

Northwest Atlantic



Fisheries Organization

Serial No. N1598

NAFO SCR Doc. 89/22

SCIENTIFIC COUNCIL MEETING - JUNE 1989

An Estimation of the Size of the 1984 Year-class of Cod off West  
Greenland from CPUE Data in the Trawl Fisheries

by

Holger Hovgård and Frank Riget

Greenland Fisheries Research Institute, Tagensvej 135  
DK-2200 Copenhagen N, Denmark

Abstract

Catch rates of cod in 1988 are compared to catch rates by the same fleet in 1977 as the stock situation in 1988 closely resembles that in 1977 (one strong year-class totally dominating catches). The CPUE of 4-year old cod in 1988 is about twice as high as found in 1977. The year-class size of the 1973 year-class is estimated to 180 mill. age 4 by VPA. Using this value together with the observed ratio in catch rates leads to a size of the 1984 year-class of 370 mill. age 4. This estimate is about half the survey estimate found from the combines trawl survey by the Federal Republic of Germany and the Greenlandic inshore survey. Some considerations about the discrepancy between the two estimates are discussed.

Introduction

Since 1984 the size of the West Greenland cod stock has been estimated from trawl surveys carried out by the Federal Republic of Germany (FRG). The calculations are based on the swept-area concept, i.e. assuming that the catch corresponds to the cod found in the area between the trawl wings. This implies that no herding or escapement takes place or alternatively that herding and escapement counterbalance each other. If this assumption is not fulfilled the stock size estimates may be biased.

In this work the catch rates of the Greenland Home Rule (GHT) trawlers in 1988 are compared to the catch rates of the same fleet in 1977. The latter period has been chosen because the stock situation in 1988 closely resembles that in 1977, when the strong 1973 year-class recruited after years of very poor recruitment. The 1973 year-class is fished up by now and it is possible to estimate its size by VPA-technique.

The idea of this work is to estimate the size of the 1984 year-class as

$$N(1984) = \frac{CPUE_{88}}{CPUE_{77}} \times N(1973)$$

where  $N(1973)$  is determined by VPA and the CPUE is observed by GHT trawlers. Secondly this estimate is compared with the survey estimate from the combined trawl survey and inshore survey.

#### Material and methods

Catch and effort data were compiled from logbooks of the GHT trawlers in 1977 and 1988. The trawlers regarded are all sister ships built in 1971-73, of a size of 721 GRT supplied with 2000 HP engines. There has, however, been a change in the trawls used with 'Granton' trawls (120 mm codend) being used in 1977 and a 'Alfredo' trawl (140 mm codend) used today. The wing spread of the two trawls are equal (19 m) but the vertical opening of the Alfredo is 5.5 m compared to 4.0 m in the Granton. It is estimated that the Alfredo trawl will fish 10 to 20 percent more efficient than the Granton (E. Sørensen Danish Inst. Fish Tech., pers. comm.).

In 1977 directed cod fishery by trawlers was banned from July and to the end of that year to protect undersized fish. For this reason only data from January - June are compared.

The size distribution of cod in trawl landings has been compiled from samples of landings in 1977 and 1988 (Fig. 1).

#### Results

The effort distribution by NAFO divisions and months is given in Table 1. In 1988 most effort is in Div. 1D whereas effort in 1977 is more evenly spread on Div. 1C to 1E. However, the positions of catches does indicate that the difference between the two years is not great (Fig. 2). In both years the fishery takes place on the outer slopes of the banks, centered roughly around Div. 1D. The monthly effort distribution however shows different trends between the two years - in 1977 with effort generally decreasing from January to June contrasted to 1988 where the maximum effort was exerted in March - April 1988.

The size composition of landings from the period January-June in 1977 and in 1988 is based on 4 and 7 samples, respectively, with very small between-sample differences (Fig. 1). The mean size is somewhat larger in 1988 than in 1977, probably caused by the increase in the Greenland minimum landing size to 44 cm in 1988 from the 40 cm in force in 1977. The 4-year old cod are very dominating in the catches in both years (Fig. 1) constituting 79.8% and 86.8% (by weight) of the landings in 1977 and 1988, respectively.

CPUE (tons per hour) of 4 year old cod is given in Table 2. The CPUE generally increases from north to south and is higher in the second than in the first quarter. The overall CPUE was 0.99 tons per hour in 1977, half that in 1988 (2.00 tons per hour).

To account for difference between 1977 and 1988 in effort distribution between division and month but assuming identical distribution of the stock CPUE data has been analysed by the multiplicative model:

$$\text{Log}_e(\text{CPUE}) = \text{Intercept} + \text{Year} + \text{Month} + \text{Div} + \text{Residual}$$

The statistics and parameter estimates are given in Table 3. Back-transformation from the logarithmic scale gives the relative size of CPUE between 1988 and 1977 as:

$$\frac{\exp(1988)}{\exp(1977)} = \frac{\exp(0)}{\exp(-0.72)} = 2.05$$

i.e. that the CPUE of 4-year old cod in 1988 is about twice that in 1977.

The size of the 1973 year-class was calculated by cohort analyses assuming an emigration coefficient of 0.05 and 0.30 from age 6 and onwards. An emigration of 0.05 have been used traditionally in catch projections however, in the 1987 an emigration of 0.30 was used (Anon., 1987). The size of the 1973 year-class is shown in the text table below and the full cohort analyses with input parameters are given in Table 4.

Text table

<u>1973 year-class</u>	<u>Stock size</u>	<u>E = 0.05</u>	<u>E = 0.30</u>
	at age 3	200	232
	at age 4	154	180

Discussion

The 1973 and the 1984 year-classes are the largest year-classes seen at West Greenland since the mid 60'ies and both are thought to have a major component of Icelandic origin (Hovgård and Messtorff, 1987), i.e. of fish carried from Iceland to West Greenland by the Irminger current as larvae and 0-group fish.

Taking CPUE(88)/CPUE(77) as 2.05 leads to a size of the 1984 year-class of between 316 and 370 mill. fish at age 4 (1. January 1988), assuming E=0.05 and E=0.3 respectively. In this calculation no account is given to the differences in efficiencies of the trawl used or changes in minimum landing sizes as these two effects counterbalance each other.

The survey in November 1987 gave an abundance estimate of 514 mill. cod of the 1984 year-class (Anon., 1988). This figure was raised to 681 mill. when supplemented by the fraction of the stock being in the inshore area as determined by the concurrent Greenland inshore long-line survey (Hovgård et al., 1988). The survey estimate from November 1987 and the 1. January 1988 estimates derived from the CPUE comparison above thus differ with factors of 1.8 - 2.2 with the survey estimate being highest. This difference can be caused by too low an estimate from the cohort analysis or because the survey-based estimate is too high.

A higher VPA estimate can be achieved only by assuming higher natural mortality and/or emigration. This should apply especially for age-groups 4-6 as these contributed most to the fisheries. Assuming that the estimate of 681 mill. age 4 is correct and that the difference of catch rate as observed it will lead to an estimate of the 1973 year-class of 332 mill. age 4. To reproduce this value an emigration of 0.74 on age 6 and onwards is required (Table 4). This value seems unrealistical large.

The other alternative is that the survey estimate is too high. This estimate is based on the concepts of swept area with a catchability constant of 1 (all fish between the trawl wings caught). However if fish are herded into the trawl path by the trawl doors and sweep lines at a higher rate than the concurrent escapement then the efficiently swept area will be larger than assumed (this is equivalent to a catchability factor above 1). In this case the survey will overestimate abundance. By using the catch rates from 1977 and 1988 combined with the cohort analysis stock size, all at face value, it is possible to calculate a catchability factor of approximately 1.8 - 2.2.

Finally, if assuming that the 1973 and 1984 year-classes will behave in the same manner, i.e. that they migrate and are fished at the same rates, then an ad hoc estimate of the yield of the 1984 year-class can be derived from the observed differences in catch rates. The total landings from West Greenland waters of the 1973 year-class during its lifetime amount to 239.000 tons and with the estimate of the 1984 year-class strength as being 2.05 times higher, we can expect a total landing of the 1984 year-class during its lifetime of about 500.000 tons.

#### References

- Anon., 1987. Report of the Working Group on Cod Stocks off East Greenland. ICES, Doc. C.M.1987/Assess:10.
- Anon., 1988. Report of the Working Group on Cod Stocks off East Greenland. ICES, Doc. C.M.1988/Assess:11.
- Hovgård, H., and J.Messdorff 1987. Is the West Greenland Cod Mainly Recruited from Icelandic Waters? An Analysis Based on the Use of Juvenile Haddock as an Indicator of Larval Drift. NAFO SCR Doc. 87/31 (mimeo).
- Hovgård, H., K. H. Nygård and K. M. Lehmann 1988: Inshore and Offshore Distribution and Abundance of the West Greenland Cod Stock, Autumn 1987. NAFO SCR Doc. 88/43 (mimeo).

TABLE 1 Hours trawled by the Greenland Home Rule trawlers in 1977 and in 1988 by months and NAFO divisions. Number of hauls in brackets.

1977

DIV MONTH	1C	1D	1E	1F	TOTAL
1	794 (438)	354 (205)	671 (500)	0	1819 (1143)
2	797 (457)	217 (155)	435 (377)	0	1449 (989)
3	674 (380)	374 (217)	411 (288)	0	1459 (885)
4	103 (45)	156 (80)	757 (631)	0	1016 (756)
5	28 (17)	307 (170)	745 (535)	0	1080 (722)
6	0	104 (61)	380 (215)	33 (22)	517 (298)
TOTAL	2396 (1337)	1512 (888)	3399 (2546)	33 (22)	7340 (4793)

1988

DIV MONTH	1C	1D	1E	1F	TOTAL
1	0	228 (209)	11 (11)	0	239 (220)
2	3 (1)	252 (115)	24 (9)	0	279 (125)
3	5 (2)	343 (176)	153 (96)	0	501 (274)
4	0	70 (53)	196 (146)	135 (108)	401 (307)
5	0	249 (171)	71 (49)	0	320 (220)
6	0	34 (28)	0	0	34 (28)
TOTAL	8 (3)	1176 (752)	455 (311)	135 (108)	1774 (1174)

TABLE 2: CPUE (tons per hour) of the 1973 year-class in 1977 and of the 1984 year-class in 1988 by Greenland Home Rule trawlers by months and NAFO divisions. Weighted means are calculated as sum of catches divided by sum of effort.

1977

DIV. MONTH	1C	1D	1E	1F	Weighted means
1	.78	.78	1.29	-	.97
2	.93	.63	1.26	-	.98
3	.55	.22	.35	-	.41
4	.09	.18	1.31	-	1.01
5	.86	1.39	1.28	-	1.30
6	-	1.61	1.92	2.52	1.89
Weighted mean	.74	.74	1.24	2.52	.99

1988

DIV. MONTH	1C	1D	1E	1F	Weighted means
1	-	1.61	.57	-	1.56
2	1.32	1.26	.22	-	1.17
3	.00	.84	1.04	-	.89
4	-	2.36	3.35	3.99	3.39
5	-	3.11	1.88	-	2.84
6	-	3.62	-	-	3.62
Weighted mean	.49	1.73	2.11	3.99	2.00

**TABLE 3: Statistics and parameter estimates of the multiplicative model**  
 $\text{Log}_e(\text{CPUE}) = \text{Intercept} + \text{Year} + \text{Month} + \text{Div} + \text{Residual}$

<u>Source</u>	<u>Df</u>	<u>SS</u>	<u>MS</u>	<u>F-value</u>	<u>P(F)</u>
Year	1	3.47	3.47	5.68	0.03
Month	5	5.50	1.10	1.80	0.16
Div	3	1.39	0.46	0.76	0.53
Error	21	12.83	0.61		
Total	30	23.19			

Estimates:

Intercept: 2.01

Year: 1977 = -0.72      1988 = 0

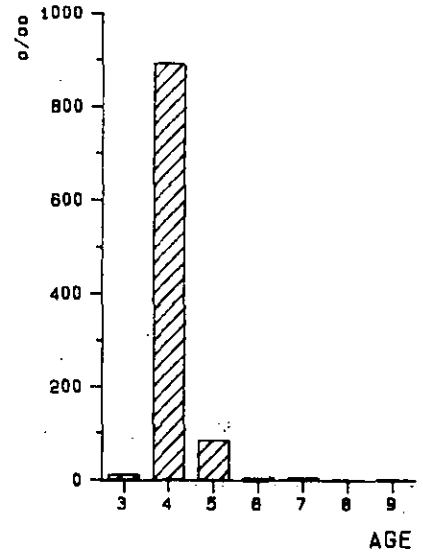
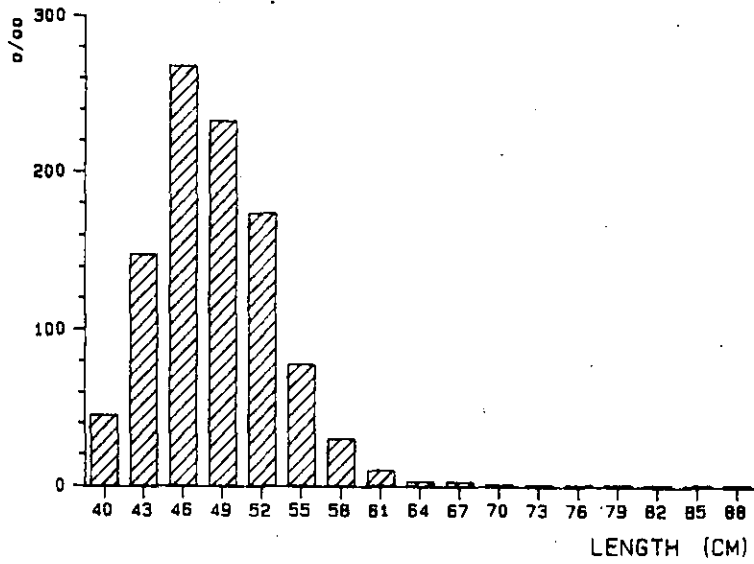
Month: Jan = -0.77      Feb = -0.96      Marts = -1.36  
 Apr = -0.98      May = -0.26      June = 0

Div : 1C = -1.06      1D = -0.87      1E = -0.79      1F = 0

**TABLE 4: Input parameters and results of cohort analyses of the 1973 year class with emigration coefficients of 0.05, 0.30 and 0.742, respectively from age 6 and onwards.**

Age	Catch	M	E	N	F	E	N	F	E	N	F
3	10760	.2	.0	199,763	.063	.0	232,007	.053	.0	417,828	.029
4	46649	.2	.0	153,535	.405	.0	180,326	.334	.0	332,353	.169
5	30039	.2	.0	83,883	.498	.0	105,717	.347	.0	229,898	.156
6	18970	.2	.05	41,738.72	.706	.3	59,547.17	.505	.742	161,044	.209
7	8140	.2	.05	16,049.14	.829	.3	21,796.21	.621	.742	50,938.24	.296
8	3382	.2	.05	5,454.83	1.154	.3	7,103.63	.877	.742	14,775.70	.457
9	610	.2	.05	1,340.04	0.707	.3	1,792.93	.549	.742	3,648.62	.312
10	343	.2	.05	514.45	1.323	.3	627.79	1.092	.742	1,041.54	.750
11	69	.2	.05	106.66	1.248	.3	127.75	1.071	.742	191.88	.858
12	8	.2	.05	23.84	.471	.3	26.55	.471	.742	31.72	.471

1977



1988

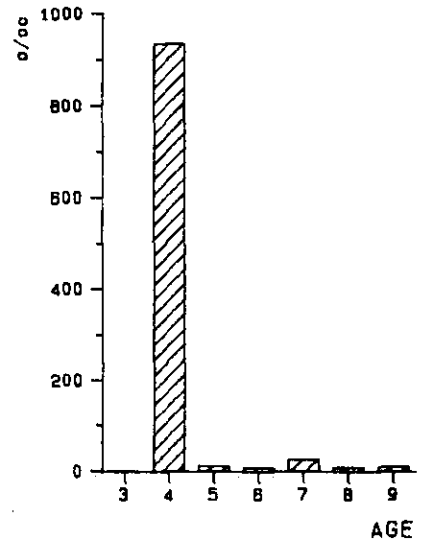
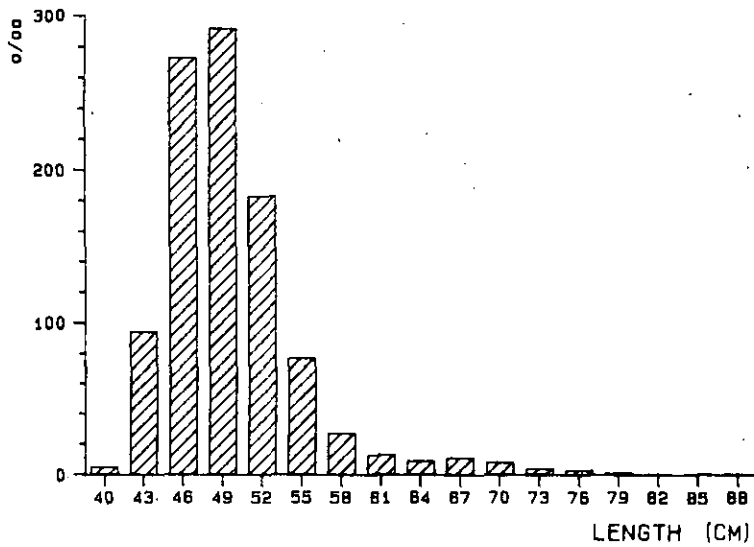
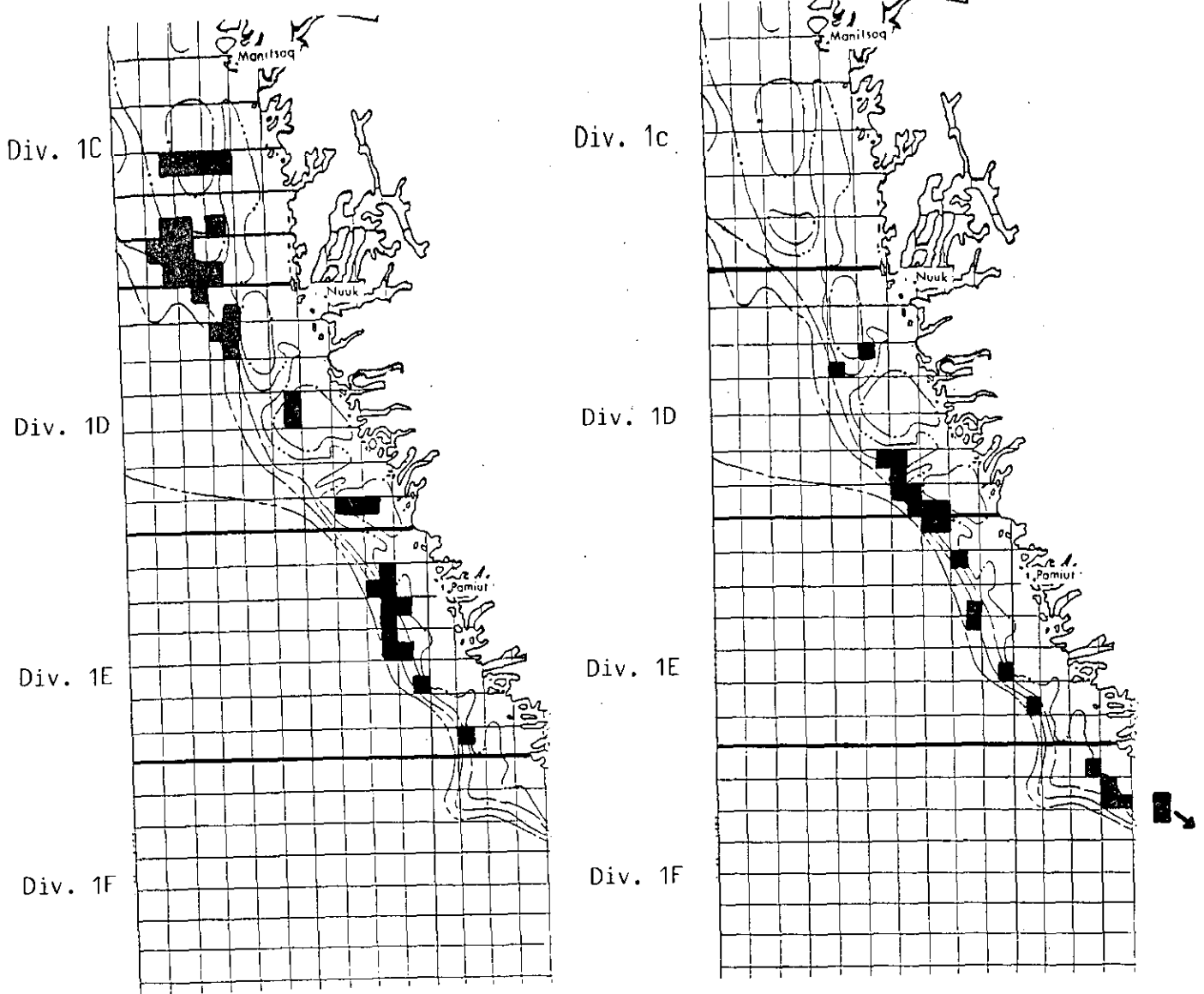


Fig. 1: Length and age distributions of cod from trawl landings in January-June 1977 and 1988.



1977

1988



**Fig. 2:** Distribution of the Greenland Home Rule fishery in January-June 1977 and 1988. Filled signature indicates statistical squares with a catch of above 50 tons.