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

by

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Abstract

Using Extended Survivors Analysis (XSA), estimates of stock status of Greenland Halibut in Subarea 2 and Divisions 3KLMNO are updated using the most recent catches and survey information. Results indicate that exploitable (ages 5+) biomass is estimated to be the lowest in the time series, the current estimate of average fishing mortality is amongst the highest in the time series and the strength of recent year-classes is weak. Projections conducted under various catch options including those specified under the Fisheries Commission rebuilding plan indicate that prospects for stock rebuilding are poor unless fishing mortality is substantially reduced. Projection results under the Fisheries Commission rebuilding plan show that by 2009, the 5+ biomass will not have recovered to the level estimated for 2003, the year in which the rebuilding plan was established.

Introduction

Recent assessments of Greenland Halibut in Subarea 2 and Div. 3KLMNO have been based on the application of the Extended Survivors Analysis model (XSA; Shepherd, 1999) fitted within the Lowestoft assessment suite (Darby and Flatman, 1994). This assessment updates the estimates of population abundance and of fishing mortality, and medium-term projections are presented which provide the basis for discussion on various catch/management options, including the Fisheries Commission re-building plan for this stock.

Results of the 2005 NAFO Scientific Council assessment of this stock indicated that the exploitable biomass (ages 5+) was at the lowest level in the time series and that fishing mortality had increased substantially in recent years (NAFO, 2005; Healey and Mahé, 2005). The 2005 assessment also included analyses of stock status using the ADAPTive framework (ADAPT, Gavaris, 1988). The ADAPT results indicated similar trends over the entire time period, but the ADAPT estimate of terminal biomass was lower than the final XSA run and average fishing mortality in the final two years were considerably higher than estimated by XSA. The XSA model accepted by the Scientific Council was used as a basis for projections and provision of advice. We re-evaluate the status of the stock using the most recent stock surveys and catches.

Fisheries Commission established a fifteen year re-building plan for this stock (NAFO, 2003), in which TACs were set at 20, 19, 18.5, 16 ('000 tons), respectively, for the years 2004-2007 (Fig. 1). Subsequent TAC levels "*shall not be set at levels beyond 15% less or greater than the TAC of the preceding year*".

Input Data

Catches

Catches increased from low levels in the early-1960s when the fishery began to over 36 000 tons in 1969, ranged from 18 000 tons to 39 000 tons until 1990 (Table 1, 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 entire stock unit by the Fisheries Commission (previous TACs were set autonomously by Canada), and the catch declined to just over 15 000 tons in 1995, 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 increased since then and by 2001 had reached 38 000 tons before declining to 34 000 tons in 2002. In 2003, STACFIS could not precisely estimate the total catch; it was estimated to be within the range 32 000 tons to 38 500 tons. Catches have decreased under the FC rebuilding plan: the STACFIS estimate of catches for 2004 and 2005 are 25,486 and 23,225 tons, respectively. However, estimated catches have exceeded the TAC by 27% and 22%, respectively, in the first two years of the re-building plan.

Catch-at-age

Length sampling provided by EU-Portugal (Vargas *et al.*, 2006), EU-Spain (González *et al.*, 2006), and Russia (Vaskov *et al.*, 2006) for 2005 fisheries 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 (see Alpoim *et al*., 2002; Darby *et al.*, 2003). At a given age, the Spanish data have greater mean lengths than Canadian data. Until the differences can be resolved, Canadian age-length keys were applied in place of the Spanish age-length keys. Recent research suggests that despite these inconsistencies, the Canadian, EU and Russian age determination methods may be substantially underestimating ages (Treble *et al.*, 2005). A workshop on age determination methods for Greenland Halibut was held in early 2006 (Treble and Dwyer, 2006). Consensus on age-readings for this species has not been attained; active research on this problem continues.

Computation of Canadian catch-at-age is described by Brodie and Power (2006). Samples from the Canadian fishery were used to derive catch-at-age independently for each gear (see Table 5 of Brodie and Power, 2006). The 1997 and 1998 year-classes (ages 7 and 8 in 2005) dominated the Canadian catch; 60% of the catch (in numbers) came from these two cohorts.

Due to the age-reading discrepancies previously noted, the age distribution of the Spanish, Russian and Portuguese catches are no longer presented. The length samples from these nations are converted to catch-at-age using Canadian aging data.

No sampling data are available for the 2005 catches by EU-Latvia, EU-Estonia, Japan, St. Pierre & Miquelon (EU-France) and the Faroe Islands (EU-Denmark) (1 832 tons combined catch), all operating in the NAFO Regulatory Area (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 fisheries operating within the NRA.

The catch numbers-at-age for 1975-2005 are given in Table 2. As in the recent past, in 2005 the modal catch was at age 7, corresponding to the 1998 year-class. Catch weights at age (Table 3) are computed as weighted means of the values from national sampling, and indicate no trends over time. However, note that catch weights at age in 2005 were slightly higher than those in previous years. To illustrate changes in the age composition of the catch over the past four years (particularly ages 8+), the combined C@A from 2002-2005 is plotted in Fig. 2. The sum-of-products is 0.985 for the 2005 data, and is close to 1 for all four years.

The 2004 catch at age has been modified resulting from corrections to the length frequency sampling in the Spanish fishery. The changes to the total catch at age were minor; the largest change was a 5% increase in the age 4 catches. Catch weights at age were modified in the third decimal place. The 2005 assessment was reproduced using the corrected data and differences in results (not shown) are imperceptible.

Survey Data

The input data set used to calibrate the XSA is unchanged from the previous assessment. Specifically, the following data series are included (all expressed as mean numbers per tow, MNPT; see Table 4):

a) EU 3M - a European Union summer survey in Div. 3M from 1995-2005, ages 1-12 (González Troncoso *et al.*, 2006).
b) Can 2J+3K autumn survey, true Campelen data from 1995-2005, ages 1 to 14 (Healey *et al.*, 2006).
c) Can 3LNO spring survey, true Campelen data from 1996-2005, ages 1 to 8 (Healey *et al.*, 2006).

During the 2003 assessment, STACFIS agreed (NAFO, 2003; Darby *et al*., 2003) to exclude survey data from 1978-1994 from the calibration dataset to exclude time periods when changes in survey catchability were apparent. Retrospective patterns in biomass, fishing mortality and recruitment were less severe when the 1978-1994 data were excluded. Darby *et al*. (2003) also reported improved within survey correlations for the shortened time series. The 1995 data from the Canadian fall survey were excluded as the survey coverage in that year was incomplete; several of the deep water strata were not surveyed (see Tables 7-9 of Brodie, 2005).

Gonzaléz Costas and Gonzaléz Troncoso (2006) present an update on quality evaluation of surveys for Greenland Halibut. One measure of consistency considered was computing the correlation coefficient for successive ages within each survey series, for example, the time-series correlation between age 5 data in one year and age 6 data the next (measurements from the same cohort) in a given survey. Each of the survey series considered indicate similar results: the correlation between survey measurements at successive ages are very consistent up to ages 5 to 6; for older ages, the correlations are quite weak, even negative in some instances. Nonetheless, due to the fact that XSA uses within cohort information to produce estimates of survivors, VPA analyses for this stock are still considered appropriate. Bubble plots of the indices used in tuning the XSA (scaled within each survey-age) are presented in Fig. 3a-3c.

Results and Discussion

Plus Group Considerations

Considering the age-determination concerns for this species (Treble *et al.*, 2005; Treble and Dwyer, 2006), a sensitivity analysis was conducted to evaluate the impact of reducing the plus-group age in the catch-at-age matrix. Using catches up to 2004 and survey data to 2005, several XSA analyses were reviewed to determine if increasing the size of the plus group, or equivalently, reducing the number of true ages in the assessment, improved the model fit or altered the perceptions of stock status. Results indicated that the residual patterns commented on in previous assessments (see Healey and Mahé, 2005) remained, and that differences in estimated stock size were minimal (Fig. 4). Thus, any potential age mis-specification at the oldest ages does not appear to be causing the systematic residual patterns in this assessment.

XSA Assessment

Survey data over 1995-2005 and catch information from 1975-2005 were used to estimate numbers at age using the XSA formulation applied during the 2005 assessment. Preliminary investigations indicated that the XSA settings used in the previous assessment were suitable (see Healey and Mahé, 2005 for sensitivity analyses) and have not been altered in this analysis. The XSA settings, diagnostics and results can be found in Table 5. Estimated numbers at age and fishing mortality at age are presented in Tables 6 and 7, with a summary of the estimates presented in Table 8. Figures 5-7 illustrate the exploitable (ages 5+) biomass, average fishing mortality and the age 1 recruitment. Estimates of 2006 survivors from the XSA are used to compute 2006 biomass assuming the 2006 stock weights are equal to the 2003-2005 average.

The strong recruiting year-classes of the mid-1980s, coupled with relatively low fishing mortalities contributed to a substantial increase in the exploitable biomass over 1985-1991. Subsequently, intense fishing pressure and poor recruitment contributed to significant stock declines (on the order of two-thirds reduction) in the early 1990s. The large 1993-1995 year-classes lead to improvements in the exploitable biomass around the turn of the millennium. However, fishing mortality has remained high, and the contribution to the stock from these year-classes has been less than expected. The 2006 5+ biomass is estimated to be about 69 000 tons. This is the lowest value in the time series; we note that declines in exploitable biomass are continuing in spite of reduced catches under the FC rebuilding plan. (Exploitable biomass has decreased approximately 25% since the institution of the rebuilding plan.)

From 1975-1990, average fishing mortality over ages 5-10 (F_{bar}(5-10)), although variable, was generally low. As a result of high catches in 1991-94, average fishing mortality (ages 5-10; exceeded 0.50. F_{bar}(5-10) then declined to about 0.20 in 1995 with the substantial reduction in catch. F_{bar}(5-10) increased since then and has remained high in spite of the Fisheries Commission rebuilding plan. The 2003 and 2005 estimates are substantially higher, F_{bar}(5-10) in 2005 is estimated to be 0.63.

The above average 1993-95 year-classes comprised most of the fishery in the recent past although their overall contribution to the stock was less than previously expected. The most recent year-classes are estimated to be below average strength. The result confirms the low abundance of the recruitment (1998-2001 year-classes) entering the exploitable biomass as estimated in the previous assessment (Healey and Mahé, 2005). The estimated abundance of the 2003 and 2004 year-classes are the lowest two values in the time series, and the 2004 value is more than 50% smaller than the 2003 year-class estimate. Although the estimated abundance of the 2004 year-class is based only on the 2005 survey data; results from all three survey series confirm the low abundance of this cohort.

The XSA estimated catchabilities (Q), the standard error of Log(Q), and also the scaled weights used to compute the estimates of survivors at each age of the estimated population are presented in Figure 8. Darby and Flatman (1994) suggest that Log(Q) standard errors in excess of 0.5 are indicative of poor fit. In this analysis, the Log(Q) standard errors exceed 0.5 for a majority of index-ages, and exceed 1 for age 8 in the spring 3LNO series.

Selection patterns of the recent past are plotted in Fig. 9. Recent changes to fishing regulations within the Canadian EEZ likely explain the changes at the oldest ages, as the majority of the older individuals are taken in the Canadian fishery.

Residual graphics are presented for the final XSA run in Fig. 10. The trends and patterns are similar to those described in previous assessments of this stock: there are trends in the residuals along the cohorts, plus evidence of year-effects in some of the surveys. The mean squared residual (Fig. 10a) is largest for ages 7 and 8 in the Canadian spring survey, and ages 11 and 12 in the EU summer survey. Increasing trends in the mean annual residual in both of the Canadian surveys are cause for concern. Note that most of the residuals in the 2005 Canadian fall survey for ages 6 and above are positive. (Healey *et al*. (2006) discuss the unusual age composition of the 2005 survey in detail.) Again, the residual bubble plots (Fig. 10c) display problematic trends – evidence of cohort tracking and year effects, each of which indicate poor model fit.

Retrospective analysis

A retrospective analysis was conducted to examine the influence of removing successive years' data on the terminal estimates of biomass, fishing mortality and recruitment (Figure 11). Estimates of 5+ biomass have been generally consistent; however, with the exclusion of three years of survey and catch data, a substantial change in 5+ biomass is observed. Retrospective patterns in stock size estimates have been problematic in previous assessments of this stock (see Darby *et al*. 2003). Most notably, the 2002 assessment was rejected by STACFIS in part due to retrospective concerns (NAFO, 2003). Results indicate that the recent recruitment estimates have been revised upwards as additional data is included in the model. Trends are evident in the retrospective estimates of fishing mortality, with revisions to the estimates for the early 1990s, and to the most recent estimates as additional data is included.

There are two notable features in these retrospective figures. One is that the direction of the retrospective pattern has reversed over time; during the late 1990s and early 2000s, the successive assessments appear to have underestimated average fishing mortality, and consequently over-estimate the exploitable biomass. This was caused by downwards revisions to the estimated recruitment of the 1993-1995 year-classes. However, in the recent past, fishing mortality appears to be over-estimated and biomass underestimated as the estimated recruitment since 2000 has been revised upwards in each successive assessment. The second unusual feature of the retrospective analysis is the changing trend in average fishing mortality between the 2005 assessment and the current assessment (Fig. 11). In the 2005 assessment, the estimated of average fishing mortality over ages 5-10 increased between 2003 and 2004. In the current assessment, however, average fishing mortality decreases from 2003 to 2004. The estimated of average fishing mortality for 2004 is 0.52 in the current assessment, compared to 0.71 in the previous assessment. To gain further insight into this difference, Tables 9 and 10 provide a measure of the sensitivity of the XSA output to the addition of the 2005 catch and survey data. The tables present ratios of the estimated numbers at age and fishing mortality at age from the current assessment and the 2005 assessment with changes exceeding 10% in magnitude highlighted. The one year retrospective differences are driven primarily by revisions to the 1997 and 1998 year-classes.

Reference Points

Precautionary approach reference points have not previously been defined for this stock. Several of the standard approaches typically available for age-disaggregated assessments are not applicable for this stock given the difficulties in determining the spawner biomass (or appropriate proxy). Limit reference points could not be determined for this stock at this time. However, we note that the exploitable biomass is currently estimated to be the lowest in the 1975-2006 time-series.

Based on average weights and partial recruitment for the past 3 years, F_{Max} = 0.26 and $F_{0.1}$ = 0.15. The XSA estimate of average fishing mortality (ages 5-10) for 2005 is 0.63, over 2.5 times the F_{Max} level or four times the $F_{0.1}$ level.

Projections

Three year deterministic and stochastic projections of stock size (to 1 Jan 2009) were conducted. As noted previously, the Fisheries Commission has implemented a 15-year rebuilding plan for this resource by instituting an exploitable biomass target (ages 5+) of 140 000 tons (NAFO, 2003). As an initial step, the Fisheries Commission established TACs of 20 000, 19 000, 18 500, and 16 000 tons for 2004-2007, respectively. Shelton (2005a) suggests that the FC plan has a low probability of achieving the rebuilding plan target (exploitable biomass of 140 000 tons), and proposes alternative rebuilding plans which are compliant with the precautionary approach (see also Shelton, 2005b).

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

Several projection scenarios were considered:

1. Assume future catches follow the rebuilding plan (with 2008 catch assumed equal to the 2007 catch)
2. Assume future catches follow the rebuilding plan + 20% over-run, (with 2008 catch assumed equal to the 2007 catch),
3. Assume 2006 catch equals rebuilding plan + 20% over-run; catches in 2007 and 2008 correspond to a fishing mortality level of $F_{0.1}$.
4. Assume 2006 catch equals rebuilding plan + 20% over-run; catches in 2007 and 2008 correspond to a fishing mortality level of F_{Max}.
5. Assume 2006 catch equals rebuilding plan + 20% over-run; catches in 2007 and 2008 correspond to the current fishing mortality level (F_{2005}).

Projections which include catches corresponding to a 20% over-run on the rebuilding plan TACs were conducted because these may more accurately reflect future catch levels. During the first two years of the FC rebuilding plan, the catches have exceed the TAC by 27% and 22%, respectively.

The projection inputs are summarized in Table 11 with the variability in the projection parameters for the stochastic projections described by the coefficients of variation (column CV in the table). Numbers at age 2 and older at 1st of January 2006 and corresponding CVs are computed from the XSA output. Deterministic projections were conducted assuming a future recruitment value of the 1996-2002 geometric mean from XSA estimates. Recruitment for the stochastic projections was bootstrapped from the 1975-2002 age 1 numbers from the XSA. In both cases, more recent estimates of recruitment are susceptible to retrospective revision and are considered unreliable. (We note that in the three year projections, the age 1 recruitment assumption has zero impact on the 5+ biomass or on the average fishing mortality over ages 5-10.) Scaled selection pattern and corresponding CVs are derived from the 2003 to 2005 average from the XSA. Weights at age in the stock and in the catch and corresponding CVs are computed from the 2003-2005 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 catch levels. The stochastic distributions were generated using @Risk software. Re-sampled quantities such as weights at age, etc. are sampled in the first year of the projection and held fixed in subsequent years in each projection iteration. The distribution was assumed lognormal for the numbers at age and normal for the other input data.

We present the results of the deterministic projections for scenarios 1-5 outlined above, and for the stochastic projections, results from scenarios 1 and 2 only.

Deterministic projections (Table 12; Fig. 12) indicate that by 2009, the 5+ biomass will remain stable with little increase if catches follow the FC rebuilding plan. If catches exceed the rebuilding plan targets, then the recent declines in biomass will continue. Projected average fishing mortality (Fig. 12) decreases for each of these scenarios. For projection scenarios 3-5 (*F*-based), exploitable biomass is projected to decrease substantially if fishing mortality remains at current levels, remains stable under F_{Max}, and biomass is projected to increase if fishing mortality is reduced to $F_{0.1}$. We note that for all projections considered, the exploitable biomass in 2009 will not have recovered to the 2003 level, the year that the FC rebuilding plan was implemented.

The results of the stochastic projection (average fishing mortality, 5+ biomass and 10+ biomass) under scenarios 1 and 2 are plotted in Fig. 13 and 14, and tabulated in Table 13. The trend in ages 10+ biomass is presented to illustrate the short term development of older portion of the population and should not be considered to represent SSB which is not precisely known. Median projected values of average fishing mortality decline in both scenarios. Median projected values of exploitable biomass show the same pattern as in the deterministic projections: exploitable biomass remains stable if future catch levels follow the rebuilding plan, and exploitable biomass continues to decline should future catches exceed the rebuilding plan TACs. For both scenarios there is a low to very low probability that the exploitable biomass in 2009 will have recovered to the 2003 level.

Conclusion

The status of this stock has worsened since the last assessment. Current estimates of exploitable biomass are at an all-time low, fishing mortality has increased substantially in recent years, and is currently amongst the highest estimate in the time series.

Deterministic and stochastic projections indicate that under the Fisheries Commission rebuilding plan, prospects for stock rebuilding are currently poor. Projection results also indicate that by 2009, the 5+ biomass will not have recovered to the level estimated for 2003, the year in which the rebuilding plan was established.

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Table 1. Landings and Total Allowable Catches (all in 000 tons) for Greenland Halibut in Sub-area 2 and Div. 3KLMNO. TACs were set autonomously by Canada until 1994. Since 1995, the TAC has been established by the Fisheries Commission of NAFO.

Year	TAC - Canada	TAC - FC	Catch
1960			0.9
1961			0.7
1962			0.6
1963			2
1964			4
1965			10
1966			19
1967			27
1968			32
1969			37
1970			37
1971			25
1972			30
1973			29
1974	40		28
1975	40		29
1976	30		25
1977	30		32
1978	30		39
1979	30		34
1980	35		33
1981	55		31
1982	55		26
1983	55		28
1984	55		27
1985	75		20
1986	100		18
1987	100		32
1988	100		19
1989	100		20
1990	50		47
1991	50		65
1992	50		63
1993	50		62
1994	25		51
1995		27	15
1996		27	19
1997		27	20
1998		27	20
1999		33	24
2000		35	34
2001		40	37
2002		44	34
2003		42	35
2004		20*	25
2005		19*	23
2006		18.5*	
2007		16*	

* TAC specified under FC Rebuilding Plan (FC Doc. 03/13).

Table 2. Catch at age matrix (000s) for Greenland Halibut in SA 2 + Div. 3KLMNO.

Cn	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
1975	0	0	0	0	334	2819	5750	4956	3961	1688	702	135	279	288
1976	0	0	0	0	17	610	3231	5413	3769	2205	829	260	101	53
1977	0	0	0	0	534	5012	10798	7346	2933	1013	220	130	116	84
1978	0	0	0	0	2982	8415	8970	7576	2865	1438	723	367	222	258
1979	0	0	0	0	2386	8727	12824	6136	1169	481	287	149	143	284
1980	0	0	0	0	209	2086	9150	9679	5398	3828	1013	128	53	27
1981	0	0	0	0	863	4517	9806	11451	4307	890	256	142	43	69
1982	0	0	0	0	269	2299	6319	5763	3542	1684	596	256	163	191
1983	0	0	0	0	701	3557	9800	7514	2295	692	209	76	106	175
1984	0	0	0	0	902	2324	5844	7682	4087	1259	407	143	106	183
1985	0	0	0	0	1983	5309	5913	3500	1380	512	159	99	87	86
1986	0	0	0	0	280	2240	6411	5091	1469	471	244	140	70	117
1987	0	0	0	0	137	1902	11004	8935	2835	853	384	281	225	349
1988	0	0	0	0	296	3186	8136	4380	1288	465	201	105	107	129
1989	0	0	0	0	181	1988	7480	4273	1482	767	438	267	145	71
1990	0	0	0	95	1102	6758	12632	7557	4072	2692	1204	885	434	318
1991	0	0	0	220	2862	7756	13152	10796	7145	3721	1865	1216	558	422
1992	0	0	0	1064	4180	10922	20639	12205	4332	1762	1012	738	395	335
1993	0	0	0	1010	9570	15928	17716	11918	4642	1836	1055	964	401	182
1994	0	0	0	5395	16500	15815	11142	6739	3081	1103	811	422	320	215
1995	0	0	0	323	1352	2342	3201	2130	1183	540	345	273	251	201
1996	0	0	0	190	1659	5197	6387	1914	956	504	436	233	143	89
1997	0	0	0	335	1903	4169	7544	3215	1139	606	420	246	137	89
1998	0	0	0	552	3575	5407	5787	3653	1435	541	377	161	92	51
1999	0	0	0	297	2149	5625	8611	3793	1659	623	343	306	145	151
2000	0	0	0	271	2029	12583	21175	3299	973	528	368	203	129	104
2001	0	0	0	448	2239	12163	22122	5154	1010	495	439	203	156	75
2002	0	0	0	479	1662	7239	17581	6607	1244	659	360	224	126	81
2003	0	0	0	1279	4491	10723	16764	6385	1614	516	290	144	76	85
2004	0	0	0	947	4196	8367	10480	4069	1301	532	289	184	88	76
2005	0	0	0	534	1652	5999	10313	3996	1410	444	244	114	64	46

Table 3. Catch weight at age (kg) matrix for Greenland Halibut in SA 2 + Div. 3KLMNO.

Cw	1	2	3	4	5	6	7	8	9	10	11	12	13
1975	0.00	0.00	0.13	0.24	0.61	0.76	0.96	1.19	1.58	2.21	2.70	3.37	3.88
1976	0.00	0.00	0.13	0.24	0.61	0.76	0.96	1.19	1.58	2.21	2.70	3.37	3.88
1977	0.00	0.00	0.13	0.24	0.61	0.76	0.96	1.19	1.58	2.21	2.70	3.37	3.88
1978	0.00	0.00	0.13	0.24	0.61	0.76	0.96	1.19	1.58	2.21	2.70	3.37	3.88
1979	0.00	0.00	0.13	0.24	0.61	0.76	0.96	1.19	1.58	2.21	2.70	3.37	3.88
1980	0.00	0.00	0.13	0.24	0.51	0.66	0.87	1.05	1.15	1.26	1.57	2.71	3.12
1981	0.00	0.00	0.13	0.24	0.39	0.60	0.79	0.99	1.24	1.70	2.46	3.51	4.79
1982	0.00	0.00	0.13	0.24	0.53	0.68	0.89	1.13	1.40	1.79	2.38	3.47	4.51
1983	0.00	0.00	0.13	0.24	0.41	0.63	0.86	1.18	1.65	2.23	3.01	3.96	5.06
1984	0.00	0.00	0.13	0.24	0.38	0.58	0.83	1.10	1.46	1.94	2.63	3.49	4.49
1985	0.00	0.00	0.13	0.24	0.57	0.75	0.94	1.24	1.69	2.24	2.95	3.71	4.85
1986	0.00	0.00	0.13	0.24	0.35	0.58	0.81	1.10	1.58	2.12	2.89	3.89	4.95
1987	0.00	0.00	0.13	0.24	0.36	0.59	0.84	1.16	1.59	2.13	2.82	3.60	4.63
1988	0.00	0.00	0.13	0.24	0.36	0.57	0.81	1.16	1.66	2.22	3.01	3.93	5.09
1989	0.00	0.00	0.13	0.24	0.40	0.56	0.77	1.08	1.66	2.24	3.00	3.86	4.92
1990	0.00	0.00	0.09	0.18	0.34	0.55	0.77	1.12	1.61	2.17	2.85	3.73	4.69
1991	0.00	0.00	0.13	0.24	0.38	0.59	0.83	1.23	1.81	2.46	3.31	4.14	5.33
1992	0.00	0.00	0.18	0.29	0.43	0.58	0.79	1.23	1.82	2.46	3.12	3.97	5.10
1993	0.00	0.00	0.13	0.23	0.37	0.55	0.81	1.21	1.73	2.31	3.00	3.97	4.82
1994	0.00	0.00	0.08	0.20	0.33	0.51	0.79	1.18	1.70	2.27	2.99	3.77	4.88
1995	0.00	0.00	0.08	0.29	0.36	0.53	0.81	1.20	1.76	2.45	3.12	3.81	4.89
1996	0.00	0.00	0.16	0.24	0.36	0.54	0.83	1.27	1.80	2.48	3.15	3.86	4.95
1997	0.00	0.00	0.12	0.21	0.34	0.49	0.77	1.16	1.73	2.36	3.05	3.95	5.11
1998	0.00	0.00	0.12	0.23	0.37	0.54	0.81	1.20	1.75	2.35	3.10	4.01	5.13
1999	0.00	0.00	0.18	0.25	0.36	0.53	0.83	1.25	1.68	2.29	2.89	3.51	4.46
2000	0.00	0.00	0.00	0.25	0.35	0.52	0.79	1.19	1.77	2.28	2.90	3.65	4.49
2001	0.00	0.00	0.00	0.25	0.38	0.57	0.83	1.17	1.79	2.37	2.95	3.72	4.59
2002	0.00	0.00	0.22	0.25	0.37	0.56	0.84	1.19	1.76	2.28	2.90	3.58	4.41
2003	0.00	0.00	0.19	0.25	0.39	0.56	0.82	1.20	1.65	2.17	2.70	3.40	4.38
2004	0.00	0.00	0.18	0.25	0.38	0.53	0.81	1.20	1.63	2.15	2.73	3.54	4.38
2005	0.00	0.00	0.25	0.30	0.40	0.56	0.85	1.25	1.69	2.18	2.71	3.46	4.26

Table 4. Survey data (all MNPT) used in XSA assessment of Greenland Halibut in SA 2 + Div. 3KLMNO. The decimalized year reflects the timing of each survey series (e.g. EU summer survey).

2J3K Fall	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1996.9	98.680	47.820	32.010	9.539	6.283	2.466	0.836	0.191	0.179	0.039	0.024	0.012	0.017	0.006
1997.9	28.050	58.620	43.610	21.130	10.370	5.007	1.998	0.641	0.203	0.055	0.032	0.022	0.009	0.003
1998.9	23.350	25.070	31.190	21.870	10.860	4.452	2.066	0.565	0.132	0.059	0.028	0.021	0.013	0.002
1999.9	15.990	34.420	24.070	28.280	20.040	10.530	3.811	0.703	0.139	0.072	0.021	0.006	0.025	0.002
2000.9	38.570	21.940	16.430	13.200	13.760	7.207	2.161	0.502	0.063	0.030	0.015	0.004	0.000	0.007
2001.9	43.900	22.720	17.000	14.070	9.765	7.591	3.403	0.692	0.112	0.023	0.014	0.004	0.011	0.001
2002.9	40.670	24.080	12.500	9.679	6.027	1.974	0.719	0.190	0.039	0.013	0.004	0.000	0.003	0.000
2003.9	45.700	26.670	11.690	9.490	6.389	2.271	0.893	0.268	0.040	0.017	0.010	0.006	0.002	0.000
2004.9	32.490	32.930	13.890	12.310	9.209	2.684	1.198	0.358	0.083	0.032	0.006	0.004	0.008	0.000
2005.9	15.490	16.120	8.400	13.400	10.300	6.559	3.847	0.662	0.116	0.034	0.027	0.009	0.007	0.002

3LNO Spr	1	2	3	4	5	6	7	8
1996.4	1.621	4.241	4.599	2.183	0.827	0.284	0.057	0.001
1997.4	1.162	3.924	5.160	3.227	1.461	0.507	0.099	0.013
1998.4	0.220	0.814	3.847	6.186	4.955	1.238	0.326	0.072
1999.4	0.292	0.552	1.149	1.982	3.388	1.090	0.242	0.050
2000.4	0.793	1.069	1.068	1.506	1.954	2.037	0.556	0.031
2001.4	0.565	0.714	0.739	0.676	0.796	0.716	0.279	0.023
2002.4	0.642	0.572	0.603	0.581	0.608	0.208	0.049	0.006
2003.4	0.926	2.137	1.663	1.569	1.055	0.206	0.051	0.008
2004.4	0.662	0.572	1.181	1.184	1.161	0.259	0.041	0.020
2005.4	0.353	0.306	1.090	0.946	1.372	0.823	0.206	0.025

EU Survey	1	2	3	4	5	6	7	8	9	10	11	12
1995.6	12.41	2.54	2.23	1.91	2.66	5.10	3.77	2.12	1.31	0.26	0.07	0.02
1996.6	5.84	7.97	2.42	3.04	4.20	5.82	2.49	1.62	0.42	0.09	0.03	0.04
1997.6	3.33	3.78	6.00	6.50	7.11	8.46	4.99	2.15	0.66	0.22	0.03	0.02
1998.6	2.74	2.13	7.69	11.00	12.33	11.30	7.84	2.62	0.75	0.20	0.03	0.01
1999.6	1.06	0.70	3.01	10.47	13.41	12.58	5.55	1.82	0.35	0.10	0.01	0.00
2000.6	3.75	0.29	0.60	2.17	7.09	14.10	5.40	2.32	0.45	0.11	0.05	0.00
2001.6	8.03	1.43	1.81	0.99	2.79	7.79	6.63	3.21	0.18	0.05	0.01	0.00
2002.6	4.08	2.94	2.80	1.67	3.79	5.59	5.73	1.28	0.13	0.06	0.02	0.01
2003.6	2.20	1.00	0.61	1.51	2.48	2.94	1.93	0.47	0.13	0.10	0.02	0.01
2004.6	2.19	3.29	4.37	1.97	6.97	7.80	2.54	0.64	0.29	0.13	0.08	0.05
2005.6	0.54	0.81	3.18	2.50	6.89	7.59	2.92	0.61	0.11	0.12	0.06	0.02

Table 5a. XSA structure.

Lowestoft VPA Version 3.1

7/06/2006 13:14

Extended Survivors Analysis

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

CPUE data from file GhalTUN2006.txt

Catch data for 31 years. 1975 to 2005. Ages 1 to 14.

Fleet	First year	Last year	First age	Last age	Alpha	Beta
EU Survey(I	1995	2005	1	12	0.5	0.6
CAN 2J3K F	1996	2005	1	13	0.8	1
CAN 3LNO	1996	2005	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 2005
shrunk towards 1.000 * the mean F of ages 10 - 12

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

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

Individual fleet weighting not applied

Tuning converged after 38 iterations

Table 5b. XSA Diagnostic results.

Fleet : EU Survey(MNPT)

Age	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
1	0.79	0.18	-0.17	-0.18	-0.99	0.19	0.97	0.25	-0.34	0.03	-0.72
2	0.12	1.06	0.45	0.09	-0.83	-1.57	-0.07	0.68	-0.45	0.78	-0.26
3	0.18	-0.27	0.44	0.83	0.1	-1.33	-0.08	0.27	-1.23	0.69	0.41
4	0	0.29	0.53	0.85	0.94	-0.42	-1.01	-0.36	-0.53	-0.24	-0.06
5	-0.49	0.15	0.49	0.52	0.39	-0.11	-0.82	-0.33	-0.56	0.39	0.36
6	-0.06	-0.08	0.48	0.6	0.14	0.09	-0.35	-0.5	-0.84	0.35	0.16
7	0.25	-0.45	0.17	0.77	0.37	-0.05	-0.02	-0.05	-0.9	-0.32	0.24
8	0.34	0.11	0.28	0.44	0.29	0.51	0.76	-0.38	-1.27	-0.74	-0.34
9	1.15	0.07	0.58	0.73	0	0.45	-0.53	-0.76	-0.92	-0.01	-0.76
10	0.48	-0.58	0.41	0.39	-0.14	0.03	-0.77	-0.51	0.17	0.28	0.24
11	0.55	-0.42	-0.31	-0.03	-1.38	0.75	-1.34	-0.06	-0.11	1.53	0.84
12	-0.23	0.49	-0.11	-1.23	-1.85	99.99	99.99	-0.36	-0.73	1.45	0.74
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	-10.2358	-10.7459	-10.2112	-9.8144	-8.9341	-8.2287	-8.0223	-8.1762	-8.9764	-9.4691
S.E(Log q)	0.5823	0.7646	0.7076	0.6031	0.4827	0.432	0.4474	0.6129	0.6826	0.4382

Age	11	12
Mean Log	-10.371	-10.371
S.E(Log q)	0.8875	1.0348

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	0.58	1.836	10.75	0.68	11	0.31	-10.24
2	0.43	1.694	11.12	0.49	11	0.3	-10.75
3	0.54	0.928	10.68	0.31	11	0.38	-10.21
4	0.44	2.188	10.48	0.63	11	0.22	-9.81
5	0.84	0.344	9.23	0.34	11	0.42	-8.93
6	1.93	-1.168	6.14	0.15	11	0.82	-8.23
7	1.91	-1.332	6.24	0.19	11	0.82	-8.02
8	150.28	-0.995	******	0	11	92.16	-8.18
9	0.26	1.943	8.42	0.43	11	0.16	-8.98
10	0.68	0.6	8.88	0.28	11	0.31	-9.47
11	-2.52	-1.317	-1.12	0.02	11	2.15	-10.37
12	14.39	-1.066	64.21	0	9	14.44	-10.57

Table 5b (cont). XSA diagnostic results.

Fleet : CAN 2J3K Fall(MNPT)

Age	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
1	0.56	-0.48	-0.48	-0.72	0.07	0.23	0.11	0.25	0.28	0.18
2	0	0.34	-0.3	0.21	-0.11	-0.16	-0.07	-0.02	0.23	-0.12
3	0.31	0.42	0.23	0.18	-0.01	0.16	-0.24	-0.28	-0.15	-0.62
4	-0.12	0.15	-0.02	0.38	-0.17	0.08	-0.15	-0.24	0.04	0.07
5	-0.01	0.31	-0.16	0.23	-0.01	-0.13	-0.42	-0.14	0.13	0.2
6	-0.39	0.51	0.23	0.48	-0.02	0.2	-0.99	-0.49	-0.1	0.57
7	-0.77	0.04	0.2	0.83	0	0.24	-1.23	-0.72	-0.16	1.56
8	-0.95	0.21	0.07	0.55	0.15	0.49	-1.01	-0.53	-0.1	1.1
9	0.33	0.55	0.18	0.3	-0.36	0.13	-0.75	-0.88	-0.06	0.55
10	-0.2	0.22	0.39	0.74	-0.09	-0.21	-0.78	-0.34	0.07	0.19
11	0.03	0.36	0.31	0.12	0.04	0.13	-1.01	-0.19	-0.45	0.66
12	-0.13	0.47	0.36	-0.57	-1.01	-0.63	99.99	0.02	-0.41	0.55
13	0.5	0.08	0.34	1.02	99.99	0.64	-0.16	-0.26	0.99	0.69

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

Age	1	2	3	4	5	6	7	8	9	10
Mean Log	-7.7224	-7.8218	-8.14	-8.1841	-8.2864	-8.6333	-8.5452	-9.0634	-9.9235	-10.4897
S.E(Log q)	0.4145	0.1979	0.3209	0.1831	0.2243	0.504	0.8069	0.6683	0.5068	0.424

Age	11	12	13
Mean Log	-10.7235	-10.7235	-10.7235
S.E(Log q)	0.4663	0.5675	0.6492

Regression statistics :

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

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Q
1	1.1	-0.243	7.36	0.43	10	0.48	-7.72
2	0.83	0.871	8.44	0.76	10	0.17	-7.82
3	0.5	3.191	9.7	0.83	10	0.11	-8.14
4	0.73	1.671	8.95	0.83	10	0.12	-8.18
5	1.03	-0.116	8.2	0.61	10	0.25	-8.29
6	1.25	-0.352	8.17	0.2	10	0.66	-8.63
7	115.86	-1.328	******	0	10	89.75	-8.55
8	-1.41	-1.659	9.08	0.06	10	0.86	-9.06
9	0.56	0.55	9.17	0.16	10	0.29	-9.92
10	0.55	0.976	9.18	0.37	10	0.23	-10.49
11	0.52	1.613	8.98	0.59	10	0.22	-10.72
12	1.18	-0.26	11.64	0.24	9	0.68	-10.87
13	0.83	0.543	9.58	0.6	9	0.41	-10.3

Table 5b (cont). XSA diagnostic results.

Fleet : CAN 3LNO Spr(MNPT)

Age	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
1	0.44	0.32	-1.15	-0.73	0.18	-0.13	-0.05	0.35	0.38	0.39
2	0.92	0.98	-0.38	-0.58	0.22	-0.27	-0.47	0.8	-0.48	-0.74
3	0.83	0.75	0.59	-0.4	-0.29	-0.52	-0.81	0.23	-0.16	-0.21
4	0.61	0.48	0.93	-0.07	-0.13	-0.74	-0.76	0.16	-0.1	-0.38
5	-0.11	0.28	0.97	0.38	-0.03	-0.71	-0.79	-0.06	-0.04	0.11
6	-0.46	0.31	1.03	0.35	0.79	-0.11	-1.15	-0.89	-0.44	0.57
7	-0.68	-0.22	1.14	0.75	1.12	0.27	-1.33	-1.09	-0.97	1
8	-2.67	-0.25	1.42	1.24	0.75	0.34	-1.23	-0.84	0.32	0.93
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	-11.8194	-11.2718	-10.7017	-10.503	-10.3431	-10.9416	-11.6924	-12.8816
S.E(Log q)	0.5417	0.6709	0.5667	0.5576	0.5087	0.7272	0.9763	1.2736

Regression statistics :

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

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Q
1	1.24	-0.396	11.92	0.26	10	0.7	-11.82
2	0.37	2.728	11.33	0.7	10	0.19	-11.27
3	0.35	3.626	11.06	0.79	10	0.13	-10.7
4	0.48	1.565	10.78	0.53	10	0.25	-10.5
5	0.66	0.859	10.49	0.45	10	0.34	-10.34
6	0.92	0.101	10.91	0.18	10	0.71	-10.94
7	2.48	-0.611	14.12	0.02	10	2.51	-11.69
8	-6.12	-0.52	-14.23	0	10	8.13	-12.88

Table 5b (cont). XSA diagnostic results.

Terminal year survivor and F summaries :

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

Year class = 2004

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU Survey	13863	0.608	0	0	1	0.276	0
CAN 2J3K	34288	0.5	0	0	1	0.408	0
CAN 3LNC	42324	0.568	0	0	1	0.316	0
F shrinka	0	0.5				0	0

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
28548	0.32	0.32	3	1.006	0

1

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

Year class = 2003

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU Survey	41203	0.484	0.137	0.28	2	0.246	0
CAN 2J3K	48173	0.354	0.201	0.57	2	0.46	0
CAN 3LNC	41780	0.442	0.547	1.24	2	0.294	0
F shrinka	0	0.5				0	0

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
44456	0.24	0.15	6	0.637	0

Age 3 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	62465	0.405	0.335	0.83	3	0.234	0
CAN 2J3K	50158	0.289	0.287	1	3	0.461	0
CAN 3LNC	49476	0.355	0.243	0.68	3	0.305	0
F shrinka	0	0.5				0	0

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
52583	0.2	0.15	9	0.752	0

1

Table 5b (cont). XSA diagnostic results.

Age 4 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	49973	0.341	0.218	0.64	4	0.218	0.01
CAN 2J3K	44021	0.25	0.057	0.23	4	0.405	0.011
CAN 3LNC	43635	0.303	0.235	0.77	4	0.275	0.011
F shrinka	33969	0.5				0.102	0.014

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
43964	0.16	0.09	13	0.55	0.011

Age 5 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	39026	0.282	0.354	1.25	5	0.246	0.038
CAN 2J3K	33381	0.224	0.093	0.42	5	0.39	0.044
CAN 3LNC	31279	0.264	0.11	0.42	5	0.281	0.047
F shrinka	19587	0.5				0.083	0.074

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
32586	0.14	0.11	16	0.787	0.045

1

Age 6 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	22237	0.246	0.13	0.53	6	0.271	0.218
CAN 2J3K	20496	0.206	0.127	0.62	6	0.38	0.235
CAN 3LNC	18948	0.249	0.184	0.74	6	0.258	0.252
F shrinka	14984	0.5				0.092	0.309

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
19952	0.13	0.08	19	0.603	0.241

Age 7 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	2882	0.226	0.236	1.04	7	0.258	1.444
CAN 2J3K	3488	0.202	0.227	1.12	7	0.285	1.302
CAN 3LNC	2703	0.245	0.212	0.86	7	0.193	1.493
F shrinka	5530	0.5				0.264	0.989

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
3570	0.16	0.13	22	0.77	1.285

Table 5b (cont). XSA diagnostic results.

Age 8 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	987	0.246	0.123	0.5	8	0.239	1.539
CAN 2J3K	1866	0.225	0.224	0.99	8	0.249	1.078
CAN 3LNO	927	0.262	0.222	0.85	8	0.146	1.589
F shrinka	2705	0.5				0.365	0.849

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
1656	0.2	0.14	25	0.671	1.158

Age 9 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	657	0.291	0.096	0.33	9	0.242	1.079
CAN 2J3K	1380	0.274	0.171	0.62	9	0.319	0.655
CAN 3LNO	889	0.258	0.186	0.72	8	0.101	0.89
F shrinka	1968	0.5				0.338	0.5

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
1244	0.2	0.12	27	0.572	0.706

Age 10 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	1020	0.309	0.145	0.47	10	0.321	0.332
CAN 2J3K	1042	0.284	0.088	0.31	10	0.368	0.326
CAN 3LNO	1020	0.254	0.229	0.9	8	0.057	0.332
F shrinka	776	0.5				0.254	0.417

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
959	0.19	0.07	29	0.351	0.35

Table 5b (cont). XSA diagnostic results.

Age 11 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	750	0.31	0.169	0.54	11	0.277	0.258
CAN 2J3K	708	0.273	0.186	0.68	10	0.434	0.271
CAN 3LNC	949	0.286	0.271	0.95	7	0.033	0.209
F shrinka	345	0.5				0.256	0.494

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
604	0.19	0.12	29	0.595	0.311

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

Year class = 1993

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU Survey	349	0.334	0.203	0.61	11	0.227	0.259
CAN 2J3K	210	0.275	0.165	0.6	10	0.439	0.4
CAN 3LNC	443	0.313	0.127	0.41	6	0.019	0.209
F shrinka	169	0.5				0.315	0.475

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
223	0.21	0.11	28	0.494	0.38

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

Year class = 1992

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU Survey	171	0.294	0.236	0.8	10	0.186	0.292
CAN 2J3K	150	0.267	0.172	0.64	10	0.459	0.327
CAN 3LNC	279	0.34	0.132	0.39	5	0.022	0.189
F shrinka	139	0.5				0.332	0.349

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
152	0.21	0.1	26	0.452	0.324

Table 6. XSA estimated numbers at age (000s). Note that the age1 2006 value is the age 1 geometric mean over 2002-2005.

N@A (XSA)	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1975	112356	126305	110174	66823	53829	31897	23092	14337	9312	3931	1773	415	720	735
1976	116750	91989	103410	90203	54710	43769	23564	13703	7254	4040	1691	816	218	113
1977	107605	95587	75314	84665	73852	44777	35283	16369	6322	2529	1313	635	433	311
1978	82496	88099	78260	61662	69318	59982	32126	19117	6755	2522	1154	876	402	459
1979	99185	67542	72130	64074	50485	54054	41495	18186	8797	2938	763	291	385	757
1980	130431	81206	55299	59055	52459	39174	36359	22369	9337	6144	1970	365	103	52
1981	132219	106788	66486	45275	48350	42761	30186	21489	9556	2760	1567	697	183	292
1982	131703	108252	87431	54434	37068	38805	30922	15841	7233	3927	1455	1051	442	512
1983	147539	107829	88629	71582	44567	30105	29690	19600	7755	2717	1691	652	629	1033
1984	154546	120795	88283	72564	58607	35854	21430	15441	9248	4273	1598	1196	465	797
1985	168147	126531	98899	72280	59410	47167	27252	12257	5691	3873	2359	940	850	837
1986	188202	137667	103595	80971	59178	46847	33813	16962	6868	3411	2708	1788	680	1133
1987	157153	154086	112712	84816	66294	48197	36328	21883	9281	4294	2366	1996	1337	2063
1988	129369	128666	126155	92281	69442	54153	37740	19786	9832	5033	2744	1590	1380	1659
1989	113400	105919	105343	103287	75553	56586	41454	23537	12236	6884	3700	2065	1207	589
1990	108073	92844	86719	86248	84564	61694	44530	27171	15404	8677	4942	2633	1449	1053
1991	94696	88483	76014	70999	70528	68238	44396	25028	15408	8927	4668	2957	1355	1013
1992	71253	77530	72444	62235	57930	55154	48851	24448	10723	6150	3942	2135	1321	1111
1993	84647	58337	63477	59312	49991	43647	35273	21321	8973	4859	3441	2312	1080	485
1994	143380	69303	47762	51970	47647	32270	21323	12849	6672	3146	2317	1863	1020	680
1995	174801	117390	56741	39105	37668	24080	12111	7376	4422	2675	1578	1163	1143	910
1996	152464	143115	96110	46455	31724	29617	17596	7019	4112	2550	1701	980	705	436
1997	123049	124827	117173	78689	37863	24472	19546	8627	4015	2501	1632	998	591	381
1998	101998	100744	102200	95933	64122	29277	16264	9176	4154	2256	1500	956	595	328
1999	89070	83509	82482	83674	78044	49264	19078	8079	4208	2103	1358	887	637	659
2000	96830	72924	68371	67530	68238	61952	35244	7828	3183	1944	1158	801	449	359
2001	94446	79278	59705	55977	55044	54032	39337	9695	3424	1725	1114	615	472	225
2002	98920	77326	64907	48883	45425	43040	33232	12189	3274	1889	965	515	320	203
2003	95813	80989	63309	53142	39588	35687	28688	11300	4002	1555	951	464	219	242
2004	66321	78445	66308	51833	42351	28349	19516	8319	3475	1816	806	516	250	213
2005	34869	54299	64225	54288	41626	30999	15758	6439	3078	1662	1008	399	256	183
2006	60512	28548	44456	52583	43964	32586	19952	3570	1656	1244	959	604	223	260

Table 7. XSA estimated fishing mortality at age.

F @ AGE(XSA)	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1975	0.000	0.000	0.000	0.000	0.007	0.103	0.322	0.481	0.635	0.643	0.576	0.446	0.560	0.560
1976	0.000	0.000	0.000	0.000	0.000	0.016	0.164	0.574	0.854	0.924	0.780	0.434	0.720	0.720
1977	0.000	0.000	0.000	0.000	0.008	0.132	0.413	0.685	0.719	0.585	0.205	0.257	0.351	0.351
1978	0.000	0.000	0.000	0.000	0.049	0.169	0.369	0.576	0.633	0.995	1.179	0.622	0.942	0.942
1979	0.000	0.000	0.000	0.000	0.054	0.197	0.418	0.467	0.159	0.200	0.537	0.837	0.529	0.529
1980	0.000	0.000	0.000	0.000	0.004	0.061	0.326	0.651	1.019	1.166	0.840	0.490	0.841	0.841
1981	0.000	0.000	0.000	0.000	0.020	0.124	0.445	0.889	0.689	0.441	0.199	0.255	0.300	0.300
1982	0.000	0.000	0.000	0.000	0.008	0.068	0.256	0.514	0.779	0.642	0.603	0.314	0.524	0.524
1983	0.000	0.000	0.000	0.000	0.018	0.140	0.454	0.551	0.396	0.331	0.147	0.138	0.206	0.206
1984	0.000	0.000	0.000	0.000	0.017	0.074	0.359	0.798	0.670	0.394	0.331	0.142	0.290	0.290
1985	0.000	0.000	0.000	0.000	0.038	0.133	0.274	0.379	0.312	0.158	0.077	0.124	0.120	0.120
1986	0.000	0.000	0.000	0.000	0.005	0.054	0.235	0.403	0.270	0.166	0.105	0.091	0.121	0.121
1987	0.000	0.000	0.000	0.000	0.002	0.045	0.408	0.600	0.412	0.248	0.198	0.169	0.206	0.206
1988	0.000	0.000	0.000	0.000	0.005	0.067	0.272	0.281	0.156	0.108	0.084	0.076	0.090	0.090
1989	0.000	0.000	0.000	0.000	0.003	0.040	0.222	0.224	0.144	0.131	0.140	0.154	0.143	0.143
1990	0.000	0.000	0.000	0.001	0.015	0.129	0.376	0.367	0.346	0.420	0.314	0.464	0.402	0.402
1991	0.000	0.000	0.000	0.003	0.046	0.134	0.397	0.648	0.718	0.617	0.583	0.606	0.607	0.607
1992	0.000	0.000	0.000	0.019	0.083	0.247	0.629	0.802	0.592	0.381	0.334	0.481	0.401	0.401
1993	0.000	0.000	0.000	0.019	0.238	0.516	0.810	0.962	0.848	0.541	0.414	0.618	0.528	0.528
1994	0.000	0.000	0.000	0.122	0.482	0.780	0.862	0.867	0.714	0.490	0.489	0.288	0.426	0.426
1995	0.000	0.000	0.000	0.009	0.041	0.114	0.346	0.384	0.351	0.253	0.277	0.300	0.278	0.278
1996	0.000	0.000	0.000	0.005	0.060	0.216	0.513	0.359	0.297	0.246	0.333	0.305	0.254	0.254
1997	0.000	0.000	0.000	0.005	0.057	0.209	0.556	0.531	0.376	0.312	0.335	0.318	0.296	0.296
1998	0.000	0.000	0.000	0.006	0.064	0.228	0.500	0.580	0.481	0.308	0.326	0.206	0.187	0.187
1999	0.000	0.000	0.000	0.004	0.031	0.135	0.691	0.732	0.572	0.397	0.327	0.480	0.290	0.290
2000	0.000	0.000	0.000	0.004	0.033	0.254	1.091	0.627	0.412	0.357	0.433	0.329	0.382	0.382
2001	0.000	0.000	0.000	0.009	0.046	0.286	0.972	0.886	0.395	0.381	0.572	0.454	0.454	0.454
2002	0.000	0.000	0.000	0.011	0.041	0.206	0.879	0.914	0.545	0.487	0.532	0.656	0.572	0.572
2003	0.000	0.000	0.000	0.027	0.134	0.404	1.038	0.979	0.590	0.457	0.411	0.420	0.485	0.485
2004	0.000	0.000	0.000	0.019	0.112	0.387	0.909	0.794	0.537	0.389	0.504	0.501	0.486	0.486
2005	0.000	0.000	0.000	0.011	0.045	0.241	1.285	1.158	0.706	0.350	0.311	0.380	0.324	0.324

Table 8. Stock summary table from XSA analysis (no SOP correction; shrinkage parameters fixed at 0.5).

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

	RECRUITS Age 1	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	FBAR 5-10
1975	112356	132753	21901	28814	1.3156	0.3652
1976	116750	134526	17671	24611	1.3927	0.422
1977	107605	156988	14818	32048	2.1627	0.4236
1978	82496	167809	15907	39070	2.4562	0.465
1979	99185	162618	15625	34104	2.1827	0.2489
1980	130431	131010	12408	32867	2.6488	0.5378
1981	132219	115398	14041	30754	2.1904	0.4346
1982	131703	121484	19903	26278	1.3203	0.3779
1983	147539	122993	24208	27861	1.1509	0.3148
1984	154546	115531	24346	26711	1.0972	0.3854
1985	168147	148643	29109	20347	0.699	0.2156
1986	188202	138699	33695	17976	0.5335	0.1888
1987	157153	165541	42511	32442	0.7631	0.2857
1988	129369	170296	44555	19215	0.4313	0.1481
1989	113400	183650	44147	20034	0.4538	0.1273
1990	108073	207861	56309	47454	0.8427	0.2754
1991	94696	227003	64062	65008	1.0148	0.4267
1992	71253	195158	50045	63193	1.2627	0.4556
1993	84647	151101	39054	62455	1.5992	0.6524
1994	143380	105986	30375	51029	1.68	0.6991
1995	174801	80564	27674	15272	0.5519	0.2478
1996	152464	80118	21702	18840	0.8681	0.2817
1997	123049	76940	20249	19858	0.9807	0.3401
1998	101998	90157	18843	19946	1.0585	0.36
1999	89070	105604	18497	24226	1.3098	0.4262
2000	96830	113491	14704	34177	2.3244	0.4624
2001	94446	114660	13049	38232	2.93	0.4942
2002	98920	100450	11461	34062	2.9719	0.5118
2003	95813	89047	9782	35151	3.5933	0.6003
2004	66321	72703	10234	25486	2.4904	0.5214
2005	34869	70351	9772	23225	2.3768	0.6306
Arith. Mean	116185	130617	25505	31960	1.5695	0.3976
0 Units	(Thousar	(Tonnes	(Tonnes)	(Tonnes)		

Table . Retrospective comparison of numbers at age estimated from XSA. Year/age entries in the table is are ratios of the estimated N(year, age) in the 2006 updated run and the 2005 assessment. Shaded entries highlight changes in excess of +/- 10%.

2006/2005 N@A Ratio Matrix	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1975	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1976	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1977	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1978	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1979	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1980	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1981	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1982	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1983	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1984	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1985	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1986	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1987	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1988	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1989	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1990	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1991	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.99	0.99	0.99	0.99	0.99	0.99
1992	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.99	0.99	0.99	0.99	0.99	0.99
1993	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.99	0.99	0.99	0.98	0.99	0.98	0.98
1994	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.99	0.98	0.98	0.98	0.97	0.98	0.98
1995	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.99	0.98	0.96	0.96	0.96	0.96	0.96
1996	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.99	0.99	0.97	0.95	0.95	0.95	0.95
1997	1.06	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.99	0.98	0.96	0.94	0.94	0.94
1998	1.16	1.06	1.00	1.00	1.00	1.00	1.00	1.00	0.99	0.99	0.98	0.94	0.92	0.92
1999	1.25	1.16	1.06	1.00	1.00	1.00	1.00	1.00	1.00	0.99	0.98	0.97	0.93	0.93
2000	1.04	1.25	1.16	1.06	1.00	1.00	1.00	1.00	1.00	0.99	0.98	0.98	0.95	0.95
2001	1.00	1.04	1.25	1.16	1.06	1.00	1.00	1.00	1.00	0.99	0.99	0.98	0.97	0.97
2002	0.97	1.00	1.04	1.25	1.17	1.06	1.01	1.01	0.99	1.00	0.99	0.98	0.96	0.97
2003	0.91	0.97	1.00	1.04	1.26	1.17	1.07	1.01	1.03	0.98	1.00	0.98	0.96	0.96
2004	0.79	0.91	0.97	1.00	1.04	1.31	1.29	1.24	1.04	1.06	0.98	1.01	0.97	0.97
2005		0.79	0.91	0.97	1.00	1.04	1.53	2.22	1.75	1.07	1.09	0.96	1.01	0.75

Table 10. Retrospective comparison of fishing mortality at age estimated from XSA. Year/age entries in the table is are ratios of the estimated F(year, age) in the 2006 updated run and the 2005 assessment. Shaded entries highlight changes in excess of +/- 10%. The average fishing mortality for this assessment is the age 5-10 average.

2006/2005 F@A Ratio Matrix	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1975					1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1976					1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1977					1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1978					1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1979					1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1980					1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1981					1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1982					1.01	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1983					1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1984					1.01	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1985					1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1986					1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1987					1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1988					1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1989					1.04	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1990				1.00	1.00	1.00	1.00	1.01	1.00	1.00	1.00	1.00	1.00	1.00
1991				1.00	1.00	1.00	1.00	1.01	1.01	1.01	1.01	1.01	1.01	1.01
1992				1.01	1.00	1.00	1.01	1.01	1.01	1.02	1.01	1.01	1.01	1.01
1993				1.00	1.00	1.00	1.01	1.01	1.02	1.02	1.02	1.02	1.02	1.02
1994				1.00	1.00	1.00	1.01	1.02	1.03	1.03	1.03	1.03	1.03	1.03
1995				1.00	1.00	1.00	1.00	1.01	1.03	1.04	1.04	1.05	1.04	1.04
1996				1.00	1.00	1.00	1.00	1.01	1.01	1.04	1.06	1.06	1.06	1.06
1997				1.00	1.00	1.00	1.00	1.00	1.01	1.02	1.05	1.08	1.08	1.08
1998				1.00	1.00	1.00	1.00	1.00	1.01	1.01	1.03	1.06	1.10	1.10
1999				1.00	1.00	1.00	1.00	1.00	1.01	1.01	1.02	1.04	1.08	1.08
2000				0.96	0.99	1.00	1.00	1.00	1.01	1.01	1.02	1.03	1.06	1.06
2001				0.86	0.94	0.99	0.99	1.01	1.00	1.01	1.02	1.03	1.04	1.04
2002				0.79	0.86	0.94	0.99	0.98	1.01	1.00	1.01	1.03	1.05	1.05
2003				0.96	0.78	0.82	0.88	0.98	0.96	1.02	0.99	1.02	1.05	1.05
2004				1.00	0.96	0.71	0.62	0.70	0.95	0.93	1.03	0.99	1.04	1.04

Table 11. Input data used in deterministic and stochastic projections.

Name	Value	Uncertainty (CV)	Name	Value	Uncertainty (CV)
Population at age in 2006			Selection pattern		(2003-2005)
N1	Bootstrap (1975-2002)		sH1	0.000	0.00
N2	28548	0.32	sH2	0.000	0.00
N3	44456	0.24	sH3	0.000	0.00
N4	52583	0.20	sH4	0.033	0.43
N5	43964	0.16	sH5	0.170	0.50
N6	32586	0.14	sH6	0.599	0.32
N7	19952	0.13	sH7	1.836	0.09
N8	3570	0.16	sH8	1.664	0.10
N9	1656	0.20	sH9	1.044	0.07
N10	1244	0.20	sH10	0.687	0.17
N11	959	0.19	sH11	0.715	0.33
N12	604	0.19	sH12	0.754	0.25
N13	223	0.20	sH13	0.751	0.29
N14	260	0.21	sH14	0.751	0.29
Weight in the catch		(2003-2005)	Weight in the stock		(2003-2005)
WH1	0.000	0.00	WS1	0.000	0.00
WH2	0.000	0.00	WS2	0.000	0.00
WH3	0.207	0.10	WS3	0.000	0.00
WH4	0.266	0.01	WS4	0.000	0.00
WH5	0.387	0.03	WS5	0.387	0.03
WH6	0.554	0.03	WS6	0.554	0.03
WH7	0.826	0.02	WS7	0.826	0.02
WH8	1.214	0.00	WS8	1.214	0.00
WH9	1.657	0.04	WS9	1.657	0.04
WH10	2.163	0.03	WS10	2.163	0.03
WH11	2.712	0.04	WS11	2.712	0.04
WH12	3.469	0.03	WS12	3.469	0.03
WH13	4.341	0.00	WS13	4.341	0.00
WH14	5.444	0.03	WS14	5.444	0.03

TAC	Scenario 1	Scenario 2	CV
2006	18500	22000	0.05
2007	16000	19200	0.05
2008	16000	16000	0.05

Table 12. Results of Deterministic projections under various catch levels and fishing mortality options.

	Rebuilding Plan			Re-building TACs*1.2		
Year	5+ Biomass	Yield	F	5+ Biomass	Yield	F
2006	68413	18500	0.434	68413	22200	0.557
2007	72281	16000	0.313	67540	19200	0.448
2008	74839	16000	0.267	65365	19200	0.417
2009	71867			57210		

	Fcurrent			F_0.1*			F_Max*		
Year	5+ Biomass	Yield	F	5+ Biomass	Yield	F	5+ Biomass	Yield	F
2006	68413	24184	0.631	68413	22200	0.557	68413	22200	0.557
2007	65000	23141	0.631	67540	7621	0.148	67540	12429	0.259
2008	57417	21696	0.631	80233	10592	0.148	74056	15520	0.259
2009	45021			84931			71716		

*Note that the assumed removals in 2006 for the $F_{0.1}$ and F_{Max} scenarios add a 20% over-run on the rebuilding plan TAC.

Table 13. Results of stochastic projections assuming the catches follow the rebuilding plan TACs (upper table) and with catches 20% in excess of the rebuilding plan TACs (lower table).

Stochastic (median values)	2006	2007	2008	2009
Catch (t)	18500	16000	16000	
F (5-10)	0.43	0.31	0.26	
5+B (t)	68391	72724	75485	72688
10+B (t)	9713	9080	9069	12189

Catch (t)	22211	19202	19202	
F (5-10)	0.55	0.45	0.41	
5+B (t)	68348	67823	65827	57965
10+B (t)	9722	8262	7274	7972

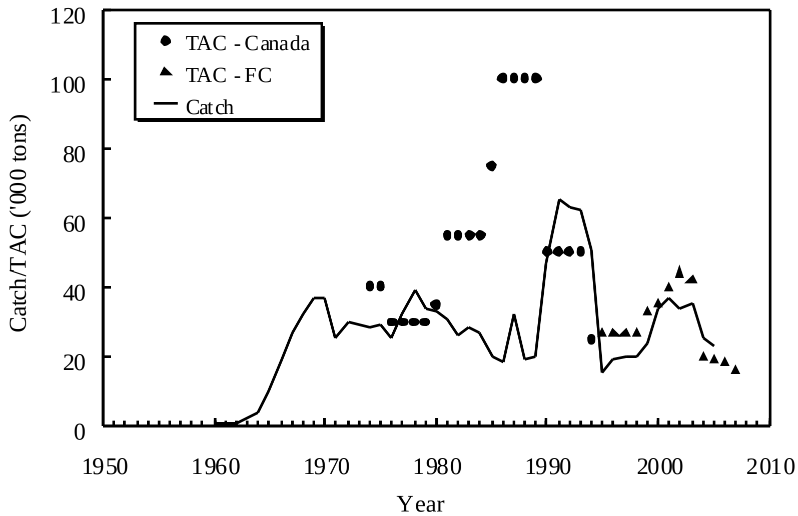

Fig. 1. Catch and TAC for Greenland Halibut in SA2 and Div. 3KLMNO. TACs are specified to 2007 under the Fisheries Commission Rebuilding plan.

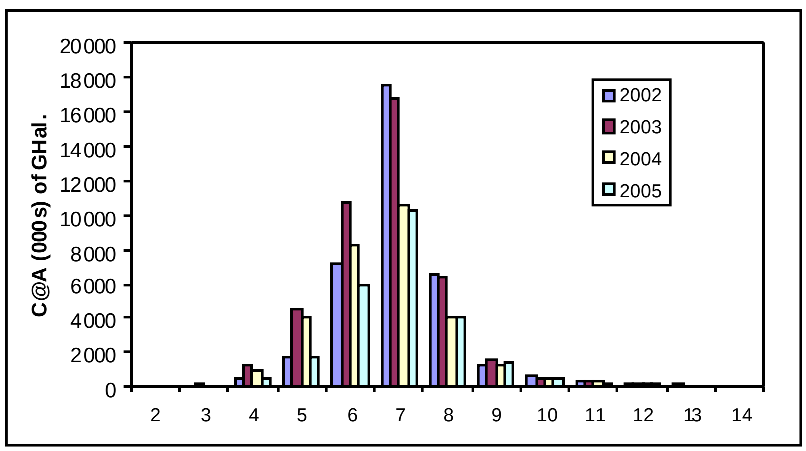

Fig. 2. Catch at age of Greenland Halibut in SA2+Div. 3KLMNO from 2002-2005. Landings (as agreed by STACFIS for assessment purposes) in these years have totaled 34 100, 35 150, 25 500, and 23 300 t, respectively.

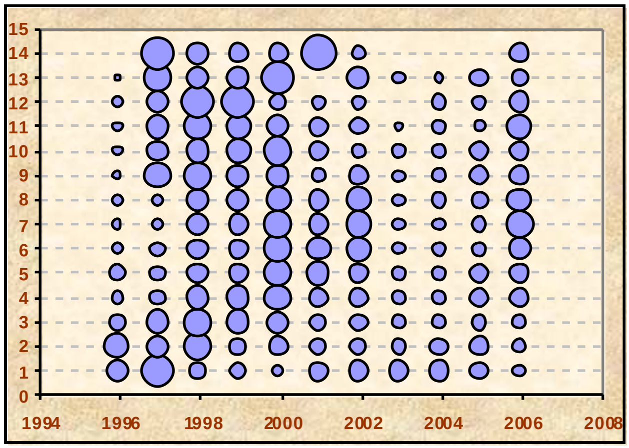

Fig. 3a. MNPT of Greenland Halibut in Canadian fall surveys in Div. 2J3K combined. Note that the x-axis reflects the timing of the survey (e.g. fall 2005 survey plotted at 2005.9). Bubbles are scaled within each age.

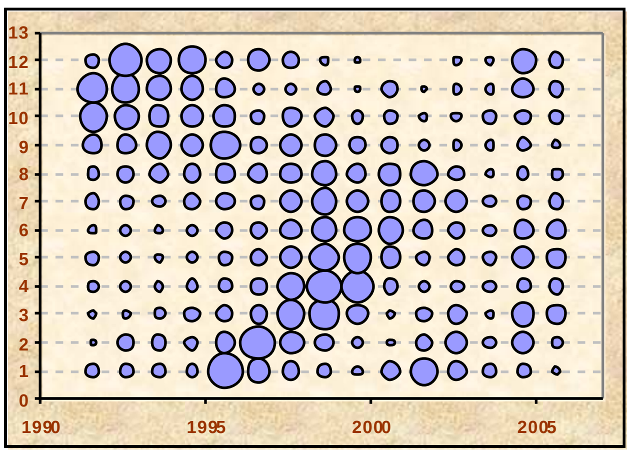

Fig. 3b. MNPT of Greenland Halibut in EU summer surveys in Div. 3M. Note that the x-axis reflects the timing of the survey (e.g. summer 2005 survey plotted at 2005.6). Bubbles are scaled within each age.

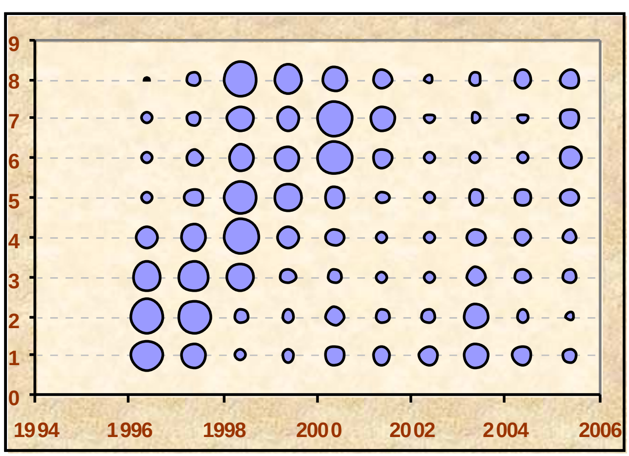

Fig. 3c. MNPT of Greenland Halibut in Canadian spring surveys in Div. 3LNO. Note that the x-axis reflects the timing of the survey (e.g. spring 2005 survey plotted at 2005.4). Bubbles are scaled within each age.

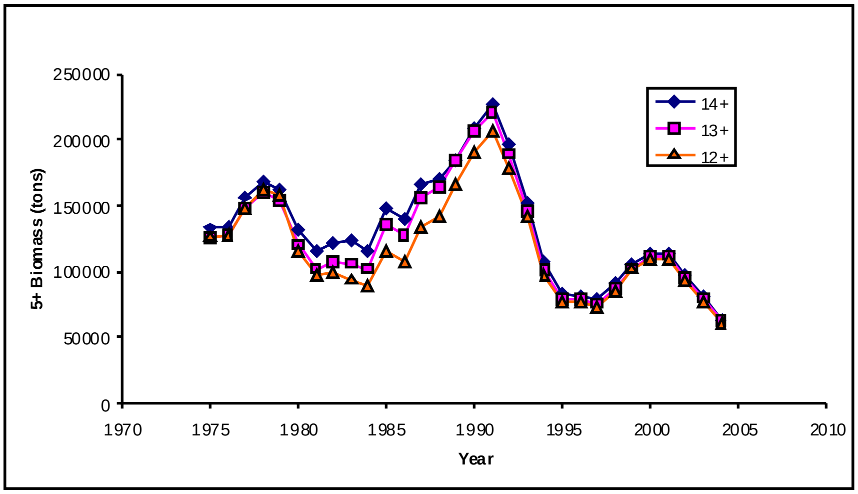

Fig. 4. XSA estimates of exploitable biomass (ages 5+) for various plus-group options.

Fig. 5. XSA estimate of exploitable biomass (ages 5+) for Greenland Halibut in SA2 and Div. 3KLMNO. Average weights at age from 2003-2005 are used to compute the 2006 biomass.

Fig. 6. XSA estimate of average fishing mortality (ages 5-10) for Greenland Halibut in SA2 and Div. 3KLMNO.

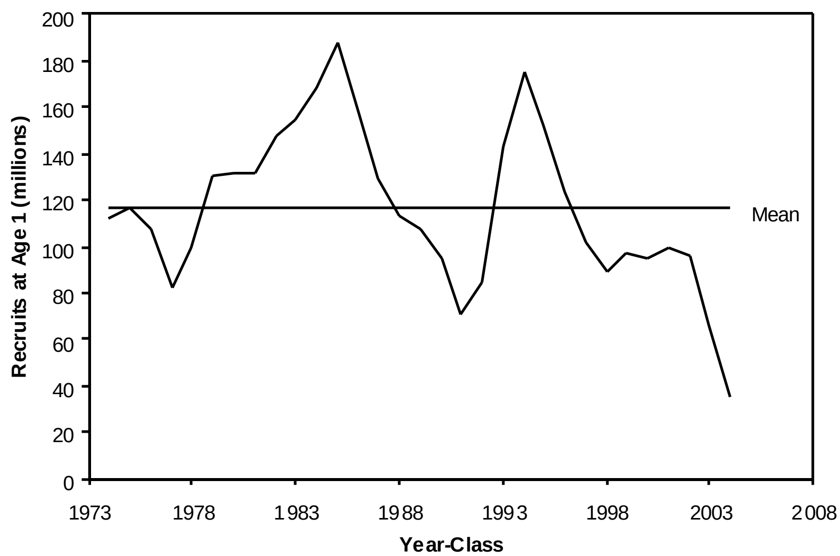

Fig. 7. XSA estimate of recruitment (age 1) for Greenland Halibut in SA2 and Div. 3KLMNO.

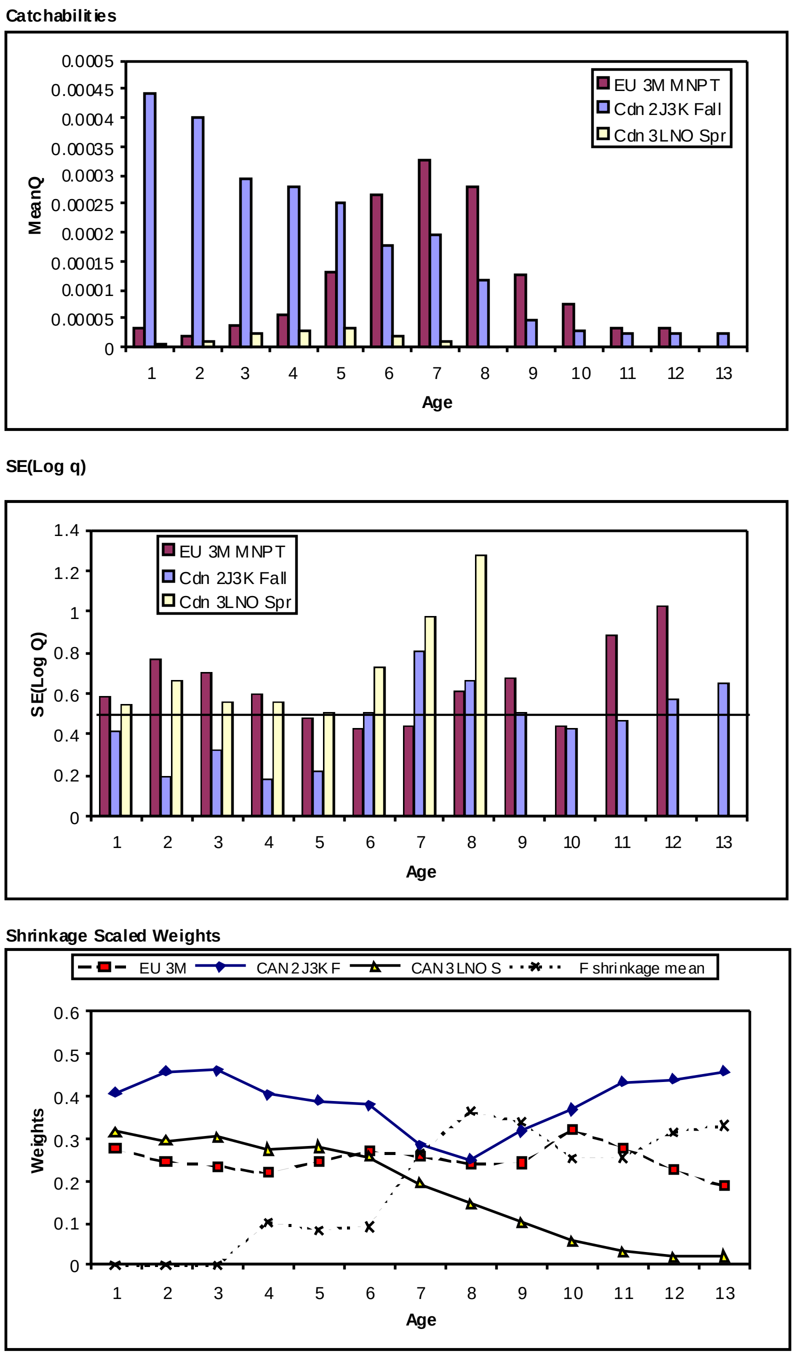

Fig. 8. XSA estimates of catchability coefficients, associated standard errors, and the scaled weights used to estimate survivors in the terminal year.

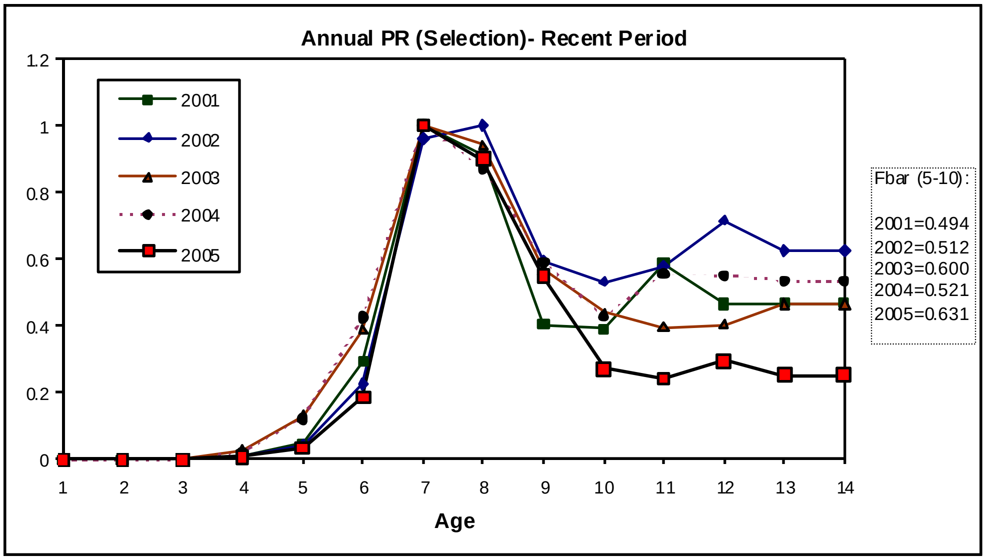

Fig. 9. XSA estimated selection pattern in the most recent five years.

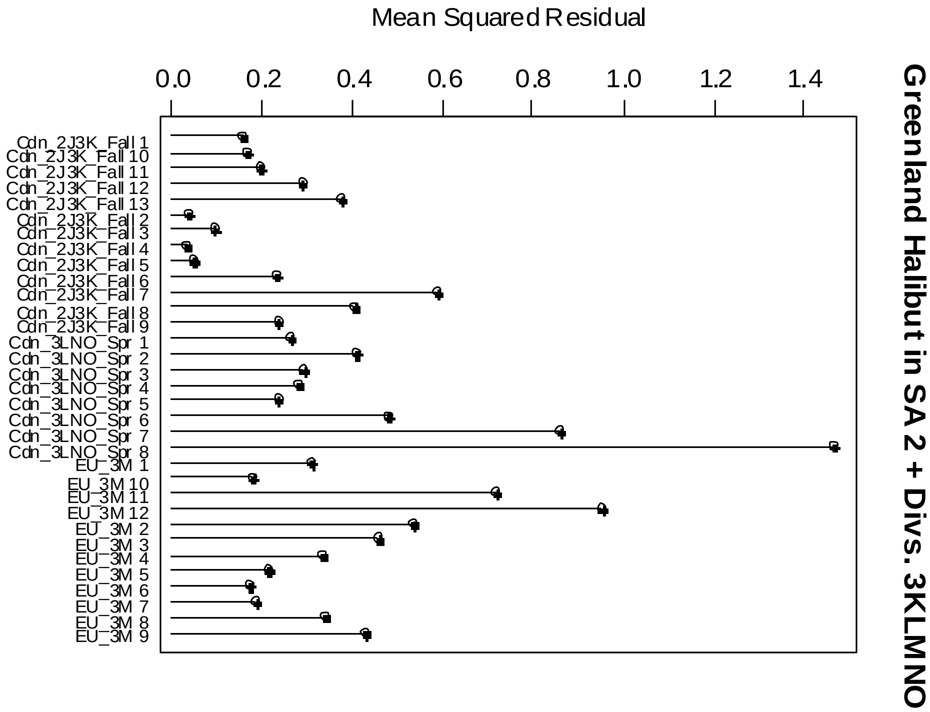

Fig. 10a. Mean-square residuals from XSA, for each survey-age.

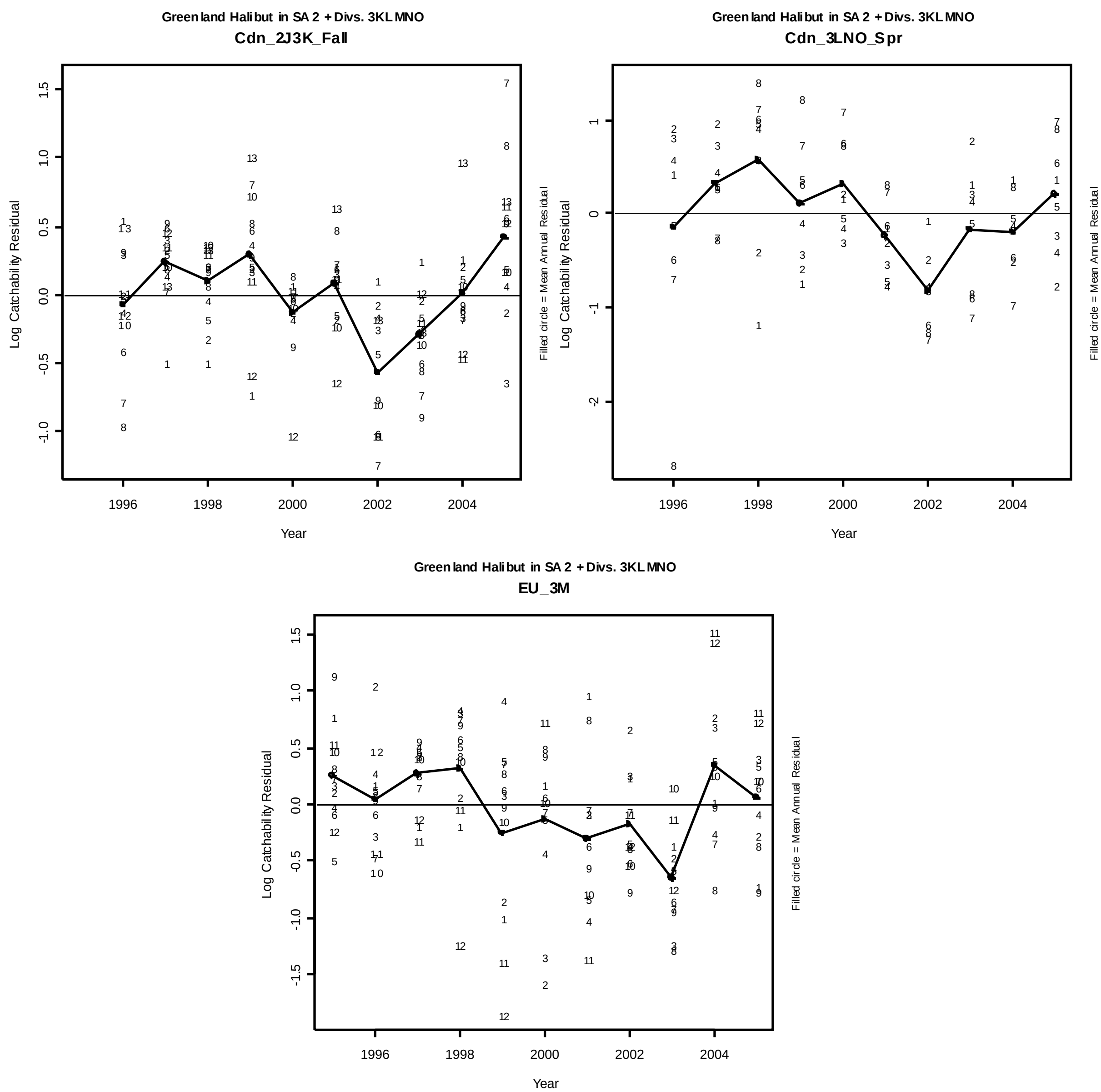

Fig. 10b. XSA residuals by survey, age and year. Symbol=age, solid circle=mean annual residual.

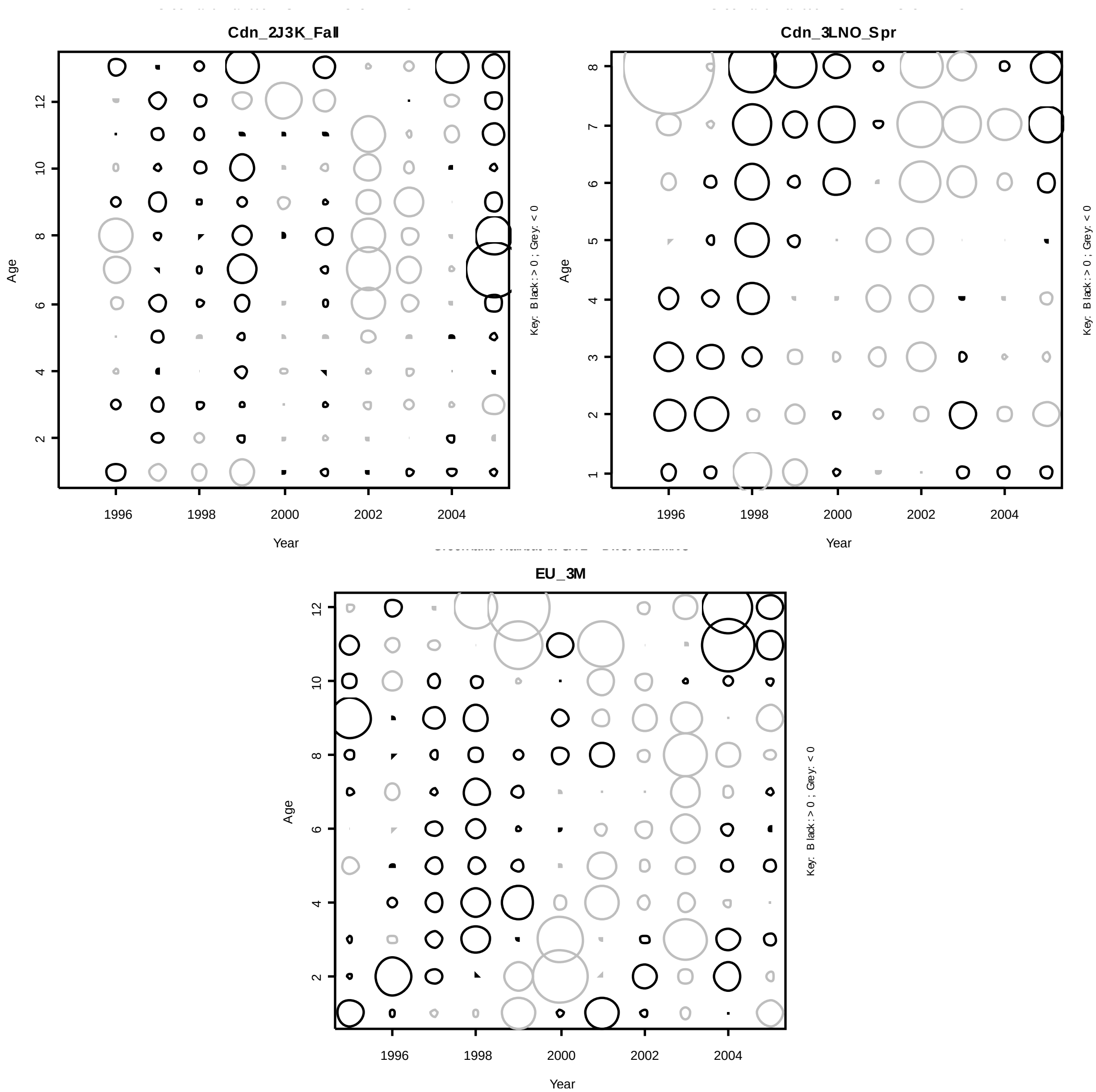

Fig. 10c. XSA Residuals. Black=positive residual; grey=negative residual. Symbols are scaled to the overall maximum residual to permit comparisons across surveys.

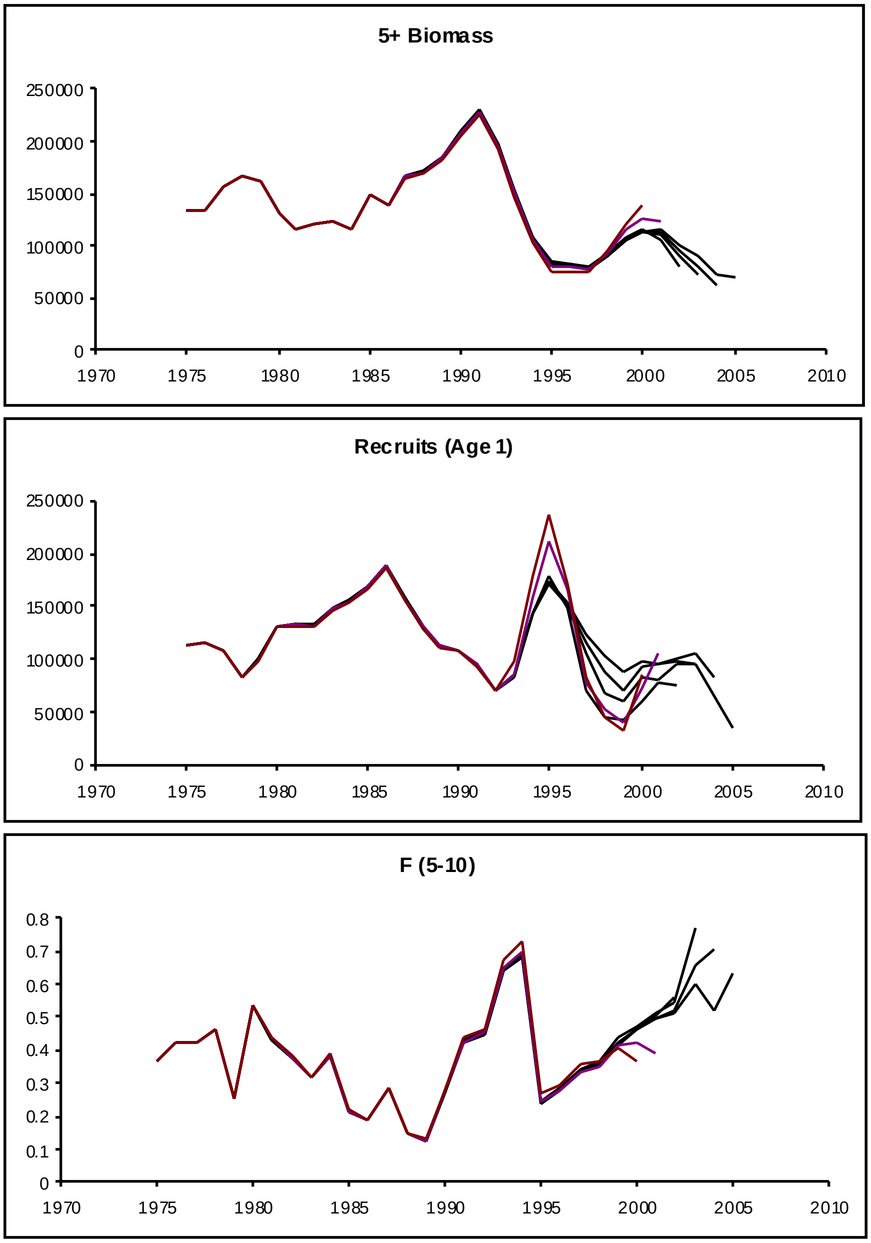

Fig. 11. Retrospective Analysis – 5+ biomass (t), Age 1 recruitment (000s) and average *F* from ages 5-10.

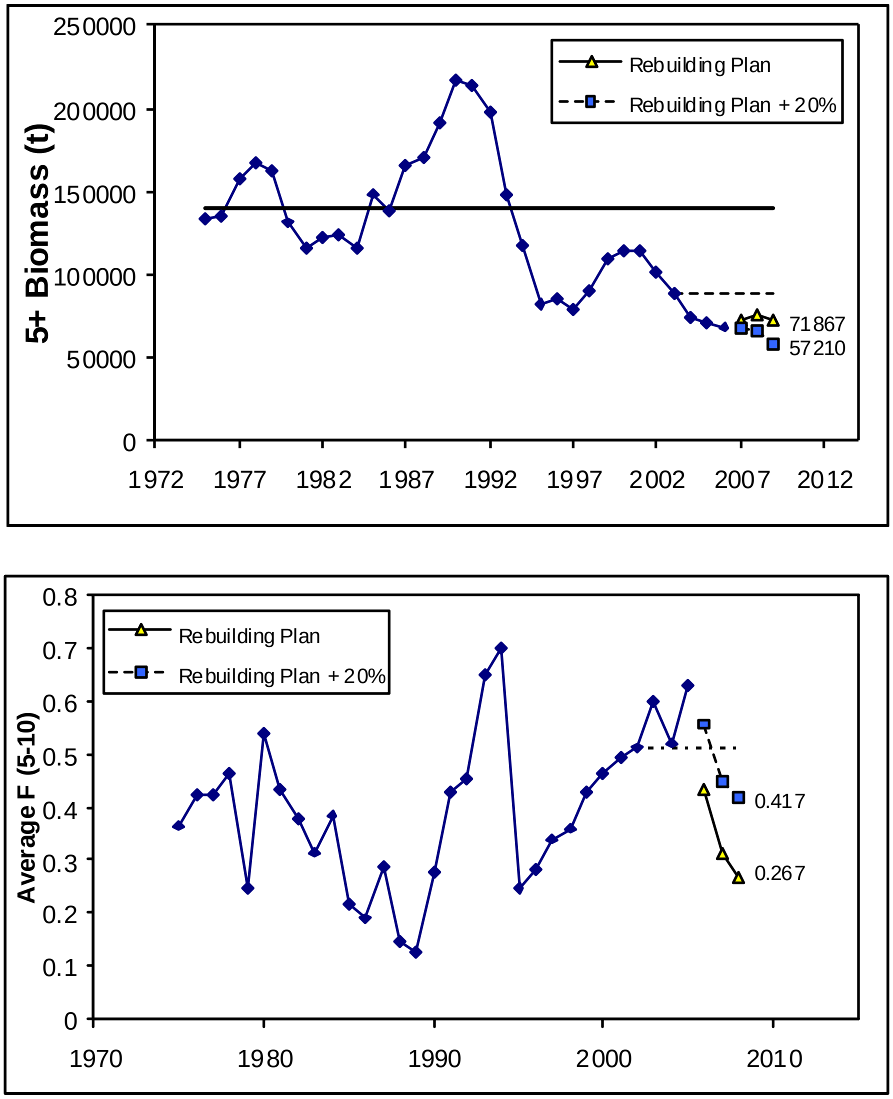

Fig. 12. Deterministic Projection of 5+ biomass (upper panel) and average fishing mortality (lower panel). Labels indicate the 2009 exploitable biomass and 2008 average fishing mortality.

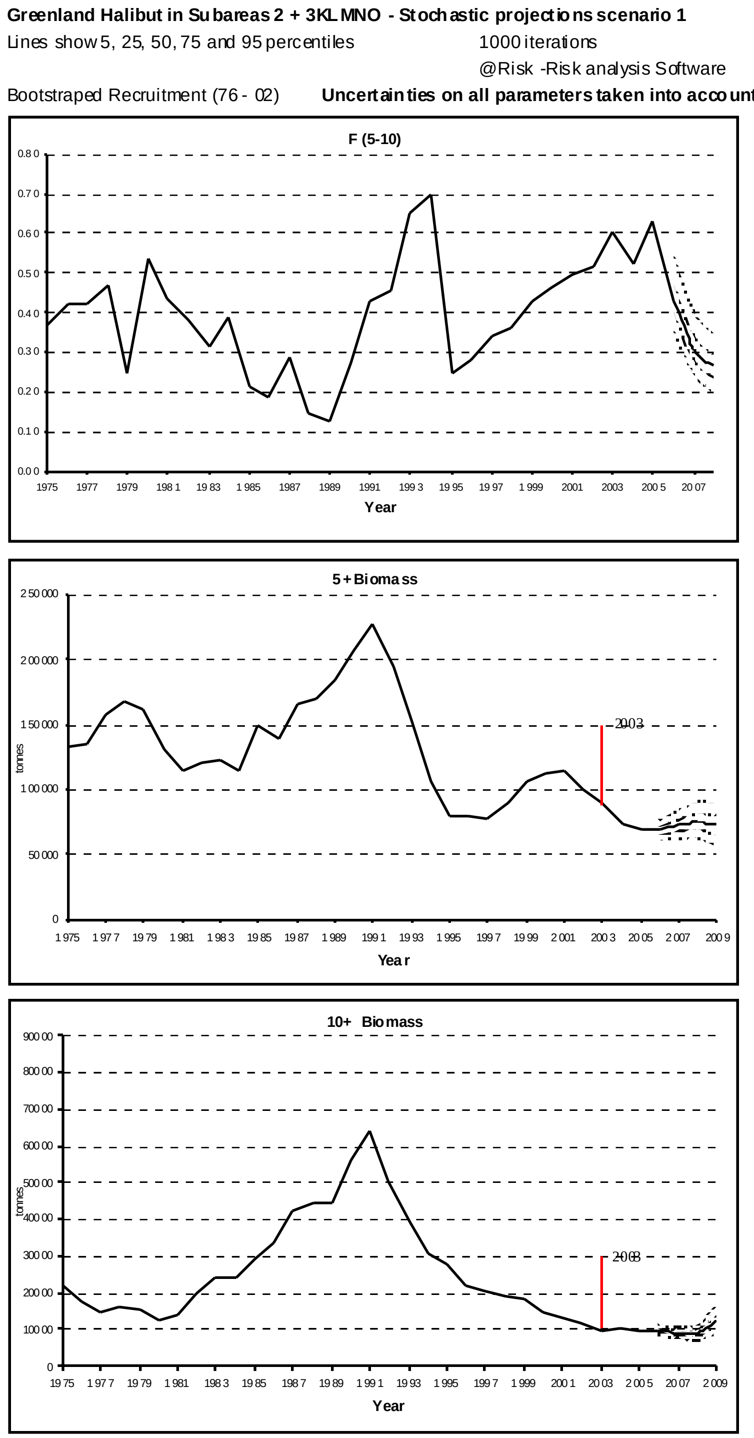

Fig. 13. Stochastic Projection estimates of average fishing mortality, 5+ biomass, and 10+ biomass over 2005-2007 under Fisheries Commission rebuilding plan. The biomass levels of 2003 (year in which rebuilding plan developed) are highlighted. The 5th, 25th, 50th (thick line), 75th, and 95th percentiles are shown.

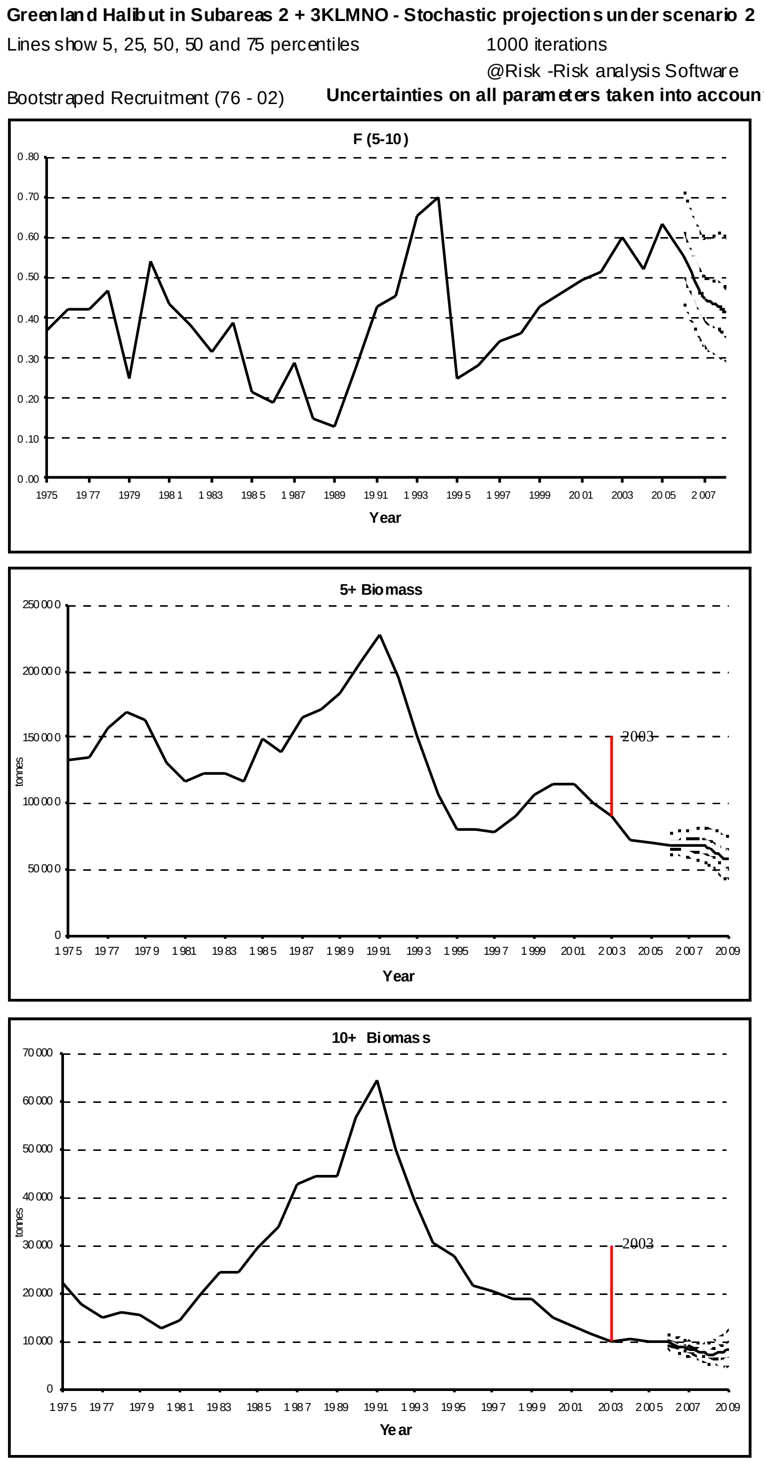

Fig. 14. Stochastic Projection estimates of average fishing mortality, 5+ biomass, and 10+ biomass over 2005-2007 under catches 20% in excess of Fisheries Commission rebuilding plan. The biomass levels of 2003 (year in which rebuilding plan developed) are highlighted. The 5th, 25th, 50th (thick line), 75th, and 95th percentiles are shown.