Northwest Atlantic Fisheries Organization

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Inshore and Offshore Distribution and Abundance of the

West Greenland Cod Stock, Autumn 1987

by

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1. Abstract.

A long line survey was conducted in inshore and offshore areas in
Div. 1CDE in oct./nov. 1987 with the purpose of describing the
distribution pattern of the cod stock. Highest densities were
found in shallow waters (0-100m) in Div. 1D and 1E at the banks.
The inshore stock component accounted for 22% of the total stock.

In the assesment of the West Greenland cod the stock size is
estimated on the basis of the offshore abundance as found in the
annual FRG trawl surveys. The present survey indicates, that this
procedure leads to a substantial underestimation of stock size.
As stock size is used in the calculation of fishing mortalities
and migration coefficients any bias in stock size will proliferate
to these parameters. Therefore the abundance should be raised
with a factor to correct for the proportion of the stock outside
the trawlable area.

2. Introduction.

Assesment of the cod stock off West Greenland has in recent
years been based on estimates of trawlable stock size derived
from trawl surveys carried out by the Federal Republic of Germany.
These trawl surveys does not include the area within the 3 nautical
mile coastal line, and a proportion of the stock is therefore not
covered. This leads to an underestimation of total stock size and
this bias will further influence other stock parameters
(Anon. 1986).

In order to quantify the size of the inshore component, Greenland
Fisheries Research Institute conducted a long line survey in
inshore areas in 1986 (Nygaard and Hougård 1987). This survey
showed that relative large densities of cod were found inshore,
but firm quantification on the size of this component could not

be achieved. It was therefore recommended that the survey should
be reassumed and expanded in 1987 (Anon. 1987).

3. Materials and methods.

3.1. Survey design.

The survey was carried out in october-november 1987 by R/V Adolf
Jensen and R/V Misilisoq concurrent with the offshore trawl survey
by R/V Walther Herwig of the Federal Republic of Germany (FRG).

The bottom topography in the inshore areas off West Greenland is
generally rough and unsuitable for trawling, and hence other gear
types must be used. After a pilot study in 1986 it was decided to
use long lines. The lines used (equal type at the two vessels)
were of 7mm polypropylene, anchored in both ends and with minor
loads for every 200m. Hooks (Mustad no.6) were mounted on 50cm
snoods with 2m interval. At most fishing stations a line of 400
hooks was used, but at a few stations only 200 hooks were used.

Fishing was only done during the light hours, and average fishing
time was 4.8 hours (range 3.7 to 7.8 hours). Results are expressed
in catch in numbers per 100 hooks disregarding any difference in
fishing time.

As in the 1986 survey lines were baited with capelins. Capelins
used ranged from 11 to 17cm (mean 15.3cm).

As line fishing requires that the lines are at the bottom for
some hours the fishing stations to be covered in one day must
necessarily be relative close to each other, and this restricted
the randomization. Instead stations were distributed in groups of
4 or 5, and these were then distributed randomly in NAFO Divisions
1C, 1D and 1E according to a stratified sampling scheme with 100m
depth strata in the three areas: fiord, coast and offshore (banks).

Number of valid sets totaled 115, and distribution of sets per
stratum is shown in table 4.1.

3.2. Survey area.

In order to asses the relative importance of the inshore stock
component the size of the different areas must be known. The West
Greenland sea-area was divided into three main areas: The offshore
area is defined as the area outside a line 3 nautical miles off
the baseline, the coastal area from the 3 mile line to straight
lines at the entrance of the fiords and the fiord area inside these
lines.

From trawlsurveys offshore and from the 1986 long line survey it is known that concentrations of cod in waters deeper than 300m are neglectable, and the present survey therefore only covers the upper 300m zone.

Each area was divided into 100m depth strata (Table 3.1.). Offshore stratum areas were taken from Anon.(1987), and coastal stratum areas were recorded by planimeter measurements. In fiord areas the depth information is generally poor, and the areas can not be directly measured. However bathygraphic lines was subjectively drawn according to information available for 13 fiords, and areas of depth strata were hereafter recorded by planimeter (Table 3.2.). In this way 89, 14, 46, 4 and 17 % of the total fiord area was measured in Divisions 1B to 1F respectively. The mean depth distribution found was then raised to cover the total fiord area of each division.

4. Results.

4.1. Length distribution and selection pattern.

There were no marked differences in length distribution between divisions or between the inshore and offshore areas, and cod from the whole area is consequently treated together.

The length frequency distribution off the offshore line catches is shown in figure 4.1. The distribution is bimodal with modes around 46-48cm and 67-69cm. This distribution is very different from the trawl catches in Div. 1C-1E of R/V Walther Herwig (Fig. 4.2.) which show one dominant mode at 40-45cm reoresenting the very abundant 1984 year class. This must be attributed to gear selection, with smaller cod not being fully recruited to the lines. Full selection seems to occure for cod larger than approximately 67cm (Fig. 4.3.).

The low catchability of the smaller cod causes problems when interpreting results. A straight forward analysis of CPUE- data will mainly reflect the density of larger cod and reversively ignore the importance of 1984-yearclass which compromise more than 90% of the total stock. To avoid such biases small and large cod are treated seperatly in the following analysis. The division in the two groups is made at 54cm as this is the length that best seperates the 1984-yearclass from the older cod.

4.2. Distribution of cod.

Mean density, expressed as catch per 100 hooks are given for all strata in tables 4.1. and 4.2. for small and large cod respectively. In general highest densities are found in Div. 1DE, at the banks and in shallow waters (0-100m).

In order to get a better discription of the seperate effects of division, area and depth an analysis of variance was performed. The condition of homogeneity of variances is however not fulfilled by the present catchrate data, as the standard deviation is proportional to the mean (Fig. 4.4.), and hence data was log-transformed prior to analysis. The model used was:

$$Log10(CPUE+1) = s + div(i) + area(j) + depth(k) + E(ijkl)$$

s = overall mean

i = 1C, 1D and 1E

j = bank, coast and fiord

k = 0-100m, 100-200m and 200-300m

E(i,j,k,l) = residual

For large cod the model explains 58% of the total variance and all effects are significant (5% level). For small cod only 28% of the variance is explained and for this group only area and depth effects are statistical different (Table 4.3.).

The estimated effects of division, area and depth are shown in figure 4.5.. For area and depth similar distribution patterns are found for small and large cod. For both size groups the density declines with increasing depth and density declines gradually when moving from the banks into coastal areas and further into the fiords. For the north-southern distribution a sharp increase in density is seen for large cod when moving south of division 1C, whereas this difference is not pronouced for the smaller cod.

4.3. Abundance index.

The mean density (i.e. catch per 100 hooks) of each of the three areas is computed as a stratified random survey, i.e.

$$CPUE = \frac{\sum CPUE(i,k) \times area(i,k)}{\sum area(i,k)}$$

where i and k refers to division and depth respectively.

Mean density and 95% confidence limits for the estimates are given by sizegroup of cod and area in table 4.4.. By raising theese densities by the size of the areas the relative distribution of the stock can be computed.

Area	Relative distribution of cod in Div.1CDE (%).	
	small (<54cm)	large (>=54cm)
Bank	79	78
Coast	19	21
Fiord	2	1

For both the abundant 1984 yearclass and the larger cod around
21-22% of the cod in Divs. 1C to 1E are found outside the area
covered by the FRG trawl survey. However the large and small cod
are different distributed in coastal and fiord areas with relative
more large cod in the coastal zone (Table 4.4.).

In general it may be concluded, that when estimating the stock
size in Divs. 1C to 1E solely by the offshore component only 78%
of the stock is included. This cooresponds to an underestimation
of the stock by a factor of 1.28.

5. Discussion.

For the offshore area it is possible to compare the distribution
of the cod in the linesurvey with the concurrent FRG trawl survey.
Data from the this survey has kindly been provided by Dr. J.
Messtorf, Bundesforschungsanstalt für Fisherei, and have been
analysed by the model:

$$\log(CPUE+1) = R + Div.(i) + depth (j) + error$$

where i denotes Div. 1C, 1D and 1E and j the three depth zones
0-100m, 100-200m and 200-300m. The estimated densities in numbers
per 30 min. tow are shown for small and large cod in figure 5.1.
A sharp increase is found in densities when moving from 1C to 1D
as were seen for large cod in the line survey. For both size-
groups there were no differences in density in the two upper water
strata, whereas density is much lower at 200-300m of depth. The
two surveys gives similar results, i.e. the cod are found in the
more shallow areas and concentrated in Div. 1D and southward.
However, the distribution with depth differs somewhat between the
surveys as the gradual decrease with depth observed in the line
survey is contrasted by the uniform distribution in the upper
two depth zones in the trawl survey.

When comparing the results of the 1987 line survey to the 1986
survey (Nygaard and Hougaard 1987) little difference in
distribution is found. These comparisons are restricted to the
inshore areas (coast and fiords) in Divs. 1C and 1D, as no other
areas was covered in 1986. In both years densities were declining
from Div. 1C to 1D and from coast to fiord, and were highest in
the upper waters. For large cod the density were of the same
magnitude in both years, but the catch rate of smaller cod has
increased approximately 3 times from 1986 to 1987. This is however
to be expected, as the mean size of the cod from the abundant 1984
yearclass has increased by approximately 10 cm and the cod hereby
become more available to the long line.

In the reporting of the 1986 line survey it was proposed to assume the same density of cod in the inshore and offshore area, but results from the present survey indicates that the density inshore is somewhat smaller. However when considering the size of the inshore area the inshore stock component amounts to approximately 22% of the total stock. Disregarding this component will lead to underestimation of stock size by a factor of 1.28. Further, as stock size is used in the calculations of fishing mortalities and emigration coefficients (Anon. 1987) these factors will also be affected. If assuming that 22% of the stock has been hiding inshore also in the previous years F should be reduced by 1.28 and emigration rate increased in the range of 25 to 50% of the previous values.

6. References.

Anon., 1986: Report of the Working Group on Cod Stocks off East Greenland. ICES C.M. 1986/Asses:11.

Anon., 1987: Report of the Working Group on Cod Stocks of East Greenland. ICES C.M. 1987/Asses:10.

Nygaard, K.H. and H. Hovgård, 1987: On Inshore Distribution and Abundance of the West Greenland Cod Stock, Autumn 1986. NAFO/SCR Doc. 87/30.

Tables.

Table 3.1. Stratum area by division (square nautical miles)

		0-100m	100-200m	200-300m	total
Div.1B	fiord	78	50	43	171
	coast	380	176	40	596
	bank	865	1256	297	2418
	total	1323	1482	380	3185
Div.1C	fiord	269	131	121	521
	coast	962	135	34	1131
	bank	1191	3476	967	5634
	total	2422	3742	1122	7286
Div.1D	fiord	381	185	134	700
	coast	1093	85	86	1264
	bank	1475	892	657	3024
	total	2949	1162	877	4988
Div.1E	fiord	258	102	63	423
	coast	963	184	21	1168
	bank	276	1662	464	2402
	total	1497	1948	548	3993
Div.1F	fiord	485	291	255	1031
	coast	844	742	52	1638
	bank ($)	366	2202	607	3175
	total	1695	3235	914	5844
Div.1C-1E	fiord	908	418	318	1644
	coast	3018	404	141	3563
	bank	2942	6030	2088	11060
	total	6868	6852	2547	16267

Bank areas from ICES (C.M.1987/Asses:10).
$ Estimated from area distribution in Div. 1E (see Anon. 1987, table 5.1.2.)

Table 3.2. Fiord areas measured (square nautical miles).

Div.1B	total	0-100m	1-200m	2-300m	3-400m	4-600m	6-1000m
Itivdleq	50	21	9	7	9	4	-
Amerdloq	35	14	6	4	5	5	1
Kangerdluarssuk	44	14	13	6	-	-	-
Ikertoq	63	21	17	15	9	1	-
total	192	69	44	38	29	12	1
%	100	36	23	20	15	6	+

Div.1C							
Kangia	30	14	9	6	2	-	-
Angmagssivik	13	9	1	1	1	+	-
Hamborgsund	22	9	5	4	4	+	-
Søndre Isortoq	16	6	4	7	-	-	-
total	81	38	19	18	7	1	-
%	100	47	23	21	8	1	-

Div.1D							
Godthåbsfjord	473	177	83	62	46	72	33
%	100	37	18	13	10	15	7

Div.1E							
Grædefjord	19	10	4	2	2	1	-
%	100	53	21	13	9	4	-

Div.1F							
Lichtenau	36	11	8	7	8	2	-
Tunugdliarfik	69	25	16	20	8	1	-
Igaliko	97	45	25	15	9	2	-
total	202	80	49	42	25	5	-
%	100	40	24	21	12	3	-

Table 4.1. Mean catch per unit of effort (100 hooks) for smaller cod (<54cm). Number of valid sets in brackets.

		0-100m		100-200m		200-300m	
Div.1C	Bank	0.86	(3)	0.45	(7)	0.09	(3)
	Coast	1.78	(7)	0.67	(7)	0.00	(2)
	Fiord	1.32	(3)	0.00	(1)	-	(0)
Div.1D	Bank	5.01	(11)	1.38	(6)	0.63	(5)
	Coast	0.83	(8)	1.17	(4)	0.56	(3)
	Fiord	0.12	(5)	0.00	(3)	0.09	(6)
Div.1E	Bank	0.52	(1)	1.48	(7)	0.00	(2)
	Coast	0.59	(7)	0.00	(7)	0.28	(1)
	Fiord	0.00	(2)	0.00	(2)	0.00	(2)

Table 4.2. Mean catch per unit of effort (100 hooks) for larger
cod (>=54cm). Number of valid sets in brackets.

		0-100m		100-200m		200-300m	
Div.1C	Bank	0.10	(3)	0.08	(7)	0.00	(3)
	Coast	0.84	(7)	0.16	(7)	0.00	(2)
	Fiord	0.28	(3)	0.00	(1)	-	(0)
Div.1D	Bank	7.97	(11)	7.08	(6)	1.85	(5)
	Coast	5.09	(8)	2.62	(4)	1.13	(3)
	Fiord	0.94	(5)	0.10	(3)	0.09	(6)
Div.1E	Bank	25.45	(1)	12.91	(7)	2.07	(2)
	Coast	6.14	(7)	1.50	(7)	1.11	(1)
	Fiord	0.39	(2)	0.14	(2)	0.26	(2)

Table 4.3. Results from the ANOVA.

Small cod (<54cm).

Source	Df	SS	MS	F	P(F>Fobs)
Area	2	0.976	0.488	8.77	0.0003
Depth	2	1.121	0.561	10.07	0.0001
Division	2	0.280	0.140	2.51	0.0857
Error	108	6.014	0.055		

$R^2 = 0.28$

Large cod (>=54cm).

Source	Df	SS	MS	F	P(F>Fobs)
Area	2	3.483	1.742	21.96	0.0001
Depth	2	2.426	1.213	15.29	0.0001
Division	2	6.146	3.073	38.74	0.0001
Error	108	8.567	0.079		

$R^2 = 0.58$

Table 4.4.   Mean density weighted by area for smaller and larger
cod. For the 200-300m fiord stratum not covered in
division 1C a density of 0 is assumed. For two strata
with only one station the variance is estimated from
the relationship between mean and standard deviation
(Fig.4.4.)

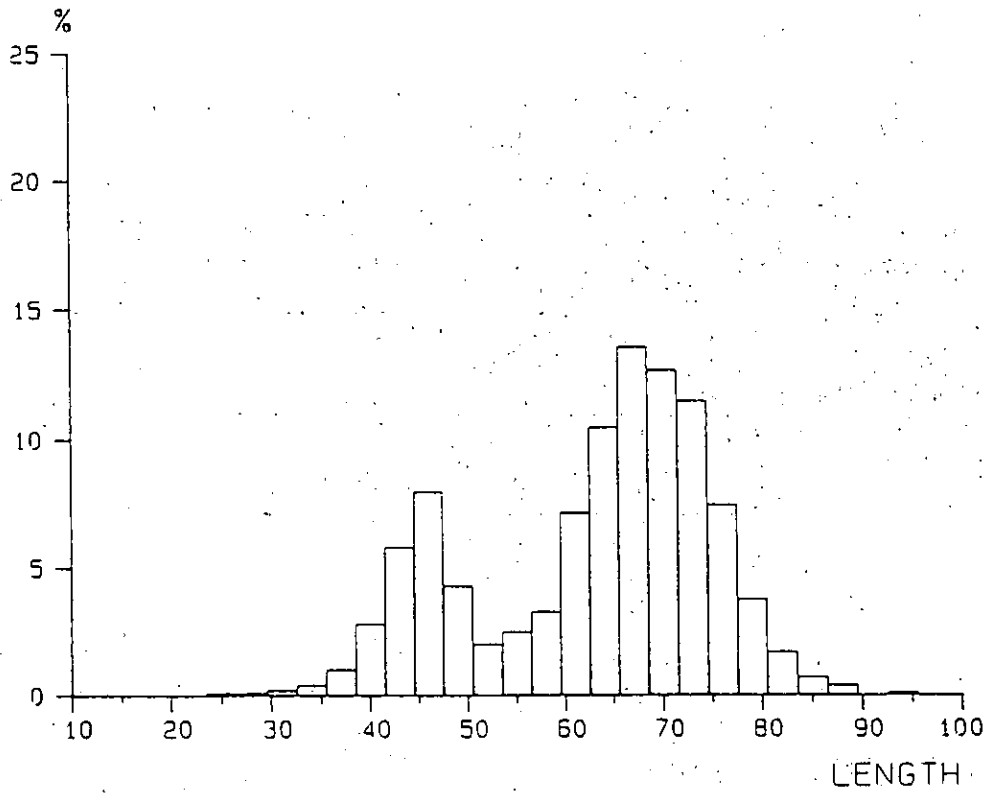|	Density Cod per 100 hooks	
	smaller cod (<54cm)	larger cod (>=54cm)
Bank	1.29 +/- 41%	4.44 +/- 32%
Coast	0.96 +/- 36	3.63 +/- 35%
Fiord	0.25 +/-122%	0.36 +/- 35%
Total	1.12 +/- 33%	3.85 +/- 26%

Fig.4.1. Length frequency distribution of offshore line catches
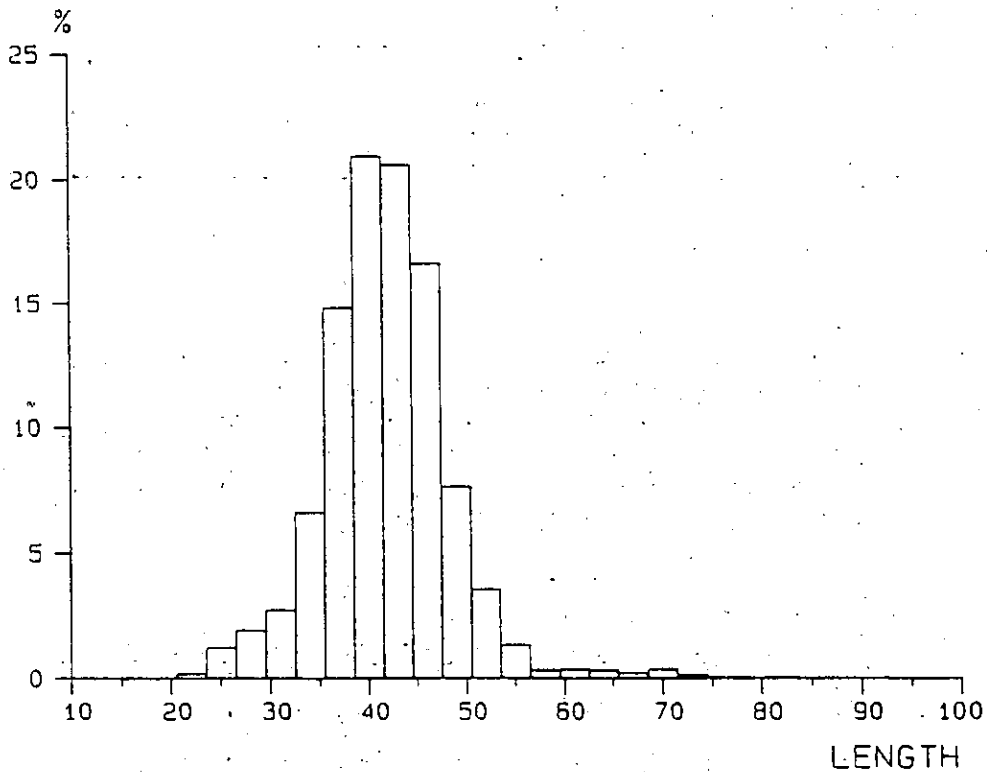   Div. 1C to 1E.

Fig.4.2. Length frequency distribution of offshore trawl catches
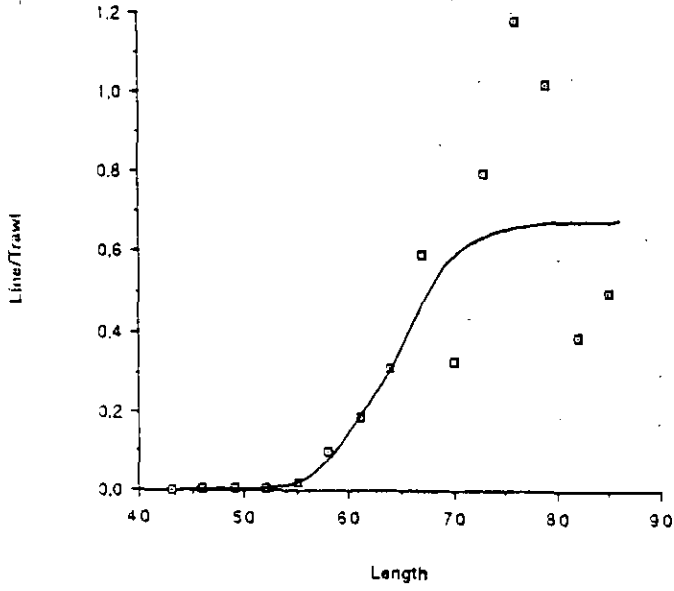   by R/V Walther Herwig. Div. 1C to 1E.
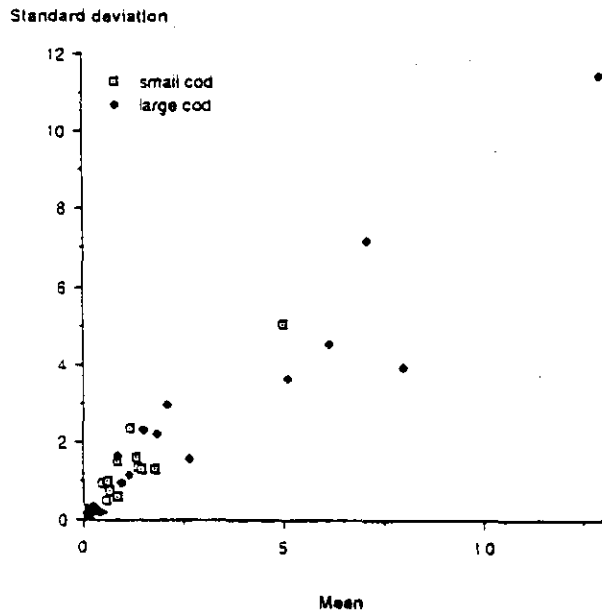
Fig. 4.3. Linecatches divided by trawlcatches
Line drawn by eye.

Fig.4.4. Standard deviation versus mean for small cod (<54cm)
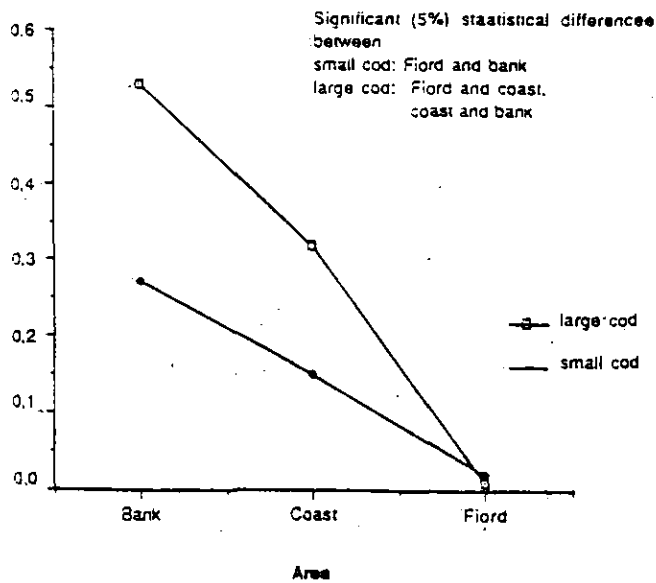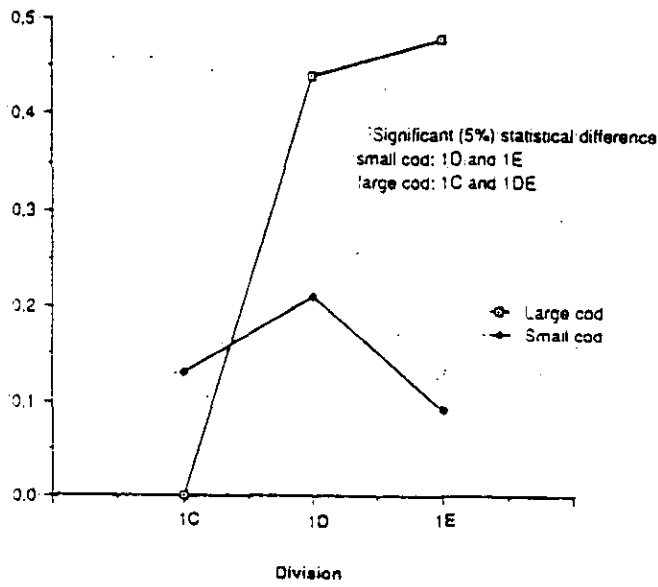and large cod (≥54cm). CPUE=catch per 100 hooks.

Log CPUE

Significant (5%) statistical difference
small cod: 50m and 150-250m
large cod: 50m and 150m, 150m and 250m

○ Large cod
◆ Small cod

Depth

Significant (5%) statistical difference
small cod: 1D and 1E
large cod: 1C and 1DE

○ Large cod
◆ Small cod

Division

Significant (5%) staatistical differencee
between
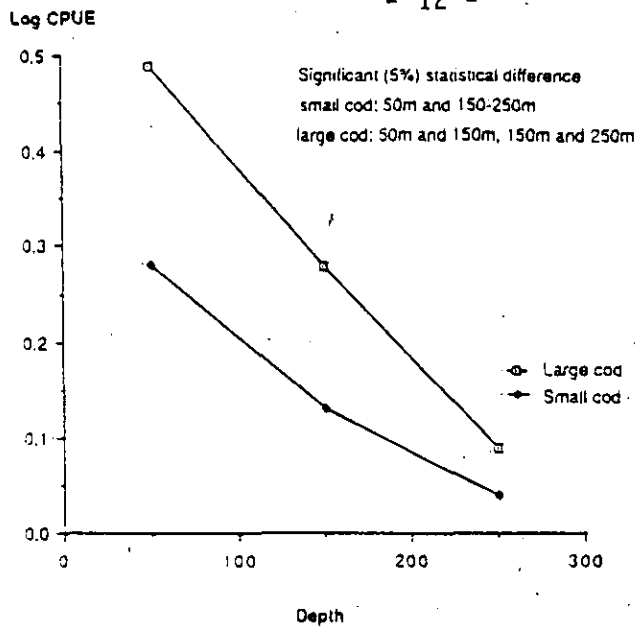small cod: Fiord and bank
large cod: Fiord and coast,
coast and bank

□ large cod
◆ small cod

Area

Fig.4.5. Log CPUE from linecatches (catch per 100 hooks)
for smaller (≤54cm) and larger cod (≥54cm).

Log CPUE

3

Significant (5%) statistical difference
small cod: 50-150m and 250m
large cod: 50-150m and 250m

2

1

-□- Large cod
-◆- Small cod

0

0   100   200   300

Depth

3

2

Significant (5%) statistical difference
small cod: 1C and 1DE
large cod: 1C and 1DE

1

-○- Large cod
-◆- Small cod

0

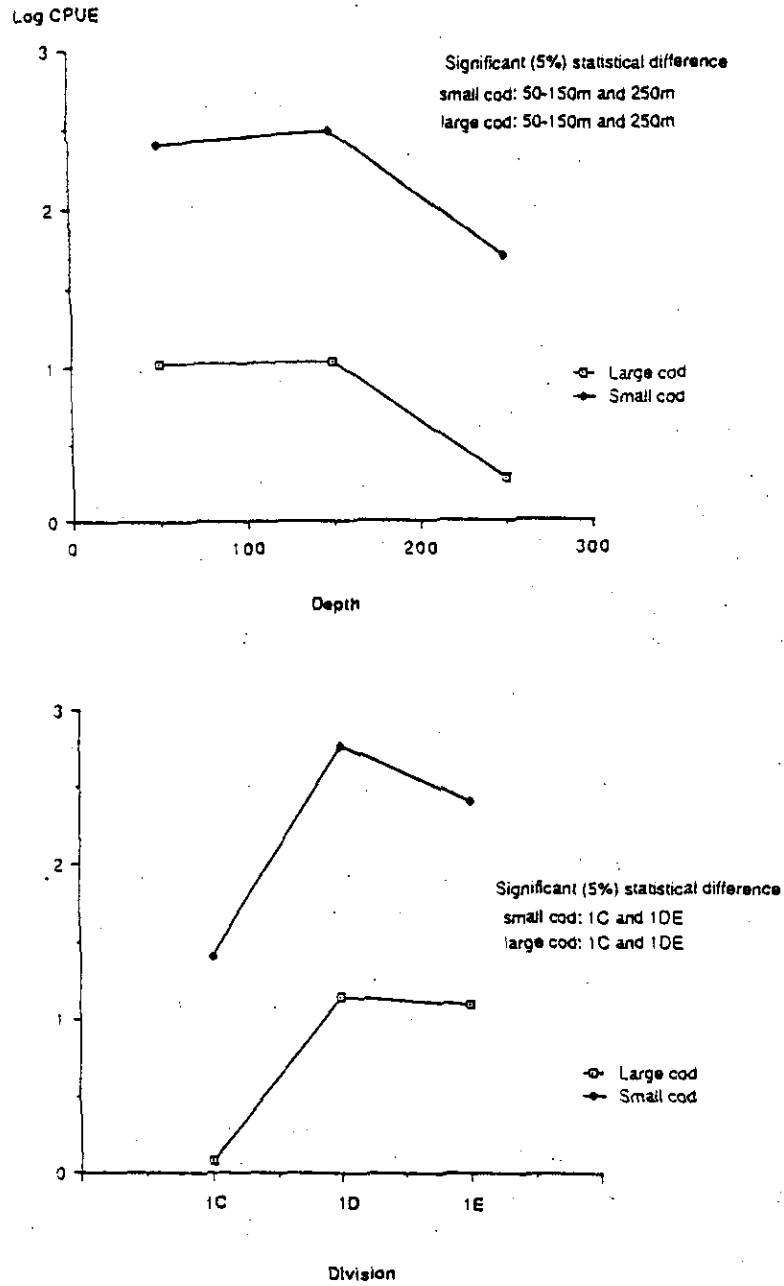1C   1D   1E

Division

Fig.5.1. Log CPUE from FRG trawl catches (30 min. towing)
for small (<54cm) and large cod (≥54cm).