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A Catch Rate Index for West Greenland Cod for 1975-89 Based on Logbook Information from the Commercial Fleet

by

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Introduction

Catch rates from the commmercial fishery are assumed to be an index of abundance. However such data have in previous assessments of the West Greenland cod stock been applied only qualitatively without any formal analysis.

This paper uses catch rate data for the Greenlandic cod fishery in the period 1975-89. The data are analysed using a multiplicative model (Gavaris, 1980). The analysis presented is preliminary as the data base has not yet been fully scrutinized.

The description of the catch rate data will focus on the spatial distribution and seasonal pattern. This is especially important when using the multiplicative approach because this method assumes that there are well defined patterns which repeat themselves from one year to the next, i.e. interactions between these categories are not taken into account.

The catch rate indices obtained from the commercial fleet can be compared with the abundance estimate from FRG bottom trawl survey. Combining these two sets of abundance estimates with catch at age data, the ADAPT framework (Gavaris, 1988) can be applied and this will constitute an integrated analysis providing estimates of stock in numbers and fishing mortalities.

Data

Logbooks from Greenlandic trawlers in the period 1975-89 are available, though until 1986 this system applied only to trawlers owned by the Greenland Home Rule Administration. From 1986 onwards logbooks have been compulsory for all vessels above 50 GRT. A total of 12 trawlers has contributed to the database, but 6 sister trawlers owned by the Greenland Home Rule (each of 721 GRT) account for about 90% of the total effort.

In the mid- 70'ies cod abundance was low and some trips or part thereof were directed towards other species such as redfish, Greenland halibut and wolffish. If 20% or more of the hauls during a cruise have been directed towards species other than cod, or if an evident geografic shift or change in dominating species in the catch took place during the cruise, then data from the entire cruise have been excluded from the database. Based on this criterion less than 5% of the total number of cruises have been omitted from the database.

General trends in catch and effort during 1975-89

Fig. 1 shows total catch and effort during 1975-89 for all Greenlandic trawlers irrespective whether they were fishing on West Greenland or on East Greenland. During this period three good year-classes of cod are easy discernible. The 1973 year-class estimated to about 220 mill. fish at age 3 accounts for the peak in catches in 1978-79, the 1977 year-class estimated to about 118 mill. age 3 was recruited to the fishery in 1981 and 82, and the big 1984 year-class estimated to about 500 mill. age 3 is responsible for the very high increase in catch in 1988 and 1989.

In 1986 catch and effort in the cod fishery were at a very low level due to management restrictions. No directed trawl fishery for cod was allowed in 1986, and for the first ten months of 1987 directed trawl fishery was banned for vessels above 80 GRT.

Spatial distribution during 1975-89

Effort, catch and catch rates for all Greenlandic trawlers are shown on Fig. 2. and Appendix 1 and 2. The West Greenland fishing area is divided into NAFO divisions while FRG trawl survey areas are used for the areal breakdown on East Greenland. The cod fishery is concentrated mainly on the fishing banks, and it may be more relevant to use an areal breakdown following the fishing banks. No attempt has been made to standardize fishing power of vessels, this may cause problems but the bulk of the effort is exerted by 6 sister ships which should have similar fishing power.

The geographical pattern of fishing effort and catch varies markedly from year to year. In 1975-77 the fishing effort and catch are relatively evenly distributed, while in the periods 1983-84 and 1988 the southern divisions dominate. In 1989 the fishery has been unusually southernly concentrated with an important component off East Greenland. No general applicable pattern can be discerned but the northern divisions 1B and 1C loose their importance as fishing areas in the 80'ies. Using a multiplicative model for separating out an annual trend of abundance this shift in effort would invalidate the findings if the seasonal patterns within divisions change over time. It is therefore necessary to evaluate the impact of this interaction on the results from the multiplicative model.

Seasonal pattern during the period 1975-89

The seasonal pattern by quarter of fishing effort, catch and catch rate is shown in Fig. 3. Data are from Subarea 1 only and for six sister trawlers owned by the Greenland Home Rule. As mentioned these trawlers account for about 90% of the total effort in the fishery for cod.

In the period 1975-82 effort generally peaks in the first or second quarter of the year, while the lowest effort is excerted in the third quarter. Since 1983, this pattern is blurred coinciding with the decline in fishing effort and catch. In 1988 and 89 the effort again reversed to the general pattern. The catch rate pattern follows this pattern. The catch rate in the second quarter of 1989 is the highest in this time series with about 10 t/hours, twice of what has been seen earlier in the period.

Fig. 3 suggests a significant interaction between season and year, i.e. there is no stable clear cut seasonal pattern in the catch rate and this will affect the results from the multiplicative model.

Standardizing catch rates by a multiplicative model.

Data from the six sisters trawler owned by the Greenland Home Rule Administration (each of 721 GRT) in the period 1975-

89 were chosen for this analysis. It is assumed that the fishing power of the vessels are identical. Only data from Subarea 1 are included, and NAFO divisions are chosen as geographical categories. The seasonal breakdown is by month.

Fishing effort and catch are aggregated by year, month and division. Values of effort below 10 hours for a given year, month and division combination data are eliminated.

The linear regression model applied to the data is :

$$\ln(\text{CPUE}) = I + a * \text{YEAR} + b * \text{DIVISION} + c * \text{MONTH} + \text{error}$$

A preliminary run of the multiplicative model showed that the residuals were not normally distributed, because of some very low catch values in some year, division and month combinations. This is caused by recording trawl hauls with very little catch. The catch is recorded in units of 100 kg, and when the catch is below this level a zero or a blank is entered in the logbook. It was decided to replace these recordings by 50 kg assumed to be the average catch in these trawl hauls. The residuals of the model were now normally distributed and the parameter estimates were almost unaffected.

Table 1 shows the results of the multiplicative analysis, and Fig. 4 gives the year indices from 1975 to 1989. The model explains 59% of the total variation, and the year, division and month effect are highly significant.

By successive testing it was shown that an interaction between year and division is significant (1%-level) as expected. Div. 1B has a much lower annual catch rate than the other divisions and data from Div. 1B are scarce as can be seen in Fig. 2. Omitting Div. 1B data from the analysis leaves the estimated year indices largely unaffected and a significant division effect does no longer exist. As the yearly index for abundance is unaffected the results presented as final annual indices include Div. 1B data in the analysis.

Succesive testing also shows a significant (1%-level) interaction between year and month. Table 1 shows high and not very different catch rate from January to June, which is the period when most of the effort and catch occur. Then a drop in catch rate occurs during July to October before raising again during November and December. We think that the interaction effect between year and month derives mainly from the summer period when effort and catches are low, and do not expect any major impact on the year indices from the summer period data.

Fig. 5 compares the year index derived from the multiplicative analyses with and an index calculated as the logaritmic value of the overall yearly catch rate. The two indices are very alike and show the same trends. This adds to the impression that the indices derived from the multiplicative model are very robust, and ignoring the interaction effects does not cause much concern.

Table 1. Results of the multiplicative analysis of CPUE data for cod in Subarea 1, 1975-89.

Source of variation	Df	Sum of squares	Mean squares	F-value	R-square
Model	29	377.829	13.029	16.69	0.590
Year	14	184.690	13.192	16.90	
Division	4	37.321	9.330	11.95	
Month	11	78.317	7.120	9.12	
Error	337	263.056	0.781		

Parameter estimates

year	estimate	std.error
1975	-2.181	0.213
1976	-2.027	0.223
1977	-1.429	0.246
1978	-0.364	0.261
1979	-0.972	0.264
1980	-1.188	0.239
1981	-0.397	0.255
1982	-0.469	0.226
1983	-1.296	0.226
1984	-1.819	0.271
1985	-2.117	0.291
1986	-1.540	0.360
1987	-0.766	0.547
1988	-0.507	0.252
1989	0	-

division	estimate	std.error
1B	-1.158	0.260
1C	-0.074	0.205
1D	0.133	0.187
1E	0.299	0.184
1F	0	-

month	estimate	std.error
Jan	0.391	0.212
Feb	0.505	0.220
Mar	0.174	0.209
Apr	0.553	0.213
May	0.552	0.216
June	0.707	0.228
July	0.031	0.237
Aug	-0.183	0.241
Sep	-0.770	0.213
Oct	-0.833	0.225
Nov	-0.259	0.213
Dec	0	-

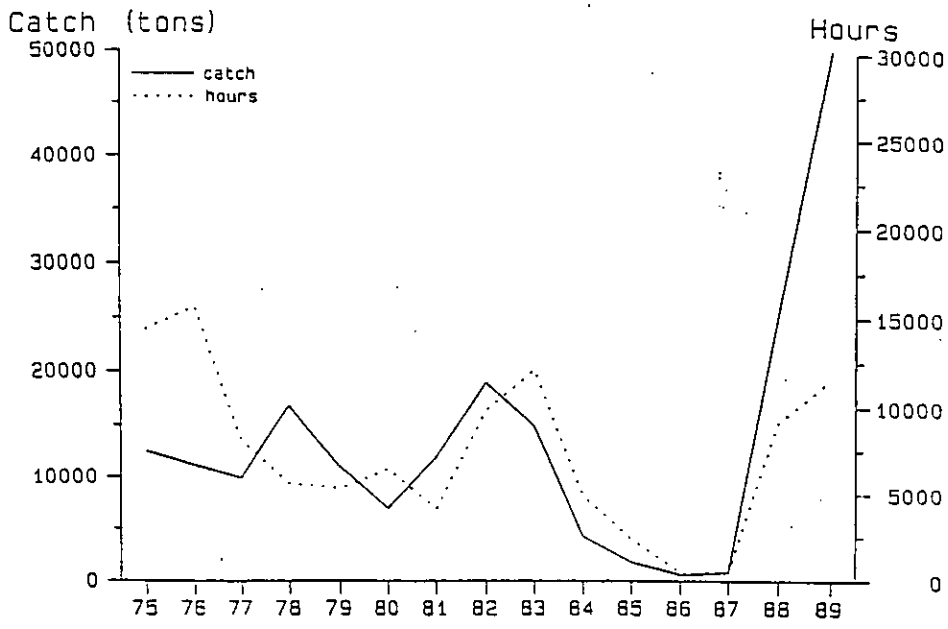


Fig. 1. Catch and effort, 1975-89, all greenlandic trawlers.

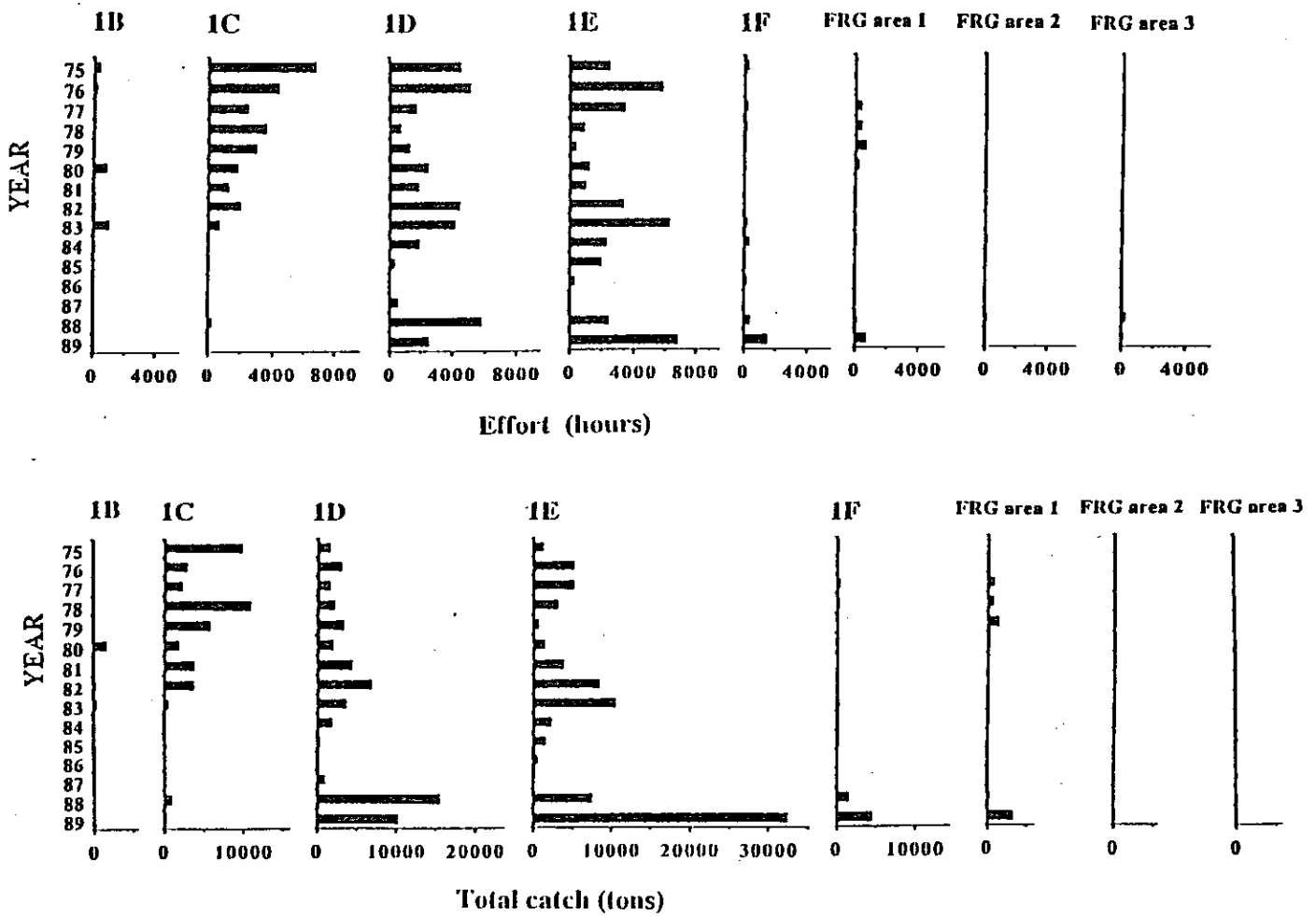


Fig. 2. Effort, catch and CPUE by area, 1975-89, all greenlandic trawlers.

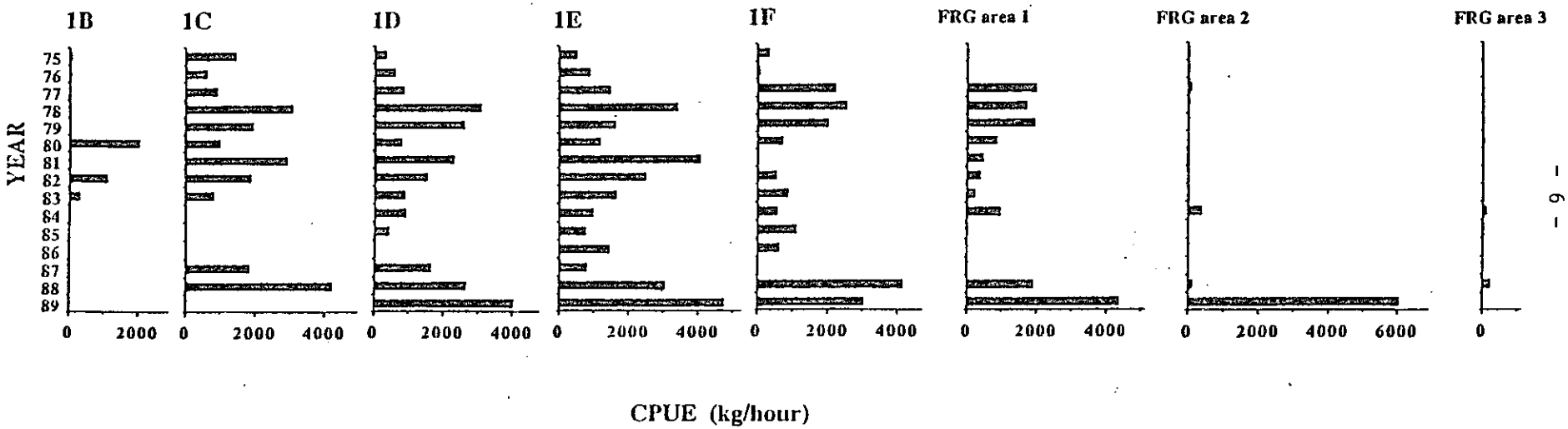


Fig. 2. continued

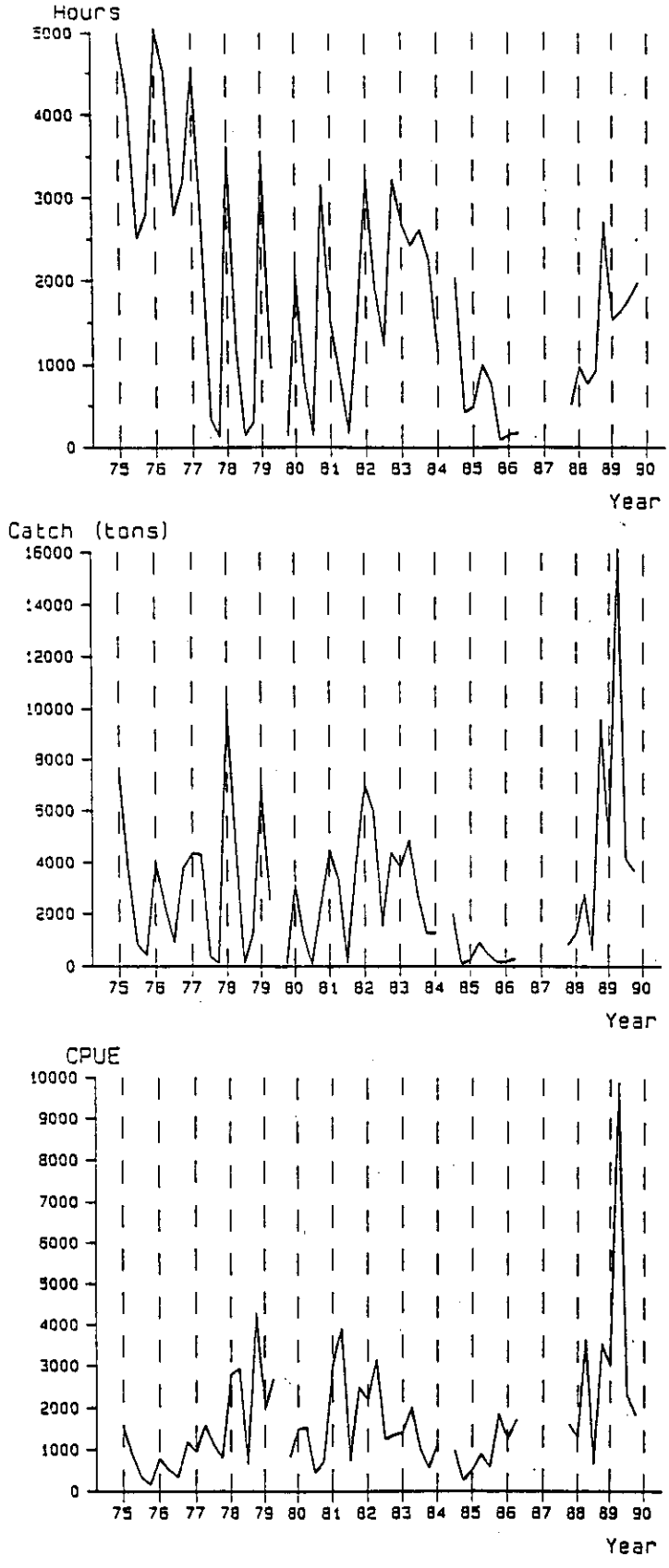


Fig. 3. Effort, catch and CPUE by quarter, 1975-89, six Home Rule trawlers.

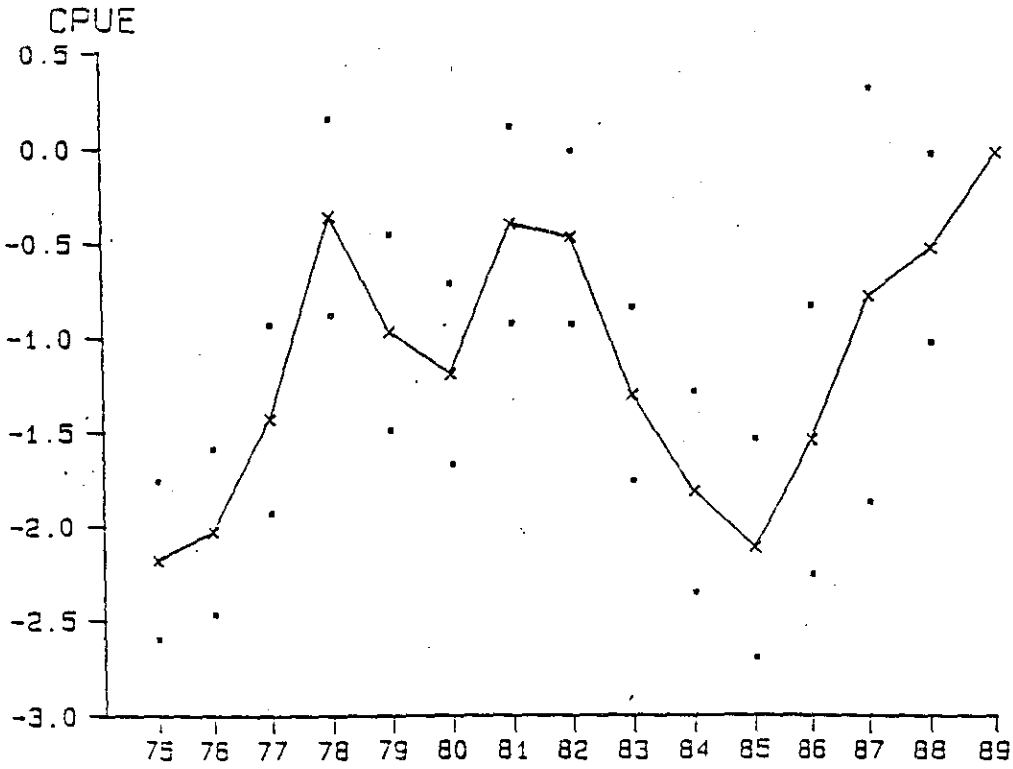


Fig. 4. CPUE from multiplicative model, with error bars (+- 2 x S.E.), for cod in Subarea 1.

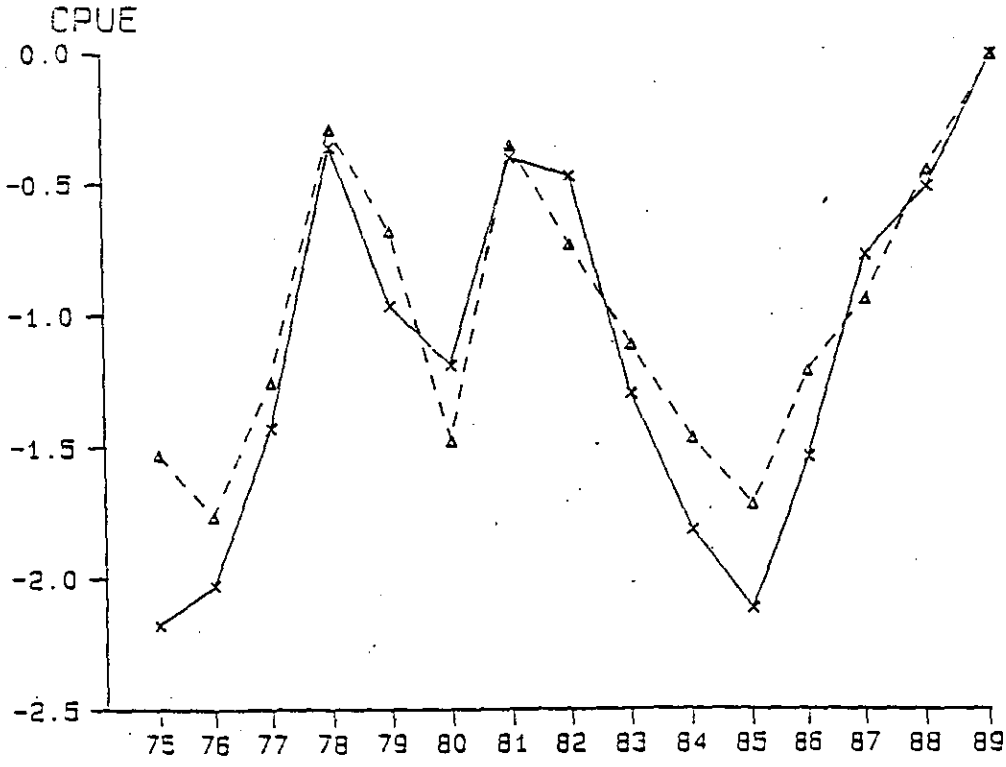


Fig. 5. Comparisons between CPUE from multiplicative model and mean annual CPUE.

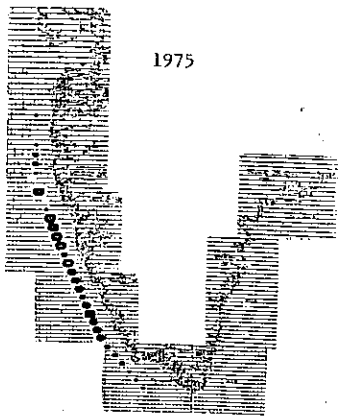
Appendix 1. Geographical distribution of effort (hours trawled) in the fishery for cod by Greenland trawlers. Symbols are given for every 15 n. m. shift in latitude. For each year the 15 n. m. zones where fishing took place are grouped in four categories, viz.

i) that quart of the zones which each has higher effort than any of the rest (biggest symbol).

ii) that quart of the zones which each has less effort than any of the rest (smallest symbol).

iii and iv) the remaining zones split in two halves according to their effort. Symbols accordingly.

Thus for each year there is an equal number of zones in the four categories, but categories are not comparable between years in terms of actual amount of effort.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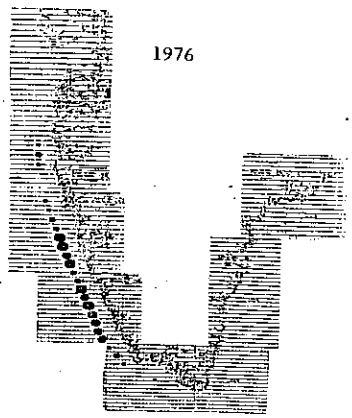
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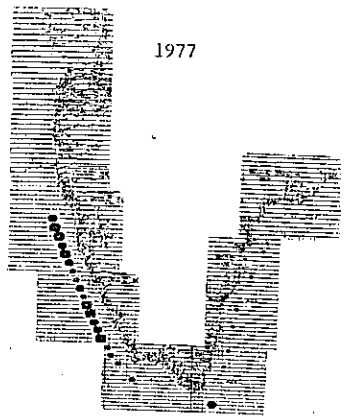
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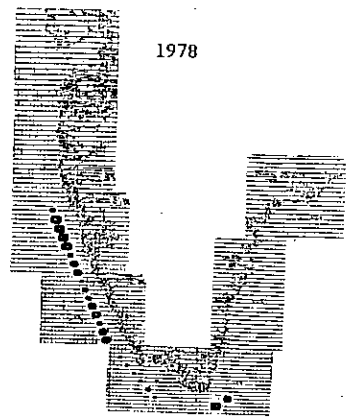
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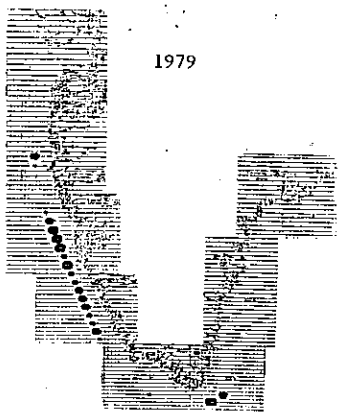
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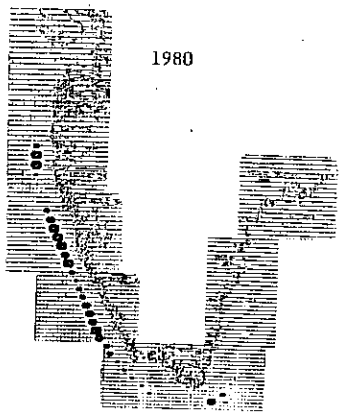
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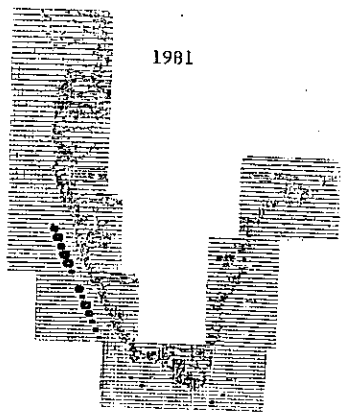
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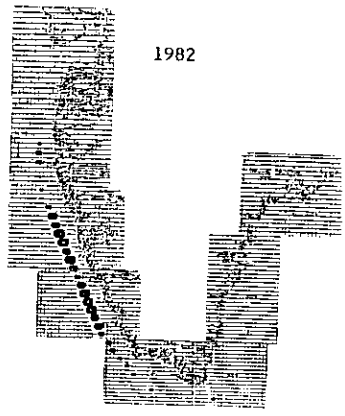
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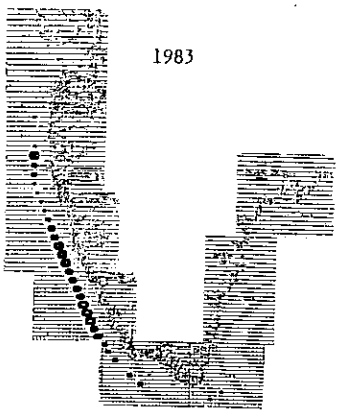
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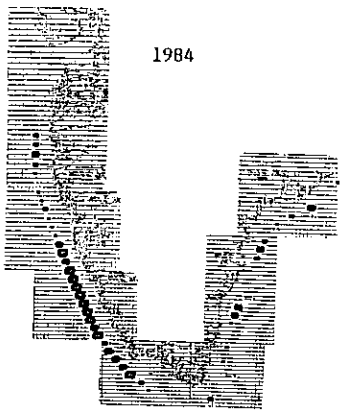
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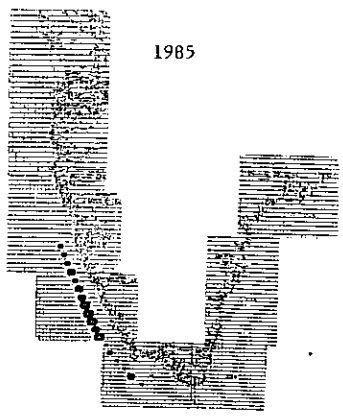
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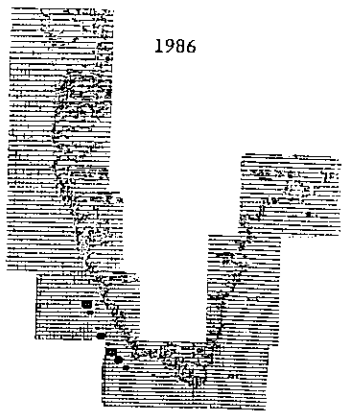
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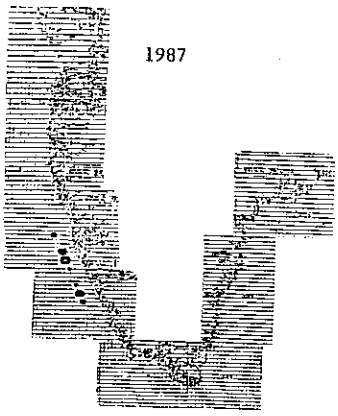
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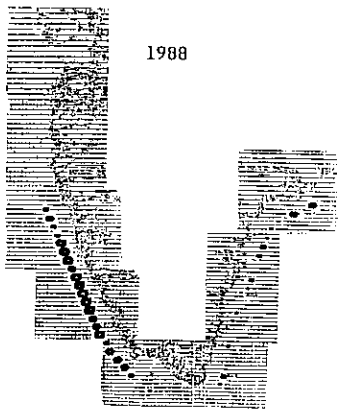
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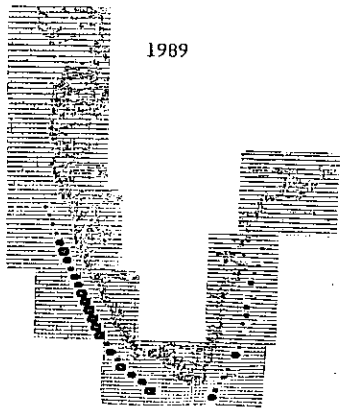
1989

Appendix 2. Geographical distribution of effort (hours trawled) in the fishery for cod by Greenland trawlers by quarter in 1989. Symbols as in Appendix 1.