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Distribution and Abundance of the Inshore Component of the West Greenland Cod Stock in Autumn 1988

by

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1 Introduction

In recent years assessment of the West Greenland cod stock has been based on trawl surveys carried out by the Federal Republic of Germany. These trawl surveys do not include the area within three nautical miles from the base line, and hence a proportion of the stock is not covered.

In order to quantify the size of the inshore component a longline survey was conducted in inshore areas in 1986 (Nygaard and Hovgård, 1987) and in both inshore and offshore areas in 1987. The surveys showed that significant amounts of cod were found inshore. In 1987 the inshore stock component was estimated to 22% of the total stock by comparing the trawl survey estimates with the offshore component estimated by the longline survey (Hovgård et al. 1988).

In this work the results of the longline survey in 1988 are presented and an algorithm for converting abundance estimates obtained by longline catches into equivalent trawl catches based on the 1987 and the 1988 surveys is established. This algorithm is used to estimate the abundance of the inshore stock component in 1988.

2 Materials and methods

2.1 Survey design

The surveys were carried out by R/V Misiliisoq in 1986 and by both R/V Adolf Jensen and R/V Misiliisoq in 1987-1988. The surveys were conducted in October-November simultaneously with the offshore trawl survey by R/V Walter Herwig of the Federal Republic of Germany (FRG). Large inshore areas off West Greenland are unsuitable for trawling, therefore longlines are used. The lines (equal type on both vessels) were of 7mm polypropylene, anchored at both ends and with minor loads for every 200m. Hooks (Mustad no. 6) were mounted on 50cm snoods with 2m intervals. On all fishing stations a line of 400 hooks was used. Capelin were used as bait. Fishing was done during the light hours, and average fishing time was 4.3, 4.8 and 4.5 hours (range 2.25 to 7.8 hours) in 1986, 87 and 88 respectively. Results are expressed in catch in numbers per 100 hooks disregarding any difference in fishing time.

Fishing stations were distributed in groups of 4 or 5, each group represents one day of fishing. The groups were distributed in NAFO divisions according to a stratified sampling scheme with 100m depth strata in the three areas: fiord, coast and offshore (banks). In 1986 the survey covered the fiord and coast in Div. 1C and 1D, and in 1987 and 1988 all three areas were covered in Div. 1C, 1D and 1E.

The number of valid sets were 60, 104 and 98 in 1986, 87 and 88 respectively. The distribution of sets per stratum is shown in table 1.

2.2 Survey area.

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 is defined as the area from 3 mile line to straight lines at the entrance of the fiords and the fiord area is the area inside these straight lines. Each area was further divided into 100m depth strata (table 2). For a description of area calculations, see Hovgård et al. (1987).

3 Results.

3.1 Convertion of longline catches into equivalent trawl catches.

The longline surveys and FRG trawl surveys were carried out almost simultaneously. Length frequency distributions obtained in the offshore area show marked differences between longline catches and FRG trawl survey catches in both 1987 and 1988 (fig. 1). This difference is attributed to gear selection.

A relationship between cpue of trawl and longline catch data was constructed. This relationship is based on data from the offshore area for both 1987 and 1988. For 1987 data from Div. 1C, 1D all depth strata and Div. 1E depth strata 100-200m were included. For 1988 only data from Div 1D all depth strata were selected. Cpue were calculated for each division and each year by 6cm length groups. Cod below 36 cm were not included because of the low catchability by longlines of these size groups. Cod above 71cm were aggregated into one length group.

The standard deviations of catchrate data were found to be proportional to the means, and hence data were logtransformed prior to analysis. Zero mean catchrates were omitted from the analysis.

The algoritm assumes that both trawl and longlines provide an estimate of abundance, but the longline estimate is confounded by selection. Let L be the mean cpue for longline and T the mean cpue for trawl for a given combination of division, month and lengthgroup. Since both L and T are estimates of the abundance then

$$T = q \times S \times L$$

where q is the efficiency ratio between trawl and longlines for fully recruited length groups while S is the longline selectivity. The trawl used is assumed to be unselective for the cod considered above 36 cm. Inspection of the data suggests surprisingly that not even cod above 65 cm are fully recruited by longline. We can therefore approximate the longline selection by and exponential function, exp(b x length), this expression can of course not be exterpolated to larger size cod. Introducing this selection function into the model given above and taking logarithms, we regress log(T) on log(L) and length, the results are given in table 3.

The regression implies that the relationship between trawl cpue (T) and longline cpue (L) is not quite linear, however the coefficient found is not largely different from 1 (table 3), and therefore the more simple model is chosen.

$$\log(T) = b_0 + b_1 \times \text{length} + \log(L)$$

Both T and L are observed quantities with considerable variances and the regression model assumes that the independent variable is observed without error. Therefore we use log(T/L) in order to have the variance on catches in the dependent variable. The equation is rearranged and ends up with a linear regression model log(T/L) vs. length.

The relationship may vary between years therefore b_1 was estimated using 1987 and 1988 data separately, table 4. t-test for difference in parameter estimates for the two years show no (5% significant level) difference between the estimates.

$$\log(T/L) = b_0 + b_1 \times \text{length}$$

This regression model establishes the relationship between longline and trawl catches. The regression analysis and the parameter estimates are shown in table 5. Fig. 2 shows a plot of the predicted values together with observed values against length.

When back-transforming from the logaritmic values to the required arithmetic it is necessary to consider the error structure of the model. If we assume that the error of L and T are multiplikative and that our sampling is unbiased, the correction term in our model would be $\exp(-s^2/2)$. From table 5 this correction factor become 3.64 and this correction decreases the estimate of cod inshore measured in trawl units. We have however not applied this correction as it for the larger groups takes values at the border or outside the range observed. This to us suggest that either the standard deviation estimated is invalid, or that the error structure assumed is not correct. The analysis will be taken a bit further at a later stage but until such time we are satisfied with not applying the correction.

This gives the final equations, which convert longline catches to equivalent trawl catches :

36-41cm :	T = 600 x L
42-47cm :	T = 231 x L
48-53cm :	T = 89 x L
54-59cm :	T = 34 x L
60-65cm :	T = 13 x L
66-71cm :	T = 7 x L
>72cm :	T = 2 x L

3.2 Distribution and abundance in the inshore area.

Table 6 gives for each length group mean densities, expressed as catch per 100 hooks, for the inshore strata. The highest densities are found in Div. 1CD, at the coast and in shallow waters (0-100m).

After conversion to trawl units, the longline densities were raised to total abundance taking area of strata into account in a same procedure as used when estimating abundance from the FRG trawl survey (Anon., 1989).

Otoliths were sampled during the longline survey to establish an age-length key. This was applied to the abundances estimates given in table 7 and this table do also provide the age distributions. The abundance of the 3 year and to a lesser degree the 4-year old cod are likely underestimated because some fish of these age groups are below 36cm and therefore not included in the estimates. In all divisions the inshore abundance are highest in shallow waters (0-100m). The abundance estimate of Div. 1C is about 75 mill., which are considerably higher than those of Div. 1D (about 27 mill.) and Div. 1E (about 5 mill.).

To estimate the overall abundance of the inshore stock component it is necessary to make assumptions about the densities in Div. 1B and 1F, because no fishing took place there during the longline survey. The mean densities by strata in Div. 1B are assumed to be the same as those found by the longline survey in Div. 1C, and the mean densities in Div. 1F are assumed to be the same as those found in Div. 1E. Further, it is assumed that no cod are found in Div. 1A. The total inshore stock component is then estimated to be about 149 mill. When comparing this inshore abundance estimate with that derived from the FRG trawl survey at about 564 mill. the inshore stock component accounts for 21% of the total stock.

4 Discussion.

In last years assessment of the inshore stock component catches were aggregated in two size groups : smaller and larger than 54 cm, i.e. a grouping that separated the strong 1984 year-class from the older and much smaller year-classes (Hovgård et al., 1988). For both size groups the relative density inshore was expressed as the ratio in catch rates between inshore and offshore line settings. The density in the inshore areas were then calculated by multiplying these ratios with the densities found in the offshore trawl survey. Inshore abundance was finally achieved by raising densities with the inshore areas. By this procedure the inshore abundance was found to account for 22% of the total stock (Anon., 1988).

In the present work further considerations are given to the difference in selection between trawl and longline by comparing catch rates within 6cm groups. Data from two years of concurrent fishing by the gears in the offshore area have been used and a direct relationship between catch rates of longline and trawl is established. This relationship is then used to raise the inshore longline abundance estimates to equivalent trawl estimates. When more data will become available in future this relationship can be improved.

At present the cod stock is totally dominated by the 1984 year-class whereas older and larger cod are scarce. This causes some problems when relating longline catches to trawl catches as the numbers of large cod caught by both gears are very small. The regression model used for converting the longline catchrates is equivalent to an exponential selection ogive. One would have expected some kind of a S-shaped relation, however, data inspection suggests that for longlines the asymptotic level or even efficiency decrease is not reached for length groups observed. Expecting a S-shaped curve it might seem contradictionary to use one length group consisting of all cod above 71cm. However, this length group is kept in the modelling proces because no improvement is obtained by excluding them. With these considerations in mind one should be warned against using this regression model outside the covered length range.

Mean densities in the inshore areas decline from coast to fiord (except in Div. 1E, where the effort, however, was very small). This distribution pattern was also found in the two previous surveys. In the inshore areas highes densities were seen in the shallow waters (0-100m) and also this is in good agreement with the findings from 1986 and 1987.

The abundance estimates for inshore area showed decreasing abundance southward (74 mill. in Div. 1C, 27 mill. in 1D and 5 mill. in 1E). Both in 1986 and 1987 the inshore abundance in Div. 1C were found to be substantially higher than that of Div. 1D and 1E, although the differences were not so big as found in this year.

The pattern of distribution in the inshore areas seems in general to have been relatively stable during the 1986-88 period with higher abundance in Div. 1C than in Div. 1D and 1E. The offshore distribution as found by the FRG trawl survey is somewhat different as high densities of cod have been observed only south of Tovqussaq bank (the very southermost bank area of Div. 1C) during the same period. The offshore distribution also seem more variable; in 1987 densities was found to be rather uniform in Div. 1DEF whereas the stock in 1988 was concentrated in Div. 1D (4 mill. in Div. 1BC, 460 mill in Div. 1D, 43 mill. in Div. 1E and 56 mill. in 1F (Anon., 1989)).

The inshore stock component is estimateds to account for 21% of the total stock, which is the same as found in 1987 (22%). The abundance estimate from the FRG trawl survey should hence be raised by this proportion to account for the part of the stock found inshore.

5 References.

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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).

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Table 1. Number of valid set per stratum in the longline survey off West Greenland 1986-88. 1 set equal 400 hooks.

			1986	1987	1988
1C					
	bank	0-100m		3	4
		100-200m		6	5
		200-300m		3	1
	coast	0-100m	6	7	10
		100-200m	6	7	7
		200-300m	6	2	3
	fiord	0-100m	4	2	3
		100-200m	4	2	3
		200-300m	4		2
1D	bank	0-100m		8	7
		100-200m		3	8
		200-300m		5	4
	coast	0-100m	5	8	10
		100-200m	5	3	11
		200-300m	5	3	3
	fiord	0-100m	5	5	2
		100-200m	5	3	4
		200-300m	5	6	2
1E	bank	0-100m		1	1
		100-200m		7	
		200-300m		2	2
	coast	0-100m		6	1
		100-200m		6	2
		200-300m		1	1
	fiord	0-100m		1	1
		100-200m		2	1
		200-300m		2	

Table 2. 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	3493	996	5680
	total	2422	3759	1151	7332
Div. 1D	fiord	381	185	134	700
	coast	1093	85	86	1264
	bank	1475	875	628	2978
	total	2949	1145	848	4942
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
(a)	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 Anon. (1987), inshore areas from Hovgård et al. (1988)

(a) Estimated from area distribution in Div. 1E (see Anon. (1987), table 5.1.2.).

Table 3. Multiple regression of log(T) on log(L) and length.

Model: $\log(T) = b_0 + b_1 \times \text{Length} + b_2 \times \log(L) + E$

	DF	SS	MS	F	PR>F	R^2
MODEL	2	184.439	92.219	35.40	0.001	0.572
ERROR	53	138.063	2.605			
SOURCE						
Length	1	111.281		42.72	0.0001	
log(L)	1	73.158		28.08	0.0001	

Parameter estimate		std. error of estimate
b_0	13.0834	1.1948
b_1	-0.1662	0.0202
b_2	1.1690	0.2206

Table 4. Regression of log(L/T) versus length nested within year.

Model: $\log(L/T) = b_0 + b_{1(year)} \times \text{Length} + E$

	DF	SS	MS	F	PR>F	R^2
MODEL	2	210.253	105.126	41.56	0.0001	0.611
ERROR	53	134.066	2.530			

Parameter estimate		std. error of estimate
b_0	-12.7393	1.0086
$b_{1,87}$	0.1659	0.0183
$b_{1,88}$	0.1546	0.1796

Table 5. Regression of log(L/T) versus length.

Model: $\log(L/T) = b_0 + b_1 \times \text{Length} + E$

	DF	SS	MS	F	PR>F	R^2
MODEL	1	204.727	204.727	79.197	0.0001	0.595
ERROR	54	139.591	2.585			

Parameter estimate		std. error of estimates
b_0	-12.6061	1.0156
b_1	0.1592	0.0179

Table 6. Mean catch per unit of effort (100 hooks) for 6cm length group in the longline survey in 1988.

		Fiord			Coast		
		0-100	100-200	200-300	0-100	100-200	200-300
Div.1C	36-41	0.52	0.10	0.00	1.14	0.41	0.00
	42-47	0.11	0.69	0.00	3.51	1.02	0.91
	48-53	0.31	0.59	0.18	3.19	1.82	1.46
	54-59	0.41	0.20	0.00	0.75	0.93	0.46
	60-65	0.11	0.10	0.00	0.20	0.05	0.09
	66-71	0.00	0.00	0.00	0.13	0.00	0.00
	≥72	0.10	0.00	0.00	0.26	0.40	0.00
	Total	1.56	1.68	0.18	9.18	4.63	2.92
Div.1D	36-41	0.00	0.00	0.00	0.30	0.18	0.09
	42-47	0.14	0.00	0.00	1.02	0.66	0.47
	48-53	0.00	0.00	0.13	1.41	0.98	0.63
	54-59	0.00	0.00	0.00	0.78	0.26	0.18
	60-65	0.00	0.07	0.00	0.56	0.31	0.00
	66-71	0.00	0.00	0.00	1.57	0.49	0.10
	≥72	0.00	0.08	0.00	1.37	0.36	0.00
	Total	0.14	0.15	0.13	7.01	3.24	1.47
Div.1E	36-41	0.59	0.00	-	0.00	0.00	0.00
	42-47	0.30	0.00	-	0.00	0.00	0.00
	48-53	1.18	0.00	-	0.00	0.00	0.00
	54-59	0.59	0.00	-	0.00	0.00	0.00
	60-65	0.00	0.00	-	0.00	0.00	0.00
	66-71	0.30	0.00	-	0.00	0.00	0.59
	≥72	0.59	0.00	-	0.30	0.00	0.30
	Total	3.55	0.00	-	0.30	0.00	0.89

Table 7. Abundance estimates ('000') by strata in the inshore area from the longline survey in 1988.

	Age	0-100	100-200	200-300	Total
Div. 1C	3	16975	955	9	17939
	4	51560	3801	513	55874
	5	223	21	3	247
	6	85	11	2	98
	7	9	1	-	10
	8	42	3	-	45
	9	45	3	-	48
	10	7	-	0	7
	11	1	-	0	1
	Total	68947	4795	527	74269
Div. 1D	3	4643	219	109	4971
	4	19177	928	662	20767
	5	117	5	4	126
	6	104	5	1	110
	7	42	2	-	44
	8	240	8	1	249
	9	298	9	1	308
	10	62	2	-	64
	11	12	-	-	12
	Total	24695	1178	778	26651
Div. 1E	3	1999	0	0	1999
	4	3278	0	-	3278
	5	15	0	0	15
	6	11	0	-	11
	7	2	0	-	2
	8	13	0	1	14
	9	27	0	2	29
	10	9	0	-	9
	11	2	0	-	2
	Total	5356	0	3	5359

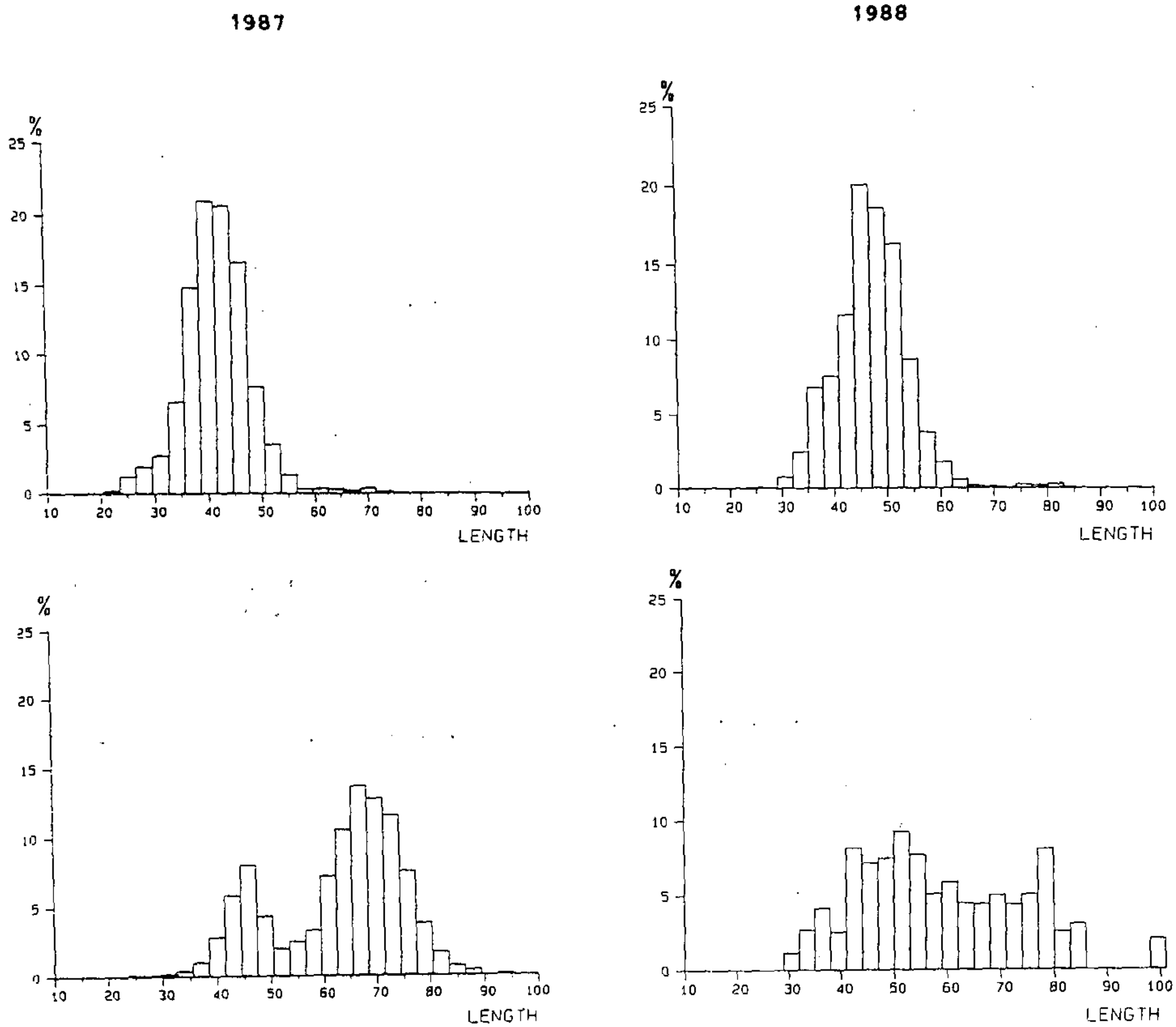

Fig. 1. Length distribution in 1987 and 1988 of offshore trawl catches by R/V Walter Herwig, Div. 1C-1E (upper) and of offshore longline catches, Div. 1C-1E (lower)

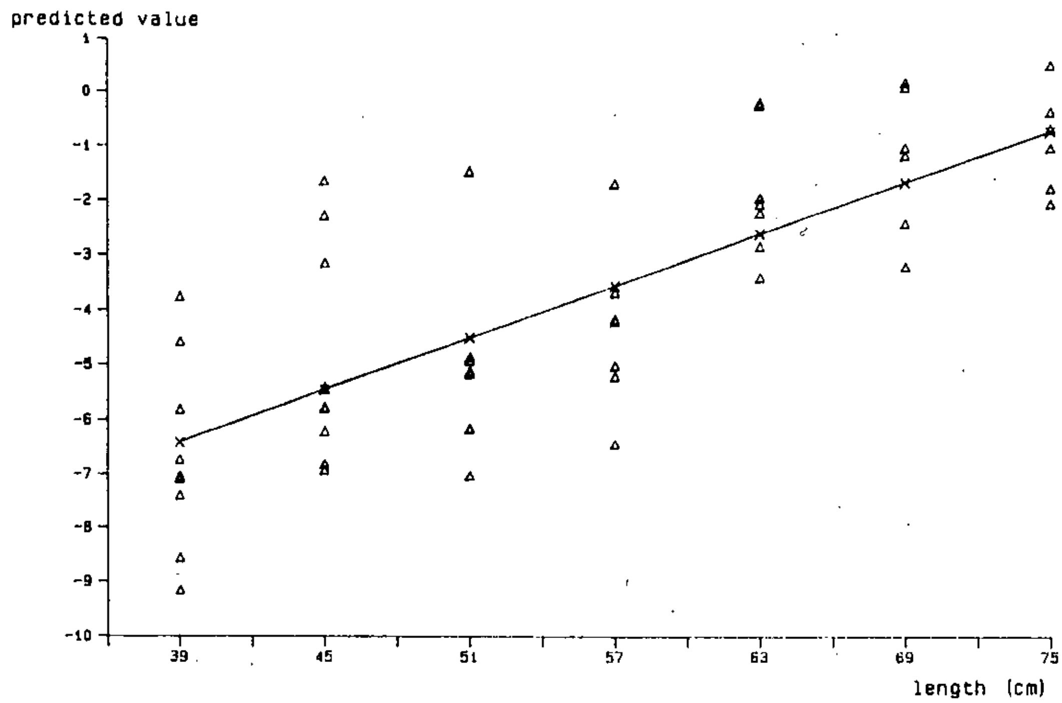

Fig. 2. Plot of predicted values by the regression model together with observed values against length.