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DISTRIBUTION AND ABUNDANCE OF 0-GROUP NORWAY POUT AND HADDOCK IN THE NORTH SEA JULY-AUGUST 1978

O. Nakken and C. J. Rørvik
Institute of Marine Research
P.O.Box 1870-72, 5011 Bergen-Nordnes, Norway

ABSTRACT

In order to assess the 0-group abundance of Norway pout and haddock in the North Sea a combined acoustic/trawl survey was carried out in July - August 1978. The 0-group of both species were concentrated in a scattering layer between surface and 40 m depth during the night. During the day all the 0-group Norway pout and most of the 0-group haddock were found in the vicinity of the bottom but a minor portion of the 0-group haddock occurred in scattered schools throughout the entire water column.

Acoustic estimates of the 0-group stocks of the two species amounted to $165 \cdot 10^9$ specimens of Norway pout and $23 \cdot 10^9$ specimens of haddock. The figure for Norway pout compares resonably well with estimates based on independent data, but regarding the haddock the acoustic estimate seems high compared with estimates based on other data sources.

INTRODUCTION

Information about the abundance of the young yearclasses of fish can to some extent be derived from commercial fish landings. However, for short lived species like Norway pout the catch statistics can only enable fishery scientists to describe the history of the stock and there is an urgent need for abundance figures of the 0-group before the yearclass enter the fishery. At the Institute of Marine Research a combination of acoustic surveys and trawl surveys have been applied successfully for a number of years in assessing the stocks of capelin and young cod and haddock in the Barents Sea (Nakken and Dommasnes 1975, Dalen, Hylen and Smedstad 1977). A similar survey was carried out during the summer 1978 aiming at an assessment of the abundance of 0-group Norway pout and haddock in the North Sea. The results from this survey are reported in this paper.

MATERIAL AND METHODS

The northern North Sea was covered with the two research vessels "G.O. Sars" and "Johan Hjort" in the period 23 July - 11 August 1978 (Fig. 1). Both vessels were equipped with identical acoustic systems and fishing gears. The acoustic systems consisted of a 38 kHz echosounder (Simrad scientific sounder EK 38) working in conjunction with a six depth channel echointegrator. The midwater trawls were 1600 meshes (20 cm mesh size) in circumference; the bottom trawls were shrimp trawls measuring 1800 meshes (4 cm mesh size) with a groundrope of 63 feet and a headline of 96 feet. Both gears were equipped with an inner bag of 1 cm mesh size.

In order to obtain satisfactory information on species and size composition of the organisms which contributed to the echo recordings, frequent trawling were carried out (Fig. 1). In addition several "check" hauls were undertaken in the uppermost water layer (0 - 10 m depth) where the echosounders have a deadzone.

The echo recordings were scrutinized daily, and the integrator outputs were grouped in 3 categories, pelagic fish - bottom fish and plankton, according to their appearance on the echogram and the composition of the trawlcatches.

RESULTS AND DISCUSSION

Echo recordings

Scattering layers and schools of 0-group fish were recorded within the entire area. Fig. 2 shows the distribution of the total echo integrator outputs from 0-group fish. 0-group Norway pout were predominant in the trawl catches, but also 0-group haddock contributed significantly. The contributions to the echo integrator outputs in Fig. 2 from other 0-group fish and from older yearclasses were found to be insignificant. Before discussing the echo recordings we shall describe the distribution of 0-group Norway pout and haddock in more detail.

Distribution of 0-group Norway pout

The fish was found over the entire bank plateau; the largest concentrations being observed east and southeast of Shetland (Fig. 2). During the day it stayed in small schools in the vicinity of the bottom - from the bottom and up to 10 m above. At sunset it ascended towards the surface and formed a homogeneous scattering layer in 0 - 40 m depth in the watermasses above the thermocline. The length distributions (Fig. 5) show a tendency of increasing fish length from north to south, and the fish caught in bottom trawl were slightly bigger than those caught in pelagic trawl.

Distribution of 0-group haddock

0-group haddock (Fig. 4) was also found in most of the area but in considerably smaller numbers than 0-group Norway pout. The differences in mean fish lenght between pelagic and bottom trawl were quite large (Fig. 6); the pelagic trawl catching smaller fish than the bottom trawl. This is most probably caused by differences in behaviour by size. The biggest specimens undertook exactly the same diurnal vertical migration as the 0-group Norway pout; they occurred in the near bottom schools during the day and in the scattering layer in 0 - 40 m depth in night time. A minor portion of the 0-group haddock - being the smallest individuals - was however found in small schools in midwater in 50 - 100 m depth also during the day and thus sampled by the midwater trawl more frequent than the larger ones. A slight difference in mesh selection between the two types of gear might also have occurred.

Summary of findings regarding fish distribution and behaviour

Table 1 shows the average catch composition according to gear and time of the day. The conclusion which can be drawn from Table 1 are:

1. During the night the number of 0-group fish at the bottom was insignificant. All the 0-group fish were then found in the upper layer.
2. During the day most of the 0-group fish was found close to the bottom. (Except for a minor portion of the 0-group haddock).
3. The older agegroups were situated close to the bottom both night and day.

Analyses of the echo integrator outputs

As mentioned previously the echo integrator values, M, were grouped in 3 categories, pelagic fish, bottom fish and plankton. All the pelagic - and bottom fish values were thereafter grouped in day and night observations and mean values were made within each statistical square (Fig. 7). These mean values are presented in Table 2. Mean values for the total area are given at the bottom of Table 2. The observations, n, referred to in Table 2 are the number of 5 nautical mile intervals which are sampled within each square. The echo integrator outputs were given as mm deflection per nautical mile averaged over 5 nautical mile intervals.

Bearing in mind the findings regarding fish distribution and behaviour, we will categorize as follows regarding the contribution to the echo integrator values (Table 2) from the different species and sizegroups:

1. M(P.N) <u>All 0-group fish</u> contributed to these values but <u>no older agegroups</u>.
2. M(P.D) <u>Some 0-group haddock</u> contributed to the values but <u>no contribution from older agegroups</u>.
3. M(B.N) <u>No 0-group fish contributed</u> and <u>all older agegroups</u>.
4. M(B.D) <u>Most of the 0-group contributed</u> and <u>all older agegroups</u>.

For an acoustic assessment of the 0-group biomass the values of M(P.N) can be used alone as this category has received contribution from 0-group fish only. However, as the number of night observations is low as compared to the number of day observations the amount of data would increase considerably if also the day values could be used in the computations. The day values M(B.D) can be used if we find a way to subtract the contribution to this category from older agegroups. Since the older agegroups stayed close to the bottom both day and night we assumed that their contribution to the bottom fish values in daytime equalled their contribution to the bottom fish values in night time. As the older agegroups were alone at the bottom during night time they were the only contributors to M(B.N). Consequently we can establish the following formula for the best estimate of mean integratorvalue for 0-group fish, M (0-group), for each statistical square.

$$M\ (0\text{-group}) = \frac{M(P.N) \cdot n(N) + [M(P.D) + M(B.D) - M(B.N)]\, n(D)}{n(N) + n(D)} \qquad (I)$$

where N and D refer to night- and day observations.

Values of M (0-group) are given in the right hand side of Table 2. These values will later be used to compute the number of 0-group Norway pout and haddock within each statistical square.

The figures in Table 2 can also be used to investigate differences in the integratorvalues between day and night. Theoretically the following balance should exist within each statistical square:

$$M\ (0\text{-group}, D) - M\ (0\text{-group}, N) = 0 \qquad \text{(II)}$$

or

$$[M(B.D)+M(P.D)-M(B.N)] - M(P.N) = 0$$

This is what we would expect if the observations were collected randomly in space and time within each square and the number of observations was large enough. The geographical distribution of the scattering layers (Fig. 2) and the systematic way of sampling by steering straight courses allow us, however, not to expect these balances to exist within each single square. For the total area of investigations, however, the balance equations above ought to be fulfilled. Applying the numbers for the total area at the bottom of Table 2 in the balance equation (II) we arrive at:

$$(67.3 + 10.5 - 7.1) - 68.6 = 2.1$$

This shows that on an average for the total area we recorded 3 percent more 0-group fish during the day than during night time. The difference is small but significant and is propably caused by the diurnal behaviour of the 0-group; a minor portion being above the echosounder level during night time. The remarkable good correspondance between night and day values strengthen the confidence to the values in Table 2 being a reliable basis for computing the number of 0-group fish within the investigated area.

Computations

The computations were performed as described by Nakken and Dommasnes (1975), Dalen, Raknes and Røttingen (1976). The following formula was applied:

$$^{\rho}A_{ji} = k_{ji} \frac{M}{\sum_{j=1}^{P} \sum_{i=1}^{n} \frac{k_{ji}}{C_{ji}}} \qquad \text{(III)}$$

Where j refers to species

i refers to lenghtgroups

ρA_{ji} is the number of fish per unit area of the j-th species and the i-th lenghtgroup

k_{ji} is the proportion of the total catch of the j-th species and the i-th lenghtgroup

M is the echointegrator value

C_{ji} is an experimentally determined factor expressing the number of fish per unit area which contribute to one unit of M.

The values of M (0-group) in Table 2 were used in the computations. Mean values of k for each statistical square were made and used in formula (III). 0-group Norway pout and haddock were assumed to have identical scattering properties and the value of C applied by Dalen et al. (1977) on haddock in the Barents Sea

$C = 3.81 \cdot 10^6 \cdot L^{-1.87}$, (L is fish length in cm)

was used.

The numbers of specimens within each statistical square were found by multiplying the calculated average densities, ρ_A, by the areas of the squares. These numbers are presented in Fig. 8 and Fig. 9 for Norway pout and haddock respectively. When adding the figures in all squares we arrive at the following estimates for these two 0-group populations:

Haddock: $23 \cdot 10^9$ number of specimens
Norway pout: $165 \cdot 10^9$ number of specimens

Since a portion of the 0-group haddock was observed in midwater layers both day and night all the midwater day hauls showed almost pure catches of 0-group haddock. These trawlcatches are thus representative for the integratorvalue of pelagic recordings in day time, M(P.D), and they do not fully represent the composition of fish contributing to the total 0-group contribution, M (0-group). It is therefore likely that the estimate of $23 \cdot 10^9$ number of individuals for 0-group haddock is biased upwards. The bias introduced by not taking into account the other 0-group species is negligible due to the low number of these fishes as compared to haddock and Norway pout.

Comparison of the acoustic estimates with independent estimates.

Haddock

Anon. (1979 a) (Table 4.1.2) gives an estimate of the 1978 yearclass at age 1 of $793 \cdot 10^6$ on the basis of the results from the International Young Herring surveys (IYHS) and VPA. Assuming this estimate to be correct and that the present estimate of 23×10^9 for the 0-group is correct for 1 August 1978, then the total annual instantaneous mortality Z in the last 5 months on 1978 of the 0-group was

$$Z = (12/5) \cdot \log_e (23 \cdot 10^9 / 793 \cdot 10^6) = 8.08$$

$249 \cdot 10^6$ 0-group haddock are reported caught in 1978 (Anon. 1979 a, Table 4.1.4). This catch is small compared with the estimated reduction of the yearclass which is about 22×10^9, thus $Z \approx M$.

The value of M (=8.08) seems high compared with the natural mortality of 1.6 and 2.0 used by Anon. (1979 b) for Norway pout. If the acoustic estimate of 0-group haddock is biased upwards as indicated above, an unbiased estimate would reduce M.

Norway pout

Anon. (1979 b) did a VPA on Norway pout, although the size estimates of the individual yearclasses at different ages are not given. However, in Anon. (1978) the results from a VPA on the agegroup 0 to 5 for 1974 and 1977 are given.

Depending on the correctness of the assumed natural mortality of 1.6 and the estimates of catch compositions, the VPA estimates of the 1974 and 1975 yearclasses at age 0 can be regarded as fairly reliable. Only a small proportion of the yearclasses survire to age 3 (Anon. 1978, Table 2.4.5).

The estimates of the two yearclasses 1974 and 1975 for the North Sea at age 0 is $408 \cdot 10^9$ and $384 \cdot 10^9$ respectively (Anon. 1978, Table 2.4.5), on the average $396 \cdot 10^9$. Projecting this average estimate to 1 August with the same M (=1.6) as used in the VPA gives:

$$396 \cdot 10^9 \cdot e^{-1.6 \times 7/12} = 156 \cdot 10^9.$$

Anon. 1979 b (Table 2.6.1) gives 0-group indices for the yearclasses 1974, 1975 and 1978 based on pelagic 0-group surveys and the Scottish autumn surveys. Assuming proportionality between these indices, I_j, and the strength of the yearclasses, the 1978 yearclass at 1 August can be estimated as

$$\frac{I_{1978}}{(I_{1974} + I_{1975}) \frac{1}{2}} \cdot 156 \cdot 10^9$$

This gives $135 \cdot 10^9$ and $358 \cdot 10^9$ respectively as estimates of the 1978 yearclass.

Using the abundance indices of I-group Norway pout from the IYHS (Anon. 1979 b, Table 2.6.1), and ignoring the small sizes and differences of the fishing mortalities on 0-group Norway pout, the estimate is $54 \cdot 10^9$.

These three estimates derived from Anon. (1978,1979 b), and especially the average of these estimates of 182×10^9, compares well with the present acoustic estimates of $165 \cdot 10^9$. If the acoustic estimate of 0-group haddock is biased upwards as indicated above, this means that the acoustic estimate of 0-group Norway pout is too low. However, since 0-group Norway pout dominates, the percentage underestimation of this species is likely to be less than the percentage observations of 0-group haddock. It might be concluded that the acoustic estimates is of the same order as would be expected from independent data.

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Table 1. Average catch (number per hour trawling) for all fishing stations.

Group of fish	Night		Day	
	Bottom trawl	Pelagic trawl	Bottom trawl	Pelagic trawl
0-group	58	9600	53300	800
1 + group	1610	22	7200	4
Number of stations	8	22	28	19

Table 2. Mean values of echo integrator outputs for each statistical square. Figures in brackets are average values for the total area.

M(P.N): Pelagic recordings in night time
M(P.D): Pelagic recordings in day time
M(B.N): Bottom recordings in night time
M(B.D): Bottom recordings in day time
n : Number of observations

Sq.no.	M(P.N)	n	M(P.D)	n	M(B.N)	n	M(B.D)	n	Values for computations M_{0-gr}	M_{I+}
42-62		0	6.0	6	(7.1)	0	170.0	6	(68.0)	(7.1)
42-63	9.6	8	18.1	23	8.4	8	101.9	22	82.8	8.4
42-64	29.3	14	18.3	12	10.8	13	127.8	14	76.9	10.8
42-65	75.6	8	2.5	24	5.8	8	69.9	24	67.4	5.8
42-52	28.5	2	3.4	7	12.5	2	78.2	6	55.8	12.5
42-53	110.8	12	31.0	17	24.1	12	68.0	18	81.7	24.1
42-54	42.7	9	11.5	15	13.1	9	47.3	15	42.0	13.1
42-55	88.8	8	11.6	16	2.9	8	52.9	17	69.5	2.9
42-42	31.0	2	7.2	10	5.0	2	160.4	10	139.8	5.0
42-43	103.0	8	38.9	20	6.6	8	125.5	20	140.5	6.6
42-44	90.3	15	49.5	10	1.5	15	68.6	8	99.2	1.5
42-45	86.5	17	14.5	7	3.9	17	63.3	10	79.3	3.9
08-14	260.0	1	2.8	14	35.0	1	30.4	8	68.5	(7.1)
42-32	48.0	10	14.0	10	8.4	10	46.2	10	45.7	8.4
42-33	80.6	8	13.3	19	2.4	7	178.0	18	154.8	2.4
42-34	24.0	2	14.4	20	1.3	3	43.3	21	53.4	1.3
42-35	44.2	5	5.4	18	0.0	5	61.2	18	61.7	0.0
08-13	24.7	3	0.5	10	0.0	3	54.5	13	32.8	0.0
42-21		0	0.9	7	(7.1)	0	24.6	7	18.2	7.3
42-22	77.9	16	13.6	5	5.2	18	45.1	3	69.6	5.2
42-23	127.1	8	17.5	11	13.9	10	20.2	11	61.4	13.9
42-24		0	0.1	17	(7.1)	0	22.4	15	15.0	7.3
42-25		0	1.1	23	(7.1)	0	59.8	24	52.7	(7.3)
08-11	63.8	4	1.9	9	0.0	4	49.8	10	51.7	0.0
42-11		0	7.9	10	(7.1)	0	34.5	11	36.4	(7.1)
42-12	110.8	4	4.7	10	4.7	3	63.8	11	77.5	4.7
42-13	91.3	7	19.8	4	14.6	7	55.0	4	70.7	14.6
42-14	65.5	12	0.2	9	4.0	13	25.9	9	36.4	4.0
42-15	13.8	8	0.4	13	0.0	7	32.1	11	23.6	0.0
08-09	3.3	4	0.3	20	4.0	3	42.7	20	32.3	4.0
42-04	79.3	3	0.3	14	3.0	2	66.4	14	65.6	3.0
42-05	68.6	3	8.3	6	15.5	2	49.4	8	43.7	15.5
42-06	44.3	4	8.3	4	2.0	4	10.8	4	29.7	2.0
08-05		0	0.0	11	(7.1)	0	14.5	11	7.2	(7.3)
08-06	18.2	6		0	6.0	6		0	18.2	6.0
Mean	68.6	211	10.5	431	7.1	210	67.3	431		

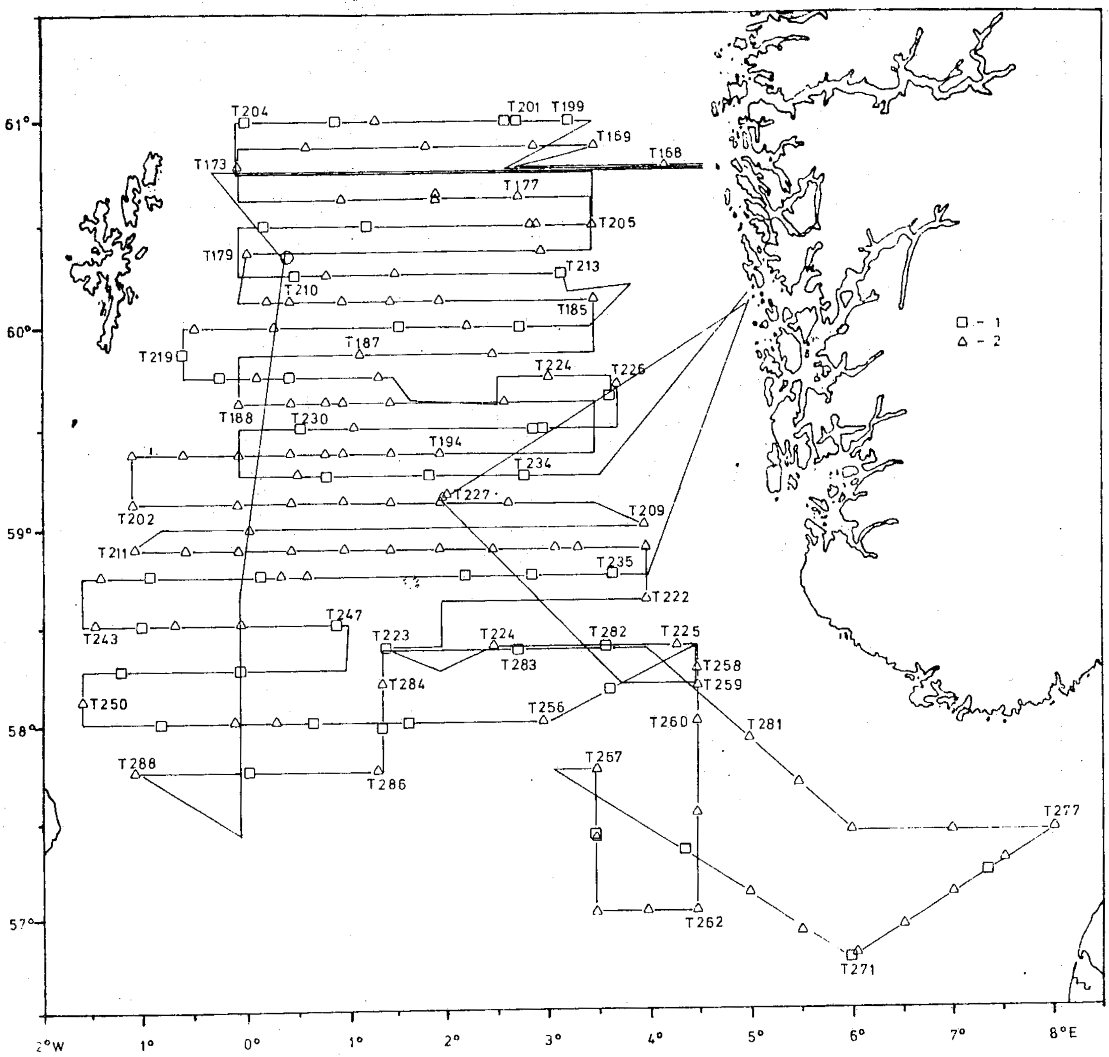


Fig. 1. Survey grid and trawlstations for R/V "G.O. Sars" and R/V "Johan Hjort" 23. July - 11. August 1978. 1. Bottom trawl, 2. Pelagic trawl.

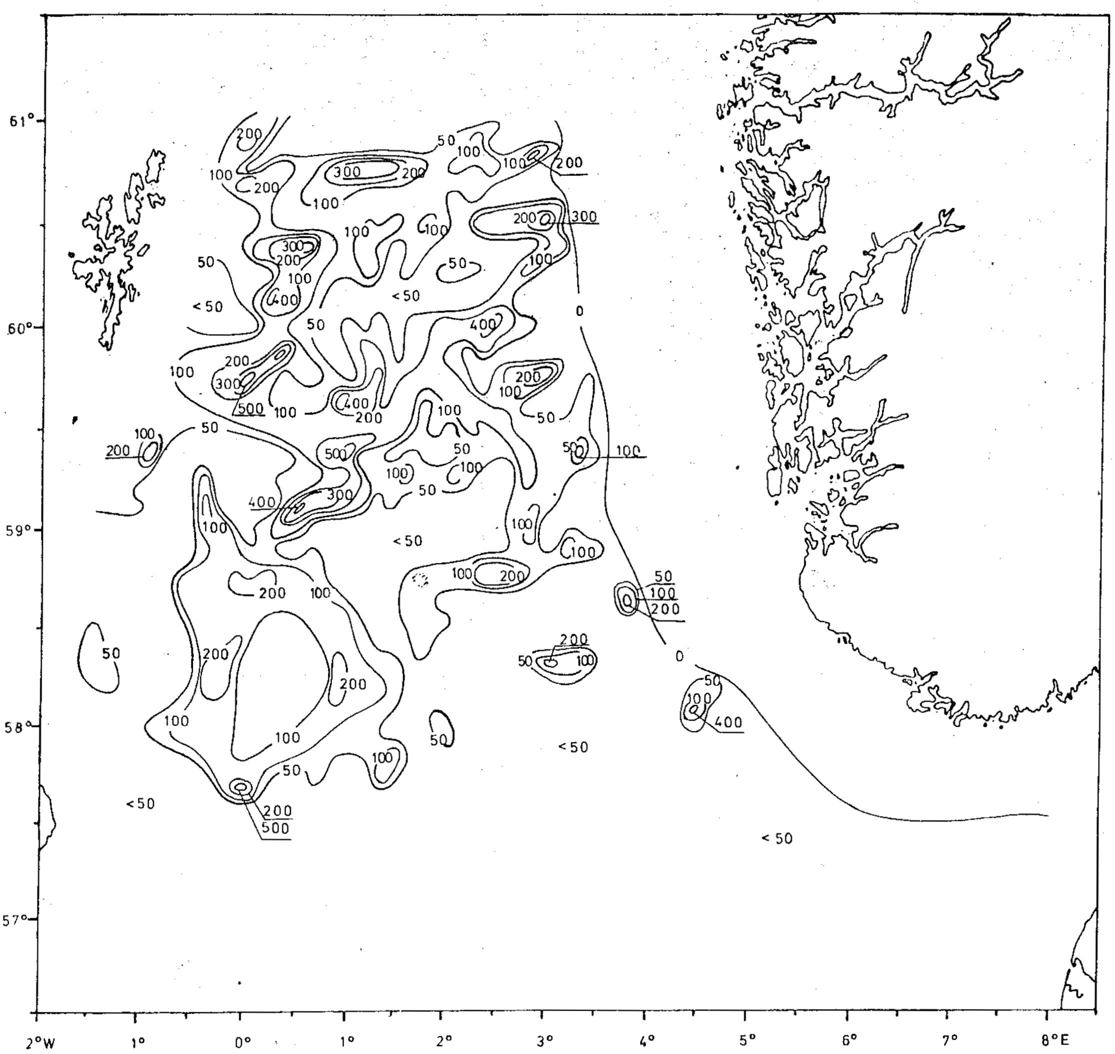


Fig. 2. Distribution of echointegrator values (mm/nautical mile).

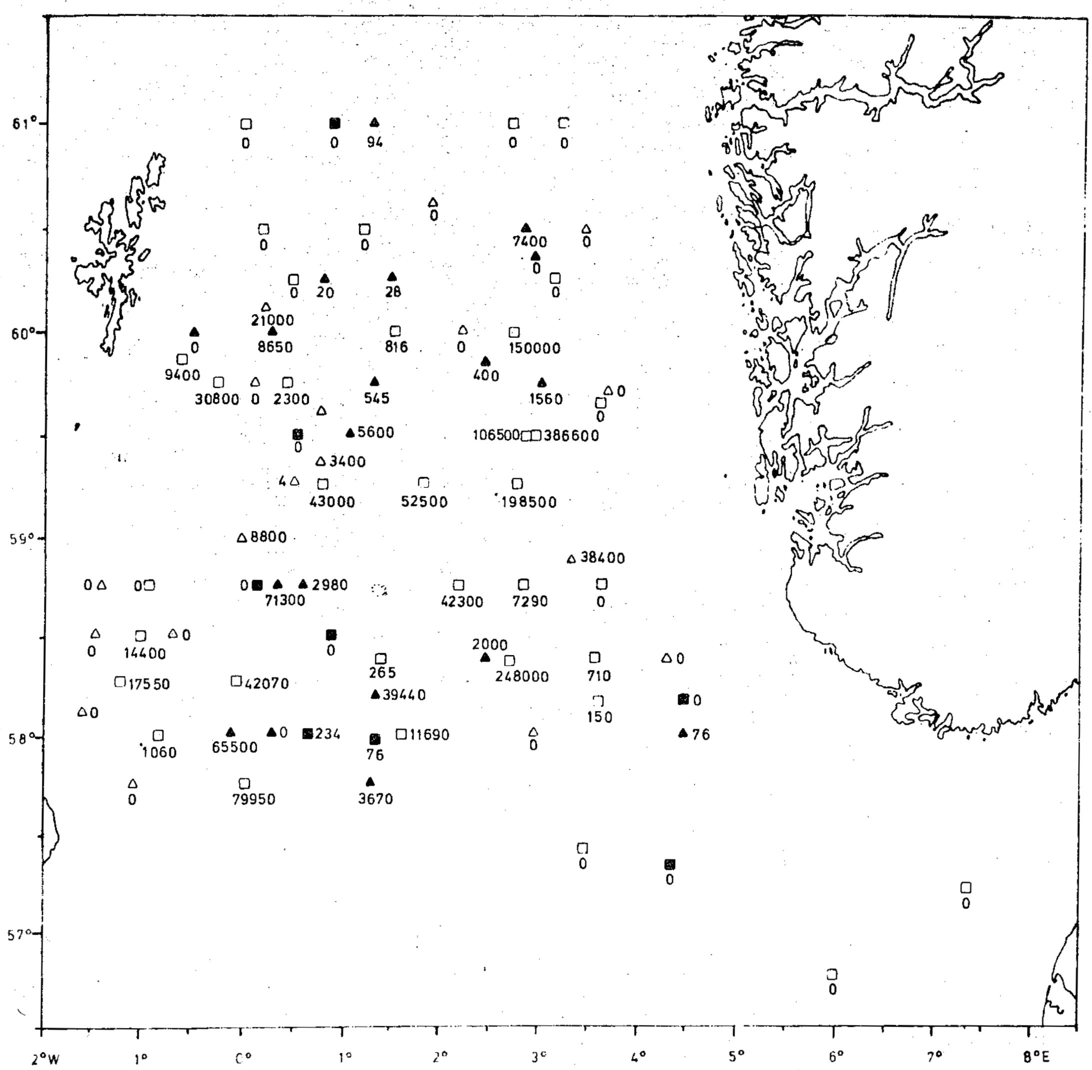


Fig. 3. Catch (numbers per hour trawling) of 0-group Norway pout. Black symbols indicate night stations. Legend as in Fig. 1.

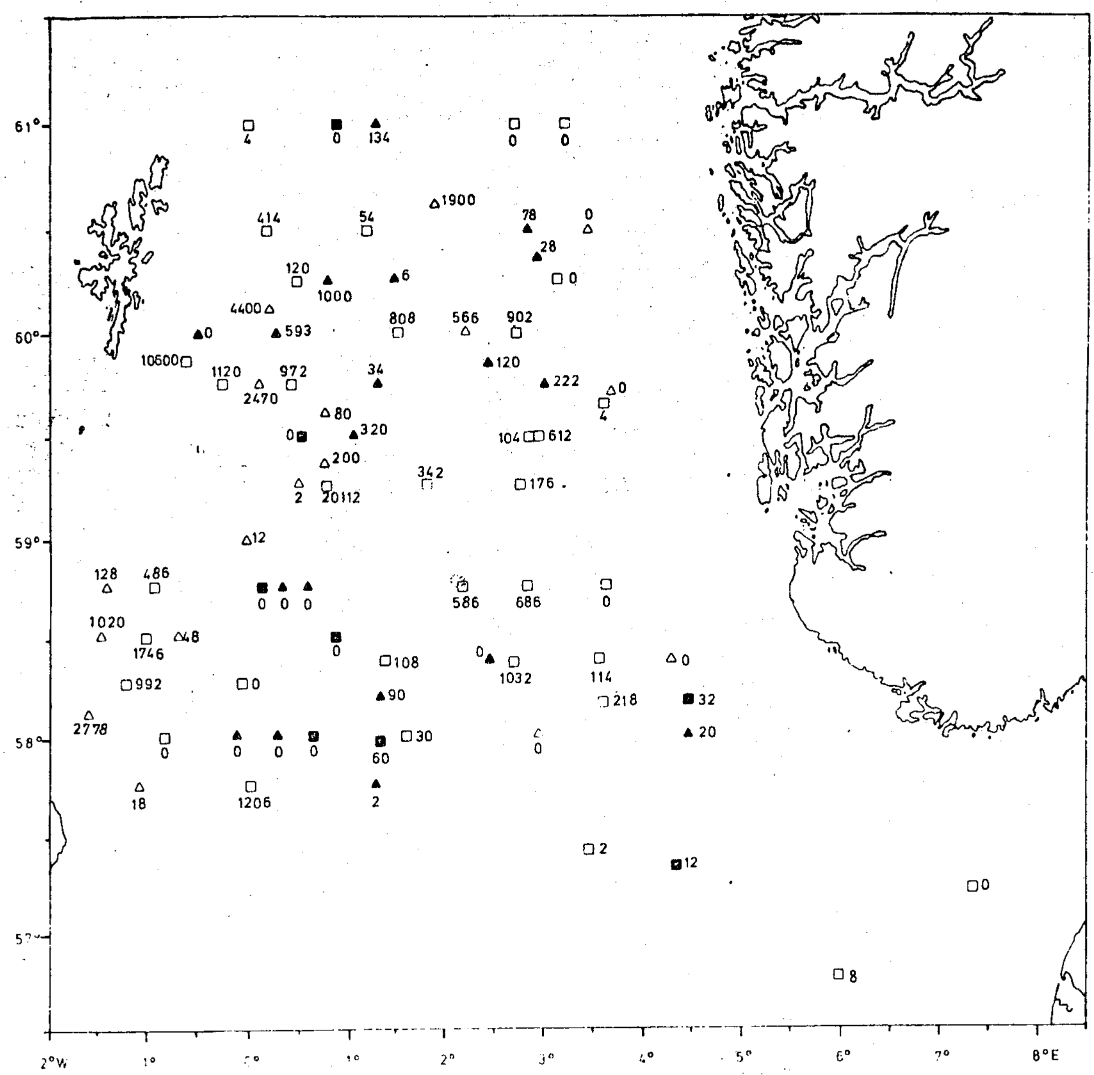
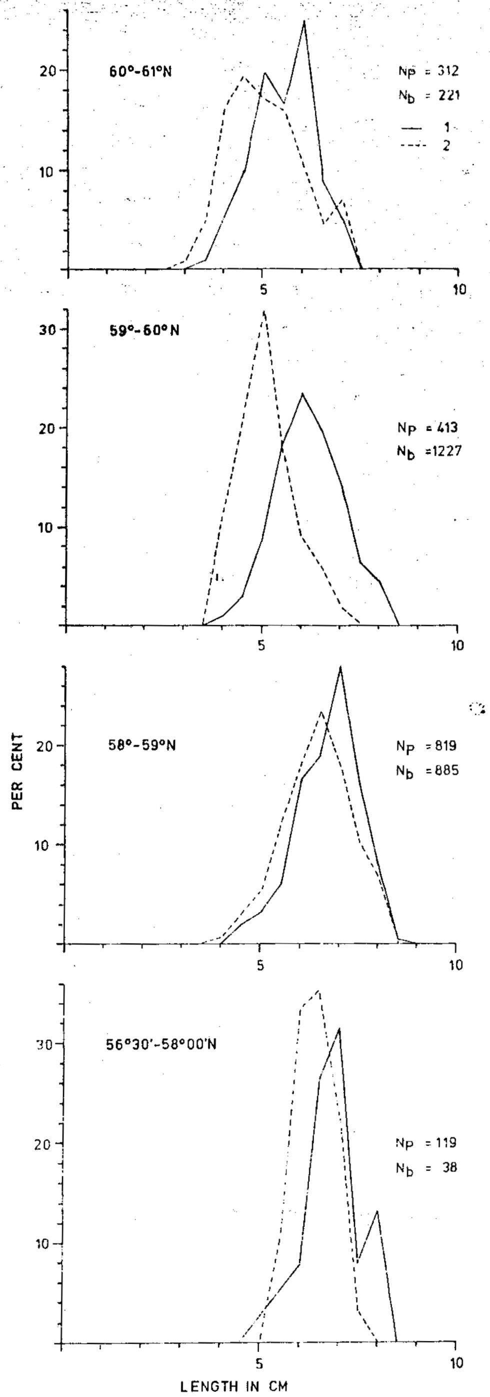


Fig. 4. Catch (number per hour trawling) of o-group haddock. Black symbols indicate night stations. Legend as in Fig. 1.



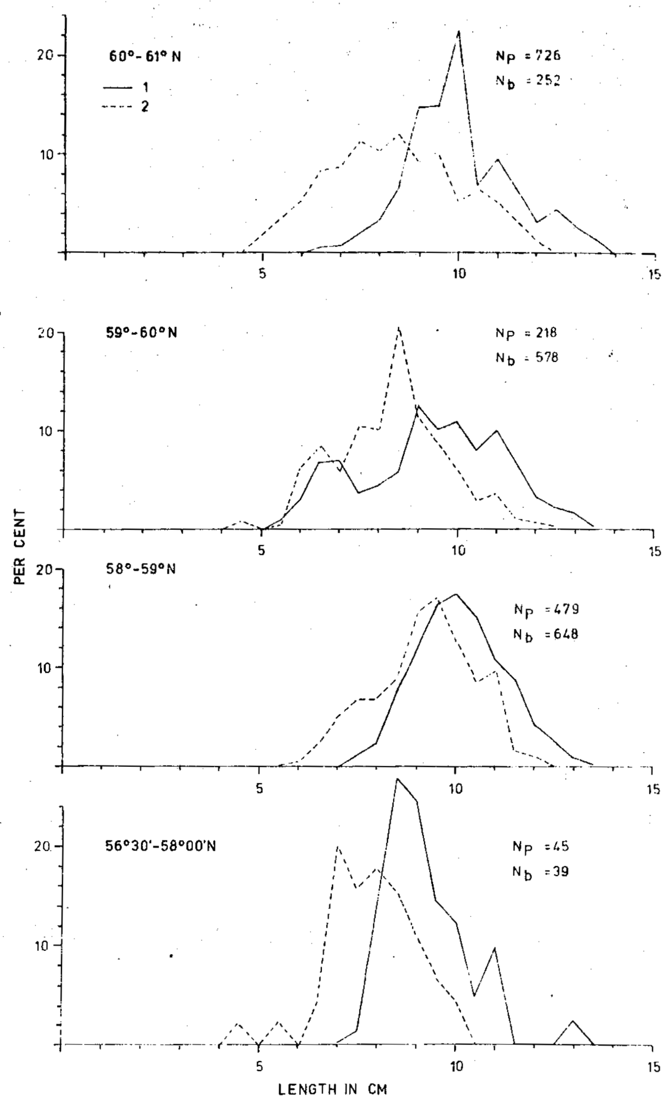


Fig. 5. Length frequency distribution of 0-group Norway pout.
1. Bottom trawl,
2. Pelagic trawl

Fig. 6. Lenght frequency distribution of 0-group haddock.
1. Bottom trawl
2. Pelagic trawl

N_p Number of fish measured from pelagic trawl hauls.

N_b Number of fish measured from bottom trawl hauls.

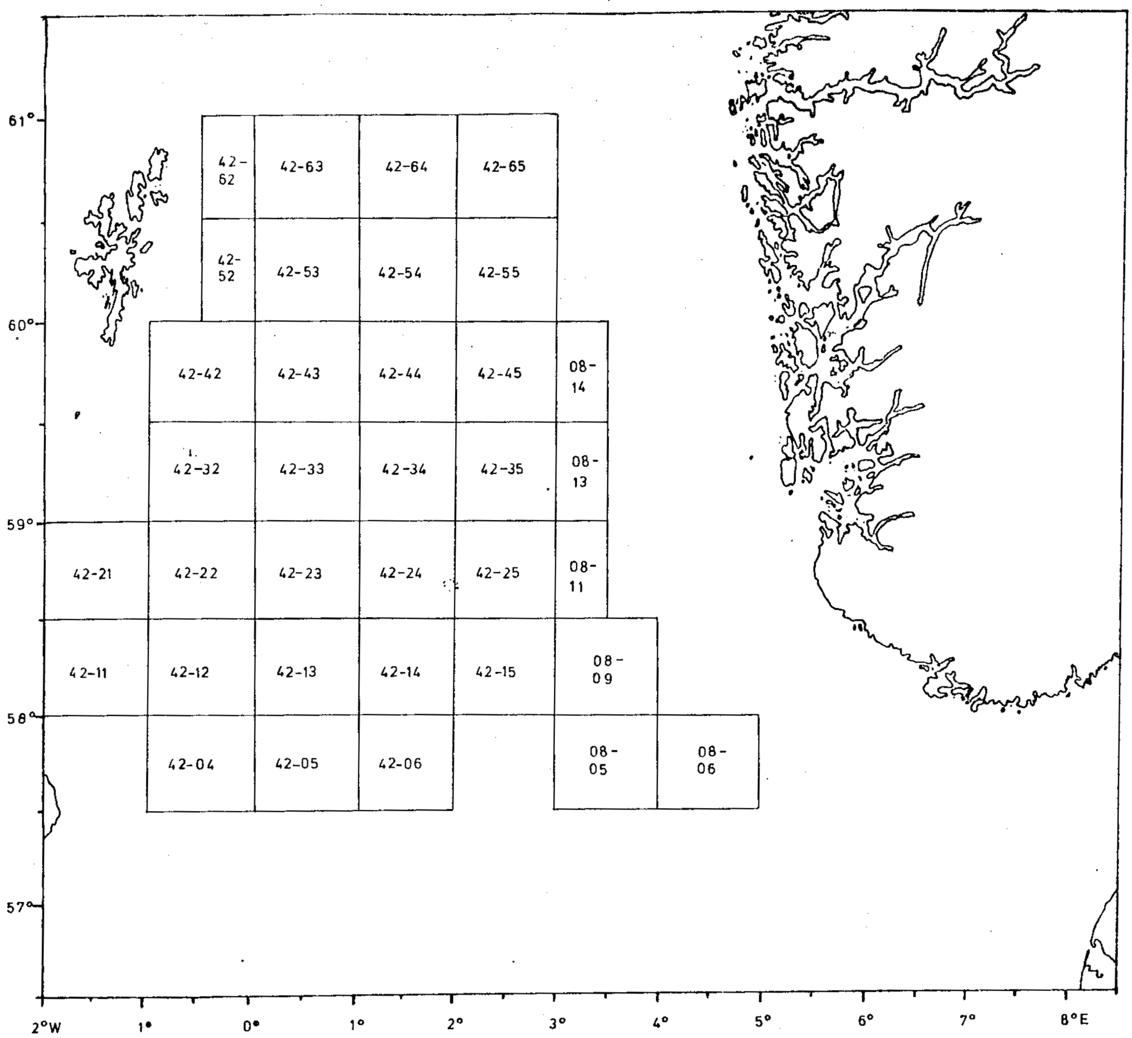


Fig. 7. Statistical squares with reference number.

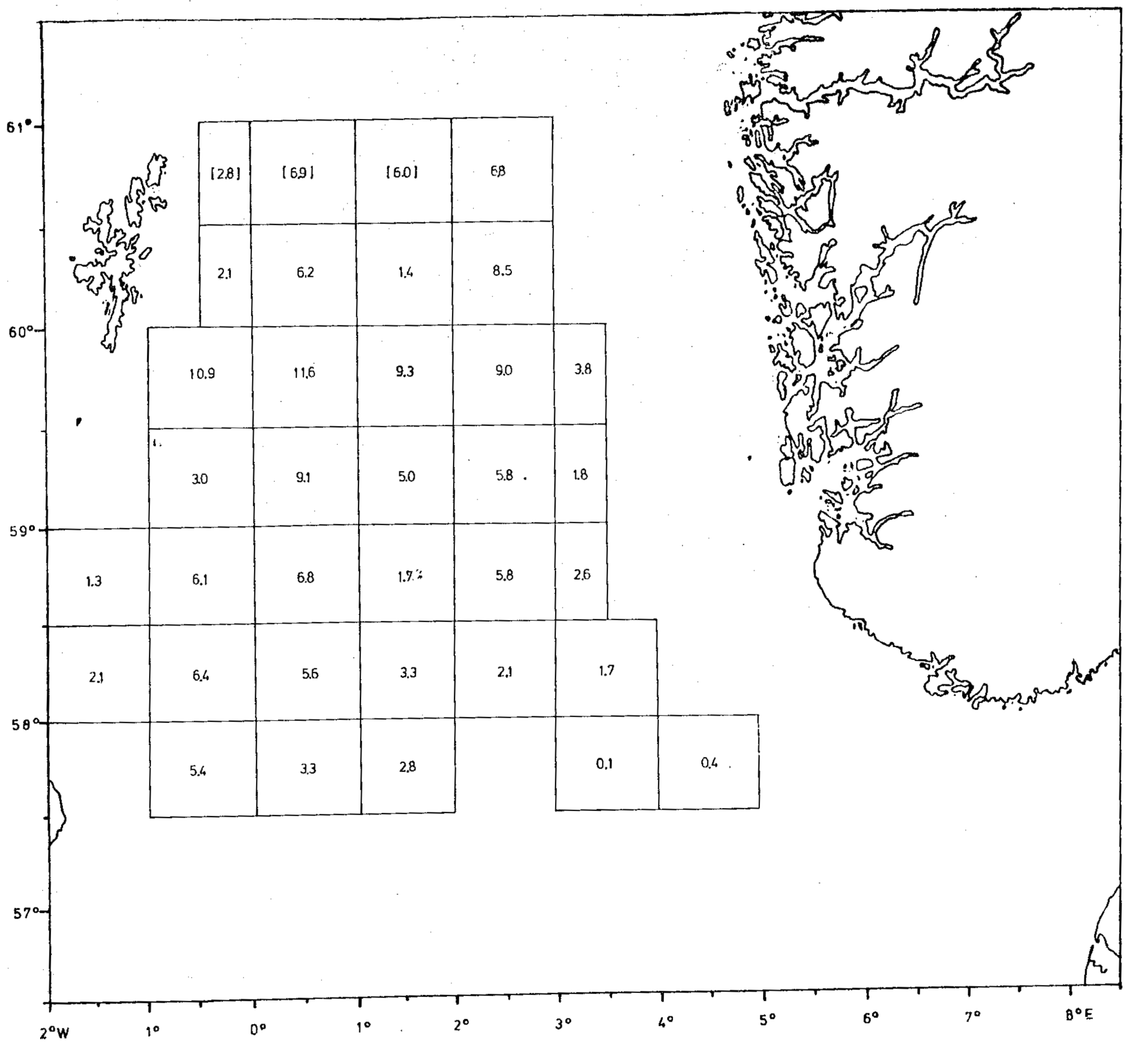


Fig. 8. Estimated numbers of 0-group Norway pout ($\cdot 10^9$) from acoustic data.

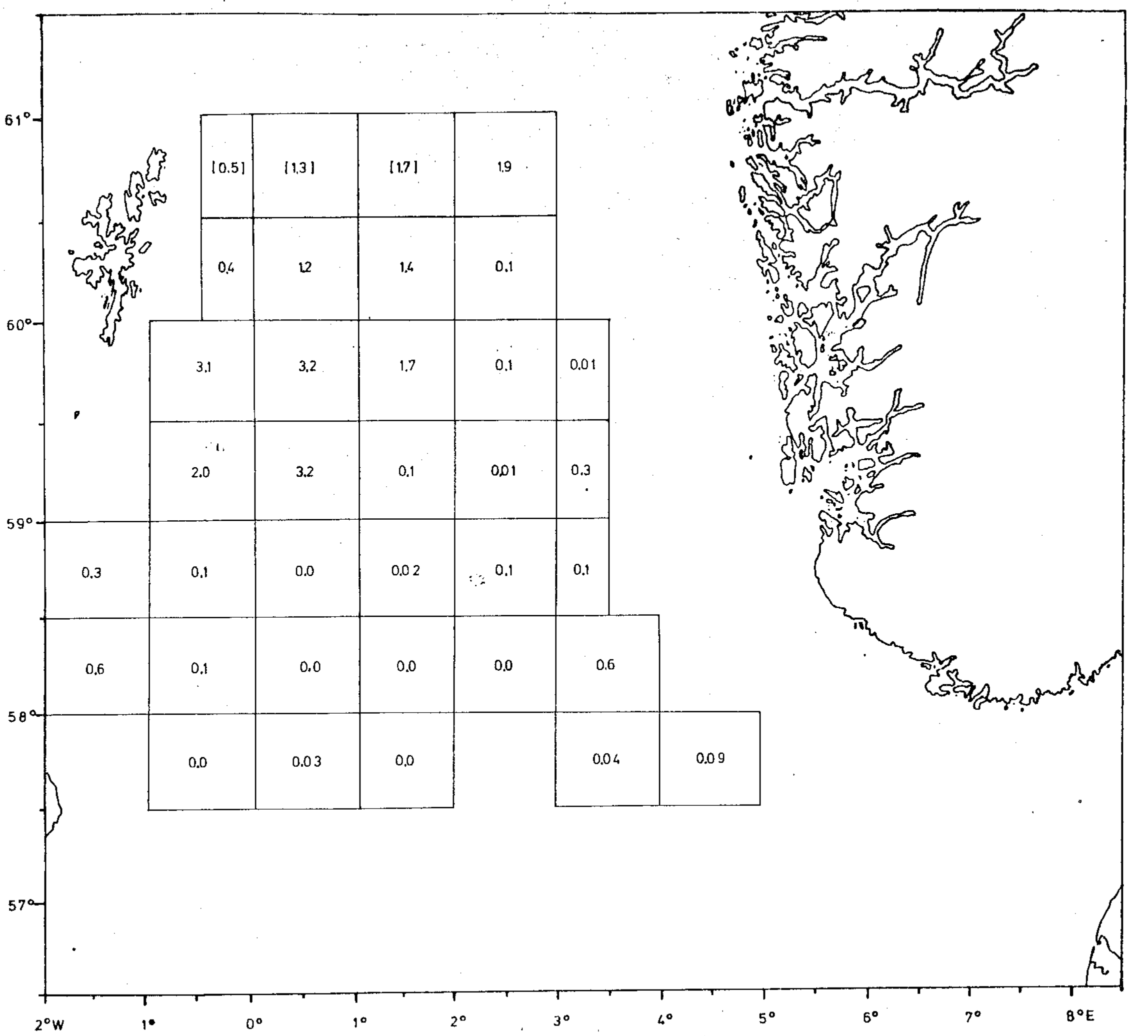


Fig. 9. Estimated numbers of 0-group haddock ($\cdot 10^9$).