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ECHO ABUNDANCE INDICES OF O-GROUP FISH IN THE BARENTS SEA 1965-1972

By

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INTRODUCTION

During late summer and early autumn fish fry of many species occur pelagically in the Barents Sea. Since 1965 joint international surveys have been carried out yearly in this area during 12-15 days in late August and early September (Fig. 1). The primary aim of these surveys is to map the geographical distribution and to obtain estimates of yearclass strength of O-group fish. Yearly preliminary results from the surveys have been reported to the ICES annual meeting (ANON. 1965-72 and DRAGESUND 1970c). DRAGESUND (1970 a and b) and HYLEN and DRAGESUND (1970) have made further analyses of some of the results. In the annual reports the year-class strength of the different species has been stated to be poor, average or strong, and this grading has so far been based mainly on the experience of the participating scientists. For some of the involved species, indices of echo abundance have been used to classify the yearclass strength (DRAGESUND and NAKKEN 1970). DRAGESUND (1971) has compared the echo abundance indices at the O-group stage with abundance indices obtained by other methods at

age $\geq$ 3 years for some species, and he concludes: "A very close correlation is found between the two independent estimates of yearclass strength and it is concluded therefore, that the abundance indices of O-group fish obtained from the acoustic surveys give a fairly good estimate of yearclass strength".

Echo abundance indices for the most numerous species of O-group fish sampled during the international surveys are presented in this paper. The method of calculation is described, and the results are discussed.

MATERIAL AND METHODS

The distribution and density of the pelagic scattering layers have been estimated from the echosounder paper records, and the organisms forming the scattering layers were identified from sampling with small meshed pelagic trawls (DRAGESUND, MIDTTUN and OLSEN 1970). In the reports to the ICES annual meeting, distribution charts for each species have been given. Fig. 2 shows the distribution of redfish in 1972.

The density of the scatterers has been estimated by visual grading of the paper recordings and classified according to the following code:

Code	0	1	2	3	4
Classification	No recording	Very scattered	Scattered	Dense	Very dense

During the cruise the classification has been carried out on-board the vessels for each nautical mile sailed. The distribution charts (Fig. 2) of O-group fish have, as a rule, been given two density grades, scattered and dense. This grading has partly been based on the visual paper grading and partly on the amount of fish in the trawl catches. By careful examination of all the distribution charts it appears that the criteria used to discriminate between scattered and dense may have varied somewhat from year to year. The following method for calculating

the abundance indices was therefore adopted.

A) A certain number of fish per haul was used to discriminate between scattered and dense in the distribution charts. This number was found by examining the trawl catches, which contained only one specie, and compared the number of fish per haul with the corresponding visual density grading (Table 1). Assuming a linear relationship between the logarithm of the catch and the visually estimated densities, one arrived at the following values for discrimination between scattered and dense:

Species	Cod	Capelin	Redfish	Polarcod
No. of fish per haul	85	1050	85	110

B) New distribution charts were drawn up for each species where these values were used for the above mentioned discrimination.

C) The abundance indices, T, were calculated from the formula

$$T = A_s + k \cdot A_d$$

Where A_s and A_d denote the areas within which the densities were found to be scattered (A_s) and dense (A_d). The coefficient k, is the ratio between fish densities, classified as dense (3 and 4) and scattered (1 and 2). This coefficient was determined by DRAGESUND (1970b) to have and approximate value of 10. Table 2 shows that the echo integrator readings, obtained during the 1971 cruise, indicate a value of k between 6 and 8. The calculated abundance indices for the period 1965-1972, using k=10, are listed in Table 3.

For the period 1965-1972 two average indices have been calculated for each species (Table 4). Average 1 is the arithmetic mean of all eight values and Average 2 is the arithmetic mean of six of the values, the highest and lowest are excluded. Finally an interval was selected (Table 3) within which the indices corresponds to an average yearclass strength. The ratio between

the upper and lower limit of these intervals was chosen to be approximately 2, and new estimates of yearclass strength were obtained by comparing the indices for each year with the averages.

RESULTS AND DISCUSSION

The results of the calculation, and the contribution to the indices from scattered and dense consentrations are shown in Table 3. Table 4 shows the classification of yearclass strength given in the annual reports (E_1) and found from the calculated average indices (E_2).

For most of the species the coincidence between the two classifications is good, but for capelin some discrepancies occur. It seems that the annual estimates made just after the cruises are more optimistic than those based on the calculations. Later observations on the spawning stock of capelin have shown that the yearclasses 1967 and 1969 were approximately equal in strength while the 1968 yearclass was weaker (DRAGESUND et al. 1973). This may indicate that the indices in Table 3 for capelin are subjected to large errors.

When comparing the indices in Table 3 the various sources of error, and their influence on the calculated numbers, should be kept in mind. The most important sources of error are:

1. The rather crude method of classification of density from the recording paper. Although care has been taken to avoid biases caused by differences in power and gain settings of the echo-sounders by introducing calibration - and control courses, the accuracy of this classification will always depend on the interpretation of the different scientists.

2. The errors involved in the choise of catch per haul for discrimination between scattered and dense. Again the interpretation made by the personell is an important but unknown factor, and the number of fish per haul shows large variances (Table 1).

The large differences in relative units between catches and integrator deflections (Table 2 and 3) are probably caused by a systematic underestimation of low fish densities when using trawls.

3. The difference in mean length of the species each year, which affects the average target strength of the individuals and thus also the contribution to the index. This might be the reason for the low index figure for the 1967 yearclass of capelin as compared to the 1968 yearclass. In 1967 the O-group capelin was significantly smaller than in 1968 (DRAGESUND 1970c Fig. 31). For other species which show less differences in mean length from year to year, this matter is believed to be of less importance.

4. The selection of k. The effect of using a k of 6 or 8 instead of 10 can easily be studied in Table 3. This will reduce the highest estimates, but not change the rank of the indices.

Information on the contributions to the total biomass from the different species can, only to a little extent, be extracted from Tables 3 and 4. In order to make such a comparison, knowledge of the sound reflecting properties and much more accurate information of relative densities are needed. For related species like cod and haddock, which can be assumed to have equal reflection properties, a comparison might hold.

However, even though considerable inaccuracies are present in the figures there is no doubt that the indices for each species reflect relative strengths of yearclasses of the O-group fishes in the Barents Sea.

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Table 1. Mean values and standard deviations of the number of 0-group fish in pelagic trawl catches at different visual densitities, estimated from the recording paper. N is the number of trawl catches.

Species	Cod			Capelin			Redfish			Polarcod		
Density	Mean	St.dev.	N	Mean	St.dev.	N	Mean	St.dev.	N	Mean	St.dev.	N
1	5	6	34	11	26	29	9	15	32	5	9	15
2	34	30	9	90	91	15	34	44	19	60	43	18
3	240	386	6	18628	18801	5	223	281	8	212	177	8
4	1330	1090	2	417	254	2	815	963	5	16250	18031	2

Table 2. Mean values and standard deviations of echo integrator deflections (mm/nautical mile) and relative units of density at different visual densities estimated from the recording paper. N is the number of integrator deflections.

Visual density	Integrator deflection						Relative density	
	G.O. Sars			Johan Hjort			G.O. Sars	Johan Hjort
	Mean	St.dev.	N	Mean	St.dev.	N		
1	7.6	8.5	105	3.9	3.0	148	1.0	1.0
2	24.6	14.1	57	11.3	10.0	54	3.2	2.9
3	55.3	38.8	24	32.5	16.0	6	7.3	8.3
4	126.1	81.0	54				16.6	

Table 3. Abundance indices ((nautical mile)$^2 \cdot 10^{-3}$). A_s is the area of scattered density. A_d is the area classified as dense and $T = A_s + 10\ A_d$

Species	Herring			Capelin			Polarcod West			Polarcod East			Polarcod W+E			Cod		
Year	A_s	$10\ A_d$	T	A_s	$10\ A_d$	T	A_s	$10\ A_d$	T	A_s	$10\ A_d$	T	A_s	$10\ A_d$	T	A_s	$10\ A_d$	T
1965	4	0	4	37	0	37	0	0	0	0	0	0	0	0	0	0	6	6
-66	21	0	21	77	42	119	13	15	28	27	74	101	40	89	129	<1	0	<1
-67	2	0	2	78	11	89	0	0	0	12	153	165	12	153	165	27	7	34
-68	0	0	0	99	0	99	34	0	34	26	0	26	60	0	60	25	0	25
-69	<1	0	<1	104	5	109	17	0	17	18	173	191	35	173	208	77	16	93
-70	0	0	0	42	9	51	11	18	29	30	138	168	41	156	197	115	491	606
-71	0	0	0	151	0	151	31	0	31	45	105	150	76	105	181	122	35	157
-72	0	0	0	172	103	275	16	0	16	48	76	124	64	76	140	129	11	140

Species	Haddock			Saithe			Redfish			Mackerel			Long rough dab			Greenland halibut			Sum of species		
Year	A_s	$10\ A_d$	T	A_s	$10\ A_d$	T	A_s	$10\ A_d$	T	A_s	$10\ A_d$	T	A_s	$10\ A_d$	T	A_s	$10\ A_d$	T	A_s	$10\ A_d$	T
1965	7	0	7	0	0	0	68	91	159	0	0	0	66	0	66	0	0	0	182	97	279
-66	<1	0	<1	<1	0	<1	64	172	236	0	0	0	97	0	97	0	0	0	299	303	602
-67	42	0	42	10	23	33	44	0	44	0	0	0	73	0	73	0	0	0	288	194	482
-68	8	0	8	4	0	4	21	0	21	0	0	0	17	0	17	0	0	0	234	0	234
-69	82	0	82	0	0	0	65	230	295	20	0	20	26	0	26	0	0	0	409	424	833
-70	88	27	115	<1	0	<1	32	215	247	0	0	0	12	0	12	<1	0	<1	330	898	1228
-71	73	0	73	0	0	0	79	93	172	0	0	0	81	0	81	<1	0	<1	582	233	815
-72	46	0	46	<1	0	<1	77	100	177	<1	0	<1	65	0	65	8	0	8	561	290	851

Table 4. Estimates of yearclass strength, P(poor), A(average) and S(strong), and the corresponding abundance indices, T. E_1 is the estimate from annual reports, E_2 is the estimate based on the average indices at the bottom of the table.

Species	Cod			Capelin			Haddock			Redfish			Polar cod			Long rough dab		
Year	E_1	T	E_2	E_1	T	E_2	E_1	T	E_2	E_1	T	E_2	E_1	T	E_2	E_1	T	E_2
1965	P	6	P	A	37	P	P	7	P	S	159	A	P	0	P	S	66	A
1966	P	<1	P	S	119	A	P	<1	P	S	236	S	S	129	A	S	97	S
1967	P	34	P	S	89	A	A	42	A	?	44	P	A	165	A	S	73	A
1968	P	25	P	S	99	A	P	8	P	?	21	P	A	60	P	P	17	P
1969	?	93	A	S	109	A	?	82	S	S	295	S	S	208	S	P	26	P
1970	S	606	S	P	51	P	?	115	S	S	247	S	S	197	S	P	12	P
1971	A-S	157	S	S	151	S	A	73	S	?	172	A	A	181	S	?	81	S
1972	A-S	140	A	S	275	S	?	46	A	A	177	A	?	140	A	P	65	A
Average 1		133			116			47			169			135			55	
Average 2		75			103			43			173			145			55	
Average Index		75-150			75-150			30-60			100-225			75-175			40-80	

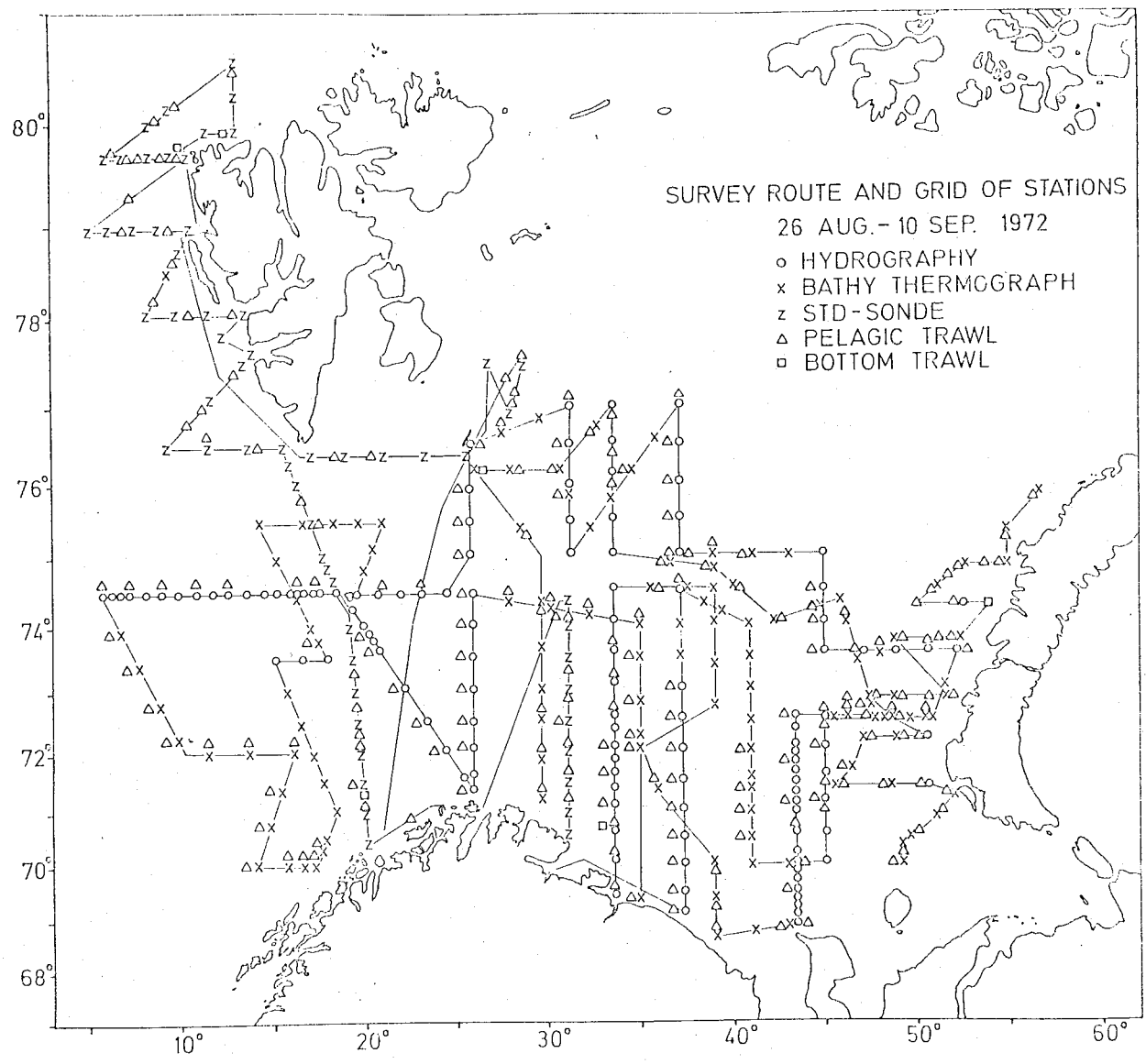

Fig. 1. Survey routes and grid of stations 1972.

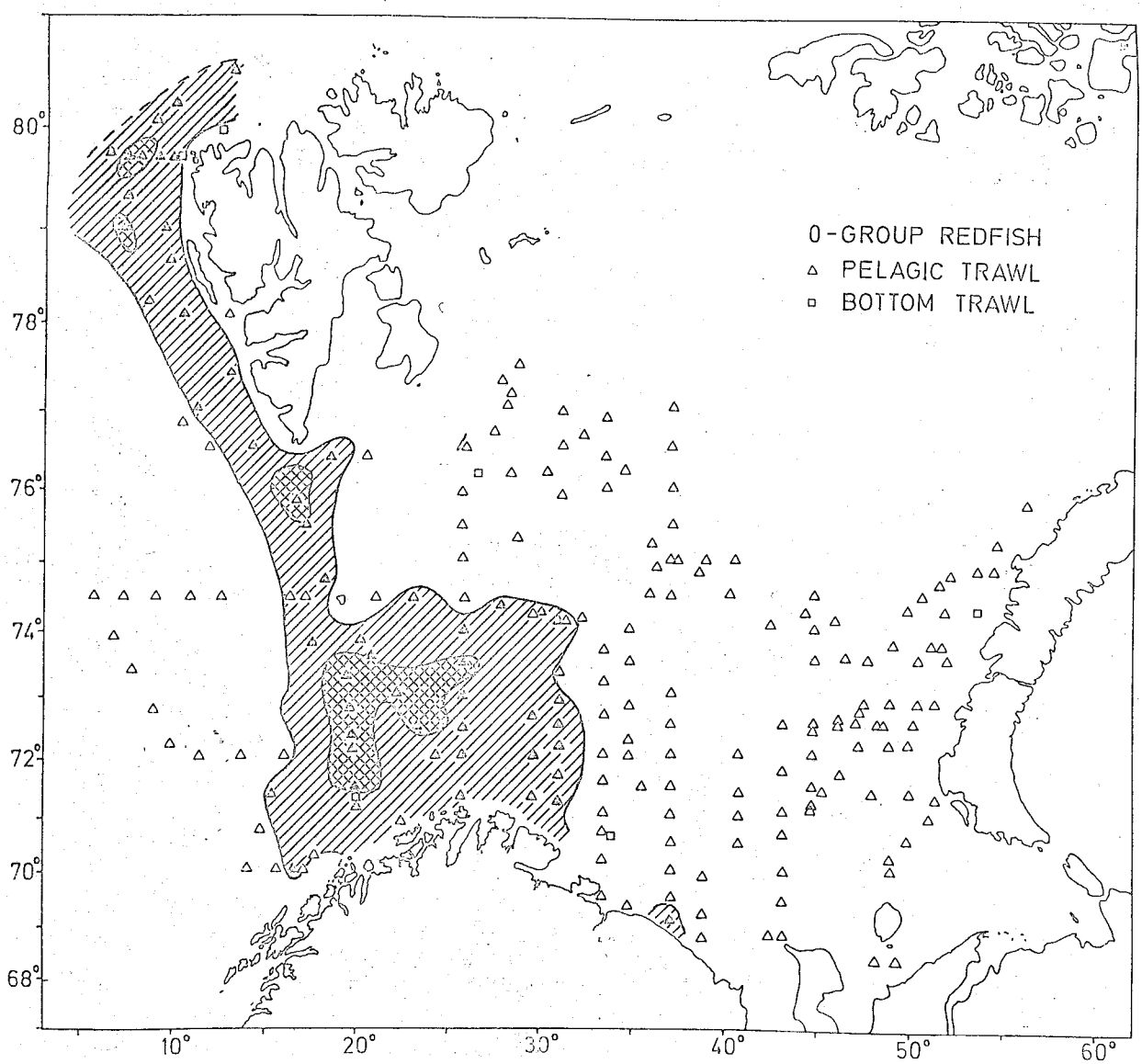

Fig. 2. Distribution of 0-group redfish 1972.