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ECHO ABUNDANCE INDICES OF 0-GROUP FISH IN THE BARENTS SEA, 1965–1972

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In order to obtain estimates of year class strength of 0-group fish, joint international surveys have been conducted each year since 1965 in the Barents Sea. The density of fish has been estimated by visual grading of the echo-sounder paper recordings and the scattering layers have been identified by small-meshed pelagic trawls. The year class strengths of the species under consideration have been stated to be poor, average or strong, and this grading has so far been based on the experience of the participating scientists. In the present paper, abundance indices for each year are calculated for the most important species. The indices are based on the visual density grading of the echograms and on the size of the trawl catches. Echo integrator readings are used to calculate the true ratio between the 'visual' density groups. The usefulness of such indices will increase with increasing knowledge of the sound reflecting properties of the scatterers.

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 twelve to fifteen days in late August and early September (Fig. 226). The primary aim of these surveys has been to map the geographical distribution of 0-group fish and to obtain estimates of the year class strengths. Preliminary results from the surveys have been reported yearly to ICES (Anon., 1965–72; Dragesund, 1970c). Dragesund (1970a and b) and Hylen and Dragesund (1973) have made further analyses of some of the results. In the annual reports, the year class strengths of the different species have 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 species involved, indices of echo abundance have been used to classify the year class strengths (Dragesund and Nakken 1973). Dragesund (1971) has compared the echo abundance indices at the 0-group stages with abundance indices obtained by other methods at age ≥ 3 years for some species, and he concludes: "A very close correlation is found between the two independent estimates of year class strength and it is concluded therefore, that the abundance indices of 0-group fish obtained from the acoustic surveys give a fairly good estimate of year class strength".

Echo abundance indices for the most numerous species of 0-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 echo-sounder paper records, and the organisms forming the scattering layers have been identified from sampling with small-meshed pelagic trawls (Dragesund, Midttun and Olsen, 1970). Distribution charts for each species have been given in the reports to the ICES annual meetings. Figure 227 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 No.	0	1	2	3	4
Classification	No recording	Very scattered	Scattered	Dense	Very dense

During the cruises the classification has been carried out aboard the vessels for each nautical mile sailed. The distributions of 0-group fish have generally been plotted (Fig. 227) in the three density grades, absent, scattered and dense. This grading has been based partly on visual grading of the echograms and partly on the amount of fish in the trawl catches. From 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 trawl haul was used to decide between scattered and dense in the

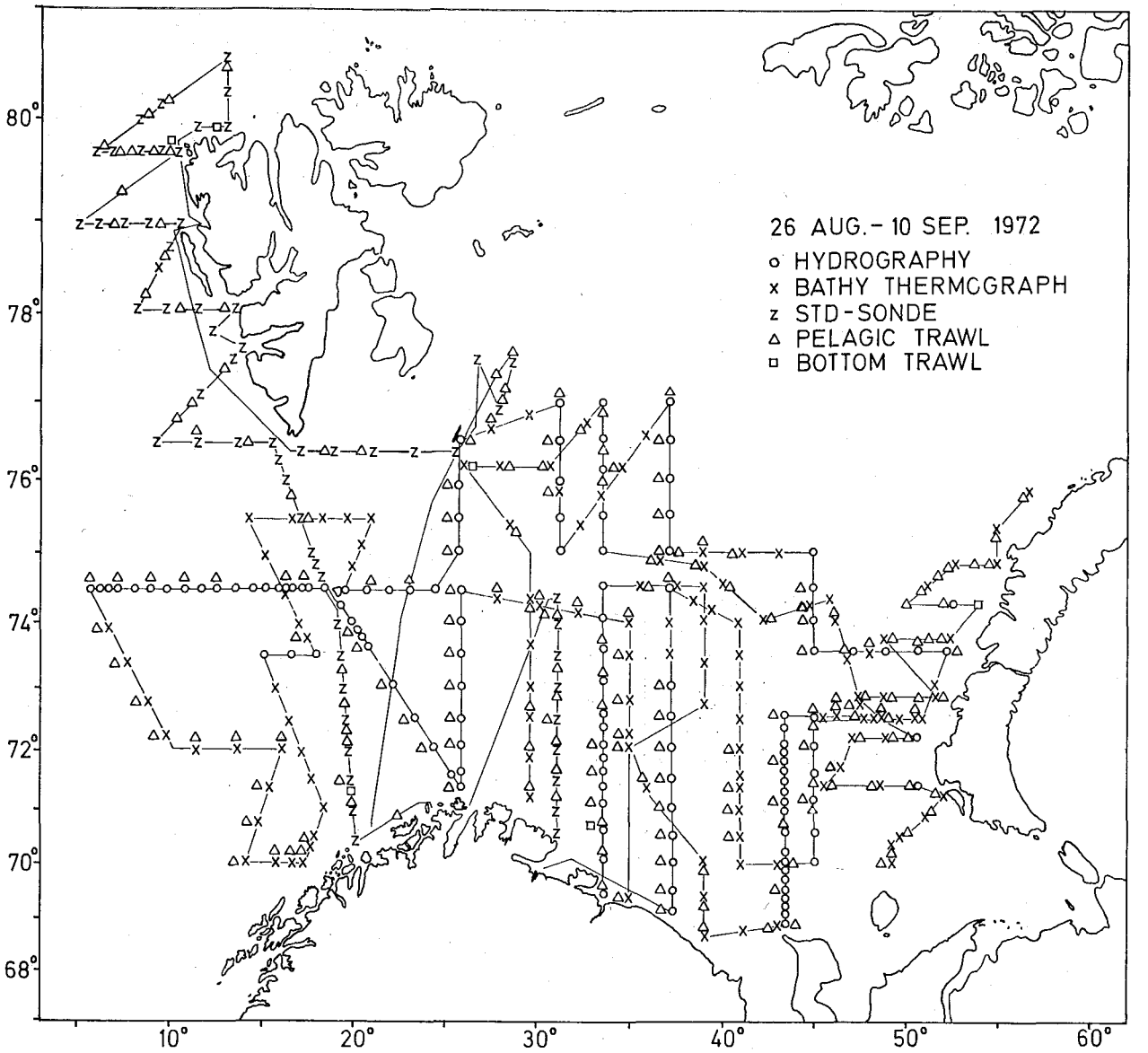

Figure 226. Survey routes and grid of stations, 1972.

distribution charts. This number was found by examining the trawl catches which contained only one species and comparing the number of fish per haul with the corresponding visual grading of the echo trace (Table 60). Assuming a linear relationship between the logarithm of the catch and the visually estimated densities, the following values for distinguishing between scattered and dense were found:

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

(b) The data for each species and year were replotted using these values for the above-mentioned separation.

(c) The abundance indices, T, were calculated from the formula

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

where A_s and A_d denote the areas within which the densities were found to be respectively scattered and dense. The coefficient k is the ratio between fish densities, classified as dense (code nos. 3 and 4) and scattered (code nos. 1 and 2). This coefficient was deter-

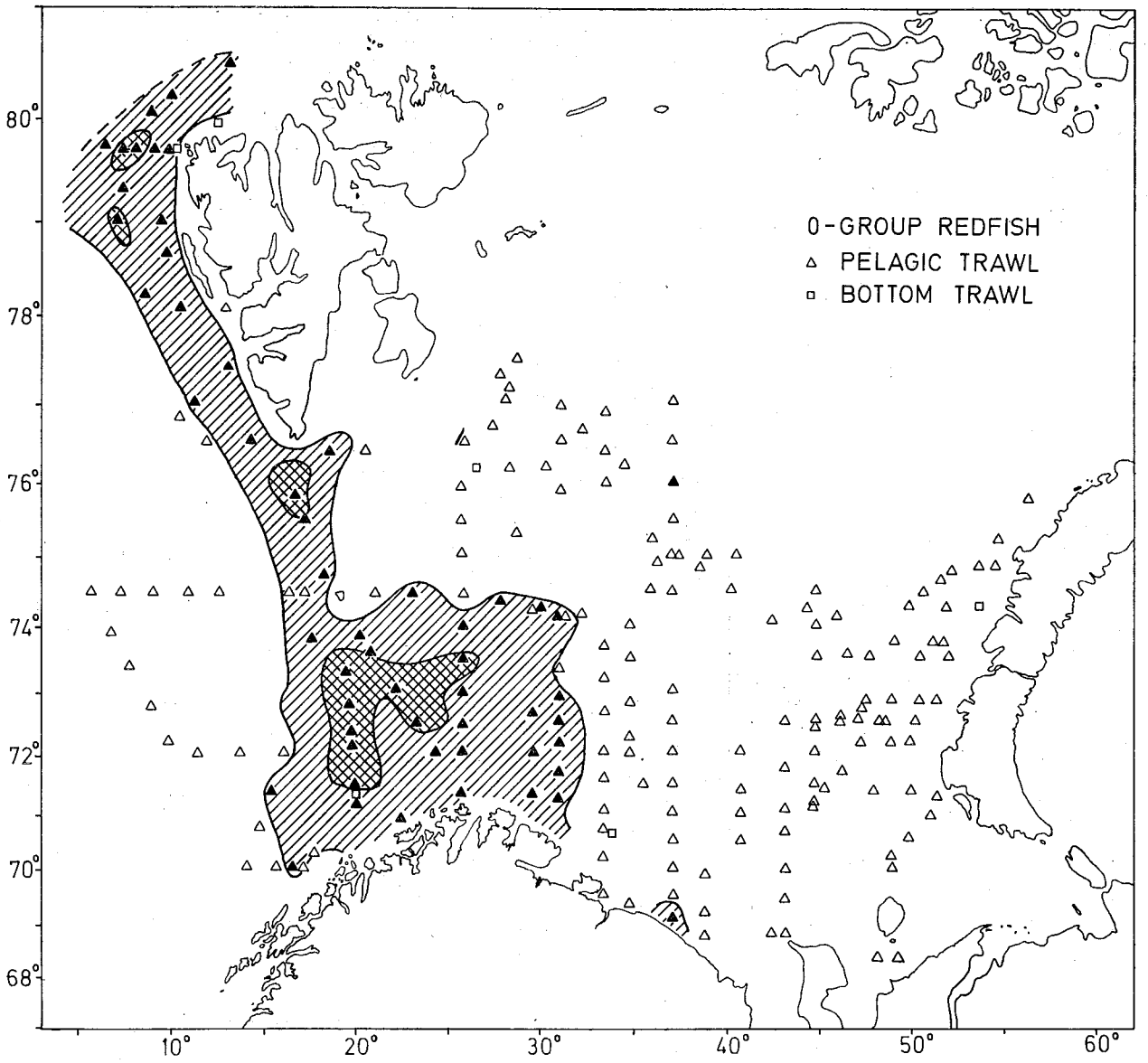

Figure 227. Distribution of 0-group redfish, 1972.

mined by Dragesund (1970b) as having an approximate value of 10. Table 61 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 62.

For the period 1965–1972, two average indices have been calculated for each species (Table 63). 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 being excluded. Finally, for each species, an interval was selected (the upper and lower limits being chosen so that the ratio between them was approximately 2) within which the indices correspond to average strength year classes, and new estimates of year class strength were obtained by comparing the indices for each year with the averages.

RESULTS AND DISCUSSION

The results of the calculations, and the contribution to the indices from scattered and dense concentrations

are shown in Table 62. Table 63 shows the classification of year class strengths as given in the earlier annual reports (E_1) and as found from the calculated average indices (E_2).

For most species the coincidence between the two classifications is good, but for capelin some discrepancies occur. For capelin 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 1967 and 1969 year classes were approximately equal in strength while the 1968 year class was weaker

Table 60. Mean values and standard deviations of the number of 0-group fish in pelagic trawl catches at classified visual densities as estimated from the recording paper. N is the number of trawl hauls

Species	Cod			Capelin			Redfish			Polar cod		
Density	Mean	s.d.	N	Mean	s.d.	N	Mean	s.d.	N	Mean	s.d.	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	18 628	18 801	5	223	281	8	212	177	8
4	1 330	1 090	2	417	254	2	815	963	5	16 250	18 031	2

Table 61. Mean values and standard deviations of echo integrator deflections (mm/nautical mile) and relative units of density at classified visual densities estimated from the recording paper on cruises by "G. O. Sars" and "Johan Hjort". N is the number of integrator deflections

Visual density	Integrator deflection						Relative density	
	"G. O. Sars"			"Johan Hjort"			"G. O. Sars"	"Johan Hjort"
	Mean	s.d.	N	Mean	s.d.	N		
1	7·6	8·5	105	3·9	3·0	148	1·0	1·0
2	24·5	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 62. Abundance indices of ten species in terms of area occupied (nautical mile$^2 \times 10^{-3}$). 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			West			Polar cod East			W + E			Cod		
Year	A_s	$10A_d$	T	A_s	$10A_d$	T	A_s	$10A_d$	T	A_s	$10A_d$	T	A_s	$10A_d$	T	A_s	$10A_d$	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	$10A_d$	T	A_s	$10A_d$	T	A_s	$10A_d$	T	A_s	$10A_d$	T	A_s	$10A_d$	T	A_s	$10A_d$	T	A_s	$10A_d$	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 63. Estimates of year class 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
-66	P	< 1	P	S	119	A	P	< 1	P	S	236	S	S	129	A	S	97	S
-67	P	34	P	S	89	A	A	42	A	?	44	P	A	165	A	S	73	A
-68	P	25	P	S	99	A	P	8	P	?	21	P	A	60	P	P	17	P
-69	?	93	A	S	109	A	?	82	S	S	295	S	S	208	S	P	26	P
-70	S	606	S	P	51	P	?	115	S	S	247	S	S	197	S	P	12	P
-71	A–S	157	S	S	151	S	A	73	S	?	172	A	A	181	S	?	81	S
-72	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	

(Dragesund, Gjøsæter and Monstad, 1973). This may indicate that the indices for capelin in Table 62 are subject to large errors.

When comparing the indices in Table 62, 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 echograms. Although care has been taken to avoid biases caused by differences in power and gain settings of the echo-sounders by training staff in calibration and control, the accuracy of this classification will always depend on the interpretation of the different scientists.
2. the amount of catch per haul for distinguishing between the classifications scattered and dense. Again, personal interpretation is an important but unknown factor. Furthermore, the number of fish per haul shows large variances (Table 60).

The large differences in relative units between catches and integrator deflections (Tables 61 and 62) 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 year class of capelin as compared with the 1968 year class. In 1967 the 0-group capelin were significantly smaller than in 1968 (Dragesund, 1970c). For other species which show smaller 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 62. This will reduce the highest estimates, but not change the rank of the indices.

Information on the contributions of different species to the total biomass can be extracted only partially from Tables 62 and 63. 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.

Even though there are considerable inaccuracies in the figures, there is no doubt that the indices for each species reflect relative strengths of year classes of the 0-group fish in the Barents Sea.

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