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Greenland Halibut Subareas 2+3
Calculation of SSB as a Function of Relative Effort

by

Hans Lassen

Danish Institute for Fisheries Research, Charlottenlund Slot
DK-2920 Charlottenlund, Denmark

This paper is prepared in an attempt to answer a special request by Canada on how SSB for the 1990 year-class could be saved.

The request asked "What changes in management of the fishery in 1995 and future years would be needed to minimize catches of this year class while it is young and rapidly growing and allow it to make a) 25%, b) 50% or c) 75 % of the contribution to future spawning biomass that it would if none of it was caught at immature ages".

An answer to this request could be based on calculation of spawning biomass per recruit comparing the biomass at the age at first maturity for different scenarios of the fishing mortalities to which this cohort is exposed between age 5 (year class 1990 in 1995) and age 10 (age at first maturity).

Although the request specifically addresses the year class 1990 calculations based on a recruiting age of 2 are also included. Age group 2 is the first age which appears in the Spanish age compositions of their catches in 1994. Such calculations are therefore relevant for future yearclasses.

Assumptions in the calculations

1. The age at first maturity is taken to be age 10.
2. Estimates of F-at-age and mean weights-at-age are based on the Spanish data provided for the Greenland halibut fishery outside the Canadian Exclusive Fishing Zone in Subarea 3 for 1994, see Casey (1995).
3. The natural mortality applied is $M = 0.15$ per year.
4. The yearclass 1990 has already been exposed to fishing in 1990-1994 although the exploitation of this year class before 1992 was virtually nil. The year class is 5 year of age in 1995 and therefore this age is in the calculations taken as the recruiting age.
5. Only effort regulation e.g. through a TAC is available as the management tool. This effort regulation is translated in the calculation to a factor which is applied to the entire F-at-age array. So a 50 % reduction of effort is assumed to introduce a 50 % reduction in fishing mortality on all age groups compared to the current estimate, see Casey (1995).

The calculations are made on a spreadsheet (in Microsoft EXCEL 5.0), see tables 1 and 2. These spreadsheet calculate the biomass at age 10 of 1000 recruits at age 2 and of age 5 respectively.

These biomass are calculated for no fishing ages 5-9 and for an exploitation corresponding to the F-at-age array found for the Spanish age compositions in 1994, Casey (1995).

Based on this setup the surviving biomass is calculated for each age group with an exploitation equal the F-at-age array given for Spanish age composition in 1994 multiplied by the "relative effort level". The ratio SSB (exploited)/SSB(non-exploited) for age 10 is plotted vs. the relative effort 1994 on fig. 1 for recruiting age 5 (the 1990 year class) and age 2 (a future year class).

The specific numbers requested can be read from the text table below

Ratio (%) Biomass	Rel. Effort % (1994 = 1) Recruit age 5	Rel. Effort % (1994 = 1) Recruit age 2
25	99.7	68.0
50	49.9	34.0
75	20.7	14.1

The request addresses the 1990 year class specifically therefore the time frame of this effort reduction would be year 1995 - 1999.

Literature

Casey, J. (1995) An extremely quick and dirty look at yield-per-recruit for Greenland halibut in Subareas 2 and 3. NAFO SCR Doc., No. 66, Serial No. N2581.

Table 1. Greenland halibut SA 2+3 Calculation of Biomass at age 10 for exploited and non exploited yearclass

Age	Stock	Weight	Rel. F at age	F-at-age	Maturity	Ogive SSB	Stock No fishing	% SSB with fishing of SSB without fishing
2	1000	0.064	0.14	0.14	0	0	1000	0
3	748.2636	0.087	0.24	0.24	0	0	860.708	0
4	506.617	0.208	0.27	0.27	0	0	740.8182	0
5	332.8711	0.398	0.28	0.28	0	0	637.6282	0
6	216.5357	0.58	0.28	0.28	0	0	548.8116	0
7	140.8584	0.814	0.28	0.28	0	0	472.3666	0
8	91.62968	1.196	0.28	0.28	0	0	406.5697	0
9	59.60594	1.815	0.27	0.27	0	0	349.9377	0
10	39.1639	2.445	0.26	0.26	1	95.75572	301.1942	736.4198
11	25.99113	3.064	0.24	0.24	1	79.63682	259.2403	794.3122
12	17.59747	3.984	0.23	0.23	1	70.10833	223.1302	888.9506
13	12.03423	5.12	0.21	0.21	1	61.61527	192.0499	983.2955
14	8.395999	6.091	0.19	0.19	1	51.14003	165.2989	1006.836
15	5.976023	7.125	0.18	0.18	1	42.57916	142.2741	1013.703
16	4.296305	8.462	0.15	0.15	1	36.35533	122.4564	1036.226
17	3.182781	8.462	0.13	0.13	1	26.93269	105.3992	891.8882
18+	9.555605	9.763	0.14	0.14	1	93.29137	651.2789	6358.436
Total SSB						557.4147	13710.07	

Sheet1

Greenland halibut SA 2+3		Calculation of Biomass at age 10 for exploited and non exploited yearclass											
Calculation based on age 5 recruits													
Age	Stock	Weight	Rel. F at age	F-at-age	Maturity	Ogive SSB	Stock No fishing	% SSB with fishing of SSB without fishing		AGE 10	REL. SSB		
								0	1000	0	0	24.90753	13.00287
5	1000	0.398	0.28	0.28	0	0	0	0	1000	0	0	0	100
6	650.5091	0.58	0.28	0.28	0	0	0	0	860.708	0	0	0	100
7	423.1621	0.814	0.28	0.28	0	0	0	0	740.8182	0	0	0	100
8	275.2708	1.196	0.28	0.28	0	0	0	0	637.6282	0	0	0	100
9	179.0661	1.815	0.27	0.27	0	0	0	0	548.8116	0	0	0	100
10	117.6548	2.445	0.26	0.26	1	287.6661	472.3666	1154.936	24.90753	0.1	87.0228	81.54624	100
11	78.08167	3.064	0.24	0.24	1	239.2422	406.5697	1245.728	0.2	75.72968	66.49789	100	
12	52.86573	3.984	0.23	0.23	1	210.6171	349.9377	1394.152	0.25	70.6452	60.04956	100	
13	36.15283	5.12	0.21	0.21	1	185.1025	301.1942	1542.114	0.3	65.90209	54.22653	100	
14	25.22297	6.091	0.19	0.19	1	153.6331	259.2403	1579.032	0.4	57.34985	44.21969	100	
15	17.95296	7.125	0.18	0.18	1	127.9149	223.1302	1589.802	0.5	49.90744	36.05949	100	
16	12.90681	8.462	0.15	0.15	1	109.2174	192.0499	1625.126	0.6	43.43086	29.40516	100	
17	9.561602	8.462	0.13	0.13	1	80.91028	165.2989	1398.759	0.7	37.79475	23.9788	100	
18+	28.70662	9.763	0.14	0.14	1	280.2628	1021.409	9972.012	0.75	35.25721	21.65357	100	
Total SSB							1674.566	21501.66			0.8	32.89005	19.55381
											0.9	28.62184	15.9454
											1	24.90753	13.00287

Relative contribution to SSB vs effort level

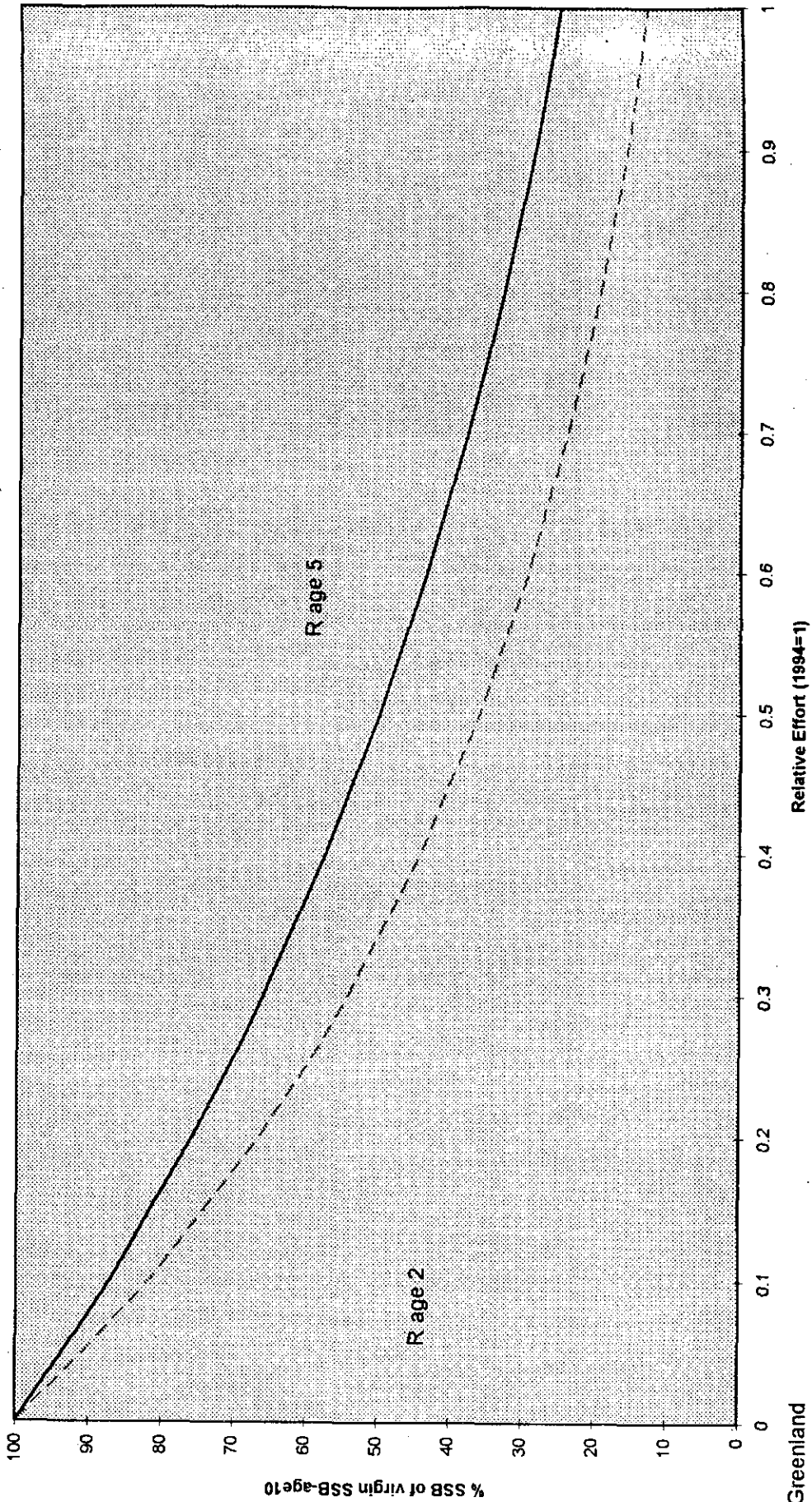


Fig.1 Greenland halibut SA 2+3