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An Extended Survivors Analysis (XSA) of the Greenland Halibut in NAFO SA 0+1

by

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Abstract

An assessment of the Greenland halibut in NAFO Divisions 0+1 was carried out using Extended Survivors Analysis (XSA). Although the assessment results are considered to be provisional due to problems with the catch at age data and the short time series, the assessment is considered to reflect the dynamics of the stock. The results indicate that the stock increased during 1987- 1990 and has since remained stable. The rate of exploitation has been relatively constant in recent years between 0.2-0.3.

Methods

The Extended Survivors Analysis (XSA, Shepherd ….; Darby and Flatman, 1995) stock assessment model was fitted to the stock data for the Greenland halibut in NAFO Subareas 0+1 offshore. The model was calibrated with trawl survey data from Div. 1CD for the years 1997-2001 at ages 5-15. Catchability was assumed to be constant in time at all ages and constant with age after age 10. Shrinkage to the mean fishing mortality was applied over the final three years and oldest two ages using a c.v. of 1.0. The minimum permitted value for the survey catchability standard error at each age was set to 0.3.

Results

The assessment data, fitted model diagnostics and population abundance and exploitation rates are presented. Fig. 1 illustrates the estimated biomass series, Fig. 2 the average fishing mortality for ages 7-13 and Fig. 3 recruitment.

The residuals of the model fit to the survey data show that there is extensive noise in the log catchability estimates for the youngest age, especially in 1997. At the older ages catchability has relatively low standard errors with no strong patterns indicating departures from the model assumptions.

Fishing mortality has a dome shaped pattern at age in the most recent years and is estimated to be increasing in line with the levels of catches.

Spawning stock and total biomass are estimated to have increased during 1987-1993 and have subsequently remained stable.

There are concerns as to the availability of the length distributions used to derive the catch at age data for this stock and the results are therefore considered to be representative of the overall trends and levels of the stock and exploitation dynamics.

References

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

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

Run title : GREENLAND HALIBUT NAFO SUBAREAS 0+1

At 12/06/2002 14:06

Table 1 Catch numbers at age Numbers*10**-3

YEAR / AGE	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
5	2	1	1	4	20	53	241	254	152	151	41	71	262	415	70
6	31	29	36	87	318	678	651	862	552	530	311	372	1092	1106	987
7	182	190	244	592	1742	2967	2242	2472	1628	1818	1556	677	1759	1677	3238
8	296	354	409	1711	2679	4311	2356	1692	940	1575	2110	1187	1174	1144	1817
9	193	245	212	1356	1418	2604	1048	954	558	660	1042	900	672	772	1164
10	77	115	75	711	533	951	590	294	259	306	438	572	375	501	780
11	40	80	47	359	221	398	224	183	228	160	232	422	234	443	506
12	18	61	48	195	144	231	130	160	188	127	118	205	184	291	274
13	10	58	44	189	108	158	72	125	104	64	96	153	172	178	101
14	9	46	42	115	60	85	59	58	80	57	21	98	95	68	50
15	6	35	26	67	36	45	37	55	85	39	13	19	61	75	22
+gp	9	20	13	20	8	24	32	51	69	71	12	4	62	27	18
TOTALNUM	873	1234	1197	5406	7287	12505	7682	7160	4843	5558	5990	4680	6142	6697	9027
TONSLAND	1295	2605	2207	10540	10982	18070	11423	10144	8270	8982	9101	8693	9691	10689	13285
SOPCOF %	101	100	101	104	103	100	99	101	100	100	100	100	100	100	100

Table 2 Catch weight and stock weight at age (kg)

YEAR / AGE	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
5	0.289	0.29	0.29	0.33	0.338	0.33	0.58	0.43	0.49	0.52	0.36	0.5	0.54	0.53	0.48
6	0.508	0.51	0.51	0.54	0.538	0.56	0.72	0.62	0.66	0.69	0.55	0.74	0.7	0.72	0.67
7	0.739	0.74	0.74	0.79	0.794	0.8	0.96	0.91	0.94	0.94	0.86	1	0.98	1	0.91
8	1.078	1.08	1.08	1.1	1.124	1.13	1.26	1.26	1.34	1.38	1.27	1.24	1.28	1.29	1.3
9	1.41	1.42	1.42	1.52	1.57	1.59	1.8	1.72	1.81	1.91	1.83	1.54	1.66	1.71	1.76
10	1.965	2.05	2	2.11	2.27	2.28	2.43	2.19	2.37	2.48	2.38	2.22	2.25	2.26	2.29
11	2.582	2.8	2.68	2.94	3.22	3.02	3.25	2.73	2.89	3.18	3.01	3.08	2.74	2.84	2.91
12	3.522	3.88	3.73	3.9	4.24	4.02	4.1	3.43	3.62	4.04	3.84	3.84	3.68	3.59	3.51
13	4.643	5.01	4.87	4.96	5.5	5.33	5.26	4.48	4.44	5.05	4.93	4.74	4.73	4.23	4.3
14	5.789	6.16	6.2	6.26	6.82	6.76	6.17	5.75	5.61	5.95	5.69	6.04	5.58	5.19	5.6
15	6.605	7.44	7.65	7.96	8.33	7.76	7.42	6.58	6.65	7.34	6.79	6.6	6.68	5.85	6.11
+gp	9.4286	9.1987	9.3903	10.2023	9.8263	8.7338	8.3281	8.2841	8.8694	9.5011	8.0256	13.3927	8.5144	7.883	8.2956
SOPCOFAC	1.0093	1.0017	1.0061	1.0363	1.0251	1.0007	0.9852	1.0107	0.9988	0.999	1.002	0.9992	1.0002	1.0007	1.0011

Proportion of F before spawning 0.0
Proportion of M before spawning 0.0

Natural mortality 0.2

Proportion mature at age	5	6	7	8	9	10	11	12	13	14	15	+gp
	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Lowestoft VPA Version 3.1

12/06/2002 13:40

Extended Survivors Analysis

GREENLAND HALIBUT NAFO SUBAREAS 0+1

CPUE data from file tun.dat

Catch data for 15 years. 1987 to 2001. Ages 5 to 16.

Fleet	Firs year	Last year	First age	Last age	Alpha	Beta
Survev	1997	2001	5	15	0.5	0.6

Time series weights :

Tapered time weighting not applied

Catchabilitv analvsis :

Catchability independent of stock size for all ages

Catchability independent of age for ages >= 10

Terminal population estimation :

Survivor estimates shrunk towards the mean F
of the final 3 years or the 2 oldest ages.

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

Minimum standard error for population
estimates derived from each fleet = .300

Prior weighting not applied

Tuning converged after 77 iterations

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Regression weights

1 1 1 1 1

Fishing mortalities

Age	1997	1998	1999	2000	2001
5	0.002	0.005	0.014	0.016	0.011
6	0.033	0.028	0.092	0.075	0.048
7	0.193	0.095	0.179	0.2	0.329
8	0.361	0.221	0.236	0.169	0.348
9	0.283	0.256	0.187	0.24	0.26
10	0.167	0.248	0.161	0.207	0.408
11	0.131	0.241	0.151	0.291	0.335
12	0.089	0.163	0.157	0.285	0.294
13	0.113	0.159	0.201	0.224	0.151
14	0.038	0.162	0.14	0.114	0.09
15	0.061	0.044	0.144	0.157	0.049

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XSA population numbers (Thousands)

	AGE										
YEAR	5	6	7	8	9	10	11	12	13	14	15
1997	1.83E+04	1.05E+04	9.81E+03	7.70E+03	4.67E+03	3.15E+03	2.09E+03	1.53E+03	9.90E+02	6.24E+02	2.41E+02
1998	1.68E+04	1.49E+04	8.29E+03	6.63E+03	4.40E+03	2.88E+03	2.18E+03	1.50E+03	1.15E+03	7.23E+02	4.92E+02
1999	2.08E+04	1.37E+04	1.19E+04	6.18E+03	4.35E+03	2.79E+03	1.84E+03	1.40E+03	1.05E+03	8.03E+02	5.04E+02
2000	2.91E+04	1.68E+04	1.02E+04	8.14E+03	4.00E+03	2.96E+03	1.94E+03	1.30E+03	9.82E+02	7.00E+02	5.71E+02
2001	7.20E+03	2.35E+04	1.28E+04	6.84E+03	5.63E+03	2.57E+03	1.97E+03	1.19E+03	7.97E+02	6.43E+02	5.12E+02

Estimated population abundance at 1st Jan 2002

0.00E+00	5.83E+03	1.83E+04	7.53E+03	3.96E+03	3.55E+03	1.40E+03	1.15E+03	7.25E+02	5.61E+02	4.81E+02

Taper weighted geometric mean of the VPA populations:

1.71E+04	1.44E+04	1.06E+04	7.07E+03	4.34E+03	2.61E+03	1.71E+03	1.13E+03	7.68E+02	5.19E+02	3.53E+02

Standard error of the weighted Log(VPA populations) :

0.3044	0.2172	0.2137	0.2292	0.2003	0.1799	0.2248	0.2593	0.2748	0.2873	0.3145

Log catchability residuals.

Fleet : Survey

Age	1997	1998	1999	2000	2001
5	-13.31	3.28	2.8	2.76	4.47
6	-0.16	0.14	0.08	-0.08	0.03
7	0.01	0.03	0.06	-0.07	-0.03
8	0.76	-0.03	-0.13	-0.4	-0.2
9	0.88	-0.35	-0.95	0.49	-0.07
10	0.03	0.17	-0.12	-0.03	-0.07
11	0.18	-0.01	-0.11	0.07	0.06
12	-0.01	-0.05	0.26	-0.25	-0.1
13	0.21	-0.19	0.12	-0.1	0.15
14	-0.28	-0.54	0.36	-0.78	-0.24
15	0.02	0.2	-0.02	0.08	0.11

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

Age	5	6	7	8	9	10	11	12	13	14	15
Mean Log q	3.6095	7.1424	7.5652	7.0261	6.4437	6.114	6.114	6.114	6.114	6.114	6.114
S.E(Log q)	7.473	0.1186	0.0517	0.4433	0.7139	0.1112	0.1177	0.188	0.1809	0.5389	0.121

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
5	-0.63	-0.317	18.1	0.01	5	5.33	3.61
6	0.87	0.677	-5	0.9	5	0.11	7.14
7	1.04	-0.239	-8.3	0.91	5	0.06	7.57
8	0.59	0.311	-0.5	0.16	5	0.3	7.03
9	1.04	-0.012	-7.04	0.03	5	0.86	6.44
10	0.62	0.768	-0.8	0.58	5	0.07	6.11
11	0.56	0.916	-0.15	0.6	5	0.06	6.15
12	0.61	0.688	-0.88	0.51	5	0.12	6.08
13	3.75	-1.176	-42.08	0.06	5	0.63	6.15
14	0.35	0.83	2.18	0.35	5	0.16	5.82
15	0.92	0.615	-5.26	0.96	5	0.09	6.19

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Terminal year survivor and F summaries :

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

Year class = 1996

Fleet		Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
Survey	507123	8.186	0	0	1	0.015	0
F shrinkage mean	5457	1				0.985	0.012

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
5829	0.99	4.5	2	4.532	0.011

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

Year class = 1995

Fleet		Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
Survey	18884	0.3	0.099	0.33	2	0.914	0.046
F shrinkage mean	13210	1				0.086	0.065

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
18311	0.29	0.1	3	0.348	0.048

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

Year class = 1994

Fleet		Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
Survey	7145	0.212	0.054	0.26	3	0.939	0.344
F shrinkage mean	17059	1				0.061	0.158

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
7534	0.21	0.13	4	0.63	0.329

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

Year class = 1993

Fleet		Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
Survey	3808	0.195	0.073	0.38	4	0.939	0.359
F shrinkage mean	7059	1				0.061	0.209

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
3955	0.19	0.1	5	0.508	0.348

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

Year class = 1992

Fleet	I S	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
Survey	3522	0.19	0.176	0.92	5	0.941	0.262
F shrinkage mean	4092	1				0.059	0.229

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
3553	0.19	0.15	6	0.814	0.26

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

Year class = 1991

Fleet	I S	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
Survey	1341	0.166	0.068	0.41	5	0.948	0.423
F shrinkage mean	3079	1				0.052	0.206

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
1400	0.17	0.1	6	0.624	0.408

Age 11 Catchability constant w.r.t. time and age (fixed at the value for age) 10

Year class = 1990

Fleet	I S	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
Survey	1128	0.167	0.095	0.57	5	0.953	0.341
F shrinkage mean	1782	1				0.047	0.229

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
1152	0.17	0.09	6	0.566	0.335

Age 12 Catchability constant w.r.t. time and age (fixed at the value for age) 10

Year class = 1989

Fleet	I S	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
Survey	711	0.166	0.101	0.61	5	0.955	0.299
F shrinkage mean	1103	1				0.045	0.203

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
725	0.16	0.1	6	0.592	0.294

Age 13 Catchability constant w.r.t. time and age (fixed at the value for age) 10

Year class = 1988

Fleet		Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
Survey	567	0.152	0.107	0.7	5	0.966	0.149
F shrinkage mean	424	1				0.034	0.195

Weighted prediction :

Survivors at end of year		Int s.e	Ext s.e	N	Var Ratio	F
	561	0.15	0.1	6	0.641	0.151

Age 14 Catchability constant w.r.t. time and age (fixed at the value for age) 10

Year class = 1987

Fleet		Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
Survey	489	0.15	0.079	0.53	5	0.965	0.088
F shrinkage mean	303	1				0.035	0.139

Weighted prediction :

Survivors at end of year		Int s.e	Ext s.e	N	Var Ratio	F
	481	0.15	0.08	6	0.538	0.09

Age 15 Catchability constant w.r.t. time and age (fixed at the value for age) 10

Year class = 1986

Fleet		Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
Survey	411	0.149	0.12	0.81	5	0.971	0.047
F shrinkage mean	155	1				0.029	0.121

Weighted prediction :

Survivors at end of year		Int s.e	Ext s.e	N	Var Ratio	F
	399	0.15	0.13	6	0.877	0.049

Table 8 Fishing mortality (F) at age

YEAR	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	FBAR 99-01
AGE																
5	0.0002	0.0001	0.0001	0.0002	0.0013	0.0034	0.0152	0.0157	0.0109	0.013	0.0025	0.0047	0.014	0.0159	0.0108	0.0136
6	0.0036	0.0027	0.0024	0.0055	0.0217	0.0545	0.053	0.0692	0.0428	0.0477	0.0334	0.0279	0.0924	0.0754	0.0476	0.0718
7	0.031	0.027	0.0282	0.0496	0.1447	0.2876	0.2564	0.291	0.1806	0.1936	0.1926	0.0946	0.1787	0.2004	0.3285	0.2359
8	0.0802	0.0777	0.0748	0.2811	0.3297	0.6359	0.3904	0.3139	0.1706	0.2663	0.3606	0.2206	0.2358	0.1689	0.3476	0.2508
9	0.0828	0.0882	0.0609	0.3775	0.3982	0.6229	0.3064	0.2694	0.1608	0.1738	0.2832	0.2564	0.1871	0.2402	0.2596	0.229
10	0.0566	0.0649	0.0351	0.2972	0.2487	0.512	0.2734	0.1311	0.1082	0.1243	0.1671	0.2478	0.1611	0.2075	0.4081	0.2589
11	0.0452	0.0768	0.034	0.234	0.1409	0.2977	0.2137	0.1268	0.1423	0.0901	0.1307	0.2408	0.1514	0.2906	0.3346	0.2589
12	0.0324	0.09	0.0603	0.193	0.1383	0.2146	0.1489	0.233	0.1859	0.1099	0.0888	0.1634	0.1567	0.2854	0.294	0.2454
13	0.0238	0.1387	0.0866	0.3548	0.1555	0.2217	0.0955	0.209	0.2335	0.0888	0.1134	0.1591	0.2007	0.2237	0.1508	0.1917
14	0.0276	0.1453	0.1411	0.3407	0.1805	0.1764	0.1201	0.1039	0.2005	0.1937	0.0379	0.1622	0.1401	0.1135	0.0899	0.1145
15	0.0257	0.1425	0.1142	0.35	0.1687	0.1999	0.1082	0.157	0.218	0.1418	0.0614	0.0436	0.1437	0.1567	0.0487	0.1164
+gp	0.0257	0.1425	0.1142	0.35	0.1687	0.1999	0.1082	0.157	0.218	0.1418	0.0614	0.0436	0.1437	0.1567	0.0487	
FBAR 7-13	0.0503	0.0805	0.0543	0.2553	0.2223	0.3989	0.2407	0.2249	0.1688	0.1495	0.1909	0.1975	0.1816	0.2309	0.3033	

Run title : GREENLAND HALIBUT NAFO SUBAREAS 0+1

At 11/06/2002 19:15

Terminal Fs derived using XSA (With F shrinkage)

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

YEAR	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	GMST
AGE																	
5	14506	20236	21440	20005	17280	17080	17678	18058	15526	12959	18273	16779	20848	29108	7197	0	17574
6	9650	11875	16567	17553	16375	14129	13936	14256	14555	12574	10473	14923	13673	16832	23456	5829	13700
7	6597	7873	9696	13531	14292	13119	10955	10821	10892	11417	9815	8293	11882	10207	12780	18311	10472
8	4246	5236	6274	7718	10543	10125	8056	6940	6622	7444	7703	6628	6177	8136	6839	7534	7016
9	2684	3208	3967	4766	4771	6208	4389	4464	4151	4571	4670	4397	4352	3995	5626	3955	4277
10	1546	2023	2405	3056	2676	2623	2726	2645	2792	2894	3146	2880	2786	2955	2572	3553	2591
11	1001	1196	1552	1901	1859	1708	1287	1698	1900	2051	2092	2179	1841	1941	1966	1400	1673
12	624	783	907	1228	1232	1322	1038	851	1225	1349	1535	1503	1402	1295	1189	1152	1117
13	470	495	586	699	829	878	873	733	552	833	990	1150	1045	982	797	725	751
14	366	376	353	440	402	581	576	650	487	358	624	723	803	700	643	561	499
15	261	291	266	251	256	274	399	418	480	326	241	492	504	571	512	481	330
+gp	391	166	134	75	57	146	344	386	387	591	224	106	510	205	418	725	
TOTAL	42342	53759	64147	71224	70571	68194	62257	61920	59567	57367	59784	60054	65823	76928	63995	44228	

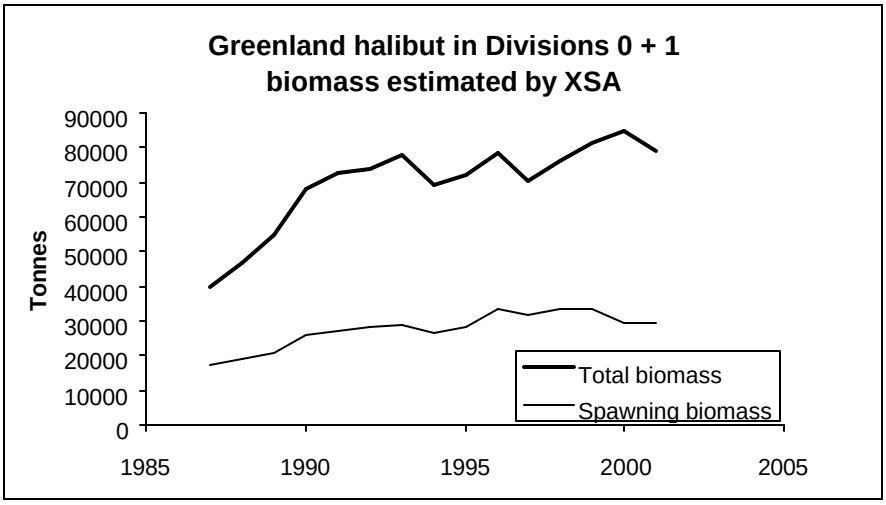
Run title : GREENLAND HALIBUT NAFO SUBAREAS 0+1

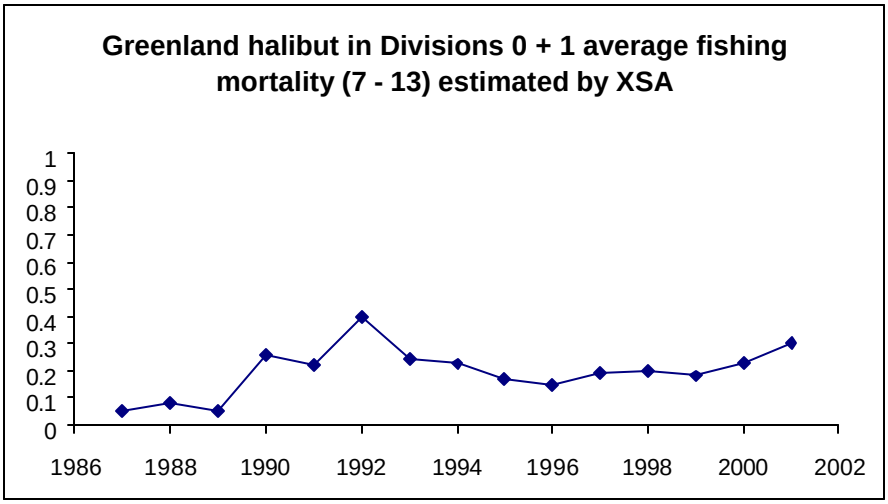
At 12/06/2002 13:41

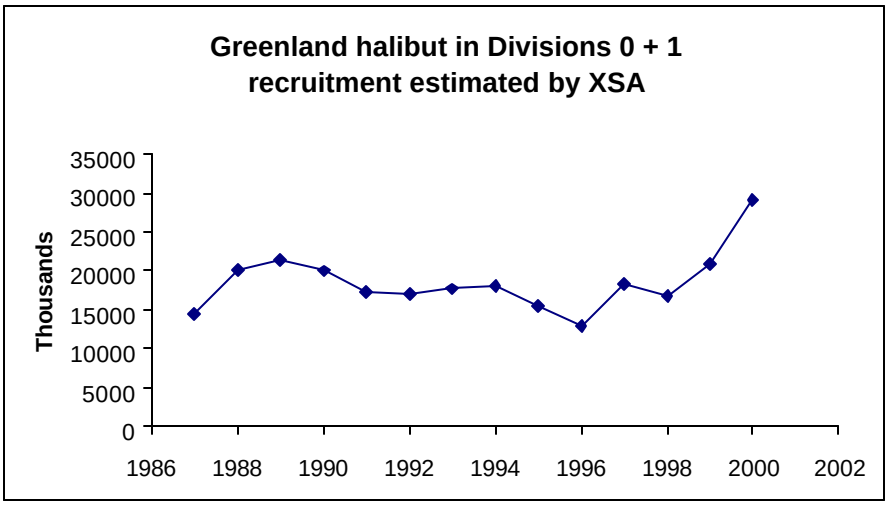
Table 16 Summary (without SOP correction)

Terminal Fs derived using XSA (With F shrinkage)

	RECRUITS Age 5	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	FBAR 7-13
1987	14506	39860	17529	1295	0.0739	0.0503
1988	20236	46984	19022	2605	0.1369	0.0805
1989	21440	54937	20686	2207	0.1067	0.0543
1990	20005	68314	25809	10540	0.4084	0.2553
1991	17280	72617	27279	10982	0.4026	0.2223
1992	17080	73824	28468	18070	0.6347	0.3989
1993	17678	77888	29033	11423	0.3934	0.2407
1994	18058	69191	26317	10144	0.3854	0.2249
1995	15526	72184	28344	8270	0.2918	0.1688
1996	12959	78646	33495	8982	0.2682	0.1495
1997	18273	70649	31542	9101	0.2885	0.1909
1998	16779	76076	33360	8693	0.2606	0.1975
1999	20848	81205	33599	9691	0.2884	0.1816
2000	29108	84666	29586	10689	0.3613	0.2309
2001	7197	78995	29402	13285	0.4518	0.3033
Arith. Mean	17798	69736	27565	9065	0.3168	0.1967
Units	(Thousands)	(Tonnes)	(Tonnes)	(Tonnes)		


Greenland halibut in Divisions 0 + 1
biomass estimated by XSA
Tonnes
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
1985
1990
1995
2000
2005
Total biomass
Spawning biomass


Greenland halibut in Divisions 0 + 1 average fishing
mortality (7 - 13) estimated by XSA
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1986
1988
1990
1992
1994
1996
1998
2000
2002


Greenland halibut in Divisions 0 + 1
recruitment estimated by XSA
Thousands
35000
30000
25000
20000
15000
10000
5000
0
1986
1988
1990
1992
1994
1996
1998
2000
2002