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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

by

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Abstract

Extended Survivors Analysis was applied to the commercial catch-at-age data for Greenland Halibut in NAFO Subarea 2 and Div. 3KLMNO from 1975-2002 to assess the current status of the stock. The analysis was calibrated using Canadian and European Union research vessel survey data. The XSA model formulation was optimized in order to remove a retrospective bias in the estimated parameters. The exploitable stock biomass is estimated to be decreasing to the lowest level in the recorded time series, fishing mortality is increasing and is double the level of $F_{0.1}$. The trends in stock biomass and level of exploitation are consistent with all additional sources of information from the commercial fishery and surveys.

Introduction

At the 2002 NAFO Scientific Council Meeting (NAFO, 2002), an XSA based assessment of Greenland Halibut in NAFO Subarea 2 and Div. 3KLMNO was presented (Mahe and Bowering, 2002). Biomass was estimated to be increasing following the recruitment of three strong year classes. However, the trend in biomass directly contradicted the trends in catch rates obtained from the commercial fishery and the stock surveys, the majority of which were declining. STACFIS considered that the assessment estimated biomasses were inconsistent with the fishery and survey information and the assessment was rejected. At the 2003 NAFO Scientific Council Meeting (NAFO, 2003), the information available for assessment of the stock and the formulation of the fitted assessment model were reviewed. A new model structure using a shorter time period of calibration data is recommended. Population estimates were projected forwards in time in order to examine the potential consequences of future exploitation strategies.

Input data

Catch and weight-at-age data

In 2003 the catch-at-age data for 2001 was revised from that used for the 2002 assessment. In 2002 individual country age-length-keys had been applied to derive the age composition of the 2001 data. However, it was noted that there were marked differences in the interpretation of ages between readers and this was considered to introduce uncertainty to the catch-at-age matrix. In previous years a single Canadian age-length-key had been applied to the length distributions for all countries. Therefore in 2003 the 2001 data set was again computed using only the Canadian key for that year (Brodie and Power 2003). The commercial catch-at-age data are listed in Table 1. The proportional contribution of older ages in the catches has been decreasing throughout the time period. Catches in recent years are dominated by fishes of ages 6 to 8. Catch weights-at-age (Table 2) at the older ages have been decreasing in recent years; this is more pronounced at ages 11 and over. Catch weights at age and stock weight at age are assumed to be the same.

Calibration data

Four survey series were available as age disaggregated catch per unit effort:

a) EU - a European Union summer survey in Div. 3M from 1991–2002, ages 1 – 12 (Saborido and Vázquez, 2003).
b) Can RV0 - a Div. 2J+3K autumn survey, Engel converted to Campelen data from 1978 to 1994, ages 1 to 16.
c) Can RV4 - a Div. 2J+3KL autumn survey, true Campelen data from 1995 to 2002, ages 1 to 14.
d) Can RV5 - a Div. 3LNO spring survey, true Campelen data from 1996 to 2002, ages 1 to 8.

The Canadian survey time series have been revised in 2003 (Dwyer and Bowering, 2003) to indices computed as stratified mean numbers per tow, a revision from the swept area indices. Historically the Can RV0 and RV4 series have been used as a single time series after conversion to Campelen trawl units. The data used in the assessment model, that is ages 1 to 13, are presented in Tables 3 and 4.

Survey Data Screening

A recent EU funded study on the Evaluation of Research Surveys in relation to management advice (Beare *et. al.*, 2001) suggested that simple tests are useful for evaluating the ability of surveys to track cohort strength. The tests include within and between survey consistency using simple correlation analyses.

The tests are grouped into three categories:

1. Within survey consistency: correlation between log transformed indices at age (a) and year (y) with log-transformed indices at age (a+1) and year (y+1) from the same survey.
2. Between survey consistency: correlation between log transformed indices at each age from different surveys.
3. Consistency between survey indices and the output from an analytical assessment: correlation between log-transformed indices surveys and estimated total number at age from the analytical model.

The tests were conducted on the survey data for ages 1 to 8, the age range covered by all surveys. The results are presented in Tables 5 to 7

Internal survey consistency

Results from the internal tests are presented in Table 5. The general pattern is that, for the younger ages (<7) the recent survey data (Can RV4, RV5, EU) show more consistency between ages than the historic time series (Can RV0). The Div. 2J+3K time series (Can RV0) has high correlation coefficients for ages 6 and older but the correlation is driven by outliers and is considered to be spurious.

Between surveys consistency

Table 6 presents the results of the between survey analysis. Due to the different time coverage of the surveys, the comparison for the historic Canadian Survey in Div. 2J+3K (Can RV0) could only be computed with the EU Survey. The results revealed poor correlation but the number of years with overlapping coverage is small. The other surveys have acceptable agreement at most ages.

Consistency with XSA estimates

The recent time series have the best correlation with XSA population estimates, mostly for the Canadian surveys at ages 6 and younger (Table 7).

These simple analyses provide an initial first step to detecting the ability of survey data to track cohort strength and provide a guide as to the quality of the tuning indices that are used in the analytical assessments. The results indicate that the recent survey data are the most informative. The low levels of internal and external correlation of the historic CAN RV0 indicate that it may be introducing noise to the assessment results.

An XSA assessment of Greenland Halibut in Subarea 2 and Divisions 3KLMNO

An XSA assessment using the 2002 model formulation.

The Extended Survivors Analysis (XSA, Shepherd, 1999; Darby and Flatman, 1994) stock assessment model was fitted to the revised catch and survey data. In the absence of an agreed maturity ogive, the 10+ biomass is used as a proxy for spawning stock biomass. The 5+ biomass is used as an estimate of exploitable biomass. As in previous assessments of this stock, natural mortality was assumed to be constant at age and in all years at 0.2. The initial model fit retained the survey time series and model specifications used for the 2002 assessment (Mahe and Bowering, 2002).

The estimated time series of 5+ exploitable biomass, recruitment and fishing mortality gave a very different perception of the dynamics of the stock to the 2002 model formulation (Fig. 1-3). Fishing mortality was estimated to be higher and biomass lower. Although substantially revised, the latest model estimated trends are more consistent with the perception of the stock dynamics derived from the survey and commercial catch rates; the main reason for the rejection of the 2002 XSA assessment results. A major contributor to the change in the biomass dynamics is the estimated abundance of the 1993-1997 year-classes (Fig. 3).

A series of XSA models were fitted to the full time series of available data in order to examine potential causes for the difference between the model fitted to the 2002 and 2003 data sets. The runs examined:

a) the effect of the revision of the Canadian CPUE survey series on the model estimates when fitted to the 1975-2001 catch data, with the original 2001 data set.
b) the additive effect of the revision of the catch-at-age data for 2001 and the Canadian CPUE survey series on the model estimates when fitted to the 1975-2001 catch data
c) the effect of adding the 2002 catch and revised survey data to the time series when fitting the model with the original 2001 catch data
d) adding the 2002 catch and revised survey data to the time series when fitting the model to the catch data with the revised 2001 data

Figures 4-6 present the results of the sensitivity analysis for the estimates of fishing mortality, 5+ exploitable biomass and recruitment.

Revision of the Canadian survey data (run a) re-scales the estimates when compared to the 2002 XSA formulation but does not alter the recent trends in the time series. The peak of fishing mortality in 1994 is estimated to be marginally higher and the low point of the biomass series in 1995 slightly lower.

Revising the catch data for 2001 (run b) had an additive effect with the revision of the Canadian survey series, raising estimates of fishing mortality for recent years and lowering the biomass estimates, but as with the survey revision, recent stock trends are largely unaffected.

The major changes to the estimated dynamic history of the stock result from the addition of the 2002 catch and survey data to the assessed time series (runs c and d). Fishing mortality in 2001 is revised upwards by a factor of three compared to estimate from the rejected 2002 XSA formulation. The biomass estimate for 2001 is reduced by a factor of 2. This results from a marked downward revision of the estimated strength of the 1993-1997 year-classes. The comparison is not sensitive to the structure of the catch-at-age data recorded in 2001.

The sensitivity analysis of the XSA formulation has shown that the revision of the catch-at-age data for 2001 and the changes to the Canadian survey indices only have a minor effect on the level of estimates derived from an XSA analysis of this stock. The major contribution to the change in the perception of the stock trends in recent years; is the cumulative effect of new years of data. This applies to both the surveys and catches. The data has provided more information on the abundance of the 1993-97 year-classes. This is an example of retrospective uncertainty in the assessment estimates. This uncertainty has been identified in many studies and is an active area of assessment research (e.g. Sinclair *et al*., 1991; ICES, 2002).

An XSA retrospective analysis was run with the new stock data series and the time series of estimated fishing mortality, 5+ exploitable biomass and recruitment plotted to evaluate consistency of the series. The results are plotted in Fig. 7-9, they indicate that there is a strong retrospective pattern in the model estimates when the 2002 XSA formulation is used. Estimated fishing mortality is revised upwards each year and biomass downwards. As data has been added to the assessment series, estimated abundance of the above average 1993-1995 year-classes has been reduced by 44%.

Retrospective uncertainty is generally introduced into assessment model estimates as a result of model mis-specification, usually an assumption of constancy in a parameter that in reality exhibits a trend or step to a new level. Retrospective patterns can be induced by changes in the level of mis-reporting, natural mortality or catchability (ICES, 1991; Mohn, 1999). Retrospective uncertainty can be reduced by changes to model structure, such as adding extra parameters or by down-weighting (removing) sections of the data that do not conform to the model structure. If this cannot be carried out or if the cause of the uncertainty is uncertain then shrinkage (ICES 1991, 1993) can be used as a time series constraint to stabilize sequential estimates.

The log catchability residuals from the XSA model fitted to the full range of survey data from Canada, (including the Engels data converted to a Campelen index) and the EU survey series, were examined in order to determine whether time series correlation was present Fig. 10-11. Systematic change in catchability, a trend or step, is the most common cause of retrospective patterns. Correlated residual patterns were found for both the EU and the full time series of the Canadian surveys. The largest change occurred concurrently in the surveys during 1990-95. Large negative residuals are estimated with a decreasing trend in time. Catchability during this period was not constant and the low values estimated result in an under-estimation bias in the catchability parameter. This induces under-estimation bias into fishing mortality estimates and over-estimation of population abundance and therefore biomass.

Catchability is the link between survey catches and population abundance as estimated from the catch-at-age data. The residuals indicate departures of either the survey indices or the population abundance from the correlation. In the case of the survey indices, the correlated residuals could result from environmental changes such as the cold temperatures recorded in the NAFO Divisions during the early-1990s (Colbourne and Fitzpatrick, 2003) or from changes in gear such as occurred in 1995/6 with the change from Engels to Campelen trawls. Departures of the population abundance from the correlation generally result from bias in the catch-at-age data. It is notable that the low residuals occur during the period of the highest landings from the fishery, a time when the actual levels of landings are considered to be in doubt (Bowering and Brodie, 2000).

A revised XSA assessment model formulation

In an attempt to reduce the retrospective pattern in the estimates from the XSA model induced by the changes in catchability, the survey series were shortened to include only the years 1995-2002. This is the period when the gear used in the Canadian survey was only the Campelen trawl and is after the period of high/uncertain landings data. Recent survey indices are also more consistent between ages and surveys, as discussed previously, giving greater assurance as to their reliability. In addition to the EU survey series from Div. 3M and the Canadian autumn survey series in Div. 2J+3KL, the Canadian spring survey series in Div. 3LNO was evaluated within the assessment model formulation.

The diagnostic output from the fit of the revised XSA model is presented in Tables 8a-8e. The log catcability residuals for each survey show a marked improvement (Tables 8b-8d and Fig. 12-14). There are no strong trends in the residual time series and the only large residuals occur at ages 9- 11 in the Canadian autumn survey data in 1995. The series could be shortened further to remove the values at these ages. The inverse variance weighting used within XSA down-weights the influence of the survey at those ages on the parameter estimates. The standard errors for log catchability are consistent with the correlation analysis of the survey data described previously. The Canadian surveys have lower standard errors at the youngest ages and (due to the 1995 outlier) higher values at the oldest ages. The individual assessment results are consistent with other sources of information from the fishery.

The XSA estimates of survivors at the beginning of 2002 derived from each survey, their standard errors and the combined weighted average are presented in Table 8. For each of the ages, apart from ages 2 and 4, the estimates of survivors are consistent among surveys.

At age 2 the estimates from the surveys differ by a factor of 2, at age 4 the Canadian autumn survey estimates the survivors to be double the abundance of the other surveys. The variance of the catchability estimates at the two ages are similar between surveys therefore they receive equal weight in the combined estimate for that age and the survivors are an average. Ages 2 and 4 do not contribute to exploitable biomass (ages 5+) or fishing mortality (ages 5-10) series that are used as management indices for the stock. Therefore the state of the stock will not be sensitive to the variability. Stock projections will be sensitive to the estimated values at the ages.

At ages 4-7, population estimates derived from shrinkage are generally higher than those from the surveys, this is due to the trend in the recent levels of fishing mortality. However, at those ages the weight of the shrinkage derived estimate is low and this is not considered to have biased the estimates significantly. At the older ages where the standard errors of the surveys are higher, shrinkage has a greater influence on the final population estimates. The shrinkage estimates at the older ages show close agreement with the surveys.

Consistency of the revised XSA model estimates between surveys

An analysis of the consistency of the estimates computed from each survey series was carried out by fitting single fleet calibrations of XSA to the data from the individual series. The estimated stock and exploitation trends were consistent across surveys and showed similar trends to those of the combined assessment results. Figure 15 presents an illustration of the consistency in the estimates of average fishing mortality and 5+ exploitable biomass.

Retrospective consistency of the revised XSA model estimates

Figures 16-18 present the retrospective assessment estimates from the revised model fitted to the shortened survey series. While not removing the retrospective bias completely, shortening the survey series has reduced the retrospective bias in the series of assessment results.

Bootstrapping of the revised XSA model

In order to estimate uncertainty in the XSA parameter estimates and computed time series, a non-parametric bootstrap procedure was used to generate 1 000 fits of the model to the survey data. The residuals of log catchability from the fitted model were sampled independently for each age, with replacement, and new survey indices computed for each year and age. The XSA model was re-fitted to the new survey indices and new population and exploitation parameters estimated. Bias corrected percentiles were generated for each parameter or population time series.

Assessment Results

The XSA estimated fishing mortalities are presented in Table 9, population numbers in Table 10 and the population and exploitation trends in Table 11. Figures 19-21 show the percentile distributions from the bootstrap of the XSA model.

Fishing mortality (Fig.19) has generally followed the landings from the fishery. After a decline during the 1970s and 1980s, the high landings removed during 1990-94 resulted in fishing mortality reaching levels exceeding F = 0.50. The reduction in landings in 1995 resulted in a sharp reduction in fishing mortality to values close to F = 0.2; subsequently landings and fishing mortality have increased and are now estimated to be 0.44, a level equal to the average of the time series. Fishing mortality is currently estimated to be twice that of $F_{0.1}$ (0.16).

Figures 20 and 21 illustrate the estimated recruitment at age 1 and the stock biomass for ages 5 and older, respectively. During 1980-90, a period of sustained good recruitment and relatively low fishing mortality resulted in an increase in stock biomass to a historic high in 1991. The increased landings and high mortality rates during 1991-94 reduced the biomass to a historic low from 1995-97. The stock increased during 1998-2000 following the substantial reduction in landings and the recruitment of three above average year-classes (1993-95). Subsequently, increased landings and the resulting higher mortality rates are estimated to have halted the increase in biomass and the stock is now estimated to currently be in decline.

Short-term Stock Projections

Short-term stock projections and yield per recruit were calculated, based on the XSA data and results presented in Tables 2, 9 and 10. The exploitation pattern used for the computations was the average of the final three years (2000-2002) of the assessment, scaled to the final year. Selection-at-age has been relatively constant during 2000-2003 therefore the scaled average reflects recent exploitation patterns. Weight-at-age was taken as average over the same years and natural mortality and maturity-at-age were as used in the assessment model, 0.2 and knife-edged at age 10+. The projection input vectors are presented in Table 12.

A range of options was discussed for the level of catch in 2003 that is required for the projections for 2004-2005. The TAC for 2003 is 42 000 tons, the landings in 2002 were 34 000 tons. At a fishing mortality of 0.44, as estimated for 2002, the catch in 2003 is estimated to be 24 000 tons. STACFIS agreed on a catch of 30 000 tons for 2003 and the projections were conditioned on that estimate. The estimate is the mid-point between the catches estimated for 2002 and a status quo fishing mortality estimate of catches in 2003, derived from the VPA population numbers and exploitation rate.

Short-term projections for 5+ exploitable biomass and landings for the Greenland halibut stock in SA 2 and Div. 3KLMNO are presented in Table 13, a short-term management options table, and Fig. 22. If a catch of 30 000 tons is taken in 2003 fishing mortality is projected to increase to F = 0.61 and 5+ exploitable biomass at the start of 2004 will decrease to 58 000 tons. Catches greater than 16 000 tons during 2004 will result in a further decline in the biomass in 2005.

The computed yield-per-recruit values are plotted in Fig. 23. $F_{0.1}$ was estimated to be 0.16, F_{max} at 0.28.

Medium-term Stock Projections

Stochastic medium-term, stock projections were generated in order to illustrate a series of potential management scenarios for rebuilding 5+ exploitable biomass. Each projection was a continuation of the XSA assessment bootstrap replicates described previously. In each bootstrap replicate: a) recruitment was re-sampled, with replacement, from the estimates for 1975-1999, b) selection-at-age was calculated as the average of the years 2000 – 2002 scaled by the ratio of average fishing mortality (ages 5-10) in 2002 to that of the three year average, c) weight-at-age was calculated as the average of the years 2000-2002.

The projections were conditioned on the assumption of a 30 000 tons catch in 2003, with constant landings or exploitation rate in each of the years 2004-2007. Projections were run for 5 years, a range over which the outcomes are not heavily influenced by the assumption of future recruitment.

Five scenarios are illustrated:

1)	constant fishing mortality at $F_{0.1}$ (0.16),	Fig. 24
2)	constant fishing mortality at F_{max} (0.28),	Fig. 25
3)	constant fishing mortality at $F_{status\ quo}$ (0.44),	Fig. 26
4)	constant catch of 20 000 tons,	Fig. 27
5)	constant catch of 30 000 tons,	Fig. 28

All of the simulations indicate that if the landings in 2003 reach 30 000 tons, stock biomass in 2004 will be reduced below the historic low of the time series. This is because of the recent high fishing mortality and the relatively low recruitment. The lower fishing mortality scenarios ($F_{0.1}$, F_{max}) result in an increase in 5+ exploitable biomass by 2007, but only to the historic low level observed in 1995-97. Staus quo fishing mortality (0.44) and constant landings at 20 000 tons stabilize the biomass at the new low point. The stochastic projections indicate that there is a high probability that a constant landings constraint of 20 000 tons or 30 000 tons will result in high mortality rates and low 5+ exploitable biomass.

Summary

The revised XSA assessment of the stock is considerably more pessimistic than the model fitted and rejected in 2002. The trend in the XSA estimated stock biomass is consistent with the catch per unit effort from the International and Portuguese commercial fisheries and all of the stock surveys. All of the information series have declined in the last few years. The assessment is considered to be representative of the current stock and fishery dynamics.

The exploitable stock biomass is estimated to be decreasing to the lowest level in the recorded time series, fishing mortality is increasing and is double the level of $F_{0.1}$. Recent recruitment has been poor and if catches continue at recent levels then the stock will decline further.

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Table 1. Catch numbers at age and total landings for Greenland Halibut in Subarea 2 and Div.3KLMNO.

	Year								
Age	**1975**	**1976**	**1977**	**1978**	**1979**	**1980**	**1981**	**1982**	**1983**
1	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0
5	334	17	534	2982	2386	209	863	269	701
6	2819	610	5012	8415	8727	2086	4517	2299	3557
7	5750	3231	10798	8970	12824	9150	9806	6319	9800
8	4956	5413	7346	7576	6136	9679	11451	5763	7514
9	3961	3769	2933	2865	1169	5398	4307	3542	2295
10	1688	2205	1013	1438	481	3828	890	1684	692
11	702	829	220	723	287	1013	256	596	209
12	135	260	130	367	149	128	142	256	76
13	279	101	116	222	143	53	43	163	106
+gp	288	53	84	258	284	27	69	191	175
Total Nb	20912	16488	28186	33816	32586	31571	32344	21082	25125
Landings (t)	**28814**	**24611**	**32048**	**39070**	**34104**	**32867**	**30754**	**26278**	**27861**

	Year								
Age	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**
1	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	95	220	1064
5	902	1983	280	137	296	181	1102	2862	4180
6	2324	5309	2240	1902	3186	1988	6758	7756	10922
7	5844	5913	6411	11004	8136	7480	12632	13152	20639
8	7682	3500	5091	8935	4380	4273	7557	10796	12205
9	4087	1380	1469	2835	1288	1482	4072	7145	4332
10	1259	512	471	853	465	767	2692	3721	1762
11	407	159	244	384	201	438	1204	1865	1012
12	143	99	140	281	105	267	885	1216	738
13	106	87	70	225	107	145	434	558	395
+gp	183	86	117	349	129	71	318	422	335
Total Nb	22937	19028	16533	26905	18293	17092	37749	49713	57584
Landings (t)	**26711**	**20347**	**17976**	**32442**	**19215**	**20034**	**47454**	**65008**	**63193**

	Year									
Age	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	2002
1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	37
4	1010	5395	323	190	335	552	297	271	448	479
5	9570	16500	1352	1659	1903	3575	2149	2029	2239	1662
6	15928	15815	2342	5197	4169	5407	5625	12583	12163	7239
7	17716	11142	3201	6387	7544	5787	8611	21175	22122	17581
8	11918	6739	2130	1914	3215	3653	3793	3299	5154	6607
9	4642	3081	1183	956	1139	1435	1659	973	1010	1244
10	1836	1103	540	504	606	541	623	528	495	659
11	1055	811	345	436	420	377	343	368	439	360
12	964	422	273	233	246	161	306	203	203	224
13	401	320	251	143	137	92	145	129	156	126
+gp	182	215	201	89	89	51	151	104	75	81
Total Nb	65222	61543	12141	17708	19803	21631	23702	41662	44504	36299
Landings (t)	**62455**	**51029**	**15272**	**18840**	**19858**	**19946**	**24226**	**34177**	**38232**	34062

Table 2. Catch weights at age for Greenland Halibut in Subarea 2 and Div. 3KLMNO.

Age	Year 1975	1976	1977	1978	1979	1980	1981	1982	1983
1	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0
3	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126
4	0.244	0.244	0.244	0.244	0.244	0.244	0.244	0.244	0.244
5	0.609	0.609	0.609	0.609	0.609	0.514	0.392	0.525	0.412
6	0.76	0.76	0.76	0.76	0.76	0.659	0.598	0.684	0.629
7	0.955	0.955	0.955	0.955	0.955	0.869	0.789	0.891	0.861
8	1.19	1.19	1.19	1.19	1.19	1.05	0.985	1.13	1.18
9	1.58	1.58	1.58	1.58	1.58	1.15	1.24	1.4	1.65
10	2.21	2.21	2.21	2.21	2.21	1.26	1.7	1.79	2.23
11	2.7	2.7	2.7	2.7	2.7	1.57	2.46	2.38	3.01
12	3.37	3.37	3.37	3.37	3.37	2.71	3.51	3.47	3.96
13	3.88	3.88	3.88	3.88	3.88	3.12	4.79	4.51	5.06
+gp	5.764	5.144	5.992	5.894	6.077	5.053	7.426	7.359	7.061

Age	Year 1984	1985	1986	1987	1988	1989	1990	1991	1992
1	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0
3	0.126	0.126	0.126	0.126	0.126	0.126	0.09	0.126	0.175
4	0.244	0.244	0.244	0.244	0.244	0.244	0.181	0.244	0.289
5	0.377	0.568	0.35	0.364	0.363	0.4	0.338	0.383	0.43
6	0.583	0.749	0.584	0.589	0.569	0.561	0.546	0.592	0.577
7	0.826	0.941	0.811	0.836	0.805	0.767	0.766	0.831	0.793
8	1.1	1.24	1.1	1.16	1.163	1.082	1.119	1.228	1.234
9	1.46	1.69	1.58	1.59	1.661	1.657	1.608	1.811	1.816
10	1.94	2.24	2.12	2.13	2.216	2.237	2.173	2.461	2.462
11	2.63	2.95	2.89	2.82	3.007	2.997	2.854	3.309	3.122
12	3.49	3.71	3.89	3.6	3.925	3.862	3.731	4.142	3.972
13	4.49	4.85	4.95	4.63	5.091	4.919	4.691	5.333	5.099
+gp	7.016	7.01	7.345	6.454	7.164	6.37	6.391	7.081	6.648

Age	Year 1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0
3	0.134	0.08	0.08	0.161	0.12	0.119	0.176	0	0	0.217
4	0.232	0.196	0.288	0.242	0.206	0.228	0.253	0.254	0.249	0.251
5	0.368	0.33	0.363	0.36	0.336	0.373	0.358	0.346	0.376	0.369
6	0.547	0.514	0.531	0.541	0.489	0.543	0.533	0.524	0.57	0.557
7	0.809	0.788	0.808	0.832	0.771	0.81	0.825	0.787	0.83	0.841
8	1.207	1.179	1.202	1.272	1.159	1.203	1.253	1.192	1.168	1.193
9	1.728	1.701	1.759	1.801	1.727	1.754	1.675	1.774	1.794	1.76
10	2.309	2.268	2.446	2.478	2.355	2.351	2.287	2.279	2.367	2.277
11	2.999	2.99	3.122	3.148	3.053	3.095	2.888	2.895	2.95	2.896
12	3.965	3.766	3.813	3.856	3.953	4.01	3.509	3.645	3.715	3.579
13	4.816	4.882	4.893	4.953	5.108	5.132	4.456	4.486	4.585	4.407
+gp	6.489	6.348	6.79	6.312	6.317	6.124	5.789	5.531	5.458	5.477

Table 3. The European Union survey in Div. 3M catch numbers at age data set for Greenland Halibut in Subarea 2 and Div. 3KLMNO.

Start of fishing	0.5
End of fishing	0.6

		Numbers at age											
Year	**Effort**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
1991	1	349	-1	235	993	1956	1253	2283	545	464	388	122	-1
1992	1	922	800	286	861	1600	1996	1793	991	473	266	139	67
1993	1	937	933	599	566	960	1574	1732	1388	905	257	141	51
1994	1	832	706	1082	1224	1365	2233	2096	1213	689	264	95	54
1995	1	6165	1394	1369	1249	1709	3793	3026	1729	1134	254	68	26
1996	1	2874	4613	1527	2066	3070	4394	2020	1378	392	75	31	35
1997	1	1597	2113	4396	5157	5216	6045	3885	1709	593	200	33	22
1998	1	1434	1268	5149	7835	9168	8821	6334	2339	703	201	27	6
1999	1	525	426	1904	7178	9818	9599	4382	1544	322	101	8	4
2000	1	1602	147	312	1405	5557	11591	4093	1701	351	98	49	-1
2001	1	4157	839	1154	687	2044	5927	5569	2978	168	49	7	-1
2002	1	1996	1638	1619	1099	2734	4165	4704	998	130	59	20	-1

Table 4. The Canadian surveys catch numbers at age data set for Greenland Halibut in Subarea 2 and Div. 3KLMNO.

CAN RV0 **Div. 2J3K Fall Engel Campelen converted**

Start of fishing	0.8
End of fishing	1

Year	Effort	Numbers at age												
		1	2	3	4	5	6	7	8	9	10	11	12	13
1978	1	9.61	40.24	33.37	19.52	12.5	8.34	5.15	2.26	1.27	0.96	0.81	0.49	0.32
1979	1	10.81	18.07	13.47	7.15	7.47	7.21	3.5	1.41	0.67	0.64	0.42	0.37	0.31
1980	1	6.78	6.53	6.2	5.58	7.07	7.56	4.72	1.59	0.71	0.56	0.63	0.41	0.27
1981	1	19.39	22.99	15.42	6.01	6.58	7.25	5.15	2.21	1.02	0.59	0.48	0.22	0.12
1982	1	4.75	5.1	12.78	10.81	8.09	5.76	6.06	6.29	2.65	1.02	0.6	0.38	0.27
1983	1	1.66	4.45	10.56	11.41	10.45	7.45	7.56	5.67	2.19	0.65	0.46	0.33	0.24
1984	1	4.47	7.11	9.56	10.29	15.34	7.74	5.44	3.5	1.7	0.74	0.35	0.24	0.2
1985	1	24.59	14.67	8.71	6.87	9.5	8.86	5.98	2.26	1.03	0.75	0.3	0.27	0.12
1986	1	17.21	13.96	16.62	14.64	9.49	11.04	9.54	3.19	1	0.34	0.26	0.23	0.12
1987	1	5.04	11.21	29.44	12.17	9.62	6.89	6.39	3.27	1.25	0.37	0.19	0.19	0.1
1988	1	8.82	10.54	15.04	17.03	14.9	7.82	5.65	1.65	0.43	0.16	0.1	0.06	0.05
1989	1	7.1	12.54	23.84	25.22	17.4	9.95	5.34	1.36	0.4	0.11	0.08	0.02	-1
1990	1	1.34	5.26	9.95	23.39	15.38	9.21	4.81	0.83	0.21	0.1	0.09	0.05	0.03
1991	1	13.8	5.59	6.08	13.32	9.05	5.41	1.29	0.26	0.08	0.05	0.02	0.01	-1
1992	1	5.69	23.78	20.4	13.59	4.84	3.11	1.27	0.12	0.02	0.01	-1	-1	-1
1993	1	8.08	43.64	64	19.28	5.56	1.76	0.74	0.23	0.03	-1	-1	0.02	-1
1994	1	29.79	21.62	22.61	18.9	7.22	1.32	0.61	0.19	0.03	0.01	-1	-1	-1

CAN RV4 **Div. 2J3KL Fall True Campelen**

Start of fishing	0.8
End of fishing	1

Year	Effort	Numbers at age												
		1	2	3	4	5	6	7	8	9	10	11	12	13
1995	1	30.31	31.19	9.695	3.626	4.528	1.548	0.294	0.071	0.011	0.006	0.003	0.004	0.004
1996	1	59.31	29.08	20.85	6.588	4.616	2.031	0.831	0.182	0.131	0.041	0.018	0.011	0.012
1997	1	17.1	34.25	26.66	15.3	7.78	3.745	1.75	0.601	0.167	0.051	0.03	0.021	0.013
1998	1	13.19	15.5	18.82	14.01	10.16	3.997	1.78	0.474	0.134	0.043	0.026	0.018	0.008
1999	1	8.647	20.62	15.96	15.87	12.83	7.758	2.495	0.476	0.089	0.042	0.015	0.007	0.023
2000	1	23.21	13.91	9.738	7.681	8.749	5.447	1.832	0.351	0.055	0.023	0.016	0.006	0.005
2001	1	25.96	12.85	10.05	9.749	6.109	5.612	2.493	0.494	0.087	0.019	0.01	0.008	0.012
2002	1	23.87	14.56	7.64	6.29	4.37	1.63	0.73	0.23	0.03	0.01	0.01	-1	0.01

CAN RV5 **Div. 3LNO Spring True Campelen**

Start of fishing	0.3
End of fishing	0.45

Year	Effort	Numbers at age							
		1	2	3	4	5	6	7	8
1996	1	1.621	4.241	4.599	2.183	0.827	0.284	0.057	0.001
1997	1	1.162	3.924	5.16	3.227	1.461	0.507	0.099	0.013
1998	1	0.22	0.814	3.847	6.186	4.955	1.238	0.326	0.072
1999	1	0.292	0.552	1.149	1.982	3.388	1.09	0.242	0.05
2000	1	0.793	1.069	1.068	1.506	1.954	2.037	0.556	0.031
2001	1	0.565	0.714	0.739	0.676	0.796	0.716	0.279	0.023
2002	1	0.642	0.572	0.603	0.581	0.608	0.208	0.049	0.006

Table 5. Internal survey consistency - Correlation coefficients R and number of data point N, for Ln(Na+1,y+1,s1)/Ln(Na,y,s1).

	Can RV0		Can RV4		Can RV5		EU Surv.	
	R	N	R	N	R	N	R	N
Age1/2	0.22	16	0.66	7	0.60	6	0.72	11
Age2/3	0.38	16	0.80	7	0.85	6	0.68	10
Age3/4	0.38	16	0.80	7	0.92	6	0.88	11
Age4/5	0.26	16	0.70	7	0.87	6	0.87	11
Age5/6	0.65	16	0.73	7	0.76	6	0.86	11
Age6/7	0.74	16	0.29	7	0.44	6	0.84	11
Age7/8	0.80	16	0.36	7	-0.03	6	0.20	11
Age8/9	0.91	16	-0.50	7			-0.57	11

Table 6. Between survey consistency - Correlation coefficients R and number of data point N, for Ln(Na,y,s1)/Ln(Na,y,s2).

	RV0/EU		RV4/RV5		RV5/EU		EU/RV4	
	R	N	R	N	R	N	R	N
Age 1	-0.25	4	0.79	7	0.52	7	0.76	8
Age 2	0.94	3	0.83	7	0.56	7	0.56	8
Age 3	0.59	4	0.93	7	0.58	7	0.65	8
Age 4	-0.23	4	0.61	7	0.86	7	0.72	8
Age 5	0.51	4	0.92	7	0.95	7	0.90	8
Age 6	-0.72	4	0.84	7	0.97	7	0.86	8
Age 7	0.15	4	0.81	7	0.53	7	0.56	8
Age 8	-0.29	4	0.79	7	0.54	7	0.37	8
Age 9	-0.29	4	0.00	7	0.00	7	-0.11	8

Table 7. Consistency between surveys and XSA - Correlation coefficients R and number of data point N, for Ln(Na,y,s)/Ln(Na,y,NXSAa,y).

	RV0/XSA		RV4/XSA		RV5/XSA		EU/XSA	
	R	N	R	N	R	N	R	N
Age 1	0.15	17	0.85	8	0.83	7	0.41	12
Age 2	-0.40	17	0.83	8	0.85	7	0.85	11
Age 3	0.00	17	0.86	8	0.95	7	0.35	12
Age 4	0.51	17	0.68	8	0.93	7	0.63	12
Age 5	0.59	17	0.90	8	0.91	7	0.33	12
Age 6	0.25	17	0.80	8	0.73	7	-0.13	12
Age 7	-0.10	17	0.49	8	0.22	7	-0.19	12
Age 8	-0.34	17	0.31	8	0.11	7	-0.66	12
Age 9	-0.42	17	-0.23	8	0.00	7	0.34	12

RV0: Canadian 2J3K 1978-1994 Engel series converted to Campelen
RV4: Canadian 2J3KL Fall 1995-2002 Campelen series
RV5: Canadian Div. 3LNO 1996-2002 Spring True Campelen
EU: EU 3M survey 1991-2002

Table 8a. The 2003 XSA model formulation for Greenland Halibut in Subarea 2 and Div. 3KLMNO.

Lowestoft VPA Version 3.1

10/06/2003 15:52

Extended Survivors Analysis

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

CPUE data from file GhalTUN5.txt

Catch data for 28 years. 1975 to 2002. Ages 1 to 14.

Fleet	First year	Last year	First age	Last age	Alpha	Beta
EU Survey	1995	2002	1	12	0.5	0.6
CAN RV4	1995	2002	1	13	0.8	1
CAN RV5	1996	2002	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 2002
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 90 iterations

Regression weights

1	1	1	1	1	1	1	1

Table 8b. The diagnostics of the XSA fit to the Canadian autumn survey catch per unit effort data for the years 1995-2001 (CAN RV4), for Greenland Halibut in NAFO Subarea 2 and Div. 3KLMNO.

Fleet : CAN RV4

Age	1995	1996	1997	1998	1999	2000	2001	2002
1	-0.48	0.36	-0.15	-0.01	-0.33	0.36	0.16	0.09
2	-0.08	-0.36	-0.03	-0.09	0.6	0.3	-0.08	-0.26
3	-0.34	-0.09	-0.06	-0.24	0.33	0.24	0.37	-0.21
4	-0.7	-0.27	0.05	-0.25	0.05	0.05	0.7	0.36
5	-0.31	-0.11	0.23	-0.01	-0.02	-0.23	0.18	0.27
6	-0.54	-0.37	0.41	0.32	0.39	-0.11	0.13	-0.24
7	-1.14	-0.34	0.36	0.49	0.82	0.25	0.3	-0.74
8	-1.4	-0.45	0.64	0.41	0.62	0.23	0.51	-0.55
9	-1.96	0.61	0.91	0.66	0.33	-0.07	0.29	-0.77
10	-1.52	0.36	0.73	0.61	0.59	0.06	-0.07	-0.76
11	-1.6	0.16	0.62	0.65	0.13	0.22	-0.1	-0.08
12	-0.76	0.12	0.75	0.45	-0.14	-0.37	-0.05	99.99
13	-0.67	0.78	0.69	0.12	1.07	-0.04	0.78	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 q	-8.0663	-8.0241	-8.2139	-8.4622	-8.5521	-8.9063	-9.1027	-9.7503	-10.6858	-11.2923
S.E(Log q)	0.3055	0.3084	0.2725	0.4226	0.2132	0.3667	0.6713	0.7312	0.9457	0.7831

Age	11	12	13
Mean Log q	-11.4287	-11.4287	-11.4287
S.E(Log q)	0.7025	0.5034	0.7198

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	1.02	-0.089	7.99	0.72	8	0.34	-8.07
2	1.64	-2.289	6	0.68	8	0.4	-8.02
3	1.39	-1.646	7.12	0.75	8	0.34	-8.21
4	1.52	-1.146	7.24	0.45	8	0.63	-8.46
5	1.28	-1.272	7.95	0.78	8	0.26	-8.55
6	0.8	0.697	9.23	0.66	8	0.3	-8.91
7	0.73	0.568	9.36	0.43	8	0.52	-9.1
8	0.64	0.395	9.55	0.17	8	0.5	-9.75
9	-0.44	-0.736	7.48	0.04	8	0.43	-10.69
10	47.42	-0.295	166.32	0	8	39.82	-11.29
11	0.66	0.209	10.11	0.06	8	0.5	-11.43
12	0.19	2.127	7.96	0.58	7	0.08	-11.43
13	-10.13	-0.814	-36.62	0	8	5.91	-11.02

Table 8c. The diagnostics of the XSA fit to the Canadian spring survey catch per unit effort data for the years 1996-2001 (CAN RV5), for Greenland Halibut in NAFO Subarea 2 and Div. 3KLMNO.

Fleet : CAN RV5

Age	1995	1996	1997	1998	1999	2000	2001	2002
1	99.99	0.21	0.6	-0.66	-0.28	0.42	-0.23	-0.08
2	99.99	0.47	0.56	-0.29	-0.27	0.49	-0.21	-0.75
3	99.99	0.46	0.36	0.23	-0.25	0.08	-0.19	-0.69
4	99.99	0.27	0.15	0.59	-0.38	0.07	-0.32	-0.37
5	99.99	-0.31	0.08	0.79	0.19	-0.2	-0.35	-0.2
6	99.99	-0.65	0.1	0.82	0.15	0.58	-0.28	-0.71
7	99.99	-0.83	-0.35	0.99	0.59	0.97	0.09	-1.45
8	99.99	-2.55	-0.16	1.53	1.31	0.81	0.35	-1.28
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 q	-11.6161	-10.8828	-10.3751	-10.221	-10.207	-10.7992	-11.636	-13.1249
S.E(Log q)	0.4385	0.5052	0.4021	0.3737	0.4003	0.585	0.9286	1.4726

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	0.69	1.001	11.49	0.68	7	0.3	-11.62
2	0.73	0.976	10.95	0.72	7	0.37	-10.88
3	0.67	2.26	10.58	0.9	7	0.21	-10.38
4	0.73	1.54	10.4	0.86	7	0.24	-10.22
5	0.68	1.553	10.37	0.82	7	0.24	-10.21
6	0.67	0.801	10.72	0.53	7	0.4	-10.8
7	1.34	-0.224	12.13	0.08	7	1.35	-11.64
8	1.02	-0.006	13.21	0.02	7	1.65	-13.12

Table 8d. Diagnostics of the fit to the European Union summer survey data for the years 1995-2001, for Greenland Halibut in NAFO Subarea 2 and Div. 3KLMNO.

Fleet : EU Survey

Age	1995	1996	1997	1998	1999	2000	2001	2002
1	0.31	-0.29	-0.15	0.15	-0.76	0.06	0.7	-0.01
2	-0.24	0.75	0.14	0.35	-0.34	-1.3	0.14	0.5
3	-0.18	-0.58	0.26	0.59	0.32	-1.09	0.32	0.36
4	-0.41	-0.08	0.32	0.52	0.6	-0.3	-0.61	-0.04
5	-0.75	0	0.35	0.41	0.24	-0.16	-0.4	0.31
6	-0.22	-0.2	0.29	0.5	0.03	0.03	-0.45	0.03
7	0.14	-0.56	0.03	0.66	0.22	-0.24	-0.14	-0.11
8	0.12	-0.09	-0.03	0.27	0.02	0.08	0.51	-0.87
9	0.95	-0.01	0.44	0.56	-0.17	0.05	-0.78	-1.05
10	0.7	-0.55	0.56	0.62	-0.08	-0.03	-0.66	-0.55
11	0.96	0.13	0.15	0.11	-1.07	0.76	-1.07	0.02
12	0.52	0.72	0.23	-1.18	-1.31	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 q	-3.6032	-4.1339	-3.4952	-2.9755	-2.2544	-1.5316	-1.3188	-1.3569	-2.2227	-3.0027
S.E(Log q)	0.4291	0.6359	0.5731	0.4426	0.414	0.2979	0.3589	0.401	0.6732	0.5629

Age	11	12
Mean Log q	-4.1043	-4.1043
S.E(Log q)	0.7405	0.9916

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	0.79	0.771	5.19	0.7	8	0.35	-3.6
2	0.59	1.788	7.03	0.76	8	0.33	-4.13
3	0.82	0.502	4.81	0.58	8	0.5	-3.5
4	0.59	3.823	6.23	0.93	8	0.15	-2.98
5	0.88	0.38	3.3	0.61	8	0.39	-2.25
6	1.29	-0.755	-1.08	0.53	8	0.4	-1.53
7	1.53	-1.089	-3.36	0.41	8	0.54	-1.32
8	28.15	-1.418	******	0	8	10.55	-1.36
9	0.21	1.309	7.16	0.31	8	0.13	-2.22
10	0.31	1.016	6.43	0.26	8	0.17	-3
11	0.3	0.963	6.49	0.24	8	0.22	-4.1
12	-2.88	-0.169	15.41	0	5	3.2	-4.31

Table 8e. The XSA estimates of survivors at the beginning of 2002 derived from each survey, their standard errors and the combined weighted average; for Greenland Halibut in NAFO Subarea 2 and Div. 3KLMNO.

Terminal year survivor and F summaries :

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

Year class = 2001

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU Survey	66975	0.5	0	0	1	0.333	0
CAN RV4	74520	0.5	0	0	1	0.333	0
CAN RV5	62810	0.5	0	0	1	0.333	0
F shrinkage mean	0	0.5				0	0

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
67932	0.29	0.05	3	0.173	0

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

Year class = 2000

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU Survey	106359	0.402	0.096	0.24	2	0.287	0
CAN RV4	53773	0.354	0.21	0.59	2	0.37	0
CAN RV5	35585	0.367	0.26	0.71	2	0.343	0
F shrinkage mean	0	0.5				0	0

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
56739	0.22	0.22	6	1	0

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

Year class = 1999

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU Survey	40331	0.335	0.092	0.27	3	0.275	0
CAN RV4	34838	0.289	0.17	0.59	3	0.371	0
CAN RV5	29069	0.296	0.331	1.12	3	0.353	0
F shrinkage mean	0	0.5				0	0

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
34023	0.18	0.12	9	0.698	0

Table 8e (cont). The XSA estimates of survivors at the beginning of 2002 derived from each survey, their standard errors and the combined weighted average; for Greenland Halibut in NAFO Subarea 2 and Div. 3KLMNO.

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

Year class = 1998

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU Survey	13541	0.278	0.331	1.19	4	0.267	0.032
CAN RV4	24081	0.25	0.17	0.68	4	0.33	0.018
CAN RV5	18137	0.255	0.188	0.74	4	0.319	0.024
F shrinkage mean	54605	0.5				0.084	0.008

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
20221	0.14	0.16	13	1.096	0.021

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

Year class = 1997

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU Survey	13093	0.243	0.252	1.04	5	0.278	0.109
CAN RV4	24070	0.224	0.129	0.58	5	0.329	0.061
CAN RV5	12798	0.227	0.12	0.53	5	0.32	0.111
F shrinkage mean	29055	0.5				0.073	0.05

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
16830	0.13	0.12	16	0.937	0.086

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

Year class = 1996

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU Survey	13409	0.219	0.12	0.55	6	0.287	0.398
CAN RV4	14608	0.204	0.088	0.43	6	0.329	0.37
CAN RV5	12866	0.213	0.179	0.84	6	0.3	0.412
F shrinkage mean	27952	0.5				0.085	0.211

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
14500	0.12	0.08	19	0.704	0.373

Table 8e (cont). The XSA estimates of survivors at the beginning of 2002 derived from each survey, their standard errors and the combined weighted average; for Greenland Halibut in NAFO Subarea 2 and Div. 3KLMNO.

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

Year class = 1995

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU Survey	12449	0.202	0.154	0.76	7	0.297	0.823
CAN RV4	11626	0.197	0.123	0.62	7	0.301	0.862
CAN RV5	11714	0.209	0.193	0.92	7	0.263	0.858
F shrinkage mean	15987	0.5				0.14	0.691

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
12428	0.12	0.08	22	0.669	0.824

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

Year class = 1994

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU Survey	5562	0.21	0.211	1	8	0.335	0.73
CAN RV4	5024	0.207	0.093	0.45	8	0.277	0.784
CAN RV5	8475	0.236	0.176	0.75	7	0.18	0.534
F shrinkage mean	7961	0.5				0.208	0.56

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
6284	0.14	0.09	24	0.654	0.668

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

Year class = 1993

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU Survey	2318	0.255	0.237	0.93	8	0.35	0.396
CAN RV4	2654	0.264	0.159	0.6	8	0.253	0.354
CAN RV5	4189	0.263	0.128	0.48	6	0.127	0.238
F shrinkage mean	2686	0.5				0.27	0.35

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
2690	0.18	0.1	23	0.568	0.35

Table 8e (cont). The XSA estimates of survivors at the beginning of 2002 derived from each survey, their standard errors and the combined weighted average; for Greenland Halibut in NAFO Subarea 2 and Div. 3KLMNO.

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

Year class = 1992

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU Survey	1351	0.239	0.16	0.67	8	0.407	0.366
CAN RV4	1541	0.271	0.183	0.67	8	0.266	0.327
CAN RV5	2433	0.297	0.149	0.5	5	0.1	0.219
F shrinkage mean	2036	0.5				0.228	0.257

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
1629	0.17	0.1	22	0.565	0.312

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

Year class = 1991

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU Survey	860	0.248	0.149	0.6	8	0.404	0.321
CAN RV4	951	0.3	0.128	0.43	8	0.287	0.294
CAN RV5	1107	0.362	0.329	0.91	4	0.062	0.258
F shrinkage mean	1064	0.5				0.246	0.267

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
947	0.18	0.08	21	0.435	0.296

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

Year class = 1990

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU Survey	446	0.27	0.191	0.71	7	0.364	0.374
CAN RV4	586	0.336	0.102	0.3	7	0.252	0.297
CAN RV5	490	0.519	0.572	1.1	3	0.031	0.346
F shrinkage mean	795	0.5				0.353	0.227

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
588	0.22	0.11	18	0.499	0.296

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

Year class = 1989

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU Survey	557	0.277	0.194	0.7	6	0.271	0.186
CAN RV4	606	0.298	0.136	0.46	8	0.436	0.172
CAN RV5	278	0.861	0.327	0.38	2	0.012	0.344
F shrinkage mean	322	0.5				0.281	0.303

Weighted prediction :

Table 9. The estimates of fishing mortality at age derived from an XSA model fitted to the data for Greenland Halibut in NAFO Subarea 2 and Div. 3KLMNO.

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

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

Table 8 Fishing mortality (F) at age

YEAR	1975	1976	1977	1978	1979	1980	1981	1982
AGE								
5	0.0069	0.0003	0.008	0.0487	0.0536	0.0044	0.0199	0.008
6	0.1028	0.0155	0.132	0.1685	0.1965	0.0606	0.1241	0.0677
7	0.3218	0.1643	0.4128	0.369	0.4178	0.3258	0.4445	0.2558
8	0.4813	0.5737	0.685	0.5761	0.4666	0.6503	0.8887	0.5138
9	0.635	0.8538	0.719	0.6324	0.1588	1.0183	0.6889	0.7786
10	0.6434	0.9241	0.5846	0.9947	0.1995	1.1659	0.4403	0.6415
11	0.5755	0.7801	0.2048	1.1792	0.5367	0.8394	0.199	0.6023
12	0.4456	0.4338	0.2566	0.6219	0.8365	0.4894	0.2551	0.3132
13	0.5595	0.7195	0.3509	0.9422	0.5285	0.8402	0.2998	0.5231
+gp	0.5595	0.7195	0.3509	0.9422	0.5285	0.8402	0.2998	0.5231
FBAR 5-10	0.3652	0.422	0.4236	0.4649	0.2488	0.5376	0.4344	0.3776

YEAR	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
AGE										
5	0.0175	0.0171	0.0375	0.0052	0.0023	0.0047	0.0026	0.0143	0.0447	0.0813
6	0.1398	0.0742	0.1327	0.0542	0.0443	0.0674	0.0395	0.1267	0.1319	0.2394
7	0.4535	0.3583	0.2738	0.2349	0.4068	0.2704	0.223	0.3746	0.3872	0.6128
8	0.5506	0.7972	0.3786	0.4022	0.599	0.2798	0.2221	0.3685	0.6431	0.7677
9	0.3956	0.6691	0.3113	0.2691	0.4106	0.156	0.1432	0.3417	0.7228	0.5839
10	0.3302	0.3933	0.1575	0.1652	0.2471	0.1073	0.131	0.4179	0.6063	0.3847
11	0.1466	0.3299	0.0772	0.1046	0.1971	0.0841	0.1396	0.3125	0.578	0.3242
12	0.1378	0.1415	0.1234	0.0903	0.1685	0.0755	0.1536	0.4615	0.6024	0.4751
13	0.2058	0.2898	0.1198	0.1204	0.2052	0.0892	0.1419	0.4	0.6008	0.3974
+gp	0.2058	0.2898	0.1198	0.1204	0.2052	0.0892	0.1419	0.4	0.6008	0.3974
FBAR 5-10	0.3145	0.3849	0.2152	0.1885	0.285	0.1476	0.1269	0.274	0.4227	0.445

YEAR	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
AGE										
4	0.0182	0.1165	0.0086	0.0043	0.0045	0.006	0.0038	0.0072	0.0179	0.0212
5	0.2302	0.4568	0.0386	0.056	0.0539	0.0606	0.029	0.0324	0.0758	0.0856
6	0.5008	0.7392	0.1058	0.2041	0.1944	0.2132	0.1279	0.2362	0.2761	0.3728
7	0.7677	0.8106	0.3154	0.4648	0.5131	0.4523	0.6204	0.9867	0.8486	0.8242
8	0.9074	0.7691	0.3449	0.3159	0.4522	0.5051	0.6123	0.5146	0.6934	0.6685
9	0.7688	0.6286	0.2854	0.2559	0.3147	0.3735	0.4534	0.3074	0.2899	0.3495
10	0.5285	0.4092	0.2074	0.1885	0.2559	0.2415	0.2746	0.2523	0.2531	0.312
11	0.4203	0.4711	0.2146	0.2578	0.2372	0.2505	0.2377	0.2587	0.3446	0.2955
12	0.5898	0.2946	0.2842	0.22	0.2265	0.1339	0.3316	0.2156	0.2218	0.2962
13	0.5169	0.3943	0.2862	0.2361	0.1945	0.1234	0.1716	0.2262	0.256	0.2086
+gp	0.5169	0.3943	0.2862	0.2361	0.1945	0.1234	0.1716	0.2262	0.256	0.2086
FBAR 5-10	0.6172	0.6356	0.2162	0.2475	0.2974	0.3077	0.3529	0.3883	0.4062	0.4354

Table 10. Greenland Halibut in NAFO Subarea 2 and Div. 3KLMNO: estimates of population numbers at age derived from an XSA model.

Run title : G. halibut SA2+3KLMNO Index file: (Combined sexes with plus group)
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Terminal Fs derived using XSA with final year & oldest age shrinkage.

Table 10 Stock number at age (start of year) Numbers*10**-3

YEAR	1975	1976	1977	1978	1979	1980	1981	1982
AGE								
1	112396	116804	107653	82563	99303	130549	132417	132417
2	126320	92022	95631	88138	67597	81302	106885	108414
3	110188	103422	75341	78296	72162	55343	66565	87510
4	66828	90215	84675	61684	64103	59081	45311	54499
5	53833	54714	73861	69326	50503	52483	48371	37098
6	31898	43773	44781	59989	54061	39189	42781	38822
7	23093	23566	35286	32128	41501	36365	30198	30939
8	14338	13704	16370	19119	18188	22375	21494	15851
9	9313	7254	6322	6756	8799	9339	9561	7236
10	3931	4040	2529	2522	2939	6146	2762	3931
11	1773	1691	1313	1154	764	1971	1568	1456
12	415	816	635	876	291	366	697	1052
13	720	218	433	402	385	103	183	442
+gp	735	113	311	459	757	52	292	513
TOTAL	555780	552351	545141	503413	481350	494664	509085	520179

YEAR	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
AGE										
1	147223	155052	171074	191296	161335	132182	116609	112701	98766	75615
2	108414	120536	126946	140064	156620	132090	108221	95471	92272	80863
3	88762	88762	98687	103935	114674	128229	108146	88604	78165	75546
4	71647	72672	72672	80798	85094	93887	104985	88542	72543	63996
5	44620	58659	59499	59499	66152	69669	76869	85955	72406	59194
6	30130	35897	47210	46919	48460	54036	56773	62771	69377	56692
7	29705	21450	27287	33849	36387	37955	41358	44683	45278	49783
8	19613	15453	12274	16991	21912	19835	23713	27093	25153	25170
9	7763	9259	5701	6882	9304	9855	12276	15548	15344	10825
10	2720	4279	3882	3419	4305	5052	6903	8710	9045	6098
11	1694	1601	2364	2715	2373	2753	3716	4958	4695	4039
12	653	1198	942	1792	2002	1595	2072	2646	2970	2157
13	630	466	852	682	1340	1385	1211	1455	1366	1331
+gp	1035	799	839	1135	2069	1665	591	1057	1021	1120
TOTAL	554607	586082	630228	689974	712028	690189	663443	640194	588401	512427

YEAR	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
AGE											
1	89656	150247	186108	157036	75941	50739	45967	61994	84644	82971	0
2	61908	73404	123012	152372	128571	62175	41542	37635	50756	69301	67932
3	66205	50686	60098	100714	124752	105265	50905	34011	30813	41556	56739
4	61852	54204	41498	49204	82457	102138	86183	41677	27846	25227	34023
5	51433	49726	39497	33684	40113	67207	83124	70292	33877	22393	20221
6	44682	33450	25782	31114	26077	31120	51790	66112	55715	25710	16830
7	36533	22170	13077	18990	20772	17578	20586	37312	42742	34610	14500
8	22084	13880	8070	7810	9768	10180	9155	9063	11389	14978	12428
9	9564	7297	5267	4680	4662	5089	5029	4063	4435	4661	6284
10	4943	3630	3186	3241	2966	2787	2868	2617	2446	2717	2690
11	3398	2386	1974	2120	2198	1880	1792	1784	1665	1555	1629
12	2391	1828	1219	1304	1341	1419	1198	1157	1128	966	947
13	1098	1085	1114	751	857	876	1016	704	763	740	588
+gp	493	723	887	465	554	484	1054	565	365	473	806
TOTAL	456239	464717	510789	563485	521028	458936	402210	368987	348584	327857	235618

Table 11. Greenland Halibut in NAFO Subarea 2 and Div. 3KLMNO: XSA summary table of population and exploitation trends.

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

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Table 17 Summary (with SOP correction)

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

	RECRUITS Age 1	TOTALBIO AGE 5+	TOTSPBIO AGE 10+	LANDINGS	YIELD/SSB	FBAR 5-10
1975	112396	132746	21900	28814	1.3157	0.3652
1976	116804	134550	17673	24611	1.3925	0.422
1977	107653	157009	14820	32048	2.1625	0.4236
1978	82563	167833	15908	39070	2.4559	0.4649
1979	99303	162659	15629	34104	2.1821	0.2488
1980	130549	131050	12412	32867	2.648	0.5376
1981	132417	115440	14049	30754	2.1891	0.4344
1982	132417	121566	19922	26278	1.3191	0.3776
1983	147223	123099	24241	27861	1.1493	0.3145
1984	155052	115661	24386	26711	1.0953	0.3849
1985	171074	148861	29175	20347	0.6974	0.2152
1986	191296	138983	33771	17976	0.5323	0.1885
1987	161335	165854	42620	32442	0.7612	0.285
1988	132182	170705	44703	19215	0.4298	0.1476
1989	116609	192347	46155	20034	0.4341	0.1269
1990	112701	218799	59067	47454	0.8034	0.274
1991	98766	215807	60698	65008	1.071	0.4227
1992	75615	201398	51084	63193	1.2371	0.445
1993	89656	153006	38894	62455	1.6058	0.6172
1994	150247	124123	35620	51029	1.4326	0.6356
1995	186108	88713	30449	15272	0.5016	0.2162
1996	157036	95196	28067	18840	0.6713	0.2475
1997	75941	91520	27792	19858	0.7145	0.2974
1998	50739	103323	25624	19946	0.7784	0.3077
1999	45967	124608	27403	24226	0.8841	0.3529
2000	61994	129203	21836	34177	1.5652	0.3883
2001	84644	121002	20281	38232	1.8852	0.4062
2002	82971	98034	20054	34062	1.6985	0.4354
Arith. Mean	116473	140825	29437	32389	1.2719	0.3565
Units	(Thousands)	(Tonnes)	(Tonnes)	(Tonnes)		

Table 12. Greenland Halibut in NAFO Subarea 2 and Div. 3KLMNO: input for the short-term projection.

2003

Age	N	M	Mat	PF	PM	SWt	Selection	CWt
1	130000	0.2	0	0	0	0.000	0.000	0.000
2	67932	0.2	0	0	0	0.000	0.000	0.000
3	56739	0.2	0	0	0	0.000	0.000	0.072
4	34023	0.2	0	0	0	0.000	0.016	0.251
5	20221	0.2	0	0	0	0.364	0.069	0.364
6	16830	0.2	0	0	0	0.550	0.313	0.550
7	14500	0.2	0	0	0	0.819	0.942	0.819
8	12428	0.2	0	0	0	1.184	0.664	1.184
9	6284	0.2	0	0	0	1.776	0.335	1.776
10	2690	0.2	1	0	0	2.308	0.289	2.308
11	1629	0.2	1	0	0	2.914	0.318	2.914
12	947	0.2	1	0	0	3.646	0.260	3.646
13	588	0.2	1	0	0	4.493	0.245	4.493
14	806	0.2	1	0	0	5.489	0.245	5.489

2004

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	130000	0.2	0	0	0	0.000	0.000	0.000
2		0.2	0	0	0	0.000	0.000	0.000
3		0.2	0	0	0	0.000	0.000	0.072
4		0.2	0	0	0	0.000	0.016	0.251
5		0.2	0	0	0	0.364	0.069	0.364
6		0.2	0	0	0	0.550	0.313	0.550
7		0.2	0	0	0	0.819	0.942	0.819
8		0.2	0	0	0	1.184	0.664	1.184
9		0.2	0	0	0	1.776	0.335	1.776
10		0.2	1	0	0	2.308	0.289	2.308
11		0.2	1	0	0	2.914	0.318	2.914
12		0.2	1	0	0	3.646	0.260	3.646
13		0.2	1	0	0	4.493	0.245	4.493
14		0.2	1	0	0	5.489	0.245	5.489

2005

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	130000	0.2	0	0	0	0.000	0.000	0.000
2		0.2	0	0	0	0.000	0.000	0.000
3		0.2	0	0	0	0.000	0.000	0.072
4		0.2	0	0	0	0.000	0.016	0.251
5		0.2	0	0	0	0.364	0.069	0.364
6		0.2	0	0	0	0.550	0.313	0.550
7		0.2	0	0	0	0.819	0.942	0.819
8		0.2	0	0	0	1.184	0.664	1.184
9		0.2	0	0	0	1.776	0.335	1.776
10		0.2	1	0	0	2.308	0.289	2.308
11		0.2	1	0	0	2.914	0.318	2.914
12		0.2	1	0	0	3.646	0.260	3.646
13		0.2	1	0	0	4.493	0.245	4.493
14		0.2	1	0	0	5.489	0.245	5.489

Input units are thousands and kg - output in tonnes

Table 13. Greenland Halibut in NAFO Subarea 2 and Div. 3KLMNO: short-term projection management options table for 2003-2005.

G. halibut SA2+3KLMNO Index file
Time and date: 20:37 14/06/03

2003		
5+ Biomass Tonnes	FBar (5 - 10)	Landings Tonnes
76000	0.61	30000

2004			2005
5+ Biomass Tonnes	FBar	Landings Tonnes	5+ Biomass Tonnes
58000	0.00	000	78000
.	0.04	1,900	76000
.	0.09	3,700	74000
.	0.13	5,400	72000
.	0.17	7,000	70000
.	0.22	8,500	68000
.	0.26	10,000	66000
.	0.30	11,400	64000
.	0.35	12,700	63000
.	0.39	14,000	61000
.	0.44	15,200	60000
.	0.48	16,400	58000
.	0.52	17,500	57000
.	0.57	18,600	56000
.	0.61	19,600	55000
.	0.65	20,600	53000
.	0.70	21,600	52000
.	0.74	22,500	51000
.	0.78	23,400	50000
.	0.83	24,200	49000
.	0.87	25,000	48000

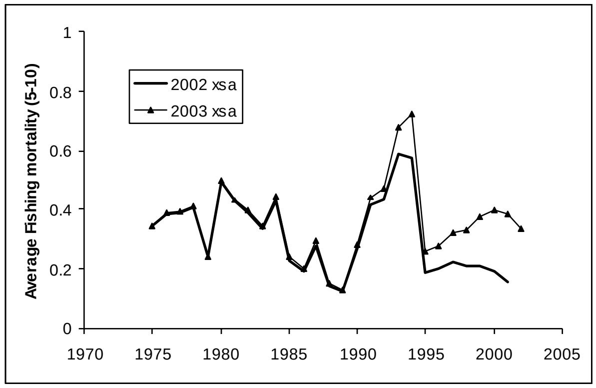


Fig. 1. Greenland halibut in Subarea 2 and Div. 3KLMNO : A comparison of the fishing mortality time series computed by XSA model fits to the data set constructed for the 2002 and 2003 assessments.

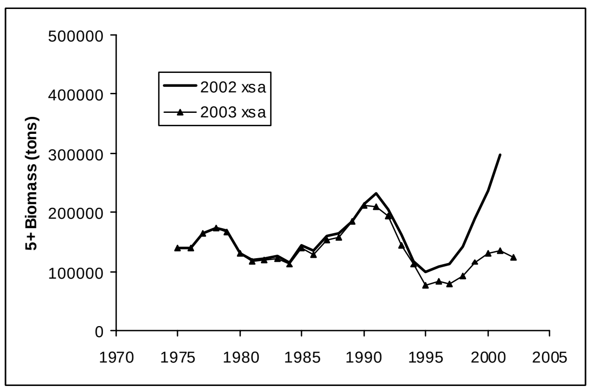


Fig. 2. Greenland halibut in Subarea 2 and Div. 3KLMNO : A comparison of the 5+ exploitable biomass time series from computed by XSA model fits to the data sets constructed for the 2002 and 2003 assessments.

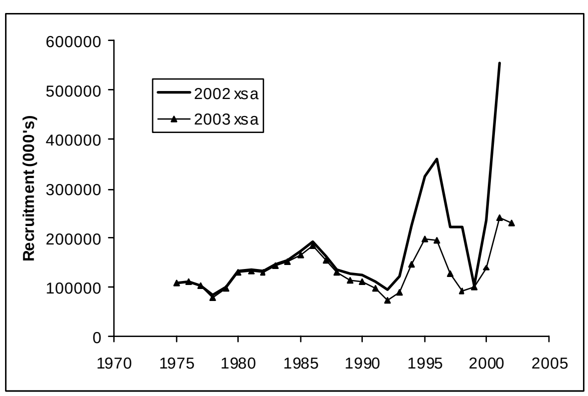


Fig. 3. Greenland halibut in Subarea 2 and Div. 3KLMNO : A comparison of the time series of recruitment at age 1 computed by XSA models fitted to the assessment data collated for 2002 and 2003

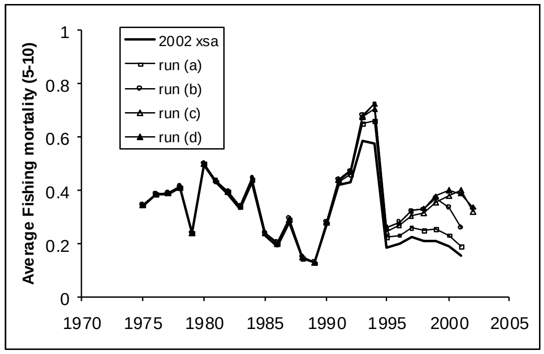


Fig. 4. Greenland halibut in Subarea 2 and Div. 3KLMNO : A comparison of the average fishing mortality time series computed by XSA models fitted to the data collated in 2002 and 2003. Refer to the text for the run keys.

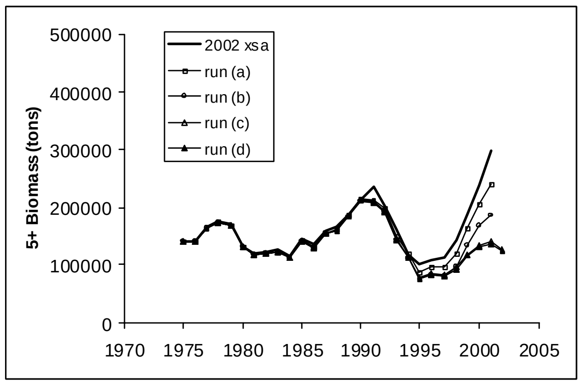


Fig. 5 Greenland halibut in Subarea 2 and Div. 3KLMNO : A comparison of the 5+ exploitable biomass time series computed by XSA models fitted to the data collated in 2002 and 2003. Refer to the text for the run keys.

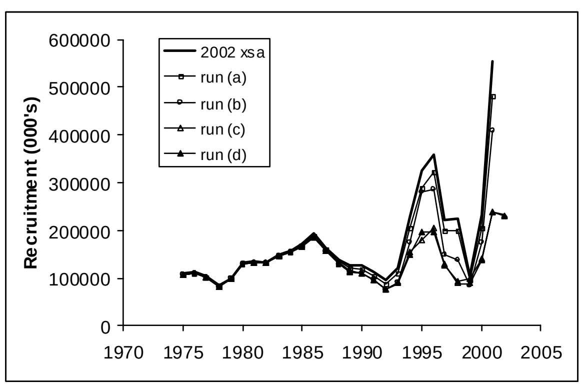


Fig. 6. Greenland halibut in Subarea 2 and Div. 3KLMNO : A comparison of the time series of recruitment at age 1 computed by XSA models fitted to the data for 2002 and 2003. Refer to the text for the run keys.

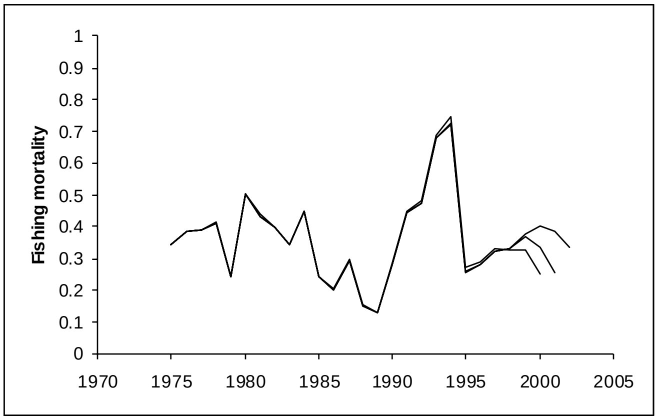


Fig. 7. Greenland halibut in Subarea 2 and Div. 3KLMNO: A retrospective plot of the time series of XSA estimated average fishing mortality (ages 5-10). 2002 XSA model formulation.

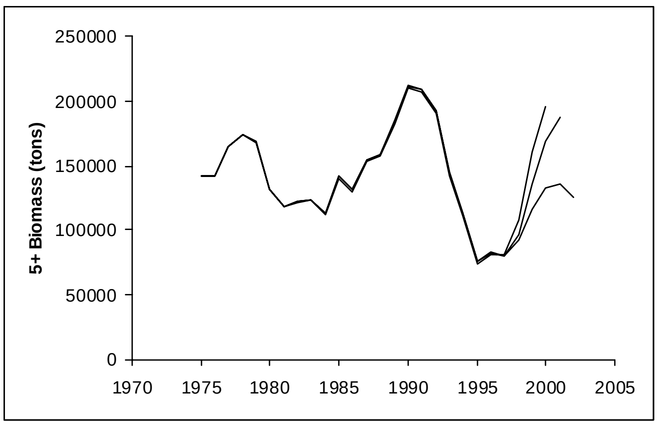


Fig. 8. Greenland halibut in Subarea 2 and Div. 3KLMNO: A retrospective plot of the time series of XSA estimated 5+ exploitable biomass. 2002 XSA model formulation.

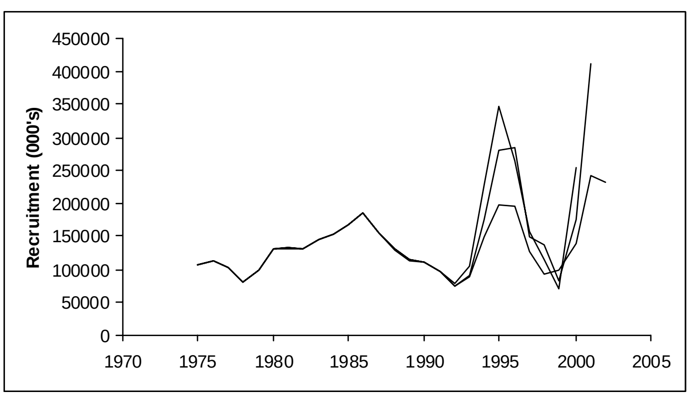


Fig. 9. Greenland halibut in Subarea 2 and Div. 3KLMNO: A retrospective plot of the time series of XSA estimated recruitment at age 1. 2002 XSA model formulation.

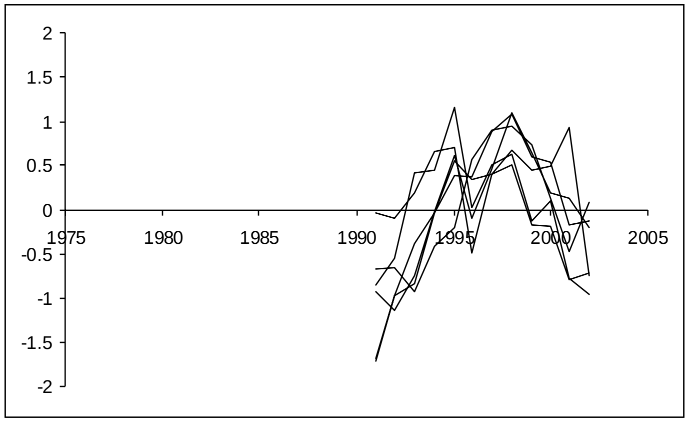


Fig. 10. Greenland halibut in Subarea 2 and Div. 3KLMNO: Log catchability residuals for the EU summer survey in Div. 3M from 1991-2002, ages 5-0

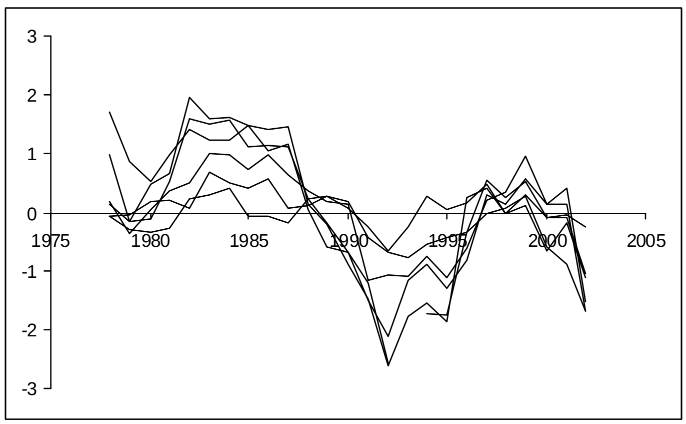


Fig. 11. Greenland halibut in Subarea 2 and Div. 3KLMNO: Log catchability residuals for the time series of the Campelen converted Canadian autumn survey in Div. 2J+3KL, ages 5- 10. Prior to 1995 the data are Engels indices converted to Campelen indices.

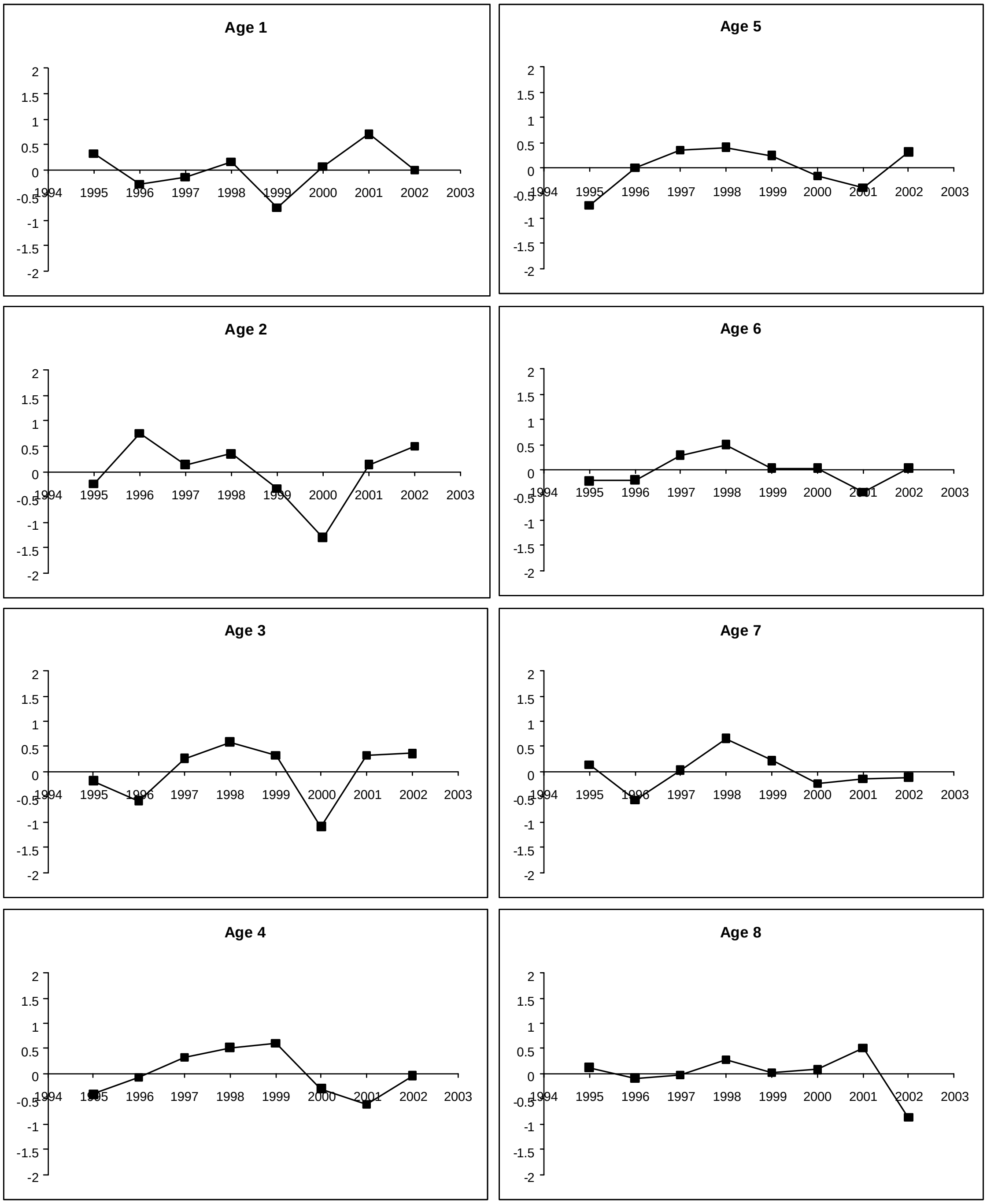


Fig. 12a. Log catchability residuals for the EU summer survey in Div. 3M from 1995-2002.

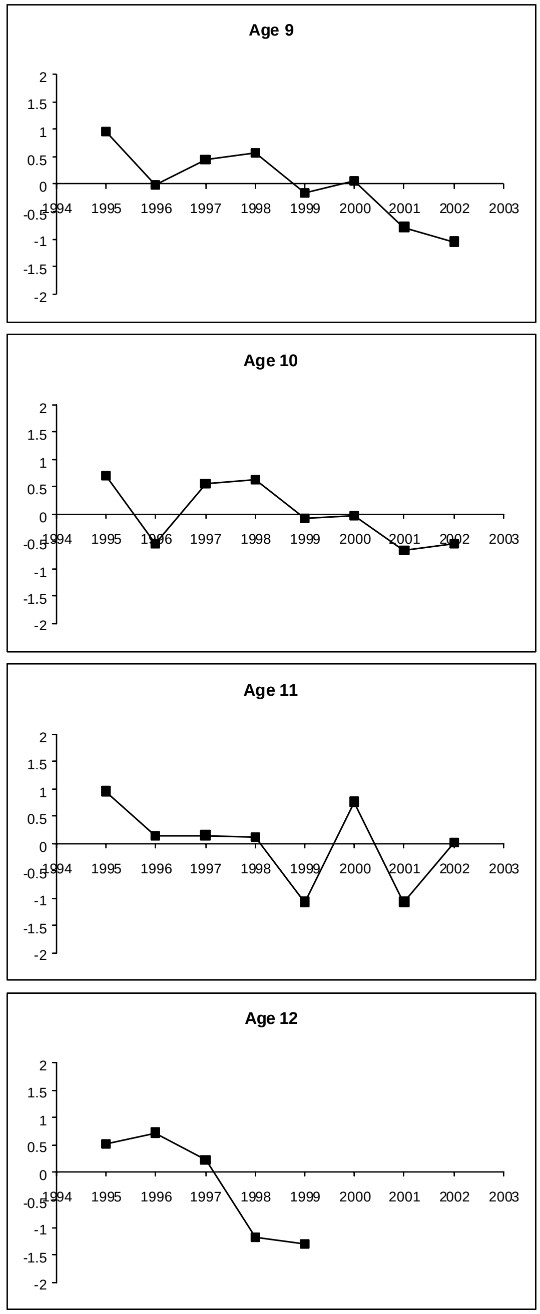


Fig. 12b. Log catchability residuals for the EU summer survey in Division 3M from 1995–2002.

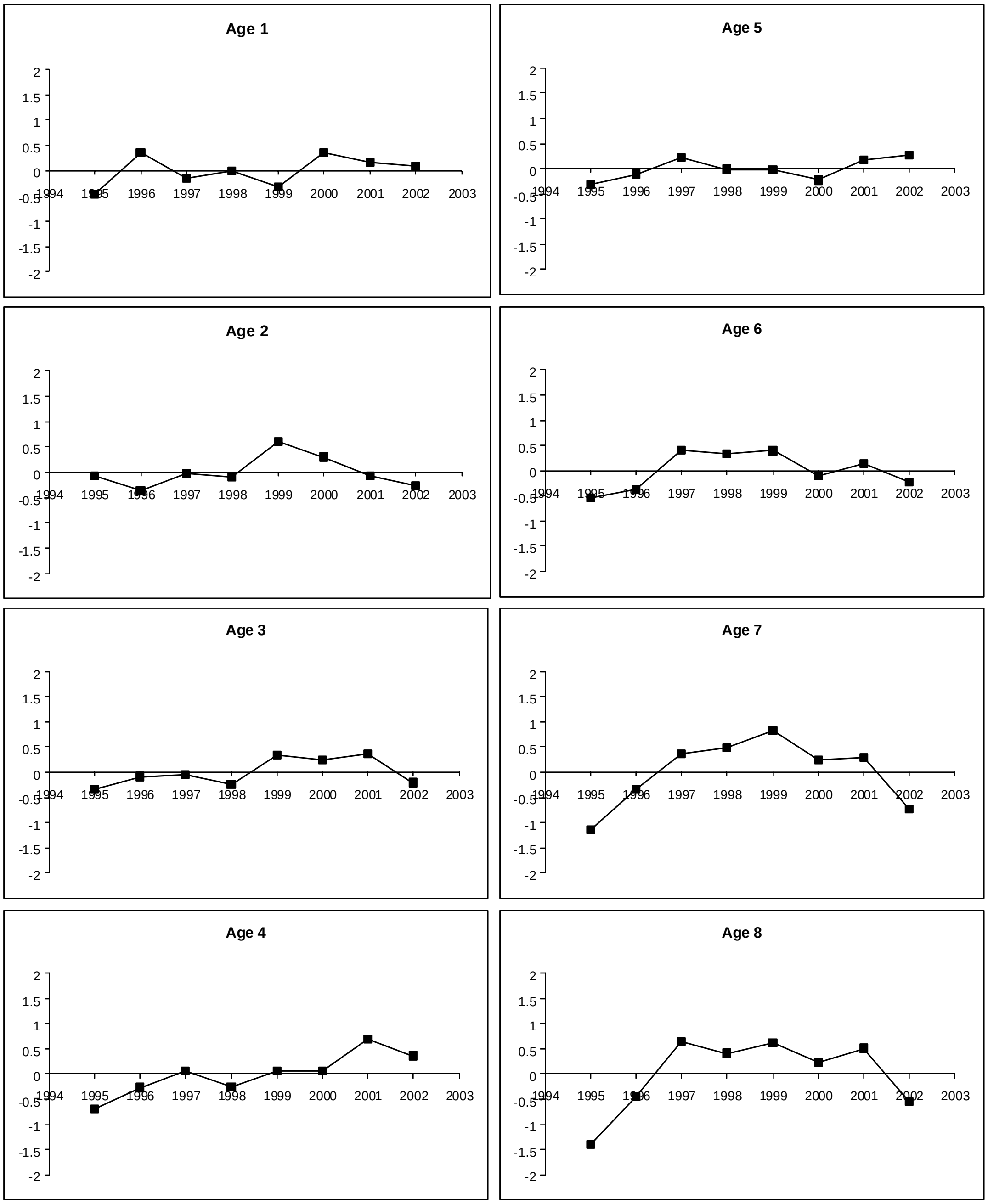


Fig. 13a. Log catchability residuals for the time series of the Campelen Canadian autumn survey (CAN RV4) in Division 2J3KL 1995 – 2002.

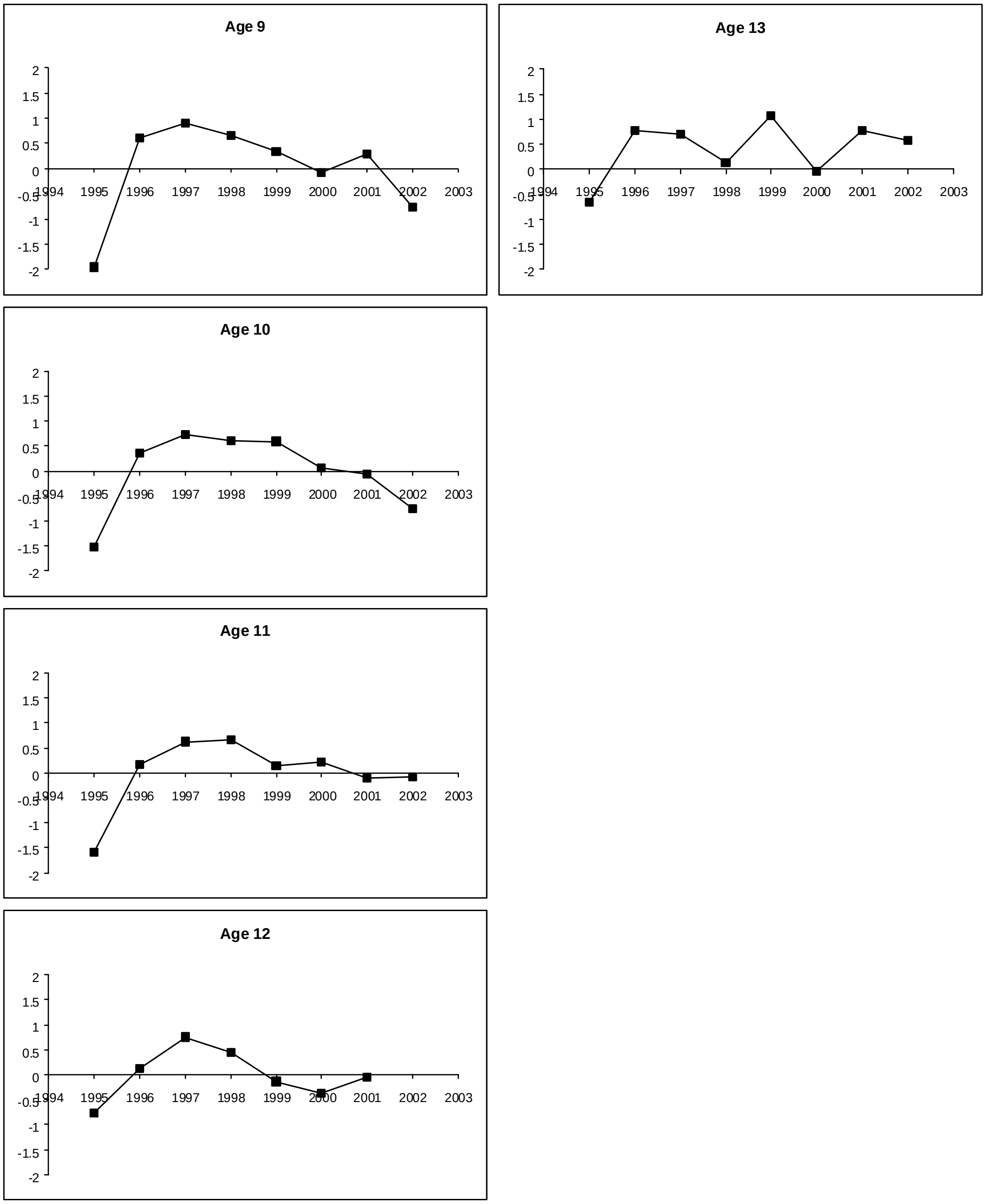


Fig. 13b. Log catchability residuals for the time series of the Campelen Canadian autumn survey (CAN RV4) in Div. 2J+3KL, 1995-2002.

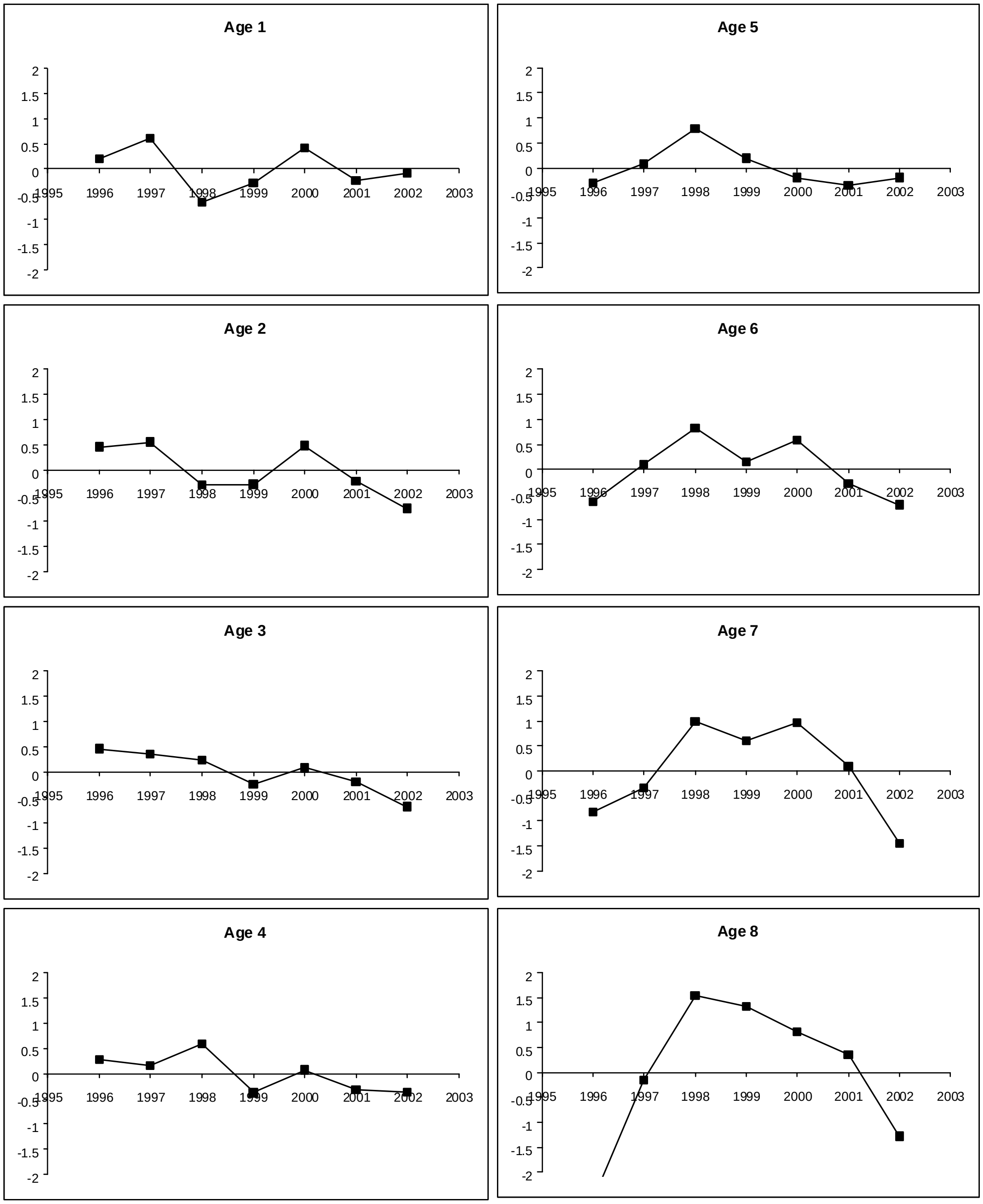


Fig. 14. Log catchability residuals for the time series of the Campelen Canadian spring (Can RV5) survey in Div. 2J+3KL 1995-2002.

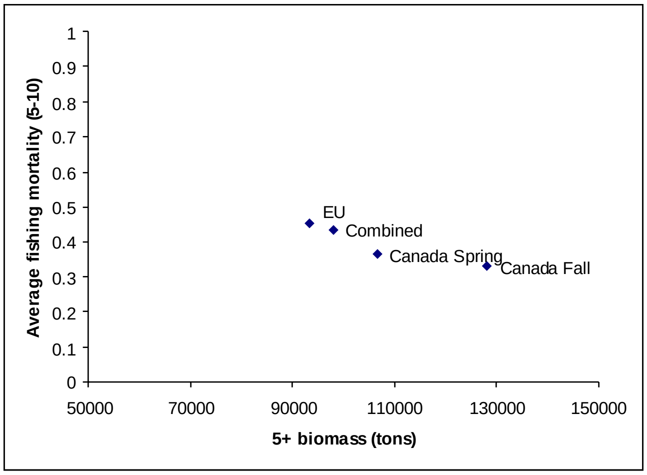


Fig. 15. Greenland halibut in Subarea 2 and Div. 3KLMNO: Estimates of 2002, beginning of the year, 5+ exploitable biomass and average fishing mortality at ages 5-10 from XSA assessment fitted to the individual survey series available for tuning, and the estimates from the combined assessment.

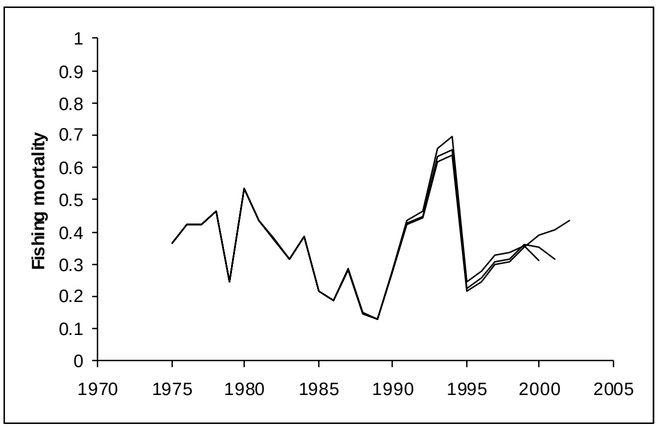


Fig. 16. Greenland halibut in Subarea 2 and Div. 3KLMNO : A retrospective plot of the time series of estimated average fishing mortality (ages 5-10) computed using the 2003 XSA formulation.

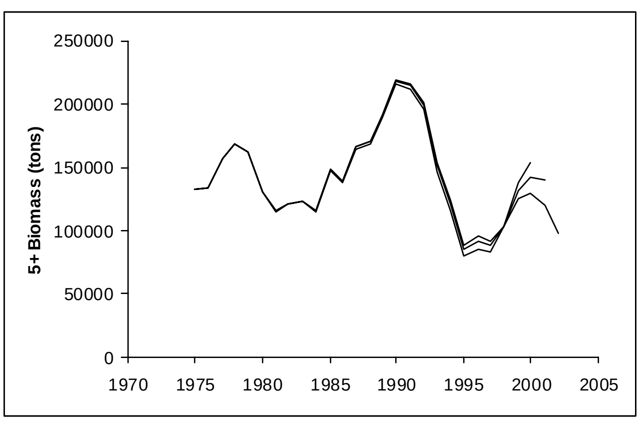


Fig. 17. Greenland halibut in Subarea 2 and Div. 3KLMNO : A retrospective plot of the time series of estimated 5+ exploitable biomass computed using the 2003 XSA formulation.

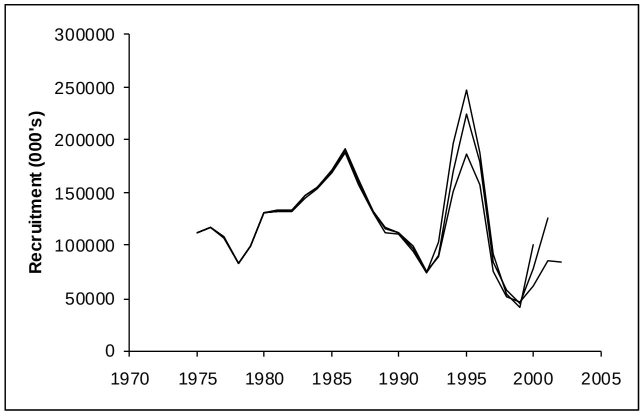


Fig. 18. Greenland halibut in Subarea 2 and Div. 3KLMNO : A retrospective plot of the time series of estimated recruitment at age 1 computed using the 2003 XSA formulation.

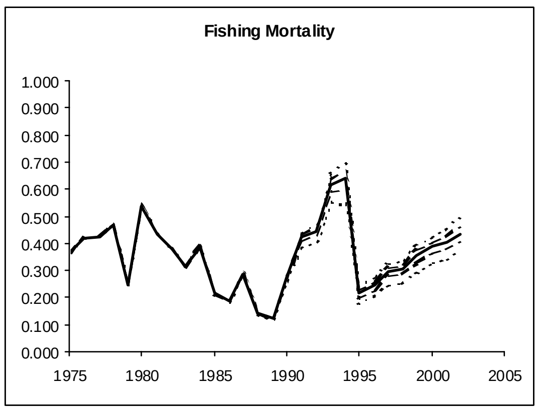


Fig. 19. Greenland halibut in Subarea 2 and Div. 3KLMNO: average fishing for ages 5-10 (5th, 25th, 50th, 75th and 95th percentiles) computed by non-parametric bootstrap XSA

.

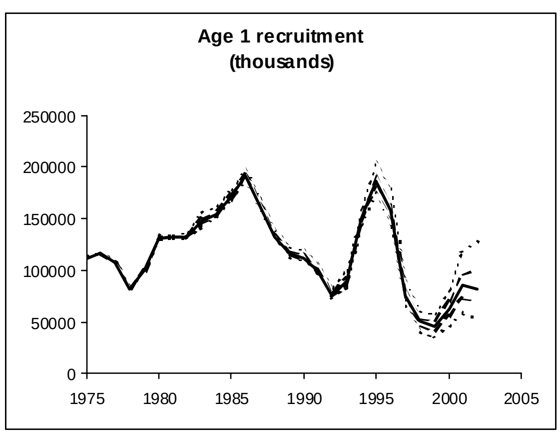


Fig. 20. Greenland halibut in Subarea 2 and Div. 3KLMNO: recruitment (5th, 25th, 50th, 75th and 95th percentiles) computed by non-parametric bootstrap of XSA.

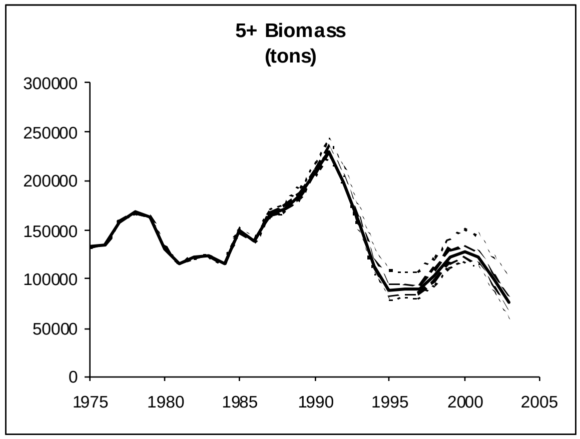


Fig. 21. Greenland halibut in Subarea 2 and Div. 3KLMNO: age 5+ exploitable biomass (5th, 25th,50th,75th and 95th percentiles) computed by non-parametric bootstrap of XSA.

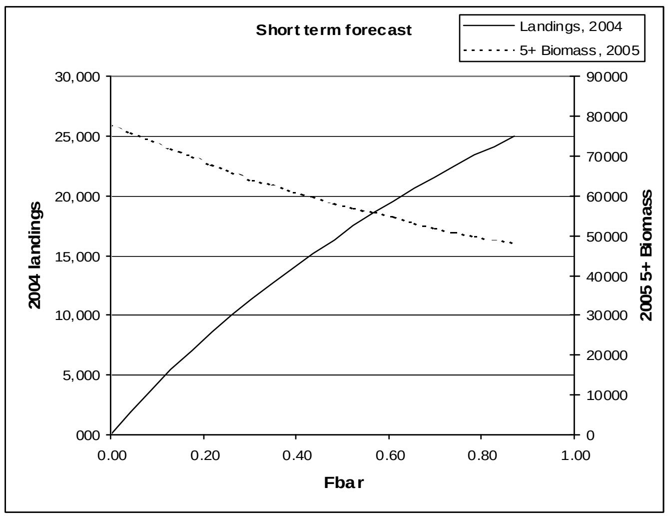
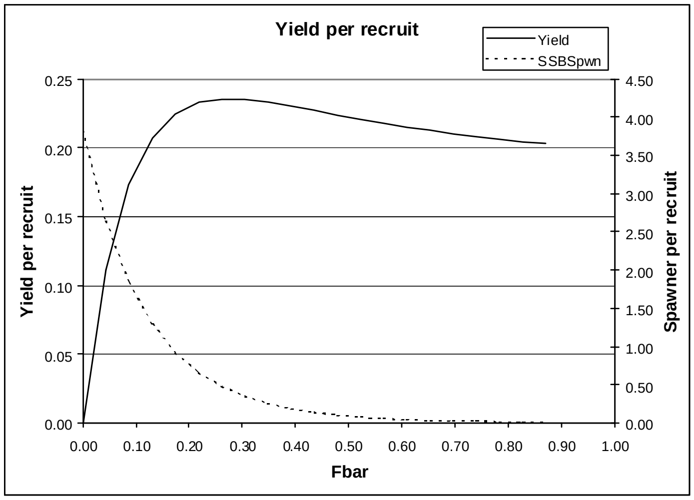


Fig. 22. Greenland halibut in Subarea 2 and Div. 3KLMNO: short-term projections for fishing landings in 2004 and 5+biomass in 2005 at a range of fishing mortalities.



Reference point	F multiplier	Absolute F
Fbar(5-10)	1.0000	0.4354
FMax	0.6306	0.2746
F0.1	0.3732	0.1625
F35%SPR	0.2897	0.1262

Weights in kilograms

Fig. 23. Greenland halibut in Subarea 2 and Div. 3KLMNO: yield-per-recruit.

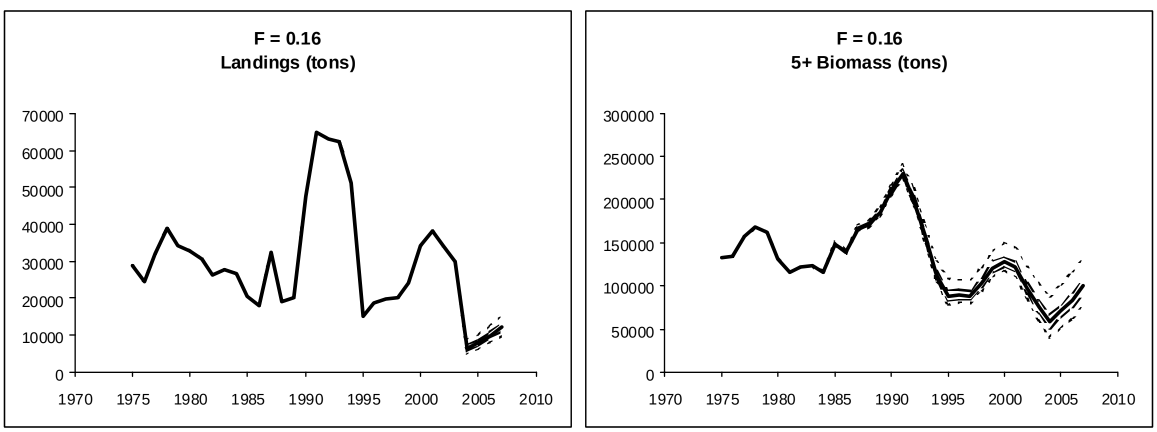


Fig. 24. Greenland halibut in Subarea 2 + Div. 3KLMNO: A stochastic projection for landings and ages 5+ exploitable biomass at a constant fishing mortality of F = 0.16 (F0.1) in the years 2004- 2007.

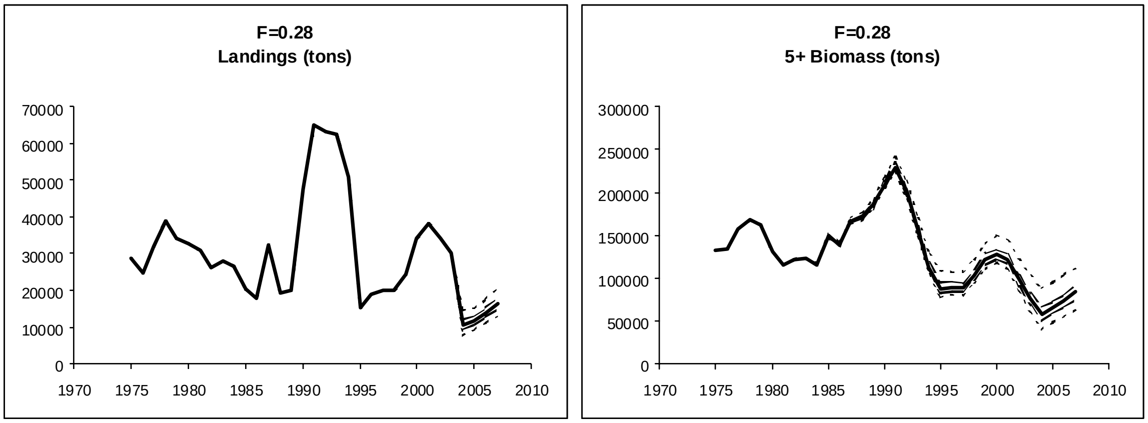


Fig. 25. Greenland halibut in Subarea 2 + Div. 3KLMNO: A stochastic projection for landings and ages 5+ exploitable biomass at a constant fishing mortality of F = 0.28 (Fmax) in the years 2004-2007.

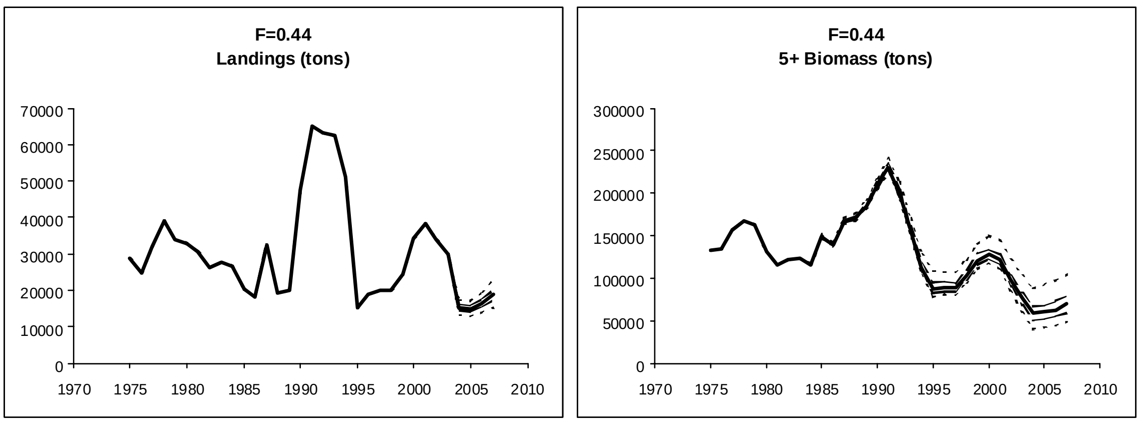


Fig. 26. Greenland halibut in Subarea 2 + Div. 3KLMNO: A stochastic projection for landings and ages 5+ exploitable biomass at a constant fishing mortality of F = 0.44 (F status quo) in the years 2004- 2007.

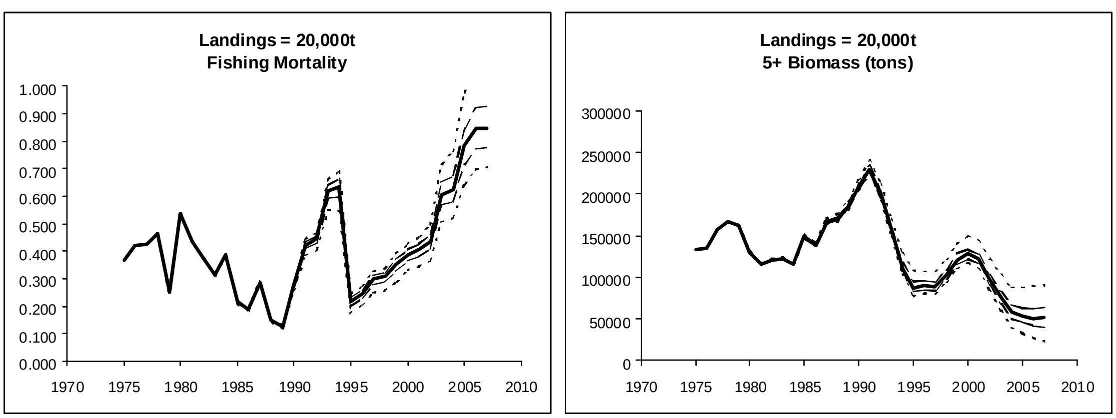


Fig. 27. Greenland halibut in Subarea 2 + Div. 3KLMNO: A stochastic projection for fishing mortality and ages 5+ exploitable biomass at a constant catch of 20 000 tons in the years 2004- 2007.

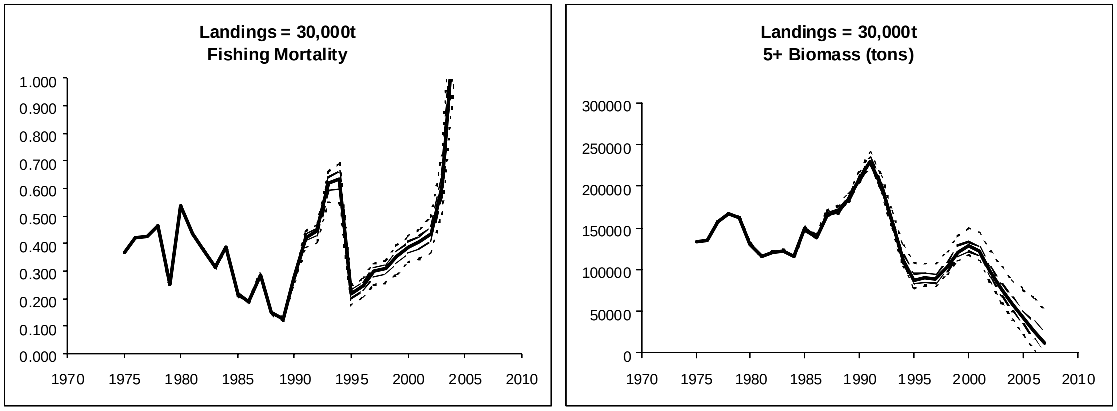


Fig. 28. Greenland halibut in Subarea 2 + Div. 3KLMNO: A stochastic projection for fishing mortality and ages 5+ exploitable biomass at a constant catch of 30 000 tons in the years 2004-2007.