Northwest Atlantic Fisheries Organization

Serial No. N4106 **NAFO SCR Doc. 99/47**

SCIENTIFIC COUNCIL MEETING – JUNE 1999

Analysis of data from the commercial fishery for Greenland halibut in Subarea 0.

by

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Abstract

Data on Greenland halibut from the commercial fishery in Subarea 0 were analyzed. Catch at age showed a slight shift to younger fish after 1993, with a peak at age 7 in each year. There were no major trends in weight at age during the 1990's. There was little range in the standardized catch rate from 1990 to 1998, although CPUE in 1995 was slightly higher than in 1996-1998. Standardized effort was lower in the 1994-98 period than in the earlier 4 years, due mainly to the reduced quota available for the fleets in the latter period. Due to the frequency of fleet changes in this fishery, the index of CPUE may not be a reliable indicator of stock abundance in this area.

Introduction

Catches of Greenland halibut in Subarea 0 increased from less than 1000 tons annually in the late 1980's to an average of about 12,000 tons per year in 1990-92 (Jorgensen 1998). A new management unit was introduced in 1995, which excluded Division 1A in the inshore waters of Greenland from the TAC for Subareas 0+1. As a result, the TAC for Subarea 0+1 offshore was decreased from 25,000 tons to 11,000 tons, and catches in Subarea 0 were reduced to between 5,000 and 6,000 tons per year in 1995 to 1997. A further reduction to about 4400 tons occurred in 1998, as some allocations were not fished. With the exception of a relatively small inshore fishery in Cumberland Sound, and recent exploratory fishing in Subarea 0, almost all the catch in Subarea 0 occurs offshore in Division 0B. Catches are taken mainly by otter trawl, although catches by gillnet are becoming more important. Relatively small amounts of longline catch also occur. In 1997, about 70 % of the catch of 5740 tons was taken by otter trawl, but this percentage was lower in 1998 (Table 1). Vessels from Canada, Japan, Faroes, Russia, and Norway have been the main participants in the fishery since the late 1980's, although there have been many changes to fleet compositions over time. During the 1990's, much of the Canadian quota in this fishery has been caught under charter agreements with vessels from most of the nations listed above. This paper updates catch at age and mean weights at age from the offshore fishery in Div. 0B from 1998, and presents an analysis of CPUE data from stern otter trawlers for the period 1990-98.

Methods and Materials

Brodie and Bowering (1998) presented catch at age and mean weight at age data from 1988-93 taken from Atkinson et al. (1994), as well as the data for 1994-97, which had been calculated annually and incorporated in the assessments of the G. halibut stock in Subareas 0+1 (eg. Jorgensen 1998). Data from the fishery in 1998 were used to generate the catch at age and weights at age for that year, using the same procedures as for the previous years. Most of the sampling data used in these analyses were collected at sea by observers, although some port sampling information was also included. CPUE data were collected by observers on a set by set basis, and aggregated in this analysis by vessel and month. A multiplicative model (Gavaris 1980) was used to derive a standardized catch rate series. As in the previous analysis (Brodie and

Bowering 1998), categories used in the model were country-gear-tonnage class (CGT), month, and year. Observations with fewer than 10 tons of catch or 10 hours of effort were deleted, along with CGT categories with fewer than 3 observations and months with 5 or fewer data points. A total of 368 observations were analyzed from an original dataset of 425. All data used were from the second half of the year, as there were only 5 observations from the first half (all in June). Data from the exploratory fishery in Div 0A in 1996 and 1997 were included in the catch rate analysis, but excluded from the catch at age calculations, as these will be presented elsewhere.

Results and Discussion

Catch at age

Table 2 shows the catch at age calculations for the 1998 fishery. Sampling of the gillnet fishery was derived from length frequencies in the month of July totaling about 800 measurements, while the otter trawl component contained many samples, consisting of over 15,000 measurements. As was the case with the 1997 data, this discrepancy can be explained by the deployment of observers on all otter trawl vessels in the fishery in 1997. Gillnet sampling was applied to the longline catch, as the latter gear was not sampled in 1998. Despite the considerable difference in sampling, the C.V.'s on the numbers at age in the gillnet fishery in 1998 are similar to those in the otter trawl fisheries (Canada and Faroes). Age length keys, again made up largely (869 of 1096 otoliths) of samples collected by observers on the otter trawl fleet, was used to derive the age composition in 1998. Age compositions in the two otter trawl fisheries were very similar, with ages 7 and 8 ranking first and second in each catch (Table 2). Gillnet catches were dominated by ages 10 and 11. Overall, sampling levels were better in 1998 than 1997, although the fixed gear fisheries were still not sampled adequately in 1998, particularly with respect to season.

Table 3 (a and b) shows the catch at age and mean weights at age for 1988-1998, along with a sum-of-products (S.O.P.) check (Table 3c). The nominal catches used to derive the total catch at age values were taken from Table 1 of Jorgensen (1998). For 1998, mean weights at age were calculated from mean lengths at age using the length-weight relationship for NAFO Div. 2G, calculated from survey data obtained in 1997 (Gundersen and Brodie 1999). As noted by Atkinson et al. (1994), there was a shift in the catch at age to younger fish with the increased otter trawl fishery in 1990 onward. In 1988-89, catches were taken mainly by longlines in deep water, and contained proportionally more old fish. From 1990-93, age 8 was predominant in catches, but from 1994-98, the modal age in each year was 7. This may be due in part to the fishery occurring slightly later in the year in the latter period. Few fish older than 13 years appeared in the catch at age after 1990, although a few individuals as old as 16 were taken in the fishery every year. Mean weights at ages 7 to 12 showed little in the way of trends over time (Fig. 1). The S.O.P. check (Table 3c) indicated a slight bias toward underestimating the catch weight in most years, the reason for which is not apparent, although there is no length weight relationship available for Subarea 0 during the period studied here.

CPUE

The results of the CPUE analysis are shown in Table 4. All 3 factors (CGT, month, year) were significant, and the regression explained 82% of the variation. There was a seasonal trend, with CPUE from November, and particularly December, being higher than other months. This is probably due to the formation of pre-spawning concentrations of G.halibut in deep water. There were also significant differences between fleets, with Norwegian CPUE being highest and Russian being lowest. It should be noted that the Russian data include vessels which were previously coded as Soviet Union, and also vessels which were previously Soviet Union but became vessels of Baltic countries. There was little range in the standardized catch rate over time (Table 5, Fig. 2). The CPUE in 1995 was slightly higher than previous and subsequent years, although between-year differences were not statistically significant. Standardized effort was lower in the 1994-98 period than in the earlier 4 years, due mainly to the reduced quota available for the fleets in this period.

The lack of overlap of fleets throughout the time series may cause some problems in the CPUE standardization. This can be seen in the unstandardized catch rates in Fig. 3, where there is not a single fleet which is present in all 9 years of the time series. The longest series, Faroes TC 7, shows a relatively constant increase over time, although this fleet did not fish in 1998. Other factors not accounted for in the model but which could affect CPUE include learning, since the otter trawl fishery was new in 1990, and migration in either

direction between Subarea 0 and 1, given the geographic features of the deep strata in the area of the boundary. There are no recent research vessel surveys of Div. 0B to verify trends in CPUE, although USSR/Russia conducted stratified random trawl surveys in this area from 1979-92 (Gorchinsky 1993). These data show a sharp drop in biomass from higher levels in 1979-86 to a much lower value in 1987. The biomass increased slightly up to 1990, then declined in 1992 to just above the 1987 value. Given the wide confidence limits around the recent CPUE estimates, and the lack of continuity in the fleet composition, it is unlikely that the CPUE series calculated here can be considered a reliable index of stock abundance.

References

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Table 1. Catches of Greenland halibut in Subarea 0 in 1998.

	Can(M) OT	Can(N) OT	Can(N) LL	Faroes (OT)	**Total**
Jan					
Feb					
Mar					
Apr					
May					
Jun		415			**415**
Jul		694	81		**775**
Aug		266	92		**358**
Sep		169			**169**
Oct		231	60		**291**
Nov	604	79		51	**734**
Dec	574			584	**1158**
Total	**1178**	**1854**	**233**	**635**	**3900**

Total catch estimate is 4370, based on Canadian quota reports.
Some data are month caught, others are month landed.

Table 2. Catch at age with associated statistics, and mean lengths and weights at age of Greenland halibut caught in the commercial fishery in Div. 0B in 1997. The 4 tables show the data for gillnet, otter trawl (Canada and Faroes), and total.

Gillnet

AGE	AVERAGE WEIGHT	AVERAGE LENGTH	CATCH MEAN	CATCH STD. ERR.	CATCH C. V.
7	1.234	52.111	6	1.26	0.21
8	1.340	53.376	29	4.90	0.17
9	1.948	59.909	105	11.01	0.10
10	2.511	64.775	165	15.15	0.09
11	3.232	69.998	160	15.62	0.10
12	3.931	74.374	69	11.62	0.17
13	4.846	79.279	58	9.00	0.15
14	6.048	84.808	42	7.44	0.18
15	6.951	88.571	5	2.74	0.56

OTB (Faroes)

AGE	WEIGHT	LENGTH	MEAN	STD. ERR.	C. V.
4	0.281	32.923	1	0.42	0.37
5	0.450	37.974	13	3.82	0.29
6	0.566	40.950	60	6.91	0.11
7	0.901	47.178	229	9.37	0.04
8	1.351	53.504	83	8.76	0.11
9	1.819	58.633	60	6.59	0.11
10	2.433	64.175	22	3.42	0.16
11	2.936	67.996	9	1.88	0.20
12	3.726	73.149	5	0.87	0.17
13	4.460	77.328	1	0.38	0.32
14	5.075	80.500		0.18	0.46
15	6.695	87.579			0.01
16	7.977	92.500			0.01

OTB (Canada)

AGE	WEIGHT	LENGTH	MEAN	STD. ERR.	C. V.
3	0.173	28.500			0.01
4	0.353	35.398	4	1.15	0.30
5	0.450	38.104	24	4.16	0.17
6	0.657	42.772	140	15.82	0.11
7	0.908	47.302	282	23.47	0.08
8	1.250	52.214	259	19.87	0.08
9	1.758	57.928	108	10.19	0.09
10	2.433	64.177	39	3.92	0.10
11	3.009	68.454	30	3.07	0.10
12	3.818	73.671	12	1.79	0.14
13	4.658	78.271	7	1.24	0.17
14	5.666	83.180	2	0.49	0.32
15	5.943	84.500		0.31	0.68

Total

AGE	WEIGHT	LENGTH	MEAN	STD. ERR.	C. V.
3	0.173	28.500			0.01
4	0.337	34.832	6	1.37	0.25
5	0.450	38.059	42	6.33	0.15
6	0.630	42.225	225	19.35	0.09
7	0.909	47.303	579	28.36	0.05
8	1.280	52.593	416	24.94	0.06
9	1.845	58.846	307	18.36	0.06
10	2.490	64.614	253	17.95	0.07
11	3.185	69.671	224	17.96	0.08
12	3.903	74.203	97	13.21	0.14
13	4.819	79.135	75	10.19	0.14
14	6.025	84.712	49	8.36	0.17
15	6.858	88.197	6	3.09	0.50
16	7.977	92.500			0.01

Table 3. Catch-at-Age (000s) and Weight-at-Age (kg) of Greenland Halibut in Subarea 0 (mainly Div. 0B). (Catches from SCR 98/56 used to adjust catch numbers at age)

A) Catch-at-Age

					Year						
Age	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
1	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	1
4	0	0	0	0	9	1	2	0	2	6	6
5	0	0	2	14	45	30	46	18	28	58	42
6	0	0	53	208	524	332	183	189	243	355	225
7	1	2	398	1191	2078	1668	1044	1254	1417	1273	579
8	5	9	1387	1888	2738	1933	743	641	980	1050	416
9	9	11	1186	1059	1688	891	488	388	489	478	307
10	18	13	663	447	657	474	142	245	254	216	253
11	24	14	335	175	217	156	86	168	110	173	224
12	31	30	184	122	147	89	83	168	69	90	97
13	39	32	183	96	120	50	58	62	28	67	75
14	30	34	111	50	60	22	25	29	14	15	49
15	24	20	63	30	24	13	17	16	8	9	6
16	8	8	14	4	6	4	11	5	2	7	1
17	1	0	2	0	1	0	2	1	1	1	0
18	0	0	0	0	0	0	1	0	0	0	0
Total	190	173	4580	5285	8313	5663	2931	3184	3645	3798	2281
Catch(t)	**1024**	**907**	**9498**	**8606**	**12358**	**7489**	**4321**	**5299**	**5519**	**5740**	**4370**

B) Weight- at Age (kg)

					Year						
Age	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
1											
2											
3											0.173
4					0.196	0.175	0.228		0.269	0.241	0.337
5			0.376	0.356	0.333	0.302	0.406	0.358	0.351	0.359	0.450
6			0.562	0.554	0.572	0.526	0.559	0.568	0.537	0.547	0.630
7	0.818	0.785	0.813	0.820	0.829	0.810	0.857	0.897	0.896	0.862	0.909
8	1.200	1.076	1.098	1.143	1.162	1.170	1.210	1.302	1.321	1.276	1.280
9	1.781	1.585	1.533	1.632	1.692	1.716	1.690	1.810	1.814	1.838	1.845
10	2.446	2.149	2.122	2.333	2.420	2.357	2.235	2.523	2.397	2.378	2.490
11	3.244	2.878	2.961	3.390	3.390	3.264	2.767	3.152	3.141	3.005	3.185
12	4.169	3.822	3.916	4.364	4.309	4.266	3.426	3.927	3.979	3.831	3.903
13	5.136	4.929	4.986	5.610	5.555	5.519	4.608	5.007	5.132	4.932	4.819
14	6.317	6.265	6.275	7.022	7.176	6.803	6.038	5.893	5.943	5.713	6.025
15	7.736	7.825	8.049	8.669	8.786	7.976	6.534	6.849	6.568	6.783	6.858
16	9.511	9.883	10.354	10.849	10.269	9.786	6.106	8.654	8.168	8.002	7.977
17	10.772		12.804		11.951		10.006	9.937	8.694	8.641	
18							6.655				

C) Sum of products (t)

					Year						
Age	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
4	0.0	0.0	0.0	0.0	1.8	0.2	0.5	0.0	0.5	1.4	2.0
5	0.0	0.0	0.7	5.0	14.9	8.9	18.7	6.4	9.8	20.8	18.9
6	0.0	0.0	29.9	115.2	299.7	174.9	102.3	107.4	130.5	194.2	141.8
7	0.8	1.6	324.0	976.8	1722.5	1351.4	894.7	1124.8	1269.6	1097.3	526.3
8	6.0	9.7	1522.9	2158.2	3181.9	2261.6	899.0	834.6	1294.6	1339.8	532.5
9	16.0	17.4	1817.8	1728.9	2856.4	1529.4	824.7	702.3	887.0	878.6	566.4
10	44.0	27.9	1405.9	1043.2	1590.3	1117.6	317.4	618.1	608.8	513.6	630.0
11	77.9	40.3	990.9	592.1	736.2	510.5	238.0	529.5	345.5	519.9	713.4
12	129.2	114.7	719.6	533.6	631.9	377.7	284.4	659.7	274.6	344.8	378.6
13	200.3	157.7	911.5	538.9	665.4	276.9	267.3	310.4	143.7	330.4	361.4
14	189.5	213.0	698.0	349.6	433.8	147.2	151.0	170.9	83.2	85.7	295.2
15	185.7	156.5	506.0	257.4	206.6	102.0	111.1	109.6	52.5	61.0	41.1
16	76.1	79.1	140.2	47.4	57.5	38.5	67.2	43.3	16.3	56.0	8.0
17	10.8	0.0	24.8	0.0	13.4	0.0	20.0	9.9	8.7	8.6	0.0
18	0.0	0.0	0.0	0.0	0.0	0.0	6.7	0.0	0.0	0.0	0.0
SOP	**936**	**818**	**9092**	**8346**	**12412**	**7897**	**4203**	**5227**	**5125**	**5452**	**4216**
SOP/catch	**0.91**	**0.90**	**0.96**	**0.97**	**1.00**	**1.05**	**0.97**	**0.99**	**0.93**	**0.95**	**0.96**

Table 4. Results of regression of catch and effort data, with a multiplicative model, for Greenland halibut in Subare 0. Category 1 is country-gear-tonnage class (CGT), category 3 is month, and category 4 is year. Types 1-3 in the sums of square table refer to the 3 categories.

REGRESSION OF MULTIPLICATIVE MODEL

MULTIPLE R..... 0.906
MULTIPLE R SQUARED..... 0.822

ANALYSIS OF VARIANCE

SOURCE OF VARIATION	DF	SUMS OF SQUARES	MEAN SQUARES	F-VALUE
INTERCEPT	1	8.899E0	8.899E0	
REGRESSION	22	2.680E0	1.218E-1	72.247
TYPE 1	9	1.223E0	1.358E-1	80.566
TYPE 2	5	1.045E-1	2.089E-2	12.393
TYPE 3	8	4.579E-2	5.723E-3	3.395
RESIDUALS	345	5.817E-1	1.686E-3	
TOTAL	368	1.216E1		

REGRESSION COEFFICIENTS

CATEGORY	CODE	VARIABLE	COEFFICIENT	STD. ERROR	NO. OBS.
1	20126	INTERCEPT	-1.279	0.044	368
3	10				
4	90				
1	3126	1	0.377	0.062	13
	3127	2	0.832	0.059	29
	5126	3	0.625	0.106	7
	5127	4	0.852	0.048	46
	14124	5	0.296	0.048	25
	14125	6	0.486	0.124	3
	15126	7	1.052	0.050	26
	15127	8	1.001	0.070	10
	20127	9	0.002	0.037	51
3	7	10	-0.020	0.044	34
	8	11	0.102	0.036	64
	9	12	0.027	0.033	92
	11	13	0.161	0.035	64
	12	14	0.367	0.055	24
4	91	15	0.070	0.046	52
	92	16	0.183	0.046	90
	93	17	0.064	0.047	75
	94	18	0.045	0.055	46
	95	19	0.162	0.071	13
	96	20	0.051	0.069	17
	97	21	0.032	0.079	14
	98	22	0.027	0.095	9

CGT code	Definition
3126	Canada, stern OT, TC6
3127	Canada, stern OT, TC7
5126	Faroes, stern OT, TC6
5127	Faroes, stern OT, TC7
14124	Japan, stern OT, TC4
14125	Japan, stern OT, TC5
15126	Norway, stern OT, TC6
15127	Norway, stern OT, TC7
20126	Russia/USSR/Baltic, stern OT, TC6
20127	Russia/USSR/Baltic, stern OT, TC7

Table 5. Results of catch rate standardization for Greenland halibut in Subarea 0.

STANDARDS USED VARIABLE NUMBERS: 20126 10

PREDICTED CATCH RATE

YEAR	LN TRANSFORM MEAN	LN TRANSFORM S.E.	RETRANSFORMED MEAN	RETRANSFORMED S.E.	CATCH	EFFORT
90	-1.2792	0.0019	0.278	0.012	9498	34137
91	-1.2089	0.0020	0.298	0.013	8606	28833
92	-1.0965	0.0011	0.334	0.011	12358	36985
93	-1.2153	0.0011	0.297	0.010	7489	25239
94	-1.2337	0.0020	0.291	0.013	4321	14841
95	-1.1168	0.0055	0.327	0.024	5299	16219
96	-1.2280	0.0053	0.292	0.021	5519	18879
97	-1.2475	0.0067	0.286	0.023	5740	20036
98	-1.2518	0.0095	0.285	0.028	4370	15340

AVERAGE C.V. FOR THE RETRANSFORMED MEAN: 0.058

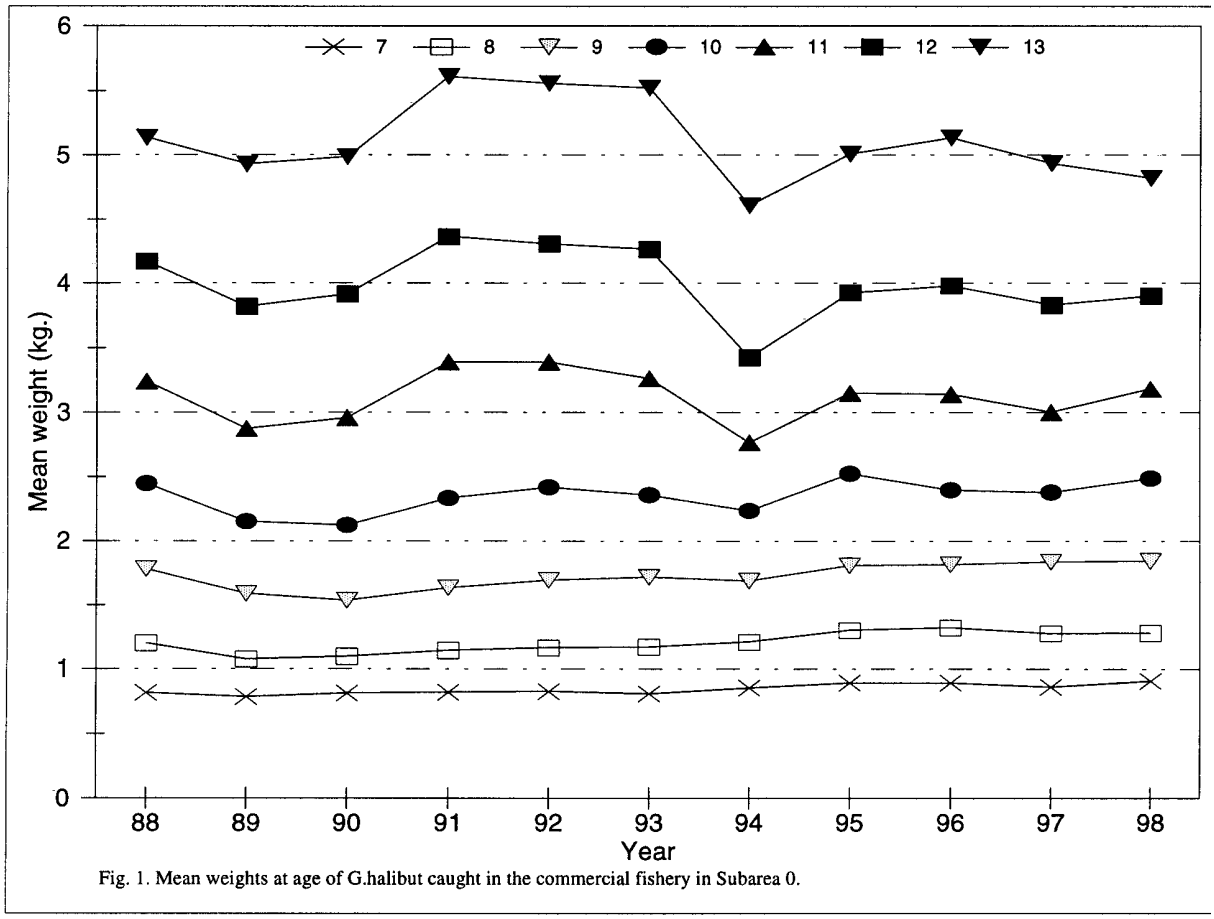

Fig. 1. Mean weights at age of G.halibut caught in the commercial fishery in Subarea 0.

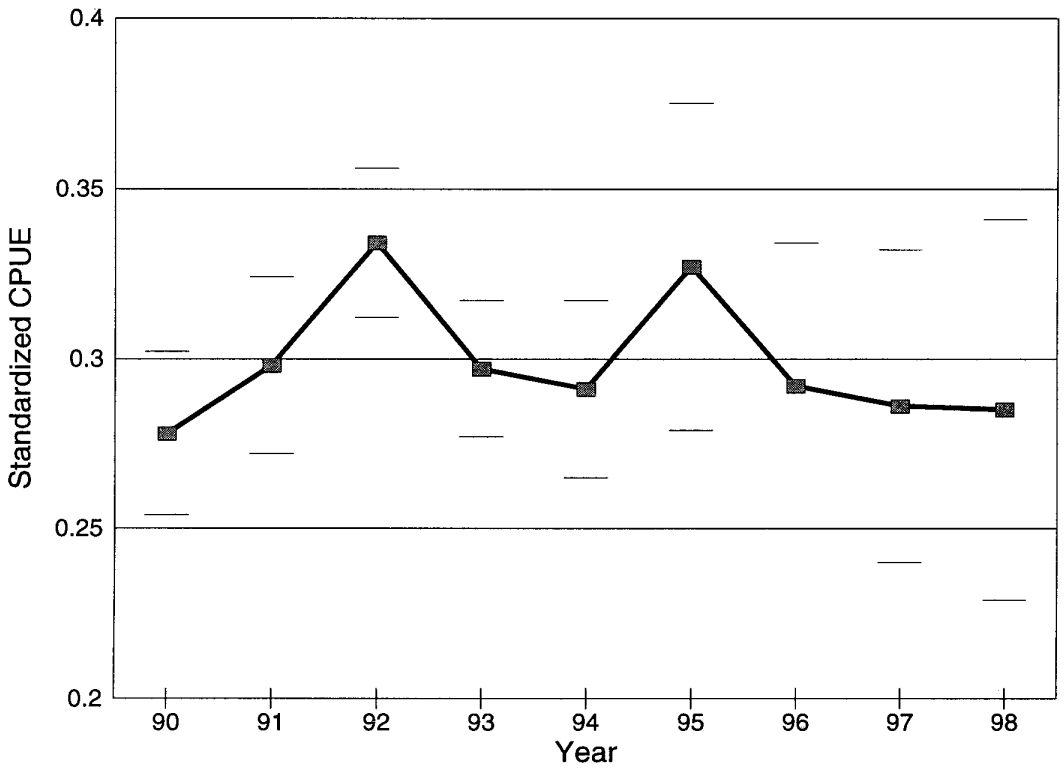

Fig. 2. Standardized CPUE (+/- 2 S.E.) for G.halibut in Subarea 0, 1990-98.

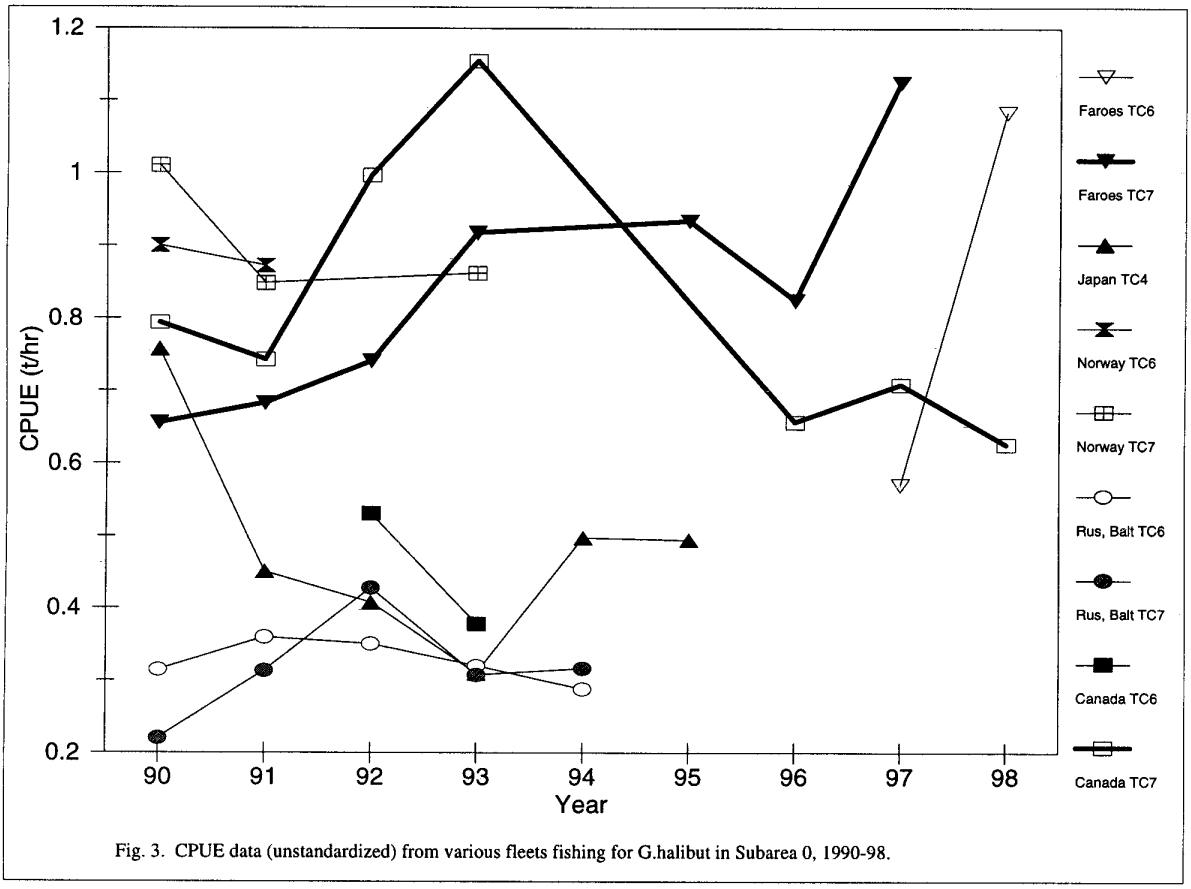

Fig. 3. CPUE data (unstandardized) from various fleets fishing for G.halibut in Subarea 0, 1990-98.