0.407	0.407	0.278
1991	0	0	0	0.004	0.046	0.135	0.400	0.658	0.735	0.628	0.593	0.618	0.619	0.619	0.434
1992	0	0	0	0.019	0.084	0.250	0.637	0.813	0.609	0.396	0.343	0.496	0.415	0.415	0.465
1993	0	0	0	0.019	0.240	0.521	0.827	0.990	0.875	0.570	0.439	0.647	0.556	0.556	0.670
1994	0	0	0	0.122	0.485	0.791	0.878	0.910	0.763	0.521	0.535	0.313	0.460	0.460	0.725
1995	0	0	0	0.009	0.041	0.115	0.354	0.398	0.383	0.281	0.303	0.343	0.311	0.311	0.262
1996	0	0	0	0.005	0.060	0.217	0.518	0.371	0.312	0.278	0.386	0.345	0.304	0.304	0.293
1997	0	0	0	0.005	0.058	0.210	0.561	0.541	0.396	0.333	0.395	0.392	0.351	0.351	0.350
1998	0	0	0	0.007	0.064	0.232	0.504	0.588	0.496	0.331	0.357	0.257	0.247	0.247	0.369
1999	0	0	0	0.004	0.032	0.136	0.708	0.744	0.588	0.416	0.362	0.555	0.390	0.390	0.437
2000	0	0	0	0.005	0.034	0.260	1.111	0.657	0.425	0.372	0.466	0.378	0.481	0.481	0.476
2001	0	0	0	0.009	0.046	0.293	1.012	0.929	0.427	0.399	0.612	0.511	0.565	0.565	0.518
2002	0	0	0	0.009	0.039	0.207	0.918	1.019	0.601	0.551	0.571	0.748	0.704	0.704	0.556
2003	0	0	0	0.022	0.105	0.379	1.048	1.099	0.751	0.541	0.503	0.471	0.618	0.618	0.654
2004	0	0	0	0.015	0.089	0.285	0.805	0.813	0.693	0.595	0.675	0.707	0.588	0.588	0.547
2005	0	0	0	0.009	0.035	0.184	0.703	0.849	0.743	0.536	0.612	0.625	0.574	0.574	0.508
2006	0	0	0	0.004	0.038	0.185	0.691	0.896	0.589	0.438	0.309	0.221	0.353	0.353	0.473
2007	0	0	0	0.002	0.014	0.098	0.615	0.782	0.588	0.553	0.349	0.301	0.307	0.307	0.442
2008	0	0	0	0.001	0.015	0.105	0.447	0.662	0.492	0.374	0.248	0.155	0.150	0.150	0.349
2009	0	0	0	0.003	0.023	0.141	0.445	0.631	0.515	0.317	0.343	0.224	0.149	0.149	0.345

Table 15. Stock summary table from “split EU” XSA analysis (no SOP correction; shrinkage parameters fixed at 0.5).

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

	RECRUITS Age 1	5+BIO	10+BIO	LANDINGS	YIELD/S	FBAR 5-10
1975	112270	132743	21900	28814	1.3157	0.3652
1976	116644	134511	17670	24611	1.3928	0.422
1977	107498	156960	14817	32048	2.1629	0.4237
1978	82352	167770	15904	39070	2.4566	0.4651
1979	98987	162552	15618	34104	2.1837	0.249
1980	130053	130931	12401	32867	2.6504	0.5382
1981	131766	115296	14021	30754	2.1934	0.4351
1982	131030	121322	19866	26278	1.3228	0.3786
1983	146382	122765	24138	27861	1.1542	0.3155
1984	153414	115242	24260	26711	1.101	0.3866
1985	167270	148150	28973	20347	0.7023	0.2164
1986	186759	138126	33518	17976	0.5363	0.1896
1987	155607	164672	42263	32442	0.7676	0.2873
1988	128535	169140	44245	19215	0.4343	0.1492
1989	112594	182301	43787	20034	0.4575	0.1284
1990	107584	206153	55795	47454	0.8505	0.2783
1991	94295	224594	63219	65008	1.0283	0.4337
1992	70885	192319	48721	63193	1.297	0.4648
1993	83612	148172	37538	62455	1.6638	0.6703
1994	142229	102790	28547	51029	1.7875	0.7247
1995	171706	76894	25158	15272	0.6071	0.2618
1996	149558	76766	19168	18840	0.9829	0.2927
1997	122531	73876	17922	19858	1.1081	0.3497
1998	107185	86911	16378	19946	1.2178	0.3692
1999	111718	102079	16202	24226	1.4953	0.4371
2000	119879	110389	13359	34177	2.5584	0.4763
2001	120388	111450	12016	38232	3.1818	0.5176
2002	125793	98103	10416	34062	3.2702	0.5559
2003	101735	90755	8474	35151	4.1482	0.6538
2004	72585	78969	7994	25486	3.188	0.5467
2005	52227	83586	6399	23225	3.6297	0.5082
2006	46722	89628	5487	23531	4.2884	0.4729
2007	73830	90671	6289	22747	3.6169	0.4416
2008	47717	93874	7039	21178	3.0087	0.3492
2009	73122	86269	9543	23156	2.4266	0.3452

Table 16a. XSA Settings, analysis with F-shrinkage applied over three years, with log(SE) set at 1.0.

Lowestoft VPA Version 3.1

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Extended Survivors Analysis

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

CPUE data from file GhalTUN2010_run4.txt

Catch data for 35 years. 1975 to 2009. Ages 1 to 14.

Fleet	First year	Last year	First age	Last age	Alpha	Beta
EU3M_0_	1995	2009	1	12	0.5	0.6
F2J3K	1996	2009	1	13	0.8	1
S3LNO	1996	2009	1	8	0.3	0.45
EU3M_0_	2004	2009	1	13	0.5	0.6

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 3 years.
S.E. of the mean to which the estimates are shrunk = 1.000

Oldest age survivor estimates for the years 1975 to 2009
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

Tuning converged after 52 iterations

Table 16b. XSA Diagnostics, analysis with F-shrinkage applied over three years, with log(SE) set at 1.0.

Log catchability residuals.
Fleet : EU3M_0_700

Age	1995	1996	1997	1998	1999
1	0.89	0.27	-0.1	-0.17	-1.17
2	0.32	1.27	0.66	0.28	-0.71
3	0.41	-0.04	0.68	1.06	0.31
4	0.03	0.33	0.56	0.9	0.98
5	-0.37	0.27	0.62	0.65	0.53
6	0.01	-0.01	0.55	0.68	0.21
7	0.24	-0.46	0.16	0.75	0.37
8	0.22	-0.02	0.14	0.31	0.14
9	1.06	-0.03	0.47	0.62	-0.11
10	0.54	-0.52	0.47	0.44	-0.09
11	0.8	-0.15	-0.03	0.24	-1.12
12	0.01	0.75	0.19	-0.94	-1.55
13	No data for this fleet at this age				

Age	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1	-0.01	0.74	-0.02	-0.44	99.99	99.99	99.99	99.99	99.99	99.99
2	-1.63	-0.14	0.56	-0.6	99.99	99.99	99.99	99.99	99.99	99.99
3	-1.18	-0.12	0.21	-1.33	99.99	99.99	99.99	99.99	99.99	99.99
4	-0.4	-1.05	-0.58	-0.77	99.99	99.99	99.99	99.99	99.99	99.99
5	0.02	-0.71	-0.28	-0.72	99.99	99.99	99.99	99.99	99.99	99.99
6	0.17	-0.27	-0.45	-0.88	99.99	99.99	99.99	99.99	99.99	99.99
7	-0.06	-0.01	-0.04	-0.95	99.99	99.99	99.99	99.99	99.99	99.99
8	0.38	0.64	-0.44	-1.36	99.99	99.99	99.99	99.99	99.99	99.99
9	0.31	-0.62	-0.83	-0.88	99.99	99.99	99.99	99.99	99.99	99.99
10	0.07	-0.76	-0.43	0.27	99.99	99.99	99.99	99.99	99.99	99.99
11	1	-1.08	0.13	0.2	99.99	99.99	99.99	99.99	99.99	99.99
12	99.99	99.99	-0.07	-0.54	99.99	99.99	99.99	99.99	99.99	99.99
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	-10.322	-10.9459	-10.4359	-9.8484	-9.0557	-8.2935	-8.0071	-8.0287	-8.8506	-9.4873
S.E(Log q	0.6129	0.8727	0.7967	0.743	0.5479	0.4848	0.4876	0.5905	0.6782	0.4794

Age	11	12
Mean Log	-10.5879	-10.5879
S.E(Log q	0.7244	0.8335

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	0.24	2.828	11.43	0.67	9	0.11	-10.32
2	0.17	3.18	11.49	0.68	9	0.1	-10.95
3	0.48	0.754	10.91	0.23	9	0.4	-10.44
4	0.53	0.956	10.43	0.37	9	0.39	-9.85
5	0.87	0.216	9.28	0.28	9	0.51	-9.06
6	1.91	-0.96	6.26	0.14	9	0.93	-8.29
7	2	-1.21	5.98	0.17	9	0.95	-8.01
8	-1.22	-1.745	10.36	0.08	9	0.64	-8.03
9	0.22	2.242	8.36	0.54	9	0.12	-8.85
10	0.57	0.829	8.68	0.34	9	0.28	-9.49
11	0.89	0.095	10.22	0.1	9	0.69	-10.59
12	0.73	0.366	9.77	0.27	7	0.61	-10.89

Table 16b. XSA Diagnostics, analysis with F-shrinkage applied over three years, with log(SE) set at 1.0.

Fleet : F2J3K

Age	1995	1996	1997	1998	1999
1	99.99	0.66	-0.4	-0.47	-0.89
2	99.99	0.12	0.46	-0.2	0.24
3	99.99	0.45	0.57	0.37	0.3
4	99.99	-0.09	0.18	0.03	0.41
5	99.99	0.03	0.36	-0.12	0.28
6	99.99	-0.41	0.48	0.21	0.46
7	99.99	-0.76	0.05	0.2	0.85
8	99.99	-1.05	0.11	-0.04	0.43
9	99.99	0.18	0.4	0.02	0.14
10	99.99	-0.31	0.11	0.27	0.62
11	99.99	-0.13	0.2	0.14	-0.06
12	99.99	-0.32	0.33	0.21	-0.7
13	99.99	0.3	-0.09	0.23	0.9

Age	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1	-0.11	0	-0.16	0.16	0.17	-0.24	0.46	0.18	99.99	0.65
2	-0.26	-0.32	-0.28	-0.26	0.15	-0.21	0.19	-0.03	99.99	0.4
3	0.05	0.03	-0.38	-0.46	-0.37	-0.65	-0.31	0.4	99.99	-0.01
4	-0.15	0.04	-0.39	-0.5	-0.26	-0.23	0.21	0.63	99.99	0.11
5	0.03	-0.11	-0.47	-0.4	-0.14	-0.04	0.05	-0.08	99.99	0.6
6	-0.03	0.18	-1.03	-0.63	-0.53	0.21	0.41	0.39	99.99	0.3
7	0.02	0.29	-1.19	-0.76	-0.41	0.62	0.42	0.67	99.99	0
8	0.06	0.41	-1.02	-0.57	-0.31	0.33	0.73	0.97	99.99	-0.05
9	-0.54	-0.01	-0.86	-0.86	-0.1	0.2	0.51	0.98	99.99	-0.06
10	-0.22	-0.38	-0.87	-0.4	0.23	0.23	-0.09	0.8	99.99	-0.02
11	-0.15	-0.05	-1.27	-0.31	-0.51	0.89	0.48	0.84	99.99	-0.06
12	-1.17	-0.79	99.99	-0.25	-0.46	0.58	0.27	0.87	99.99	-0.62
13	99.99	0.52	-0.25	-0.33	0.7	0.73	99.99	0.55	99.99	-0.16

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	-7.8139	-7.9324	-8.2767	-8.2148	-8.3232	-8.6058	-8.5501	-8.9451	-9.745	-10.3334
S.E(Log q	0.4493	0.2743	0.4015	0.3162	0.2891	0.4904	0.6188	0.6125	0.521	0.4499

Age	11	12	13
Mean Log	-10.4912	-10.4912	-10.4912
S.E(Log q	0.5623	0.6434	0.5241

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	1.5	-0.788	5.95	0.18	13	0.69	-7.81
2	1.22	-0.876	7.16	0.58	13	0.34	-7.93
3	0.88	0.324	8.63	0.41	13	0.37	-8.28
4	1.33	-0.776	7.26	0.33	13	0.43	-8.21
5	1.6	-1.403	6.82	0.33	13	0.44	-8.32
6	1.02	-0.044	8.56	0.23	13	0.52	-8.61
7	1.15	-0.199	8.31	0.14	13	0.74	-8.55
8	0.8	0.391	9	0.26	13	0.51	-8.95
9	0.72	0.574	9.32	0.27	13	0.38	-9.74
10	0.96	0.072	10.23	0.26	13	0.45	-10.33
11	1.35	-0.44	11.74	0.12	13	0.79	-10.49
12	2.54	-1.207	17.17	0.06	12	1.54	-10.66
13	0.95	0.161	10	0.54	11	0.43	-10.21

Table 16b. XSA Diagnostics, analysis with F-shrinkage applied over three years, with log(SE) set at 1.0.

Fleet : S3LNO

Age	1995	1996	1997	1998	1999
1	99.99	0.58	0.44	-1.1	-0.87
2	99.99	1.14	1.19	-0.19	-0.45
3	99.99	1.08	1	0.84	-0.17
4	99.99	0.87	0.73	1.2	0.19
5	99.99	0	0.4	1.09	0.51
6	99.99	-0.41	0.35	1.08	0.4
7	99.99	-0.78	-0.32	1.02	0.65
8	99.99	-3.01	-0.59	1.08	0.89
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				

Age	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1	0.03	-0.33	-0.28	0.29	0.31	-0.03	99.99	1.19	0.34	-0.57
2	0.16	-0.35	-0.59	0.65	-0.46	-0.74	99.99	0.08	0.19	-0.63
3	-0.12	-0.54	-0.84	0.15	-0.27	-0.15	99.99	0.19	0.37	-1.53
4	0.11	-0.57	-0.77	0.13	-0.17	-0.48	99.99	-0.79	0.08	-0.54
5	0.09	-0.61	-0.75	-0.23	-0.23	-0.1	99.99	0.03	0.26	-0.47
6	0.85	-0.05	-1.12	-0.95	-0.74	0.27	99.99	0.68	0.17	-0.53
7	1.02	0.19	-1.42	-1.22	-1.25	0.25	99.99	1.61	0.82	-0.56
8	0.43	0.01	-1.5	-1.14	-0.1	0.15	99.99	1.67	1.92	0.18
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	-11.9471	-11.4751	-10.9454	-10.7556	-10.4578	-10.9846	-11.5829	-12.5347
S.E(Log q	0.6272	0.6498	0.7388	0.638	0.4966	0.6993	0.9995	1.3415

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	1.45	-0.557	12.14	0.12	13	0.94	-11.95
2	0.51	2.033	11.43	0.61	13	0.3	-11.48
3	0.59	1.096	11.06	0.39	13	0.43	-10.95
4	0.6	1.251	10.86	0.47	13	0.37	-10.76
5	0.69	0.951	10.56	0.47	13	0.35	-10.46
6	0.73	0.494	10.87	0.23	13	0.52	-10.98
7	0.77	0.298	11.26	0.14	13	0.8	-11.58
8	0.39	1.305	10.5	0.29	13	0.5	-12.53

Table 16b. XSA Diagnostics, analysis with F-shrinkage applied over three years, with log(SE) set at 1.0.

Fleet : EU3M_0_1400

Age	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1	99.99	99.99	99.99	99.99	1.48	0.41	0.63	-0.23	-0.45	-1.84
2	99.99	99.99	99.99	99.99	2.28	1.22	0.8	-0.88	-0.88	-2.54
3	99.99	99.99	99.99	99.99	1.52	1.39	0.18	0.35	-1.03	-2.41
4	99.99	99.99	99.99	99.99	0.87	0.91	0.46	-0.32	-0.61	-1.3
5	99.99	99.99	99.99	99.99	0.51	0.2	0.22	-0.02	-0.31	-0.6
6	99.99	99.99	99.99	99.99	0.25	-0.22	-0.06	-0.13	0.04	0.13
7	99.99	99.99	99.99	99.99	0.06	-0.44	-0.36	0.13	0.26	0.34
8	99.99	99.99	99.99	99.99	0.06	-0.31	-0.12	0.27	0.16	-0.07
9	99.99	99.99	99.99	99.99	0.51	-0.57	-0.17	0.22	0.22	-0.22
10	99.99	99.99	99.99	99.99	-0.09	-0.02	-0.24	0.13	0.29	-0.08
11	99.99	99.99	99.99	99.99	0.18	-0.01	0.06	-0.07	0.15	-0.3
12	99.99	99.99	99.99	99.99	0.17	0.21	0.03	-0.11	0.07	0.01
13	99.99	99.99	99.99	99.99	0.57	-0.15	-0.23	-0.42	-0.05	0.39

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	-12.3368	-12.8425	-11.7927	-11.5003	-9.3715	-8.3193	-7.9392	-8.2372	-8.4578	-7.8126
S.E(Log q	1.1309	1.7509	1.5001	0.89	0.3989	0.1711	0.3238	0.2087	0.389	0.1879

Age	11	12	13
Mean Log	-7.6815	-7.6815	-7.6815
S.E(Log q	0.177	0.1347	0.3798

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	1.35	-0.086	12.76	0.01	6	1.7	-12.34
2	0.17	2.448	11.31	0.69	6	0.22	-12.84
3	0.27	1.499	11.19	0.52	6	0.37	-11.79
4	0.31	7.696	11.04	0.97	6	0.08	-11.5
5	0.47	4.745	10.1	0.95	6	0.08	-9.37
6	2.47	-1.651	4.95	0.24	6	0.36	-8.32
7	0.54	1.238	9.02	0.64	6	0.16	-7.94
8	0.83	0.753	8.44	0.83	6	0.18	-8.24
9	1.09	-0.149	8.47	0.4	6	0.47	-8.46
10	0.92	0.303	7.79	0.79	6	0.19	-7.81
11	2.22	-2.006	8.78	0.4	6	0.31	-7.68
12	1.26	-1.171	8	0.83	6	0.14	-7.62
13	0.65	1.072	6.94	0.71	6	0.24	-7.66

Table 16b. XSA Diagnostics, analysis with F-shrinkage applied over three years, with log(SE) set at 1.0.

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

Year class = 2008

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU3M_0_	1	0	0	0	0	0	0
F2J3K	122789	0.5	0	0	1	0.569	0
S3LNO	36236	0.651	0	0	1	0.336	0
EU3M_0_	10207	1.221	0	0	1	0.095	0
F shrinka	0	1				0	0

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
64301	0.38	0.58	3	1.536	0

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

Year class = 2007

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU3M_0_	1	0	0	0	0	0	0
F2J3K	52296	0.5	0	0	1	0.421	0
S3LNO	30919	0.468	0.486	1.04	2	0.48	0
EU3M_0_	12077	1.026	0.953	0.93	2	0.1	0
F shrinka	0	1				0	0

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
35112	0.32	0.31	5	0.965	0

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

Year class = 2006

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU3M_0_	1	0	0	0	0	0	0
F2J3K	48261	0.354	0.094	0.27	2	0.513	0
S3LNO	49008	0.4	0.765	1.92	3	0.402	0
EU3M_0_	16496	0.867	0.66	0.76	3	0.085	0
F shrinka	0	1				0	0

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
44308	0.25	0.3	8	1.195	0

Table 16b. XSA Diagnostics, analysis with F-shrinkage applied over three years, with log(SE) set at 1.0.

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

Year class = 2005

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU3M_0_	1	0	0	0	0	0	0
F2J3K	32627	0.289	0.143	0.5	3	0.556	0.002
S3LNO	25380	0.402	0.265	0.66	3	0.286	0.002
EU3M_0_	13876	0.644	0.475	0.74	4	0.112	0.004
F shrinka	23822	1				0.046	0.002

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
27197	0.22	0.14	11	0.674	0.002

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

Year class = 2004

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU3M_0_	1	0	0	0	0	0	0
F2J3K	27654	0.25	0.18	0.72	4	0.477	0.015
S3LNO	19130	0.315	0.155	0.49	4	0.301	0.022
EU3M_0_	14946	0.395	0.222	0.56	5	0.191	0.028
F shrinka	21486	1				0.03	0.02

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
21831	0.17	0.11	14	0.652	0.02

Age 6 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
EU3M_0_	1	0	0	0	0	0	0
F2J3K	23797	0.224	0.17	0.76	5	0.452	0.112
S3LNO	17068	0.283	0.247	0.87	5	0.284	0.153
EU3M_0_	21938	0.31	0.215	0.69	6	0.238	0.121
F shrinka	22919	1				0.026	0.116

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
21215	0.15	0.11	17	0.733	0.125

Age 7 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
EU3M_0_	11361	0.646	0	0	1	0.044	0.531
F2J3K	16928	0.211	0.135	0.64	6	0.421	0.386
S3LNO	16596	0.279	0.127	0.46	6	0.241	0.392
EU3M_0_	22089	0.27	0.175	0.65	6	0.264	0.308
F shrinka	11850	1				0.03	0.514

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
17570	0.14	0.08	20	0.589	0.374

Table 16b. XSA Diagnostics, analysis with F-shrinkage applied over three years, with log(SE) set at 1.0.

Age 8 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
EU3M_0_	8534	0.529	0.274	0.52	2	0.053	0.572
F2J3K	9631	0.198	0.095	0.48	7	0.416	0.521
S3LNO	11973	0.293	0.207	0.71	7	0.184	0.438
EU3M_0_	11934	0.245	0.14	0.57	6	0.308	0.439
F shrinka	7341	1				0.04	0.64

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
10525	0.13	0.07	23	0.561	0.486

Age 9 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
EU3M_0_	4765	0.447	0.642	1.43	3	0.049	0.315
F2J3K	4150	0.215	0.113	0.52	8	0.389	0.354
S3LNO	4697	0.275	0.303	1.1	7	0.145	0.319
EU3M_0_	4321	0.248	0.104	0.42	6	0.367	0.342
F shrinka	3501	1				0.05	0.408

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
4281	0.14	0.09	25	0.613	0.345

Age 10 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
EU3M_0_	1952	0.388	0.209	0.54	4	0.043	0.211
F2J3K	2391	0.241	0.134	0.56	9	0.378	0.176
S3LNO	2315	0.268	0.238	0.89	7	0.102	0.181
EU3M_0_	2460	0.25	0.102	0.41	6	0.429	0.171
F shrinka	1271	1				0.048	0.309

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
2320	0.15	0.07	27	0.479	0.181

Table 16b. XSA Diagnostics, analysis with F-shrinkage applied over three years, with log(SE) set at 1.0.

Age 11 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
EU3M_0_	385	0.322	0.221	0.69	5	0.037	0.395
F2J3K	1050	0.269	0.187	0.69	10	0.346	0.163
S3LNO	588	0.259	0.161	0.62	7	0.06	0.275
EU3M_0_	878	0.255	0.126	0.5	6	0.501	0.192
F shrinka	872	1				0.055	0.194

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
884	0.17	0.09	29	0.515	0.191

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

Year class = 1997

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU3M_0_	266	0.273	0.164	0.6	6	0.034	0.205
F2J3K	588	0.261	0.191	0.73	11	0.342	0.098
S3LNO	269	0.269	0.153	0.57	8	0.043	0.203
EU3M_0_	536	0.243	0.06	0.25	6	0.534	0.107
F shrinka	392	1				0.048	0.144

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
517	0.17	0.08	32	0.472	0.111

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

Year class = 1996

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU3M_0_	205	0.242	0.169	0.7	7	0.024	0.128
F2J3K	356	0.254	0.131	0.52	12	0.331	0.076
S3LNO	237	0.273	0.193	0.71	8	0.022	0.112
EU3M_0_	339	0.231	0.124	0.54	6	0.478	0.08
F shrinka	160	0.5				0.145	0.162

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
303	0.16	0.08	34	0.497	0.082

Table 17. XSA estimates of numbers at age (000s) from reduced shrinkage run (3y, log (SE)=1.0)

	Age													
N@A(XSA)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14+**
1975	112333	126296	110166	66820	53827	31896	23092	14337	9312	3931	1773	415	720	735
1976	116722	91970	103402	90196	54708	43767	23563	13703	7254	4040	1691	816	218	113
1977	107576	95564	75299	84659	73847	44776	35282	16369	6321	2529	1313	635	433	311
1978	82458	88076	78241	61649	69313	59977	32124	19116	6755	2522	1154	876	402	459
1979	99132	67511	72110	64058	50474	54050	41491	18185	8796	2938	763	290	385	756
1980	130327	81163	55273	59039	52446	39166	36356	22366	9336	6144	1970	365	103	52
1981	132104	106702	66450	45254	48337	42750	30179	21487	9554	2760	1566	696	183	292
1982	131522	108158	87360	54405	37051	38794	30914	15835	7230	3925	1454	1051	442	512
1983	147187	107681	88552	71525	44543	30091	29682	19593	7750	2715	1690	651	629	1032
1984	154321	120506	88162	72500	58559	35834	21418	15434	9242	4269	1597	1194	464	797
1985	167849	126347	98662	72181	59358	47128	27236	12248	5685	3869	2356	939	849	836
1986	187584	137423	103444	80778	59097	46804	33782	16949	6861	3406	2704	1785	679	1131
1987	156594	153581	112512	84693	66135	48131	36293	21857	9270	4288	2362	1993	1335	2060
1988	128865	128209	125742	92117	69341	54023	37685	19757	9810	5024	2739	1587	1378	1656
1989	113035	105505	104968	102949	75419	56504	41347	23492	12213	6867	3693	2060	1204	587
1990	107801	92545	86381	85941	84287	61584	44462	27084	15368	8658	4928	2627	1445	1050
1991	94459	88260	75770	70722	70276	68011	44306	24973	15337	8897	4653	2945	1350	1009
1992	71364	77337	72261	62035	57704	54948	48665	24374	10677	6092	3918	2122	1311	1103
1993	84147	58428	63318	59162	49827	43461	35105	21169	8912	4822	3393	2292	1069	480
1994	142782	68893	47837	51840	47524	32136	21171	12711	6548	3097	2287	1823	1004	669
1995	172728	116900	56405	39166	37562	23980	12001	7252	4309	2573	1537	1138	1111	884
1996	151121	141418	95709	46181	31774	29529	17514	6929	4010	2458	1618	946	685	424
1997	124584	123727	115783	78360	37638	24513	19474	8560	3941	2418	1556	930	564	364
1998	110213	102001	101300	94795	63853	29093	16297	9118	4099	2196	1431	894	539	297
1999	115586	90235	83511	82937	77112	49043	18927	8107	4160	2058	1308	831	586	606
2000	127903	94634	73878	68373	67634	61190	35064	7705	3205	1905	1121	761	403	322
2001	130431	104718	77480	60486	55734	53538	38712	9548	3323	1744	1082	585	439	209
2002	140871	106788	85736	63435	49117	43605	32828	11678	3154	1807	980	488	295	187
2003	115327	115335	87431	70195	51503	38710	29151	10969	3583	1456	883	476	197	218
2004	81091	94422	94429	71582	56313	38103	21990	8698	3204	1473	725	460	260	222
2005	60573	66392	77306	77312	57795	42430	23744	8465	3388	1440	727	332	210	150
2006	60651	49593	54357	63293	62814	45824	29311	10108	3315	1498	777	375	169	210
2007	80734	49657	40603	44504	51624	49737	31681	13009	3841	1729	890	513	264	186
2008	52380	66099	40655	33243	36357	41751	37344	15160	5752	2031	988	581	348	200
2009	78537	42885	54118	33286	27191	29361	31186	20896	7383	3395	1308	705	434	475
2010		64301	35112	44308	27197	21831	21215	17570	10525	4281	2320	884	517	685

Table 18. XSA estimates of fishing mortality at age (000s) from reduced shrinkage run (3y, log (SE)=1.0)

	Age													
F@A(XSA)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14+**	**Fbar(5-10)**
1975	0	0	0	0.000	0.007	0.103	0.322	0.481	0.635	0.643	0.576	0.446	0.560	0.560	0.365
1976	0	0	0	0.000	0.000	0.016	0.164	0.574	0.854	0.924	0.780	0.434	0.720	0.720	0.422
1977	0	0	0	0.000	0.008	0.132	0.413	0.685	0.719	0.585	0.205	0.257	0.351	0.351	0.424
1978	0	0	0	0.000	0.049	0.169	0.369	0.576	0.633	0.995	1.179	0.622	0.942	0.942	0.465
1979	0	0	0	0.000	0.054	0.197	0.418	0.467	0.159	0.200	0.537	0.837	0.529	0.529	0.249
1980	0	0	0	0.000	0.004	0.061	0.326	0.651	1.019	1.167	0.840	0.490	0.841	0.841	0.538
1981	0	0	0	0.000	0.020	0.124	0.445	0.889	0.690	0.441	0.199	0.255	0.300	0.300	0.435
1982	0	0	0	0.000	0.008	0.068	0.256	0.515	0.780	0.643	0.603	0.314	0.524	0.524	0.379
1983	0	0	0	0.000	0.018	0.140	0.454	0.551	0.396	0.331	0.147	0.138	0.206	0.206	0.316
1984	0	0	0	0.000	0.017	0.074	0.359	0.799	0.671	0.394	0.331	0.142	0.291	0.291	0.387
1985	0	0	0	0.000	0.038	0.133	0.274	0.380	0.312	0.158	0.078	0.124	0.120	0.120	0.216
1986	0	0	0	0.000	0.005	0.054	0.235	0.403	0.270	0.166	0.105	0.091	0.121	0.121	0.190
1987	0	0	0	0.000	0.002	0.045	0.408	0.601	0.413	0.248	0.198	0.169	0.206	0.206	0.287
1988	0	0	0	0.000	0.005	0.067	0.273	0.281	0.157	0.108	0.085	0.076	0.090	0.090	0.149
1989	0	0	0	0.000	0.003	0.040	0.223	0.224	0.144	0.132	0.141	0.155	0.143	0.143	0.128
1990	0	0	0	0.001	0.015	0.129	0.377	0.369	0.347	0.421	0.315	0.466	0.403	0.403	0.278
1991	0	0	0	0.003	0.046	0.135	0.398	0.650	0.723	0.620	0.585	0.609	0.610	0.610	0.434
1992	0	0	0	0.019	0.083	0.248	0.632	0.806	0.595	0.385	0.336	0.485	0.405	0.405	0.465
1993	0	0	0	0.019	0.239	0.519	0.816	0.973	0.857	0.546	0.421	0.625	0.535	0.535	0.670
1994	0	0	0	0.122	0.484	0.785	0.871	0.882	0.734	0.500	0.498	0.295	0.434	0.434	0.725
1995	0	0	0	0.009	0.041	0.114	0.349	0.393	0.362	0.264	0.285	0.308	0.287	0.287	0.262
1996	0	0	0	0.005	0.059	0.216	0.516	0.364	0.306	0.257	0.354	0.318	0.262	0.262	0.293
1997	0	0	0	0.005	0.058	0.208	0.559	0.536	0.385	0.324	0.354	0.346	0.313	0.313	0.350
1998	0	0	0	0.007	0.064	0.230	0.498	0.585	0.489	0.318	0.344	0.222	0.209	0.209	0.369
1999	0	0	0	0.004	0.031	0.136	0.699	0.728	0.581	0.407	0.342	0.523	0.319	0.319	0.437
2000	0	0	0	0.004	0.034	0.258	1.101	0.641	0.409	0.366	0.451	0.349	0.436	0.436	0.476
2001	0	0	0	0.008	0.045	0.289	0.998	0.908	0.409	0.377	0.595	0.484	0.498	0.498	0.518
2002	0	0	0	0.008	0.038	0.203	0.896	0.982	0.573	0.516	0.521	0.707	0.638	0.638	0.556
2003	0	0	0	0.020	0.101	0.366	1.009	1.031	0.689	0.497	0.451	0.407	0.555	0.555	0.654
2004	0	0	0	0.014	0.083	0.273	0.755	0.743	0.600	0.506	0.580	0.583	0.462	0.462	0.547
2005	0	0	0	0.008	0.032	0.170	0.654	0.738	0.616	0.417	0.463	0.477	0.410	0.410	0.508
2006	0	0	0	0.004	0.033	0.169	0.612	0.768	0.451	0.321	0.215	0.149	0.235	0.235	0.473
2007	0	0	0	0.002	0.012	0.087	0.537	0.616	0.437	0.359	0.226	0.189	0.188	0.188	0.442
2008	0	0	0	0.001	0.014	0.092	0.381	0.520	0.327	0.241	0.138	0.092	0.086	0.086	0.349
2009	0	0	0	0.002	0.020	0.125	0.374	0.486	0.345	0.181	0.191	0.111	0.082	0.082	0.345

Table 19. Stock summary table from reduced shrinkage XSA analysis (no SOP correction; F-shrinkage over 3 years, with the log SE parameter set to 1.0)

	RECRUITS Age 1	5+BIO	10+BIO	LANDINGS	YIELD/S	SOPCO	FBAR 5-
1975	112333	132739	21899	28814	1.3158	0.9999	0.3652
1976	116722	134538	17673	24611	1.3926	1.0001	0.422
1977	107576	156988	14819	32048	2.1627	1	0.4236
1978	82458	167804	15907	39070	2.4562	1	0.465
1979	99132	162610	15624	34104	2.1828	1.0001	0.2489
1980	130327	130991	12406	32867	2.6492	1	0.5379
1981	132104	115364	14035	30754	2.1913	0.9999	0.4347
1982	131522	121446	19894	26278	1.3209	1	0.3781
1983	147187	122926	24188	27861	1.1518	0.9999	0.315
1984	154321	115453	24322	26711	1.0982	1	0.3857
1985	167849	148511	29072	20347	0.6999	1	0.2158
1986	187584	138509	33639	17976	0.5344	0.9997	0.189
1987	156594	165274	42438	32442	0.7645	0.9998	0.2861
1988	128865	169956	44463	19215	0.4322	0.9998	0.1484
1989	113035	190957	45893	20034	0.4365	1.0419	0.1276
1990	107801	216669	58693	47454	0.8085	1.0449	0.2762
1991	94459	212577	59972	65008	1.084	0.9395	0.4286
1992	71364	196807	50326	63193	1.2557	1.0132	0.4583
1993	84147	147550	38002	62455	1.6435	0.9828	0.6584
1994	142782	116248	33112	51029	1.5411	1.1084	0.7094
1995	172728	80207	27203	15272	0.5614	1.0123	0.2537
1996	151121	83933	22228	18840	0.8476	1.0635	0.2865
1997	124584	78269	19963	19858	0.9947	1.0342	0.345
1998	110213	89109	17838	19946	1.1182	1.0042	0.364
1999	115586	107280	18074	24226	1.3404	1.0314	0.4303
2000	127903	112961	14086	34177	2.4264	1.0097	0.468
2001	130431	112795	12583	38232	3.0384	0.995	0.5044
2002	140871	100811	11057	34062	3.0805	1.0028	0.5345
2003	115327	93453	9140	35151	3.846	0.9931	0.6155
2004	81091	85339	9307	25486	2.7383	1.0145	0.4931
2005	60573	92669	8064	23225	2.8802	1.0161	0.4377
2006	60651	102504	7615	23531	3.0901	1.0198	0.3924
2007	80734	107572	9416	22747	2.4159	1.0233	0.3413
2008	52380	107160	10703	21178	1.9786	0.9543	0.2622
2009	78537	106836	16163	23156	1.4327	0.9946	0.255

Table 20. Retrospective comparison (one year) of numbers at age estimated from XSA (reduced shrinkage – 3 years / log(SE) =1.0). Table entries provide the ratio of the estimated numbers from the current assessment to those estimated in the previous assessment (model formulation unchanged). Shaded entries highlight changes in excess of +/- 10%.

2010/2009 Ratio Matrix	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1975	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1976	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1977	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1978	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1979	1.001	1.001	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1980	1.001	1.001	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1981	1.001	1.001	1.001	1.001	1.000	1.000	1.000	1.000	1.000	1.000	1.001	1.000	1.000	1.000
1982	1.001	1.001	1.001	1.001	1.001	1.000	1.000	1.000	1.000	1.001	1.001	1.001	1.002	1.000
1983	1.002	1.001	1.001	1.001	1.001	1.000	1.000	1.000	1.001	1.001	1.001	1.000	1.002	1.000
1984	1.003	1.002	1.001	1.001	1.001	1.001	1.001	1.000	1.001	1.001	1.001	1.001	1.000	1.001
1985	1.001	1.003	1.002	1.001	1.001	1.001	1.001	1.001	1.001	1.001	1.001	1.001	1.002	1.001
1986	1.002	1.001	1.003	1.002	1.001	1.001	1.001	1.001	1.001	1.001	1.001	1.002	1.001	1.002
1987	1.003	1.002	1.001	1.003	1.002	1.001	1.001	1.001	1.001	1.002	1.002	1.002	1.002	1.002
1988	1.001	1.003	1.002	1.001	1.003	1.002	1.001	1.002	1.002	1.002	1.002	1.003	1.002	1.002
1989	1.002	1.001	1.003	1.002	1.001	1.003	1.002	1.002	1.002	1.003	1.002	1.002	1.002	1.002
1990	1.000	1.002	1.001	1.003	1.002	1.001	1.003	1.003	1.002	1.003	1.003	1.002	1.002	1.003
1991	1.000	1.000	1.002	1.001	1.003	1.002	1.001	1.004	1.004	1.003	1.004	1.004	1.004	1.004
1992	1.002	1.000	1.000	1.002	1.001	1.003	1.002	1.002	1.007	1.008	1.007	1.007	1.008	1.008
1993	1.002	1.002	1.000	1.000	1.002	1.001	1.004	1.003	1.004	1.013	1.012	1.009	1.011	1.011
1994	1.001	1.002	1.002	1.000	1.000	1.002	1.002	1.009	1.009	1.010	1.024	1.018	1.017	1.018
1995	1.002	1.001	1.002	1.002	1.000	1.001	1.004	1.004	1.022	1.019	1.016	1.038	1.026	1.026
1996	0.999	1.002	1.001	1.002	1.002	1.000	1.001	1.006	1.006	1.032	1.025	1.020	1.054	1.055
1997	1.008	0.999	1.002	1.001	1.002	1.003	1.001	1.001	1.009	1.008	1.042	1.037	1.029	1.028
1998	1.000	1.008	0.999	1.002	1.001	1.002	1.003	1.001	1.002	1.013	1.010	1.062	1.053	1.053
1999	0.995	1.000	1.008	0.999	1.002	1.001	1.003	1.005	1.002	1.003	1.018	1.015	1.077	1.078
2000	0.996	0.995	1.000	1.008	0.999	1.002	1.001	1.006	1.011	1.003	1.005	1.026	1.023	1.025
2001	0.970	0.996	0.995	1.000	1.008	0.999	1.002	1.004	1.011	1.017	1.005	1.009	1.035	1.035
2002	0.991	0.970	0.996	0.995	1.000	1.008	0.999	1.007	1.011	1.017	1.025	1.006	1.014	1.011
2003	1.028	0.991	0.970	0.996	0.995	1.000	1.010	0.998	1.018	1.019	1.029	1.042	1.015	1.014
2004	1.077	1.028	0.991	0.970	0.996	0.994	1.001	1.028	0.995	1.036	1.031	1.045	1.066	1.067
2005	1.054	1.077	1.028	0.991	0.969	0.995	0.993	1.001	1.061	0.991	1.060	1.057	1.082	1.087
2006	0.891	1.054	1.077	1.028	0.990	0.968	0.994	0.986	1.002	1.119	0.986	1.103	1.097	1.099
2007	0.720	0.891	1.054	1.077	1.028	0.990	0.963	0.990	0.971	1.004	1.173	0.983	1.119	1.120
2008	1.010	0.720	0.891	1.054	1.077	1.029	0.989	0.938	0.981	0.955	1.005	1.226	0.980	0.980
2009		1.010	0.720	0.891	1.054	1.078	1.032	0.984	0.900	0.974	0.944	1.006	1.251	1.128

Table 21. Retrospective comparison (one year) of fishing mortality at age estimated from XSA (reduced shrinkage – 3 years / log(SE) =1.0). Table entries provide the ratio of the estimated fishing mortality from the current assessment to those estimated in the previous assessment (model formulation unchanged). Shaded entries highlight changes in excess of +/- 10%.

2009/2008 Ratio Matrix	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1975					1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1976					1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1977					1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1978					1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1979					1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1980					1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1981					1.000	1.000	1.000	1.000	1.000	1.000	0.999	1.000	1.000	1.000
1982					1.000	0.999	1.000	0.999	1.000	0.999	0.999	0.999	0.999	0.999
1983					0.994	0.999	1.000	0.999	0.999	0.999	0.999	0.999	1.000	1.000
1984					1.000	1.000	0.999	0.999	0.999	0.999	0.999	0.999	0.999	0.999
1985					0.997	0.999	1.000	0.999	0.999	0.998	0.999	0.998	0.999	0.999
1986					1.000	0.998	0.999	0.999	0.999	0.999	0.999	0.999	0.998	0.998
1987					1.000	1.000	0.999	0.998	0.999	0.998	0.998	0.998	0.999	0.999
1988					1.000	0.999	0.998	0.998	0.998	0.998	0.998	0.997	0.998	0.998
1989					1.000	0.997	0.998	0.998	0.998	0.998	0.998	0.998	0.997	0.997
1990				1.000	1.000	0.999	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997
1991				1.000	0.998	0.999	0.998	0.995	0.994	0.995	0.995	0.995	0.995	0.995
1992				0.995	0.999	0.996	0.997	0.997	0.990	0.990	0.992	0.991	0.991	0.991
1993				0.995	0.998	0.999	0.994	0.994	0.994	0.982	0.985	0.987	0.985	0.985
1994				1.000	0.999	0.997	0.998	0.985	0.987	0.988	0.970	0.978	0.979	0.979
1995				1.000	1.000	0.999	0.995	0.996	0.974	0.978	0.982	0.956	0.971	0.971
1996				1.000	0.997	1.000	0.999	0.993	0.994	0.964	0.970	0.976	0.941	0.941
1997				1.000	0.998	0.997	0.999	0.999	0.989	0.991	0.951	0.958	0.967	0.967
1998				1.000	0.998	0.997	0.996	0.999	0.997	0.985	0.988	0.935	0.944	0.944
1999				1.000	1.000	0.999	0.996	0.992	0.998	0.996	0.979	0.981	0.915	0.915
2000				1.000	1.000	0.998	0.997	0.992	0.986	0.996	0.994	0.970	0.970	0.970
2001				1.000	0.991	1.001	0.996	0.993	0.986	0.980	0.994	0.990	0.954	0.954
2002				1.012	1.000	0.991	1.001	0.989	0.986	0.978	0.968	0.988	0.982	0.982
2003				1.000	1.005	0.999	0.983	1.003	0.975	0.975	0.964	0.950	0.978	0.978
2004				1.030	1.005	1.007	0.999	0.959	1.007	0.955	0.958	0.940	0.922	0.922
2005				1.013	1.032	1.005	1.010	0.998	0.920	1.011	0.927	0.929	0.901	0.901
2006				0.974	1.009	1.036	1.008	1.021	0.997	0.874	1.015	0.902	0.900	0.900
2007				0.917	0.976	1.011	1.051	1.015	1.038	0.996	0.835	1.018	0.884	0.884
2008				1.000	0.926	0.971	1.013	1.086	1.023	1.053	0.995	0.808	1.021	1.021

Table 22: Input vectors for stochastic projections, with associated coefficients of variation.

Name	**Value**	**Uncertainty (CV)**
Population at age ir		2010
N1	Bootstrap (1999-2008)	
N2	64301	0.58
N3	35112	0.32
N4	44308	0.30
N5	27197	0.22
N6	21831	0.17
N7	21215	0.15
N8	17570	0.14
N9	10525	0.13
N10	4281	0.14
N11	2320	0.15
N12	884	0.17
N13	517	0.17
N14	685	0.16
Weight in the catch	(2007-2009)	
WH1	0.000	0.00
WH2	0.000	0.00
WH3	0.000	0.00
WH4	0.278	0.01
WH5	0.394	0.02
WH6	0.599	0.03
WH7	0.862	0.03
WH8	1.163	0.03
WH9	1.572	0.04
WH10	2.028	0.04
WH11	2.653	0.05
WH12	3.141	0.03
WH13	3.844	0.10
WH14	4.702	0.06
Natural mortality pattern		
M1	0.20	0.15
M2	0.20	0.15
M3	0.20	0.15
M4	0.20	0.15
M5	0.20	0.15
M6	0.20	0.15
M7	0.20	0.15
M8	0.20	0.15
M9	0.20	0.15
M10	0.20	0.15
M11	0.20	0.15
M12	0.20	0.15
M13	0.20	0.15
M14	0.20	0.15

Name	**Value**	**Incertainty (CV)**
Selection pattern	(2007-2009	
sH1	0.000	0.000
sH2	0.000	0.000
sH3	0.000	0.000
sH4	0.006	0.002
sH5	0.055	0.020
sH6	0.365	0.119
sH7	1.497	0.067
sH8	1.897	0.088
sH9	1.294	0.054
sH10	0.893	0.173
sH11	0.646	0.113
sH12	0.446	0.103
sH13	0.401	0.130
sH14	0.401	0.130
Weight in the stock	(2007-2009	
WS1	0.000	0.00
WS2	0.000	0.00
WS3	0.000	0.00
WS4	0.000	0.00
WS5	0.394	0.02
WS6	0.599	0.03
WS7	0.862	0.03
WS8	1.163	0.03
WS9	1.572	0.04
WS10	2.028	0.04
WS11	2.653	0.05
WS12	3.141	0.03
WS13	3.844	0.10
WS14	4.702	0.06
Maturity ogive pattern		
MT1	0.000	0.000
MT2	0.000	0.000
MT3	0.000	0.000
MT4	0.000	0.000
MT5	0.000	0.000
MT6	0.000	0.000
MT7	0.000	0.000
MT8	0.000	0.000
MT9	0.000	0.000
MT10	1.000	0.000
MT11	1.000	0.000
MT12	1.000	0.000
MT13	1.000	0.000
MT14	1.000	0.000

Table 23: Results of Stochastic projections under various catch levels and fishing mortality options. Labels p5, p50, p95 refer to 5th, 50th and 95th percentiles of each quantity.

	5+ Biomass (000 t)					Yield (000 t)				10+ Biomass (000t)				
	2010	2011	2012	2013	2014	2010	2011	2012	2013	2010	2011	2012	2013	2014
p5	93	86	87	88	93	23.2	12.1	11.8	11.9	20.1	26.9	31.7	34.3	34.6
p50	102	98	100	104	112	23.2	14.5	14.1	14.7	22.7	30.6	37.5	40.6	42.0
p95	113	113	116	128	139	23.2	17.8	16.9	18.2	25.9	35.3	43.7	48.0	49.6

Status Quo Catch in 2010; F_2009 over 2011-2013

	5+ Biomass (000 t)					Yield (000 t)				10+ Biomass (000t)				
	2010	2011	2012	2013	2014	2010	2011	2012	2013	2010	2011	2012	2013	2014
p5	92	87	84	83	84	23.2	14.9	14.0	13.5	19.9	26.5	30.5	31.3	30.7
p50	102	98	96	98	103	23.2	17.5	16.3	16.4	22.7	30.6	35.7	36.8	36.4
p95	112	113	111	120	129	23.2	20.7	19.2	20.2	25.7	35.4	42.0	43.4	43.1

Status Quo Catch in 2010; 16,000t over 2011-2013

	5+ Biomass (000 t)					Yield (000 t)				10+ Biomass (000t)				
	2010	2011	2012	2013	2014	2010	2011	2012	2013	2010	2011	2012	2013	2014
p5	92	85	81	79	87	23.2	16.0	16.0	16.0	19.9	26.4	30.3	29.6	28.0
p50	101	98	97	100	111	23.2	16.0	16.0	16.0	22.6	30.6	36.4	37.8	37.9
p95	112	111	113	124	140	23.2	16.0	16.0	16.0	25.8	35.3	43.5	47.6	49.3

Status Quo Catch over 2010-2013

	5+ Biomass (000 t)					Yield (000 t)				10+ Biomass (000t)				
	2010	2011	2012	2013	2014	2010	2011	2012	2013	2010	2011	2012	2013	2014
p5	92	86	74	63	62	23.2	23.2	23.2	23.2	20.0	26.6	26.5	21.6	15.1
p50	101	98	90	83	86	23.2	23.2	23.2	23.2	22.6	30.5	32.7	28.9	23.5
p95	112	112	106	108	116	23.2	23.2	23.2	23.2	25.7	35.3	40.0	38.3	34.1

16,000t in 2010-2013

	5+ Biomass (000 t)					Yield (000 t)				10+ Biomass (000t)				
	2010	2011	2012	2013	2014	2010	2011	2012	2013	2010	2011	2012	2013	2014
p5	92	95	92	91	97	16.0	16.0	16.0	16.0	20.0	29.2	35.6	37.1	35.8
p50	102	107	107	109	120	16.0	16.0	16.0	16.0	22.7	33.8	42.3	45.6	45.9
p95	112	121	123	133	148	16.0	16.0	16.0	16.0	25.8	38.4	49.4	55.2	57.5

Table 24: Biomass growth (%) under various projections. The exploitable (5+) at the end of the projection period (2013) is compared to the biomass at the beginning of the projection (2008; 79 000 tons) and the biomass in 2003, when the rebuilding plan was instituted (93 800 tons).

Projection Scenario	Biomass Change [B(2014)-B(2010)]/B(2010)		
	Ages 5+	Ages 10+	Ages 5-9
Status Quo Catch in 2010; F0.1 over 2011-2013	10%	85%	-11%
Status Quo Catch in 2010; F_2009 over 2011-2013	1%	60%	-16%
Status Quo Catch in 2010; 16,000t over 2011-2013	10%	67%	-7%
Status Quo Catch over 2010-2013	-15%	4%	-21%
16,000t in 2010-2013	18%	102%	-6%

Table 25: Comparison of the biomass at the end of the projection period to the rebuilding plan target of 140 000 tons.

Projection Scenario	B(2014) / 140Kt
Status Quo Catch in 2010; F0.1 over 2011-2013	0.80
Status Quo Catch in 2010; F_2009 over 2011-2013	0.74
Status Quo Catch in 2010; 16,000t over 2011-2013	0.79
Status Quo Catch over 2010-2013	0.61
16,000t in 2010-2013	0.86

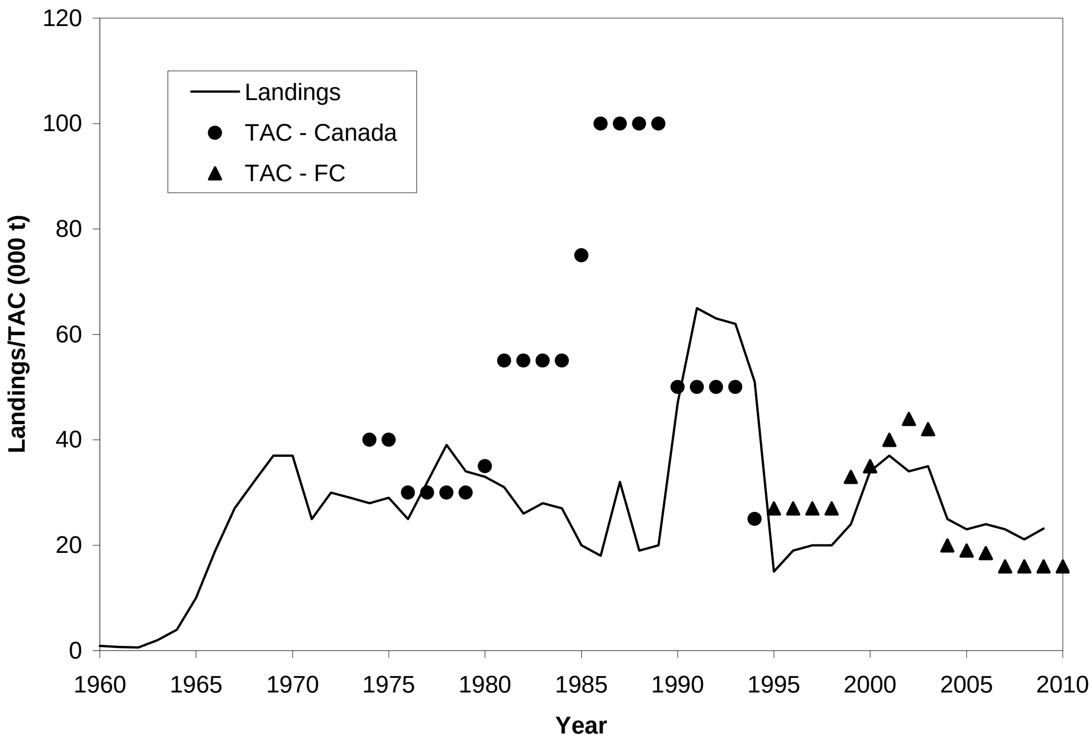


Figure 1 – Catches (line) and TAC (triangle) of Greenland Halibut in Sub-Area 2 and Divisions 3KLMNO.

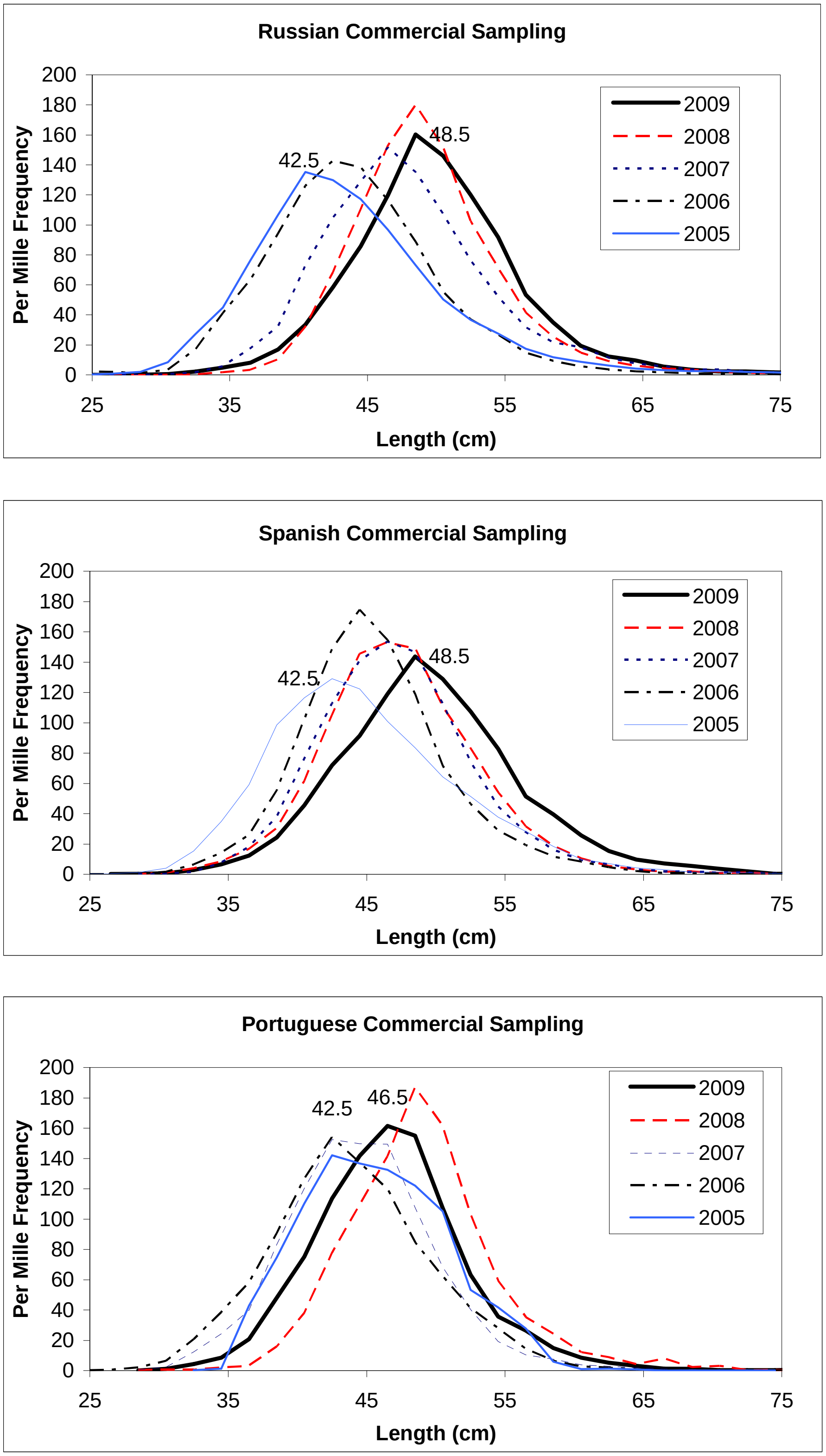


Figure 2 – Available Length Sampling over 2005- 2009 for fisheries within the NRA. Data labels indicate modal length group in sampling during 2005 and in 2009.

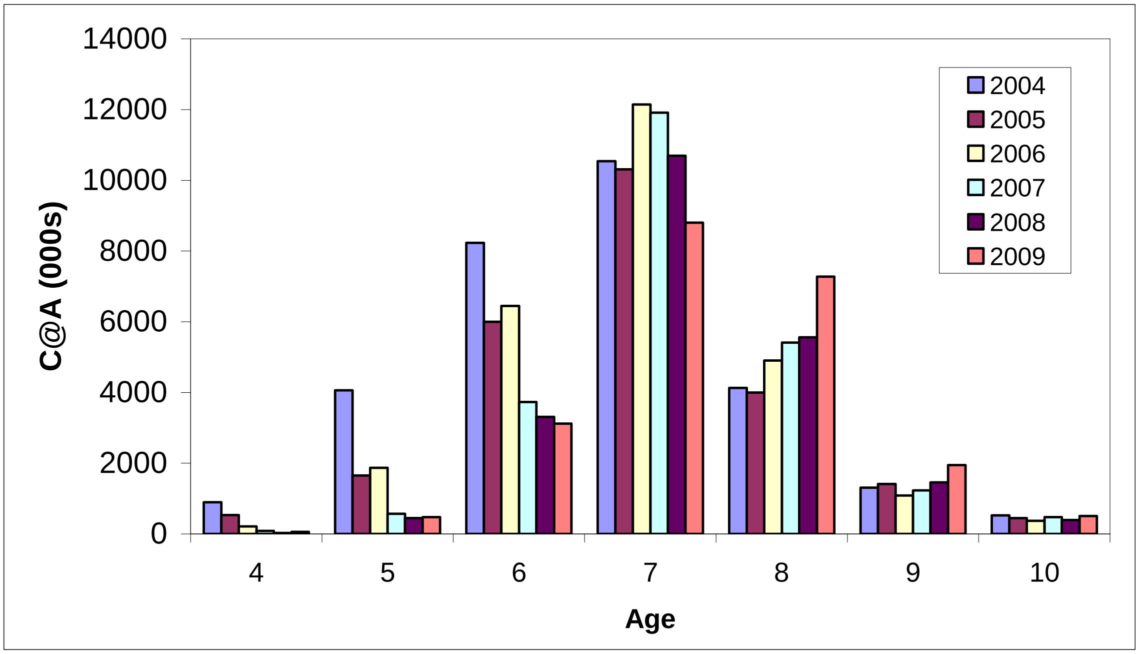


Figure 3 – Total catch at age, in thousands, for Greenland Halibut in Sub-Area 2 and Divisions 3KLMNO in recent years (2004-2009) over ages 4-10.

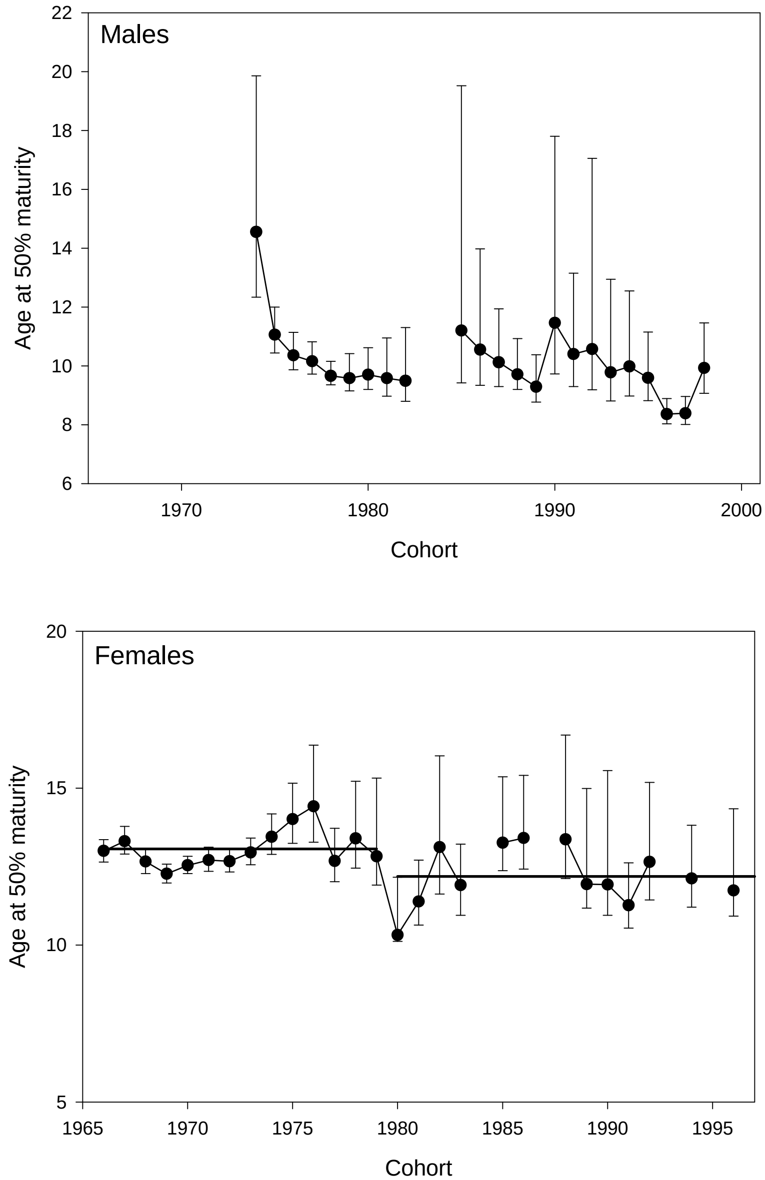


Figure 4. Age at 50% maturity (+ 95% fiducial limits) for male and female Greenland halibut in NAFO Divs. 2J3K by cohort. Data are from Canadian fall surveys in Div. 2J3K. The horizontal lines on the female panel indicate the average A50 from 1966-1979 and from 1980-1996

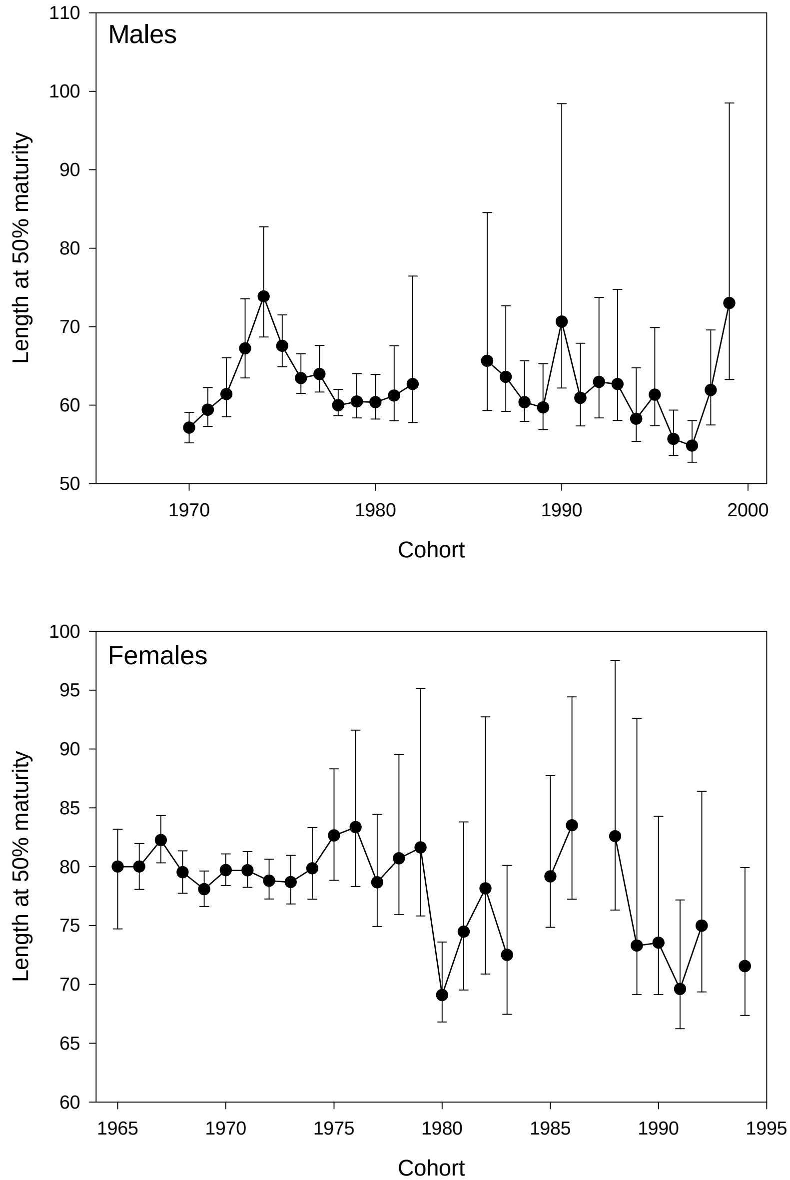


Figure 5. Length at 50% maturity (+ 95% fiducial limits) for male and female Greenland halibut in NAFO Divs. 2J3K by cohort. Data are from Canadian fall surveys in Div. 2J3K.

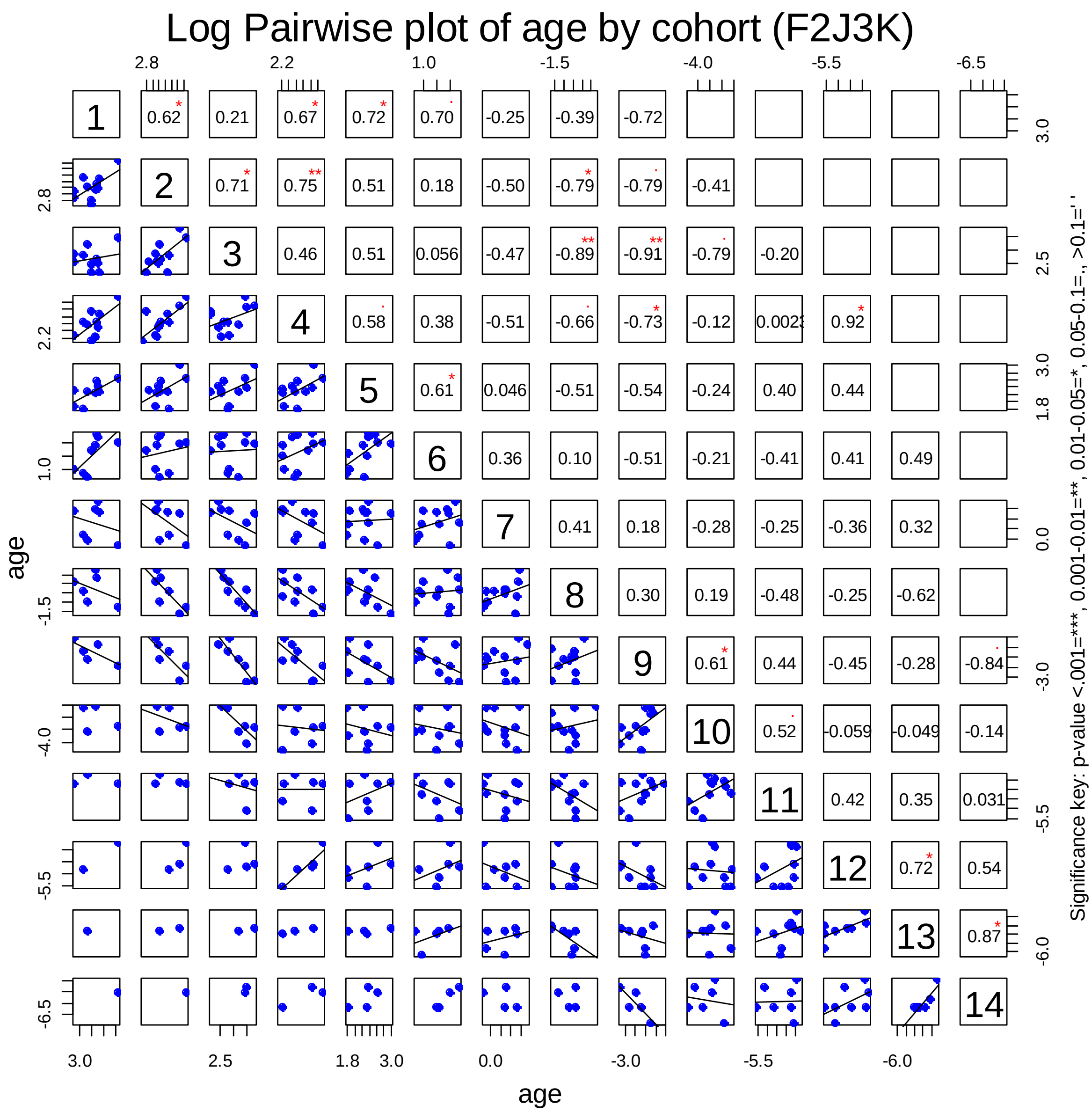


Figure 6a: Pair-wise scatter plot of age-disaggregated survey data (log-scale) from Canadian fall survey in Divs. 2J3K (1996-2009). Refer to text for details.

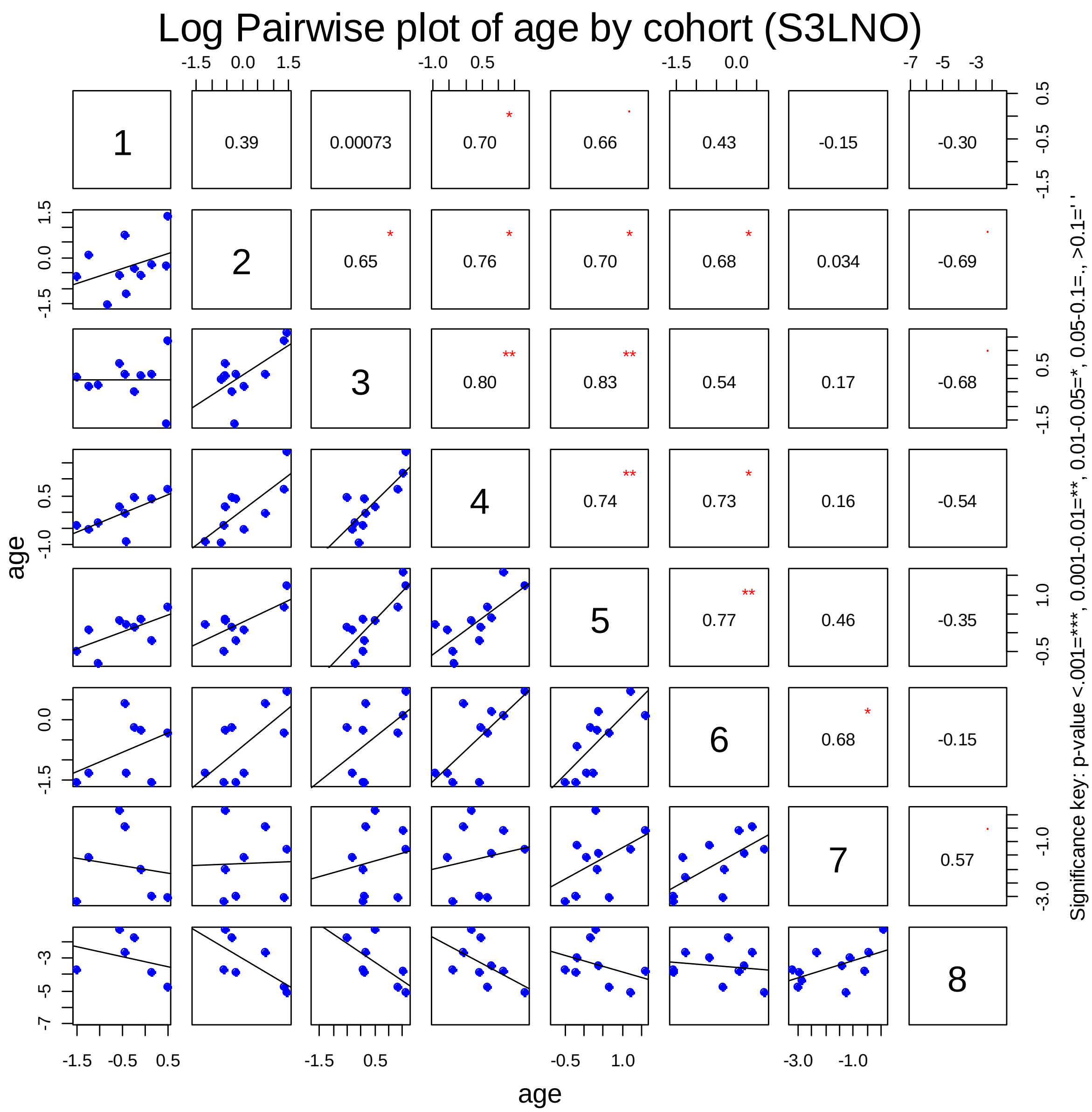


Figure 6b: Pair-wise scatter plot of age-disaggregated survey data (log-scale) from Canadian spring survey in Divs. 3LNO (1996-2009). Refer to text for details.

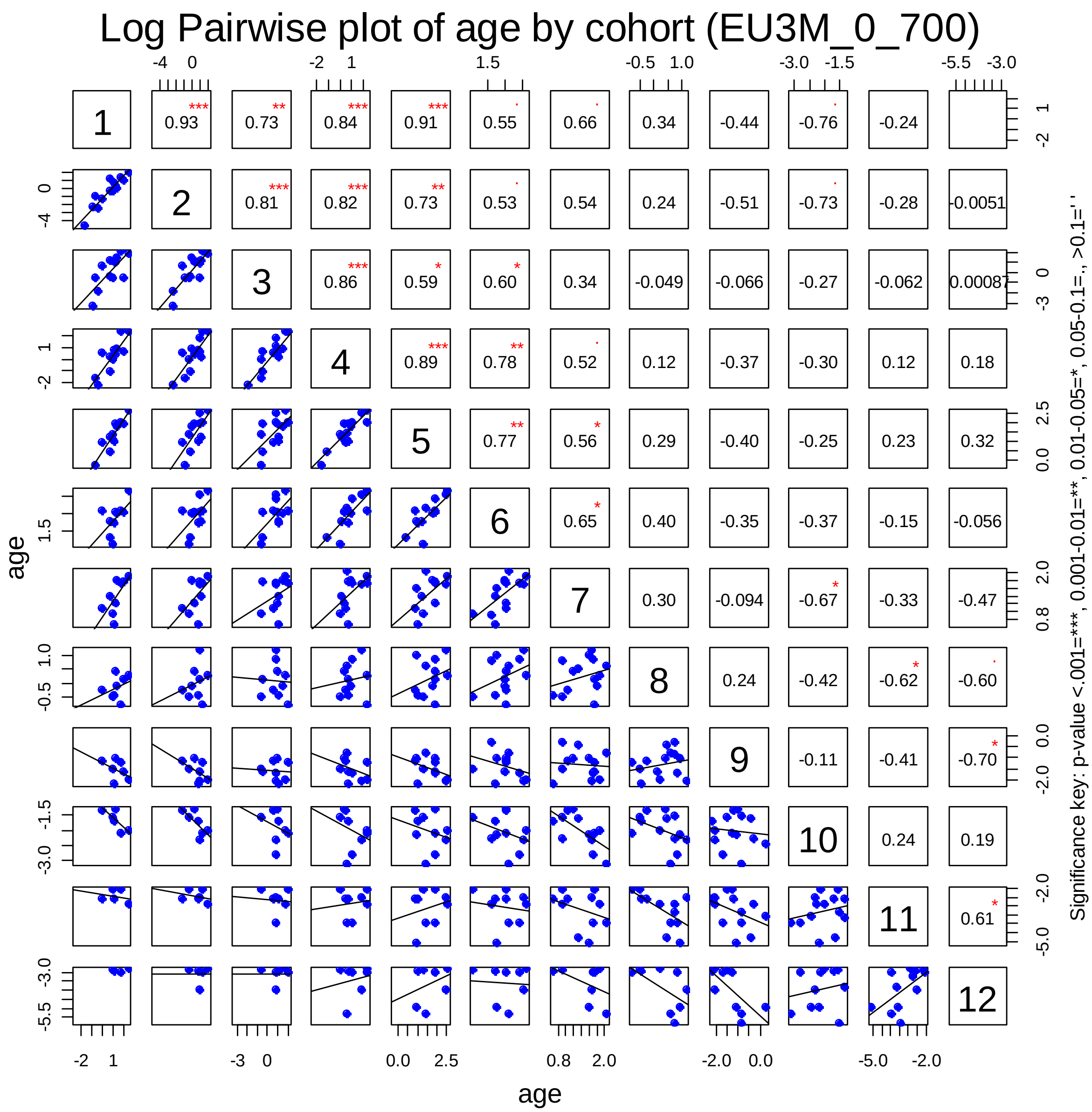


Figure 6c: Pair-wise scatter plot of age-disaggregated survey data (log-scale) from EU Flemish Cap survey (0-700m only; 1995-2009). Refer to text for details.

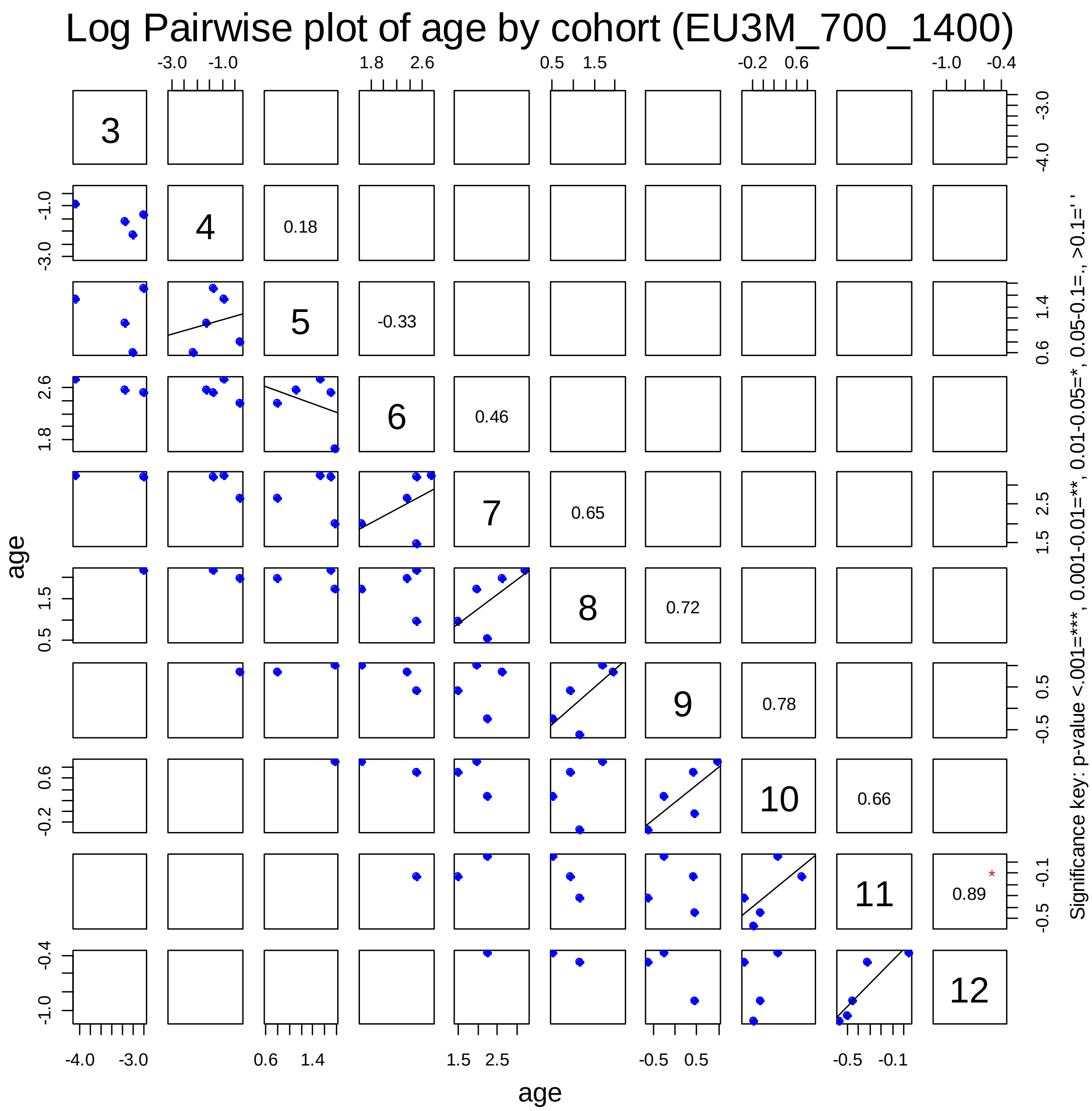


Figure 6d: Pair-wise scatter plot of age-disaggregated survey data (log-scale) from EU Flemish Cap survey (700-1400m only; 2004-2009). Refer to text for details.

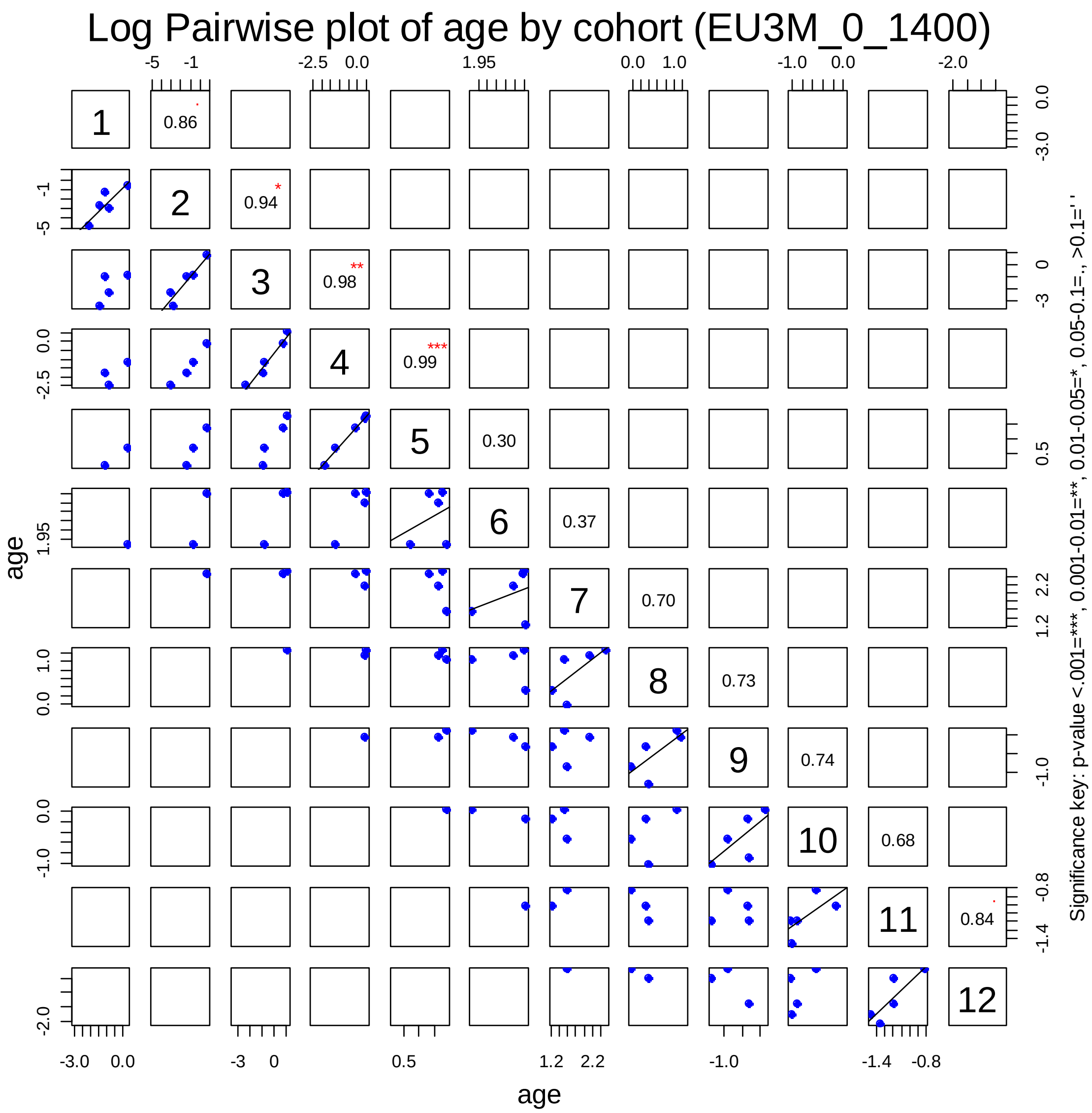


Figure 6e: Pair-wise scatter plot of age-disaggregated survey data (log-scale) from EU Flemish Cap survey (0-1400m only; 2004-2009). Refer to text for details.

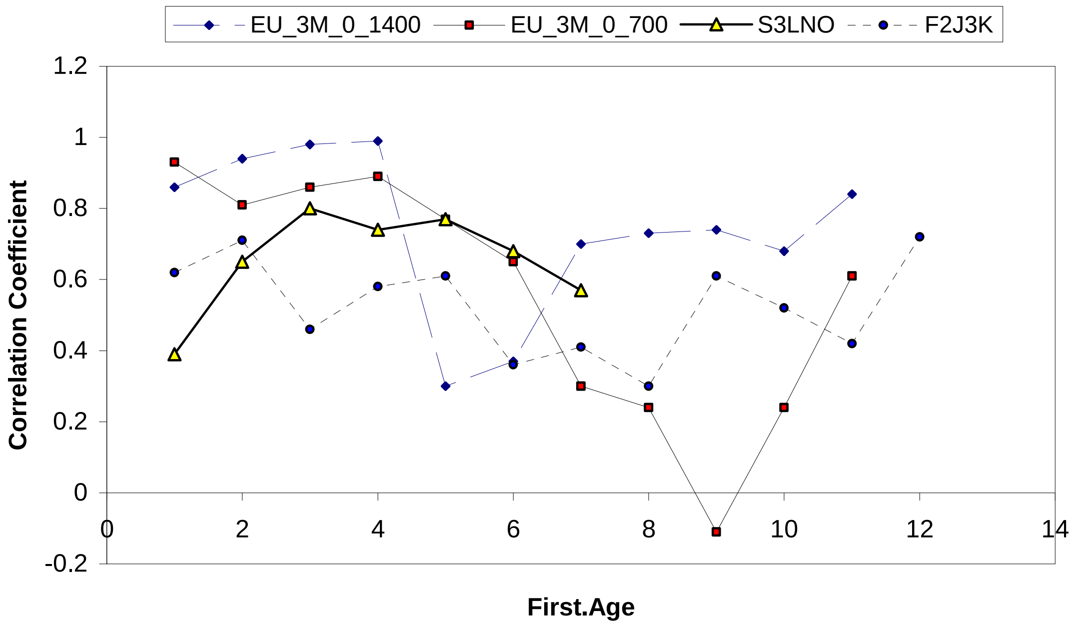


Figure 7. Correlation coefficients computed between successive age groups from each survey series. “First Age” identifies the youngest age being considered, correlations were computed on logged index data.

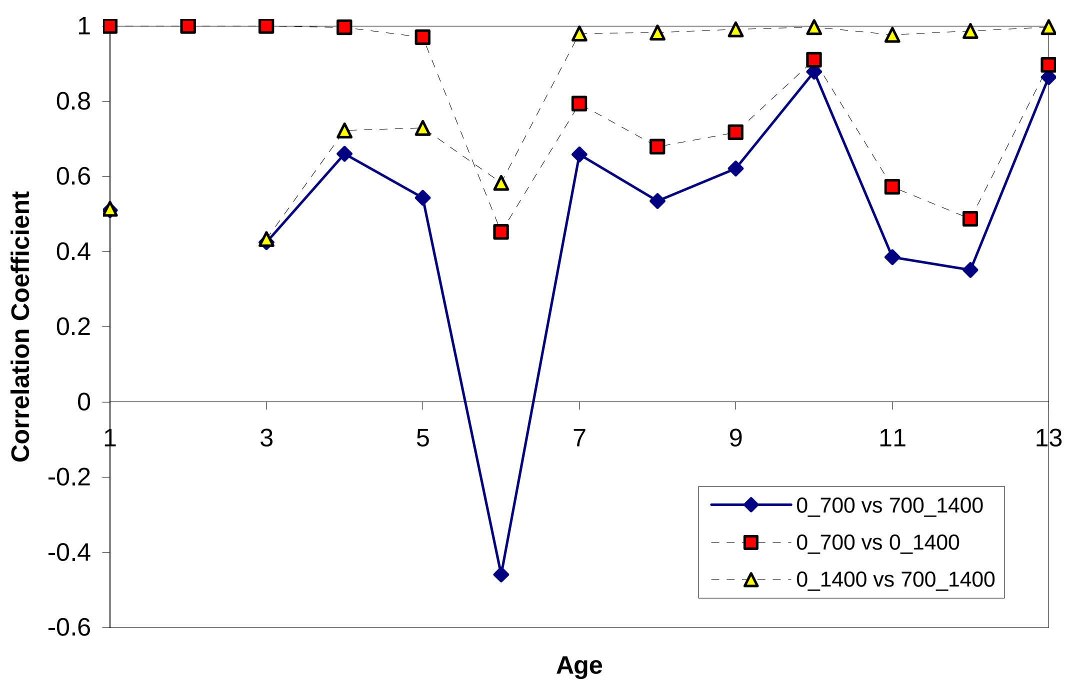


Figure 8. Correlation coefficients at age between abundance at age indices from the EU Flemish Cap survey analyzed over various depth classes, 2004-2009.

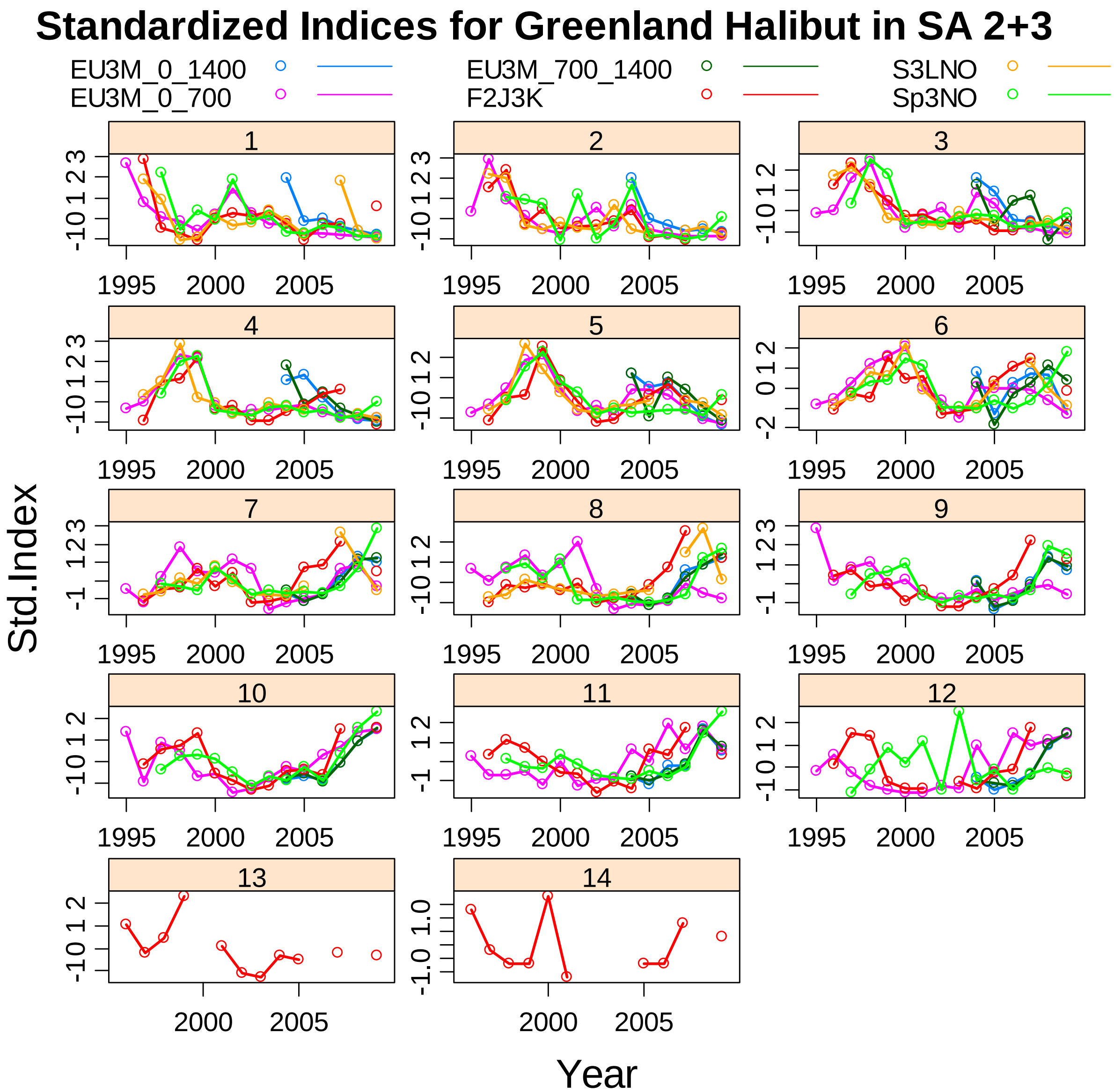


Figure 9a. Standardized age-disaggregated Greenland Halibut survey indices. For each survey-age, the survey data are standardized to have a mean of 0 and a variance of 1.

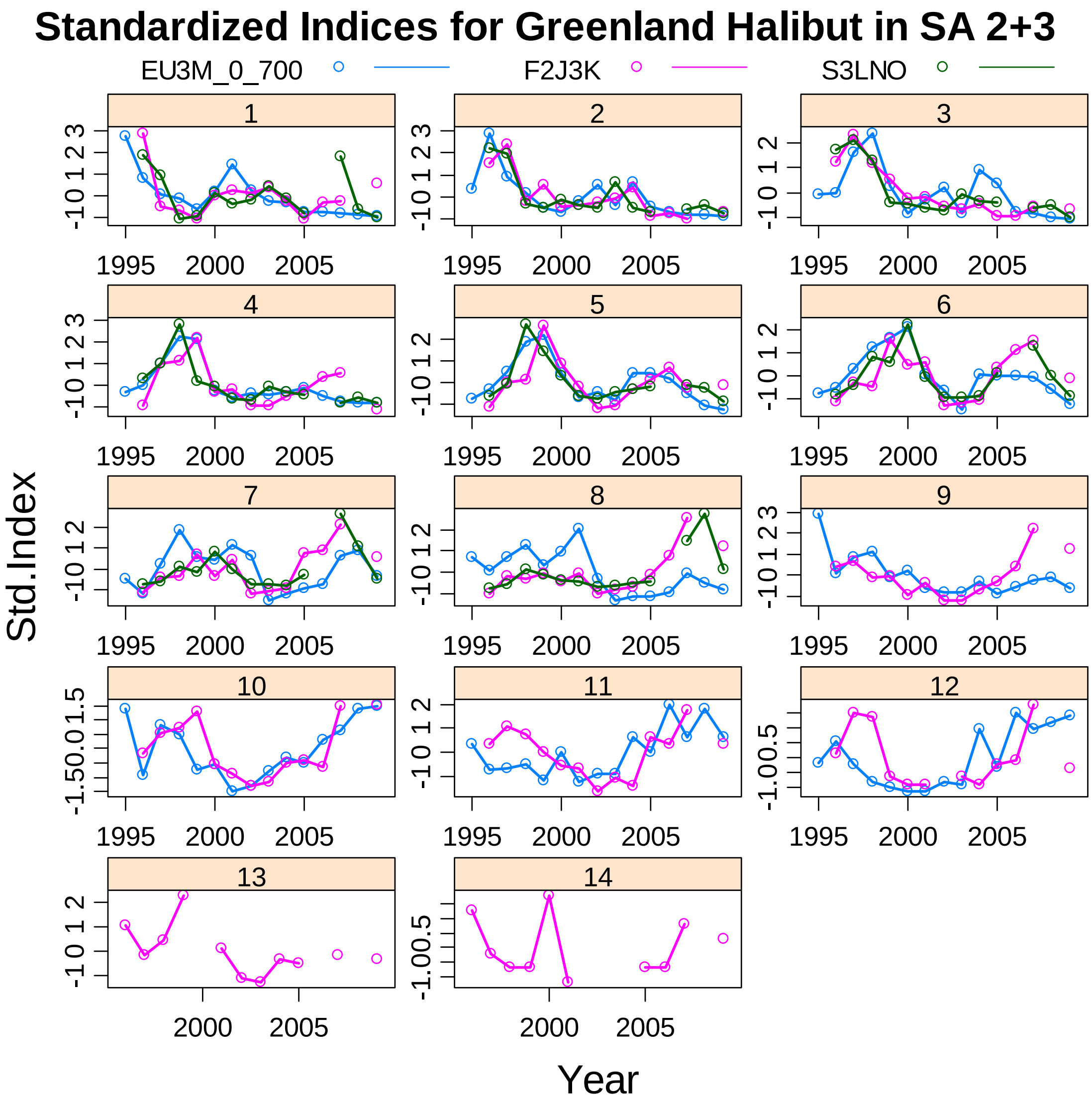


Figure 9b. Standardized age-disaggregated Greenland Halibut survey indices – includes only the surveys used to calibrate the previous analytical assessment. For each survey-age, the survey data are standardized to have a mean of 0 and a variance of 1.

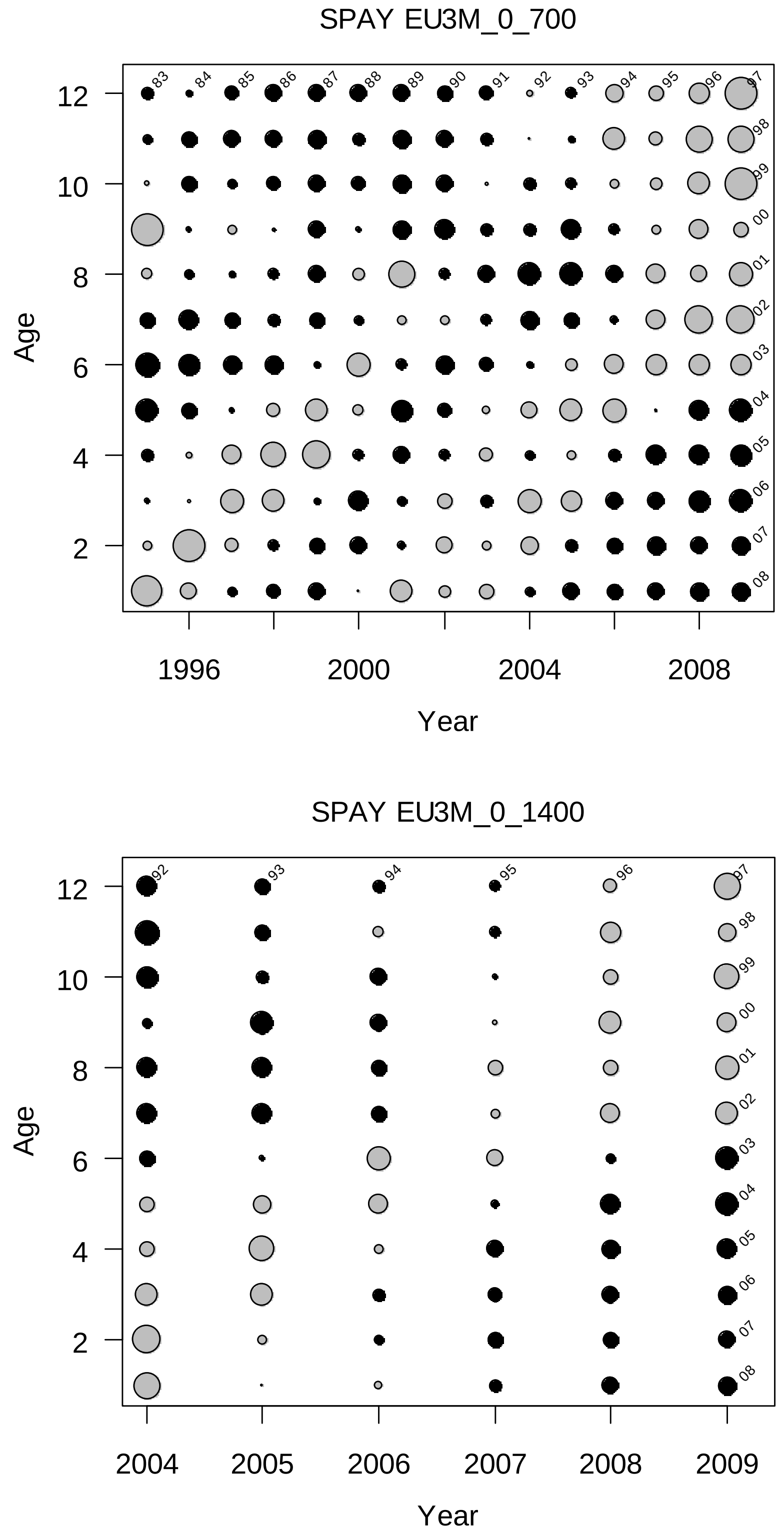
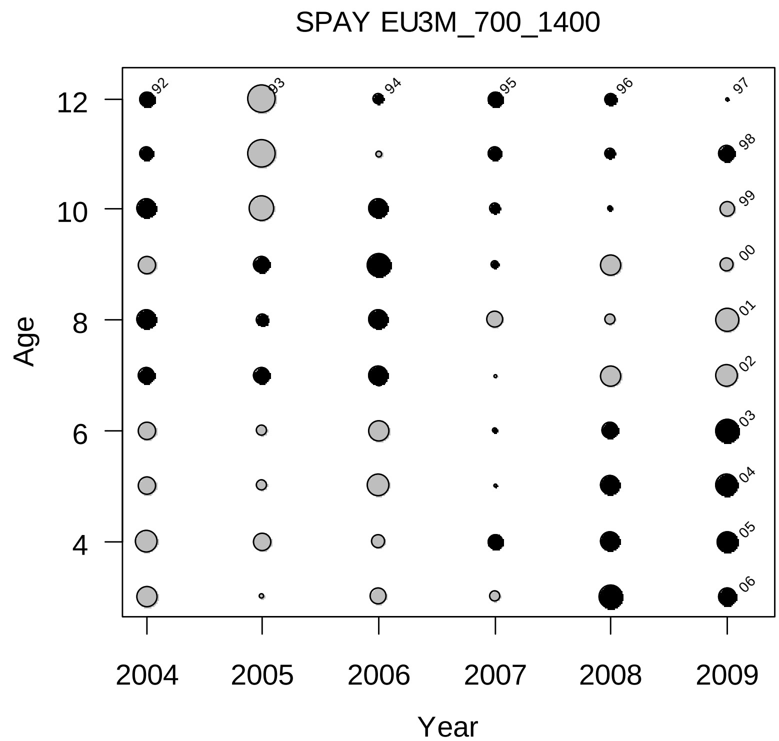


Figure 10a. Plot of standardized proportions by age across years (SPAY). Annual index proportions were standardized at each age to have a mean of 0 and a variance of 1. Index name identified in panel title.



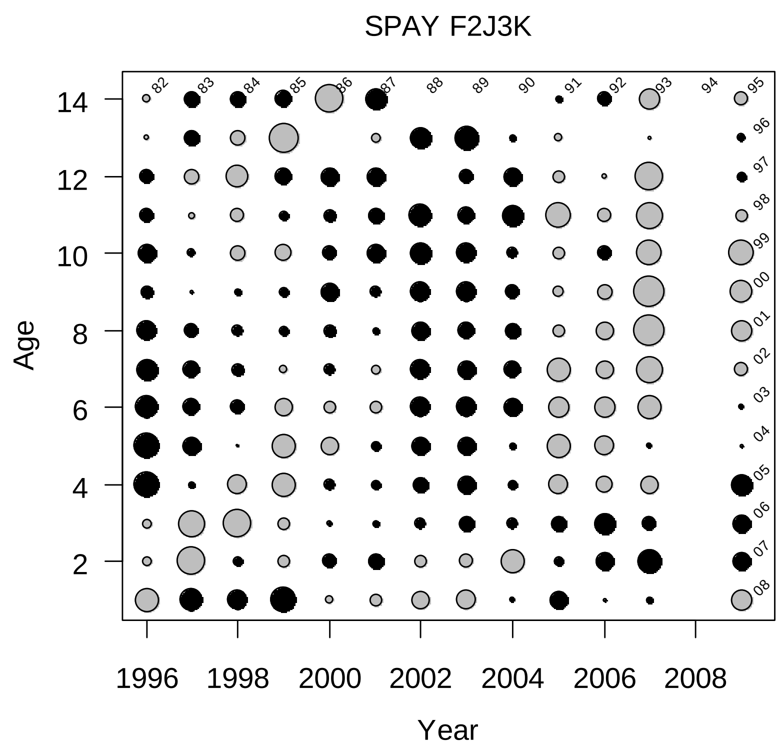


Figure 10b. Plot of standardized proportions by age across years (SPAY). Annual index proportions were standardized at each age to have a mean of 0 and a variance of 1. Index name identified in panel title.

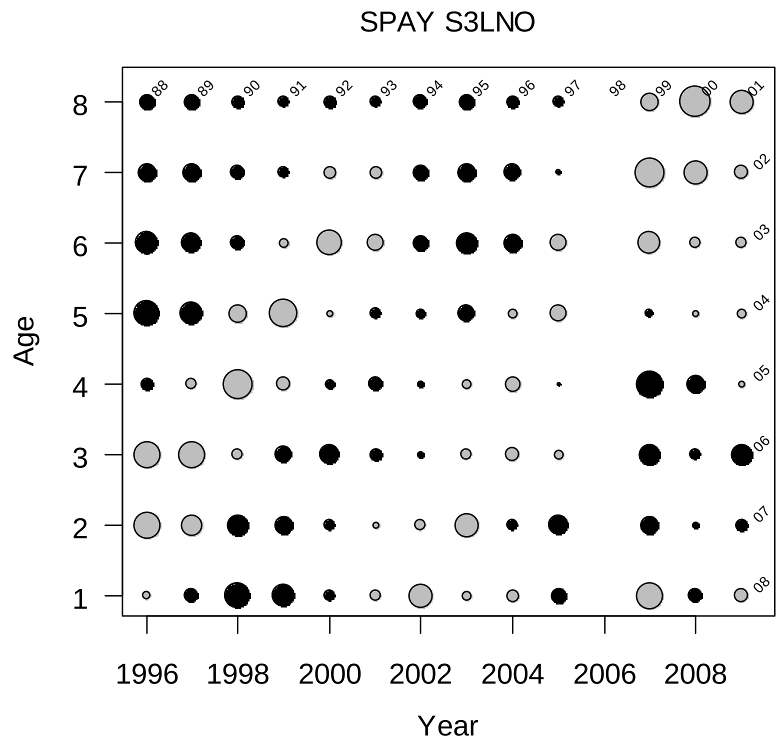


Figure 10c. Plot of standardized proportions by age across years (SPAY). Annual index proportions were standardized at each age to have a mean of 0 and a variance of 1. Index name identified in panel title.

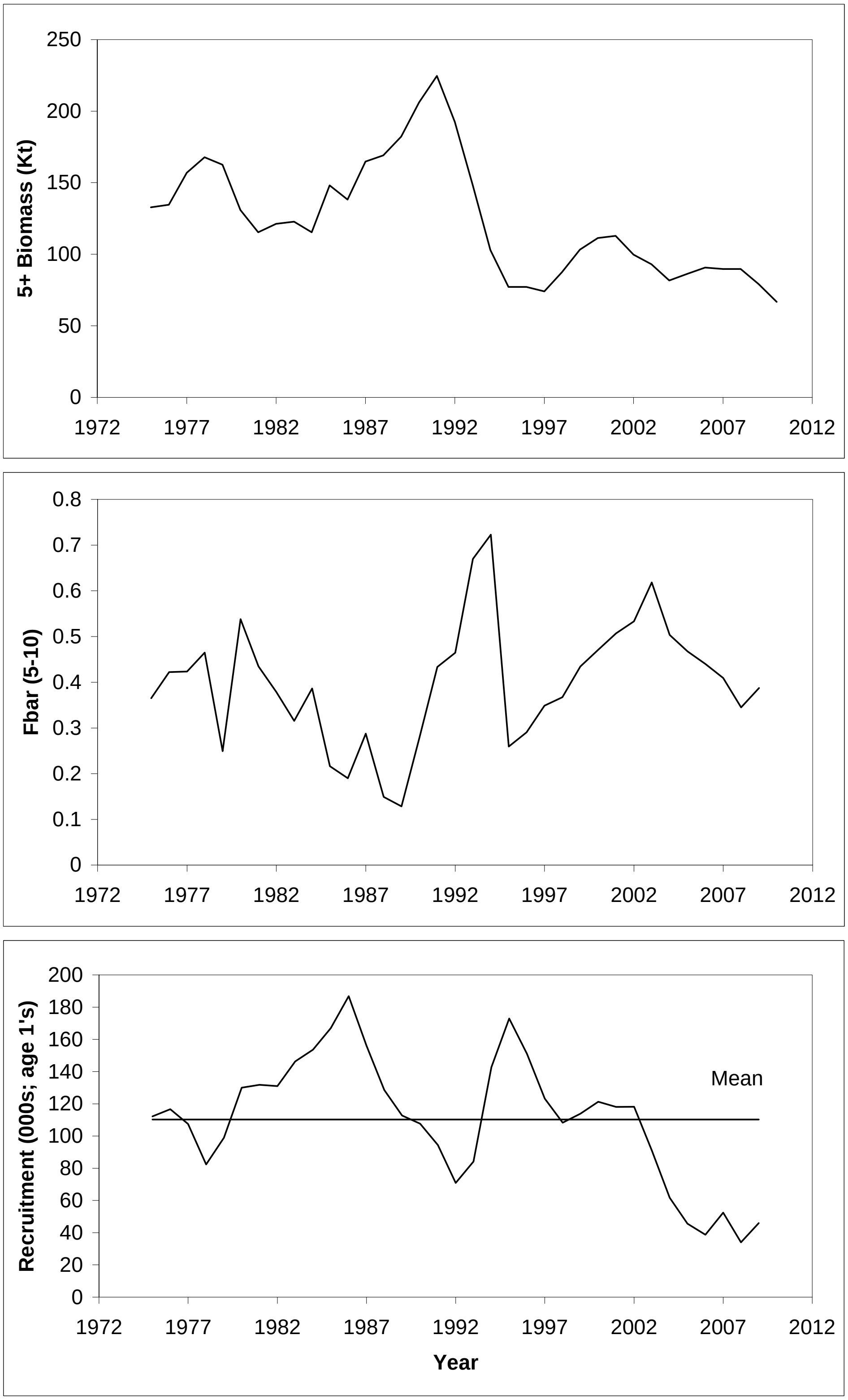
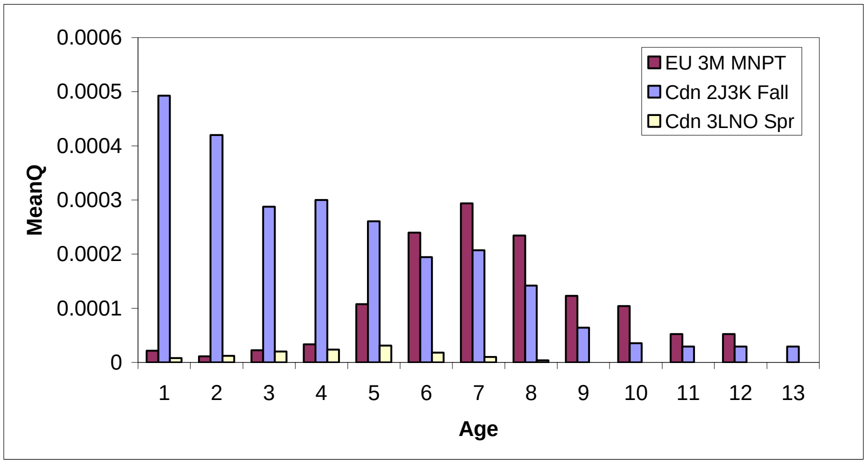
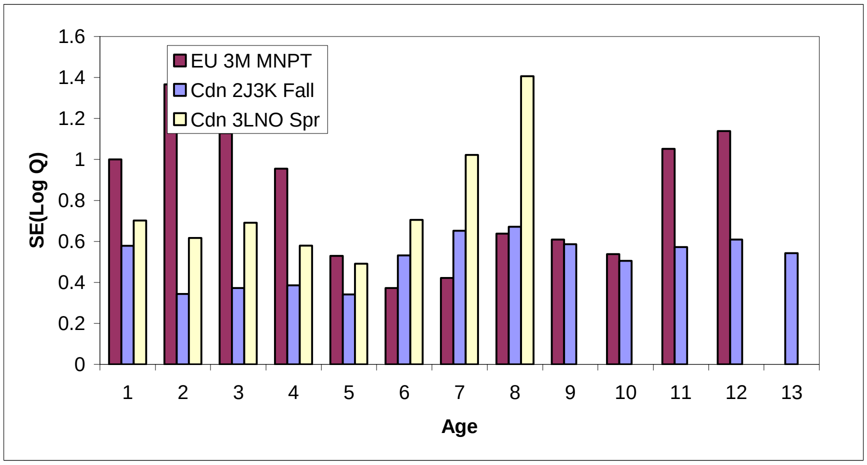


Figure 11. XSA (update run) estimates of exploitable biomass (ages 5+ in tons; upper panel), average fishing mortality (ages 5-10) and recruitment (000's at age 1) for Greenland Halibut in Sub-Area 2 and Divisions 3KLMNO.

Catchabilities



SE(Log q)



Shrinkage Scaled Weights

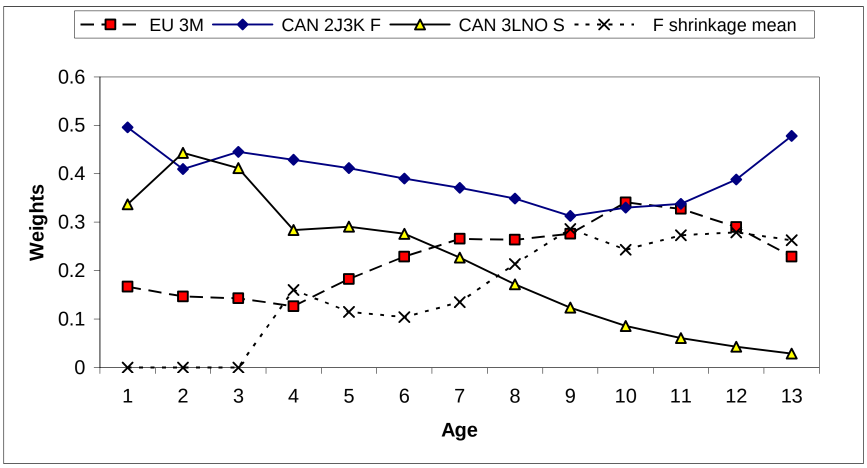


Figure 12. XSA (update run) estimated catchabilities, associated standard errors, and the scaled weights used to estimate survivors in the terminal year.

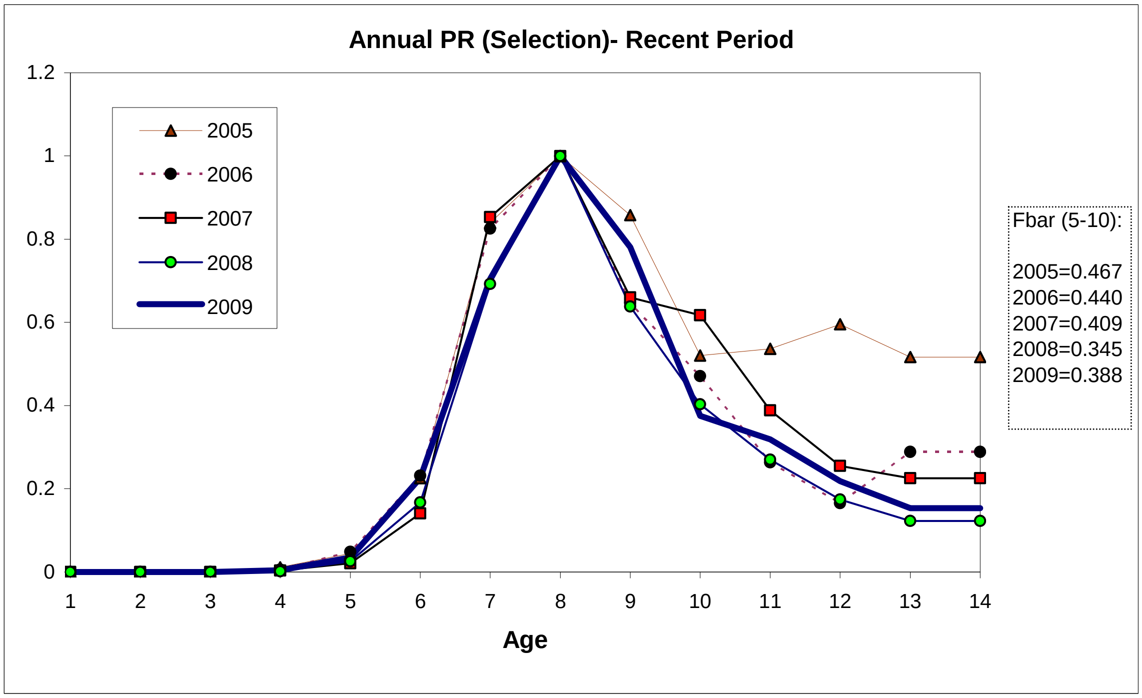


Figure 13. XSA (update run) estimated selection pattern in the most recent five years.

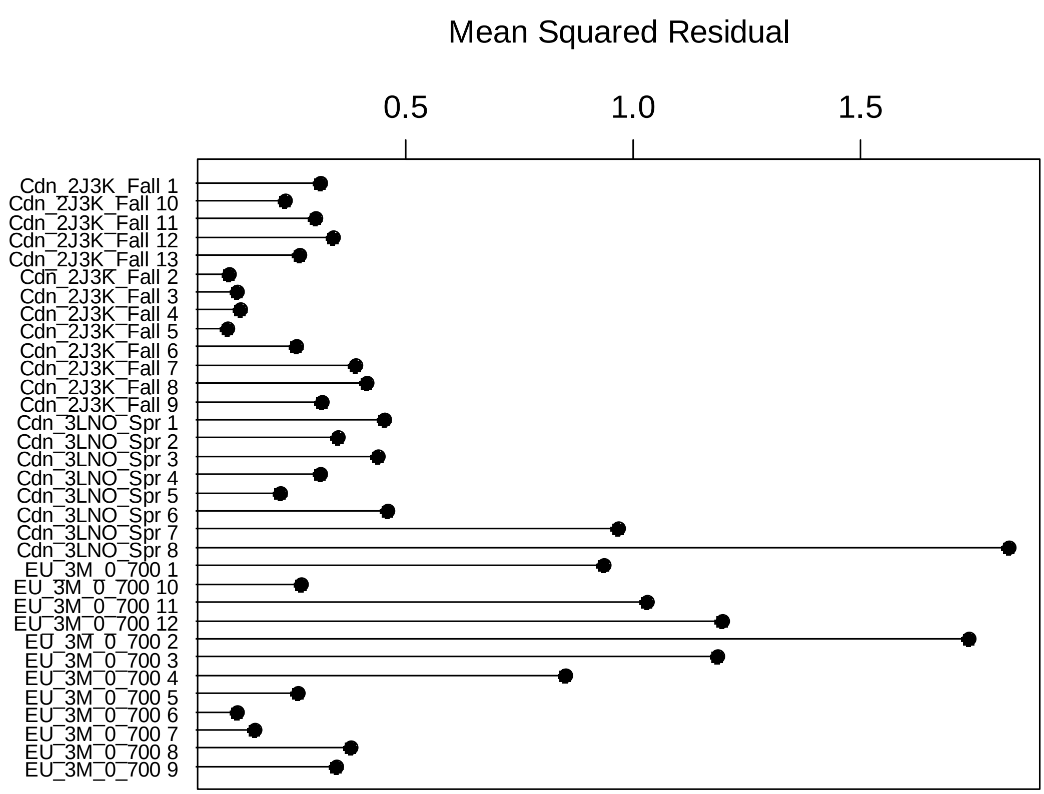


Figure 14a. Mean square residuals from XSA (update run) for each survey-age.

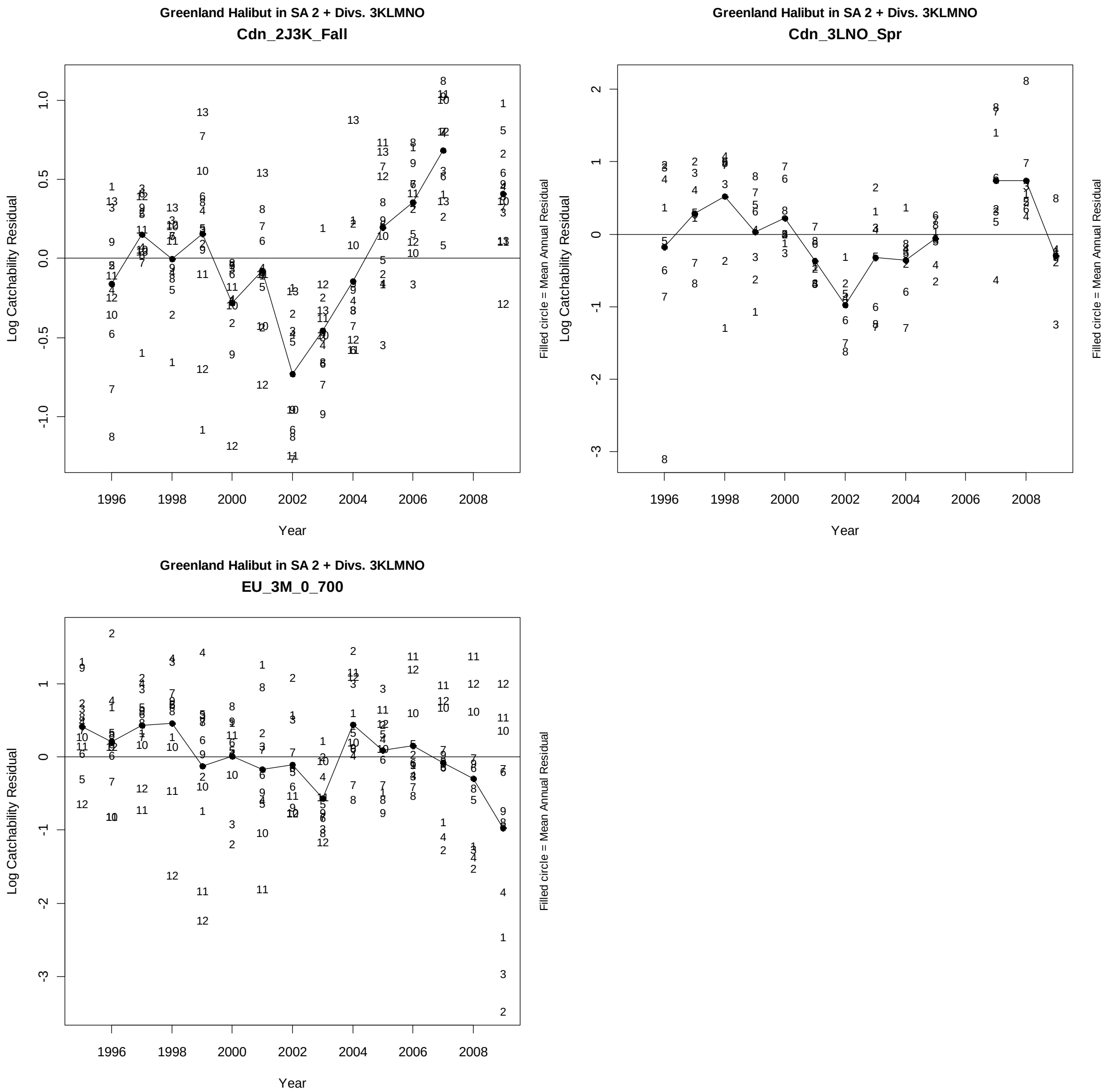


Figure 14b. XSA (update run) residuals by survey, age and year. Symbol=age, solid circle=mean annual residual.

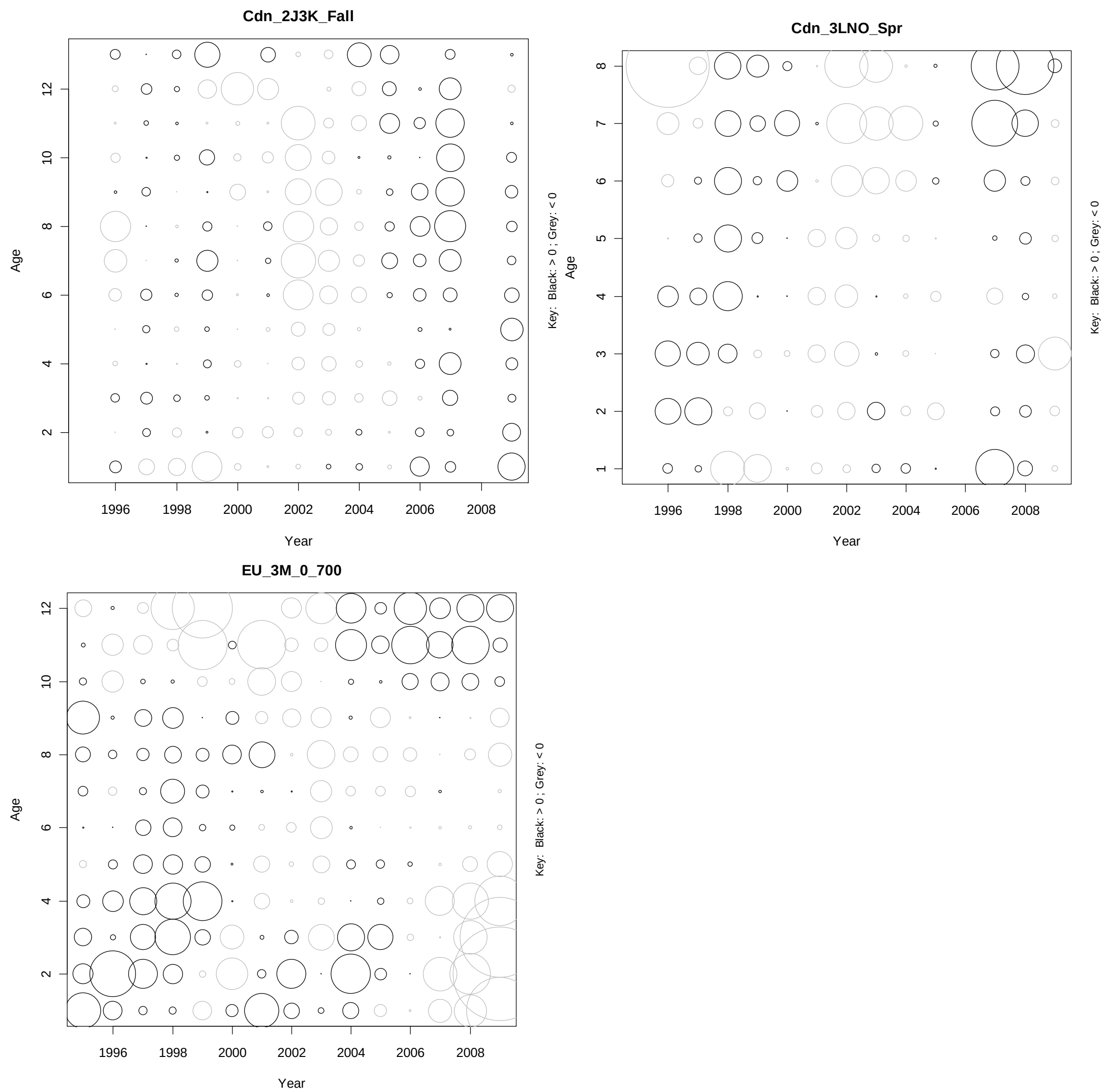


Figure 14c. XSA Residuals (update run; cont.) Black=positive residual; grey=negative residual. Symbols are scaled to the overall maximum residual to permit comparisons across survey series.

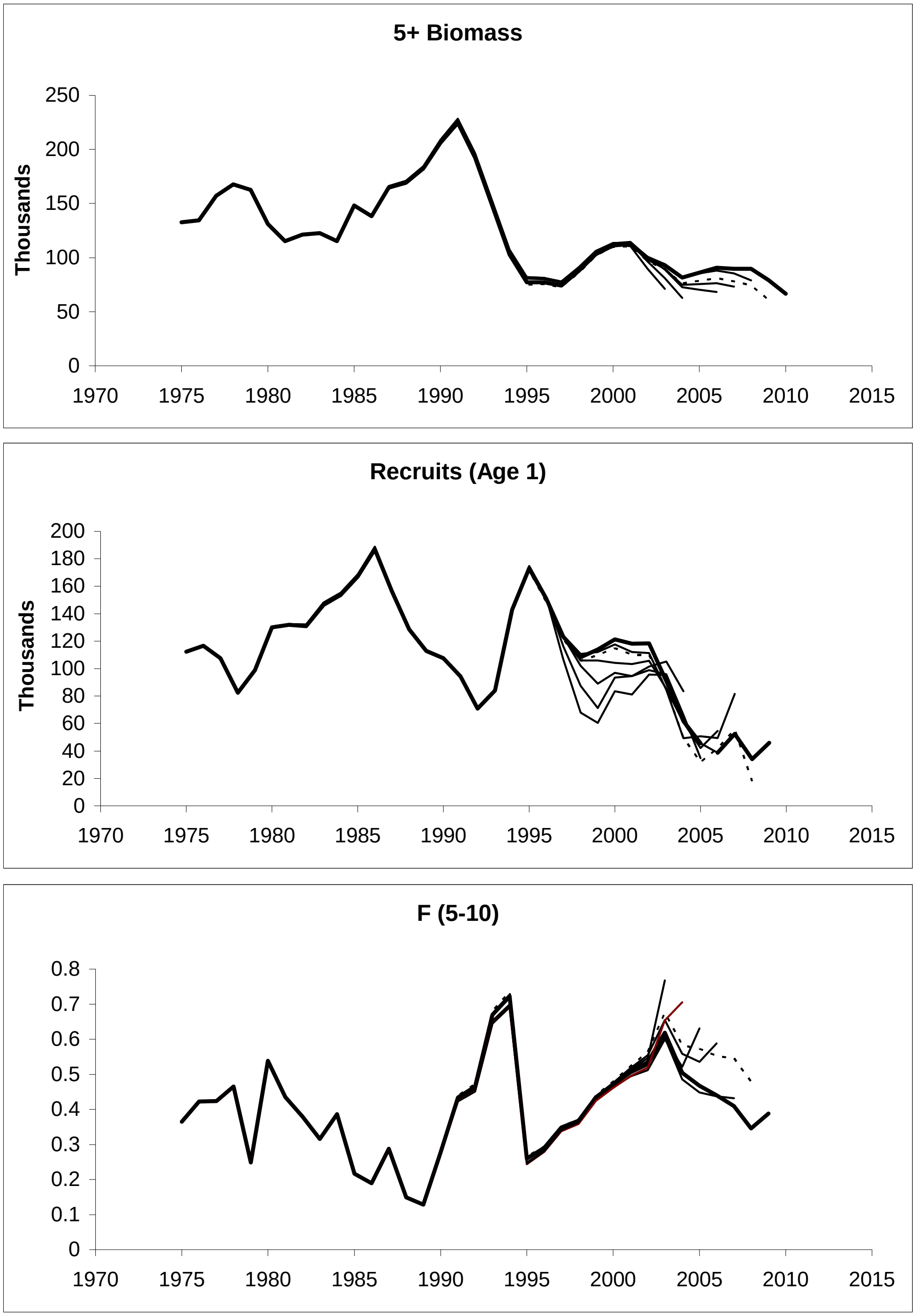


Figure 15. Retrospective Analysis, update run – 5+ biomass (t), Age 1 recruitment (000s) and average fishing mortality (ages 5-10). Bold lines highlight the current assessment. Results from the one-year retrospective (dashed line) are difficult to interpret due to the missing 2008 Canadian fall survey data. Refer to Healey and Mahé (2009) for further detail.

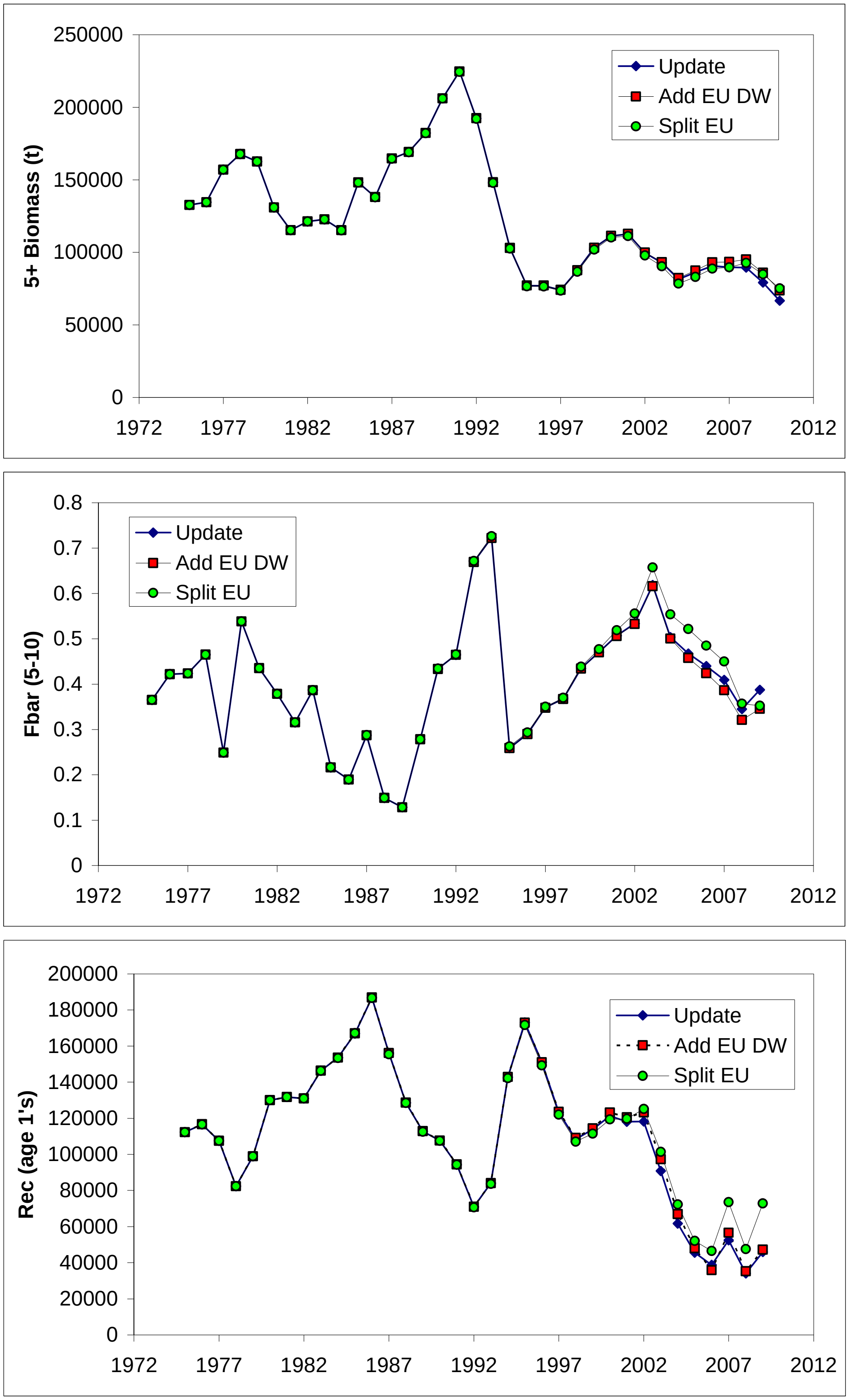


Figure 16. Comparison of updated run, an XSA analysis which adds the EU 3M data from 700-1400m depth over 2004-2009 to the calibration dataset ("Add EU DW") and an XSA analysis which splits the EU survey information, using data from 0-700m over 1995-2003, and data from 0-1400m over 2004-2009.

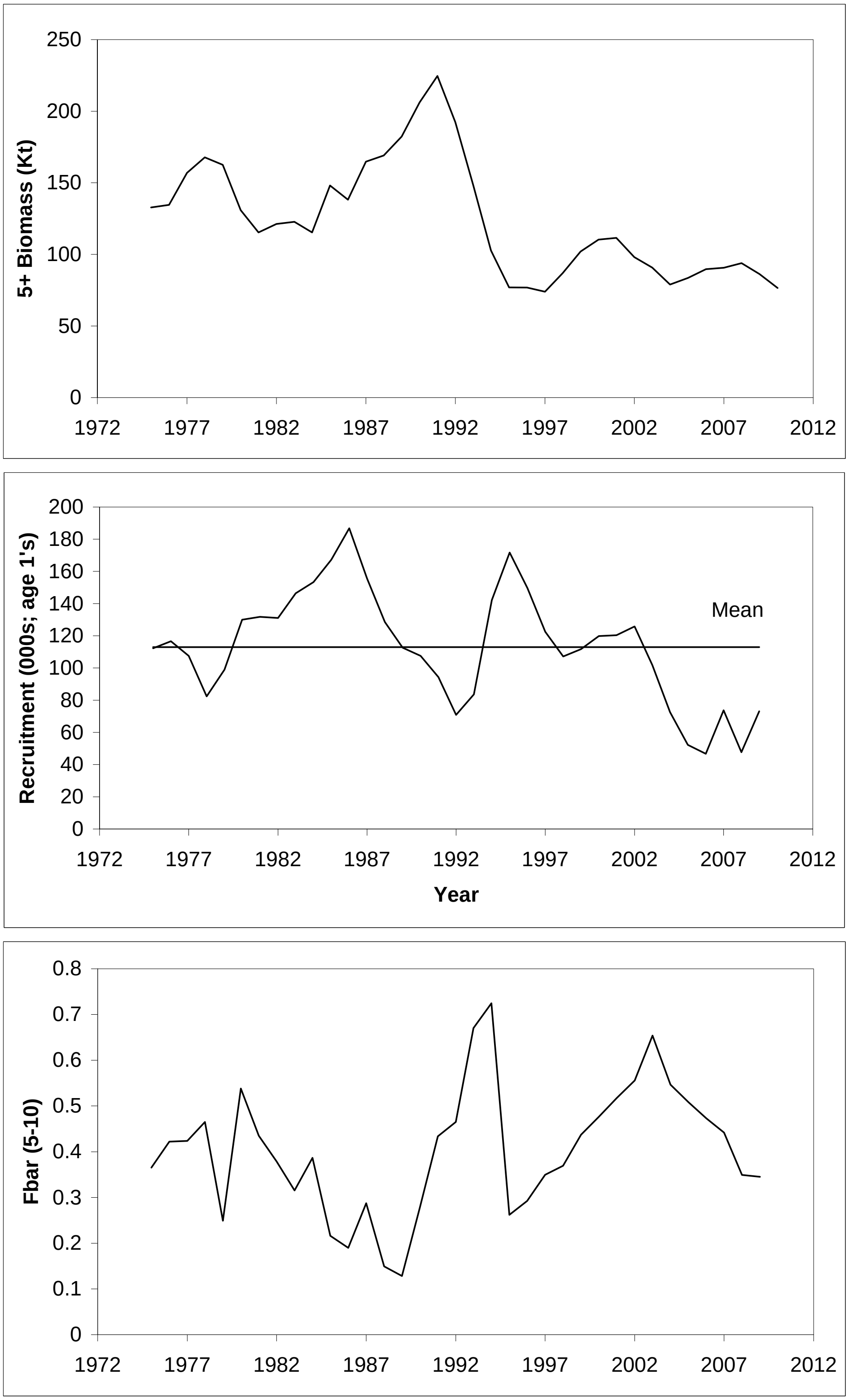


Figure 17. XSA estimates of exploitable biomass (ages 5+ in tons; upper panel), average fishing mortality (ages 5-10) and recruitment (000's at age 1) for Greenland Halibut in Sub-Area 2 and Divisions 3KLMNO. The EU survey data is split in two periods, and age 13 data from the deep water series is included.

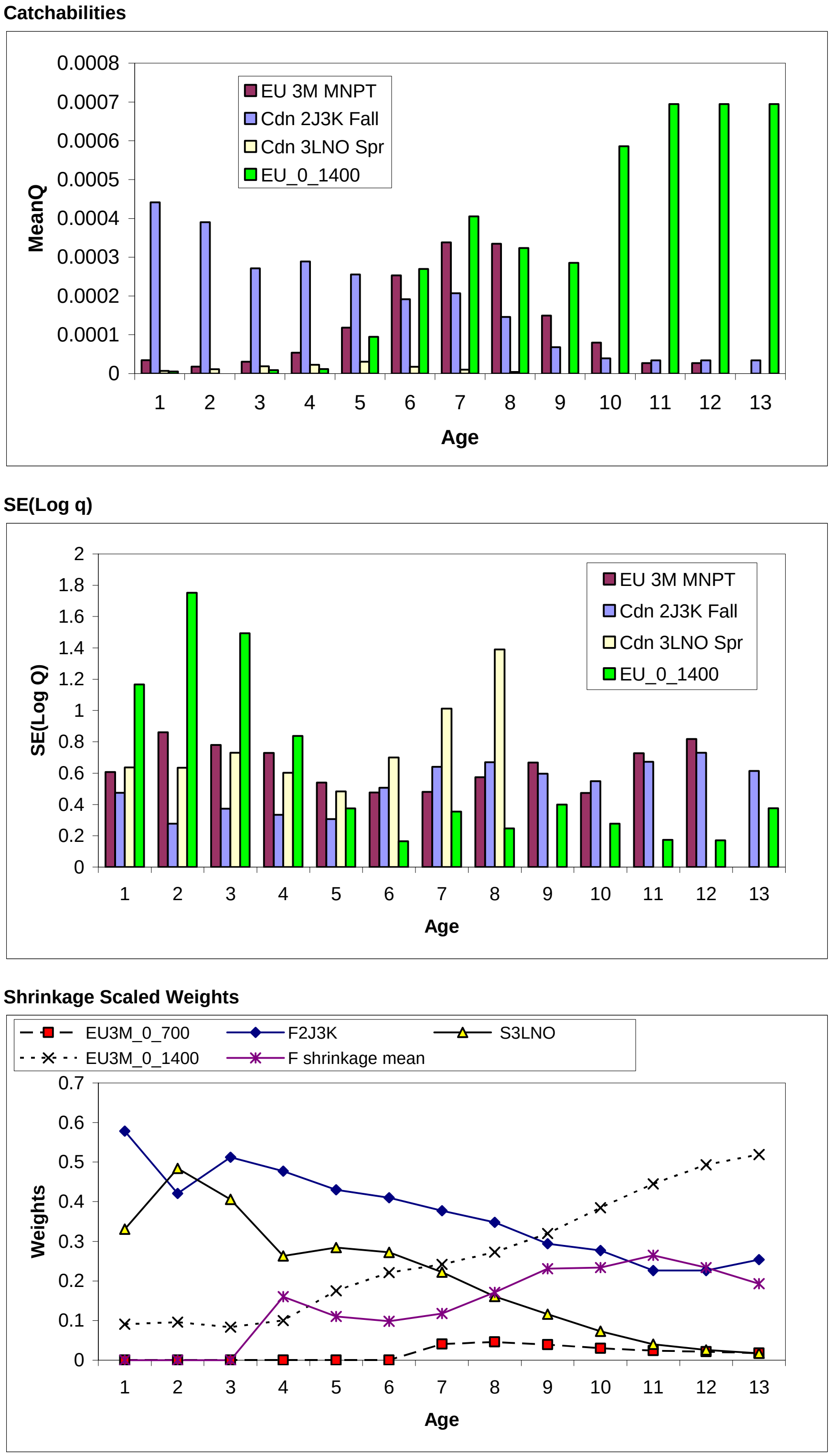


Figure 18. XSA (split EU run) estimated catchabilities, associated standard errors, and the scaled weights used to estimate survivors in the terminal year.

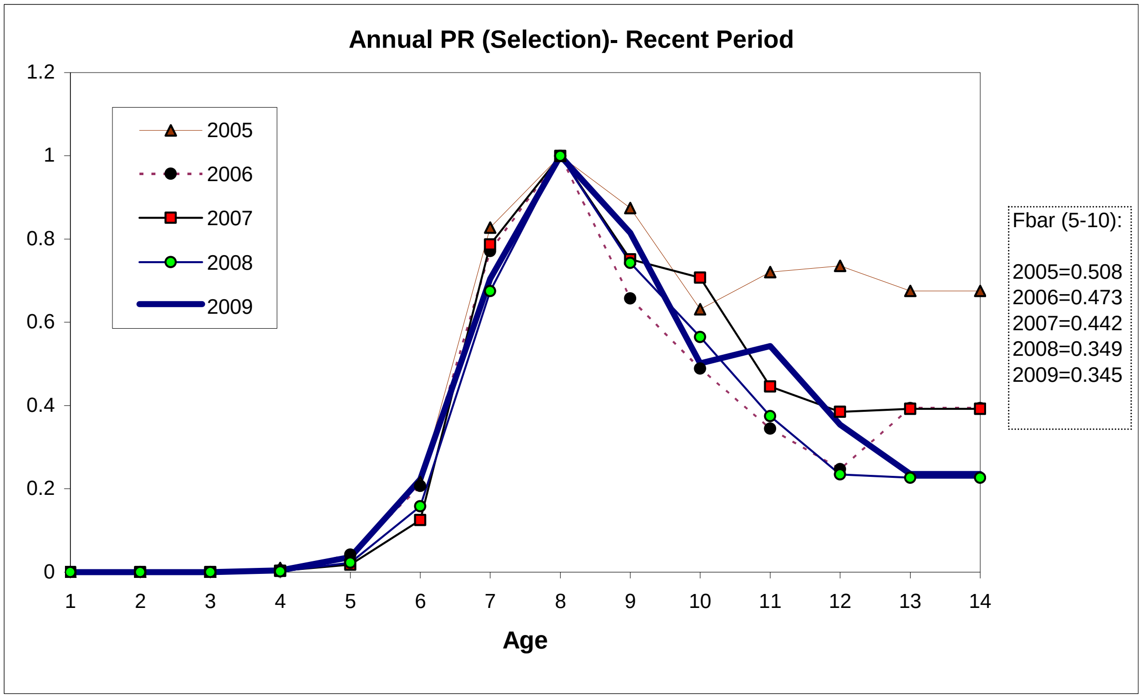


Figure 19. XSA (split EU run) estimated selection pattern in the most recent five years.

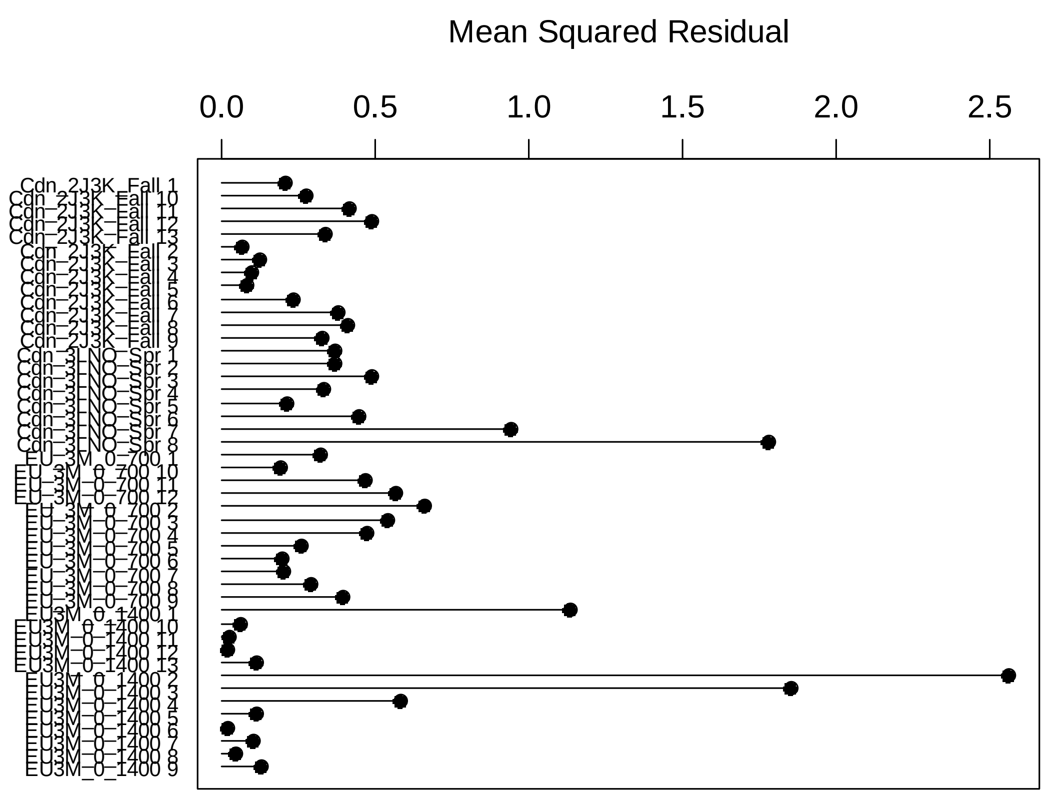


Figure 20a. Mean square residuals from XSA (split EU run) for each survey-age.

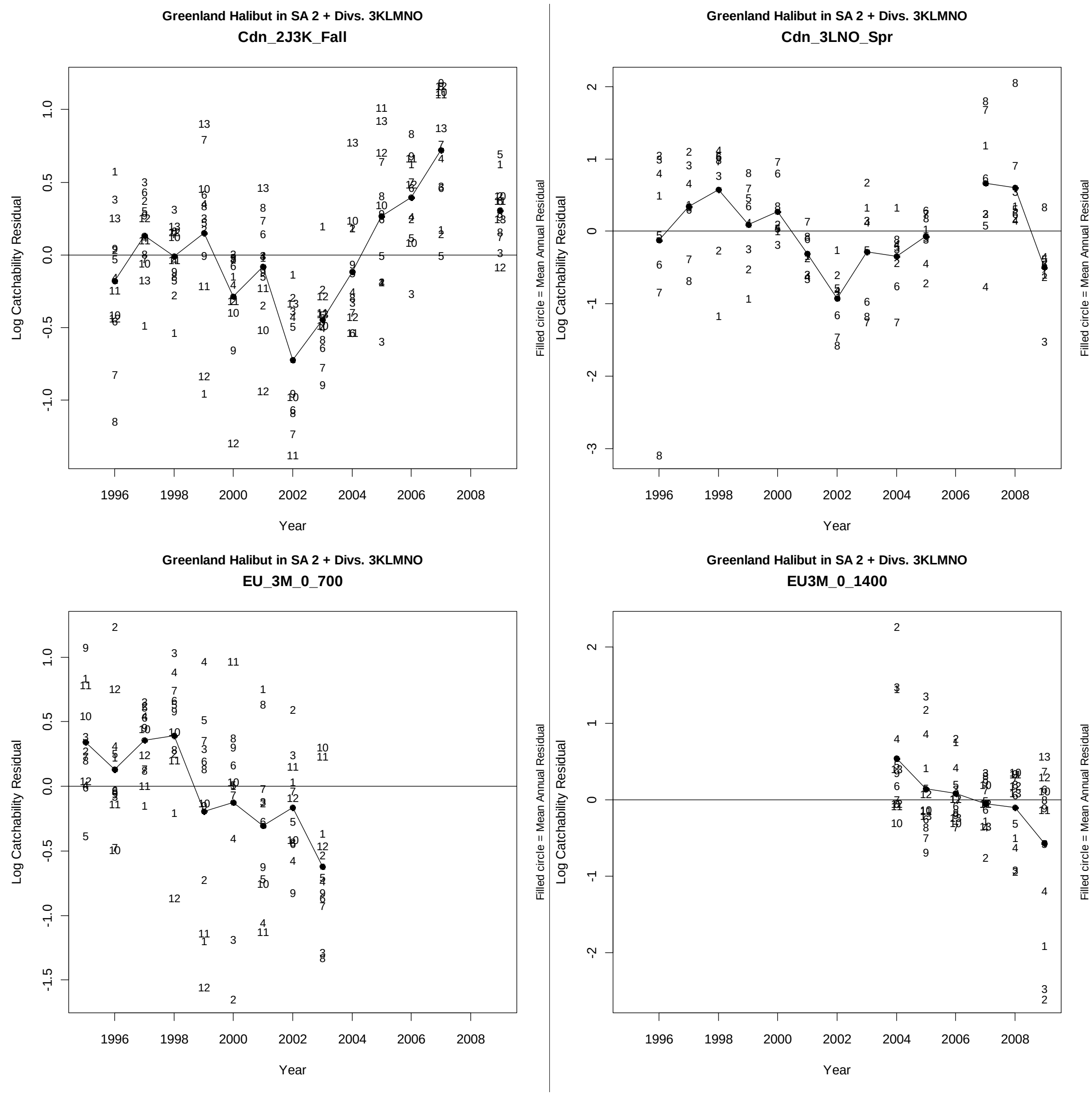


Figure 20b. XSA (split EU run) residuals by survey, age and year. Symbol=age, solid circle=mean annual residual.

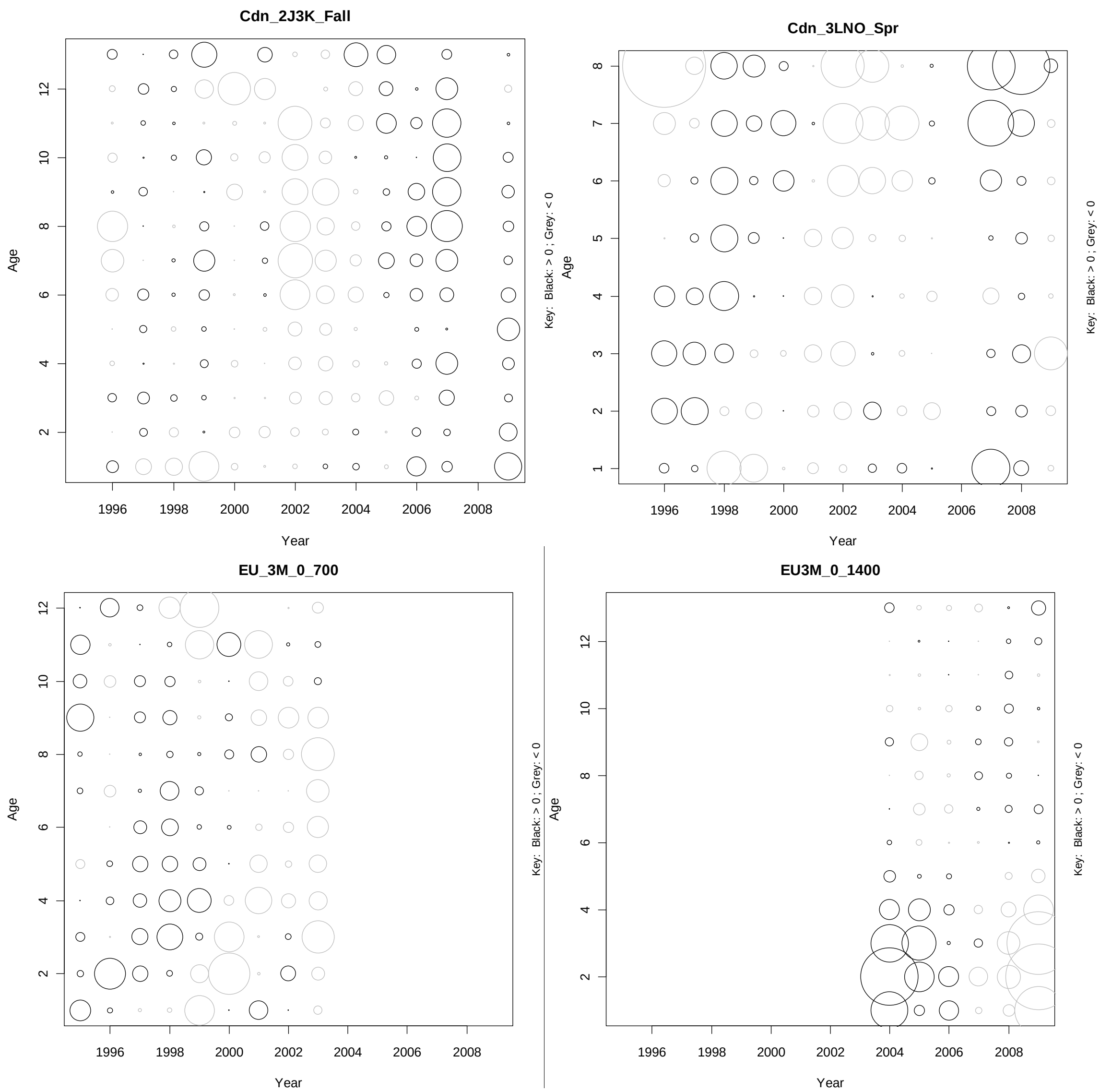


Figure 20c. XSA Residuals (split EU run) Black=positive residual; grey=negative residual. Symbols are scaled to the overall maximum residual to permit comparisons across survey series.

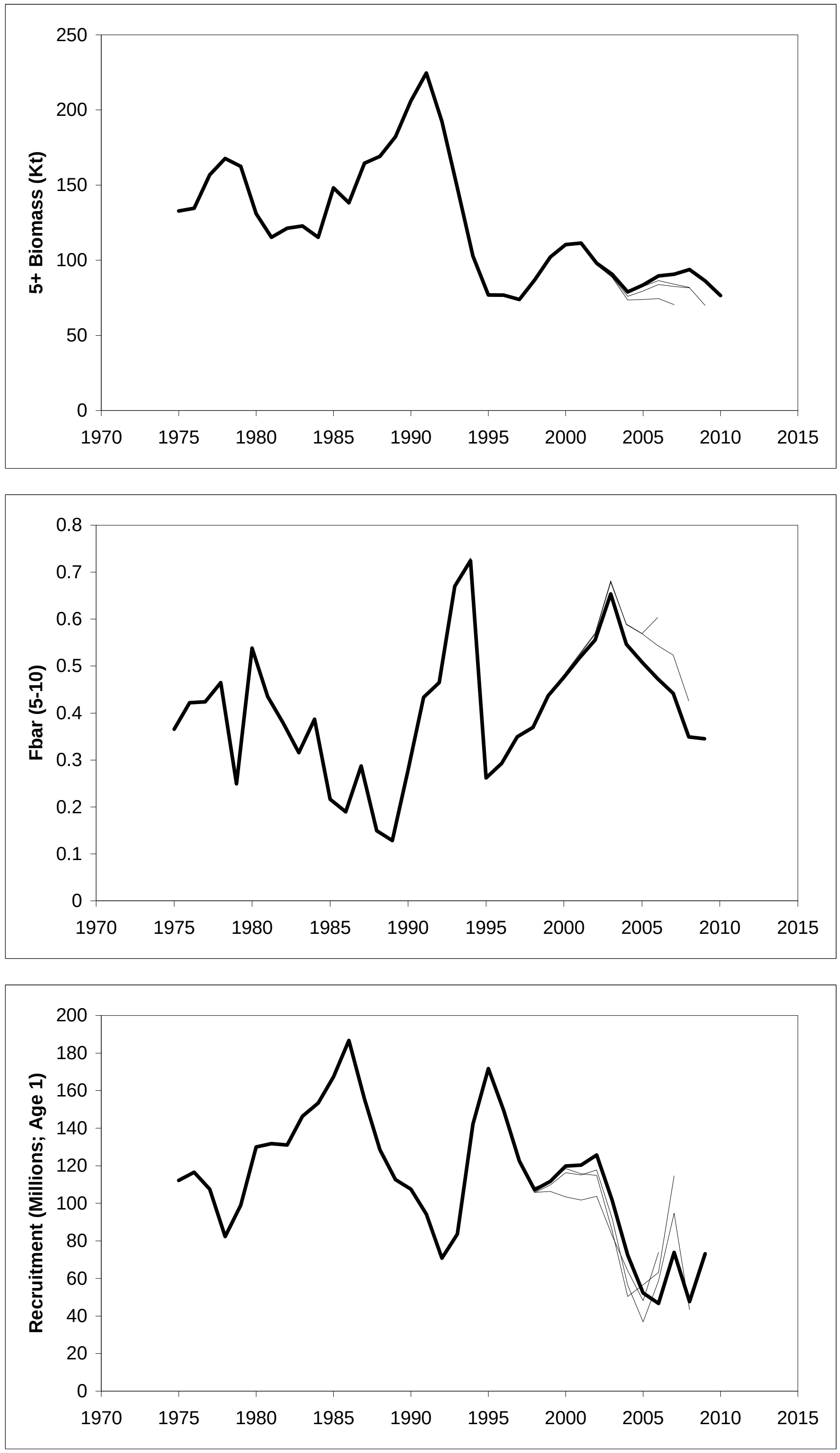


Figure 21. Biomass, Average Fishing Mortality and Recruitment retrospective for “split EU” XSA run. Bold lines indicate the assessment for the current year.

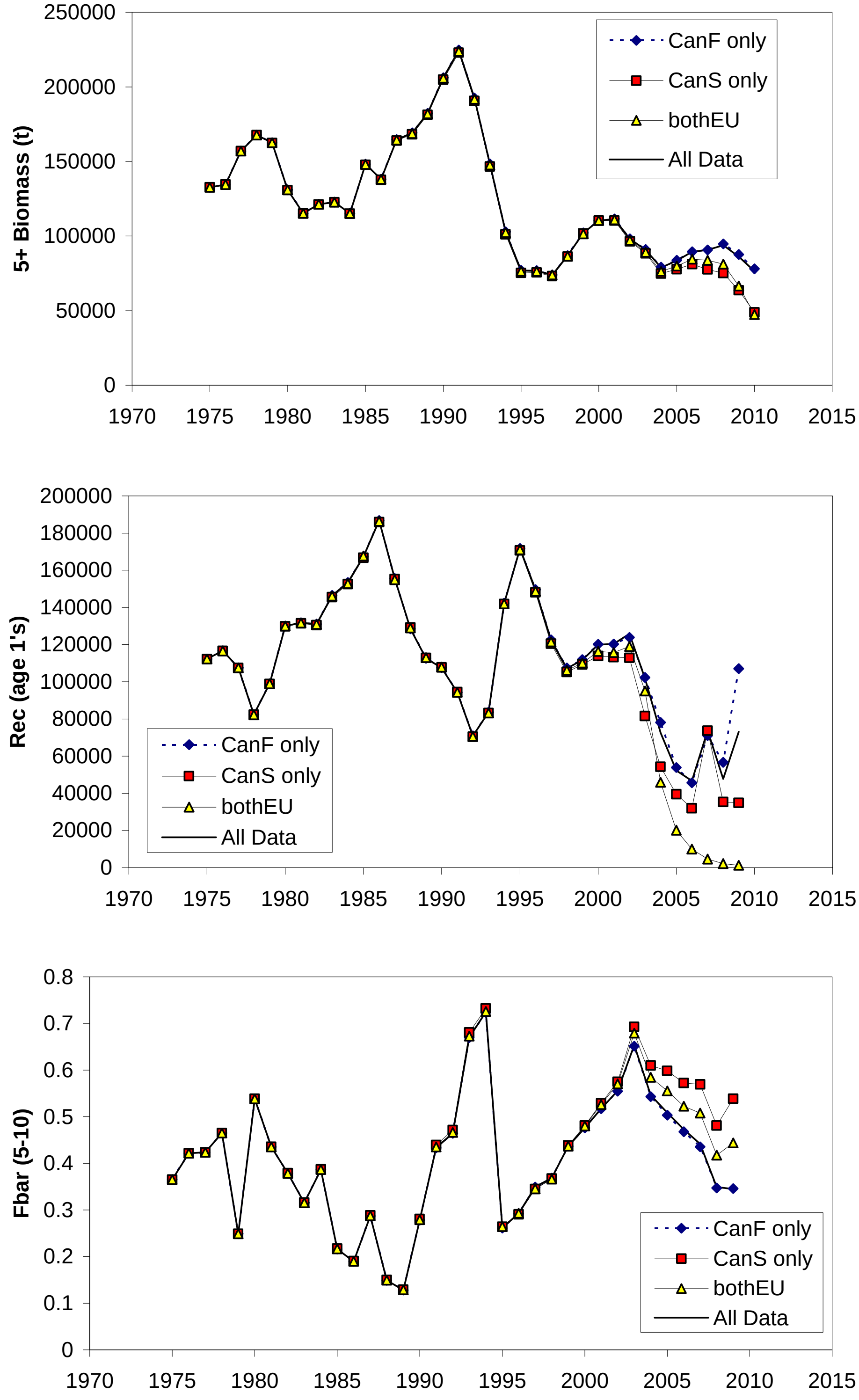


Figure 22. Biomass (5+; tons), Recruitment (age 1; 000s), and average fishing mortality (ages 5-10) from XSA analyses which ***include*** only the survey series identified by the series label. The "All Data" series results use all of the data series.

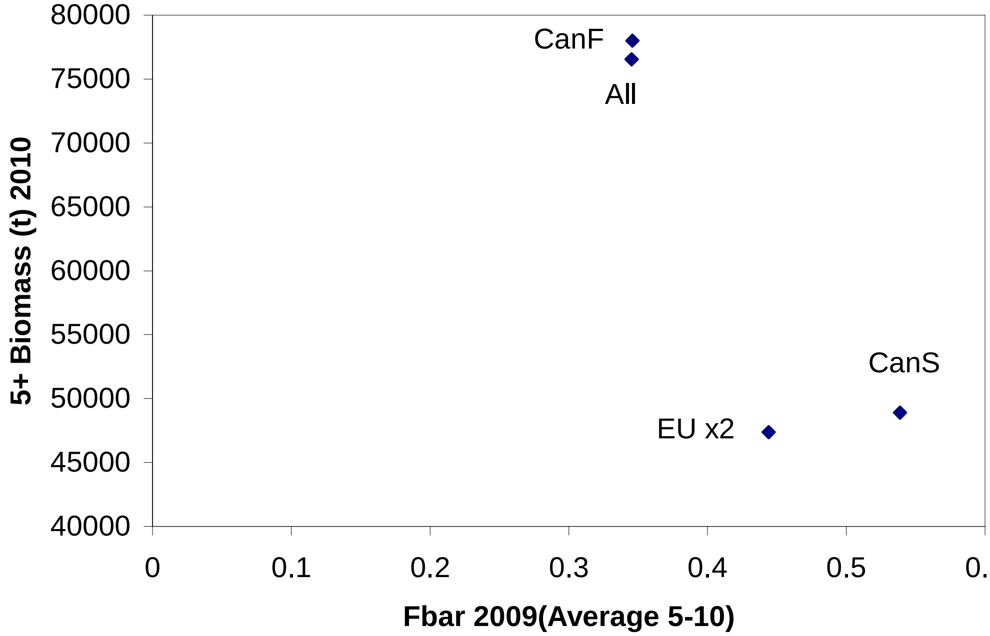


Figure 23. Comparison of exploitable biomass in 2010 and fishing mortality in 2009 for XSA results produced by ***including*** only the named survey series in the analysis. “All” refers to the analysis which includes all four data series.

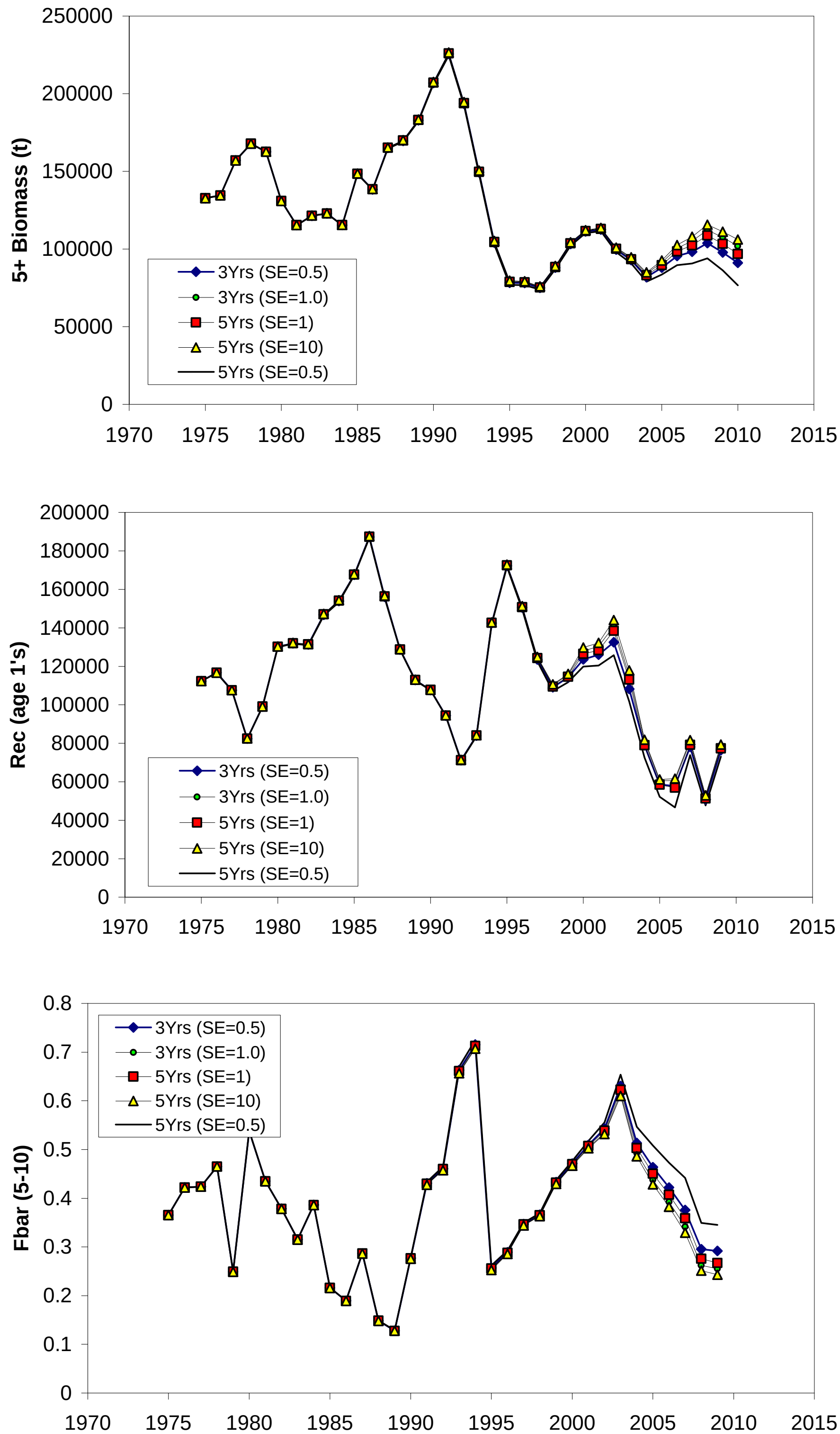


Figure 24. Biomass (5+; tons), Recruitment (age 1; 000s), and average fishing mortality (ages 5-10) from XSA analyses using varied shrinkage options: legend identifies the number of years and log standard error parameters (lower SE values imply stronger shrinkage) used compute the mean F for each age to which estimates of survivors are shrunk towards.

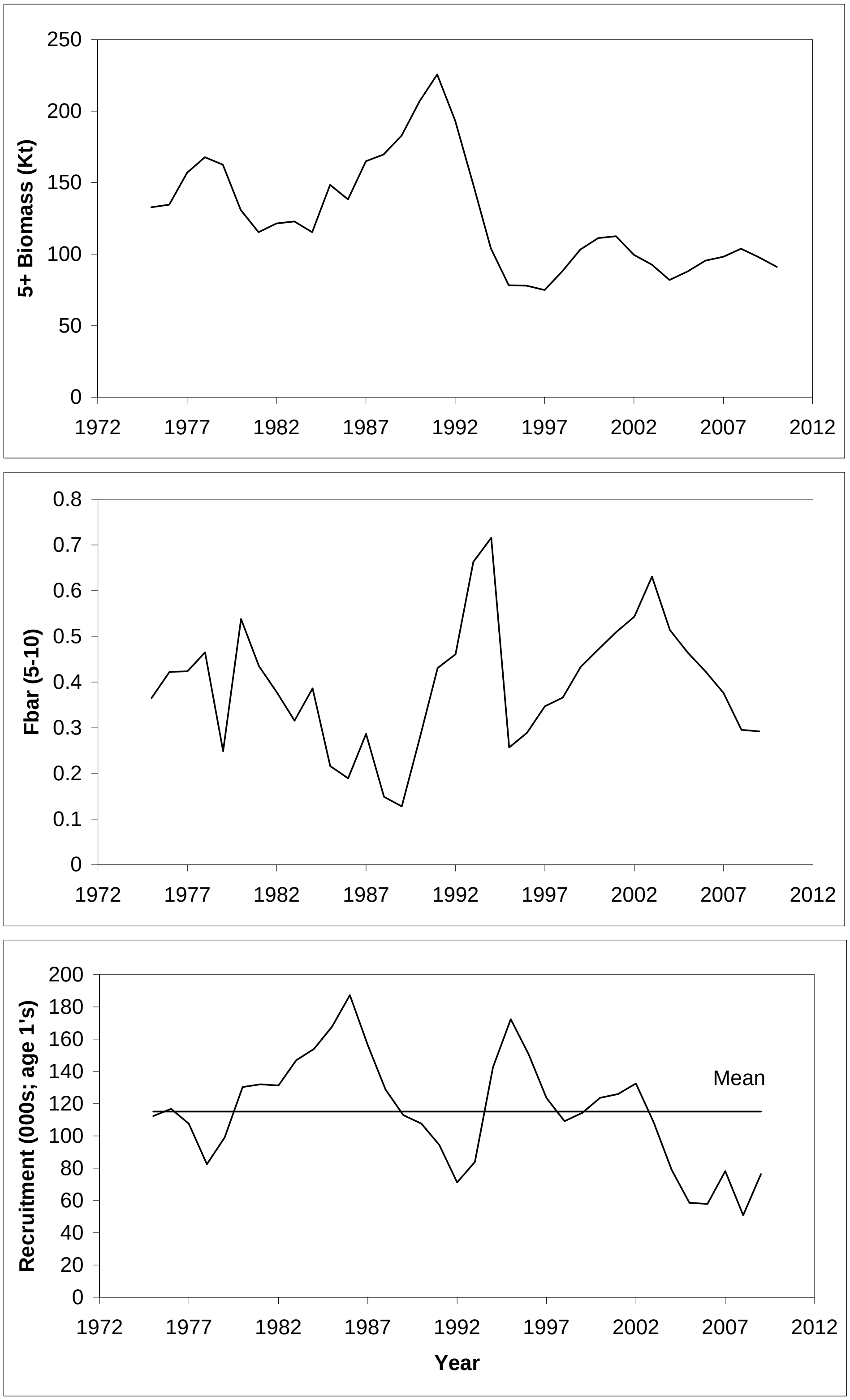
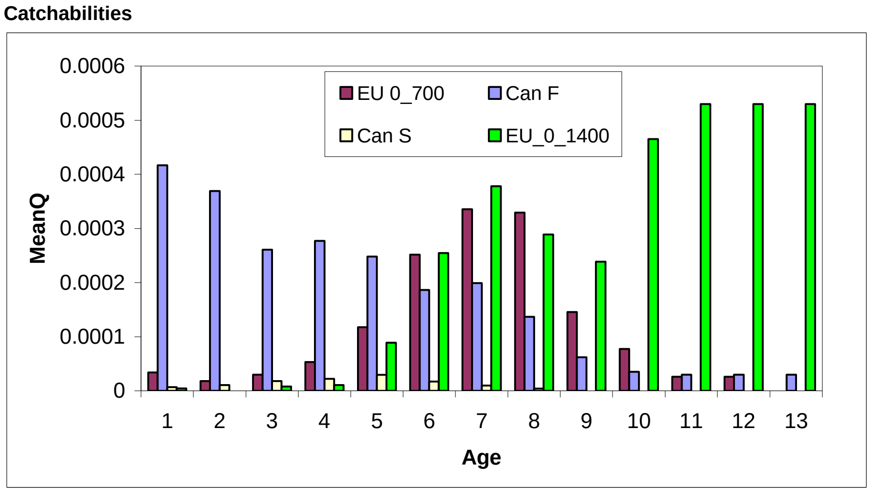
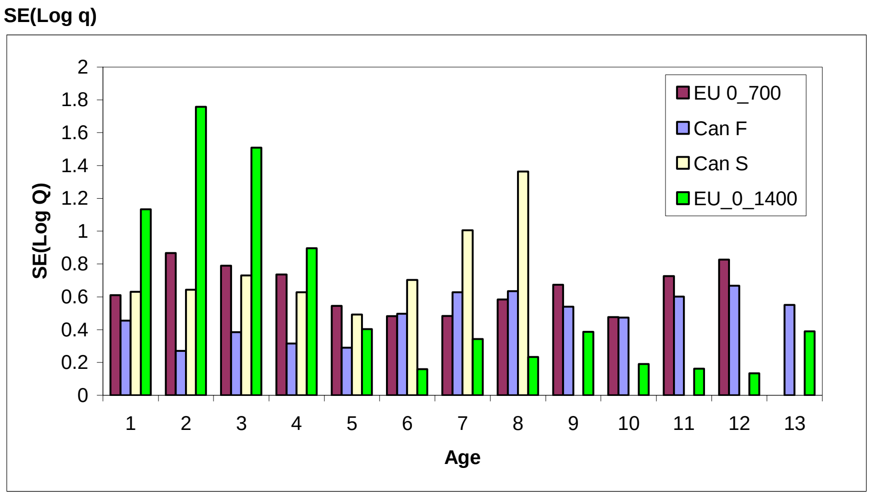


Figure 25. XSA run with reduced shrinkage (3Years, log(SE)=0.5). Estimates of exploitable biomass (ages 5+ in tons), average fishing mortality (ages 5-10) and recruitment (000s at age 1) for Greenland Halibut in Sub-Area 2 and Divisions 3KLMNO.





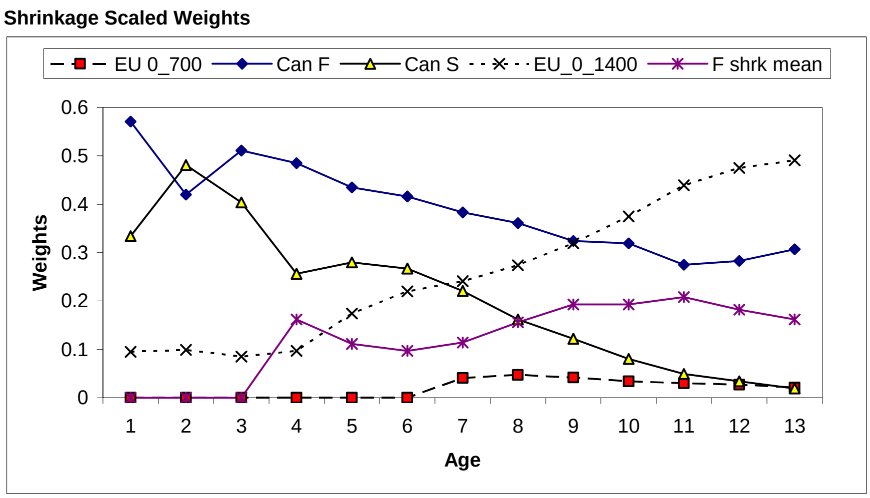


Figure 26. XSA run with reduced shrinkage (3Years, log(SE)=0.5). Estimated catchabilities, associated standard errors, and the scaled weights used to estimate survivors in the terminal year.

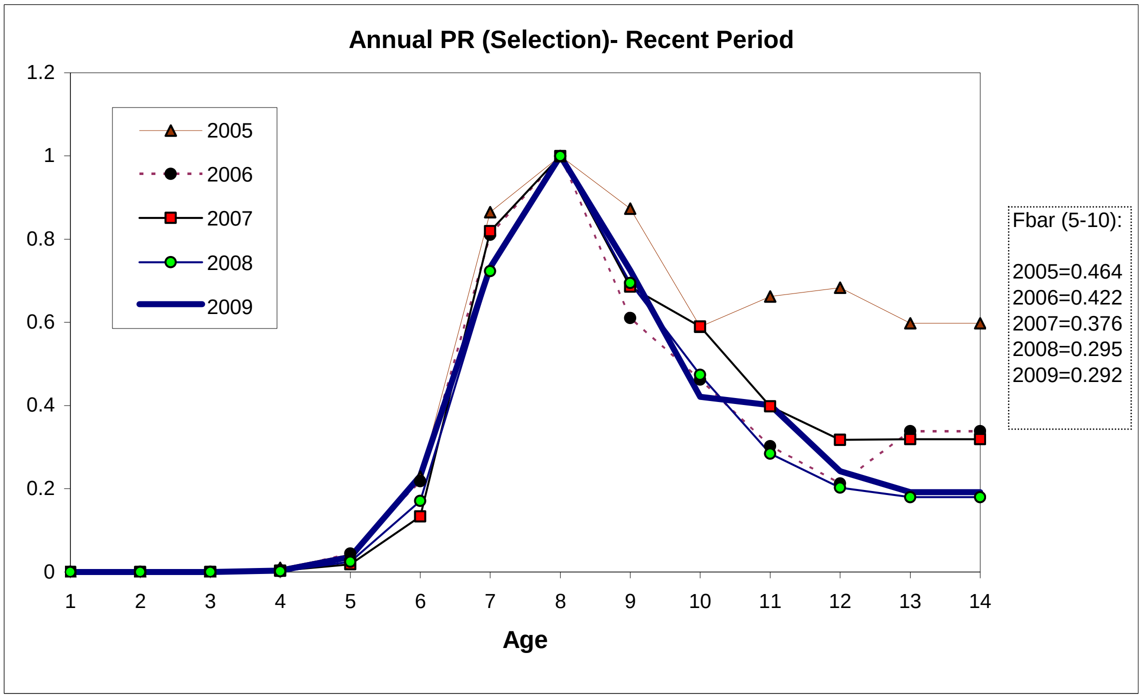


Figure 27. XSA run with reduced shrinkage (3Years, log(SE)=0.5). Estimated selection pattern in the most recent five years.

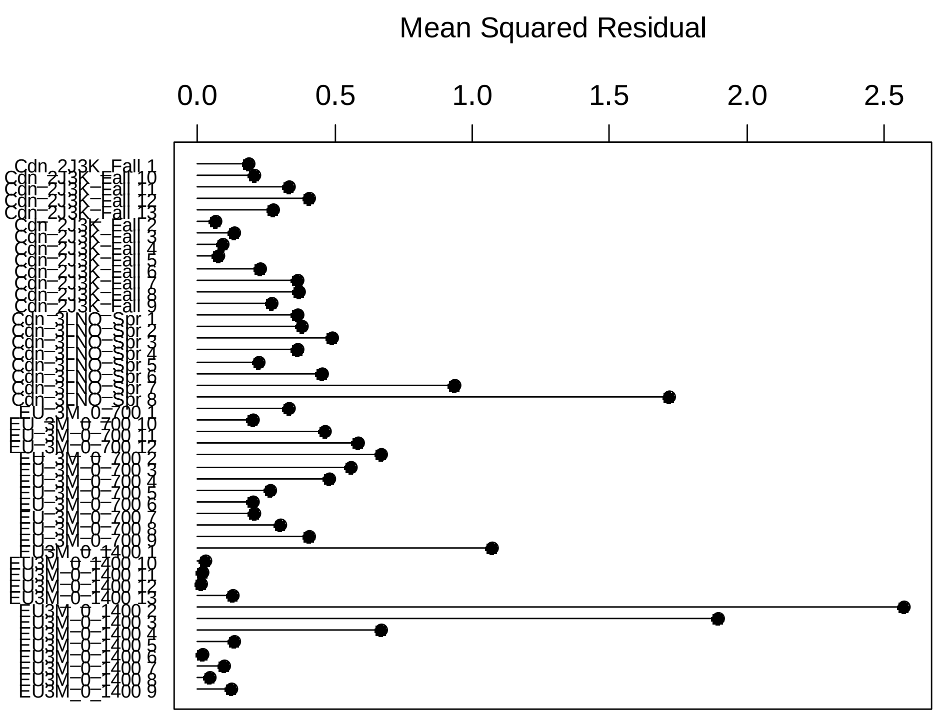


Figure 28a. Mean square residual at each survey-age from XSA run with reduced shrinkage (3Years, log(SE)=0.5).

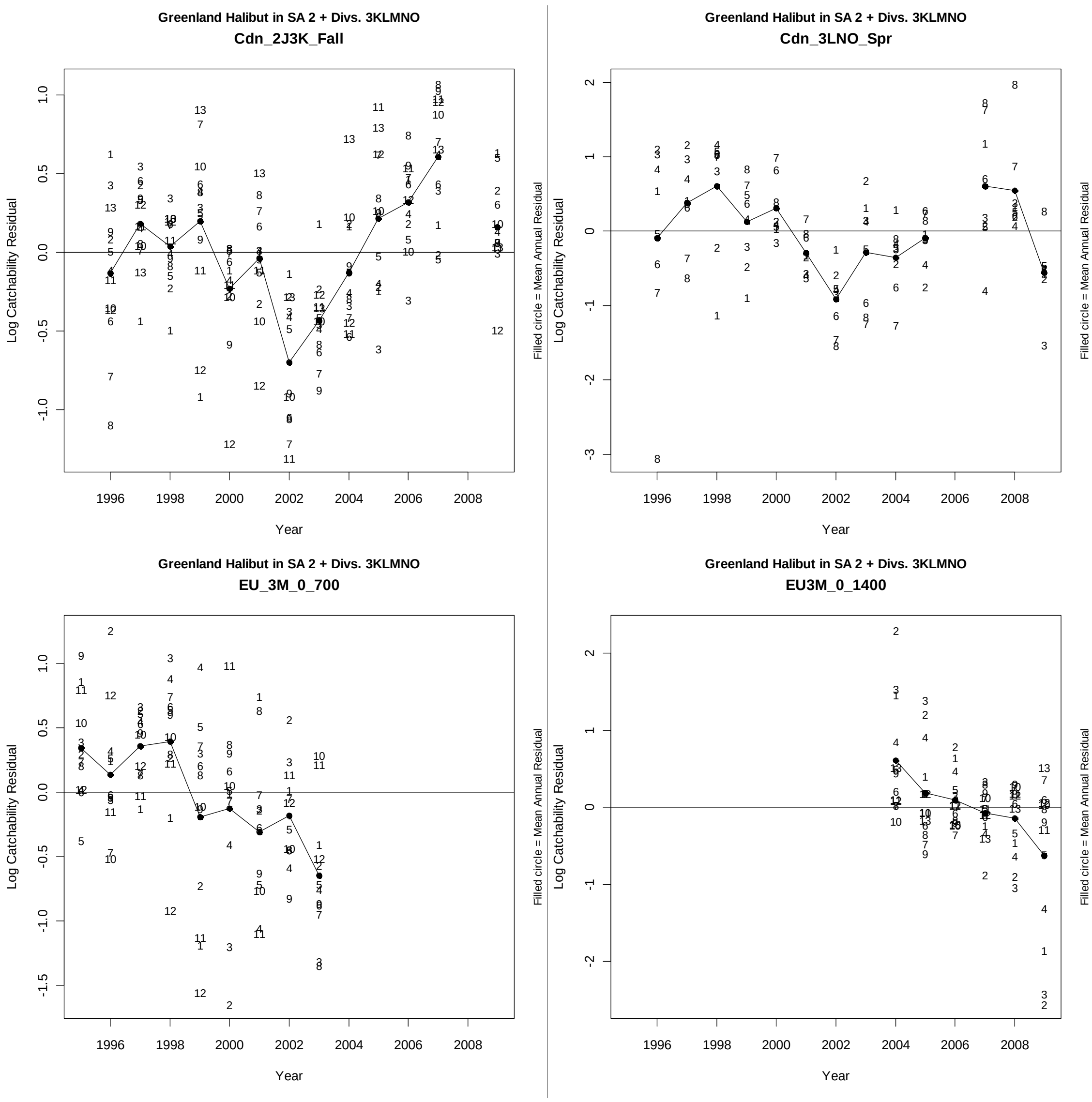


Figure 28b. XSA run with reduced shrinkage (3Years, log(SE)=0.5). Residuals by survey, age and year. Symbol=age, solid circle=mean annual residual.

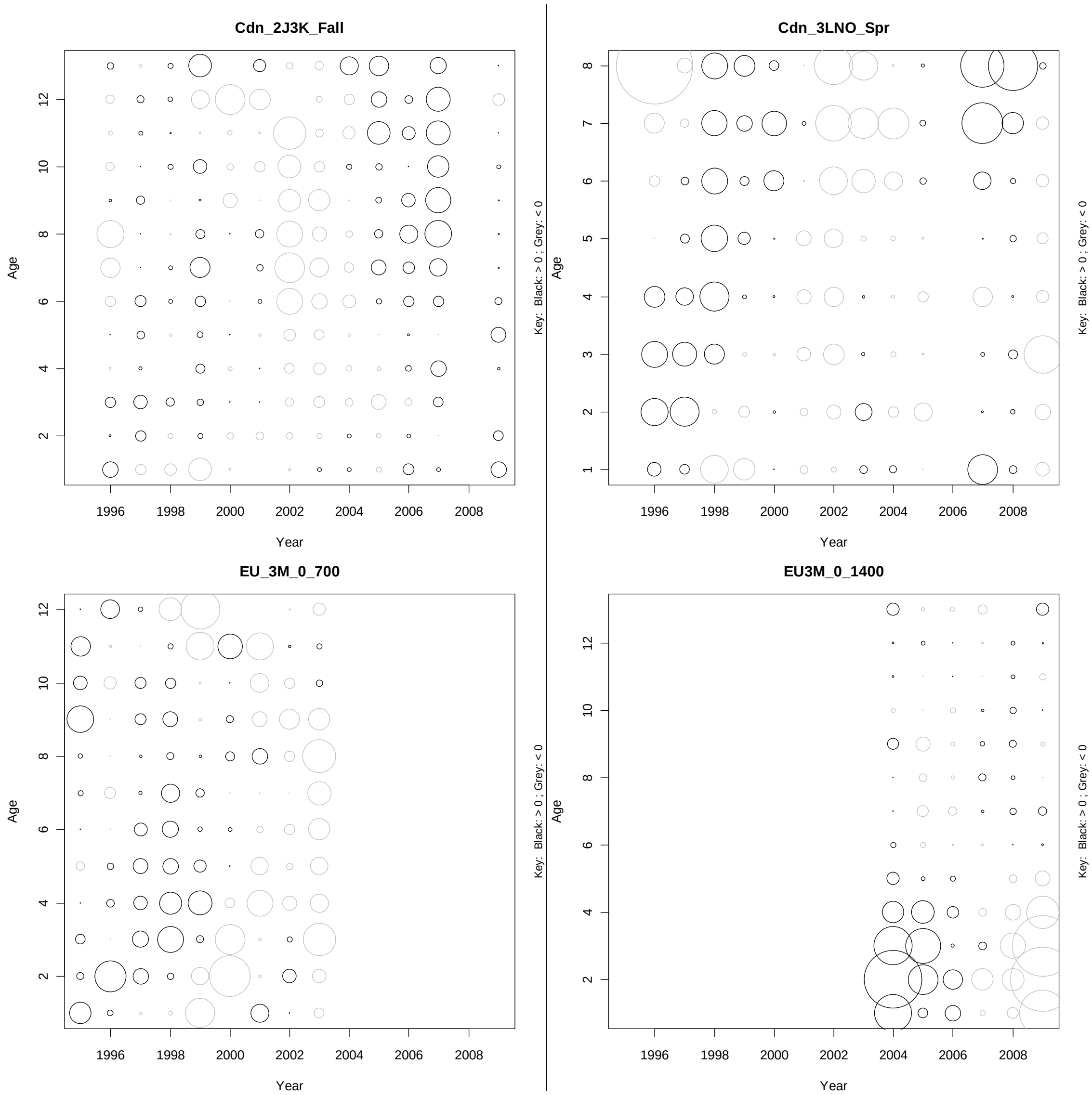
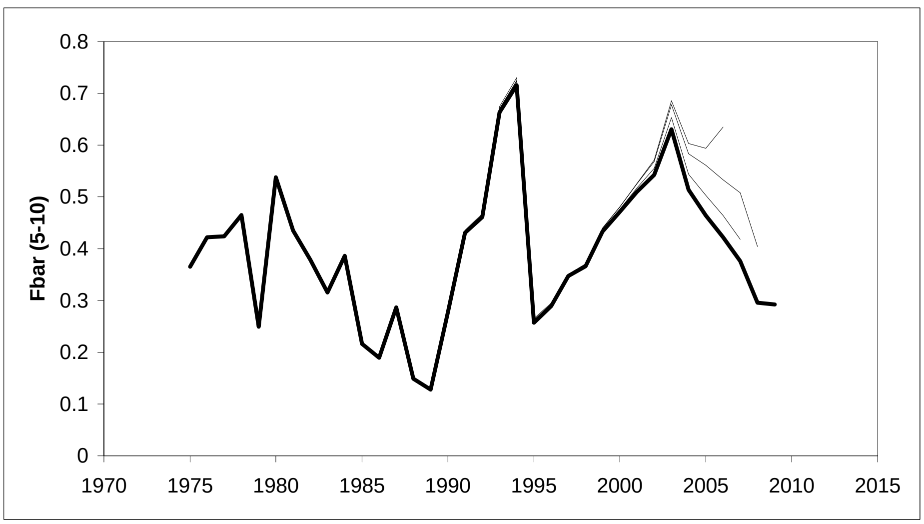


Figure 28c. XSA run with reduced shrinkage (3Years, log(SE)=0.5) – residual bubble plots. Black=positive residual; grey=negative residual. Symbols are scaled to the overall maximum to permit comparisons across survey series.



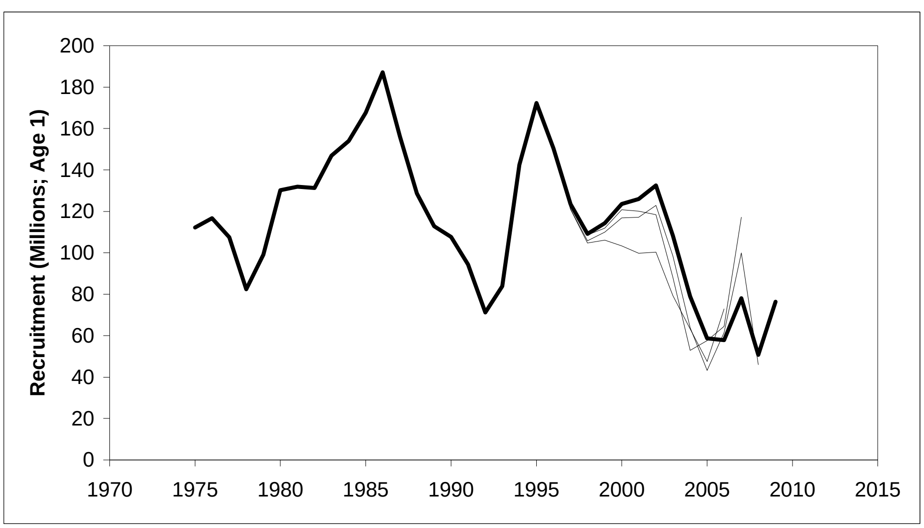


Figure 29. Biomass, Average Fishing Mortality and Recruitment retrospective for XSA run with reduced shrinkage (3Years, log(SE)=0.5). Bold lines indicate the assessment for the current year.

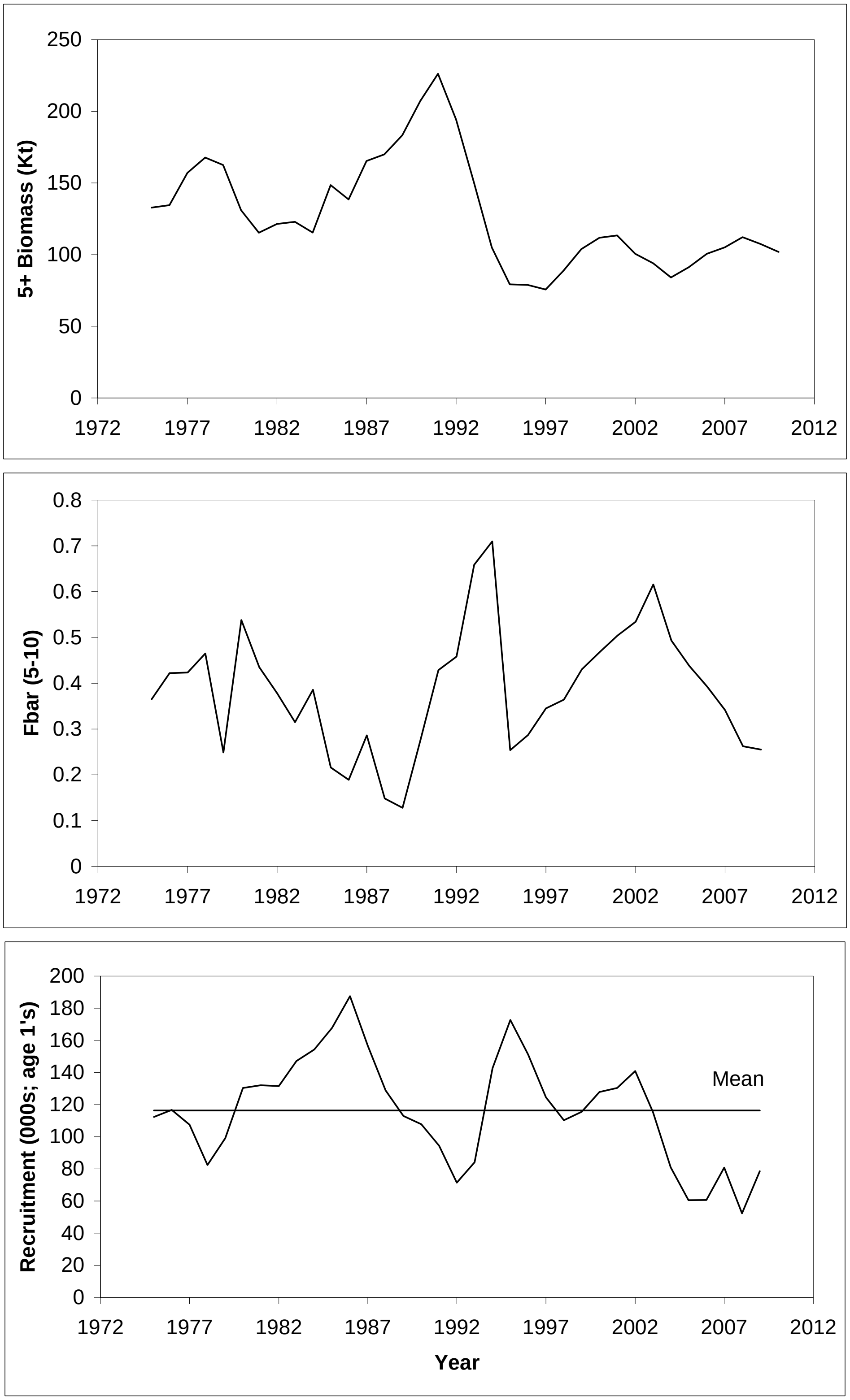
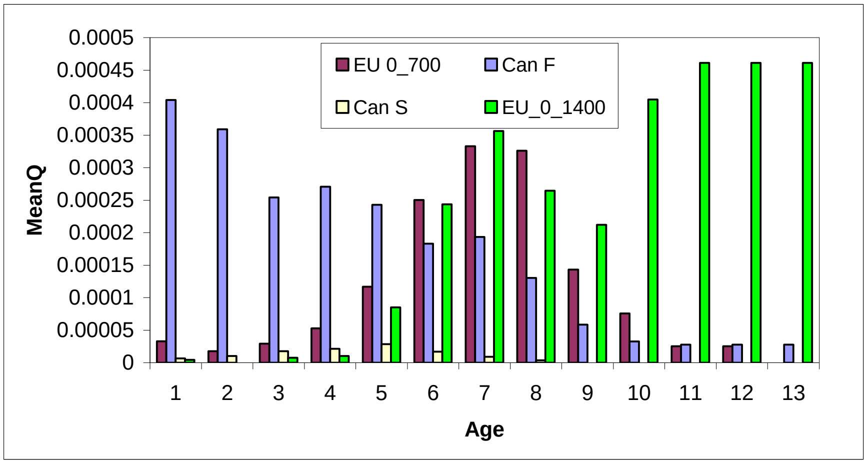
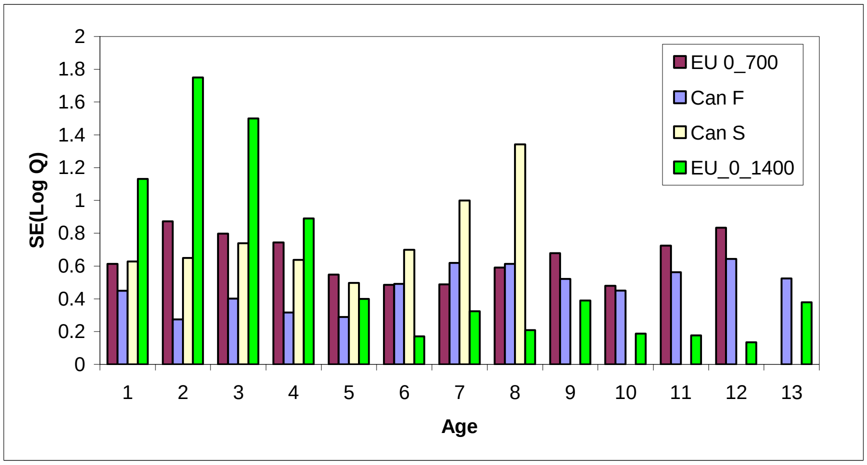


Figure 30. XSA run with reduced shrinkage (3Years, log(SE)=1.0). Estimates of exploitable biomass (ages 5+ in tons), average fishing mortality (ages 5-10) and recruitment (000s at age 1) for Greenland Halibut in Sub-Area 2 and Divisions 3KLMNO.

Catchabilities



SE(Log q)



Shrinkage Scaled Weights

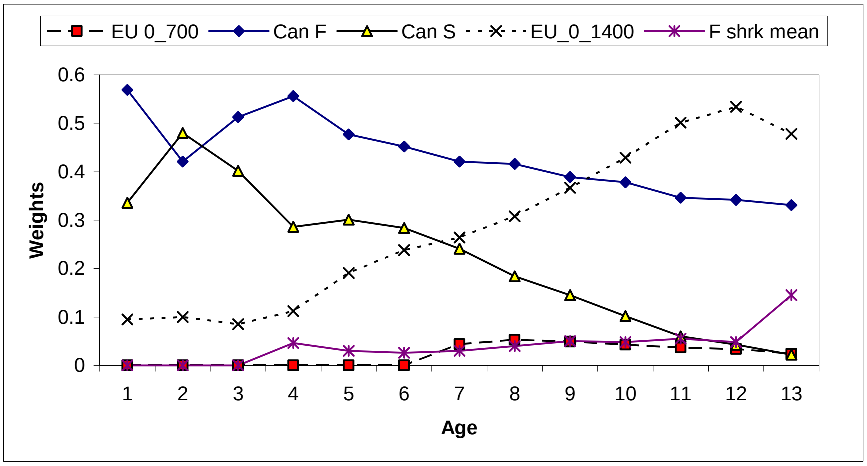


Figure 31. XSA run with reduced shrinkage (3Years, log(SE)=1.0). Estimated catchabilities, associated standard errors, and the scaled weights used to estimate survivors in the terminal year.

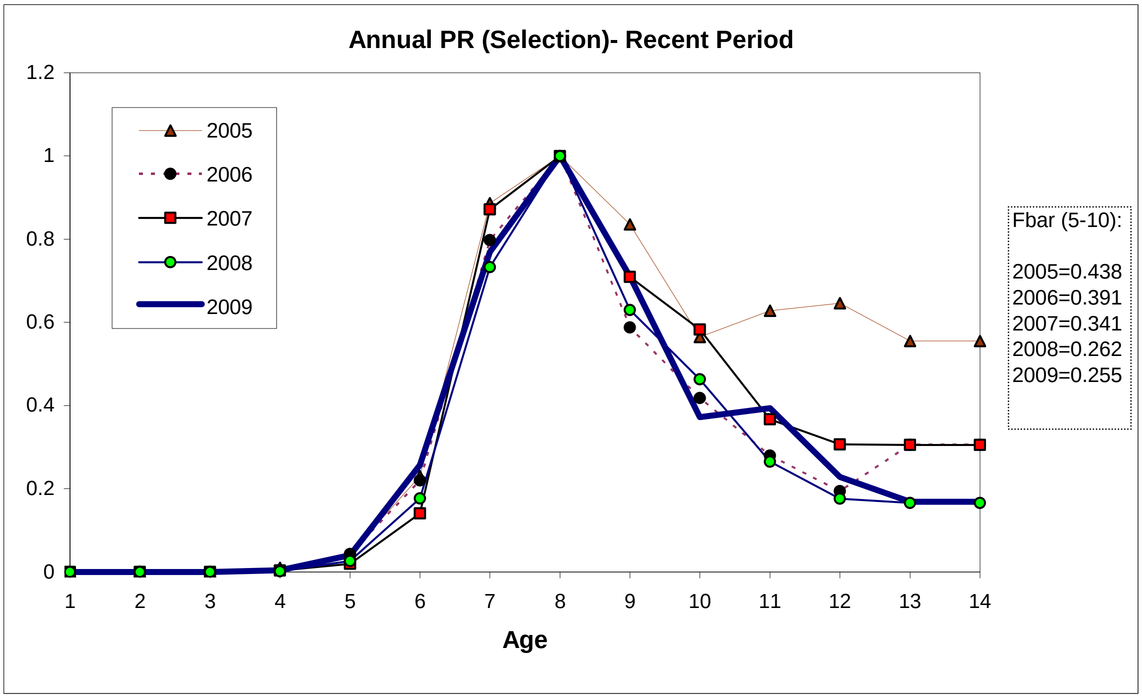


Figure 32. XSA run with reduced shrinkage (3Years, log(SE)=1.0). Estimated selection pattern in the most recent five years.

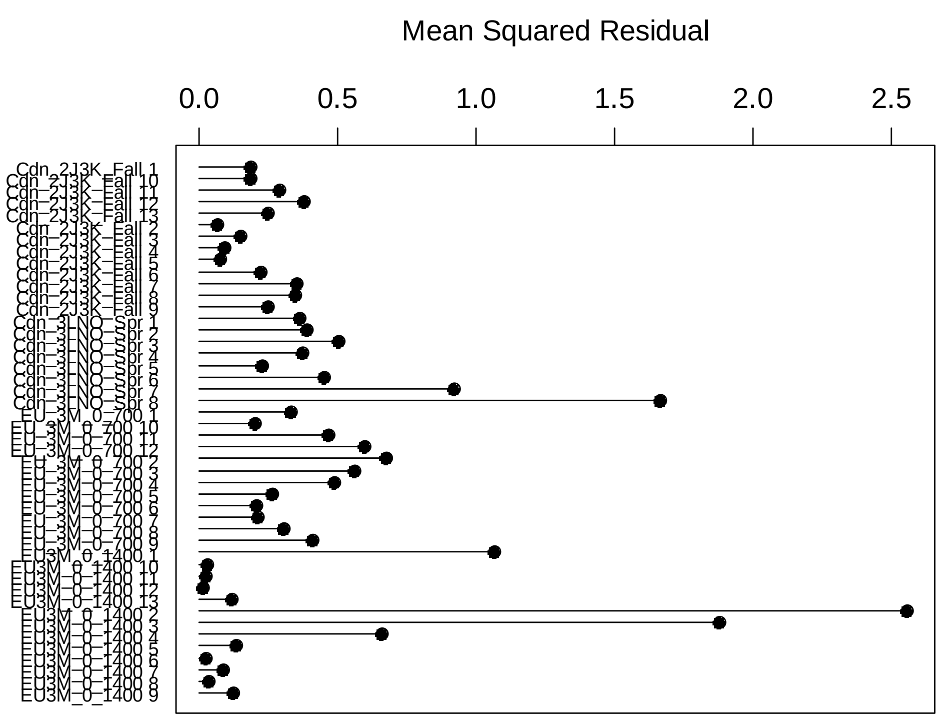


Figure 33a. Mean square residual at each survey-age from XSA run with reduced shrinkage (3Years, log(SE)=1.0).

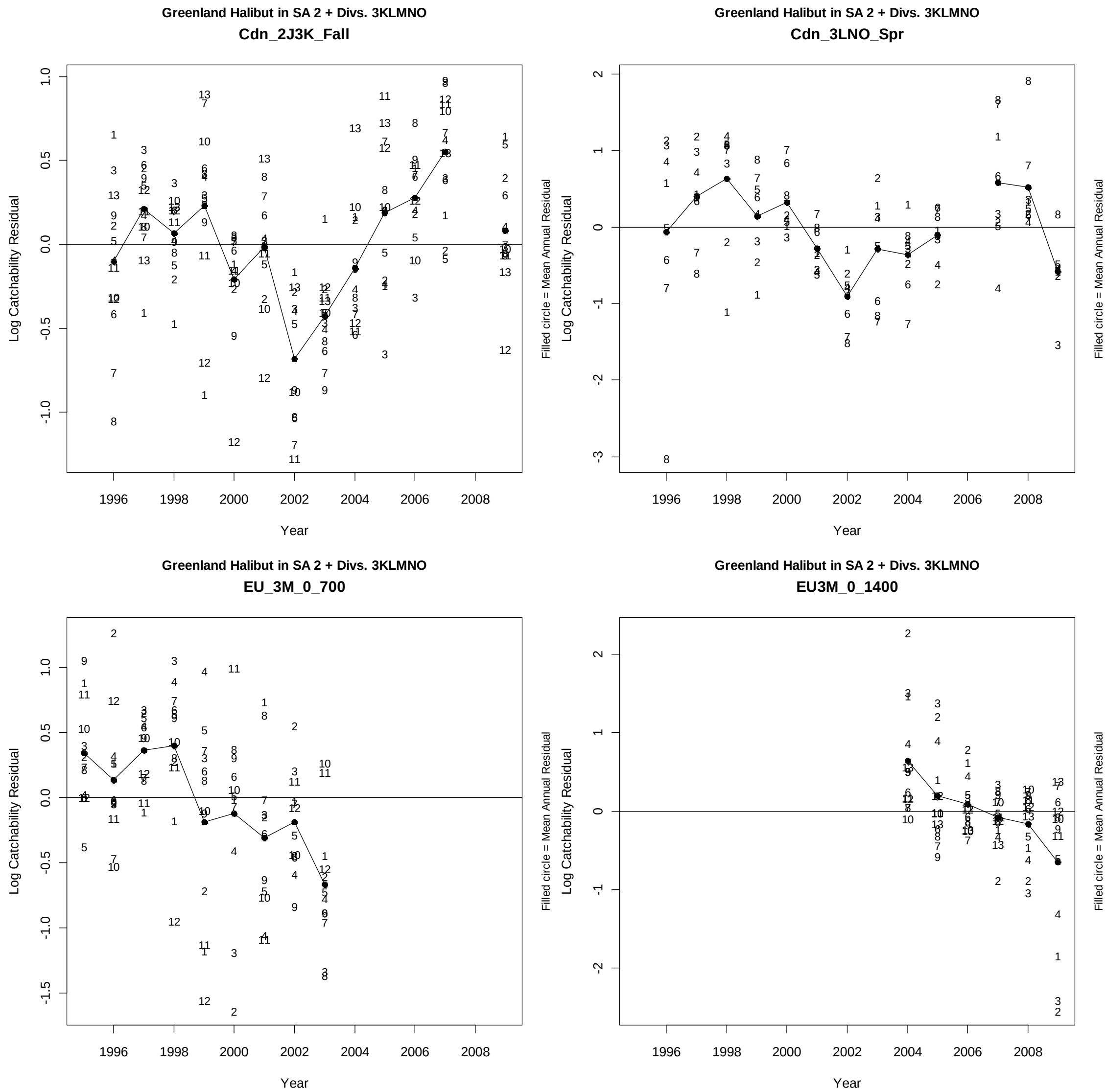


Figure 33b. XSA run with reduced shrinkage (3Years, log(SE)=1.0). Residuals by survey, age and year. Symbol=age, solid circle=mean annual residual.

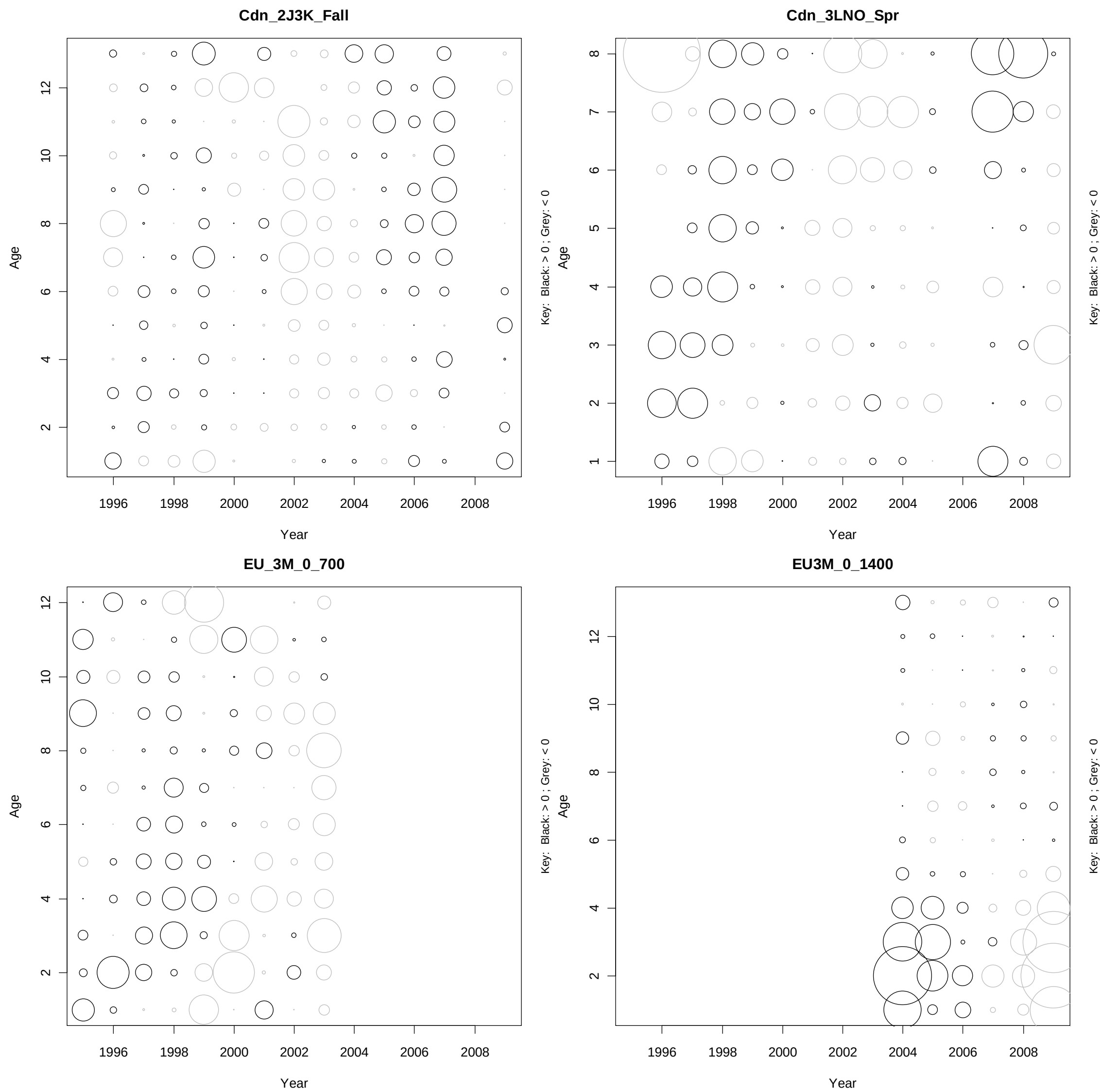


Figure 33c. XSA run with reduced shrinkage (3Years, log(SE)=1.0) – residual bubble plots. Black=positive residual; grey=negative residual. Symbols are scaled to the overall maximum to permit comparisons across survey series.

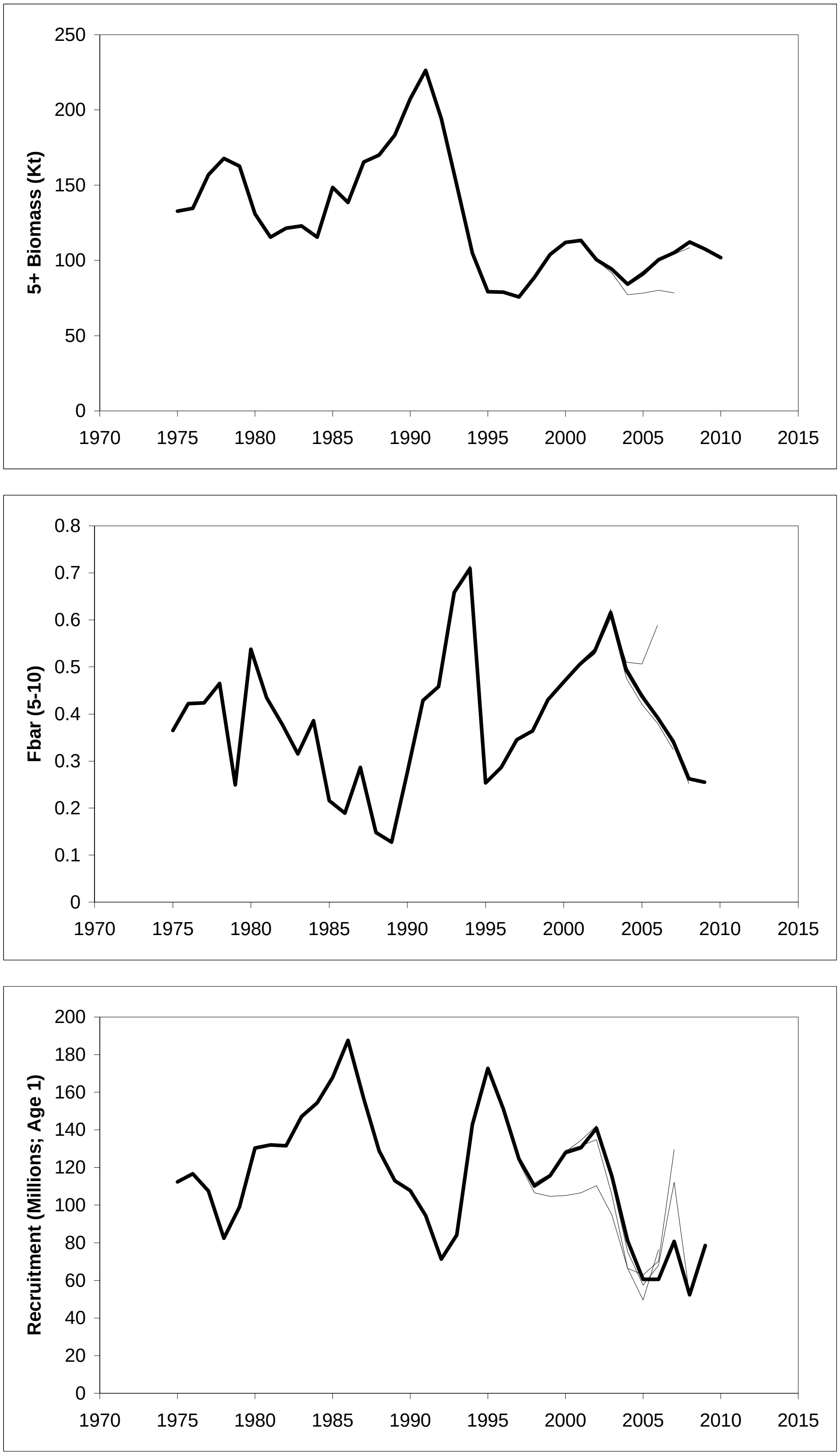


Figure 35. Biomass, Average Fishing Mortality and Recruitment retrospective for XSA run with reduced shrinkage (3Years, log(SE)=1.0). Bold lines indicate the assessment for the current year.

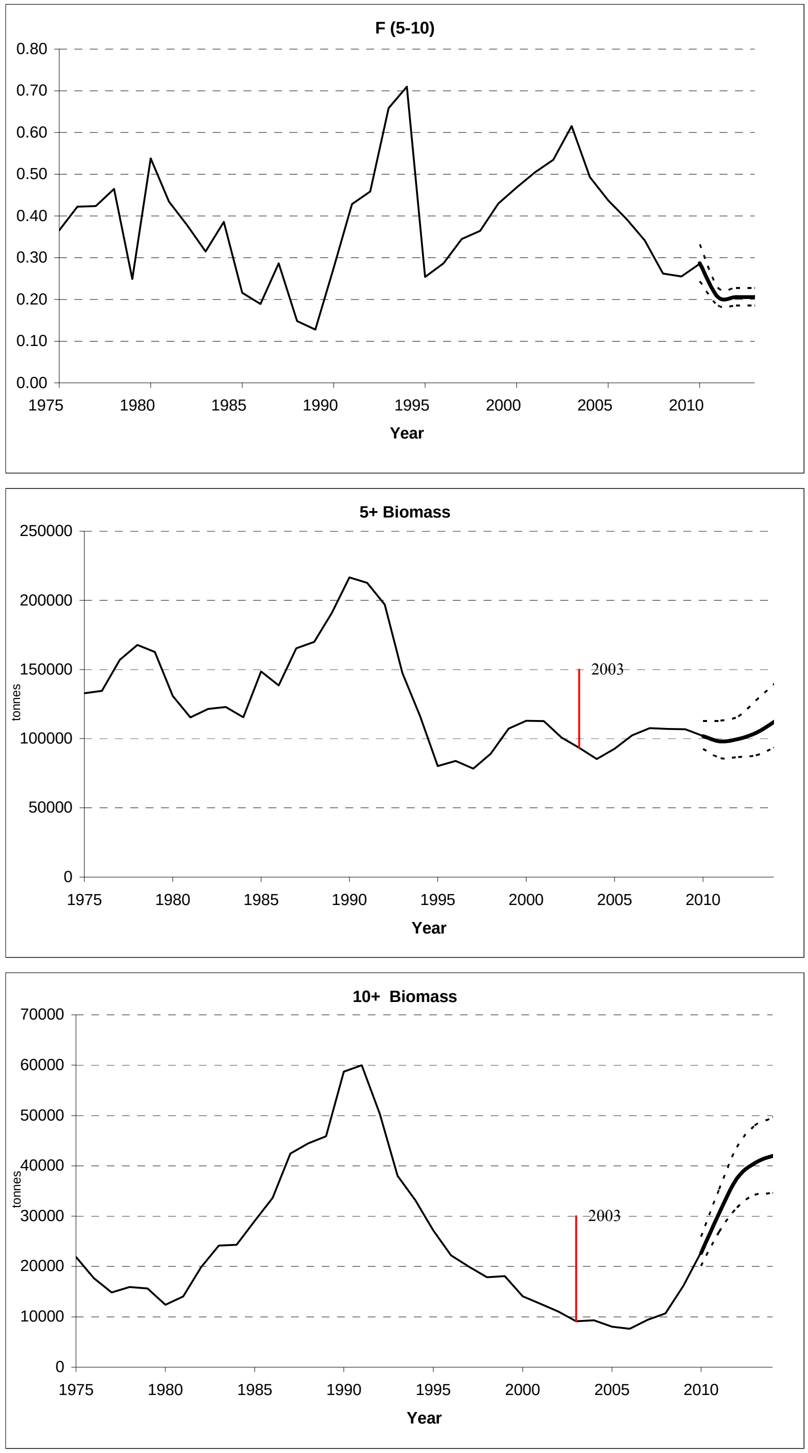


Figure 36. Projection estimates of average fishing mortality, 5+ biomass, and 10+ biomass over 2010-2014 assuming status quo catch in 2010 and 2011-2013 catches correspond to the F0.1 level. The biomass level of 2003 (year in which rebuilding plan developed) is highlighted. The 5th, 50th (thick line), and 95th percentiles are shown.

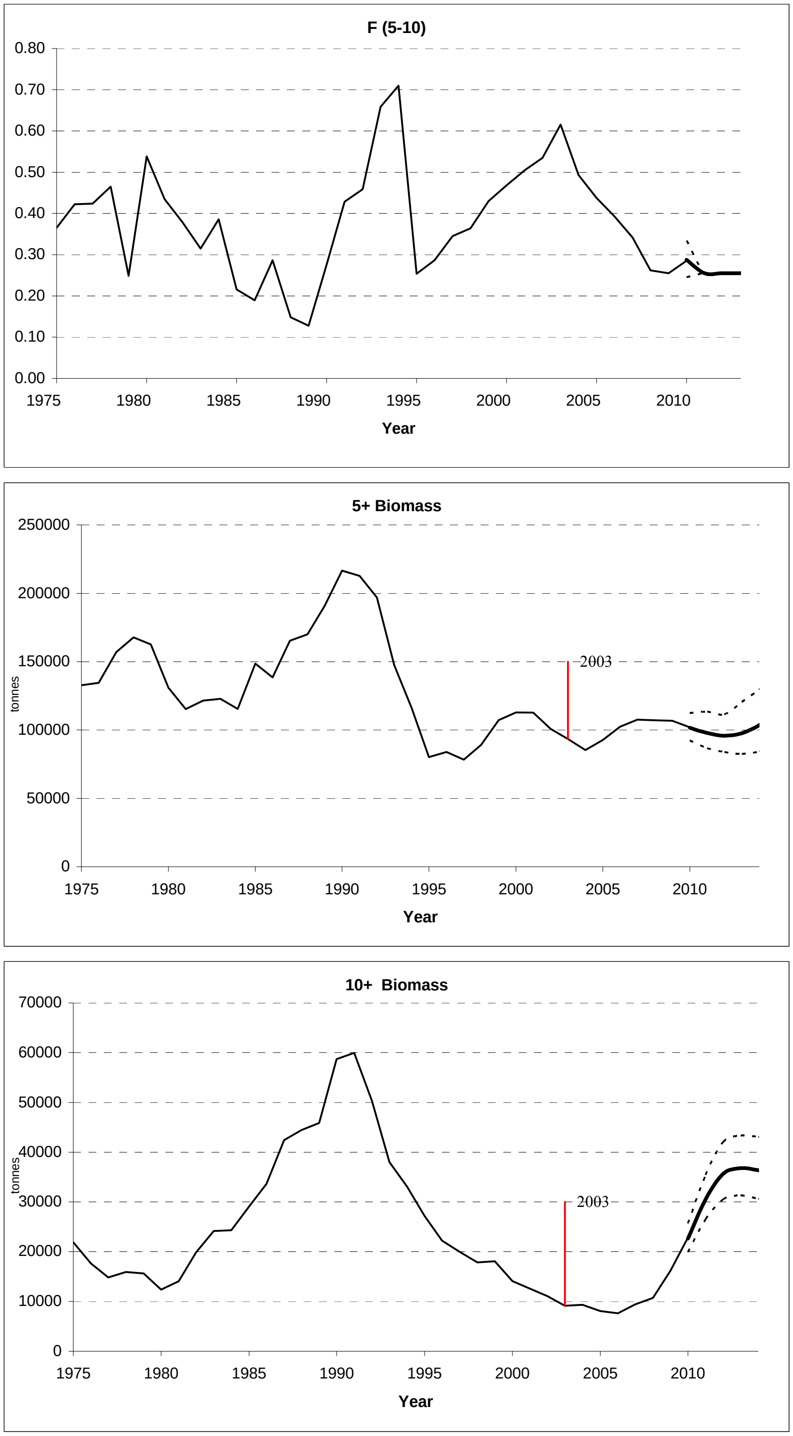


Figure 37. Projection estimates of average fishing mortality, 5+ biomass, and 10+ biomass over 2010-2014 assuming status quo catch in 2010 and 2011-2013 catches correspond to the F2009 level. The biomass level of 2003 (year in which rebuilding plan developed) is highlighted. The 5th, 50th (thick line), and 95th percentiles are shown.

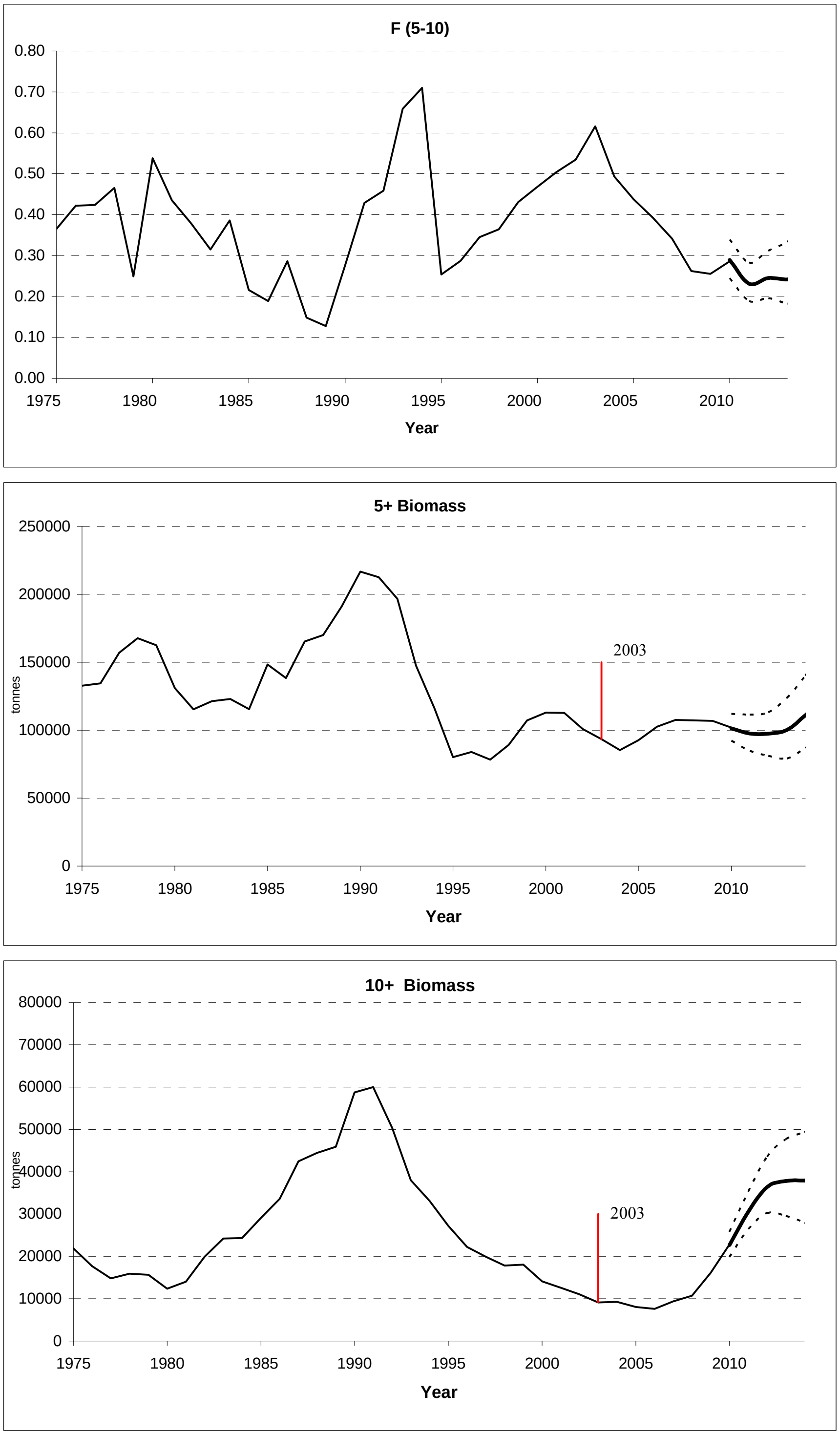


Figure 38. Projection estimates of average fishing mortality, 5+ biomass, and 10+ biomass over 2010-2014 assuming status quo catch in 2010 and 2011-2013 catches equal 16, 000 tons. The biomass level of 2003 (year in which rebuilding plan developed) is highlighted. The 5th, 50th (thick line), and 95th percentiles are shown.

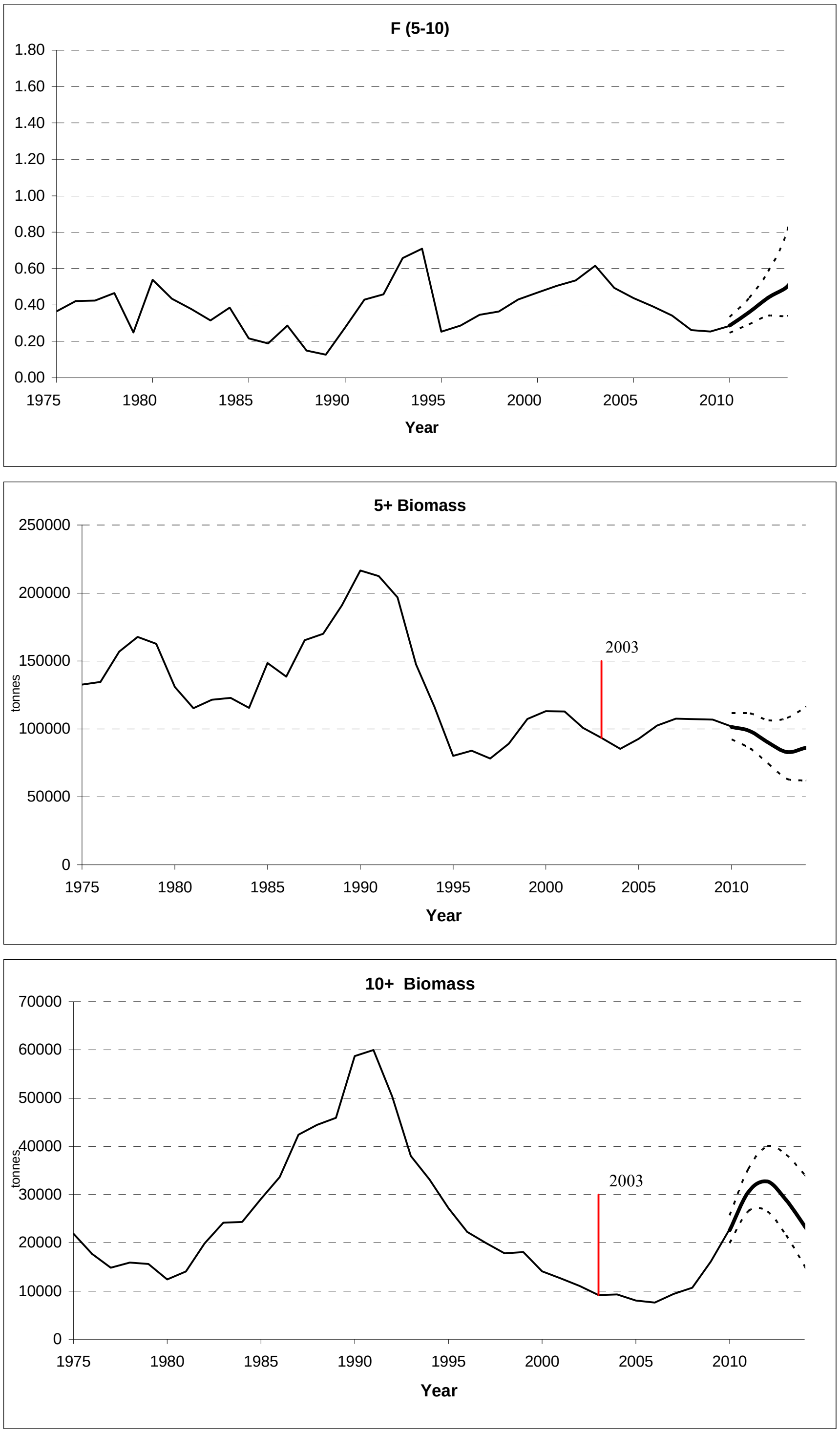


Figure 39. Projection estimates of average fishing mortality, 5+ biomass, and 10+ biomass over 2010-2014 under constant removals of 23, 150 tons. The biomass level of 2003 (year in which rebuilding plan developed) is highlighted. The 5th, 25th, 50th (thick line), 75th, and 95th percentiles are shown.

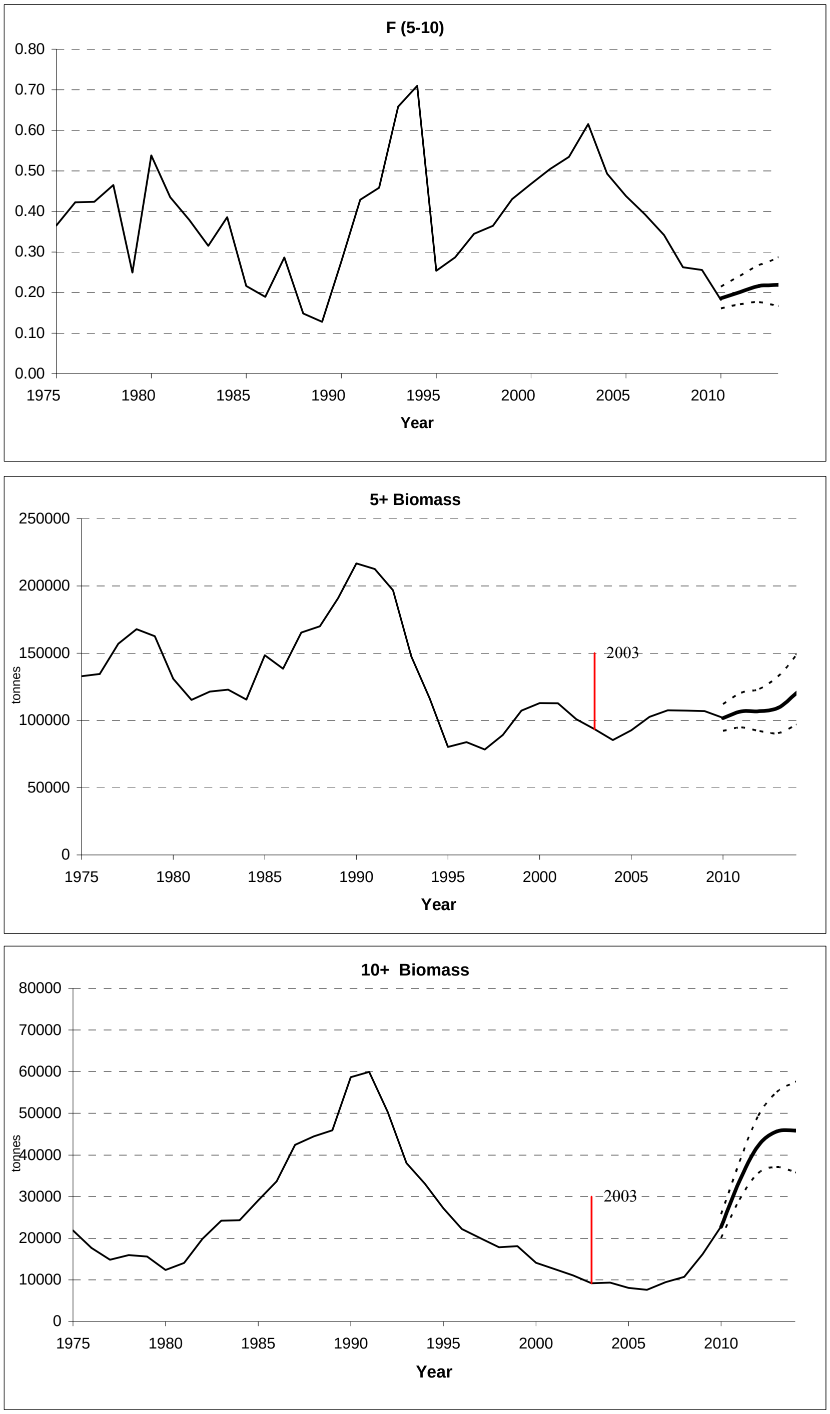


Figure 40. Projection estimates of average fishing mortality, 5+ biomass, and 10+ biomass over 2010-2014 assuming catches in 2010 and also 2011-2013 correspond to 16 000 t. The biomass level of 2003 (year in which rebuilding plan developed) is highlighted. The 5th, 50th (thick line), and 95th percentiles are shown.