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RECRUITMENT INDICES OF NORWEGIAN SPRING-SPAWNING HERRING FOR THE
PERIOD 1965-1984 BASED ON THE INTERNATIONAL O-GROUP FISH SURVEYS.

by

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Abstract

The trawl data from the International O-group fish surveys in the Barents Sea are analyzed. The fishing powers of the participating vessels are estimated and corrected for. A relative index of year class strength is computed on a logarithmic scale applying the method described by RANDA (1982). The average yearly recruitment of Norwegian spring-spawning herring is very low in the period, and only the 1983 year class can be characterized as a strong one. A few other year classes, 1966, 1973, 1979 and 1984 may be rated as slightly above the average if the 1983 year class is not taken into account.

In the period 1975-82 an index of recruitment of herring was obtained through bioacoustic measurements in the fjords of northern Norway. In 1983 and 84 the distribution of O-group herring changed and most of the O-group herring was concentrated in the Barent Sea.

Introduction

Since 1965 the international O-group surveys have been carried out every year in the Barents Sea. The aim has been to measure the level of recruitment of the most important fish species in the area. In particular the results have been used in the assessment of the Arcto-Norwegian cod stock (ANON 1980). However, since the late sixties, when the stock of the Norwegian spring-spawning herring was reduced to a minimum, the recruitment to this stock has been at quite a low level. The O-group herring has been found mainly in the fjords of northern Norway and indices of recruitment have been obtained through bioacoustic estimation of the recruiting year classes in the fjords every autumn since 1975. During the time period 1970-82 only a few yearclasses have been on a level of abundance to appear in the catches during the O-group surveys

conducted in August. However, the spawning stock of the Norwegian spring-spawning herring has gradually increased in abundance and it was shown in 1983 that the stock was large enough to produce quite a rich year class, RØTTINGEN (1984). When rich year classes of herring appear, the indices obtained from the acoustic surveys in the fjords will be less representative for the total abundance of the year class because most of the fingerlings will be found in the Barents Sea. The results and the index of abundance estimated from the international 0-group fish surveys therefore have to be taken into account when assessing the recruitment to this stock.

This paper re-analyses the basic data from the international 0-group surveys and gives recruitment indices for the Norwegian spring-spawning herring for the period 1966-1984. The methods referred to in this paper are partly outlined and described by RANDA (1982) and he has also developed related computer programmes. The method for computing the old indices is given in HAUG and NAKKEN (1977) and results are given in ANON (1981).

Material

The survey is a trawl survey carried out by three to five research vessels. Trawl stations using a small meshed pelagic trawl, are taken every 30 nautical mile, or when echo recordings change. The trawl depth is decided from the echograms and the trawl is towed at the depth the recordings were made, mostly less than 50 m. If no fish is registered 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). The trawl is towed for 10 minutes with the headline at each of the following depths: 0 m, 20 m, and 40 m. The towing speed is 3 knots. The recorded data from each of the trawl hauls constitute the basic material for this analysis.

Methods

The methods described here are a summary of the methods originally described by RANDA (1982).

Relative fishing powers of the vessels.

Altogether 11 different vessels have participated in the survey 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. Various types of pelagic trawls have been used. The most common one, the Norwegian "Harstadtrawl", has been used since 1972 by Norwegian and UK vessels. Before that the Bothbay trawl and the Engel trawl were used by UK vessels and the Norwegian vessels used a trawl similar to the Engel trawl. The Russian pelagic trawl has been used by the USSR vessels throughout the whole period.

To assess the difference between vessels and gear, the relative fishing power for different vessels and gear has been estimated using the methods of ROBSON (1966).

Calculations were done using a computer programme developed by FOX (1971), and also by RANDA (1982).

Statistical distribution and transformation of data

The great variance between trawl hauls show that few, if any species of fish are distributed randomly in the sea. To estimate abundance with any precision a great number of trawl hauls are needed. Several investigations indicate that a negative binomial distribution may fit the observed distribution of trawl catches, PENNINGTON and GROSSLEIN (1978), DAAN, HISLOP, HOLDEN and LAHN-JOHANNESSEN (1975), BECKER and CORTON (1974), JONES (1956) and TAYLOR (1953). In order to be able to calculate confidence limits and perform statistical tests, the catch data needs to be transformed. The purpose of a transformation is to normalize the data and make mean and variance independent. Due to the highly positive skewness PENNINGTON and GROSSLEIN (1978) indicate that the transformation $y = \ln(x)$, $x \neq 0$ is the most appropriate and RANDA (1982) has shown that it normalizes catch data for 0-group cod. This transformation results in a distribution called the Delta Distribution and the assumptions underlying this are that a fixed proportion p of the observations are zero and the positive nonzero observations follow a lognormal distribution. Estimators for the mean and the variance in this distribution are given by AITCHINSON and BROWN (1957).

Estimation of recruitment index.

As a basic index of year class abundance the stratified mean catch in numbers per 1.0 nautical mile is used. The index is on a logarithmic scale 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 surveyed area was divided into 18 strata (Fig. 1). These strata should be considered as geographical regions and not strata in the proper statistical meaning of the word. This is because the strata were constructed after the surveys, and allocation of trawl stations to the different strata on statistical considerations was not possible.

For each region each year the following quantities are calculated:

The logarithmic mean

$$\bar{X}_j = \frac{1}{N_{1j}} \sum_{i=1}^{N_{1j}} \ln(X_{ij})$$

The logarithmic variance

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

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 region j , N_{1j} is the number of nonzero hauls in region j and N_j is the total number of hauls in region j . An index of abundance in region j is computed as $X_j * p_j$ and a combined index for several regions is computed as follows:

The stratified logarithmic mean catch and the standard error of this mean is calculated as

$$R = \frac{1}{A} \sum_{j=1}^K a_j * X_j$$

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

where a_j is the area of region j , A is the total area and k is the number of regions.

An area weighted proportion for several regions and its standard error is calculated as

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

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

The final logarithmic index of abundance is calculated as

$$L = R * Q$$

Confidence intervals

Confidence limits of L are obtained by first calculating the 95% intervals around R and Q based on normal theory as follows, HARPELIN and MANTEL (1963), HARPELIN (1964).

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

$$R' < R < R''$$

and

$$Q - 2 * SEQ < Q < Q + 2 * SEQ \quad \text{or}$$

$$Q' < Q < Q''$$

The confidence limits for L are then given as the product of the confidence intervals around the stratified transformed mean and the proportion of nonzero hauls as follows PENNINGTON and GROSSLEIN (1978).

$$R' * Q' < R * Q < R'' * Q'' \quad \text{or}$$

$$L' < L < L''$$

The size of this confidence interval is above 90% and probably near 95% HARPELIN and MANTEL (1963), HARPELIN (1964).

Results and discussion.

Analysis of fishing power

The relative fishing power 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.

0-group cod and herring are distributed in much the same area and depth and are of similar length during the survey period. It therefore seems reasonable to assume that their catchability are about equal. The relative fishing powers estimated for cod are therefore also used for the herring 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 herring are assumed to be 1.0. The same assumption is made for the new vessels "Michael Sars" (Norway) and

"Persey III" (USSR). This seems reasonable because both vessels used a trawl similar to that of the selected standard vessel "G.O. Sars".

Index of yearclass abundance.

The estimated indices of abundance for herring are given in table 2 together with their confidence limits. For comparison the arithmetic mean of the number of herring in the catches each year is given. As can be seen from the table the recruitment of herring has been very sparse in the whole period since the 0-group surveys started in 1965. Only one year class may be rated as strong, the one from 1983. A few other year classes, those from 1966, 1973 and 1979 may be rated as slightly above the average for the period if the 1983 year class is not taken into account. The 1984 year class is also a fairly strong one being on the level of 1/5 of the 1983 year class.

Due to lack of proper catch data it has not been possible to verify this 0-group index by the use of VPA. However the abundance estimates from tagging which have been carried out since 1975 clearly verify the trend of year class strength estimated from the 0-group surveys.

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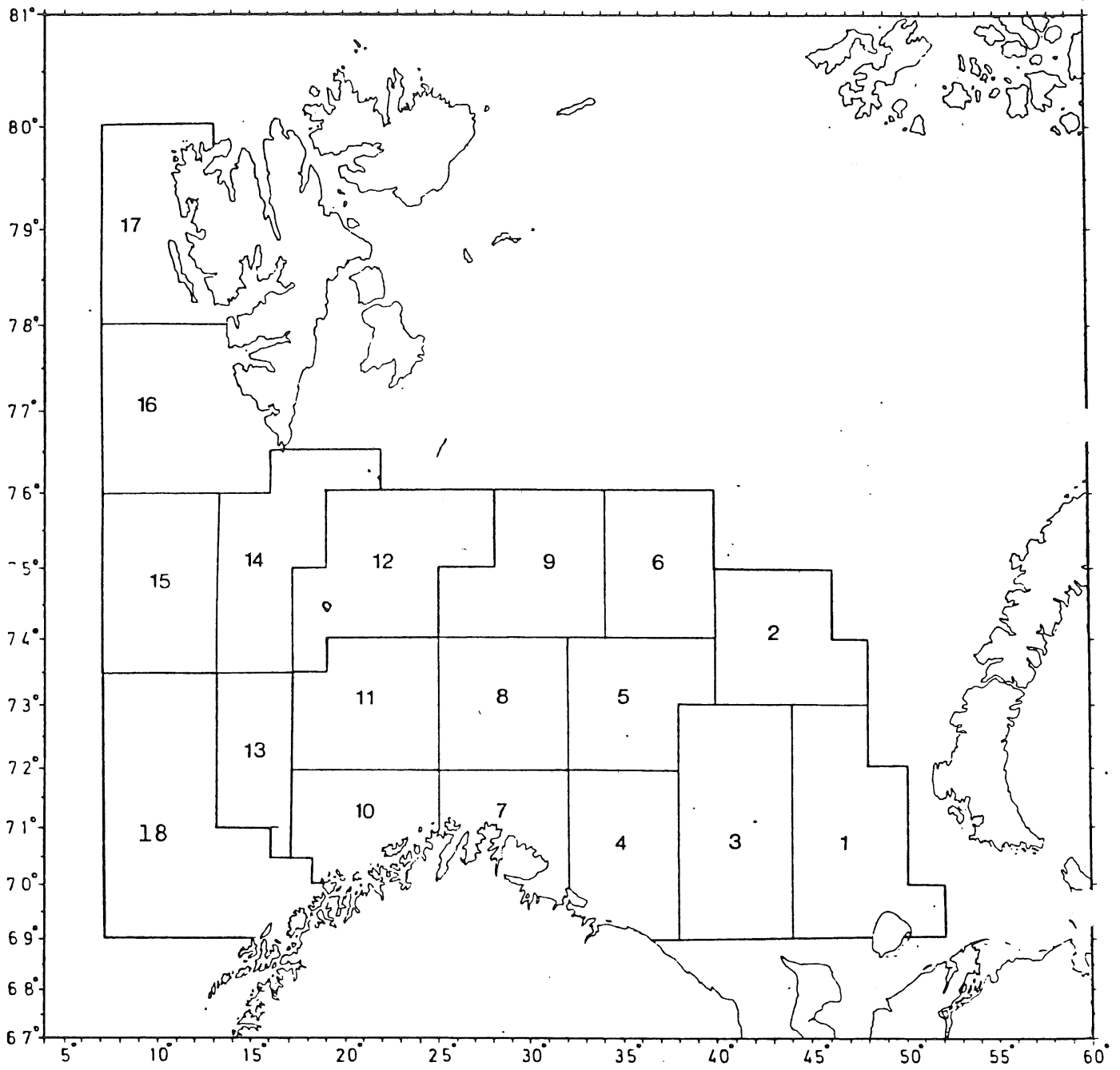


Figure 1. Stratification of the Barents Sea for the estimation of the 0-group indices.

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 (1973-1979)	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

Table 2. Estimated index with confidence limits of year class abundance for herring, 1965-1984. Arithmetic mean of the catches with confidence limits for the same period.

Year class	Logarithmic index	Confidence limits (95%)	Arithmetic mean	Confidence limits (95%)
1965	-	-	2.6	-1.6- 6.8
1966	0.14	0.04-0.31	5.2	-1.0- 11.4
1967	0.00	-	0.1	-
1968	0.00	-	0.0	-
1969	0.01	0.00-0.04	0.1	0.0- 0.2
1970	0.00	-	0.1	-0.1- 0.3
1971	0.00	-	0.0	-
1972	0.00	-	0.0	-
1973	0.05	0.03-0.08	1.3	-0.2- 2.8
1974	0.01	0.01-0.01	0.2	0.1- 0.2
1975	0.00	-	0.0	-
1976	0.00	-	0.3	-0.3- 1.0
1977	0.01	0.00-0.03	0.2	0.0- 0.4
1978	0.02	0.01-0.05	1.1	0.1- 2.1
1979	0.09	0.01-0.20	6.7	-5.8- 19.3
1980*	-	-	-	-
1981	0.00	-	0.1	-
1982	0.00	-	0.3	0.0- 0.7
1983	1.77	1.29-2.33	751.8	217.5-1286.0
1984	0.34	0.20-0.52	66.9	18.9- 114.9

(*) Data missing

