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Status of Greenland Halibut (*Reinhardtius hippoglossoides* Walb.) Stocks and Feasible Yield in NAFO Subareas 0, 1 and Div. 2GH

by

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INTRODUCTION

Authors involved with identification of Greenland halibut stocks in NW Atlantic came to a conclusion that the range of Greenland-Canadian population covers a vast area on the shelf and continental slope of Canadian coast approximately from 42°N northward to the Arctic Region in the Baffin Sea (78°N), and also on the shelf and continental slope of West Greenland (Templeman,1973; Chumakov, 1975; Bowering, 1977, 1982a, b; Ernst, 1987).

Halibut available to the fishery are concentrated both in coastal waters off Newfoundland (Divs. 3KL), in fjords of West Greenland (Subarea 1) and on continental slope of Labrador (Subarea 2), Baffin Land (Div. 0B), West Greenland (Subarea 1).

From the beginning of trawl fishery on continental slope and prior to introduction of 200-mile zones the total halibut yield in NW Atlantic varied from 29 x 10^3 to 53.6 x 10^3 t, on the average - 39.9 x 10^3 t. The average annual yields taken by the USSR and GDR fishing fleets in NW Atlantic in 1969-76 were 16.0 x 10^3 and 3.8 x 10^3 t respectively. The highest number of halibut was fished on continental slope in the North and Central Labrador (Divs. 2GH) and in Davis Strait (Subareas 0 and 1). The yearly catch size of these countries depended, to a great extent, on the level of school availability to the fishery and also on the amount of fishing efforts. As the fishing areas were surveyed and the experience in deepwater trawl fishery was gained the total size of halibut yield increased in the northern areas (Subareas 0 and 1, Divs. 2GH) (Table 1). With introduction of 200-mile zones in 1977 the international legal fishing conditions have completely changed in NW Atlantic. A new boundary separating fishing zones of Greenland and Canada was set in Davis Strait to divide NAFO Subareas 0 and 1. A part of most productive fishing areas passed on to the Greenland fishing zone. The fishery of halibut (as of other commercial fishes) became just possible owing to mutually beneficial agreements with coastal states. The introduction of zones resulted in total decrease of halibut catches on continental slope in Subareas 0+1 and Divs. 2GH, first of all, due to reduced fishing efforts of USSR, Poland, GDR in the Canada fishing zone and fishery cut in the Greenland fishing zone. At the same time Canada and Greenland considerably increased halibut catches in their coastal waters (Table 2). For instance, in 1987 and 1988 the Greenland catch accounted for 90 and 86% respectively of total halibut yield taken in Davis Strait (Subareas 0+1).

Until 1983 very dense halibut schools were observed practically on the whole continental slope of Baffin Land and Labrador (Subareas 0, 2), the national catch quota was allocated, and since 1984 despite a high stock level (Bowering, 1984; Bowering and Brodie, 1984) the USSR was not taken up in Subarea 0 (Chumakov et al., 1986, 1987).

Denser halibut schools were found in this period in Divs. 2HJ and fjords of West Greenland. Statistical data for 1985-87 (Table 2) indicate to the decrease of Canadian catches in Divs. 3KL and to the increase of local catches in fjords of West Greenland (Subarea 1).

Canadian scientists Bowering and Brodie (1986, 1987, 1989) explain this decrease as being due to fishery production curtailment and redistribution of fishing efforts to the other objects. At the same time halibut fishery in West Greenland intensively expands developing from small-scale long-line to large-scale gill-net fishing (Boje and Riget, 1987, 1989).

In the present paper we made an attempt to estimate Greenland halibut stocks in Subareas 0, 1 and Divs. 2GH on the basis of joint USSR-GDR biological data and fisheries statistics from the countries fishing in these areas.

MATERIAL AND METHODS

Abundance and biomass of exploitable Greenland halibut stock of Greenland-Canadian population were estimated in Subareas 0, 1 and Divs. 2GH by the VPA method. The quantitative composition of catches and mean weights by age groups and years of fishery (Tables 3, 4) were obtained from the joint USSR-GDR data for 1975-89. Preliminary international catch data were used for 1989.

Mortality of commercial fishes for various reasons happens as a consequence of interaction between stock specimens and a large number of interdependent and indipendent ecological factors. Usually it is considered to be invariable in time and independent on the age. In certain fishes the error allowed for with second assumption is more than 100% of the indication of numbers for some age groups (Blinov, 1979). Therefore, three values of natural mortality coefficient (M) were estimated for Greenland halibut of Canadian-Greenland population:

1. Natural mortality coefficients obtained by the methods described by Tretyak and others (Tretyak, 1983; Efimov, Savateeva and Tretyak, 1986) (Table 5).

2. A constant coefficient of natural mortality equal to 0.1 (Ernst and Borrmann, 1987).

3. A constant coefficient of natural mortality equal to 0.2 (Bowering and Brodie, 1981).

M=0.1 for all age groups was assumed as a basis of the stock state analysis and TAC estimates since the mean M value was close to M=0.1 according to variant 1, and M=0.2 was only a hypothesized variant.

The fishing effort for 1975-86 was given for a standard Soviet large trawler. The average annual fishing efficiency of Japanese vessels carrying out fishery in the northern areas (Vozumi, 1989) was used in calculations for 1987-88 so far as, in our opinion, the fishing efficiency of the USSR and GDR vessels fishing Greenland halibut was not representative.

To find starting coefficients of fishing mortality the methods of VPA "tuning" published in the paper by Pope and Shepperd (1983) were used. That or another method was chosen by the following criteria: the maximum coefficients of correlation between fishing mortality and effort by age groups, and also the minimum error in tuning the method calculated for dependent and independent part of data.

The stock state and TAC are predicted for 1991 with allowance for coefficients of partial recruitment estimated by the method of Rivard (1983) (Table 5). Parameters of optimum exploitation of Greenland halibut stocks of Greenland-Canadian population were obtained by the method of Thompson and Bell (Ricker, 1975) (Fig. 1).

RESULTS AND DISCUSSION

The numbers of age groups 5-17 - the most intensively exploitable in Greenland-Canadian population of Greenland halibut - were estimated for Subareas 0+1 and Divs. 2GH. About 80% of commercial catches taken in 1987-89 consisted of fish aged 6-9. Specimens of the 1982 and 1981 yearclasses accounted for 38% and 20% respectively of the catch taken in 1989.

To estimate starting coefficients F the combined method of Pope and Shepperd (1983) was applied with the highest coefficients of correlation between fishing mortality and effort.

Analysis of estimated abundance and biomass values, fishing mortality coefficients (Fig. 2, Tables 6, 7, 8) indicates to a relatively steady stock increase after some decrease observed in 1976-77, and to a tendency of fishing mortality decrease. In 1989 the numbers and biomass were 105.5×10^6 spec. and 200×10^3 t This tendency is confirmed by analogous estimates obtained by Canadian scientists Bowering and Brodie (1987) for southern part of Greenland halibut stock in Subarea 2 and Divs. 3KL.

The catch decrease with relatively stable recruitment leads naturally to fishing mortality decrease. As is seen from Table 7 and Fig. 2 the mean coefficient of fishing mortality equalled 0.17 in 1975. This value is higher than coefficients of subsequent years but much lower than the maximum sustainable yield F_{max}. According to estimated yield per recruit ($\frac{Y}{R}$) dependent on fishing intensity (Fig. 1), halibut catch will be 18.5×10^3 t at precautious fishing level ($F_{0.1}$=0.14) and 25.2×10^3 t at F_{max}=0.22.

The results of fishery show that halibut stocks are obviously underexploited in northern areas. So, the fishery level $F_{0.1}$=0.14 was reported only in 1976-79 while during the subsequent years the actual catch was considerably lower than the precatious level (Table 7).

Besides, the biomass and TAC estimates obtained are very low, to our mind, and do not represent the real state of fish stocks.

A successful application of VPA method is known to be conceivable at rather a high level of exploitation of the whole commercial stock and with representative catch-at-effort data. As is seen from Table 10 the fishing efficiency decreased from 1.53 t per hour trawling in 1982 to 0.45 t per hour trawling in 1985 and increased thereupon to 1.02 t per hour trawling in 1988.

A number of investigators (Chumakov et al., 1986, 1987; Chumakov and Savvatimsky, 1987; Chumakov and Bowering, 1988) explain the variations in halibut schools density by redistribution of concentrations to other areas due to anomalous fluctuations in water temperature.

Bowering and Brodie (1989) fairly observe that it is difficult to obtain catch-at-effort statistics giving accurate estimates of total stock numbers with regard for fishery conditions and migration behaviour of the species as well as a low level of directed fishery.

Trawl survey data on halibut biomass and abundance in the area investigated indicate also to underestimation of stock values when using the VPA method.

Fig. 3 summarizes the highest biomass figures (Divs. OB and 2GH) equal to 501.0 and 547.7 x 10^3 t in 1982 and 1983 respectively. These figures are more than twice as high as estimated biomass values by the VPA method. There are good reasons to assume that in above years there were the most favourable conditions for formation of dense halibut concentrations on continental slope which resulted in a high level of fish availability during the stock evaluation by the trawl survey method.

Thus, the obtained values of biomass and abundance should be regarded as minimum ones, and TAC estimates - very precautious.

Taking into account a wide range of Greenland halibut, its behaviour and also a low level of directed fishery the trawl survey can be concluded under certain environmental conditions to be the most reliable method of stock study and rationally arranged fishery.

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Table 1. Landings (metric tons) of Greenland halibut by NAFO Subareas 0, 1 and Divs. 2GHJ, 3KL, NK for 1969-88

Year	Subarea, Division						Total
	0+1	2G	2H	2J	3KL	NK	
I969	25I0	282	I522	8045	I6592	I0079	39030
I970	I884	36	722	3394	22442	9808	38286
I97I	4336	390I	3702	2596	I4I93	262	28990
I972	I3897	I42	I679	8465	I7I78	2358	437I9
I973	9558	I565	6909	5964	I4506	-	38502
I974	I4257	4542	2902	8I65	II5I4	-	4I380
I975	24948	2I32	I707	8I94	I6648	-	53629
I976	I5788	237I	3I77	3528	I5522	I	40387
I977	I2649	I778	I524	8237	20402	-	44590
I978	II653	I899	I207	3723	3I703	-	50I85
I979	I9I88	577	I623	34I5	28453	I	53257
I980	8272	36	444	I466	30696	-	409I4
I98I	956I	I799	2I4I	I358	25384	-	40243
I982	928I	370	8984	593I	I0929	-	35495
I983	8687	III	567I	6028	I6029	-	36526
I984	703I	2I4	4663	6368	I3564	-	3I840
I985	I0I7I	I93	2358	6724	9335	-	2878I
I986	8977	455	I564	6I44	7045	-	24I85
I987	9928	2700	2576	9949	I2977	-	38I30
I988	9909	I328	2447	I889	I2635	3	282II

Note: 1969-1985 - Statistical Bull. NAFO, Historical catches of selected species by stock, area and countries for the period 1963-1984, NAFO SCS Doc.86/2

1986-1988 - Provisional nominal catches in NW Atlantic, NAFO SCS Doc.87/20, NAFO SCS Doc.88/18, NAFO SCS Doc.89/21

Table 2. Landings (metric tons) of Greenland halibut by all countries in NW Atlantic (SA 0,1,2 and Divs. 3KL) according to NAFO Stat.Bull. data

Year	USSR	Canada	FRG	Greenland	GDR	Poland	Faeroes	Portugal	Others	Total
I965	48I	8082	-	3045	-	942	I8	-	2	I2570
I966	242	I6209	423	2573	I355	III4	2	-	2	2I920
I967	4287	I6604	300	I834	I650	3296	-	-	-	2797I
I968	I02I7	I3322	I37	I568	4259	5806	-	-	-	35309
I969	I0204	II553	270	I477	I0022	5407	I	-	96	39030
I970	8043	I0706	26	I2I2	9I58	8266	-	-	875	38286
I97I	I0937	9408	I6	II59	I02I	5234	38	-	II77	28990
I972	I9825	8952	2I4	2950	965	7I2I	I4I2	-	2280	437I9
I973	I2783	6840	772	4632	2435	9060	950	207	823	38502
I974	I9I6I	5745	5I7	4060	3302	7I05	4	I93	I293	4I380
I975	29669	7807	646	3724	208I	8447	825	272	I58	53629
I976	I7733	9306	I020	3546	I672	5942	95I	I68	49	40387
I977	8664	I7967	I345	6II0	2528	5998	I357	II9	502	44590
I978	5632	24692	5987	5985	I636	52I5	820	-	2I8	50I85
I979	2948	29940	I2893	5273	I78	I8I3	50	38	I24	53257
I980	I784	3I9I0	I229	5356	3I6	203	60	2I	35	409I4
I98I	695I	24I25	I0	5755	I350	I806	I70	I6	60	40243
I982	5009	I9248	66	5397	2487	IIII	337	I8I8	22	35495
I983	4709	I7II3	I6	4I36	2587	5258	774	I9I8	I5	36526
I984	549	I7283	24	6509	2498	943	370	26I2	I052	3I840
I985	328	I2277	482	9I27	2I85	460	7I8	2940	264	2878I
I986	802	8076	I6	8705	I867	I77	69I	3I07	744	24I85
I987	4092	I4448	-	8634	3266	I00I	2I58	I390	3I4I	38I30
I988	II22	8406	43	8266	2247	904	-	4II8	3I05	282II

Table 3. Age composition of Greenland halibut catches, 10^6 spec.

Age group	I975	I976	I977	I978	I979	I980	I98I	I982	I983	I984	I985	I986	I987	I988	I989
5	0.I8	0.I0	0.45	I.6I	0.24	0.I0	0.33	0.I4	0.20	0.I4	0.30	I.25	0.38	0.37	0.24
6	0.83	0.64	I.25	2.09	0.79	0.37	I.3I	0.56	0.73	0.40	0.64	0.88	I.78	I.69	I.04
7	2.46	2.I7	2.43	I.78	I.75	0.78	2.37	I.23	I.23	0.90	I.04	I.73	3.73	3.64	3.I9
8	2.45	2.50	2.30	I.96	2.20	I.03	I.84	I.56	I.62	0.80	I.I2	I.34	2.40	2.25	I.67
9	2.30	I.74	I.30	0.60	I.9I	0.88	I.06	I.46	I.08	0.56	0.79	I.05	I.07	0.95	I.00
I0	I.64	I.I5	0.73	0.52	I.33	0.59	0.64	I.05	0.6I	0.35	0.49	0.35	0.48	0.40	0.38
II	0.98	0.55	0.3I	0.2I	0.62	0.28	0.3I	0.60	0.37	0.33	0.28	0.28	0.I7	0.I6	0.2I
I2	0.58	0.43	0.23	0.I2	0.46	0.2I	0.25	0.44	0.23	0.I7	0.23	0.I6	0.I2	0.I2	0.22
I3	0.40	0.44	0.22	0.I5	0.42	0.I9	0.23	0.36	0.I9	0.I6	0.20	0.I2	0.I2	0.I5	0.I7
I4	0.22	0.22	0.I0	0.I2	0.20	0.07	0.09	0.24	0.I2	0.I2	0.I9	0.07	0.07	0.08	0.09
I5	0.I6	0.I6	0.08	0.I2	0.I4	0.04	0.05	0.I6	0.07	0.I3	0.05	0.02	0.06	0.05	0.II
I6	0.09	0.08	0.04	0.07	0.08	0.02	0.02	0.I0	0.07	0.I0	0.06	0.06	0.04	0.02	0.07
I7	0.08	0.I3	0.06	0.03	0.I3	0.02	0.03	0.2I	0.I0	0.07	0.06	0.I2	0.06	0.03	0.0I
Total	I2.4	I0.3	9.5	9.4	I0.3	4.6	8.6	8.I	6.6	4.2	5.5	7.4	I0.5	9.9	8.4
Mean age	9.0	9.0	8.2	7.5	9.0	8.9	8.I	9.4	8.7	9.I	8.7	7.8	7.7	7.7	8.0

Table 4. Mean weight by age groups, g

Age group	I975	I976	I977	I978	I979	I980	I98I	I982	I983	I984	I985	I986	I987	I988	I989
5	689	7I6	678	566	566	589	607	6I3	657	690	52I	375	637	608	63I
6	9I7	898	870	790	790	790	79I	807	850	902	720	688	835	8I6	842
7	I203	II5I	II54	II39	II39	II4I	I07I	III2	II34	I226	I0II	943	I063	I057	I094
8	I662	I455	I460	I506	I506	I5II	I4I0	I5II	I495	I589	I348	I2II	I365	I36I	I462
9	2I7I	I833	I808	I865	I865	I845	I796	I845	I94I	20I7	I665	I564	I725	I707	I807
I0	262I	22I5	2I75	22I5	22I5	22I2	2209	220I	2398	23II	2093	I829	2066	2097	2I79
II	3257	2699	2665	2649	2649	2678	2724	2680	2806	3846	2690	2223	26II	2690	264I
I2	3539	320I	3I70	3I23	3I23	3I35	3I49	3I73	3687	3953	3824	3303	3I93	3362	34II
I3	4852	3928	3866	3837	3837	3744	37I7	3844	4744	5I75	44I4	4094	4033	4I36	4377
I4	5677	4832	4772	480I	480I	4488	4523	4700	55II	5450	5450	4908	50I6	4949	5252
I5	687I	5700	5695	5786	5786	5240	544I	5585	6073	6285	6285	58I9	5894	5722	5942
I6	7574	6099	6II2	6202	6202	5765	5902	60I3	7I48	636I	8939	6465	636I	6084	76I6
I7	9279	7I37	7I7I	725I	725I	6725	7003	7025	8II0	7490	8238	7440	7490	7455	906I

Table 5. Natural mortality and partial recruitment coefficients by age groups

Age group	Natural mortality coefficient M (τ)	Partial recruitment coefficient at M=0.1
5	0.II6	0.I696
6	0.097	0.35II
7	0.08I	I.0000
8	0.069	0.9847
9	0.060	0.7060
I0	0.056	0.3933
II	0.056	0.3288
I2	0.06I	0.4I9I
I3	0.072	0.6868
I4	0.089	0.9386
I5	0.II3	0.4764
I6	0.I46	0.63I0
I7	0.I89	0.6703

Table 6. Abundance of Greenland halibut of different age groups by years of fishery, 10^6 spec.

Age group	I975	I976	I977	I978	I979	I980	I98I	I982	I983	I984	I985	I986	I987	I988	I989
5	I4.46	I2.93	I2.85	I8.I4	2I.30	I4.67	I4.28	I7.99	I5.87	I9.78	I8.43	20.58	27.75	23.40	I7.33
6	I7.22	I2.90	II.6I	II.20	I4.88	I9.05	I3.I8	I2.6I	I6.I4	I4.I7	I7.76	I6.38	I7.43	24.75	20.82
7	I4.09	I4.80	II.07	9.32	8.I5	I2.7I	I6.89	I0.67	I0.88	I3.9I	I2.44	I5.47	I3.99	I4.08	20.78
8	9.I4	I0.42	II.33	7.7I	6.74	5.7I	I0.76	I3.03	8.49	8.68	II.73	I0.26	I2.35	9.I2	9.28
9	8.48	5.94	7.06	8.07	5.II	4.0I	4.I9	7.99	I0.30	6.I4	7.08	9.55	8.0I	8.90	6.I2
I0	7.25	5.49	3.73	5.I5	6.73	2.82	2.79	2.78	5.85	8.29	5.03	5.66	7.64	6.23	7.I8
II	5.35	5.00	3.88	2.68	4.I7	4.83	2.00	I.92	I.53	4.7I	7.I7	4.09	4.79	6.46	5.25
I2	2.9I	3.9I	4.00	3.22	2.23	3.I9	4.II	I.5I	I.I7	I.03	3.95	6.22	3.43	4.I7	5.70
I3	I.74	2.08	3.I2	3.40	2.80	I.58	2.68	3.48	0.95	0.84	0.78	3.36	5.47	2.99	3.66
I4	0.73	I.20	I.46	2.6I	2.94	2.I3	I.24	2.2I	2.80	0.68	0.6I	0.5I	2.93	4.83	2.57
I5	I.3I	0.45	0.88	I.23	2.25	2.47	I.86	I.04	I.77	2.42	0.50	0.37	0.39	2.58	4.29
I6	0.87	I.03	0.26	0.72	I.00	I.90	2.20	I.64	0.79	I.54	2.07	0.4I	0.3I	0.30	2.28
I7	0.82	0.70	0.85	0.20	0.59	0.82	I.7I	I.97	I.38	0.65	I.29	I.82	0.3I	0.24	0.25
Total	84.4	76.9	72.I	73.6	78.9	75.9	77.9	78.8	77.9	82.9	88.8	94.7	I04.8	I08.I	I05.5

Table 7. Fishing mortality coefficients

Age group	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
5	0.0135	0.0079	0.0374	0.0979	0.0119	0.0074	0.0249	0.0084	0.0133	0.0076	0.0175	0.0660	0.0144	0.0170	0.0149
6	0.0517	0.0537	0.1202	0.2174	0.6575	0.8205	0.1107	0.0477	0.0486	0.0300	0.0386	0.0580	0.1136	0.0745	0.0539
7	0.2024	0.1669	0.2613	0.2236	0.2552	0.0667	0.1596	0.1293	0.1261	0.0705	0.0924	0.1248	0.3276	0.3165	0.1756
8	0.3303	0.2894	0.2394	0.3108	0.4185	0.2098	0.1974	0.1343	0.2233	0.1025	0.1059	0.1478	0.2278	0.2993	0.2097
9	0.3345	0.3670	0.2142	0.0811	0.4945	0.2619	0.3096	0.2127	0.1171	0.1004	0.1253	0.1224	0.1515	0.1192	0.1829
10	0.2714	0.2475	0.2286	0.1115	0.2317	0.2457	0.2751	0.5009	0.1156	0.0456	0.1070	0.0666	0.0682	0.0707	0.0573
11	0.2144	0.1231	0.0879	0.0866	0.1693	0.0623	0.1803	0.3955	0.2896	0.0757	0.0422	0.0755	0.0371	0.0257	0.0425
12	0.2367	0.1242	0.0628	0.0397	0.2448	0.0721	0.0669	0.3606	0.2275	0.1857	0.0633	0.0283	0.0368	0.0312	0.0416
13	0.2727	0.2510	0.0779	0.0461	0.1702	0.1357	0.0939	0.1164	0.2294	0.2219	0.3201	0.0370	0.0239	0.0526	0.0488
14	0.3759	0.2123	0.0776	0.0490	0.0726	0.0361	0.0781	0.1200	0.0445	0.2126	0.4066	0.1675	0.0273	0.0187	0.0371
15	0.1405	0.4545	0.0952	0.1075	0.0680	0.0167	0.0286	0.1782	0.0430	0.0598	0.1107	0.0739	0.1694	0.0223	0.0283
16	0.1112	0.0910	0.1808	0.1023	0.0905	0.0105	0.0115	0.0683	0.09[illegible]	0.0737	0.0294	0.1747	0.1341	0.0768	0.0342
17	0.1091	0.2232	0.0826	0.1558	0.2647	0.0298	0.[illegible]18	0.1216	0.0822	0.1129	0.0483	0.0701	0.2412	0.1327	0.0342
5-17	0.1744	0.1581	0.1525	0.1467	0.1577	0.0685	0.1258	0.1204	0.0958	0.0562	0.0681	0.0868	0.1165	0.1072	0.0899

Table 8. Biomass of Greenland halibut of different age groups by years of fishery, 10^3 t

Age group	I975	I976	I977	I978	I979	I980	I98I	I982	I983	I984	I985	I986	I987	I988	I989
5	9.96	9.26	8.7I	I0.27	I2.06	8.64	8.67	II.03	I0.42	I3.65	9.60	7.72	I7.67	I4.23	I0.94
6	I5.79	II.59	I0.I0	8.85	II.76	I5.05	I0.42	I0.I7	I3.72	I2.78	I2.79	II.27	I4.55	20.I9	I7.63
7	I6.96	I7.03	I2.77	I0.6I	9.28	I4.50	I8.08	II.87	I2.33	I7.06	I2.58	I4.58	I4.87	I4.88	22.74
8	I5.I9	I5.I5	I6.55	II.6I	I0.I5	8.53	I5.I7	I9.58	I2.69	I3.78	I5.8I	I2.43	I6.86	I2.42	I3.57
9	I8.4I	I0.90	I2.76	I5.05	9.54	7.40	7.53	I4.75	20.00	I2.39	II.80	I4.93	I3.82	I5.I9	II.06
I0	I9.0I	I2.I6	8.II	II.42	I4.92	6.24	6.I7	6.I3	I4.02	I9.I7	I0.52	I0.34	I5.79	I3.06	I5.58
II	I7.44	I3.50	I0.34	7.II	II.05	I2.94	5.44	5.I5	4.28	I8.I2	I9.29	9.08	I2.50	I7.38	I3.87
I2	I0.30	I2.5I	I2.69	I0.04	6.95	9.99	I2.94	4.79	4.3I	4.09	I5.I2	20.54	I0.95	I4.03	I9.43
I3	8.46	8.I7	I2.08	I3.05	I0.73	5.90	9.97	I3.37	4.52	4.36	3.43	I3.74	22.06	I2.37	I6.02
I4	4.I4	5.80	6.98	I2.55	I4.II	9.58	5.63	I0.39	I5.43	3.73	3.33	2.50	I4.68	23.92	I3.48
I5	8.97	2.58	5.0I	7.09	I3.04	I2.96	I0.I3	5.82	I0.77	I5.23	3.I5	2.I4	2.30	I4.75	25.50
I6	6.57	6.26	I.59	4.48	6.I7	I0.98	I2.99	9.85	5.64	9.78	I8.47	2.62	I.97	I.8I	I7.37
I7	7.63	5.0I	6.08	I.42	4.28	5.53	II.94	I3.83	II.22	4.86	I0.64	I3.50	2.3I	I.83	2.26
Total	I58.8	I29.9	I23.8	I23.6	I34.0	I28.4	I35.I	I36.8	I39.4	I49.0	I46.5	I35.4	I60.3	I76.I	I99.4

Table 9. Greenland halibut stock status and TAC forecasting for 1991 in SA 0, 1 and Divs. 2GH at constant natural mortality coefficient (M=0.1)

Age group	1989		1990			1991				
	Numbers, 10^6 spec	F	Numbers, 10^6 spec	Biomass, 10^3 t	TAC, 10^3 t F_{1989}	Numbers, 10^6 spec.	Biomass, 10^3 t	TAC, 10^3 t F_{1989}	TAC, 10^3 t $F_{0.1}$=0.14	TAC, 10^3 t F_{max}=0.22
5	25.56	0.0I49	25.56	I6.I3	0.22	25.56	I6.I3	0.22	0.32	0.53
6	2I.33	0.0539	2I.67	I8.25	0.89	2I.67	I8.25	0.89	0.77	I.23
7	2I.28	0.I756	I7.39	I9.03	2.85	I7.67	I9.34	2.90	2.36	3.48
8	9.50	0.2097	I5.37	22.47	3.96	I2.56	I8.36	3.23	2.52	3.I5
9	6.27	0.I889	6.63	II.99	I.92	I0.73	I9.38	3.II	2.0I	2.52
I0	7.32	0.0573	4.47	9.73	0.50	4.73	I0.30	0.53	0.62	0.80
II	5.38	0.0425	5.95	I5.72	0.6I	3.63	9.58	0.37	0.44	0.58
I2	5.84	0.04I5	4.44	I5.I4	0.57	4.9I	I6.75	0.63	0.98	I.32
I3	3.75	0.0488	4.82	2I.I0	0.93	3.66	I6.04	0.7I	I.48	2.00
I4	2.63	0.037I	3.07	I6.I5	0.55	3.95	20.75	0.70	2.50	3.26
I5	4.40	0.0283	2.I8	I2.96	0.34	2.55	I5.I5	0.39	0.9I	I.20
I6	2.34	0.0342	3.68	28.03	0.88	I.83	I3.90	0.43	I.I6	I.62
I7	0.26	0.0342	1.94	I7.6I	0.55	3.06	27.73	0.87	2.42	3.49
Total	II5.9		II7.2	224.3	I4.8	II6.5	22I.7	I5.0	I8.5	25.2

Table 10. Fishing efficiency of the USSR large trawlers and estimated fishing effort of all countries carrying out halibut fishery in SA O, 1 and Divs. 2GH in 1975–1988

Year	Catch per hour trawling, t	Total fishing effort, 10^3 t per hr.tr.
I975	I.48	I9.5
I976	I.76	I2.I
I977	I.I9	I3.4
I978	I.47	I0.0
I979	I.44	I4.9
I980	I.49	5.9
I98I	I.5I	8.9
I982	I.53	I2.2
I983	0.92	I5.7
I984	0.78	I5.3
I985	0.45	28.3
I986	0.65	I6.9
I987	I.0I*	I5.I
I988	I.02*	I3.4

* Average annual fishing efficiency of Japanese vessels (Vozumi, 1989)

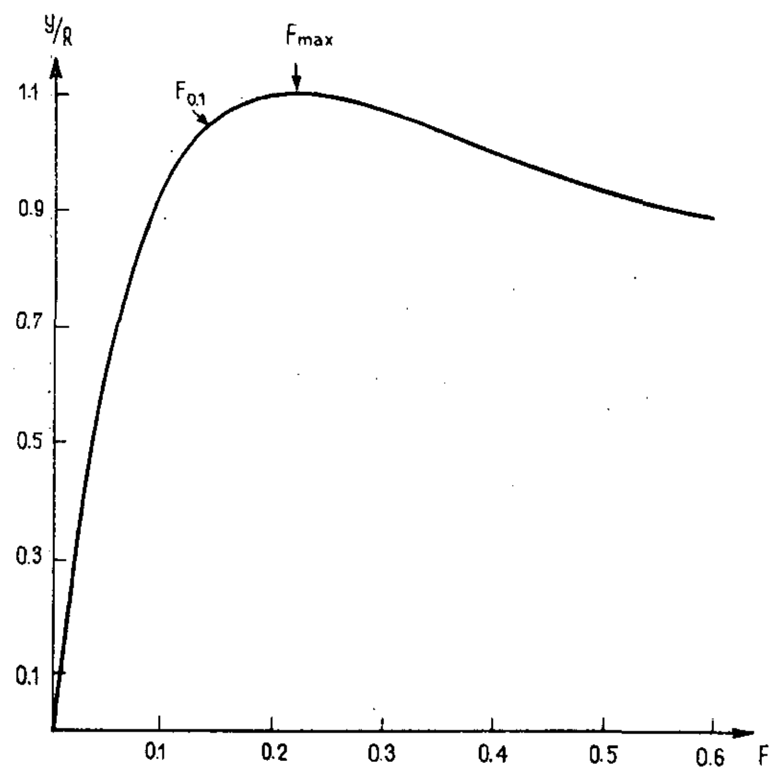

Fig.1 Yield per recruit for Greenland halibut in NAFO Subareas 0, 1 and Divs. 2GH.

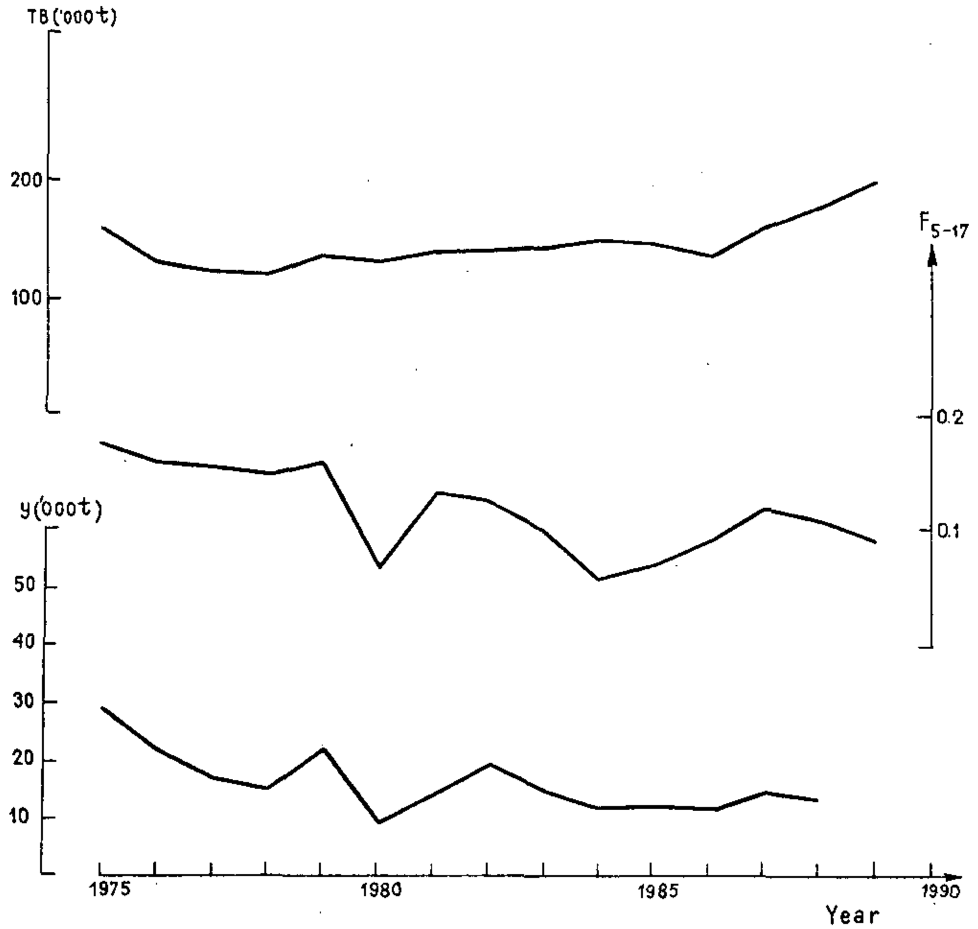

Fig.2 Trend of total stock biomass (TB), catch in weght (Y) and fishing mortality coefficient (F) of Greenland halibut in NAFO Subareas 0, 1 and Divs. 2GH.

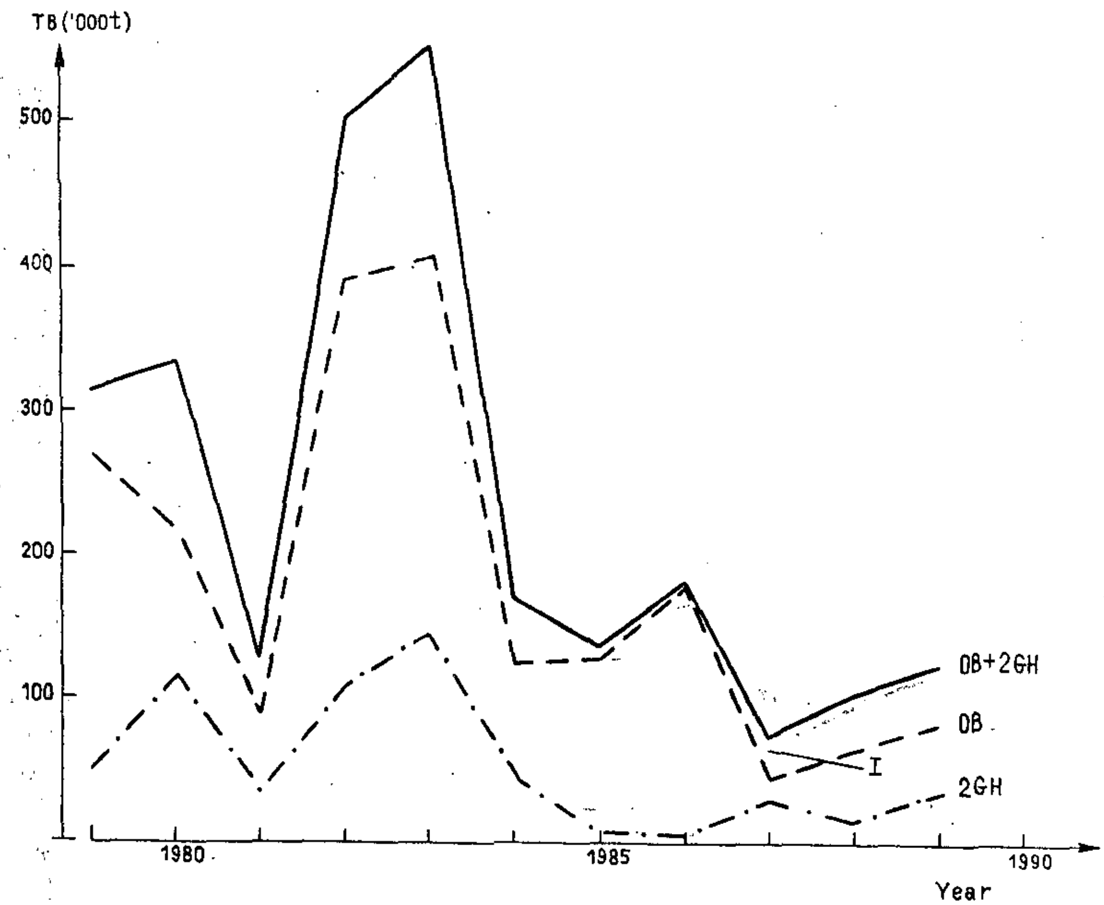

Fig.3 Indices of Greenland halibut biomass in NAFO Subarea 1 and Divs. OB, 2GH according to data from Soviet trawl surveys carried out in 1979–1989.