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Greenland Halibut (*Reinhardtius hippoglossoides*) in Subarea 2 and Divisions 3KLMNO: an Assessment of Stock Status Based on upon Extended Survivors Analysis, ADAPT, and ASPIC Analyses, with Stochastic Projections of Potential Stock Dynamics

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Abstract

The population size of Greenland Halibut in Subarea 2 and Divisions 3KLMNO was estimated using Extended Survivors Analysis (XSA). A sensitivity analysis of the XSA model formulation was conducted in order to examine the robustness of the estimated population trends. The diagnostics from a fit of the 2003 XSA formulation to the 2004 catch at age and survey data sets were reviewed. We conclude that the XSA formulation used in 2003 was still appropriate for fitting the model to the data and therefore retained the 2003 formulation.

The XSA estimates are contrasted with estimates from an alternate age-disaggregated model (ADAPT), and a stock production model (ASPIC). All analyses indicate that in the recent period, stock biomass (5+) is estimated to be at the lowest level in the time series. Further, all of the methods indicate that fishing mortality increased steadily over 1995 to 2002, and that estimates of fishing mortality for 2003 represent a substantial increase over recent levels.

Deterministic and stochastic projections of XSA results suggest that under the current rebuilding plan, the 5+ biomass will remain stable through 2005 at the current low level. By the year 2008, the 5+ biomass will slowly increase to reach the level estimated for 2003.

Introduction

Recent assessments of Greenland Halibut in Subarea 2 and Div. 3KLMNO have been based on the application of the Extended Survivors Analysis model (XSA, Shepherd, 1999) fitted within the Lowestoft assessment suite (Darby and Flatman, 1994). Results of the 2003 NAFO Scientific Council assessment of the state of the stock indicated that the exploitable biomass was at the lowest level in the time series and that fishing mortality was twice the level of $F_{0.1}$ and increasing (NAFO, 2003a; Darby *et al*., 2003). In this paper we re-evaluate the status of the stock using the most recent stock surveys and catches. The results from fit of the 2004 XSA model are compared with estimates derived from a variety of alternative XSA formulations and assessment models. In all analysis, the 2003 catch is set at 35,151 tons, the 2003 STACFIS estimate of removals.

Input Data

Catches

Catches increased from low levels in the early-1960s when the fishery began to over 36 000 tons in 1969, ranged from 18 000 tons to 39 000 tons until 1990 (Fig. 1), when an extensive fishery developed in the deep water of the NAFO Regulatory Area (Bowering and Brodie, 1995). The total catch estimated by STACFIS for 1990-94 was in the range of 47 000 to 63 000 tons annually, although estimates in some years were as high as 75 000 tons. Beginning in 1995, TACs for the resource were established for the whole stock areal distribution by the Fisheries Commission, and the catch declined to just over 15 000 tons in 1995, a reduction of about 75% compared to the average annual catch of the previous 5 years. The catch from 1996-98 was around 20 000 tons per year. Catches have been increasing since then and by 2001 had reached 38 000 tons before declining to 34 000 tons in 2002. During the last 9 years the catch has achieved the TAC in only one year. In 2003, the total catch was estimated to be within the range 32 000 tons to 38 500 tons. The STACFIS estimate of catch for 2003 was 35 000 tons.

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

Catch at age

The 2003 length sampling provided by EU-Portugal (Vargas *et al*., 2004), EU-Spain (González *et al*., 2004), and Russia (Sigaev *et al.*, 2004) are quite similar, all indicating a modal catch length of about 40-44 cm. However, available age-length keys highlight the difference between Spanish and Canadian age interpretations (Alpoim *et al*., 2002; Darby *et al.*, 2003). At a given age, the Spanish data have greater mean lengths than Canadian data. Until the differences can be resolved, Canadian age-length keys were applied in place of the Spanish age-length keys.

Computation of Canadian catch-at-age is described by Brodie and Power (2004). Samples from the Canadian fishery were used to derive catch-at-age independently for each gear (see Table 5 of Brodie and Power, 2004). The 1996 year-class (age 7 in 2003) dominated the Canadian catch.

Russian aging was similar to Spanish aging, indicating a modal catch at age 6 for 2003. Therefore, the Russian catch was also derived by age using Canadian sampling data. The Portuguese length samples are also converted to catch-at-age using Canadian aging data as no aging data from EU-Portugal from 2003 catches are available. Norwegian sampling data are used to compute the at-age removals from an 80 ton longline fishery in Div. 3L.

No sampling data are available from Lithuania, Estonia, Japan, and Faeroese catches (4 318 tons combined catch), also operating in the NRA. A catch at age was developed for these fleets under the assumption that the age-composition was similar to that of the combined Spanish, Portuguese and Russian catches.

The catch numbers-at-age for 1975-2003 are given in Table 1. As in the recent past, in 2003 the modal catch was at age 7, corresponding to the 1996 year-class. Catch weights at age (Table 2) are computed as weighted means of the values from national sampling, and indicate no trends over time.

Survey Indices

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

a) EU - a European Union summer survey in Div. 3M from 1991-2003, ages 1-12 (Casas, 2004).

b) Can RV0 - a 2J+3K autumn survey, Engel series converted to Campelen data from 1978 to 1994, ages 1 to 16 (Dwyer *et al*. 2004).

c) Can RV4 - a 2J+3KL autumn survey, true Campelen data from 1995 to 2003, ages 1 to 14 (Dwyer *et al*., 2004).

d) Can RV5 - a 3LNO spring survey, true Campelen data from 1996 to 2002, ages 1 to 8 (Dwyer *et al*., 2004).

The Canadian survey series were revised in 2003 (Dwyer and Bowering, 2003) to indices computed as stratified mean numbers per tow, a revision from swept area indices. In 2004, two slight changes to the Canadian survey series used in the 2003 assessment were made to correct minor errors in the Canadian Fall 1995 mean numbers per tow values. A re-run of last year's assessment indicated that these changes would not have altered perceptions of stock status.

In this year's assessment the EU Summer survey Abundance indices at age were replaced by mean numbers per tow; a STACFIS recommendation. A re-run of the 2003 assessment using the alternative data series indicated no change in the perception of stock status. However, the estimated variability in the log catchability at the older ages of the EU index decreased.

Darby *et al*. (2003) examined the consistency within and between the EU and Canadian age disaggregated survey series covering different portions of the stock area. The results indicated good agreement between and within surveys in the most recent time period.

Two other survey series contain information on Greenland halibut, but currently are not suitable for inputs to the assessment models: a Spanish 3NO survey (González Troncoso *et al*., 2004) and a Russian survey in 3M (Vaskov and Igashov, 2003). The Spanish survey is not age disaggregated at present. The Russian survey series was last updated in 2003. The series cannot be used to evaluate trends in stock abundance because the data for the years 2001 and 2002 are not comparable with those collected from 1987 - 1996 due to vessel changes and substantial changes to the area and depth coverage.

Historically, the Canadian autumn survey series from 1978-1994, which utilized a hi-rise Engels trawl, and the series from 1995-2003 using a Campelen shrimp trawl were used as a single time series after conversion of the pre-1995 data to Campelen trawl units (see Warren *et al*., 1997). However, as discussed in Darby *et al* (2003), the environmental changes which affected the Northwest Atlantic during the late-1980's and early-1990's were considered to have had a major effect on the catchability of older Greenland halibut in Divisions 2J3KL. In 1993 STACFIS noted for Greenland halibut in Subarea 2 and Div. 3KLMNO:

"*The current assessment clearly indicated that all indices of stock size in the traditional area of the fishery declined in recent years and by 1992 were at the lowest levels observed in the time series. It had been previously indicated from pre-recruit surveys that the 1984-86 year-classes were strong and an improvement in stock abundance and biomass was expected in this area. However, 1991 surveys showed a marked decline in their abundance and by 1992 these year-classes had virtually disappeared in Div. 2J and 3KL as determined by Canadian groundfish surveys. However, EEC surveys in Div. 3M do not show this declining trend at least to depths down to 732 m.*

After evaluating the data presented at this meeting STACFIS agreed that there has probably been a redistribution of the Greenland halibut resource in recent years and that a substantial part of the stock component being exploited in the Regulatory Area of Div. 3L, 3M and 3N is likely to have originated in Divisions to the north, at least from Div. 2J and 3KL. This was particularly apparent in that the strong 1984-86 year-classes, which disappeared in Div. 2J, 3K in recent years, appeared as a main component of the catch in 1992 in the Regulatory Area especially the 1986 year-class."

The declining trend in the Canadian fall surveys in Div. 2J and 3K from the mid-1980's to the early-1990's was considered to represent Greenland halibut emigrating from the survey area to the deep waters of the Flemish Pass as opposed to a severe decline in the stock. In the Flemish Pass they were exploited by what has become the main component of the commercial fishery.

Since the mid-1990's, survey indices both in the Regulatory Area and in Div. 2J and 3K show similar trends suggesting that emigration does not appear be a significant contributing factor to the overall trends in the recent years. Given these observations, it was concluded (Darby *et al*., 2003) that it would be inappropriate to use the Canadian fall Div. 2J and 3K survey index prior to the mid-1990's as a calibration index in a VPA based assessment.

Assessment Methods

In this assessment, we consider two age-disaggregated analyses, XSA (Shepherd, 1999; Darby and Flatman, 1994), ADAPT (Gavaris, 1988), and also an age-aggregated production model, ASPIC (Prager, 1994). In the following sections, we compare the results from the XSA, ADAPT and ASPIC formulations considered.

An assessment of Greenland halibut in Subarea 2 and Div. 3KLMNO using XSA

An XSA analysis (Shepherd, 1999; Darby and Flatman, 1994) was carried out using identical settings to those applied in the 2003 assessment (Darby *et al*., 2003).The XSA was tuned using age-disaggregated index data from 1995 onward, with commercial catch-at-age from 1975-2003. A listing of the XSA settings used in the assessment is provided in Table 4.

The results of the assessment run using all available data and using the XSA framework from the 2003 assessment (see Darby *et al*., 2003) are presented in Tables 5-9. Plots of recruitment, biomass (5+), average F(5-10) and some diagnostic plots are given in Fig. 2. Log catchability residuals from the model fit are plotted in Fig. 3. XSA estimates of survivors at the beginning of 2004 are used to compute the biomass in that year. The 2004 stock weights at age are assumed equal to the average of 2001-2003. The model fit indicates that the stock 5+ biomass continues to decline; estimated biomass for the beginning of 2004 is 60,000 tons, the lowest in the time series. In recent years, increased catches have led to a sustained increase in the fishing mortality. Since 1995, average F is estimated to have increased steadily from 0.24 to 0.49 in 2003 fishing mortality is estimated to have increased sharply to 0.68, the highest level in the analysis. Based on average exploitation patterns and weight-at-age for the years 2001-2003, $F_{0.1}$ is estimated to be 0.15, and F_{max} = 0.25.

Retrospective analyses

Figure 4 presents retrospective analysis of the recruitment at age 1, exploitable biomass (ages 5+) and average fishing mortality at ages 5-10. Figure 4a illustrates the difficulty that the aged based assessment models have had in estimation of the abundance of the 1993 – 1995 year-classes. The year-classes were initially estimated to be the strongest in the time series but their strength has been revised downwards with each subsequent assessment. The 2004 assessment has revised the estimates of the most recent year-classes upward; however, they are still estimated to be below average.

The influence of the downwards revision of the 1993-1995 year-classes on the estimates of the 5+ biomass is seen in Fig. 4b. The recent trend in biomass has been substantially revised downwards. The estimates from the last two retrospective assessments are more consistent. The fishing mortality retrospective pattern illustrates a consistent under-estimation; however, the increase in recent years is consistent between assessments.

Sensitivity analysis of the XSA estimates

A series of alternative XSA model formulations were used examine the robustness of the estimated trends in the population dynamics of the stock.

Single fleet analyses

XSA was fitted independently to each of the survey time series for which age based information was available.

The analysis using the EU survey and the Canadian fall series used the same XSA formulation as described previously. The Canadian spring survey comprises ages 1-8, therefore XSA was fitted with an 11+ catch data age range. Ideally the catch data age range would be reduced further to make it equivalent to that of the survey data. This reduces the dominance of shrinkage at the older ages for which there are no tuning data. However, such an analysis would apply the high fishing mortality estimates, at the mid-range ages, to the plus group, rather than the lower values resulting from the dome shaped selection pattern.

Figures 5a and 5b present the XSA estimated 5+ biomass and Fig. 5c the average fishing mortality at ages 5-10. The comparative analyses illustrate the close agreement of the XSA models when fitted to each of the survey series independently. As discussed previously, the Canadian Spring survey has a reduced age range and, therefore, higher average fishing mortality estimated at the mid-range ages are applied to the oldest assessment age and to the plus group. The result is higher average mortality estimates and lower total biomass, but the same relative trends in the stock dynamics.

Canadian fall survey data from 1978 - 1994

Survey data collected prior to 1995 were excluded from the final model fit due to variation in survey catchability resulting from changes in the spatial distribution of the stock during the environmental perturbation that occurred during the late-1980's and early-1990's (NAFO 1993, Darby *et al*., 2003). In order to examine the signal provided by the early survey information on historic stock trends, the series was included within the XSA model fit as a separate index series. This allowed the early part of the time series to be fitted with catchability indices that were independent of the more recent survey information.

Although the Canadian fall survey log catchability residuals at ages 1-6 (Fig. 6a) are not of concern; the ages 7-13 residuals (Fig. 6b) have strong trends during the period 1987-1994, consistent with the perception of changes in catchability discussed previously.

The inclusion of the survey series in the XSA model fit does not change the trends in the estimated stock metrics Figure 6c.

Assessment age range

At the older ages in the assessment age range the estimates of catchability have relatively higher standard errors. Although the reduced numbers of fish estimated at the oldest ages have little impact on the stock trends, the uncertainty may be influential on younger ages.

The tuning data at the oldest ages cannot be removed from the assessment model structure without reducing the plus group age, as these results in a biased model fit. The stronger relative influence of shrinkage (average fishing mortality) for those ages without tuning data results in an underestimation of current fishing mortality and over estimation of biomass. This assessment is especially sensitive to this given the recent strong upwards trend in mortality. Therefore, in order to examine the effect of removing those ages from the assessment the plus group age was reduced from 14+ to 12+ and 11+ and the XSA model refitted. For this analysis, only, the average fishing mortality range was reduced to age 5- 9 in order to minimise the effect of plus group collation at ages close to the original maximum range in the average (age 10).

Figure 7 presents the estimates of 5+ biomass and average fishing mortality at ages 5-9 for the XSA fitted with 11+, 12+ and 14+ groups. The results indicate that, although there is variability in the level of the estimated fishing mortality resulting from sensitivity to the dome shaped exploitation pattern, the trends in the stock estimates are insensitive to the choice of plus group. In each case the stock is estimated to be declining to the lowest levels observed and the fishing mortality is estimated to be at the highest levels observed.

2003 Catch Total

Various sources of information indicated a wide range of total landings for the 2003 fishery. Thus, STACFIS could not precisely estimate the 2003 catch. To examine the effect of the range of 2003 catch levels, the accepted XSA formulation was used to re-run the assessment using 2003 catch estimates of 32 000 tons and 38 500 tons, comparing the results to the agreed assessment value of 35 000 tons. Figures of average fishing mortality, and 5+ biomass are presented (Fig. 8a and 8b).

Results indicate that changing the 2003 catch total has no significant effect on estimates of fishing mortality or 5+ biomass.

Discussion of the sensitivity analysis results

The sensitivity analyses have shown that the XSA estimated trends in the stock dynamics are robust to the data series used for the fitting of the model, the inclusion or exclusion of the historic Canadian fall survey data, as a separate time series and the choice of plus group used for the analysis. Further, the alternate catch levels considered for 2003 do not alter perceptions of stock status.

ADAPT Analysis

An ADAPT analysis (Gavaris, 1988) was conducted using the same input data as used in the XSA analysis, structuring the ADAPT as close as possible to the XSA setup. From the survey data, we estimate terminal numbers from ages 2-14+ in 2004, with separate catchability parameters for each survey-age.

The ADAPT results presented use the "FIRST" plus group option for computing numbers in the plus group, and the fishing mortality at the last true age (13) is set equal to the average of the fishing mortality at ages 10 to 12. Using the FIRST plus-group method, "population abundance of the plus group in the first time of the VPA must be specified"[1], and subsequently, all other plus-group values can be filled. All indices are equally weighted (unlike XSA which uses inverse-variance weighting).

ADAPT results are presented in Table 10. The trends in estimated biomass and fishing mortality (see Fig. 9) are consistent with the XSA formulations presented. Results indicate that the 5+ biomass and average fishing mortality are quite similar to the results obtained from the XSA. However, as ADAPT does not 'shrink' the estimates of fishing mortality to the nearest ages/years as in the XSA analysis, the current reference F is estimated to be much higher than that of the XSA. Residuals from the ADAPT analysis (not shown) are also consistent with those from the XSA.

Production Modeling – An age-aggregated approach

Two ASPIC formulations were examined for Greenland Halibut in Subarea 2 and Div. 3KLMNO.

The first formulation uses identical inputs to the agreed XSA analysis (tuning data from 1995 onwards; Table 11). The diagnostics are presented in Table 12, and for each survey series, plots of observed and fitted indices are presented (Figure 10a), as well as the time trends in the ratios F/FMSY, B/BMSY (Figure 10b). The analysis suggests that current biomass is very low compared to historic values. Further, the ratio F/FMSY is currently estimated to be 3.5, and current biomass is estimated to be less than one-half of BMSY.

A second production model was estimated, adding the Converted Engels MNPT data from Canadian autumn surveys in Divs. 2J+3K from 1978-1994 to the inputs used for the first formulation. All available catch data from 1960-2003 were used in the analysis (see Table 13). Results (Table 14 and Fig. 11) are similar to the previous run, although the fit between the observed Engels MNPT and estimated biomass indicates a downward trend in the residuals.

In both models, although results for the early time period seem unreliable, the recent trends mirror those estimated by the age-disaggregated analyses.

A plot comparing the results of the two ASPIC runs, and comparing both ASPIC formulations to the XSA estimated biomass (Fig. 12) indicates that the estimates of biomass in the recent period are consistent in that all show declines from previous levels. All are currently estimated to be among the lowest over the time period considered. In recent years, the agreed XSA is the most optimistic of the three estimation methods. The ASPIC model is calibrated with survey biomass, which is comprised mainly of fish aged 1-4. The ASPIC model therefore responds to changes in the biomass of younger ages, which occur earlier than the changes in the 5+ biomass as estimated by XSA and ADAPT. These are calibrated using numbers at age scaled by the appropriate catchability.

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[1] ADAPT ver3.0 Help file.

Other ASPIC analyses were conducted attempting to include the commercial CPUE series (Power, 2004) as a calibration index. However, in all ASPIC formulations examined that included this index in estimation, the CPUE series was poorly fitted.

Bootstrapping of the 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 1000 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. The percentile distributions from the bootstrap procedure are illustrated in Fig. 13.

The bootstrap distributions do not take into consideration co-variance, which will reduce the uncertainty, or variance in inputs such as maturity, natural mortality and catch at age, all of which will increase the uncertainty. As discussed by Patterson *et. al*. (2000), current bootstrapping and stochastic projection methods generally underestimate uncertainty. However, the same authors also concluded that provision of uncertainty estimates has led to better informed management decisions than if only deterministic projections had been provided. The boostrap percentiles are therefore presented as relative measures of the risks associated with the current harvesting practices. They should not be taken as representing the actual probabilities of eventual outcomes.

Short, Medium Term Projections and the Fisheries Commission Re-building Plan.

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

The projection inputs are summarized in Table 15 with the variability in the projection parameters for the stochastic projections described by the coefficients of variation (column CV in the table). Numbers at age 2 and older for January 2004 and the corresponding CVs are from the XSA output. Recruitment numbers at age 1were bootstrapped from the 1975-2000 age 1 XSA estimates. Scaled selection pattern and corresponding CVs are derived from the 2001 to 2003 average from the XSA estimates of fishing mortality. Weights at age in the stock and in the catch and corresponding CVs are computed from the 2001-2003 average input data. Natural mortality was assumed to be 0.2 with a CV of 0.15 and a CV of 0.05 was assumed for the implementation of the management plan to allow for slight deviation from the TACs from the rebuilding plan. The stochastic realizations were generated using @Risk software. The numbers at age distribution was assumed lognormal; all other input data were assumed to be normally distributed.

The projection results are tabled in Table 16, and results of the stochastic projection (average fishing mortality, 5+ and 10+ biomass) are plotted in Fig. 14. The trend in ages 10+ biomass is presented to illustrate the short term development of the older portion of the population and should not be considered to represent SSB which is not precisely known.

Under the current management plan, the exploitable biomass (ages 5+) is expected to remain stable in 2005 and slowly increase until 2008. The exploitable biomass increases as the improved estimates of age 1 recruits enter the 5+ biomass. Retrospective analyses indicate these estimates of recruitment have been revised downward in the most recent assessments. If this trend continues, the projections would be overly optimistic.

The deterministic and stochastic projections both suggest that in 2008 the 5+ biomass only will have recovered to the level estimated in 2003, approximately 80 000 tons. The projections indicate there is less than a 5% probability that the target 5+ biomass will be reached by 2008. The 10+ biomass is expected to decrease as the strong 1993-1995 year-classes are moving out of the exploitable stock, and are replaced by subsequent year-classes which are much weaker.

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Table 1: Greenland halibut in Subarea 2 and Div. 3KLMNO: Catch Numbers at Age (000s).

	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 Numbers	20912	16488	28186	33816	32586	31571	32344	21082	25125
Total Landings (t)	28814	24611	32048	39070	34104	32867	30754	26278	27861

	Year									
AGE	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
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	0
4	0	0	0	0	0	0	95	220	1064	1010
5	902	1983	280	137	296	181	1102	2862	4180	9570
6	2324	5309	2240	1902	3186	1988	6758	7756	10922	15928
7	5844	5913	6411	11004	8136	7480	12632	13152	20639	17716
8	7682	3500	5091	8935	4380	4273	7557	10796	12205	11918
9	4087	1380	1469	2835	1288	1482	4072	7145	4332	4642
10	1259	512	471	853	465	767	2692	3721	1762	1836
11	407	159	244	384	201	438	1204	1865	1012	1055
12	143	99	140	281	105	267	885	1216	738	964
13	106	87	70	225	107	145	434	558	395	401
+gp	183	86	117	349	129	71	318	422	335	182
Total Numbers	22937	19028	16533	26905	18293	17092	37749	49713	57584	65222
Total Landings (t)	26711	20347	17976	32442	19215	20034	47454	65008	63193	62455

	Year									
AGE	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
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	0
4	5395	323	190	335	552	297	271	448	479	1279
5	16500	1352	1659	1903	3575	2149	2029	2239	1662	4491
6	15815	2342	5197	4169	5407	5625	12583	12163	7239	10723
7	11142	3201	6387	7544	5787	8611	21175	22122	17581	16764
8	6739	2130	1914	3215	3653	3793	3299	5154	6607	6385
9	3081	1183	956	1139	1435	1659	973	1010	1244	1614
10	1103	540	504	606	541	623	528	495	659	516
11	811	345	436	420	377	343	368	439	360	290
12	422	273	233	246	161	306	203	203	224	144
13	320	251	143	137	92	145	129	156	126	76
+gp	215	201	89	89	51	151	104	75	81	85
Total Numbers	61543	12141	17708	19803	21631	23702	41662	44504	36262	42367
Total Landings (t)	51029	15272	18840	19858	19946	24226	34177	38232	34062	35151

Table 2: Greenland halibut in Subarea 2 and Div. 3KLMNO: Catch Weights-at-age (kg).

	Year								
AGE	1975	1976	1977	1978	1979	1980	1981	1982	1983
1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
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	0.760	0.760	0.760	0.760	0.760	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	1.190	1.190	1.190	1.190	1.190	1.050	0.985	1.130	1.180
9	1.580	1.580	1.580	1.580	1.580	1.150	1.240	1.400	1.650
10	2.210	2.210	2.210	2.210	2.210	1.260	1.700	1.790	2.230
11	2.700	2.700	2.700	2.700	2.700	1.570	2.460	2.380	3.010
12	3.370	3.370	3.370	3.370	3.370	2.710	3.510	3.470	3.960
13	3.880	3.880	3.880	3.880	3.880	3.120	4.790	4.510	5.060
+gp	5.764	5.144	5.992	5.894	6.077	5.053	7.426	7.359	7.061

	Year									
AGE	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3	0.126	0.126	0.126	0.126	0.126	0.126	0.090	0.126	0.175	0.134
4	0.244	0.244	0.244	0.244	0.244	0.244	0.181	0.244	0.289	0.232
5	0.377	0.568	0.350	0.364	0.363	0.400	0.338	0.383	0.430	0.368
6	0.583	0.749	0.584	0.589	0.569	0.561	0.546	0.592	0.577	0.547
7	0.826	0.941	0.811	0.836	0.805	0.767	0.766	0.831	0.793	0.809
8	1.100	1.240	1.100	1.160	1.163	1.082	1.119	1.228	1.234	1.207
9	1.460	1.690	1.580	1.590	1.661	1.657	1.608	1.811	1.816	1.728
10	1.940	2.240	2.120	2.130	2.216	2.237	2.173	2.461	2.462	2.309
11	2.630	2.950	2.890	2.820	3.007	2.997	2.854	3.309	3.122	2.999
12	3.490	3.710	3.890	3.600	3.925	3.862	3.731	4.142	3.972	3.965
13	4.490	4.850	4.950	4.630	5.091	4.919	4.691	5.333	5.099	4.816
+gp	7.016	7.010	7.345	6.454	7.164	6.370	6.391	7.081	6.648	6.489

	Year									
AGE	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3	0.080	0.080	0.161	0.120	0.119	0.176	0.000	0.000	0.217	0.188
4	0.196	0.288	0.242	0.206	0.228	0.253	0.254	0.249	0.251	0.247
5	0.330	0.363	0.360	0.336	0.373	0.358	0.346	0.376	0.369	0.389
6	0.514	0.531	0.541	0.489	0.543	0.533	0.524	0.570	0.557	0.564
7	0.788	0.808	0.832	0.771	0.810	0.825	0.787	0.830	0.841	0.822
8	1.179	1.202	1.272	1.159	1.203	1.253	1.192	1.168	1.193	1.199
9	1.701	1.759	1.801	1.727	1.754	1.675	1.774	1.794	1.760	1.651
10	2.268	2.446	2.478	2.355	2.351	2.287	2.279	2.367	2.277	2.166
11	2.990	3.122	3.148	3.053	3.095	2.888	2.895	2.950	2.896	2.700
12	3.766	3.813	3.856	3.953	4.010	3.509	3.645	3.715	3.579	3.404
13	4.882	4.893	4.953	5.108	5.132	4.456	4.486	4.585	4.407	4.377
+gp	6.348	6.790	6.312	6.317	6.124	5.789	5.531	5.458	5.477	5.409

Table 3: Greenland halibut in Subarea 2 and Div. 3KLMNO: Index Data from Surveys of Greenland Halibut in Subarea 2 and Divisions 3KLMNO. Values of "-1" represent zeroes, treated as missing values within XSA and ADAPT.

EU Survey (MNPT)

Start	0.5
End	0.6

Year	Age 1	2	3	4	5	6	7	8	9	10	11	12
1991	0.43	-1	0.29	1.23	2.43	1.56	2.84	0.68	0.58	0.49	0.15	-1
1992	1.15	0.99	0.36	1.07	1.99	2.48	2.23	1.23	0.59	0.33	0.17	0.08
1993	1.17	1.16	0.75	0.71	1.2	1.96	2.16	1.73	1.13	0.32	0.18	0.06
1994	1.03	0.88	1.34	1.52	1.7	2.78	2.61	1.51	0.86	0.33	0.12	0.07
1995	7.66	1.74	1.7	1.55	2.13	4.72	3.76	2.15	1.41	0.32	0.08	0.03
1996	3.57	5.74	1.9	2.57	3.82	5.46	2.51	1.71	0.49	0.1	0.04	0.04
1997	1.98	2.63	5.46	6.41	6.49	7.51	4.83	2.12	0.74	0.25	0.04	0.03
1998	1.79	1.58	6.4	9.75	11.4	10.97	7.88	2.91	0.87	0.25	0.04	0.01
1999	0.65	0.53	2.37	8.93	12.21	11.94	5.45	1.92	0.4	0.12	0.01	-1
2000	1.99	0.18	0.39	1.75	6.91	14.41	5.09	2.11	0.44	0.12	0.06	-1
2001	5.17	1.04	1.43	0.85	2.54	7.37	6.93	3.7	0.21	0.06	0.01	-1
2002	2.44	2.04	2.01	1.37	3.4	5.18	5.85	1.24	0.16	0.07	0.02	0.01
2003	2.1	1.38	0.98	2.54	4.12	4.81	2.96	0.71	0.18	0.13	0.02	0.01

CAN RV4 (MNPT) Div. 2J3KL Fall True Campelen

Start	0.8
End	1

Year	Age 1	2	3	4	5	6	7	8	9	10	11	12	13	14
1995	30.32	31.18	9.691	3.624	4.526	1.547	0.293	0.071	0.011	0.006	0.003	-1	-1	-1
1996	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	0.004
1997	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	0.011
1998	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	0.006
1999	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	0.003
2000	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	0.004
2001	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	0.001
2002	23.87	14.56	7.639	6.291	4.368	1.626	0.726	0.233	0.034	0.011	0.006	0.003	0.005	-1
2003	27.44	15.88	8.125	6.809	4.487	1.677	0.714	0.188	0.032	0.014	0.007	0.003	0.004	-1

CAN RV5 (MNPT) Div. 3LNO Spring True Campelen

Start	0.3
End	0.45

Year	Age 1	2	3	4	5	6	7	8
1996	1.621	4.241	4.599	2.183	0.827	0.284	0.057	0.001
1997	1.162	3.924	5.16	3.227	1.461	0.507	0.099	0.013
1998	0.22	0.814	3.847	6.186	4.955	1.238	0.326	0.072
1999	0.292	0.552	1.149	1.982	3.388	1.09	0.242	0.05
2000	0.793	1.069	1.068	1.506	1.954	2.037	0.556	0.031
2001	0.565	0.714	0.739	0.676	0.796	0.716	0.279	0.023
2002	0.642	0.572	0.603	0.581	0.608	0.208	0.049	0.006
2003	0.926	2.137	1.663	1.569	1.055	0.206	0.051	0.008

CAN RV0 (MNPT) Earlier 2J3K data Engels - Campelen converted

Start	0.8
End	1

Year	Age 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1978	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	0.1	0.07	0.05
1979	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	0.15	0.1	0.09
1980	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	0.15	0.06	0.03
1981	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	0.06	0.04	-1
1982	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	0.28	0.18	0.09
1983	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	0.16	0.07	0.02
1984	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	0.18	0.09	0.06
1985	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	0.13	0.08	0.04
1986	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	0.07	0.08	0.04
1987	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	0.08	0.05	0.03
1988	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	0.04	0.03	0.02
1989	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	0.01	0.01	-1
1990	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	0.02	0.01	-1
1991	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	-1	-1	-1
1992	5.69	23.78	20.4	13.59	4.84	3.11	1.27	0.12	0.02	0.01	-1	-1	-1	-1	-1	-1
1993	8.08	43.64	64	19.28	5.56	1.76	0.74	0.23	0.03	-1	-1	0.02	-1	-1	-1	-1
1994	29.79	21.62	22.61	18.9	7.22	1.32	0.61	0.19	0.03	0.01	-1	-1	-1	-1	-1	-1

Table 4: Greenland halibut in Subarea 2 and Div. 3KLMNO: XSA Model Structure.

Extended Survivors Analysis

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

CPUE data from file GhalTUN5.txt

Catch data for 29 years. 1975 to 2003. Ages 1 to 14.

Fleet	First year	Last year	First age	Last age	Alpha	Beta
EU Survey	1995	2003	1	12	0.5	0.6
CAN RV4(	1995	2003	1	13	0.8	1
CAN RV5(	1996	2003	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 2003
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

Natural Mortality=0.2 for all years and ages.

Table 5a: Greenland halibut in Subarea 2 and Div. 3KLMNO: XSA Diagnostics – EU Summer Survey.

Fleet : EU Survey(MNPT)

Age	1995	1996	1997	1998	1999	2000	2001	2002	2003
1	0.61	-0.02	-0.26	0.07	-0.85	-0.08	0.86	-0.04	-0.28
2	-0.03	0.97	0.32	0.17	-0.5	-1.48	-0.08	0.58	0.04
3	0.1	-0.33	0.54	0.83	0.19	-1.19	0.21	0.2	-0.54
4	-0.26	0.08	0.45	0.68	0.72	-0.56	-0.85	-0.27	0
5	-0.69	0.08	0.43	0.45	0.32	-0.12	-0.76	-0.03	0.33
6	-0.18	-0.16	0.35	0.56	0.05	0.09	-0.44	-0.44	0.17
7	0.15	-0.55	0.05	0.7	0.27	-0.23	-0.07	-0.14	-0.17
8	0.16	-0.02	0.06	0.38	0.19	0.26	0.65	-0.6	-1.08
9	1.03	-0.02	0.48	0.63	-0.05	0.25	-0.57	-0.9	-0.86
10	0.55	-0.51	0.4	0.54	-0.15	0	-0.53	-0.41	0.11
11	0.7	0.01	0.13	0.13	-1.12	0.79	-0.77	0.09	0.04
12	0.09	0.45	0.2	-0.81	99.99	99.99	99.99	-0.02	0.05
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	-10.5429	-10.9956	-10.4102	-9.768	-8.9601	-8.2139	-7.9481	-8.0314	-8.8177	-9.4368
S.E(Log q)	0.498	0.6951	0.6036	0.5418	0.4581	0.3371	0.3517	0.5283	0.6739	0.4333

Age	11	12
Mean Log	-10.5096	-10.5096
S.E(Log q)	0.6116	0.4275

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	0.6	1.261	10.94	0.59	9	0.29	-10.54
2	0.39	3.236	11.23	0.8	9	0.18	-11
3	0.53	1.593	10.76	0.62	9	0.29	-10.41
4	0.46	3.589	10.39	0.86	9	0.16	-9.77
5	0.91	0.211	9.11	0.45	9	0.45	-8.96
6	1.47	-0.996	7.16	0.39	9	0.49	-8.21
7	1.56	-1.186	6.77	0.39	9	0.54	-7.95
8	-1.82	-1.839	11.11	0.06	9	0.84	-8.03
9	0.34	0.986	8.48	0.24	9	0.23	-8.82
10	0.42	1.816	8.45	0.58	9	0.16	-9.44
11	0.68	0.537	9.46	0.28	9	0.43	-10.51
12	0.91	0.188	10.19	0.54	6	0.43	-10.52

Table 5b: Greenland halibut in Subarea 2 and Div. 3KLMNO: XSA Diagnostics – Canadian Autumn Survey.

Fleet : CAN RV4(MNPT)

Age	1995	1996	1997	1998	1999	2000	2001	2002	2003
1	-0.22	0.58	-0.31	-0.14	-0.47	0.17	0.26	0.04	0.09
2	0.16	-0.1	0.19	-0.25	0.47	0.17	-0.26	-0.15	-0.21
3	-0.08	0.14	0.2	-0.02	0.17	0.1	0.23	-0.39	-0.35
4	-0.52	-0.1	0.2	-0.07	0.18	-0.19	0.48	0.14	-0.12
5	-0.23	-0.02	0.33	0.06	0.07	-0.18	-0.16	-0.06	0.19
6	-0.49	-0.31	0.49	0.39	0.43	-0.03	0.15	-0.75	0.11
7	-1.17	-0.36	0.35	0.5	0.85	0.24	0.36	-0.8	0.03
8	-1.47	-0.48	0.64	0.43	0.71	0.34	0.58	-0.31	-0.43
9	-1.93	0.53	0.89	0.68	0.41	0.09	0.46	-0.51	-0.63
10	-1.66	0.36	0.59	0.56	0.61	0.15	0.13	-0.41	-0.32
11	-1.74	0.07	0.71	0.55	0.15	0.35	0.17	-0.17	-0.11
12	99.99	0	0.7	0.6	-0.18	-0.27	0.2	-0.27	-0.26
13	99.99	0.45	0.59	0.09	1.3	-0.02	0.99	0.29	0.62

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	-8.2676	-8.2268	-8.4152	-8.5804	-8.5887	-8.9088	-9.001	-9.6212	-10.5215	-11.0483
S.E(Log q)	0.3217	0.2538	0.2336	0.2875	0.1819	0.4349	0.6544	0.7253	0.8878	0.7277

Age	11	12	13
Mean Log	-11.2006	-11.2006	-11.2006
S.E(Log q)	0.7117	0.4014	0.7276

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	0.72	1.16	9.2	0.71	9	0.23	-8.27
2	1.19	-0.582	7.64	0.58	9	0.31	-8.23
3	0.9	0.444	8.68	0.74	9	0.22	-8.42
4	0.94	0.217	8.72	0.66	9	0.29	-8.58
5	1.1	-0.491	8.39	0.79	9	0.21	-8.59
6	0.93	0.177	9.02	0.46	9	0.43	-8.91
7	0.75	0.543	9.26	0.41	9	0.52	-9
8	0.79	0.193	9.52	0.1	9	0.61	-9.62
9	-3.2	-0.486	1.21	0	9	2.99	-10.52
10	2.19	-0.353	14.98	0.01	9	1.69	-11.05
11	1.35	-0.251	12.6	0.07	9	1.03	-11.2
12	0.6	1.648	9.39	0.74	8	0.21	-11.13
13	1.01	-0.02	10.7	0.41	8	0.48	-10.66

Table 5c: Greenland halibut in Subarea 2 and Div. 3KLMNO: XSA Diagnostics – Canadian Spring Survey.

Fleet : CAN RV5(MNPT)

Age	1995	1996	1997	1998	1999	2000	2001	2002	2003
1	99.99	0.45	0.47	-0.76	-0.39	0.26	-0.09	-0.11	0.17
2	99.99	0.66	0.71	-0.51	-0.47	0.29	-0.46	-0.7	0.47
3	99.99	0.66	0.59	0.42	-0.43	-0.08	-0.35	-0.9	0.09
4	99.99	0.45	0.3	0.76	-0.25	-0.17	-0.54	-0.6	0.05
5	99.99	-0.21	0.18	0.86	0.28	-0.14	-0.67	-0.5	0.19
6	99.99	-0.52	0.25	0.97	0.27	0.72	-0.18	-1.06	-0.46
7	99.99	-0.73	-0.25	1.11	0.73	1.06	0.24	-1.38	-0.79
8	99.99	-2.51	-0.11	1.6	1.43	0.94	0.44	-1.08	-0.71
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	-11.8423	-11.021	-10.5497	-10.3389	-10.2508	-10.8859	-11.6747	-13.0786
S.E(Log q)	0.4273	0.5897	0.5474	0.4788	0.488	0.6808	0.932	1.396

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	0.45	3.281	11.65	0.86	8	0.12	-11.84
2	0.51	1.658	11.18	0.66	8	0.27	-11.02
3	0.49	2.38	10.87	0.79	8	0.21	-10.55
4	0.56	1.975	10.62	0.77	8	0.22	-10.34
5	0.69	0.967	10.4	0.62	8	0.34	-10.25
6	0.73	0.494	10.79	0.37	8	0.53	-10.89
7	1.47	-0.295	12.41	0.06	8	1.47	-11.67
8	2.49	-0.207	18.93	0	8	3.74	-13.08

Table 6: Greenland halibut in Subarea 2 and Div. 3KLMNO: XSA Estimates of 2003 survivors, their standard errors and the combined weighted average (weighted combination conducted on log-scale).

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

Year class = 2002

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU Survey(MNPT)	72749	0.525	0	0	1	0.312	0
CAN RV4(MNPT)	104767	0.5	0	0	1	0.344	0
CAN RV5(MNPT)	113598	0.5	0	0	1	0.344	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
96136	0.29	0.13	3	0.46	0

Age 2 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(MNPT)	71178	0.427	0.039	0.09	2	0.274	0
CAN RV4(MNPT)	65905	0.354	0.124	0.35	2	0.399	0
CAN RV5(MNPT)	80882	0.391	0.283	0.73	2	0.327	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
71971	0.22	0.09	6	0.403	0

Age 3 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(MNPT)	72974	0.354	0.433	1.22	3	0.27	0
CAN RV4(MNPT)	47086	0.289	0.181	0.63	3	0.407	0
CAN RV5(MNPT)	41820	0.324	0.223	0.69	3	0.323	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
51008	0.18	0.16	9	0.88	0

Table 6 (cont.): Greenland halibut in Subarea 2 and Div. 3KLMNO: XSA Estimates of 2003 survivors, their standard errors and the combined weighted average (weighted combination conducted on log-scale).

Age 4 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(MNPT)	40085	0.301	0.063	0.21	4	0.248	0.028
CAN RV4(MNPT)	34290	0.25	0.121	0.48	4	0.359	0.033
CAN RV5(MNPT)	32830	0.273	0.262	0.96	4	0.301	0.035
F shrinkage mean	133244	0.5				0.092	0.009

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
39879	0.15	0.14	13	0.961	0.029

Age 5 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(MNPT)	13999	0.258	0.314	1.22	5	0.264	0.255
CAN RV4(MNPT)	20276	0.224	0.13	0.58	5	0.35	0.183
CAN RV5(MNPT)	15788	0.242	0.171	0.71	5	0.3	0.229
F shrinkage mean	82942	0.5				0.086	0.048

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
19254	0.13	0.16	16	1.229	0.191

Age 6 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(MNPT)	7585	0.229	0.22	0.96	6	0.271	0.824
CAN RV4(MNPT)	11880	0.204	0.106	0.52	6	0.341	0.597
CAN RV5(MNPT)	6201	0.229	0.092	0.4	6	0.269	0.942
F shrinkage mean	38010	0.5				0.118	0.227

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
10126	0.13	0.15	19	1.221	0.672

Table 6 (cont.): Greenland halibut in Subarea 2 and Div. 3KLMNO: XSA Estimates of 2003 survivors, their standard errors and the combined weighted average (weighted combination conducted on log-scale).

Age 7 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(MNPT)	3483	0.21	0.122	0.58	7	0.26	1.678
CAN RV4(MNPT)	3802	0.197	0.111	0.57	7	0.286	1.607
CAN RV5(MNPT)	3367	0.224	0.193	0.86	7	0.217	1.706
F shrinkage mean	12017	0.5				0.237	0.816

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
4757	0.15	0.15	22	0.97	1.432

Age 8 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(MNPT)	2979	0.222	0.239	1.08	8	0.288	1.078
CAN RV4(MNPT)	3783	0.208	0.144	0.69	8	0.268	0.927
CAN RV5(MNPT)	3918	0.231	0.205	0.88	8	0.181	0.906
F shrinkage mean	5427	0.5				0.263	0.725

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
3907	0.16	0.11	25	0.656	0.908

Age 9 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(MNPT)	1635	0.272	0.214	0.79	9	0.308	0.638
CAN RV4(MNPT)	1734	0.266	0.106	0.4	9	0.251	0.611
CAN RV5(MNPT)	3127	0.262	0.204	0.78	7	0.107	0.383
F shrinkage mean	2559	0.5				0.334	0.451

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
2066	0.2	0.1	26	0.481	0.535

Table 6 (cont.): Greenland halibut in Subarea 2 and Div. 3KLMNO: XSA Estimates of 2003 survivors, their standard errors and the combined weighted average (weighted combination conducted on log-scale).

Age 10 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(MNPT)	1150	0.29	0.16	0.55	9	0.402	0.341
CAN RV4(MNPT)	1089	0.328	0.127	0.39	9	0.245	0.357
CAN RV5(MNPT)	2044	0.288	0.122	0.42	6	0.065	0.206
F shrinkage mean	1053	0.5				0.288	0.367

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
1148	0.2	0.08	25	0.382	0.341

Age 11 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(MNPT)	492	0.266	0.118	0.44	9	0.396	0.427
CAN RV4(MNPT)	549	0.318	0.12	0.38	9	0.261	0.391
CAN RV5(MNPT)	914	0.315	0.152	0.48	5	0.051	0.252
F shrinkage mean	536	0.5				0.292	0.398

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
536	0.2	0.06	24	0.325	0.399

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

Year class = 1991

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU Survey(MNPT)	266	0.266	0.101	0.38	9	0.399	0.399
CAN RV4(MNPT)	238	0.312	0.093	0.3	9	0.318	0.437
CAN RV5(MNPT)	369	0.386	0.357	0.93	4	0.022	0.302
F shrinkage mean	303	0.5				0.261	0.358

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
267	0.2	0.06	23	0.299	0.397

Age 13 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(MNPT)	129	0.272	0.118	0.43	8	0.301	0.428
CAN RV4(MNPT)	167	0.324	0.137	0.42	9	0.337	0.344
CAN RV5(MNPT)	157	0.568	0.608	1.07	3	0.009	0.363
F shrinkage mean	148	0.5				0.353	0.382

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
148	0.22	0.07	21	0.313	0.382

Table 7: Greenland halibut in Subarea 2 and Div. 3KLMNO: XSA Estimates of fishing mortality at age.

	Year								
AGE	1975	1976	1977	1978	1979	1980	1981	1982	1983
1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5	0.007	0.000	0.008	0.049	0.054	0.004	0.020	0.008	0.018
6	0.103	0.016	0.132	0.168	0.197	0.061	0.124	0.068	0.140
7	0.322	0.164	0.413	0.369	0.418	0.326	0.444	0.256	0.453
8	0.481	0.574	0.685	0.576	0.466	0.650	0.888	0.513	0.550
9	0.635	0.854	0.719	0.632	0.159	1.018	0.688	0.777	0.395
10	0.643	0.924	0.585	0.994	0.199	1.165	0.440	0.640	0.329
11	0.576	0.780	0.205	1.179	0.536	0.839	0.199	0.601	0.146
12	0.446	0.434	0.257	0.622	0.836	0.489	0.255	0.313	0.137
13	0.559	0.720	0.351	0.942	0.528	0.840	0.299	0.522	0.205
+gp	0.559	0.720	0.351	0.942	0.528	0.840	0.299	0.522	0.205
Avg (5-10)	0.365	0.422	0.424	0.465	0.249	0.537	0.434	0.377	0.314

	Year									
AGE	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.003	0.019	0.019
5	0.017	0.037	0.005	0.002	0.005	0.003	0.014	0.046	0.082	0.236
6	0.074	0.132	0.054	0.044	0.067	0.039	0.128	0.133	0.246	0.509
7	0.358	0.273	0.234	0.405	0.270	0.220	0.372	0.390	0.621	0.803
8	0.795	0.377	0.401	0.595	0.278	0.221	0.361	0.637	0.779	0.935
9	0.667	0.310	0.268	0.409	0.155	0.142	0.340	0.697	0.573	0.794
10	0.392	0.157	0.164	0.246	0.107	0.130	0.414	0.602	0.362	0.512
11	0.329	0.077	0.104	0.196	0.084	0.139	0.309	0.569	0.321	0.384
12	0.141	0.123	0.090	0.168	0.075	0.153	0.458	0.590	0.463	0.579
13	0.289	0.119	0.120	0.204	0.089	0.141	0.396	0.592	0.384	0.496
+gp	0.289	0.119	0.120	0.204	0.089	0.141	0.396	0.592	0.384	0.496
Avg (5-10)	0.384	0.215	0.188	0.284	0.147	0.126	0.272	0.418	0.444	0.631

	Year									
AGE	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4	0.121	0.009	0.005	0.005	0.006	0.004	0.005	0.013	0.015	0.029
5	0.474	0.040	0.059	0.057	0.063	0.031	0.033	0.052	0.060	0.192
6	0.769	0.111	0.214	0.208	0.228	0.132	0.252	0.281	0.238	0.672
7	0.836	0.337	0.496	0.550	0.497	0.688	1.050	0.953	0.852	1.432
8	0.850	0.364	0.346	0.502	0.569	0.725	0.622	0.803	0.871	0.908
9	0.670	0.339	0.275	0.358	0.440	0.554	0.406	0.389	0.452	0.535
10	0.433	0.229	0.236	0.281	0.287	0.347	0.339	0.373	0.477	0.341
11	0.448	0.232	0.292	0.315	0.283	0.298	0.355	0.528	0.513	0.399
12	0.260	0.264	0.243	0.266	0.191	0.393	0.289	0.339	0.569	0.397
13	0.383	0.243	0.215	0.220	0.150	0.263	0.285	0.378	0.365	0.382
+gp	0.383	0.243	0.215	0.220	0.150	0.263	0.285	0.378	0.365	0.382
Avg (5-10)	0.672	0.2366	0.2711	0.3262	0.3473	0.4128	0.4503	0.4753	0.4917	0.6799

Table 8: Greenland halibut in Subarea 2 and Div. 3KLMNO: XSA Estimated Numbers at age.

	Year								
AGE	1975	1976	1977	1978	1979	1980	1981	1982	1983
1	112474	116897	107752	82693	99462	130953	132815	132710	149121
2	126349	92086	95707	88220	67703	81433	107215	108739	108654
3	110215	103446	75393	78358	72228	55431	66672	87780	89028
4	66837	90236	84694	61727	64154	59135	45383	54586	71868
5	53841	54721	73879	69342	50538	52525	48416	37156	44691
6	31901	43779	44787	60004	54074	39218	42815	38859	30178
7	23093	23568	35292	32133	41513	36376	30221	30967	29735
8	14338	13704	16372	19124	18192	22384	21503	15870	19636
9	9313	7254	6322	6758	8802	9342	9569	7244	7779
10	3932	4041	2529	2522	2940	6149	2764	3937	2726
11	1773	1692	1313	1154	764	1972	1571	1458	1700
12	415	816	635	876	291	366	698	1054	654
13	720	218	433	402	385	103	184	443	632
+gp	735	113	311	459	757	52	293	514	1037
Total	555935	552571	545420	503772	481804	495438	510117	521317	557438

	Year									
AGE	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
1	155775	170087	189690	157779	130763	114237	109572	95204	71445	84828
2	122090	127538	139256	155305	129179	107059	93529	89710	77946	58494
3	88958	99959	104419	114013	127153	105763	87653	76575	73448	63817
4	72890	72833	81839	85491	93346	104104	86591	71764	62695	60134
5	58841	59677	59631	67004	69994	76425	85233	70809	58556	50367
6	35956	47359	47065	48568	54734	57039	62408	68786	55384	44160
7	21489	27335	33970	36507	38043	41930	44901	44980	49299	35462
8	15477	12306	17030	22011	19933	23785	27561	25332	24926	21688
9	9277	5721	6908	9336	9937	12356	15607	15727	10971	9364
10	4292	3898	3435	4327	5079	6970	8776	9094	6411	5063
11	1605	2375	2728	2386	2771	3737	5013	4749	4078	3655
12	1202	946	1801	2013	1606	2086	2664	3015	2201	2423
13	467	855	685	1348	1393	1220	1467	1380	1368	1134
+gp	801	842	1141	2080	1675	595	1066	1032	1151	510
Total	589122	631731	689598	708169	685606	657308	632039	578156	499880	441099

	Year										
AGE	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
1	145905	176314	154605	108603	70823	64348	91327	92942	107368	117420	0
2	69451	119457	144353	126579	88917	57985	52683	74772	76095	87905	96136
3	47891	56862	97803	118187	103635	72799	47474	43133	61218	62301	71971
4	52249	39210	46555	80075	96763	84849	59603	38868	35315	50121	51008
5	48320	37896	31810	37944	65256	78723	69200	48553	31417	28480	39879
6	32578	24631	29803	24543	29344	50193	62509	54820	37726	24218	19254
7	21743	12363	18047	19699	16322	19132	36005	39792	33877	24337	10126
8	13003	7720	7225	8996	9302	8127	7873	10318	12562	11828	4757
9	6973	4549	4393	4184	4457	4310	3222	3460	3784	4307	3907
10	3467	2921	2654	2732	2395	2350	2028	1757	1919	1973	2066
11	2484	1840	1903	1717	1688	1471	1361	1182	991	975	1148
12	2038	1300	1195	1163	1025	1041	894	781	571	485	536
13	1112	1287	817	767	730	694	575	548	456	265	267
+gp	741	1024	506	496	403	718	461	262	291	294	312
Total	447954	487373	541669	535683	491058	446740	435213	411191	403590	414911	301366

Table 9: Greenland halibut in Subarea 2 and Div. 3KLMNO: Summary of XSA population and exploitation trends.

Table 17 Summary (with SOP correction)

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

	Recruits Age 1	5+ Biomass (t)	10+ Biomass (t)	Landings (t)	YIELD/SSB	SOPCOFA	FBAR 5-10
1975	112474	132755	21900	28814	1.3157	0.9999	0.3652
1976	116897	134563	17674	24611	1.3925	1.0001	0.4219
1977	107752	157034	14821	32048	2.1623	1	0.4235
1978	82693	167869	15911	39070	2.4556	1	0.4648
1979	99462	162718	15635	34104	2.1812	1.0001	0.2487
1980	130953	131120	12418	32867	2.6466	1	0.5372
1981	132815	115532	14066	30754	2.1863	0.9999	0.434
1982	132710	121712	19955	26278	1.3168	1	0.3769
1983	149121	123300	24304	27861	1.1463	0.9999	0.3139
1984	155775	115928	24464	26711	1.0919	1	0.3838
1985	170087	149315	29297	20347	0.6945	1	0.2145
1986	189690	139458	33931	17976	0.5298	0.9997	0.1877
1987	157779	166718	42844	32442	0.7572	0.9998	0.2836
1988	130763	171810	44973	19215	0.4273	0.9998	0.1467
1989	114237	193351	46512	20034	0.4307	1.0419	0.1258
1990	109572	219655	59563	47454	0.7967	1.0449	0.2716
1991	95204	216128	61296	65008	1.0606	0.9395	0.4175
1992	71445	201414	52567	63193	1.2021	1.0132	0.4439
1993	84828	152110	40324	62455	1.5488	0.9828	0.6314
1994	145905	122043	36682	51029	1.3911	1.1084	0.672
1995	176314	86247	31478	15272	0.4852	1.0123	0.2366
1996	154605	89445	25962	18840	0.7257	1.0635	0.2711
1997	108603	83684	24122	19858	0.8232	1.0342	0.3262
1998	70823	94073	21269	19946	0.9378	1.0042	0.3473
1999	64348	112065	21172	24226	1.1443	1.0314	0.4128
2000	91327	118213	17114	34177	1.997	1.0097	0.4503
2001	92942	114702	14418	38232	2.6518	0.995	0.4753
2002	107368	95896	12920	34062	2.6364	1.0028	0.4917
2003	117420	76810	11228	35151	3.1307	0.9931	0.6799
Arithmetic Mean	119790	136747	27890	32484	1.423		0.3812
Units	(Thousar	(Tonnes)	(Tonnes)	(Tonnes)			

Table 10: Greenland halibut in Subarea 2 and Div. 3KLMNO: ADAPT Results.

Parameter	Age/q_ID	q_ID	Estimate	Standard Error	Rel Error	Bias	Rel Bias
N[2004 2]	2		78271.35	28267.34	0.361145	5560.444	0.071041
N[2004 3]	3		61560.42	15894.58	0.258195	2399.274	0.038974
N[2004 4]	4		42377.69	8976.198	0.211814	1182.178	0.027896
N[2004 5]	5		29122.49	5521.912	0.18961	665.3259	0.022846
N[2004 6]	6		13043.08	2712.466	0.207962	308.2031	0.02363
N[2004 7]	7		5467.397	1809.875	0.33103	240.4863	0.043986
N[2004 8]	8		1965.787	942.8518	0.479631	217.8695	0.110831
N[2004 9]	9		1076.437	519.9896	0.483065	125.4043	0.116499
N[2004 10]	10		622.9706	305.3518	0.490154	70.56719	0.113275
N[2004 11]	11		679.4684	263.8313	0.388291	49.39481	0.072696
N[2004 12]	12		344.3804	136.541	0.396483	25.08139	0.07283
N[2004 13]	13		140.9292	61.3207	0.435117	11.83457	0.083975
q ID#[1]	1	Cdn_F	0.000311	6.45E-05	0.207407	4.91E-06	0.015802
q ID#[2]	2	Cdn_F	0.000318	6.4E-05	0.201262	4.74E-06	0.014911
q ID#[3]	3	Cdn_F	0.00026	5.14E-05	0.197757	3.78E-06	0.014543
q ID#[4]	4	Cdn_F	0.000217	4.24E-05	0.1956	3.16E-06	0.014567
q ID#[5]	5	Cdn_F	0.000211	4.1E-05	0.194625	3.19E-06	0.015144
q ID#[6]	6	Cdn_F	0.000154	3.02E-05	0.195809	2.6E-06	0.016864
q ID#[7]	7	Cdn_F	0.000149	2.98E-05	0.19924	2.31E-06	0.015434
q ID#[8]	8	Cdn_F	8.67E-05	1.74E-05	0.201251	1.2E-06	0.01379
q ID#[9]	9	Cdn_F	3.51E-05	7.14E-06	0.203671	5.66E-07	0.016129
q ID#[10]	10	Cdn_F	2.01E-05	4.07E-06	0.202424	3.35E-07	0.016625
q ID#[11]	11	Cdn_F	1.86E-05	3.81E-06	0.205006	3.50E-07	0.018825
q ID#[12]	12	Cdn_F	2.24E-05	4.98E-06	0.222318	5.73E-07	0.025549
q ID#[13]	13	Cdn_F	4.16E-05	9.02E-06	0.216592	1.07E-06	0.025778
q ID#[14]	1	Cdn_S	8.9E-06	1.97E-06	0.221878	1.65E-07	0.018517
q ID#[15]	2	Cdn_S	1.99E-05	4.27E-06	0.214593	3.45E-07	0.017334
q ID#[16]	3	Cdn_S	3.14E-05	6.6E-06	0.21043	5.28E-07	0.016836
q ID#[17]	4	Cdn_S	3.81E-05	7.91E-06	0.207776	6.34E-07	0.016655
q ID#[18]	5	Cdn_S	4.05E-05	8.35E-06	0.20626	6.82E-07	0.016861
q ID#[19]	6	Cdn_S	2.12E-05	4.38E-06	0.205979	3.79E-07	0.017864
q ID#[20]	7	Cdn_S	9.99E-06	2.06E-06	0.206467	1.70E-07	0.017043
q ID#[21]	8	Cdn_S	2.6E-06	5.39E-07	0.207738	3.96E-08	0.015251
q ID#[22]	1	EU_Sum	3.23E-05	6.69E-06	0.207409	5.10E-07	0.015802
q ID#[23]	2	EU_Sum	2.01E-05	4.06E-06	0.201265	3.00E-07	0.014911
q ID#[24]	3	EU_Sum	3.57E-05	7.06E-06	0.197759	5.19E-07	0.014543
q ID#[25]	4	EU_Sum	6.68E-05	1.31E-05	0.195551	9.71E-07	0.014542
q ID#[26]	5	EU_Sum	0.000147	2.85E-05	0.194392	2.2E-06	0.015027
q ID#[27]	6	EU_Sum	0.000311	6.06E-05	0.194646	5.05E-06	0.01621
q ID#[28]	7	EU_Sum	0.000431	8.46E-05	0.19602	6.53E-06	0.015128
q ID#[29]	8	EU_Sum	0.00042	8.3E-05	0.197466	5.68E-06	0.013515
q ID#[30]	9	EU_Sum	0.000192	3.83E-05	0.19996	2.82E-06	0.014689
q ID#[31]	10	EU_Sum	0.000101	2.03E-05	0.200188	1.59E-06	0.015735
q ID#[32]	11	EU_Sum	3.7E-05	7.47E-06	0.201958	6.50E-07	0.017582
q ID#[33]	12	EU_Sum	4.29E-05	1.07E-05	0.249111	1.36E-06	0.031736

Table 11: Greenland halibut in Subarea 2 and Div. 3KLMNO: ASPIC Input Data - Formulation 1 (Input data used in XSA).

Catch data: 1975-2003
Indices : Can 2J3KL fall 1995-2003
EU 3M survey 1995-2003
Can 3LNO Spring 1996-2003

Aspic input data parameters:

```
FIT                         ## Run type (FIT, BOT, or IRF)
"Greenland Halibut in SA 2+3 EU 95-03 catch in Ktons"
LOGISTIC YLD SSE            ## See notes at end of this file
12                          ## Verbosity on screen (0-3); add 10 for SUM & PRN files
500                         ## Number of bootstrap trials, <= 1000
0 20000                     ## 0=no MC search, 1=search, 2=repeated srch; N trials
1d-8                        ## Convergence crit. for simplex
3d-8    6                   ## Convergence crit. for restarts, N restarts
1d-4    24                  ## Conv. crit. for F; N steps/yr for gen. model
 8d0                         ## Maximum F when cond. on yield
1d0                         ## Stat weight for B1>K as residual (usually 0 or 1)
3                           ## Number of fisheries (data series)
1d0  1d0  1d0  1d0          ## Statistical weights for data series
0.7                         ## B1/K (starting guess, usually 0 to 1)
30                          ## MSY (starting guess)
300                         ## K (carrying capacity) (starting guess)
1.00d-1 2.0d-1 3.5d-2       ## q (starting guesses -- 1 per data series)
1 1 1 1 1 1  1              ## Estimate flags (0 or 1) (B1/K,MSY,K,q1...qn)
5 300                       ## Min and max constraints -- MSY
50 2000                     ## Min and max constraints -- K
3941285                     ## Random number seed (large integer)
29                          ## Number of years of data in each series
```

Table 12: Greenland halibut in Subarea 2 and Div. 3KLMNO: Aspic diagnostics, - Formulation 1 (Input data used in XSA).

```
Greenland Halibut in SA 2+3 EU 95-03 catch in Ktons                                                Page 1
                                                                         Wednesday, 09 Jun 2004 at 14:43:24
ASPIC -- A Surplus-Production Model Including Covariates (Ver. 5.05)
                                                                                           FIT program mode
Author:     Michael H. Prager; NOAA Center for Coastal Fisheries and Habitat Research    LOGISTIC model mode
            101 Pivers Island Road; Beaufort, North Carolina  28516  USA                   YLD conditioning
            Mike.Prager@noaa.gov                                                           SSE optimization

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

CONTROL PARAMETERS USED (FROM INPUT FILE)      Input file: c:\valise\nwatlq\nafo\06_2004\glh2+3\aspic\ghl75_03_kt_v55c.
------------------------------------------------------------------------------------------------------------------------
-
Operation of ASPIC:  Fit logistic (Schaefer) model by direct optimization.
Number of years analyzed:                        29            Number of bootstrap trials:                           0
Number of data series:                            3            Lower bound on MSY:                          5.000E+00
Objective function:                   Least squares            Upper bound on MSY:                          3.000E+02
Relative conv. criterion (simplex):       1.000E-08            Lower bound on K:                            5.000E+01
Relative conv. criterion (restart):       3.000E-08            Upper bound on K:                            2.000E+03
Relative conv. criterion (effort):        1.000E-04            Random number seed:                            3941285
Maximum F allowed in fitting:                 8.000            Monte Carlo search mode, trials:        0             0
Identical convergences required in fitting:       6


PROGRAM STATUS INFORMATION (NON-BOOTSTRAPPED ANALYSIS)                                                 error code   0
------------------------------------------------------------------------------------------------------------------------
-
Normal convergence
Number of restarts required for convergence:     67
```

Table 12 (cont.): Greenland halibut in Subarea 2 and Div. 3KLMNO: Aspic diagnostics, - Formulation 1 (Input data used in XSA).

CORRELATION AMONG INPUT SERIES EXPRESSED AS CPUE (NUMBER OF PAIRWISE OBSERVATIONS BELOW)

		1	2	3
1	Canadian Div. 2J3K Fall (Part 2)...	1.000		
		9		
2	EU 3M Surveys	0.754	1.000	
		9	9	
3	Canadian 3LNO Spring	0.597	0.911	1.000
		8	8	8

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

Loss component number and title		Weighted SSE	N	Weighted MSE	Current weight	Inv. var. weight	R-squared in CPUE
Loss(-1)	SSE in yield	0.000E+00					
Loss(0)	Penalty for B1 > K	3.113E-06	1	N/A	1.000E+00	N/A	
Loss(1)	Canadian Div. 2J3K Fall (Part 2) - catc	2.411E-01	9	3.445E-02	1.000E+00	1.434E+00	0.665
Loss(2)	EU 3M Surveys	2.692E-01	9	3.845E-02	1.000E+00	1.284E+00	0.575
Loss(3)	Canadian 3LNO Spring	1.541E+00	8	2.569E-01	1.000E+00	1.923E-01	0.281
TOTAL OBJECTIVE FUNCTION, MSE, RMSE:		2.05156761E+00		1.026E-01	3.203E-01		

NOTE: B1-ratio penalty term contributing to loss. Sensitivity analysis advised.

Estimated contrast index (ideal = 1.0): 0.8783 C* = (Bmax-Bmin)/K

Estimated nearness index (ideal = 1.0): 1.0000 N* = 1 - |min(B-Bmsy)|/K

Table 12 (cont.): Greenland halibut in Subarea 2 and Div. 3KLMNO: Aspic diagnostics, - Formulation 1 (Input data used in XSA).

Greenland Halibut in SA 2+3 EU 95-03 catch in Ktons Page 2

MODEL PARAMETER ESTIMATES (NON-BOOTSTRAPPED)

Parameter		Estimate	User/pgm guess	2nd guess	Estimated	User guess
B1/K	Starting relative biomass (in 1975)	1.002E+00	7.000E-01	5.049E-01	1	1
MSY	Maximum sustainable yield	3.240E+01	3.000E+01	2.763E+01	1	1
K	Maximum population size	2.650E+02	3.000E+02	1.658E+02	1	1
phi	Shape of production curve (Bmsy/K)	0.5000	0.5000	----	0	1
---------	Catchability Coefficients by Data Series ---------------					
q(1)	Canadian Div. 2J3K Fall (Part 2) - catc	3.153E-01	1.000E-01	4.750E-01	1	1
q(2)	EU 3M Surveys	1.639E-01	2.000E-01	1.140E+00	1	1
q(3)	Canadian 3LNO Spring	2.954E-02	3.500E-02	4.750E-01	1	1

MANAGEMENT and DERIVED PARAMETER ESTIMATES (NON-BOOTSTRAPPED)

Parameter		Estimate	Logistic formula	General formula
MSY	Maximum sustainable yield	3.240E+01	----	----
Bmsy	Stock biomass giving MSY	1.325E+02	K/2	K*n**(1/(1-n))
Fmsy	Fishing mortality rate at MSY	2.446E-01	MSY/Bmsy	MSY/Bmsy
n	Exponent in production function	2.0000	----	----
g	Fletcher's gamma	4.000E+00	----	[n**(n/(n-1))]/[n-1]
B./Bmsy	Ratio: B(2004)/Bmsy	2.468E-01	----	----
F./Fmsy	Ratio: F(2003)/Fmsy	3.527E+00	----	----
Fmsy/F.	Ratio: Fmsy/F(2003)	2.835E-01	----	----
Y.(Fmsy)	Approx. yield available at Fmsy in 2004	7.998E+00	MSY*B./Bmsy	MSY*B./Bmsy
	...as proportion of MSY	2.468E-01	----	----
Ye.	Equilibrium yield available in 2004	1.402E+01	4*MSY*(B/K-(B/K)**2)	g*MSY*(B/K-(B/K)**n)
	...as proportion of MSY	4.328E-01	----	----
---------	Fishing effort rate at MSY in units of each CE or CC series ---------			
fmsy(1)	Canadian Div. 2J3K Fall (Part 2) - catc	7.756E-01	Fmsy/q(1)	Fmsy/q(1)

Table 12 (cont.): Greenland halibut in Subarea 2 and Div. 3KLMNO: Aspic diagnostics, - Formulation 1 (Input data used in XSA).

Greenland Halibut in SA 2+3 EU 95-03 catch in Ktons Page 3
ESTIMATED POPULATION TRAJECTORY (NON-BOOTSTRAPPED)

-

Obs	Year or ID	Estimated total F mort	Estimated starting biomass	Estimated average biomass	Observed total yield	Model total yield	Estimated surplus production	Ratio of F mort to Fmsy	Ratio of biomass to Bmsy
1	1975	0.114	2.654E+02	2.528E+02	2.881E+01	2.881E+01	5.613E+00	4.661E-01	2.003E+00
2	1976	0.104	2.422E+02	2.358E+02	2.461E+01	2.461E+01	1.268E+01	4.268E-01	1.828E+00
3	1977	0.144	2.303E+02	2.224E+02	3.205E+01	3.205E+01	1.744E+01	5.892E-01	1.738E+00
4	1978	0.189	2.157E+02	2.066E+02	3.907E+01	3.907E+01	2.221E+01	7.732E-01	1.628E+00
5	1979	0.176	1.988E+02	1.942E+02	3.410E+01	3.410E+01	2.536E+01	7.181E-01	1.501E+00
6	1980	0.176	1.901E+02	1.869E+02	3.287E+01	3.287E+01	2.692E+01	7.190E-01	1.435E+00
7	1981	0.168	1.841E+02	1.826E+02	3.075E+01	3.075E+01	2.777E+01	6.887E-01	1.390E+00
8	1982	0.144	1.812E+02	1.820E+02	2.628E+01	2.628E+01	2.787E+01	5.904E-01	1.367E+00
9	1983	0.152	1.828E+02	1.827E+02	2.786E+01	2.786E+01	2.775E+01	6.235E-01	1.379E+00
10	1984	0.146	1.826E+02	1.831E+02	2.671E+01	2.671E+01	2.766E+01	5.963E-01	1.379E+00
11	1985	0.109	1.836E+02	1.870E+02	2.035E+01	2.035E+01	2.690E+01	4.449E-01	1.386E+00
12	1986	0.093	1.901E+02	1.941E+02	1.798E+01	1.798E+01	2.539E+01	3.789E-01	1.435E+00
13	1987	0.167	1.976E+02	1.938E+02	3.244E+01	3.244E+01	2.544E+01	6.843E-01	1.491E+00
14	1988	0.099	1.906E+02	1.938E+02	1.922E+01	1.922E+01	2.544E+01	4.054E-01	1.438E+00
15	1989	0.101	1.968E+02	1.990E+02	2.003E+01	2.003E+01	2.423E+01	4.115E-01	1.485E+00
16	1990	0.250	2.010E+02	1.896E+02	4.745E+01	4.745E+01	2.631E+01	1.023E+00	1.517E+00
17	1991	0.403	1.798E+02	1.612E+02	6.501E+01	6.501E+01	3.070E+01	1.649E+00	1.357E+00
18	1992	0.491	1.455E+02	1.288E+02	6.319E+01	6.319E+01	3.223E+01	2.006E+00	1.098E+00
19	1993	0.645	1.146E+02	9.691E+01	6.246E+01	6.246E+01	2.991E+01	2.635E+00	8.648E-01
20	1994	0.754	8.202E+01	6.764E+01	5.103E+01	5.103E+01	2.453E+01	3.085E+00	6.191E-01
21	1995	0.258	5.552E+01	5.911E+01	1.527E+01	1.527E+01	2.245E+01	1.056E+00	4.191E-01
22	1996	0.288	6.271E+01	6.534E+01	1.884E+01	1.884E+01	2.408E+01	1.179E+00	4.733E-01
23	1997	0.281	6.794E+01	7.071E+01	1.986E+01	1.986E+01	2.535E+01	1.148E+00	5.128E-01
24	1998	0.260	7.344E+01	7.683E+01	1.995E+01	1.995E+01	2.668E+01	1.061E+00	5.543E-01
25	1999	0.296	8.017E+01	8.192E+01	2.423E+01	2.423E+01	2.768E+01	1.209E+00	6.051E-01
26	2000	0.427	8.362E+01	8.006E+01	3.418E+01	3.418E+01	2.732E+01	1.746E+00	6.311E-01
27	2001	0.547	7.676E+01	6.987E+01	3.823E+01	3.823E+01	2.514E+01	2.237E+00	5.794E-01
28	2002	0.600	6.367E+01	5.713E+01	3.430E+01	3.430E+01	2.190E+01	2.455E+00	4.806E-01
29	2003	0.863	5.126E+01	4.117E+01	3.552E+01	3.552E+01	1.696E+01	3.527E+00	3.869E-01
30	2004		3.270E+01						2.468E-01

Table 13: Greenland halibut in Subarea 2 and Div. 3KLMNO: Aspic Input Data, - Formulation 2 (All available input data).

```
catch data 1960-2003
Indices :   Can 2J3KL fall 1978 - 1994
            Can 2J3KL fall 1995 - 2003
            EU 3M survey 1995 - 2003
            Can 3LNO Spring 1996-2003

FIT                     ## Run type (FIT, BOT, or IRF)
Greenland Halibut in SA 2+3 EU 95-03 catch in Ktons
LOGISTIC YLD SSE        ## See notes at end of this file
13                      ## Verbosity on screen (0-3); add 10 for SUM & PRN files
500                     ## Number of bootstrap trials, <= 1000
0 20000                 ## 0=no MC search, 1=search, 2=repeated srch; N trials
1d-8                    ## Convergence crit. for simplex
3d-8    6               ## Convergence crit. for restarts, N restarts
1d-4    24              ## Conv. crit. for F; N steps/yr for gen. model
8d0                     ## Maximum F when cond. on yield
1d0                     ## Stat weight for B1>K as residual (usually 0 or 1)
4                       ## Number of fisheries (data series)
1d0  1d0  1d0  1d0      ## Statistical weights for data series
1.0                     ## B1/K (starting guess, usually 0 to 1)
35                      ## MSY (starting guess)
250                     ## K (carrying capacity) (starting guess)
2.00d-1 3.0d-1 2.0d-1 3.5d-2    ## q (starting guesses -- 1 per data series)
1 1 1 1 1 1  1          ## Estimate flags (0 or 1) (B1/K,MSY,K,q1...qn)
5 300                   ## Min and max constraints -- MSY
50  2000                ## Min and max constraints -- K
3941285                 ## Random number seed (large integer)
44  # Number of years of data in each series
```

Table 14: Greenland halibut in Subarea 2 and Div. 3KLMNO: Aspic diagnostics, - Formulation 2 (All available input data).

```
Greenland Halibut in SA 2+3 EU 95-03 catch in Ktons                                                      Page 1
                                                                                      Thursday, 10 Jun 2004 at 10:32:25
ASPIC -- A Surplus-Production Model Including Covariates (Ver. 5.05)
                                                                                                      FIT program mode
Author:     Michael H. Prager; NOAA Center for Coastal Fisheries and Habitat Research             LOGISTIC model mode
            101 Pivers Island Road; Beaufort, North Carolina  28516  USA                             YLD conditioning
            Mike.Prager@noaa.gov                                                                     SSE optimization

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

CONTROL PARAMETERS USED (FROM INPUT FILE)      Input file: c:\valise\nwatlq\nafo\06_2004\glh2+3\aspic\ghl60_03_kt_v55.i
----------------------------------------------------------------------------------------------------------------------
-
Operation of ASPIC:  Fit logistic (Schaefer) model by direct optimization.
Number of years analyzed:                        44             Number of bootstrap trials:                            0
Number of data series:                            4             Lower bound on MSY:                            5.000E+00
Objective function:                   Least squares             Upper bound on MSY:                            1.000E+02
Relative conv. criterion (simplex):       1.000E-08             Lower bound on K:                              5.000E+01
Relative conv. criterion (restart):       3.000E-08             Upper bound on K:                              5.000E+02
Relative conv. criterion (effort):        1.000E-04             Random number seed:                              3941285
Maximum F allowed in fitting:                 8.000             Monte Carlo search mode, trials:        0              0
Identical convergences required in fitting:       6


PROGRAM STATUS INFORMATION (NON-BOOTSTRAPPED ANALYSIS)                                                    error code   0
----------------------------------------------------------------------------------------------------------------------
-
Normal convergence
Number of restarts required for convergence:      5
```

Table 14 (cont.): Greenland halibut in Subarea 2 and Div. 3KLMNO: Aspic diagnostics, - Formulation 2 (All available input data).

CORRELATION AMONG INPUT SERIES EXPRESSED AS CPUE (NUMBER OF PAIRWISE OBSERVATIONS BELOW)

		1	2	3	4
1	Canadian Div. 2J3K Fall (Part 1)...	1.000 17			
2	Canadian Div. 2J3K Fall (Part 2)	0.000 0	1.000 9		
3	EU 3M Surveys	0.000 0	0.754 9	1.000 9	
4	Canadian	0.000 0	0.597 8	0.911 8	1.000 8

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

Loss component number and title		Weighted SSE	N	Weighted MSE	Current weight	Inv. var. weight	R-squared in CPUE
Loss(-1)	SSE in yield	0.000E+00					
Loss(0)	Penalty for B1 > K	4.741E-06	1	N/A	1.000E+00	N/A	
Loss(1)	Canadian Div. 2J3K Fall (Part 1) - catc	2.067E+00	17	1.378E-01	1.000E+00	4.685E-01	0.356
Loss(2)	Canadian Div. 2J3K Fall (Part 2)	2.366E-01	9	3.380E-02	1.000E+00	1.910E+00	0.673
Loss(3)	EU 3M Surveys	2.563E-01	9	3.662E-02	1.000E+00	1.763E+00	0.586
Loss(4)	Canadian	1.571E+00	8	2.619E-01	1.000E+00	2.466E-01	0.274
TOTAL OBJECTIVE FUNCTION, MSE, RMSE:		4.13174124E+00		1.148E-01	3.388E-01		

NOTE: B1-ratio penalty term contributing to loss. Sensitivity analysis advised.
Estimated contrast index (ideal = 1.0): 0.8850 C* = (Bmax-Bmin)/K
Estimated nearness index (ideal = 1.0): 1.0000 N* = 1 - |min(B-Bmsy)|/K

Table 14 (cont.): Greenland halibut in Subarea 2 and Div. 3KLMNO: Aspic diagnostics, - Formulation 2 (All available input data).

MODEL PARAMETER ESTIMATES (NON-BOOTSTRAPPED)

Parameter		Estimate	User/pgm guess	2nd guess	Estimated	User guess
B1/K	Starting relative biomass (in 1960)	1.002E+00	1.000E+00	9.000E-01	1	1
MSY	Maximum sustainable yield	3.349E+01	3.500E+01	2.367E+01	1	1
K	Maximum population size	2.495E+02	2.500E+02	1.420E+02	1	1
phi	Shape of production curve (Bmsy/K)	0.5000	0.5000	----	0	1
---------	Catchability Coefficients by Data Series ---------------					
q(1)	Canadian Div. 2J3K Fall (Part 1) - catc	1.577E-01	2.000E-01	1.140E+00	1	1
q(2)	Canadian Div. 2J3K Fall (Part 2)	3.446E-01	3.000E-01	1.140E+00	1	1
q(3)	EU 3M Surveys	1.791E-01	2.000E-01	1.140E+00	1	1
q(4)	Canadian	3.215E-02	3.500E-02	4.750E-01	1	1

MANAGEMENT and DERIVED PARAMETER ESTIMATES (NON-BOOTSTRAPPED)

Parameter		Estimate	Logistic formula	General formula
MSY	Maximum sustainable yield	3.349E+01	----	----
Bmsy	Stock biomass giving MSY	1.248E+02	K/2	K*n**(1/(1-n))
Fmsy	Fishing mortality rate at MSY	2.685E-01	MSY/Bmsy	MSY/Bmsy
n	Exponent in production function	2.0000	----	----
g	Fletcher's gamma	4.000E+00	----	[n**(n/(n-1))]/[n-1]
B./Bmsy	Ratio: B(2004)/Bmsy	2.343E-01	----	----
F./Fmsy	Ratio: F(2003)/Fmsy	3.520E+00	----	----
Fmsy/F.	Ratio: Fmsy/F(2003)	2.841E-01	----	----
Y.(Fmsy)	Approx. yield available at Fmsy in 2004	7.849E+00	MSY*B./Bmsy	MSY*B./Bmsy
	...as proportion of MSY	2.343E-01	----	----
Ye.	Equilibrium yield available in 2004	1.386E+01	4*MSY*(B/K-(B/K)**2)	g*MSY*(B/K-(B/K)**n)
	...as proportion of MSY	4.137E-01	----	----
---------	Fishing effort rate at MSY in units of each CE or CC series ---------			
fmsy(1)	Canadian Div. 2J3K Fall (Part 1) - catc	1.702E+00	Fmsy/q(1)	Fmsy/q(1)

Table 14 (cont.): Greenland halibut in Subarea 2 and Div. 3KLMNO: Aspic diagnostics, - Formulation 2 (All available input data).

ESTIMATED POPULATION TRAJECTORY (NON-BOOTSTRAPPED)

Obs	Year or ID	Estimated total F mort	Estimated starting biomass	Estimated average biomass	Observed total yield	Model total yield	Estimated surplus production	Ratio of F mort to Fmsy	Ratio of biomass to Bmsy
1	1960	0.004	2.500E+02	2.508E+02	9.900E-01	9.900E-01	1.867E-03	1.470E-02	2.004E+00
2	1961	0.003	2.491E+02	2.501E+02	7.900E-01	7.900E-01	3.656E-01	1.177E-02	1.996E+00
3	1962	0.002	2.486E+02	2.498E+02	6.200E-01	6.200E-01	5.022E-01	9.243E-03	1.993E+00
4	1963	0.007	2.485E+02	2.481E+02	1.620E+00	1.620E+00	7.728E-01	2.432E-02	1.992E+00
5	1964	0.017	2.477E+02	2.463E+02	4.250E+00	4.250E+00	1.706E+00	6.427E-02	1.985E+00
6	1965	0.042	2.451E+02	2.418E+02	1.007E+01	1.007E+01	3.996E+00	1.551E-01	1.965E+00
7	1966	0.083	2.391E+02	2.330E+02	1.928E+01	1.928E+01	8.241E+00	3.082E-01	1.916E+00
8	1967	0.120	2.280E+02	2.209E+02	2.653E+01	2.653E+01	1.355E+01	4.472E-01	1.828E+00
9	1968	0.156	2.150E+02	2.076E+02	3.239E+01	3.239E+01	1.869E+01	5.811E-01	1.724E+00
10	1969	0.192	2.013E+02	1.937E+02	3.724E+01	3.724E+01	2.321E+01	7.159E-01	1.614E+00
11	1970	0.203	1.873E+02	1.817E+02	3.684E+01	3.684E+01	2.649E+01	7.550E-01	1.501E+00
12	1971	0.139	1.770E+02	1.783E+02	2.483E+01	2.483E+01	2.733E+01	5.187E-01	1.418E+00
13	1972	0.169	1.794E+02	1.780E+02	3.004E+01	3.004E+01	2.738E+01	6.284E-01	1.438E+00
14	1973	0.166	1.768E+02	1.760E+02	2.929E+01	2.929E+01	2.784E+01	6.198E-01	1.417E+00
15	1974	0.157	1.753E+02	1.755E+02	2.759E+01	2.759E+01	2.795E+01	5.854E-01	1.406E+00
16	1975	0.164	1.757E+02	1.753E+02	2.881E+01	2.881E+01	2.800E+01	6.122E-01	1.408E+00
17	1976	0.139	1.749E+02	1.765E+02	2.461E+01	2.461E+01	2.772E+01	5.192E-01	1.402E+00
18	1977	0.182	1.780E+02	1.758E+02	3.205E+01	3.205E+01	2.789E+01	6.791E-01	1.427E+00
19	1978	0.232	1.738E+02	1.686E+02	3.907E+01	3.907E+01	2.933E+01	8.629E-01	1.393E+00
20	1979	0.210	1.641E+02	1.622E+02	3.410E+01	3.410E+01	3.048E+01	7.831E-01	1.315E+00
21	1980	0.206	1.605E+02	1.594E+02	3.287E+01	3.287E+01	3.090E+01	7.678E-01	1.286E+00
22	1981	0.194	1.585E+02	1.587E+02	3.075E+01	3.075E+01	3.102E+01	7.219E-01	1.271E+00
23	1982	0.163	1.588E+02	1.611E+02	2.628E+01	2.628E+01	3.065E+01	6.076E-01	1.273E+00
24	1983	0.170	1.632E+02	1.643E+02	2.786E+01	2.786E+01	3.012E+01	6.314E-01	1.308E+00
25	1984	0.160	1.654E+02	1.670E+02	2.671E+01	2.671E+01	2.966E+01	5.958E-01	1.326E+00
26	1985	0.118	1.684E+02	1.727E+02	2.035E+01	2.035E+01	2.854E+01	4.389E-01	1.350E+00
27	1986	0.099	1.766E+02	1.811E+02	1.798E+01	1.798E+01	2.664E+01	3.697E-01	1.415E+00
28	1987	0.178	1.852E+02	1.820E+02	3.244E+01	3.244E+01	2.644E+01	6.639E-01	1.485E+00
29	1988	0.105	1.792E+02	1.829E+02	1.922E+01	1.922E+01	2.621E+01	3.914E-01	1.437E+00
30	1989	0.106	1.862E+02	1.887E+02	2.003E+01	2.003E+01	2.470E+01	3.954E-01	1.493E+00
31	1990	0.264	1.909E+02	1.797E+02	4.745E+01	4.745E+01	2.691E+01	9.833E-01	1.530E+00
32	1991	0.427	1.703E+02	1.521E+02	6.501E+01	6.501E+01	3.168E+01	1.591E+00	1.365E+00
33	1992	0.523	1.370E+02	1.208E+02	6.319E+01	6.319E+01	3.330E+01	1.948E+00	1.098E+00
34	1993	0.696	1.071E+02	8.978E+01	6.246E+01	6.246E+01	3.068E+01	2.591E+00	8.586E-01
35	1994	0.838	7.533E+01	6.088E+01	5.103E+01	5.103E+01	2.459E+01	3.122E+00	6.038E-01
36	1995	0.292	4.889E+01	5.235E+01	1.527E+01	1.527E+01	2.220E+01	1.086E+00	3.919E-01
37	1996	0.322	5.583E+01	5.843E+01	1.884E+01	1.884E+01	2.402E+01	1.201E+00	4.475E-01
38	1997	0.311	6.101E+01	6.386E+01	1.986E+01	1.986E+01	2.551E+01	1.158E+00	4.891E-01
39	1998	0.284	6.666E+01	7.026E+01	1.995E+01	1.995E+01	2.709E+01	1.058E+00	5.343E-01
40	1999	0.319	7.380E+01	7.590E+01	2.423E+01	2.423E+01	2.836E+01	1.189E+00	5.916E-01
41	2000	0.457	7.793E+01	7.477E+01	3.418E+01	3.418E+01	2.811E+01	1.703E+00	6.247E-01
42	2001	0.585	7.186E+01	6.534E+01	3.823E+01	3.823E+01	2.587E+01	2.179E+00	5.760E-01
43	2002	0.644	5.950E+01	5.325E+01	3.430E+01	3.430E+01	2.247E+01	2.399E+00	4.770E-01
44	2003	0.945	4.767E+01	3.758E+01	3.552E+01	3.552E+01	1.708E+01	3.520E+00	3.821E-01
45	2004		2.923E+01						2.343E-01

Table 15. Greenland halibut in Subarea 2 + Div. 3KLMNO: Inputs for projections.

Greenland Halibut in Subareas 2 + 3KLMNO
Input data for stochastic projections

Name	Value	Uncertainty (CV)	Name	Value	ncertainty (CV)
Population at age in 2004			Selection pattern	(2001-2003	
N1	Bootstrap (1975-2000)		sH1	0.000	0.00
N2	96136	0.29	sH2	0.000	0.00
N3	71971	0.22	sH3	0.000	0.00
N4	51008	0.18	sH4	0.033	0.24
N5	39879	0.15	sH5	0.171	0.56
N6	19254	0.16	sH6	0.688	0.39
N7	10126	0.15	sH7	1.948	0.10
N8	4757	0.15	sH8	1.598	0.14
N9	3907	0.16	sH9	0.841	0.08
N10	2066	0.20	sH10	0.752	0.31
N11	1148	0.20	sH11	0.914	0.31
N12	536	0.20	sH12	0.818	0.37
N13	267	0.22	sH13	0.699	0.17
N14+	312	0.25	sH14+	0.699	0.17
Weight in the catch (2001-2003)			Weight in the stock (2001-2003		
WH1	0.000	0.00	WS1	0.000	0.00
WH2	0.000	0.00	WS2	0.000	0.00
WH3	0.000	0.00	WS3	0.000	0.00
WH4	0.249	0.01	WS4	0.000	0.00
WH5	0.378	0.03	WS5	0.378	0.03
WH6	0.564	0.01	WS6	0.564	0.01
WH7	0.831	0.01	WS7	0.831	0.01
WH8	1.187	0.01	WS8	1.187	0.01
WH9	1.735	0.04	WS9	1.735	0.04
WH10	2.270	0.04	WS10	2.270	0.04
WH11	2.849	0.05	WS11	2.849	0.05
WH12	3.566	0.04	WS12	3.566	0.04
WH13	4.456	0.03	WS13	4.456	0.03
WH14+	5.448	0.01	WS14+	5.448	0.01
TAC					
2004	20000	0.05			
2005	19000	0.05			
2006	18500	0.05			
2007	16000	0.05			
2008	16000	0.05			

Table 16: Greenland halibut in Subarea 2 + Div. 3KLMNO: Results of Deterministic and Stochastic Projections assuming the catches follow the rebuilding plan TACs.

Deterministic	2004	2005	2006	2007	2008
Catch (t)	20000	19000	18500	16000	
5+B (t)	59500	59100	62700	69600	81200

Stochastic (median values)	2004	2005	2006	2007	2008
F (5-10)	0.60	0.59	0.49	0.35	
5+B (t)	59300	58700	61900	68800	81300
10+B (t)	12600	12200	9400	7200	6700

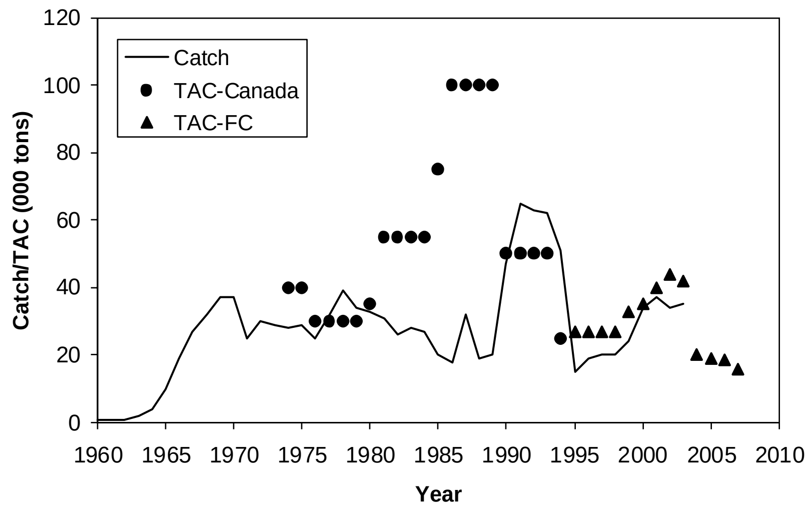

Fig. 1: Catches and Total Allowable Catches (TACs) for Greenland Halibut in Subarea 2 and Div. 3KLMNO. TACs were set autonomously by Canada from 1985-1994, and have been subsequently established by Fisheries Commission.

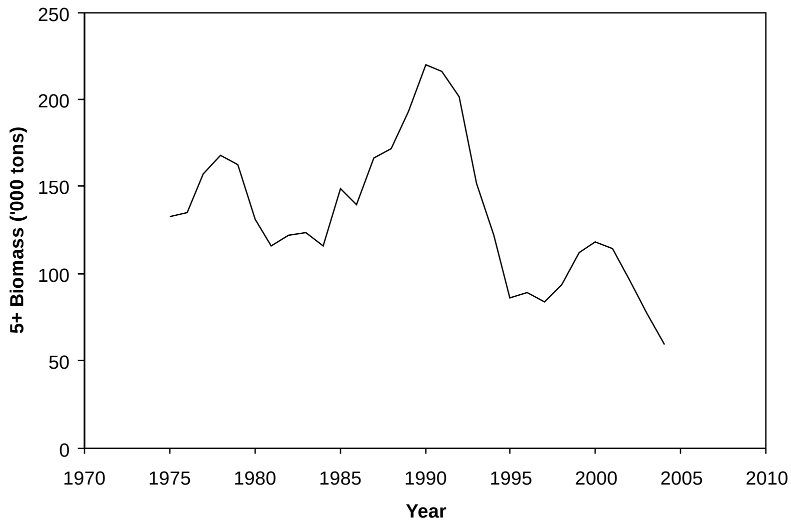

Fig. 2a: Greenland halibut in Subarea 2 and Div. 3KLMNO: Estimated 5+ Biomass (t) from XSA Analysis.

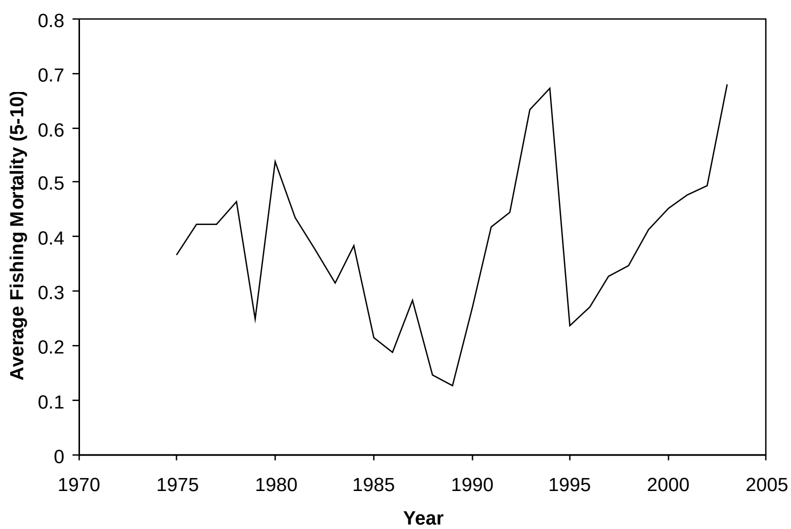

Fig. 2b: Greenland halibut in Subarea 2 and Div. 3KLMNO: Average Fishing Mortality (ages 5-10) from XSA Analysis.

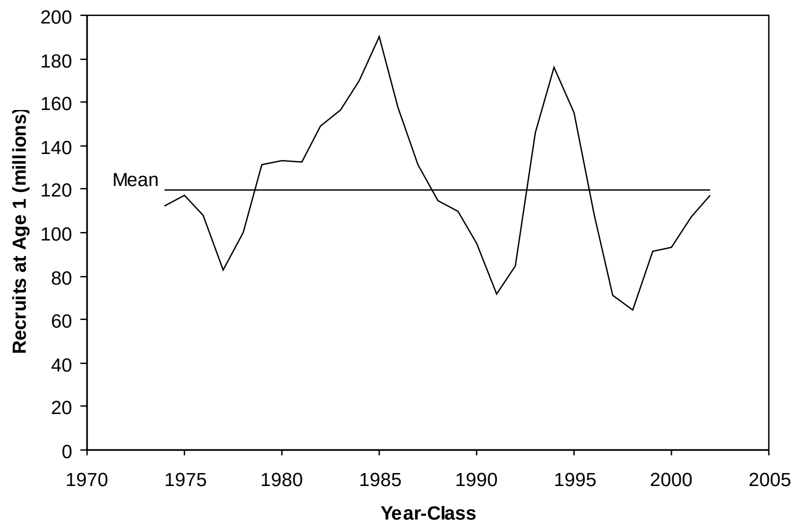

Fig. 2c: Greenland halibut in Subarea 2 and Div. 3KLMNO: Age 1 Recruitment (millions) estimated from XSA analysis.

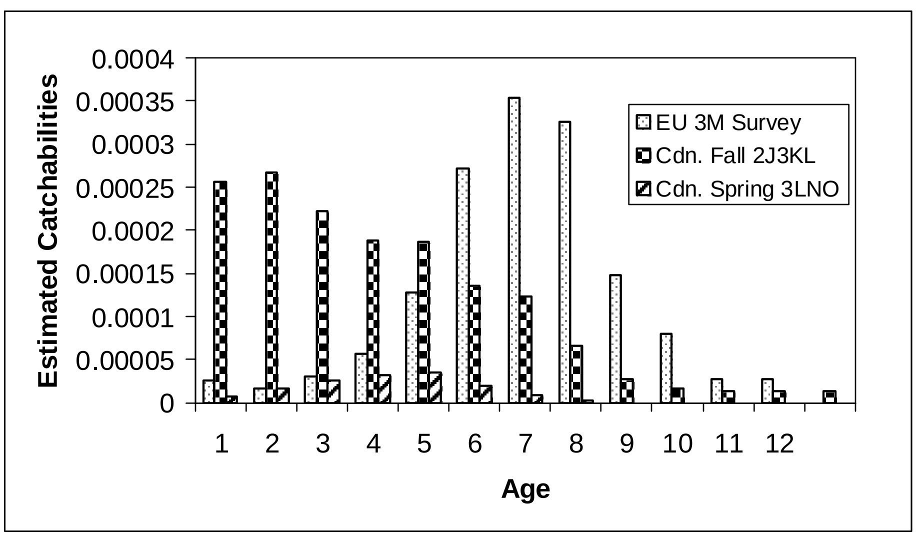

Fig. 2d: Greenland halibut in Subarea 2 and Div. 3KLMNO: Estimates of Survey Catchabilities from XSA analysis.

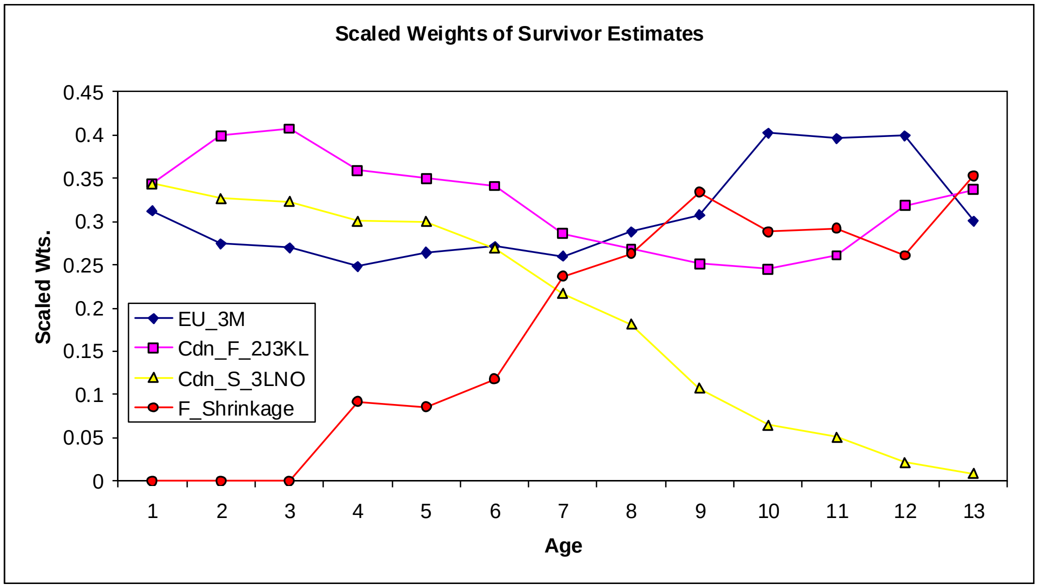

Fig. 2e: Greenland halibut in Subarea 2 and Div. 3KLMNO: Estimates of scaled weights from XSA analysis. (Weightings used to compute log-survivors at age).

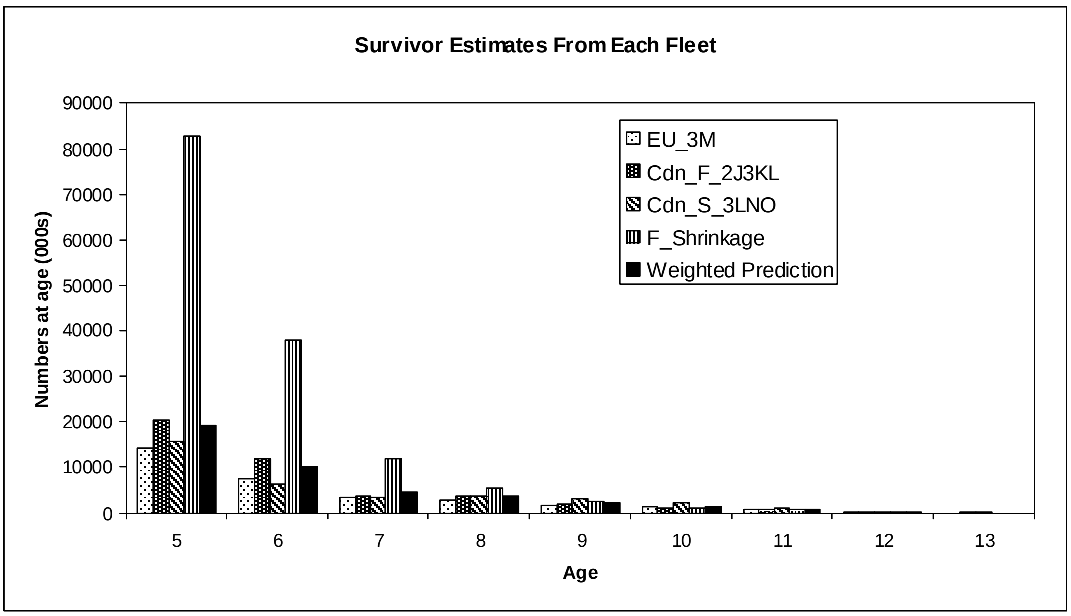

Fig. 2f: Greenland halibut in Subarea 2 and Div. 3KLMNO: Survivor estimates at age from each tuning index; from XSA analysis.

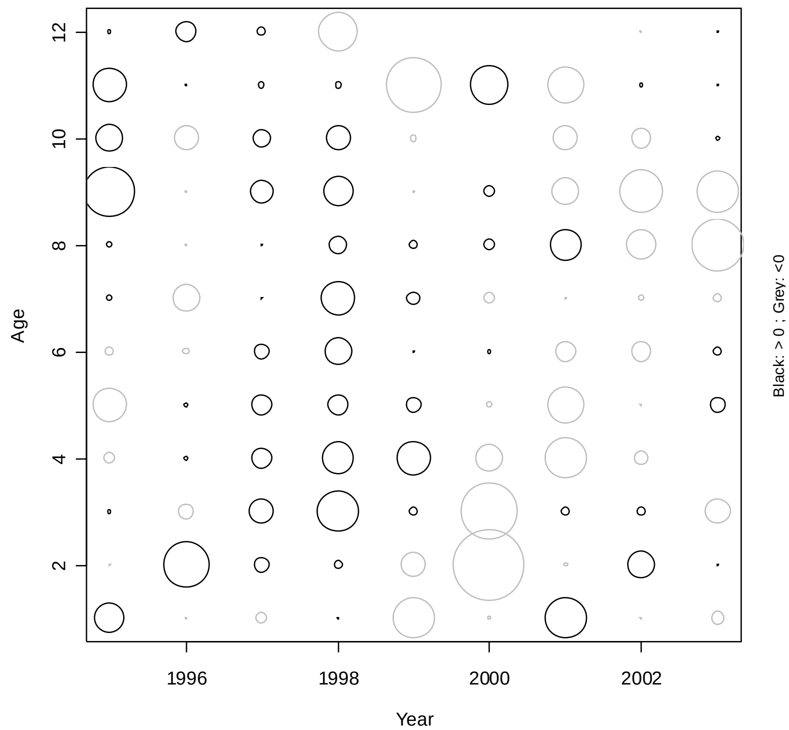

Fig. 3a: Greenland halibut in Subarea 2 and Div. 3KLMNO: Residuals from XSA analysis; EU Div. 3M Summer Survey Series.

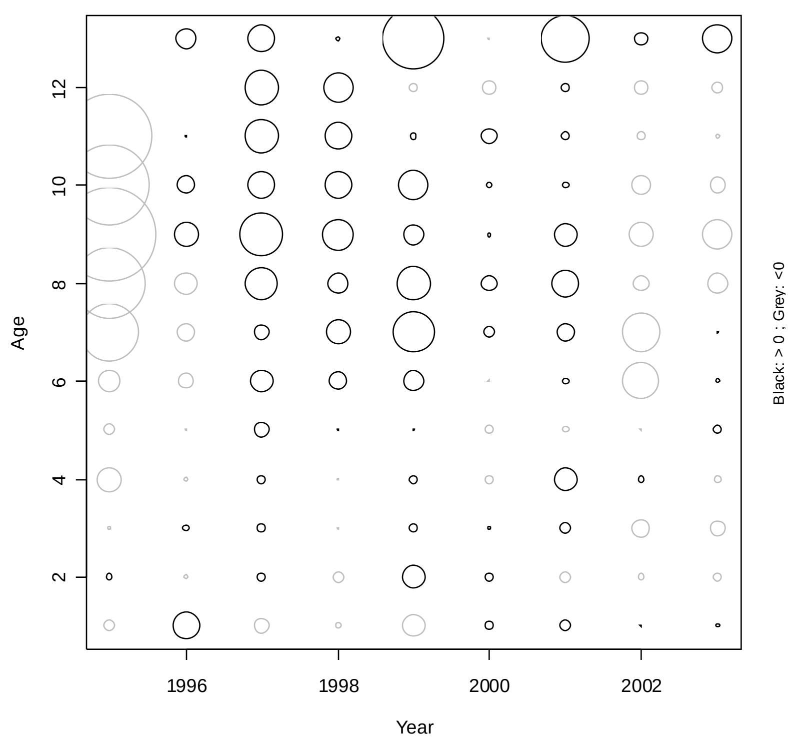

Fig. 3b: Greenland halibut in Subarea 2 and Div. 3KLMNO: Residuals from XSA analysis; Canadian Autumn Div. 2J3KL Series.

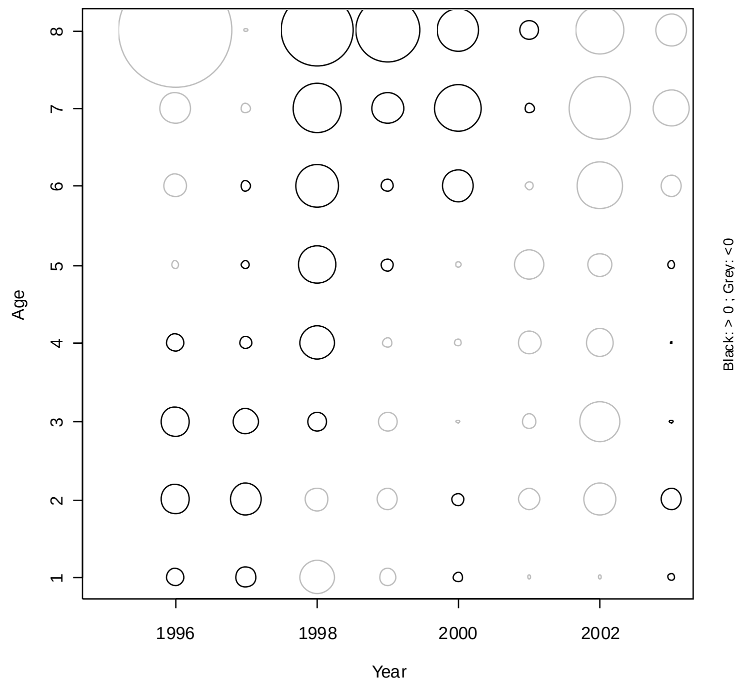

Fig. 3c: Greenland halibut in Subarea 2 and Div. 3KLMNO: Residuals from XSA analysis; Canadian Spring Div. 3LNO Series.

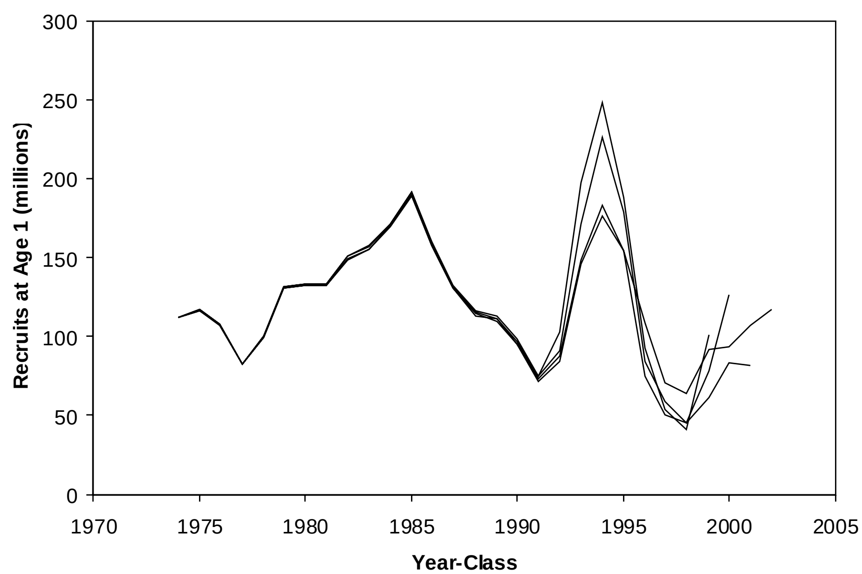

Fig. 4a: Greenland halibut in Subarea 2 + Div. 3KLMNO: XSA retrospective analysis; age 1 recruitment.

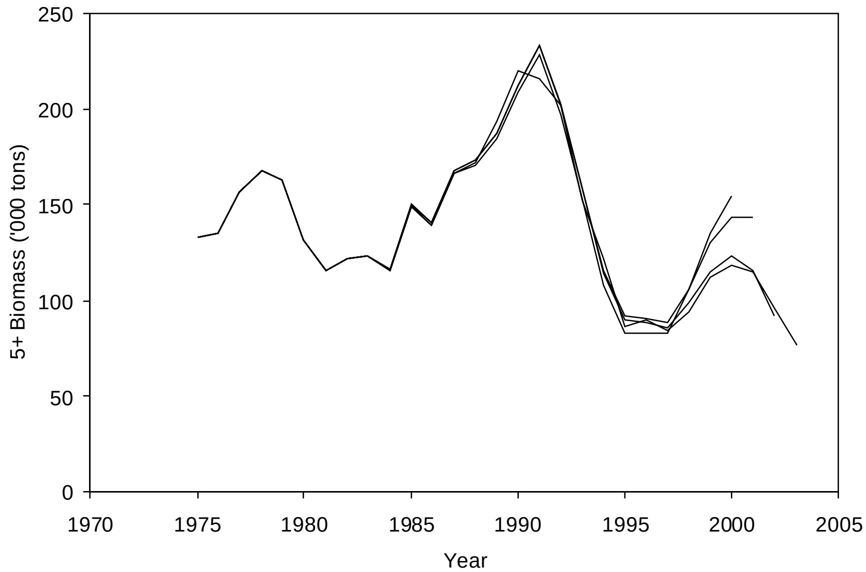

Fig. 4b: Greenland halibut in Subarea 2 + Div. 3KLMNO: XSA retrospective analysis; 5+ biomass.

Fig. 4c: Greenland halibut in Subarea 2 + Div. 3KLMNO: XSA retrospective analysis; average fishing mortality at ages 5 – 10.

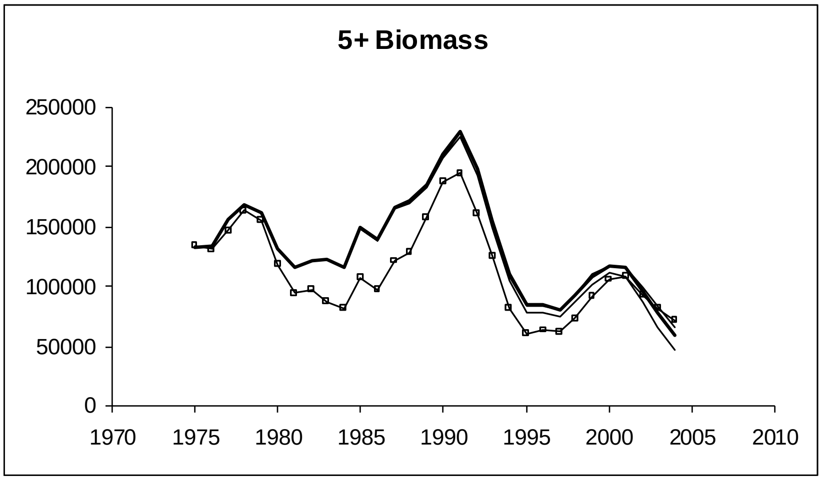

Fig. 5a: Greenland halibut in Subarea 2 + Div. 3KLMNO: 5+ biomass trends estimated by XSA applied to the Canadian Spring, Fall and EU survey data series. The Solid line illustrates the fit to all series the thin lines the Fall and EU surveys and the thin line with boxes the spring survey which only records ages 1 – 8.

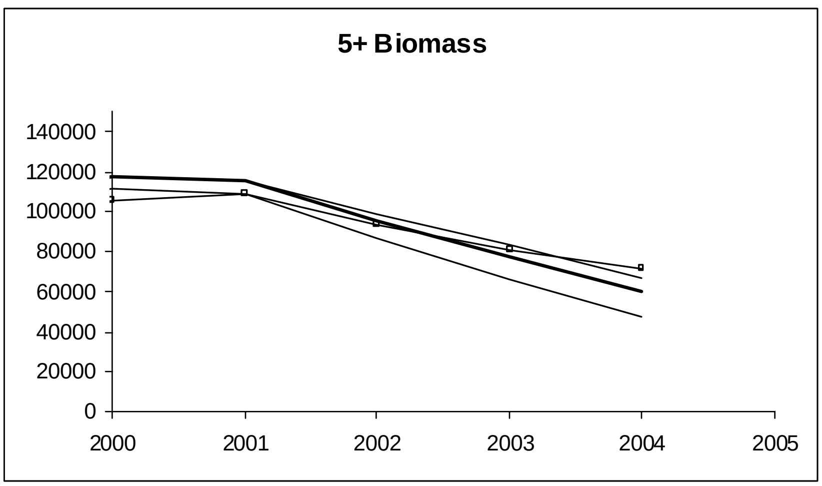

Fig. 5b: Greenland halibut in Subarea 2 + Div. 3KLMNO: 5+ biomass trends in 2000 – 2004, as estimated by XSA applied to the Canadian Spring, Fall and EU survey data series. The Solid line illustrates the fit to all series the thin lines the Fall and EU surveys and the thin line with boxes the spring survey which only records ages 1 – 8.

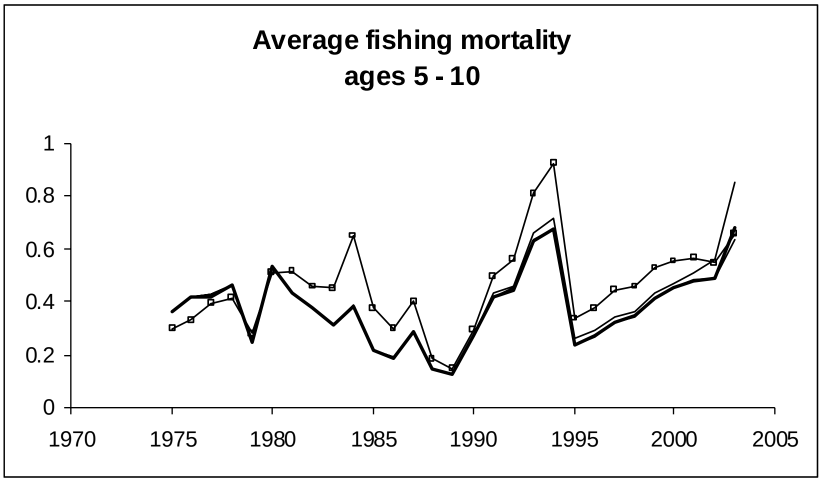

Fig. 5c: Greenland halibut in Subarea 2 + Div. 3KLMNO: Average fishing mortality as estimated by XSA applied to the Canadian Spring, Fall and EU survey data series. The Solid line illustrates the fit to all series the thin lines the Fall and EU surveys and the thin line with boxes the spring survey which only records ages 1 – 8.

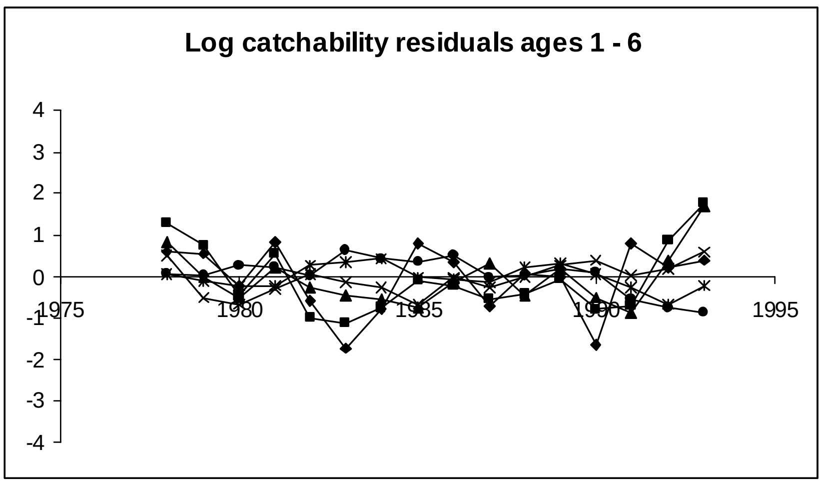

Fig. 6a: Greenland halibut in Subarea 2 + Div. 3KLMNO: XSA log catchability residuals for the Canadian fall survey for ages 1 – 6 during 1978 – 1994.

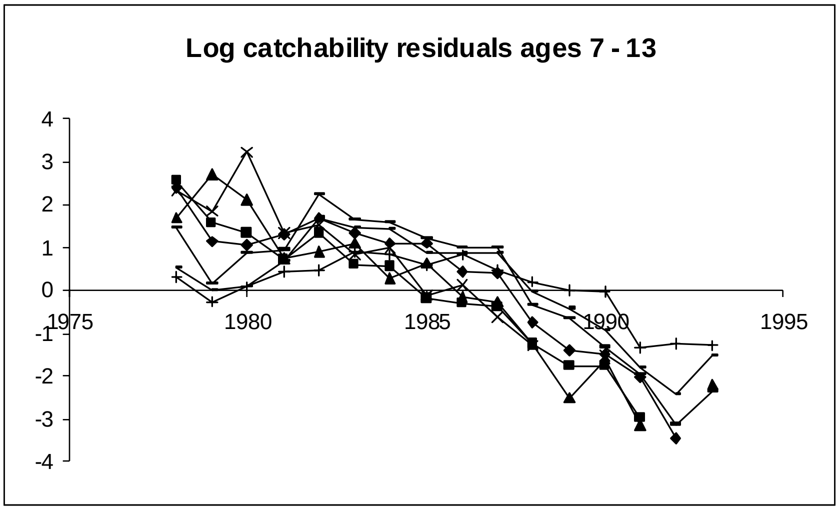

Fig. 6b: Greenland halibut in Subarea 2 + Div. 3KLMNO: XSA log catchability residuals for the Canadian fall survey for ages 7 – 13 during 1978 – 1994.

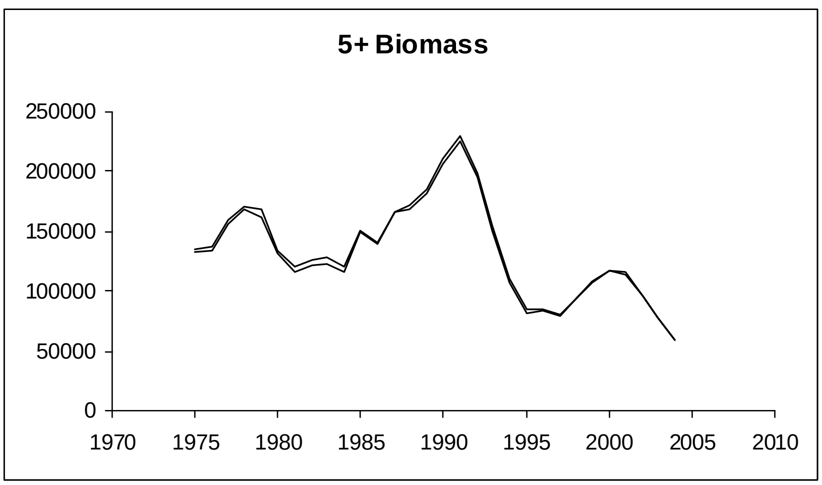

Fig. 6c Greenland halibut in Subarea 2 + Div. 3KLMNO: 5+ biomass trends, as estimated by XSA applied to the Canadian Spring, Fall and EU survey data series. The two lines represent the inclusion, exclusion of the Canadian Fall 1978 – 1994 series.

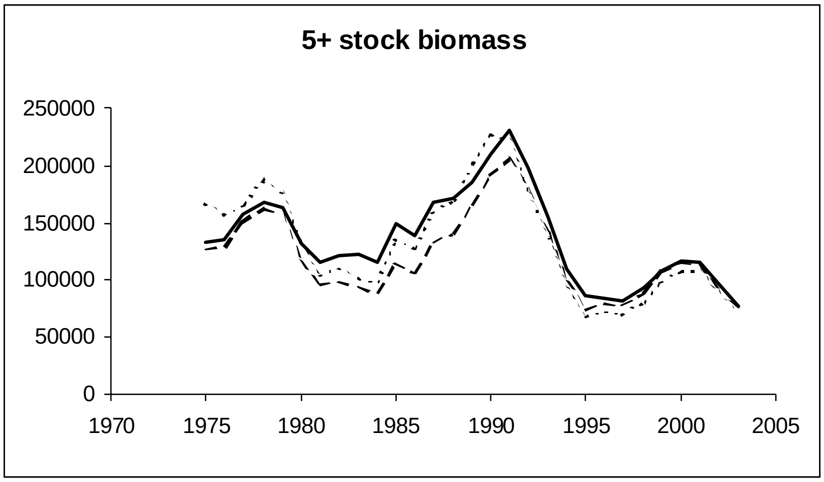

Fig. 7a: Greenland halibut in Subarea 2 + Div. 3KLMNO: 5+ biomass, as estimated by XSA applied to the Canadian Spring, Fall and EU survey data series. The Solid line illustrates the fit to a 14+ group, large hashes 12+ and small hashes 11+.

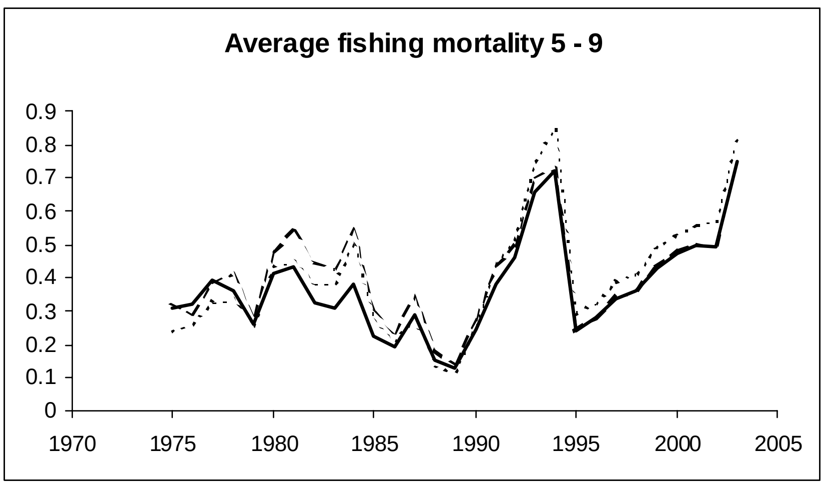

Fig. 7b: Greenland halibut in Subarea 2 + Div. 3KLMNO: Average fishing mortality (ages 5 – 9) as estimated by XSA applied to the Canadian Spring, Fall and EU survey data series. The Solid line illustrates the fit to a 14+ group, large hashes 12+ and small hashes 11+.

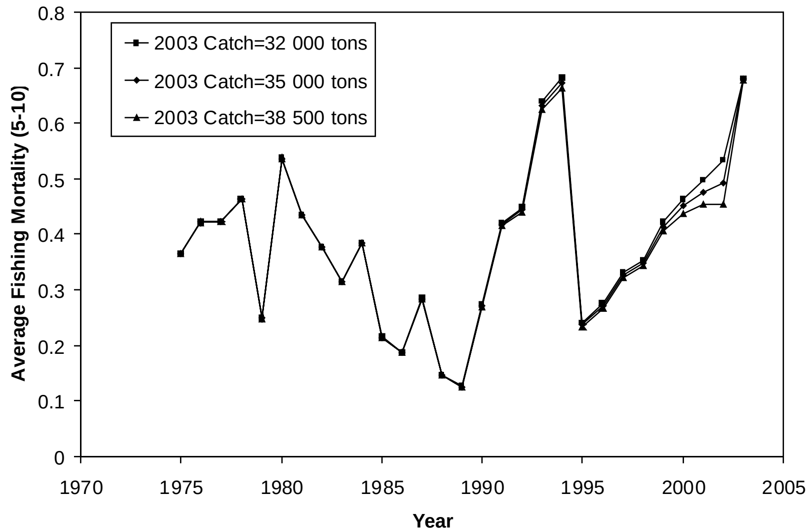

Fig. 8a: Greenland halibut in Subarea 2 + Div. 3KLMNO: Estimated average fishing mortality (ages 5-10) assuming three levels of 2003 landings.

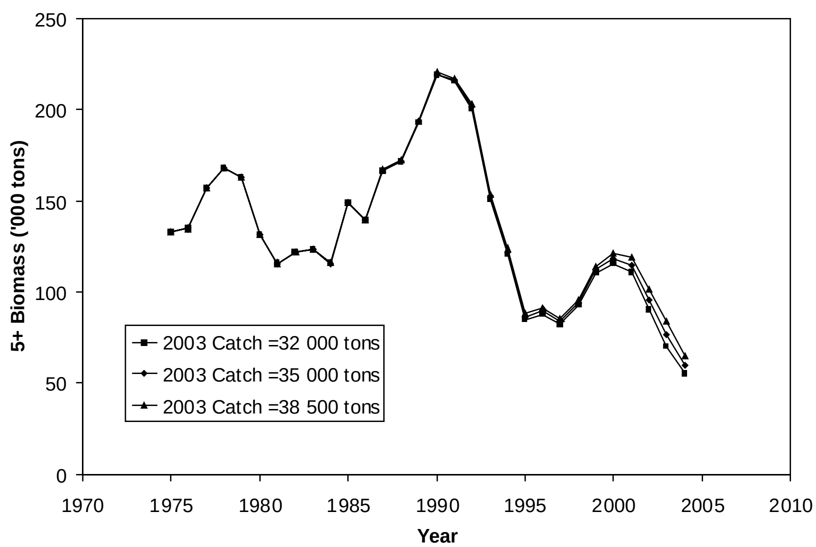

Fig. 8b: Greenland halibut in Subarea 2 + Div. 3KLMNO: Estimated biomass assuming three levels of 2003 landings.

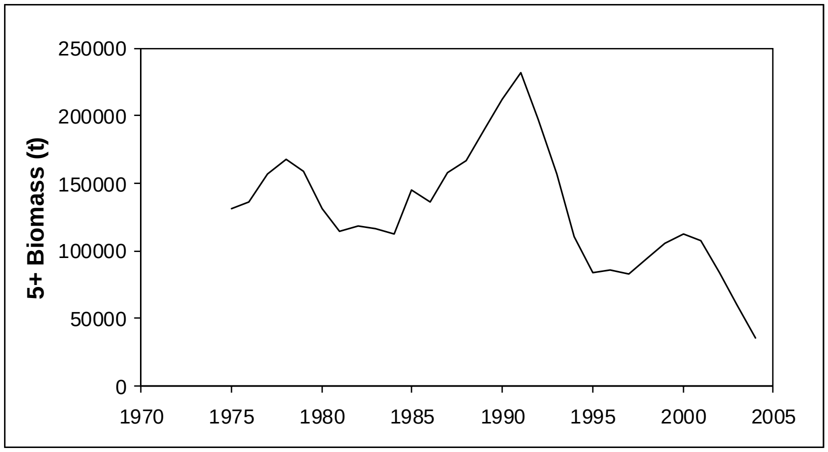

Fig. 9a: Greenland halibut in Subarea 2 + Div. 3KLMNO: Exploitable biomass estimated from ADAPT.

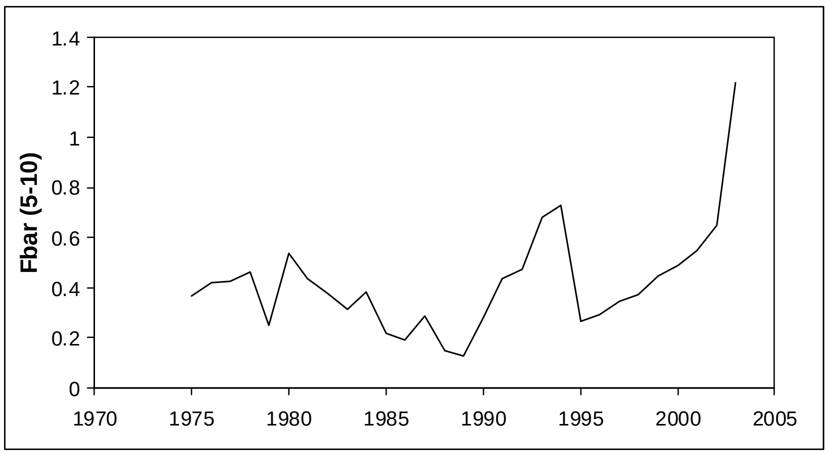

Fig. 9b: Greenland halibut in Subarea 2 + Div. 3KLMNO: Average fishing mortality estimated from ADAPT.

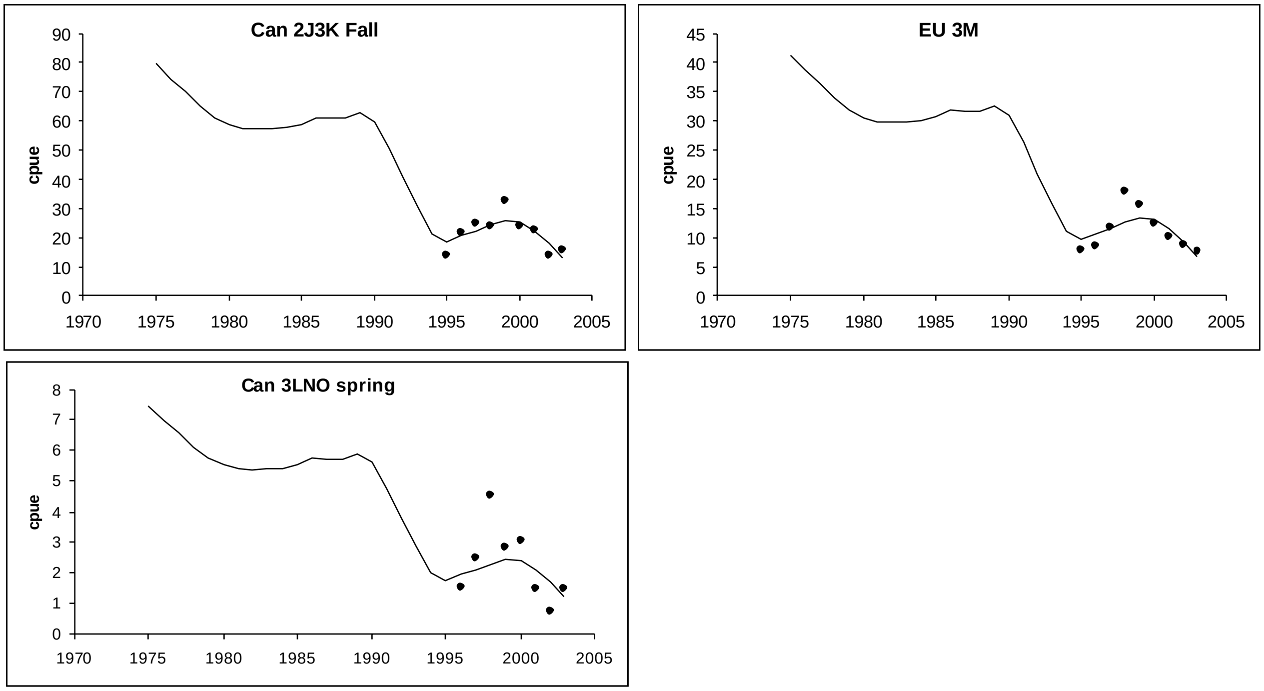

Fig. 10a: Greenland halibut in Subarea 2 + Div. 3KLMNO: ASPIC fitted as XSA estimated and observed CPUE.

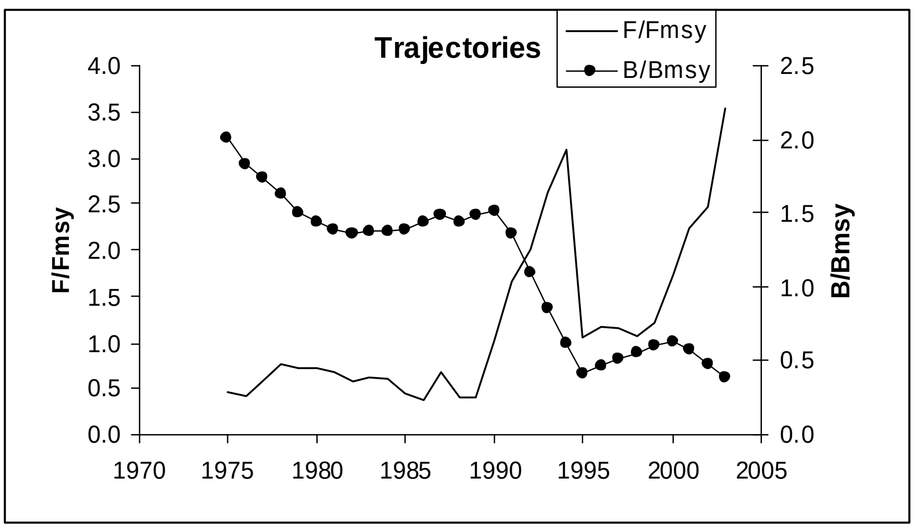

Fig. 10b: Greenland halibut in Subarea 2 + Div. 3KLMNO: ASPIC fitted as XSA, F and B trajectories.

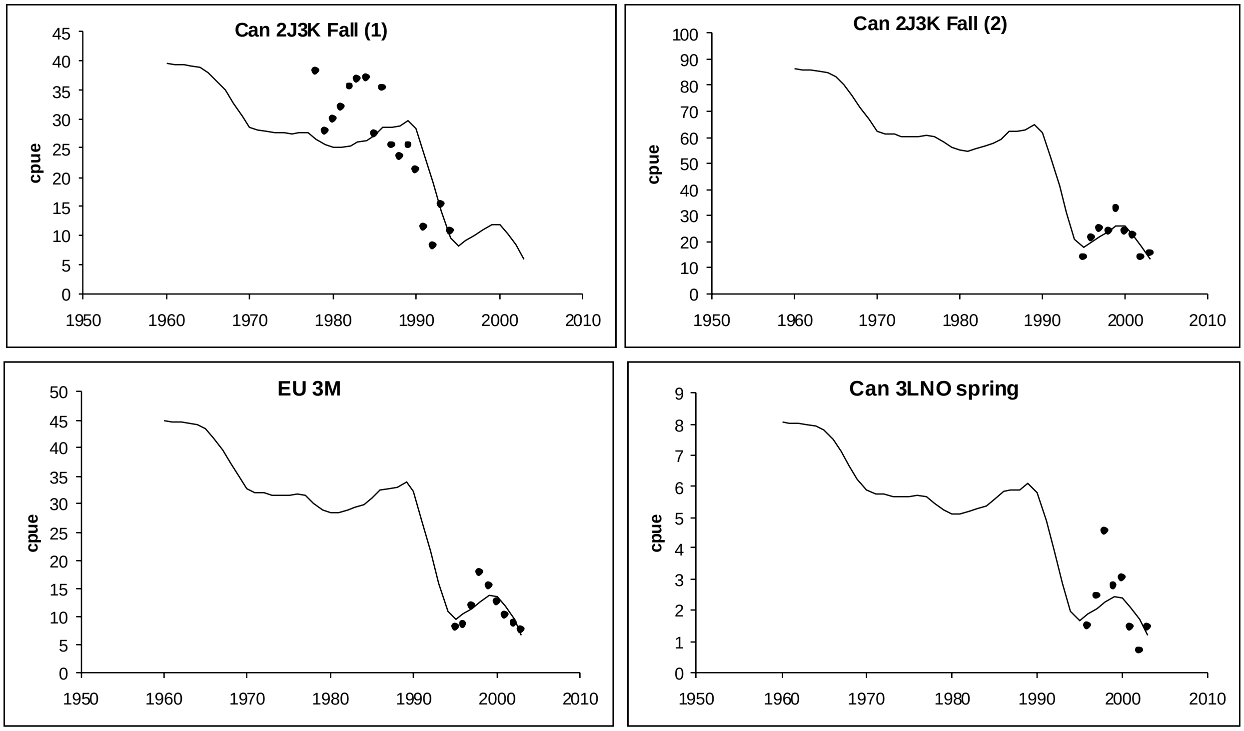

Fig. 11a: Greenland halibut in Subarea 2 + Div. 3KLMNO: ASPIC formulation 2; estimated and observed CPUE.

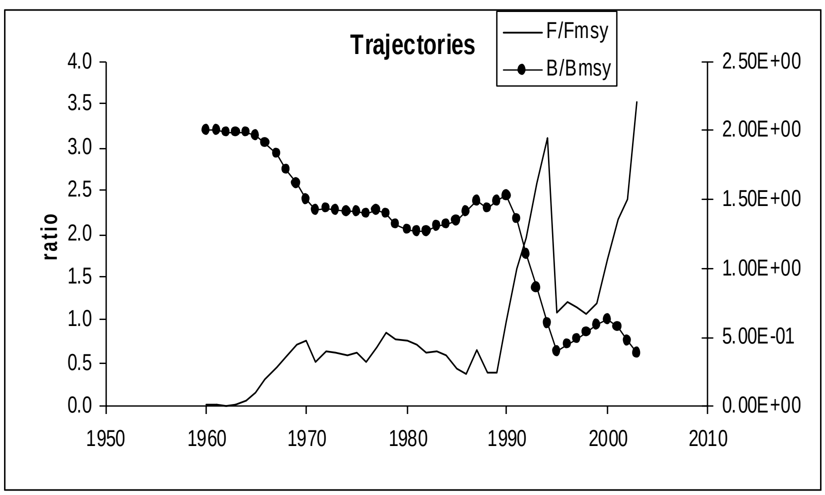

Fig. 11b: Greenland halibut in Subarea 2 + Div. 3KLMNO: ASPIC formulation 2; F and B trajectories.

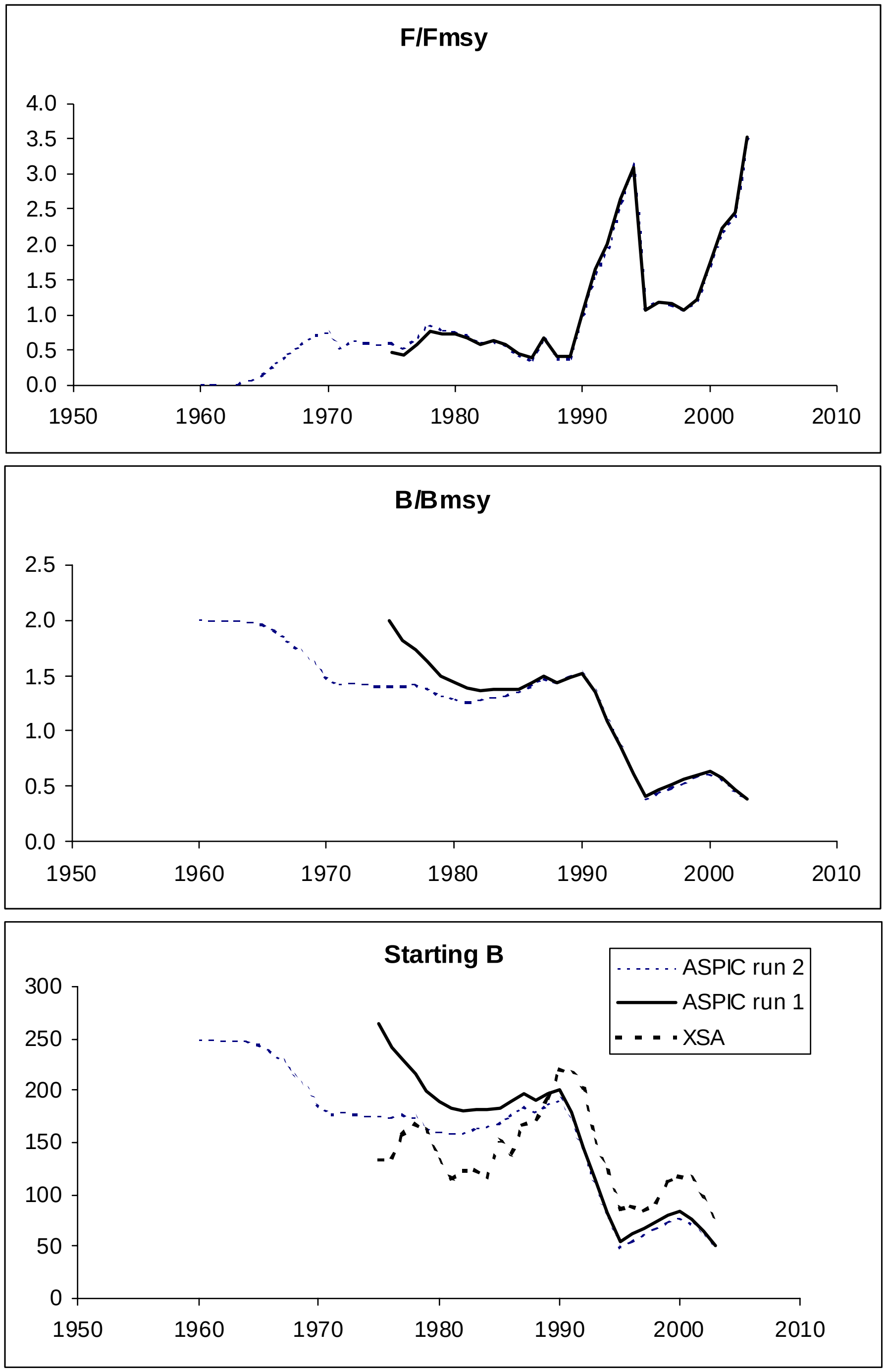

Fig. 12: Greenland halibut in Subarea 2 + Div. 3KLMNO: Comparison of estimates from each ASPIC formulation, with comparison to XSA (Biomass).

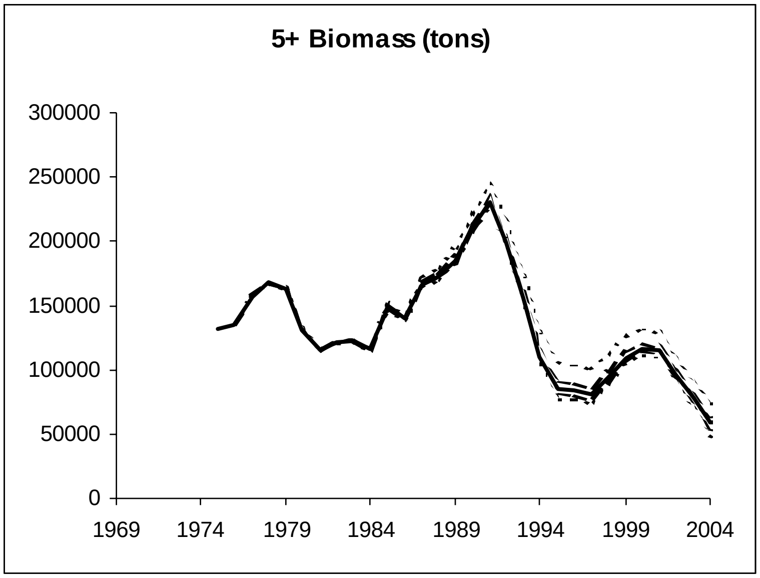

Fig. 13a: Greenland halibut in Subarea 2 + Div. 3KLMNO: 5+ biomass (5th, 25th,50th,75th and 95th percentiles) computed by non-parametric bootstrap XSA.

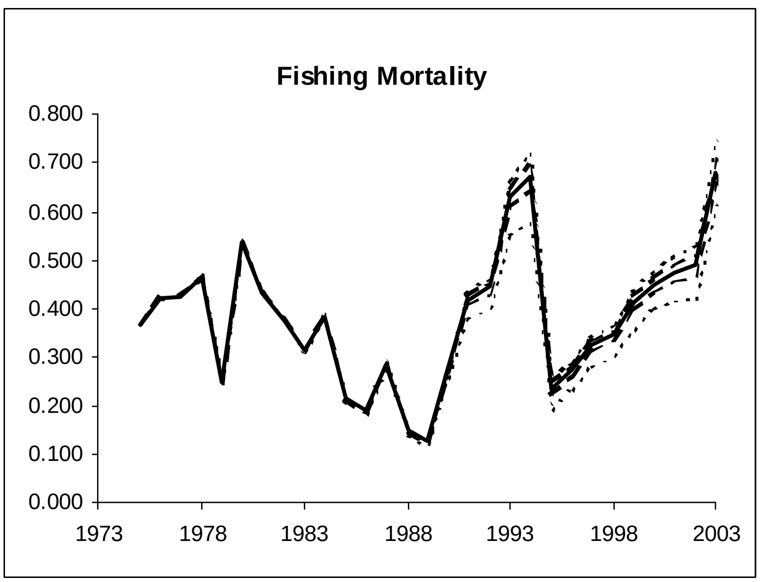

Fig. 13b: Greenland halibut in Subarea 2 + Div. 3KLMNO: Average fishing for ages 5-10 (5th, 25th,50th,75th and 95th percentiles) computed by non-parametric bootstrap XSA.

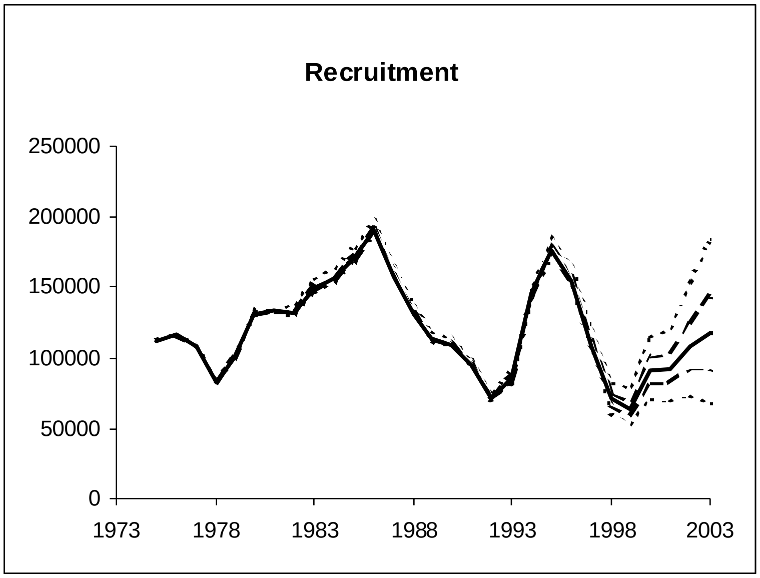

Fig. 13c: Greenland halibut in Subarea 2 + Div. 3KLMNO: Recruitment at age 1 (5th, 25th,50th,75th and 95th percentiles) computed by non-parametric bootstrap XSA.

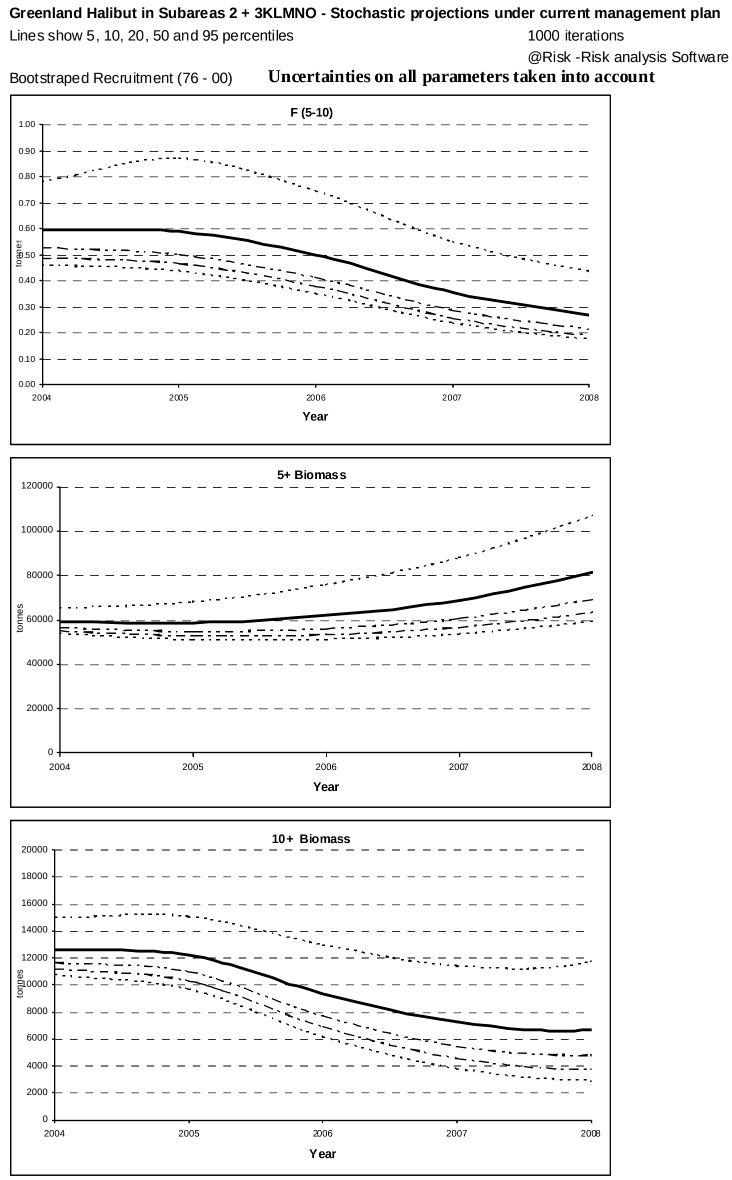

Fig. 14: Greenland halibut in Subarea 2 + Div. 3KLMNO: Stochastic projection estimates of average fishing mortality, 5+ biomass, 10+ biomass over 2004-2008 under Fisheries Commission rebuilding plan.