ABUNDANCE AND DISTRIBUTION OF 0-GROUP ARCTO-NORWEGIAN COD AND HADDOCK 1965 - 1982

by

Kjell Randa
Institute of Marine Research

ABSTRACT

The trawl data from the International 0-group fish surveys in the Barents Sea are reanalysed for cod and haddock. Relative indices of yearclass abundance are estimated on a logarithmic scale. The most abundant yearclasses at the 0-group stage, for cod, are the 1970, 1973 and 1975 yearclasses and the 1970, 1974 and 1975 yearclasses for haddock. The estimated indices of yearclass strength give a correlation of 0.92 for cod and 0.89 for haddock with VPA (Virtual Population Analysis) estimates for the corresponding yearclasses at age 3 for the yearclasses 1970 - 1976.

0-group haddock show a more western distribution than cod which may be related to a more western spawning area for haddock. Both cod and haddock show similar trends in changes in the east-west distribution over time. This is probably related to hydrographical factors such as changes in the relative strength of the different currents in the area. A good correlation is found for both cod and haddock between the part of a yearclass found in the Barents Sea and the temperature anomalities in the Kola Meridian hydrographical section, but no correlation was found between the part of a yearclass in the Spitsbergen/

Bear Island area and temperature anomalies in the Bear Island West hydrographical section.

INTRODUCTION

The knowledge of the size of the recruiting yearclasses is one of the basic needs for a successful stock assessment. The International 0-group fish surveys in the Barents Sea have been conducted since 1965, and the results from these surveys have been used in the assessment of the Arcto-Norwegian cod and haddock stocks (Anon, 1983a).

Recruitment indices for several species have been computed based on the data from these surveys using a method described by Haug and Nakken (1977). The recruitment indices are calculated on basis of the number caught of a species and its area of distribution.

In this paper a new set of recruitment indices are calculated based on the number caught in different areas. The recorded data from each of the trawlhauls constitute the basic material for this analysis.

MATERIAL

Each year since 1965 joint international (Norway, USSR and up until 1976 UK) 0-group fish surveys have been carried out in the Barents Sea in August - September. The aim of these surveys is to measure the level of recruitment of the most important fish species in the area. This include species like cod, haddock, capelin, herring, redfish, polar cod, Greenland halibut and long rough dab.

The survey is a trawl survey carried out by three to five research vessels. Pelagic trawl hauls are taken at every 30 nautical mile or when echo recordings change, using a small meshed pelagic trawl. The trawl depth is decided from the echograms, and the trawl is towed in the depths of the recordings, mostly less than 50 m. If no recordings are present, the trawl is towed at the surface using 6 big floats on the headrope. The trawl is towed for 1 nautical mile at about 3 knots.

In 1981 a new standard trawl procedure was chosen (Anon, 1981). After 1981 trawling has been done in a stepwise manner. The trawl is towed for 10 minutes with the headline in each of the following depths: 0 m, 20 m and 40 m. The towing speed is 3 knots.

METHODS

RELATIVE FISHING POWER OF THE VESSELS

Altogether 11 different vessels have participated in the surveys in the period since 1965. Both the trawls and the vessels have increased in size and there has been a change from side to stern trawlers.

In order to assess the differences between vessels and trawls the relative fishing power of the different vessels and trawls have been estimated using the methods of Robson(1966). The calculations were done using a computer program described by Fox (1971), and also by Randa (1982).

ESTIMATION OF RECRUITMENT INDEXES

As a basic index of yearclass abundance the stratified mean catch in numbers per 1.0 nautical mile towed on a logarithmic scale is used. A logarithmic scale is used to reduce the effect of a few large catches that are not representative for more than a very small area, and to normalize the catch data.

The total area was divided into 17 areas (Fig. 1) and area 1-11 make up the eastern area and area 12-17 the western area.

Trawl data are usually highly positively skewed and a transformation is necessary to normalize the data. Pennington and Grosslein (1978) indicate that the transformation $y = \ln(x)$,

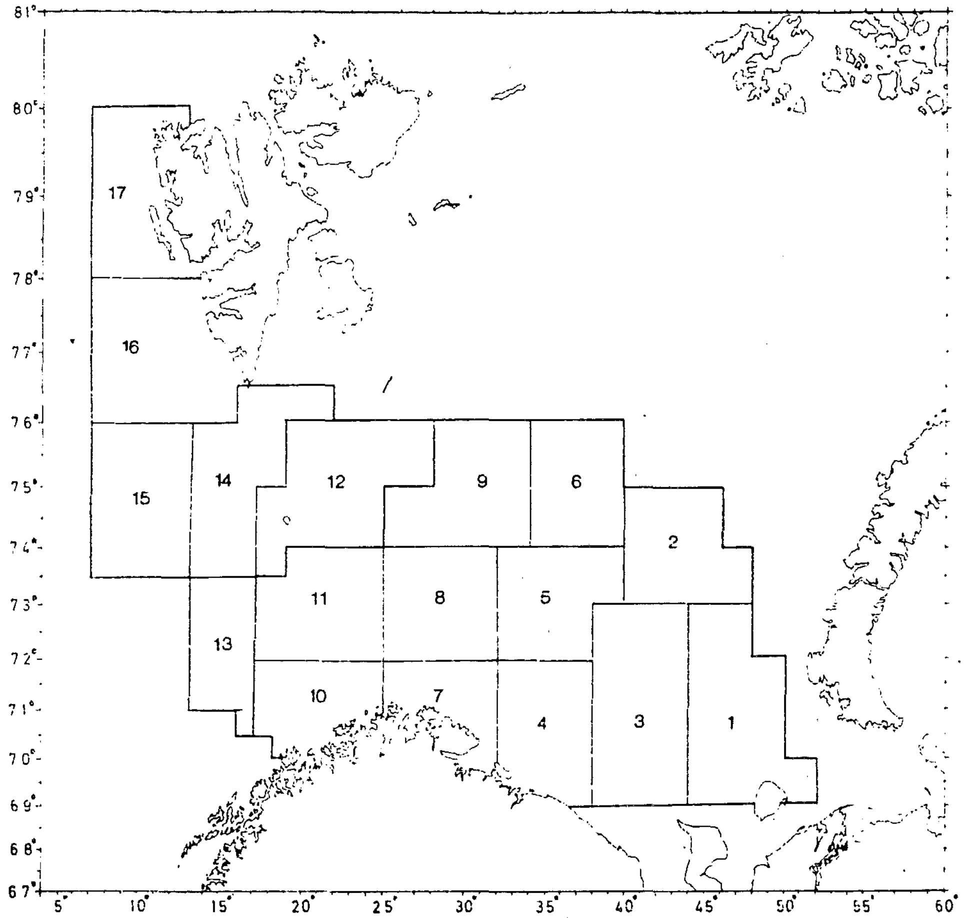

Figure 1. The strata used in estimating abundace indices.
The eastern area: Strata 1 - 11.
The western area: Strata 12 - 17.

$x \neq 0$ is the most appropriate and Randa (1982) has shown that this transformation normalize catch data for 0-group cod. For each area each year the following quantities are calculated:

The logarithmic mean $$\overline{X}_j = \frac{1}{N_{1j}} \sum_{i=1}^{N_{1j}} \ln(X_{ij})$$

The logarithmic variance $$S_j^2 = \frac{1}{N_{1j}-1} \sum_{i=1}^{N_{1j}} (\ln(X_{ij})-\overline{X}_j)^2$$

The Proportion of nonzero hauls $$p_j = \frac{N_{1j}}{N_j}$$

The variance of this proportion $$S_{pj}^2 = \frac{1}{N_j-1} p_j(1-p_j)$$

X_{ij} is the catch in number at station i in area j, N_{1j} is the number of nonzero hauls in area j and N_j is the total number of hauls in area j.

An index of abundance in area j is computed as $X_j \cdot p_j$. A combined index for several areas is computed in the following way:

Calculate the stratified logarithmic mean catch and its standard error.

$$R = \frac{1}{A} \sum_{j=1}^{k} a_j \cdot \overline{X}_j$$

$$SER = \sqrt{\frac{1}{A^2} \sum_{j=1}^{k} \frac{a_j^2 \; S_j^2}{N_{1j}}}$$

where a_j is the areal of area j, A is the total areal and k is the number of areas.

A areal weighted proportion for several areas and its standard error is calculated in the following manner:

$$Q = \frac{1}{A} \sum_{j=1}^{k} a_j \cdot p_j$$

$$SEQ = \sqrt{\frac{1}{A^2} \sum_{j=1}^{k} a_j^2 \cdot S_{pj}^2}$$

The final logarithmic index of yearclass abundance is then calculated as

$$L = R \cdot Q$$

CONFIDENCE LIMITS

Confidence limits of L is obtained in the following manner (Harpelin and Mantel, 1963; Harpelin, 1964): First calculate 95% confidence limits on R and Q based on normal theory.

$$R - 2 \cdot SER < R < R + 2 \cdot SER \quad \text{or}$$
$$R' < R < R''$$

and

$$Q - 2 \cdot SEQ < Q < Q + 2 \cdot SEQ$$
$$Q' < Q < Q''$$

Then the confidence limits for L are given as

$$R' \cdot Q' < R \cdot Q < R'' \cdot Q'' \quad \text{or}$$
$$L' < L < L''$$

The size of these confidence limits are above 90% and probably near 95% (Harpelin and Mantel; Harpelin, 1964). The calculated indices for cod and their confidence limits given in this paper differs from those given by Randa (1982) because of unweighted estimate of Q was used in that paper.

RESULTS AND DISCUSSION

ANALYSIS OF FISHING POWER

The relative fishing powers of the different vessels for cod are taken from Randa (1982) and are given in table 1. Randa (1982) also gives a detailed description of how they are computed. The low values for the non-Norwegian vessels probably reflect the smaller trawls used by these vessels.

Since 0-group cod and haddock are distributed in much the same area and depth and are of similar length during the survey period, it seems reasonable to assume that their catchability are much the same. Therefore the relative fishing powers estimated for cod are also used on the haddock catches.

Two vessels "Havdrøn" (Norway) and "Jastreb" (USSR) have only participated one year each in the survey and their relative fishing power for both cod and haddock is assumed to be 1.0.

Table 1. Estimated fishing powers with confidence limits relative to G.O.Sars (1971-1979). Taken from Randa 1982.

Vessel	Relative Fishing Power	Confidence Limits
G.O.Sars (1971-1979)	1.000	
G.O.Sars (1970)	0.221	0.060-1.706
G.O.Sars (1965-1969)	0.493	0.148-2.931
J.Hjort (1965-1973)	1.936	0.856-5.481
J.Hjort (1975-1979)	1.536	0.697-4.172
E.Holt (Pelagic trawl)	0.518	0.106-9.601
E.Holt (Boothbay trawl)	0.574	0.175-3.291
Cirolana (Pelagic trawl)	0.551	0.253-1.464
Cirolana (Boothbay trawl)	0.040	0.012-0.220
A. Knipovich	0.563	0.241-1.678
F.Nansen	0.734	0.350-1.844
Poisk	0.537	0.280-1.178
Odissey	0.723	0.305-2.216

The same assumption is made for the new vessels "Michael Sars" (Norway) and "Percey III" (USSR). This seems reasonable because both these vessels have used a trawl similar to that of the selected standard vessel "G.O. Sars".

INDICES OF YEARCLASS ABUNDANCE

Cod

The estimated indices of yearclass abundance for cod in the western, eastern and total area together with their confidence limits are given in Tables 2, 3 and 4, and are shown in Figs. 2, 3 and 4. Fig. 4 shows that there is a great variability in yearclass strength of about two orders of magnitudes. The strongest yearclasses are the 1970, 1973 and 1975 (Table 5). The distribution of the 1973 and 1975 yearclasses are very different from the 1970 yearclass. From Tables 2, 3 and 4 it is seen that the 1973 and 1975 yearclasses had a very eastern distribution and were only found in small numbers in the Spitsbergen/Bear Island area. This is in contrast to the 1970 yearclass which also was numerous in the western area.

Table 2. Estimated indices with confidence limits of yearclass abundance for 0-group cod and haddock in the western area.

	Cod			Haddock		
Year-class	Logarithmic index	Confidence limits (95%)		Logarithmic index	Confidence limits (95%)	
1965	0.00			0.01	0.00	0.01
1966	+			0.01	0.00	0.02
1967	+			0.04	0.00	0.08
1968	+			+		
1969	0.18	0.07	0.33	0.47	0.19	0.89
1970	1.71	0.86	2.75	1.10	0.54	1.85
1971	0.32	0.13	0.60	0.38	0.18	0.63
1972	0.06	0.01	0.13	0.31	0.10	0.67
1973	0.11	0.03	0.25	0.22	0.05	0.49
1974	0.01	0.00	0.05	0.33	0.12	0.62
1975	0.07	0.01	0.19	0.23	0.09	0.45
1976	0.00			0.35	0.14	0.70
1977	0.22	0.08	0.43	0.34	0.09	0.69
1978	0.32	0.13	0.60	0.30	0.10	0.60
1979	0.63	0.31	1.06	0.30	0.11	0.60
1980	0.18	0.06	0.38	0.26	0.10	0.46
1981	0.13	0.04	0.30	0.07	0.00	0.27
1982	0.33	0.14	0.54	0.58	0.29	0.90

Table 3. Estimated indices with confidence limits of yearclass abundance for 0-group cod and haddock in the eastern area.

	Cod			Haddock		
Year-class	Logarithmic index	Confidence limits (95%)		Logarithmic index	Confidence limits (95%)	
1965	+			0.02	0.00	0.04
1966	0.03	0.01	0.06	0.01	0.00	0.02
1967	0.09	0.04	0.15	0.09	0.04	0.19
1968	0.03	0.01	0.08	0.00	0.00	0.04
1969	0.27	0.18	0.39	0.21	0.12	0.32
1970	2.87	2.32	3.50	0.49	0.28	0.76
1971	1.00	0.73	1.32	0.21	0.13	0.31
1972	0.83	0.54	1.18	0.11	0.04	0.23
1973	2.49	1.98	3.05	0.25	0.13	0.44
1974	0.51	0.31	0.76	0.62	0.41	0.83
1975	1.50	1.10	1.97	0.80	0.52	1.19
1976	0.25	0.12	0.44	0.37	0.23	0.55
1977	0.63	0.45	0.85	0.33	0.20	0.48
1978	0.19	0.11	0.28	0.06	0.03	0.12
1979	0.32	0.16	0.54	0.15	0.08	0.24
1980	0.10	0.06	0.14	0.11	0.06	0.18
1981	0.11	0.04	0.16	0.01	0.00	0.02
1982	0.66	0.44	0.92	0.30	0.23	0.43

Table 4. Estimated indices with confidence limits of yearclass abundance for cod and haddock in the total area. Number of 3 years old is taken from Anon, 1983a and Anon, 1983b.

	Cod				Haddock			
Year-class	No 3-years old (mill)	Logarithmic index	Confidence limits (95%)		No 3-years old (mill)	Logarithmic index	Confidence limits (95%)	
1965	170	+			20	0.01	0.00	0.04
1966	112	0.02	0.01	0.04	17	0.01	0.00	0.03
1967	197	0.04	0.02	0.08	164	0.08	0.03	0.13
1968	405	0.02	0.01	0.04	96	0.00	0.00	0.02
1969	1016	0.25	0.17	0.34	1032	0.29	0.20	0.41
1970	1818	2.51	2.02	3.05	291	0.64	0.42	0.91
1971	524	0.77	0.57	1.01	57	0.26	0.18	0.36
1972	620	0.52	0.35	0.72	50	0.16	0.09	0.27
1973	616	1.48	1.18	1.82	58	0.26	0.15	0.40
1974	371	0.29	0.18	0.42	131	0.51	0.39	0.68
1975	794	0.90	0.66	1.17	201	0.60	0.40	0.85
1976	241	0.13	0.06	0.22	188	0.38	0.24	0.51
1977	(175)	0.49	0.36	0.65	(22)	0.33	0.21	0.48
1978	(257)	0.22	0.14	0.32	(15)	0.12	0.07	0.19
1979	(191)	0.40	0.25	0.59	(55)	0.20	0.12	0.28
1980		0.13	0.08	0.18		0.15	0.10	0.20
1981		0.10	0.06	0.18		0.03	0.00	0.05
1982		0.59	0.43	0.77		0.38	0.30	0.52

( ) Preliminary

The yearclasses 1971, 1972, 1977 and 1982 may be considered medium at the 0-group stage, and the rest of the yearclasses in the period 1965 - 1982 are poor. From Fig. 5 it can be seen that it appears to have been two periods of poor recruitment to the Arcto-Norwegian cod. This is the period 1965 - 1969 and 1976 - 1981. Between these two periods of low recruitment there was a period of high recruitment.

The confidence limits for the recruitment indices (Table 4) show that the yearclasses 1965 - 1968 are very poorly estimated. The confidence limits are in the range of 100%. This is due to several factors. In these years the survey was poorly standardized. The participating vessels used several different trawls and the trawl parameters are badly documented in the database. Number of hauls were fewer and the trawl depth was not easily determined due to lack of instrumentation. All these factors add variance components that are unknown and are not caused by the variation in fish distribution. Therefore these four yearclasses are not used when the estimated indices of yearclass abundance are compared with other estimates of yearclass abundance. When the estimated indices (Table 4) are compared with the VPA (Virtual Population Analysis) estimates of number of 3 years old fish taken from Anon (1983a) it is obvious that the index for the 1969 yearclass is much too low and this estimate is considered as an outlier and is not used further in this comparative analysis.

It is assumed that the VPA gives reliable estimates for all yearclasses 1976 and older. This gives a regression line for the relation between the estimated indices and the VPA estimates for the same yearclasses in the period 1970 - 1976 as follows: $VPA = 582.7 \cdot L + 162.6$ $r = 0.92$ which is a highly significant regression. This regression line is shown in Fig. 5.

The predicted number of 3-years old cod from the regression line for the 1970 - 1982 yearclasses are given in Table 5. The greatest discrepancy is observed for the 1973 yearclass which is overestimated in the 0-group survey by approximately 66% compared to the VPA estimate. Table 5 indicate that the yearclasses 1977 - 1981 are poor, but the estimates for the 1977 and 1979 yearclasses are well above the estimates given in Anon (1983a).

Several cautions should be taken when using this regression line for predicting yearclass abundance. Fig. 5 shows that this regression line is very dependent upon the 1970 point. Errors in either the VPA or the survey estimate for this yearclass would have a rather large effect on the regression line. Also there is a large intercept in the regression of 163 millions 3 year old fish. This mean that more than 50% of the estimate of a poor yearclass is made up of this intercept.

Haddock

The estimated indices of yearclass abundance for haddock in the western, eastern and the total area together with their confi-

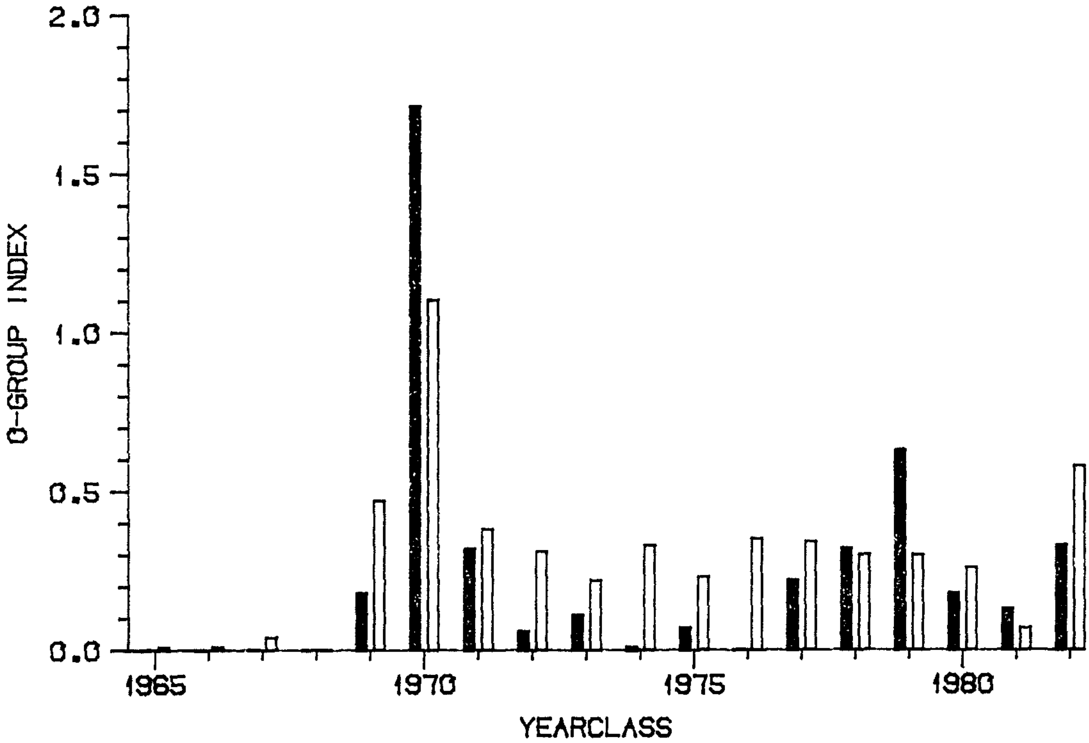

Fig. 2. Estimated yearclass strength at the 0-group stage in the western area. Cod shaded columns, haddock open.

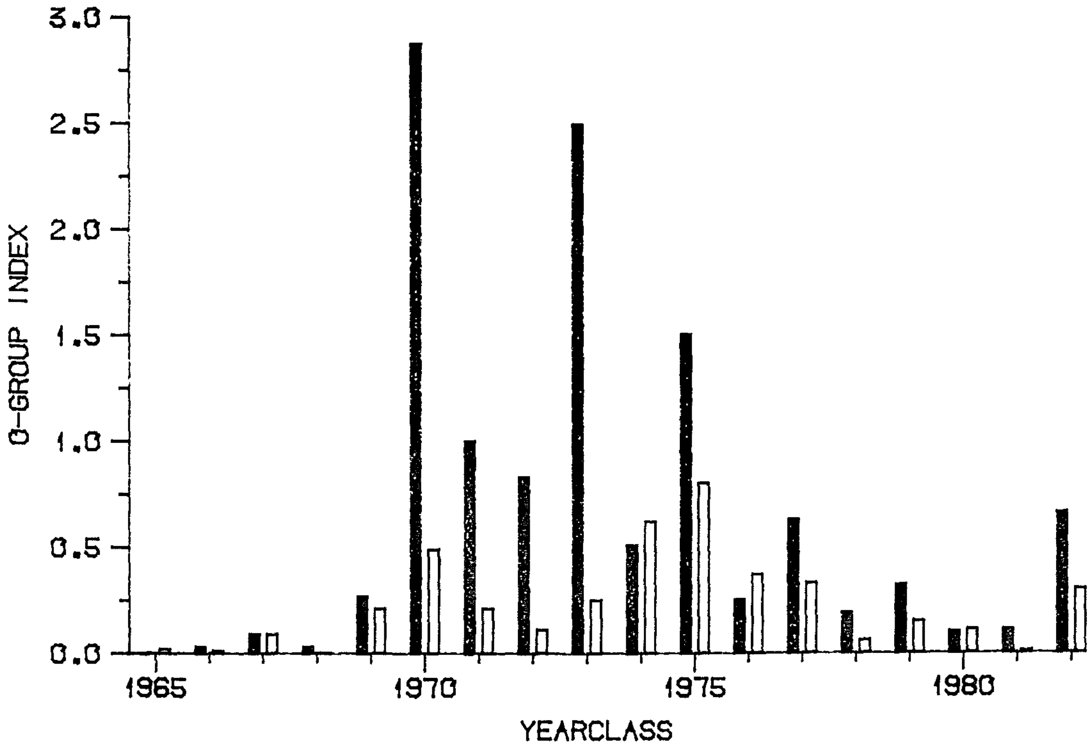

Fig. 3. Estimated yearclass strength at the 0-group stage in the eastern area. Cod shaded columns, haddock open.

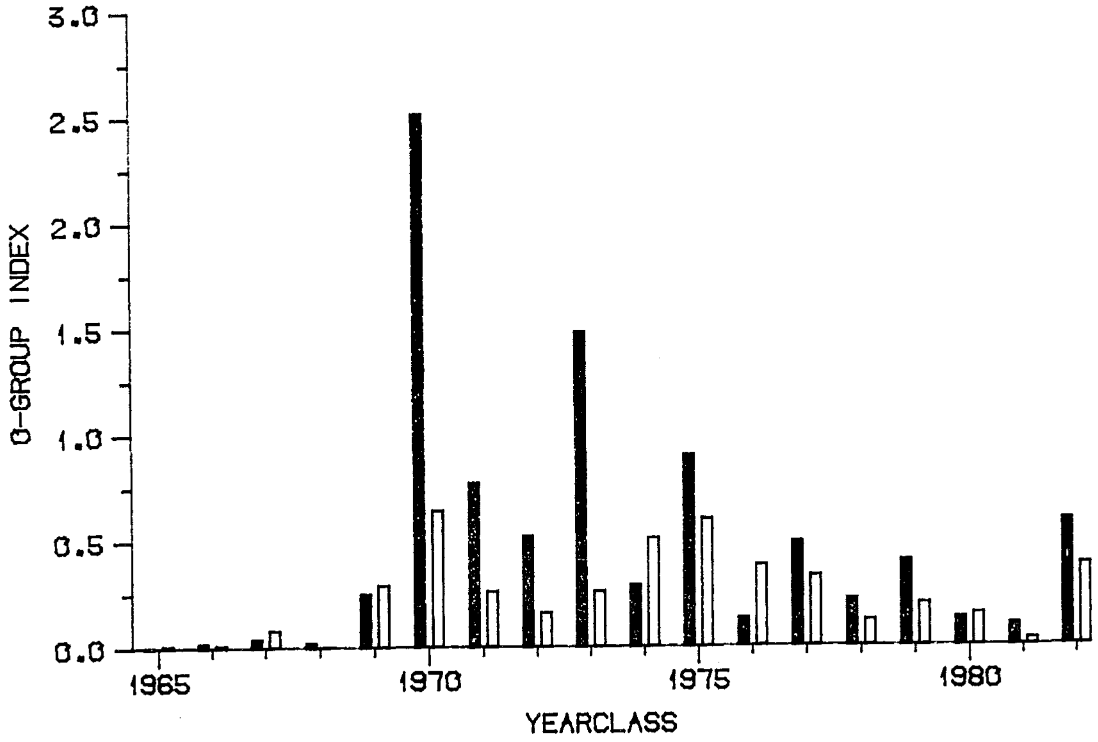

Fig. 4. Estimated yearclass strength at the 0-group stage in the total area. Cod shaded columns, haddock open.

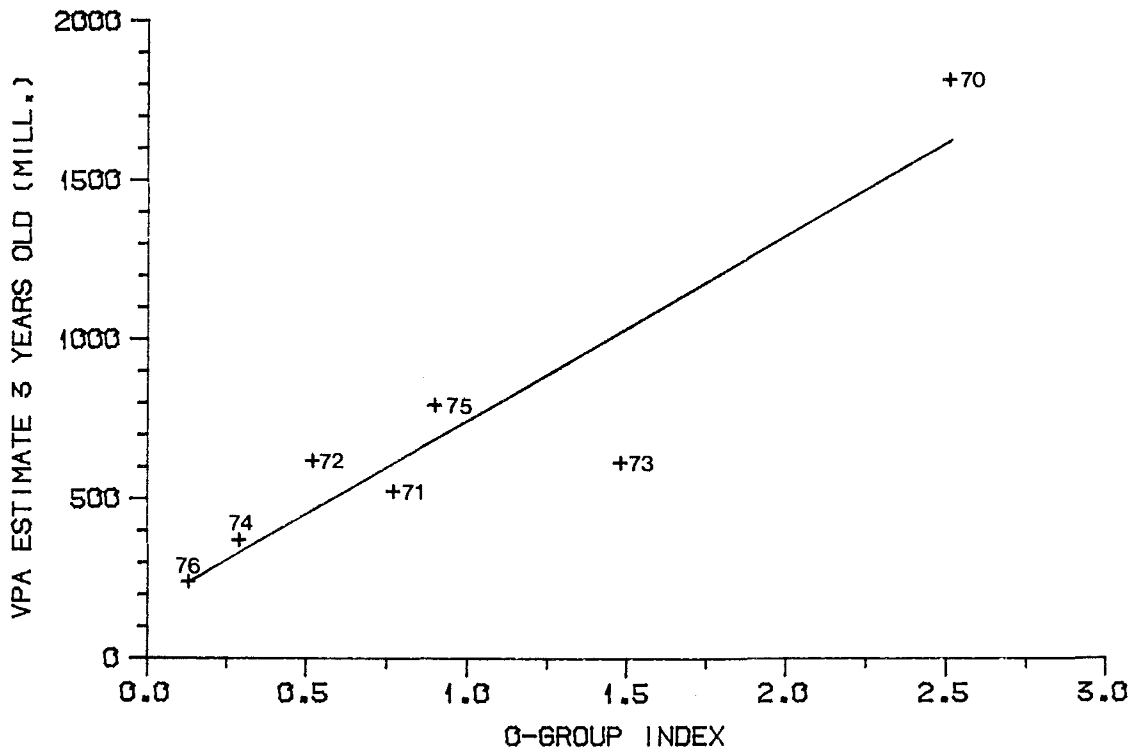

Fig. 5. The regression line between 0-group estimates of yearclass strength on VPA estimates of th same yearclass at age 3 for cod.

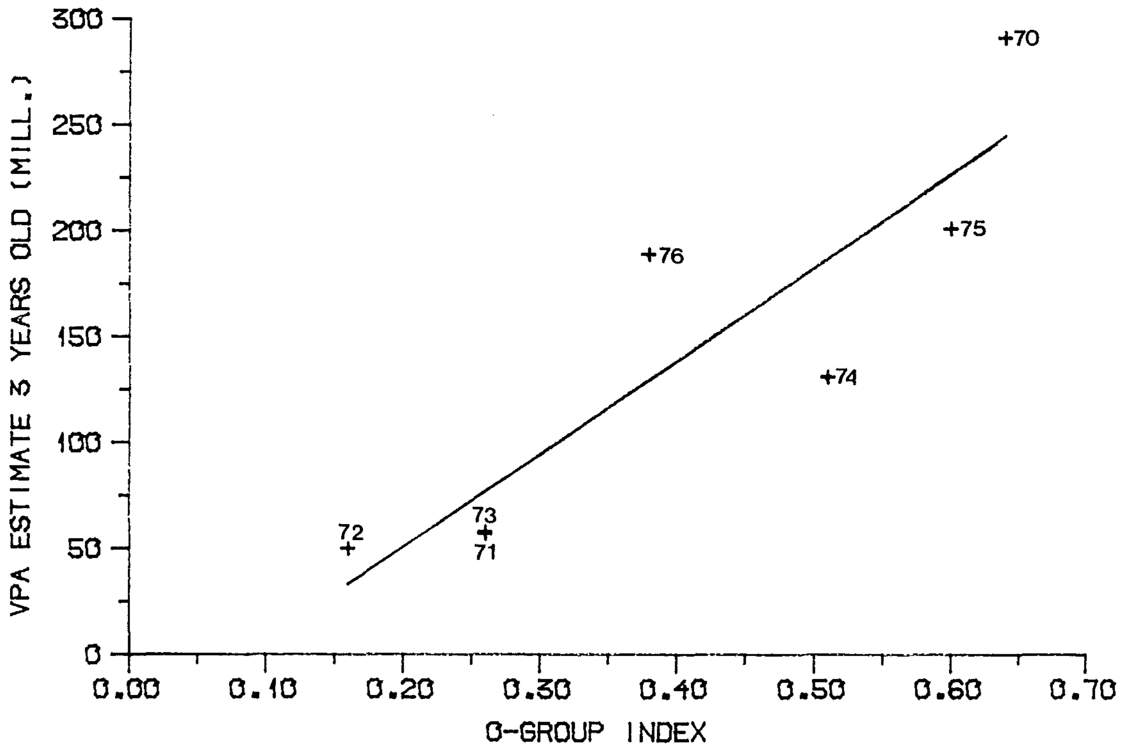

Fig. 6. The regression line bewteen 0-group estimates of yearclass strength on VPA estimates of the same yearclass at age 3 for haddock.

dence limits are given in Tables 2, 3 and 4, and are shown in Figs. 2, 3 and 4. Fig. 4 shows that there is a great variability in yearclass strength, but not to the same degree as for cod. The strongest yearclasses are the 1970, 1974, 1975 yearclasses, medium yearclasses are the 1969, 1976, 1977 and 1982. The rest of the yearclasses in the period 1965 - 1982 appears to be of low abundance judged from the estimated indices.

Tables 2 and 3 indicate that the 0-group haddock is more evenly distributed between the western and eastern area than cod. No yearclass is dominated totally by a western or eastern component.

For the same reasons as stated for cod only the 1970 - 1976 yearclasses are used in the regression between estimated indices and VPA estimates of three years old taken from Anon (1983a) with the modification stated in Anon (1983b). The

Table 5. Number of 3 years old cod and haddock predicted from the regression of 0-group indices on VPA estimates.

Year-class	Cod	Haddock
1970	1625	245
1971	611	77
1972	460	33
1973	1024	77
1974	332	187
1975	687	227
1976	238	130
1977	448	108
1978	291	15
1979	396	51
1980	238	29
1981	221	-
1982	506	130

resulting regression line is VPA = 440.8•L-37.5 (r = 0.89) which is highly significant. This regression is shown in Fig. 6. Predicted VPA values from this regression is given in Table 5. Compared to the VPA estimates given in Table 4 there is a reasonable good agreement for yearclasses 1970-1975. The 1976 yearclass is underestimated by approximately 43% and the 1977 yearclass is very badly overestimated by the 0-group index.

The yearclasses 1978 - 1981 seems to be very poor. The regression line gives estimates from 51 mill. 3-years old and downwards, and this is well below the 1970 - 1976 average of approximately 140 mill.

The index for the 1982 yearclass gives an estimate of 130 mill. which is close to the 1970 - 1976 average.

The regression line for haddock has a negative intercept and will generate negative VPA estimates for all 0-group indices less than 0.085. However, the regression is based on indices greater than 0.16 and should not be used to extrapolate values outside the range of 0-group indices used during the regression.

THE DISTRIBUTION OF 0-GROUP COD AND HADDOCK

Tables 6 and 7 show for each yearclass the percentage of the yearclass found in each of the 17 strata. Figs. 7 and 8 show the percentage of a yearclass found in the western and eastern area for both cod and haddock. This figures show that 0-group haddock generally has a more western distribution than 0-group cod. This may have several explanations, but perhaps the most obvious would be to assume that haddock eggs start to drift from a point further to the west and south than the eggs of cod that start in the Lofoten area. Dragesund, Midttun and Olsen (1970) indicate that the spawning area for haddock is off the Norwegian coast between 63°N and the Røst Bank, which is in accordance with a more western distribution of the 0-group haddock than observed for cod.

From Figs. 7 and 8 there seems to be a similar time trend in the percentage of a yearclass found in the western and eastern area for both cod and haddock. The percentage of a yearclass found in the eastern area increased to a maximum in the mid seventies and then fell off at the end of the seventies and early eighties.

These similarities in the changes in the distribution of both cod and haddock both probably reflect changes in the hydrographical condition in the Barents Sea. The 0-group distribution of both cod and haddock are determined by the strength of the currents transporting them from the spawning area and into the Barents Sea and the Spitsbergen/Bear Island area. Such changes in the current condition may partly be read from temperature indices on standard hydrographical sections. In the eastern area the Kola Meridian section (N69°30', E33°30' - N70°00', E33°30') is used and in the western area the Bear Island West section (N74°30', E06°34' - N74°30', E15°55') is used. Temperature indices for 0-200 m for both these sections are given in Anon (1982a). Figs. 9 and 10 show the anomalies in these two

Table 6. Cod. The percentage of a yearclass found in the different strata during the survey.

Year-class	Strata number 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	East	West
1965	0	0	0	0	0	0	0	0	0	0	100	0	0	0	0	0	0	100	0
1966	0	0	0	15	0	0	22	24	0	17	13	10	0	0	0	0	0	90	10
1967	0	0	0	27	10	9	18	22	8	3	3	0	0	0	0	0	0	100	0
1968	0	0	15	54	0	0	16	10	0	0	0	0	0	0	0	4	0	96	4
1969	0	0	3	20	0	2	8	20	19	0	10	6	0	7	0	5	1	81	19
1970	6	0	12	20	7	3	5	8	11	4	3	7	0	5	3	3	3	79	21
1971	0	0	4	16	9	3	6	17	16	3	13	7	0	3	0	1	3	86	14
1972	22	4	8	6	12	12	3	14	12	0	2	0	0	0	0	3	2	95	5
1973	20	6	21	11	11	8	3	8	7	1	1	2	0	0	0	0	0	98	2
1974	0	6	17	31	18	5	2	10	4	3	3	0	0	0	0	1	0	99	1
1975	2	1	15	30	11	2	10	12	7	3	5	1	0	1	0	0	0	98	2
1976	0	0	6	29	24	3	6	13	8	4	7	0	0	0	0	0	0	100	0
1977	0	0	7	20	7	0	12	23	2	7	13	1	1	3	0	3	3	89	11
1978	0	0	0	8	3	0	9	13	7	8	12	4	0	9	0	19	10	58	42
1979	4	0	0	5	2	6	2	11	6	2	15	1	2	10	10	17	5	55	45
1980	0	0	0	2	4	0	0	15	6	7	28	6	0	4	0	21	8	61	39
1981	0	0	0	31	3	0	12	14	4	1	11	0	0	7	3	13	1	76	24
1982	2	0	2	20	13	0	8	21	7	2	13	1	0	4	2	5	3	85	15

Table 7. Haddock. The percentage of a yearclass found in the different strata during the survey.

Year-class	Strata number 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	East	West
1965	0	0	0	0	0	0	22	42	0	0	15	0	0	21	0	0	0	79	21
1966	0	0	0	20	0	0	14	20	0	0	17	0	17	12	0	0	0	71	29
1967	0	0	0	14	0	0	8	30	7	5	23	3	0	0	0	0	10	87	13
1968	0	0	0	50	0	0	0	35	0	0	0	0	0	0	0	15	0	85	15
1969	0	0	0	5	2	0	1	19	13	5	21	6	4	12	0	11	2	65	35
1970	0	0	2	20	2	0	7	7	1	4	13	1	0	13	14	8	9	55	45
1971	0	0	0	0	2	2	5	25	13	0	20	2	0	14	0	10	8	66	34
1972	0	0	0	10	0	0	8	5	16	3	18	8	0	9	0	14	9	60	40
1973	0	0	10	13	1	0	5	18	5	6	18	5	0	10	0	3	6	76	24
1974	0	0	1	12	7	2	5	20	12	11	15	8	1	3	1	2	1	84	16
1975	0	1	8	29	4	1	10	21	8	2	5	4	0	3	1	2	0	90	10
1976	0	0	0	5	7	0	14	24	8	9	13	5	0	2	4	2	8	79	21
1977	0	0	0	8	4	0	15	32	1	4	18	2	3	3	0	5	5	82	18
1978	0	0	0	0	0	0	6	12	1	12	23	10	0	12	0	19	6	53	47
1979	0	0	0	8	0	0	5	21	7	6	22	3	5	10	8	4	0	70	30
1980	7	0	0	0	2	0	0	17	5	7	27	3	5	8	0	12	7	65	35
1981	0	0	0	0	0	0	0	10	0	6	19	0	28	8	11	11	8	34	66
1982	0	0	0	4	2	0	7	27	8	2	21	1	3	7	4	8	5	72	28

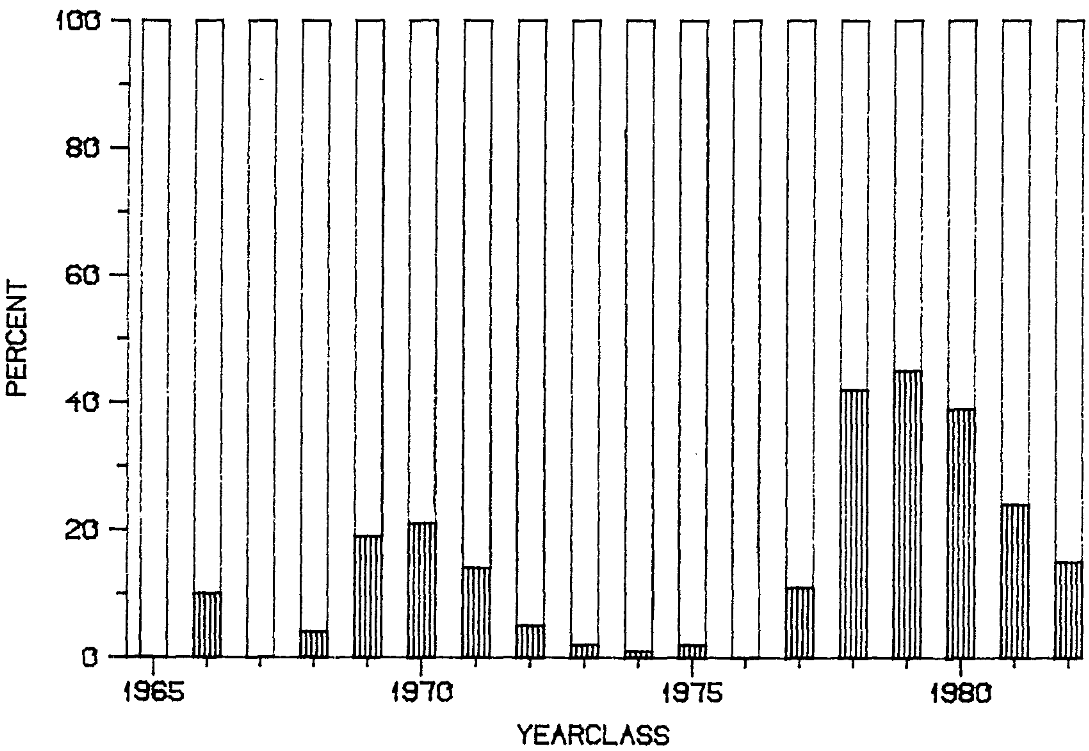

Fig. 7. Cod. The percentage of a yearclass found in the western and the eastern areas, at the 0-group stage. Western area shaded columns, eastern open.

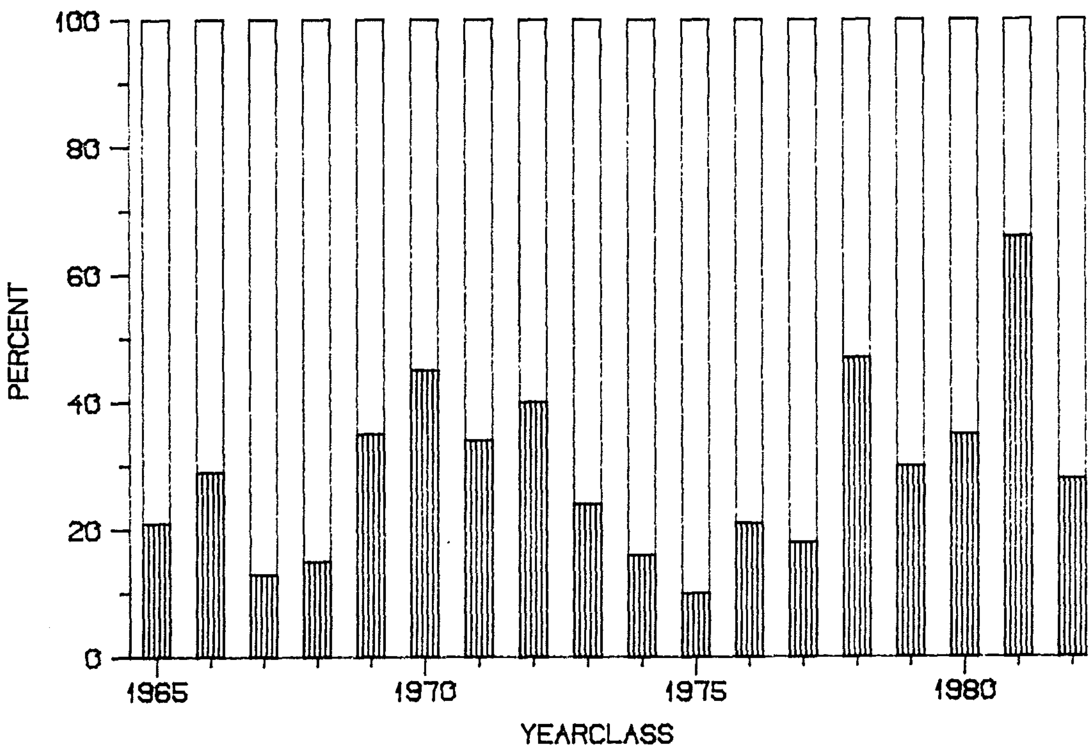

Fig. 8. Haddock. The percentage of a yearclass found in the western and the eastern areas at the 0-group stage. Western area shaded columns, eastern open.

sections plotted for the period 1965 - 1982. Both sections show similar trends: A changing period 1965 - 1971 in the Kola section and 1965 - 1972 in the Bear Island West section, followed by a period of high temperature in the mid seventies. In both sections there is sudden drop in the temperature in 1977 and 1978 followed by an increasing trend up to 1982. The drop in 1977-78 is especially severe in the Kola Meridian where the following increase in temperature is slower than in the Bear Island West section.

The anomalities in the Kola Meridian have been correlated with the percentage of a yearclass in the eastern area for both cod and haddock for the period 1970 - 1982 and the anomalities in the Bear Island West section with the percentage of a yearclass in the western area for the period 1971 - 1982. (Anon, 1982a gives no temperature index for the Bear Island West section in 1970). The correlations are given in the following text-table:

	Kola Meridian	Bear Island West
Cod	0.81	0.21
Haddock	0.60	0.34

There seems to be a good correlation between the temperature condition in the Kola Meridian and the percentage of a year-class in the Barents Sea for both cod and haddock. This means that in years with a strong Atlantic influx in the Barents Sea there is a high probability that the major part of a yearclass will be transported into the Barents Sea.

On the other hand there seems to be no correlation between the percentage of a yearclass in the western area and the temperature anomalies in the Bear Island West section. This may have several explanations. The temperature condition in the Bear Island West section may be of only minor importance in determining the percentage of yearclass that will be transported into the western area. The division is probably dependant on the starting point of the eggs. A southern and western starting point favours transport into the western area. Cod spawn along

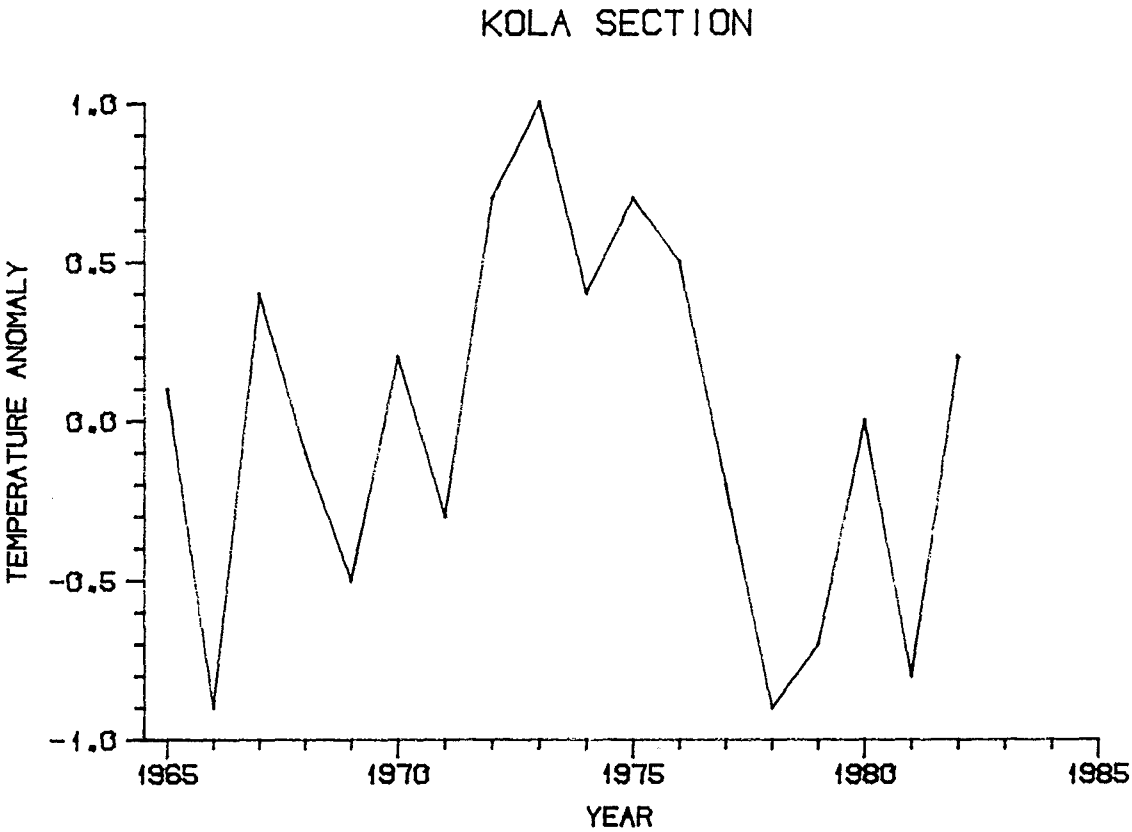

Fig. 9. The temperature anomalities in the Kola hydrographical section 1965-1982. Data taken from ANON 1982a.

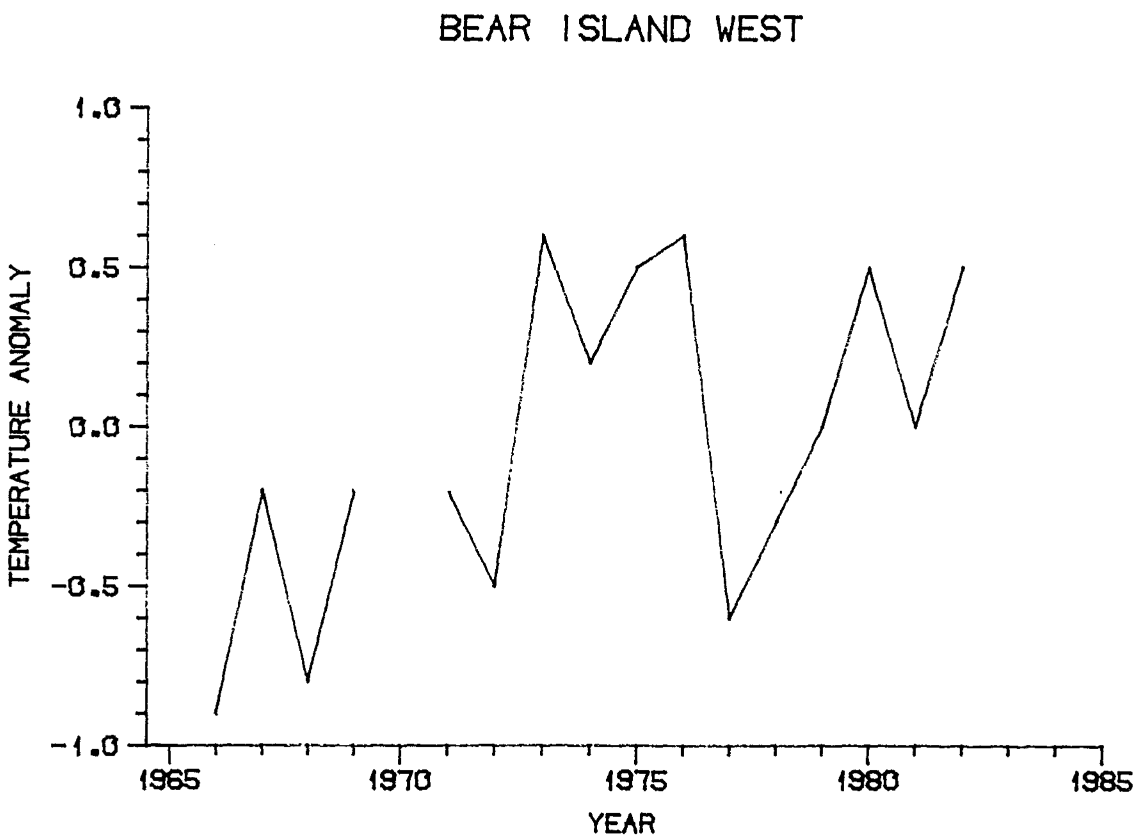

Fig. 10. The temperature anomalities in the Bear Island West hydrographical section 1965-1982. Data taken from ANON 1982a.

the whole Norwegian Coast north of $62^{o}N$ (Anon, 1982b) with the main spawning area in the Lofoten Islands. The part of the stock spawning south of Lofoten varies from year to year, and no data have been found that can be used to quantify this for the period 1965 - 1982. With such data present it would perhaps be possible to show some correlation between the percentage of a yearclass in the western area and the relative amount of cod spawning south of Lofoten.

REFERENCES

Anon 1981. Preliminary report of the international 0-group fish survey in the Barents Sea and adjacent waters in August - September 1981. Coun. Meet. int. Coun. Explor. Sea, 1981 (G:78): 1-26. Mimeo.

Anon 1982a. Preliminary report of the international 0-group fish survey in the Barents Sea and adjacent waters in August - September 1982. Coun. Meet. int. Coun. Explor. Sea, 1982 (G:44): 1-27. Mimeo.

Anon 1982b. Report on minisymposium on spawning, egg and larvae of cod: A comparison of the Icelandic and Arcto-Norwegian cod tribes. Minisymposium organized by the Working Group on Larval Fish Ecology, Biological Oceanography Committee, ICES. Reykjavik, 8-11 February, 1982.

Anon 1983a. Report of the arctic fisheries working group. Coun. Meet. int. Coun. Explor. Sea, 1983 (Assess:2): 1-62. Mimeo.

Anon 1983b. Reports of the ICES advisory committee on fishery management 1982. Int. Coun. Explor. Sea, Cooperative Res. Repr. 119 (1983).

Dragesund, O., Midttun, L. and Olsen, S. 1970. Methods for estimating distribution and abundance of 0-group fish. In Dragesund, O. (Ed.) International 0-group fish survey in the Barents Sea 1965 - 1968. Int. Coun. Explor. Sea, Cooperative Res. Rep., Ser. A, No. 18: 1-81.

Fox, W.W. 1971. User's guide to FPOW, a computer program for estimating relative fishing power and relative population density by the method of analysis of variance. Quantitative science paper No. 27. Center for quantitative science in forestry, fisheries and wildlife. University of Washington, Seattle. 1-6. Mimeo.

Harpelin, M. 1964. Interval estimation of nonlinear function. Parametric function II. J. Amer. Stat. Assoc. 59 (1964): 168-81.

Harpelin, M. and Mantel, W. 1963. Interval estimation of non-linear parametric functions. J. Amer. Stat. Assoc. 58 (1963): 611-27.

Haug, A. and Nakken, O. 1977. Echo abundance indices of 0-group fish in the Barents Sea, 1965 - 1972. Rapp. P.-v. Réun. Cons. int. Explor. Mer, 170: 259-64.

Pennington, M.R. and Grosslein, M.D. 1978. Accuracy of abundance indices based on stratified random trawl surveys. Coun. Meet. int. Coun. Explor. Sea, 1978 (D:31): 1- 35. Mimeo.

Randa, K. 1982. Recruitment indices for the Arcto-Norwegian Cod for the period 1965 - 1979 based on the international 0-group fish survey. Coun. Meet. int. Coun. Explor. Sea, 1982 (G:43): 1-22. Mimeo.

Robson, D.S. 1966. Estimation of the relative fishing power of individual ships. Res. Bull. int. Comm. NW. Atl. Fish, 3: 3-14.