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SC WG ON GREENLAND HALIBUT ASSESSMENT METHODS – JUNE 2009

Greenland Halibut in NAFO Sub-area 2 & Divisions 3KLMNO
Investigations on different Sequential Population Analysis formulations

by

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Abstract

Estimates of stock size using different ADAPT and XSA formulations are compared to the XSA estimates from the 2008 assessment (Healey & Mahé, 2008). Adapt analysis are conducted with NOAA Fisheries Toolbox VPA v2.8 (http://nft.nefsc.noaa.gov) and with B-Adapt (Anon. 2004, 2007). Results showed that XSA runs with no shrinkage and NFT Adapt with inverse variance weighting gave similar results while XSA formulation with shrinkage to the average F of the last 5 years gave lower estimates of stock size. NFT Adapt with equal weighting gave higher estimates of stock size. Within these formulations the better fit was observed for the NFT Adapt with no inverse variance weighting and XSA with no shrinkage (it is however difficult to compare the diagnostics between those two models as they are not based on there same fitting procedure). None of these formulations could reduce the trends in the residuals observed in the Canadian surveys indices for the last ten years.

The results of the B-Adapt formulation estimating bias in the landings for the last ten years improved significantly the fit as trends in the residuals were much reduced. However the rectified figures of catches fell outside of any reasonable estimates. This obviously points out that the trends observed in the residuals are due to changes of the surveys catchability over time. Since the surveys had stable sampling protocols over the period, these changes are most probably related to availability of the fish to the sampling gear.

Material and Methods

Models

Models used include XSA (Darby and Flatman, 1994), NOAA Fisheries Toolbox VPA v2.8 (http://nft.nefsc.noaa.gov) and B-Adapt (Anon. 2004, 2007).

The NFT and B-Adapt basic model formulations are very similar as constraint have to be specified on the last true age F value and a Marquadt minimisation algorithm is used to minimize an objective function (sum of mean square residuals of index at ages observed and predicted values). The B- Adapt also include a possibility of estimating bias in the total catch at age data for a number of years (following text taken from ICES CM 2005/ACFM:07 Appendix 4) :

A modification to the Gavaris and Van Eeckhaute ADAPT model (Gavaris and Van EeckHaute, 1998) can be made by assuming that the time series of landings can be divided into two periods; a historic time series in which landings were relatively unbiased and a recent period during which landings at age were biased by a common factor across all ages.

Smoothing of catches was introduced by an addition to the objective function sum of squares:

$$SSQcatches = \lambda \Sigma \{\ln (B_y \Sigma_a [C_{a,y} CW_{a,y}]) - \ln (B_{y+1} \Sigma_a [C_{a,y+1} CW_{a,y+1}])\}^2$$

Here $CW_{a,y}$ are the catch weights at age a in year y and natural logarithms were used to provide residuals of equivalent magnitude to those of log catchability within SSQvpa. λ is a user defined weight that allowed the effect of the smoothing constraint to be examined. The year range for the summation of the catch smoothing objective function was from the last year of the unbiased catches to the last year of the assessment.

The total objective function used to estimate the model parameters was therefore

$$SSQ = SSQvpa + SSQcatches$$

The least squares objective function was mimimised using the NAG Gauss–Newton algorithm with uncertainty estimated using two methods, calculation of the variance covariance matrix and bootstrap re-sampling of the log catchability residuals to provide new CPUE indices.

Formulations

All inputs are as for the XSA 2008 assessment (Healey & Mahé, 2008) and are given in Tables. 1-3

A - No error assumed in catch matrix

XSA : XSA assessment 2008
XSA_No_Shr: XSA assessment 2008 but no F shrinkage
NFT1 : NOAA Adapt F13 = average F10-12, inverse variance weighting
NFT2 : NOAA Adapt F13 = average F10-12, no weighting

B - Error assumed in catch matrix

B-Adapt : F13 = average F10-12, no inverse variance weighting, bias in catches estimated for the period 1998 – 2007, λ =0.5

Results and discussion

Comparison of model fit

Statistics given for the XSA and the ADAPT models cannot be directly compared except for the residual patterns. The XSA model using an iterative linear weighted estimates of survivors (Darby and Flatman 1994), no objective function minimizing algorithm being used whereas in the ADAPT formulations (Gavaris, 1988) there is.

The XSA diagnostics (Healey and Mahé, 2008) showed that shrinkage to the mean F was giving a better stability with respect to retrospective pattern and decreased slightly the residual pattern. This lead the Scientific Council to accept the XSA formulation with shrinkage to the mean F.

The statistics concerning the 2 NFT runs and the B-Adapt run are given below:

NFT1 :
Levenburg-Marquardt Algorithm Completed 35 Iterations
Residual Sum of Squares = 1138.45

Number of Residuals = 395
Number of Parameters = 12
Degrees of Freedom = 383
Mean Squared Residual = 2.97247
Standard Deviation = 1.72408

NFT2 :
Levenburg-Marquardt Algorithm Completed 9 Iterations
Residual Sum of Squares = 163.595

Number of Residuals = 395
Number of Parameters = 12
Degrees of Freedom = 383
Mean Squared Residual = 0.427140
Standard Deviation = 0.653560

B-ADAPT :
INITIAL SSQ = 7637.897341
PARAMETERS = 22
OBSERVATIONS = 406

SSQ = 111.11553
QSSQ = 109.33175
CSSQ = 1.78378

Within these formulations the better fit were observed for the NFT Adapt with no inverse variance weighting and B-adapt. Log catchability residuals for the B-Adapt and the NFT adapt with no inverse variance weighting are shown in figure 1 and compared to the XSA from the 2008 assessment. None of the formulations assuming exact catches could reduce the trends in the residuals observed in the Canadian surveys indices for the last ten years. The results of the B-Adapt formulation estimating bias in the landings for the last ten years improved significantly the fit as trends in the residuals were much reduced.

Results in terms of exploitable (5+) biomass showed that XSA runs with no shrinkage and NFT Adapt with inverse variance weighting gave similar results while XSA formulation with shrinkage to the average F of the last 5 years gave lower estimates of stock size (fig.2). NFT Adapt with equal weighting gave higher estimates of stock size.

The results from the B-Adapt show very much increased trends in the biomass over the period for which bias in the catch levels is estimated. However the rectified figures of catches fell outside of any reasonable estimates (fig. 3). This obviously points out that the trends observed in the residuals are due to changes of the surveys catchability over time. Since the surveys had stable sampling protocols over the period, these changes are most probably related to availability of the fish to the sampling gear.

References

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Table 1. Catch at age matrix (000s) for Greenland Halibut in Sub-Area 2 and Divisions 3KLMNO.

	Age													
Year	**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	897	4062	8236	10542	4126	1307	529	289	184	87	75
2005	0	0	0	534	1652	5999	10313	3996	1410	444	244	114	64	46
2006	0	0	0	216	1869	6450	12144	4902	1089	372	136	47	32	40
2007	0	0	0	88	570	3732	11912	5414	1230	472	163	80	41	29

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

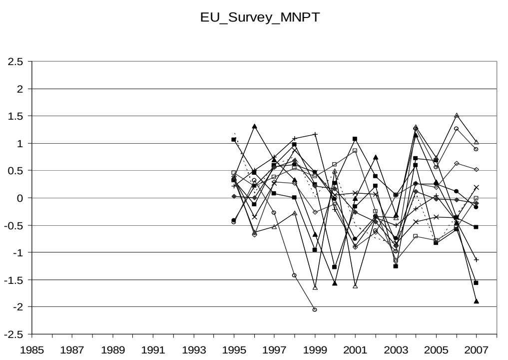
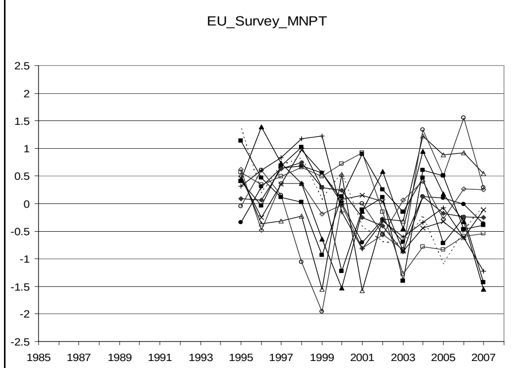
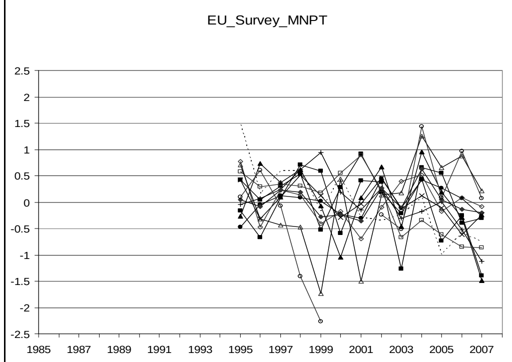
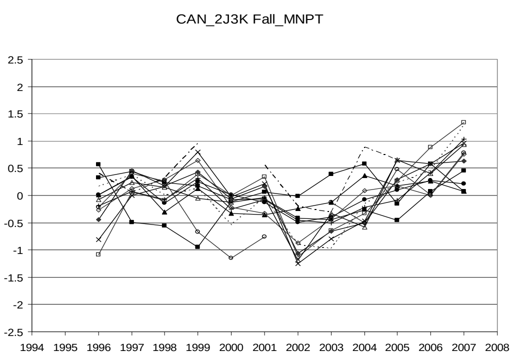
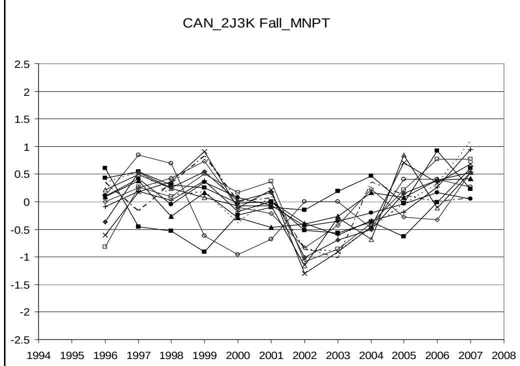
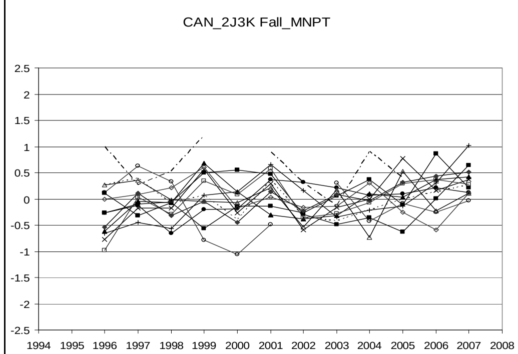
	Age													
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14+**
1975	0.000	0.000	0.126	0.244	0.609	0.760	0.955	1.190	1.580	2.210	2.700	3.370	3.880	5.764
1976	0.000	0.000	0.126	0.244	0.609	0.760	0.955	1.190	1.580	2.210	2.700	3.370	3.880	5.144
1977	0.000	0.000	0.126	0.244	0.609	0.760	0.955	1.190	1.580	2.210	2.700	3.370	3.880	5.992
1978	0.000	0.000	0.126	0.244	0.609	0.760	0.955	1.190	1.580	2.210	2.700	3.370	3.880	5.894
1979	0.000	0.000	0.126	0.244	0.609	0.760	0.955	1.190	1.580	2.210	2.700	3.370	3.880	6.077
1980	0.000	0.000	0.126	0.244	0.514	0.659	0.869	1.050	1.150	1.260	1.570	2.710	3.120	5.053
1981	0.000	0.000	0.126	0.244	0.392	0.598	0.789	0.985	1.240	1.700	2.460	3.510	4.790	7.426
1982	0.000	0.000	0.126	0.244	0.525	0.684	0.891	1.130	1.400	1.790	2.380	3.470	4.510	7.359
1983	0.000	0.000	0.126	0.244	0.412	0.629	0.861	1.180	1.650	2.230	3.010	3.960	5.060	7.061
1984	0.000	0.000	0.126	0.244	0.377	0.583	0.826	1.100	1.460	1.940	2.630	3.490	4.490	7.016
1985	0.000	0.000	0.126	0.244	0.568	0.749	0.941	1.240	1.690	2.240	2.950	3.710	4.850	7.010
1986	0.000	0.000	0.126	0.244	0.350	0.584	0.811	1.100	1.580	2.120	2.890	3.890	4.950	7.345
1987	0.000	0.000	0.126	0.244	0.364	0.589	0.836	1.160	1.590	2.130	2.820	3.600	4.630	6.454
1988	0.000	0.000	0.126	0.244	0.363	0.569	0.805	1.163	1.661	2.216	3.007	3.925	5.091	7.164
1989	0.000	0.000	0.126	0.244	0.400	0.561	0.767	1.082	1.657	2.237	2.997	3.862	4.919	6.370
1990	0.000	0.000	0.090	0.181	0.338	0.546	0.766	1.119	1.608	2.173	2.854	3.731	4.691	6.391
1991	0.000	0.000	0.126	0.244	0.383	0.592	0.831	1.228	1.811	2.461	3.309	4.142	5.333	7.081
1992	0.000	0.000	0.175	0.289	0.430	0.577	0.793	1.234	1.816	2.462	3.122	3.972	5.099	6.648
1993	0.000	0.000	0.134	0.232	0.368	0.547	0.809	1.207	1.728	2.309	2.999	3.965	4.816	6.489
1994	0.000	0.000	0.080	0.196	0.330	0.514	0.788	1.179	1.701	2.268	2.990	3.766	4.882	6.348
1995	0.000	0.000	0.080	0.288	0.363	0.531	0.808	1.202	1.759	2.446	3.122	3.813	4.893	6.790
1996	0.000	0.000	0.161	0.242	0.360	0.541	0.832	1.272	1.801	2.478	3.148	3.856	4.953	6.312
1997	0.000	0.000	0.120	0.206	0.336	0.489	0.771	1.159	1.727	2.355	3.053	3.953	5.108	6.317
1998	0.000	0.000	0.119	0.228	0.373	0.543	0.810	1.203	1.754	2.351	3.095	4.010	5.132	6.124
1999	0.000	0.000	0.176	0.253	0.358	0.533	0.825	1.253	1.675	2.287	2.888	3.509	4.456	5.789
2000	0.000	0.000	0.000	0.254	0.346	0.524	0.787	1.192	1.774	2.279	2.895	3.645	4.486	5.531
2001	0.000	0.000	0.000	0.249	0.376	0.570	0.830	1.168	1.794	2.367	2.950	3.715	4.585	5.458
2002	0.000	0.000	0.217	0.251	0.369	0.557	0.841	1.193	1.760	2.277	2.896	3.579	4.407	5.477
2003	0.000	0.000	0.188	0.247	0.389	0.564	0.822	1.199	1.651	2.166	2.700	3.404	4.377	5.409
2004	0.000	0.000	0.180	0.249	0.376	0.535	0.808	1.196	1.629	2.146	2.732	3.538	4.381	5.698
2005	0.000	0.000	0.252	0.301	0.396	0.564	0.849	1.247	1.691	2.177	2.705	3.464	4.264	5.224
2006	0.000	0.000	0.129	0.267	0.405	0.605	0.815	1.092	1.495	1.874	2.396	3.139	3.747	4.701
2007	0.000	0.000	0.000	0.276	0.389	0.581	0.833	1.137	1.500	1.948	2.607	3.057	3.869	4.954

Table 3. Survey data (mean numbers per tow) used to calibrate XSA assessment of Greenland Halibut in Sub-Area 2 and Divisions 3KLMNO. 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
1996.9	98.68	47.82	32.01	9.54	6.28	2.47	0.84	0.19	0.18	0.04	0.02	0.01	0.02
1997.9	28.05	58.62	43.61	21.13	10.37	5.01	2.00	0.64	0.20	0.06	0.03	0.02	0.01
1998.9	23.35	25.07	31.19	21.87	10.86	4.45	2.07	0.57	0.13	0.06	0.03	0.02	0.01
1999.9	15.99	34.42	24.07	28.28	20.04	10.53	3.81	0.70	0.14	0.07	0.02	0.01	0.03
2000.9	38.57	21.94	16.43	13.20	13.76	7.21	2.16	0.50	0.06	0.03	0.02	0.00	0.00
2001.9	43.90	22.72	17.00	14.07	9.77	7.59	3.40	0.69	0.11	0.02	0.01	0.00	0.01
2002.9	40.67	24.08	12.50	9.68	6.03	1.97	0.72	0.19	0.04	0.01	0.00	0.00	0.00
2003.9	45.70	26.67	11.69	9.49	6.39	2.27	0.89	0.27	0.04	0.02	0.01	0.01	0.00
2004.9	32.49	32.93	13.89	12.31	9.21	2.68	1.20	0.36	0.08	0.03	0.01	0.00	0.01
2005.9	16.06	16.15	8.56	13.84	10.98	6.85	3.96	0.66	0.12	0.03	0.03	0.01	0.01
2006.9	32.34	17.98	8.50	17.60	13.03	9.11	4.18	1.15	0.18	0.03	0.02	0.01	0.00
2007.9	32.61	14.51	12.81	18.77	9.57	10.35	6.17	2.14	0.34	0.08	0.04	0.02	0.01

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
2006.6	0.68	0.40	0.65	1.17	5.98	7.46	3.31	0.77	0.22	0.18	0.13	0.06
2007.6	0.42	0.09	0.57	0.34	3.44	7.37	5.76	1.51	0.31	0.21	0.08	0.05

3LNO Spr	1	2	3	4	5	6	7	8
1996.4	1.62	4.24	4.60	2.18	0.83	0.28	0.06	0.00
1997.4	1.16	3.92	5.16	3.23	1.46	0.51	0.10	0.01
1998.4	0.22	0.81	3.85	6.19	4.96	1.24	0.33	0.07
1999.4	0.29	0.55	1.15	1.98	3.39	1.09	0.24	0.05
2000.4	0.79	1.07	1.07	1.51	1.95	2.04	0.56	0.03
2001.4	0.57	0.71	0.74	0.68	0.80	0.72	0.28	0.02
2002.4	0.64	0.57	0.60	0.58	0.61	0.21	0.05	0.01
2003.4	0.93	2.14	1.66	1.57	1.06	0.21	0.05	0.01
2004.4	0.66	0.57	1.18	1.18	1.16	0.26	0.04	0.02
2005.4	0.35	0.31	1.09	0.95	1.37	0.82	0.21	0.03
2006.4			**Survey not completed**					
2007.4	1.595	0.516	0.802	0.399	1.405	1.491	1.121	0.183

XSA 2008	NFT 2	B-Adapt 10 yrs catches estimated
		
		

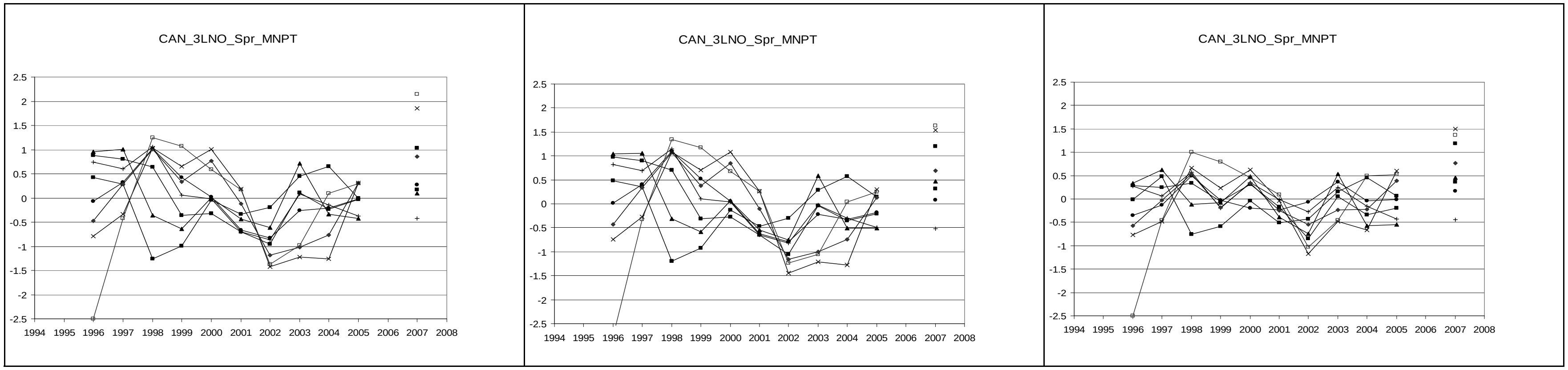


Figure 1 : Greenland Halibut in SA 2+3 - residuals from different SPA Formulations

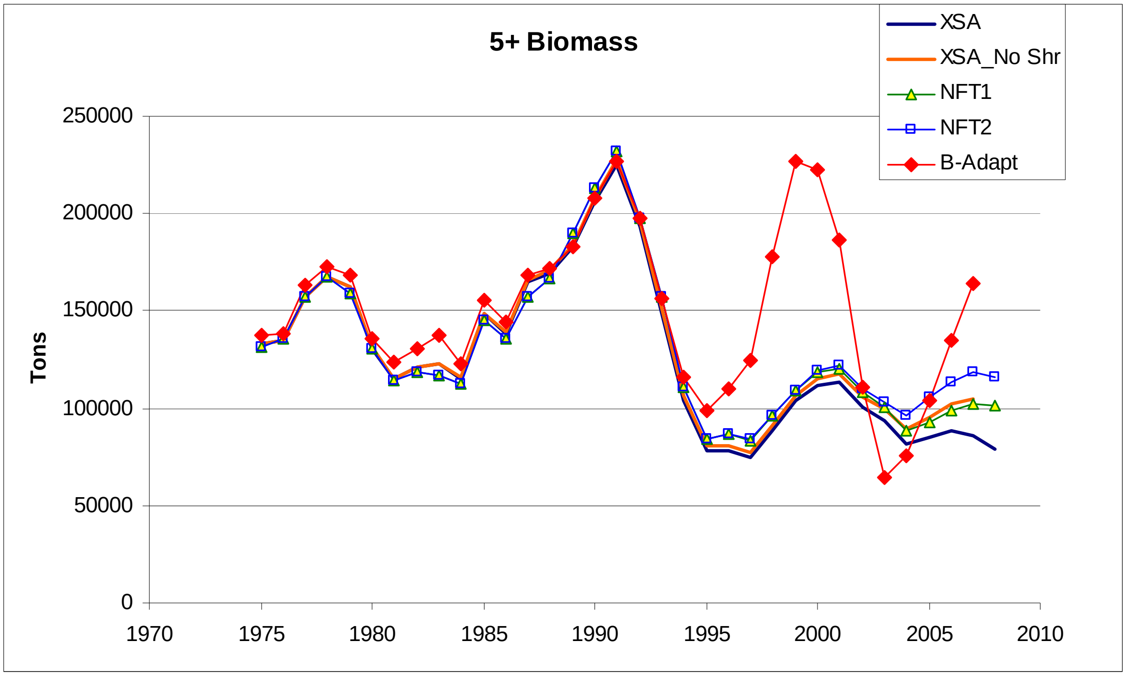


Figure 2 : Comparison of 5+ biomass estimates from different SPA models and formulations.

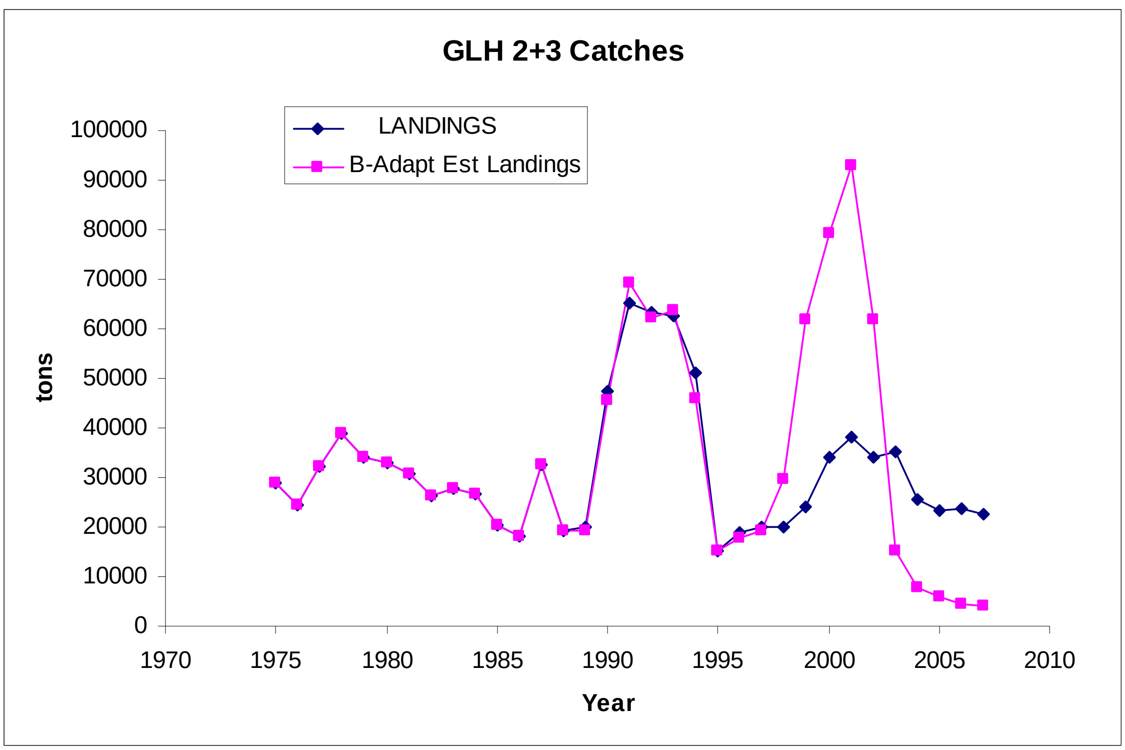


Figure 3 : B-Adapt formulation, no inverse variance weighting, model estimated vs fishery's assumed catches for the last 10 years.